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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Intel Corporation
Petitioner

v.

Qualcomm Incorporated
Patent Owner

Case IPR2018-01152

**PETITION FOR *INTER PARTES* REVIEW OF
U.S. PATENT NO. 8,698,558
CHALLENGING CLAIMS 12-14**

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Petitioner Intel Corporation (“Intel”) respectfully requests *Inter Partes* Review of claims 12-14 of U.S. Patent No. 8,698,558 (the “’558 patent”) (Ex. 1001) pursuant to 35 U.S.C. §§ 311-19 and 37 C.F.R. § 42.1 *et seq.*

I. INTRODUCTION

The ’558 patent claims various structures for “efficiently generating a power supply for a power amplifier.” Ex. 1001, 1:30-31. Power supply generators for power amplifiers, however, were well-known at the time of the claimed invention, and the challenged claims either are not novel or are obvious variations of known power supply generators. The aspects of the ’558 patent that are identified by the patent as inventive and that the Patent Owner *itself* has identified as inventive in parallel litigation (*i.e.*, the addition of a boost converter to an envelope amplifier and the use of an “offset” current to generate a larger supply current) were known in the prior art at the time of the claimed invention, and they provide only known and predictable results that cannot justify a patent.

Moreover, the primary prior art references, Chu and Kwak, relied upon in this and related petitions—neither of which was before the Patent Office during prosecution—disclose the key elements that the Examiner found to be allegedly missing from the prior art during prosecution. For example, the Examiner allowed claims 12-14 because he found that the prior art of record did not disclose the

required operational amplifier, driver, and PMOS and NMOS transistors. The Chu reference cited in this Petition discloses those limitations.

Accordingly, the prior art cited in this Petition anticipates and/or renders obvious claims 12-14 of the '558 patent.

II. MANDATORY NOTICES

A. Real Party-in-Interest

Intel Corporation ("Petitioner") is a real party-in-interest and submits this *inter partes* review Petition for review of certain claims of U.S. Patent No. 8,698,558 (the "'558 patent"). Petitioner also identifies Apple Inc. ("Apple") as a real party-in-interest.

B. Related Matters

Qualcomm Incorporated ("Qualcomm" or "Patent Owner") has asserted the '558 patent against Apple in *Certain Mobile Electronic Devices and Radio Frequency and Processing Components Thereof*, Investigation No. 337-ITC-1065, currently pending before the International Trade Commission. Qualcomm also has asserted the '558 patent against Apple in *Qualcomm Inc. v. Apple Inc.*, No. 3:17-cv-1375 (S.D. Cal.).

Concurrently with this *inter partes* review Petition, Petitioner is also filing *inter partes* review petitions for claims 1-9 of the '558 patent (IPR2018-01153), claims 15-20 of the '558 patent (IPR2018-01154), and claims 10 and 11 of the

'558 patent (IPR2018-01240). Petitioner requests that these petitions be assigned to the same panel.

C. Counsel

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III. CERTIFICATION OF GROUNDS FOR STANDING

Petitioner certifies pursuant to Rule 42.104(a) that the patent for which review is sought is available for *inter partes* review and that Petitioner is not barred or estopped from requesting an *inter partes* review challenging the patent claims on the grounds identified in this Petition.

IV. OVERVIEW OF CHALLENGE AND RELIEF REQUESTED

Pursuant to Rules 42.22(a)(1) and 42.104(b)(1)-(2), Petitioner challenges claims 12-14 of the '558 patent.

A. Prior Art Patents and Printed Publications

The '558 patent was filed June 23, 2011 and does not claim priority to any prior applications.

The following references are pertinent to the grounds of unpatentability explained below:

1. Chu, W.Y. et al., "*A 10 MHz Bandwidth, 2 mV Ripple PA Regulator for CDMA Transmitters*," IEEE Journal of Solid-State Circuits 2809-2819 (2008) ("Chu") (Ex. 1004). Chu was published in 2008 and is prior art under at least 35 U.S.C. § 102(b). Ex. 1005 at ¶14.

2. Choi, J. et al., “*Envelope Tracking Power Amplifier Robust to Battery Depletion*,” Microwave Symposium Digest (MTT), 2010 IEEE MTT-S International 1332-36 (2010) (“Choi 2010”) (Ex. 1006). Choi 2010 has been available from the IEEE *Xplore* website at <http://ieeexplore.ieee.org/abstract/document/5517825/> since July 23, 2010 and is therefore prior art under at least 35 U.S.C. § 102(a). Ex. 1007 at ¶11. Choi 2010 is also prior art under 35 U.S.C. § 102(b). Choi 2010 was presented in May 2010 at a leading technical conference of skilled artisans, the IEEE International Microwave Symposium (“IMS”) 2010 conference, in Anaheim, California. Ex. 1008 at ¶¶8-9; Ex. 1006 at cover; Ex. 1009 at ¶¶4-5; Ex. 1007 at ¶11. Choi 2010 was distributed to hundreds of conference attendees via USB drives in May 2010. Ex. 1008 at ¶17; Ex. 1009 at ¶¶6-9.
3. Blanken, P.G. et al., “*A 50MHz Bandwidth Multi-Mode PA Supply Modulator for GSM, EDGE and UMTS Application*,” 2008 Radio Frequency Integrated Circuits Symposium (IEEE) 401-04 (2008) (“Blanken”) (Ex. 1010). Blanken was published in 2008 and is prior art under at least 35 U.S.C. § 102(b). Ex. 1005 at ¶12.
4. U.S. Patent No. 5,929,702, “Method and Apparatus for High Efficiency High Dynamic Range Power Amplification” to Myers et al.

(“Myers”) (Ex. 1012). Myers was filed on November 28, 1997 and issued on July 27, 1999 and is prior art under at least 35 U.S.C. § 102(a), (b), and (e).

B. Grounds for Challenge

Petitioner requests cancellation of claims 12-14 of the ’558 patent as unpatentable under 35 U.S.C. §§ 102 and/or 103. This Petition, supported by the declaration of Dr. Alyssa Apsel (Ex. 1003) filed herewith, demonstrates that there is a reasonable likelihood that Petitioner will prevail with respect to cancellation of at least one challenged claim. *See* 35 U.S.C. § 314(a).

V. BRIEF DESCRIPTION OF TECHNOLOGY

The challenged claims of the ’558 patent are directed to an apparatus for generating a power supply signal for a power amplifier. The apparatus includes several components that were well known in the art—envelope amplifiers, boost converters, and power amplifiers—as explained below.

A. Radio Frequency (RF) Power Amplifiers

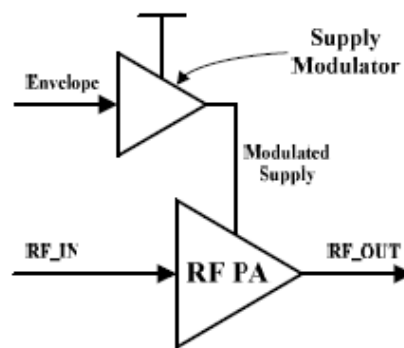
In wireless communications, mobile devices exchange information (such as phone calls, text messages, or other data to and from the Internet) with a base station that connects the mobile devices to other devices and a wider network. This information is transmitted using radio frequency (“RF”) signals. To reach a base station or a mobile device, RF signals require a certain amount of power.

Mobile devices and base stations therefore commonly contain a component known as a “power amplifier” (or “PA”) that increases the power of RF signals to a level sufficient to reach the receiving base station or mobile device. Typically, the further the device moves from a base station, the more power amplification is needed to ensure successful transmission of the RF signal. Ex. 1003 at ¶¶34-35.

In operation, a PA accepts an input signal (such as the signal that carries voice data for a cell phone call) and produces an output signal that, ideally, replicates the input signal but with proportionally greater power. Ex. 1003 at ¶36.

B. Power Supplies for Power Amplifiers

A PA needs to receive power sufficient to amplify the input signal. A PA typically receives its power in the form of a supply voltage from a power supply generator/modulator. For example, in the prior-art structure shown below, the PA receives a supply voltage (“Modulated Supply”) from a power supply generator/modulator:

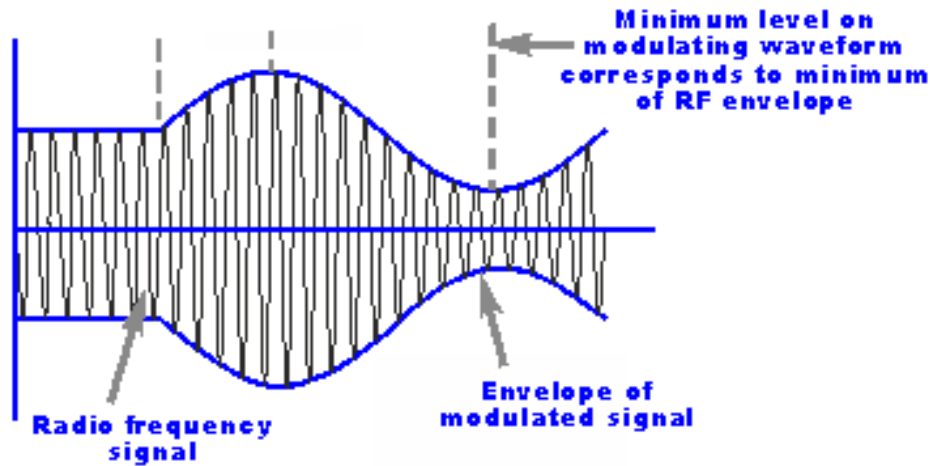


Kim – Figure 1(b)

Ex. 1013 [Kim, D. et al., “*High Efficiency and Wideband Envelope Tracking Power Amplifier with Sweet Spot Tracking*,” Radio Frequency Integrated Circuits Symposium (RFIC): 255-258 (2010) (“Kim”)] at 255. In this case, the supply voltage provides the PA with sufficient power to transmit an output signal (“RF_OUT”) based on the input signal that the PA receives (“RF_IN”), without degrading the quality of the signal or wasting power through resistive losses. The amount of power required at the RF PA depends on the RF signal to be transmitted. Ex. 1003 at ¶¶37-38.

1. Envelope Amplifiers

An envelope amplifier—also sometimes referred to as a “linear amplifier”—is one type of power supply generator for a PA. As shown in the diagram above, the envelope amplifier (the “Supply Modulator”) receives an “envelope” signal, which is a signal that tracks the RF signal to be transmitted. As shown in the diagram below, the envelope signal (shown in blue) tracks the outermost points of the oscillating RF signal (shown in black):



Ex. 1003 at ¶¶39-40. The envelope amplifier receives the envelope signal and uses it to provide a supply voltage to the PA that increases and decreases as the amplitude of the envelope signal increases and decreases. Ideally, the power provided to the PA will match the envelope signal as closely as possible—thereby providing the power that the PA needs to transmit the RF signal, but without providing more power than necessary. Ex. 1003 at ¶40.

Envelope amplifiers have many advantages: they have a simple circuit configuration; they can generate output signals that are accurate copies of the input signals, even when the input changes rapidly (i.e., when the RF signal has a high bandwidth); and they do not generate significant noise that could affect other circuits. Ex. 1003 at ¶41.

Envelope amplifiers, however, are also energy inefficient and generate considerable heat. To generate a voltage for the PA, an envelope amplifier

requires its own input supply voltage. An envelope amplifier is a type of “linear regulator,” which is a device that takes an input voltage and reduces (or “steps-down”) that voltage as necessary to generate the output supply voltage for the PA. This step-down in voltage is necessarily inefficient because it involves dissipating the power difference between the input and output voltages in the form of heat. Using an envelope amplifier alone to supply power to a PA therefore consumes more power than desired. Ex. 1003 at ¶41.

2. Switchers

Another prior art device for supplying power to a PA is a “switcher,” also sometimes referred to as a “switching regulator” or “switching amplifier.” A switcher takes small chunks of energy from an input voltage source and stores them in energy-storing elements (such as an inductor) that will transform the energy into an output. A switcher accomplishes this task by alternately connecting and disconnecting the input supply voltage (*e.g.*, the battery of the mobile device) to the energy-storage element. When the switcher connects the input supply voltage to the energy storage element, energy is added to the storage element. The storage element can then release this energy in the form of a steady current to the PA. By controlling the timing of these alternating connections / disconnections to increase the energy in the storage element, a switcher can supply energy to a PA without dissipating voltage as heat, like an envelope amplifier does. The energy

losses involved in moving chunks of energy around in this way are thus relatively small. Ex. 1003 at ¶42.

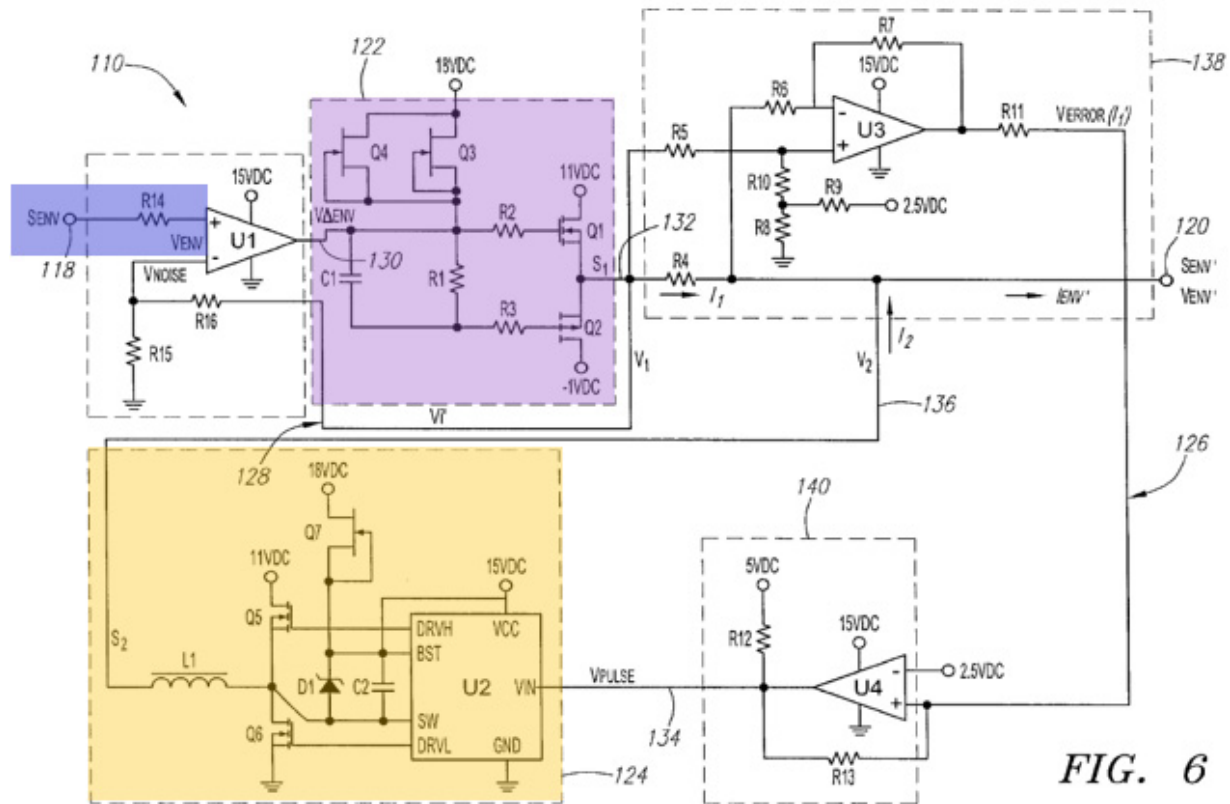
As a result, switchers generally achieve higher efficiency than envelope amplifiers. But there are limits on the frequency at which switchers can operate. Because of this, switchers were generally known to have higher efficiency, but lower operating bandwidth, than envelope amplifiers. Ex. 1003 at ¶43.

3. Hybrid Supply Generators

Hybrid supply generators combine envelope amplifiers and switchers to gain the benefits of both. A hybrid supply generator can use the envelope amplifier and/or the switcher, as appropriate, to supply the power to a power amplifier, thereby obtaining both (a) the high frequency response of an envelope amplifier, and (b) the high efficiency of a switcher. Ex. 1003 at ¶44.

Hybrid supply generators were well known in the art at the time of the purported invention of the '558 patent. For example, another patent filed eleven years earlier by the lead inventor of the '558 patent discloses combining a linear amplifier with a type of switcher known as a synchronous buck DC/DC converter. Ex. 1014 [U.S. Patent No. 6,300,826, "Apparatus and Method for Efficiently Amplifying Wideband Envelope Signals" (filed May 5, 2000) ("Mathe '826")]. As shown below, circuit 110 in Mathe '826 is a circuit that includes (1) an envelope amplifier ("an AB-type RF amplifier 122" highlighted in purple), which is

described as “a moderately power efficient device having high bandwidth capabilities”, and (2) a switcher (“synchronous buck DC/DC converter 124” highlighted in yellow), which is described as “a highly efficient device having low bandwidth capabilities.” *Id.* at 5:17-22; Ex. 1003 at ¶45.



Mathe '826 – Figure 6

A paper by Ertl from 1997 also discloses a hybrid supply generator. Ex. 1016 [Ertl, H. et al., “Basic Considerations and Topologies of Switched-Mode Assisted Linear Power Amplifiers,” IEEE Transactions on Industrial Electronics 44.1 (1997): 116-123 (“Ertl”)]. Ertl presents “a combined power amplifier system”

consisting of an envelope amplifier (“linear amplifier unit”) and a switcher (“a switched-mode (class D) current dumping stage”), as shown in Figure 2 below:

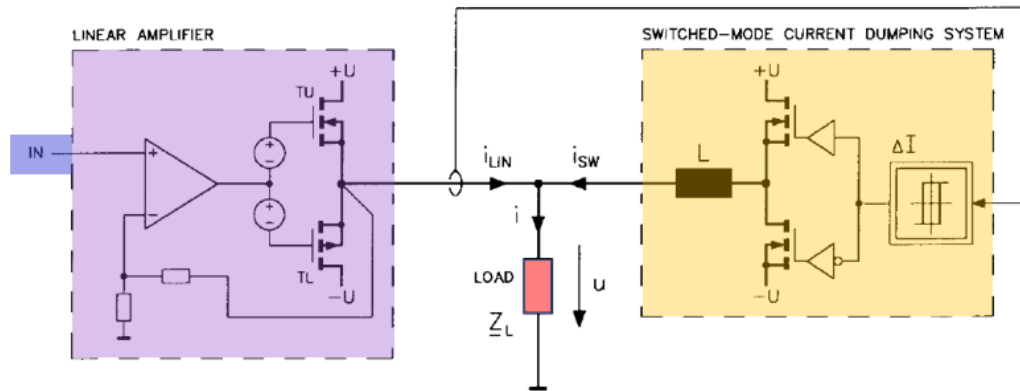


Fig. 2. Circuit diagram of a switched-mode assisted linear power amplifier.

Ertl – Figure 2

Ex. 1016 at 117. Ertl touts this combination as providing the best of both worlds:

(a) “the fundamental drawback of conventional linear power amplifiers—the high loss—is avoided;” and (b) “[c]ompared to a pure class D (switching) amplifier, the presented system needs no output filter to reduce the switching frequency harmonics.” *Id.*; Ex. 1003 at ¶46.

Blanken also proposes a hybrid supply modulator for a PA, combining “a high-bandwidth class-AB linear regulator [envelope amplifier] with an efficient DC/DC converter [switcher] in a master-slave configuration.” Ex. 1010 at 401.

Blanken explains that:

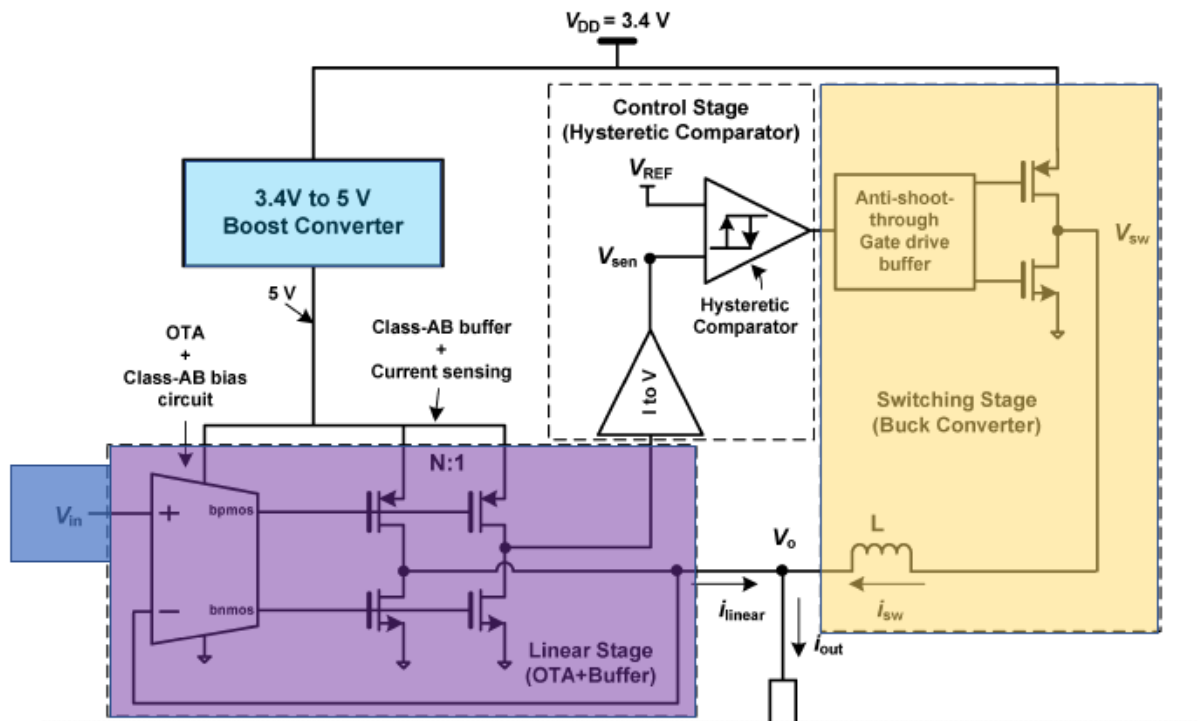
[h]igh-efficiency voltage conversion can be obtained with a switched-mode inductive DC/DC buck converter, but its bandwidth is limited

due to practical limits to the switching frequency. Alternatively, linear regulators enable higher bandwidth at the cost of efficiency. As a good compromise between efficiency and bandwidth, hybrid supply modulators have been proposed combining a switched-mode DC/DC converter in parallel to a linear regulator.

Id.; *see also id.* (“The supply-modulator topology is shown in Fig. 1. It contains a linear regulator and a DC/DC converter in master-slave configuration. The linear regulator is formed by a Miller-compensated two-stage amplifier built with class-A input transconductor g_{in} and class-AB output transconductor g_o [T]he DC/DC converter supplies the DC and low-frequency part of the load current, and the linear regulator supplies the high-frequency part.”). Ex. 1003 at ¶47.

Finally, a 2010 paper by Kang describes “a highly efficient supply modulator” that combines an envelope amplifier with a switcher. Ex. 1017 [Kang, D. et al., “*A Multimode/Multiband Power Amplifier With a Boosted Supply Modulator*,” IEEE Transactions on Microwave Theory and Techniques 58.10 (2010): 2598-2608 (“Kang”)]. Kang acknowledges the disadvantages of both linear amplifiers (i.e., envelope amplifiers) and switching amplifiers (i.e., switchers): “the limited BW [bandwidth] of switching amplifiers and the low efficiency of wideband linear amplifiers.” Ex. 1017 at 2599. Kang explains that researchers therefore have utilized both envelope amplifiers and switchers in hybrid systems that are “suitable for the envelope signal of modern wireless

communication systems, which has the most power in the low-frequency region.”
Id. at 2599. Kang specifically proposes “a hybrid switching amplifier (HSA) for multistandard applications.” *Id.* As shown in Figure 4 below, Kang’s hybrid supply generator includes not only an envelope amplifier (“linear stage”) and a switcher (“switching stage”), but also a boost converter (highlighted in light blue and discussed further in the next section):



Kang – Figure 4

Id. at 2602; Ex. 1003 at ¶48.

4. Boost Converters

If the supply voltage from a device's battery is too low, the output signal from the PA can be distorted. A boost converter (also known as a “step-up” converter) can prevent this by boosting the battery voltage to a higher voltage, which the envelope amplifier can then use to provide power to the PA. This boosting capability is achieved by storing energy in a storage element, and then releasing the energy in the form of a higher voltage. Ex. 1003 at ¶49.

Boost converters have been standard components in power electronics since well before the earliest alleged priority date of the '558 patent. For example, a patent from the 1990s discloses a boost (“step-up”) converter that provides increased voltage to a power amplifier to prevent distortion. Ex. 1018 [U.S. Patent No. 5,834,977, “Amplifying Circuit with Power Supply Switching Circuit” (filed October 30, 1996 and issued November 10, 1998) (“Maehara”)] at Abstract (“An amplifying circuit according to the present invention has an amplifying unit for amplifying an input signal to produce an amplified signal, a battery for generating a constant voltage (a first voltage), a step-up converter for always generating an increased voltage (or a second voltage) by increasing the constant voltage [B]ecause the increased voltage is always generated by the step-up converter ... any distortion of the amplified signal can be prevented.”). Ex. 1003 at ¶50.

Similarly, as noted in the preceding section, the Kang paper from 2010 discloses a hybrid supply generator that includes a boost converter connected to the envelope amplifier. Ex. 1017 at 2602 (“An HSA [hybrid switching amplifier] consists of a boost converter, linear stage, hysteretic comparator, and switching stage, as shown in Fig. 4. The boost converter is connected to the linear stage to boost the output voltage swing.”). Ex. 1003 at ¶51.

Finally, during prosecution, the Examiner found that Kim disclosed a hybrid supply generator with a boost converter, as required by the ’558 patent. *See* Ex. 1013. The Examiner initially rejected patent claims 6-8 and 10-11 (prosecution claims 10-12, 14-15) because Kim disclosed, among other things, the required boost converter. Ex. 1002 at 61-62. The applicant did not dispute the Examiner’s rejection on this ground but instead made a narrowing amendment. *Id.* at 81-82, 86-87; Ex. 1003 at ¶52.

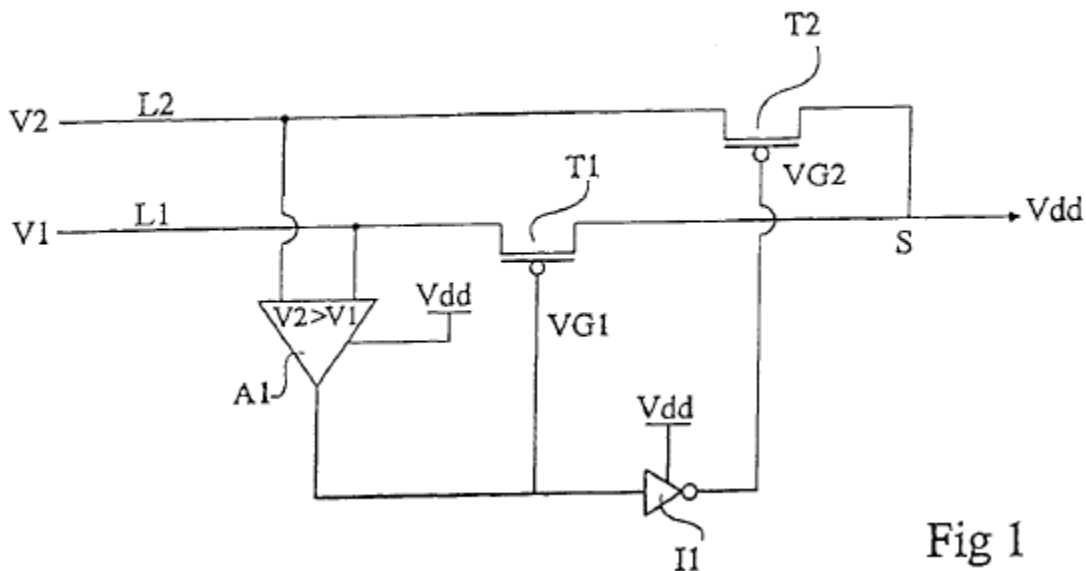
C. Multiplexers

A multiplexer is a circuit with several input signals and a single selectable output signal. As U.S. Patent No. 5,870,340 to Ohsawa explains, “a signal line is selected from the plurality of signal lines, and the selected signal line is electrically connected to the single signal line.” Ex. 1019 [U.S. Patent No. 5,870,340, “Multiplexer” (filed July 8, 1997 and issued February 9, 1999) (Ohsawa)] at 1:17-

20. At the time of the alleged invention, it was well known that multiplexers could be used for data selection in many electronic devices. Ex. 1003 at ¶53.

For example, Ohsawa discloses a multiplexer circuit using PMOS transistors. Each input signal is connected to the gate of a PMOS transistor, and the drain of each transistor is connected to a common node. Ex. 1019 at 4:50-5:5, Fig. 4. When an input signal is to be selected, the PMOS transistor associated with that signal turns on, which sends the signal to the common node. *Id.*; Ex. 1003 at ¶54.

Such multiplexers have been used to select between multiple power supplies. A two-input multiplexer for selecting between power supplies V1 and V2 is shown in Figure 1 of U.S. Patent No. 6,566,935 to Renous:



Renous – Figure 1

Ex. 1020 [U.S. Patent No. 6,566,935, “Power Supply Circuit With a Voltage Selector” (filed August 28, 2000 and issued May 20, 2003) (“Renous”)] at Fig. 1. Renous explains that Figure 1 “shows a conventional power supply circuit receiving two supply voltages V1 and V2 on two respective supply lines L1 and L2, and providing a voltage Vdd on an output node S.” Ex. 1020 at 1:14-17; Ex. 1003 at ¶55.

The multiplexer uses two PMOS transistors (T1 and T2) to implement the selection between the two supply voltages (V1 and V2). A comparator A1 determines which voltage supply should be used. The comparator A1 sends one control signal to the gate of transistor T1 and a second control signal (which is an inverted version of the first control signal) to the gate of transistor T2. This will activate one or the other of the transistors and thereby send one of the supply voltages (V1 or V2) to the output node S. *Id.* at 1:17-25 (“[T]he output of comparator A1 is at a low level when voltage V1 is greater than voltage V2 and at a high level otherwise. The output of comparator A1 is directly connected to the gate of transistor T1, and is connected to the gate of transistor T2 via an inverter I1.”). Ex. 1003 at ¶56.

VI. OVERVIEW OF THE '558 PATENT

A. The Alleged Problem in the Art

The '558 patent describes “techniques for efficiently generating a power supply for a power amplifier and/or other circuits.” Ex. 1001 at 1:30-31. The '558 patent explains that although it is advantageous to operate a wireless device using a low battery voltage to reduce power consumption and extend battery life, a power amplifier sometimes “may need to operate with a PA supply voltage (e.g., 3.2V) that is higher than the battery voltage.” *Id.* at 3:51-52. The '558 patent also acknowledges that it was known to use boost converters to generate the necessary higher PA supply voltage. *Id.* at 3:52-54. But the '558 patent says using a boost converter to “directly supply the PA supply voltage” may “increase cost and power consumption.” *Id.* at 3:54-56; Ex. 1003 at ¶57. These alleged problems, however, had already been identified and solved in the prior art before the filing of the '558 patent, as discussed below.

B. The Alleged Invention of the '558 Patent

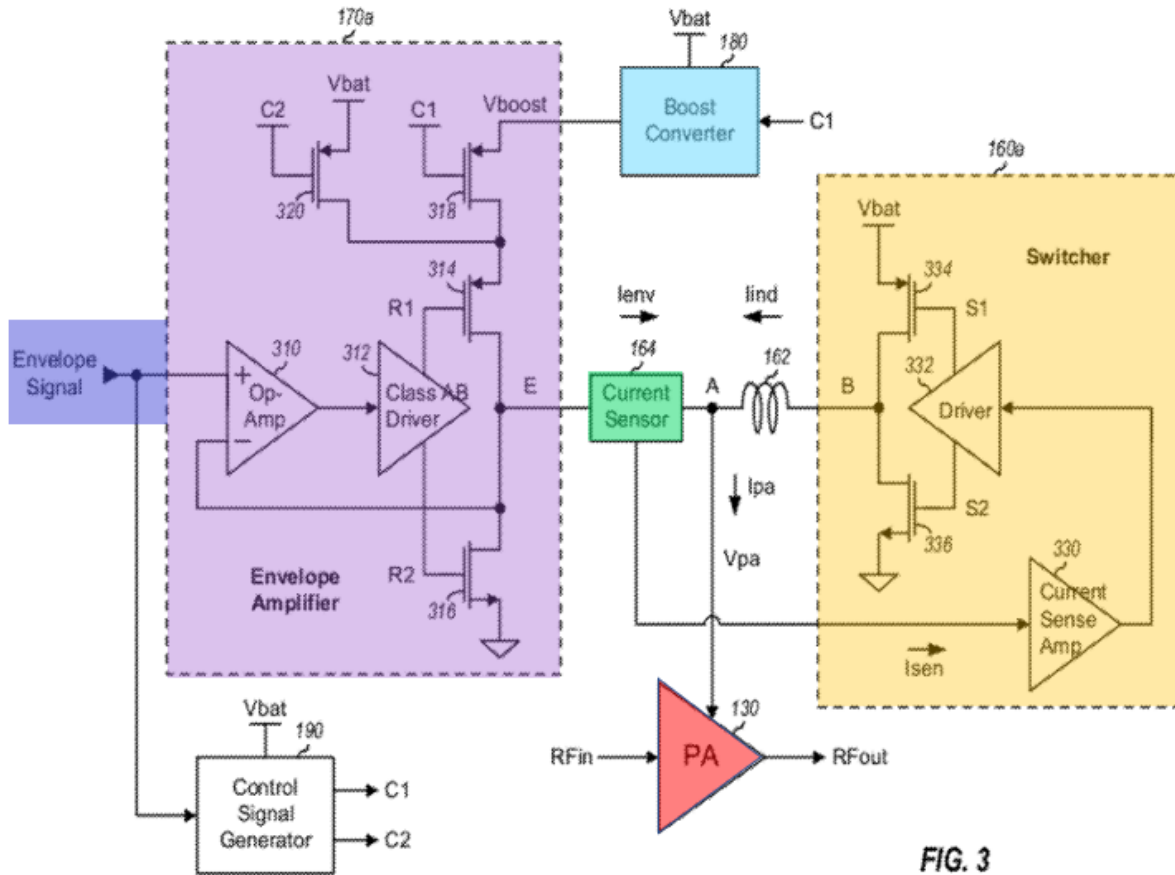
The challenged claims of the '558 patent comprise combinations of well-known components in the field: specifically, PAs, envelope amplifiers, switchers, hybrid supply generators (envelope amplifier + switcher), and boost converters. The '558 patent does not claim to have invented any of these components, all of

which were known in the prior art years before the filing date of the '558 patent, as explained above. Ex. 1003 at ¶58.

The '558 patent purports to provide two alleged improvements to hybrid supply generators: (1) connecting a boost converter to the envelope amplifier; and (2) adding an “offset” current to the switcher’s input current to increase the amount of current generated by the switcher.¹ Ex. 1003 at ¶58. As explained in this Petition, each of these techniques was known in the prior art.

First, the '558 patent proposes a hybrid supply generator with a specific type of envelope amplifier—i.e., one connected to a boost converter, as shown below in Figure 3 from the '558 patent:

¹ These are the only two allegedly inventive aspects that the Patent Owner has identified in the parallel ITC litigation. *See* Ex. 1022 at 12-15 (“*First*, the ‘558 patent discloses connecting a boost converter (which ‘boosts’ or increases the battery voltage to a higher level) only with the envelope amplifier, and not the switcher, to reduce overall usage of the boost converter. ... *Second*, the ‘558 patent discloses that an ‘offset’ may be used to increase the amount of current generated by the switcher.”).

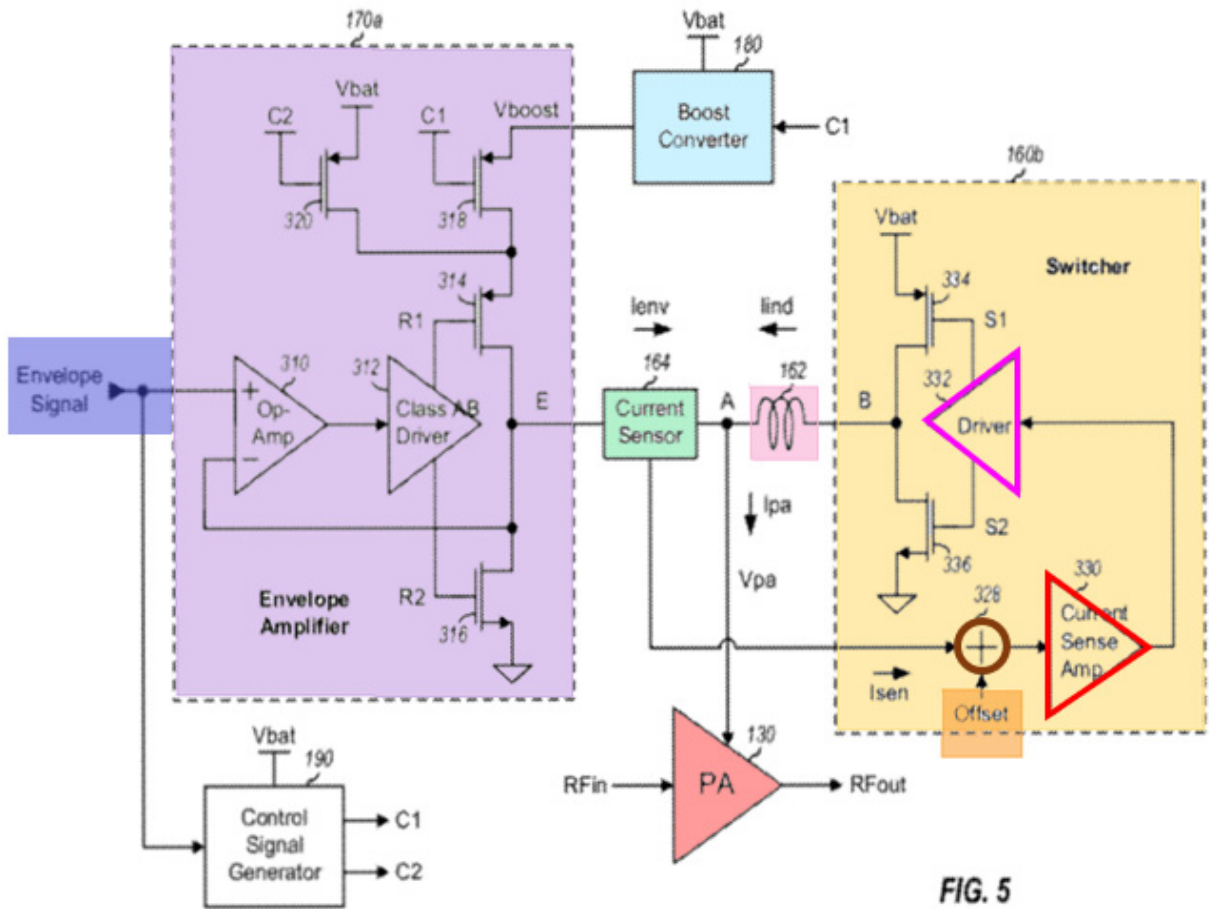


'558 Patent – Figure 3

The envelope amplifier 170a (highlighted in purple) and switcher 160a (highlighted in yellow) cooperate to provide power to power amplifier 130 (highlighted in red). The envelope amplifier receives an envelope signal (highlighted in blue). The boost converter 180 (highlighted in light blue) is connected to the envelope amplifier and adds extra voltage to the envelope amplifier when needed. According to the patent, this configuration is efficient

because the boost converter will provide extra voltage only when the envelope amplifier needs it. Ex. 1001 at 3:57-67 (“PA supply generator 150 can efficiently generate the PA supply voltage with envelope tracking to avoid the disadvantages of using a boost converter to directly provide the PA supply voltage. Switcher 160 may provide the bulk of the power for power amplifier 130 and may be connected directly to the battery voltage. Boost converter 180 may provide power to only envelope amplifier 170. PA supply generator 150 can generate the PA supply voltage to track the envelope of the RFin signal provided to power amplifier 130, so that just the proper amount of PA supply voltage is supplied to power amplifier 130.”); *id.* at 6:29-33 (“[E]fficiency may be improved by operating envelope amplifier 170 based on the Vboost voltage only when needed for large amplitude envelope and based on the Vbat voltage the remaining time, as shown in FIG. 3 and described above.”). Ex. 1003 at ¶59.

Second, the ’558 patent proposes a hybrid supply generator with a particular type of switcher—one that can use an “offset” current to increase the amount of current generated by the switcher, as shown in Figure 5:



'558 Patent – Figure 5

See Ex. 1001 at 7:5-48. The envelope amplifier 170a (highlighted in purple) and switcher 160b (highlighted in yellow) again cooperate to provide power to PA 130 (highlighted in red). But in the embodiment of Figure 5, an offset (highlighted in

orange) is used to increase the amount of current provided to the PA.² Ex. 1003 at ¶60.

When the switcher is on, it provides a current (“I_{ind}”) via inductor 162 (highlighted in pink). That current is joined with the current from the envelope amplifier (“I_{env}”) to provide a combined current (“I_{pa}”) to the PA. Ex. 1001 at 3:21-27 (“Envelope amplifier 170 ... provides a second supply current (I_{env}) comprising high frequency components at node A. The PA supply current (I_{pa}) provided to power amplifier 130 includes the I_{ind} current from switcher 160 and the I_{env} current from envelope amplifier 170.”). The offset proposed by the ’558 patent causes the switcher to remain on longer and thereby increases the amount of current that the switcher provides to the PA. Ex. 1003 at ¶61.

The switcher’s operation begins with the receipt of output current I_{sen} from the envelope amplifier at summer 328 (outlined in brown). Ex. 1001 at 4:60-63 (“Sensor 164 passes most of the I_{env} current to node A and provides a small sensed current (I_{sen}) to switcher 160a. The I_{sen} current is a small fraction of the I_{env} current from envelope amplifier 170a.”). Summer 328 receives and adds an

² The offset is present only in claims 15-20, which are not challenged by this Petition.

“offset” current (highlighted in orange) to the Isen current, which changes the Isen current sent to the current sense amplifier 330 (outlined in red). The current sense amplifier provides a voltage to driver 332 (outlined in fuchsia) to turn the switcher on or off. The addition of the offset changes the voltage that the current sense amplifier provides, thereby allegedly causing the switcher to remain on longer and increasing the amount of current that the switcher provides to the PA via the inductor 162. *Id.* at 7:19-21 (“[A] progressively larger offset may be used to generate a progressively larger inductor current than without the offset.”); *id.* at 7:29-30 (“An offset to increase the inductor current may be added via summer 328, as shown in FIG. 5.”). Ex. 1003 at ¶62.

The ’558 patent explains that the offset may be added “via any suitable mechanism,” Ex. 1001 at 7:29-32, and the offset’s magnitude may be determined in a variety of ways based on particular design goals, *id.* at 7:21-27 (“In one design, the offset may be a fixed value selected to provide good performance, e.g., good efficiency. In another design, the offset may be determined based on the battery voltage. For example, a progressively larger offset may be used for a progressively lower battery voltage. The offset may also be determined based on the envelope signal and/or other information.”). Ex. 1003 at ¶63.

C. Relevant Prosecution History

The '558 patent issued from U.S. Appl. No. 13/167,659, which was filed on June 23, 2011. The application was published on December 27, 2012 as US 2012/0326783 A1.

1. November 23, 2012 Office Action

The Examiner initially rejected prosecution claims 10-12 and 14-15 based on Kim, which the Examiner found disclosed a hybrid switching supply modulator with the required boost converter. Ex. 1002 at 61-64.

The Examiner explained that prosecution claims 4, 5, and 18 would be allowable if rewritten because they required certain internal components of the envelope amplifier and switcher that apparently were not disclosed in Kim: (1) an operational amplifier (op-amp) operative to receive the envelope signal and provide an amplified signal; (2) a driver operative to receive the amplified signal and provide a first control signal and a second control signal; (3) a PMOS transistor with certain characteristics; and (4) an NMOS transistor with various characteristics. *Id.* at 63-64.

The Examiner also explained that prosecution claims 22 and 23 would be allowable if rewritten because they required other elements relating to the required “offset” current that apparently were not present in Kim: (1) a summer operative to sum the input current and an offset current and provide a summed current; (2) a

current sense amplifier operative to receive the summed current and provide a sensed signal; and (3) a driver operative to receive the sensed signal and provide at least one control signal used to generate the switching signal for the inductor. *Id.*

2. February 19, 2013 Amendment

In response to the initial office action, the applicant amended the claims to rewrite prosecution claims 4, 5, 18, 22, and 23 as requested. *Id.* at 79-84.

The applicant also amended prosecution claims 10, 12, and 14 to include the internal components of the envelope amplifier that the Examiner had found were not disclosed in Kim, specifically, the operational amplifier, the driver, the PMOS transistor, and the NMOS transistor. The applicant also argued that Kim did not disclose these elements. *Id.* at 81-82, 86-87.

3. May 10, 2013 Office Action

In response to the applicant's amendments, the Examiner allowed the rewritten prosecution claims 4, 5, 10, 12, 14, 18, 22, and 23, which ultimately issued as patent claims 1, 3, 6, 8, 10, 12, 15, and 17. The Examiner also allowed the claims that depended from these claims, including prosecution claims 11, 15, 17, 19, 21, and 24-26, which issued as patent claims 7, 11, 13, 14, 16, and 18-20. *Id.* at 134.

4. April 15, 2015 Patent Issuance

After various miscellaneous prosecution actions not relevant here, the '558 patent issued on April 15, 2014. Ex. 1001 at Cover.

5. June 27, 2017 Certificate of Correction

In response to a request from the applicant, the Patent Office issued a Certificate of Correction to correct a “cut and paste error” that appeared in patent claim 12. Ex. 1021.

VII. OVERVIEW OF THE PRIOR ART REFERENCES

There is nothing inventive or non-obvious in any of the claims of the '558 patent. The references cited in this Petition disclose all the allegedly inventive elements of the challenged claims of the '558 patent. In fact, the primary prior art reference cited here (Chu) was not before the Examiner during prosecution and discloses all the elements of the challenged claims that the Examiner found to be missing from the prior art of record. Ex. 1003 at ¶69.

A. Chu

Chu is a 2008 paper that, like the '558 patent, discloses a hybrid supply generator—a linear amplifier and switcher that work together to supply an envelope-tracking supply voltage to the power amplifier. Ex. 1004 at 2809 (“A combined class-AB [linear amplifier] and switch-mode regulator based supply modulator with a master–slave architecture achieving wide bandwidth and low

ripple is presented.”). Chu discloses the miscellaneous claim elements that the Examiner found were missing in the prior art during prosecution (operational amplifier, driver, and PMOS and NMOS transistors). Ex. 1003 at ¶70.

Chu first describes a conventional power supply regulator for a PA, which tracks the envelope variations of a modulated waveform at the PA, as shown below in Figure 2:

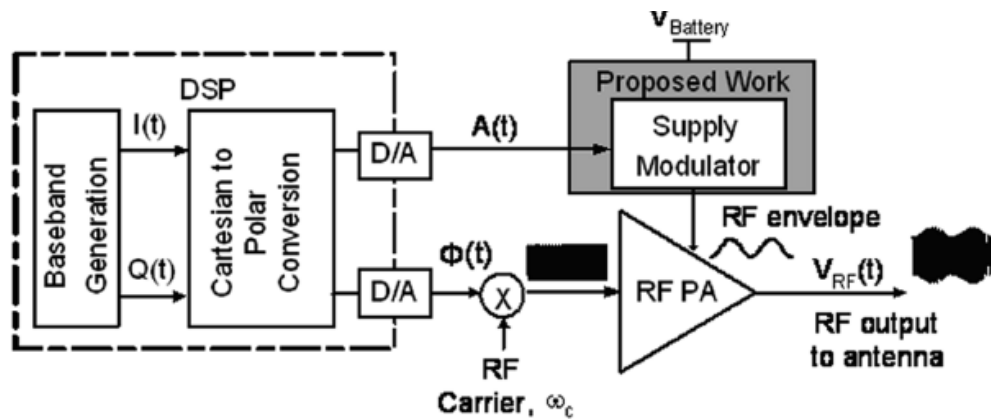


Fig. 2. Typical polar modulation based transmitter block diagram.

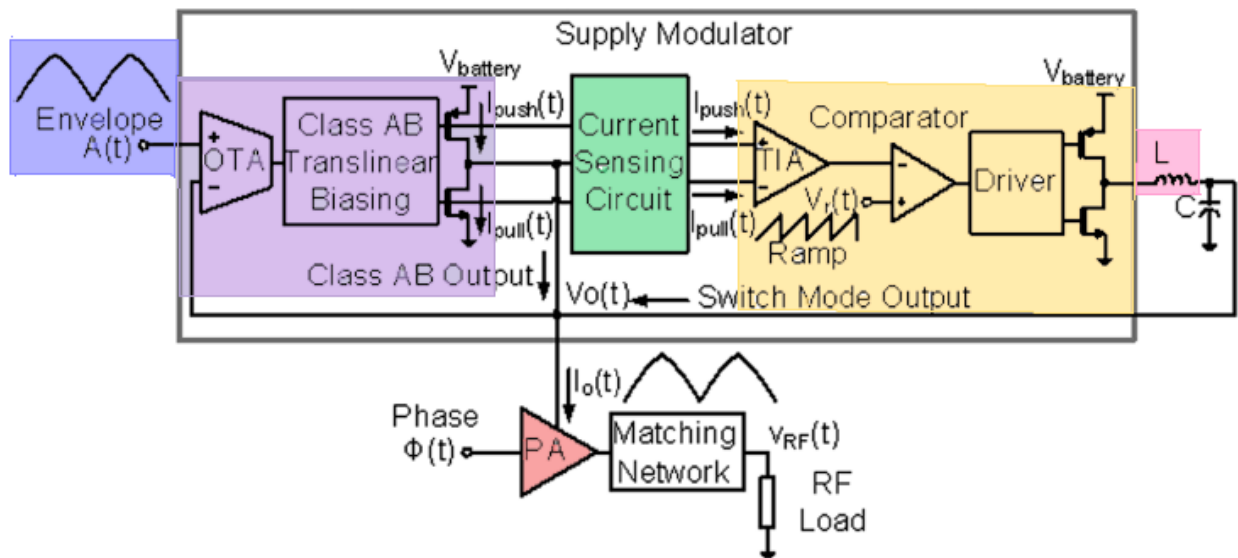
Chu – Figure 2

Ex. 1004 at 2809 (“An envelope detector extracts the envelope waveform and this is applied as input to a wideband supply regulator, as shown in Fig. 2 [1], [2].”).

Chu identifies disadvantages of the system in Figure 2, and notes that switchers (“switch-mode supply regulators”) can be used to increase efficiency. *Id.* But Chu notes that switchers have disadvantages as well, most notably their limited operating bandwidth. *Id.* at 2809 (“Although switch-mode supply regulators boost

frequency.”). Ex. 1003 at ¶¶71-72.

system, which is shown in Figure 4:



Chu – Figure 4

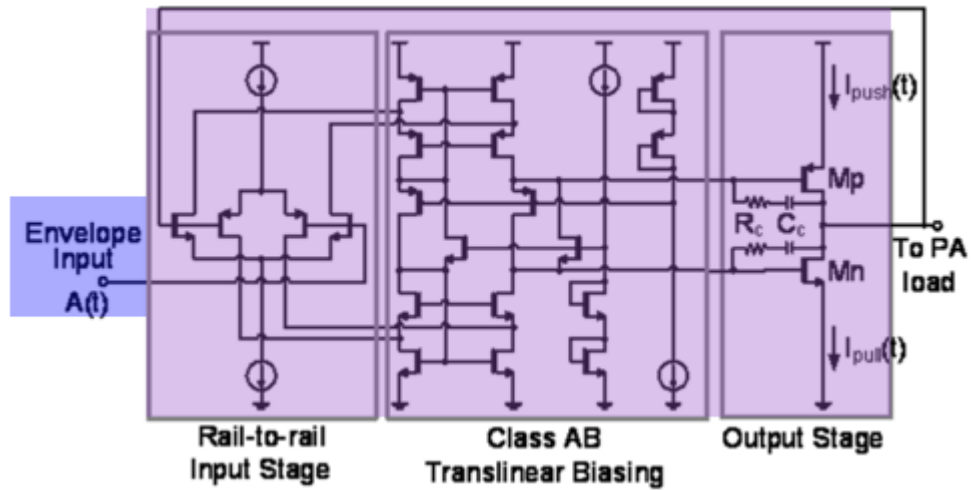
As can be seen in Figure 4, the supply modulator (a hybrid supply generator) receives an envelope signal (highlighted in blue) and provides power to a power amplifier (highlighted in red). The system includes an envelope amplifier (“high GBW [gain–bandwidth] linear amplifier” (highlighted in purple)) that “ensures that output node tracks the reference envelope voltage.” *Id.* at 2810. The system also

includes a switch-mode regulator or switcher (highlighted in yellow) that provides “a large portion of the load current” based on the operation of the current sensing circuit (highlighted in green).

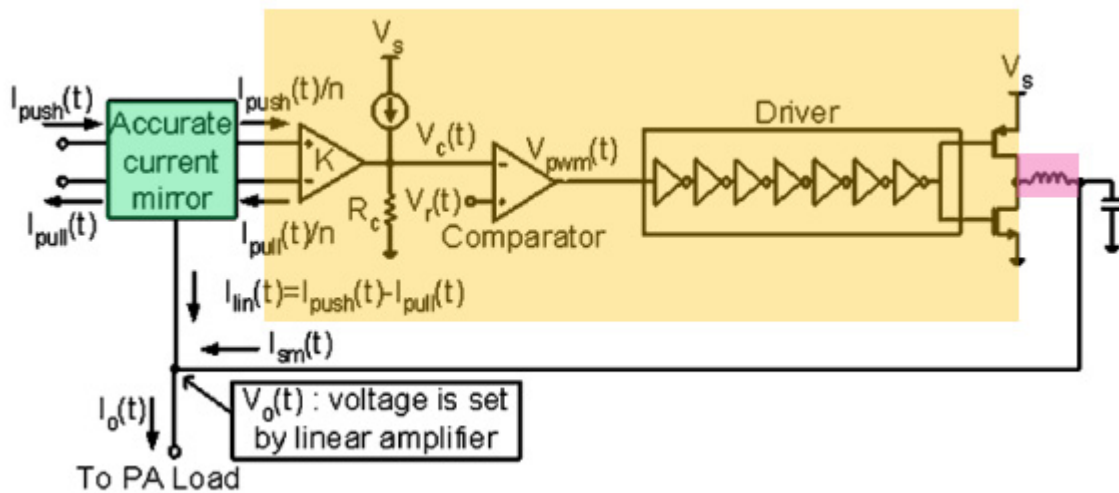
The current sensing circuit receives a current from the linear amplifier, and when the signal is within the switcher’s bandwidth, the supply modulator “suppresses the current output from the [lower efficiency] linear amplifier within the switch-mode regulator bandwidth.” *Id.* at 2810. The envelope amplifier and switcher thereby work together to provide power to the PA. *Id.* at 2811 (“At low frequencies, the linear amplifier current output is suppressed and the switch-mode regulator dominates the output current. Conversely, at high frequencies, the switch-mode regulator current response starts rolling off and the linear amplifier takes over the output current. The switch-mode regulator and linear amplifier current response combine and form a flat frequency response for the master–slave regulator.”). Ex. 1003 at ¶¶73-74.

As shown in Figure 4 (and as explained in detail in the specific grounds section below), Chu discloses the internal structure of the supply generator, including the miscellaneous claim elements that the Examiner found were missing from the prior art during prosecution (operational amplifier, driver, and PMOS and NMOS transistors). Even more detailed views of Chu’s envelope amplifier,

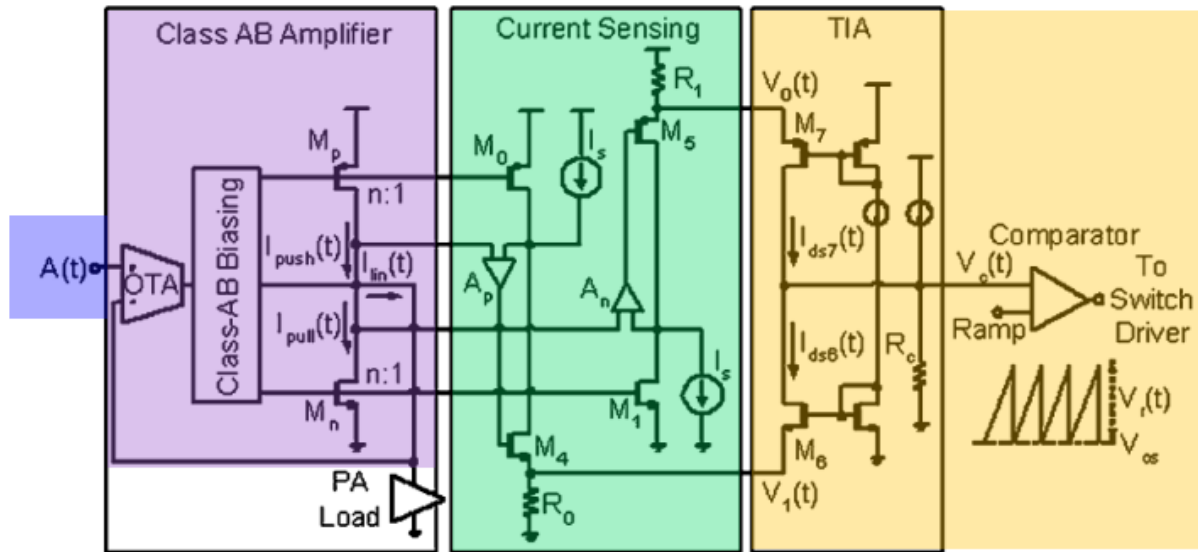
switcher, and current sensing circuit are shown in Figures 14, 15, and 16, respectively:



Chu – Figure 14



Chu – Figure 15



Chu – Figure 16

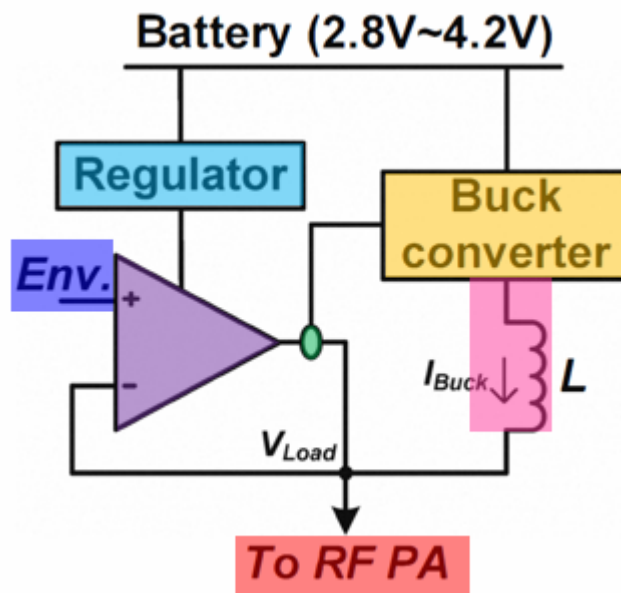
Ex. 1004 at 2814 (“A two-stage class-AB amplifier with a common-source output stage, as shown in Fig. 14, is used for the linear amplifier.”); *id.* at 2815 (“In the master–slave regulator configuration, the switch-mode regulator serves as the slave stage, as shown in Fig. 15, and is driven by the class-AB amplifier sensed output currents.”); *id.* at 2815 (“[T]he proposed accurate current sensing circuit shown in Fig. 16 ... [has] two low-loss accurate current mirrors sensing output push and pull currents $I_{push}(t)$ and $I_{pull}(t)$ from the class-AB amplifier.”). Ex. 1003 at ¶75.

B. Choi 2010

Choi 2010 also discloses a hybrid “supply modulator” for a PA. The supply modulator of Choi 2010 includes not only an envelope amplifier and a switcher, but also a boost converter that is connected to the envelope amplifier. Ex. 1007 at

1074 (“[A] new supply modulator architecture employing a hybrid switching amplifier and a boost converter is proposed.”).

Figure 5 shows the Choi 2010 hybrid supply modulator and its components:



Choi 2010 – Figure 5

As annotated above, Figure 5 shows a purple linear amplifier (also referred to as a “low drop-out (LDO) regulator”), which is a type of envelope amplifier. This envelope amplifier works together with a buck converter (highlighted in yellow), which is a type of a switcher, to provide a supply voltage to a PA (highlighted in red). *See id.* at 1074 (“The hybrid switching amplifier (HSA) combines the advantage of the LDO [low drop-out regulator (i.e., envelope amplifier)] and buck converter [i.e., switcher] and simultaneously achieves high efficiency and linearity.”); *id.* at 1075 (“[T]he LDO [envelope amplifier] operates as an

independent voltage source with a low output impedance, while the switching buck converter [switcher] roles as a dependent current source with a high output impedance and supplies most of the current needed at the output. The current sensing unit detects the current flowing from the linear amplifier to the output and it changes the state of the switching amplifier according to the magnitude and polarity of the sensed current.”). Ex. 1003 at ¶76.

Figure 5 also shows a “regulator” (highlighted in light blue) that is a “boost converter”: the regulator is used to keep the power supply to the envelope amplifier stable and robust even when the battery is depleted. Ex. 1007 at 1074 (“A wideband envelope tracking power amplifier, which is robust to battery depletion, is introduced. An integrated boost converter keeps a stable operation of the PA supply modulator.”); *id.* at 1075 (“As the load voltage is regulated by the linear amplifier, boosting up the supply voltage of the linear amplifier results in a stable supply voltage to the RF PA regardless of the battery depletion. Thus, the additional 5V boost converter ... is coupled to the supply of the linear amplifier, while that of the switching amplifier is directly connected to the battery as illustrated in Fig. 5.”). Ex. 1003 at ¶77.

VIII. CLAIM CONSTRUCTION

Claims of an unexpired patent should be construed using the broadest reasonable interpretation in light of the specification. 37 C.F.R. §42.100(b); *see*

Cuozzo Speed Techs., LLC v. Lee, 136 S. Ct. 2131, 2142 (2016). Should the Patent Owner, to avoid the prior art, contend that any claim term has a construction different from its broadest reasonable interpretation, the appropriate course is for the Patent Owner to seek to amend the claim to expressly correspond to its contentions in this proceeding. *See* 77 Fed. Reg. 48764 (Aug. 14, 2012).

The invalidity analysis in this Petition does not depend on whether the claims are analyzed under the broadest reasonable interpretation standard or the standard established by *Phillips v. AWH Corp.*, 415 F.3d 1303, 1312 (Fed. Cir. 2005). The two claim constructions addressed below and applied in this Petition are either the correct claim construction under *Phillips* or are an even narrower construction proposed by the Patent Owner. The challenged claims are invalid under those constructions and also would be invalid under any broader construction based on the broadest reasonable interpretation standard.

A. “current sense amplifier” (claim 12)

In the parallel ITC litigation, the administrative law judge (ALJ) construed “current sense amplifier” to mean “amplifier that produces a voltage from a current.” Petitioner applies the ALJ’s construction in this Petition. The Patent Owner’s proposed construction in the ITC litigation (“amplifier that senses changes in current”) incorporates a limitation—i.e., that the amplifier “senses changes in current”—found nowhere in the claims. By contrast, the ALJ’s

construction is consistent with the claims, specification, and knowledge of a POSA. Ex. 1001 at 4:64-66, 5:7-10, 5:18-20 (“Within switcher 160a, a current sense amplifier 330 has its input coupled to current sensor 164 and its output coupled to an input of a switcher driver 332. . . . Switcher 160a operates as follows. Switcher 160a is in an On state when current sensor 164 senses a high output current from envelope amplifier 170a and *provides a low sensed voltage to driver 332*. . . . Conversely, switcher 160a is in an Off state when current sensor 164 senses a low output current from envelope amplifier 170a and *provides a high sensed voltage* to driver 332.”); Ex. 1023 at 11-12 (same).

B. “envelope signal” (claim 12)

The ITC ALJ construed “envelope signal” to mean “signal indicative of the upper bound of the output RF signal,” which is the construction proposed by Patent Owner in the ITC litigation. Petitioner applies the ALJ’s construction in this Petition. This construction is slightly narrower (and thus only more favorable to the Patent Owner here) than the construction proposed by Apple in the ITC litigation (i.e., plain meaning or, in the alternative, “signal indicative of the upper boundary of *another* signal”). Ex. 1023 at 13-14.

IX. LEVEL OF ORDINARY SKILL IN THE ART

A person of ordinary skill in the art would have had, at the time the ’558 patent was filed in June 2011: a Master’s degree in Electrical Engineering,

Computer Engineering, or Computer Science plus at least two years of relevant experience, or a Bachelor's degree in one of those fields plus at least four years of relevant experience. "Relevant experience," in the context of the asserted patent, refers to experience with mobile device architecture as well as transmission and power circuitry for radio frequency devices. *See* '558 patent (Ex. 1001) at Abstract at 1:7-9, 30-31 ("Techniques for efficiently generating a power supply for a power amplifier and/or other circuits are described herein."); Ex. 1003 at ¶¶84-85.

X. SPECIFIC GROUNDS FOR PETITION

Pursuant to Rule 42.104(b)(4)-(5), the following sections (as confirmed in Dr. Apsel's declaration, Ex. 1003 ¶¶86-141, and accompanying claim charts) demonstrate in detail how the prior art discloses each and every limitation of claims 12-14 of the '558 patent, and how those claims are therefore anticipated and/or rendered obvious by the prior art. To summarize:

Claim 12 requires an ordinary hybrid supply generator for a power amplifier, without either of the purported novelties of the '558 patent (a boost converter or an offset current). Chu discloses these elements. Claim 14 adds two basic elements to claim 12: that the supply current from the switcher (the "first supply current") comprise direct current (DC) and low frequency components, and that the supply current from the envelope amplifier (the "second supply current") comprise higher

frequency components. Chu also discloses these elements. Chu therefore anticipates claims 12 and 14 (Ground I).

Claim 14's allocation of signal components between the first and second supply currents was also obvious because it was a basic principle for hybrid supply generators expressly taught by Blanken. Claim 14 is also obvious over the combination of Chu and Blanken (Ground II).

Claim 13 requires a hybrid supply generator that includes a boost converter connected to the envelope amplifier. As explained above, the Examiner found that the boost converter limitations of these claims were disclosed by Kim, but they are also disclosed by Choi 2010. These claims would have been obvious over the combination of Chu and Choi 2010 (Ground III).

A. Ground I: Claims 12 and 14 are anticipated by Chu

1. Claim 12

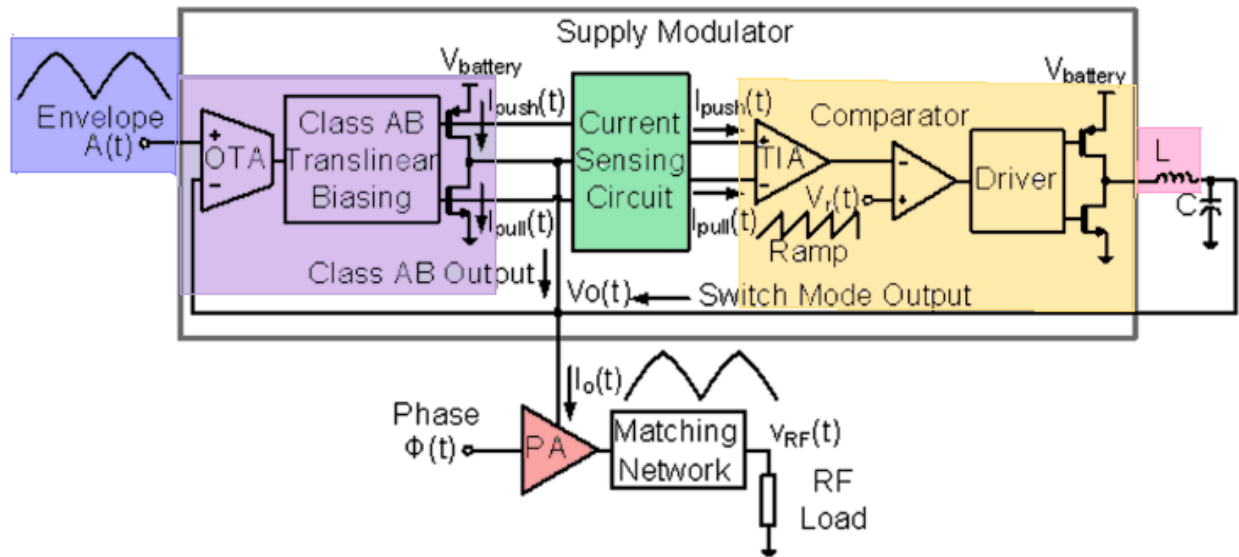
Claim 12 is anticipated by Chu, as explained below. Ex. 1003 at ¶¶87, 110.

(a) “An apparatus comprising:”

Chu discloses this limitation. Figure 4 of Chu is a block diagram of a supply modulator and a power amplifier, i.e., “an apparatus.” Ex. 1004 at 2810 (“Fig. 4 shows the block diagram of the proposed master–slave linear and switch-mode combined supply modulator loaded with a PA.”). Ex. 1003 at ¶88.

(b) “a switcher operative to receive a first supply voltage and provide a first supply current;”

Chu discloses this limitation. Chu discloses a switcher, referred to as the switch-mode supply modulator or regulator, which is highlighted below in yellow:



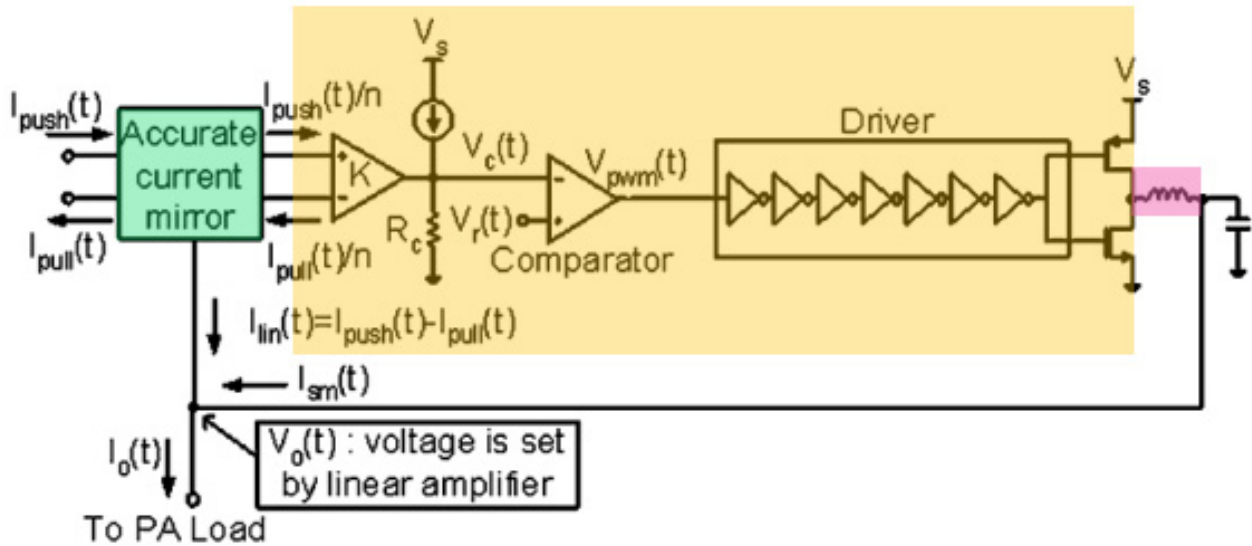
Chu – Figure 4

See Ex. 1004 at 2809 (“In this paper, a master–slave linear and switch-mode supply modulator with fast dynamic transient response is presented.”); *id.* at 2811 (“At low frequencies, the linear amplifier current output is suppressed and the switch-mode regulator dominates the output current.”). Chu describes the switch-mode supply modulator or regulator in the same way as the ’558 patent describes the switcher. *Id.* at 2810 (“A current sensing circuit, high gain transimpedance amplifier and switch-mode regulator forms a global feedback control loop that suppresses the current output from the linear amplifier within the switch-mode

regulator bandwidth. Consequently, *a large portion of the load current is provided by the switch-mode regulator.*”); see also Ex. 1001 at 6:19-24 (“Switcher 160a has high efficiency and *delivers a majority of the supply current for power amplifier 130*. Envelope amplifier 170a operates as a linear stage and has relatively high bandwidth (e.g., in the MHz range). Switcher 160a operates *to reduce the output current from envelope amplifier 170a, which improves overall efficiency.*”).³ Ex. 1003 at ¶¶89-90.

The switcher disclosed in Chu (i.e., the switch-mode regulator) is shown in more detail in Figure 15. Ex. 1004 at 2815 (“In the master–slave regulator configuration, the *switch-mode regulator* serves as the slave stage, as shown in Fig. 15, and is driven by the class-AB amplifier sensed output currents.”); *id.* at Fig. 4 (showing the Class AB Output). Like the switcher of the ’558 patent, the switcher in Chu receives “a first supply voltage,” which is labeled as $V_{battery}$ in Figure 4 above and as V_s in Figure 15 below:

³ All emphasis has been added, except where otherwise noted.



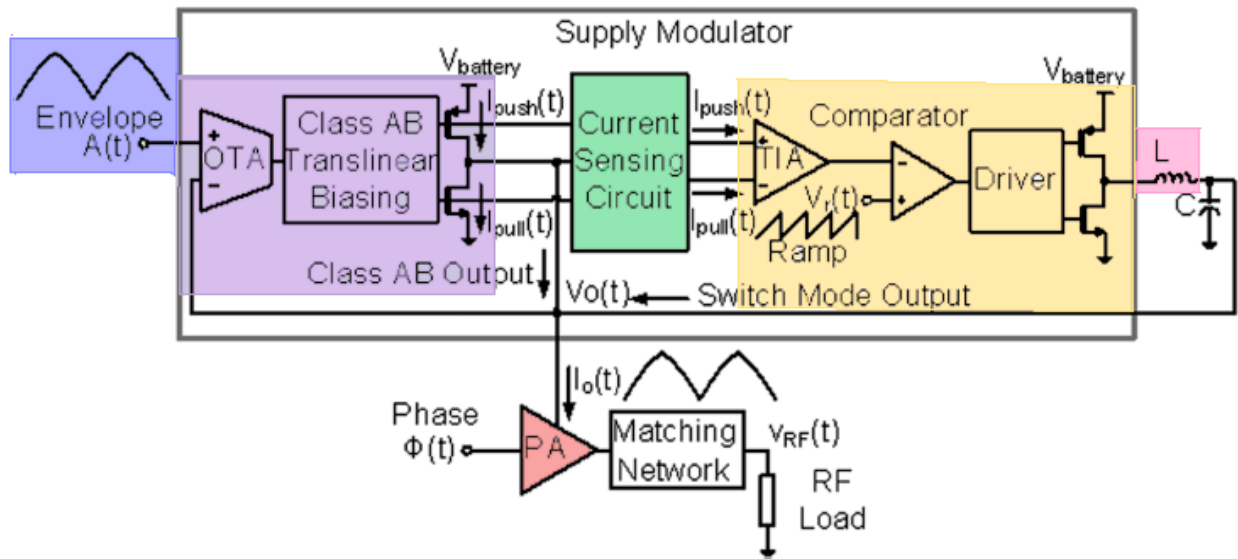
Chu – Figure 15

Ex. 1001 at 3:60-62 (“Switcher 160 may provide the bulk of the power for power amplifier 130 and *may be connected directly to the battery voltage.*”). Ex. 1003 at ¶91.

The switcher in Chu also provides a “first supply current.” This current is labeled “Switch Mode Output” in Figure 4 and $I_{sm}(t)$ in Figure 15. Ex. 1004 at 2811 (“The *switch-mode regulator output current* I_{sm} can be shown as”); *id.* at 2810 (“The transient response of currents at the output of the switch-mode regulator $I_{sm}(t)$, the linear amplifier $I_{lin}(t)$, and combined master–slave supply modulator $I_o(t)$ is shown in Fig. 5.”); *id.* (“The steady state output current of switch-mode regulator I_{sm} can be defined by the linear regulator current I_{lin} as follows:”). Ex. 1003 at ¶92.

- (c) “an envelope amplifier operative to receive an envelope signal and provide a second supply current based on the envelope signal; and”

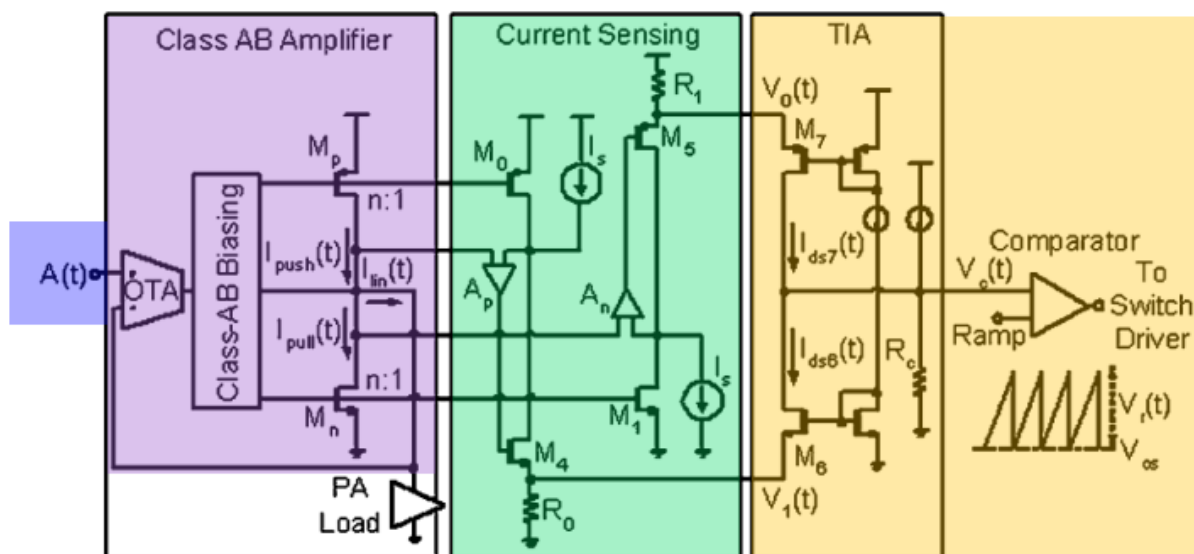
Chu discloses this limitation. The linear amplifier in Chu is an envelope amplifier, highlighted below in purple.



Chu – Figure 4

Ex. 1004 at 2810 (“Fig. 4 shows the block diagram of the proposed master-slave linear and switch-mode combined supply modulator loaded with a PA. A high GBW linear amplifier in voltage follower configuration ensures that output node $V_o(t)$ tracks the reference envelope voltage $A(t)$.”). Ex. 1003 at ¶93.

As shown in Figure 4 above and Figure 16 below, the envelope amplifier receives an envelope signal $A(t)$:



Chu – Figure 16

Ex. 1004 at 2815. The signal $A(t)$ is labeled as an “Envelope” in Figure 4 and described as an “envelope” voltage in the text. *Id.* at 2810 (“[O]utput node $V_O(t)$ tracks the reference envelope voltage $A(t)$.”); *id.* at 2811 (“ A represents the input envelope signal”). Ex. 1003 at ¶94.

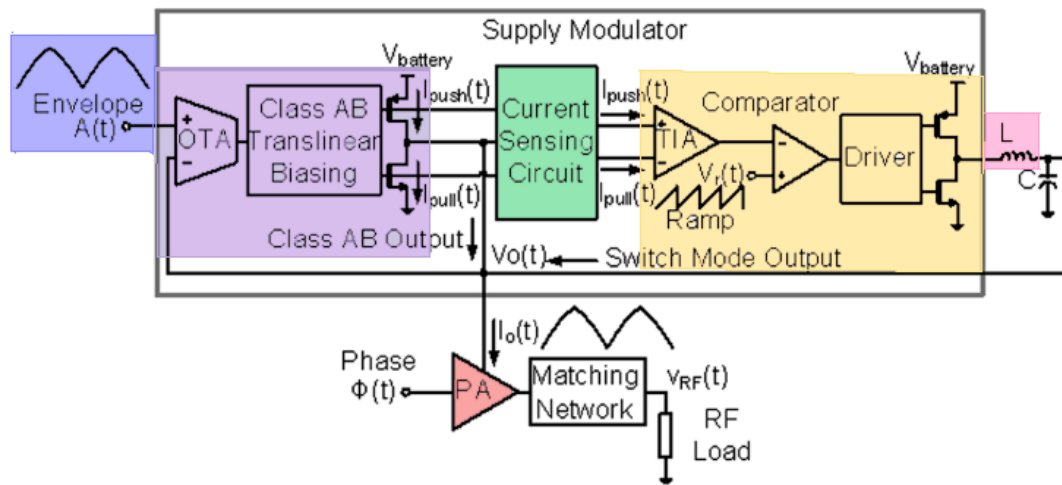
Chu’s envelope amplifier also “provides a second supply current based on the envelope signal.” This supply current is labeled “Class AB Output” in Figure 4 and as $I_{lin}(t)$ in Figure 16. Ex. 1004 at 2810 (“A high GBW linear amplifier in voltage follower configuration ensures that output node $V_O(t)$ tracks the reference envelope voltage $A(t)$ The lower efficiency linear amplifier sources small amounts of output current $I_{lin}(t)$ The transient response of currents at the output of the switch-mode regulator $I_{sm}(t)$, the linear amplifier $I_{lin}(t)$ and combined

master–slave supply modulator $I_O(t)$ is shown in Fig. 5.”); *id.* (“The steady state output current of switch-mode regulator I_{sm} can be defined by the linear regulator current I_{lin} as follows:”); *id.* at 2811 (“[T]he linear amplifier output current I_{lin} is represented by”). Ex. 1003 at ¶¶95-96.

(d) “a power amplifier operative to receive a total supply current comprising the first supply current and the second supply current,”⁴

Chu discloses this limitation. Chu discloses a power amplifier (“PA”), highlighted in red below:

⁴ Claim 12, as printed in the issued version of the ’558 patent, includes the limitation “a power amplifier operative to receive an envelope signal and provide a second supply current based on the envelope signal,” which is not part of the claim. This printing error was corrected in the Certificate of Correction dated June 27, 2017. *See* Ex. 1001 and Ex. 1021.



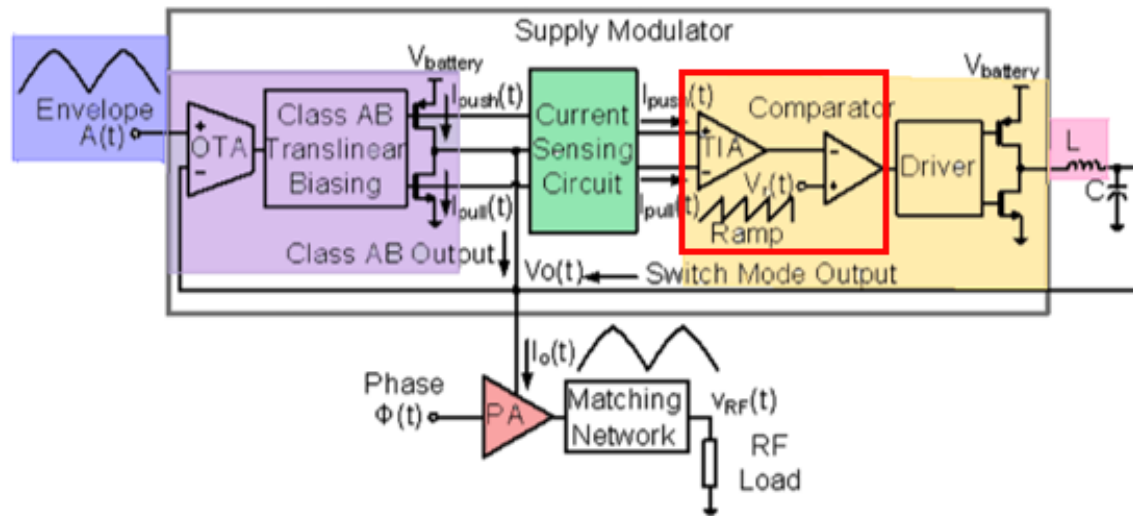
Chu – Figure 4

See Ex. 1004 at 2810 (“Fig. 4 shows the block diagram of the proposed master–slave linear and switch-mode combined supply modulator loaded with a PA.”).

The PA receives a total supply current (denoted $I_O(t)$) that comprises both the first supply current (“Switch Mode Output” or $I_{sm}(t)$ from the switcher) and the second supply current (Class AB Output or $I_{lin}(t)$ from the envelope amplifier). *Id.* at 2810 (“The transient response of currents at the output of the switch-mode regulator $I_{sm}(t)$, the linear amplifier $I_{lin}(t)$ **and combined master–slave supply modulator $I_O(t)$** is shown in Fig. 5. Assuming an infinite GBW linear amplifier, this architecture will generate a ripple free output current $I_O(t)$ to the load.”); *id.* (“[W]e can derive the transfer function of the **combined output current I_O** as follows:”). Ex. 1003 at ¶¶97-98.

- (e) “wherein the switcher comprises a current sense amplifier operative to sense the first supply current, or the second supply current, or the total supply current and provide a sensed signal,”

Chu discloses this limitation. As explained above for the “switcher” limitation, Chu discloses a switcher (highlighted in yellow). Chu’s switcher includes a current sense amplifier (outlined in red):

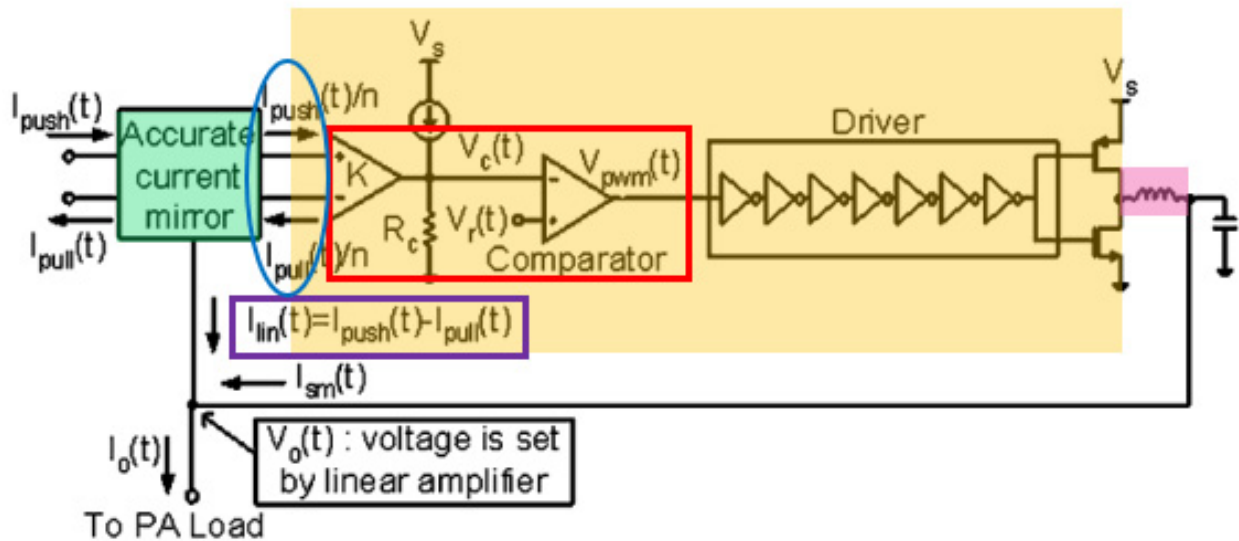


Chu – Figure 4

Ex. 1004 at 2810. Under the ALJ’s construction from the parallel ITC litigation (*see supra* Section VIII.A), a current sense amplifier is an “amplifier that produces a voltage from a current.” In Chu, the current sense amplifier comprises the transimpedance amplifier (TIA) and the comparator. A transimpedance amplifier is a current-to-voltage amplifier, and the overall current sense amplifier converts a current input into a voltage output, which is then sent to the “Driver” block as

shown in Figure 4. *Id.* at 2810 (“The sensed current is amplified by the transimpedance amplifier, comparator and the voltage divider formed by equivalent series resistance (ESR) of the loading inductor and resistive component R_L of the PA load.”); *id.* at 2814 (“Fig. 13 plots the frequency response of each block inside the switch-mode regulating loop. It shows that the total current to voltage conversion gain of current sensing and transimpedance stage is approximately 30 dB, followed by a comparator gain of 10 dB yielding an in-band gain of 40 dB. The transimpedance error amplifier and comparator are designed to have wide BW.”). Ex. 1003 at ¶¶99-100.

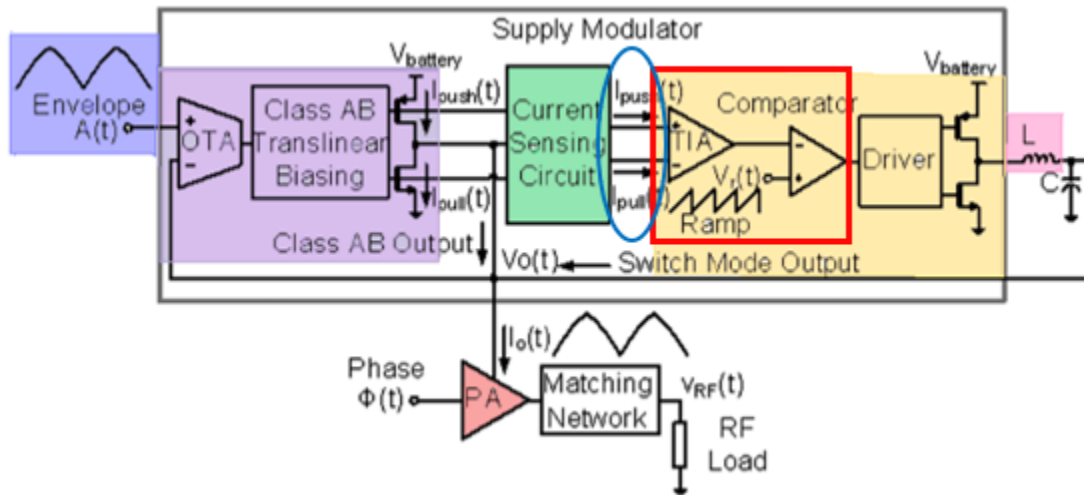
Claim 12 requires the current sense amplifier to sense one of three currents: the first supply, the second supply, or the total supply current. Chu satisfies this limitation because its current sense amplifier senses the claimed “second supply current.” As explained above, the second supply current—i.e., the output of the envelope amplifier—is $I_{lin}(t)$. Ex. 1004 at 2810 (describing $I_{lin}(t)$ as output current of linear amplifier). As shown in Figure 15 above in the equation outlined in purple, this second supply current ($I_{lin}(t)$) is equal to the difference between $I_{push}(t)$ and $I_{pull}(t)$: “ $I_{lin}(t) = I_{push}(t) - I_{pull}(t)$ ”.



Chu – Figure 15

Ex. 1004 at 2814. As shown in Figure 4 below and Figure 15 above, the current sense amplifier (outlined in red) receives currents $I_{push}(t)$ and $I_{pull}(t)$ (circled in blue) as inputs:⁵

⁵ In the detailed view of the circuitry shown in Figure 15, the inputs (outlined in blue) received by the current sense amplifier (outlined in red) are actually scaled versions of the $I_{push}(t)$ and $I_{pull}(t)$ currents (as indicated by the notation “ $I_{push}(t)/n$ ” and “ $I_{pull}(t)/n$ ”). This is the same as the disclosure of the ’558 patent, in which the Isen current received by the current sense amplifier “is a small fraction of the Ienv current from envelope amplifier 170a.” Ex. 1001 at 4:58-63 (“A current sensor 164 is coupled between node E and node A and senses the Ienv current provided



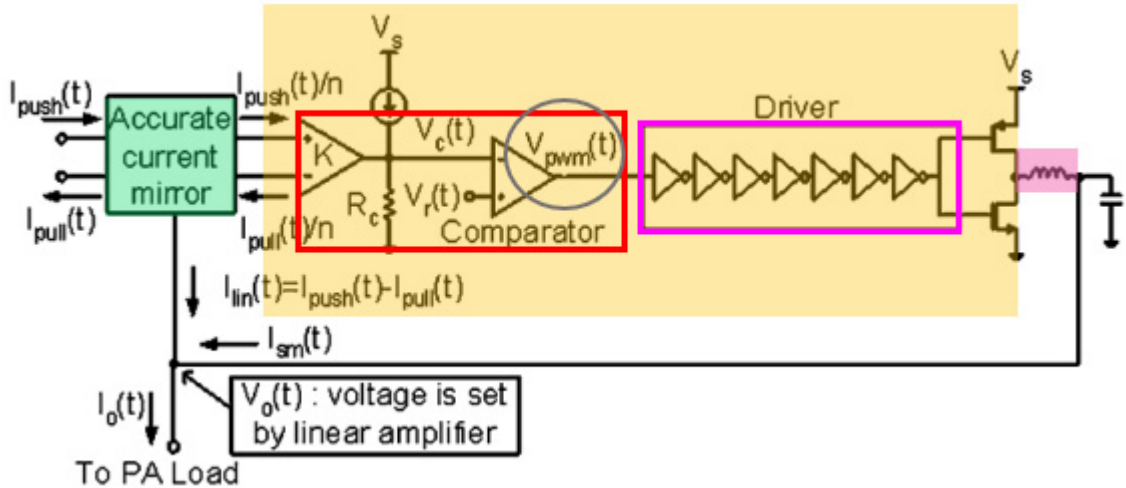
Chu – Figure 4

Ex. 1004 at 2810. Within the current sense amplifier, the TIA converts the difference between these currents to a voltage (labeled $V_c(t)$ in Figure 15).

Because the difference between these two inputs is the second supply current $I_{\text{lin}}(t)$, the TIA is sensing $I_{\text{lin}}(t)$ —the second supply current—and converting it to a voltage. *Id.* at 2810 (“The sensed current is amplified by the transimpedance amplifier”). Ex. 1003 at ¶101.

by envelope amplifier 170a. Sensor 164 passes most of the I_{env} current to node A and provides a small sensed current (I_{sen}) to switcher 160a. The I_{sen} current is a small fraction of the I_{env} current from envelope amplifier 170a.”). Likewise, in Figure 16 of Chu, the $I_{ds6}(t)$ and $I_{ds7}(t)$ currents received at the TIA correspond to scaled versions of $I_{push}(t)$ and $I_{pull}(t)$.

Finally, as shown below in Figure 15 from Chu, the current sense amplifier (outlined in red) provides a sensed signal ($V_{pwm}(t)$, outlined in gray) to the driver (outlined in fuchsia):



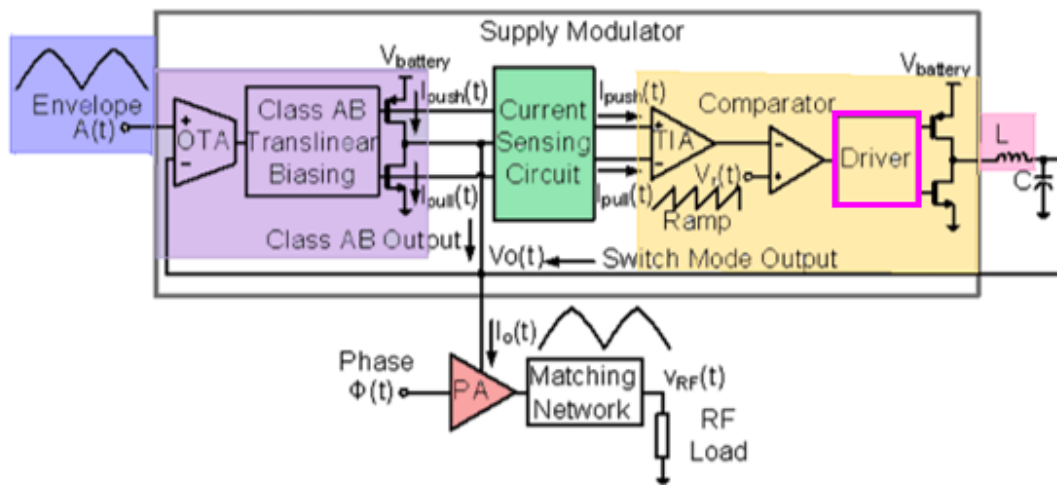
Chu – Figure 15

Ex. 1004 at 2814 (“As shown in Fig. 11, linearized gain of the comparator is defined by the ratio of its output voltage swing to the amplitude of its ramp input. $V_{pwm}(t)$ is the switching version of $V_o(t)$ that has equal magnitude but contains stronger and more high-frequency harmonics.”); *id.* at Fig. 4. Ex. 1003 at ¶102.

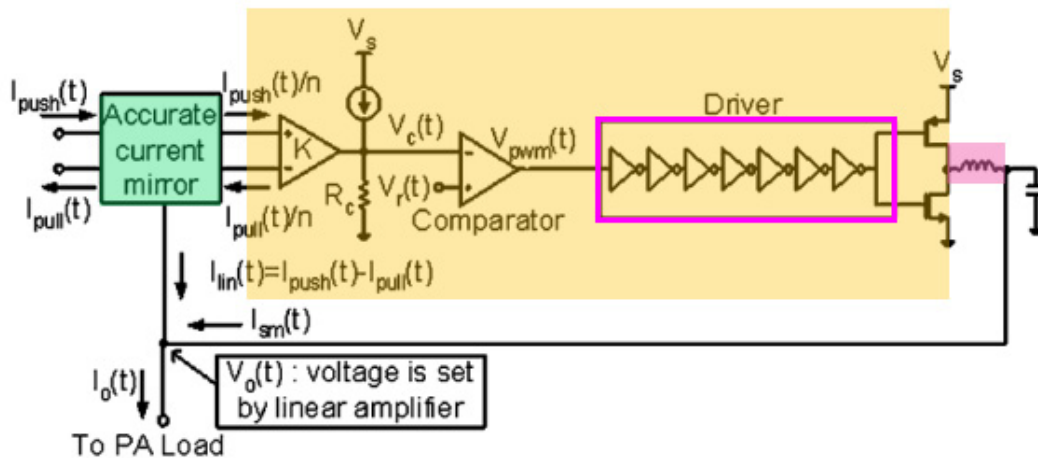
Accordingly, Chu discloses that “the switcher comprises a current sense amplifier [i.e., the transimpedance amplifier (TIA) and the comparator] operative to sense ... the second supply current [i.e., the output $I_{lin}(t)$ of the envelope amplifier]” and “provide a sensed signal [i.e., $V_{pwm}(t)$].” Ex. 1003 at ¶103.

- (f) “a driver operative to receive the sensed signal and provide a first control signal and a second control signal,”

Chu discloses this limitation. As shown below in Figures 4 and 15, Chu discloses switcher (highlighted in yellow) and that switcher comprises a driver (outlined in fuchsia):



Chu – Figure 4

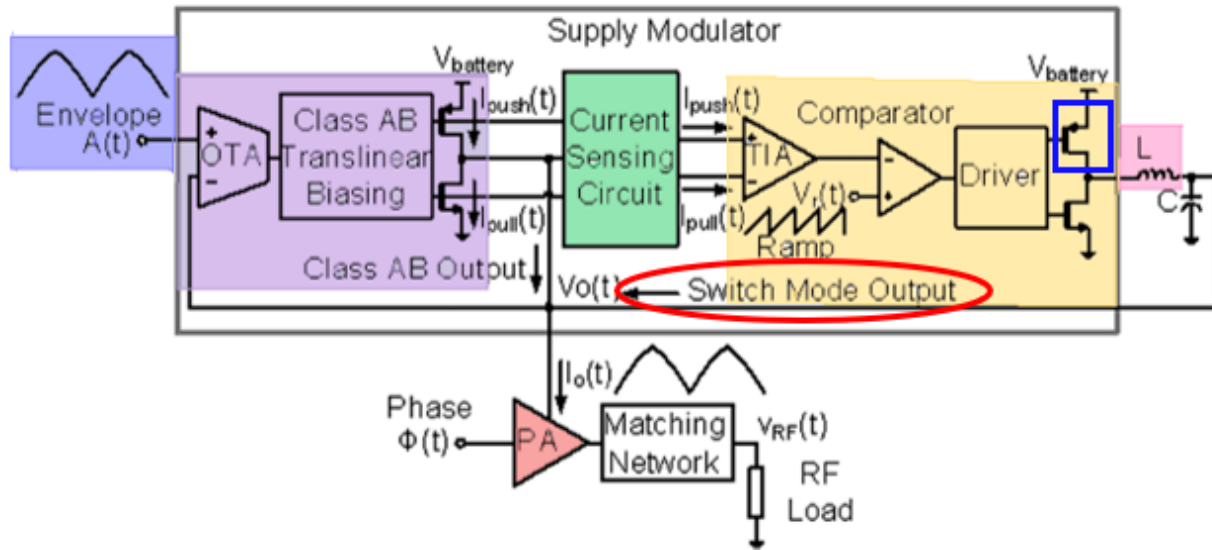


Chu – Figure 15

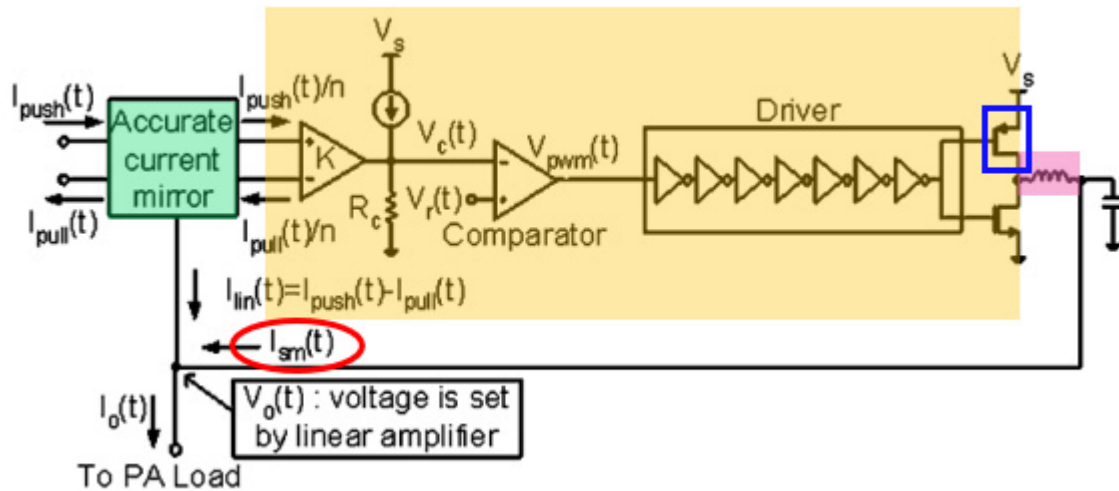
Ex. 1004 at 2811, 2814. As shown in Figure 15, the driver receives the sensed signal ($V_{\text{pwm}}(t)$) from the current sense amplifier. *See id.* at 2814 (“[L]inearized gain of the comparator is defined by the ratio of its output voltage swing to the amplitude of its ramp input. $V_{\text{pwm}}(t)$ is the switching version of $V_{\text{O}}(t)$ that has equal magnitude but contains stronger and more high-frequency harmonics.”). The cascaded inverters in the driver in Chu condition the input signal $V_{\text{pwm}}(t)$ by increasing its driving strength and dividing the signal to two separate transistors, all without imposing too much delay. *See id.* at 2815 (“The gate driver uses seven cascaded tapered inverter stages, which is optimized for minimum delay.”). The driver thus conditions the input signal $V_{\text{pwm}}(t)$ and outputs two control signals to the two transistors coupled to the right of the driver. Ex. 1003 at ¶104.

- (g) “a P-channel metal oxide semiconductor (PMOS) transistor having a gate receiving the first control signal, a source receiving the first supply voltage, and a drain providing a switching signal for an inductor providing the first supply current, and”**

Chu discloses this limitation. As shown in Figures 4 and 15 below, Chu discloses that the switcher (highlighted in yellow) contains a PMOS transistor (outlined in blue). Figures 4 and 15 depict this transistor with a common symbol for PMOS transistors, i.e., as shown by the arrow pointing into the transistor gate in the blue boxes below:



Chu – Figure 4



Chu – Figure 15

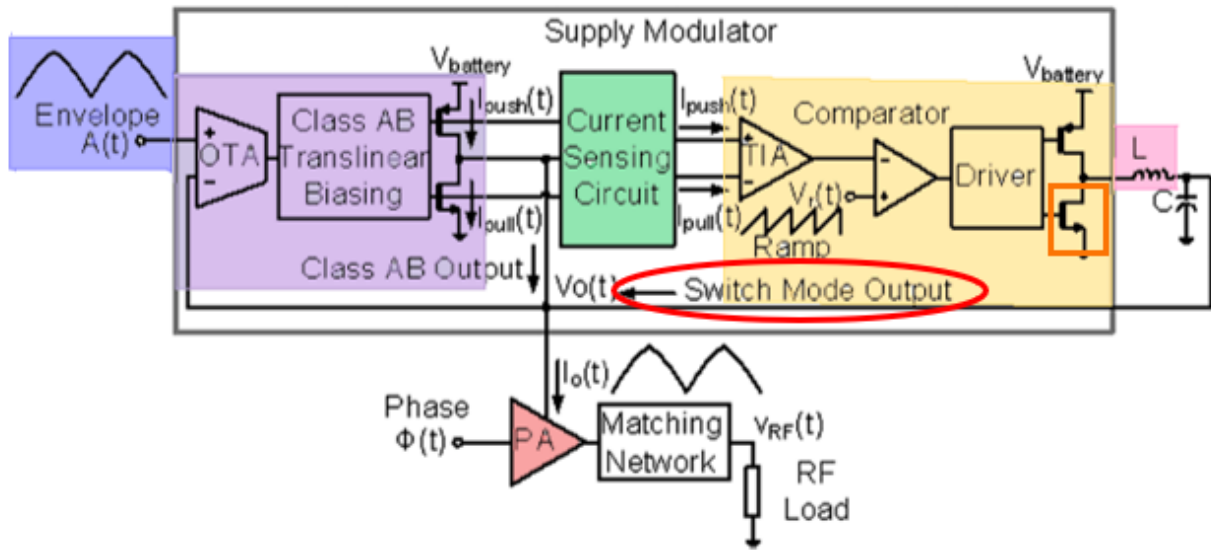
see also Ex. 1001 at 4:66-5:6 (describing element 334 in switcher 160a as a PMOS transistor), Figure 3 (depicting element 334 using the same symbol as in Figures 4 and 15 of Chu). The PMOS transistor has a gate that receives the first control

signal from the driver. The PMOS transistor is also shown with its source (the top terminal of the transistor) receiving the first supply voltage (V_{battery} in Figure 4, V_s in Figure 15). Ex. 1004 at 2811, 2814; Ex. 1003 at ¶105.

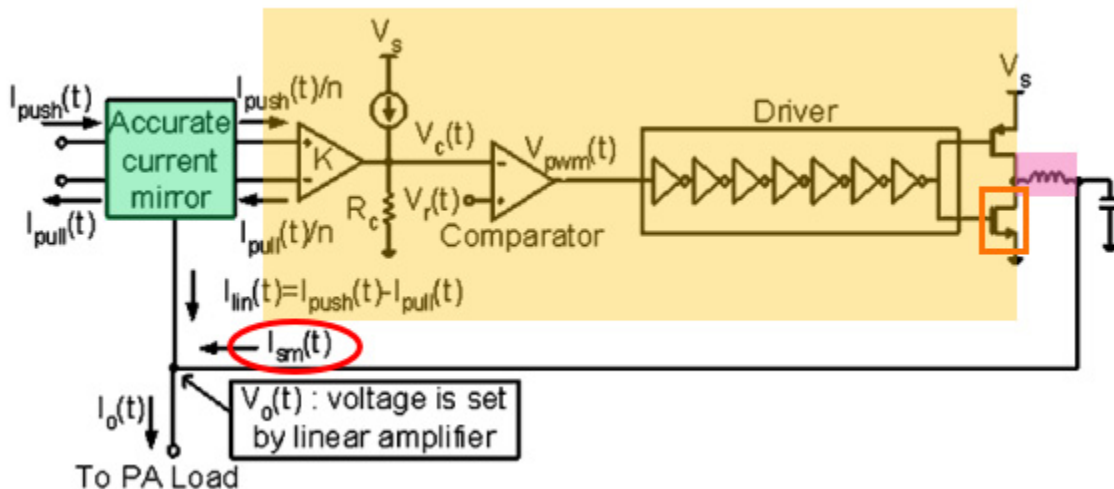
The PMOS transistor is also shown as having a drain (the bottom terminal of the transistor) that provides a switching signal for an inductor (shown by the standard figure for an inductor, highlighted in pink) that provides the first supply current (“Switch Mode Output” in Figure 4 or $I_{\text{sm}}(t)$ in Figure 15). Ex. 1004 at 2811, 2814; Ex. 1003 at ¶105.

(h) “an N-channel metal oxide semiconductor (NMOS) transistor having a gate receiving the second control signal, a drain providing the switching signal, and a source coupled to circuit ground.”

Chu discloses this limitation. As shown in Figures 4 and 15, Chu discloses that the switcher (highlighted in yellow) contains an NMOS transistor (outlined in orange). Chu’s Figures 4 and 15 depict this transistor with a common symbol for NMOS transistors, i.e., as shown by the arrow pointing out of the transistor gate outlined in orange below:



Chu – Figure 4



Chu – Figure 15

Ex. 1004 at 2811, 2814; *see also* Ex. 1001 at 4:66-5:6 (describing element 336 as an NMOS transistor), Figure 3 (depicting element 336 using the same symbol as in Chu Figures 4 and 15). The NMOS transistor has a gate that receives the second control signal from the driver. The NMOS transistor is also shown with its drain

(the top terminal of the transistor) as providing the switching signal for the inductor (highlighted in pink) that provides the first supply current (“Switch Mode Output” in Figure 4 or $I_{sm}(t)$ in Figure 15). Finally, the NMOS transistor is shown with its source (the bottom terminal of the transistor) as coupled to circuit ground (shown by the standard figure for ground—the downward-pointing arrow). Ex. 1003 at ¶106.

2. Claim 14

Claim 14 is anticipated by Chu, as explained below. Ex 1003 at ¶¶107, 110.

- (a) **“The apparatus of claim 12, wherein the first supply current comprises direct current (DC) and low frequency components, and wherein the second supply current comprises higher frequency components.”**

As explained above, Chu discloses the apparatus of claim 12. Chu also discloses that the “first supply current”—the output of the switcher (“Switch Mode Output”/ $I_{sm}(t)$)—comprises direct current (DC) and low frequency components. Chu explains that “[a]t low frequencies ... the switch-mode regulator dominates the output current.” Ex. 1004 at 2811; *see also id.* at 2809 (“Low frequency content of the envelope waveform is provided by a synchronous-rectifier based switch-mode power supply”). Chu does not specifically mention DC components, but a DC signal has zero frequency; thus, the first supply current from the switcher

would—by including the “low frequencies”—comprise any zero-frequency DC components. Ex. 1003 at ¶108.

Chu also discloses that the “second supply current”—the output of the envelope amplifier (Class AB Output/ $I_{lin}(t)$)—comprises higher frequency components. Chu explains that “at high frequencies, the switch-mode regulator current response starts rolling off and the linear amplifier takes over the output current.” Ex. 1004 at 2811 (“At low frequencies, the linear amplifier current output is suppressed and the switch-mode regulator dominates the output current. Conversely, at high frequencies, the switch-mode regulator current response starts rolling off and the linear amplifier takes over the output current.”); *see also id.* at 2809 (“Low frequency content of the envelope waveform is provided by a synchronous-rectifier based switch-mode power supply while high frequency content is provided by a rail-to-rail class-AB amplifier.”). Ex. 1003 at ¶109.

B. Ground II: Claim 14 is obvious over Chu combined with Blanken

1. Claim 14

Claim 14 is obvious over Chu in view of Blanken, as explained below. Ex 1003 at ¶¶111, 118.

- (a) **“The apparatus of claim 12, wherein the first supply current comprises direct current (DC) and low frequency components, and wherein the second supply current comprises higher frequency components.”**

As explained above, Chu discloses the apparatus of claim 12. As explained in the immediately preceding section, Chu also discloses the additional requirements of claim 14. Ex. 1003 at ¶112.

To the extent that Chu is found not to disclose the additional elements of claim 14, Blanken discloses these elements. Blanken describes a hybrid supply regulator/modulator for a power amplifier. The supply modulator combines (1) an envelope amplifier (a “linear regulator”), and (2) a switcher (a “DC/DC converter”). Ex. 1010 at 401 (“The supply-modulator topology is shown in Fig. 1. It contains a linear regulator and a DC/DC converter in master-slave configuration.”); *see also id.* (“High-efficiency voltage conversion can be obtained with a switched-mode inductive DC/DC buck converter, but its bandwidth is limited due to practical limits to the switching frequency. Alternatively, linear regulators enable higher bandwidth at the cost of efficiency. As a good compromise between efficiency and bandwidth, hybrid supply modulators have been proposed combining a switched-mode DC/DC converter in parallel to a linear regulator.”). Ex. 1003 at ¶113.

Claim 14 requires a “first supply current” from the switcher that comprises direct current (DC) and low frequency components, and a “second supply current” from the envelope amplifier that comprises higher frequency components.”

Blanken discloses these same elements: “the DC/DC converter [switcher] supplies the DC and low-frequency part of the load current, and the linear regulator [envelope amplifier] supplies the high-frequency part.” Ex. 1010 at 401; Ex. 1003 at ¶114.

(i) Motivation to Combine Chu and Blanken

It would have been obvious to generate a first supply current that has DC and low frequency signal components and a second supply current that has high frequency signal components using the hybrid supply generator of Chu, as taught by Blanken. Both Chu and Blanken are from the same field of endeavor—power supply modulators for power amplifiers—and Chu and Blanken both disclose similar envelop tracking architectures. Ex. 1004 at 2809 (“A combined class-AB [linear amplifier] and switch-mode regulator based supply modulator with a master–slave architecture achieving wide bandwidth and low ripple is presented.”); Ex. 1010 at 401 (“The supply-modulator topology is shown in Fig. 1. It contains a linear regulator and a DC/DC converter in master-slave configuration.”).

Both Chu and Blanken recognized the high bandwidth but low efficiency of the envelope amplifier, and the low bandwidth but high efficiency of a switcher,

and both proposed a hybrid supply generator as a solution. Ex. 1004 at 2809 (“Although switch-mode supply regulators boost efficiency of the PA, their operating bandwidth is limited by the switching frequency. Alternatively, LDO regulators provide wide bandwidth while enhancing the linearity of the PA, but they are inefficient at backed-off power levels. ... In this paper, a master–slave linear and switch-mode supply modulator with fast dynamic transient response is presented.”), Ex. 1010 at 401 (“High-efficiency voltage conversion can be obtained with a switched-mode inductive DC/DC buck converter, but its bandwidth is limited due to practical limits to the switching frequency. Alternatively, linear regulators enable higher bandwidth at the cost of efficiency. As a good compromise between efficiency and bandwidth, hybrid supply modulators have been proposed combining a switched-mode DC/DC converter in parallel to a linear regulator.”). Chu also recognized the importance of performance optimization in the hybrid supply generator. Ex. 1004 at 2812-13. Given this knowledge of the different capabilities and efficiencies of the envelope amplifier and the switcher, which work in parallel, a POSA would have been motivated to use the bandwidth-constrained but high-efficiency switcher to supply the DC and low frequency signal components and the less-efficient envelope amplifier to supply the higher frequency signal components, as Chu already suggests. *See* Ex. 1010 at 401 (explaining that “the DC/DC converter [switcher] supplies the DC and low-

frequency part of the load current, and the linear regulator [envelope amplifier] supplies the high-frequency part”); Ex. 1004 at 2809 (“Low frequency content of the envelope waveform is provided by a synchronous-rectifier based switch-mode power supply”). Ex. 1003 at ¶¶115-116.

Moreover, combining these elements of Chu and Blanken would have yielded only expected, predictable results. Such a combination would have involved merely (a) combining prior-art elements according to known methods to yield predictable results, because a POSA would understand, for example, that using the switcher to supply the zero-frequency DC and low-frequency signal components and the envelope amplifier to supply the high-bandwidth components was merely optimizing the known features of the components; (b) the use of a known technique (Blanken’s use of different supply generators for different signal components) to improve a similar device (Chu’s hybrid supply generator) in the same way; and (c) applying a known technique (Blanken’s use of different supply generators for different signal components) to a known device ready for improvement (Chu’s hybrid supply generator) to yield predictable results. Ex. 1003 at ¶117.

C. Ground III: Claim is obvious in view of Chu combined with Choi 2010

Claim 13 is obvious in view of Chu combined with Choi 2010, as explained below. Ex. 1003 at ¶¶119, 131.

As explained above in Section X.A.1, Chu anticipates claim 12. Chu combined with Choi 2010 also renders the additional limitations in claim 13 obvious. Chu discloses a supply generator (the “Supply Modulator”) as shown in Figure 4 below.

Chu – Figure 4

Ex. 1004 at 2811. The supply generator receives an envelope signal ($A(t)$, highlighted in blue at the left) and a supply voltage (V_{battery} circled in dark blue at the top). Chu generates an output supply voltage ($V_O(t)$ circled in gray) for the PA (highlighted in red) based on the envelope signal and V_{battery} . Ex. 1004 at 2810 (“Fig. 4 shows the block diagram of the proposed master–slave linear and switch-mode combined supply modulator loaded with a PA. A high GBW linear amplifier in voltage follower configuration ensures that output node $V_O(t)$ tracks the reference envelope voltage $A(t)$.”). Ex. 1003 at ¶¶120-122.

It would have been obvious to a POSA to modify Chu to incorporate a boost converter to boost the supply voltage V_{battery} to a higher voltage to produce a boosted supply voltage for use by the envelope amplifier. As shown below, Choi 2010 (like Chu) discloses a supply generator (“supply modulator”) for a PA, and Choi 2010’s supply generator (like Chu’s) includes an envelope amplifier (highlighted in purple) that receives an envelope signal “Env.” (highlighted in blue at the left):

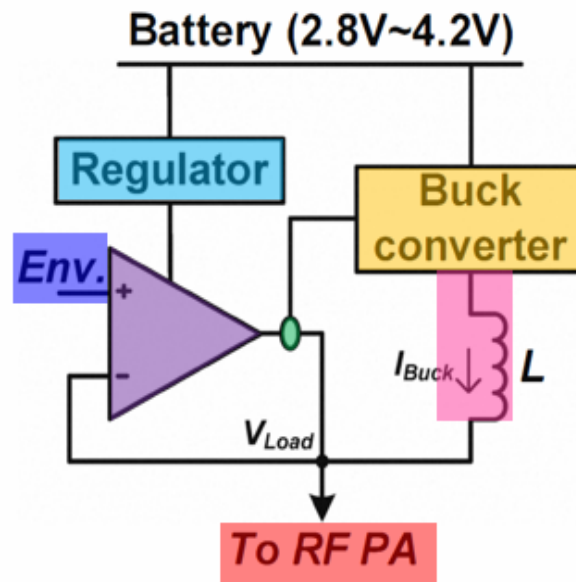


Fig. 5. Battery-to-5V boosting PA supply modulator.

Choi 2010 – Figure 5

Ex. 1007 at Fig. 5. The supply modulator in Choi 2010 receives a first supply voltage (“Battery (2.8V-4.2V)”) and employs a boost converter (“Regulator,” highlighted in blue) to generate a boosted supply voltage greater than the first supply voltage. *Id.* at 1074 (“To prevent the degradation of the output power, a **boost converter**, whose **output voltage is always higher than the input voltage**, can be utilized.”), *id.* at 1075 (“As the load voltage is regulated by the linear amplifier, boosting up the supply voltage of the linear amplifier results in a stable supply voltage to the RF PA regardless of the battery depletion. Thus, the additional 5V boost converter, whose input range is from 2.8V to 4.2V, is coupled to the supply of the linear amplifier, while that of the switching amplifier is

directly connected to the battery as illustrated in Fig. 5. . . . As the supply voltage of the modulator is boosted up to the 5V, considering the 0.5V drop across the modulator, the PA now operates with 4.5V supply voltage.”). Ex. 1003 at ¶123.

Accordingly, Chu, as modified to incorporate the boost converter disclosed in Choi 2010, comprises a supply generator that includes “a boost converter operative to receive the first supply voltage and provide a boosted supply voltage having a higher voltage than the first supply voltage.” Ex. 1003 at ¶124.

(i) Motivation to Combine Chu and Choi 2010

It would have been obvious to modify Chu’s supply modulator to incorporate the boost converter of Choi 2010. Both Chu and Choi 2010 are from the same field of endeavor—each discloses a hybrid supply modulator for a PA. Indeed, Choi 2010 even cites Chu as prior art that Choi 2010’s apparatus builds upon. Ex. 1007 at 1074, 1077 (reference [7]). Ex. 1003 at ¶125.

Moreover, one of ordinary skill in the art would have been motivated to use a boost converter to prevent distortion as the battery becomes depleted and the voltage provided by the battery falls. Specifically, it would have been desirable to operate Chu’s linear amplifier with a boosted voltage so that (1) when the battery voltage starts depleting, Chu’s linear amplifier is more robust, and/or (2) when the battery voltage is lower than the peak voltage magnitude of the amplified reference envelope voltage $A(t)$, distortion of the amplified reference envelope voltage is

prevented. These advantages are specifically taught by Choi 2010, and would have motivated a POSA to modify Chu accordingly. *See* Ex. 1007 at 1074 (“An integrated boost converter keeps a stable operation of the PA supply modulator. Even at the battery depletion from 4.2V to 2.8V, there is no significant degradation of output power and linearity in the power amplifier.”); *id.* (“By boosting up the supply voltage of the linear amplifier to 5V regardless of the battery voltage variation, while that of the buck converter is still coupled to the battery in the HSA, the supply modulator dynamically regulates the PA with the peak voltage of 4.5V.”); *id.* at 1077 (“For the additional boost converter, the proposed supply modulator presents the robust performance over the battery voltage variation while the efficiency degradation is minimized.”). Ex. 1003 at ¶126.

Using a boost converter to power a PA to prevent distortion of the amplified signal was also common and well-known in the prior art. The Maehara patent, for example, taught using a boost converter (“step-up converter”) in an amplifying circuit to prevent distortion. *See* Ex. 1018 at Abstract (“An amplifying circuit according to the present invention has an amplifying unit for amplifying an input signal to produce an amplified signal, a battery for generating a constant voltage (a first voltage), *a step-up converter for always generating an increased voltage* (or a second voltage) by increasing the constant voltage [B]ecause the increased voltage is always generated by the step-up converter ... *any distortion of the*

amplified signal can be prevented”). Similarly, a 2008 datasheet for a Maxim amplifier taught using a boost converter to extend battery life and maintain output levels when the battery voltage drops. Ex. 1015 [Maxim Integrated Products, Inc., *MAX9738 –16V_{P-P} Class G Amplifier with Inverting Boost Converter*, Datasheet 19-3700; Rev. 0 (March 2008) (“Maxim”)] at 8 (“The MAX9738 Class G power amplifier with inverting boost converter is the latest in linear amplifier technology. The Class G output stage offers improved performance over a Class AB amplifier while increasing efficiency to extend battery life. The integrated inverting boost converter generates a negative supply capable of delivering up to 400mA. The negative supply is only used when the output signal requires a larger supply voltage differential. As the battery voltage drops, the boost converter output becomes more negative to maintain amplifier output swing all the way down to $V_{BAT} = 2.7V$.”). Ex. 1003 at ¶127.

Maehara and Maxim are examples of references that would have further confirmed for a POSA the advantages of modifying Chu’s supply modulator to incorporate the boost converter of Choi 2010, and thus further confirm the motivation for this modification. Because adding a boost converter had been used to improve numerous similar devices, a POSA would have recognized that this same technique would also improve the Chu’s supply modulator: references such as Maehara and Maxim show that the results of incorporating a boost converter

such as Choi 2010's boost converter into Chu's supply modulator were entirely predictable, and in line with the results to be expected from the express teaching of Choi 2010. Ex. 1003 at ¶127.

It was also well known in the art that the voltage output of a battery declines over time with use. Specifically, it was known that a battery will start at a fully charged voltage output level, but that the voltage level output by the battery will decline over time as the battery becomes depleted through use. A person of ordinary skill in the art would have understood that the output of a battery is not binary (i.e., not either fully on or fully off) but instead will decay over time until the battery's voltage output approaches zero. Given this state of battery technology in the prior art, it was obvious to use a boost converter to boost a falling battery voltage and provide the boosted voltage to circuit components, such as Chu's envelope amplifier, to maintain operation and minimize distortion as battery voltages drop. Ex. 1003 at ¶128.

Finally, adding the Choi 2010 boost converter to Chu's supply generator would have yielded only expected, predictable results. Combining the teachings of Choi 2010 with Chu would have been: (a) a combination of prior-art elements according to known methods to yield predictable results, because a POSA would have understood, for example, the effect on the output of an envelope amplifier from modifying that amplifier to receive a boosted supply voltage; (b) a simple

substitution of one known element (a boosted supply or a combination of a boosted supply and battery voltage) for another (a battery supply) to obtain predictable results; (c) a use of a known technique (operating an envelope amplifier with a boosted power supply) to improve a similar device (Chu's envelope amplifier) in the same way disclosed by Choi 2010; (d) an application of a known technique (providing a boosted voltage) to a known device (Chu's envelope amplifier) that was ready for improvement to yield predictable results; and (e) obvious to try—a choice of different envelope trackers, from a finite number of identified, predictable solutions, with a reasonable expectation of success. Ex. 1003 at ¶129.

(b) “wherein the envelope amplifier operates based on the first supply voltage or the boosted supply voltage.”

Chu in combination with Choi 2010 discloses this limitation. The envelope amplifier in Choi 2010 (highlighted in purple) also generates a supply voltage (V_{Load}) based on the boosted supply voltage, and provides this supply voltage to the PA. Ex. 1007 at 1075 (“[T]he additional 5V boost converter, whose input range is from 2.8V to 4.2V, is coupled to the supply of the linear amplifier ... as illustrated in Fig. 5.”); *id.* at 1074 (“An integrated boost converter keeps a stable operation of the PA supply modulator. Even at the battery depletion from 4.2V to 2.8V, there is no significant degradation of output power and linearity in the power amplifier.”); *id.* (“By boosting up the supply voltage of the linear amplifier to 5V regardless of

the battery voltage variation, while that of the buck converter is still coupled to the battery in the HSA, the supply modulator dynamically regulates the PA with the peak voltage of 4.5V.”). As discussed above in connection with limitation 13(a), it would have been obvious for the envelope amplifier of Chu to use the boosted voltage because using a boosted voltage can improve performance, particularly to prevent distortion of the amplified signal. *See* Section X.C.1(a). Ex. 1003 at ¶130.

D. Ground IV: Claim 13 is obvious in view of Chu combined with Choi 2010 and Myers

1. Claim 13

As explained above in the immediately preceding section, claim 13 is obvious in view of Chu combined with Choi 2010. The plain language of limitation 13(b) requires only that the envelope amplifier operates based on one or the other of the first supply voltage or the boosted supply voltage. Claim 13 does not require the envelope amplifier to be able to *select* either the first supply voltage or the boosted supply voltage at any given time. But if selectivity is required, this limitation would have been obvious in light of Chu in combination with Choi 2010 and Myers. When combined with Myers, the Chu envelope amplifier would also be able to operate selectively by choosing a power source—either the boosted voltage generated by the boost converter provided by Choi 2010 or the battery supply voltage (the “first supply voltage”) already disclosed in Chu—and generate

the second supply voltage based on either the first supply voltage (battery voltage) or the boosted supply voltage, as circumstances warrant. Ex. 1003 at ¶¶132, 141.

Myers discloses a power supply modulator for a PA that “efficiently amplifies the envelope of the input signal” by selecting among different power sources based on operating conditions. Ex. 1012 at Abstract. The input signal is compared to a reference voltage (V_{REF}), and based on that comparison, one of multiple power sources is selected for use by the amplifier, as shown below:

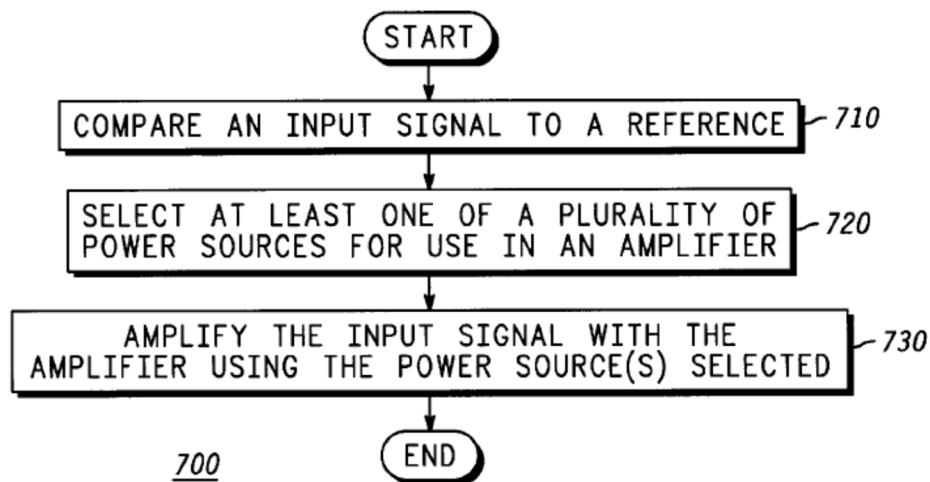


FIG. 7

Myers – Figure 7

Ex. 1012 at 9:8-21 (“FIG. 7 shows a flowchart for a method of amplifying a signal in accordance with a preferred embodiment of the present invention. Method 700 begins with step 710 when an input signal is compared to a reference. Then in step 720, as a result of the comparison in step 710, *at least one of a plurality of power*

sources is selected for use in an amplifier. Then in step 730, the input signal is amplified with the amplifier that uses the power sources selected. Method 700 as shown in FIG. 7 is a method which *selects a power source to be used* in an amplifier where the selection is a function of the amplitude of the input signal. This allows an amplifier to be operated in a more efficient range because a power source can be chosen close to the amplitude of the input signal.”); *see also id.* Fig. 8; *id.* at 9:22-41. A POSA would have understood that because the power amplification apparatus in Myers can be used in a communications device, which uses a battery, the reference voltage used in the comparison could be based on the battery voltage (e.g., on the battery voltage itself or some fraction of the battery voltage depending on the envelope amplifier’s gain), as the ’558 patent discloses. Ex. 1012 at 9:18-21, 1:19-23 (“High dynamic range allows the communications devices to communicate more reliably over a variety of distances, and high efficiency allows the devices to operate longer on a single battery.”); Ex. 1001 at 6:4-5 (“The first threshold may be a fixed threshold or may be determined based on the Vbat voltage.”). Ex. 1003 at ¶¶133, 134.

(a) Motivation to Combine Chu with Choi 2010 and Myers

It would have been obvious to a POSA to modify Chu's envelope amplifier (in view of Choi 2010 and Myers) so that it operated selectively with either a battery supply or boosted voltage. Ex. 1003 at ¶135.

All three references—Chu, Choi 2010, and Myers—are from the same field of endeavor (hybrid power supply modulators). Combining the Chu envelope amplifier with the Choi 2010 boost converter would have been obvious for the reasons stated above regarding limitation 13(a). Combining the Chu envelope amplifier as modified by Choi 2010 with the selection functionality of Myers would have had further advantages: Myers “selects a power source to be used in an amplifier where the selection is a function of the amplitude of the input signal,” i.e., how much power is needed for the specific input signal, which “allows an amplifier to be operated in a more efficient range because a power source can be chosen *close to the amplitude of the input signal*.” Ex. 1012 at 9:18-21.

Consequently, choosing a power source close to the amplitude of the input signal avoids the waste of power that would occur by supplying an unnecessarily high voltage. *See id.* Ex. 1003 at ¶136.

A person of ordinary skill in the art would have understood that the selection of the power source may be based on the battery voltage when implementing the

envelope amplifier of Chu with the boost converter of Choi 2010. For example, a POSA would have understood that, when the voltage requirements of the amplified envelope signal is **lower** than the battery voltage, the envelope tracker of Chu as modified by Choi 2010 should use the battery voltage, because the battery voltage is sufficient to support the voltage needs of the PA, and using the boosted the voltage would unnecessarily provide extra power and deplete the battery more quickly. Ex. 1003 at ¶137.

Conversely, a POSA would also have understood the common-sense notion that, when the voltage requirements of the amplified envelope signal is **greater** than the battery voltage, then it would be necessary to operate Chu's envelope tracker (as modified by Choi 2010) with a boosted voltage closer to the amplitude of the input signal, in order to supply the PA with the necessary output voltage. A POSA would have understood that using a boosted supply in this circumstance prevents distortion of the amplified envelope signal. Ex. 1003 at ¶137.

Myers expressly teaches that choosing the power source based on the amplitude of the input signal “allows an amplifier to be operated in a more efficient range,” and suggests that high efficiency is important to battery life. Ex. 1012 at 9:18-21, 1:19-23 (“High dynamic range allows the communications devices to communicate more reliably over a variety of distances, and high efficiency allows the devices to operate longer on a single battery.”). Myers also

discloses that the second power supply Vdd2 is larger than Vdd1, and that (like the apparatus in the '558 patent) the second power source will be used only when needed and the first power source will be used the rest of the time. *Id.* at 3:47-59 (“The operation of multi-range modulator 200 differs based on whether the amplitude of the envelope signal is below or above the reference voltage shown as Vref in FIG. 2. When the amplitude of the envelope signal is below Vref, multi-range modulator 200 operates in a first mode. When the amplitude of the envelope signal is above Vref, multi-range modulator 200 operates in a second mode. Multi-range modulator 200 changes from the first mode of operation to the second as the amplitude of the envelope signal increases, and changes from the second mode of operation to the first as the amplitude of the envelope signal decreases.”); *see also id.* at 3:60-4:43 (describing the switch between Vdd1 and Vdd2); *see also* Ex. 1001 at 5:31-33 (“In one design, envelope amplifier 170 a operates based on the Vboost voltage only when needed and based on the Vbat voltage the remaining time in order to improve efficiency.”). A POSA would have known that one purpose of implementing selection between a battery voltage and a boosted supply voltage was to preserve battery voltage, which is limited. Ex. 1003 at ¶138.

Therefore, a POSA would have been motivated to combine the selection functionality of Myers with the Chu envelope amplifier, as modified by Choi 2010, so that: (1) when a boosted voltage is not required, Chu’s linear amplifier operates

efficiently with the battery voltage, and (2) when the battery voltage is lower than the peak voltage magnitude of the amplified reference envelope voltage $A(t)$, Chu's linear amplifier operates with the boosted voltage to prevent distortion of the amplified reference envelope voltage $A(t)$. Modifying Chu to selectively use either the battery or boosted voltages as taught by Myers would have been a particularly obvious approach in view of the well-known state of battery technology, i.e., that batteries do not operate solely at a fixed output voltage level and instead start out operating an initial fully charged level and then experience reduced output voltage over time as the battery is discharged. Ex. 1003 at ¶139.

Finally, adding the selectable power sources of Myers to the Chu envelope amplifier (in view of Choi 2010) would have yielded only expected, predictable results. Using the power selection method disclosed in Myers with Chu, as modified by Choi 2010 to include the boost converter, would have been: (a) a combination of prior-art elements (providing a battery supply and a boosted supply) according to known methods to yield predictable results, because a POSA would have understood, for example, allowing the envelope amplifier to selectively receive either a battery supply or a boosted supply would satisfy the power requirements of the power amplifier while improving battery preservation; (b) a simple substitution of one known element (switching operation between two power supplies) for another (operating with one power supply) to obtain

predictable results; (c) a use of a known technique (operating an envelope amplifier with either a boosted power supply or a battery power supply) to improve a similar device (the envelope amplifier of Chu) in the same way; (d) an application of a known technique (selectively receive either a boosted power supply or a battery power supply) to a known device (the envelope amplifier of Chu) ready for improvement to yield predictable results; and (e) obvious to try—a choice of one type of power supply from a finite number of identified, predictable solutions, with a reasonable expectation of success. Ex. 1003 at ¶140.

XI. CONCLUSION

Based on the foregoing, claims 12-14 of the '558 patent recite subject matter that is unpatentable. Petitioner requests institution of *inter partes* review to cancel these claims.

Respectfully Submitted,

/David L. Cavanaugh/

David L. Cavanaugh
Registration No. 36,476

Table of Exhibits for U.S. Patent 8,698,558 Petition for *Inter Partes* Review

Exhibit	Description
1001	U.S. Patent No. 8,698,558
1002	File History for U.S. Patent No. 8,698,558
1003	Declaration of Dr. Alyssa B. Apsel
1004	Chu, W.Y. et al., “ <i>A 10 MHz Bandwidth, 2 mV Ripple PA Regulator for CDMA Transmitters</i> ,” IEEE Journal of Solid-State Circuits 2809-2819 (2008) (“Chu”)
1005	Declaration of IEEE regarding Chu, Kwak, Kim, and Blanken (“IEEE Chu Decl.”)
1006	Choi, J. et al., “ <i>Envelope Tracking Power Amplifier Robust to Battery Depletion</i> ,” Microwave Symposium Digest (MTT), 2010 IEEE MTT-S International 1332-36 (2010) (“Choi 2010”)
1007	Declaration of IEEE regarding Choi 2010 (“IEEE Choi Decl.”)
1008	Declaration of Debabani Choudhury (“Choudhury Decl.”)
1009	Declaration of Jinsung Choi (“Choi Decl.”)
1010	Blanken, P.G. et al., “ <i>A 50MHz Bandwidth Multi-Mode PA Supply Modulator for GSM, EDGE and UMTS Application</i> ,” 2008 Radio Frequency Integrated Circuits Symposium (IEEE) 401-04 (2008) (“Blanken”)
1011	Kwak, T.W. et al., “ <i>A 2 W CMOS Hybrid Switching Amplitude Modulator for EDGE Polar Transmitters</i> ,” IEEE Journal of Solid-State Circuits 2666-76 (2007) (“Kwak”)
1012	U.S. Patent No. 5,929,702, “Method and Apparatus for High Efficiency High Dynamic Range Power Amplification,” to Myers et al. (“Myers”)
1013	Kim, D. et al., “ <i>High Efficiency and Wideband Envelope Tracking Power Amplifier with Sweet Spot Tracking</i> ,” Radio Frequency Integrated Circuits Symposium (RFIC): 255-258 (2010) (“Kim”)

1014	U.S. Patent No. 6,300,826, “Apparatus and Method for Efficiently Amplifying Wideband Envelope Signals” (filed May 5, 2000) (“Mathe ’826”)
1015	Maxim Integrated Products, Inc., <i>MAX9738 –16VP-P Class G Amplifier with Inverting Boost Converter</i> , Datasheet 19-3700, Rev. 0 (March 2008) (“Maxim”)
1016	Ertl, H. et al., “ <i>Basic Considerations and Topologies of Switched-Mode Assisted Linear Power Amplifiers</i> ,” IEEE Transactions on industrial electronics 44.1 (1997): 116-123 (“Ertl”)
1017	Kang, D. et al., “ <i>A Multimode/Multiband Power Amplifier With a Boosted Supply Modulator</i> ,” IEEE Transactions on Microwave Theory and Techniques 58.10 (2010): 2598-2608 (“Kang”)
1018	U.S. Patent No. 5,834,977, “Amplifying Circuit with Power Supply Switching Circuit” (filed October 30, 1996 and issued November 10, 1998) (“Maehara”)
1019	U.S. Patent No. 5,870,340, “Multiplexer” (filed July 8, 1997 and issued February 9, 1999) (“Ohsawa”)
1020	U.S. Patent No. 6,566,935, “Power Supply Circuit With a Voltage Selector” (filed August 28, 2000 and issued May 20, 2003) (“Renous”)
1021	Certificate of Correction for U.S. Patent No. 8,698,558 (“558 COC”)
1022	Qualcomm Incorporated’s Initial Claim Construction Brief, <i>Certain Mobile Electronic Devices and Radio Frequency and Processing Components Thereof</i> , Investigation No. 337-TA-1065 (“Qualcomm CC Brief”)
1023	Order No. 28: Construing Terms of the Asserted Patents, <i>Certain Mobile Electronic Devices and Radio Frequency and Processing Components Thereof</i> , Investigation No. 337-TA-1065 (“Markman Order”)

CERTIFICATE OF SERVICE

I hereby certify that on June 28, 2018, I caused a true and correct copy of the foregoing materials:

- Petition for *Inter Partes* Review of U.S. Patent No. 8,698,558 Under 35 U.S.C. § 312 and 37 C.F.R. § 42.104
- Table of Exhibits for Petition for *Inter Partes* Review of U.S. Patent No. 8,698,558
- Exhibits 1001 – 1023
- Word Count Certificate of Compliance
- Power of Attorney
- Fee Authorization

to be served via Express Mail on the following attorney of record as listed on PAIR:

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/Scott Bertulli/
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Registration No. 75,886

WORD COUNT CERTIFICATE OF COMPLIANCE

I hereby certify that the foregoing Petition for *Inter Partes* Review of U.S. Patent No. 8,698,558 contains 13,800 words as measured by the word processing software used to prepare the document, in compliance with 37 C.F.R. § 42.24(d).

Respectfully submitted,

Dated: June 27, 2018

/Theodoros Konstantakopoulos/
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