

DECLARATION OF R. JACOB BAKER, PH.D., P.E.
UNDER 37 C.F.R. § 42.100 REGARDING U.S. PATENT NOS. 7,639,982;
8,326,218; 8,577,286; 9,332,402

Declaration

I declare that all statements made herein on my own knowledge are true and that all statements made on information and belief are believed to be true, and further, that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Date: Aug. 11, 2021

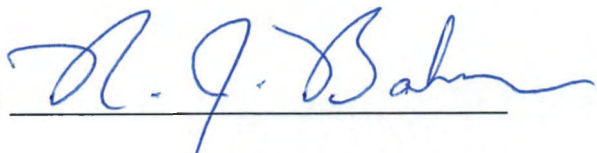
By: 
R. Jacob Baker, Ph.D., P.E.

Table of Contents

I.	Qualifications.....	1
II.	Relevant Legal Standards	9
III.	Person Of Ordinary Skill In The Art	11
IV.	Technology Background.....	12
	A. General Concepts	12
	1. Cellular Communications	12
	2. Propagation Impairments	19
	3. Distributed Antenna Systems.....	20
	B. The '982, '218, '286, and '402 Patents	24
V.	Overview Of The Prosecution Histories.....	28
	A. The '982 Patent	28
	B. The '218 Patent	28
	C. The '286 Patent	28
	D. The '402 Patent	29
VI.	Claim Construction.....	29
	A. The '982 Patent	29
VII.	Overview Of The Prior Art.....	31
	A. Overview Of Oh	31
	B. Overview of Wala	42
	C. Overview of Farber	44
	D. Overview Of Schwartz	46
	E. Overview Of Koschek	51
	F. Overview of Allpress	53
VIII.	The Claims of the '982 Patent Are Unpatentable.....	55
	A. Claims 1-10, 25-32, 34, 35, 37-51, and 81 Are Obvious Over Oh	55
	1. Independent Claim 1	55
	2. Dependent Claim 2	66

3.	Dependent Claim 3	67
4.	Dependent Claim 4	68
5.	Dependent Claim 5	71
6.	Dependent Claim 6	72
7.	Dependent Claim 7	73
8.	Dependent Claim 8	74
9.	Dependent Claim 9	75
10.	Dependent Claim 10	79
11.	Independent Claim 25	81
12.	Dependent Claim 26	90
13.	Dependent Claim 27	91
14.	Independent Claim 28	95
15.	Dependent Claim 29	105
16.	Dependent Claim 30	106
17.	Dependent Claim 31	108
18.	Dependent Claim 32	109
19.	Independent Claim 34	111
20.	Dependent Claim 35	119
21.	Independent Claim 37	119
22.	Dependent Claim 38	123
23.	Dependent Claim 39	124
24.	Dependent Claim 40	125
25.	Dependent Claim 41	126
26.	Dependent Claim 42	127
27.	Dependent Claim 43	129
28.	Dependent Claim 44	130
29.	Independent Claim 45	131

30.	Dependent Claims 46-50.....	131
31.	Independent Claim 51	132
32.	Independent Claim 81	132
B.	Claims 75-80 Are Obvious Over Oh in view of Wala.....	141
1.	Independent Claim 75	141
2.	Dependent Claims 76-77.....	146
3.	Independent Claim 78	146
4.	Dependent Claims 79-80.....	146
C.	Claims 65-69 and 74 Are Obvious Over Oh.....	147
1.	Independent Claim 65	147
2.	Dependent Claim 66	158
3.	Dependent Claim 67	162
4.	Dependent Claim 68	164
5.	Dependent Claim 69	166
6.	Independent Claim 74	167
D.	Claims 11-24, 33, and 36 Are Obvious Over Oh in view of Schwartz	170
1.	Motivation to Combine	170
2.	Independent Claim 14	172
3.	Dependent Claim 15	186
4.	Dependent Claim 16	187
5.	Dependent Claim 17	188
6.	Dependent Claim 18	190
7.	Dependent Claim 19	190
8.	Dependent Claim 20	192
9.	Dependent Claim 21	194
10.	Dependent Claim 22	194

11.	Dependent Claim 23	196
12.	Dependent Claim 24	197
13.	Dependent Claim 11	201
14.	Dependent Claims 12 and 13	203
15.	Independent Claim 33	204
16.	Independent Claim 36	217
E.	Claims 52-64 and 70-73 Are Obvious Over Oh in view of Koschek	219
1.	Independent Claim 52	219
2.	Dependent Claim 53	223
3.	Dependent Claim 54	223
4.	Dependent Claim 55	225
5.	Dependent Claim 56 and 57.....	226
6.	Independent Claim 58	227
7.	Dependent Claims 59-63.....	229
8.	Independent Claim 64	229
9.	Independent Claim 70	229
10.	Dependent Claims 71-73.....	230
IX.	The Claims of the '218 Patent Are Unpatentable.....	231
A.	Claims 1-10, 12-14, 16-20, 23-25, and 27-28 Are Obvious Over Oh.....	231
1.	Independent Claim 1	231
2.	Dependent Claim 2	245
3.	Dependent Claim 3	251
4.	Dependent Claim 4	255
5.	Dependent Claim 5	257
6.	Dependent Claim 6	262
7.	Dependent Claim 7	263

8.	Dependent Claim 8	265
9.	Dependent Claim 9	266
10.	Dependent Claim 10	266
11.	Independent Claim 12	269
12.	Dependent Claim 13	273
13.	Dependent Claim 14	275
14.	Dependent Claims 16-20.....	276
15.	Dependent Claims 23-24.....	276
16.	Independent Claim 25	276
17.	Dependent Claims 27-28.....	277
B.	Claims 11, 15, 21-22, and 26 Are Obvious Over Oh in view of Schwartz	278
1.	Motivation to Combine	278
2.	Dependent Claim 11	279
3.	Dependent Claim 15	288
4.	Independent Claim 21	289
5.	Dependent Claim 22	296
6.	Dependent Claim 26	300
X.	The Claims of the '286 Patent Are Unpatentable.....	301
A.	Claims 1-4, 7-17, 19-34, and 37-39 Are Obvious Over Oh.....	301
1.	Independent Claim 1	301
2.	Dependent Claim 2	315
3.	Dependent Claim 3	317
4.	Dependent Claim 4	318
5.	Dependent Claim 7	319
6.	Dependent Claim 8	320
7.	Dependent Claim 9	321

8.	Dependent Claim 10	323
9.	Dependent Claim 11	324
10.	Dependent Claim 12	326
11.	Dependent Claim 13	327
12.	Dependent Claim 14	328
13.	Independent Claim 15	330
14.	Dependent Claims 16-17 and 19-22	335
15.	Independent Claim 23	335
16.	Dependent Claim 24	337
17.	Dependent Claims 25-31	337
18.	Independent Claim 32	337
19.	Dependent Claims 33-34	339
20.	Independent Claim 37	340
21.	Dependent Claims 38-39	340
B.	Claims 5-6, 18, 35-36, and 40 Are Obvious Over Oh in view of Allpress	340
1.	Motivation to Combine	340
2.	Dependent Claim 5	341
3.	Dependent Claim 6	342
4.	Dependent Claim 18, 35, 36, and 40	342
XI.	The Claims of the '402 Patent Are Unpatentable	343
A.	Claims 1, 2, 5-7, 10-21, 24, 25, 27-32, 35-44, 47, 48, 51, 52, 55, and 56 Are Obvious Over Oh	343
1.	Independent Claim 1	343
2.	Dependent Claim 2	357
3.	Dependent Claim 5	358
4.	Dependent Claim 6	360
5.	Dependent Claim 7	361

6.	Dependent Claim 10	362
7.	Dependent Claim 11	363
8.	Dependent Claim 12	364
9.	Dependent Claim 13	365
10.	Dependent Claim 14	367
11.	Dependent Claim 15	368
12.	Dependent Claim 16	369
13.	Dependent Claims 17 and 18	371
14.	Dependent Claim 19	372
15.	Independent Claim 20	374
16.	Dependent Claim 21	379
17.	Dependent Claims 24-25 and 27-30	380
18.	Independent Claim 31	380
19.	Dependent Claim 35	381
20.	Dependent Claims 32 and 36-42.....	381
21.	Independent Claim 43	382
22.	Dependent Claims 44, 47, and 48	384
23.	Independent Claim 51	385
24.	Dependent Claims 52, 55, and 56	385
B.	Claims 3, 4, 22, 23, 33, 34, 45, 46, 53, and 54 are unpatentable under 35 U.S.C. § 103 over Oh in view of Schwartz;.....	385
1.	Motivation to Combine	392
2.	Dependent Claims 3-4.....	387
3.	Dependent Claims 22, 23, 33, 34, 45, 46, 53, and 54	392
C.	Claims 8, 9, 26, 49, 50, and 57 are unpatentable under 35 U.S.C. § 103 over Oh in view of Allpress	392
1.	Motivation to Combine	392
2.	Dependent Claim 8	392

3.	Dependent Claim 9	393
4.	Dependent Claims 26, 49, 50, and 57	394

I, R. Jacob Baker, do hereby declare:

1. I am making this declaration at the request of SOLiD, Inc. (“SOLiD”) in the matter of the *Inter Partes* Reviews (“IPRs”) of U.S. Patent Nos. 7,639,982 (the ’982 patent); 8,326,218 (the ’218 patent); 8,577,286 (the ’286 patent); and 9,332,402 (the ’402 patent).

2. I am being compensated for my work in this matter at my standard hourly rate of \$615 for such consulting services. My compensation in no way depends on the outcome of this proceeding.

I. Qualifications

3. My qualifications generally are set forth in my *curriculum vitae*, which is submitted as Appendix A.

4. I have been working as an Engineer since 1985 and I have been teaching Electrical and Computer Engineering courses since 1991. I am currently a Professor of Electrical and Computer Engineering at the University of Nevada, Las Vegas (“UNLV”). I am also currently an industry consultant for Freedom Photonics. I am the named inventor on over 150 U.S. patents resulting from my industry work.

5. I received the B.S. and M.S. degrees in Electrical Engineering from UNLV in 1986 and 1988, respectively. I received my Ph.D. in Electrical Engineering from the University of Nevada, Reno, in 1993.

6. My doctoral research, culminating in the award of a Ph.D., investigated the use of power Metal-Oxide-Semiconductor Field-Electronic Transistors (“MOSFETs”) in the design of very high peak power, and high-speed, instrumentation. I developed techniques to reliably stack power MOSFETs to switch higher voltages, that is, greater than 1,000 V and 100 Amps of current with nanosecond switching times. This work was reported in the paper entitled “Transformerless Capacitive Coupling of Gate Signals for Series Operation of Power MOSFET Devices,” published in the IEEE Transactions on Power Electronics. The paper received the Best Paper Award in 2000.

Industry Experience

7. I have done technical and expert witness consulting for over 100 companies since I started working as an engineer in 1985. From 1985 to 1993, I worked for EG&G Energy Measurements and the Lawrence Livermore National Laboratory designing nuclear diagnostic instrumentation for underground nuclear weapon tests at the Nevada test site. During this time, I designed, and oversaw the fabrication of, over 30 electronic and electro-optic instruments including high-speed cable and fiber-optic receiver/transmitters, Phase-Locked Loop (“PLLs”), frame and bit-syncs, data converters, streak-camera sweep circuits, Pockel’s cell drivers, micro-channel plate gating circuits, charging circuits for battery backup of equipment for recording test data, and analog oscilloscope electronics.

8. My work during this time, as one example, had a direct impact on my doctoral research work using power MOSFETs, subsequent publishing efforts, and industry designs. In addition to the 2000 Best Paper Award from the IEEE Power Electronics Society, I published several other papers in related areas while working in industry. I hold a patent, Patent No. 5,874,830, in the area of power supply design, titled, “Adaptively biased voltage regulator and operating method,” which was issued on February 23, 1999. I have designed dozens of linear and switching power supplies for commercial products and scientific instrumentation.

9. I am a licensed Professional Engineer and have extensive industry experience in circuit design, fabrication, and manufacture of Dynamic Random Access Memory (“DRAM”) semiconductor integrated circuit chips, Phase-Change Random Access Memory (“PCRAM”) chips, and Complementary Metal-Oxide Semiconductor (“CMOS”) Image Sensors (“CISs”) at Micron Technology, Inc. (“Micron”) in Boise, Idaho. I spent considerable time working on the development of Flash memory chips while at Micron. My efforts resulted in more than a dozen patents relating to Flash memory. One of my projects at Micron included the development, design, and testing of circuit design techniques for a Multi-Level Cell (“MLC”) Flash memory using signal processing. Another project focused on the design of buffers for high-speed double-data rate DRAM which resulted in around 10 US patents in buffer design. Among many other experiences, I led the development

of the delay locked loop (“DLL”) in the late 1990s so that Micron DRAM products could transition to the Double Data Rate (“DDR”) memory protocol, used in mobile and non-mobile (server, desktop, cell phones, tablets, etc.) computing systems as main computer memory, for addressing and controlling accesses to memory via Interprocess Communications (“IPC”) with the Memory Controller (“MC”). I provided technical assistance with Micron’s acquisition of Photobit during 2001 and 2002, including transitioning the manufacture of CIS products into Micron’s process technology. Further, I did consulting work at Sun Microsystems and then Oracle on the design of memory modules during 2009 and 2010. This work entailed the design of low-power, high-speed, and wide interconnection methods with the goal of transmitting data to/from the memory module and the MC at higher speeds.

10. I have extensive experience in the development of instrumentation and commercial products in a multitude of areas including: integrated electrical/biological circuits and systems, array (memory, imagers, and displays) circuit design, CMOS analog and digital circuit design, diagnostic electrical and electro-optic instrumentation for scientific research, Computer-Aided Design (“CAD”) tool development and online tutorials, low-power interconnect and packaging techniques, design of communication/interface circuits (to meet commercial standards such as Universal Serial Bus (“USB”), firewire, DDR, Peripheral Component Interconnect Express (“PCIe”), Serial Peripheral Interface (“SPI”), etc.), circuit design for the use

and storage of renewable energy, and power electronics. For example, a part of my research at Boise State University (“BSU”), for many years, focused on the use of Thru-Silicon-Vias (“TSVs”), aka Thru-Wafer Vias (“TWVs”), for high-density packaging. These packaging techniques were utilized in the memory module development work I did with Sun Microsystems and Oracle. As another example, I’ve designed circuitry for use in implementing USB interface circuits while I did consulting at Tower Semiconductor. I designed Peripheral Component Interconnect (“PCI”) communication circuits for IPC between a Graphics Processor Unit (“GPU”) and memory while consulting for Rendition, Inc.

11. My current research work is focused in part on the design of integrated circuits for wireless sensing using Light Detection And Ranging (“LIDAR”). I have worked with several companies in the development of these circuits and systems including Freedom Photonics, Aerius Photonics and FLIR. In the early 1990s I worked on wireless systems for wideband impulse radar while at Lawrence Livermore Laboratory. Further, part of my research for several years focused on the digitization of IQ channels using delta-sigma modulation. The knowledge and experience gained from this effort are reflected in my textbook *CMOS Mixed-Signal Circuit Design* and a presentation, which I have presented at several universities and companies, http://cmosedu.com/jbaker/papers/talks/BP_DSM_talk.pdf.

Academic Experience

12. I was an adjunct faculty member in the Electrical Engineering department of the University of Nevada, Las Vegas in 1991 and 1992. From 1993 to 2000, I served on the faculty at the University of Idaho as an Assistant Professor and then as a tenured Associate Professor of Electrical Engineering. In 2000, I joined a new Electrical and Computer Engineering program at Boise State University (BSU) where I served as department chair from 2004 to 2007. At BSU, I helped establish graduate programs in Electrical and Computer Engineering including, in 2006, the university's second Ph.D. degree. In 2012, I re-joined the faculty at UNLV. Over the course of my career as a professor I have advised over 90 masters and doctoral students.

13. I have been recognized for my contributions as an educator in the field. While at BSU, I received the President's Research and Scholarship Award (2005), Honored Faculty Member recognition (2003), and Outstanding Department of Electrical Engineering Faculty recognition (2001). In 2007, I received the Frederick Emmons Terman Award (the "Father of Silicon Valley"). The Terman Award is bestowed annually upon an outstanding young electrical/computer engineering educator in recognition of the educator's contributions to the profession. In 2011, I received the IEEE Circuits and Systems Education Award. I received the Tau Beta

Pi Outstanding Electrical and Computer Engineering Professor Award every year it was awarded while I have been back at UNLV.

14. I have authored several books and papers in the electrical and computer engineering area. My published books include *CMOS Circuit Design, Layout, and Simulation* (Baker, R.J., *Wiley-IEEE*, ISBN: 978-0470881323 (3rd ed., 2010)) and *CMOS Mixed-Signal Circuit Design* (Baker, R.J., *Wiley-IEEE*, ISBN: 978-0470290262 (2nd ed., 2009) and ISBN: 978-0471227540 (1st ed., 2002)). I co-authored *DRAM Circuit Design: Fundamental and High-Speed Topics* (Keeth, B., Baker, R.J., Johnson, B., and Lin, F., *Wiley-IEEE*, ISBN: 978-0-470-18475-2 (2008)), *DRAM Circuit Design: A Tutorial* (Keeth, B. and Baker, R.J., *Wiley-IEEE*, ISBN: 0-7803-6014-1 (2001)), and *CMOS Circuit Design, Layout and Simulation* (Baker, R.J., Li, H.W., and Boyce, D.E., *Wiley-IEEE*, ISBN: 978-0780334168 (1998)). I contributed as an editor and co-author on several other electrical and computer engineering books.

Other Relevant Experience

15. I have performed technical and expert witness consulting for over 100 companies and laboratories and given more than 50 invited talks at conferences, companies, and Universities. Further, I am the author and co-author of more than 100 papers and presentations in the areas of electrical and computer engineering design, fabrication and packaging.

16. I currently serve, or have served, as a volunteer on: the IEEE Press Editorial Board (1999-2004); as editor for the Wiley-IEEE Press Book Series on Microelectronic Systems (2010-present); as the Technical Program Chair of the 2015 IEEE 58th International Midwest Symposium on Circuits and Systems (MWSCAS 2015); on the IEEE Solid-State Circuits Society (SSCS) Administrative Committee (2011-2016); as a Distinguished Lecturer for the SSCS (2012-2015); and as the Technology Editor (2012-2014) and Editor-in-Chief (2015-2020) for the *IEEE Solid-State Circuits Magazine*. These meetings, groups, and publications are intended to allow researchers to share and coordinate research. My active participation in these meetings, groups, and publications allowed me to see what other researchers in the field have been doing.

17. In addition to the above, I am an IEEE Fellow for contributions to memory design and a member of the honor societies Eta Kappa Nu and Tau Beta Pi.

18. I have considered information from various sources in forming my opinions. I considered the materials in the Exhibit List included with the Petitions. I may review additional documents filed in connection with this proceeding as they become available.

19. My curriculum vitae is attached to this declaration as Appendix A.

II. Relevant Legal Standards

20. I have been asked to provide my opinion as to whether certain claims of the '982, '218, '286, and '402 patents are anticipated or would have been obvious to a person of ordinary skill in the art at the time of the invention, in view of the prior art.

21. I am an engineer by training and profession. The opinions I am expressing in this report involve the application of my knowledge and experience to the evaluation of certain prior art with respect to the '982, '218, '286, and '402 patents. My formal knowledge of patent law is no different than that of any lay person. Therefore, I have requested the attorneys from Jones Day, who represent SOLiD, to provide me with guidance as to the applicable patent law in this matter. The paragraphs below express my understanding of how I must apply current principles related to patent validity to my analysis.

22. It is my understanding that in determining whether a patent claim is anticipated or obvious in view of the prior art, the Patent Office must apply the *Phillips* standard to construe the claim by giving the claim its plain and ordinary meaning, consistent with the specification and prosecution history. For the purposes of this review, I have construed each claim term in accordance with its plain and ordinary meaning under the *Phillips* standard except where particular constructions are discussed.

23. It is my understanding that a claim is anticipated under 35 U.S.C. § 102 if each and every element and limitation of the claim is found either expressly or inherently in a single prior art reference.

24. It is my understanding that a claim is unpatentable under 35 U.S.C. § 103 if the claimed subject matter as a whole would have been obvious to a person of ordinary skill in the art at the time of the invention. I also understand that an obviousness analysis takes into account the scope and content of the prior art, the differences between the claimed subject matter and the prior art, and the level of ordinary skill in the art at the time of the invention.

25. In determining the scope and content of the prior art, it is my understanding that a reference is considered analogous prior art if it falls within the field of the inventor's endeavor. In addition, a reference is analogous prior art if it is reasonably pertinent to the particular problem with which the inventor was involved. A reference is reasonably pertinent if it logically would have commended itself to an inventor's attention in considering his problem. If a reference relates to the same problem as the claimed invention, that supports use of the reference as prior art in an obviousness analysis.

26. To assess the differences between prior art and the claimed subject matter, it is my understanding that 35 U.S.C. § 103 requires the claimed invention to be considered as a whole. This "as a whole" assessment requires showing that one of

ordinary skill in the art at the time of invention, confronted by the same problems as the inventor and with no knowledge of the claimed invention, would have selected the elements from the prior art and combined them in the claimed manner.

27. It is my further understanding that the Supreme Court has recognized several rationales for combining references or modifying a reference to show obviousness of claimed subject matter. Some of these rationales include: combining prior art elements according to known methods to yield predictable results; simple substitution of one known element for another to obtain predictable results; a predictable use of prior art elements according to their established functions; applying a known technique to a known device (method or product) ready for improvement to yield predictable results; choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success; and some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill in the art to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention.

III. Person Of Ordinary Skill In The Art

28. It is my understanding that when interpreting the claims of the '982, '218, '286, and '402 patents, I must do so based on the perspective of one of ordinary skill in the art (a "POSITA") as of the relevant priority date. My understanding is that

the earliest claimed priority date of the '982, '218, '286, and '402 patents is July 19, 2000.

29. In my opinion, a person of ordinary skill in the art for the '982, '218, '286, and '402 patents would have possessed at least a bachelor's degree in electrical engineering with at least two years of industry experience with data communications systems (or equivalent degree or experience). A person could also have qualified as a person of ordinary skill in the art with some combination of (1) more formal education (such as a master's of science degree) and less technical experience, or (2) less formal education and more technical or professional experience.

30. As described in detail above in the "Qualifications" section, my own training and experience exceeds that of one of ordinary skill in the art.

IV. Technology Background

A. General Concepts

31. Generally speaking, the '982, '218, '286, and '402 patents involve technologies relevant to a type of system used to distribute cellular radio signals between base stations and radiating antennas.

1. Cellular Communications

32. Cellular communication systems are systems that extend telephone and data services (such as email and web browsing) via wireless radio frequency ("RF") waves to mobile devices (such as cell phones and laptop computers). Components of

cellular systems include base stations, mobile devices, and infrastructure. The basic idea is to extend service from base stations to the mobile devices via wireless RF signals over a distance that rarely exceeds a few miles, and is often much less. Between the base station and the other end point of a connection (which may, for example, be a wired telephone or a web site), the signals are carried via conventional wired facilities (such as buried telephone cabling and fiber optic cables) over distances that may range up to several thousand miles. Thus, one of the responsibilities of a base station and its associated antenna system is to convert wireless RF signals into conventional wired electronic signals, and vice-versa.

33. Thus, cellular systems are essentially wireless access systems, providing access to the world-wide telecommunications infrastructure. The infrastructure consists of buried cabling and various types of switches such as Internet routers. Accordingly, it is typically only the “last mile” that uses a wireless RF signal; for most of the journey, the signals are carried by conventional, non-radio-based, cabled facilities.

34. In some instances, ultimate destination of a cellular signal may be another mobile device, in which case the signal path would consist of a short wireless RF segment from the first mobile device to its base station, a long non-radio-based segment over buried cabling and other infrastructure equipment from the first base station to the destination base station (which may be several thousand miles away),

and another short wireless RF segment from the destination base station to the destination mobile device.

35. Generally speaking, each base station communicates with (or “serves”) what may be a large number of mobile devices using its antenna to transmit and receive propagating wireless RF waves. Since these RF signals attenuate with distance as they propagate away from the originating antenna, a base station’s “cell” consists of the region over which the wireless RF signals sent from a base station remain sufficiently strong to be detectable at the receiving mobile devices, and vice-versa. The region over which cellular service is to be extended is divided into a set of overlapping “cells,” each of which typically has its own base station. The coverage area of a base station is often referred to as its “footprint.”

36. The direction of signal flow from the base station to a mobile device is known as the “forward” path, “downlink,” or “downstream” direction, and the direction of signal flow from a mobile device to the base station is known as the “reverse” path, “uplink” or “upstream” direction. It is typically (but not always) the case that the downlink signals occupy a different portion of the electromagnetic radio spectrum than the uplink signals.

37. A base station is typically owned and operated by a wireless service provider using certain wireless radio frequency spectrum purchased or licensed from Federal Communications Commission (“FCC”) (“licensed RF spectrum”). Since

each base station is capable of serving several or many mobile devices, a mechanism is needed to allow the radio frequency resources of the base station to be shared among the mobile devices. There are several ways of accomplishing this, including Frequency Division-Multiple-Access (“FDMA”).

38. Consider first the downlink direction. In FDMA, the downlink RF spectrum is divided into some number of non-overlapping radio channels, each capable of carrying a signal intended for one mobile device at any moment in time. Each radio channel consists of a range of radio frequencies, with the range of frequencies assigned to one channel being different than the range of frequencies assigned to every other channel. Accordingly, each mobile device then “tunes” to the radio channel (or range of RF frequencies) that carries its downlink signal. This is similar to broadcast entertainment radio, wherein each radio transmitting station is assigned to one radio channel, and each radio receiver “tunes” to and accepts the signal from only one of the broadcasted channels.

39. In the downlink direction, the base station collects the electronic signals intended for its served mobile devices from the infrastructure, processes and converts each to an RF signal on a different radio channel, combines these radio signals (each on a different set of RF frequencies) together, and sends this composite signal to its antenna over a segment of conventional cable (that is, the signal is not yet propagating wirelessly). The function of the antenna is to cause this composite signal to radiate

into space without any underlying cable. The antenna is essentially a “transducer” which accepts an electrical RF signal (having RF spectrum and containing some arbitrary composite of underlying modulated information signals) that arrives over a segment of cable and converts it into a wireless signal that radiates, without any cabling, over the footprint of the base station’s cell.

40. A base station radiates signals over the footprint of a cell. The much smaller antenna in each mobile device within that cell captures a replica of the composite signal radiated by the base station’s antenna. After conversion from a radio to electrical format, the electronics within the mobile begins the process of recovering, from the composite, those underlying signals intended for itself.

41. At the base station, the process of converting the electrical signals into corresponding RF signals may be a multistage process. For example, the electrical signals might first be converted into “intermediate frequency” signals prior to final conversion into electrical RF signals. The intermediate frequency signals are similar to RF signals, but are each of a lower frequency.

42. Similar procedures apply in the uplink direction. The uplink may be partitioned into a number of radio channels, each assigned at any given time to one mobile device. Each mobile device converts its electrical signal into an electrical RF signal over the range of RF frequencies assigned to its radio channel (again, this might be a two-step process involving a conversion first to an intermediate frequency

signal), and sends this to its antenna for cable-free transmission toward the base station. The electrical RF signal (which occupies only those radio channels assigned to that mobile) is then radiated by the mobile's antenna and becomes a wireless RF signal.

43. The base station is tuned to receive all of the RF frequencies in the service provider's uplink RF spectrum, including whatever noise or mobile uplink signals may be carried on those frequencies. The base station antenna collects the received wireless RF uplink spectrum and any signals which may be carried on any frequencies within that spectrum, and feeds the composite received RF spectrum into a segment of cabling (as an RF electrical signal). Due to frequency division multiplexing, each of the individual RF signals that make up the composite upstream RF signal remains distinguishable since each is on its own unique set of RF frequencies. The base station then separates this composite electrical RF signal into its constituent channels and converts the signal on each channel into an electrical signal appropriate for transmission within the infrastructure.

44. RF spectrum is regulated by the FCC. Wireless service providers (such as AT&T and Verizon) purchase or license segments of broadband RF spectrum from the FCC, and then employ that RF spectrum at RF antenna sites to provide wireless service to its customers within an RF antenna's coverage area, illustrated in the drawing above. The base station transmits its licensed segment of broadband analog

RF spectrum to the antenna. The antenna radiates the broadband RF spectrum wirelessly to cell phones within its coverage area.

45. Each licensed RF spectrum has a bandwidth defining a range of RF frequencies, also known as RF carriers or RF carrier frequencies. The number of usable RF carrier frequencies within a segment of RF spectrum will depend on the communication scheme employed by the wireless service provider. For example, Orthogonal Frequency-Division Multiple Access (“OFDMA”) based schemes use very tight frequency spacing compared to conventional FDMA-based communication schemes, and thus defined more usable frequencies.

46. As explained earlier, an information signal or original data signal (also known as original baseband signal, *e.g.*, voice, video, computer data) refers to the signal before it has been encoded or modulated onto an RF frequency carrier. So that the information can be transmitted wirelessly, the base station will encode or modulate information signals onto RF carrier frequencies. The wireless communication protocol (4G, 3G, etc.) employed by the service provider determines how the information signals are encoded onto the RF carrier frequencies. The level of activity within the wireless network will determine how many of the RF frequencies have been encoded with information signals. Regardless of which, if any, RF frequencies have been encoded with information signals, the composite of all the RF frequencies within

the licensed spectrum is transported to the co-located RF antenna where it is wirelessly propagated throughout the radio cell.

2. Propagation Impairments

47. Propagating RF signals suffer from a number of impairments. RF signals suffer impairments both when transmitted wirelessly and also when transmitted over cables. As already mentioned, wireless RF signals attenuate with distance as they propagate away from the radiating antenna. Also, wireless RF signals may be blocked by physical impairments encountered along the path from the transmitting to receiving antenna. For example, a large building in the line-of-sight path between the transmitting and receiving antennas may reflect a large portion of an incident signal, with only a very small portion penetrating the building to continue toward the receiving antenna; this is known as shadow fading.

48. In addition, inside buildings, signals from wireless base station attenuate dramatically, thus significantly impacting the ability to communicate with wireless telephones located in the buildings. That is, when the base station and its antenna is located outside a building, very little of the radio signal radiated from the base station's antenna may penetrate into the building's interior. Moreover, even if the entire base station is relocated to within the building and is installed, say, in the building's telecommunications closet on a low floor or within the basement, very little of the radiated RF signal may penetrate to the higher floors of the building since the

physical construction of each floor, itself, may reflect or otherwise attenuate the propagating wireless RF signal.

3. Distributed Antenna Systems

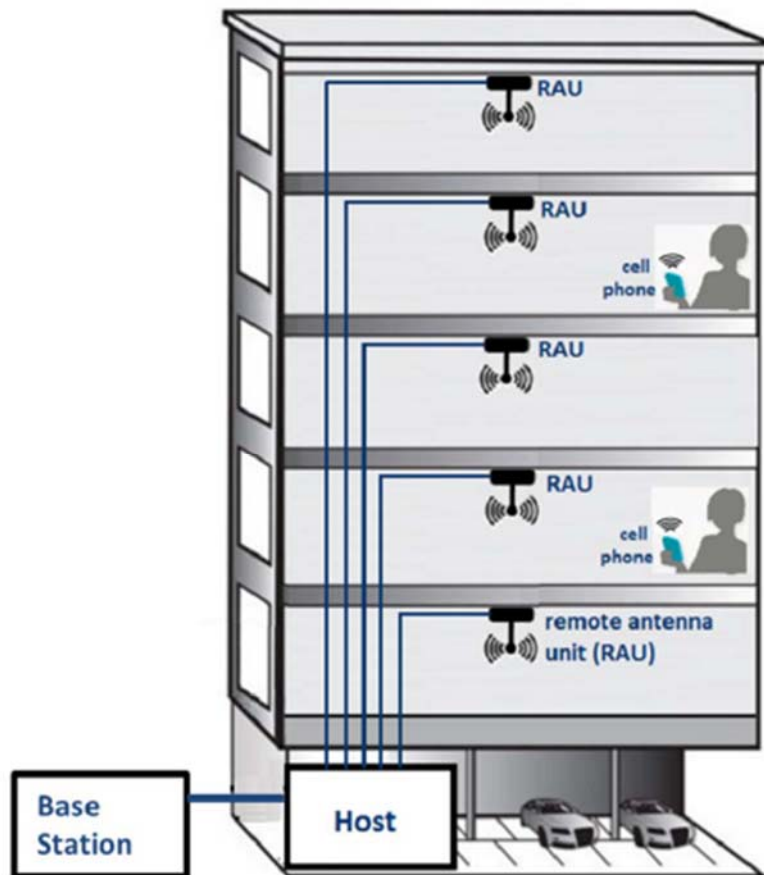
49. Where a cell of a cellular communication system includes obstructions such as tall buildings or terrain (hills, valleys, tunnels) that cause fading of the wireless signal between the base station antenna and mobile units in the cell, additional systems have been employed to reach mobile devices located in the shadowed areas of the cell (inside buildings, tunnels).

50. One solution employs a network of distributed lower-powered remote antenna units (or “RAUs”) each located within a shadowed area (microcell) but coupled to the base station via a cable. The network of cabling connecting the base station and the antenna units operate like a set of extension cords inserted between the base station and the remote antenna units. A network of antennas used in this fashion is sometimes referred to as a distributed antenna system (or by the acronym “DAS”). Such systems can be used to abate the effect of shadow fading inside or behind objects such as buildings.

51. In the downstream direction, each RAU receives RF signals from the base station over the cable and then radiates those signals to mobile devices in the shadowed area. In the upstream direction, the distributed RAUs receive wireless RF

signals from the mobile devices and communicate signals back to the base station over the connecting cabling.

52. Such DASs are often deployed and operated by a service provider seeking to expand its wireless service inside a building using its licensed wireless RF spectrum, as shown in the illustrative drawing below.



53. Frequencies within the service provider's licensed RF spectrum are allocated to and used by mobile devices (*e.g.*, cell phones) to carry uplink signals (*e.g.*, data that the mobile device has modulated onto the allocated RF frequencies using a 3G or 4G wireless communication protocol). In the downlink, the host unit (located

in an underground floor in the illustrative drawing above) receives the service provider's composite RF signal over cable and splits that composite RF signal (which contains the collection of individual channels, each intended for a particular mobile) a number of ways, with a replica of the composite RF signal being sent along cabling to each RAU.

54. At each RAU, the received RF signal is converted into wireless form for radiation to mobile devices located on that floor. The RAUs may have no way of knowing which, if any, mobile devices are located in that floor, nor which radio channels need to be radiated, in which case, each remote antenna unit may radiate the service provider's entire licensed RF spectrum.

55. Accordingly, the service provider's RF spectrum is provided wirelessly with adequate strength for reception throughout each floor, thereby abating the damaging effects of shadow fading. As is the case for a "conventional" antenna system (that is, a system using a single antenna which is co-located with the base station), each mobile device tunes to its assigned radio channel to receive its intended signal.

56. In the upstream direction, the RAU located on each floor in the above illustrative drawing is tuned to receive the service provider's wireless RF spectrum from its coverage area (*e.g.*, the floor on which the antenna unit is located), including whatever data may be carried on frequencies within that RF spectrum. The antenna

unit converts the received wireless RF spectrum to electrical signals which are transmitted over cabling back to the host and ultimately the base station.

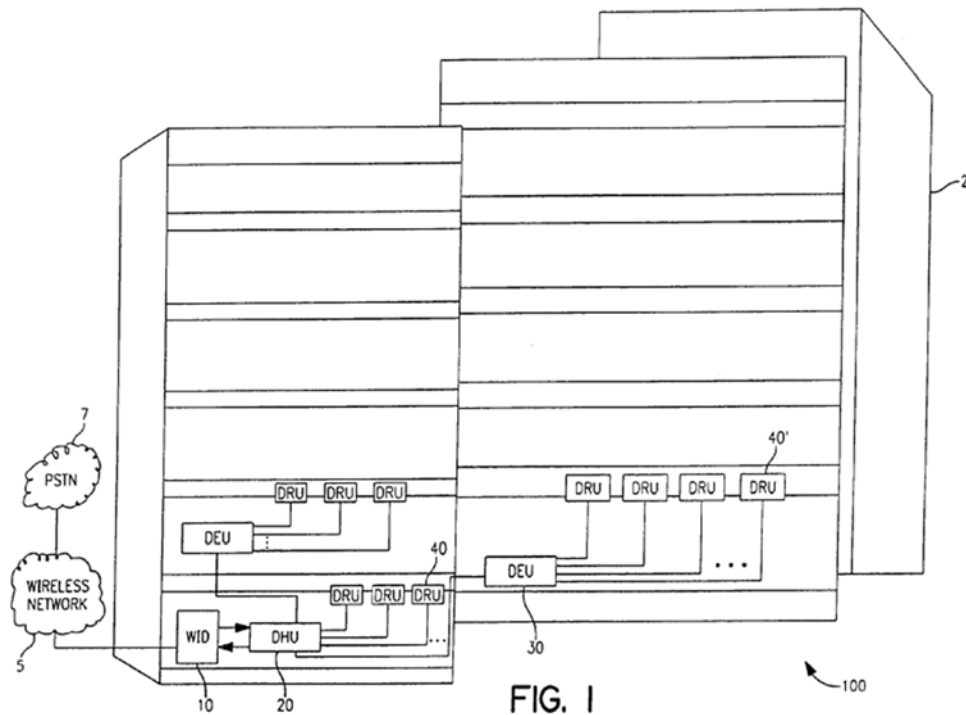
57. The host unit receives the composite uplink electrical signals from each of the antenna units. Equipment in the host unit combines these signals and feeds these signals to the base station as if they had been received on a single conventional antenna. That is, the presence of the DAS in the above illustration is transparent to the base station. As before, it is the base station that then separates this composite signal into its constituent channels and converts the signal on each channel into an electronic signal appropriate for distribution within the telecommunications infrastructure upstream from the base station.

58. A DAS system may include different types of combiners: analog combiners and digital combiners. A POSITA would recognize that these two types of combiners would involve different circuitries and thus perform different operations. In particular, a POSITA would understand that an analog combiner receives multiple input analog signals, which typically operate on different carrier frequencies. These analog signals are continuously added together in the analog domain such that the input signals are combined into a single composite analog output signal that is representative of the input analog signals. In contrast, a POSITA would understand that a digital combiner receives multiple input digital values (*e.g.*, 12-bit data values) within a given time period. When all of the input digital values are received (*e.g.*, as

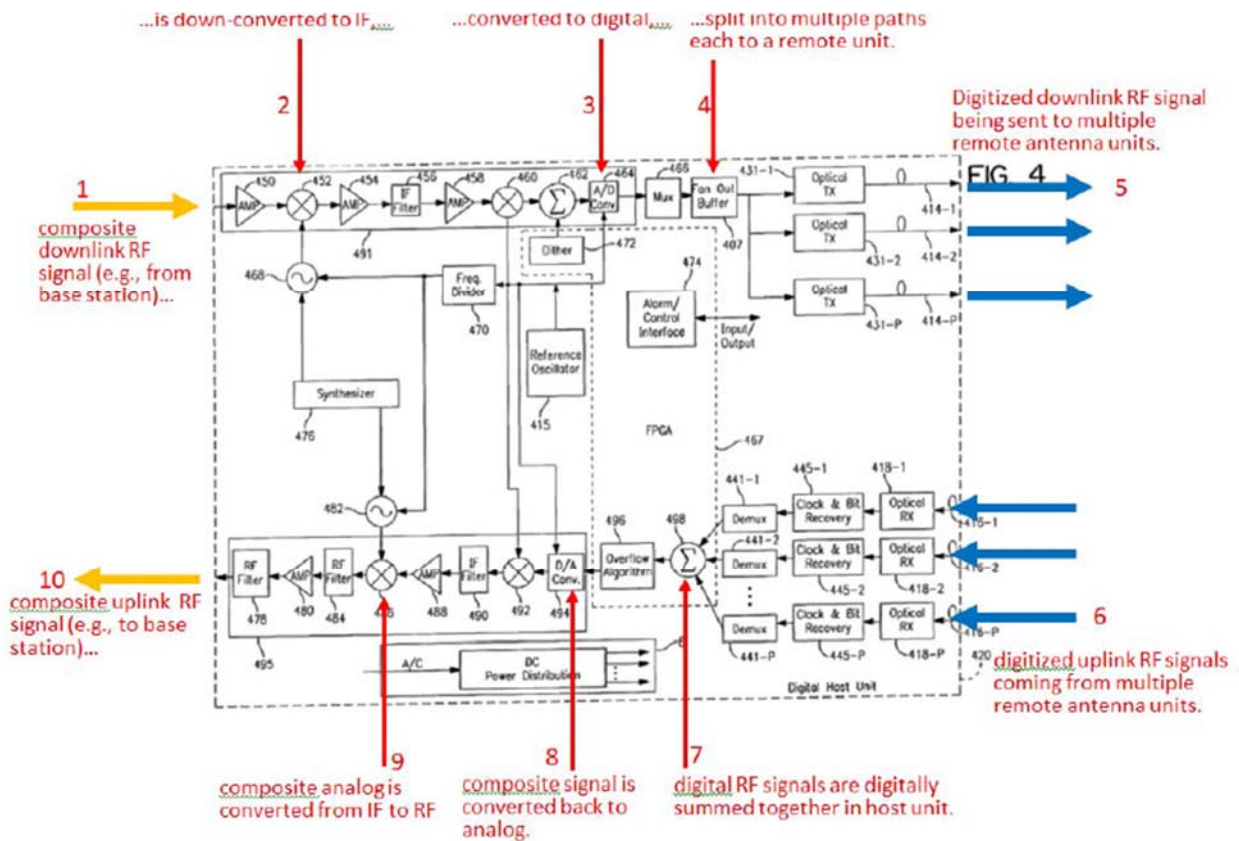
signaled by a rising or falling clock edge), the digital combiner adds the values together, thereby combining those multiple digital values into a single digital output value that is the sum of the input digital values (*e.g.*, (1010 1010 1010 (2,730) + 1100 1100 1100 (3,276) + 1111 1111 1111 (4,095) + 0000 1100 1100 (204) = 10 1000 0100 0001 (10,305)). Whether referred to as “adding,” “combining,” or “aggregating,” in this context, the operation of a digital combiner produces a digital sum. Even though, both the digital and analog combiners are referred using the label “combiner,” a POSITA can identify the type of a combiner used in a circuit by determining whether analog signals or digital values are provided as inputs to the combiner and are output from the combiner.

B. The '982, '218, '286, and '402 Patents

59. The '982, '218, '286, and '402 patents share a common specification (specification citations are generally to the '982 patent herein) that is directed to a digital DAS illustrated in Fig. 1 having a host unit and multiple distributed remote antenna units (denoted as “DRU”).

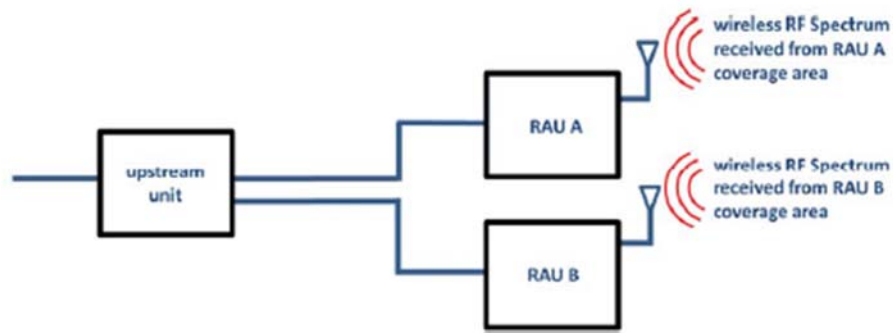


60. Annotated Fig. 4 of the '982 patent below illustrates a host unit that provides digitization of an RF signal received from a base station (top left) for distribution to multiple digital remote units (top right). Annotated Fig. 4 further illustrates creation of an uplink RF signal for transmission to the base station (bottom left) based on digital samples received from multiple digital remote units (bottom right).

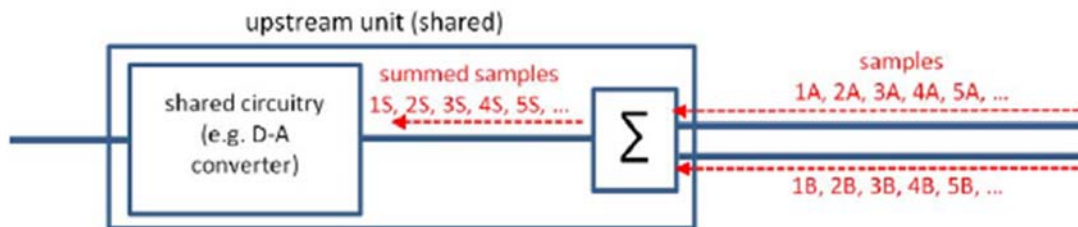


61. In the downlink direction, the host unit down-converts a composite downlink RF signal, takes a sequence of digitized samples, and delivers a sequence of digitized samples over a fiber optic cable to each of several remote units. Ex. 1001, 7:3-17. At each digital remote unit, the arriving stream of digital samples are converted back into the analog signal from which they are derived and then delivered to an antenna for transmission. *Id.*, 9:5-20.

62. In the uplink direction, each digital remote unit receives the wireless RF spectrum from its coverage area and converts this to a sequence of digital samples that are sent over a fiber optic cable to the host unit.



Ex. 1001, 9:34-38 (drawing from Ex. 1008, ¶173, Patent Owner's background description of this patent family showing RAU relaying signals from wireless devices to an upstream unit, *e.g.*, a host unit). The upstream unit receives the sequence of samples from the respective remote units and digitally sums the corresponding digital samples from the respective remote units by summing corresponding digital values of the recorded samples.



63. Ex. 1001, 7:53-8:7; Ex. 1008, ¶177. The summed digital samples are then converted into an analog signal and converted to an RF signal for delivery to the base station. *Id.*

V. Overview Of The Prosecution Histories

A. The '982 Patent

64. The '982 patent issued after eight Office Actions and corresponding responses. The Applicant amended certain aspects of the claims (*e.g.*, claim 1) to recite that the digital host unit digitally sums the digitized radio frequency signals received at the digital host unit. Ex. 1006, 465. Applicant further differentiated the claims from the Examiner cited prior art based on the resolution of signals involved in digitally summing operations (*e.g.*, claim 37, Ex. 1006, 69-70), and the location of summing operations being at the host unit and not remote units (*e.g.*, claim 1, Ex. 1006, 72-73). The Oh reference was not considered by the Examiner during prosecution of the '982 patent.

B. The '218 Patent

65. The '218 patent issued after a single Office Action having only a nonstatutory double patenting rejection against U.S. Patents 6,704,545 and 7,639,982. *See* Ex. 1016, 26-62. The '218 patent was allowed after a terminal disclaimer was filed. *Id.*, 39-40. Oh was not considered by the Examiner during prosecution of the '218 patent.

C. The '286 Patent

66. The '286 patent issued after a single Office Action having only a double patenting rejection. The '286 patent was allowed after filing of a terminal disclaimer.

Ex. 1017, 117, 15. Oh was not considered by the Examiner during prosecution of the '286 patent.

D. The '402 Patent

67. The '402 patent issued after a single Office Action having only a double patenting rejection. The '402 patent was allowed after filing of a terminal disclaimer.

Ex. 1018, 132, 119. Oh was not considered by the Examiner during prosecution of the '402 patent.

VI. Claim Construction

68. It is my opinion that no claim terms of the '218, '286, or '402 patents require construction beyond their ordinary and customary meaning at this time.

A. The '982 Patent

69. I identify following functions and corresponding structures for the various means-plus-function terms introduced in claim 81.

<u>Claim 81 Limitation</u>	<u>Function</u>	<u>Structure</u>
means for communicatively coupling...	communicatively coupling the first unit to a plurality of second units	Fig. 4: Optical Transmission Lines 414, 416
means for digitizing...	digitizing an original downstream analog radio frequency signal in order	Fig. 4: Amplifier 450, Mixer 452, Amplifier/Filter 454, 456,

	to produce downstream digital RF samples	458, Mixer 460, A/D Converter 464
means for communicating...	communicating at least a portion of the downstream digital RF samples to the plurality of second units	Fig. 4: Optical Transmitters 431-1 – 431-P
means for receiving...	receiving from the plurality of second units respective upstream digital RF samples	Fig. 4: Optical Receivers 418
means for digitally summing...	digitally summing respective upstream digital RF samples received from the plurality of second units in order to produce each of a stream of summed upstream digital RF samples	Fig. 4: Summer 498
means for converting...	converting the stream of summed upstream digital RF samples to a replicated upstream analog radio frequency	Fig. 4: D/A Converter 494, Mixer 492, Amplifier/Filter 488, 490, Mixer 486

VII. Overview Of The Prior Art

A. Overview Of Oh

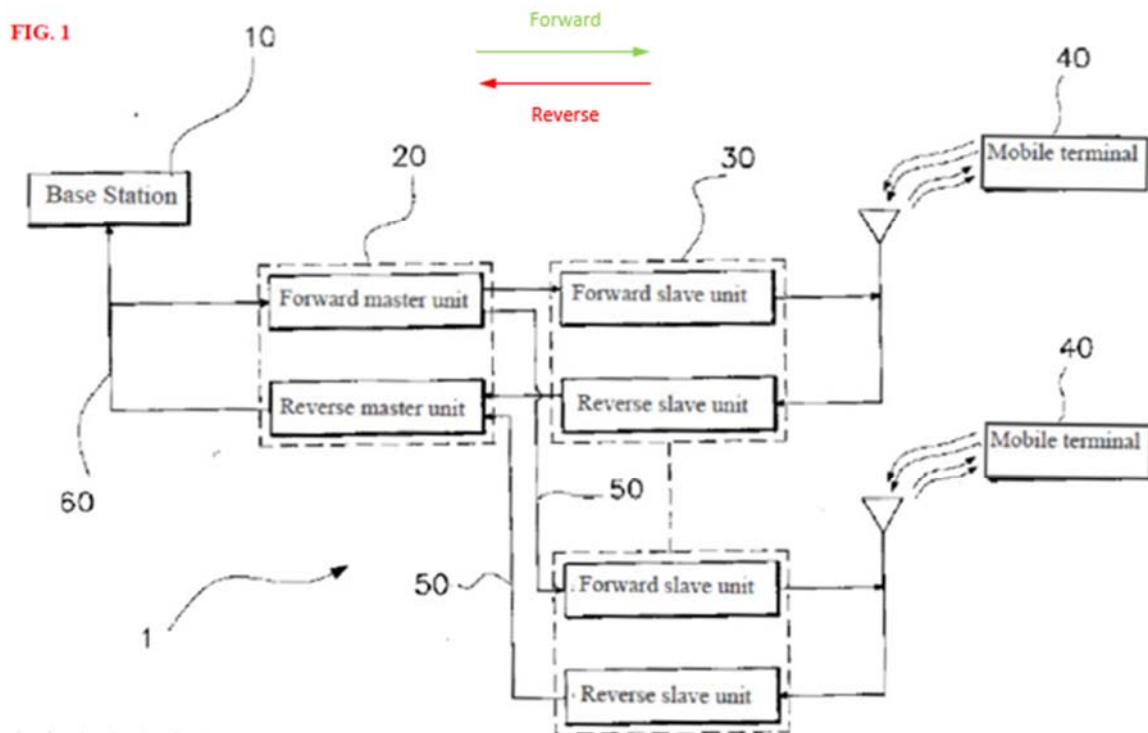
70. Oh is a publication of a Korean patent application filed by Yong Hoon Oh on April 3, 1999. Oh was published on August 5, 1999.

71. Oh discloses an optic repeater system that is installed to facilitate communications to and from “radio wave shadow area” where base station signals are unable to reach. Ex. 1007, 2:4-7. When a “base station is far away” or when the mobile terminal is “in the radio wave shadow area, the base station cannot perform streamlined transmission/reception to/from the mobile terminals.” *Id.*, 2:11-13.

72. Optic repeater systems were used prior to Oh in an attempt to provide wireless access to mobile terminals in the radio wave shadow area. *Id.*, 2:16-19. In those historic systems, transmissions between the primary unit and the remote units across an optic line were analog. *Id.*, 2:20-22. But because “the RF signals transmitted/received to/from said first optic repeater and a second optic repeater [were] analog signals, the strength of the signals is greatly decreased during transmission through the optical line.” *Id.*, 28-30. This analog signal attenuation required implementation of signal amplifiers in prior systems, which exacerbated signal-to-noise ratio issues. *Id.*, 2:30-33.

73. To address the analog signal attenuation issue, Oh “provide[s] a digital optical repeater that can maximize the efficiency of signal transmission in such a way

that the optic repeater converts the intermediate frequency signals, analog signals, to the digital signals and transmits/receives them through the optical line.” *Id.*, 2:36-39. An Oh optic repeater system includes a first optic repeater (master unit 20) that is in communication with the base station 10 and second optic repeaters (slave units 30) that are distributed within the radio wave shadow area. *Id.*, Abstract, 2:19-20.



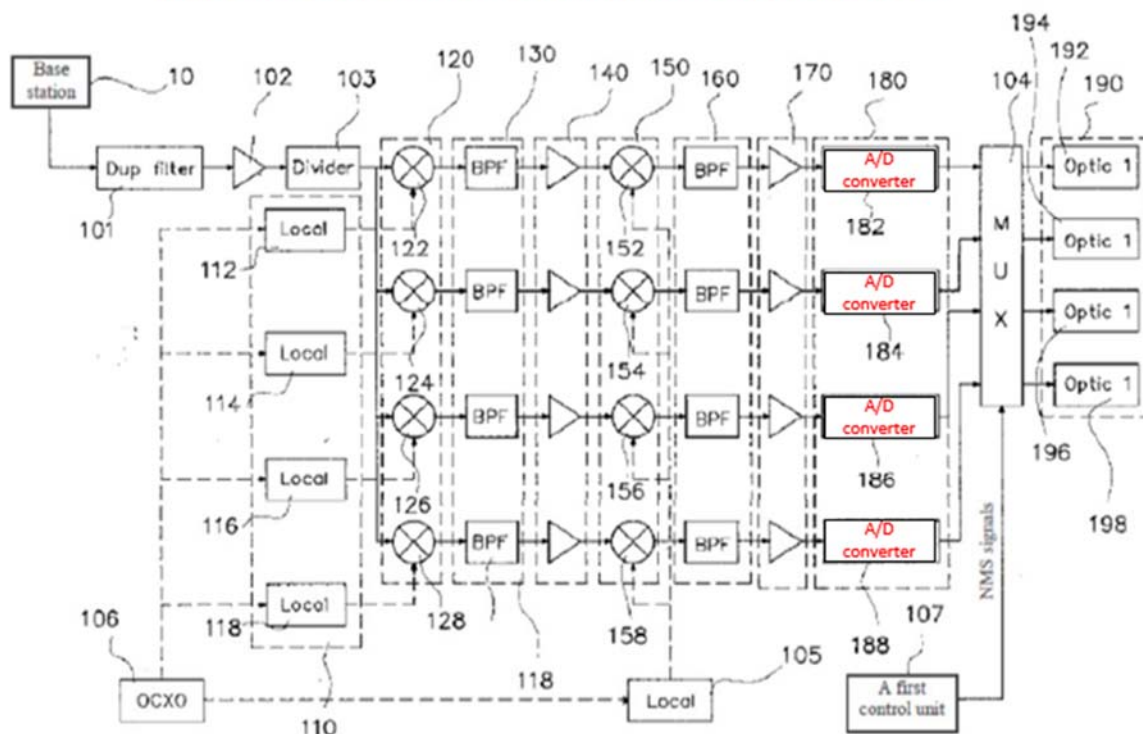
74. On the forward path (left-to-right in Fig. 1), RF signals are received by the forward portion of master unit 20 from the base station 10 and are processed by the forward master unit 100. *Id.*, 2:72-73. The forward master unit 100 “converts RF signals, analog signals, transmitted from the base station 10 to the intermediate frequency signals; converts them to digital signals; and transmits them to the slave unit 30 through the optic line 50.” *Id.*, 3:5-6. The forward portion of the slave units

30 (e.g., forward slave unit 200) “converts digital signals to the intermediate frequency signals, analog signals; converts the intermediate frequency signals to RF signals; and transmits them to the mobile terminals 40. *Id.*, 3:1-4.

75. On the reverse path (right-to-left in Fig. 1), the reverse portion of slave unit 30 (e.g., reverse slave unit 300) converts analog RF signals received from the mobile terminals 40 to digital signals and transmits them to master unit 20 through the optic line 50. *Id.*, 4:23-25. The reverse portion of master unit 20 (e.g., reverse master unit 400) “converts the digital signals transmitted from the slave unit 30 through the optic line 50 to the intermediate frequency signals, analog signals, converts them to the RF signals, and transmits them to the base station 10.” *Id.*, 4:62-64.

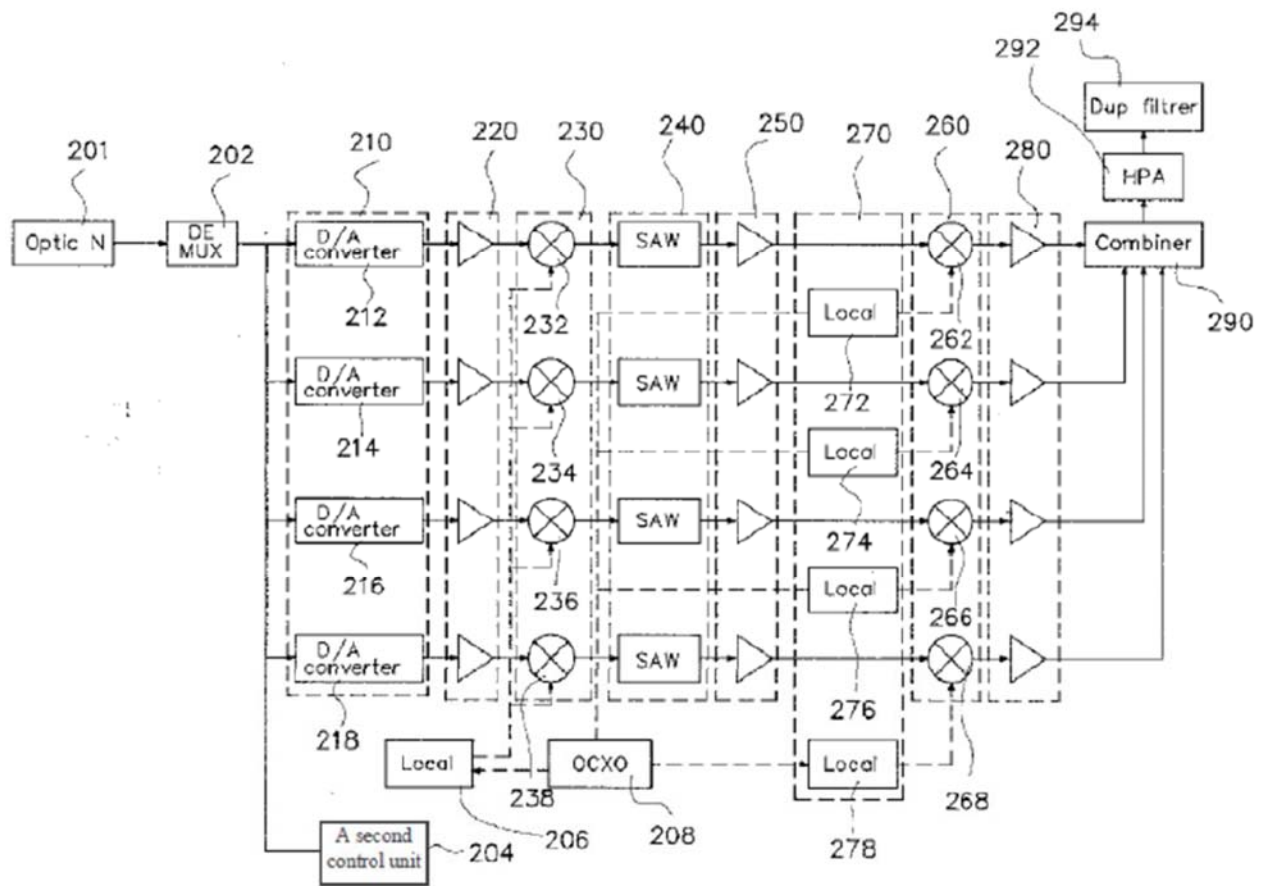
FIG. 2

Labels for 182, 184, 186, 188 fixed here. See Oh, 3:40 (“four A/D converters 182, 184, 186, and 188”)



76. Fig. 2 provides example detail of the forward portion of Oh's master unit 20. The forward master unit receives RF signals from the base station 10 through a bi-directional filter 101. A divider 103 divides the RF signals into its component frequency bands (*i.e.*, the component frequency bands that make up the RF signal received from the base station 10), where each of those component band signals is processed in parallel through first mixer unit 120, band pass filter (BPF) 130, amplifier 140, second mixer unit 150, second BPF 160, and second amplifier 170 collectively to transition the signals from their band frequencies to baseband frequency close to DC. *Id.*, 3:6-14. Analog to Digital (A/D) converters 182, 184, 186, 188 sample the baseband signals to convert them to digital representations of the analog component frequency band signals. *Id.*, 3:14-16. Multiplexer 104 multiplexes the four 12-bit digital sample values with 4-bit network management system (NMS) control data from control unit 107 and applies that 52-bit (*i.e.*, the 4-12-bit words plus the 4-bit NMS control information) serial data stream to each of a plurality of optic converters 192, 194, 196, 198 for transmission across optic lines 50 to destination slave units. *Id.*, 3:38-44.

FIG. 3

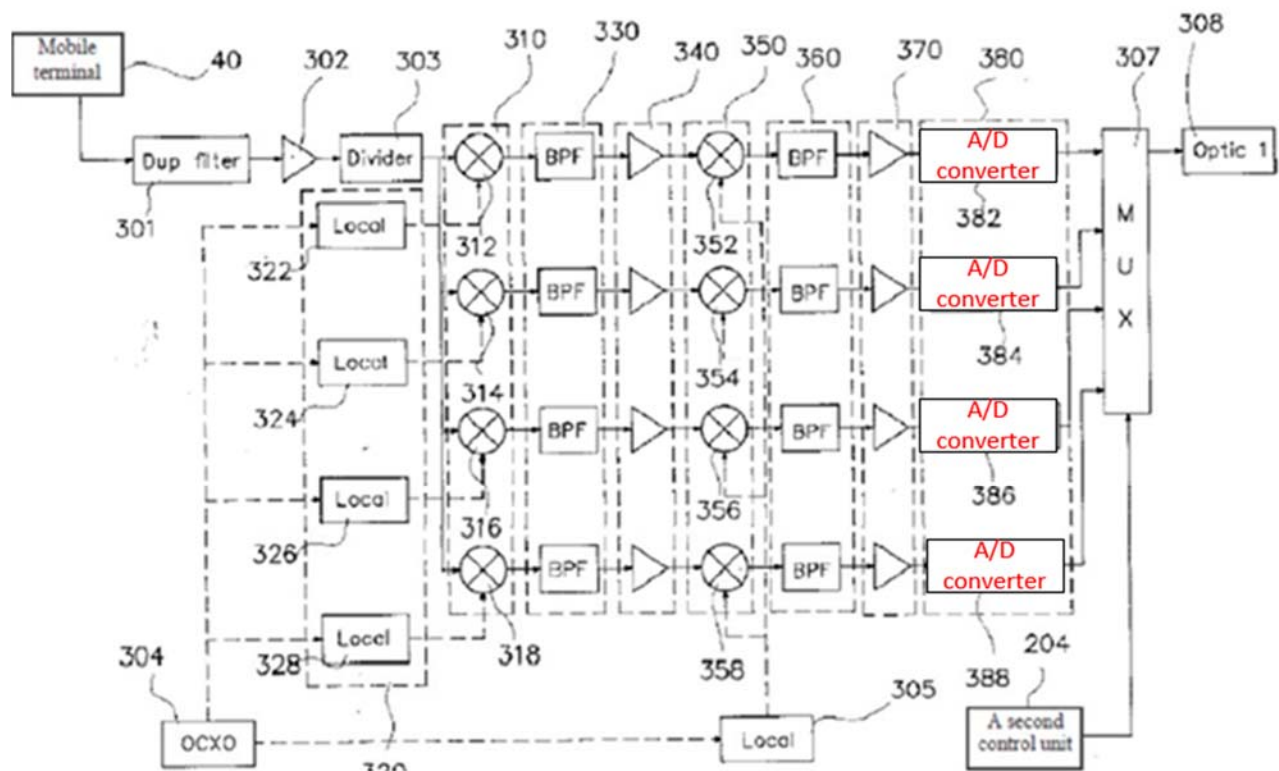


77. Fig. 3 provides example detail of the forward portion of one of Oh's slave units 30. The 52-bit digital signal transmitted on one of the optic lines 50 is received at a second optic converter unit 201. The 4 bits of control data are provided to control unit 204. Each of the 12-bit sample signals is routed to a respective digital to analog (D/A) converter 212, 214, 216, 218 at the start of respective paths for recreating the RF signal received from the base station *Id.*, 3:62-25. Each D/A converter converts its 12-bit digital signals to intermediate frequency signals, which are amplified at 220, mixed with a step up frequency at 230, amplified again at 250, mixed with a respective

frequency at 260 to recreate the analog band frequency signals, and amplified again at 280. *Id.*, 3:50-59. “[C]ombiner 290 [] combines the RF signals of four different frequency bands... and transmits them to the mobile terminals 40 through a second power amplifier 292 and a second bi-directional filter 294.” *Id.*, 3:59-61.

FIG. 4

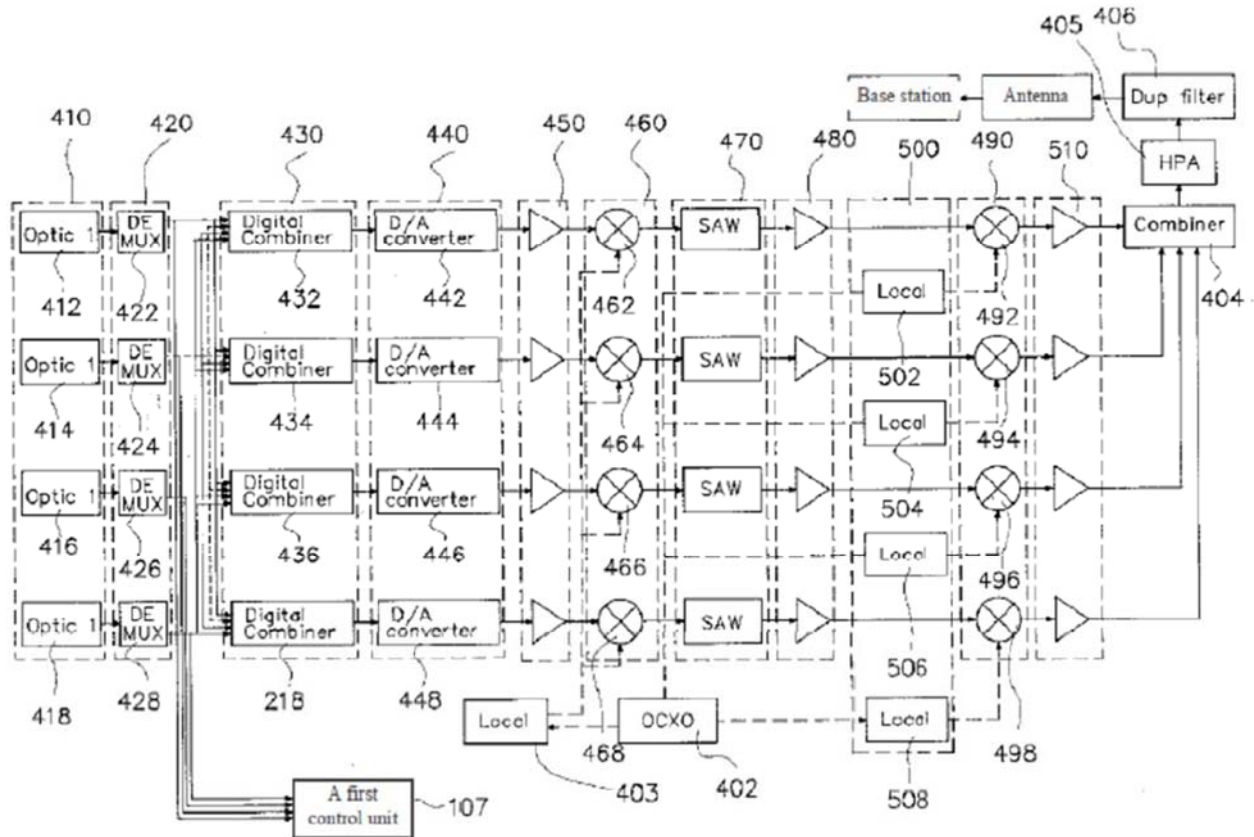
Labels for 382, 384, 386, 388 fixed here. See Oh, 4:53-54 (“four A/D converters 382, 384, 386, 388”)



78. Fig. 4 illustrates example details of the reverse path at a slave unit 30 (e.g., reverse slave unit 300). “RF signals transmitted from the mobile terminals 40 to the reverse slave unit 300 of the slave unit 30 through the antenna are converted to the intermediate frequency signals close to DC..., mixed with the NMS signals transmitted from a second control unit 204, and transmitted to the reverse master unit 400 through the optic line.” *Id.*, 4:16-18. RF signals from the mobile terminals 40

are directed through a bi-directional filter 301 to a divider 303. Similar to the master unit divider of Fig. 2, the divider 303 divides the RF signal from the mobile terminals 40 into component frequency bands, where each of those component band signals is processed in parallel through mixer unit 310, BPF 330, amplifier 340, mixer unit 350, BPF 360, and amplifier 370 collectively to transition the signals from their band frequencies to baseband frequency close to DC. *Id.*, 4:26-34. A/D converters 382, 384, 386, 388 sample the baseband signals to convert them to digital representations of the analog component frequency band signals. *Id.*, 3:14-16. Multiplexer 307 multiplexes the four 12-bit digital sample values with 4-bit NMS control data from control unit 204 and applies that 52-bit serial data stream to optic converter 308 for transmission across optic line 50 to master unit 20. *Id.*, 3:56-61.

FIG. 5



79. Fig. 5 illustrates example detail of the reverse path at the master unit 20 (e.g., reverse master unit 400), which receives four streams of digital data from four slave units over optic lines (i.e., digital data from a first slave unit at 412, a second slave unit at 414, a third at 416, and a fourth at 418). Each demultiplexer 422-428 is associated with a respective one of the remote slave units to route digital sample data to its respective frequency band path in the reverse unit. Each demultiplexer 422-428 receives digital sample data and control data from one slave unit 30 and separates that digital sample data according to frequency band. *Id.*, 5:4-10. In the example where the reverse master unit of Fig. 5 is connected to four slave units 30, the 52-bit data

from the slave unit is demultiplexed at a first demultiplexer, with one 12-bit data sample being sent to each of four digital combiners and 4-bit control data to control unit 107. *Id.*, 5:11-12. Thus, demultiplexer 422 sends a 12-bit sample associated with a first frequency band to first digital combiner 432, a 12-bit sample for second band to combiner 434, a 12-bit sample for third band to combiner 436, and a 12-bit sample for fourth band to combiner 438. Demultiplexers 424, 426, 428 similarly send 12-bit samples to each of the digital combiners 432, 434, 436, 438. *Id.*, 5:11-15.

80. Each digital combiner 432, 434, 436, 438 receives four digital samples associated with its band and “aggregates the same digital signals transmitted from each demultiplexer.” Specifically, upon receiving four 12-bit signals (one from each of demultiplexer 422, 424, 426, 428), each digital combiner 432, 434, 436, 438 operates on those 12-bit signals to “creat[e a] 14-bit intermediate frequency signal[] by combining¹ four 12-bit intermediate frequency signals in the same frequency band” (e.g., (1010 1010 1010 (2,730) + 1100 1100 1100 (3,276) + 1111 1111 1111 (4,095) + 0000 1100 1100 (204) = 10 1000 0100 0001 (10,305)). *Id.*, 4:69; 5:16-17.² Those

¹ I understand that the parties have discussed whether this word should be translated as “adding” or “combining.” Regardless of which of these terms is used, the digital combiners are operating to produce a digital sum (*i.e.*, they are performing a digital summing operation).

² Note that a POSITA would understand that whether the digital combiner’s operation on the 12-bit signals is referred to as “adding,” “aggregating,” or “combining,” the result of that operation is a 14-bit “digital sum.” This is evidenced

14-bit digital sum signals are then applied to respective D/A converters 442, 444, 446, 448 to provide intermediate frequency signals. *Id.*, 5:18. The intermediate frequency signals are shifted to their respective band frequencies by being amplified at 450, mixed with a step up frequency at 460, filtered at 470, amplified again at 480, mixed with a respective frequency at 490 to recreate the frequency signals, and amplified again at 510. *Id.* 4:73-5:2. “[C]ombiner 404 aggregates the RF signals in different frequency bands ... amplifies the strengths and level in a first power amplification unit 405, and transmits them to the base station 10 through a fourth bi-directional filter 406” such as via an antenna as depicted in Fig. 5 or an RF cable. *Id.*, 5:27-29.

81. Oh shows multiple, different example ways of communicating with a base station. For example, a wired connection (*e.g.*, RF cable 60) is illustrated in FIG. 1 between the base station 10 and master unit 20. Oh also illustrates a wireless connection (*e.g.*, antenna in Fig. 5) between the first bi-directional filter 406 of the master unit 20 and the base station 10. A POSITA would understand that the most

by the CommScope patents themselves referring their “sum” operation as “combining.” *See*, Ex. 1001, 4:67-5:16 (“Both DHU and DEU split signals in the forward path **and sum signals in the reverse path**...Splitting **and combining** the signals in a digital state avoids the combining and splitting losses experienced with an analog system.” *See also, e.g.*, Ex. 1027, 4:32-51 (“Common to the output of unit 8 is the digital combiner circuit... Combiner circuit 11 **sums** the weighted signal outputs of each of the channel units 8.”); Ex. 1028, Abstract (“The signals are digitally filtered, re-sampled at a common output rate and digitally combined (*e.g.*, summed).”)

straightforward, inexpensive system would perform downstream and upstream communications with the base station using the same medium type (*e.g.*, RF cable or wireless). Oh's explicit disclosure of wired and wireless base station communication options evidences the obviousness of implementing upstream and downstream communications with the base station in a wired implementation or a wireless implementation.

82. The similarities between Oh's implementation and the specification examples of the '982 patent are striking. The only differences of arguable import are the lack of explicit disclosure of expansion units in Oh (addressed by the Schwartz obviousness combination detailed in the companion IPR petition addressing '982 patent claims), and the fact that Oh divides and then digitizes and reconstructs its analog signals on a per frequency band basis (notice four rows of processing in each of Oh's Figs. 2-5), while the '982 patents performs a single digitization of its entire received analog signals.

83. This difference is a matter of design choice and is of little technical import, and more importantly is irrelevant to the claims. Whether one samples an entirety of a received analog signal for optical transmission and subsequent analog recreation at once, or one divides the received analog signal into its component bands before sampling, transporting, recreating those bands and combining them (*e.g.*, at combiner 404), the resulting analog signal at the destination carries the same

information. And most importantly, when the claims discuss digitizing an analog signal, there are no recited requirements about how that analog signal is represented by the digital data (*i.e.*, there are no requirements regarding whether the digital data represents only a single analog wave form, rather than representing its (4) component bands that when combined form the analog waveform). Thus Oh's difference in implementation choice is irrelevant to the unpatentability analysis for this matter.

84. Further, the number of bands that Oh processes is configurable (*see*, 3:9 (“*e.g.*, 4 ea.”)). In the nominal case where Oh operates on only a single frequency band channel, Oh's operation (*i.e.*, a single sampling/reconstruction path representing the entire received analog signal) is almost identical to that of the '982 patent.

85. Oh is analogous art to the '982 patent because it is in the same field of endeavor (RF data communications) and it is associated with the common problem of extending RF data communications into hard to reach areas. Ex. 1007, 2:4-13.

B. Overview of Wala

86. Like the '982 patent and Oh, Wala addresses expansion of RF signal coverage into hard to reach areas “including shadow areas, tunnels, and the interiors of high-rise office buildings.” Ex. 1009, 585. Also like the '982 patent and Oh, Wala recognizes the limitations of forwarding of analog signals in such coverage extension systems including signal-to-noise ratio issues. Thus Wala proposes a digital radio frequency transport system similar to the '982 patent and Oh.

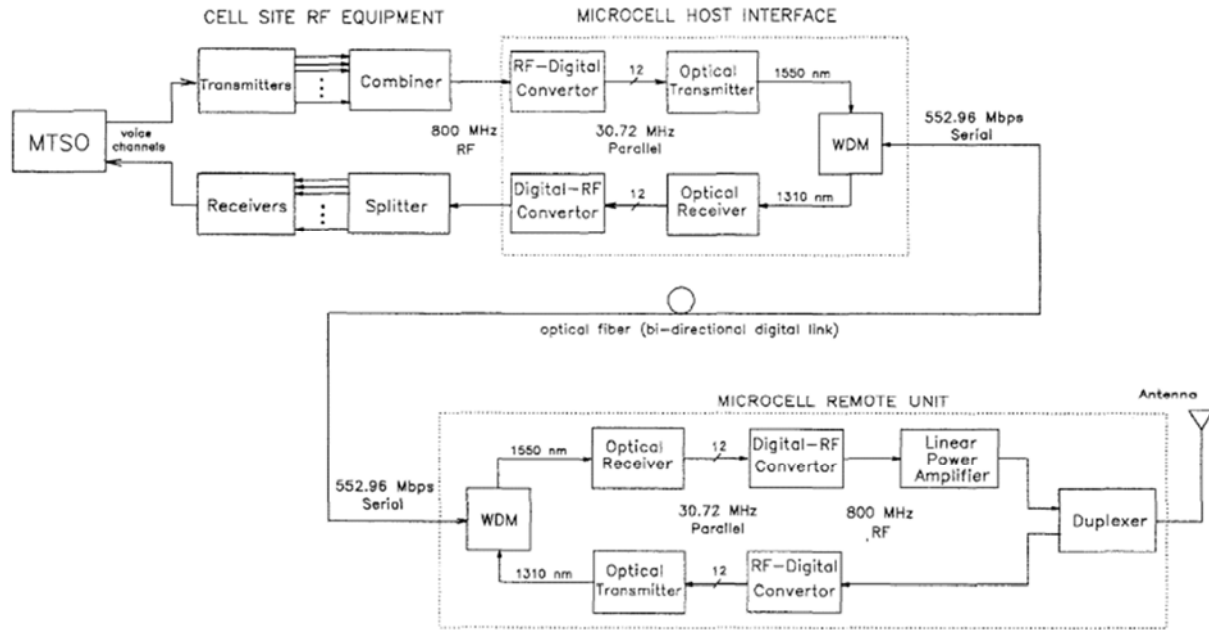


Fig.1. Digital RF transport microcell: system block diagram

In the forward or “downlink” path, the host interface takes the combined channels from the cell site transmitters and digitizes the broadband signal at a sample rate of 30.72 MHz. An optical transmitter adds overhead and signaling information and creates a 552.96 Mbps serial data stream which is used to digitally modulate an optical carrier. At the remote site, an optical receiver demodulates the incoming optical carrier, and reconstructs the original 30.72 MHz parallel word, which is then converted back to RF by a digital-to-RF converter. At this point, the combined forward link channels have been reconstructed, and are ready to be linearly amplified for transmission.

In the reverse or “uplink” path, signals coming in through the antenna from mobiles or handhelds are filtered to remove out-of-band signals. The 12.5 MHz spectrum is then digitized in much the same way as the forward link spectrum, and a similar serial data stream is constructed for digital optical transport. At the host site, the optical carrier is

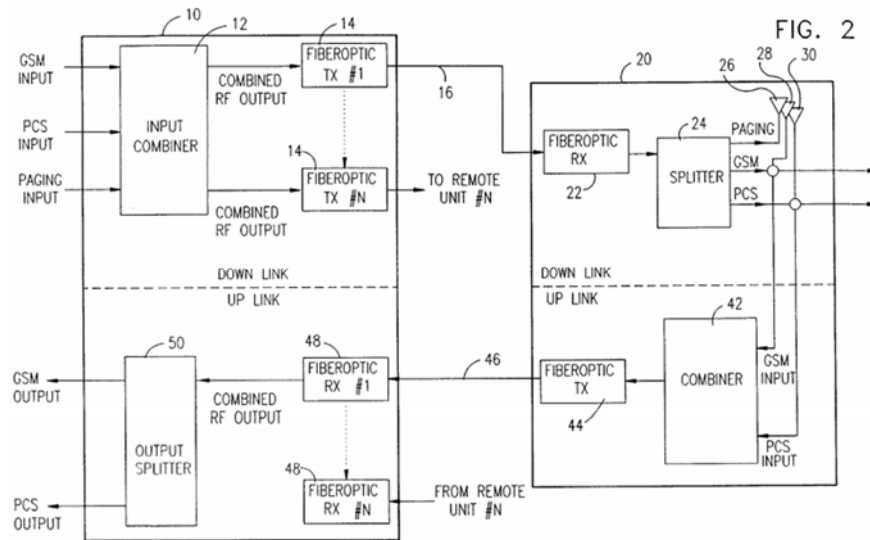
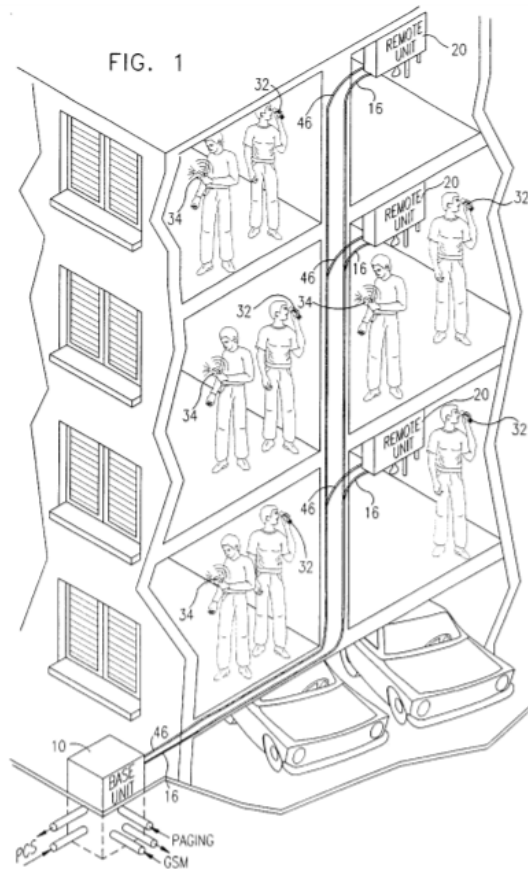
demodulated, and the original RF signal is reconstructed and sent on to the individual channel receivers.

Ex. 1009, 586.

87. Wala is analogous art to the '982 patent because it is in the same field of endeavor (RF data communications) by the '982 patent's inventor and it is associated with the common problem of extending RF data communications into hard to reach areas. Ex. 1009, 585-586.

C. Overview of Farber

88. Farber is a U.S. Patent filed in July 1997 entitled "Communications System," that describes a wireless communications station employing optical fibers. Ex. 1022, 1:4-6. Farber discloses the use of fiber in an antenna system for reaching difficult coverage areas such as buildings, as illustrated in Fig. 1, and other shadowed areas that is very similar to the digital system of Oh. *Id.*, 4:30-33. Farber states that the optical fibers "may be single or multi mode." *Id.*, 2:59-60. With reference to Fig. 2, Farber describes that "[p]referably the transmitter 14 employs a vertical cavity surface emitting laser or an edge emitting laser coupled to a single or multi-mode fiber 16." *Id.*, 4:30-32.



D. Overview Of Schwartz

89. Like the '982 patent and Oh, Schwartz addresses expansion of RF signal coverage into hard to reach areas “especially within structures or around other obstacles, man-made or natural, which otherwise tend to block or disrupt radio waves.” Ex. 1010, 1:26-30. Schwartz proposes a radio frequency transport system similar to the '982 patent and Oh, differing in that Schwartz propagates signals from its host unit (central station 20) to its remote units (remote stations 22) using analog signals. Oh recognized such analog RF distribution systems as state of the art prior to its invention of its digital relays. *See*, Ex. 1007, 2:28-30 (Conventional Technology – “Since the RF signals transmitted/received to/from said first optic repeater and a second optic repeater are analog signals, the strength of the signals is greatly decreased during transmission through the optical line.”)

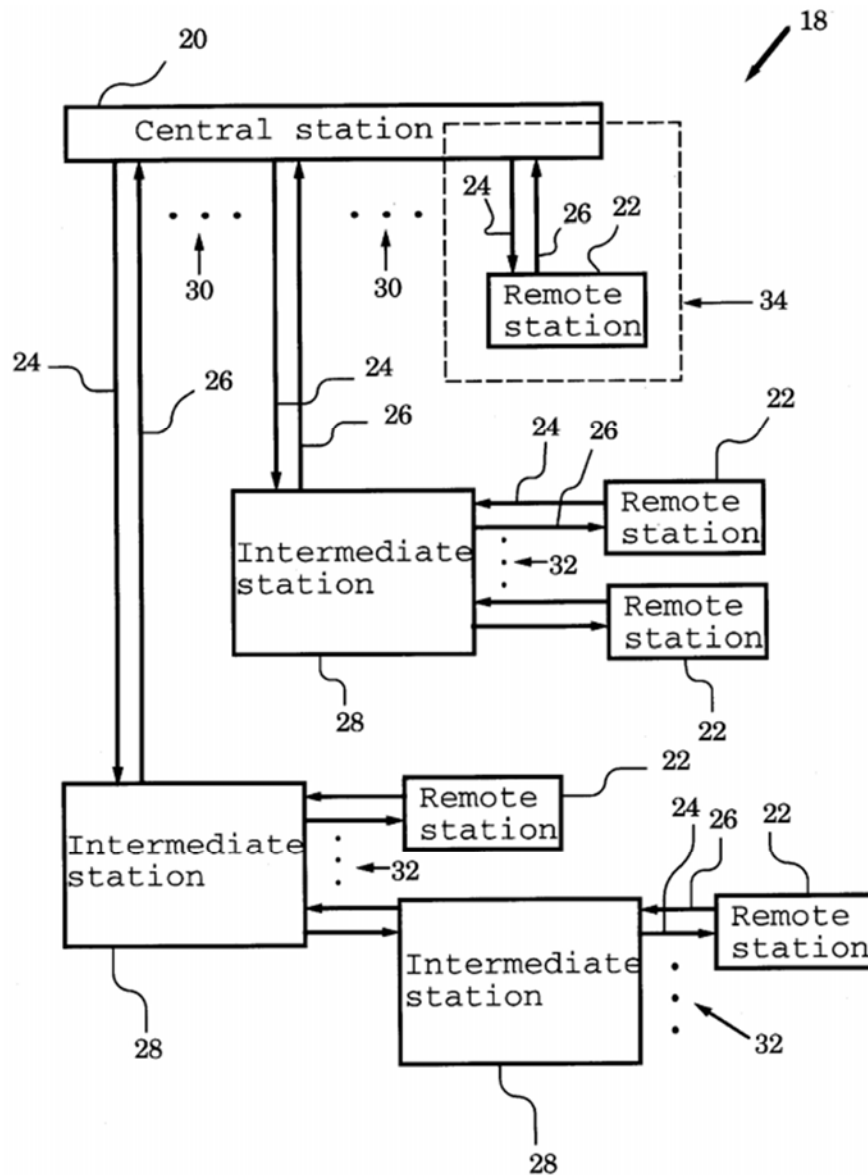


FIG. 1

90. While Schwartz discloses an analog RF signal distribution platform, the likes of which Oh improved upon via its relay digitization, Schwartz evidences that it was well known to implement RF signal distribution systems using topologies beyond the host↔remote unit arrangement of Oh. Schwartz, like Oh discloses

implementations where some branches may contain remote units directly connected to the host unit, as illustrated at 34. Ex. 1010, 42-44.

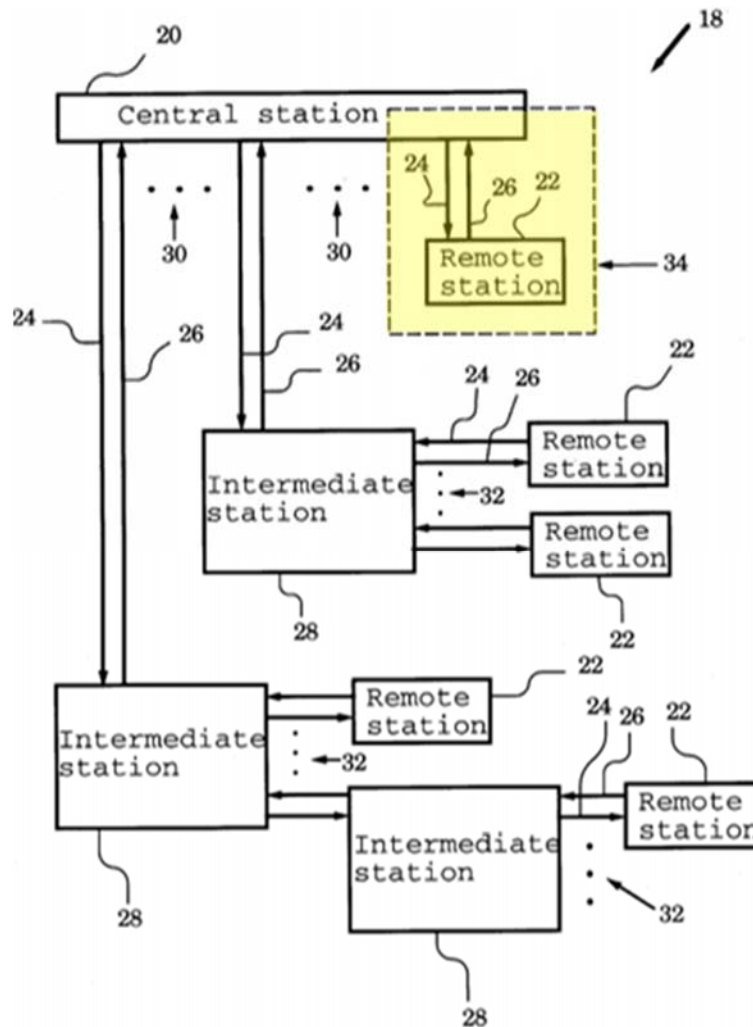


FIG. 1

Schwartz also discloses additional branches whereby intermediate stations 28 may be connected to the host central station 20, and even to other intermediate stations 28, so as to expand the number of remote stations 22 to which the central station is ultimately responsive.

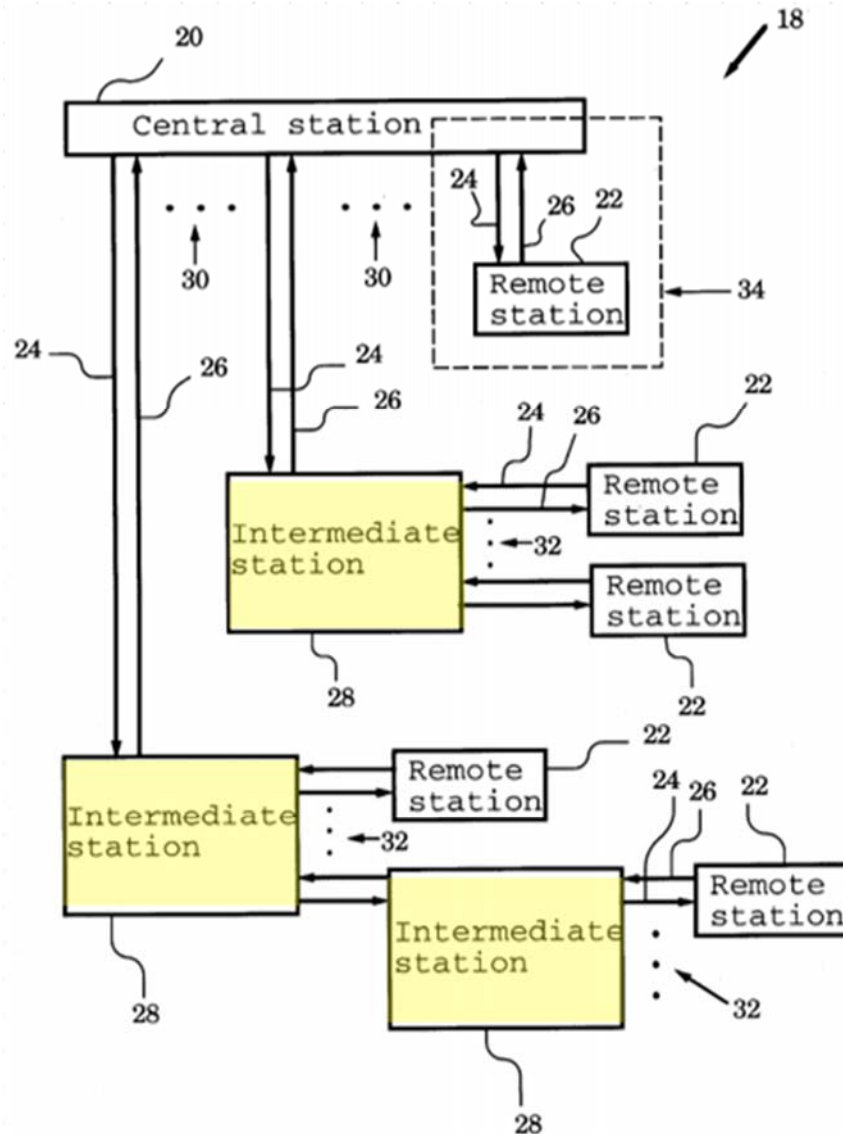


FIG. 1

Ex. 1010, 4:38-42 (“Intermediate stations 28, preferably are repeaters and likewise have pairs of downlink cable 24 and uplink cable 26 which in turn connect to any number of other intermediate stations 28 and/or remote stations 22.”)

91. Schwartz's intermediate stations 28 "preferably are repeaters" (4:38-39), where example intermediate station 28 implementation details are shown in Fig. 7a. Ex. 1010, 10:13-15.

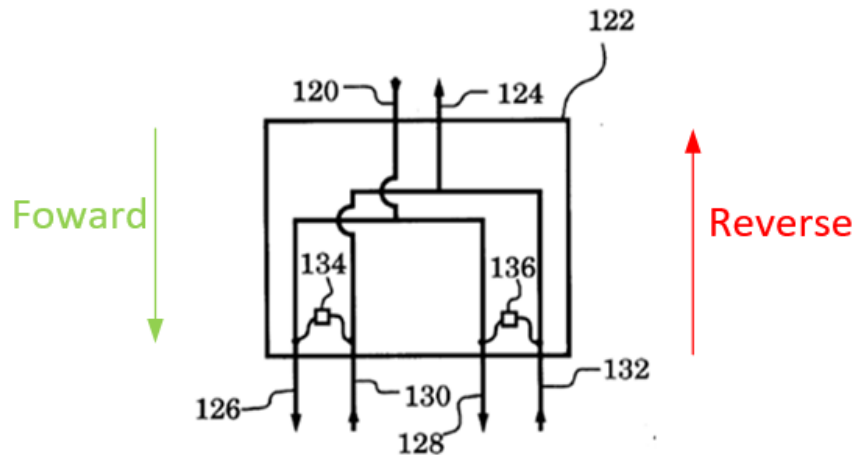


FIG. 7a

In the forward direction (top to bottom in the figure), "downlink connection 120 splits into two secondary downlink connections 126 and 128 before exiting station 122." Ex. 1010, 10:15-18. In the reverse direction (bottom to top in the figure), "uplink connection 124 is fed by two secondary uplink connections 130 and 132." *Id.*, 10:19-20. In that uplink operation, signals from downstream units (*e.g.*, remote units) are received at 130, 132 and applied to a common uplink connection line 124, aggregating the analog signals received on those lines.

92. Schwartz's RF signal distribution topology that supports intermediate expansion units enables a network where host central station 20 is connected to "any number of intermediate stations 28 and/or remote stations 22," providing an RF signal distribution platform that is customizable to the difficult RF environment into which

the platform is installed. Ex. 1010, 4:34-38; 1:24-30 (“[I]ntermediate stations provide bi-directional branching points within the network. Such a system is highly advantageous for providing wireless two-way communication service especially within structures or around other obstacles, man-made or natural, which otherwise tend to block or disrupt radio waves.”).

E. Overview Of Koschek

93. Like the '982 patent and Oh, Koschek addresses expansion of radio frequency analog signal coverage into hard to reach areas, “such as a building or a tunnel.” Ex. 1013, 1:12-16. Koschek proposes a radio frequency transport system similar to the '982 patent and Oh, whereby a terminal stage 102 with an antenna for broadcasting and receiving signals is connected to upstream units via a series of connecting stages, where each of those connecting stages may also include an antenna for receiving radio frequency signals in their vicinity.

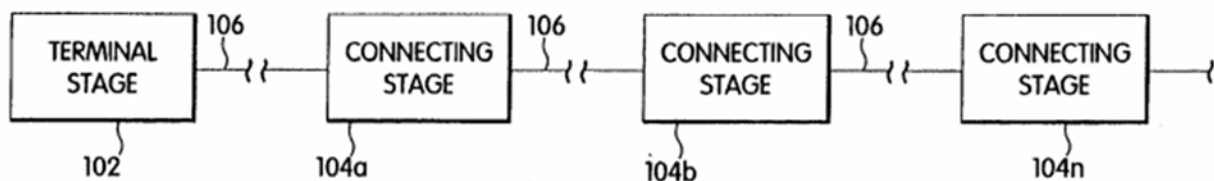


Fig. 1

94. Fig. 2 illustrates an upstream path in a terminal stage at 102, which includes an antenna 130, a filter 131, and an amplifier 132. Ex. 1013, 3:50-54. An example connecting stage includes its own antenna 134 and corresponding filter 135.

A coupler 136 receives filtered radio frequency signals from terminal stage 102's antenna and connecting stage 104's antenna and those signals "are combined into a single signal on line 140 by coupler 136" before propagation to further upstream stages. *Id.*, 4:8-10.

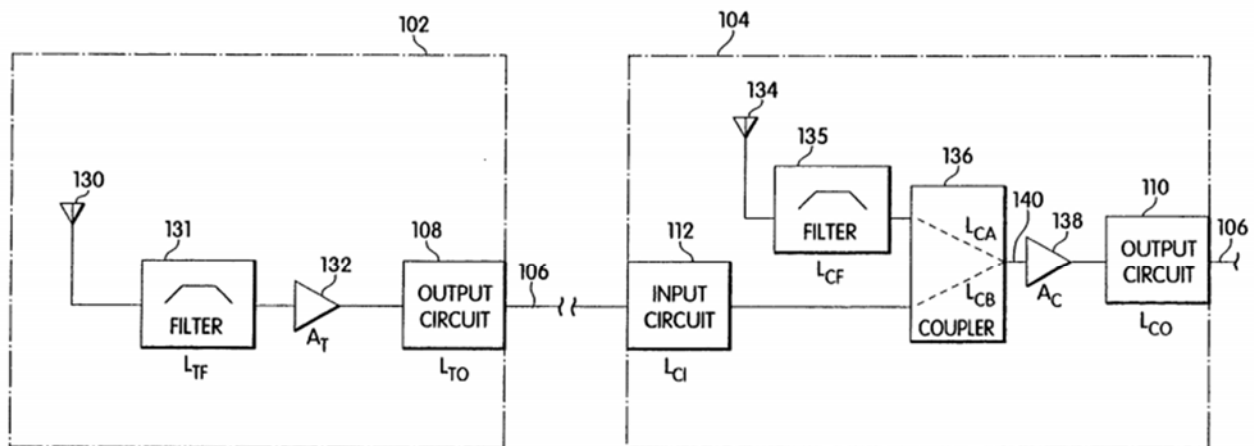


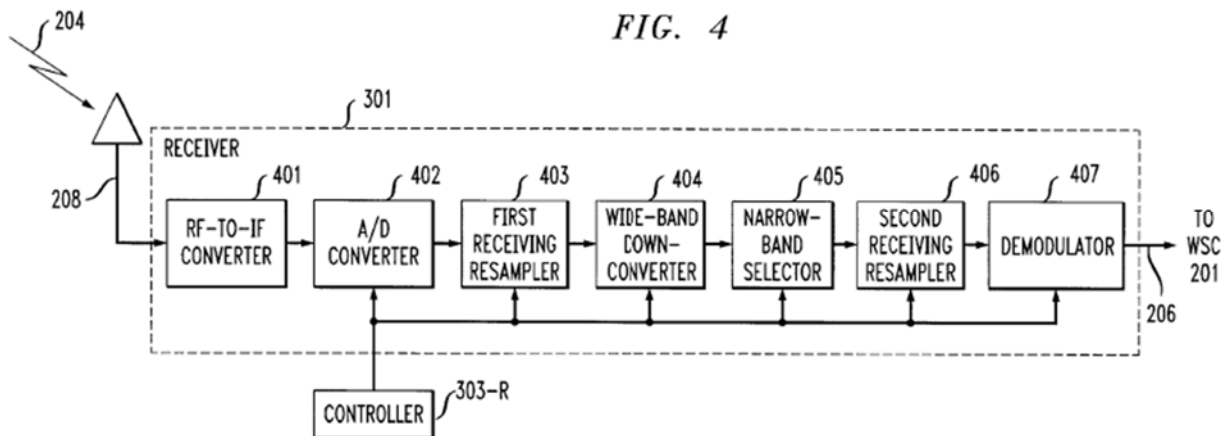
Fig. 2

95. The amplifiers (e.g., 132, 138) of Koschek's stages may be powered in a variety of ways. In one example, "the amplifiers may be powered remotely, from power transmitted down the signal or other cables. In [that] configuration, a single, DC power supply may be located at any centrally convenient point in the system." *Id.*, 5:41-45. The modular configuration of Koschek enables easy replacement of stages or changes to the configuration of the network without requiring redesign, calibration, or adjustment. *Id.*, 5:17-20.

F. Overview of Allpress

96. Allpress is a U.S. Patent filed in July 1998 entitled “Software-Defined Transceiver for a Wireless Telecommunications System,” that describes techniques for receiving and transmitting wireless telecommunications using a software-defined transceiver. Ex. 1021, Abstract. Allpress states that software transceivers can avoid the need for “duplicative hardware.” Allpress further states that its “generic architecture” is not “standard specific” and thus can be easily ported to different implementations without modification, a benefit that would not be possible with a hardware implementation with hardwired physical components. Ex. 1021, 2:5-50. Allpress states that its software transceivers may be implemented in a variety of locations such as “in a base station or at a location other than a base station,” including locations that communicate with base stations. Ex. 1021, 3:46-48.

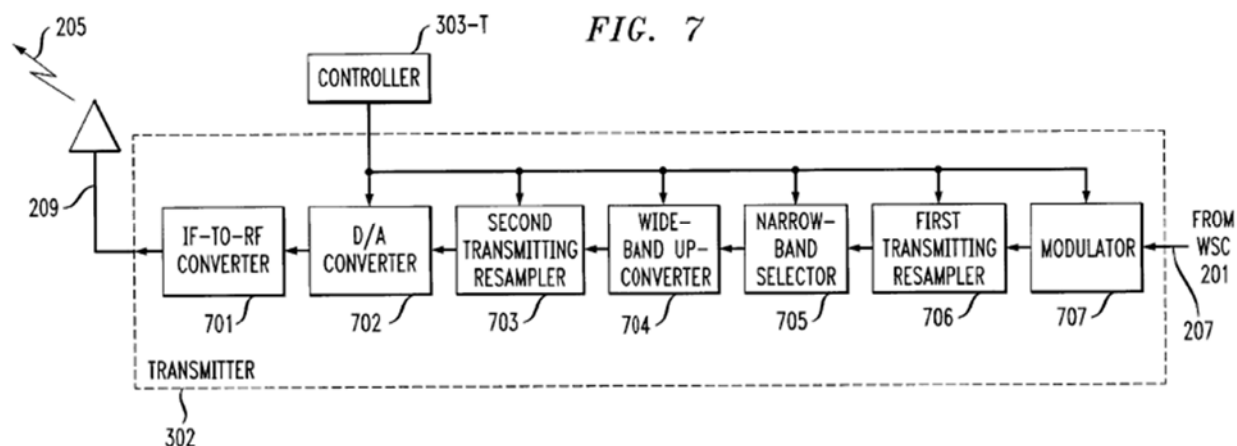
97. Fig. 4 depicts a software-based RF receiver, and Fig. 7 depicts a software-based RF transmitter.



Allpress describes its receiver stating:

FIG. 4 depicts a schematic diagram of a portion of receiver 301 of the illustrative embodiment of the present invention, which comprises RF-to-IF converter 401, analog to-digital converter 402, first receiving resampler 403, wide band down-converter 404, narrow-band selector 405, second receiving resampler 406, demodulator 407 and controller 303-R, interconnected as shown. First receiving resampler 403, wide-band down-converter 404, narrow-band selector 405, and second receiving resampler 406 are software defined devices.

Ex. 1021, 4:43-53.



Allpress further describes its transmitter stating:

As depicted in FIG. 7 transmitter 302 comprises IF-to-RF converter 701, digital-to-analog converter 702, second transmitting resampler 703, wide-band up-converter 704, narrow-band selector 705, first transmitting resampler 706, modulator 707 and controller 303-T, interrelated as shown. For illustrative purposes controller 303-T, which controls transmitter 302, and controller 303-R, which controls receiver

301, are depicted as separate devices. It should be understood, however, that a single controller can be used to control both the receiving and transmitting sections. Second transmitting resampler 703, wide-band up-converter 704, narrow-band selector 705, and first transmitting resampler 706 are software-defined devices.

Ex. 1021, 8:30-42.

VIII. The Claims of the '982 Patent Are Unpatentable

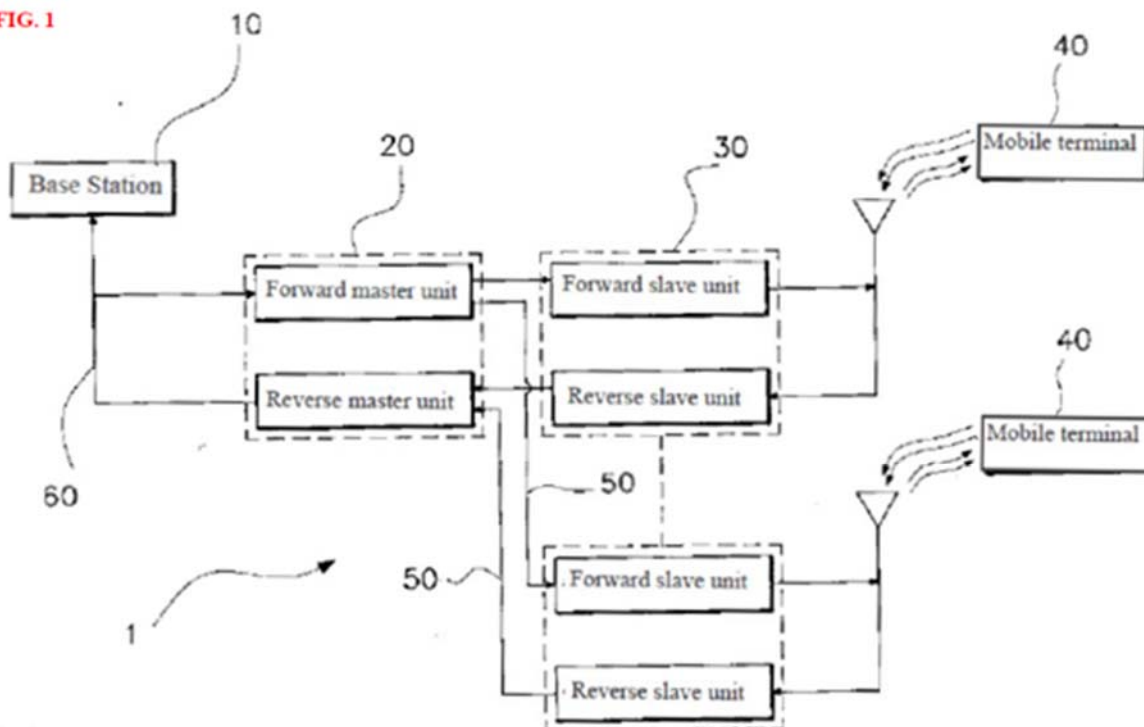
A. Claims 1-10, 25-32, 34, 35, 37-51, and 81 Are Obvious Over Oh

1. Independent Claim 1

a) Preamble: "A digital radio frequency transport system, comprising:"

98. To the extent the preamble of claim 1 is limiting, it is rendered obvious by Oh. As I discussed above, Oh discloses a Digital Optic Repeater system that receives RF signals, from a base station 10 at a master unit 20 and from mobile terminals 40 at remote slave units 30. The optic repeater 1 is installed in a radio wave shadow area and converts received analog signals to intermediate frequency signals (e.g., close to DC in the example at 3:11-14) and then to digital signals for mutual transmission and reception to one another across optic lines 50. Ex. 1007, Abstract, Fig. 1. At a destination unit, the digital signals transmitted across the optic lines 50 are converted to analog signals, and upconverted to RF signals for transmission to their destination (e.g., base station 10 or mobile terminals 40). *Id.*

FIG. 1

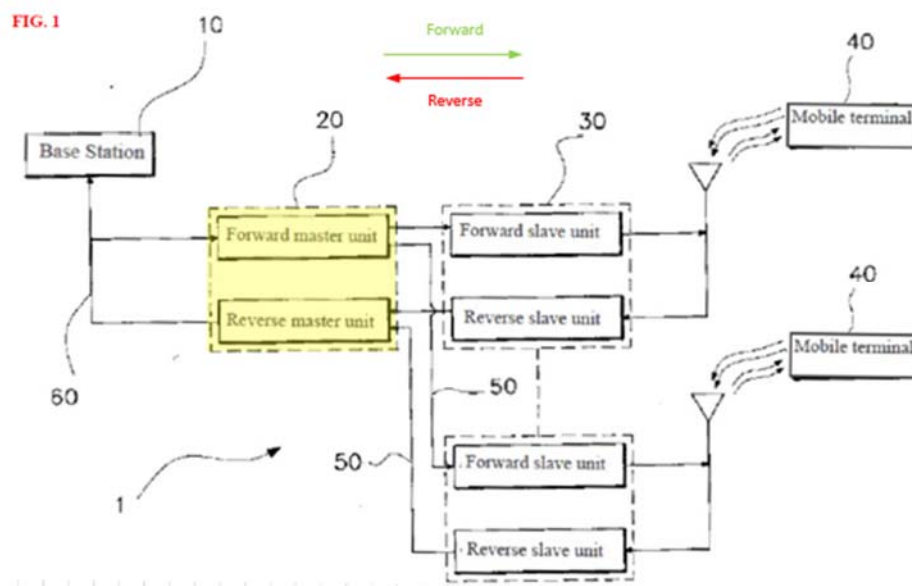


99. Patent Owner has made clear in a prior litigation that “digital radio frequency (RF)” as that term is used in the ’982 patent refers to sampling of any of baseband signals, intermediate frequency signals, or radio frequency signals. *See*, Ex. 1008, Acampora Report, ¶136 (“Accordingly, the baseband digital samples, any intermediate frequency digital samples, and any radio frequency digital samples are all referred to a[s] being digital RF.”) Oh’s disclosure of A/D conversion (*i.e.*, sampling) of intermediate frequency signals, including signals down converted to close to DC (*i.e.*, baseband signals) is disclosure of digital radio frequency data as that term is used in the ’982 patent.

100. Oh therefore renders obvious each limitation recited in the preamble of claim 1 by disclosing a digital radio frequency (digital samples of intermediate frequency/baseband analog signals) transport system (transmission of those digital signals among the master 20 and slave units 30 across optic lines 50).

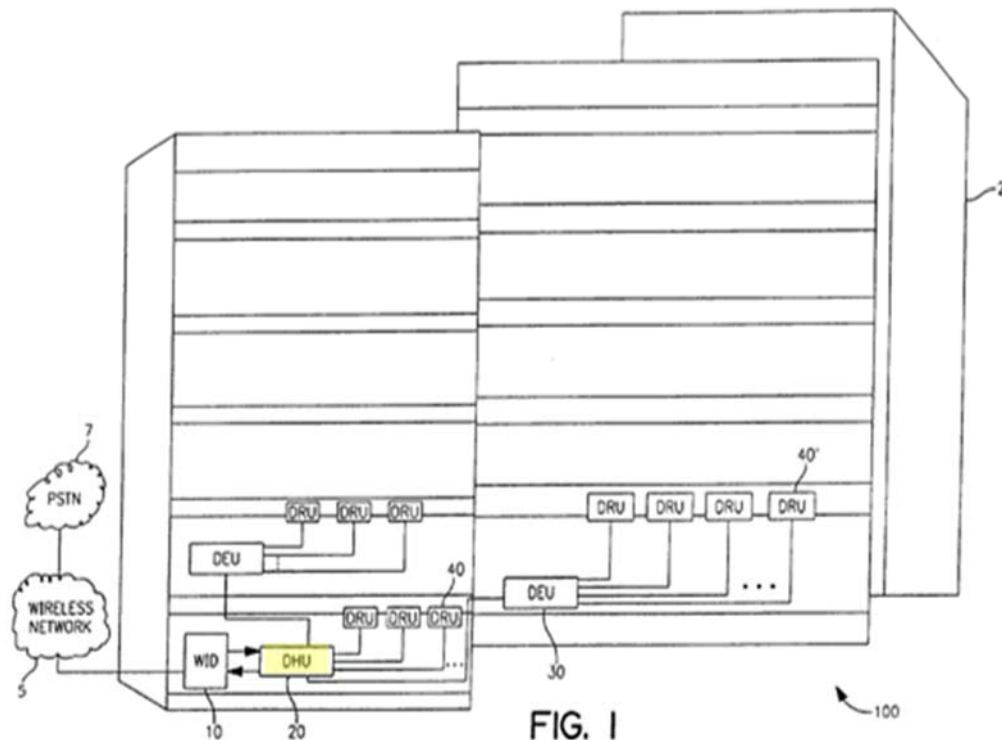
b) Element 1: “a digital host unit;”

101. Element 1 of claim 1 is rendered obvious by Oh. As discussed above and as shown in Fig. 1, Oh's master unit 20 transmits/receives analog signals to/from the base station and relays digital samples of those analog signals to/from remote slave units 30 across optic lines 50. Ex. 1006, 2:70-3:1; 4:62-64.



102. Oh's master unit 20 is analogous to the '982 patent's digital host unit (DHU) 20 which interfaces with a wireless interface device (WID) 10 that in embodiments comprises a base station (Ex. 1001, 4:28-29). And like Oh's master unit 20, on the forward path the '982 patents DHU "receives RF signals from WID 10 [*i.e.*,

base station] and converts the RF signals to digital RF signals. DHU 20 further optically transmits the digital RF signals to multiple DRUs 40.”

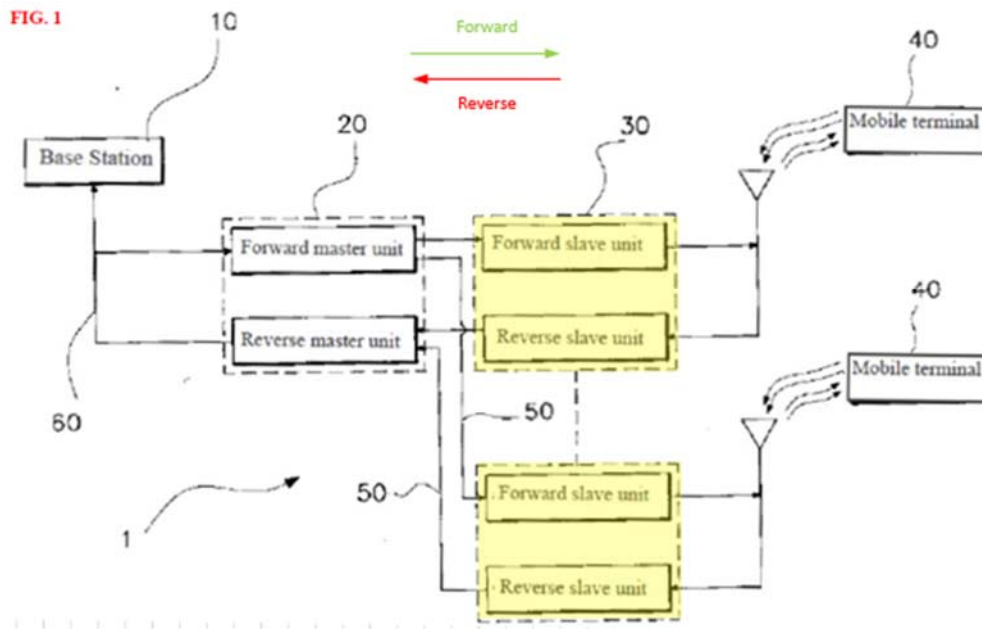


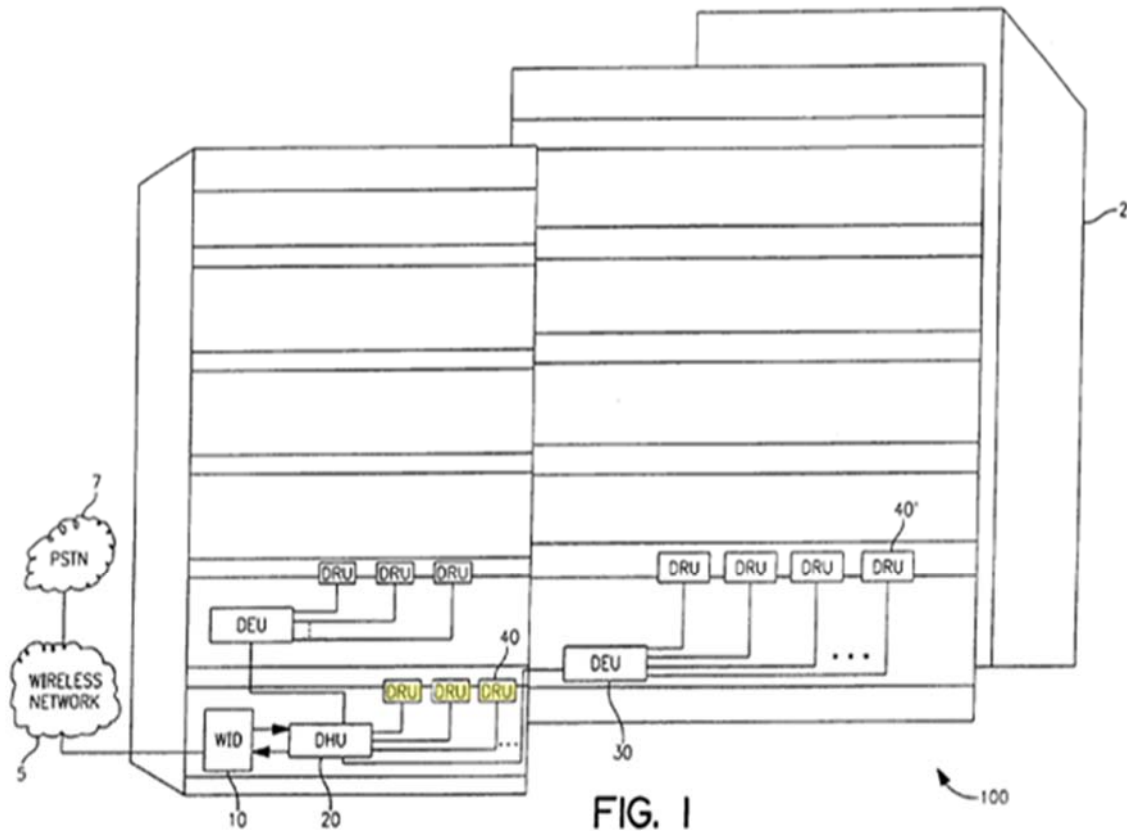
103. Because Oh’s master unit 20 communicates analog signals bi-directionally with a base station, and communicates digital signals bi-directionally with multiple remote units (slave units 30), it is analogous to the host unit described in the ’982 patent. Thus Oh renders obvious a digital host unit (master unit 20).

c) Element 2a: “at least two digital remote units coupled to the digital host unit,”

104. Element 2a is rendered obvious by Oh. Oh’s slave units 30 convert “the digital signals transmitted from the master unit 20 through the optic line 50 to the intermediate frequency signals, analog signals; converts them to the RF signals and

transmits them to the mobile terminals 40.” Ex. 1007, 3:47-49. Oh’s slave units 30 further convert analog signals from the mobile terminals 40 to digital signals and transmit them to master unit 20. *Id.*, 4:23-25.

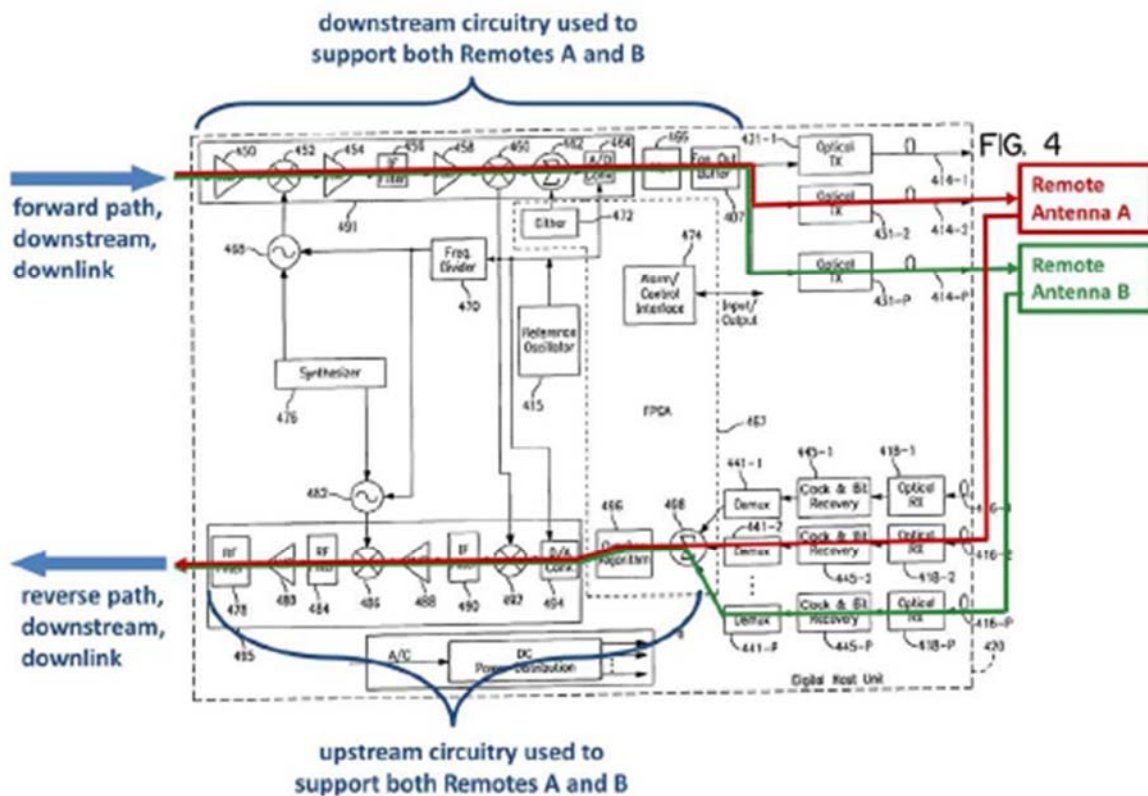




105. Oh's slave units 30 are analogous to the '982 patent's digital remote units (DRUs) that digitally communicate with the DHU via optic cables (Ex. 1001, 3:61-64) and wirelessly communicate with devices in their area (*e.g.*, via antenna 599). Thus Oh renders obvious at least two digital remote units (slave units 30) coupled to the digital host unit (master unit 20).

d) Element 2b: “wherein the digital host unit includes shared circuitry that performs bi-directional simultaneous digital radio frequency distribution of digitized radio frequency signals between the digital host unit and the at least two digital remote units;”

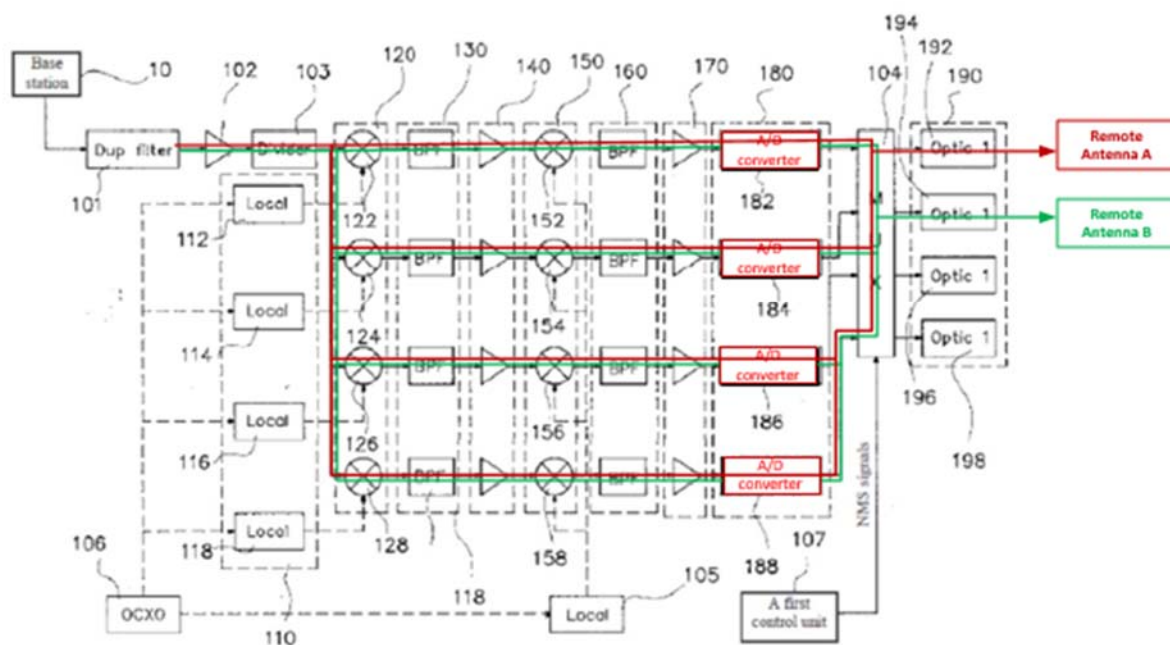
106. Element 2b is rendered obvious by Oh. While the '982 patent's specification does not use the term “shared circuitry” beyond paraphrases of the claim language, in a prior litigation, Patent Owner has clarified their position that “‘shared circuitry’ was intended to mean circuitry that is used to support more than one remote unit.” Ex. 1008, ¶316. In that same document, Patent Owner illustrated and discussed what it envisioned as the “shared circuitry” at paragraphs 323-324.



107. There it identified '982 patent's "circuitry in box 491, the mux 465, and fan out buffer 431" as the downstream shared circuitry for providing digital radio frequency distribution of digitized radio frequency signals, and "summing unit 498 of the FPGA, the overflow algorithm and circuits of box 495" as the upstream shared circuitry. *Id.*, ¶324

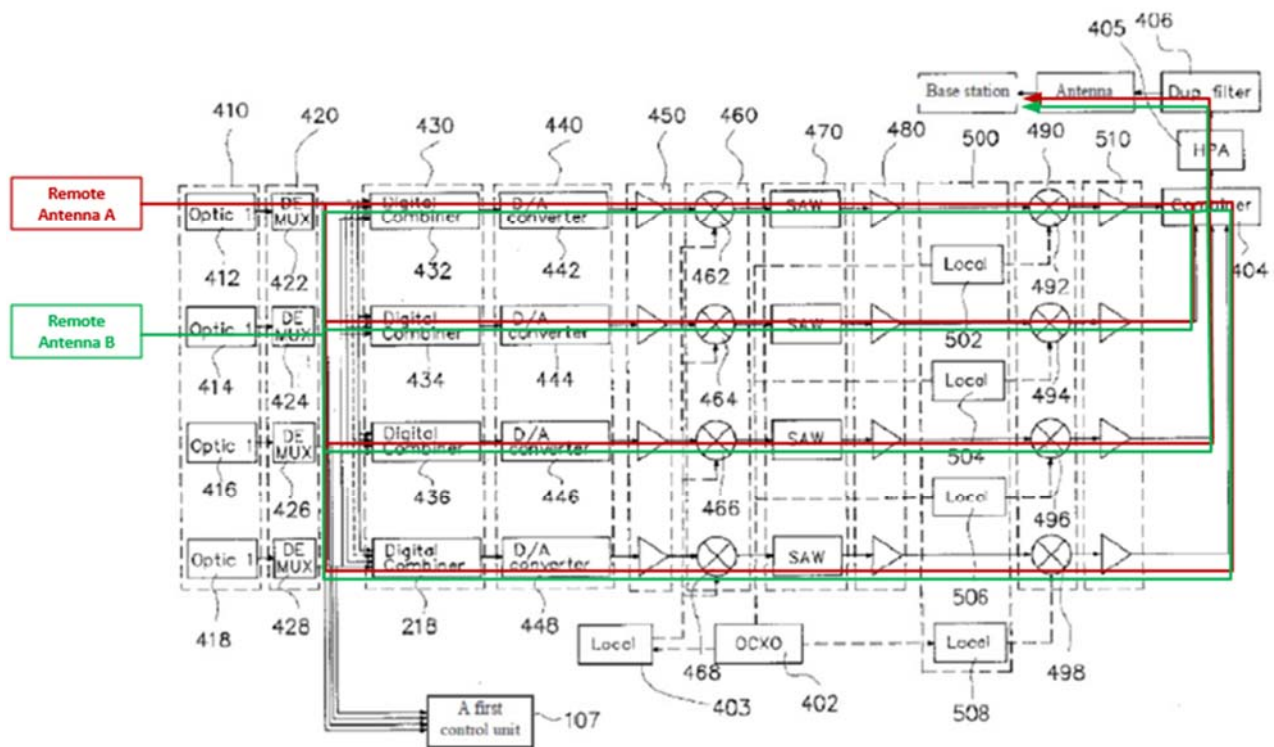
108. Oh discloses an analogous arrangement of components. On the downstream path of Fig. 2, Oh's circuitry at 120, 130, 140, 150, 160, 170, 180 down converts the analog signals received from the base station to near DC and samples that data, just like the '982 patent's "circuitry in box 491." Oh similarly includes a multiplexer 104 that serializes the digitized data and distributes it to the remote slave units.

FIG. 2



109. And on the reverse path, Oh's digital combiner unit 430 aggregates (*i.e.*, digitally sums) digitized radio frequency signals received at master unit 20 from multiple slave units 30 (*see*, Ex. 1007, 4:68-70; 5:16-17) and then converts the resulting sums to analog signals and processes those analog signals to generate a signal at 404 that represents all of the data received from the multiple slave units 30 (*i.e.*, an output RF signal containing the same information contained in the '982 patent's RF output).

FIG. 5



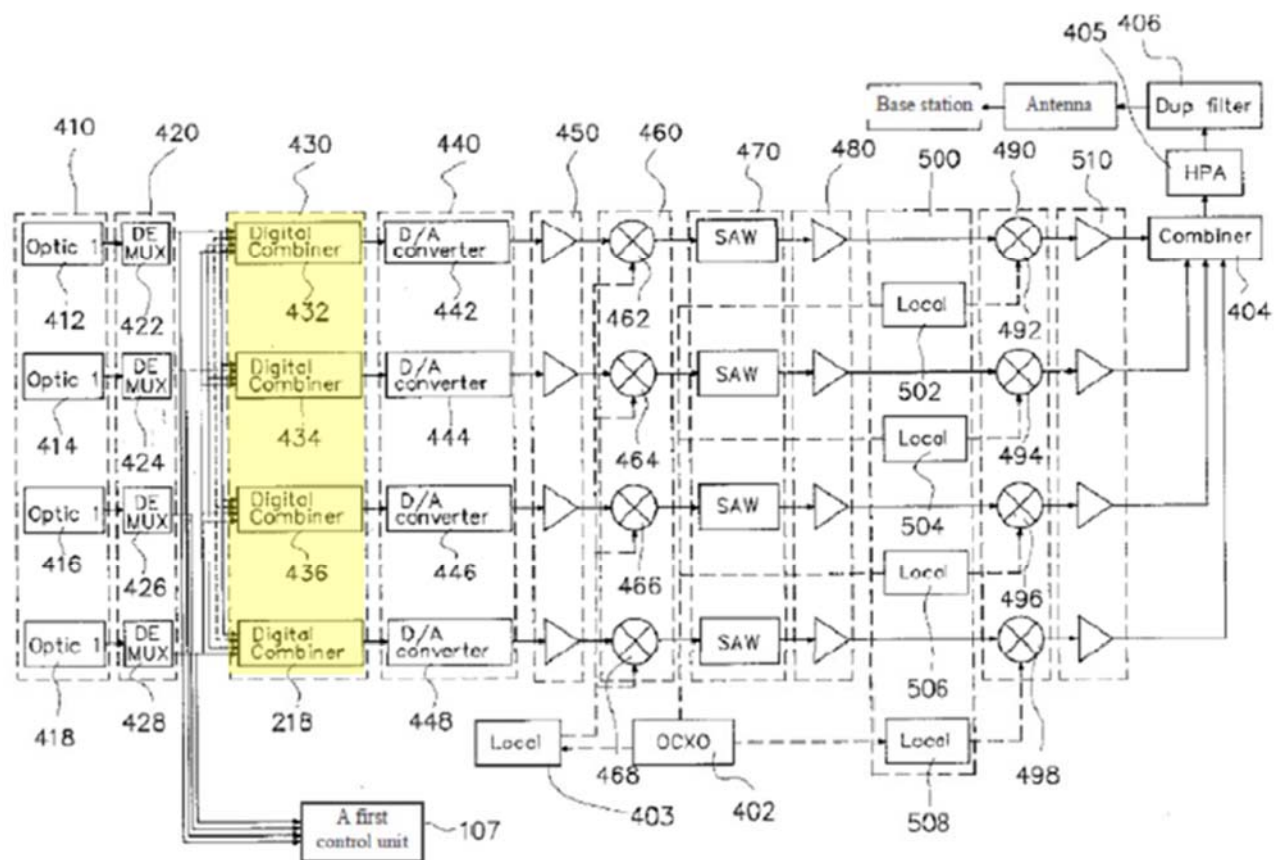
110. Thus Oh renders obvious the digital host unit (master unit 20) includes shared circuitry (downstream 104, 120-190); upstream 420-510, 404) that performs bi-directional simultaneous digital frequency distribution (signals transmitted from

190 and at the same time, signals received at 430 at the same time) of digitized radio frequency signals (intermediate frequency signals sampled at the master unit at 180 and slave units at 380) between the digital host unit (master unit 20) and the at least two digital remote units (slave units 30).

e) Element 3: “wherein the digital host unit digitally sums the digitized radio frequency signals received at the digital host unit.”

111. Element 3 of claim 1 is rendered obvious by Oh. Oh’s master unit 20 includes a digital combiner unit 430 that aggregates digital signals transmitted from each demultiplexer 422, 424, 426, 428 of demultiplexer unit 420. Ex. 1007, 4:68-70.

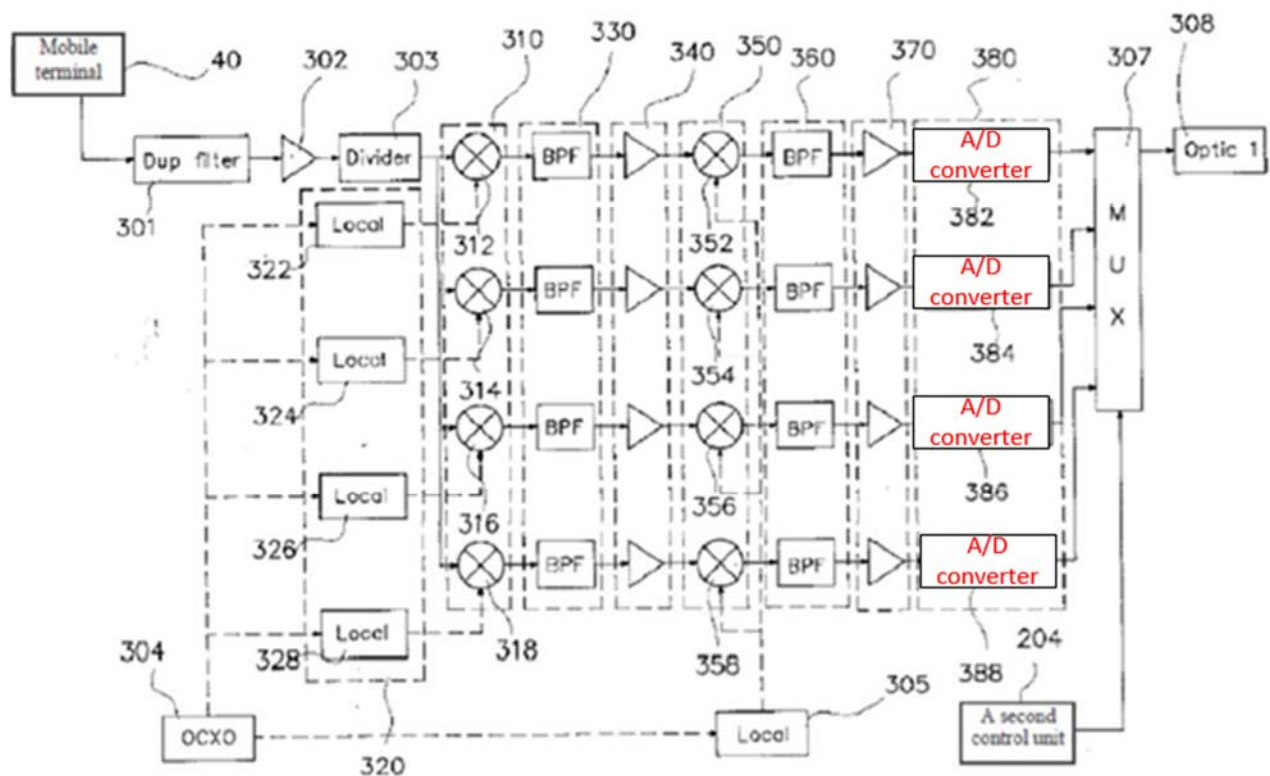
FIG. 5



Those demultiplexers at 420 receive data from individual remote slave units 30 at 410.

112. As depicted in Fig. 4, each slave unit 30 receives an analog signal from mobile terminals 40, divides the received analog signal into its component frequency bands at 303 and downconverts the frequency band signals to near DC at 310-370. Ex. 1007, 4:26-34. The downconverted band signals are then sampled at 380 to create 12-bit digitized radio frequency signals. *Id.*, 4:56-61. The multiplexer 307 multiplexes the four 12-bit samples with 4 bits of control data from 204 to form 52-bit serial data signals that are forwarded to master unit 20. *Id.*

FIG. 4



113. Referring back to Fig. 5, each demultiplexer 422, 424, 426, 428 receives a 52-bit signal from its respective slave unit 30. Each demultiplexer forwards 12-bits

of sample data to the appropriate digital combiner associated with the proper frequency band for that 12-bit sample and forwards its 4 bits of control data to control unit 107. Upon receiving four 12-bit signals (one from each of demultiplexer 422, 424, 426, 428), each digital combiner 432, 434, 436, 438 combines those 12-bit signals to “creat[e a] 14-bit intermediate frequency signals by combining³ four 12-bit intermediate frequency signals in the same frequency band” (*e.g.*, (1010 1010 1010 (2,730) + 1100 1100 1100 (3,276) + 1111 1111 1111 (4,095) + 0000 1100 1100 (204) = 10 1000 0100 0001 (10,305)). Ex. 1007, 5:16-17. Those 14-bit signals are then converted to analog signals at 440, upconverted, combined, and transmitted to the base station 10. *Id.*, 5:17-29.

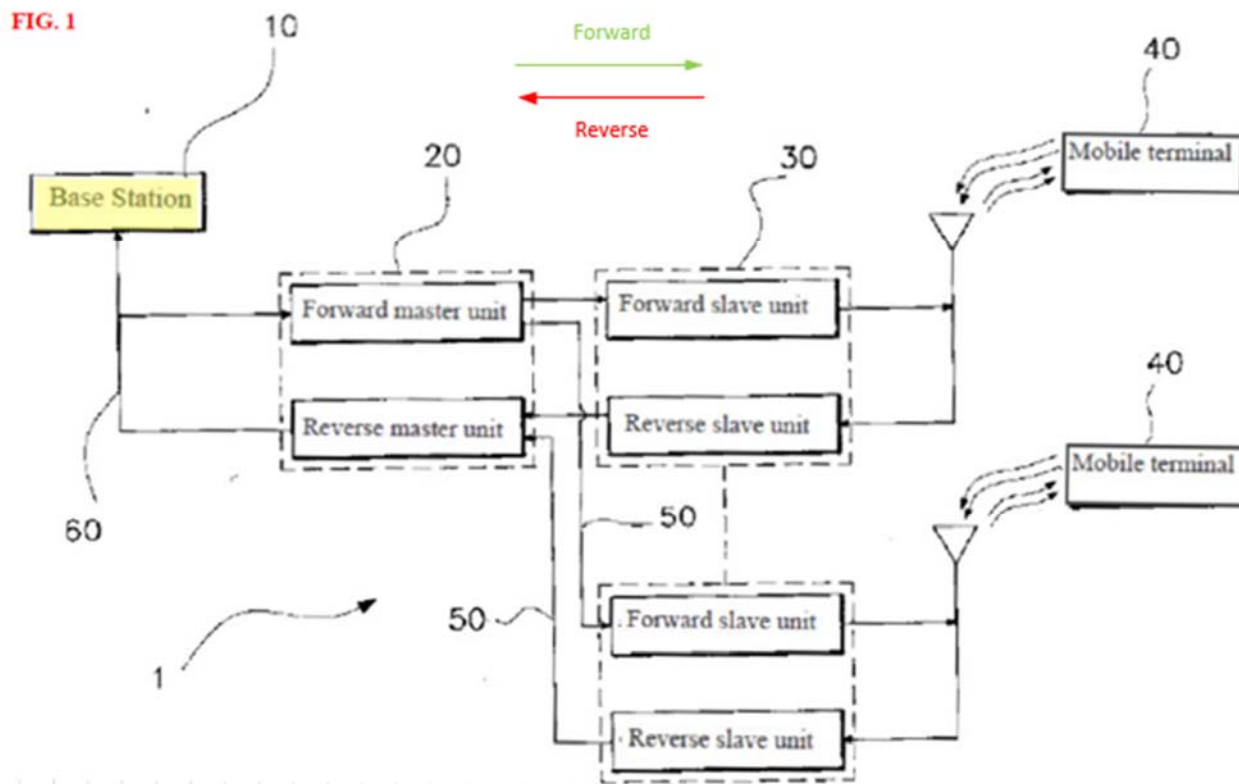
114. Thus Oh renders obvious the digital host unit (master unit 20) digitally sums the digitized radio frequency signals (creates 14-bit signals by combining four 12-bit signals) received at the digital host unit. Oh therefore renders obvious each limitation recited in claim 1.

2. Dependent Claim 2

115. Claim 2 recites “a wireless interface device coupled to the digital host unit.” The ’982 patent states that in one embodiment a wireless interface device

³ I understand that the parties have discussed whether this word should be translated as “adding” or “combining.” Regardless of which of these terms is used, the digital combiners are operating to produce a digital sum (*i.e.*, they are performing a digital summing operation).

comprises a base station. Ex. 1001, 4:28-30. Fig. 1 of Oh depicts a base station 10 coupled to master unit 20.



Thus Oh renders obvious a wireless interface device (base station 10) coupled to the digital host unit (master unit 20).

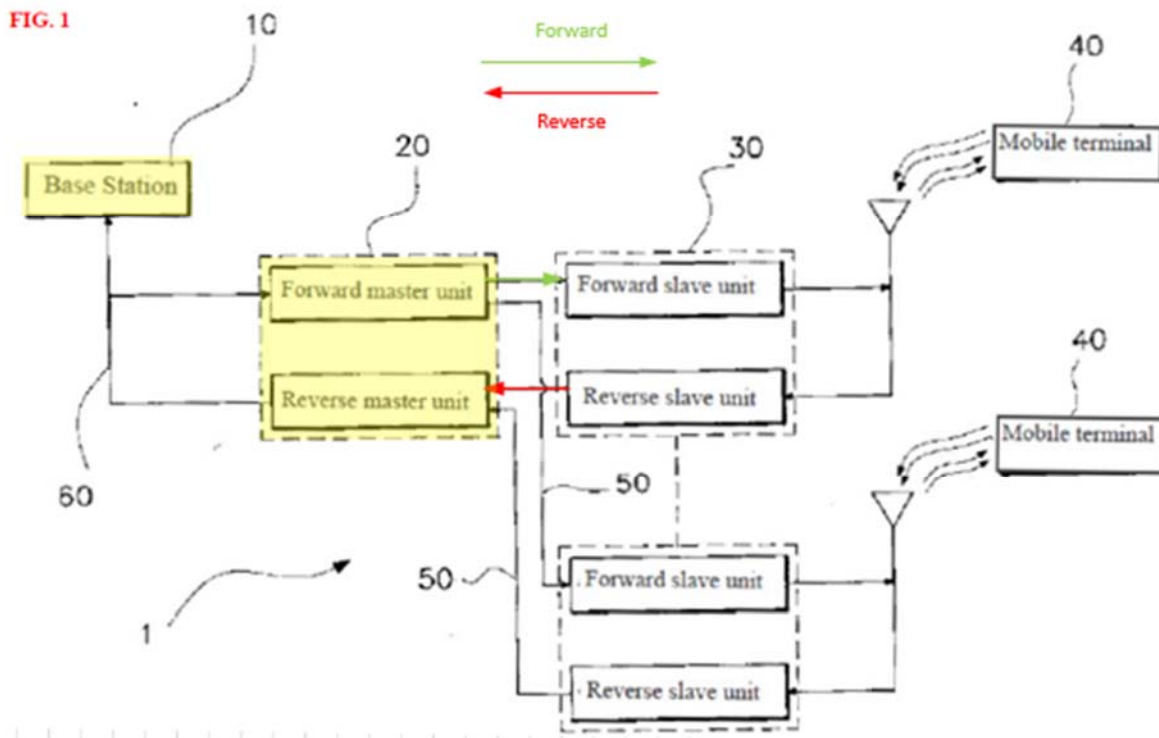
3. Dependent Claim 3

116. Claim 3 recites that “the wireless interface device comprises a base station that couples directly to the digital host unit via coaxial cables.” Oh discloses that RF signals are transmitted from base station 10 to master unit 20 through “RF cable.” Ex. 1007, 2:71-72. A POSITA in July 2000 would have understood a reference to RF cable to mean coaxial cable. *See, e.g.*, Ex. 1025, 1:27-29. Thus Oh

renders obvious the wireless interface device comprises a base station (10) that couples directly to the digital host (30) unit via coaxial cables (RF cable).

4. Dependent Claim 4

117. Claim 4 recites that “the wireless interface device comprises a base station that wirelessly connects to the digital host unit via a bi-directional amplifier.” As discussed above in addressing claim 2, Oh discloses that its master unit 20 bi-directionally communicates with base station 10.



Figs. 2 and 5 illustrate that those bi-directional communications are via a bi-directional amplifier, where Oh’s master unit 20 communicates with the base station 10 via a bi-directional filter 101, 406 connected to amplifiers 102, 405.

FIG. 2

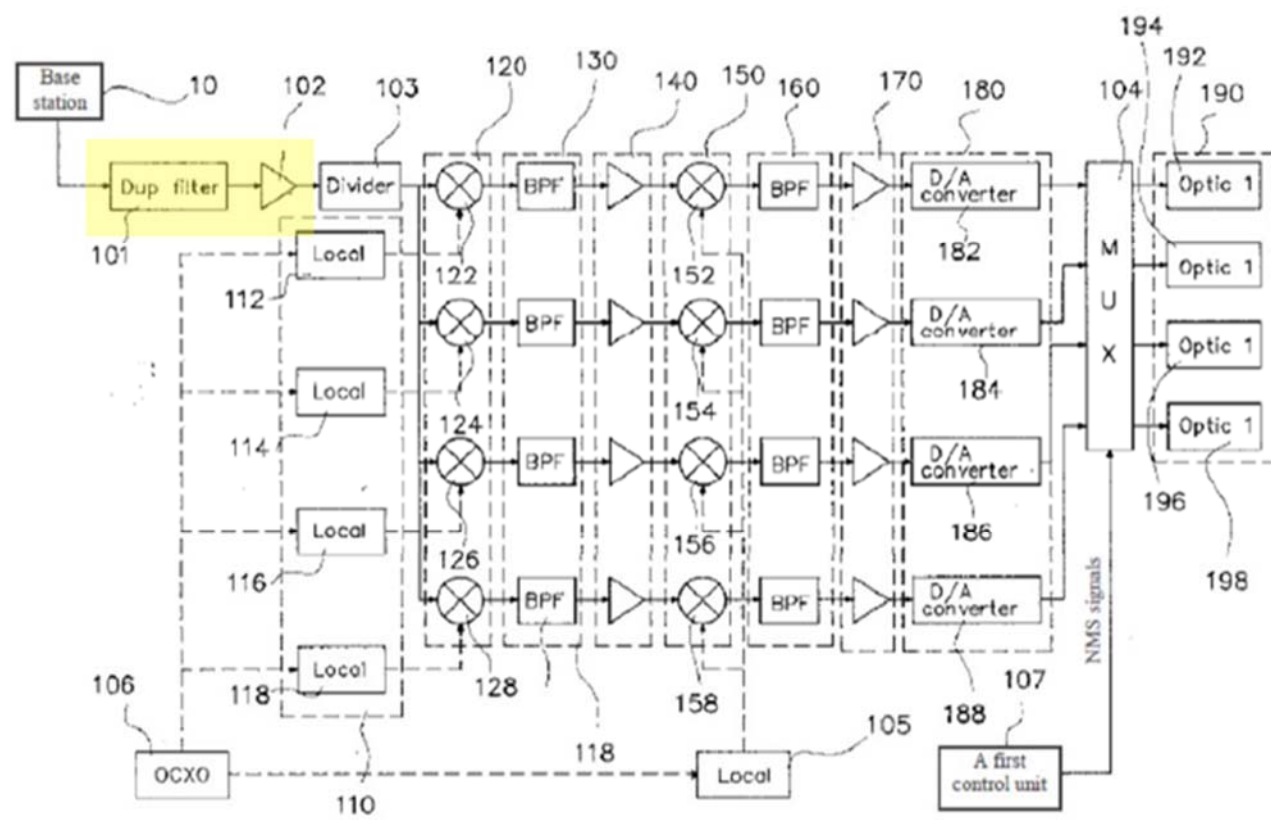
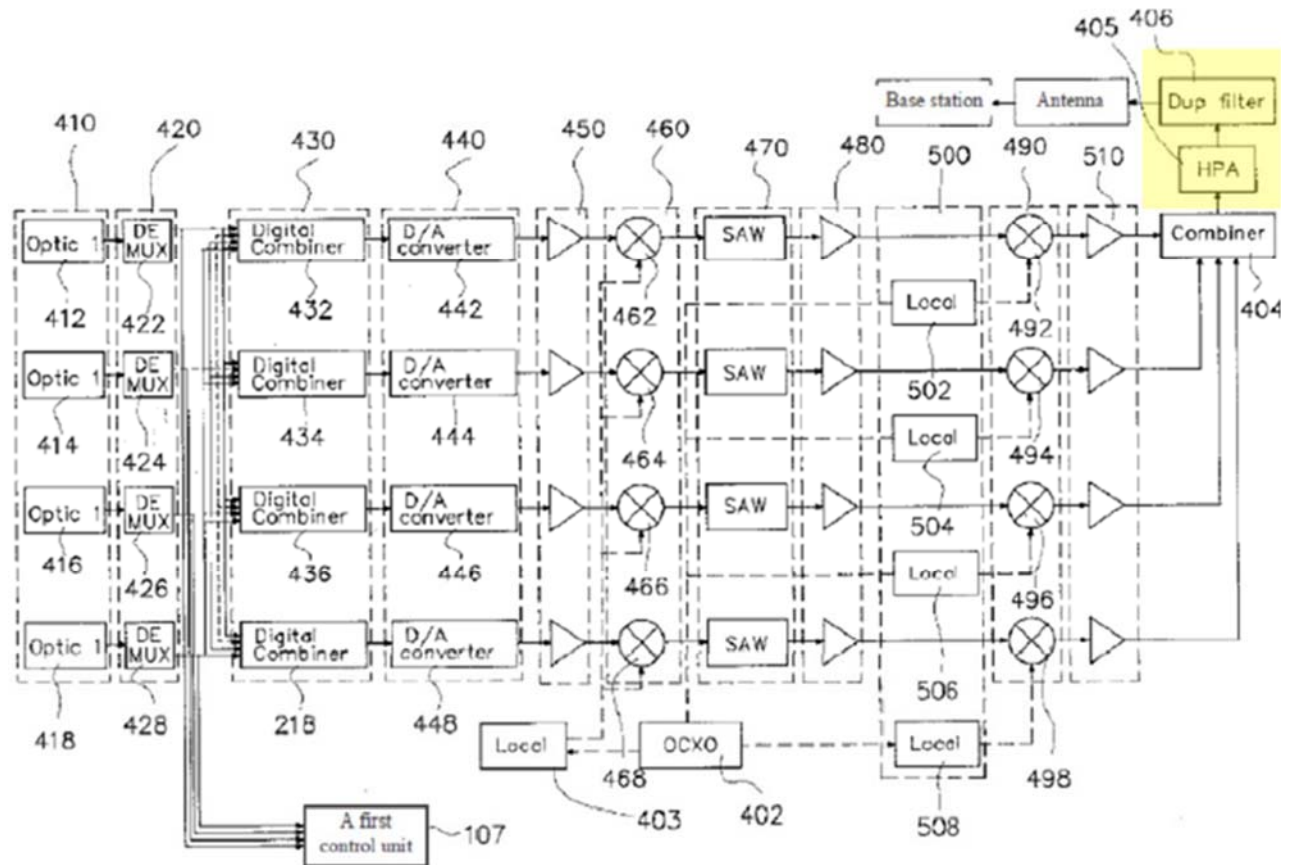


FIG. 5



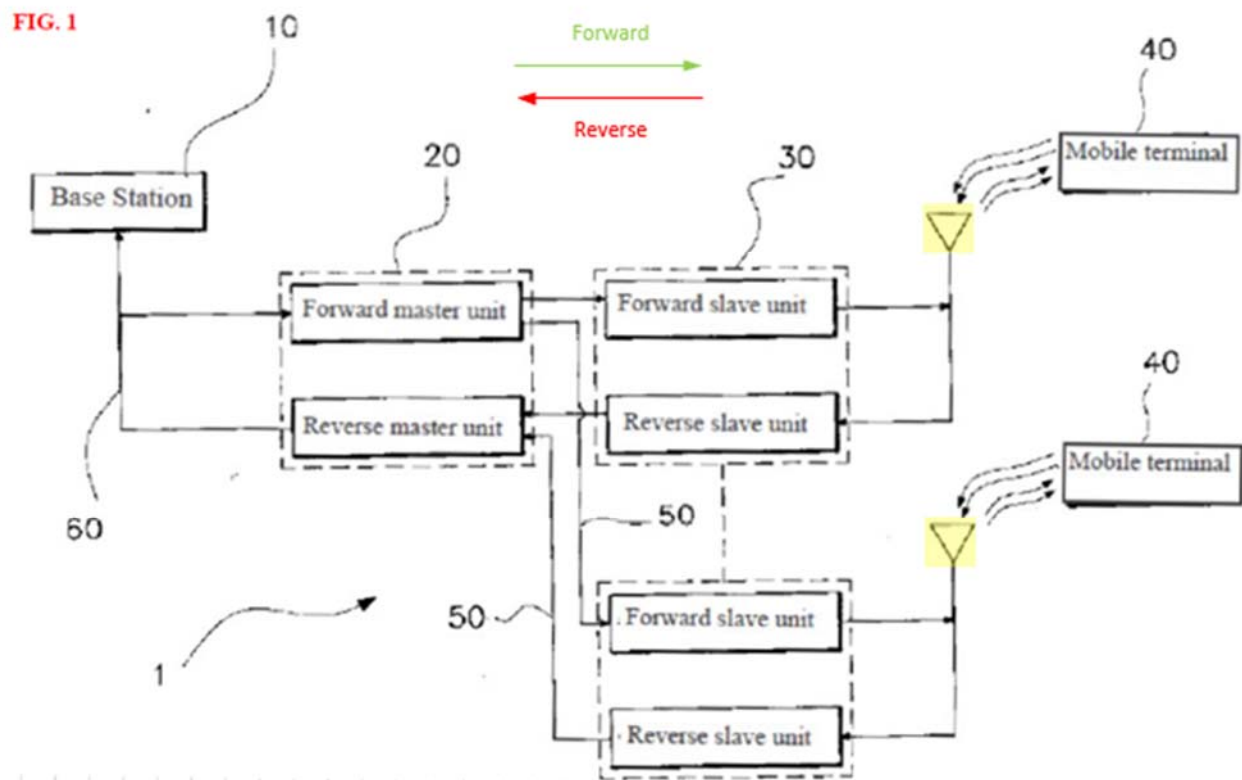
118. A POSITA understands that a bi-directional amplifier comprises a bi-directional duplex filter component to prevent the transmit signal from interfering with the receive channel and an amplifier component. Fig. 5 of Oh illustrates its bi-directional filter 406 being connected to an antenna for wireless communication with the base station 10.

119. Thus Oh renders obvious the wireless interface device comprises a base station (10) that wirelessly connects (*see* Fig. 5 Antenna) to the digital host unit (master unit 20) via a bi-directional amplifier (101, 102, 405, 406).

5. Dependent Claim 5

120. Claim 5 recites that “the at least two digital remote units each include a main radio frequency antenna which transmits and receives radio frequency signals.”

Fig. 1 of Oh depicts two slave units 30, each of which has an antenna that is depicted as transmitting signals to and receiving signals from mobile terminals 40. Oh explicitly says that the transmitted and received signals are RF. Ex. 1007, 3:59-61; 4:16-19.

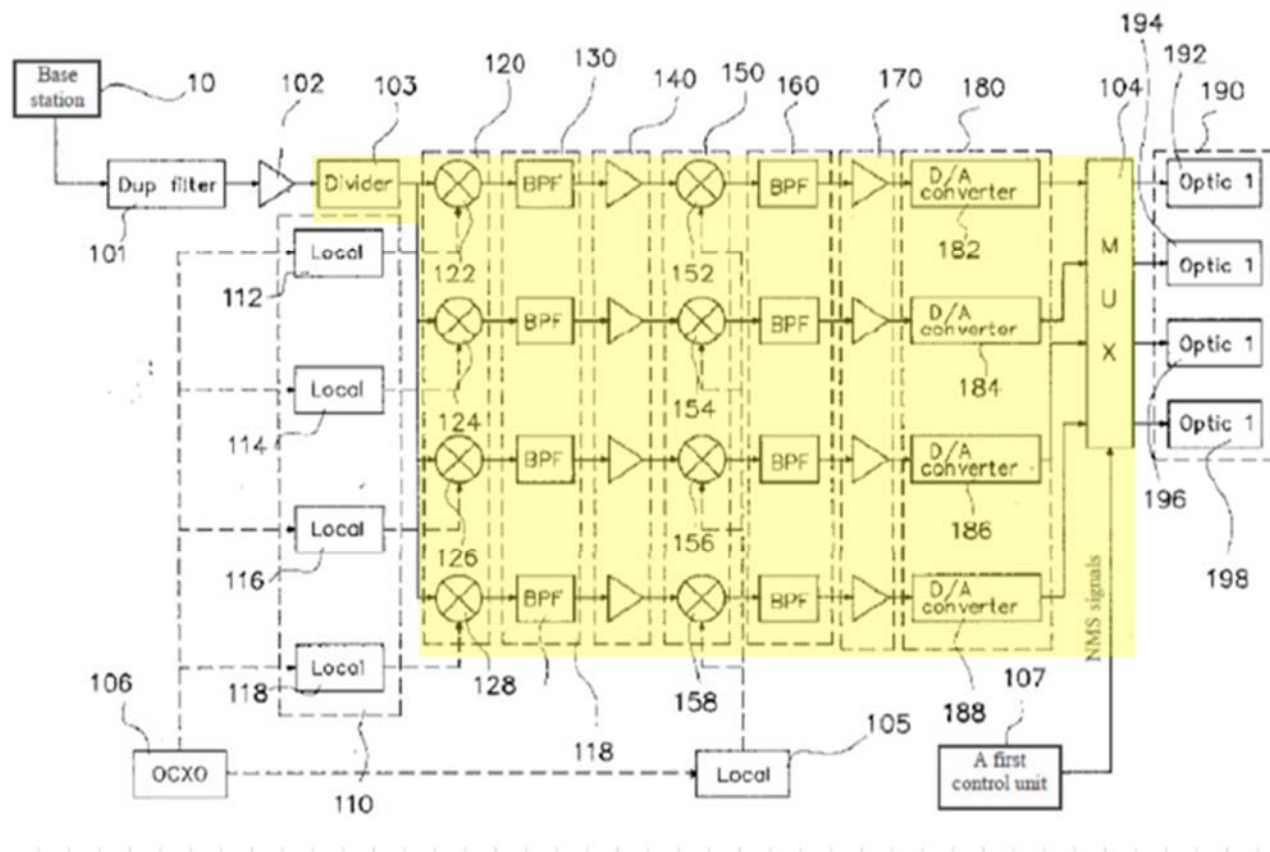


121. Thus Oh renders obvious at least two digital remote units (slave units 30) each include a main radio frequency antenna which transmits and receives radio frequency signals.

6. Dependent Claim 6

122. Claim 6 recites that “the digital host unit includes a radio frequency to digital converter that converts a main radio frequency signal to at least a portion of the digitized radio frequency signals.” Fig. 2 of Oh depicts the master unit 20 that receives a radio frequency signal and outputs digital representation of the received radio frequency signal.

FIG. 2



123. As described at 3:6-18, a first divider 103 divides the received RF signal among 4 rows of frequency band digitization circuitry. The frequency band signals from the divider are downconverted 120, filtered 130, amplified 140, further

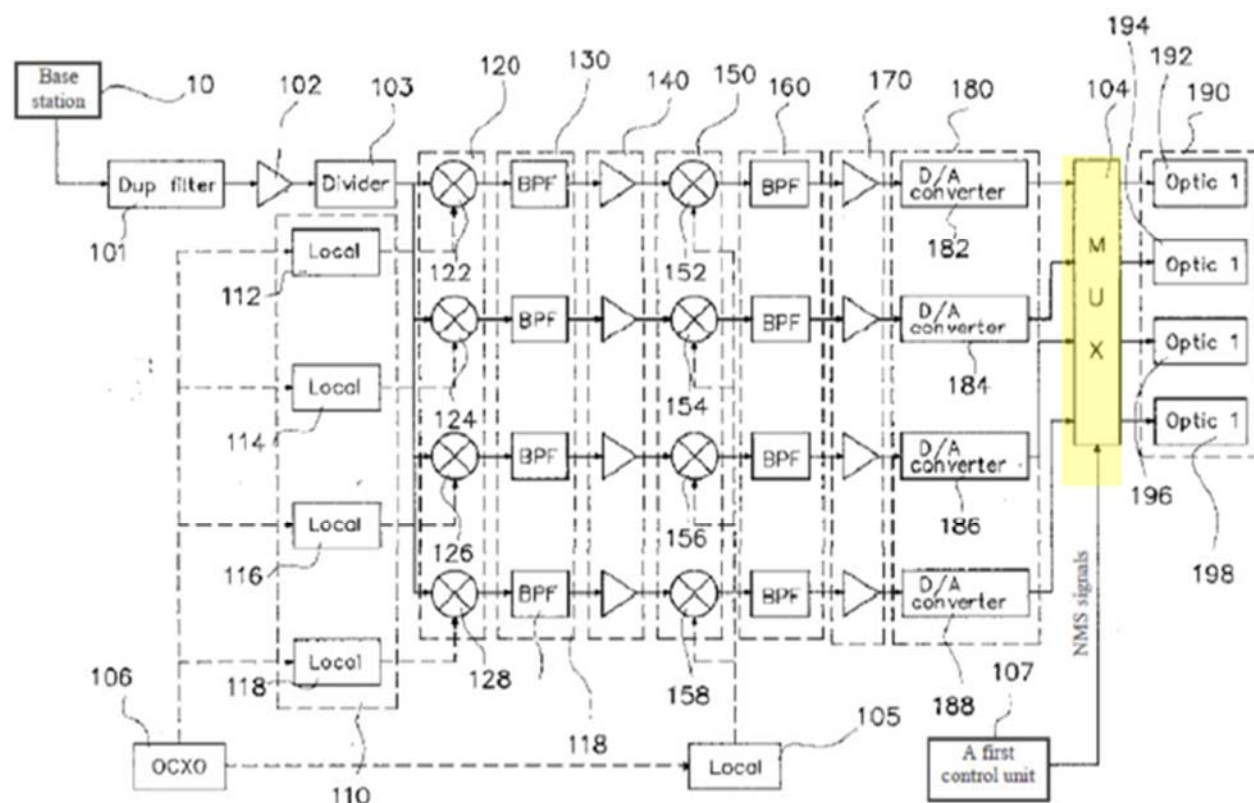
downconverted 150, further filtered 160, and further amplified 170 before being sampled at 180 to create a digital representation of the received main radio frequency signal in the form of four 12-bit samples, one from each frequency band path. The multiplexer 104 multiplexes those four 12-bit samples, which together represent the main radio frequency signal received from the base station 10, and 4 bits of control data 107 that is transmitted to the remote slave units 30

124. Thus Oh renders obvious the digital host unit (master unit 20) includes a radio frequency to digital converter (103, 120-180, 104) that converts a main radio frequency signal (received from base station 10) to at least a portion of the digitized radio frequency signals (output from mux 104 to remote slave units 30).

7. Dependent Claim 7

125. Claim 7 recites that “the digital host unit further includes a multiplexer which splits the digitized radio frequency signals into at least two digital signals for optical transmission to the at least two digital remote units.” Fig. 2 of Oh depicts master unit 20’s multiplexer 104. Multiplexer 104 receives the 12-bit samples from the A/D converter unit 180 and multiplexes them along with the control data from 107 and outputs copies of those 52-bit signals to four remote slave units 30 via optical converters depicted at 190. Ex. 1007, 3:16-19.

FIG. 2



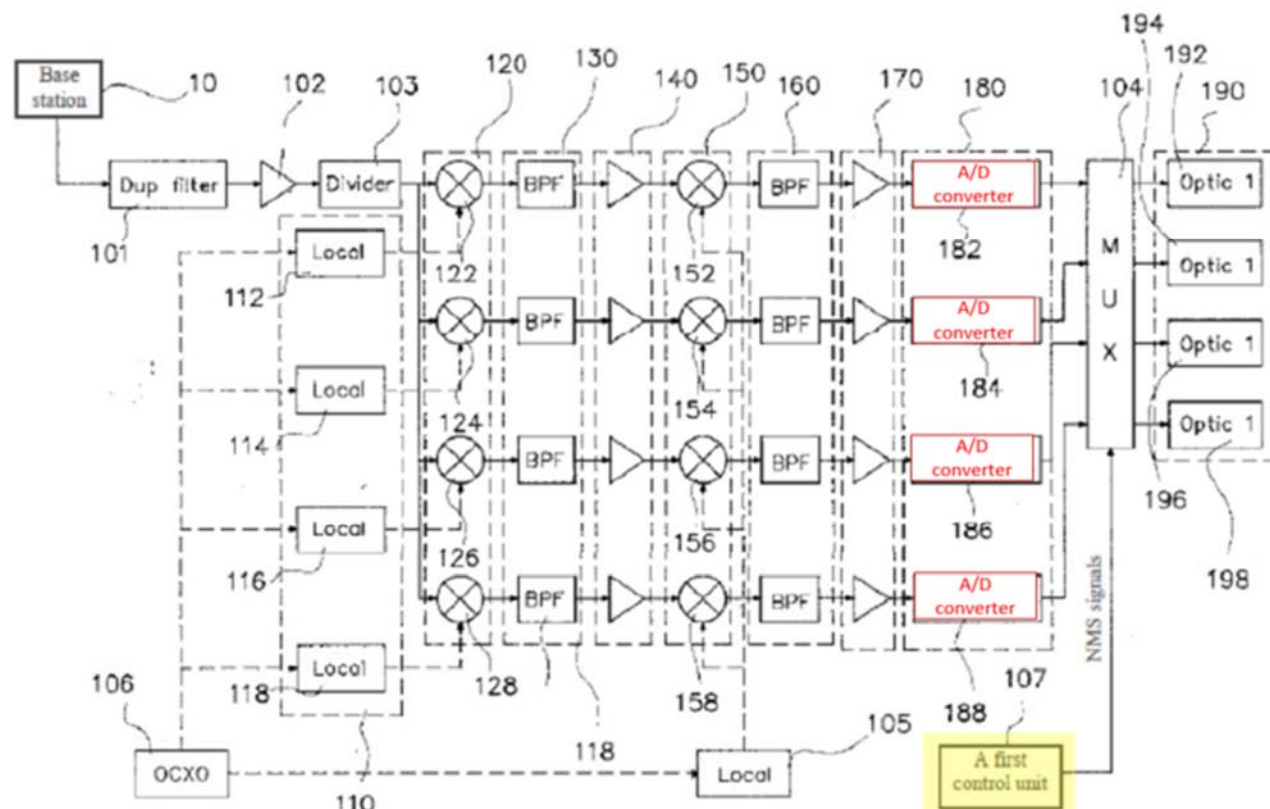
126. Thus Oh renders obvious the digital host unit (master unit 20) further includes a multiplexer (104) which splits the digitized radio frequency signals (52-bit signals) into at least two digital signals (mux 104 splits for transmission on 192, 194, 196, 198) for optical transmission to the at least two digital remote units (remote slave units 30).

8. Dependent Claim 8

127. Claim 8 recites that “the digital host unit further comprises an alarm/control interface circuit coupled to the multiplexer.” Fig. 2 of Oh depicts first control unit 107 that is coupled to multiplexer 104. That control unit 107 appends 4

bits of NMS (Network Management System) control data to each set of digital sample data transmitted across optic lines 50.

FIG. 2



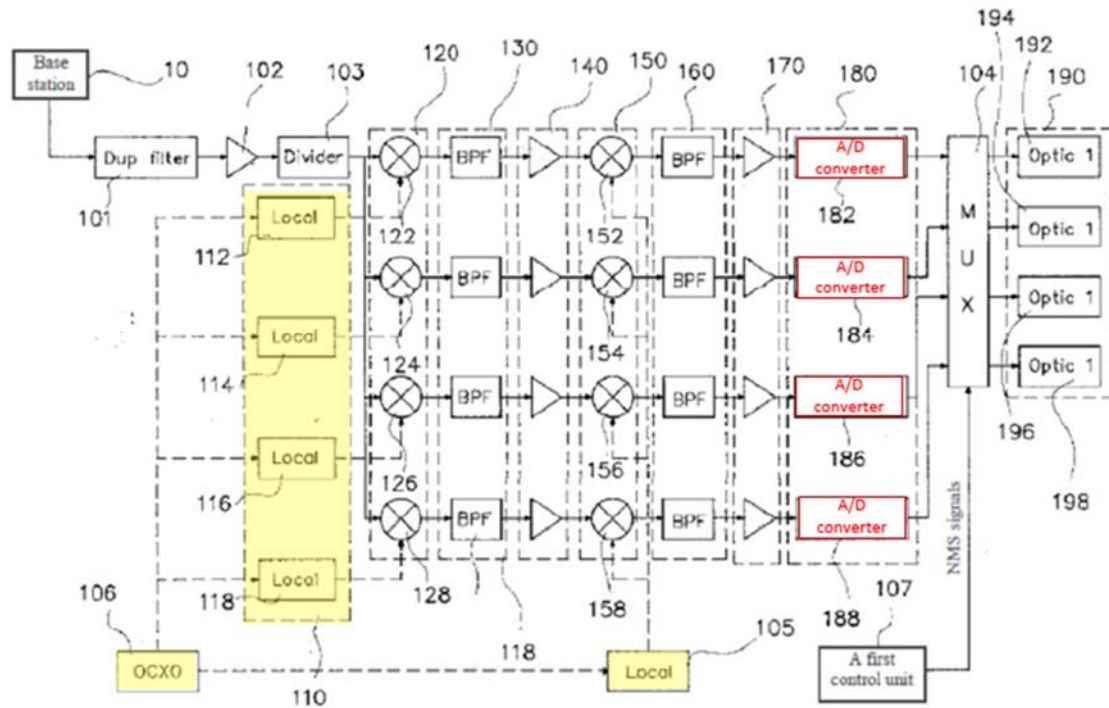
128. Thus Oh renders obvious the digital host unit (master unit 20) further comprises an alarm/control interface circuit (first control unit 107) coupled to the multiplexer (104).

9. Dependent Claim 9

129. Claim 9 recites that “the digital host unit includes local oscillators coupled to a reference oscillator for synchronization of the radio frequency signal in the forward direction and in the reverse direction.” Oh discloses that master unit 20 includes local oscillators 112, 114, 116, 118 (for converting from 801.23, 803.69,

806.15, 808.61 to 70Mhz: Ex. 1007, 3:20-25), and 105 (for converting from 70MHz to near DC: Ex. 1007, 3:34-37), coupled to oven-controlled reference oscillator 106 in the forward direction of Fig. 2.

FIG. 2



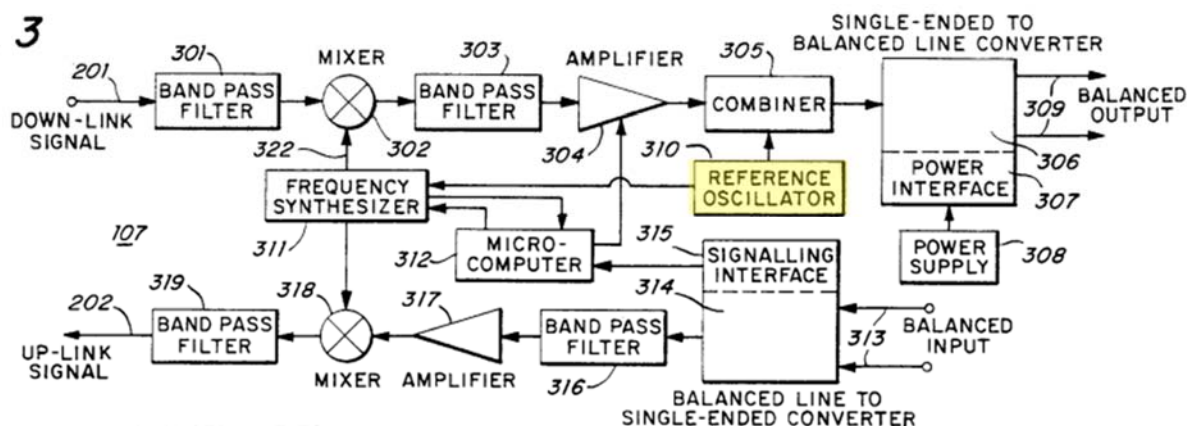
And Oh discloses that master unit 20 includes local oscillators 403 (for converting from near DC to 70 MHz: Ex. 1007, 5:19-22), 502, 504, 506, 508 (for converting from 70 to 801.23, 803.69, 806.15, 808.61 Mhz: Ex. 1007, 5:23-26) coupled to oven-controlled reference oscillator 402 in the forward direction of Fig. 2.

-77-

because using a single reference oscillator would have reduced part count (and associated cost), reduced power consumption, and reduced reliability concerns caused by additional moving parts that would be present if discrete reference oscillators were used. As illustrated in Figs. 2 and 5 already, a single reference oscillator can be used to generate several local frequency signals. Thus implementing master unit 20 with a single reference oscillator 106/402 would have been obvious.

131. To any extent that the use of a common reference oscillator is deemed not within the general skill of the art, a POSITA would have been motivated to implement a common reference oscillator for forward and reverse direction operations as disclosed in van der Kaay (Ex. 1019), where a common reference oscillator 310 is used to generate frequencies for frequency shifting operations in the forward and reverse directions. A POSITA would be motivated to combine the disclosures because use of a common reference oscillator would reduce part count (and associated cost), reduce power consumption, and reduce reliability concerns caused by additional moving parts that would be present if discrete reference oscillators were used. Further “[s]ince the same reference oscillator signal (representative of the output of the referenced oscillator 310) is used throughout the RF signal distribution system, frequency accuracy is maintained at a high level.” Ex. 1019, 9:62-65.

FIG. 3

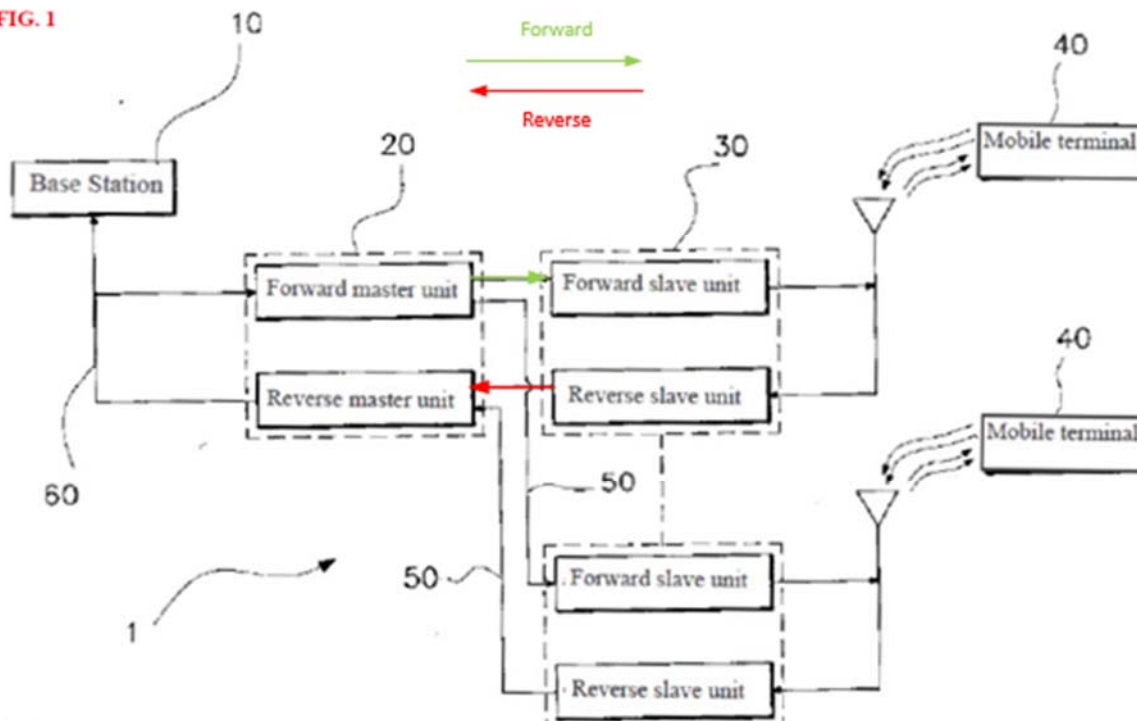


132. Thus Oh renders obvious the digital host unit (20) includes local oscillators (105, 112, 114, 116, 118, 403, 502, 504, 506, 508) coupled to a reference oscillator (106/402) for synchronization of the radio frequency signal in the forward direction (Fig. 2) and the reverse direction (Fig. 5).

10. Dependent Claim 10

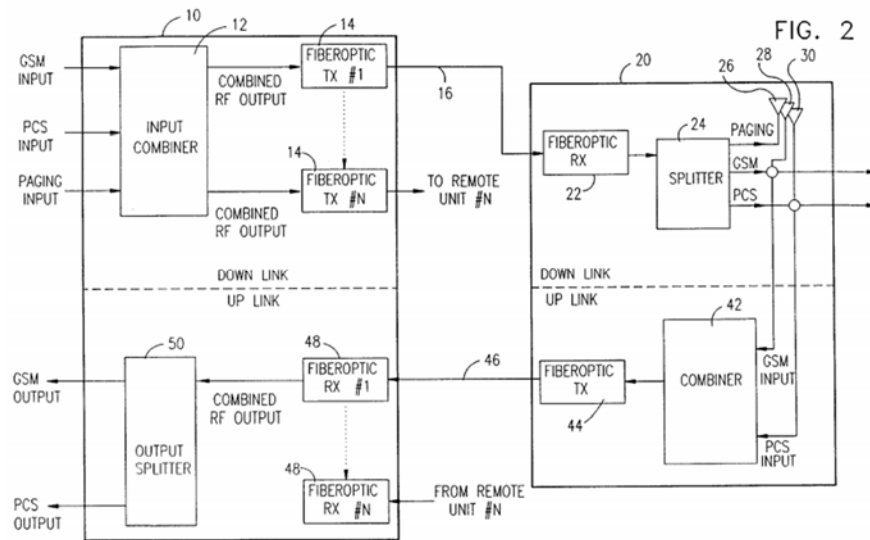
133. Claim 10 recites that “the digital host unit is coupled to each of the at least two digital remote units by a multimode fiber pair.” Oh Fig. 1 illustrates master unit 20 communicating in the forward direction to a slave unit 30 using a first optic line 50, highlighted in green, and in the reverse direction from a slave unit using a second optic line 50 highlighted in red. Thus Oh discloses master unit 20 communicating with each slave unit 30 via fiber pairs.

FIG. 1



134. Oh discloses that the master unit 20 communicates digital data to slave units 30 via optic lines 50. Ex. 1007, 3:4-6. Oh is agnostic as to whether multimode or single mode fiber is used. A POSITA would consider selection of multimode or single mode to be a matter of design choice. This is evidenced by Farber which describes the use of single or multimode fiber in an antenna system for reaching difficult coverage areas (see Fig. 1) that is very similar to the digital system of Oh. Ex. 1022 (“Farber”), 4:30-33 (“Preferably the transmitter 14 employs a vertical cavity surface emitting laser or an edge emitting laser coupled to a single or multi-mode fiber 16.”); Fig. 2. As further evidence of obviousness of using multimode fiber, Haas illustrates the cost-benefit analysis of selection of multimode or single mode fiber for an application. Ex. 1012, 1125. A POSITA would have been motivated to select

multimode fiber as disclosed by Haas for communicating among a host and remote units when cost is a significant factor for the project. Additionally as disclosed by Haas, in some instances multimode fiber may already be installed in an area into which an RF distribution network is being implemented, making reuse of that multimode fiber an attractive option.



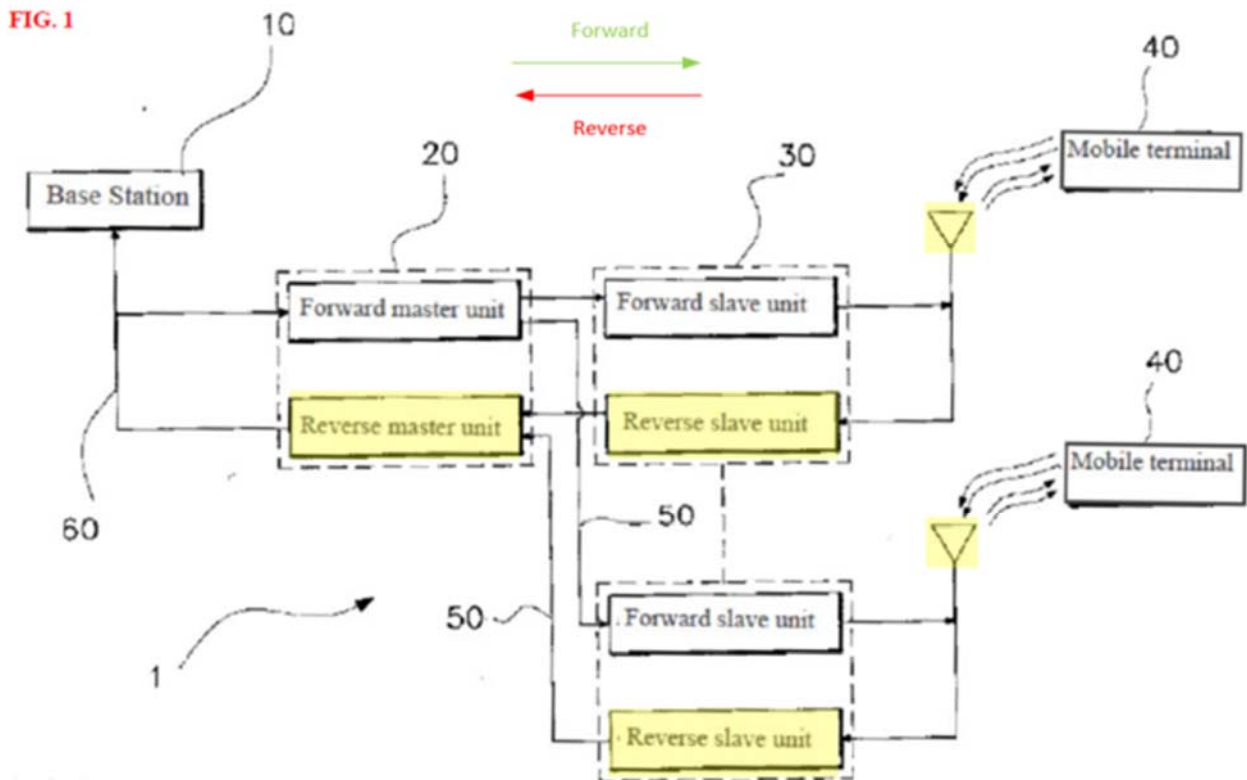
135. Thus Oh alone, or in view of Farber, renders obvious the digital host unit 20 is coupled to each of the at least two digital remote units 30 by a multimode (*e.g.*, as disclosed by Farber) fiber pair (see red and green annotations between 20, 30 in Oh Fig. 1).

11. Independent Claim 25

a) Preamble: "A method of performing multipoint-to-point digital radio frequency transport, the method comprising:"

136. To the extent the preamble of claim 25 is limiting, it is rendered obvious by Oh. Oh discloses digital radio frequency transport for the reasons noted above in

addressing the preamble of claim 1. Oh's disclosure of multipoint-to-point digital radio frequency transport is evidenced in FIG. 1, where reverse slave units of multiple slave units 30 receive RF signals from mobile terminals 40 via the antennas of the slave units 30.



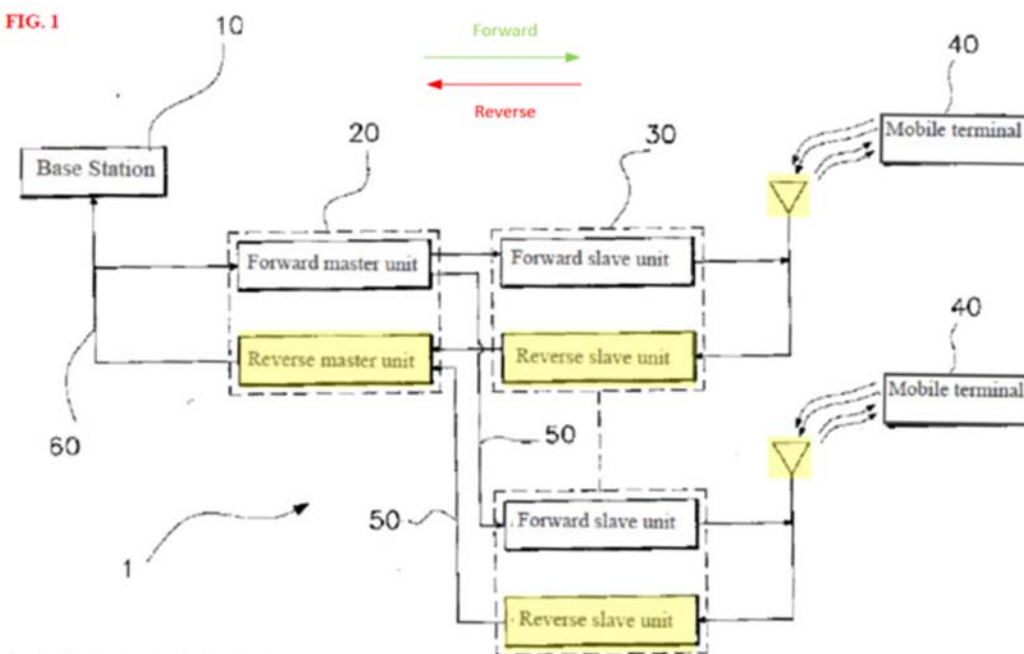
137. RF signals from the mobile terminals 40 are downconverted and converted to digital representations at 380. The digital signals from A/D converter unit 380 are then transmitted from the reverse slave units 300 to the reverse master unit 400 via optic lines 50. Ex. 1007, 4:26-39.

138. Oh therefore renders obvious each limitation recited in the preamble of claim 25 by disclosing multipoint (multiple slave units 30) to point (master unit 20)

digital radio frequency (digital samples of intermediate frequency/baseband analog signals) transport (transmission of those digital signals from the multiple slave units 30 to the master unit 20 across optic lines 50).

b) Element 1: “receiving analog radio frequency signals at multiple digital remote units;”

139. Oh discloses that each reverse slave unit 300 “converts the RF signals, analog signals, transmitted from the mobile terminals 40 ... to the digital signals; and transmits them to the master unit 20.” Ex. 1007, 4:22-25. Fig. 1 depicts multiple slave units 30 receiving analog RF signals from mobile terminals 40.

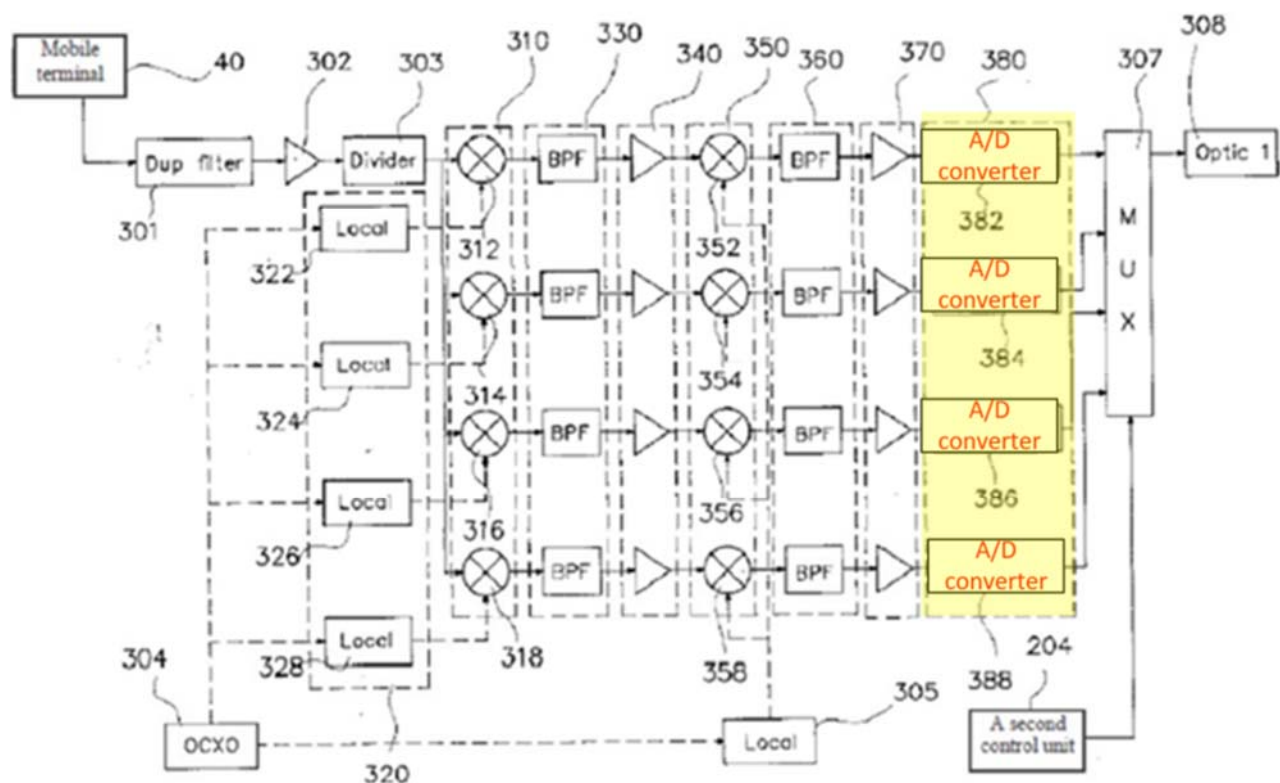


140. Thus Oh discloses receiving analog radio frequency signals (RF signals from mobile terminals 40) at multiple digital remote units (multiple slave units 30).

c) Element 2: “converting the analog radio frequency signals to digital radio frequency signals at each of the digital remote units;”

141. Oh discloses that each reverse slave unit 300 “converts the RF signals, analog signals, transmitted from the mobile terminals 40 through a third bi-directional filter 301, to the digital signals.” Ex. 1007, 4:23-25. That digitization is illustrated at Fig. 4 where “A/D converter unit 380 converts the intermediate frequency signals, analog signals, to the digital signals.” *Id.*, 4:56-67.

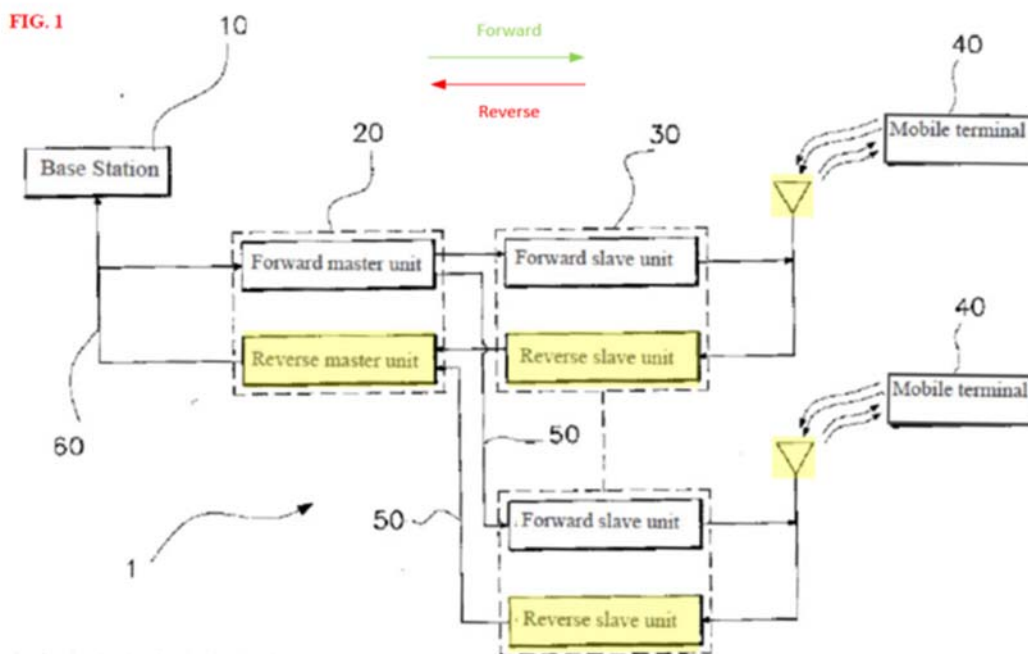
FIG. 4



142. Thus, Oh discloses “converting the analog radio frequency signals (downconverted RF signals from mobile terminals 40) to digital radio frequency signals at each of the digital remote units (at A/D converters of slave units 30).”

d) Element 3: “optically transmitting the digital radio frequency signals from each of the digital remote units to a digital host unit;”

143. Oh discloses that its reverse slave units 300 multiplex “all the digital signals transmitted from said second A/D converter unit 380... to serial data signals and outputs them to the reverse master unit 400 through a third optic converter unit 308 and the optic line 50.” Ex. 1007, 4:36-39.



144. Thus Oh discloses optically transmitting the digital radio frequency signals (optic lines 50) from each of the digital remote units (slave units 30) to a digital host unit (master unit 20).

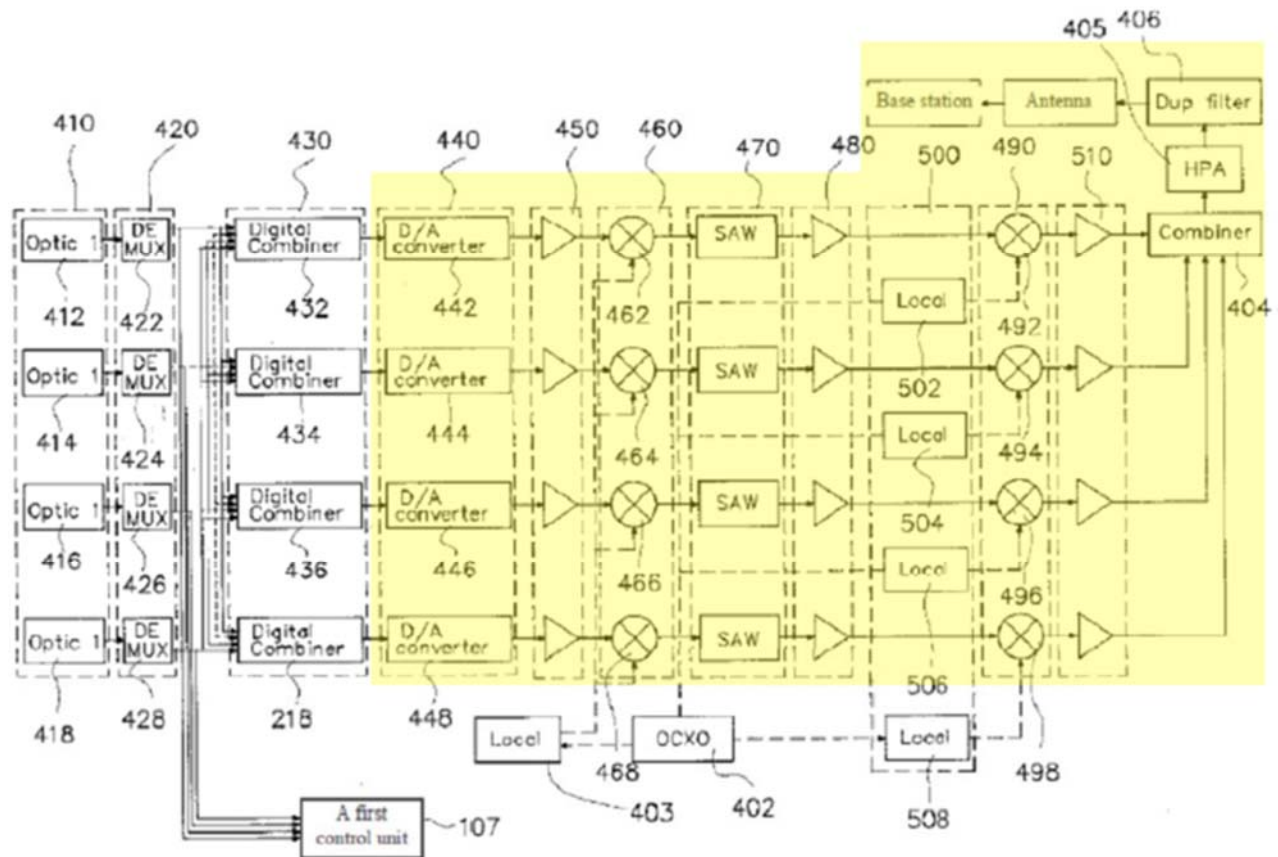
f) Element 5: “digitally summing the multiple digital radio frequency signals together;”

147. Oh discloses Element 5 for the reasons discussed above for Claim 1, Element 3.

g) Element 6: “converting the summed multiple digital radio frequency signals back to analog radio frequency signals and transmitting the signals to a wireless interface device for further transmission to a switched telephone network.”

148. Following the digital summing operation of Element 5, the summed digital data values are converted to analog signals, up converted to the appropriate frequency signals associated with their particular bands to create component analog signals, that are then combined and transmitted to a base station via an antenna. As discussed above, Oh, as evidenced by Fig. 5’s depiction of master unit 20 communicating with base station 10 via an antenna, evidences the obviousness of wireless communications between a base station and master unit.

FIG. 5



Specifically Oh states:

After creating 14-bit intermediate frequency signals by combining four 12-bit intermediate frequency signals in the same frequency band, said digital combiner transmits them to a first D/A converter unit 440. Each D/A converter 442, 444, 446, and 448 of said first D/A converter unit 440 converts 14-bit digital signals to the intermediate [frequency] signals, analog signals; and transmits 1.23MHz or 1.5MHz intermediate frequency signals to each mixer 462, 464, 466, and 468 of a third mixer unit 460 through a third amplification unit 450. Said third mixer unit 460 outputs 70MHz intermediate frequency signals by mixing 1.23MHz or 1.5MHz intermediate frequency signals

transmitted from a first D/A converter unit 440 with 68.77MHz or 68.5MHz oscillating frequency transmitted from a third local unit 403. The intermediate frequency signals outputted from said third mixer unit 460 are transmitted to a fourth mixer unit 490 through a first saw filter unit 470 and a fourth amplification unit 480. Said fourth mixer unit 490 mixes the oscillating frequency in different frequency bands transmitted from a fourth local unit 500 with 70MHz intermediate frequency signals; and transmits 800MHz RF signals in different frequency bands to a first combiner 404 through a fifth amplification unit 510.

Ex. 1007, 5:16-26. The analog signals are combined at 404 to “aggregate[] the RF signals in different frequency bands transmitted from four mixers 492, 494, 496, and 498,” and are amplified at 510 and run through a bi-directional filter 406 to an antenna and a base station.⁴ The Patent Owner admits that a POSITA would understand a base station to include conventional base station hardware includes radio controller or interface circuitry 322 to an MTSO or telephone switched network. Ex. 1001, 6:24-27. Further, Wala (Ex. 1009) evidences that it was well known in the art for RF transport systems to communicate with switched telephone networks (*e.g.*, via base stations). *See*, Ex. 1009, Fig. 1, 588 (“Because the voice channels between the mobile telephone switching office (MTSO) and the cell site are often already in digitized

⁴ Recall that '982 states that a wireless interface device may comprise a base station.

form...”).

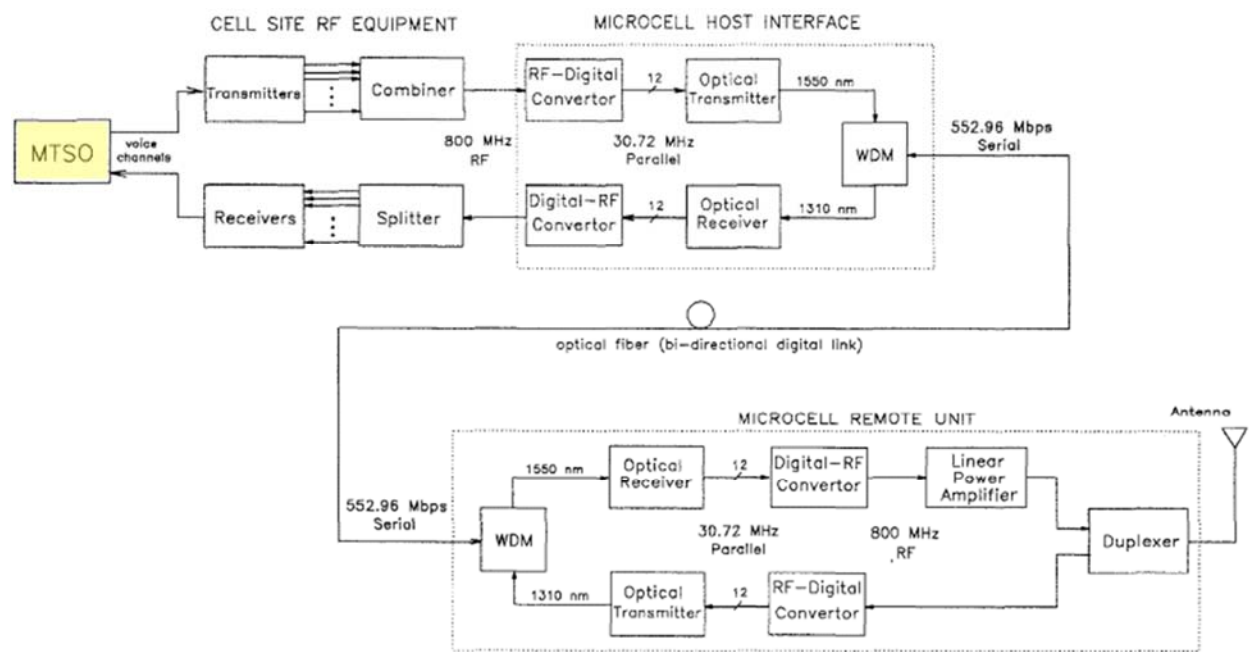


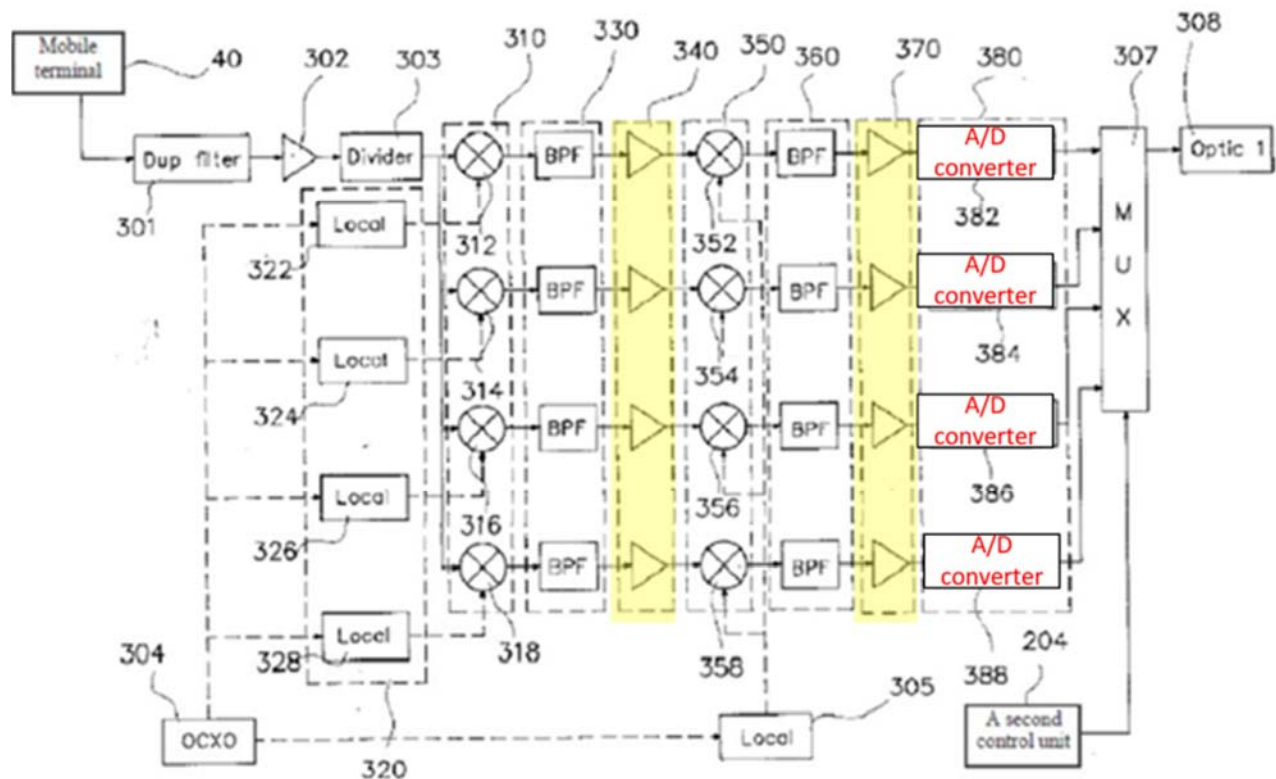
Fig.1. Digital RF transport microcell: system block diagram

149. Thus Oh discloses converting the summed multiple digital radio frequency signals (outputs of 430) back to analog radio frequency signals (at 440) and transmitting the signals (signals combined at 404) to a wireless interface device (405, 406, antenna, base station) for further transmission to a switched telephone network (to which a POSITA would understand the base station to be connected by conventional means).

12. Dependent Claim 26

150. Claim 26 recites that “converting the analog radio frequency signals to digital radio frequency signals comprises amplifying the analog radio frequency signals.” In Oh, prior to digitizing the analog radio frequency signals at 380, those signals are passed through amplification units 340 and 370.

FIG. 4



151. Thus Oh renders obvious converting the analog radio frequency signals to digital radio frequency signals comprises amplifying the analog radio frequency signals (amplification at 340, 370 prior to conversion to digital at 380).

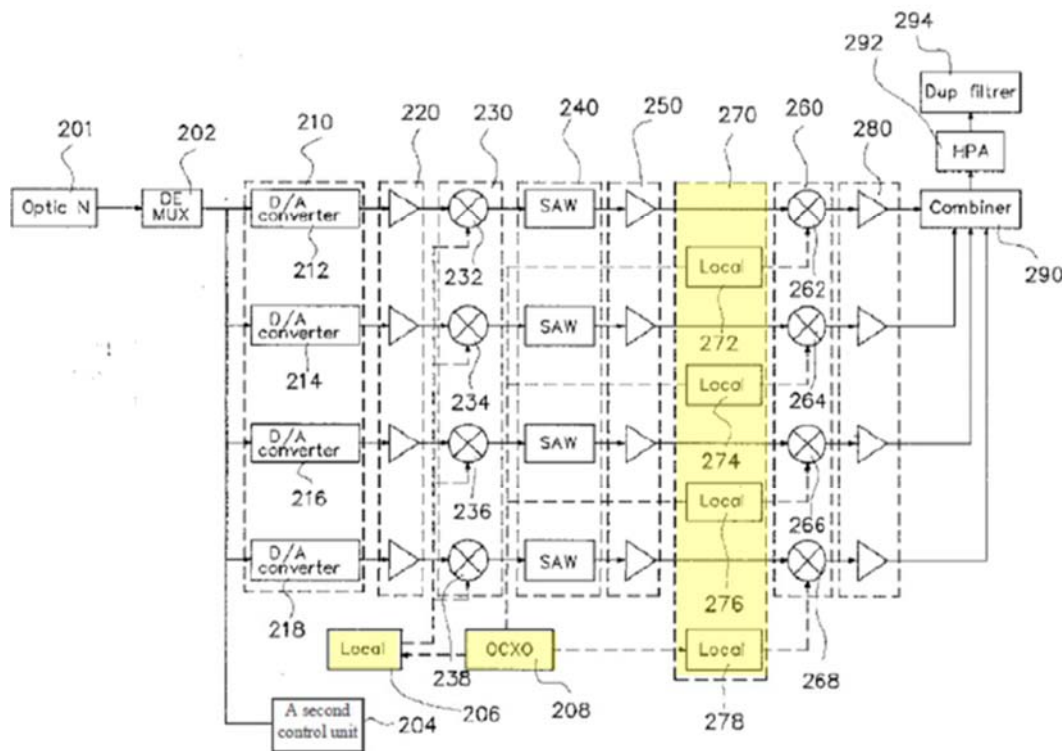
13. Dependent Claim 27

152. Claim 27 recites that “converting the analog radio frequency signals to digital radio frequency signals comprises synchronizing a reverse path local oscillator to a master clock so as to reduce end-to-end frequency translation.” The ’982 patent notes that reference oscillators in its units (*e.g.*, digital host unit 420 and digital remote units 540) operate as “master clocks” for forward and reverse signal processing, where a “local oscillator is locked to the reference oscillator... as a master clock so that the

down conversion of the RF signals is the same as the up conversion. The result is[,] end to end, from DHU to DRU, or DHU to one or more DEUs to DRU, no frequency shift in the signals received and transmitted.” Ex. 1001, 7:25-30. Similar to the limitation of claim 9 above, which referenced synchronizing forward and reverse oscillators in a host unit, claim 27 describes such synchronization in remote units.

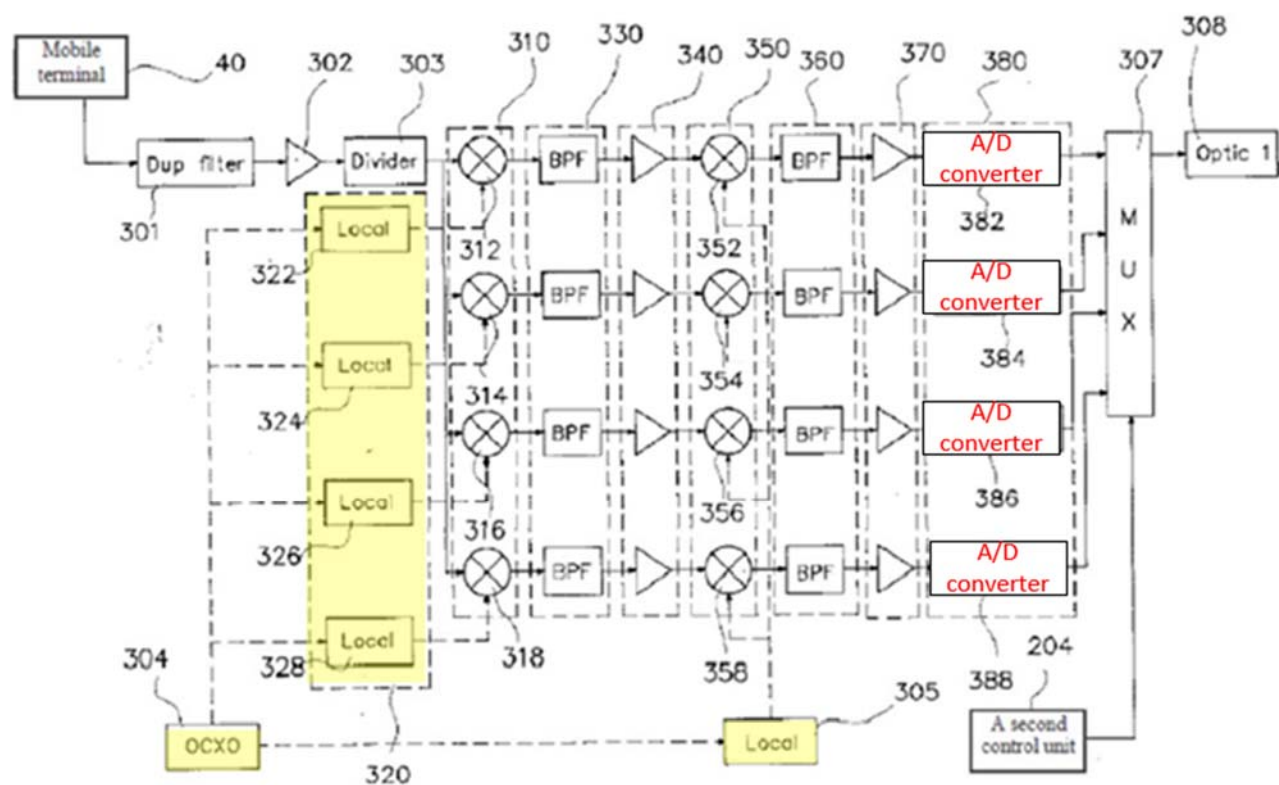
153. Oh discloses that slave units 30 include local oscillators 206 (for converting from near DC to 70 MHz: Ex. 1007, 3:54-56), 272, 274, 276, 278 (for converting from 70 to 801.23, 803.69, 806.15, 808.61 Mhz: Ex. 1007, 4:6-9) coupled to oven-controlled reference oscillator 208 in the forward direction of Fig. 3.

FIG. 3



154. And Oh discloses that slave units 30 include local oscillators local oscillators 322, 324, 326, 328 (for converting from 801.23, 803.69, 806.15, 808.61 to 70Mhz: Ex. 1007, 4:43-47), and 305 (for converting from 70MHz to near DC: Ex. 1007, 4:48-53) coupled to oven-controlled reference oscillator 304 in the reverse direction of Fig. 4.

FIG. 4

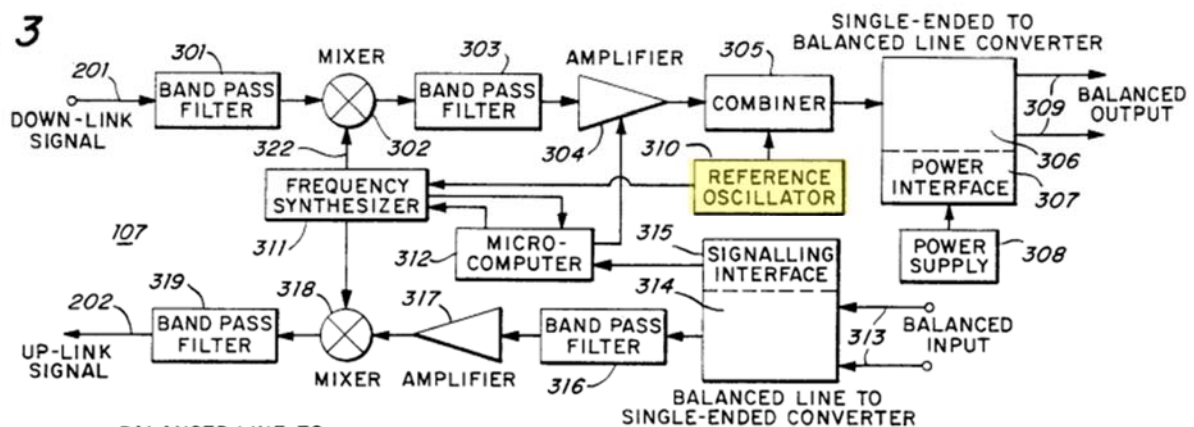


Oh's disclosure of oven controlled reference oscillator (208 in Fig. 3, 304 in Fig. 4) in remote slave unit 30 teaches the limitation. To the extent that Oh is not explicit that reference 208 in Fig. 3 and 304 in Fig. 4 are indicating the same reference oscillator, such an implementation would be obvious to a POSITA. Because the forward and reverse frequency translations are to the same frequencies (*i.e.*, 70MHz to/from about

800MHz; near DC to/from 70MHz), the local oscillators operating in Figs. 3 and 4 will be operating at about the same frequencies. Having those common local frequencies being generated in Figs. 2 and 5 using a single, common oven-controlled reference oscillator would have been an obvious design choice because using a single reference oscillator would have reduce part count, reduced power consumption, and reduced reliability concerns caused by additional parts that would be present if separate oven controlled reference oscillators were used. As illustrated in Figs. 2 and 5 already, a single reference oscillator is used to generate several local oscillator frequency signals. Thus implementing master unit 20 with a single reference oscillator 106/402 would have been obvious.

155. And as discussed above with reference to claim 9, forward and reverse synchronization was well known and obvious, as evidenced by van der Kaay (Ex. 1019), which a POSITA would have been motivated to combine with Oh for the reasons discussed above with reference to claim 9.

FIG. 3



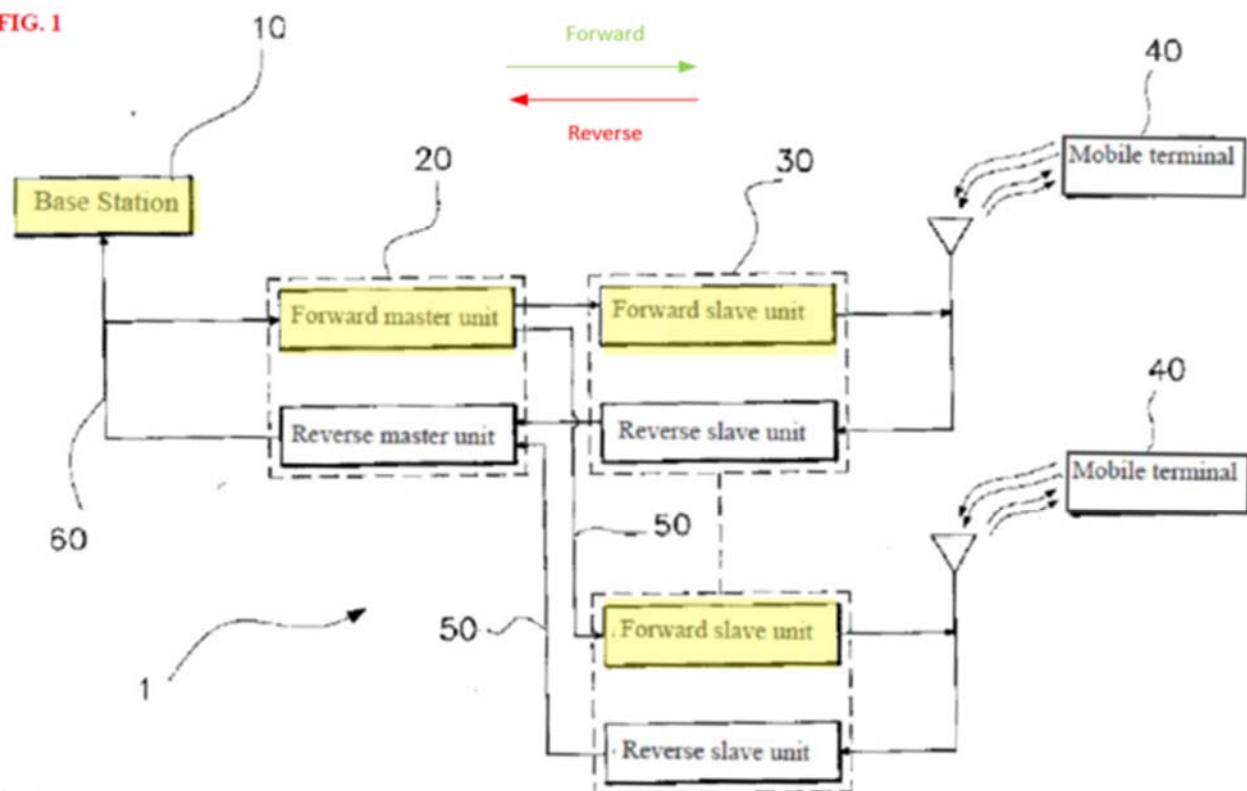
156. Thus Oh renders obvious converting the analog radio frequency signals to digital radio frequency signals (in slave unit 30) comprises synchronizing a reverse path local oscillator (one of 305, 322, 324, 326, 328) to a master clock (208, 304, a single oscillator operating in slave unit 30's forward and reverse paths) so as to reduce end-to-end frequency translation (*e.g.*, as described with reference to oscillators 415, 468 in Ex. 1001, 7:22-30).

14. Independent Claim 28

a) Preamble: "A method of performing point-to-multipoint digital radio frequency transport, the method comprising:"

157. To the extent the preamble of claim 28 is limiting, it is rendered obvious by Oh. Oh discloses digital radio frequency transport for the reasons noted above in addressing the preamble of claim 1. Oh's disclosure of point-to-multipoint digital radio frequency transport is evidenced in FIG. 1, where the master unit 20 receives RF signals from base station 10.

FIG. 1



158. RF signals from base station 10 are downconverted and converted to digital representations at 380. The digital signals from A/D converter unit 180 unit are then transmitted from the forward master unit forward slave units of multiple slave units 30 via optic lines 50. Ex. 1007, 3:38-44.

159. Oh therefore renders obvious each limitation recited in the preamble of claim 28 by disclosing point (master unit 20) to multipoint (multiple slave units 30) digital radio frequency (digital samples of intermediate frequency/baseband analog signals from the base station 10) transport (transmission of those digital signals from the master unit 20 to the slave units 30 across optic lines 50).

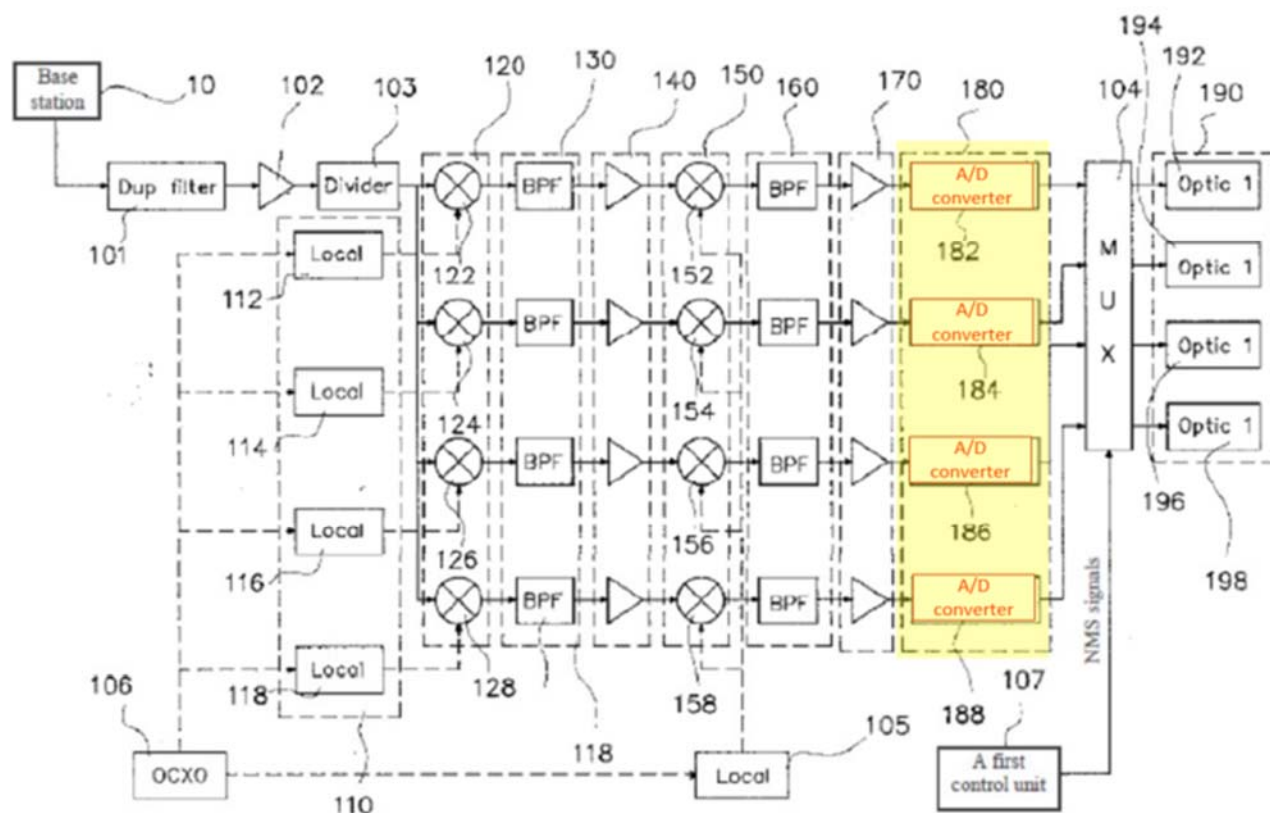
b) Element 1: “receiving radio frequency signals at a digital host unit;”

160. Oh states that the forward master unit 100 of the master unit 20 “executes a first means that converts RF signals, analog signals, transmitted from the base station 10 to the intermediate frequency signals; converts them to digital signals; and transmits them to the slave unit 30 through the optic line 50.” Ex. 1007, 3:4-6. Thus Oh renders obvious receiving radio frequency signals (RF signals from base station 10) at a digital host unit (master unit 20).

c) Element 2: “converting, using a shared analog-to-digital converter, the radio frequency signals to a digitized radio frequency spectrum;”

161. Following receipt from base station 10, Oh’s forward master unit divides the received analog RF signal at 103 into its component frequency bands, downconverts those frequency band signals to near DC at 120-270, and digitizes those component band signals at A/D converter unit 180. Ex. 1007, 3:6-18.

FIG. 2

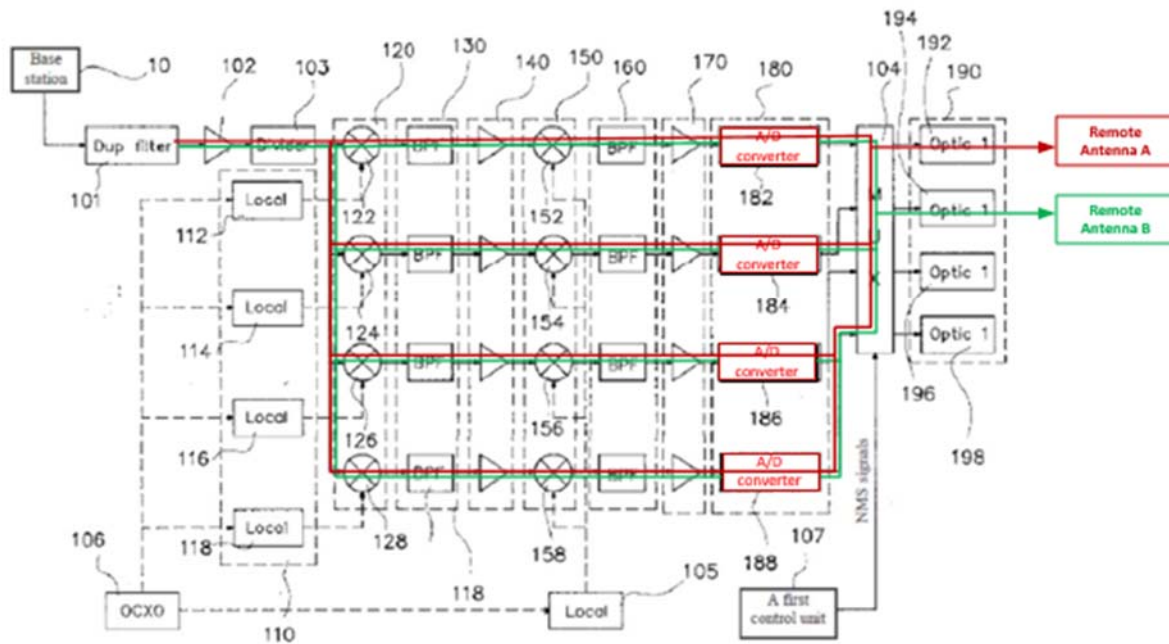


162. As discussed above, the '982 does not use the term “shared circuitry” beyond paraphrases of the claim language. But in a prior litigation, Patent Owner has clarified that “‘shared circuitry’ was intended to mean circuitry that is used to support more than one remote unit.” Ex. 1008, ¶316. There it identified '982 patent’s “circuitry in box 491, the mux 465, and fan out buffer 431” as support for downstream shared circuitry in the specification. *Id.*, ¶324

163. Oh discloses analogous components. On the downstream path of Fig. 2, Oh’s circuitry at 120, 130, 140, 150, 160, 170, 180 down converts the analog signals received from the base station to near DC and samples that data, just like the '982

patent's "circuitry in box 491." Oh similarly includes a multiplexer 104 that serializes the digitized data and distributes it to the remote slave units 30.

FIG. 2



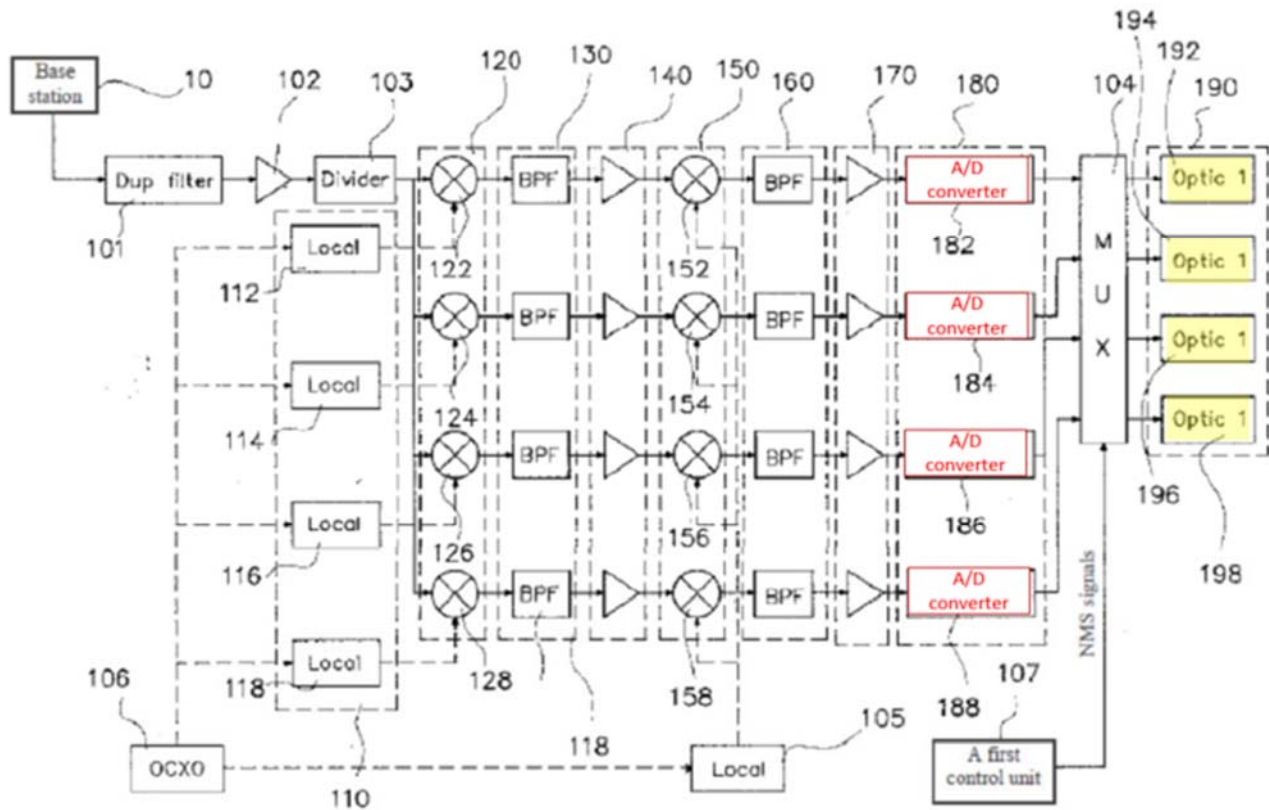
164. By disclosing one A/D converter unit 180 that digitizes the component analog signals for transmission of digital samples to multiple remote units, Oh renders obvious converting, using a shared analog-to-digital converter (A/D converter unit 180 that services multiple slave units 30 via optic lines 192, 194, 196, 198), the radio frequency signals to a digitized radio frequency spectrum.

d) Element 3: “optically transmitting the digitized radio frequency spectrum output by the shared analog-to-digital converter to a plurality of digital remote units;”

165. Oh discloses a first MUX 104 that multiplexes “all digital signals transmitted from said first A/D converter unit 180 with the NMS signals transmitted

from a first control unit 107 and outputs the serial data signals to the forward slave unit 200 of the slave unit 30 through a first optic converter unit 190 and the optic line 50.” Ex. 1007, 3:16-18; 38-44.

FIG. 2

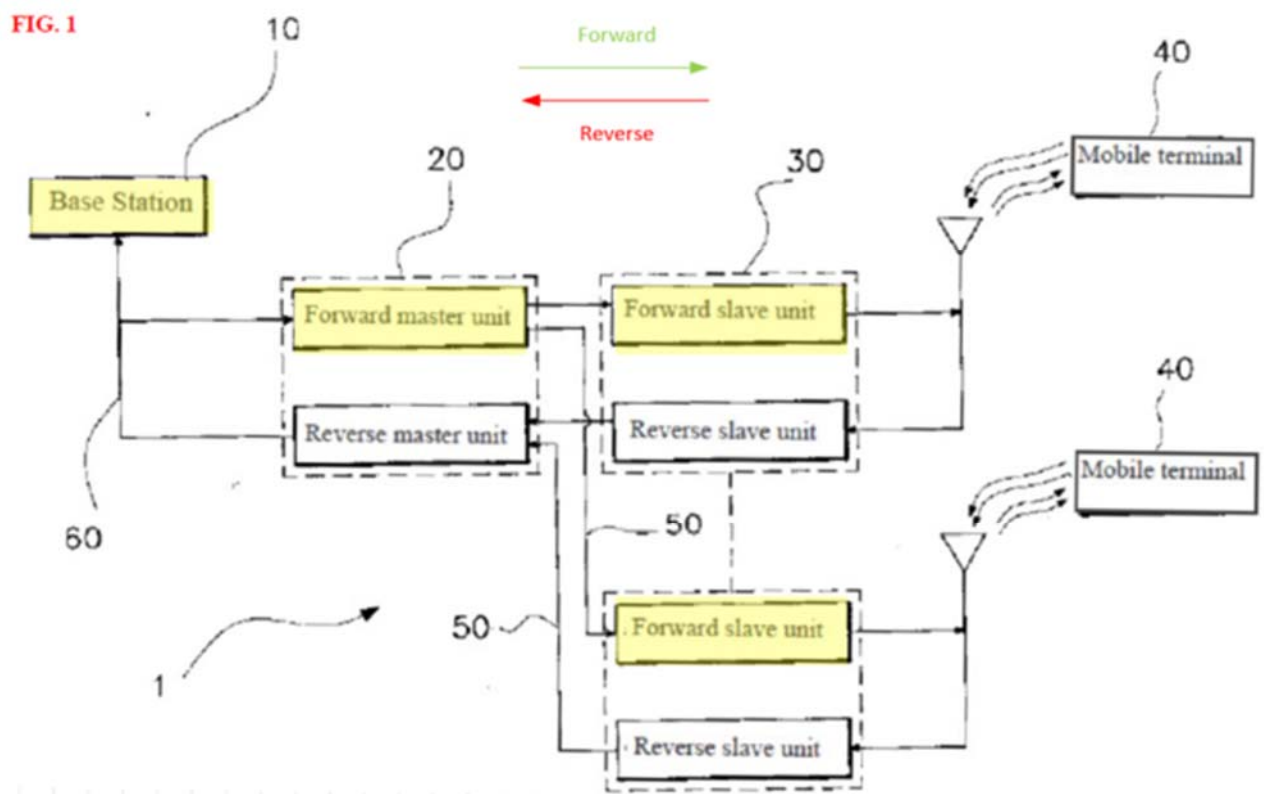


166. Oh thus renders obvious optically transmitting (using optic converters 192, 194, 196, 198) the digitized radio frequency spectrum output by the shared analog-to-digital converter (A/D converter unit 180) to a plurality of digital remote units (slave units 30).

e) Element 4: “receiving the digitized radio frequency spectrum at the plurality of digital remote units;”

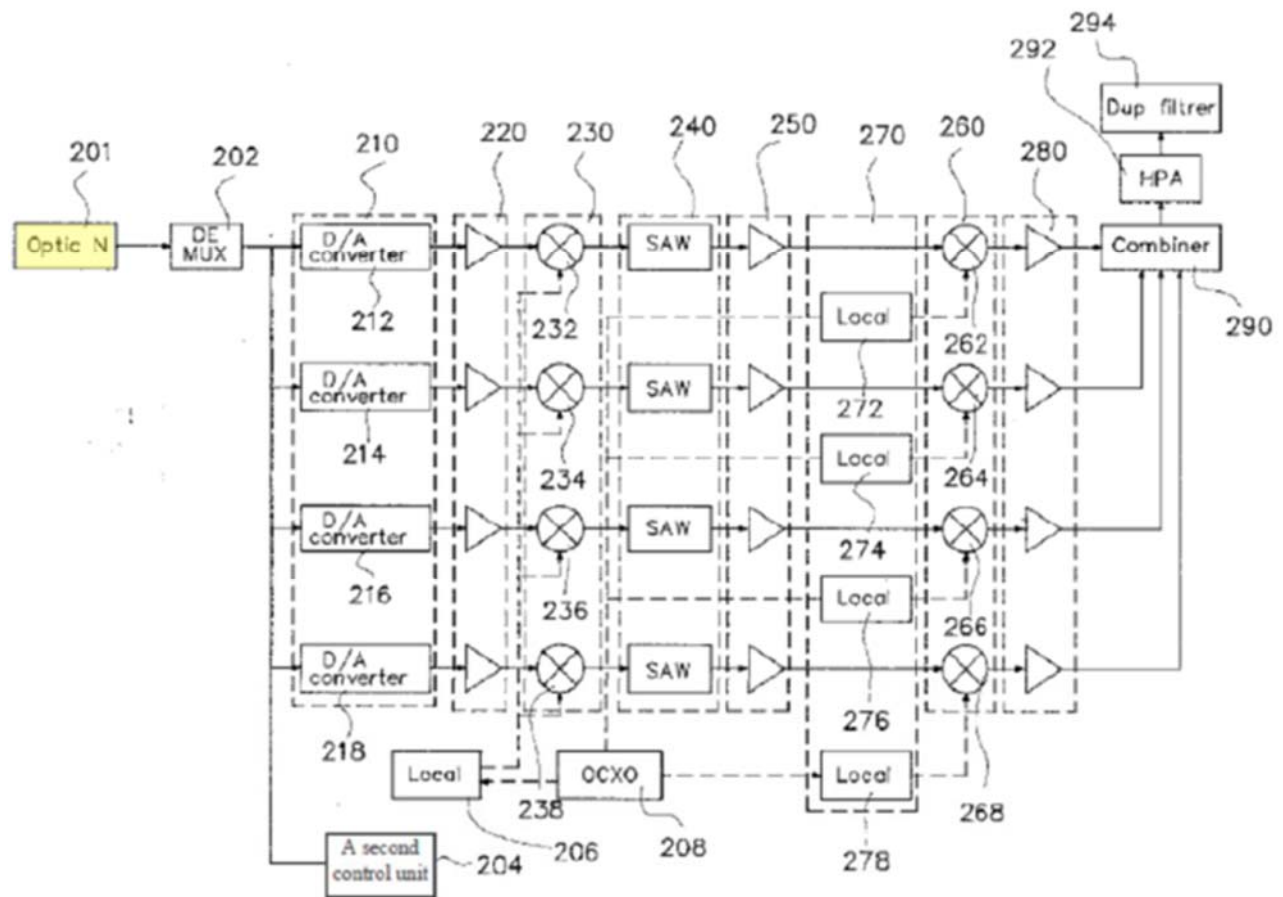
167. Oh discloses that the optic converter unit 190 transmits digitized radio frequency spectrum data to multiple slave units over optic line 50 as depicted in FIG.

1. Ex. 1007, 3:16-18; 38-44.



168. The forward slave unit 200 of the slave unit 30 “converts the digital signals transmitted from the master unit 20 through the optic line 50 to the intermediate frequency signals, analog signals; converts them to the RF signals and transmits them to the mobile terminals 40.” Ex. 1007, 3:47-49.

FIG. 3



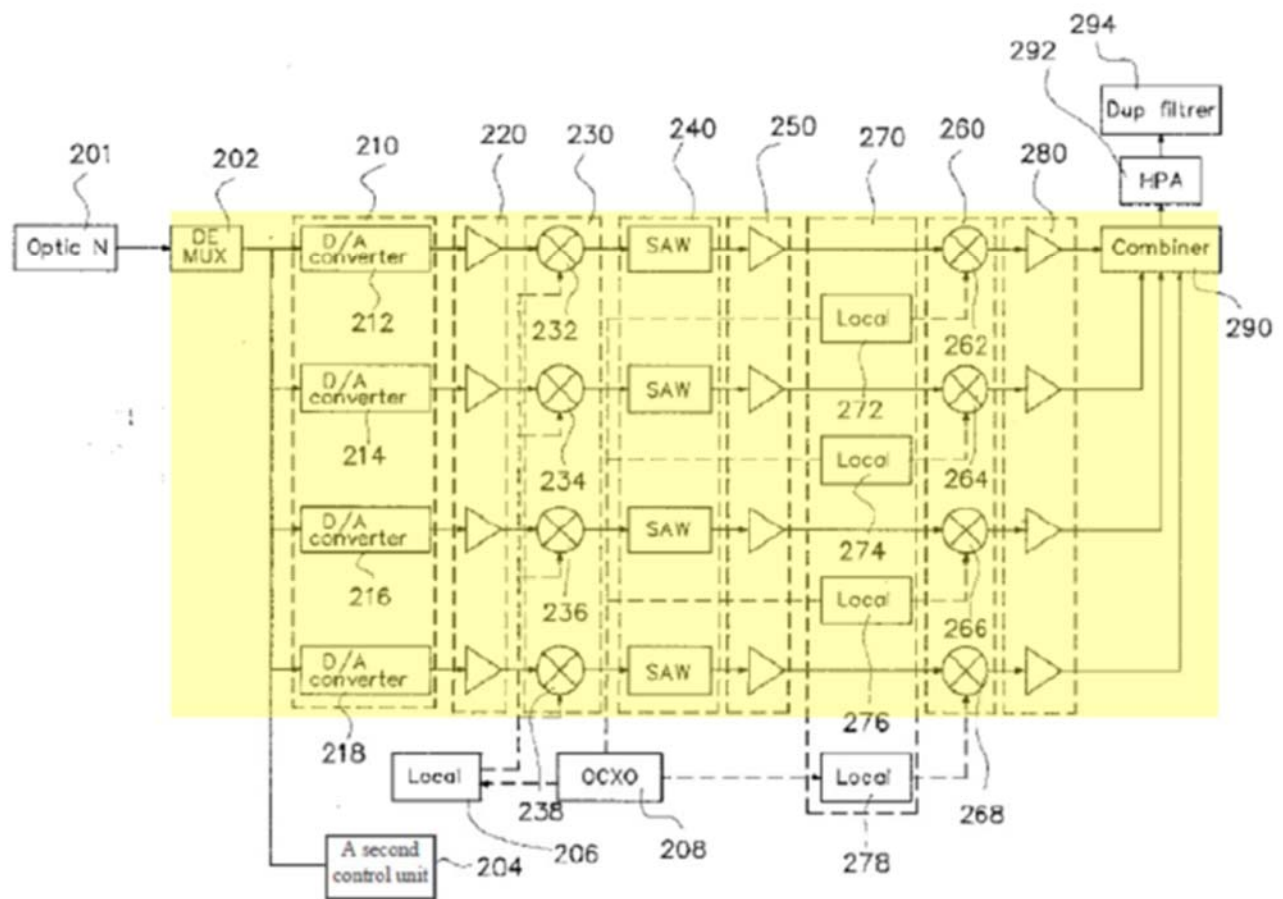
169. Oh thus renders obvious receiving the digitized radio frequency spectrum (digital samples from master unit 20) at the plurality of digital remote units (slave units 30 at 201).

f) Element 5: “converting the digitized radio frequency spectrum to analog radio frequency signals;”

170. Oh discloses that the forward slave unit 200 of the slave unit 30 “converts the digital signals transmitted from the master unit 20 through the optic line 50 to the intermediate frequency signals, analog signals; converts them to the RF signals and transmits them to the mobile terminals 40.” Ex. 1007, 3:47-49. That process is

described in further detail at 3:50-61, where the digital samples from the master unit 20 are routed for recreation of the component analog band signals and upconverted to component analog radio frequency signals which are combined at 290 prior to transmission to mobile terminals 40.

FIG. 3

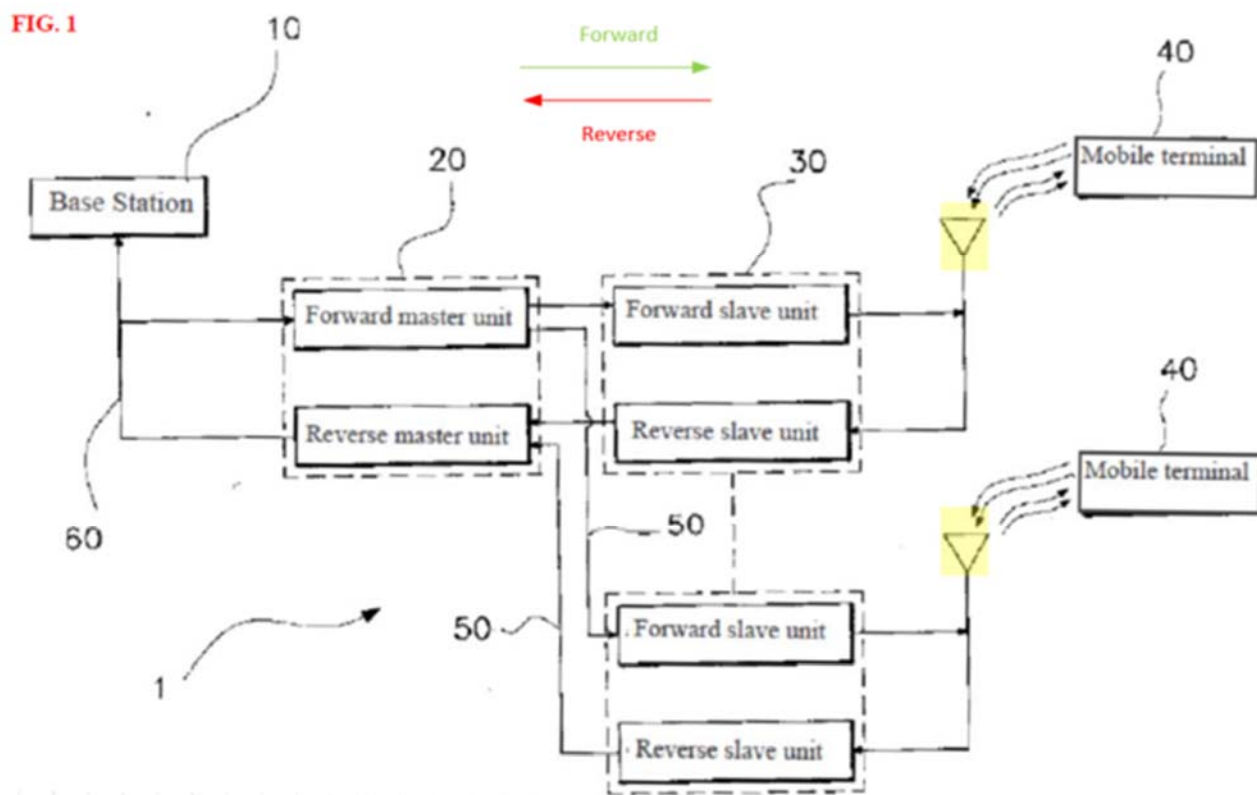


171. Thus Oh renders obvious converting the digitized radio frequency spectrum (digital sample data received from master unit 20 at 201) to analog radio frequency signals (converting from digital to analog signals, upconverting the analog

signals to their respective band frequencies, and combining to form analog radio frequency signals for transmission to mobile terminals 40).

g) Element 6: “transmitting the analog radio frequency signals via a main radio frequency antenna at each of the plurality of digital remote units.”

172. Oh discloses that the digital signals from the master unit 20 are converted to analog, upconverted to RF, and transmitted to the mobile terminals 40. Ex. 1007, 3:47-49. Fig. 1 of Oh depicts the main frequency antenna associated with each slave unit 30 for bidirectional communications with the mobile terminals 40.

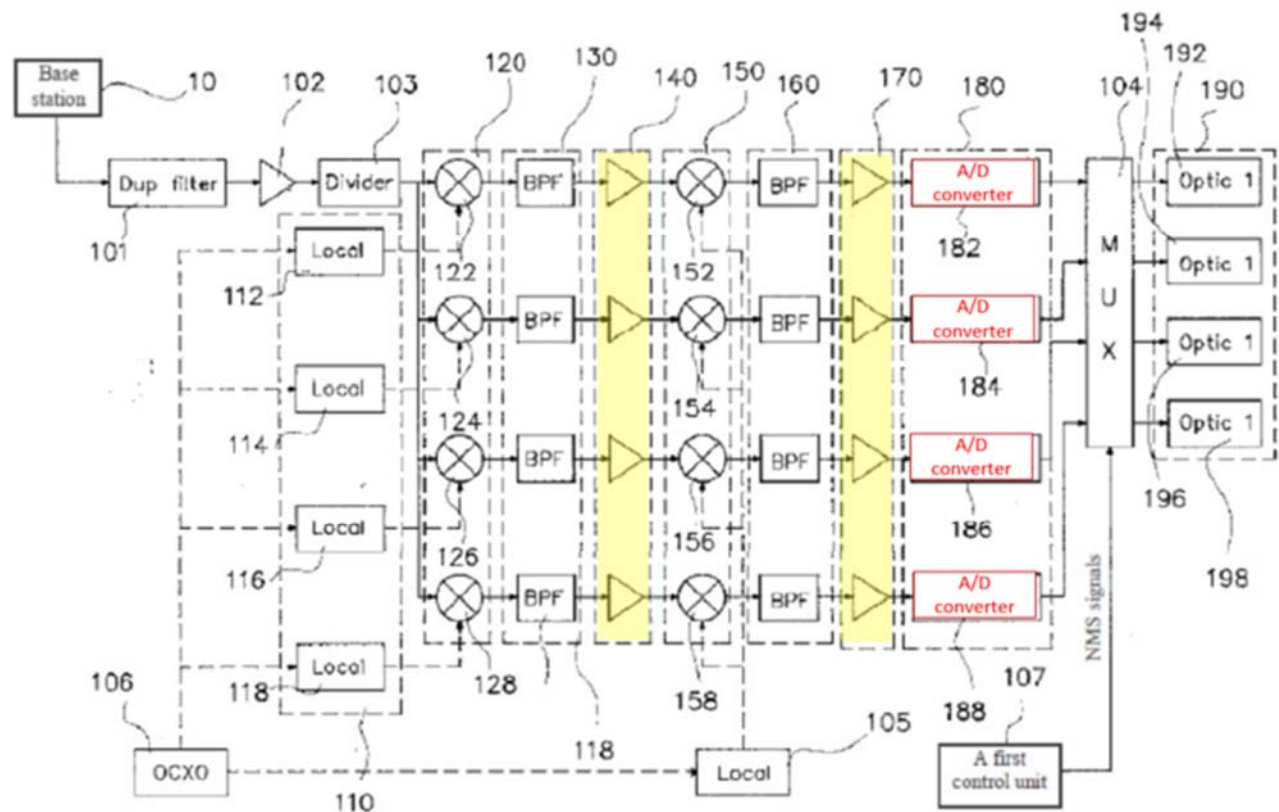


173. Thus Oh renders obvious transmitting the analog radio frequency signals (signals from combiner 290) via a main radio frequency antenna at each of the plurality of digital remote units (slave units 30).

15. Dependent Claim 29

174. Claim 29 recites that “converting the radio frequency signals to a digitized radio frequency spectrum comprises amplifying the radio frequency signals.” In Oh, prior to digitizing the analog radio frequency signals at 180, those signals are passed through amplification units 140 and 170.

FIG. 2

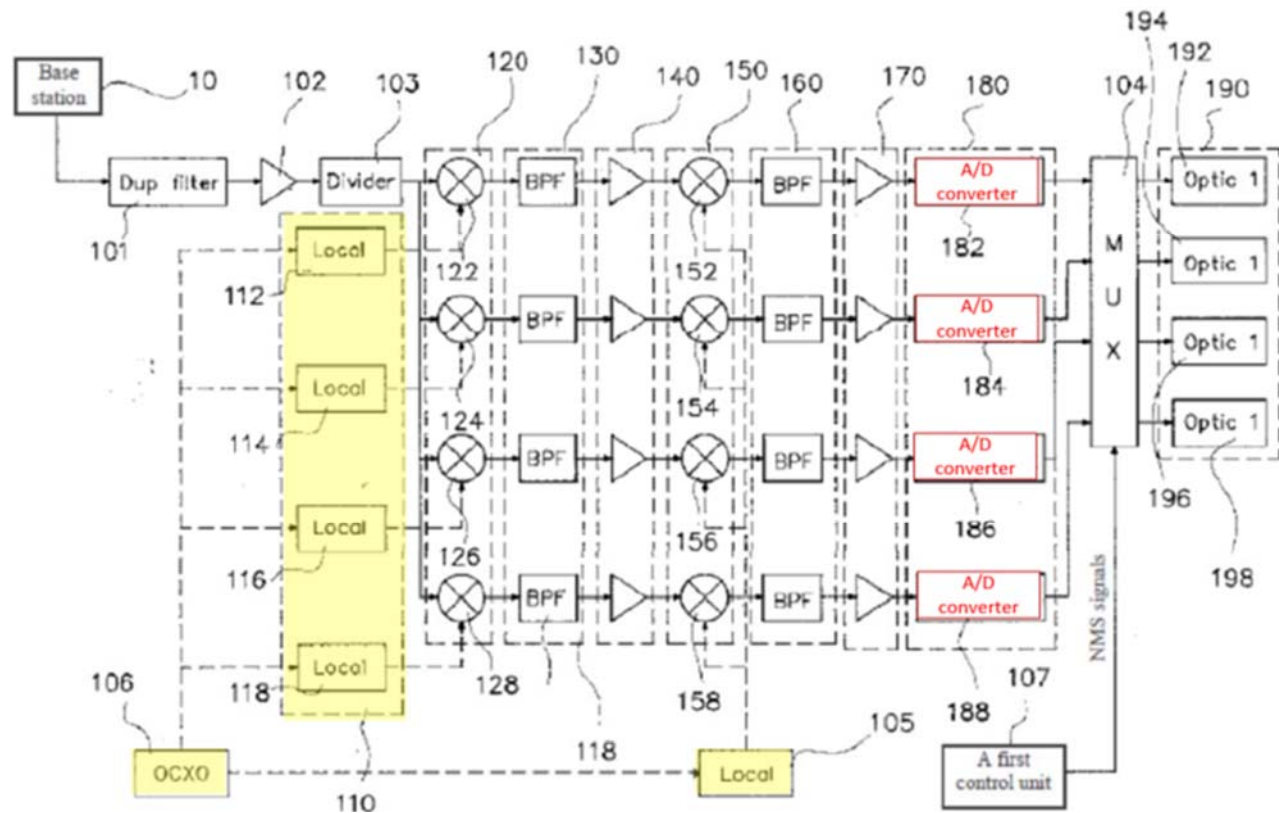


175. Thus Oh renders obvious converting the radio frequency signals to a digitized radio frequency spectrum comprises amplifying the radio frequency signals (amplification at 140, 170 prior to conversion to digital at 180).

16. Dependent Claim 30

176. Claim 30 recites that “converting the radio frequency signals to a digitized radio frequency spectrum digital radio frequency signals comprises synchronizing a forward path local oscillator to a reference oscillator so as to reduce end-to-end frequency translation.” Oh discloses the process of downconverting the component band analog signals prior to digitization, mixing operations are performed at 120 and 150 to bring the band components close to DC. Ex. 1007, 3:6-14. Those mixing operations using signals from forward path oscillators 112, 114, 116, 118 from first local oscillator unit 110 and second local oscillator unit 105. The local oscillators are synchronized with the reference oven controlled crystal oscillator (OCXO). “Said first local unit 110 and second local unit 105 convert the oscillating frequencies transmitted from the oscillator 106 and transmits the oscillating frequency to each mixer of a first mixer unit 120 and a second mixer unit 150.” *Id.*, 3:45-46.

FIG. 2



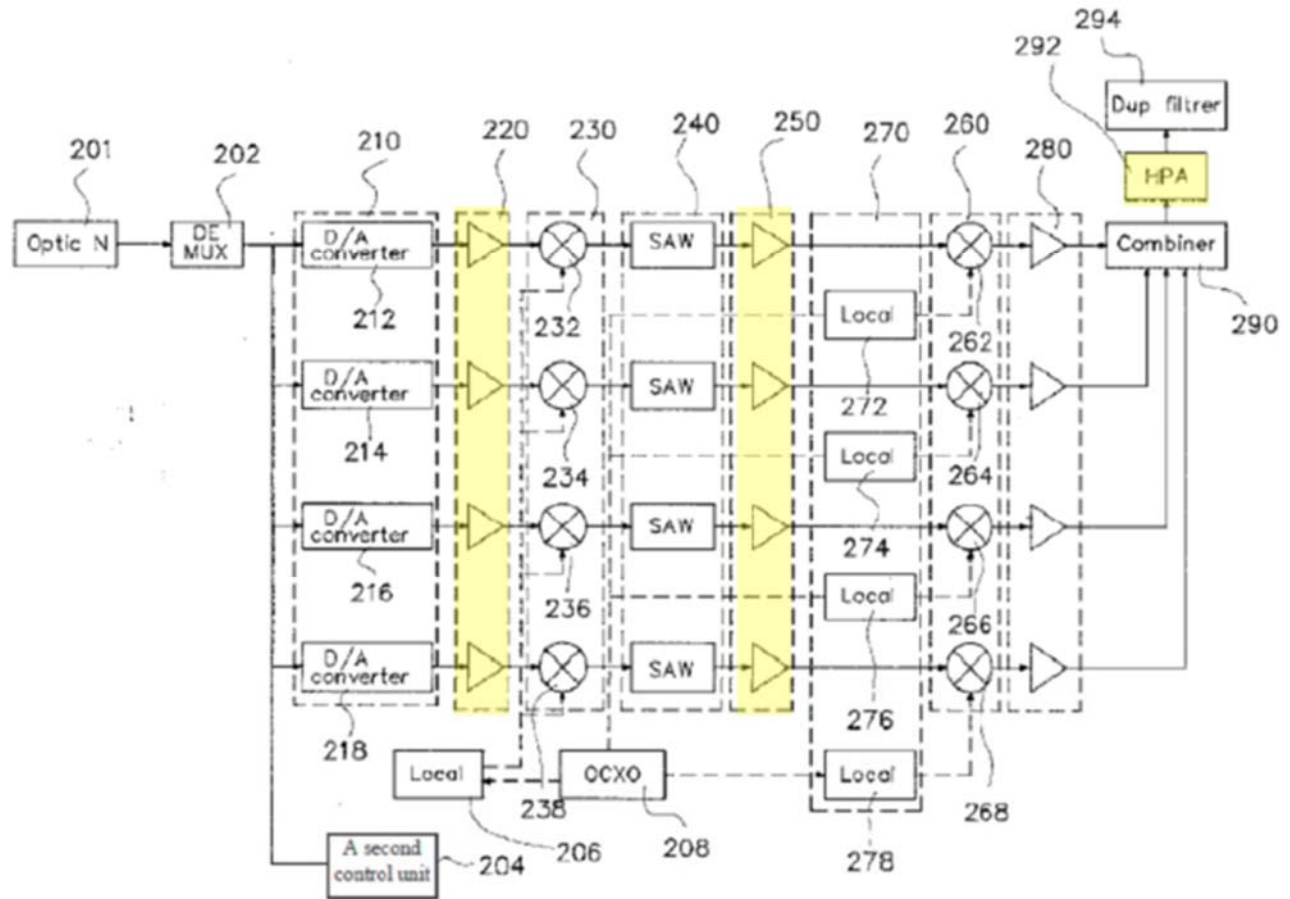
177. As noted above in addressing claim 27, the '982 patent states that frequency shifts are minimized when a common reference oscillator is used "as a master clock so that the down conversion of the RF signals is the same as the up conversion." Ex. 1001, 7:25-30. As noted above in addressing claim 9, a POSITA would have considered it obvious to implement Oh's master unit 20 using a single oven controlled reference oscillator for both forward and reverse frequency conversions. Thus using a single oven controlled reference oscillator for converting the radio frequency signals to a digitized radio frequency spectrum reduces end-to-end frequency translation.

178. Thus Oh renders obvious converting the radio frequency signals to a digitized radio frequency spectrum digital radio frequency signals (at 180) comprises synchronizing a forward path local oscillator (local oscillators 112, 114, 116, 118, 105) to a reference oscillator (106) so as to reduce end-to-end frequency translation.

17. Dependent Claim 31

179. Claim 31 recites that “converting the digitized radio frequency spectrum to analog radio frequency signals comprises amplifying the analog radio frequency signals.” In Oh, after converting the digital samples from the master unit 20 to analog at 210 and prior to transmitting the analog radio frequency signals to the mobile terminals 40, those signals are passed through amplification units 220 and 250 during their band component upconversion, and then the combined analog signal from 290 is further amplified by high power amplifier 292. Ex. 1007, 3:50-61.

FIG. 3

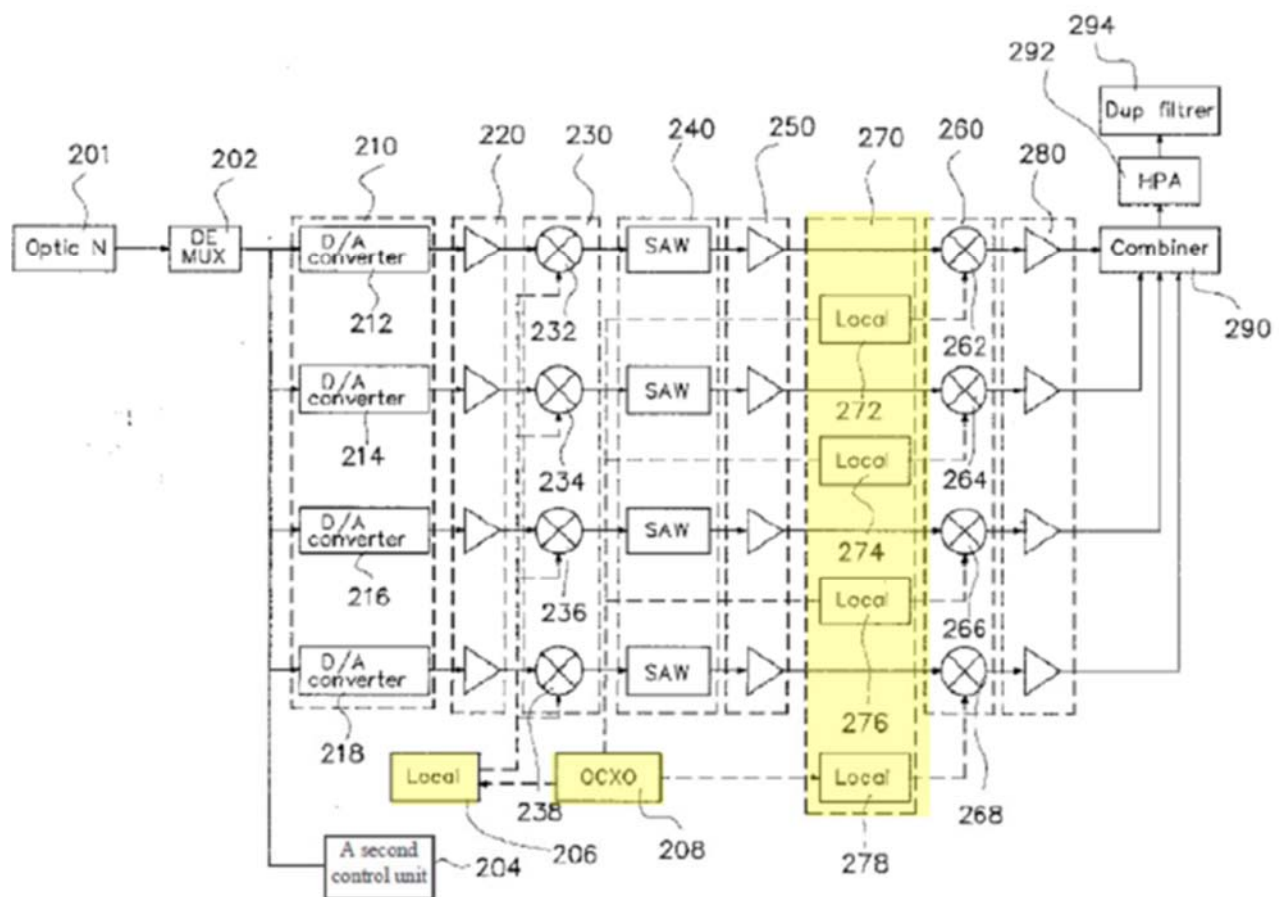


180. Thus Oh renders obvious converting the digitized radio frequency spectrum to analog radio frequency signals comprises amplifying the analog radio frequency signals (amplification at 220, 250, 292 prior to transmission to the mobile terminals 40).

18. Dependent Claim 32

181. Claim 32 recites that “converting the digitized radio frequency spectrum to analog radio frequency signals comprises synchronizing a forward path local oscillator to a reference oscillator so as to reduce end-to-end frequency translation.”

Oh discloses the process of upconverting the component band analog signals after conversion to analog at 210 and prior to transmission to the mobile terminals, mixing operations are performed at 230 and 260 to bring the band components to their appropriate band frequencies. Ex. 1007, 3:50-61. Those mixing operations use signals from forward path oscillators 206, 272, 274, 276, and 278. The local oscillators are synchronized with the reference oven controlled crystal oscillator (OCXO) 208. *Id.*, 3:69-4:5.



182. As noted above in addressing claim 27, the '982 patent states that frequency shifts are minimized when a common reference oscillator is used “as a master clock so that the down conversion of the RF signals is the same as the up conversion.” Ex. 1001, 7:25-30. As further noted above in addressing claim 27, a POSITA would have considered it obvious to implement Oh’s slave unit 30 using a single oven controlled reference oscillator for both forward and reverse frequency conversions.

183. Thus Oh renders obvious converting the digitized radio frequency spectrum to analog radio frequency signals comprises synchronizing a forward path local oscillator (local oscillators 206, 272, 274, 276, 278) to a reference oscillator (208) so as to reduce end-to-end frequency translation.

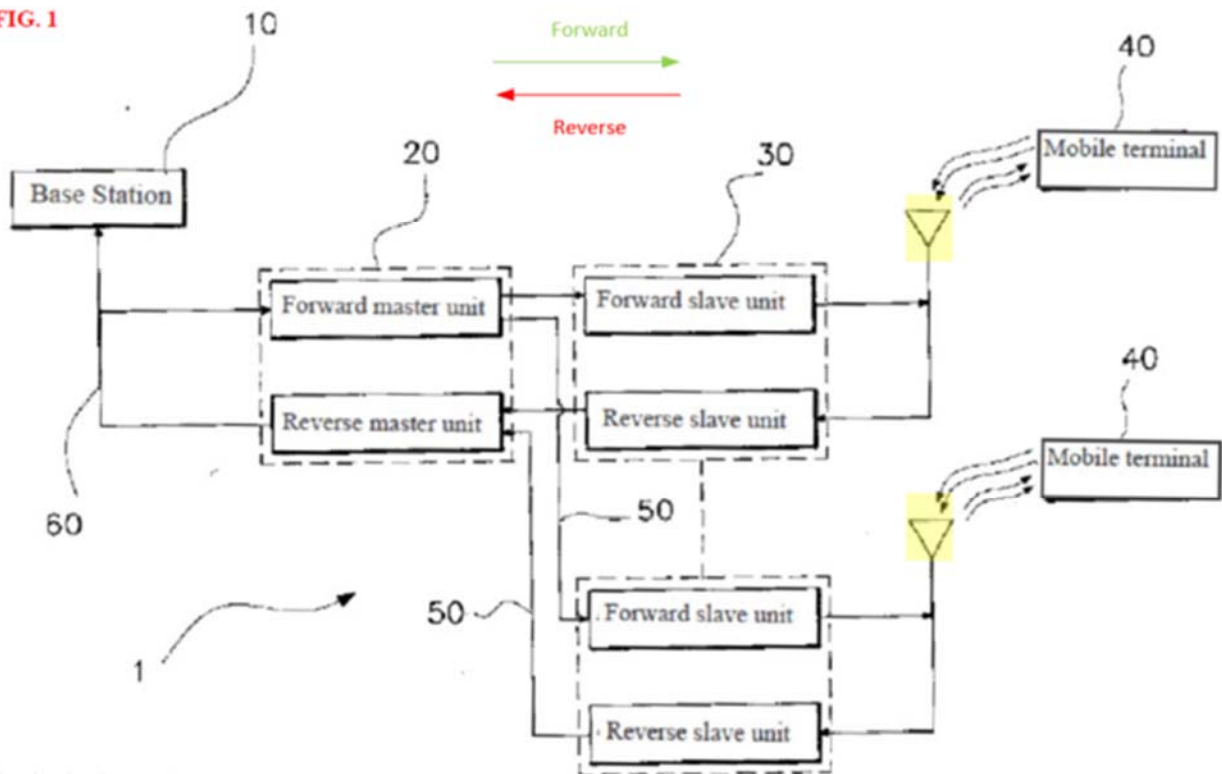
19. Independent Claim 34

184. The preamble of claim 34 is rendered obvious for the reasons discussed for the preamble to claim 1. Elements 1 and 2 are rendered obvious for the reasons of claim 1, elements 1 and 2, respectively. Element 3 is rendered obvious for the reasons of claim 5.

a) Element 4: “a duplexer coupled to the main radio frequency antenna which receives radio frequency signals in the reverse path and transmits radio frequency signals in the forward path;”

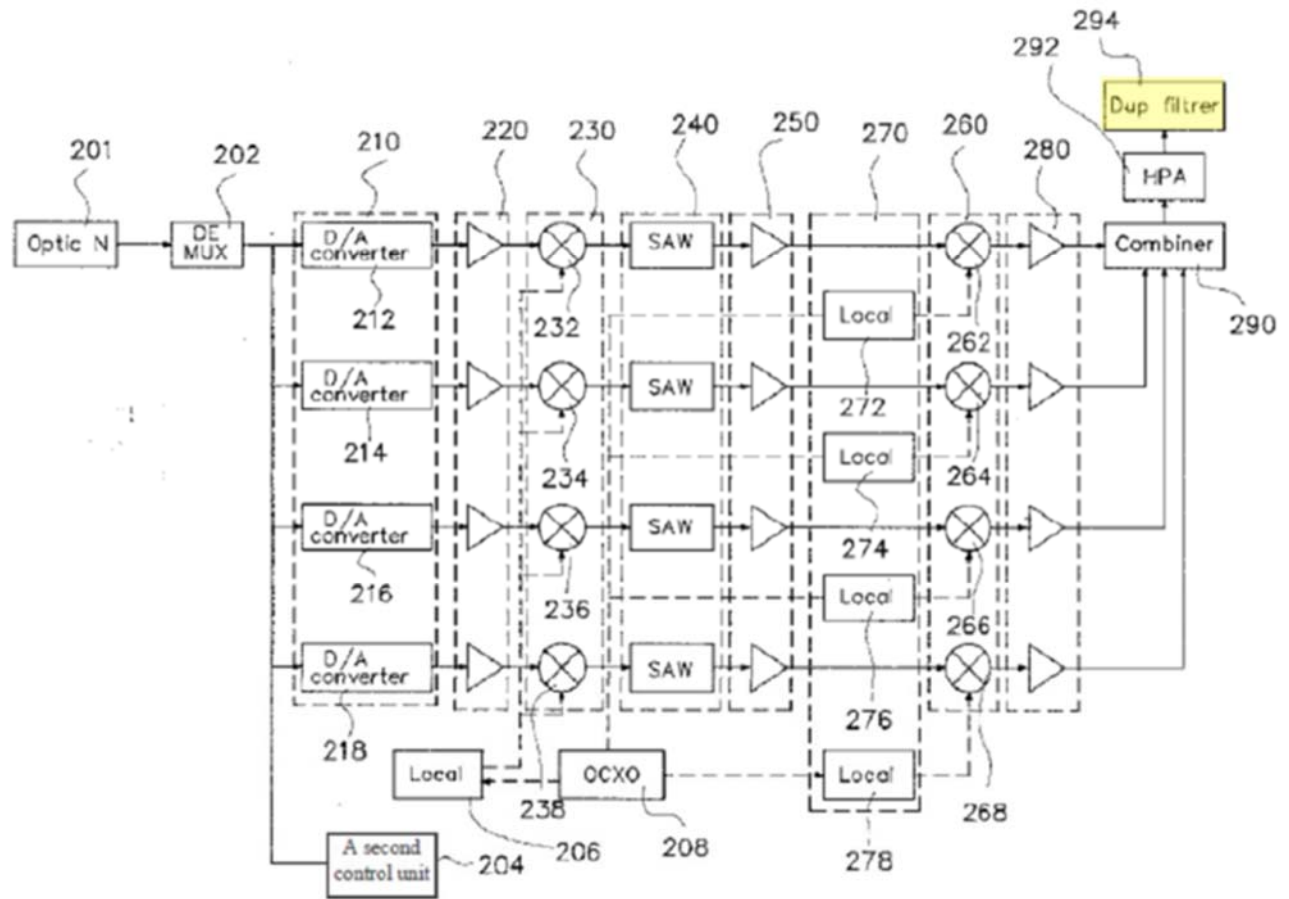
185. Oh’s remote slave units 30 include bi-directional filters, shown in the forward path of Fig. 3 at 294 and the reverse path of Fig. 4 at 301.

FIG. 1



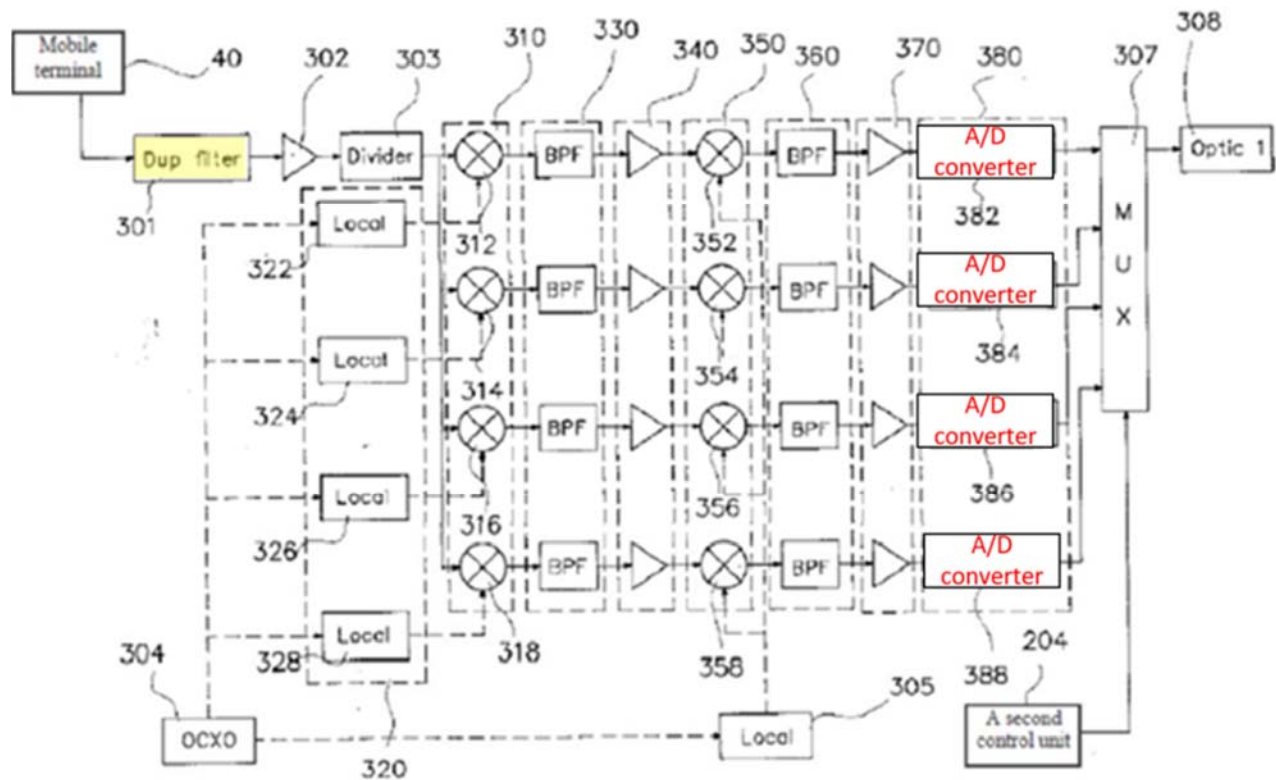
In the forward path, said “second combiner 290 combines the RF signals of different frequency bands transmitted from four mixers, respectively, comprising a sixth mixer unit 260, amplifies the strength and level at a second power amplifier 292, and transmits them to a mobile terminals 40 through a second bi-directional filter 294, allowing the mobile terminals 40 to receive the RF signals generated from the base station 10 through the optic repeater in a streamline manner.” Ex. 1007, 4:10-14.

FIG. 3



In the reverse path, slave unit 30 “converts the RF signals, analog signals, transmitted from the mobile terminals 40 through a third bi-directional filter 301, to the digital signals; and transmits them to the master unit 20.” *Id.*, 4:24-25.

FIG. 4



186. Thus Oh renders obvious a duplexer (duplex filter 294, 301) coupled to the main radio frequency antenna (shown in Fig. 1) which receives radio frequency signals in the reverse path and transmits radio frequency signals in the forward path (to mobile terminals 40).

b) Elements 5 and 6

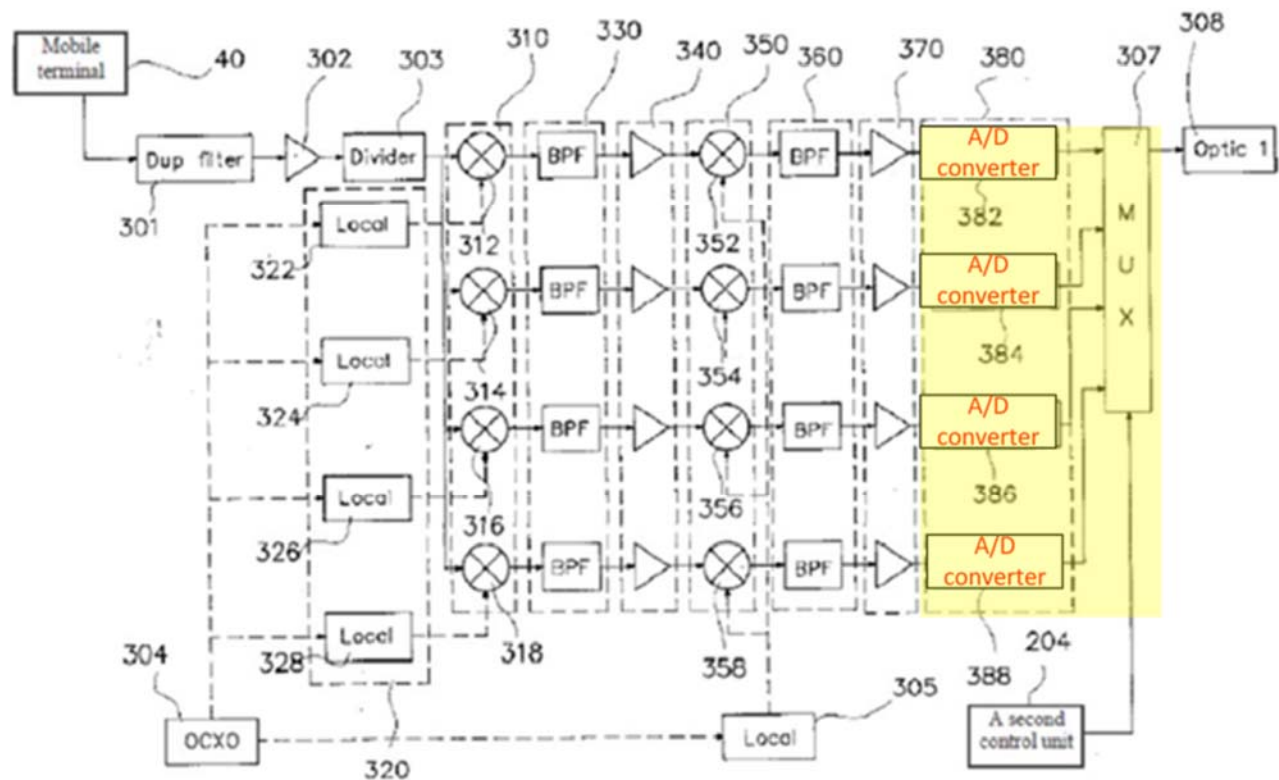
187. Regarding element 5, Oh discloses a radio frequency to digital converter coupled to the duplexer 294, 301 in the reverse path for the reasons represented above for claim 25, element 2. Regarding element 6, Oh discloses a digital to radio frequency converter coupled to the duplexer 294, 301 in the forward path for the reasons represented above for claim 28, element 5.

c) *Element 7: “a multiplexer chip set coupled to the radio frequency to digital converter in the reverse path and the digital to radio frequency converter in the forward path;”*

188. Oh’s slave units 30 each include multiplexer/demultiplexer components.

On the reverse path, A/D converters 380 are coupled to multiplexer 307 to organize the digital samples for transmission to master unit 20 for recreation of the analog signal received from the antenna. *Id.*, 4:36-39.

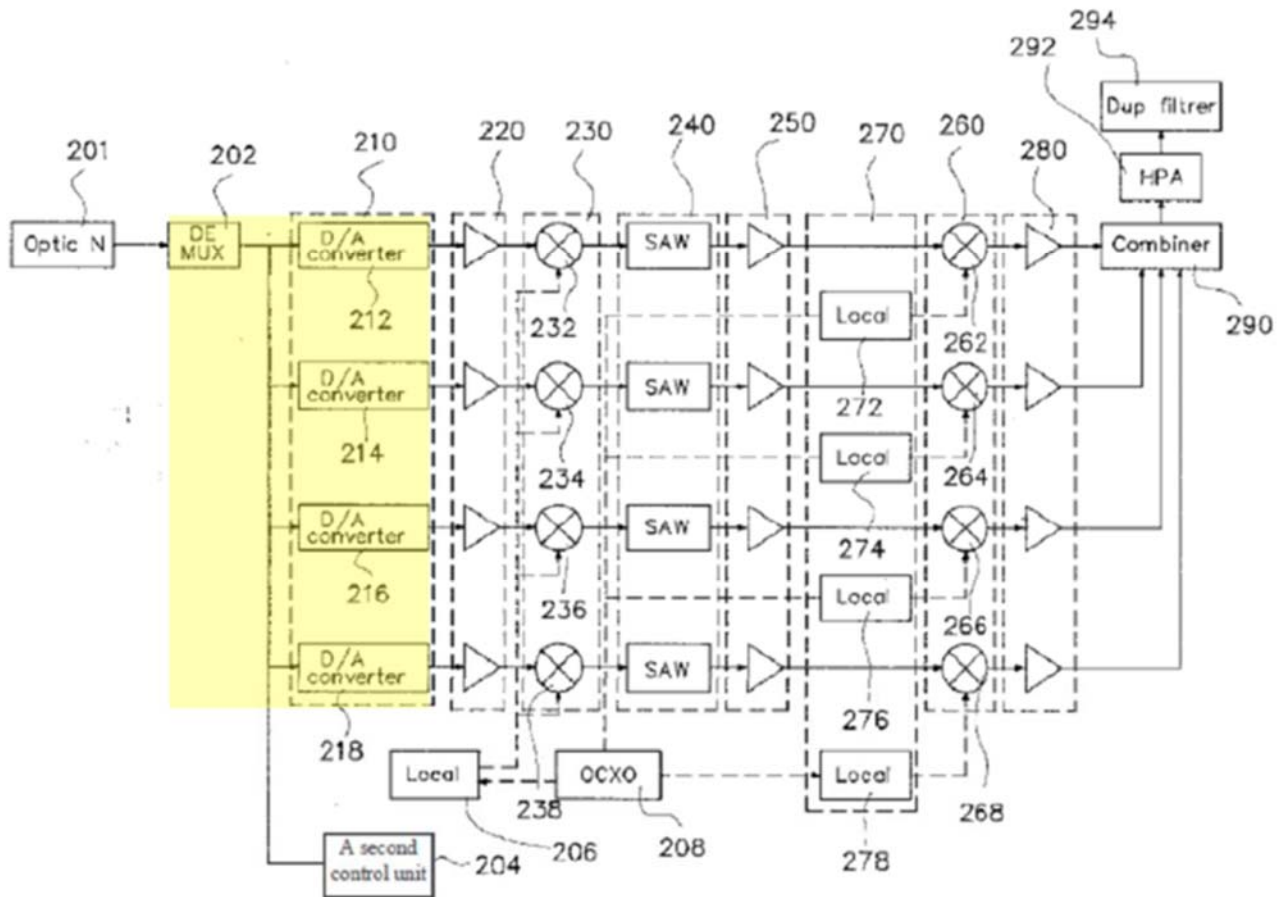
FIG. 4



189. On the forward path, demultiplexer 202 routes digital sample data from the master unit 20 to the D/A converter 210 of the corresponding row of components

for processing that frequency band of the analog signal to be transmitted to the mobile terminals 40. Ex. 1007, 3:50-53.

FIG. 3



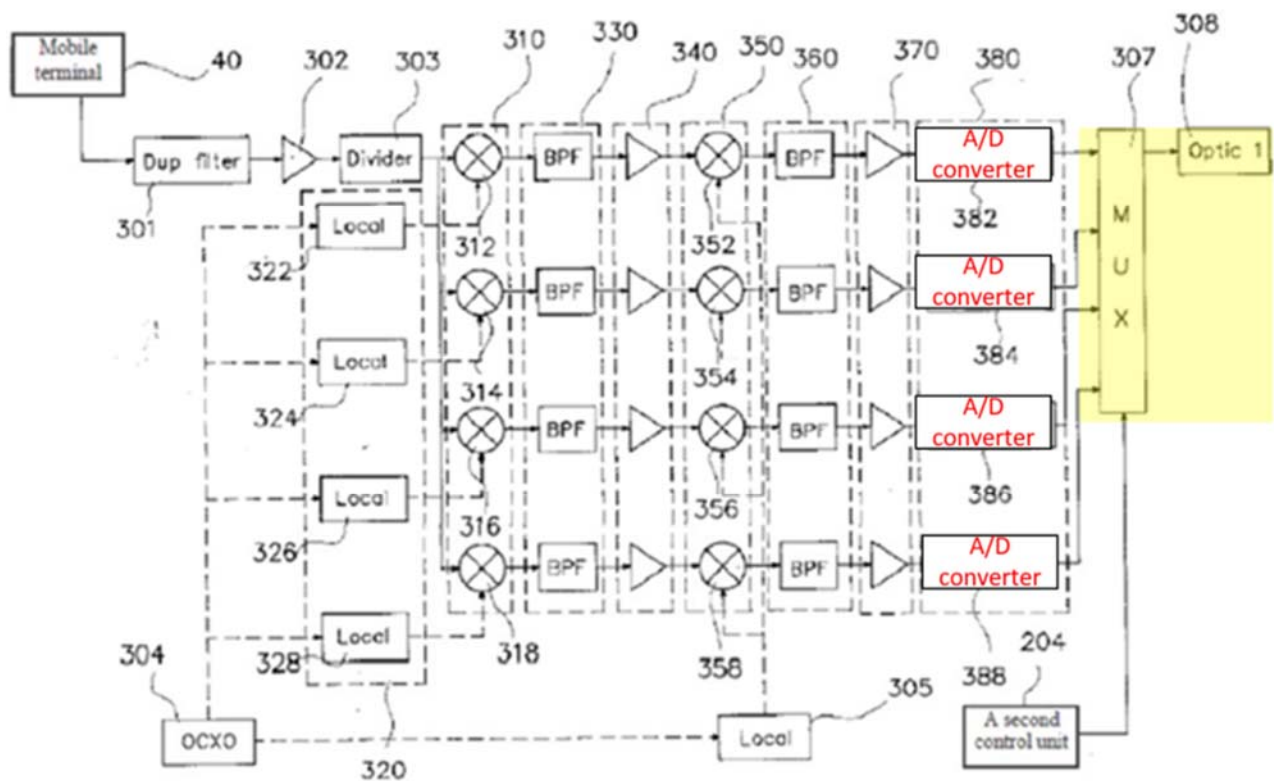
190. With multiplexer 307 and demultiplexer 210 being in the same slave unit 30, a POSITA would recognize 307 and 210 as multiplexer chip set. Multiplexer chip sets for use with optical-fiber networks were well known as of 2000 and a matter of design choice, as evidenced by Ex. 1011, "A 10-GHz 8-b multiplexer/demultiplexer chip set for the SONET STS-192 system," IEEE Dec. 1991.

191. Thus Oh renders obvious a multiplexer chip set (307, 210) coupled to the radio frequency to digital converter (380) in the reverse path and the digital to radio frequency converter (210) in the forward path.

d) Element 8: “an optical transmitter coupled to an output of the multiplexer chip set;”

192. On the reverse path, multiplexer 307 is coupled to optic converter unit 308.

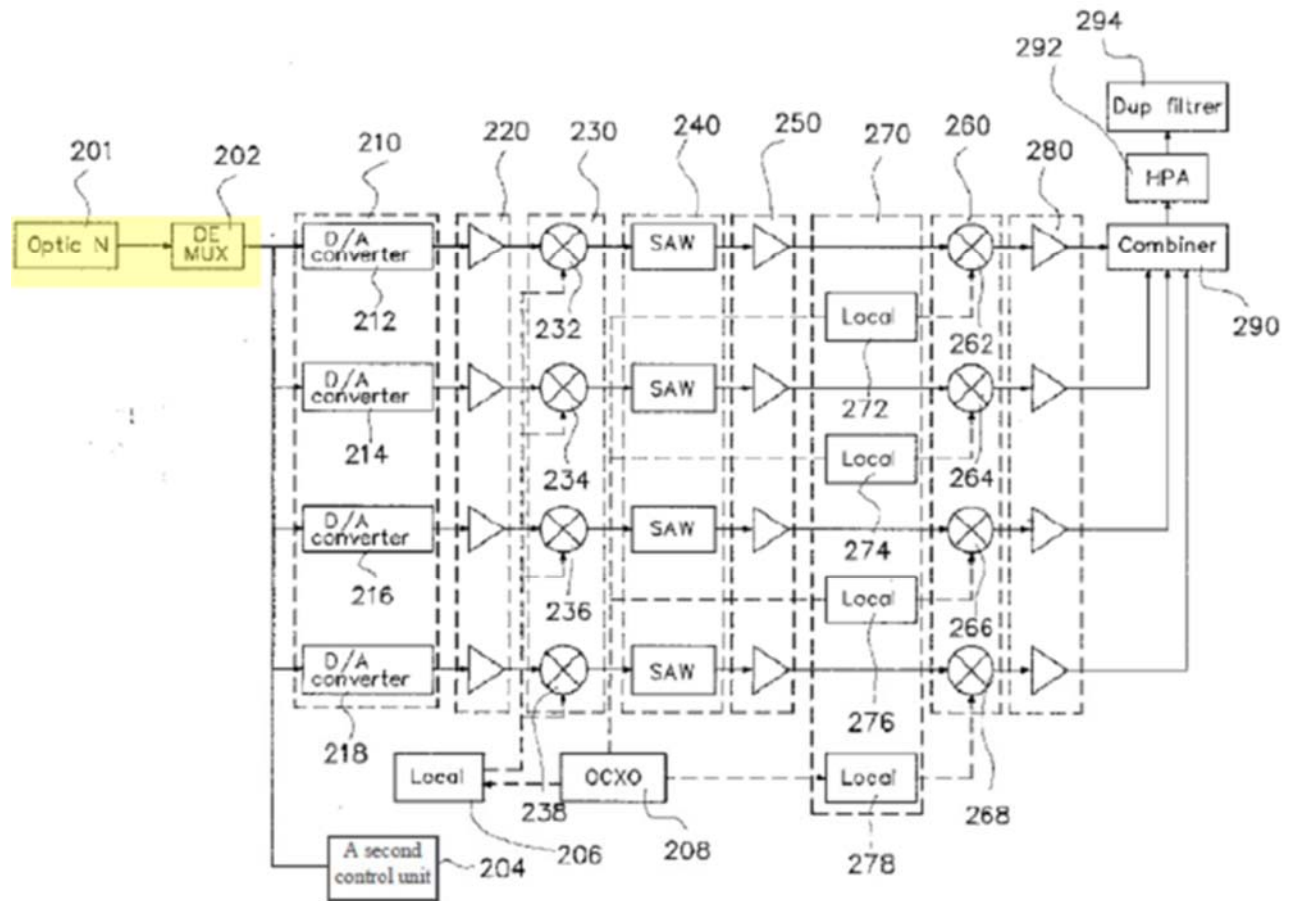
FIG. 4



e) Element 9: “an optical receiver coupled to an input of the multiplexer chip set;”

193. On the forward path, demultiplexer 202 is coupled to optical converter unit 201 that receives digital data from master unit 20 over optic line 50.

FIG. 3



f) Elements 10 and 11

194. Regarding element 10, Oh discloses the claimed shared circuitry for the reasons presented above for claim 1, element 2b. And for element 11, Oh discloses the claimed digital summing operation for the reasons presented for claim 1, element 3.

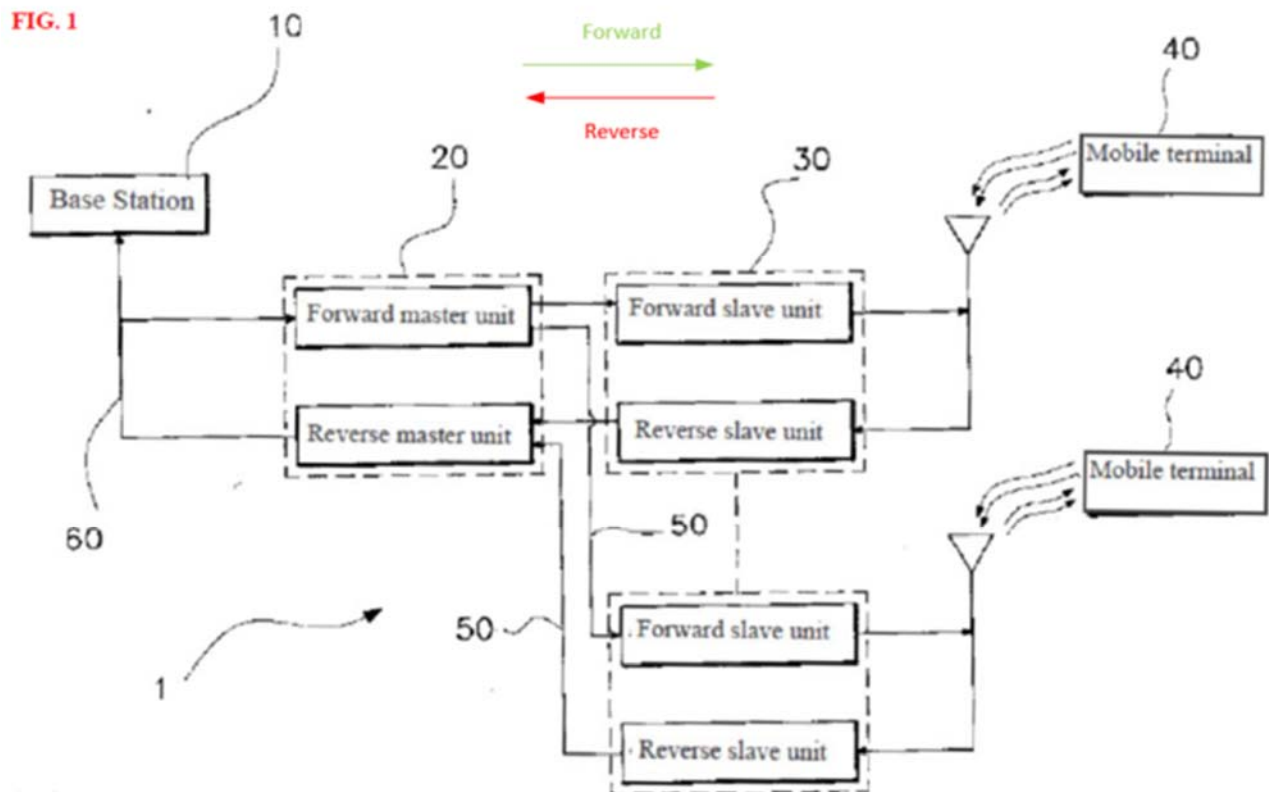
20. Dependent Claim 35

195. Claim 35 recites that “the digital host unit includes an alarm/control interface circuit.” Oh renders obvious that limitation for the reasons above for claim 8.

21. Independent Claim 37

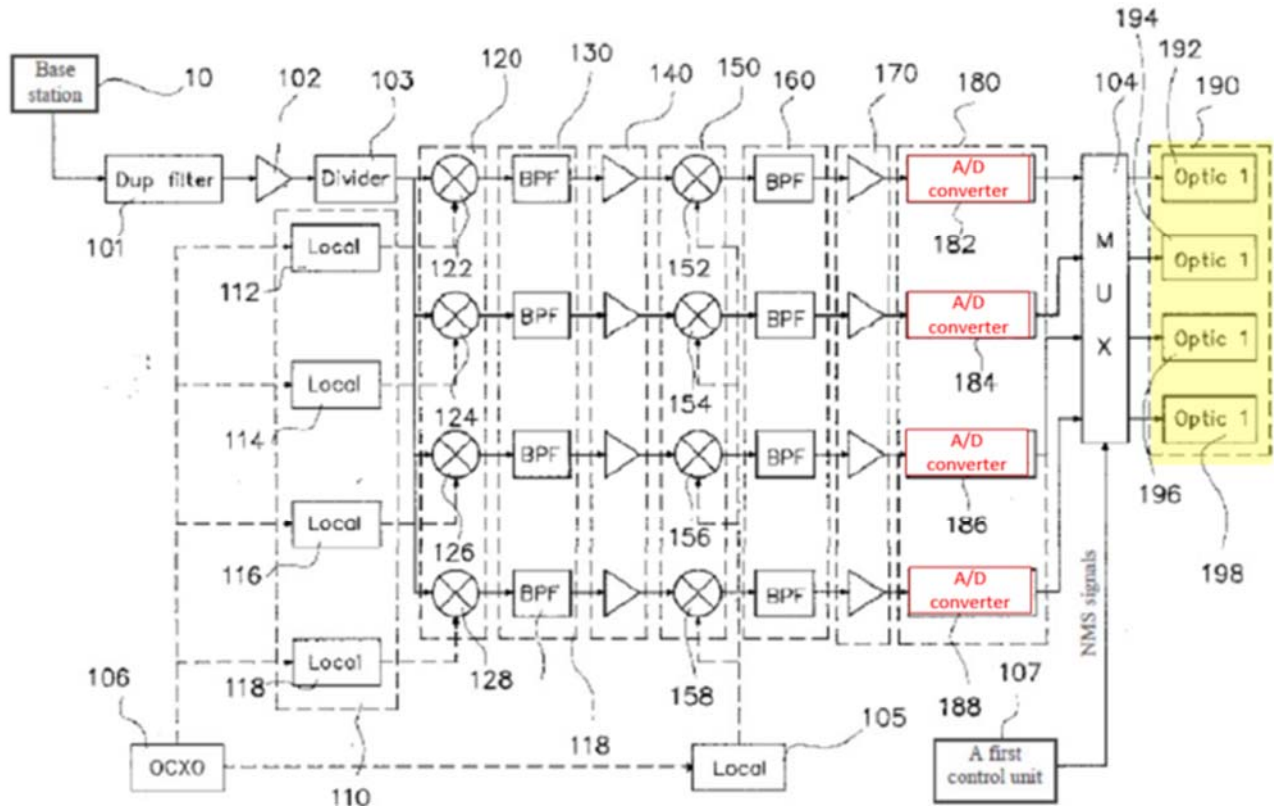
a) *Preamble and element 1: “A first unit comprising: an interface to communicatively couple the first unit to a plurality of second units using at least one communication medium, wherein the plurality of second units are located remotely from the first unit;”*

196. Oh discloses master unit 20 is coupled to multiple remote slave units 30 via optic lines 50.



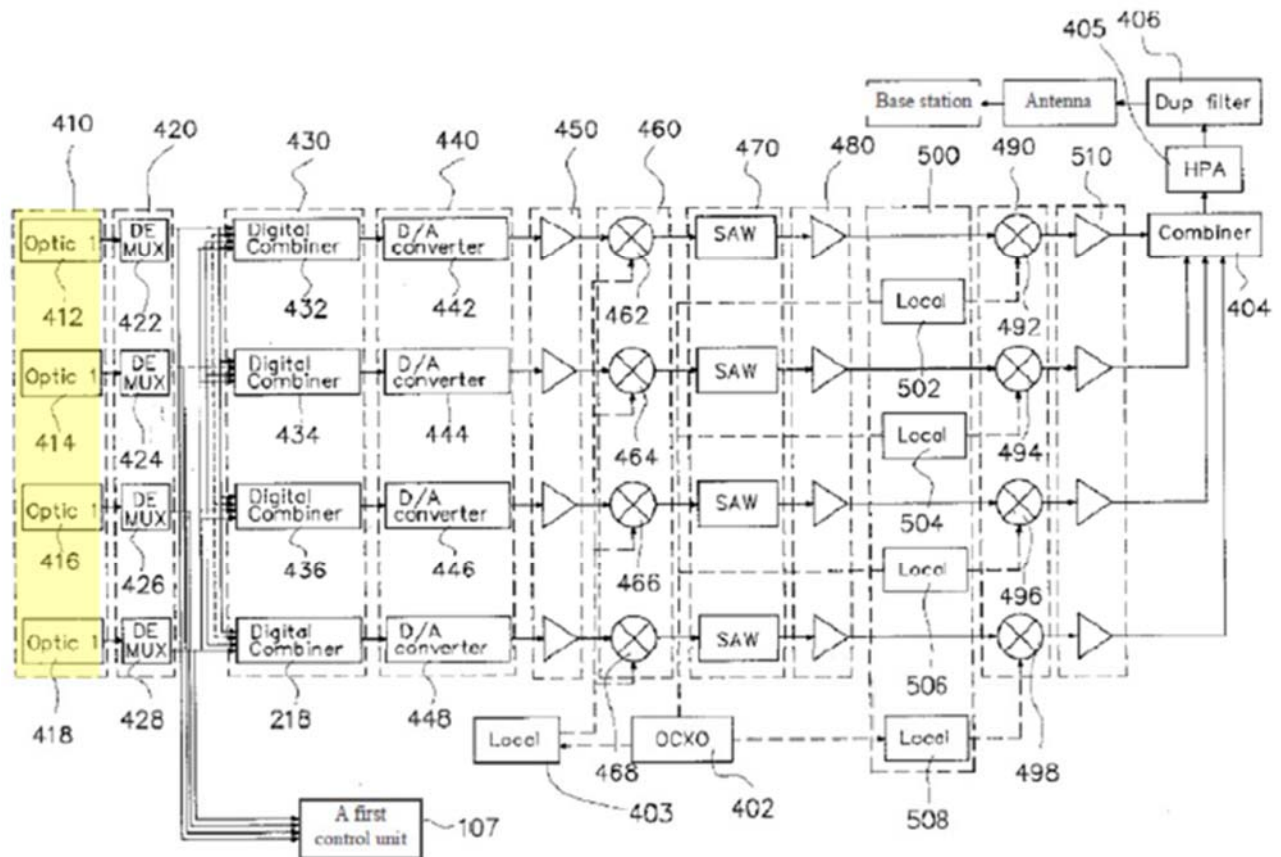
197. Fig. 2 of Oh depicts optic converter unit 190 that provides a downstream interface between master unit 20 and remote slave units 30.

FIG. 2



198. And Fig. 5 illustrates optic converter unit 410 that provides an upstream interface from slave units 30 to master unit 20.

FIG. 5



199. Thus Oh renders obvious a first unit (20) comprising: an interface (190, 410) to communicatively couple the first unit to a plurality of second units (30) using at least one communication medium, (50) wherein the plurality of second units are located remotely from the first unit.

b) Elements 2-4

200. Regarding element 2, Oh discloses the claimed analog-to-digital unit 180 for digitizing an analog signal from a base station 10 for the reasons provided for claim 28, element 2. Regarding element 3, Oh discloses the claimed D/A converter unit 440 for the reasons provided for claim 25, element 6. Regarding element 4, Oh discloses

the claimed digital summer 430 for the reasons provided above for claim 1, element 3.

c) Element 5: “wherein the upstream digital RF samples received from the plurality of second units have an associated resolution;”

201. Oh discloses that its A/D converters sample the downconverted analog signals at each frequency band at 12-bits of resolution. Ex. 1007, 3:38-39; 3:61-64; 4:16. On the reverse path at the master unit 20, digital combiner units 432, 434, 436, 438 “creat[e] 14-bit intermediate frequency signals by combining four 12-bit intermediate frequency signals in the same frequency band.” *Id.*, 5:16-17. Thus Oh renders obvious wherein the upstream digital RF samples received from the plurality of second units have an associated resolution (12-bit resolution).

d) Element 6: “wherein the digital summer has a resolution that is greater than the resolution associated with the digitized radio frequency signals being digitally summed;”

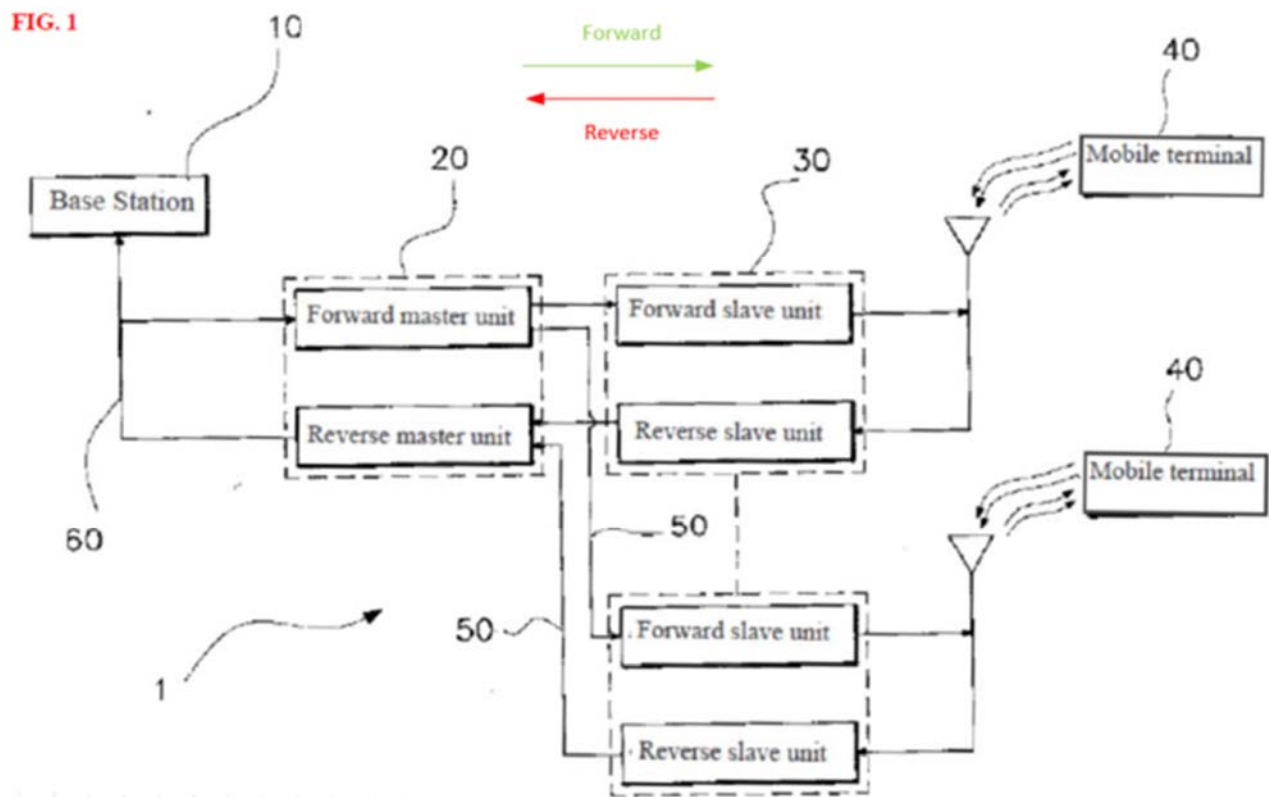
202. As noted above, on the reverse path at the master unit 20, digital combiner units 432, 434, 436, 438 “creat[e] 14-bit intermediate frequency signals by combining four 12-bit intermediate frequency signals in the same frequency band.” *Id.*, 5:16-17. Thus Oh renders obvious wherein the digital summer has a resolution (14 bits) that is greater than the resolution associated with the digitized radio frequency signals being digitally summed (12 bits).

e) Element 7

203. Regarding element 7, Oh discloses downstream transmission of digital samples for the reasons provided for claim 28, element 3.

22. Dependent Claim 38

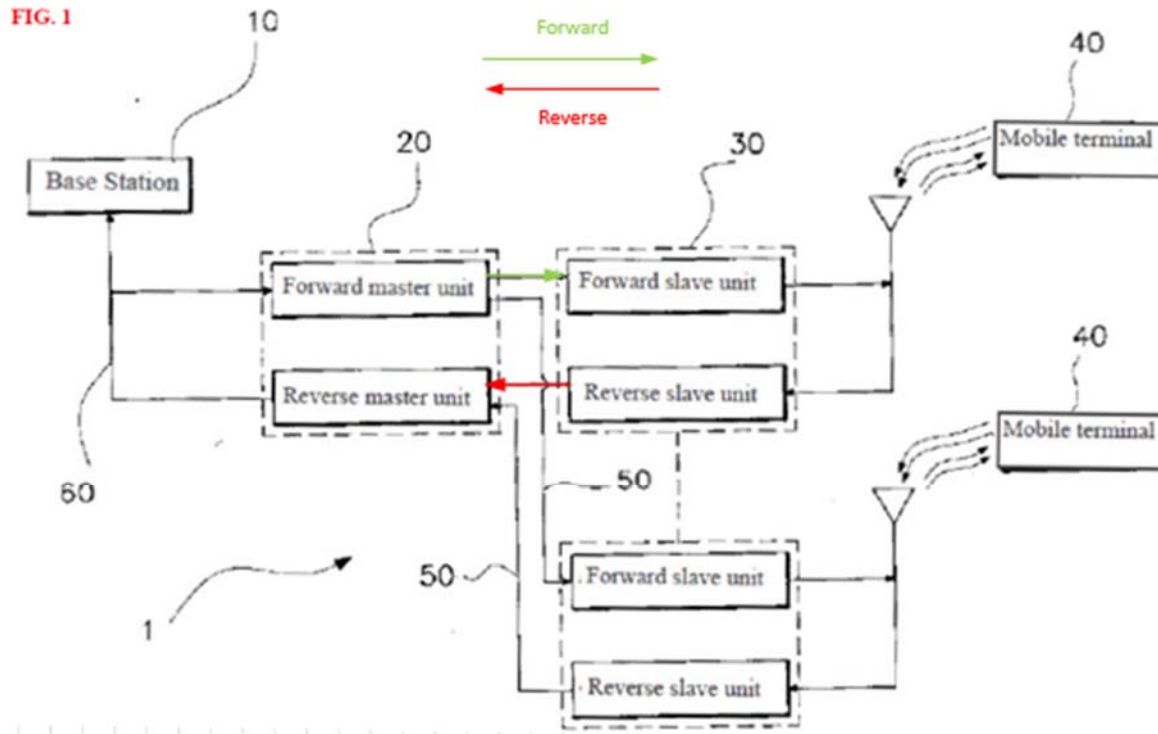
204. Claim 38 recites that “the communication medium comprises at least one of single mode optical fiber, multi-mode optical fiber, and coaxial cable.” Oh discloses that the master unit 20 communicates digital data to slave units 30 via optic lines 50. Ex. 1007, 3:4-6. Optic lines were known to be of two types, either single mode or multi-mode. Thus a POSITA would have considered it obvious to select one of the two possible choices to implement optic lines 50, where the claim encompasses both possible choices.



23. Dependent Claim 39

205. Claim 39 recites that “the interface is operable to communicatively couple the first unit to at least one second unit using a pair of optical fibers, wherein a first optical fiber included in the pair is used to communicate the at least a portion of the downstream digital RF samples to the at least one second unit and a second optical fiber included in the pair is used to receive respective upstream digital RF samples from the at least one second unit.”

206. Oh Fig. 1 illustrates master unit 20 communicating in the forward direction to a slave unit 30 using a first optic line 50, highlighted in green, and in the reverse direction from a slave unit using a second optic line 50 highlighted in red.



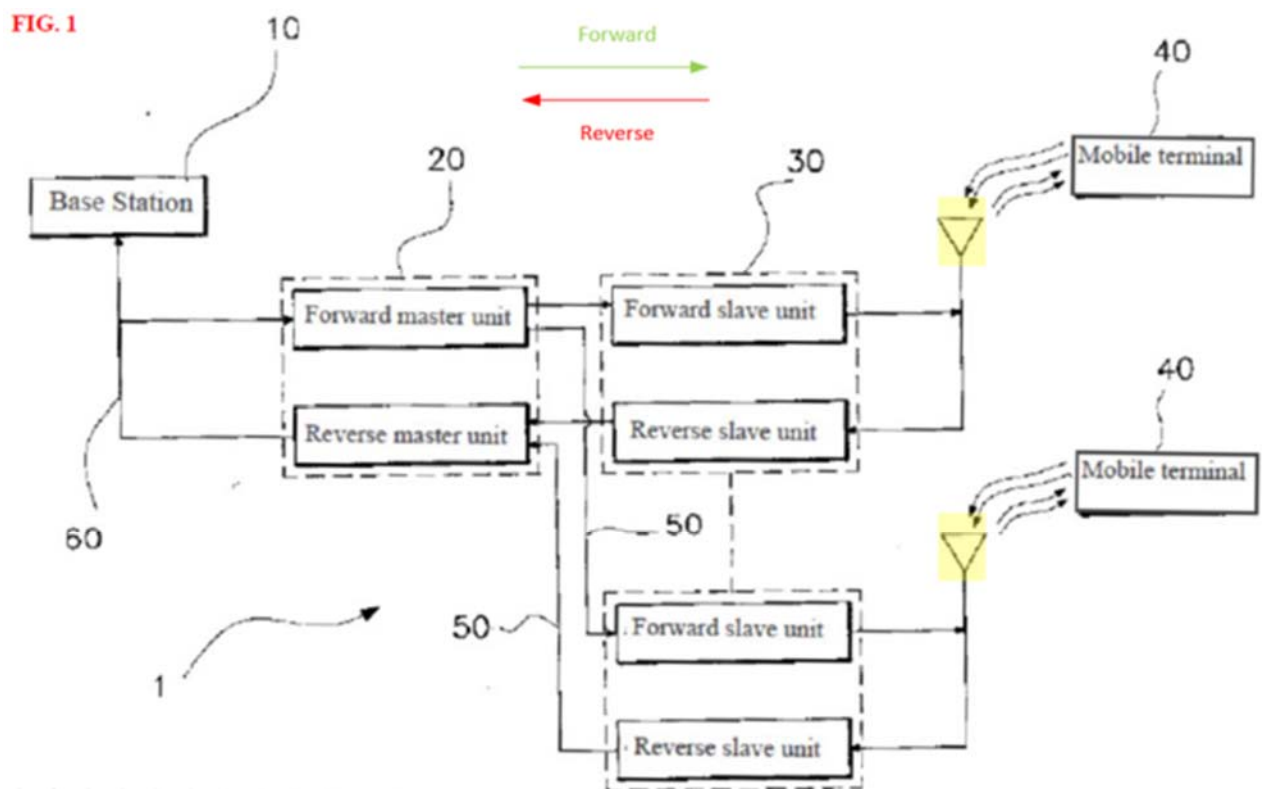
207. Thus Oh renders obvious the interface (Fig. 2, 190; Fig. 4 410) is operable to communicatively couple the first unit (20) to at least one second unit (30) using a pair of optical fibers, wherein a first optical fiber (50, green) included in the pair is used to communicate the at least a portion of the downstream digital RF samples to the at least one second unit and a second optical fiber (50, red) included in the pair is used to receive respective upstream digital RF samples from the at least one second unit.

24. Dependent Claim 40

208. Claim 40 recites that “the first unit comprises at least one of a digital host unit and a digital expansion unit.” Oh discloses a digital host unit for the reasons provided above for claim 1, element 1.

25. Dependent Claim 41

209. Claim 41 recites that “each of the plurality of second units comprises at least one of a remote antenna unit and a remote expansion unit.” Oh discloses multiple remote slave units 30, each slave unit 30 including an antenna for communicating with mobile terminals 40. Because each slave unit 30 includes an antenna that is remote from master unit 20, slave units 30 are “remote antenna units.”

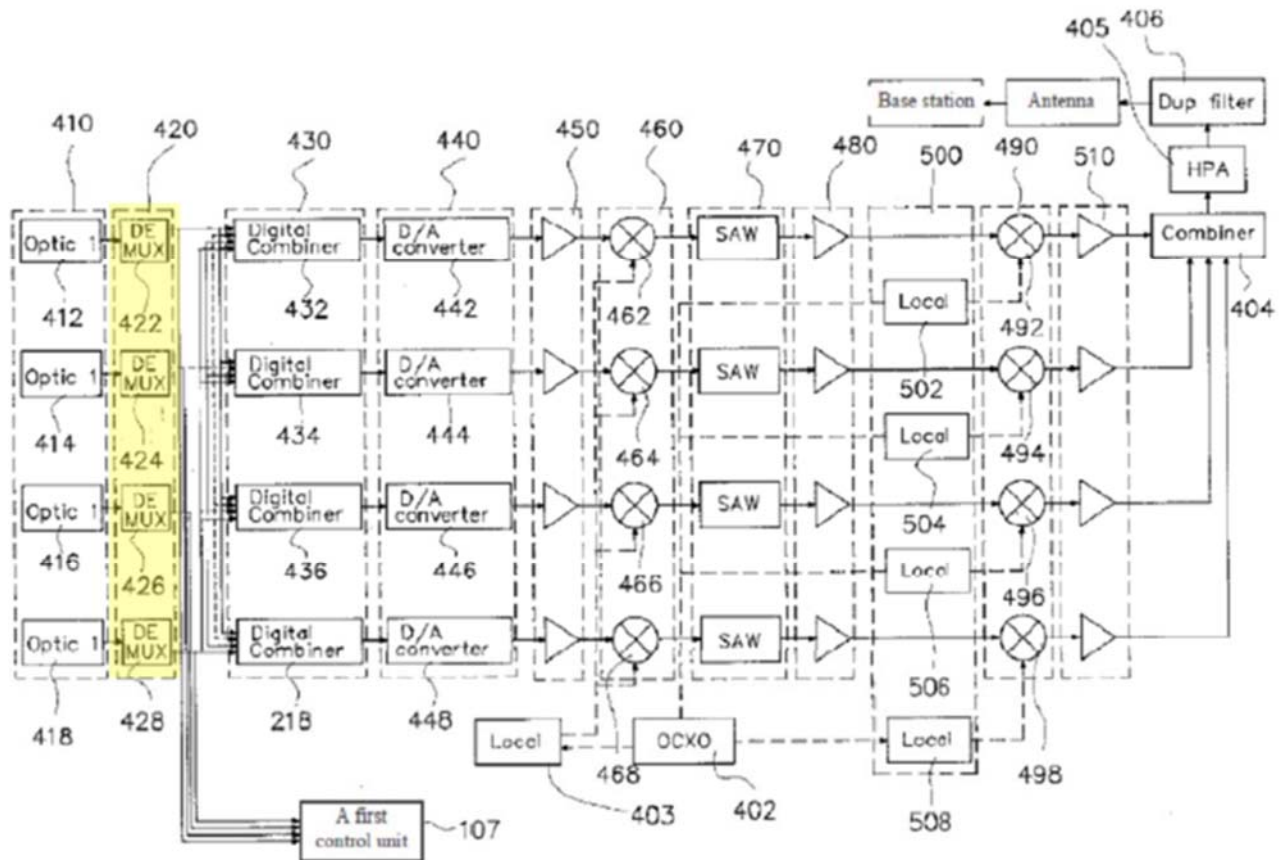


210. Thus Oh renders obvious each of the plurality of second units (30) comprises at least one of a remote antenna unit and a remote expansion unit (*i.e.*, a remote antenna unit).

26. Dependent Claim 42

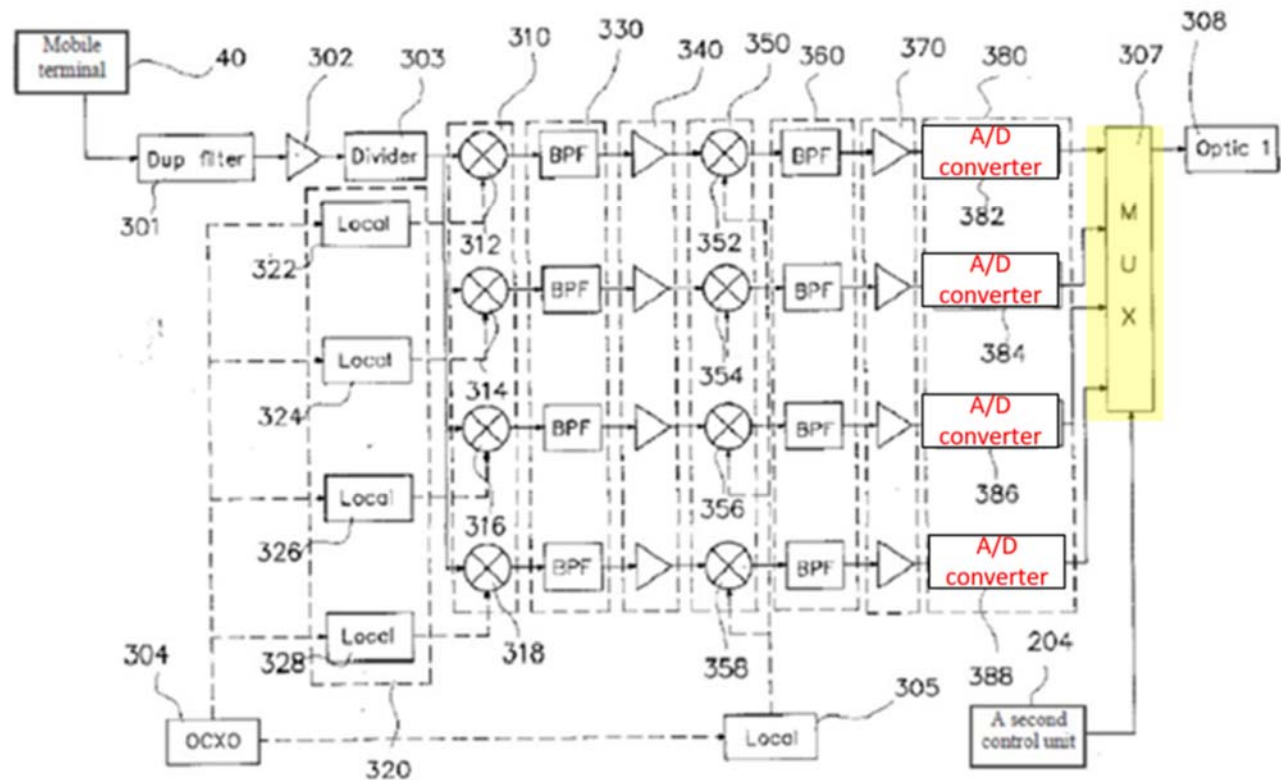
211. Claim 42 recites “a respective demultiplexer for each of the plurality of second units, wherein each of the demultiplexers extracts the first digital samples from a framed serial bit stream received from a respective one of the plurality of second units.” Fig. 5 of Oh discloses four demultiplexers 422, 424, 426, 428 at master unit 20, each one configured to handle data from a respective remote slave unit 30. Ex. 1007, 4:65-70.

FIG. 5



212. The serial data signals from slave units 30 are multiplexed by multiplexer 307. Multiplexer 307 multiplexes four 12-bit digital samples, one for each frequency band, and 4-bit control data from 204 into 52-bit word frames. *Id.*, 4:56-59.

FIG. 4



213. Demultiplexers 422, 424, 426, 428 of Fig. 5 then unpack those frames, each sending one 12-bit sample to each of the digital combiners associated with one frequency band each, and the 4 bits of control data to control unit 107.

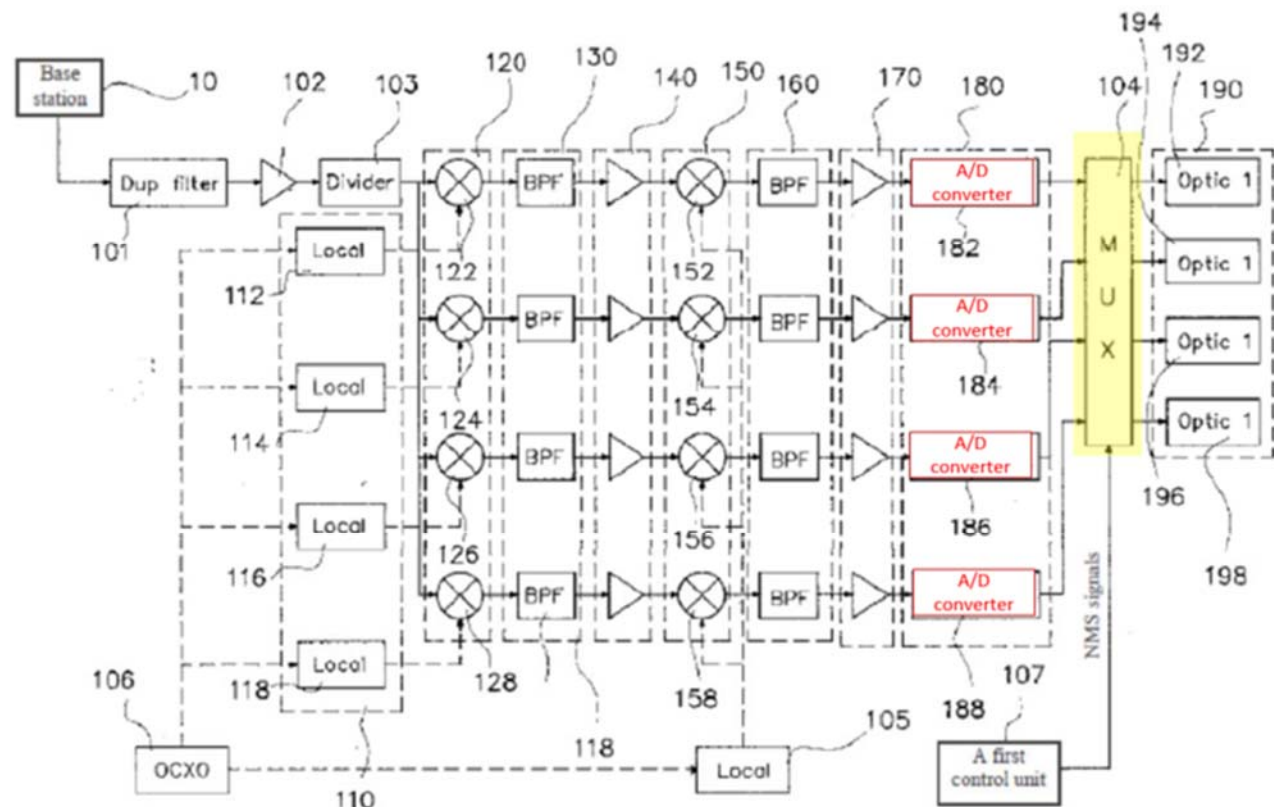
214. Thus Oh renders obvious a respective demultiplexer (422, 424, 426, 428) for each of the plurality of second units (slave units 30), wherein each of the demultiplexers extracts the first digital samples (12-bit data samples) from a framed

serial bit stream (52-bit word frames) received from a respective one of the plurality of second units.

27. Dependent Claim 43

215. Claim 43 recites “a multiplexer to produce a framed serial bit stream from the second digital samples, wherein the framed serial bit stream is communicated to the plurality of second units.” Frames of data from master unit 20 are multiplexed by multiplexer 104 prior to transmission to multiple remote slave units 30 over optic lines 50. Multiplexer 104 multiplexes four 12-bit digital samples, one for each frequency band, and 4-bit control data from 107 into 52-bit word frames. *Id.*, 3:38-44.

FIG. 2



216. Thus Oh renders obvious a multiplexer (104) to produce a framed serial bit stream (52-bit word frames) from the second digital samples (12-bit samples taken at 180), wherein the framed serial bit stream is communicated to the plurality of second units (30).

28. Dependent Claim 44

217. Claim 44 recites “a clock recovery circuit.” A POSITA would understand optic receiver 410 to include a phase locked loop or other mechanism for extracting timing data so that the data can be accurately received. Wherever a serial communication channel does not transmit a clock signal along with the data stream the clock must be regenerated at the receiver using a clock recovery circuit. The clock recovery circuit uses timing information extracted from the data stream. In high data rate systems, the receiver typically generates a clock from an approximate frequency reference and then phase-aligns its clock to transitions in the data stream with a phase locked loop.

218. To the extent that a clock recovery circuit is not determined to be obvious to a POSITA, it is obvious based on Oh in view of Bodeep. Ex. 1014. Bodeep discloses a clock recovery circuit 346 at the end of an optical link 420 that is used by a receive detector 352 to receive data. Ex. 1014, Fig. 3, 4:31-5:10. A POSITA would be motivated to incorporate a clock recovery circuit 346 at an Oh entity that receives data across an optic line 50 because such a clock recovery circuit 346 would allow

received high speed data to be extracted without a need for clock signal data to be transmitted across the optic line 50, simplifying transmission and reducing power consumption.

29. Independent Claim 45

219. Oh renders obvious the elements of claim 45 for the reasons presented above as follows:

<u>Element</u>	<u>Analogous Element Addressed Above</u>
Preamble, 1, 2	Claim 1, Preamble, Element 1, Elements 2a, 2b
3-6	Claim 37, Elements 1-4
7	Claim 28, Element 3
8	Upstream digitization and transmission to host: Claim 25, Elements 2-3 Resolution: Claim 37, Element 5
9	Claim 28, Element 5
10	Claim 37, Element 6

30. Dependent Claims 46-50

220. Oh renders claim 46-49 obvious for the reasons provided above for claims 40-44.

31. Independent Claim 51

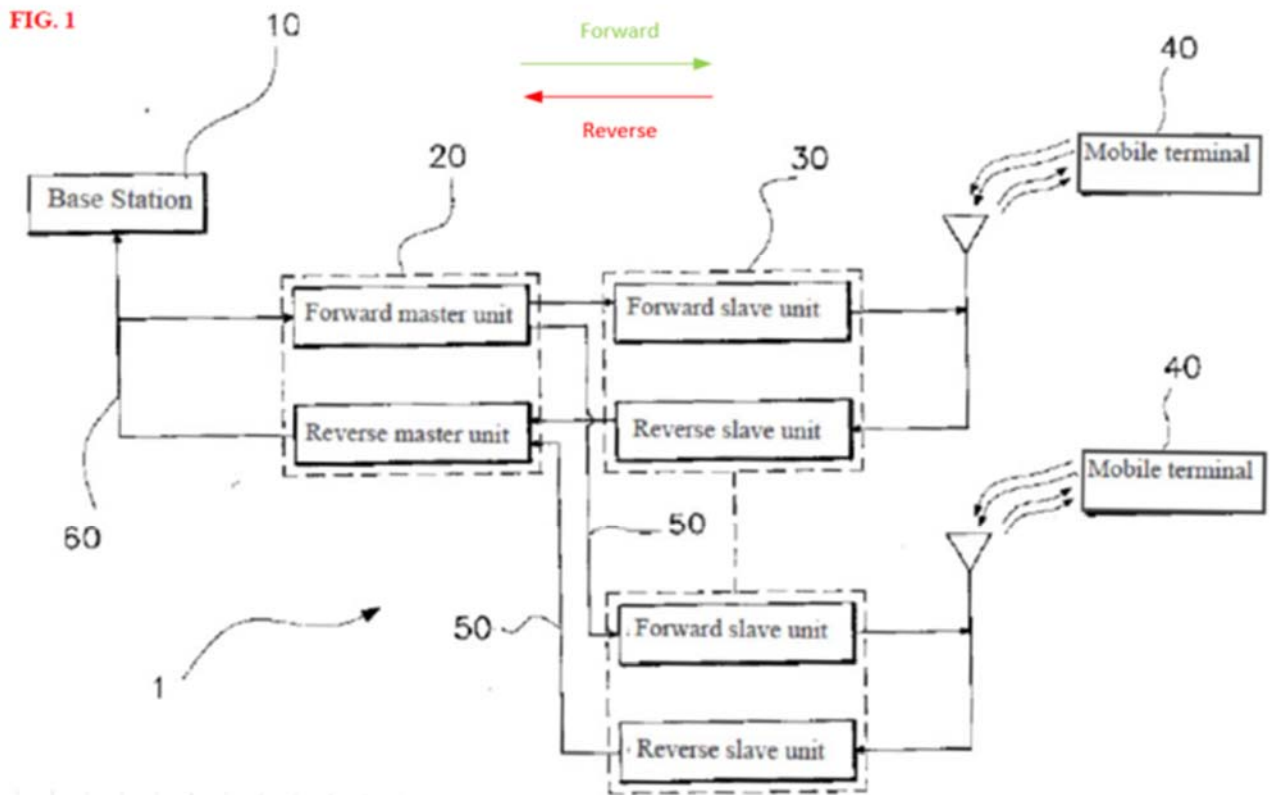
221. Regarding the preamble and elements 1 and 2 of claim 51, Oh discloses digitizing a downstream RF radio signal at a host unit and communicating digital data representative thereof to multiple remote units for the reasons provided above for claim 28, elements 2 and 3. The claimed digital summing operation of element 4 is rendered obvious by Oh for the reasons provided for claim 1, element 3. The resolution of the received digital samples (12-bits in Oh) from remote units and resolution of the summing (14-bits in Oh) recited in elements 3 and 4 of claim 51 are rendered obvious for the reasons provided above for claim 37, elements 5 and 6. Element 5 of claim 51 is rendered obvious for the reasons provided above for claim 25, element 6.

32. Independent Claim 81

a) Preamble and Element 1: “A first unit comprising: means for communicatively coupling the first unit to a plurality of second units;”

222. The recited means for communicatively coupling is properly construed as having a function of “communicatively coupling the first unit to a plurality of second units” and corresponding structure of Optical Transmission Lines 414, 416 shown in Fig. 4 of the '982 patent.

223. Oh discloses optic lines 50 that communicatively couple master unit 20 to slave units 30.



224. Thus Oh renders obvious A first unit (master unit 20) comprising: means (optic lines 50) for communicatively coupling the first unit to a plurality of second units (30) by providing components that provide the same function, in the same way, with the same result as Optical Transmission Lines 414, 416 of the '982 patent.

b) Element 2: “means for digitizing an original downstream analog radio frequency signal in order to produce downstream digital RF samples;”

225. The recited means for digitizing is properly construed as having a function of “digitizing an original downstream analog radio frequency signal in order to produce downstream digital RF samples” and corresponding structure of Amplifier

450, Mixer 452, Amplifier/Filter 454, 456, 458, Mixer 460, A/D Converter 464 shown in Fig. 4 of the '982 patent.

226. Oh discloses processing of a predetermined number of frequency bands as described at 3:9-11. Oh's examples depict parallel processing of four frequency bands in each of Figs. 2-5 but contemplate more or fewer rows of processing. In the nominal case where an Oh configuration is used to digitize and relay a single frequency band, each of Figs. 2-5 would include a single row of processing (*e.g.*, 120, 130, 140, 150, 160, 170, 180 of Fig. 2).

227. Oh discloses components for digitizing an original downstream analog radio frequency in order to produce downstream digital RF samples in Fig. 2 that provide the same function, in the same way, to provide the same result as the corresponding structure of the '982 patent when Oh is processing a single frequency band as follows:

<u>'982 Structure</u>	<u>Corresponding Oh Structure</u>
Amplifier 450	Amplifier 102
Mixer 452	First Mixer 122
Amplifier/Filter 454, 456, 458	Amplifier 140/Filter 130
Mixer 460	Mixer 152
A/D Converter 464	A/D Converter 182

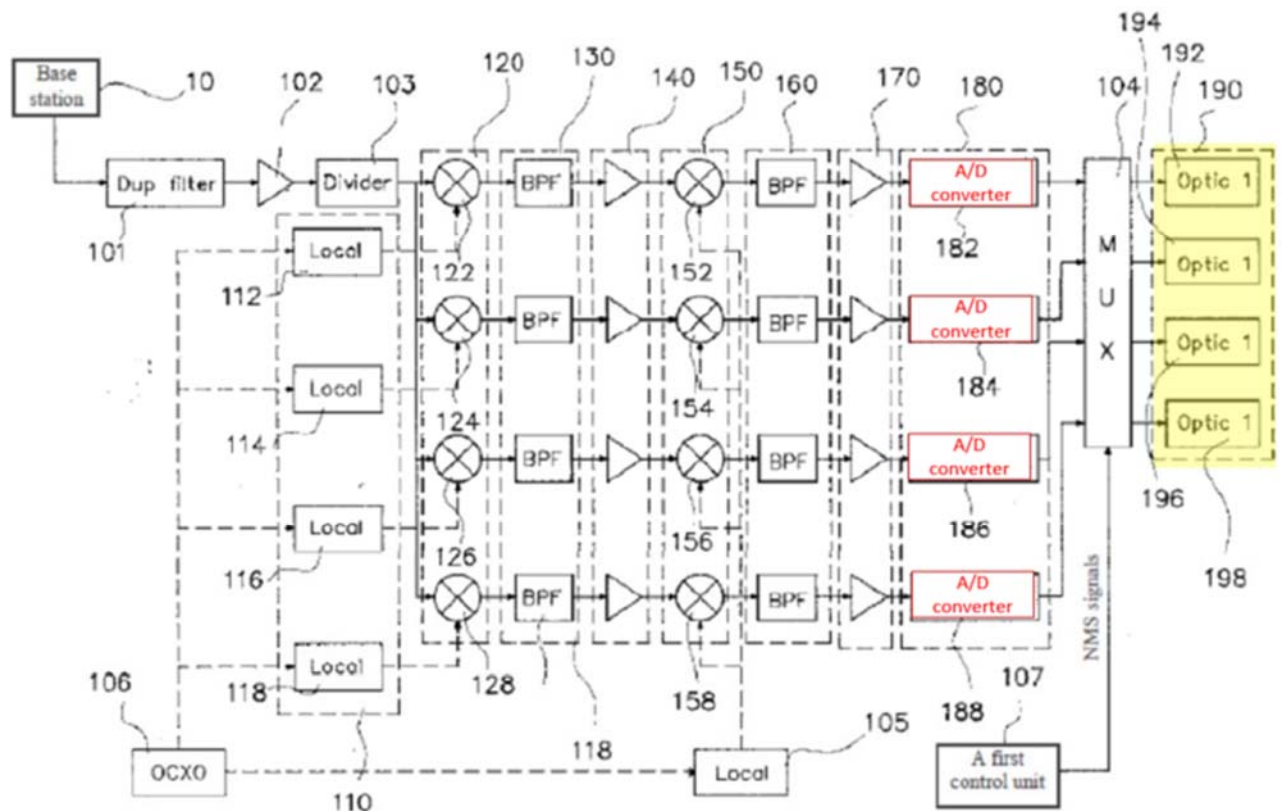
Thus Oh renders Element 2 obvious.

c) Element 3: “means for communicating at least a portion of the downstream digital RF samples to the plurality of second units;”

228. The recited means for communicating is properly construed as having a function of “communicating at least a portion of the downstream digital RF samples to the plurality of second units” and corresponding structure of Optical Transmitters 431-1 – 431-P shown in Fig. 4 of the ’982 patent.

229. Oh discloses communicating forward digital samples from master unit 20 to remote slave units 30 via optic converters 192, 194, 196, 198.

FIG. 2



230. Thus Oh renders obvious means (192, 194, 196, 198) for communicating at least a portion of the downstream digital RF samples to the plurality of second units (30) that provide the same function, in the same way, with the same result as Optical Transmitters 431-1 – 431-P of the '982 patent.

d) Element 4: “means for receiving from the plurality of second units respective upstream digital RF samples, the upstream digital RF samples having an associated resolution;”

231. The recited means for receiving is properly construed as having a function of “receiving from the plurality of second units respective upstream digital RF samples” and corresponding structure of Optical Receivers 418 shown in Fig. 4 of the '982 patent.

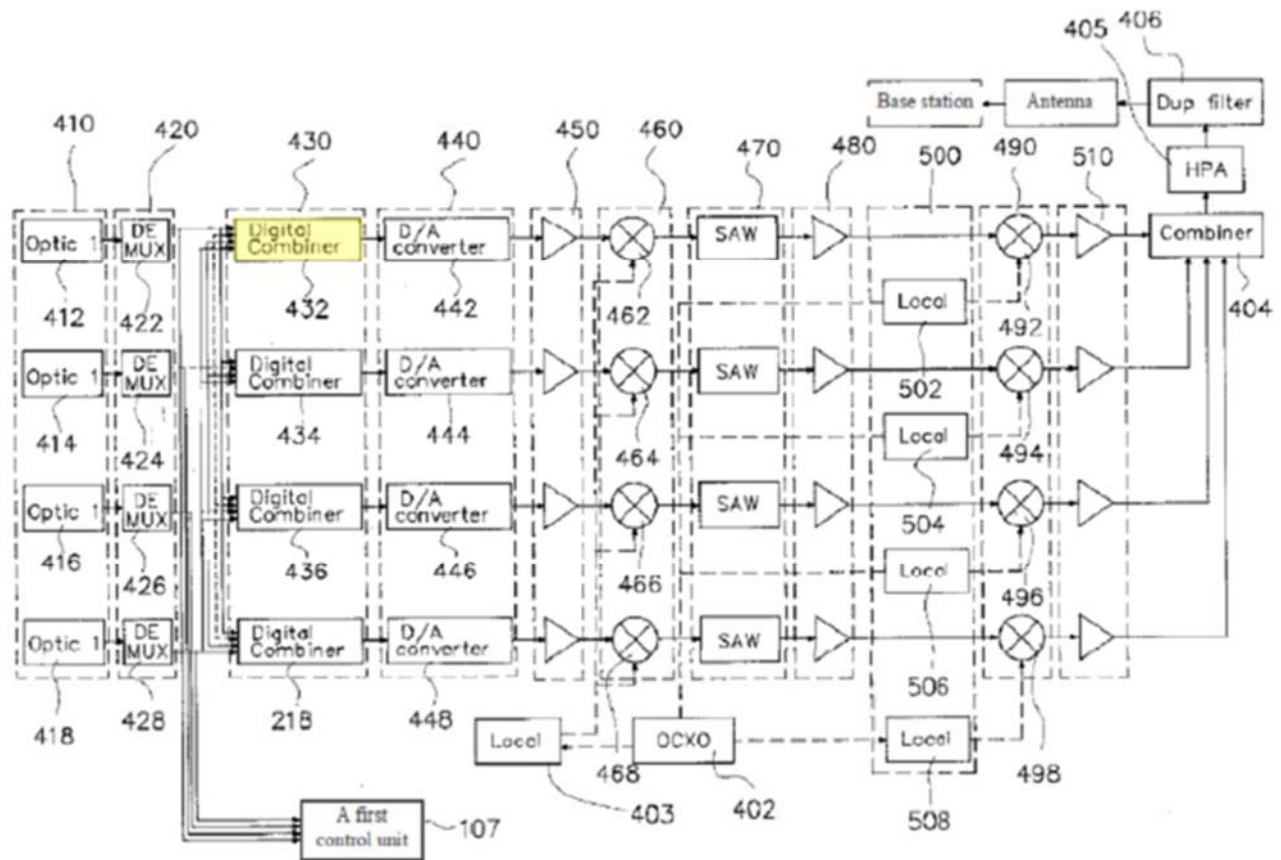
233. Thus Oh discloses means (412, 414, 416, 418) for receiving from the plurality of second units (slave units 30) respective upstream digital RF samples, the

upstream digital RF samples having an associated resolution (12-bit resolution) that provide the same function, in the same way, with the same result as Optical Receivers 418 of the '982 patent.

e) Element 5: “means for digitally summing respective upstream digital RF samples received from the plurality of second units in order to produce each of a stream of summed upstream digital RF samples, wherein the means for digitally summing has a resolution that is greater than the resolution of the upstream digital RF samples being summed;”

234. The recited means for digitally summing is properly construed as having a function of “digitally summing respective upstream digital RF samples received from the plurality of second units in order to produce each of a stream of summed upstream digital RF samples” and corresponding structure of Summer 498 shown in Fig. 4 of the '982 patent. Oh's digital combiner 432 “creat[es] 14-bit intermediate frequency signals by combining four 12-bit intermediate frequency signals,” with one of those 12-bit digital samples being provided by each of four remote slave units 30. Ex. 1007, 5:16-17.

FIG. 5



235. Thus Oh discloses means for digitally summing (430) respective upstream digital RF samples received from the plurality of second units (30) in order to produce each of a stream of summed upstream digital RF samples (output from 430), wherein the means for digitally summing has a resolution (14 bits) that is greater than the resolution of the upstream digital RF samples being summed (12 bits) that provide the same function, in the same way, with the same result as Summer 498 of the '982 patent.

f) Element 6: “means for converting the stream of summed upstream digital RF samples to a replicated upstream analog radio frequency.”

236. The recited means for converting is properly construed as having a function of “converting the stream of summed upstream digital RF samples to a replicated upstream analog radio frequency” and corresponding structure of Fig. 4: D/A Converter 494, Mixer 492, Amplifier/Filter 488, 490, Mixer 486 shown in Fig. 4 of the '982 patent.

237. Oh discloses converting its 14-bit sum from 432 into an analog signal at 442 and upconverting the analog signal to the proper analog radio frequency via mixer 462, filter 470, amplifier 480 and mixer 490. Ex. 1007, 16-29.

238. Oh discloses components for converting the stream of summed upstream digital RF samples to a replicated upstream analog radio frequency in Fig. 5 that provide the same function, in the same way, to provide the same result as the corresponding structure of the '982 patent when Oh is processing a single frequency band as follows:

<u>'982 Structure</u>	<u>Corresponding Oh Structure</u>
D/A Converter 494	D/A Converter 442
Mixer 492	Mixer 462
Amplifier/Filter 488, 490	Amplifier/Filter 470, 480

Mixer 486	Mixer 492

Thus Oh renders Element 6 obvious.

B. Claims 75-80 Are Obvious Over Oh in view of Wala

1. Independent Claim 75

a) Motivation to Combine

239. A POSITA would be motivated to combine Oh and Wala for several reasons. First, the Oh and Wala systems are highly compatible in that they both provide digital RF transport systems for extending RF communications into hard to reach areas, such as radio wave shadow areas. *Compare* Ex. 1007, 2:4-13; Ex. 1009, 585. Both Oh and Wala disclose forward transmissions with host units that receive RF signals, digitize those signals, forward the digitized signals to remote units via optical fiber, where the RF signals are recreated and wirelessly distributed via antennas. On the reverse path, both Oh and Wala receive RF signals via an antenna at remote units, the remote units digitize those signals and send them to the host unit via optical fiber, where the RF signals are recreated for transmission. *Compare*, Oh Fig. 1, Wala Fig. 1.

FIG. 1

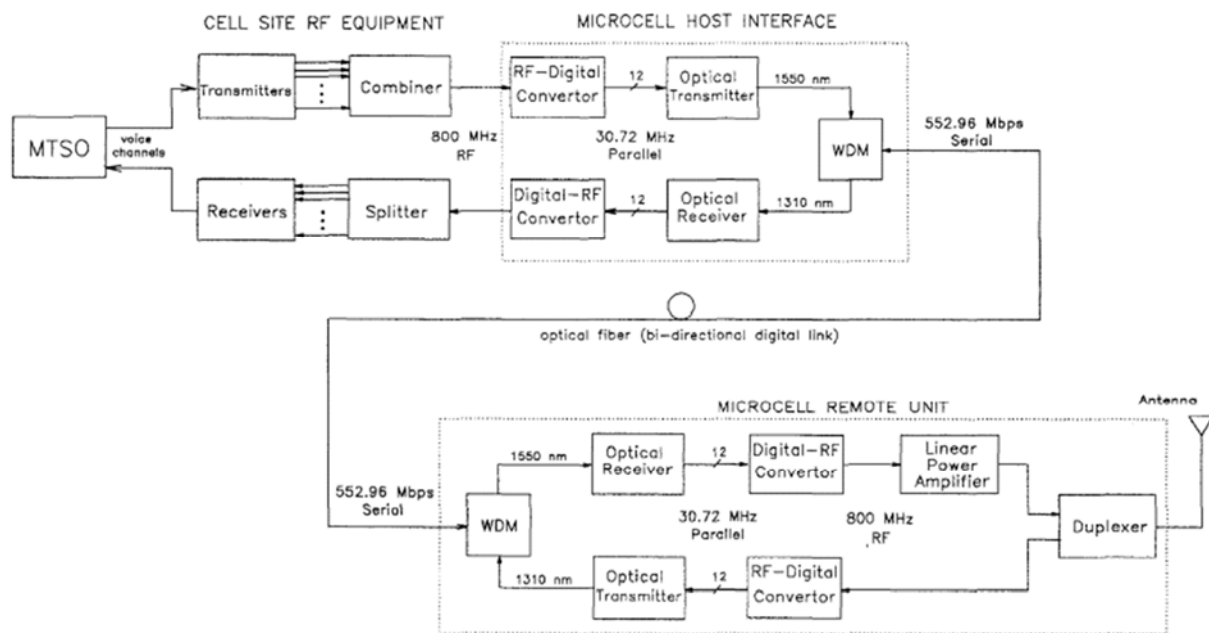
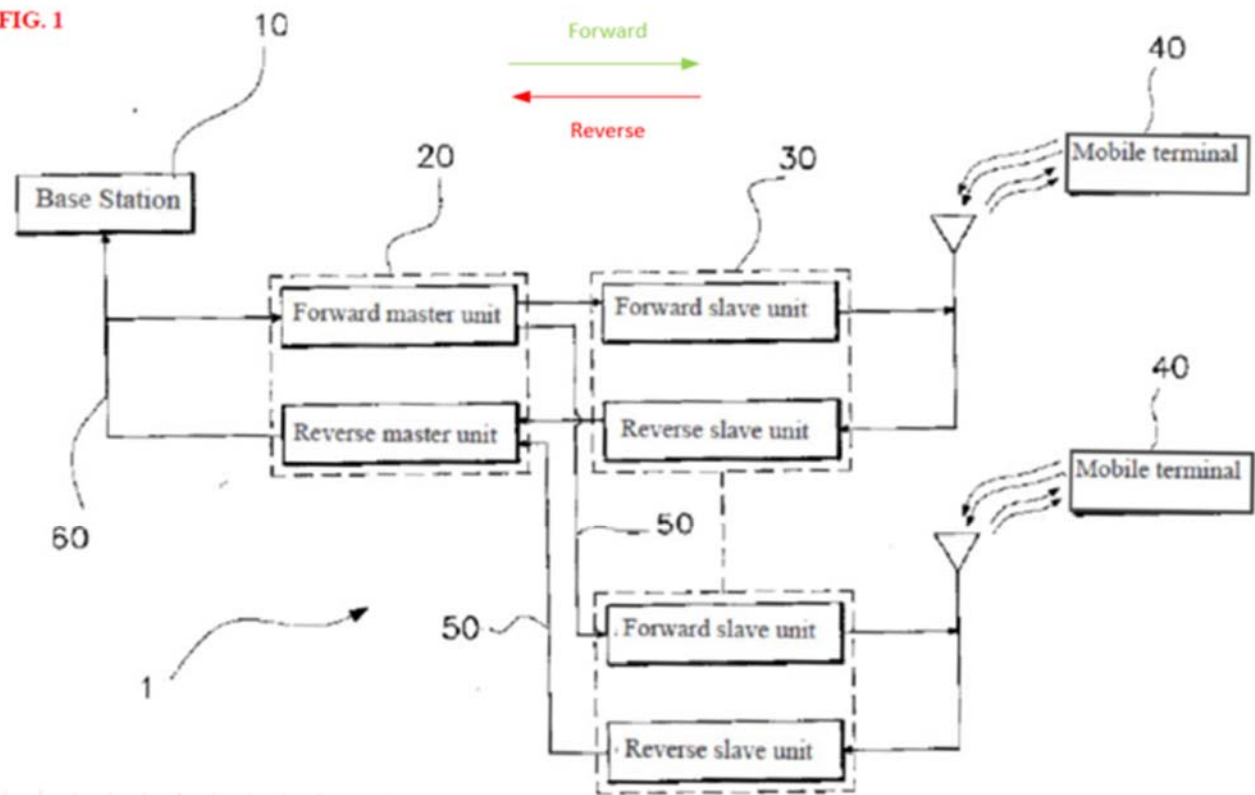


Fig.1. Digital RF transport microcell: system block diagram

240. While each of Oh and Wala provide sufficient detail for a POSITA to recreate their systems, each includes differing levels of detail on specific

implementation details that could streamline system design and implementation. For example, Wala discloses specific sampling frequencies (*e.g.*, 30.72 MHz) used at its host and remote units, where Oh does not disclose example sampling rates. Wala also discloses example optical wavelengths (*e.g.*, 1310 nm, 1550nm) for its digital sample forwarding, where such wavelengths are not illustrated in Oh. Wala also discloses types of external networks (*e.g.*, a mobile telephone switching office (MTSO)) to which a digital RF transport system like Oh or Wala can be connected, where Oh does not explicitly identify that data source/designation.

241. Likewise, in certain areas where Wala provides limited detail, Oh provides additional example implementation details. For example, where Wala discloses only a high level RF-digital converter box, Oh discloses embodiments where received RF signals are downconverted to near DC before sampling on both the upstream and downstream sides. Oh discloses various mixers, filters, amplifiers, and frequency generators to implement downconversion operations (and corresponding operations for upconversions during RF signal recreation) that Wala omitted because such details would have been readily ascertainable or discoverable to a POSITA.

242. Thus a POSITA would have been motivated to combine Oh and Wala to have a more complete starting point for designing and implementing a digital RF transport system to extend RF coverage into hard to reach areas, as disclosed in both Oh and Wala.

b) Preamble and Elements 1-5

243. The preamble of claim 75 and elements 1-5 are analogous to the preamble and elements 1-4, 7 of claim 37. Those elements are rendered obvious for the reasons provided above in addressing claim 37.

c) Element 6: “wherein sample rates used by the host unit and the other units are locked together.”

244. Oh discloses A/D conversion at 180 on the forward path in master unit (e.g., forward master unit 100) and on the reverse path in the slave units 30 at 380.

FIG. 2

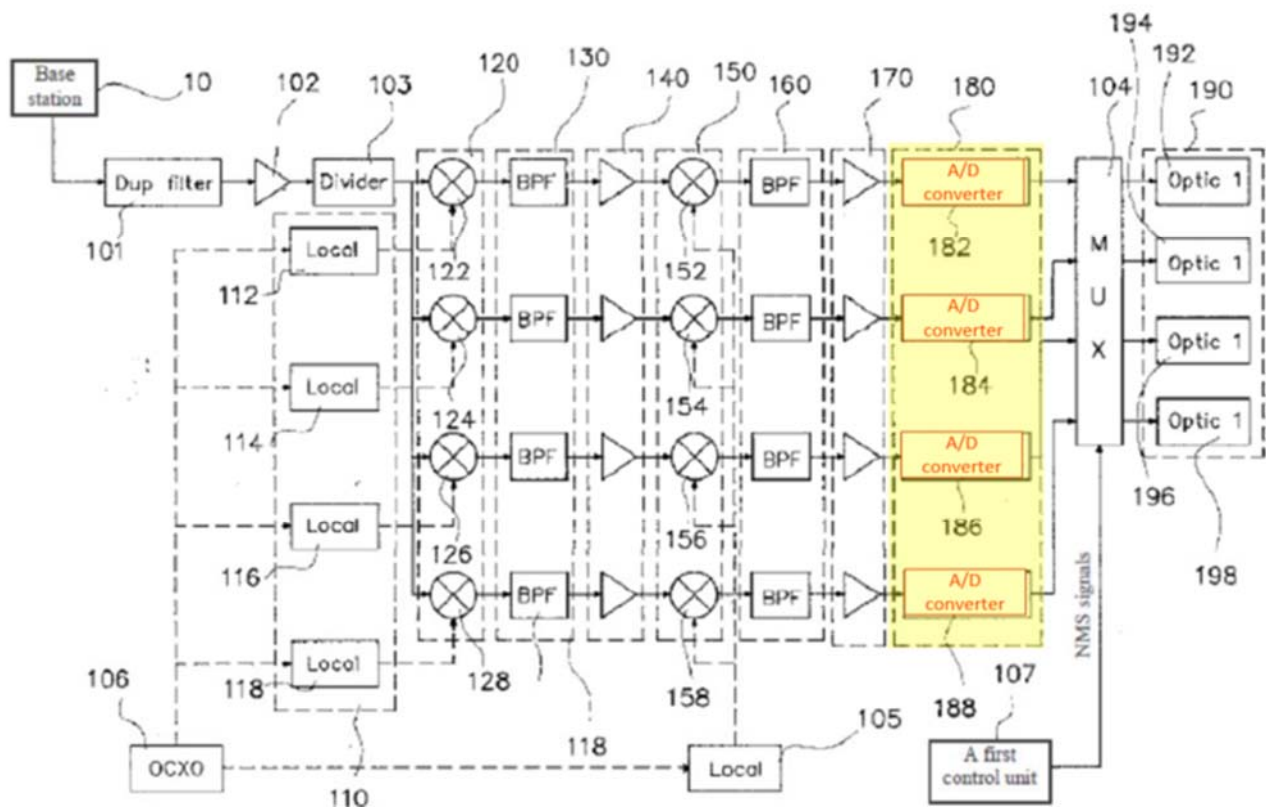
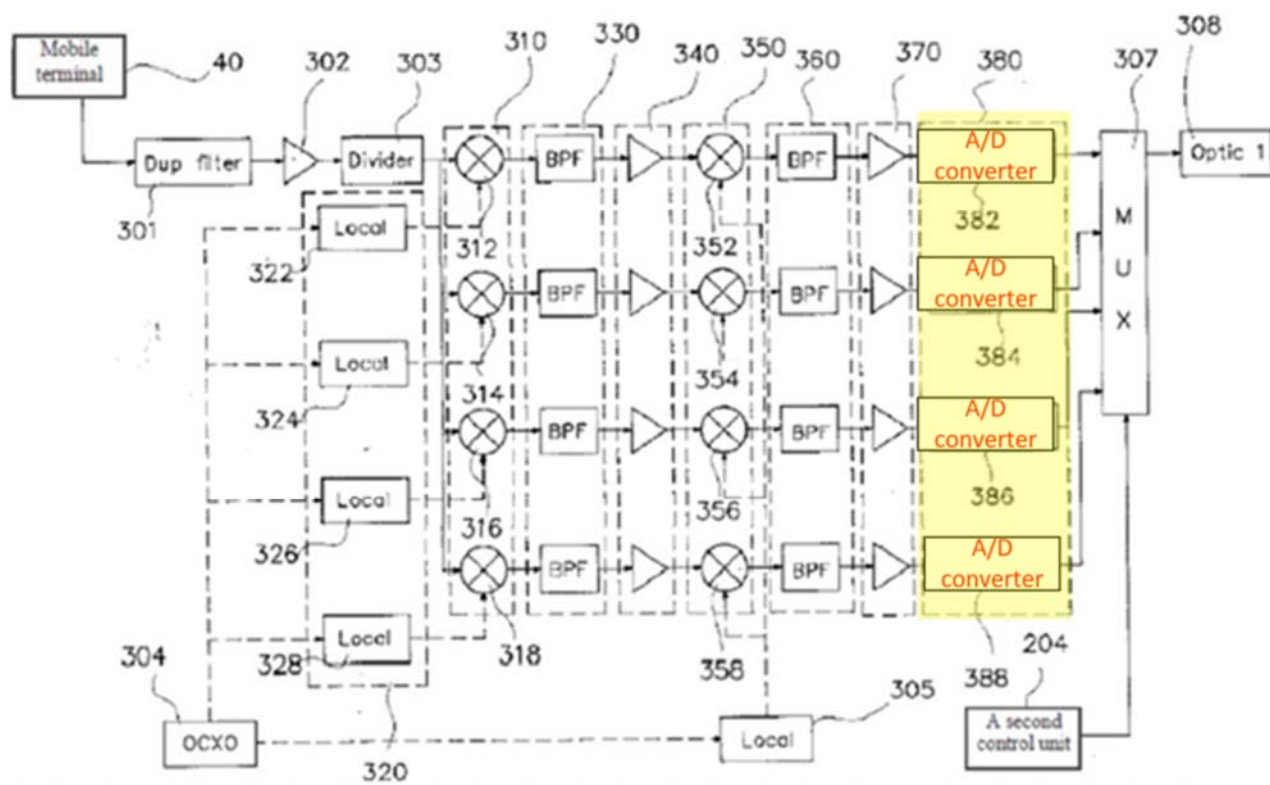


FIG. 4



245. To any extent that Oh does not explicitly or implicitly disclose that the sampling at 180, 380 (which is sampling analog wave forms in the same frequency ranges) is not providing that sampling at common, locked sampling rate, such locked rate sampling is rendered obvious by Oh in view of Wala. Wala discloses that its A/D sampling at both the host and remote units is performed at a common, locked 30.72 MHz.

246. Thus Oh in view of Wala renders obvious wherein sample rates used by the host unit and the other units are locked together (*e.g.*, at 30.72 MHz). Thus Oh in view of Wala renders claim 75 obvious.

2. Dependent Claims 76-77

247. The additional features of claims 76-77 are disclosed by Oh for the reasons noted above with reference to claims 40-41. Claims 76-77 are thus obvious based on Oh in view of Wala.

3. Independent Claim 78

248. Independent claim 78 is analogous to independent claim 45. The only differences of substance are that claim 78 does not discuss the resolution of certain signals, but claim 78 does additionally recite that “sample rates used by the host unit and the other units are locked together.”

249. The analogous elements of claim 78 are rendered obvious by Oh for the reasons provided above for claim 45. To any extent that Oh does not explicitly or implicitly disclose the locked sampling in the final element of claim 78, that feature is disclosed by Wala for the reasons discussed above in addressing the final limitation of claim 75. Thus Oh in view of Wala renders claim 78 obvious.

4. Dependent Claims 79-80

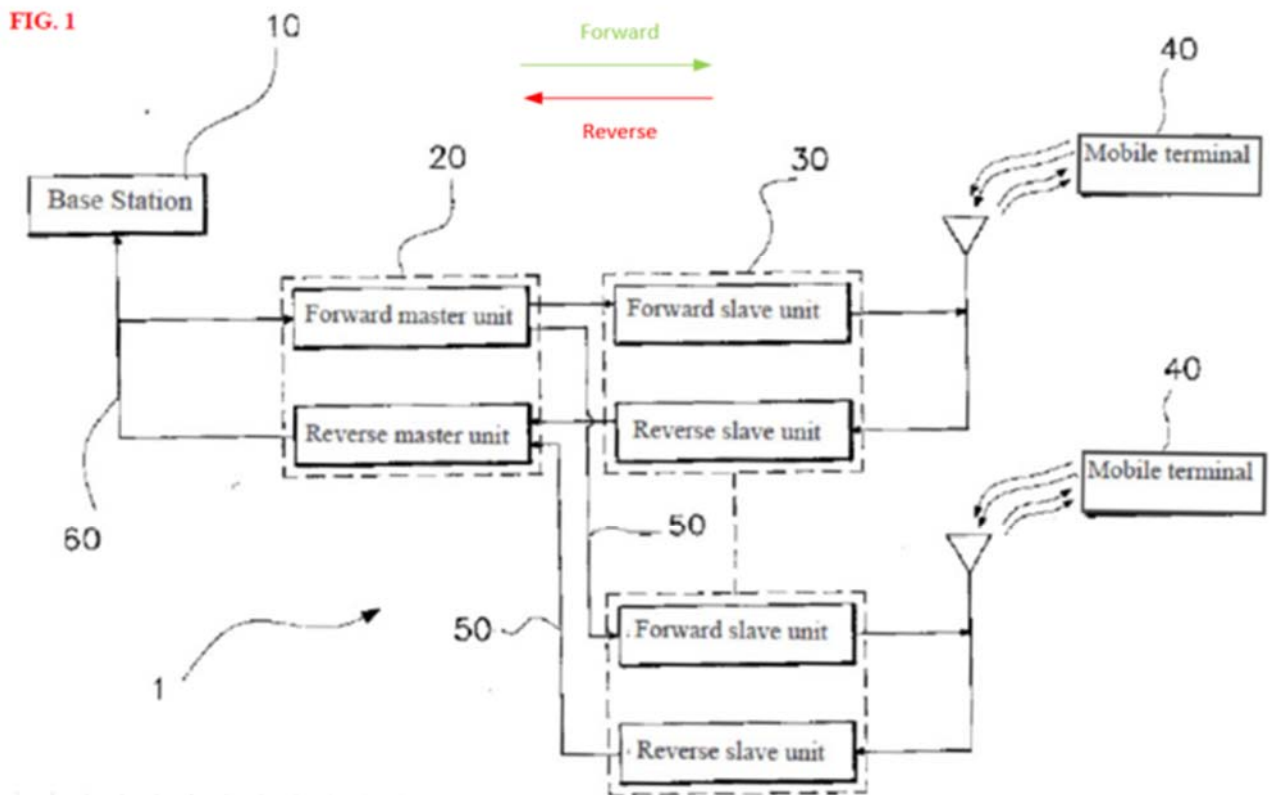
250. The additional features of claims 79-80 are disclosed by Oh for the reasons noted above with reference to claims 40-41. Claims 79-80 are thus obvious based on Oh in view of Wala.

C. Claims 65-69 and 74 Are Obvious Over Oh

1. Independent Claim 65

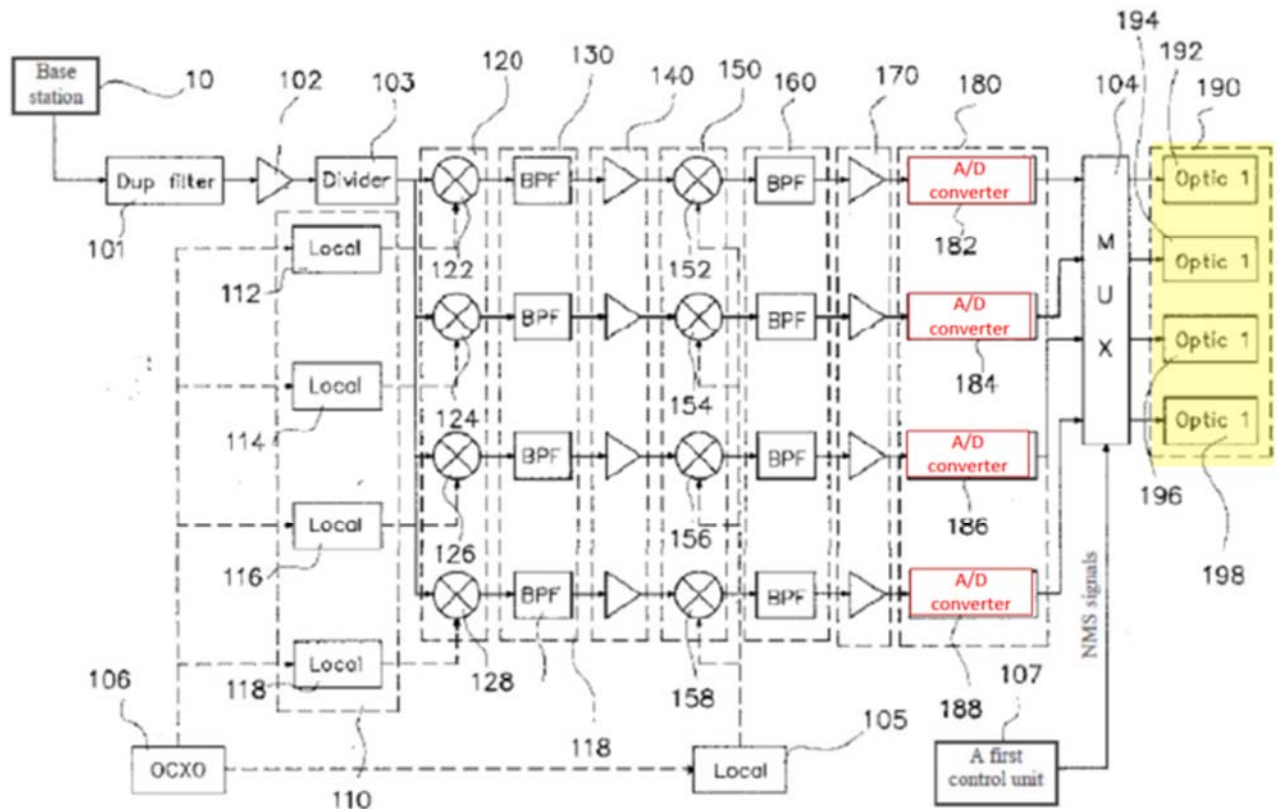
a) *Preamble and element 1: “A first unit comprising: an interface to communicatively couple the first unit to a plurality of second units using at least one communication medium, wherein the first unit uses the interface to communicate to the plurality of second units downstream digital RF samples produced from an original downstream analog radio frequency signal;”*

251. Oh discloses master unit 20 is coupled to multiple remote slave units 30 via optic lines 50. That master unit 20 receives analog RF signals from base station 10 and digitizes that analog signal on a per frequency band basis at 180 for communications to slave units 30.



252. Fig. 2 of Oh depicts optic converter unit 190 that provides an interface between forward master unit 100 of master unit 20 and forward slave unit 200 of remote slave units 30.

FIG. 2

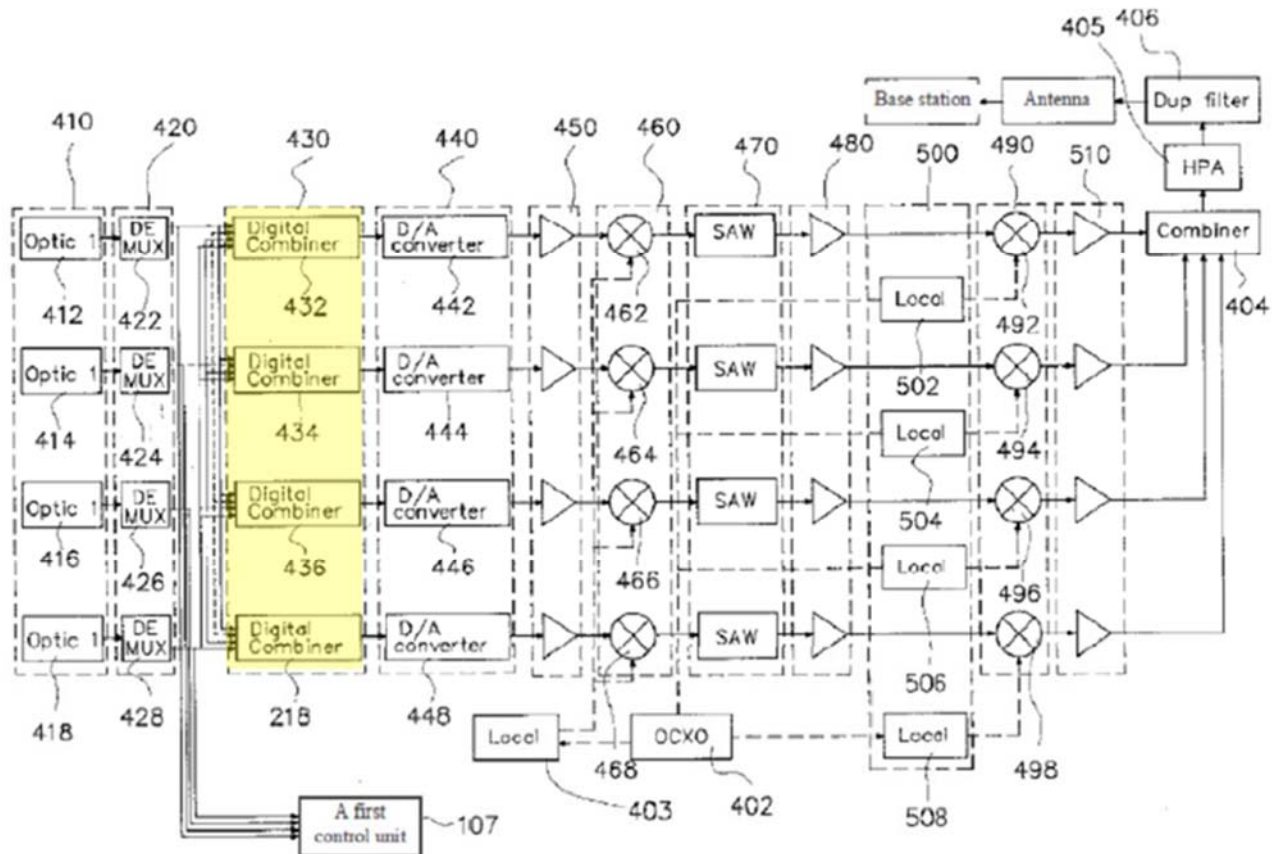


253. Thus Oh renders obvious a first unit (20) comprising: an interface (190) to communicatively couple the first unit to a plurality of second units (30) using at least one communication medium (50), wherein the first unit uses the interface to communicate to the plurality of second units downstream digital RF samples (generated at 180) produced from an original downstream analog radio frequency signal (from base station 10).

b) Elements 2 and 3: “a digital-to-analog unit to convert a stream of summed upstream digital RF samples to a replicated upstream analog radio frequency; wherein each of the summed upstream digital RF samples is produced by digitally summing respective upstream digital RF samples received from the plurality of second units;”

254. Oh’s master unit 20 includes a digital combiner unit 430 that aggregates digital signals transmitted from each demultiplexer 422, 424, 426, 428 of demultiplexer unit 420. Ex. 1007, 4:68-70.

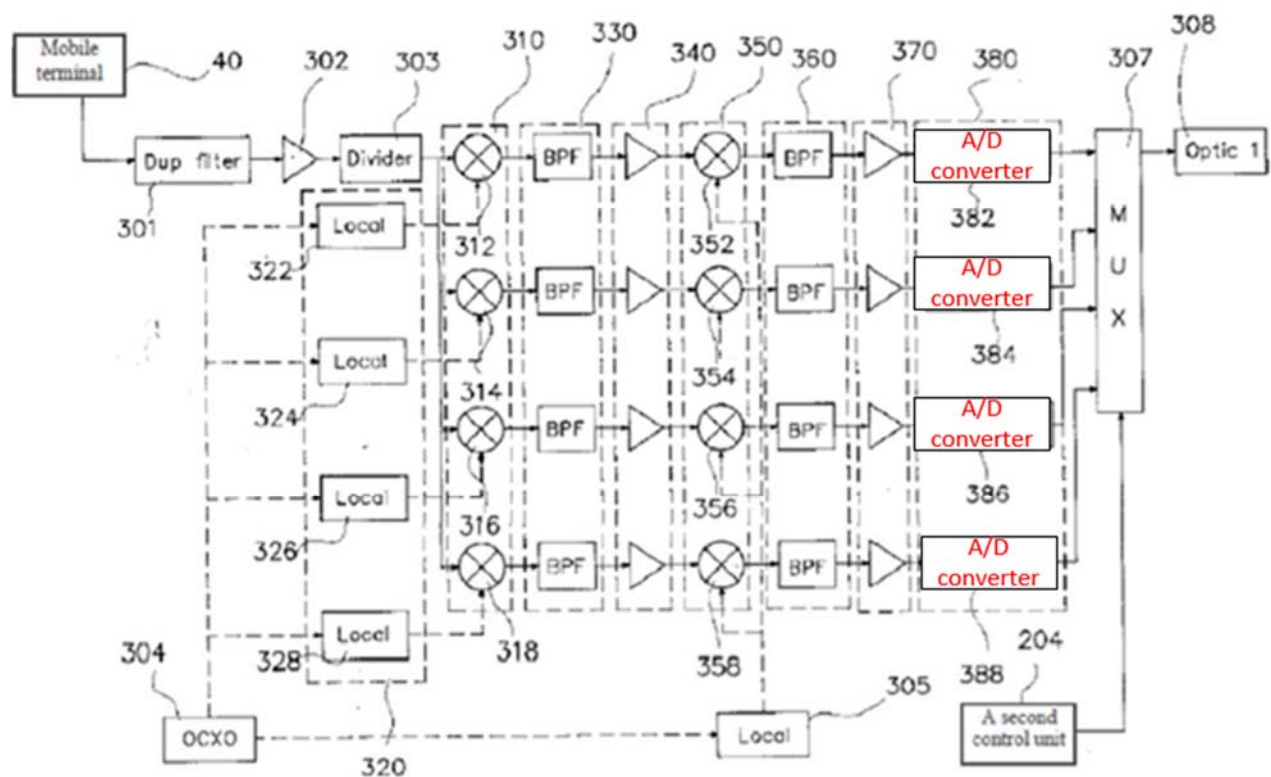
FIG. 5



Those demultiplexers at 420 receive data from individual remote slave units 30 at 410.

255. As depicted in Fig. 4, each slave unit 30 receives an analog signal from a mobile terminal 40, divides the received analog signal into its component frequency bands at 303 and downconverts the frequency band signals to near DC at 310-370. Ex. 1007, 4:26-34. The downconverted band signals are then sampled at 380 to create 12-bit digitized radio frequency signals. *Id.*, 4:56-61. The multiplexer 307 multiplexes the four 12-bit samples with 4 bits of control data from 204 to form 52-bit serial data signals that are forwarded to master unit 20. *Id.*

FIG. 4



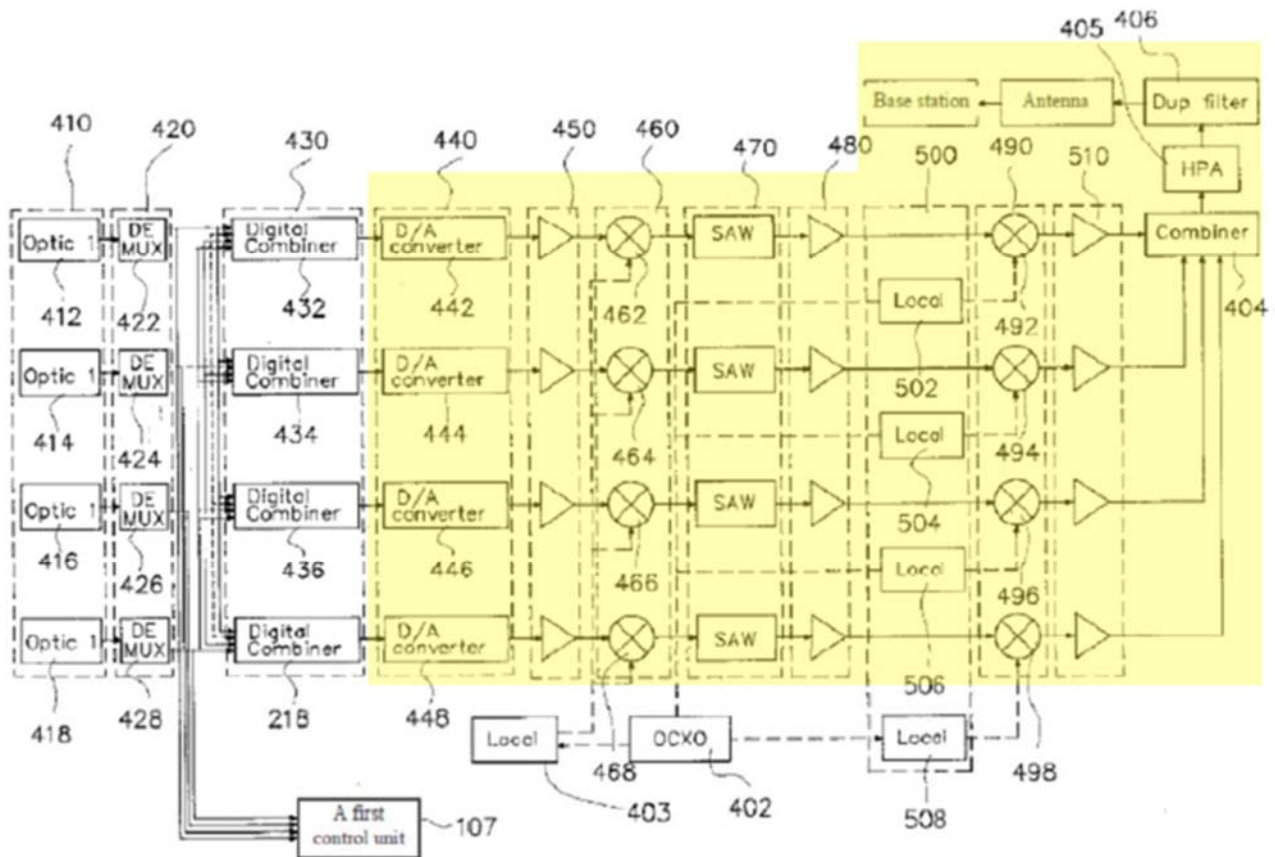
256. Referring back to Fig. 5, each demultiplexer 422, 424, 426, 428 receives a 52-bit signal from its respective slave unit 30. Each demultiplexer forwards 12-bits of sample data to the appropriate digital combiner associated with the proper

frequency band for that 12-bit sample and forwards its 4 bits of control data to control unit 107. Upon receiving four 12-bit signals (one from each of demultiplexer 422, 424, 426, 428), each digital combiner 432, 434, 436, 438 combines those 12-bit signals to “creat[e a] 14-bit intermediate frequency signals by combining⁵ four 12-bit intermediate frequency signals in the same frequency band” (*e.g.*, (1010 1010 1010 (2,730) + 1100 1100 1100 (3,276) + 1111 1111 1111 (4,095) + 0000 1100 1100 (204) = 10 1000 0100 0001 (10,305)). Ex. 1007, 5:16-17. Those 14-bit signals are then converted to analog signals at 440, upconverted, combined, and transmitted to the base station 10. *Id.*, 5:17-29.

257. Following the digital summing operation of Element 5, the summed digital data values are converted to analog signals, up converted to the appropriate frequency signals associated with their particular bands to create component analog signals, that are then combined and transmitted to a base station via an antenna.

⁵ I understand that the parties have discussed whether this word should be translated as “adding” or “combining.” Regardless of which of these terms is used, the digital combiners are operating to produce a digital sum (*i.e.*, they are performing a digital summing operation).

FIG. 5



Specifically Oh states:

After creating 14-bit intermediate frequency signals by combining four 12-bit intermediate frequency signals in the same frequency band, said digital combiner transmits them to a first D/A converter unit 440. Each D/A converter 442, 444, 446, and 448 of said first D/A converter unit 440 converts 14-bit digital signals to the intermediate [frequency] signals, analog signals; and transmits 1.23MHz or 1.5MHz intermediate frequency signals to each mixer 462, 464, 466, and 468 of a third mixer unit 460 through a third amplification unit 450. Said third mixer unit 460 outputs 70MHz intermediate frequency signals by mixing 1.23MHz or 1.5MHz intermediate frequency signals

transmitted from a first D/A converter unit 440 with 68.77MHz or 68.5MHz oscillating frequency transmitted from a third local unit 403. The intermediate frequency signals outputted from said third mixer unit 460 are transmitted to a fourth mixer unit 490 through a first saw filter unit 470 and a fourth amplification unit 480. Said fourth mixer unit 490 mixes the oscillating frequency in different frequency bands transmitted from a fourth local unit 500 with 70MHz intermediate frequency signals; and transmits 800MHz RF signals in different frequency bands to a first combiner 404 through a fifth amplification unit 510.

Ex. 1007, 5:16-26. The analog signals are combined at 404 to “aggregate[] the RF signals in different frequency bands transmitted from four mixers 492, 494, 496, and 498,” and are amplified at 510 and run through a bi-directional filter 406 to an antenna and a base station.⁶

258. Thus Oh renders obvious a digital-to-analog unit (shown in Fig. 5 after digital combiners 430) to convert a stream of summed upstream digital RF samples (from 430) to a replicated upstream analog radio frequency (output from combiner unit 430 for transmission to the base station); wherein each of the summed upstream digital RF samples is produced by digitally summing (432, 434, 436, 438 each create

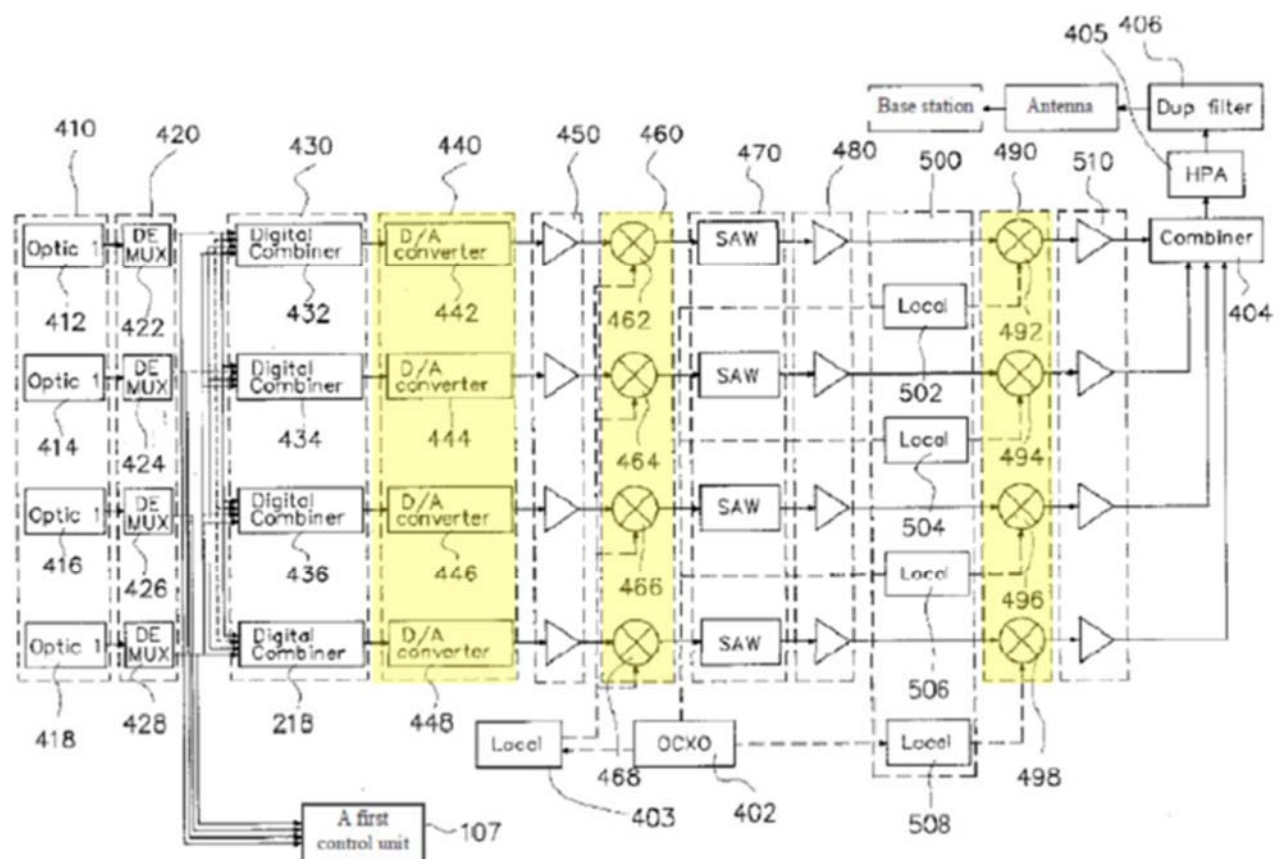
⁶ Recall that '982 states that a wireless interface device may comprise a base station.

14-bit signals by combining four 12-bit signals) respective upstream digital RF samples (routed by demultiplexer unit 420 to digital combiners associated with the frequency band of each of four samples received from each slave unit 30) received from the plurality of second units (30).

c) Element 4: “wherein the digital-to-analog unit comprises a digital-to-analog converter, a first mixer, and a second mixer”

259. Fig. 5 of Oh depicts the reverse master unit 400 includes D/A converter unit 440, third mixer unit 460, and fourth mixer unit 490 on the reverse path. Ex. 1007, 4:70-76.

FIG. 5



Thus Oh renders obvious the digital-to-analog unit comprises a digital-to-analog converter unit (440), a first mixer (460), and a second mixer (490).

d) Element 5: “wherein the stream of summed upstream digital RF samples is converted to an analog signal by the digital-to-analog converter”

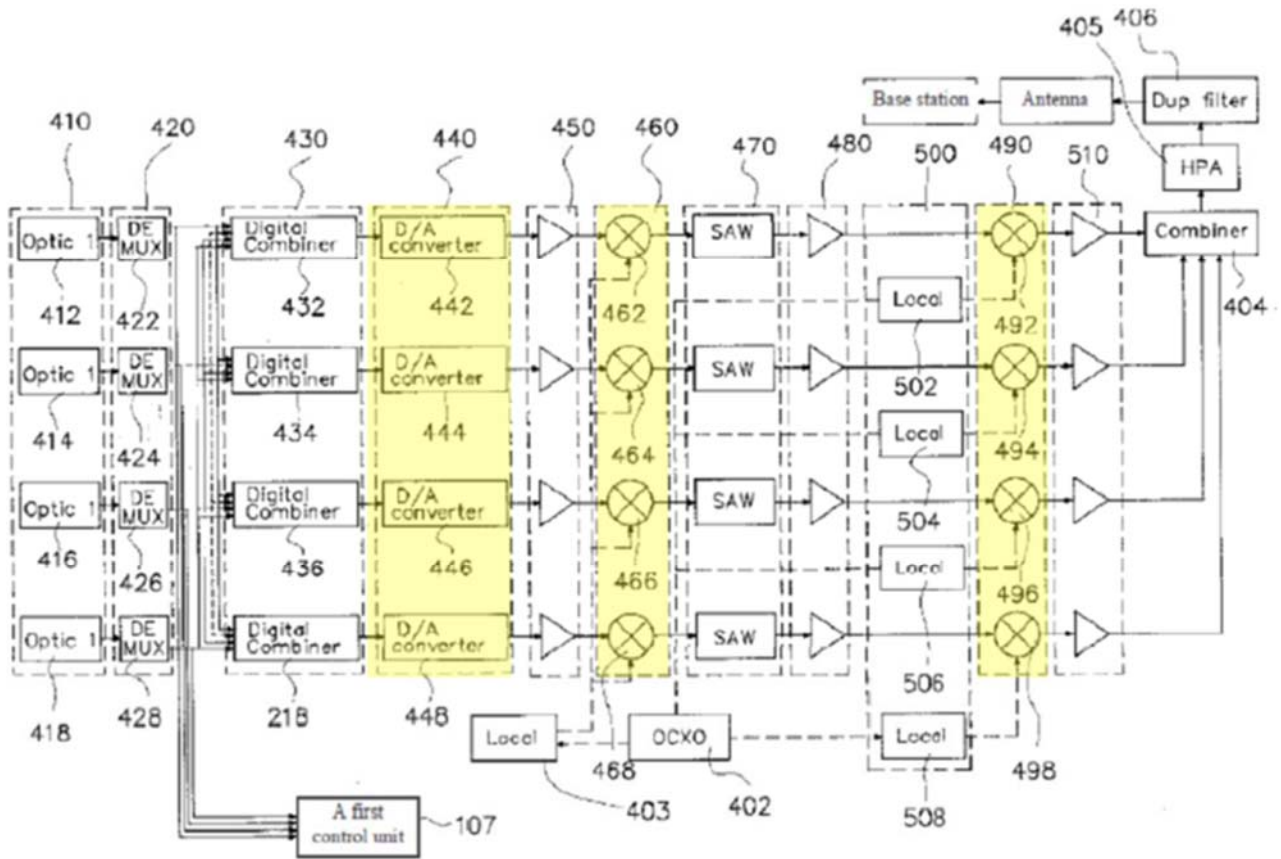
260. Oh discloses D/A converter unit 440 receiving the summed upstream digital RF samples from digital combiner unit 430. “D/A converter unit 440 that converts the digital signals transmitted from said digital combiner unit 430 to analog signals, respectively.” Ex. 1007, 4:70-71. Thus Oh renders obvious the stream of summed upstream digital RF samples (from 430) is converted to an analog signal by the digital-to-analog converter unit (440).

e) Elements 6, 7: “wherein a signal derived from the analog signal is mixed with a first reference signal by the first mixer; wherein a signal derived from a signal output by the first mixer is mixed with a second reference signal by the second mixer;”

261. Oh discloses that its analog signals output from 440 are amplified at 450, mixed with a signal from local oscillator 403 at 460, filtered and amplified at 470, 480, and mixed with signals from local oscillators 502, 504, 506, 508 at 490. The signals mixed with the first reference signal from 403 at 460 are amplified versions of outputs from 440 and are thus “derived from the analog signal” produced at 440. Similarly, the signals mixed with the second reference signals from 500 at 490 are

amplified/filtered signals from the first mixer at 460 and are thus “derived from a signal output by the first mixer.”

FIG. 5

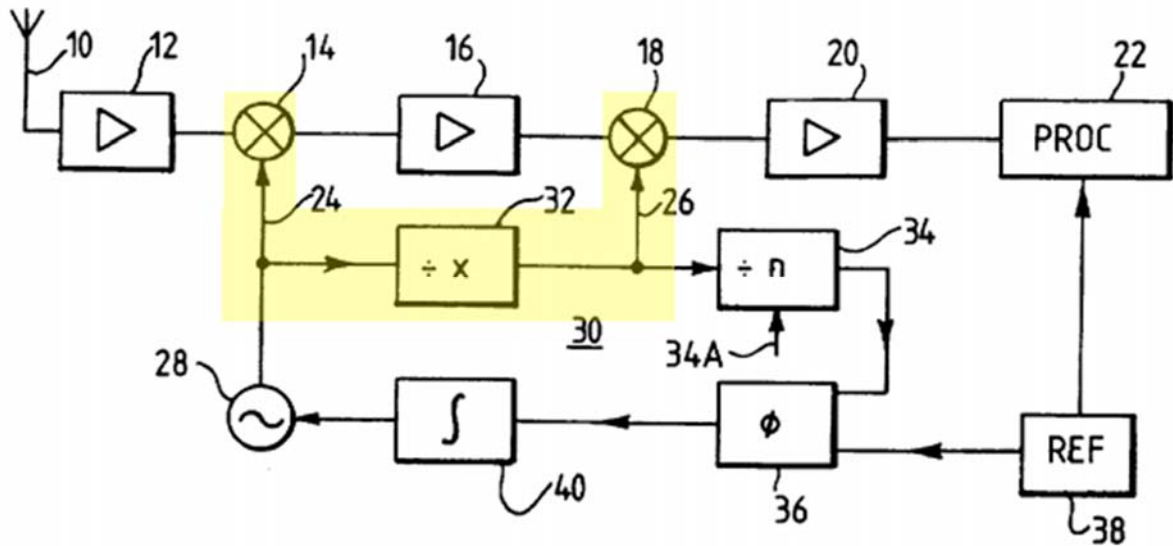


262. Thus Oh renders obvious wherein a signal derived from the analog signal (output of 450 originating from 440) is mixed with a first reference signal (403) by the first mixer (460); wherein a signal derived from a signal output by the first mixer (output of 480 originating at 460) is mixed with a second reference signal (500) by the second mixer (490).

f) Element 8: “wherein the second reference signal is generated by frequency dividing the first reference signal.”

263. The intermediate frequency selected in the translation of the near DC signals at 440 to the ~800MHz signals at 490 is a matter of design choice. If the frequency translation from DC to 800 MHz is performed as: DC→600 MHz→800 MHz, then Fig. 8 could be implemented with OCXO 402 = Local 403 = 600 MHz and Local 502, 504, 506, 508 = 200 Mhz. In such an instance, local oscillators 502, 504, 506, 508 would be generated by frequency dividing the first reference signal by a factor of 3.

264. Such frequency dividing in generating oscillator signals for frequency translation in radio transmitter/receiver systems was well known many years prior to the '982 patent as evidenced by Hasler (Ex. 1020), which utilizes the reference oscillator 28 frequency for a first frequency translation, and a divided frequency, using the divider 32, at 18 for a second frequency translation, reducing the number of local oscillators in the system by one, reducing cost and power consumption.



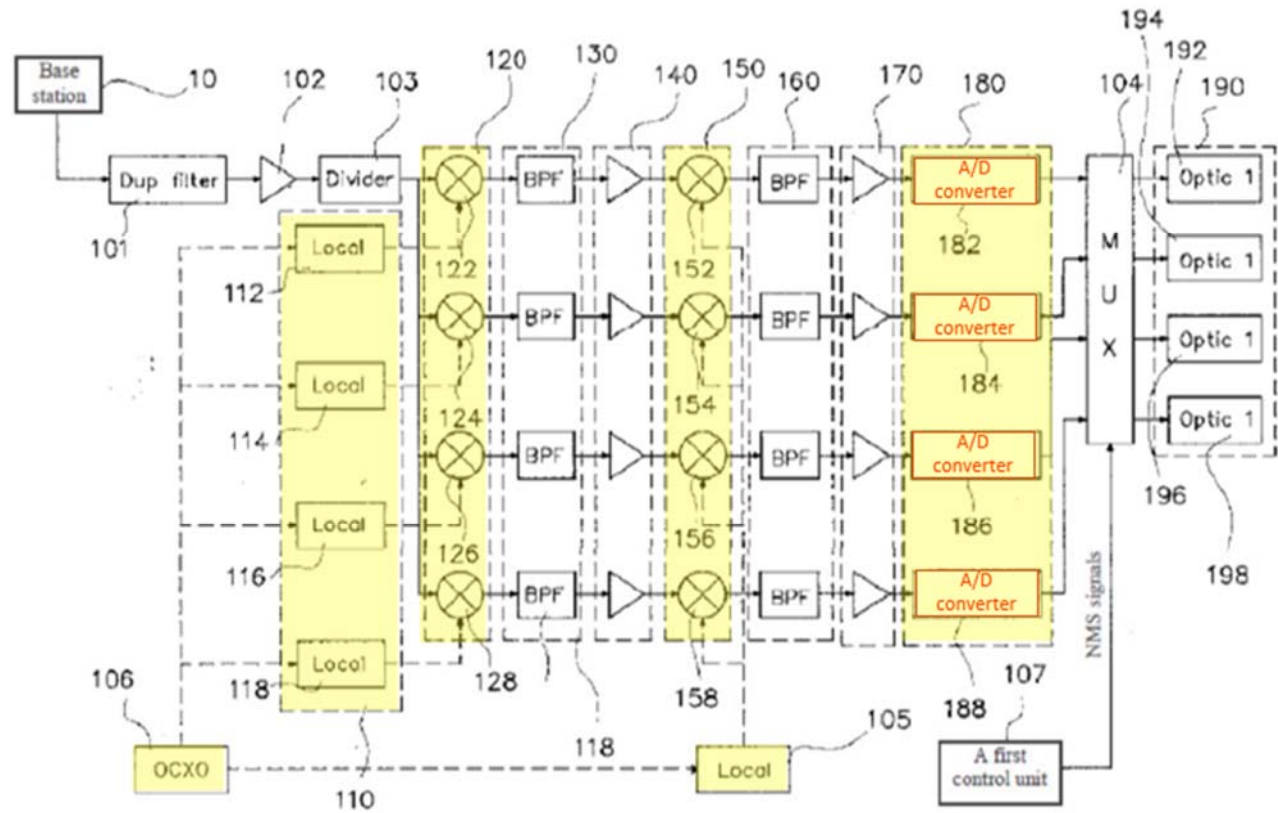
Thus a POSITA would have considered it obvious to generate the second reference signals by frequency dividing the first reference signal.

2. Dependent Claim 66

265. Dependent claim 66 recites “an analog-to-digital unit to digitize the original downstream analog radio frequency signal in order to produce the downstream digital RF samples, wherein the analog-to-digital unit comprises a third mixer, a fourth mixer, and an analog-to-digital converter; wherein a signal derived from the original downstream analog radio frequency signal is mixed with a third reference signal by the third mixer; wherein a signal derived from a signal output by the third mixer is mixed with the first reference signal by the fourth mixer; and wherein a signal derived from a signal output by the fourth mixer is digitized to produce the downstream digital RF samples; wherein the third reference signal is generated by frequency dividing the first reference signal.”

266. Oh's master unit 20 receives RF signals from a base station 10 and divides it into its component frequency bands at 103. Those frequency bands are downconverted to from around 800Mhz to about 70MHz by mixers at 120 that are controlled by local oscillators 110 deriving frequencies from oven controlled oscillator (OCXO) 106. Following filtering 130 and amplification, those intermediate frequency signals are further downconverted to near DC at 150 based on a signal from local oscillator 105, responsive to OCXO 106 before A/D conversion at 180. Ex. 1007, 3:19-39. Based on frequency shifting principles, where mixing a signal at a frequency of f_0 with a frequency of f_1 produces signals at $f_0 \pm f_1$, where an unwanted one of those signals is filtered out of the system, a same reference signal (*e.g.*, a 70MHz) is useful for upconverting from near DC to the intermediate frequency (70 MHz in Oh) on the reverse path (claim 65) at the host/master unit as is useful for downconverting from the intermediate frequency to near DC on the forward path (claim 66).

FIG. 2



267. Thus Oh renders obvious an analog-to-digital unit (depicted in Fig. 2) to digitize the original downstream analog radio frequency signal in order to produce the downstream digital RF samples, wherein the analog-to-digital unit comprises a third mixer (120), a fourth mixer (150), and an analog-to-digital converter (180); wherein a signal derived from the original downstream analog radio frequency signal is mixed with a third reference signal (from 110) by the third mixer; wherein a signal derived from a signal output by the third mixer is mixed with the first reference signal (from 105, a same frequency used for upconversion to the intermediate frequency in Fig. 5)

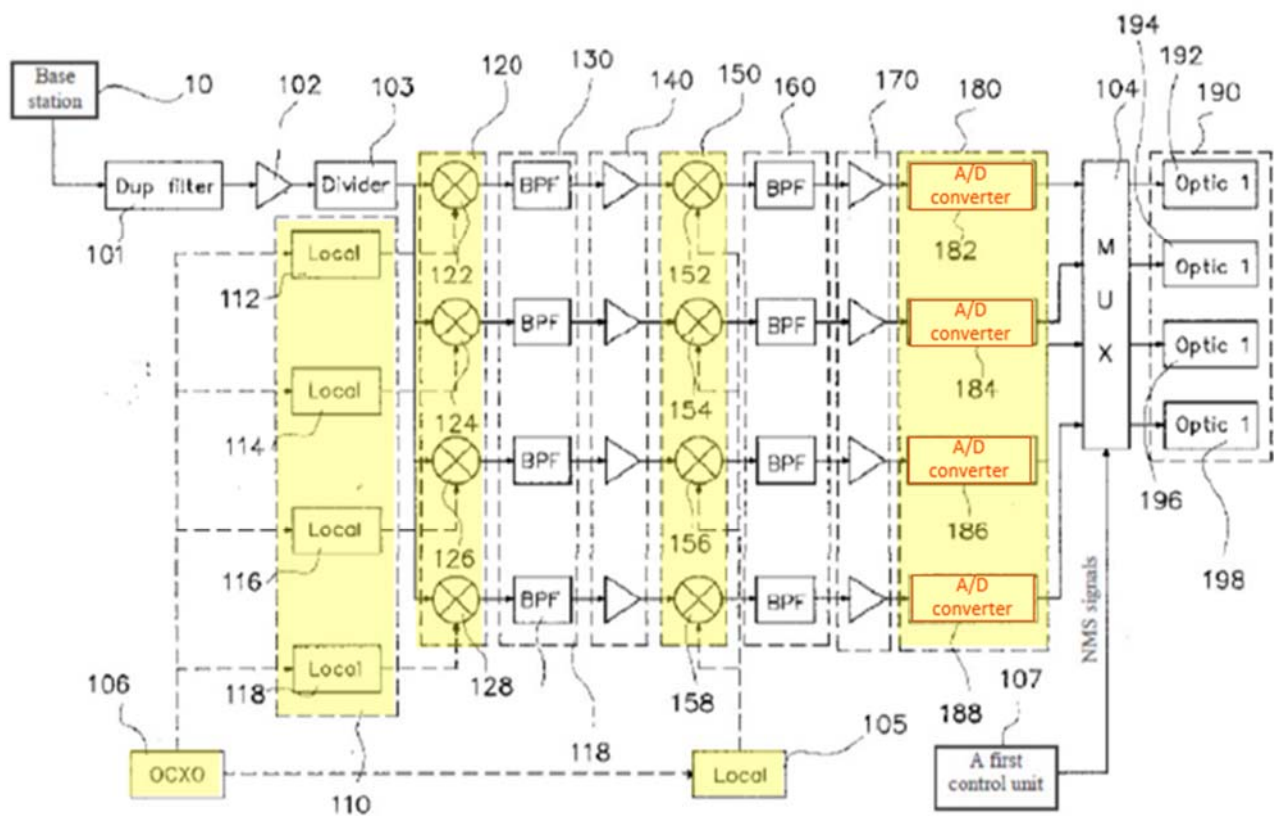
by the fourth mixer; and wherein a signal derived from a signal output by the fourth mixer is digitized (at 180) to produce the downstream digital RF samples.

268. Claim 66 further recites wherein the third reference signal is generated by frequency dividing the first reference signal. The intermediate frequency selected in the translation of the ~800Mhz at 120 to near DC signals at 150 is a matter of design choice. If the frequency translation from 800MHz to DC is performed as: 800→600 MHz→DC, then Fig. 2 could be implemented with OCXO 106 = Local 105 = 600 MHz and Local 112, 114, 116, 118 $\approx$ 200 Mhz. In such an instance, local oscillators 112, 114, 116, 118 (operating at 200 Mhz) would be generated by frequency dividing the first reference signal (operating at 600 Mhz (see claim 65 above)) by a factor of about 3. Because Oh's forward and reverse master units are components of the same master unit 20, a POSITA would have considered it obvious to generate the third reference signal by frequency dividing the first reference signal. Using a common oscillator to produce the first reference signal that is utilized in those forward and reverse master units would reduce power consumption and part count (compared to using multiple, separate oscillators, one in each of the forward and reverse sides of master unit 20), which provides a corresponding reduction in cost (component and power) as well as an increase in reliability.

3. Dependent Claim 67

269. Dependent claim 67 recites “the signal derived from the signal output by the fourth mixer that is digitized to produce the downstream digital RF samples is produced by adding dither to the signal output by fourth mixer.” As discussed above with reference to claim 66, Oh discloses digitization of the output of the fourth mixer unit 150 at 180.

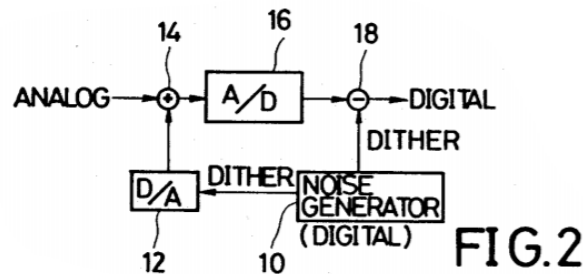
FIG. 2



270. A person of ordinary skill in the art would recognize that applying dither to a signal prior to digitization can reduce quantization error and that inclusion of a dither generator in an A/D converter (e.g., A/D converter unit 180) would have been obvious because agitating, or moving around, the input to the A/D will allow the

digital output of the A/D to more accurately represent the analog signal prior to digitization. As an example of this, if the input to the A/D is 3.8 mV and the resolution of the A/D is 1 mV then the A/D, with no dither applied to the input signal, may constantly output a digital value of 4 mV. By adding a 0.5 mV dither signal to the input signal, the digital A/D output of the will occasionally drop down to 3 mV. By averaging the outputs of the A/D over time, for example, 4 mV, 4 mV, 3 mV, 4 mV, a more accurate representation of the 3.8 mV input can be made. To the extent that the limitation is not deemed obvious based on Oh, Curbelo evidences that the dither feature is obvious. Curbelo discloses an A/D converter whose resolution is improved through the use of a dither generator. Specifically, “[a]n analog signal to be digitized is combined with a dither signal, the resultant dithered signal is then sampled a plurality of times, and at least some of the sampled values are digitized (by the A/D converter). At least some of the digitized values are co-added (in effect averaged) to provide an output having a digitization error reduced by a factor of up to the square root of the number of values averaged.” Ex. 1015, 3:35-42. A POSITA would be motivated to incorporate dither into Oh’s A/D converter to reduce digitization error, as described by Curbelo. As further evidence of obviousness of applying dither to a signal prior to digitization, Noro discloses using a dither circuit “for improving linearity in analog-to-digital (A/D) or digital-to-analog (D/A) conversion of a signal” to address quantizing noise inherently generated in A/D or D/A conversion. Ex. 1023,

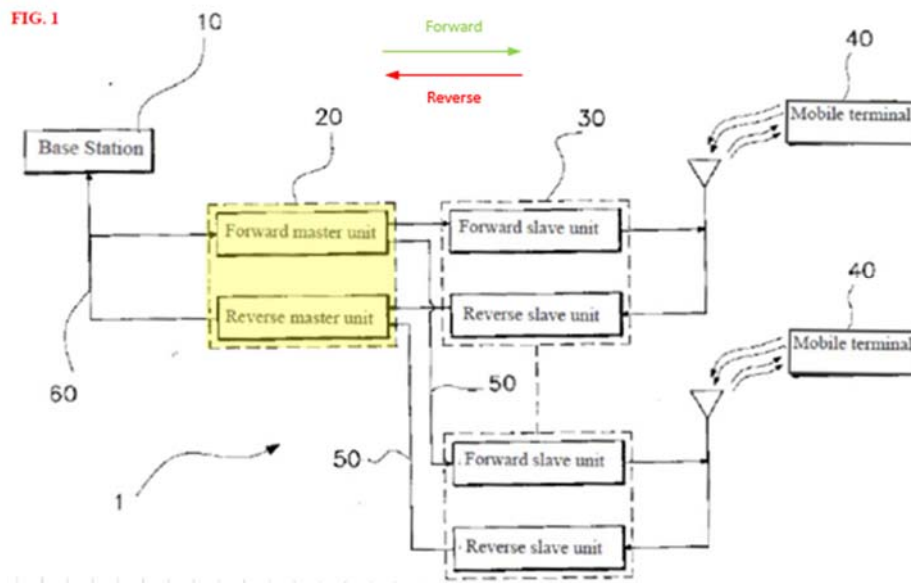
1:10-19. Specifically, “in the case of A/D conversion, as shown in FIG. 2, dither (digital signal) generated by a noise generator 10 is converted to an analog signal by a D/A converter 12 and the converted dither is superposed on an input analog signal by an adder 14. After the input signal superposed with dither is A/D-converted by an A/D converter 16.” *Id.*, 1:33-39.



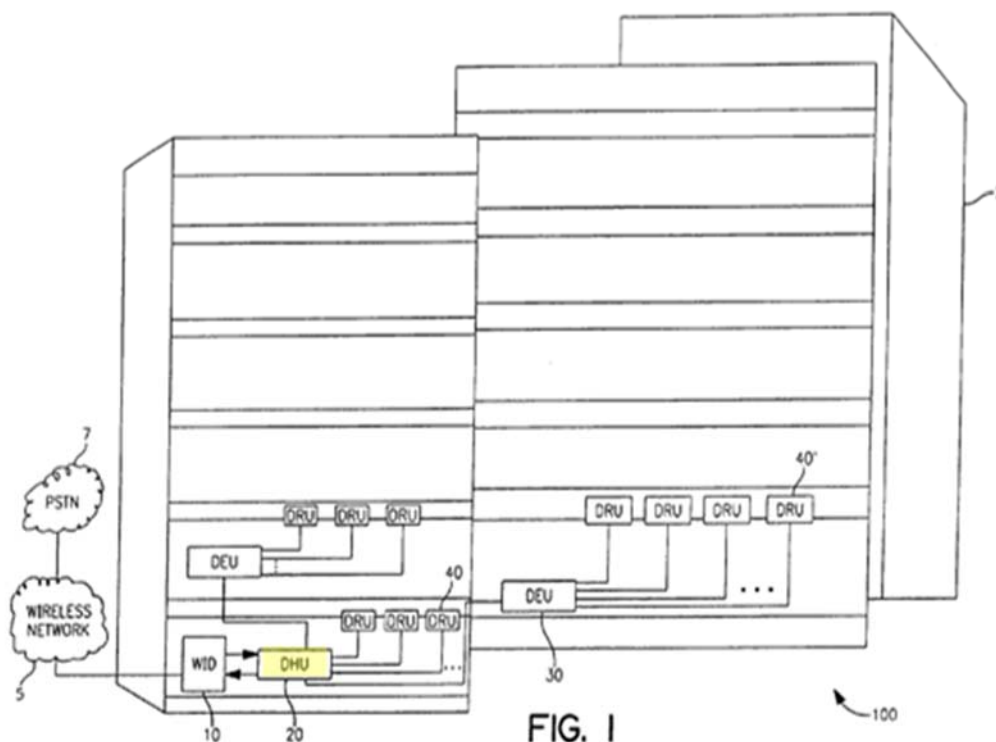
271. Thus Oh, alone or in combination with Curbelo renders obvious the signal derived from the signal output by the fourth mixer (150) that is digitized (at 180) to produce the downstream digital RF samples is produced by adding dither to the signal output by fourth mixer (*e.g.*, as described by Curbelo).

4. Dependent Claim 68

272. Dependent claim 68 recites “the first unit comprises at least one of a digital host unit and a digital expansion unit.” Oh’s master unit 20 transmits/receives analog signals to/from the base station and relays digital samples of those analog signals to/from remote slave units 30 across optic lines 50. Ex. 1007, 2:70-3:1; 4:62-64.



273. Oh's master unit 20 is analogous to the '982 patent's digital host unit (DHU) 20 which interfaces with a wireless interface device (WID) 10 that in embodiments comprises a base station (Ex. 1001, 4:28-29). And like Oh's master unit 20, on the forward path the '982 patent's DHU "receives RF signals from WID 10 [*i.e.*, base station] and converts the RF signals to digital RF signals. DHU 20 further optically transmits the digital RF signals to multiple DRUs 40."

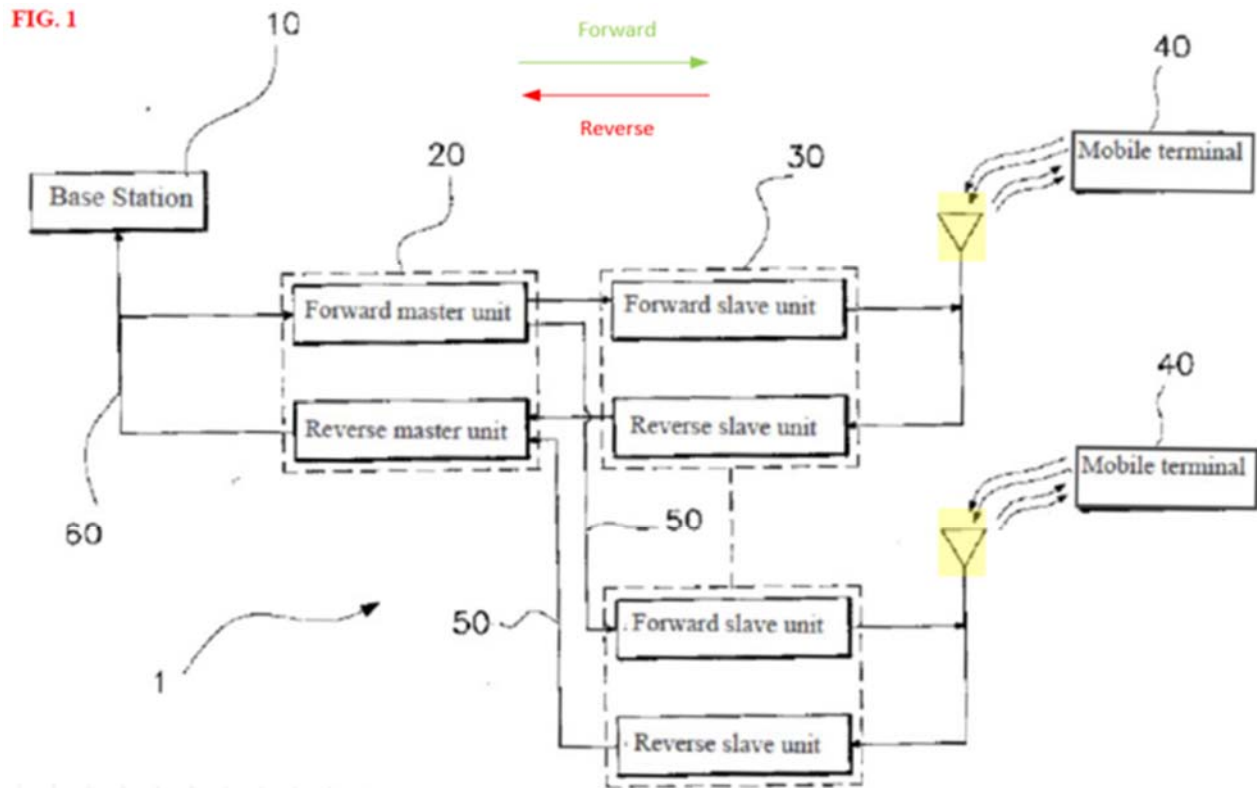


274. Because Oh's master unit 20 communicates analog signals bi-directionally with a base station, and communicates digital signals bi-directionally with multiple remote units (slave units 30), it is analogous to the host unit described in the '982 patent. Thus Oh renders obvious the first unit comprises at least one of a digital host unit (master unit 20) and a digital expansion unit.

5. Dependent Claim 69

275. Dependent claim 69 recites "each of the plurality of second units comprises at least one of a remote antenna unit and a remote expansion unit." Oh discloses multiple remote slave units 30, each slave unit 30 including an antenna for communicating with mobile terminals 40. Because each slave unit 30 includes an

antenna that is remote from master unit 20, those slave units 30 are “remote antenna units.”



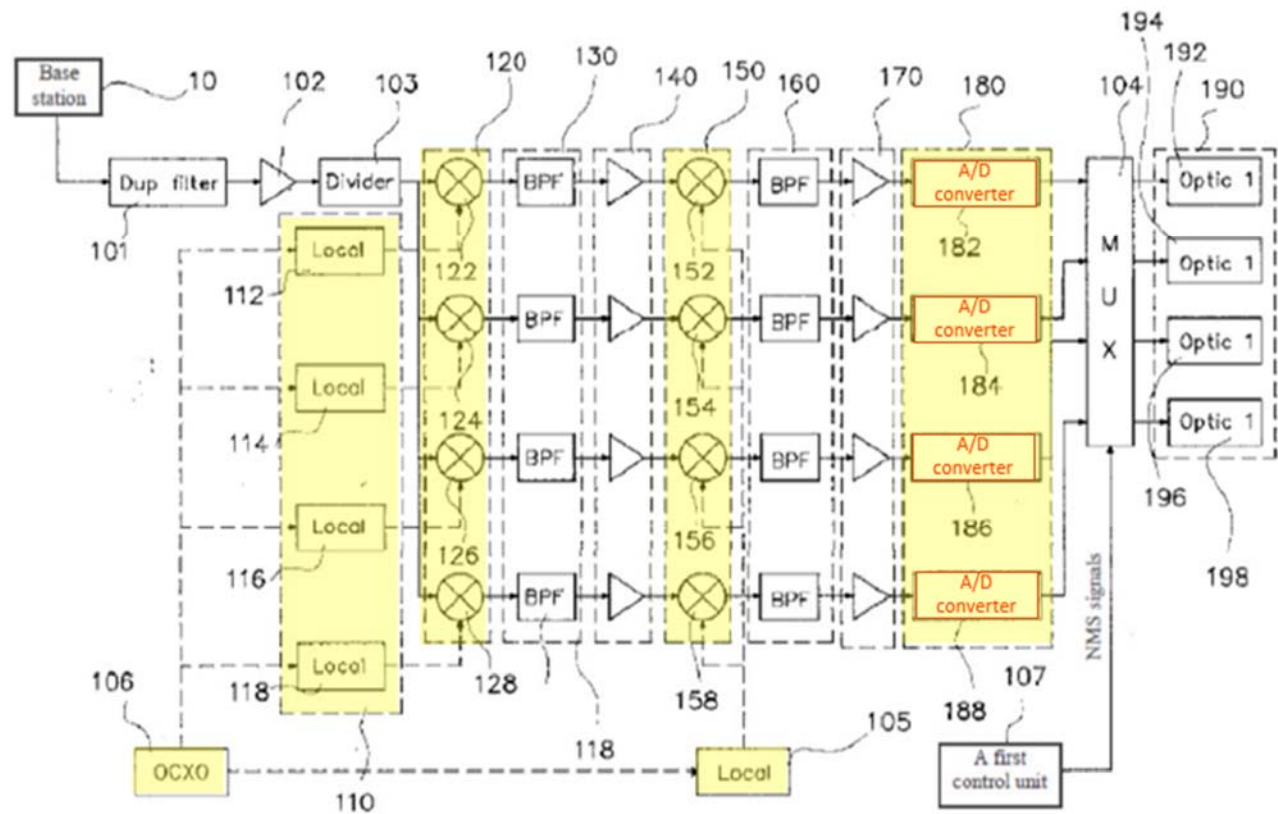
276. Thus Oh renders obvious each of the plurality of second units (30) comprises at least one of a remote antenna unit (*i.e.*, a remote antenna unit) and a remote expansion unit.

6. Independent Claim 74

277. The preamble of claim 74 recites a method relevant to a first unit that is communicatively coupled to a plurality of second units. The preamble is obvious based on Oh for the reasons noted above for the preamble and first element of claim 65. The first element of claim 74 is disclosed for the reasons provided above for claim

66, where Oh's A/D converter unit 180 digitizes downstream an analog frequency signal from the base station 10.

FIG. 2

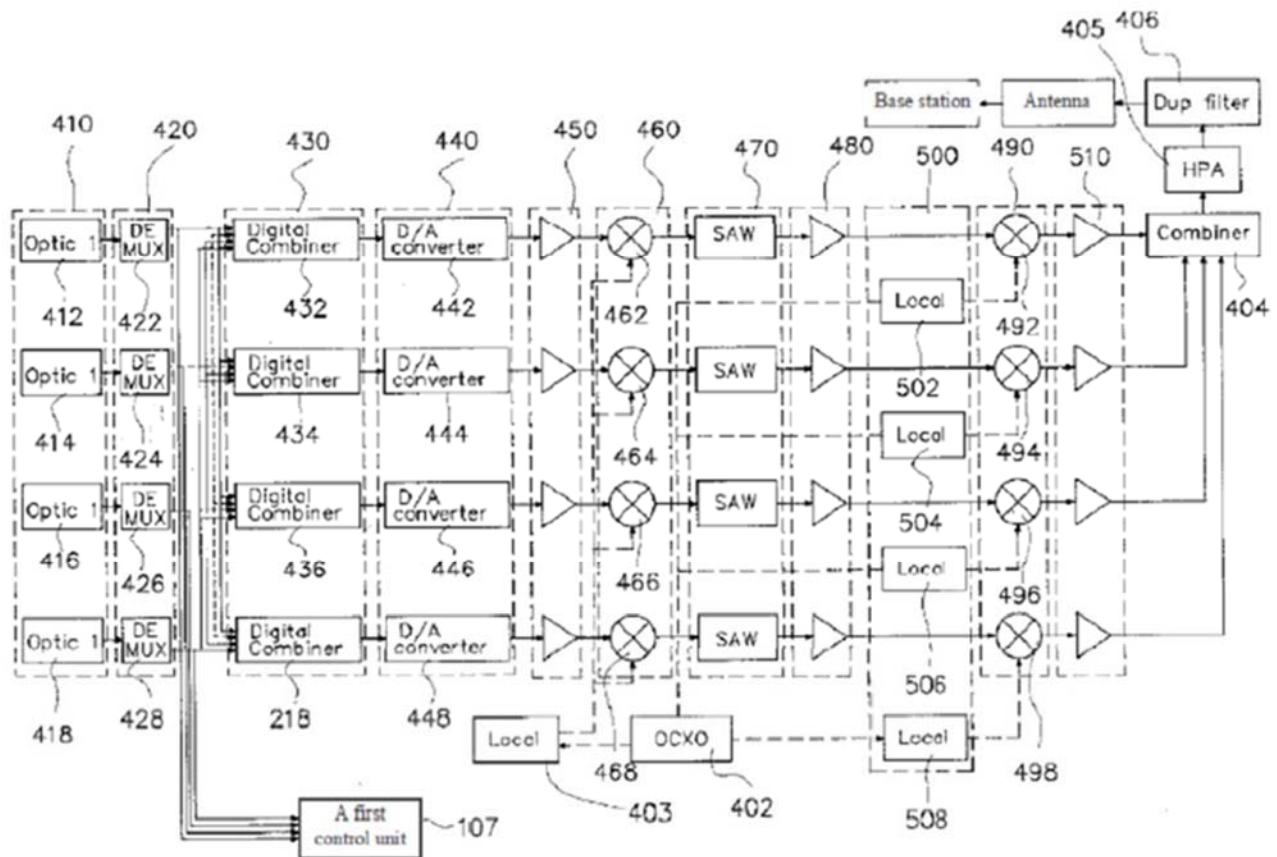


278. Regarding the second element of claim 74, Oh renders that limitation obvious for the reasons provided for element 1 of claim 65, where optic converter unit 190 provide an interface for communicating digital samples to slave units 30.

279. Regarding elements 3-5, Oh renders those limitations obvious for the reasons provided for 2 and 3 of claim 65, where optic converter unit 410 receives digital sample data from slave units 30, that digital sample data is unpacked and routed to the row associated with an appropriate frequency band at 420, and frequency band

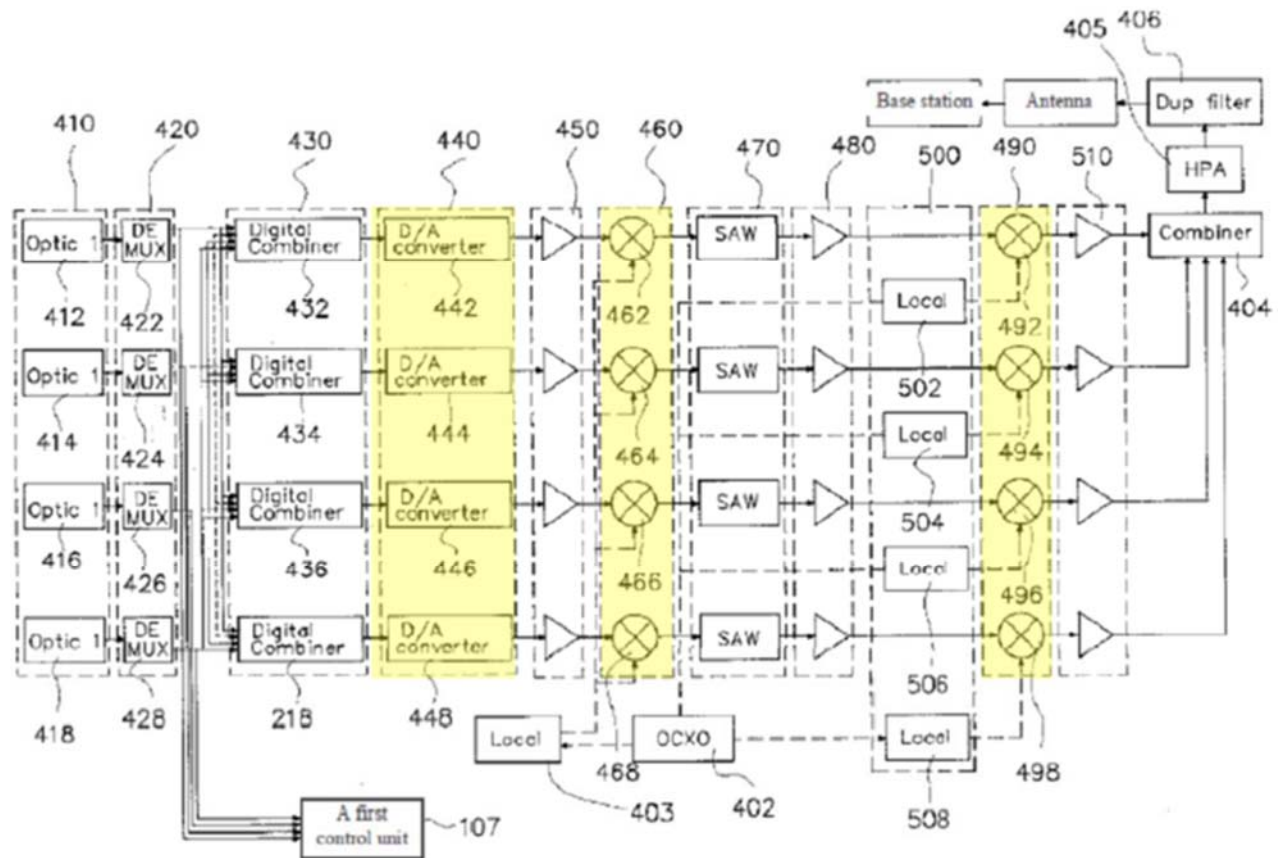
samples from the four slave units 30 connected to 412, 414, 416, 418 are summed at 430 to produce summed upstream digital RF samples that are converted from digital to analog at 440.

FIG. 5



280. Regarding elements 6-8, those elements are rendered obvious by Oh for the reasons provided above for claim 65, elements 6-8, where outputs from the D/A converter at 440 are mixed for a first time at 460 and a second time at 490 with reference signals from local oscillators, 403, 502, 504, 506, 508.

FIG. 5



D. Claims 11-24, 33, and 36 Are Obvious Over Oh in view of Schwartz

1. Motivation to Combine

281. A person of ordinary skill in the art would be motivated to combine the disclosures of Oh and Schwartz for a variety of reasons. As an initial matter, Oh expressly mentions the types of all-analog RF distribution system described by Schwartz in its “Conventional Technology” section, where Oh notes that in those systems where “the RF signals transmitted/received to/from said first optic repeater and a second optic repeater are analog signals, the strength of the signals is greatly decreased during transmission through the optical line.” Ex. 1007, 2:29-30. The

resulting amplification can cause signal-to-noise ratio issues in the analog signals that ultimately reach destinations at the host or remote units. *Id.*, 2:30-33. Because Oh expressly discusses the types of conventional, all-analog systems described in Schwartz, a POSITA would have recognized compatibilities in those systems and that Oh's digital relay improvements would have been applicable to Schwartz-type topologies (*i.e.*, topologies that incorporate intermediate stations 28 for distribution network expansion).

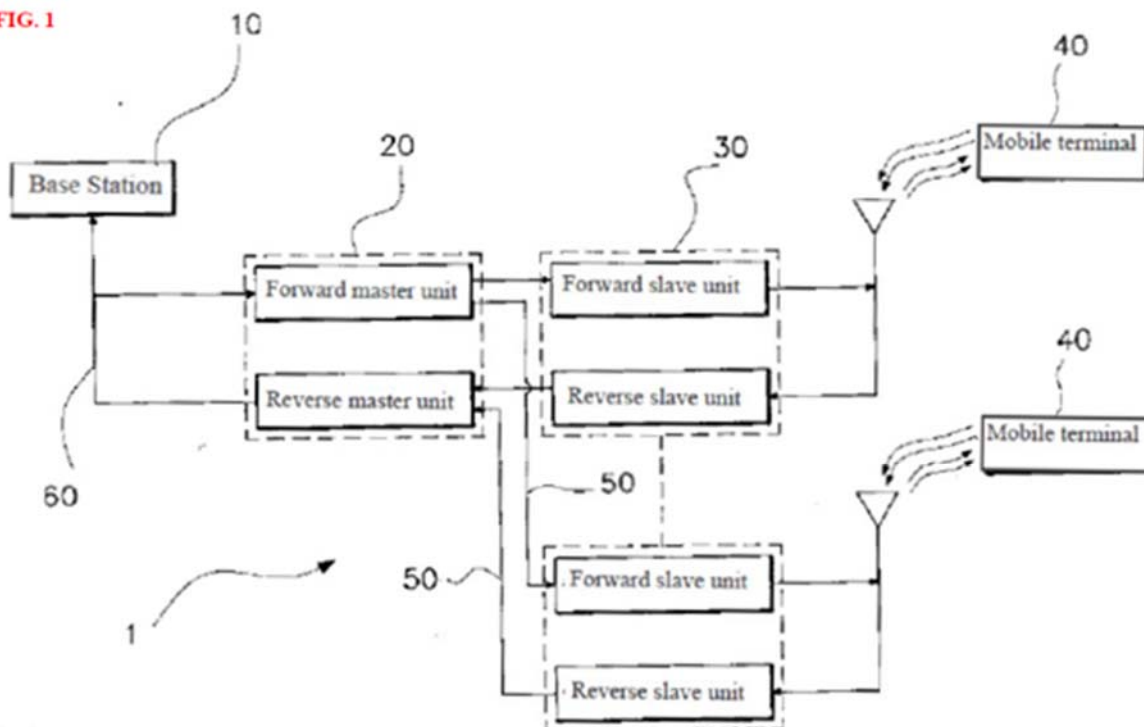
282. Additionally, a POSITA starting with Oh would have readily recognized a limitation in Oh's disclosure, where an RF distribution topology would have been limited to the number of remote slave units 30 corresponding to the number of master unit 20 optical ports (*i.e.*, four optic converters 192, 194, 196, 198 on the forward path and four optic converters 412, 414, 416, 418 on the reverse path limit master unit 20 to connection to four slave units 30). Schwartz's topology that supports intermediate stations 28 for RF distribution network expansion beyond the number of physical ports available at the host (*i.e.*, central station 20). Fig. 1 of Schwartz depicts the ability to daisy-chain intermediate stations 28 together such that a Schwartz network can be expanded to "any number of intermediate stations 28 and/or remote stations 22." Ex. 1010, 4:33-38. Thus a POSITA starting with Oh but looking to provide a large RF distribution network (*e.g.*, in a large building, a sports arena) would be motivated to utilize Schwartz intermediate stations 28 to facilitate that expansion.

2. Independent Claim 14

a) Preamble: “A digital radio frequency transport system, comprising:”

283. To the extent the preamble of claim 14 is limiting, it is rendered obvious by Oh. As discussed above, Oh discloses a Digital Optic Repeater system that receives RF signals, from a base station 10 at a master unit 20 and from mobile terminals at remote slave units 30. The optic repeater 1 is installed in a radio wave shadow area and converts received analog signals to intermediate frequency signals (*e.g.*, close to DC in the example at 3:11-14) and then to digital signals for mutual transmission and reception to one another across optic lines 50. Ex. 1007, Abstract, Fig. 1. At a destination unit, the digital signals transmitted across the optic lines 50 are converted to analog signals, and upconverted to RF signals for transmission to their destination (*e.g.*, base station 10 or mobile terminals 40). *Id.*

FIG. 1



284. Patent Owner has made clear in a prior litigation that “digital radio frequency (RF)” as that term is used in the ’982 patent refers to sampling of any of baseband signals, intermediate frequency signals, or radio frequency signals. *See*, Ex. 1008, Acampora Report, ¶136 (“Accordingly, the baseband digital samples, any intermediate frequency digital samples, and any radio frequency digital samples are all referred to a[s] being digital RF.”) Oh’s disclosure of A/D conversion (*i.e.*, sampling) of intermediate frequency signals, including signals down converted to close to DC (*i.e.*, baseband signals) is disclosure of digital radio frequency data as that term is used in the ’982 patent.

285. Oh therefore renders obvious each limitation recited in the preamble of claim 14 by disclosing a digital radio frequency (digital samples of intermediate frequency/baseband analog signals) transport system (transmission of those digital signals among the master 20 and slave units 30 across optic lines 50).

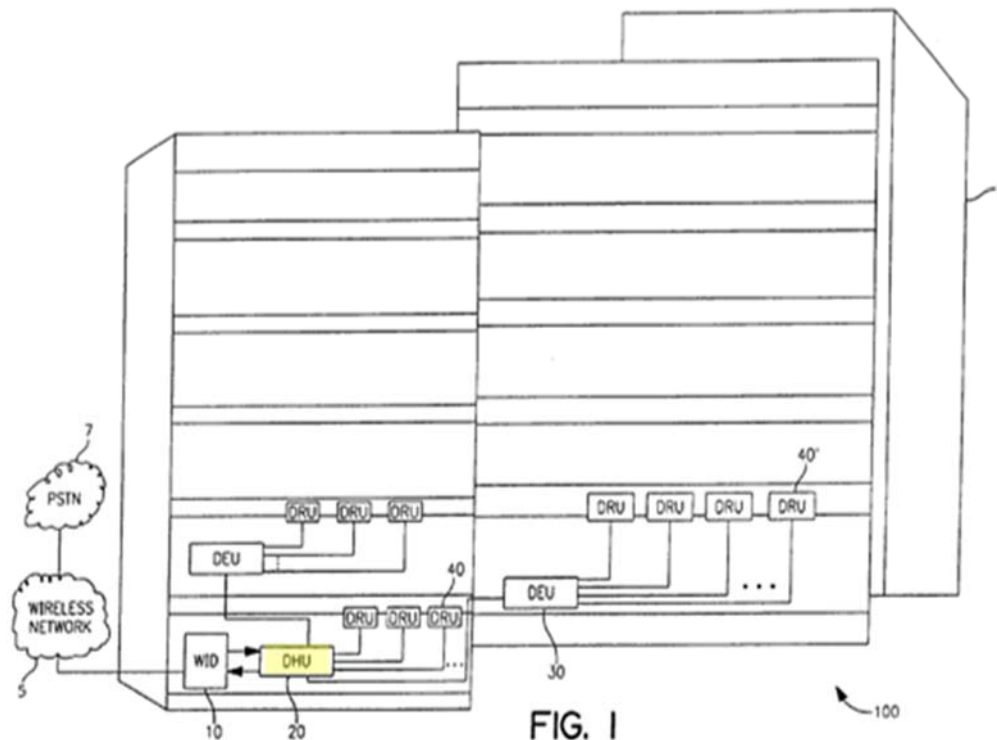
b) Element 1: “a digital host unit;”

286. Element 1 of claim 14 is rendered obvious by Oh. As discussed above and as shown in Fig. 1, Oh’s master unit 20 transmits/receives analog signals to/from the base station and relays digital samples of those analog signals to/from remote slave units 30 across optic lines 50. Ex. 1007, 2:70-3:1; 4:62-64.



287. Oh’s master unit 20 is analogous to the ’982 patent’s digital host unit (DHU) 20 which interfaces with a wireless interface device (WID) 10 that in embodiments comprises a base station (Ex. 1001, 4:28-29). And like Oh’s master unit 20, on the forward path the ’982 patent’s DHU “receives RF signals from WID 10

[i.e., base station] and converts the RF signals to digital RF signals. DHU 20 further optically transmits the digital RF signals to multiple DRUs 40.”



288. Because Oh’s master unit 20 communicates analog signals bi-directionally with a base station, and communicates digital signals bi-directionally with multiple remote units (slave units 30), it is analogous to the host unit described in the ’982 patent. Thus Oh renders obvious a digital host unit (master unit 20).

c) Element 2: “at least one digital expansion unit coupled to the digital host unit;”

289. Element 2 is rendered obvious by Oh in view of Schwartz. Schwartz discloses an RF distribution network whereby external RF signals are transmitted to remote stations for wireless transmission via a central station 20. Schwartz discloses

that remote stations may be directly connected to the central station 20 or through intermediate stations 28, where each intermediate station 28 may be connected to multiple remote stations 22. And further intermediate stations 28 may be connected to additional intermediate stations 28 to act as signal relays between central station 20 and remote stations 22. Such intermediate stations 28 enable topologies that “connect central station 20 directly to any number of intermediate stations 28 and/or remote stations 22.” Ex. 1010, 4:33-38.

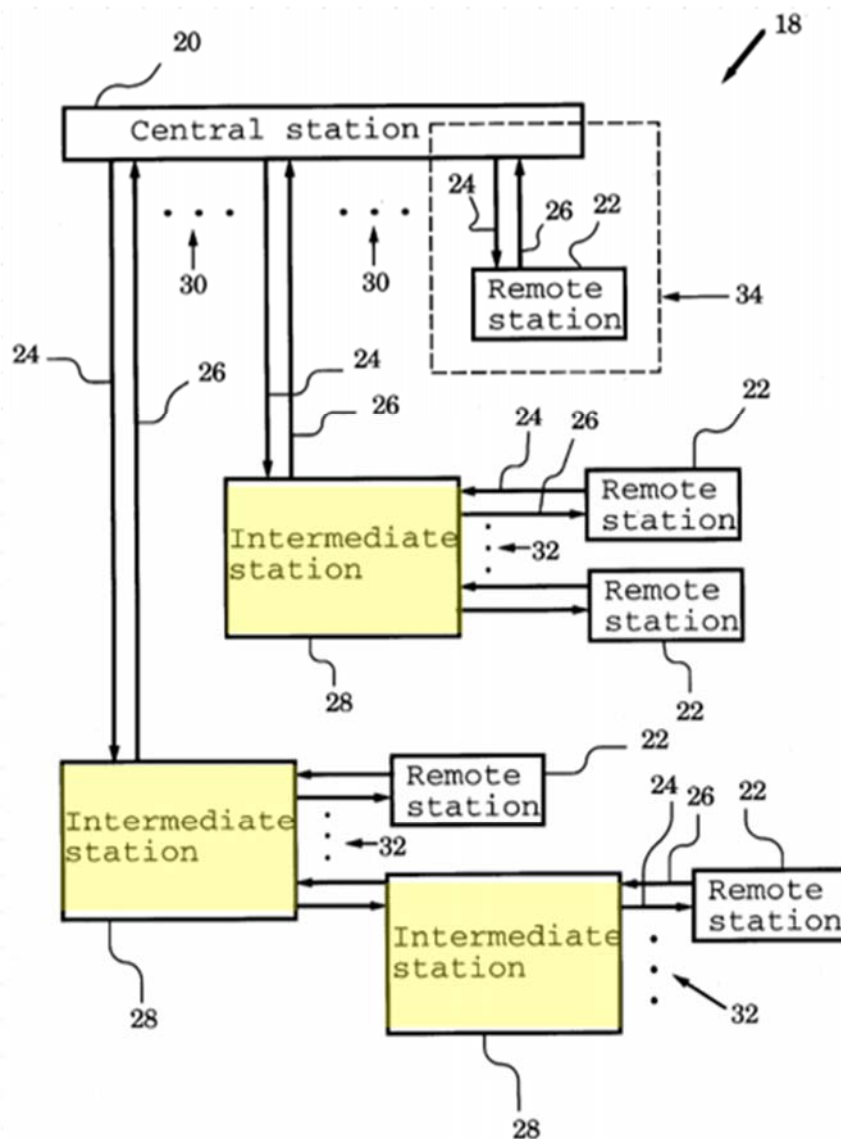


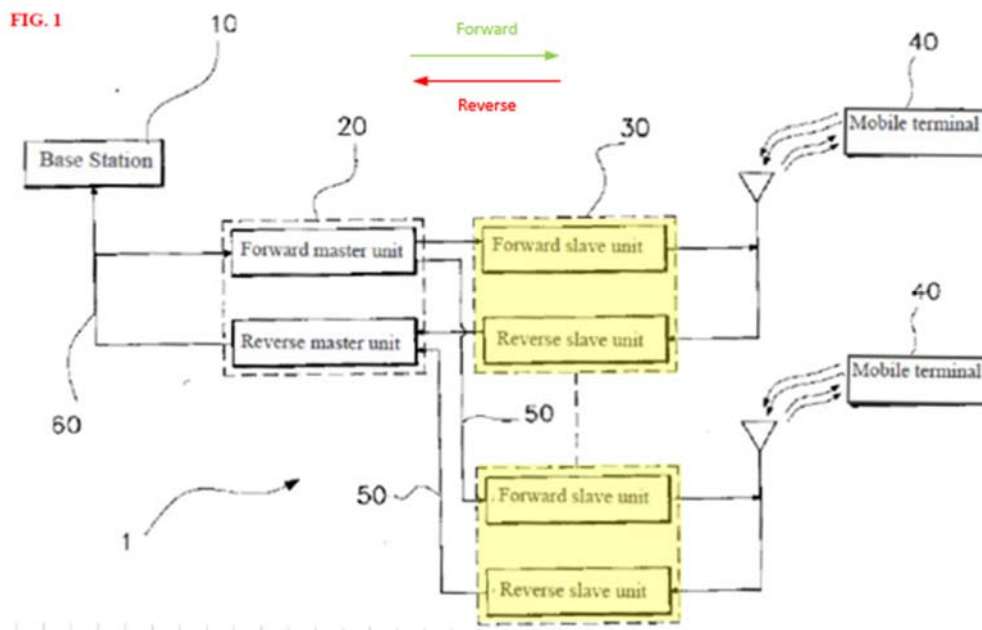
FIG. 1

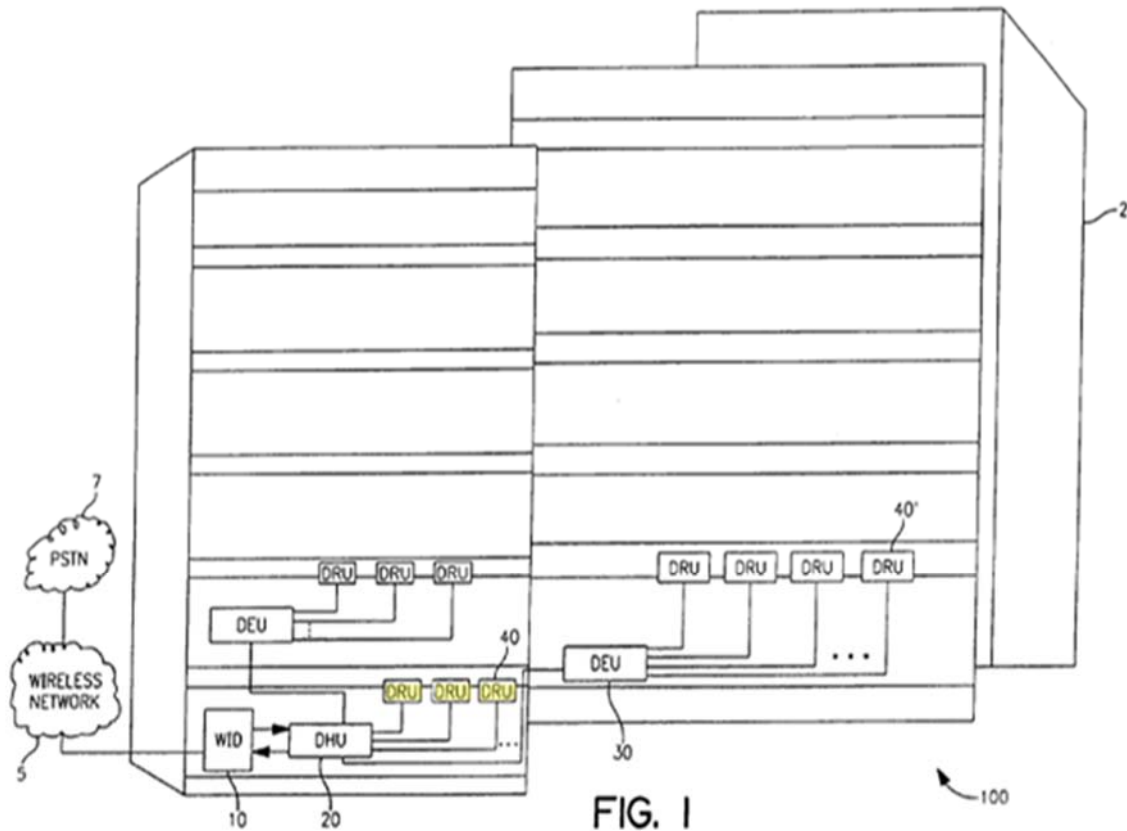
290. As described above, a POSITA would have been motivated to incorporate Schwartz intermediate stations 28 into Oh's system to enable connection to more remote units (*e.g.*, slave units 30), where Oh's system was limited in the number of slave units 30 to which master unit 20 could be connected by master unit 20's optical ports (*e.g.*, four ports in Figs. 2 & 5). Thus Oh in view of Schwartz

renders obvious at least one digital expansion unit (Schwartz intermediate station 28) coupled to the digital host unit (Oh master unit 20).

d) Element 3a: “at least two digital remote units, each coupled to one of the digital host unit and the digital expansion unit,”

291. Element 3a is rendered obvious by Oh in view of Schwartz. Oh’s slave units 30 convert “the digital signals transmitted from the master unit 20 through the optic line 50 to intermediate frequency signals, analog signals; converts them to the RF signals and transmits them to the mobile terminals 40.” Ex. 1007, 3:47-49. Oh’s slave units 30 further convert analog signals from the mobile terminals 40 to digital signals and transmit them to master unit 20. *Id.*, 4:23-25.





292. Oh's slave units 30 are analogous to the '982 patent's digital remote units (DRUs) that digitally communicate with the DHU via optic cables (Ex. 1001, 3:61-64) and wirelessly communicate with devices in their area (*e.g.*, via antenna 599). Thus Oh discloses remote units coupled directly to a host unit.

293. Schwartz Fig. 1 discloses remote stations 22 connected both directly to host central station 20 and expansion intermediate stations 28.

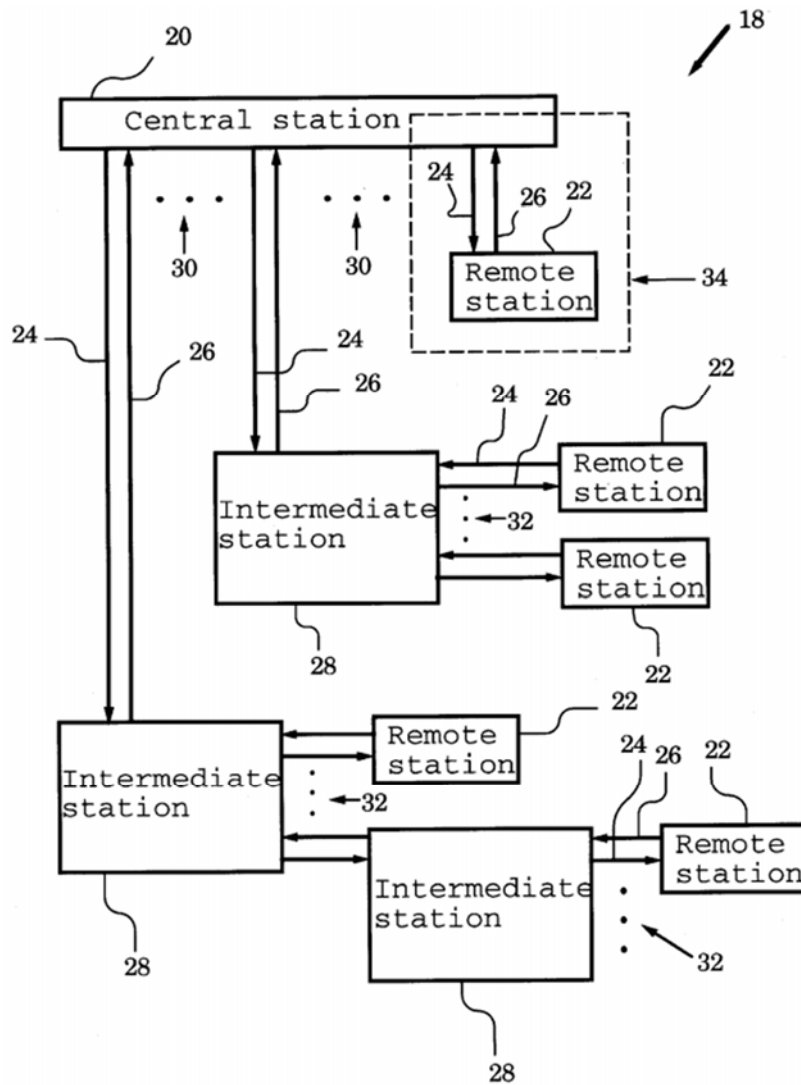
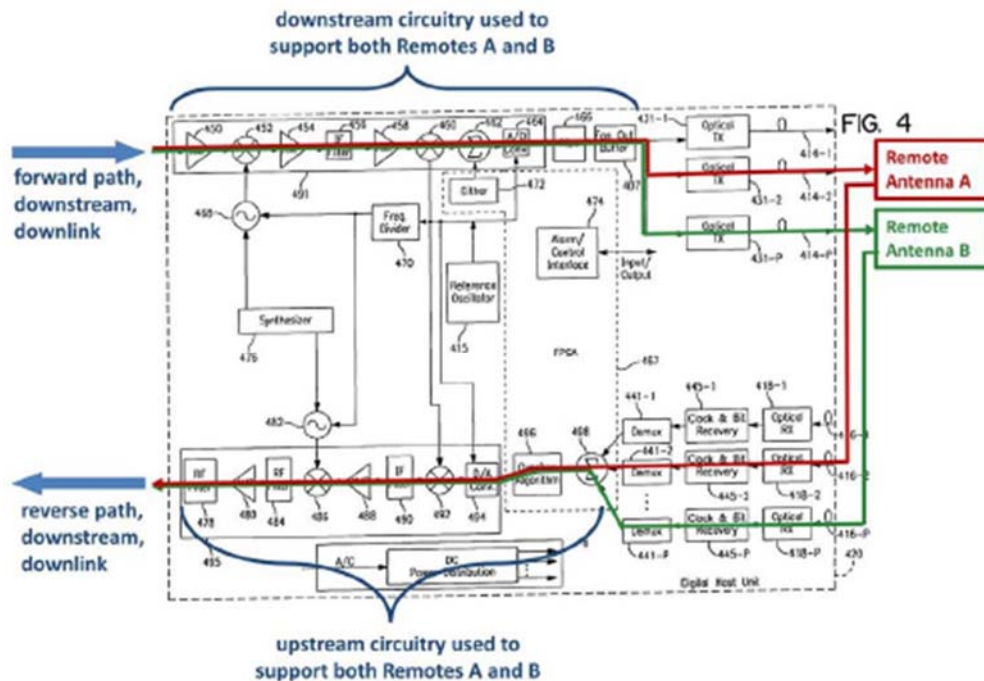


FIG. 1

294. Thus Oh in view of Schwartz renders obvious at least two digital remote units (Oh slave units 30; Schwartz remote stations 22), each coupled to one of the digital host unit (Oh master unit 20; Schwartz central station 20) and the digital expansion unit (Schwartz intermediate station 28).

e) *Element 3b: “wherein the digital host unit includes shared circuitry that performs bi-directional simultaneous digital radio frequency distribution of digitized radio frequency signals between the digital host unit and the at least two digital remote units;”*

295. Element 3b is rendered obvious by Oh. While the '982 patent's specification does not use the term “shared circuitry” beyond paraphrases of the claim language, in a prior litigation, Patent Owner has clarified their position that “‘shared circuitry’ was intended to mean circuitry that is used to support more than one remote unit.” Ex. 1008, ¶316. In that same document, Patent Owner illustrated and discussed what it envisioned as the “shared circuitry” at paragraphs 323-324.

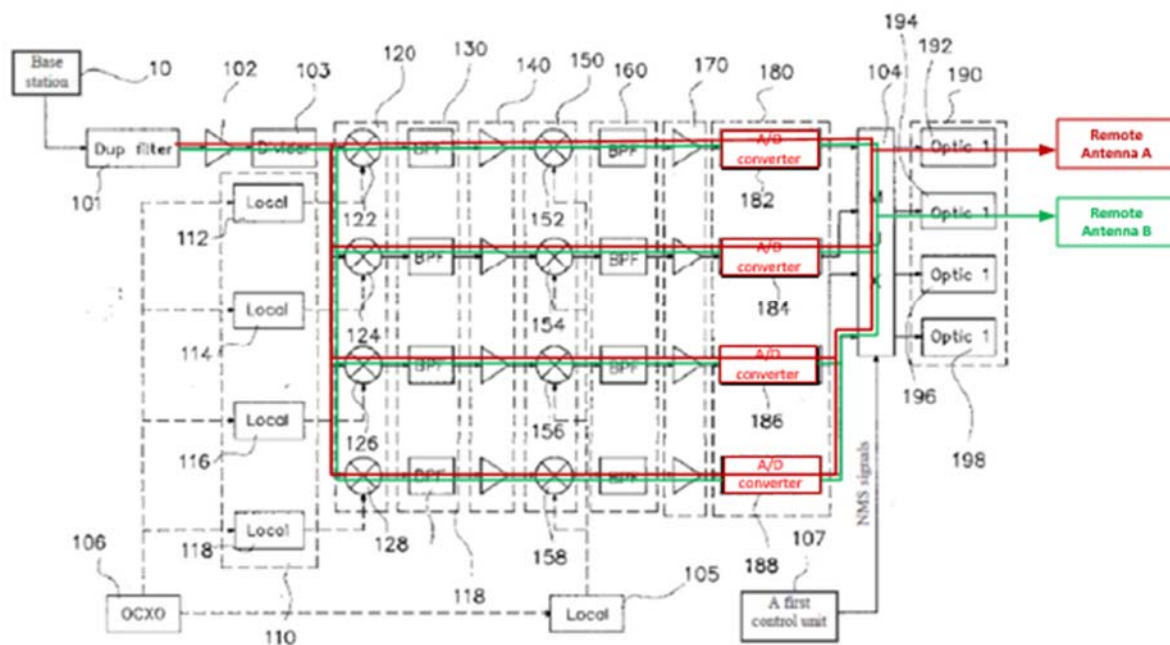


296. There it identified '982 patent's “circuitry in box 491, the mux 465, and fan out buffer 431” as the downstream shared circuitry for providing digital radio

frequency distribution of digitized radio frequency signals, and “summing unit 498 of the FPGA, the overflow algorithm and the circuits of box 495” as the upstream shared circuitry. *Id.*, ¶324

297. Oh discloses an analogous arrangement of components. On the downstream path of Fig. 2, Oh’s circuitry at 120, 130, 140, 150, 160, 170, 180 down converts the analog signal received from the base station to near DC and samples that data, just like the ’982 patent’s “circuitry in box 491.” Oh similarly includes a multiplexer 104 that serializes the digitized data and distributes it to the remote slave units.

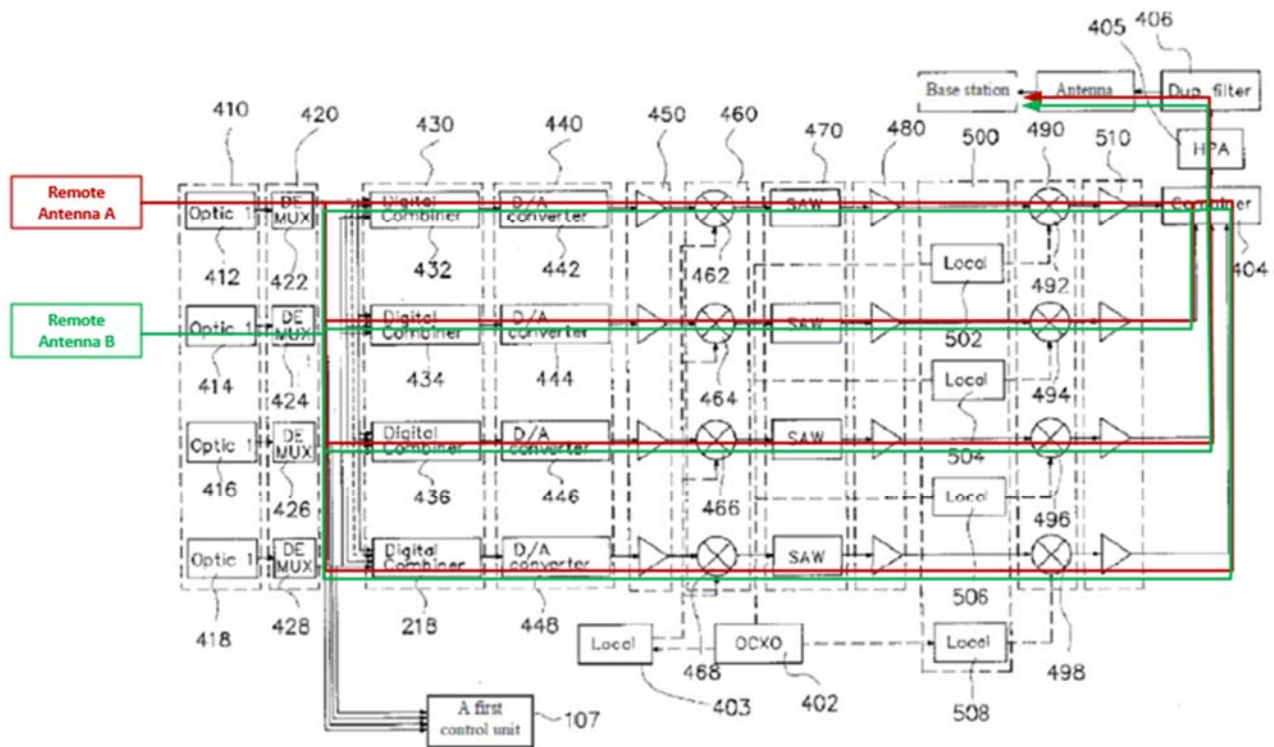
FIG. 2



298. And on the reverse path, Oh’s digital combiner unit 430 aggregates (*i.e.*, digitally sums) digitized radio frequency signals received at master unit 20 from

multiple slave units 30 (*see*, Ex. 1007, 4:68-70; 5:16-17) and then converts the resulting sums to analog signals and processes those analog signals to generate a signal at 404 that represents all of the data received from the multiple slave units 30 (*i.e.*, an output RF signal containing the same information contained in the '982 patent's RF signal output).

FIG. 5



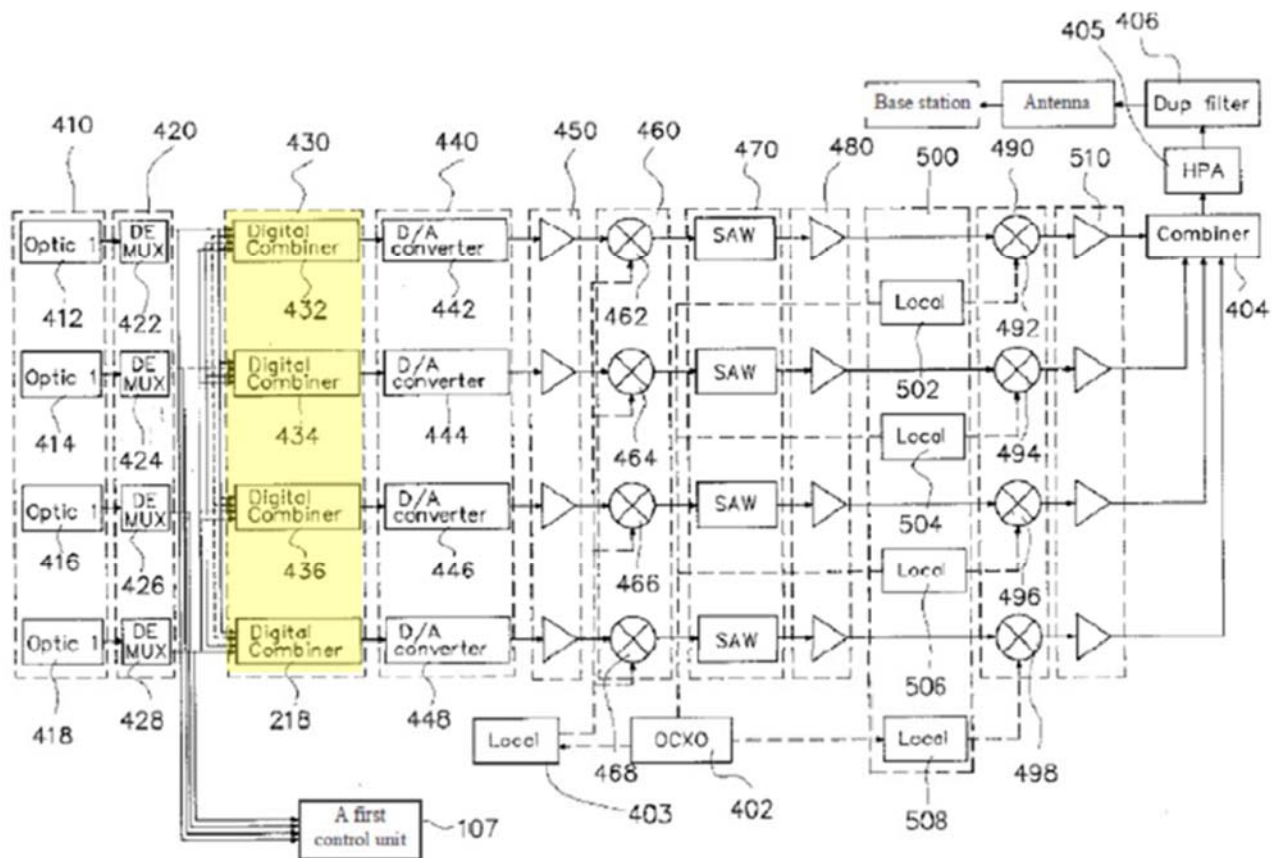
299. Thus Oh renders obvious the digital host unit (master unit 20) includes shared circuitry (downstream 104, 120-190); upstream 420-510, 404) that performs bi-directional simultaneous digital frequency distribution (signals transmitted from 190 and at the same time, signals received at 430 at the same time) of digitized radio frequency signals (intermediate frequency signals sampled at the master unit at 180

and slave units at 380) between the digital host unit (master unit 20) and the at least two digital remote units (slave units 30).

f) Element 4: “wherein the digital host unit digitally sums the digitized radio frequency signals received at the digital host unit.”

300. Element 4 of claim 14 is rendered obvious by Oh. Oh’s master unit 20 includes a digital combiner unit 430 that performs digital combining by aggregating digital signals transmitted from each demultiplexer sub-unit 422, 424, 426, 428 of demultiplexer unit 420. Ex. 1007, 4:68-70.

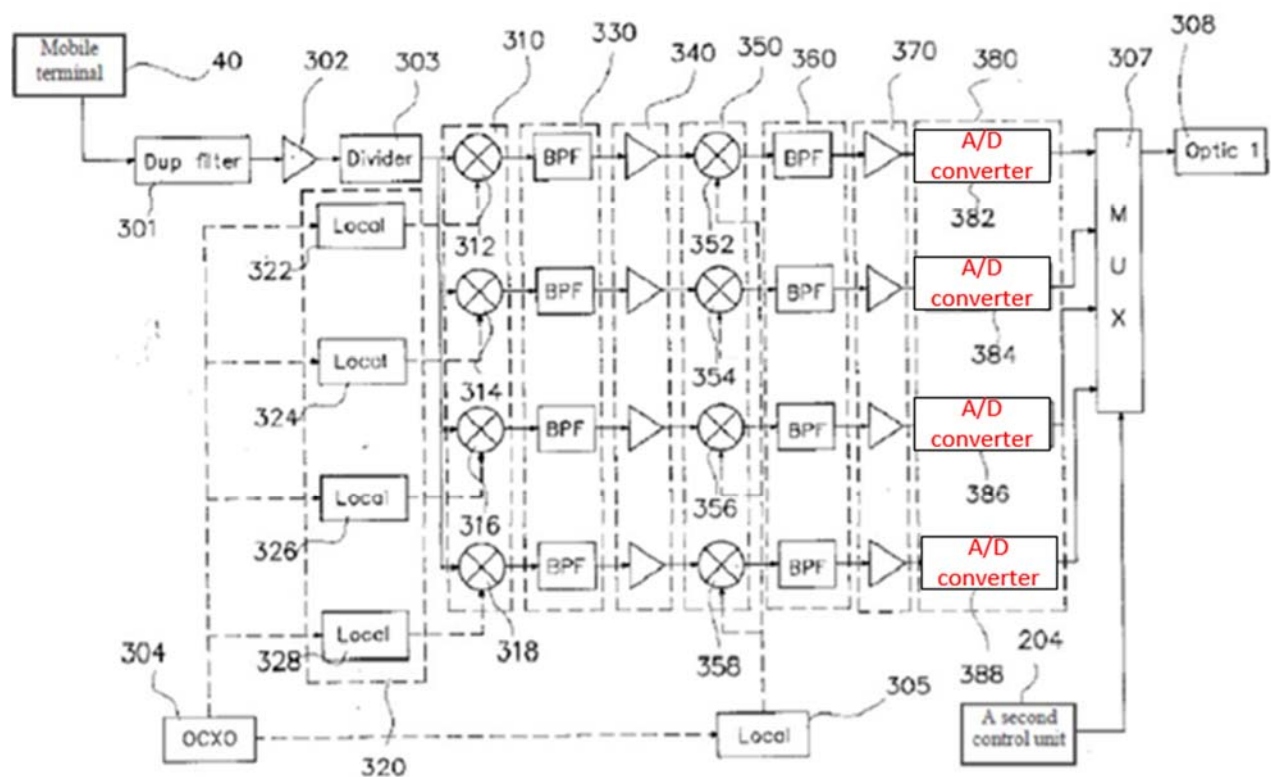
FIG. 5



Those demultiplexers at 420 receive data from individual remote slave units 30 at 410.

301. As depicted in Fig. 4, each slave unit 30 receives an analog signal from mobile terminals 40, divides the received analog signal into its component frequency bands at 303 and downconverts the frequency band signals to near DC at 310-370. Ex. 1007, 4:26-34. The downconverted band signals are then sampled at 380 to create 12-bit digitized radio frequency signals. *Id.*, 4:56-61. The multiplexer 307 multiplexes the four 12-bit samples with 4 bits of control data from 204 to form 52-bit serial data signals that are forwarded to master unit 20. *Id.*

FIG. 4



302. Referring back to Fig. 5, each demultiplexer 422, 424, 426, 428 receives a 52-bit signal from its respective slave unit 30. Each demultiplexer forwards 12-bits of sample data to the appropriate digital combiner associated with the proper

frequency band for that 12-bit sample and forwards its 4 bits of control data to control unit 107. Upon receiving four 12-bit signals (one from each of demultiplexer 422, 424, 426, 428), each digital combiner 432, 434, 436, 438 combines those 12-bit signals to “creat[e a] 14-bit intermediate frequency signals by combining⁷ four 12-bit intermediate frequency signals in the same frequency band” (*e.g.*, (1010 1010 1010 (2,730) + 1100 1100 1100 (3,276) + 1111 1111 1111 (4,095) + 0000 1100 1100 (204) = 10 1000 0100 0001 (10,305)). Ex. 1007, 5:16-17. Those 14-bit signals are then converted to analog signals at 440, upconverted, combined, and transmitted to the base station 10. *Id.*, 5:17-29.

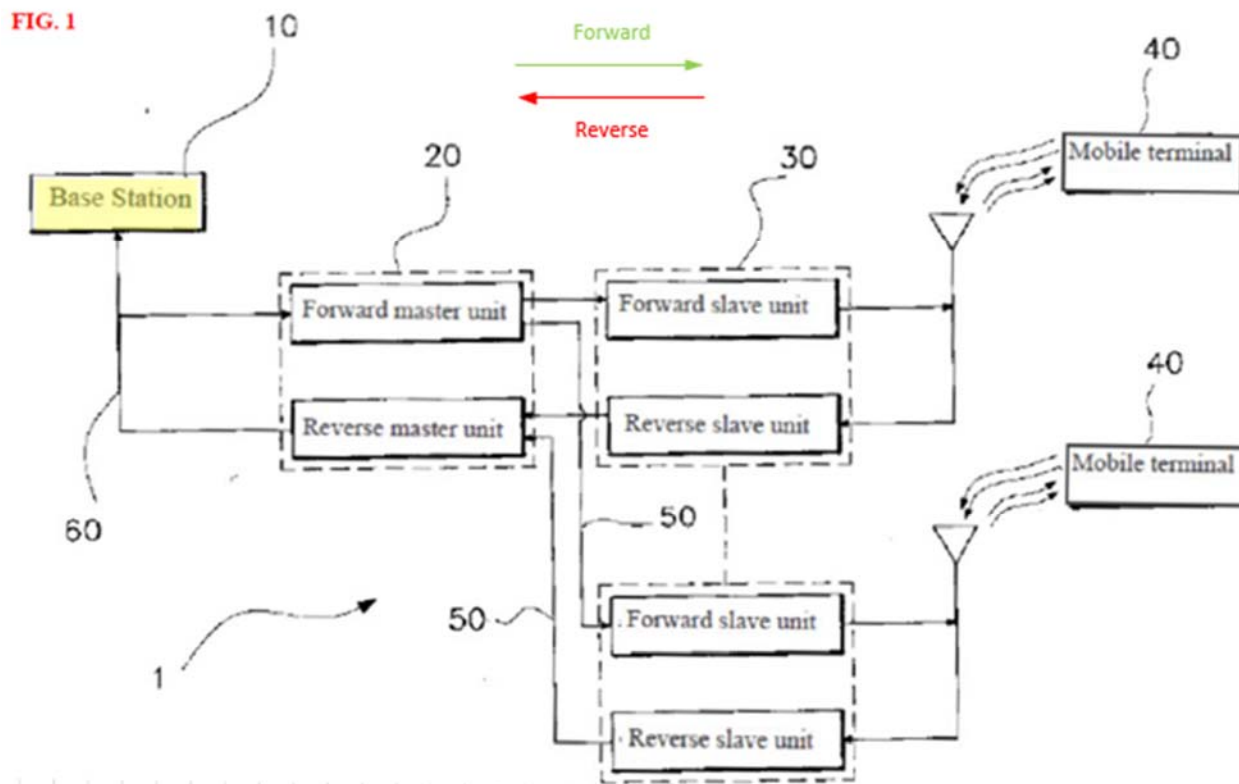
303. Thus Oh renders obvious the digital host unit (master unit 20) digitally sums the digitized radio frequency signals (creates 14-bit signals by combining four 12-bit signals) received at the digital host unit. Oh in view of Schwartz therefore renders obvious each limitation recited in claim 14.

3. Dependent Claim 15

304. Claim 15 recites “a wireless interface device coupled to the digital host unit.” The ’982 patent states that in one embodiment a wireless interface device

⁷ I understand that the parties have discussed whether this word should be translated as “adding” or “combining.” Regardless of which of these terms is used, the digital combiners are operating to produce a digital sum (*i.e.*, they are performing a digital summing operation).

comprises a base station. Ex. 1001, 4:28-30. Fig. 1 of Oh depicts a base station 10 coupled to master unit 20.



305. Thus Oh renders obvious a wireless interface device (base station 10) coupled to the digital host unit (master unit 20).

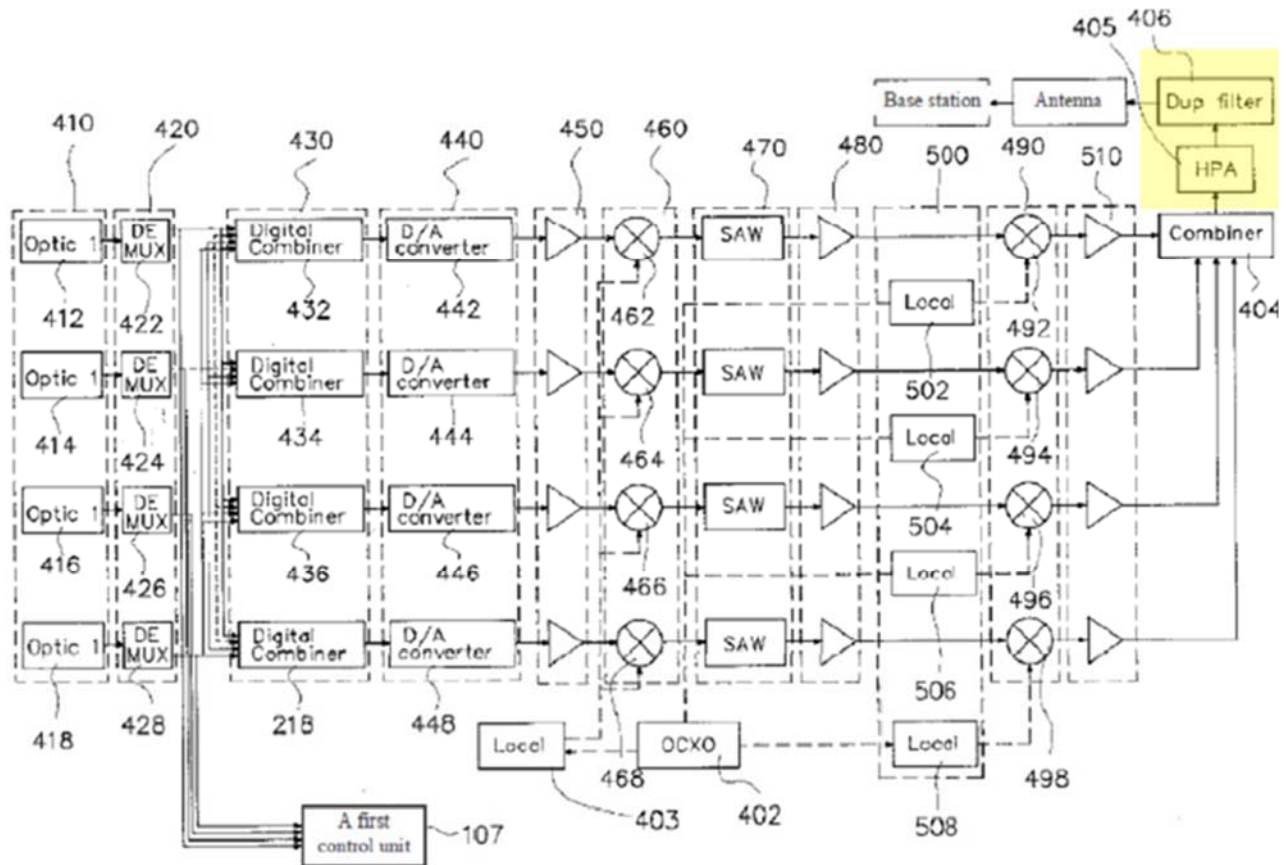
4. Dependent Claim 16

306. Claim 16 recites that “the wireless interface device comprises a base station that couples directly to the digital host unit via coaxial cables.” Oh discloses that RF signals are transmitted from base station 10 to master unit 20 through “RF cable.” Ex. 1007, 2:71-72. A POSITA in July 2000 would have understood a reference to RF cable to mean coaxial cable. *See, e.g.,* Ex. 1025, 1:27-29. Thus Oh

renders obvious the wireless interface device comprises a base station (10) that couples directly to the digital host (30) unit via coaxial cables (RF cable).

FIG. 2

FIG. 5

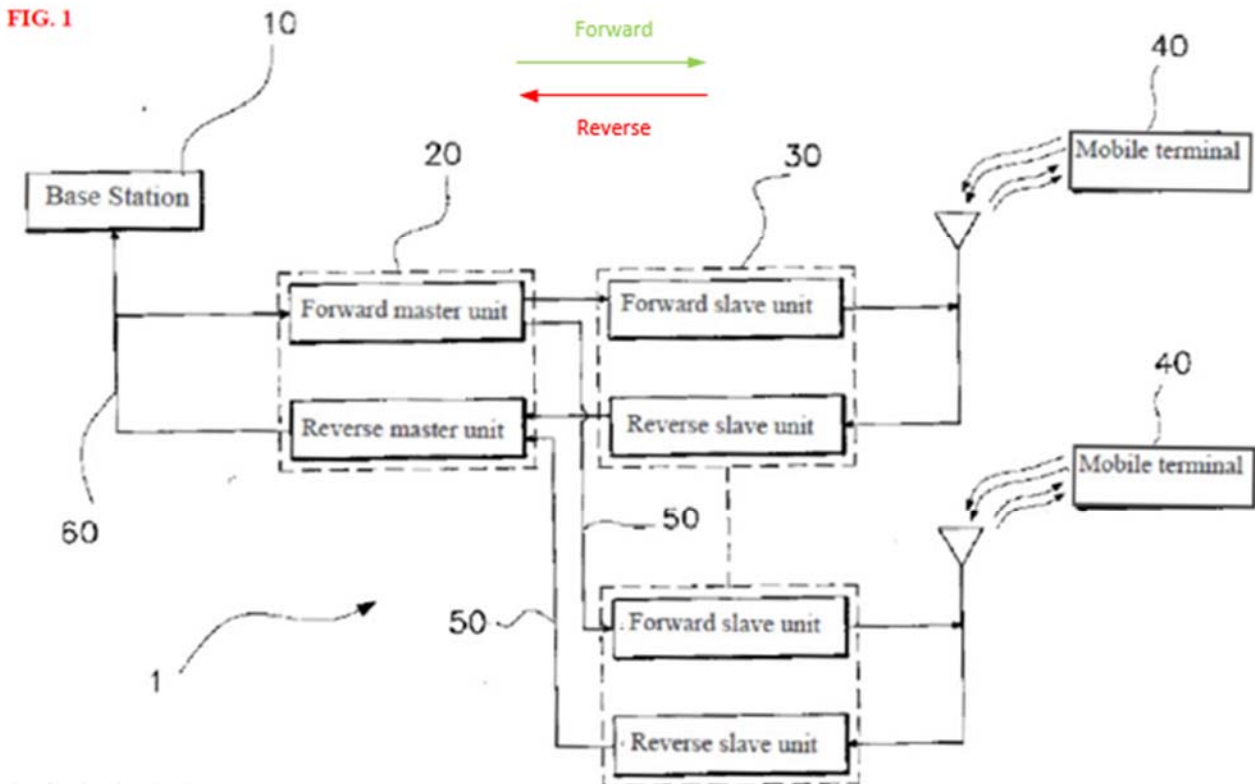


308. A POSITA understands that a bi-directional amplifier comprises a bi-directional duplex filter component to prevent the transmit signal from interfering with the receive channel and an amplifier component. Fig. 5 of Oh illustrates its bi-directional filter 406 being connected to an antenna for wireless communication with the base station 10.

309. Thus Oh renders obvious the wireless interface device comprises a base station (10) that wirelessly connects (*see* Fig. 5 Antenna) to the digital host unit (master unit 20) via a bi-directional amplifier (101, 102, 405, 406).

6. Dependent Claim 18

310. Claim 18 recites that “at least one of the at least two digital remote units is coupled to the digital host unit.” Oh discloses multiple slave units 30 connected to master unit 20 via optic lines 50.



311. Thus Oh renders obvious at least one of the at least two digital remote units (slave units 30) is coupled to the digital host unit (master unit 20).

7. Dependent Claim 19

312. Claim 19 recites that “at least one of the at least two digital remote units is coupled to the at least one digital expansion unit.” As noted above, a POSITA would have been motivated to incorporate Schwartz-type intermediate stations 28 to

enable RF distribution network expansion. Schwartz discloses remote stations 22 that are connected directly to the central station 20 at 34, as well as several remote stations 22 connected to expansion intermediate stations 28.

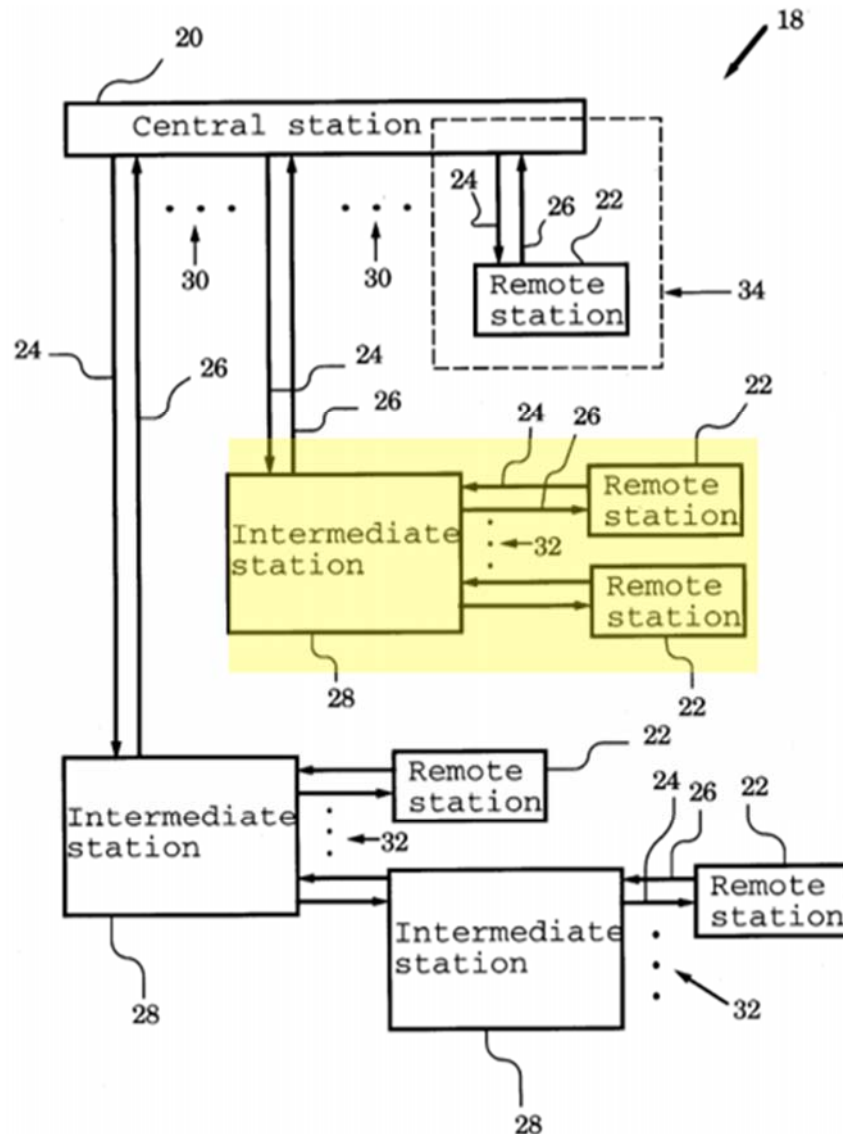


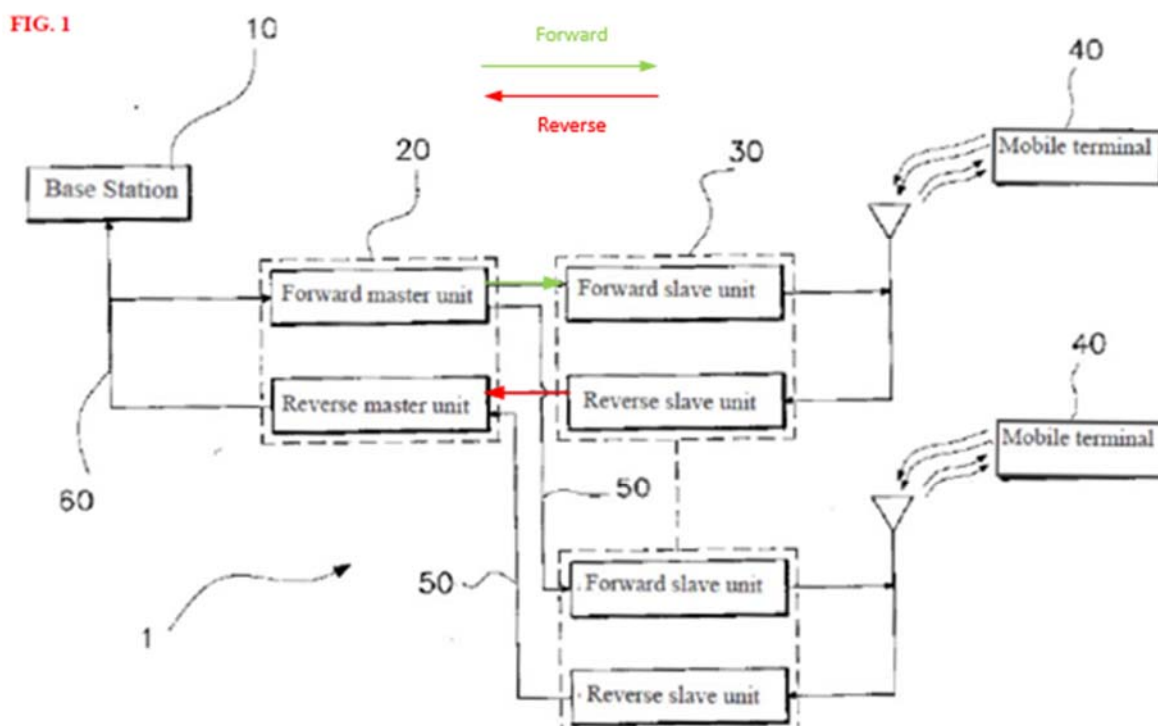
FIG. 1

Thus Oh in view of Schwartz renders obvious at least one of the at least two digital remote units (remote station 22) is coupled to the at least one digital expansion

unit (intermediate station 28).

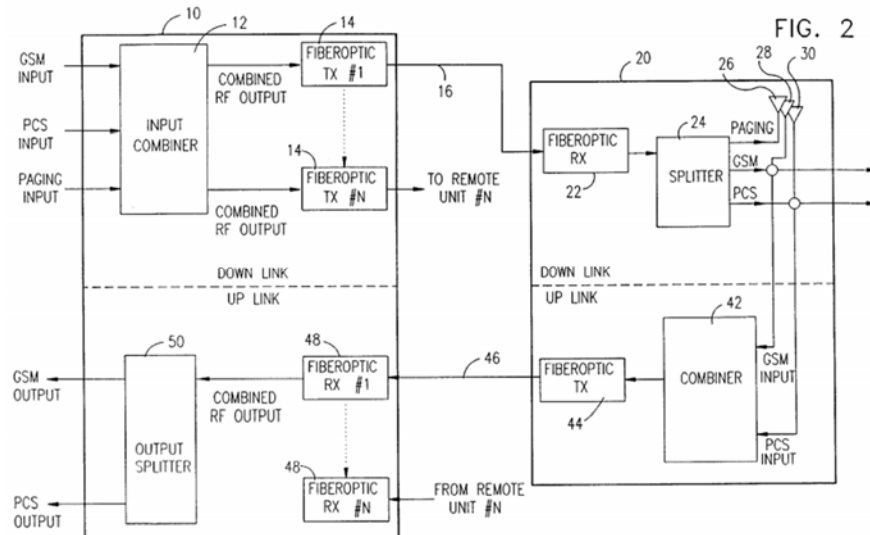
8. Dependent Claim 20

313. Claim 20 recites that “the at least one digital expansion units are each coupled to the digital host unit via a multimode fiber pair.” Schwartz Fig. 1 illustrates its intermediate stations 28 being coupled to central station 20 via separate downlink cable 24 and uplink cable 26, this is similar to Oh Fig. 1, which illustrates master unit 20 communicating in a forward direction with a slave unit 30 using one optic line 50, and in a reverse direction with that same slave unit 30 using a second optic line 50.



314. In an Oh-Schwartz system that communicates using optic lines, like in Oh, a POSITA would consider selection of multimode or single mode to be a matter of design choice. This is evidenced by Farber which describes the use of single or

multimode fiber in an antenna system for reaching difficult coverage areas (see Fig. 1) that is very similar to the digital system of Oh. Ex. 1022 (“Farber”), 4:30-33 (“Preferably the transmitter 14 employs a vertical cavity surface emitting laser or an edge emitting laser coupled to a single or multi-mode fiber 16.”); Fig. 2. As further evidence of obviousness of using single or multimode fiber, Haas illustrates the cost-benefit analysis of selection of multimode or single mode fiber for an application. Ex. 1012, 1125. A POSITA would have been motivated to select multimode fiber as disclosed by Haas for communicating among a host and remote units when cost is a significant factor for the project. Additionally as disclosed by Haas, in some instances multimode fiber may already be installed in an area into which an RF distribution network is being implemented, making reuse of that multimode fiber an attractive option.



315. Thus Oh in view of Schwartz, or further in view of Farber to the extent that the cost-benefit analysis of single vs. multimode fiber was not background state of the art knowledge, renders obvious the at least one digital expansion units (intermediate station 28) are each coupled to the digital host unit (Oh master unit 20) by a multimode fiber pair (*e.g.*, as disclosed by Farber).

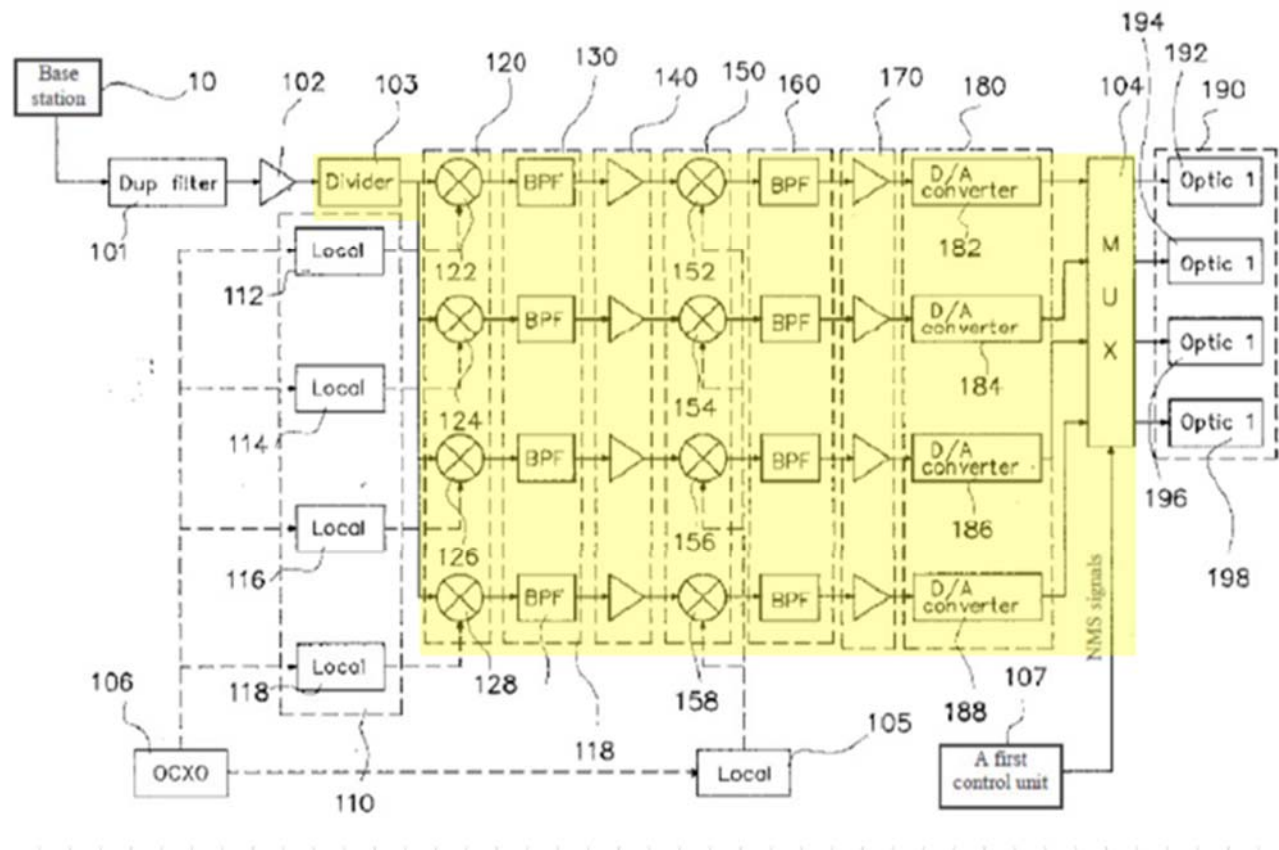
9. Dependent Claim 21

316. Claim 21 recites “the at least one digital expansion unit is coupled to the digital host unit via a single mode fiber.” As noted above with reference to claim 20, where speed is a critical factor, single mode fiber was known to be an optimum choice. Ex. 1012, 1125. Thus Oh in view of Schwartz, or further in view of Farber to the extent that the cost-benefit analysis of single vs. multimode fiber was not background state of the art knowledge, renders obvious the at least one digital expansion unit (intermediate station 28) is coupled to the digital host unit (Oh master unit 20) by single mode fiber (*e.g.*, as disclosed by Farber).

10. Dependent Claim 22

317. Claim 22 recites that “the digital host unit includes a radio frequency to digital converter that converts a main radio frequency signal to at least a portion of the digitized radio frequency signals.” Fig. 2 of Oh depicts the master unit 20 that receives a radio frequency signal and outputs digital representation of the received radio frequency signal.

FIG. 2



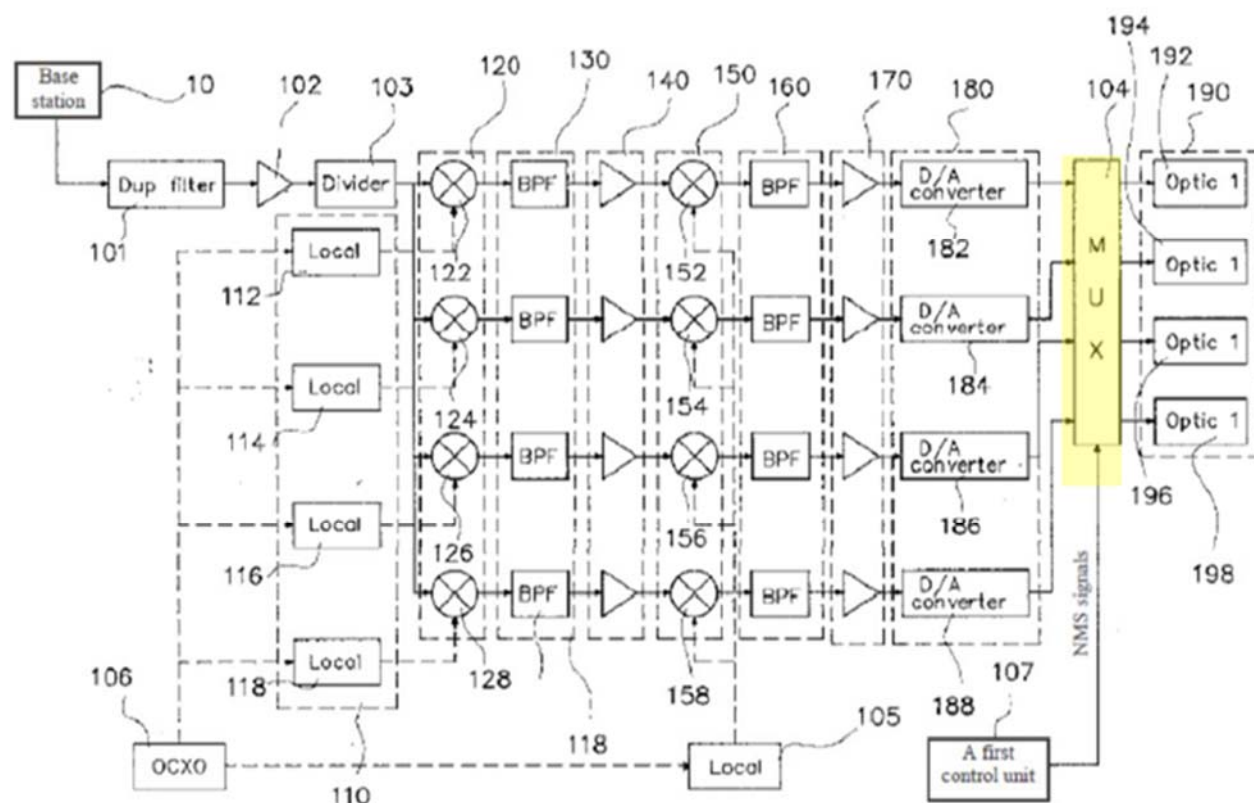
318. As described at 3:6-18, a first divider 103 divides the received RF signal among 4 rows of frequency band digitization circuitry. The frequency band signals from the divider are downconverted 120, filtered 130, amplified 140, further downconverted 150, further filtered 160, and further amplified 170 before being sampled at 180 to create a digital representation of the received main radio frequency signal in the form of four 12-bit samples, one from each frequency band path. The multiplexer 104 multiplexes those four 12-bit samples, which together represent the main radio frequency signal received from the base station 10, and 4 bits of control data 107 that is transmitted to the remote slave units 30.

319. Thus Oh renders obvious the digital host unit (master unit 20) includes a radio frequency to digital converter (103, 120-180, 104) that converts a main radio frequency signal (received from base station 10) to at least a portion of the digitized radio frequency signals (output from mux 104 to remote slave units 30).

11. Dependent Claim 23

320. Claim 23 recites that “the digital host unit further includes a multiplexer which splits the digitized radio frequency signals into at least two digital signals for optical transmission to the at least two digital remote units.” Fig. 2 of Oh depicts master unit 20’s multiplexer 104. Multiplexer 104 receives the 12-bit samples from the A/D converter unit 180 and multiplexes them along with the control data from 107 and outputs copies of those 52-bit signals to four remote slave units 30 via optical converters depicted at 190. Ex. 1007, 3:16-19.

FIG. 2



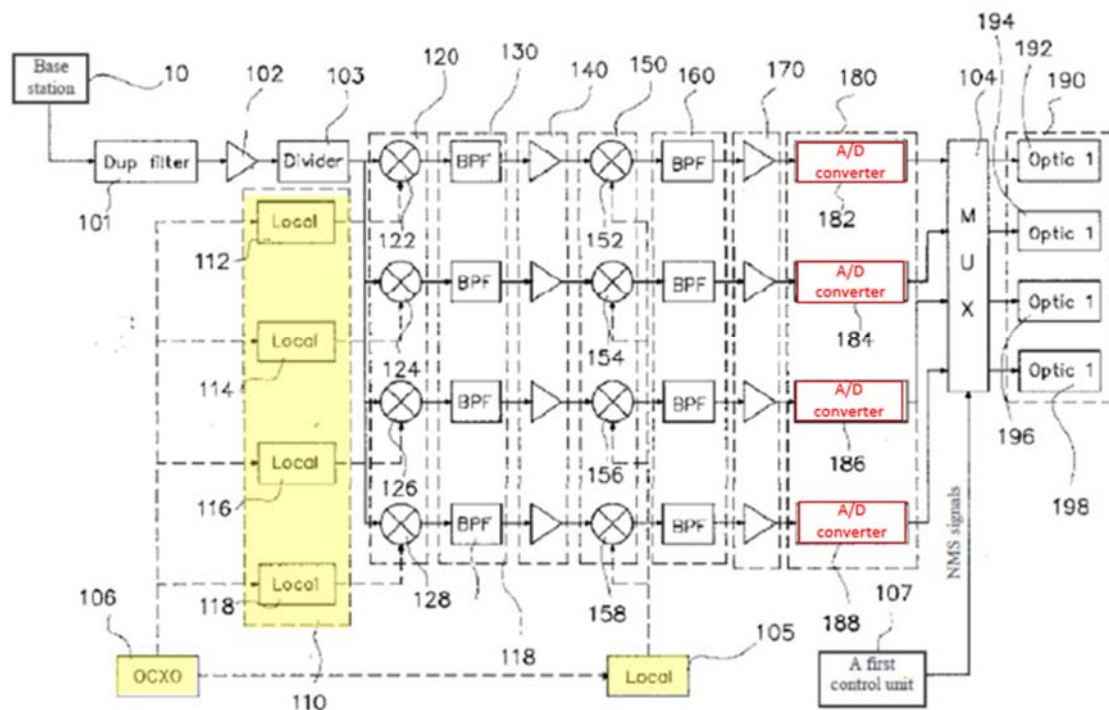
321. Thus Oh renders obvious the digital host unit (master unit 20) further includes a multiplexer (104) which splits the digitized radio frequency signals (52-bit signals) into at least two digital signals (mux 104 splits for transmission on 192, 194, 196, 198) for optical transmission to the at least two digital remote units (remote slave units 30).

12. Dependent Claim 24

322. Claim 24 recites that “the digital host unit includes local oscillators coupled to a reference oscillator for synchronization of the radio frequency signal in the forward direction and in the reverse direction.” Oh discloses that the digital host unit discloses local oscillators 105 (for converting from 70MHz to near DC: Ex. 1007,

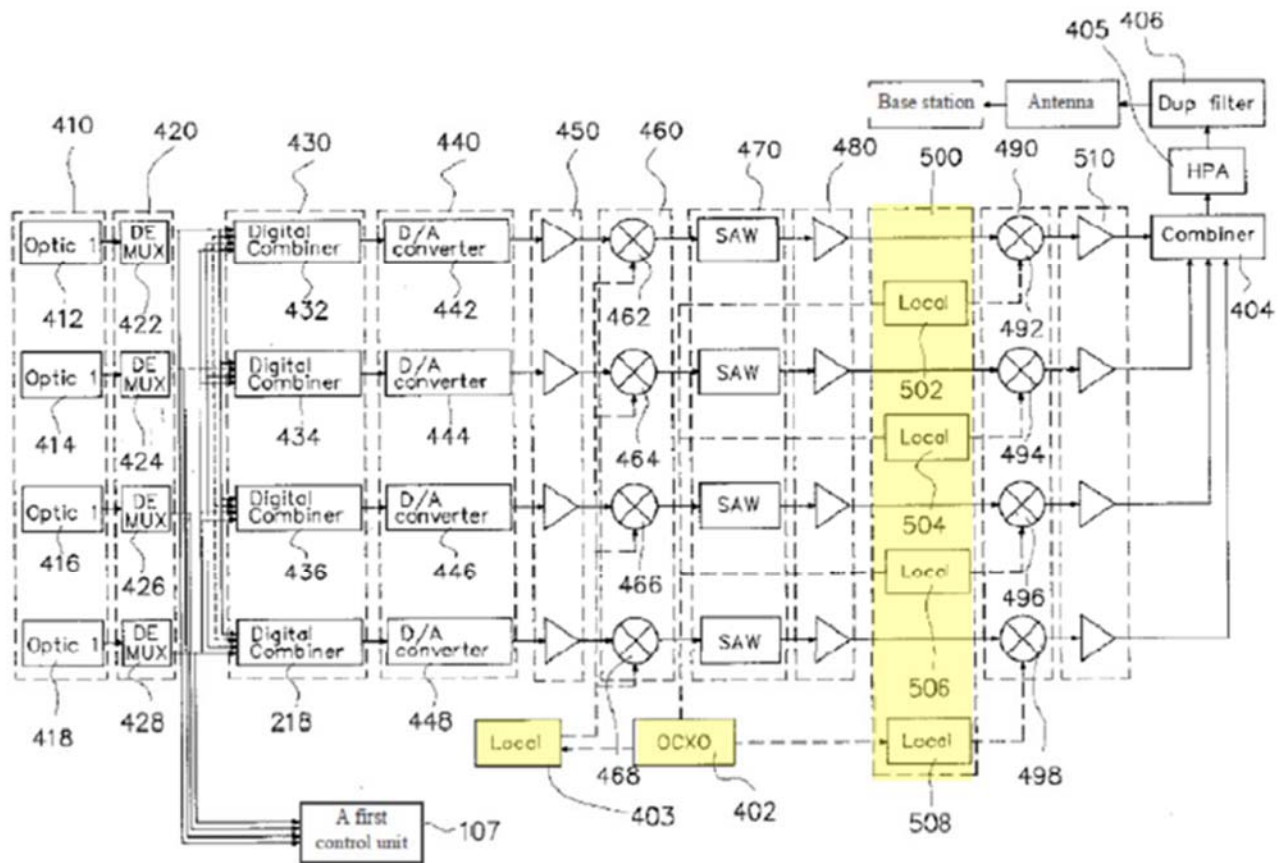
3:34-37) , 112, 114, 116, 118 (for converting from 801.23, 803.69, 806.15, 808.61 to 70Mhz: Ex. 1007, 3:20-25) coupled to OCXO 106 in the forward direction of Fig. 2.

FIG. 2



And Oh discloses that the digital host unit discloses local oscillators 403 (for converting from near DC to 70 MHz: Ex. 1007, 5:19-22), 502, 504, 506, 508 (for converting from 70 to 801.23, 803.69, 806.15, 808.61 Mhz: Ex. 1007, 5:23-26) coupled to oven-controlled reference oscillator 402 in the forward direction of Fig. 2.

FIG. 5

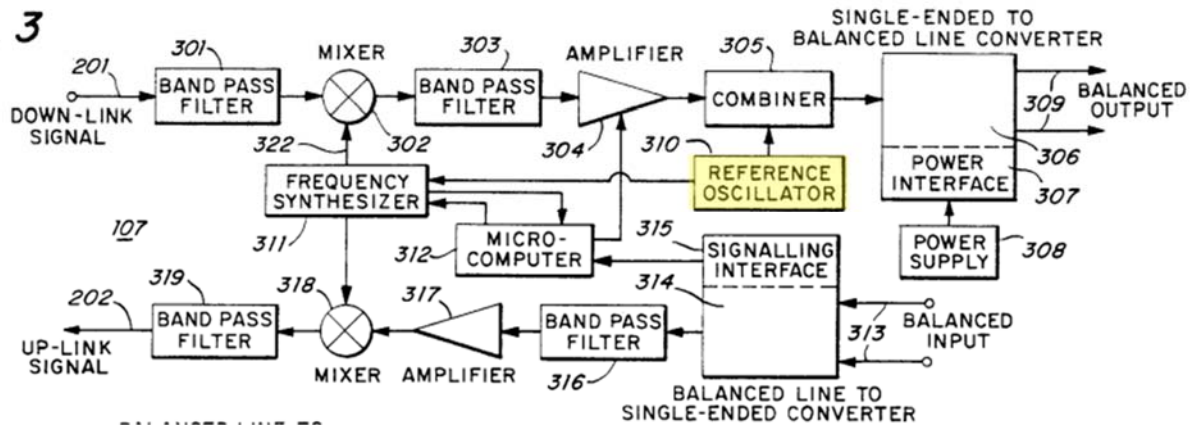


323. Oh's disclosure of OCXO (106 in Fig. 2, 402 in Fig. 5) in host master unit 10 teaches the limitation. To the extent that Oh is not explicit that OCXO 106 in Fig. 2 and 402 in Fig. 5 are indicating the same reference oscillator, such an implementation would be obvious to a POSITA. Because the forward and reverse frequency translations are to the same frequencies (*i.e.*, 70MHz to/from about 800MHz; near DC to/from 70MHz), the local oscillators operating in Figs. 2 and 5 will be operating at about the same frequencies. Having those common local frequencies being generated in Figs. 2 and 5 using a single, common oven-controlled reference oscillator would have been an obvious design choice because using a single

reference oscillator would have reduce part count, reduced power consumption, and reduced reliability concerns caused by additional moving parts that would be present if discrete reference oscillators were used. As illustrated in Figs. 2 and 5 already, a single reference oscillator can be used to generate several local frequency signals. Thus implementing master unit 30 with a single OCXO 106/402 would have been obvious.

324. To any extent that the use of a common reference oscillator is deemed not within the general skill of the art, a POSITA would have been motivated to implement a common reference oscillator for forward and reverse direction operations as disclosed in van der Kaay (Ex. 1019), where a common reference oscillator 310 is used to generate frequencies for frequency shifting operations in the forward and reverse directions. A POSITA would be motivated to combine the disclosures because use of a common reference oscillator would reduce part count (and associated cost), reduce power consumption, and reduce reliability concerns caused by additional moving parts that would be present if discrete reference oscillators were used. Further “[s]ince the same reference oscillator signal (representative of the output of the referenced oscillator 310) is used throughout the RF signal distribution system, frequency accuracy is maintained at a high level.” Ex. 1019, 9:62-65.

FIG. 3



325. Thus Oh renders obvious the digital host unit (30) includes local oscillators (105, 112, 114, 116, 118, 403, 502, 504, 506, 508) coupled to a reference oscillator (106/402) for synchronization of the radio frequency signal in the forward direction (Fig. 2) and the reverse direction (Fig. 5).

13. Dependent Claim 11

326. Dependent claim 11 depends from claim 1. With regard to the features of claim 1, those features are rendered obvious by Oh for the reasons provided above for the preamble, and elements 1, 3a, 3b, and 4 of claim 14.

327. Claim 11 further recites “a digital expansion unit coupled to the digital host unit, wherein the digital expansion unit contains circuitry that performs bi-directional simultaneous digital radio frequency distribution between the digital host unit and the digital remote unit.” As detailed above with reference to claim 14, a POSITA would have considered it obvious to use intermediate units, such as intermediate station 28 of Schwartz to provide expanded coverage of an RF distribution network like the one disclosed in Oh. As depicted in Fig. 7a of Schwartz,

those intermediate stations 28 forward RF signals received from upstream (e.g., at 120) to multiple downstream units (e.g., remote stations 22 and/or other intermediate stations 28 via 126, 128). And those intermediate stations 28 further receive RF signals from multiple downstream units (e.g., at 130, 132), combine those received RF signals, and forward the combined signal to an upstream unit (e.g., at 124).

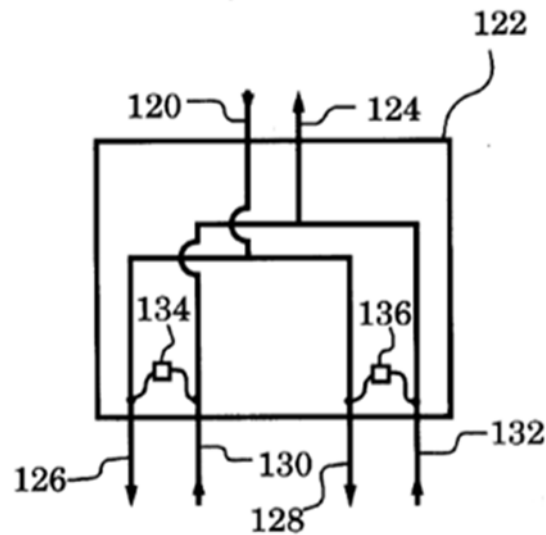


FIG. 7a

328. Thus when connected between central station 20 two remote stations 22, as the highlighted intermediate station 28 is in Fig. 1 below, Oh in view of Schwartz renders obvious digital expansion unit (28) coupled to the digital host unit (20), wherein the digital expansion unit contains circuitry that performs bi-directional simultaneous digital radio frequency distribution (downstream from 120 to 126, 128; upstream from 130, 130 to 124) between the digital host unit and the digital remote unit.

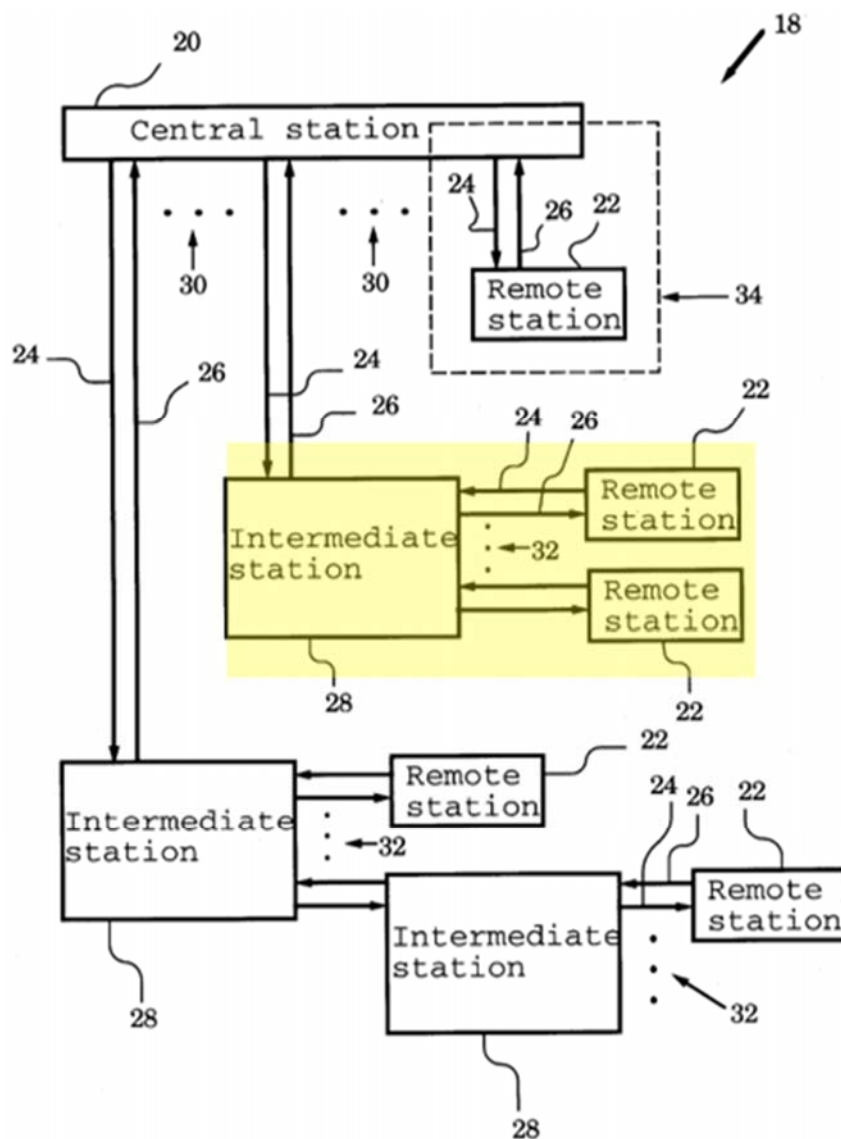


FIG. 1

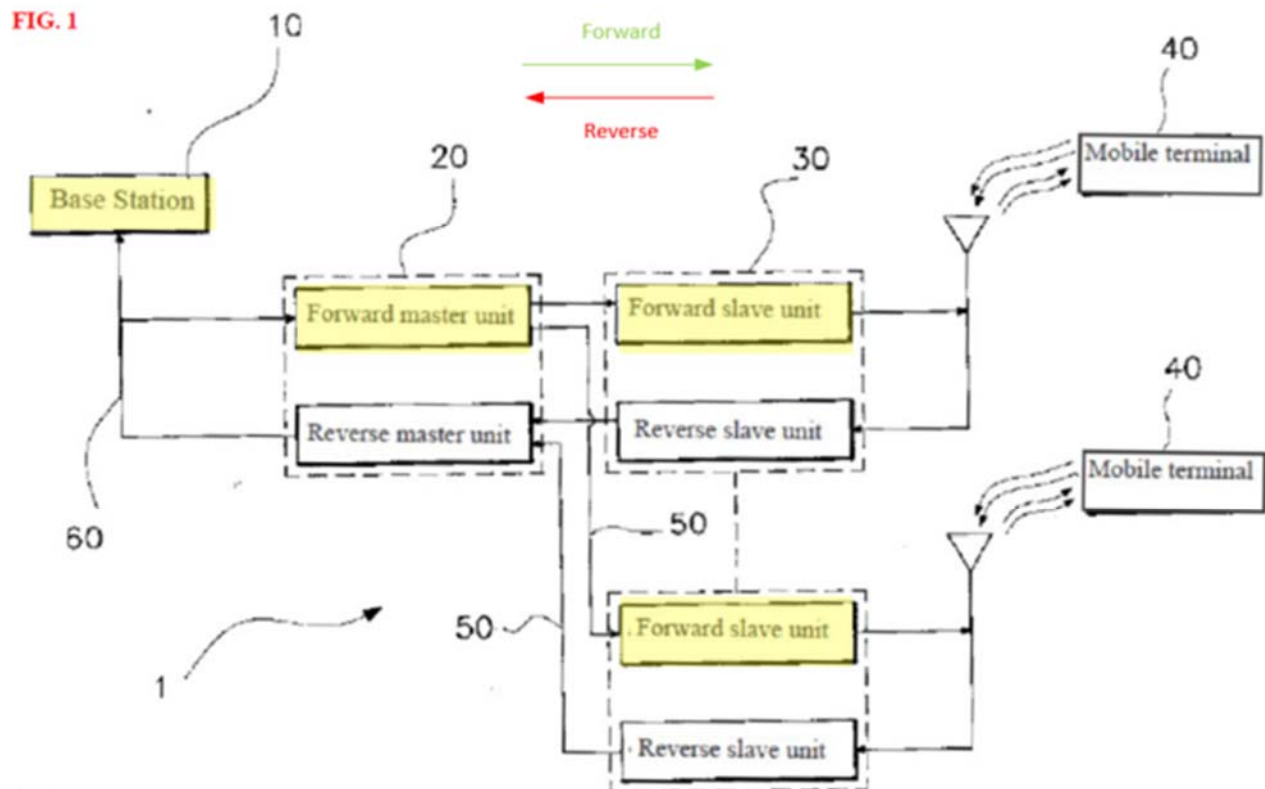
14. Dependent Claims 12 and 13

329. Claims 12 and 13 recite features that are analogous to those recited in claims 20 and 21. The limitations of claims 12 and 13 are rendered obvious for the additional reasons provided in addressing claims 20 and 21, respectively.

15. Independent Claim 33

a) Preamble: “A method of performing point-to-multipoint digital radio frequency transport, the method comprising:”

330. To the extent the preamble of claim 33 is limiting, it is rendered obvious by Oh. Oh discloses digital radio frequency transport for the reasons noted above in addressing the preamble of claim 1. Oh’s disclosure of point-to-multipoint digital radio frequency transport is evidenced in FIG. 1, where the master unit 20 receives RF signals from base station 10.



331. RF signals from base station 10 are downconverted and converted to digital representations at 180. The digital signals from A/D converter unit 180 are

then transmitted from the forward master unit forward slave units of multiple slave units 30 via optic lines 50. Ex. 1007, 3:38-44.

332. Oh therefore renders obvious each limitation recited in the preamble of claim 28 by disclosing point (master unit 20) to multipoint (multiple slave units 30) digital radio frequency (digital samples of intermediate frequency/baseband analog signals from the base station 10) transport (transmission of those digital signals from the master unit 20 to the slave units 30 across optic lines 50).

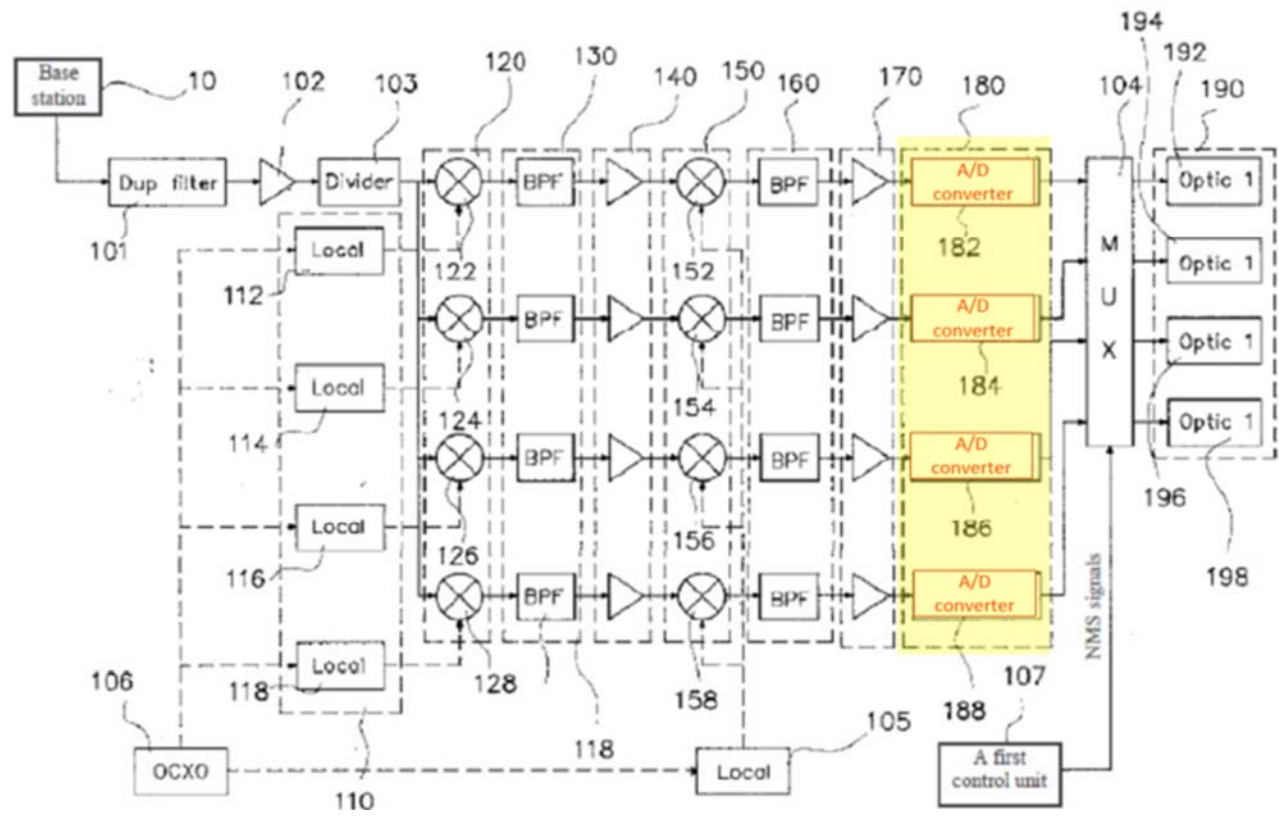
b) Element 1: “receiving radio frequency signals at a digital host unit;”

333. Oh states that the forward master unit 100 of the master unit 20 “executes a first means that converts RF signals, analog signals, transmitted from the base station 10 to the intermediate frequency signals; converts them to digital signals; and transmits them to the slave unit 30 through the optic line 50.” Ex. 1007, 3:4-6. Thus Oh renders obvious receiving radio frequency signals (RF signals from base station 10) at a digital host unit (master unit 20).

c) Element 2: “converting the radio frequency signals to a digitized radio frequency spectrum;”

334. Following receipt from base station 10, Oh’s forward master unit divides the received analog RF signal at 103 into its component frequency bands, downconverts those frequency band signals to near DC at 120-270, and digitizes those component band signals at A/D converter unit 180. Ex. 1007, 3:6-18.

FIG. 2



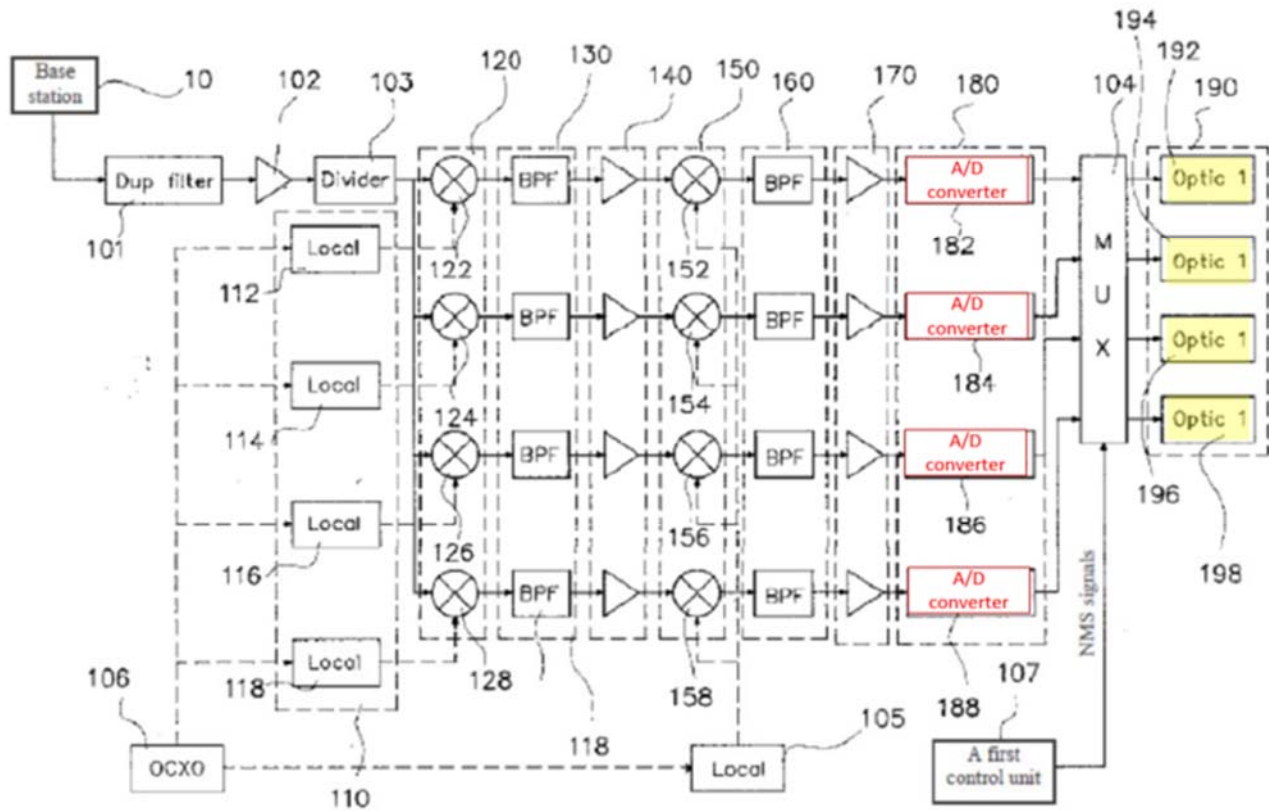
335. By disclosing an A/D converter unit 180 that digitizes the component analog signals for transmission of digital samples to multiple remote units, Oh renders obvious converting (at 180) the radio frequency signals to a digitized radio frequency spectrum.

d) Element 3: “optically transmitting a first digitized radio frequency spectrum to a first plurality of digital remote units and at least one digital expansion unit;”

336. Oh discloses “a first MUX 104 that [multiplexes] all digital signals transmitted from said first A/D converter unit 180 with the NMS signals transmitted from a first control unit 107 and outputs the serial data signals to the forward slave

unit 200 of the slave unit 30 through a first optic converter unit 190 and the optic line 50.” Ex. 1007, 3:16-18; 38-44.

FIG. 2

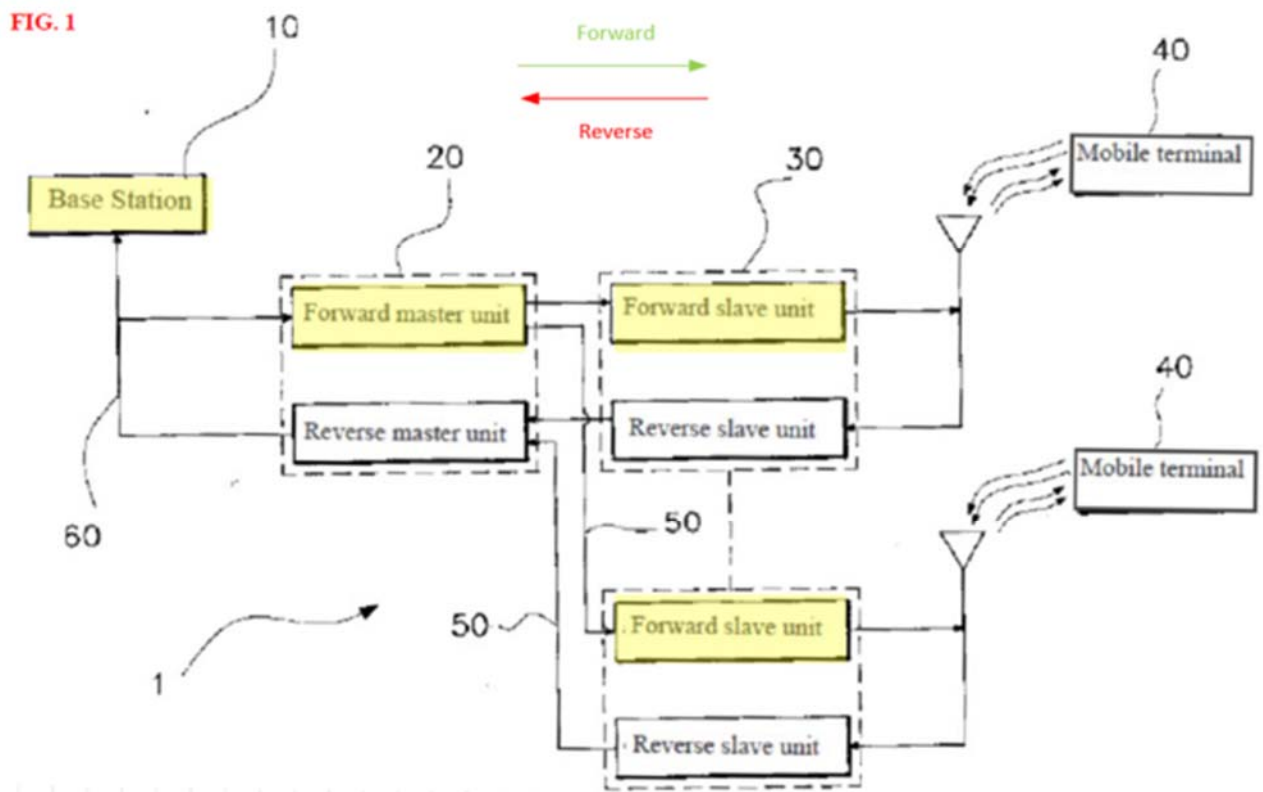


Schwartz discloses transmitting forward path signals to multiple remote units and a digital expansion unit

e) Element 4: “receiving the digitized radio frequency spectrum at the first plurality of digital remote units;”

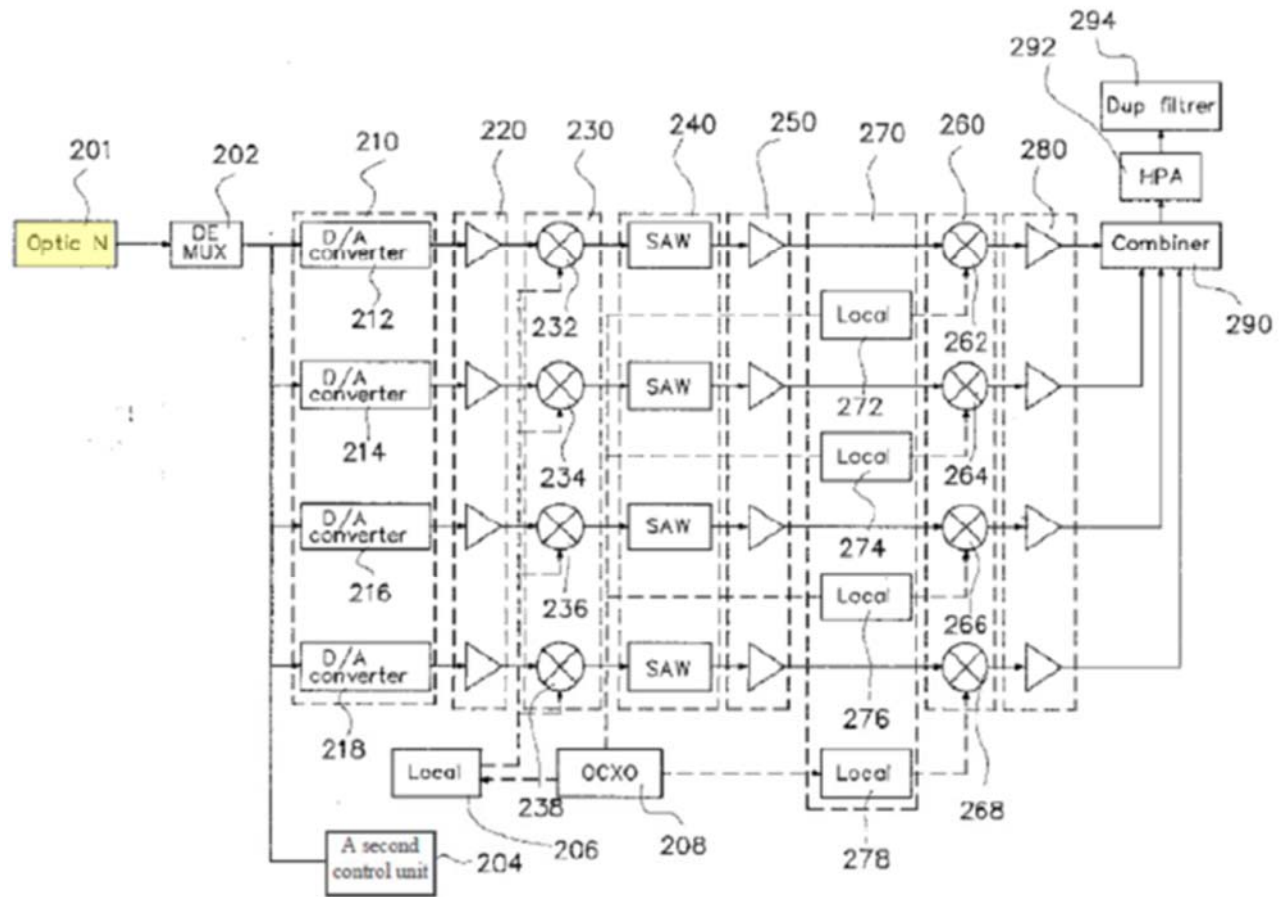
338. Oh discloses that the optic converter unit 190 transmits digitized radio frequency spectrum data to multiple slave units over optic line 50 as depicted in FIG.

1. Ex. 1007, 3:16-18; 38-44.



339. The forward slave unit 200 of the slave unit 30 “converts the digital signals transmitted from the master unit 20 through the optic line 50 to the intermediate frequency signals, analog signals; converts them to the RF signals and transmits them to the mobile terminals 40.” Ex. 1007, 3:47-49.

FIG. 3



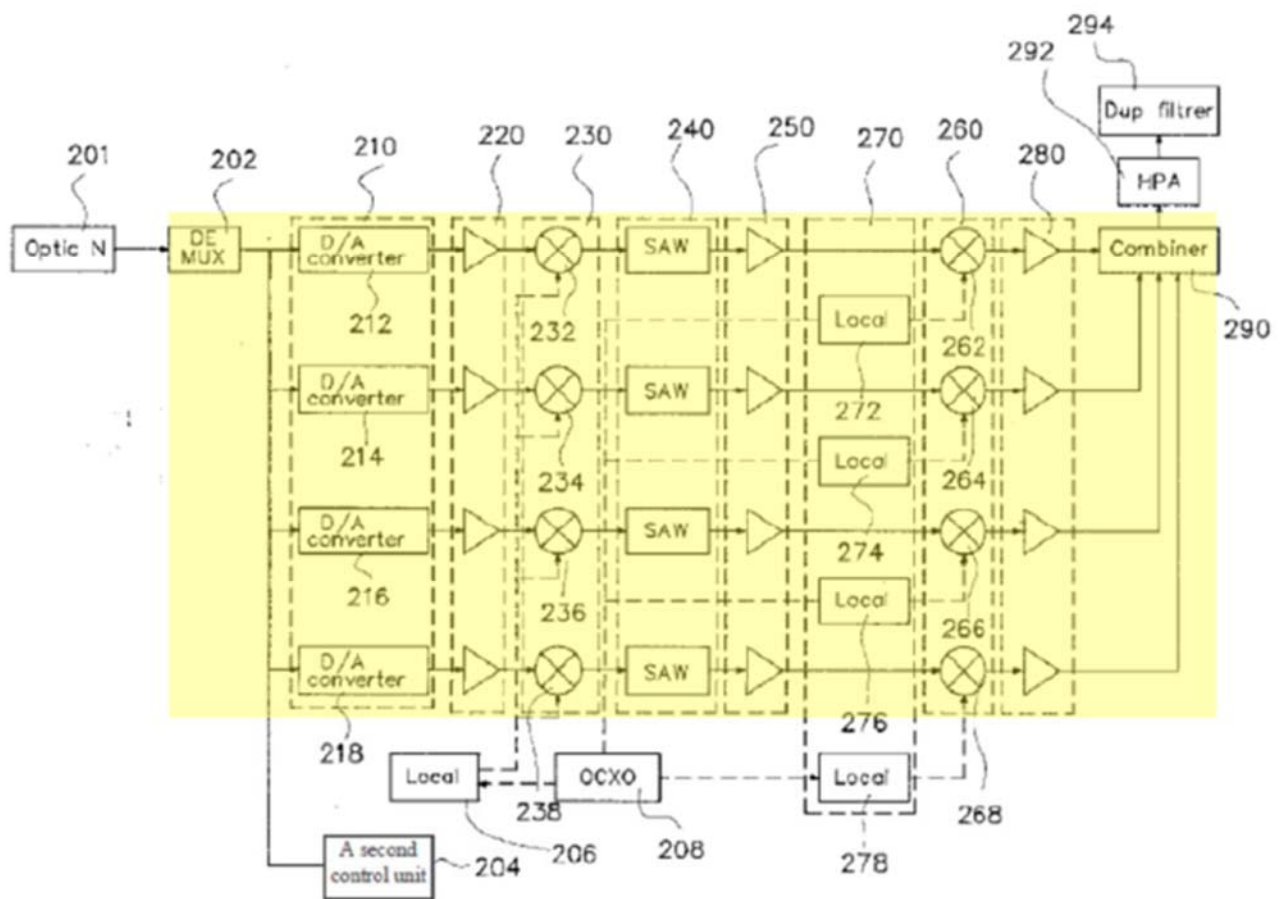
340. Oh in view of Schwartz thus renders obvious receiving the digitized radio frequency spectrum (digital samples from master unit 20) at the plurality of digital remote units (slave units 30 at 201 positioned at the locations of Schwartz remote stations 22 highlighted in referencing element 3 above).

f) Element 5: “converting the digitized radio frequency spectrum to analog radio frequency signals at each of the first plurality of digital remote units;”

341. Oh discloses that the forward slave unit 200 of the slave unit 30 “converts the digital signals transmitted from the master unit 20 through the optic line 50 to the

intermediate frequency signals, analog signals; converts them to the RF signals and transmits them to the mobile terminals 40.” Ex. 1007, 3:47-49. That process is described in further detail at 3:50-61, where the digital samples from the master unit 20 are routed for recreation of the component analog band signals and upconverted to component analog radio frequency signals which are combined at 290 prior to transmission to mobile terminals 40.

FIG. 3



342. Thus Oh renders obvious converting the digitized radio frequency spectrum (digital sample data received from master unit 20 at 201) to analog radio

frequency signals (converting from digital to analog signals, upconverting the analog signals to their respective band frequencies, and combining to form analog radio frequency signals for transmission to mobile terminals 40) at each of the first plurality of digital remote units (slave units 30).

g) Element 6: “receiving the digital radio frequency signals at the at least one digital expansion unit;”

343. As noted above with reference to Element 3, in the Oh-Schwartz combination, digital RF data from the host unit (master unit 20) is transmitted to a digital expansion unit placed in an RF distribution network topology as Schwartz’s intermediate station 28 is. That intermediate station 28 receives the digital RF data from the host unit.

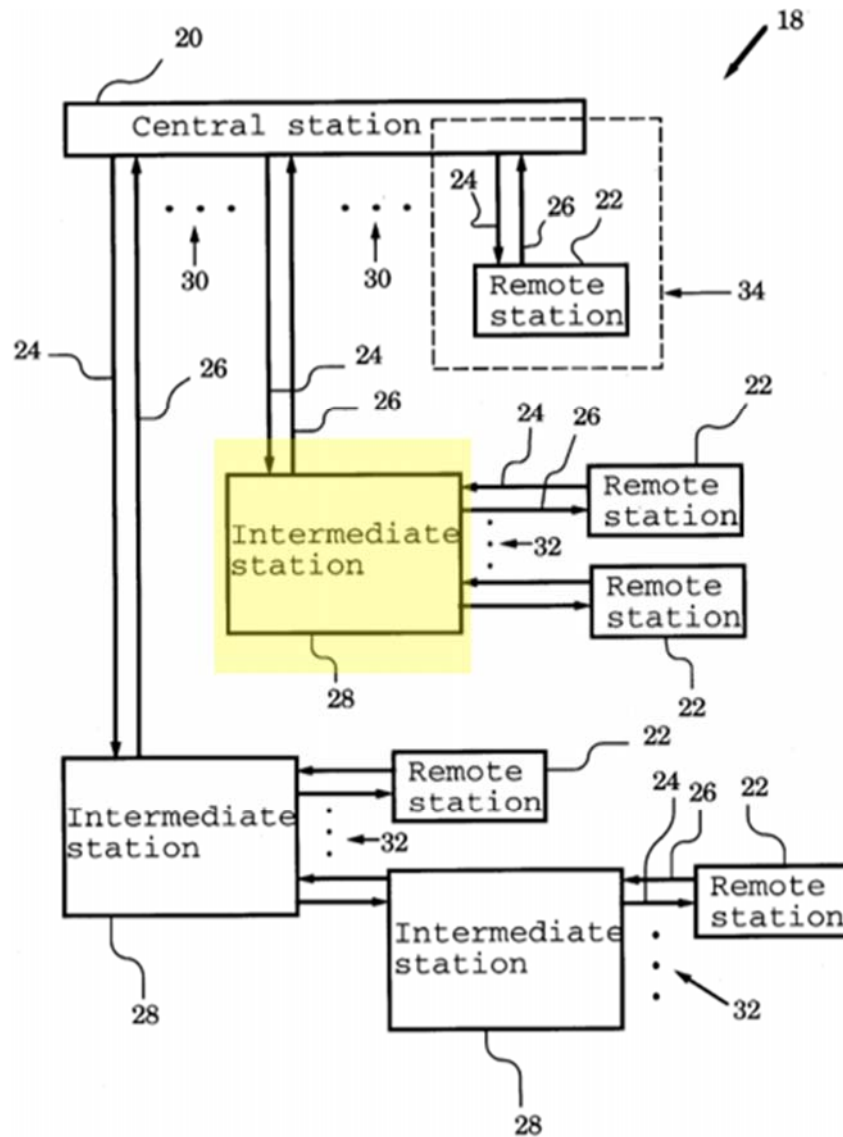


FIG. 1

344. Thus Oh in view of Schwartz renders obvious receiving the digital radio frequency signals at the at least one digital expansion unit (intermediate station 28).

h) Elements 7, 8: “optically transmitting a second digitized radio frequency spectrum to a second plurality of digital remote units; receiving the second digitized radio frequency spectrum at the second plurality of digital remote units;”

345. As illustrated below, the Schwartz intermediate station 28 highlighted in discussing element 6 forward its RF data to the two highlighted remote stations 22, which are different from the remote stations 22 highlighted in referencing element 4 above. In the Oh-Schwartz combination, that RF data would be digital sample data from Oh’s master unit 20 transmitted across optic lines 50, which would be forwarded through intermediate station 28, similar to how intermediate station 28 forwards analog RF data in its prior art system.

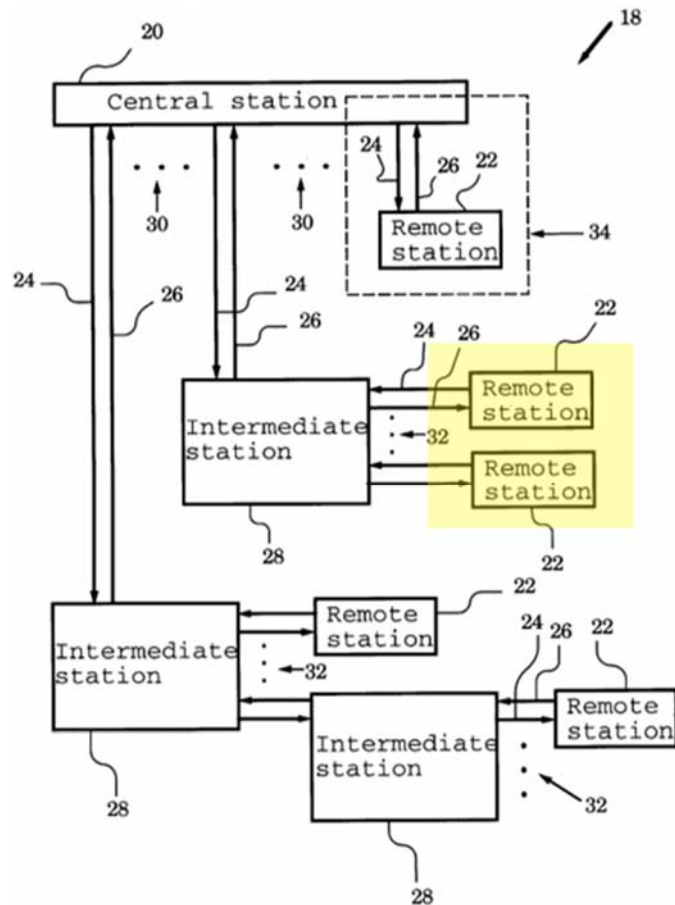


FIG. 1

346. Thus Oh in view of Schwartz renders obvious optically transmitting a second digitized radio frequency spectrum to a second plurality of digital remote units (remote stations 22 highlighted above, which are different from those highlighted with reference to element 4 above); and receiving the second digitized radio frequency spectrum at the second plurality of digital remote units (22).

i) Element 9: “converting the second digitized radio frequency spectrum to analog radio frequency signals at each of the second plurality of digital remote units;”

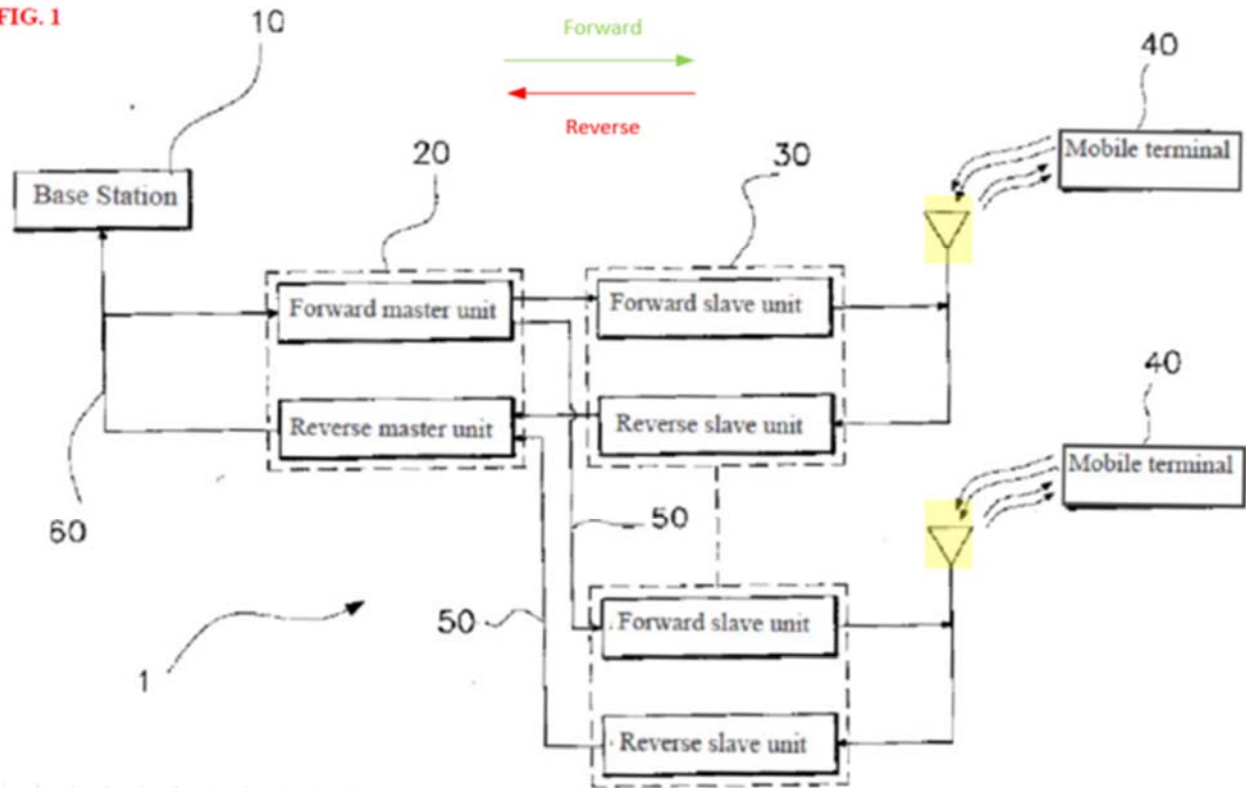
347. As discussed above with reference to element 5, all of the remote units in the Oh-Schwartz combination, including the two highlighted with reference to elements 8 and 9 above, convert digital RF data originating from the host unit (master unit 20) to analog radio frequency signals in preparation for transmission.

348. Thus Oh in view of Schwartz renders obvious converting the second digitized radio frequency spectrum (digital sample data received from master unit 20 at 201) to analog radio frequency signals (converting from digital to analog signals, upconverting the analog signals to their respective band frequencies, and combining to form analog radio frequency signals for transmission to mobile terminals 40) at each of the second plurality of digital remote units (slave units 30 positioned at the positions of remote stations 22 highlighted with reference to elements 8 and 9).

j) Element 10: “transmitting the analog radio frequency signals via a main radio frequency antenna at each of the first and second plurality of digital remote units.”

349. Oh discloses that the digital signals from the master unit 20 are converted to analog, upconverted to RF, and transmitted to the mobile terminals 40. Ex. 1007, 3:47-49. Fig. 1 of Oh depicts the main frequency antenna associated with each slave unit 30 for bidirectional communications with the mobile terminals 40.

FIG. 1



350. Thus Oh renders obvious transmitting the analog radio frequency signals (signals from combiner 290) via a main radio frequency antenna at each of the plurality of digital remote units (slave units 30 positioned, one each at the remote station 22 positions of Fig. 1 of Schwartz).

16. Independent Claim 36

a) Preamble and Element 1a

351. Claim 36's preamble recites "A digital radio frequency transport system." Element 1a recites "a digital host unit." Those elements are rendered obvious by Oh for the reasons noted above with respect to the preamble and element 1 of claim 14.

353. Each Oh digital combiner is associated with a “frequency band” (Ex. 1007, 5:16-17) (*i.e.*, a channel). Thus Oh renders obvious the digital host unit (master unit 20) includes a channel summer (any of 432, 434, 436, 438) to digitally sum digitized RF signals received at the digital host.

c) Elements 2 and 3

354. Elements 2 and 3 are rendered obvious by Oh in view of Schwartz for the reasons presented above in addressing claim 14, elements 2 and 3.

E. Claims 52-64 and 70-73 Are Obvious Over Oh in view of Koschek

1. Independent Claim 52

a) Motivation to Combine

355. A POSITA would be motivated to combine Oh and Koschek for several reasons. First, the Oh and Koschek systems are highly compatible in that they both provide RF transport systems for extending RF communications into hard to reach areas, such as buildings and tunnels. *Compare* Ex. 1007, 2:4-13; Ex. 1013, 1:12-16. On a reverse path, both Oh and Koschek receive RF signals via an antenna at remote units, and send them to upstream units where those signals are combined with other received analog signals received at different remote units. *Compare* Oh combining at 430 with Koschek combining at 136 (“Signals received by antenna 134 and input circuit 112 are combined” 4:8-10).

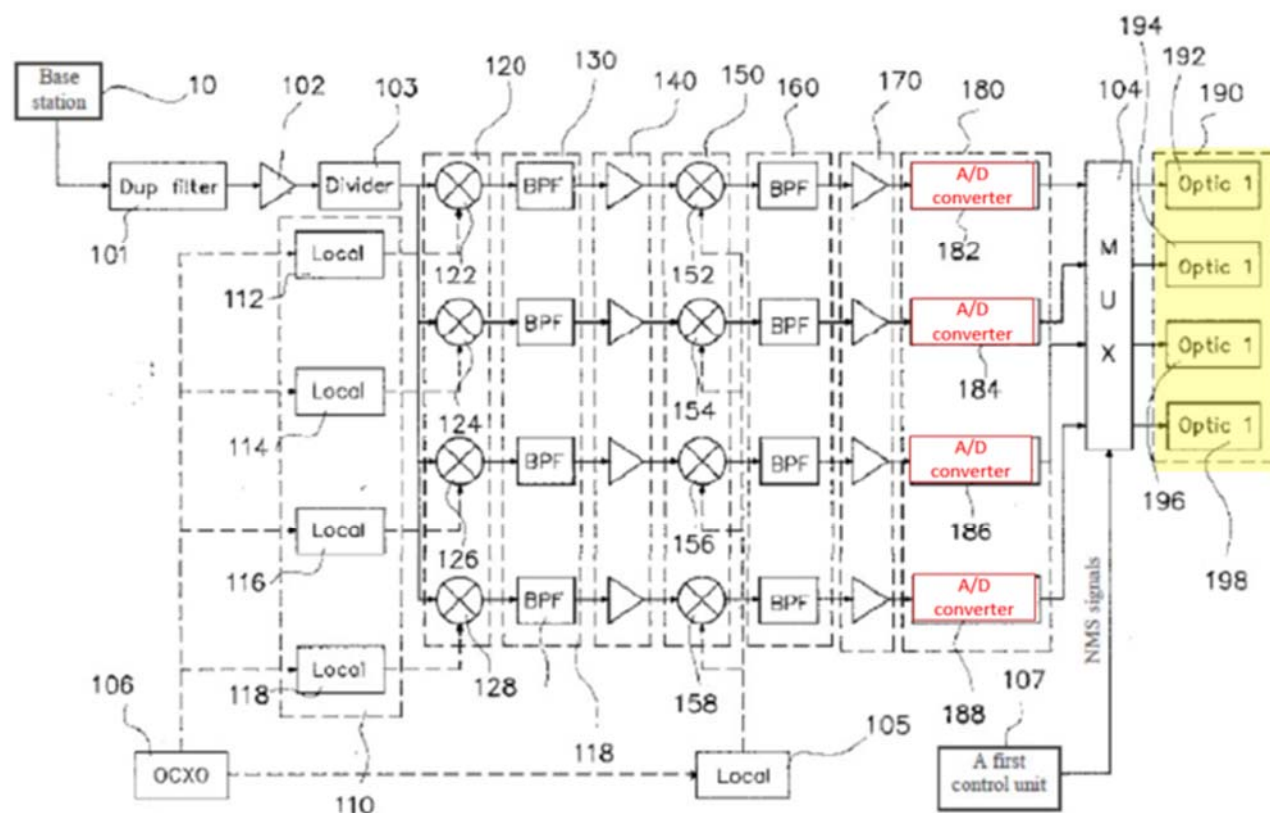
356. While Oh is silent as to powering of its remote slave units 30, Koschek states that remote unit power may be routed along with the signal or other cables. Ex.

1013, 5:41-45. Providing power from a central location enables placement of remote units in locations where power may not be easily accessible (*e.g.*, at a point not near a wall power outlet). Because an installer will need to run signal lines when installing an Oh or Koschek system, a person of ordinary skill in the art would provide power to remote units in the network either using “power transmitted down the signal or other cables,” where the added labor of such power during signal line installation is minimal.

b) Preamble and Element 1

357. The preamble and element 1 of claim 52 are rendered obvious by Oh for the reasons provided above for element 1 of claim 65, where Oh discloses optic converter 190 that provides an interface from master unit 20 to slave units 30 for transmission of the digitized RF samples that are used at the slave units 30 to reconstitute the RF signal received from the base station 10 for broadcast over the slave unit 30 antennas.

FIG. 2



c) Element 2: “a power distribution interface configured to provide power to at least one of the plurality of second units;”

358. Oh is agnostic as to how its remote slave units 30 are powered. Koschek states that the amplifiers in its remote terminal/connecting stages may be powered in a variety of ways, including power from a central point in the network. Koschek states that “[e]ach amplifier may be powered ... remotely, from power transmitted down the signal or other cables. In [that] configuration, a single, DC power supply may be located at any centrally convenient point in the system.” Ex. 1013, 5:37-45. A POSITA would understand Oh’s master unit 20 to be precisely such a “centrally convenient point in the system” from which it would be obvious to route power.

359. Thus Oh in view of Koschek renders obvious a power distribution interface (to provide power from master unit 20) configured to provide power to at least one of the plurality of second units (remote slave units 30).

d) Elements 3 and 4

360. Elements 3, 4 of claim 52 is rendered obvious by Oh for the reasons provided for elements 2, 3 of claim 65, respectively.

e) Elements 5 and 6: “wherein the upstream digital RF samples received from the plurality of second units have an associated resolution; and wherein the upstream digital RF samples are digitally summed with a resolution that is greater than the resolution associated with the upstream digital RF samples being digitally summed.”

361. Oh discloses that its A/D converters sample the downconverted analog signals at each frequency band at 12-bits of resolution. Ex. 1007, 3:38-39; 3:61-64; 4:16. On the reverse path at the master unit 20, digital combiners 432, 434, 436, 438 “creat[e] 14-bit intermediate frequency signals by combining four 12-bit intermediate frequency signals in the same frequency band.” *Id.*, 5:16-17. Thus Oh renders obvious wherein the upstream digital RF samples received from the plurality of second units have an associated resolution (12-bit resolution). Oh further renders obvious wherein the upstream digital RF samples are digitally summed with a resolution (14 bits) that is greater than the resolution associated with the upstream digital RF samples being digitally summed (12 bits).

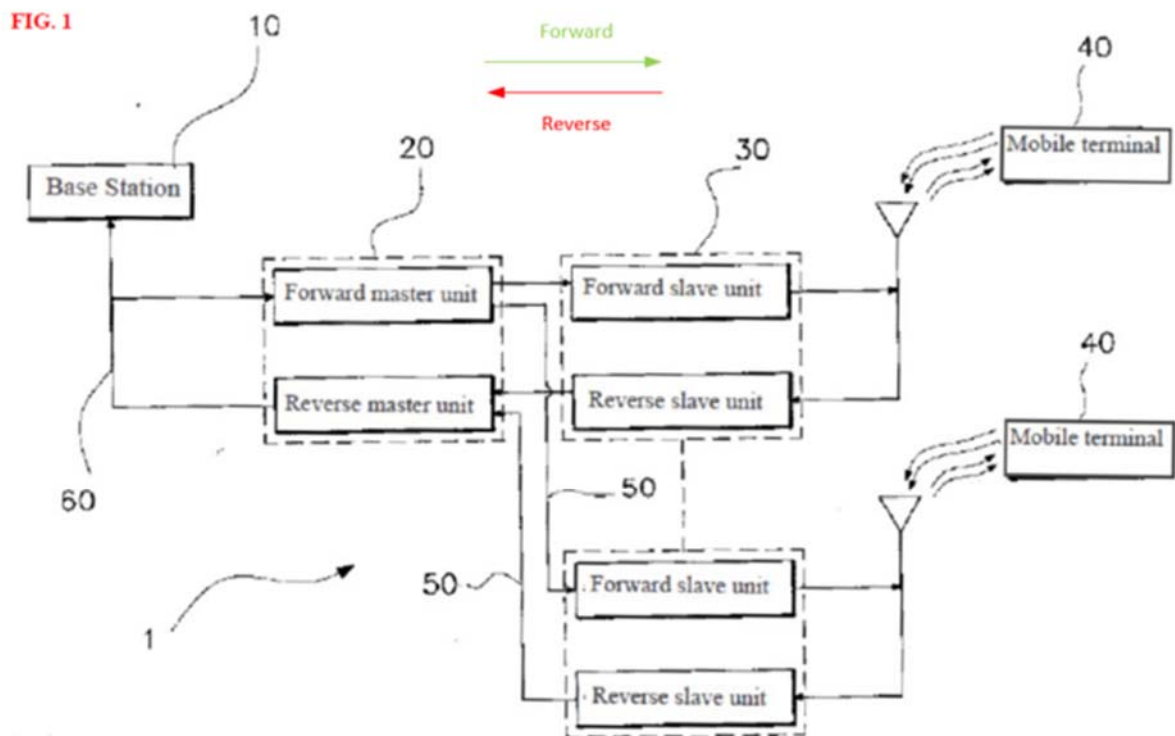
2. Dependent Claim 53

362. Claim 53 is rendered obvious by Oh for the reasons provided above for claim 66.

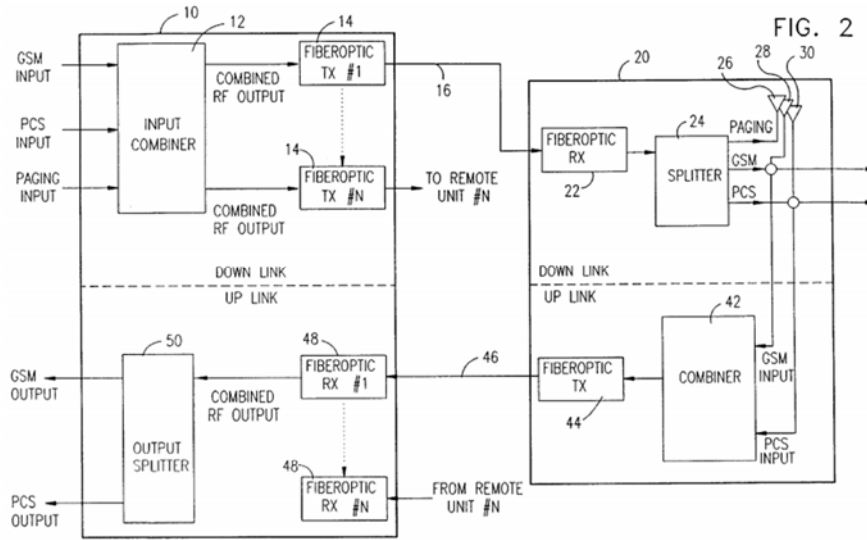
3. Dependent Claim 54

363. Claim 54 recites that “the communication medium comprises at least one of single mode optical fiber, multi-mode optical fiber, and coaxial cable.”

364. Oh Fig. 1 illustrates master unit 20 communicating in the forward direction to a slave unit 30 using a first optic line 50, highlighted in green, and in the reverse direction from a slave unit using a second optic line 50 highlighted in red. Thus Oh discloses master unit 20 communicating with each slave unit 30 via fiber pairs.



365. Oh discloses that the master unit 20 communicates digital data to slave units 30 via optic lines 50. Ex. 1007, 3:4-6. Oh is agnostic as to whether multimode or single mode fiber is used. A POSITA would consider selection of multimode or single mode to be a matter of design choice. This is evidenced by Farber which describes the use of single or multimode fiber in an antenna system for reaching difficult coverage areas (see Fig. 1) that is very similar to the digital system of Oh. Ex. 1022 (“Farber”), 4:30-33 (“Preferably the transmitter 14 employs a vertical cavity surface emitting laser or an edge emitting laser coupled to a single or multi-mode fiber 16.”); Fig. 2. As further evidence of obviousness of using single or multimode fiber, Haas illustrates the cost-benefit analysis of selection of multimode or single mode fiber for an application. Ex. 1012, 1125. A POSITA would have been motivated to select multimode fiber as disclosed by Haas for communicating among a host and remote units when cost is a significant factor for the project. Additionally as disclosed by Haas, in some instances multimode fiber may already be installed in an area into which an RF distribution network is being implemented, making reuse of that multimode fiber an attractive option.

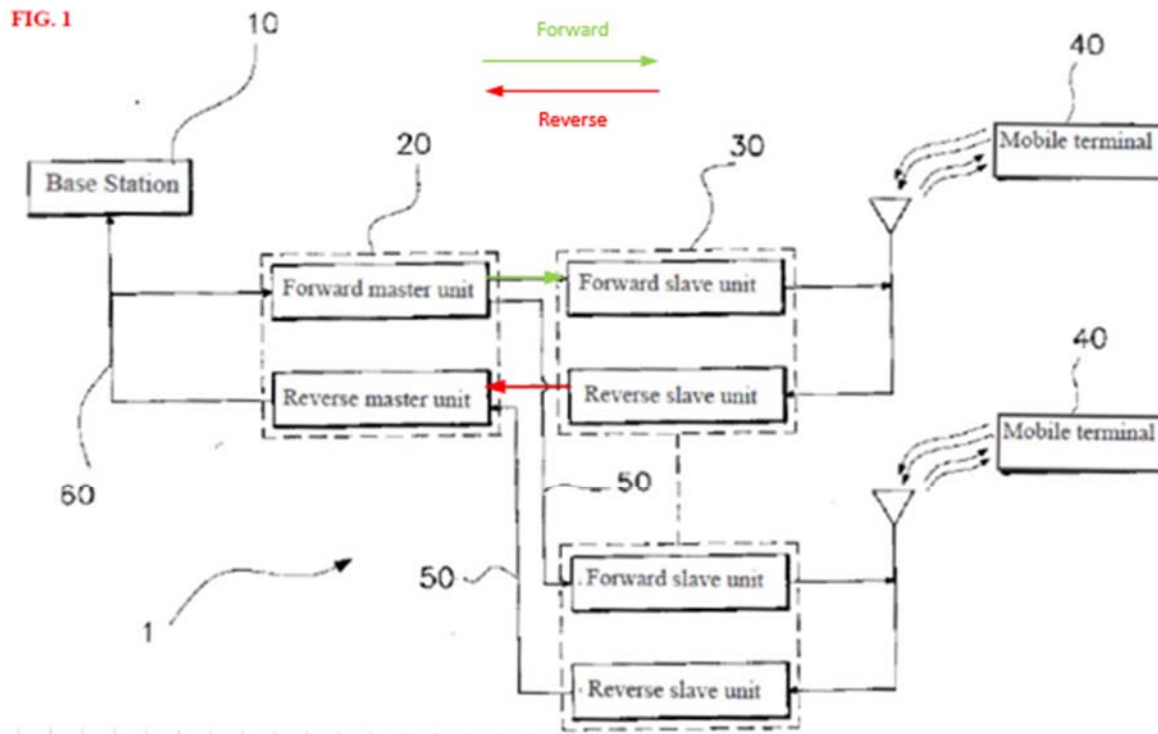


366. Thus a POSITA would have considered it obvious to select one of the two possible choices to implement optic lines 50, where the claim encompasses both possible choices.

4. Dependent Claim 55

367. Claim 55 recites that “the interface is operable to communicatively couple the first unit to at least one second unit using a pair of optical fibers, wherein a first optical fiber included in the pair is used to communicate the at least a portion of the downstream digital RF samples to the at least one second unit and a second optical fiber included in the pair is used to receive respective upstream digital RF samples from the at least one second unit.”

368. Oh Fig. 1 illustrates master unit 20 communicating in the forward direction to a slave unit 30 using a first optic line 50, highlighted in green, and in the reverse direction from a slave unit using a second optic line 50 highlighted in red.



369. Thus Oh renders obvious the interface (Fig. 2, 190; Fig. 4 410) is operable to communicatively couple the first unit (20) to at least one second unit (30) using a pair of optical fibers, wherein a first optical fiber (50, green) included in the pair is used to communicate the at least a portion of the downstream digital RF samples to the at least one second unit and a second optical fiber (50, red) included in the pair is used to receive respective upstream digital RF samples from the at least one second unit.

5. Dependent Claim 56 and 57

370. Dependent claims 56 and 57 are rendered obvious by Oh for the reasons provided above with reference to claims 68 and 69, respectively.

6. Independent Claim 58

a) Preamble and Elements 1-2

371. Oh renders obvious a system for bi-directional radio frequency distribution that includes a host unit (master unit 20) and a plurality of other units (remote slave units 30) coupled to the host unit using at least one communication medium (optic lines 50), wherein the plurality of other units are located remotely from the host unit.

b) Elements 3-6

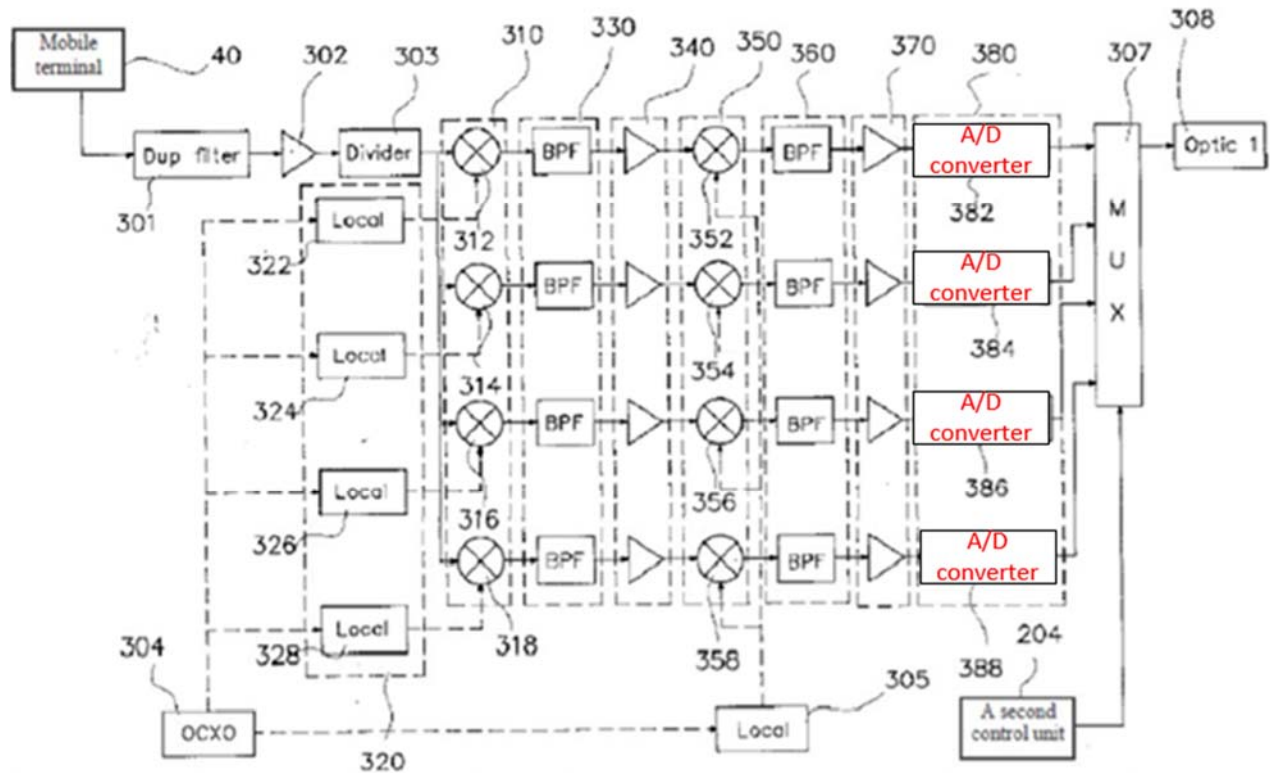
372. Elements 3-6, describing host unit components, are rendered obvious by Oh in view of Koschek for the reasons provided above with reference to elements 1-4 of claim 52.

c) Element 7: “wherein each of the other units digitizes an original upstream analog radio frequency signal produced for radiation from a respective antenna in order to produce the upstream digital RF samples, at least a portion of which are communicated to the host unit, wherein the upstream digital RF samples have an associated resolution;”

373. As depicted in Fig. 4 of Oh, each slave unit 30 receives an analog signal from a mobile terminal 40, divides the received analog signal into its component frequency bands at 303 and downconverts the frequency band signals to near DC at 310-370. Ex. 1007, 4:26-34. The downconverted band signals are then sampled at 380 to create 12-bit digitized radio frequency signals. *Id.*, 4:56-61. The multiplexer

307 multiplexes the four 12-bit samples with 4 bits of control data from 204 to form 52-bit serial data signals that are forwarded to master unit 20. *Id.*

FIG. 4



374. Thus Oh renders obvious each of the other units (30) digitizes an original upstream analog radio frequency signal produced for radiation from a respective antenna (from mobile terminals 40) in order to produce the upstream digital RF samples, at least a portion of which are communicated to the host unit (20), wherein the upstream digital RF samples have an associated resolution (12 bit samples).

d) Elements 8-10

375. Element 8 is rendered obvious by Oh for the reasons provided above for element 6, where the summer resolution is 14 bits compared to the 12 bit resolution

of the digital samples being summed. Element 9 is rendered obvious by Oh for the reasons provided above for element 5 of claim 33. Element 10 is rendered obvious based on Oh in view of Koschek for the reasons provided for claim 52, element 2, where amplifiers of the remote and intermediate stations are powered from a “DC power supply [that] may be located at any centrally convenient point in the system,” such as at Oh’s master unit 20.

7. Dependent Claims 59-63

376. Dependent Claims 59-63 are rendered obvious by Oh in view of Koschek for the reasons provided above for claims 53-57, respectively.

8. Independent Claim 64

a) Preamble and Elements 1-6

377. Oh renders obvious the preamble and elements 1-2 of claim 64 for the reasons provided above for claim 52’s preamble and element 1. Elements 3-5 of claim 64 are rendered obvious by Oh for the reasons provided above for elements 3-6 of claim 52. Element 6 of claim 64 regarding power distribution is rendered obvious by Oh in view of Koschek for the reasons provided above for claim 52, element 2.

9. Independent Claim 70

a) Preamble through Host Unit Limitations

378. Oh renders obvious the preamble of claim 70 through the initial host unit limitations (*i.e.*, through “wherein each of the summed upstream...”) and further

through the five limitations describing mixing operations at the host unit the reasons provided above for claim 65.

b) The Other Unit Limitations

379. Remote unit digitization of upstream data is disclosed by Oh for the reasons provided above for claim 58, limitation 7. Conversion of downstream digital data to analog for transmission is rendered obvious by Oh for the reasons provided above for claim 33, elements 4-5.

c) Remote Powering Of Other Units

380. The final limitation is disclosed by Oh in view of Koschek for the reasons provided for claim 52, element 2.

10. Dependent Claims 71-73

381. Dependent claims 71 and 72 is rendered obvious by Oh for the reasons provided above for claims 66 and 67, respectively. Claim 73 is a broader form of claim 71 and is also rendered obvious by Oh for the reasons provided for claim 66 above.

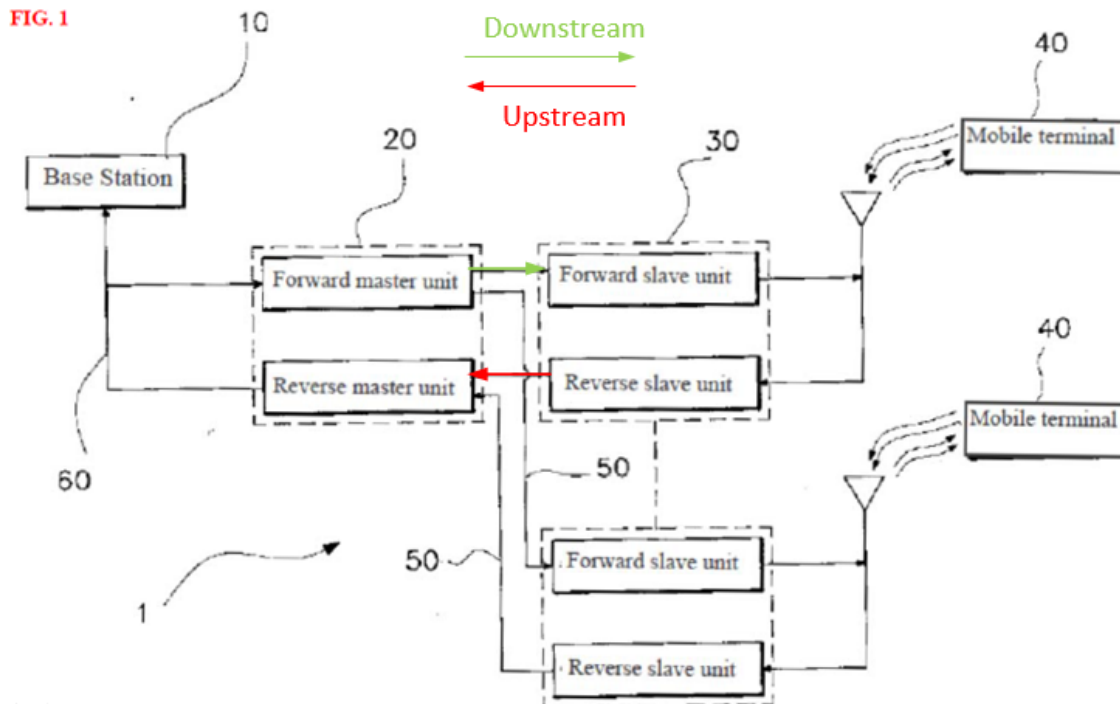
IX. The Claims of the '218 Patent Are Unpatentable

A. Claims 1-10, 12-14, 16-20, 23-25, and 27-28 Are Obvious Over Oh

1. Independent Claim 1

a) Preamble: “A system for wireless radio frequency signal distribution within a coverage area in which one or more wireless units wirelessly transmit in an upstream wireless radio frequency spectrum, the system comprising:”

382. To the extent the preamble of claim 1 is limiting, it is rendered obvious by Oh. As discussed above, Oh discloses a Digital Optic Repeater system that receives RF signals from a base station 10 at a master unit 20 and from mobile terminals 40 at remote slave units 30. The optic repeater 1 is installed in a radio wave shadow area having multiple mobile terminals 40 and converts received analog signals to intermediate frequency signals (*e.g.*, close to DC in the example at 3:11-14) and then to digital signals for mutual transmission and reception to one another across optic lines 50. Ex. 1007, Abstract, Fig. 1. At a destination unit, the digital signals transmitted across the optic lines 50 are converted to analog signals, and upconverted to RF signals for transmission to their destination (*e.g.*, base station 10 or mobile terminals 40). *Id.*

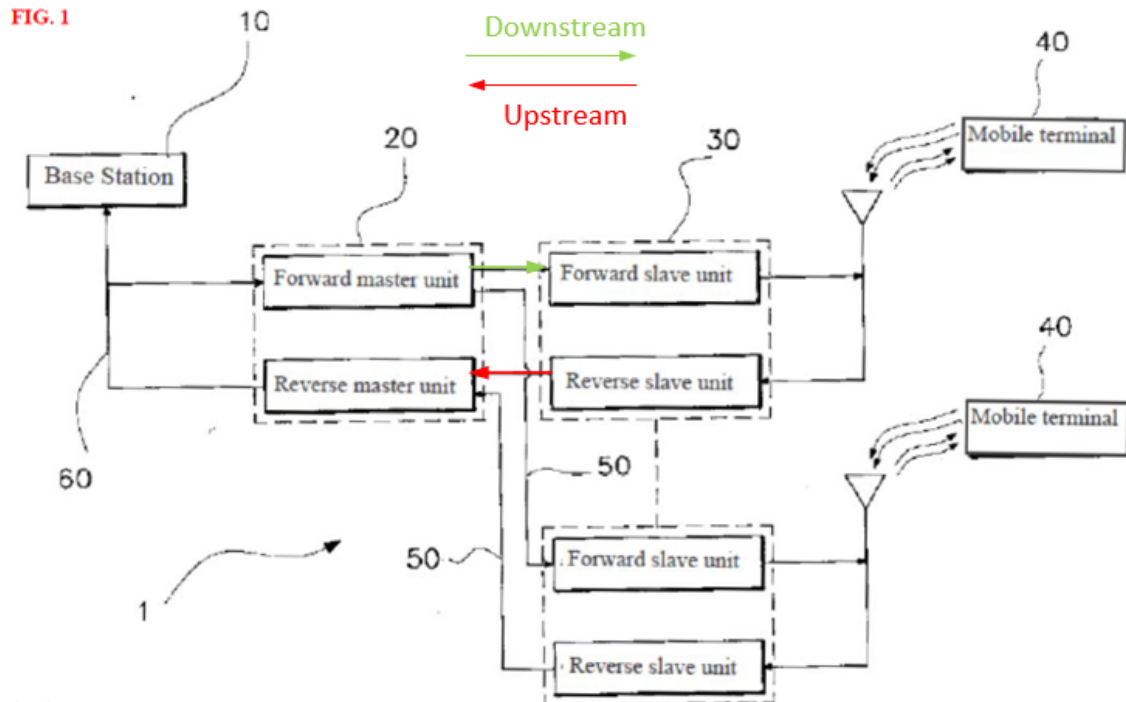


383. Oh therefore renders obvious each limitation recited in the preamble of claim 1 by disclosing a system for wireless radio frequency signal (RF data from base station 10) distribution (transmission of those RF signals to mobile terminals 40 using antennas via the master 20 and slave units 30 across optic lines 50) within a coverage area (radio wave shadow area) in which one or more wireless units (mobile terminals 40) wirelessly transmit in an upstream wireless radio frequency spectrum (analog signals transmitted from mobile terminals 40 to antennas of slave units 30 in the upstream direction).

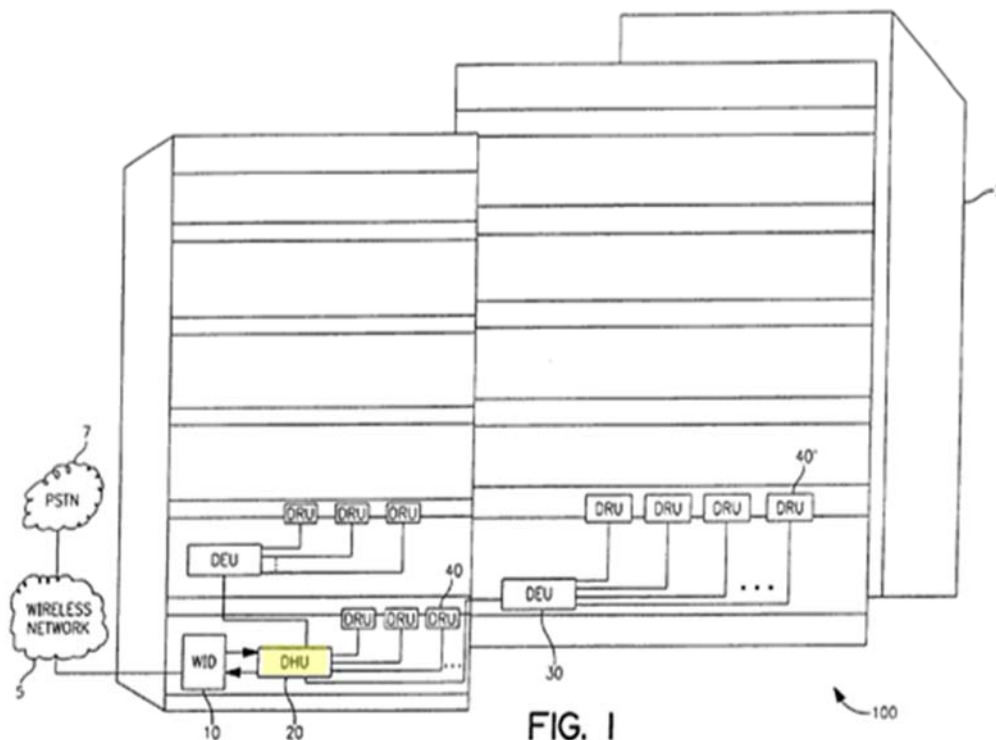
b) Element 1: “a host unit;”

384. As discussed above and as shown in Fig. 1, Oh’s master unit 20 transmits/receives analog signals to/from the base station and relays digital samples

of those analog signals to/from remote slave units 30 across optic lines 50. Ex. 1007, 3:1-6; 4:66-5:1.



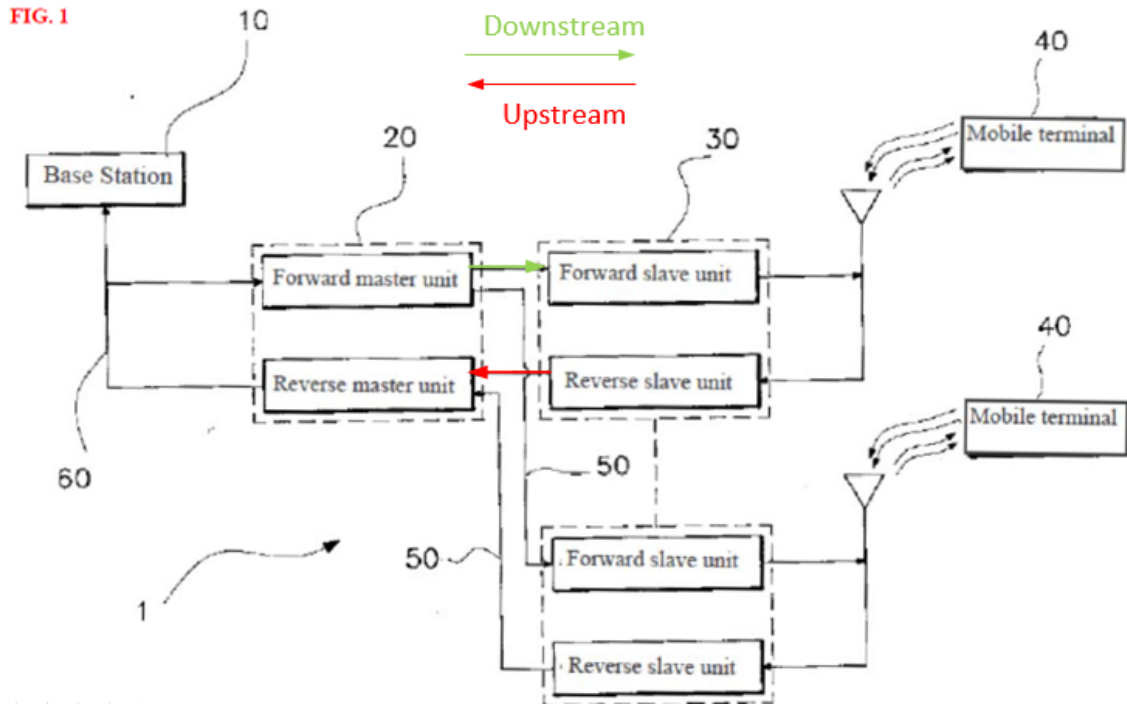
385. Oh's master unit 20 is analogous to the '218 patent's digital host unit (DHU) 20 which interfaces with a wireless interface device (WID) 10 that in embodiments comprises a base station (Ex. 1002, 4:40-43). And like Oh's master unit 20, on the downstream path the '218 patent's DHU "receives RF signals from WID 10 [*i.e.*, base station] and converts the RF signals to digital RF signals. DHU 20 further optically transmits the digital RF signals to multiple DRUs 40."



386. Because Oh's master unit 20 communicates analog signals bi-directionally with a base station, and communicates digital signals bi-directionally with multiple remote units (slave units 30), it is analogous to the host unit described in the '218 patent. Thus Oh renders obvious a host unit (master unit 20).

c) Element 2a: "a plurality of remote units communicatively coupled to the host unit using at least one communication medium,"

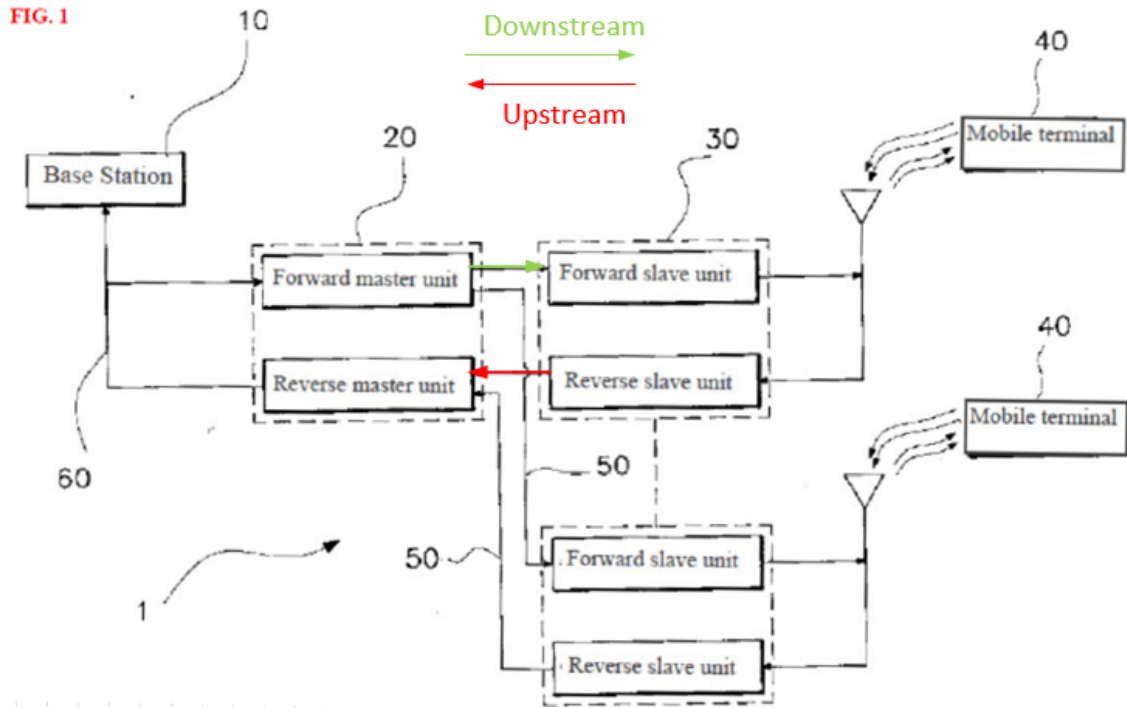
387. Oh discloses master unit 20 is coupled to multiple remote slave units 30 via optic lines 50.



Thus Oh renders obvious a plurality of remote units (30) communicatively coupled to the host unit (20) using at least one communication medium (50).

d) Element 2b: “wherein each of the plurality of remote units is associated with a portion of the coverage area;”

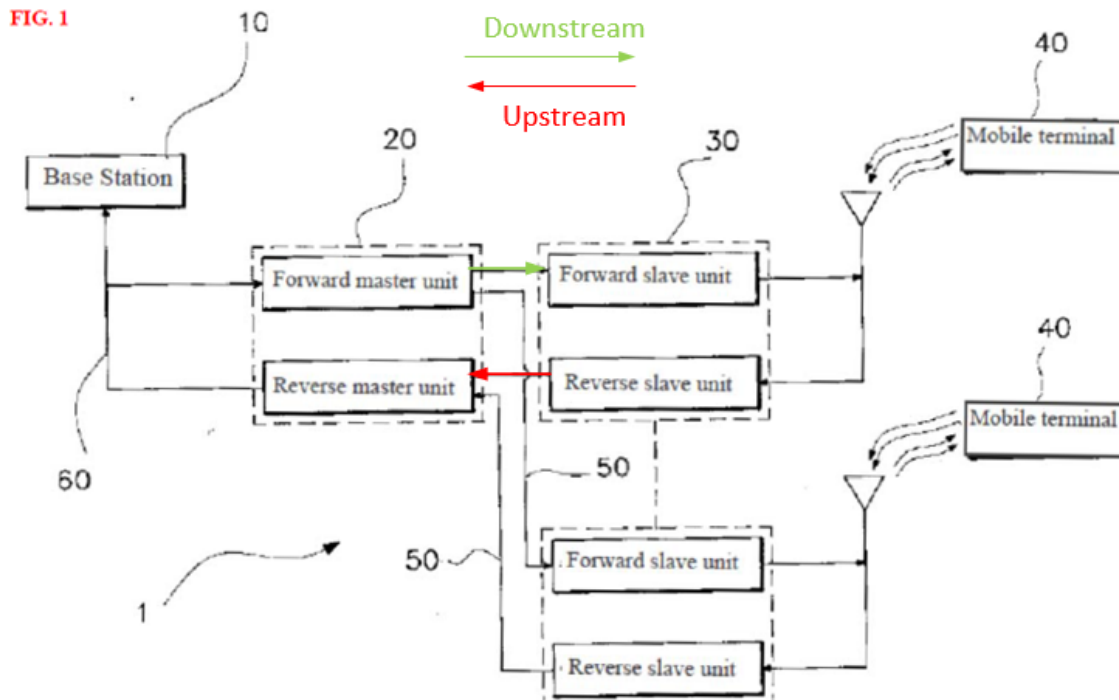
388. Oh discloses optic repeater 1 having multiple slave units 30 is installed in a radio wave shadow area having multiple mobile terminals 40. Each mobile terminal 40 is associated with a slave unit 30 of the radio wave shadow area.



Thus Oh renders obvious each of the plurality of remote units (30) is associated with a portion of the coverage area (radio shadow wave area).

e) Element 3: “wherein each of the plurality of remote units receives a respective original upstream analog wireless signal comprising the upstream radio frequency spectrum and any upstream transmissions from any of the wireless units that are within the portion of the coverage area associated with that remote unit;”

389. As depicted in Fig. 1 of Oh, each slave unit 30 receives an analog signal from a mobile terminal 40. Each mobile terminal 40 is associated with a slave unit 30 of the radio wave shadow area.

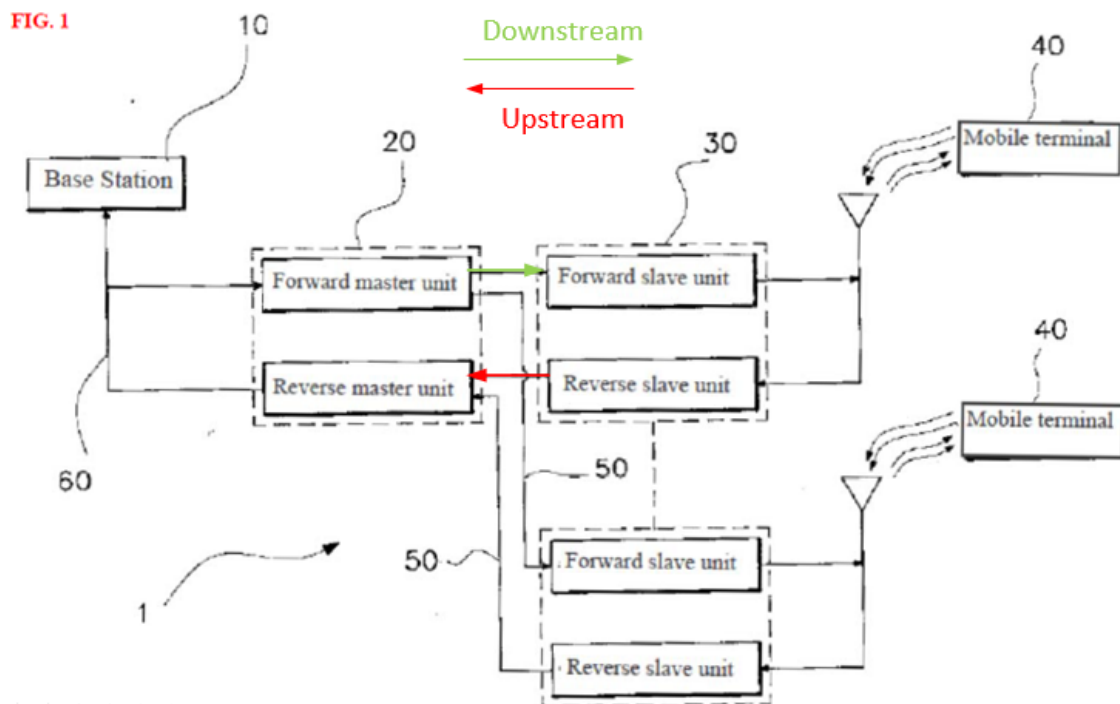


Thus Oh renders obvious each of the plurality of remote units (slave units 30) receives a respective original upstream analog wireless signal comprising the upstream radio frequency spectrum and any upstream transmissions from any of the wireless units (from mobile terminals 40) that are within the portion of the coverage area (radio wave shadow area) associated with that remote unit (slave units 30).

f) Element 4: “wherein each of the plurality of remote units generates respective upstream digital RF samples indicative of the respective original upstream analog wireless signal received at that remote unit;”

390. Patent Owner has made clear in a prior litigation that “digital radio frequency (RF)” as that term is used in the ’218 patent refers to sampling of any of baseband signals, intermediate frequency signals, or radio frequency signals. *See*, Ex. 1008, Acampora Report, ¶136 (“Accordingly, the baseband digital samples, any

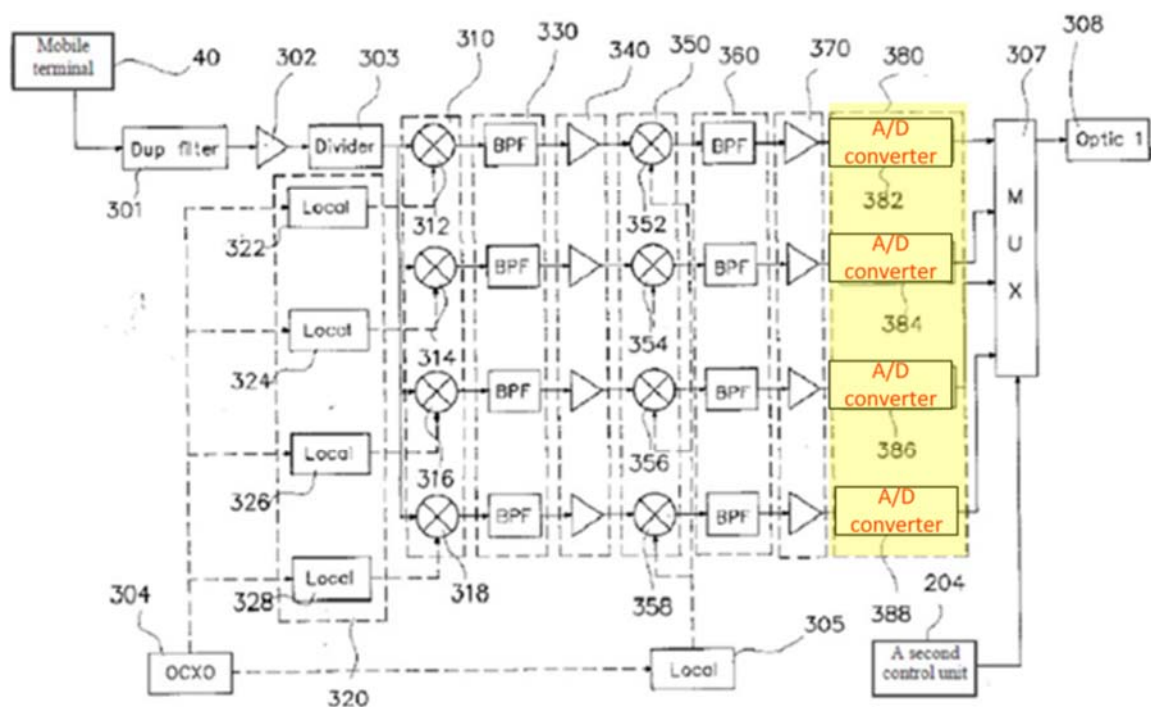
intermediate frequency digital samples, and any radio frequency digital samples are all referred to a[s] being digital RF.”) Additionally, Patent Owner also has made clear that use of the term “wireless” to modify “radio frequency spectrum” is “to emphasize that the ‘radio frequency spectrum’ being received and digitized by the remote antenna units is spectrum that is associated with wireless communications.” Ex. 1008, Acampora report, ¶408. Oh’s disclosure of A/D conversion (*i.e.*, sampling) of intermediate frequency signals, including signals down converted to close to DC (*i.e.*, baseband signals) is disclosure of wireless radio frequency distribution as that term is used in the ’218 patent.



391. As depicted in Fig. 4 of Oh, each slave unit 30 receives an analog signal from a mobile terminal 40, divides the received analog signal into its component

frequency bands at 303, and downconverts the frequency band signals to near DC at 310-370. Ex. 1007, 4:26-34. The downconverted band signals are then sampled at 380 to create 12-bit digitized radio frequency signals. *Id.*, 4:56-61. The multiplexer 307 multiplexes the four 12-bit samples with 4 bits of control data from 204 to form 52-bit serial data signals that are forwarded to master unit 20. *Id.*

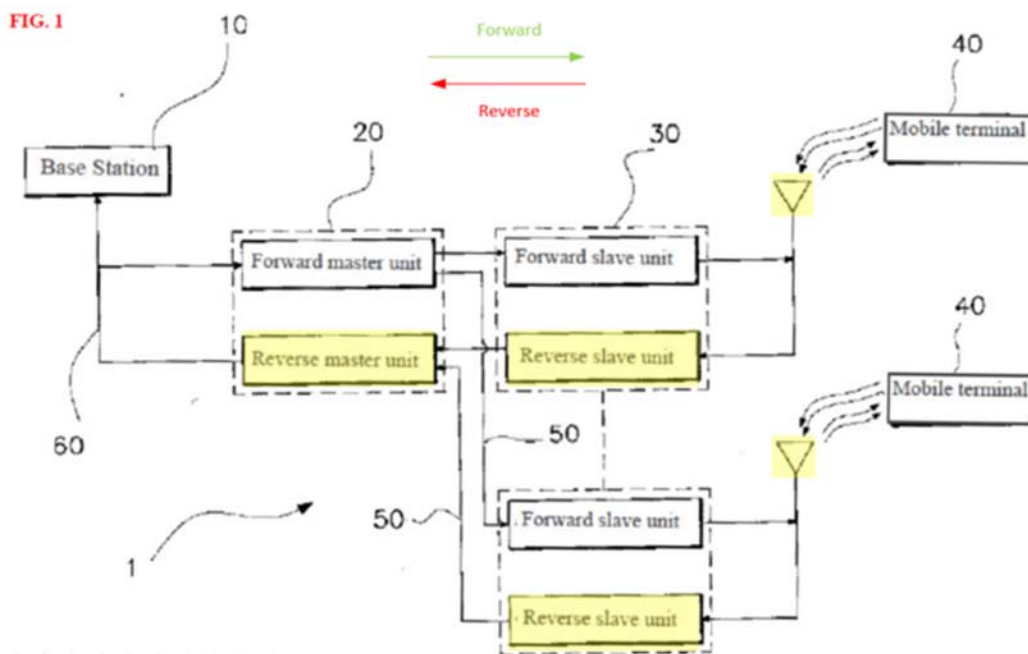
FIG. 4



392. Thus Oh renders obvious each of the plurality of remote units (slave units 30) generates respective upstream digital RF samples (output from A/D converter unit 380) indicative of the respective original upstream analog wireless signal (from mobile terminals 40) received at that remote unit (slave units 30).

g) Element 5: “wherein each of the plurality of remote units communicates the respective upstream digital RF samples generated by that remote unit to the host unit using the at least one communication medium;”

393. Oh discloses that its reverse slave units 300 multiplex “all the digital signals transmitted from said second A/D converter unit 380 ... to serial data signals and outputs them to the reverse master unit 400 through a third optic converter unit 308 and the optic line 50.” Ex. 1007, 4:36-39.

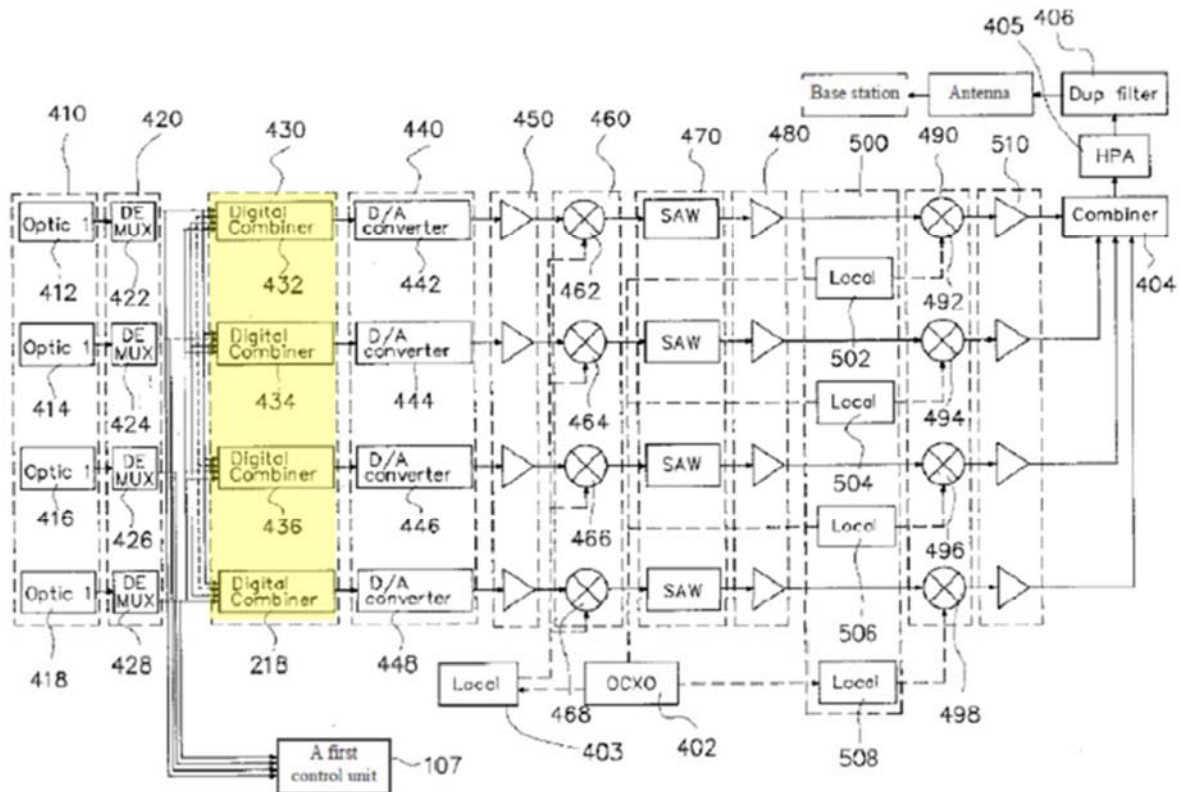


Thus Oh renders obvious that each of the plurality of remote units (slave units 30) communicates the respective upstream digital RF samples generated by that remote unit to the host unit (master unit 20) using the at least one communication medium (optic lines 50).

h) Element 6: “wherein the host unit digitally sums corresponding upstream digital RF samples received from the plurality of remote units to produce summed upstream digital RF samples;”

394. Oh’s master unit 20 includes a digital combiner unit 430 that performs digital combining by aggregating digital signals transmitted from each demultiplexer 422, 424, 426, 428 of demultiplexer unit 420. Ex. 1007, 4:68-70.

FIG. 5

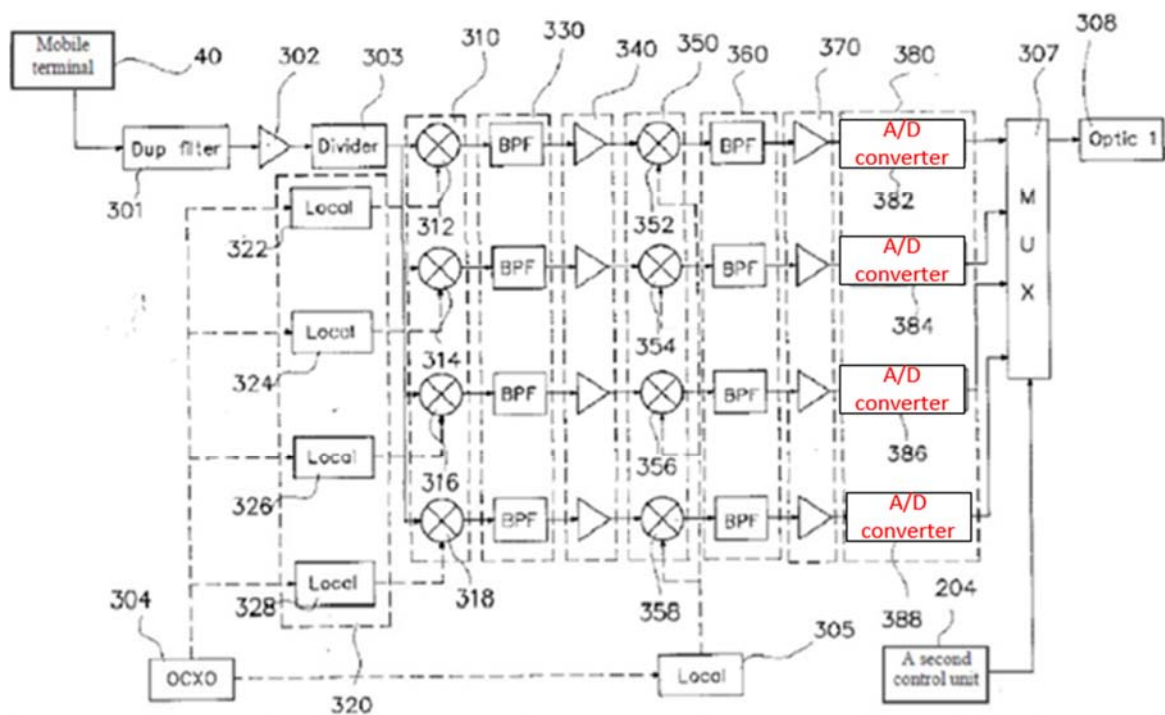


Those demultiplexers at 420 receive data from individual remote slave units 30 at 410.

395. As depicted in Fig. 4, each slave unit 30 receives an analog signal from mobile terminals 40, divides the received analog signal into its component frequency bands at 303 and downconverts the frequency band signals to near DC at 310-370.

Ex. 1007, 4:26-34. The downconverted band signals are then sampled at 380 to create 12-bit digitized radio frequency signals. *Id.*, 4:56-61. The multiplexer 307 multiplexes the four 12-bit samples with 4 bits of control data from 204 to form 52-bit serial data signals that are forwarded to master unit 20. *Id.*

FIG. 4



396. Referring back to Fig. 5, each demultiplexer 422, 424, 426, 428 receives a 52-bit signal from its respective slave unit 30. Each demultiplexer forwards 12-bits of sample data to the appropriate digital combiner associated with the proper frequency band for that 12-bit sample and forwards its 4 bits of control data to control unit 107. Upon receiving four 12-bit signals (one from each of demultiplexer 422, 424, 426, 428), each digital combiner 432, 434, 436, 438 combines those 12-bit

signals to “creat[e a] 14-bit intermediate frequency signals by combining⁸ four 12-bit intermediate frequency signals in the same frequency band” (e.g., (1010 1010 1010 (2,730) + 1100 1100 1100 (3,276) + 1111 1111 1111 (4,095) + 0000 1100 1100 (204) = 10 1000 0100 0001 (10,305)). Ex. 1007, 5:16-17. Those 14-bit signals are then converted to analog signals at 440, upconverted, combined, and transmitted to the base station 10. *Id.*, 5:17-29.

397. Thus Oh renders obvious the host unit (master unit 20) digitally sums the corresponding upstream digital RF samples (digital samples from slave units 30) received from the plurality of remote units (slave units 30) to produce summed upstream digital RF samples (creates 14-bit signals by combining four 12-bit signals).

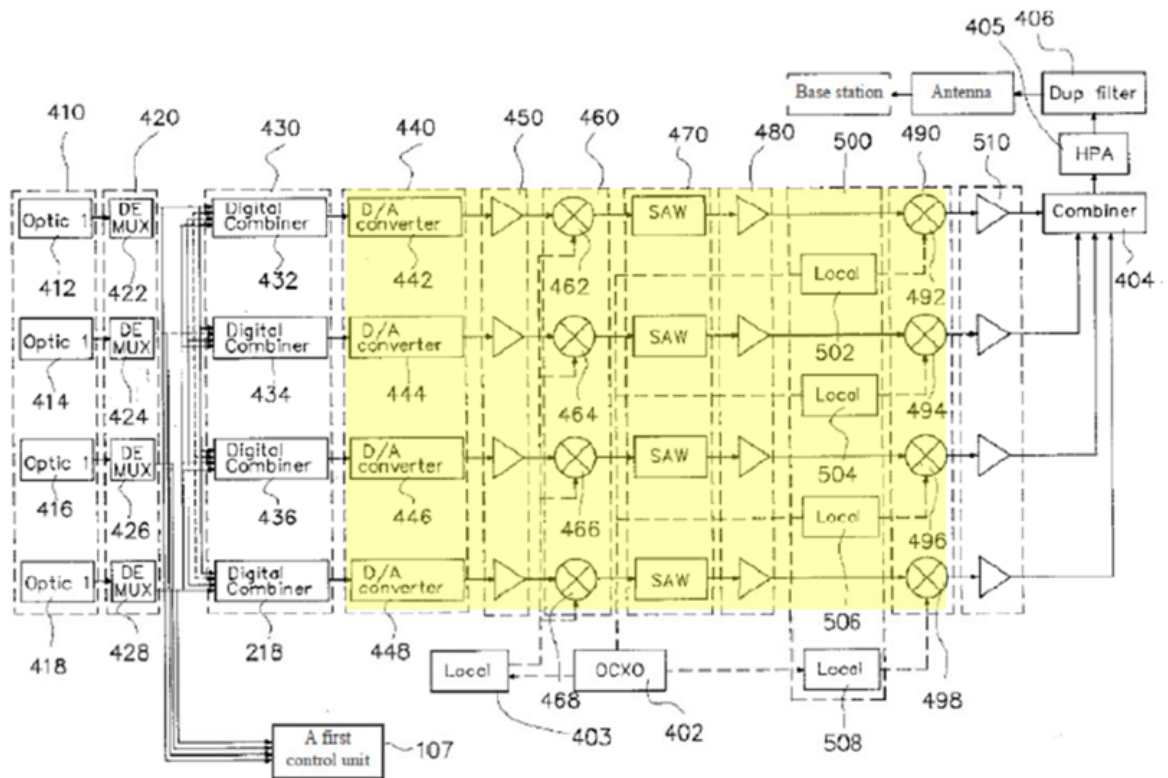
i) Element 7: “wherein the host unit converts the summed upstream digital RF samples to a replicated upstream analog wireless radio frequency signal.”

398. The upstream portion of master unit 20 (e.g., reverse master unit 400) “converts the digital signals transmitted from the slave unit 30 through the optic line 50 to the intermediate frequency signals, analog signals, converts them to the RF signals, and transmits them to the base station 10.” Ex. 1007, 4:62-64.

⁸ I understand that the parties have discussed whether this word should be translated as “adding” or “combining.” Regardless of which of these terms is used, the digital combiners are operating to produce a digital sum (*i.e.*, they are performing a digital summing operation).

399. As depicted in Fig. 5, the 14-bit digital signals output from digital combiner unit 430 are then applied to respective D/A converter units 440 to provide intermediate frequency analog signals. *Id.*, 5:18. The intermediate frequency analog signals are shifted to their respective band frequencies by being amplified at 450, mixed with a step up frequency at 460, filtered at 470, amplified again at 480, mixed with a respective frequency at 490 to recreate the analog band frequency signals, and amplified again at 510. *Id.*, 4:73-5:2.

FIG. 5

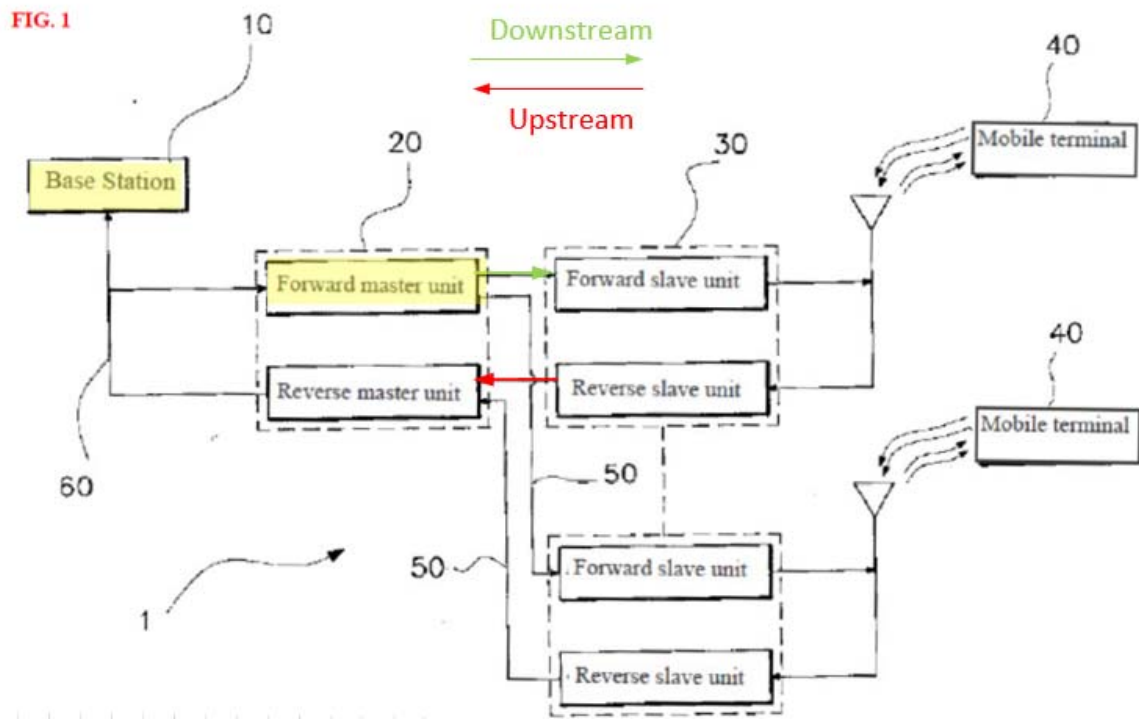


Thus Oh renders obvious the host unit (master unit 20) converts the summed upstream digital RF samples (output from digital combiner unit 430) to a replicated upstream analog wireless radio frequency signal (through 450, 460, 470, 480, 490).

2. Dependent Claim 2

a) *Element 1: “wherein the host unit receives an original downstream analog wireless signal comprising a downstream radio frequency spectrum and any downstream transmissions for the wireless units;”*

400. As depicted in Fig. 1, RF signals are received by the forward portion of master unit 20 from the base station 10. Ex. 1007, 2:72-73.



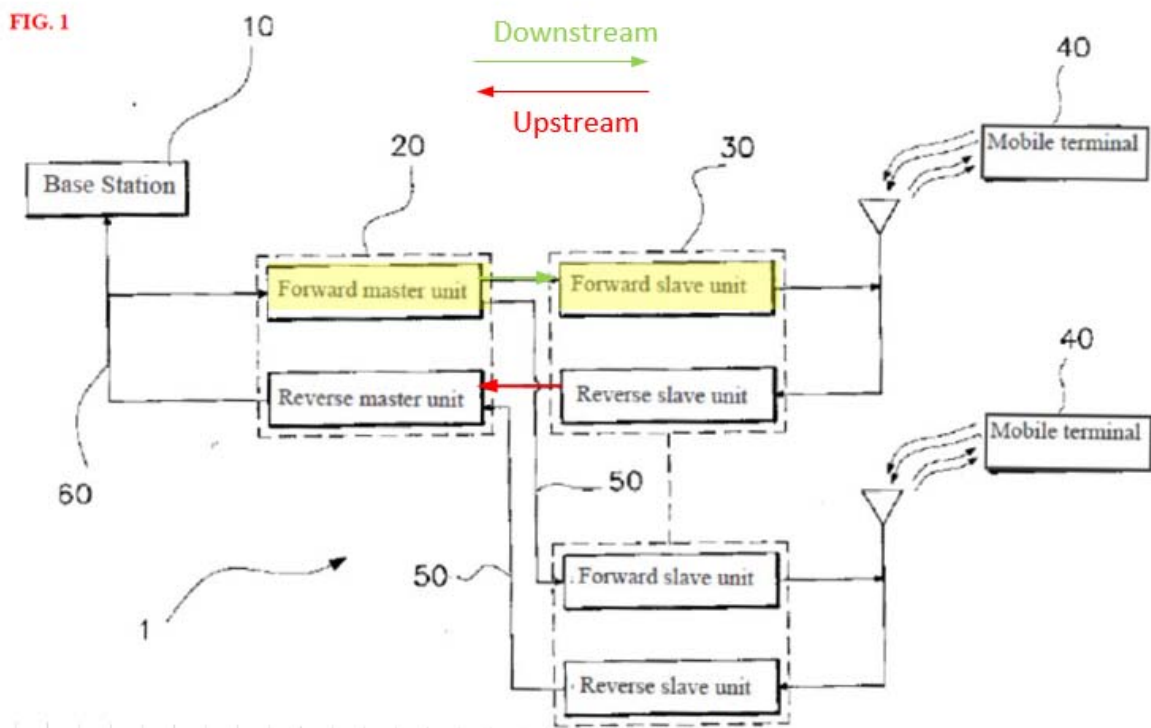
b) *Element 2: “wherein the host unit generates downstream digital RF samples indicative of the original downstream analog wireless signal;”*

401. Oh discloses master unit 20 is coupled to multiple remote slave units 30 via optic lines 50. That master unit 20 receives analog RF signals from base station

Thus Oh renders obvious the host unit (master unit 20) generates downstream digital RF samples (generated at 180) indicative of the original downstream analog wireless signal (from base station 10).

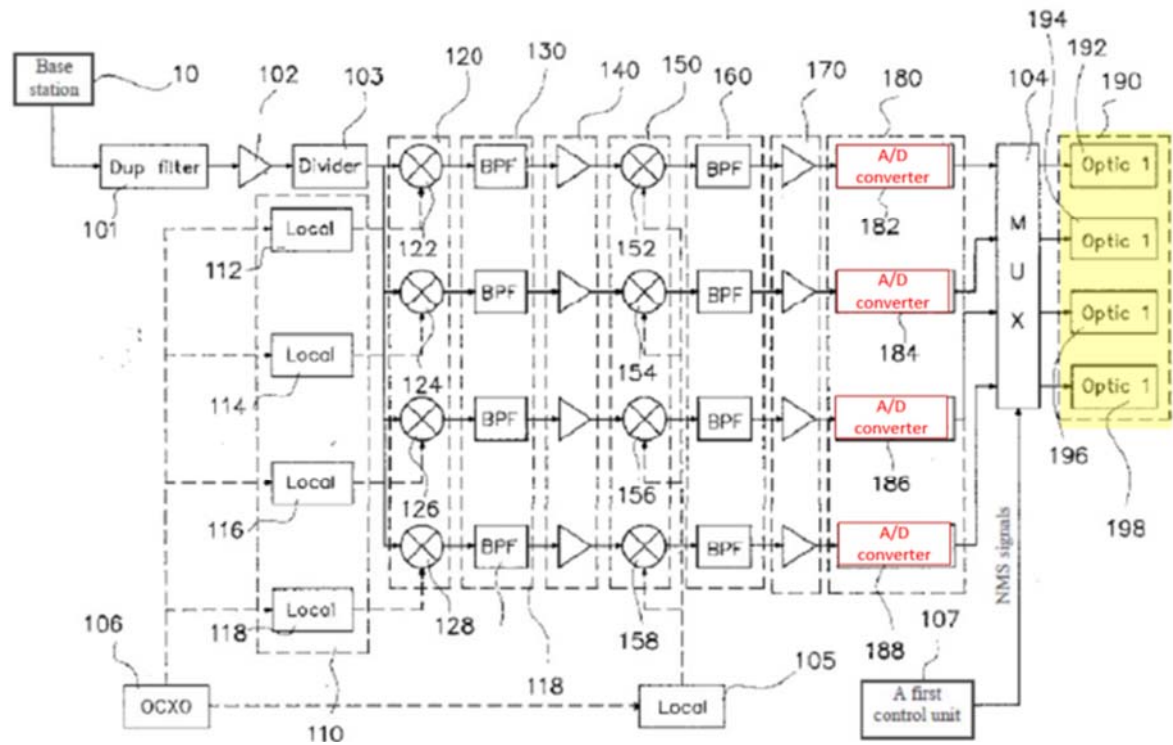
c) Element 3: “wherein the host unit communicates the downstream digital RF samples to at least some of the plurality of remote units using the at least one communication medium;”

402. Oh discloses master unit 20 is coupled to multiple remote slave units 30 via optic lines 50. That master unit 20 receives analog RF signals from base station 10 and digitizes that analog signal on a per frequency band basis at 180 for communications to slave units 30.



403. Fig. 2 of Oh depicts optic converter unit 190 that provides an interface between forward master unit 100 of master unit 20 and forward slave unit 200 of remote slave units 30.

FIG. 2

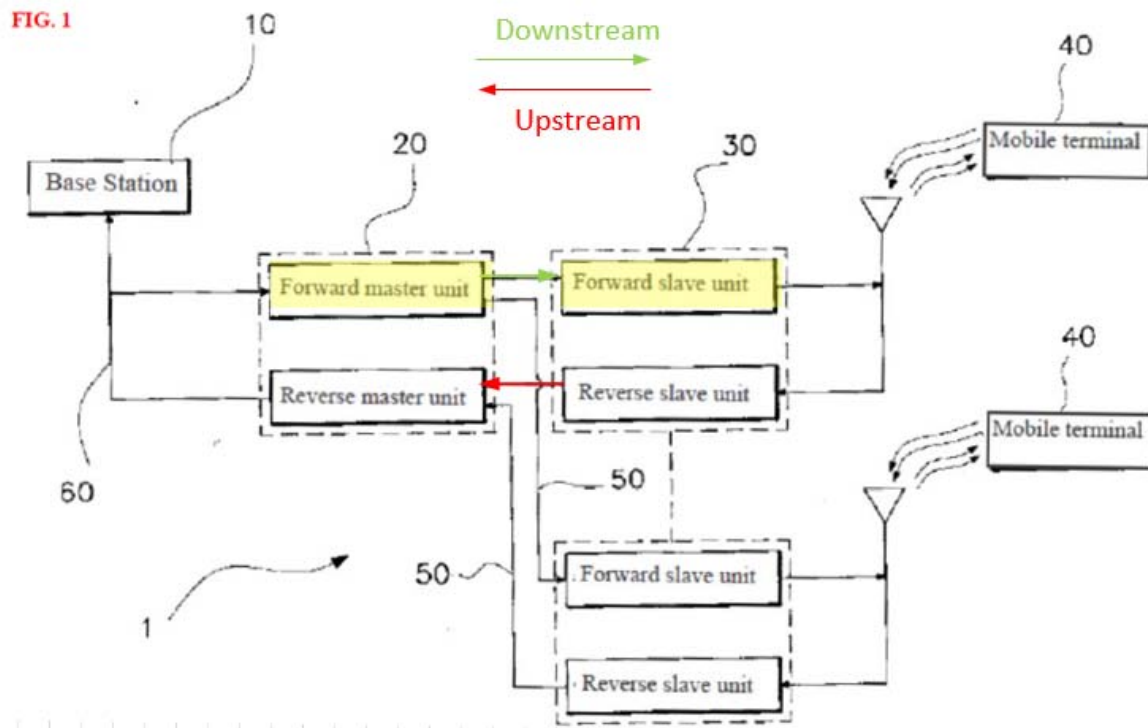


404. Thus Oh renders obvious a host unit (master unit 20) that communicates (optic converter 190) the downstream digital RF samples (generated at 180) to at least some of the plurality of remote units (slave units 30) using the at least one communication medium (optic lines 50).

d) Element 4: “wherein each of the at least some of the plurality of remote units to which the host unit communicates the downstream digital RF samples converts the downstream digital RF samples to a replicated downstream analog wireless radio frequency signal.”

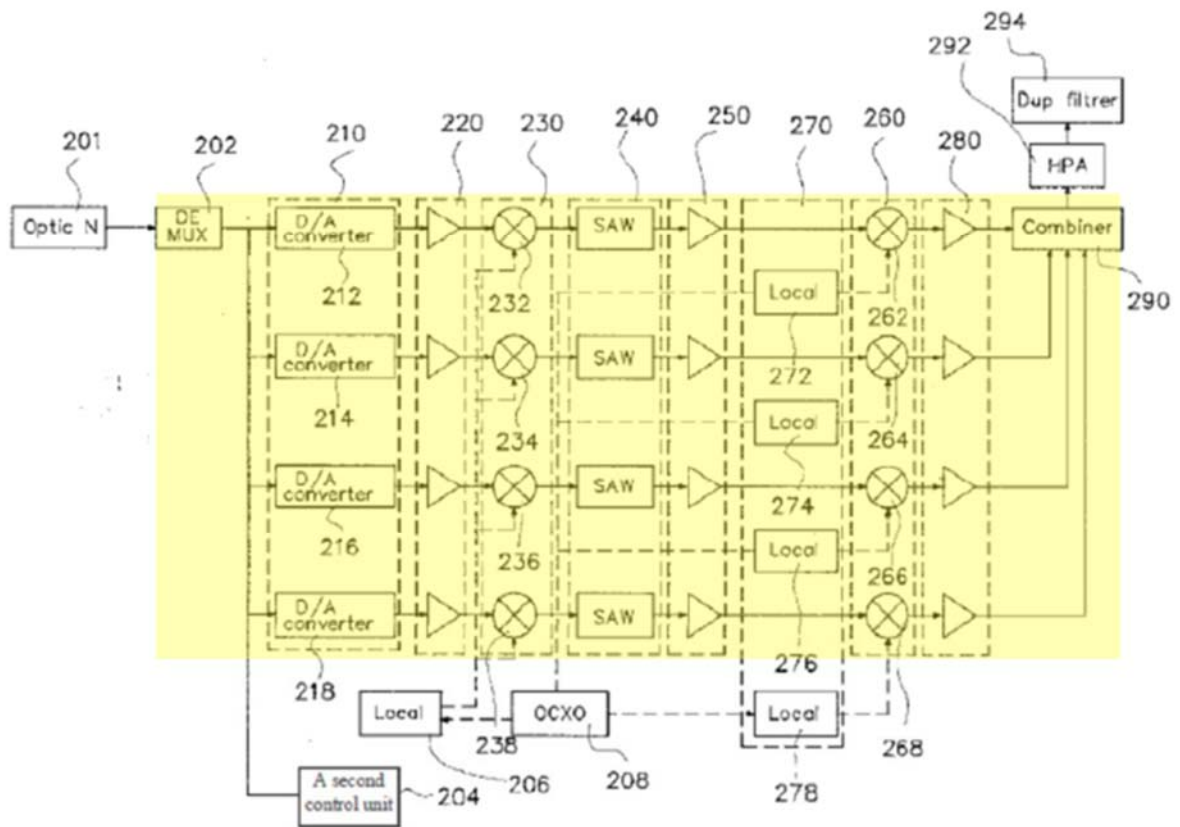
405. Oh discloses that the optic converter unit 190 transmits digitized radio frequency spectrum data to multiple slave units over optic line 50 as depicted in FIG.

1. Ex. 1007, 3:16-18; 38-44.



406. The forward slave unit 200 of the slave unit 30 “converts the digital signals transmitted from the master unit 20 through the optic line 50 to the intermediate frequency signals, analog signals; converts them to the RF signals and transmits them to the mobile terminals 40.” Ex. 1007, 3:47-49.

FIG. 3



407. Oh discloses that the forward slave unit 200 of the slave unit 30 “converts the digital signals transmitted from the master unit 20 through the optic line 50 to the intermediate frequency signals, analog signals; converts them to the RF signals and transmits them to the mobile terminals 40.” Ex. 1007, 3:47-49. That process is described in further detail at 3:50-61, where the digital samples from the master unit 20 are routed for re-creation of the component analog band signals and upconverted to component analog radio frequency signals which are combined at 290 prior to transmission to mobile terminals 40.

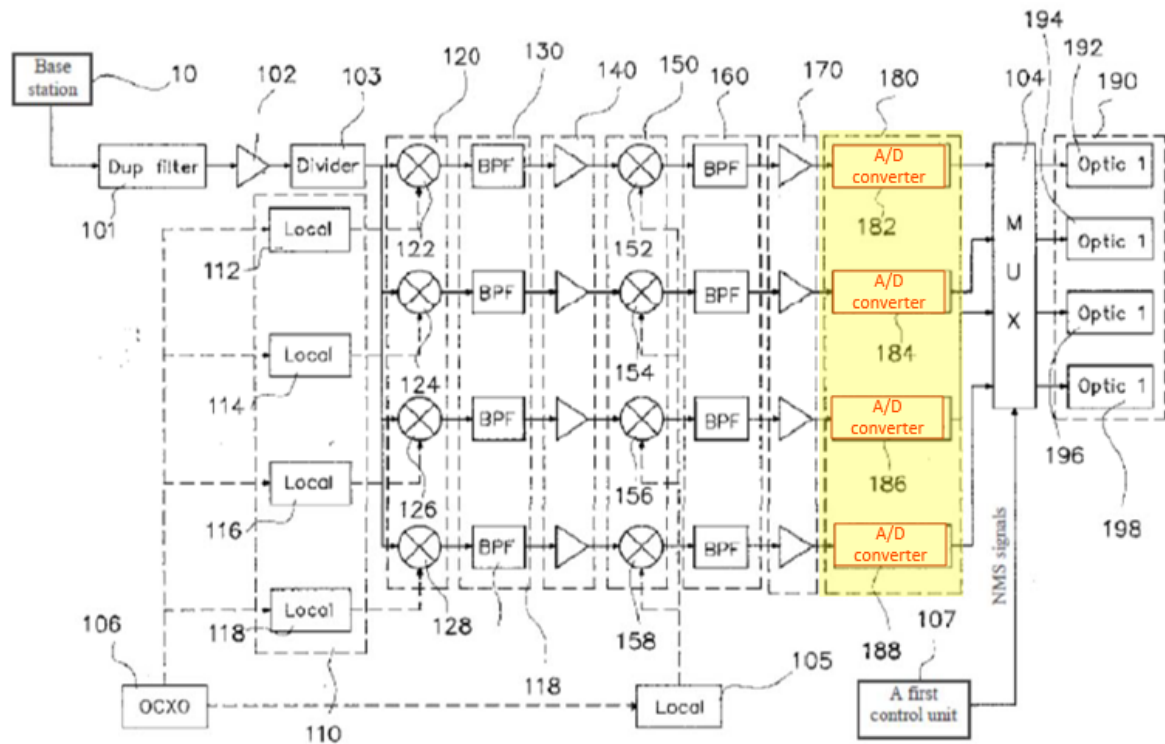
408. Thus Oh renders obvious each of the at least some of the plurality of remote units (slave units 30) to which the host unit (master unit 20) communicates the downstream digital RF samples (digital sample data received from master unit 20 at 201) converts the downstream digital RF samples to a replicated downstream analog wireless radio frequency signal (converting from digital to analog signals, upconverting the analog signals to their respective band frequencies, and combining to form analog radio frequency signals for transmission to mobile terminals 40).

3. Dependent Claim 3

a) Element 1: “wherein the host unit comprises: an analog-to-digital converter to digitize the original downstream analog wireless radio frequency signal in order to produce the downstream digital RF samples;”

409. Oh’s master unit 20 receives RF signals from a base station 10 and divides it into its component frequency bands at 103. Those frequency bands are downconverted to from around 800Mhz to about 70MHz by mixers at 120 that are controlled by local oscillators 110 deriving frequencies from oven controlled oscillator (OCXO) 106. Following filtering 130 and amplification, those intermediate frequency signals are further downconverted to near DC at 150 based on a signal from local oscillator 105, responsive to OCXO 106 before A/D conversion at 180. Ex. 1007, 3:19-39.

FIG. 2

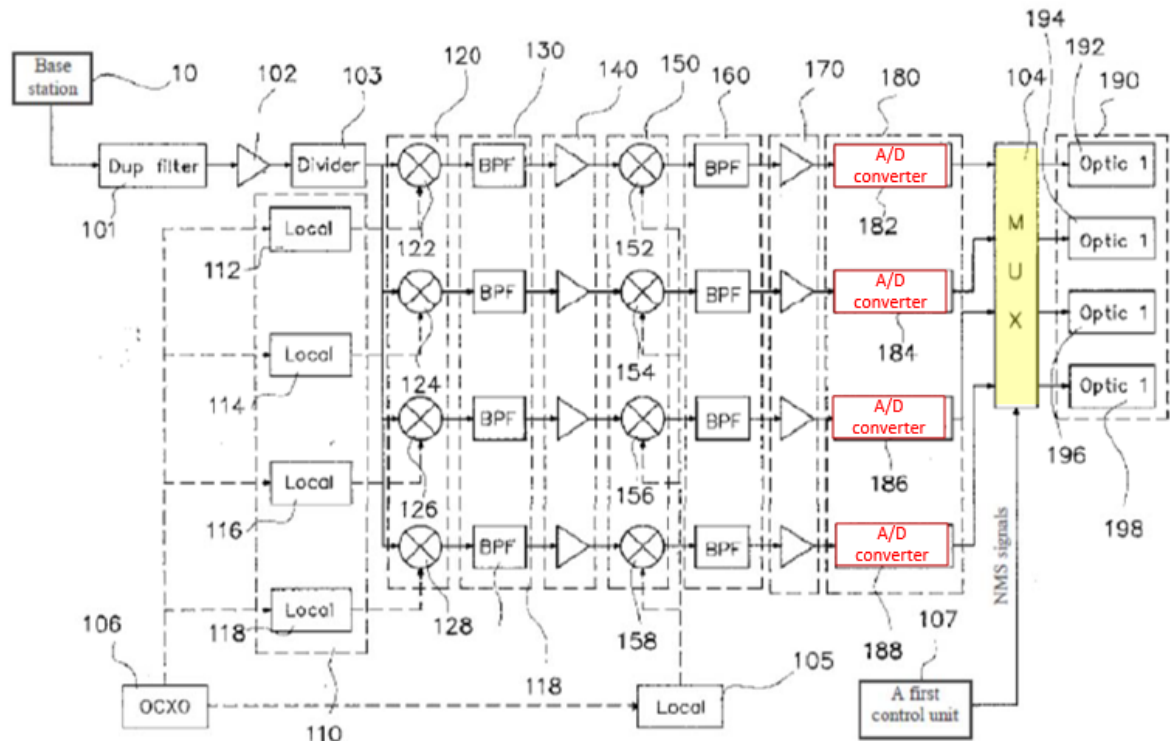


410. Thus, Oh describes a host unit (20) comprises: an analog-to-digital converter (180) to digitize the original downstream analog wireless radio frequency signal (from base station 10) in order to produce the downstream digital RF samples.

b) Element 2: “a multiplexer to frame the downstream digital RF samples for communication to at least some of the plurality of remote units as a downstream framed signal;”

411. Multiplexer 104 multiplexes the four 12-bit digital sample values with 4-bit network management system (NMS) control data from control unit 107 and applies that 52-bit (*i.e.*, the 4-12-bit words plus the 4-bit NMS control information) serial data stream to each of a plurality of optic converters 192, 194, 196, 198 for transmission across optic lines 50 to destination slave units.

FIG. 2

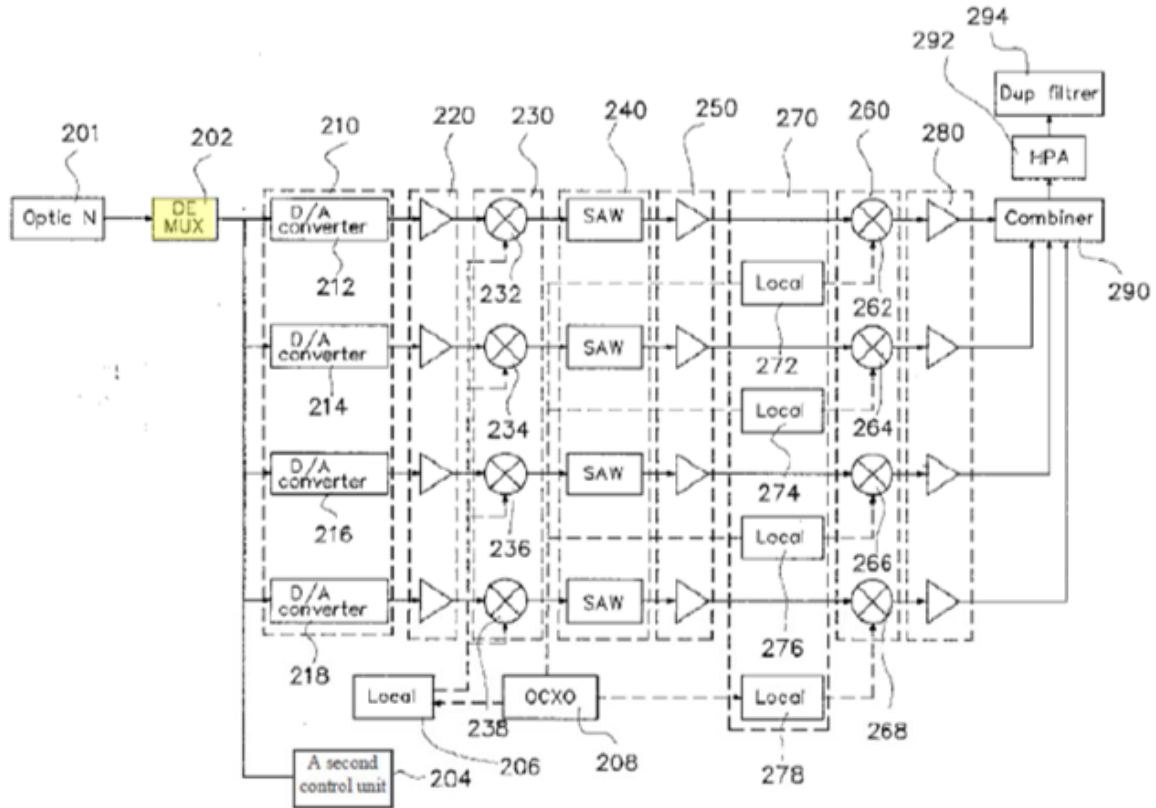


412. Thus Oh renders obvious a multiplexer (104) to frame the downstream digital RF samples for communication to at least some of the plurality of remote units (30) as a downstream framed signal (output from multiplexer 104).

c) Element 3 and element 3(a): “wherein each of the plurality of remote units comprises: a respective demultiplexer to extract the downstream digital RF samples from the downstream framed signal received from the host unit;”

413. Oh describes a demultiplexer 202 that routes digital sample data from the master unit 20 to the D/A converter 210 of the corresponding row of components for processing that frequency band of the analog signal to be transmitted to the mobile terminals 40. Ex. 1007, 3:50-53.

FIG. 3



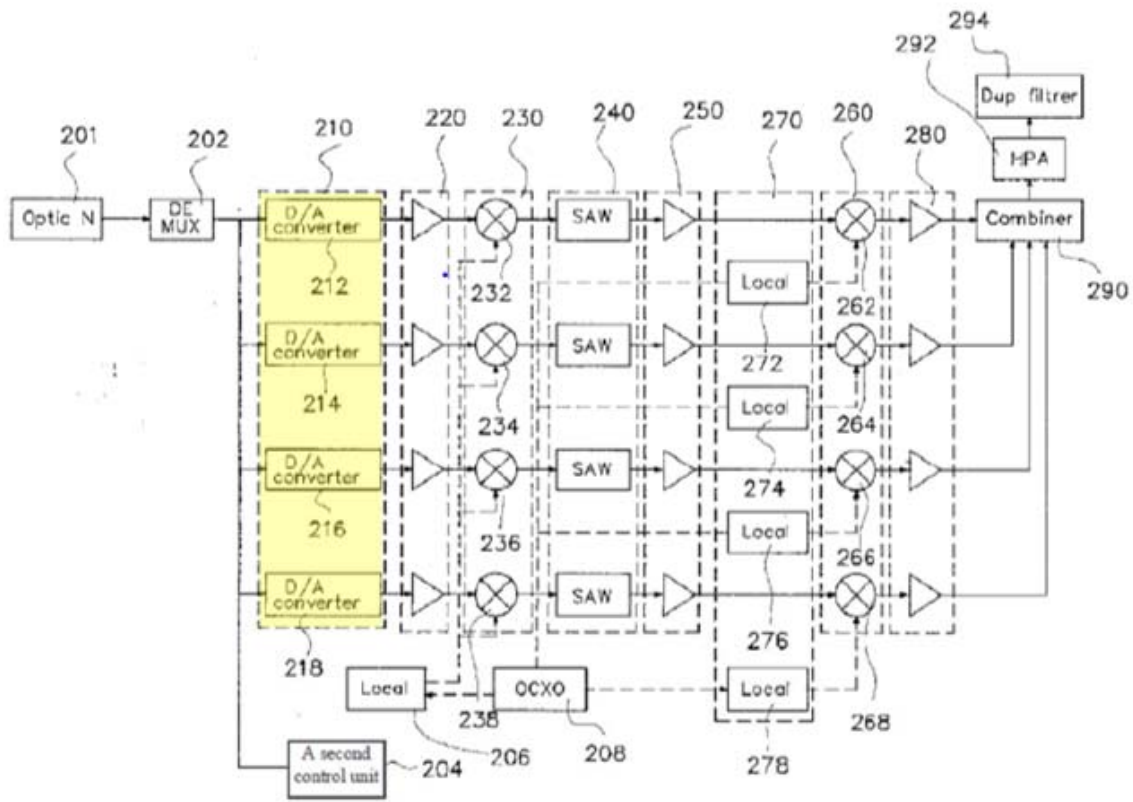
414. Thus Oh renders obvious wherein each of the plurality of remote units (30) comprises: a respective demultiplexer (202) to extract the downstream digital RF samples from the downstream framed signal received from the host unit (20).

d) Element 3(b): “a respective digital-to-analog converter to convert the downstream digital RF samples to the respective replicated downstream analog wireless radio frequency signal.”

415. Oh describes a demultiplexer 202 that routes digital sample data from the master unit 20 to the D/A converter 210 of the corresponding row of components for processing that frequency band of the analog signal to be transmitted to the mobile terminals 40. Ex. 1007, 3:50-53. Following conversion to analog, the signals are

processed for upconversion at 220, 230, 340, 250, 270, 260, 280 and are combined at 290 to form the replicated downstream analog wireless radio frequency signal for transmission to the mobile terminals 40. *Id.*, 3:50-61.

FIG. 3



416. Thus Oh renders obvious a respective digital-to-analog converter (210) to convert the downstream digital RF samples to the respective replicated downstream analog wireless radio frequency signal (via processing at 220, 230, 240, 250, 270, 260, 280 and combination at 290).

4. Dependent Claim 4

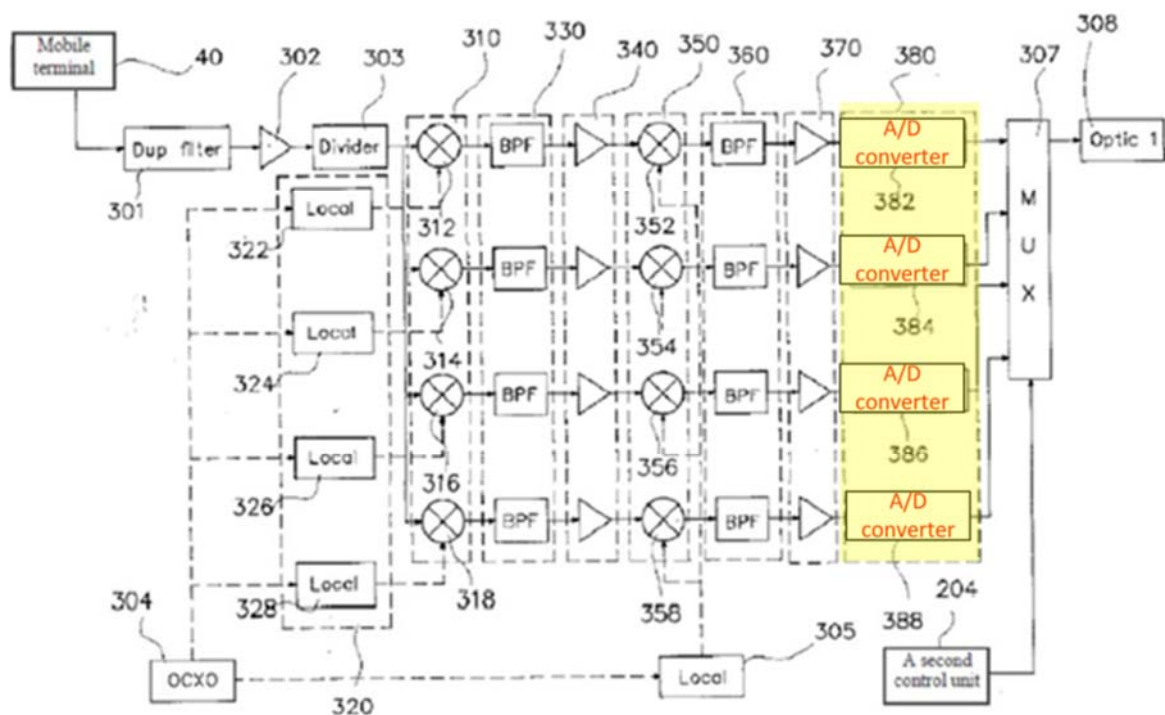
417. Claim 4 recites that “wherein the respective replicated downstream analog wireless radio frequency signal generated at each of the at least some of the

5. Dependent Claim 5

a) Element 1 and 1(a): “wherein each of the plurality of remote units comprises: a respective analog-to-digital converter to digitize the original upstream analog wireless radio frequency signal received at that remote unit in order to produce the respective upstream digital RF samples;”

419. Oh discloses that each reverse slave unit 300 “converts the RF signals, analog signals, transmitted from the mobile terminals 40 through a third bi-directional filter 301, to the digital signals.” Ex. 1007, 4:23-25. That digitization is illustrated at Fig. 4 where “A/D converter unit 380 converts the intermediate frequency signals, analog signals, to the digital signals.” *Id.*, 4:56-67.

FIG. 4

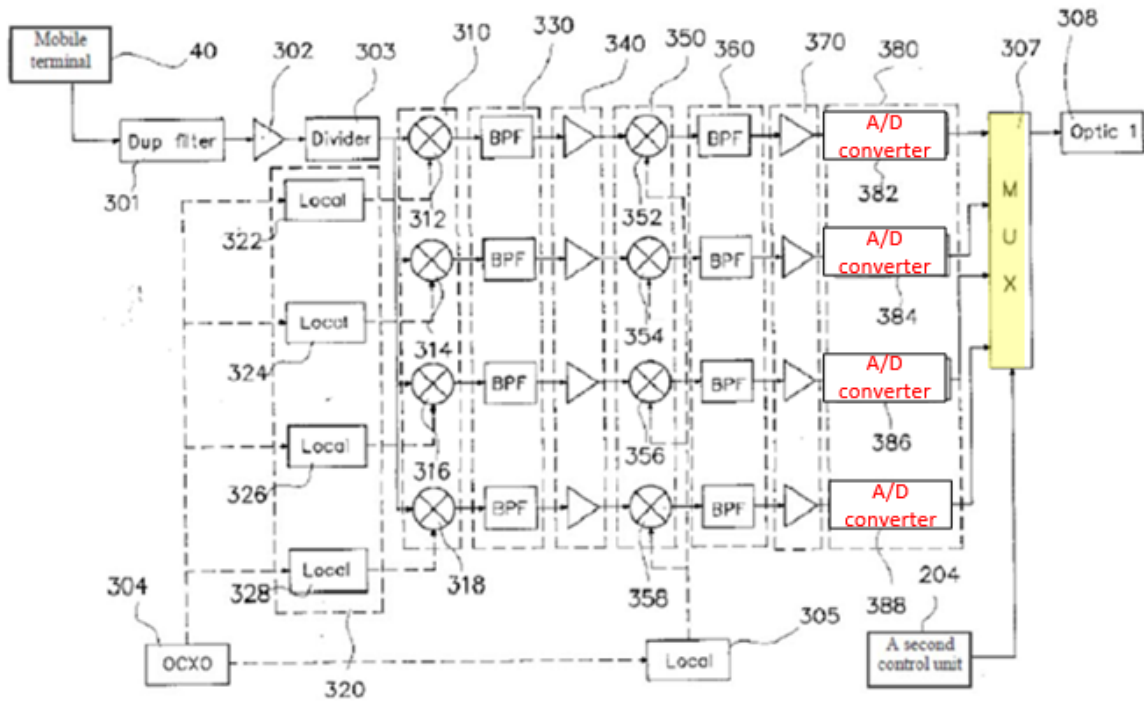


420. Thus Oh renders obvious each of the plurality of remote units (30) comprises: a respective analog-to-digital converter (380) to digitize the original upstream analog wireless radio frequency signal (from mobile terminals 40) received at that remote unit (30) in order to produce the respective upstream digital RF samples (output from A/D converter unit 380).

b) Element 1(b): “a respective multiplexer to frame the respective upstream digital RF samples for communication to the host unit as a respective upstream framed signal;”

421. Oh describes the serial data signals from slave units 30 are multiplexed by multiplexer 307. Multiplexer 307 multiplexes four 12-bit digital samples, one for each frequency band, and 4-bit control data from 204 into 52-bit word frames. *Id.*, 4:56-59. And applies that 52-bit serial data stream to optic converter 308 for transmission across optic line 50 to master unit 20. *Id.*, 3:56-61.

FIG. 4



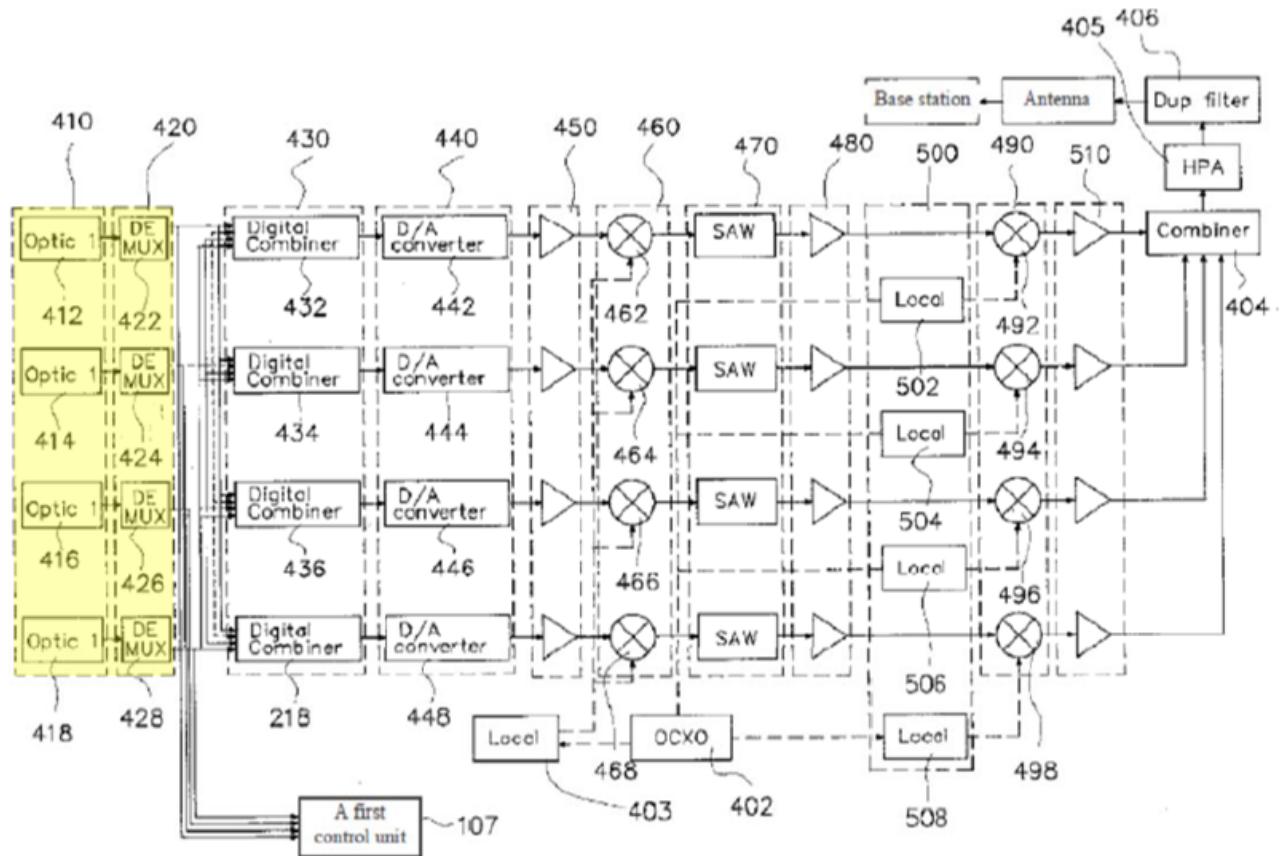
422. Thus Oh renders obvious a respective multiplexer (307) to frame the respective upstream digital RF samples (output from A/D converter unit 380) for communication to the host unit (20) as a respective upstream framed signal.

c) Element 2 and 2(a): “wherein the host unit comprises: at least one demultiplexer to extract the respective upstream digital RF samples from the respective upstream framed signals received from the plurality of remote units;”

423. Oh describes demultiplexers 422-428 associated with each of the remote slave units to route digital sample data to its respective frequency band path in the reverse slave unit. Each demultiplexer 422-428 receives digital sample data and control data from one slave unit 30 and separates that digital sample data according to

frequency band. *Id.*, 5:4-10. Those demultiplexers at 420 receive data from individual remote slave units 30 at 410.

FIG. 5

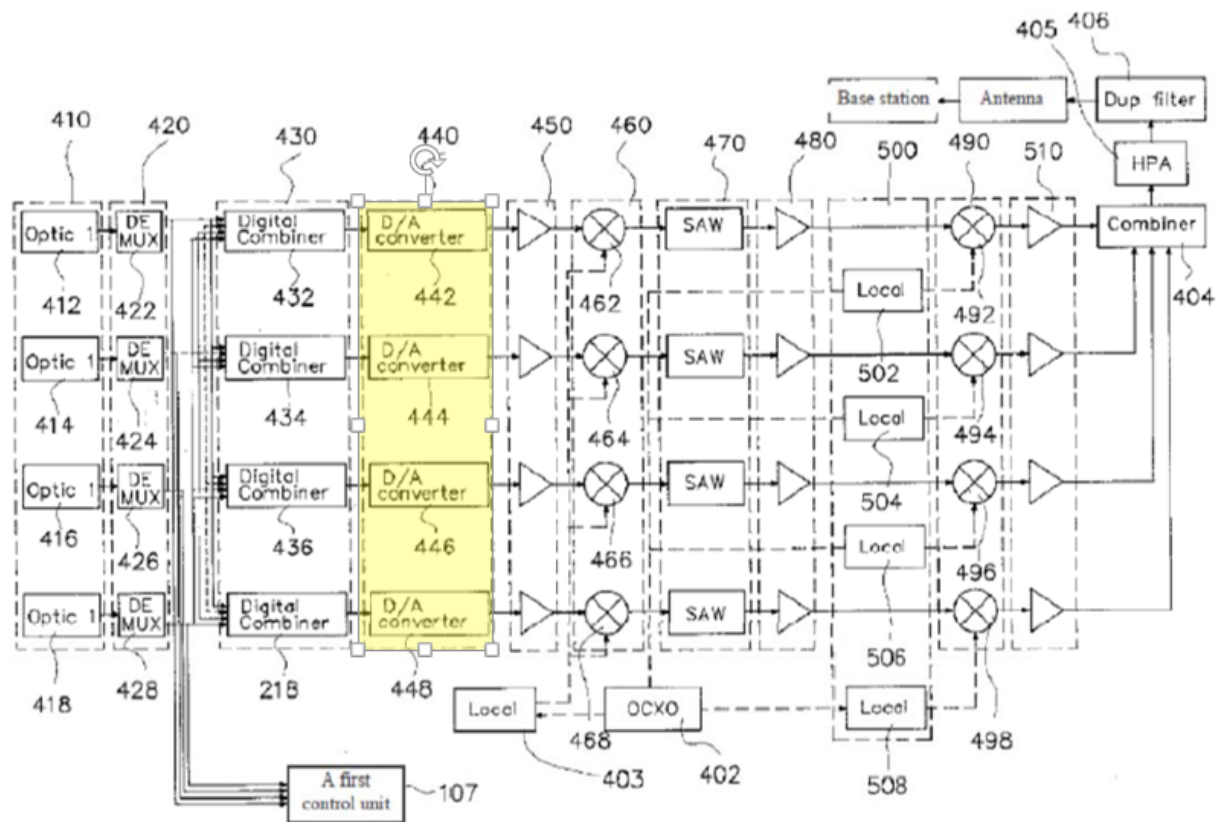


424. Thus Oh renders obvious a host unit (20) comprises: at least one demultiplexer (420) to extract the respective upstream digital RF samples (output from A/D converter unit 380 of slave unit 30) from the respective upstream framed signals received (at 410) from the plurality of remote units (30).

d) Element 2(b): “a digital-to-analog converter to convert the summed upstream digital RF samples to the replicated upstream analog wireless radio frequency signal.”

425. Oh discloses D/A converter unit 440 receiving the summed upstream digital RF samples from digital combiner unit 430. “D/A converter unit 440 that converts the digital signals transmitted from said digital combiner unit 430 to analog signals, respectively.” Ex. 1007, 4:70-71.

FIG. 5

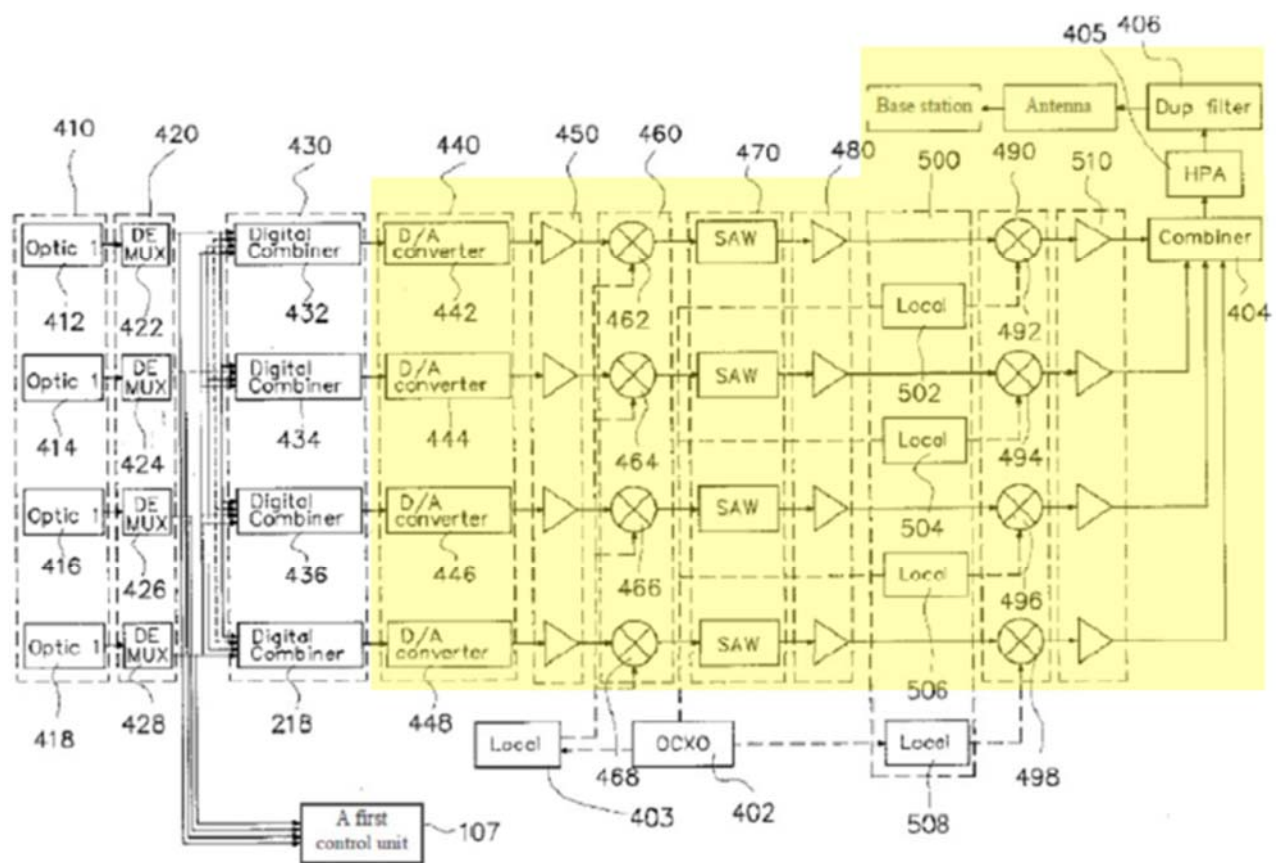


426. Thus Oh renders obvious a digital-to-analog converter unit (440) to convert the summed upstream digital RF samples to the replicated upstream analog wireless radio frequency signal.

6. Dependent Claim 6

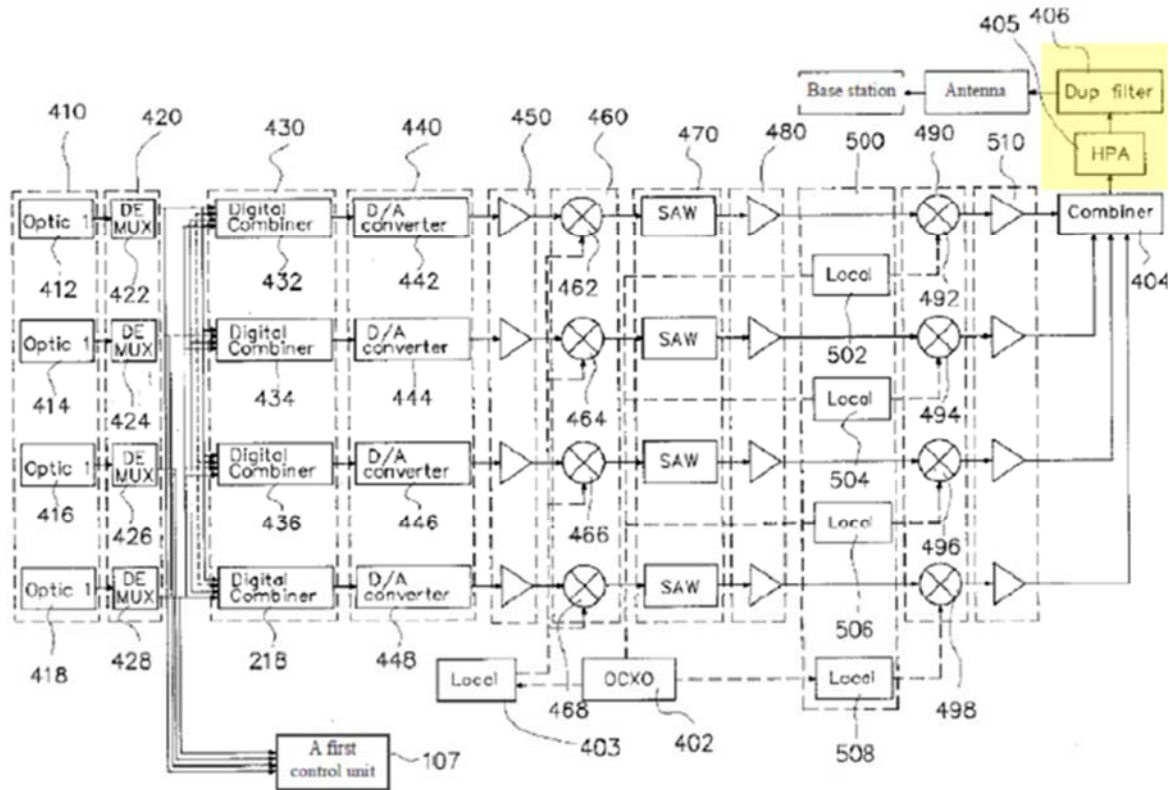
427. Claim 6 recites that “the replicated upstream analog wireless radio frequency signal is communicated from the host unit to at least one base station.” Following the digital summing operation of Element 2b of claim 5, the summed digital data values are converted to analog signals, up converted to the appropriate frequency signals associated with their particular bands to create component analog signals, that are then combined and transmitted to a base station via an antenna.

FIG. 5



Thus Oh renders obvious the replicated upstream analog wireless radio frequency signal (output from mixers 490) is communicated (using 405, 406, antenna) from the

FIG. 5



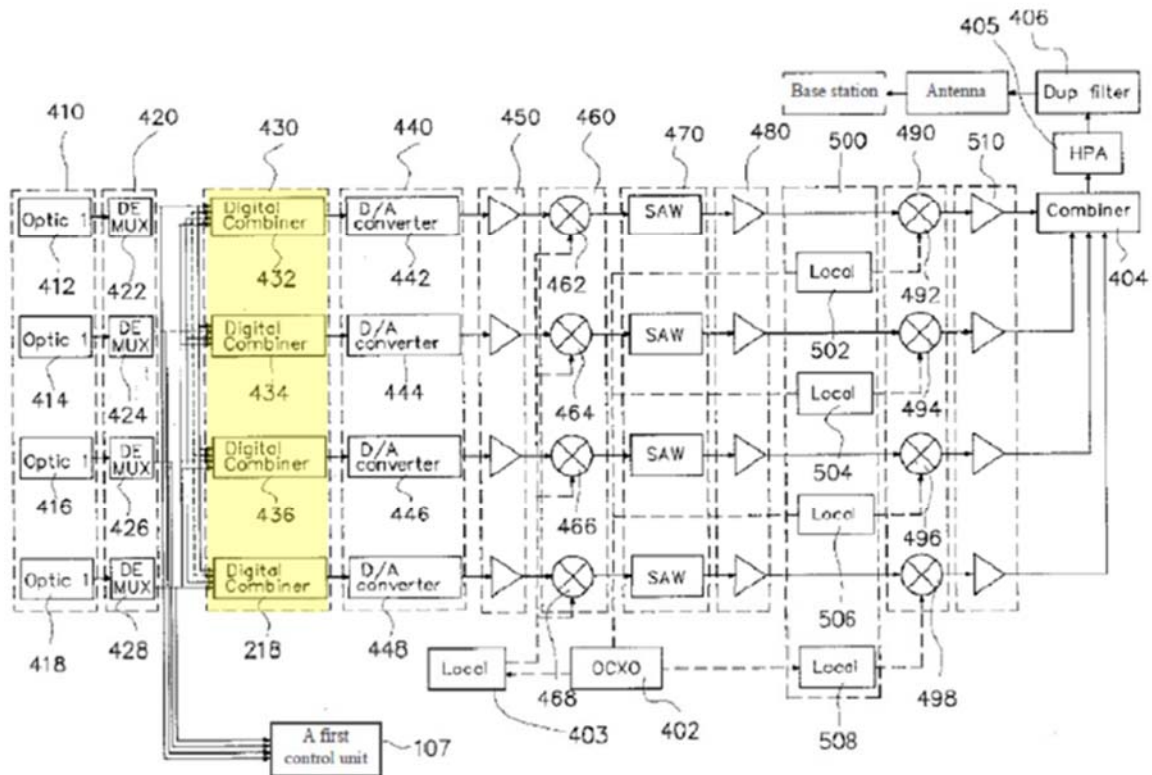
430. A POSITA understands that a bi-directional amplifier comprises a bi-directional duplex filter component to prevent the transmit signal from interfering with the receive channel and an amplifier component. Fig. 5 of Oh illustrates its bi-directional filter 406, which is labeled as a duplex filter, being connected to an antenna for wireless communication with the base station 10.

431. Thus Oh renders obvious the replicated upstream analog wireless radio frequency signal (output from mixers 490) is communicated from the host unit (20) to the at least one base station using at least one bi-directional amplifier (405, 406).

8. Dependent Claim 8

432. Claim 8 recites that “the host unit digitally sums the corresponding upstream digital RF samples received from the plurality of remote units in order to produce the summed upstream digital RF samples at a resolution greater than a resolution of the upstream digital RF samples being summed.” Oh discloses that its A/D converter unit 380 of slave unit 30 samples the downconverted analog signals at each frequency band at 12-bits of resolution. Ex. 1007, 3:38-39; 3:61-64; 4:16. On the reverse path at the master unit 20, digital combiners 432, 434, 436, 438 “creat[e] 14-bit intermediate frequency signals by combining four 12-bit intermediate frequency signals in the same frequency band.” *Id.*, 5:16-17.

FIG. 5



Thus Oh renders obvious the host unit (20) digitally sums (at 430) the corresponding upstream digital RF samples received from the plurality of remote units (30) in order to produce the summed upstream digital RF samples at a resolution (14 bits) greater than a resolution (12 bits) of the upstream digital RF samples being summed.

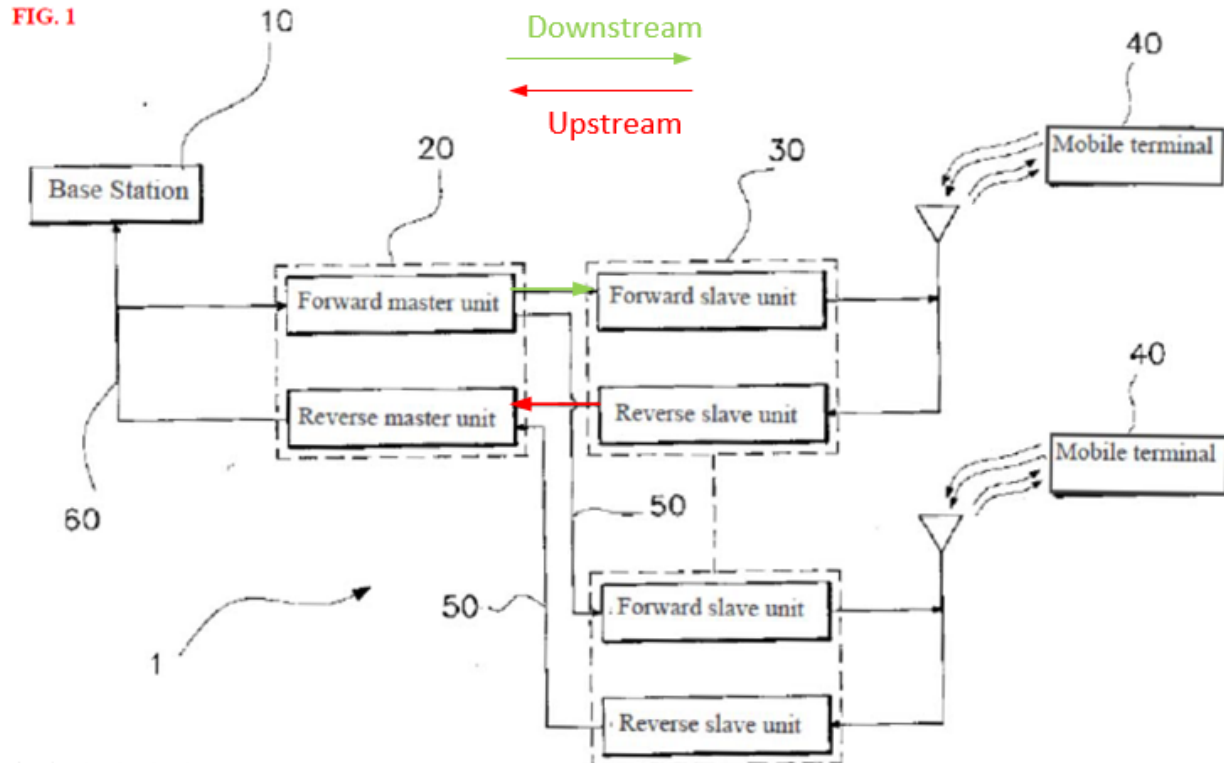
9. Dependent Claim 9

433. Claim 9 recites that “the upstream radio frequency spectrum comprises a cellular radio frequency spectrum.” Oh discloses receiving and operations on base station/mobile terminal signals at 800MHz and 1800MHz Ex. 1007, 3:19, 4:40. The 800MHz frequency corresponds to the first mobile commercial standard, the Advanced Mobile Phone System. As demand grew for cellular services, carriers acquired licenses in 1800MHz band. Both 800 MHz and 1800 MHz are within the cellular radio frequency spectrum. Thus Oh renders obvious the wireless radio frequency spectrum comprises a cellular radio frequency spectrum (800MHz, 1800MHz).

10. Dependent Claim 10

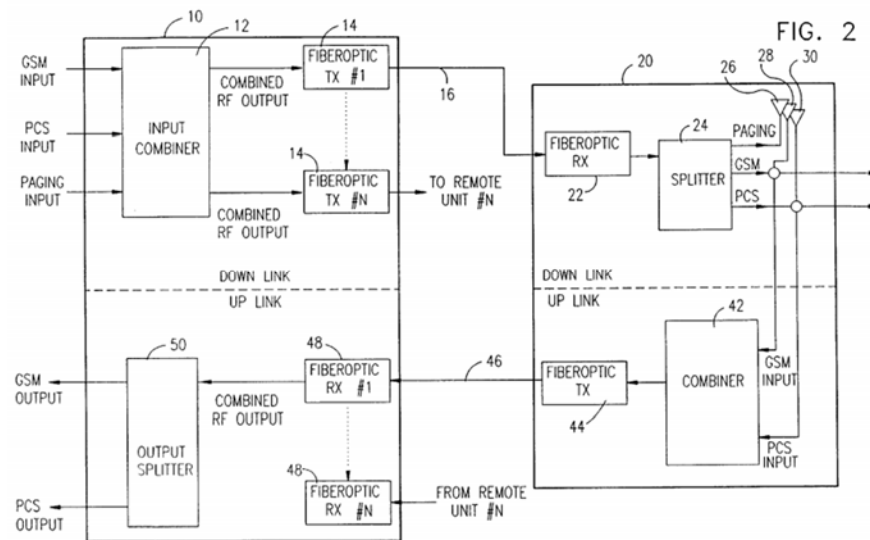
434. Claim 10 recites that “the at least one communication medium comprises at least one of: a single mode optical fiber, a multi-mode optical fiber, and a coaxial cable.” Oh Fig. 1 illustrates master unit 20 communicating in the downstream direction to a slave unit 30 using a first optic line 50, highlighted in green, and in the upstream direction from a slave unit using a second optic line 50 highlighted in red.

Thus Oh discloses master unit 20 communicating with each slave unit 30 via fiber pairs.



435. Oh is agnostic as to whether multimode or single mode fiber is used. A POSITA would consider selection of multimode or single mode to be a matter of design choice. This is evidenced by Farber which describes the use of single or multimode fiber in an antenna system for reaching difficult coverage areas (see Fig. 1) that is very similar to the digital system of Oh. Ex. 1022 (“Farber”), 4:30-33 (“Preferably the transmitter 14 employs a vertical cavity surface emitting laser or an edge emitting laser coupled to a single or multi-mode fiber 16.”); Fig. 2. As further evidence of obviousness of using single mode or multimode fiber, Haas illustrates the cost-benefit analysis of selection of multimode or single mode fiber for an application.

Ex. 1012, 1125. A POSITA would have been motivated to select multimode fiber as disclosed by Haas for communicating among a host and remote units when cost is a significant factor for the project. Additionally as disclosed by Haas, in some instances multimode fiber may already be installed in an area into which an RF distribution network is being implemented, making reuse of that multimode fiber an attractive option.



436. Thus Oh alone, or in view of Farber renders obvious the digital host unit 20 is coupled to each of the at least two digital remote units 30 by a multimode (*e.g.*, as disclosed by Farber) fiber pair (see red and green annotations between 20, 30 in Oh Fig. 1).

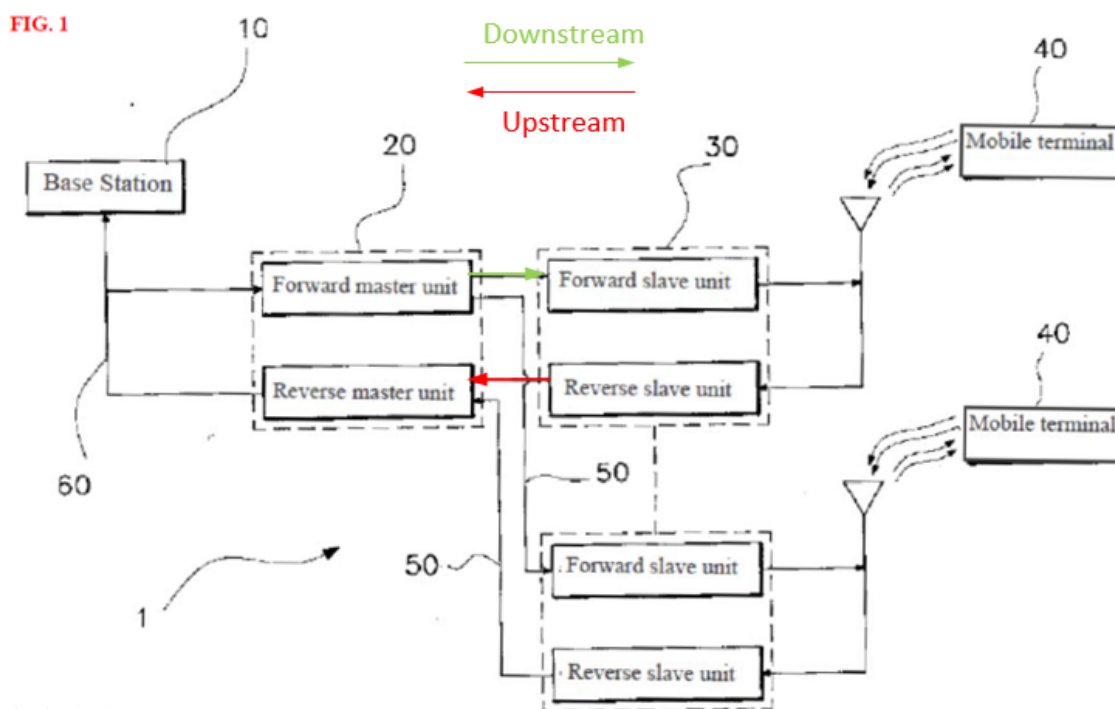
11. Independent Claim 12

a) *Preamble: “A host unit for wireless radio frequency signal distribution within a coverage area in which one or more wireless units transmit in an upstream wireless radio frequency spectrum, the host unit comprising:”*

437. Oh discloses the preamble for the reasons discussed above for claim 1, preamble.

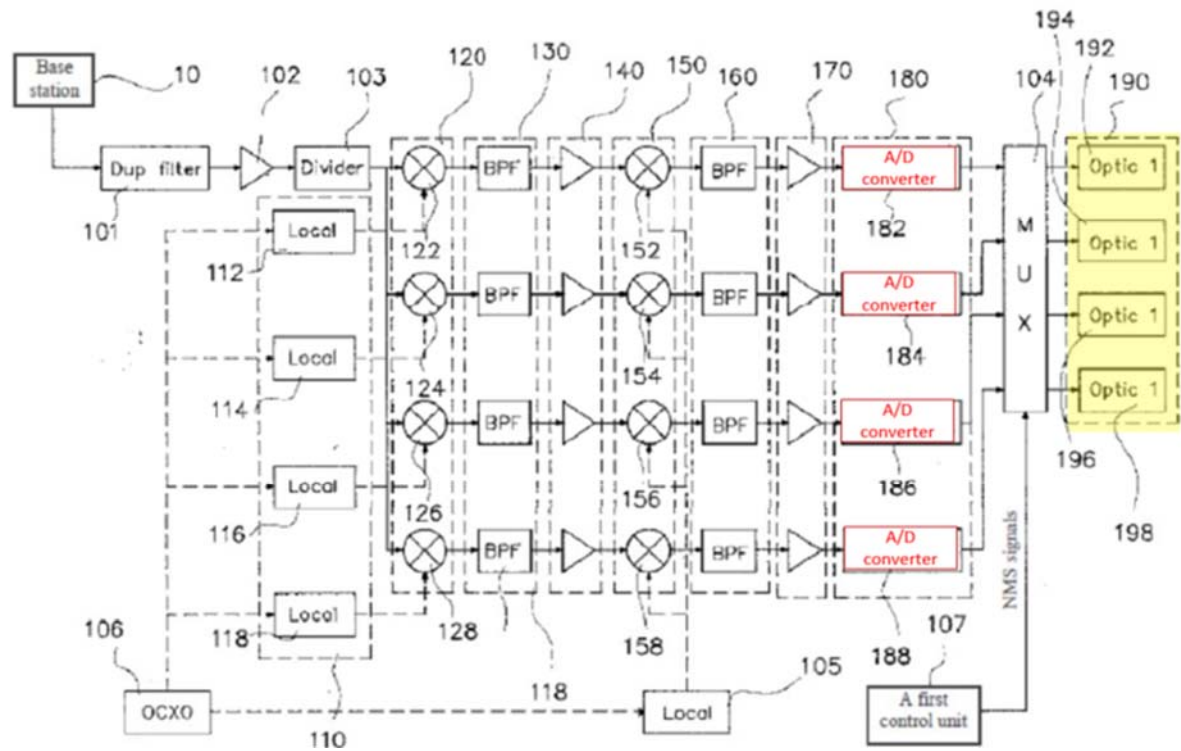
b) *Element 1a: “an interface to communicatively couple the host unit to a plurality of remote units using at least one communication medium,”*

438. Oh discloses master unit 20 is coupled to multiple remote slave units 30 via optic lines 50. That master unit 20 receives analog RF signals from base station 10 and digitizes that analog signal on a per frequency band basis at 180 for communications to slave units 30.



439. Fig. 2 of Oh depicts optic converter unit 190 that provides a downstream interface between forward master unit 100 of master unit 20 and forward slave unit 200 of remote slave units 30.

FIG. 2



440. And Fig. 5 illustrates optic converter unit 410 that provides an upstream interface from slave units 30 to master unit 20.

The diagram illustrates a multi-channel communication system architecture. It features four parallel processing channels, each consisting of an input section (410-418), a digital combiner (430-436), a D/A converter (440-446), a variable gain amplifier (450-456), a mixer (460-466), a SAW filter (470-476), a variable gain amplifier (480-486), a mixer (490-496), and a duplexer (500-506). A common base station interface (400) is connected to the output of the duplexers (500-506) via a combiner (404). The system is controlled by a first control unit (107) which provides signals to the digital combiners (430-436) and the D/A converters (440-446). A local oscillator (OCXO) (402) provides a common clock signal (403) to the mixers (460-466) and the duplexers (500-506). The system is designed for multi-channel communication, with each channel having its own set of components for signal processing and transmission.

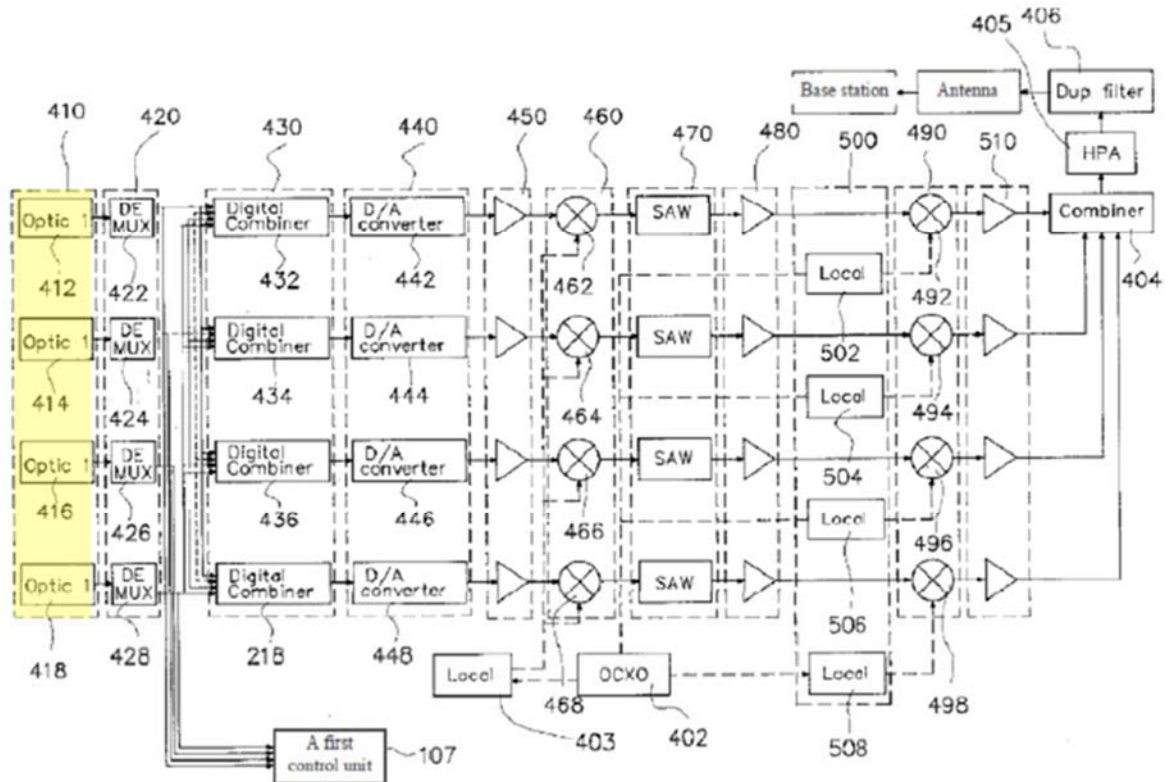
c) Elements 1b-1d

d) Element 1e: “wherein the interface is used to receive the upstream digital RF samples from the plurality of remote units:”

SOLiD Ex. 1005

Fig. 5 illustrates optic converter unit 410 that provides an upstream interface from slave units 30 to master unit 20.

FIG. 5



Thus Oh renders obvious the interface (410) is used to receive the upstream digital RF samples from the plurality of remote units (30).

e) Element 2: “a digital summer to digitally sum corresponding upstream digital RF samples received from the plurality of remote units to produce summed upstream digital RF samples;”

443. Oh discloses element 2 for the reasons discussed above for claim 1, element 6.

f) Element 3: “a digital-to-analog converter to convert the summed upstream digital RF samples to a replicated upstream analog wireless radio frequency signal.”

444. Oh discloses element 3 for the reasons discussed above for claim 5, element 2b.

12. Dependent Claim 13

a) Element 1: “wherein the interface is used to receive, at the host unit, an original downstream analog wireless signal comprising a downstream radio frequency spectrum and any downstream transmissions for the wireless units;”

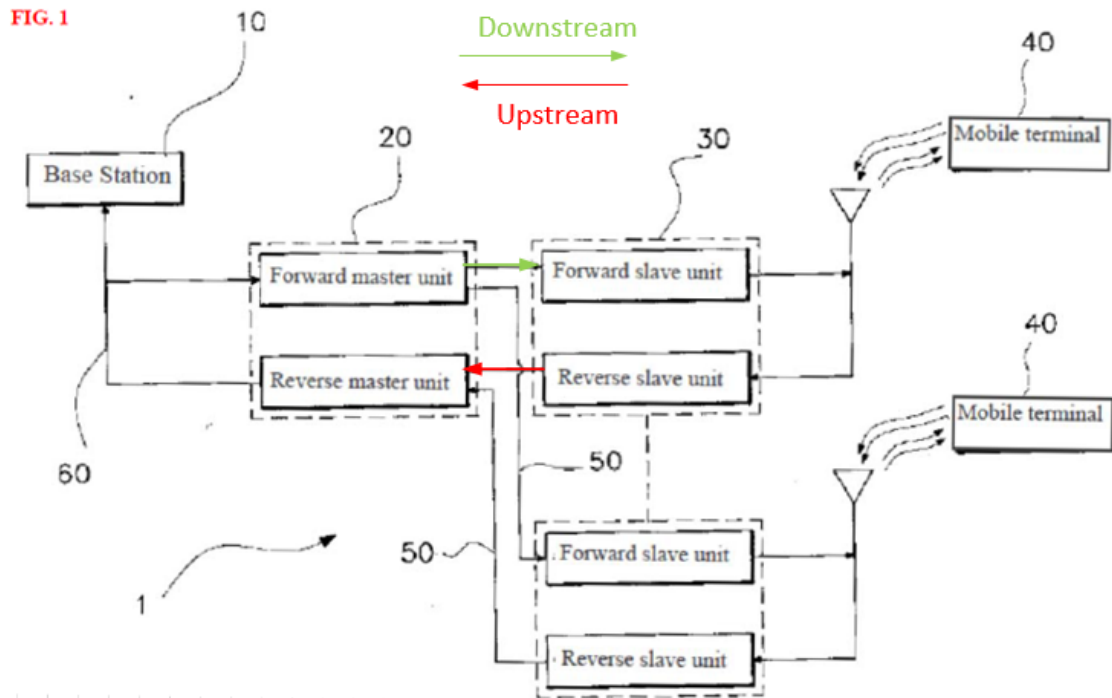
445. Oh discloses element 1 for the reasons discussed above for claim 2.

b) Element 2: “wherein the host unit further comprises an analog-to-digital converter to digitize the original downstream analog wireless radio frequency signal in order to generate downstream digital RF samples indicative of the original downstream analog wireless signal;”

446. Oh discloses element 2 for the reasons discussed above for claim 3, element 1.

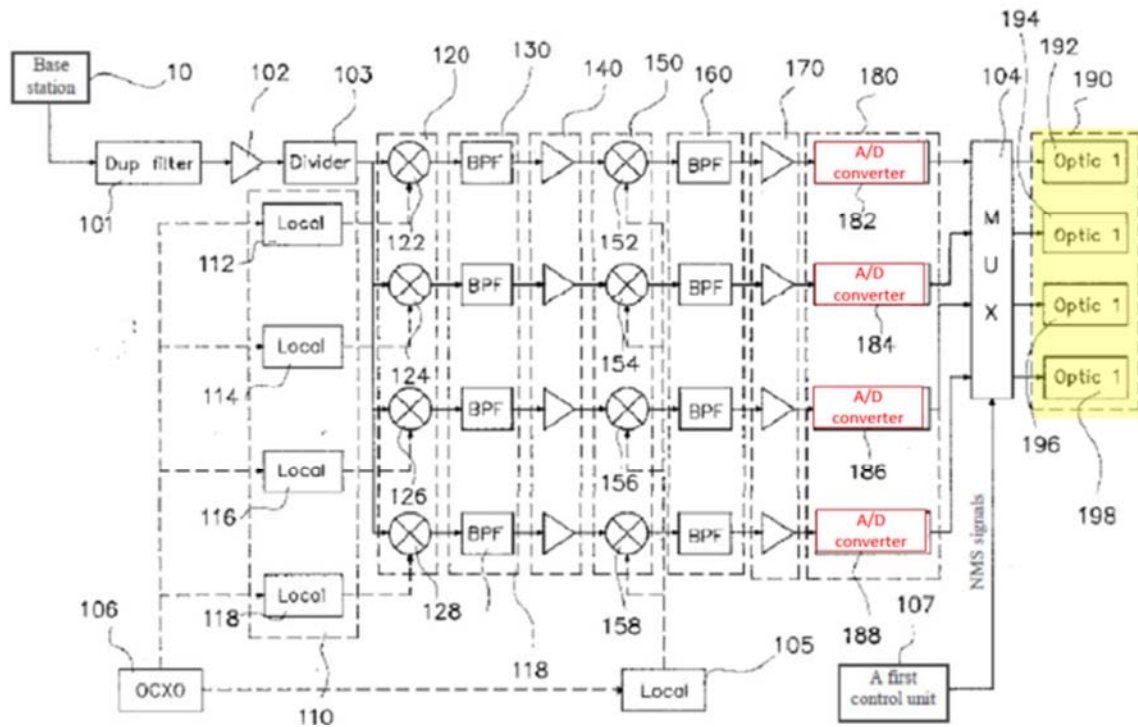
c) Element 3: “wherein the interface is used to communicate the downstream digital RF samples to at least some of the plurality of remote units using the at least one communication medium;”

447. Oh discloses master unit 20 is coupled to multiple remote slave units 30 via optic lines 50. That master unit 20 receives analog RF signals from base station 10 and digitizes that analog signal on a per frequency band basis at 180 for communications to slave units 30.



448. Fig. 2 of Oh depicts optic converter unit 190 that provides a downstream interface between forward master unit 100 of master unit 20 and forward slave unit 200 of remote slave units 30.

FIG. 2



Thus Oh renders obvious the interface (190) is used to communicate the downstream digital RF samples (generated at 180) to at least some of the plurality of remote units (30) using the at least one communication medium (optic line 50).

d) Element 4: “wherein each of the at least some of the plurality of remote units to which the host unit communicates the digital RF samples converts the downstream digital RF samples to a replicated downstream analog wireless radio frequency signal.”

449. Oh discloses element 4 for the reasons discussed above for claim 2, element 4.

13. Dependent Claim 14

450. Oh renders dependent claim 14 obvious for the reasons provided above with respect to element 2 of claim 3.

14. Dependent Claims 16-20

451. Dependent claims 16-20 are rendered obvious by Oh for the reasons provided above for claims 6-10, respectively.

15. Dependent Claims 23-24

452. Dependent claims 23-24 are rendered obvious by Oh for the reasons provided above for claims 8-9, respectively.

16. Independent Claim 25

a) Preamble and Element 1: “A method of distributing wireless radio frequency signals within a coverage area in which one or more wireless units transmit in an upstream wireless radio frequency spectrum, the method using a host unit and a plurality of remote units, each of the plurality of remote units being associated with a portion of the coverage area, the method comprising: at each of the plurality of remote units:

453. Oh discloses the preamble and element 1 for the reasons discussed above for claim 1, preamble-2b.

b) Element 2: “receiving a respective original upstream analog wireless signal comprising the upstream radio frequency spectrum and any upstream transmissions from any of the wireless units that are within the portion of the coverage area associated with that remote unit;”

454. Oh discloses element 2 for the reasons discussed above for claim 1, element 3.

c) Element 3: “generating respective upstream digital RF samples indicative of the respective original upstream analog wireless signal received at that remote unit;”

455. Oh discloses element 3 for the reasons discussed above for claim 1, element 4.

d) Element 4: “communicating the respective upstream digital RF samples generated by that remote unit to the host unit using at least one communication medium;”

456. Oh discloses element 4 for the reasons discussed above for claim 1, element 2a.

e) Element 5: “at the host unit: digitally summing corresponding upstream digital RF samples received from the plurality of remote units to produce summed upstream digital RF samples;”

457. Oh discloses element 5 for the reasons discussed above for claim 1, element 6.

f) Element 7: “converting the summed upstream digital RF samples to a replicated upstream analog wireless radio frequency signal.”

458. Oh renders element 7 obvious for the reasons provided above with respect to claim 1, element 7.

17. Dependent Claims 27-28

459. Oh renders dependent claims 27-28 obvious for the reasons provided above with respect to claims 8-9, respectively.

B. Claims 11, 15, 21-22, and 26 Are Obvious Over Oh in view of Schwartz

1. Motivation to Combine

460. A person of ordinary skill in the art would be motivated to combine the disclosures of Oh and Schwartz for a variety of reasons. As an initial matter, Oh expressly mentions the types of all-analog RF distribution system described by Schwartz in its “Conventional Technology” section, where Oh notes that in those systems where “the RF signals transmitted/received to/from said first optic repeater and a second optic repeater are analog signals, the strength of the signals is greatly decreased during transmission through the optical line.” Ex. 1007, 2:29-30. The resulting amplification can cause signal-to-noise ratio issues in the analog signals that ultimately reach destinations at the host or remote units. *Id.*, 2:30-33. Because Oh expressly discusses the types of conventional, all-analog systems described in Schwartz, a POSITA would have recognized compatibilities in those systems and that Oh’s digital relay improvements would have been applicable to Schwartz-type topologies (*i.e.*, topologies that incorporate intermediate stations 28 for distribution network expansion).

461. Additionally, a POSITA starting with Oh would have readily recognized a limitation in Oh’s disclosure, where an RF distribution topology would have been limited to the number of remote slave units 30 corresponding to the number of master unit 20 optical ports (*i.e.*, four optic converters 192, 194, 196, 198 on the downstream

path and four optic converters 412, 414, 416, 418 on the upstream path limit master unit 20 to connection to four slave units 30). Schwartz's topology that supports intermediate stations 28 for RF distribution network expansion beyond the number of physical ports available at the host (*i.e.*, central station 20). Fig. 1 of Schwartz depicts the ability to daisy-chain intermediate stations 28 together such that a Schwartz network can be expanded to "any number of intermediate stations 28 and/or remote stations 22." Ex. 1010, 4:33-38. Thus a POSITA starting with Oh but looking to provide a large RF distribution network (*e.g.*, in a large building, a sports arena) would be motivated to utilize Schwartz intermediate stations 28 to facilitate that expansion.

2. Dependent Claim 11

a) Element 1: "a digital expansion unit that is communicatively coupled to the host unit;"

462. Element 1 is rendered obvious by Oh in view of Schwartz. Schwartz discloses an RF distribution network whereby external RF signals are transmitted to remote stations for wireless transmission via a central station 20. Schwartz discloses that remote stations may be directly connected to the central station 20 or through intermediate stations 28, where each intermediate station 28 may be connected to multiple remote stations 22. And further intermediate stations 28 may be connected to additional intermediate stations 28 to act as signal relays between central station 20 and remote stations 22. Such intermediate stations 28 enable topologies that "connect

central station 20 directly to any number of intermediate stations 28 and/or remote stations 22.” Ex. 1010, 4:33-38.

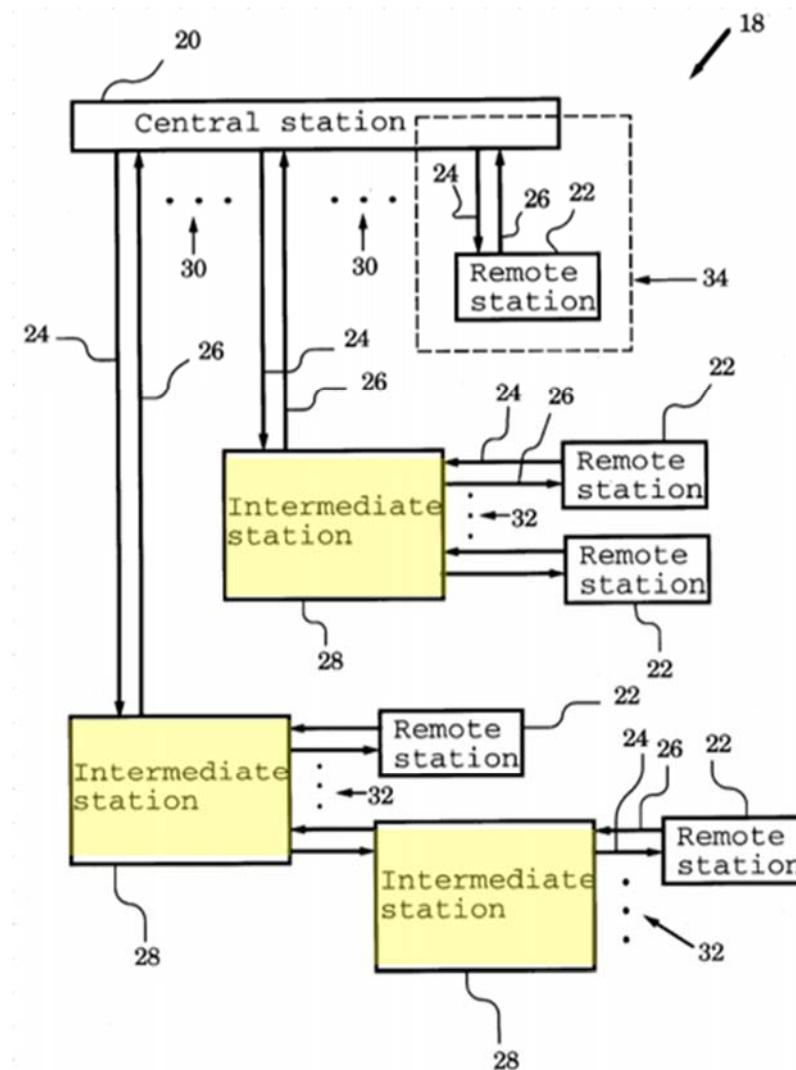


FIG. 1

463. As described above, a POSITA would have been motivated to incorporate Schwartz intermediate stations 28 into Oh’s system to enable connection to more remote units (*e.g.*, slave units 30), where Oh’s system was limited in the number of slave units 30 to which master unit 20 could be connected by master unit

20's optical ports (e.g., four ports in Figs. 2 & 5). Thus Oh in view of Schwartz renders obvious a digital expansion unit (Schwartz intermediate station 28) coupled to the host unit (Oh master unit 20).

b) Element 2: “a second plurality of remote units that are communicatively coupled to the digital expansion unit;”

464. As noted above, a POSITA would have been motivated to incorporate Schwartz-type intermediate stations 28 to enable RF distribution network expansion. Schwartz discloses remote stations 22 that are connected directly to the central station 20 at 34, as well as several remote stations 22 connected to expansion intermediate stations 28.

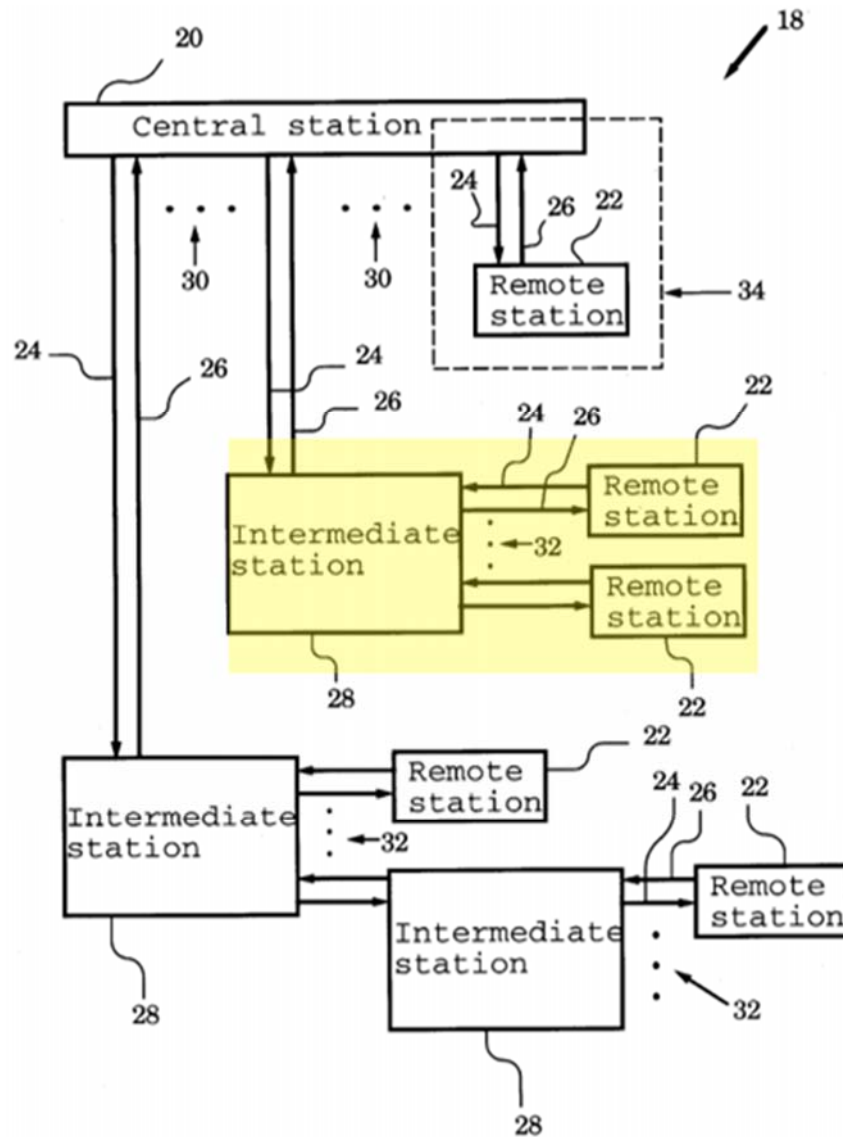


FIG. 1

Thus Oh renders obvious a second plurality of remote units (remote station 22) that are communicatively coupled to the digital expansion unit (intermediate station 28).

c) Elements 3-5

465. Oh discloses elements 3-5 for the reasons discussed above for claim 1, elements 3-5, respectively.

d) Elements 6-7: “wherein the digital expansion unit digitally sums corresponding upstream digital RF samples received from the second plurality of remote units to produce summed upstream digital RF samples; wherein the digital expansion unit communicates the summed upstream digital RF samples to the host unit;

466. As detailed above with reference to claim 1, element 6, a POSITA would have considered it obvious to use intermediate units, such as intermediate station 28 of Schwartz to provide expanded coverage of an RF distribution network like the one disclosed in Oh. As depicted in Fig. 7a of Schwartz, those intermediate stations 28 forward RF signals received from upstream (e.g., at 120) to multiple downstream units (e.g., remote stations 22 and/or other intermediate stations 28 via 126, 128). And those intermediate stations 28 further receive RF signals from multiple downstream units (e.g., at 130, 132), combine those received RF signals, and forward the combined signal to an upstream unit (e.g., at 124).

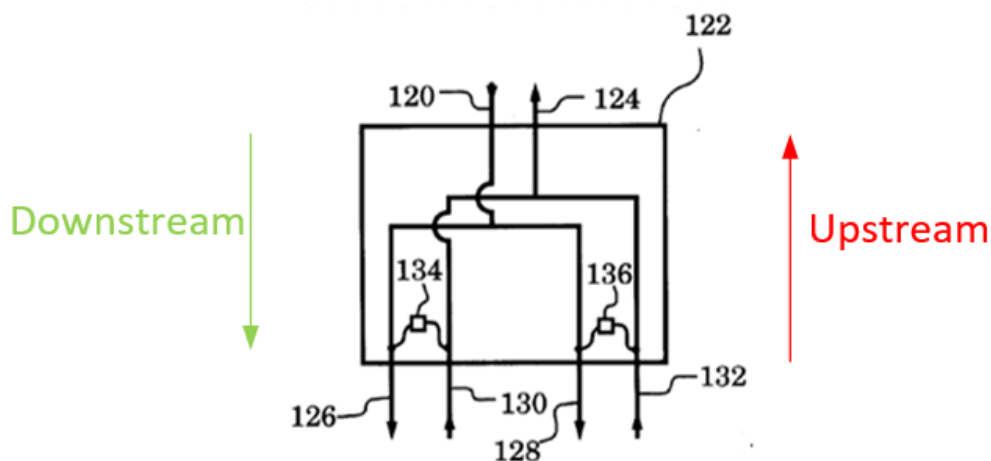


FIG. 7a

467. Thus when connected between central station 20 two remote stations 22, as the highlighted intermediate station 28 is in Fig. 1 below, Oh in view of Schwartz renders obvious an expansion unit (28) that combines signals received from the second plurality of remote units to provide combined RF signals. As noted above, Schwartz's combining is combining analog signals, accomplished by applying signals from remote stations to a common line that is forwarded to the central station. The obviousness combination of Oh and Schwartz would be operating in a digital domain. The digital version of Schwartz's analog combining is digitally summing the signals received at the intermediate station from the multiple remote station before forwarding those sums to the central station. Thus Oh in view of Schwartz renders obvious the digital expansion unit digitally summing corresponding upstream digital RF samples received from the second plurality of remote units (22) to produce summed upstream digital RF samples (124); wherein the digital expansion unit (28) communicates the summed upstream digital RF samples to the host unit (20).

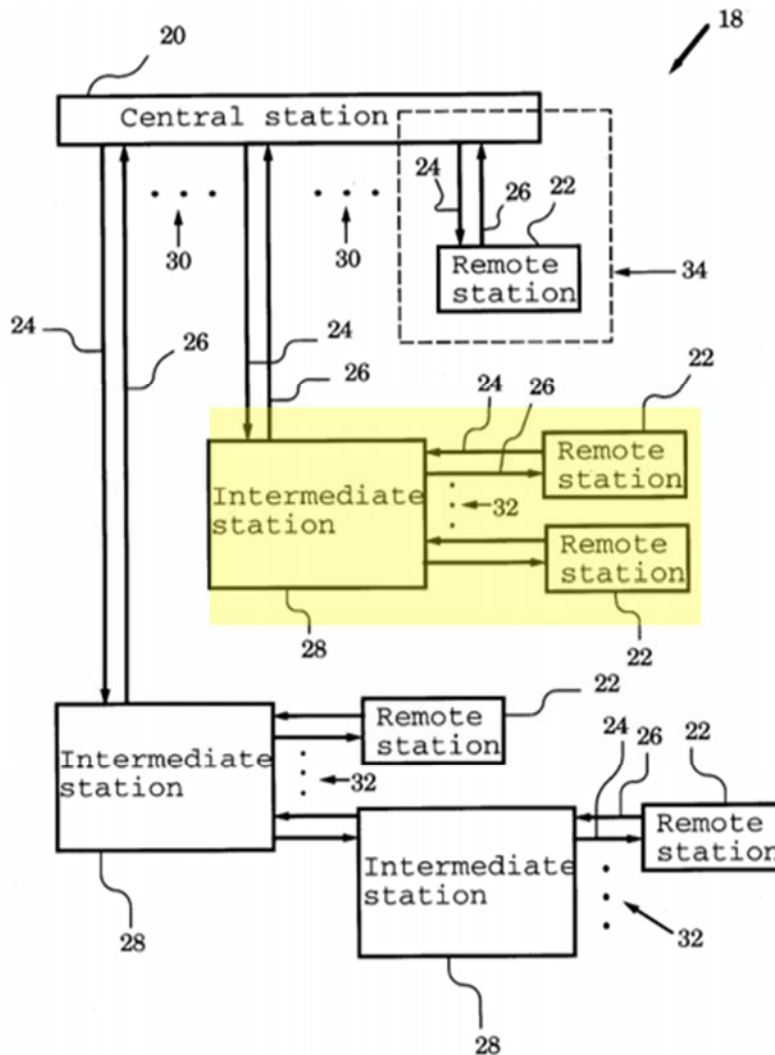


FIG. 1

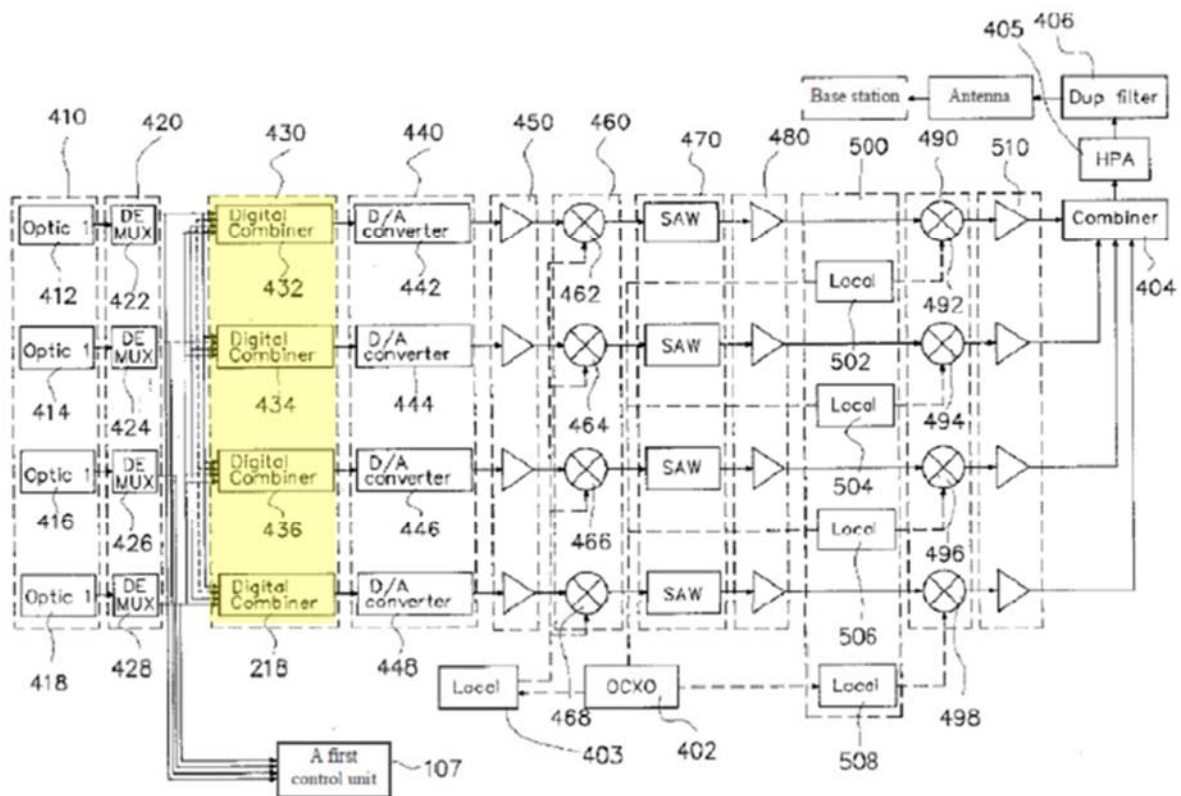
e) Element 8: “wherein the host unit digitally sums the upstream digital RF samples received from the digital expansion unit with corresponding digital RF samples received from the plurality of remote units.”

468. As detailed above with reference to elements 6-7, a POSITA would have considered it obvious to use intermediate units, such as intermediate station 28 of Schwartz to provide expanded coverage of an RF distribution network like the one disclosed in Oh. The central station of Schwartz receives signals from both remote

stations and intermediate stations. It would be obvious to utilize functionality of Oh's master unit to provide digital operations.

469. As described in claim 1, element 6, Oh's master unit 20 includes a digital combiner unit 430 that aggregates digital signals transmitted from each demultiplexer 422, 424, 426, 428 of demultiplexer unit 420. Ex. 1007, 4:68-70.

FIG. 5

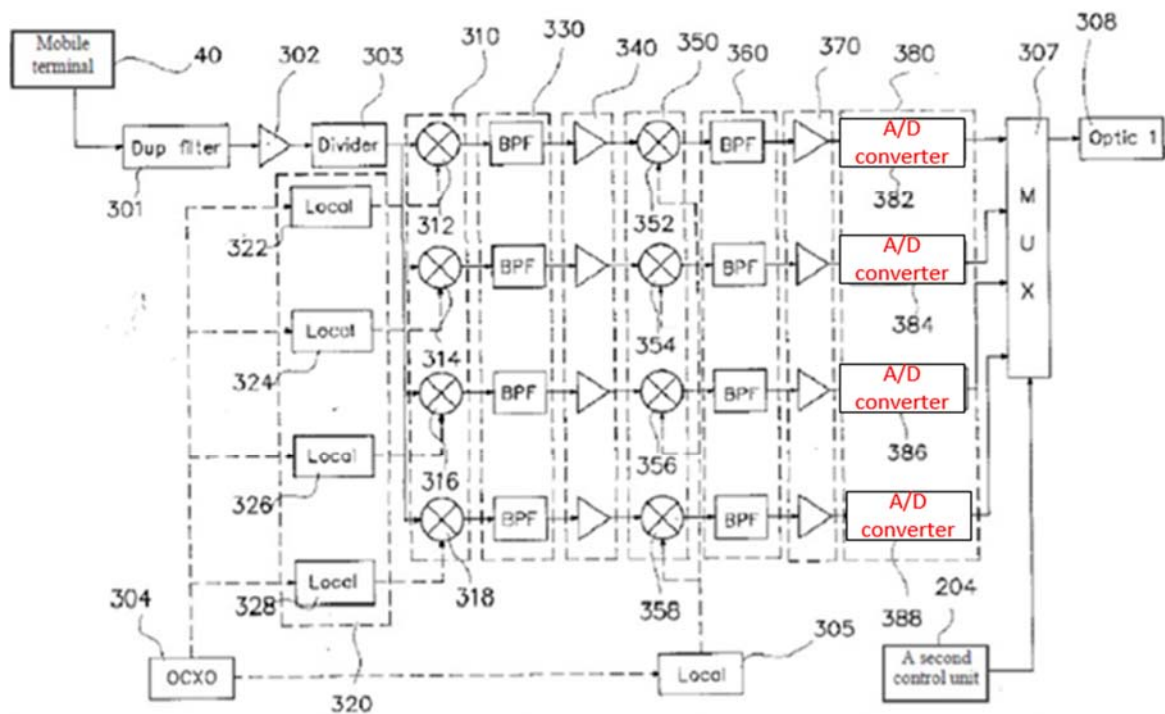


Those demultiplexers at 420 receive data from individual remote slave units 30 at 410.

470. As depicted in Fig. 4, each slave unit 30 receives an analog signal from mobile terminals 40, divides the received analog signal into its component frequency bands at 303 and downconverts the frequency band signals to near DC at 310-370. Ex. 1007, 4:26-34. The downconverted band signals are then sampled at 380 to create

12-bit digitized radio frequency signals. *Id.*, 4:56-61. The multiplexer 307 multiplexes the four 12-bit samples with 4 bits of control data from 204 to form 52-bit serial data signals that are forwarded to master unit 20. *Id.*

FIG. 4



471. Referring back to Fig. 5, each demultiplexer 422, 424, 426, 428 receives a 52-bit signal from its respective slave unit 30. Each demultiplexer forwards 12-bits of sample data to the appropriate digital combiner associated with the proper frequency band for that 12-bit sample and forwards its 4 bits of control data to control unit 107. Upon receiving four 12-bit signals (one from each of demultiplexer 422, 424, 426, 428), each digital combiner 432, 434, 436, 438 combines those 12-bit

signals to “creat[e a] 14-bit intermediate frequency signals by combining⁹ four 12-bit intermediate frequency signals in the same frequency band” (e.g., (1010 1010 1010 (2,730) + 1100 1100 1100 (3,276) + 1111 1111 1111 (4,095) + 0000 1100 1100 (204) = 10 1000 0100 0001 (10,305)). Ex. 1007, 5:16-17. Those 14-bit signals are then converted to analog signals at 440, upconverted, combined, and transmitted to the base station 10. *Id.*, 5:17-29.

472. Thus the combination of Oh and Schwartz renders obvious the host unit (Oh master unit 20) digitally sums the upstream digital RF samples (output from A/D converter unit 380 of slave unit 30) received from the digital expansion unit (Schwartz intermediate station 28) with corresponding digital RF samples received from the plurality of remote units (Schwartz remote station 22).

3. Dependent Claim 15

a) Element 1: “wherein each of the plurality of remote units frames the respective upstream digital RF samples for communication to the host unit as a respective upstream framed signal;”

473. Oh discloses element 1 for the reasons discussed above for claim 5, elements 1b.

⁹ I understand that the parties have discussed whether this word should be translated as “adding” or “combining.” Regardless of which of these terms is used, the digital combiners are operating to produce a digital sum (*i.e.*, they are performing a digital summing operation).

b) Element 2: “wherein the host unit comprises at least one demultiplexer to extract the respective upstream digital RF samples from the respective upstream framed signals received from the plurality of remote units.

474. Oh discloses element 2 for the reasons discussed above for claim 5, elements 2-2a.

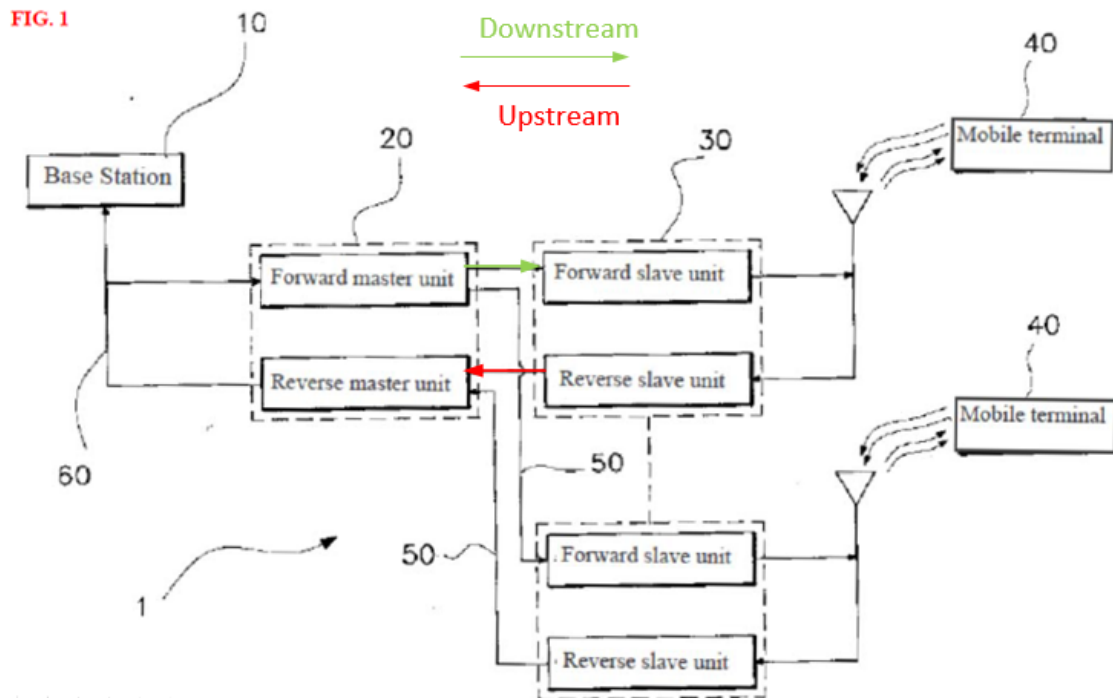
4. Independent Claim 21

a) Preamble: “A digital expansion unit for wireless radio frequency signal distribution within a coverage area in which one or more wireless units transmit in an upstream wireless radio frequency spectrum, the digital expansion unit comprising:”

475. Oh discloses the preamble for the reasons discussed above for claim 11 and claim 1, preamble.

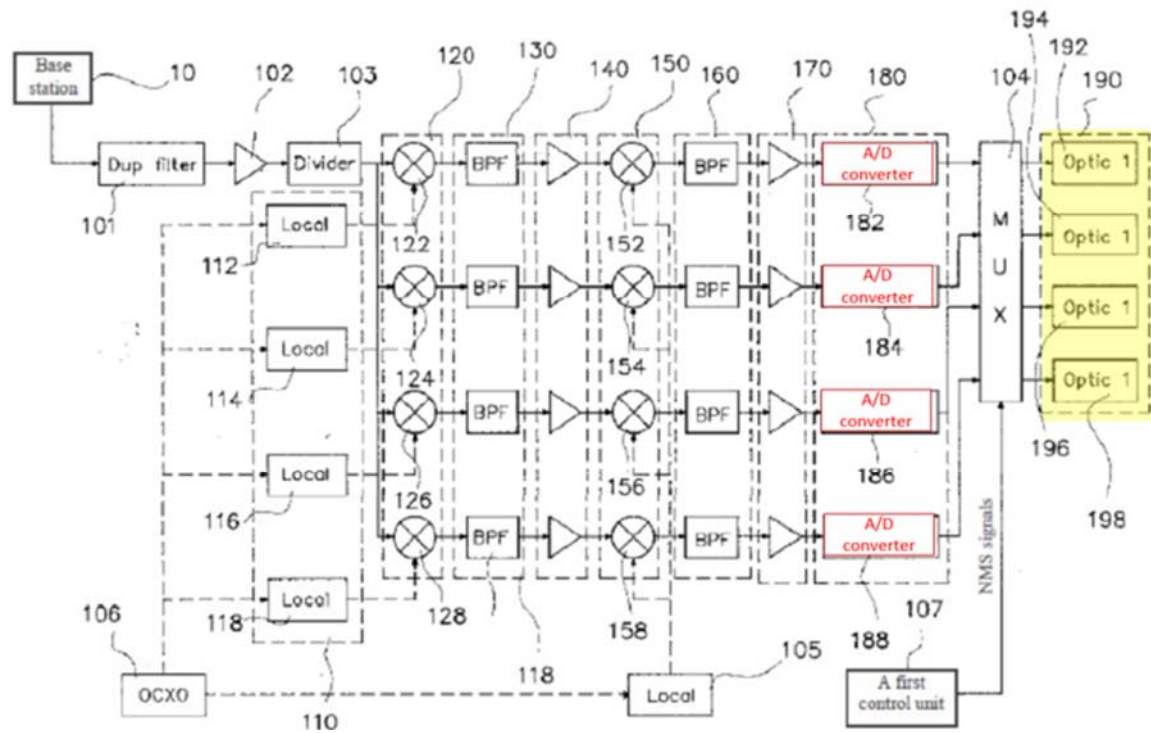
b) Element 1: “a host unit interface to communicatively couple the digital expansion unit to a host unit;”

476. Oh discloses master unit 20 is coupled to multiple remote slave units 30 via optic lines 50.



477. Fig. 2 of Oh depicts optic converter unit 190 that provides a downstream interface between forward master unit 100 of master unit 20 and forward slave unit 200 of remote slave units 30.

FIG. 2



478. And Fig. 5 illustrates optic converter unit 410 that provides an upstream interface from reverse master unit 300 of slave units 30 to reverse master unit 400 of master unit 20.

480. Thus Oh renders obvious a host unit interface (190, 410) to communicatively couple the digital expansion unit (Schwartz intermediate station 28) to a host unit (Oh master unit 20).

481. Schwartz discloses remote stations 22 that are connected directly to the central station 20 at 34, as well as several remote stations 22 connected to expansion

intermediate stations 28. Schwartz describes a pair of cables (e.g., “downlink cable 24 and uplink cable 26” that “connect central station 20 directly to any number of intermediate stations 28 and/or remote stations 22.” Ex. 1010, 4:35-38.

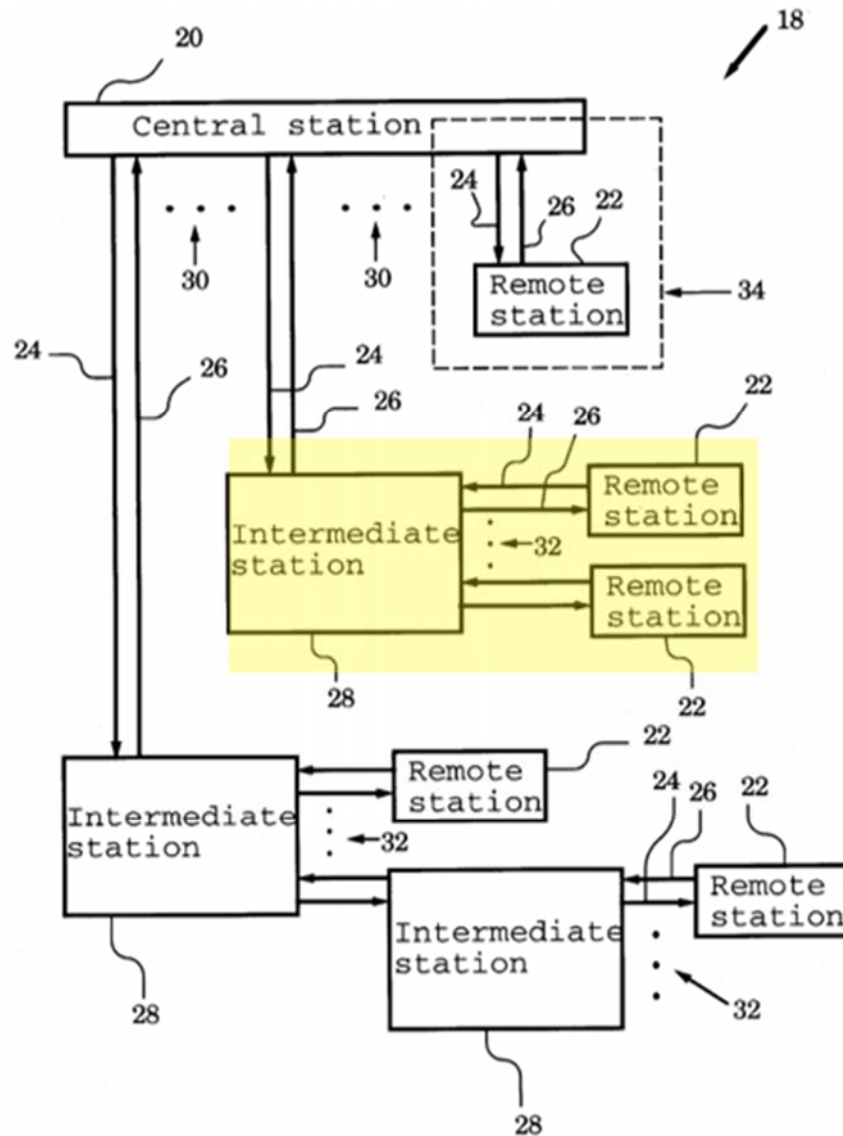
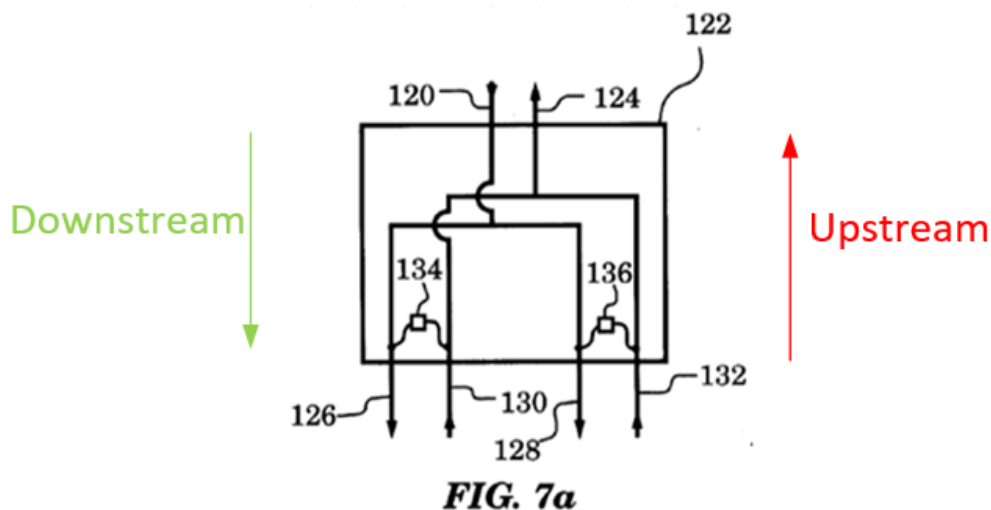


FIG. 1

482. Schwartz's intermediate stations 28 "preferably are repeaters" (4:38-39), where example intermediate station 28 implementation details are shown in Fig. 7a. Ex. 1010, 10:13-15.



In the downstream direction (top to bottom in the figure), "downlink connection 120 splits into two secondary downlink connections 126 and 128 before exiting station 122." Ex. 1010, 10:15-18. In the upstream direction, "uplink connection 124 is fed by two secondary uplink connections 130 and 132." *Id.*, 10:19-20. In that uplink operation, signals from downstream units (*e.g.*, remote units) are received at 130, 132 and applied to a common uplink connection line 124, aggregating the analog signals received on those lines.

483. Thus Oh renders obvious a remote unit interface (connection between 22/28) to communicatively couple the digital expansion unit (28) to a plurality of remote units (22).

d) Element 2b: “wherein each of the plurality of remote units is associated with a portion of the coverage area”

484. Oh discloses element 2b for the reasons discussed above for claim 1, element 2b.

e) Element 2c: “each of the plurality of remote units receives a respective original upstream analog wireless signal comprising the upstream radio frequency spectrum and any upstream transmissions from any of the wireless units that are within the portion of the coverage area associated with that remote unit”

485. Oh discloses element 2c for the reasons discussed above for claim 1, element 3.

f) Element 2d: “wherein each of the plurality of remote units generates respective upstream digital RF samples indicative of the respective original upstream analog wireless signal received at that remote unit,”

486. Oh discloses element 2d for the reasons discussed above for claim 1, element 4.

g) Element 2e: “wherein the remote unit interface is used to receive the upstream digital RF samples from the plurality of remote units,”

487. Oh discloses element 2e for the reasons discussed above for claim 12, element 1e.

h) Element 3: “a digital summer to digitally sum corresponding upstream digital RF samples received from the plurality of remote units to produce summed upstream digital RF samples;”

488. Oh discloses element 3 for the reasons discussed above for claim 1, element 6.

i) Element 4: “wherein the digital expansion unit communicates at least a portion of the summed upstream digital RF samples to the host unit.”

489. Oh discloses element 4 for the reasons discussed above for claim 11, elements 6-7.

5. Dependent Claim 22

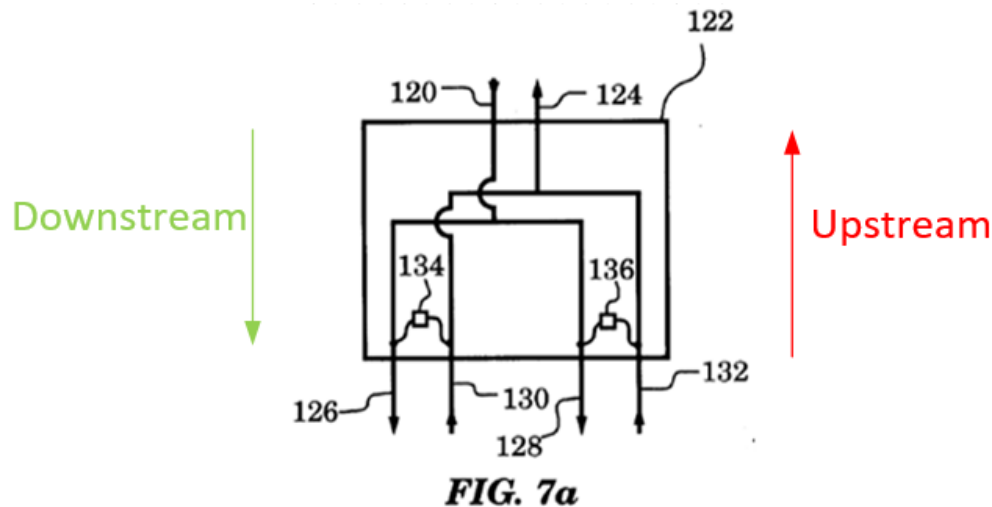
a) Element 1: “wherein each of the plurality of remote units frames the respective upstream digital RF samples for communication to the digital expansion unit as a respective upstream framed signal;”

490. Oh discloses element 1 for the reasons discussed above for claim 15, element 1.

b) Elements 2-3: “wherein the digital expansion unit comprises at least one demultiplexer to extract the respective upstream digital RF samples from the respective upstream framed signals received from the plurality of remote units; wherein the digital expansion unit comprises a multiplexer to frame the summed upstream digital RF samples for communication to the host unit.”

491. As depicted in Fig. 7a of Schwartz, those intermediate stations 28 forward RF signals received from upstream (e.g., at 120) to multiple downstream units

(e.g., remote stations 22 and/or other intermediate stations 28 via 126, 128). And those intermediate stations 28 further receive RF signals from multiple downstream units (e.g., at 130, 132), combine those received RF signals, and forward the combined signal to an upstream unit (e.g., at 124).

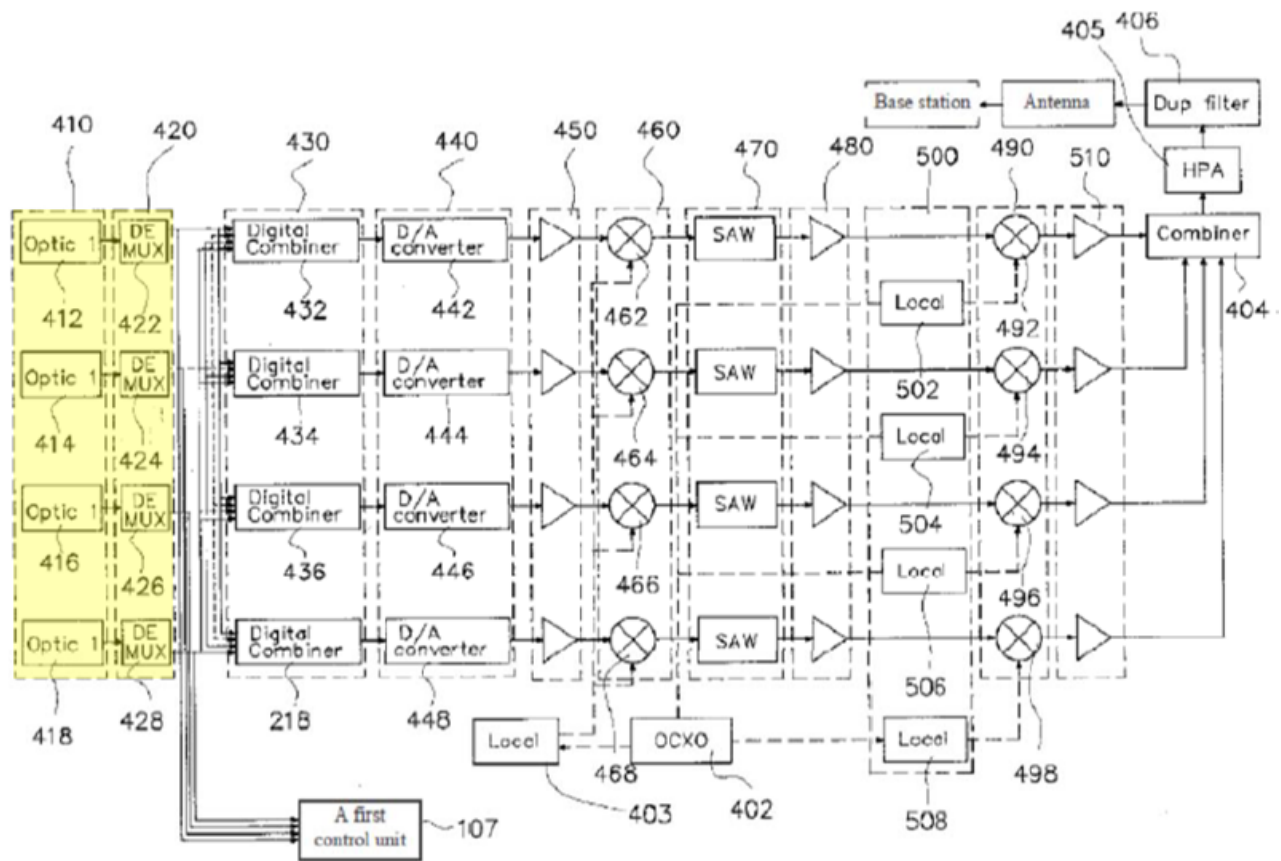


492. As previously discussed, Oh expressly discusses the types of conventional, all-analog systems described in Schwartz, a POSITA would have recognized compatibilities in those systems and that Oh's digital relay improvements would have been applicable to Schwartz-type topologies (*i.e.*, topologies that incorporate intermediate stations 28 for distribution network expansion).

493. In Schwartz Fig. 7a, two analog signals received at 130, 132 are added to generate the forward signal at 124. Turning to Oh, signals are combined using demultiplexer unit 420 and digital combiner unit 430 to form band sum signals. More specifically, Oh describes each demultiplexer at 420 associated with each of the remote slave units routing digital sample data to its respective frequency band path in

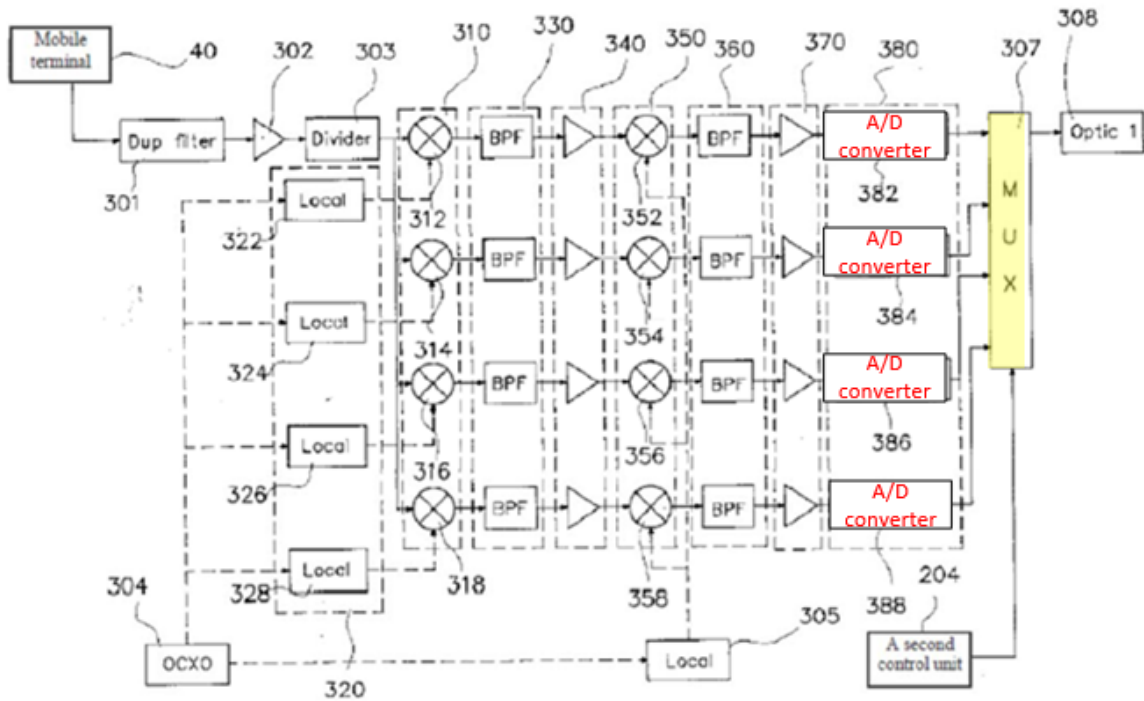
the reverse slave unit. Each demultiplexer 422-428 receives digital sample data and control data from one slave unit 30 and separates that digital sample data according to frequency band. *Id.*, 5:4-10. Those demultiplexers at 420 receive data from individual remote slave units 30 at 410.

FIG. 5



494. Upon generating four frequency band sums at an intermediate station based on digital data from multiple remote stations, it would be obvious to package those four 12-bit band frequency samples, along with any intermediate station control data using a multiplexer, like multiplexer 307 in Oh's slave units, to form 52-bit signals for transmission to the central station/master unit over the optic line 50.

FIG. 4



495. Thus Oh renders obvious the digital expansion unit (Schwartz intermediate station 28) comprises at least one demultiplexer (Oh 420) to extract the respective upstream digital RF samples (output from A/D converter unit 380) from the respective upstream framed signals received (at 410) from the plurality of remote units (30); wherein the digital expansion unit (Schwartz intermediate station 28) comprises a multiplexer (Oh 307) to frame the summed upstream digital RF samples for communication to the host unit (20).

6. Dependent Claim 26

a) Element 1: “wherein each of the plurality of remote units frames the respective upstream digital RF samples for communication to the digital expansion unit as a respective upstream framed signal;”

496. Oh discloses element 1 for the reasons discussed above for claim 15, element 1.

b) Element 2: “wherein the method further comprises, at the host unit, for each of the plurality of remote units, extracting the respective upstream digital RF samples from the respective upstream framed signal received from that remote unit;”

497. Oh discloses element 2 for the reasons discussed above for claim 5, elements 2-2a.

c) Element 3: “wherein the method further comprises, at the host unit, framing the summed upstream digital RF samples for communication to the host unit.”

498. Oh discloses element 3 for the reasons discussed above for claim 5, element 1b.

X. The Claims of the '286 Patent Are Unpatentable

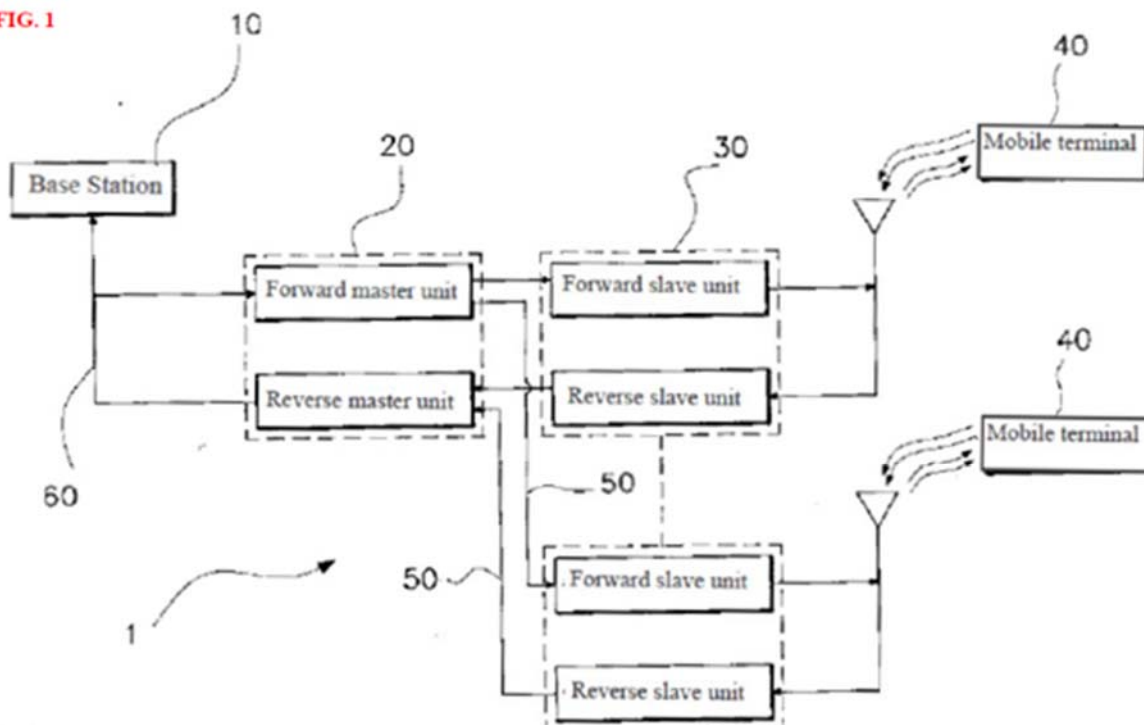
A. Claims 1-4, 7-17, 19-34, and 37-39 Are Obvious Over Oh

1. Independent Claim 1

a) Preamble: "A system for use with a coverage area in which one or more wireless units wirelessly transmit using a wireless radio frequency spectrum, the system comprising:"

499. To the extent the preamble of claim 1 is limiting, it is rendered obvious by Oh. As discussed above, Oh discloses a Digital Optic Repeater system that receives RF signals, from a base station 10 at a master unit 20 and from mobile terminals 40 at remote slave units 30. The optic repeater 1 is installed in a radio wave shadow area and converts received analog signals to intermediate frequency signals (e.g., close to DC in the example at 3:11-14) and then to digital signals for mutual transmission and reception to one another across optic lines 50. Ex. 1007, Abstract, Fig. 1. At a destination unit, the digital signals transmitted across the optic lines 50 are converted to analog signals, and upconverted to RF signals for transmission to their destination (e.g., base station 10 or mobile terminals 40 (e.g., at 800 MHz, 1800MHz)). *Id.*, Abstract, Fig. 1, 3:19, 4:40. Fig. 5 of Oh illustrates the communications between master unit 20 and the base station 10 may be wireless communications via an antenna.

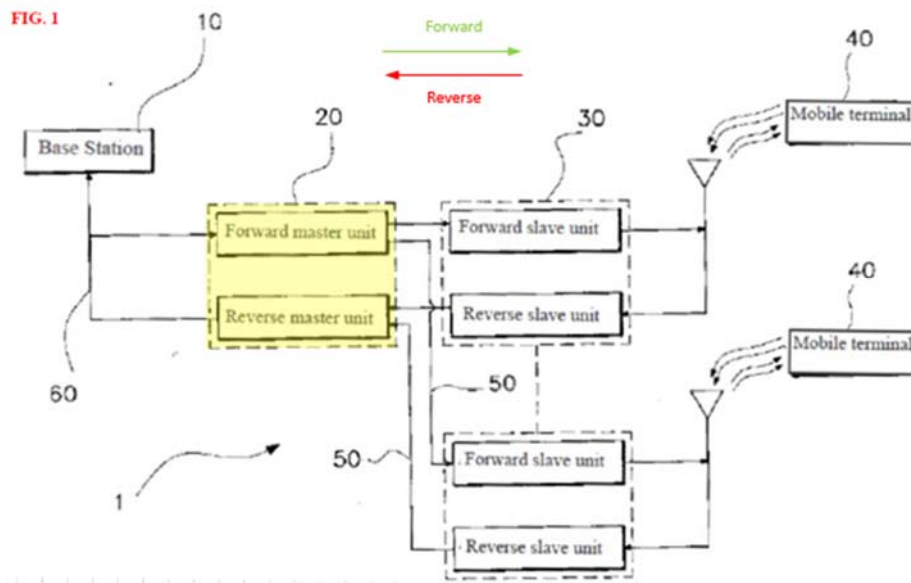
FIG. 1



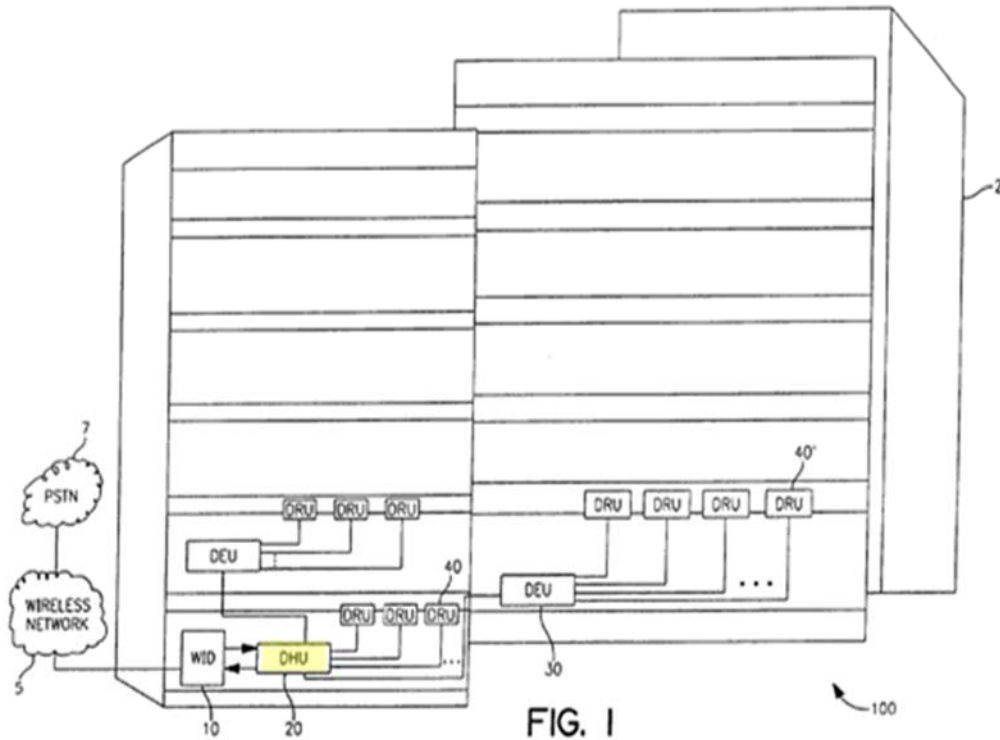
500. Oh therefore renders obvious each limitation recited in the preamble of claim 1 by disclosing a system (Fig. 1) for use with a coverage area in which one or more wireless units (40) wirelessly transmit using a wireless radio frequency spectrum (e.g., 800 MHz, 1800MHz).

b) Elements 1 and 2: “a first unit; and a plurality of second units communicatively coupled to the first unit using at least one communication medium, wherein each of the plurality of second units is associated with a portion of the coverage area;”

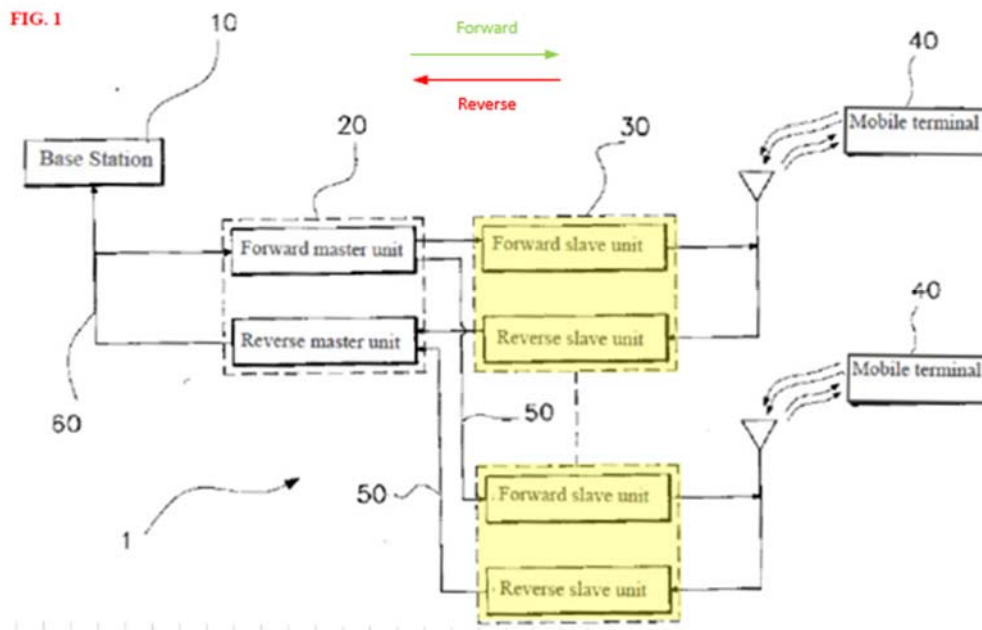
501. Elements 1 and of claim 1 is rendered obvious by Oh. As discussed above and as shown in Fig. 1, Oh’s master unit 20 transmits/receives analog signals to/from the base station and relays digital samples of those analog signals to/from remote slave units 30 across optic lines 50. Ex. 1007, 2:70-3:1; 4:62-64.



502. Oh's master unit 20 is analogous to the '286 patent's digital host unit (DHU) 20 which interfaces with a wireless interface device (WID) 10 that in embodiments comprises a base station (Ex. 1003, 4:35-36). And like Oh's master unit 20, on the forward path the '286 patent's DHU "receives RF signals from WID 10 [*i.e.*, base station] and converts the RF signals to digital RF signals. DHU 20 further optically transmits the digital RF signals to multiple DRUs 40." *Id.*, 4:45-49.



503. Oh's slave units 30 convert "the digital signals transmitted from the master unit 20 through the optic line 50 to the intermediate frequency signals, analog signals; converts them to RF signals and transmits them to the mobile terminals 40." Ex. 1007, 3:47-49. Oh's slave units 30 further convert analog signals from the mobile terminals 40 to digital signals and transmit them to master unit 20. *Id.*, 4:23-25.

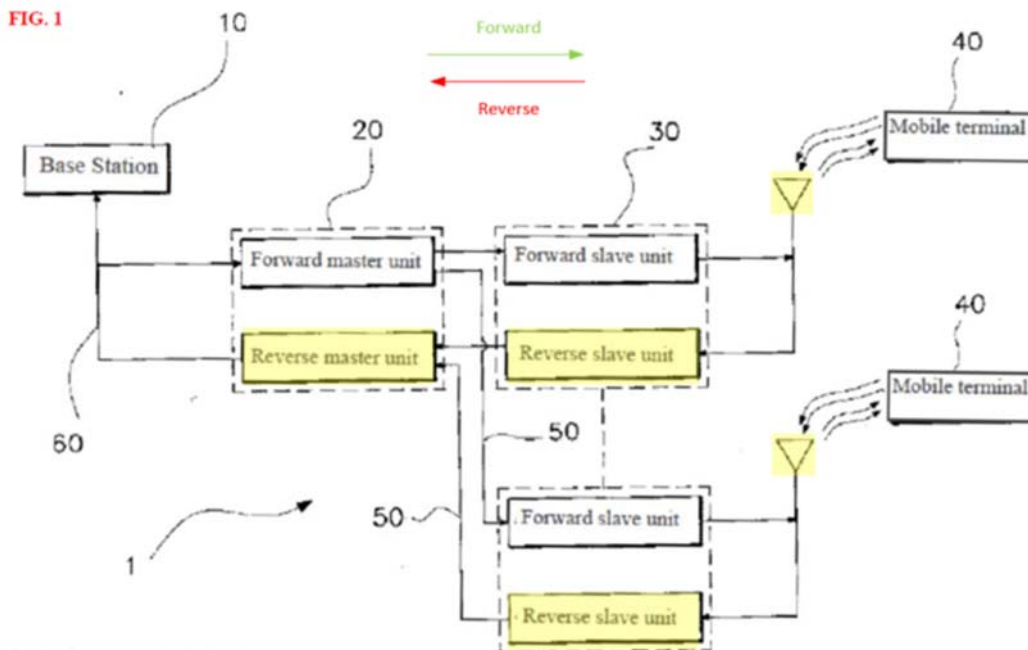


Oh's slave units 30 are analogous to the '286 patent's digital remote units (DRUs) that digitally communicate with the DHU via optic cables (Ex. 1003, 4:3-6) and wirelessly communicate with devices in their area (e.g., via antenna 599). Thus Oh renders obvious a first unit (20); and a plurality of second units (30) communicatively coupled to the first unit using at least one communication medium (50), wherein each of the plurality of second units is associated with a portion of the coverage area.

c) Element 3: “wherein each of the plurality of second units receives a respective analog wireless signal comprising the radio frequency spectrum and any transmissions from any of the wireless units that are within the portion of the coverage area associated with that second unit,”

504. Oh discloses that each reverse slave unit 300 “converts the RF signals, analog signals, transmitted from the mobile terminals 40... to the digital signals; and

transmits them to the master unit 20.” Ex. 1007, 4:22-25. Fig. 1 depicts multiple slave units 30 receiving analog RF signals from mobile terminals 40.



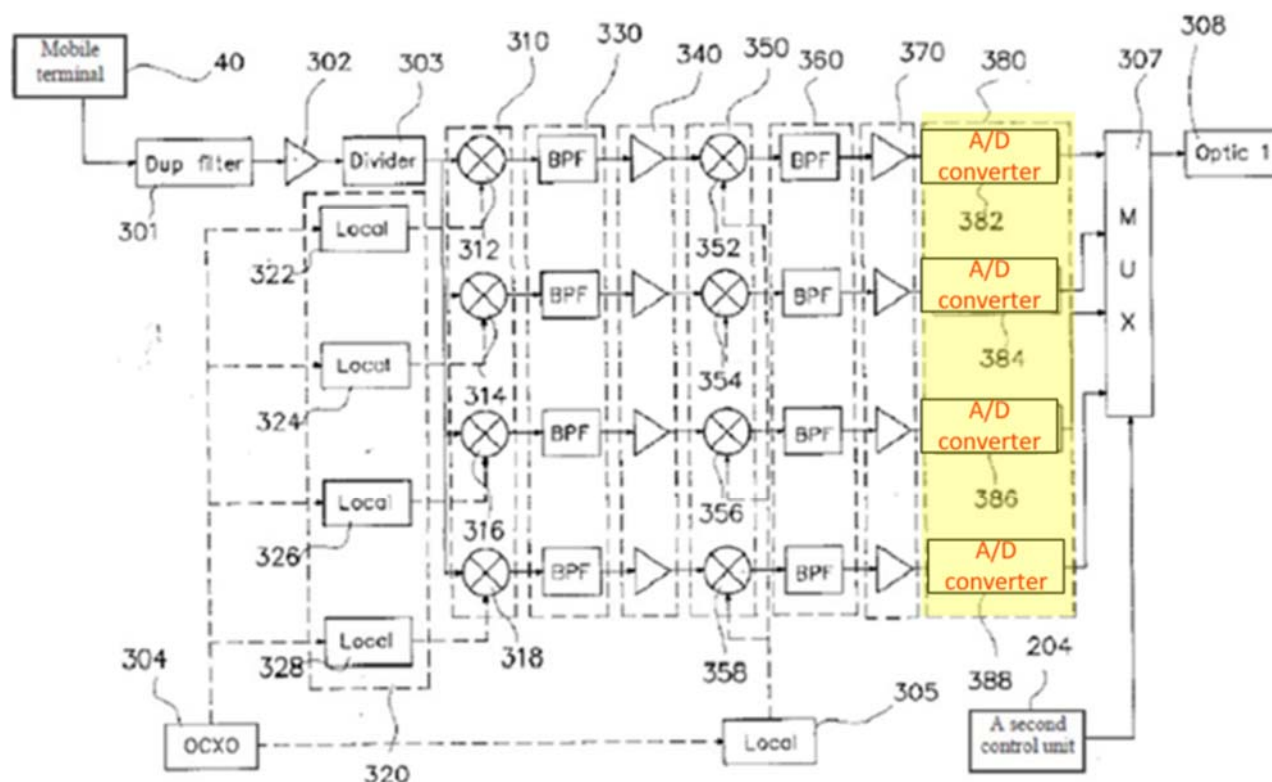
505. Thus Oh discloses each of the plurality of second units (30) receives a respective analog wireless signal comprising the radio frequency spectrum and any transmissions from any of the wireless units (40) that are within the portion of the coverage area associated with that second unit.

d) Element 4: “wherein each of the plurality of second units generates respective digital RF samples indicative of the respective analog wireless signal received at that second unit;”

506. Oh discloses that each reverse slave unit 300 “converts the RF signals, analog signals, transmitted from the mobile terminals 40 through a third bi-directional filter 301, to the digital signals.” Ex. 1007, 4:23-25. That digitization is illustrated at

Fig. 4 where “A/D converter unit 380 converts the intermediate frequency signals, analog signals, to the digital signals.” *Id.*, 4:56-67.

FIG. 4



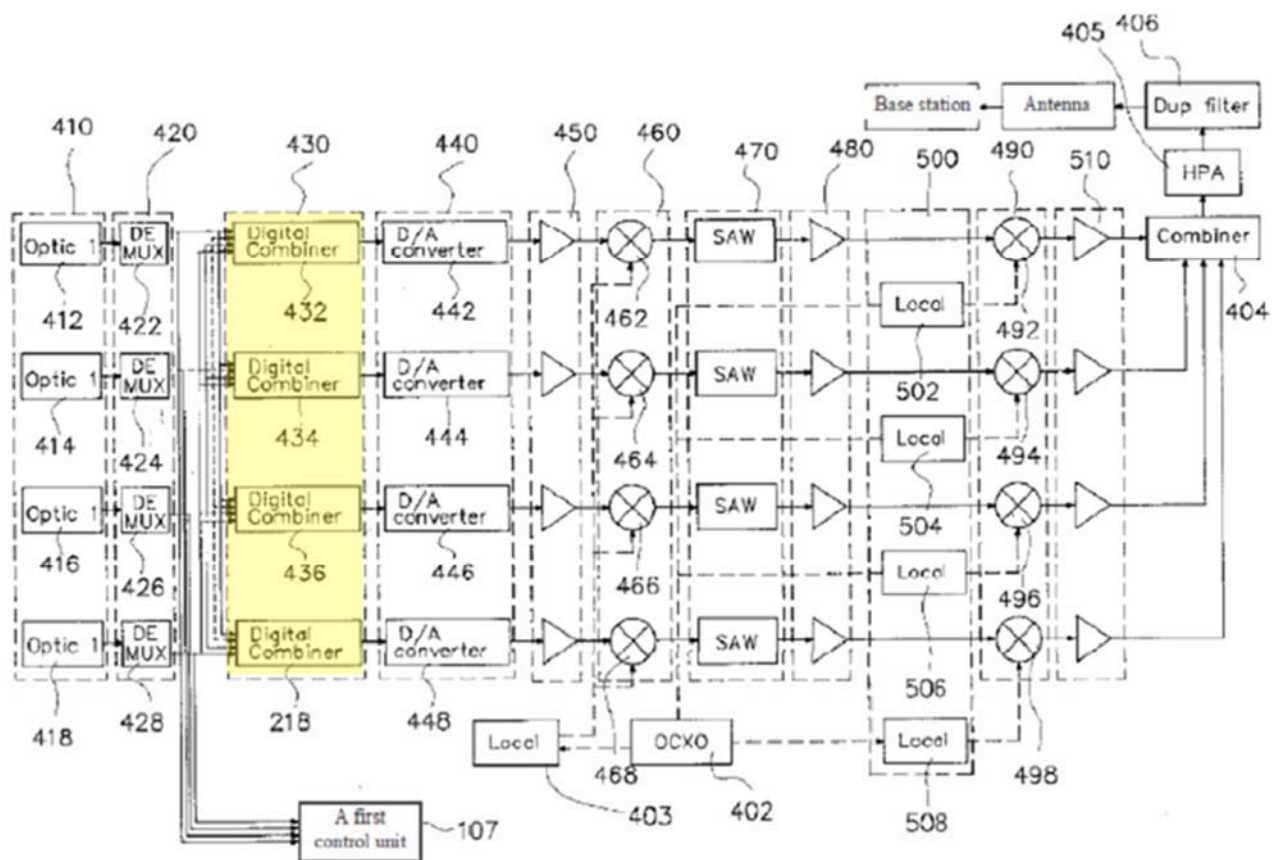
507. Patent Owner has made clear in a prior litigation that “digital radio frequency (RF)” as that term is used in the ’286 patent refers to sampling of any of baseband signals, intermediate frequency signals, or radio frequency signals. *See*, Ex. 1008, Acampora Report, ¶136 (“Accordingly, the baseband digital samples, any intermediate frequency digital samples, and any radio frequency digital samples are all referred to a[s] being digital RF.”) Oh’s disclosure of A/D conversion (*i.e.*, sampling) of intermediate frequency signals, including signals down converted to

510. Thus Oh renders obvious each of the plurality of second units (30) communicates the respective digital RF samples generated by that second unit to the first unit (20) using the at least one communication medium (50).

f) Element 6: “wherein the first unit digitally sums corresponding digital RF samples received from the plurality of second units to produce summed digital RF samples;”

511. Oh’s master unit 20 includes a digital combiner unit 430 that aggregates digital signals transmitted from each demultiplexer 422, 424, 426, 428 of demultiplexer unit 420. Ex. 1007, 4:68-70.

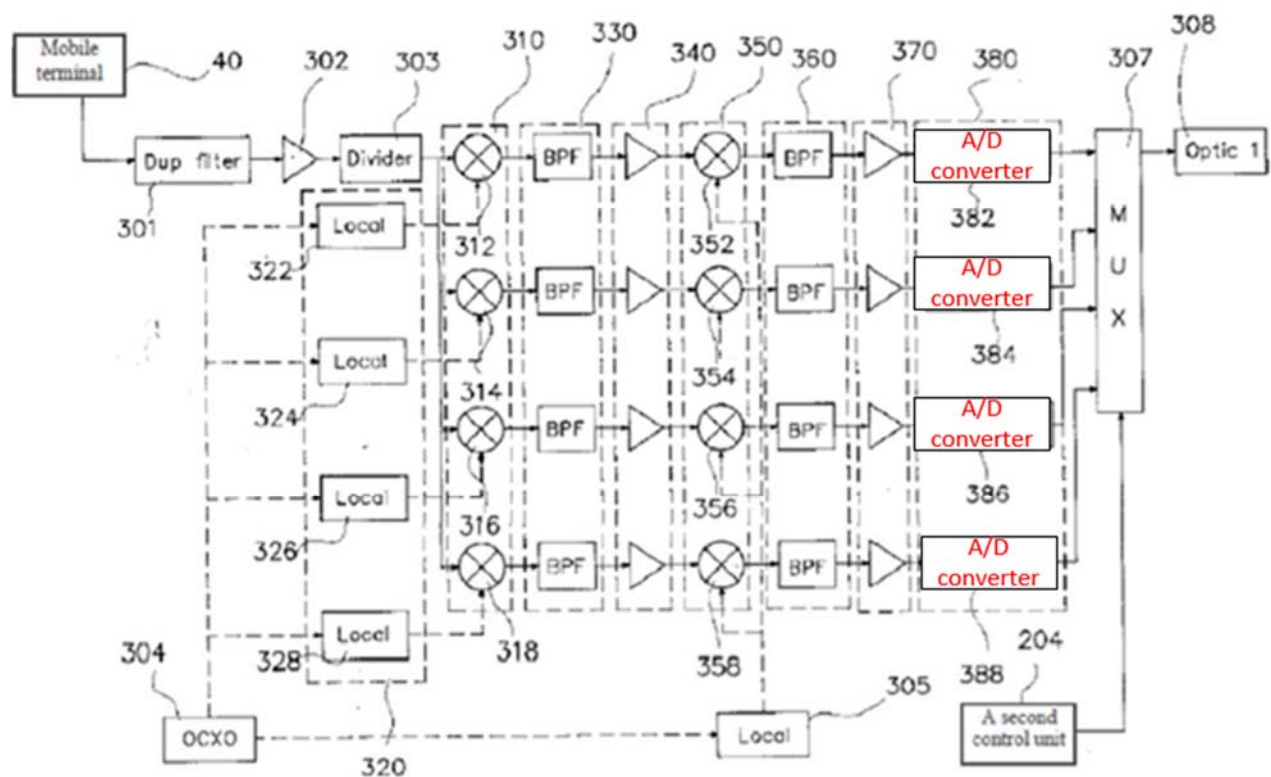
FIG. 5



Those demultiplexers at 420 receive data from individual remote slave units 30 at 410.

512. As depicted in Fig. 4, each slave unit 30 receives an analog signal from mobile terminals 40, divides the received analog signal into its component frequency bands at 303 and downconverts the frequency band signals to near DC at 310-370. Ex. 1007, 4:26-34. The downconverted band signals are then sampled at 380 to create 12-bit digitized radio frequency signals. *Id.*, 4:56-61. The multiplexer 307 multiplexes the four 12-bit samples with 4 bits of control data from 204 to form 52-bit serial data signals that are forwarded to master unit 20. *Id.*

FIG. 4



513. Referring back to Fig. 5, each demultiplexer 422, 424, 426, 428 receives a 52-bit signal from its respective slave unit 30. Each demultiplexer forwards 12-bits of sample data to the appropriate digital combiner associated with the proper

frequency band for that 12-bit sample and forwards its 4 bits of control data to control unit 107. Upon receiving four 12-bit signals (one from each of demultiplexer 422, 424, 426, 428), each digital combiner 432, 434, 436, 438 combines those 12-bit signals to “creat[e a] 14-bit intermediate frequency signals by combining¹⁰ four 12-bit intermediate frequency signals in the same frequency band” (e.g., (1010 1010 1010 (2,730) + 1100 1100 1100 (3,276) + 1111 1111 1111 (4,095) + 0000 1100 1100 (204) = 10 1000 0100 0001 (10,305)). Ex. 1007, 5:16-17. Those 14-bit signals are then converted to analog signals at 440, upconverted, combined, and transmitted to the base station 10. *Id.*, 5:17-29.

514. Thus Oh renders obvious the first unit (20) digitally sums (at 430) corresponding digital RF samples received from the plurality of second units (30) to produce summed digital RF samples.

g) Element 7: “wherein the system is configured so that an input used for base station processing is derived from the resulting summed digital RF samples.”

515. The term “base station processing” is not used in the ’286 patent specification. But the Patent Owner has made clear its view that “base station processing” encompasses first (*i.e.*, host) unit functionality. In its complaint, Patent

¹⁰ I understand that the parties have discussed whether this word should be translated as “adding” or “combining.” Regardless of which of these terms is used, the digital combiners are operating to produce a digital sum (*i.e.*, they are performing a digital summing operation).

Owner maps Distribution and Aggregation Unit (DAU) to the “first unit” of claim 1, element 1. Ex. 1024, ¶44. Patent Owner then alleges that the same DAU alleged to be the “first unit” performs the “base station processing” of element 7. Specifically, Patent Owner states “DAU is configured to derive an input used for base station processing from the resulting summed digital RF samples. As seen, for example, in Figure 2.1 above, the upstream signal of the DAU is used as an input to a base station for base station processing.” Ex. 1024, ¶51. Thus Patent Owner has argued that “base station processing” means processing signals in preparation/transmission of those processed signals to a base station, including at the first/host unit.

516. Claim 3 further corroborates that “base station processing” can encompass first/host unit functionality. Claim 3 states that “the base station processing functionality is at least one of: co-located with the first unit and remote from the first unit.” Because claim 1 must necessarily be at least as broad, if not broader, than claim 3 (35 U.S.C. § 112, ¶4), “base station processing” in claim 1 also encompasses base station processing “co-located with the first unit.”

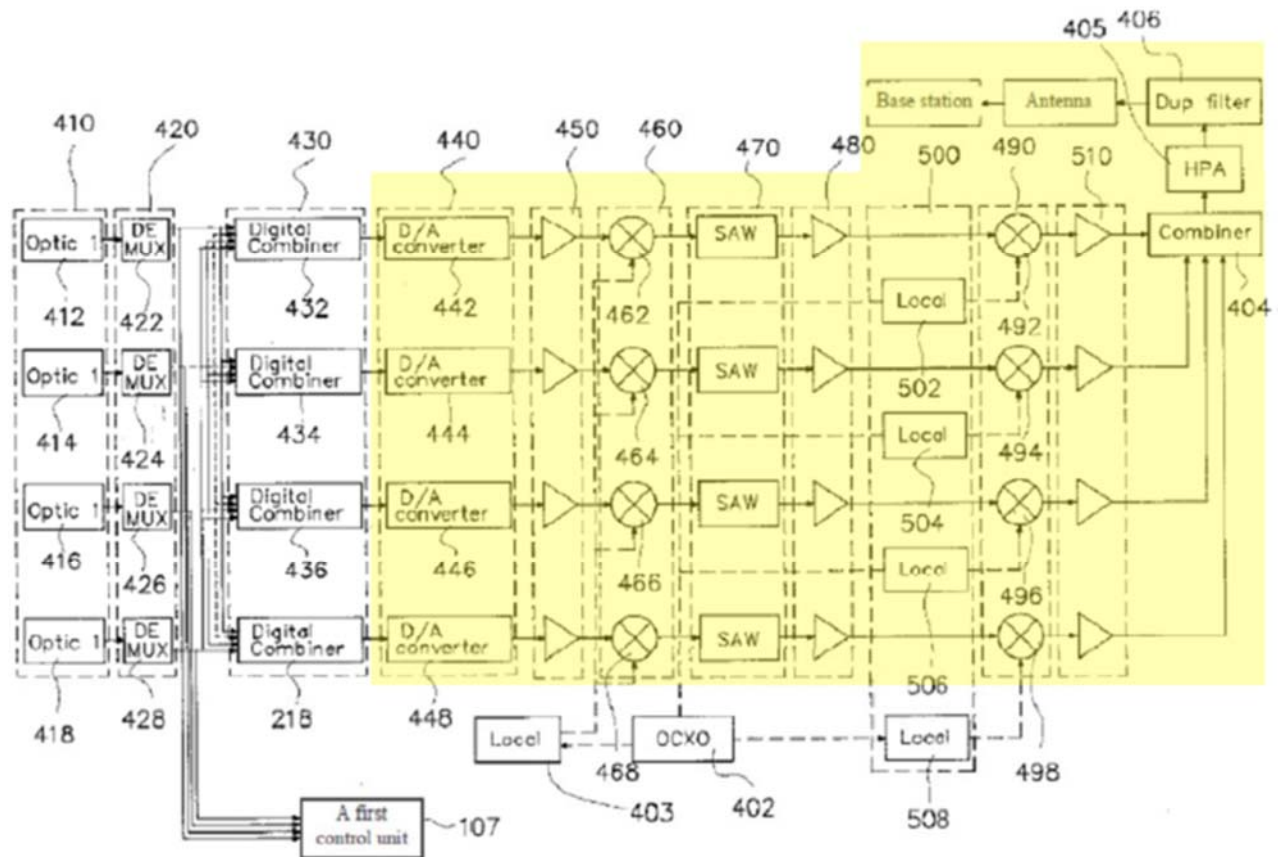
517. Further, the ’286 patent specification lacks description of performing processing of signals post-digital summing at a base station other than mere transmission of an analog signal to the base station. Ex. 1003, 5:59-63.

518. Thus, the “base station processing” recited by claim 1 cannot be limited to signal processing that is performed at a base station, because claim 3 necessarily

means that “base station processing” can encompass first/host unit functionality, and because Patent Owner has accused what it alleges to be a first/host unit of performing base station functionality in litigation. Instead, “base station processing” should be understood for purposes of this proceeding to include processing signals in preparation/transmission of those processed signals to a base station including at a first/host unit.

519. Oh renders that limitation obvious. Following the digital summing operation referenced above in addressing element 6, the summed digital data values in Oh are converted to analog signals, up converted to the appropriate frequency signals associated with their particular bands to create component analog signals, that are then combined and transmitted to a base station via an antenna.

FIG. 5



Specifically Oh states:

After creating 14-bit intermediate frequency signals by combining four 12-bit intermediate frequency signals in the same frequency band, said digital combiner transmits them to a first D/A converter unit 440. Each D/A converter 442, 444, 446, and 448 of said first D/A converter unit 440 converts 14-bit digital signals to the intermediate [frequency] signals, analog signals; and transmits 1.23MHz or 1.5MHz intermediate frequency signals to each mixer 462, 464, 466, and 468 of a third mixer unit 460 through a third amplification unit 450. Said third mixer unit 460 outputs 70MHz intermediate frequency signals by mixing 1.23MHz or 1.5MHz intermediate frequency signals

transmitted from a first D/A converter unit 440 with 68.77MHz or 68.5MHz oscillating frequency transmitted from a third local unit 403. The intermediate frequency signals outputted from said third mixer unit 460 are transmitted to a fourth mixer unit 490 through a first saw filter unit 470 and a fourth amplification unit 480. Said fourth mixer unit 490 mixes the oscillating frequency in different frequency bands transmitted from a fourth local unit 500 with 70MHz intermediate frequency signals; and transmits 800MHz RF signals in different frequency bands to a first combiner 404 through a fifth amplification unit 510.

Ex. 1007, 5:16-26. The analog signals are combined at 404 to “aggregate[] the RF signals in different frequency bands transmitted from four mixers 492, 494, 496, and 498,” and are amplified at 510 and run through a bi-directional filter 406 to an antenna and a base station.

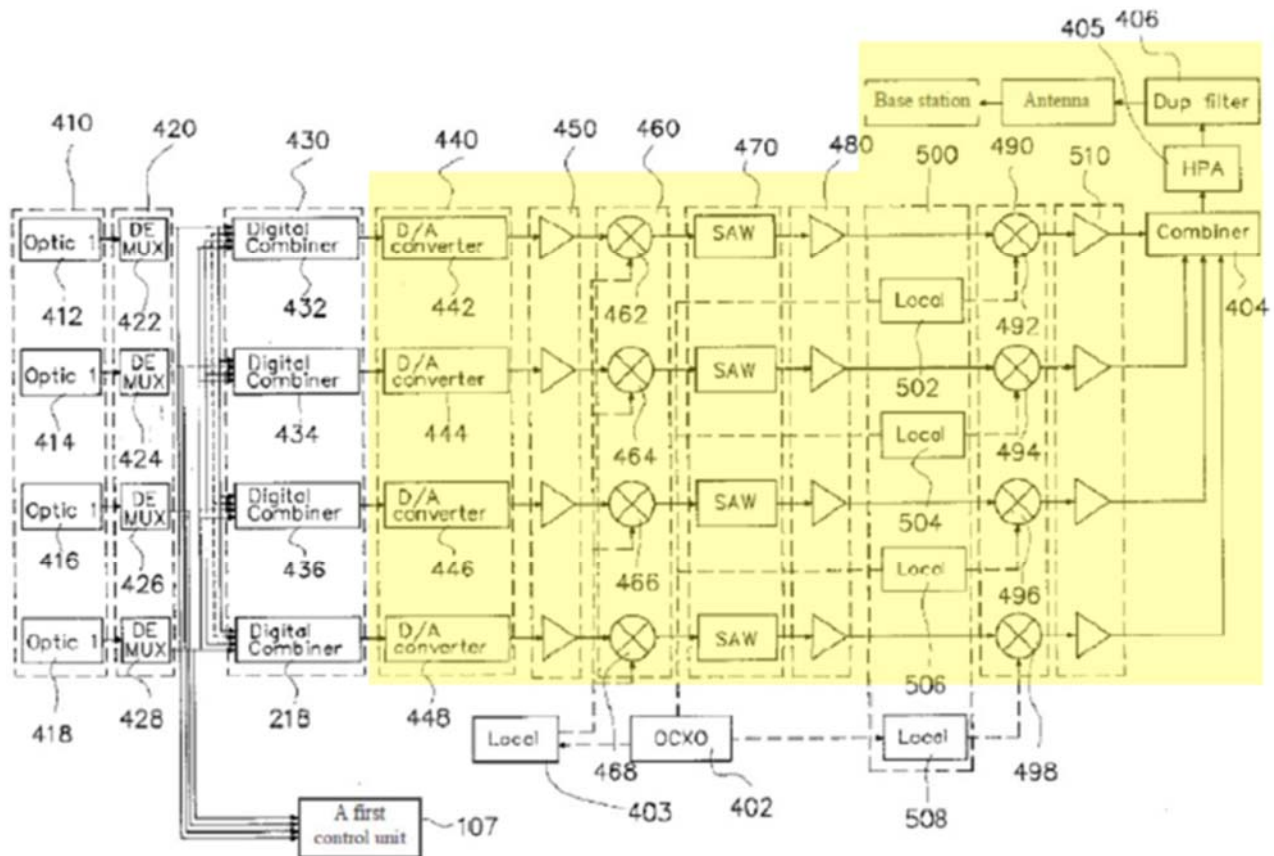
520. Thus Oh renders obvious the system being configured so that an input used for base station processing is derived from the resulting summed digital RF samples (the output of 430 is used as an input to circuitry at 440, 450, 460, 470, 480, 490, 520, 404, 405, 406 in preparation for transmission to the base station). Thus Oh renders claim 1 obvious.

2. Dependent Claim 2

521. Claim 2 recites “the system includes base station signal processing functionality configured to perform base station processing.” As discussed above

with reference to claim 1, element 7, the digitally summed values from 430 are processed through the remainder of Fig. 5 of Oh in preparation for transmission to the base station, such as via the antenna depicted in Fig. 5. That processing in preparation for transmission to the base station includes D/A conversion at 440, amplification at 450, an initial upconversion at 460 followed by filtering at 470 and amplification at 480. Further upconversion of the frequency bands occurs at 490, followed by amplification at 510 and combining at 404 to form the replicated analog signal for transmission to the base station. That combined signal is amplified at 405 and transits a duplex filter 406 before transmission. Ex. 1007, 5:16-26.

FIG. 5

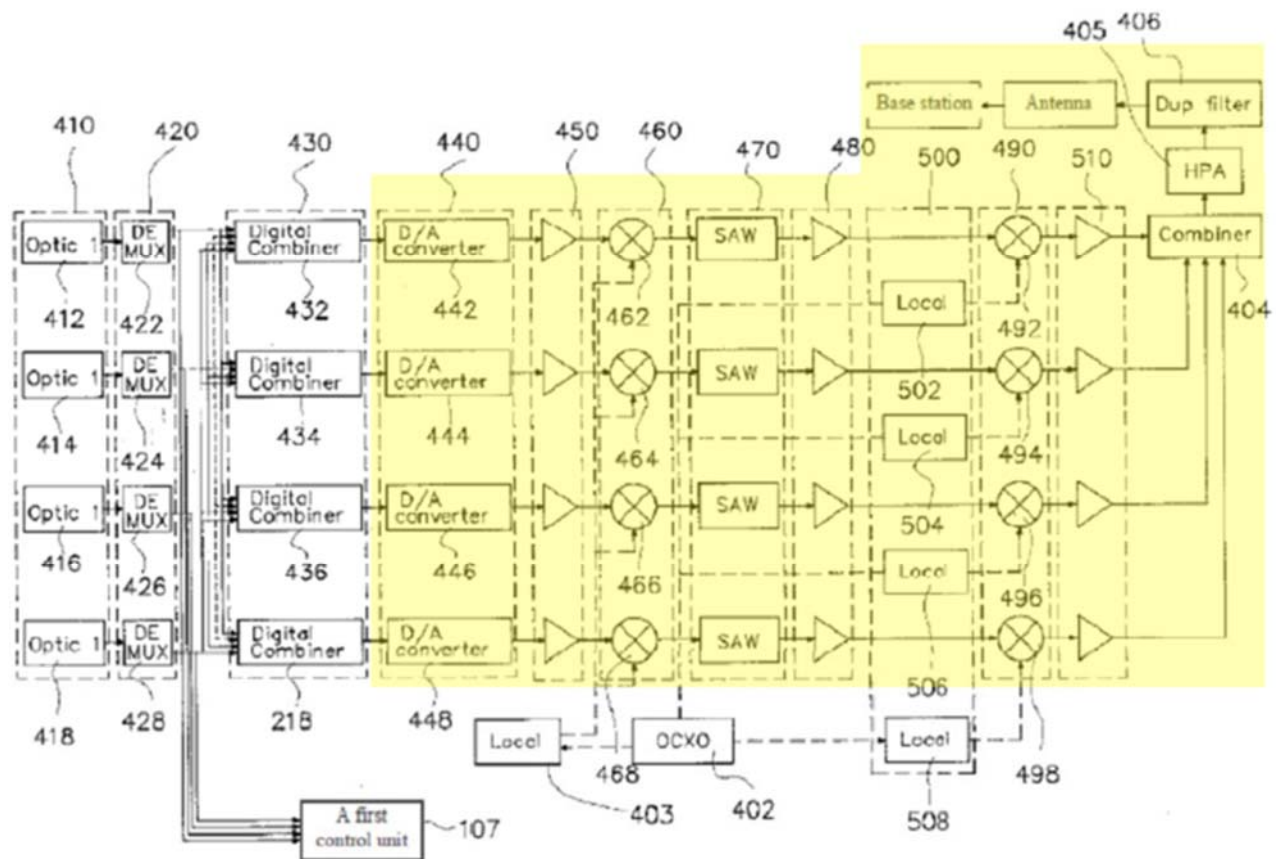


522. Thus Oh renders obvious the system including base station signal processing functionality (440, 450, 460, 470, 480, 490, 520, 404, 405, 406) configured to perform base station processing.

3. Dependent Claim 3

523. Claim 3 recites that “the base station processing functionality is at least one of: co-located with the first unit and remote from the first unit.” As depicted in Fig. 5 of Oh, the base station processing (440, 450, 460, 470, 480, 490, 520, 404, 405, 406) occurs in master unit 20’s reverse master unit 400. Ex. 1007, 4:65.

FIG. 5

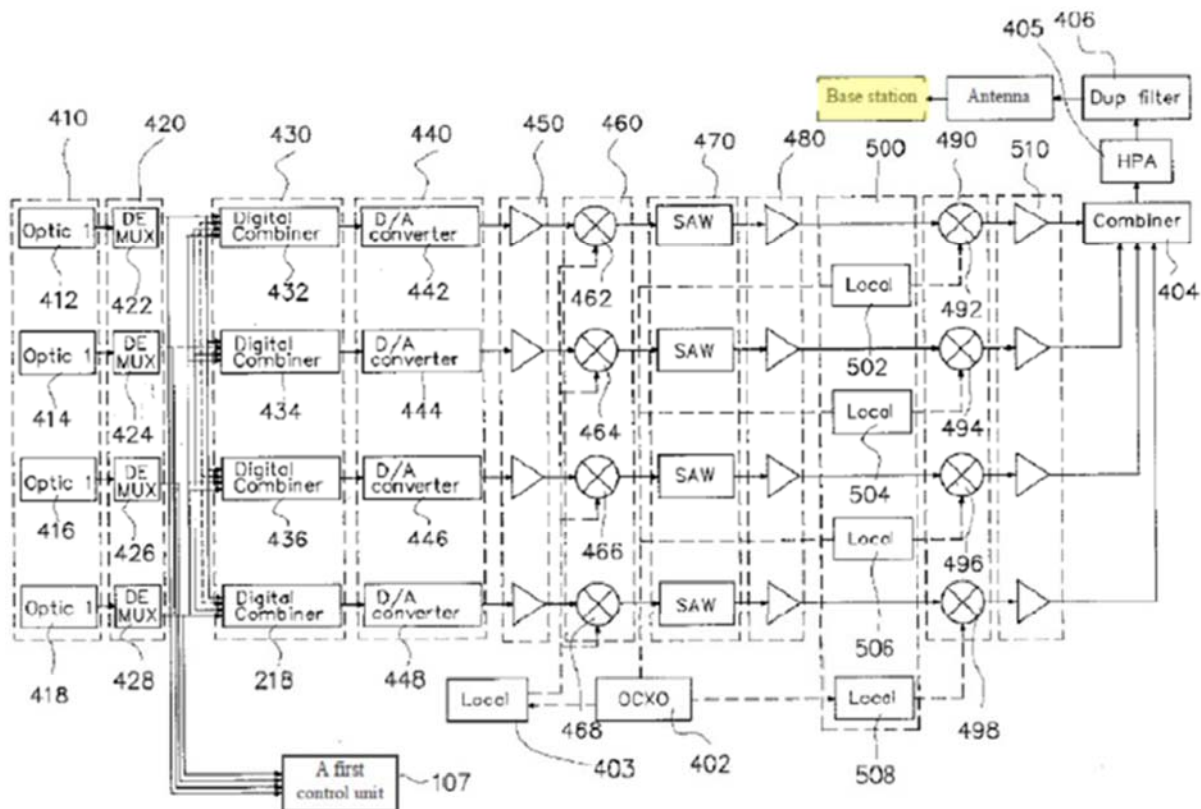


524. Thus in Oh the base station processing functionality (440, 450, 460, 470, 480, 490, 520, 404, 405, 406) is at least one of: co-located with the first unit (master unit 20 at reverse master unit 400) and remote from the first unit.

4. Dependent Claim 4

525. Claim 4 recites “the system comprises at least a portion of a base station for performing the base station processing.” As noted above with reference to claim 1, a POSITA would understand “base station processing” to mean processing signals in preparation/transmission of those processed signals to a base station. Oh discloses a system that culminates with transmission of analog RF signals to a base station, as highlighted below. Oh states that its “base station” “constitutes the mobile telecommunication network” and is thus involved in transmission of processed signals. Ex. 1007, 2:4-5.

FIG. 5



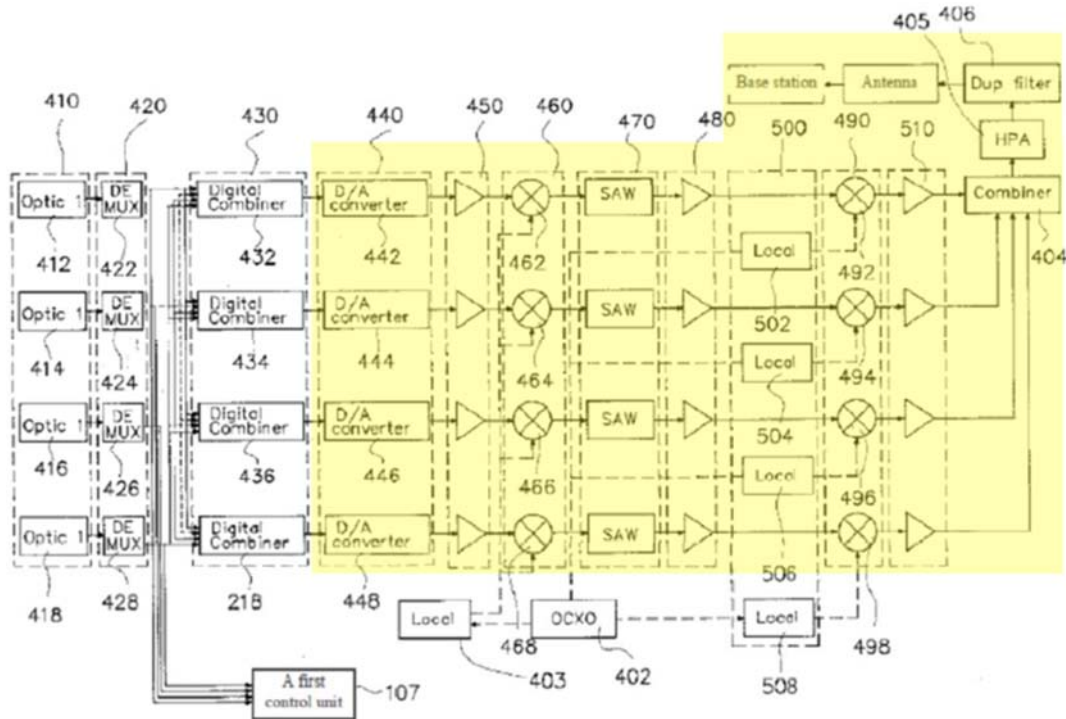
526. Thus Oh renders obvious the system comprises at least a portion of a base station (highlighted Fig. 5 Base station, “which constitutes the mobile telecommunications network”) for performing the base station processing (processing signals in preparation/transmission of those processed signals to a base station).

5. Dependent Claim 7

527. Claim 7 recites “the system is configured to convert the summed digital RF samples to a replicated analog wireless radio frequency signal.” Oh discloses that the output of digital combiner unit 430 (*i.e.*, the summed digital RF samples), are converted to analog signals at 440, upconverted to RF frequency signals at 450, 460,

470, 480, 490, 510, and combined at 404 to form an analog signal that is transmitted to the base station. Ex. 1007, 5:16-26.

FIG. 5



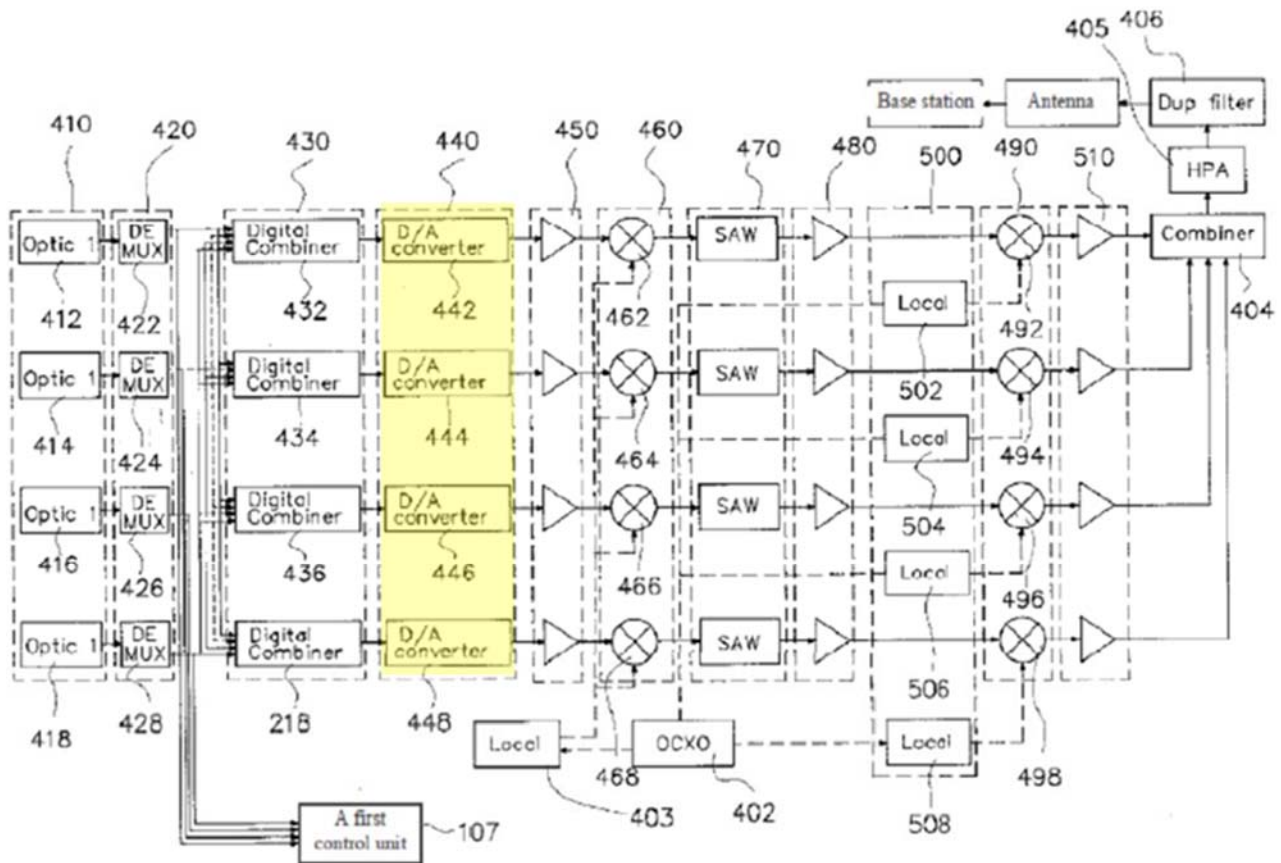
528. Thus Oh discloses the system is configured to convert the summed digital RF samples (output of 430) to a replicated analog wireless radio frequency signal (via 450, 460, 470, 480, 490, 510, 404).

6. Dependent Claim 8

529. Claim 8 recites “the system comprises a digital-to-analog converter to convert the summed digital RF samples to the replicated analog wireless radio frequency signal.” As noted above, Oh discloses D/A converter unit 440 that receives the summed digital RF samples from 430 and converts them to analog signals, prior

to those analog signals being up converted to form the replicated analog wireless frequency signal.

FIG. 5



530. Thus Oh renders obvious the system comprises a digital-to-analog converter unit (440) to convert the summed digital RF samples (from 430) to the replicated analog wireless radio frequency signal.

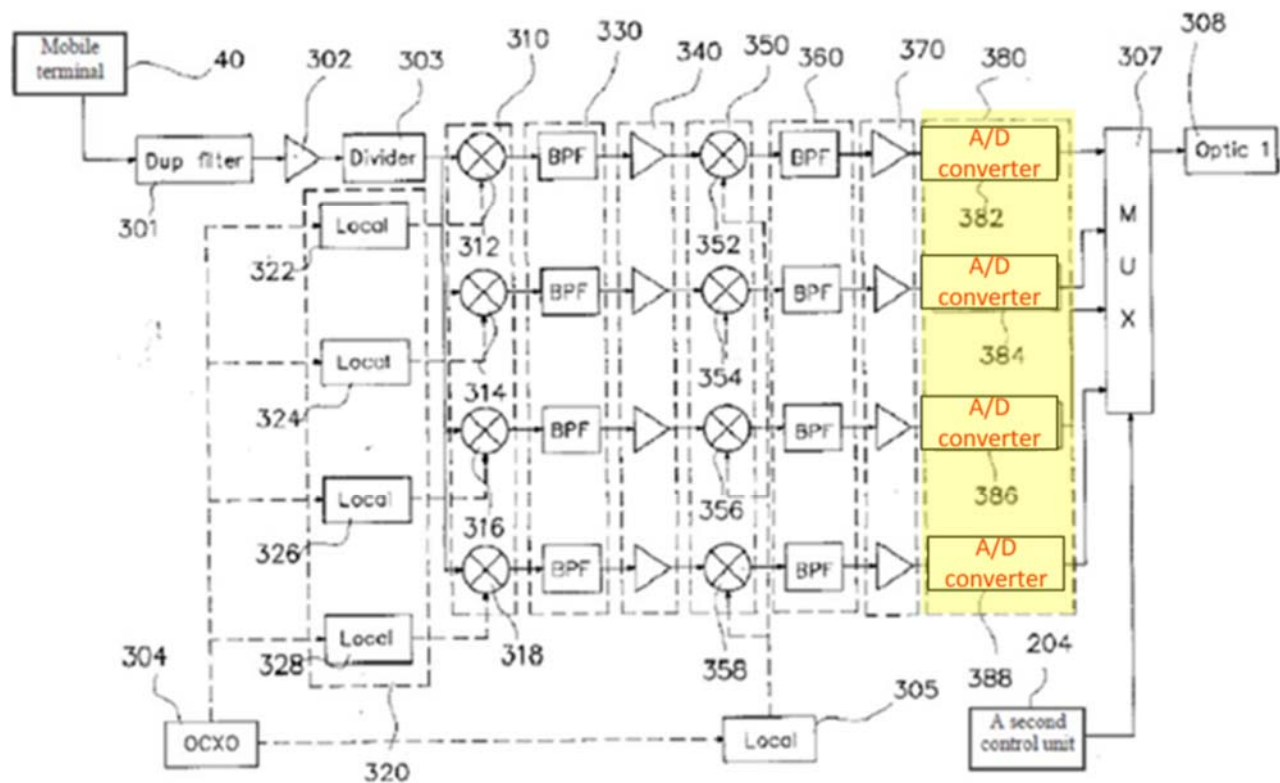
7. Dependent Claim 9

531. Claim 9 recites that “each of the plurality of second units comprises: a respective analog-to-digital converter to digitize the respective analog wireless radio

frequency signal received at that second unit in order to produce the respective digital RF samples.”

532. Oh discloses that each reverse slave unit 300 “converts the RF signals, analog signals, transmitted from the mobile terminals 40 through a third bi-directional filter 301, to the digital signals.” Ex. 1007, 4:23-25. That digitization is illustrated at Fig. 4 where “A/D converter unit 380 converts the intermediate frequency signals, analog signals, to the digital signals.” *Id.*, 4:56-67.

FIG. 4



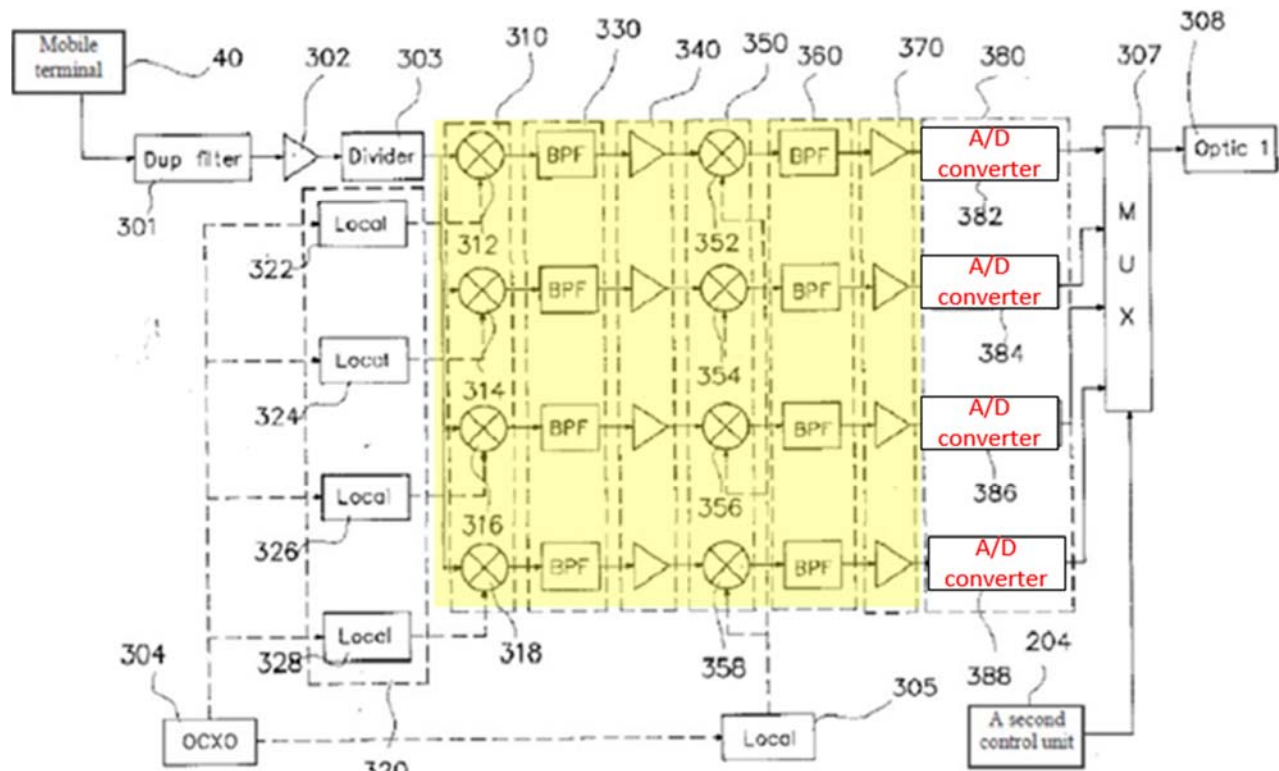
533. Thus, Oh discloses each of the plurality of second units (30) comprises: a respective analog-to-digital converter (380) to digitize the respective analog wireless

radio frequency signal received at that second unit in order to produce the respective digital RF samples.

8. Dependent Claim 10

534. Claim 10 recites “each of the plurality of second units generates the respective digital RF samples indicative of the respective analog wireless signal received at that second unit by frequency shifting the respective analog wireless radio frequency signal received at that second unit and digitizing the frequency-shifted analog wireless radio frequency signal.” Oh discloses that each remote slave unit 30 includes circuitry for downconverting RF signals received from mobile terminals 40 to near DC prior to performing A/D conversion at 380. Specifically, a first stage of downconverting at 310 transitions signals from their near 800MHz bands to ~70MHz, followed by a second frequency shift from ~70MHz to near DC. Ex. 1007, 4:43-55.

FIG. 4



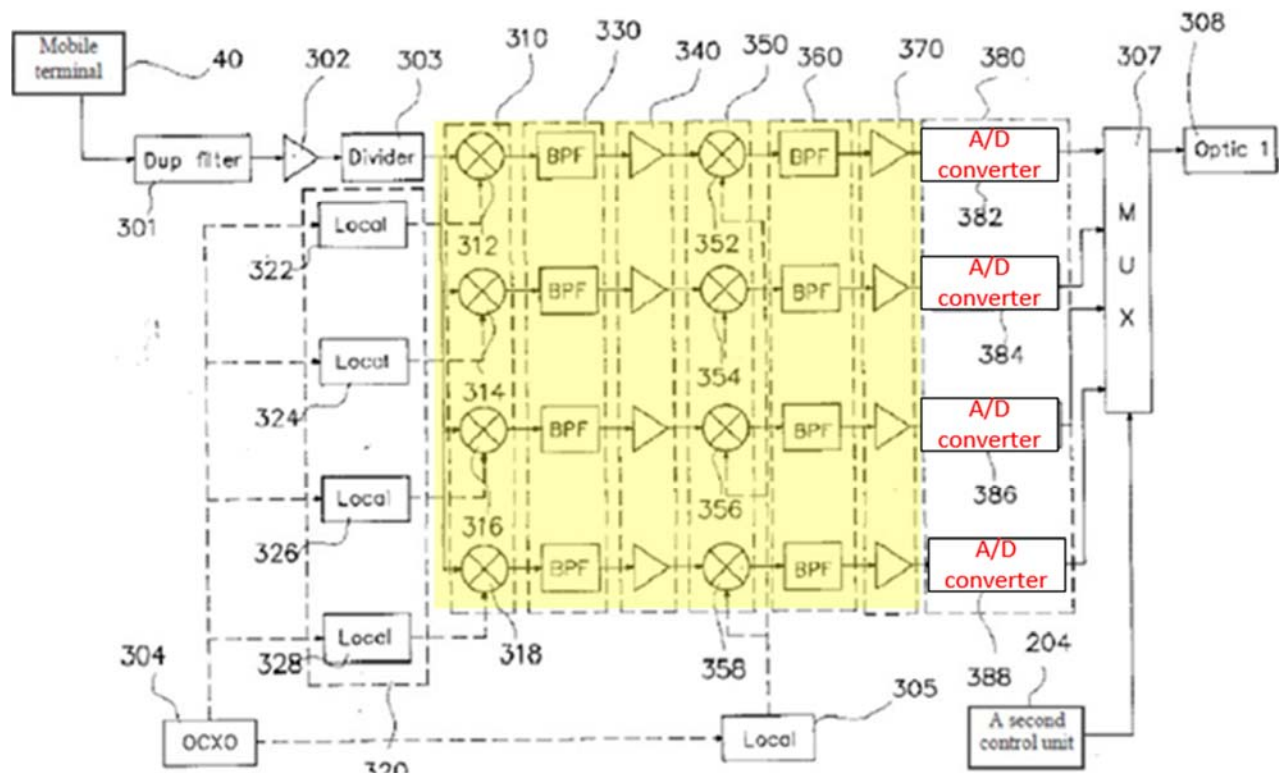
535. Thus Oh renders obvious each of the plurality of second units (30) generates the respective digital RF samples (at 380) indicative of the respective analog wireless signal received at that second unit (from 40) by frequency shifting (downconverting at 310, 350) the respective analog wireless radio frequency signal received at that second unit and digitizing (380) the frequency-shifted analog wireless radio frequency signal.

9. Dependent Claim 11

536. Claim 11 recites “each of the plurality of second units generates the respective digital RF samples indicative of the respective analog wireless signal received at that second unit by down converting the respective analog wireless radio

frequency signal received at that second unit and digitizing the down-converted analog wireless radio frequency signal.” As discussed above with reference to claim 10, each Oh remote slave unit downconverts received analog signals from ~800Mhz→~70MHz→~DC at 310, 350 prior to A/D conversion at 380.

FIG. 4

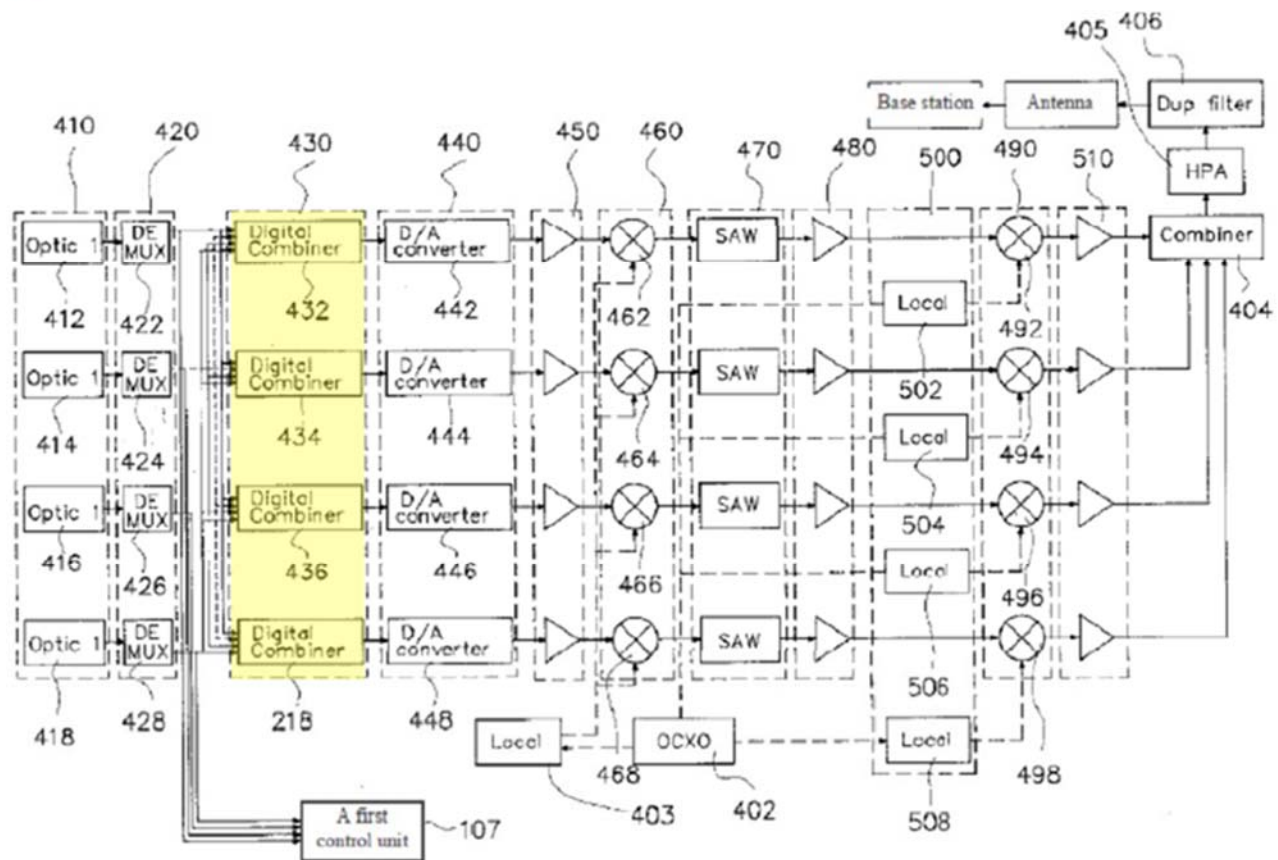


537. Thus Oh renders obvious each of the plurality of second units (30) generates the respective digital RF samples indicative of the respective analog wireless signal received at that second unit by down converting (at 310, 350) the respective analog wireless radio frequency signal received at that second unit and digitizing (at 380) the down-converted analog wireless radio frequency signal.

10. Dependent Claim 12

538. Claim 12 recites “the first unit digitally sums the corresponding digital RF samples received from the plurality of second units in order to produce the summed digital RF samples at a resolution greater than a resolution of the digital RF samples being summed.” Oh discloses that its A/D converters 380 sample the downconverted analog signals at each frequency band at 12-bits of resolution. Ex. 1007, 3:38-39; 3:61-64; 4:16. On the reverse path at the master unit 20, digital combiner units 432, 434, 436, 438 “creat[e] 14-bit intermediate frequency signals by combining four 12-bit intermediate frequency signals in the same frequency band.” *Id.*, 5:16-17.

FIG. 5



539. Thus Oh renders obvious the first unit (20) digitally sums (at 430) the corresponding digital RF samples received from the plurality of second units (30) in order to produce the summed digital RF samples at a resolution (14 bits) greater than a resolution (12 bits) of the digital RF samples being summed.

11. Dependent Claim 13

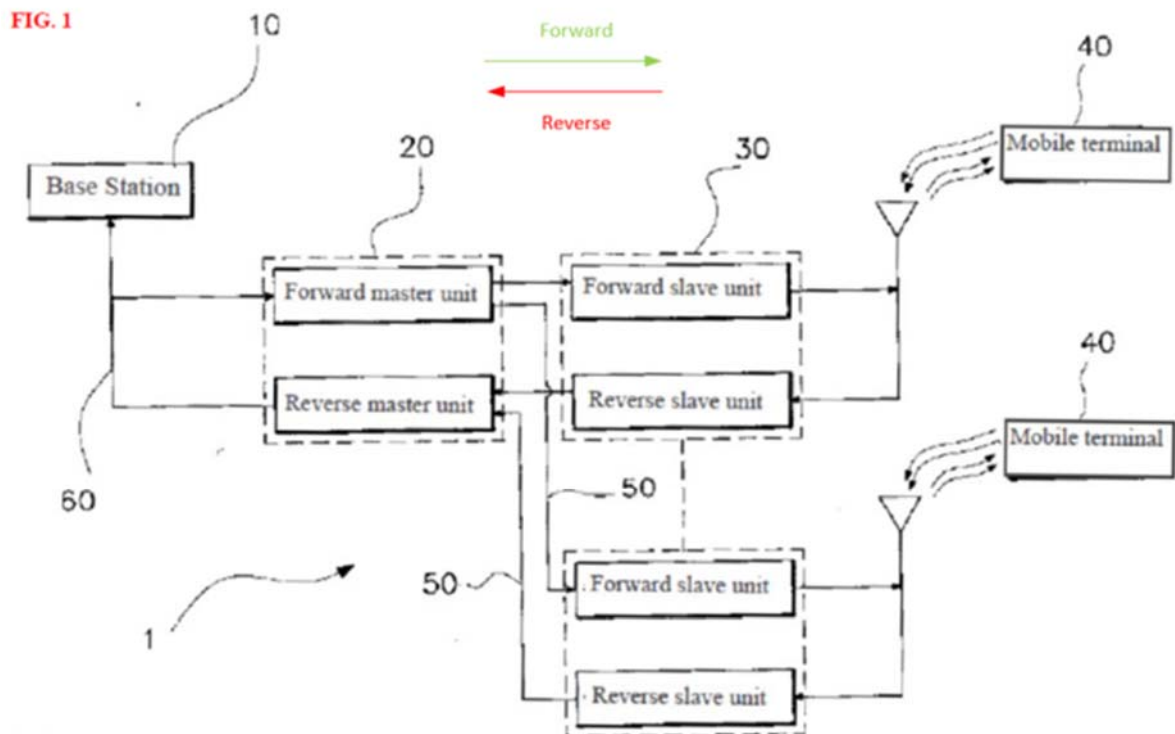
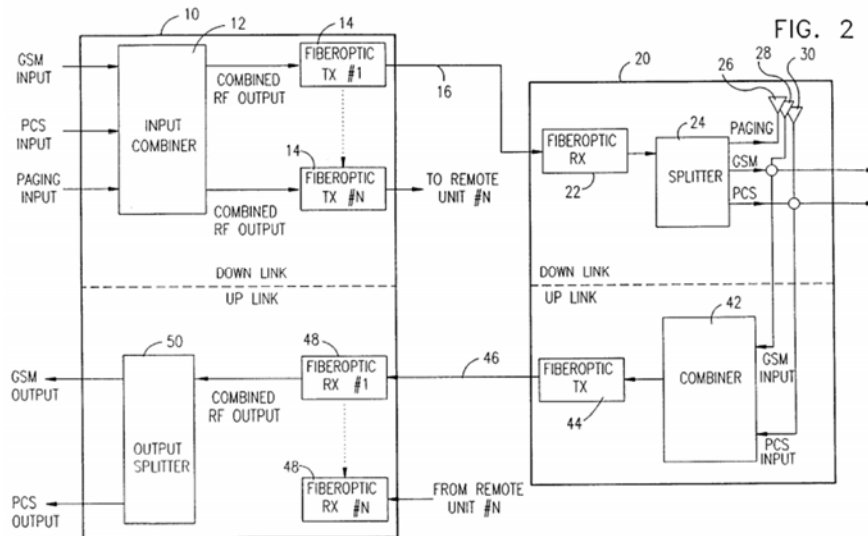
540. Claim 13 recites “the wireless radio frequency spectrum comprises a cellular radio frequency spectrum.” Oh discloses receiving and operations on base station/mobile terminal signals at 800MHz and 1800MHz Ex. 1007, 3:19, 4:40. The 800MHz frequency corresponds to the first mobile commercial standard, the

Advanced Mobile Phone System. As demand grew for cellular services, carriers acquired licenses in the 1800MHz band. Both 800 MHz and 1800 MHz are within the cellular radio frequency spectrum. Thus Oh renders obvious the wireless radio frequency spectrum comprises a cellular radio frequency spectrum (800MHz, 1800MHz).

12. Dependent Claim 14

541. Claim 14 recites “the at least one communication medium comprises at least one of: a single mode optical fiber, a multi-mode optical fiber, and a coaxial cable.” Oh discloses that the master unit 20 communicates digital data to slave units 30 via optic lines 50. Ex. 1007, 3:4-6. Oh is agnostic as to whether multimode or single mode fiber is used. A POSITA would consider selection of multimode or single mode to be a matter of design choice. This is evidenced by Farber which describes the use of single or multimode fiber in an antenna system for reaching difficult coverage areas (see Fig. 1) that is very similar to the digital system of Oh. Ex. 1022 (“Farber”), 4:30-33 (“Preferably the transmitter 14 employs a vertical cavity surface emitting laser or an edge emitting laser coupled to a single or multi-mode fiber 16.”); Fig. 2. As further evidence of obviousness of using single or multimode fiber, Haas illustrates the cost-benefit analysis of selection of multimode or single mode fiber for an application. Ex. 1012, 1125. A POSITA would have been motivated to select multimode fiber as disclosed by Haas for communicating among a host and remote

units when cost is a significant factor for the project. Additionally as disclosed by Haas, in some instances multimode fiber may already be installed in an area into which an RF distribution network is being implemented, making reuse of that multimode fiber an attractive option.



542. Thus a POSITA would have considered it obvious to select one of the two possible choices to implement optic lines 50, where the claim encompasses both possible choices.

13. Independent Claim 15

a) Preamble: “A first unit for use with a coverage area in which one or more wireless units transmit in a wireless radio frequency spectrum,”

543. To the extent the preamble is limiting, Oh renders the preamble obvious for the reasons provided above for the preamble of claim 1, where Oh describes a first unit (20) for use within a coverage area in which one or more wireless units 40 transmit in a wireless radio frequency spectrum (*e.g.*, 800 MHz, 1800MHz).

b) Element 1a: “an interface to communicatively couple the first unit to a plurality of second units using at least one communication medium,”

544. Oh discloses master unit 20 is coupled to multiple remote slave units 30 via optic lines 50.

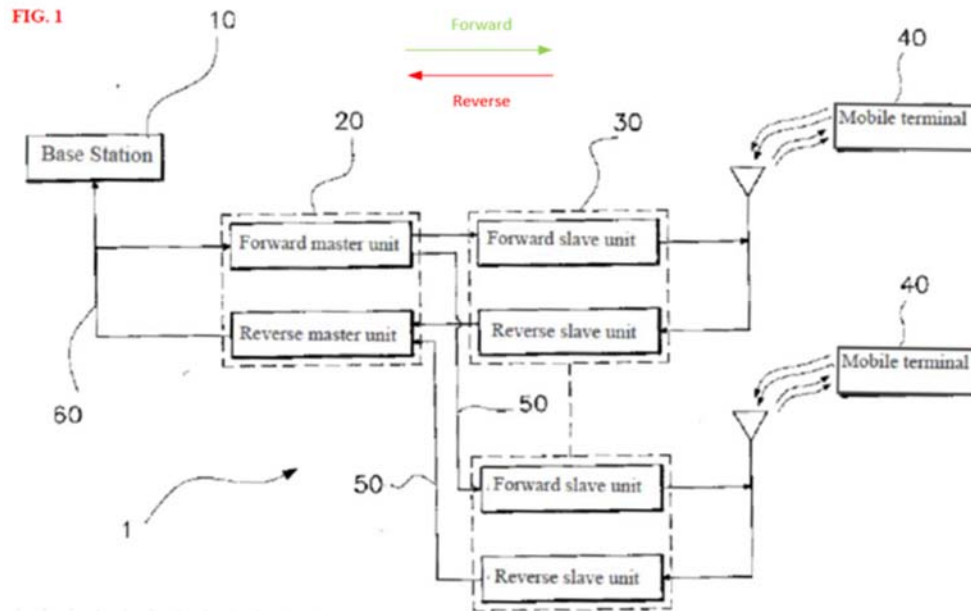
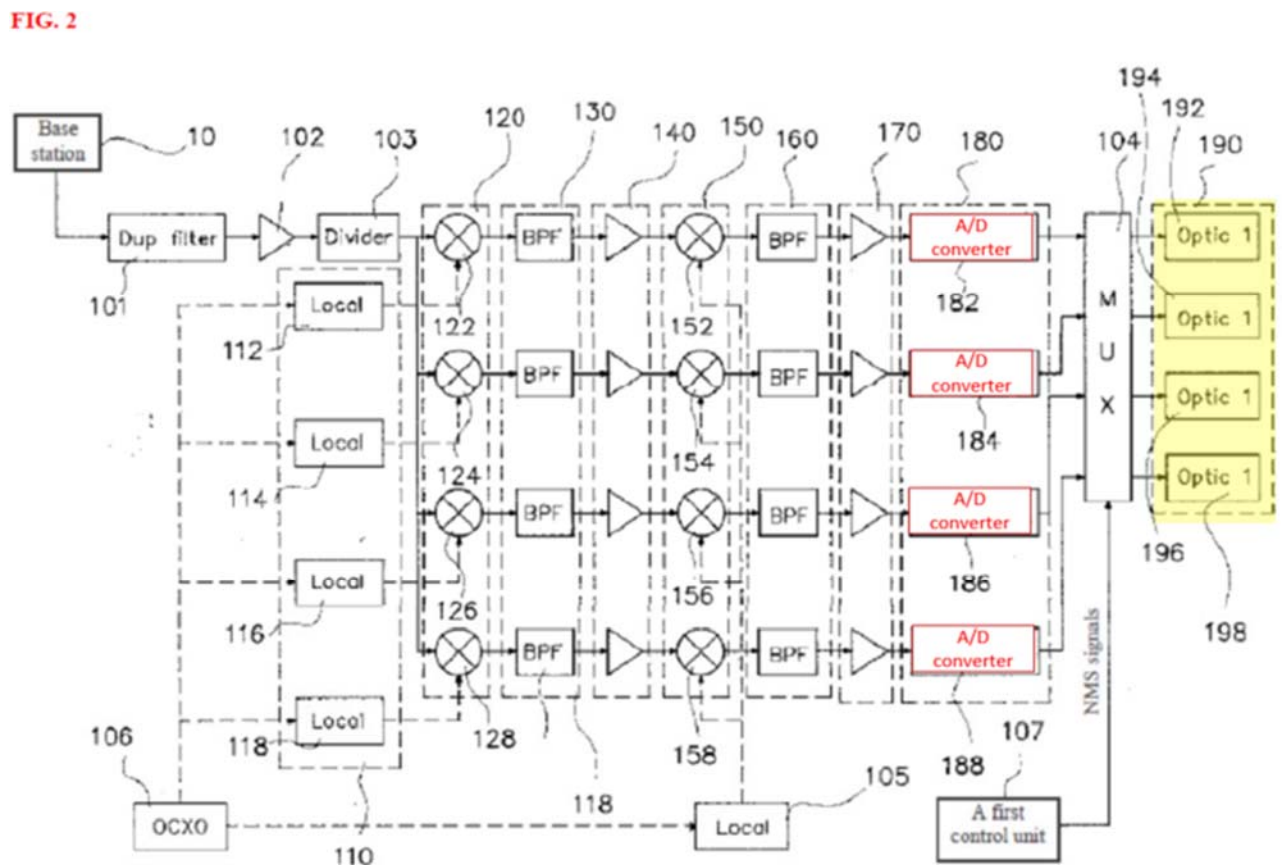
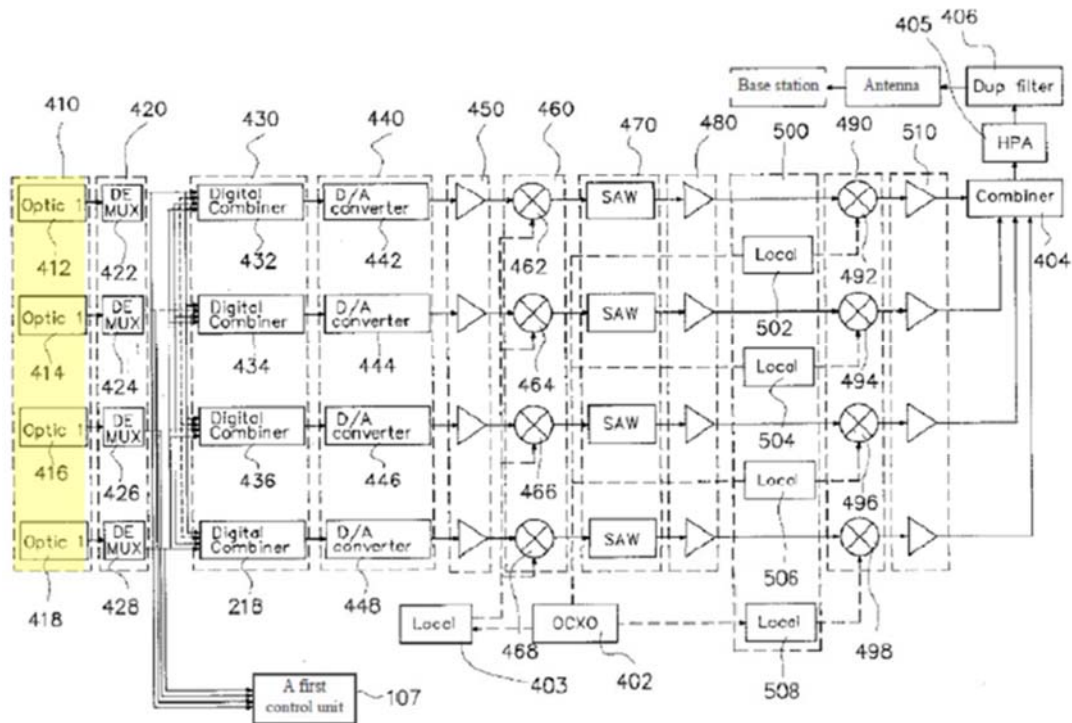


Fig. 2 of Oh depicts optic converter unit 190 that provides a downstream interface between master unit 20 and remote slave units 30.



And Fig. 5 illustrates optic converter unit 410 that provides an upstream interface from slave units 30 to master unit 20.

FIG. 5



545. Thus Oh renders obvious an interface (190, 410) to communicatively couple the first unit (20) to a plurality of second units (30) using at least one communication medium (50).

c) Element 1b: “wherein each of the plurality of second units is associated with a portion of the coverage area and each of the plurality of second units receives a respective analog wireless signal comprising the wireless radio frequency spectrum and any transmissions from any of the wireless units that are within the portion of the coverage area associated with that second unit”

546. Oh renders element 1b obvious for the reasons provided above with respect to elements 2 and 3 of claim 1.

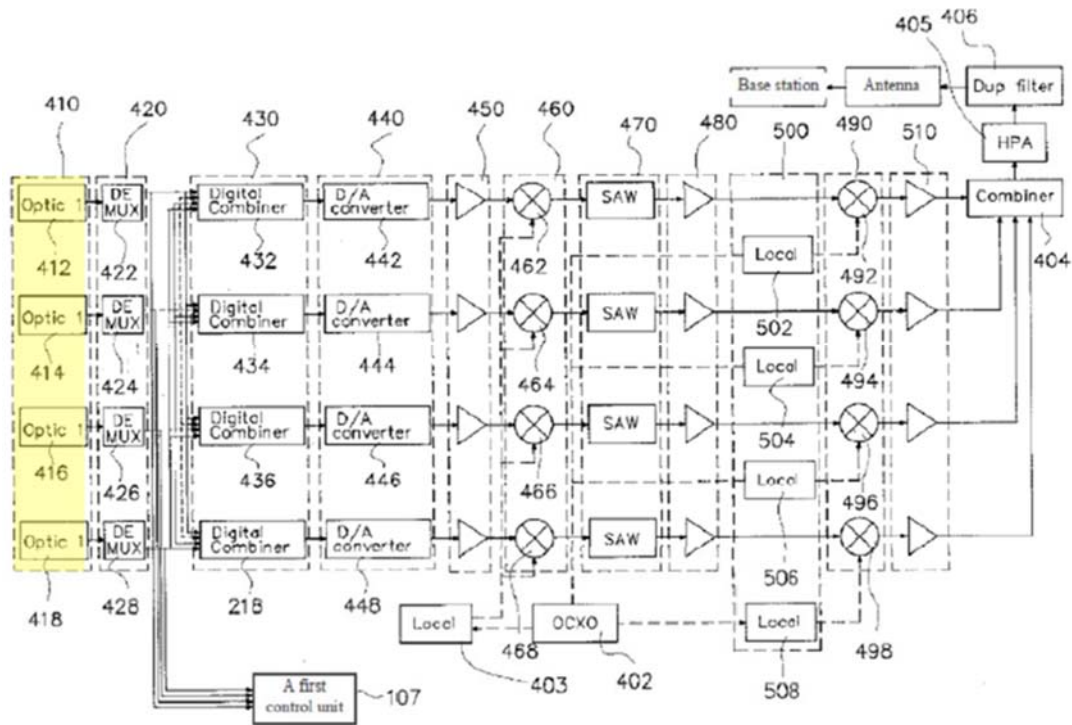
d) Element 1c: “wherein each of the plurality of second units generates respective digital RF samples indicative of the respective analog wireless signal received at that second unit,”

547. Oh renders element 1c obvious for the reasons provided above with respect to element 4 of claim 1.

e) Element 1d: “wherein the interface is used to receive the digital RF samples from the plurality of second units;”

548. Oh Fig. 5 illustrates optic converter unit 410 that provides an upstream interface from slave units 30 to master unit 20 that receives “the serial data signals transmitted from each slave unit 30.” Ex. 1007, 4:65-66.

FIG. 5



549. Thus Oh renders obvious the interface (410) is used to receive the digital RF samples from the plurality of second units (30).

f) Element 2: “a digital summer to digitally sum corresponding digital RF samples received from the plurality of second units to produce summed digital RF samples;”

550. Oh renders element 2 obvious for the reasons provided above for claim 1, element 6, where digital combiner unit 430 sums digital samples received from the remote slave units 30 to produce summed digital RF samples.

g) Element 3: “wherein the first unit is configured so that an input used for base station processing is derived from the resulting summed digital RF samples.”

551. Oh renders element 3 obvious for the reasons provided above for claim 1, element 7.

14. Dependent Claims 16-17 and 19-22

552. Dependent claims 16-17 and 19-22 are rendered obvious by Oh for the reasons provided above for claims 3, 4, 7, 8, 12, 13, respectively.

15. Independent Claim 23

a) Preamble: “A method used with wireless radio frequency signals within a coverage area in which one or more wireless units transmit in a wireless radio frequency spectrum, the method using a first unit and a plurality of second units, each of the plurality of second units being associated with a portion of the coverage area, the method comprising:”

553. To the extent the preamble is limiting, it is rendered obvious by Oh for the reasons provided above for the preamble and elements 1-2 of claim 1, where one or more wireless units (40) transmit in a wireless radio frequency spectrum, in a system that includes a first unit (20) and a plurality of second units (30), each of the plurality of second units being associated with a portion of the coverage area.

b) Element 1: “at each of the plurality of second units: receiving a respective analog wireless signal comprising the wireless radio frequency spectrum and any transmissions from any of the wireless units that are within the portion of the coverage area associated with that second unit;”

554. Element 1 is rendered obvious by Oh for the reasons provided above for claim 1, element 3.

c) Element 2: “generating respective digital RF samples indicative of the respective analog wireless signal received at that second unit;”

555. Element 2 is rendered obvious by Oh for the reasons provided above for claim 1, element 4.

d) Element 3: “communicating the respective digital RF samples generated by that second unit to the first unit using at least one communication medium;”

556. Element 3 is rendered obvious by Oh for the reasons provided above for claim 1, element 5.

e) Element 4: “at the first unit, digitally summing corresponding digital RF samples received from the plurality of second units to produce summed digital RF samples.”

557. Element 4 is rendered obvious by Oh for the reasons provided above for claim 1, element 6.

16. Dependent Claim 24

558. Claim 24 recites “performing base station processing using an input derived from the resulting summed digital RF samples.” Oh renders this limitation obvious for the reasons provided above for claim 1, element 7.

17. Dependent Claims 25-31

559. Dependent claims 25-31 are rendered obvious by Oh for the reasons provide above for claims 3, 4, 8, 12, 13, 10, and 11, respectively.

18. Independent Claim 32

a) Preamble and Elements 1-6

560. Oh renders the preamble and elements 1-6 of claim 32 obvious for the reasons provided above for the preamble and elements 1-6 of claim 1.

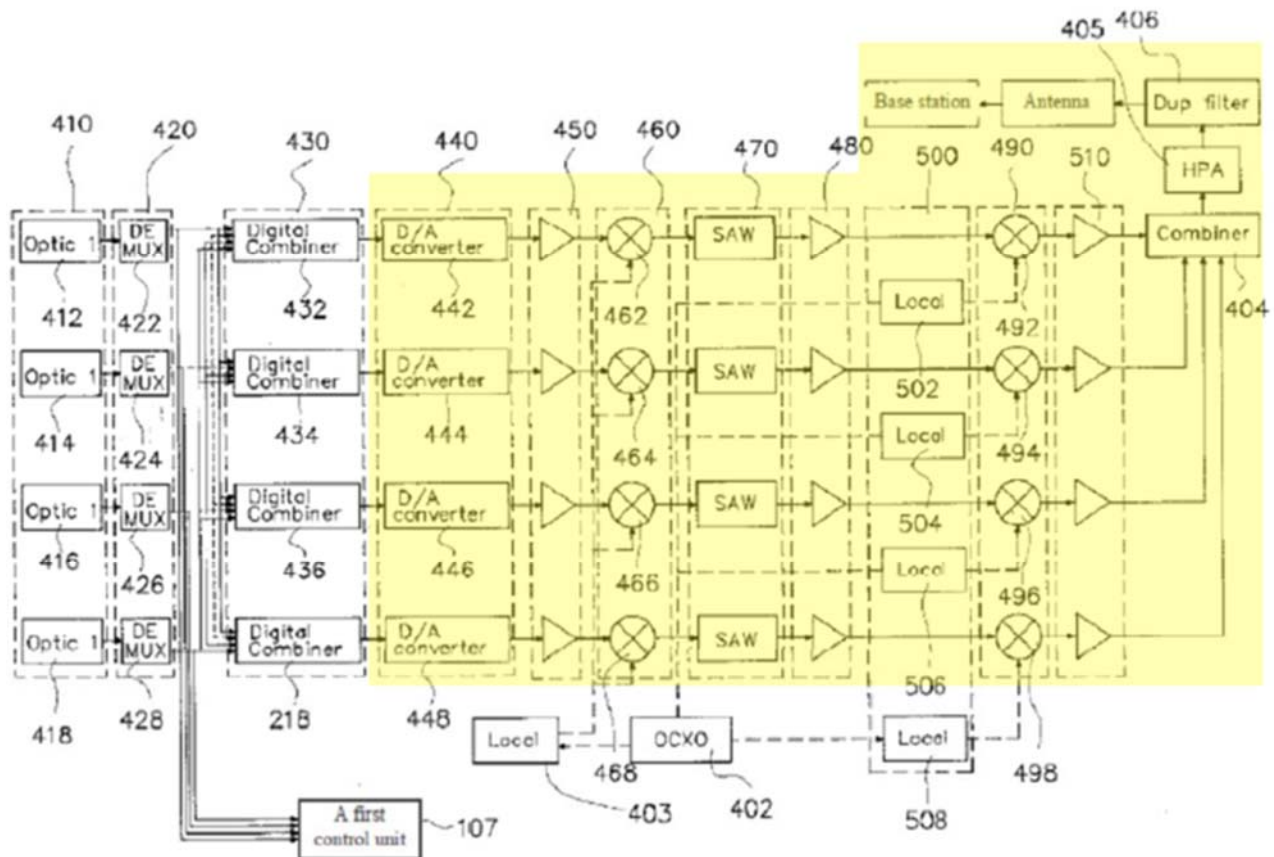
b) Element 7: “wherein the system is configured so that an input used for wireless protocol processing is derived from the resulting summed digital RF samples”

561. The term “wireless protocol processing” is not used in the '286 patent specification. A POSITA would understand “wireless protocol processing” to mean processing signals in preparation/transmission of those processed signals according to a wireless protocol.

562. Oh renders that limitation obvious. Following the digital summing operation referenced above in addressing element 6, the summed digital data values in Oh are converted to analog signals, up converted to the appropriate frequency

signals associated with their particular bands to create component analog signals, that are then combined and wirelessly transmitted to a base station via an antenna.

FIG. 5



Specifically Oh states:

After creating 14-bit intermediate frequency signals by combining four 12-bit intermediate frequency signals in the same frequency band, said digital combiner transmits them to a first D/A converter unit 440. Each D/A converter 442, 444, 446, and 448 of said first D/A converter unit 440 converts 14-bit digital signals to the intermediate [frequency] signals, analog signals; and transmits 1.23MHz or 1.5MHz intermediate frequency signals to each mixer 462, 464, 466, and 468 of a third mixer unit 460 through a third amplification unit 450. Said third

mixer unit 460 outputs 70MHz intermediate frequency signals by mixing 1.23MHz or 1.5MHz intermediate frequency signals transmitted from a first D/A converter unit 440 with 68.77MHz or 68.5MHz oscillating frequency transmitted from a third local unit 403. The intermediate frequency signals outputted from said third mixer unit 460 are transmitted to a fourth mixer unit 490 through a first saw filter unit 470 and a fourth amplification unit 480. Said fourth mixer unit 490 mixes the oscillating frequency in different frequency bands transmitted from a fourth local unit 500 with 70MHz intermediate frequency signals; and transmits 800MHz RF signals in different frequency bands to a first combiner 404 through a fifth amplification unit 510.

Ex. 1007, 5:16-26. The analog signals are combined at 404 to “aggregate[] the RF signals in different frequency bands transmitted from four mixers 492, 494, 496, and 498,” and are amplified at 510 and run through a bi-directional filter 406 to an antenna and a base station.

563. Thus Oh renders obvious the system being configured so that an input used for wireless protocol processing is derived from the resulting summed digital RF samples (the output of 430 is used as an input to circuitry at 440, 450, 460, 470, 480, 490, 520, 404, 405, 406 in preparation for wireless transmission to the base station).

19. Dependent Claims 33-34

564. Dependent claims 33 and 34 are rendered obvious by Oh for the reasons provided above for claims 3 and 4.

20. Independent Claim 37

a) Preamble and Elements 1 and 2

565. The preamble and elements 1 and 2 are rendered obvious by Oh for the reasons provided above for the preamble and elements 1 and 2 of claim 15 above.

b) Element 3: “the first unit is configured so that an input used for wireless protocol processing is derived from the resulting summed digital RF samples”

566. Element 3 of claim 37 is rendered obvious by Oh for the reasons provided above for element 7 of claim 32.

21. Dependent Claims 38-39

567. Dependent claims 38 and 39 are rendered obvious by Oh for the reasons provided above for claims 3 and 4.

B. Claims 5-6, 18, 35-36, and 40 Are Obvious Over Oh in view of Allpress

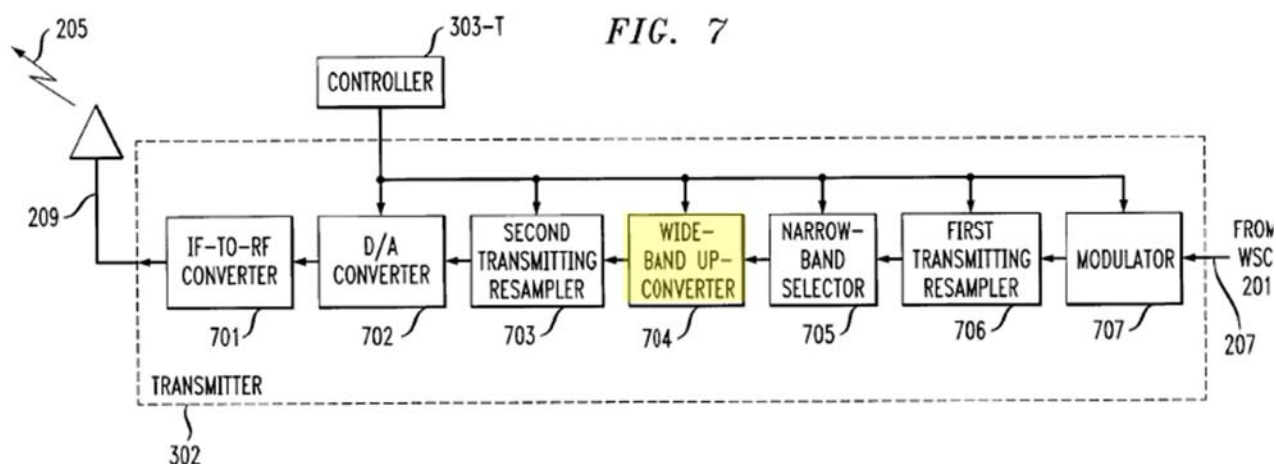
1. Motivation to Combine

568. A POSITA would be motivated to combine the teachings of Allpress with Oh for a variety of reasons. As noted in Allpress, implementation of software transceivers can offer a cost and complexity advantage over hardware implementations by avoiding the need for “duplicative hardware” that has associated expense and maintenance costs. Further, software transceivers are more portable to different systems, using different communications protocols, where software transceiver behavior can be modified through adjustment of software settings as

opposed to replacement of physical hardware components. Thus a software transceiver is not “standards specific” and can be configured to the requirements of a communications system such as the one taught in Oh.

2. Dependent Claim 5

569. Claim 5 recites “the system further comprises software configured to perform the base station processing using the input derived from the resulting summed digital RF samples.” While Oh depicts a hardware implementation of its reverse master unit that performs “base station processing,” a POSITA would consider implementation of some or all of Oh’s post-summing (430) processing in software, where Allpress discloses a transmitter in Fig. 7 that provides upconversion 704 and other functions analogous to Oh’s base station processing in software. Ex. 1020, 8:40-43.



570. Thus Oh in view of Allpress renders obvious the system further comprises software (*e.g.*, software upconversion and other functionality as disclosed

in Allpress) configured to perform the base station processing using the input derived from the resulting summed digital RF samples (outputs of Oh 430).

3. Dependent Claim 6

571. Claim 6 recites “the first unit comprises the software configured to perform the base station processing using the input derived from the resulting summed digital RF samples.” As discussed above, Oh in view of Allpress renders obvious using software to perform certain of Oh’s reverse master unit functionality depicted in Fig. 5. A POSITA would consider it obvious to implement that software functionality in Oh’s master unit 20 (*i.e.*, the same location as Oh’s hardware implementation).

572. Thus Oh in view of Allpress renders obvious the first unit (Oh, 20) comprises the software configured to perform the base station processing using the input derived from the resulting summed digital RF samples.

4. Dependent Claim 18, 35, 36, and 40

573. Dependent claim 35 is rendered obvious by Oh in view of Allpress for the reasons provided above for claim 5. Dependent claims 18, 36, and 40 are rendered obvious by Oh in view of Allpress for the reasons provided above for claim 6.

XI. The Claims of the '402 Patent Are Unpatentable

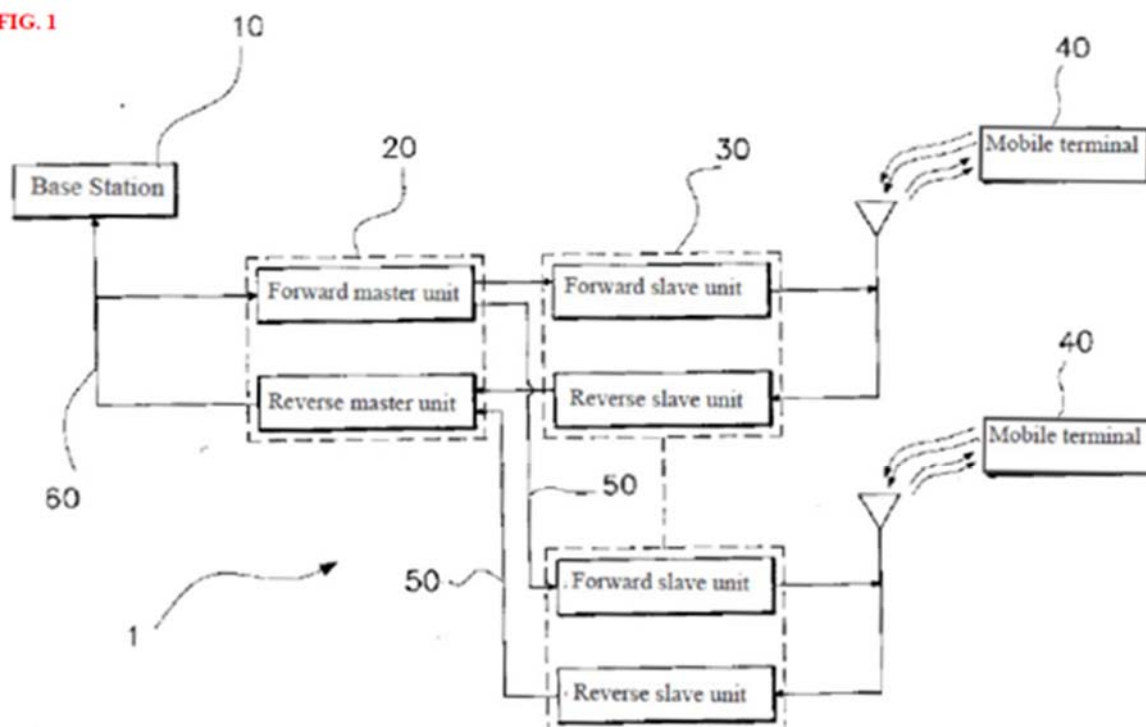
A. Claims 1, 2, 5-7, 10-21, 24, 25, 27-32, 35-44, 47, 48, 51, 52, 55, and 56 Are Obvious Over Oh

1. Independent Claim 1

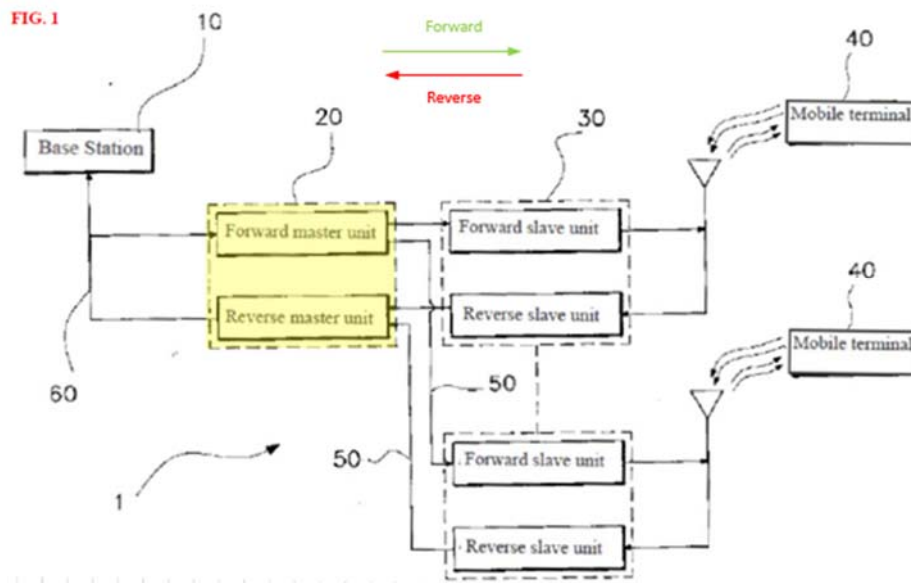
a) Preamble and Elements 1 and 2: “A system for digital transport of a wireless spectrum, the system comprising: a first unit; and a plurality of second units communicatively coupled to the first unit using at least one wired communication link and remotely located from the first unit;”

574. As discussed above, Oh discloses a Digital Optic Repeater system that receives RF signals, from a base station 10 at a master unit 20 and from mobile terminals 40 at remote slave units 30. The optic repeater 1 is installed in a radio wave shadow area and converts received analog signals to intermediate frequency signals (e.g., close to DC in the example at 3:11-14) and then to digital signals for mutual transmission and reception to one another across optic lines 50. Ex. 1007, Abstract, Fig. 1. At a destination unit, the digital signals transmitted across the optic lines 50 are converted to analog signals, and upconverted to RF signals for transmission to their destination (e.g., base station 10 or mobile terminals 40 (e.g., at 800 MHz, 1800MHz)). Ex. 1007, Abstract, Fig. 1, 3:19, 4:40. Fig. 5 of Oh illustrates the communications between master unit 20 and the base station 10 may be wireless communications via an antenna.

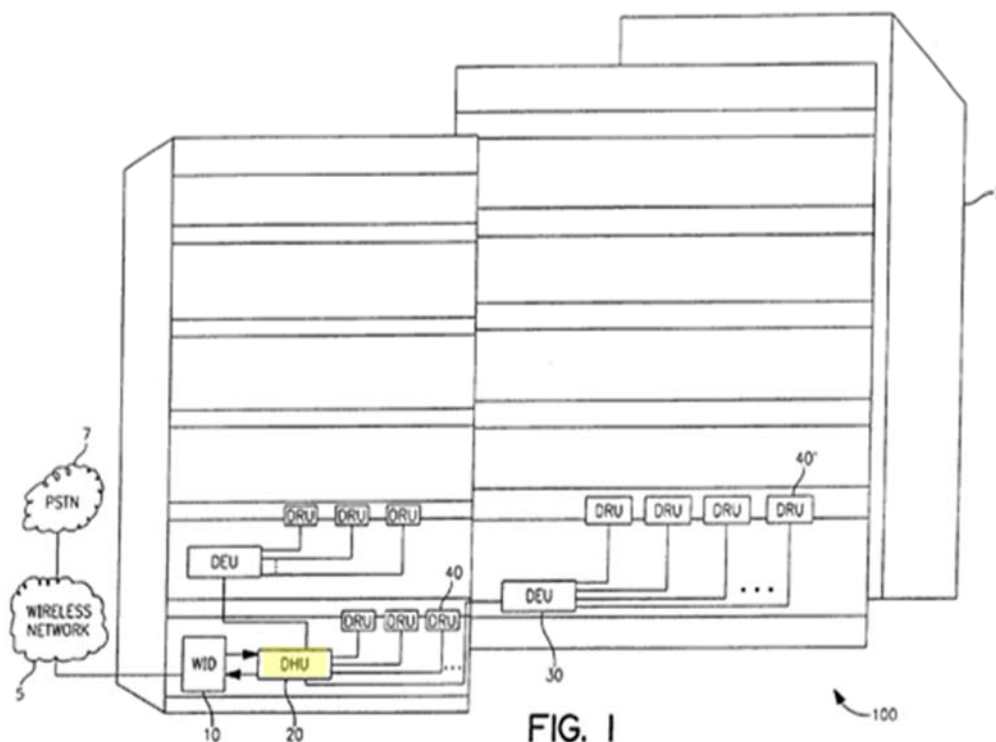
FIG. 1



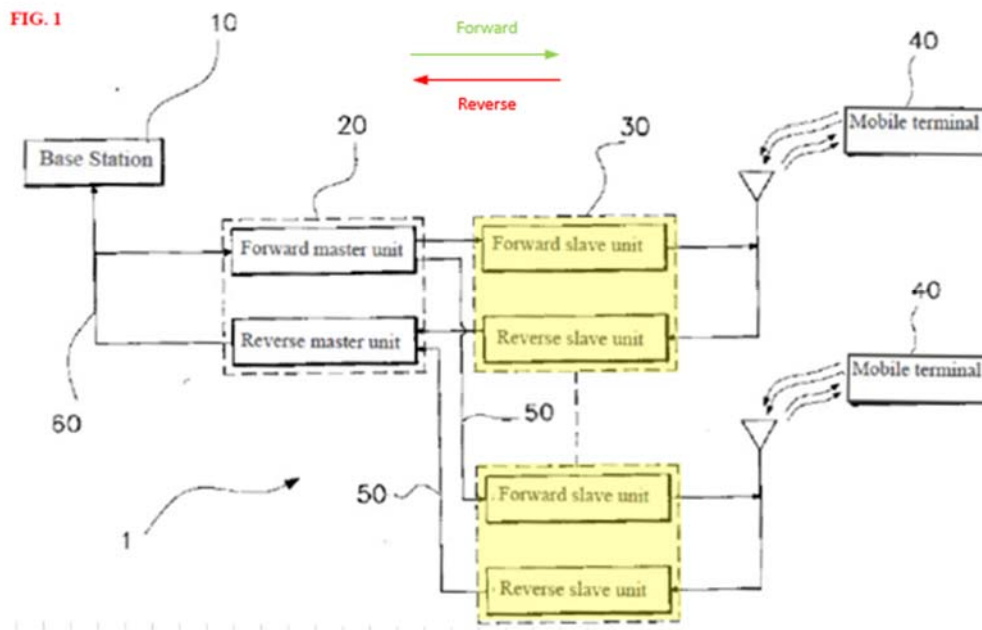
575. As discussed above and as shown in Fig. 1, Oh's master unit 20 transmits/receives analog signals to/from the base station and relays digital samples of those analog signals to/from remote slave units 30 across optic lines 50. Ex. 1007, 2:70-3:1; 4:62-64.



576. Oh's master unit 20 is analogous to the '402 patent's digital host unit (DHU) 20 which interfaces with a wireless interface device (WID) 10 that in embodiments comprises a base station (Ex. 1004, 4:37-38). And like Oh's master unit 20, on the forward path the '402 patent's DHU "receives RF signals from WID 10 [*i.e.*, base station] and converts the RF signals to digital RF signals. DHU 20 further optically transmits the digital RF signals to multiple DRUs 40." *Id.*, 4:48-51.



577. Oh's slave units 30 convert "the digital signals transmitted from the master unit 20 through the optic line 50 to the intermediate frequency signals, analog signals; converts them to RF signals and transmits them to the mobile terminals 40." Ex. 1007, 3:47-49. Oh's slave units 30 further convert analog signals from the mobile terminals 40 to digital signals and transmit them to master unit 20. *Id.*, 4:23-25.



578. Oh's slave units 30 are analogous to the '402 patent's digital remote units (DRUs) that digitally communicate with the DHU via optic cables (Ex. 1004, 4:5-6) and wirelessly communicate with devices in their area (*e.g.*, via antenna 599).

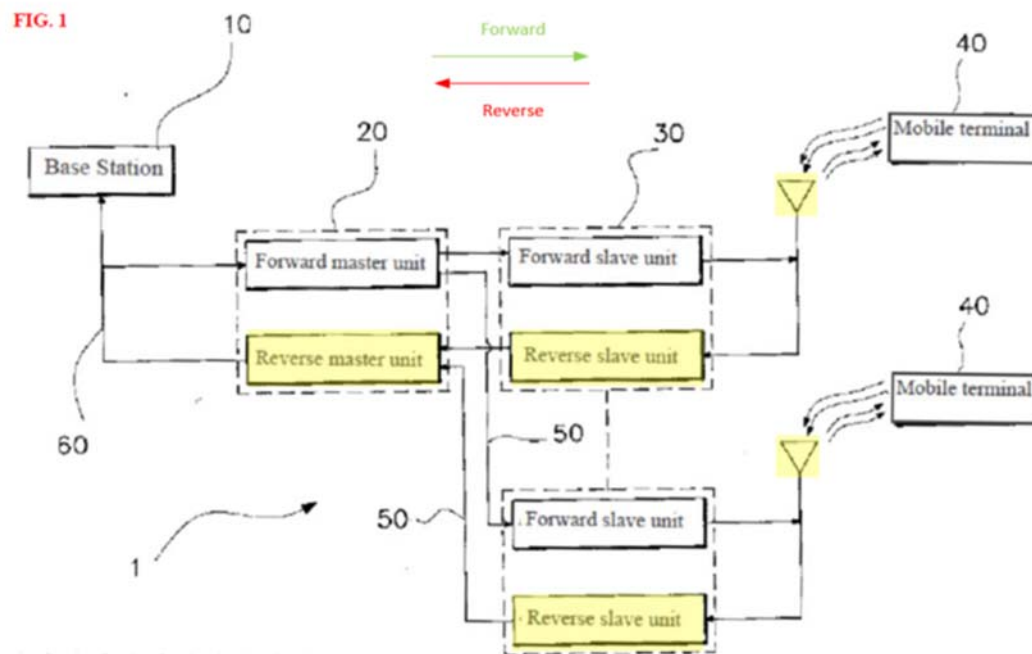
579. As discussed above, Oh, as evidenced by Fig. 5's depiction of master unit 20 communicating with base station 10 via an antenna, evidences the obviousness of wireless communications between a base station and master unit.

580. Thus Oh renders obvious a system for digital transport of a wireless spectrum (transmission of digital data among master unit 20 and slave unit 30 representative of analog signals transmitted wirelessly (*e.g.*, at 800 MHz, 1800MHz to/from base station 10 via antenna), the system comprising: a first unit (20); and a

plurality of second units (30) communicatively coupled to the first unit using at least one wired communication link (50) and remotely located from the first unit.

b) Element 3: “wherein each of the plurality of second units receives a respective analog wireless signal comprising the wireless spectrum and any transmissions from any wireless units within a respective coverage area associated with that second unit;”

581. Oh discloses that each reverse slave unit 300 “converts the RF signals, analog signals, transmitted from the mobile terminals 40... to the digital signals; and transmits them to the master unit 20.” Ex. 1007, 4:22-25. Fig. 1 depicts multiple slave units 30 receiving analog RF signals from mobile terminals 40.



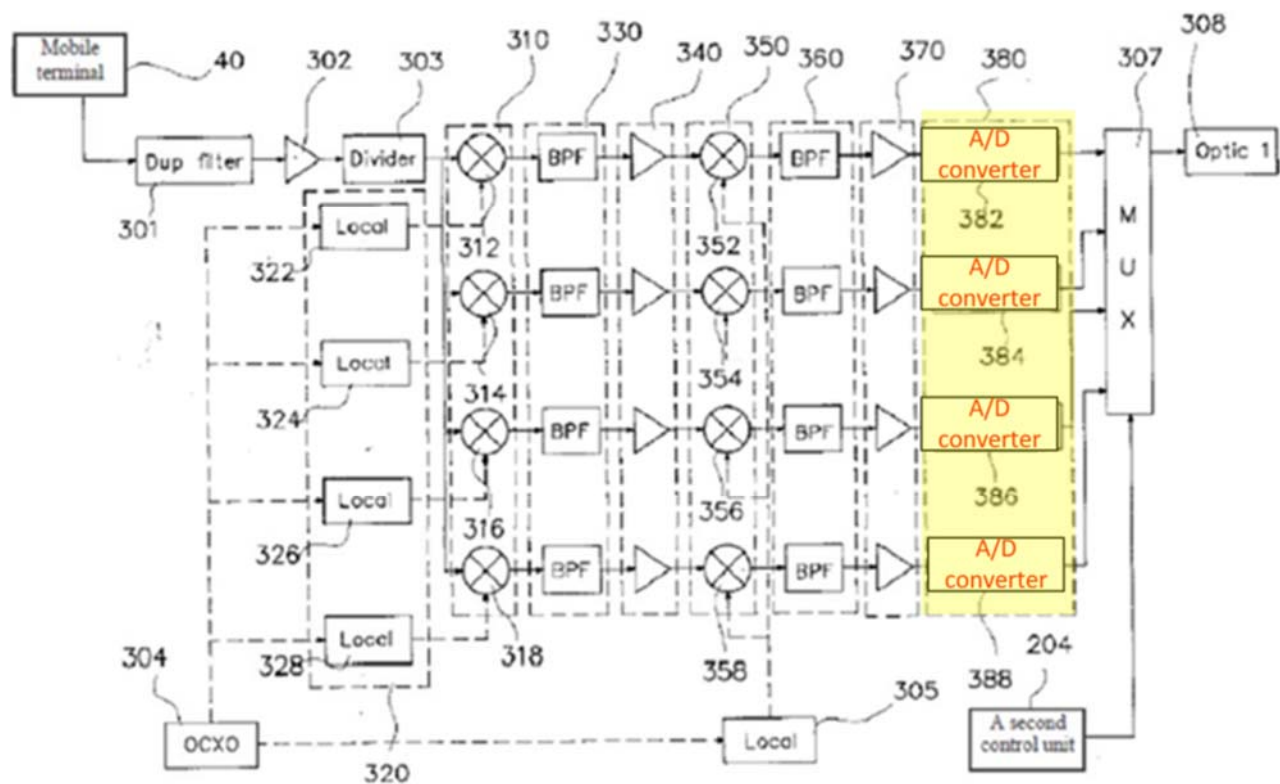
582. Thus Oh discloses each of the plurality of second units (30) receives a respective analog wireless signal comprising the wireless spectrum and any

transmissions from any wireless units (40) within a respective coverage area associated with that second unit.

c) Element 4: “wherein each of the plurality of second units is configured to generate respective digital samples indicative of at least a portion of the wireless spectrum of the respective analog wireless signal received at that second unit;”

583. Oh discloses that each reverse slave unit 300 “converts the RF signals, analog signals, transmitted from the mobile terminals 40 through a third bi-directional filter 301, to the digital signals.” Ex. 1007, 4:23-25. That digitization is illustrated at Fig. 4 where “A/D converter unit 380 converts the intermediate frequency signals, analog signals, to the digital signals.” *Id.*, 4:56-67.

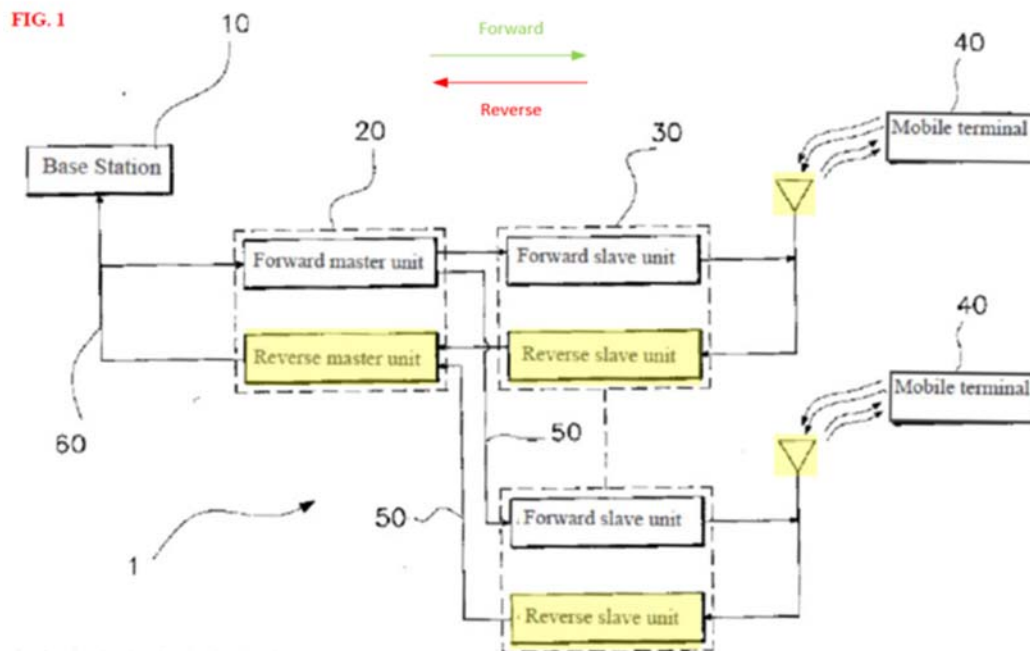
FIG. 4



584. Thus Oh renders obvious each of the plurality of second units (30) is configured to generate respective digital samples (at 380) indicative of at least a portion of the wireless spectrum of the respective analog wireless signal received at that second unit.

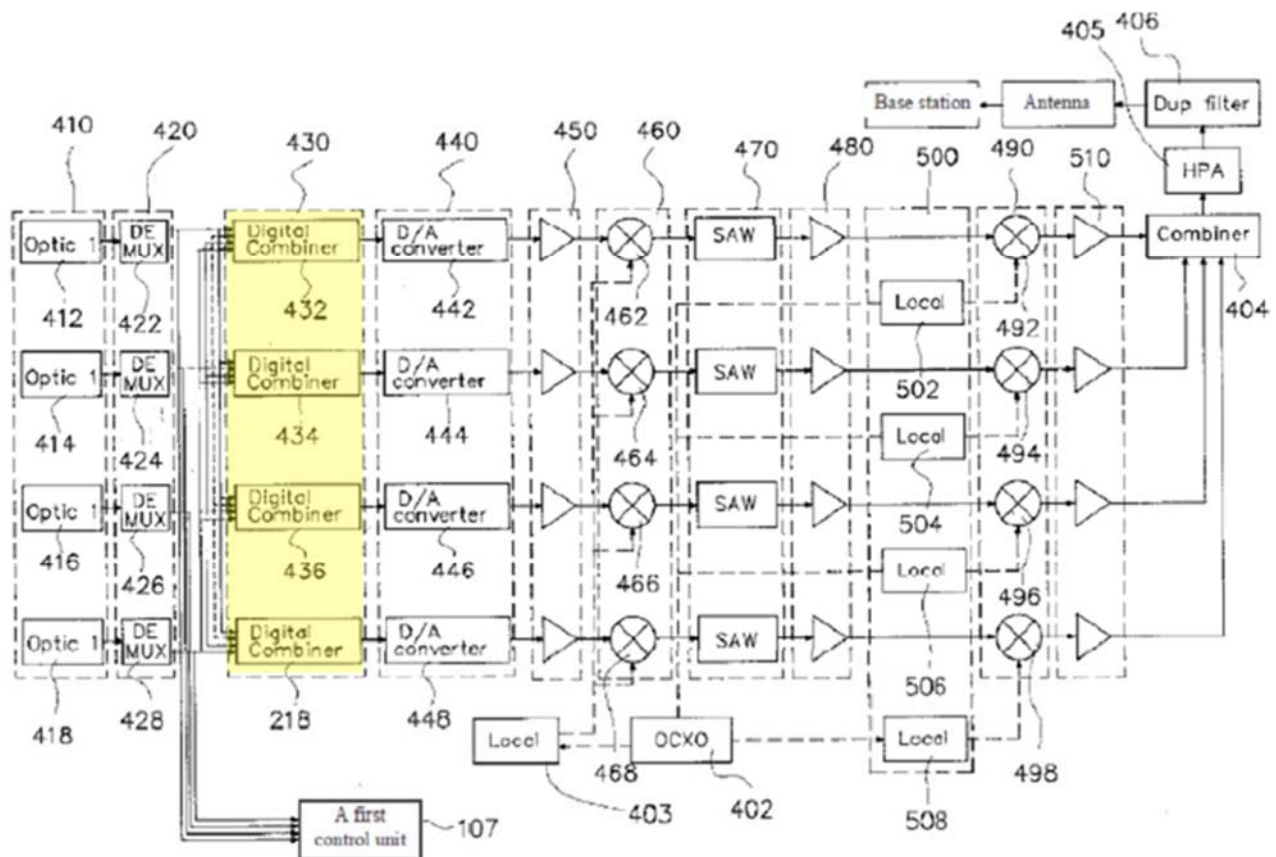
d) Element 5: “wherein each of the plurality of second units is configured to communicate the respective digital samples generated by that second unit to the first unit using the at least one wired communication link;”

585. Oh discloses that its reverse slave units 300 multiplex “all the digital signals transmitted from said second A/D converter unit 380 ... to serial data signals and outputs them to the reverse master unit 400 through a third optic converter unit 308 and the optic line 50.” Ex. 1007, 4:36-39.



586. Thus Oh renders obvious each of the plurality of second units (30) is configured to communicate the respective digital samples generated by that second unit to the first unit (20) using the at least one wired communication link (50).

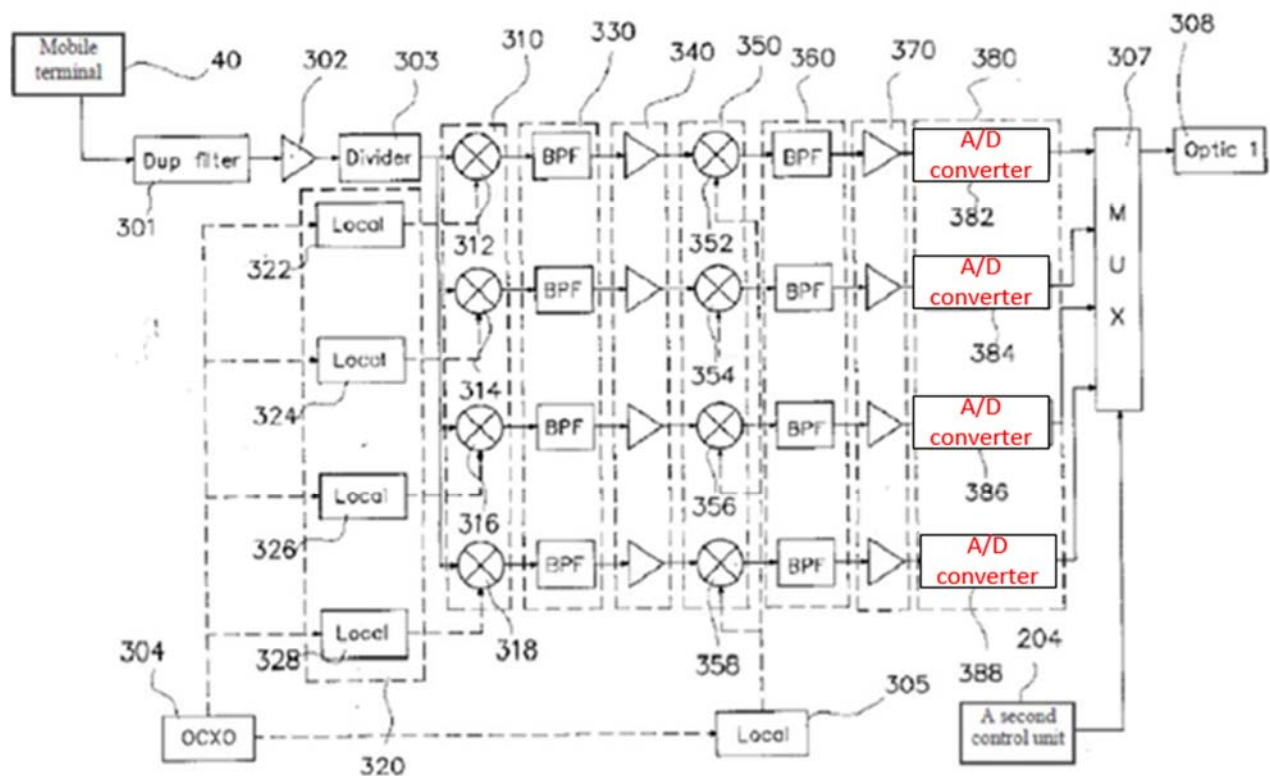
587. Oh's master unit 20 includes a digital combiner unit 430 that aggregates digital signals transmitted from each demultiplexer 422, 424, 426, 428 of demultiplexer unit 420. Ex. 1007, 4:68-70.



Those demultiplexers at 420 receive data from individual remote slave units 30 at 410.

588. As depicted in Fig. 4, each slave unit 30 receives an analog signal from mobile terminals 40, divides the received analog signal into its component frequency bands at 303 and downconverts the frequency band signals to near DC at 310-370. Ex. 1007, 4:26-34. The downconverted band signals are then sampled at 380 to create 12-bit digitized radio frequency signals. *Id.*, 4:56-61. The multiplexer 307 multiplexes the four 12-bit samples with 4 bits of control data from 204 to form 52-bit serial data signals that are forwarded to master unit 20. *Id.*

FIG. 4



589. Referring back to Fig. 5, each demultiplexer 422, 424, 426, 428 receives a 52-bit signal from its respective slave unit 30. Each demultiplexer forwards 12-bits

of sample data to the appropriate digital combiner associated with the proper frequency band for that 12-bit sample and forwards its 4 bits of control data to control unit 107. Upon receiving four 12-bit signals (one from each of demultiplexer 422, 424, 426, 428), each digital combiner 432, 434, 436, 438 combines those 12-bit signals to “creat[e a] 14-bit intermediate frequency signals by combining¹¹ four 12-bit intermediate frequency signals in the same frequency band” (e.g., (1010 1010 1010 (2,730) + 1100 1100 1100 (3,276) + 1111 1111 1111 (4,095) + 0000 1100 1100 (204) = 10 1000 0100 0001 (10,305)). Ex. 1007, 5:16-17. Those 14-bit signals are then converted to analog signals at 440, upconverted, combined, and transmitted to the base station 10. *Id.*, 5:17-29.

590. Thus Oh renders obvious the first unit (20) is configured to digitally sum (at 430) corresponding digital samples derived from the digital samples received from the plurality of second units (30) to produce summed digital samples.

f) Element 7: “wherein the system is configured so that an input used for base station processing is derived from the resulting summed digital samples.”

591. The term “base station processing” is not used in the ’402 patent specification. But the Patent Owner has made clear its view that “base station

¹¹ I understand that the parties have discussed whether this word should be translated as “adding” or “combining.” Regardless of which of these terms is used, the digital combiners are operating to produce a digital sum (*i.e.*, they are performing a digital summing operation).

processing” encompasses first (*i.e.*, host) unit functionality. In its complaint, Patent Owner maps Distribution and Aggregation Unit (DAU) to the “first unit” of claim 1, element 1. Ex. 1024, ¶54. Patent Owner then alleges that the same DAU alleged to be the “first unit” performs the “base station processing” of element 7. Specifically, Patent Owner states “DAU is configured to derive an input used for base station processing from the resulting summed digital samples. As seen, for example, in Figure 2.1 in paragraph 40 above, the upstream signal of the DAU is used as an input to a base station for base station processing.” Ex. 1024, ¶61. Thus Patent Owner has argued that “base station processing” means processing signals in preparation/transmission of those processed signals to a base station, including at the first/host unit.

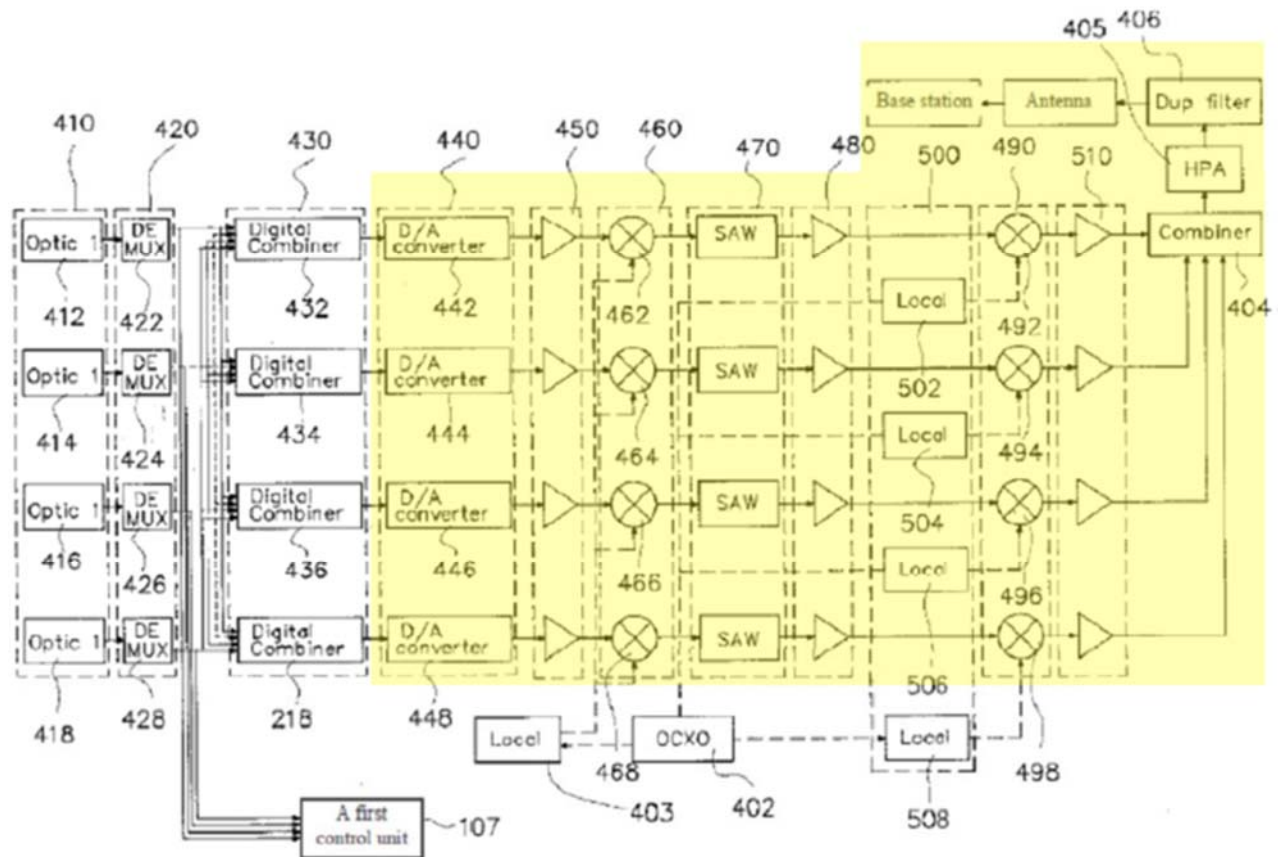
592. Claim 6 further corroborates that “base station processing” can encompass first/host unit functionality. Claim 6 states that “the base station processing functionality is at least one of: co-located with the first unit and remote from the first unit.” Because claim 6 must necessarily be at least as broad, if not broader, than claim 3 (35 U.S.C. § 112, ¶4), “base station processing” in claim 1 also encompasses base station processing “co-located with the first unit.”

593. Further, the ’402 patent specification lacks description of performing processing of signals post-digital summing at a base station other than mere transmission of an analog signal to the base station. Ex. 1003, 5:59-64.

594. Because the '402 patent does not describe signal processing that is performed at a base station, because claim 6 necessarily means that “base station processing” can encompass first/host unit functionality, and because Patent Owner has accused what it alleges to be a first/host unit of performing base station functionality in litigation, “base station processing” should be understood for purposes of this proceeding to include processing signals in preparation/transmission of those processed signals to a base station including at a first/host unit.

595. Oh renders that limitation obvious. Following the digital summing operation referenced above in addressing element 6, the summed digital data values in Oh are converted to analog signals, up converted to the appropriate frequency signals associated with their particular bands to create component analog signals, that are then combined and transmitted to a base station via an antenna.

FIG. 5



Specifically Oh states:

After creating 14-bit intermediate frequency signals by combining four 12-bit intermediate frequency signals in the same frequency band, said digital combiner transmits them to a first D/A converter unit 440. Each D/A converter 442, 444, 446, and 448 of said first D/A converter unit 440 converts 14-bit digital signals to the intermediate [frequency] signals, analog signals; and transmits 1.23MHz or 1.5MHz intermediate frequency signals to each mixer 462, 464, 466, and 468 of a third mixer unit 460 through a third amplification unit 450. Said third mixer unit 460 outputs 70MHz intermediate frequency signals by mixing 1.23MHz or 1.5MHz intermediate frequency signals

transmitted from a first D/A converter unit 440 with 68.77MHz or 68.5MHz oscillating frequency transmitted from a third local unit 403. The intermediate frequency signals outputted from said third mixer unit 460 are transmitted to a fourth mixer unit 490 through a first saw filter unit 470 and a fourth amplification unit 480. Said fourth mixer unit 490 mixes the oscillating frequency in different frequency bands transmitted from a fourth local unit 500 with 70MHz intermediate frequency signals; and transmits 800MHz RF signals in different frequency bands to a first combiner 404 through a fifth amplification unit 510.

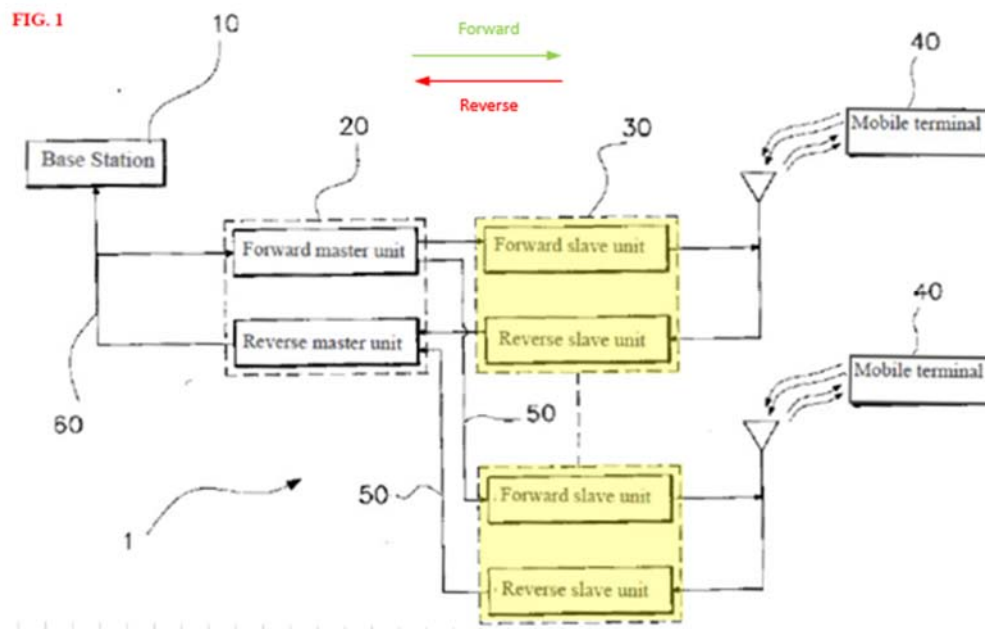
Ex. 1007, 5:16-26. The analog signals are combined at 404 to “aggregate[] the RF signals in different frequency bands transmitted from four mixers 492, 494, 496, and 498,” and are amplified at 510 and run through a bi-directional filter 406 to an antenna and a base station.

596. Thus Oh renders obvious the system is configured so that an input used for base station processing is derived from the resulting summed digital samples (the output of 430 is used as an input to circuitry at 440, 450, 460, 470, 480, 490, 520, 404, 405, 406 in preparation for transmission to the base station).

2. Dependent Claim 2

597. Claim 2 recites “at least some of the plurality of second units are communicatively coupled to the first unit at least in part using a separate wired communication link.” Fig. 1 of Oh discloses that each slave unit 30 is connected to

master unit 20 via a distinct set of optic lines 50. (This is in contrast to when an intermediate expansion unit is used, where remote units downstream of an expansion unit share a link from the expansion unit to the host unit.)



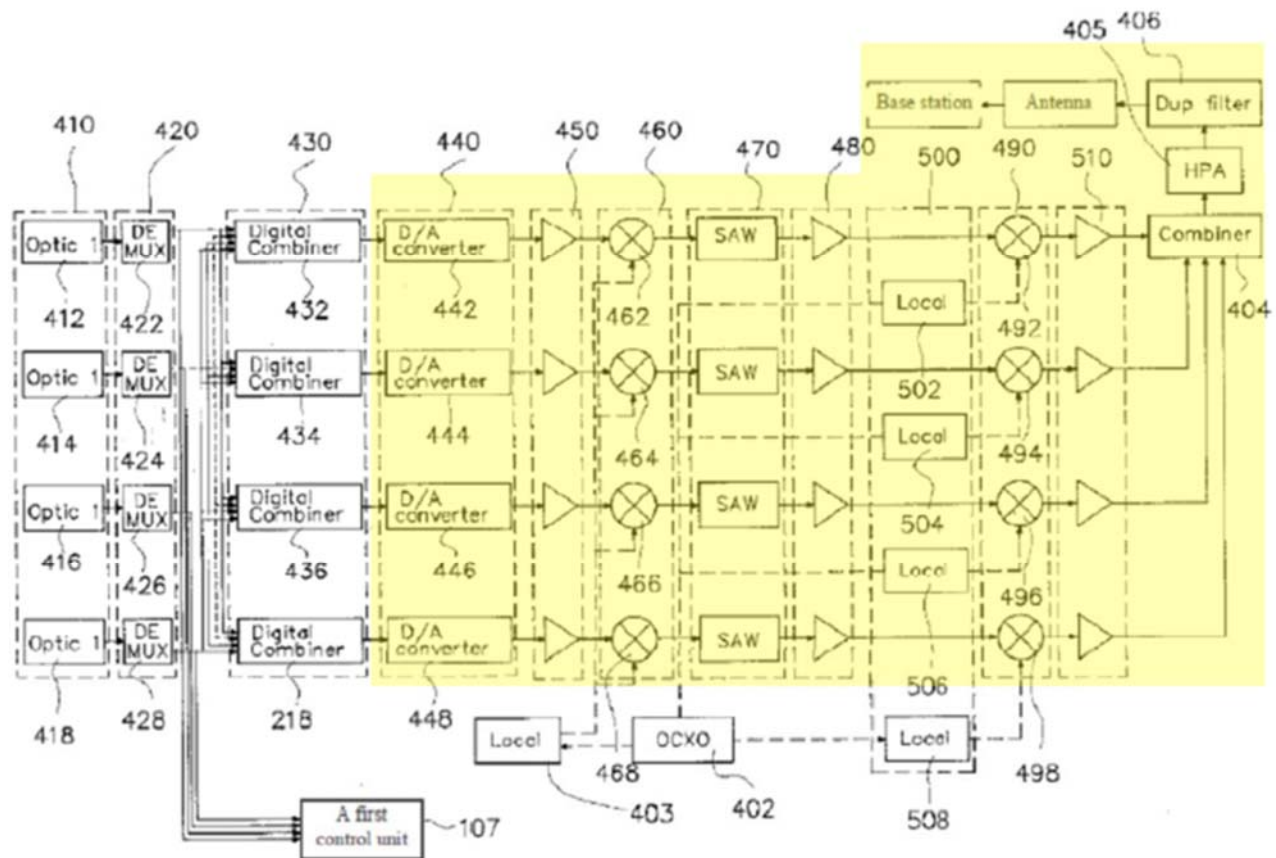
598. Thus Oh renders obvious at least some of the plurality of second units (30) are communicatively coupled to the first unit (20) at least in part using a separate wired communication link (50).

3. Dependent Claim 5

599. Claim 5 recites “the system includes base station signal processing functionality configured to perform base station processing.” As discussed above with reference to claim 1, element 7, the digitally summed values from 430 are processed through the remainder of Fig. 5 of Oh in preparation for transmission to the base station, such as via the antenna depicted in Fig. 5. That processing in preparation

for transmission to the base station includes D/A conversion at 440, amplification at 450, an initial upconversion at 460 followed by filtering at 470 and amplification at 480. Further upconversion of the frequency bands occurs at 490, followed by amplification at 510 and combining at 404 to form the replicated analog signal for transmission to the base station. That combined signal is amplified at 405 and transits a duplex filter 406 before transmission. Ex. 1007, 5:16-26.

FIG. 5

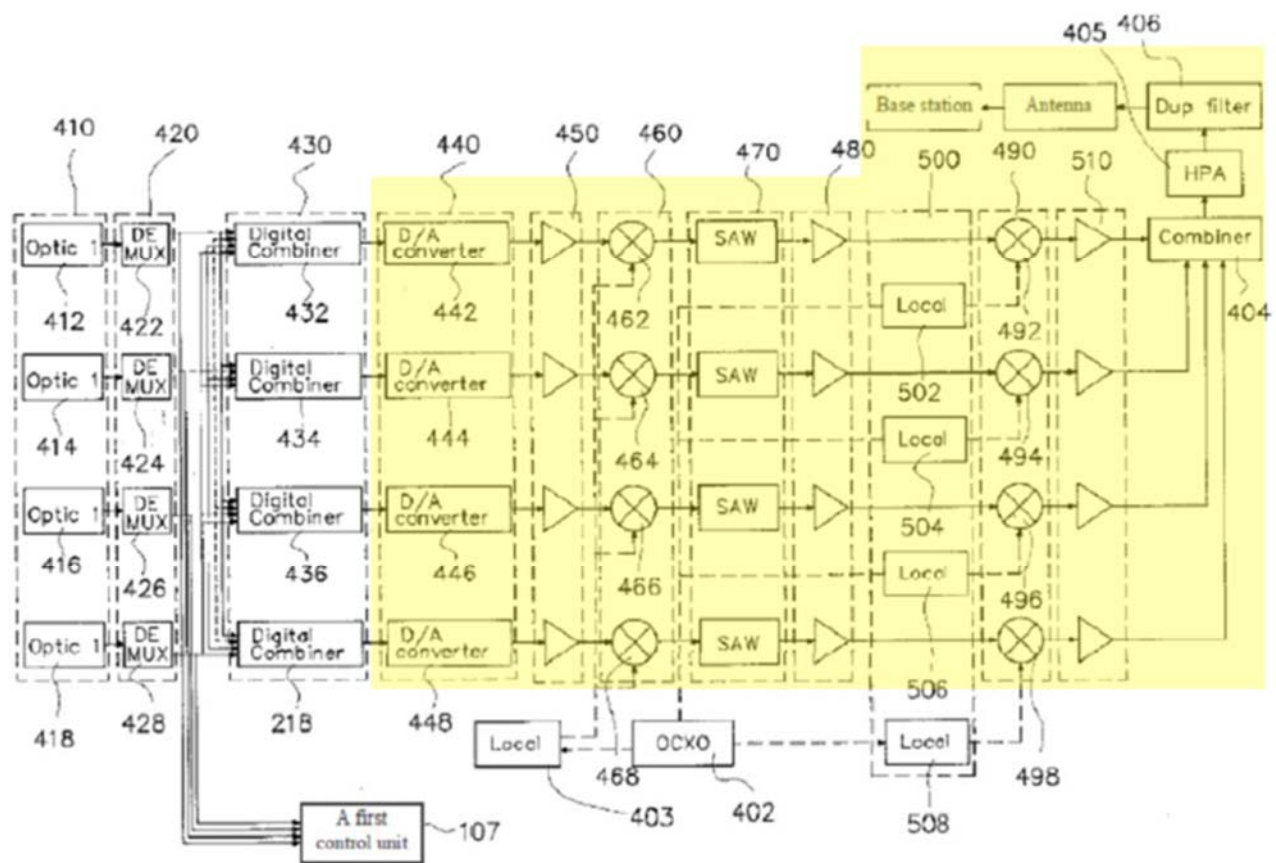


600. Thus Oh renders obvious the system including base station signal processing functionality (440, 450, 460, 470, 480, 490, 520, 404, 405, 406) configured to perform base station processing.

4. Dependent Claim 6

601. Claim 6 recites “the base station processing functionality is at least one of: co-located with the first unit and remote from the first unit.” As depicted in Fig. 5 of Oh, the base station processing (440, 450, 460, 470, 480, 490, 520, 404, 405, 406) occurs in master unit 20’s reverse master unit 400. Ex. 1007, 4:65.

FIG. 5

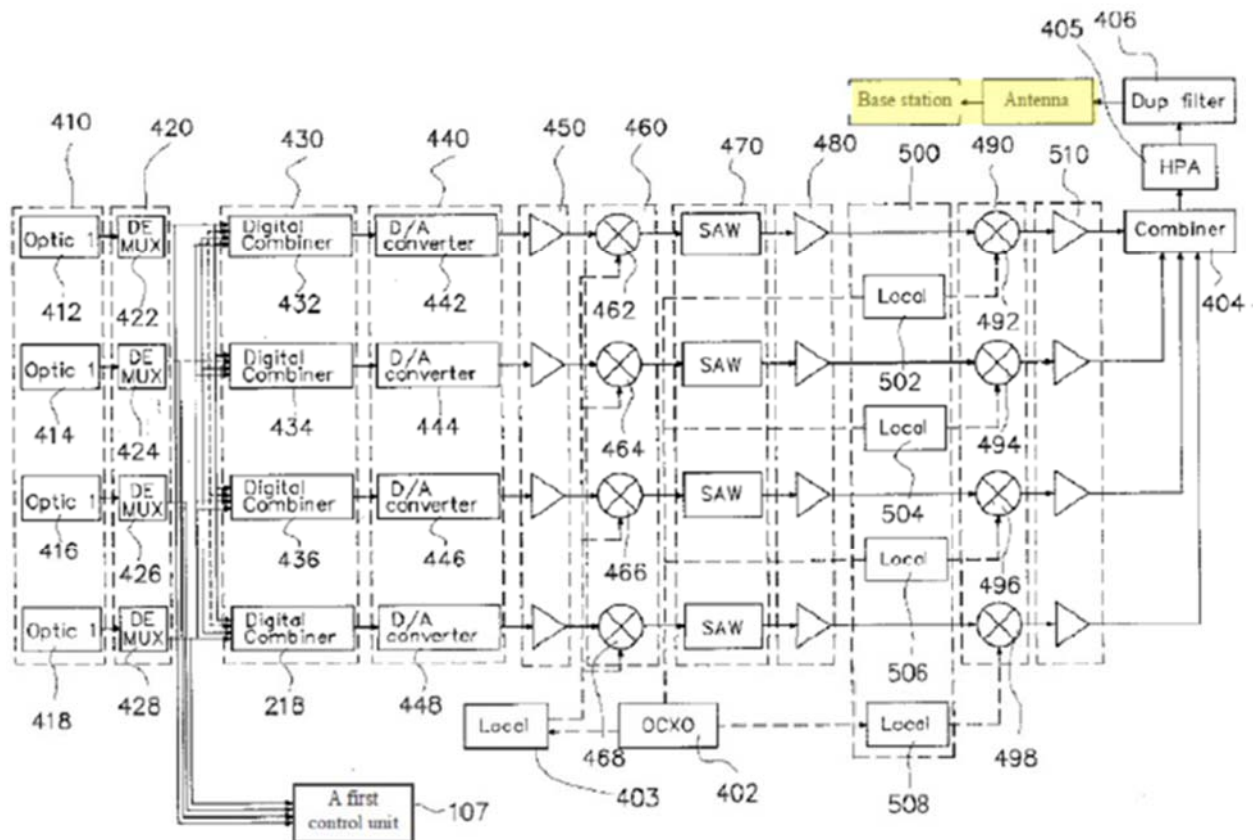


602. Thus in Oh the base station processing functionality (440, 450, 460, 470, 480, 490, 520, 404, 405, 406) is at least one of: co-located with the first unit (master unit 20 at reverse master unit 400) and remote from the first unit.

5. Dependent Claim 7

603. Claim 7 recites “the system comprises at least a portion of a base station for performing the base station processing.” As noted above with reference to claim 1, a POSITA would understand “base station processing” to mean processing signals in preparation/transmission of those processed signals to a base station. Oh discloses a system that culminates with transmission of analog RF signals to a base station, as highlighted below. Oh states that its “base station” “constitutes the mobile telecommunication network” and is thus involved in transmission of processed signals. Ex. 1007, 2:4-5.

FIG. 5

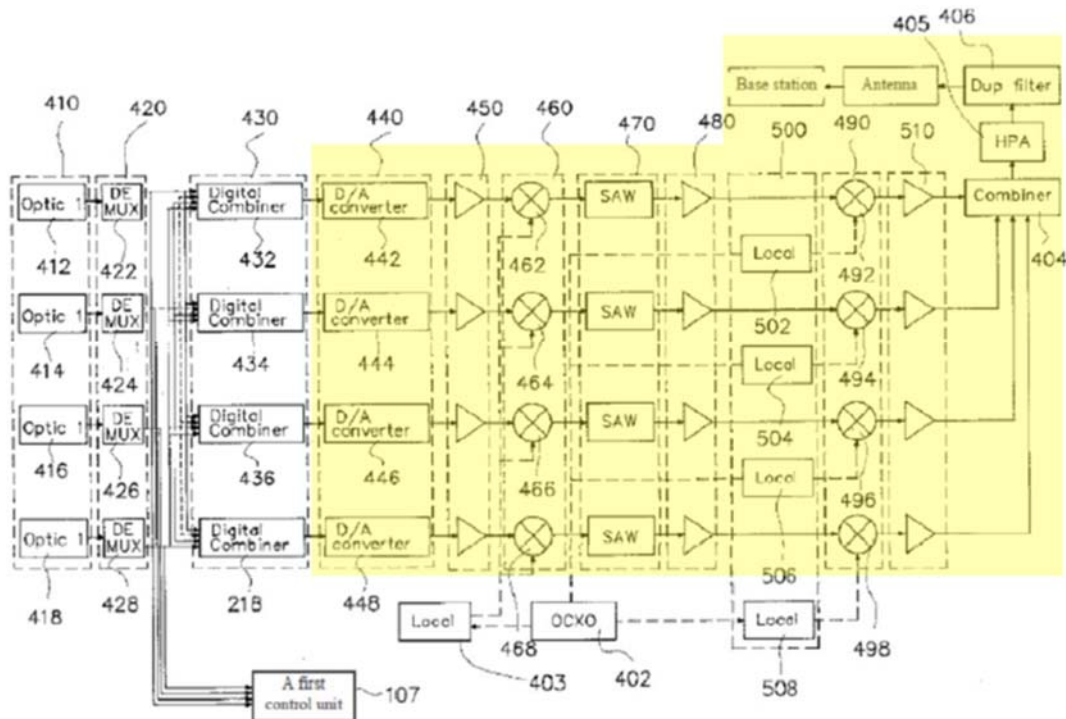


604. Thus Oh renders obvious the system comprises at least a portion of a base station (highlighted Fig. 5 Base station, “which constitutes the mobile telecommunications network”) for performing the base station processing (processing signals in preparation/transmission of those processed signals to a base station).

6. Dependent Claim 10

605. Claim 10 recites “the system is configured to convert the summed digital samples to a replicated analog wireless signal.” Oh discloses that the output of digital combiner unit 430 (*i.e.*, the summed digital RF samples), are converted to analog signals at 440, upconverted to RF frequency signals at 450, 460, 470, 480, 490, 510, and combined at 404 to form an analog signal that is transmitted to the base station. Ex. 1007, 5:16-26.

FIG. 5

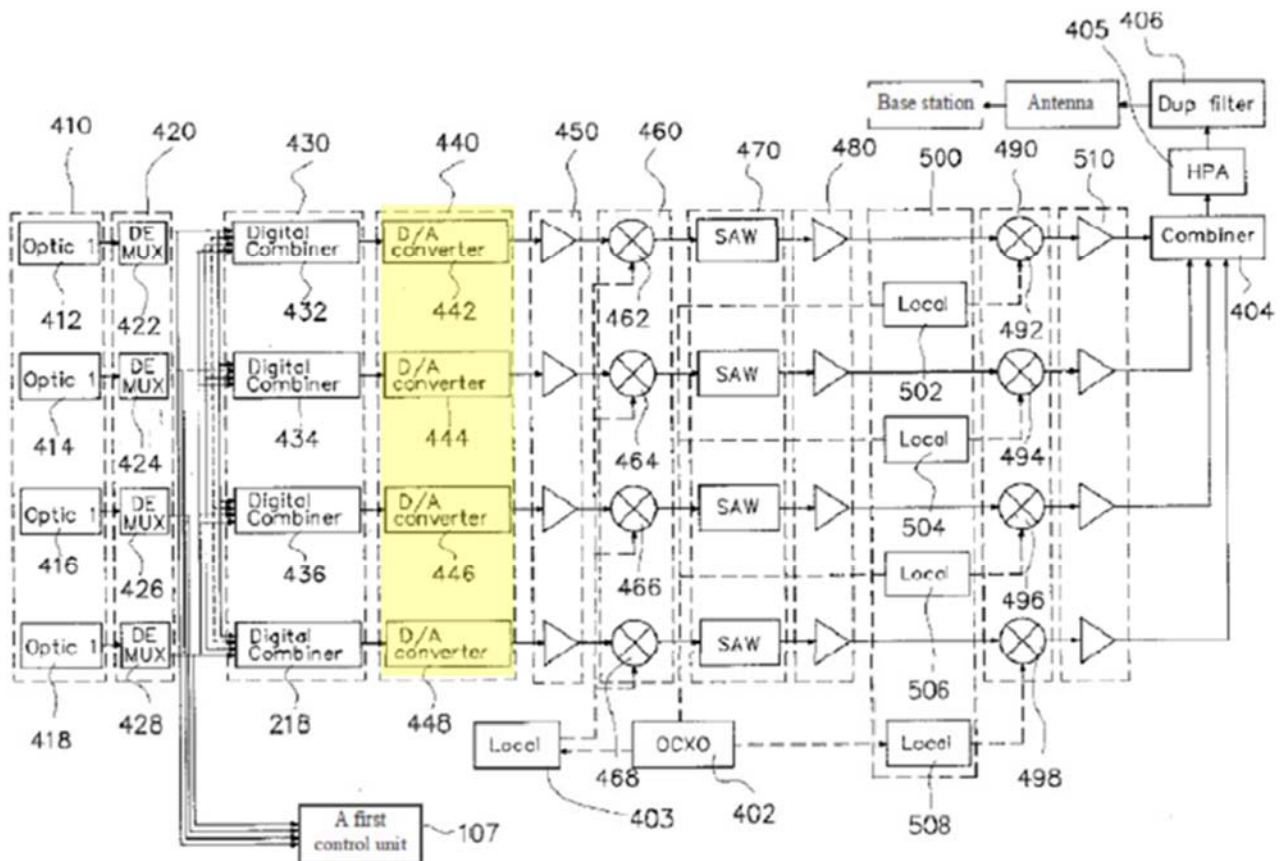


606. Thus Oh renders obvious the system is configured to convert the summed digital samples (output of 430) to a replicated analog wireless signal (via 450, 460, 470, 480, 490, 510, 404).

7. Dependent Claim 11

607. Claim 11 recites “the system comprises a digital-to-analog converter to convert the summed digital samples to the replicated analog wireless signal.” As noted above, Oh discloses D/A converter unit 440 that receives the summed digital RF samples from 430 and converts them to analog signals, prior to those analog signals being up converted to form the replicated analog wireless frequency signal.

FIG. 5

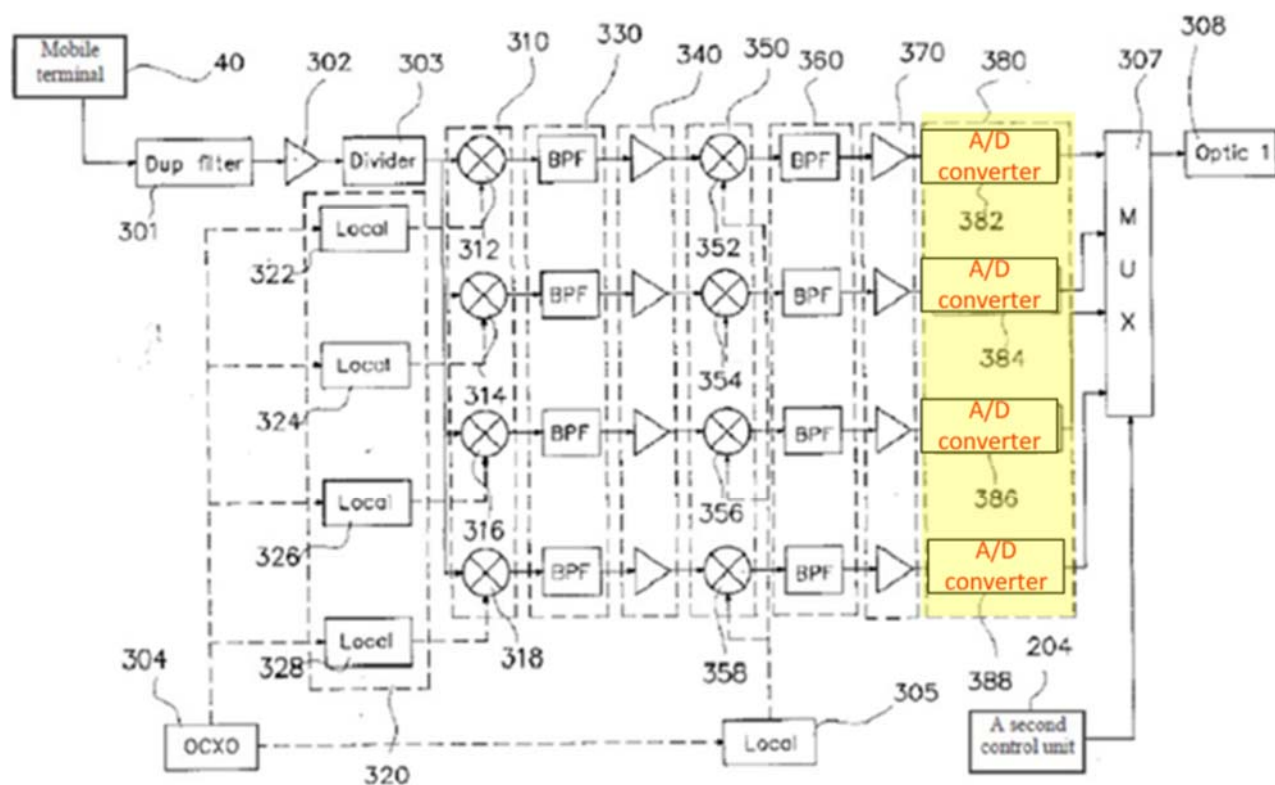


608. Thus Oh renders obvious the system comprises a digital-to-analog converter unit (440) to convert the summed digital samples (from 430) to the replicated analog wireless signal.

8. Dependent Claim 12

609. Claim 12 recites “each of the plurality of second units comprises: a respective analog-to-digital converter to digitize the respective analog wireless signal received at that second unit in order to produce the respective digital samples.” Oh discloses that each reverse slave unit 300 “converts the RF signals, analog signals, transmitted from the mobile terminals 40 through a third bi-directional filter 301, to the digital signals.” Ex. 1007, 4:23-25. That digitization is illustrated at Fig. 4 where “A/D converter unit 380 converts the intermediate frequency signals, analog signals, to the digital signals.” *Id.*, 4:56-67.

FIG. 4



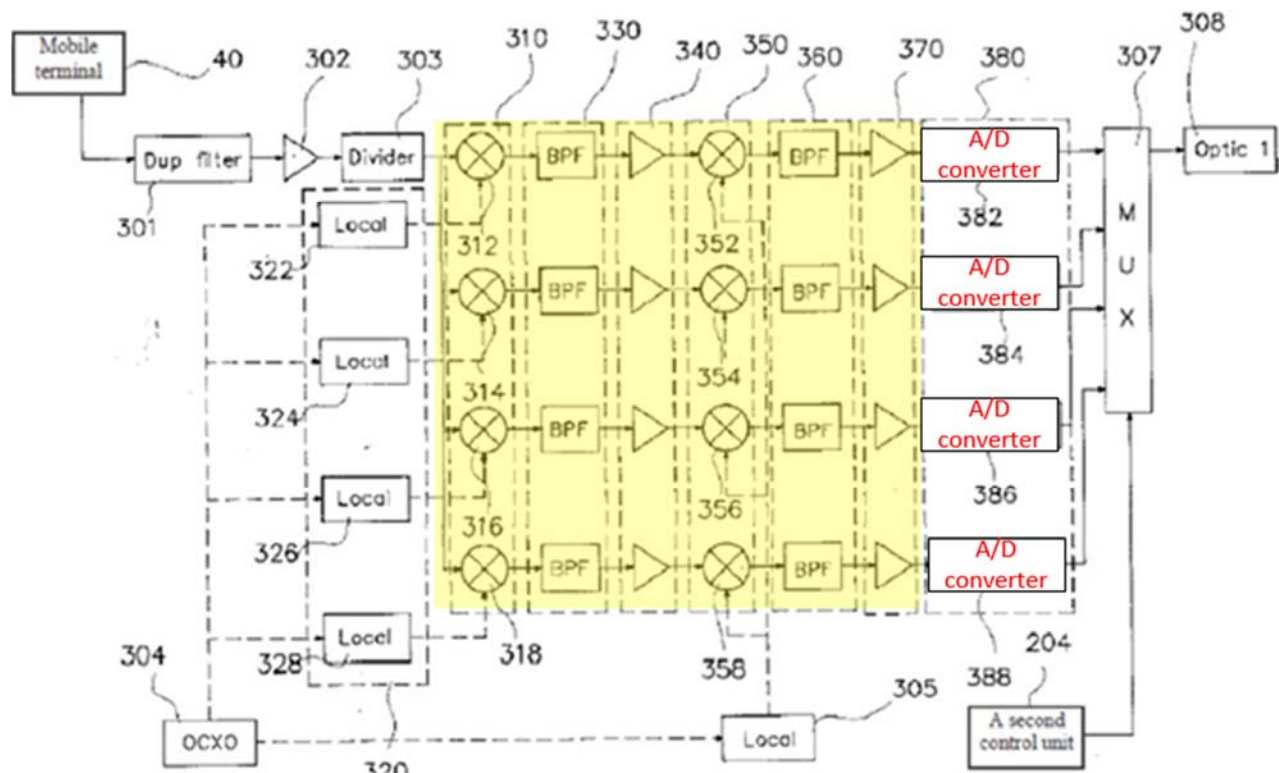
610. Thus Oh renders obvious each of the plurality of second units (30) comprises: a respective analog-to-digital converter (380) to digitize the respective analog wireless signal received at that second unit in order to produce the respective digital samples.

9. Dependent Claim 13

611. Claim 13 recites “each of the plurality of second units generates the respective digital samples indicative of the respective analog wireless signal received at that second unit by frequency shifting the respective analog wireless signal received at that second unit and digitizing the frequency-shifted analog wireless signal.” Oh discloses that each remote slave unit 30 includes circuitry for downconverting RF

signals received from mobile terminals 40 to near DC prior to performing A/D conversion at 380. Specifically, a first stage of downconverting at 310 transitions signals from their near 800MHz bands to ~70MHz, followed by a second frequency shift from ~70MHz to near DC. Ex. 1007, 4:43-55.

FIG. 4

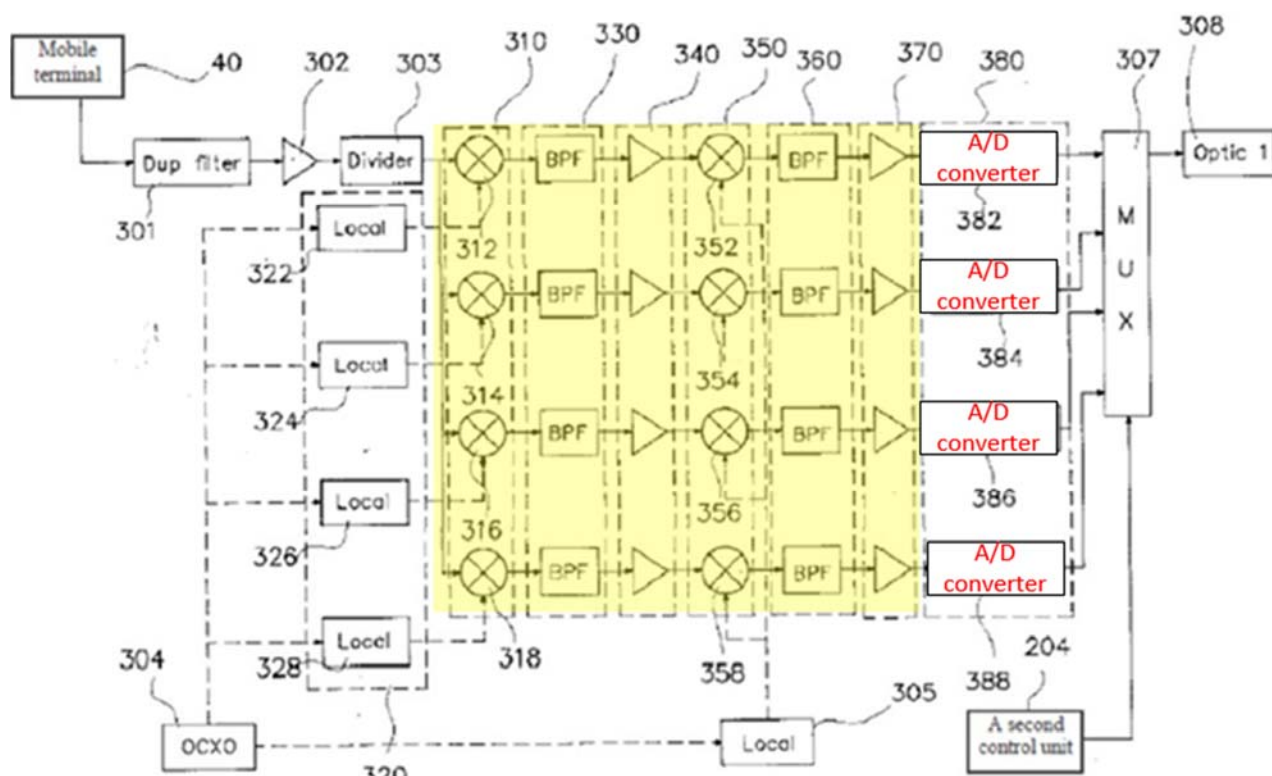


612. Thus Oh renders obvious each of the plurality of second units (30) generates the respective digital samples (at 380) indicative of the respective analog wireless signal received at that second unit (from 40) by frequency shifting (down converting at 310, 350) the respective analog wireless signal received at that second unit and digitizing (at 380) the frequency-shifted analog wireless signal.

10. Dependent Claim 14

613. Claim 14 recites “each of the plurality of second units is configured to generate the respective digital samples indicative of the respective analog wireless signal received at that second unit by down converting the respective analog wireless signal received at that second unit and digitizing the down-converted analog wireless signal.” As discussed above with reference to claim 13, each Oh remote slave unit downconverts received analog signals from $\sim 800\text{MHz} \rightarrow \sim 70\text{MHz} \rightarrow \sim \text{DC}$ at 310, 350 prior to A/D conversion at 380.

FIG. 4



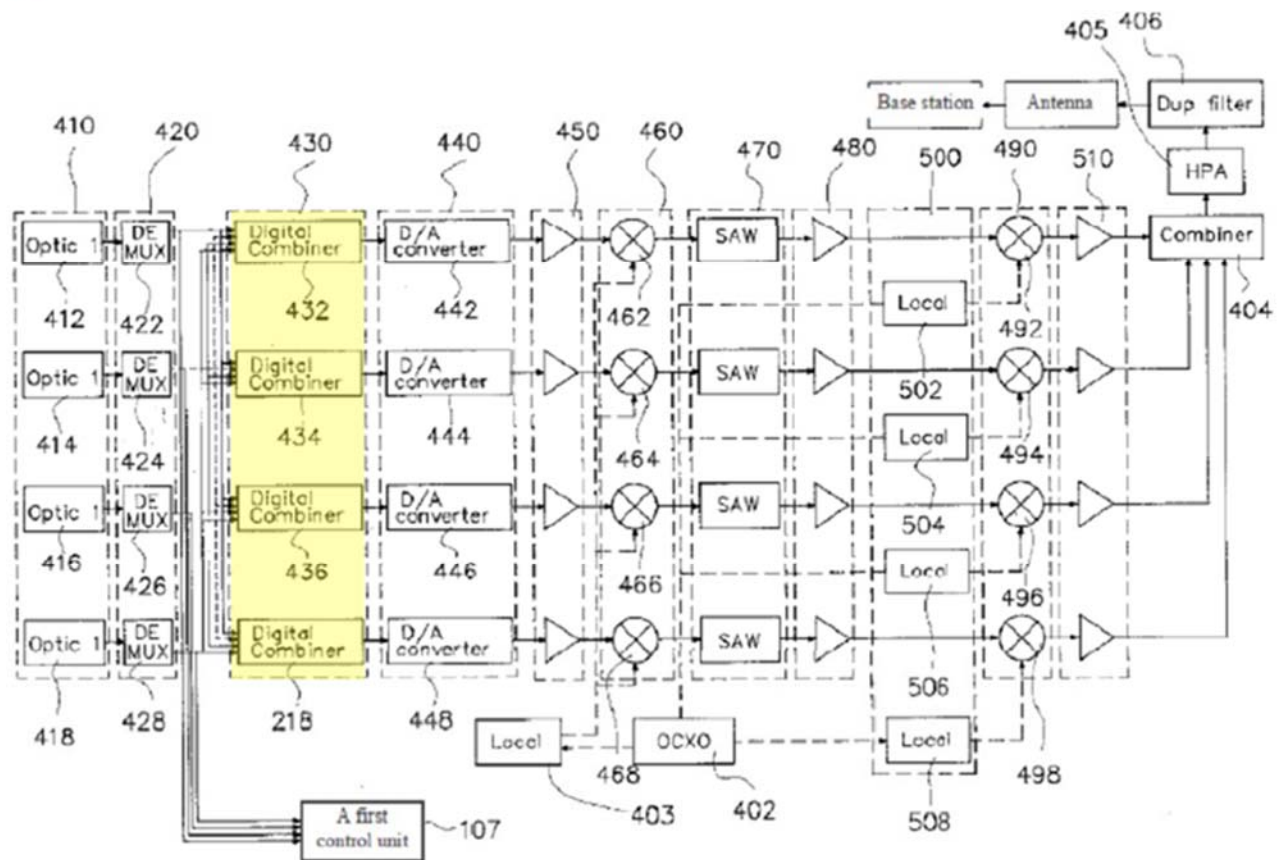
614. Thus Oh renders obvious each of the plurality of second units (30) is configured to generate the respective digital samples indicative of the respective

analog wireless signal received at that second unit by down converting (at 310, 350) the respective analog wireless signal received at that second unit and digitizing (at 380) the down-converted analog wireless signal.

11. Dependent Claim 15

615. Claim 15 recites “the first unit is configured to digitally sum the corresponding digital samples derived from the digital samples received from the plurality of second units as a part of generating the summed digital samples at a resolution greater than a resolution of the digital samples being summed.” Oh discloses that its A/D converters 380 sample the downconverted analog signals at each frequency band at 12-bits of resolution. Ex. 1007, 3:38-39; 3:61-64; 4:16. On the reverse path at the master unit 20, digital combiners 432, 434, 436, 438 “creat[e] 14-bit intermediate frequency signals by combining four 12-bit intermediate frequency signals in the same frequency band.” *Id.*, 5:16-17.

FIG. 5



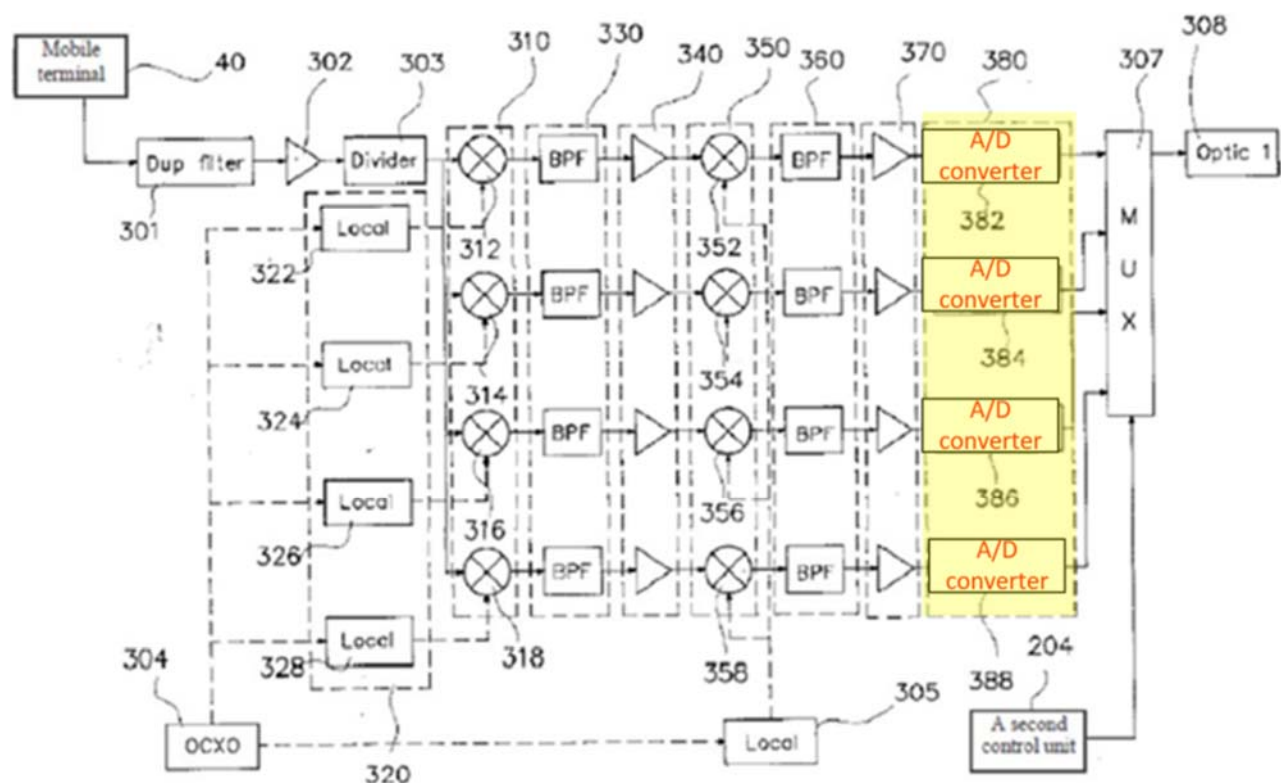
616. Thus Oh renders obvious the first unit (20) is configured to digitally sum (at 430) the corresponding digital samples derived from the digital samples received from the plurality of second units (30) as a part of generating the summed digital samples at a resolution (14 bits) greater than a resolution of the digital samples being summed (12 bits).

12. Dependent Claim 16

617. Claim 16 recites “the wireless spectrum comprises a cellular radio frequency spectrum and any modulated transmissions from the wireless units carried by the cellular radio frequency spectrum of the wireless spectrum, and wherein the

digital samples generated by and received from each of the second units comprise digital radio frequency samples in that the digital samples are indicative of the modulation of the transmissions carried by the cellular radio frequency spectrum of the wireless spectrum.” Oh discloses receiving and operations on base station/mobile terminal signals at 800MHz and 1800MHz Ex. 1007, 3:19, 4:40. Those 800MHz and 1800MHz examples are both within the cellular radio frequency spectrum. Oh’s remote slave units 30 “converts the RF signals, analog signals, transmitted from the mobile terminals 40 through a third bi-directional filter 301, to the digital signals; and transmits them to the master unit 20.” Ex. 1007, 4:24-25.

FIG. 4

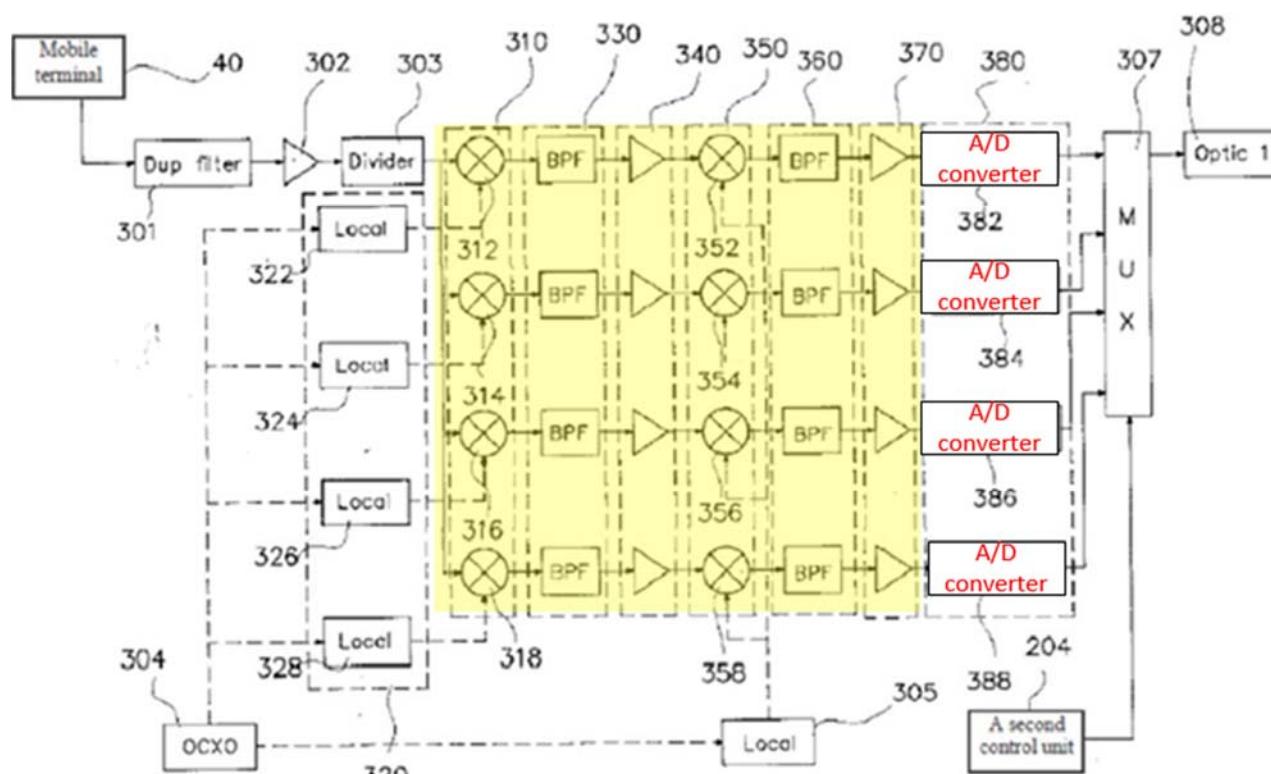


618. Thus Oh renders obvious the wireless spectrum comprises a cellular radio frequency spectrum (800MHz, 1800MHz) and any modulated transmissions from the wireless units (40) carried by the cellular radio frequency spectrum of the wireless spectrum, and wherein the digital samples generated by (380) and received from each of the second units (at Fig. 5, 410) comprise digital radio frequency samples in that the digital samples are indicative of the modulation of the transmissions carried by the cellular radio frequency spectrum of the wireless spectrum.

13. Dependent Claims 17 and 18

619. Claim 17 recites “each of the second units is configured to perform a down-conversion in connection with generating the digital radio frequency samples,” and claim 18 recites “each of the second units is configured to perform a down-conversion of an analog signal in connection with generating the digital radio frequency samples.” As noted above with respect to claim 14, each Oh remote slave unit downconverts received analog signals from ~800Mhz→~70MHz→~DC at 310, 350 prior to A/D conversion at 380.

FIG. 4

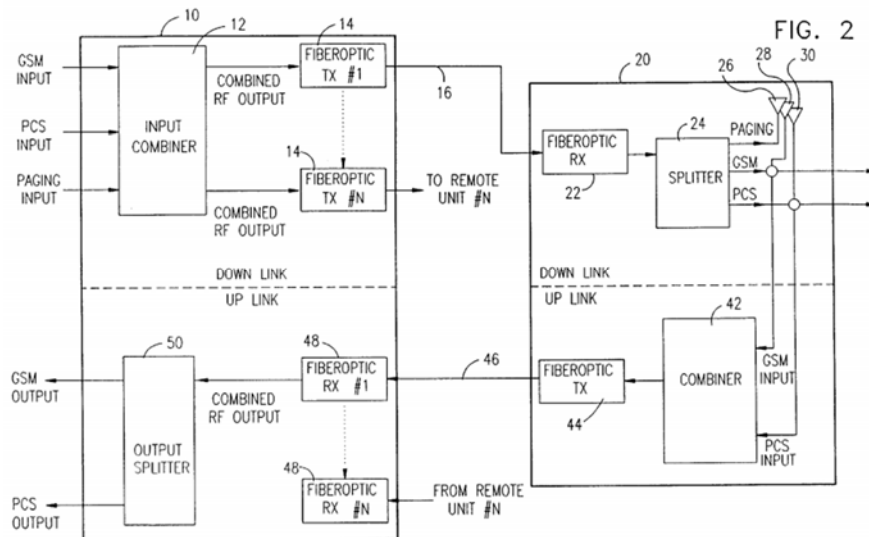


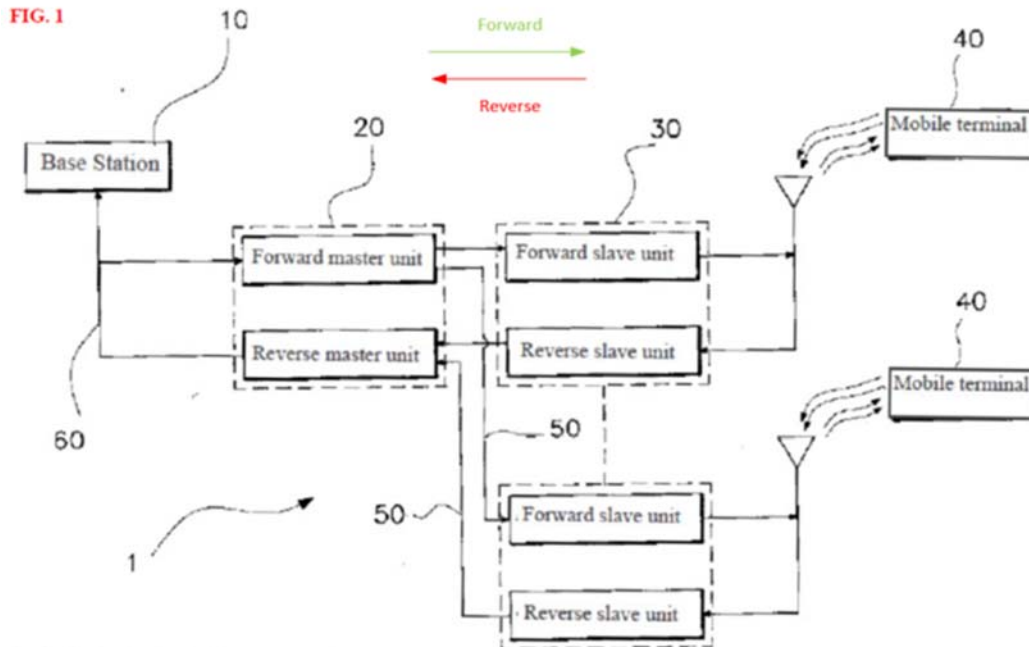
Thus Oh renders dependent claims 17 and 18 obvious.

14. Dependent Claim 19

620. Claim 19 recites “the at least one wired communication link comprises at least one of: a single mode optical fiber, a multi-mode optical fiber, a coaxial cable, and a category cable.” Oh discloses that the master unit 20 communicates digital data to slave units 30 via optic lines 50. Ex. 1007, 3:4-6. Oh is agnostic as to whether multimode or single mode fiber is used. A POSITA would consider selection of multimode or single mode to be a matter of design choice. This is evidenced by Farber which describes the use of single or multimode fiber in an antenna system for reaching difficult coverage areas (see Fig. 1) that is very similar to the digital system of Oh.

Ex. 1022 (“Farber”), 4:30-33 (“Preferably the transmitter 14 employs a vertical cavity surface emitting laser or an edge emitting laser coupled to a single or multi-mode fiber 16.”); Fig. 2. As further evidence of obviousness of using single or multimode fiber, Haas illustrates the cost-benefit analysis of selection of multimode or single mode fiber for an application. Ex. 1012, 1125. A POSITA would have been motivated to select multimode fiber as disclosed by Haas for communicating among a host and remote units when cost is a significant factor for the project. Additionally as disclosed by Haas, in some instances multimode fiber may already be installed in an area into which an RF distribution network is being implemented, making reuse of that multimode fiber an attractive option.





621. Thus a POSITA would have considered it obvious to select one of the two possible choices to implement optic lines 50, where the claim encompasses both possible choices.

15. Independent Claim 20

a) Preamble: "A first unit used in digital transport of a wireless spectrum,"

622. To the extent the preamble is limiting, Oh renders the preamble obvious for the reasons provided above for the preamble of claim 1, where Oh describes a first unit (20) used in digital transport of a wireless spectrum (*e.g.*, 800 MHz, 1800MHz).

b) Element 1a: “at least one interface to communicatively couple the first unit to a plurality of second units using at least one wired communication link,”

623. Oh discloses master unit 20 is coupled to multiple remote slave units 30 via optic lines 50.

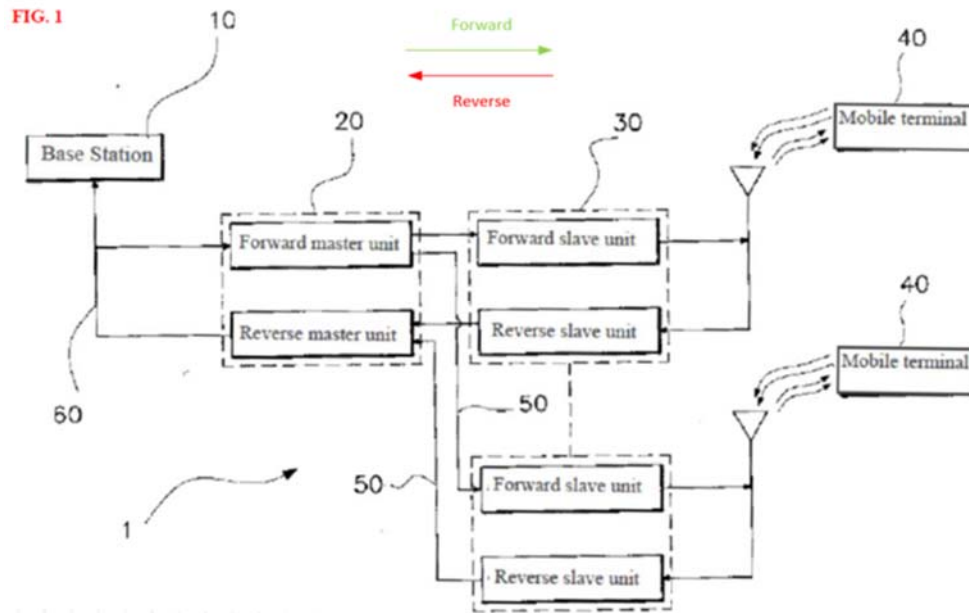
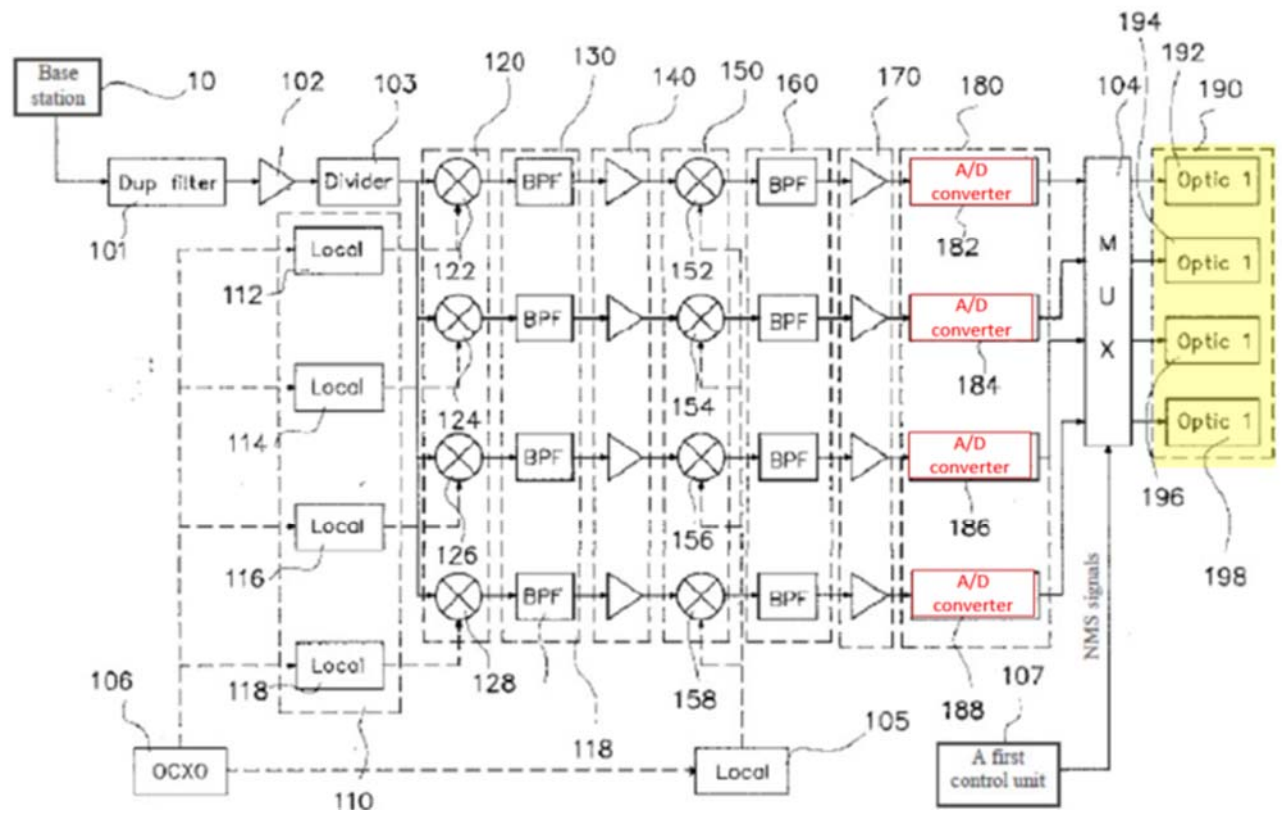


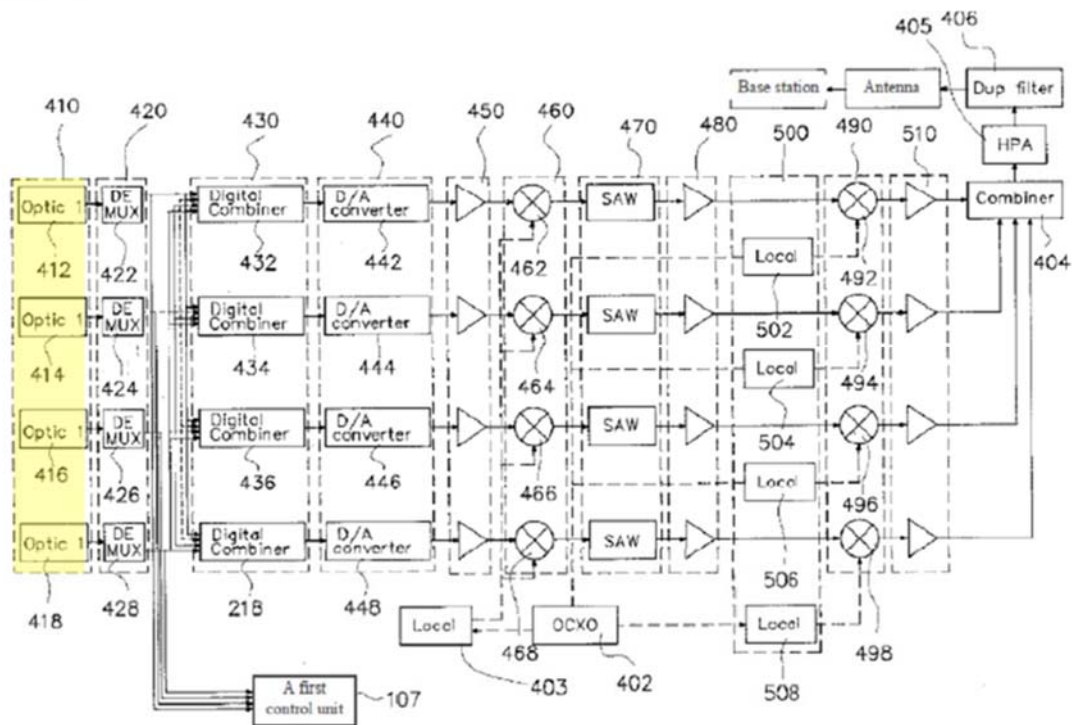
Fig. 2 of Oh depicts optic converter unit 190 that provides a downstream interface between master unit 20 and remote slave units 30.

FIG. 2



And Fig. 5 illustrates optic converter unit 410 that provides an upstream interface from slave units 30 to master unit 20.

FIG. 5



624. Thus Oh renders obvious at least one interface (190, 410) to communicatively couple the first unit (20) to a plurality of second units (30) using at least one wired communication link (50).

c) Element 1b: “wherein each of the plurality of second units is remotely located from the first unit and each of the plurality of second units receives a respective analog wireless signal comprising the wireless spectrum and any transmissions from any wireless units that are within a coverage area associated with that second unit”

625. Oh renders element 1b obvious for the reasons provided above with respect to elements 2 and 3 of claim 1.

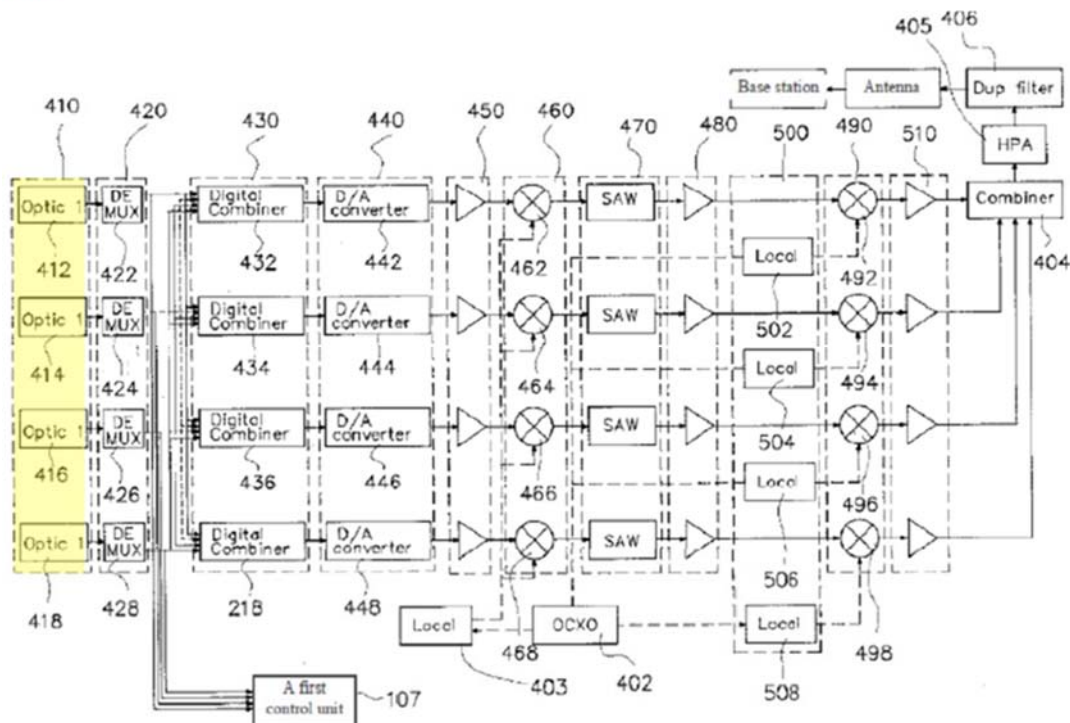
d) Element 1c: “wherein each of the plurality of second units is configured to generate respective digital samples indicative of at least a portion of the wireless spectrum of the respective analog wireless signal received at that second unit,”

626. Oh renders element 1c obvious for the reasons provided above with respect to element 4 of claim 1.

e) Element 1d: “wherein the interface is used to receive the digital samples from the plurality of second units;”

627. Oh Fig. 5 illustrates optic converter unit 410 that provides an upstream interface from slave units 30 to master unit 20 that receives “the serial data signals transmitted from each slave unit 30.” Ex. 1007, 4:65-66.

FIG. 5



Thus Oh renders obvious the interface (410) is used to receive the digital samples

from the plurality of second units (30).

f) Element 2: “a digital summer to digitally sum corresponding digital samples derived from the digital samples received from the plurality of second units to produce summed digital samples;”

628. Oh renders element 2 obvious for the reasons provided above for claim 1, element 6, where digital combiner unit 430 sums digital samples received from the remote slave units 30 to produce summed digital samples.

g) Element 3: “wherein the first unit is configured so that an input used for base station processing is derived from the resulting summed digital samples.”

629. Oh renders element 3 obvious for the reasons provided above for claim 1, element 7.

16. Dependent Claim 21

630. Dependent claim 21 is rendered obvious by Oh for the reasons provided above for claim 2, where at least some of the plurality of second units (30) are communicatively coupled to the first unit (20) at least in part using a separate wired communication link (50), wherein the first unit comprises a separate interface (Fig. 2, 192, 194, 196, 198 in the forward direction; Fig. 5, 412, 414, 416, 418 in the reverse direction) configured to communicatively couple the first unit to each of said at least some of the plurality of second units using the respective separate wired communication link.

17. Dependent Claims 24-25 and 27-30

631. Dependent claims 24-25 and 27-30 are rendered obvious by Oh for the reasons provided above for claims 36, 7, 10, 11, 15, and 16, respectively.

18. Independent Claim 31

a) Preamble: “A method for digital transport of a wireless spectrum used with a first unit and a plurality of second units, each of the plurality of second units being remotely located from the first unit, the method comprising:”

632. To the extent the preamble is limiting, it is rendered obvious by Oh for the reasons provided above for the preamble and elements 1-2 of claim 1, which included discussion of Oh’s disclosed technique for digitally transporting radio frequency signals (e.g., 800 MHz, 1800 MHz) from the base station and through the master unit 20 and slave units 30. Thus the Oh system provides digital transport (over optic lines 50) of a wireless spectrum (RF signals received from the base station) used with a first unit (20) and a plurality of second units (30), each of the plurality of second units being remotely located from the first unit.

b) Element 1: “at each of the plurality of second units: receiving a respective analog wireless signal comprising the wireless spectrum and any transmissions from any of the wireless units that are within a coverage area associated with that second unit;”

633. Element 1 is rendered obvious by Oh for the reasons provided above for claim 1, element 3.

c) Element 2: “generating respective digital samples indicative of at least a portion of the wireless spectrum of the respective analog wireless signal received at that second unit;”

634. Element 2 is rendered obvious by Oh for the reasons provided above for claim 1, element 4.

d) Element 3: “communicating the respective digital samples generated by that second unit to the first unit using at least one communication medium;”

635. Element 3 is rendered obvious by Oh for the reasons provided above for claim 1, element 5.

e) Element 4: “at the first unit, digitally summing corresponding digital samples derived from the digital samples received from the plurality of second units to produce summed digital samples.”

636. Element 4 is rendered obvious by Oh for the reasons provided above for claim 1, element 6.

19. Dependent Claim 35

637. Claim 35 recites “performing base station processing using an input derived from the resulting summed digital samples.” Oh renders this limitation obvious for the reasons provided above for claim 1, element 7.

20. Dependent Claims 32 and 36-42

638. Dependent claims 32 and 36-42 are rendered obvious by Oh for the reasons provide above for claims 2, 6, 7, 10, 15, 16, 13, and 14, respectively.

21. Independent Claim 43

a) Preamble and Elements 1-6

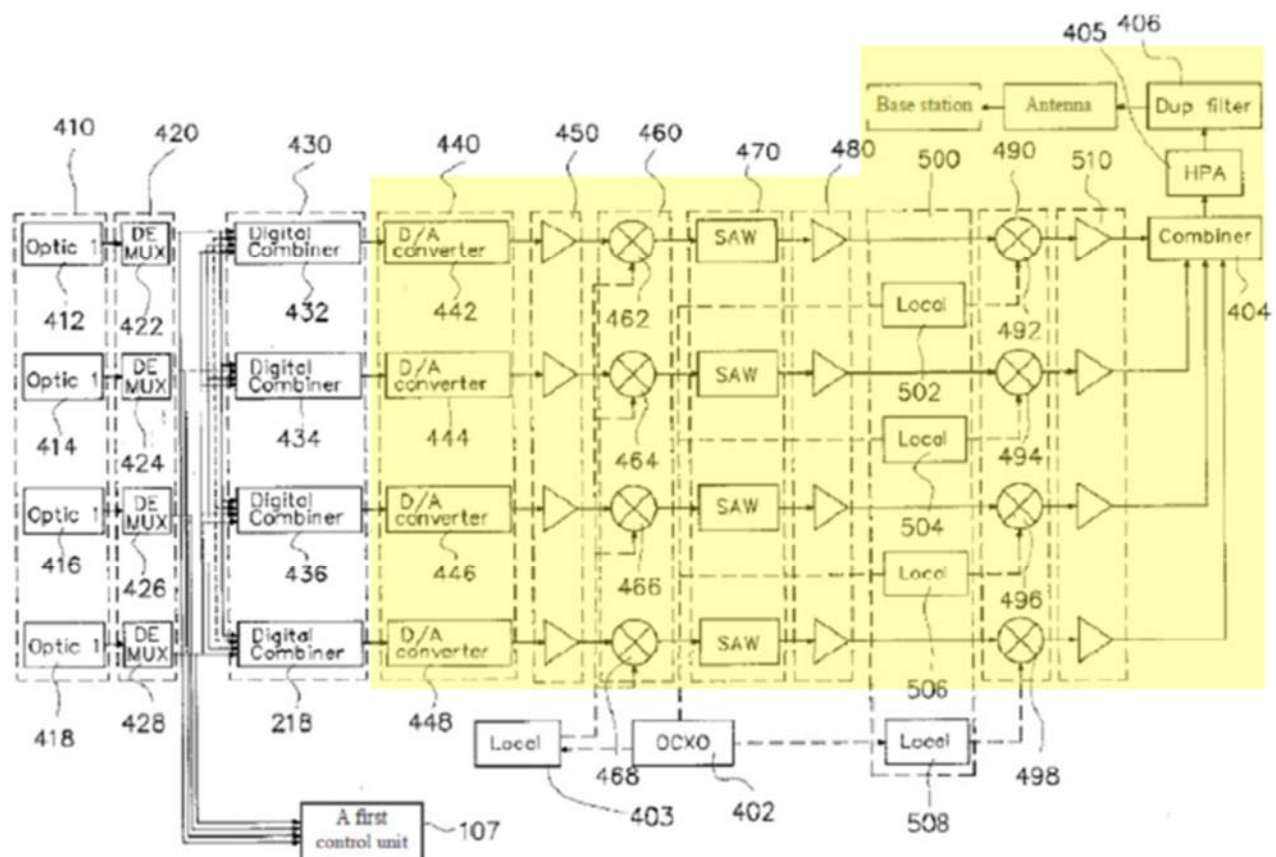
639. Oh renders the preamble and elements 1-6 of claim 43 obvious for the reasons provided above for the preamble and elements 1-6 of claim 1.

b) Element 7: “wherein the system is configured so that an input used for wireless protocol processing is derived from the resulting summed digital samples”

640. The term “wireless protocol processing” is not used in the ’402 patent specification. As discussed above, POSITA would understand “wireless protocol processing” to mean processing signals in preparation/transmission of those processed signals according to a wireless protocol.

641. Oh renders that limitation obvious. Following the digital summing operation referenced above in addressing element 6, the summed digital data values in Oh are converted to analog signals, up converted to the appropriate frequency signals associated with their particular bands to create component analog signals, that are then combined and wirelessly transmitted to a base station via an antenna.

FIG. 5



Specifically Oh states:

After creating 14-bit intermediate frequency signals by combining four 12-bit intermediate frequency signals in the same frequency band, said digital combiner transmits them to a first D/A converter unit 440. Each D/A converter 442, 444, 446, and 448 of said first D/A converter unit 440 converts 14-bit digital signals to the intermediate [frequency] signals, analog signals; and transmits 1.23MHz or 1.5MHz intermediate frequency signals to each mixer 462, 464, 466, and 468 of a third mixer unit 460 through a third amplification unit 450. Said third mixer unit 460 outputs 70MHz intermediate frequency signals by mixing 1.23MHz or 1.5MHz intermediate frequency signals

transmitted from a first D/A converter unit 440 with 68.77MHz or 68.5MHz oscillating frequency transmitted from a third local unit 403. The intermediate frequency signals outputted from said third mixer unit 460 are transmitted to a fourth mixer unit 490 through a first saw filter unit 470 and a fourth amplification unit 480. Said fourth mixer unit 490 mixes the oscillating frequency in different frequency bands transmitted from a fourth local unit 500 with 70MHz intermediate frequency signals; and transmits 800MHz RF signals in different frequency bands to a first combiner 404 through a fifth amplification unit 510.

Ex. 1007, 5:16-26. The analog signals are combined at 404 to “aggregate[] the RF signals in different frequency bands transmitted from four mixers 492, 494, 496, and 498,” and are amplified at 510 and run through a bi-directional filter 406 to an antenna and a base station.

642. Thus Oh renders obvious wherein the system is configured so that an input used for wireless protocol processing is derived from the resulting summed digital samples (the output of 430 is used as an input to circuitry at 440, 450, 460, 470, 480, 490, 520, 404, 405, 406 in preparation for wireless transmission to the base station).

22. Dependent Claims 44, 47, and 48

643. Dependent claims 44, 47, and 48 are rendered obvious by Oh for the reasons provided above for claims 2, 6, and 7, respectively.

23. Independent Claim 51

a) Preamble and Elements 1 and 2

644. The preamble and elements 1 and 2 are rendered obvious by Oh for the reasons provided above for the preamble and elements 1 and 2 of claim 20 above.

b) Element 3: “wherein the first unit is configured so that an input used for wireless protocol processing is derived from the resulting summed digital samples”

645. Element 3 of claim 51 is rendered obvious by Oh for the reasons provided above for element 7 of claim 43.

24. Dependent Claims 52, 55, and 56

646. Dependent claims 52, 44, and 56 are rendered obvious by Oh for the reasons provided above for claims 21, 6, and 7, respectively.

B. Claims 3, 4, 22, 23, 33, 34, 45, 46, 53, and 54 are unpatentable under 35 U.S.C. § 103 over Oh in view of Schwartz;

1. Motivation to Combine

647. A person of ordinary skill in the art would be motivated to combine the disclosures of Oh and Schwartz for a variety of reasons. As an initial matter, Oh expressly mentions the types of all-analog RF distribution system described by Schwartz in its “Conventional Technology” section, where Oh notes that in those systems where “the RF signals transmitted/received to/from said first optic repeater and a second optic repeater are analog signals, the strength of the signals is greatly decreased during transmission through the optical line.” Ex. 1007, 2:29-30. The

resulting amplification can cause signal-to-noise ratio issues in the analog signals that ultimately reach destinations at the host or remote units. *Id.*, 2:30-33. Because Oh expressly discusses the types of conventional, all-analog systems described in Schwartz, a POSITA would have recognized compatibilities in those systems and that Oh's digital relay improvements would have been applicable to Schwartz-type topologies (*i.e.*, topologies that incorporate intermediate stations 28 for distribution network expansion).

648. Additionally, a POSITA starting with Oh would have readily recognized a limitation in Oh's disclosure, where an RF distribution topology would have been limited to the number of remote slave units 30 corresponding to the number of master unit 20 optical ports (*i.e.*, four optic converters 192, 194, 196, 198 on the forward path and four optic converters 412, 414, 416, 418 on the reverse path limit master unit 20 to connection to four slave units 30). Schwartz's topology that supports intermediate stations 28 for RF distribution network expansion beyond the number of physical ports available at the host (*i.e.*, central station 20). Fig. 1 of Schwartz depicts the ability to daisy-chain intermediate stations 28 together such that a Schwartz network can be expanded to "any number of intermediate stations 28 and/or remote stations 22." Ex. 1010, 4:33-38. Thus a POSITA starting with Oh but looking to provide a large RF distribution network (*e.g.*, in a large building, a sports arena) would be motivated to utilize Schwartz intermediate stations 28 to facilitate that expansion.

2. Dependent Claim 3

649. Claim 3 recites “at least some of the plurality of second units are communicatively coupled to the first unit at least in part using a shared wired communication link.” Schwartz discloses an RF distribution network whereby external RF signals are transmitted to remote stations for wireless transmission via a central station 20. Schwartz discloses that remote stations may be directly connected to the central station 20 or through intermediate stations 28, where each intermediate station 28 may be connected to multiple remote stations 22. And further intermediate stations 28 may be connected to additional intermediate stations 28 to act as signal relays between central station 20 and remote stations 22. Such intermediate stations 28 enable topologies that “connect central station 20 directly to any number of intermediate stations 28 and/or remote stations 22.” Ex. 1010, 4:33-38.

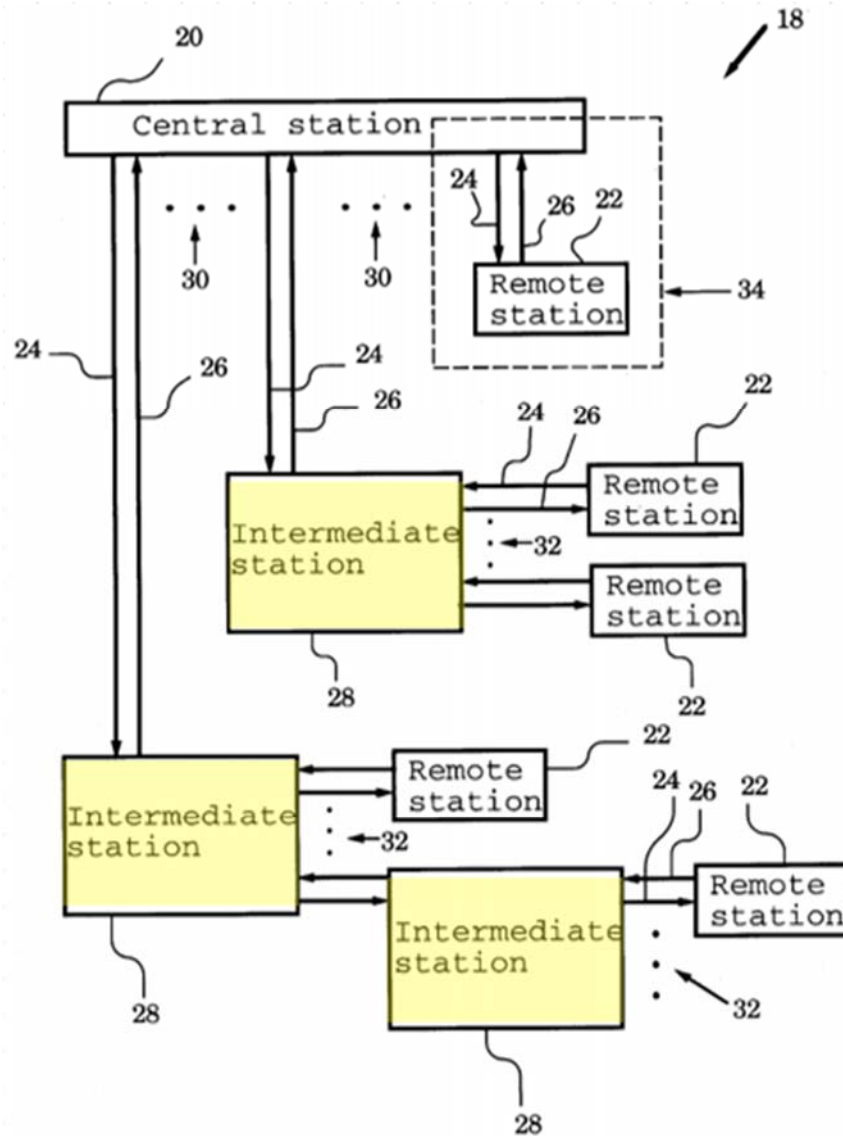


FIG. 1

650. As noted below, the remote stations highlighted in yellow are coupled to the host central station via a shared communication link highlighted in green.

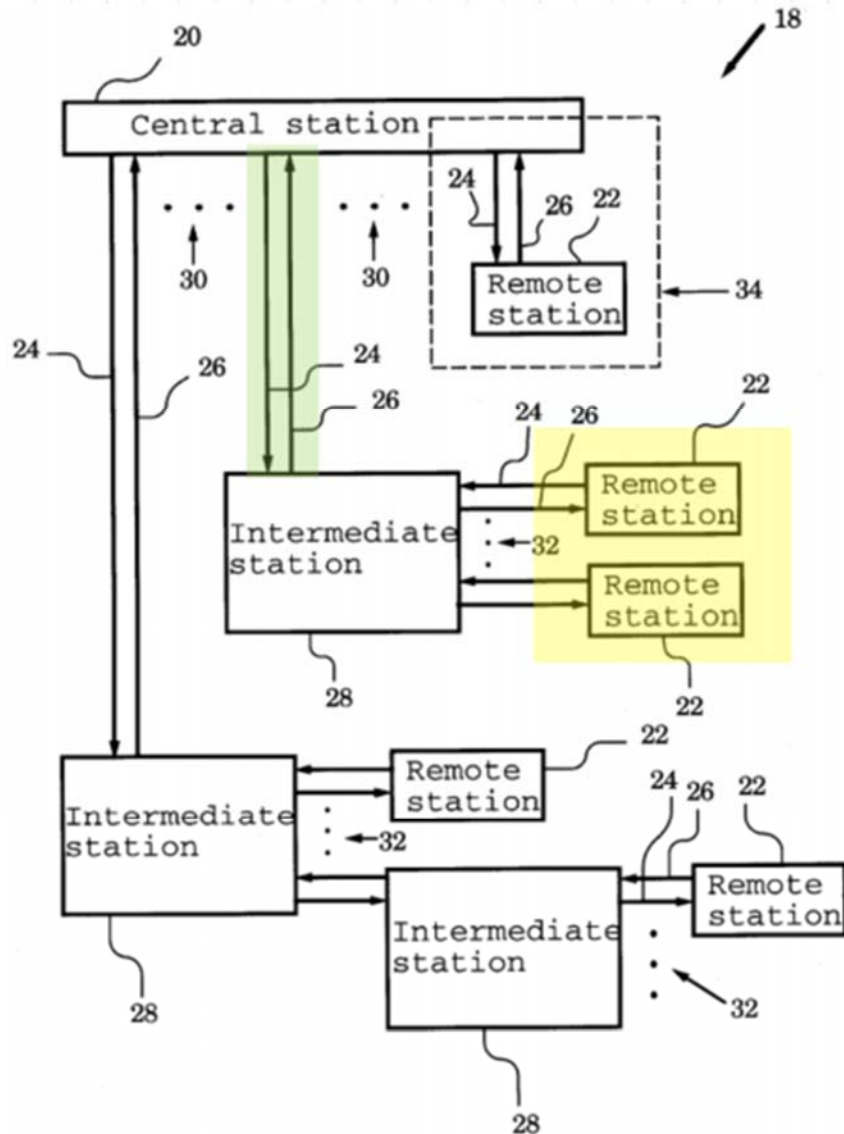


FIG. 1

651. As described above, a POSITA would have been motivated to incorporate Schwartz intermediate stations 28 into Oh's system to enable connection to more remote units (*e.g.*, slave units 30), where Oh's system was limited in the number of slave units 30 to which master unit 20 could be connected by master unit 20's optical ports (*e.g.*, four ports in Figs. 2 & 5). Thus Oh in view of Schwartz

renders obvious at least some of the plurality of second units are communicatively coupled to the first unit at least in part using a shared wired communication link (green highlighted link above).

3. Dependent Claim 4

652. Claim 4 recites “at least some of the plurality of second units are communicatively coupled to the first unit using an intermediary digital expansion unit.” Schwartz discloses that remote stations may be directly connected to the central station 20 or through intermediate stations 28, where each intermediate station 28 may be connected to multiple remote stations 22. Such intermediate stations 28 enable topologies that “connect central station 20 directly to any number of intermediate stations 28 and/or remote stations 22.” Ex. 1010, 4:33-38.

4. Dependent Claims 22, 23, 33, 34, 45, 46, 53, and 54

654. Dependent claims 22, 33, 45, and 53 are rendered obvious by Oh in view of Schwartz for the reasons provided above for claim 3. Dependent claims 23, 34, 46, and 54 are rendered obvious by Oh in view of Schwartz for the reasons provided above for claim 4.

C. Claims 8, 9, 26, 49, 50, and 57 are unpatentable under 35 U.S.C. § 103 over Oh in view of Allpress

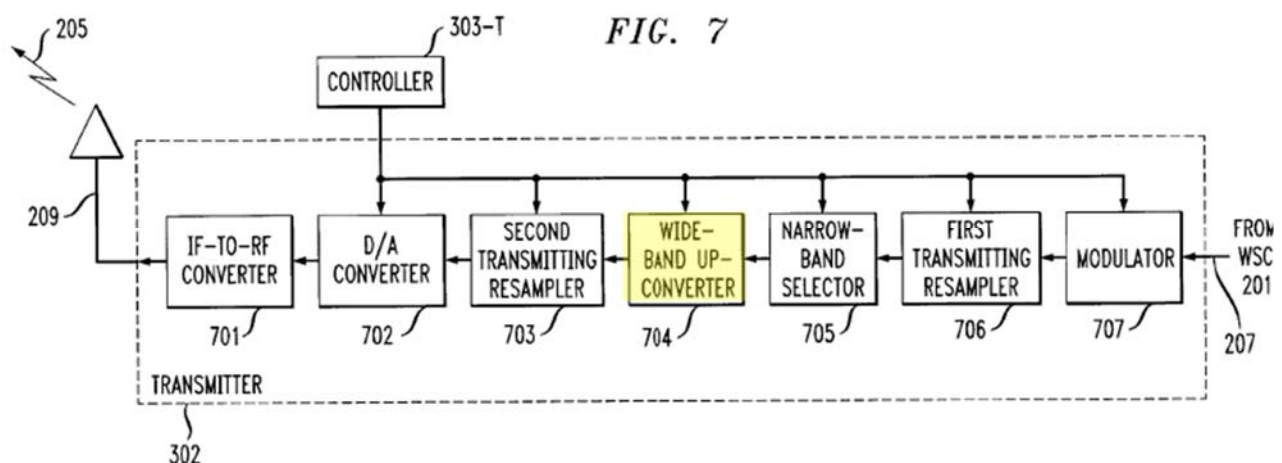
1. Motivation to Combine

655. A POSITA would be motivated to combine the teachings of Allpress with Oh for a variety of reason. As noted in Allpress, implementation of software transceivers can offer a cost and complexity advantage over hardware implementations by avoiding the need for “duplicative hardware” that has associated expense and maintenance costs. Further, software transceivers are more portable to different systems, using different communications protocols, where software transceiver behavior can be modified through adjustment of software settings as opposed to replacement of physical hardware components. Thus a software transceiver is not “standards specific” and can be configured to the requirements of a communications system such as the one taught in Oh.

2. Dependent Claim 8

656. Claim 8 recites “the system further comprises software configured to perform the base station processing using the input derived from the resulting summed

digital samples.” While Oh depicts a hardware implementation of its reverse master unit that performs “base station processing,” a POSITA would consider implementation of some or all of Oh’s post-summing (430) processing in software, where Allpress discloses a transmitter in Fig. 7 that provides upconversion 704 and other functions analogous to Oh’s base station processing in software. Ex. 1021, 8:40-43.



657. Thus Oh in view of Allpress renders obvious the system further comprises software (*e.g.*, software upconversion and other functionality as disclosed in Allpress) configured to perform the base station processing using the input derived from the resulting summed digital samples (outputs of Oh 430).

3. Dependent Claim 9

658. Claim 9 recites “the first unit comprises the software configured to perform the base station processing using the input derived from the resulting summed digital samples.” As discussed above, Oh in view of Allpress renders obvious using

software to perform certain of Oh's reverse master unit functionality depicted in Fig.

5. A POSITA would consider it obvious to implement that software functionality in Oh's master unit 20 (*i.e.*, the same location as Oh's hardware implementation).

659. Thus Oh in view of Allpress renders obvious the first unit (Oh, 20) comprises the software configured to perform the base station processing using the input derived from the resulting summed digital samples.

4. Dependent Claims 26, 49, 50, and 57

660. Dependent claim 49 is rendered obvious by Oh in view of Allpress for the reasons provided above for claim 8. Dependent claims 26, 50, and 57 are rendered obvious by Oh in view of Allpress for the reasons provided above for claim 9.

Appendix A

R. JACOB (JAKE) BAKER, PH.D., P.E.

Intellectual Property Consultant
Professor of Electrical and Computer Engineering

6775 Agave Azul Court
Las Vegas, NV 89120

(725) 777-3755 (Home Office)
(208) 850-0517 (Cell)

Email: rjacobbaker@gmail.com

Website: <http://CMOSedu.com/jbaker/jbaker.htm>

PROFESSIONAL SUMMARY

Russel Jacob (Jake) Baker, Ph.D., P.E. (IEEE Student Member 1983, Member 1988, Senior Member 1997, and Fellow 2013) was born in Ogden, Utah, on October 5, 1964. He received the B.S. and M.S. degrees in electrical engineering from the University of Nevada, Las Vegas, in 1986 and 1988. He received the Ph.D. degree in electrical engineering from the University of Nevada, Reno in 1993. His Google Scholar profile is [here](#) and his ResearchGate profile is [here](#).

From 1981 to 1987 he served in the United States Marine Corps Reserves (Fox Company, 2nd Battalion, 23rd Marines, 4th Marine Division). From 1985 to 1993 he worked for E. G. & G. Energy Measurements and the Lawrence Livermore National Laboratory designing nuclear diagnostic instrumentation for underground nuclear weapons tests at the Nevada Test Site. During this time, he designed, and oversaw the fabrication and manufacture of, over 30 electronic and electro-optic instruments including high-speed cable and fiber-optic receiver/transmitters, PLLs, frame- and bit-syncs, data converters, streak-camera sweep circuits, Pockels cell drivers, micro-channel plate gating circuits, and analog oscilloscope electronics. From 1991-1992 he was an adjunct faculty member in the department of electrical engineering at the University of Nevada, Las Vegas (UNLV). From 1993 to 2000 he served on the faculty in the department of electrical engineering at the University of Idaho (UI), first as an untenured Assistant Professor and then from 1998 as a tenured Associate Professor. In 2000 he joined a new electrical and computer engineering (ECE) program at Boise State University (BSU) where he was promoted to Full Professor in 2002. He then served as the ECE department chair at BSU from 2004 to 2007. At BSU he helped establish graduate programs in ECE including, in 2006, the university's second PhD degree. In 2012 he re-joined the faculty at UNLV as a tenured Full Professor of ECE. During his service at the UI, BSU, and UNLV he has been the major professor to more than [100 graduate students](#). In addition to this industry and academic experience, he has done consulting, both technical and expert witness, for over [125 companies and laboratories](#).

Over the last 35+ years his [research/development interests](#) and [publications](#) have been, or currently are, focused on: analog-to-digital/digital-to-analog data conversion and transmission, optoelectronics (LIDARs, APDs, SiPMs, and associated electronics), analog and digital integrated circuit design and fabrication, design of diagnostic electrical and electro-optic instrumentation for scientific research, integrated electrical/biological circuits and systems, array (memory, imagers, and displays) fabrication and design, CAD tool development and online tutorials, low-power interconnect and packaging (electrical and optical) techniques, design of wired/wireless communication and interface circuits, circuit design for the use and storage of renewable energy, power electronics and power supply design, and the delivery of [online engineering education](#).

Dr. Baker is the named inventor on over [150 US patents](#). He is a member of the honor societies Eta Kappa Nu and Tau Beta Pi, a licensed Professional Engineer, a popular lecturer that has delivered over [50 invited talks](#) around the world, an IEEE Fellow, and the author of the books CMOS Circuit Design, Layout, and Simulation, CMOS Mixed-Signal Circuit Design, and a coauthor of DRAM Circuit Design: Fundamental and High-Speed Topics. He received

the 2000 Best Paper Award from the IEEE Power Electronics Society, the 2007 Frederick Emmons Terman Award, and the 2011 IEEE Circuits and Systems Education Award.

His service activities include the IEEE Press Editorial Board (1999-2004), editor for the Wiley-IEEE Press Book Series on Microelectronic Systems (2010-2018), the Technical Program Chair of the 2015 IEEE 58th International Midwest Symposium on Circuits and Systems (MWSCAS 2015), the IEEE Solid-State Circuits Society (SSCS) Administrative Committee (2011-2016), Distinguished Lecturer for the SSCS (2012-2015), Technology Editor (2012-2014) and Editor-in-Chief (2015-2020) for the IEEE Solid-State Circuits Magazine, IEEE Kirchhoff Award Committee (2020-present), and advisor for the student branch of the IEEE at UNLV (2013-present).

INDUSTRY EXPERIENCE

2013 - present: Working with Freedom Photonics, Santa Barbara, CA, on the integration, fabrication and design, of optoelectronics with CMOS integrated circuits. Work includes the design of compact optical transceivers for range finding applications, high-efficiency integrated silicon avalanche photodetectors for quantum key receivers, Geiger mode SiGe receivers for long-range communications, cryptography, and the fabrication of near-infrared focal plane arrays. Packaging and testing of numerous chips fabricated in both CMOS and SiGe technologies using LEDs, ILDs, PIN, APDs, and ROICs.

2009 - present: Expert witness in intellectual property disputes in electrical, electro-optic, and computer engineering matters for: 1) district court and ITC patent disputes, 2) inter partes reviews at the PTAB, and 3) arbitrations and mediations.

2017 - 2019: Worked with Vorpil Research Systems, Las Vegas, NV on the design of integrated circuit electronics and optoelectronics for optical transceivers used in LIDARs/LADARs.

2016 - 2019: Worked with Attollo Engineering on the design of transient digitizers for the capture of high-speed signals for range finders using LEDs and lasers in compact optical transceivers.

2013 - 2018: Working with Mission Support and Test Services, LLC (MSTS, formerly National Security Technologies, LLC, [NSTec]) on the Design and Fabrication of Integrated electrical/photonics application specific integrated circuit (ASIC) design for use in the implementation of diagnostic instrumentation.

2013 - 2015: Consultant for OmniVision. Working on integrating CMOS image sensors (CIS) with memory for very high-speed consumer imager products. Design specialty DRAM, high-speed interfaces between CIS and DRAM, packaging techniques to pair the CIS with DRAM.

2010 - 2013: Worked with Arete' Associates on the design of high-speed compressive transimpedance amplifiers for LADAR projects and the design of ROIC unit cells. Work funded by the U. S. Air Force.

2013: Cirque, Inc. Consulting on the design of analog-to-digital interfaces for capacitive touch displays and pads.

2012: Consultant at Lockheed-Martin Santa Barbara Focal Plane Array. CMOS circuit design and fabrication for the development and manufacture of infrared components and imaging systems with an emphasis on highest sensitivity Indium Antimonide (InSb) focal plane arrays (FPAs) in linear through large staring formats. Product groups include FPAs, integrated dewar assemblies (IDCAs), camera heads, high-speed interfaces between image processors and imaging systems, and infrared imaging systems.

2010 - 2012: Working with Aerius Photonics (and then FLIR Inc. when Aerius was purchase by FLIR) on the design of Focal Plane Arrays funded (SBIRs and STTRs) by the U.S. Air Force, Navy, and Army. Experience with readout integrated circuits (ROICs) and the design/layout of photodetectors in standard CMOS.

2009 - 2010: Sun Microsystems, Inc. (and then Oracle) VLSI research group. Provided consulting on memory circuit design/fabrication and proximity connection (PxC) interfaces to DRAMs and SRAMs for lower power, 3D packaging, for memory modules and controllers implemented with FPGAs and custom ASICs.

2009 - 2010: Contour Semiconductor, Inc. Design of NMOS voltage and current references as well as the design of a charge pump for an NMOS memory chip.

1994 - 2008: Affiliate faculty (Senior Designer), Micron Technology. Designed CMOS circuits for DRAMs including DLLs, PLLs for embedded graphics chips, voltage references and regulators, data converters, field-emitting display drivers, sensing for MRAM (using delta-sigma data conversion topologies), SRAMs, RFIDs, CMOS active pixel imagers and sensors, power supply design (linear and switching), input buffers, etc. Worked on a joint research

project between Micron and HP labs in magnetic memory fabrication and design using the MTJ memory cell. Worked on numerous technologies ranging from LED lighting to medical imaging using CMOS image sensors (too many to list) resulting in numerous US patents (see following list). Considerable experience working with product engineering to ensure high-yield from the production line from fabrication to test. Co-authored a book on DRAM circuit design through the support of Micron. Gained knowledge in the entire memory design process from fabrication to packaging. Developed, designed, and tested circuit design techniques for multi-level cell (MLC) Flash memory using signal processing.

January 2008: Consultant for Nascentric located in Austin, TX. Provide directions on circuit operation (DRAM, memory, and mixed-signal) for fast SPICE circuit simulations.

May 1997 - May 1999: Consultant for Tower Semiconductor, Haifa, Israel. Designed CMOS integrated circuit cells for various modem chips, interfaces, and serial buses including USB circuits, charging circuits based upon power up/down circuits using an MOS or bandgap reference, pre-amplifiers, comparators, etc.

Summer 1998: Consultant for Amkor Wafer Fabrication Services, Micron Technology, and Rendition, Inc., Design PLLs and DLLs for custom ASICs and a graphics controller chip.

Summers 1994 - 1995: Micron Display Inc. Designing phase locked loop for generating a pixel clock for field emitting displays and a NTSC to RGB circuit on chip in NMOS. These displays are miniature color displays for camcorder and wrist watch size color television. Worked on the fabrication and design of video peripheral circuits for these displays.

September - October 1993: Lawrence Berkeley Laboratory. Designed and constructed a 40 A, 2 kV power MOSFET pulse generator with a 3 ns rise-time and 8 ns fall-time for driving Helmholtz coils.

Summer 1993: Lawrence Livermore National Laboratory, Nova Laser Program. Researched picosecond instrumentation, including time-domain design for impulse radar and imaging.

December 1985 - June 1993: (from July 1992 to June 1993 employed as a consultant while finishing up my Ph.D.), E.G.&G. Energy Measurements Inc., Nevada, Senior Electronics Design Engineer. Responsible for the design and manufacturing of instrumentation used in support of Lawrence Livermore National Laboratory's Nuclear Test Program. Responsible for designing and fabricating over 30 electronic and electro-optic instruments including: CCD camera design, communication networks, fiber optic transmitters employing high speed laser drive electronics, receivers employing envelop tracking for DC voltage restoration and regeneration of received information, receiver low noise amplifier design, frame synchronizers for re-assembling transmitted images, high-speed SRAM memory system design with battery back-up, calibration equipment design such as a tunnel diode pulse generator for testing compensation of oscilloscopes and DAC design for calibrating CCD readout electronics, power supply and battery charger designs, sweep circuits for streak cameras, Pockel's cell drive electronics, vertical amplifier design using HBTs for analog oscilloscopes used at the Nevada Test Site, and 10 kV ramp designs using a planar triode to name some of the designs.

This position provided considerable fundamental grounding in EE with a broad exposure ranging from the design of PC boards to, for example, the design of cable equalizers. Summarizing, gained experience in circuit design technologies including: bipolar, vacuum tubes (planar triodes for high voltages), hybrid integrated circuit fabrication and design, GaAs (high speed logic and HBTs), Mach-Zehnder interferometers, Pockels cells, krytrons, power MOSFETs, microwave techniques, power supplies, fiber optic transmitters/receivers, etc.

Summer 1985: Reynolds Electrical Engineering Company, Las Vegas, Nevada. Gained hands on experience in primary and secondary power system design, installation and trouble-shooting electric motors on mining equipment.

ACADEMIC EXPERIENCE

January 1991 - Present: Professor of Electrical and Computer Engineering at the **University of Nevada, Las Vegas** from August 2012 to present. From January 2000 to July 2012 held various positions at **Boise State University** including: Professor (2003 – 2012), Department Chair (2004 - 2007), and tenured Associate Professor (2000 - 2003). From August 1993 to January 2000 was a tenured/tenure track faculty member at the **University of Idaho**: Assistant Professor (1993 - 1998) and then tenured Associate Professor (1998 - 2000). Lastly, from January 1991 to May 1993 held adjunct faculty positions in the departments of Electrical Engineering at the University of Nevada, Las Vegas and Reno. Additional details:

- Research is focused on analog and mixed-signal integrated circuit fabrication and design. Worked with multi-disciplinary teams (civil engineering, biology, materials science, etc.) on projects that have been funded by EPA, DARPA, NASA, Army, DMEA, Navy, and the AFRL.
- Current and past research and development interests are:
 - Design and packaging of electrical/optical systems (e.g., LiDARs/LADARs) using LEDs, semiconductor lasers, lens for focusing and directing light, integrated circuits, and associated control and communication systems/circuits.
 - Capacitive sensing techniques using delta-sigma modulation and interfacing to sensors
 - Design of high-voltage and energy switching circuits
 - Circuit design and fabrication for the control, use, and storage of renewable energy using thermoelectric generators
 - Design of electrical/biological/optical circuits and systems using electrowetting on dielectric for automating and controlling biological experiments
 - Design of readout integrated circuits (ROICs) for use with focal plane arrays (FPAs)
 - Heterogeneous integration of III-V photonic devices (e.g., FPAs and VCSELs) with CMOS
 - Methods (e.g., 3D packaging and capacitive interconnects) to reduce power consumption in semiconductor memories, memory modules, and digital systems using custom and non-custom (e.g., FPGAs) implementations
 - Analog and mixed-signal circuit fabrication and design for communication systems, synchronization, energy storage, data conversion, and interfaces
 - The design of writing and sensing circuitry for emerging nonvolatile memory technologies, focal planes, and displays (arrays) in nascent nanotechnologies (e.g., magnetic, chalcogenide)
 - Reconfigurable electronics design and fabrication using nascent memory technologies such as the memristor to implement FPGAs
 - Finding an electronic, that is, no mechanical component, replacement for the hard disk drive using nascent fabrication technologies
 - Power electronics circuit design for consumers and consumer electronics including power management and adaptive control to reduce power consumption
 - Design of bandpass delta-sigma modulators for IQ demodulation in wireless communication systems in OFDM, WiFi, 802.11, Bluetooth, 3G, 4G, etc.
 - University prototyping, fabricating, and packaging of integrated circuits
- Led, as chair, the department in graduate curriculum (MS and PhD), program development, and ABET accreditation visits.
- Worked with established and start-up companies to provide technical expertise and identify employment opportunities for students.
- Held various leadership and service positions including: ECE chair, graduate coordinator, college curriculum committee (chair), promotion and tenure committee, scholarly activities committee, faculty search committee, university level search committees, etc. Collaborate with College of Engineering faculty on joint research projects.
- Taught courses in circuits, analog IC design, digital VLSI design and fabrication, fiber optics, and mixed-signal integrated circuit design to both on- and, via the Internet, off-campus students. Research emphasis in integrated circuit design using nascent technologies.

EDUCATION

- Ph.D. in Electrical Engineering; December 1993; University of Nevada, Reno, GPA 4.0/4.0. Dissertation Title: *Applying power MOSFETs to the design of electronic and electro-optic instrumentation.*
- M.S. and B.S. in Electrical Engineering: May 1986 and May 1988; University of Nevada, Las Vegas. Thesis Title: *Three-dimensional simulation of a MOSFET including the effects of gate oxide charge.*

MEMBERSHIPS IN PROFESSIONAL AND SCHOLARLY ORGANIZATIONS

IEEE (student, 1983; member, 1988; senior member, 1997; Fellow, 2013)
Member of the honor societies Eta Kappa Nu and Tau Beta Pi
Licensed Professional Engineer

HONORS AND AWARDS

- Consolidated Students of the University of Nevada, Las Vegas (CSUN) Faculty Award, 2017
- Tau Beta Pi UNLV Outstanding Professor of the Year in 2013, 2014, 2015 and 2016
- UNLV ECE Department Distinguished Professor of the Year in 2015
- IEEE Fellow for contributions to the design of memory circuits - 2013
- Distinguished Lecturer for the IEEE Solid-State Circuits Society, 2012 - 2015
- IEEE Circuits and Systems (CAS) Education Award - 2011
- Twice elected to the Administrative Committee of the Solid-State Circuits Society, 2011 - 2016
- Frederick Emmons Terman Award from the American Society of Engineering Education - 2007
- President's Research and Scholarship Award, Boise State University - 2005
- Honored Faculty Member - Boise State University Top Ten Scholar/Alumni Association 2003
- Outstanding Department of Electrical Engineering faculty, Boise State 2001
- Recipient of the IEEE Power Electronics Society's Best Paper Award in 2000
- University of Idaho, Department of Electrical Engineering outstanding researcher award, 1998-99
- University of Idaho, College of Engineering Outstanding Young Faculty award, 1996-97

SERVICE

Reviewer for IEEE transactions on solid-state circuits, circuits and devices magazine, education, instrumentation, nanotechnology, VLSI, etc. Reviewer for several American Institute of Physics journals as well (Review of Scientific Instruments, Applied Physics letters, etc.) Board member of the IEEE press (reviewed dozens of books and book proposals). Reviewer for the National Institutes of Health. Technology editor and then Editor-in-Chief for the Solid-State Circuits Magazine.

Led the Department on ABET visits, curriculum and policy development, and new program development including the PhD in electrical and computer engineering. Provided significant University and College service in infrastructure development, Dean searches, VP searches, and growth of academic programs. Provided university/industry interactions including starting the ECE department's advisory board. Held positions as the ECE department Master's graduate coordinator and coordinator for the Sophomore Outcomes Assessment Test (SOAT).

Also currently serves, or has served, on the IEEE Press Editorial Board (1999-2004), as a member of the first Academic Committee of the State Key Laboratory of Analog and Mixed-Signal VLSI at the University of Macau, as editor for the Wiley-IEEE Press Book Series on Microelectronic Systems (2010-2018), on the IEEE Solid-State Circuits Society (SSCS) Administrative Committee (2011-2016), as an Advisory Professor to the School of Electronic and Information Engineering at Beijing Jiaotong University, as a Distinguished Lecturer for the SSCS (2012-2015), as the Technical Program Chair for the IEEE 58th 2015 International Midwest Symposium on Circuits and Systems, MWSCAS 2015, as advisor for the student branch of the IEEE at UNLV (2013-present), and as the Technology Editor (2012-2014) and Editor-in-Chief (2015-2020) for the *IEEE Solid-State Circuits Magazine*, and IEEE Kirchhoff Award Committee (2020-present).

ARMED FORCES

6 years United States Marine Corps reserves (Fox Company, 2nd Battalion, 23rd Marines, 4th Marine Division), Honorable Discharge, October 23, 1987. Military Occupational Specialty was Machine Gunner (MOS 0331)

TEXTBOOKS AUTHORED

Baker, R. J., "CMOS Circuit Design, Layout and Simulation, Fourth Edition" *Wiley-IEEE Press*, 1234 pages. ISBN 9781119481515 (2019) **Over 50,000 copies of this book in print.** (Third Edition published in 2010, Revised Second Edition published in 2008, and Second Edition Published in 2005)

Baker, R. J., "CMOS Mixed-Signal Circuit Design," *Wiley-IEEE*, 329 pages. ISBN 978-0470290262 (second edition, 2009) and ISBN 9780471227540 (First Edition published in 2002)

Keeth, B., Baker, R. J., Johnson, B., and Lin, F., "DRAM Circuit Design: Fundamental and High-Speed Topics", *Wiley-IEEE*, 2008, 201 pages. ISBN: 9780470184752

Keeth, B. and Baker, R. J., "DRAM Circuit Design: A Tutorial", *Wiley-IEEE*, 2001, 201 pages. ISBN 0780360141

Baker, R. J., Li, H.W., and Boyce, D.E. "CMOS Circuit Design, Layout and Simulation," *Wiley-IEEE*, 1998, 904 pages. ISBN 9780780334168

BOOKS, OTHER (edited, chapters, etc.)

Saxena, V. and Baker, R. J., "Analog and Digital VLSI," chapter in the CRC Handbook on Industrial Electronics, edited by J. D. Irwin and B. D. Wilamowski, *CRC Press*, 2009 second edition.

Baker, R. J., "CMOS Analog Circuit Design," (A self-study course with study guide, videos, and tests.) IEEE Education Activity Department, 2000. ISBN 0-7803-4822-2 (with textbook) and ISBN 0-7803-4823-0 (without textbook)

Baker, R. J., "CMOS Digital Circuit Design," (A self-study course with study guide, videos, and tests.) *IEEE Education Activity Department*, 2000. ISBN 0-7803-4812-5 (with textbook) and ISBN 0-7803-4813-3 (without textbook)

Li, H.W., Baker, R. J., and Thelen, D., "CMOS Amplifier Design," chapter 19 in the CRC VLSI Handbook, edited by Wai-kai Chen, *CRC Press*, 1999 (ISBN 0-8493-8593-8) and the second edition in 2007 (ISBN 978-0-8493-4199-1)

INVITED TALKS AND SEMINARS

Have given over 50 invited talks and seminars at the following locations: AMD (Fort Collins), AMI semiconductor, Arizona State University, Beijing Jiaotong University, Boise State University, Carleton University, Carnegie Mellon, Columbia University, Dublin City University (Ireland), E.G.&G. Energy Measurements, Foveon, the Franklin Institute, Georgia Tech, Gonzaga University, Hong Kong University of Science and Technology, ICSEng Keynote, ICySSS keynote, IEEE Computing and Communication Workshop (CCWC), IEEE Electron Devices Conference (NVMETS), IEEE Workshop on Microelectronics and Electron Devices (WMED), Indian Institute of Science (Bangalore, India), Instituto de Informatica (Brazil), Instituto Tecnológico y de Estudios Superiores de Monterrey (ITESM, Mexico), Iowa State University, Lawrence Livermore National Laboratory, Lehigh University, Lockheed-Martin, Micron Technology, Nascentric, National Semiconductor, Princeton University, Rendition, Saintgits College (Kerala, India), Southern Methodist University, Sun Microsystems, Stanford University, ST Microelectronics (Delhi, India), Temple University, Texas A&M University, Tower Semiconductor (Israel), University of Alabama (Tuscaloosa), University of Arkansas, University of Buenos Aires (Argentina), University of Houston, University of Idaho, University of Illinois (Urbana-Champaign), Université Laval (Québec City, Québec), University of Macau, University of Maryland, Université de Montréal (École Polytechnique de Montréal), Xilinx (Ireland), University of Nevada (Las Vegas), University of Nevada (Reno), University of Toronto, University of Utah, Utah State University, and Yonsei University (Seoul, South Korea).

RESEARCH FUNDING (LAST 5 YEARS AS A PROFESSOR)

Recent funding listed below. In-kind, equipment, and other non-contract/grant funding [e.g., MOSIS support, money for travel for invited talks, etc.] not listed.

- Goldman, J., Menezes, J., and Baker, R. J., (2021) "Monitored Compression Therapy: Using Smart Technology to Optimize the Treatment of Lower Extremity Swelling," UNLV Sports Research & Innovation Initiative. Proof of Concept Grant Program, \$50,000
- Baker, R. Jacob, (2019-2021) "Tiled Silicon Photomultiplier Array Read-Out Integrated Circuit," NASA, \$225,238
- Baker, R. Jacob, (2019-2021) "Dual-Mode, Extended Near-Infrared, Focal Plane Arrays Fabricated with CMOS Compatible GeSiSn Alloy Materials," DARPA, \$149,998
- Baker, R. Jacob, (2018-2020) "Geiger Mode SiGe Receiver for Long-Range Optical Communications," NASA, \$99,996
- Baker, R. Jacob, (2019) "Improved Quantum Efficiency Photo-Detector," Navy, \$29,999
- Baker, R. Jacob, (2018-2019) "Tiled Silicon Photomultiplier Array Read-Out Integrated Circuit – Phase I," NASA, \$29,999

- Baker, R. Jacob, (2017-2019) "Quantum Cryptography Detector Chip," Defense MicroElectronics Activity (DMEA), \$266,029
- Baker, R. Jacob, (2017-2019) "Advanced Printed Circuit Board Design Methods for Compact Optical Transceiver," U.S. Army/DOD, \$299,605
- Baker, R. Jacob, (2016-2018) "High-Sensitivity Monolithic Silicon APD and ROIC," U.S. Air Force/DOD, \$299,665
- Baker, R. Jacob, (2017-2018) "Transimpedance Amplifier Integrated Circuit Collaboration," Department of Energy, National Security Technologies, LLC, \$100,436
- Baker, R. Jacob, (2017) "Geiger Mode SiGe Receiver for Long-Range Optical Communications," NASA, \$30,000
- Baker, R. Jacob, (2016-2017) "Testing and development of BiCMOS photodetectors and diagnostic instrumentation," Department of Energy, National Security Technologies, LLC, \$181,605
- Baker, R. Jacob, (2016-2017) "Dual-Mode, Extended Near Infrared, Focal Plane Arrays fabricated with a Commercial SiGe BiCMOS Process," DARPA, \$41,892

DOCTORAL STUDENT SUPERVISION

11. Mario Valles Montenegro (underway)
10. Sachin Namboodiri – A Multi-channel MCP-PMT based Readout Integrated Circuit for LiDAR Applications (2020)
9. Wenlan Wu – High-Speed Radhard Mega-Pixel CIS Camera for High-Energy Physics (2019)
8. Kostas Moutafis – A Highly-Sensitive Global-Shutter CMOS Image Sensor with On-Chip Memory for Hundreds of kilo-frames per second Scientific Experiments (2019)
7. Yiyan Li – Portable High Throughput Digital Microfluidics and On-Chip Bacteria Cultures (2016)
6. Yacouba Moumouni – Designing, Building, and Testing a Solar Thermoelectric Generation, STEG, for Energy Delivery to Remote Residential Areas in Developing Regions (2015)
5. Qawi IbnZayd Harvard – Low-Power, High-Bandwidth, and Ultra-Small Memory Module Design (2011)
4. Vishal Saxena – K-Delta-1-Sigma Modulators for Wideband Analog-to-Digital Conversion (2010)
3. Robert Russell Hay – Digitally-Tunable Surface Acoustic Wave Resonator (2009)
2. Xiangli Li (the first Boise State University College of Engineering PhD graduate) – MOSFET Modulated Dual Conversion Gain CMOS Image Sensors (2008)
1. Feng Lin, Research and Design of Low Jitter, Wide Locking-Range Phase-Locked and Delay-Locked Loops (2000)

MASTERS STUDENT SUPERVISION

92. Armani Alvarez (underway)
91. Chris Barr (underway)
90. Jazmin Boloor (underway)
89. Minsung Cho (underway)
88. Francisco Mata-carlos (underway)
87. David Santiago (underway)
86. Daniel Senda (underway)
85. James Skelly (underway)
84. Khulan Tsogt (underway)
83. Gonzalo Arteaga – Current-mode photon-counting circuit with SiGe BiCMOS input stage (2020)
82. Jason Silic – Design and Fabrication of a 6-bit Current-Mode ADC for Lidar and High-Speed Applications (2020)
81. Brandon Wade (2020)
80. Mario Valles Montenegro – Front-End CMOS Transimpedance Amplifiers on a Silicon Photomultiplier Resistant to Fast Neutron Fluence (2020)
79. Jonathan DeBoy (2018)
78. Dane Gentry – Design, Layout, and Testing of SiGe APDs Fabricated in a BiCMOS Process (2018)
77. James Mellot – Variable Transition Time Inverters in a Digital Delay Line with Analog Storage for Processing Fast Signals and Pulses (2018)
76. Eric Monahan – High Speed Fast Transient Digitizer Design and Simulation (2018)
75. Shada Sharif – Design and Analysis of First and Second Order K-Delta-1-Sigma Modulators in Multiple Fabrication Processes (2018)

74. Vikas Vinayaka – Analysis and Design of Analog Front-End Circuitry for Avalanche Photodiodes (APD) and Silicon Photo-Multipliers (SiPM) in Time-of-Flight Applications (2018)
73. Claire Tsagkari – Design, Fabrication and Testing of a Capacitive Sensor Using Delta-Sigma Modulation (2017)
72. Kevin Buck – Fast Transient Digitizer and PCB Interface (2015)
71. Marzieh Sharbat Maleki (2015)
70. Angsuman Roy – Design, Fabrication and Testing of Monolithic Low-Power Passive Sigma-Delta Analog-to-Digital Converters (2015)
69. Daniel Anderson – Design and Implementation of an Instruction Set Architecture and Instruction Execution Unit for the RZ9 Coprocessor System (2014)
68. Jared Gordon – Design and Fabrication of an Infrared Optical Pyrometer ASIC (2013)
67. Justin Butterfield (2012)
66. Adam Johnson – Methods and Considerations for Testing Resistive Memories (2012)
65. Ben Millemon – CMOS Characterization, Modeling, and Circuit Design in the Presence of Random Local Variation (2012)
64. Justin Wood (2012)
63. Chamunda Ndinawe Chamunda (2011)
62. Gary VanAckern – Design Guide for CMOS Process On-Chip 3D Inductors using Thru-Wafer Vias (2011)
61. Lucien Jan Bissey – High-Voltage Programmable Delta-Sigma Modulation Voltage-Control Circuit (2010)
60. Kaijun Li (2010)
59. Yingting Li (co-supervised with Maria Mitkova) (2010)
58. Lael Matthews (co-supervised with Said Ahmed-Zaid) (2010)
57. Priyanka Mukeshbhai Parikh (2010)
56. Todd Plum (co-supervised with Jeff Jessing) – Design and Fabrication of a Chemicapacitive Sensor for the Detection of Volatile Organic Compounds (2010)
55. Rahul Srikonda (2010)
54. Avani Falgun Trivedi (2010)
53. Kuang Ming Yap – Gain and Offset Error Correction for CMOS Image Sensors using Delta-Sigma Modulation (2010)
52. Mahesh Balasubramanian – Phase Change Memory - Array Development and Sensing Circuits using Delta-Sigma Modulation (2009)
51. Lincoln Bollschweiler (2009)
50. Shantanu Gupta (2009)
49. Qawi Harvard – Wide I_O DRAM Architecture Utilizing Proximity Communication (2009)
48. Avinash Rajagiri (2009)
47. Ramya Ramarapu (2009)
46. Harikrishna Rapole (2009)
45. Aruna Vadla (2009)
44. Hemanth Ande (2008)
43. Curtis Cahoon – Low-Voltage CMOS Temperature Sensor Design using Schottky Diode-Based References (2008)
42. Prashanth Busa (2008)
41. John McCoy III (2008)
40. Dennis Montierth – Using Delta-Sigma-Modulation for Sensing in a CMOS Imager (2008)
39. Rudi Rashwand (2008)
38. Barsha Shrestha (co-supervised with Zhu Han) – Wireless Access in Vehicular Environments using Bit Torrent and Bargaining (2008)
37. Eric Becker – Design of an Integrated Half-Cycle Delay Line Duty Cycle Corrector Delay Locked Loop (2007)
36. Matthew Leslie – Noise-Shaping Sense Amplifier for Cross-Point Arrays (2007)
35. Jose Monje (2007)
34. Sanghyun Park (2007)
33. Vishal Saxena – Indirect Feedback Compensation Techniques for Multi-Stage Operational Amplifiers (2007)
32. Meshack Appikarla (2006)

31. Eric Booth – Wide Range, Low Jitter Delay-Locked Loop Using a Graduated Digital Delay Line and Phase Interpolator (2006)
30. Sucheta Das (2006)
29. Krishna Duvvada – High Speed Digital CMOS Input Buffer Design (2006)
28. Krishnamraju Kurra (2006)
27. Soumya Narasimhan (2006)
26. Roger Porter (2006)
25. David Butler – Low-Voltage Bandgap Reference Design Utilizing Schottky Diodes (2005)
24. Dragos Dimitriu (2005)
23. Surendranath Eruvuru – Sensing Circuit Design for an Ion Mobility Spectrometer (2005)
22. Sandhya Sandireddy (2005)
21. Harish Singidi (2005)
20. Indira Vemula – Delta-Sigma Modulator Used in CMOS Imagers (2005)
19. Bhavana Kollimarla – A 1-Bit Analog-to-Digital Converter Using Delta Sigma Modulation for Sensing in CMOS Imagers (2004)
18. Sandeep Pemmaraju – High Voltage Charge Pump Circuit for an Ion Mobility Spectrometer (2004)
17. Ravindra Puthumbaka – Circuit Design for an Ion Mobility Spectrometer (2004)
16. Brandon Roth – Comparison of Asynchronous vs. Synchronous Design Technologies using a 16-bit Binary Adder (2004)
15. Jennifer Taylor – Reading and Writing Flash Memory Using Delta-Sigma Modulation (2004)
14. Jing Plaisted – Methods for Memory Testing (2003)
13. Murugesh Subramaniam – Flash Memory Sensing Using Averaging (2003)
12. Brian Johnson – Application of an Asynchronous FIFO in a DRAM Data Path (2002)
11. Scott Ward – Electrostatic Discharge (ESD) Protection in CMOS (2002)
10. Tyler Gomm – Design of a Delay-Locked Loop with a DAC-Controlled Analog Delay Line (2001)
9. Gexin Huang (2001)
8. Chris Atkins (2000)
7. Thaddeus Black (2000)
6. Zuxu Qin (2000)
5. Hao Chen (1999)
4. Doug Hackler (co-supervised with Steve Parke) – TMOS: A Novel Design for MOSFET Technology (1999)
3. Song Liu – Design of a CMOS 6-bit Folding and Interpolating Analog-to-Digital Converter (1999)
2. Ben Ba (1997)
1. Brent Keeth – A Novel Architecture for Advanced High Density Dynamic Random Access Memories (1996)

GRANTED US PATENTS

152. Baker, R. J., "Quantizing circuits having improved sensing," **10,658,018**, May 19, 2020.
151. Baker, R. J., "Quantizing circuits having improved sensing," **10,403,339**, September 3, 2019.
150. Baker, R. J., "Digital Filters with Memory," **10,366,744**, July 30, 2019.
149. Baker, R. J., "Quantizing circuits having improved sensing," **10,127,954**, November 13, 2018.
148. Baker, R. J. and Parkinson, W., "NMOS regulated voltage reference," **9,753,481**, September 5, 2017.
147. Baker, R. J., "Digital Filters with Memory," **9,734,894**, August 15, 2017.
146. Baker, R. J. and Keeth, B., "Optical interconnect in high-speed memory systems," **9,697,883**, July 7, 2017
145. Baker, R. J., "Comparators for delta-sigma modulators," **9,641,193**, May 2, 2017.
144. Baker, R. J., "Quantizing circuits having improved sensing," **9,449,664**, September 20, 2016.
143. Baker, R. J., "Error detection for multi-bit memory," **9,336,084**, May 10, 2016.
142. Baker, R. J. and Keeth, B., "Optical interconnect in high-speed memory systems," **9,299,423**, March 29, 2016.
141. Baker, R. J., "Methods for sensing memory elements in semiconductor devices," **9,299,405**, March 29, 2016.
140. Baker, R. J., "Comparators for delta-sigma modulators," **9,135,962**, September 15, 2015.
139. Baker, R. J., "Resistive memory element sensing using averaging," **9,081,042**, July 14, 2015.
138. Baker, R. J., "Digital Filters with Memory," **9,070,469**, June 30, 2015.
137. Baker, R. J., "Reference current sources," **8,879,327**, November 4, 2014.

136. Baker, R. J. and Beigel, K. D., "Multi-resistive integrated circuit memory," **8,878,274**, November 4, 2014.
135. Baker, R. J., "Methods for sensing memory elements in semiconductor devices," **8,854,899**, October 7, 2014.
134. Baker, R. J., "Quantizing circuits with variable parameters," **8,830,105**, September 9, 2014.
133. Baker, R. J., "Integrators for delta-sigma modulators," **8,754,795**, June 17, 2014.
132. Baker, R. J., "Methods of quantizing signals using variable reference signals," **8,717,220**, May 6, 2014.
131. Baker, R. J. and Keeth, B., "Optical interconnect in high-speed memory systems," **8,712,249**, April 29, 2014.
130. Baker, R. J., "Resistive memory element sensing using averaging," **8,711,605**, April 29, 2014.
129. Baker, R. J., "Memory with correlated resistance," **8,681,557**, March 25, 2014.
128. Baker, R. J., "Reference current sources," **8,675,413**, March 18, 2014.
127. Baker, R. J., "Methods for sensing memory elements in semiconductor devices," **8,582,375**, November 12, 2013.
126. Linder, L. F., Renner, D., MacDougall, M., Geske, J., and Baker, R. J., "Dual well read-out integrated circuit (ROIC)," **8,581,168**, November 12, 2013.
125. Li, W., Schoenfeld, A., and Baker, R. J., "Method and apparatus for providing symmetrical output data for a double data rate DRAM," **8,516,292**, August 20, 2013.
124. Baker, R. Jacob, "Resistive memory element sensing using averaging," **8,441,834**, May 14, 2013.
123. Qawi, Q. I., Drost, R. J., and Baker, R. Jacob, "Increased DRAM-array throughput using inactive bitlines," **8,395,947**, March 12, 2013.
122. Baker, R. Jacob, "Memory with correlated resistance," **8,289,772**, October 16, 2012.
121. Lin, F. and Baker, R. Jacob, "Phase splitter using digital delay locked loops," **8,218,708**, July 10, 2012.
120. Baker, R. Jacob, "Subtraction circuits and digital-to-analog converters for semiconductor devices," **8,194,477**, June 5, 2012.
119. Baker, R. J., "Digital Filters for Semiconductor Devices," **8,149,646**, April 3, 2012.
118. Baker, R. J., "Error detection for multi-bit memory," **8,117,520**, February 14, 2012.
117. Baker, R. J., "Integrators for delta-sigma modulators," **8,102,295**, January 24, 2012.
116. Baker, R. J., "Devices including analog-to-digital converters for internal data storage locations," **8,098,180**, January 17, 2012.
115. Baker, R. J. and Beigel, K. D., "Multi-resistive integrated circuit memory," **8,093,643**, January 10, 2012.
114. Baker, R. J., "Quantizing circuits with variable parameters," **8,089,387**, January 3, 2012.
113. Baker, R. J., "Reference current sources," **8,068,367**, November 29, 2011.
112. Baker, R. J., "Methods of quantizing signals using variable reference signals," **8,068,046**, November 29, 2011.
111. Baker, R. J., "Systems and devices including memory with built-in self-test and methods of making using the same," **8,042,012**, October 18, 2011.
110. Baker, R. J., "Memory with correlated resistance," **7,969,783**, June 28, 2011.
109. Baker, R. J. and Keeth, B., "Optical interconnect in high-speed memory systems," **7,941,056**, May 10, 2011.
108. Baker, R. J., "K-delta-1-sigma modulator," **7,916,054**, March 29, 2011.
107. Li, W., Schoenfeld, A., and Baker, R. J., "Method and apparatus for providing symmetrical output data for a double data rate DRAM," **7,877,623**, January 25, 2011.
106. Lin, F. and Baker, R. J., "Phase splitter using digital delay locked loops," **7,873,131**, January 18, 2011.
105. Hush, G. and Baker, R. J., "Complementary bit PCRAM sense amplifier and method of operation," **7,869,249**, January 11, 2011.
104. Baker, R. J., "Subtraction circuits and digital-to-analog converters for semiconductor devices," **7,839,703**, November 23, 2010.
103. Baker, R. J., "Digital Filters with Memory" **7,830,729**, November 9, 2010.
102. Baker, R. J., "Systems and devices including memory with built-in self test and methods of making using the same," **7,818,638**, October 19, 2010.
101. Baker, R. J., "Integrators for delta-sigma modulators," **7,817,073**, October 19, 2010.
100. Baker, R. J., "Digital filters for semiconductor devices," **7,768,868**, August 3, 2010.
99. Baker, R. J., "Quantizing circuits with variable reference signals," **7,733,262**, June 8, 2010.
98. Baker, R. J., "Quantizing circuits for semiconductor devices," **7,667,632**, February 23, 2010.
97. Baker, R. J., and Beigel, K. D., "Multi-resistive integrated circuit memory," **7,642,591**, January 5, 2010.

96. Baker, R. J., "Offset compensated sensing for a magnetic random access memory," **7,616,474**, November 10, 2009.
95. Baker, R. J., "Resistive memory element sensing using averaging," **7,577,044**, Aug. 18, 2009.
94. Baker, R. J., "Quantizing circuits with variable parameters," **7,538,702**, May 26, 2009.
93. Baker, R. J., "Method and system for reducing mismatch between reference and intensity paths in analog to digital converters in CMOS active pixel sensors," **7,528,877**, May 5, 2009.
92. Baker, R. J., "Method and system for reducing mismatch between reference and intensity paths in analog to digital converters in CMOS active pixel sensors," **7,515,188**, April 7, 2009.
91. Taylor, J. and Baker, R. J., "Method and apparatus for sensing flash memory using delta-sigma modulation," **7,495,964**, February 24, 2009.
90. Baker, R. J., "Noise resistant small signal sensing circuit for a memory device," **7,489,575**, February 10, 2009.
89. Baker, R. J., "Per column one-bit ADC for image sensors," **7,456,885**, November 25, 2008.
88. Staples, T. and Baker, R. J., "Input buffer design using common-mode feedback," **7,449,953**, November 11, 2008.
87. Li, W., Schoenfeld, A., and Baker, R. J., "Method and apparatus for providing symmetrical output data for a double data rate DRAM," **7,421,607**, September 2, 2008.
86. Baker, R. J., "Methods for resistive memory element sensing using averaging," **7,372,717**, May 13, 2008.
85. Taylor, J. and Baker, R. J., "Method and apparatus for sensing flash memory using delta-sigma modulation," **7,366,021**, April 29, 2008.
84. Hush, G. and Baker, R. J., "Method of operating a complementary bit resistance memory sensor and method of operation," **7,366,003**, April 29, 2008.
83. Baker, R. J., "Noise resistant small signal sensing circuit for a memory device," **7,330,390**, February 12, 2008.
82. Baker, R. J., "Input and output buffers having symmetrical operating characteristics and immunity from voltage variations," **7,319,620**, January 15, 2008.
81. Staples, T. and Baker, R. J., "Method and apparatus providing input buffer design using common-mode feedback," **7,310,018**, December 18, 2007.
80. Baker, R. J., "Offset compensated sensing for a magnetic random access memory," **7,286,428**, October 23, 2007.
79. Baker, R. J., and Cowles, T. B., "Method and apparatus for reducing duty cycle distortion of an output signal," **7,271,635**, September 18, 2007.
78. Baker, R. J., and Cowles, T. B., "Method and apparatus for reducing duty cycle distortion of an output signal," **7,268,603**, September 11, 2007.
77. Hush, G., Baker, R. J., and Moore, J., "Skewed sense AMP for variable resistance memory sensing," **7,251,177**, July 31, 2007.
76. Hush, G. and Baker, R. J., "Method of operating a complementary bit resistance memory sensor," **7,242,603**, July 10, 2007.
75. Li, W., Schoenfeld, A., and Baker, R. J., "Method and apparatus for providing symmetrical output data for a double data rate DRAM," **7,237,136**, June 26, 2007.
74. Moore, J. and Baker, R. J., "Rewrite prevention in a variable resistance memory," **7,224,632**, May 29, 2007.
73. Baker, R. J., "Integrated charge sensing scheme for resistive memories," **7,151,698**, December 19, 2006.
72. Baker, R. J., "Adjusting the frequency of an oscillator for use in a resistive sense amp," **7,151,689**, December 19, 2006.
71. Baker, R. J., "Resistive memory element sensing using averaging," **7,133,307**, Nov. 7, 2006.
70. Lin, F. and Baker, R. J., "Phase detector for all-digital phase locked and delay locked loops," **7,123,525**, October 17, 2006.
69. Baker, R. J., and Beigel, K. D., "Integrated circuit memory with offset capacitor," **7,109,545**, September 19, 2006.
68. Baker, R. J., "Input and output buffers having symmetrical operating characteristics and immunity from voltage variations," **7,102,932**, September 5, 2006.
67. Baker, R. J., "Noise resistant small signal sensing circuit for a memory device," **7,095,667**, August 22, 2006.
66. Baker, R. J., "Offset compensated sensing for a magnetic random access memory," **7,082,045**, July 25, 2006.
65. Baker, R. J., "System and method for sensing data stored in a resistive memory element using one bit of a digital count," **7,009,901**, March 7, 2006.

64. Hush, G. and Baker, R. J., "Complementary bit resistance memory sensor and method of operation," **7,002,833**, February 21, 2006.
63. Lin, F. and Baker, R. J., "Phase detector for all-digital phase locked and delay locked loops," **6,987,701**, January 17, 2006.
62. Baker, R. J., "Adjusting the frequency of an oscillator for use in a resistive sense amp," **6,985,375**, January 10, 2006.
61. Baker, R. J., "Method for reducing power consumption when sensing a resistive memory," **6,954,392**, October 11, 2005.
60. Baker, R. J., "Noise resistant small signal sensing circuit for a memory device," **6,954,391**, October 11, 2005.
59. Baker, R. J., "Noise resistant small signal sensing circuit for a memory device," **6,954,390**, October 11, 2005.
58. Lin, F. and Baker, R. J., "Phase splitter using digital delay locked loops," **6,950,487**, September 27, 2005.
57. Baker, R. J., "Method and apparatus for measuring current as in sensing a memory cell," **6,930,942**, August 16, 2005.
56. Baker, R. J., "Offset compensated sensing for a magnetic random access memory," **6,917,534**, July 12, 2005.
55. Baker, R. J., "Dual loop sensing scheme for resistive memory elements," **6,914,838**, July 5, 2005.
54. Baker, R. J., "High speed low power input buffer," **6,914,454**, July 5, 2005.
53. Baker, R. J., and Beigel, K. D., "Method for stabilizing or offsetting voltage in an integrated circuit," **6,913,966**, July 5, 2005.
52. Moore, J. and Baker, R. J., "PCRAM rewrite prevention," **6,909,656**, June 21, 2005.
51. Baker, R. J., "Integrated charge sensing scheme for resistive memories," **6,901,020**, May 31, 2005.
50. Hush, G., Baker, R. J., and Moore, J., "Skewed sense AMP for variable resistance memory sensing," **6,888,771**, May 3, 2005.
49. Baker, R. J., "Method for reducing power consumption when sensing a resistive memory," **6,885,580**, April 26, 2005.
48. Moore, J. and Baker, R. J., "PCRAM rewrite prevention," **6,882,578**, April 19, 2005.
47. Baker, R. J., "Integrated charge sensing scheme for resistive memories," **6,870,784**, March 22, 2005.
46. Baker, R. J., "Sensing method and apparatus for a resistive memory device," **6,859,383**, February 22, 2005.
45. Baker, R. J., "Noise resistant small signal sensing circuit for a memory device," **6,856,564**, February 15, 2005.
44. Baker, R. J., "Offset compensated sensing for a magnetic random access memory," **6,856,532**, February 15, 2005.
43. Baker, R. J., "Dual loop sensing scheme for resistive memory elements," **6,829,188**, Dec. 7, 2004.
42. Baker, R. J., "Noise resistant small signal sensing circuit for a memory device," **6,826,102**, Nov. 30, 2004.
41. Baker, R. J., "Resistive memory element sensing using averaging," **6,822,892**, Nov. 23, 2004.
40. Baker, R. J., "System and method for sensing data stored in a resistive memory element using one bit of a digital count," **6,813,208**, Nov. 2, 2004.
39. Baker, R. J., "Wordline driven method for sensing data in a resistive memory array," **6,809,981**, Oct. 26, 2004.
38. Baker, R. J., "Noise resistant small signal sensing circuit for a memory device," **6,798,705**, Sept. 28, 2004.
37. Baker, R. J., "Methods and apparatus for measuring current as in sensing a memory cell," **6,795,359**, Sept. 21, 2004.
36. Hush, G. and Baker, R. J., "Complementary bit PCRAM sense amplifier and method of operation," **6,791,859**, Sept. 14, 2004.
35. Baker, R. J., "Method and apparatus for sensing resistance values of memory cells," **6,785,156**, August 31, 2004.
34. Lin, F. and Baker, R. J., "Phase detector for all-digital phase locked and delay locked loops," **6,779,126**, August 17, 2004.
33. Baker, R. J., and Lin, F. "Digital dual-loop DLL design using coarse and fine loops," **6,774,690**, August 10, 2004.
32. Hush, G., Baker, R. J., and Voshell, T., "Producing walking one pattern in shift register," **6,771,249**, August 3, 2004.
31. Baker, R. J., "Sensing method and apparatus for resistance memory device," **6,741,490**, May 25, 2004.
30. Li, W., Schoenfeld, A., and Baker, R. J., "Method and apparatus for providing symmetrical output data for a double data rate DRAM," **6,704,881**, March 9, 2004.
29. Baker, R. J., "Method and system for writing data in an MRAM memory device," **6,687,179**, February 3, 2004.
28. Baker, R. J., "High speed digital signal buffer and method," **6,683,475**, January 27, 2004.

27. Baker, R. J., "High speed low power input buffer," **6,600,343**, July 29, 2003.
26. Baker, R. J., "Offset compensated sensing for magnetic random access memory," **6,597,600**, July 22, 2003.
25. Baker, R. J., "Sensing method and apparatus for resistive memory device," **6,577,525**, June 10, 2003.
24. Baker, R. J., "Method and apparatus for sensing resistance values of memory cells," **6,567,297**, May 20, 2003.
23. Baker, R. J., "High-speed digital signal buffer and method," **6,538,473**, March 25, 2003.
22. Baker, R. J. and Beigel, K. D., "Electronic device with interleaved portions for use in integrated circuits," **6,509,245**, January 21, 2003.
21. Baker, R. J., "Resistive memory element sensing using averaging," **6,504,750**, January 7, 2003.
20. Baker, R. J., "High-speed digital signal buffer and method," **6,483,347**, November 19, 2002.
19. Baker, R. J., and Lin, F., "Digital dual-loop DLL design using coarse and fine loops," **6,445,231**, September 3, 2002.
18. Baker, R. J., "Method and apparatus for receiving synchronous data," **6,424,684**, July 23, 2002.
17. Baker, R. J. and Beigel, K. D., "Comb-shaped capacitor for use in integrated circuits," **6,410,955**, June 25, 2002.
16. Baker, R. J., "High-speed, low-power input buffer," **6,407,588**, June 18, 2002.
15. Miller, J., Schoenfeld, A., Ma, M., and Baker, R. J., "Method and apparatus for improving the performance of digital delay locked loop circuits," **6,316,976**, Nov. 13, 2001.
14. Keeth, B. and Baker, R. J., "Low skew differential receiver with disable feature," **6,256,234**, July 3, 2001.
13. Keeth, B. and Baker, R. J., "Low skew differential receiver with disable feature," **6,104,209**, August 15, 2000.
12. Miller, J., Schoenfeld, A., Ma, M., and Baker, R. J., "Method and apparatus for improving the performance of digital delay locked loop circuits," **6,069,506**, May 30, 2000.
11. Keeth, B. and Baker, R. J., "Low skew differential receiver with disable feature," **6,026,051**, February 15, 2000.
10. Baker, R. J., and Manning, T. A., "Method and apparatus for adaptively adjusting the timing of a clock signal used to latch digital signals, and memory device using same," **6,026,050**, February 15, 2000.
9. Baker, R. J., and Manning, T. A., "Method and apparatus for adaptively adjusting the timing of a clock signal used to latch digital signals, and memory device using same," **5,953,284**, September 14, 1999.
8. Baker, R. J., "Fully-differential amplifier," **5,953,276**, September 14, 1999.
7. Hush, G., Baker, R. J., and Voshell, T., "Timing Control for a Matrixed Scanned Array," **5,909,201**, June 1, 1999.
6. Hush, G. and Baker, R. J., "Field emission display having pulsed capacitance current control," **5,894,293**, April 13, 1999.
5. Baker, R. J., "Adaptively biased voltage regulator and operating method," **5,874,830**, February 23, 1999.
4. Hush, G. Baker, R. J., and Voshell, T., "Serial to Parallel Conversion with a Phase-Locked Loop," **5,818,365**, October 1, 1998.
3. Hush, G., Baker, R. J., and Voshell, T., "Timing Control for a Matrixed Scanned Array," **5,638,085**, June 10, 1997.
2. Wilson, A. J., Baker, R. J., and Schoenfeld, A., "Waveshaping circuit generating two rising slopes for a sense amplifier pulldown device," **5,614,856**, March 25, 1997.
1. Hush, G., Baker, R. J., and Voshell, T., "Serial to Parallel Conversion with a PLL," **5,598,156**, January 28, 1997.

INVITED TALKS (PARTIAL LISTING)

- Harvard, Q. I. and Baker, R. J., "Low-Power, High-Bandwidth, and Ultra-Small Memory Module Design," a presentation covering semiconductor packaging, DRAM architectures, and I/O circuits. The goal of this work is to investigate replacing the currently used dual in-line memory modules (DIMMs) with a smaller and a lower power memory module, a "Nano-Module."
- Baker, R. J., and Campbell, K. A., "Reconfigurable Analog Electronics using the Memristor."
- Baker, R. J., and Saxena, V., "A K-Delta 1-Sigma Modulator for Wideband Analog-to-Digital Conversion."
- Li, K., Saxena, V., and Baker, R. J., "The Baker ADC: An Overview,"
- Saxena, V., and Baker, R. J., "High-Speed Op-Amp Design: Compensation and Topologies for Two and Three Stage Designs,"
- Baker, R. J., "Circuit Design for MLC Flash: Towards a Semiconductor Replacement for the Hard Disk Drive."
- Baker, R. J., Terman Award Acceptance Speech, given at the Frontiers in Education Conference (FIE 2007), Milwaukee, WI, October 11, 2007.

- Baker, R. J., "The One-Transistor, One-Capacitor (1T1C) Dynamic Random Access Memory (DRAM), and its Impact on Society," presented at the Franklin Institute, in the symposium honoring Dr. Robert H. Dennard and his receipt of the 2007 Benjamin Franklin Medal in Electrical Engineering, April 25, 2007.
- Baker, R. J. and Saxena, V., "Design of Bandpass Delta-Sigma Modulators: Avoiding Common Mistakes."
- Baker, R. J., "Sensing Circuits for Resistive Memory."
- Hadrick, M. and Baker, R. J., "Sensing in CMOS Imagers using Delta-Sigma Modulation."
- Baker, R. J., "Design of High-Speed CMOS Op-Amps for Signal Processing," IEEE/EDS Workshop on Microelectronics and Electron Devices (WMED), April, 2005
- Baker, R. J., "Delta-Sigma Modulation for Sensing," IEEE/EDS Workshop on Microelectronics and Electron Devices (WMED), April, 2004
- Rivera, B. and Baker, R. J., "Design and Layout of Schottky Diodes in a Standard CMOS Process," MURI Review, November, 2001.

REFEREED JOURNAL PAPERS

25. Senda, D., Strong, H., Hines, D., Hines, R., and Baker, R. J., "A Compact 1200V, 700A, IGBT-Based Pulse Generator for Repetitive Transcranial Magnetic Stimulation In Vivo Laboratory Experiments," accepted for publication in *Review of Scientific Instruments* (2021).
24. Wu, W., Baker, R. J., Bikkina, P., Long, Y., Levy, A., and Mikkola, E., "Design and Analysis of a Feedback Time Difference Amplifier with Linear and Programmable Gain," *Analog Integrated Circuits and Signal Processing*, Springer, 16 October, 2017.
23. Moumouni, Y. and Baker, R. J., "Modeling, Simulation, and Implementation of a Solar Thermoelectric Energy Harvesting System," *Journal of Energy and Power Engineering*, vol. 10, pp. 296-312, 2016.
22. Li, Y., Baker, R. J., and Raad, D., "Improving the Performance of Electrowetting on Dielectric Microfluidics Using Piezoelectric Top Plate Control," *Sensors and Actuators B: Chemical*, vol. 229, pp. 63-74, 2016.
21. Li, Y., Li, H., and Baker, R. J., "A Low-Cost and High-Resolution Droplet Position Detector for an Intelligent Electrowetting on Dielectric Device," *Journal of Laboratory Automation*, Vol. 20, No. 6, pp. 663-669, 2015.
20. Moumouni, Y., Ahmad, S., and Baker, R. J., "A System Dynamics Model for Energy Planning in Niger," *International Journal of Power and Energy Engineering*, Vol. 3, No. 6, pp. 308-322, 2014.
19. Estrada, D., Ogas, M. L., Southwick III, R. G., Price, P. M., Baker, R. J., and Knowlton, W. B., *Impact of Single pMOSFET Dielectric Degradation on NAND Circuit Performance*, Microelectronics Reliability, Vol. 48, No. 3, pp 354-363, 2008.
18. Leslie, M. B., and Baker, R. J., "Noise-Shaping Sense Amplifier for MRAM Cross-Point Arrays," *IEEE Journal of Solid-State Circuits*, Vol. 41, No. 3, pp. 699-704, 2006.
17. Hess, H. L., and Baker, R. J., "Transformerless Capacitive Coupling of Gate Signals for Series Operation of Power MOS Devices," *IEEE Transactions on Power Electronics*, Vol. 15, No. 5, pp. 923-930, 2000.
16. Lin, F., Miller, J., Schoenfeld, A., Ma, M., and Baker, R. J., "A Register-Controlled Symmetrical DLL for Double-Data-Rate DRAM," *IEEE Journal of Solid-State Circuits*, Vol. 34, No. 4, pp. 565-568, 1999.
15. Bruce, J. D., Li, H. W., Dallabetta, M. J., and Baker, R. J., "Analog layout using ALAS!" *IEEE Journal of Solid-State Circuits*, Vol. 31, No. 2, pp. 271-274, 1996.
14. Li, H. W., Dallabetta, M. J., and Baker, R. J., "An interactive impulse response extraction system," *Review of Scientific Instruments* 66(10), 5092-5095, 1995.
13. Ward, S. T., Baker, R. J., and Li, H. W., "A microchannel plate image intensifier gating circuit capable of pulse widths from 30 ns to 10 μ s," *Measurement Science and Technology*, Vol. 6, No. 11, pp. 1631-1633, 1995.
12. Keeth, B., Baker, R. J., and Li, H. W., "CMOS transconductor VCO with adjustable operating and center frequencies," *Electronics Letters*, 31(17), 1397-98, 1995.
11. Baker, R. J., "Time domain operation of the TRAPATT diode for picosecond-kilovolt pulse generation," *Review of Scientific Instruments*, 65(10), 3286-88, 1994.
10. Baker, R. J. and Ward, S. T., "Designing nanosecond high voltage pulse generators using power MOSFETs," *Electronics Letters*, 30(20), 1634-35, 1994.
9. Baker, R. J. and Johnson, B. P., "Sweep circuit design for a picosecond streak camera," *Measurement Science and Technology*, 5(4). 1994.

8. Baker R. J., Hodder, D. J., Johnson, B. P., Subedi, P. C., and Williams, D. C., "Generation of kilovolt-subnanosecond pulses using a nonlinear transmission line" *Measurement Science and Technology*, 4(8), 893-95, 1993.
7. Baker R. J., and Johnson, B. P., "Series operation of power MOSFETs for high speed, high voltage switching applications," *Review of Scientific Instruments* 65(6), 1993.
6. Baker R. J., and Johnson, B. P., "Applying the Marx bank circuit configuration to power MOSFETs," *Electronics Letters* 29(1), 56-57, 1993.
5. Baker R. J., and Johnson, B. P., "Stacking power MOSFETs for use in high speed instrumentation," *Review of Scientific Instruments*, 63(12), 5799-5801, 1992.
4. Baker R. J., and Johnson, B. P., "A 500 Volt nanosecond pulse generator using cascode connected power MOSFETs," *Measurement Science and Technology*, 3(8), 775-77, 1992.
3. Baker R. J., Perryman, G. T., and Watts, P. W., "A fiber-optically triggered avalanche transistor," *IEEE Transactions on Instrumentation and Measurement*, 40(3), 649-52, 1991.
2. Baker R. J., "High voltage pulse generation using current mode second breakdown in a bipolar junction transistor," *Review of Scientific Instruments*, 62(4), 1031-1036, 1991.
1. Baker R. J., and Pocha, M. D. "Nanosecond switching using power MOSFETs," *Review of Scientific Instruments* 61(8), 2211-2213, 1990.

REFERRED CONFERENCE PAPERS AND MAGAZINE ARTICLES

84. Arteaga, G., Namboodiri, S. P., Roy, A., and Baker, R. J., "Current Comparator with SiGe BiCMOS Input Stage for Photon-Counting LiDAR Applications," accepted for publication in *IEEE 64th International Midwest Symposium on Circuits and Systems*, August 9-11, 2021.
83. Namboodiri, S. P. and Baker, R. J., "Incorporation of Chopping in Continuous Time K-Delta-1-Sigma Modulator," IEEE 19th IEEE Interregional NEWCAS Conference, June 13-16, 2021.
82. Namboodiri, S. P., Arteaga, G., Skelly, J., Mata-carlos, F., Roy, A., and Baker, R. J., "A Current-Mode Photon Counting Circuit for Long-Range LiDAR Applications," *IEEE 63rd International Midwest Symposium on Circuits and Systems*, August 9-12, pp. 146-149, 2020.
81. Vinayaka, V., Namboodiri, S. P., Roy, A., and Baker, R. J., "Segmented Digital SiPM," *IEEE 62nd International Midwest Symposium on Circuits and Systems*, August 4-7, pp. 1118-1121, 2019.
80. Mellott, J. K., Monahan, E., Vinayaka, V., Namboodiri, S. P., Roy, A., and Baker, R. J., "Variable Fast Transient Digitizer," *IEEE 62nd International Midwest Symposium on Circuits and Systems*, August 4-7, pp. 125-128, 2019.
79. Vinayaka, V., Namboodiri, S. P., Abdalla, Kerstetter, B., Mata-Carlos, F., Senda, D., Skelly, J., Roy, A., and Baker, R. J., "Monolithic 8x8 SiPM with 4-bit Current-Mode Flash ADC with Tunable Dynamic Range," *Proceedings of the ACM Great Lakes Symposium on VLSI (GLSVLSI)*, pp. 57-62, Tysons Corner, VA, May 9-11, 2019.
78. Woodson, M., Estrella, S., Hay, K., Roy, A., Sun, K., Morgan, J., Beling, A., Baker, R. J., Renner, D., and Mashanovitch, M., "Photodetection at or below 1 micron wavelengths," *Proc. SPIE 10912, Physics and Simulation of Optoelectronic Devices XXVII*, 1091210, March 8, 2019.
77. Buck, K. and Baker, R. J., "Fast Transient Digitizer Chip for Capturing Single-Shot Events," *Proceedings of 12th IEEE Dallas Circuits and Systems Conference*, October 9-10, 2016.
76. Wu, W., Baker, R. J., Kumar, P., Garcia, F., and Mikkola, E., "A Linear High Gain Time Difference Amplifier Using Feedback Gain Control," *Proceedings of 12th IEEE Dallas Circuits and Systems Conference*, October 9-10, 2016.
75. Moumouni, Y. and Baker, R. J., "Analysis of a Residential 5kW Grid-tied Photovoltaic System," *Proceedings of the 2016 Clemson University Power Systems Conference*, March 8-11, 2016.
74. Moumouni, Y. and Baker, R. J., "LTspice Model of a Solar Thermoelectric Generation System," *Proceedings of the 2016 Clemson University Power Systems Conference*, March 8-11, 2016.
73. Li, Y. and Baker, R. J., "Computer Vision Assisted Measurement of the Displacements of a Bimorph Piezoelectric Cantilever Beam," *Proceedings of the IEEE Biomedical Circuits and Systems (BioCAS 2015) Conference*, October 22-24, 2015.
72. Li, Y. and Baker, R. J., "A Highly Efficient and Reliable Electrowetting on Dielectric Device for Point-of-Care Diagnostics," *Proceedings of 11th IEEE Dallas Circuits and Systems Conference*, October 12-13, 2015.
71. Roy, A. and Baker, R. J., "A Low-Power Switched-Capacitor Passive Sigma-Delta Modulator," *Proceedings of 11th IEEE Dallas Circuits and Systems Conference*, October 12-13, 2015.

70. Li, Y. and Baker, R. J., "Precise EWOD Top Plate Positioning Using Inverse Preisach Model Based Hysteresis Compensation," *Proceedings of 11th IEEE Dallas Circuits and Systems Conference*, October 12-13, 2015.
69. Moumouni, Y. and Baker, R. J., "Buffer Sizing of Concentrated Photovoltaic Batteries: An Economic Analysis," *IEEE 58th International Midwest Symposium on Circuits and Systems*, pp. 704-707, August 2-5, 2015.
68. Moumouni, Y. and Baker, R. J., "Application of Used Electric Vehicle Batteries to Buffer Photovoltaic Output Transients," *IEEE 58th International Midwest Symposium on Circuits and Systems*, pp. 700-703, August 2-5, 2015.
67. Roy, A., Meza, M., Yurgelon, J., and Baker, R. J., "An FPGA Based Passive K-Delta-1-Sigma Modulator," *IEEE 58th Midwest Symposium on Circuits and Systems*, pp. 121-124, August 2-5, 2015.
66. Moumouni, Y. and Baker, R. J., "Concise Thermal to Electrical Parameters Extraction of Thermoelectric Generator for Spice Modeling," *IEEE 58th International Midwest Symposium on Circuits and Systems*, pp. 596-599, August 2-5, 2015.
65. Moumouni, Y. and Baker, R. J., "Improved SPICE Modeling and Analysis of a Thermoelectric Module," *IEEE 58th International Midwest Symposium on Circuits and Systems*, pp. 600-603, August 2-5, 2015.
64. Li, Y., Li, H., and Baker, R. J., "Volume and Concentration Identification by Using an Electrowetting on Dielectric Device," *Proceedings of 10th IEEE Dallas Circuits and Systems Conference*, October 12-13, 2014.
63. Li, Y., Chen, R., and Baker, R. J., "A Fast Fabricating Electro-wetting Platform to Implement Large Droplet Manipulation," *Proceedings of the IEEE 57th International Midwest Symposium on Circuits and Systems*, pp. 326-329, August 3-6, 2014.
62. Roy, A. and Baker, R. J., "A Passive 2nd-Order Sigma-Delta Modulator for Low-Power Analog-to-Digital Conversion," *Proceedings of the IEEE 57th International Midwest Symposium on Circuits and Systems*, pp. 595-598, August 3-6, 2014.
61. Baker, R. J., "Massive Open Online Courses for Educating Circuit Designers: What Works and What Doesn't," *IEEE Solid-State Circuits Magazine*, Vol. 6, No. 2, pp. 63-65, 2014.
60. Montierth, D., Strand, T., Leatham, J., Linder, L., and Baker, R. J., "Performance and Characteristics of Silicon Avalanche Photodetectors in the C5 Process," *IEEE 55th International Midwest Symposium on Circuits and Systems*, August 5-8, 2012.
59. VanAckern, G., Baker, R. J., Moll, A. J., and Saxena, V. "On-Chip 3D Inductors using Thru-Wafer Vias," *Proceedings of the IEEE/EDS Workshop on Microelectronics and Electron Devices (WMED)*, April 20, 2012.
58. Yap, K. and Baker, R. J., "Two Techniques to Reduce Gain and Offset Errors in CMOS Image Sensors using Delta-Sigma Modulation," *Proceedings of the IEEE/EDS Workshop on Microelectronics and Electron Devices (WMED)*, April 20, 2012.
57. Labaziewicz, A. and Baker, R. J., "A 2 GHz Effective Sampling Frequency K-Delta-1-Sigma Analog-to-Digital Converter," *Proceedings of the IEEE 54th International Midwest Symposium on Circuits and Systems*, August 7-10, 2011.
56. Saxena, V., Balagopal, S., and Baker, R. J., "Systematic Design of Three-Stage Op-amps using Split Length Compensation," *Proceedings of the IEEE 54th International Midwest Symposium on Circuits and Systems*, August 7-10, 2011.
55. Harvard, Q. and Baker, R. J., "A Scalable I/O Architecture for Wide I/O DRAM," *Proceedings of the IEEE 54th International Midwest Symposium on Circuits and Systems*, August 7-10, 2011.
54. Wald, S., Baker, R. J., Mitkova, M., and Rafla, N., "A Non-Volatile Memory Array Based on Nano-Ionic Conductive Bridge Measurements," *Proceedings of the IEEE/EDS Workshop on Microelectronics and Electron Devices (WMED)*, pp. 43-46, April 22, 2011.
53. Saxena, V. and Baker, R. J., "Synthesis of Higher-Order K-Delta-1-Sigma Modulators for Wideband ADCs," *Proceedings of the IEEE 53rd International Midwest Symposium on Circuits and Systems*, August 1-4, 2010.
52. Saxena, V. and Baker, R. J., "Indirect Compensation Techniques for Three-Stage Fully-Differential Op-Amps," (invited) *Proceedings of the IEEE 53rd International Midwest Symposium on Circuits and Systems*, August 1-4, 2010.
51. Harvard, Q., Baker, R. J., and Drost, R., "Main Memory with Proximity Communication: A Wide I/O DRAM Architecture," *Proceedings of the IEEE/EDS Workshop on Microelectronics and Electron Devices (WMED)*, pp. 40-43, April 16, 2010.

50. Yap, K. M. and Baker, R. J., "Gain Error Correction for CMOS Image Sensor using Delta-Sigma Modulation," *Proceedings of the IEEE/EDS Workshop on Microelectronics and Electron Devices (WMED)*, pp. 52-55, April 16, 2010.
49. Gagliano, C. and Baker, R. J., "A Compact Delay-Locked Loop for Multi-Phase Non-Overlapping Clock Generation," *Proceedings (poster) of the IEEE/EDS Workshop on Microelectronics and Electron Devices (WMED)*, April 16, 2010.
48. Montierth, D., Yap, K. M., and Baker, R. J., "CMOS Image Sensor using Delta-Sigma Modulation," *4th Annual Austin Conference on Integrated Circuits & Systems*, Oct. 26-27, 2009.
47. Saxena, V. and Baker, R. J., "Synthesis of Higher-Order K-Delta-1-Sigma Modulators for Wideband Analog to Digital Conversion," *4th Annual Austin Conference on Integrated Circuits & Systems*, Oct. 26-27, 2009.
46. Li, K., Saxena, V., Zheng, G., and Baker, R. J., "Full Feed-Forward K-Delta-1-Sigma Modulator," *4th Annual Austin Conference on Integrated Circuits & Systems*, Oct. 26-27, 2009.
45. Bollschweiler, L., English, A., Baker, R. J., Kuang, W., Chang, Z.-C., Shih, M.-H., Knowlton, W.B., Hughes, W.L., Lee, J., Yurke, B., Cockerham, N. S., and Tyree, V. C., "Chip-Scale Nanophotonic Chemical and Biological Sensors using CMOS Process," *Proceedings of the IEEE 52nd Midwest Symposium on Circuits and Systems*, pp. 413-416, August 2-5, 2009.
44. Saxena, V., Li, K., Zheng, G., and Baker, R. J., "A K-Delta 1-Sigma Modulator for Wideband Analog to Digital Conversion," *Proceedings of the IEEE 52nd International Midwest Symposium on Circuits and Systems*, pp. 411-415, August 2-5, 2009.
43. Saxena, V. and Baker, R. J., "Indirect Compensation Techniques for Three-Stage CMOS Op-amps," *Proceedings of the IEEE 52nd International Midwest Symposium on Circuits and Systems*, pp. 9-12, August 2-5, 2009.
42. Regner, J., Balasubramanian, M., Cook, B., Li, Y., Kassayebetre, H., Sharma, A., Baker, R. J., and Campbell, K. A., "Integration of IC Industry Feature Sizes with University Back-End-of-Line Post Processing: Example Using a Phase-Change Memory Test Chip," *Proceedings of the IEEE/EDS Workshop on Microelectronics and Electron Devices (WMED)*, pp. 28-31, April, 2009.
41. Gupta, S. Saxena, V., Campbell, K. A., and Baker, R. J., "W-2W Current Steering DAC for Programming Phase Change Memory," *Proceedings of the IEEE/EDS Workshop on Microelectronics and Electron Devices (WMED)*, pp. 59-62, April, 2009.
40. Rapole, H., Rajagiri, A., Balasubramanian, M., Campbell, K. A., and Baker, R. J., "Resistive Memory Sensing Using Delta-Sigma Modulation," *Proceedings of the IEEE/EDS Workshop on Microelectronics and Electron Devices (WMED)*, pp. 63-66, April, 2009.
39. Kassayebetre, H., Regner, J., Rajagiri, A., Sharma, A., Hay, R. R., Baker, R. J., and Campbell, K.A., "Surface Acoustic Wave Device Fabrication using Zinc Oxide and Chalcogenide Thin Films," poster presentation at the *IEEE/EDS Workshop on Microelectronics and Electron Devices (WMED)*, April, 2009.
38. Ande, H. K., Busa, P., Balasubramanian, M., Campbell, K. A., and Baker, R. J., "A New Approach to the Design, Fabrication, and Testing of Chalcogenide-Based Multi-State Phase-Change Nonvolatile Memory," *Proceedings of the IEEE 51st International Midwest Symposium on Circuits and Systems*, pp. 570-573, August 10-13, 2008.
36. Saxena, V., and Baker, R. J., "Compensation of CMOS Op-Amps using Split-Length Transistors," *Proceedings of the IEEE 51st Midwest Symposium on Circuits and Systems*, pp. 109-112, August 10-13, 2008.
36. Saxena, V., and Baker, R. J., "Indirect Compensation Technique for Low-Voltage Op-Amps," *Proceedings of the 3rd Annual Austin Conference on Integrated Systems and Circuits (ACISC)*, May 7-9, 2008.
35. Cahoon, C., and Baker, R. J., "Low-Voltage CMOS Temperature Sensor Design using Schottky Diode-Based References," *Proceedings of the IEEE/EDS Workshop on Microelectronics and Electron Devices (WMED)*, pp. 16-19, April, 2008.
34. Knowlton, W. B., Araujo, D., Price, P.M., Brotherton, J., Coonse, K., Hendricks, K., Southwick III, R. G., Henderson, J., Oxford, J., Moll, A., Kuang, W., and Baker, R. J., "Progress Towards a Biomolecular Nanowire Sensor Array for Biomedical Applications," invited talk presented at the 6th Annual INBRE/COBRE Research Conference, Moscow, ID, August 6, 2007
33. Knowlton, W. B., Araujo, D., Price, P.M., Brotherton, J., Coonse, K., Southwick III, R.G., Oxford, J., Moll, A., Baker, R. J., and Kuang, W., "Development of Biomolecular Nanostructure Sensor Arrays," presented at the Sensors

and Sensor Technology session for the program of the 88th annual meeting of the AAAS, Pacific Division, June 2007, Boise, ID

32. Knowlton, W. B., Kuang, W., Araujo D., Price, P. M., Brotherton, J., Coonse, K. Bollschweiler, L., Southwick, R., Oxford, J. Moll, A., and Baker, R. J., "Nanofabrication of 3D Sensor Arrays for Detection," Advanced Fuel Cycle Workshop, May 8-9, 2007, Boise, ID
31. Loo, S. M., Cole, J., Youngberg, R., Baker, R. J., Gribb, M. M., "Field-programmable gate array in a miniature ion mobility spectrometer sensor system," *Proceedings of the 2006 International Conference on Embedded Systems & Applications*, June 26-29, 2006, Las Vegas, NV.
30. Saxena, V., and Baker, R. J., "Indirect Feedback Compensation of CMOS Op-Amps," *Proceedings of the IEEE/EDS Workshop on Microelectronics and Electron Devices (WMED)*, pp. 3-4, April, 2006.
29. Duvvada, K., Saxena, V., and Baker, R. J., High Speed Digital Input Buffer Circuits, *Proceedings of the IEEE/EDS Workshop on Microelectronics and Electron Devices (WMED)*, pp. 11-12, April, 2006.
28. Saxena, V., Plum, T. J., Jessing, J. R., and Baker, R. J., "Design and Fabrication of a MEMS Capacitive Chemical Sensor System," *Proceedings of the IEEE/EDS Workshop on Microelectronics and Electron Devices (WMED)*, pp. 17-18, April, 2006.
27. Gorseth, T. L., Estrada, D., Kiepert, J., Ogas, M. L., Cheek, B. J., Price, P. M., Baker, R. J., Bersuker, G., and Knowlton, W.B., "Preliminary Study of NOR Digital Response to Single pMOSFET Dielectric Degradation," presented at the *Workshop on Microelectronic Devices* (Boise, Idaho; April 14, 2006)
26. Sevier, D., Gribb, M., Plumlee, D., Moll, A. J., Hill, H. H., Hong, F., Baker, R. J., Loo, S. M., Walters, R. and Imonigie, J., "An In-Situ Ion Mobility Spectrometer Sensor System for Detecting Gaseous VOCs in the Vadose Zone," *Fourth International Conference on Unsaturated Soils (UNSAT '06) Conference, April 2-6, 2006, Carefree, AZ.*
25. Gribb, M., Hill, H. H., Baker, R. J., Loo, S. M., and Moll, A. J., "Ion Mobility Spectrometer (IMS) Sensor Project," presented at the *Environmental & Subsurface Science Symposium*, Inland Research Alliance, Sept. 19-21, 2005, Big Sky, Montana.
24. Ogas, M. L., Price, P. M., Kiepert J., Baker R. J., Bersuker G., and Knowlton W.B., *Degradation of Rise Time in NAND Gates Using 2.0 nm Gate Dielectrics*, oral presentation and publication at the 2005 IEEE Integrated Reliability Workshop, October 2005.
23. Butler, D. L. and Baker, R. J., *Low-Voltage Bandgap Reference Design Utilizing Schottky Diodes*, *Proceedings of the IEEE 48th International Midwest Symposium on Circuits and Systems*, Aug. 7-10, 2005.
22. Cheek, B. J., Southwick III, R. G., Ogas, M. L., Nagler, P. E., Whelchel, D., Kumar, S., Baker, R. J., and Knowlton, W. B., "Preliminary Soft Breakdown (SBD) Effects In CMOS Building Block Circuits," poster presentation at *2004 IEEE International Integrated Reliability Workshop*, Oct. 18-21, 2004.
21. Ogas, M., Southwick, R. G., Cheek, B. J., Lawrence, C. E., Kumar, S., Haggag, A., Baker, R. J., and Knowlton, W. B., "Multiple Waveform Pulse Voltage Stress Technique for Modeling Noise in Ultra-Thin Oxides," poster presentation at the *Workshop on Microelectronics and Electron Devices*, Boise, Idaho, April 16, 2004.
20. Ogas, M. L., Southwick III, R. G., Cheek, B. J., Baker, R. J., Bersuker, G., and Knowlton, W. B., "Survey of Oxide Degradation in Inverter Circuits Using 2.0nm MOS Devices," in *Proceedings of the 2004 IEEE International Integrated Reliability Workshop*, pp. 32-36.
19. Cheek, B. J., Stutzke, N., Santosh, K., Baker, R. J., Moll, A. J., and Knowlton, W. B., Investigation of Circuit-Level Oxide Degradation and its Effect on CMOS Inverter Operation Performance and MOSFET Characteristics, *2004 IEEE International Reliability Physics Symposium*, April, 25-29.
18. Stutzke, N., Cheek, B. J., Wiscombe, M., Lowman, T., Kumar, S., Baker, R. J., Moll, A. J., and Knowlton, W. B., *Effects of Circuit-Level Stress on Inverter Performance and MOSFET Characteristics*, 2003 IEEE International Integrated Reliability Workshop, Oct, 20-23.
17. Ogas, M. L., Southwick, R. G., Cheek, B. J., Lawrence, C. E., Kumar, S., Haggag, A., Baker, R. J., and Knowlton, W. B., *Investigation of Multiple Waveform Pulse Voltage Stress (MWPVS) Technique in Ultra-Thin Oxides*, poster presentation at the 2003 IEEE International Integrated Reliability Workshop Oct, 20-23.
16. Baker, R. J., *Mixed-Signal Design in the Microelectronics Curriculum*, IEEE University/Government/Industry Microelectronics (UGIM) Symposium, June 30 - July 2.

15. Hartman, J. A., Baker, R. J., Gribb, M., Hill, H. H., Jessing, J., Moll, A. J., Prouty, and Russell, D., *A Miniaturized Ion Mobility Spectrometer (IMS) Sensor for Wireless Operation*, FAME (Frontiers in Assessment Methods for the Environment) Symposium, Sponsored by NSF, Minneapolis, Minnesota, August 10-13, 2003.
14. Lawrence, C.E., Cheek, B. J., Lawrence, T. E., Kumar, S., Haggag, A., Baker, R. J., and Knowlton, W. B., *Gate Dielectric Degradation Effects on nMOS Devices Using a Noise Model Approach*, IEEE University/Government/Industry Microelectronics (UGIM) Symposium, June 30 - July 2, 2003.
13. Cheek, B., Lawrence, C., Lawrence, T., Gomez, J., Caldwell, T., Kiri, D., Kumar, S., Baker, R. J., Moll, A. J., and Knowlton, W. B., *Gate Dielectric Degradation Effects on nMOS Devices and Simple IC Building Blocks (SICBBs)*, IEEE Electron Devices Society Boise Meeting, Boise, ID Oct. 25, 2002.
12. Lawrence, C., Cheek, B., Caldwell, T., Lawrence, T., Kiri, D., Kumar, S., Baker, R. J., Moll, A. J., and Knowlton, W. B., *Pulse voltage stressing of ultrathin gate oxides in NMOS devices, poster session at IEEE International Integrated Reliability Workshop*, October 21-24, 2002.
11. Cheek, B., Lawrence, C., Lawrence, T., Caldwell, T., Kiri, D., Kumar, S., Baker, R. J., Moll, A. J., and Knowlton, W. B., *Circuit level reliability of ultrathin gate oxides for SICBBs: Preliminary study concentrated on the effect of stress on the NMOSFET of an inverter, poster session at the IEEE International Integrated Reliability Workshop*, October 21-24, 2002.
10. Baker, R. J., "Sensing Circuits for Resistive Memory," *IEEE Electron Devices Society Meeting*, Boise, Idaho October 25, 2002.
9. Rivera, B., Baker, R. J., Melngailis, J., "Design and Layout of Schottky Diodes in a Standard CMOS Process," 2001 International Semiconductor Device Research Symposium, Washington DC, Dec. 2001.
8. Hess, H. and Baker, R. J., "Easier Method to Simultaneously Trigger Series-Connected MOS Devices," *Power Systems World Conference 2000*, Boston, Massachusetts, September 2000.
7. Baker, R. J., and Hess, H., "Transformerless Capacitive Coupling of Gate Signals for Series Operation of Power MOSFET Devices." *International Electric Machines and Drives Conference*, Seattle, Washington, May 1999, pp. 673-676.
6. Baker, R. J., "A windows based integrated circuit design tool for distance education," *International Conference on Simulation and Multimedia in Engineering Education*."
5. Chen, H. and Baker, R. J., "A CMOS Standard-Cell Library for the PC-based LASI Layout System," *Proceedings of the 41st International Midwest Symposium on Circuits and Systems*, August 9-12, 1998.
4. Liu, S. and Baker, R. J., "Process and temperature performance of a CMOS beta-multiplier voltage reference," *Proceedings of the 41st International Midwest Symposium on Circuits and Systems*, August 9-12, 1998.
3. Boyce, D.E. and Baker, R. J., "A Complete Layout System for the PC," *IEEE 40th International Midwest Symposium on Circuits and Systems*, 1997.
2. Baker, R. J., and Blair, J. J., "Step response considerations and the design of a suitable step generator for high speed digitizer testing," *LLNL's Third Annual Workshop on High Speed Digitizers*, April 3-4, Las Vegas, Nevada, 1991.
1. Baker, R. J., "Step-recovery diodes sharpen pulses," *Engineering Design News Magazine*, pp. 154-156, May 10, 1990.

EXPERT WITNESS EXPERIENCE

The law firms and clients (underlined) whom I have provided expert witness services in electrical and computer engineering are listed below. I have been deposed 71 times, given expert testimony at 10 trials (6 USITC, 2 D. Del., 1 S.D. Cal., and 1 E.D. Tex.), and participated in 1 mediation.

Unified Patents, LLC (Washington, DC)

Case – Ex Parte Reexamination

Case Number – 90/019,015. Request filed on July 20, 2021.

Case Subject Matter – Voltage-controlled oscillator (VCO) temperature compensation.

Work Performed – Provided expert consulting services and wrote declaration.

Winston & Strawn LLP (Dallas, TX and Palo Alto, CA)

Case – Micron Technology, Inc.; Micron Semiconductor Products, Inc.; Micron Technology Texas LLC v. Unification Technologies LLC

Case Numbers – IPR2021-00940, IPR2021-00941, and IPR2021-00942. Petitions filed on June 4, 2024.

Case Subject Matter – Solid-State Drive (SSD), flash non-volatile memory management, memory controller operation and addressing.

Work Performed – Provided expert consulting services for inter partes reviews and wrote declarations.

O'Melveny & Myers LLP (San Francisco, CA)

Case – Super Interconnect Technologies LLC v. Google LLC

Case Number – Texas, ED (Marshall) 2:18-cv-00463 (complaint filed November 2, 2018) and Texas, WD (Waco) 6:21-cv-00259 (complaint filed March 15, 2021).

Case Subject Matter – Transmission of data and clock signals. Serial signals such as transition minimized differential signaling. Communications between processors and non-volatile storage such as Universal Flash Storage (UFS) and embedded MultiMedia Controller (eMMC).

Work Performed – Provided expert consulting services and wrote expert reports.

Orrick, Herrington & Sutcliffe LLP (Houston, TX, Irvine, CA, and Menlo Park, CA)

Case – TCT Mobile Inc. and TCL Communication, Inc. v. Fundamental Innovation Systems International LLC

Case Numbers – IPR2021-00597, IPR2021-00598, and IPR2021-00599. Petitions filed on February 26, 2021.

Case Number – IPR2021-00428. Petition filed on January 13, 2021.

Case Number – IPR2021-00410. Petition filed on January 11, 2021.

Case Number – IPR2021-00395. Petition filed on December 31, 2020.

Case Subject Matter – Universal Serial Bus (USB) for charging mobile devices.

Work Performed – Provided expert consulting services including writing declarations for inter partes reviews.

Paul Hastings LLP (Austin, TX and Washington, DC)

Case – Samsung, Inc. v. Pictos Technologies, Inc.

Case Number – IPR2021-00557. Petition filed on February 18, 2021.

Case Number – IPR2021-00436. Petition filed on January 19, 2021.

Case Numbers – IPR2021-00437 and IPR2021-00438. Petitions filed on January 15, 2021.

Case Subject Matter – Solid-state imaging devices including red, green, and blue pixels, data conversion circuits, and interpolation circuits. CMOS imagers including fabrication and design, active pixels, and semiconductor physics.

Work Performed – Provided expert consulting services and wrote declarations for inter partes reviews.

O'Melveny & Myers LLP (San Francisco, CA) and DLA Piper (New York, NY)

Case – Solas OLED Ltd. v. BOE Technology Group Co. Ltd. and Samsung Electronics

Case Number – ITC Investigation No. 337-TA-1243. Complaint filed January 5, 2021.

Case Subject Matter – Active matrix OLED display devices and components

Work Performed – Provided expert consulting services.

Paul Hastings LLP (Washington, DC)

Case – Samsung, Inc. v. Garrity Power Services LLC

Case Number – IPR2021-00389. Petition filed on December 31, 2020.

Case Subject Matter – Power electronics including full-bridge PWM modules for wireless power transmission using magnetic coupling via antennas and transformers. Design of inductors and coils.

Work Performed – Provided expert consulting services and wrote declaration for inter partes reviews.

Morgan, Lewis & Bockius LLP (Palo Alto, CA and Shanghai, CN)

Case – Monolithic Power Systems, Inc. v. Meraki Integrated Circuit Technology, Inc. and Promate Electronic Company, LTD.

Case Number – Texas, WD (Waco) 6:20-cv-00876. Complaint filed on December 24, 2020.

Case Subject Matter – Design of switching power supplies including synchronous rectification.

Work Performed – Provided expert consulting services including declaration for claim construction, trade secret analysis and declaration, and Markman tutorial.

Winston & Strawn LLP (Dallas, TX and Palo Alto, CA)

Case – Micron Technology, Inc.; Micron Semiconductor Products, Inc.; Micron Technology Texas LLC; Dell Technologies Inc.; Dell Inc.; and HP Inc. v. Unification Technologies LLC

Case Numbers – IPR2021-00343, IPR2021-00344, and IPR2021-00345. Petitions filed on December 22, 2020.

Case Subject Matter – Solid-State Drive (SSD), flash non-volatile memory management, memory controller operation and addressing.

Work Performed – Provided expert consulting services for inter partes reviews and wrote declarations.

O'Melveny & Myers LLP (Los Angeles, CA)

Case – Cosemi Technologies, Inc. v. EverPro Technologies, Fibbr Technologies, Logitech, Inc., and Facebook Technologies

Case Number – ITC Investigation No. 337-TA-1233. Complaint filed October 28, 2020.

Case Subject Matter – Data cables, including HDMI, Display Port, and USB Type A, USB Type C and USB Type A/C data cables.

Work Performed – Provided expert consulting services.

Kirkland & Ellis LLP (Boston, MA and New York, NY)

Case – Pictos Technologies, Inc. v. Samsung Electronics Co., LTD. and Samsung Semiconductor, Inc.

Case Number – ITC Investigation No. 337-TA-1231. Complaint filed September 25, 2020.

Case Subject Matter – Solid-state imaging devices including red, green, and blue pixels, correction of bad pixels, data conversion circuits, and interpolation circuits. CMOS imagers including fabrication and design, active pixels, and semiconductor physics.

Work Performed – Provided expert consulting services and wrote expert report.

Orrick, Herrington & Sutcliffe LLP (Houston, TX, Irvine, CA, and Menlo Park, CA)

Case – Fundamental Innovation Systems International LLC v. TCT Mobile Inc. and TCL Communication, Inc.

Case Number – Delaware, 1:20-cv-00552. Complaint filed on September 11, 2020.

Case Subject Matter – Universal Serial Bus (USB) for charging mobile devices.

Work Performed – Provided expert consulting services including writing declarations.

Walters Wilson LLP (Redwood City, CA)

Case – Western Digital Corporation and SanDisk, LLC v. Martin Kuster

Case Numbers – IPR2020-01410 and IPR2020-01411. Petitions filed on August 3, 2020.

Case Subject Matter – Computer connectors such as universal serial bus (USB) that connect to peripheral devices such as mice, keyboards, displays, printers, external storage, etc.

Work Performed – Provided expert consulting services for inter partes review, wrote declarations and was deposed.

O'Melveny & Myers LLP (Los Angeles, CA)

Case – Advanced Micro Devices, Inc. v. Monterey Research, LLC

Case Number – IPR2020-01315. Petition filed on July 16, 2020.

Case Number – IPR2020-00985. Petition filed on May 26, 2020.

Case Subject Matter – Reading and writing to semiconductor memory such as SRAM and DRAM. Buffer circuits with variable current supplies for controlling the rise and fall times of output signals.

Work Performed – Provided expert consulting services for inter partes review, wrote declarations and was deposed twice.

Winston & Strawn LLP (Dallas, TX and Palo Alto, CA)

Case – Unification Technologies LLC v. Micron Technology, Inc.; Micron Semiconductor Products, Inc.; Micron Technology Texas LLC

Case Number – Texas, WD (Waco) 6:20-cv-00500. Complaint filed June 5, 2020.

Case Subject Matter – Solid-State Drive (SSD), flash non-volatile memory management, memory controller operation and addressing.

Work Performed – Provided expert consulting services, wrote declaration for claim construction, and was deposed.

Ari Law, P.C. (Palo Alto, CA) and Hill, Kertscher & Wharton, LLP (Atlanta, GA)

Case – Sanho Corporation v. Kaijet Technology, Magic Control Technology, and Starview Global

Case Numbers – Georgia, ND (Atlanta) 1:18-cv-05385 (third amended complaint filed November 14, 2019) and Georgia, ND (Atlanta) 1:20-cv-02150 (filed May 19, 2020).

Case Subject Matter – Port extension apparatus for headphone jack, USB (Universal Serial Bus or Type-C ports), and video ports such as VGA (Video Graphics Array), DVI (Digital Visual Interface), HDMI (High-Definition Multimedia Interface), DP (Display Port), and mini-DP.

Work Performed – Provided expert consulting services and wrote declaration for claim construction.

Orrick, Herrington & Sutcliffe LLP (Houston, TX, Irvine, CA, and Menlo Park, CA)

Case – Fundamental Innovation Systems International LLC v. Coolpad Group Limited, Coolpad Technologies, Inc., and Yulong Computer Telecommunication Scientific Co. Ltd.

Case Number – Texas, ED (Marshall) 2:20-cv-00117. Complaint filed on April 23, 2020.

Case Subject Matter – Universal Serial Bus (USB) for charging mobile devices.

Work Performed – Provided expert consulting services including writing declaration for claim construction.

Pillsbury Winthrop Shaw Pittman LLP (San Francisco, CA and Shanghai, China)

Case – SMIC, Americas v. Innovative Foundry Technologies LLC

Case Numbers – IPR2020-00837 and IPR2020-00839. Petitions filed on April 14, 2020.

Case Subject Matter – Methods of manufacturing a semiconductor component, such as a short-channel MOS device, including forming graded-junctions using spacers along the sidewalls of a transistor's gate.

Work Performed – Provided expert consulting services for inter partes reviews and wrote declarations.

Russ August & Kabat (Los Angeles, CA)

Case – Seoul Semiconductor Co., Ltd. v. Document Security Systems, Inc.

Case Number – IPR2020-00938. Petition filed on May 18, 2020.

Case – Nichia Corporation v. Document Security Systems, Inc.

Case Number – IPR2020-00908. Petition filed on May 18, 2020.

Case – Cree, Inc. v. Document Security Systems, Inc.

Case Number – IPR2020-00557. Petition filed on February 11, 2020.

Case Subject Matter – Light emitting diodes (LEDs) as a light source, extraction of light.

Work Performed – Provided expert consulting services, wrote declaration for inter partes reviews, and was deposed three times.

Paul Hastings LLP (Austin, TX and Washington, DC)

Case – Flex Logix Technologies, Inc. v. Konda Technologies Inc.

Case Numbers – IPR2020-00260, IPR2020-00261, and IPR2020-00260. Petitions filed on December 16, 2019.

Case Numbers – PGR2019-00037, PGR2019-00040, and PGR2019-00042. Petitions filed on March 18, 2019.

Case Subject Matter – FPGA layout routing for integrated circuits and networks, electrical and computer engineering.

Work Performed – Provided expert consulting services and wrote declarations for post grant and inter partes reviews.

DLA Piper (Chicago, IL, Houston, TX, and Washington, DC) and White & Case LLP (New York, NY and Washington, DC)

Case – M-Red Inc. v. Panasonic Corporation

Case Number – Texas, ED (Marshall) 2:19-cv-00251. Complaint filed on July 16, 2019.

Case Subject Matter – Integrated circuit electronics adjustment, such as ring oscillators, using auto calibration. Evaluating a known good die using both wire and flip-chip interconnects.

Work Performed – Provided expert consulting services and wrote declaration for claim construction.

Paul Hastings LLP (Austin, TX and Washington, DC)

Case – Samsung, Inc. v. NuCurrent, Inc.

Case Number – IPR2019-01217. Petition filed on June 19, 2019.

Case Numbers – PGR2019-00049 and PGR2019-00050. Petitions filed on May 28, 2019.

Case Numbers – IPR2019-00858, IPR2019-00859, IPR2019-00860, IPR2019-00861, IPR2019-00862, and IPR2019-00863. Petitions filed on March 22, 2019.

Case Subject Matter – Wireless power transmission using magnetic coupling via antennas and transformers. Design of inductors and coils.

Work Performed – Provided expert consulting services and wrote declarations for post grant and inter partes reviews. Was deposed five times.

DLA Piper (East Palo Alto, CA)

Case – InvenSense Corporation and Tessera Advanced Technologies, Inc. v. NVIDIA Corporation

Case Number – Delaware, 1:19-cv-00861. Complaint filed on May 8, 2019.

Case Subject Matter – Reference voltage circuits (programmable bandgaps) having a substantially zero temperature coefficient using bipolar and MOS transistors.

Work Performed – Provided expert consulting services.

Irell & Manella LLP (Los Angeles, CA)

Case – VLSI Technology LLC v. Intel Corporation

Case Number – Texas, WD (Waco) 6:19-cv-00256. Complaint filed on April 11, 2019.

Case Subject Matter – Static Random Access Memory (SRAM) having a variable power supply using charge-sharing capacitors, methods for designing digital systems, and hardware managed interrupt control.

Work Performed – Provided expert consulting services, wrote expert reports, declaration, and was deposed.

Paul Hastings LLP (Austin, TX and Washington, DC)

Case – Samsung, Inc. v. ProMOS Technologies, Inc.

Case Numbers – IPR2019-00779, IPR2019-00780, IPR2019-00781, IPR2019-00784, and IPR2019-00785. Petitions filed on March 5, 2019.

Case Subject Matter – Programmable latches that include non-volatile programmable elements, digital delay elements, and decoders for memory chips.

Work Performed – Provided expert consulting services, wrote declarations for inter partes reviews, and was deposed four times.

Pillsbury Winthrop Shaw Pittman LLP (San Francisco, CA)

Case – Kingston Technology Company, Inc. v. Memory Technologies, LLC

Case Numbers – IPR2019-00645, IPR2019-00648, IPR2019-00651, and IPR2019-00654. Petitions filed on January 31, 2019.

Case Numbers – IPR2019-00642, IPR2019-00643, and IPR2019-00644. Petitions filed on January 30, 2019.

Case Number – IPR2019-00638. Petition filed on January 29, 2019.

Case Subject Matter – Memory cards including PC cards, compact flash (“CF”) cards, secure digital (“SD”) cards, programmable credit cards, and embedded multimedia cards (“eMMC”). Uses of EEPROM and Flash memory in built-in operating system (BIOS).

Work Performed – Provided expert consulting services for inter partes reviews and wrote declarations.

Russ August & Kabat (Los Angeles, CA)

Case – Ring LLC v. SkyBell Technologies, Inc.

Case Numbers – IPR2019-00443, IPR2019-00444, IPR2019-00445, IPR2019-00446, and IPR2019-00447. Petitions filed on December 17, 2018.

Case Subject Matter – Electronic doorbell system with digital chime, video, motion detection, wired and wireless communication, and control panel.

Work Performed – Provided expert consulting services, wrote declarations for inter partes reviews, and was deposed three times.

Baker Botts LLP (Austin, TX)

Case – Semiconductor Components Industries, LLC d/b/a ON Semiconductor v. Power Integrations, Inc.

Case Numbers – IPR2018-01810, IPR2018-01812, IPR2018-01816, and IPR2018-01818. Petitions filed on September 28, 2018.

Case Subject Matter – Switched-mode power supplies (e.g., flyback, buck, boost), controllers, transformers, and sensing multiple voltage values.

Work Performed – Provided expert consulting services and wrote declarations for inter partes reviews.

Kirkland & Ellis LLP (Washington, DC) and Fish & Richardson P.C. (Washington, DC)

Case – Samsung Electronics Co., LTD. and SK hynix Inc. v. BiTMICRO, LLC

Case Number – IPR2018-01720. Petition filed on September 19, 2018.

Case Number – IPR2018-01545. Petition filed on August 23, 2018.

Case Subject Matter – Solid state storage drives, stacked consumer electronics components (3D packaging, solder balls, flip-chip, TSVs, etc.), and products.

Work Performed – Provided expert consulting services including writing declarations for inter partes reviews.

Knobbe, Martens, Olson, & Bear, LLP (Los Angeles, CA) and White & Case LLP (Palo Alto, CA and Washington, DC)

Case – Toshiba America Information Systems, Inc. and MSI Computer Corp. v. Wallex Microelectronics Ltd.

Case Number – IPR2018-01538. Petition filed on August 10, 2018.

Case Subject Matter – Double-sided male USB and various card-shaped devices and connectors, electrical and computer engineering.

Work Performed – Provided expert consulting services including writing declarations for inter partes review and was deposed.

Jones Day LLP (Cleveland, OH and Pittsburgh, PA)

Case – Intel Corp. v. Qualcomm, Inc.

Case Numbers – IPR2018-01344 and IPR2018-01346. Petitions filed on July 6, 2018.

Case Numbers – IPR2018-01261, IPR2018-01293, and IPR2018-01295. Petitions filed on June 29, 2018.

Case Subject Matter – Communications, e.g., PCI Express (PCIe), USB, Firewire (IEEE-1394), between two processing nodes within a computing device such as a cell phone, tablet, or computer.

Work Performed – Provided expert consulting services for inter partes reviews including writing declaration and was deposed.

Orrick, Herrington & Sutcliffe LLP (Menlo Park, CA) and Weil, Gotshal & Manges LLP (Redwood Shores, CA)

Case – Micron Technology, Inc. v. North Star Innovations, Inc.

Case Numbers – IPR2018-00998 and IPR2018-00999. Petitions filed on May 1, 2018.

Case Number – IPR2018-00989. Petition filed on April 27, 2018.

Case Subject Matter – Output circuits for memory integrated circuits and voltage boosting circuits.

Work Performed – Provided expert consulting services including writing declarations for inter partes reviews, and was deposed.

Paul Hastings LLP (Austin, TX and Washington, DC)

Case – Samsung, Inc. v. Red Rock Analytics, LLC

Case Numbers – IPR2018-00555, IPR2018-00556, and IPR2018-00557. Petitions filed on February 5, 2018.

Case Subject Matter – Calibration of IQ balance in transceivers in wireless communications (OFDM, 802.11, Bluetooth, 3G, 4G, etc.).

Work Performed – Provided expert consulting services and wrote declarations for inter partes reviews.

Covington & Burling LLP (Palo Alto, CA and Washington, DC)

Case – Phenix (sic) Longhorn, LLC v. Texas Instruments, Inc.

Case Number - Texas, ED (Marshall) 2:18-cv-00020. Complaint filed January 22, 2018.

Case Subject Matter – Circuit with non-volatile memory for gamma correction in a display screen.

Work Performed – Provided expert consulting services, wrote declaration for claim construction, expert reports, and was deposed twice.

Kirkland & Ellis LLP (Washington, DC) and Fish & Richardson P.C. (Washington, DC)

Case – BiTMICRO, LLC v. Samsung Electronics Co., LTD., SK hynix Inc., Dell Inc., Lenovo Group Inc., HP Inc., ASUSTek Computer Inc., ASUS Computer International, ACER Inc., VAIO Corporation, and Transcosmos America Inc.

Case Number – ITC Investigation No. 337-TA-1097. Complaint filed January 8, 2018.

Case Subject Matter – Solid state storage drives (SSDs), stacked electronics components (3D packaging, solder balls, flip-chip, TSVs, etc.), and products.

Work Performed – Provided expert consulting services including direct witness statement, deposition, and testified at trial for pilot 100-day ITC proceeding.

Morrison & Foerster LLP (Los Angeles, CA)

Case – SK hynix, Inc. v. Netlist, Inc.

Case Numbers – IPR2018-00364 and IPR2018-00365. Petitions filed on December 27, 2017.

Case Numbers – IPR2018-00362 and IPR2018-00363. Petitions filed on December 22, 2017.

Case Subject Matter – Memory modules, components, and products.

Work Performed – Provided expert consulting services for patent owner in inter partes reviews, wrote declarations, and was deposed twice.

Quinn Emanuel Urquhart & Sullivan, LLP (San Francisco, CA and Chicago, IL) and Norton Rose Fulbright US LLP (Houston, TX)

Case – Qualcomm, Inc. v. Apple, Inc.

Case Number – ITC Investigation No. 337-TA-1093. Complaint filed November 30, 2017.

Case Subject Matter – Certain mobile electronic devices and radio frequency integrated circuits and processing components thereof. Communications, e.g., PCI Express (PCIe), USB, Firewire (IEEE-1394), between two processing nodes.

Work Performed – Provided expert consulting services.

Baker Botts LLP (Austin, TX, and Houston, TX)

Case – Semiconductor Components Industries, LLC d/b/a ON Semiconductor v. Power Integrations, Inc.

Case Number – IPR2018-00160. Petition filed on November 7, 2017.

Case Subject Matter – Switched-mode power supplies and power supply controllers.

Work Performed – Provided expert consulting services and wrote declaration for inter partes review.

Mintz, Levin, Cohn, Ferris, Glovsky and Popeo, P.C. (Boston, MA)

Case – Netlist, Inc. v. SK hynix, Inc.

Case Number – ITC Investigation No. 337-TA-1089. Complaint filed on October 31, 2017.

Case Subject Matter – Memory modules and components thereof.

Work Performed – Provided expert consulting services including validity analysis, expert report, deposition, and testified at trial.

Baker Botts LLP (Austin, TX, and Houston, TX)

Case – ON Semiconductor and Semiconductor Components Industries v. Power Integrations, Inc.

Case Number – Delaware, 1:17-cv-00247. First amended complaint filed on September 8, 2017.

Case Subject Matter – Switched-mode power supplies and power supply controllers.

Work Performed – Provided expert consulting services.

Quinn Emanuel Urquhart & Sullivan, LLP (San Francisco, CA, Chicago, IL and Seattle, WA)

Case – Qualcomm, Inc. v. Apple, Inc.

Case Number – California, SD 3:17-cv-01375. Complaint filed on August 25, 2017.

Case Subject Matter – Electronics in consumer mobile devices. Communications, e.g., PCI Express (PCIe), USB, Firewire (IEEE-1394), between two processing nodes.

Work Performed – Provided expert consulting services including infringement analysis, validity analysis, expert reports, was twice deposed, and testified at trial.

Baker Botts LLP (Austin, TX, and Houston, TX)

Case – Power Integrations v. ON Semiconductor and Semiconductor Components Industries

Case – ON Semiconductor and Semiconductor Components Industries v. Power Integrations, Inc.

Case Numbers – California, ND (San Jose) 5:16-cv-06371 and California ND (San Jose) 5:17-cv-03189. Second amended complaint filed on August 14, 2017.

Case Subject Matter – Switched-mode power supplies and power supply controllers (power electronics).

Work Performed – Provided expert consulting services and wrote declaration for claim construction.

Fish & Richardson P.C. (Washington, DC)

Case – Ex Parte Reexamination

Case Number – 90/020,112. Request filed on July 31, 2017.

Case Subject Matter – Multi-level non-volatile floating gate memory (MLC), e.g. EPROM, EEPROM, and flash technologies.

Work Performed – Provided expert consulting services and wrote declaration.

K&L Gates LLP (Chicago, IL)

Case – United Microelectronics Corp., UMC Group (USA), Semiconductor Manufacturing International Corp. (Shanghai and Beijing), and SMIC (Americas), v. Lone Star Silicon Innovations LLC

Case Number – IPR2017-01513. Petition filed on July 20, 2017.

Case Subject Matter – CMOS circuit fabrication.

Work Performed – Provided expert consulting services and wrote declaration for inter partes review.

Bosch Jehle and Fieldfisher (Munich and Düsseldorf, Germany)

Case – Netlist, Inc. v. SK hynix, Inc.

Case Number – Complaint filed on July 11, 2017 in the German Federal Patent Court.

Case Subject Matter – Memory modules and components and products containing same.

Work Performed – Provided expert consulting services and attended trial at the German Federal Patent Court in Munich.

Quinn Emanuel Urquhart & Sullivan, LLP (San Francisco, CA, Chicago, IL, and Seattle, WA)

Case – Qualcomm, Inc. v. Apple, Inc.

Case Number – ITC Investigation No. 337-TA-1065. Complaint filed July 7, 2017.

Case Subject Matter – Certain mobile electronic devices and radio frequency and processing components thereof.

Work Performed – Provided expert consulting services including infringement analysis, validity analysis, expert reports, was deposed, and testified at trial.

Mintz, Levin, Cohn, Ferris, Glovsky and Popeo, P.C. (Boston, MA and Washington, DC)

Case – Netlist, Inc. v. SK hynix

Case Number – California, CD 8:17-cv-01030. Complaint filed on June 14, 2017.

Case Subject Matter – Memory modules and components and products containing same.

Work Performed – Provided expert consulting services.

Russ August & Kabat (Los Angeles, CA)

Case – Document Security Systems, Inc. v. Lite-On, Inc.

Case Number – California, CD 2:17-cv-06050. Complaint filed on August 15, 2017.

Case – Document Security Systems, Inc. v. Everlight Electronics Co.

Case Number – California, CD 2:17-cv-04273. Complaint filed on June 8, 2017.

Case – Document Security Systems, Inc. v. Cree, Inc.

Case Number – California, CD 2:17-cv-04263. Complaint filed on June 8, 2017.

Case – Document Security Systems, Inc. v. Seoul Semiconductor Company, LTD.

Case Number – California, CD 8:17-cv-00981. Complaint filed on June 7, 2017.

Case Subject Matter – Light Emitting Diode ("LED") lighting products.

Work Performed – Provided expert consulting services, wrote claim construction declarations and was deposed.

Dovel & Luner LLP (Santa Monica, CA)

Case – X2Y Attenuators, LLC v. Intel Corporation

Case Number – Oregon, D (Portland) 3:18-cv-01394 (moved from Pennsylvania, WD [Erie]). Complaint filed June 22, 2017.

Case Subject Matter – Circuit arrangements that use relative groupings of energy pathways in capacitive filters for filtering noise on printed circuit boards (PCBs), electrical engineering.

Work Performed – Provided expert consulting services.

Kirkland & Ellis LLP (New York, NY and Washington, DC)

Case – Fundamental Innovation Systems International LLC v. Samsung Electronics Co., LTD.

Case Number – Texas, ED (Marshall) 2:17-cv-00145. Complaint filed May 15, 2017.

Case Subject Matter – Universal Serial Bus (USB) connections for data communications and charging.

Work Performed – Provided expert consulting services, wrote expert reports on invalidity and noninfringement, and was deposed.

Paul Hastings LLP (Austin, TX and Washington, DC)

Case – Samsung, Inc. v. ProMOS Technologies, Inc.

Case Numbers – IPR2017-01412, IPR2017-01413, IPR2017-01414, IPR2017-01415, and IPR2017-01416. Petitions filed on May 12, 2017.

Case Subject Matter – Delay-Locked Loop (DLL) design, power supplies, and sensing in semiconductor memory.

Work Performed – Provided expert consulting services, wrote declarations for inter partes reviews, and was deposed three times.

Baker Botts LLP (Austin, TX, Dallas, TX, and Palo Alto, CA)

Case – SanDisk LLC v. Memory Technologies, LLC

Case Number – IPR2017-01420. Petition filed on May 10, 2017.

Case Number – IPR2017-01360. Petition filed on May 3, 2017.

Case Number – IPR2017-01116. Petition filed on March 20, 2017.

Case Number – IPR2017-01022. Petition filed on March 3, 2017.

Case Number – IPR2017-00868. Petition filed on February 9, 2017.

Case Subject Matter – Memory cards including PC cards, compact flash ("CF") cards, secure digital ("SD") cards, programmable credit cards, and multimedia cards ("MMC"). Uses of EEPROM and Flash memory in built-in operating system (BIOS).

Work Performed – Provided expert consulting services for inter partes review and wrote declarations.

DLA Piper (Atlanta, GA and East Palo Alto, CA)

Case – Macronix International Co. v. Toshiba, Inc.

Case Number – ITC Investigation No. 337-TA-1046. Complaint filed March 7, 2017.

Case Subject Matter – Non-volatile memory, such as flash and resistive (phase-change memory [PCM] using chalcogenide materials and programmable contacts in cross-point arrays) memory, and products containing the same.

Work Performed – Provided expert consulting services. Also provided Markman tutorial, expert reports, was deposed, and testified at trial.

Morrison & Foerster LLP (Los Angeles, CA)

Case – SK hynix, Inc. v. Netlist, Inc.

Case Number – IPR2017-00577. Petition filed on January 5, 2017.

Case Subject Matter – Memory modules, components, and products.

Work Performed – Provided expert consulting services for patent owner in an inter partes review, wrote declaration, and was deposed.

McAndrews Held & Malloy LTD (Chicago, IL)

Case – SK hynix, Inc. v. Netlist, Inc.

Case Number – IPR2017-00692. Petition filed on January 17, 2017.

Case Number – IPR2017-00587. Petition filed on January 6, 2017.

Case Number – IPR2017-00561. Petition filed on January 5, 2017.

Case Numbers – IPR2017-00560 and IPR2017-00562. Petitions filed on January 3, 2017.

Case Subject Matter – Volatile and non-volatile memory systems.

Work Performed – Provided expert consulting services for patent owner in an inter partes review, wrote declarations, and was deposed twice.

O'Melveny & Myers LLP (Newport Beach and Los Angeles, CA)

Case – Janus Semiconductor, LLC v. Micron Technology, Inc.

Case Number – Texas, ED (Marshall) 2:16-cv-01409. Complaint filed December 13, 2016.

Case Subject Matter – Self-timed and self-enabled distributed clocking in electronic integrated circuits.

Work Performed – Provided expert consulting services.

Baker Botts LLP (Austin, TX, Dallas, TX, and Palo Alto, CA)

Case – Memory Technologies, LLC v. SanDisk LLC and Western Digital Corporation

Case Number – ITC Investigation No. 337-TA-1034. Complaint filed November 30, 2016.

Case Subject Matter – SD Cards, microSD cards, programmable credit cards, eMMC (embedded Multi-Media Controller), and eMCP (embedded Multi-Chip Packages) products.

Work Performed – Provided expert consulting services and wrote declaration.

Kilpatrick Townsend & Stockton LLP (Denver, CO and Shanghai, China)

Case – Broadcom, Ltd. v. Invensas

Case Number – IPR2017-00171. Petition filed on October 31, 2016.

Case Subject Matter – Semiconductor random access memory circuit timing and operation.

Work Performed – Provided expert consulting services, wrote declaration, and was deposed.

Paul Hastings LLP (Washington, DC)

Case – Samsung, Inc. v. ProMOS Technologies, Inc.

Case Numbers – IPR2017-00036, IPR2017-00038, and IPR2017-00039. Petitions filed on October 7, 2016.

Case Subject Matter – Sensing in semiconductor memory integrated circuits.

Work Performed – Provided expert consulting services, wrote declarations for inter partes reviews, and was deposed three times.

Munck Wilson Mandala LLP (Dallas, TX)

Case – ams AG, ams-TAOS, and Samsung v. JIL Technologies and 511 Innovations, Inc.

Case Numbers – IPR2016-01788, IPR2016-01792, IPR2016-01793, IPR2016-01804, IPR2016-01810, IPR2016-01818, and IPR2016-01819. Petitions filed on September 14, 2016.

Case Number – IPR2016-01787. Petition filed on September 13, 2016.

Case Subject Matter – Color and optical measuring systems.

Work Performed – Provided expert consulting services and wrote declarations for inter partes reviews.

Mintz, Levin, Cohn, Ferris, Glovsky and Popeo, P.C. (Boston, MA and Washington, DC)

Case – Netlist, Inc. v. SK hynix, Inc.

Case Number – ITC Investigation No. 337-TA-1023. Complaint filed on September 1, 2016.

Case Subject Matter – Memory modules and components and products containing same.

Work Performed – Provided expert consulting services including validity analysis, expert report, deposition, technology tutorial at trial, and trial testimony.

Mintz, Levin, Cohn, Ferris, Glovsky and Popeo, P.C. (Boston, MA and Washington, DC)

Case – Netlist, Inc. v. SK hynix

Case Number – California, CD (Santa Ana) 8:16-cv-01605. Complaint filed on August 31, 2016.

Case Subject Matter – Memory modules and components and products containing same.

Work Performed – Provided expert consulting services and wrote declaration for claim construction.

Baker & Hostetler LLP (Cleveland, OH)

Case – Evolv, LLC v. Joyetech and Wismec

Case Number – California, CD 8:16-cv-00459.

Complaint filed on March 9, 2016. Case Subject Matter – Electronic personal vaporizers (also known as electronic cigarettes) containing power and USB battery charging electronics and switching power supplies using CMOS and power MOSFETs.

Work Performed – Provided expert consulting services including lab testing and infringement analysis. Wrote declaration.

Vinson & Elkins LLP (San Francisco, CA)

Case – Polaris Innovations Limited v. Kingston Technology Company, Inc.

Case Number – California, CD 8:16-cv-300. Complaint filed on February 19, 2016.

Case Subject Matter – Semiconductor memory, circuits, and the design and fabrication of memory modules.

Work Performed – Provided expert consulting services.

Mintz, Levin, Cohn, Ferris, Glovsky and Popeo, P.C. (Boston, MA)

Case – Advanced Silicon Technologies LLC v. BMW, Fujitsu, Harman, Honda, NVIDIA, Renesas, Texas Instruments, Toyota, Volkswagen, and Audi

Case Number – ITC Investigation No. 337-TA-984. Complaint filed on December 28, 2015.

Case Subject Matter – Computing or graphics systems, components thereof, and vehicles containing same.

Work Performed – Provided expert consulting services and wrote declaration for claim construction.

DLA Piper (East Palo Alto, CA, Chicago, IL, and Reston, VA)

Case – Lincoln Electric v. ESAB, Inc.

Case Number – Texas, ED (Marshall) 2:15-cv-01404. Complaint filed on December 15, 2015.

Case Subject Matter – Power electronics including switching power supplies using power MOSFETs for welding equipment.

Work Performed – Provided expert consulting, claim construction, noninfringement analysis, invalidity analysis, expert reports, and was deposed twice.

Weil, Gotshal & Manges LLP (Houston, TX and Redwood Shores, CA)

Case – Micron Technology, Inc. v. Innovative Memory Systems LLC

Case Numbers – IPR2016-00320, IPR2016-00322, IPR2016-00325, IPR2016-00326, and IPR2016-00327. Petitions filed on December 14, 2015.

Case Subject Matter – Data conversion, semiconductor fabrication, flash memory, and semiconductor memory device operation/control.

Work Performed – Provided expert consulting services, wrote declarations for inter partes reviews, and was deposed three times.

Munck Wilson Mandala LLP (Dallas, TX) and O'Melveny & Myers LLP (Los Angeles, CA)

Case – 511 Innovations, Inc. v. Samsung, Huawei, ZTE, and ams-TAOS

Case Number – Texas, ED (Marshall) 2:15-cv-01526. Complaint filed on September 14, 2015.

Case Subject Matter – Color and optical measuring systems.

Work Performed – Provided expert consulting, claim construction, wrote declaration, expert reports, and was deposed twice.

Davis Wright Tremaine LLP (San Francisco, CA and Seattle, WA) and Mayer Brown LLP (Washington, DC)

Case – 511 Innovations, Inc. v. Microsoft and Avago

Case Number – Texas, ED (Marshall) 2:15-cv-01525. Complaint filed on September 14, 2015.

Case Subject Matter – Color and optical measuring systems.

Work Performed – Provided expert consulting services.

Weil, Gotshal & Manges LLP (Houston, TX, Redwood Shores, CA, and Washington, DC)

Case – Micron Technology, Inc. v. Limestone Memory Systems LLC

Case Numbers – IPR2016-00093, IPR2016-00094, IPR2016-00095, IPR2016-00096, and IPR2016-00097. Petitions filed on October 27, 2015.

Case Subject Matter – Semiconductor memory.

Work Performed – Provided expert consulting services and wrote declarations for inter partes reviews.

DLA Piper (East Palo Alto and Los Angeles, CA)

Case – Apple, Inc. v. Longitude Flash Memory Systems S.A.R.L.

Case Number – IPR2015-01933. Petition filed on September 21, 2015.

Case Numbers – IPR2015-01924 and IPR2015-01925. Petitions filed on September 17, 2015.

Case Numbers – IPR2015-01908 and IPR2015-01909. Petitions filed on September 14, 2015.

Case Subject Matter – Non-volatile semiconductor flash memory fabrication and design.

Work Performed – Provided expert consulting services and wrote declarations for inter partes reviews.

Paul Hastings LLP (New York City, NY and Washington, DC)

Case – Samsung, Inc. v. Elbrus International Limited

Case Numbers – IPR2015-01523 and IPR2015-01524. Petitions filed on June 26, 2015.

Case Subject Matter – High-speed, low-power data transfer.

Work Performed – Provided expert consulting services, wrote declarations for inter partes reviews, and was deposed.

Kilpatrick Townsend & Stockton LLP (Menlo Park and San Francisco, CA)

Case – Consultant for SK hynix, Inc. on matters relating to investigation of certain patents owned by Longitude Licensing Ltd.

Case Subject Matter – Semiconductor random access memory and communication interfaces.

Work Performed – Provided expert consulting services in 2015.

Ropes & Gray LLP (New York City, NY)

Case – Samsung, Inc. v. Imperium IP Holdings (Cayman), Ltd.

Case Number – IPR2015-01233. Petition filed on May 21, 2015.

Case Subject Matter – Data interface circuits, such as I/O buffers, that can be either a single-ended interface or a differential interface.

Work Performed – Provided expert consulting services, wrote declarations for inter partes review, and was twice deposed.

Morgan, Lewis & Bockius LLP (Palo Alto, CA)

Case – Silergy Corporation v. Monolithic Power Systems, Inc.

Case Numbers – IPR2015-00803 and IPR2015-00804. Petitions filed on February 24, 2015.

Case Subject Matter – Microelectronic packaging.

Work Performed – Provided expert consulting services, wrote declarations for inter partes reviews, and was deposed.

Weil, Gotshal & Manges LLP (Houston, TX, Redwood Shores, CA, and Washington, DC)

Case – Limestone Memory Systems LLC v. Micron Technology, Inc.

Case Number – California, CD 8:15-cv-00278. Complaint filed on February 17, 2015.

Case Subject Matter – Semiconductor memory.

Work Performed – Provided expert consulting, claim construction, noninfringement analysis, and invalidity analysis.

Jones Day LLP (San Diego, CA)

Case – Micron Technology, Inc. v. eDigital Corp.

Case Number – IPR2015-00519. Petition filed on December 31, 2014.

Case Subject Matter – Methods for memory management in non-volatile flash memories.

Work Performed – Provided expert consulting services and wrote declaration for inter partes review.

Fish & Richardson P.C. (Atlanta, GA and Washington, DC)

Case – Micron Technology, Inc. v. MLC Intellectual Properties and BTG USA/International Inc.

Case Number – IPR2015-00504. Petition filed on December 24, 2014.

Case Subject Matter – Multi-level non-volatile floating gate memory, e.g. EPROM, EEPROM, and flash technologies.

Work Performed – Provided expert consulting services and wrote declaration for inter partes review.

Weil, Gotshal & Manges LLP (Houston, TX and Redwood Shores, CA)

Case – Innovative Memory Systems LLC v. Micron Technology, Inc.

Case Number – Delaware, 1:14-cv-01480. Complaint filed on December 15, 2014.

Case Subject Matter – Data conversion, semiconductor fabrication, flash memory, and semiconductor memory device operation/control.

Work Performed – Provided expert consulting, claim construction, noninfringement analysis, and invalidity analysis.

Skadden, Arps, Slate, Meagher & Flom LLP & Affiliates (Palo Alto, CA)

Case – ALFRED T. GIULIANO, Chapter 7 Trustee of the Ritz Estate; CPM ELECTRONICS INC.; E.S.E. ELECTRONICS, INC. and MFLASH, INC., on Behalf of Themselves and All Others Similarly Situated v. SanDisk Corp.

Case Number – California, ND (Oakland) 4:10-cv-02787. Fourth amended complaint filed on September 24, 2014.

Case Subject Matter – Non-volatile semiconductor flash memory fabrication and design.

Work Performed – Provided expert consulting services.

DLA Piper (East Palo Alto and Los Angeles, CA)

Case – Longitude Licensing Ltd. and Longitude Flash Memory Systems S.A.R.L., v. Apple, Inc.

Case Number – California, ND 3:14-cv-04275. Complaint filed on September 23, 2014.

Case Subject Matter – Non-volatile semiconductor flash memory fabrication and design.

Work Performed – Provided expert consulting, claim construction, noninfringement analysis, and invalidity analysis.

Singularity LLP (Redwood Shores, CA)

Case – VIA Technologies, Inc. v. ASUS Computer International, AUSTEK Computer, and ASMedia Technology, Inc.

Case Number – California, ND (San Jose) 5:14-cv-03586. Complaint filed on August 7, 2014.

Case Subject Matter – USB 3.0 circuits.

Work Performed – Provided expert consulting services including: noninfringement, invalidity, and trade secret analyses. Wrote expert reports, was deposed twice, and participated in mediation.

Paul Hastings LLP (New York City, NY and Washington, DC)

Case – Cascades Computer Innovation, LLC v. Samsung Electronics Co., Ltd.

Case Number - Illinois, ED 14-cv-05691. Complaint filed on July 24, 2014.

Case Subject Matter – DRAM memory data transfer.

Work Performed – Provided expert consulting, noninfringement analysis, and invalidity analysis.

Morgan, Lewis & Bockius LLP (Palo Alto, CA)

Case – Monolithic Power Systems, Inc. v. Silergy Corporation

Case Number – California, ND 3:14-cv-01745. First amended complaint filed on July 7, 2014.

Case Subject Matter – Microelectronic packaging.

Work Performed – Provided expert consulting, noninfringement analysis, and invalidity analysis.

Ropes & Gray LLP (East Palo Alto, CA, New York City, NY, and Washington, DC)

Case – Macronix International Co., Ltd. v. Spanion, Inc., Aerohive Networks, Allied Telesis, Ciena, Delphi Automotive, Polycom, Ruckus Wireless, ShoreTel, Tellabs, and TiVo

Case Number – ITC Investigation No. 337-TA-922. Complaint filed on June 27, 2014.

Case Subject Matter – Devices containing non-volatile memory and products containing the same.

Work Performed – Provided expert consulting, noninfringement analysis, invalidity analysis, Markman tutorial, and expert report.

Ropes & Gray LLP (Boston, MA and New York City, NY)

Case – Imperium IP Holdings (Cayman), Ltd. v. Samsung, Inc.

Case Number – Texas, ED (Sherman) 4:14-cv-00371. Complaint filed on June 9, 2014.

Case Subject Matter – Data interface circuits that can be either a single-ended interface or a differential interface.

Work Performed – Provided expert consulting, noninfringement analysis, invalidity analysis, expert reports, deposition, and testimony at the trial.

Quinn Emanuel Urquhart & Sullivan, LLP (San Francisco, CA and Washington, DC)

Case – Freescale Semiconductor, Inc. v. MediaTek, Inc., et. al.

Case Number – ITC Investigation No. 337-TA-920. Amended complaint filed on May 27, 2014.

Case Subject Matter – Semiconductor integrated circuits and devices containing the same.

Work Performed – Provided expert consulting services.

DLA Piper (East Palo Alto and San Diego, CA)

Case – GSI Technology, Inc. v. Cypress Semiconductor Corporation

Case Number – IPR2014-00419. Petition filed on February 7, 2014.

Case Subject Matter – Semiconductor static random access memory (SRAM) circuit design.

Work Performed – Provided expert consulting services and wrote declaration for inter partes review.

Ropes & Gray LLP (Washington, DC)

Case – Macronix International Co., Ltd. v. Spansion, Inc., et al.

Case Number – Virginia, ED (Alexandria) 3:13-cv-00679. Complaint filed on November 20, 2013.

Case Subject Matter – Non-volatile semiconductor flash memory fabrication and design.

Work Performed – Provided expert consulting, noninfringement analysis, and invalidity analysis.

Cooley LLP (San Diego, CA)

Case – HSM Portfolio LLC and Technology Properties Limited LLC v. Fujitsu, AMD, Qualcomm, Inc., Elpida, SK Hynix, Micron, ProMOS, SanDisk, Sony, ST Microelectronics, Toshiba, ON, and Zoran

Case Number – Delaware, 1:11-cv-00770. Third amended complaint filed on June 28, 2013.

Case Subject Matter – Semiconductor sensing circuits.

Work Performed – Provided expert consulting, noninfringement analysis, and invalidity analysis.

DLA Piper (East Palo Alto and San Diego, CA)

Case – Cypress Semiconductor Corporation v. GSI Technology, Inc.

Case Number – California, ND 3:13-cv-02013. Complaint filed on May 1, 2013.

Case Subject Matter – Semiconductor static random access memory (SRAM) circuit design.

Work Performed – Provided expert consulting, claim construction, noninfringement analysis, and invalidity analysis.

Montgomery McCracken Walker & Rhoads LLP (Philadelphia, PA)

Case – Simon Nicholas Richmond v. Winchance Solar Fujian Technology, Target, Creative Industries, et. al.

Case Number – New Jersey, 3:13-cv-01954. Amended complaint filed on March 27, 2013.

Case Subject Matter – Circuitry including solar cells, charging circuits, re-chargeable batteries, energy conversion for solar lighting.

Work Performed – Provided expert consulting, noninfringement analysis, and invalidity analysis.

DLA Piper (East Palo Alto, CA)

Case – Intellectual Ventures I/II LLC v. Toshiba, Inc.

Case Number – Delaware, 1:13-cv-00453. Complaint filed on March 20, 2013.

Case Subject Matter – Semiconductor memory and electronic interface circuits.

Work Performed – Provided expert consulting, noninfringement analysis, invalidity analysis, expert report, was deposed, and testified at trial.

Alston & Bird, DLA Piper, Gibson Dunn, Katten, O'Melveny, Orrick, and WilmerHale (various locations in the USA)

Case – Freescale v. Funai, CSR, Zoran, MediaTek, Vizio, Sanyo, TPF, Top Victory Electronics, Envision Peripherals, AmTRAN, and Marvell

Case Number – Texas, WD (Austin) 1:12-cv-00644. Amended complaint filed on January 14, 2013.

Case Subject Matter – Semiconductor circuitry for voltage regulators, bus terminations, packaging, and signal processing.

Work Performed – Provided expert consulting, claim construction, noninfringement analysis, invalidity analysis, and Markman tutorial.

Amin, Turocy & Watson LLP (San Jose and San Francisco, CA)

Case – InvenSense, Inc. v. Robert Bosch GmbH

Case Subject Matter – Microelectromechanical systems (MEMS) sensor design and manufacture.

Work Performed – Provided expert consulting services in 2013.

Morrison & Foerster LLP (Los Angeles, Palo Alto, and San Francisco, CA)

Case – STMicroelectronics, Inc. v. InvenSense, Inc.

Case Number – California, ND 3:12-cv-02475. Complaint filed on May 16, 2012.

Case Subject Matter – Microelectromechanical systems (MEMS) sensors including Gyroscopes and accelerometers.

Work Performed – Provided expert consulting, noninfringement analysis, invalidity analysis, and wrote declaration.

Kilpatrick Townsend & Stockton LLP (Menlo Park and San Francisco, CA)

Case – Consultant for SK hynix, Inc. on matters relating to investigation of certain patents owned by Round Rock Research LLC

Case Subject Matter – Semiconductor random access memory.

Work Performed – Provided expert consulting services in 2012.

Keker & Van Nest LLP (San Francisco, CA)

Case – Round Rock Research LLC v. SanDisk Corp.

Case Number – Delaware, 1:12-cv-00569. Complaint filed on May 3, 2012.

Case Subject Matter – Semiconductor non-volatile flash memory.

Work Performed – Provided expert consulting including: invalidity analysis, noninfringement analysis, expert reports, and was deposed.

Perkins Coie LLP (San Diego, CA)

Case – ASUS Computer International v. Round Rock Research LLC

Case Number – California, ND 3:12-cv-02099. Complaint filed on April 26, 2012.

Case Subject Matter – Semiconductor memory and image sensors (CMOS imagers).

Work Performed – Provided expert consulting, claim construction, noninfringement analysis, invalidity analysis, expert reports, and was deposed.

Morgan, Lewis & Bockius LLP (Palo Alto, CA)

Case – Dr. Michael Jaffe’ as insolvency administrator for Qimonda AG v. LSI, Atmel Corp, Cypress, MagnaChip, and ON Semiconductor

Case Number – California, ND 3:12-cv-03166 (San Francisco). Complaint filed on January 10, 2012.

Case Subject Matter – Semiconductor processing and manufacturing.

Work Performed – Provided expert consulting, noninfringement analysis, and invalidity analysis.

Useful Arts IP (Cupertino, CA)

Case – Tezzaron (formerly Tachyon Semiconductor) v. Elm Technology Corporation

Case Number – Patent Interference No. 105,859. Declared on December 1, 2011.

Case Subject Matter – Packaging of semiconductors and through silicon vias (TSVs).

Work Performed – Patent interference, wrote declaration, and was deposed.

Morgan, Lewis & Bockius LLP (Palo Alto, CA)

Case – Nanya Technology Corporation v. Elpida Memory, Inc. and Kingston Technology Company, Inc.

Case Number – ITC Investigation No. 337-TA-821. Complaint filed on November 21, 2011.

Case Subject Matter – Semiconductor DRAM design, fabrication, and manufacture.

Work Performed – Provided expert consulting and reports on validity, infringement, and domestic industry. Also provided declarations and was deposed.

Morgan, Lewis & Bockius LLP (Washington, DC)

Case – Elpida Memory, Inc. v. Nanya Technology Corporation

Case Number – ITC Investigation No. 337-TA-819. Complaint filed on November 15, 2011.

Case Subject Matter – Semiconductor DRAM design, fabrication, and manufacture.

Work Performed – Provided expert consulting and reports on infringement, domestic industry, and validity. Also provided Markman tutorial, declarations, deposition, and testimony at the trial.

Ropes & Gray LLP (New York City, NY)

Case – Intellectual Ventures v. Sendai Nikon Corporation

Case Number – Delaware, 1:11-cv-01025. Complaint filed on October 26, 2011.

Case Subject Matter – CMOS image sensor design and manufacture.

Work Performed – Provided expert consulting, noninfringement analysis, and invalidity analysis.

Farella Braun + Martel LLP (San Francisco, CA)

Case – Round Rock Research LLC v. Dell, Inc.

Case Number – Delaware, 1:11-cv-00976. Complaint filed on October 14, 2011.

Case Subject Matter – Semiconductor DRAM design and manufacture.

Work Performed – Provided expert consulting, noninfringement analysis, invalidity analysis, and wrote declaration.

Latham & Watkins LLP (San Francisco, CA)

Case – Altera Corp. v. LSI Corp. and Agere Systems, Inc.

Case Number – California, ND 4:11-cv-03139. Complaint filed on June 24, 2011.

Case Subject Matter – Semiconductor devices and electronics including phase-locked loops and clock recovery circuits.

Work Performed – Provided expert consulting, noninfringement analysis, and invalidity analysis.

Fish & Richardson P.C. (Washington, DC)

Case – Spansion LLC v. Samsung Electronics Co., Ltd., Apple, Inc., Nokia Corp., PNY Technologies, Inc. Research In Motion Corporation, Transcend Information Inc.

Case Number – ITC Investigation No. 337-TA-735. Complaint filed on August 6, 2010.

Case Subject Matter – Semiconductor flash memory manufacture, fabrication, and design.

Work Performed – Provided expert consulting, noninfringement analysis, and invalidity analysis.

Jones Day LLP (Palo Alto, CA)

Case – LSI and Agere, Inc. v. Xilinx, Inc.

Case Number – New York, SD 1:09-cv-09719. Complaint filed on November 23, 2009.

Case Subject Matter – Semiconductor digital design and clocking.

Work Performed – Provided expert consulting, noninfringement analysis, and invalidity analysis.

Morrison & Foerster LLP (New York City, NY)

Case – Innurvation, Inc. et al v. Fujitsu Microelectronics America, Inc., Sony Corporation of America, Toshiba America Electronics Components, Inc., and Freescale Semiconductor, Inc.

Case Number – Maryland, 1:09-cv-01416. Complaint filed on May 29, 2009.

Case Subject Matter – Semiconductor circuit layout.

Work Performed – Provided expert consulting, noninfringement analysis, and invalidity analysis.

Wilson Sonsini Goodrich & Rosati P.C. (Palo Alto, CA)

Case – Panavision Imaging, LLC, v. OmniVision Technologies, Inc., Canon U.S.A., Inc., Micron Technology, Inc., Aptina Imaging Corporation, and Aptina, LLC.

Case Number – California, CD 2:09-cv-01577. Complaint filed on March 6, 2009.

Case Subject Matter – CMOS image sensor (CMOS imager) design, fabrication, and manufacture.

Work Performed – Provided expert consulting, noninfringement analysis, invalidity analysis, two expert reports, and wrote declaration.

McDermott Will & Emery (Menlo Park, CA)

Case – Volterra Semiconductor Corp. v. Primarion & Infineon Technologies North America & Infineon Technologies, A.G.

Case Number – California, ND 3:08-cv-05129. Complaint filed on November 12, 2008.

Case Subject Matter – High-performance analog and mixed-signal power management semiconductors and switching power supplies in CMOS using power MOSFETs.

Work Performed – Provided expert consulting, noninfringement analysis, invalidity analysis, two expert reports, and was deposed.

Morrison & Foerster LLP (Palo Alto and San Francisco, CA) and Baker Botts LLP (Austin and Houston, TX)

Case – Power Integrations, Inc. v. Fairchild Semiconductor International, Inc.

Case Number – Delaware, 1:08-cv-00309. Complaint filed on May 23, 2008.

Case Subject Matter – Power conversion and power management integrated circuits used as power supplies for cell phones, LCD monitors, and computers. Circuits and techniques for the reduction of electromagnetic interference (EMI) and radio-frequency interference (RFI).

Work Performed – Provided expert consulting services, expert report, was deposed, and testified at re-trial for damages in November, 2018.

pre-2008 Minor expert witness work. Was deposed twice, once as an expert witness and the other time as a corporate witness.