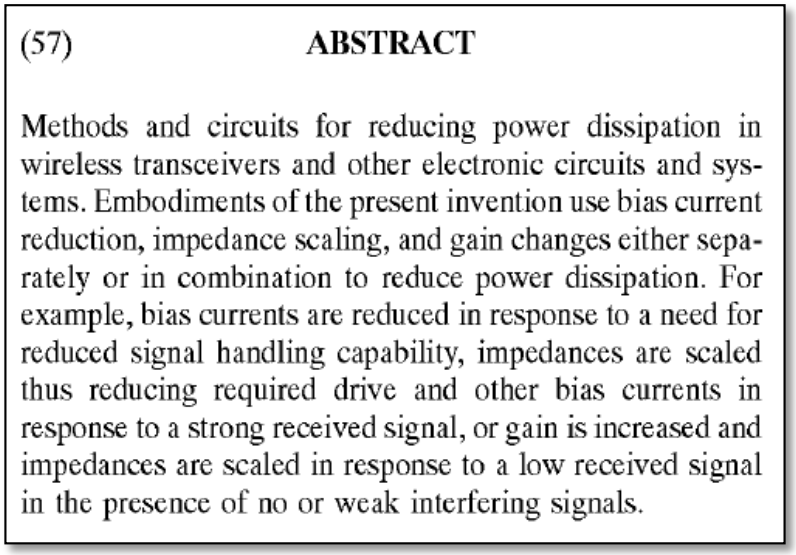
Inter Partes Review
U.S. Patent No. 7,010,330
U.S. Patent No. 10,129,825
U.S. Patent No. 10,524,202
U.S. Patent No. 11,564,164
U.S. Patent No. 11,638,210

Oral Argument, August 27, 2025

Apple Inc. v. Theta IP, LLC.;
Case Nos. IPR2024-00816, -817, -818, -819, -820

Theta Patents

- The ’330 Patent was filed on February 23, 2004, claiming priority to Provisional Application Nos. 60/451,229 and 60/451,230, both filed **March 1, 2003**.



(57) **ABSTRACT**

Methods and circuits for reducing power dissipation in wireless transceivers and other electronic circuits and systems. Embodiments of the present invention use bias current reduction, impedance scaling, and gain changes either separately or in combination to reduce power dissipation. For example, bias currents are reduced in response to a need for reduced signal handling capability, impedances are scaled thus reducing required drive and other bias currents in response to a strong received signal, or gain is increased and impedances are scaled in response to a low received signal in the presence of no or weak interfering signals.

Patent	Filing Date	Relationship
’825 Patent	March 24, 2016	Continuation chain from ’330 Patent
’202 Patent	November 28, 2017	Continuation chain from ’330 Patent
’164 Patent	August 20, 2021	Continuation chain from ’330 Patent
’210 Patent	December 21, 2022	Continuation chain from ’330 Patent

’330 Patent at Abstract

Theta Patents' Disclosure

(1) Determine relative desired & interferer signals
(2) Decrease current to save power when possible

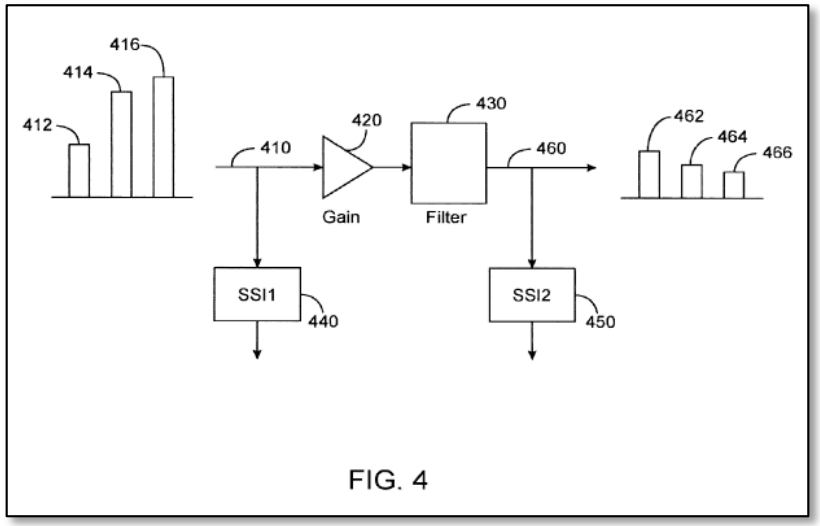


FIG. 4

1210 RECEIVED SIGNAL		1220 RESPONSE TO RECEIVED SIGNAL		
SIGNAL STRENGTH	INTERFERER STRENGTH	DECREASE SMAX	INCREASE IMPEDANCE NOT GAIN	INCREASE IMPEDANCE AND GAIN
SMALL (1230)	SMALL	YES	NO	YES
LARGE (1240)	SMALL	NO	YES	NO
LARGE (1250)	LARGE	NO	YES	NO
SMALL (1260)	LARGE	NO	NO	NO

FIG. 12

One reason why this power drain is high is that electronic circuits are typically designed to function properly under worst-case operating conditions. For a wireless transceiver, the worst case condition is when a desired signal reception strength is low, while other transceivers or nearby electronic equipment generate interfering signals and other spurious noise.

But a wireless transceiver does not always operate in these worst-case conditions. For example, a base station, router or access point may be nearby such that the received signal is strong. Also, there may be no interfering signals, or they may be relatively weak. In these situations, receiver circuit currents can be reduced below what is necessary for the worst case condition. If this is done, power dissipation is reduced, and battery life is increased.

Thus, what is needed are circuits and methods that can adapt to a better-than-worst-case condition and reduce circuit currents and therefore power dissipation accordingly.

'330 Patent at Figs. 4, 12, 1:31-48; Petition (Paper 1) at 1-7, 30-31

All citations in demonstratives are to -816 record unless indicated otherwise.

Theta Patents' Disclosure

Dynamically adjust "function block" in the signal path

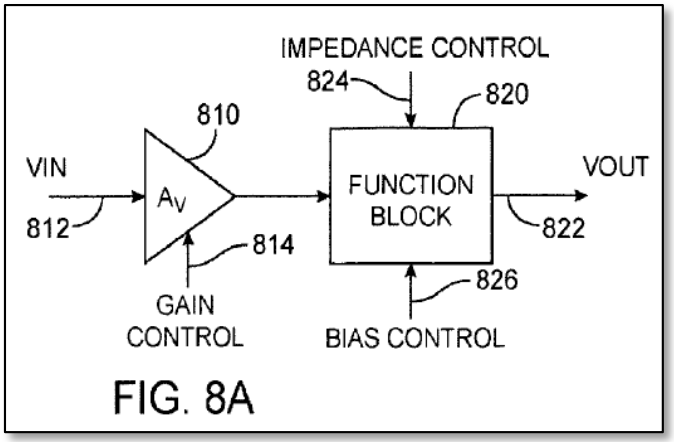


FIG. 8A

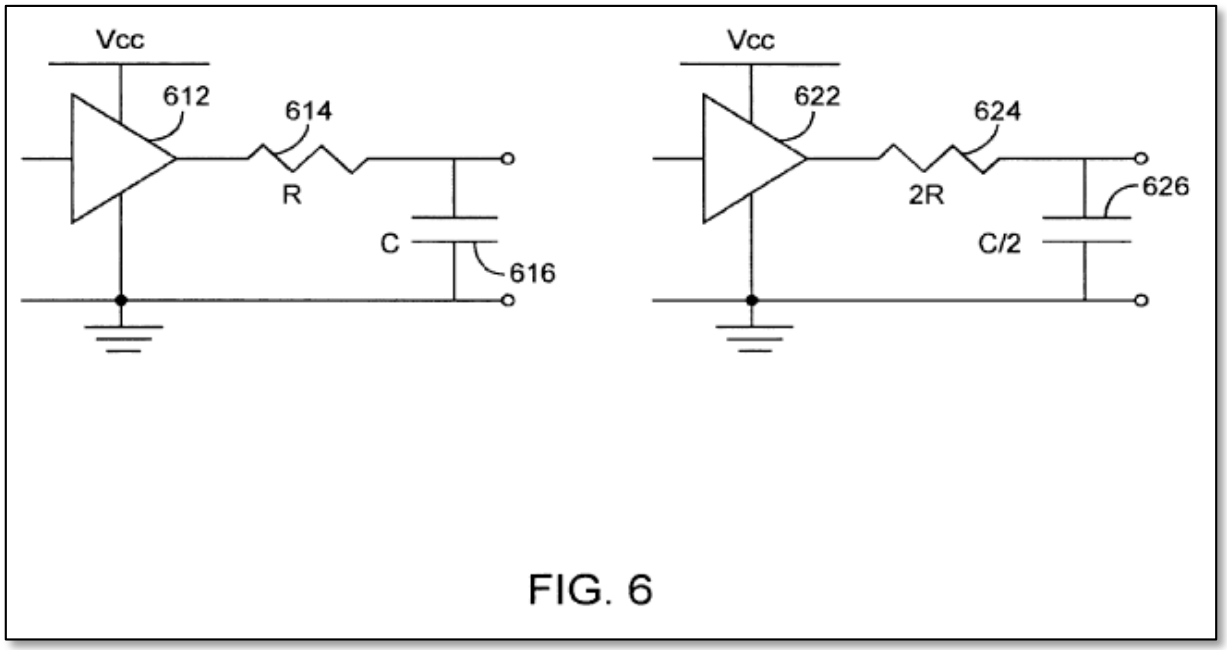


FIG. 6

'330 Patent at Figs. 6, 8A; Petition (Paper 1) at 1-7, 37-38; Reply (Paper 18) at 2-3, 9-11, 16-17

Theta Patents' exemplary claim

1. A method of receiving a signal using an integrated circuit, the integrated circuit comprising a signal path including a low-noise amplifier configured to receive the signal, a mixer having an input coupled to an output of the low-noise amplifier, and a low-pass filter having an input coupled to an output of the mixer, the method comprising:

determining a first signal strength at a first node in the signal path in the integrated circuit; and

reducing a switching current in the signal path by dynamically changing an impedance of a component in the signal path based on the first signal strength.

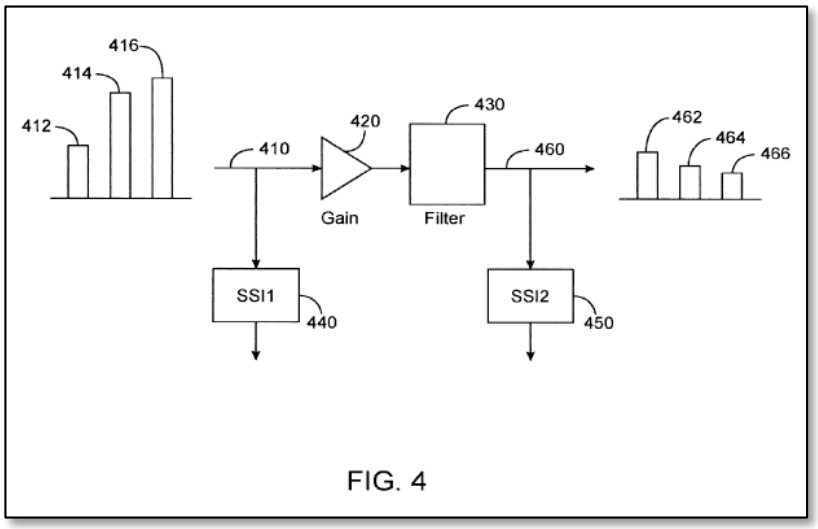
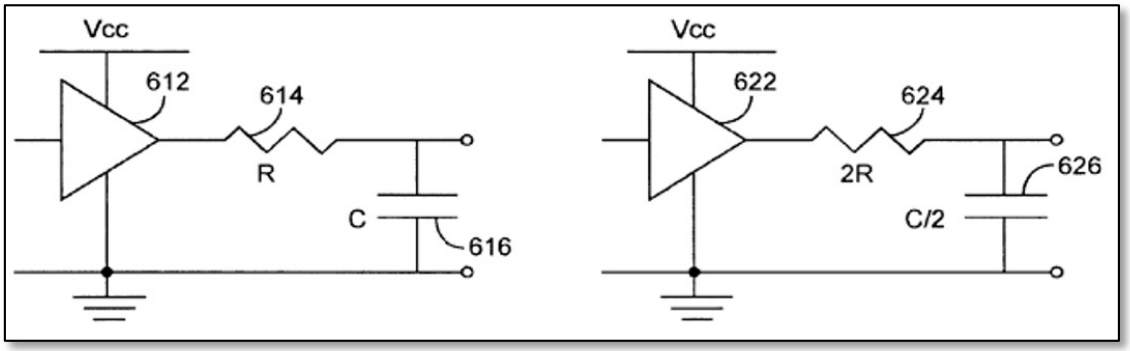


FIG. 4



Proposed Grounds

1) Behbahani (Ex. 1004), Leete (Ex. 1005), and Tan (Ex. 1006):

- IPR2024-00816 (’330 Patent)—Claims 1-7, 9-13, 16, 23, 25-26, 28-29
- IPR2024-00817 (’825 Patent)—Claim 1-8
- IPR2024-00818 (’202 Patent)—Claims 1-2, 4-23
- IPR2024-00819 (’164 Patent)—Claims 1-20

2) Behbahani (Ex. 1004) and Tan (Ex. 1006):

- IPR2024-00820 (’210 Patent)—Claims 1-3, 5-6, 8-11

Undisputed aspects of proposed grounds

1. Behbahani, Leete, and Tan describe the same project and are properly treated conjunctively.

2. Behbahani's receiver operation. Both parties agree that:
   - Behbahani's variable filter is dynamically adjusted to save power.
   - Dynamic adjustments based on measured desired and interferer signals.
   - Behbahani's high-power branch has lower impedance and higher bias current.
   - Behbahani's low-power branch has higher impedance and lower bias current.

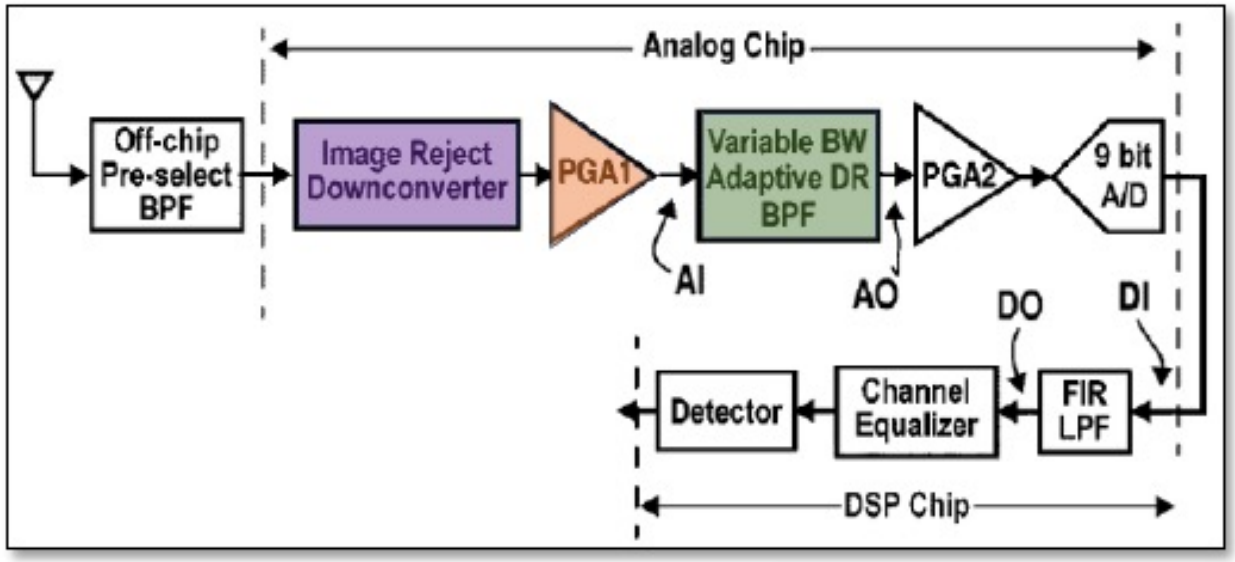
Behbahani (Ex. 1004)

Behbahani teaches a wireless receiver that implements an "adaptive dynamic range" method to save power by decreasing the dynamic range when conditions are better than worst case:

> This receiver implements ***adaptive dynamic range*** in the IF [Intermediate Frequency] section. ***Most wireless systems are designed for the worst case***; that is, the dynamic range is specified for the desired signal at a minimum detectable level, accompanied by the largest anticipated interferers. ***In practice, the receiver only infrequently needs this high instant*** DR [***dynamic range***]. ***DR is obtained at the expense of a disproportionate rise in power consumption*** . . . . An important idea here, which has also been noted elsewhere [4], is that ***providing no more than the required DR at any given time lowers the average power consumption***.

Behbahani, 1205.

Behbahani (Ex. 1004)



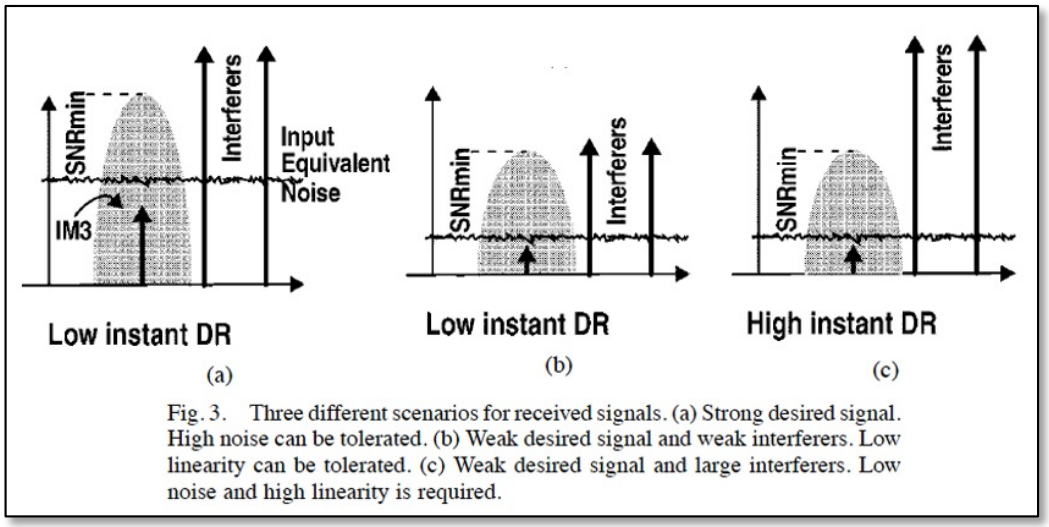


Fig. 3. Three different scenarios for received signals. (a) Strong desired signal. High noise can be tolerated. (b) Weak desired signal and weak interferers. Low linearity can be tolerated. (c) Weak desired signal and large interferers. Low noise and high linearity is required.

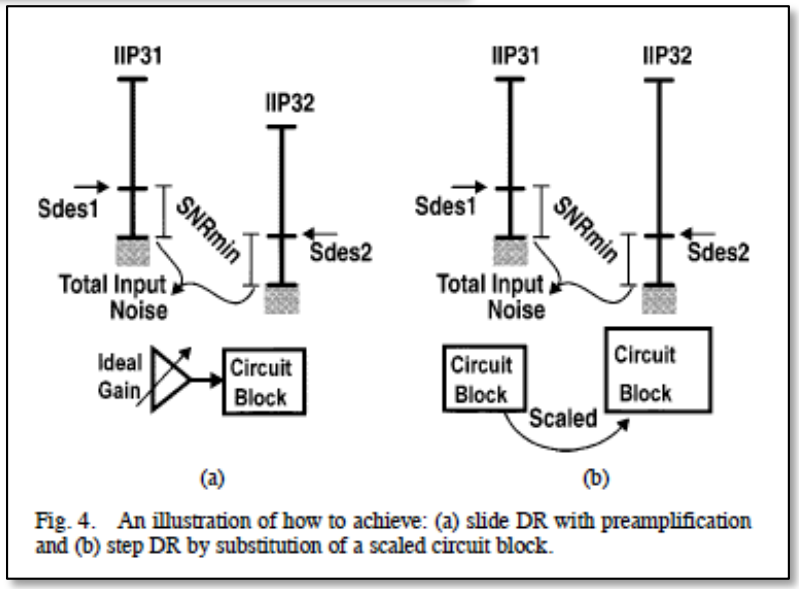


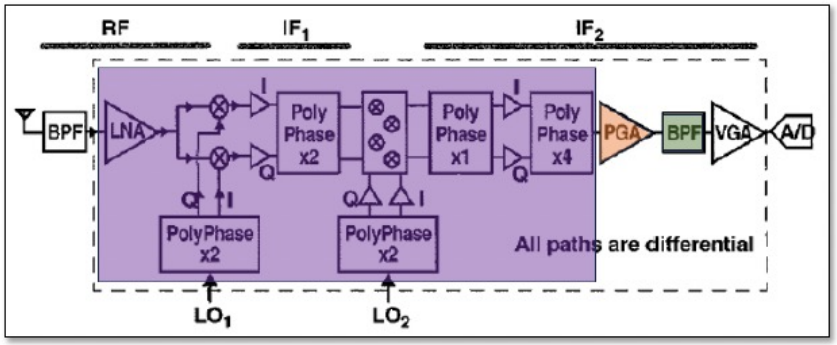
Fig. 4. An illustration of how to achieve: (a) slide DR with preamplification and (b) step DR by substitution of a scaled circuit block.

Petition (Paper 1) at 14-16, 20-21

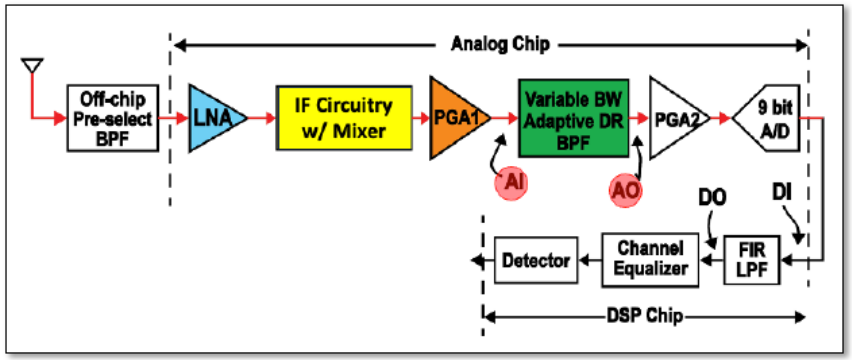
Leete (Ex. 1005)

- Leete—a Behbahani companion reference—provides detailed descriptions of the LNA and mixer.

As *Behbahani* notes, *Leete* provides the details of this downconverter circuitry. *Leete* teaches that the "RF front-end comprises a ***low noise amplifier (LNA)*** and an ***RF quadrature mixer***, which downconverts the RF signal to the first IF (IF1)." *Leete*, 1908 (further noting an additional "IF mixer *downconverts* the *desired* signal at IF1 to a low IF2"). This detailed circuitry is depicted in *Leete's* Fig. 1 below:



Consistent with *Behbahani's* express intent to use the two references conjunctively, the "Image Reject Downconverter" box from *Behbahani's* Fig. 2 has been replaced with an LNA and the other IF circuitry, including the mixer stage:



Behbahani modified by *Leete*, Figure 2 (annotated).

Petition (Paper 1) at 21-22

Tan (Ex. 1006)

- Tan—another Behbahani companion reference—provides detailed descriptions of the BPF.

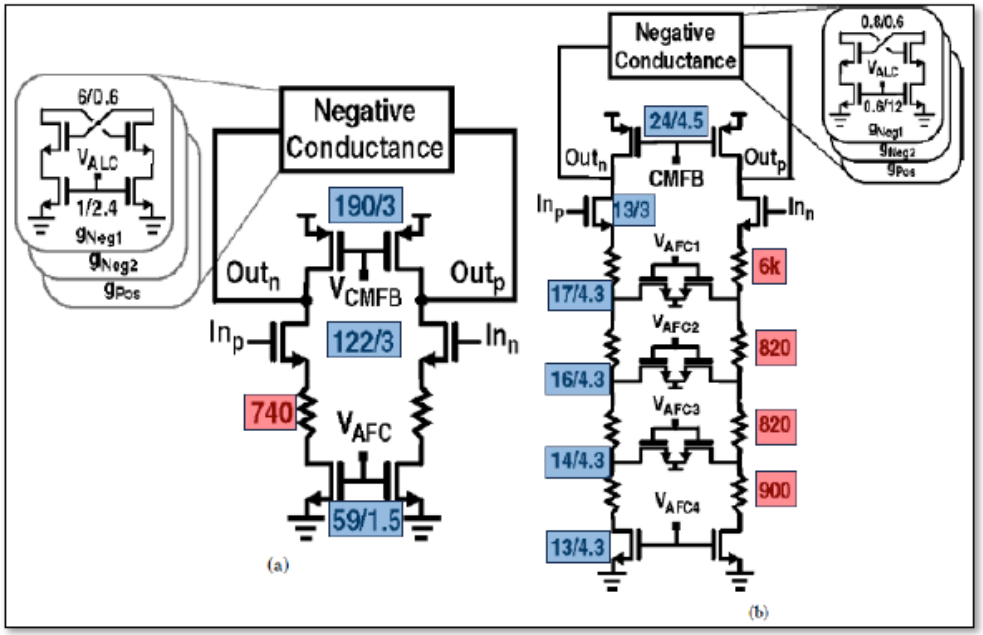
> *Behbahani* cites *Tan* to describe the details of the bandpass filter used in *Behbahani*: "The details of the BPF design are presented elsewhere [7]." *Behbahani*, 1210. The citation [7] in *Behbahani* is to *Tan*.

> Consistent with *Behbahani's* own teachings, *Tan* describes a low-power filter that exhibits "the same frequency response and linearity" as the high-power filter, but that scales all "transconductances and capacitors in th[e] filter . . . by a factor of 10" and "consumes 10x lower power." *Tan*, 480. *Tan* also confirms that the high-power filter utilizes a higher transconductance G_m (accompanied by lower resistance), higher capacitance, and higher bias current. *Id.*, 481; *Dec.*, ¶¶117-124 (explaining how *Tan's* teachings confirm that the signal path impedance changes when switching between scaled filters).

Petition (Paper 1) at 18, 43

Tan (Ex. 1006) (cont.)

Examining the G_m circuit—a circuit that dictates the overall filter characteristics—reveals that the proposed low-power filter does in fact have lower transconductance, higher resistance, lower capacitance, and a lower bias current. *Dec.*, ¶¶117-124. Figs. 6(a) and 6(b) below illustrate how the transconductances and resistances vary together in the proposed scaled filters:



Petition (Paper 1) at 18, 43

Petitioner's DX-12

Theta Patents

(1) Assess relative desired and interferer signals
(2) Adjust dynamic range when possible

In the example of FIG. **2A**, a received desired signal **206** is large in comparison to interfering signals **208** and **210**. In these examples, two interfering signals are shown for illustrative purposes, though there may be no such signals, one such signal, or more than two such signals in the frequency range of interest. Also, while for these examples the interferers are shown as being at a higher frequency than the desired signal, there may be one or more interferers at higher or lower frequencies as the desired signal. In this specific example, the acceptable noise floor **214** is relatively high, while maximum signal handling capability Smax **212** (that is the maximum signal power that can be handled with an acceptably low distortion) needs only to be high enough to accommodate the desired signal. For this specific example, the circuit receiving this input spectrum only requires a relatively small dynamic range for proper operation, that is the range between Smax **212** and the noise floor **214** is relatively small.

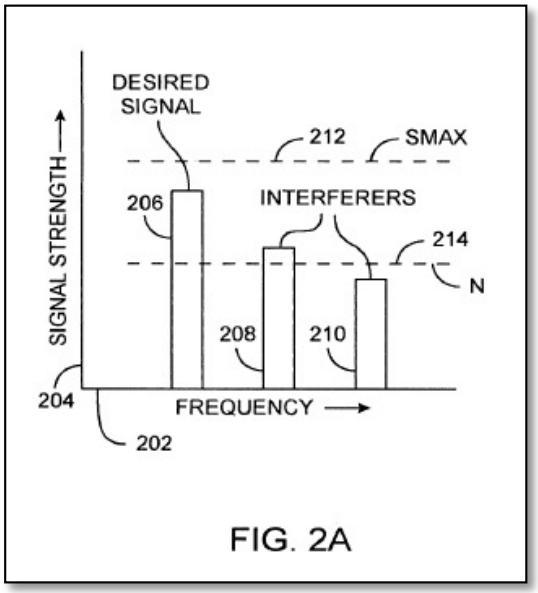


FIG. 2A

Conversely, in the example shown in FIG. **2B**, the desired signal **256** is relatively weak compared to the large interferers **258** and **260**. In this example, the noise floor **264** should be relatively low so as to prevent an unacceptable level of error in the recovery the desired signal **256**. The maximum signal handling capability Smax **262** should be relatively high to accommodate the large interferers in order to avoid the creation of intermodulation products as described below. Accordingly, in this specific example, the circuit receiving this input spectrum should have a large dynamic range, particularly in comparison to the example of FIG. **2A**.

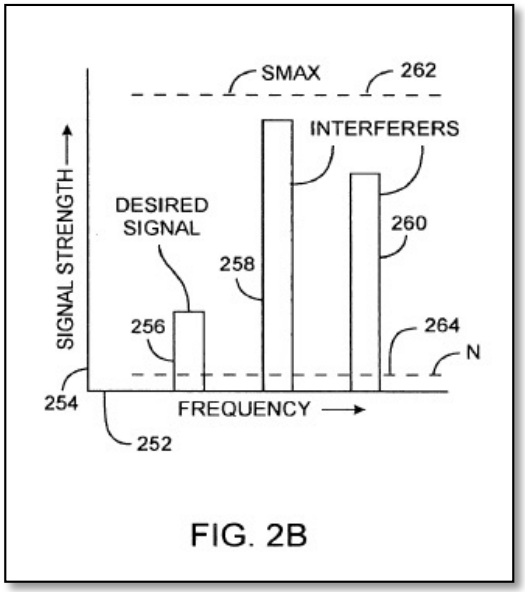


FIG. 2B

Petition (Paper 1) at 2-3; '330 Patent at Figs. 2A-2B, 5:28-62

Behbahani

(1) Assesses relative desired and interferer signals
(2) Adjusts dynamic range when possible

Abstract—An IF strip for a wireless receiver supports a variable baud rate by changing analog filter bandwidth. Sliding and step adaptive dynamic range are both used at IF to dissipate only the necessary power at prevailing channel conditions. A combination of VGA and PGA is developed for 64-QAM. The total signal processor draws an average of 16 mA from 3.3 V and a peak of 73 mA. The differential input noise is as low as 3.9nV/$\sqrt{\text{Hz}}$, while maximum IIP3 is +22 dBm with respect to 100 ohms.

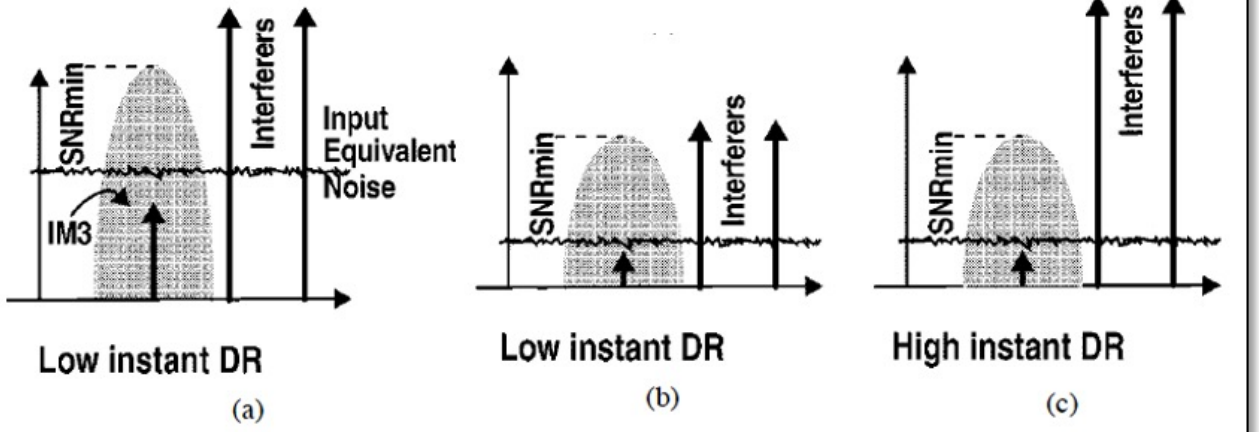


Fig. 3. Three different scenarios for received signals. (a) Strong desired signal. High noise can be tolerated. (b) Weak desired signal and weak interferers. Low linearity can be tolerated. (c) Weak desired signal and large interferers. Low noise and high linearity is required.

Petition (Paper 1) at 12-16; Behbahani (Ex. 1004) at Abstract

Theta Patents measure before and after filter to determine relative strength of desired and interferers

The signal strength indicators **440** and **450** do not provide information as to the relative sizes of the desired and interfering signals. Rather, a cumulative signal level is provided at their outputs. For example, the first signal strength indicator **440** outputs a level corresponding to the sum of desired signal **412** and interfering signals **414** and **416**, while the second signal strength indicator **450** provides a signal level corresponding to the sum of desired signal **462** and interfering signals **464** and **466**. In this specific example, the gain of the gain and filter circuit combinations is shown as approximately one, while the interfering signals **414** and **416** signal levels are reduced.

A comparison of the signal levels provided by the signal strength indicators **440** and **450** indicates that much of the combined received signal on line **410** has been filtered. Accordingly, it may be deduced that large interfering signals present at the input are being filtered by the filter **430**. From this information, as will be shown in greater detail below, the bias, impedance, and gain of the gain stage **420** and filter **430** combination may be optimized to reduce power dissipation.

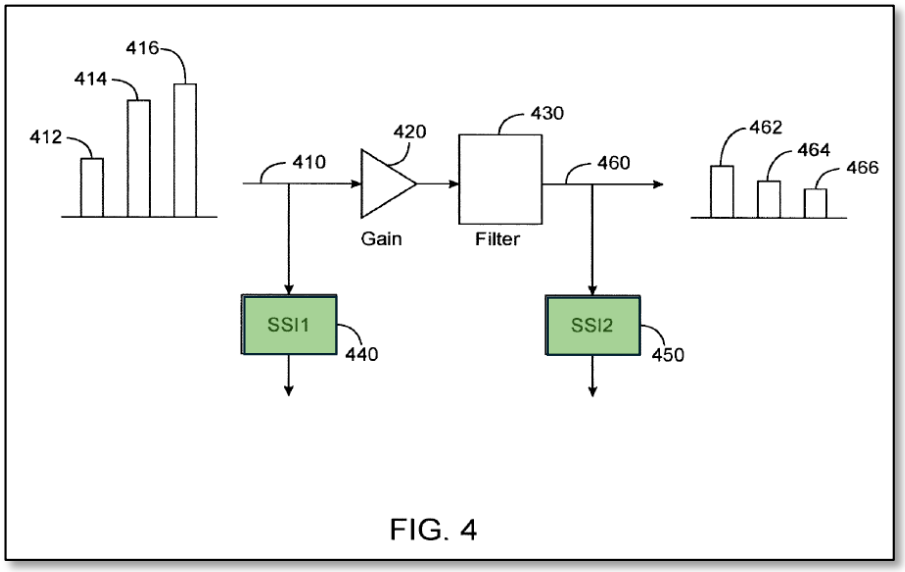
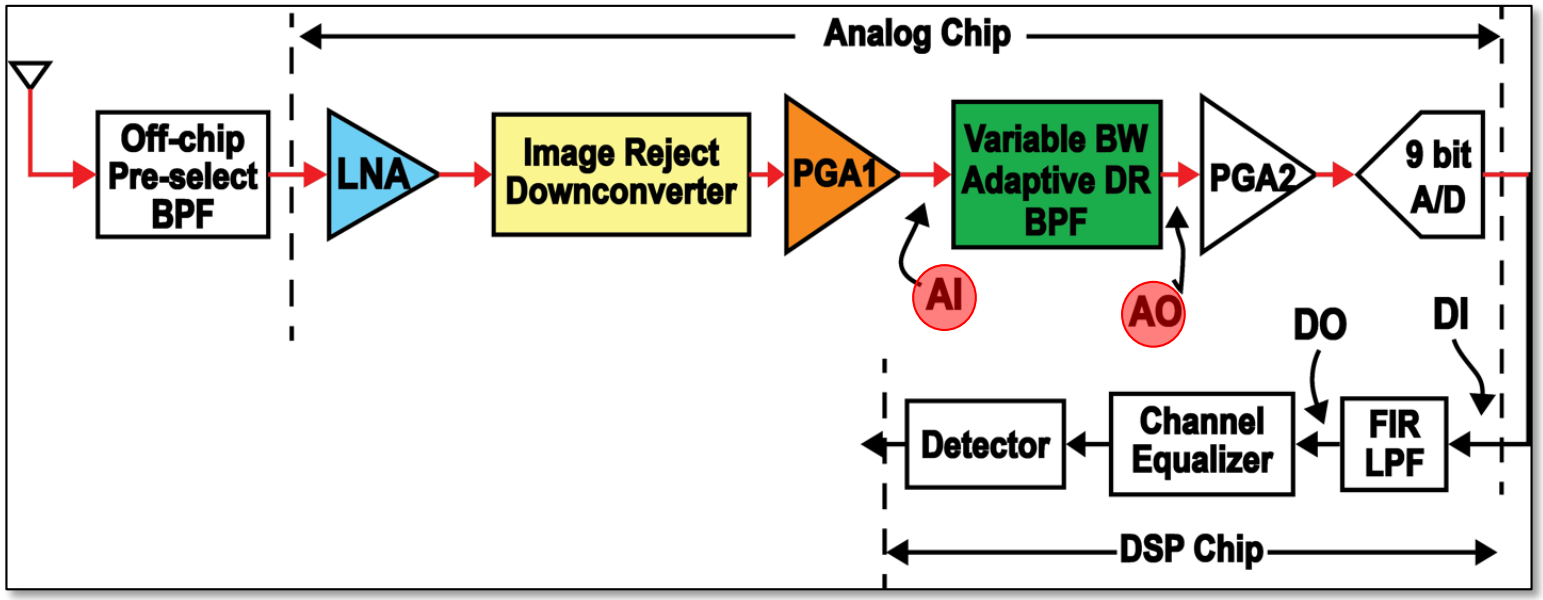


FIG. 4

'330 Patent at 6:56-7:8, Fig. 4; Petition (Paper 1) at 30-35; Reply (Paper 18) at 23-28

Behbahani measures before and after filter to determine relative strength of desired and interferers

The signal level at A_I and A_o is a measure of the out-of-band interferers being rejected by the analog BPF. If the *desired* signal at the output of the analog BPF is strong, as measured by $\text{Power}_{Do} - \text{Gain}_{\text{Post-analog-filter}}$, the scenario is as shown in Fig. 3(a). If the total signal power is comparable at A_I and A_o, and at D_I and D_o, the condition is like Fig. 3(a) or (b). In both cases, the required instant DR is low. If the signal levels are significantly different at either of the above pairs of nodes (A_I and A_o and D_I and D_o) and there is a weak signal at D_o, the condition must be the one shown in Fig. 3(c).



Behbahani (Ex. 1004) at 1207; Petition (Paper 1) at 30-35; Reply (Paper 18) at 23-28

Theta Patents teach scaling a filter block to save power when possible

FIG. **6** is an example of how a circuit's impedances may be scaled to reduce drive currents, and, depending on the circuit configuration used, associated bias currents as well. A driver **612** has a load R **614** and C **616**. The frequency response of this circuit is the same as that seen by driver **622**, which drives an impedance of 2R **624** and C/**2 626**. But the impedance of the load seen by driver **622** is double that seen by **612**, thus the output current required by the driver **622** is reduced by one-half.

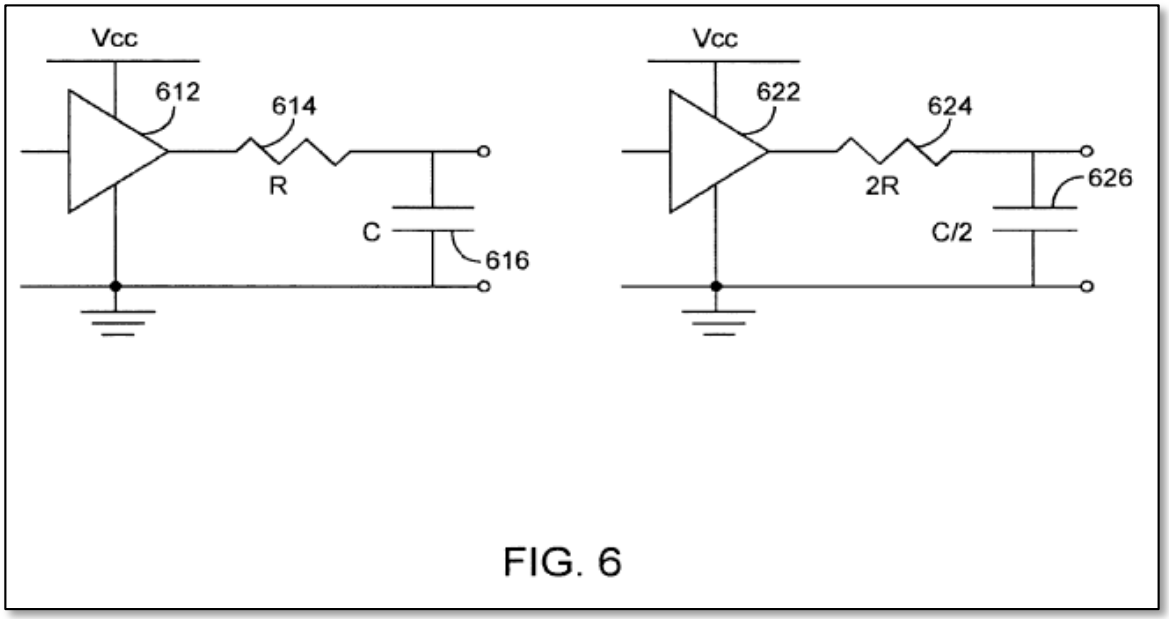


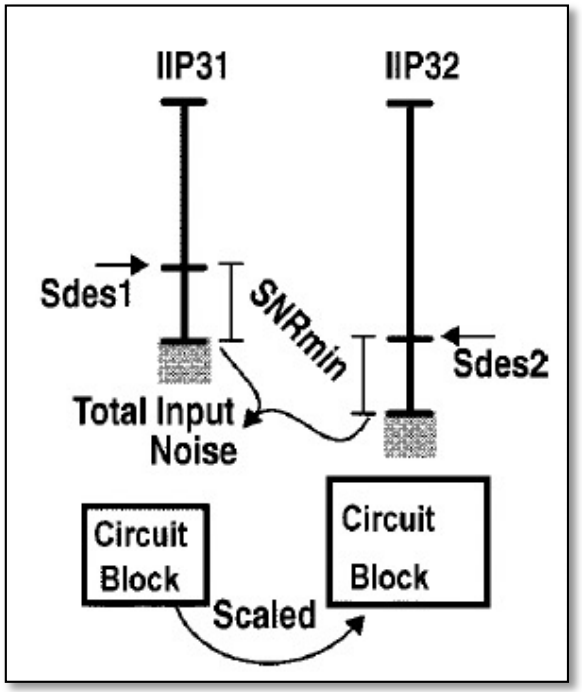
FIG. 6

'330 Patent at Figs. 8B-8C; Petition (Paper 1) at 6-7

Behbahani teaches scaling a filter block to save power when possible

Suppose that at some point the receiver needs higher DR. Scaling up all the transistors in a circuit keeping $V_{GS} - V_t$ constant and scaling down all resistors by the same factor lowers input mean square noise and raises bias current proportional to the scale factor, while IIP3 remains unchanged [Fig. 4(b)]. The scaled circuit can pass a weak desired signal accompanied by strong interferers. Thus, DR may be *stepped up* by substituting a scaled version of a nominal circuit.

The on-chip filter is usually the bottleneck to achievable DR in a fully integrated RX. In this design, the BPF adapts power dissipation to the instantaneous needs, as shown in Fig. 4(b). Two filters are implemented with the same topology, but one, scaled up to consume $10\times$ more power, offers $10\times$ lower mean square noise but the same linearity. An algorithm described below senses which of the previously described conditions is present. In the first two instances [Fig. 3(a) and (b)], a BPF dissipating low power is employed for nominal RX DR. However, in the worst-case scenario, the high-power scaled filter is switched in raising total DR. Since the worst-case scenario is infrequent, the low-power filter determines the average RX power consumption.



Remaining Disputes

1) Theory Presented

- Whether Petitioner relied on Behbahani's variable filter block as the dynamically adjusted "circuit" or "component" in the signal path

2) Claim Construction

- Whether the claimed "circuit" or "component" that is dynamically adjusted should be construed to exclude switching between high- and low-power filter branches within Behbahani's variable filter

3) Signal Strength Measurement Circuit

- Whether Behbahani's signal strength measurement teaching sufficiently teaches or suggests the claimed signal strength measurement limitations

4) Discretionary Denial

- Whether vacating institution on discretionary bases is appropriate after the parties and Board have invested extensive resources

Remaining Disputes

1) Theory Presented

- Whether Petitioner relied on Behbahani's variable filter block as the dynamically adjusted "circuit" or "component" in the signal path

2) Claim Construction

- Whether the claimed "circuit" or "component" that is dynamically adjusted should be construed to exclude switching between high- and low-power filter branches within Behbahani's variable filter

3) Signal Strength Measurement Circuit

- Whether Behbahani's signal strength measurement teaching sufficiently teaches or suggests the claimed signal strength measurement limitations

4) Discretionary Denial

- Whether vacating institution on discretionary bases is appropriate after the parties and Board have invested extensive resources

The Board correctly held at institution that Petitioner relied on Behbahani's variable filter

- Preliminary Sur-Reply (Paper 11 at 1-3):

> On preliminary Reply, Apple changes course, drawing a new, contrived line around the two swapped low-pass filters—and arguing for the first time that *Behbahani* involves changing between two "modes" or "filter branches" of that invented "variable filter block" box. Reply, 1.

> The Petition (and Declaration) relied exclusively on what Apple repeatedly described as *Behbahani*'s "switching from a high-power filter to a low-power filter."
>
> . . .
>
> Nowhere did Apple or its Declarant mention a "variable filter block" or "filter branches."

- Institution Decision (Paper 12 at 41, fn.6):

> [6] We disagree with Patent Owner's arguments in the Preliminary Sur-reply that Petitioner raised a new theory in the Preliminary Reply. *See* Prelim. Sur-reply 1–3. Rather, Petitioner clearly relied upon Behbahani's Variable BW Adaptive DR BPF to teach the recited "filter," and on Behbahani's switching from the high-power filter to the low-power filter. *E.g.*, Pet. 25, 35, 39–40. On this record, we do not view Petitioner's use of the word "branch" in the Preliminary Reply to result in a new theory of unpatentability, as Patent Owner argues.

PO continues to incorrectly argue that the Petition did not rely on Behbahani's variable filter

- Motion to Strike (Paper 23 at 3):

> In the Petition and Original Declaration, Apple and Dr. Abidi identified the high- and low-power, ***low-pass filter portions*** of the design disclosed in the *Behbahani* papers as the components being dynamically adjusted. Petition (Paper 1) at 43-44 ("switching from *Behbahani's* high-power filter to its low-power filter dynamically changes … a component (the filter) in the signal path, as claimed"); EX1003 (Original Declaration), ¶124 ("switch from high-power to low-power filter"); *see also* Paper 1 at 25 ("a low-pass filter, satisfying the filter component").
>
> . . .
>
> On Reply, however, Apple seeks to draw a bigger box around a larger portion of the circuit—and say for the first time that, the whole "Variable BW Adaptive DR BPF" does not just ***include*** the alleged dynamically altered components, but rather it ***is*** the dynamically altered component. *See* Reply, 6-7 ("this variable filter block is dynamically adjusted"). But there is no evidentiary support for this in the Petition.

See also Sur-Reply (Paper 24) at 3-5, 11-13 (alleging the Reply advanced a "new theory")

Petitioner mapped Behbahani's variable filter

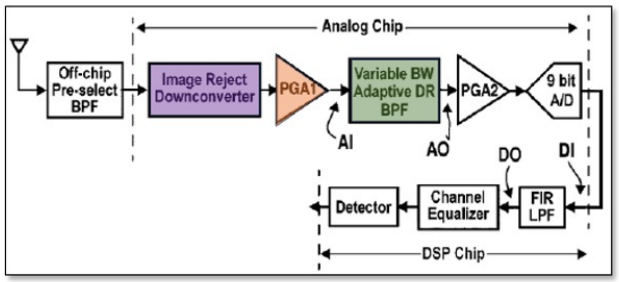
Context from the full mapping rebuts alleged ambiguity

1. Claim 1

Claim 1(Pre): "1. A method of receiving a signal using an integrated circuit, the integrated circuit comprising a signal path including a low-noise amplifier configured to receive the signal, a mixer having an input coupled to an output of the low-noise amplifier, and a low-pass filter having an input coupled to an output of the mixer, the method comprising:"

• • •

On the "analog chip" and in advance of PGA1 and the variable filter, *Behbahani* represents the receiver circuitry with a single box labeled "Image Reject Downconverter":



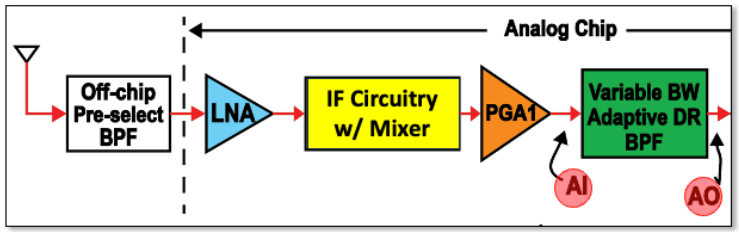
Behbahani, Fig. 2 (annotated).

• • •

Accordingly, a POSITA would have understood that *Behbahani's* BPF includes a low-pass filter, satisfying the filter component recited in the preamble.

Dec., ¶77.

Behbahani's Fig. 2 depicts certain components of the receiver as being contained within an analog integrated circuit. Specifically, as shown below in an annotated excerpt of Figure 2, an "analog chip" includes a signal path (annotated in red), an LNA (annotated in blue) configured to receive the signal, a mixer (annotated in yellow) having an input coupled to an output of the LNA, and a low-pass filter (annotated in green) having an input coupled to an output of the mixer (annotated in yellow):



Behbahani modified by *Leete*, Figure 2 (excerpt, annotated); *Dec.*, ¶¶85-89 (explaining the signal path).

Petitioner mapped Behbahani's variable filter

Context from the full mapping rebuts alleged ambiguity

Claim 1(b): "reducing a switching current in the signal path by dynamically changing an impedance of a component in the signal path based on the first signal strength."

• • •

As set forth below, satisfying both parties' proposals, when *Behbahani's* system switches from its high-power filter to its low-power filter, it increases the "opposition to the flow of alternating current" (i.e., impedance) in the analog signal path and results in a reduced current that carries the AC signal through a load (i.e., through the filter load).

• • •

A POSITA would have understood that, consistent with the '330 Patent and its inventors own publications, switching from *Behbahani's* high-power filter to its low-power filter dynamically changes (increases) an impedance of a component (the filter) in the signal path, as claimed. *Dec.*, ¶124.

• • •

In sum, switching from *Behbahani's* high-power filter to its low-power filter based on signal strength measurements (1) increases the signal path impedance and (2) lowers the DC bias applied to the filter stage. It also lowers the switching current—the current carrying an AC signal. *Id*, ¶133.

Claim 5: "The method of claim 2 wherein the component in the signal path comprises a MOS transistor."

• • •

Accordingly, a POSITA would have understood that the variable filter described by Tan and relied upon by Petitioner in the mapping above does in fact comprise MOS transistors, as claimed. *Id.*, ¶¶141-44.

Claim 9: The method of claim 4 wherein the component in the signal path is included in the low-pass filter.

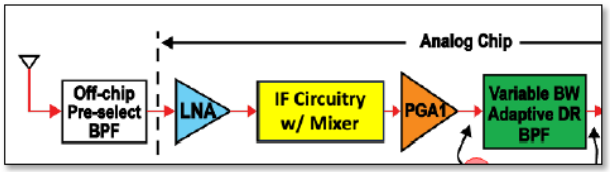
Behbahani switches between a high-power filter and low-power filter based on signal strength measurements, and the specific filter structures are described in detail by *Tan* and illustrated at least in Figs. 6(a)-(b) and Fig. 9. *See* Claim [1(b)]. Further, as described above with respect to claim [1(Pre)], *Behbahani* discloses that the component (i.e., variable BW adaptive DR BPF) in the signal path includes a low-pass filter (LPF). *See* Claim 1(Pre) (explaining *Behbahani's* BPF as a high-order LPF cascaded with a low-order HPF). As discussed in detail with reference to Claim [1(b)], the impedance of the low-pass filter, specifically, is increased when switching from the high-power filter to the low-pass filter, resulting from changes to the transconductance stages and capacitors that comprise the variable low-pass filters. *See* Claim [1(b)].

Petition (Paper 1) at 35, 54-57

Dr. Abidi's analysis aligned with and supported the Petition

[77.] *Behbahani* describes that its "BPF realized by an [low-pass filter] LPF in series with [high-pass filter] HPF lowers power consumption." *Id.*, 1216. Because *Behbahani's* BPF includes a low-pass filter stage, it satisfies the preamble's "low-pass filter."

85. *Behbahani*'s Fig. 2 depicts an "analog chip" that includes multiple components on the signal path (annotated in red), including an LNA (annotated in blue) configured to receive the signal, a mixer (annotated in yellow) having an input coupled to an output of the LNA, and a low-pass filter (annotated in green) having an input coupled to an output of the mixer (annotated in yellow):



Behbahani modified by *Leete* at Figure 2 (excerpt, annotated).

136. *Behbahani* cautions that, to ensure bit errors that result from the switching have settled out before the data portion is received, "the ***desired filter is switched during the preamble*** and settles during that time." *Behbahani* at 1207. Accordingly, *Behbahani* teaches changing the signal path impedance (e.g., switching from high-power filter to its low-power filter) of the filter component while receiving the preamble portion of the signal, as claimed.

Petitioner's Expert Decl. (Ex. 1003) at ¶¶ 77, 85, 136

Remaining Disputes

1) Theory Presented

- Whether Petitioner relied on Behbahani's variable filter block as the dynamically adjusted "circuit" or "component" in the signal path

2) Claim Construction

- Whether the claimed "circuit" or "component" that is dynamically adjusted should be construed to exclude switching between high- and low-power filter branches within Behbahani's variable filter

3) Signal Strength Measurement Circuit

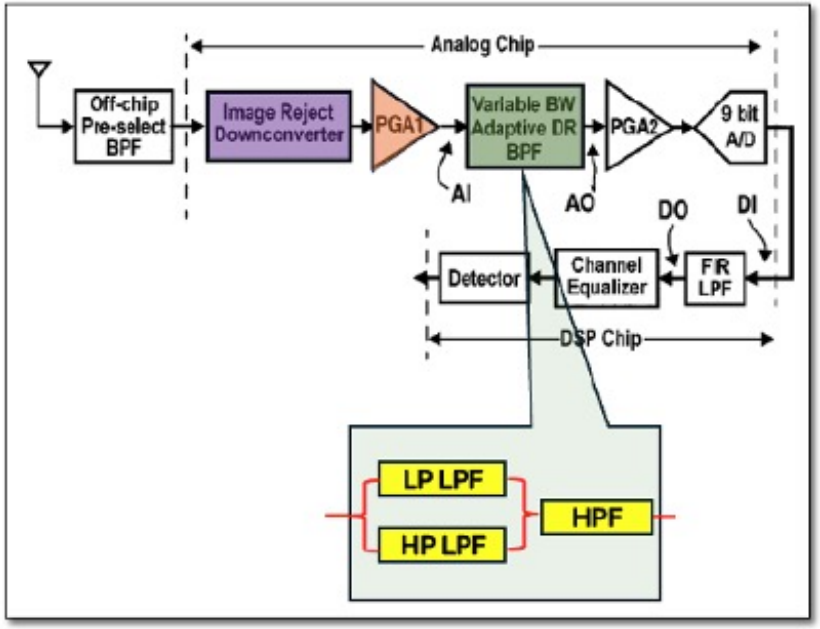
- Whether Behbahani's signal strength measurement teaching sufficiently teaches or suggests the claimed signal strength measurement limitations

4) Discretionary Denial

- Whether vacating institution on discretionary bases is appropriate after the parties and Board have invested extensive resources

The parties do not dispute the operation of Behbahani's variable filter

As illustrated below, this variable filter block is dynamically adjusted by switching between two scaled low pass filter ("LPF") paths—one high power ("HP LPF") and the other low power ("LP LPF")—both of which feed back into the same high pass filter ("HPF"):



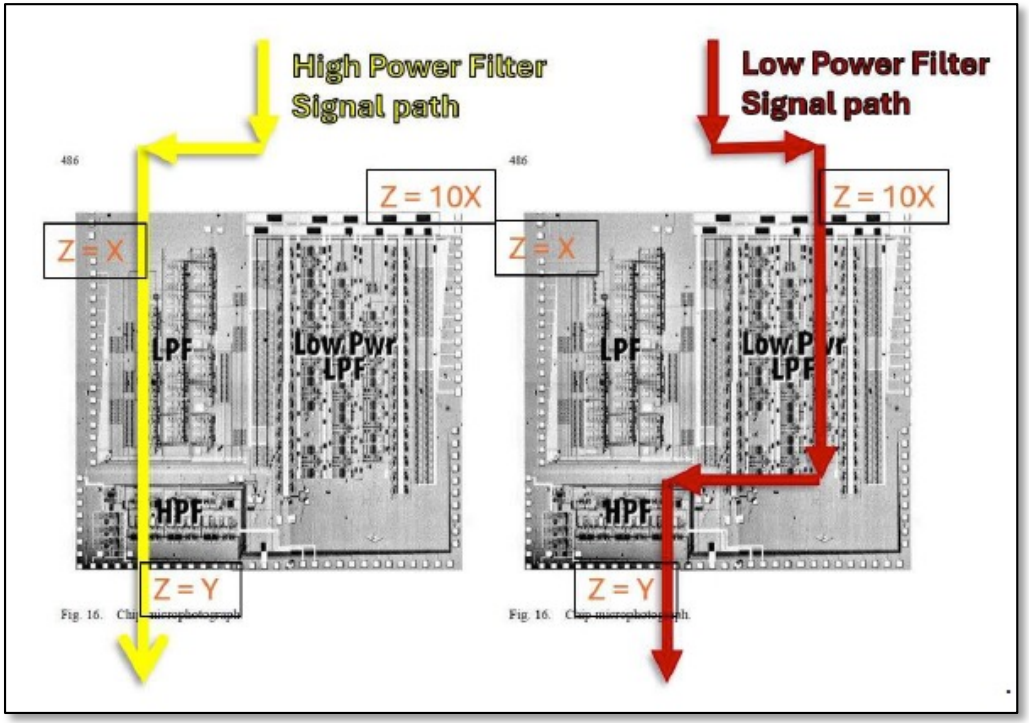
Ex. 1042, ¶¶4-6 (explaining that a signal enters the variable BPF block, traverses one of the two LPF branches, and then passes through the HPF).

The parties do not dispute the operation of Behbahani's variable filter (cont.)

- PO's expert explains impedance:
  - Q. [T]he impedance experienced by a signal flowing through the low-power low-pass filter is 10 times higher than the impedance experienced by the signal flowing through the high-power low-pass filter; is that right?
  - A. Yeah. I think that signal will experience different impedances, and it's very much like Figure 6 in Tsividis; right? [W]e talked about different impedance levels, and so that would be, in this case, a 10X difference.

  Ex. 1043 at 66:7-18 (cleaned up)
- PO's expert explains bias current:
  - Q. Is it correct that these two filter branches will have approximately a 10X difference in their bias currents?
  - A. Yes, as reported here of 5.4 and 56 milliamps, respectively.

  Ex. 1043 at 67:17-22 (cleaned up)



PO's Expert Decl. (Ex. 2020) at ¶82

Reply (Paper 18) at 7-8

The Board correctly held at institution that the claim language encompasses Behbahani's variable filter

We also disagree with Patent Owner's argument that the depiction of a single Function Block 820 in Figure 8A of the '330 patent means that a filter swap (as in Behbahani) cannot satisfy limitation [1(b)]. *See* Prelim. Resp. 38. The '330 patent explains that Figure 8A is merely "an ***embodiment*** of the present invention" that describes a "***possible*** power saving technique[]," and we do not see a basis to read this particular embodiment into the claim. Ex. 1001, 3:30–31, 8:20–22 (emphasis added). Moreover, the '330 patent describes Function Block 820 broadly, explaining that it "may be a filter, mixer, amplifier, ***or other circuit or circuits*** in a wireless transceiver or other electronic circuits or system." *Id.* at 8:22–25 (emphasis added). Based on this disclosure, we see no reason why Function Block 820 could not include multiple filters, such as the ones used in Behbahani's filter swap. Similarly, we are not persuaded by Patent Owner's reliance on Figure 6, which the '330 patent describes as merely "***an example*** of how a circuit's impedances may be scaled to reduce drive currents." *Id.* at 3:24–27, 7:44–46 (emphasis added).

Institution Decision (Paper 12) at 42-43

The claims capture Behbahani's approach

1. The Theta Patents broadly define a "function block" as the circuit/component in the signal path that is dynamically adjusted.

2. The dynamically adjusted function block may be a filter.

3. Fig. 6 is sole intrinsic illustration of dynamically adjusting a filter.

4. PO's expert concedes that Fig. 6 does not mandate adjusting individual elements, but may involve a wholesale circuit swap.

The Theta Patents describe generic "function blocks" that are dynamically adjusted

¶¶46-48, 77-80 ("the teachings and challenged claim language of the Tsividis Patents would be understood by a person of ordinary skill in the art to be referring to impedance and bias current adjustments made dynamically for a single function block"); EX1001, 9:36-59 ("one or more impedance in the function block 920 may be increased"), Fig. 9A:

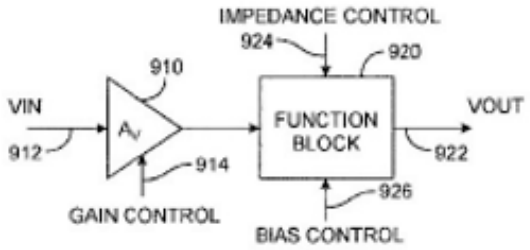


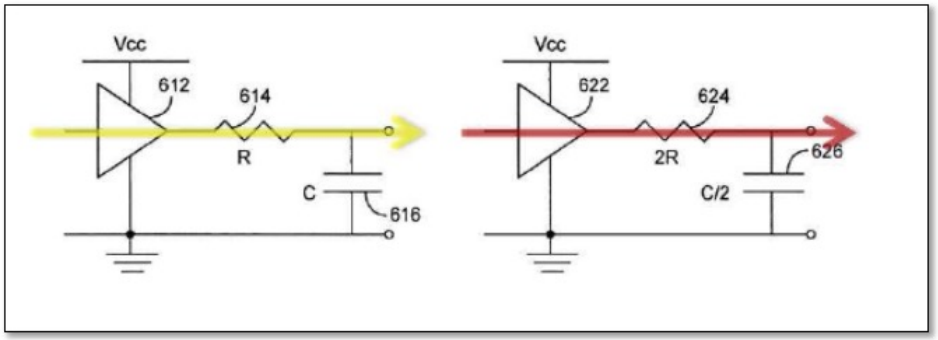
FIG. 9A

PO concedes the dynamically adjusted circuit/component may be a filter

> The '330 Patent uses "a circuit" or "a component" to refer to individual units or elements of the receiver such as an amplifier, "the low pass filter," "a mixer," "a MOS transistor," "a resistor," etc. *See, e.g.*, EX1001, 13:13-22 ("wherein the component in the signal path comprises,"), 7:44-46 ("FIG. 6 is an example of how ***a circuit's*** impedances may be scaled to reduce drive currents, and, depending on the circuit configuration used, associated bias currents as well."); *see also id.*, 7:57-59 ("In this way, an impedance can be scaled in order to decrease ***a circuit's*** required drive current.").

The Theta Patents are not limited to changing individual element to the exclusion of larger changes

As it did pre-institution, PO focuses on Figure 6 of the '330 Patent as the sole specific example of dynamic impedance adjustment. Paper 16, 2–3, 25, 51, 65. Namely, PO argues that Fig. 6 depicts varying a resistor within a filter circuit by simply increasing its impedance from R to 2R:



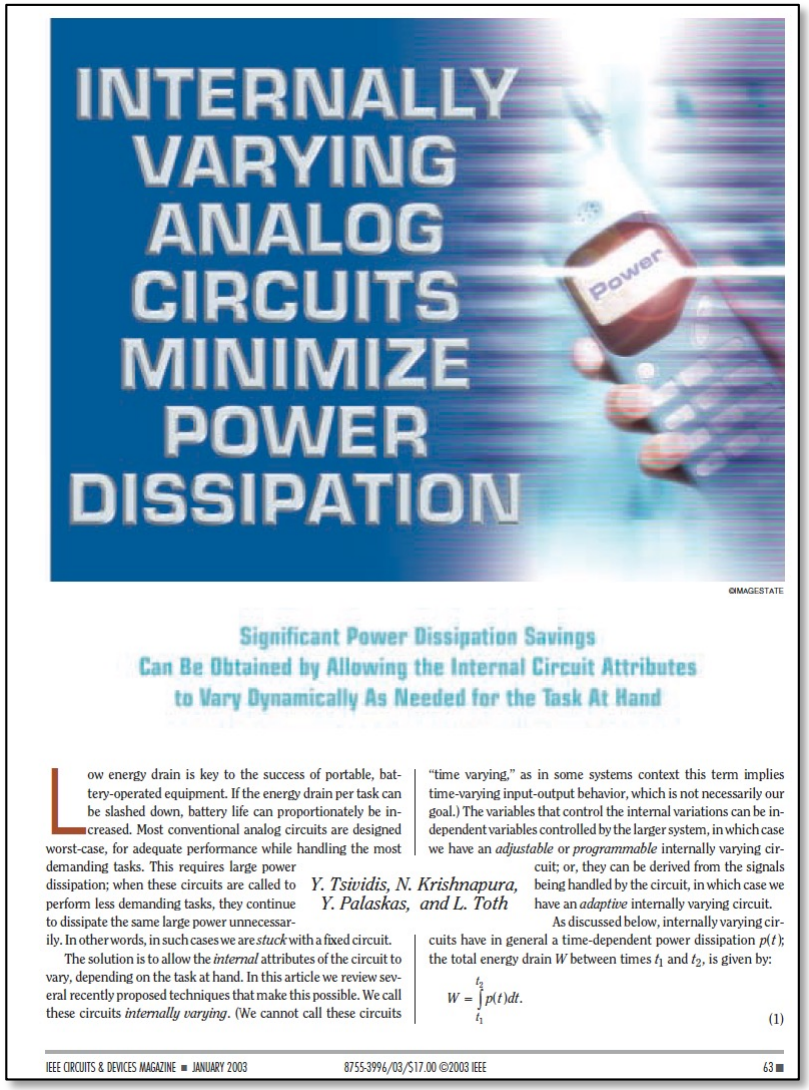
Q. Could Driver 612 be a different circuit than Driver 622 based on the description in the '330 Patent?

A. It could be different. It could be the same. The patent is silent on this issue.

Ex. 1043 at 33:10-14

The inventor published multiple related articles

Each confirms that Behbahani's approach is consistent



INTERNALLY VARYING ANALOG CIRCUITS MINIMIZE POWER DISSIPATION

©IMAGESTATE

Significant Power Dissipation Savings Can Be Obtained by Allowing the Internal Circuit Attributes to Vary Dynamically As Needed for the Task At Hand

Y. Tsividis, N. Krishnapura, Y. Palaskas, and L. Toth

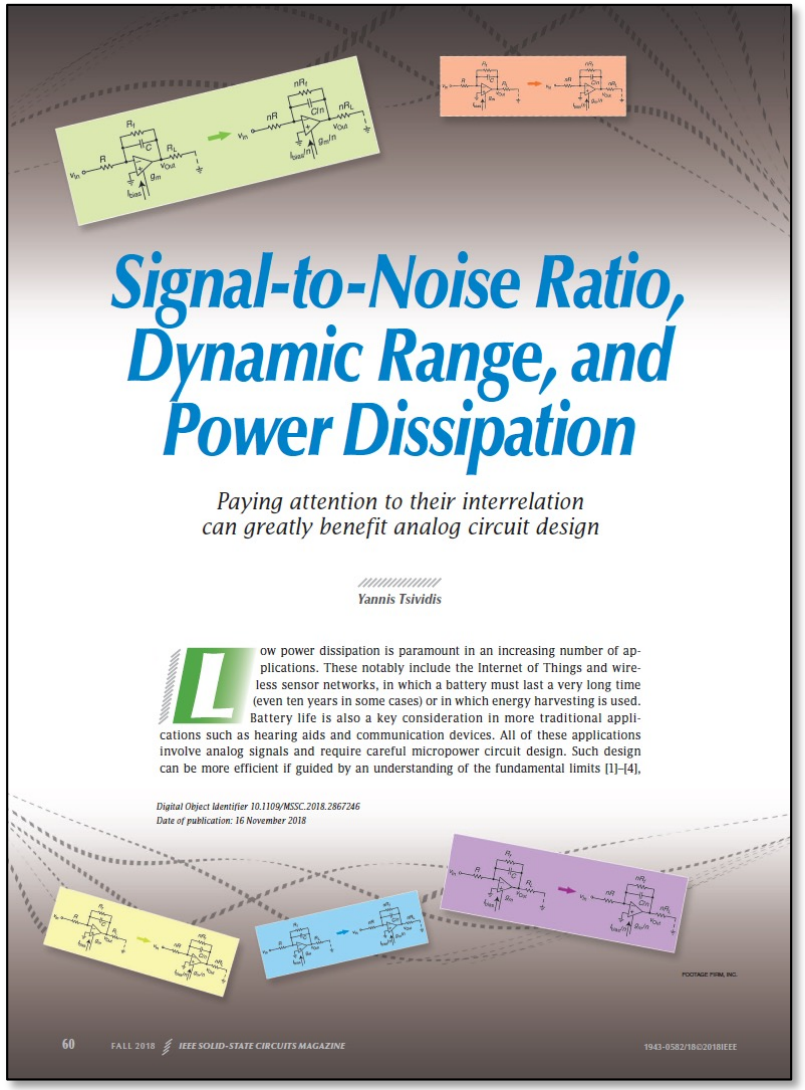
Low energy drain is key to the success of portable, battery-operated equipment. If the energy drain per task can be slashed down, battery life can proportionately be increased. Most conventional analog circuits are designed worst-case, for adequate performance while handling the most demanding tasks. This requires large power dissipation; when these circuits are called to perform less demanding tasks, they continue to dissipate the same large power unnecessarily. In other words, in such cases we are *stuck* with a fixed circuit.

The solution is to allow the *internal* attributes of the circuit to vary, depending on the task at hand. In this article we review several recently proposed techniques that make this possible. We call these circuits *internally varying*. (We cannot call these circuits "time varying," as in some systems context this term implies time-varying input-output behavior, which is not necessarily our goal.) The variables that control the internal variations can be independent variables controlled by the larger system, in which case we have an *adjustable* or *programmable* internally varying circuit; or, they can be derived from the signals being handled by the circuit, in which case we have an *adaptive* internally varying circuit.

As discussed below, internally varying circuits have in general a time-dependent power dissipation $p(t)$; the total energy drain W between times t_1 and t_2, is given by:

$$W = \int_{t_1}^{t_2} p(t)dt. \quad (1)$$

8755-3996/03/$17.00 ©2003 IEEE



Signal-to-Noise Ratio, Dynamic Range, and Power Dissipation

Paying attention to their interrelation can greatly benefit analog circuit design

Yannis Tsividis

Low power dissipation is paramount in an increasing number of applications. These notably include the Internet of Things and wireless sensor networks, in which a battery must last a very long time (even ten years in some cases) or in which energy harvesting is used. Battery life is also a key consideration in more traditional applications such as hearing aids and communication devices. All of these applications involve analog signals and require careful micropower circuit design. Such design can be more efficient if guided by an understanding of the fundamental limits [1]–[4],

Digital Object Identifier 10.1109/MSSC.2018.2867246
Date of publication: 16 November 2018

1943-0582/18©2018IEEE

Ex. 1011 (left); Ex. 2004 (right)

The inventor's 2018 article confirms larger changes are captured

PO claims that Fig. 16 in the 2018 article is "an example showing a combination of both impedance scaling (multiplying RC impedance by n via nR_x combined with C/n), and also bias current scaling (dividing I_{bias} by n)." *Id.*, 24.

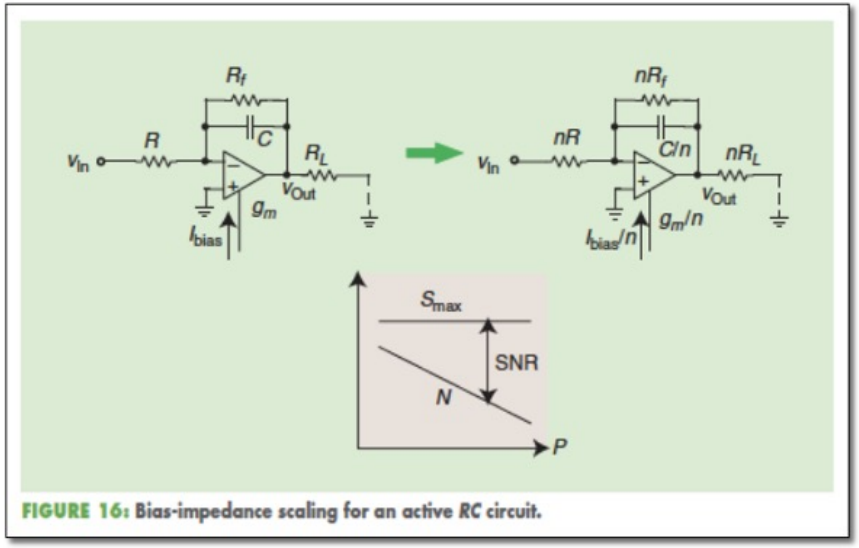


FIGURE 16: Bias-impedance scaling for an active *RC* circuit.

Ex. 2004, Fig. 16.

As the article explains, bias and impedance scaling not only scales the resistances, capacitances, and bias currents, but also divides the transconductances by the same "n" scaling factor. Ex. 2004, 65-67 (indicated as g_m/n); *see also id.* at Fig. 12 (depicting multiple transconductors in parallel as a means of adjusting the circuit's transconductance). Accordingly, inventor Tsividis's 2018 article does not support PO's interpretation of the invention as capturing only minimal changes (e.g., to the values of resistors and capacitors). Instead, this article confirms that his alleged invention contemplates and captures much more substantial scaling, including to resistor and capacitor values, but also by switching transconductors in and out of circuit to scale the entire filter block. As explained in the Petition and supporting expert declaration, this precise set of adjustments—scaling resistances, capacitances, transconductances, and bias currents—is what Behbahani describes. *See* Paper 1, 37-48; Ex. 1003, ¶¶100-128.

The 2003 article expressly identified Behbahani's approach as exemplary

Technique 2: Dynamic Impedance Scaling

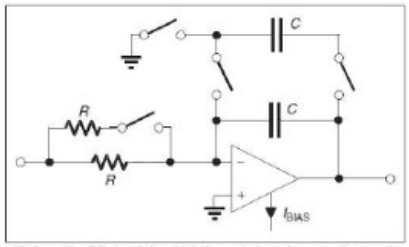
Consider a system designed to handle very small signals in the worst case, as in Figure 4(a). Due to the large UDR, the capacitance values will be large, as seen from (6). However, this worst-case signal situation may not be present continuously; part of the time, this same system may be called to handle large signals with limited UDR or SNR_{max}. This, for example, can be the case in wireless systems, when the desired signal happens to be strong and no strong blocker is present [32]. At those instances, the very low noise floor of this system is unnecessary and can be allowed to increase by scaling C down [33], resulting, for example, in the situation shown in Figure 4(b). Of course, the transconductances or conductances of the filter will have to be scaled together with C, in order to leave the frequency response unchanged. The reason one may want to do such impedance scaling becomes clear from (7): lowering capacitances and transconductances allows one to also lower I_{BIAS}, and thus the total power dissipation can be made small. This can also be seen from the transconductor characteristics in Figure 3(d). In principle, for every 3 dB reduction in UDR, the power dissipation can be cut to half.

One way to achieve the above scenario would be to use two filters, designed with different capacitance values, and place one or the other in service as required [34], turning the other filter off. This, however, causes transients at the output, which may take a long time to die out, especially in the case of filters with high-Q poles; the result may be loss of data.

Ex. 1011 at 70; *see also* Petition (Paper 1) at 36-39; Reply (Paper 18) at 11-14, 18-22

PO insists this paper's transient discussion rejects, rather than embraces, Behbahani

The article notes problems with *Behbahani*'s approach. EX1011, 8 ("output transients" and "loss of data"), 8 ("delay" from attempt to mitigate transients with hand-off); *see also* EX1004, 1208 ("bit error rate "BER" increases"). And then the article ***teaches improvements on*** *Behbahani*'s approach—specifically relevant here is ***dynamic*** scaling of a ***single filter's structure via individual elements***. EX1011, 8 ("switching individual filter elements rather than entire filters"), 9 ("use a single filter and vary its structure dynamically"); EX2020, ¶¶66-70. Professor Tsividis' article refers to ***dynamic*** impedance scaling only with reference to its own Figure 12—which shows a single RC circuit, adjusted via switching individual elements that are in the signal path. EX1011, 9 ("dynamic impedance scaling (Figure 12)"), Fig. 12 ("An active RC circuit in which dynamic impedance scaling can be performed"):



12. An active RC circuit in which dynamic impedance scaling can be performed without causing output transients.

POR (Paper 16) at 60-61

Petitioner's DX-37

The Theta Patents embrace transient-causing dynamic adjustments

2003 Article:

Avoiding Output Transients

The use of companding in filters encounters a difficulty not present in companding transmission systems. Filters are dynamical circuits; changes at the input appear as changes at the output with certain delay. Assume that, in Figure 5, the input signal strength suddenly changes, thus momentarily changing the signal at the input of the filter. The envelope detector senses the system input change and adjusts g to restore the filter input to its original level. The output element's gain, $1 / g$, changes accordingly at the same time, which is *before* the change at the filter input has had a chance to propagate to the output. Thus, the output element's gain changes too soon, and an undesirable transient occurs at the system output [17]. In some applications this is not a problem, as these changes may occur before the time comes to process the useful signal (for example, during the preamble slot in certain wireless protocols).

Ex. 1011 at 68

'330 Patent:

Since the gain, impedance and biasing of these blocks are being dynamically varied, care must be taken to not negatively affect the signal being processed. For example, specific embodiments of the present invention perform some or all of these variations during preamble.

'330 Patent at 12:33-37

2. The method of claim **1** wherein the signal comprises a preamble portion and a data portion, the impedance of a component is changed while receiving the preamble portion, and the method further comprises receiving the data portion of the signal.

'330 Patent at Claim 2

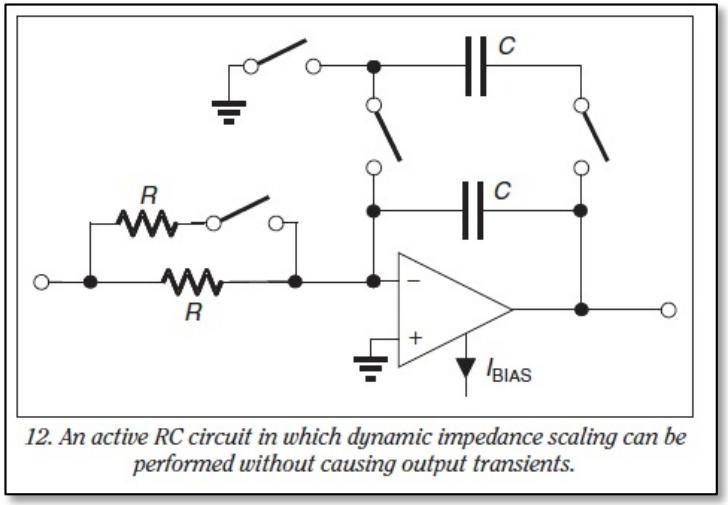
Reply (Paper 18) at 20; Preliminary Reply (Paper 10) at 5

PO misunderstands the 2003 paper's discussion of varying filter structure

Technique 4: Dynamic Structure Variation

A fourth possibility is to dynamically vary the very structure of the circuit (e.g., change the architecture of a filter dynamically). A straightforward way to accomplish this is to use two or more filters with different structures and make sure that output transients are avoided using the technique in Figure 11. It may also be possible to use a single filter and vary its structure dynamically, using techniques related to the ones discussed. This approach has not been investigated to any extent yet.

Ex. 1011 at 71-72



12. An active RC circuit in which dynamic impedance scaling can be performed without causing output transients.

Ex. 1011 at Fig. 12

Reading on from Apple's excerpts reveals that Professor Tsividis' article instead teaches ***away*** from *Behbahani*'s error-prone approach, and towards "vary[ing] structure dynamically" in a single filter and using "individual filter elements rather than entire filters." EX1011, 8, 9, Fig. 12; EX2020, ¶¶66-74.

POR (Paper 16) at 61-62

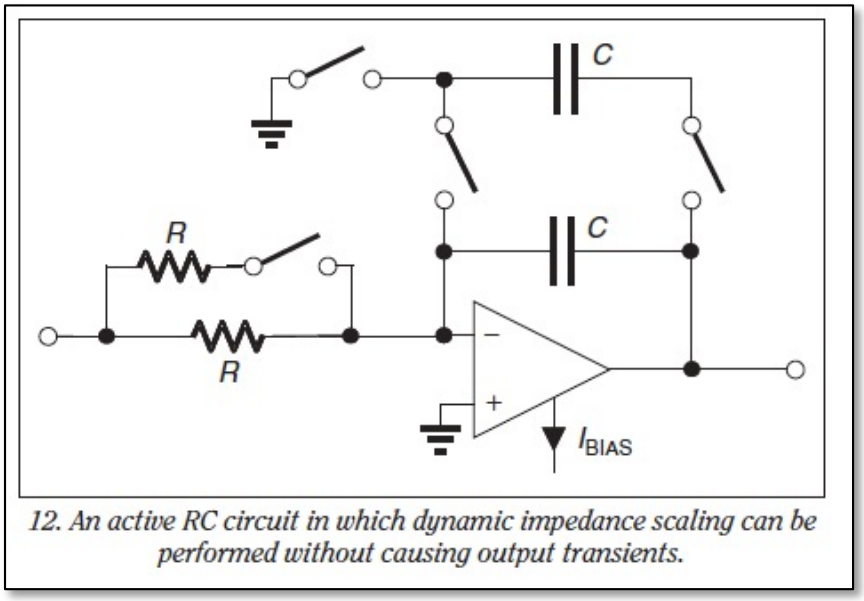
Professor Tsividis' article was published in IEEE Circuits & Devices Magazine in January of 2003. EX1011, footer. In the meantime, and separately, Theta and Professor Tsividis were in fact investigating and developing techniques for dynamically varying circuit structure via adjusting internal components. They filed provisional patent applications, and then the '330 Patent on February 23, 2004. EX1001, 1.

POR (Paper 16) at 62

But Professor Tsividis also discussed "switching individual filter elements rather than entire filters," to "use a single filter and vary its structure dynamically"—as a different approach for future "investigation" and, in this case, patenting. *Id.*

Sur-Reply (Paper 24) at 19-20

Not even PO's expert agrees that switching individual filter elements varies the structure



12. An active RC circuit in which dynamic impedance scaling can be performed without causing output transients.

Ex. 1011 at Fig. 12

- Q. Do you consider Figure 12, switching in and out a resistor and a capacitor, to vary the structure of the circuit?
- A. Yeah, it's an interesting question. I would have to say it doesn't vary the structure of the circuit, but it varies the elements within the structure of the circuit. So, the structure of the circuit doesn't change.

Ex. 1043 at 105:25-106:19 (cleaned up)

Remaining Disputes

1) Theory Presented

- Whether Petitioner relied on Behbahani's variable filter block as the dynamically adjusted "circuit" or "component" in the signal path

2) Claim Construction

- Whether the claimed "circuit" or "component" that is dynamically adjusted should be construed to exclude switching between high- and low-power filter branches within Behbahani's variable filter

3) Signal Strength Measurement Circuit

- Whether Behbahani's signal strength measurement teaching sufficiently teaches or suggests the claimed signal strength measurement limitations

4) Discretionary Denial

- Whether vacating institution on discretionary bases is appropriate after the parties and Board have invested extensive resources

Signal strength measurements

- Theta argues that Apple failed to show Behbahani teaches or suggests:
  - circuits for determining signal strengths
    - *See* IPR2024-00816 ('330 Patent), Sur-Reply (Paper 24) at 21
    - *See* IPR2024-00817 ('825 Patent), Sur-Reply (Paper 23) at 21
    - *See* IPR2024-00820 ('210 Patent), Sur-Reply (Paper 23) at 21
  - determining the signal strength of the interferer signal or comparing signal strengths
    - *See* IPR2024-00818 ('202 Patent), Sur-Reply (Paper 23) at 21
    - *See* IPR2024-00819 ('164 Patent), Sur-Reply (Paper 24) at 21

Theta Patents measure before and after filter to determine relative strength of desired and interferers

The signal strength indicators **440** and **450** do not provide information as to the relative sizes of the desired and interfering signals. Rather, a cumulative signal level is provided at their outputs. For example, the first signal strength indicator **440** outputs a level corresponding to the sum of desired signal **412** and interfering signals **414** and **416**, while the second signal strength indicator **450** provides a signal level corresponding to the sum of desired signal **462** and interfering signals **464** and **466**. In this specific example, the gain of the gain and filter circuit combinations is shown as approximately one, while the interfering signals **414** and **416** signal levels are reduced.

A comparison of the signal levels provided by the signal strength indicators **440** and **450** indicates that much of the combined received signal on line **410** has been filtered. Accordingly, it may be deduced that large interfering signals present at the input are being filtered by the filter **430**. From this information, as will be shown in greater detail below, the bias, impedance, and gain of the gain stage **420** and filter **430** combination may be optimized to reduce power dissipation.

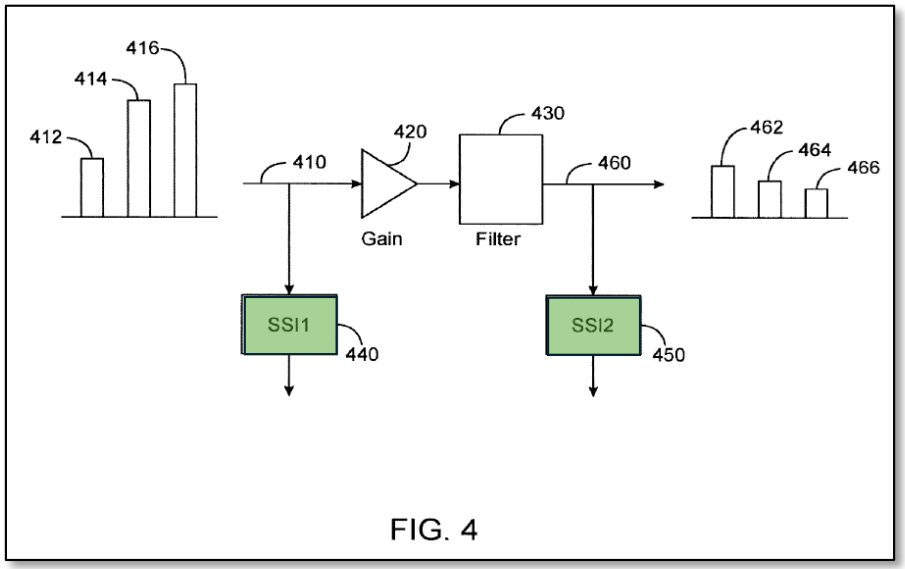
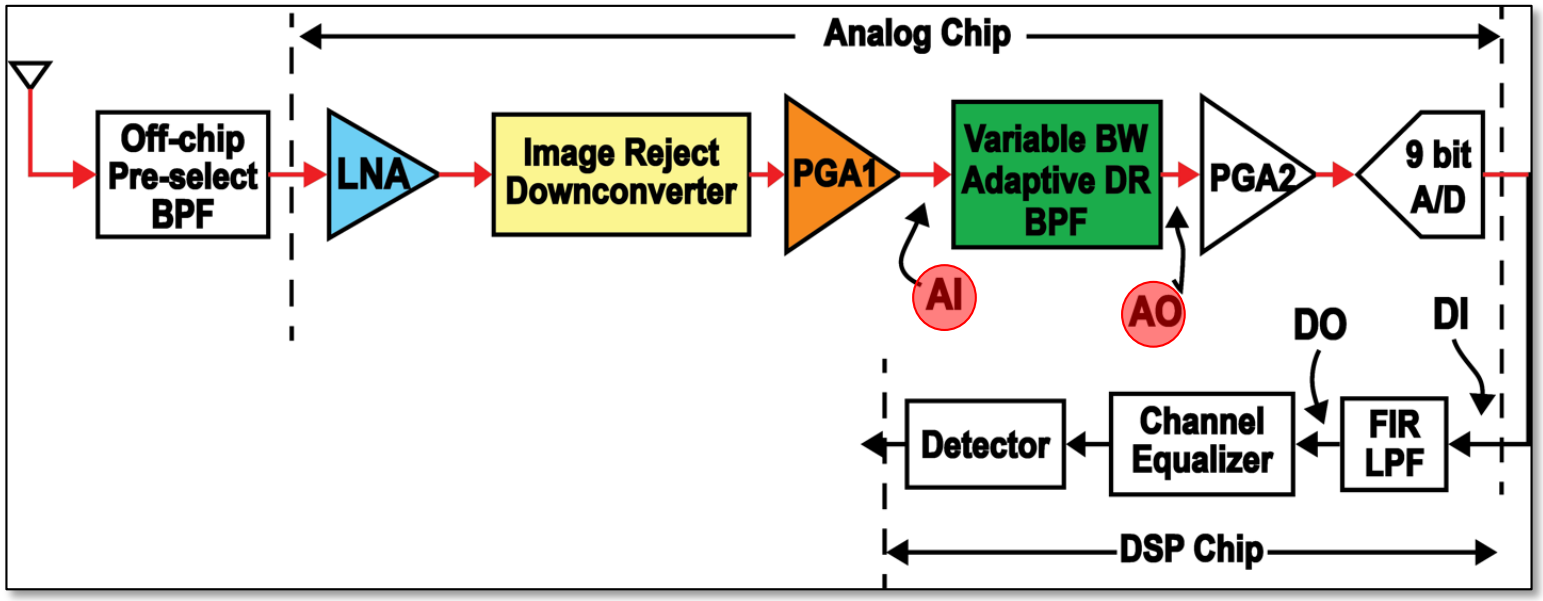


FIG. 4

'330 Patent at 6:56-7:8, Fig. 4

Behbahani also measures before and after filter to determine relative strength of desired and interferers

The signal level at A_I and A_o is a measure of the out-of-band interferers being rejected by the analog BPF. If the *desired* signal at the output of the analog BPF is strong, as measured by Power_{Do}–$\text{Gain}_{\text{Post-analog-filter}}$, the scenario is as shown in Fig. 3(a). If the total signal power is comparable at A_I and A_o, and at D_I and D_o, the condition is like Fig. 3(a) or (b). In both cases, the required instant DR is low. If the signal levels are significantly different at either of the above pairs of nodes (A_I and A_o, and D_I and D_o) and there is a weak signal at D_o, the condition must be the one shown in Fig. 3(c).



Behbahani (Ex. 1004) at 1207; Petition (Paper 1) at 29-35

The Theta Patents and Behbahani assume signal strength measurement circuits were well-understood

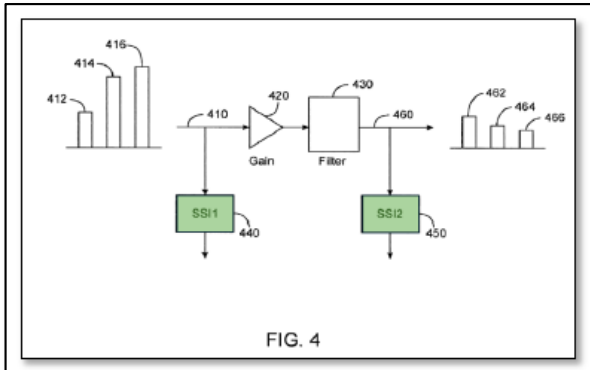


FIG. 4

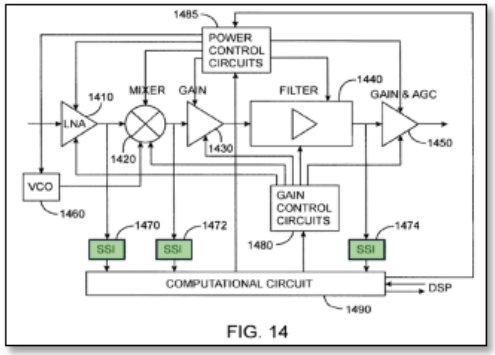


FIG. 14

Ex. 1001, Figs. 4, 14 (annotated). These figures offer no information regarding the circuitry, logic, or algorithms that perform the signal strength measurements. The accompanying text in the specification similarly lacks any technical detail, treating the SSI circuits as functional blocks without elaboration. A POSITA would therefore understand that the '330 Patent assumes the use of conventional, well-understood techniques for measuring signal strength. Consistent with this understanding, Behbahani also assumes that a POSITA would have understood how to implement a conventional and well-understood technique for measuring signal strength.

Petitioner's Suppl. Expert Decl. (Ex. 1042) at ¶14; *see also* Reply (Paper 18) at 23-24

Behbahani suggests *a circuit* for signal strength measurement, assuming conventional measuring signal strength techniques

b) Claim 23(a): "a first signal strength indicator circuit coupled to the signal path, and configured to determine a first signal strength;"

179. As I discussed above, *Behbahani* teaches determining a first signal strength at a first node (A_I) in the signal path in the integrated circuit. *See* Claim [1(a)].

181. Finally, a POSITA would further have understood that signal strength measurement circuitry was well understood that the time, which further motivates the combination and supports a conclusion that a POSITA would have expected success in combining these teachings. As one example, an article titled "A CMOS Limiting Amplifier and Signal-Strength Indicator" to Khorram et al. ("*Khorram*") teaches strength detectors fabricated in a similar technology as *Behbahani*—CMOS—that are also designed for wireless communications in a mobile device.

13. While I acknowledged that Behbahani "does not provide details about the specific circuit used to measure signal strength," a POSITA would indeed have understood that Behbahani suggested some circuit for measuring signal strength at A_I and A_O. Indeed, the purpose of Behbahani was to accommodate "a fully integrated receiver." It was our intent, which a POSITA would have understood, to include the described functionality integrated on a single chip, including circuitry for measuring signal strength at A_I and A_O. As I discussed in my original declaration, there is functionality described in the digital domain that was intended to be off chip (i.e., on a DSP chip), but the analog measurements A_I and A_O were taken on the "Analog Chip" illustrated in Fig. 2 and an on-chip measurement circuit accomplished this functionality.

Petitioner's Expert Decl. (Ex.1003) at 179-181; Reply (Paper 18) at 23-25; Petitioner's Suppl. Expert Decl. (Ex. 1042) at ¶13-14

Behbahani suggests circuits for measuring signal strength with the same level of detail as the Theta Patents

- *Bradium Techs., LLC v. Iancu*, 923 F.3d 1032, 1049 (Fed. Cir. 2019) (affirming Board's obviousness finding that a claim requiring a specific prioritization value was obvious over prior art that did not expressly disclose such a value, but fairly suggested it to a POSITA).

- *Uber Techs., Inc. v. X One, Inc*., 957 F.3d 1334, 1339 (Fed. Cir. 2020) ("The specification is entirely silent on [claimed function,]...suggesting that a person of ordinary skill in the art was more than capable of selecting between the known methods of accomplishing this").

- *Omega Liner Co., Inc, v. Buergofol GMBH*, IPR2023-01372, Paper 85, at *47 (Mar. 14, 2025) (where a component served a similar function as in the prior art, the patent's silence on specific implementation details indicated that overcoming them was an exercise of ordinary skill in the art).

Tan—an express component of the combination—teaches "a signal strength indicator circuit"

Although *Behbahani* does not provide details about the specific circuit used to measure signal strength, *Tan* does. *Tan*—a reference expressly referenced by *Behbahani* and intended to be used in conjunction with *Behbahani* (*see* Claim [1(b)])—provides an example of circuitry used to detect signals at various points in the low-pass filter signal path as a means of implementing a prefilter automatic gain control (AGC). *Tan*, 481. In this example, signal peaks are detected by current summing circuitry that is designed to "lower the input signal" via gain control when peak values exceed a predefined limit. *Id*. A POSITA would have been motivated to utilize *Tan's* signal strength measurement circuitry to measure nodes A_I and A_O in *Behbahani* for a number of reasons. First, as already explains with reference to

Petition (Paper 1) at 60-61; *see also* Reply (Paper 18) at 25

Via attorney argument, PO insists Tan cannot measure signal strength at AI and AO *because* it also measures peak values

> Without any disclosed circuit to point to, Apple mentions a peak detector circuit, used for a different purpose, shown in a figure of the *Tan* paper. Petition, 60-61; *see also* EX2021, 89:4-19. A peak detector, even if it were applied to the task of measuring at points "A_I" and "A_O"—and it was not in Professor Abidi's design—can detect that a signal has gone above a preset threshold. EX2021, 89:12-14; EX1004, Fig. 8 ("VRef").

POR (Paper 16) at 70

Petitioner's DX-49

Tan's circuit captures total signal energy, straightforwardly providing A_I and A_O

I understand that Patent Owner (though not Patent Owner's expert, Dr. Larson) has disputed whether Tan's circuit could properly function to provide A_I and A_O. It can, and I believe a POSITA would have considered using a simplified version of Tan's circuit to provide A_I and A_O a straightforward use of the circuit. Namely, each peak detector in Tan's circuit rectifies the total composite waveform at a given point along the filter path and outputs a representation of the maximum value across all points as a DC voltage. This means that it is measuring the strength of the desired signal and any interferers at each point along the filter path. Because there are peak detectors at the input (A_I) and output (A_O) of the filter, Tan's circuit provides a measure of the signal strength, capturing the desired and interferer signals, at both A_I and A_O, as I explained in my original declaration.

Ex. 1042 at ¶15

Remaining Disputes

1) Theory Presented

- Whether Petitioner relied on Behbahani's variable filter block as the dynamically adjusted "circuit" or "component" in the signal path

2) Claim Construction

- Whether the claimed "circuit" or "component" that is dynamically adjusted should be construed to exclude switching between high- and low-power filter branches within Behbahani's variable filter

3) Signal Strength Measurement Circuit

- Whether Behbahani's signal strength measurement teaching sufficiently teaches or suggests the claimed signal strength measurement limitations

4) Discretionary Denial

- Whether vacating institution on discretionary bases is appropriate after the parties and Board have invested extensive resources

Discretionary Considerations

- Theta asks the Board to vacate institution pursuant to *Ecto World* (§325(d) requires material error showing) & Theta's alleged "settled expectations"

  - *See Supercell OY v. Gree, Inc.*, PGR2018-0008, Paper 42 at 53 (PTAB Jan. 2, 2019) ("Patent Owner was unaware of any instance where the Board, essentially, de-instituted a trial portion of a proceeding based on 35 U.S.C. § 325(d), let alone de-institute after oral hearing where all that is left is the issuance of a final written decision. . . . ***the absence of previous such actions*** by the Board, nevertheless, ***weighs against our exercise of discretion in such a manner***.")

  - *See* March 26, 2025 Memorandum re Interim Processes for PTAB ***Workload Management***:
    - Newly identifying "settled expectations"
    - Explaining the new discretionary process intended to ensure the "PTAB [can] comply with . . . its statutory deadlines for AIA proceedings, and other workload needs" and noting "[t]he ***processes described herein are temporary in nature due, in part, to the current workload needs of the PTAB***."

  - *See Microsoft Corp. v. Daedalus Blue*, LLC, IPR2021-00830, Paper 36 at 65 (PTAB Oct. 27, 2022) ("***Patent Owner's request to de-institute is a request to reconsider our Decision on Institution and should have been raised by means of a motion for rehearing***. . . .Because Patent Owner failed to raise this issue in either the Preliminary Response or by way of a timely motion for rehearing of our Decision on Institution, we deny the request to de-institute as untimely.")