BL O/0753/23

08 August 2023

**PATENTS ACT 1977**

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|---|---|
| APPLICANT | Skyworks Solutions, Inc. |
| ISSUE | Whether applications GB2106631.1, GB2106633.7, GB2212005.9, GB2201631.1, GB2213632.9 and GB2217377.7 comply with Sections 1(1)(a) and 1(1)(b) of the Patent Act 1977. |
| HEARING OFFICER | Dr Stephen Brown |

## DECISION

### Introduction

1 Patent application GB2106631.1 is the national phase of a PCT application published as WO 2020/041209 and has a filing date of 19 August 2019. It claims a priority date of 21 August 2018 from US application 62/720584. GB2106631.1 was subsequently republished as GB2592158 on 18 August 2021.

2 Patent application GB2106633.7 is the national phase of a PCT application published as WO 2020/041212 and has the same filing date as GB2106631.1 (19 August 2019). It too claims a priority date of 21 August 2018, in this case from US application 62/720550. GB2106633.7 was subsequently republished as GB2592159 on 18 August 2021.

3 GB2212005.9 and GB2217377.7 are divisional applications of GB2106631.1. These were published as GB2607770 (on 14 December 2022) and GB2610122 (on 22 December 2022), respectively. GB2213631.1 and GB2213632.9 are two of three divisional applications of GB2106633.7. These were published as GB2608333 (on 28 December 2022) and GB2607845 (on 14 December 2022), respectively. The third divisional application, GB 2213633.7, has been granted so I do not need to consider it here.

4 The applicant was not able to convince the examiner that any of the 6 applications listed above are both Novel, as required by Section 1(1)(a) of the Act, and provide an Inventive Step, as required by Section 1(1)(b) of the Act. Therefore, for each of these applications, the applicant requested a decision by a Hearing Officer, based on the papers on file. The matter has accordingly come before me.

**The Applications**

5 The applications are concerned with compensating for coexistence interference, the coexistence interference arising from the simultaneous use of two different transceivers within a mobile device.

6 The applications share very similar specifications, though each have independent claims of different scope. To understand the applications, it is useful to refer to Figure 6, which is common to all of them, which I have reproduced below. The applications are each directed to a mobile device, which has a first transceiver 303 and a second transceiver 304. For example, one of the transceivers may be a cellular transceiver, and the other may be a Wi-Fi (RTM) transceiver. A radio frequency (RF) signal (317) transmitted from one of the transceivers (303) acts as an aggressor transmit signal and interferes with the reception of a second, victim RF signal 318 at the other transceiver. To address this problem, after the received RF signal has been down-converted 423/429 in frequency from RF to baseband, the resulting received baseband signal is compensated 431 for the transmitter interference. This involves observing the transmit signal and generating a digital observation signal therefrom. In many embodiments this is achieved tapping off 313 a portion of the transmit RF signal within a front end system 305 associated with the aggressor transceiver 303.The compensation 431 is performed using the digital observation data.

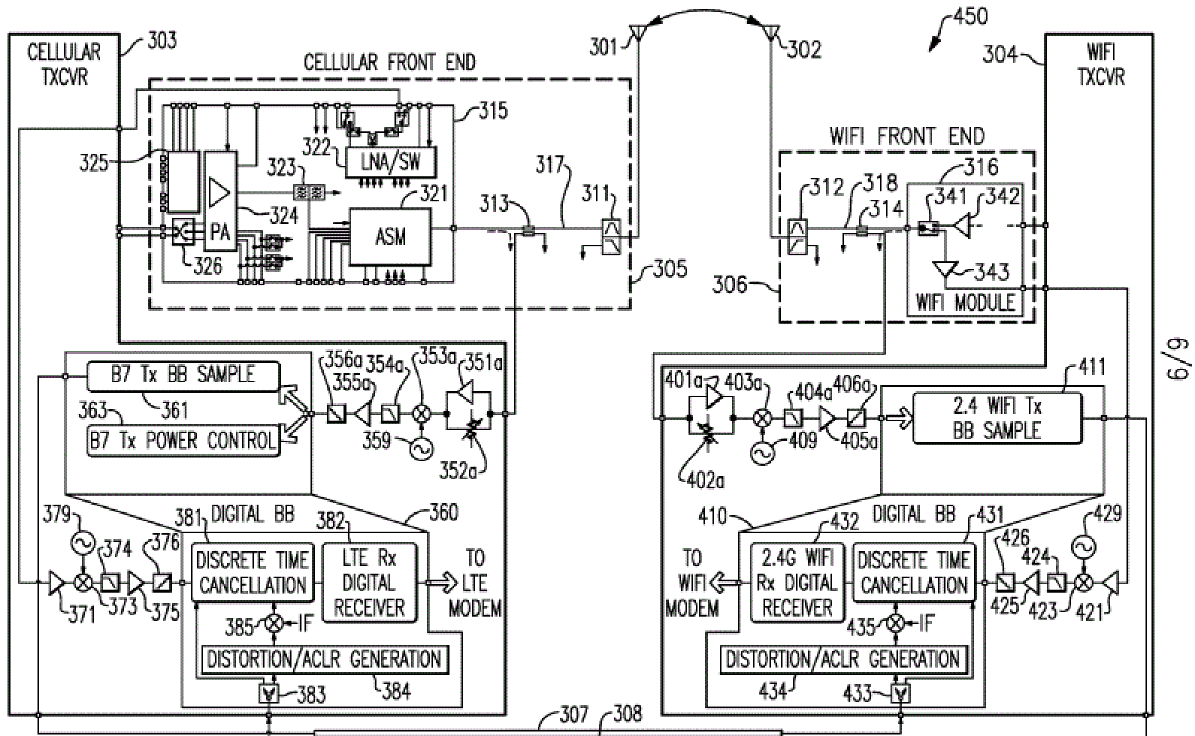


FIG.6

Figure 6 of GB2213631.1

<u>GB2213631.1 (Compensation in each transceiver)</u>

7 GB 2213631.1 is further directed to a mobile device in which each of the two transceivers compensates for transmit interference from the other.

GB2106631.1 (Discrete time cancellation)

8 GB2106631.1 is further directed to performing the compensation using a discrete time cancellation circuit.

GB2106633.7, GB2212005.9, GB2213632.9 and GB2217377.9 (Spectral Regrowth)

9 These four applications are each directed to compensating for interference resulting from spectral regrowth of transmit signals. Paragraphs 73-76 of the description of GB2106633.7, as originally filed, identify two different types of transmit leakage: direct leakage, and regrowth leakage. Direct leakage describes the situation where the frequency of a RF transmit signal lies sufficiently close to the frequency of a RF receive signal to cause interference. Spectral leakage describes the situation where, due to non-linearities in the power amplifier, transmit signal frequencies can spread, or leak, creating new frequency components which are not present in the original transmit signals. This spectral leakage from transmit signals can cause interference with a received signal. This is shown in Figure 3B of each of the applications. GB2106633.7, GB2212005.9, GB2213632.9 and GB2217377.9 are all concerned with spectral leakage, though GB2212005.9 additionally relates to discrete time cancellation as well.

**The Claims**

GB2213631.1 (Compensation in each transceiver)

10 The latest set of claims was submitted on 13 February 2023. There are three independent claims (1, 9 and 13). Claim 9 is the broadest of the three. The other two claims are reproduced in the Annex at the end of this decision. Claim 9 reads as follows:

> *9. A radio frequency communication system comprising:*
>
> *a first front end system configured receive a first incoming radio frequency receive signal and to output a first outgoing radio frequency transmit signal;*
>
> *a second front end system configured to receive a second incoming radio frequency receive signal and to output a second outgoing radio frequency transmit signal, the second front end system further configured to generate a radio frequency observation signal based on observing the second outgoing radio frequency transmit signal;*
>
> *a first transceiver configured to downconvert the first incoming radio frequency receive signal to generate a first baseband receive signal, and to compensate the first baseband receive signal for radio frequency signal leakage based on first digital observation data;*
>
> *and a second transceiver configured to generate the first digital observation data based on processing the radio frequency observation signal, the second transceiver being configured to compensate a second baseband receive*

*signal for radio frequency signal leakage based on second digital observation data from the first transceiver.*

GB2106631.1 (Discrete time cancellation)

11 The latest set of claims on this application were submitted on 27 June 2022. There are three independent claims (1, 14 and 17). All three are reproduced in the Annex at the end of this decision.

GB2106633.7 (Spectral Regrowth)

12 The latest set of claims were also submitted on 27 June 2022. There are three independent claims (1, 12 and 15). Claim 15 is a method claim corresponding to apparatus claim 12 but is limited to a mobile device. Apparatus claim 1 is similar in substance to claim 12, except that it is further limited to a mobile device with two antennas. Claim 12 is reproduced in the Annex.

GB2217377.7 (ACLR Modelling of Spectral Regrowth)

13 The latest set of claims for this application were submitted on 21 February 2023. There are three independent claims (1,9 and 17). Claim 9 is a method claim corresponding to apparatus claim 1. Apparatus claims 1 and 17 are reproduced in the Annex.

GB2213632.9 (Compensating cellular receive signal for spectral regrowth caused by WLAN leakage)

14 The latest set of claims were submitted on 27 January 2023. There are three independent claims (1,10 and 19). Claim 10 is a method claim corresponding to apparatus claim 1. Apparatus claims 1 and 19 are reproduced in the Annex.

GB2212005.9 (Using discrete time cancellation to compensate a cellular receive signal for spectral regrowth caused by WLAN leakage)

15 The claims are as originally filed on 17 August 2022. There are three independent claims (1,10 and 16). Claim 10 is a method claim corresponding to apparatus claim 1. Apparatus claims 1 and 16 are reproduced in the Annex.

**Novelty and Inventive Step**

<u>The Law</u>

*16* *Section 1(1) of the Act states that:*

> *A patent may be granted only for an invention in respect of which the following conditions are satisfied, that is to say –*
>
> *(a) the invention is new;*
>
> *(b) it involves an inventive step;*

17 Sections 2(1) & 2(2) of the Act read:

> *An invention shall be taken to be new if it does not form part of the state of the art.*
>
> *The state of the art in the case of an invention shall be taken to comprise all matter (whether a product, a process, information about either, or anything else) which has at any time before the priority date of that invention been made available to the public (whether in the United Kingdom or elsewhere) by written or oral description, by use or in any other way.*

18 Section 3 of the Act states:

> *An invention shall be taken to involve an inventive step if it is not obvious to a person skilled in the art, having regard to any matter which forms part of the state of the art by virtue only of section 2(2) above (and disregarding section 2(3) above).*

19 In addition to statute, the courts have long used the so-called Windsurfing test to assess issues of inventive step. This test was reformulated by the Court of Appeal in Pozzoli[1]. Paragraph 23 of this decision lays out the test as:

> *(1) (a) Identify the notional "person skilled in the art"*
>
> *(b) Identify the relevant common general knowledge of that person;*
>
> *(2) Identify the inventive concept of the claim in question or if that cannot readily be done, construe it;*
>
> *(3) Identify what, if any, differences exist between the matter cited as forming part of the "state of the art" and the inventive concept of the claim or the claim as construed;*

[1] Pozzoli Spa v BDMO SA & Anor [2007] EWCA Civ 588

*(4) Viewed without any knowledge of the alleged invention as claimed, do those differences constitute steps which would have been obvious to the person skilled in the art or do they require any degree of invention?*

**Analysis**

GB2213631.1 (Compensation in each transceiver)

20 The Examiner cited the following prior art documents as demonstrating a lack of novelty in this application:

*US 2014/269858 A1 (LUKASHEVICH)*

*EP 2637313 A1 (MEDIATEK)*

21 Each of these documents was published before the priority date of the current application. I will begin by construing claim 9 as it is slightly broader than claim 1.

22 Claim 9 is reasonably clear. I note that the term “first digital observation data”, which first appears in the first transceiver section of the claim, is subsequently defined in the second transceiver section of the claim. Although not explicitly stated, it seems implicit that the second baseband receive signal is obtained by down-converting the second radio frequency receive signal. Otherwise, the claim is straightforward to construe. Notably, it requires each transceiver to compensate its baseband receive signal for transmit leakage from the other transceiver.

23 The examination reports on file identified the embodiment of Figure 9 of *LUKASHEVICH* as being relevant to the claimed invention. I have reproduced Figure 9 below. This embodiment is described at paragraphs 84-93 of the citation. Paragraph 84 refers to “transmitters” 915 and “receivers” 925. Clearly, “transmitter” and “receiver” cannot be being used here in the conventional sense to refer to entire transmitter and receiver assemblies. Paragraph 22 discloses that the embodiment of Figure 1 includes a duplexer connected to an antenna (not shown), the duplexer including a transmit section 115 and a receive section 125. Furthermore, paragraph 123 clarifies that embodiments may be implemented using a duplexer connected to a single antenna; or may be implemented with separate transmit and receive antennas. It is therefore clear to me that the two “transmitters” 915 of Figure 9 may be transmit sections of respective duplexers or means for connecting each power amplifier to a respective transmit antenna. Similarly, I understand the term “receivers” 925 of Figure 9 to refer to receive sections of respective duplexers, or to means for connecting receive antennas to receive circuitry.

FIG. 9

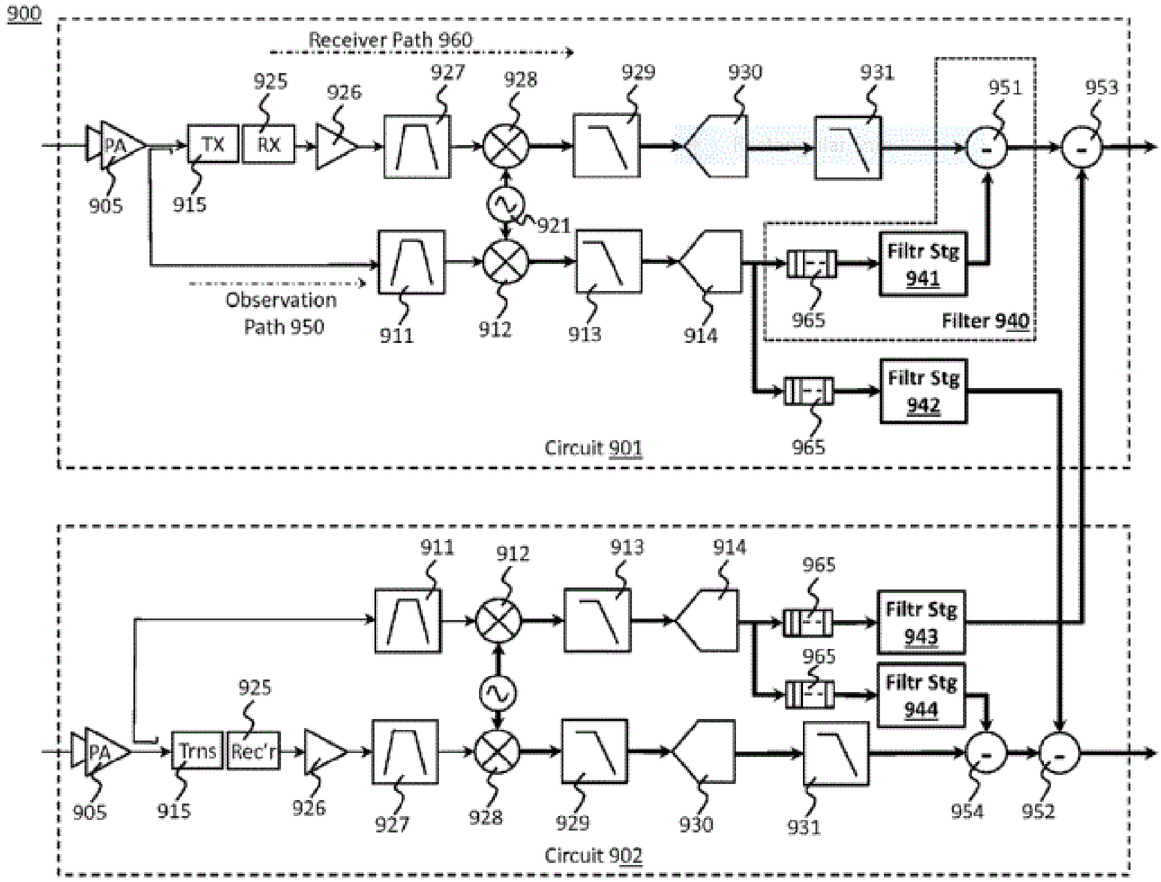


Figure 9 of US 2014/269858 (LUKASHEVICH)

24 The term “front-end” is widely understood to refer to the part of a radio transceiver between the antenna and the mixer stage. It follows that the components 905, 915, 925, 926, 927 and 911 within circuit 901 can be equated to the first front end system of claim 1; the corresponding components in circuit 902 can be equated to the second front end system of claim 9; the remaining components of circuit 901 correspond to the first transceiver of claim 9 and the remaining components of circuit 902 correspond to the second transceiver of claim 9.

25 The front-end portion of circuit 901 receives a RF signal at receive section 925 and passes this to low-noise amplifier 926; this signal is equivalent to the “first incoming radio frequency receive signal” of claim 1. The signal passed from power amplifier 905 to the transmit section 915 of circuit 901 is equivalent to the “first outgoing radio frequency transmit signal”. Similarly, the front-end portion of circuit 902 receives a “second incoming radio frequency receive signal” at its receive section 925 and outputs “a second outgoing radio frequency transmit signal” through its transmit section 915. The signal which is tapped-off from the path between the power amplifier 905 and transmit section 915 of circuit 902 (and which is subsequently passed through filter 911) is equivalent to the “radio frequency observation signal” of claim 9.

26 As the signal received at receive section 925 of circuit 901 passes through receiver path 960 the receive signal is down-converted at mixer 928. At subtractor 953 the

down-converted receive signal is compensated for transmit signal leakage from circuit 902 based on (first) digital observation data output from filter 943 of circuit 902. Paragraph 87 of *LUKASHEVICH* states: "*Filter stage 943 and its subtractor 953 may be configured to reduce transmitter noise from transmitter 915 in circuit 902 from the incoming signal received at receiver 925 of circuit 901*". Paragraphs 20 and 21 confirm that the digital observation data is down-converted to baseband. As the down-converted receive signal is combined with the first digital observation data in subtractor 953 it is implicit that mixer 928 must down-convert to baseband too, outputting a signal equivalent to the "first baseband receive signal" of claim 9.

27 The first digital observation data output from filter 943 of circuit 902 is generated from the radio frequency observation signal output from circuit 902's filter 911 by down-conversion at mixer 912 and analogue-to-digital conversion (ADC) at ADC 914. The circuit 902 also compensates, at subtractor 952, a second baseband receive signal (output form ADC 930 of circuit 902) for transmit signal leakage from circuit 901 based on second digital observation data (output from filter stage 942 of circuit 901).

28 From the above analysis, it is clear Figure 9 of *LUKASHEVICH* discloses each of the features of claim 9 of GB2213631.1. Claim 9 therefore lacks novelty over this citation.

29 The applicant's attorney's letter of 13 February 2023 seems to acknowledge that in one transceiver, subtractor 952 compensates a baseband receive signal for an amount of radio frequency signal leakage indicated by digital observation data. But the letter argues that there is no disclosure of a "*second transceiver similarly compensating a baseband signal for signal leakage based on a second set of digital observation data generated at the first transceiver*". It appears that the attorney has failed to appreciate that subtractor 952 performs compensation in one transceiver whilst subtractor 953 performs compensation in another transceiver. Paragraphs 86 and 87 of *LUKASHEVICH* confirm that each circuit 901, 902 contains a respective subtractor 952, 953 which each cancels transmit leakage from the other circuit.

30 Method claim 13 is almost directly equivalent to apparatus claim 9. However, claim 13 additionally stipulates that it applies to a mobile device. Paragraph 3 of *LUKASHEVICH* states than an aim of the invention is to reduce the need for larger duplexers in wireless devices such as phones and tablets. This implies that the invention of *LUKASHEVICH* is to be implemented in a mobile device. Applying similar analysis to claim 13 as I applied to claim 9, above, I conclude that claim 13 also lacks novelty over *LUKASHEVICH*.

31 I shall now turn to apparatus claim 1. This is broadly similar to apparatus claim 9, but there are some minor differences. Claim 9 compensates "*the first digital baseband receive signal for radio frequency signal leakage based on first digital observation data*" whereas claim 1 compensates "*the baseband receive signal for **an amount of** radio frequency signal leakage **indicated** by the first digital observation data*" (emphasis added).

32 Does this wording provide an additional limitation to claim 1 which is absent from claim 9? I don't think that it does. Furthermore, the applicant has not put forward such an argument. Looking at the specification, there is very little information on how

the compensation is carried out. The description does not provide an unambiguous disclosure of making a measurement of the magnitude of transmit leakage and reporting this to another transceiver, certainly not in the case of direct transmit leakage, as claimed in dependent claim 2. The "amount of" wording therefore cannot require measurement of a magnitude of interference. A person skilled in the art would readily appreciate that to compensate for an interfering signal it is necessary to know the phase and magnitude of the interfering signal (or its frequency components). Clearly then, compensating for transmit leakage using an observation signal (as disclosed in *LUKASHEVICH*) necessarily involves compensating for an *amount* of transmit leakage in the observation signal.

33 Additionally, in claim 1, some of the features appear in a different order than in claim 9. However, the only differences in substance between the two claims that I can identify are that claim 1 additionally requires that the apparatus is a mobile device with two antennas. I have already concluded that *LUKASHEVICH* discloses use in a mobile device. I thus conclude that claim 1 also lacks novelty over *LUKASHEVICH*.

34 I shall now consider whether claim 9 lacks novelty over EP 2637313 (*MEDIATEK)*. Figure 12 of this citation seems the most relevant as it shows a device which operates both in a first mode ("Case 1") in which an LTE module is receiving while a WiFi (RTM) module is transmitting and in a second mode ("Case 2") in which the WiFi nodule is receiving while the LTE module is transmitting. I have reproduced Figure 12 below. Figure 12 is described at paragraphs 67-76 of *MEDIATEK*. These paragraphs are primarily concerned with case 2, and the description acknowledges that some apparatus necessary for implementing case 1 is therefore omitted from Figure 12. Nevertheless, paragraphs 73 and 76 make clear that the apparatus of Figure 12 can be switched from case 2 to case 1. Switches SW1, SW2 and SW3 are provided for this purpose.

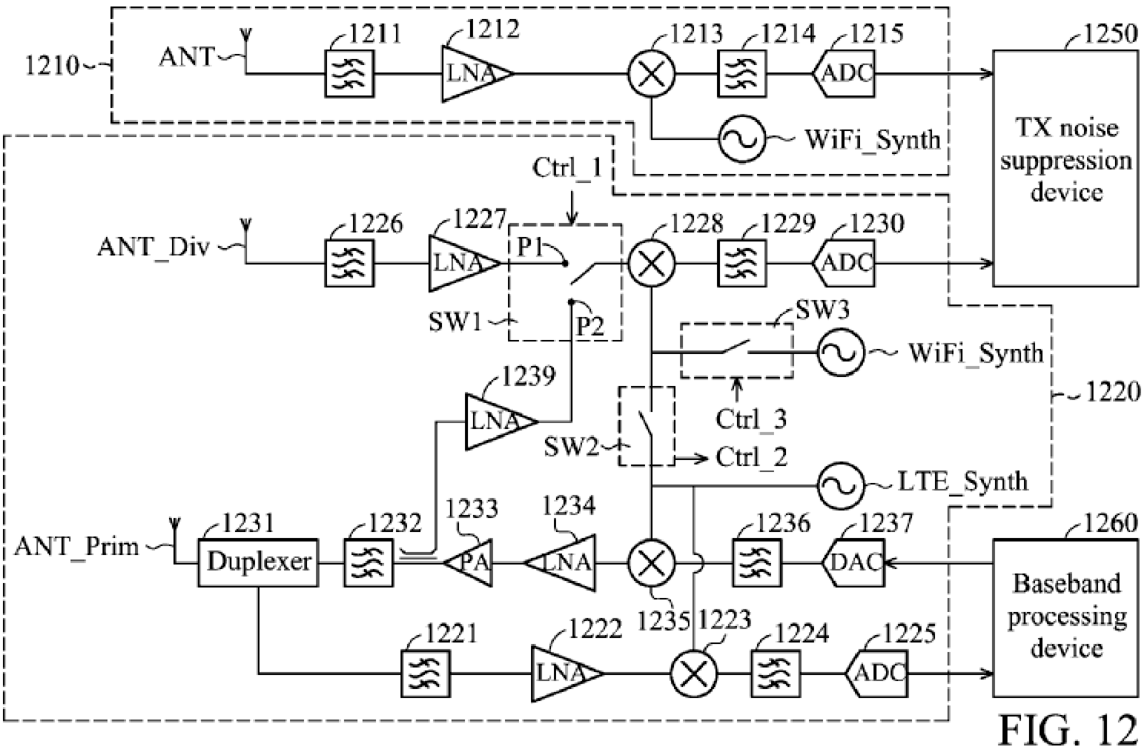


Figure 12 of EP 2637313 (*MEDIATEK)*

35 Paragraph 69 of *MEDIATEK* describes circuit 1210 as representing **only a portion** of a radio transceiver circuit of a Wi-Fi module; the circuit 1210 omits a Wi-Fi transmit path. Components 1211 and 1212 of this circuit correspond to the first front end system of claim 9 of GB 2213631.1 and I consider the remaining components of circuit 1210, together with the TX noise suppression device 1250, to be equivalent to the first transceiver of claim 9. Similarly, the components of the cellular circuit 1220 to the left of the mixer can be considered to provide a second front end system, whilst the mixers and the components to the right of the mixers, together with baseband processing device 1260, are analogous to the second transceiver of claim 9.

36 A signal received through the antenna of circuit 1210 corresponds to the first incoming radio frequency signal of claim 9. Similarly, a signal emitted from the Wi-Fi transmitting path referred to in paragraph 69 can be regarded as a first outgoing radio frequency transmit signal. A signal received at antenna "Ant_Prim" is equivalent to the second incoming radio frequency signal and the signal output from PA 1233 is equivalent to the second outgoing radio frequency transmit signal. The signal passing through LNA 1239 and pole P2 of switch SW1 is the outgoing radio frequency observation signal.

37 The output of the ADC 1215 is equivalent to the first baseband receive signal. The Tx noise suppression device 1250 compensates this signal for transmit leakage based on the signal output from ADC 1230, which is equivalent to the first digital observation data.

38 So far, I have established that *MEDIATEK* discloses each feature of the first 14 lines of claim 9 (as reproduced above). It remains to determine whether this citation additionally discloses that the LTE module also compensates a second baseband receive signal for signal leakage, based on second digital observation data from the Wi-Fi transceiver. The attorney's letter of 13 February 2023 argues that *MEDIATEK* fails to disclose coexistence management in *each* of the transceivers. Admittedly, Figure 12 does not explicitly show compensation in the LTE module, nor second digital observation data. However, as I have already noted above, paragraph 69 states that Figure 12 only shows a portion of the modules and the description makes clear that Figure 12 can also be operated in Case 1 (LTE module is receiving while WiFi module is transmitting). I shall now consider the relevance of Case 1 to the final part of claim 9.

39 Case 1 is described from paragraph 38 of *MEDIATEK*. In Case 1, the diversity capability of an LTE transceiver is sacrificed to provide suppression of transmit noise from a Wi-Fi module. A signal, $r_1[n]$, received at one of the LTE module's antennas is filtered to produce a filtered signal, f[n], and a signal, $r_2[n]$, received at the other of LTE module's antennas is subtracted from this filtered signal. With appropriate selection of coefficients for the filter, this allows transmit leakage from the Wi-Fi module to be compensated for. Figure 5 of *MEDIATEK* shows a circuit for providing this compensation. In the reference-based approach ("Method 1"), described at paragraphs 45-52, a baseband signal, s[n], transmitted by the interfering Wi-Fi module is used as a reference signal in the selection of the filter coefficients. It seems to me that those baseband signals meet the claim 9 requirement for "second digital observation data".

40 Although Figure 12 does not explicitly show a Tx noise suppression device for the LTE module, it does disclose a baseband processing device 1260. Figure 3 and paragraph 35 of *MEDIATEK* show that a baseband processing device may perform transmission noise suppression. It therefore seems implicit that, when operating in Case 1, the baseband processing device 1260 of Figure 12 would perform the transmission noise suppression described at paragraphs 38-50 and shown in Figure 5, using the Wi-Fi transmit baseband signal s[n] as second digital observation data. I consider the signal from ADC 1225 to be equivalent to the second baseband receive signal. This would serve as the signal $r_1[n]$ when performing transmit noise suppression in Case 1. The baseband processing device 1260 thus discloses the compensation features of the final part of claim 9. For completeness, I note that although Figure 12 does not explicitly show a path from the diversity antenna, ANT_Div, to the baseband processing device, it will be readily understood that there must be such a path, otherwise neither diversity reception of LTE signals nor the transmit noise suppression in Case 1 could take place.

41 Following the above analysis, I conclude that claim 9 lacks novelty over *MEDIATEK*. As the invention of *MEDIATEK* is preferably implemented in a mobile device (see paragraph 3), it follows that method claim 13 also lacks novelty over this citation. Furthermore, as Figure 12 of EP 267313 clearly shows at least one antenna for each of the Wi-Fi and LTE modules, claim 1 also lacks novelty.

42 I will return to the dependent claims of this application after I have made a decision on the independent claims of each of the other 5 applications under consideration.

<u>GB2106631.1 (Discrete time cancellation)</u>

43 Upon reading claim 1 of GB 2106631.1, the only feature I can see which is absent from claim 1 of GB 2213631.1 (analysed above) is the requirement for the first transceiver to perform signal leakage compensation using a “discrete time cancellation circuit”. I will thus start my assessment of this claim 1 by construing this term. This term is particularly relevant because both the examiner and the applicant are of the opinion that it is this feature which distinguishes the claimed invention from the cited prior art, at least in terms of novelty.

44 Oppenheim and Schafer’s textbook, *Discrete-Time Signal Processing*[2]**,** was briefly discussed in the examiner’s pre-hearing report of 27 April 2023. The following passages from pages 8 and 9 of that book appear relevant to the issue at hand:

> *The independent variable in the mathematical representation of a signal may be either continuous or discrete. Continuous-time signals are defined along a continuum of times and thus are represented by a continuous independent variable. Continuous-time signals are often referred to as analog signals. Discrete-time signals are defined at discrete times, and thus, the independent variable has discrete values; i.e., discrete-time signals are represented as sequences of numbers…Besides the independent variables*

[2] Alan V Oppenheim and Ronald W Schafer with John R Buck, “Discrete-Time Signal processing”, 2e, 1999, Prentice-Hall, Inc, pages 8 & 9

*being either continuous or discrete, the signal amplitude may be either continuous or discrete. Digital signals are those for which both time and amplitude are discrete.*

*Signal-processing systems may be classified along the same lines as signals. That is, continuous-time systems are systems for which both the input and the output are continuous-time signals, and discrete-time systems are those for which both the input and the output are discrete-time signals. Similarly, a digital system is a system for which both the input and the output are digital signals.*

*Discrete-time signals may arise by sampling a continuous-time signal, or they may be generated directly by some discrete-time process.*

45 Claim 1 states that the *"discrete time cancellation circuit (is) configured to compensate the first digital baseband receive signal for radio frequency signal leakage based on digital observation data".* This requires two digital inputs to the cancellation circuit (the first digital baseband receive signal and the digital observation data) and a digital output (the compensated first digital baseband receive signal). We know from Oppenheim and Schafer i) that digital signals are necessarily discrete-time signals and ii) that a circuit with discrete time inputs and discrete time outputs is a discrete time circuit. Given that claim 1 already specifies that the baseband receive signal and the observation data are digital I do not believe that the reference to "discrete time" provides any additional limitation to the claim.

46 As for the term 'cancellation', it is my understanding that circuits which cancel interference usually involve subtracting the interference from a received signal. However, I can see no specific disclosure of subtraction in the specification. I am therefore reluctant to infer that the cancellation circuit of claim 1 must perform subtraction. I also believe that those skilled in the art of interference mitigation would understand that it would be unrealistic to expect an interference cancellation circuit to perfectly eliminate interference rather than merely reduce it. I will thus construe the term 'cancellation' in claim 1 to be no more limiting than the term 'compensation'.

47 The Examiner has cited each of the following documents in relation to inventive step:

*US 2014/269858 A1 (LUKASHEVICH)*

*EP 2637313 A1 (MEDIATEK)*

These are the same documents as were cited against GB2213631.1. The other documents cited in the pre-hearing report were cited as examples of the common general knowledge. I shall begin by checking whether claim 1 is novel over the two documents listed above.

48 Figure 3 of *LUKASHEVICH* is reproduced below. Components 305.1, 315.1, 325.1, 326.1 and 327.1 can be equated to the first front end system of claim 1 of GB 2106631.1; similarly, components 305.2, 315.2, 325.2, 326.2, 227.2, 355 and 311 can be equated to the second front end system of claim 1. Components 321.1, 328.1, 329.1, 330.1, 342.1 and 341.1 correspond to the first transceiver of claim 1

and components 321.2, 328.2, 329.2, 330.2, 311, 312, 313 and 314 correspond to the second transceiver of claim 1.

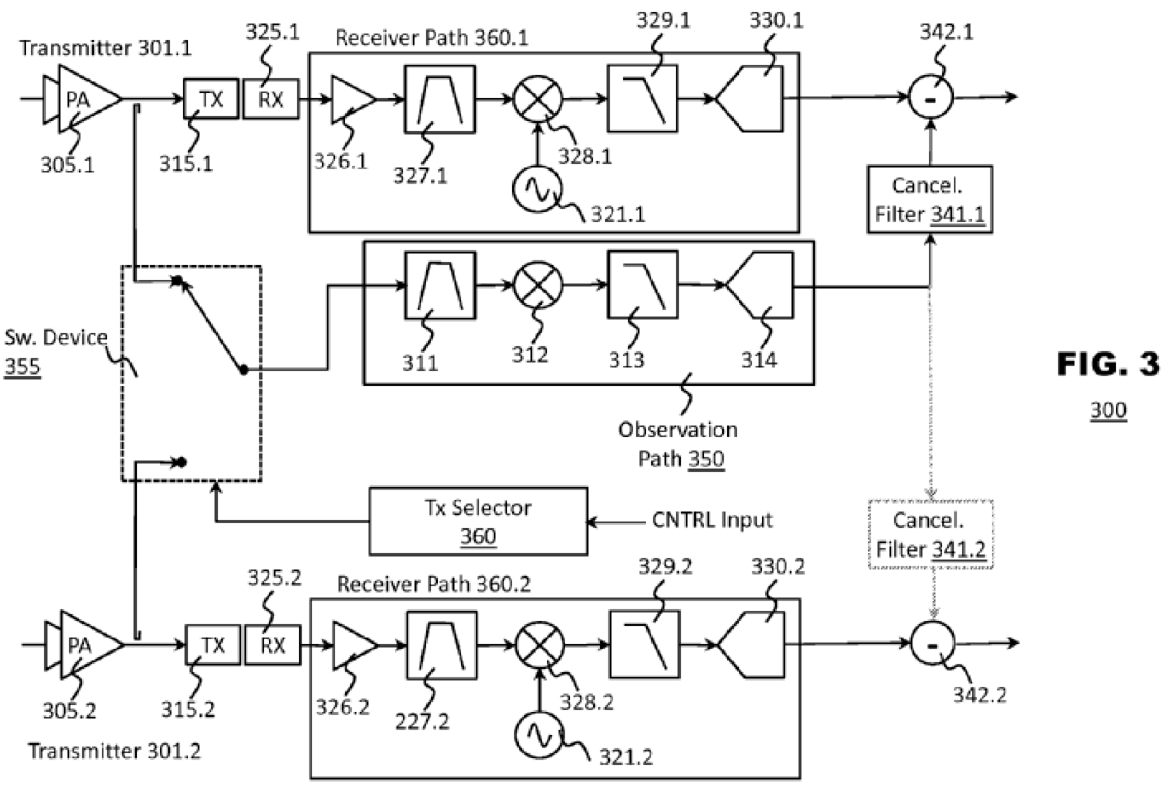


Figure 3 of US 2014/269858 (*LUKASHEVICH)*

49 When the switch 355 is in the lower position, an observation signal (which observes leakage from transmitter 301.2) passes through observation path 350. The combination of cancellation filter 341.2 and subtractor 342.1 is equivalent to the discrete time cancellation circuit of claim 1. This circuit receives as inputs a digital baseband receive signal from ADC 330.1 and digital observation data from ADC 314. As the cancellation circuit 342.1/341.1 receives digital signal inputs and therefore outputs a digital signal from subtractor 342.1 we know, from Oppenheim and Shafer, that it can be classed as a discrete time circuit. I thus conclude that claim 1 lacks novelty over *LUKASHEVICH*.

50 Applying the same analysis to method claim 17, I find that this claim also lacks novelty over *LUKASHEVICH*.

51 Claim 14 has a different scope to claim 1 as it is directed, not towards the whole mobile device, but to just one transceiver. Furthermore, claim 14 requires the transceiver to both generate a first digital observation data and to perform compensation using second digital observation data. Recall, from the analysis of GB 2213661.1 above, that the transceiver section of circuit 902 generates first digital observation data (which is output from its ADC 914) and performs compensation at subtractor 952 using second digital observation data output from circuit 901’s ADC 914. Furthermore, subtractor 952 serves as a discrete time cancellation circuit. Claim 14 therefore also lacks novelty over *LUKASHEVICH*.

52 I shall now consider whether the independent claims are novel over *MEDIATEK*. As with GB 2213631.1, I regard components 1210 and 1211 of the of the Wi-Fi module 1210 (along with the Wi-Fi transmit chain referred to in paragraph 69) as equivalent to the first front end system of claim 1 and I consider the remaining components of circuit 1210, together with the TX noise suppression device 1250, to be equivalent to the first transceiver of claim 1. Similarly, I consider the components of the LTE circuit 1220 to the left of the mixer to provide a second front end system, whilst the mixers and the components to the right of the mixers, together with baseband processing device 1260, are analogous to the second transceiver of claim 1. Compensation is provided in TX noise suppression device 1250. Paragraph 74 of *MEDIATEK* states that the TX noise suppression approaches disclosed for Case 1 operation also apply to Case 2. It is clear from Figures 4 and 5 that the Tx noise suppression does not involve digital-to-analogue conversion. In Figure 12, the inputs to the Tx noise suppression device 1250 are the outputs of ADCs 1215 and 1230. As the inputs and outputs of the Tx noise suppression device are digital, the TX noise suppression device can be regarded as a discrete time circuit. *MEDIATEK* therefore also demonstrates that claims 1 and 17 lack novelty.

53 It should be clear, from my analysis of Figure 12 of *MEDIATEK* for GB 2213631.1 above, why I consider the combination of the baseband processing device 1260 and the right-hand side of the LTE module 1220 to be equivalent to the transceiver of claim 14. In a Case 1 operating mode, the baseband processing device 1260, operating as a discrete-time circuit, performs Tx noise suppression to compensate a digital baseband receive signal from ADC 1225 for Wi-Fi transmit leakage using a (second) digital observation data s[n] (see paragraph 39 and Figure 5). *MEDIATEK* therefore also demonstrates that claim 14 is not novel.

54 Again, I will returned to the dependent claims once I have considered the independent claims of each of the other applications in turn.

<u>GB2106633.7 (Spectral Regrowth)</u>

NOVELTY

55 The pre-hearing report cites EP 2637313 (MEDIATEK) as demonstrating that each of the independent claims lack novelty. The other documents cited in that report appear to have been included merely to illustrate the background art. MEDIATEK was cited for the first time in the examination report of 16 February 2023. The applicants' response to that report was a brief letter requesting a hearing on the papers. I note that the applicants have not put forward any arguments as to why they consider the examiner's objections based on MEDIATEK to be invalid.

56 The only features of claim 12 of GB 2106633.7 which are not also present in the previously discussed claim 9 of GB 2213631.1 are the following spectral regrowth features: *"the first transceiver including a spectral regrowth modeling circuit configured to estimate an amount of aggressor spectral regrowth present in the first incoming radio frequency receive signal based on the digital observation data".*

57 It is worth taking a little time to construe this section of the claim before returning to MEDIATEK. Figure 3B of GB 2106633.7 illustrates spectral regrowth. Paragraph 76 of the description states that the "*non-linearity of the power amplifier 81 gives rise to spectral regrowth in the RF output signal that is close in frequency to RF signals processed by the victim receiver 82*". It is my understanding that spectral regrowth describes the situation where the output of a system contains frequencies which were not present at the input to the system. The pre-hearing report helpfully refers to a textbook by Behzad[3]. This book confirms that spectral regrowth can arise in a nonlinear system, such as a power amplifier, due to frequency components (e.g. $f_1$, $f_2$) of an input multitone signal interacting to generate intermodulation terms (e.g. $2f_1 – f_2$ and $2f_2 – f_1$). Thus, spectral regrowth can arise from such intermodulation distortion.

58 Paragraph 111 of the description of GB2106633.7 (as originally filed) states:

"*the digital baseband circuit 410 of the WiFi transceiver 304 includes the distortion/ ACLR generation circuit 434 and the digital mixer 435, which correspond to one embodiment of a spectral regrowth modeling circuit. In certain implementations, the distortion/ ACLR generation circuit 434 generates digital distortion/ ACLR data based on the first digital observation data received from the cellular transceiver 303".*

Figure 6 shows that the only input to the distortion generation circuit is a digital observation signal 308, which was generated based on observation of a RF transmit signal. This suggests that the output from the distortion circuit 434 is an estimated amount of spectral regrowth in the transmit leakage signal, not in the incoming radio frequency receive signal as claimed. Paragraph 62 of the description refers to estimating spectral regrowth by modelling the adjacent channel leakage ratio (ACLR) and paragraph 63 very briefly describes compensation by discrete time cancellation, using a least mean squares (LMS) algorithm and a finite impulse response (FIR) filter. Unfortunately, I can find no further details within the specification of how the compensation of claim 12 could be put into practice. However, US 2014/161159 A1 (BLACK) provides an example of a similar prior art document which hints at how claim 12 of the present application could be worked.

59 BLACK was cited in the examination report of 9 September 2022 but not in the final pre-hearing report. In this document a baseband intermodulation distortion (IMD) calculation circuit (244, Fig. 2) estimates IMD based on transmit baseband signals (see for example paragraph 33) and outputs a distortion signal. As explained in paragraphs 36-38, an adaptive filter 252, adapted using a least mean squares (LMS) algorithm, adapts amplitude and phase of the distortion signal to generate a canceller signal. The canceller signal is then subtracted 258, 256 from a baseband receive signal to compensate the received signal for transmit leakage.

60 By analogy with BLACK, I speculate that an FIR filter within the discrete time cancellation circuit 381 of Figure 6 of the present application could adapt the amplitude and phase of the output of the distortion generation circuit 384 using an LMS algorithm to generate a cancellation signal for subtraction (not explicitly disclosed) from a baseband receive signal (output from ADC 376). In which case, the

[3] Arya Behzad, "Wireless LAN Radios: System Definition to Transistor Design", John Wiley & Sons, Inc, 2008, pp29-32.

cancellation signal would in effect provide an estimate of an amount of aggressor spectral regrowth present in a received signal, as claimed in claim 12. This would seem to me to suggest that a literal construction of the spectral modelling features of claim 12 is probably justified, with the caveat that the spectral regrowth modelling circuit of claim 12 cannot refer solely to the distortion generation circuit 384 (and mixer 385) but must also include components from the discrete time cancelation circuit 381. While I am not completely comfortable using such speculation when construing claims, the lack of any better detail in the disclosure of GB 2106633.7 leaves me no alternative.

61 Returning now to MEDIATEK, as with claim 9 of GB2213631.1, I consider components 1211 and 1212 of Wi-Fi module 1210, together with the Wi-Fi transmit chain of paragraph 69 to correspond to the first front end system of claim 12 of GB 2106633.7. The remaining components of Wi-Fi module 1210, together with the TX noise suppression device 1250 correspond to the first transceiver of claim 12. Similarly, I consider the components 1231, 1232, 1233, 1234, 1221, 1222 and 1239 to be equivalent to the second front end system of claim 12, whilst components 1228, 1229 and 1230 are analogous to the second transceiver of claim 12. The output of the ADC 1215 is equivalent to the first baseband receive signal. The Tx noise suppression device 1250 compensates this receive signal for transmit leakage based on the signal output from ADC 1230, which is equivalent to the first digital observation data.

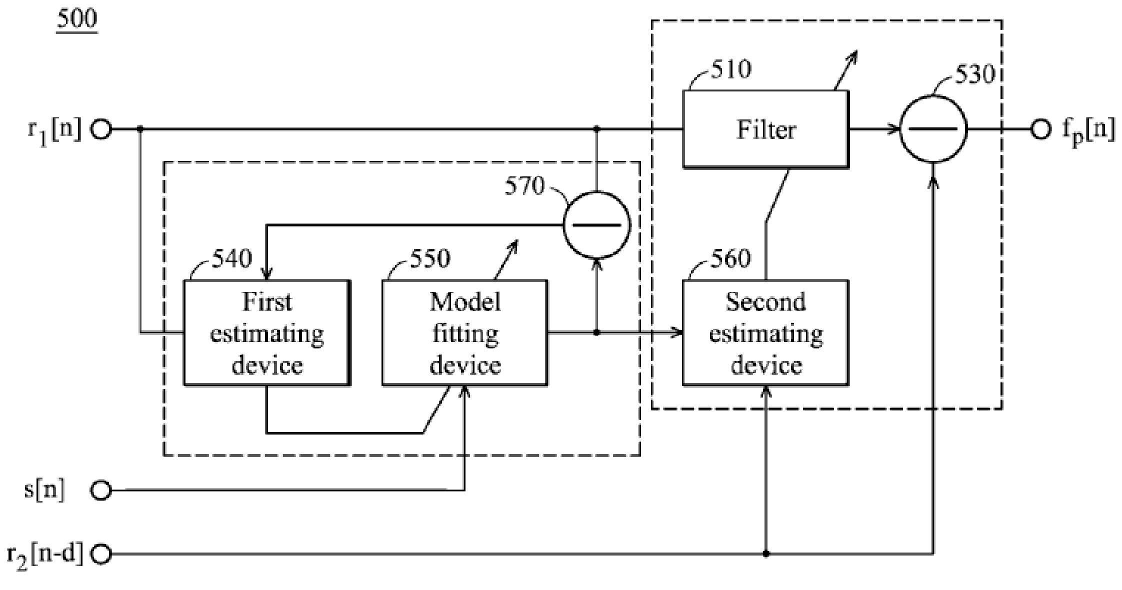


FIG. 5

Figure 5 of EP2637313 (MEDIATEK)

62 Paragraph 74 of MEDIATEK states "*the above-mentioned reference-based approach (i.e. method 1) and non-reference based approaches…are all applicable in case 2 and the structure as shown in Figure 12 for performing transmission noise suppression*". Recall that Case 2 refers to the mode of operation where the Wi-Fi module is receiving while the LTE module is transmitting. The transmit noise suppression device 1250 is responsible for transmit leakage cancellation in Case 2. Paragraphs 38-52 of the description are primarily concerned with Case 1 (LTE

module is receiving whilst Wi-Fi module is transmitting). As previously discussed, in Case 1, the diversity capability of an LTE transceiver is sacrificed to provide suppression of transmit noise from a Wi-Fi module. Figure 5 of MEDIATEK shows a circuit for providing this compensation. I have reproduced Figure 5 above.

63 At the foot of paragraph 40 of MEDIATEK, an explanation is provided of how the transmit noise suppression system should be adapted for operation in Case 2: *"the signal $r_1[n]$ may be the downlink signals received by the WiFi module and the signals $r_2[n-d]$ may be the uplink signals to be transmitted by the LTE module, where the uplink LTE signals may be received by the WiFi module through a coupling path, which will be illustrated later"*. The clear implication here is that the TX noise suppression device 1250, when adopting a reference-based approach, applies the transmit noise suppression system of Figure 5, with the output of ADC 1215 providing $r_1[n]$ and the output of ADC 1230 providing $r_2[n-d]$.

64 Figure 1 of MEDIATEK provides a frequency spectrum illustrating a transmit signal, its "transmit skirt" and a receive signal which experiences interference from the transmit skirt. Paragraph 46 explains that a major component of the transmit skirt is intermodulation distortion arising due to the non-linearity of a power amplifier. The transmit skirt is clearly equivalent to the spectral regrowth of the present application. Paragraphs 46-48 propose estimating the intermodulation distortion, $\hat{X}_{IM}[n]$, using the expression:

$$\hat{X}_{IM}[n] = \sum_{k=1,3,\ldots K} \hat{a}_k \left|s[n]\right|^{k-1} s[n]$$

where "*s[n] is the baseband signal to be transmitted by radio module operating in uplink mode*" and $\hat{a}_k$ are estimated intermodulation coefficients. These coefficients are estimated by using components 540, 550 and 570 of Figure 5 to minimise the mean square error (MSE) of the cost function $J_1$:

$$J_1 = E\left\{\left|r_1[n] - \hat{X}_{IM}[n]\right|^2\right\}$$

65 In the examiner's view, estimating the intermodulation distortion, $\hat{X}_{IM}[n]$, anticipates "*a spectral regrowth modeling circuit configured to estimate an amount of aggressor spectral regrowth present in the first incoming radio frequency receive signal based on the digital observation data".* I agree that $\hat{X}_{IM}[n]$ estimates an amount of aggressor spectral regrowth, in a (downconverted) radio frequency receive signal, $r_1[n]$, based on digital observation data s[n]. However, I can see no explicit disclosure that the baseband signal s[n] is based on processing an RF observation signal, as required by the last part of claim 12 of the present application. Figure 12 of MEDIATEK does show that the output of ADC 1230 is based on an RF observation signal but this is used to provide the signal $r_2[n]$ rather than the signal s[n].

66 I thus conclude that in a first scenario, in which the components 540/550/570 are regarded as a spectral regrowth modelling circuit, these components do not in fact disclose all the features of the spectral regrowth circuit claimed in claim 12. I will now consider a second scenario where the second estimating device 560 (in combination

with the components 540/550/570) is regarded as a spectral regrowth modelling circuit.

67 Paragraph 49 of MEDIATEK explains that the second estimating device determines filter parameters, g[l], for the filter 510 by minimising the MSE of the cost function $J_2$:

$$J_2 = E\left\{\left| r_2[n] - \sum_{l=0}^{L-1} g[l] \cdot \hat{X}_{IM}[n-l] \right|^2\right\}$$

It seems to me that the term to the right of the minus sign of this equation effectively estimates the intermodulation distortion/spectral regrowth present in the signal $r_2[n]$ based on an estimate in the intermodulation distortion, $X^{\wedge}_{IM}[n]$, present in the signal $r_1[n]$ (recall the cost function $J_1$). However, according to paragraphs 40 and 50, $r_2[n]$ would appear to relate to an observation signal (the output of ADC 1230) derived from the RF transmit signal, rather than to a radio frequency receive signal. Therefore, the second scenario also does not anticipate each of the spectral regrowth modelling circuit features of claim 12 either. I therefore conclude that claim 12 is novel over MEDIATEK.

INVENTIVE STEP

68 I shall now consider whether claim 12 provides an inventive step over MEDIATEK. I will begin by applying the Windsurfing/Pozzoli test: I consider the skilled person of step 1 of the test to be an engineer with experience of designing interference cancellation systems. The skilled person would have a degree in electronics, telecommunications engineering, or similar. It would be within the skilled person's common general knowledge that interference can be cancelled from a corrupted signal if a reference signal, containing the interference, is available. The skilled person would appreciate that the interference can be cancelled by subtracting the reference signal from the corrupted signal, provided the gain and phase of the reference and corrupted signals match. The skilled person would appreciate this was commonly achieved by passing either the corrupted signal or the reference signal through an adaptive filter, prior to subtracting the signals. Furthermore, the skilled person would know that it was common to pass the reference signal through the adaptive filter. This is shown in Figure 1 of Widrow et al[4] (not previously cited) for one example. Each of the other Figures of WIDROW builds on the foundations provided in Figure 1. IEEExplore indicates WIDROW has been cited in 2,904 academic papers and 382 patents. I thus believe that the information displayed in Figure 1 of WIDROW can be considered to form part of the common general knowledge of the skilled person.

69 Regarding step 2 of the test, I apply the same construction to claim 12 as I did when analysing the novelty of the claim.

[4] Widrow, B et al, "Adaptive noise cancelling: Principles and applications", Proc. of the IEEE, Vol. 63, no. 12, pp1692-1716, 1975, https://ieeexplore.ieee.org/document/1451965

70 Proceeding to step 3 of the test, in the first scenario I identified above, MEDIATEK differs from the inventive concept of claim 12 in that it does not explicitly state that the transmit signal s[n] is based on a RF transmit signal. In the second scenario, the difference is that the second estimating device 560 estimates an amount of aggressor spectral regrowth present in digital observation data, rather than in an incoming radio frequency receive signal.

71 In the final part of the test, I must decide whether either of these differences would be obvious to the person skilled in the art. I shall start with the second scenario identified above. I believe it would be obvious to a person skilled in the art to use the downconverted incoming RF signal from ADC 1215 as the signal $r_2[n]$ of Figure 5, and the digital observation signals from ADC 1230 as the signal $r_1[n]$. Such an assignment is the opposite to that suggested at paragraphs 40 and 50 of MEDIATEK but is consistent with the common general knowledge approach of applying adaptive filtering to the reference signal rather than the desired signal. This approach has the advantage that it is not necessary to alter the gain or phase of the desired signal. If the signal from ADC 1215 was used as $r_2[n]$ then adaption of the filter coefficients in the second estimating device 560 would involve estimating the spectral regrowth in that receive signal (recall the cost function $J_2$) based on an estimate $X^{\wedge}_{IM}[n]$ of the intermodulation distortion present in digital observation data $r_1[n]$ output from ADC 1230. In short, I believe that it would be obvious to a person skilled in the art to reverse the assignment of signals to $r_1[n]$ and $r_2[n]$, in which case Figure 5 would disclose all the spectral regrowth modelling circuit features of claim 12. I therefore consider claim 12 to lack an inventive step over MEDIATEK.

72 Applying the same analysis to independent claims 1 and 15, I conclude that those claims are also novel but not inventive with respect to MEDIATEK. Again, I will return to the dependent claims later.

<u>GB2217377.7 (ACLR Modelling of Spectral Regrowth)</u>

73 As was the case with the previous application, the examiner has objected that each of the independent claims of this application lacks an inventive step over MEDIATEK. Once again, I shall apply the Windsurfing/Pozzoli test to the invention, starting with the broadest claim, claim 17.

74 In step 1 of the test, I will take the skilled person to be as I previously defined them above.

75 Continuing with step 1 of the test, as discussed above, spectral regrowth describes the situation where the output of a system contains frequencies which were not present at the input to the system. Spectral regrowth can occur in a nonlinear system, such as a power amplifier, due to frequency components of an input multitone signal interacting to generate intermodulation distortion. I believe that this would all fall within the skilled person’s common general knowledge. The skilled person would also be familiar with the concept of adjacent channel leakage ratio and have some understanding of how this term is defined and used. They would appreciate that the adjacent channel leakage ratio (ACLR) is a figure of merit that describes the degree of spectral regrowth in an adjacent band to the band of an

assigned transmit channel[5]. ACLR is defined as the ratio of the power in an adjacent band to the power in the assigned band. ACLR1 denotes the ACLR of an immediately adjacent band to the assigned band and ACLR2 refers to the ACLR of an "alternate" band which is a second bandwidth offset from the assigned band. The skilled person would know that telecommunications standards set decibel limits on permitted ACLR levels[6]. They would also understand that the main contribution to ACLR1 is third order intermodulation distortion (IMD3) whilst the main contribution to ACLR2 is fifth order intermodulation distortion (IMD5)[7].

76 The agent's letter of 19 December 2022 argued that there is insufficient evidence that the common general knowledge would include "*spectral regrowth modelling circuits themselves…, let alone modelling based on ACLR using predistortion*". However, in my view, equation 6.96 of Rouphael[8] can be viewed as a model of ACLR, and thus of spectral regrowth, and demonstrates that it was common general knowledge to model ACLR1 as a function of IMD3 relative power. Equation 6.97 of Rouphael shows, in turn, that IMD3 can be expressed in terms of a third order operating point, OIP3, which characterises the power amplifier.

77 I also agree with the examiner that the use of digital predistortion (DPD) would have been common general knowledge to the skilled person. DPD is widely understood to involve passing the signal to be transmitted through a predistortion filter, upstream of a transmitter's power amplifier, to pre-compensate the transmit signal for the non-linearity of the power amplifier[9]. Such pre-distortion was understood to mitigate spectral regrowth and hence reduce ACLR.

78 Turning now to the second step of Windsurfer/Pozzoli, the first 11 lines of claim 17 are familiar from GB2106633.7 and so the discussion of claim construction for GB2106633.7 provided above also applies here. In summary, a literal construction of "spectral regrowth modelling circuit" can apply, with the caveat that this feature cannot refer solely to the distortion generation circuit 434 and mixer 435 because the distortion generation circuit estimates distortion present in the transmit signal. I should also emphasise that in claim 17 of the present application (GB2217377.7) there is no requirement that the digital observation data has been generated from a radio frequency signal, as was the case with the invention claimed in GB 2106633.7.

79 The claim 17 feature "modelling adjacent channel leakage ratio using predistortion" requires careful consideration. Paragraph 58 of the published description states:

"*the spectral regrowth model is generated by pre-distortion, for instance, by modeling adjacent channel leakage ratio (ACLR), such as ACLR2.".*

Very similar passages appear in paragraphs 82 and 92. Paragraph 107 states:

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[5] Tony, J Rouphael, "*RF and Digital Signal Processing for Software-Defined Radio: A Multi-Standard Multi-Mode Approach*", 2009, Newnes, at Section 6.6
[6] 3GPP TS 38.101-1 V15.2.0 (July 2018), at Section 6.5.2.4
[7] Rouphael, loc. cit.
[8] Rouphael, op. cit. at equation 6.96
[9] Lindemeier, S and Robert, W (Editors), "*Electromagnetic and Network Theory and Their Microwave Technology Applications: A Tribute to Peter Russer",* Springer Science & Business Media, 2011 at Section 19.1.

"*WiFi transceiver 304 includes the distortion/ACLR generation circuit 434 and the digital mixer 435, which correspond to one embodiment of a spectral regrowth modeling circuit. In certain implementations, the distortion/ACLR generation circuit 434 generates digital distortion/ACLR data based on the first digital observation data received from the cellular transceiver 303.*"

Digital pre-distortion (DPD) is only very briefly mentioned, in passing, in paragraph 62 and that paragraph is silent in respect of ACLR. I can find no other parts of the description which are relevant to the final part of claim 17.

80 Although the term pre-distortion is conventionally used to refer to inserting distortion into the transmit signal, upstream of a transmitter's power amplifier, there is nothing in the description to suggest that is what is intended by the term "pre-distortion" here. Furthermore, claim 17 refers to modelling ACLR "using pre-distortion" but in the description the relationship between ACLR and pre-distortion is reversed: "*the spectral regrowth model is generated by pre-distortion, for instance, by modeling adjacent channel leakage ratio (ACLR)*". Taking the description into account, I construe the final 3 lines of claim 17 as requiring that *spectral regrowth is modelled using an estimate of distortion generated using a model of ACLR*. In the embodiment of Figure 6, a distortion signal output from distortion/ACLR generation circuit 434 is provided as an input to a discrete time cancellation circuit 431, which compensates a WLAN receive signal for cellular signal leakage.

81 Having construed claim 17, I can now proceed to step 3 of the test. I consider the combination of circuit 1210 and Tx noise suppression device 1250 in MEDIATEK to be analogous to the WLAN transceiver of claim 17. Figure 12 shows only the receive portion of the transceiver but paragraph 69 refers to the transmit portion. A WLAN receive signal is output from ADC 1215. As explained above, when analysing the other applications, it is implicit that the Tx noise suppression device 1250 implements the transmit noise compensation apparatus of Figure 5, with the output of ADC 1215 providing an input to $r_1[n]$. As previously explained, I consider the transmit noise suppression device to compensate the WLAN signal for transmit leakage from cellular transmissions. Here, I regard the baseband signal s[n] as equivalent to claim 17's "digital observation data from a cellular transceiver". As previously discussed, this baseband signal is applied in the equations of paragraph 48 of MEDIATEK to estimate intermodulation distortion $X^{\wedge}_{IM}[n]$, and therefore spectral regrowth. Therefore, MEDIATEK discloses modelling spectral regrowth using an estimate of distortion, $X^{\wedge}_{IM}[n]$, which is generated using a model of intermodulation products:

$$\hat{X}_{IM}[n] = \sum_{k=3,5,\ldots K} \hat{a}_k \left|s[n]\right|^{k-1} s[n]$$

and a digital baseband signal, s[n]. The difference between the disclosure of MEDIATEK and the invention of claim 17, as I have construed it, is that MEDIATEK models distortion using estimated intermodulation products, rather than using ACLR.

82 In the final step of the test I must decide whether this difference would have been obvious to a person skilled in the art. The attorney's letter of 21 February 2023 argues that, without the benefit of hindsight, the skilled person would not be

motivated by MEDIATEK to model spectral regrowth for interference compensation based on “ACLR using predistortion”. The “predistortion” aspect is not relevant to claim 17 as construed. Nevertheless, I do need to decide whether it would be obvious to replace the intermodulation distortion model of MEDIATEK with an ACLR model.

83 It is worth looking at the intermodulation distortion equation of MEDIATEK (reproduced above) in more detail. The k=3 term estimates IMD3 distortion and the k=5 term estimates IMD5 distortion. Here IMD3 and IMD5 are expressed as absolute values. In contrast, ACLR1 effectively provides a relative measure of IMD3 and ACLR2 effectively provides a relative measure of IMD5. It seems to me that the intermodulation distortion model of MEDIATEK and the ACLR model of the present invention provide the same information but present it in different ways, with MEDIATEK providing distortion estimates as absolute values but ACLR modelling providing distortion estimates as relative values. To my mind, the skilled person would readily appreciate that it would be a trivial matter to convert (or replace) the distortion estimates, $X^{\wedge}_{IM}[n]$, of MEDIATEK, to (or with) ACLR estimates. Admittedly, there would be little motivation for the skilled person to carry out such a conversion because there would be no clear advantage and it would then be necessary to express $r_2[n]$ of equation 5 in relative terms too. Nevertheless, I believe that such a modification would be an obvious possibility to the skilled person. The intermodulation distortion model of MEDIATEK, once converted to ACLR values, is effectively an ACLR model. I therefore conclude that claim 17 lacks an inventive step over MEDIATEK.

84 If the use of an ACLR model resulted in an unforeseen advantage over MEDIATEK’s inter-modulation distortion model, then that could very well be a different matter. I can envisage a scenario in which an ACLR model benefited from knowledge of third-order operating point (OIP3) information for a transmitter’s power amplifier. This could provide the advantage of eliminating the need to calculate a cost function, $J_1$, as referred to in equation 4 of MEDIATEK. However, in the present application, the ACLR modelling feature is simply not claimed or even disclosed in sufficient detail to bring out any advantages it may provide.

85 Claim 1 is narrower than claim 17, as it includes the additional limitation that the digital observation signal is generated from a radio frequency observation signal which is based on observation of a cellular transmit signal. There is no suggestion in MEDIATEK that baseband signal s[n] is derived from a radio frequency signal. Therefore, I will consider the output of ADC 1230 to be equivalent to the digital observation signal of claim 1. This is generated from an RF cellular signal output from power amplifier 1233.

86 However, as acknowledged in my analysis of GB2106633.7, the output of ADC 1230 is used as the input $r_2[n]$ to the noise suppression device of Figure 5, rather than the input $r_1[n]$. Therefore, the second estimating device 560 estimates an amount of aggressor spectral regrowth present in digital observation data, rather than in an incoming radio frequency receive signal. This provides a second difference at step 3 of the *Pozzoli* test, in addition to the first difference identified above.

87 However, as explained in my analysis of GB 2106633.7, I believe it would be obvious to reverse the inputs to $r_1[n]$ and $r_2[n]$ in the light of the common general knowledge

in the art. As I consider each of the differences to be obvious, and there is no synergy between them, I conclude that they remain obvious even when considered in the same claim. I therefore conclude that independent apparatus claim 1, and corresponding method claim 9, also fail to provide an inventive step over MEDIATEK.

GB2213632.9 (Compensating cellular receive signal for spectral regrowth caused by WLAN leakage)

NOVELTY

88 For this application, the pre-hearing report indicates that the examiner considers each of the independent claims to lack novelty over EP 2637313 (MEDIATEK). However, the attorney's letter dated 27 January 2023 argues that this citation fails to disclose "processing the digital observation data to determine an estimated amount of aggressor spectral regrowth present in the radio frequency cellular receive signal using a spectral regrowth modelling circuit of the cellular transceiver" (attorney's emphasis). I will consider first whether claim 19 is novel, as that is the broadest claim in this application.

89 Here, I can make use of my earlier analysis from GB 2213631.1. It is Case 1 of MEDIATEK (an LTE module receiving while a Wi-Fi module transmits) which is relevant to the present application. Case 1 is described from paragraph 38 of MEDIATEK. The diversity capability of an LTE transceiver is sacrificed to provide suppression of transmit noise from a Wi-Fi module. A signal, $r_1[n]$, received at one of the LTE module's antennas is filtered to produce a filtered signal, f[n], and a signal, $r_2[n]$, received at the other of LTE module's antennas is subtracted from the filtered signal. With appropriate selection of coefficients for the filter, this allows transmit leakage from the Wi-Fi module to be compensated for. In the reference-based approach ("Method 1") of paragraphs 45-52 and Figure 5, a baseband signal, s[n], transmitted by the interfering Wi-Fi module is used as a reference signal in the selection of the filter coefficients. The baseband signal s[n] is equivalent to the "digital observation data from a wireless local area network transceiver" of claim 19 of the present application. Furthermore, as will be discussed further below, MEDIATEK's signal $r_1[n]$ can be considered equivalent to the digital baseband cellular signal of claim 19.

90 In my earlier analysis for GB 2106633.7, I explained why I regarded the estimation of the intermodulation distortion, $X^{\wedge}_{IM}[n]$, within the signal $r_1[n]$[10] to be a form of spectral regrowth modelling which makes use of the observation signal s[n]. Furthermore, the subtractor 530 of Figure 5 of MEDIATEK compensates for RF signal leakage based on the amount of intermodulation distortion/spectral regrowth, the latter being used to control the filter 510. Figure 5 thus discloses all the features of the spectral regrowth modelling circuit of claim 19.

91 In my analysis of GB 2213631.1, I explained why I considered it was implicit that the baseband processing device 1260 of Figure 12 of MEDIATEK would perform the

[10] See paragraphs 46-48 of EP2637313

transmission noise suppression described at paragraphs 38-50 and Figure 5 of the same document. It follows that ADC 1225 outputs the signal $r_1[n]$. Figure 12 confirms this is a digital baseband signal derived from a radio frequency cellular receive signal by down-conversion at mixer 1223.

92 I have thus demonstrated that MEDIATEK discloses each of the features of claim 19. I therefore conclude that claim 19 is not novel.

93 Claim 1 is narrower than claim 19, additionally specifying that the WLAN digital observation data must be generated from a **RF** WLAN transmit signal. In the examiner's view, the reference path 1539/1500 is used in generating such WLAN digital observation data. Incidentally, this reference path is very similar to the reference path 1239/1228/1229/1230 of Figure 12. However, these reference paths derive digital observation data from a RF **cellular** transmit signal output from power amplifier 1233, and not from a RF Wi-Fi/WLAN transmit signal.

94 In the pre-hearing, report the examiner acknowledges that Figures 12 and 15 are concerned with cancelling transmit leakage from LTE (Case 2) but argues that paragraphs 80 and 81 of MEDIATEK suggest that the techniques disclosed in these Figures are also applicable to the "reverse" operation (i.e. Case 1). To me, paragraph 80 is merely suggesting that the noise suppression system of Case 1 can form the basis for a noise suppression device in Case 2, which doesn't seem relevant to the question of the direction of the reference path. However, the first two sentences of paragraph 81 of MEDIATEK require more careful consideration. These read:

"*In yet another embodiment, the reference path 1500 may belong to one of the circuits 1510 and 1520, i.e., the mixer 1528, the low pass filter 1529 and the analog to digital converter 1530 may be a part of a WiFi receiving path or a part of a LTE receiving path. In other words, the proposed architecture can be applied to any number of antennas/receiving paths with slight modifications.*"

95 I can appreciate why the examiner has interpreted these sentences as disclosing a RF based WLAN/Wi-Fi observation signal. However, I think it is more likely that the intention here was to suggest that if the Wi-Fi circuit has two antennas and two receive chains, then rather than "borrowing" a receive chain[11] from the cellular module (as in Figure 12), the Wi-Fi module can use one of its own receive chains to implement the reference path 1500 (from cellular to Wi-Fi). I certainly don't think these sentences can be taken as an unambiguous disclosure of a reference path 1500 from the Wi-Fi circuit to the cellular circuit 1520. The remaining sentences of paragraph 81 describe the situation where there are multiple reference paths 1500 from the cellular circuit to the Wi-Fi circuit.

96 I consider the baseband signal s[n] to be an observation signal derived from a Wi-Fi transmit signal but I can find no disclosure in MEDIATEK that it is derived from a *RF* signal. The signal s[n] could be taken from the Wi-Fi front end prior to upconversion to RF. I therefore conclude that claim 1 is novel over MEDIATEK. Applying similar analysis to claim 10, I find that claim 10 is also novel over MEDIATEK.

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[11] EP2637313 (MEDIATEK), paragraph 68

INVENTIVE STEP

97 I now need to decide whether claims 1 and 10 provide an inventive step over MEDIATEK. I shall, of course, start by applying the *Windsurfing/Pozzoli* test to the invention of claim 1.

98 In step 1 of the test, I will take the skilled person to be as I previously defined them above. Such a skilled person would also be considered to have some general awareness of common mobile phone hardware features. In this case, I consider the relevant common general knowledge of the skilled person to include an understanding that mobile phones generally included both a cellular communication capability and a Wi-Fi communication capability. They would also appreciate that, at the filing date, mobile phones commonly included 4 cellular antennas to provide a 4-stream multi-input-multi-output (4x4 MIMO) capability[12] [13] for efficient operation in 4G LTE networks. The skilled person would also appreciate that, at the priority date, mobile phones could include a single Wi-Fi antenna, or a pair of Wi-Fi antennas, the latter providing a 2-stream (2x2 MIMO) capability for Wi-Fi.

99 Turning now to the second step of the test, claim 1 does not require any special construction. I note only that, as previously discussed for the other applications, a literal construction of "spectral regrowth modelling circuit" can apply, with the caveat that this feature cannot refer solely to the distortion generation circuit 434/mixer 435 of the present application because the distortion generation circuit estimates distortion present in the transmit signal.

100 From my assessment of novelty above, it should be apparent that the difference between the invention of claim 1 and MEDIATEK is that the latter discloses digital observation data, s[n], generated from a WLAN transmit signal, rather than from an RF WLAN transmit signal.

101 In the final step of the test, I must decide whether this difference is obvious. When assessing claim 19, I indicated that the baseband signal s[n] could be considered equivalent to the digital observation data of claim 19. However, it seems unlikely to me that a skilled person would consider it obvious to generate this from a RF WLAN signal, as there is no disclosure in MEDIATEK of a WLAN RF observation signal and using a baseband signal generated from RF would add distortion.

102 I will now consider whether it would be obvious to reverse the direction of the reference path 1500 of Figure 15 of MEDIATEK. This reference path is very similar to the reference path defined by the circuit elements 1228/1229/1230 of Figure 12 of the same document but, in the embodiment of Fig. 15, need not be borrowed from the cellular receiver (see paragraph 79). If reversed, the reference path 1500 would provide a RF WLAN observation signal.

103 It is useful to step back from the disclosure of Figure 15 and look at the teachings of MEDIATEK more broadly. These are summarised in paragraph 84 of the document:

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[12] Pixel phone hardware tech specs - Pixel Phone Help (google.com) – Pixel 3 specifications
[13] iPhone XS - Technical Specifications (UK) (apple.com)

“*According to an embodiment of the invention, when the radio module operating in downlink mode is equipped with at least two antennas, the first signals and the second signals may both be the downlink signals received by the radio module operating in the downlink mode (for example, respectively received via different antennas of the radio module). However, when the radio module operating in downlink mode is equipped with only one antenna, the first signals may be the downlink signals received by the radio module operating in the downlink mode and the second signals may be a portion of the uplink signals received from another radio module operating in the uplink mode (as in the antenna borrowing scheme illustrated in case 2).*”

104 In short, paragraph 84 teaches that if a victim radio module has multiple antennas, then interference should be cancelled using signals received at that radio module’s antennas, without any RF reference signal (Case 1). However, if the radio module has a single antenna only, it is necessary to cancel interference using a RF reference signal from the aggressor radio module (Case 2). The skilled person, presented with MEDIATEK, would have in their mind the problem of cancelling interference in a cellular transceiver and not the narrower problem of cancelling interference in a single-antenna cellular receiver. They would appreciate that cellular transceivers generally had multiple antennas. *Prima facie*, paragraph 84 would therefore direct the skilled person to apply Case 1. Case 1 does not involve a reference path 1500 for communicating an RF observation signal.

105 On the other hand, the last part of paragraph 81 would seem to contradict the guidance of paragraph 84, as it suggests that when a Wi-Fi module with multiple antennas is the victim receiver, it may still cancel interference using reference paths from a cellular transceiver, to preserve the Wi-Fi module’s diversity capability. Would paragraph 81 motivate the skilled person to provide one or more RF reference paths in the opposite direction, from Wi-Fi to cellular, to preserve the cellular transceiver’s full diversity capability? As there would typically be fewer Wi-Fi antennas than cellular antennas in a device, there is less scope for “borrowing” receive chains for use in reference paths when the cellular receiver is the victim. It would therefore likely be necessary to provide one or more dedicated receive chains to process a Wi-Fi to cellular RF reference signal, as is the case in the Figure 6 of the present application. This could deter the skilled person from reversing the direction of the reference path if this disadvantage outweighed the advantage of preserving full diversity capability.

106 Taking all the above into account, I have decided that, on balance, it would not be obvious for the skilled person to reverse the direction of the reference path 1500 of MEDIATEK. Case 1 of this document provides a credible solution to the problem of coexistence interference, as it affects a cellular receiver, and in my view the skilled person would be unlikely to look beyond the guidance of paragraph 84. I therefore conclude that independent claims 1 and 10 are inventive over MEDIATEK.

GB2212005.9 (Using discrete time cancellation to compensate a cellular receive signal for spectral regrowth caused by WLAN leakage)

107 For this application, the pre-hearing report indicates that the examiner considers each of the independent claims to lack an inventive step over EP 2637313 A1 (MEDIATEK). The other documents cited in that report are provided to illustrate the common general knowledge, as the examiner sees it.

108 In the above analysis of GB 2106631.1, I explained why I regarded MEDIATEK as disclosing that, in a Case 1 operating mode, the baseband processing device 1260, operates as a discrete-time circuit to perform Tx noise suppression to compensate a cellular digital baseband receive signal from ADC 1225 for Wi-Fi transmit leakage using digital observation data s[n]. Furthermore, it should be clear from my analysis of claim 19 of GB2213632.9 above that MEDIATEK also discloses all the remaining features of claim 16 of the present application, including the compensation involving spectral regrowth modelling. In the light of my earlier analysis for GB 2106631.1 and GB 2213632.9 I thus conclude that claim 16 of GB2212005.9 lacks novelty over MEDIATEK.

109 Claims 1 and 10 of the present application each require that the digital observation data is generated from a RF WLAN signal. When I analysed GB2213632.9, above, I decided that this feature was not known or obvious from MEDIATEK. I therefore conclude that claims 1 and 10 of GB2212005.9 are novel and inventive.

110 I do note however that, as reasoned above, “discrete time cancellation” is implicit in each of the independent claims, due to their use of digital signals. Therefore, prima facie, claim 1, 10 and 16 of GB2212005.9 conflict with claims 1, 10 and 19 of GB2213632.9 respectively, contrary to Section 18(5) of the Act.

**Dependent Claims**

111 I will now consider the dependent claims of each application to see if any of them contain the necessary inventive step.

112 As I have decided that independent claims 1 and 10 of GB2213632.9 are novel and inventive, I need only assess claim 20, which is dependent on claim 19. Claim 20 relates to determining spectral regrowth based on modelling ACLR. In my analysis of the independent claims of GB2217377.7, I explained that I did not consider modelling using ACLR to provide an inventive step. Consequently, claim 20 of GB 2213632.9 also lacks an inventive step.

113 Similarly, I need only consider dependent claims 17-20 of GB 2212005.9. Claim 17 corresponds to claim 20 of GB 2213632.9 and so, applying the analysis of the previous paragraph, I conclude claim 17 lacks an inventive step. The cellular transmit path 1237/1236/1235/1233/1232/1231 of Figure 12 of MEDIATEK anticipates the additional features of claim 18 and the reference path 1239/1228/1229/1230 anticipates the additional features of claims 19 and 20. Thus these claims lack novelty.

114 Turning now to GB 2213631.1, it seems common ground between the examiner and the applicant that US 2014/269858 *(LUKASHEVICH)* is not concerned with spectral regrowth; it must therefore be concerned with direct leakage, as claimed in claim 2. It should be clear from my analysis of GB2106633.7 why I consider the additional features of claim 3 to be anticipated by EP 2637313 A1 (MEDIATEK). The analysis of the two preceding paragraphs is relevant to claim 4. Regarding claim 5, a RF observation signal is coupled from circuit 902 of Figure 9 of *LUKASHEVICH* from between the power amplifier 905 and transmission means 915 connected to an antenna. There is no inventive merit in specifying this coupling is achieved by a directional coupler; directional couplers were common general knowledge in the art. Claims 5 and 6 therefore lack an inventive step over *LUKASHEVICH*. Similarly, the coupling between power amplifier 1233 and ANT-Prim of Figure 12 of MEDIATEK is likewise relevant to claims 5 and 6.

115 *LUKASHEVICH* does not disclose any WLAN embodiments. However, the examiner has argued that claims 7 and 8 of GB 2213631.1 lack an inventive step because WLAN and cellular were very well-known radio access technologies. I agree that WLAN and cellular communications were ubiquitous, but there is no evidence to suggest the cancellation of transmit leakage between co-located WLAN and cellular communications modules was common general knowledge at the priority date. I therefore conclude claims 7 and 8 are novel and inventive over *LUKASHEVICH*. However, Figure 12 of MEDIATEK discloses the additional features of claim 8. Claim 7 claims that the first front end system is a cellular front-end system whilst the second front end system is a Wi-Fi front end system. In the light of my analysis of GB2213632.9 I conclude that claim 7 is novel and inventive over MEDIATEK. Claims 10-12 and 14-16 do not introduce any new features which have not already been discussed. I therefore conclude that only claim 7 of GB 2213631.1 is novel and inventive with respect to the citations.

116 Similarly, the additional features of claim 8 of GB 2106631.1 correspond to the additional features of claim 7 of GB 2213631.1. I conclude that only claim 8 of GB 2106631.1 is novel and inventive over both *LUKASHEVICH* and MEDIATEK. Figure 9 of *LUKASHEVICH* shows an RF observation path 950 in each circuit 901, 902, thus disclosing the additional digital observation data signal of claim 10.

117 In the case of GB 2106633.7, I need only consider whether the dependent claims are novel and inventive with respect to MEDIATEK. In their pre-hearing report, the examiner suggests that paragraph 50 discloses direct transmit leakage. That paragraph discloses that transmit noise may be modelled alongside inter-modulation distortion. However, I am far from convinced that transmit noise can be considered equivalent to direct transmit leakage, as described at paragraphs 73 and 74 of the present application. I believe the direct transmit leakage would be understood to be interference (not noise) with a well-defined bandwidth. The term “noise” would seem to imply less structure and more randomness to the signal. I therefore conclude that claim 2 is novel and inventive over MEDIATEK.

118 Claim 6 of GB 2106633.7 claims that the first front end system is a cellular front-end system whilst the second front end system is a Wi-Fi front end system. In the light of my analysis of GB2213632.9 I conclude that claim 6 is novel and inventive over MEDIATEK. I consider the baseband signal s[n] used in Case 1 of MEDIATEK to correspond to the second baseband receive signal of claim 8. However, this

baseband signal is not derived from an RF signal so I conclude that claim 9 is novel and inventive. Claims 10 and 11 are dependent on claim 9. I thus conclude that dependent claims 2, 6 and 9-11 of GB 2106633.7 are novel and inventive whilst claims 3-5, 8, 13, 14, 16 and 17 are not.

119 Finally, I conclude that dependent claim 3 of GB2217377.7, which relates to observing direct transmit leakage, is novel and inventive over MEDIATEK, but the remaining dependent claims are not.

**Decision**

120 I have decided that the independent claims of GB 2213631.1 are not novel. Of this application's dependent claims, I consider only claim 7 to be both novel and inventive over the cited prior art.

121 Similarly, the independent claims of GB 2106631.1 are not novel and I consider only dependent claim 8 to be both novel and inventive over the cited documents.

122 I have decided that the independent claims of GB 2106633.7 are novel, but do not provide the necessary inventive step. In my view, only claims 2, 6, and 9-11 of GB 2106633.7 are both novel and inventive.

123 The independent claims of GB2217377.7 are novel but, again, lack an inventive step. In my view, only claim 3 of GB2217377.7 is novel and inventive.

124 I have decided that independent claims 1 and 10 of GB 2213632.9 are novel and inventive over the cited prior art. However, I decide that independent claim 19 and dependent claim 20 are not novel.

125 Finally, I consider independent claims 1 and 10 of GB 2212005.9 to be novel and inventive. However, I find that independent claim 16 and dependent claims 18-20 are not novel. Furthermore, I find that claim 17 lacks an inventive step. Additionally, there may be claim conflict, under Section 18(5), between GB 2213632.9 and GB 2212005.9.

126 In each of the six applications, those claims which I consider to be novel and inventive over the cited prior art claim either i) generation of digital observation data which indicates both an amount of spectral regrowth and an amount of direct transmit leakage or ii) compensation of a cellular receive signal for leakage from a WLAN transmission.

127 Having identified allowable claims in each application, I remit all 6 applications back to the examiner to allow the applicants the opportunity to amend suitably. If they do not do so before the expiry of the relevant compliance periods then the applications may be refused.

**Appeal**

128 Any appeal must be lodged within 28 days after the date of this decision.

**Dr Stephen Brown**

Deputy Director, acting for the Comptroller

**Annex – Independent claims**

GB2213631.1 (Compensation in each transceiver)

*1. A mobile device comprising:*

*a plurality of antennas including a first antenna and a second antenna;*

*a plurality of front end systems including a first front end system and a second front end system, the first front end system configured to receive a radio frequency receive signal from the first antenna, the second front end system configured to provide a radio frequency transmit signal to the second antenna and to generate a radio frequency observation signal based on observing the radio frequency transmit signal; and*

*a plurality of transceivers including a first transceiver and a second transceiver, the second transceiver configured to process the radio frequency observation signal to generate first digital observation data for the first transceiver, the first transceiver configured to process the radio frequency receive signal to generate a baseband receive signal, and to compensate the baseband receive signal for an amount of radio frequency signal leakage indicated by the first digital observation data, the second transceiver being configured to compensate a second baseband receive signal for radio frequency signal leakage based on second digital observation data from the first transceiver.*

*9. A radio frequency communication system comprising:*

*a first front end system configured receive a first incoming radio frequency receive signal and to output a first outgoing radio frequency transmit signal;*

*a second front end system configured to receive a second incoming radio frequency receive signal and to output a second outgoing radio frequency transmit signal, the second front end system further configured to generate a radio frequency observation signal based on observing the second outgoing radio frequency transmit signal;*

*a first transceiver configured to downconvert the first incoming radio frequency receive signal to generate a first baseband receive signal, and to compensate the first baseband receive signal for radio frequency signal leakage based on first digital observation data;*

*and a second transceiver configured to generate the first digital observation data based on processing the radio frequency observation signal, the second transceiver being configured to compensate a second baseband receive signal for radio frequency signal leakage based on second digital observation data from the first transceiver*

*13. A method of coexistence management in a mobile device, the method comprising:*

*providing a radio frequency receive signal from a first front end system to a first transceiver;*

*generating a radio frequency transmit signal and a radio frequency observation signal using a second front end system, the radio frequency observation signal generated based on observing the radio frequency transmit signal;*

*generating first digital observation data based on the radio frequency observation signal using a second transceiver;*

*downconverting the radio frequency receive signal to generate a baseband receive signal using the first transceiver;*

*compensating the baseband receive signal for radio frequency signal leakage based on the first digital observation data using the first transceiver; and*

*compensating a second baseband receive signal for radio frequency signal leakage based on second digital observation data from the first transceiver using a second transceiver.*

<u>GB2106631.1 (Discrete time cancellation)</u>

*1. A mobile device comprising:*

*a first antenna and a second antenna;*

*a first front end system coupled to the first antenna;*

*a first transceiver configured to generate a first digital baseband receive signal based on processing a radio frequency receive signal received from the first antenna through the first front end system, the first transceiver including a discrete time cancellation circuit configured to compensate the first digital baseband receive signal for radio frequency signal leakage based on digital observation data;*

*a second front end system coupled to the second antenna, and configured to generate a radio frequency observation signal based on observing a radio frequency transmit signal; and*

*a second transceiver configured to process the radio frequency observation signal to generate the digital observation data, and to provide the digital observation data to the first transceiver.*

*14. A transceiver comprising:*

*a receive channel configured to process a radio frequency receive signal to generate a digital baseband receive signal;*

*an observation channel configured to process a radio frequency observation signal to generate a digital observation signal;*

*a baseband sampling circuit configured to sample the digital observation signal to generate first digital observation data;*

*an output configured to output the first digital observation data;*

*an input configured to receive second digital observation data; and*

*a discrete time cancellation circuit configured to compensate the digital* *baseband receive signal for radio frequency signal leakage based on the second digital observation data.*

*17. A method of coexistence management in a mobile device, the method comprising:*

*providing a radio frequency receive signal from a first front end system to a first transceiver;*

*processing the radio frequency receive signal to generate a first digital baseband receive signal using the first transceiver;*

*compensating the first digital baseband receive signal for radio frequency signal leakage based on digital observation data using a discrete time cancellation circuit of the first transceiver;*

*generating a radio frequency observation signal based on observing a radio frequency transmit signal using a second front end system; and*

*processing the radio frequency observation signal to generate the digital observation data using a second transceiver.*

GB2106633.7 (Spectral Regrowth)

*12. A radio frequency communication system comprising:*

*a first front end system configured receive a first incoming radio frequency receive signal and to output a first outgoing radio frequency transmit signal;*

*a second front end system configured to receive a second incoming radio frequency receive signal and to output a second outgoing radio frequency transmit signal, the second front end system further configured to generate a radio frequency observation signal based on observing the second outgoing radio frequency transmit signal;*

*a first transceiver configured to downconvert the first incoming radio frequency receive signal to generate a first baseband receive signal, and to compensate the first baseband receive signal for radio frequency signal leakage based on digital observation data, the first transceiver including a spectral regrowth modeling circuit configured to estimate an amount of aggressor spectral regrowth present in the first incoming radio frequency receive signal based on the digital observation data; and*

*a second transceiver configured to generate the digital observation data based on processing the radio frequency observation signal.*

GB2217377.7 (ACLR Modelling of Spectral Regrowth)

*1. A mobile device comprising:*

*a cellular front end system configured to generate a radio frequency observation signal based on observing a cellular transmit signal;*

*a cellular transceiver configured to process the radio frequency observation signal to generate digital observation data; and*

*a wireless local area network transceiver configured to generate a digital wireless local area network receive signal based on processing a radio frequency wireless local area network receive signal, the wireless local area network transceiver including a spectral regrowth modeling circuit configured to process the digital observation data to determine an estimated amount of aggressor spectral regrowth present in the radio frequency wireless local area network receive signal, and to compensate the digital wireless local area network receive signal for radio frequency signal leakage based on the estimated amount of aggressor spectral regrowth,*

*the spectral regrowth modeling circuit being configured to determine the estimated amount of aggressor spectral regrowth based on modeling adjacent channel leakage ratio using predistortion,*

*17. A wireless local area network transceiver comprising:*

*a wireless local area network receive channel configured to process a radio frequency wireless local area network receive signal from a wireless local area network*

*front end system to generate a digital wireless local area network receive signal;*

*an input configured to receive digital observation data from a cellular transceiver; and*

*a spectral regrowth modeling circuit configured to process the digital observation data to determine an estimated amount of aggressor spectral regrowth present in the radio frequency wireless local area network receive signal, and to compensate the digital wireless local area network receive signal for radio frequency signal leakage based on the estimated amount of aggressor spectral regrowth,*

*the spectral regrowth modeling circuit being configured to determine the estimated amount of aggressor spectral regrowth based on modeling adjacent channel leakage ratio using predistortion.*

GB2213632.9 (Compensating cellular receive signal for spectral regrowth caused by WLAN leakage)

*1. A mobile device comprising:*

*a wireless local area network front end system configured to generate a radio frequency observation signal based on observing a wireless local area network transmit signal;*

*a wireless local area network transceiver configured to process the radio frequency observation signal to generate digital observation data; and a cellular transceiver configured to generate a digital baseband cellular receive signal based on processing a radio frequency cellular receive signal, the cellular transceiver* *including a spectral regrowth modeling circuit configured to process the digital observation data to determine an estimated amount of aggressor spectral regrowth present in the radio frequency cellular receive signal, and to compensate the digital baseband cellular receive signal for radio frequency signal leakage based on the estimated amount of aggressor spectral regrowth.*

*19. A cellular transceiver comprising:*

*a cellular receive channel configured to process a radio frequency cellular receive signal from a cellular front end system to generate a digital baseband cellular signal;*

*an input configured to receive digital observation data from a wireless local area network transceiver; and*

*a spectral regrowth modeling circuit configured to process the digital observation data to determine an estimated amount of aggressor spectral regrowth present in the radio frequency cellular receive signal, and to compensate the digital baseband cellular receive signal for radio frequency signal leakage based on the estimated amount of aggressor spectral regrowth.*

<u>GB2212005.9 (Using discrete time cancellation to compensate a cellular receive signal for spectral regrowth caused by WLAN leakage)</u>

*1. A mobile device comprising:*

*a wireless local area network front end system to generate a radio frequency observation signal based on observing a wireless local area network transmit signal;*

*a wireless local area network transceiver configured to process the radio frequency observation signal to generate digital observation data; and*

*a cellular transceiver configured to generate a digital baseband cellular receive signal based on processing a radio frequency cellular receive signal, the cellular transceiver including a discrete time cancellation circuit configured to compensate the digital baseband cellular receive signal for radio frequency signal leakage based on the digital observation data, the discrete time cancellation circuit including a spectral regrowth modeling circuit configured to estimate an amount of aggressor spectral regrowth present in the radio frequency cellular receive signal based on the digital observation data.*

*16. A cellular transceiver comprising:*

*a cellular receive channel configured to process a radio frequency cellular receive signal from a cellular front end system to generate a digital cellular baseband receive signal;*

*an input configured to receive digital wireless local area network observation data from a wireless local area network transceiver; and*

*a discrete time cancellation circuit configured to compensate the digital cellular baseband receive signal for radio frequency signal leakage based on the digital wireless local area network observation data, the discrete time cancellation circuit including a spectral regrowth modeling circuit configured to estimate an amount of aggressor spectral regrowth present in the radio frequency cellular receive signal based on the digital wireless local area network observation data.*