

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

LG ELECTRONICS INC.,

Petitioner,

v.

PANTECH CORPORATION,

Patent Owner.

Case IPR2023-01269

U.S. Patent No. 9,854,545

**DECLARATION OF DANIEL VAN DER WEIDE
IN SUPPORT OF PETITION FOR *INTER PARTES* REVIEW
OF U.S. PATENT NO. 9,854,545**

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I. INTRODUCTION

1. I have been retained by LG Electronics Inc. (I will refer to it as “LGE”) to provide my opinions on certain issues related to U.S. Patent No. 9,854,545 (the “’545 patent,” which I understand has been designated as Exhibit 1001) in connection with the above-captioned *inter partes* review (IPR) proceeding. I have been asked to provide my insights, analysis, and opinions regarding whether claims 2 and 3 of the ’545 patent (“Challenged Claims”) are obvious over the prior art references identified below and as to whether persons interested and ordinarily skilled in the subject matter or art exercising reasonable diligence could have located these references.

2. I understand the ’545 patent is titled “Apparatus and Method for Establishing Uplink Synchronization in a Wireless Communication System,” identifies as its named inventors Kibum Kwon, and Myungcheul Jung, and is currently owned by Pantech Corporation. I have considered the ’545 patent.

3. I understand that the file history of the ’545 patent has been designated as Exhibit 1002. I have considered this file history, and I will refer to it as the “’545 File History” or by its exhibit number.

4. I understand that the ’545 patent was filed as U.S. Patent Application 14/733,068 on June 8, 2015.

5. I have considered the following non-exhaustive list of references in preparing my declaration. I have been instructed to assume that each of these references qualifies as prior art.

- **U.S. Patent Application Publication No. 2011/0158116** to Tenny (“Tenny”), titled “Method and Apparatus that Facilitates a Timing Alignment in a Multicarrier System,” filed June 17, 2010 and published June 30, 2011. I understand that a copy of this reference has been designated as Exhibit 1005.
- **U.S. Provisional Application No. 61/218769** to Tenny (“Tenny-Prov.”), titled “Timing Alignment in a Multicarrier System,” filed June 19, 2009. I understand that a copy of this reference has been designated as Exhibit 1006.
- **R2-100423, *Supporting multiple timing advance groups* 3GPP TSG-RAN WG2#68 (dated January 18-22, 2010) (“Qualcomm”).** I understand that a copy of this reference has been designated as Exhibit 1007.
- **3GPP TS 36.300 v8.11.0 (2009-12) (“TS36.300”),** 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2 (Release 8). I understand that a copy of this reference has been designated as Exhibit 1008.
- **3GPP TS 36.331 v9.0.0 (2009-09) (“TS36.331”),** 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA) Radio Resource Control (RRC); Protocol specification (Release 9),. I understand that a copy of this reference has been designated as Exhibit 1009.
- **U.S. Patent Application Publication No. 2010/0260136** to Fan (“Fan”), titled “Random Access Channel Response Handling with Aggregated Component Carriers,” filed April 10, 2009 and published October 14,

2010. I understand that a copy of this reference has been designated as Exhibit 1010.

6. I understand that there is a pending district court litigation between Petitioner and Pantech (“LGE Litigation”) involving the ’545 patent.

7. I am being compensated by LGE at my standard hourly consulting rate of \$700 for my time on this matter. My compensation is not dependent on the outcome of this proceeding.

8. In forming my opinions, I relied on the documents cited in this declaration and the documents identified in the attached Appendix B. These documents comprise patents, file histories, printed publications, and other related documents. As discussed below, each document is a type that experts in my field would have reasonably relied upon when forming their opinions. Further, experts in my field would have had access to each document either through the applicable patent offices and/or well-known libraries, conferences, or publications in the field. My opinions are also based upon my personal and professional experience.

9. In parallel with this declaration, I have prepared declarations for IPR2023-01270. I also understand that declarations are being prepared by other experts in IPR2023-01267, IPR2023-01268, IPR2023-01271, IPR2023-01272, and IPR2023-01273. Due to overlap in subject matter and prior art references and similarities in corresponding analyses, I understand that some parts of my

declaration may bear superficial similarities to documents filed in these other IPRs, but all analysis and opinions presented herein are my own.

II. QUALIFICATIONS

10. I am qualified by education and experience to testify as an expert in the field of telecommunications. Attached as Appendix A to this declaration is a copy of my curriculum vitae detailing my education and experience. Additionally, the following overview of my background pertains to my qualifications for providing expert testimony in this matter.

11. I am a Full Professor in the Department of Electrical and Computer Engineering at the University of Wisconsin-Madison. I received my Bachelor of Science Degree in Electrical Engineering from the University of Iowa in 1987; my Master of Science Degree in Electrical Engineering from Stanford University in 1990; and my Ph.D. degree in Electrical Engineering from Stanford in 1993. I teach several courses in my area of expertise, which includes high frequency electrical measurement and communications systems and advanced high-frequency circuit design and measurement. Specifically, I perform research on digital radio and communications systems ranging from RFID tags to lightwave transceivers, with emphasis on wireless and microwave technology. My first full-time employment upon graduation was as an engineer with Motorola Inc. International Cellular

Subscriber division. The patents-in-suit refer generally to cell search and synchronization, which involve, among other techniques, sampling and coherent signal detection. I have built and published electronic circuits that have generated and measured the shortest pulses on record (480 fs @ 3.5V), and these results incorporate sampling and coherent signal detection. In addition, in 2007 I co-founded Optametra, a company developing and selling hardware and software for analysis of coherent communications in long-haul single mode optical fiber using many of the same techniques found in modern wireless communications, such as high-order modulation, forward error correction, and multicarrier transmission. Optametra sold its systems worldwide to many major telecommunications vendors and carriers—competing directly and successfully with Agilent Technologies (the major telecom test and measurement vendor)—and was acquired by Tektronix in 2012. Before and during the timeframe relevant to the ‘545 patent’s purported invention, I trained students in both analog and digital wireless communications techniques and standards, many of whom have been hired by Qualcomm, Google (formerly Motorola) and Skyworks. I am a Fellow of the IEEE.

12. I have previously testified as an expert witness in wireless telecommunications matters, as well as in matters related to adjacent wireless fields, such as RFID. Over the past two years, I’ve testified as an expert in more than twelve

proceedings, and several of these were in wireless telecommunications, including written testimony on 3G standards in HTC Corp. v. Telefonaktiebolaget LM Ericsson Case No. 23844/FS Arbitration, International Chamber of Commerce. I currently serve on the Working Group for the IEEE P1765 Modulated Signal Measurement Uncertainty standards-setting body.

III. LEGAL UNDERSTANDING

A. My Understanding of Claim Construction

13. I have been informed that patent claims are construed from the viewpoint of a person of ordinary skill in the art (POSITA) of the patent at the time of the invention. I have been informed that patent claims generally should be interpreted consistent with their plain and ordinary meaning as understood by a person of ordinary skill in the art in the relevant time period (*i.e.*, at the time of the purported invention, or the so called “effective filing date” of the patent application), after reviewing the patent claim language, the specification, and the prosecution history (*i.e.*, the intrinsic record).

14. I have further been informed that a person of ordinary skill in the art must read the claim terms in the context of the claim itself, as well as in the context of the entire patent specification. I understand that in the specification and prosecution history, the patentee may specifically define a claim term in a way that

differs from the plain and ordinary meaning. I understand that the prosecution history of the patent is a record of the proceedings before the U.S. Patent and Trademark Office and may contain explicit representations or definitions made during prosecution that affect the scope of the patent claims. I understand that an applicant may, during the course of prosecuting the patent application, limit the scope of the claims to overcome prior art or to overcome an examiner's rejection, by clearly and unambiguously arguing to overcome or distinguish a prior art reference, or clearly and unambiguously disavowing claim coverage.

15. In interpreting the meaning of the claim language, I understand that a person of ordinary skill in the art may also consider "extrinsic" evidence, including expert testimony, inventor testimony, dictionaries, technical treatises, other patents, and scholarly publications. I understand this evidence is considered to ensure that a claim is construed in a way that is consistent with the understanding of those of ordinary skill in the art at the time of the claimed invention. For example, this can be useful for a technical term whose meaning may differ from its ordinary English meaning. I understand that extrinsic evidence may not be relied on if it contradicts or varies the meaning of claim language provided by the intrinsic evidence, particularly if the applicant has explicitly defined a term in the intrinsic record.

B. My Understanding of Anticipation

16. I understand that a patent claim is invalid as “anticipated” if all of the limitations of the claim are present, either expressly or inherently, in a single previous device, or described, either expressly or inherently, in a single prior art publication or patent. I understand that, in the relevant time period, 35 U.S.C. § 102 stated that a person shall be entitled to a patent unless, among other bases:

- The invention was known or used by others in this country, or patented or described in a printed publication in this or a foreign country, before the invention thereof by the applicant for patent, or
- The invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of the application for patent in the United States, or
- The invention was described in—(1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section

351(a) shall have the effects for the purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

17. I also understand that a prior art reference can disclose a claimed feature because the feature is expressly described or because the feature is inherent in the disclosure. I understand that something is inherent in a prior art reference if the missing descriptive matter must necessarily be present, not merely probably or possibly present, and it would be so recognized by a person of ordinary skill in the art as of the priority date of the patent. I understand that it is acceptable to examine evidence outside of the prior art reference (i.e., extrinsic evidence) in determining whether a feature, while not expressly discussed in the reference, is necessarily present in it.

C. My Understanding of Obviousness

18. I understand that a claim may be invalid if the subject matter described by the claim as a whole would have been obvious to a hypothetical person of ordinary skill in the art in view of a prior art reference or in view of a combination of references at the time the claimed invention was made. Therefore, I understand that obviousness is determined from the perspective of a hypothetical person of

ordinary skill in the art and that the asserted claims of the patent should be read from the point of view of such a person at the time the claimed invention was made. I further understand that a hypothetical person of ordinary skill in the art is assumed to know and to have all relevant prior art in the field of endeavor covered by the patent in suit.

19. I have been informed that there are two criteria for determining whether prior art is analogous and thus can be considered prior art: (1) whether the art is from the same field of endeavor, regardless of the problem addressed, and (2) if the reference is not within the field of the patentee's endeavor, whether the reference still is reasonably pertinent to the particular problem with which the patentee is involved. I have also been informed that the field of endeavor of a patent is not limited to the specific point of novelty, the narrowest possible conception of the field, or the particular focus within a given field. I have also been informed that a reference is reasonably pertinent if, even though it may be in a different field from that of the patentee's endeavor, it is one which, because of the matter with which it deals, logically would have commended itself to a patentee's attention in considering their problem.

20. I have also been advised that an analysis of whether a claimed invention would have been obvious should be considered in light of the scope and content of

the prior art, the differences (if any) between the prior art and the claimed invention, and the level of ordinary skill in the pertinent art involved. I understand as well that a prior art reference should be viewed as a whole.

21. I have also been advised that in considering whether a claimed invention could be obvious over a combination of prior art references, I may assess whether there are apparent reasons to combine known elements in the prior art in the manner claimed in view of interrelated teachings of multiple prior art references, the effects of demands known to the design community or present in the marketplace, and/or the background knowledge possessed by a person of ordinary skill in the art. I understand that other principles may be relied on in evaluating whether a claimed invention would have been obvious, and that these principles include the following:

- A combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results;
- When a device or technology is available in one field of endeavor, design incentives and other market forces can prompt variations of it, either in the same field or in a different one, so that if a person of ordinary skill can implement a predictable variation, the variation is likely obvious;
- If a technique has been used to improve one device, and a person of ordinary skill in the art would recognize that it would improve similar devices in the same way, using the technique is obvious unless its actual application is beyond their skill;
- An explicit or implicit teaching, suggestion, or motivation to combine two prior art references to form the claimed combination may demonstrate obviousness, but proof of

- obviousness does not depend on or require showing a teaching, suggestion, or motivation to combine;
- Market demand, rather than scientific literature, can drive design trends and may show obviousness;
 - In determining whether the subject matter of a patent claim would have been obvious, neither the particular motivation nor the avowed purpose of the named inventor controls whether the claim is obvious;
 - One of the ways in which a patent's subject can be proved obvious is by noting that there existed at the time of invention a known problem for which there was an obvious solution encompassed by the patent's claims;
 - Any need or problem known in the field of endeavor at the time of invention and addressed by the patent can provide a reason for combining the elements in the manner claimed;
 - "Common sense" teaches that familiar items may have obvious uses beyond their primary purposes, and in many cases a person of ordinary skill will be able to fit the teachings of multiple patents together like pieces of a puzzle;
 - A person of ordinary skill in the art is also a person of ordinary creativity, and is not an automaton;
 - A patent claim can be proved obvious by showing that the claimed combination of elements was "obvious to try," particularly when there is a design need or market pressure to solve a problem and there are a finite number of identified, predictable solutions such that a person of ordinary skill in the art would have had good reason to pursue the known options within his or her technical grasp; and
 - One should be cautious of using hindsight in evaluating whether a claimed invention would have been obvious.

22. I further understand that, in making a determination as to whether the claimed invention would have been obvious to a person of ordinary skill, the Board may consider certain objective factors if they are present, such as: commercial success of products practicing the claimed invention; long-felt but unsolved need;

teaching away; unexpected results; copying; and praise by others in the field. These factors are generally referred to as “secondary considerations” or “objective indicia” of nonobviousness. I understand, however, that for such objective evidence to be relevant to the obviousness of a claim, there must be a causal relationship (called a “nexus”) between the claim and the evidence, and that this nexus must be based on a novel element of the claim rather than something in the prior art. I also understand that even when they are present, secondary considerations may be unable to overcome primary evidence of obviousness (such as motivation to combine with predictable results) that is sufficiently strong.

D. My Understanding of Written Description and Enablement

23. I understand that the written description and enablement requirements are set forth in Pre-AIA 35 U.S.C. §112. This section provides:

The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same, and shall set forth the best mode contemplated by the inventor of carrying out his invention.

24. I have been informed that to have an adequate written description, the patent must convey with reasonable clarity to a person skilled in the art that, as of the filing date sought, the named inventor was in possession of the invention.

25. I have also been advised that, to demonstrate possession of the invention, the specification must permit a person with ordinary skill in the art to visualize or recognize the identity of the subject matter purportedly described. Although the specification need not describe the claimed subject matter verbatim to demonstrate possession of the invention, generalized language will not suffice if it does not convey the detailed identity of an invention.

26. I have also been advised that, to have an adequate written description, each limitation of the claimed invention must be disclosed expressly or inherently in the specification. It is not sufficient that the missing claim limitation may be obvious from the specification.

27. To be an enabling disclosure, the specification must adequately disclose to a person skilled in the art how to make or carry out the claimed invention without undue experimentation.

28. The omission of minor details from a patent specification's written description does not cause the specification to fail to meet the enablement requirement. However, when there is no disclosure of any specific starting material or of any of the conditions under which a process can be carried out, undue experimentation is required and there is a failure to meet the enablement requirement

that cannot be rectified by asserting that all the disclosure related to the process is within the skill of the art.

E. My Understanding of the Priority Date of a Patent for Prior Art Purposes

29. I understand that for a prior art patent or patent application to be entitled to the priority date of a provisional application to which that patent or patent application claims priority, the specification of the provisional must contain a written description of the invention and the manner and process of making and using it, in such full, clear, concise, and exact terms, to enable a person of ordinary skill in the art to practice the invention claimed in the non-provisional application. To satisfy this requirement, I understand that the disclosure of the provisional application must provide enabling written description support for both the claims of the patent and the subject matter of the patent relied upon for prior art purposes.

30. My understanding is that, similarly, a patent can claim priority to an earlier filing date of a foreign patent application if the patent expressly claims the benefit of the earlier filing date, and if disclosure of the foreign patent application provides support for the claims of the patent. I also understand, however, that a patent reference cannot claim the benefit of a filing date of a foreign priority document to establish the patent as prior art.

IV. BACKGROUND OF THE TECHNOLOGY

31. The '545 patent is generally directed to “a method and apparatus for establishing an uplink (UL) synchronization in a wireless communication system,” and more specifically, “between a user equipment (UE),” such as a mobile phone, and “an evolved node B (eNB),” a base station in an LTE network. '545, 1:23-33. Without synchronization, “transmission/reception of information between the UE and the eNB may not be performed.” '545, 1:29-33, 5:33-36. For example, the '545 patent explains that the communication problem arises in the absence of uplink synchronization because “[i]n a wireless communication environment, an electric wave may experience a propagation delay while the electric wave is transferred from a transmitter [UE] to a receiver [eNB]” due to the “distance between the [UE] and the [eNB], an ambient propagation environment, and the like.” '545, 5:15-22, 5:59-64. Moreover, the propagation delay “may vary over time when the [UE] moves.” '545, 5:20-24. “When the [eNB] is not accurately aware of a point in time when a signal transmitted from the [UE] is to be received, the [eNB] may fail to receive the signal, or may receive a signal distorted due to the propagation delay and may fail to perform communication.” '545, 5:24-29. As such, to account for the propagation delay, uplink synchronization involves transmission of timing information (specifically, a “Timing Advance (TA) value”) from the eNB to the UE, specifying

when the UE should transmit data, as well as updating this information when necessary, so that UE's data transmissions can be received by the eNB at an expected time. '545, 3:13-14, 6:12-45, Figure 2.

32. The purported invention of the '545 patent is specifically directed to a "LTE/LTE-A system may extend a bandwidth to satisfy a high data transmission rate corresponding to a system requirement, and may use a plurality of component carriers (CCs) which are unit carriers." '545, 4:52-55. However, "when a synchronization obtaining scheme used for a single carrier is applied as is," difficulties may arise in obtaining the UL synchronization for the available CCs. '545, 7:57-62. In particular, "[u]nlike a process of obtaining a TA when a single carrier is utilized, in a wireless system that uses a plurality of CCs, TA values of the CCs may have a high probability of being different from each other when locations of center frequencies of the CCs are significantly distant from each other as shown in FIG. 1, when the CCs are supported by different devices in a network, or the like." '545, 8:50-56, Figure 1. Thus, using the same TA value for all CCs may increase the transmission error rates and deteriorate the UL performance. '545, 7:57-8:11. To mitigate this problem, the '545 patent proposes a UL synchronization scheme that groups together CCs with similar timing characteristics into the same "UL

timing groups” and selecting a “delegate CC” to request timing information (e.g., “timing advance value”) for each UL timing group.

33. Based on my experience in the field, however, the functionalities of the ’545 patent were already known in the art prior to the ’545 patent’s priority date. For example, Tenny discloses “assign[ing] a UE at least one so-called timing group, i.e., a group of carriers with uplink timings that are the same to within some tolerance,” receiving this UL timing group information in an “RRC” “signalling” message that maps a “group identifier” to the set of CCs, and selecting a “carrier candidate” for each timing group to request and obtain a single TA value for all CCs in the group. Tenny-Prov., AppxA(1:17-19, 2:7-26, 3:26-4:8, 5:3-10, claim 6), ¶¶35-37, 39-40 Figure 3. Qualcomm also similarly discloses that “UL component carriers configured for a UE should be divided into timing groups,” where all UL CCs within a timing group “share the same timing,” receiving information about these “configured carriers” through a “RRC signalling,” and choosing a “unique CC” to request a TA value for each UL timing group. Qualcomm, 2-3.

34. The Challenged Claims are primarily directed to this CC grouping, which was a known method for establishing synchronization in wireless networks utilizing multiple CCs. Moreover, the additional details recited in the claims were all standard techniques that were well-known to apply in performing synchronization

in LTE/LTE-A systems. For example, as specified in the LTE specification TS36.300, a “Random Access Preamble” (RAP) and “Random Access Response” (RAR) were routinely used to request and receive TA values and apply TA values in subsequent UL transmissions for synchronizing the communication between a UE and an eNB. TS36.300, 44-46, 52-54, Figure 10.1.5.1-1, 10.1.5.2-1.

35. As I discuss below, the Challenged Claims are anticipated and/or obvious over the prior art. Further, there were no technological barriers to combining these elements to form the claimed invention and a person of ordinary skill in the art would have been motivated to combine these elements and would have understood that the combination would have yielded predictable results.

V. THE '545 PATENT

A. '545 Patent Overview

36. The '545 patent discloses “a method and apparatus for establishing an uplink (UL) synchronization in a wireless communication system, and more particularly, to a method and apparatus for configuring UL synchronization with respect to at least one Component Carrier (CC).” '545, 1:23-27. The '545 proposes this method to be used in a “LTE/LTE-A system” that “may use a plurality of component carriers (CCs) which are unit carriers.” '545, 4:44-64.

37. The '545 patent notes that, “a conventional wireless communication system . . . supports a single component carrier (CC) or a single service band” for performing synchronization. '545, 1:34-39. However, as the demand for bandwidth increases in current wireless communication systems, “there is a desire for a scheme for effective synchronization” that uses “a plurality of CCs” that can carry more user data. '545, 1:34-43. For example, “when five CCs having a maximum bandwidth of 20 MHz are used, a bandwidth may be expanded up to 100 MHz to support a quality of service.” '545, 4:65-67.

38. Independent claims 2-3 are generally directed to a scheme utilizing “one or more CCs” to establish UL synchronization between a UE and eNB. '545 patent, claims 2-3. For example, “a plurality of CCs may be bound and used as a single system band,” which is referred to as “carrier aggregation (CA).” '545 patent, 4:62-64. The '545 patent discloses that, depending on the “scheduling of the CA,” “an allocable frequency band, which may be determined by each CC, may be contiguous or non-contiguous.” '545, 4:67-5:3, 7:50-56. When the CCs are non-contiguous, meaning “when locations of center frequencies of the CCs are significantly distant from each other,” “TA values of the CCs may have a high probability of being different from each other.” '545, 7:50-56. The same issue may also arise “when the CCs are supported by different devices in a network, or the

like.” *Id.* The ’545 patent notes, “when a synchronization obtaining scheme used for a single carrier is applied as is,” performing stable UL communication for all available CCs may not be possible. ’545, 7:57-61. Accordingly, the ’545 patent teaches configuring groups of CCs that share similar timing into UL timing groups as a method to reduce the deterioration of UL performance. ’545, 1:22-27, 5:15-6:33, 8:4-18, 8:23-26, 10:23-26, Fig. 4.

39. In the ’545 patent’s UL timing synchronization scheme, the eNB assigns a group of CCs to the UE by including “CC set information” in a Radio Resource Control (RRC) reconfiguration message sent to the UE, based on the hardware performance of the UE and the available resources of the eNB. ’545, 9:35-57. The ’545 patent anticipates that the CC set information may need to be updated upon changing conditions. ’545, 9:58-10:2. For example, when an existing connection to the eNB is dropped or the UE moves to another cell, e.g., in the case of handover, the eNB may send an updated “UL CC set” to the UE in an RRC message. *Id.* The RRC reconfiguration message may further include “system information (SI) associated with CCs in the CC set, based on the received CC set information.” ’545, 10:3-5, 10:16-22; *see also* 17:9-16, 18:53-59, 19:11-14. As such, the UL CC set and the associated SI together constitutes the claimed UL timing information set. The ’545 patent further discloses that “[t]he eNB may set a CC set

including at least one available CC with respect to an RRC_CONNECTED UE, and may transmit CC set information associated with the CC set to the UE.” ’545, 17:9-12.

40. As a next step, “[t]he UE 480 may configure a UL timing group including CCs in the CC set as elements of the UL timing group, based on the received SI,” which is included in the RRC message as part of the UL timing group information set. ’545, 10:3-5, 10:23-25. Furthermore, “When the UL timing group is generated, the UE 480 may select a delegate CC for each group.” ’545, 11:16-17; *see also* 19:27-28, 19:37-39.

41. After setting a UL timing group and a corresponding delegate CC, “to obtain a UL synchronization, the UE 480 may set an RAP through a delegate CC of each group, and may transmit the set preamble by selecting one of the resources defined in SI of each CC.” ’545 12:59-13:3; *see also* 17:29-43, 19:40-43. For example, the ’545 discloses that, “CC1, CC2, CC3, CC4, and CC5 exist, and CC1 and CC2 are configured to be group 1, and CC3, CC4, and CC5 are configured to be group 2.” ’545, 13:41-44. “A delegate CC of group 1 is CC1,” and “a delegate CC of group 2 is CC3.” ’545, 13:44-45. Accordingly, when synchronization needs to be obtained for group 1, the UE transmits an RAP through CC1, and similarly, “when

synchronization needs to be obtained for group 2, the UE 480 may transmit an RAP through CC3.” ’545, 13:45-50.

42. In response to the RAP, the UE receives a random access response (RAR), which includes “UL grant information and a TA value of a UL timing group (a delegate CC).” ’545, 13:62-64, *see also* 17:44-48, 19:44-47. The eNB “calculate[s] a TA value for each group with respect to each CC group (each delegate CC) based on the received RAP signal.” ’545, 13:60-62. As such, the “TA value” serves as “an example of UL synchronization information” required by the UE to “adjust[] a UL transmission time” in order to effectively communicate with the eNB. ’545, 13:65-66, 17:49-51.

43. Finally, the UE applies the TA values that are received though the respective delegate CCs in the corresponding timing group. ’545, 14:1-10; *see also* 19:60-61. For example, “TA values associated with CC1 and CC3 may be applied to CCs each included in group 1 and group 2,” respectively. ’545, 14:5-10.

B. Prosecution History of the ’545 Patent

44. In formulating my opinions, I considered the contents of the prosecution history of the ’545 patent and its parent. *See* Ex. 1002; Ex. 1011. The prosecution history shows the Challenged Claims were allowed (as they were originally filed) after the Applicant argued, without amendment, that none of the

Examiner's relied-upon prior art references disclosed the claimed "UL timing group information set" comprising "one or more UL timing groups" (corresponding to [2.a]/[3.a], [2.d]/[3.d], and [2.e]/[3.e]). Ex. 1002, 474-76, 523.¹

45. In particular, I understand that during prosecution, pending claims 2-3 (corresponding to issued claims 2-3) were initially rejected as being obvious in view of the references Yoo (US 2009/0279495), Marinier (US 2012/0008600),² and Narasimha (US 2008/0268850). Ex. 1002, 418-424. The Examiner stated that "Yoo does not explicitly disclose [a controller configured to configure/configuring] one or more UL timing groups based on the UL timing group information set, the one or more UL timing groups each comprising one or more CCs," and instead relied on Marinier's "UL control carrier (CC) set" teachings for this missing feature in Yoo. Ex. 1002, 421, 423. In response, the Applicant argued that Marinier's teachings of a "UL CC set" itself does not disclose the claimed "UL timing group information set" comprising "one or more UL timing groups." Ex. 1002, 474-75. Neither the Examiner nor Applicant apparently considered other teachings from either Marinier

¹ The Applicant only argued about claim 1 and noted that "Claims 2 and 3 recite similar features as noted above with respect to claim 1, and should be deemed allowable for similar reasons." Ex. 1002, 476.

² With respect to Marinier, the Examiner noted that citations would refer to the Marinier-Prov. *See* Ex. 1002, 418 ("For citation purposes, hereinafter, the Office Action refers to the cited by Marinier et al. with provisional 61/293271, which qualifies as prior art date.").

or Yoo, including for example Marinier’s separate teachings of using a “group index of the UL CC set” to “identify[] UL carriers that use the same TA” (Marinier-Prov., ¶27). In response to these arguments, the Examiner instead issued a Notice of Allowance, stating that the “Prior Art of Record, singly or in combination” failed to teach each and every limitation of the allowed claims. *Id.*, 528-30.

VI. THE ’545 PATENT PRIORITY DATE

46. I understand the ’545 patent was filed on June 8, 2015. I have not formulated any opinion about the correct priority date for the ’545 patent. For purposes of this declaration, I was asked to assume, with respect to each of the prior art Grounds discussed in this declaration, that the ’545 patent is entitled to the priority date of February 10, 2011. I have been instructed to consider the patent and the prior art from the perspective of a person of ordinary skill in the art as of February 10, 2011.

VII. LEVEL OF ORDINARY SKILL IN THE ART

47. In rendering the opinions set forth in this declaration, I was asked to consider the patent claims and the prior art through the eyes of a person of ordinary skill in the art at the time of the alleged invention. I understand that the factors considered in determining the ordinary level of skill in a field of art include the level of education and experience of persons working in the field; the types of problems

encountered in the field, the teachings of the prior art, and the sophistication of the technology at the time of the alleged invention. I understand that a person of ordinary skill in the art is not a specific real individual, but rather is a hypothetical individual having the qualities reflected by the factors above. I understand that a person of ordinary skill in the art would also have knowledge from the teachings of the prior art, including the art cited below.

48. With respect to all of the Grounds, I have been asked to assume that the '545 patent is entitled to the priority date of February 10, 2011. Upon consideration of these factors, in my opinion, on or before this priority date, a person of ordinary skill in the art relating to the technology of the '545 patent would have had a bachelor's degree in electrical or computer engineering, computer science, or the equivalent thereof, and at least two years of experience with wireless communication systems. Additional graduate education could substitute for professional experience, or significant experience in the field could substitute for formal education.

49. I am qualified to opine concerning what a person of ordinary skill in the art would have known and understood during that time. Well before February 10, 2011, my level of skill in the art was at least that of a person of ordinary skill. I am qualified to opine concerning what a person of ordinary skill in the art would have known and understood at the time of the '545 patent's purported invention. My

analysis and conclusions herein are from the perspective of a person of ordinary skill in the art as of February 10, 2011.³

50. I understand that Pantech's expert, Peter Rysavy, has taken the position that a POSITA "would have a bachelor's degree in electrical engineering, or equivalent training, and approximately two years of experience working in the field of wireless networking." Ex. 1016, ¶30. This definition is consistent with the level of ordinary skill in the art I have proposed above, and I have applied both definitions (both mine and Mr. Rysavy's) in my analysis in this declaration. Under either definition, the prior art renders the Claims unpatentable for the reasons explained herein.

VIII. CLAIM CONSTRUCTION

51. I have been instructed that the Challenged Claims of the '545 patent are to be given their ordinary and customary meaning as understood by one of ordinary skill in the art at the time of the alleged invention in light of the specification and the prosecution history pertaining to the patent. I have followed these principles in my analysis set forth in this document.

³ I understand that the filing date of the earliest foreign priority document (KR 10-2010-0012564) is February 10, 2010, but that Pantech has not shown that the Claims are entitled to that earlier filing date. Even if the priority date of the '545 Claims is found to be February 10, 2010, none of my opinions in this declaration, including that I possessed the level of ordinary skill in the art, would change.

52. I understand that there is a pending district court litigation involving the '545 patent, and the parties have proposed the constructions reflected in Exhibit 1017. These constructions do not impact my opinions as the limitations of Claims 2-3 are met under either parties' proposed construction for the reasons I discuss below in Section IX.

A. Preambles

53. I understand the preamble of a claim may or may not be limiting. For purposes of this declaration, I have not been asked to formulate any opinion as to whether any claim preamble is limiting and have not formulated any such opinion. Instead, I have been instructed to consider whether the prior art discloses the preambles, to the extent they are limiting. To the extent they are limiting, they are disclosed by the prior art as discussed in Section IX.

B. “wherein each TA value is transmitted from the eNB for the respective UL timing group based on the transmitted RAP associated with a delegate CC of the respective UL timing group” ([2.d], [3.c])

54. I understand from counsel that in the pending LGE Litigation, LGE contends this term should be interpreted as “wherein each TA value is transmitted from the eNB for the respective UL timing group in response to the transmitted RAP through its delegate CC of the respective UL timing group,” while Pantech asserts this term should be interpreted in accordance with its plain and ordinary meaning

without specifying what that is. For the purposes of this declaration, I was instructed to consider whether the prior art meets the claims under each of these two interpretations and I concluded that the prior art discloses this limitation under both constructions for the reasons discussed below in Section IX.

C. “evolved NodeB (eNB)” ([2.a], [2.d], [3.a], [3.c])

55. I am aware that in the pending LGE Litigation, the parties dispute whether this term should be interpreted as any “base station” or in accordance with its plain and ordinary meaning. Ex. 1017, 2-3. For the purposes of this declaration, I was instructed to consider whether the prior art meets the claims under each of these two interpretations, and concluded that under any reasonable interpretation, the prior art discloses this limitation because it discloses an “eNB” in an LTE work, which is a type of “base station.” *See* Section IX.

IX. GROUNDS OF UNPATENTABILITY

56. In this section, I will explain why combinations of teachings from the following references render obvious each of the Challenged Claims. I have been instructed to assume that each of these references qualifies as prior art. I have been instructed to assume that each of these references qualifies as prior art. I understand that Petitioner has retained Dr. Friedhelm Rodermund, an expert on 3GPP proceedings, to provide testimony regarding public accessibility of **Qualcomm**,

TS36.300, and **TS36.331**. See Declaration of Friedhelm Rodermund in Support of Petition for *Inter Partes* Review of U.S. Patent No. 9,854,545 (Ex.1004, “Rodermund”). I have reviewed his declaration and agree with his analysis, which is incorporated into the table below.

Name	U.S. Publication/ Title	Filed	Published/ Issued
Tenny	U.S. Patent Application Publication No. 2011/0158116	6/17/2010 (earliest provisional filing 6/19/2009)	6/30/2011
Qualcomm	R2-100423, “Supporting multiple timing advance groups”	N/A	By 1/22/2010 ⁴
TS36.300	3GPP Technical Specification 36.300 v8.11.0 (2009-12)	N/A	By 2/9/2010 ⁵
TS36.331	3GPP Technical Specification 36.331 v9.0.0 (2009-09)	N/A	By 10/13/2009 ⁶

⁴ Rodermund, ¶¶83-101.

⁵ Rodermund, ¶¶102-21. I understand from Dr. Rodermund’s analysis that in addition to publication of TS36.300 by 3GPP, the ETSI organization also published a substantively identical version TS 136.300 (Ex. 1084). My analysis with respect to TS36.300 applies equally to ETSI’s TS 136.300.

⁶ Rodermund, ¶¶122-40. I understand from Dr. Rodermund’s analysis that in addition to publication of TS36.331 by 3GPP, the ETSI organization also published a substantively identical version TS 136.331 (Ex. 1099). My analysis with respect to TS36.300 applies equally to ETSI’s TS 136.331.

Name	U.S. Publication/ Title	Filed	Published/ Issued
Fan	U.S. Patent Application Publication No. 2010/0260136	4/10/2009	10/14/2010

57. As I explain below, the Challenged Claims are invalid based upon the following prior art grounds:

58. **Ground 1:** Challenged Claims 2 and 3 of the '545 patent are anticipated or rendered obvious by Tenny.

59. **Ground 2:** Challenged Claims 2 and 3 of the '545 patent are rendered obvious by Qualcomm in view of TS36.331.

60. **Grounds 3-4:** Challenged Claims of the '545 patent in the corresponding Grounds 1-2 are rendered obvious in further view of TS36.300.

61. **Grounds 5-8:** Challenged Claims of the '545 patent in the corresponding Grounds 1-4 are rendered obvious in further view of Fan.

62. It is my opinion that Challenged Claims of the '545 patent are unpatentable as explained below. I note that in this discussion, I may focus on the particular language in the specific claims, but it should be understood that my analysis applies to the corresponding elements of all Challenged Claims containing identical or substantially identical language.

A. Ground 1: Tenny (Claims 2-3)

1. Overview of Tenny⁷

63. Tenny “describes solutions to several issues that arise in relation to maintaining timing synchronisation for a UE in a multicarrier LTE-Advanced (LTE-A) system.” Tenny-Prov., AppxA(1:1-3). Similar to the ’545 patent, Tenny notes that “even co-sited carriers could experience some variation in timing for a number of reasons (e.g., cable delays, distance between the base station site and a remote radio head), which would make separate timing offsets per carrier beneficial or even necessary. Tenny-Prov., AppxA(1:9-14).

64. To address the variations in timing, Tenny proposes “assign[ing] a UE to at least one so-called timing group, i.e., a group of carriers with uplink timings that are the same to within some tolerance.” Tenny-Prov., AppxA(1:17-23). For example, Figure 1 below shows that a “UE,” such as a mobile phone, is “assigned carriers from multiple timing groups,” namely “Timing group A” and “Timing group B.” Tenny-Prov., AppxA(1:24-2:6, Figure 1). In particular, Tenny discloses that,

⁷ Tenny incorporates by reference the full disclosure of **Tenny-Prov.**, which includes “Appendix A” (“AppxA”). Tenny, ¶1; Tenny-Prov. ¶41 (“[I]ncorporated is an Appendix A (attached) ... a document that describes aspects of the claimed subject matter, and the Appendix forms part of this specification. In particular, Appendix A shows examples of timing group formation and alignment in multicarrier systems.”).

although the Timing group A and group B carriers originate from the same “Main eNB site,” they are separated into different groups because “a remote radio head belonging to the eNode B causes some carriers to have different timing from others,” which justifies “maintain[ing] timing separately for each group.” Tenny-Prov., AppxA(1:24-2:6, Figure 1).

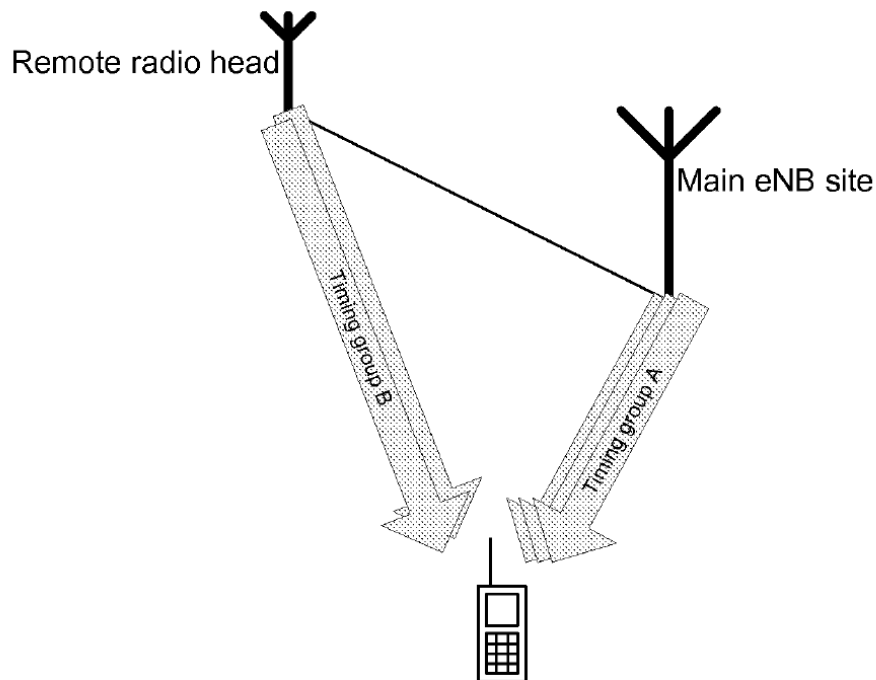


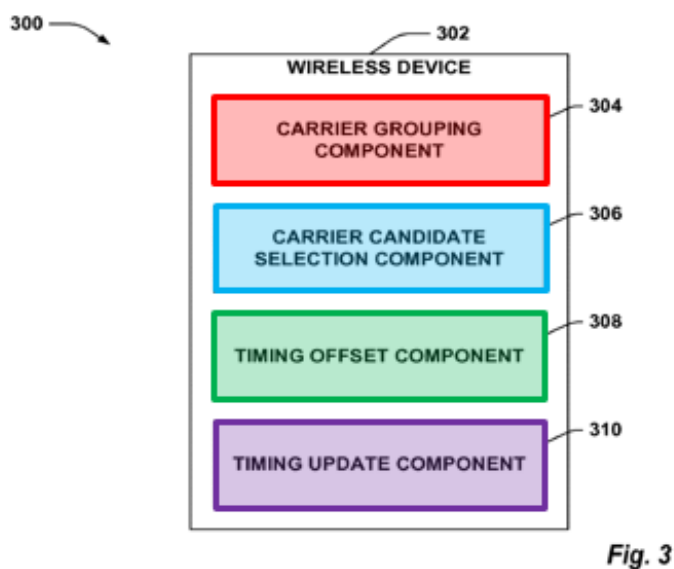
Figure 1: Two timing groups from a single eNode B

65. As a “general framework,” Tenny teaches “assign[ing] a UE to at least one so-called *timing group*, i.e., a group of carriers with uplink timings that are the same to within some tolerance.” Tenny-Prov., AppxA(1:17-19). Tenny teaches that the assignment can be made by the network and sent to the UE via “group identifier[s],” each consisting of “a small number of bits, e.g., as an index into the

set of timing groups with which the UE was configured.” Tenny-Prov., AppxA(5:3-8). This “mapping could be established by explicit signalling (in higher layers such as the RRC) at the time the UE is configured with particular carriers.” Tenny-Prov., AppxA(5:8-10).

66. Tenny discloses, “Within each timing group, the UE may need to occasionally perform random access to update its timing,” where the UE “interact[s] with the base station” (i.e. eNB) to receive “timing adjustments” for each group. Tenny-Prov., AppxA(2:7-17, 4:15-20).

67. Figure 3, highlighted below depicts a wireless device “that facilitates carrier grouping and updating timing for carrier groups,” including a “carrier grouping component,” a “carrier candidate selection component,” “a timing offset component,” and a “timing update component.” Tenny-Prov., ¶¶8, 34, Figure 3.



68. Tenny-Prov., Figure 3 (highlighted). The **“carrier grouping component 304”** “receive[s] one or more groupings” from the “wireless network,” such as the “group identifier[s]” included in the RRC signaling sent by the eNB. Tenny-Prov., ¶35, Figures 3, 4, AppxA(5:5-10). Tenny discloses that the wireless device configures UL timing groups in two steps: (1) by “generat[ing] the association of the plurality of carriers into one or more timing groups according to [the] grouping receiv[ed] from the base station associated with a subset of the plurality of carriers” and (2) by “choos[ing] a carrier in the group from which to acquire timing updates” using the **“carrier selection component 306.”** Tenny-Prov., claim 15, ¶36.

69. Upon configuring the timing groups, the “UE performs random access for timing synchronisation” on the “single carrier of [each] timing group” selected by the **“carrier selection component 306”** to “acquire timing updates.” Tenny-Prov., AppxA(2:7-26, claim 6); Tenny-Prov., ¶36, Figure 3.

70. In particular, a timing update is acquired by **“timing offset component 308”** as a “timing offset” on “candidate carrier” selected by the **“carrier selection component 306”** for “a given group.” Tenny-Prov., ¶¶36-37, 40, Figure 3. As such, the “timing offset” serves “a single timing advance value” that is “indicated to the UE for use with all carriers in the group.” Tenny-Prov., AppxA(claim 1, 2:8-10).

71. Finally, the “**timing update component 310**” “updat[es] timing for the group of carriers based on the offset” received from the “candidate carrier” chosen for the respective timing group. Tenny-Prov., ¶37, Figure 3, AppxA(3:26-4:8, claim 1).

2. Tenny’s Effective Priority Date

72. **Tenny** was filed on 6/17/2010 and, based on this date alone, qualifies as prior art under §102(e). **Tenny** also claims priority to Tenny-Prov. (Ex. 1006), filed on 6/19/2009. For purposes of this IPR, I have been asked to determine whether the Tenny-Prov. provides enabling written description support for: 1) at least claims 1 and 53 of Tenny, and 2) the subject matter in **Tenny** that anticipates or renders obvious Claims 2-3. As shown below, **Tenny-Prov.** provides enabling written description support for at least claims 1 and 53 of **Tenny**. I have reviewed the intrinsic record of **Tenny**, and as shown below, **Tenny-Prov.** provides enabling written description support for the subject matter in **Tenny** that anticipates or renders obvious Claims 2-3. *See also* Ex. 1012.

73. Because **Tenny-Prov.** is incorporated by reference into **Tenny**, the disclosures in **Tenny-Prov.** are part of **Tenny** and thus constitute prior art. Tenny, ¶1 (“incorporat[ing] by reference” Tenny-Prov. “in [its] entirety”).

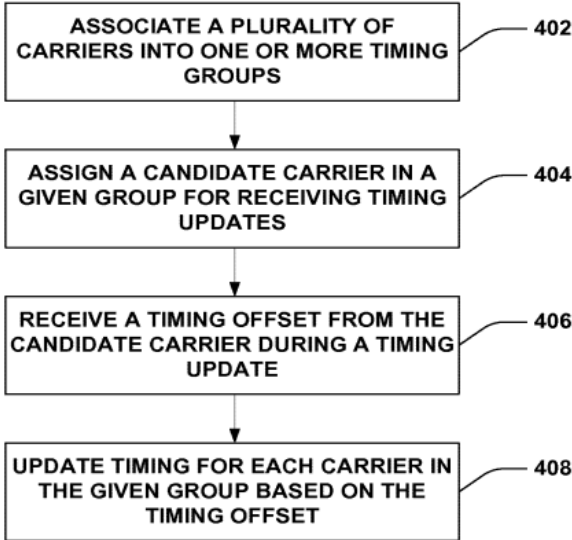
74. Moreover, as shown below, claims 1 and 53 of **Tenny** are supported and enabled by at least the following disclosures from **Tenny-Prov.** In preparing this table, it was unnecessary for me to construe any of the claim terms in **Tenny** or to determine whether the preambles from claims 1 and 53 of **Tenny** were limiting, because under any reasonable interpretation of the claim, **Tenny-Prov.** provides more than sufficient enabling written description support. I reserve the right to consider the proper construction of claim 1 and 53 of **Tenny** or supplement this table if asked to do so later. Based on the disclosures in the provisional cited herein and in the table below comparing claims 1 and 53 of **Tenny**, a person of ordinary skill in the art at that time (relative to the **Tenny**) would have been able to practice claims 1 and 53 of **Tenny** without undue experimentation. By that timeframe, these concepts were well-understood in the field.

Tenny Claim 1	Tenny-Prov.
[1.pre] A method that facilitates a timing alignment in a multicarrier system, the method comprising:	Tenny-Prov. discloses a method that facilitates a timing alignment in a multicarrier system. For example, Tenny-Prov. discloses “[a] method of maintaining timing alignment between a mobile device and a network operating on a plurality of frequencies” involving multiple “carriers in each timing group” and “maintaining timing synchronization for a UE in a multicarrier LTE-Advanced (LTE-A) system.” <i>See, e.g.,</i> Tenny-Prov., AppxA(claim 1, 1:1-23). <u>E.g.</u> • Tenny-Prov., AppxA(claim 1) (“1. <i>A method of maintaining timing alignment between a mobile device and a network operating on a plurality of frequencies</i>, the method comprising

Tenny Claim 1	Tenny-Prov.
	an association of the frequencies into one or more timing groups, such that: <i>the carriers in each timing group</i> share common transmission timing to within some first tolerance; a single timing advance value can be indicated to the UE for use with all the carriers in the group, such that the resulting uplink timing when the UE transmits with this timing advance value towards any carrier in the group will be sufficiently accurate for communication with that carrier, where ‘sufficiently accurate’ is defined in terms of some second tolerance.”) • Tenny-Prov., AppxA(1:1-23) (“This document describes <i>solutions to several issues that arise in relation to maintaining timing synchronisation for a UE in a multicarrier LTE-Advanced (LTE-A) system.</i> • In a single-carrier environment, the maintenance of timing synchronisation for a UE is well understood; the UE receives an uplink/downlink offset from the network, which occasionally needs to be updated, indicating how it should align its uplink transmissions in relation to the received downlink timing. • <i>In a multicarrier environment</i>, however, the situation is less straightforward. Assuming that all carriers serving a single UE are transmitted from the same cell site, it appears that a common offset should be adequate; however, even co-sited carriers could experience some variation in timing for a number of reasons (e.g., cable delays, distance between the base station site and a remote radio head), which would make separate timing offsets per carrier beneficial or even necessary. • As a general framework, <i>we propose that it should be possible to assign a UE to at least one so-called timing group, i.e., a group of carriers with uplink timings that are the same to within some tolerance. Depending on the tolerance, a timing</i>

Tenny Claim 1	Tenny-Prov.
	<i>group might consist of carriers that share a common controlling site (but may still have fine differences in timing), or only of carriers whose antennae are collocated. Different carriers with synchronised downlinks but significant differences in uplink timing for a given UE (e.g., from different cell sites in a synchronous network) would not normally belong to the same timing group in this sense.”)</i> • ¶34 (FIG. 3 illustrates <i>an example system 300 that facilitates grouping carriers by timing to facilitate efficient timing synchronization in multicarrier wireless networks</i>. System 300 includes a wireless device 302, which can be a mobile device, access point, a portion thereof, and/or substantially any device that communicates in a wireless network. Wireless device 302 includes a carrier grouping component 304 that can associate a plurality of carriers in a timing group based on respective timing differences within a threshold range, a carrier candidate selection component 306 that can choose a carrier in the group from which to acquire timing, a timing offset component 308 that can obtain a timing offset for a group of characters, and a timing update component 310 that can update timing for carriers in a group based on the timing offset.”) • Fig. 3

Tenny Claim 1	Tenny-Prov.
	<pre> graph TD 300 --> 302[WIRELESS DEVICE] 302 --> 304[CARRIER GROUPING COMPONENT] 302 --> 306[CARRIER CANDIDATE SELECTION COMPONENT] 302 --> 308[TIMING OFFSET COMPONENT] 302 --> 310[TIMING UPDATE COMPONENT] </pre> Fig. 3 • ¶39 (“FIG. 4 illustrates <i>an example methodology 400 that facilitates grouping carriers and performing group-based timing updates</i>. At 402, a plurality of carriers can be associated into one or more timing groups. As described, the carriers can be associated according to a timing difference such that similarly timed carriers (e.g., below a threshold difference) can be included in a single group. At 404, a candidate carrier can be assigned in a given timing group for receiving timing updates. The candidate carrier can be chosen by a network component or UE, for example, such that the same carrier is not the candidate carrier for the timing group at all devices. As described, the candidate carrier can be chosen according to a hash value, random function, time-based function, and/or the like.”) • Fig. 4

Tenny Claim 1	Tenny-Prov.
	400 →  Fig. 4
[1.a] determining at least one downlink timing associated with at least one downlink carrier;	Tenny-Prov. discloses determining at least one downlink timing associated with at least one downlink carrier. For example, Tenny-Prov. discloses that the UE “receive[s] its timing information from either carrier 1 or carrier 2,” which are designated as “DL” for downlink. <i>See</i> Tenny-Prov., AppxA(3:24-27, Figure 2). For example, Tenny-Prov. discloses that the UE “tracks the (downlink) timing of each carrier in the group separately, so that when a single DL/UL offset is received, the UE can apply the offset separately to each carrier and take an average of the results to provide a ‘happy medium’ uplink timing for use with all carriers in the group.” <i>See</i> Tenny-Prov., ¶37, AppxA(3:21-4:13, Figure 3 (“Actual UL timing = (DL1 + DL2/2 + offset”), claim 7, 16). <u>E.g.</u> • Tenny-Prov., AppxA (Figure 2)

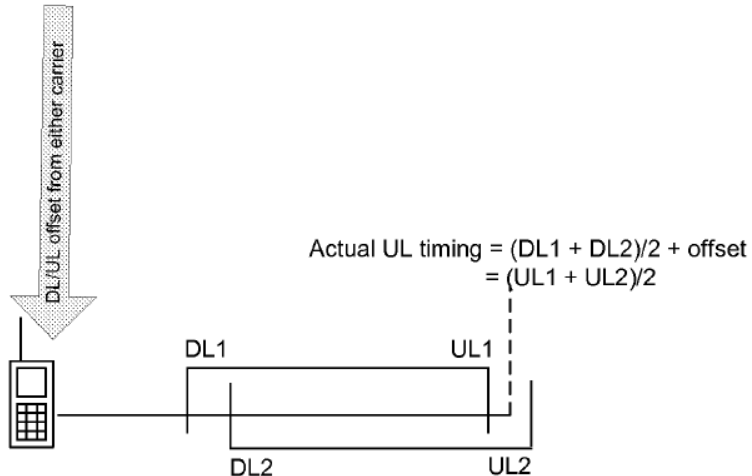
Tenny Claim 1	Tenny-Prov.
	Figure 2: Ambiguous uplink timing Tenny-Prov., AppxA (Figure 3) Tenny-Prov., AppxA(3:19-4:13) (“Within a timing group, if all carriers are precisely aligned in both downlink and uplink timing, there is no ambiguity about what the "correct" timing alignment for a given UE should be. However, in the case of small differences between carrier transmission timing (e.g., due to cable delays), carriers with the same timing offset may nevertheless have different absolute timings. An example is shown in Figure 2. <i>A UE in the environment of Figure 2 could receive its timing information from either carrier 1 or carrier 2. The timings of</i>

Tenny Claim 1	Tenny-Prov.
	the two carriers differ, but by less than the tolerance that the deployment requires for a timing group; and it follows that, depending on which carrier the UE received its last update from, a UE connected to both carriers could consider the correct uplink timing to be at either UL1 or UL2 in the figure. The simplest approach is for the UE simply to apply the timing offset to the carrier on which it received it, and assume that the timing of other carriers in the group is ‘close enough’; in terms of the figure, this would mean that the system considered UL1 and UL2 to be the same for purposes of uplink timing accuracy. As an alternative, however, the UE could apply the offset, not to <i>the received downlink timing from the carrier that transmitted the offset</i>, but to the average timing of the carriers in the timing group. In such a case, although <i>the UE received its timing information from a particular carrier, it tracks the (downlink) timing of each carrier in the group separately</i>, so that when a single DL/UL offset is received, the UE can apply the offset separately to each carrier and take an average of the results to provide a ‘happy medium’ uplink timing for use with all carriers in the group. Such an averaging behaviour could be either a specified UE behaviour (to allow greater downlink tolerances within a timing group while still keeping the variation in uplink timing acceptable) or left to UE implementation.”) • ¶34 (FIG. 3 illustrates an example system 300 that facilitates grouping carriers by timing to facilitate efficient timing synchronization in multicarrier wireless networks. System 300 includes a wireless device 302, which can be a mobile device, access point, a portion thereof, and/or substantially any device that communicates in a wireless network. Wireless device 302 includes a carrier grouping component 304 that can associate a plurality of carriers in a timing group based on respective timing differences within a threshold range, <i>a carrier candidate selection component 306 that can choose a carrier in the group</i>

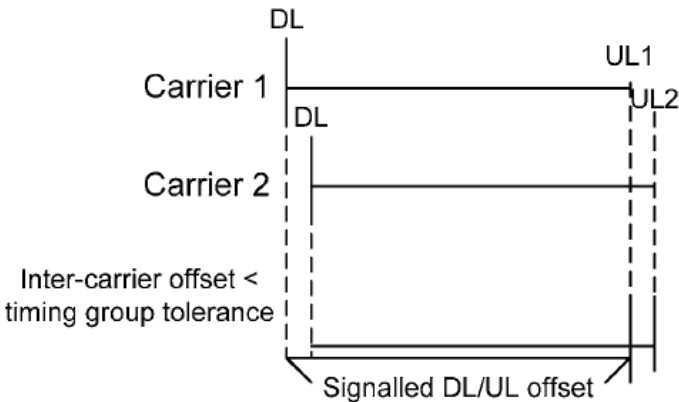
Tenny Claim 1	Tenny-Prov.
	<i>from which to acquire timing</i>, a timing offset component 308 that can obtain a timing offset for a group of characters, and a timing update component 310 that can update timing for carriers in a group based on the timing offset.”) • ¶37 (“Timing offset component 308 can acquire a timing offset from the candidate carrier for a given group using a random access procedure and/or the like, and the timing update component 310 can update timing for the group of carriers based on the offset. In another example, <i>the timing update component 310 can track downlink timing over carriers in a group, add the offset received from the timing offset component 308 to each carrier timing, average the timing differences, and apply the average difference as an offset for use with all carriers in the group.</i>”) • Claim 1 (“A method, comprising: associating a plurality of carriers utilized for communication into one or more timing groups of carriers; <i>assigning a candidate carrier in at least one of the one or more timing groups for timing updates;</i> receiving a timing offset from the candidate carrier during a timing update; and updating timing for each carrier in the at least one timing group based on the timing offset.”) • Claim 7 (“The method of claim 1, further comprising <i>monitoring a downlink timing for each carrier in the at least one timing group</i> and modifying the timing offset according to an average of the offset <i>applied to the monitored downlink timings for each carrier.</i>”) • Claim 16 (“The wireless communications apparatus of claim 10, wherein the at least one processor is further configured to <i>monitor a downlink timing for each carrier in the at least one timing group</i> and update the timing offset according to an

Tenny Claim 1	Tenny-Prov.
	average of the offset <i>applied to the monitored downlink timings for each carrier.</i> ”)
[1.b] ascertaining an uplink timing associated with an uplink group of carriers, wherein the uplink timing is ascertained based on a processing of at least one downlink timing and a timing offset associated with the uplink group of carriers; and	Tenny-Prov. discloses ascertaining an uplink timing associated with an uplink group of carriers, wherein the uplink timing is ascertained based on a processing of at least one downlink timing and a timing offset associated with the uplink group of carriers. For example, as discussed above in [1.a], Tenny-Prov. discloses that the UE calculates an “uplink timing for use with all carriers in the group” based on the “(downlink) timing of each carrier in the group” by, e.g., “apply[ing] the offset...to the average timing of the carriers in the timing group” (e.g., “Actual UL timing = (DL1 + DL2/2 + offset”). See [1.a]; Tenny-Prov., AppxA(3:31-4:13, Figures 2-3). The “offset” is transmitted from a “carrier” (e.g., “candidate carrier”) that is assigned to an uplink group of carriers to “acquire timing updates” for the carriers in the group. See, e.g., Tenny-Prov., ¶¶33-34, 36, claim 1, AppxA(3:19-4:13). <u>E.g.</u> • ¶33 (According to aspects described herein, <i>carriers from one or more access points can be grouped according to uplink timing.</i> For example, carriers having similar timing (e.g., within a threshold difference) can be grouped for a given UE such that the UE maintains timing for each given group, rather than necessarily each carrier. In one example, <i>the UE can update timing for only one carrier in the group and accordingly update timing for the rest of the carriers in the group according to the same offset.</i> As described herein, selecting the carrier to utilize for updating can be network- and/or UE-based.”) • ¶34 (FIG. 3 illustrates an example system 300 that facilitates grouping carriers by timing to facilitate efficient timing synchronization in multicarrier wireless networks. System 300 includes a wireless device 302, which can be a mobile device, access point, a portion thereof, and/or substantially any device that communicates in a wireless network. Wireless device 302

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	includes a carrier grouping component 304 that can associate a plurality of carriers in a timing group based on respective timing differences within a threshold range, <i>a carrier candidate selection component 306 that can choose a carrier in the group from which to acquire timing, a timing offset component 308 that can obtain a timing offset for a group of characters, and a timing update component 310 that can update timing for carriers in a group based on the timing offset.</i>") • ¶36 ("In an example, <i>carrier candidate selection component 306 can choose a carrier in the group from which to acquire timing updates</i>. Similarly, the carrier candidate selection component 306 can receive a carrier candidate selection from one or more related access points or the wireless network. In one example, the candidate carrier selection component 306 can select the carrier to use in timing updates based on a hash function to attempt even distribution of candidate carriers in a group (e.g., to prevent all UEs using the group to update using the same carrier). The candidate carrier selection component 306, for example, can use a hash function with a varying value so the candidate can change for the UE 302 for each update.") • Claim 1 ("A method, comprising: associating a plurality of carriers utilized for communication into one or more timing groups of carriers; <i>assigning a candidate carrier in at least one of the one or more timing groups for timing updates;</i> <i>receiving a timing offset from the candidate carrier during a timing update; and</i> <i>updating timing for each carrier in the at least one timing group based on the timing offset.</i>") • Claim 5 ("The method of claim 1, wherein associating the plurality of carriers into one or more timing groups includes evaluating a timing difference of each of the plurality of

Tenny Claim 1	Tenny-Prov.
	carriers and grouping the plurality of carriers according to a threshold difference.”) Tenny-Prov., AppxA(Figure 3)  Actual UL timing = $(DL1 + DL2)/2 + \text{offset}$ $= (UL1 + UL2)/2$ Tenny-Prov., AppxA(3:19-23) (“Within a timing group, if all carriers are precisely aligned in both downlink and uplink timing, there is no ambiguity about what the ‘correct’ timing alignment for a given UE should be. However, in the case of small differences between carrier transmission timing (e.g., due to cable delays), carriers with the same timing <i>offset</i> may nevertheless have different <i>absolute</i> timings. An example is shown in Figure 2.”) Tenny-Prov., AppxA(Figure 2)

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	Figure 2: Ambiguous uplink timing Tenny-Prov., AppxA(3:26-4:13) (“UE in the environment of Figure 2 could receive its timing information from either carrier 1 or carrier 2. The timings of the two carriers differ, but by less than the tolerance that the deployment requires for a timing group; and it follows that, depending on which carrier the UE received its last update from, a UE connected to both carriers could consider the correct uplink timing to be at either UL1 or UL2 in the figure. <i>The simplest approach is for the UE simply to apply the timing offset to the carrier on which it received it, and assume that the timing of other carriers in the group is ‘close enough’; in terms of the figure, this would mean that the system considered UL1 and UL2 to be the same for purposes of uplink timing accuracy. As an alternative, however, the UE could apply the offset, not to the received downlink timing from the carrier that transmitted the offset, but to the average timing of the carriers in the timing group. In such a case, although the UE received its timing information from a particular carrier, it tracks the (downlink) timing of each carrier in the group separately, so that when a single DL/UL offset is received, the UE can apply the offset separately to each carrier and take an average of the results to provide a ‘happy medium’ uplink timing for use with all carriers in the group....</i>

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	Such an averaging behaviour could be either a specified UE behaviour (to allow greater downlink tolerances within a timing group while still keeping the variation in uplink timing acceptable) or left to UE implementation.”)
[1.c] transmitting each of the uplink group of carriers within a threshold value of the uplink timing.	Tenny-Prov. discloses transmitting each of the uplink group of carriers within a threshold value of the uplink timing. For example, Tenny-Prov. discloses that carriers are “associated according to a timing difference such that similarly timed carriers (e.g., below a threshold difference) can be included in a single group.” Tenny-Prov., ¶¶39, 34, claims 5, 14, 23, 32. Put another way, Tenny-Prov. defines a “<i>timing group</i>” as “i.e., a group of carriers with uplink timings that are the same to within some tolerance.” Tenny-Prov., AppxA(1:17-23, claim 1). Thus, each of the carriers are transmitted within a threshold value of the uplink timing that was calculated for all carriers within the group (<i>see</i> [1.b] above). <u>E.g.</u> <i>See</i> [1.b]. • Tenny-Prov., AppxA(Figure 2)  Figure 2: Ambiguous uplink timing • Tenny-Prov., AppxA(Figure 3)

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	¶34 (FIG. 3 illustrates an example system 300 that facilitates grouping carriers by timing to facilitate efficient timing synchronization in multicarrier wireless networks. System 300 includes a wireless device 302, which can be a mobile device, access point, a portion thereof, and/or substantially any device that communicates in a wireless network. <i>Wireless device 302 includes a carrier grouping component 304 that can associate a plurality of carriers in a timing group based on respective timing differences within a threshold range</i>, a carrier candidate selection component 306 that can choose a carrier in the group from which to acquire timing, a timing offset component 308 that can obtain a timing offset for a group of characters, and a timing update component 310 that can update timing for carriers in a group based on the timing offset.”) ¶35 (“According to an example, the wireless device 302 can participate in a multicarrier wireless network communicating over multiple carriers to one or more access points or other devices. The carrier grouping component 304 can associate carriers having similar timing into timing groups. For example, <i>where multiple carriers have a timing difference below a threshold value, the multiple carriers can be grouped</i>. In one example, the carrier grouping component 304 can group the carriers according to observed timing. In another example, the

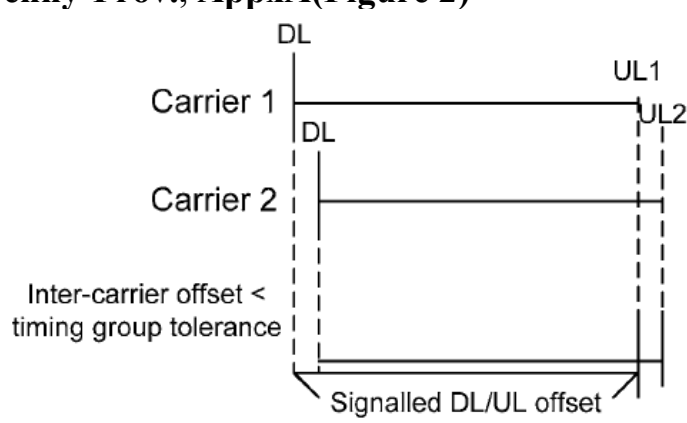
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	carrier grouping component 304 can receive one or more groupings from one or more related access points or the wireless network. Thus, for example, where an access point provides multiple carriers utilized by the wireless device 302, the access point can transmit a grouping to the wireless device 302.”) ¶37 (“Timing offset component 308 can acquire a timing offset from the candidate carrier for a given group using a random access procedure and/or the like, and the timing update component 310 can update timing for the group of carriers based on the offset. In another example, the timing update component 310 can track downlink timing over carriers in a group, add the offset received from the timing offset component 308 to each carrier timing, average the timing differences, and <i>apply the average difference as an offset for use with all carriers in the group.</i>”) ¶39 (“FIG. 4 illustrates an example methodology 400 that facilitates grouping carriers and performing group-based timing updates. <i>At 402, a plurality of carriers can be associated into one or more timing groups. As described, the carriers can be associated according to a timing difference such that similarly timed carriers (e.g., below a threshold difference) can be included in a single group.</i> At 404, a candidate carrier can be assigned in a given timing group for receiving timing updates. The candidate carrier can be chosen by a network component or UE, for example, such that the same carrier is not the candidate carrier for the timing group at all devices. As described, the candidate carrier can be chosen according to a hash value, random function, time-based function, and/or the like.”) ¶40 (“At 406, a timing offset can be received from the candidate carrier during the timing update. This can be in response to a random access procedure, in one example, and can be related to a timing difference related to the candidate

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	carrier. At 408, timing can be updated for each carrier in the timing group based on the timing offset. In one example, the updating can occur using an average of the offset applied to monitored timings for each carrier, as described. In another example, the offset received from the candidate carrier can be applied to all carriers in the group.”) • Claim 5 (“5. The method of claim 1, wherein associating the plurality of carriers into one or more timing groups includes <i>evaluating a timing difference of each of the plurality of carriers and grouping the plurality of carriers according to a threshold difference.</i>”) • Claim 14 (“14. The wireless communications apparatus of claim 10, wherein the at least one processor generates the <i>association of the plurality of carriers into one or more timing groups by evaluating a timing difference of each of the plurality of carriers and grouping the plurality of carriers into the timing groups according to a threshold difference.</i>”) • Claim 23 (“23. The apparatus of claim 19, wherein the means for <i>associating the plurality of carriers into one or more timing groups analyzes a timing difference of each of the plurality of carriers and groups the plurality of carriers according to a threshold difference.</i>”) • Claim 32 (“32. The computer program product of claim 28, wherein <i>associating the plurality of carriers into one or more timing groups includes evaluating a timing difference of each of the plurality of carriers and grouping the plurality of carriers according to a threshold difference.</i>”) • Tenny-Prov., AppxA(1:17-21) (“As a general framework, we propose that it should be possible to assign a UE to at least one so-called timing group, i.e., <i>a group of carriers with uplink timings that are the same to within some tolerance.</i> Depending on the tolerance, a timing group might consist of carriers that share a common controlling site (but may still

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	have fine differences in timing), or only of carriers whose antennae are collocated.”) • Tenny-Prov., AppxA(2:18-22) (“A network-based solution is extremely simple: When the UE is assigned to carriers in a particular timing group, the network provides the UE with instructions regarding which carrier in that group to use for random access. The instructions could be absolute (‘always use this carrier’) or subject to relaxation based on conditions at the UE (<i>‘use this carrier preferentially, unless radio conditions on that carrier are worse than indicated by a threshold’</i>).”). • Tenny-Prov., AppxA(3:19-4:13) (“<i>Within a timing group, if all carriers are precisely aligned in both downlink and uplink timing, there is no ambiguity about what the ‘correct’ timing alignment for a given UE should be. However, in the case of small differences between carrier transmission timing (e.g., due to cable delays), carriers with the same timing offset may nevertheless have different absolute timings. An example is shown in Figure 2.</i>”). A UE in the environment of Figure 2 could receive its timing information from either carrier 1 or carrier 2. <i>The timings of the two carriers differ, but by less than the tolerance that the deployment requires for a timing group; and it follows that, depending on which carrier the UE received its last update from, a UE connected to both carriers could consider the correct uplink timing to be at either UL1 or UL2 in the figure. The simplest approach is for the UE simply to apply the timing offset to the carrier on which it received, it and assume that the timing of other carriers in the group is ‘close enough’; in terms of the figure, this would mean that the system considered UL1 and UL2 to be the same for purposes of uplink timing accuracy.</i> As an alternative, however, the UE could apply the offset, not to the received downlink timing from the carrier that transmitted the offset, but to the average timing of the carriers in the timing group. In such a case, although <i>the UE received its</i>

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	<i>timing information from a particular carrier, it tracks the (downlink) timing of each carrier in the group separately, so that when a single DL/UL offset is received, the UE can apply the offset separately to each carrier and take an average of the results to provide a ‘happy medium’ uplink timing for use with all carriers in the group.</i> Such an averaging behaviour could be either a specified UE behaviour (to allow greater downlink tolerances within a timing group while still keeping the variation in uplink timing acceptable) or left to UE implementation.”) • Tenny-Prov., AppxA(Claim 1) (“1. A method of maintaining timing alignment between a mobile device and a network operating on a plurality of frequencies, the method comprising an association of the frequencies into one or more timing groups, such that: the carriers in each timing group share common transmission timing to within some first tolerance; <i>a single timing advance value can be indicated to the UE for use with all the carriers in the group, such that the resulting uplink timing when the UE transmits with this timing advance value towards any carrier in the group will be sufficiently accurate for communication with that carrier, where "sufficiently accurate" is defined in terms of some second tolerance.</i>”)

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[53.pre] A method that facilitates a timing alignment in a multicarrier system, the method comprising:	Tenny discloses a method that facilitates a timing alignment in a multicarrier system. See [1.pre] above.
[53.a] transmitting a downlink	Tenny-Prov. discloses transmitting a downlink communication to a wireless terminal via at least one downlink carrier. For

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communication to a wireless terminal via at least one downlink carrier;	example, Tenny-Prov. discloses that a “UE...receive[s] downlink timing from the carrier that transmitted the offset.” <i>See</i> Tenny-Prov., AppxA(4:2-3). In particular, Tenny-Prov. discloses that the UE “receive[s] its timing information from either carrier 1 or carrier 2,” which are designated as “DL” for downlink carriers. <i>See</i> [1.a]; Tenny-Prov., AppxA(3:24-27, Figure 2). Carriers are transmitted from “one or more access points.” Tenny-Prov. ¶33. <u><i>E.g.</i></u> <i>See</i> [1.a]. • Tenny-Prov., AppxA(Figure 2)  Figure 2: Ambiguous uplink timing • Tenny-Prov., AppxA(Figure 3)

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	Tenny-Prov., AppxA(3:19-4:13) (“Within a timing group, if all carriers are precisely aligned in both downlink and uplink timing, there is no ambiguity about what the "correct" timing alignment for a given UE should be. However, in the case of small differences between carrier transmission timing (e.g., due to cable delays), carriers with the same timing offset may nevertheless have different absolute timings. An example is shown in Figure 2. <i>A UE in the environment of Figure 2 could receive its timing information from either carrier 1 or carrier 2.</i> The timings of the two carriers differ, but by less than the tolerance that the deployment requires for a timing group; and it follows that, depending on which carrier the UE received its last update from, a UE connected to both carriers could consider the correct uplink timing to be at either UL1 or UL2 in the figure. The simplest approach is for the UE simply to apply the timing offset to the carrier on which it received it, and assume that the timing of other carriers in the group is ‘close enough’; in terms of the figure, this would mean that the system considered UL1 and UL2 to be the same for purposes of uplink timing accuracy. As an alternative, however, the UE could apply the offset, not to <i>the received downlink timing from the carrier that transmitted</i>

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	<i>the offset</i>, but to the average timing of the carriers in the timing group. In such a case, although the UE received its timing information from a particular carrier, it <i>tracks the (downlink) timing of each carrier in the group separately</i>, so that when a single DL/UL offset is received, the UE can apply the offset separately to each carrier and take an average of the results to provide a ‘happy medium’ uplink timing for use with all carriers in the group. Such an averaging behaviour could be either a specified UE behaviour (to allow greater downlink tolerances within a timing group while still keeping the variation in uplink timing acceptable) or left to UE implementation.”) • ¶16 (“<i>An access point may be a fixed station used for communicating with the terminals and may also be referred to as an access point, a Node B, or some other terminology.</i> An access terminal may also be called an access terminal, user equipment (UE), a wireless communication device, terminal, access terminal or some other terminology.”) • ¶33 (“According to aspects described herein, <i>carriers from one or more access points can be grouped according to uplink timing.</i> For example, carriers having similar timing (e.g., within a threshold difference) can be grouped for a given UE such that the UE maintains timing for each given group, rather than necessarily each carrier. In one example, <i>the UE can update timing for only one carrier in the group and accordingly update timing for the rest of the carriers in the group according to the same offset.</i> As described herein, selecting the carrier to utilize for updating can be network- and/or UE-based.”) • ¶34 (FIG. 3 illustrates an example system 300 that facilitates grouping carriers by timing to facilitate efficient timing synchronization in multicarrier wireless networks. System 300 includes a wireless device 302, which can be a mobile device, access point, a portion thereof, and/or substantially any device

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	that communicates in a wireless network. Wireless device 302 includes a carrier grouping component 304 that can associate a plurality of carriers in a timing group based on respective timing differences within a threshold range, a carrier candidate selection component 306 that can choose a carrier in the group from which to acquire timing, a timing offset component 308 that can obtain a timing offset for a group of characters, and a timing update component 310 that can update timing for carriers in a group based on the timing offset.”) • Claim 1 (“A method, comprising: associating a plurality of carriers utilized for communication into one or more timing groups of carriers; assigning a candidate carrier in at least one of the one or more timing groups for timing updates; <i>receiving a timing offset from the candidate carrier during a timing update</i>; and updating timing for each carrier in the at least one timing group based on the timing offset.”)
[53.b] assigning a timing offset to an uplink group of carriers;	Tenny-Prov. discloses assigning a timing offset to an uplink group of carriers. For example, Tenny-Prov. discloses that an “offset” is transmitted from a “carrier” (e.g., “candidate carrier”) that is assigned to an uplink group of carriers to “acquire timing updates” for the carriers in the group. <i>See, e.g.,</i> Tenny-Prov., ¶¶33-34, 36, claim 1, AppxA(3:19-4:13). <u>E.g.</u> • Tenny-Prov., AppxA(Figure 2)

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	Figure 2: Ambiguous uplink timing • Tenny-Prov., AppxA(Figure 3) • ¶16 (“<i>An access point may be a fixed station used for communicating with the terminals and may also be referred to as an access point, a Node B, or some other terminology. An access terminal may also be called an access terminal, user equipment (UE), a wireless communication device, terminal, access terminal or some other terminology.</i>”) • ¶33 (“According to aspects described herein, <i>carriers from one or more access points can be grouped according to uplink timing</i>. For example, carriers having similar timing (e.g., within a threshold difference) can be grouped for a given UE such that the UE maintains timing for each given group, rather

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	than necessarily each carrier. In one example, <i>the UE can update timing for only one carrier in the group and accordingly update timing for the rest of the carriers in the group according to the same offset</i>. As described herein, selecting the carrier to utilize for updating can be network- and/or UE-based.”) • ¶34 (FIG. 3 illustrates an example system 300 that facilitates grouping carriers by timing to facilitate efficient timing synchronization in multicarrier wireless networks. System 300 includes a wireless device 302, which can be a mobile device, access point, a portion thereof, and/or substantially any device that communicates in a wireless network. Wireless device 302 includes a carrier grouping component 304 that can associate a plurality of carriers in a timing group based on respective timing differences within a threshold range, <i>a carrier candidate selection component 306 that can choose a carrier in the group from which to acquire timing, a timing offset component 308 that can obtain a timing offset for a group of characters, and a timing update component 310 that can update timing for carriers in a group based on the timing offset.</i>”) • ¶36 (“In an example, <i>carrier candidate selection component 306 can choose a carrier in the group from which to acquire timing updates</i>. Similarly, the carrier candidate selection component 306 can receive a carrier candidate selection from one or more related access points or the wireless network. In one example, the candidate carrier selection component 306 can select the carrier to use in timing updates based on a hash function to attempt even distribution of candidate carriers in a group (e.g., to prevent all UEs using the group to update using the same carrier). The candidate carrier selection component 306, for example, can use a hash function with a varying value so the candidate can change for the UE 302 for each update.”)

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	• ¶37 (“<i>Timing offset component 308 can acquire a timing offset from the candidate carrier for a given group using a random access procedure and/or the like, and the timing update component 310 can update timing for the group of carriers based on the offset. In another example, the timing update component 310 can track downlink timing over carriers in a group, add the offset received from the timing offset component 308 to each carrier timing, average the timing differences, and apply the average difference as an offset for use with all carriers in the group.</i>”) • ¶38 (“In addition, one or more groups of carriers can be entirely controlled at a common site. In this example, the timing offset component 308 can receive timing adjustments for substantially all groups at the common site in a vector from a base station at the common site. In an example, the vector can be absolute measurements or differences relative to a timing of one of the groups. Knowledge regarding which groups are utilized by the UE 302 can be maintained at the wireless network, in one example, at the UE 302, and/or the like.”) • ¶39 (“FIG. 4 illustrates an example methodology 400 that facilitates grouping carriers and performing group-based timing updates. At 402, a plurality of carriers can be associated into one or more timing groups. As described, the carriers can be associated according to a timing difference such that similarly timed carriers (e.g., below a threshold difference) can be included in a single group. At 404, a candidate carrier can be assigned in a given timing group for receiving timing updates. The candidate carrier can be chosen by a network component or UE, for example, such that the same carrier is not the candidate carrier for the timing group at all devices. As described, the candidate carrier can be chosen according to a hash value, random function, time-based function, and/or the like.”)

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	• ¶40 (“At 406, <i>a timing offset can be received from the candidate carrier during the timing update</i>. This can be in response to a random access procedure, in one example, and can be related to a timing difference related to the candidate carrier. <i>At 408, timing can be updated for each carrier in the timing group based on the timing offset</i>. In one example, <i>the updating can occur using an average of the offset applied to monitored timings for each carrier</i>, as described. In another example, <i>the offset received from the candidate carrier can be applied to all carriers in the group.</i>”) • Claim 1 (“A method, comprising: associating a plurality of carriers utilized for communication into one or more timing groups of carriers; assigning a candidate carrier in at least one of the one or more timing groups for timing updates; <i>receiving a timing offset from the candidate carrier during a timing update; and</i> <i>updating timing for each carrier in the at least one timing group based on the timing offset.</i>”) • Claim 8 (“The method of claim 1, wherein carriers in the at least one of the one or more timing groups are transmitted at a common site.”) • Claim 9 (“The method of claim 8, wherein the timing offset is received in a vector of a plurality of timing offsets for the at least one of the one or more timing groups from the common site.”) • Tenny-Prov., AppxA(3:26-4:13) (“A UE in the environment of Figure 2 could receive its timing information from either carrier 1 or carrier 2. The timings of the two carriers differ, but by less than the tolerance that the deployment requires for a timing group; and it follows that, depending on which carrier the UE received its last update from, a UE connected to both carriers could consider the correct uplink timing to be at either UL1 or UL2 in the figure.

Tenny Claim 53	Tenny-Prov.
	<i>The simplest approach is for the UE simply to apply the timing offset to the carrier on which it received it, and assume that the timing of other carriers in the group is ‘close enough’; in terms of the figure, this would mean that the system considered UL1 and UL2 to be the same for purposes of uplink timing accuracy. As an alternative, however, the UE could apply the offset, not to the received downlink timing from the carrier that transmitted the offset, but to the average timing of the carriers in the timing group. In such a case, although the UE received its timing information from a particular carrier, it tracks the (downlink) timing of each carrier in the group separately, so that when a single DL/UL offset is received, the UE can apply the offset separately to each carrier and take an average of the results to provide a ‘happy medium’ uplink timing for use with all carriers in the group.</i> Such an averaging behaviour could be either a specified UE behaviour (to allow greater downlink tolerances within a timing group while still keeping the variation in uplink timing acceptable) or left to UE implementation.”)
[53.c] providing the timing offset to the wireless terminal via the at least one downlink carrier; and	Tenny-Prov. discloses providing the timing offset to the wireless terminal via the at least one downlink carrier. For example, as discussed above in [53.b], Tenny-Prov. discloses that the “offset” is transmitted to the UE via a “carrier” (e.g., “candidate carrier”). <i>See</i> [53.b]. As discussed in [53.a], the carriers are downlink carriers because they are transmitted from “one or more access points.” <i>See</i> [53.a]; Tenny-Prov. ¶33. <u>E.g.</u> See [53.a]-[53.b]. • Tenny-Prov., AppxA(Figure 2)

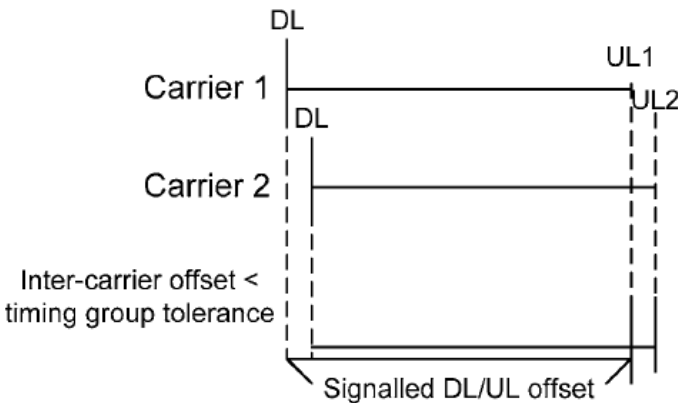
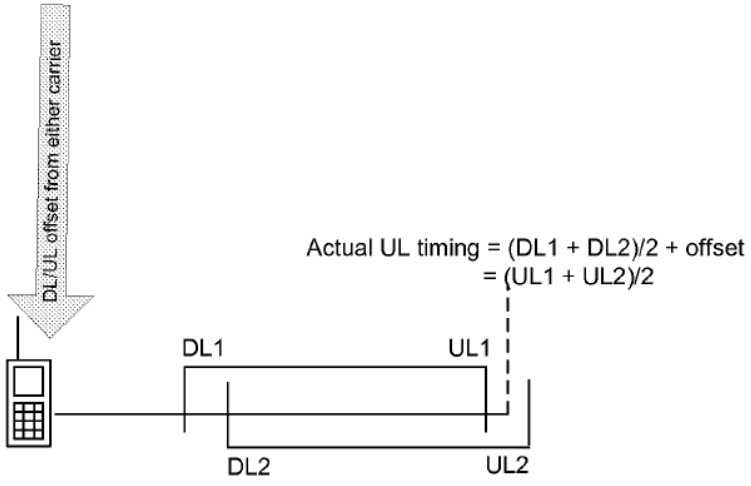
Tenny Claim 53	Tenny-Prov.
	Figure 2: Ambiguous uplink timing • Tenny-Prov., AppxA(Figure 3) • ¶16 (“<i>An access point may be a fixed station used for communicating with the terminals and may also be referred to as an access point, a Node B, or some other terminology. An access terminal may also be called an access terminal, user equipment (UE), a wireless communication device, terminal, access terminal or some other terminology.</i>”) • ¶33 (“According to aspects described herein, <i>carriers from one or more access points can be grouped according to uplink timing</i>. For example, carriers having similar timing (e.g., within a threshold difference) can be grouped for a given UE

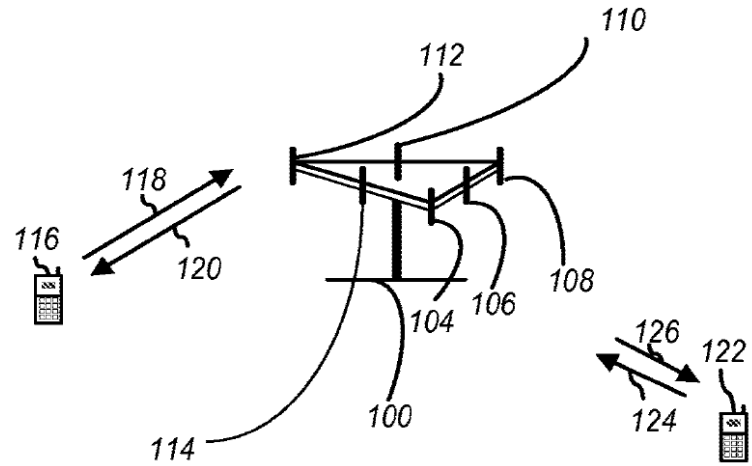
Tenny Claim 53	Tenny-Prov.
	such that the UE maintains timing for each given group, rather than necessarily each carrier. In one example, <i>the UE can update timing for only one carrier in the group and accordingly update timing for the rest of the carriers in the group according to the same offset</i>. As described herein, selecting the carrier to utilize for updating can be network- and/or UE-based.”) ¶34 (FIG. 3 illustrates an example system 300 that facilitates grouping carriers by timing to facilitate efficient timing synchronization in multicarrier wireless networks. System 300 includes a wireless device 302, which can be a mobile device, access point, a portion thereof, and/or substantially any device that communicates in a wireless network. Wireless device 302 includes a carrier grouping component 304 that can associate a plurality of carriers in a timing group based on respective timing differences within a threshold range, <i>a carrier candidate selection component 306 that can choose a carrier in the group from which to acquire timing, a timing offset component 308 that can obtain a timing offset for a group of characters, and a timing update component 310 that can update timing for carriers in a group based on the timing offset.</i>”) ¶36 (“In an example, <i>carrier candidate selection component 306 can choose a carrier in the group from which to acquire timing updates</i>. Similarly, the carrier candidate selection component 306 can receive a carrier candidate selection from one or more related access points or the wireless network. In one example, the candidate carrier selection component 306 can select the carrier to use in timing updates based on a hash function to attempt even distribution of candidate carriers in a group (e.g., to prevent all UEs using the group to update using the same carrier). The candidate carrier selection component 306, for example, can use a hash function with a varying value so the candidate can change for the UE 302 for each update.”)

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	• ¶37 (“<i>Timing offset component 308 can acquire a timing offset from the candidate carrier for a given group using a random access procedure and/or the like</i>, and the timing update component 310 can update timing for the group of carriers based on the offset. In another example, the timing update component 310 can track downlink timing over carriers in a group, add the offset received from the timing offset component 308 to each carrier timing, average the timing differences, and apply the average difference as an offset for use with all carriers in the group.”) • ¶38 (“In addition, one or more groups of carriers can be entirely controlled at a common site. In this example, the <i>timing offset component 308 can receive timing adjustments for substantially all groups at the common site</i> in a vector from a base station at the common site. In an example, the vector can be absolute measurements or differences relative to a timing of one of the groups. Knowledge regarding which groups are utilized by the UE 302 can be maintained at the wireless network, in one example, at the UE 302, and/or the like.”) • ¶39 (“FIG. 4 illustrates an example methodology 400 that facilitates grouping carriers and performing group-based timing updates. At 402, a plurality of carriers can be associated into one or more timing groups. As described, the carriers can be associated according to a timing difference such that similarly timed carriers (e.g., below a threshold difference) can be included in a single group. At 404, a candidate carrier can be assigned in a given timing group for receiving timing updates. The candidate carrier can be chosen by a network component or UE, for example, such that the same carrier is not the candidate carrier for the timing group at all devices. As described, the candidate carrier can be chosen according to a hash value, random function, time-based function, and/or the like.”)

Tenny Claim 53	Tenny-Prov.
	• ¶40 (“At 406, <i>a timing offset can be received from the candidate carrier during the timing update. This can be in response to a random access procedure</i>, in one example, and can be related to a timing difference related to the candidate carrier. At 408, timing can be updated for each carrier in the timing group based on the timing offset. In one example, the updating can occur using an average of the offset applied to monitored timings for each carrier, as described. In another example, the offset received from the candidate carrier can be applied to all carriers in the group.”) • Claim 1 (“A method, comprising: associating a plurality of carriers utilized for communication into one or more timing groups of carriers; assigning a candidate carrier in at least one of the one or more timing groups for timing updates; <i>receiving a timing offset from the candidate carrier during a timing update</i>; and updating timing for each carrier in the at least one timing group based on the timing offset.”) • Claim 8 (“The method of claim 1, wherein carriers in the at least one of the one or more timing groups are transmitted at a common site.”) • Claim 9 (“The method of claim 8, wherein <i>the timing offset is received in a vector of a plurality of timing offsets for the at least one of the one or more timing groups from the common site</i>.”) • Tenny-Prov., AppxA(3:26-4:13) (“<i>A UE in the environment of Figure 2 could receive its timing information from either carrier 1 or carrier 2</i>. The timings of the two carriers differ, but by less than the tolerance that the deployment requires for a timing group; and it follows that, depending on which carrier the UE received its last update from, a UE connected to both carriers could consider the correct uplink timing to be at either UL1 or UL2 in the figure.

Tenny Claim 53	Tenny-Prov.
	The simplest approach is for the UE simply to <i>apply the timing offset to the carrier on which it received it</i>, and assume that the timing of other carriers in the group is ‘close enough’; in terms of the figure, this would mean that the system considered UL1 and UL2 to be the same for purposes of uplink timing accuracy. As an alternative, however, the UE could apply the offset, not to <i>the received downlink timing from the carrier that transmitted the offset</i>, but to the average timing of the carriers in the timing group. In such a case, although <i>the UE received its timing information from a particular carrier</i>, it tracks the (downlink) timing of each carrier in the group separately, so that when a single DL/UL offset is received, the UE can apply the offset separately to each carrier and take an average of the results to provide a ‘happy medium’ uplink timing for use with all carriers in the group. Such an averaging behaviour could be either a specified UE behaviour (to allow greater downlink tolerances within a timing group while still keeping the variation in uplink timing acceptable) or left to UE implementation.”)
[53.d] receiving an uplink communication via the uplink group of carriers, wherein the uplink group of carriers are received according to the timing offset.	Tenny-Prov. discloses receiving an uplink communication via the uplink group of carriers, wherein the uplink group of carriers are received according to the timing offset. For example, Tenny-Prov. discloses that the UE calculates a UL timing to perform uplink transmissions. <i>See</i> [53.c]; Tenny-Prov., AppxA(1:1-14) (“UE receives an uplink/downlink offset from the network” to determine “how it should align its uplink transmissions in relation to the received downlink timing”). As discussed above in [53.b]-[53.c] and [1.a]-[1.b], the UL timing is calculated by “apply[ing] the offset separately to each carrier” to provide an “uplink timing for use with all carriers in the group.” <i>See</i> [53.b]-[53.c], [1.a]-[1.b]; Tenny-Prov., ¶37, AppxA(3:21-4:13, Figure 3 (“Actual UL timing = (DL1 + DL2/2 + offset”), claim 7, 16). The “access point” (“fixed station used for communicating with the terminals”) then receives the uplink

Tenny Claim 53	Tenny-Prov.
	communication based on this calculated uplink timing via the uplink group of carriers. Tenny-Prov., ¶16. <u>E.g.</u> See [53.b]-[53.c], [1.a]-[1.b]. Tenny-Prov., AppxA(Figure 2)  Figure 2: Ambiguous uplink timing Tenny-Prov., AppxA(Figure 3)  Actual UL timing = $(DL1 + DL2)/2 + \text{offset}$ $= (UL1 + UL2)/2$ Figure 1

Tenny Claim 53	Tenny-Prov.
	 Fig. 1 Tenny-Prov., AppxA(1:1-14) (“This document describes solutions to several issues that arise in relation to <i>maintaining timing synchronisation for a UE in a multicarrier LTE-Advanced (LTE-A) system.</i> In a single-carrier environment, <i>the maintenance of timing synchronisation for a UE is well understood; the UE receives an uplink/downlink offset from the network, which occasionally needs to be updated, indicating how it should align its uplink transmissions in relation to the received downlink timing. In a multicarrier environment,</i> however, the situation is less straightforward. Assuming that all carriers serving a single UE are transmitted from the same cell site, it appears that a common offset should be adequate; however, even co-sited carriers could experience some variation in timing for a number of reasons (e.g., cable delays, distance between the base station site and a remote radio head), <i>which would make separate timing offsets per carrier beneficial or even necessary.</i>”)

Tenny Claim 53	Tenny-Prov.
	• ¶13 (Referring to Fig. 1, a multiple access wireless communication system according to one embodiment is illustrated. An access point 100 (AP) includes multiple antenna groups, one including 104 and 106, another including 108 and 110, and an additional including 112 and 114. In Fig. 1, only two antennas are shown for each antenna group, however, more or fewer antennas may be utilized for each antenna group. <i>Access terminal 116 (AT) is in communication with antennas 112 and 114, where antennas 112 and 114 transmit information to access terminal 116 over forward link 120 and receive information from access terminal 116 over reverse link 118.</i> Access terminal 122 is in communication with antennas 106 and 108, where antennas 106 and 108 transmit information to access terminal 122 over forward link 126 and receive information from access terminal 122 over reverse link 124. In a FDD system, communication links 118,120, 124 and 126 may use different frequency for communication. For example, forward link 120 may use a different frequency then that used by reverse link 118.”) • ¶16 (“<i>An access point may be a fixed station used for communicating with the terminals and may also be referred to as an access point, a Node B, or some other terminology.</i> An access terminal may also be called an access terminal, user equipment (UE), a wireless communication device, terminal, access terminal or some other terminology.”) • ¶33 (“According to aspects described herein, carriers from one or more access points can be grouped according to uplink timing. For example, <i>carriers having similar timing (e.g., within a threshold difference) can be grouped for a given UE</i> such that the UE maintains timing for each given group, rather than necessarily each carrier. In one example, <i>the UE can update timing for only one carrier in the group and accordingly update timing for the rest of the carriers in the group according to the same offset.</i> As described herein,

Tenny Claim 53	Tenny-Prov.
	selecting the carrier to utilize for updating can be network- and/or UE-based.”) ¶35 (“According to an example, <i>the wireless device 302 can participate in a multicarrier wireless network communicating over multiple carriers to one or more access points or other devices</i>. The carrier grouping component 304 can associate carriers having similar timing into timing groups. For example, <i>where multiple carriers have a timing difference below a threshold value, the multiple carriers can be grouped</i>. In one example, the carrier grouping component 304 can group the carriers according to observed timing. In another example, the carrier grouping component 304 can receive one or more groupings from one or more related access points or the wireless network. Thus, for example, where an access point provides multiple carriers utilized by the wireless device 302, the access point can transmit a grouping to the wireless device 302.”) ¶39 (“FIG. 4 illustrates an example methodology 400 that facilitates grouping carriers and performing group-based timing updates. At 402, a plurality of carriers can be associated into one or more timing groups. As described, the carriers can be associated according to a timing difference such that similarly timed carriers (e.g., below a threshold difference) can be included in a single group. At 404, a candidate carrier can be assigned in a given timing group for receiving timing updates. The candidate carrier can be chosen by a network component or UE, for example, such that the same carrier is not the candidate carrier for the timing group at all devices. As described, the candidate carrier can be chosen according to a hash value, random function, time-based function, and/or the like.”) Tenny-Prov., AppxA(3:26-4:13) (“A UE in the environment of Figure 2 could receive its timing information from either carrier 1 or carrier 2. The timings of the two carriers differ, but by less

Tenny Claim 53	Tenny-Prov.
	than the tolerance that the deployment requires for a timing group; and it follows that, depending on which carrier the UE received its last update from, <i>a UE connected to both carriers could consider the correct uplink timing to be at either UL1 or UL2 in the figure.</i> The simplest approach is for the UE simply to apply the timing offset to the carrier on which it received it, and assume that the timing of other carriers in the group is ‘close enough’; in terms of the figure, this would mean that <i>the system considered UL1 and UL2 to be the same for purposes of uplink timing accuracy.</i> As an alternative, however, the UE could apply the offset, not to the received downlink timing from the carrier that transmitted the offset, but to the average timing of the carriers in the timing group. In such a case, although the UE received its timing information from a particular carrier, it tracks the (downlink) timing of each carrier in the group separately, so that when a single DL/UL offset is received, the <i>UE can apply the offset separately to each carrier and take an average of the results to provide a ‘happy medium’ uplink timing for use with all carriers in the group.</i> Such an averaging behaviour could be either a specified UE behaviour (to allow greater downlink tolerances within a timing group while still keeping the variation in uplink timing acceptable) or left to UE implementation.”)

3. Invalidity of Claims 2-3 Over Tenny

75. As I discuss below, the Challenged Claims are anticipated or rendered obvious by **Tenny** (including **Tenny-Prov.**). **Tenny-Prov.** (including its **AppxA**) is incorporated by reference into **Tenny** (Tenny, ¶1) and is therefore part of **Tenny’s** disclosure. In addition to my discussion §IX.A.1, the following discussion identifies

example disclosures followed by bulleted excerpts that each disclose and/or render obvious the Challenged Claims.

(a) Element [2.pre]

76. Element [2.pre] recites “A method for establishing an uplink (UL) synchronization by a User Equipment (UE), the method comprising.” This element is met by Tenny alone.

77. Tenny discloses a method for establishing an uplink (UL) synchronization by a User Equipment (UE) (e.g., “maintaining timing synchronisation for a UE in a multicarrier LTE-Advanced (LTE-A) system” by “assign[ing] a UE” to “a group of carriers with uplink timings”).

- **Tenny-Prov., AppxA(Figure 1)**

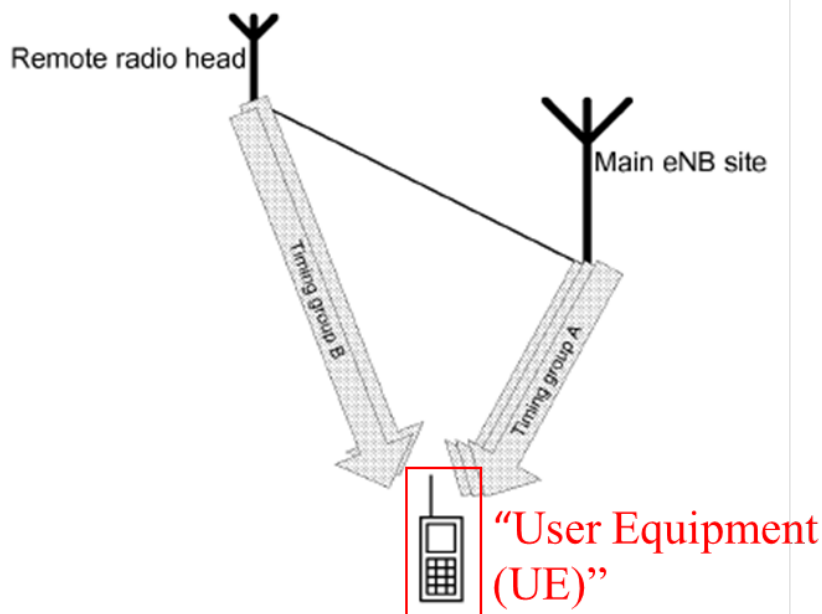
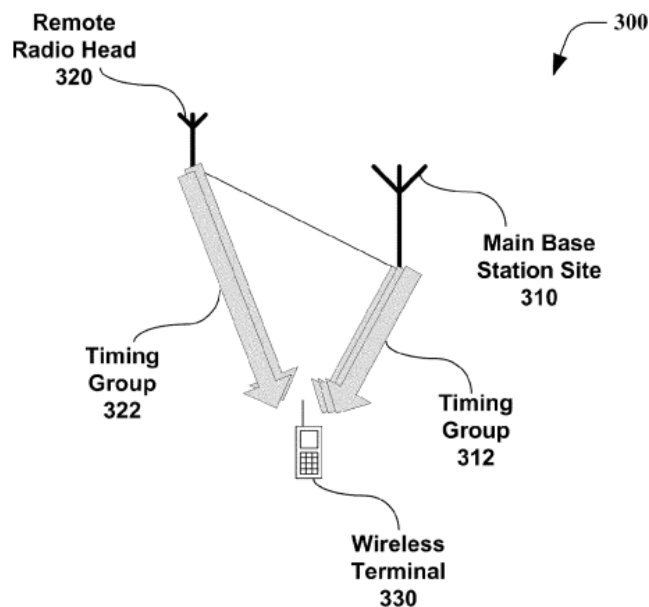


Figure 1: Two timing groups from a single eNode B

- Tenny-Prov., AppxA(1:2-3) (“This document describes solutions to several issues that arise in relation to *maintaining timing synchronisation for a UE in a multicarrier LTE-Advanced (LTE-A) system.*”)
- Tenny-Prov., AppxA(1:17-19) (“As a general framework, we propose that it should be possible to *assign a UE to at least one so-called timing group, i.e., a group of carriers with uplink timings* that are the same to within some tolerance.”)
- Tenny-Prov., AppxA(claim 6) (“The method of claim 5, wherein the *UE performs random access for timing synchronisation on a single carrier of the timing group for which it requires timing information.*”)
- Tenny, Figure 3

FIG. 3



- Tenny, ¶¶2-3 (“I. Field [¶] The following description relates generally to wireless communications, and more particularly to methods and apparatuses that facilitate *maintaining timing synchronization for user equipment in a multicarrier Long Term Evolution-Advanced (LTE-A) system.*”)
- Tenny, ¶12 (“[V]arious aspects are described in connection with *maintaining timing synchronization for user equipment in a LTE-A*

system. In one aspect, methods and computer program products are disclosed that facilitate a timing alignment in a multicarrier system. These embodiments include ***determining at least one downlink timing associated with at least one downlink carrier, and ascertaining an uplink timing associated with an uplink group of carriers. For these embodiments, the uplink timing is ascertained based on a processing of at least one downlink timing and a timing offset associated with the uplink group of carriers. Each of the uplink group of carriers is then transmitted within a threshold value of the uplink timing.***)

- **Tenny, ¶58** (“Indeed, within each timing group, *a UE may occasionally perform random access to update its timing* (e.g., if timing is maintained through a separate procedure for each timing group).”)
- **See also Tenny-Prov., ¶¶13, 16-17, 34- 35, 37, 38, 40, 41, Figures 1, 3, AppxA(2:8-10, Figures 2-3, claims 1, 5).**

78. **Tenny** teaches “solutions” for “maintaining timing synchronisation for a UE in a multicarrier LTE-Advanced (LTE-A) system.” Tenny-Prov., AppxA (1:2-3, Fig. 1); Tenny, ¶¶2-3, 12, Figure 3. The timing synchronization solutions include “[a] method of maintaining timing alignment between a mobile device and a network operating on a plurality of frequencies” by “association of the frequencies into one or more timing groups.” Tenny-Prov., AppxA(claim 1); Tenny, ¶12. For example, **Tenny** discloses “assign[ing] a UE to at least one ... *timing group*, i.e., a group of carriers with uplink timings that are the same to within some tolerance.” Tenny-Prov., AppxA(1:17-19); Tenny, ¶12. The UE then may establish uplink “timing synchronisation” by “perform[ing] random access . . . on a single carrier of the timing group for which it requires timing information.” Tenny-Prov., AppxA(claim

6); Tenny, ¶58. In particular, during the random access process, the UE receives a “timing offset” on “the candidate carrier” selected for “a given group”, which serves “a single timing advance value” “for use with all carriers in the group.” Tenny-Prov., ¶¶37, 40, Figure 3, AppxA(claim 1, 2:8-10), Tenny, ¶12.

(b) Element [2.a]

79. **Element [2.a] recites “receiving a Radio Resource Control (RRC) signaling including a UL timing group information set, which has been set by an evolved NodeB (eNB).” This element is met by Tenny alone.**

80. **Tenny discloses receiving a Radio Resource Control (RRC) signaling including a UL timing group information set (e.g., UE receives in a “RRC” signaling “mapping” a “group identifier” representing a UL “timing group” with the “particular carriers” assigned to the UE), which has been set by an evolved NodeB (eNB) (e.g., “the mapping of group identities” is assigned by a network element, such as an “eNode B”).**

- **Tenny-Prov., AppxA(Fig. 1)**

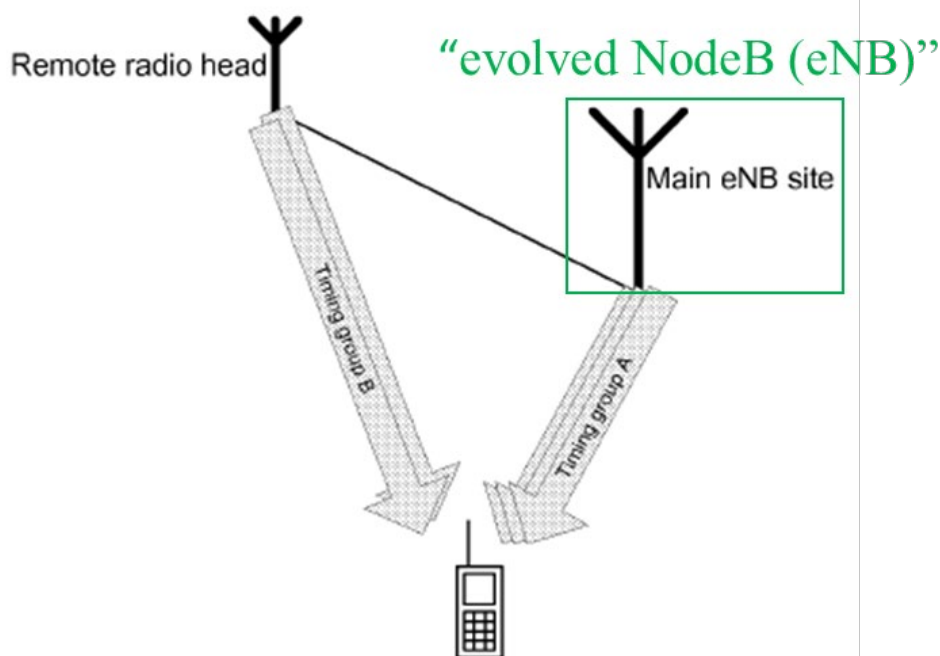


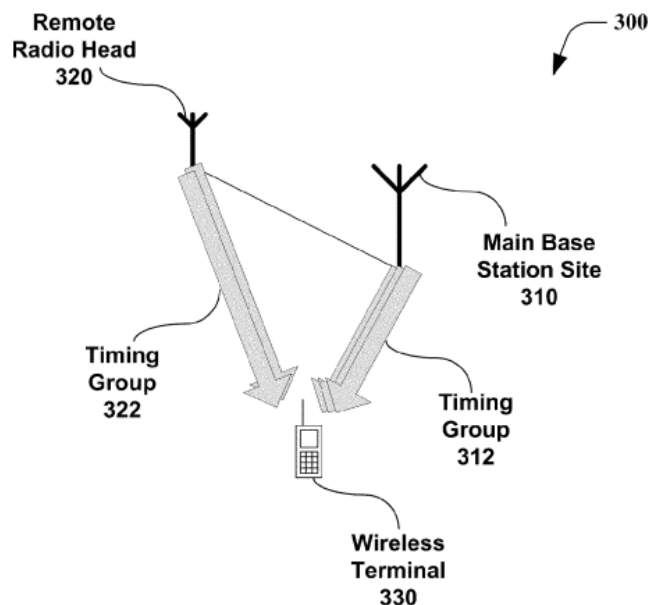
Figure 1: Two timing groups from a single eNode B

- Tenny-Prov., AppxA(1:2-3) (“This document describes solutions to several issues that arise in relation to *maintaining timing synchronisation for a UE in a multicarrier LTE-Advanced (LTE-A) system.*”)
- Tenny-Prov., AppxA(1:17-19) (“As a general framework, we propose that *it should be possible to assign a UE to at least one so-called timing group, i.e., a group of carriers with uplink timings that are the same to within some tolerance.*”)
- Tenny-Prov., AppxA(1:29-32) (“[I]f the tolerances defining a timing group are fine, it is possible that a UE could be assigned carriers from multiple timing groups originating from the same cell site. *An example, in which a remote radio head belonging to the eNode B causes some carriers to have different timing from others, is shown in Figure 1.*”)
- Tenny-Prov., AppxA(5:3-10) (“In a ‘degenerate’ form of this vector approach, the network could opt to send only a single timing advance command per MAC element, but *indicate which timing group the value is associated with.* This approach would minimise the specification impact to the concerned MAC control element, since the existing information only

needs to be augmented by *a group identifier*. It is presumed that *such an identifier could be sent with a small number of bits, e.g., as an index into the set of timing groups with which the UE was configured. Such a mapping could be established by explicit signalling (in higher layers such as the RRC)* at the time the UE is configured with particular carriers.”)

- Tenny-Prov., AppxA(claim 33) (“The method of claim 31, wherein *the proper subset is determined by the network.*”)
- Tenny-Prov., AppxA(claim 35) (“The method of claim 34, wherein *the indication of which timing groups are contained in the proper subset relies on a mapping of group identities shared between the network and the UE.*”)
- Tenny-Prov., AppxA(claim 36) (“The method of claim 35, wherein *the mapping of group identities is configured in association with the assignment to the UE of dedicated radio resources on carriers in one or more of the concerned timing groups.*”)
- Tenny, Figure 3

FIG. 3



- Tenny, ¶40 (“*A base station can be utilized for communicating with access terminal(s) and can also be referred to as an access point, Node B, Evolved Node B (eNodeB), access point base station, or some other terminology.*”.)
- Tenny, ¶70 (“In another aspect of this vector approach, *the network could opt to send only a single timing advance command per MAC element, but indicate which timing group the value is associated with.* Such approach would minimize the specification impact to the concerned MAC control element, since *the existing information only needs to be augmented by a group identifier.* It is presumed that such an identifier could be sent with a small number of bits (e.g., as an index into the set of timing groups with which the UE was configured). *Such a mapping could be established by explicit signaling (in higher layers such as the Radio Resource Control) at the time the UE is configured with particular carriers.*”)
- Tenny, claim 33 (“The apparatus of claim 30, wherein the received timing message includes *an indication of which of the uplink group of carriers are included in the uplink group subset.*”)
- Tenny, claim 34 (“The apparatus of claim 33, wherein the message processing component is configured to *decode the indication according to a mapping of group identities shared with a network.*”)
- See also Tenny-Prov., ¶¶16, 27, 32, 34-35, AppxA(1:26-39, claims 27, 31, 34, 37, 38); Tenny, claims 26, 31, 37, 38, 62, 63, 66, 67.

81. See my discussion of [2.pre]. Tenny discloses that the UE receives an “explicit signalling” in the “RRC” layer (*i.e.*, RRC signalling) including a “group identifier” as an “index into the set of timing groups with which the UE was configured.” Tenny-Prov., AppxA (5:3-10, Claim 6); Tenny, ¶70. In particular, the RRC signalling “establishe[s]” a “mapping” between the set of timing groups and a set of “group identifier[s],” where each group identifier is “associated with” a “timing group.” Tenny-Prov., AppxA (5:3-10); Tenny, ¶70. As discussed in [2.pre],

each “so-called timing group” assigned to the UE is a UL timing group because it represents “a group of carriers with uplink timings that are the same to within some tolerance.” *See* Tenny-Prov., AppxA(1:17-19); [2.pre]. As such, the group identifiers representing the set of timing groups that UE is configured with, and which UE receives via the RRC signalling, constitute an uplink (UL) group information set. **Tenny** teaches using the group identifiers in the network’s transmission of “timing advance command.” Tenny-Prov., AppxA(5:3-10); Tenny, ¶70. In particular, **Tenny** teaches “augment[ing]” the timing advance command with “a group identifier” consisting of “a small number of bits” to serve “as an index into the set of timing groups with which the UE was configured.” *Id.*

82. **Tenny** discloses that the UE is “assigned” with a set of timing groups via RRC signalling that is sent by the “network.” Tenny-Prov., AppxA(1:29-32, 5:3-10); Tenny, ¶70. A person of ordinary skill in the art would have understood that the set of timing groups assigned to each UE are set by the network so that the associated group identifiers can be included in the RRC message that the network sends. Moreover, **Tenny’s** uplink timing synchronization solutions are tailored for the “LTE design” that existed at the time, which utilized “eNode B(s)” (or “eNB(s)”) for performing network-side synchronization functionality. Tenny-Prov., AppxA(1:26-32, Figure 1); Tenny, ¶40. Accordingly, a person of ordinary skill in

the art would have understood that the set of timing groups that the UE is assigned to are set by the eNB. And at minimum, it would have been obvious to use an eNB as the network element that sets the group identifier information in the RRC signaling message because the eNB was conventionally responsible at the time of the invention for performing network-side synchronization functionality in an LTE system. *See, e.g.*, TS36.300 at 44-46 (“UE performs synchronisation to target eNB and accesses the target cell via RACH. . . . UE derives target eNB specific keys and configures the selected security algorithms to be used in the target cell. . . . The target eNB responds with UL allocation and timing advance”), 52, 54 (eNB sending a “Random Access Response” conveying “Timing Alignment Information” to a UE as part of the “Random Access Procedure” in LTE); Ex. 1015 at 299 (“[I]t suffices to note that the LTE radio-access architecture consists of a single node – the eNodeB[]]. The eNodeB communicates with one or several mobile terminals, as known as UEs.”) & n.1 (“The term eNodeB is introduced in LTE to indicate the additional functionality placed in the eNodeB compared to the functionality in the NodeB in WCDMA/HSPA.”); Ex. 1016 (Rysavy Rpt.) at ¶35 (“a person of ordinary skill in the art would understand that...base stations in a 4G cellular network are often referred to as ‘eNBs’”); Ex. 1022 (Rysavy Tr.) at 69:12-15 (“the base stations

in 4G are referred to as eNodeB.”), 65:12-16 (“I have used the term eNodeB to refer to an LTE base station.”); *see also* Tenny-Prov., AppxA(1:26-32, Figure 1).

(c) Element [2.b]

83. **Element [2.b] recites “configuring one or more UL timing groups based on the UL timing group information set, the one or more UL timing groups each comprising one or more UL CCs.”** This element is met by Tenny alone.

84. **Tenny discloses configuring one or more UL timing groups** (e.g., “generates the association of the plurality of carriers into one or more timing groups according to a grouping received from a base station associated with a subset of the plurality of carriers”; UE’s “carrier grouping component 304” “receive[s] one or more groupings from one or more related access points or the wireless network” and “choose[s] a carrier in the group from which to acquire timing”; “timing groups” are “group[s] of carriers with uplink timings that are the same to within some tolerance”) **based on the UL timing group information set** (e.g., “mapping” of “multiple carriers” to timing groups via “group identifier[s]” received in the RRC signaling; *see* [2.a]), **the one or more UL timing groups each comprising one or more UL CCs** (e.g., “a plurality of carriers can be associated into one or more timing groups”).

- **Tenny-Prov., Figure 3 (annotated)**

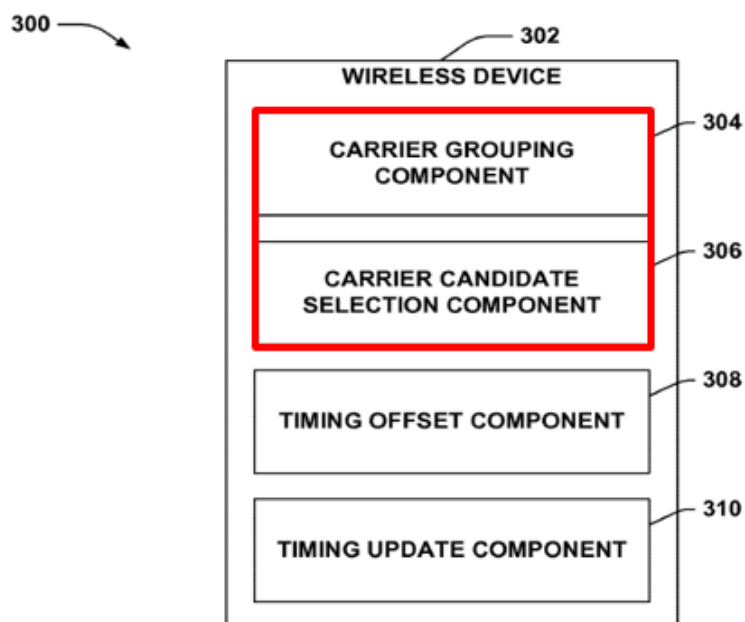


Fig. 3

- Tenny-Prov., Figure 4 (annotated)

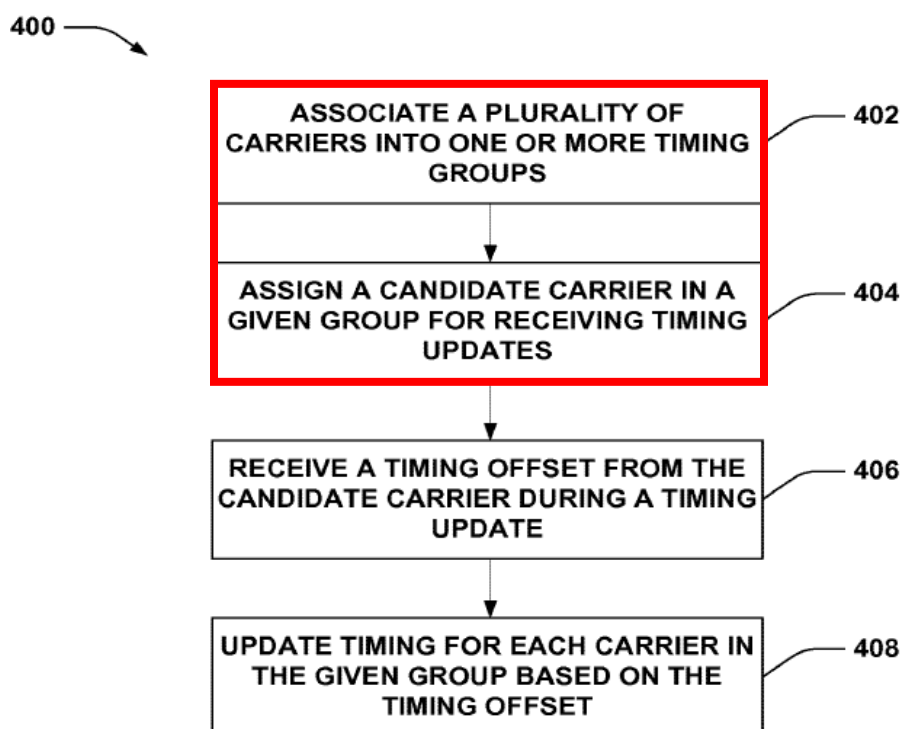


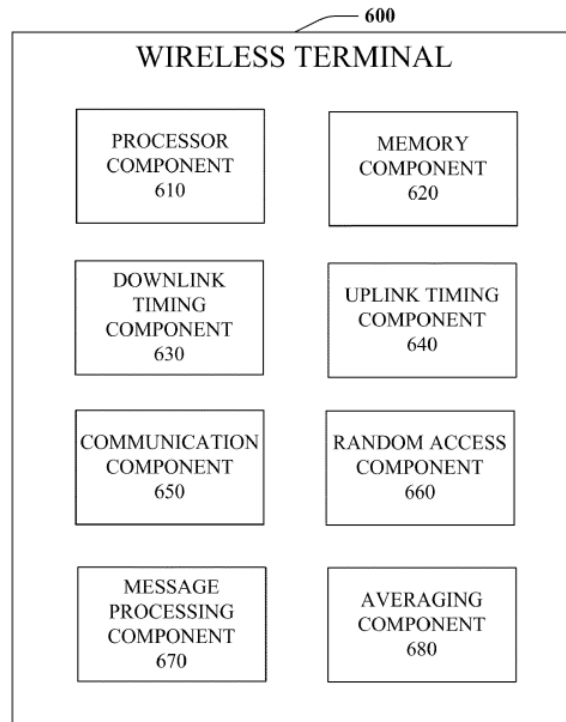
Fig. 4

- Tenny-Prov., AppxA(1:17-19) (“As a general framework, we propose that *it should be possible to assign a UE to at least one so-called timing group, i.e., a group of carriers with uplink timings that are the same to within some tolerance.*”)
- Tenny-Prov., AppxA(5:3-10) (“In a ‘degenerate’ form of this vector approach, the network could opt to send only a single timing advance command per MAC element, but *indicate which timing group the value is associated with.* This approach would minimise the specification impact to the concerned MAC control element, since the existing information only needs to be augmented by *a group identifier.* It is presumed that *such an identifier could be sent with a small number of bits, e.g., as an index into the set of timing groups with which the UE was configured. Such a mapping could be established by explicit signalling (in higher layers such as the RRC)* at the time the UE is configured with particular carriers.”)
- Tenny-Prov., ¶34 (“*FIG. 3 illustrates an example system 300 that facilitates grouping carriers by timing* to facilitate efficient timing synchronization in multicarrier wireless networks. *System 300 includes a wireless device 302, which can be a mobile device....*”)
- Tenny-Prov., ¶35 (“...*The carrier grouping component 304 can associate carriers having similar timing into timing groups....*In another example, *the carrier grouping component 304 can receive one or more groupings from one or more related access points or the wireless network.* Thus, for example, where an access point provides multiple carriers utilized by the wireless device 302, the access point can transmit a grouping to the wireless device 302....”)
- Tenny-Prov., ¶36 (“In an example, *carrier candidate selection component 306 can choose a carrier in the group from which to acquire timing updates.* ... In one example, the candidate carrier selection component 306 can select the carrier to use in timing updates based on a hash function to attempt even distribution of candidate carriers in a group (e.g., to prevent all UEs using the group to update using the same carrier).”)
- Tenny-Prov., ¶39 (“*FIG. 4 illustrates an example methodology 400 that facilitates grouping carriers and performing group-based timing updates. At 402, a plurality of carriers can be associated into one or more timing*”)

groups. As described, the carriers can be associated according to a timing difference such that similarly timed carriers (*e.g.*, below a threshold difference) can be included in a single group. At 404, ***a candidate carrier can be assigned in a given timing group for receiving timing updates. The candidate carrier can be chosen by...UE***, for example, such that the same carrier is not the candidate carrier for the timing group at all devices.”)

- **Tenny-Prov. ¶40** (“At 406, a timing offset can be received from the candidate carrier during the timing update. This can be in response to a random access procedure, in one example, and can be related to a timing different related to the candidate carrier. ***At 408, timing can be updated for each carrier in the timing group based on the timing offset...In another example, the offset received from the candidate carrier can be applied to all carriers in the group.***”)
- **Tenny-Prov., Claim 15** (“The *wireless communications apparatus* of claim 10, the at least *one processor generates the association of the plurality of carriers into one or more timing groups according to a grouping received from a base station associated with a subset of the plurality of carriers.*”)
- **Tenny, Figure 6**

FIG. 6



- Tenny, ¶70 (“In another aspect of this vector approach, *the network could opt to send only a single timing advance command per MAC element, but indicate which timing group the value is associated with.* Such approach would minimize the specification impact to the concerned MAC control element, since *the existing information only needs to be augmented by a group identifier.* It is presumed that such an identifier could be sent with a small number of bits (e.g., as an index into the set of timing groups with which the UE was configured). *Such a mapping could be established by explicit signaling (in higher layers such as the Radio Resource Control) at the time the UE is configured with particular carriers.*”)
- Tenny, ¶78 (“Particular embodiments are also contemplated wherein the uplink group subset includes assigned carriers. For instance, *in one embodiment, each uplink group within the uplink group subset includes at least one carrier with an assigned radio resource. In another embodiment, the uplink group of carriers comprises a set of uplink groups in which each uplink group includes at least one carrier with an assigned radio resource, wherein the uplink group subset is a subset of the set of uplink groups.*”)

- **Tenny, ¶79** (“For some embodiments, it is contemplated that the uplink group subset is determined by a network entity. For instance, message processing component 670 may be configured to submit a request requesting the network entity to provide the uplink group subset, wherein the uplink group subset is determined by the network entity in response to the request. Indeed, it should be noted that *the received timing message itself may include an indication of which of the uplink group of carriers are included in the uplink group subset*. For such embodiments, *message processing component 670 may be configured to decode the indication according to a mapping of group identities shared with the network*. In an aspect, the mapping of group identities is configured in association with an assignment of dedicated radio resources on uplink carriers within at least one uplink group of the uplink group subset.”)
- **Tenny, ¶82** (“Wireless terminal 600 may also include random access component 660, which is configured to perform a random access procedure. Within such embodiment, *random access component 660 is configured to perform the random access procedure on at least one random access carrier included in a downlink group of carriers that includes the at least one downlink carrier received from the network*. In a particular aspect, the random access procedure is performed on a single carrier, wherein the single carrier is an assigned carrier provided by a network prior to the performing of the random access procedure. Alternatively, the random access procedure may include receiving the single carrier as part of a dedicated radio resource configuration.”)
- **Tenny, ¶84** (“In addition to selecting the alternative carrier, *it is also contemplated that the single carrier is independently selected by random access component 660*. Within such embodiment, the selecting may comprise applying a determination function across a set of available carriers in the downlink group of carriers.”)
- **Tenny, claim 30** (“The apparatus of claim 26, wherein *the uplink group of carriers comprise a set of uplink groups in which each uplink group within the set of uplink groups includes at least one carrier with an assigned radio resource, and wherein the uplink group subset is a subset of the set of uplink groups*.”)

- **Tenny, claim 35** (“The apparatus of claim 34, wherein the mapping of group identities is configured in association with ***an assignment of dedicated radio resources on uplink carriers within at least one uplink group of the uplink group subset.***”)
- *See also* Tenny-Prov., claims 1, 6, 8, 17, AppxA(1:17-2:6, 2:23-3:17, 4:15-25, Figure 1, claim 3); Tenny, ¶¶44, 56, 60-61, Figure 7.

85. See my discussion for elements [2.pre] and [2.a] above, and [2.c] below (in connection with candidate carrier). **Tenny** also discloses a “wireless device 302” including a “carrier grouping component 304.” Tenny-Prov., ¶35; Tenny, ¶79 (“message processing component 670” serving the same function). The carrier group component 304 “receive[s] one or more groupings from one or more related access points or the wireless network.” *Id.* For example, “where an access point provides multiple carriers utilized by the wireless device 302, the access point can transmit a grouping to the wireless device 302.” *Id.* Here, the “wireless device 302” (which **Tenny** discloses “can be a mobile device”) refers to the UE (Tenny-Prov., ¶34), and “one or more groupings” refer to the “group identifier[s]” that UE receives in an earlier RRC signalling, as I discuss in element [2.a]. *Id.*; *see* [2.a].

86. **Tenny** discloses that the UE configures one or more UL timing groups based on these grouping(s) received from the network in two instances. In the first instance, **Tenny’s** discloses a “wireless communications apparatus,” such as wireless device 302 (e.g., UE, mobile device), that “generates the association of the

plurality of carriers into one or more timing groups according to a grouping received from a base station.” Tenny-Prov., claim 15, ¶39, Fig. 4, AppxA(5:3-10); Tenny, ¶79, claims 30, 35. Referring back to my discussion in element [2.a], **Tenny’s** UE receives an “RRC” signalling that establishes a “mapping” between a set of group identifiers (*i.e.*, the UL timing group information set) and the carriers that have been grouped into timing groups assigned to the UE. *See* [2.a]. Additionally, as discussed in [2.pre] and [2.a], these “timing groups”/groupings are UL timing groups because they represent “a group of carriers with uplink timings that are the same to within some tolerance.” Tenny-Prov., AppxA(1:17-19). As such, by associating the plurality of carriers into one or more timing groups according to a one or more groupings received from the network, the UE configures one or more UL timing groups based on the UL timing group information set received in the RRC signaling. Tenny-Prov., claim 15, ¶39, Fig. 4, AppxA(5:3-10); Tenny, ¶79, claims 30, 35.

87. In the second instance, **Tenny** discloses that the “carrier candidate selection component 306” of the wireless device additionally configures a UL timing group by “choos[ing] a carrier in the group from which to acquire timing updates.” Tenny-Prov., ¶36; Tenny, ¶¶61, 82, 84 (“random access component” serving the same function), Figures 6-7. As part of this UE configuration, the wireless device “assign[s] a candidate carrier” in each “given timing group for receiving timing

updates” to “be applied to all carriers in the group,” each of which is a UL timing group. Tenny-Prov., ¶¶39-40, Figure 4, claim 1; Appx(1:17-19); Tenny ¶¶84, Figure 6-7. Again, this second step of configuration performed on the grouping(s) received in the RRC signalling (*see* [2.a]); thus, **Tenny** discloses another instance of a UE configuring one or more UL timing groups based on the UL timing group information set received in the RRC signalling (*see* [2.a]) by selecting a candidate carrier from which to acquire further timing updates on behalf of the respective timing group (*see also* discussion of the claimed “delegate CC” in [2.c] below). By “associat[ing]” “a plurality of carriers...into one or more timing groups,” **Tenny** discloses that each UL timing group configured by the UE comprises one or more UL CCs. Tenny-Prov., ¶39.

(d) Element [2.c]

88. **Element [2.c] recites “transmitting a Random Access Preamble (RAP) through one or more UL CCs, each of the one or more UL CCs transmitting an RAP being set as a delegate CC in the respective UL timing group.”** This element is met by Tenny alone.

89. **Tenny discloses transmitting a Random Access Preamble (RAP) through one or more UL CCs** (*e.g.*, UE’s “timing offset component 308” uses “a random access procedure” to “acquire a timing offset from the candidate carrier”

from the eNB), each of the one or more UL CCs transmitting an RAP being set as a delegate CC in the respective UL timing group (e.g., “candidate carrier” chosen by “carrier candidate selection component 306” to “acquire timing updates for a given [UL timing] group”).

- **Tenny-Prov., Figure 3**

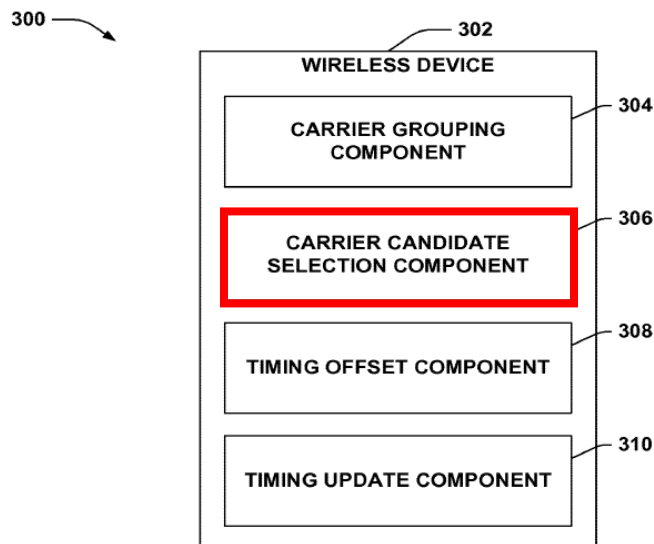


Fig. 3

- **Tenny-Prov., Figure 4 (annotated)**

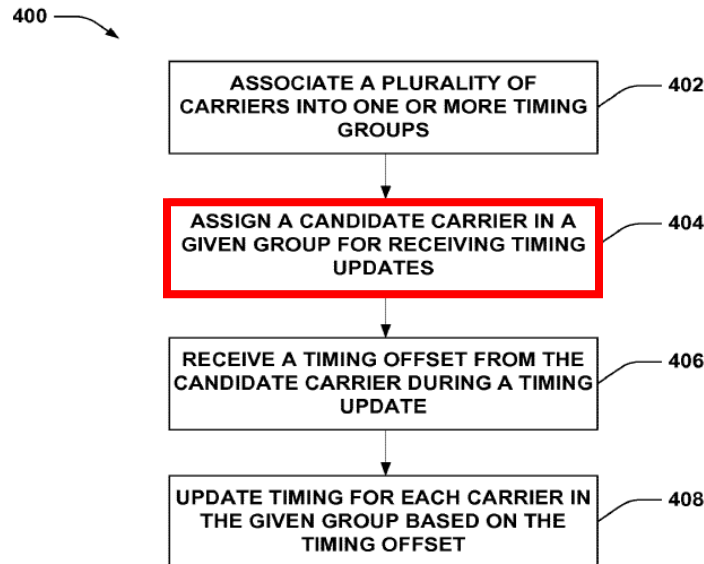


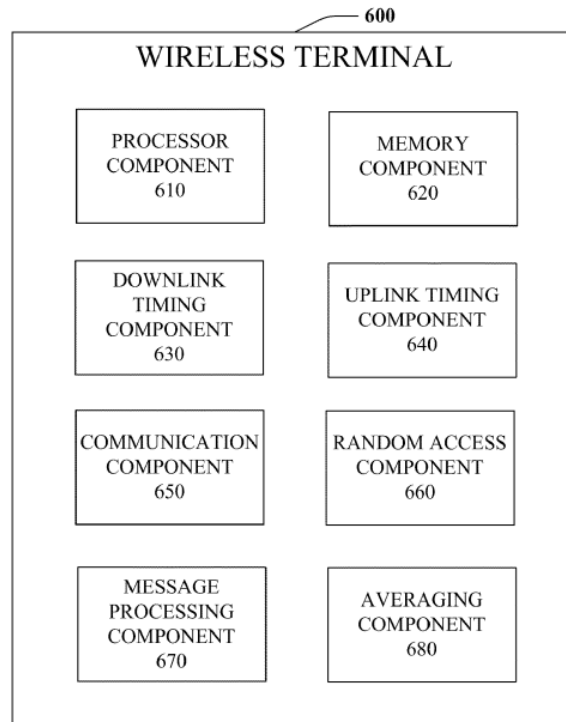
Fig. 4

- Tenny-Prov., ¶36 (“In an example, *carrier candidate selection component 306 can choose a carrier in the group from which to acquire timing updates*. ... In one example, the candidate carrier selection component 306 can select the carrier to use in timing updates based on a hash function to attempt even distribution of candidate carriers in a group (e.g., to prevent all UEs using the group to update using the same carrier).”)
- Tenny-Prov., ¶37 (“*Timing offset component 308 can acquire a timing offset from the candidate carrier for a given group using a random access procedure* and/or the like, and the timing update component 310 can update timing for the group of carriers based on the offset.”)
- Tenny-Prov., ¶39 (“At 404, *a candidate carrier can be assigned in a given timing group for receiving timing updates. The candidate carrier can be chosen by...UE*, for example, such that the same carrier is not the candidate carrier for the timing group at all devices.”)
- Tenny-Prov., AppxA(1:2-3) (“This document describes solutions to several issues that arise in relation to *maintaining timing synchronisation for a UE in a multicarrier LTE-Advanced (LTE-A) system*.”)
- Tenny-Prov., AppxA(1:17-19) (“As a general framework, we propose that *it should be possible to assign a UE to at least one so-called timing group*,

i.e., a group of carriers with uplink timings that are the same to within some tolerance.”)

- **Tenny-Prov., AppxA(2:7-25)** (“3.2. Carrier selection for random access *Within each timing group, the UE may need to occasionally perform random access to update its timing* (e.g., if timing is maintained through a separate procedure for each timing group). By definition, *this update only needs to be performed with one carrier of each timing group*; and the issue arises of how the UE should decide which carrier this is.... *In a UE-based approach, each UE would select a single carrier for random access for timing updates autonomously*, based on some function that tends to distribute UEs more or less evenly across the timing group.”)
- **Tenny-Prov., AppxA(claim 6)** (“The method of claim 5, wherein the *UE performs random access for timing synchronisation on a single carrier of the timing group for which it requires timing information.*”)
- **Tenny, ¶58** (“In an aspect, embodiments directed towards selecting carriers for performing a random access procedure are also contemplated. Indeed, within each timing group, a UE may occasionally perform random access to update its timing (e.g., if timing is maintained through a separate procedure for each timing group). Here, although this update only needs to be performed with one carrier of each timing group, the issue arises of how the UE should decide which carrier this is. In an aspect, the UE is configured to avoid performing unnecessary timing updates (i.e., to select a single carrier from the timing group to use for its timing control).”)
- **Tenny, Figure 6**

FIG. 6



- Tenny, ¶61 (“*In an exemplary UE-based approach, each UE selects a single carrier for random access for timing updates autonomously.* Here, similar to the exemplary network-based solution, the determination of the carrier could be absolute or subject to modification. In a particular embodiment, carrier selection is based on a function that tends to distribute UEs more or less evenly across the timing group.”)
- Tenny, ¶82 (“Wireless terminal 600 may also include random access component 660, which is configured to perform a random access procedure. Within such embodiment, *random access component 660 is configured to perform the random access procedure on at least one random access carrier included in a downlink group of carriers that includes the at least one downlink carrier received from the network.* In a particular aspect, *the random access procedure is performed on a single carrier*, wherein the single carrier is an assigned carrier provided by a network prior to the performing of the random access procedure. Alternatively, the random access procedure may include receiving the single carrier as part of a dedicated radio resource configuration.”)

- **Tenny, ¶84** (“In addition to selecting the alternative carrier, *it is also contemplated that the single carrier is independently selected by random access component 660*. Within such embodiment, the selecting may comprise applying a determination function across a set of available carriers in the downlink group of carriers.”)
- **Tenny, claim 2** (“The method of claim 1, further comprising *performing a random access procedure on at least one random access carrier*, wherein the at least one random access carrier is included in a downlink group of carriers that includes the at least one downlink carrier.”)
- **Tenny, claim 3** (“The method of claim 2, wherein the performing comprises *performing the random access procedure on a single carrier*.”)
- **See also Tenny-Prov., ¶¶2-3, 34, Figure 4, AppxA(claim 5); Tenny, ¶¶60, 80, claims 4, 52.**

90. See my discussion for elements [2.pre] and [2.b] above and [2.d]-[2.e] below with respect to discussion of **Tenny’s** candidate carrier. **Tenny** also discloses that in an “LTE-A” system the UE updates its timing in order to “maintain[] timing synchronisation.” Tenny-Prov., AppxA(1:2-3); Tenny, ¶¶2-3. “[T]o update its timing,” the UE “perform[s] random access” “[w]ithin each timing group.” Tenny-Prov., AppxA(1:2-3, 2:7-26); Tenny, ¶82. In particular, for each timing group, the “UE performs random access for timing synchronisation on a single carrier of the timing group for which it requires timing information.” Tenny-Prov., AppxA(claim 6); Tenny, claims 2-3. “Timing offset component 308” of the UE “acquire[s] a timing offset from the candidate carrier for a given group using a random access

procedure and/or the like, and the timing update component 310 can update timing for the group of carriers based on the offset.” Tenny-Prov., ¶¶37; Tenny, ¶80.

91. A person of ordinary skill in the art would have understood that **Tenny’s** UE “acquire[s] a timing offset” using a “random access procedure” by transmitting a Random Access Preamble, or “RAP,” to the eNB to request timing information from the eNB. The random access procedure was well-known in LTE to perform uplink synchronization between a UE and an eNB at the time of the alleged invention. *See, e.g.*, TS36.300 at 52 (“The random access procedure is performed for the following five events . . . E.g. when UL synchronisation status is ‘non-synchronised’”); Ex. 1015 at 432 (“In LTE, random access is used for several purposes, including . . . to establish uplink synchronization if uplink or downlink data arrives when the terminal is in RRC_CONNECTED and the uplink is not synchronized”). As shown in the figure below, the first step in the random access procedure is for the UE to transmit a RAP to the eNB to request timing information needed to perform synchronization with an eNB.

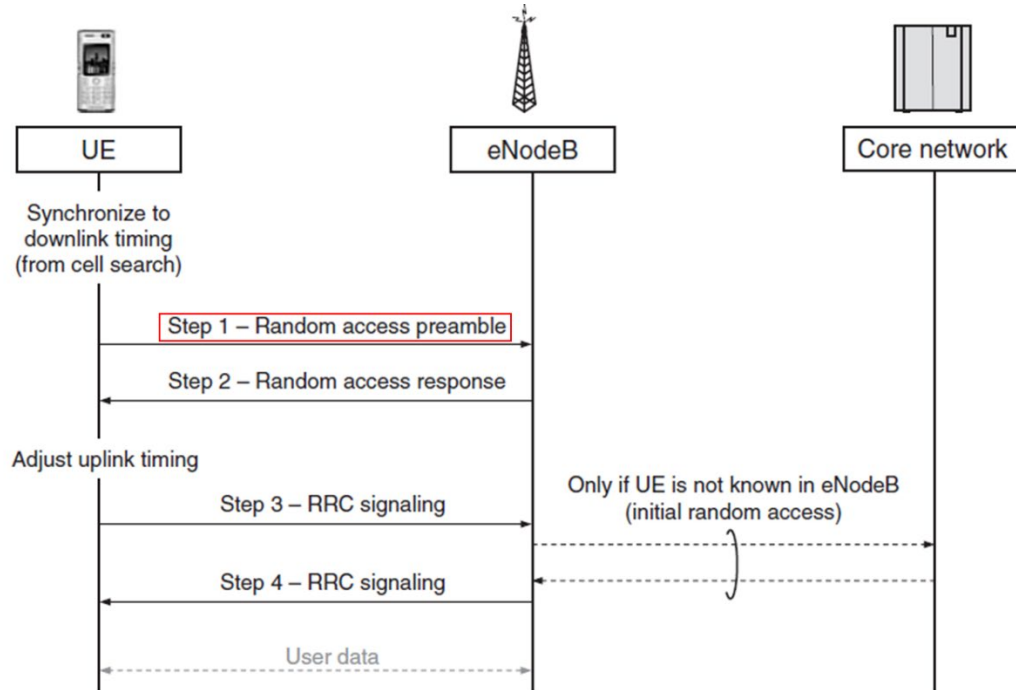


Figure 18.8 Overview of the random-access procedure.

See Ex. 1015 at 433 (“The basis for random access is a contention-based procedure, illustrated in Figure 18.8, and consists of four steps: 1. The first step consists of transmission of a random-access preamble, allowing the eNodeB to estimate the transmission timing of the terminal. Uplink synchronization is necessary as the terminal otherwise cannot transmit any uplink data.”), 434 (“The first step in the random-access procedure is the transmission of a random access preamble. The main purpose of the preamble transmission is to indicate to the base station the presence of a random-access attempt and to allow the base station to estimate the delay between the eNodeB and the terminal. The delay estimate will be used in the second step to adjust the uplink timing.”); TS36.300 at 52 (“The four steps of the

contention based random access procedures are: 1) Random Access Preamble on RACH in uplink....”). Indeed, I understand that Pantech itself has indicated that a person of ordinary skill in the art would have understood a “Random Access Preamble” to be defined by the LTE standard, as set forth in TS36.300. *See* Ex. 1022 (Rysavy Tr.) at 47:20-22 (“The plain and ordinary meaning of the random access preamble is the particular item used in LTE for performing the random access procedure”); Ex. 1016, ¶42 (Pantech’s expert citing to “3GPP TS 36.300” to support his opinion that “a person of ordinary skill in the art would understand that the claim term’s use of ‘RAP’ (or ‘random access preamble’) and ‘TA value’ is consistent with the plain and ordinary meaning of those terms.”); Ex. 1018 at 3-4 (Pantech citing to “TS 36.300” to support definition of “transmitting a [RAP]”). Thus, a person of ordinary skill in the art would have at least found it obvious to implement Tenny to use a Random Access Preamble (RAP) to request the timing offset from the eNB as part of the well-known random access procedure in LTE.

92. As I discuss for element [2.b], “carrier candidate selection component 306” of the UE “choose[s]” a “candidate carrier” in “the [timing] group from which to acquire timing updates”. *See* [2.b]; Tenny-Prov., ¶¶36, 39, Figures 3-4, claim 1; Tenny ¶¶82, 84, Figure 6-7. Consequently, the UE’s “[t]iming offset component 308” “acquire[s] a timing offset from the candidate carrier for a given group using a

random access procedure.” Tenny-Prov., ¶37, Figure 3; Tenny ¶¶80, 82, 84, Figure 6-7. As discussed in [2.pre] and [2.b], the timing group from which the candidate carrier is selected is a UL timing group. *See* [2.pre], [2.b]; Tenny-Prov., AppxA(1:17-19). And as discussed above and as further discussed below in [2.d], because **Tenny’s** “candidate carrier” is used by the UE (“[t]iming offset component 308”) to transmit the RAP to “acquire a timing offset...using a random access procedure” from the eNB, it constitutes a UL CC that transmits a RAP. Furthermore, the “candidate carrier” is set as a delegate CC in its respective UL timing group because it is chosen to “acquire a timing offset...for a given group.” *See* Tenny-Prov., ¶¶37, 39; Figures 3-4, claim 1; Tenny ¶¶82, 84, Figure 6-7; *see also* [2.d]-[2.e] below (discussing applying the timing offset received through the candidate carrier to the CCs in the respective UL timing group).

93. Based on the discussion above, a person of ordinary skill in the art would have understood that the UE transmits a RAP through one or more uplink carriers set as a “candidate” or delegate carrier for their respective timing groups, and at minimum, a person of ordinary skill in the art would have found obvious to implement the UE to do so.

(e) Element [2.d]

94. Element [2.d] recites “receiving a Random Access Response (RAR) including a Timing Advanced (TA) value for UL CCs in the respective UL timing group, wherein each TA value is transmitted from the eNB for the respective UL timing group based on the transmitted RAP associated with a delegate CC of the respective UL timing group.” This element is met by Tenny alone.

95. Tenny discloses receiving a Random Access Response (RAR) including a Timing Advanced (TA) value for UL CCs in the respective UL timing group (e.g., “timing offset” is received “in response to a random access procedure”; “a single timing advance value can be indicated to the UE for use with all the carriers in the group”), wherein each TA value is transmitted from the eNB for the respective UL timing group (e.g., “this [timing] update only needs to be performed with one carrier of each timing group”; “UE ... to receive timing adjustments ... [from] the base station,” such as a “eNB”) based on the random access procedure associated with a delegate CC of the respective UL timing group (e.g., “timing offset can be received from the candidate carrier during the timing update...in response to a random access procedure”; *see* [2.c]).

- **Figure 3**

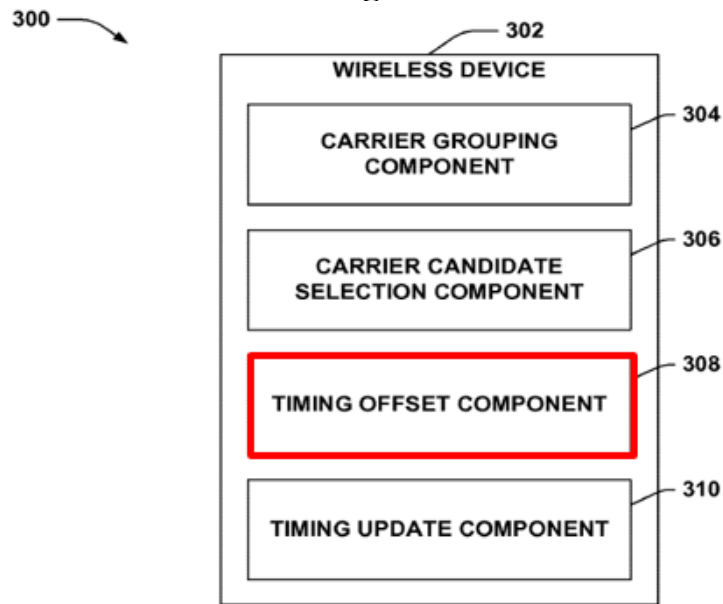


Fig. 3

- **Tenny-Prov., AppxA(Figure 1)**

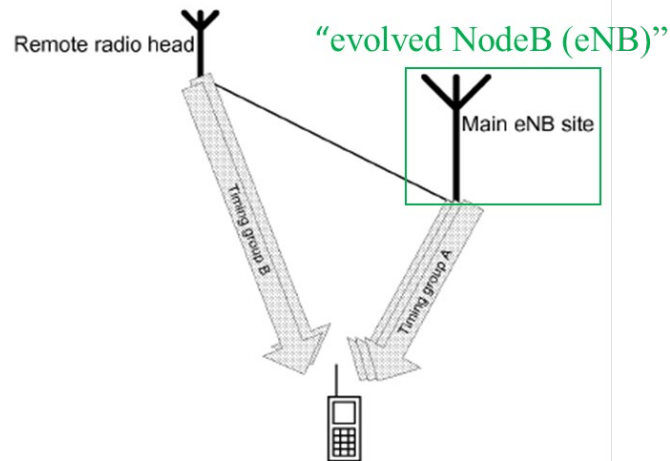


Figure 1: Two timing groups from a single eNode B

- **Tenny-Prov., AppxA(Figure 2)**

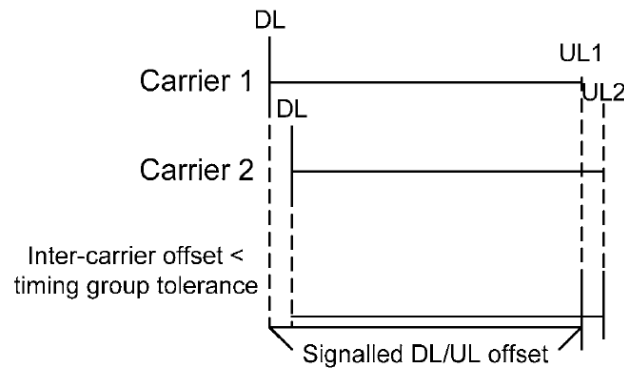


Figure 2: Ambiguous uplink timing

- Tenny-Prov., ¶36 (“In an example, *carrier candidate selection component 306 can choose a carrier in the group from which to acquire timing updates.*”)
- Tenny-Prov., ¶37 (“*Timing offset component 308 can acquire a timing offset from the candidate carrier for a given group using a random access procedure* and/or the like, and the timing update component 310 can update timing for the group of carriers based on the offset.”)
- Tenny-Prov., ¶39 (“At 404, *a candidate carrier can be assigned in a given timing group for receiving timing updates. The candidate carrier can be chosen by...UE*, for example, such that the same carrier is not the candidate carrier for the timing group at all devices.”)
- Tenny-Prov., ¶40 (“At 406, *a timing offset can be received from the candidate carrier* during the timing update. *This can be in response to a random access procedure*, in one example, and can be related to a timing difference related to the candidate carrier. At 408, *timing can be updated for each carrier in the timing group based on the timing offset...*In another example, *the offset received from the candidate carrier can be applied to all carriers in the group.*”)
- Tenny-Prov., AppxA(1:9-32) (“Assuming that all carriers serving a single UE are transmitted from the same cell site, it appears that a common offset should be adequate; however, even co-sited carriers could experience some variation in timing for a number of reasons (e.g., cable delays, *distance between the base station site and a remote radio head*), which would make

separate timing offsets per carrier beneficial or even necessary.... An example, in which *a remote radio head belonging to the eNode B causes some carriers to have different timing from others*, is shown in Figure 1.”)

- **Tenny-Prov., AppxA(2:8-10)** (“Within each timing group, the UE may need to occasionally perform random access to update its timing (e.g., if timing is maintained through a separate procedure for each timing group). By definition, *this update only needs to be performed with one carrier of each timing group*....”)
- **Tenny-Prov., AppxA(4:15-17)** (“In the event that a UE is assigned to several timing groups that are controlled from a common site, it may be able to *receive timing adjustments for all groups with a single interaction with the base station*.”)
- **Tenny-Prov., AppxA(claim 1)** (“...*a single timing advance value can be indicated to the UE for use with all the carriers in the group*, such that *the resulting uplink timing when the UE transmits with this timing advance value towards any carrier in the group* will be sufficiently accurate for communication with that carrier....”)
- **Tenny-Prov., AppxA(claim 6)** (“The method of claim 5, wherein the *UE performs random access for timing synchronisation on a single carrier of the timing group for which it requires timing information*.”)
- **Tenny, ¶58** (“In an aspect, embodiments directed towards selecting carriers for *performing a random access procedure are also contemplated*. Indeed, within each timing group, a UE may occasionally perform random access to update its timing (e.g., if timing is maintained through a separate procedure for each timing group). Here, although *this update only needs to be performed with one carrier of each timing group*, the issue arises of how the UE should decide which carrier this is. In an aspect, the UE is configured to avoid performing unnecessary timing updates (i.e., to select a single carrier from the timing group to use for its timing control).”)
- **Tenny, ¶65** (“In a particular embodiment, *the UE applies the timing offset to the carrier on which it received the timing offset, and assumes that the timing of other carriers in the group is “close enough”*. With respect to FIG. 4, this would mean that the system considered uplink 414 and uplink 424 to be the same for purposes of uplink timing accuracy.”)

- **Tenny, ¶66** (“As an alternative, however, the UE could apply the timing offset, not to the received downlink timing from the carrier that transmitted the offset, but to the average timing of the carriers in the timing group. In such a case, although *the UE received its timing information from a particular carrier*, it tracks the (downlink) timing of each carrier in the group separately, so that when a single downlink/uplink offset is received, the UE can apply the offset separately to each carrier and take an average of the results to provide an “adequate” uplink timing for use with all carriers in the group. Such an averaging behavior could be either a specified UE behavior (to allow greater downlink tolerances within a timing group while still keeping the variation in uplink timing acceptable) or left to UE implementation”)
- **Tenny, ¶77** (“As illustrated, wireless terminal 600 may also include message processing component 670. Within such embodiment, message processing component 670 is configured to process a received timing message encoded with a set of uplink timing instructions respectively corresponding to an uplink group subset of the uplink group of carriers. In a particular aspect, *message processing component 670 is configured to associate the uplink group of carriers with one of a plurality of downlink groups, wherein the timing message is encoded with a set of uplink timing instructions respectively corresponding to a downlink group subset of the plurality of downlink groups. Here, it should be noted that the received timing message may be a timing advance command*, and/or may comprise a vector encoded with timing adjustment values associated with the uplink group subset.”)
- **Tenny, ¶82** (“Wireless terminal 600 may also include random access component 660, which is configured to perform a random access procedure. *Within such embodiment, random access component 660 is configured to perform the random access procedure on at least one random access carrier included in a downlink group of carriers that includes the at least one downlink carrier received from the network*. In a particular aspect, the random access procedure is performed on a single carrier, wherein the single carrier is an assigned carrier provided by a network prior to the performing of the random access procedure. Alternatively, the random access procedure may include receiving the single carrier as part of a dedicated radio resource configuration.”)

- *See also* Tenny-Prov., ¶¶16, 33-34, Figures 3, 4, AppxA(claims 3, 5, 28); Tenny, ¶¶9, 40, 57, 61, 69-70, 80, claim 27, 48, 56.

96. See my discussion for elements [2.a]-[2.c] above and [2.e] below. As I discuss for element [2.c], **Tenny** discloses that “[t]iming offset component 308” of the wireless device “acquire[s] a timing offset from the candidate carrier for a given group,” where the timing offset is received “in response to a random access procedure.” Tenny-Prov., ¶¶37, 40, Figure 3; Tenny ¶¶80, 82, 84, Figure 6-7; *see* [2.c]. As such, the wireless device receives the timing offset as “a single timing advance value” “indicated to the UE for use with all the carriers in the group.” Tenny-Prov., AppxA(claim 1); Tenny ¶¶58, 66, 77. Thus, to update the timing for a given timing group, the “update only needs to be performed with one carrier of each timing group.” Tenny-Prov., AppxA(2:8-10); Tenny, ¶58. As discussed above in [2.c], this candidate carrier is a delegate CC that is chosen to receive timing updates/timing offset for a given UL timing group. *See* [2.c].

97. A person of ordinary skill in the art would have understood that **Tenny’s** UE “acquire[s] a timing offset from the candidate carrier for a given group” in a “Random Access Response” in “response to a random access procedure.” *See* Tenny-Prov., ¶¶37, 40. As I discuss in [2.c], the random access procedure is a well-known protocol used in LTE to perform uplink synchronization between a UE and an eNB. As shown in the figure below, in response to a random access preamble

(RAP) received from a UE, the eNB sends to the UE a random access response (RAR) as a routine part of the random access procedure. *See* Ex. 1015 at 433 (Figure 18.8).

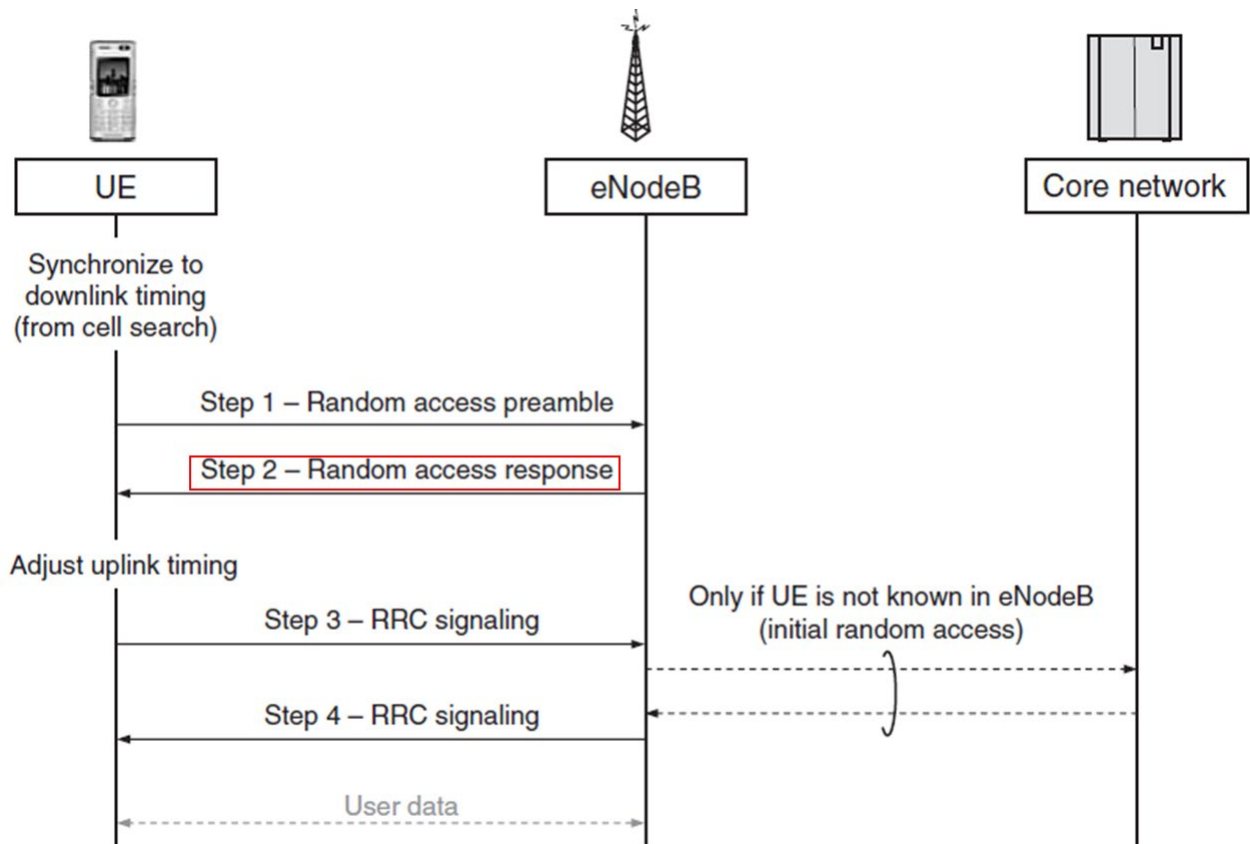


Figure 18.8 *Overview of the random-access procedure.*

See also Ex. 1015 at 433 (“The basis for random access is a contention-based procedure, illustrated in Figure 18.8, and consists of four steps: 1. The first step consists of transmission of a random-access preamble 2. The second step consists of the network transmitting a timing advance command to adjust the terminal transmit timing....”); TS36.300 at 52 (“The four steps of the contention

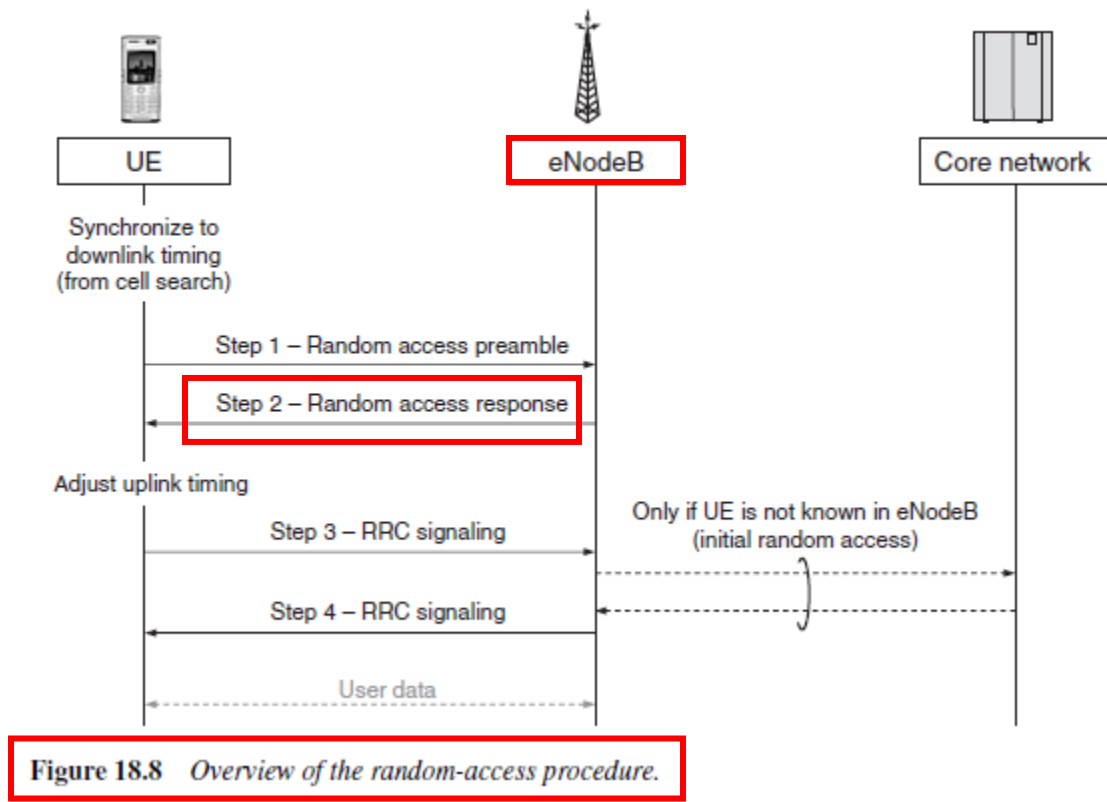
based random access procedures are: 1) Random Access Preamble on RACH in uplink . . . 2) *Random Access Response* generated by MAC on DL-SCH . . . [c]onveys . . . Timing Alignment information.” (emphases added)), 54. Indeed, I understand that Pantech itself has indicated that a person of ordinary skill in the art would have understood a “Random Access Response” to be defined by the LTE standard, as set forth in TS36.300. *See* Ex. 1018 at 4 (Pantech citing to “TS 36.300” to support definition of “receiving a [RAR]”); Ex. 1022 (Rysavy Tr.) at 55:20-23 (“A person of ordinary skill in the art would understand that a random access response is a response from a base station as part of a random access procedure.”).

98. **Tenny** discloses that the RAR includes a Timing Advanced (TA) value. For example, **Tenny** discloses that the “timing advance command” includes a “timing advance value,” functioning as a timing offset. *Tenny-Prov.*, AppxA(claims 1, 3, 28). Additionally, as discussed above, a POSITA would have understood that it was well-known that a random access procedure, as taught in **Tenny** (e.g., *Tenny-Prov.*, ¶¶36, 39), involved transmitting a “timing advance command” in a RAR to convey “Timing Alignment Information” to a UE. *See, e.g.*, Ex. 1015 at 433 (“The basis for random access is a contention-based procedure, illustrated in Figure 18.8, and consists of four steps: 2. The second step consists of *the network transmitting a timing advance command to adjust the terminal transmit*

timing....”); TS36.300 at 52 (“The four steps of the contention based random access procedures are: 1) Random Access Preamble on RACH in uplink . . . 2) **Random Access Response** generated by MAC on DL-SCH . . . *[c]onveys . . . Timing Alignment information.*” (emphases added)), 54. Thus, in light of the above, a POSITA would have understood that **Tenny** discloses a Random Access Response (RAR) that includes a Timing Advanced (TA) value (e.g., “timing offset,” “timing advance value”) for UL CCs in the respective UL timing group. And at minimum, a POSITA would have found it obvious to implement **Tenny’s** “random access” procedure such that the UE receives a Random Access Response (RAR) including a Timing Advanced (TA) value for UL CCs in the respective UL timing group.

99. **Tenny** further discloses that the UE “receive[s] timing adjustments” from a “base station,” such as an “eNB.” *Tenny-Prov.*, AppxA(1:9-32, 4:15-17, Figure 1); *Tenny*, ¶¶40, 80. Thus, the eNB “indicate[s] to the UE” “a single timing advance value . . . for use with all the carriers in the group.” *Tenny-Prov.*, AppxA(claim 1); *Tenny*, ¶¶58, 65-66. Additionally, as shown below, a POSITA would have understood that it was well-known for a random access procedure, as taught in **Tenny** (e.g., *Tenny-Prov.*, ¶¶36, 39) to transmit a TA value from the *eNB* in a RAR. *See, e.g.*, Ex. 1015 at Figure 18.8 (annotated below), 433 (“The basis for random access is a contention-based procedure, illustrated in Figure 18.8, and

consists of four steps: . . . 2. The second step consists of *the network transmitting a timing advance command to adjust the terminal transmit timing....*) (emphasis added).



See TS36.300 at 52 (Figure 10.1.5.1-1, annotated below), 54 (Figure 10.1.5.2-1, not shown).

10.1.5.1 Contention based random access procedure

The contention based random access procedure is outlined on Figure 10.1.5.1-1 below:

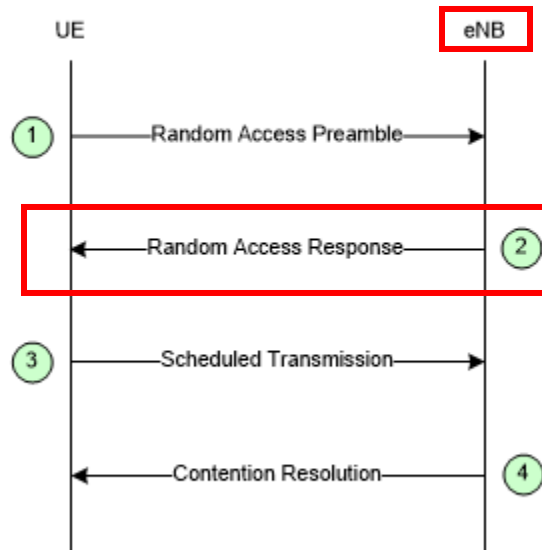


Figure 10.1.5.1-1: Contention based Random Access Procedure

Thus, a POSITA would have further understood **Tenny's** random access procedure to disclose that the UE receives the TA value in a RAR from **Tenny's** eNB.

100. Based on the discussion above, a person of ordinary skill in the art would have understood and at minimum found obvious that, in **Tenny's** random access procedure, the UE receives a Random Access Response (RAR) including a Timing Advanced (TA) value for UL CCs in the respective UL timing group, wherein each TA value is transmitted from the eNB for the respective UL timing group based on the transmitted RAP associated with a delegate CC of the respective UL timing group.

101. To the extent the “wherein” clause in limitation [2.d] is construed to mean “wherein each TA value is transmitted from the eNB for the respective UL timing group in response to the transmitted RAP through its delegate CC of the respective UL timing group” (as discussed in §VIII), **Tenny** also discloses this limitation under that interpretation because **Tenny** at least discloses that the same candidate carrier is used to transmit the RAP (as I discussed in [1.c]) and receive the TA value on the RAR. For example, **Tenny** discloses that the “timing offset” is received from the “candidate carrier” for a given UL timing group, which is the same candidate/delegate carrier used in “random access” to transmit the RAP (*see* my discussion in [2.c]). *See* Tenny-Prov., ¶36 (“carrier candidate selection component 306 can choose a carrier in the group from which to acquire timing updates”), ¶37 (“Timing offset component 308 can acquire a timing offset from the candidate carrier for a given group using a random access procedure”), ¶39 (“a candidate carrier can be assigned in a given timing group for receiving timing updates”), ¶40 (“a timing offset can be received from the candidate carrier during the timing update...In another example, the offset received from the candidate carrier can be applied to all carriers in the group.”); Tenny-Prov., AppxA(Figure 2), claim 6, 2:7-25; Tenny, ¶¶58, 61, 80; *see* [2.c].

(f) Element [2.e]

102. Element [2.e] recites “applying each TA value to CCs in the respective UL timing group.” This element is met by Tenny alone.

103. Tenny discloses applying each TA value to CCs in the respective UL timing group (e.g., “timing update component 310...update[s] timing for the group of carriers based on the offset” received from the “candidate carrier” chosen for the respective timing group; “a single timing advance value can be indicated to the UE for use with all the carriers in the group”; *see* [2.c]).

- Tenny-Prov., Figure 3

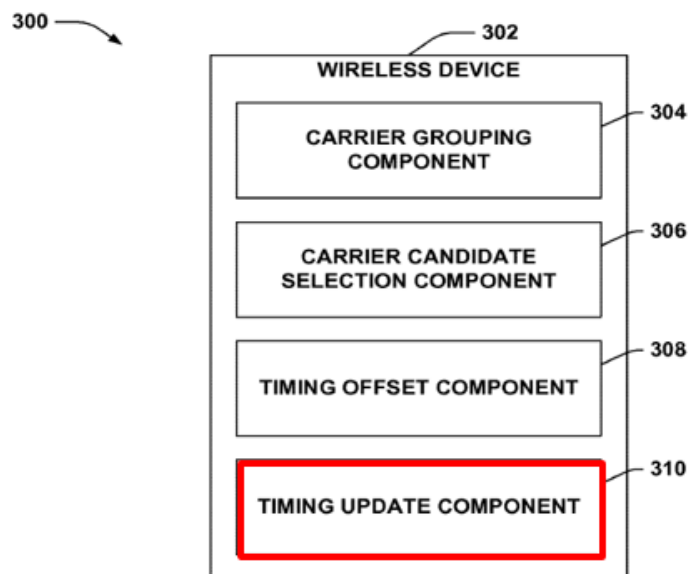


Fig. 3

- Tenny-Prov., AppxA(Figure 3)

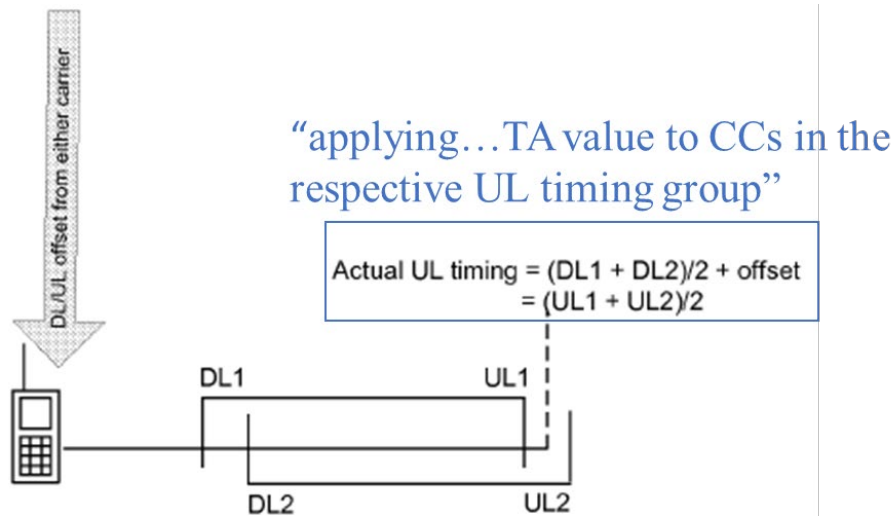


Figure 3: UE averaging of uplink timing from two carriers

- Tenny-Prov., ¶37 (“In another example, *the timing update component 310 can track downlink timing over carriers in a group, add the offset received from the timing offset component 308 to each carrier timing, average the timing differences, and apply the average difference as an offset for use with all carriers in the group.*”)
- Tenny-Prov., ¶40 (“In another example, *the offset received from the candidate carrier can be applied to all carriers in the group.*”)
- Tenny-Prov., AppxA(3:26-4:8) (“UE in the environment of Figure 2 could receive its timing information from either carrier 1 or carrier 2. The timings of the two carriers differ, but by less than the tolerance that the deployment requires for a timing group; and it follows that, depending on which carrier the UE received its last update from, a UE connected to both carriers could consider the correct uplink timing to be at either UL1 or UL2 in the figure.

The simplest approach is for the UE simply to apply the timing offset to the carrier on which it received it, and assume that the timing of other carriers in the group is ‘close enough’; in terms of the figure, this would mean that the system considered UL1 and UL2 to be the same for purposes of uplink timing accuracy. As an alternative, however, the UE could apply the offset, not to the received downlink timing from the carrier that transmitted the offset, but to the average timing of the carriers in the timing group. In such a case, although the UE received its timing information from a particular

carrier, it tracks the (downlink) timing of each carrier in the group separately, so that when a single DL/UL offset is received, *the UE can apply the offset separately to each carrier and take an average of the results to provide a ‘happy medium’ uplink timing for use with all carriers in the group.*”)

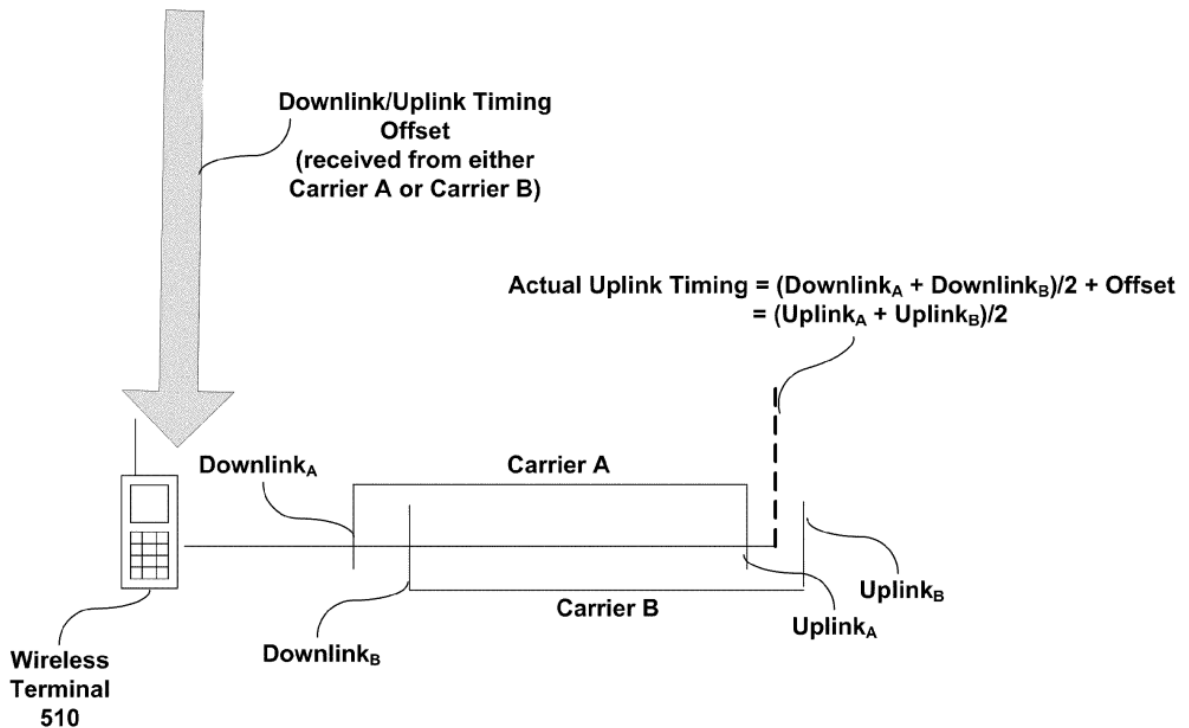
- **Tenny-Prov., AppxA(claim 1)** (“A method of maintaining timing alignment between a mobile device and a network operating on a plurality of frequencies, the method comprising an association of the frequencies into one or more timing groups, such that:

the carriers in each timing group share common transmission timing to within some first tolerance;

a single timing advance value can be indicated to the UE for use with all the carriers in the group, such that the resulting uplink timing when the UE transmits with this timing advance value towards any carrier in the group will be sufficiently accurate for communication with that carrier, where "sufficiently accurate" is defined in terms of some second tolerance.”)

- **Tenny, Figure 5**

FIG. 5



- Tenny, ¶65 (“In a particular embodiment, *the UE applies the timing offset to the carrier on which it received the timing offset, and assumes that the timing of other carriers in the group is “close enough”*. With respect to FIG. 4, this would mean that the system considered uplink 414 and uplink 424 to be the same for purposes of uplink timing accuracy”)
- Tenny, ¶66 (“As an alternative, however, the UE could apply the timing offset, not to the received downlink timing from the carrier that transmitted the offset, but to the average timing of the carriers in the timing group. In such a case, although the UE received its timing information from a particular carrier, it tracks the (downlink) timing of each carrier in the group separately, so that when a single downlink/uplink offset is received, *the UE can apply the offset separately to each carrier* and take an average of the results to provide an “adequate” uplink timing for use with all carriers in the group. Such an averaging behavior could be either a specified UE behavior (to allow greater downlink tolerances within a timing group while still keeping the variation in uplink timing acceptable) or left to UE implementation.”)

- **See also Tenny-Prov., ¶¶33-34, Figure 4, AppxA(Figure 2); Tenny, ¶67, Figure 4.**

104. See my discussion for elements [2.c]-[2.d]. As I discuss in [2.c], the UE chooses a candidate (or delegate) uplink component carrier (UL CC) for each UL timing group to receive timing updates for the whole UL timing group and acquires a timing offset (*i.e.*, timing advance value) from the candidate carrier for the entire group using a random access procedure. *See* [2.c]. **Tenny** also discloses that “timing update component 310” of “wireless device” 302 “updat[es] timing for the group of carriers based on the offset” received from the “candidate carrier” chosen for the respective timing group. Tenny-Prov., ¶37, Figure 3; Tenny ¶65-66, Figure 5. In particular, the UE “appl[ies] the offset,” which is “a single timing advance value...for use with all carriers in the group” to “all carriers in the group.” Tenny-Prov, ¶¶37, 40, AppxA(claim 1). **Tenny** discloses different ways the UE can apply the timing offset to the CCs in a given UL timing group. *See, e.g.*, Tenny-Prov., ¶¶37, 40, AppxA(3:26-4:8, claim 1); Tenny, Fig. 5, ¶¶65-66. In the “simplest approach,” the “UE simply appl[ies] the timing offset to the carrier on which it received it, and assume[s] that the timing of other carriers in the group is ‘close enough.’” Tenny-Prov., AppxA(3:31-32); Tenny, ¶65. In another example, **Tenny** discloses that “the UE can apply the offset separately to each carrier and take an average of the results to provide a ‘happy medium’ uplink timing for use with all

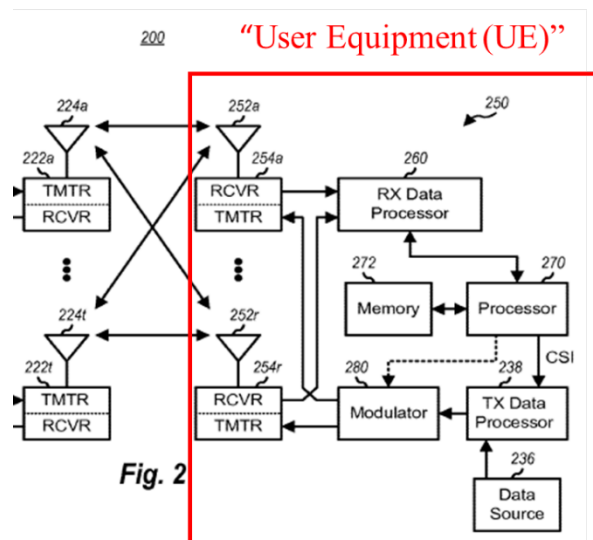
carriers in the group.” Tenny-Prov., AppxA(4:6-8, claim 1); ¶66. As such, **Tenny** discloses applying each timing advance value sent for the respective UL timing group to all carriers (CCs) in the group.

(g) Element [3.pre]

105. **Element [3.pre]** recites “A User Equipment (UE) to establish an uplink (UL) synchronization in a wireless communication system, the UE comprising.” This element is met by **Tenny** alone.

106. **Tenny** discloses a User Equipment (UE) to establish an uplink (UL) synchronization (e.g., *see* [2.pre], Fig. 2) in a wireless communication system (e.g., “in a multicarrier LTE-Advanced (LTE-A) system”).

• **Tenny-Prov., Figure 2**



- Tenny-Prov., AppxA(1:2-3) (“This document describes solutions to several issues that arise in relation to *maintaining timing synchronisation for a UE in a multicarrier LTE-Advanced (LTE-A) system.*”)
- Tenny-Prov., ¶17 (“FIG. 2 is a block diagram of an embodiment of a transmitter system 210 (also known as the access point) and *a receiver system 250 (also known as access terminal)* in a MIMO system 200”)
- Tenny-Prov., ¶16 (“*An access terminal may also be called* an access terminal, *user equipment (UE)*, a wireless communication device, terminal, access terminal or some other terminology.”)
- Tenny, Figure 2

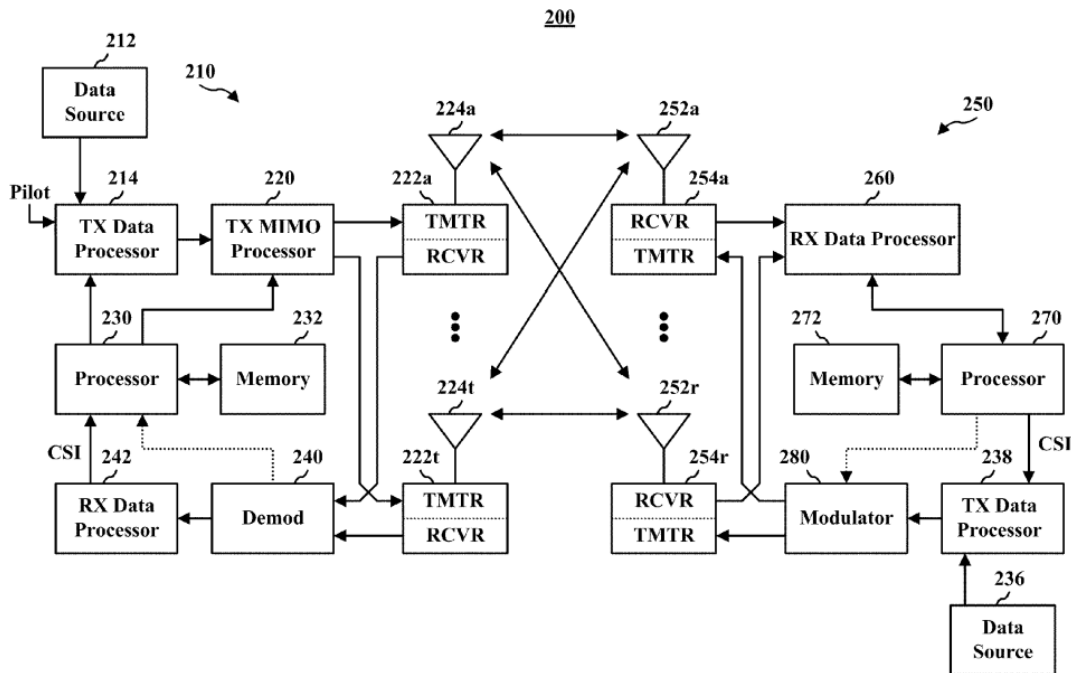


FIG. 2

- Tenny, ¶3 (“The following description relates generally to wireless communications, and more particularly to methods and apparatuses that facilitate *maintaining timing synchronization for user equipment in a multicarrier Long Term Evolution-Advanced (LTE-A) system.*”)
- Tenny, ¶40 (“Various embodiments are described herein in connection with an access terminal. *An access terminal can also be called a system, subscriber unit, subscriber station, mobile station, mobile, remote station,*

remote terminal, mobile device, user terminal, terminal, wireless communication device, user agent, user device, or user equipment (UE).”)

- **Tenny, ¶44** (“FIG. 2 shows an example wireless communication system 200. The wireless communication system 200 depicts one base station 210 and one access terminal 250 for sake of brevity. However, it is to be appreciated that system 200 can include more than one base station and/or more than one access terminal, wherein additional base stations and/or access terminals can be substantially similar or different from example base station 210 and access terminal 250 described below. In addition, it is to be appreciated that base station 210 and/or access terminal 250 can employ the systems and/or methods described herein to facilitate wireless communication there between.”)

107. See my discussion for element [2.pre]. As I discuss for element [2.pre],

Tenny discloses a method for establishing an uplink (UL) synchronization by a user equipment (UE). *See* [2.pre].

108. **Tenny** discloses its “timing synchronisation” method “for a UE in a multicarrier LTE-Advanced (LTE-A) system,” which is a wireless communication system. Tenny-Prov., AppxA(1:2-3); Tenny, ¶3.

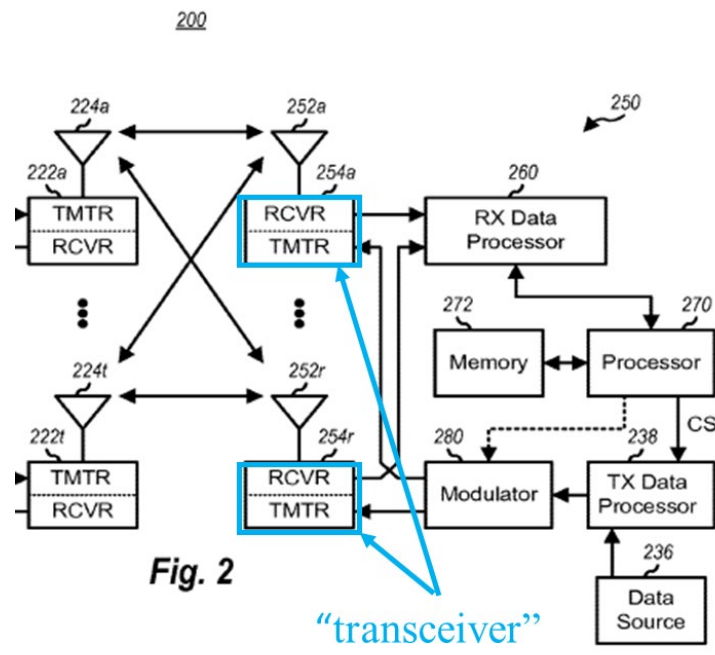
(h) Element [3.a]

109. **Element [3.a]** recites “a transceiver configured to receive a Radio Resource Control (RRC) signaling including a UL timing group information set, which has been set by an evolved NodeB (eNB).” This element is met by **Tenny** alone.

110. **Tenny** discloses the UE (*see* [3.pre]) comprising a transceiver (e.g., “receiver[s] (RCVR)” and “transmitters” (“TMTR”)) **configured to receive a**

Radio Resource Control (RRC) signaling including a UL timing group information set, which has been set by an evolved NodeB (eNB) (see [2.a]).

- Tenny-Prov., Figure 2



- Tenny-Prov., ¶22 (“At receiver system 250, the transmitted modulated signals are received by N_R antennas 252a through 252r and the received signal from each antenna 252 is provided to *a respective receiver (RCVR) 254a through 254r*. Each receiver 254 conditions (e.g., filters, amplifies, and downconverts) a respective received signal, digitizes the conditioned signal to provide samples, and further processes the samples to provide a corresponding “received” symbol stream.”)
- Tenny-Prov., ¶25 (“The reverse link message is then processed by a TX data processor 238, which also receives traffic data for a number of data streams from a data source 236, modulated by a modulator 280, *conditioned by transmitters 254a through 254r, and transmitted back to transmitter system 210.*”)
- Tenny, Figure 2

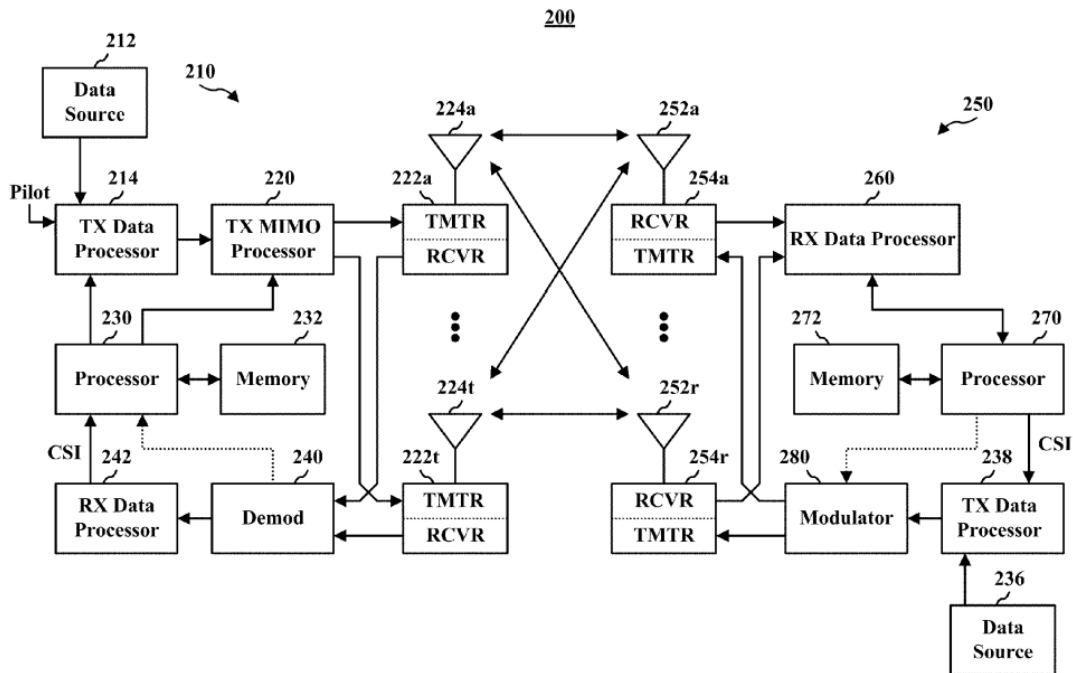


FIG. 2

- Tenny, ¶49 (“At access terminal 250, *the transmitted modulated signals are received by N_R antennas 252a through 252r and the received signal from each antenna 252 is provided to a respective receiver (RCVR) 254a through 254r*. Each receiver 254 conditions (e.g., filters, amplifies, and downconverts) a respective signal, digitizes the conditioned signal to provide samples, and further processes the samples to provide a corresponding “received” symbol stream.”)
- Tenny, ¶52 (“The reverse link message can comprise various types of information regarding the communication link and/or the received data stream. *The reverse link message can be processed by a TX data processor 238, which also receives traffic data for a number of data streams from a data source 236, modulated by a modulator 280, conditioned by transmitters 254a through 254r, and transmitted back to base station 210.*”)

111. See my discussion for element [2.a]. As I discuss for element [2.a],

Tenny discloses receiving a Radio Resource Control (RRC) signaling including a

UL timing group information set, which has been set by an evolved NodeB (eNB).
See [2.a].

112. **Tenny** also discloses that the UE includes “receiver (RCVR)” and “transmitters” (“TMTR”), receiving and transmitting “modulated signals.” Tenny-
Prov., ¶¶20, 22, 25, Figure 2; Tenny, ¶¶49, 52, Figure 2. A person of ordinary skill
in the art would have understood that the UE’s receiver and transmitters together
constitute a transceiver that receives timing-related information from a network,
including the RRC signalling that includes UL timing group information. At
minimum, a person of ordinary skill in the art would have found it obvious to
implement the UE’s receivers and transmitters as a transceiver that receives the RRC
signalling as part of **Tenny’s** random access procedure (*see* [2.a]) because it was
known to use transceivers in UEs to receive information as part of performing a
random access procedure in a LTE-A network, like **Tenny’s**. *See e.g.*, Fan, ¶¶95,
99, Figure 2A (disclosing a UE operating in an “LTE-A” network and including a
“radio frequency (RF) transceiver 10D for bidirectional wireless communications
with the eNB 12.”), Abstract (“Disclosed herein are methods, computer program
instructions and apparatus for performing random access procedures in a wireless
communication system.”), ¶1 (“The exemplary and non-limiting embodiments of
this invention relate generally to wireless communication systems, methods devices

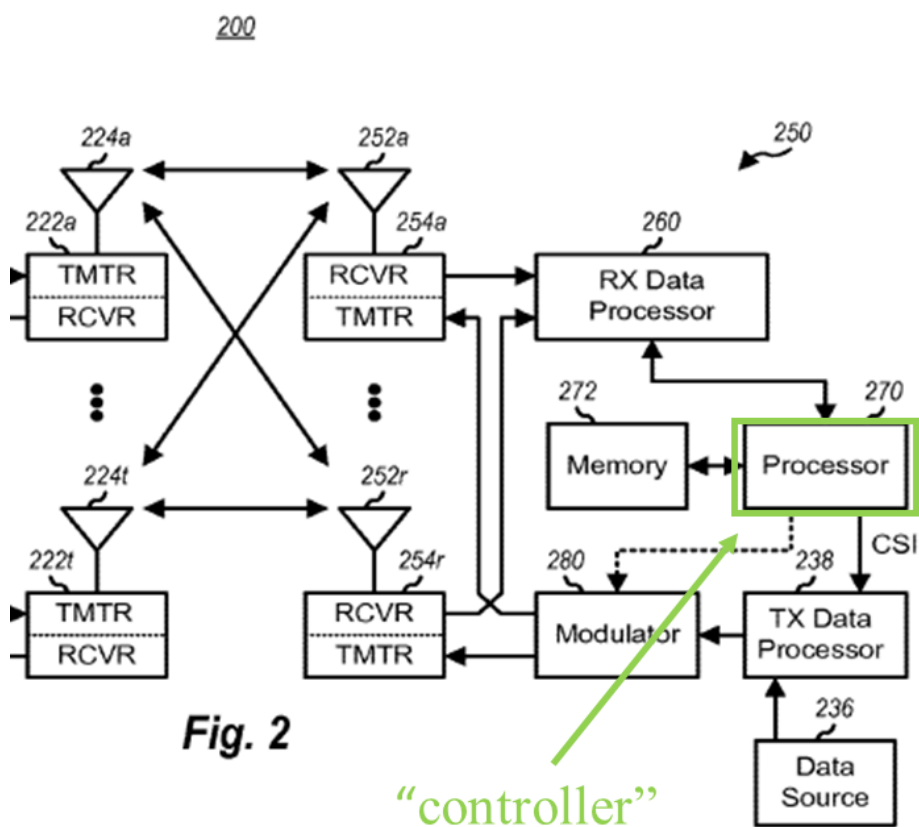
and computer programs and, more specifically, relate to random access channel signaling techniques between a mobile node and a network access node”), ¶39 (showing the “overall architecture of the EUTRAN system” of “3GPP TS 36.300,” which “includes eNBs, providing the EUTRA user plane...and control plane (RRC) protocol terminations towards the UE”), ¶60 (“Of particular interest herein are the further releases of 3GPP LTE targeted towards...LTE-Advanced (LTE-A)”). As such, a person of ordinary skill in the art would have understood, and at minimum found obvious, that **Tenny’s** UE includes a transceiver is configured to receive a Radio Resource Control (RRC) timing group information set, which has been set by an evolved NodeB (eNB), as I discuss in [2.a].

(i) Element [3.b]

113. **Element [3.b] recites “a controller configured to configure one or more UL timing groups based on the UL timing group information set, the one or more UL timing groups each comprising one or more UL CCs.”** This element is met by **Tenny** alone.

114. **Tenny discloses the UE (see [3.pre]) comprising a controller (e.g., “processor may be any conventional...controller”) configured to configure one or more UL timing groups based on the UL timing group information set, the one or more UL timing groups each comprising one or more UL CCs (see [2.b]).**

- **Tenny-Prov., ¶45** (“The various illustrative logical blocks, modules, and circuits described in connection with *the examples disclosed herein may be implemented or performed with a general purpose processor*, a digital signal processor (DSP). . . . A general-purpose processor may be a microprocessor, but in the alternative, *the processor may be any conventional processor, controller, microcontroller*, or state machine. A processor may also be implemented as a combination of computing devices, e.g., a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration.”)
- **Tenny-Prov., ¶46** (“*The methods or algorithms described in connection with the examples disclosed herein may be embodied directly in hardware, in a software module executed by a processor, or in a combination of the two. . . .*”)
- **Tenny-Prov., Figure 2** (excerpted)



- Tenny, Figure 2

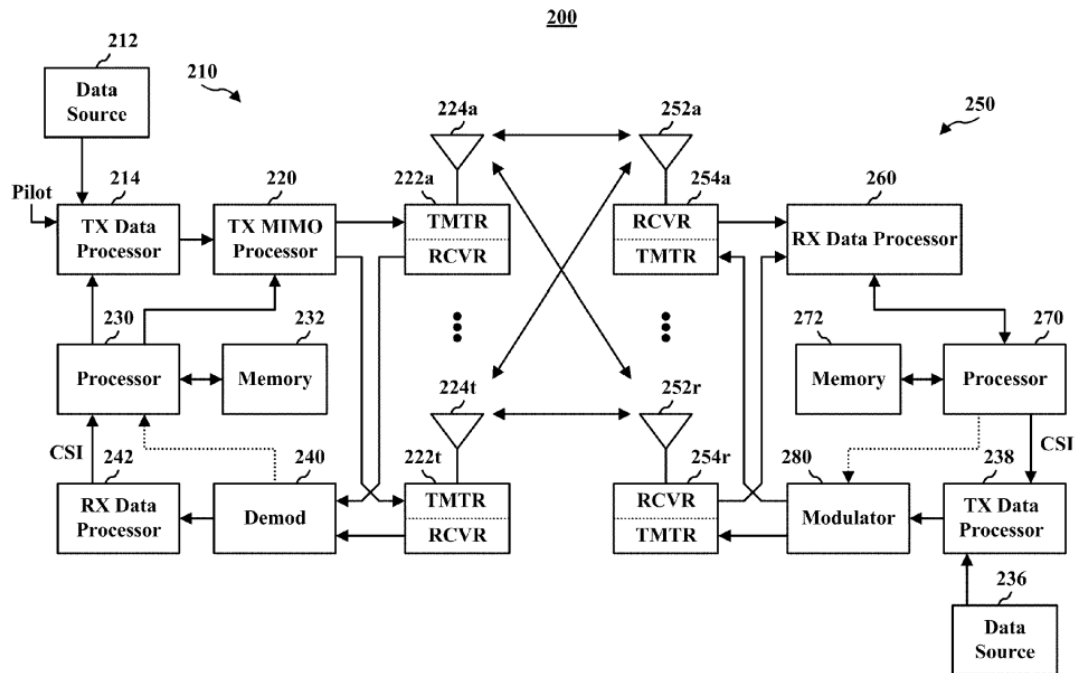


FIG. 2

- Tenny, ¶54 (“*Processor 230 and 270 can direct (e.g., control, coordinate, manage, etc.) operation at base station 210 and access terminal 250, respectively. Respective processors 230 and 270 can be associated with memory 232 and 272 that store program codes and data.*”)
- Tenny, ¶123 (“*For a hardware implementation, the processing units can be implemented within one or more application specific integrated circuits (ASICs), digital signal processors (DSPs)...processors, controllers, micro-controllers, microprocessors, other electronic units designed to perform the functions described herein, or a combination thereof.*”)
- See also Tenny, ¶¶71-72, 76.

115. See my discussion for element [2.b]. As I discuss for element [2.b],

Tenny discloses configuring one or more UL timing groups based on the UL timing

group information set, the one or more UL timing groups each comprising one or more UL CCs. *See* [2.b].

116. **Tenny** also discloses that the “examples disclosed herein may be implemented or performed with a general purpose processor,” which may be “any conventional processor, controller, microcontroller,” such as processor 270 depicted in illustrative Figure 2 (annotated above). *Tenny-Prov.* ¶45, Figure 2; *Tenny*, ¶¶54, 123, Fig. 2. **Tenny** further discloses that “[t]he methods or algorithms described in connection with the examples disclosed herein may be embodied directly in hardware, in a software module executed by a processor, or in a combination of the two.” *Tenny-Prov.* ¶46. As such, a person of ordinary skill in the art would have understood that **Tenny** discloses a “processor” that acts as a “controller” to perform the functions disclosed in **Tenny**, such as configuring one or more UL timing groups based on the UL timing group information set received from the eNB (*see* [2.b]). At minimum, a POSITA would have found it obvious to implement **Tenny**’s UE to use a controller to perform this configuring function because controllers were known to be used to operate with receivers and transmitters to handle different component carriers in the context of a random access procedure in an LTE network. *See e.g.*, *Fan*, ¶¶95, 99, Figure 2A (disclosing a UE including a “controller,” which can be “a data processor (DP) 10A,” “configured to operate with a wireless receiver and

wireless transmitter”), ¶60 (“Of particular interest herein are the further releases of 3GPP LTE targeted towards...LTE-Advanced (LTE-A”), ¶67 (“In yet another aspect thereof the exemplary embodiments of this invention provide an apparatus that comprises a controller configured to operate with a wireless receiver and a wireless transmitter, where the controller is further configured to transmit to a network access node in a time and frequency resource allocated for preamble transmission, of one of a plurality of component carriers, a random access request, and to receive a random access response that is aggregated with other random access responses in a time and frequency resource of the same or a different component carrier.”), ¶¶141, 146, Abstract (“Disclosed herein are methods, computer program instructions and apparatus for performing random access procedures in a wireless communication system.”), ¶1 (“The exemplary and non-limiting embodiments of this invention relate generally to wireless communication systems, methods devices and computer programs and, more specifically, relate to random access channel signaling techniques between a mobile node and a network access node”). As such, a person of ordinary skill in the art would have understood, and at minimum found obvious, that **Tenny’s** UE includes a controller that is configured to configure one or more UL timing groups based on the UL timing group information set, the one or

more UL timing groups each comprising one or more UL CCs, as I discussed in [2.b].

(j) Element [3.c]

117. Element [3.c] recites “wherein the transceiver transmits a Random Access Preamble (RAP) through one or more UL CCs, each of the one or more UL CCs transmitting an RAP being set as a delegate CC in the respective UL timing group, and receives a Random Access Response (RAR) including a Timing Advanced (TA) value for UL CCs in the respective UL timing group, wherein each TA value is transmitted from the eNB for the respective UL timing group based on the transmitted RAP associated with a delegate CC of the respective UL timing group.” This element is met by Tenny alone.

118. Tenny discloses that the transceiver (*see* [3.a]) transmits a Random Access Preamble (RAP) through one or more UL CCs, each of the one or more UL CCs transmitting an RAP being set as a delegate CC in the respective UL timing group (*see* [2.c]), and receives a Random Access Response (RAR) including a Timing Advanced (TA) value for UL CCs in the respective UL timing group, wherein each TA value is transmitted from the eNB for the respective UL timing group based on the transmitted RAP associated with a delegate CC of the respective UL timing group (*see* [2.d]).

119. See my discussion for elements [2.c]-[2.d], [3.a]. As I discuss for [2.c], **Tenny** discloses, or at minimum renders obvious, transmitting a Random Access Preamble (RAP) through one or more UL CCs, each of the one or more UL CCs transmitting an RAP being set as a delegate CC in the respective UL timing group. *See* [2.c]. As I discuss for [2.d], **Tenny** discloses, or at minimum renders obvious, receiving a Random Access Response (RAR) including a Timing Advanced (TA) value for UL CCs in the respective UL timing group, wherein each TA value is transmitted from the eNB for the respective UL timing group based on the transmitted RAP associated with a delegate CC of the respective UL timing group. *See* [2.d]. Furthermore, as I discuss for element [3.a], **Tenny** discloses, or at minimum renders obvious, that its UE includes a transceiver that receives and transmits “modulated signals.” *See* [3.a]. As such, a person of ordinary skill in the art would have understood that **Tenny’s** UE includes a transceiver transmits a Random Access Preamble (RAP) through one or more UL CCs, each of the one or more UL CCs transmitting an RAP being set as a delegate CC in the respective UL timing group, and receives a Random Access Response (RAR) including a Timing Advanced (TA) value for UL CCs in the respective UL timing group, wherein each TA value is transmitted from the eNB for the respective UL timing group based on the transmitted RAP associated with a delegate CC of the respective UL timing

group (*see* [2.c]-[2.d]). At minimum, a POSITA would have found it obvious to implement **Tenny’s** UE to use a transceiver to transmit a RAP and receive a RAR, as transceivers were known to perform these functionalities. *See, e.g.*, Fan, ¶¶95, 99, Figure 2A (disclosing a UE operating in an “LTE-A” network and including a “radio frequency (RF) transceiver 10D for bidirectional wireless communications with the eNB 12.”), ¶66 (“In yet another aspect thereof the exemplary embodiments of this invention provide a method that comprises transmitting to a network access node, in a time and frequency resource of one of a plurality of component carriers, a random access request; and receiving an random access response...”), ¶109 (“after transmitting a preamble on a CC the UE 10 receives the Random Access response”), ¶131 (“UE 10 is permitted or allowed to transmit the random access preamble”). As such, a person of ordinary skill in the art would have understood, and at minimum found it obvious, that **Tenny’s** UE includes a transceiver that transmits a RAP and receives a RAR, as I discussed in [2.c]-[2.d].

(k) Element [3.d]

120. **Element [3.d] recites “wherein the controller applies each TA value to CCs in the respective UL timing group.”** This element is met by **Tenny** alone.

121. **Tenny discloses that the controller (*see* [3.b]) applies each TA value to CCs in the respective UL timing group (*see* [2.e]).**

122. See my discussion for elements [2.e], [3.b]. As I discuss for element [2.e], **Tenny** discloses applying each TA value to CCs in the respective UL timing group. *See* [2.e]. Moreover, as I discuss for [3.b], **Tenny** discloses, and at minimum renders obvious, that its UE includes “a processor that may be any conventional...controller.” *See* [3.b]. As such, a person of ordinary skill in the art would have understood that **Tenny’s** UE includes a controller that applies each TA value to CCs in the respective UL timing group (*see* [2.e]). At minimum, a POSITA would have found it obvious to implement **Tenny’s** UE to use a controller to apply each TA value to CCs in the respective UL timing group, because controllers were known to be used to handle processing related to component carriers in the context of a random access procedure in an LTE network. *See e.g.*, Fan, ¶¶95, 99, Figure 2A (disclosing a UE including a “controller,” which can be “a data processor (DP) 10A,” “configured to operate with a wireless receiver and wireless transmitter”), ¶60 (“Of particular interest herein are the further releases of 3GPP LTE targeted towards...LTE-Advanced (LTE-A)”), ¶67 (“In yet another aspect thereof the exemplary embodiments of this invention provide an apparatus that comprises a controller configured to operate with a wireless receiver and a wireless transmitter, where the controller is further configured to transmit to a network access node in a time and frequency resource allocated for preamble transmission, of one of a

plurality of component carriers, a random access request, and to receive a random access response that is aggregated with other random access responses in a time and frequency resource of the same or a different component carrier.”), ¶¶141, 146, Abstract (“Disclosed herein are methods, computer program instructions and apparatus for performing random access procedures in a wireless communication system.”), ¶1 (“The exemplary and non-limiting embodiments of this invention relate generally to wireless communication systems, methods devices and computer programs and, more specifically, relate to random access channel signaling techniques between a mobile node and a network access node”). As such, a person of ordinary skill in the art would have understood, and at minimum found obvious, that **Tenny’s** UE includes a controller that applies each TA value to CCs in the respective UL timing group, as I discussed in [2.e].

B. Ground 2: Qualcomm in view of TS36.331 (Claims 2-3)

1. Overview of Qualcomm

123. **Qualcomm** describes a “design for multiple timing advances” to be used with “multiple LTE CCs” (*i.e.*, “component carriers”) and “recommend[s] adoption of this design . . . in LTE-A.” Qualcomm, 1-2. In particular, **Qualcomm** sets forth proposals for establishing synchronization for uplink (UL) transmissions between a UE and network element when the transmissions are performed using

multiple CCs. Qualcomm, 1-3. **Qualcomm's** proposals relate to handling multiple CCs during a UL timing synchronization process, including forming "timing groups" that are comprised of "UL component carriers" (UL CCs) that "share the same timing," "[d]elivery of timing advance," and "[m]aintenance of UE [t]iming [a]lignment." *Id.* For example, similar to the '545 patent, **Qualcomm** recognizes that "different component carriers could see substantially different propagation environments due to different frequency selective repeaters and hence see different time-of-flights," and proposes that "configured component carriers can be divided into groups to reduce the number of separate timings to be maintained by the UE." *Id.*

124. **Qualcomm** also recognizes the need for reconfiguring CCs during handover, where a UE moves from one network cell to a new "target cell," and teaches how to handle the changes in available CCs during handover. Qualcomm, 2. In particular, **Qualcomm** discloses that the "network" transmits a "dedicated RRC signalling" to the UE via a "handover command." *Id.* Via the RRC signalling, the UE receives instructions to "configure[] multiple timing groups" that are "at the target cell" and "assign[ed]" to the UE. *Id.* The UE then configures the timing groups that are assigned to it as the network indicates to the UE that "a newly

configured UL carrier...belong[s] to a new timing group,” where each UL timing group may include “more than one CC” that “share the same timing.” *Id.*

125. **Qualcomm** also discloses how to perform UL synchronization for the timing groups that the UE configures. Qualcomm, 2. In particular, **Qualcomm** discloses that “[i]n order to obtain a timing advance, the UE has to send a RACH.” *Id.* Specifically, the “UE initiates RACH (either with a randomly selected RACH preamble, or with a RACH preamble assigned by the network).” *Id.* “RACH” stands for “Random Access Channel.” Ex. 1008 (TS36.300), 14. In light of **Qualcomm’s** disclosures, a POSITA would have understood **Qualcomm’s** discussion of UE-initiated RACH to refer to the random access procedure initiated over the RACH channel, as defined by LTE specifications. For example, 3GPP TS 36.300, a technical specification that covers one aspect of LTE technology, discloses that step 1 of the random access procedure involves a UE sending a “Random Access Preamble on RACH in uplink” to an “eNB.” Ex. 1008 at 52, 54, Figures 10.1.5.1-1, 10.1.5.2-1; *see also* Ex. 1022 (Rysavy Tr.) at 46:6-47:9 (admitting that “TS 36.300” “cover[s] LTE technology”). Thus, **Qualcomm’s** “RACH preamble” is a Random Access Preamble (RAP) that is transmitted by the UE as part of the random access procedure defined by LTE to initiate UL synchronization between a UE and eNB. As **Qualcomm** discloses, RACH is initiated by the UE on “all the timing

groups,” where “[a] unique UL carrier is identified to be used for RACH on each timing group.” *Id.* Thus, a POSITA would have understood that the UE uses the “unique UL carrier” to transmit the “RACH preamble” (*i.e.*, RAP) to “obtain a timing advance” for each timing group. Qualcomm, 2. In response to the RACH preamble, **Qualcomm** discloses that the “timing advance is delivered to the UE” from the “network” using “[a] unique DL carrier,” which “is identified as the TA-providing carrier for each timing group.” Qualcomm, 2. The UE, using the TA values received from the network, then “calculates uplink timing by adding a timing advance to the received downlink reference timing,” wherein “[t]he UL component carriers within a timing group share the same timing.” *Id.*

2. Motivation to Apply the TS36.331’s Teachings to Qualcomm

126. **Qualcomm** discloses a design for LTE-A with a mechanism to “[i]nitiat[e] use of timing groups other than those containing special cell,” referring to the serving cell during handover. Qualcomm, 2. Qualcomm also discloses that initiating “new timing group(s)” may be necessary during “handover” to “configure[] multiple timing groups at the target cell.” *Id.* Qualcomm discloses that the “configured carriers are added by dedicated RRC signalling.” *Id.* As such, the network sends a “handover command,” instructing the UE to “configure[] multiple timing groups at the target cell” based on information in an “RRC signaling,” which

indicates “if a newly configured UL carrier...belong[s] to a new timing group.” *Id.* The UE then uses this information to “maintain[]” “[a] separate timing alignment timer instance should be maintained by the UE for each timing group.” Qualcomm, 3. Although Qualcomm recognizes that new carriers need to be reconfigured into new timing groups to perform handover, it does not expressly disclose the specific protocol that is used to perform reconfiguration of new timing groups (*e.g.*, during handover). Qualcomm, 2.

127. **TS36.331** discloses a specific RRC protocol that is used to reconfigure resources for handover in an LTE system, in other words “to modify an RRC connection, *e.g.*, to establish/modify/ release RBs, to perform handover.” TS36.331, 40 (§5.3.5). Accordingly, TS36.331 dedicates a section for this purpose (Section 5.3.5.4), entitled “Reception of an *RRCCConnectionReconfiguration* including the *mobilityControlInfo* by the UE (handover).” TS36.331, 40-42. This section discloses a “*RRCCConnectionReconfiguration*” message, which provides information to the UE to “perform the radio resource configuration procedure as specified in 5.3.10” via the parameter “*radioResourceConfigDedicated*” included in the message. TS36.331, 41. Section 5.3.10 of **TS36.331** is entitled “Radio resource configuration” and discloses detailed instructions to a UE to reconfigure radio resources. TS36.331, 48. For example, the Section 5.3.10 teaches, “if the received

radioResourceConfigDedicated includes the *physicalConfigDedicated*,” the “UE shall . . . reconfigure the physical channel configuration as specified in 5.3.10.6.”
Id.

128. **Qualcomm and TS36.331** are analogous to and in the same field as the ’545 patent, which includes signaling schemes to support uplink transmission in LTE systems (*e.g.*, random access procedure), and reasonably pertinent to the alleged problems identified in the ’545 patent—*e.g.*, providing a scheme for effective synchronization in a wireless communication. *See, e.g.*, ’545, 1:38-43 (“[A] detailed scheme for synchronization with respect to the plurality of CCs has not been provided yet. [¶] Accordingly, there is a desire for a scheme for effective synchronization in a wireless communication using a plurality of CCs since synchronization is a factor that has a great effect on an efficiency of a network.”); Qualcomm, 1-2 (“The need for multiple timing advance with carrier aggregation has been discussed in RAN2. . . . In this paper, we describe a design for multiple timing advances, and recommend adoption of this design in case multiple timing advances are adopted in LTE-A. . . . Proposal 1: The UL component carriers configured for a UE should be divided into timing groups, where the network controls the grouping of component carriers.”); TS36.331, 39-40 (“5.3.5. RRC connection reconfiguration . . . The purpose of this procedure is to modify an RRC connection, *e.g.* to establish/

modify/ release RBs, to perform handover, to setup/ modify/ release measurements.”), 40-41 (“5.3.5.4 Reception of an *RRCCConnectionReconfiguration* including the *mobilityControlInfo* by the UE (handover) . . . start synchronising to the DL of the target cell . . . The UE should perform the handover as soon as possible following the reception of the RRC message triggering the handover.”).

129. It was well-known for a UE to perform reconfiguration of resources based on instructions provided by a base station. *See, e.g.,* Tenny-Prov., ¶35 (“carrier grouping component 304” of “wireless device 302” “receive[s] one or more groupings from one or more related access points or the wireless network”), ¶36 (“carrier candidate selection component 306” of wireless device 302 configures timing group by “choos[ing] a carrier in the group from which to acquire timing updates”), claim 15 (“wireless communication apparatus” that “generates the association of the plurality of carriers into one or more timing groups according to a grouping received from the base station associated with a subset of the plurality of carriers”); TS36.331, 39-42, 40 (*RRCCConnectionReconfiguration* message containing instructions to a UE to “establish/modify/release RBs, to perform handover”); Marinier, ¶65 (“[T]he definition of a UL CC set may depend on the WTRU capability.”).

130. A person of ordinary skill in the art would have been motivated to implement **Qualcomm's** "handover command" according to the teachings of **TS.36.331's** "handover" protocol, which includes RRC-protocol-based instructions for a UE to reconfigure radio resources, for several reasons. First, a person of ordinary skill in the art would have been motivated to use **TS36.331's** "handover" protocol, which provides detailed RRC-based instructions to UE, such as "*RRCConnectionReconfiguration*" handover message, to reconfigure resources during handover in implementing **Qualcomm's** handover command to advantageously render the UE's operation during handover LTE-compatible, as desired by Qualcomm's design for "LTE-A." Qualcomm, 1-2; TS.36.331, 39-42, 48. Second, performing "radio resource configuration" by a UE advantageously reduces the load on the base station, which is typically responsible for managing numerous UEs at a given time, thereby enhancing the overall network efficiency by avoiding bottlenecks. Third, reconfiguration by the UE would also improve the efficiency and accuracy of handover execution as the UE is in a better position to accurately and quickly assess the availability of resources, including the UL carriers available for transmission, during handover.

131. A person of ordinary skill in the art also would have had a reasonable expectation of success in applying **TS36.331's** teachings on handover protocol in

implementing **Qualcomm's** handover command. Because **Qualcomm** proposes its design explicitly for "LTE-A," using TS36.331's handover scheme in Qualcomm's design would have been a straightforward application requiring minimal disruption to the existing LTE infrastructure. Qualcomm, 1. In particular, **Qualcomm's** teaching of adding new UL timing groups in an RRC message would be compatible with LTE as it was well-understood to associate component carriers (CCs) with UL timing group identifiers in an RRC message. *See, e.g.,* Tenny, ¶70 ("[A]n identifier [for a timing group] could be sent with a small number of bits (e.g., as an index into the set of timing groups with which the UE was configured). Such a mapping could be established by explicit signaling (in higher layers such as the Radio Resource Control) at the time the UE is configured with particular carriers"); Marinier, ¶73 ("Some embodiments may identify UL carriers that use the same timing advance by defining a group index of a few bits for each UL CC set (possibly a single bit if there is a maximum of 2 UL CC sets). The WTRU may obtain the group index of the UL CC set to which an UL carrier belongs when this UL carrier is being configured by the network (e.g., in the RRC message).").

3. Invalidity of Claims 2-3 Over Qualcomm in view of TS36.331

132. In addition to my discussion in §§IX.B.1-IX.B.2, the following identifies example disclosures followed by bulleted excerpts that each disclose and/or render obvious the Challenged Claims.

(a) Element [2.pre]

133. Element [2.pre] recites “A method for establishing an uplink (UL) synchronization by a User Equipment (UE), the method comprising.” This element is met by Qualcomm alone.

134. Qualcomm discloses a method for establishing an uplink (UL) synchronization by a User Equipment (UE) (e.g., “a design for multiple timing advances,” wherein a “UE has to send a RACH” to “obtain a timing advance” to “calculate[] uplink timing”).

- 1 (§1) (“In this paper, we describe *a design for multiple timing advances, and recommend adoption of this design* in case multiple timing advances are adopted in LTE-A.”)
- 2 (§2.3) (“The *UE calculates uplink timing by adding a timing advance to the received downlink reference timing*. When different timing groups are present, the downlink reference needs to be specified. ... Having a DL timing reference that is specific to a timing group is important as it reduces the magnitude of the timing advance values...[T]he timing advances commands may originate from different nodes in the network, and having group specific references is important.”)
- 2 (§2.4 Delivery of Timing Advance, ¶3) (“*In order to obtain a timing advance, the UE has to send a RACH*. In case there is more than one CC in a timing group, there is the question of which CC to use. The simplest

solution is for the network to assign one UL CC per timing group where the UE sends RACH.”)

- **2 (Proposal 6)** (“The *UE initiates RACH* upon configuration of a new timing group. In case of handover, *if multiple timing groups are configured, the UE initiates RACH on all the timing groups.*”)
- *See also 3.*

135. **Qualcomm** discloses “a design for multiple timing advances, and recommend[s] adoption of this design in case multiple timing advances are adopted in LTE-A.” Qualcomm, 1 (§1). In this design, “[i]n order to obtain a timing advance, the UE has to send a RACH.” Qualcomm, 2 (§2.4). “[I]f multiple timing groups are configured” for the UE, “the UE initiates RACH on all the timing groups.” *Id.* (Proposal 6). The UE then “calculates uplink timing by adding a timing advance to the received downlink reference timing.” Qualcomm, 1. As discussed above in §IX.B.1, a POSITA would have understood that **Qualcomm** discloses that the UE uses the Random Access Channel (RACH) to initiate the random access procedure to perform uplink synchronization between a UE and eNB. At minimum, a POSITA would have found it obvious for a UE to use RACH for this purpose because it was well-known that the random access procedure defined in LTE, for which Qualcomm’s proposal is designed, uses RACH to initiate uplink synchronization by a UE with an eNB. *See, e.g.*, TS36.300 at 52 (“The random access procedure is performed for the following five events . . . E.g. when UL

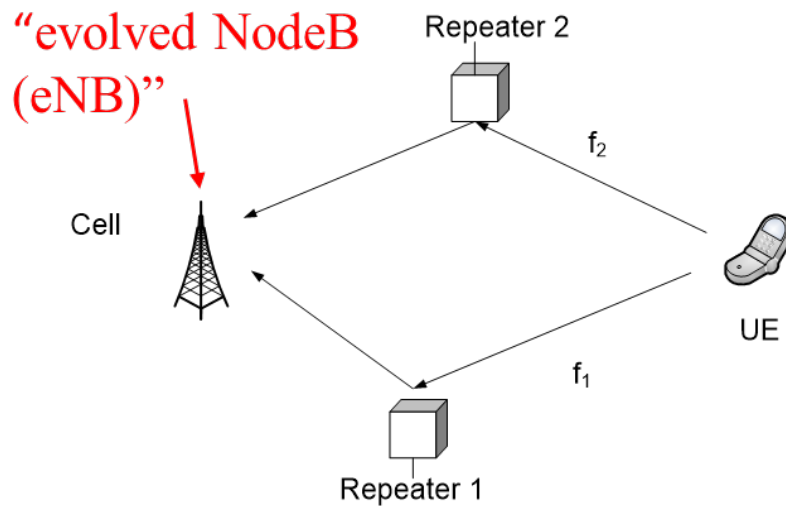
synchronisation status is ‘non-synchronised.’”), 54 (“random access procedure . . . [c]onveys at least: Timing Alignment information and initial UL grant for handover; Timing Alignment information for DL data arrival”); Ex. 1015 at 432 (“In LTE, random access is used for several purposes, including . . . to establish uplink synchronization if uplink or downlink data arrives when the terminal is in RRC_CONNECTED and the uplink is not synchronized.”). As such, a person of ordinary skill in the art would have understood, and at minimum found obvious, that **Qualcomm** teaches a RACH-based method for establishing UL synchronization.

(b) Element [2.a]

136. **Element [2.a] recites “receiving a Radio Resource Control (RRC) signaling including a UL timing group information set, which has been set by an evolved NodeB (eNB).”** This element is met by **Qualcomm** alone.

137. **Qualcomm discloses receiving a Radio Resource Control (RRC) signaling including a UL timing group information set** (e.g., UE receiving “dedicated RRC signalling” from the “network” which “indicate[s]” that “a newly configured UL carrier...belong[s] to a new timing group”), **which has been set by an evolved NodeB (eNB)** (e.g., “network” base station in “LTE[]”).

- **Figure 2**



- **1 (§1)** (“In this paper, we describe *a design for multiple timing advances, and recommend adoption of this design* in case multiple timing advances are adopted in LTE-A”)
- **2 (Proposal 1)** (“*The UL component carriers configured for a UE should be divided into timing groups, where the network controls the grouping of component carriers.*”)
- **2 (Proposal 2)** (“*The UL component carriers within a timing group share the same timing*”)
- **2 (§2.4 Initiating use of timing groups other than those containing special cell, ¶1)** (“*It is already agreed that configured carriers are added by dedicated RRC signalling, subsequent to the connection establishment. If a newly configured UL carrier is indicated by the network as belonging to a new timing group, then the UE should perform RACH before starting any other UL transmissions. The same issue arises after handover, in the case where the handover command configures multiple timing groups at the target cell.*”)
- **2 (Proposal 6)** (“The UE initiates RACH upon configuration of a new timing group. In case of handover, *if multiple timing groups are configured, the UE initiates RACH on all the timing groups.*”)

- 1-2 (§2.2) (“In the scenario above, *it is possible that f1 and f2 each constitute multiple LTE CCs*. ... [T]he *configured component carriers can be divided into groups* to reduce the number of separate timings to be maintained by the UE.”)

138. **Qualcomm** discloses that the UE may communicate with the network via multiple “UL component carriers” or “multiple LTE CCs” (UL CCs). Qualcomm, 1-2. The “configured carriers are added by dedicated RRC signalling, subsequent to the connection establishment.” *Id.* **Qualcomm** also discloses that “[t]he UL component carriers configured for a UE should be divided into timing groups.” Qualcomm, 2. Because **Qualcomm’s** “timing groups” are comprised of UL CCs, the timing groups are UL timing groups. *Id.* at Proposal 1 (“The *UL component carriers* configured for a UE should be *divided into timing groups*”), Proposal 2 (“The *UL component carriers within a timing group* share the same timing.”) (emphases added). “In case of handover,” where a UE moves from one network cell to a new “target cell,” UL carriers assigned to the UE may need to be reconfigured because the UL carriers originally assigned to the UE at the old cell may no longer be available at the target cell, and new UL carriers become available at the new target cell. *Id.* Accordingly, **Qualcomm** discloses that “newly configured UL carrier[s]” are “indicated by the network as belonging to [] new timing group[s]” via the “handover command,” which is used to “configure[] multiple timing groups at the target cell.” *Id.* In light of the above disclosures in **Qualcomm**, a POSITA

would have understood that, in a handover situation, the UE receives the “handover command” in a “dedicated RRC signalling” message that includes a UL timing group information set that indicates which “newly configured UL carrier[s]” “belong” to which “new timing group[s].” *Id.* The UE then uses this UL timing group information set included in the “handover command” to “configure[] multiple timing groups at the target cell.” *Id.*

139. **Qualcomm** discloses that the “handover command,” which a RRC signaling message, is sent by the “network” to the UE. Qualcomm, 2. Moreover, **Qualcomm** “recommend[s] adoption of [its] design” for “LTE-A,” which utilized “eNode B(s)” (or “eNB(s)”) for performing network functionality in serving a cell, as shown in Figure 2. Qualcomm, Figure 2. Accordingly, a POSITA would have understood that the set of UL timing groups that the UE is configured with is set by the eNB. And at minimum, it would have been obvious to a POSITA to use an eNB as the network element that sets the UL timing group information set in **Qualcomm’s** “dedicated RRC signalling” message (Qualcomm, 2), because as discussed in Ground 1 in connection with [2.a], eNBs were conventionally used as network elements, such as base stations, to perform UL synchronization with a UE in an LTE network. *See* §IX.A.3(b).

(c) Element [2.b]

140. Element [2.b] recites “configuring one or more UL timing groups based on the UL timing group information set, the one or more UL timing groups each comprising one or more UL CCs.” This element is met by Qualcomm in view of TS36.331.

141. Qualcomm discloses configuring one or more UL timing groups based on the UL timing group information set (e.g., “handover command configures multiple timing groups” based on “RRC signalling,” which indicates “if a newly configured UL carrier...belong[s] to a new timing group”; see [2.a]), the one or more UL timing groups each comprising one or more UL CCs (e.g., “more than one CC in a timing group”).

- 1-2 (§2.2) (“From the above observations, it can be concluded that *the configured component carriers can be divided into groups to reduce the number of separate timings to be maintained by the UE.*”)
- 2 (§2.4 Initiating use of timing groups, ¶1) (“*It is already agreed that configured carriers are added by dedicated RRC signalling*, subsequent to the connection establishment. *If a newly configured UL carrier is indicated by the network as belonging to a new timing group*, then the UE should perform RACH before starting any other UL transmissions. *The same issue arises after handover, in the case where the handover command configures multiple timing groups at the target cell.*”)
- 2 (Proposal 2) (“The UL *component* carriers within *a timing group* share the same timing.”)
- 2 (§2.4 Delivery of Timing Advance, ¶3) (“*In order to obtain a timing advance, the UE has to send a RACH.* In case there is more than one CC in

a timing group, there is the question of which CC to use. *The simplest solution is for the network to assign one UL CC per timing group where the UE sends RACH.*")

- **2 (Proposal 5)** (“*A unique UL carrier is identified* to be used for RACH on *each timing group.*”)
- **2 (Proposal 6)** (“The UE initiates RACH upon configuration of a new timing group. In case of handover, *if multiple timing groups are configured, the UE initiates RACH on all the timing groups.*”)

142. See my discussion for element [2.a]. As I discuss in element [2.a], as new UL carriers become available to the UE during handover, the network indicates to the UE that they belong to new timing groups via RRC signalling. *See* [2.a]. **Qualcomm** further discloses that the “handover command” that network sends to the UE instructs the UE to “configure[] multiple timing groups at the target cell” using the timing group information included in the RRC signalling (indicating “[i]f a newly configured UL carrier...belong[s] to a new timing group”). Qualcomm, 2; *see* [2.a]. **Qualcomm** teaches that “the configured component carriers can be divided into groups to reduce the number of separate timings to be maintained by the UE.” Qualcomm, 1-2. As discussed in [2.a], **Qualcomm’s** timing groups are UL timing groups because they comprise UL CCs. *See* [2.a]. **Qualcomm** discloses that each UL timing group may include “more than one CC in a timing group,” where all UL CCs within each group “share the same timing.” Qualcomm, 2. As such, a person of ordinary skill in the art would have understood that, as the UE receives the

set of timing group information pertaining to the new UL carriers during handover, it configures in real time one or more UL timing groups, where each timing group includes “more than one CC,” and maintains locally separate timings for each timing group. Qualcomm, 1-2. At minimum, a person of ordinary skill in the art would have found it obvious to have the UE reconfigure the timing groups during handover, as it was well known to use UEs to reconfigure radio resources during handover based on the instructions include in the RRC messages that the network sends. *See e.g.*, TS36.331 at 39-40, 48 (further discussed below).

143. **To the extent further disclosure of the UE performing this step is required, TS36.331 further discloses a UE configuring radio resources based on the information for configuring resources transmitted in an RRC signaling** (e.g., UE “perform[s] the radio resource configuration procedure” if “the *RRCConnectionReconfiguration* messages includes the *radioResourceConfigDedicated*,” which instructs the UE on how to establish, modify, and release radio resources; *see* [2.a]).

- **39-40** (“5.3.5 RRC connection reconfiguration”) (“***The purpose of this procedure is to modify an RRC connection, e.g. to establish/ modify/ release RBs, to perform handover,*** to setup/ modify/ release measurements. As part of the procedure, NAS dedicated information may be transferred from E-UTRAN to the UE.”)
- **40-41** (“5.3.5.4 *Reception of an RRCConnectionReconfiguration* including the *mobilityControlInfo by the UE (handover)*”) (“If the

RRConnectionReconfiguration message includes the *mobilityControlInfo* and ***the UE is able to comply with the configuration included in this message***, the UE shall:...if the *RRConnectionReconfiguration* message includes the *radioResourceConfigDedicated*: [] ***perform the radio resource configuration as specified in 5.3.10.***")

- **48-49** ("§5.3.10 Radio resource configuration ... ***The UE shall:***

1> if the received *radioResourceConfigDedicated* includes the ***srb-ToAddModList***:

2>**perform the SRB addition or reconfiguration** as specified in 5.3.10.1;

1> if the received *radioResourceConfigDedicated* includes the ***drb-ToReleaseList***:

2>**perform DRB release** as specified in 5.3.10.2;

1> if the received *radioResourceConfigDedicated* includes the ***drb-ToAddModList***:

2>**perform DRB addition or reconfiguration** as specified in 5.3.10.3;

1> if the received *radioResourceConfigDedicated* includes the ***mac-MainConfig***:

2>**perform MAC main reconfiguration** as specified in 5.3.10.4;

1> if the received *radioResourceConfigDedicated* includes ***sps-Config***:

2> **perform SPS reconfiguration** according to 5.3.10.5;

1> if the received *radioResourceConfigDedicated* includes the

physicalConfigDedicated:

2> **reconfigure the physical channel configuration** as specified in 5.3.10.6....")

144. See also my discussion in [2.a]. As I discuss above, **Qualcomm** discloses that the UE receives from the network a "handover command" that

“configures multiple timing groups at the target cell,” and the configuration is performed based on the newly identified UL carriers indicated by the RRC signalling of the handover command. But **Qualcomm** does not provide details about how the timing groups are configured at the target cell by the UE.

145. **TS36.331** discloses standardized protocols through which the UE reconfigures radio resources in response to the RRC signalling. TS36.331, 39-40, 48. In particular, **TS36.331** provides explicit disclosure of a handover protocol, where the UE is instructed by the network to reconfigure radio resources through a “RRC connection reconfiguration,” including “radio resource configuration,” which takes place as part of a process “to establish/ modify/ release RBs, to perform handover.” TS36.331, 39-40 (§5.3.5). The network instructs the UE to perform this reconfiguration process by sending it a “*RRCConnectionReconfiguration*” message. TS36.331, 39-40, 48. For example, if “*RRCConnectionReconfiguration*” includes “*radioResourceConfigDedicated*,” the “UE shall” “perform the radio resource configuration procedure as specified in 5.3.10.” TS36.331, 40-41 (§5.3.5.4). Section 5.3.10 (“Radio resource configuration”) specifies that “[t]he UE shall” add, modify, release, and/or otherwise reconfigure resources under various conditions, such as “perform the SRB addition or reconfiguration,” “perform DRB release,” “perform DRB addition or reconfiguration,” “perform MAC main reconfiguration,”

and “reconfigure the physical channel configuration,” among other things. TS36.331, 48-49. As such, the “*RRConnectionReconfiguration* message . . . convey[s] information” to the UE to perform “radio resource configuration (including RBs, MAC main configuration and physical channel configuration).” TS36.331, 91 (§6.2.2). Here, “RB” refers to “radio bearer,” which is a type of radio resource. *See e.g.*, TS36.331 at 15. In view of **TS.36.331’s** RRC “handover” protocol, which instructs the UE to configure radio resources during handover, a person of ordinary skill in the art would have found it obvious to implement **Qualcomm’s** UE to configure UL timing groups as new UL carriers become available to the UE during handover. Qualcomm, 1-2.

146. As I discuss in more detail in Section IX.B.2, a person of ordinary skill in the art would have been motivated to apply **TS36.331’s** handover protocol in implementing **Qualcomm’s** handover command to make **Qualcomm’s** system LTE-compatible, reduce the load on the network by assigning the radio resources configuration responsibility to the UE, and improve efficiency and accuracy of **Qualcomm’s** handover execution.

(d) Element [2.c]

147. **Element [2.c]** recites “transmitting a Random Access Preamble (RAP) through one or more UL CCs, each of the one or more UL CCs

transmitting an RAP being set as a delegate CC in the respective UL timing group.” This element is met by Qualcomm alone.

148. **Qualcomm discloses transmitting a Random Access Preamble (RAP)** (e.g., “initiat[ing] RACH (either with a randomly selected RACH preamble, or with a RACH preamble assigned by the network)”) **through one or more UL CCs** (e.g., “if multiple timing groups are configured, the UE initiates RACH on all the timing groups”; “one UL CC per timing group where the UE sends RACH”), **each of the one or more UL CCs transmitting an RAP being set as a delegate CC in the respective UL timing group** (e.g., “A unique UL carrier is identified to be used for RACH on each timing group”).

- **2 (Proposal 2)** (“The *UL component carriers within a timing group* share the same timing.”)
- **2 (§2.4 Delivery of Timing Advance, ¶3)** (“*In order to obtain a timing advance, the UE has to send a RACH.* In case there is more than one CC in a timing group, there is the question of which CC to use. *The simplest solution is for the network to assign one UL CC per timing group where the UE sends RACH.*”)
- **2 (Proposal 5)** (“*A unique UL carrier is identified* to be used for RACH on *each timing group.*”)
- **2 (§2.4 Initiating use of timing groups other than those containing special cell, ¶2)** (“There are two options to *initiate a RACH for the UE to acquire timing on this carrier* [¶] - *UE initiates RACH* (either with a *randomly selected RACH preamble*, or with a *RACH preamble assigned by the network*).”)

- **2 (Proposal 6)** (“The UE initiates RACH upon configuration of a new timing group. In case of handover, *if multiple timing groups are configured, the UE initiates RACH on all the timing groups.*”)

149. See my discussion for elements [2.b], [2.d]-[2.e]. **Qualcomm** also discloses that “[t]he UE initiates RACH upon configuration of a new timing group. In case of handover, if multiple timing groups are configured, the UE initiates RACH on all the timing groups.” Qualcomm, 2. In particular, “[i]n order to obtain a timing advance” for a timing group, “the UE has to send a RACH” for that timing group. *Id.* The UE sends a RACH via a “RACH preamble,” which is either “randomly selected” or “assigned by the network.” *Id.* As discussed above in the Overview of Qualcomm, a person of ordinary skill in the art would have understood that in the context of **Qualcomm’s** “LTE-A” system, **Qualcomm’s** “RACH preamble” is a Random Access Preamble (RAP). See §IX.B.1. At minimum, a person of ordinary skill in the art would have found it obvious to implement **Qualcomm** to send a Random Access Preamble (RAP) to obtain timing advances for timing groups as part of **Qualcomm’s** “RACH” initiation (Qualcomm, 1), which a POSITA would have understood refers to the well-known random access procedure in LTE (as I discussed in §IX.B.1).

150. **Qualcomm** further discloses that “[i]n case there is more than one CC in a timing group, there is the question of which CC to use [for sending RACH].

The simplest solution is for the network to assign one UL CC per timing group where the UE sends RACH.” Qualcomm, 2 (§2.4). Specifically, **Qualcomm** proposes that “[a] unique UL carrier is identified to be used for RACH on each timing group” (Proposal 5), and that “[i]n order to obtain a timing advance, the UE has to send a RACH.” Qualcomm, 2 (§2.4). Because **Qualcomm’s** “unique UL carrier” is “used for RACH” to “obtain a timing advance” for its timing group,” a POSITA would have understood that the “unique UL carrier” is used to transmit a RAP to obtain a timing advance for its timing group. Thus, the “unique UL carrier” is set as a delegate CC in its respective UL timing group because the “unique UL carrier” is used to obtain a timing advance for its timing group. Qualcomm, 2 (§2.4). Based on the discussion above, a person of ordinary skill in the art would have understood that **Qualcomm’s** UE transmits a RAP through one UL CC per timing group, and at minimum, a person of ordinary skill in the art would have found obvious to implement the UE to do so.

(e) Element [2.d]

151. **Element [2.d] recites “receiving a Random Access Response (RAR) including a Timing Advanced (TA) value for UL CCs in the respective UL timing group, wherein each TA value is transmitted from the eNB for the respective UL timing group based on the transmitted RAP associated with a**

delegate CC of the respective UL timing group.” This element is met by Qualcomm alone.

152. Qualcomm discloses receiving a Random Access Response (RAR) including a Timing Advanced (TA) value for UL CCs in the respective UL timing group (e.g., in response to the initiated RACH (*see* [2.c]), “timing advance is delivered to the UE” in “[a] unique DL carrier...for each timing group”), **wherein each TA value is transmitted from the eNB** (e.g., “timing advance[] commands may originate from different nodes in the network”; *see* 2[a]) **for the respective UL timing group** (e.g., “A unique DL carrier is identified as the TA-providing carrier for each timing group”) **based on the transmitted RAP associated with a delegate CC of the respective UL timing group** (“timing advance” requested by “RACH preamble” is delivered” using a “unique DL carrier”; *see* [2.c]).

- **1 (§1)** (“In this paper, we describe *a design for multiple timing advances, and recommend adoption of this design* in case multiple timing advances are adopted in LTE-A.”)
- **2 (Proposal 2)** (“The *UL component carriers* within *a timing group* share the same timing.”)
- **2 (Proposal 4)** (“*A unique DL carrier is identified* as the TA-providing carrier *for each timing group*. The *signalling formats for TA* are as *specified in Rel-8*.”)
- **2 (Proposal 5)** (“*A unique UL carrier is identified to be used for RACH on each timing group*.”)

- **2 (§2.4 Delivery of Timing Advance, ¶1)** (“The timing advance is delivered to the UE using a DL MAC control element. ... in LTE-A, this mapping has to be specified, so that *a timing command received on a given DL CC uniquely addresses a timing group*”)
- **2 (§2.4 Delivery of Timing Advance, ¶3)** (“*In order to obtain a timing advance, the UE has to send a RACH.* In case there is more than one CC in a timing group, there is the question of which CC to use. *The simplest solution is for the network to assign one UL CC per timing group where the UE sends RACH.*”)
- **2 (§2.4 Initiating use of timing groups other than those containing special cell, ¶2)** (“There are two options to *initiate a RACH for the UE to acquire timing on this carrier* [¶] - *UE initiates RACH* (either with a *randomly selected RACH preamble*, or with a *RACH preamble assigned by the network*).”)
- **2 (§2.3 Calculation of timing reference, ¶3)** (“Having a DL timing reference that is specific to a timing group is important as it reduces the magnitude of the timing advance values. Also, for scenarios 3 and 4 described in [1], *the timing advances commands may originate from different nodes in the network*, and having group specific references is important.”)

153. See my discussion for elements [2.a]-[2.c], [2.e]. As I discuss for element [2.c], **Qualcomm** discloses that the UE sends a RACH preamble (*i.e.*, RAP) in order to obtain timing advance (TA) using a “unique UL carrier,” which is a delegate CC “identified to be used for RACH on each timing group” (*i.e.*, “one UL CC per timing group”). Qualcomm, 2 (§2.4 Delivery of Timing Advance); *see* [2.c]. In response to the RAP, **Qualcomm** proposes that “[t]he timing advance [TA] is delivered to the UE” using “[a] unique DL carrier” that “is identified as the TA-providing carrier for each timing group.” Qualcomm, 2 (§2.4 Proposal 4). The

“timing command received on a given DL CC uniquely addresses a timing group.” Qualcomm, 2 (§2.4 Delivery of Timing Advance). Thus, the timing advance value is for UL CCs in the respective UL timing group of the delegate CC.

154. A person of ordinary skill in the art would have understood that **Qualcomm’s** UE receives the timing advance, which it requests via a “RACH preamble,” in a Random Access Response (RAR). As I discuss in the Overview of Qualcomm, a POSITA would have understood that **Qualcomm’s** “RACH” initiation refers to the random access procedure initiated over the RACH channel, as defined by LTE specifications, such as TS36.300. *See* §IX.B.1. As I also discuss in Ground 1 based on Tenny ([2.d]), the UE receives a random access response (RAR) in response to the RAP as a routine part of the random access procedure, and it was well known in the art for a RAR to include timing advance to adjust the transmit timing of the UE. *See* §IX.A.3 ([2.d]). Thus, a person of ordinary skill in the art would have at least found it obvious to implement **Qualcomm’s** RACH such that the UE receives a Random Access Response (RAR) including a Timing Advanced (TA) value for UL CCs in the respective UL timing group.

155. **Qualcomm** further discloses that “the timing advances commands may originate from different nodes in the network,” each “[h]aving a DL timing reference

that is specific to a timing group.” Qualcomm, 2 (§2.3). As I discuss in [2.a], these nodes are evolved NodeBs (eNBs) in Qualcomm’s proposed LTE-A system.

156. Based on the discussion above, a person of ordinary skill in the art would have understood that, in **Qualcomm’s** RACH, the UE receives a Random Access Response (RAR) including a Timing Advanced (TA) value for UL CCs in the respective UL timing group, wherein each TA value is transmitted from the eNB for the respective UL timing group based on the transmitted RAP associated with a delegate CC of the respective UL timing group. At minimum, a person of ordinary skill in the art would have found obvious to implement the UE to do so.

157. To the extent the “wherein” clause in limitation [2.d] is construed to mean “wherein each TA value is transmitted from the eNB for the respective UL timing group in response to the transmitted RAP through its delegate CC of the respective UL timing group” (as discussed in §VIII), **Qualcomm** does not specify whether the same or a different delegate CC is used for UL and DL, and it would have at least been obvious to a POSITA to use the same CC for the “unique UL carrier” identified for the timing group to transmit the RAP (Qualcomm, 2; *see* [2.c]) and “unique DL carrier...identified as the TA-providing carrier for each timing group” to receive the TA value in the RAR (e.g., in a TDD implementation) in order to advantageously reduce the signaling complexity involved in assigning a separate

DL carrier since the UL carrier is already specifically designated for the respective timing group.

(f) Element [2.e]

158. Element [2.e] recites “**applying each TA value to CCs in the respective UL timing group.**” This element is met by **Qualcomm** alone.

159. **Qualcomm** discloses **applying each TA value to CCs in the respective UL timing group** (e.g., “calculat[ing] uplink timing by adding a timing advance to the received downlink reference timing,” wherein “[t]he UL component carriers within a timing group share the same timing”).

- **2 (§2.3 Calculation of timing reference)** (“*The UE calculates uplink timing* by adding a timing advance to the received downlink reference timing. When different timing groups are present, the downlink reference needs to be specified...Having a DL timing reference that is specific to a timing group is important as it reduces the magnitude of the timing advance values. ...[T]he timing advances commands may originate from different nodes in the network, and having group specific references is important.”)
- **2 (Proposal 2)** (“*The UL component carriers within a timing group share the same timing.*”)
- **2 (Proposal 4)** (“*A unique DL carrier is identified* as the TA-providing carrier *for each timing group*. The *signalling formats for TA* are as *specified in Rel-8.*”)
- **2 (§2.4 Delivery of Timing Advance, ¶3)** (“*In order to obtain a timing advance, the UE has to send a RACH.* In case there is more than one CC in a timing group, there is the question of which CC to use. *The simplest solution is for the network to assign one UL CC per timing group where the UE sends RACH.*”)

- **3 (§2.5 Maintenance of UE Timing Alignment, Proposal 7)** (“*A separate timing alignment timer instance* should be maintained by the UE *for each timing group.*”)

160. See my discussion for elements [2.c]-[2.d]. As I discuss in [2.d], **Qualcomm** discloses that the UE receives a “timing advance” for “each timing group.” Qualcomm, 2 (§2.4 Proposal 4); *see* [2.d]. “The UE calculates uplink timing by adding a timing advance to the received downlink reference timing,” which “needs to be specified” for each timing group—it can be a “common” timing reference for “[a]ll timing groups” based on “a common DL carrier” or each timing group may use “a network specified DL carrier as timing reference.” *Id.* Furthermore, **Qualcomm** discloses that “UL component carriers within a timing group share the same timing.” Qualcomm, 2 (Proposal 2). As such, by “calculat[ing] uplink timing” for each UL “timing group” using the “timing advance” received for that respective UL timing group, the UE applies the TA value to CCs in that respective UL timing group. Qualcomm, 2.

(g) Element [3.pre]

161. Element [3.pre] recites “**A User Equipment (UE) to establish an uplink (UL) synchronization in a wireless communication system, the UE comprising.**” This element is met by **Qualcomm** alone.

162. **Qualcomm discloses or renders obvious a User Equipment (UE) to establish an uplink (UL) synchronization (see [2.pre]) in a wireless communication system (e.g., “LTE-A”).**

- **1 (§1)** (“In this paper, we describe *a design for multiple timing advances, and recommend adoption of this design* in case multiple timing advances are adopted in LTE-A.”)

163. See my discussion for element [2.pre]. **Qualcomm** proposes its “design for multiple timing advances” and “recommend[s] adoption of [its] design” for “LTE-A,” where wireless communication occurs between a UE and the network. As I discuss in element [2.pre], **Qualcomm** discloses, and at minimum renders obvious, a RACH-based method for establishing UL synchronization where the UE sends a RACH in order to obtain a timing advance, and then calculates uplink timing by adding a timing advance to the received downlink reference timing. See [2.pre]. By performing these steps, the UE establishes the UL synchronization. As such, **Qualcomm** discloses, and at minimum renders obvious, a User Equipment (UE) to establish an uplink (UL) synchronization in a wireless communication system.

(h) Element [3.a]

164. **Element [3.a] recites “a transceiver configured to receive a Radio Resource Control (RRC) signaling including a UL timing group information set, which has been set by an evolved NodeB (eNB).” This element is met by Qualcomm alone.**

165. Qualcomm discloses or renders obvious a transceiver (e.g., transceiver of a “UE,” such as a mobile phone, that transmits and receives information from the network) **configured to receive a Radio Resource Control (RRC) signaling including a UL timing group information set, which has been set by an evolved NodeB (eNB) (see [2.a]).**

- **Figure 2**

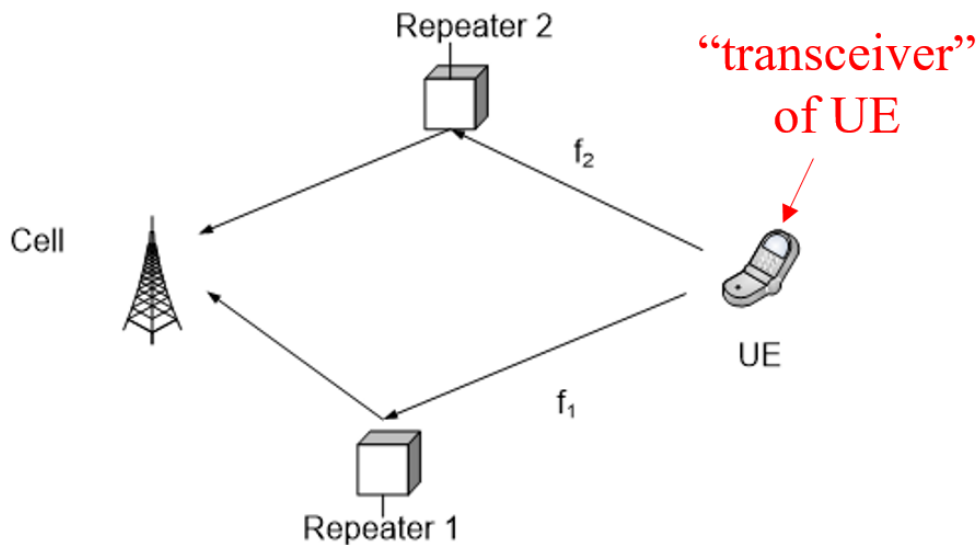


Figure 2 Frequency Selective Repeaters

- **2 (§2.4 Delivery of Timing Advance, ¶1)** (“The timing advance is delivered to the UE using a DL MAC control element. ... in LTE-A, this mapping has to be specified, so that *a timing command received on a given DL CC uniquely addresses a timing group.*”)
- **2 (§2.4 Delivery of Timing Advance, ¶3)** (“*In order to obtain a timing advance, the UE has to send a RACH.* In case there is more than one CC in a timing group, there is the question of which CC to use. *The simplest solution is for the network to assign one UL CC per timing group where the UE sends RACH.*”)

166. See my discussion for element [2.a]. As I discuss for element [2.a], **Qualcomm** discloses or renders obvious receiving a Radio Resource Control (RRC) signaling including a UL timing group information set, which has been set by an evolved NodeB (eNB). *See* [2.a].

167. **Qualcomm** further discloses a “UE,” such as a mobile phone, that transmits and receives timing-related information to and from a network. Qualcomm, 2, Fig. 2. A person of ordinary skill in the art would have understood that **Qualcomm’s** UE includes a transceiver for transmitting and receiving timing-related information to and from the network, including the RRC signalling that includes UL timing group information. At minimum, a person of ordinary skill in the art would have found it obvious to implement **Qualcomm’s** UE to include a transceiver that is configured to receive **Qualcomm’s** RRC signalling (*see* [2.a]) as part of **Qualcomm’s** RACH/random access procedure (*see* §IX.B.1), because it was known to use transceivers in UEs to receive information as part of performing a random access procedure in a LTE-A network, like **Qualcomm’s**. *See* §IX.A.3 (Ground 1, [3.a]). As such, a person of ordinary skill in the art would have understood, and at minimum found obvious, that **Qualcomm’s** UE includes a transceiver is configured to receive a Radio Resource Control (RRC) timing group information set, which has been set by an evolved NodeB (eNB), as I discuss in [2.a].

(i) Element [3.b]

168. Element [3.b] recites “a controller configured to configure one or more UL timing groups based on the UL timing group information set, the one or more UL timing groups each comprising one or more UL CCs.” This element is met by Qualcomm in view of TS36.331.

169. Qualcomm in view of TS36.331 renders obvious a controller (e.g., controller of “UE,” such as a mobile phone) configured to configure one or more UL timing groups based on the UL timing group information set, the one or more UL timing groups each comprising one or more UL CCs (*see* [2.b]).

- Figure 2

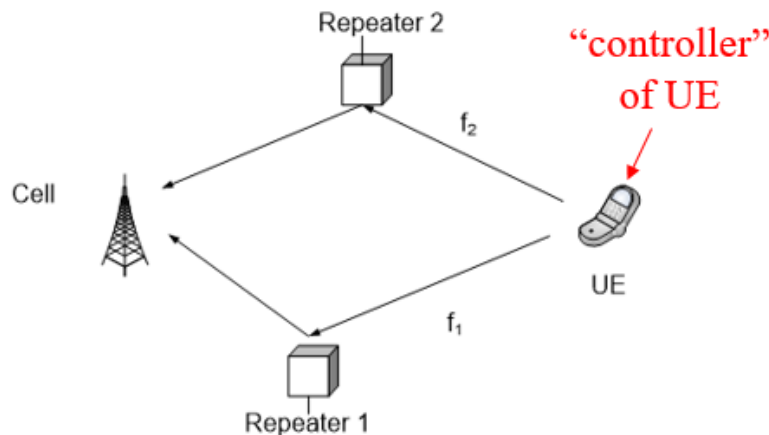


Figure 2 Frequency Selective Repeaters

170. See my discussion for elements [2.a], [2.b], [3.a]. As I discuss for element [2.b], Qualcomm in view of TS36.331 renders obvious configuring one or

more UL timing groups based on the UL timing group information set, the one or more UL timing groups each comprising one or more UL CCs. *See* [2.b].

171. As I discuss for elements [2.a] and [2.b], **Qualcomm** further discloses a “UE,” such as a mobile phone, for configuring one or more UL timing groups based on the UL timing group information set received in the “RRC signalling” from the eNB. Qualcomm, Fig. 2, 2; *see* [2.a]-[2.b]. Thus, a person of ordinary skill in the art would have understood **Qualcomm**’s UE includes a controller for performing UE’s processing functions, including configuring one or more UL timing groups based on the UL timing group information set. At minimum, a POSITA would have found it obvious to implement **Qualcomm**’s UE to use a controller to perform this configuring function because controllers were known to be used to operate with receivers and transmitters to handle different component carriers in the context of a random access procedure in an LTE network. *See* §IX.A.3 (Ground 1, [3.b]). As such, a person of ordinary skill in the art would have understood, and at minimum found obvious, the UE includes a controller is configured to configure one or more UL timing groups based on the UL timing group information set, the one or more UL timing groups each comprising one or more UL CCs, as I discussed in [2.b].

(j) Element [3.c]

172. **Element [3.c] recites “wherein the transceiver transmits a Random Access Preamble (RAP) through one or more UL CCs, each of the one or more UL CCs transmitting an RAP being set as a delegate CC in the respective UL timing group, and receives a Random Access Response (RAR) including a Timing Advanced (TA) value for UL CCs in the respective UL timing group, wherein each TA value is transmitted from the eNB for the respective UL timing group based on the transmitted RAP associated with a delegate CC of the respective UL timing group.” This element is met by Qualcomm alone.**

173. **Qualcomm discloses or renders obvious that the transceiver (*see* [3.a]) transmits a Random Access Preamble (RAP) through one or more UL CCs, each of the one or more UL CCs transmitting an RAP being set as a delegate CC in the respective UL timing group (*see* [2.c]), and receives a Random Access Response (RAR) including a Timing Advanced (TA) value for UL CCs in the respective UL timing group, wherein each TA value is transmitted from the eNB for the respective UL timing group based on the transmitted RAP associated with a delegate CC of the respective UL timing group (*see* [2.d]).**

174. See my discussion for elements [2.c]-[2.d], [3.a]. As I discuss for [2.c], **Qualcomm** discloses, or at minimum renders obvious, transmitting a Random Access Preamble (RAP) through one or more UL CCs, each of the one or more UL CCs transmitting an RAP being set as a delegate CC in the respective UL timing group. See [2.c]. As I discuss for [2.d], **Qualcomm** discloses, or at minimum renders obvious, receiving a Random Access Response (RAR) including a Timing Advanced (TA) value for UL CCs in the respective UL timing group, wherein each TA value is transmitted from the eNB for the respective UL timing group based on the transmitted RAP associated with a delegate CC of the respective UL timing group. See [2.d]. Furthermore, as I discuss for element [3.a], **Qualcomm** discloses, or at minimum renders obvious, that its UE includes a transceiver for receiving and transmitting timing-related information to and from a network. See [3.a]. As such, a person of ordinary skill in the art would have understood, and at minimum found obvious that **Qualcomm's** UE includes a transceiver transmits a Random Access Preamble (RAP) through one or more UL CCs, each of the one or more UL CCs transmitting an RAP being set as a delegate CC in the respective UL timing group, and receives a Random Access Response (RAR) including a Timing Advanced (TA) value for UL CCs in the respective UL timing group, wherein each TA value is transmitted from the eNB for the respective UL timing group based on the

transmitted RAP associated with a delegate CC of the respective UL timing group (*see* [2.c]-[2.d]). At minimum, a POSITA would have found it obvious to implement **Qualcomm's** UE to use a transceiver to transmit a RAP (*see* [2.c]) and receive a RAR ([2.d]), as transceivers were known to perform these functionalities. *See* §IX.A.3 (Ground 1, [3.c]). As such, a person of ordinary skill in the art would have understood, and at minimum found it obvious, that **Qualcomm's** UE includes a transceiver that transmits a RAP and receives a RAR, as I discussed in [2.c]-[2.d].

(k) Element [3.d]

175. **Element [3.d] recites “wherein the controller applies each TA value to CCs in the respective UL timing group.”** This element is met by Qualcomm alone.

176. **Qualcomm discloses or renders obvious that the controller (*see* [3.b]) applies each TA value to CCs in the respective UL timing group (*see* [2.e]).**

177. *See* my discussion for elements [2.e], [3.b]. As I discuss for element [2.e], Qualcomm discloses applying each TA value to CCs in the respective UL timing group. *See* [2.e]. Moreover, as I discuss for [3.b], Qualcomm discloses, and at minimum renders obvious, that its UE includes a controller for performing UE's processing functions. *See* [3.b]. As such, person of ordinary skill in the art would have understood that **Qualcomm's** UE includes a controller that applies each TA

value to CCs in the respective UL timing group (*see* [2.e]). At minimum, a POSITA would have found it obvious to implement **Qualcomm's** UE to use a controller to apply each TA value to CCs in the respective UL timing group, because controllers were known to be used to handle processing related to component carriers in the context of a random access procedure in an LTE network. *See* §IX.A.3 (Ground 1, [3.d]). As such, a person of ordinary skill in the art would have understood, and at minimum found obvious, that **Qualcomm's** UE includes a controller that applies each TA value to CCs in the respective UL timing group, as I discussed in [2.e].

C. Grounds 3-4: Grounds 1-2 in further view of TS36.300 (Claims 2-3)

178. Elements [2.c], [2.d], and [3.c] require the transmission of a RAP and reception of a RAR to establish uplink synchronization. As I discuss in Sections IX.A.3, IX.B.3 ([2.c]-[2.d], [3.c]), **Tenny** discloses or at minimum renders obvious (Ground 1), and **Qualcomm in view of TS36.331** renders obvious (Ground 2) transmission of a RAP and reception of a RAR to establish uplink synchronization. *See* Sections IX.A.3, IX.B.3 ([2.c]-[2.d], [3.c]). To the extent further disclosure is required, TS36.300 provides explicit teachings of the claimed use of RAP and RAR.

179. As I discuss in Sections IX.A.1, IX.B.1, both **Tenny and Qualcomm** disclose that the UE performs random access procedure to acquire timing

information from an LTE network with respect to each timing group in establishing uplink synchronization. *See* Sections IX.A.1, IX.B.1.

180. **TS36.300** expressly discloses the LTE protocol for performing the random access procedure that Tenny and Qualcomm discuss. As highlighted in Figures 10.1.5.1-1 and 10.1.5.2-1 below, TS36.300 discloses two types of “random access procedure”: “contention based random access procedure” and “non-contention based random access procedure,” where both types include a “UE[’s]” transmission of a “**Random Access Preamble**” and its reception of a “**Random Access Response**” that includes timing information. *See, e.g.,* TS36.300, 52-54, 44-45, Figure 10.1.5.1-1, Figure 10.1.5.2-1. In particular, the contention based random access procedure is depicted in Figure 10.1.5.1-1 below (highlighted).

The contention based random access procedure is outlined on Figure 10.1.5.1-1 below:

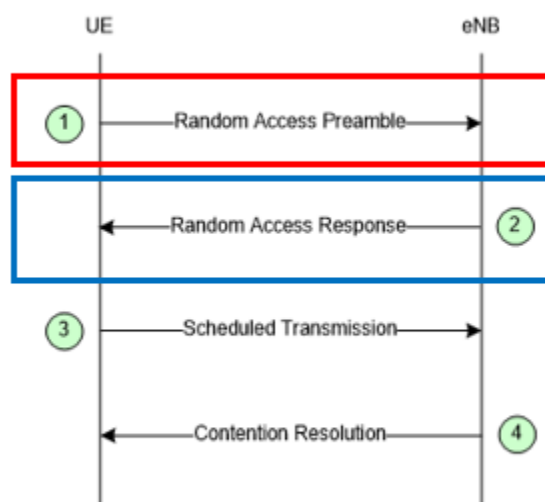


Figure 10.1.5.1-1: Contention based Random Access Procedure

181. **TS36.300** discloses the first two steps of the 4-step contention based random access procedure as follows (TS36.300, 52-53):

1. “**Random Access Preamble**” sent from the UE to the “eNB” “on RACH in uplink”
2. “**Random Access Response**,” sent from the eNB to the UE “on DL-SCH,” that “[c]onveys at least RA-preamble identifier, Timing Alignment information, initial UL grant . . .”

182. The non-contention based random access procedure is depicted in Figure 10.1.5.2-1 below (highlighted).

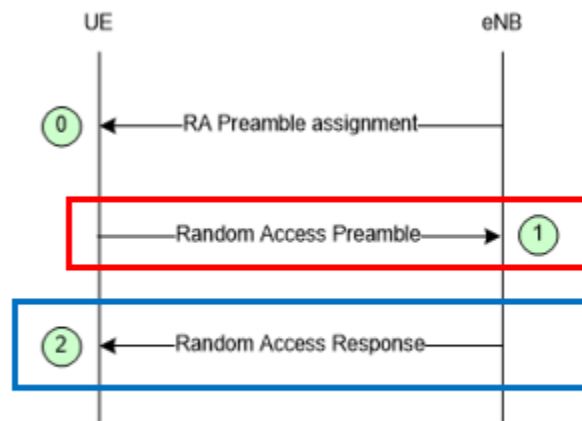


Figure 10.1.5.2-1: Non-contention based Random Access Procedure

183. **TS36.300** discloses the second (step “1”) and the third (step “2”) of the 3-step non-contention based random access procedure as follows (TS36.300, 54):

1. “UE transmits the assigned non-contention **Random Access Preamble**” on “on RACH in uplink”
2. The “eNB” transmits “**Random Access Response** on DL-SCH,” that “[c]onveys at least:

- Timing Alignment information and initial UL grant for handover;
- Timing Alignment information for DL data arrival;
- RA-preamble identifier.”

184. **TS36.300** also teaches performing a random access procedure as part of its handover procedure, where “the target eNB” receives via the RAP sent on the RACH and “responds with UL allocation and timing advance.” TS36.300, 45-46.

185. Like Tenny, Qualcomm, and TS36.331, **TS36.300** is analogous to and in the same field as the ’545 patent, which includes signaling schemes to support uplink transmission in LTE systems (e.g., random access procedure), and are reasonably pertinent to the alleged problems identified in the ’545 patent—*e.g.*, providing a scheme for effective synchronization in wireless communication. *See, e.g.*, ’545, 1:38-43; TS36.300, §10.1.2.1 (“10.1.2.1 Handover . . . Part of the HO command comes from the target eNB and is transparently forwarded to the UE by the source eNB . . . UE accesses the target cell via RACH following a contention-free procedure using a dedicated RACH preamble or following a contention-based procedure if dedicated RACH preambles are not available.”).

186. A person of ordinary skill in the art would have been motivated to apply the “Random Access Procedure” specified in **TS36.300** in implementing **Tenny’s** and **Qualcomm’s** random access procedure as both **Tenny’s** and **Qualcomm’s**

systems were designed to operate in an “LTE-A” network, and **TS36.300** provides the LTE protocol for performing the Random Access Procedure. *See e.g.*, Tenny-Prov., AppxA(1:2-3) (“This document describes solutions to several issues that arise in relation to maintaining timing synchronisation for a UE in a multicarrier LTE-Advanced (LTE-A) system”); Qualcomm, 1 (“In this paper, we describe a design for multiple timing advances, and recommend adoption of this design in case multiple timing advances are adopted in LTE-A.”); TS36.300, 11 (“The present document provides an overview and overall description of the E-UTRAN radio interface protocol architecture” of LTE). As such, implementing **Tenny’s and Qualcomm’s** random access procedures according to **TS36.300’s** Random Access Procedure such that the UEs in **Tenny and Qualcomm** transmit a RAP and receive a RAR would advantageously enable **Tenny’s and Qualcomm’s** systems to interoperate with more LTE systems.

187. A person of ordinary skill in the art also would have had a reasonable expectation of success in using **TS36.300’s** teachings on its random access procedure in implementing **Tenny’s and Qualcomm’s** random access procedures because both **Tenny and Qualcomm** disclose systems that are explicitly designed to provide solutions to issues arising in a LTE-A system, and thus doing so would

have been straightforward and require minimal disruption to the existing LTE infrastructure.

188. A person of ordinary skill in the art would have understood that the specifications for transmitting a “RAP” and receiving a “TA value” in a RAR are set forth in 3GPP technical specifications, such as **TS36.300**. I understand that Pantech agrees. Indeed, in the LGE Litigation, I understand that Pantech has explicitly cited to “TS 36.300” to support a POSITA’s understanding of what “RAP” and “RAR” mean. *See* Ex. 1016 at ¶42 (Mr. Rysavy citing to sections of “TS 36.300” regarding “Random Access Preamble” and “Random Access Response” to support how a “person of ordinary skill in the art” would have understood the claimed “RAP” and “TA value” terms); Ex. 1018 at 3-4 (Pantech citing to “TS 36.300” to support definition of “transmitting a [RAP]”); Ex. 1022 (Rysavy Tr.) at 46:6-47:9 (agreeing that he cited to “3GPP TS36.300 Section 10.1.5 and also 3GPP TS36.321 Section 6.1.5 and 6.2.3” to “support [his] opinion [that] a person of ordinary skill would understand the meaning of specific claim terms use of RAP or random access preamble and TA value”).

D. Grounds 5-8: Grounds 1-4 in further view of Fan (Claim 3)

189. **Claim 3 in elements [3.a]-[3.d] requires a “transceiver” and “controller.”** As I discuss in Sections IX.A.3, IX.B.3 ([3.a]-[3.d]), **Tenny discloses**

(Ground 1) and Qualcomm in view of TS36.331 renders obvious (Ground 2) the claimed “transceiver” and “controller.” To the extent further disclosure is required for these elements, **Fan** provides explicit teachings of transceivers and controllers.

190. Like Tenny and Qualcomm, **Fan** discloses a “UE” that operates in an “LTE-A” network. *See* Sections IX.A.1, IX.B.1; **Fan** ¶¶38-39, 53, 99 (“The UE 10 may be a Rel-8 compatible UE, or a later than Rel-8 UE, such as a Rel-9 or an LTE-A compatible UE. In general, there will be some population of UEs 10 served by the eNB 12, and the population may be mixed between UEs operating as Rel-8, Rel-9 and LTE-A UEs, as non-limiting examples”). **Fan** discloses a “UE 10” comprising “a controller, such as a computer or a data processor (DP) 10A” and a “radio frequency (RF) transceiver 10D for bidirectional wireless communications with the eNB 12,” as annotated in the Figure 2a below. **Fan** ¶95, Fig. 2A. In particular, the “controller” is “configured to operate with a wireless receiver and wireless transmitter,” such as a transceiver. **Fan**, ¶¶141, 146; Figure 2 (highlighted below); *see also* §§IX.A.3-IX.B.3 (discussion of **Fan**’s disclosures of “transceiver” and “controller” in connection with [3.a]-[3.d]).

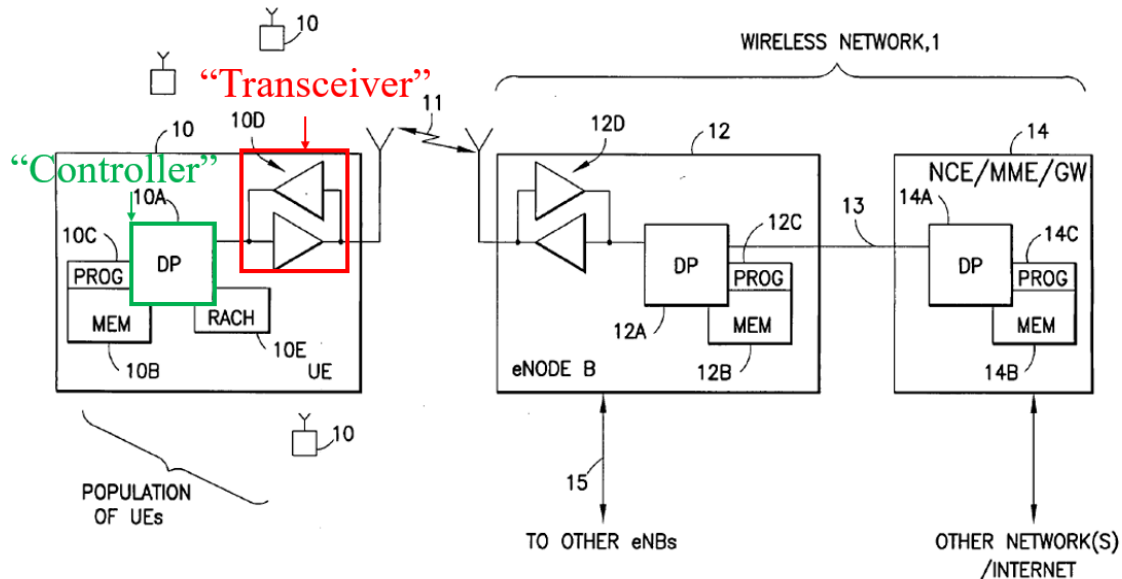


FIG.2A

191. **Fan** also discloses that the UE implements various LTE protocols set forth in 3GPP specifications, such as “TS 36.300,” and the procedures that are included in those specifications. *See e.g.*, Fan ¶¶38-39, 48-49, 53, 67, 85, 88, 98-99, 109, 113, 118, 122, 124, 131, 143. For example, **Fan** discloses a “Random Access (RA) procedure” occurring between the UE and an “eNB,” which involves “select[ing] a CC,” “transmit[ting] a preamble sequence on that CC” using a “Random Access Preamble,” and “receiv[ing] the Random Access response” including a “timing advance (TA) command.” *See, e.g.*, Fan ¶¶67, 85, 109, 113, 122, 143.

192. Like Tenny, Qualcomm, TS36.331, and TS36.300, **Fan** is analogous to and in the same field as the ’545 patent, which includes signaling schemes to support

uplink transmission in LTE systems (*e.g.*, random access procedure), and are reasonably pertinent to the alleged problems identified in the '545 patent—*e.g.*, providing a scheme for effective synchronization in a wireless communication. *See, e.g.*, '545, 1:38-43; Fan, ¶48 (“In the present LTE system preamble responses are sent utilizing both the PDCCH and the PDSCH. Each RACH resource (time and frequency resource reserved for preamble transmission) is associated with a RA-RNTI (random access radio network temporary identity). When the base station (eNB) observes a preamble, it transmits the preamble response on the PDSCH on a resource that is indicated by a PDCCH addressed with the RA-RNTI. More specifically, when a Random Access Response message is transmitted, the CRC word of the corresponding PDCCH is masked by RA-RNTI.”), ¶67 (“In yet another aspect thereof the exemplary embodiments of this invention provide an apparatus that comprises a controller configured to operate with a wireless receiver and a wireless transmitter, where the controller is further configured to transmit to a network access node in a time and frequency resource allocated for preamble transmission, of one of a plurality of component carriers, a random access request, and to receive a random access response that is aggregated with other random access responses in a time and frequency resource of the same or a different component carrier.”).

193. A person of ordinary skill in the art would have been motivated to apply **Fan's** teachings of a UE including a “transceiver” and “controller,” which the UE uses to perform random access functionalities in a LTE network, in implementing **Tenny's** and **Qualcomm's** UEs to advantageously enable both UEs to perform a “random access” procedure to maintain UL synchronization in an LTE network. *See* Sections IX.A.1, IX.B.1; Fan, ¶67 (“In yet another aspect thereof the exemplary embodiments of this invention provide an apparatus that comprises a controller configured to operate with a wireless receiver and a wireless transmitter, where the controller is further configured to transmit to a network access node in a time and frequency resource allocated for preamble transmission, of one of a plurality of component carriers, a random access request, and to receive a random access response that is aggregated with other random access responses in a time and frequency resource of the same or a different component carrier.”), ¶95, ¶141 (“The exemplary embodiments of this invention also pertain to an apparatus that comprises a controller configured to operate with a wireless receiver and a wireless transmitter, where the controller is further configured respond to a reception in different time and frequency resources allocated for preamble transmission, and in different ones of a plurality of component carriers, a plurality of random access requests from individual ones of a plurality of user equipments and to transmit a corresponding

plurality of random access responses in a time and frequency resource of a single component carrier.”), ¶146 (“The exemplary embodiments of this invention also pertain to an apparatus that comprises a controller configured to operate with a wireless receiver and a wireless transmitter, where the controller is further configured to transmit to a network access node, in a time and frequency resource reserved for preamble transmission, of one of a plurality of component carriers, a random access request, and to receive a random access response that is aggregated with other random access responses in a time and frequency resource of the same or a different component carrier.”), Fig. 2A; *see also* §§IX.A.3-IX.B.3 (discussion of **Fan’s** disclosures of “transceiver” and “controller” in connection with [3.a]-[3.d]).

194. A person of ordinary skill in the art would also have had a reasonable expectation of success using **Fan’s** transceiver and controller in implementing **Tenny’s** teachings (**optionally in view of TS36.300**) and **Qualcomm’s** teachings (**in view of TS36.331 and optionally in view of TS36.300**) on elements [3.a]-[3.d] because transceivers and controllers were standard components routinely used by mobile devices to transmit, receive, and process information at the time of the alleged invention, and thus it would have been straightforward to implement transceivers and controllers in **Tenny’s** and **Qualcomm’s** UEs.

X. SECONDARY CONSIDERATIONS

195. I have seen no evidence in the '545 patent's prosecution history or elsewhere supporting any secondary considerations arguments, or evidence of nexus to any of the Challenged Claims. *See generally* '545 FH. Indeed, per my discussion of the prior art referenced herein, any purported solutions to problems or unexpected results in the '545 patent were already well known. To the extent Pantech asserts the existence of any secondary considerations in its responses, I reserve my right to address any such evidence.

XI. CONCLUSION

196. In summary, I have concluded that the Challenged Claims are anticipated and/or rendered obvious over the prior art references as discussed above. Specifically, in my opinion, for at least the reasons above, the Challenged Claims of the '545 patent are disclosed and rendered obvious as follows.

Ground	Claims	Anticipation or Obviousness	Prior Art References
1	2,3	Anticipated and Obvious	Tenny
2	2,3	Obvious	Qualcomm in view of TS36.331
3-4	2,3	Obvious	Grounds 1-2 in further view of TS36.300
5-8	3	Obvious	Grounds 1-4 in further view of Fan

197. To the extent it is argued that any further disclosure is required for an element in the Challenged Claims that I have identified as being disclosed, a person of ordinary skill in the art would certainly have found that element obvious to include based on the sample explicit disclosure or inherent disclosures and analysis I have identified above.

198. I reserve the right to supplement my opinions in the future to respond to any arguments that Patent Owner or its expert(s) may raise and to take into account new information as it becomes available to me.

199. In signing this declaration, I recognize that the declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I also recognize that I may be subject to cross-examination in the case and that cross-examination will take place within the United States. If cross-examination is required of me, I will appear for cross-examination within the United States during the time allotted for cross-examination.

200. I reserve the right to supplement my opinions in the future to respond to any arguments that Patent Owner or its expert(s) may raise and to take into account new information as it becomes available to me.

201. In signing this declaration, I recognize that the declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the

United States Patent and Trademark Office. I also recognize that I may be subject to cross-examination in the case and that cross-examination will take place within the United States. If cross-examination is required of me, I will appear for cross-examination within the United States during the time allotted for cross-examination.

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

Executed this 10th day of August 2023, in Madison, WI.

Respectfully submitted,

A handwritten signature in black ink, appearing to read 'Daniel van der Weide', written over a horizontal line.

Daniel van der Weide, Ph.D.

APPENDIX A

DANIEL W. VAN DER WEIDE

Department of Electrical & Computer Engineering University of Wisconsin-Madison
1415 Engineering Drive
Madison, WI 53706

Phone: (608) 265-6561

danvdw@engr.wisc.edu <http://vdw.ece.wisc.edu>

<https://scholar.google.com/citations?user=Cy2A2foAAAAJ&hl=en&oi=sra>

ACADEMIC EXPERIENCE

- | | | |
|--|--|--|
| • PROFESSOR
ELECTRICAL AND COMPUTER
ENGINEERING (COURTESY
APPOINTMENTS IN
RADIOLOGY, BIOMEDICAL
ENGINEERING AND
MATERIALS SCIENCE) | MICROFABRICATED HIGH-FREQUENCY
ELECTROMAGNETIC SENSORS; localized broadband
spectroscopy and microscopy, low-dimensional
devices and circuits using multifunctional scanning
probes; THz spectroscopy with nonlinear
transmission lines; instruments for wireless
communications. Contactless sensors. | May 2004–
Present
(Associate
September 1999–
May 2004) |
| UNIVERSITY OF WISCONSIN-
MADISON | | |
| • ASSOCIATE PROFESSOR
ELECTRICAL AND COMPUTER
ENGINEERING | | May 1998–
August 1999
(Assistant
September 1995–
May 1998) |
| UNIVERSITY OF DELAWARE | | |
| • POST-DOCTORAL
RESEARCHER
ABTEILUNG VON KLITZING | CONTACTLESS HIGH-FREQUENCY
SPECTROSCOPY OF LOW-DIMENSIONAL
ELECTRON SYSTEMS; achieved current record
(480 fs, 3.5 V) nonlinear transmission lines | August 1993–
August 1995 |
| MAX-PLANCK-INSTITUT FÜR
FESTKÖRPERFORSCHUNG | | |
| • DOCTOR OF PHILOSOPHY
MASTER OF SCIENCE
ELECTRICAL ENGINEERING | Dissertation: “All-electronic Generation and
Detection of Terahertz Radiation with
Subpicosecond Pulses.” Attained the first sub-ps
and record 880 fs electrical pulses with GaAs
nonlinear transmission lines; used these pulses for
free-space signal generation and detection from
6 GHz–3 THz | September 1988–
December 1992 |
| STANFORD UNIVERSITY | | |
| | Advisor: D. M. Bloom | |
| • BACHELOR OF SCIENCE
ELECTRICAL ENGINEERING
MINOR IN LATIN | Collegiate Scholar Award, 1987
Dean’s Scholarship, 1982–86
University Scholarship, 1981–86
Member, Tau Beta Pi, Eta Kappa Nu
President, IEEE Student Chapter, 1986 | August 1981–
May 1987 |
| UNIVERSITY OF IOWA | | |

RECOGNITION

- FELLOW, IEEE, SENIOR MEMBER OPTICA (OSA), MEMBER APS, MRS

• VILAS ASSOCIATE	UNIVERSITY OF WISCONSIN	\$86,400	2002-04
• ALEXANDER VON HUMBOLDT FELLOWSHIP	“Localized microwave excitation of low-dimensional electronic devices” (J.P. Kotthaus, Munich)		1999–2000 (postponed)
• PECASE AWARD NATIONAL SCIENCE FOUNDATION	“Pioneering research on nanoscale-dimension electronic circuits and development of a web-based virtual laboratory that provides student access to advanced scientific instrumentation”	\$510,000 (incorporates NSF CAREER Award; one of two engineers in NSF ECS Division selected)	June 1998– May 2003
• YOUNG INVESTIGATOR PROGRAM AWARD OFFICE OF NAVAL RESEARCH	“Coherent signal generation with integrated circuits for wideband 100 GHz network measurements”	\$327,394	May 1998– June 2002
• INNOVATION/TECHNICAL ACHIEVEMENT AWARD DARPA ULTRA PROGRAM	“Significant Technical Achievement by an Individual Performer”	(one of two individual awardees)	October 1997
• UNIVERSITY RESEARCH AWARD FORD MOTOR COMPANY	“All-Electronic Terahertz Spectroscopy for On-Board Exhaust-Gas Monitoring”	\$150,000 (award rate < 4%)	April 1996– March 1999
• ANNUAL MEETING INVITED WORKSHOP SPEAKER OPTICAL SOCIETY OF AMERICA	“Presenting Scientific Information on the World-Wide Web”	\$2,000	October 1996

INSTITUTIONAL RECOGNITION

• DEAN’S MERIT INCREASE + PROVOST’S SPECIAL MERIT INCREASE UNIVERSITY OF DELAWARE	“Extraordinarily high level of performance as an engineering faculty member”		June 1996, June 1997, June 1998
• FELLOW NATIONAL SCIENCE FOUNDATION	Institute for Transforming Undergraduate Education, University of Delaware		May 1997– April 1998
• FELLOW UNIVERSITY OF DELAWARE	Center for Teaching Effectiveness		May 1996– April 1997

OUTSTANDING EDITORIAL ACHIEVEMENT AWARDS	“A YIG-Tuned Nonlinear Transmission Line Multiplier” and two other papers	March 1992– February 1993
WATKINS-JOHNSON COMPANY		

CURRENT AND RECENT SPONSORED RESEARCH

SOLE PRINCIPAL INVESTIGATOR UNLESS OTHERWISE NOTED

RESEARCH GRANT	SBIR: Treatment of Onychomycosis Utilizing Targeted, Controlled High-Frequency Energy (Scientific PI)	\$233,750	February 2021– January 2023 Phase II extension proposal January 2023– December 2025
RESEARCH GRANT	Self-winding Helices as Slow-wave Structures for mm and sub-mm Traveling Wave Tubes (co-PI with Francesca Cavallo (UNM) and Max Lagally (UW))	\$856,319 \$1,700,000	April 2019– March 2022 Phase II extension proposal August 2022– July 2025
RESEARCH GRANT	WiMi: A Reconfigurable Platform for Millimeter-Wave Wireless Networking and Sensing (Xinyu Zhang, Parameswaran Ramanathan and Daniel van der Weide)	\$899,279	October 2015– June 2019
RESEARCH GRANT	STTR Phase I: Near-field fiber laser comb spectroscopy (NFLCS) (with Polaronyx)	\$100,000	October 2009– June 2010
RESEARCH GRANT	Complex modulation and coherent detection for enhanced near-field far-infrared spectroscopy	\$285,000	May 2008– August 2010
RESEARCH GRANT	Comb spectrometer development	\$206,325	March 2007– November 2008
RESEARCH GRANT	RFID Partnership for Innovation in Wisconsin’s Packaging and Printing Industry Cluster (Raj Veermani, PI and Marc Anderson, co-PI)	\$600,000	January 2008– December 2009
RESEARCH GRANT	SCANNING PROBE MICROSCOPY FOR NEAR-FIELD MICROWAVE ANALYSIS	\$40,000	June 2006– May 2007
AGILENT TECHNOLOGIES INC.			

• RESEARCH GRANT NIH R01	MICROWAVE TUMOR ABLATION (F.T. Lee, Jr., PI)	\$1,087,500	May 2006– April 2010
• RESEARCH GRANT NIH R01	ULTRAWIDEBAND MICROWAVE DETECTION OF BREAST CANCER (Susan Hagness, PI, Barry Van Veen, co- PI)		April 2005– March 2010
• EQUIPMENT GRANT ONR DURIP	METAL-ORGANIC CHEMICAL VAPOR DEPOSITION (MOCVD)CRYSTAL-GROWTH SYSTEM (with Dan Botez)	\$198,450	May 2005– April 2006
• AIR FORCE OFFICE OF SCIENTIFIC RESEARCH	“Microfabricated Traveling Wave Tubes for High Power Millimeter- Wave and THz-regime Radiation Sources” (PI: J.H. Booske Co-PIs: H. Jiang, D. van der Weide)	\$149,970	March 2005– February 2006
• RESEARCH GRANT NIH STTR	Noncontact membrane protein probe (with Prairie Technologies)	\$600,000	May 2005– April 2008
• RESEARCH GRANT AFOSR	MURI: “Nanoprobe Tools for Molecular Spectroscopy and Control” (PI with co-PI’s Robert Blick (UW) and Dennis Prather, University of Delaware)	\$5,661,700	August 2003– July 2008
• RESEARCH GRANT ARO Breast Cancer Imaging Research Program (BCIRP)	“Compact low-cost microwave reflectometer for breast cancer detection” (PI with co-PI’s Susan Hagness and Barry Van Veen)	\$478,959	February 2004– January 2007
• RESEARCH GRANT NIH R-21	“Microcatheter microwave ablation for cancer treatment” with Fred Lee, Jr. MD	\$436,500	May 2004– April 2006
• RESEARCH GRANT DARPA	“Single-Receptor Interfaces for Real-Time Kinetics” (PI with co- PI Robert Blick)	\$650,000	July 2003– December 2004
• RESEARCH GRANT AFOSR	DURIP: “Device Measurement and Modeling System for Electronic Terahertz Sensing”	\$290,000	May 2003– December 2003
• RESEARCH GIFT AGILENT TECHNOLOGIES	“Near field microwave probing”	\$20,000	January 2003
• RESEARCH GRANT NSF NIRT	“Nanotubes and nanowires as biological sensors and actuators,” with R. Hamers (PI) and L. Smith	\$1,748,936	July 2002–June 2006
• RESEARCH GRANT ARO	“Space-time microwave imaging for early-stage breast cancer detection” with S. Hagness (PI) and B. Van Veen	\$424,701	March 2002– March 2005
• RESEARCH GRANT	“Biomolecular interaction sensing with sub-terahertz fields”	\$533,227	May 2002–

ARO			April 2005
• RESEARCH GRANT AFOSR	“Electronic terahertz spectroscopic imaging of explosives and weapons”	\$497,102	July 2002–June 2005
• RESEARCH GRANT AFOSR/DARPA	“Broadband High-Gain Antennas for Terahertz Systems”	\$99,000	July 2003–June 2004
• RESEARCH GRANT DARPA	“MOSAIC: Atomic resolution magnetic resonance force microscope imaging using very high frequency cantilevers,” with M. Roukes, Caltech (PI), et al.	\$348,414 (UW share)	May 2002–April 2004
• RESEARCH GRANT NIH R-21	“Space-time microwave imaging for breast cancer detection” with S. Hagness (PI) and B. Van Veen	\$145,500	June 2002–March 2003
• SUPPORT GRANT UNIVERSITY OF WISCONSIN	“Nanotechnology Cluster Conference” with M. Eriksson, C.-B. Eom, and R. Carpick	\$20,000	July 2002–June 2003
• RESEARCH GRANT NIH STTR	“Noncontact membrane protein probe” with Prairie Technologies, LLC	\$244,000 \$1,200,000	Phase I May 2002–April 2004 Phase II April 2005–March 2009
• RESEARCH GRANT DARPA/NRO	“Wideband optical arbitrary waveforms using Fourier and wavelet composition”	\$982,815	December 2001–November 2004
• RESEARCH GRANT NSF NIRT	“Complex epitaxial magnetic oxide heterostructures for nanoscale spin devices,” with C.-B. Eom (PI), et al.	\$1,550,000	July 2002–June 2006
• RESEARCH GRANT ARO	“Solid state quantum computing using nanostructured logic gates,” PI with Mark Eriksson, Bob Joynt and Max Lagally	\$1,199,000	May 2001–April 2005
• RESEARCH GRANT ANALEX CORP.	“Computational tools for optimized design of advanced traveling wave tubes,” with John Booske (PI)	\$130,000	January 2001–December 2002
• RESEARCH GRANT DARPA	“Sonic MEMS,” with Amit Lal (PI), et al.	\$1,700,000	September 2000–August 2003
• RESEARCH GRANT ONR MURI	“Stochastic chemical sensing with engineered channel proteins” with Hagan Bayley: Texas A&M; Daniel Kahne: Princeton; Reza Ghadiri: Scripps; Leslie Loew:	\$1,196,515 \$6,543,734 total	May 1999–October 2004

• RESEARCH GRANT AFOSR STTR	University of Connecticut “Terahertz traveling wave tubes: a breakthrough innovation in coherent radiation sources,” with John Booske (PI)	\$600,000	March 2001– February 2002
• RESEARCH GRANT ONR	“Nanoscience of microwave-based integrated biological sensors,” with Bob Hamers (PI) and Lloyd Smith	\$800,000	May 2001– December 2001
• RESEARCH GRANT NSF SGER	“Measurement based channel modeling for coherent terahertz communications” with B. Van Veen (PI) and A. Sayeed	\$60,000	August 2001– July 2002
• SMALL GRANT FOR EXPLORATORY RESEARCH NSF	“Scanning near-field microscopy for non-contact imaging of ion channel dynamics in the DC–THz regime,” co-PI: Prof. Phillip Haydon, Iowa State University	\$45,000	July 1998– June 1999
• RESEARCH GRANT DARPA INFORMATION TECHNOLOGY OFFICE ULTRASCALE COMPUTING	“Nanoscale field localization for manipulation and probing of computationally interesting biomolecules”	\$763,116	September 1998– August 2003
• RESEARCH GRANT FEDERAL AVIATION ADMINISTRATION	“Terahertz spectroscopic reflection imaging to detect explosives and weapons on personnel”	\$80,000 (pilot study) \$605,218 (follow-on)	March 1997– January 2001
• “THE CENTER FOR NANOMACHINED SURFACES,” A DELAWARE ADVANCED TECHNOLOGY CENTER STATE OF DELAWARE	CENTER DIRECTOR, with Rodel, Dupont Photomask, CFM Technologies, and Delaware Diamond Knives as industrial partners; Mark Barteau (Chem E) and Mary Wirth (Chemistry)	\$6,753,897 (State portion is \$2.88MM; balance from industry)	August 1997– August 1999
• RESEARCH GRANT UNIVERSITY OF DELAWARE RESEARCH FOUNDATION	“Localized FIR spectroscopy with scanning probes”	\$30,000	June 1997– May 1998
• RESEARCH GRANT W. L. GORE & ASSOCIATES AND DEL. RESEARCH PARTNERSHIP	“High-frequency field scanning for smart shielding” and “Gigabit optoelectronic communications”	\$210,223	October 1996– September 1999
• USER’S GRANT NSF NNUN	“Multifunctional scanning probes”	\$5,000	August 1996– July 1997
• RESEARCH GRANT	“Microfabricating a nanoscilloscope”	\$499,717	July 1996– June 1999

DARPA ELECTRONICS
TECHNOLOGY OFFICE ULTRA
ELECTRONICS

- RESEARCH GRANT “Probing local device fields using AC scanning force microscopy” \$441,855 July 1996–June 1999
OFFICE OF NAVAL RESEARCH
- ENGINEERING RESEARCH “Reactive ion etcher and annealer” Co-PI with P. Berger, J. Olowolafe, and J. Kolodzey \$100,000 August 1996–July 1997
EQUIPMENT GRANT
NATIONAL SCIENCE FOUNDATION

RESEARCH SUPERVISION

POST-DOCTORAL AND AFFILIATED RESEARCHERS

Matt Dwyer	Electronic THz systems	January 2016– January 2020
Marcos Martinez	Advanced Sensing with Chipless RFID	January 2016– August 2021
Chiya Saeidi	Field simulations for contactless measurements	January 2015– May 2018
Alexander Kozyrev	Nonlinear transmission lines for high power generation	January 2003– May 2015
John Grade	OptoMEMS and contactless sensors/applicators	February 2004– Present
Charles Paulson	Scanning near-field microscopy of biomolecules and cells	January 2003– February 2006
Yaqiang Wang	Microfabricated near-field electromagnetic antennas	September 2003– January 2006
Il-Seok (Sunny) Son	BioMEMS	October 2003– August 2004
George Kumar (Joint with Robert Blick)	Single-molecule biophysics	July 2003–August 2004
Kelvin Fu	Microfabricated circuits and mechanical structures for integrated optics	June 2003– December 2004
Bjoern Rosner	Near-field probes, scanning spin microscopy	June 2002– December 2002
Bhagwati Prasad	Electromagnetic spectroscopy of biomolecules and cells	March 2000– February 2001
Moises Cywiak	Interferometric near-field measurement of quartz surface properties	September 1998– September 1999
Janusz Murakowski	Detection of gas species using THz spectroscopy	May 1998– September 1999
Pavel Neuzil	Microfabrication of multifunctional scanning probes	April 1996– September 1999
Vivek Agrawal	Localized and far-field microwave spectroscopy	June 1996– December 1999

GRADUATE (CURRENT)

Name	Degree	Topic	Expected Grad. Date
Yu Huang	Ph.D.	High-frequency field measurement	2025
Tingyou Guo	Ph.D.	Helices in	2025
Yuchen Gu	Ph.D.	Using high frequencies in medical imaging	2023
Atul Bhadkhamkar	Ph.D.	Optical sources for broadband spectroscopy	2023

GRADUATE (PAST)

Matt Fayyad	M.S.	Transduction of biological signals with microwaves	2022
M.R. Naeini	Ph.D.	3D Printed Highly Integrated Microwave Components for Arrays and Sensing	2021
Aaron Day	M.S.	Timing stabilization for coherent measurements	2019
Matt Dwyer	Ph.D.	Electronic THz systems in wide bandgap semiconductors	2017
Marcos Martinez	Ph.D.	Advanced Sensing with Chipless RFID	2016
Pushkar Kulkarni	Ph.D.	RF sensing circuits for medical diagnostics	2016
Madhav Venkateswaran	Ph.D.	MRI coils and RF-powered medical diagnostics	2016
Babita Yadav	M.S.	Design of Active Filter using Substrate Integrated Waveguide	2016
Vincent Chen	Ph.D.	RFID antennas	2012
Chiya Saeidi	Ph.D.	Engineering plasmonic metasurfaces to manipulate optical waves	2015
Paul Laeseke (joint with Fred Lee, Radiology)	M.D./ Ph.D.	Interstitial tumor ablation with microwaves	2009
Min Zhao (joint with Susan Hagness)	Ph.D.	Receivers for breast cancer detection	2009
Hai Huang	M.S.	Broadband antennas and interfaces	2009
Anuj Dron (joint with Susan Hagness)	M.S.	Broadband antennas for biospectroscopy	2006
Chao Qin	Ph.D.	Meta-material nearfield antennas	2007
Sung-Jin Ho	Ph.D.	Ultra-high-speed transistors	2006
Abdi Karbassi	Ph.D.	Near field probing techniques	2006
Min-Ki Choi	Ph.D.	Terahertz spectroscopy	2006
Hongjoon Kim	Ph.D.	Left-handed nonlinear transmission lines	2006
Modhurin Banerjee (joint with Tom Grist, Radiology)	M.S.	Medical imaging with microfabricated magnetic mixers	2007
Jake Shea (joint with Susan Hagness)	M.S.	Antennas for cancer detection	2007
Chih-Chuan Yen	M.S.	RFID antennas	2006
Kae-Oh Sun	Ph.D.	Compact microwave filters and wave control circuits	2006

Chris Brace (joint with Fred T. Lee, Jr, Radiology)	Ph.D.	Ablation of tumors with localized microwaves	2005
Kimberly Taylor, Biophysics	Ph.D.	Protein spectroscopy with microwaves	2005
Jim Truitt (joint with Mark Eriksson, Physics)	Ph.D.	Localized ESR, nanoscale quantum gates and quantum computation	2004
John Peck (joint with Robert Hamers, Chemistry)	Ph.D.	Biomolecule spectroscopy and near-zone antennas	2003
Douglas Lagally	M.S.	Near-field magnetic antennas	2005
Luke Palmer (joint with Susan Hagness, ECE)	M.S.	Antennas for breast cancer detection	2004
Rashmi Pathak (joint with Peter Timbie, Physics)	M.S.	Arrays of antenna-coupled microbolometers	2005
Jill Pamperin	M.S.	Metamaterial antennas	2005
Guoqing Ning (joint with Robert Blick, and Rob Carpick)	M.S.	BioMEMS and near-field scanning probes	2005
Greg Meyer		Project assistant for integration of research and teaching	2003-04
Daniel Imaizumi		Electrophysiology/microscopy of nerve cells	2001-02
Hui Liu	M.S.	Electromagnetic spectroscopy of biomolecules and cells	2001
XiaoQing Wang		Integrated terahertz electronic circuits	1998-99
Prayoot Akkaraekthalin	Ph.D.	Integrated frequency translation for low-cost, high-performance network analysis	1998
Jon Bergey	M.S.	Scanning field measurements and instrumentation	1999
Toralf Bork	M.S.	Measurement system for electromagnetic near-zone fields (thesis completed with Technical Univ. of Chemnitz-Zwickau)	1999
Tom Clupper	M.S.	Nonlinear device measurements and modeling	1999
Rob March	M.S.	Web-based remote-access instrumentation and high-frequency CMOS device and circuit models	1999
Alexander Ukhanov		Scale-model broadband antenna measurements	1996-97

TEACHING EXPERIENCE

ECE 230, CIRCUIT ANALYSIS, University of Wisconsin-Madison. Fall 2018, 2021 Spring 2019, 2020, Fall 2021, Spring 2022, Fall 2023. Core undergraduate circuit analysis course, based on Alexander & Sadiku and flipped-classroom approach.

ECE 270, 271, CIRCUIT LABORATORY, University of Wisconsin-Madison. Fall 2020, Spring 2021. Core undergraduate circuit laboratory courses taught using online methods.

ECE 340, ELECTRONIC CIRCUITS I, University of Wisconsin-Madison. Fall 2011, 2014, 2016-20. Core undergraduate transistor circuits course, based on Sedra & Smith and interactive quizzing.

ECE 342, ELECTRONIC CIRCUITS II, University of Wisconsin-Madison. Spring 2014. Follow-on advanced circuits course with emphasis on R.D. Middlebrook's analysis techniques and Sedra & Smith.

ECE 447, APPLIED COMMUNICATIONS SYSTEMS, University of Wisconsin-Madison. Spring 2000, Fall 2000, 2001, 2002, 2008-19, 2021, 2023 (supervised teaching by M. Martinez Fall 2018, 2020). Developed and taught advanced time- and frequency-domain analysis and design graduate level course. This course draws on electromagnetic theory for transmission lines, device physics for linear and nonlinear circuit models, time- and frequency-domain measurements, and CAD software. Final project is an ADS simulation.

ECE 547, ADVANCED COMMUNICATIONS CIRCUIT DESIGN, University of Wisconsin-Madison. Spring 2001, 2003, 2005, 2007, 2009-22 Developed and taught advanced communications circuits course, with emphasis on PLL's, transceiver architecture, IC concepts, PCM, and components; introduced laboratory and component projects for 2.4 GHz transceiver system.

ECE 420, ELECTROMAGNETIC WAVE TRANSMISSION. Fall 2008-09; SPRING 2012-13, (supervised teaching by M. Martinez Fall 2018).

ECE 601, BUSINESS FOR ENGINEERS, University of Wisconsin-Madison. Fall 2002-05. Developed and taught popular business course for primarily seniors in all engineering departments. Course features significant business planning, accounting and case analysis.

ECE 545, ADVANCED COMMUNICATIONS ENGINEERING LABORATORY, University of Wisconsin-Madison. Spring 2002, 2006, 2010, 2014, 2021. Developed and taught laboratory course on microwave and communications circuits measurements. Covered slotted-line measurements, scalar and vector network analyzers, time-domain reflectometers, transistor amplifier design and construction, mixers, couplers, filters and computer-aided design.

SELECTED FOR NSF NEW CENTURY SCHOLARS WORKSHOP, Stanford University. Summer 1998.

ELEG467/667, HIGH-SPEED/MICROWAVE INTEGRATED CIRCUITS, University of Delaware. Spring 1995–99. Developed and taught advanced time- and frequency-domain analysis and design graduate level course. This course draws on electromagnetic theory for transmission lines, device physics for linear and nonlinear circuit models, time- and frequency-domain measurements, and CAD software (e.g., HSPICE, Libra, and Sonnet Software's *em*) for a comprehensive introduction to time- and frequency-domain IC concepts in the picosecond/GHz realm. The course features an industrially relevant final project.

ELEG661, MATERIALS & DEVICES SEMINAR, University of Delaware. Spring 1996–97. Graduate seminar with invited speakers.

SCANNING PROBE MICROSCOPY FOR MATERIALS CHARACTERIZATION, University of Delaware. Spring 1996–97. Highly ranked Engineering Outreach short course with industrial and academic participants.

ELEG312, ADVANCED ELECTRONIC CIRCUITS, University of Delaware. Autumn 1995–98. Junior-level core circuits course covering Sedra & Smith Chapters 5–8 (FETs through feedback). *Nominated by students for a University Teaching Award for 1996–97 and 1997–98 semesters.*

EE139, DESIGN PROJECT, Assistant to Professor David M. Bloom, Stanford University. Spring 1991–92. Discussed and assisted with electronic projects for seniors in EE.

EE392L, BUSINESS MANAGEMENT FOR ELECTRICAL ENGINEERS, Assistant to Consulting Professor Robert Maxfield, Stanford University. Spring 1990–91. Managed all grading, held discussions and lectured on entrepreneurship for 60 students.

IE273, ENTREPRENEURSHIP IN HIGH TECHNOLOGY, Assistant to Lecturer Charles Banfe, Stanford University. Autumn 1990–91. Selected students, managed all grading, held discussions and lectured on entrepreneurship for 60 students; awarded a departmental certificate of recognition for this work.

EE246, MICROWAVE CIRCUIT DESIGN, Assistant to Professor Bertram A. Auld, Stanford University. Winter 1989–90. Managed all grading, held discussions and lectured on microstrip resonators and computer-aided design.

PROFESSIONAL ACTIVITIES AND SERVICE

- Work featured in US News & World Report
<http://www.vdwdesign.com/projects/THz/briefings/usnews-thz-aug2003.jpg> (scanned copy of article)
- Work featured in “Battling Bioterror” by Noah Shachtman
<http://www.techcentralstation.com/1051/defensewrapper.jsp?PID=1051-350&CID=1051-112202A>
- Work featured in Laser Focus World, April 2003 article on THz imaging
http://lfw.pennnet.com/Articles/Article_Display.cfm?Section=ARCHI&Subsection=Display&ARTICLE_ID=174912&KEYWORD=weide&p=12
- “Terahertz imaging: T-ray specs” *Nature* **424**, 721 - 722 (14 Aug 2003) News Feature
http://www.vdwdesign.com/projects/THz/briefings/Nature_THz_424721a_r.pdf
- Cover issue of Optical Society of America’s Optics and Photonics News, April 2003
http://www.vdwdesign.com/projects/THz/briefings/opn_thz_2003.pdf
- Organized and lead a FIAP focus session on “Biosensors & physics for high-throughput drug screening” at the APS March Meeting, 2003
- NSF annual site review team for Cornell Nanobiotechnology Center, September 2002
- NSF Panel Review, June 2002
- Coordinating Bionanofab Facility proposal
- Authored (with D. Beebe) “Keck Center for Engineered Cellular Scale Exploration” proposal
- Ph.D. thesis review for Singapore
- Mid-term review for faculty member at Rice University
- Advised MEPP program student Nicholas Thompson (2002)
- Advisor to cluster hire in Chemical Genomics
- Member of the SURE/REU research projects team
- Army Research Office proposal review, “Biological sensing with terahertz circular dichroism spectroscopy”
- Organized and Chaired Invited Special Topic Session, “THz Contrast Mechanisms in Chemical and Biological Systems,” at 9th International Conference on Terahertz Electronics, Charlottesville VA, Oct 15-16, 2001.
- Co-organized UW-Madison/Promega Symposium on Biological Imaging: Solving Biological Problems with Imaging Technology, May 25, 2001
- Co-organized UW-Madison Interdisciplinary Workshop: Emerging Techniques in Screening and Imaging Science, October 19, 2000; organizing follow-on conference on high-throughput screening for DNA, proteins and therapeutic discovery for Fall 2001
- NSF PFET Review Panel, June 1997, March 1998

- Head, NSF SBIR Phase I Review Panel, October 1995
- NSF mail reviews, December 1995–Present
- Swiss NSF mail reviews, May 1997–Present
- Ireland NSF mail reviews, 2001
- Journal Reviewer, *IEEE Nano*, *Optics Comm.*, *Macromolecules*, *Appl. Phys. Lett.*, *Proc. IEEE*, *IEEE Trans. Microwave Theory Tech.*, *IEEE Electron Dev. Lett.*, *Rev. Sci. Instrum.*
- Textbook Reviewer, *Microelectronic Circuits*, Sedra & Smith, 4th Ed., 1996; *Microwave and RF Design of Wireless Systems*, Pozar, 2001
- Member, OSA Emerging Technology Committee, 1997–2010

UNIVERSITY ACTIVITIES AND SERVICE

- Faculty Senate, 2016-present
- University Conflict of Interest Committee, 2007-15
- Representing the College of Engineering on the Faculty Advisory Council for the Kauffman/VIEW (“Values in Entrepreneurship at Wisconsin”) Campus Initiative; presented at a site visit “Discussions of Wisconsin cross-campus and entrepreneurial activities” (October 7, 2003, School of Business)
- 2003 “Conversations in Science” series, hosted by Prof. Bassam Shakashiri (October 2, 2003, Edgewood High School, Madison)
- Visited a University of Wisconsin preschool class and demonstrated separation of mixed dyes using an agar gel matrix to demonstrate a visible aspect of nanotechnology (May 2003)
- Co-chair and organizer of “NanoExpo ’03,” a one-and-a-half-day symposium emphasizing the emerging role of nanotechnology in our lives during the next 10 years. The conference was held May 30 and 31, 2003, in Madison. Conference website <http://nano.engr.wisc.edu> and report <http://www.engr.wisc.edu/news/headlines/2003/Jun02.html>
- Helped produce a 6-minute video short on nanotechnology at Wisconsin (May 2003)
- Hosted and co-organized a Materials Science Program Open House. This event brought together faculty of materials science and physics from regional four-year schools to introduce them to the nanoscience work going on at the University of Wisconsin (May 2003)
- Invited affiliate of the Genome Center of Wisconsin (2003)
- Initiated the UW response to NSF renewal for National Nanofabrication User’s Network (NNUN)
- Co-organized and co-hosted “NanoExpo ’03,” a one-and-a-half-day symposium emphasizing the emerging role of nanotechnology in our lives during the next 10 years. The conference was held May 30 and 31, 2003, in Madison, Wisconsin. This conference, with local, regional, and national speakers, drew industry professionals interested in new opportunities and trends in nanotechnology, academic researchers who wished to learn about the latest nanotechnology applications, teachers at all levels who wished to exchange ideas for nano education and outreach programs, and members of the public curious about nanotechnology.
- Demonstrated wireless and optical communications to kindergarten class at Thoreau Elementary School, Madison WI for NSF 50th Anniversary Service Program, Jan 2001
- Graduate admissions committee, 2000–2016
- Curriculum committee, 2001–present

- MATHCOUNTS Day 1997: Organized and conducted demonstrations and tours of Electrical Engineering for 400 middle-school students, Jan 16, 1997
- MATHCOUNTS Day 1996: Organized and conducted demonstrations and tours of Electrical Engineering for 250 middle-school students, Jan 18, 1996
- Dupont Explorer Scouts Tour (with D. Vengroff): Organized and conducted laboratory demonstrations and tours of Electrical Engineering for 35 high-school students and parents/advisors, Feb 10, 1997

MULTIDISCIPLINARY ACTIVITIES IN TEACHING, RESEARCH AND SERVICE

- Appointments in Radiology, Biomedical Engineering and Materials Science
- Trainer (member) of UW Biophysics Degree Program, an interdisciplinary program offering the Ph.D. degree—advised Kimberly Taylor in this program.
- Two of the professionals in my laboratory (Steve Limbach and Alan Betterman) have degrees in biology
- Ongoing collaboration with Phil Haydon (Neuroscience, Tufts University) on local probing of protein activity in cells
- Initiated a collaboration with Homme Hellinga (Biochemistry, Duke University) on nanopore sequencing of nucleic acids
- Collaborations and student exchanges with Ed Chapman (Physiology), Gerard Marriott (Physiology), Matt Jones (Physiology), Fred Blattner (Genetics), Jo Handelsmann (Plant Pathology), Robert Goodman (Plant Pathology) [wrote two NIH proposals with the last three people]
- Collaboration with Bob Hamers and Lloyd Smith (Chemistry), joint proposals written and funded; John Peck (my graduate student) now funded in Chemistry; regular group meetings and joint publications
- Collaboration with Ron Raines (Biochemistry) in protein stretching with scanning force microscopes as well as studying transport of cationic peptides across lipid bilayers using electrophysiology

PROFESSIONAL EXPERIENCE

START-UPS

- Founder and Business Development, AntenneX, B.V. (millimeter-wave antenna measurements)
- Founder and Board Member, Elucet Medical, Inc. (wireless surgical navigation)
- Founder, Accure Medical, LLC (RF treatment for finger- and toenail infection)
- Founder, ThroughPuter, LLC (Platform-as-a-Service authentication)
- Founder, President, vdW Design, LLC (Incubator, SBIR awardee)
- Founder, Board Member, Advisor, Micrablate, LLC, now NeuWave Medical, Inc. (Microwave percutaneous ablation devices; acquired by Johnson & Johnson 2016)
- Founder, President, NFI, LLC (Near-field imaging for skin cancer)
- Founder, President, Tera-X, LLC (Ultrawideband antennas, imaging radar, SBIR awardee)
- Founder, VP of Engineering, Optametra, LLC (Coherent lightwave signal analyzers; acquired by Tektronix 2011)

MICROWAVE DEVICE RESEARCH AND DEVELOPMENT, Advanced Development Department, Watkins-Johnson Company, Palo Alto, California. June 1988–July 1993. Designed and built several broadband YIG-tuned microwave oscillators; published the lowest-reported phase noise for an oscillator

with a magnetostatic-wave resonator; developed and published division-wide computer-aided circuit design capabilities with Unix workstations, including nonlinear device and circuit modeling, and electromagnetic simulations; taught seminars on microwave oscillator theory, circuit simulation and MESFET analysis.

CELLULAR TELEPHONE ENGINEERING, International Cellular Subscriber Division, Motorola, Inc., Schaumburg, Illinois. August 1987–April 1988. Designed and developed a fixed-subscriber unit for remote cellular telephone installations; investigated field quality and cellular coverage in Hong Kong and Thailand; wrote a database application to track international cellular subscriber field failure types for feedback to design and production; worked with Division Management to implement Motorola’s “Six-Sigma” quality program for international cellular telephones.

INTERACTIVE SPEECH AND WRITING THERAPY, sola mente, Inc., Iowa City, Iowa. August 1985–August 1987. Started and ran a university-incubated company to design and build combined speech- and handwriting-recognition device for therapeutic and language-acquisition applications.

MICROWAVE RESONATOR RESEARCH AND DEVELOPMENT, Signal Analysis Division, Hewlett-Packard Company, Santa Rosa, California. May 1985–August 1985. Studied, measured, and reported on new magnetostatic-wave signal processing devices; improved resonator characterization by automating the HP8510A network analyzer. Taught a noontime course entitled “Latin at Lunch.”

DYE LASER CONTROL ENGINEERING, Laser Isotope Separation Division, Lawrence-Livermore National Laboratory, Livermore, California. May 1984–August 1984. Observed, documented, and improved dye laser temperature control system for precise uranium isotope enrichment.

AUTOMATIC TEST EQUIPMENT ENGINEERING, Production Automation, Division of EWA, Inc., Santa Clara, California. May 1983–December 1983. Assisted in design, construction, and testing of production ATE for Apple Computer, Western Electric, and Comdial. Made engineering drawings, specified components, and wrote spreadsheets to assist in bidding.

JOURNAL PUBLICATIONS

CURRENT

1. D. C. Gold, A. S. Bhadkamkar, S. Carpenter, L. T. Hogan, M. Dwyer, M. Beede, R. H. Goldsmith, D. van der Weide, and D. D. Yavuz, “High-power near-CW Raman lasing in mm-sized glass disks,” *Opt. Lett.* 47, 4171-4174 (2022)
2. Marcos Martínez Argudo, Shiva Hajitabarmarznaki, Divya J. Prakash, Matthew M. Dwyer, Max G. Lagally, Daniel W. van der Weide, and Francesca Cavallo, “Amplification of THz waves by beam-wave interaction in self-assembled helical slow-wave structures with single and double chirality”, *AIP Advances* 12, 085121 (2022)
3. Divya J. Prakash, Matthew M. Dwyer, Marcos Martínez Argudo, Mengistie L. Debasu, Hassan Dibaji, Max G. Lagally, Daniel W. van der Weide, and Francesca Cavallo, “Self-Winding Helices as Slow-Wave Structures for Sub-Millimeter Traveling-Wave Tubes,” *ACS Nano* 15 (1), 1229-1239 (2021)
4. A. M. Day, M. M. Dwyer and D. W. van der Weide, “Phase Perturbation as a Measurement Metric: A Novel Noncontact In-Line Production Measurement Through an All-Electronic Millimeter-Wave System Tracking Millidegree Perturbations in Phase,” *IEEE Microwave Magazine*, vol. 22, no. 1, pp. 79-85 (2021)
5. M. Ranjbar Naeini, M. Mirmozafari and D. van der Weide, “Monolithic 3-D-Printing of an Integrated Marchand Balun with a Dipole Antenna,” in *IEEE Transactions on Components, Packaging and Manufacturing Technology*. vol. 10, no. 4, pp. 654-658 (2020)

6. Mohammadreza Ranjbar Naeini and Daniel van der Weide, "Cascaded 3D-Printed X-band Components for Subsystems," *IEEE Microwave and Wireless Components Letters* 29 (5), 333 (2019)
7. C. Saeidi and D. van der Weide, "Nanoscale nonlinear circuit elements at optical frequencies," *IEEE Trans. Nanotech.*, 17 (3), 611 (2018)
8. Atul Bhadkamkar, Matthew Dwyer, and Daniel van der Weide, "Analysis of half-tapered fiber coupling for microresonators," *Opt. Express* 25, 32841-32852 (2017)
9. M. Martinez and D. van der Weide, "Compact single-layer depolarizing chipless RFID tag," *Microw. Opt. Technol. Lett.*, 58, 1897-1900 (2016)
10. P.B. Kulkarni and D. van der Weide, "Wideband circularly polarized SIW cavity-backed slot antenna with sequential rotation feeding," *Microw. Opt. Technol. Lett.*, 58: 2566-2570 (2016)
11. C. Saeidi and D. van der Weide, "A figure of merit for focusing metasurfaces," *Applied Physics Letters*, 106 (11), 113110 (2015)
12. C. Saeidi and D. van der Weide, "Wideband plasmonic focusing metasurfaces," *Applied Physics Letters*, 105 (5), 053107 (2014)
13. C. Saeidi and D. van der Weide, "Bandwidth-tunable optical filters with nanoparticle arrays," *Optics Express*, vol. 22, pp. 12499-12504 (2014)
14. C. Saeidi and D. van der Weide, "Nanoparticle array based optical frequency selective surfaces: theory and design: errata," *Optics Express*, vol. 21, pp. 24119-24119 (2013)
15. C. Saeidi and D. van der Weide, "Nanoparticle array based optical frequency selective surfaces: theory and design," *Optics Express* vol. 21, pp. 16170-16180 (2013)
16. C. Saeidi and D. van der Weide, "Synthesizing metasurfaces with nanodisks," *Applied Physics Letters* vol. 103, pp. 183101, Oct 2013.
17. C. Saeidi and D. van der Weide, "Periodic Substrate Structure Suppresses Spurious Response in Coupled Line Filters," *Microwave and Optical Technology Letters*, vol. 54, pp. 2175-2178, Sep 2012.
18. S. Ramachandran, D. W. van der Weide, and R. H. Blick, "Direct microwave transmission on single α -hemolysin pores," *Applied Physics Letters*, vol. 99, pp. 093105-093105-3, 2011.
19. H. Kim, S. Ramachandran, E. Stava, D. van der Weide, and R. Blick, "Radio-frequency response of single pores and artificial ion channels," *New Journal of Physics*, vol. 13, p. 093033, 2011.
20. H. Y. Chen, A. S. Bhadkamkar, T. H. Chou, and D. W. van der Weide, "Vector backscattered signals improve piggyback modulation for sensing with passive UHF RFID tags," *IEEE Transactions on Microwave Theory and Techniques*, vol. 59, pp. 3538-3545, 2011.
21. G. Qin, N. Jiang, J. H. Seo, N. Cho, G. E. Ponchak, D. van der Weide, P. Ma, S. Stetson, M. Racanelli, and Z. Ma, "Cryogenic operation of a 24 GHz MMIC SiGe HBT medium power amplifier," *Semiconductor Science and Technology*, vol. 25, p. 125002, 2010.
22. S. Zhang, D. van der Weide, and J. Oliver, "Superfast phase-shifting method for 3-D shape measurement," *Opt. Express*, vol. 18, pp. 9684-9689, 2010.
23. S. Ramachandran, R. H. Blick, and D. W. van der Weide, "Radio frequency rectification on membrane bound pores," *Nanotechnology*, vol. 21, p. 075201, 2010.
24. A. B. Kozyrev and D. W. van der Weide, "Pulse formation in nonlinear left-handed transmission line media," *Applied Physics Letters*, vol. 96, p. 104106, 2010.
25. S. Sengele, H. Jiang, J. H. Booske, C. L. Kory, D. W. van der Weide, and R. L. Ives, "Microfabrication and Characterization of a Selectively Metallized W-Band Meander-Line TWT Circuit," *IEEE Transactions on Electron Devices*, vol. 56, pp. 730-737, 2009.

26. A. M. Marconnet, M. M. He, S. Sengele, S.-J. Ho, H. Jiang, N. J. Ferrier, D. W. van der Weide, V. Madhavan, N. Nelson, and J. H. Booske, "Microfabricated Silicon High-Frequency Waveguide Couplers and Antennas," *IEEE Transactions on Electron Devices*, vol. 56, pp. 721-729, 2009.
27. Laeseke, Paul F, Lee, Fred T, Sampson, Lisa A, van der Weide, Daniel W, Brace, Christopher L, "Microwave ablation versus radiofrequency ablation in the kidney: high-power triaxial antennas create larger ablation zones than similarly sized internally cooled electrodes," *Journal of vascular and interventional radiology*, *Journal of Vascular and Interventional Radiology*, vol. 20, p. 1224, 2009
28. Laeseke P.F., Lee F.T. Jr., van der Weide D.W. and Brace C.L., "Multiple-Antenna Microwave Ablation: Spatially Distributing Power Improves Thermal Profiles and Reduces Invasiveness," *Journal of Interventional Oncology*, vol. 2, p. 65, 2009.
29. I. V. Shadrivov, A. B. Kozyrev, D. W. van der Weide, and Y. S. Kivshar, "Nonlinear magnetic metamaterials," *Opt. Express*, vol. 16, pp. 20266-20271, 2008.
30. T. Ganz, M. Brehm, H. G. von Ribbeck, D. W. van der Weide, and F. Keilmann, "Vector frequency-comb Fourier-transform spectroscopy for characterizing metamaterials," *New Journal of Physics*, p. 123007, 2008. (IOP Select)
31. A. B. Kozyrev and D. W. van der Weide, "Nonlinear left-handed transmission line metamaterials," **Invited Topical Review**, *Journal of Physics D: Applied Physics*, p. 173001, 2008.
32. I. V. Shadrivov, A. B. Kozyrev, D. W. van der Weide, and Y. S. Kivshar, "Tunable transmission and harmonic generation in nonlinear metamaterials," *Applied Physics Letters*, vol. 93, p. 161903, 2008. (selected for the November 2008 issue of Virtual Journal of Ultrafast Science)
33. Nathan A. Durick, Paul F. Laeseke, Lynn S. Broderick, Fred T. Lee, Jr, Lisa A. Sampson, Tina M. Frey, Thomas F. Warner, Jason P. Fine, D.W. van der Weide, and Christopher L. Brace, "Microwave Ablation with Triaxial Antennas Tuned for Lung: Results in an in Vivo Porcine Model," *Radiology* vol. 247, pp. 80-87, 2008.
34. A. Karbassi, D. Ruf, A. D. Bettermann, C. A. Paulson, D. W. van der Weide, H. Tanbakuchi, and R. Stancliff, "Quantitative scanning near-field microwave microscopy for thin film dielectric constant measurement," *Review of Scientific Instruments*, vol. 79, p. 094706, 2008.
35. M. Zhao, J. D. Shea, S. C. Hagness, D. W. van der Weide, B. D. Van Veen, and T. Varghese, "Numerical Study of Microwave Scattering in Breast Tissue via Coupled Dielectric and Elastic Contrasts," *IEEE Antennas and Wireless Propagation Letters*, vol. 7, pp. 247-250, 2008.
36. H.-G. von Ribbeck, M. Brehm, D. W. van der Weide, S. Winnerl, O. Drachenko, M. Helm, and F. Keilmann, "Spectroscopic THz near-field microscope," *Optics Express*, vol. 16, issue 5, pp. 3430-3438, 2008.
37. C. Qin, A. B. Kozyrev, A. Karbassi, and D. W. van der Weide, "Microfabricated V-band left-handed transmission lines," *Metamaterials*, vol. 2, pp. 26-35, 2008.
38. A. B. Kozyrev and D. W. van der Weide, "Trains of Envelope Solitons in Nonlinear Left-Handed Transmission Line Media," *Applied Physics Letters*, vol. 91, pp. 254111-3, 2007.

39. A. B. Kozyrev, C. Qin, I. V. Shadrivov, Yu. S. Kivshar, I. L. Chuang and D. W. van der Weide, "Wave scattering and splitting by magnetic metamaterials," *Optics Express*, vol. 15, no. 18, pp. 11714-11722, 2007.
40. J. Grade, P. Haydon, and D. W. van der Weide, "Electronic terahertz antennas and probes for spectroscopic detection and diagnostics," *Proceedings of the IEEE*, vol. 95, pp. 1583-1591, 2007.
41. Ho, S. J., Choi, M. K., van der Weide, D. W. (2007). A robust parameter extraction method for HBT small-signal equivalent circuit. *Microwave and Optical Technology Letters*, 49(8), 1845-1848.
42. Chih-Chuan Yen, Gutierrez, A. E., Veeramani, D., & van der Weide, D. (2007). Radar cross-section analysis of backscattering RFID tags. *IEEE Antennas and Wireless Propagation Letters*, 6(1), 279-81, 2007.
43. Y. Wang, A. D. Bettermann, and D. W. van der Weide, "Process for scanning near-field microwave microscope probes with integrated ultratall coaxial tips," *Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures*, vol. 25, pp. 813-816, 2007.
44. CL Brace, PF Laeseke, LA Sampson, TM Frey, D.W. van der Weide, and FT Lee Jr., "Microwave ablation with multiple simultaneously powered small-gauge triaxial antennas: Results from an in vivo swine liver model," *Radiology*, vol. 244, pp. 151-156, 2007.
45. Srijit Goswami, K. A. Slinker, Mark Friesen, L.M. McGuire, J. L. Truitt, Charles Tahan, L. J. Klein, J. O. Chu, P. M. Mooney, D. W. van der Weide, Robert Joynt, S. N. Coppersmith, and M. A. Eriksson, "Controllable valley splitting in silicon quantum devices," *Nature Physics*, vol. 3, pp. 41-45, 2007.
46. Hongjoon Kim, Alexander B. Kozyrev, Abdolreza Karbassi, and D.W. van der Weide, "Compact left-handed transmission line as a linear phase-voltage modulator and efficient harmonic generator," *IEEE Transactions on Microwave Theory and Techniques* 55(3), 571-578, 2007.
47. CL Brace, PF Laeseke, LA Sampson, TM Frey, D.W. van der Weide, and FT Jr. Lee, "Microwave ablation with a single small-gauge triaxial antenna: In vivo porcine liver model," *Radiology*, vol. 242, pp. 435-440, 2007.
48. M. Zhao, J. D. Shea, S. C. Hagness, and D.W. van der Weide, "Calibrated free-space microwave measurements with an ultrawideband reflectometer-antenna system," *IEEE Microwave and Wireless Component Letters*, vol. 16, pp. 675-677, 2006.
49. V. Joshkin, M. Lagally, and D.W. van der Weide, "Double layer based electronic nanodevices fabricated on silicon nanoneedles," *Journal of Applied Physics*, vol. 100, pp. 084329, 2006. (also cited in *Virtual Journal of Nanoscale Science & Technology*, 2006.)
50. Hongjoon Kim, Sung-Jin Ho, Min-Ki Choi, Alexander B. Kozyrev, and D.W. van der Weide, "Combined Left- and Right- Handed Tunable Transmission Lines With Tunable Passband and 0° Phase Shift," *IEEE Transactions on Microwave Theory and Techniques*, vol. 54, pp. 4178-4184, 2006.
51. Alexander B. Kozyrev, Hongjoon Kim and D.W. van der Weide, "Parametric amplification in left-handed transmission line media," *Applied Physics Letters*, vol. 88, pp. 264101, 2006.

52. A. Karbassi, C. A. Paulson, A. B. Kozyrev, M. Banerjee, Y. Wang, and D. W. van der Weide, "Quadraxial probe for high resolution near-field scanning RF/microwave microscopy," *Applied Physics Letters*, vol. 89, pp. 153113, 2006. (also cited in *Virtual Journal of Nanoscale Science & Technology*, 2006.)
53. A. B. Kozyrev and D.W. van der Weide, "Reply to the Comment on "Explanation of the Inverse Doppler Effect Observed in Nonlinear Transmission Lines,"" *Physical Review Letters*, vol. 96, pp. 069403, 2006.
54. C. L. Brace, P. F. Laeseke, L. A. Sampson, T. M. Frey, D.W. van der Weide, and F. T. Lee, Jr., "Microwave ablation with small-gauge triaxial antennas. Part II: Using multiple antennas to create large volumes of ablation in vivo," *Radiology*, 2006.
55. L. J. Klein, K. L. M. Lewis, K. A. Slinker, Srijit Goswami, D.W. van der Weide, R. H. Blick, P. M. Mooney, J. O. Chu, S. N. Coppersmith, Mark Friesen, and M. A. Eriksson, "Quantum dots and etch-induced depletion of a silicon two-dimensional electron gas," *Journal of Applied Physics* **99**, 023509 (2006).
56. M. K. Choi, M. Zhao, S. C. Hagness, and D. W. van der Weide, "Compact mixer-based 1-12 GHz reflectometer," *IEEE Microwave and Wireless Components Letters*, vol. 15, no. 11, pp. 781-783, Nov. 2005.
57. Albert Schliesser, Markus Brehm, Fritz Keilmann, and D.W. van der Weide, "Frequency-comb infrared spectrometer for rapid, remote chemical sensing," *Optics Express*, vol. 13, no. 22, 9029-9038, October 31, 2005. <http://www.opticsexpress.org/abstract.cfm?id=86071>
58. Y. Wang and D.W. van der Weide, "Microfabrication and Application of High-Aspect-Ratio Silicon Tips" *Journal of Vacuum Science & Technology B*, vol. 23, pp. 1582-1584, 2005.
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BOOK SECTIONS

1. I. V. Shadrivov, M. Lapine, Y. S. Kivshar, A. Kozyrev, and D. van der Weide, "Nonlinear and Tunable Left-Handed Transmission Lines," in *Nonlinear, Tunable and Active Metamaterials*. vol. 200, ed: Springer International Publishing, 2015, pp. 89-103.

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3. M. Fanciulli, J. Truitt, K. Slinker, K. Lewis, D. Savage, C. Tahan, L. Klein, J. Chu, P. Mooney, A. Tyryshkin, D. van der Weide, R. Joynt, S. Coppersmith, M. Friesen, and M. Eriksson, "Si/SiGe Quantum Devices, Quantum Wells, and Electron-Spin Coherence," in *Electron Spin Resonance and Related Phenomena in Low-Dimensional Structures*, pp. 101-127, 2009.
4. D.W. van der Weide, John Grade, Min Ki Choi, and Alan Bettermann, "THz Spectroscopic Detection with Electronic Techniques," *Proceedings of NATO Advanced Research Workshop: Terahertz Frequency Detection and Identification of Materials and Objects*, Spiez, Switzerland, 2006.
1. C. A. Paulson and D.W. van der Weide, "Near-field High Frequency Probing," in *Scanning Probe Microscopy*, S. Kalinin and A. Gruverman, Eds. New York: Springer-Verlag, 2007, pp. 315-345. <http://www.springerlink.com/content/p02166j771n03800/fulltext.pdf>
2. M.K. Choi, K. Taylor, A. Bettermann, and D.W. van der Weide, "Spectroscopy with Electronic Terahertz Techniques for Chemical and Biological Sensing," Chapter 2, Volume II. *Emerging Scientific Applications and Novel Device Concepts, Terahertz Sensing Technology*, Editors: D. L. Woolard, M. S. Shur and W. R. Loerop, World Scientific, 2003.
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4. D.W. van der Weide, "Electronic Sources and Detectors for Wideband Sensing in the Terahertz Regime," in *Sensing with terahertz radiation*, Vol. 85, *Springer Series in Optical Sciences*, D. M. Mittleman, Ed.: Springer, 2003.

CONFERENCE PRESENTATIONS

PAPERS AWARDED PRIZES

1. A. Day, M. Dwyer, D. van der Weide, "Millimeter-wave thickness-deviation measurement system," in 2020 IEEE Radio and Wireless Symposium (RWS) 2020, *First Prize Student Paper Competition*.
2. C.L. Brace, P. Laeseke, L.A. Sampson, T.M. Frey, D.W. van der Weide and F.T. Lee. "Principles of microwave ablation," RSNA 2005, *Educational Exhibit Certificate of Merit*.
3. T. Löffler, T. Pfeifer, H. G. Roskos, H. Kurz, and D.W. van der Weide, "Stable optoelectronic detection of free-running microwave signals with 150-GHz bandwidth," *European Conference on Optical and Beam Probing*, 1995. *Best poster award*.
4. D.W. van der Weide, "A YIG-tuned nonlinear transmission line multiplier," at IEEE MTT-S International Microwave Symposium, Atlanta GA, 1993. *Student paper contest award*.
5. D.W. van der Weide, "Thin-film YIG oscillators with low phase noise and high spectral purity," at IEEE MTT-S International Microwave Symposium, Albuquerque NM, 1992. *Student paper contest award*.

INVITED

1. D.W. van der Weide, "Ohm vs. Maxwell: Using electromagnetic fields as treatment modalities" Plenary invited speaker, European Computer Assisted Liver Surgery Society annual meeting, Oct. 17-19, 2019, Bern, Switzerland.

2. A. B. Kozyrev and D.W. van der Weide, "Prospects for Nonlinear Left-Handed Transmission Lines" invited presentation at Metamaterials 2007: The First International Congress on Advanced Electromagnetic Materials in Microwave and Optics, Rome, Italy, October 22-26, 2007.
3. D.W. van der Weide, John Grade, Min Ki Choi, and Alan Bettermann, "THz Spectroscopic Detection with Electronic Techniques," presented at NATO Advanced Research Workshop: Terahertz Frequency Detection and Identification of Materials and Objects, Spiez, Switzerland, 2006.
4. D.W. van der Weide and John Grade, "THz Antennas with Broadband Gain," presented at NATO Advanced Research Workshop: Terahertz Frequency Detection and Identification of Materials and Objects, Spiez, Switzerland, 2006.
5. D.W. van der Weide, "Materials contrast for electronic terahertz imaging," Spring MRS Meeting, San Francisco, CA, April 2006.
6. A. B. Kozyrev, H. Kim, A. Karbassi and D. W. van der Weide, "Higher Harmonic Generation and Parametric Instabilities in Left-Handed Nonlinear Transmission Lines", 2005 IEEE AP-S Int. Symposium and USNC/URSI National Radio Science Meeting, 3-8 July 2005, vol. 2B, pp. 209-212 (2005).
7. Interviewed about use of terahertz technology for counter-terrorism in a 30 minute show "Connect" on BBC Radio 4 by Julian Mayers, November, 2005.
8. A.B. Kozyrev, H.J. Kim, D.W. van der Weide, "Parametric gain and nonlinearities in mesoscopic media," presented at NPMS-7/SIMD-5, Maui, HI, November 28-Dec 2, 2005.
9. D.W. van der Weide, "Landscape of US THz initiatives," presented at Terahertz Sources and Systems for Security Use, Durham, UK, 2005.
10. F. Keilmann, M. Brehm, A. Schliesser, and D.W. van der Weide, "Novel FTIR Spectrometer Featuring Rapid Acquisition with a Coherent, Laser-Like Beam," presented at ICAVS-3, Lake Delavan WI, 2005.
11. D.W. van der Weide, "Stand-off detection with pulsed electronic THz systems," Joint Terahertz Imaging System Technology Assessment, Falls Church, VA, 31 August – 1 September 2005
12. D.W. van der Weide, M. Choi, K. Taylor, and A. Bettermann, "Sensing biomolecules with microwave and terahertz frequencies," presented at EMC Zürich, 2005.
13. X. Li, E. J. Bond, S. C. Hagness, B. D. Van Veen, and D. van der Weide, "Three-dimensional microwave imaging via space-time beamforming for breast cancer detection," IEEE Antennas and Propagation Society International Symposium and USNC/URSI Radio Science Meeting, San Antonio, TX, June 2002.
14. X. Li, E. J. Bond, S. Davis, M. Choi, P. Gustafson, S. C. Hagness, B. D. Van Veen, and D. van der Weide, "Computational and Experimental Investigations of Microwave Breast Cancer Detection via Space-Time Beamforming," 3rd World Congress on Microwave and Radio Frequency Applications, Sydney, Australia, September 22-26, 2002.
15. S. C. Hagness, X. Li, E. J. Bond, S. Davis, M. Choi, P. Gustafson, B. D. Van Veen, and D. van der Weide, "Microwave Imaging via Space-Time Beamforming for Breast Cancer Detection: Experimental Studies using Breast Phantoms," XXVIIth General Assembly of the International Union of Radio Science (URSI), Maastricht, The Netherlands, August 2002.
16. X. Li, S. C. Hagness, B. D. Van Veen, and D. van der Weide, "Experimental Investigation of Microwave Imaging via Space-Time Beamforming for Breast Cancer Detection," accepted for

presentation at the IEEE MTT-S International Microwave Symposium, Philadelphia, PA, June 2003.

17. X. Li, L. O. Palmer, S. C. Hagness, B. D. Van Veen, D. van der Weide, "Microwave breast cancer detection via space-time beamforming: A computational and experimental study of breast phantom and sensor design parameters," accepted for presentation at the IEEE Antennas and Propagation Society International Symposium and USNC/URSI Radio Science Meeting, Columbus, OH, June 2003.
18. D.W. van der Weide, M. Choi, K. Taylor, and A. Bettermann, "Sensing biomolecules with microwave and terahertz frequencies," presented at EMC Zurich, 2005.
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20. S. Bhattacharjee, J. H. Booske, C. L. Kory, D.W. van der Weide, S. Limbach, S. Gallagher, A. Stevens, M. Genack, J. Welter, M. Lopez, R. M. Gilgenbach, J. Wohlbier, R. L. Ives, M. E. Read, R. Divan, and D. C. Mancini, "Investigations of folded waveguide TWT oscillators for THz radiation," presented at 4th IEEE International Conference on Vacuum Electronics, 2003.
21. D.W. van der Weide, "Terahertz systems for concealed weapons sensing," *DSTL* Ft. Halstead, UK, 30 September 2003.
22. D.W. van der Weide, "Terahertz sensing for explosives detection," *FOI-Sweden (Swedish Defense Agency)*, Linköping, Sweden, 29 August 2003
23. D.W. van der Weide, "Terahertz sensing technology," *FFI-Norway (Norwegian Defense Agency)*, Oslo, Norway, 1 September 2003
24. D.W. van der Weide, "Spectroscopy with electronic terahertz techniques for chemical and biological sensing," *Joint European Research Centre*, Ispra, Italy, 12 June 2003
25. D.W. van der Weide, "Detection of explosives, chemical and biological hazards with terahertz systems," *Gordon Conference on Illicit Substance Detection: Explosives*, Il Ciocco, Barga, Italy, 8-13 June 2003.
26. D.W. van der Weide, "Detection of chemical and biological hazards with terahertz systems," *The terahertz gap: the generation of far-infrared radiation and its applications*, Royal Society Scientific Discussion Meeting, London, England, 4-5 June, 2003.
27. D.W. van der Weide, "Detection of explosives with terahertz systems," *Expert workshop on Explosive Detection Techniques for use in Mine Clearance and Security Related Requirements*, Lake Bled, Slovenia, 2-4 June, 2003.
28. Invited speaker at 27th Annual Great Lakes Biomedical Conference, "Applications of nanotechnology," April 4, 2003.
29. K. Taylor and D.W. van der Weide, "Microwave sensing of protein conformation and binding," presented at American Physical Society March Meeting, Austin TX, 2003.
30. D.W. van der Weide, "All electronic terahertz spectroscopy," 2003 OSA Ultrafast Electronic and Optoelectronic Topical Meeting, January 15-17, 2003, in Washington DC.
31. X. Li, E. J. Bond, S. Davis, M. Choi, P. Gustafson, S. C. Hagness, B.D. Van Veen, and D.W. van der Weide, "Computational and Experimental Investigations of Microwave Breast Cancer

- Detection via Space-Time Beamforming,” presented at 3rd World Congress on Microwave and Radio Frequency Applications, Sydney, Australia, 2002.
32. D.W. van der Weide, “THz sensing and screening of biomolecules and bacteria,” presented at Optical Society of America Annual Meeting, Orlando FL, 2002.
 33. M. Friesen, P. Rugheimer, D. E. Savage, M. G. Lagally, D.W. van der Weide, R. Joynt, and M.A. Eriksson, “A SiGe Quantum Dot Quantum Computer,” presented at 6th International Conference on Quantum Communication, Measurement and Computation, Boston MA, 2002.
 34. M. Friesen, P. Rugheimer, D. E. Savage, M. G. Lagally, D.W. van der Weide, R. Joynt, and M.A. Eriksson, “A SiGe Quantum Dot Quantum Computer,” presented at Quantum Device Technology Workshop, Potsdam, NY, 2002.
 35. X. Li, E. J. Bond, S. C. Hagness, B. D. V. Veen, and D.W. van der Weide, “Three-dimensional microwave imaging via space-time beamforming for breast cancer detection,” presented at IEEE Antennas and Propagation Society International Symposium and USNC/URSI Radio Science Meeting, San Antonio TX, 2002.
 36. D.W. van der Weide, “Local Electron Spin Probing with Microwaves: Interfacing to Quantum Dot Qubits in SiGe & A Route to High Power,” presented at Solid State Quantum Computing (SSQC) Workshop, Yorktown Heights, NY, 2002.
 37. D.W. van der Weide, K. Taylor, J. Peck, C. Wichaidit, S. Hagness, W. Cai, and R. Hamers, “Biomolecular Contrast Mechanisms and Sensing Techniques in the Terahertz Regime,” presented at 9th International Conference on Terahertz Electronics, Charlottesville, 2001.
 38. K. Taylor and D.W. van der Weide, “Sensing Folding of Solution Proteins with Resonant Antennas,” presented at 9th International Conference on Terahertz Electronics, Charlottesville, 2001.
 39. D.W. van der Weide, “Electronic terahertz systems for biodetection and bioimaging,” at First International Conference on Biomedical Imaging & Sensing Applications of Terahertz Technology (BISAT ’01), Leeds UK, 30 November-1 December 2001.
 40. D.W. van der Weide, “Electronic THz Imaging of Explosives” Gordon Research Conference on Illicit Substances, New London CT, 8-13 July 2000.
 41. D.W. van der Weide, “THz electronics” at NATO Advanced Research Workshop, Chateau de Bonas, France, 21-28 June 2000.
 42. D.W. van der Weide, J. Murakowski, and F. Keilmann, “Spectroscopy with electronic THz techniques,” at EurOpto ’99, Munich, Germany, 1999.
 43. D.W. van der Weide, “Microscopes for subvisible frequencies,” at International Advanced Studies Institute, Science and Technology Series, Naval Postgraduate School, Monterey, CA, 1998.
 44. D.W. van der Weide, “Electronic THz systems,” at Optical Society Annual Meeting, Baltimore, MD, 1998.
 45. V. Agrawal, T. Bork, S. Kee, and D.W. van der Weide, “Electronic THz reflection spectroscopy for detecting energetic materials,” at *Sixth IEEE International Conference on Terahertz Electronics*, Leeds UK, 1998.
 46. D.W. van der Weide, “Multifunctional scanned probes for localizing high frequency fields,” at *APS March Meeting*, Los Angeles CA, 1998.

47. D.W. van der Weide, "Complex broadband millimeter-wave response of coupled quantum dots," at DARPA Ultra Electronics Program Review, Santa Fe, NM, 1997.
48. D.W. van der Weide, "Terahertz spectroscopy of energetic materials," presented at Ignition and Combustion Branch, Propulsion and Flight Division, Weapons and Materials Directorate, Army Research Laboratory, Aberdeen, MD, 1997.
49. D.W. van der Weide, "Technology and applications of electronic terahertz systems," at Workshop on New Sources and Detectors for the Terahertz Regime, Institut für Halbleitertechnik, RWTH Aachen, Germany, 1996.
50. D.W. van der Weide and P. Neuzil, "The nanoscilloscope: Combined topography and AC field probing with a micromachined tip," at Third Workshop on Industrial Applications of Scanned Probe Microscopy, NIST, Gaithersburg MD, 1996.
51. D.W. van der Weide, "THz spectroscopy using nonlinear transmission lines," at International Workshop on Novel Terahertz Technology, Ministry of Post and Telecommunication, Kobe, Japan, 1995.
52. D.W. van der Weide, "Electronic generation and detection of terahertz free-space radiation using subpicosecond pulses," at International Seminar on Terahertz Electronics, IEMN, Villeneuve d'Ascq, France, 1994.
53. D.W. van der Weide, "A free-space spectroscopy system using nonlinear transmission lines," at SFB 254 Optoelectronics Colloquium, University of Duisburg, Germany, 1993.
54. D. M. Bloom, J. S. Bostak, D.W. van der Weide, B. A. Auld, and E. Özbay, "All-electronic generation and detection of terahertz free-space pulses and their application to a terahertz spectroscopy system," at Nonlinear Optics for High-Speed Electronics and Optical Frequency Conversion, SPIE, Los Angeles CA, 1994.
55. J. S. Bostak, D. M. Bloom, D.W. van der Weide, B. A. Auld, and E. Özbay, "All-electronic generation and detection of terahertz free-space pulses and their application to a terahertz spectroscopy system," at Millimeter and Submillimeter Waves, SPIE, San Diego CA, 1994.
56. D.W. van der Weide, J. S. Bostak, B. A. Auld, and D. M. Bloom, "All-electronic subpicosecond pulses for a 3-terahertz free-space signal generation and detection system," at International Conference on Ultra-Wide Band, Short-Pulse Electromagnetics, Brooklyn NY, 1992.

PEER-REVIEWED

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- D.W. van der Weide, "Molecular-scale bioelectronic interfaces: How will microelectronics and molecular-scale biology converge?" Presentation at University of Rochester, Rochester NY, April 7, 2006.

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- K. Taylor and D.W. van der Weide, "Microwave sensing of protein conformation and binding," Biophysical Society Annual Meeting, San Antonio TX, 2003.
- D.W. van der Weide, "Solid State Quantum Computing using Nanostructured Logic Gates: Clocking and Probing with Microwaves," Invited Quantum Information Sciences Seminar, University of Illinois, Urbana-Champaign, October 9, 2002.
- D.W. van der Weide, "Short pulse generation and measurement approaches for spectroscopy and (bio)sensing," Invited seminar, Agilent Laboratories, Palo Alto, CA, May 2002.
- D.W. van der Weide, "Near field probing of biomolecules," Invited seminar, Agilent Technologies, Santa Rosa CA, May 2002.
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- D.W. van der Weide, "Terahertz Interactions with Molecules, both Real and Artificial," Physical Chemistry Seminar, University of Wisconsin-Madison, October 3, 2000.

SELECTED PATENTS

(use [\(Dan*\) inventor:\(van der Weide,\)](#) - [Google Patents](#) for a more complete list >80 total)

	PAT. NO.	Title
17	7,768,458	Systems, methods and devices for improved imaging
16	7,725,151	Apparatus and method for near-field imaging of tissue
15	7,691,298	Plastic cantilevers for force microscopy
14	7,467,015	Segmented catheter for tissue ablation
13	7,368,305	High aspect ratio micromechanical probe tips and methods of fabrication
12	7,345,610	High speed digital-to-analog converter
11	7,244,254	Air-core microwave ablation antennas
10	7,183,055	Direct radio-frequency detection of nucleotide hybridization at microelectrodes
9	7,179,587	Method and apparatus for high frequency interfacing to biochemical membranes
8	7,146,282	Mechanical force detection of magnetic fields using heterodyne demodulation
7	7,135,917	Left-handed nonlinear transmission line media
6	6,845,655	Heterodyne feedback system for scanning force microscopy and the like
5	6,801,029	Microwave dielectric spectroscopy method and apparatus
4	6,649,402	Microfabricated microbial growth assay method and apparatus
3	6,597,010	Solid-state quantum dot devices and quantum computing using nanostructured logic gates
2	5,936,237	Combined topography and electromagnetic field scanning probe microscope
1	5,748,309	Coherent periodically pulsed radiation spectrometer

APPENDIX B

Appendix B

List of Materials Considered

Exhibit	Description
1001	U.S. Patent No. 10,869,247 (“247”)
1002	File History of U.S. Application No. 17/008,439 (“247 FH”)
1004	Declaration of Friedhelm Rodermund in Support of Petition for <i>Inter Partes</i> Review of U.S. Patent No. 9,854,545 (“Rodermund”)
1005	U.S. Patent Application Publication No. 2011/0158116 (“Tenny”)
1006	U.S. Provisional Application No. 61/218769 (“Tenny-Prov.”)
1007	R2-100423, <i>Supporting multiple timing advance groups</i> (“Qualcomm”)
1008	3GPP Technical Specification 36.300 v8.11.0 (2009-12) (“TS36.300”)
1009	3GPP Technical Specification 36.331 v9.0.0 (2009-09) (“TS36.331”)
1010	U.S. Patent Application Publication No. 2010/0260136 (“Fan”)
1011	File History of U.S. Application No. 13/578,531 (“545 parent FH”)
1012	File History of U.S. Application No. 12/818,064 (“Tenny FH”)
1013	U.S. Patent Application Publication No. 2012/0008600 (“Marinier”)
1014	U.S. Provisional Application No. 61/293,271 (“Marinier-Prov.”)
1015	3G Evolution: HSPA and LTE for Mobile Broadband (Second Edition, 2008)
1016	Claim Construction Expert Report of Peter Rysavy Concerning U.S. Patent No. 9,854,545, <i>Pantech Corp. et al. v. LG Electronics Inc. et al.</i> , Case 5:22-cv-00113-RWS-JBB (E.D. Texas) (June 23, 2023)

Exhibit	Description
1017	Joint Claim Construction and Prehearing Statement, <i>Pantech Corp. et al. v. LG Electronics Inc. et al.</i> , Case 5:22-cv-00113-RWS-JBB (E.D. Texas), Dkt. No. 118
1018	Plaintiffs' preliminary proposed constructions and supporting extrinsic evidence pursuant to P.R. 4-2 (dated June 2, 2023)
1022	Transcript of Peter Rysavy, <i>Pantech Corp. et al. v. LG Electronics Inc. et al.</i> , Case 5:22-cv-00113-RWS-JBB (E.D. Texas) (July 12, 2023)
1051	Webpage, available at https://archive.org/legal/affidavit.php
1052	Internet Archive Capture, available at https://web.archive.org/web/20110509054716/http://3gpp.org/Specification-Groups
1053	Internet Archive Capture, available at https://web.archive.org/web/20090802220720/http://www.3gpp.org/
1054	Internet Archive Capture, available at https://web.archive.org/web/20130812133550/http://3gpp.org/RAN2-Radio-layer-2-and-Radio-layer
1055	Internet Archive Capture, available at https://web.archive.org/web/20081008035555/http://www.3gpp.org/ftp/tsg_ran/WG2_RL2
1056	Internet Archive Capture, available at https://web.archive.org/web/20080517151142/http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_50/
1057	Webpage, available at ftp.3gpp.org/Specs
1058	Internet Archive Capture, available at https://web.archive.org/web/20130110164645/http://www.3gpp.org/specifications

Exhibit	Description
1059	Internet Archive Capture, available at https://web.archive.org/web/20081201021150/http://www.3gpp.org/Specification-Numbering
1060	Internet Archive Capture, available at https://web.archive.org/web/20081207063329/http://www.3gpp.org/ftp/Specs/html-info/36-series.htm
1061	Internet Archive Capture, available at https://web.archive.org/web/20080513144118/http://www.3gpp.org/ftp/Specs/html-info/TSG-WG--R2.htm
1062	Internet Archive Capture, available at https://web.archive.org/web/20081201154548/http://www.3gpp.org/ftp/specs/html-info/36300.htm
1063	Internet Archive Capture, available at https://web.archive.org/web/20140326141918/http://3gpp.org/DynaReport/TSG-WG--R2.htm
1064	Internet Archive Capture, available at https://web.archive.org/web/20140217112636/http://www.3gpp.org/DynaReport/36-series.htm
1065	Internet Archive Capture, available at https://web.archive.org/web/20140228134853/http://www.3gpp.org/DynaReport/36300.htm
1067	3GPP TS 36.300 V8.6.0 (2008-09), retrieved from https://web.archive.org/web/20140704112512/http://www.3gpp.org/ftp/Specs/archive/36_series/36.300/36300-860.zip (36300-860.doc in 36300-860.zip)
1068	Internet Archive Capture, available at https://web.archive.org/web/20081013132816/http://www.3gpp.org/ftp/Specs/latest/Rel-8/

Exhibit	Description
1069	Internet Archive Capture, available at https://web.archive.org/web/20080924051314/http://www.3gpp.org/ftp/Specs/latest/Rel-8/36_series/
1070	Internet Archive Capture, available at https://web.archive.org/web/20060105222647/http://list.etsi.org/scripts/wa.exe?SUBED1=3gpp_tsg_ran_wg2&A=1
1071	Webpage, available at https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_68bis/Docs
1072	R2-100423, retrieved from https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_68bis/Docs/R2-100423.zip (R2-100423 Supporting multiple timing advance groups.doc in R2-100423.zip)
1073	RAN WG2 #68bis skeleton report based on Agenda Proposal from 3GPP TSG RAN WG2 #68bis meeting on 18 - 22 January, Valencia, Spain (R2-10xxxx), retrieved from https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_68bis/Report/History/skeleton_report_RAN2_68bis_update.zip (skeleton_report_RAN2_68bis_update.doc in skeleton_report_RAN2_68bis_update.zip)
1074	Webpage, available at https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_68bis/Report/History/
1075	Webpage, available at https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_68bis/Report/
1076	R2-101881, retrieved from https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_68bis/Report/R2-101881.zip (101881_report_RAN2_68bis_Valencia.doc in R2-101881 - R2.zip)

Exhibit	Description
1077	Excel file “Tdoc_List_RAN2_68bis_100221.xls,” retrieved from https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_68bis/Report/R2-101881.zip
1078	Webpage, available at https://list.etsi.org/scripts/wa.exe?A2=3GPP_TSG_RAN_WG2;758681ee.1001
1079	Internet Archive Capture, available at https://web.archive.org/web/20091210102659/http://list.etsi.org:80/
1080	Internet Archive Capture, available at https://web.archive.org/web/20100115152457/http://list.etsi.org/
1081	Excel file “Participants_list_RAN2_68bis.xls,” retrieved from https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_68bis/Report/R2-101881.zip/
1082	Webpage, available at https://www.3gpp.org/ftp/Specs/archive/36_series/36.300
1083	Webpage, available at https://www.etsi.org/deliver/etsi_ts/136300_136399/136300/08.11.00_60/
1084	ETSI TS 136 300 V8.11.0 (2010-02), retrieved from https://www.etsi.org/deliver/etsi_ts/136300_136399/136300/08.11.00_60/ts_136300v081100p.pdf
1085	Internet Archive Capture, available at https://web.archive.org/web/20131115195236/http://webapp.etsi.org/key/key.asp?full_list=y
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Exhibit	Description
1087	Internet Archive Capture, available at https://web.archive.org/web/20140714052548/http://3gpp.org/ftp/specs/archive/36_series/36.300
1088	Internet Archive Capture, available at https://web.archive.org/web/20150226191038/http://www.3gpp.org:80/ftp/Specs/archive/36_series/36.300
1089	3GPP TS 36.300 V8.11.0 (2009-12), retrieved from https://www.3gpp.org/ftp/Specs/archive/36_series/36.300/36300-8b0.zip (36300-8b0.doc in 36300-8b0.zip)
1091	Internet Archive Capture, available at https://web.archive.org/web/20081113150830/http://www.3gpp.org/ftp/Specs/
1092	Internet Archive Capture, available at https://web.archive.org/web/20081013132648/http://www.3gpp.org/ftp/Specs/archive
1093	Internet Archive Capture, available at https://web.archive.org/web/20081012223857/http://www.3gpp.org/ftp/specs/archive/36_series/
1094	Internet Archive Capture, available at https://web.archive.org/web/20081201231313/http://www.3gpp.org/ftp/Specs/latest
1095	Internet Archive Capture, available at https://web.archive.org/web/20081208085335/http://www.3gpp.org:80/ftp/Specs/latest/Rel-8/
1096	Internet Archive Capture, available at https://web.archive.org/web/20081209045248/http://www.3gpp.org/ftp/Specs/latest/Rel-8/36_series/

Exhibit	Description
1097	Webpage, available at https://www.3gpp.org/ftp/Specs/archive/36_series/36.331/
1098	Webpage, available at https://www.etsi.org/deliver/etsi_ts/136300_136399/136331/09.00.00_60/
1099	ETSI TS 136 331 V9.0.0 (2009-10), retrieved from https://www.etsi.org/deliver/etsi_ts/136300_136399/136331/09.00.00_60/ts_136331v090000p.pdf
1100	Internet Archive Capture, available at https://web.archive.org/web/20081108042545/http://www.3gpp.org/Specifications
1101	Internet Archive Capture, available at https://web.archive.org/web/20081201131034/http://www.3gpp.org/ftp/specs/archive/36_series/36.331/
1102	Internet Archive Capture, available at https://web.archive.org/web/20140713200444/http://3gpp.org/ftp/specs/archive/36_series/36.331/
1103	3GPP TS 36.331 V9.0.0 (2009-09), retrieved from https://www.3gpp.org/ftp/Specs/archive/36_series/36.331/36331-900.zip (36331-900.doc in 36331-900.zip)
1104	Internet Archive Capture, available at https://web.archive.org/web/20081201163652/http://www.3gpp.org/ftp/specs/html-info/36331.htm
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Exhibit	Description
1106	Internet Archive Capture, available at https://web.archive.org/web/20140621152924/http://www.3gpp.org:80/ftp/specs/archive/36_series/36.331
1107	Internet Archive Capture, available at https://web.archive.org/web/20130110164713/http://www.3gpp.org/ftp/Specs/