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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 IPR2018-01153

**PETITION FOR *INTER PARTES* REVIEW OF
U.S. PATENT NO. 8,698,558
CHALLENGING CLAIMS 1-9**

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Petitioner Intel Corporation (“Intel”) respectfully requests *Inter Partes* Review of claims 1-9 of U.S. Patent No. 8,698,558 (the “’558 patent”) (Ex. 1101) pursuant to 35 U.S.C. §§ 311-19 and 37 C.F.R. § 42.1 *et seq.*

I. INTRODUCTION

The ’558 patent claims structures for “efficiently generating a power supply for a power amplifier.” Ex. 1101 at 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 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.

Accordingly, the prior art cited in this Petition renders obvious claims 1-9 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 12-14 of the ’558 patent (IPR2018-01152), 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 1-9 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") (E. 1104). Chu was published in 2008 and is prior art under at least 35 U.S.C. § 102(b). Ex. 1105 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. 1106). 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.

1107 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.

1108 at ¶¶8-9; Ex. 1106 at cover; Ex. 1109 at ¶¶4-5; Ex. 1107 at ¶11.

Choi 2010 was distributed to hundreds of conference attendees via

USB drives in May 2010. Ex. 1108 at ¶17; Ex. 1109 at ¶¶6-9.

3. U.S. Patent No. 5,929,702, “Method and Apparatus for High Efficiency High Dynamic Range Power Amplification,” Myers et al. (“Myers”) (Ex. 1112). Myers was filed on November 28, 1997 and issued on July 27, 1999, making it prior art under at least 35 U.S.C. § 102(a), (b), and (e).

B. Grounds for Challenge

Petitioner requests cancellation of claims 1-9 of the ’558 patent as unpatentable under 35 U.S.C. § 103. This Petition, supported by the declaration of Dr. Alyssa Apsel (Ex. 1103) 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. Ex. 1103 at ¶33.

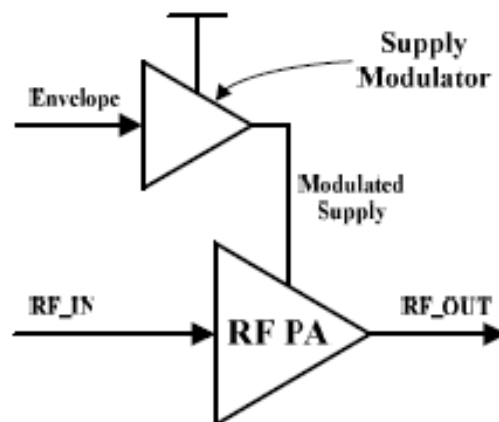
A. Radio Frequency (RF) Power Amplifiers

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. 1103 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. 1103 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 (“Supply Modulator”):



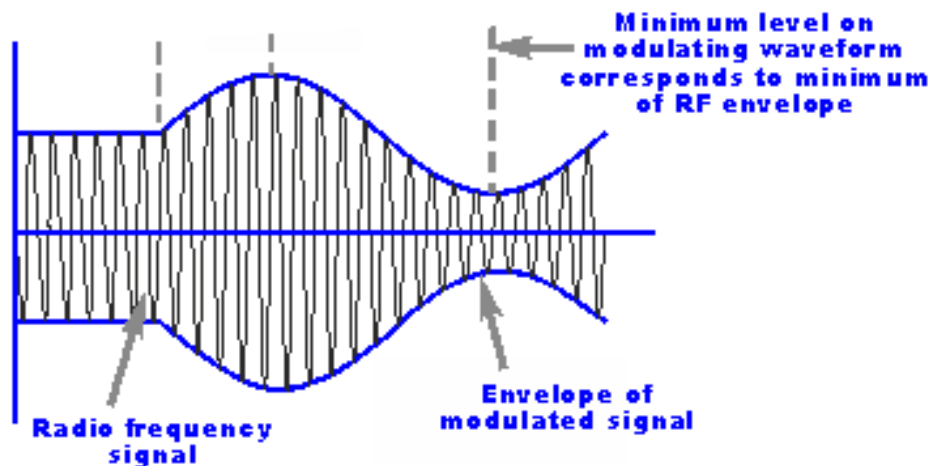
Kim – Figure 1(b)

Ex. 1113 [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. The supply voltage provides the PA with sufficient power to transmit an output signal (“RF_OUT”) based on

the input signal (“RF_IN”) that the PA receives, 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. 1103 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. 1103 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. 1103 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. 1103 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. 1103 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. 1103 at ¶¶42-43.

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. 1103 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. 1103 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. 1114 [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. 1103 at ¶45.

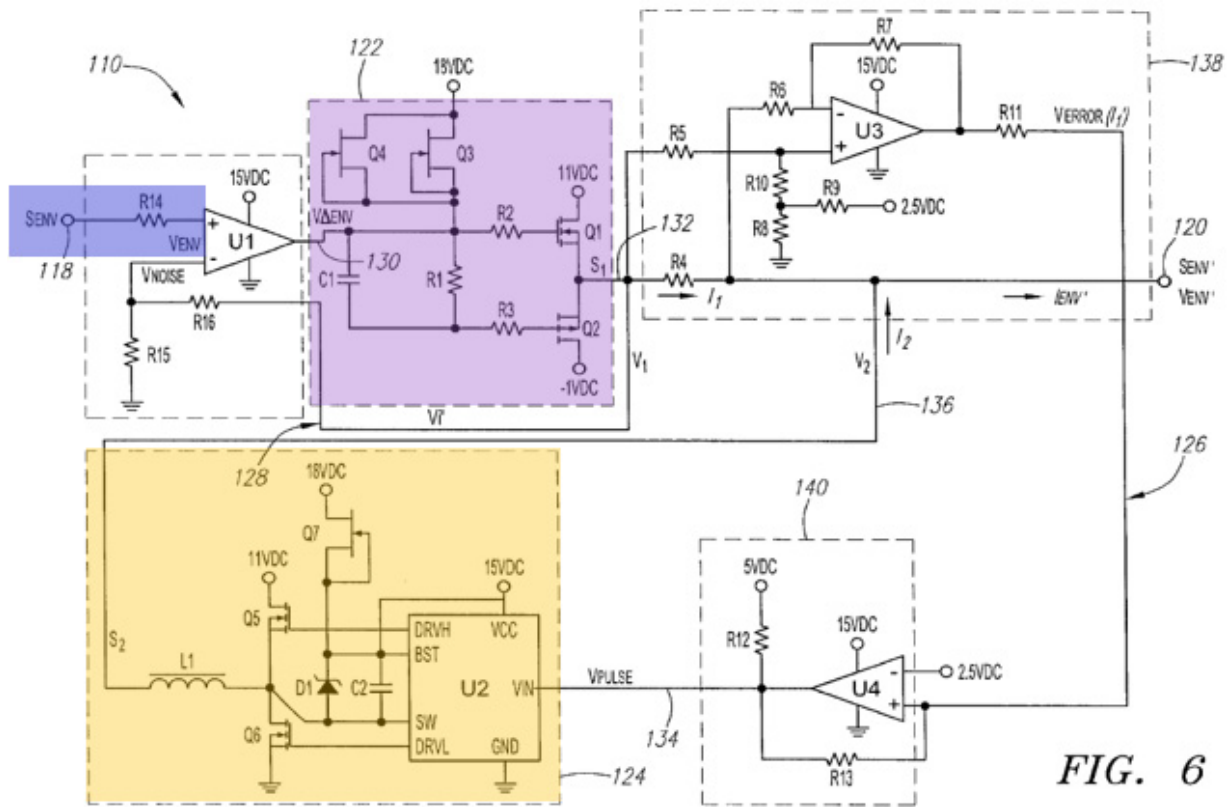


FIG. 6

Mathe '826 – Figure 6

A paper by Ertl from 1997 also discloses a hybrid supply generator. Ex. 1116 [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:

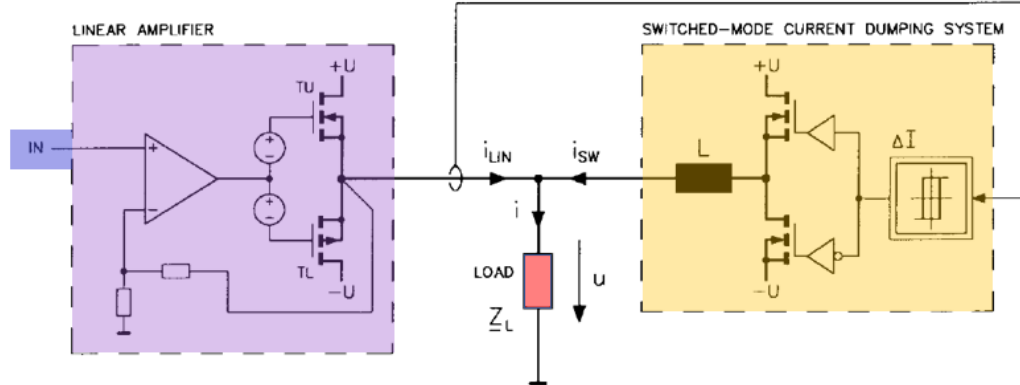


Fig. 2. Circuit diagram of a switched-mode assisted linear power amplifier.

Ertl – Figure 2

Ex. 1116 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. 1103 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. 1110 [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”)] at 401. Blanken explains that:

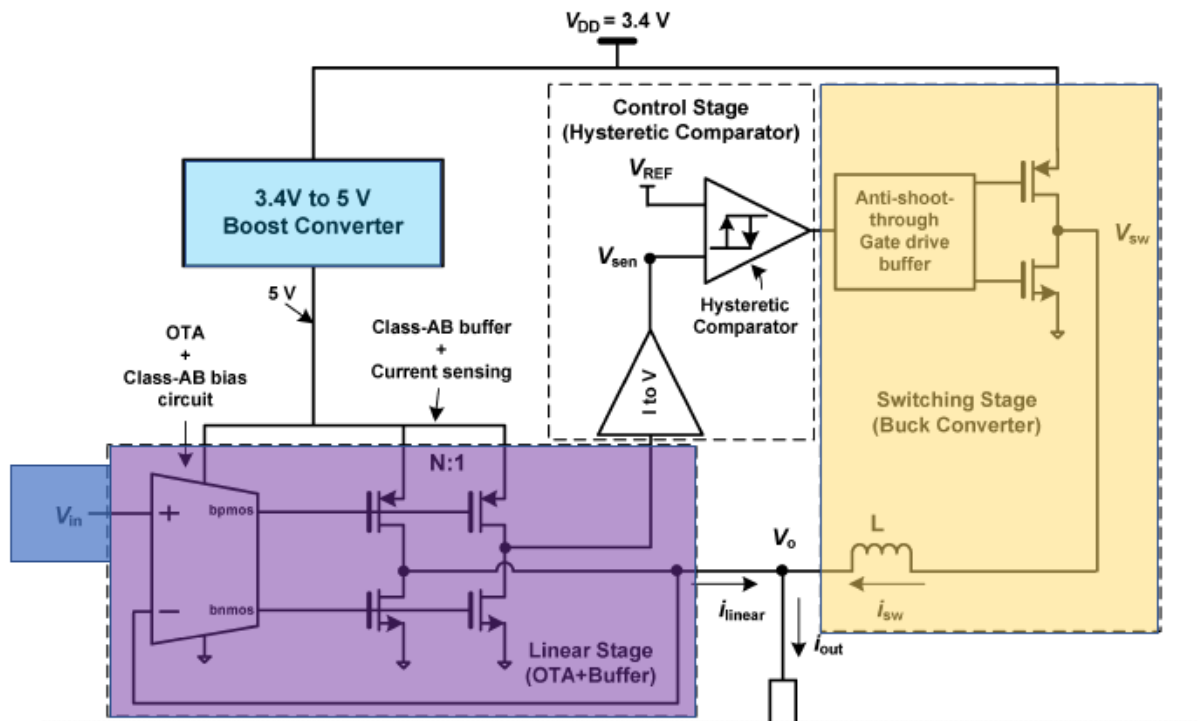
[h]igh-efficiency voltage conversion can be obtained with a switched-mode inductive DC/DC buck converter, but its bandwidth is limited

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. 1103 at ¶47.

Finally, a 2010 paper by Kang describes “a highly efficient supply modulator” that combines an envelope amplifier with a switcher. Ex. 1117 [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. 1117 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.” 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

Ex. 1117 at 2602; Ex. 1103 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. 1103 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. 1118 [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. 1103 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. 1117 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. 1103 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. 1113. 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. 1102 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. 1103 at ¶52.

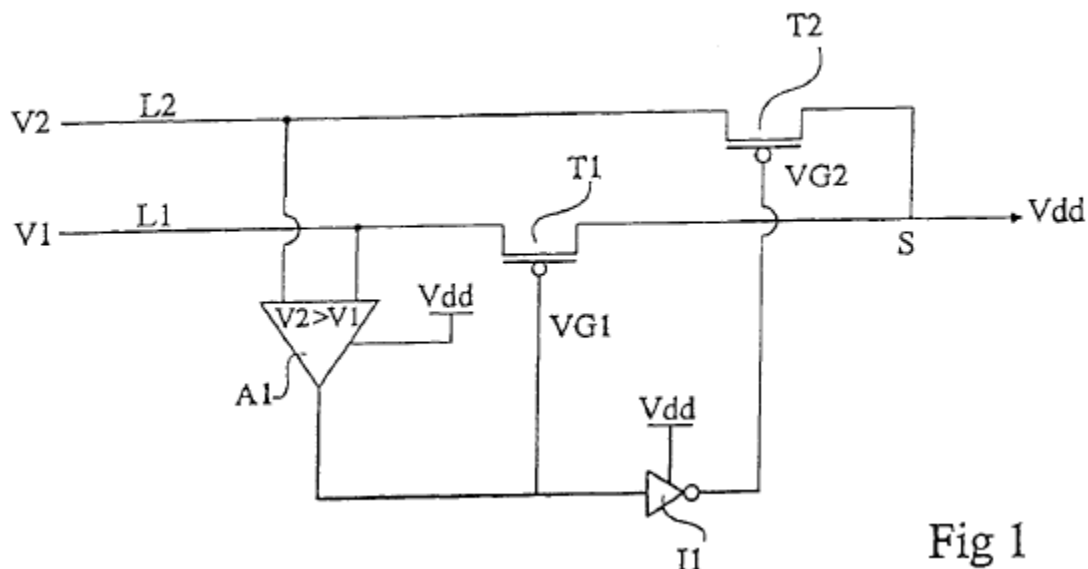
C. Multiplexers

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. 1119 [U.S. Patent No. 5,870,340, “Multiplexer” (filed July 8, 1997 and issued February 9, 1999)] 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. 1103 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. *Id.* 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. 1103 at ¶54.

Such multiplexers have been used to select between 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. 1120 [U.S. Patent No. 6,566,935, “Power Supply Circuit With a Voltage Selector” (filed August 28, 2000 and issued May 20, 2003)] 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. 1120 at 1:14-17; Ex. 1103 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. Ex. 1120 at 1:17-25 (“the 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. 1103 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. 1101 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. *See 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. 1103 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

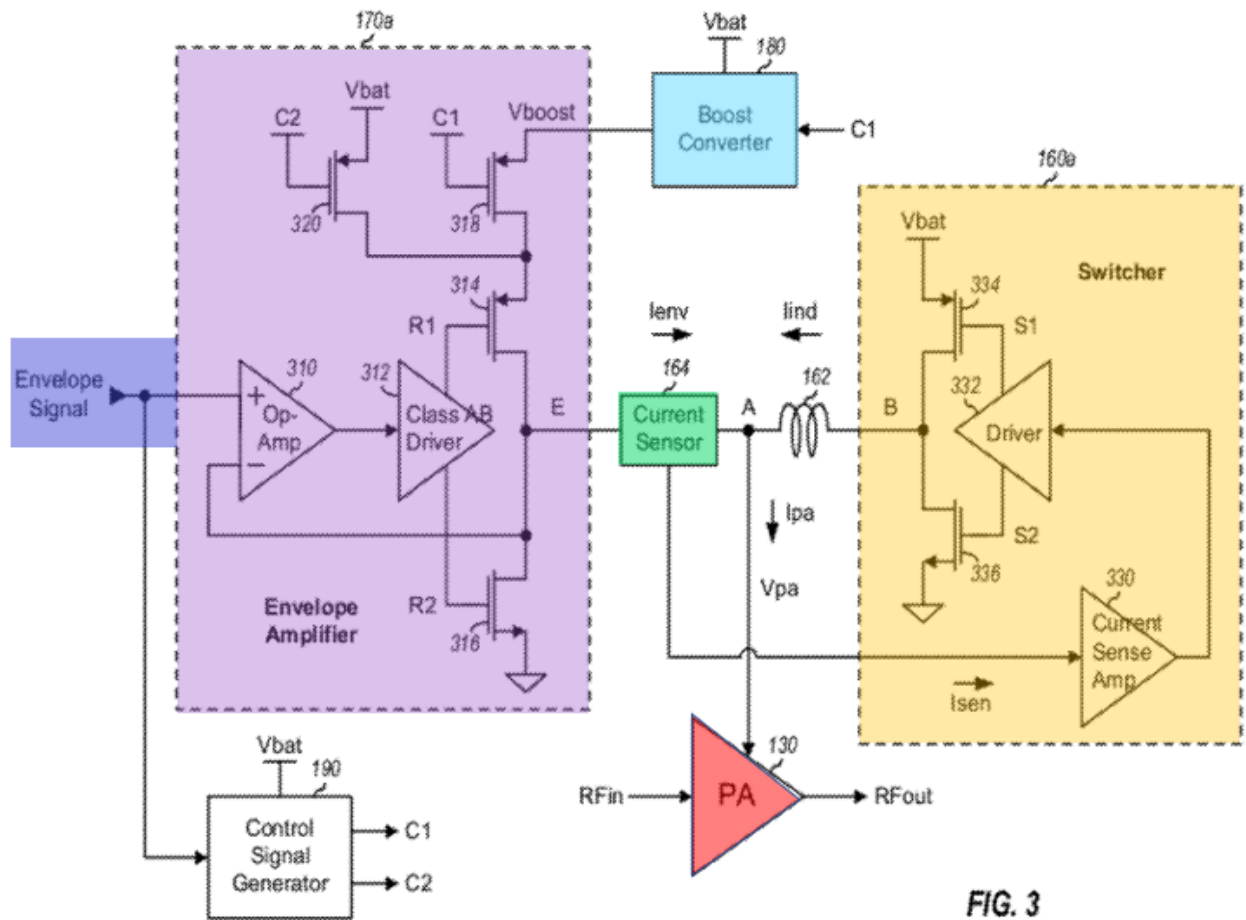
The challenged claims of the '558 patent comprise combinations of well-known components in the field: specifically, PAs, envelope amplifiers, switchers, hybrid supply generators (envelope amplifier + switcher), and boost converters. The '558 patent does not claim to have invented any of these components,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

which were known in the prior art years before the filing date of the '558 patent, as explained above. Ex. 1103 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. 1103 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. 1122 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.”).

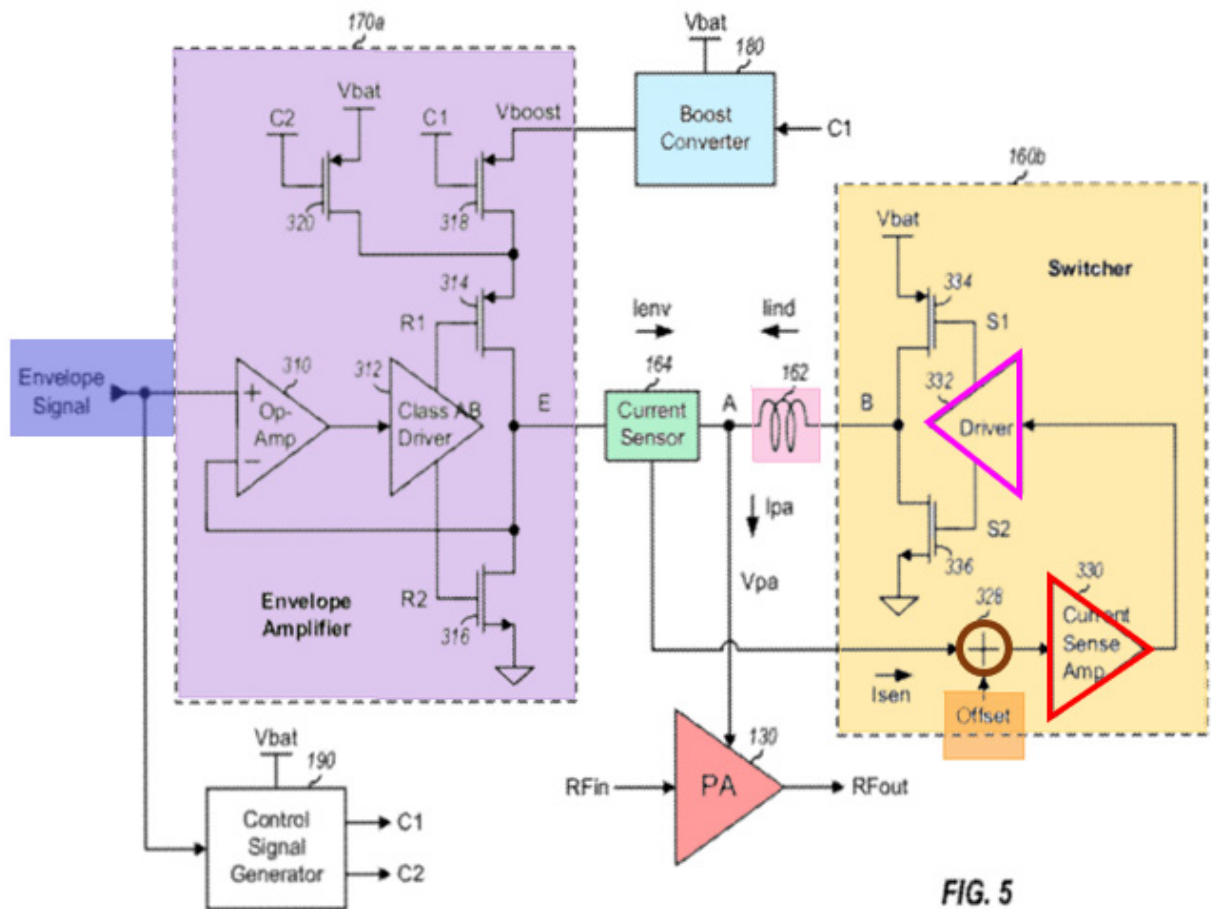


'558 Patent – Figure 3

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 dark 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. 1101 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. 1103 at ¶59.

Second, the ’558 patent also 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. 1101 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. Ex. 1103 at ¶60.

When the switcher is on, it provides a current (“Iind”) via inductor 162 (highlighted in pink). That current is joined with the current from the envelope

amplifier (“Ienv”) to provide a combined current (“Ipa”) to the PA. Ex. 1101 at 3:21-27 (“Envelope amplifier 170 ... provides a second supply current (Ienv) comprising high frequency components at node A. The PA supply current (Ipa) provided to power amplifier 130 includes the Iind current from switcher 160 and the Ienv 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. 1103 at ¶¶61-63.

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. 1102 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 its 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. 1101 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. 1121.²

² In the ITC litigation, Apple has argued that claim 1 is indefinite because it contains inconsistent requirements regarding the generation of the second supply voltage. More specifically, the scope of the claim is not reasonably certain because limitation 1(c) requires the second supply voltage to be generated based on the envelope signal and the boosted supply voltage, whereas limitation 1(d) requires it

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 alleged 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 that the Examiner found to be missing from the prior art of record. Ex. 1103 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. 1104 at 2809 (“A combined class-AB [linear amplifier] and switch-mode regulator based supply

to be generated based on (a) the first supply voltage, and (b) the first supply voltage or the boosted supply voltage. Petitioner Intel agrees with Apple’s position, but this issue does not affect this Petition, because even under the narrowest interpretation—that the claim requires the second supply voltage to be generated selectively, based sometimes on the first supply voltage and sometimes on the boosted supply voltage—the prior art renders the claim obvious, as explained in Section X.B.1(d).

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. 1103 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:

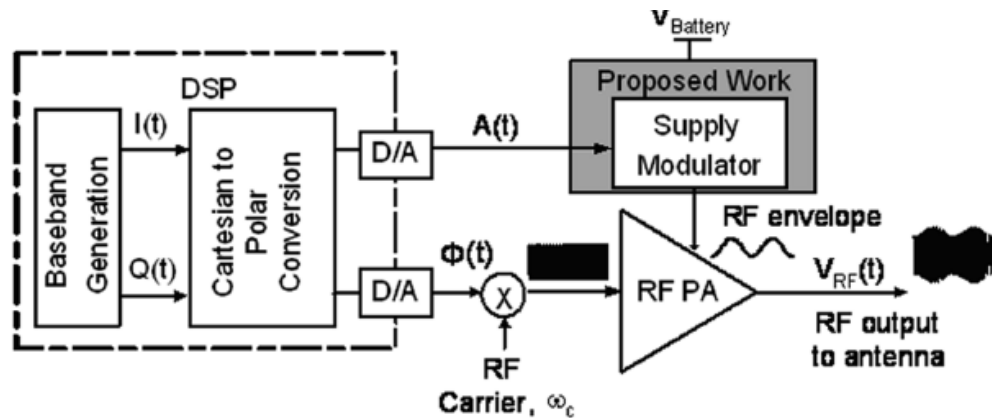


Fig. 2. Typical polar modulation based transmitter block diagram.

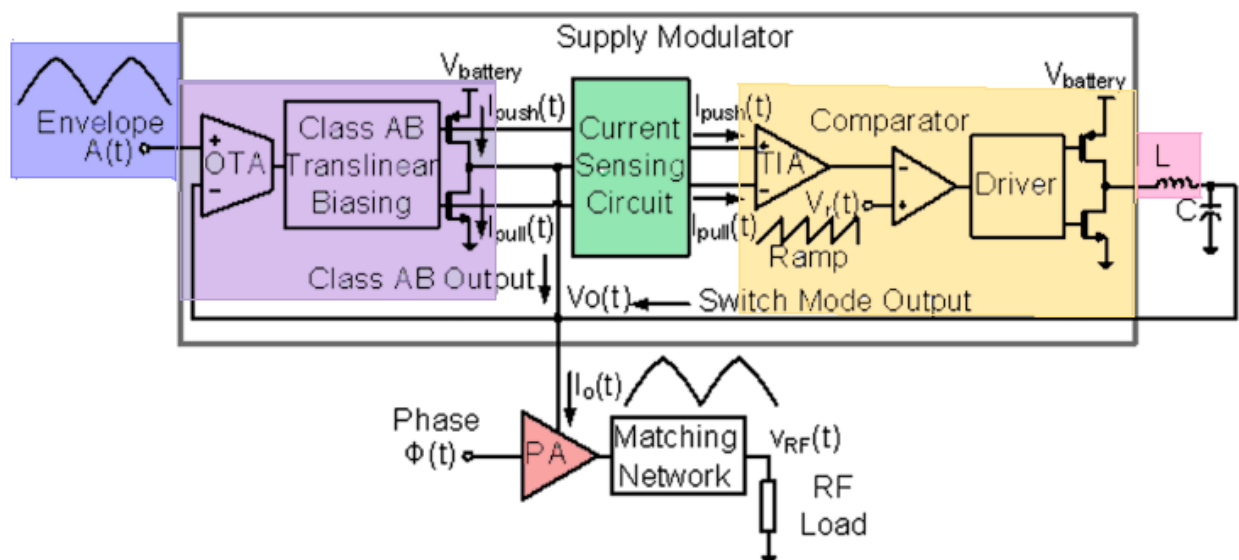
Chu – Figure 2

Ex. 1104 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 efficiency of the PA, their operating bandwidth is limited by the switching frequency.”). Ex. 1103 at ¶¶71-72.

Chu explains that “combined linear and switch-mode supply modulation techniques are gaining attention for RF PA supply implementations” to solve these issues. *Id.* at 2809. Chu proposes such a combined “supply modulator” system, which is shown in in Figure 4:



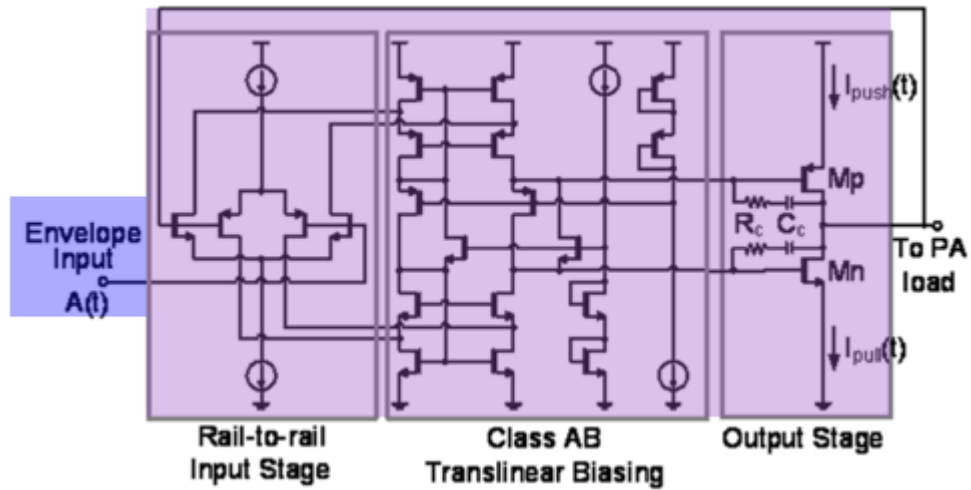
Chu – Figure 4

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

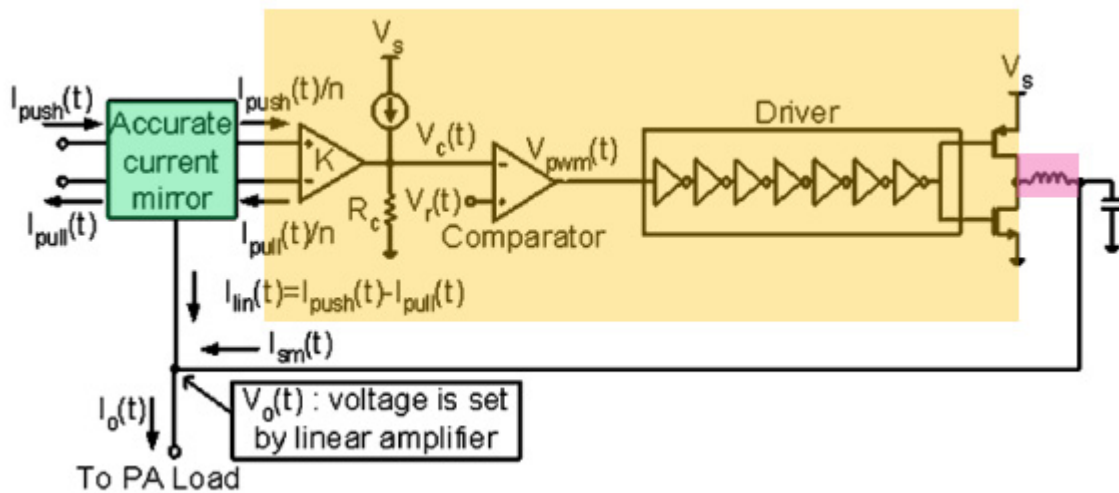
output node tracks the reference envelope voltage.” *Id.* at 2810. The system also includes a switch-mode regulator or switcher (highlighted in yellow) that provides “a large portion of the load current” based on the operation of the current sensing circuit (highlighted in green). The current sensing 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. *See 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. 1103 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,

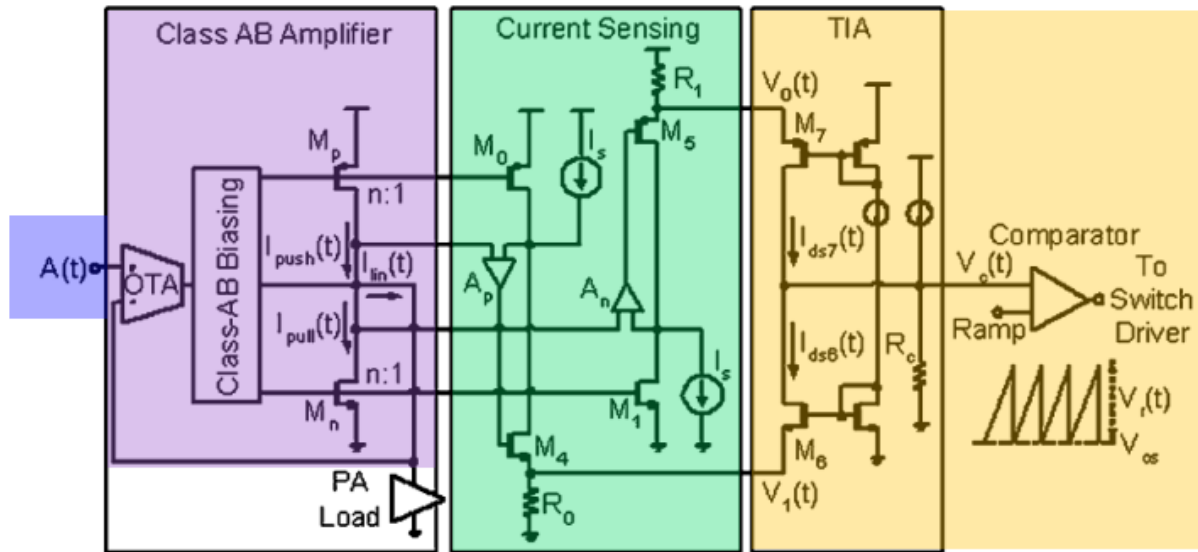
switcher, and current sensing circuit are shown in Figures 14, 15, and 16, respectively:



Chu – Figure 14



Chu – Figure 15



Chu – Figure 16

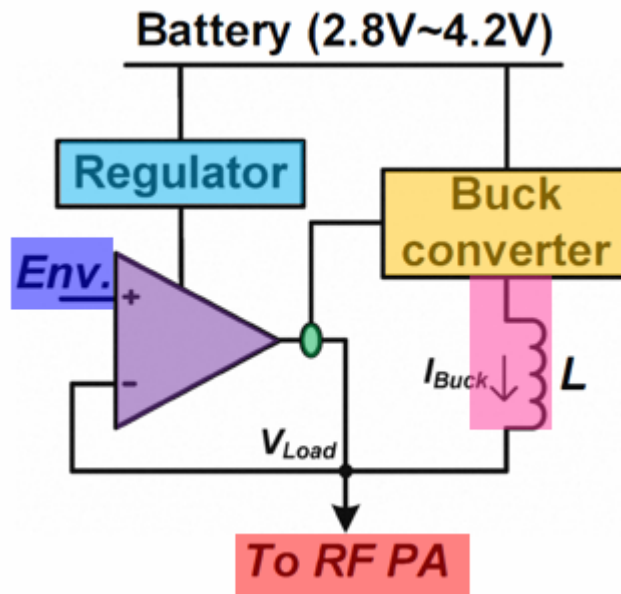
Ex. 1104 at 2814 (“A two-stage class-AB amplifier with a common-source output stage, as shown in Fig. 14, is used for the linear amplifier.”); *id.* at 2815 (“In the master–slave regulator configuration, the switch-mode regulator serves as the slave stage, as shown in Fig. 15, and is driven by the class-AB 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. 1103 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. 1107 at

1074 (“[A] new supply modulator architecture employing a hybrid switching amplifier and a boost converter is proposed.”), 1078 (“Fig. 5. Battery-to-5V PA supply modulator.”).

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. 1103 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. 1107 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. 1103 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 claim construction addressed below is a construction proposed by the Patent Owner that is narrower than the correct claim construction under *Phillips*. The challenged claims are invalid under this construction and also would be invalid under any broader construction based on the broadest reasonable interpretation standard.

A. “envelope signal” (claims 1 and 6-8)

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. 1123 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. 1101) 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. 1103 at ¶¶81-82.

X. SPECIFIC GROUNDS FOR PETITION

Pursuant to Rule 42.104(b)(4)-(5), the following sections (as confirmed in Dr. Apsel’s declaration, Ex. 1103 at ¶¶83-158) demonstrate in detail how the prior art discloses each and every limitation of claims 1-9 of the ’558 patent, and how those claims are therefore anticipated and/or rendered obvious by the prior art. To summarize:

Claims 6 and 8 require 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 I).

Claims 1-5, 7, and 9 require a hybrid supply generator that can select between using a boosted supply voltage and a battery voltage. The concepts of using a boosted voltage and being able to select between two power sources were basic, well-known concepts disclosed by the Choi 2010 and Myers references. These claims (as well as claims 6 and 8 if interpreted to require selection) are obvious over Chu in combination with Choi 2010 and Myers (Ground II).

A. Ground I: Claims 6 and 8 are obvious over Chu combined with Choi 2010

1. Claim 6

Claims 6 is obvious over Chu and Choi 2010, as explained below. Ex. 1103 at ¶¶84, 117.

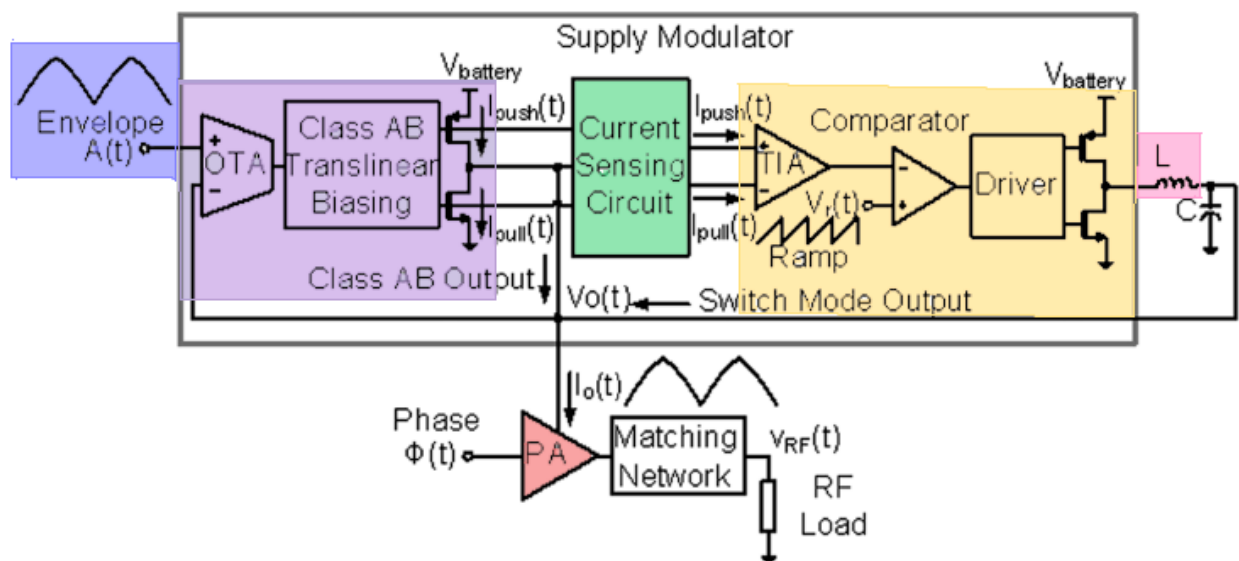
(a) “An apparatus for wireless communication, comprising:”

Chu is directed to a PA regulator (an apparatus) for CDMA transmitters, which are used in wireless communication. Ex. 1104 at Title; *see also id.* at 2809 (“Power amplifiers (PAs) consume a significant portion of the total power budget

of battery operated wireless transceivers; therefore, they are the key components for power reduction in mobile systems.”); *id.* 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. 1103 at ¶¶85-87.

(b) “a power amplifier operative to receive and amplify an input radio frequency (RF) signal and provide an output RF signal; and”

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



Chu – Figure 4

See Ex. 1104 at 2810 (“Fig. 4 shows the block diagram of the proposed master–slave linear and switch-mode combined supply modulator loaded with a PA.”).

Chu is expressly directed to CDMA transmitters, which transmit RF signals. *Id.* at

Abstract (“The regulator achieves a frequency range up to 10 MHz with less than 0.2% envelope tracking error, making this PA regulator suitable for CDMA applications.”). Moreover, the PA is shown in Figure 4 as receiving and amplifying an input RF signal ($\Phi(t)$) and outputting an RF signal ($V_{RF}(t)$). *See also id.* at Fig. 2. In this regard, the PA is like the typical PA shown in Chu Figure 2, which receives an input signal $\Phi(t)$ modulated with an “RF Carrier” and that outputs an “RF output signal”:

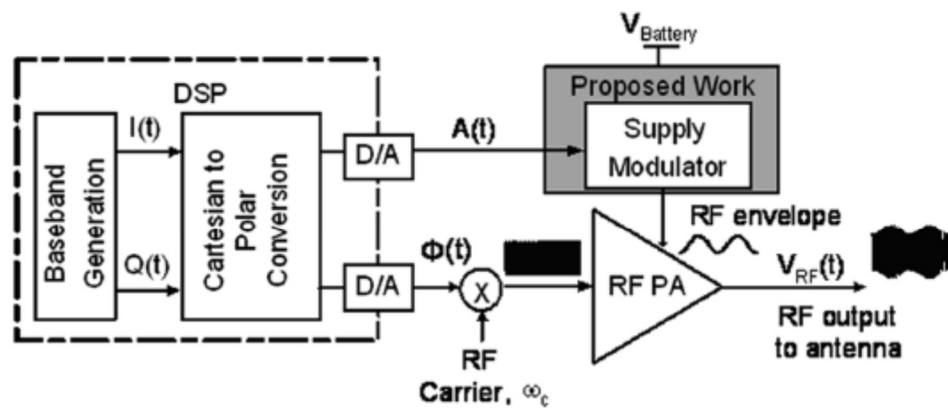


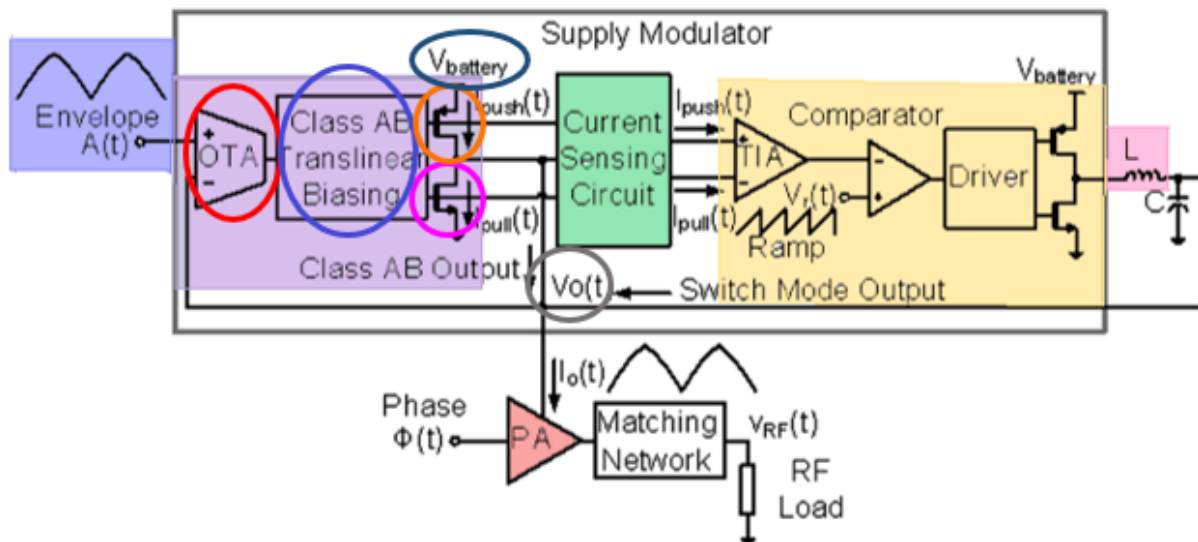
Fig. 2. Typical polar modulation based transmitter block diagram.

Chu – Figure 2

Ex. 1103 at ¶88.

- (c) “a supply generator operative to receive an envelope signal and a first supply voltage, to generate a boosted supply voltage having a higher voltage than the first supply voltage, and to generate a second supply voltage for the power amplifier based on the envelope signal and the boosted supply voltage,”

Chu combined with Choi 2010 renders this limitation obvious. Chu discloses a “supply generator” (the “Supply Modulator”) as shown in Figure 4 below.



Chu – Figure 4

Ex. 1104 at Fig. 4. The supply generator receives “an envelope signal” ($A(t)$, highlighted in blue at the left) and a “first 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} . *Id.* 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. 1103 at ¶89.

It would have been obvious to a person of ordinary skill in the art (“POSA”) to modify Chu to generate its output supply voltage based on the envelope signal and a **boosted** supply voltage (rather than V_{battery}), using a boost converter such as the one disclosed in Choi 2010. 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.”:

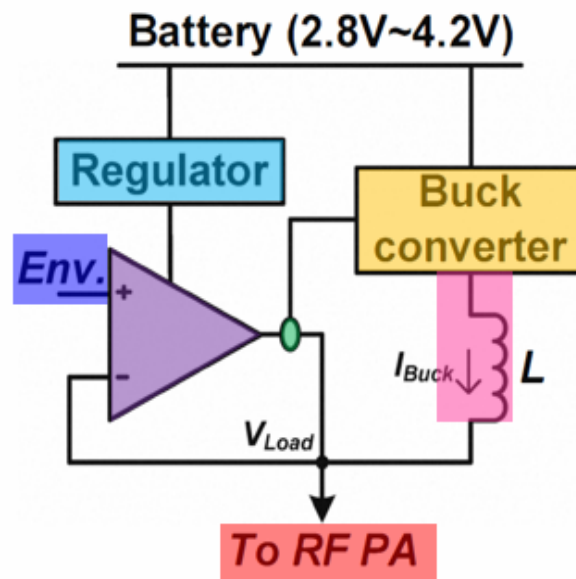


Fig. 5. Battery-to-5V boosting PA supply modulator.

Choi 2010 – Figure 5

Ex. 1107 at 1076, Fig. 5. The supply modulator 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 [3].”), 1075-76 (“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...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. 1103 at ¶90.

The envelope amplifier in Choi 2010 (highlighted in purple) also generates a second supply voltage (V_{Load}) based on the envelope signal and the boosted supply voltage, and provides the second supply voltage to the PA. Ex. 1107 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 (“By boosting up the supply voltage of the linear amplifier to 5V regardless of the battery voltage variation ... the supply modulator dynamically regulates the PA with the peak voltage of 4.5V.”); Ex. 1103 at ¶91.

Accordingly, Chu, as modified to incorporate a boost converter such as that disclosed in Choi 2010, comprises “a supply generator operative to receive an envelope signal and a first supply voltage, to generate a boosted supply voltage having a higher voltage than the first supply voltage, and to generate a second supply voltage for the power amplifier based on the envelope signal and the boosted supply voltage.” Ex. 1103 at ¶92.

(i) Motivation to Combine Chu and Choi 2010

It would have been obvious to modify Chu 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. 1107 at 1074, 1077 (reference [7]); Ex. 1103 at ¶93.

Moreover, a POSA 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. 1107 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. 1103 at ¶94.

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 Machara patent, for example, taught using a boost converter (“step-up converter”) in an amplifying circuit to prevent distortion. *See* Ex. 1118 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.”).³ 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. 1115 [Maxim Integrated Products, Inc., *MAX9738 –16VP-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. 1103 at ¶95.

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

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

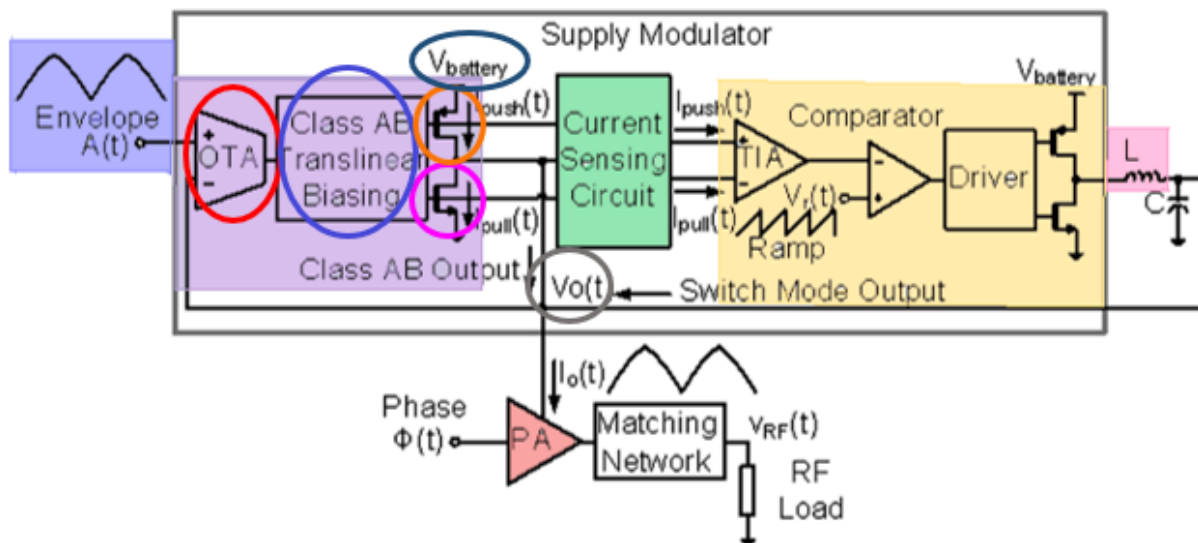
to improve numerous similar devices, a POSA would have recognized that this same technique would also improve the Chu's supply modulator. References such as Maehara and Maxim show that the results of incorporating a boost converter such as Choi 2010's boost converter into Chu's supply modulator were entirely predictable, and in line with the results to be expected from the express teaching of Choi 2010. Ex. 1103 at ¶95.

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. 1103 at ¶¶96-97.

(d) “wherein the supply generator incorporates an operational amplifier (op-amp) operative to receive the envelope signal and provide an amplified signal,”

Chu discloses this limitation. As shown below, Chu’s “supply generator” (“Supply Modulator”) includes an “operational amplifier” (OTA, circled below in red) that receives the envelope signal ($A(t)$, highlighted in blue) and provides an amplified signal to the Class AB Translinear Biasing circuitry (circled in royal blue):



Chu – Figure 4

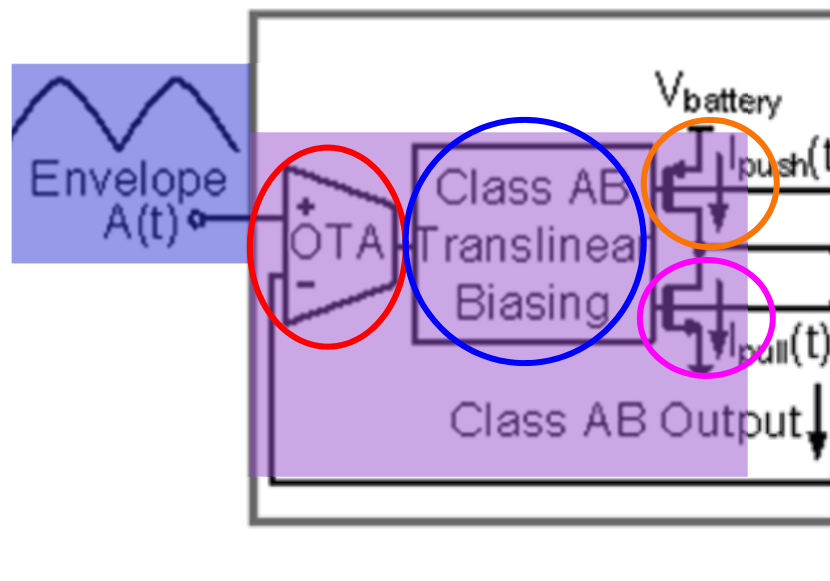
Ex. 1104 at Fig. 4. OTA stands for “*operational* transconductance *amplifier*,” which is a type of operational amplifier. An operational amplifier (or op-amp for short) has two inputs and one output, and it behaves like a high-gain difference

amplifier—amplifying the difference between two input voltages. An OTA is a type of operational amplifier in which a differential input voltage produces an output current. Ex. 1103 at ¶98.

The operational amplifier in Chu is shown receiving the envelope signal, and the amplifier provides an output that a POSA would have recognized was amplified because it was produced by an amplifier. Ex. 1103 at ¶99.

- (e) **“a driver operative to receive the amplified signal and provide a first control signal and a second control signal,”**

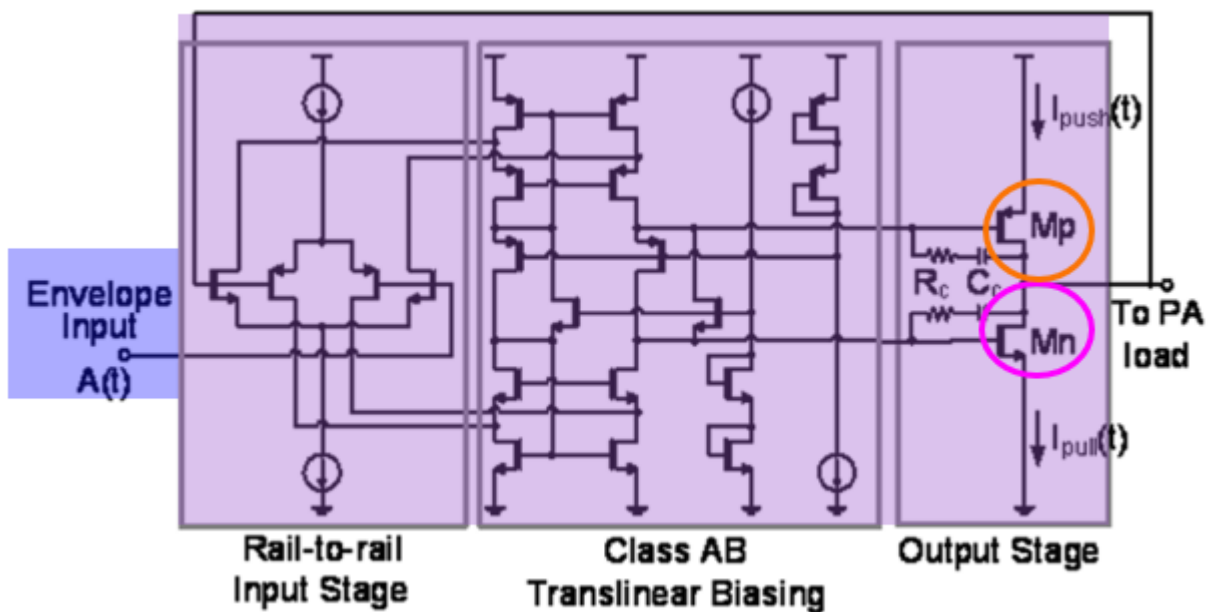
Chu discloses this limitation. As shown below, Chu discloses a supply generator (“Supply Modulator”) that includes a driver (“Class AB Translinear Biasing” circuit, circled in blue):



Chu – Figure 4

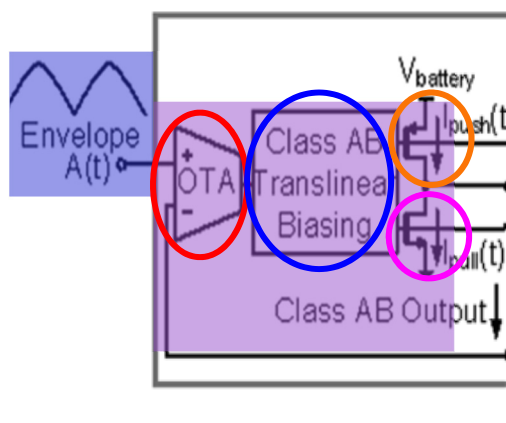
Ex. 1104 at Fig. 4. The Class AB Translinear Biasing circuitry receives the amplified signal from the operational amplifier (OTA). Ex. 1103 at ¶100.

Further, the Class AB Translinear Biasing circuit (the driver) outputs a conditioned version of its input. The Class AB Translinear Biasing circuit is shown in both Figure 4 and Figure 14 as generating two control signals that provide biasing conditions for the PMOS (M_p) and NMOS (M_n) transistors to the right:

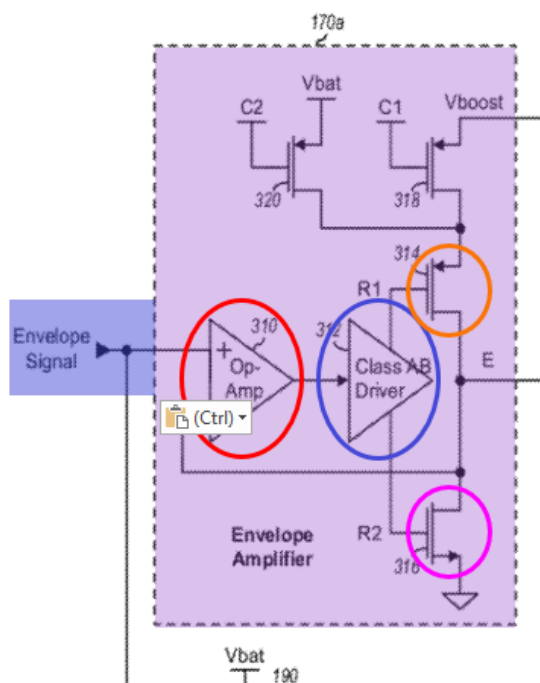


Chu – Figure 14

Ex. 1104 at Fig. 14. Chu's Class AB Translinear Biasing circuit (as shown in Figure 4) is fundamentally the same as the driver ("Class AB Driver 312") disclosed in Figure 3 of the '558 patent:



Chu – Figure 4



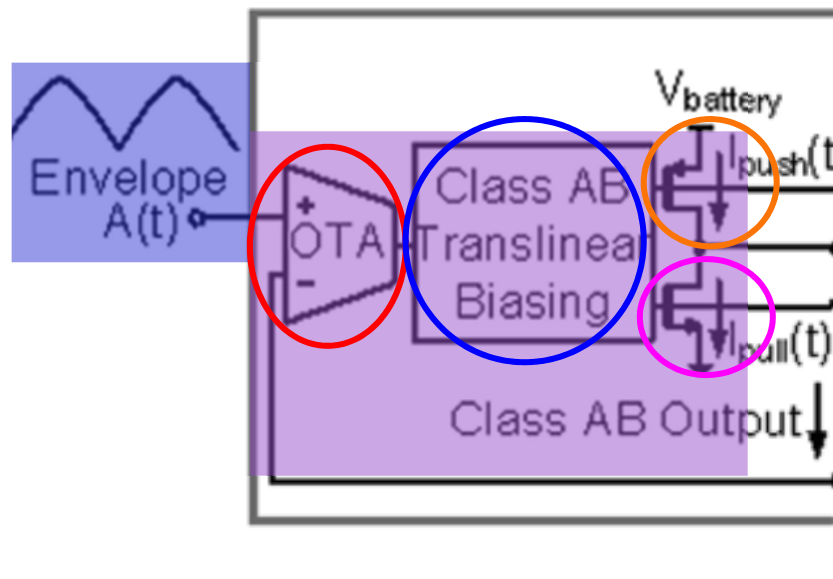
'558 Patent – Figure 3

Ex. 1101 at 4:42-46 (“Within envelope amplifier 170a, an operational amplifier (op-amp) 310 has its non-inverting input receiving the envelope signal, . . . , and its output coupled to an input of a class AB driver 312.”); *id.* at 5:61-64 (“Driver 312

may be implemented with a class AB amplifier to improve efficiency, so that large output currents can be supplied even though the bias current in transistors 314 and 316 is very low.”); Ex. 1103 at ¶101.

- (f) **“a P-channel metal oxide semiconductor (PMOS) transistor having a gate receiving a first control signal, a source receiving the boosted supply voltage or the first supply voltage, and a drain providing the second supply voltage, and”**

Chu as modified by Choi 2010 comprises this limitation. As shown below, Figure 4 of Chu discloses a supply generator (“Supply Modulator”) that includes a PMOS transistor (circled below in orange) that receives the first control signal from the driver (the Class AB Translinear Biasing circuitry):



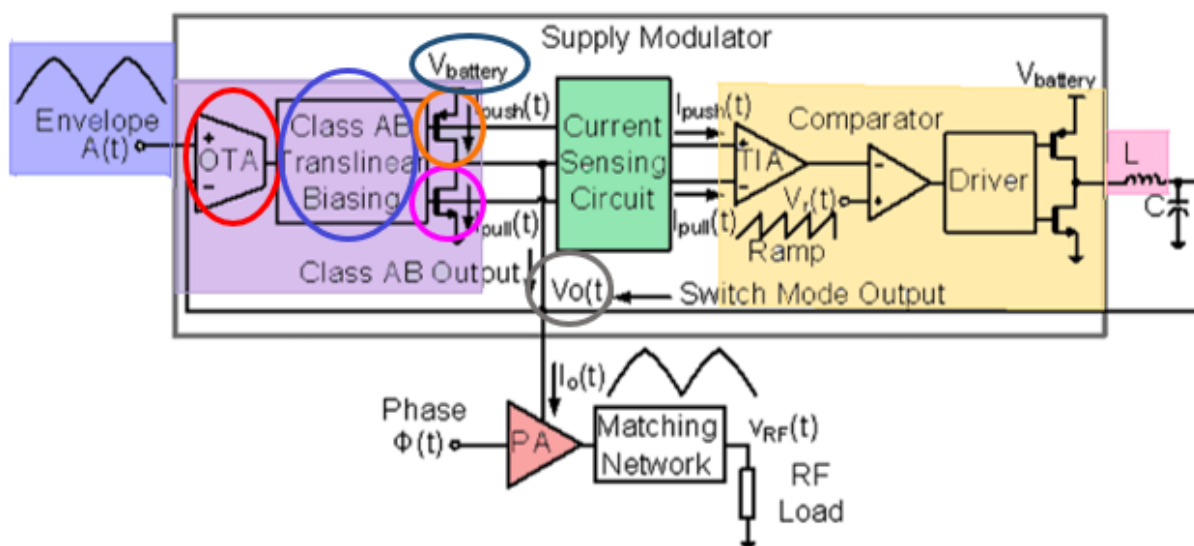
Chu – Figure 4

Ex. 1104 at Fig. 4. This same transistor is labeled Mp in Figure 14 above; the “p” stands for PMOS. The transistor is shown in Figure 4 with the common symbol for PMOS transistors, with the arrow pointing into the transistor, as also can be seen in Figure 3 of the ’558 patent. Ex. 1103 at ¶102.

This PMOS transistor also has a source (the higher terminal on the drawing of the PMOS transistor) that receives the first supply voltage (V_{battery}) from the battery. As explained above regarding limitation 6(c), Choi 2010 discloses the use of a boost converter to generate a boosted supply voltage that can be supplied to the envelope amplifier instead of a battery voltage, and it would have been obvious to modify Chu to incorporate Choi 2010’s boost converter. As modified by Choi 2010, the source of Chu’s PMOS transistor “receiv[es] the boosted supply voltage,” as required by this limitation.⁴ Ex. 1103 at ¶103.

⁴ The plain language of limitations 6(f) and 8(f), which are nearly identical, requires that the PMOS transistor’s source receive only one or the other of the boosted supply voltage and the first supply voltage. There is no basis to construe these limitations as requiring the PMOS transistor’s source to be able to receive, selectively, either the boosted supply voltage or the first supply voltage at any given time. But if they were so understood, these limitations would be disclosed

Finally, the drain of the PMOS transistor circled in the excerpt of Figure 4 above and the full Figure 4 below (the lower terminal on the PMOS transistor) provides the second supply voltage ($V_O(t)$) to the PA. Figure 4 shows that the drain of the PMOS transistor is connected directly to the output node $V_O(t)$ (circled below in Figure 4 in gray) from the envelope amplifier to the PA, and the drain and output node therefore will have the same voltage ($V_O(t)$). Ex. 1104 at 2810 (“output node $V_O(t)$ ”); *id.* at Fig. 15 (“ $V_O(t)$: voltage is set by linear amplifier”); Ex. 1103 at ¶104.

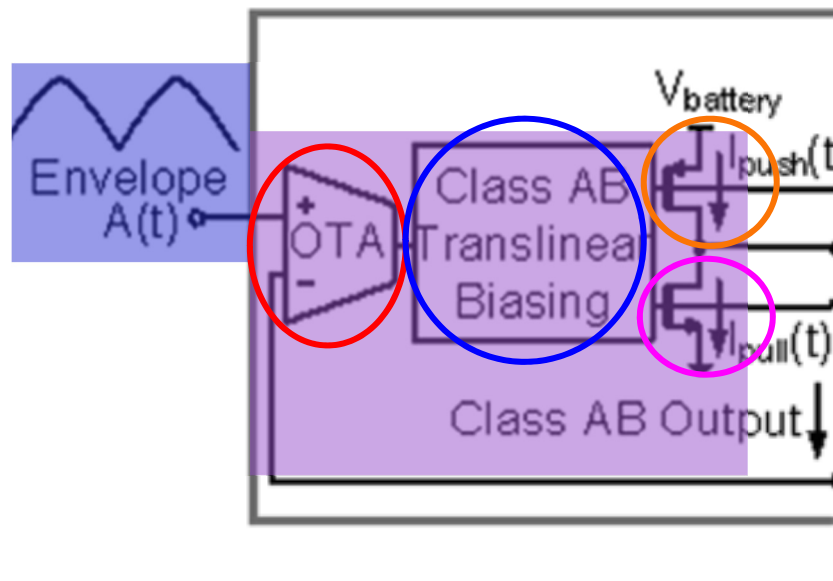


Chu – Figure 4

by Chu in combination with Choi 2010 and Myers, as explained below in Section X.B.6, and claims 6 and 8 would be invalid.

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

Chu discloses this limitation. Chu discloses a supply generator (“Supply Modulator”) comprising an NMOS transistor, as shown below in Figure 4 (circled below in fuchsia):



Chu – Figure 4

Ex. 1104 at Fig. 4. This same transistor is labeled M_n in Figure 14, the “n” standing for NMOS. Also, the transistor is shown in Figure 4 with the common symbol for NMOS transistors, with the arrow pointing out of the transistor. Ex. 1103 at ¶105.

The NMOS transistor has a gate that receives the second control signal from the Class AB Translinear Biasing circuitry. The NMOS transistor also has a drain (the higher terminal on the drawing of the NMOS transistor) that provides the second supply voltage ($V_O(t)$) to the PA: as explained above for limitation 6(f), the node between the two transistors is connected directly to the output of the envelope amplifier to the PA and therefore will have the second supply voltage ($V_O(t)$). Ex. 1103 at ¶106.

Finally, the NMOS transistor in Chu has a source (the lower terminal of the NMOS transistor) coupled to ground, as shown by the standard downward-pointing arrow notation. Ex. 1103 at ¶107.

2. Claim 8

Claim 8 is obvious in view of Chu combined with Choi 2010, as explained below. Ex. 1103 at ¶¶108, 117.

(a) “A method of generating supply voltages, comprising:”

As discussed below for limitations 8(b) and 8(c), Chu in combination with Choi 2010 comprises a method of generating a boosted supply voltage and for generating a second supply voltage. Ex. 1103 at ¶109.

- (b) “generating a boosted supply voltage based on a first supply voltage, the boosted supply voltage having a higher voltage than the first supply voltage; and”

Chu in combination with Choi 2010 renders this limitation obvious. As explained above regarding limitation 6(c), Choi 2010 discloses a supply generator for a PA, shown below, and the regulator (highlighted in light blue below) generates a higher, boosted voltage from the battery voltage:

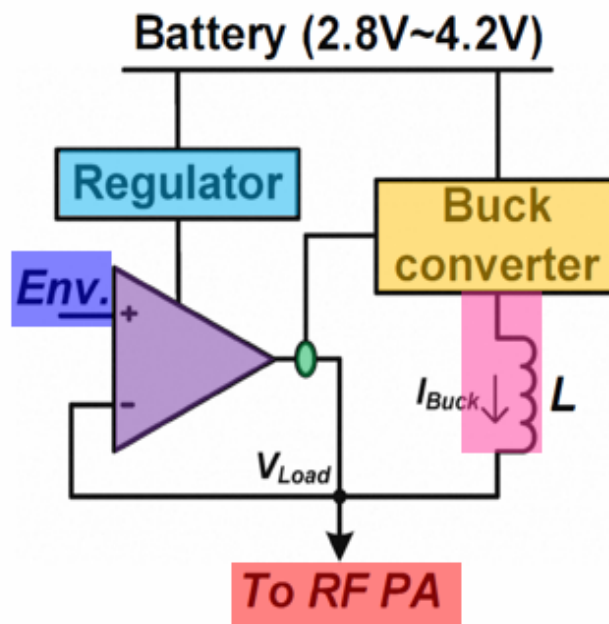


Fig. 5. Battery-to-5V boosting PA supply modulator.

Choi 2010 – Figure 5

Ex. 1107 at Fig. 5. The Choi 2010 supply modulator receives a first supply voltage (“Battery (2.8V-4.2V)”) and employs a boost converter (“Regulator,” highlighted in light blue) to generate a boosted supply voltage greater than the first supply voltage. Choi 2010 therefore discloses generating a boosted supply voltage based

on a first supply (battery) voltage, with the boosted supply voltage being higher than the first supply voltage. *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 . . . 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.”); *see* Section X.A.1(c); Ex. 1103 at ¶110.

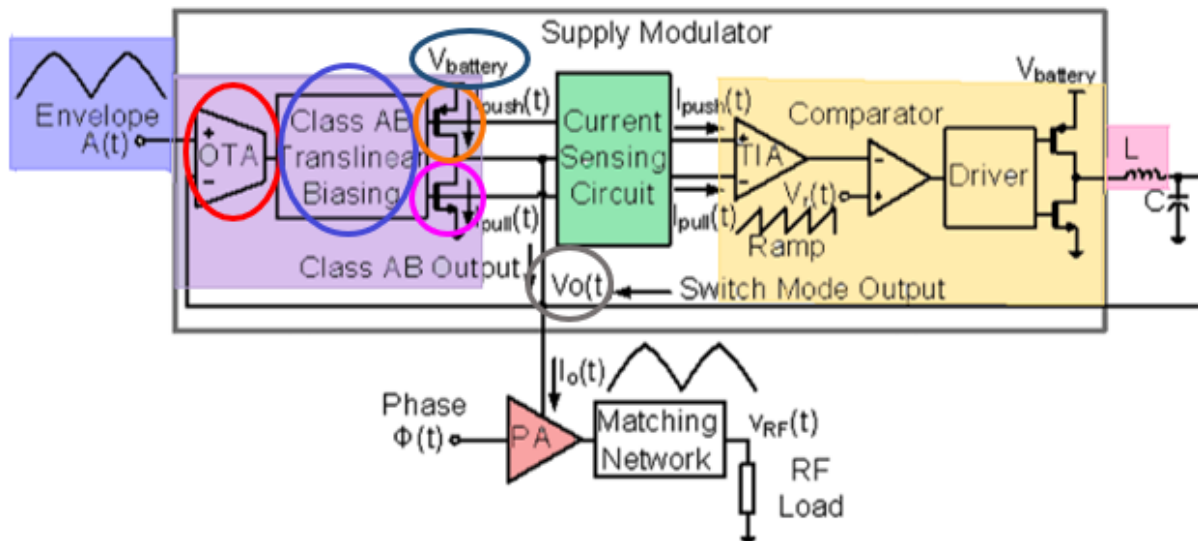
It would have been obvious to modify Chu’s supply modulator to incorporate the boost converter of Choi 2010, for the reasons stated above regarding limitation 6(c). *See* Section X.A.1(c); Ex. 1103 at ¶111.

(c) “generating a second supply voltage based on an envelope signal and the boosted supply voltage,”

Chu in combination with Choi 2010 renders this limitation obvious for the same reasons as stated above for limitation 6(c), which likewise requires “generat[ing] a second supply voltage . . . based on the envelope signal and the boosted supply voltage.” *See* Section X.A.1(c); Ex. 1103 at ¶112.

- (d) “wherein the second supply voltage is generated by an envelope amplifier that produces the second supply voltage using an operational amplifier (op-amp) that receives the envelope signal and provides an amplified signal,”

Chu discloses this limitation. As explained above for limitation 6(d), Chu’s supply modulator includes an envelope amplifier (highlighted below in purple) that produces a second supply voltage ($V_o(t)$, circled below in gray) to a PA. As also explained above regarding limitation 6(d), Chu’s envelope amplifier has an op-amp (the OTA circled in red below) that receives the envelope signal and provides an amplified signal:

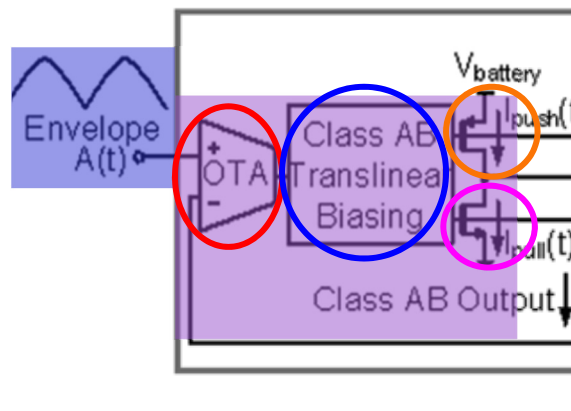


Chu – Figure 4

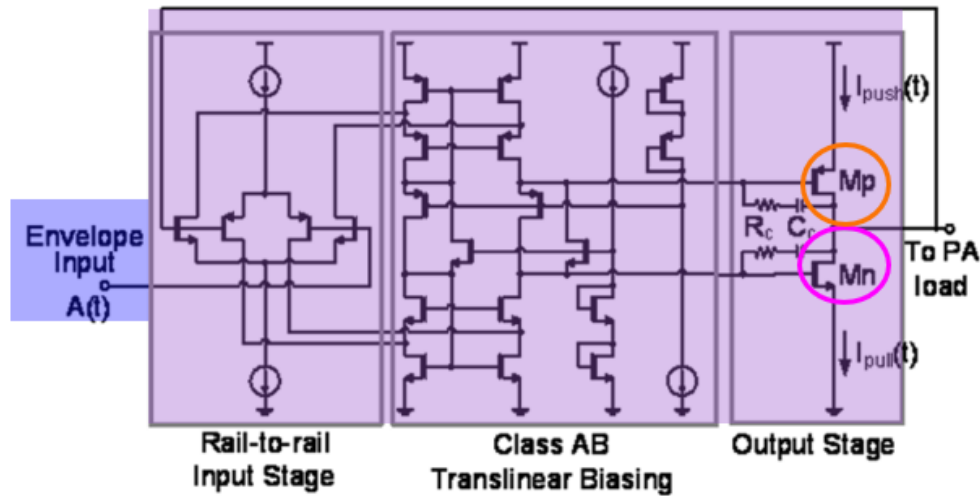
See Section X.A.1(d); Ex. 1103 at ¶113.

- (e) **“a driver that receives the amplified signal and provides a first control signal and a second control signal,”**

Chu discloses this limitation for the same reasons as stated above regarding limitation 6(e), which likewise requires “a driver operative to receive the amplified signal and provide a first control signal and a second control signal.” In both Figure 4 and Figure 14, the driver (Class AB Translinear Biasing circuit) is shown within the envelope amplifier (highlighted below in purple) that receives the amplified signal from the OTA and provides first and second control signals the transistors circled in orange and fuchsia:



Chu – Figure 4



Chu – Figure 14

See Section X.A.1(e); Ex. 1103 at ¶114.

- (f) “a P-channel metal oxide semiconductor (PMOS) transistor that receives the first control signal, a source that receives the boosted supply voltage or the first supply voltage, and a drain providing the second supply voltage and”

Chu combined with Choi renders this limitation obvious for the same reasons stated above regarding limitation 6(f), which likewise requires “a P-channel metal oxide semiconductor (PMOS) transistor having a gate receiving a first control signal, a source receiving the boosted supply voltage or the first supply voltage, and a drain providing the second supply voltage.” As shown above in Figures 4 and 14, the PMOS transistor is shown within the envelope amplifier. See Section X.A.1(f); Ex. 1103 at ¶115.

- (g) “an N-channel metal oxide semiconductor (NMOS) transistor that receives the second control signal at a gate and provides a second supply voltage through a drain, and a source for circuit grounding.”**

Chu discloses this limitation for the same reasons stated above regarding limitation 6(g), which likewise requires “an N-channel metal oxide semiconductor (NMOS) transistor having a gate receiving the second control signal, a drain providing the second supply voltage, and a source coupled to circuit ground.” As shown above in Figures 4 and 14, the NMOS transistor is shown within the envelope amplifier (highlighted in purple). *See* Section X.A.1(g); Ex. 1103 at ¶116.

B. Ground II: Claims 1-9 are obvious over Chu combined with Choi 2010 and Myers

1. Claim 1

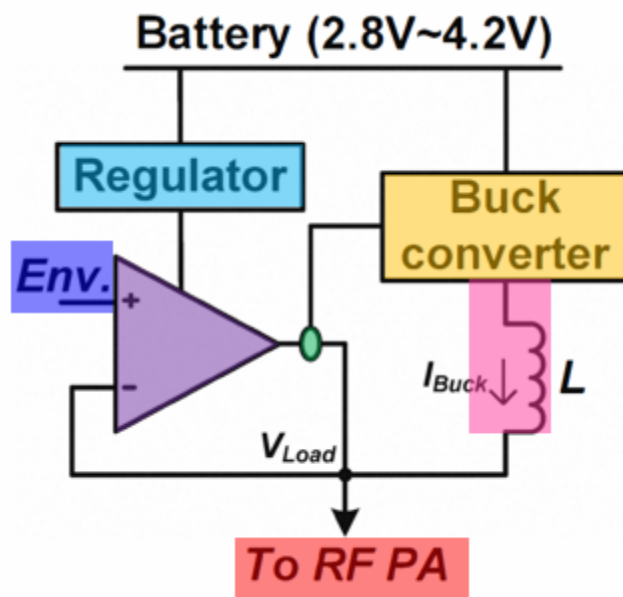
Claim 1 is obvious over Chu in combination with Choi 2010 and Myers, as explained below. Ex. 1103 at ¶¶118, 158.

- (a) “An apparatus comprising:”**

Chu discloses a “master–slave linear and switch-mode combined supply modulator loaded with a PA,” which is “an apparatus.” Ex. 1104 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. 1103 at ¶119.

- (b) “a boost converter operative to receive a first supply voltage and generate a boosted supply voltage having a higher voltage than the first supply voltage; and”

Choi 2010 discloses this limitation. Choi 2010 discloses an architecture for a hybrid supply generator/modulator that specifically employs “a boost converter.” Ex. 1107 at 1074, Abstract (“An integrated boost converter keeps a stable operation of the PA supply modulator.”). Within the supply generator/modulator, the boost converter is identified as the “Regulator” (highlighted below in light blue), as shown in Figure 5:



Choi 2010 – Figure 5

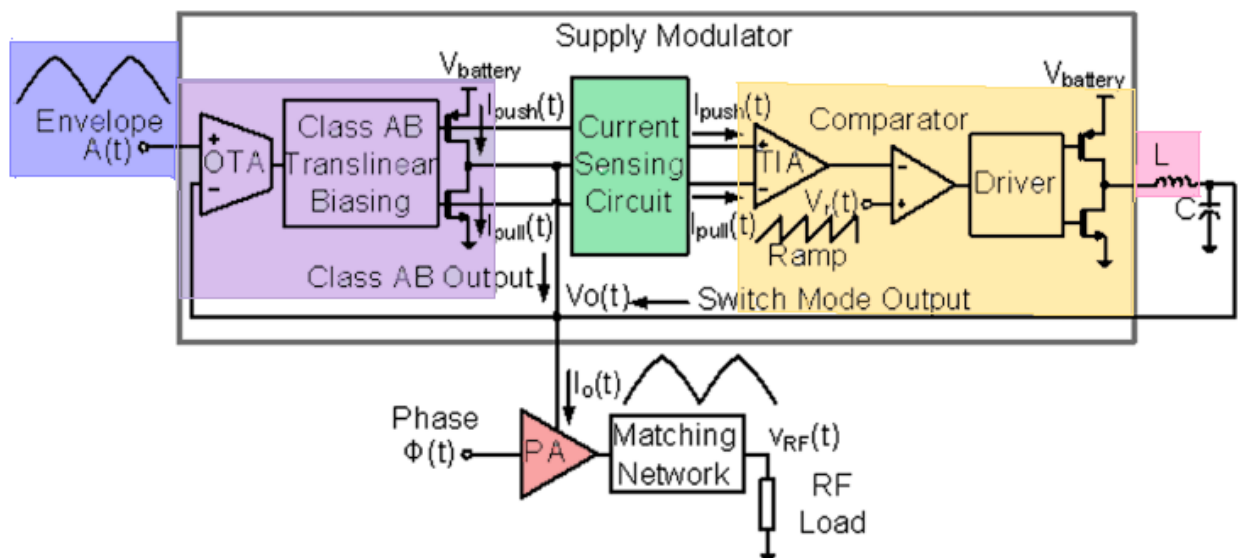
Id. at 1076 (“Fig. 5. Battery-to-5V PA supply modulator.”). As shown above, the boost converter receives a first supply voltage (Battery (2.8V-4.2V)), and as explained above in connection with limitation 6(c), the boost converter

generates a boosted supply voltage greater than the first supply voltage to maintain output power. See Section X.A.1(c); Ex. 1103 at ¶120.

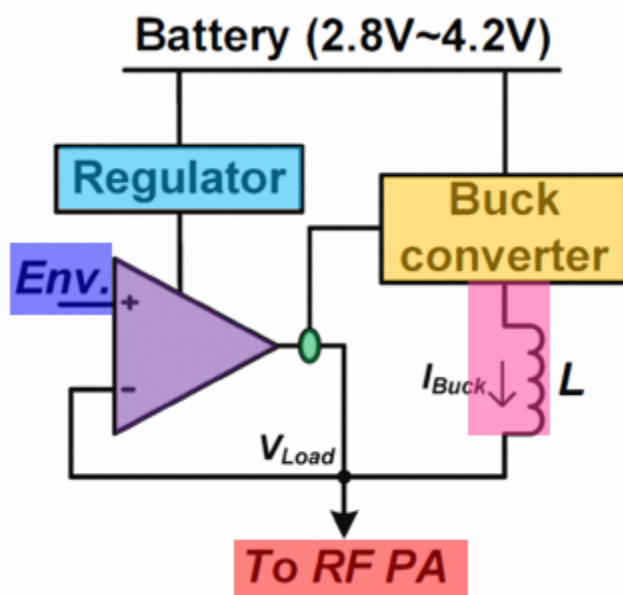
Finally, as explained above for limitation 6(c), it would have been obvious for a POSA to use Choi 2010's boost converter in Chu's hybrid supply generator. See Section X.A.1(c); Ex. 1103 at ¶121.

- (c) **“an envelope amplifier operative to receive an envelope signal and the boosted supply voltage and generate a second supply voltage based on the envelope signal and the boosted supply voltage,”**

Chu in combination with Choi 2010 discloses this limitation. Both Chu and Choi 2010 disclose supply modulators that include an envelope amplifier that receives an envelope signal. In both figures below (from Chu and Choi 2010 respectively), the envelope amplifier is highlighted in purple, and is shown receiving an envelope signal highlighted in blue:



Chu – Figure 4



Choi 2010 – Figure 5

Ex. 1104 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. 1107 at 1075 (“In the HSA, as shown in Fig. 4, the LDO [envelope amplifier] operates as an independent voltage source with a low output impedance. . . .”); Ex. 1103 at ¶122.

Choi 2010 further discloses that its envelope amplifier receives a boosted supply voltage from the “Regulator”/boost converter highlighted in light blue and generates a second voltage (V_{Load}) that is supplied to the PA (highlighted in red) and that is based on both the envelope signal and the boosted supply voltage. Ex.

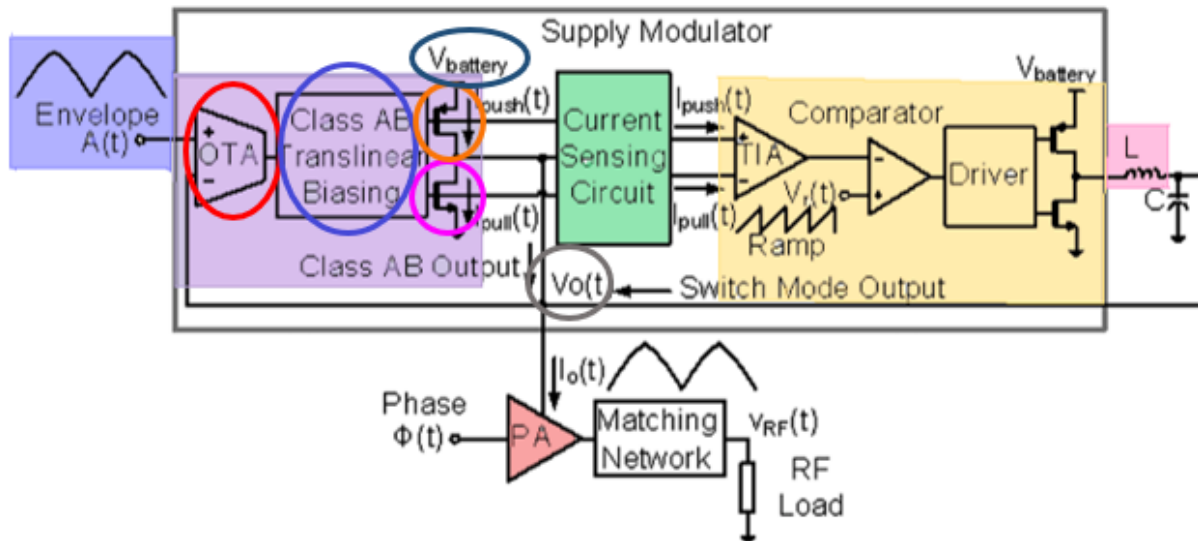
1107 at 1075 (“As the load voltage is regulated by the linear amplifier, boosting up the supply voltage of the linear amplifier results in a stable supply voltage to the RF PA regardless of the battery depletion. Thus, the additional 5V boost converter, whose input range is from 2.8V to 4.2V, is coupled to the supply of the linear amplifier, while that of the switching amplifier is directly connected to the battery as illustrated in Fig. 5.”); Ex. 1103 at ¶123.

As explained above for limitation 6(c), it would have been obvious for a POSA to modify Chu so that the output supply voltage is generated based on the envelope signal and a *boosted* supply voltage (rather than V_{battery}), using a boost converter such as the one disclosed in Choi 2010. *See* Section X.A.1(c); Ex. 1103 at ¶124.

- (d) **“wherein the envelope amplifier is operative to further receive the first supply voltage and generate the second supply voltage based on the first supply voltage and generate the second supply voltage based on the first supply voltage or the boosted supply voltage, and further wherein the envelope amplifier comprises”**

Chu in combination with Choi 2010 and Myers discloses this limitation. This limitation requires, for purposes of this Petition, an envelope amplifier that can receive the first supply voltage and generate the second supply voltage based selectively on either the first supply voltage or the boosted supply voltage. Ex. 1103 at ¶125.

As shown below, Chu discloses an envelope amplifier (highlighted in purple) that receives a first supply voltage from the battery (V_{battery}):



Chu – Figure 4

Based on that battery voltage, the Chu envelope amplifier generates a voltage $V_o(t)$ (“second supply voltage”) for powering the PA. Ex. 1104 at 2810 (“A high GBW linear amplifier in voltage follower configuration ensures that output node $V_o(t)$ tracks the reference envelope voltage $A(t)$.”). Furthermore, as explained above in connection with limitation 6(c), Chu’s envelope amplifier can be combined with the boost converter disclosed in Choi 2010 so that the envelope amplifier could generate the second supply voltage based on the boosted supply voltage from the boost converter. See Section X.A.1(c); Ex. 1103 at ¶126.

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 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. 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. 1112 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:

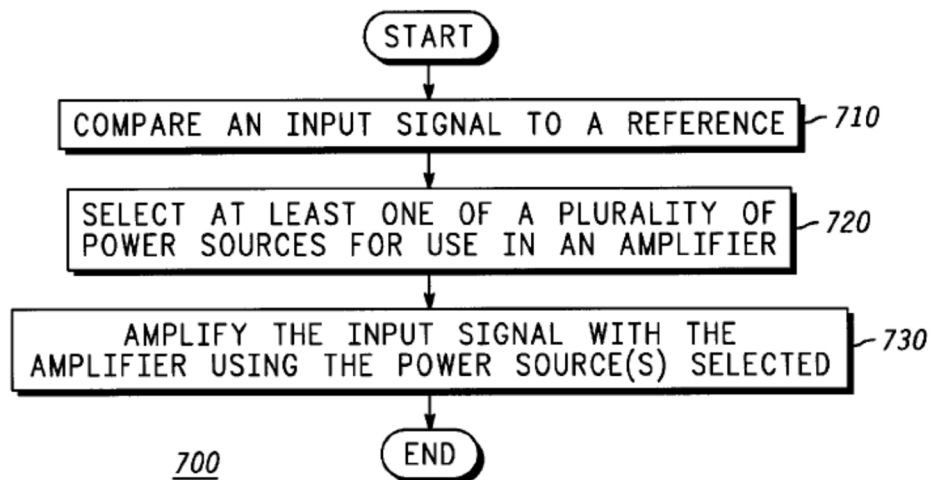


FIG. 7

Myers – Figure 7

Ex. 1112 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.* at Fig. 8; *id.* at 9:22-41; Ex. 1103 at ¶127. 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. 1112 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. 1101 at 6:4-5 (“The first threshold may be a fixed threshold or may be determined based on the Vbat voltage.”); Ex. 1103 at ¶128.

(i) 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. 1103 at ¶129.

All three references—Chu, Choi 2010, and Myers—are from the same field of endeavor (hybrid power supply modulators). Combining the Chu envelope tracker with the Choi 2010 boost converter would have been obvious for the reasons stated above regarding limitation 6(c). 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. 1112 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. Ex. 1103 at ¶130.

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 with the boost converter of 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. 1103 at ¶131.

Conversely, a POSA would also have understood the common-sense notion that, when the voltage magnitude of the amplified envelope signal is **greater** than the battery voltage—such as when the battery voltage is experiencing roll-off (as described above)—then it would be necessary to operate the envelope tracker of Chu (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. *Id.* at ¶131.

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. 1112 at 9:16-21, 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. 1101 at 5:31-33 (“In one design, envelope amplifier 170a 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. 1103 at ¶132.

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 $A(t)$ (e.g., due to roll-off of the battery), 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 at an initial fully charged level and then experience reduced output voltage over time as the battery is discharged. Ex. 1103 at ¶133.

Finally, adding the selectable power sources of Myers to the Chu 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. 1103 at ¶134.

(e) “an operational amplifier (op-amp) operative to receive the envelope signal and provide an amplified signal,”

Chu discloses this limitation for the same reasons as discussed above regarding limitation 8(d), which likewise requires “an envelope amplifier ... using an operational amplifier (op-amp) that receives the envelope signal and provides an amplified signal.” *See* Section X.A.2(d); Ex. 1103 at ¶135.

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

Chu discloses this limitation for the same reasons as discussed above regarding limitation 8(e), which likewise requires an envelope amplifier using “a

driver that receives the amplified signal and provides a first control signal and a second control signal.” See Section X.A.2(e); Ex. 1103 at ¶136.

- (g) “a P-channel metal oxide semiconductor (PMOS) transistor having a gate receiving the first control signal, a source receiving the boosted supply voltage or the first supply voltage, and a drain providing the second supply voltage, and”**

Chu in combination Choi 2010 and Myers renders this limitation obvious for the same reasons as discussed above regarding limitation 8(f), which likewise requires an envelope amplifier using “a P-channel metal oxide semiconductor (PMOS) transistor that receives the first control signal, a source that receives the boosted supply voltage or the first supply voltage, and a drain providing the second supply voltage.” See Section X.A.2(f); Ex. 1103 at ¶137.

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

Chu discloses this limitation for the same reasons as discussed above regarding limitation 8(g), which likewise requires an envelope amplifier using “an N-channel metal oxide semiconductor (NMOS) transistor that receives the second control signal at a gate and provides a second supply voltage through a drain, and a source for circuit grounding.” See Section X.A.2(g); Ex. 1103 at ¶138.

2. Claim 2

- (a) “The apparatus of claim 1, wherein the envelope amplifier is operative to generate the second supply voltage based on the boosted supply voltage if the envelope signal exceeds a first threshold, or if the first supply voltage is below a second threshold, or both.”**

As explained above, claim 1 is obvious in view of Chu combined with Choi 2010 and Myers. Chu combined with Choi 2010 and Myers also renders the additional limitations of claim 2 obvious. Ex. 1103 at ¶¶139-140, 158.

As discussed above in connection with limitation 6(c), Choi 2010 discloses a boost converter that provides a boosted supply voltage to the envelope amplifier. *See* Section X.A.1(c). Myers discloses comparing an input signal or “envelope input” (an “envelope signal”) to a reference (a “threshold”) and selecting the appropriate power source depending on the results of the comparison. Ex. 1112 at 9:8-21 (describing the steps of Figure 7); *see also id.* Fig. 8; *id.* at 9:22-41; Ex. 1103 at ¶140. For the same reasons discussed regarding limitation 1(d), it would have been obvious to a POSA to use the selection scheme described in Myers with the hybrid supply generator described in Chu as modified by Choi 2010 to generate the second supply voltage based on the boosted supply voltage if the envelope signal exceeds a first threshold, which could be based on the battery voltage. *See* Section X.B.1(d); Ex. 1103 at ¶141.

3. Claim 3

- (a) **“The apparatus of claim 1, wherein the envelope amplifier further comprises a second PMOS transistor having a gate receiving a third control signal, a source receiving the boosted supply voltage, and a drain coupled to the source of the PMOS transistor, and a third PMOS transistor having a gate receiving a fourth control signal, a source receiving the first supply voltage, and a drain coupled to the source of the PMOS transistor.”**

As explained above, claim 1 is obvious in view of Chu combined with Choi 2010 and Myers. Claim 3 is also obvious in view of Chu combined with Choi 2010 and Myers because the additional limitations of claim 3 (two PMOS transistors) comprise a simple multiplexer that selects between the boosted supply voltage and first supply voltage (the battery), and a POSA would have known that the standard way to implement the selection feature of Myers would have been to use such a multiplexer. *See* Ex. 1101 at 5:31-49 (describing the PMOS transistor operation); Ex. 1103 at ¶¶142-144, 158.

As discussed above in Section V.C, at the time of the alleged invention, multiplexers using two PMOS transistors were commonly used for selecting a single input signal among several input signals. A POSA would have known that selecting between the boosted supply voltage and the first supply voltage (as required by claim 3 and as taught by Myers) could have been easily implemented using such a multiplexer. Such a multiplexer would have included the structure

required by claim 3: two PMOS transistors, each of which has a gate receiving a control signal that performs the selection, each of which has a source coupled to one of the power supply voltages, and each of which has a drain connected to the output node. For purposes of claim 3, the output node is the source of the first PMOS transistor (from claim 1) that provides the second supply voltage to the power amplifier. Ex. 1103 at ¶145.

4. Claim 4

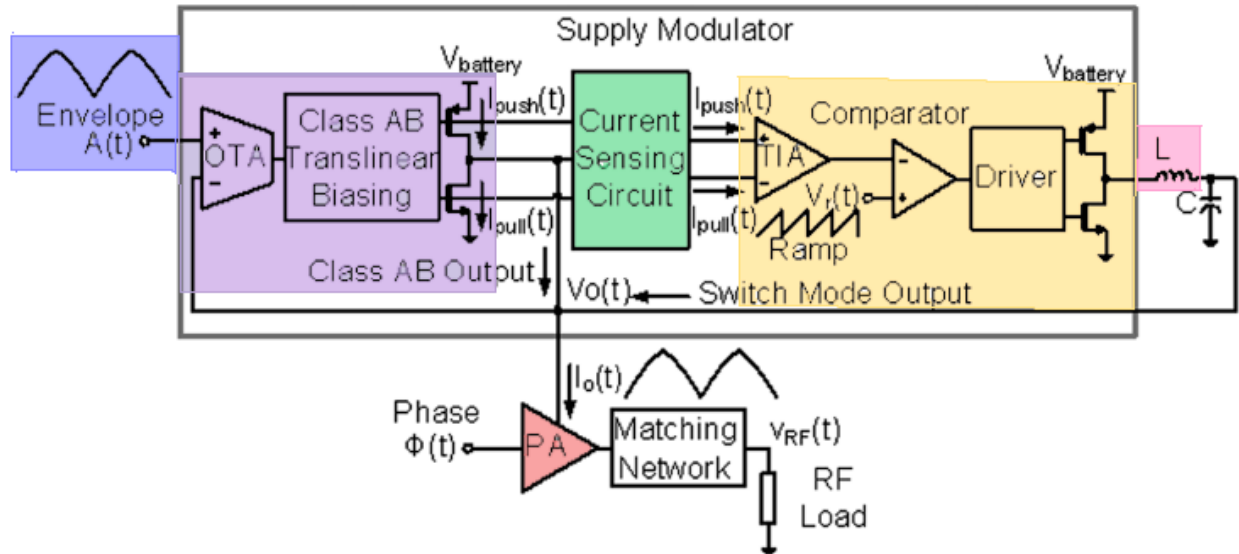
- (a) “The apparatus of claim 1, further comprising: a power amplifier operative to receive the second supply voltage from the envelope amplifier and to receive and amplify an input radio frequency (RF) signal and provide an output RF signal.”**

As explained above, claim 1 is obvious in view of Chu combined with Choi 2010 and Myers. Chu also discloses the additional limitations of claim 4. As discussed above regarding limitation 6(b), Chu discloses a “a power amplifier operative to receive and amplify an input radio frequency (RF) signal and provide an output RF signal.” *See* Section X.A.1(b). As described above regarding limitation 6(c), the power amplifier in Chu receives the second supply voltage from the envelope amplifier. Ex. 1103 at ¶¶146-147, 158.

5. Claim 5

- (a) **“The apparatus of claim 1, wherein the first supply voltage is a battery voltage for the apparatus.**

As explained above, claim 1 is obvious in view of Chu combined with Choi 2010 and Myers. Chu also discloses that the first supply voltage is a battery voltage. Figure 4 of Chu shows V_{battery} supplying the voltage that will be used as an input into the envelope amplifier.



Chu – Figure 4

Ex. 1103 at ¶¶148-150, 158.

6. Claims 6 and 8

As explained above in Sections X.A.1 and X.A.2, claims 6 and 8 are obvious in view of Chu combined with Choi 2010 (without Myers). The plain language of limitation (f) of these claims does not require the ability to *select* either the boosted

supply voltage or the first supply voltage at any given time. But if selectivity is required, these limitations would have been obvious in light of Chu in combination with Choi 2010 and Myers. As explained above regarding claim 1 and below regarding limitation 7(a), Myers discloses the ability to selectively choose among power sources, and it would have been obvious to combine Chu with Choi 2010 and Myers to add this capability. *See* Sections X.B.1(d) and X.B.7(a).

Accordingly, to the extent limitations 6(f) and 8(f) are interpreted to require this selection capability, claims 6 and 8 would be invalid based on Chu in combination with Choi 2010 and Myers. Ex. 1103 at ¶¶151, 158.

7. Claim 7

Claim 7 is obvious in view of Chu combined with Choi 2010 and Myers, as explained below. Ex. 1103 at ¶¶152, 158.

- (a) **“The apparatus of claim 6, wherein the supply generator is operative to generate the second supply voltage based on the envelope signal and either the boosted supply voltage or the first supply voltage.”**

As explained above regarding claim 6, Chu combined with Choi 2010 renders the apparatus of claim 6 obvious. *See* Section X.A.1(a); Ex. 1103 at ¶153.

Myers discloses the remaining elements of claim 7. As explained above regarding limitation 1(d), Myers discloses a power supply modulator that selects among different power sources based on operating conditions. *See* Section

X.B.1(d). Incorporating the teaching of Myers would allow Chu's supply generator to select one of multiple power sources, such as a battery voltage or a boosted voltage, and generate the second supply voltage based on either the first supply voltage (battery voltage) or the boosted supply voltage. Thus, whereas Chu combined with Choi 2010 renders obvious a supply generator that "generate[s] a second supply voltage for the power amplifier based on the envelope signal and the boosted supply voltage" (as explained above regarding limitation 6(c)), Chu combined with Choi 2010 and Myers renders obvious a supply generator that "generate[s] the second supply voltage based on the envelope signal and either the boosted supply voltage or the first supply voltage." Ex. 1103 at ¶154.

It would have been obvious to combine Chu, Choi 2010, and Myers for the reasons explained above in Section X.B.1(d) regarding limitation 1(d). Ex. 1103 at ¶155.

8. Claim 9

- (a) **"The method of claim 8, wherein the generating the second supply voltage comprises generating the second supply voltage based on the envelope signal and either the boosted supply voltage or the first supply voltage."**

As explained above, Chu in combination with Choi 2010 renders the method of claim 8 obvious. Myers discloses the remaining limitations of claim 8 for the

same reasons as discussed above with respect to claim 7. *See* Section X.B.7; Ex. 1103 at ¶¶156-158.

XI. CONCLUSION

Based on the foregoing, claims 1-9 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/

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Registration No. 36,476

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

Exhibit	Description
1101	U.S. Patent No. 8,698,558
1102	File History for U.S. Patent No. 8,698,558
1103	Declaration of Dr. Alyssa B. Apsel
1104	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”)
1105	Declaration of IEEE regarding Chu, Kwak, Kim, and Blanken (“IEEE Chu Decl.”)
1106	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”)
1107	Declaration of IEEE regarding Choi 2010 (“IEEE Choi Decl.”)
1108	Declaration of Debabani Choudhury (“Choudhury Decl.”)
1109	Declaration of Jinsung Choi (“Choi Decl.”)
1110	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”)
1111	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”)
1112	U.S. Patent No. 5,929,702, “Method and Apparatus for High Efficiency High Dynamic Range Power Amplification,” to Myers et al. (“Myers”)
1113	Kim, D. et al., “High efficiency and wideband envelope tracking power amplifier with sweet spot tracking.” <i>Radio Frequency Integrated Circuits Symposium (RFIC):</i> 255-258 (2010) (“Kim”)

1114	U.S. Patent No. 6,300,826, “Apparatus and Method for Efficiently Amplifying Wideband Envelope Signals” (filed May 5, 2000) (“Mathe ’826”)
1115	Maxim Integrated Products, Inc., <i>MAX9738 –16VP-P Class G Amplifier with Inverting Boost Converter</i> , Datasheet 19-3700, Rev. 0 (March 2008) (“Maxim”)
1116	Ertl, H. et al., “Basic considerations and topologies of switched-mode assisted linear power amplifiers,” <i>IEEE Transactions on industrial electronics</i> 44.1 (1997): 116-123 (“Ertl”)
1117	Kang, D. et al., “A multimode/multiband power amplifier with a boosted supply modulator” <i>IEEE Transactions on Microwave Theory and Techniques</i> 58.10 (2010): 2598-2608 (“Kang”)
1118	U.S. Patent No. 5,834,977, “Amplifying Circuit with Power Supply Switching Circuit” (filed October 30, 1996 and issued November 10, 1998) (“Maehara”)
1119	U.S. Patent No. 5,870,340, “Multiplexer” (filed July 8, 1997 and issued February 9, 1999) (“Ohsawa”)
1120	U.S. Patent No. 6,566,935, “Power Supply Circuit With a Voltage Selector” (filed August 28, 2000 and issued May 20, 2003) (“Renous”)
1121	Certificate of Correction for U.S. Patent No. 8,698,558 (“558 COC”)
1122	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”)
1123	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 (Ex. 1101-1123)
- Exhibits 1101 – 1123
- 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/
Scott Bertulli
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 14,000 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

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