

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

**SAMSUNG ELECTRONICS CO., LTD.,
SAMSUNG ELECTRONICS AMERICA, INC.,
FOSSIL GROUP, INC.,
FOSSIL STORES I, INC.,
FOSSIL PARTNERS, L.P.,
OURA HEALTH OY, AND
ONEPLUS TECHNOLOGY (SHENZHEN) CO., LTD.**

Petitioners,

v.

OMNI MEDSCI, INC.,

Patent Owner.

Case PGR2025-00063

Patent No. 12,268,475

**DECLARATION OF BRIAN W. ANTHONY IN SUPPORT
OF PETITION FOR POST GRANT REVIEW
OF U.S. PATENT NO. 12,268,475**

Executed this 5th day of August 2025, in Cambridge, Massachusetts.



Brian W. Anthony

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I. INTRODUCTION

1. My name is Brian W. Anthony and I am a Principal Research Scientist at the Massachusetts Institute of Technology (MIT). I have been retained on behalf of Samsung Electronics Co. Ltd. and Samsung Electronics America Inc. (“Samsung”), to provide my opinions on certain issues related to U.S. Patent No. 12,268,475 (“the ’475 patent”) in connection with the above-captioned post grant review (“PGR”) proceeding. In particular, I have been asked to provide my insights, analysis, and opinions regarding whether claims 1, 5-8, 11-13 of the ’475 patent (“Challenged Claims”) are obvious over the prior art references identified below.

2. I understand that the ’475 patent is titled “Wearable device for differential measurement on pulse rate and blood flow,” names as an inventor Mohammed N. Islam, and is currently owned by Omni Medsci Inc. I have considered the ’475 patent. I understand that the ’475 patent has been provided as Ex. 1001.

3. I understand that the file history of the ’475 patent has been provided as Ex. 1002. I have considered this file history, and I will refer to it as “the ’475 Patent File History” or by its exhibit number.

4. I understand that the ’475 patent is a continuation of application No.

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18/899,012, filed on Sep. 27, 2024, which is a continuation of application No. 18/891,970, filed on Sep. 20, 2024, which is a continuation of application No. 18/438,144, filed on Feb. 9, 2024, now Pat. No. 12,193,790, which is a continuation of application No. 18/103,408, filed on Jan. 30, 2023, now Pat. No. 11,896,346, which is a continuation of application No. 17/514,778, filed on Oct. 29, 2021, now Pat. No. 11,564,577, which is a continuation of application No. 17/078,771, filed on Oct. 23, 2020, now Pat. No. 11,160,455, which is a continuation of application No. 16/722,188, filed on Dec. 20, 2019, now Pat. No. 10,820,807, which is a continuation of application No. 16/506,885, filed on Jul. 9, 2019, now Pat. No. 10,517,484, which is a continuation of application No. 16/272,069, filed on Feb. 11, 2019, now abandoned, which is a continuation of application No. 16/029,611, filed on Jul. 8, 2018, now Pat. No. 10,201,283, which is a continuation of application No. 15/888,052, filed on Feb. 4, 2018, now Pat. No. 10,136,819, which is a continuation of application No. 15/212,549, filed on Jul. 18, 2016, now Pat. No. 9,885,698, which is a continuation of application No. 14/650,897, filed as application No. PCT/US2013/075700 on Dec. 17, 2013, now Pat. No. 9,494,567, said application No. 16/506,885 is a continuation of application No. 16/004,359, filed on Jun. 9, 2018, now Pat. No. 11,109,761, which is a continuation of application No. 14/109,007, filed on Dec. 17, 2013, now Pat. No. 9,993,159, said application No. 16/506,885 is a continuation of application No. 16/188,194, filed on Nov. 12, 2018,

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now Pat. No. 10,386,230, which is a continuation of application No. 16/004,154, filed on Jun. 8, 2018, now Pat. No. 10,126,283, which is a continuation of application No. 15/855,201, filed on Dec. 27, 2017, now Pat. No. 9,995,722, which is a continuation of application No. 15/711,907, filed on Sep. 21, 2017, now Pat. No. 9,897,584, which is a division of application No. 15/357,225, filed on Nov. 21, 2016, now Pat. No. 9,797,876, which is a continuation of application No. 14/650,981, filed on Jun. 10, 2015, now Pat. No. 9,500,634, said application No. 16/506,885 is a continuation of application No. 16/241,628, filed on Jan. 7, 2019, now Pat. No. 10,441,176, which is a continuation of application No. 16/015,737, filed on Jun. 22, 2018, now Pat. No. 10,172,523, which is a continuation of application No. 15/594,053, filed on May 12, 2017, now Pat. No. 10,188,299, which is a continuation of application No. 14/875,709, filed on Oct. 6, 2015, now Pat. No. 9,651,533, which is a continuation of application No. 14/108,986, filed on Dec. 17, 2013, now Pat. No. 9,164,032, said application No. 16/506,885 is a continuation of application No. 16/284,514, filed on Feb. 25, 2019, now abandoned, which is a continuation of application No. 16/016,649, filed on Jun. 24, 2018, now Pat. No. 10,213,113, which is a continuation of application No. 15/860,065, filed on Jan. 2, 2018, now Pat. No. 10,098,546, which is a continuation of application No. 15/686,198, filed on Aug. 25, 2017, now Pat. No. 9,861,286, which is a continuation of application No. 15/357,136, filed on Nov. 21, 2016, now Pat. No. 9,757,040, which is a continuation

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of application No. 14/651,367, filed as application No. PCT/US2013/075736 on Dec. 17, 2013, now Pat. No. 9,500,635. I have considered this file history.

5. I understand that the '475 patent claims a priority date based on the following provisional patent applications: Provisional application No. 61/747,472, filed on Dec. 31, 2012, provisional application No. 61/747,553, filed on Dec. 31, 2012, provisional application No. 61/747,487, filed on Dec. 31, 2012, provisional application No. 61/747,477, filed on Dec. 31, 2012, provisional application No. 61/754,698, filed on Jan. 21, 2013. I have been asked to assume that the Challenged Claims are entitled to the December 17, 2013 priority date for the purposes of rendering my opinions in this declaration. In IPR2025-01254 where I am providing substantively identical opinions regarding the same Challenged Claims, I was instead asked to assume that the Challenged Claims are entitled to the December 31, 2012 filing dates of the earliest filed provisional application for the purposes of rendering my opinions therein. I have not been asked to opine on whether the Challenged Claims of the '475 patent are entitled to either priority date, and do not provide any opinion on that subject for the purpose of this Declaration. My opinions regarding the Challenged Claims remain the same regardless of whether the '475 is entitled to the December 31, 2012 or December 17, 2013 priority dates.

6. My analysis and conclusions set forth in this declaration are based on my educational background and experiences in the field (Section II). I am qualified

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to opine concerning what a person of ordinary skill in the art would have known and understood during that time. Before December 17, 2013, 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 '475 patent's purported invention. My analysis and conclusions herein are from the perspective of a person of ordinary skill in the art as of December 17, 2013.

7. As part of my independent analysis for this declaration, I have considered the following: the background knowledge/technologies that were commonly known to persons of ordinary skill in the art during the time before the earliest claimed priority date for the '475 patent; my own knowledge and experiences gained from my work experience in the field of the '475 patent and related disciplines; and my experience in working with others involved in this field and related disciplines.

8. 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 No. 9,241,676 (“Lisogurski”)** to Daniel Lisogurski et al., titled “Methods and systems for power optimization in a medical device,” filed on May 31, 2012, published on December 5, 2013 and granted on January 26, 2016. I understand that a copy of this reference has been

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designated as Exhibit 1025. Throughout my declaration, references to **Lisogurski** are to Exhibit 1025.

- **U.S. Patent Application Publication No. 2010/0217102 (“LeBoeuf”)** to Steven Francis LeBoeuf et al., titled “Light-guiding devices and monitoring devices incorporating same,” filed on January 21, 2010 and published on August 26, 2010. I understand that a copy of this reference has been designated as Exhibit 1026. Throughout my declaration, references to **LeBoeuf** are to Exhibit 1026.
- **U.S. Patent No. 8,108,036 (“Tran”)** to Bao Tran, titled “Mesh network stroke monitoring appliance,” filed on June 18, 2009, published on December 24, 2009, and granted on January 31, 2012. I understand that a copy of this reference has been designated as Exhibit 1027. Throughout my declaration, references to **Tran** are to Exhibit 1027.
- **U.S. Patent Application Publication No. 2005/0049468 (“Carlson”)** to Sven-Erik Carlson et al., titled “Increasing the performance of an optical pulsoximeter,” filed on September 3, 2003 and published on March 3, 2005. I understand that a copy of this reference has been designated as Exhibit 1028. Throughout my declaration, references to **Carlson** are to Exhibit 1028.

9. I note that I previously submitted expert declarations in support of a prior IPR challenging limitations of Patent Nos. 9,651,533 (the “’533 patent”) and 10,517,484 (the “’484 patent”), which I understand have been designated as Exhibits 1081 and 1082, respectively, on behalf of Petitioner Apple Inc. in IPR2019-00916 (“the prior ’533 IPR”) and IPR2021-00453 (“the prior ’484 IPR”), which I understand have been designated as Exhibits 1004 and 1010, respectively. See Ex. 1004 (Declaration of Brian Anthony, Ph.D. Regarding U.S. Patent No. 9,651,533, herein “’533-Anthony”); 1010 (Declaration of Brian Anthony, Ph.D. Regarding U.S. Patent No. 10,517,484, herein “’484-Anthony”). As discussed

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below, certain claim limitations challenged in those proceedings are identical and/or substantially identical to the Challenged Claims of the '475 patent. Accordingly, for purposes of this Declaration, I refer to my declaration submitted in the prior '533 IPR, as my "Prior '533 Declaration," and my declaration submitted in the prior '484 IPR as my "Prior '484 Declaration," as applicable. Additionally, in this Declaration, I refer to the Board's Final Written Decision in the prior '533 IPR as "'533-FWD," which I understand has been designated as Exhibit 1008, and the Final Written Decision and Final Written Decision on Remand in the prior '484 IPR as "'484-FWD" and "'484-RFWD," which I understand have been designated as Exhibits 1015 and 1016, respectively.

10. In my Prior '533 Declaration, I opined that claims 5, 7-10, 13, and 15-17 of the '533 patent were obvious based on three independent grounds: **Lisogurski**; **Lisogurski** in view of **Carlson**, and; **Lisogurski** in view of **Carlson** and U.S. Patent No 5,746,206. '533-Anthony, ¶¶87-204. I understand that the Board considered my Prior '533 Declaration and ultimately held that all claims challenged in the prior '533 IPR were unpatentable based on those three grounds. '533-FWD, 50-51. I understand that the Federal Circuit, in its decision that I understand has been designated as Exhibit 1009, affirmed the Board's decision holding these unpatentable, and those claims are now cancelled. *See Ex. 1009 (Omni MedSci, Inc. v. Apple Inc., No. 21-01229, ECF 69 (Fed. Cir. June 8, 2022))* (the Federal Circuit's

statement that it “AFFIRMED” the Board’s decision in the prior ’533 IPR). I understand that in the prior ’533 IPR, the Board relied on the embodiments of **Lisogurski** Figures 1 and 3, as modified (Section IX.A.2). Those are the embodiments I rely on in this declaration as set forth below.

11. In my Prior ’484 Declaration, I opined that claims 1-23 of the ’484 patent were obvious based on five independent grounds: (1) **Lisogurski** alone; (2) **Lisogurski** in view of **Carlson**; (3) **Lisogurski** in view of **Carlson** and **Tran**; (4) **Lisogurski** in view of **Carlson**, **Tran**, and U.S. Patent No. 8,725,226; and (5) **Lisogurski** in view of **Carlson**, **Tran**, U.S. Patent Publication No. 2012/0197093, with or without U.S. Patent No. 8,725,226. ’484-Anthony, ¶¶87-273. I understand that the Board considered my Prior ’484 Declaration and originally held that only claims 1, 2, 7 15-23 challenged in the prior ’484 IPR were unpatentable based on those five grounds. ’484-FWD, 60-61. I understand that, following the Federal Circuit’s remand, the Board ultimately found that all challenged claims 1-23 in the prior ’484 IPR were unpatentable based on the same grounds and in consideration of my opinion. ’484-RFWD, 12-13. I understand that in the prior ’484 IPR, the Board relied on the embodiments of **Lisogurski** Figures 1 and 3, as modified (Section IX.A.2). Those are the embodiments I rely on in this declaration as set forth below.

12. As I explain further below in Sections IX.A to IX.D, it is my opinion

that **Lisogurski** alone renders obvious Challenged Claims 1, 6-8, and 11-13 of the '475 patent (Ground 1, see my discussion in Section IX.A); **Lisogurski** in view of **Tran** renders obvious Challenged Claims 5 and 7 of the '475 patent (Ground 2, see my discussion in Section IX.B); **Lisogurski** in view of **Tran** and **LeBoeuf** renders obvious Challenged Claims 6-7 of the '475 patent (Grounds 3-4, see my discussion in Section IX.C); and Grounds 1-4 in further view of **Carlson** additionally render obvious Claims 1, 5-8, 11-13 (Grounds 5-8, see my discussion in Section IX.D).

13. I understand that there are pending district court litigations between Petitioners Samsung Electronics Co. Ltd., Samsung Electronics America Inc., Fossil Group, Inc., Fossil Stores I, Inc., Fossil Partners, L.P., Oura Health Oy, and OnePlus Technology (Shenzhen) Co., Ltd. and Omni Medsci, Inc. ("Texas Case") as well as Omni MedSci, Inc. and Whoop, Inc. ("Delaware Case") involving the '475 patent. I also understand that the '484 patent, which is related to the '475 patent, is subject to the following appeal: *Omni Medsci, Inc. v. Apple, Inc.*, No. 25-1646 (Fed. Cir.).

14. I am being compensated by Samsung at my standard hourly consulting rate of \$500 for my time on this matter. My compensation is not dependent on the outcome of this proceeding or any other proceeding between the parties.

15. 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.

II. QUALIFICATIONS

16. A detailed record of my professional qualifications, including a list of publications, awards, and professional activities, is set forth in my curriculum vitae attached to this report as **Appendix A**.

17. I am qualified by education and experience to testify as an expert in the field of physiological measurement system and devices. Additionally, the following overview of my background pertains to my qualifications for providing expert testimony in this matter. I am over the age of 18 and am competent to write this declaration. I have personal knowledge, or have developed knowledge, of these technologies based upon education, training, or experience of the matters set forth herein.

18. I earned a Bachelor of Science in Engineering from Carnegie Mellon University in 1994 and a Master's degree in Engineering from MIT in 1998. My thesis topic related to anisotropic wave guides and acoustic non-destructive testing.

In 2006, I earned my Ph.D. in Engineering from MIT. My research focused on high-performance computation, signal processing, and electro-mechanical system design.

19. In 1997, I co-founded Xcitex Inc., a company that specialized in video-acquisition and motion-analysis software. I served as the Chief Technology Officer and directed and managed product development until 2006. Our first demo product was an optical ring for human motion measurement used to capture user hand motion in order to control the user's interaction with a computer. Many of the structural elements of our optical ring addressed the same system issues as those described and claimed in the patent at issue. For example, our optical ring included multiple light emitting diodes, multiple photodetectors, techniques for modulation and synchronization, noise reduction algorithms, and optical components for light blocking, light redirection, and light capture, and structural components for holding and geometrically arranging the various components. We estimated human hand-motion based on how that motion changed the detected light. In our application we did not try to eliminate motion artifact, we tried to measure it. In developing our ring, we considered well-known problems such as ambient light and noise, which are, unsurprisingly, also mentioned in the patent at issue. Motion Integrated Data Acquisition System (MiDAS) was our flagship video and data acquisition product which relied upon precise synchronization of multiple clocks for optical sensor and video acquisition, data acquisition, and external illumination.

20. I joined MIT in 2006 and was the Director of the Master of Engineering in Advance Manufacturing and Design Program for over ten years. The degree program covers four main components: Manufacturing Physics, Manufacturing Systems, Product Design, and Business Fundamentals. Many of the courses, projects, and papers my students undertake involve technologies relevant to the patent at issue, for example, sensor devices including non-invasive optical biosensors.

21. In 2011, I co-founded MIT's Medical Electronic Device Realization Center ("MEDRC") and currently serve as co-director. The MEDRC aims to create and deploy revolutionary medical technologies by collaborating with clinicians, the microelectronics, and medical devices industries. We combine expertise in computation; communications; optical, electrical, and ultrasound sensing technologies; and consumer electronics. We focus on the usability and productivity of medical devices using, for example, image and signal processing combined with intelligent computer systems to enhance practitioners' diagnostic intuition. Our research portfolio includes low power integrated circuits and systems, big data, micro electro-mechanical systems, bioelectronics, sensors, and microfluidics. Specific areas of innovation include wearable, non-invasive and minimally invasive optical biosensor devices, medical imaging, laboratory instrumentation, and the data communication from these devices and instruments to healthcare providers and

caregivers. My experience with these devices is directly applicable to the technology in the patent at issue. For example, in one current project related to this work, we use a patient-mounted mobile near infrared (NIR) camera to image and characterize the surface and subsurface structures of the skin.

22. I am also the Associate Director of MIT.nano, MIT's new 200,000 sq-ft nanofabrication and characterization facility. One of the major research initiatives with MIT.nano focuses on sensors and sensing systems. Our research in sensing science and sensing engineering is targeting innovations in advanced manufacturing, healthcare, environmental remediation, smart infrastructure, and the creation of advanced machines and materials. I also co-founded the Center for Polymer Micro-fabrication at MIT. The Center's research focuses on polymer-based manufacturing processes and the large-scale commercialization of micro fluidic devices for chemical, biomedical, and photonic applications. My experience under these initiatives is directly applicable to the technology in the patent at issue. We develop optical sensors to noninvasively monitor soft flexible materials during the manufacturing process.

23. Furthermore, my research focuses on computational instrumentation, including the development of instrumentation and measurement solutions for manufacturing systems and medical devices. Additionally, my teaching interests include the design and modeling of large-scale systems in a wide variety of decision-

making domains and developing optimization algorithms and software for analyzing and designing such systems. I teach or have taught courses in Electrical Engineering, Controls, Optics, and Signal Processing, all pertinent subject matter to the patent at issue.

24. I have published over 100 papers, and have received a number of best paper and distinguished paper awards. I am a co-author of a number of papers that relate to the technology in the patent at issue.

III. LEGAL UNDERSTANDING

25. I am not an attorney and offer no legal opinions, but in the course of my work, I have had experience studying and analyzing patents and patent claims from the perspective of a person skilled in the art.

26. I have been informed of certain legal concepts relevant to my opinions. In formulating my opinions, I have relied on my understanding of these legal concepts I have been provided with as set forth in this declaration.

27. I have been informed that in post grant review proceedings, invalidity must be shown under a preponderance of the evidence standard.

A. My Understanding of Claim Construction

28. I have been informed that patent claims are construed from the viewpoint of a person of ordinary skill in the art of the patent at the time of the invention. I have been informed that patent claims generally should be interpreted

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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).

29. 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.

30. 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

31. I understand that a patent claim is invalid as “anticipated” if all the limitations of the claim are present, either expressly or inherently, in a single prior art publication or patent.

32. 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 have been informed 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.

33. I have further been informed that where a reference discloses multiple embodiments, the reference should not be limited to a preferred embodiment. Instead, each disclosed embodiment may anticipate.

34. Moreover, I have been informed that as part of an anticipation analysis, it is proper to take into account not only specific teachings of the reference, but also the inferences that one skilled in the art would reasonably be expected to draw therefrom. A reference can anticipate a claim even if it does not expressly spell out all the limitations arranged or combined as in the claim, if a person of skill in the art, reading the reference, would at once envisage the claimed arrangement or combination.

C. My Understanding of Obviousness

35. 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.

36. 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.

37. 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.

38. I have also been advised that in considering whether a claimed invention would have been 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;

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- 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.

39. 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

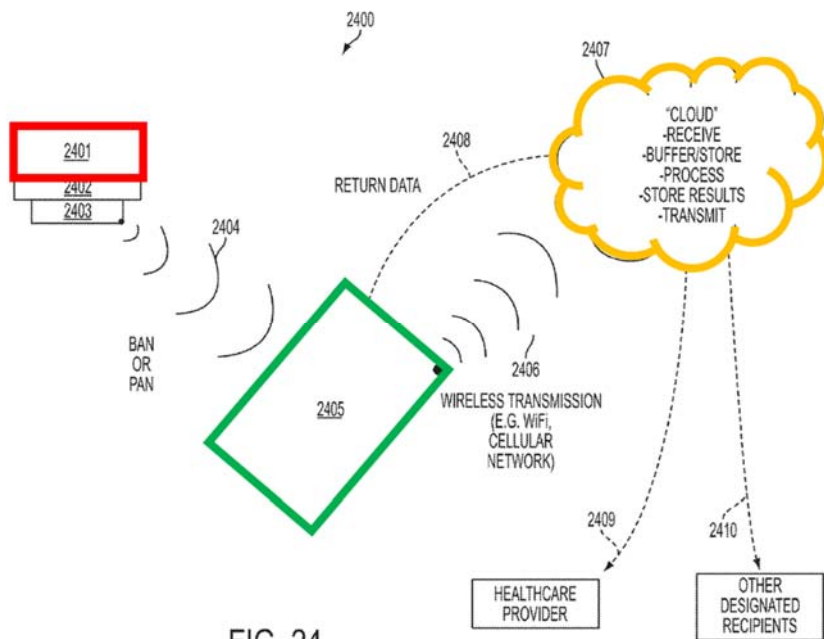
“nexus”) between the claim and the evidence, and that this nexus must be based on a novel element of the claim rather than something in the prior art. I also understand that even when they are present, secondary considerations may be unable to overcome primary evidence of obviousness (such as motivation to combine with predictable results) that is sufficiently strong.

IV. BACKGROUND OF THE TECHNOLOGY

40. In my Prior '533 and '484 Declarations, I provided a discussion of the “Technical Background” for the '533 and '484 patents, both of which I incorporate by reference as if fully stated herein. See '533-Anthony, ¶¶37-56 (discussing “Photoplethysmography” and “Industry Trends”); '484-Declaration ¶¶37-56 (discussing the same).

41. As discussed in Section V, the '475 patent is generally directed to a physiological measurement system comprising a wearable **measurement device** with light sources and detectors to generate an output signal with physiological parameters to be transmitted to a **smart phone/tablet**, and common techniques to improve signal-to-noise ratios of such signals. '475 patent, 20:59-21:13 (describing technique for “measuring a particular blood constituent” and “methods of improving the ability to discriminate between different constituents”), 35:32-37:4 (describing “the physiological measurement device that ... communicate[s] over a first communication link ... to a smart phone[or] tablet cell phone” “which ... operate[s]

through the use of one of many wireless technologies”), 58:1-22 (describing the advantages of “us[ing] ... an active illuminator,” which includes, among other advantages, the benefit of “factor[ing] out” the “variations due to sunlight and time-of-day” as well as “us[ing] modulation and lock-in techniques” and “modulat[ing]” the light source so that “higher signal-to-noise ratios may be achieved”), 70:8-27 (same), 79:7-13 (describing that in order to “permit higher signal-to-noise levels,” a “higher intensity or brightness of light sources may be used”).



'475 patent, FIG. 24.

42. In my opinion, and as further discussed below, the '475 patent recites claim limitations that are identical and/or substantially identical to those in U.S. the '533 patent and the '484 patent. Sections IX.A-D. As I opined in '533 and

'484 IPRs, such wearable measurement system and devices were well known in the art prior to the '475 patent's priority date. '533-Anthony, ¶¶37-56; '484-Anthony, ¶¶37-56.

43. While the '475 patent claims include additional limitations, they at most recite a wearable device's common locations, measurements, configurations and components, along with methods for using such a device (Sections IX.A-D). For the reasons I have further discussed below, all such additional limitations were well-known in the art (Sections IX.A-D).

V. THE '475 PATENT

A. '475 Patent Overview

44. Figure 24 of the '475 patent, annotated and reproduced below, shows an embodiment of the physiological measurement system to which the '475 patent is directed:

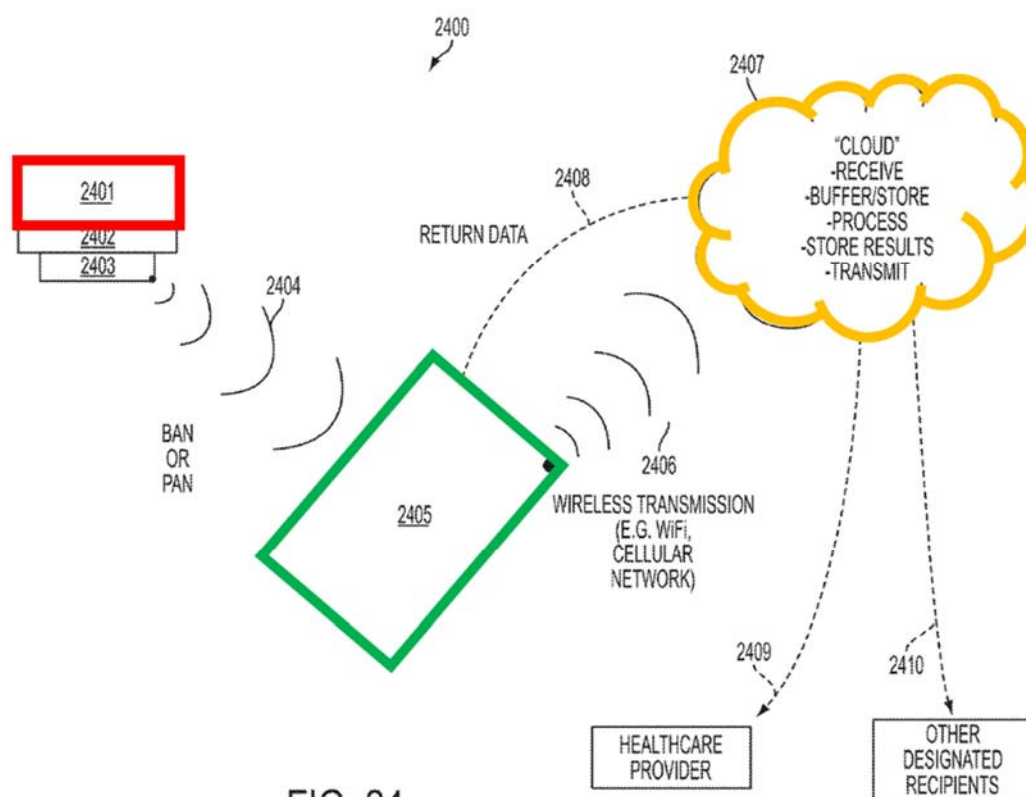


FIG. 24

'475 patent, 35:32-37:4. (describing “a particular embodiment 2400” of “the physiological measurement device”). The wearable **physiological measurement device 2401** comprises “a processor 2402” to “process some of the physiological data” and “a transmitter 2403 to communicate measurements over a first communication link 2404 ... to a receiver in a **smart phone[or] tablet cell phone ... 2405.**” '475 patent, 35:32-52. An “application program[or] software program” in **smart phone or tablet 2405** “receive[s] and process[es]” the measurements, and transmits “the processed data” to **cloud based server 2407**, which “processes the data” by using, e.g., pattern matching algorithms. See '475 patent, 35:53-37:4

(describing, that **cloud based server 2407** can process the data to determine “if the physiological parameters fall out of the acceptable range” and configure “alarms [to] be delivered” to alert a patient or other clinicians). The **wearable device 2401 comprises one or more biosensors that** can be placed on a user’s body to measure physiological parameters of the user by using a differential measurement, ’475 patent, 8:39-44. For example, one probe “may be placed over regions where there are more distinct veins” while a second probe “may be placed over a region with less prominent veins,” and the two probe signals are processed to remove interference due to “variability in the skin from environmental effects such as temperature, humidity, or pressure.” ’475 patent, 23:31-48. The physiological parameter can include a pulse rate, blood flow, and/or blood constituent. ’475 patent, 8:45-47, 17:34-18:11. The **wearable device 2401** further includes a light source comprises of a plurality of light emitting diodes configured to generate an output optical light with a plurality of optical wavelengths. ’475 patent, 8:47-50. The light source can be modulated. ’475 patent, 16:25-27, 58:5-19, 70:12-24, 74:26-46.

45. The **wearable device 2401** further comprises “one or more lenses” that receives and directs or delivers light from the semiconductor sources to a targeted region of the user’s tissue, and a detection system that receives the light reflected from the user’s tissue and generates an output signal having a signal-to-noise ratio. ’475 patent, 8:50-57. The detection system includes detectors that are spatially

separated from each other and, just like the semiconductor sources, can be “located on one or more arcs.” ’475 patent, 8:57-60.

46. The ’475 patent describes several common and well-known techniques to improve signal to noise ratio, including using increased light intensity, modulation, lock-in, and dark subtraction techniques. For example, the ’475 patent describes using a “higher light level or intensity [of light to] improve the signal-to-noise ratio for the measurement.” ’475 patent, 20:59-21:13, *see also* ’475 patent 79:7-13 (disclosing that using “higher intensity or brightness of light sources” to “permit higher signal-to-noise levels”). As another example, the ’475 patent describes “improv[ing] the signal-to-noise ratio” by “usi[ng] modulation and lock-in techniques,” which may include “modulat[ing] the light source,” using “narrow band filtering around the modulation frequency ... to reject noise outside the modulation,” and “differenc[ing]” the signal captured with the light source on and the signal captured with the light source off. ’475 patent, 58:1-22; *see also* ’475 patent, 70:8-27. In particular in some embodiments, the **wearable device** includes a processor to perform the differencing process described above. ’475 patent, 8:64-9:3, 9:13-26. Finally, the **wearable device** can detect, based on the output signal, whether or not it is being worn by a user, and, in some embodiments, this functionality is performed by a processor. ’475 patent, 9:4-5, 9:13-28.

B. The Prosecution History

47. In formulating my opinions, I considered the contents of the prosecution history of the '475 patent, a copy of which I understand has been designated as Exhibit 1002.

48. The '475 issued from U.S. Pat. App. 18/927,698, which was filed October 25, 2024. The Applicant filed a Terminal Disclaimer on January 28, 2025 in view of several other applications or patents in the patent family, including Application Nos. 18/899,012 18/891,970 and U.S. Patent Nos. 12,193,790, 11,896,346, 9,494,567, 9,993,159, 10,441,176, 11,564,577, 9,500,635, 9,164,032, and 9,500,634. '475FH, 1082-84. The Terminal Disclaimer was filed one day after an Examiner initiated interview where, according to meeting notes, the Applicant's representative was told that "the application would be in condition for allowance," if the Applicant were to "file the terminal disclaimer." '475FH, 1090. The pending claims were then allowed (i.e., the Examiner issued a Notice of Allowance) on February 13, 2025 without any amendments to the claims or any Office Actions. '475FH, 1199-1204.

49. In the Notice of Allowance, the Examiner provided a statement of reasons for allowance, noting that the prior art does not disclose or render obvious: "output...indicative of...physiological parameters," "increase the signal-to-noise ratio by increasing intensity of...light emitting diodes," "increase...signal-to-noise

ratio by comparing the first signal [responsive to light when LEDs are off] and the second signal [responsive to light when LEDs are on],” “determine...that the apparatus is being worn by the user,” “generate a third output signal using...[a] first output signal [having a first signal-to-noise ratio]...and [a] second output signal [having a second signal-to-noise ratio and responsive to the light source being off and the detector receiving ambient light],” “third output signal having a third signal-to-noise ratio that is greater than the first [and second] output signal[s],” “third output signal being associated with a physiological parameter,” and “determine, based...on the third output signal, that the wearable device is being worn by the user.” ’475FH, 1199-1204.

50. For the reasons I discuss in more detail below, **Lisogurski** alone or in view of **Tran**, **LeBoeuf**, and/or **Carlson** discloses these limitations (Sections IX.A-D).

VI. LEVEL OF ORDINARY SKILL IN THE ART

51. 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 having 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 having 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 having ordinary skill in the art would also have knowledge from the teachings of the prior art including the art cited below.

52. I have been asked to assume the Challenged Claims are entitled to the December 17, 2013 priority date for the purposes of this declaration only. Upon consideration of the relevant factors listed above, in my opinion, on or before the priority date, a person of ordinary skill in the art, at the time the application that matured into the '475 patent was filed, would have had a good working knowledge of optical sensing techniques and their applications, and some familiarity with optical system design and signal processing techniques. That knowledge would have been gained via an undergraduate education in engineering (electrical, mechanical, biomedical or optical) or a related field of study, along with relevant experience in studying or developing physiological monitoring devices (e.g., non-invasive optical biosensors) in industry or academia. This description is approximate; varying combinations of education and practical experience also would be sufficient.

53. This is the same level of ordinary skill in the art as I opined for the '484 and '533 patents in the prior '533 and '484 IPRs, which the Board adopted.

'484-Anthony, ¶35; '533-Anthony, ¶35; '533-FWD, at 8-9; '484-Inst., at 7-8; '484-FWD, at 11 n.7.

54. Well before December 17, 2013, my level of skill in the art was at least that of a person having ordinary skill. I am qualified to opine concerning what a person having ordinary skill in the art would have known and understood at the time of the '475 patent's purported invention. My analysis and conclusions herein are from the perspective of a person having ordinary skill in the art as of December 17, 2013. A different priority date would not change my opinions as long as the identified prior art were still prior art.

VII. CLAIM CONSTRUCTION

55. I have been instructed that the Challenged Claims of the '475 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, except as provided below. I have followed these principles in my analysis set forth in this document. I reserve the right to supplement my opinions in this declaration to the extent that any parties later propose claim constructions for any claim terms in the '475 patent.

A. “modulating”/“modulation” limitations ([13])

56. I understand that prior to the Board's '533-FWD, in two Eastern District of Texas cases—*Omni MedSci, Inc. v. Apple Inc.*, 2:18-cv-00134 (E.D.

Tex.), and *Omni MedSci, Inc. v. Apple Inc.*, 2:18-cv-00429 (E.D. Tex.) (“EDTX Cases”)—the district court (in its decisions that I understand have been designated as Exhibits 1018 and 1019, respectively) determined that the term “modulating at least one of the LEDs” to mean “varying the amplitude, frequency, or phase of the light produced by at least one of the LEDs to include information.” See Ex. 1018, 13-16; Ex. 1019, 15-19. In IPR2019-00914, I understand that the petitioner proposed the same construction, and I adopted that construction in providing my opinion. Ex 1083, ¶66. I understand that the Board adopted the same construction. *Apple Inc. v. Omni Medsci, Inc.*, IPR2019-00914, Paper 13 at 9-11 (Nov. 6, 2019).

57. For the reasons I discuss below, the prior art discloses this limitation under the district court’s construction previously adopted by the Board and under the plain and ordinary meaning of the term (Section IX.A.3.bb.[13]), to the extent there is any difference between them.

B. Additional Terms Discussed in ’484 and ’533 IPRs

58. In the prior ’533 IPR, I opined that a person of ordinary skill in the art would have understood the term “a plurality of lenses” to mean “a plurality of transparent surfaces used to collimate (make parallel) or focus rays of light” in the context of the ’533 patent. ’533-Anthony, ¶65.

59. I understand that in the prior ’533 IPR, the petitioner proposed construing “plurality of lenses,” which the Board declined to construe. ’533-FWD,

9-10.

60. In the prior '484 IPR, I did not opine on the meaning of “lens,” however I opined that a person of ordinary skill in the art would have understood the term “optical light” to mean “photons or light transmitted to a particular location in space” in the context of the '484 patent. '484-Anthony, ¶64.

61. In the prior '484 IPR, I understand that the petitioner proposed construing “optical light,” and informed the Board of its proposed construction for “lens” in a parallel district court case, Patent Owner did not propose constructions for these terms, and the Board declined to construe them. '484-FWD, 7-8.

62. The Board in '533 and '484-IPRs did not construe any other claim present in the '475 patent.

63. For the purposes of this Declaration, I have been instructed to adopt plain and ordinary meanings of those terms. Regardless, for the reasons I discuss below, the prior art discloses these limitations both under the plain and ordinary meaning of the terms and under the constructions that I proposed previously, to the extent there is any difference between them and the plain and ordinary meaning (Sections IX.A.3.g-h.[1.f]-[1.g], IX.A.3.t.[8.b], IX.A.3.v.[8.d]; IX.D.3.a).

C. Prior District Court Constructions

64. I understand that in the EDTX Cases, the district court determined that the term “lenses” should be given its “plain and ordinary meaning without the need

for further construction.” Ex. 1018, at 10-13 (construing “lenses” to have “its plain and ordinary meaning without the need for further construction.”); Ex. 1019, at 12-15 (construing “lens” and “lenses” to have their “plain and ordinary meanings without the need for further construction”).

65. For the purposes of this Declaration, I have been instructed to adopt the plain and ordinary meaning of those terms for my analysis. For the reasons I discuss below, the prior art discloses this limitation under the plain and ordinary meaning of the terms (Sections IX.A.3.g-h.[1.f]-[1.g], IX.A.3.t.[8.b], IX.A.3.v.[8.d]; IX.D.3.a).

D. Terms at Issue in the Texas Case

66. I understand that, in their Supplemental Invalidity and Subject Matter Eligibility Contentions served in the Texas Case between Petitioners and Patent Owner, which I understand has been designated as Exhibit 1023, Defendants (including Petitioners) identified the following limitations of the Challenged Claims as potentially indefinite:

- differential measurement (claim 1)
- a plurality of detectors that are spatially separated from each other (claim 1)
- increase the signal-to-noise ratio by comparing the first signal and the second signal (claim 1)
- wherein the detection system is configured to be synchronized to the light source (claim 1)

- configured to use artificial intelligence in making decisions associated with at least a portion of the output signal (claim 5)
- plurality of detectors arranged along an arc (claim 6)

Ex. 1023, 247-248.

67. For the purposes of this Declaration, I do not take a position on whether these terms are indefinite. And, regardless of the outer bounds of these limitations, for the reasons discussed below in Sections IX.A-C, these limitations are still disclosed and rendered obvious by the prior art because the prior art discloses and renders obvious embodiments within the indisputable scope of these limitations.

VIII. GROUNDS OF UNPATENTABILITY

68. As I explain above in Section IV, physiological measurement systems were well-known in the art.

69. In this section, I will explain why the teachings or combinations of teachings from the following references render obvious each of the Challenged Claims:

Name	Ex.	Publication	Filed	Published/ Issued
Lisogurski	1025	US 9,241,676	5/31/2012	1/26/2016
LeBoeuf	1026	US 2010/0217102	1/21/2010	8/26/2010
Tran	1027	US 8,108,036	6/18/2009	1/31/2012
Carlson	1028	US 2005/0049468	9/3/2003	3/3/2005

I have been instructed to assume that each of these references qualifies as prior art.

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

- **Ground 1:** Challenged Claims 1, 6-8, and 11-13 of the '475 patent are rendered obvious by **Lisogurski**.
- **Ground 2:** Challenged Claims 5 and 7 of the '475 patent are rendered obvious by **Lisogurski** in view of **Tran**.
- **Grounds 3-4:** Challenged Claims 6-7 of the '475 patent are rendered obvious by **Ground 1-2** in further view of **LeBoeuf**.
- **Grounds 5-8:** Challenged Claims 1, 5-8, and 11-13 of the '475 patent are rendered obvious by **Grounds 1-4** in further view of **Carlson**.

IX. SPECIFIC GROUNDS FOR CHALLENGE

71. It is my opinion that Challenged Claims of the '475 patent are unpatentable as explained below. As I explain above in Section IV, although the '475 patent purports to have invented a physiological measurement system, such devices were well-known in the art. As described below, the cited prior art provides these teachings.

72. In this section, I explain why claims 1, 5-8, and 11-13 of the '475 patent are rendered obvious by the teachings of **Lisogurski**, **Tran**, **LeBoeuf**, and **Carlson**. Regarding all Grounds, **Lisogurski** teaches a wearable apparatus for measuring physiological parameters including a light source, lenses, and detection system, and where the measurement system includes means of improving signal-noise-ratios and

detecting whether its being worn by a user. Regarding Ground 2, both **Lisogurski** and **Tran** teach the use of a physiological monitoring system for use with a smart phone, while **Tran** teaches the use of artificial intelligence for signal processing. Regarding Grounds 3-4, **LeBoeuf** further teaches the arrangement of optical emitters and detectors in an arc. Regarding Grounds 5-8, **Carlson** further teaches the use of lenses in a physiological monitoring system.

73. 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: Lisogurski (Claims 1, 8, and 11)

1. Overview of Lisogurski

74. **Lisogurski** discloses a “medical device,” specifically a “physiological monitoring system [that] monitor[s] one or more physiological parameters of a patient[by] ... using one or more physiological sensors.” **Lisogurski**, 3:44-46. The physiological parameters may include pulse rate, pulsatile flow, and parameters associated with various blood constituents, such as oxyhemoglobin. **Lisogurski**, 4:3-7, 4:15-20, 4:36-41. The physiological sensors may include a pulse oximeter with a “light sensor that is placed at a site on a patient, typically a fingertip, toe, forehead, [] earlobe, ... or ... a foot.” **Lisogurski**, 4:6-7. ’533-FWD, 12-13;

'484-FWD, 13. A person of ordinary skill in the art would have understood such disclosures as being consistent with standard, established physiological monitoring techniques and sensor placements.

75. **Lisogurski** further discloses measuring physiological parameters by placing “sensors at multiple locations” on the body. Lisogurski, 4:25-26, 17:51-53. **Lisogurski** also discloses the “detect[ion of] a signal indicative of a system error,” such as a “probe-off signal” or a signal indicative of a “physiologically impossible value.” Lisogurski, 36:66-37:2.

76. Figure 1 of **Lisogurski** is reproduced below:

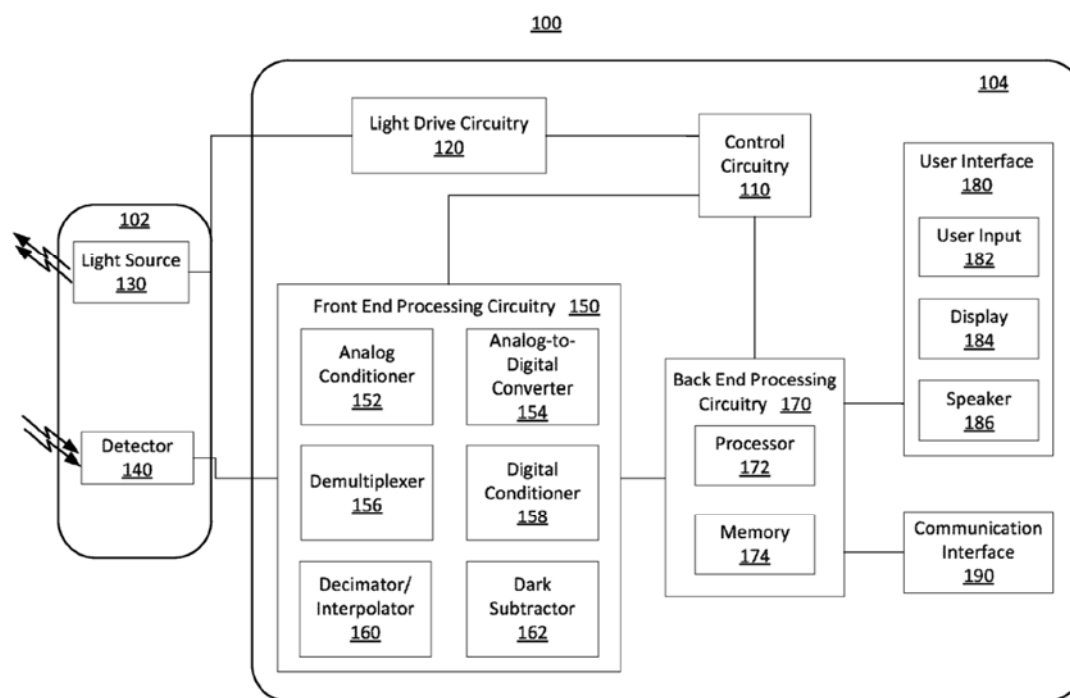


FIG. 1

77. **Lisogurski's** Figure 1 is a “block diagram of an illustrative

physiological monitoring system in accordance with some embodiments of the present disclosure.” Lisogurski, 2:11-13. The system includes “sensor 102,” which has “light source 130 and detector 140,” and “monitor 104” for “generating and processing physiological signals of a subject.” Lisogurski, 10:44-49. Light source 130 “emit[s] photonic signals having one or more wavelengths of light,” including red light and IR light, “into a subject’s tissue.” Lisogurski, 10:49-52. “[L]ight source includes a Red light emitting light source and an IR light emitting light source, e.g., Red and IR light emitting diodes (LEDs). Lisogurski, 10:52-56. The “Red wavelength” is “between 600 nm and about 700 nm” and the “IR wavelength” is “between about 800 nm and about 1000 nm.” Lisogurski, 10:52-11:8. Spatially separated detectors 140 “detect the intensity of light,” for example, “the intensity of light at the Red and IR wavelengths,” after the light “pass[es] through the subject’s tissue.” Lisogurski, 11:9-14. After detectors 140 receive the light, they then “convert[]” it to an electrical signal, and “send the detection signal to monitor 104, where the detection signal [is] ... processed [to determine] physiological parameters.” Lisogurski, 11:14-23. The light that is received by the detectors is “directly related to the absorbance and/or reflectance of light in the issue,” such that “when more light at a certain wavelength is absorbed or reflected, less light of that wavelength is received from, the tissue by detector[s] 140.” Lisogurski, 11:16-20; *see also* Lisogurski, 17:40-45 (“One or more detector 318 may also be provided in

sensor unit 312 for detecting the light that is reflected by or has traveled through the subject's tissue.”). ’533-FWD, 15-16; ’484-FWD, 15-16. A person of ordinary skill in the art would have understood that **Lisogurski’s** configuration is consistent with a common pulse oximeter system widely adopted in the field of non-invasive physiological monitoring as of the priority date of the ’475 patent. A person of ordinary skill in the art would have been familiar with the well-established physical principle underlying pulse oximetry—that is, changes in absorption and reflection of selected wavelengths correlate with physiological parameters like oxygen saturation levels in arterial blood. Furthermore, the conversion of the detected optical signals into electrical signals, and their subsequent processing to yield relevant physiological parameters, are routine operations and align with conventional designs in wearable medical sensors used at the time.

78. Monitor 104 includes several components, including “user interface 180,” “communication interface 190,” and various circuitry components, such as “control circuitry 110,” “light drive circuitry 120,” “front end processing circuitry 150,” and “back end processing circuitry 170.” Lisogurski, 11:28-32. “Control circuitry 110” controls “light drive circuitry 120.” Lisogurski, 11:33-36 (disclosing that control circuitry 110 is “coupled” to light drive circuitry 120 and that it is “configured to control [its] operation”). ’533-FWD, 16; ’484-FWD, 16.

79. “Light drive circuitry 120 ... generate[s] a light drive signal, which is

used to turn on and off light source 130, based on timing control signals.” Lisogurski, 11:38-54. “Light drive circuitry 120” also controls the intensity of light source 130. Lisogurski, 11:52-54. ’533-FWD, 16; ’484-FWD, 16.

80. “Front end processing circuitry 150” (1) operates “synchronously with light drive circuitry 120,” (2) “receive[s] a detection signal from detector 140,” (3) “processes the output signal of detector 140,” (4) provide[s] one or more processed signals to back end processing circuitry 170,” and (5) “synchronize[s] the operation of an analog-to-digital converter ... with the light drive signal based on the timing control signals.” Lisogurski, 11:40-46, 12:42-48. ’533-FWD, 16; ’484-FWD, 16. A person of ordinary skill in the art would have recognized the synchronization of front-end processing circuitry, particularly the analog-to-digital conversion and initial signal conditioning, with the operation of the optical source drive circuitry as common practice. Such synchronization significantly enhances accuracy and repeatability by ensuring consistent timing alignment between optical emission and measurement acquisition.

81. “[B]ackend processing circuitry 170” includes “processor 172 and memory 174.” Lisogurski, 14:56-57. “[B]ackend processing circuitry 170” “receive[s] and process[es] physiological signals received from front end processing circuitry 150” to “determine one or more physiological parameters based on the received physiological signals.” Lisogurski, 14:56-64. Moreover, backend

processing circuitry 170 is “communicatively coupled [to] use[r] interface 180 and communication interface 190.” Lisogurski, 15:16-18. **Lisogurski’s** backend processing circuitry 170 is consistent with the standard practice supporting user interactions and data integration with other systems.

82. “User interface 180” includes various components, including “user input 182, display 184, and speaker 186,” and may include “a keyboard, a mouse, a touch screen, buttons, switches, [and] a microphone[,] ... or any other suitable input device.” Lisogurski, 15:19-22. ’533-FWD, 17; ’484-FWD, 16-17.

83. “Communication interface 190” allows “monitor 104 to exchange information with external devices,” and includes “one or more receivers, transmitters, transceivers, antennas, plug-in connectors, ports, communication buses, communication protocols, device identification protocols, any other suitable hardware or software, or any combination thereof” to allow “wireless communication.” Lisogurski, 15:43-57. ’533-FWD, 17; ’484-FWD, 16-17.

84. **Lisogurski** further discloses that “the components of physiological monitoring system 100 are shown and described as separate components for illustrative purposes only” and that: (1) “the functionality of some of the components may be combined in a single component” and (2) “the functionality of some of the components ... may be divided over multiple components.” Lisogurski, 15:66-16:9. **Lisogurski** goes on to explain that: “[f]or example, some or all of the functionality

of control circuitry 110 may be performed in front end processing circuitry 150, in back end processing circuitry 170, or both.” Lisogurski, 16:9-12. As another example, “all of the components of physiological monitoring system 100 can be realized in processor circuitry.” Lisogurski, 16:14-16. ’533-FWD, 15; ’484-FWD, 17. A person of ordinary skill in the art would have recognized that **Lisogurski’s** disclosure of combining and dividing functionality among electronic components (such as control, front-end processing, and backend processing) was a common practice, based on design engineering considerations such as power management, miniaturization, reliability, and manufacturability.

85. **Lisogurski’s** Figure 3, reproduced below, is “a perspective view of an embodiment of a physiological monitoring system.” Lisogurski, 2:23-25. The system includes several components, such as “sensor unit 312,” “monitor 314,” and a “multi-parameter physiological monitor 326” (“MPPM”). Lisogurski, 17:35-36, 18:44-45.

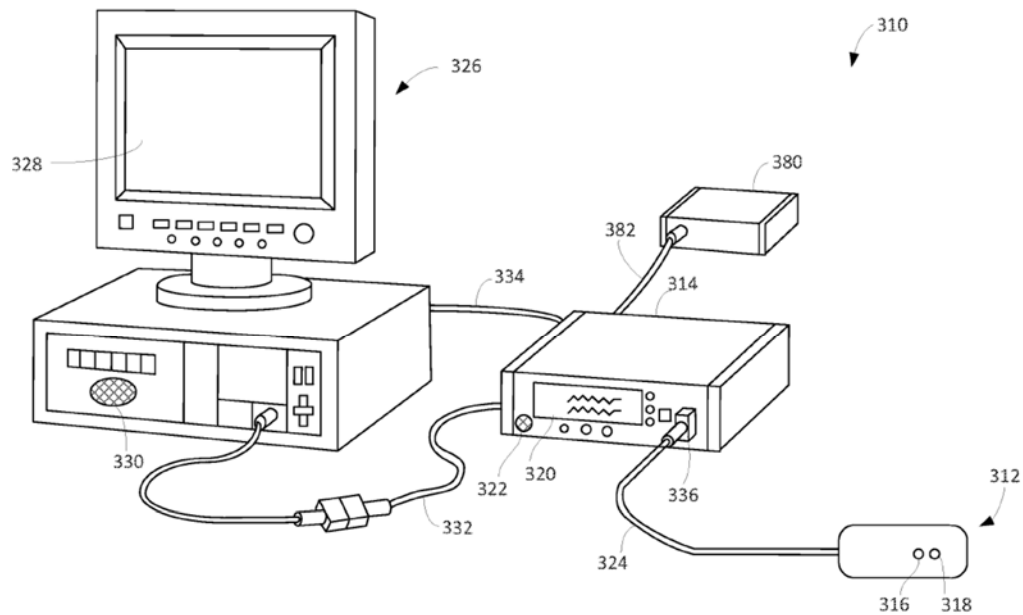


FIG. 3

86. **Lisogurski** discloses several embodiments of its physiological monitoring system, two of which are depicted in the block diagram of Figure 1 (Lisogurski, 2:11-13; element labelled “100”) and the perspective view of Figure 3 (Lisogurski, 2:23-25; element labelled “310”). Figure 3 is an exemplary application of the embodiment shown in Figure 1 and, therefore, a person of ordinary skill in the art would have understood that the disclosures in Figure 3 apply to the corresponding components or features in Figure 1. ’533-FWD, 13-15; ’484-FWD, 13-15.

87. **Lisogurski** further discloses that the system 310 in Figure 3 includes “one or more components of physiological monitoring system 100 of [Figure] 1,” such that a person of ordinary skill in the art would have understood (or at least found it obvious) that the analysis for other limitations relying on Figure 1 of **Lisogurski**

applies equally to **Lisogurski's** exemplary application shown in Figure 3. Lisogurski, 17:30-35. Indeed, **Lisogurski** explicitly discloses that “one or more components of physiological monitoring system 310 [depicted in Figure 3] may include one or more components of physiological monitoring system 100 [depicted in Figure 1].” Lisogurski, 17:30-35, 18:13-14. For example, monitor 314 (depicted in Figure 3) may be implemented as monitor 104 (depicted in Figure 1). Lisogurski, 17:30-35, 18:13-14. Sensor 312 and monitor 314 also include similar configurations as sensor 102 and monitor 104, respectively. Lisogurski, 17:37-62, 18:3-10, 19:25-27. '533-FWD, 13-15; '484-FWD, 13-15.

88. Monitor 314 is “communicatively coupled to” and “communicate[s] wirelessly” with MPPM 326. Lisogurski, 18:58-65. MPPM 326 “calculate[s] physiological parameters,” “provide[s] a display 328 for information from monitor 314,” is “coupled to a network to enable the sharing of information with servers or other workstations (not shown).” Lisogurski, 18:49-52, 18:62-65. The remote network servers “determine[s] physiological parameters” and “display[s] the determined physiological parameter[s]” on display 320 of monitor 314 (depicted in Figure 3), or display 328 of MPPM 326 (also depicted in Figure 3). Lisogurski, 20:53-58. '533-FWD, 13-15; '484-FWD, 13-15.

89. **Lisogurski** further discloses various methods for improving signal-to-noise ratio. For example, **Lisogurski** discloses: (1) modulating the light drive signal

to have a “period the same as or closely related to the period of [a] cardiac cycle, thus generating a cardiac cycle modulation,” (2) using a dark subtraction process to remove noise from the ambient light by “subtract[ing] the background or dark level from the levels received during red ‘on’ portion 274 and IR ‘on’ period 278”, and (3) varying parameters related to the light drive signal, including “drive current or light brightness, duty cycle, firing rate, modulation parameters, other suitable parameters, or any combination thereof.” Lisogurski, 6:7-19, 9:46-60, 13:60-14:10, 16:33-54, 25:49-55. ’533-FWD, 17; ’484-FWD, 17. A person of ordinary skill in the art would have understood these disclosed methods (cardiac-cycle modulation, dark subtraction, varying drive parameters) as common and well-understood strategies for improving signal-to-noise ratio and accuracy in photoplethysmography-based physiological wearable or ambulatory monitoring systems.

2. Motivation to Modify Lisogurski

90. A person of ordinary skill in the art would have been motivated to modify **Lisogurski’s** “physiological monitoring system 100” in order to place several components located within monitor 104—namely, **control circuitry 110**, **light drive circuitry 120**, and **front end processing circuitry 150**—to sensor 102, where **light source 130** is located. Figure 1 is reproduced below with annotations highlighting some of the components that I have described.

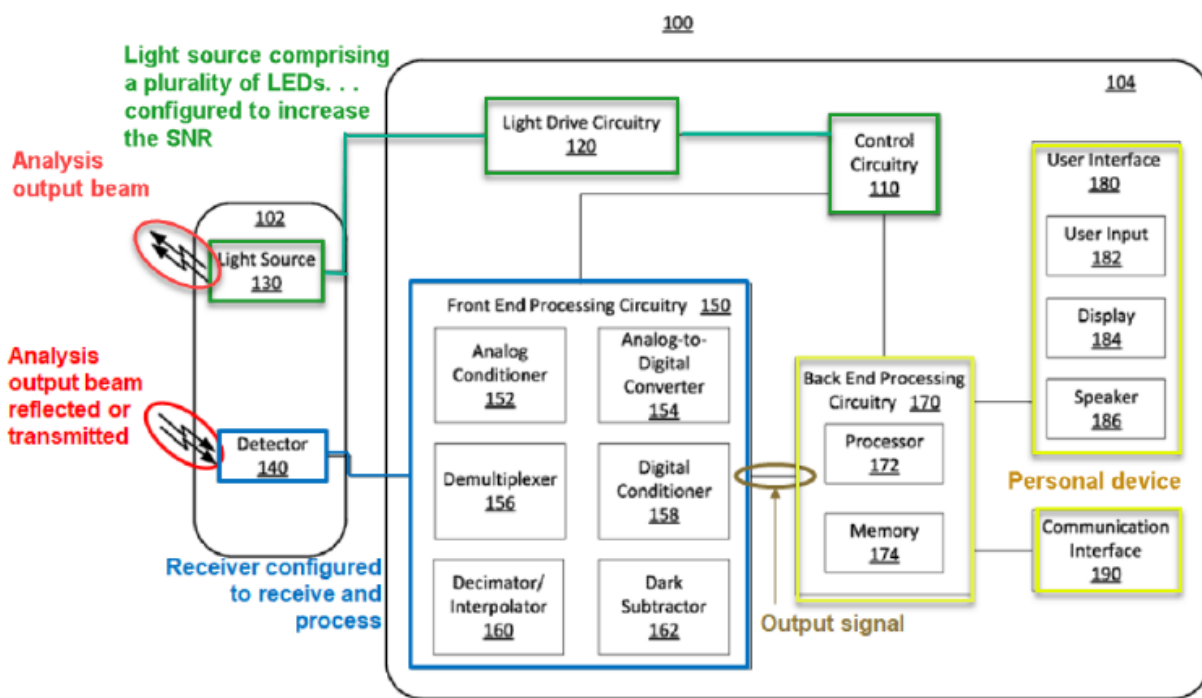


FIG. 1

91. As an initial matter, **Lisogurski** states that, even though the “components of physiological monitoring system 100 ... are shown and described as separate components are shown and described as such for illustrative purposes only,” such as in Figure 1, “the functionality of some of the components may be combined in a single component.” Lisogurski, 15:66-16:4. A person of ordinary skill in the art would have understood that this disclosure explicitly states that the functionality attributed to these separate components can, in practice, be integrated into a single combined unit. **Lisogurski** further discloses that “the functionality of some of the components of monitor 104 shown and described herein may be divided over multiple components.” Lisogurski, 16:6-9. A person of ordinary skill in the

art would have understood **Lisogurski's** disclosure of both integration and distribution allows customization and optimization of the system depending on specific design or implementation requirement considerations, such as portability, computational power, signal processing capabilities, or manufacturability.

92. As the Board found, “Lisogurski expressly suggests the modification by teaching embodiments in which ‘the functionality of some of the components may be combined in a single component’ and embodiments in which ‘the functionality of some of the components of monitor 104...may be divided over multiple components.’” ’533-FWD, 23 (quoting Lisogurski, 16:2-4, 16:7-9). As the Board further found, “numerous industry trends motivate the modification,” which “include improving the capabilities of wearable sensors for use in sports and personal fitness applications and wirelessly connecting wearable sensors to networks to remotely monitor patient health.” ’533-FWD, 23. This is consistent with my opinions provided in my Prior ’533 Declaration, which I incorporate by reference as if fully set forth herein. ’533-Anthony, ¶¶48-56, 98-103, 138, 142-146.

93. Further, in the prior ’484 IPR, I understand that the Board agreed with Petitioner’s argument that “[although] Lisogurski depicts front end processing circuitry 104 as separate from wearable sensor 102, ... incorporating the front end processing circuitry into the same device with the detector would have been consistent with Lisogurski’s teaching that the functionality of some components of

monitor 104 can be divided over multiple components and is an obvious modification to a person of ordinary skill.” ’484-FWD, 24-27. This is consistent with my opinions provided in my Prior ’484 Declaration, which I incorporate by reference as if fully set forth herein. ’484-Anthony, ¶¶48-56, 123-127, 160-164.

94. Consistent with **Lisogurski’s** disclosures, *first*, a person of ordinary skill in the art would have been motivated to combine the functionality of at least both **control circuitry 110** and **light drive circuitry 120** into a single device—specifically, within the device where **light source 120**, the LEDs, are located (i.e., sensor 102). This is because the **control circuitry 110** and light drive circuitry 120 are coupled and work in tandem with the **light source 130**: the control circuitry 110 sends timing control signals to direct the **light drive circuitry 120** to generate a light drive signal, and this signal is the electric current provided to the **light source 130** to, for example, turn the light source on and off and to regulate their brightness. Lisogurski, 11:38-41, 11:50-54, 25:52-55. It would have been obvious to include control circuitry 110 and light drive circuitry 120 in sensor 102, where the LEDs are located, because the electrical current cannot be transferred wirelessly from monitor 104 to sensor 102. Because these circuits work together to generate and apply the electric current to the LEDs, a person of ordinary skill in the art would have understood that it was at least obvious to include the **control circuitry 110** and **light drive circuitry 120** to be located alongside the **light**

source 130 within sensor 102. '533-Anthony, ¶101 (citing Lisogurski, 11:38-41, 11:50-54, 25:52-55); '484-Anthony, ¶162 (citing Lisogurski, 11:38-41, 11:50-54, 25:52-55). A person of ordinary skill in the art would have further understood that integrating control and drive circuitry directly with the LEDs is advantageous to maintaining precise synchronization and optimal signal integrity. Indeed, given the limitations in transmitting accurate electrical signals without introducing noise or timing errors, a person of ordinary skill in the art would have found such integration technically and practically advantageous.

95. Moreover, a person of ordinary skill in the art would have understood that adding the **light drive** and **control circuitry** directly to sensor 102 would not have negatively impacted the operation of **Lisogurski's** system. For example, a person of ordinary skill in the art would have appreciated that modern electronic components such as control and drive circuits are designed with compactness, power efficiency, and ease of integration in mind, making them well-suited for integration within the form factor of a wearable sensor. Their small size would not add significant bulk or weight, and their efficient power consumption helps maintain the device's overall battery life. As a result, a person of ordinary skill in the art would have found the integration of the light drive circuitry and control circuitry into sensor 102 both practical, feasible and advantageous, enhancing both performance and usability in physiological monitoring applications without compromising system

performance. '533-Anthony, ¶102 (citing Lisogurski, 16:2-9); '484-Anthony, ¶163 (citing Lisogurski, 16:2-9).

96. Lastly, as I explained above, **Lisogurski** explicitly teaches that the functionality of its components may be integrated into a single component or separated into multiple components. Integrating **control circuitry 110** and **light drive circuitry 120** into a single device, sensor 102, is consistent with these teachings.

97. Additionally, as the Board further found, a person of ordinary skill in the art would have been motivated to modify monitor 104 to be a personal device “includ[ing] only backend processing circuitry 170, user interface 180, and communication interface 190.” '533-FWD, 39-40 (citing '533-Pet., 49-53; Lisogurski, Fig. 1). As the Board explained, and as I noted above, “Lisogurski’s express suggestion and the industry trend to make wireless sensors for personal fitness tracking that transmit monitored physiological parameters to a personal device.” '533-FWD, 39-40 (citing '533-Pet., 49-53; Lisogurski, Fig. 1). This is consistent with my opinions provided in my Prior '533 Declaration, which I incorporate by reference as if fully set forth herein. '533-Anthony, ¶¶150-153.

98. **Second**, a person of ordinary skill in the art would have been further motivated to combine the functionality of **front end processing circuitry 150** into the same device where the **detector 140** is located. A person of ordinary skill in the

art would have been motivated to do so for three reasons. **One, Lisogurski** discloses that its sensor “preprocess[es]” a signal before transmitting the processed signal to the monitor. Lisogurski, 11:25-27. Accordingly, a person of ordinary skill in the art would have been motivated to combine components that perform the same functionality together in a single device to substantially minimize latency, improve signal fidelity, and simplify overall system architecture by reducing signal travel distances and potential points of interference or noise. **Two, Lisogurski** teaches that the sensor may be a separate device from monitor. Lisogurski, 17:55-57 (stating that as opposed to “draw[ing] power from monitor 314,” “[s]ensor unit 312 may be powered by an internal power source, e.g., a battery.”). Accordingly, a person of ordinary skill in the art would have understood that **front end processing circuitry 150**, although it is depicted in **Lisogurski’s** Figure 1 as part of monitor 104, can be a separate component from monitor 104. Indeed, **Lisogurski** explicitly teaches that “the functionality of some of the components of monitor 104 shown and described herein may be divided over multiple components.” Lisogurski, 16:6-9. A person of ordinary skill in the art would have recognized this as strong evidence supporting the feasibility and desirability of placing the **front-end processing circuitry 150** within the sensor device itself, further validating a self-contained, independently powered sensor architecture that integrates detection and preprocessing functions. **Three, Lisogurski** teaches that the sensor may be

wirelessly connected to the monitor. Lisogurski, 17:57-59 (“[T]he sensor may be wirelessly connected to monitor 314.”); *see also* Lisogurski, 18:23-25, 18:16-31. A person of ordinary skill in the art would have understood that even though the front end processing circuitry can be arranged to be located within the sensor rather than monitor 104, it would still be capable of communicating with components—such as back end processing circuitry 170—located within monitor 104. *E.g.*, Lisogurski, 11:46-49 (“[T]he back end processing circuitry 170 may use the timing control signals to coordinate its operation with front end processing circuitry 150.”). Accordingly, a person of ordinary skill in the art would have at least found it obvious to configure **Lisogurski’s** system such that the **front end processing circuitry** is wirelessly configured to monitor 104, allowing the two components to transmit signals wirelessly to each other, even though such wireless configuration is not depicted in Lisogurski’s figures. This arrangement helps ensure that high-quality, digitized signals are transmitted wirelessly, rather than raw, low-level analog signals that are more susceptible to interference and degradation. ’533-Anthony, ¶143 (citing Lisogurski, 11:20-27, 17:55-59, 18:16-31); ’484-Anthony, ¶124 (citing Lisogurski, 11:20-27, 17:55-59, 18:16-31).

99. Lastly, as I explained above, **Lisogurski** explicitly teaches that the functionality of its components may be integrated into a single component or separated into multiple components and integrating **front end processing circuitry**

150 into the same device where the **detector 140** is, thus, consistent with these teachings. A person of ordinary skill in the art would have understood that integrating front end signal processing circuitry directly into the sensor with the detector offers clear technical benefits, including improved signal integrity, reduced latency, simplified system architecture, and enhanced reliability of wireless communications. Furthermore, given the explicit teaching in **Lisogurski** regarding the possibility and benefit of separating and integrating different components, a person of ordinary skill in the art would have found it straightforward and logical to physically locate the front-end processing and detection functions within the sensor device. This would enhance performance and robustness of the overall physiological monitoring system and be used as part of natural design, manufacturing, and usability considerations.

100. **Third**, a person of ordinary skill in the art would have been further motivated to combine the functionality of **front end processing circuitry 150** into sensor 102 so that the sensor could process the detected signal before wirelessly transmitting it to the monitor. A person of ordinary skill in the art would have understood that for information contained in an analog signal output from the detector to be wireless transmitted effectively, it would have to be converted to digital form. The analog-to-digital conversion is performed by the **front-end processing circuitry**. A person of ordinary skill in the art would have understood

that preprocessing signals (such as amplification, filtering, and particularly analog-to-digital conversion) near the point of detection is technically beneficial because it substantially enhances signal fidelity and accuracy. Performing analog-to-digital conversion at the sensor level significantly reduces signal degradation and interference that typically accompany analog signal transmission, especially over wireless links or extended cables. This integration also enables precise and rapid tuning of signal parameters such as gain values and filtering conditions, thereby improving measurement reliability and responsiveness. A person of ordinary skill in the art would have understood that measurement accuracy would be improved by performing the analog-to-digital conversion prior to wireless transmission of digital bits instead of analog amplitudes, and by being able to tune the measurement process by, for example, adjusting any gain values (e.g. for matching the signal amplitude to the dynamic range of the analog to digital conversion). Accordingly, it would have been obvious to include the **front-end processing circuitry** in the sensor. Adding the **front end processing circuitry** to the sensor would not have negatively impacted the operation of **Lisogurski's** system. These circuits are compact and designed to be power-efficient, making them well-suited for integration within the form factor of a wearable sensor. Their small size would not add significant bulk or weight, and their efficient power consumption helps maintain the device's overall battery life. Moreover, as I explained above, **Lisogurski** explicitly teaches that the functionality

of its components may be integrated into a single component or separated into multiple components. From this explicit teaching, a person of ordinary skill in the art would have recognized that the sensor's architecture naturally lends itself to integrating front-end processing circuitry, since independent powering inherently supports local signal processing. This self-contained design enhances the sensor's versatility, allowing it to perform critical signal processing tasks without requiring continuous wired power or cable communication connections, making the sensor especially suitable for mobile, wearable, and ambulatory applications. As a result, a person of ordinary skill in the art would have found the integration of the front end processing circuitry into sensor 102 both practical and feasible without compromising system performance. '533-Anthony, ¶144; '484-Anthony, ¶125. Additionally, a person of ordinary skill in the art would have understood that integrating the **control circuitry**, **light drive circuitry**, and **front-end processing circuitry** directly with the sensor significantly enhances the system's efficiency by reducing noise, signal degradation, and latency. Such integration aligns with standard industry practices in wearable sensor technologies, commonly used to ensure compact, energy-efficient, and responsive physiological monitoring solutions. A person of ordinary skill would also have understood that integrating front-end analog-to-digital conversion circuitry directly within or closely adjacent to sensors is a conventional approach, designed to minimize noise, reduce data

transmission losses, and ensure accurate, real-time signal capture and analysis. In sum, a person of ordinary skill in the art would have understood that the close integration of **front-end processing circuitry** and the detector in a **sensor** is highly advantageous for multiple reasons: it enhances signal integrity, reduces noise and signal degradation, improves data reliability and accuracy, simplifies sensor-to-monitor communication, and ensures system responsiveness. Given the explicit teachings from **Lisogurski** about flexibility and wireless operation, a person of ordinary skill in the art would have found the integration obvious, practical, technically straightforward, and consistent with industry standards in physiological monitoring technologies.

101. The desire to relocate the **control circuitry 110**, **light drive circuitry 120**, and **front-end processing circuitry 150** from **Lisogurski**'s monitor 104 to the sensor 102 aligns with common practices at the time aimed at improving signal fidelity and reliability. **Lisogurski** itself supports this arrangement, suggesting explicitly that functionalities can be combined or distributed flexibly. **Lisogurski**, 15:66-16:9.

102. A person of ordinary skill would have understood this relocation as an obvious step, consistent with established industry practices for design, manufacturing, function, and usability. Integrating light drive circuitry and associated control components directly into sensor assemblies minimizes

interference, enhances operational efficiency, improves manufacturability, and optimizes device compactness and usability. A person of ordinary skill in the art would have been familiar with numerous examples in the field where integration of control and drive circuitry with the sensor components is a known solution for achieving optimal performance, signal clarity, and reliability. This well-established approach underscores the practicality and technical desirability of this integration in physiological monitoring devices; this concept was widely adopted by industry as early as the early 2000s as illustrated by e.g., U.S. Patent No. 8,050,703 and U.S. Patent Pub. No. 2011/0237911, which I understand have been designated as Exhibits 1031 and 1033, respectively, as further discussed below. Ex. 1031, 14:12-26, Fig. 18; Ex. 1033, [0052], Fig. 4.

103. Additionally, as I explained above, **Lisogurski** explicitly teaches that the functionality of its components may be integrated into a single component or separated into multiple components and integrating **front end processing circuitry 150** into sensor 102 is consistent with these teachings.

104. Moreover, a person of ordinary skill in the art would have found the integration of the control and light drive circuitry components and front end processing components into sensor 102, where light sources are located, as routine and straightforward. Indeed, it was common for **light sources** to include **light drive circuitry** and **control circuitry**, and for a **detector** to include a **front end**

processing circuitry.

105. For example, U.S. Patent Pub. No. 2011/0237911 (Ex. 1033) discloses, as depicted in Figure 4, front end analog signal conditioning circuitry 330 (“330”) and analog to digital conversion circuit 332 located within sensor 300 (“300”). Ex. 1033, [0052], Fig. 4. And, as disclosed in U.S. Pat. No. 5,592,124, which I understand has been designated as Exhibit 1036, a “photodiode structure” “could be provided on an integrated circuit wafer circuitry other than transimpedance amplifier 2 and output buffer 8[, such as] signal processing circuitry.” Ex. 1036, 11:7-33 (“signal processing circuitry integrated onto the same semiconductor chip as photodiode structure”), Fig. 3 (depicting the same). Further, as U.S. Pat. No. 5,942,749, which I understand has been designated as Exhibit 1034, discloses, a “photodetector with a signal processing capability” was well known in the art. Ex. 1034, 2:66-4:20 (“photodetector is also operable as a ternary circuit.”), Figs. 7-9. U.S. Pat. No. 5,822,473, which I understand has been designated as Exhibit 1035, also discloses an “integrated smart sensor,” which includes “LED 14” as well as “processing circuitry 20.” Ex. 1035, 3:37-52, Fig 2 (depicting a top view of the integrated smart sensor). Similarly, U.S. Pat. No. 8,050,730 (Ex. 1031) discloses an “apparatus” for “pulse oxygen measurement[s]” that includes collectively a “single chip data processing unit”; a “probe unit” having a red and infrared light sources and light driver circuitry; and signal processing circuitry. Ex. 1031, 14:12-26, Fig. 18.

106. Additionally, as to the **control circuitry 110** and **light drive circuitry 120**, because they work together to output the electric current that is applied to the light source, a person of ordinary skill in the art would have understood or at least found it obvious to include the circuitry in the same device as the light source. See '533-FWD, 23 (citing '533-Pet., 32-34). As to the **front-end processing circuitry 150**, because it performs analog-to-digital conversion and other initial processing of the signal, the Board also agreed that a person of ordinary skill in the art would have understood or at least found it obvious to include it in the sensor where the signal is captured. See '533-FWD, 23 (citing '533-Pet., 47-48). Indeed, it was common for light sources to include light drive circuitry and control circuitry, and for a detector to include a front end processing circuitry. See, e.g., Ex. 1031, 14:12-26, Fig. 18 (light drive circuit in probe); Ex. 1033, [0052], Fig. 4 (showing front end analog signal conditioning circuitry 330 in sensor 300); Ex. 1034, Abstract (“a photodetector with a signal processing capability”); Ex. 1035, 2:21-23 (“an embodiment of the present invention is simple integration of the sensor with other circuits such as a signal processor.”).

107. Moreover, integrating the various circuitry components, detector, and light sources into one device is consistent with a growing industry trend toward integrating additional features into wearable sensors—particularly in applications like personal fitness and sports—to enable remote monitoring of a user’s

physiological state. '533-Anthony, ¶¶48-56; '484-Anthony, ¶¶48-56.

3. Invalidity of Claims 1, 6-8, and 11-13 Over Lisogurski

108. As I discuss below, Claims 1, 6-8, and 11-13 are rendered obvious by **Lisogurski**. In addition to my discussion in Sections IX.A.1-2, the following discussion identifies example disclosures that each disclose Challenged Claims 1, 6-8, and 11-13.

a. Element [1.pre]

109. Element [1.pre] recites: “**An apparatus adapted to be worn by a user comprising.**” This element is met by **Lisogurski**.

110. Regarding a substantially identical limitation in the prior '484 IPR reciting “a wearable device **adapted** to be placed on a wrist or an ear of a **user**,” I understand that the Board determined that the petitioner demonstrated that **Lisogurski's** “system may be placed on a user's ear or wrist.” '484-FWD, 23, 26-27. This is consistent with my opinions regarding this '484 limitation provided in my Prior '484 Declaration, which I incorporate by reference as if fully set forth herein. '484-Anthony, ¶¶89-95 (citing Lisogurski, 1:10-25, 3:43-46, 3:61-4:5, 4:6-20, 4:22-25, 4:52-62, 15:19-42, 15:49-56, 17:55-59, 18:65-66, Figs. 1 & 3), 96-97 (citing Lisogurski, 4:6-20).

111. '475 patent element [1.pre] is substantially identical to the corresponding limitation in the '484 patent on which I previously opined, which

recites: “a wearable device **adapted** to be placed on a wrist or an ear of a **user**.”

Aside from turns of phrases (the ’475 patent’s use of “[a]n apparatus adapted to be worn” versus the ’484 patent’s use of “a wearable device”), the main difference between the two limitations is the ’484 patent’s specificity regarding where the device is worn on a user, while the ’475 patent simply requires that the apparatus be worn. A person of ordinary skill in the art would have understood that whether apparatus is worn on a user’s ear or wrist, it is still being worn. Thus, the differences between the two terms do not change my analysis, and my opinions regarding the ’484 patent term apply equally to ’475 patent element [1.pre]. ’484-Anthony, ¶¶89-95, 96-97.

112. As further support for this limitation, **Lisogurski** discloses that embodiments of its system include an apparatus adapted to be worn by a user (“sensor 102” or “sensor 312”) which are placed, for example, on the ear of a patient. Lisogurski, 4:6-20, 10:44-46, 17:30-35. As I discussed above (Section IX.A.1), **Lisogurski** Figure 3 is an exemplary application of **Lisogurski** Figure 1 and “one or more components of physiological monitoring system 310 [of FIG. 3] may include one or more components of physiological monitoring system 100 of FIG. 1.” Lisogurski, 17:30-35. Thus, **Lisogurski**’s “sensor 102” could be implemented as “sensor 312,” and vice versa, and can both be worn on a user.

b. Element [1.a]

113. Element [1.a] recites: “**one or more biosensors adapted to be placed on the user.**” This element is met by **Lisogurski**.

114. Regarding a substantially identical limitation in the prior ’484 IPR reciting “a wearable device **adapted to be placed on** a wrist or an ear of a **user**,” I understand that the Board determined that the petitioner demonstrated that **Lisogurski’s** “system may be placed on a user’s ear or wrist.” ’484-FWD, 23, 26-27. This is consistent with my opinions regarding this ’484 limitation provided in my Prior ’484 Declaration, which I incorporate by reference as if fully set forth herein. ’484-Anthony, ¶¶89-95 (citing Lisogurski, 1:10-25, 3:43-46, 3:61-4:5, 4:6-20, 4:22-25, 4:52-62, 15:19-42, 15:49-56, 17:55-59, 18:65-66, Figs. 1 & 3), 96-97 (citing Lisogurski, 4:6-20).

115. ’475 patent element [1.a] is substantially identical to the corresponding limitation in the ’484 patent on which I previously opined, which recites: “a wearable device **adapted to be placed on** a wrist or an ear of a **user**.” The main differences between the two limitations are the (i) ’484 patent’s use of “wearable device” versus the ’475 patent use of “biosensor” and (ii) ’484 patent’s specificity regarding where the device is worn on a user, while the ’475 patent simply requires that the biosensor be worn. **First**, a person of ordinary skill would have understood that **Lisogurski’s** biosensor (as further explained below), would be included in its overall apparatus. **Second**, a person of ordinary skill in the art would have understood that whether

biosensor is worn on a user's ear or wrist, it is still being worn. Thus, the differences between the two terms do not change my analysis, and my opinions regarding the '484 patent term apply equally to '475 patent element [1.a]. '484-Anthony, ¶¶89-95, 96-97.

116. As further support for this limitation, **Lisogurski** discloses that embodiments of its system include an apparatus (which further includes a biosensor, as I explain below) adapted to be worn by a user ("sensor 102" or "sensor 312") which are placed, for example, on the ear of a patient. Lisogurski, 4:6-20, 10:44-46, 17:30-35. As I discussed above (Section IX.A.1), **Lisogurski** Figure 3 is an exemplary application of **Lisogurski** Figure 1 and "one or more components of physiological monitoring system 310 [of FIG. 3] may include one or more components of physiological monitoring system 100 of FIG. 1." Lisogurski, 17:30-35. Thus, **Lisogurski's** "sensor 102" could be implemented as "sensor 312," and vice versa, both include a biosensor, and can both be worn on a user.

117. **Lisogurski's** sensor 102/312 includes light source 130/316 and detector 140/318, such that the light source 130/316, detector 140/318, and front end processing circuitry 150 within detector 140/318 as modified (Section IX.A.1), are adapted to be placed on the user. Lisogurski, 10:48-49, 11:35-42, Figs. 1, 3. A person of ordinary skill in the art would have understood that together a light source, detector, and front end processing circuitry, all of which are contained with

Lisogurski's sensor as modified, would comprise a “biosensor.” For example, U.S. Patent No. 8,996,088, which I understand has been designated as Exhibit 1052, discloses a “biosensor device 200” that includes three sets of detectors, each further including an “optical emitter” and “optical detector.” Ex. 1052, 10:22-49. The biosensor device 200 also includes “a processor that is configured to analyze data generated by the detectors 125, 225, 235 to determine a cardiac response to exercise and the supply, arteriovenous difference, utilization of oxygen by the muscle tissue and hydration of the muscular tissue.” Ex. 1052, 10:22-49.

118. As I discuss above in Section IX.A.2, a person of ordinary skill would have been motivated (or at least found obvious) to include front end processing circuitry 150 where the detector 140/318 is located—in sensor 102/312—because, as I understand the Board agreed, the front end processing circuitry performs analog to digital conversion and other initial processing of the signal and the detector is where the signal is captured. '533-FWD, 23. Further as I discuss above, a person of ordinary skill in the art would have understood that such modification would streamline the data transmission and minimize latency.

c. Element [1.b]

119. Element [1.b] recites: “**wherein one or more physiological parameters are measured.**” This element is met by **Lisogurski**.

120. Regarding a substantially identical limitation in the prior '484 IPR

reciting “[a] system for measuring **one or more physiological parameters**”, I understand that the Board determined that the petitioner demonstrated “Lisogurski [] disclos[es] a system for measuring one or more physiological parameters....” ’484-FWD, 23, 26-27. This is consistent with my opinions regarding this ’484 limitation provided in my Prior ’484 Declaration, which I incorporate by reference as if fully set forth herein. ’484-Anthony, ¶¶89-95 (citing Lisogurski, 1:10-25, 3:43-46, 3:61-4:5, 4:6-20, 4:22-25, 4:52-62, 15:19-42, 15:49-56, 17:55-59, 18:65-66, Figs. 1 & 3).

121. ’475 patent element [1.b] is substantially identical to the corresponding limitation in the ’484 patent on which I previously opined, and which recites: “[a] system for measuring **one or more physiological parameters**.” Aside from differing turns of phrases, the main difference between the two limitations is that ’475 patent [1.b] requires that the apparatus measures the physiological parameter while the ’484 claim limitation requires that the overall system performs the same operation. A person of ordinary skill would have understood that a system could comprise an apparatus that measures physiological parameters. Thus, my opinions regarding the ’484 patent term apply equally to ’475 patent element [1.b]. ’484-Anthony, ¶¶89-95.

122. As further support for this limitation, **Lisogurski** discloses that its sensor measures physiological parameters by, first, having light source 130/316

“emit[] light into the tissue of a subject to generate[] physiological signals.”

Lisogurski, 10:52-56. After the emitted light is passed through and reflected back from the subject’s tissue, it is captured by detector 140/318—also located in sensor 102/312—and used to generate a “detection signal” that is then processed to determine physiological parameters. Lisogurski, 10:52-64, 11:13-27, 12:45-48.

d. Element [1.c]

123. Element [1.c] recites: “**wherein measuring of the one or more physiological parameters comprises a differential measurement, and wherein the one or more physiological parameters comprises a pulse rate monitoring and a blood flow measurement.**” This element is met by **Lisogurski**, at least in part, for the reasons I discuss above regarding claim element [1.b] (Section IX.A.3.c.[1.b]).

124. **Lisogurski further discloses and renders obvious wherein measuring of the one or more physiological parameters** (*e.g.*, “physiological parameters”; see my discussion in Section IX.A.3.c.[1.b]) **comprises a differential measurement** (*e.g.*, performing a dark subtraction technique that “subtract[s] dark values from the Red and IR components to generate adjusted Red and IR signals,” to “remove ambient and background signals”; see my discussion in Section IX.B.3.n.[1.m]), **and wherein the one or more physiological parameters comprises a pulse rate monitoring** (*e.g.*, monitoring “a patient’s pulse rate”) **and**

a blood flow measurement (e.g., “monitor[ing]...pulsatile flow”). Lisogurski, 4:3-5, 4:25-26.

125. Regarding **wherein measuring of the one or more physiological parameters comprises a differential measurement**, I understand that, in the ’484 IPR in finding limitations identical to [1.k]-[1.m] met (Section IX.A.3.1-n.[1.k]-[1.m]), the Board relied on **Lisogurski’s** disclosure that its “front end processing uses the current measured when the LEDs are off to generate a dark signal representative of ambient light,” “measur[es] the signal when at least one LED is on to capture a portion of the optical beam, e.g., a red signal and an IR signal, reflected from the tissue,” and uses “a ‘dark subtraction’ technique that subtracts the dark signal from the red and IR signals to generate adjusted red and IR signals with noise removed, thereby improving signal-to-noise ratio.” ’484-FWD, 43-44 (citing ’484-Pet. 54-56 (citing Lisogurski, 6:7-19, 11:12-20, 12:52-13:6, 13:35-41, 13:60-14:10, 14:46-55, 16:33-54, 17:8-10, 17:40-42, FIGS. 2A-2B)). This is consistent with my opinions regarding the ’484 patent provided in my Prior ’484 Declaration, which I incorporate by reference as if fully set forth herein. ’484-Anthony, ¶¶193-206. See also my discussion of claim elements [1.k] to [1.m] below (Section IX.A.3.1-n.[1.k]-[1.m]).

126. A person of ordinary skill in the art would have understood (or at least found it obvious) that **Lisogurski’s** “dark subtraction” technique is a differential

measurement as it involves subtracting the results of two different measurements to improve signal-to-noise ratio. For example, U.S. Patent App. Pub. No. 2007/0149868, which I understand has been designated as Exhibit 1053, describes a physiological measurement system using “differential measurements” to “enhance a signal-to-noise ratio” by “performing an analysis before, during, and/or after photostimulation,” and then “subtract[ing]” the two signals. Ex. 1053, [0168].

127. Regarding **“the one or more physiological parameters comprises a pulse rate monitoring and a blood flow measurement,”** Lisogurski further teaches that its sensor 102/312 with light source 130/316 and detector 140/318 “measure[s] physiological parameters, such as a patient’s pulse rate....” and “monitor[s]” “pulsatile flow” of the “carotid,” “radial,” “femoral,” and “tibial” arteries. Lisogurski, 4:3-5, 4:15-20. A person of ordinary skill in the art would have understood (or at least found it obvious) that the measurement of pulsatile flow in arteries is a blood flow measurement.

128. I understand that Defendants identified a portion of this limitation—**“differential measurement”**—as potentially indefinite in the Texas Case. Ex. 1023, 247-248.

129. Regardless of its interpretation (e.g., (1) a temporal differential measurement, or (2) a spatial differential measurement), however, and without opining on whether or not it has adequate written description support, **Lisogurski**

meets this term under either interpretation.

130. Regarding a temporal differential measurement, as I discussed above, **Lisogurski's** “dark subtraction” technique is a differential measurement, which a person of ordinary skill in the art would have understood (or at least found obvious) as taking measurements at different times (e.g., before and after turning on the light source), and subtracting the results of such different measurements taken at two different points in time. Such “temporal differential measurement” was well known in the art and, for example, U.S. Patent App. Pub. No. 2007/0149868 discloses a physiological monitoring system using a “temporal differential measurement” by “performing an analysis before, during, and/or after photostimulation.” Ex. 1053, [0168]. Consistent with **Lisogurski's** disclosure, “[t]ypically, a baseline reading is performed. In one case, a noninvasive spectrum is obtained. Photostimulation is then performed. A second noninvasive spectrum is then obtained. Chemometric approaches are then used on the two spectra. Typically, these techniques are subtraction or ratio determination in order to remove background information or enhance the analyte signal-to-noise ratio. For example, the signal, precision of estimated concentration of glucose or urea, or the relative percent saturation of oxygen is enhanced via a differential measurement.” Ex. 1053, [0168].

131. Regarding a spatial differential measurement, **Lisogurski** also teaches that a plurality of its sensor 102/312 may be “positioned at two different locations”

on the user's body, where the sensors monitor "a patient's pulse rate and blood pressure." Lisogurski, 4:25-36, 17:51-53. A person of ordinary skill in the art would have found it obvious to perform **Lisogurski's** dark subtraction technique based on measurements from sensors "positioned at two different locations" on the user's body to advantageously enhance the signal to noise ratio. For example, U.S. Patent App. Pub. No. 2007/0149868 discloses a physiological monitoring system using a "spatial differential measurement" which includes "performing an analysis at two sites," wherein "[o]ne site is treated by photostimulation and the other site is left untreated," and "a baseline reading is performed at the untreated site and a sampling reading is performed at the treated site. For example, in spectroscopy the reference spectrum is collected at the untreated site and the sample spectrum is collected at the treated site. Typically these spectra are subtracted from one another or ratioed in order to enhance the signal-to-noise ratio of an analyte, though additional chemometric approaches are alternatively used. For example, the signal-to-noise ratio of glucose, forms of hemoglobin, oxygenation levels, or urea are enhanced." Ex. 1053, [0170].

e. Element [1.d]

132. Element [1.d] recites: "**a light source comprising a plurality of light emitting diodes that are configured to generate an output optical light having one or more optical wavelengths.**" This element is met by **Lisogurski**.

133. Regarding a substantially identical limitation in the prior '533 IPR reciting “**a light source comprising a plurality of semiconductor sources that are light emitting diodes, the light emitting diodes configured to generate an output optical beam with one or more optical wavelengths,**” I understand the Board determined that the “[p]etitioner demonstrate[d] how Lisogurski’s sensor 102/312 meets this limitation,” and that **Lisogurski’s** “[s]ensor 102/312 can contain multiple LEDs that emit and direct light toward a subject’s tissue, including an LED that emits red light, and an LED that emits infrared light having a wavelength between 800 and 1000 nm.” ’533-FWD, 25-26. This is consistent with my opinions regarding this ’533 limitation provided in my Prior ’533 Declaration, which I incorporate by reference as if fully set forth herein. ’533-Anthony, ¶¶92-94 (citing Lisogurski, 4:42-45, 7:38-8:3, 10:48-52, 10:56-64, 17:37-45, 19:25-31, Figs 1 & 3).

134. Regarding a substantially identical limitation in the prior '484 IPR reciting “including **a light source comprising a plurality of semiconductor sources that are light emitting diodes, each of the light emitting diodes configured to generate an output optical light having one or more optical wavelengths,**” I understand that the Board determined that the petitioner demonstrated that “Lisogurski’s wearable sensor [] disclos[es] a plurality of LED light sources generating photonic signals having one or more wavelengths configured to direct light into a subject’s tissue.” ’484-FWD, 23, 26-27. This is consistent with my

opinions regarding this '484 limitation provided in my Prior '484 Declaration, which I incorporate by reference as if fully set forth herein. '484-Anthony, ¶¶98-101 (citing Lisogurski, 4:42-45, 7:38-8:3, 10:48-52, 10:56-64, 17:37-45, 19:25-31, Figs 1 & 3).

135. '475 patent element [1.d] is substantially identical to the corresponding limitation in the '533 patent on which I previously opined, which recites: “**a light source comprising a plurality of semiconductor sources that are light emitting diodes, the light emitting diodes configured to generate an output optical beam with one or more optical wavelengths.**” Aside from differing turns of phrases, the main differences between the two limitations are: (i) the '533 patent's additional use of “semiconductor sources that are light emitting diodes;” and (ii) the '533 patent's use of “optical beam” as opposed to the '475 patent's use of “optical light.” **First**, a person of ordinary skill in the art would have understood that light emitting diodes are semiconductor light sources as shown in U.S. Patent No. 8,079,735, which I understand has been designated as Exhibit 1039. *E.g.*, Ex. 1039, 2:6-9 (“The LED is a semiconductor diode that emits incoherent narrow-spectrum light....”). **Second**, a person of ordinary skill in the art would have understood that the '533 patent's use of “optical beam” describes the general propagation (radiation-pattern or directional-shape) of light, as does the '475 patent's use of “optical light.” Thus, the differences between the two terms do not change my analysis, and my opinions regarding the

'533 patent term apply equally to '475 patent element [1.d]. '533-Anthony, ¶¶92-94.

136. '475 patent element [1.d] is substantially identical to the corresponding limitation in the '484 patent on which I previously opined, which recites: “including **a light source comprising a plurality of** semiconductor sources that are **light emitting diodes**, each of the light emitting diodes **configured to generate an output optical light having one or more optical wavelengths.**” The main difference between the two limitations is the '484 patent's additional use of “semiconductor sources that are light emitting diodes.” As I explained above, a person of ordinary skill in the art would have understood that light emitting diodes are semiconductor light sources. Thus, the differences between the two terms do not change my analysis, and my opinions regarding the '484 patent term apply equally to '475 patent element [1.d]. '484-Anthony, ¶¶98-101.

137. As further support for this limitation, **Lisogurski** discloses that its “light source 130 may include a Red light emitting light source and an IR light emitting light source, e.g., Red and IR light emitting diodes (LEDs), for emitting light into the tissue of a Subject to generate physiological signals.” Lisogurski, 10:52-56.

f. Element [1.e]

138. Element [1.e] recites: “**one or more lenses configured to receive at least a portion of the output optical light and to deliver a lens output light to**

tissue comprising skin.” This element is met by **Lisogurski**.

139. Regarding a substantially identical limitation in the prior '533 IPR reciting “...a plurality of **lenses configured to receive a portion of the output optical beam and to deliver** an analysis **output beam to** a sample,” I understand the Board determined that the “[p]etitioner demonstrate[d] how Lisogurski’s wireless sensor 102/312, when combined with the knowledge of a person of ordinary skill in the art ... meets this limitation,” and that (1) “a person skilled in the art would have known that LEDs are often covered by lensing encapsulants, and would have selected such LEDs for wireless sensor 102/312 in order to ‘direct more of the light produced by the LED outward toward the tissue,’ thereby improving the efficiency of wireless, battery-powered, sensor 102/312”; and (2) “a person skilled in the art, knowing ‘a lens is a ‘basic building block’ of an optical sensor,’ would have included lenses in Lisogurski’s wireless sensor 102/312.” ’533-FWD, 35-36. This is consistent with my opinions regarding this ’533 limitation provided in my Prior ’533 Declaration, which I incorporate by reference as if fully set forth herein. ’533-Anthony, ¶¶123-129 (citing Lisogurski, 7:38-8:3, 10:53-56; Ex. 1037, 97-98, 191-99, 266-67; Ex. 1038, 765).

140. Regarding a substantially identical limitation in the prior '484 IPR reciting “...**one or more lenses configured to receive a portion of** at least one of the **output optical lights and to** direct a lens **output light to tissue**,” I understand

the Board determined that the petitioner demonstrated that “a person of ordinary skill would have understood that glass encapsulating LEDs serves as a lens, i.e., a basic building block of an optical sensor, to receive the LED’s light and transmit that light to a particular location...” ’484-FWD, 23-24, 26-27. This is consistent with my opinions regarding this ’484 limitation provided in my Prior ’484 Declaration, which I incorporate by reference as if fully set forth herein. ’484-Anthony, ¶¶102-109 (citing Lisogurski, 7:38-8:3,10:53-56; Ex. 1037, 97-98, 191-99, 266-67; Ex. 1038, 765).

141. ’475 patent element [1.e] is substantially identical to the corresponding limitation in the ’533 patent on which I previously opined, which recites: “...a plurality of **lenses configured to receive a portion of the output optical beam and to deliver** an analysis **output** beam **to** a sample.” Aside from differing turns of phrases, the main differences between the two limitations are: (i) the ’533 patent’s use of “output optical beam” or “output beam” as opposed to the ’475 patent’s use of “output optical light” or “output light, (ii) the ’533 patent’s use of “to deliver an analysis output” as opposed to the ’475 patent’s use of “to deliver a lens output, and (iii) the ’533 patent’s use of “to deliver ... to a sample” as opposed to the ’475 patent’s use of “deliver ... to tissue.”

142. **First**, again as I explained above regarding claim element [1.d] (Section IX.A.3.e.[1.d]), a person of ordinary skill in the art would have understood that the

'533 patent's use of "optical beam" describes the general propagation (radiation-pattern or directional-shape) of light, as does the '475 patent's use of "optical light."

Second, a person of ordinary skill in the art would have understood that in the context of the '533 patent claims the term "an analysis output" refers to the light that is received by the lenses and then directed by the lens to another component or location and that '475 patent's recitation of "a lens output" refers to the same such light. See '533 patent, 4:54-58, 5:15-18 ("...a[n] ... apparatus [comprising a plurality of lenses is] configured to receive a [received] portion of the output optical beam and to deliver [to a sample] an analysis output beam, **which is a delivered portion of the output optical beam**") (emphasis my own). **Third**, a person of ordinary skill in the art would have understood that the term "sample" refers to specifically a tissue sample because the optical systems described in both the '475 and the '533 patents are used to interact with and collect data from biological tissue in order to analyze physiological parameters (Section IX.A.3.c.[1.b]). Thus, the differences between the two terms do not change my analysis, and my opinions regarding the '533 patent term apply equally to '475 patent element [1.e]. '533-Anthony, ¶¶123-129.

143. '475 patent element [1.e] is also substantially identical to the corresponding limitation in the '484 patent on which I previously opined, which recites: "...**one or more lenses configured to receive a portion of** at least one of

the **output optical lights and to direct a lens output light to tissue.**”

144. The main differences between the two limitations are: (i) the ’475 patent’s use of “receive at least a portion of the output optical light” as opposed to the ’484 patent’s use of “receive a portion of at least one of the output optical lights,” and (ii) the ’475 patent’s use of “deliver a lens output light to tissue” as opposed to the ’484 patent’s use of “direct a lens output light to tissue.” **First**, a person of ordinary skill in the art would have understood that both “receive at least a portion of the output optical light” and “receive a portion of at least one of the output optical lights” describe the same general operation of receiving some of the emitted light. **Second**, a person of ordinary skill in the art would have understood that a lens delivering and directing light refers to the same operation of receiving and guiding the received light towards the tissue in a controlled manner. Thus, the differences between the two terms do not change my analysis, and my opinions regarding the ’484 patent term apply equally to ’475 patent element [1.e]. ’484-Anthony, ¶¶102-109.

g. Element [1.f]

145. Element [1.f] recites: “**a detection system configured to receive at least a portion of the lens output light reflected from the tissue and to generate an output signal having a signal-to-noise ratio.**” This element is met by Lisogurski.

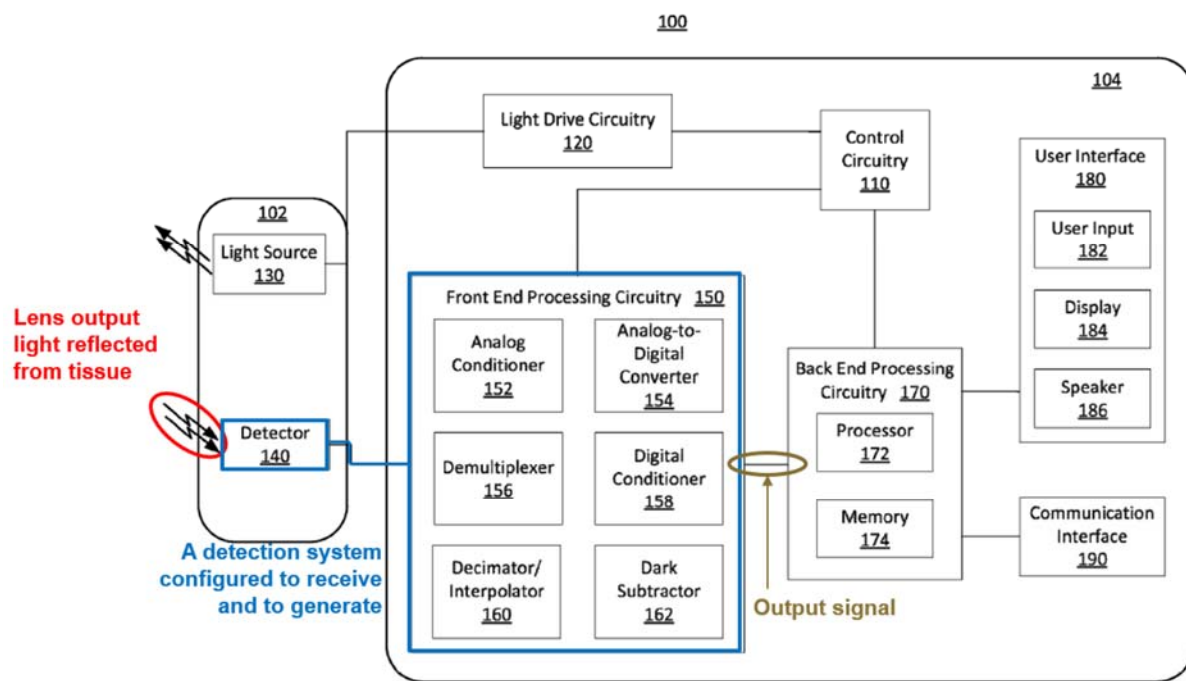
146. Regarding an identical limitation in the prior '484 IPR, I understand the Board determined that the petitioner demonstrated “Lisogurski [] disclos[es] the recited detection system in the form of a sensor with one or more detectors connected to front-end processing circuitry that may receive a detection signal, i.e., light that is reflected by or has traveled through the subject’s tissue, from detector 140, and provides processed signals, i.e., electrical signals based on the intensity of the reflected light, to back-end circuitry 170,” and (2) “the processed signals originate from detection signals that have a signal-to-noise ratio.” ’484-FWD, 23-24, 26-27. This is consistent with my opinions regarding this ’484 limitation provided in my Prior ’484 Declaration, which I incorporate by reference as if fully set forth herein. ’484-Anthony, ¶¶115-117 (citing Lisogurski, 11:9-10, 11:14-17, 11:20-27, 12:42-45, 14:49-50, 17:40-42, Figs. 1 & 3). Indeed, a person of ordinary skill in the art would have understood that the described front-end processing circuitry integrated with optical detectors in a physiological monitoring system represents standard and well-known industry practice. Such circuitry was commonly used for receiving and processing optical signals captured from patient tissue.

147. Regarding a substantially identical limitation in the prior ’533 IPR reciting “...a receiver **configured to receive** and process **at least a portion of** the analysis output beam **reflected** or transmitted **from** the sample **and to generate an output signal**,” I understand the Board determined that, regarding “[p]etitioner’s

proposed modification of sensor 102 to include front end processing circuitry 150 from monitor 104,” “[p]etitioner demonstrate[d] why a person skilled in the art would have modified Lisogurski’s wireless sensor 102/312 to include front end processing circuitry 150,” and that a person of skill in the art would have done so because of “Lisogurski’s express suggestion, the industry trend to make wireless sensors for remote healthcare and personal fitness tracking, and the need to convert ‘the analog signal output from the detector ... to digital form for wireless transmission. ... in the sensor where the signal is captured.’” ’533-FWD, 37-38. Moreover, I understand that the Board determined that “[p]etitioner demonstrates how Lisogurski’s receiver (i.e., detector 140/318 and front end processing circuitry 150) meets the ‘receiver’ limitations,” and that (1) “receiver receives and processes the output beam because it includes detector 140/318, which ‘detect[s] the light that is reflected by or has traveled through the subject’s tissue’ and ‘convert[s] the intensity of the received light into an electrical signal’”; and (2) “[t]he receiver generates an output signal because front end processing circuitry 150 ‘receive[s] a detection signal from detector 140 and provide[s] one or more processed signals to back end processing circuitry 170.’” ’533-FWD, 38-39. This is consistent with my opinions regarding this ’533 limitation provided in my Prior ’533 Declaration, which I incorporate by reference as if fully set forth herein. ’533-Anthony, ¶¶136-146 (citing Lisogurski, 2:1-2, 11:9-10, 11:14-17, 11:20-27, 11:41-46, 12:42-44, 13:6-60,

16:2-9, 16:58-62, 17:40-42, 17:55-59, 18:16-31, 19:17-19, 27:44-52, 33:47-49, 35:17-19, 35:27-31, Figs. 1 & 3).

148. **Lisogurski's** detectors and the front-end processing circuitry, each depicted in the annotated Figure 1 below, are collectively the claimed “detection system.” Lisogurski, 14:60-62.



Lisogurski, Figure 1; '533-Anthony, ¶138.

149. '475 patent element [1.f] is identical to the corresponding limitation in the '484 patent on which I previously opined, and which recites: “...**a detection system configured to receive at least a portion of the lens output light reflected from the tissue and to generate an output signal having a signal-to-noise ratio.**”

Thus, my opinions regarding the '484 patent term apply equally to '475 patent element [1.f]. '484-Anthony, ¶¶115-117.

150. As mentioned above, '475 patent element [1.f] is substantially also identical to the corresponding limitation in the '533 patent on which I previously opined, which recites: “...a receiver **configured to receive** and process **at least a portion of** the analysis output beam **reflected** or transmitted **from** the sample **and to generate an output signal.**”

151. Aside from differing turns of phrases, the main differences between the two limitations are as listed, and none change my analysis: (i) the '533 patent's use of “a receiver configured to receive and process” as opposed to the '475 patent's “a detection system configured to receive; (ii) the '533 patent's use of “at least a portion of the analysis output beam” as opposed to the '475 patent's use of “at least a portion of the lens output light”; (iii) the '533 patent's additional use of “reflected or transmitted” as opposed to the '475's patents use of “reflected,” and (iv) the '533 patent's use of “beam...from the sample” as opposed to the '475 patent's use of “light...from the tissue.”

152. **First**, a person of ordinary skill in the art would have understood that the terms “receiver” and “detection system” refer to components configured to perform at least the same functionality: receiving optical signals or light. Further, a person of ordinary skill in the art would have understood that the “detection system”

of '475 patent element [1.f] to “process” the “portion of the lens output light” as it “generate[s] an output signal” based on this light. **Second**, as I noted above, a person of ordinary skill in the art would have understood that a “beam” is one term to describe the general propagation (radiation-pattern or directional-shape) of light (Section IX.A.3.e.[1.d]), and that the claim terms “analysis output” and “lens output” refer to the light that is received by the lenses (Section IX.A.3.f.[1.e]). **Third**, a person of ordinary skill in the art would have understood that light that is received by a tissue or a sample can undergo both reflection and transmission. Thus, the inclusion of the term “or transmitted” in the '533 patent merely expands upon an aspect of the same optical interaction already covered by the '475 patent's reference to “reflected” light. **Fourth**, a person of ordinary skill in the art would have understood that the term “sample” refers to a tissue sample because the optical systems described in both the '475 and the '533 patents are used to interact with and collect data from biological tissue in order to analyze physiological parameters (Section IX.A.3.c.[1.b]). Thus, the differences between the two terms do not change my analysis, and my opinions regarding the '533 patent term apply equally to '475 patent element [1.f]. '533-Anthony, ¶¶136-146.

h. Element [1.g]

153. Element [1.g] recites: “**wherein the detection system is configured to be synchronized to the light source.**” This element is met by **Lisogurski**.

154. Regarding an identical limitation in the prior '484 IPR, I understand the Board determined that the petitioner demonstrated that “Lisogurski [] disclos[es] front end processing circuitry 150 operating synchronously with light drive circuitry 120, e.g., by synchronizing the sampling rate of an analog to digital converter to a modulated LED firing rate to provide, e.g., one or more samples to be averaged per period.” '484-FWD, 24-27. Further, in the prior '484 IPR, I understand that the Board agreed with the petitioner's argument that “[although] Lisogurski depicts front end processing circuitry 104 as separate from wearable sensor 102, ... incorporating the front end processing circuitry into the same device with the detector would have been consistent with Lisogurski's teaching that the functionality of some components of monitor 104 can be divided over multiple components and is an obvious modification to a person of ordinary skill.” '484-FWD, 24-27. This is consistent with my opinions regarding this '484 limitation provided in my Prior '484 Declaration, which I incorporate by reference as if fully set forth herein. 484-Anthony, ¶¶118-127 (citing Lisogurski, 2:1-2, 11:20-27, 11:41-46, 16:2-9, 16:67-17:2, 17:55-59, 18:16-31, 27:44-52, 33:47-49, 35:17-19, 35:27-31, Fig. 1).

155. Regarding a substantially identical limitation in the prior '533 IPR reciting “**wherein the receiver is configured to be synchronized to the light source,**” I understand the Board determined that “[p]etitioner demonstrate[d] how

Lisogurski's receiver (i.e., detector 140/318 and front end processing circuitry 150) meets the 'receiver' limitations," and that **Lisogurski's** "receiver is synchronized to the light source's pulses of light because the 'front end processing circuitry may use the timing control signals to operate synchronously with light drive circuitry 120,' i.e., the circuitry that drives Lisogurski's LED-based light source." '533-FWD, 37-39. This is consistent with my opinions regarding this '533 limitation provided in my Prior '533 Declaration, which I incorporate by reference as if fully set forth herein. '533-Anthony, ¶¶136-146 (citing Lisogurski, 2:1-2, 11:9-10, 11:14-17, 11:20-27, 11:41-46, 12:42-44, 13:6-60, 16:2-9, 16:58-62, 17:40-42, 17:55-59, 18:16-31, 19:17-19, 27:44-52, 33:47-49, 35:17-19, 35:27-31, Figs. 1 & 3), 171.

156. '475 patent element [1.g] is identical to the corresponding limitation in the '484 patent on which I previously opined, and which recites: "**wherein the detection system is configured to be synchronized to the light source.**" Thus, my opinions regarding the '484 patent term apply equally to '475 patent element [1.g]. '484-Anthony, ¶¶118-127.

157. '475 patent element [1.g] is substantially identical to the corresponding limitation in the '533 patent on which I previously opined, which recites: "**wherein the receiver is configured to be synchronized to the light source.**" The main difference between the two limitations is the '475 patent's use of "receiver" as opposed to the '484 patent's use of "detection system." As I discuss above regarding

limitation [1.f] (Section IX.A.3.g.[1.f]), a person having ordinary skill in the art would have understood that the terms “receiver” and “detection system” refer to components configured to perform at least the same functionality: receiving optical signals or light. Thus, the differences between the two terms do not change my analysis, and my opinions regarding the ’484 patent term apply equally to ’475 patent element [1.g]. ’533-Anthony, ¶¶136-146, 171.

158. As further support for this limitation, **Lisogurski** discloses that its system includes “light drive circuitry 120 [] configured to generate a light drive signal that is provided to light source 130 of sensor 102,” and that the “light drive signal may...control the intensity of light source 130 and the timing of when light source 130 is turned on and off.” Lisogurski, 11:50-54. To this end, **Lisogurski** teaches that the drive cycle of the light source includes a sequence of “on” and “off” portions to implement a dark subtraction technique, which removes background noise caused by ambient light or sensor-generated artifacts. Lisogurski, 6:16-19, 16:48-54, 16:66-17:2. This technique entails generating two signals. Lisogurski, 6:16-19, 16:48-54. The first signal is generated during the “off” (“dark”) portion, which captures the contribution of ambient light, noise, or dark current. Lisogurski, 6:16-19, 16:48-54. The second signal is generated during the “on” period, which includes the signal and the (non-signal or noise) contribution from ambient light, noise, and dark current. Lisogurski, 6:16-19, 16:48-54. The signal from the “off”

phase is then subtracted from the signal from the “on” phase. Lisogurski, 6:16-19, 16:48-54. Thus, a person of ordinary skill in the art would have understood that **Lisogurski’s** detection system would have to be synchronized to the turning on/off of the light source in order to generate separate “on” and “off” signals to subtract. A person of ordinary skill in the art would further have understood from **Lisogurski’s** explicit disclosures and widely recognized standard industry practices that synchronization between the detection system and the timing of the optical source would ensure accurate separation of physiological signals from background noise and artifacts.

159. As I discussed above, a person of ordinary skill in the art would have been motivated to combine the front end processing circuitry 150, which includes analog to digital converter (Lisogurski 13:7-12), into **Lisogurski’s** detection system and would have been further motivated to put light drive circuitry 150 into **Lisogurski’s** LED-based light source (Section IX.A.2), such that the detection system (i.e., including front end processing circuitry 150 and analog to digital converter) is synchronized to the light source (i.e., including the light drive circuitry). Such integration would ensure that the detection system, comprising the front-end processing circuitry 150 and associated analog-to-digital converter, is precisely and reliably synchronized with the operation of the light source, including the timing signals provided by the integrated light drive circuitry. Consequently,

this combined integration would enable effective synchronization, directly improving signal fidelity, reducing noise, minimizing latency, and enhancing overall measurement accuracy and reliability.

160. I understand that Defendants identified this limitation—“**wherein the detection system is configured to be synchronized to the light source**”—as potentially indefinite in the Texas Case. Ex. 1023, 247-248.

161. Regardless of its outer bounds (e.g., extent of synchronization), however, and without opining on whether it has adequate written description support, **Lisogurski** meets this term because **Lisogurski** discloses and renders obvious the indisputable scope of the limitation. For example, embodiments of the ’475 patent describe a lock-in technique for “detecting at the same frequency as the pulsed light source and also possibly phase locked to the same signal,” and a person of ordinary skill in the art would have understood that the limitation [1.g] at least includes such embodiments. *See, e.g.*, ’475 patent, 43:65-44:7.

162. Consistent with that embodiment, **Lisogurski** discloses that “front end processing circuitry 150 may...operate synchronously with light drive circuitry 120. For example, front end processing circuitry 150 may synchronize the operation of an analog-to-digital converter and a demultiplexer with the light drive signal based on the timing control signals.” **Lisogurski**, 11:41-46.

i. Element [1.h]

163. Element [1.h] recites: **“wherein the detection system comprises a plurality of detectors that are spatially separated from each other, and wherein at least one analog to digital converter is coupled to at least one of the plurality of detectors.”** This element is met by **Lisogurski**.

164. Regarding a substantially identical limitation in the prior '484 IPR reciting **“wherein the detection system comprises a plurality of spatially separated detectors, and wherein at least one analog to digital converter is coupled to at least one of the spatially separated detectors,”** I understand the Board determined that the petitioner demonstrated that “Lisogurski [] disclos[es] ... a plurality of multiple spaced detectors,” and that “Lisogurski [] disclos[es] that signals generated by the detectors are passed to front end processing circuitry that includes an A/D converter.” '484-FWD, 25-27. This is consistent with my opinions regarding this '484 limitation provided in my Prior '484 Declaration, which I incorporate by reference as if fully set forth herein. '484-Anthony, ¶¶128-131 (citing Lisogurski, 11:9-10, 11:14-16, 11:20-22, 13:6-60, 17:40-42, 17:43-45, Figs. 1 & 3).

165. The detectors and the front-end processing circuitry, each depicted in the annotated Figure 1 below, are collectively the claimed “detection system.”

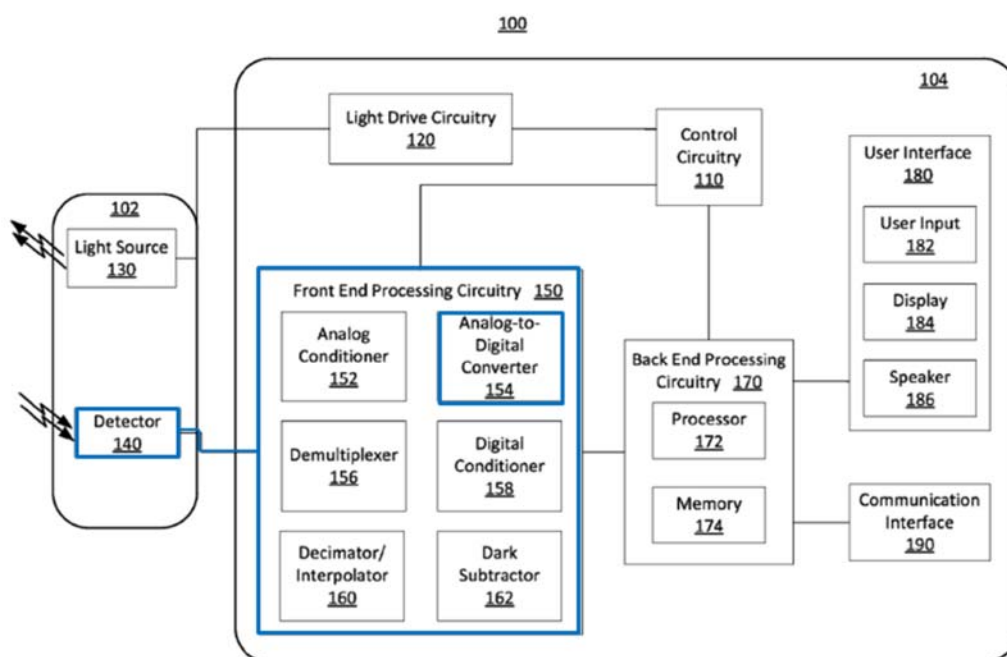


FIG. 1

Lisogurski, Figure 1; '484-Anthony, ¶131.

166. '475 patent element [1.h] is substantially identical to the corresponding limitation in the '484 patent on which I previously opined, and which recites: **“wherein the detection system comprises a plurality of spatially separated detectors, and wherein at least one analog to digital converter is coupled to at least one of the spatially separated detectors.”** Aside from differing turns of phrases (“detectors that are spatially separated from each other” versus “spatially separated detectors” and “plurality of detectors” vs. “spatially separated detectors”), these terms are identical. Thus, my opinions regarding the '484 patent term apply equally to '475 patent element [1.h]. '484-Anthony, ¶¶128-131.

167. I understand that Defendants identified a portion of this limitation—“a

plurality of detectors that are spatially separated from each other”—as potentially indefinite in the Texas Case. Ex. 1023, 247-248.

168. Regardless of its outer bounds (extent of spatial separation, e.g., right next to each other or with some intervening space), however, and without opining on whether it has adequate written description support, **Lisogurski** meets this term because **Lisogurski** discloses and renders obvious the indisputable scope of this limitation. For example, embodiments of the '475 depicted in Figure 18B show detectors 1854 and 1855 physically spaced apart from each other with at least some intervening space in a physiological monitoring device, and a person of ordinary skill in the art would have understood that the limitation [1.h] at least includes such embodiments:

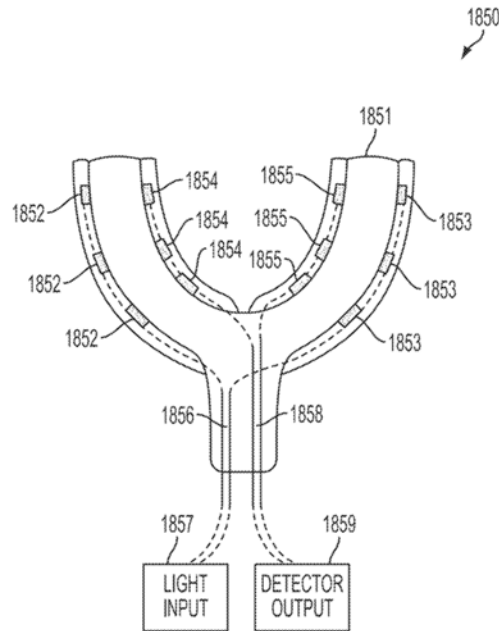


FIG. 18B

See, e.g., '475 patent, 27:34-28:4

169. Consistent with that embodiment, **Lisogurski** discloses that “[a]ny suitable configuration of light source 316 and detector 318 may be used,” and that “sensor unit 312 may include multiple light sources and detectors, which may be spaced apart.” **Lisogurski**, 17:42-45.

j. Element [1.i]

170. Element [1.i] recites: “**wherein the output signal is indicative of the one or more physiological parameters.**” This element is met by **Lisogurski**.

171. Regarding a substantially identical limitation in the prior '484 IPR reciting “**wherein the output signal is indicative of one or more of the**

physiological parameters,” I understand the Board determined that the petitioner demonstrated that “Lisogurski [] disclos[es] that data, i.e., an output signal, transmitted to a server, monitor, or remote device may be stored or published, that MPPM 326 is configured to calculate physiological parameters[.]” ’484-FWD, 26-27. This is consistent with my opinions regarding this ’484 limitation provided in my Prior ’484 Declaration, which I incorporate by reference as if fully set forth herein. ’484-Anthony, ¶¶148-154 (citing Lisogurski, 6:53-7:3, 8:45-9:11, 18:49-53, 20:8-13, 26:55-60).

172. ’475 patent element [1.i] is substantially identical to the corresponding limitation in the ’484 patent on which I previously opined, and which recites: **“wherein the output signal is indicative of one or more of the physiological parameters.”** Aside from differing turns of phrases (“indicative of the one or more physiological parameters” versus “indicative of one or more of the physiological parameters”), the terms are identical. Thus, my opinions regarding the ’484 patent term apply equally to ’475 patent element [1.i]. ’484-Anthony, ¶¶148-154.

173. As further support for this limitation, **Lisogurski** discloses the measuring of various physiological parameters such as pulsatile flow, oxygen saturation of hemoglobin, pulse rate, and blood pressure. Specifically, **Lisogurski** discloses that pulse oximeters may be placed on “any location on the body that has a strong pulsatile arterial flow” and may include multiple sensors placed at “multiple

locations,” including “the neck to monitor carotid artery pulsatile flow, the wrist to monitor radial artery pulsatile flow, the inside of a patient’s thigh to monitor femoral artery pulsatile flow, the ankle to monitor tibial artery pulsatile flow, and around or in front of the ear.” Lisogurski, 4:6-62. **Lisogurski** discloses said pulse oximeters, like its system, “measure and display various blood flow characteristics,” such as “oxygen saturation of hemoglobin in arterial blood,” “pulse rate,” (including “when each individual pulse occurs”), and “blood pressure.” Lisogurski, 3:66-4:5, 4:40-41; *see also* Lisogurski, 12:9-16 (discussing measuring oxygen saturation and other “physiological parameters”).

174. As further support for this limitation, **Lisogurski** discloses that its monitor receives output signals (“physiological signals” or “data relating to light emission and acoustic detections received from one ore more sensor units”) from the detection system, as modified to include front end processing circuitry (Section IX.A.2), to determine physiological parameters. Specifically, **Lisogurski** discloses that a processor, e.g., “processor 172,” “determine[s] one or more physiological parameters based on the received physiological signals” and a monitor, e.g., “[m]onitor 314,” “calculate[s] physiological parameters based at least in part on data relating to light emission and acoustic detections received from one ore more sensor units[,] such as sensor unit 312,” those parameters include “pulse rate, blood pressure, blood oxygen saturation (e.g., arterial, venous, or both),

hemoglobin concentration (e.g., oxygenated, deoxygenated, and/or total), any other suitable physiological parameters, or any combination thereof.” Lisogurski, 17:59-67. **Lisogurski** further discloses that processor 172 may “receive[s] and process[es] physiological signals received from front end processing circuitry 150,” and “determine[s] one or more physiological parameters based on the received physiological signals.” Lisogurski, 14:60-64.

k. Element [1.j]

175. Element [1.j] recites: **“the apparatus being configured to increase the signal-to-noise ratio by increasing light intensity of at least one of the plurality of light emitting diodes from an initial light intensity; and.”** This element is met by **Lisogurski**.

176. Regarding a substantially identical limitation in the prior ’484 IPR reciting “the wearable device **configured to increase the signal-to-noise ratio by increasing light intensity of at least one of the plurality of** semiconductor sources **from an initial light intensity,**” I understand the Board determined that the petitioner demonstrated that “Lisogurski [] disclos[es] that by increasing light intensity the system may increase the brightness of light sources in response to noise to improve signal to noise ratio.”; (2) “Lisogurski describes brightness (light intensity) as a parameter of the light drive signal, i.e., the signal that drives the LED.”; and (3) “Lisogurski states the system may use ‘drive cycle modulation,’ i.e.,

a relatively higher frequency modulation technique having a period on the order of 1.6 msec, to generate one or more wavelengths of intensity signals.” ’484-FWD, 27. This is consistent with my opinions regarding this ’484 limitation provided in my Prior ’484 Declaration, which I incorporate by reference as if fully set forth herein. ’484-Anthony, ¶¶155-171 (citing Lisogurski, 1:19-21, 1:44-46, 1:67-2:3, 5:55-6:6, 6:26-31, 8:22-26, 9:46-52, 9:57-60, 10:48-49, 11:38-41, 11:50-54, 14:49-55, 16:2-9, 17:21-29, 17:55-59, 18:16-31, 25:49-55, 31:11-24, 31:39-55, 35:5-9, 37:6-22).

177. Regarding a substantially identical limitation in the prior ’533 IPR reciting “the light source **configured to increase signal-to-noise ratio by increasing a light intensity** from at **least one of the plurality of** semiconductor sources,” I understand the Board determined that “Petitioner demonstrate[d] how Lisogurski’s LED-based light source 130/316 meets this limitation,” and that “Lisogurski teaches ‘the intensity of light source 130 and the timing of when light source 130 is turned on and off’ is controlled by a light drive signal that ‘increase[s] the brightness of the light sources in response to . . . noise to improve the signal-to-noise ratio.’” ’533-FWD, 26. This is consistent with my opinions regarding this ’533 limitation provided in my Prior ’533 Declaration, which I incorporate by reference as if fully set forth herein. ’533-Anthony, ¶¶95-109 (citing Lisogurski, 1:19-21, 1:44-46, 1:67-2:3, 5:55-6:6, 6:26-31, 8:22-26, 9:46-52, 9:57-60, 10:48-49, 11:38-41, 11:50-54, 14:49-55, 16:2-9, 16:55-59, 17:21-29, 18:23-25, 25:52-55,

35:5-9, 37:6-22).

178. **Lisogurski's** Figure 1 (annotated below) depicts relevant circuitry—namely, the light source 130, light drive circuitry 120, and control circuitry 110, as modified to (Section IX.A.2) be placed within sensor 102—that work together to alter the light drive parameters of the semiconductor sources to increase the signal-to-noise ratio. '484-Anthony, ¶¶156 (citing Lisogurski, 9:46-52, 5:55-6:6), 166 (citing Lisogurski, 9:46-60).

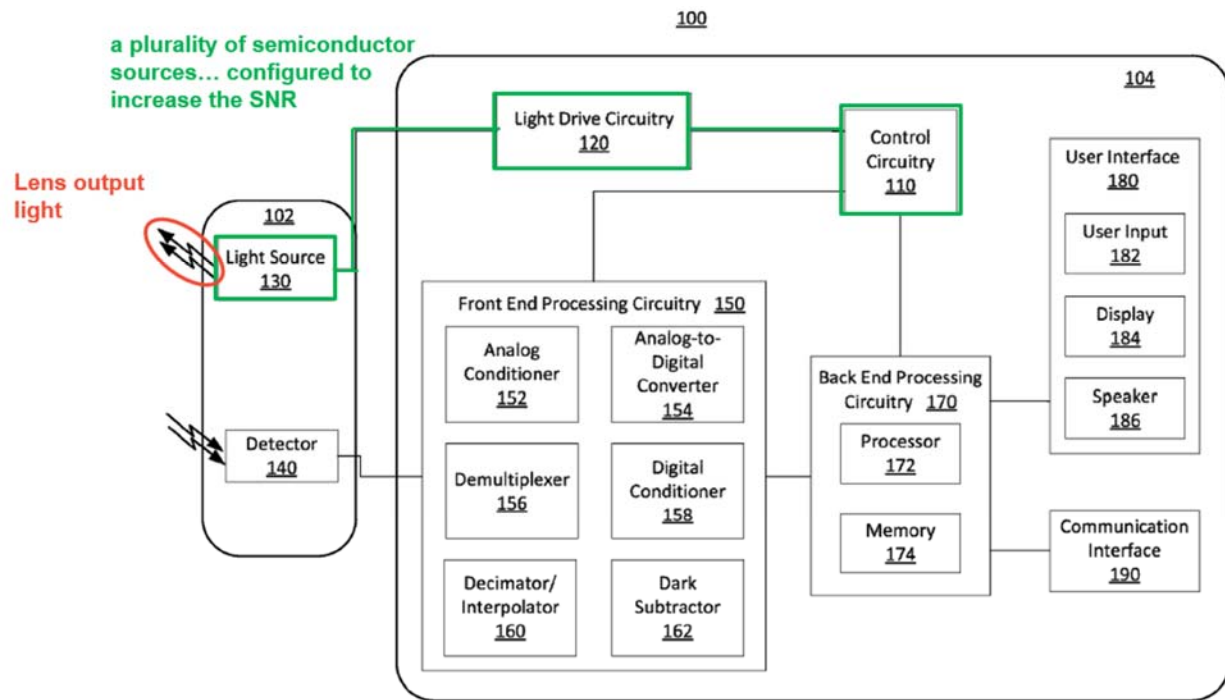


FIG. 1

Lisogurski, Fig. 1; '484-Anthony, ¶159.

179. '475 patent element [1.j] is substantially identical to a corresponding limitation in the '484 patent on which I previously opined, which recites: “the

wearable device **configured to increase the signal-to-noise ratio by increasing light intensity of at least one of the plurality of semiconductor sources from an initial light intensity.**” The main differences between the two terms are (i) the ’484 patent’s use of “wearable device” versus the ’475 patent’s use of the term “apparatus,” and (ii) the ’484 patent’s use of the term “semiconductor sources” versus the ’475 patent’s use of the term “light emitting diodes.”

180. **First**, as I discussed above regarding claim element [1.pre] (Section IX.A.3.a.[1.pre]), the apparatus is a wearable device. **Second**, as I discussed above regarding claim element [1.c] (Section IX.A.3.d.[1.c]), a light emitting diode is a semiconductor source. Thus, the differences between the two terms do not change my analysis, and my opinions regarding the ’484 patent term apply equally to ’475 patent element [1.j]. ’484-Anthony, ¶¶155-171.

181. ’475 patent element [1.j] is substantially identical to the corresponding limitations in the ’533 patent on which I previously opined, which together recite: “the light source **configured to increase signal-to-noise ratio by increasing a light intensity** from at **least one of the plurality of semiconductor sources.**” Aside from differing turns of phrases, the main differences between the two limitations are as listed, and none change my analysis: (i) the ’533 patent’s use of “the light source configured to increase signal-to-noise ratio” as opposed to the ’475 patent’s use of “the apparatus configured to increase signal-to-noise ratio”; and (ii) the ’475 patent’s

addition of “from an initial light intensity.” **First**, as I discussed above regarding claim element [1.d] (Section IX.A.3.e.[1.d]), **Lisogurski’s** apparatus includes a light source, and because the timing and activation of this light source is controlled by drive signals generated by light drive circuitry 120 (Lisogurski, 10:42-46; 11:28-31; 11:38-41), a person of ordinary skill would have recognized that the light source can be configured to increase the signal-to-noise ratio by adjusting those parameters. **Second**, a person having ordinary skill in the art would understand that increasing a signal-to-noise ratio involves increasing its relative to an initial or baseline value. Said differently, there is an original or starting signal-to-noise ratio from which the increase occurs. Thus, the differences between the two terms do not change my analysis, and my opinions regarding the ’533 patent term apply equally to ’475 patent element [1.j]. ’533-Anthony, ¶¶95-109.

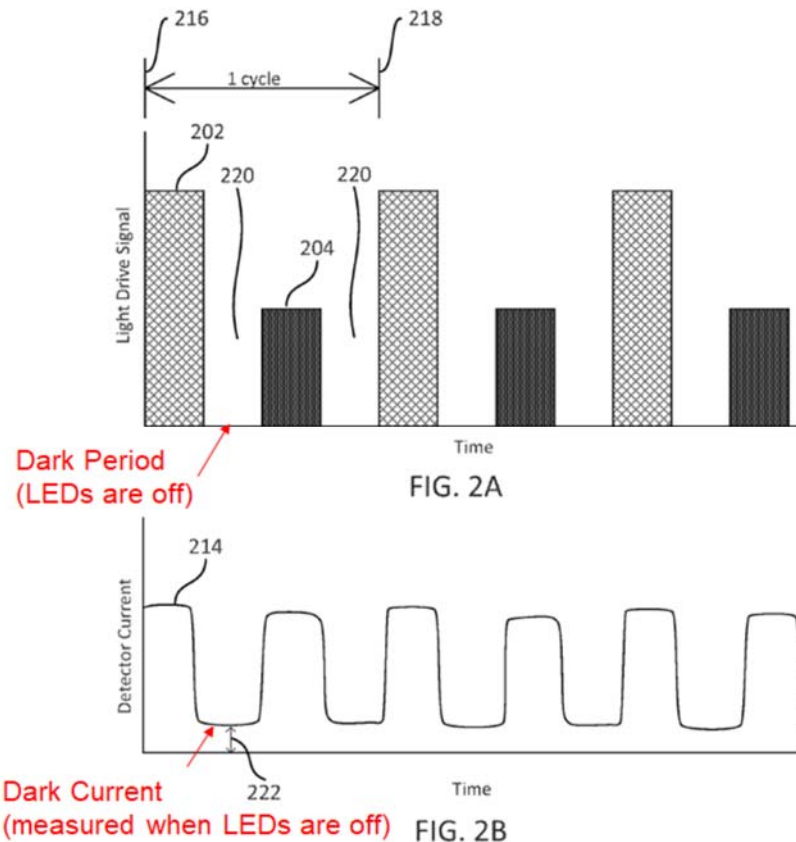
I. Element [1.k]

182. Element [1.k] recites: **“the detection system further configured to: generate a first signal responsive to light received while the light emitting diodes are off.”** This element is met by **Lisogurski**.

183. Regarding an identical limitation in the prior ’484 IPR, I understand the Board determined the petitioner had demonstrated that “Lisogurski [] disclos[es] the front end processing uses the current measured when the LEDs are off to generate a dark signal representative of ambient light.” ’484-FWD, 43-44. This is consistent

with my opinions regarding this '484 limitation provided in my Prior '484 Declaration, which I incorporate by reference as if fully set forth herein. '484-Anthony, ¶¶193-198 (citing Lisogurski, 6:7-19, 11:14-16, 12:59-13:6, 13:35-41, 13:60-14:10, 16:33-54, Figs. 2A & 2B).

184. Below are **Lisogurski's** Figures 2A and 2B with annotations to illustrate **Lisogurski's** dark subtraction technique, where **Lisogurski's** detectors and front end processing circuitry generate signals when the light source is off:



Lisogurski, Figs 2A & 2B; *see also* Lisogurski, 6:12-15, 11:14-16, 12:59-13:6, 13:35-41, 13:67-14:6; '484-Anthony, ¶196.

185. '475 patent element [1.k] is identical to the corresponding limitation in the '484 patent on which I previously opined, which recites: “**the detection system further configured to: generate a first signal responsive to light received while the light emitting diodes are off.**” Thus, my opinions regarding the '484 patent term apply equally to '475 patent element [1.k]. '484-Anthony, ¶¶193-198.

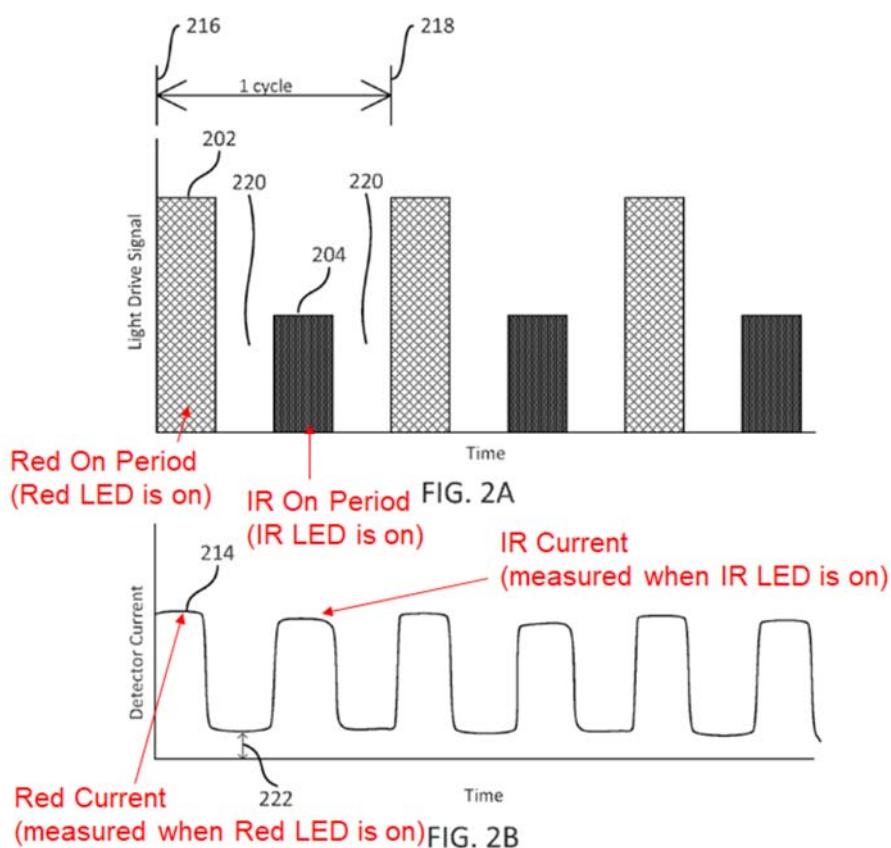
m. Element [1.l]

186. Element [1.l] recites: “**generate a second signal responsive to light received while at least one of the light emitting diodes is on, and.**” This element is met by **Lisogurski**.

187. Regarding an identical limitation in the prior '484 IPR, I understand the Board determined that the petitioner demonstrated that “Lisogurski [] disclos[es] the front end processing circuitry measuring the signal when at least one LED is on to capture a portion of the optical beam, e.g., a red signal and an IR signal, reflected from the tissue.” '484-FWD, 43-44. This is consistent with my opinions regarding this '484 limitation provided in my Prior '484 Declaration, which I incorporate by reference as if fully set forth herein. '484-Anthony, ¶¶199-202 (citing Lisogurski, 6:12-19, 11:12-20, 12:52-13:6, 13:35-41, 13:67-14:2, 17:8-10, 17:40-42, Figs. 2A & 2B).

188. Below are **Lisogurski's** Figures 2A and 2B with annotations to illustrate **Lisogurski's** dark subtraction technique, where **Lisogurski's** detectors and

front end processing circuitry generate signals when the light source is on:



Lisogurski, Figs 2A & 2B; *see also* Lisogurski, 6:12-15, 11:12-20, 13:35-41, 13:67-14:2, 17:8-10, 17:40-42; '484-Anthony, ¶202.

189. '475 patent element [1.1] is identical to the corresponding limitation in the '484 patent on which I previously opined, which recites: “**generate a second signal responsive to light received while at least one of the light emitting diodes is on.**” Thus, my opinions regarding the '484 patent term apply equally to '475 patent element [1.1]. '484-Anthony, ¶¶199-202.

n. Element [1.m]

190. Element [1.m] recites: **“increase the signal-to-noise ratio by comparing the first signal and the second signal; and.”** This element is met by **Lisogurski**.

191. Regarding an identical limitation in the prior '484 IPR, I understand the Board determined that the petitioner demonstrated that “Lisogurski [] disclos[es] a ‘dark subtraction’ technique that subtracts the dark signal from the red and IR signals to generate adjusted red and IR signals with noise removed, thereby improving signal-to-noise ratio,” and that “that Lisogurski describes ambient light as noise.” '484-FWD, 44. This is consistent with my opinions regarding this '484 limitation provided in my Prior '484 Declaration, which I incorporate by reference as if fully set forth herein. '484-Anthony, ¶¶203-206 (citing Lisogurski, 11:43-46, 13:35-41, 13:60-14:10, 14:46-55, 16:51-54, 33:65-34:13).

192. '475 patent element [1.m] is identical to the corresponding limitation in the '484 patent on which I previously opined, and which recites: **“increase the signal-to-noise ratio by comparing the first signal and the second signal.”** I understand that in the prior '484 IPR, the Board and petition stated that the corresponding '484 limitation recited “increase the signal-to-noise ratio by *differencing* the first and second signals.” '484-FWD, 43; '484-Pet., 57. However, the '484 limitation at issue actually recites “increase the signal-to-noise ratio by *comparing* the first signal and the second signal,” as recited in [1.m] of '475.

'484-FWD, 6 ('484 limitation 1(o)). This difference does not affect my analysis as a person of ordinary skill would have understood that differencing and comparing the first and signals would involve the same process—removing the effects of ambient light. Thus, my opinions regarding the '484 patent term apply equally to '475 patent element [1.m]. '484-Anthony, ¶¶203-206.

193. I understand that Defendants identified this limitation—**“increase the signal-to-noise ratio by comparing the first signal and the second signal”**—as potentially indefinite in the Texas Case. Ex. 1023, 247-248.

194. Regardless of its outer bounds (e.g., how comparing alone can increase the signal-to-noise ratio), however, and without opining on whether it has adequate written description support, **Lisogurski** meets this term because **Lisogurski** discloses and renders obvious the indisputable scope of this limitation. For example, embodiments of the '475 patent disclose achieving “higher signal-to-noise ratios” by, for example, “chang[ing] detection schemes” wherein “the detection system captures the signal with the light source on and with the light source off.... Then, the signal with and without the light source is differenced,” which “may enable the sun light changes to be subtracted out.” '475 patent, 58:1-22. A person of ordinary skill in the art would have understood that limitation [1.m] at least includes such embodiments.

195. Consistent with that embodiment, **Lisogurski** discloses “dark

subtractor 162 may subtract dark values from the Red and IR components to generate adjusted Red and IR signals. For example, dark subtractor 162 may determine a subtraction amount from the dark signal portion of the detection signal and subtract it from the peak portion of the detection signal in order to reduce the effect of the dark signal on the peak.” Lisogurski, 13:60-14:10, 16:51-54 (“The system may subtract the background or dark level from the levels received during red ‘on’ portion 286 and IR ‘on’ portion 290.”). Lisogurski, 17:8-10. Therefore, **Lisogurski** discloses comparing (e.g., differencing) two signal to improve signal-to-noise ratio.

o. Element [1.n]

196. Element [1.n] recites: **“wherein the apparatus is at least in part configured to determine, based at least in part on the output signal, that the apparatus is being worn by the user.”** This element is met by **Lisogurski**.

197. **Lisogurski discloses and renders obvious wherein the apparatus (e.g., “sensor”; see my discussion in Section IX.A.3.a.[1.pre]) is at least in part configured to determine, based at least in part on the output signal (e.g., based on when the “processed signals” (see my discussion in Section IX.A.3.g.[1.f]), that the apparatus (e.g., “sensor”; see my discussion in Section IX.A.3.a.[1.pre]) is being worn by the user (e.g., detects an “error” due to “a physiologically impossible value” or a “probe-off signal”).** Lisogurski, 15:66-16:4, 36:66-37:2.

198. **Lisogurski** discloses that its system “detect[s] a signal indicative of a

system error such as a physiologically impossible value,” or “a probe-off signal.” Lisogurski, 36:66-37:2. A person of ordinary skill would have understood (or at least found it obvious) that it is **Lisogurski’s** sensor within the system that detects a “physiologically impossible value,” or “a probe-off signal.” As **Lisogurski** explicitly discloses, in its system, “the functionality of some of the components may be combined in a single component.” Lisogurski, 15:66-16:4. Further, consistent with my discussion above (Section IX.A.2), incorporating the detection of a “physiologically impossible value,” or “a probe-off signal” into **Lisogurski’s** sensor would be consistent with the growing industry trend toward integrating additional features into wearable sensors—particularly in applications like personal fitness and sports—to enable remote monitoring of a user’s physiological state. Further, a person of ordinary skill in the art would have understood (or at least found obvious) that “physiologically impossible value” describes an error condition in which the sensor produces a nonsensical physiological parameter because, e.g., the sensor was improperly attached to the measurement region on the user or became dislodged from the user (i.e., not properly “worn by the user”), such that the “physiologically impossible value” is determined at **Lisogurski’s** sensor. **Lisogurski** further contemplates an error condition that occurs when the sensor is not worn by the user at all, such as when a “probe-off signal” is detected. Lisogurski, 36:66-37:2. Thus, when a “probe-off signal” is not detected, **Lisogurski’s** sensor would determine that

the apparatus is being worn by the user. A person of ordinary skill in the art would thus have understood (or at least found obvious) that the processed signals (see my discussion in Section IX.A.3.g.[1.f]) are used by **Lisogurski's** sensor to determine—not only whether the sensor is not being worn—but also when it *is* being worn by the user. Indeed, as shown in JP3552090, which I understand has been designated as Exhibit 1058, it was well known in the art for physiological measuring devices to incorporate mechanisms to detect both that the device is being worn and not worn. *E.g.*, 1058, claim 1, [0025], [0030], [0034] (disclosing a “pulse wave monitoring system,” that includes “attachment means,” which is “attached to a part of a human body,” along with a “sensor 2” and a “attachment detection circuit 3” that work together to “determine[] whether the attachment means 1 is fitted over a finger 11”).

p. Claim [6]

199. Claim 6 recites: **“The apparatus of claim 1, wherein the plurality of light emitting diodes comprises six light emitting diodes, and wherein the detection system comprises the plurality of detectors arranged along an arc.”**

This claim is met by **Lisogurski**.

200. See my discussion of claim 1 above (Sections IX.A.3.a-o.[1.pre]-[1.n]).

201. **Lisogurski teaches or at least renders obvious wherein the plurality of light emitting diodes** (*e.g.*, “multiple LEDs”; see my discussion in Section IX.A.3.e.[1.d]) **comprises six light emitting diodes** (*e.g.*, six “LEDs”), and

wherein the detection system (*e.g.*, one or more “detectors” connected to “front-end processing circuitry” that may receive a “detection signal”; see my discussion in Section IX.A.3.g.[1.f]) **comprises the plurality of detectors** (*e.g.*, the “one or more detector[s]”; see my discussion in Section IX.A.3.g.[1.f]) **arranged along an arc** (*e.g.*, “[a]ny suitable configuration of ... detector 318 may be used,” including having the detectors arranged along an arc). **Lisogurski**, 10:52-60, 10:65-11:6, 11:16-20, 17:37-45, 19:22-31, 27:36-43.

202. This limitation is met by **Lisogurski**, at least in part, for the reasons I discuss above regarding claim elements [1.d] and [1.h]. Sections IX.A.3.e.[1.d] (“a plurality of light emitting diodes”), IX.A.3.i.[1.h] (“a plurality of detectors”).

203. Regarding the ’475 patent’s additional recitation of “**six light emitting diodes**,” **Lisogurski** further teaches that its light source includes “one or more,” “multiple,” or “any number” of LEDs. **Lisogurski**, 10:52-60 (“For example, light source 130 may include a Red light emitting light source and an IR light emitting light source, *e.g.*, Red and IR light emitting diodes (LEDs)...”), 10:65-11:6 (“[T]he term ‘light’ may refer to energy produced by radiative sources and may include one or more of ultrasound, radio, microwave, millimeter wave, infrared, visible, ultraviolet, gamma ray or X-ray electromagnetic radiation. As used herein, light may also include any wavelength within the radio, microwave, infrared, visible, ultraviolet, or X-ray spectra, and that any suitable wavelength of electromagnetic

radiation may be appropriate for use with the present techniques.”), 17:43-45 (“[S]ensor unit 312 may include multiple light sources...”), 19:22-31 (“The light source may be one or more LEDs... In some embodiments, the light source may include LEDs of multiple wavelengths, for example, a red LED and an IR led. In some embodiments, the light source may include multiple LEDs of the same wavelength, multiple LEDs of different wavelengths, any other suitable arrangement, or any combination thereof.”), 27:36-43. From the perspective of a person of ordinary skill in the art, utilizing multiple LEDs, particularly multiple wavelengths and multiple LEDs per wavelength, was standard practice at the relevant time. Employing multiple LEDs allowed designers to improve measurement robustness, accuracy, and redundancy, and to address various physiological monitoring objectives—with improved signal to noise, and while providing redundancy to component failures, and while providing ample illumination of tissue (for obtaining ample signal and for example to be tolerant to reduction of signal because of obstructions like scars or moles).

204. It was well-known in the art that adding additional lights—particularly six or more—enhances physiological signal detection, such as enhancing the ability to distinguish among multiple absorbers within tissue and, thus, measure a broader of physiological parameters and to measure said parameters with increased accuracy. Indeed, **Lisogurski** discloses the benefit of using multiple wavelengths of light to

differentiate between high and low blood oxygen saturation levels: “blood with a relatively high blood oxygen saturation ... absorb[s] IR light more strongly than red light[, and because [a] high blood oxygen saturation [has] a relatively higher concentration of oxyhemoglobin and a relatively lower concentration of deoxyhemoglobin, [it has] higher IR sensitivity. Conversely, ... blood with a relatively low blood oxygen saturation ... absorb[s] red light more strongly than infrared light[, and because] blood with a low blood oxygen saturation [has] a relatively lower concentration of oxyhemoglobin and a relatively higher concentration of deoxyhemoglobin, [it has] higher red sensitivity.” Lisogurski, 24:58-25:3.

205. Indeed, it was well known in the art that different wavelengths penetrate tissue to varying depths and exhibit different sensitivities to specific chromophores—such as oxygenated and deoxygenated hemoglobin—as well as other physiological conditions, making each wavelength range better suited to detecting particular physiological signals. For example, violet and ultraviolet (UV) light penetrate only shallowly and are therefore better suited to capture “motion-related” physiological data, such as the condition of the thin “skin of the ear,” while green, red, and infrared wavelengths (IR) wavelengths penetrate deeper into tissue, allowing more accurate detection of blood vessels and blood analyte levels in the tissue, and blue wavelengths are “particularly useful for gauging changes in the size

of the blood vessels.” LeBoeuf, [0153].

206. Accordingly, it was well-known in the art that “when only two wavelengths are used but there are more than two significant absorbers in the patient’s tissue, the system may be underdetermined,” suggesting that the data from only two wavelengths may be insufficient to isolate and accurately quantify the concentration of each absorber. Ex. 1033, [0035], [0033]-[0037]. A person of ordinary skill in the art would have understood that the limitations associated with using only two optical wavelengths in physiological monitoring, as many real-world applications involve multiple chromophores. The problem of an “underdetermined” system was widely acknowledged in spectroscopy and pulse oximetry, requiring additional wavelengths or advanced processing methods for accurate differentiation and quantification of multiple absorbers in tissue.

207. From the perspective of a person of ordinary skill in the art, using multiple (six or more) wavelengths was a conventional solution to the known issue of limited differentiation capability inherent in dual-wavelength systems. Additional wavelengths enable a more precise quantification of multiple physiological absorbers. To address this limitation, a person of ordinary skill would have understood the benefit of “add[ing] wavelengths sensitive to additional significant absorbers” in order to “enable more accurate calculation of the concentration of each absorber and the blood oxygen saturation.” Ex. 1033, [0035],

[0033]-[0037]. Accordingly, a person having ordinary skill in the art would have understood that incorporating three or more optical wavelengths—such as those disclosed or suggested in **Lisogurski**—was a routine and effective approach to overcome this known limitation and improve the physiological parameter measurement.

208. Moreover, using six or more LEDs for a physiological measurement device was well known in the art, and a person of ordinary skill in the art would have understood that **Lisogurski's** disclosure of “one or more,” “multiple,” or “any number” (Lisogurski, 10:58-60, 17:37-39, 17:43-45), of LEDs would include six LEDs. See *e.g.*, Lamego, [0035], [0041] (“A sensor 300 has n LEDs 302, which...emit light of different wavelengths....[and can] include four, six, eight or sixteen LEDs of different wavelengths.”).

209. Regarding **plurality of detectors arranged along an arc**, **Lisogurski** further discloses that “[o]ne or more detector 318” may be arranged in “[a]ny suitable configuration.” Lisogurski, 17:39-43. A person of ordinary skill in the art would have understood (or at least found it obvious) to arrange the multiple detectors of **Lisogurski's** sensor in an arc configuration because a person of ordinary skill in the art would appreciate that light emitted into biological tissue undergoes significant scattering and absorption, and the reflected light exits the tissue at a wide range of angles (Lisogurski, 11:16-20) such that a linear or closely grouped detector

arrangement would fail to capture much of this angularly scattered light. For example, U.S. Patent No. 6,801,799, which I understand has been designated as Exhibit 1045, discloses “a sensor having six photodiodes arranged symmetrically around the LEDs....” Ex. 1045, 4:14-65. Accordingly, a person of ordinary skill in the art would have been motivated to arrange in an arc to capture more of the reflected light, thereby improving the detection of scattered light from biological tissue and increasing the signal-to-noise ratio of **Lisogurski’s** sensor.

210. I understand that Defendants identified a portion of this limitation—**“plurality of detectors arranged along an arc”**—as potentially indefinite in the Texas Case. Ex. 1023, at 247-248.

211. Regardless of its outer bounds (e.g., requiring full circular arc or more broadly encompassing any degree of curvature), however, and without opining on whether or not it has adequate written description support, **Lisogurski** discloses and renders obvious the indisputable scope of this limitation. Indeed, as I discussed above, **Lisogurski** discloses “[o]ne or more detector 318” may be arranged in “[a]ny suitable configuration” (Lisogurski, 17:39-43), and a person of ordinary skill in the art would have understood (or at least found it obvious) to arrange the multiple detectors of **Lisogurski’s** sensor in a fully circular arc configuration. *See, e.g.*, Ex. 1045, 4:14-65. See also my discussion in Section IX.C.3.a.[6].

q. Claim [7]

212. Claim 7 recites: **“The apparatus of claim 6, wherein the apparatus is further configured to communicate with a smart phone or a tablet, the smart phone or the tablet comprising a wireless receiver, a wireless transmitter, a display, a speaker, a voice input module, one or more buttons or knobs, a microprocessor, and a touch screen.”** This claim is met by **Lisogurski**.

213. See my discussion of claim 6 above (Section IX.A.3.p.[6]).

214. Regarding an identical limitation in the prior '484 IPR, I understand the Board determined that the petitioner demonstrated that “Lisogurski [] disclos[es] its sensor is designed to be used with a monitor that may be a portable, battery powered system that includes a touchscreen and has back-end processing that receives signals from the front end and includes a microprocessor and an interface with a display, speaker, and microphone,” and (2) **Lisogurski’s** “back-end processing ... can be configured for wireless communication.” 484-FWD, 25-27. This is consistent with my opinions regarding this '484 limitation provided in my Prior '484 Declaration, which I incorporate by reference as if fully set forth herein. '484-Anthony, ¶¶136-142 (citing Lisogurski, 1:16-18, 14:62-15:16, 15:19-23, 15:30-35, 15:43-48, 15:49-57, 18:11-15, 18:49-66, 26:55-60, 27:31-36, 30:42-48, 33:23-27, Fig. 1).

215. Regarding a substantially identical limitation in the prior '533 IPR reciting “a personal device **comprising a wireless receiver, a wireless transmitter,**

a display, a microphone, a speaker, one or more buttons or knobs, a microprocessor and a touch screen... I understand that, regarding “[p]etitioner’s proposed modification of monitor 104 to include only backend processing circuitry 170, user interface 180, and communication interface 190,” the Board determined that “[p]etitioner demonstrate[d] why a person skilled in the art would have modified Lisogurski’s monitor 104 in the manner proposed, including Lisogurski’s express suggestion and the industry trend to make wireless sensors for personal fitness tracking that transmit monitored physiological parameters to a personal device.” ’533-FWD, 39-42. Moreover, I understand that the Board determined that “[p]etitioner demonstrate[d] how backend processing circuitry 170 includes microprocessor 172, user interface 180 includes a display, a microphone, a speaker, buttons, and a touch screen, and communication interface 190 includes wireless receivers and transmitters for wireless communications.” ’533-FWD, 39-42. Moreover, I understand that the Board determined that (1) “[p]etitioner demonstrate[d] how Lisogurski’s monitor 104/314 (i.e., backend processing circuitry 170, user interface 180, and communication interface 190) meets these personal device limitations”; (2) “[m]onitor 104/314 receives and processes the output signal from the receiver (i.e., detector 140/318 and front end processing circuitry 150) because processor 172 in back end processing circuitry 170 ‘receive[s] and process[es] physiological signals [i.e., the output signal] received from front end

processing circuitry 150’ and ‘determine[s] one or more physiological parameters based on the received physiological signals’” (3) “[m]onitor 104/314 stores the processed output signal because it includes memory 174, which can store ‘historical information [measured in] previous cardiac cycles.’”; and (4) “monitor 104/314 transmits the processed output signal over a wireless link because communications interface 190 can use a wireless communications protocol to transmit the signal to MPPM 326 for display on remote display 328.” ’533-FWD, 39-42. This is consistent with my opinions regarding this ’533 limitation provided in my Prior ’533 Declaration, which I incorporate by reference as if fully set forth herein. ’533-Anthony, ¶¶147-153 (citing Lisogurski, 14:60-15:42, 15:43-48, 15:49-57, 18:11-15, 18:49-65, 26:54-60, 27:3-5, 27:31-36, 30:42-48, 33:23-27, Fig. 1).

216. ’475 patent claim 7 is identical to the corresponding limitation in the ’484 patent on which I previously opined, which recites: “...**the smart phone or tablet comprising a wireless receiver, a wireless transmitter, a display, a speaker, a voice input module, one or more buttons or knobs, a microprocessor and a touch screen...**” Thus, my opinions regarding the ’484 patent term apply equally to ’475 patent claim 7. ’484-Anthony, ¶¶136-142.

217. ’475 patent claim 7 is also substantially identical to the corresponding limitation in the ’533 patent on which I previously opined, which recites: “a personal device **comprising a wireless receiver, a wireless transmitter, a display, a**

microphone, **a speaker, one or more buttons or knobs, a microprocessor and a touch screen...**” Aside from reordering of the listed components, the main differences between the two limitations are: (i) the ’533 patent’s use of a “personal device” as opposed to the ’475 patent’s use of a “smartphone or tablet”; and (ii) the ’533 patent’s use of a “microphone” as opposed to the ’475 patent’s use of “a voice input module.” **First**, a person having ordinary skill in the art would have understood that both smartphones and tablets are types of personal devices because they are portable, user-owned electronics intended for personal use. **Second**, a person having ordinary skill in the art would have understood that a microphone is a type of voice input module as it captures sound waves, including voice, and converts them into electrical signals. Thus, the differences between the two terms do not change my analysis, and my opinions regarding the ’533 patent term apply equally to ’475 patent claim 7. ’533-Anthony, ¶¶147-153.

218. As I previously opined in the prior ’484 IPR, a person having ordinary skill in the art would have found it obvious that **Lisogurski’s** monitor 104, which is “portable,” “battery powered” and has a “user interface” with “a touch screen,” would include a smart phone or tablet. At the time relevant for priority of the ’475 patent, smartphones and tablets were well-known and widely recognized as portable computing devices that were designed for ease of mobility, operated on battery power, and commonly featured a touchscreen coupled with a graphical user

interface, which served as a primary form of haptic input. '484-Anthony, ¶¶48-56, 137 (citing Lisogurski, 1:16-18, 15:20-23, 18:56-66).

219. As further support for this limitation, **Lisogurski** discloses its monitor includes a memory capable of including software applications, a speaker, and a display, which person of ordinary skill in the art would have understood to be features commonly includes in a smart phone or a tablet. Specifically, **Lisogurski** discloses that its monitor 104 contains back end processing circuitry 170, which further includes memory 174. Lisogurski, 11:28-32, 14:56-67. “Memory 174 [] include[s] any suitable computer-readable media capable of storing information that can be interpreted by processor 172” also contained in back end processing circuitry 170. Lisogurski, 14:56-66. This information can be data or “computer-executable instructions, such as software applications,” that cause its microprocessor to “perform certain functions and/or computer-implemented methods.” Lisogurski, 14:67-15:16. The description by **Lisogurski** of such features would have been clearly understood by a person of ordinary skill in the art as consistent with widely adopted and well-known practices in designing wearable monitoring devices at the time of the claimed invention.

220. Additionally, **Lisogurski** teaches that its system has (1) a “display 184,” which may be “any type of display such as a cathode ray tube display, a flat panel display such a liquid crystal display or plasma display, or any other suitable

display device, to “display, for example, an estimate of a subject’s blood oxygen saturation generated by monitor 104, pulse rate information, respiration rate information, blood pressure, any other parameters, and any combination thereof” and (2) a “[s]peaker 186,” which provides “audible sound[s] that may be used “in various embodiments, such as for example, sounding an audible alarm in the event that a patient's physiological parameters are not within a predefined normal range.” Lisogurski, 15:30-42; *see also* Lisogurski, 18:3-6 (describing, similarly, that the monitor, e.g., “monitor 314,” may include a display, “display 320,” to “display the physiological parameters or other information”). An example of **Lisogurski’s** system, including at least a monitor (e.g., “monitor 314”), display (e.g., “display 320”) and a speaker (e.g., “speaker 322”), is depicted in Figure 3 below.

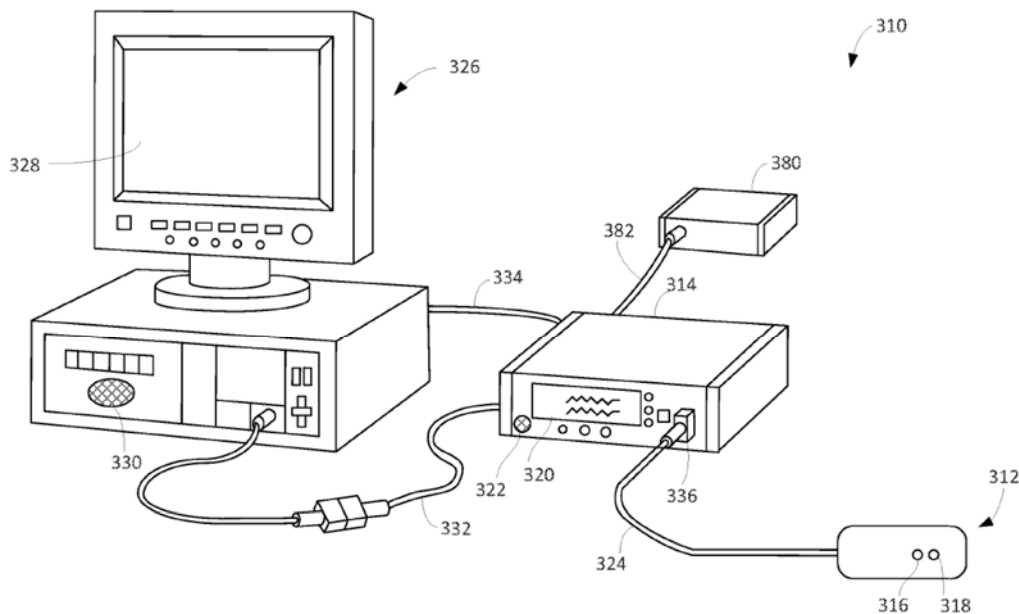


FIG. 3

221. Further, regarding **buttons or knobs**, **Lisogurski** discloses that its user interface includes “any type of user input device such as...buttons....” **Lisogurski**, 15:20-27. Regarding, **the apparatus configured to communicate with a smart phone or a tablet**, **Lisogurski** discloses that “[m]onitor 104 may be communicatively coupled to sensor 102,” and that monitor 104 includes communication interface 190, which enables monitor 104 to exchange information with external devices, such as “electronic circuitry, a device, a network, a server or other workstations, a display, or any combination thereof....” **Lisogurski**, 11:28-32, 15:43-65. Further, “the sensor may be wirelessly connected to monitor 314” and “[m]onitor 314 may include a sensor interface configured to receive physiological signals from sensor unit 312, provide signals and power to sensor unit 312, or otherwise communicate with sensor unit 312.” **Lisogurski**, 17:58-59, 18:25-28.

r. Element [8.pre]

222. Element [8.pre] recites: “**A wearable device configured to be worn by a user, the wearable device comprising.**” This element is met by **Lisogurski**.

223. For the reasons I discussed above in element [1.pre], **Lisogurski** meets this limitation (Section IX.A.3.a.[1.pre]).

224. ’475 patent element [8.pre] is substantially identical to the ’475 patent element [1.pre], which recites: “An apparatus adapted **to be worn by a user...**” Aside from differing turns of phrases (“apparatus adapted” versus “wearable device

configured”) elements [1.pre] and [8.pre] are identical. Thus, my opinions regarding ’475 patent element [1.pre] apply equally to ’475 patent element [8.pre].

s. Element [8.a]

225. Element [8.a] recites: “**a light source configured to be on or off, responsive to the light source being on, the light source generates an output light.**” This element is met by **Lisogurski**.

226. For the same reasons I discussed above regarding claim elements [1.d] and [1.k], the majority of this limitation is met by **Lisogurski**. Sections IX.A.3.e.[1.d] (“**a light source** comprising a plurality of light emitting diodes that are **configured to generate an output optical light** having one or more optical wavelengths”), IX.A.3.1.[1.k] (“...light emitting diodes are **off**”).

227. Regarding **a light source configured to be on or off**, **Lisogurski** further discloses that its “light drive circuitry 120 may generate a light drive signal, which may be used to turn on and off the light source 130, based on the timing control signals.” **Lisogurski**, 11:38-41.

228. Regarding **responsive to the light source being on, the light source generates an output light**, **Lisogurski** further discloses that “light drive signal” that is “generat[ed]” by “light drive circuitry 120” “to turn on and off” is also “used by a light source to emit a photonic signal.” **Lisogurski**, 11:38-41, 19:21-22.

t. Element [8.b]

229. Element [8.b] recites: “**a lens positioned to direct at least a portion of the output light towards a bodily tissue of the user.**” This element is met by **Lisogurski**.

230. For the reasons I discussed above in element [1.e], **Lisogurski** meets this limitation (Section IX.A.3.f.[1.e]).

231. ’475 patent element [8.b] is substantially identical to the ’475 patent element [1.e], which recites: “one or more **lenses** configured to receive **at least a portion of the output optical light** and to deliver a lens **output light** to **tissue** comprising skin.” Aside from differing turns of phrases, the main differences between the two elements are (i) element [1.e]’s recitation of one or more lenses versus element [8.b]’s recitation of a singular lens, (ii) element [1.e]’s use of “receive...and to deliver” versus element [8.b]’s use of “direct...towards,” and (iii) element [1.e]’s use of “tissue comprising skin” versus [8.b]’s use of “bodily tissue of the user.”

232. **First**, disclosure of multiple lenses satisfies the requirement of a single lens. **Second**, a person of ordinary skill in the art would have understood (or at least found it obvious), that the processes of receiving and delivering light and directing light are both met by the art for the same reasons. **Third**, a person of ordinary skill in the art would have understood (or at least found it obvious), that skin is bodily

tissue and are met by the art for the same reasons. Thus, my opinions regarding '475 patent element [1.e] apply equally to '475 patent element [8.b].

u. Element [8.c]

233. Element [8.c] recites: “**a detector; and.**” This element is met by **Lisogurski**.

234. For the reasons I discussed above in element [1.h], **Lisogurski** meets this limitation (Section IX.A.3.i.[1.h]).

235. '475 patent element [8.c] is substantially identical to a portion of '475 patent element [1.h], which recites: “a plurality of **detectors.**” The main difference between the two elements is element [1.h]’s recitation of multiple detectors versus element [8.c]’s recitation of a singular detector. Disclosure of multiple detectors satisfies the requirement of a single detector. Thus, my opinions regarding '475 patent element [1.h] apply equally to '475 patent element [8.c].

v. Element [8.d]

236. Element [8.d] recites: “**a processor configured to: (i) responsive to the light source being on and the detector receiving at least a portion of the output light that is reflected from the bodily tissue of the user, generate a first output signal having a first signal-to-noise ratio; and.**” This element is met by **Lisogurski**.

237. For the same reason I discuss above regarding claim elements [1.f] and

[1.1], the majority of this limitation is met by **Lisogurski**. Sections IX.A.3.g.[1.f] (“a detection system configured to **receive at least a portion of the lens output light reflected from the tissue** and to **generate** an output **signal having a signal-to-noise ratio**”), IX.A.3.m.[1.1] (“**generate a second signal responsive to light** received while at least one of the light emitting diodes is **on**, and,”).

238. Regarding **a processor**, a person of ordinary skill in the art would have understood (or at least found it obvious), that using a processor for **Lisogurski’s** front end processing circuitry is a well-known concept. For example, **Lisogurski** discloses that its front end processing circuitry 150 “perform[s] various analog and digital processing” of “the output signal of detector 140.” **Lisogurski**, 12:42-50. A person of ordinary skill in the art would have understood (or at least found it obvious), that these are common functions of a processor. To this end, **Lisogurski** explicitly discloses that “all of the components of physiological monitoring system 100,” which includes its front end processing circuitry, “can be realized in processor circuitry.” **Lisogurski**, 16:14-16. Further, implementing processor as a front end processing circuitry was well known in the art. For example, U.S. Patent No. 8,852,103, which I understand has been designated as Exhibit 1054, discloses a medical imaging system including “pre-processing circuitry” that performs “one or more functions” on signal from a receiver “such as determining one or more characteristics of the received signals,” and may be implemented as a “single

processor.” Ex. 1054, 28:42-45, 29:34-39.

w. Element [8.e]

239. Element [8.e] recites: “**(ii) responsive to the light source being off and the detector receiving ambient light, generate a second output signal having a second signal-to-noise ratio.**” This element is met by **Lisogurski**.

240. **Lisogurski discloses responsive to the light source being off** (e.g., during a “dark periods 220” / “‘off’ period 220,” which occurs while light source is turned off) **and the detector receiving ambient light** (e.g., detector 140/318 detects “ambient light”), **generating a second output signal having a second signal-to-noise ratio** (e.g., front end processing circuitry generates a “dark signal,” having a second signal to noise ratio). Lisogurski, 6:7-19, 11:14-16, 12:23-41, 12:59-13:6, 13:67-14:6, 16:33-54, Figs. 2A-B.

241. I understand that in the prior ’484 IPR, the Board agreed that **Lisogurski** discloses “generat[ing] a ... signal responsive to light received while the [light source is] off.” ’484-FWD, 43-44. I understand that in making this finding, the Board relied on **Lisogurski’s** disclosure of “turning on a ... light source, followed by a ‘dark period,’” which is a period during which light source is turned off. ’484-FWD 43-44. I further understand that the Board relied on **Lisogurski’s** disclosure that the current measured when the light source is off is used by the front end processing to generate a “dark signal.” ’484-FWD 43-44. This is consistent

with my opinions regarding the corresponding '484 patent limitation provided in my Prior '484 Declaration, which I incorporate by reference as if fully set forth herein. Anthony, ¶¶193-198 (citing Lisogurski, 6:7-19, 11:14-16, 12:59-13:6, 13:35-41, 13:60-14:10, 16:33-54, Figs. 2A & 2B).

242. As further support of this limitation, **Lisogurski** discloses measuring “ambient light detected by the detector during the ‘dark’ period and then subtract[ing] this ambient contribution from the signals received during the first and second ‘on’ periods.” Lisogurski, 6:16-19. Regarding these “dark” or “of” periods, **Lisogurski** discloses that its light drive includes “‘off’ periods 220 between the Red and IR light ‘on’ periods...during which no drive current may be applied to light source 130...” Lisogurski, 12:23-41. **Lisogurski** further explains that in this process “a detection signal peak corresponding to red ‘on’ period 202 may be adjusted by determining the amount of dark signal during the ‘off’ period 220 preceding red ‘on’ period 202,” and that “the dark signal amount determined in this manner may be subtracted from the detector peak corresponding to red ‘on’ period 202.” Lisogurski, 13:67-14:6.

243. Regarding **generate a second output signal having a second signal-to-noise ratio**, **Lisogurski** discloses that its “detection signals” have “a signal to noise ratio.” Lisogurski, 14:49-50. A person of ordinary skill in the art would have thus understood (or at least found it obvious) **Lisogurski’s** generated dark signal,

which is a type of detection signal described in **Lisogurski**, has a signal-to-noise ratio.

x. Element [8.f]

244. Element [8.f] recites: “**(iii) generate a third output signal using at least a portion of the first output signal and at least a portion of the second output signal, the third output signal having a third signal-to-noise ratio that is greater than the first signal-to-noise ratio and greater than the second signal-to-noise ratio, the third output signal being associated with a physiological parameter of the user; and.**” This element is met by **Lisogurski**.

245. This limitation is met by **Lisogurski**, at least in part, for the reasons I discuss above regarding claim elements [1.i], [1.m], and [8.d]-[8.e] (Sections IX.A.3.j.[1.i], IX.A.3.n.[1.m], IX.A.3.v-w.[8.d]-[8.e]).

246. Specifically, **Lisogurski discloses generating a third output signal** (*e.g.*, an output signal generated after application of a dark subtraction technique that “subtract dark values from the Red and IR components to generate adjusted Red and IR signals,” to “remove ambient and background signals”; see my discussion in Section IX.A.3.n.[1.m]) **using at least a portion of the first output signal** (*e.g.*, see my discussion in Section IX.A.3.v.[8.d]) **and at least a portion of the second output signal** (*e.g.*, see my discussion in Section IX.A.3.w.[8.e]), **the third output signal having a third signal-to-noise ratio that is greater than the first signal-**

to-noise ratio and greater than the second signal-to-noise ratio (*e.g.*, signal generated with “ambient and background signals” “remove[d],” and thereby reducing the “detrimental effect[s] on the signal-to-noise ratio of the detection signal” and improving signal-to-noise ratio; see my discussion in Section IX.A.3.n.[1.m]), **the third output signal being associated with a physiological parameter of the user** (*e.g.*, the “output signal...is configured to calculate physiological parameters”; see my discussion in Section IX.A.3.j.[1.i]). Lisogurski, 6:7-19, 13:60-14:10, 14:46-55, 16:33-54.

247. As I discuss above regarding claim element [1.m] (Section IX.A.3.n.[1.m]), **Lisogurski’s** “dark subtraction” technique “subtracts the dark signal [(second output signal)] from the red and IR signals [(first output signal)] to generate adjusted red and IR signals [(third output signal)] with noise removed, thereby improving signal-to-noise ratio.” ’484-FWD, 44. Further, **Lisogurski** discloses “more ambient light noise in the input of analog-to-digital converter” has “a detrimental effect on the signal-to-noise ratio of the detection signal,” and that “signal modification techniques,” such as its dark subtraction technique described above, “may be employed to reduce the effect of ambient light on the detection signal that is applied to analog-to-digital converter 154, and thereby reduce the contribution of the noise component to the converted digital signal.” Lisogurski 14:46-55. Therefore, a person of ordinary skill in the art would have understood (or at least

found it obvious) that the resulting third (“adjusted”) signal would have an improved signal to noise ratio. For example, U.S. Patent No. 8,922,788, which I understand has been designated as Exhibit 1057, discloses a physiological measurement system including an “ambient subtractor 162” that “remove[s] ambient values from the Red and IR components” of a “light signal” “to generate adjusted Red and IR signals,” and a person of ordinary skill in the art would have understood that performing such “filter[ing]” of the “light signal” would “remove noise.” Ex. 1057, 10:41-56, 11:1-16, 19:5-25.

y. Element [8.g]

248. Element [8.g] recites: “**(iv) determine, based at least in part on the third output signal, that the wearable device is being worn by the user.**” This element is met by **Lisogurski**.

249. See my discussion of claim elements [8.pre] and [8.f] above (Sections IX.A.3.r.[8.pre], IX.A.3.x.[8.f]).

250. **Lisogurski** discloses **determine, based at least in part on the third output signal, that the wearable device is being worn by the user** (*e.g.*, using the “dark subtract[ed]” signal as part of determining “physiologically impossible value” or “probe off signal”). **Lisogurski**, 16:12-14, 36:66-37:2.

251. As I discussed above regarding limitation [1.n] (Section IX.A.3.o.[1.n]), **Lisogurski** discloses **determining based at least in part an output**

signal, that the wearable device is being worn by the user. Further, as I discussed above regarding claim elements [8.d] to [8.f] (Sections IX.A.3.v-x.[8.d]-[8.f]), **Lisogurski** also discloses generating a third output signal based on a dark subtraction technique.

252. **Lisogurski** teaches an error condition that occurs when the sensor is not worn by the user at all, for example by using a “probe-off signal.” **Lisogurski**, 36:66-37:2. Relatedly, **Lisogurski** further discloses that its system “detect[s] a signal indicative of a system error such as a physiologically impossible value.” **Lisogurski**, 36:66-37:2. As I discussed above regarding claim element [1.n] (Section IX.A.3.o.[1.n]), a person of ordinary skill in the art would have understood (or at least found it obvious) that **Lisogurski’s** sensor would perform these measurements.

253. **Lisogurski** discloses the capability to perform the “probe-off signal” detection or “physiologically impossible value” measurement when needed. **Lisogurski**, 16:12-14 (“the functionality of one or more of the components may be performed in a different order”). Based on **Lisogurski’s** flexibility, and to ensure accurate detection of the “probe-off signal” and “physiologically impossible value” by, *e.g.*, minimizing any detrimental effect that noises in the processed signal may have on such signal or value, a person of ordinary skill in the art would have understood (or at least found obvious) that the determination of a “physiologically

impossible value” or “probe-off signal” would be based at least in part on the dark subtraction signal, which removes ambient noise (Section IX.A.3.o.[1.n]).

254. Indeed, determining whether a sensor is being worn using a signal resulting from a dark subtraction technique was well known in the art. For example, U.S. Patent No. 8,922,788 discloses a physiological monitoring system including a sensor wherein in one step it performs a “comparison of [a] first signal (e.g., the detected ambient light) to [a] second signal (e.g., the detected light signal),” by “subtract[ing]” the two signals and thereafter determining if the sensor is “not properly positioned” (e.g., properly worn) based on that comparison. Ex. 1057, 18:45-51, 20:4-6.

z. Claim [11]

255. Claim 11 recites: “**The wearable device of claim 8, wherein at least a portion of the output light has an optical wavelength between about 700 nanometers and about 2500 nanometers.**” This claim is met by **Lisogurski**.

256. See my discussion of claim 8 above (Sections IX.A.3.r-y.[8.pre]-[8.g]).

257. Regarding a substantially identical limitation in the prior ’533 IPR reciting “**...wherein at least a portion of the one or more optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers,**” I understand that the Board determined that the petitioner demonstrated that **Lisogurski’s** “[s]ensor 102/312 can contain multiple LEDs that emit and direct light

toward a subject's tissue, including an LED that emits red light, and an LED that emits infrared light having a wavelength between 800 and 1000 nm.” ’533-FWD, 25-26. This is consistent with my opinions regarding this ’533 limitation provided in my Prior ’533 Declaration, which I incorporate by reference as if fully set forth herein. ’533-Anthony, ¶¶92-94 (citing Lisogurski, 4:42-45, 7:38-8:3, 10:48-52, 10:56-64, 17:37-45, 19:25-31, Figs. 1 & 3).

258. ’475 patent claim [11] is substantially identical to the corresponding limitation in the ’533 patent on which I previously opined, which recites: “...wherein at least a portion of the one or more **optical wavelengths** is a near-infrared wavelength **between 700 nanometers and 2500 nanometers.**” Aside from differing turns of phrases, the main differences between the two is that the ’533 patent limitation specifies that the portion is near infrared wavelength.

259. A person of ordinary skill would have understood that infrared light within the 800 to 1000 nm range of wavelength falls within the near-infrared region. Thus, the differences between the two terms do not change my analysis, and my opinions regarding the ’533 patent term apply equally to ’475 patent claim [11]. ’533-Anthony, ¶¶92-94.

260. As further support for this limitation, **Lisogurski** discloses that its “light source 130 may include a Red light emitting light source and an IR light emitting light source, e.g., Red and IR light emitting diodes (LEDs), for emitting

light into the tissue of a Subject to generate physiological signals.” Lisogurski, 10:52-56.

aa. Claim [12]

261. Claim 12 recites: “**The wearable device of claim 8, wherein the physiological parameter of the user is associated with a blood constituent or a blood flow of the user.**” This claim is met by **Lisogurski**.

262. See my discussion of claim 8 above (Sections IX.A.3.r-y.[8.pre]-[8.g]).

263. **Lisogurski** meets this limitation for the reasons I discussed regarding element [1.c] (Section IX.A.3.d.[1.c]).

264. As further support for this limitation, **Lisogurski** further discloses that its sensor 102/312 is used to determine “an amount of a blood constituent,” for example, “oxyhemoglobin.” Lisogurski, 4:36-41.

bb. Claim [13]

265. Claim 13 recites: “**The wearable device of claim 8, wherein the processor is further configured to modulate the light source with a modulation frequency.**” This claim is met by **Lisogurski**.

266. See my discussion of claim 8 above (Sections IX.A.3.r-y.[8.pre]-[8.g]).

267. **Lisogurski discloses wherein the processor** (*e.g.*, “front end processing circuitry 150”; see my discussion in Section IX.A.3.v.[8.d]) **is further configured to modulate the light source** (*e.g.*, “operate a...light source according

to a...cardiac cycle modulation technique,” which entails “generat[ing] a light drive signal that varies with a period the same as or closely related to the period of the cardiac cycle,” and “apply[ing this] cardiac cycle modulation to [the] light source”), **with a modulation frequency** (e.g., “modulat[ed] with a period on the order of some multiple of the cardiac cycle period”).

268. As I discuss above (Section VII.A), I understand that in the EDTX Cases, the district court determined that the term “modulating at least one of the LEDs” to mean “varying the amplitude, frequency, or phase of the light produced by at least one of the LEDs to include information.” **Lisogurski** discloses a “cardiac cycle modulation” technique to “generate a light drive signal that varies with a period the same as or closely related to the period of the cardiac cycle.” Lisogurski, 25:49-52; *see also* Lisogurski, 5:34-36 (“In some embodiments, the system may use a cardiac cycle modulation with a period on the order of some multiple of the cardiac cycle period.”), 6:19-26 (discussing implementing drive cycle modulation as “time division multiplexing..., code division multiplexing, carrier frequency multiplexing, phase division multiplexing, feedback circuitry, DC restoration circuitry, any other suitable technique, or any combination thereof...”). The light drive signal “control[s]...the timing of when light source 130 is turned on and off” and therefore “appl[ies the]...cardiac cycle modulation to [the] light source.” Lisogurski, 11:38-41, 11:50-54, 21:34-56. A person of ordinary skill in the art would have

understood (or at least found obvious) that the light source is modulated to have a period matching the cardiac cycle. A person of ordinary skill in the art would have further understood (or at least found it obvious) that because “cardiac cycle modulation may include modulation aligned with pulses of the heart, [or] pulses of a particular muscle group,” the resulting modulated light would communicate information regarding pulses of a particular muscle group or, in this case, the heart. Lisogurski, 5:25-47.

269. Further to the modification of **Lisogurski** I discuss above in Section IX.A.2, a person of ordinary skill in the art would also have been motivated to combine **Lisogurski’s** light drive circuitry and front end processing circuitry such that the front end processing circuitry performs the function of the light drive circuitry and modulates the light source. **Lisogurski** explicitly discloses altering the functionalities of the front end processing circuitry and that “components of front end processing circuitry 150 are merely illustrative and any suitable components and combinations of components may be used to perform the front end processing operations.” Lisogurski, 14:11-14. Further, **Lisogurski** discloses that “the functionality of some of the components” which includes its front end processing circuitry and light drive circuitry, “may be combined in a single component.”. Lisogurski, 15:66-16:16. Thus, a person of ordinary skill in the art would have understood, that because the front end processing circuitry and light drive circuitry

already work together to perform certain functions, for example synchronizing the operation “of an analog to-digital converter and a demultiplexer with the light drive signal” (Lisogurski, 11:41-46), it would have been obvious to combine them. Integrated sensors were well known in the art. For example, U.S. Patent No. 5,822,473 discloses an integrated smart sensor fabricated on a semiconductor substrate with conditioning and processing circuitry and circuitry necessary to drive its LEDs. Ex. 1035, 3:36-52, 4:4-18.

B. GROUND 2: Lisogurski in view of Tran (Claims 5 and 7):

1. Overview of Tran

270. **Tran** discloses a “heart monitoring system for a patient” that can be “worn by the patient,” and includes a monitoring device, such as a “wristwatch,” to “monitor the patient,” including monitoring their “blood pressure,” “blood-oxygen levels,” and “pulse rate.” Tran, 3:6-13, 8:28-53, 9:23-54. The data can also include “pulse oximetry” measurements to “characterize the patient’s cardiac condition” (Tran, 25:36-40) as well as “blood flow velocity” (Tran, 74:29-67).

271. **Tran** discloses an “optical embodiment,” that includes a “light source and a photo-detector embedded in the wrist band portions.” Tran, 36:62-65. The “light source can be light-emitting diodes,” that output light at red and infrared wavelengths. Tran, 36:65-66. Both the light source and photo-detector can be “moved along the wrist band to optimize beam transmission.” Tran, 36:66-37:2. To

monitor the heart, after blood cells “absorb and transmit varying amounts of the red and infrared radiation depending on how much oxygen binds to the cells’ hemoglobin,” the “photo-detector detects transmission,” and provides it to a “pulse-oximetry circuit embedded within the wrist-watch.” Tran, 37:2-9. The output of the pulse-oximetry circuit is then digitized and sent back to the circuit to “analyze[and] to determine the [wearer’s] vital signs.” Tran, 37:9-13. **Tran** discloses various other optical embodiments, including an “optical heartbeat detector embodiment,” to obtain specific health information, such as a pulse oximeter waveform and blood pressure. Tran, 60:58-61:37.

272. **Tran’s** system collects patient health data and communicates it to “server 20.” Tran, 11:1-31. The server “feeds the data to a statistical analyzer.” Tran, 11:1-31. **Tran’s** statistical analyzers can, for example, “track the patient’s risk of stroke or heart attack.” Tran, 54:35-36, 46:25-42 (providing more information regarding a “stroke risk analyzer”). To do so, the analyzers can “incorporate a number of models, such as ... regression methods [and] engineered (artificial) neural networks.” Tran, 22:24-28. **Tran** teaches that the statistical analyzer is itself a neural network: “a statistical analyzer such as a neural network.” Tran, 11:7. **Tran**, itself characterizes artificial neural networks as a form of artificial intelligence: “[v]arious mathematical techniques and Artificial Intelligence (AI) analyzer can be applied[, and] ... AI approaches ... include Artificial Neural Networks (ANN).”

Tran, 94:57-65.

273. Like all neural networks and artificial intelligence, the statistical analyzer “is trained,” and is trained, specifically, “with training data where certain signals are determined to be undesirable for the patient, given his age, weight, and physical limitations.” Tran, 11:11-13. **Tran** teaches using the neural network to process physiological data to help identify potential risks, and to warn patients or health-care providers, including: “detecting heart attacks or stroke attacks” (Tran, 86:44-87:3); “classify[ing] valve-related heart disorders” (Tran, 74:45-46), and “classify[ing] ... heart sound signals into physiological and pathological murmurs” (Tran, 75:18-20). **Tran** discloses another example of using a neural network to determine when a patient’s glucose level is “any value outside of [a well-established] range,” and when such a condition is detected, it “is flagged by the statistical analyzer as a dangerous condition.” Tran, 11:13-16. Other examples include performing a “cardiovascular assessment,” and using that to “identify [trauma victims] whose injuries were so severe that they [are] not likely to survive.” Tran, 46:25-42.

274. **Tran** further discloses that its system may include “providing remote diagnostic capability so that a remote healthcare provider (such as a doctor, nurse, therapist or caregiver) can visually communicate with the patient in performing remote diagnosis.” Tran, 5:36-43. **Tran** also discloses that, while the wearable

device is outside a mesh network range, “the device searches for a cellphone,” such as a “smart phone[],” and if it detects one, it will communicate “with the cell phone and provide[] information to the server 200 using the cellular connection.” Tran, 33:50-34:40. **Tran** further discloses that the server hosts a webpage that includes a list of “recently measured blood pressure data,” “graphs that plot the systolic and diastolic blood pressure data,” and “tables and graphs corresponding to a different data measured by the wearable device such as calorie consumption/dissipation, ambulation pattern, sleeping pattern, heart rate, pulse oximetry, and temperature.” Tran, 26:17-29.

2. Motivation to Combine Lisogurski and Tran

275. Like **Lisogurski**, **Tran** is analogous art, in the same field as the ’475 patent—including physiological monitoring—and is reasonably pertinent to the problems addressed by the ’475 patent—e.g., improving optical physiological monitoring. ’475 patent, 8:39-9:5; Lisogurski, 1:10-11; Tran, 1:10-33, 2:66-67, 4:30-36, 36:62-37:12.

276. With respect to **Tran’s** smartphone teachings, in the prior ’484 IPR, I understand that the Board found that “a person of ordinary skill would have recognized **Tran’s** smartphone could be used in place of **Lisogurski’s** monitoring device, which **Lisogurski** describes as a computing device that is portable, battery powered, and has a touchscreen,” and that this is bolstered by **Tran** disclosing “using

a smartphone with a portable, wearable sensor to send data to remote devices and other monitoring devices, facilitating the detection of emergencies in a manner consistent with the use of smartphones and tablets.” ’484-FWD, 47-48. This is consistent with my opinions in my prior ’484 Declaration and my opinions herein. ’484-Anthony, ¶¶211-214.

277. With respect to **Tran’s** smartphone teachings, a person of ordinary skill in the art would have been motivated to apply **Tran’s** teaching of smart phone in implementing **Lisogurski’s** monitor 104/314 to enhance the versatility and connectivity of **Lisogurski’s** sensor. A person of ordinary skill in the art would have understood that using smartphones in wearable physiological monitoring systems was a standard industry practice at the time. Smartphones provide significant practical benefits, such as mobile connectivity, portability, and ease of integration. For example, **Tran** discloses a “smart phone[,],” and shows using the smart phone with a portable, wearable sensor to allow data to be sent to remote devices even when the person wearing it is away from home. ’484-Anthony, ¶¶215-16 (citing **Tran**, 34:4-25, 33:58-34:3, 34:25-40). Accordingly, person of ordinary skill would have recognized that **Lisogurski’s** monitor could be implemented to use or include a smartphone as described in **Tran**, and that doing so would have allowed **Lisogurski’s** monitor (modified by **Tran’s** smart phone teachings) to remain in contact with other monitoring devices (e.g., multi-parameter physiologic monitor

326) even when the person wearing it was outside of the range of a WiFi or other home network. '484-Anthony, ¶216 (citing Tran, 34:4-25, 33:58-34:3, 34:25-40).

278. Moreover, it was well-known in the art that tablets and smartphones could be used in mobile sensor systems, and there was a general trend in the industry to develop such devices. '484-Anthony, ¶¶48-56, 216 (citing Tran, 33:58-34:40). Accordingly, a person of ordinary skill in the art would have been motivated (or at least found it obvious) to implement **Lisogurski's** monitor as a smartphone as shown in **Tran**.

279. Additionally, person of ordinary skill in the art would have had a reasonable expectation of success in applying **Tran's** smart phone teachings to **Lisogurski's** system. For example, both references teach an optical-based devices and techniques for physiological measurement, and use of a device to receive and monitor the measurement. **Lisogurski** discloses an “optical physiological monitoring system,” including a monitor to receive and display data. Lisogurski, 1:10-11, 11:9-27, 15:19-42. **Tran** discloses, a system that uses an “optical transducer[, as the] ... light source,” a “photo-detector” and a “pulse-oximetry circuit” to “determine the user's vital signs,” in addition to a smartphone to receive and display data. Tran, 34:4-40, 36:62-37:12. Therefore, a person of ordinary skill in the art would have understood that **Tran's** smart phone is a common substitute for **Lisogurski's** monitor and would have also known such a combination (yielding

the claimed limitations) would predictably work and provide the expected functionality.

280. With respect to **Tran’s** artificial intelligence teachings, in the prior ’484 IPR, I understand that the Board found that “a person of ordinary skill would have looked to **Tran** for ... to improve how the data obtained by **Lisogurski’s** device is stored and analyzed,” and that a person of ordinary skill in the art would have used **Tran’s** teachings of “us[ing] neural networks to track and flag patterns in a patient’s vital signs to recognize possibly dangerous conditions.” ’484-FWD, 46-47, 52-53. This is consistent with my opinions in my prior ’484 Declaration and my opinions herein. ’484-Anthony, ¶¶218-219.

281. With respect to **Tran’s** artificial intelligence teachings, a person of ordinary skill in the art would have also looked to **Tran’s** artificial intelligence teachings to analyze the data measured by **Lisogurski’s** device improve the reliability and accuracy of monitoring the wearer’s physiological condition and to assist the wearer and others, such as clinical professionals, in assessing a wearer’s condition. ’484-Anthony, ¶218 (citing Tran, 3:6-13, 11:6-30, 22:24-30, 87:33-37, 85:60-61, 88:48-50, 90:58-61). A person of ordinary skill in the art would have understood the significant practical and technical advantages of employing artificial intelligence—particularly neural networks—in physiological monitoring and analysis systems. At the relevant time, AI-driven statistical analyses were widely

recognized as effective in identifying health events and patterns, enhancing measurement accuracy, reducing false alarms, automating clinical assessments, and increasing reliability by diminishing human observational error. For example, **Tran** discloses feeding the data measured by “wearable patient monitoring appliances” into “a statistical analyzer such as a neural network.” ’484-Anthony, ¶218 (citing Tran, 3:6-13, 11:6-30, 22:24-30, 87:33-37, 85:60-61, 88:48-50, 90:58-61); Tran, 9:23-53, 11:6-30, 3:6-13. **Tran’s** data driven analyzers incorporate “engineered (artificial) neural networks.” ’484-Anthony, ¶218 (citing Tran, 3:6-13, 11:6-30, 22:24-30, 87:33-37, 85:60-61, 88:48-50, 90:58-61); Tran, 22:24-30. Artificial neural networks are a type of artificial intelligence. Indeed, **Tran** refers to an analyzer incorporating artificial neural networks as an “Artificial Intelligence (AI) analyzer.” Tran, 94:57-65 (“Various mathematical techniques and Artificial Intelligence (AI) analyzer can be applied. Mathematical models include ... AI approaches towards signal recognition include[ing] Artificial Neural Networks (ANN)[.]”). **Tran’s** neural networks analyze patient data to “flag potentially dangerous conditions,” which “can be specified as an event or a pattern that can cause physiological or psychological damage to the patient.” ’484-Anthony, ¶218 (citing Tran, 3:6-13, 11:6-30, 22:24-30, 87:33-37, 85:60-61, 88:48-50, 90:58-61); Tran, 11:6-8, 11:16-19. **Tran** teaches the system “displays a warning to a patient and connects the patient to the appropriate emergency response authority.”

'484-Anthony, ¶218 (citing Tran, 3:6-13, 11:6-30, 22:24-30, 87:33-37, 85:60-61, 88:48-50, 90:58-61); Tran, 87:33-37, 85:60-61, 88:48-50, 90:58-61. Accordingly, a person of ordinary skill in the art would have understood that **Tran's** data analysis and artificial intelligence techniques enhance the reliability and accuracy of data analysis—particularly for medical diagnosis and health monitoring. Moreover, a person of ordinary skill in the art would have understood that integrating AI methods into physiological monitoring systems advantageously enables more accurate, consistent, and automated health assessments, reducing the reliance on subjective human observation, which can be prone to error and variability.

282. Further with respect to **Tran's** artificial intelligence teachings, in the prior '484 IPR, I understand that the Board found that a person of ordinary skill in the art would have been motivated to apply Tran's artificial intelligence teachings specifically in **Lisogurski's** sensor. '484-FWD, 46-47. **Lisogurski** already discloses that its front end processing circuitry processes “various analog and digital processing of the detector signal.” (*i.e.*, processor, see my discussion in Section IX.A.3.v.[8.d]). Lisogurski, 12:48-49; *see also* Lisogurski, 11:28-31, 10:42-47, Fig. 1. In the prior '533 IPR, I understand that the Board found that **Lisogurski** expressly suggests modifying sensor 102/312 to include the monitor's front end circuitry and related functionalities by teaching “the functionality of some of the components may be combined in a single component,” especially when “numerous industry trends

motivate the modification....includ[ing] improving the capabilities of wearable sensors.” ’533-FWD, 22-23. Therefore, a person of ordinary skill in the art would have recognized the benefit of implementing **Tran’s** artificial intelligence to locally process the detection signals within **Lisogurski’s** sensor 102/312, rather than offloading these functionalities to an external system. A person of ordinary skill in the art would have understood that doing so would have avoided the latency associated with data transmission and reduce potential privacy and security risks associated with the wireless transmission of patient data. Moreover, in the prior ’533 IPR, I understand that the Board found that person of ordinary skill in the art would have been motivated to modify **Lisogurski’s** sensor to include front end processing circuitry 150 for an alternative reason: because the front end processing circuitry 150 performs analog-to-digital conversion and other initial processing of the signal, a person of ordinary skill in the art would have understood or at least found it obvious to include it in the detector where the signal is captured, which is on sensor 102/312. ’533-FWD, 23. Indeed, as I discuss above (Section IX.A.2), it was common and advantageous for a detector to include a front end processing circuitry. *E.g.*, Exs.1034 2:66-4:20, Figs. 7-8 (photodetector with signal processing capability); 1033, [0052], Fig. 4 (showing front end analog signal conditioning circuitry 330 in sensor 300). Further, it was common and advantageous for a sensor to have artificial intelligence functionalities internally. For example, U.S. Patent No. 5,511,553,

which I understand has been designated as Exhibit 1044, discloses “WEMS' strip-patch device and system would integrate within also artificial intelligence in its incorporated set of chips. Such logic and memory capabilities would allow ‘on-patient’ portable and real-time continuous medical assessment and evaluation capabilities of multi-parameter and variable clinical conditions simultaneously.” Ex. 1044, 8:3-11, *see also* Ex. 1044, 45:65-46:12 (“Furthermore, the WEMS' strip-patch device-system integrates within and self-contains also artificial intelligence in its incorporated set of chips. Such artificial intelligent programming of microchips within said strip-patch device-system enables safe, effective, rapid and economical method for optimal ‘on-site’ (‘on-patient’) portable clinical judgement assessment of the patient, in real time. Such logic and memory resident capabilities by semiconductors, enables; ‘on-patient’ portable and real-time continuous medical assessment and evaluation capabilities of variable multi-parameter clinical conditions; simultaneous testing and multi-parameter profiling; continuous control and evaluation of drug management; and, alert the patient, by self-contained and incorporated sound and visual means, of immediate need or delayed option to seek medical help, if necessary.”).

283. From the perspective of a person of ordinary skill in the art, the use of artificial intelligence methods, including neural networks and statistical data analysis, to enhance physiological monitoring systems was commonplace and well

known as providing substantial benefits. AI-driven analyses were used to achieve higher accuracy, greater consistency, and improved reliability in clinical monitoring, diagnostics, and decision-making processes. Moreover, a person of ordinary skill in the art would have known that AI techniques were already commonly applied in the medical field to support diagnostic decision-making and real-time monitoring of physiological data. For example, U.S. Pat. No. 9,239,951, which I understand has been designated as Exhibit 1048, describes “applying artificial intelligence to assist in diagnosis.” Ex. 1048, 95:13-15. U.S. Pat. Pub. 2007/0194939, which I understand has been designated as Exhibit 1049, also discloses using “artificial intelligence routines that are operated by computers for monitoring patient vital signs and alerting [patients and clinicians to] critical conditions.” Ex. 1049, [0148]. Such use of artificial intelligence was well known in the art as shown in U.S. Patent Nos. 5,554,273 and 5,953,713, which I understand have been designated as Exhibits 1064 and 1065. Ex. 1064, 3:14-16 (“neural networks are known processing systems for... problems which are very difficult to handle by means of conventional logic,” including enhancing precision for monitoring and analysis); Ex. 1065, 2:25-39 (“an artificial neural network trained to recognize patterns characterizing sleep disorder breathing” enables automated, real-time diagnosis of sleep apnea). Accordingly, a person of ordinary skill in the art would have been motivated to apply **Tran’s** neural networks teachings to **Lisogurski’s** device to improve the processing of the

collected physiological signals: (1) to send its patient data to **Tran’s** neural networks for processing using **Tran’s** data analysis technique; and (2) to process patient data to flag clinically dangerous conditions and inform the user of these conditions. ’484-Anthony, ¶219.

284. A person of ordinary skill in the art would have had a reasonable expectation of success in applying **Tran’s** artificial intelligence technique to **Lisogurski’s** system. As discussed above, data analysis techniques such as artificial intelligence were well known in the art, such that a person of ordinary skill in the art would have easily recognized and/or applied those teachings to **Lisogurski’s** system. See ¶ 283. Thus, a person of ordinary skill in the art would have known such a combination (yielding the claimed limitations) would predictably work and provide the expected functionality.

3. Invalidity of Claims 5 and 7 Over Lisogurski in view of Tran

285. As I discuss below, Claims 5 and 7 are rendered obvious by **Lisogurski** in view of **Tran**. In addition to my discussion in Sections IX.C.1-2, the following discussion identifies example disclosures that each disclose Challenged Claims 5 and 7.

a. Claim [5]

286. Claim 5 recites: “**The apparatus of claim 1, wherein the apparatus further comprises a processor configured to be coupled to a non-transitory**

computer readable medium, and wherein the apparatus including the processor is configured to use artificial intelligence in making decisions associated with at least a portion of the output signal.” This additional limitation is met by **Lisogurski** in view of **Tran**.

287. See my discussion of claim 1 above (Sections IX.A.3.a-o.[1.pre]-[1.n]).

288. **Lisogurski discloses the apparatus** (*e.g.*, “sensor”; see my discussion in Section IX.A.3.a.[1.pre]) **further comprises a processor** (*e.g.*, “front end processing circuitry 150”; see my discussion in Section IX.A.3.v.[8.d]) **configured to be coupled to a non-transitory computer readable medium** (*e.g.*, a memory), **and wherein the apparatus** (*e.g.*, “sensor”; see my discussion in Section IX.A.3.a.[1.pre]) **including the processor** (*e.g.*, “front end processing circuitry 150”; see my discussion in Section IX.A.3.v.[8.d]). **Lisogurski**, 12:42-50, 14:56-15:18.

289. **Lisogurski** discloses that “front end processing circuitry 150” “perform[s] various analog and digital processing” of “the output signal of detector 140.” **Lisogurski**, 12:42-50. For the reasons I discuss above regarding claim element [8.d] (Section IX.A.3.v.[8.d]), a person of ordinary skill in the art would have understood (or at least found it obvious) that **Lisogurski’s** front end processing circuitry is a processor. A person of ordinary skill in the art would have also understood (or at least found obvious) that the processor performing the functions

of front end processing circuitry 150 includes a memory. Indeed, **Lisogurski** discloses that its back end processing circuitry includes a “processor” coupled to “memory,” which includes “any suitable computer-readable media capable of storing information that can be interpreted by [a] processor” and used to perform signal processing operations. Lisogurski, 14:56-15:18. Thus, a person of ordinary skill in the art would have understood (or at least found it obvious), that **Lisogurski’s** front end processing circuitry, which also performs various signal processing, would also include memory.

290. Regarding a substantially identical limitation reciting: “the wearable device **is configured to use artificial intelligence in making decisions associated with at least a portion of the output signal**” in the prior ’484 IPR, I understand the Board determined that the petitioner demonstrated “a person of ordinary skill would have looked to Tran ... to improve how the data obtained by Lisogurski’s device is stored and analyzed,” including that “a person of ordinary skill would have been motivated to seek additional ways to use tracked data, such as pulse oximetry data, in a remote or mobile scenario, e.g., using Tran’s artificial neural network to analyze such data and provide warnings,” and that the petitioner demonstrated (1) “Tran discloses feeding data from a wearable patient monitoring device such as those disclosed by Lisogurski, to a statistical analyzer, such as Tran’s neural network, which is a form of artificial intelligence”; and (2) “Tran’s analysis of patient data

can flag potentially dangerous conditions that can be specified as an event or pattern that can harm the patient.” ’484-FWD, 46-49. This is consistent with my opinions regarding this ’484 limitation provided in my Prior ’484 Declaration, which I incorporate by reference as if fully set forth herein. 484-Anthony, ¶¶217-219 (citing Tran, 3:6-13, 9:23-53, 11:6-30, 22:24-30, 85:60-61, 87:33-37, 88:48-50, 90:58-61).

291. A portion of the ’475 patent claim is substantially identical to a corresponding limitation in the ’484 patent on which I previously opined, and which recites: “the wearable device **is configured to use artificial intelligence in making decisions associated with at least a portion of the output signal.**” The main difference between the two limitations is the ’484 patent’s use of “the wearable device” as opposed to the ’475 claim 5’s use of “the apparatus including the processor.” As I discuss above in relation to claim elements [1.pre] **Lisogurski’s** apparatus is a wearable device (Section IX.A.3.a.[1.pre]). Thus, my opinions regarding the ’484 patent term apply equally to ’475 patent claim 5. ’484-Anthony, ¶¶217-219.

292. As I discuss above (Section IX.B.2), the Board found that a person of ordinary skill in the art would have been motivated to apply **Tran’s** teachings of an AI-driven statistical analyzer to **Lisogurski’s** sensor 102/312 to advantageously improve analysis of the collected physiological measurement data.

293. I understand that Defendants identified a portion of this limitation—

“wherein the measurement system is configured to use artificial intelligence in making decisions”—as potentially indefinite in the Texas Case. Ex. 1023, 247-248.

294. Regardless of its outer bounds (e.g., what constitutes “making decisions”), however, and without opining on whether or not it has adequate written description support, this term is met by **Tran** because **Tran** discloses and renders obvious the indisputable scope of this limitation. For example, an embodiment of the ’475 patent discusses using built-in “artificial intelligence” to make decisions in response to “analytical data generated in real-time.” ’475 patent, 68:34-46. A person of ordinary skill in the art would have understood that this limitation of claim 5 at least includes this embodiment contemplating analyzing physiological measurements real-time.

295. Consistent with this embodiment, and as the Board previously found, **Tran** discloses feeding “data to a statistical analyzer such as a neural network which has been trained to flag potentially dangerous conditions” based on the live data being obtained from a wearable patient monitoring device. Tran, 11:6-10; ’484-FWD, 46-49 (finding “Tran discloses feeding data from a wearable patient monitoring device such as those disclosed by Lisogurski, to a statistical analyzer, such as Tran’s neural network, which is a form of artificial intelligence” and “Tran’s analysis of patient data can flag potentially dangerous conditions that can be specified as an event or pattern that can harm the patient.”).

b. Claim [7]

296. Claim 7 recites: “**The apparatus of claim 6, wherein the apparatus is further configured to communicate with a smart phone or a tablet, the smart phone or the tablet comprising a wireless receiver, a wireless transmitter, a display, a speaker, a voice input module, one or more buttons or knobs, a microprocessor, and a touch screen.**” This additional limitation is met by **Lisogurski**.

297. See my discussion of claim 6 above (Section IX.A.3.p.[6]).

298. This additional limitation is disclosed or rendered obvious by **Lisogurski**, for the reasons I discuss above in connection with ’475 patent claim 7 (Section IX.A.3.q.[7]).

299. To the extent additional disclosure is required for the “**smart phone or a tablet**” limitations, **Tran** discloses these limitations and a person of ordinary skill in the art would have been motivated to apply **Tran’s** smart phone teachings to **Lisogurski’s** system. In the prior ’484 IPR, I understand that the Board determined that the petitioner demonstrated (1) “ a person of ordinary skill would have recognized Tran’s smartphone could be used in place of Lisogurski’s monitoring device, which Lisogurski describes as a computing device that is portable, battery powered, and has a touchscreen”; and (2) “Tran teaches using a smartphone with a portable, wearable sensor to send data to remote devices and other monitoring

devices, facilitating the detection of emergencies in a manner consistent with the use of smartphones and tablets.” ’484-FWD, 47-48. This is consistent with my opinions regarding the smart phone or tablet limitations provided in my Prior ’484 Declaration, which I incorporate by reference as if fully set forth herein. ’484-Anthony, ¶¶215-216 (citing Tran, 34:4-25, 33:58-34:3, 34:25-40).

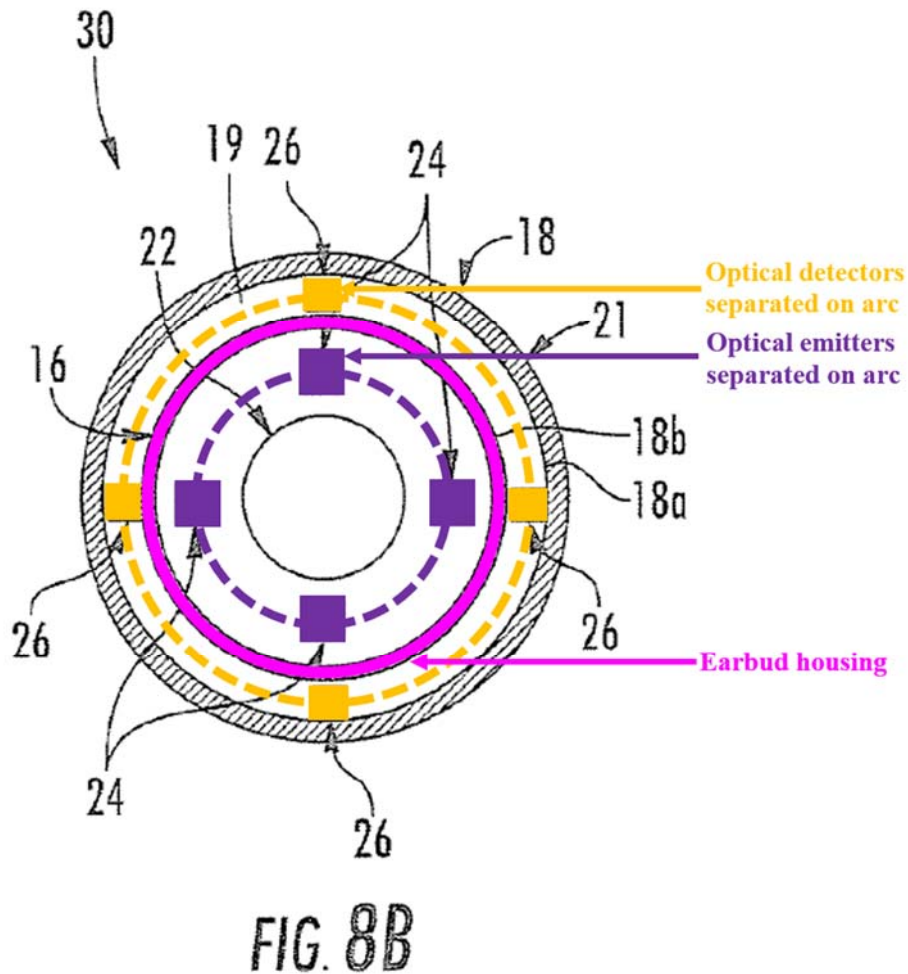
C. GROUNDS 3-4: Grounds 1-2 in further view of LeBoeuf (Claims 6-7):

1. Overview of LeBoeuf

300. **LeBoeuf** discloses various interchangeable embodiments of “an earbud” with a “light-guiding region,” including an embodiment for which the earbud has “one or more sensor modules that includes one or more sensors for sensing physiological information” such that “the earbud may function as a physiological monitor,” to measure various “types of physiological information: heart rate, pulse rate, breathing rate, blood flow, VO₂, VO₂max, heartbeat signatures, cardio-pulmonary health, organ health, metabolism, electrolyte type and/or concentration, physical activity, caloric intake, caloric metabolism, blood metabolite levels or ratios, [and] blood pH level.” LeBoeuf, [0025], [0026], [0029]. LeBoeuf explains that is describing its embodiments, “[l]ike numbers refer to like elements throughout,” and that “[f]eatures described with respect to one figure or embodiment can be associated with another embodiment or figure although not

specifically described or shown as such.” LeBoeuf, [0073].

301. **LeBoeuf’s** “light guiding earbud 30” includes several components, including: “base 50,” an **earbud housing 16** extending outwardly from the base 50 that is configured to be positioned within an ear of a subject,” and “a cover 18 that surrounds the **earbud housing 16**.” LeBoeuf, [0123]. Light guiding earbud 30 collects light and delivers the collected light to “**optical detector[s] 26**.” LeBoeuf, [0123]. Light guiding earbud 30 also includes “**optical emitter[s] 24**,” which are “light-emitting diode(s)” (LEDs). LeBoeuf, [0092]. **LeBoeuf** also discloses that its **optical detectors 26** and **optical emitters 24** are arranged in one or more arcs, as depicted in at least Figure 8B. I have annotated Figures 8B and 8C, both reproduced below, to identify these components.



2. Motivation to Combine Lisogurski and LeBoeuf

302. Like **Lisogurski and Tran**, **LeBoeuf** is in the same field as the '475 patent—which includes physiological monitoring—and are reasonably pertinent to the problems addressed by the '475 patent—e.g., improving optical physiological monitoring. '475 patent, 8:39-9:5; Lisogurski, 1:10-11; LeBoeuf, Abstract, [0025], [0026].

303. With respect to **LeBoeuf's** teaching of arc arrangement, a person of ordinary skill in the art would have been motivated to apply **LeBoeuf's** teaching to

Lisogurski's system to include a plurality of spatially separated detectors and semiconductor sources arranged along one or more arcs to increase the accuracy and reliability of the physiological measurements and increase signal-to-noise ratio. **Lisogurski** discloses a physiological monitoring device designed to be worn on different part of the body, and which operate by emitting light into biological tissue. Lisogurski, 4:6-20, 11:9-27. **Lisogurski** additionally discloses that “[a]ny suitable configuration of light source 316 and detector 318 may be used,” and that “sensor unit 312 may include multiple light sources and detectors, which may be spaced apart.” Lisogurski, 17:42-45.

304. It is well understood in the art that when light passes through biological tissue, it undergoes significant scattering and absorption due. As a result, portions of the light emitted into tissue are reflected back out of the tissue over a broad range of angles and locations. See Lisogurski, 11:16-20; LeBoeuf, [0105]. Accordingly, a person of ordinary skill in the art would have recognized that a linear or tight arrangement of detectors would be insufficient to capture much of the angularly scattered light; detectors positioned only directly opposite or very close together would only intercept a small fraction of this diffusely scattered light. This would reduce the overall amount of useful signal collected, potentially decreasing the accuracy and reliability of the physiological measurements. For example, U.S. Pat. No. 6,801,799, which is directed to a pulse oximeter, discloses that “in order to

maximize the fraction of backscattered light collected by [a] sensor,” its system includes “six photodetectors mounted in the center of the sensor **around** the LEDs.” Ex. 1045, 4:14-65 (emphasis my own). Accordingly, a person of ordinary skill in the art would have been motivated to look to a reference like **LeBoeuf** that teaches arranging detectors spatially apart from each other and along arcs. A person of ordinary skill in the art would have recognized that **LeBoeuf’s** detector arrangement enhances the amount of scattered light detected, thereby improving the signal relative to background noise and resulting in an increased signal-to-noise ratio. Accordingly, a person of ordinary skill in the art would have been motivated to modify **Lisogurski’s** wearable device with the teachings of **LeBoeuf’s** teaching to arrange spatially separate detectors and light sources on one or more arcs to increase the signal-to-noise ratio of **Lisogurski’s** device.

305. A person of ordinary skill in the art would have had a reasonable expectation of success in applying **Lebeouf’s** arc arrangement teaching to **Lisogurski’s** system. Both references teach an optical-based measurement system that employs multiple emitters and multiple detectors and disclose that “any suitable” or “various configurations” may be used to arrange those emitters and detectors. Lisogurski, 17:37-45; LeBoeuf, [0123]; *see also* LeBoeuf, [0006], [0125]. Indeed, using an arc arrangement to increase signal-to-noise ratio was also well known in the art. For example, U.S. Pat. No. 6,801,799, which is directed to a pulse

oximeter, discloses that “in order to maximize the fraction of backscattered light collected by [a] sensor,” its system includes “six photodetectors mounted in the center of the sensor **around** the LEDs.” Ex. 1045, 4:14-65 (emphasis my own). Thus, a person of ordinary skill in the art would have known that modifying **Lisogurski’s** measurement system would involve only routine changes that were already well-known in the art. A person of ordinary skill in the art would have known that such a combination (yielding the claimed limitations) was straightforward, predictable, and a routine design decision within the scope of ordinary engineering practice and provide the expected functionality. *E.g.*, Lisogurski, 17:42-45 (“Any suitable configuration of light source 316 and detector 318 may be used.”), LeBoeuf, [0123].

306. Further, **LeBoeuf’s** teaching as applied to the spatial configuration of the light sources and detectors and physical configuration of **Lisogurski’s** sensor do not concern the same aspects of **Lisogurski’s** system (i.e., the monitor and sensor and/or software within the monitor or processing circuitry within sensor) where **Tran’s** teaching of artificial intelligence or smartphone would be applied (Section IX.B.2) such that my above discussion of motivation and expectation of success applies equally to **Lisogurski’s** system applying **LeBoeuf’s** teaching.

3. Invalidity of Claims 6-7 Over Lisogurski in view of Tran and LeBoeuf

307. As I discuss below, Claims 6-7 are rendered obvious by **Lisogurski** in view of **Tran** and **LeBoeuf**. In addition to my discussion in Sections IX.D.1-2, the following discussion identifies example disclosures that each disclose Challenged Claims 6-7.

a. Claim [6]

308. Claim 6 recites: “**The apparatus of claim 1, wherein the plurality of light emitting diodes comprises six light emitting diodes, and wherein the detection system comprises the plurality of detectors arranged along an arc.**” This additional limitation is met by **Lisogurski** in view of **LeBoeuf**.

309. See my discussion of claim 1 above (Sections IX.A.3.a-o.[1.pre]-[1.n]).

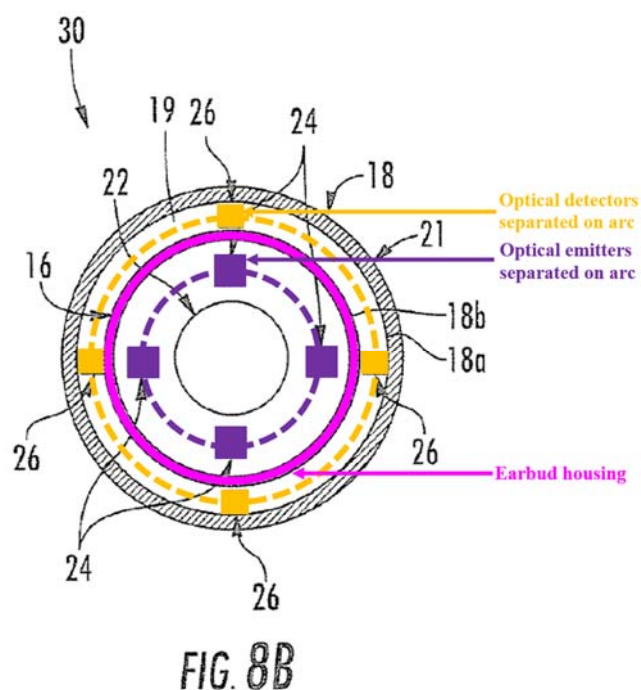
310. For the reasons I discuss above regarding claim 6 (Section IX.A.3.p.[6]), **Lisogurski** meets this additional limitation.

311. **To the extent additional disclosure is required, LeBoeuf discloses the plurality of semiconductor sources (e.g., “optical emitters 24” that are “light-emitting diode[s]”) and the plurality of detectors (e.g., “optical detectors 26”) arranged along an arc (e.g., spatially separated in an arc).** LeBoeuf, [0048]-[0050], [0092], [0123], FIGS. 8A-8B.

312. For example, **LeBoeuf** discloses a “light guiding earbud 30” that

includes: (1) “optical emitter 24,” which “may be ... light-emitting diode (LED)[s],” (2) “optical detectors 26,” which receive the light collected from the optical emitters, (3) a “base 50 that is configured to be positioned within an ear of a subject,” (4) an “earbud housing 16,” which extend[s] outwardly from the base 50,” and (5) a “cover 18 that surrounds the earbud housing 16.” LeBoeuf, [0092], [0123]. Optical emitters 24 and optical detectors 26 are located on the base 50. These components are illustrated in Figures 8A and 8C (“side section view[s]” of the earbud) and 8B (a “cross-sectional view of the earbud”). LeBoeuf [0048]-[0050]; Figs 8A-8C.

313. **LeBoeuf** further discloses that the plurality of optical emitters 24 are spaced apart and arranged along a first arc within the earbud and are surrounded by earbud housing 16, as depicted in Figure 8B. LeBoeuf, Fig. 8B. Figure 8B further depicts the plurality of optical detectors 26 are also spatially separated and arranged along a second, wider arc within the earbud, which surround earbud housing 16 and are surrounded by cover 18. LeBoeuf, Fig 8B. Accordingly, **LeBoeuf** discloses a **plurality of optical emitters 24, including LEDs, spatially separated in an arc** and a **plurality of optical detectors 26 spatially separated in another arc**. Figure 8B is reproduced below with annotations identifying the components I have described above.



314. As I discussed in Section IX.C.2, a person of ordinary skill in the art would have been motivated to apply **LeBoeuf’s** teachings to **Lisogurski’s** system—specifically, to arrange the plurality of semiconductor sources so that they are spatially separated from each another and, likewise, to arrange the plurality of spatially separated detectors to be spatially separated from each other, with both sets positioned along respective arcs. As I elaborate in Section IX.C.2, a person of ordinary skill in the art would have recognized that such an arrangement could enhance measurement accuracy by increasing the surface area of the subject’s tissue exposed to the emitted light and optimizing the geometry for detecting reflected or transmitted signals.

315. I understand that Defendants identified a portion of this limitation—

“plurality of detectors arranged along an arc”—as potentially indefinite in the Texas Case. Ex. 1023, at 247-248.

316. Regardless of its outer bounds (e.g., requiring full circular arc or more broadly encompassing any degree of curvature), however, and without opining on whether or not it has adequate written description support, **Lisogurski** discloses and renders obvious the indisputable scope of the limitations for the reasons discussed above in Section IX.A.3.p.[6]. **LeBoeuf** further discloses and renders obvious the indisputable scope of the limitations. Indeed, **LeBoeuf** discloses a plurality of optical emitters 24, including LEDs, spatially separated in a completely circular arc (i.e., arranged along a full circle) and a plurality of optical detectors 26 spatially separated in another completely circular arc (same) as shown in the annotated Figure 8B below:

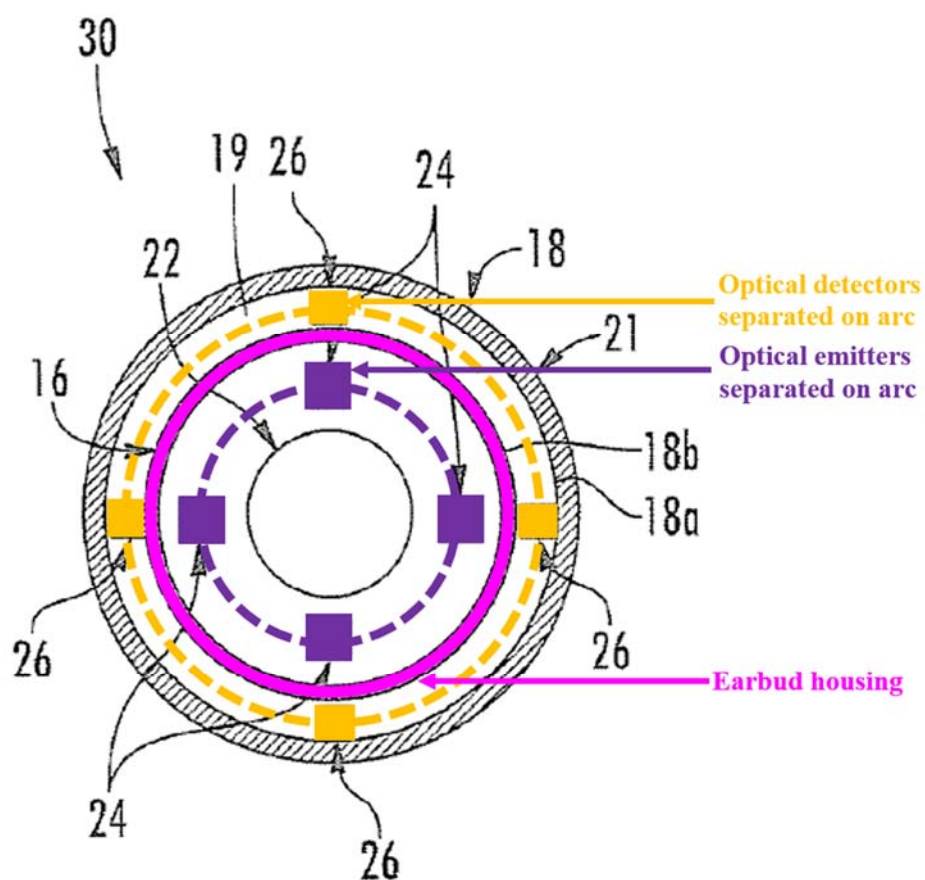


FIG. 8B

b. Claim [7]

317. Claim 7 recites: “**The apparatus of claim 6, wherein the apparatus is further configured to communicate with a smart phone or a tablet, the smart phone or the tablet comprising a wireless receiver, a wireless transmitter, a display, a speaker, a voice input module, one or more buttons or knobs, a microprocessor, and a touch screen.**” This additional limitation is met by **Lisogurski** alone or in view **Tran** in further view of **LeBoeuf**.

318. See my discussion of claim 6 above (Section IX.C.3.a.[6]).

319. For the reasons I discuss above regarding claim 7 (Sections IX.A.3.q.[7] and IX.B.3.b.[7]), **Lisogurski** alone or in view **Tran** meets additional limitation.

D. GROUNDS 5-8: Grounds 1-4 in further view of Carlson (Claims 1, 5-8, and 11-13):

1. Overview of Carlson

320. **Carlson** is directed to an “ear clip 1” which is an “optical pulsoximetry [device] used for non-invasive measurement of pulsation and oxygen saturation in arterial human or animal blood” designed to be worn on a user’s ear. Carlson, [0002]; *see also* Carlson, [0049]. The “ear clip 1” is depicted in Figure 2, which I’ve reproduced below. Carlson, [0033], Fig. 2.

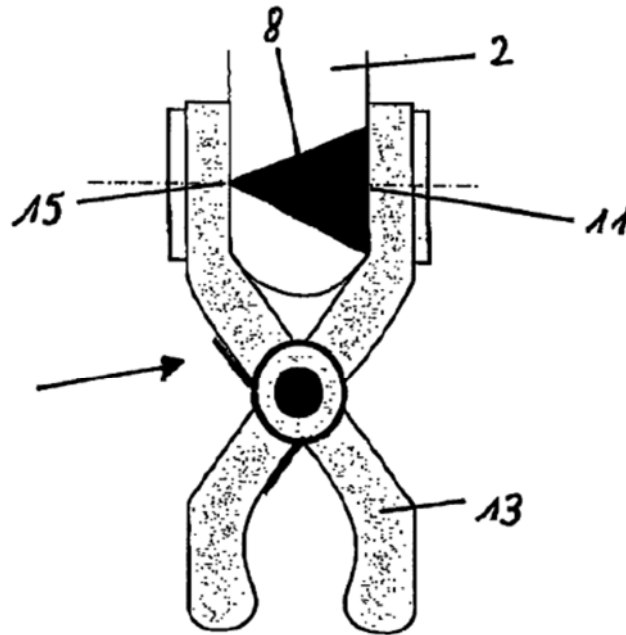


Figure 2

321. **Carlson** discloses that “ear clip 1” (also referred to in **Carlson** as “ear sensor 1”; see [0048]-[0049]) includes a “light source 15 which emits a light beam 8,” and light beam 8 travels through the patient’s earlobe 2 to “light receiver 11,” which detects the transmitted light. **Carlson**, [0049]. Light source 15 emits light at two wavelengths, one at 660 nm, and the other “within the range of 800 to 1000 nm, which ... in the present case [is] 890 nm.” **Carlson**, [0050]. **Carlson** teaches that the configuration of light source 15 includes having “two light emitting sources” (i.e., “two LEDs”). **Carlson**, [0050]. **Carlson** discloses the use various “optical ... means,” including lenses: “light is emitted from the two LEDs 15 and is shaped by the two beam shaping elements or lenses 21 to be guided as beams 12 through the

earlobe 2.” Carlson, [0062]. ’533-FWD, 18-20.

322. **Carlson** teaches that patient mobility can cause “standard pulsoximeter sensors [to] suffer from signal instability and insufficient robustness versus environmental disturbances” including ambient light, such as sunlight, that influences the measurement of the pulsoximeter sensor.” Carlson, [0004], [0068]. **Carlson** teaches that the “basic idea therefore is to use a beam-shaping element, such as e.g. diffractive or refractive lenses, to direct the emitted optical radiation of, e.g., the LED light source into the human or animal tissue and the photon detecting element in order to increase the optical signal power, detected by the pulsoximeter sensor, and thus increasing the Signal/Noise—and signal/Background ratio” by “a factor of 5.” Carlson, [0014]. ’533-FWD, 18-20.

2. Motivation to Combine Lisogurski or Tran/LeBoeuf and Carlson

323. Like **Lisogurski**, **LeBoeuf**, and **Tran**, **Carlson** is analogous art, in the same field as the ’475 patent—including physiological monitoring—and is reasonably pertinent to the problems addressed by the ’475 patent—e.g., improving optical physiological monitoring. ’475 patent, 8:39-9:5; Lisogurski, 1:10-11; LeBoeuf, Abstract, [0025], [0026]; Carlson, [0002], [0004], [0006]-[0008], [0010]. Similarly, both **Lisogurski** and **Carlson** identify similar problems, including mitigating noise from ambient light and enhancing overall signal-to-noise

performance, clearly demonstrating their direct relevance to the technological context of the '475 patent. Lisogurski, 9:46-60, 14:40-55, 26:5-14; Carlson, [0054]. A person of ordinary skill in the art would have understood that both **Lisogurski** and **Carlson** are directly within the relevant technical field, addressing analogous problems and, therefore, are compatible. The explicit discussion in both references about mitigating similar technical challenges would have made their combination straightforward and logical from a person of ordinary skill in the art's perspective.

324. With respect to **Carlson's** lenses teachings, in the prior '484 IPR, I understand that the Board found that "a person of ordinary skill would have had reason to employ lenses as taught by **Carlson** in **Lisogurski's** sensor to focus light from the LED onto a person's skin and in doing so, increase optical power and improve signal to noise ratio." 484-FWD, 23, 26-27. This is consistent with my opinions in my Prior '484 Declaration and my opinions herein. '484-Anthony, ¶¶111-114.

325. With respect to **Carlson's** lenses teachings, in the prior '533 IPR, I understand that the Board agreed, determining that "a person skilled in the art would have incorporated Carlson's lenses 21 into Lisogurski's wireless sensor 102/312 to increase its optical signal power and signal-to-noise ratio without increasing its actual power." '533-FWD, 37. This is consistent with my opinions in my Prior '533 Declaration and my opinions herein. '533-Anthony, ¶¶131-134.

326. With respect to **Carlson's** lenses teachings, a person of ordinary skill in the art would have applied **Carlson's** lens teaching to **Lisogurski's** sensor to focus the light emitted by the LEDs onto a user's skin to advantageously increase its signal-to-noise ratio without also having to increase the amount of power consumed by the device. '484-Declaration, ¶112 (citing Carlson, [0010], [0014]; Lisogurski, 6:3-6, 9:49-60, 13:60-14:10, 14:40-55, 37:6-20); '533-Declaration, ¶133 (citing Carlson, [0010], [0014]; Lisogurski, 6:3-6, 9:49-60, 13:60-14:10, 14:40-55, 37:6-20). **Lisogurski** recognizes the importance of "improv[ing] the signal-to-noise ratio" of its system. Lisogurski, 9:50-52; *see also* Lisogurski, 6:3-6, 9:49-60, 13:60-14:10, 14:40-55, 37:6-20. Thus, a person of ordinary skill in the art would have looked to a reference like **Carlson** that discloses "us[ing] a beam-shaping element, such as e.g. diffractive or refractive lenses, to direct the emitted optical radiation of, e.g., the LED light source into the human or animal tissue and the photon detecting element in order to increase the optical signal power, detected by the pulsoximeter sensor, and thus increasing the Signal/Noise—and signal/Background ratio," by a factor of 5. Carlson, [0014]; *see also* Carlson [0010]. Accordingly, a person of ordinary skill in the art would have been motivated to include lenses, as disclosed in **Carlson**, to **Lisogurski's** system to further its own goals of improving the signal-to-noise ratio of the measured optical signal. '484-Declaration, ¶112 (citing Carlson, [0010], [0014]; Lisogurski, 6:3-6, 9:49-60, 13:60-14:10, 14:40-55, 37:6-20); '533-

Declaration, ¶133 (citing Carlson, [0010], [0014]; Lisogurski, 6:3-6, 9:49-60, 13:60-14:10, 14:40-55, 37:6-20).

327. A person of ordinary skill in the art would have had a reasonable expectation of success in applying **Carlson's** lenses teaching to **Lisogurski's** system. Both **Lisogurski** and **Carlson** teach optical physiological measurement systems utilizing LEDs as light sources, and using lenses to focus the light of LEDs was well-known in the art. For example, **Lisogurski** discloses an "optical physiological monitoring system" that uses "one or more light source 316 for emitting light at one or more wavelengths into a subject's tissue." Lisogurski, 1:10-11, 17:37-45; *see also* Lisogurski, 10:48-56. **Carlson** discloses "lenses[] to direct the emitted optical radiation of, e.g., the LED light source into the human ... tissue." Carlson, [0014]; *see also* [0054]. These references demonstrate that lenses were routinely employed in optical systems to enhance the precision with which light is directed into biological tissue. The use of lenses for this purpose was well-understood and widely adopted in the field of optical physiological monitoring. Ex. 1038, 765. Accordingly, incorporating **Carlson's** lens teachings into **Lisogurski's** sensor would have been a predictable and straightforward combination of known elements within the art. *See also* '484-Declaration, ¶113; '533-Declaration, ¶134. Thus, a person of ordinary skill in the art would have known such a combination (yielding the claimed limitations) would predictably work and

provide the expected functionality.

328. **Carlson's** teaching pertains to lenses, **LeBoeuf's** teaching pertains to the spatial configuration of the multiple light sources and multiple detectors **Lisogurski's** sensor unit (Section IX.C.3), and **Tran's** teachings pertaining to **Lisogurski's** monitor and/or software within the sensor (Section IX.B.2). Because these teachings apply to distinct components of **Lisogurski's** system, the motivations and reasonable expectation of success discussions above would remain the same whether applying **Carlson's** teachings to **Lisogurski's** system alone or in view of **LeBoeuf** and/or **Tran**.

3. Invalidity of Claims 1, 5-8, and 11-13 Over Lisogurski in view of Tran, LeBoeuf, and Carlson

329. As I discuss below, Claims 1, 5-8, and 11-13 are rendered obvious by **Lisogurski** in view of **Tran**, **LeBoeuf**, and/or **Carlson**. In addition to my discussion in Sections IX.D.1-2, the following discussion identifies example disclosures that each disclose Challenged Claims 1, 5-8, and 11-13.

a. "lens" Limitations in Elements [1.e], [1.f], [8.b], [8.d]

330. As I discussed above regarding limitations in [1.e], [1.f], [8.b], and [8.d] (Sections IX.A.3.f-g.[1.e]-[1.f], IX.A.3.t.[8.b], IX.A.3.v.[8.d]), **Lisogurski** renders obvious these limitations.

331. To the extent additional disclosure is required for the "lens" limitations,

as the Board already found, **Carlson discloses the wearable device** (*e.g.*, “ear clip” “pulse oximetry” device) **comprising one or more lenses** (*e.g.*, “lenses 21”) **configured to receive at least a portion of the output optical light and to deliver a lens output light to tissue** (*e.g.*, “light...is shaped by...lenses 21 to be guided as beams 12 through the earlobe 2”). Carlson, [0002], [0010], [0013]-[0014], [0024], [0035], [0049], [0054], [0062]; Fig. 4.

332. Regarding the “lens limitations,” in the prior ’484 IPR, I understand that the Board noted that “[a]ccording to Petitioner, a person of ordinary skill would have had reason to employ lenses as taught by Carlson in Lisogurski’s sensor to focus light from the LED onto a person’s skin and in doing so, increase optical power and improve signal to noise ratio,” and that “Carlson discloses ... lenses and that ... can be diffractive or refractive and direct the emitted optical radiation into human or animal tissue.” ’484-FWD, 23, 26-27. This is consistent with my opinions regarding this ’484 limitation provided in my Prior ’484 Declaration, which I incorporate by reference as if fully set forth herein. ’484-Anthony, ¶¶110-114 (citing Carlson, [0010], [0013], [0014], [0024], [0054], [0062], Fig. 4; Lisogurski, 6:3-6, 9:49-60, 13:60-14:10, 14:40-55, 37:6-20; Ex. 1038, 765).

333. Regarding the “lens limitations,” in the prior ’533 IPR, I understand that the Board determined “Petitioner demonstrate[d] that a person skilled in the art would have included lenses in Lisogurski’s wireless sensor 102/312 because Carlson

teaches the advantages of doing so,” and that “Carlson teaches lenses 21 ‘increase the optical signal power without increasing the actual power used by the system, thereby ‘increasing the Signal/Noise . . . ratio.’” ’533-FWD, 36-37. This is consistent with my opinions regarding this ’533 limitation provided in my Prior ’533 Declaration, which I incorporate by reference as if fully set forth herein. ’533-Anthony, ¶¶130-135 (citing Carlson, [0010], [0013], [0014], [0024], [0054], [0062], Fig. 4; Lisogurski, 6:3-6, 9:49-60, 13:60-14:10, 14:40-55, 37:6-20; Ex. 1038, 765).

334. For the reasons I discuss above, the “lens” limitations are substantially identical to the ’484 and ’533 patent limitations on which I previously opined and my opinions regarding the ’484 and ’533 patent terms apply equally to the “lens” limitations (Sections IX.A.3.f-g.[1.e]-[1.f], IX.A.3.t.[8.b], IX.A.3.v.[8.d]).

335. As further support for this limitation, **Carlson** discloses that, for its system for “measurement of pulsation and oxygen saturation in arterial human or animal blood,” it is particularly important to “increas[e] the technical performance of pulsoximetry in terms of quality and robustness of the measurement signal versus environmental disturbances and energy consumption.” Carlson, [0002]. Moreover, and consistent with the noted importance of increasing technical performance, **Carlson** includes Figure 4 to show “schematically two light emitting sources for an oximetric sensor including beam shaping optics.” Carlson, [0035]; *see also* Carlson,

Fig. 4.

336. For the reasons I discuss in Section IX.D.2, a person of ordinary skill in the art would have understood been motivated to apply **Carlson's** lens teachings to **Lisogurski** to increase optical signal power and signal-to-noise ratio without increasing the system's power consumption. The same finding is true for applying **Carlson's** teachings to **Lisogurski** alone, or **Lisogurski** in view of **LeBoeuf** and/or **Tran**.

X. SECONDARY CONSIDERATIONS

337. I have found no evidence in either the '475 patent's prosecution history or elsewhere that supports any secondary considerations arguments, or evidence of nexus to any challenged Claim. *See generally* '475FH. Indeed, as I have discussed in connection to the prior art referenced herein, any purported solutions to problems or unexpected results in the '475 patent were already well-known in the field.

338. To the extent the patent owner asserts the existence of any additional secondary considerations in its responses, or presents any additional evidence or arguments, I reserve my right to address any such evidence.

XI. CONCLUSION

339. In summary, I have concluded that the Challenged Claims are 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 '475 patent obvious.

Declaration of Brian W. Anthony in Support of
Petition for Post Grant Review, U.S. Patent No. 12,268,475

340. 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.

341. 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.

342. 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.

343. 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.

APPENDIX A

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
School of Engineering Faculty Personnel Record

Date: November 20, 2024

Name:

Brian W. Anthony

Department: Mechanical Engineering / Institute of Medical Engineering and Science

1. Date of Birth: July 1972

2. Citizenship: USA

3. Education:

<u>School</u>	<u>Degree</u>	<u>Date</u>
Carnegie Mellon University	BS	1994
MIT	SM	1998
MIT	PhD	2006

4. Title of Thesis for Most Advanced Degree:
Video Based System Monitoring

5. Principal Fields of Interest:

Biomedical Imaging, Ambient and Wearable Instruments and Sensors, Computational Instrumentation, Optics, Applied ML and AI, Device Design and Manufacturing, Innovation and Product Realization, Imaging.

6. Name and Rank of Other Department Faculty in the Same Field:

Harry Asada, Professor

Ian Hunter, Professor

Kamal Youcef-Toumi, Professor

7. Non-MIT Experience (including military service):

<u>Employer</u>	<u>Position</u>	<u>Beginning</u>	<u>Ending</u>
LANL	Scientist	1992	1994
Independent Consultant	Consultant	1994	1998
Xcitex	CoFounder / CTO	1998	2005
Cooper Perkins	CTO	2005	2007
dRNome	CoFounder	2011	2016

8. History of MIT Appointments:

<u>Rank</u>	<u>Beginning</u>	<u>Ending</u>
Lecturer, Sloan	2006	2009
Lecturer, MechE	2006	(present)
Research Scientist	2006	2013
Principal Research Scientist	2013	(present)
Director Singapore MIT Alliance – Manufacturing Systems and Technology Program (SMA-MST)	2006	2010
Director Advanced Manufacturing and Design Program	2006	(present)

Faculty Lead for Education, MIT Skoltech Initiative	2011	2016
Deputy Director, MIT Skoltech Initiative	2014	2016
Associate Director, AIM Academy	2016	2017
Faculty Lead for Industry Engagement, MechE	2018	2022
Associate Director, MIT.nano	2017	(present)
Director, Clinical Technology, Center for Clinical and Translational Research	2017	(present)
Director, Immersion Lab	2017	(present)

9. Consulting Record:

Engagements greater than 3 months.

<u>Firm</u>	<u>Beginning</u>	<u>Ending</u>
Los Alamos National Labs		2000
Textron		2000
Federal Trade Commission		2000
FAA		2004
Kodak		2004
Redlake		2005
Olympus		2006
TIS	2009	2012
Photron	2009	2011
Cooper Perkins	2010	2012
IDEO	2012	---
Alcon	2012	---
Ximedica	2013	2014
Herman Miller	2014	2014
Novartis	2015	2015
Lenze	2015	2016
Baxter	2019	2019
Apple	2017	2025
Samsung	2024	2025

10. Professional Service

<u>Activity</u>	<u>Beginning</u>	<u>Ending</u>
MEngM Admissions Committee	2006	present
CDO Admissions Committee	2007	2008
Career Fair – SMA in Singapore, Org Chair	2007	2007
Career Fair – SMA/MIT in Singapore, Org Chair	2008	2008
Mfg. microFluidics Symp, Chair	2009	2010
SMART Proposal Lead on Med Devices	3/2010	9/2010
LMP Summit Co-Chair	2011	2011
MEDRC Workshop, Chair	2012	2012
Pilot IMI Proposal, MIT Lead	5/2012	6/2012
Additive mfg working group, Lead	6/2012	8/2012
Co-Chair Education Workstream, AMP 2.0	2013	2014
MIT's role in reducing the cost of health care	2014	2015

AIM Photonics Workforce Committee	2017	2017
Nextflex Collaboration Lead PI	2016	2017
Campus and Community Health Management	2020	2021
MIT-Skoltech Steering Committee	2017	2022
SPIE Conference Committee	2011	2022
MIT / Tufts CTSI TAP Committee	2020	
MIT. nano Leadership Council	2017	

11. Awards Received:

<u>Award</u>	<u>Date</u>
National Television Academy, Emmy for Innovative Technical Achievement. "Golf on CBS, SwingVision."	2005
BPLA Invented Here, Featured Honoree	2014

12. Current Organization Membership:

<u>Organization</u>	<u>Offices Held</u>
ASME	
IEEE	
SPIE	
AIUM (American Institute of Ultrasound in Medicine)	
Sigma Xi	
RSNA	

13. Patents and Patent Applications Pending:

1. US Patent 5606130 "Method for determining the octane rating of gasoline samples by observing corresponding acoustic resonances therein."
2. US Patent 6393384 "Apparatus and method for remote ultrasonic determination of thin material properties using signal correlation."
3. US Patent 6226081 "Optical height of fill detection system and associated methods."
4. US Patent 8,333,704, B. Anthony and M. Gilbertson, "Handheld Force-Controlled Ultrasound Probe," Dec 11, 2012
5. US Patent 8,328,725, B. Anthony and M. Gilbertson, "Ultrasound Probe," Dec 18, 2012
6. US Patent 8,382,671, B. Anthony and M. Gilbertson, "Handheld Ultrasound Probe," Feb 26, 2013
7. US Patent 9,121,705, B. Anthony and D. Ljubicic, "Sensor for Simultaneous Measurement of Thickness and Lateral Position of a transparent object," Sept 1, 2015
8. US Patent 9,456,800, Brian W. Anthony, Matthew W. Gilbertson, "Ultrasound scanning system", Oct 4, 2016
9. US Patent 10353191, Circular scanning technique for large area inspection, July 16, 2019.
10. MIT Case 14088, Force Controlled Ultrasound Probe, 16-Dec-09
11. MIT Case 14387, Deformation Estimation and Correction in Elastography with a Handheld Force Controlled Ultrasound Probe, 16-Jul-10
12. MIT Case 14422, High-Speed Profilometer for Manufacturing Inspection, 30-Jul-10
13. MIT Case 14966J, Force Measurement Ultrasound Probe for Sonographer Fatigue Monitoring, 10-Jun-11
14. MIT Case 15012, A 6-DOF Optical System for Freehand 3D Ultrasound, 05-Jul-11

15. MIT Case 15681J, Local Actuation and Control of Stamp Deformation in Microcontact Printing, 06-Jun-12
16. MIT Case 15782, Usability Improvements to a Handheld Force-Controlled Ultrasound Probe, 03-Aug-12
17. MIT Case 15884, Computer-Guided Restoration of Ultrasound Scan Poses by Optical Tracking, 01-Oct-12
18. MIT Case 16160, Quick-Release Mechanism for a Force-Measuring Ultrasound Probe, 22-Feb-13
19. MIT Case 16447, Force-correlated Quantitative Ultrasound Image Analysis, 02-Jul-13
20. MIT Case 17106J, Acoustic Characterization of Superficial Body Fluids, 07-May-14
21. MIT Case 17211J, Wireless Capsule Endoscopic Ultrasound, 24-Jun-14
22. MIT Case 17259K, A Concentric Circle Scanning Technique for Large Area Inspection, 09-Jul-14
23. MIT Case 17260K, Grid-Based Matching for Full-Field Large-Area Deformation Measurement, 09-Jul-14
24. MIT Case 17344, Recovery and Computer-Guided Restoration of Ultrasound Scan Poses Based on Human Skin Features, 21-Aug-14
25. MIT Case 17864J, Ultrasound-Based Individual Scatterer Detection Method Using Scatterer Motion Induced by Acoustic Radiation Force, 21-Apr-15
26. MIT Case 17865, Ultrasound-Based Absolute Scatterer Concentration Measurement Technique: Image Volume Estimation from Scatter Spread Function Extracted From the Image, 21-Apr-15
27. MIT Case 17990, Hydrogel Ultrasound Angle Wedge, 04-Jun-15
28. MIT Case 18074, Joint Camera-Ultrasound Data Acquisition for Limb Scanning, 13-Jul-15
29. MIT Case 18544, An Iterative RTM with a Priori Data to Estimate Bone Thickness Using a Cylindrically Scanning Ultrasound Tomography Scanner, 22-Feb-16
30. MIT Case 18545K, Block-Wise Inversion for the Soundspeed of Human Soft Tissue and Bone Using Ray Based Travel Time Tomographic Techniques, 22-Feb-16
31. MIT Case 18636, Concentric Ring-Based Point Pattern Matching of Skin Features, 05-Apr-16
32. MIT Case, Physical and Chemical Characterization of Aerosols with Photonic Waveguides, United States Patent Application 20190234850
33. MIT Case 19192QJ, Non-Invasive Assessment of Venous Pressure via Actuation of Reciprocal Surface Forces for Vessel Collapse Using Single-Crystal Ultrasound in Vertebrates
34. MIT Case 19409, Medical Ultrasound Device with Integrated Force Measurement and Methods for Data Synchronization
35. MIT Case 19460, Shear Wave Elastography Imaging with External Mechanical Vibration
36. MIT Case 19516, Source and Receiver Tracking for Non-Contact Ultrasound
37. MIT Case 19618, Real Time Imaging of Invisible Micron-Scale Monolayer Patterns on a Moving Web Using Condensation Figures
38. MIT Case 19626TE, Apparatus and Methods for Ultrasound Limb Scanning Under Load
39. MIT Case 19710, A Technique for Imaging Cortical Bone and Soft Tissue Using the Level-Set Method to Regularize Travel-Time and Full Waveform Tomography Techniques
40. MIT Case 19791, On chip Photonic Aerosol Spectrometer
41. MIT Case 19921, Equity Disbursement for Bionic Skins LLC (4914743)
42. MIT Case 20289, Miniaturization of External Mechanical Vibration for Ultrasound Shear Wave Elastography Imaging

43. MIT Case 20506L, Systems and Methods for Enabling Non-Contact Laser Ultrasound
44. MIT Case 21078, Microscale Photoacoustic Spectroscopy and Microscopy
45. MIT Case 21123, Tunable Filler Assembly in Multi-material Polymer Extrusions Using Direct Injection and Acoustic Radiation Forces
46. MIT Case 21145, 3D Organ and Tissue Property Mapping using Superficial Vasculature-Based RGBD-SLAM and Deep Vasculature Alignment
47. MIT Case 22420, Integrated Optofluidic Sensor for Thromboembolic and Coagulation Risk Monitoring in COVID-19 Patients at Point-of-Care
48. MIT Case 22432, High Sensitivity and Specificity, Rapid, Low Cost, On-Chip Covid-19 Virus (and Other Virus) Detection using Integrated Photonic Sensors
49. MIT Case 22652, Dynamic Control of a Fiber Manufacturing Process using Deep Reinforcement Learning
50. MIT Case 23256, Privacy-Preserving Health Diagnosis of Manufacturing Machines
51. Circular scanning technique for large area imaging (US Patent 10,735,674)
52. Method for detecting circulating cells in superficial body fluids (US Patent 10,639,012)
53. Physical and Chemical Characterization of Aerosols with Photonic Waveguides (US Patent 11,181,454)

14. Professional Registration:

N/A.

15. Major New Products, Processes Designs, or Systems:

See next.

1. Books:

Smart Manufacturing On-line course, deployed 2019 and 2020

2. Papers in Referred Journals:

- 2.1. B. Anthony, A. Abbate, D. Klimek, P. Kotidis., "Analysis of Ultrasonic Waves in Arbitrarily Oriented or Rotating Anisotropic Thin Materials", *Quantitative Nondestructive Evaluation*. Vol 18. pgs 215 - 222. (1999).
- 2.2. A. Abbate, B. Anthony, D. Klimek, P. Kotidis., "Analysis of Dispersive Ultrasonic Signals by the Ridges of the Analytic Wavelet Transform", *Quantitative Nondestructive Evaluation*. Vol 18. pgs 703 - 710. (1999).
- 2.3. Dan Klimek, Brian Anthony, Agostino Abbate, Petros Kotidis, "Laser Ultrasonic Instrumentation for Accurate Temperature Measurement of Silicon Wafers in Rapid Thermal Processing Systems", *Rapid Thermal and Integrated Processing VII*, Materials Research Society, Volume 525, pg 135. (1999)
- 2.4. Hardt, D.E., Anthony, B.W., Tor S.B., "A teaching factory for polymer microfabrication - μ Fac," *International Journal of Nanomanufacturing*, 2010, Vol. 6, No.1/2/3/4, pp. 137 - 151.
- 2.5. Shih-Yu Sun, Matthew Gilbertson, and Brian W. Anthony, "Probe Localization for Freehand 3D Ultrasound by Tracking Skin Features", Book Section, *Medical Image Computing and Computer-Assisted Intervention - MICCAI 2014*, Springer, 2014, Vol. 8674. *Lecture Notes in Computer Science*, Pages 365-372.
- 2.6. Xian Du, Brian W. Anthony, Nigel C. Kojimoto, "Grid-based matching for full-field large-area deformation measurement", *Optics and Lasers in Engineering*, Volume 66, March 2015, Pages 307-319.
- 2.7. Xian Du, Nigel C. Kojimoto, Brian W. Anthony, "Concentric circular trajectory sampling for super-resolution and image mosaicing", *Journal of the Optical Society of America A*, Volume 32, No. 2, February 2015, Pages 293-304.
- 2.8. M. Gilbertson, B. Anthony. "A Force and Position Control System for Freehand Ultrasound", *IEEE Transactions on Robotics*, Volume 31, Issue 4. 2015.
- 2.9. Andrey Kuzmin, Aaron Zakrzewski, Brian Anthony, Victor Lempitsky, "Multi-frame Elastography Using Handheld Force-Controlled Ultrasound Probe". *Transactions on Ultrasonics, Ferroelectrics, and Frequency Control*, Volume 62, Issue 8, Pages 1486 – 1500, 2015.
- 2.10. Xian Du and Brian Anthony, "Concentric circle scanning system for large-area and high-precision imaging," *Optics Express*, Vol 23, Issue 15, Pages 20014-20029, 2015.
- 2.11. Du, X., Anthony, B., "Controlled angular and radial scanning for super resolution concentric circular imaging," *Opt. Express* 24(20), 22581, United States (2016).
- 2.12. Jimenez, X., Shukla, S. K., Ortega, I., Illana, F. J., Castro-González, C., Marti-Fuster, B., Butterworth, I., Arroyo, M., Anthony, B., et al., "Quantification of Very Low Concentrations of Leukocyte Suspensions In Vitro by High-Frequency Ultrasound," *Ultrasound Med. Biol.* 42(7), 1568–1573, England (2016).
- 2.13. Koppaka, S., Shklyar, I., Rutkove, S. B., Darras, B. T., Anthony, B. W., Zaidman, C. M., Wu, J. S., "Quantitative Ultrasound Assessment of Duchenne Muscular Dystrophy Using Edge Detection Analysis," *J. Ultrasound Med.* 35(9), 1889–1897, United States (2016).
- 2.14. Lee, J., Boning, D., Anthony, B., "Measuring the Absolute Concentration of Microparticles in Suspension using High Frequency B-mode Ultrasound Imaging", *Ultrasound in Medicine and Biology*, 2018.
- 2.15. Correa-de-Araujo, R., Harris-Love, M., Miljkovic, I., Fragala, M.S., Anthony, B.W., Manini, T., Newman, A.B., "The Need for Standardized Assessment of Muscle Quality in Skeletal Muscle Function Deficit and Other Aging-Related Muscle Dysfunctions: A Symposium Report", *Frontiers in Physiology*, Section on Striated Muscle Physiology, 2017

- 2.16 Anthony, B, et al, “A Pilot Study to Precisely Quantify Forces Applied by Sonographers While Scanning: A Step Toward Reducing Ergonomic Injury”, *WORK: A Journal of Prevention, Assessment, and Rehabilitation*, 2017
- 2.17 Zakrzewski, Aaron M., Anthony, Brian W., "Non-Invasive Blood Pressure Estimation Using Ultrasound and Simple Finite Element Models", *IEEE Transactions on Biomedical Engineering*, 2017
- 2.18 Anthony, B., Fitriana, "Computationally-Efficient Optimal Video-Comparison for Machine Monitoring and Process Control", *Journal of Manufacturing Science and Engineering*, 2017
- 2.19 Lee I, Du X, Anthony B. “Hair segmentation using adaptive threshold from edge and branch length measures,” *Computers in Biology Medicine*, (2017).
- 2.20 Pigula-Tresansky AJ, Wu JS, Kapur K, Darras BT, Rutkove SB, Anthony BW. “Muscle compression improves reliability of ultrasound echo intensity,” *Muscle Nerve*, 2017.
- 2.21 Xian Du, David Hardt, and Brian W. Anthony, “Real time imaging of invisible micron-scale monolayer patterns on a moving web using condensation figure,” *IEEE Transactions on Industry Electronics*, (submitted, in review), 2017.
- 2.22 Brian W. Anthony, Xian Du, Ina Kundu, Judith Beaudoin, “Skin registration and point pattern matching of skin microrelief structure,” (submitted, in revision), 2017.
- 2.23 Ozturk A, Grajo JR, Dhyani M, Anthony BW, Samir AE. *Principles of ultrasound elastography. Abdominal Radiology*. 2018.
- 2.24 Benjamin A, Zubajlo RE, Dhyani M, Samir AE, Thomenius KE, Grajo JR, Anthony, Brian W., “A Novel Approach to the Quantification of the Longitudinal Speed of Sound and its Potential for Tissue Characterization (Part I)”, *Journal of Ultrasound in Medicine and Biology*, 2018
- 2.25 B. Anthony et al, “Experimental Validation of Longitudinal Speed of Sound Estimates in the Diagnosis of Hepatic Steatosis (Part II)”, *Journal of Ultrasound in medicine and biology*, 2018
- 2.26 A. Ozturk et al., "Quantitative Hepatic Fat Quantification in NAFLD using Ultrasound-Based Techniques: A Review of Literature and their Diagnostic Performance," *Ultrasound in Medicine and Biology*, 2018
- 2.27 Zakrzewski, A. M., Huang, A. Y., Zubajlo, R. E., & Anthony, B. W. Real-Time Blood Pressure Estimation From Force-Measured Ultrasound. *IEEE Transactions on Biomedical Engineering*, 2018 (Nov 2018 cover article).
- 2.28 Singh, R., Su, P., Kimerling, L., Agarwal, A., & Anthony, B. W. “Towards On-chip Mid Infrared Photonic Aerosol Spectroscopy.” *Applied Physics Letters*. (Accepted). 2018
- 2.29 Ranger, Bryan J., Feigin, M., Zhang, X., Moerman, Kevin M., Herr, H., Anthony, Brian W. “3D ultrasound imaging of residual limbs with camera-based motion compensation”, *Transactions on Neural Systems & Rehabilitation*, (accepted) 2018.
- 2.30 Singh, R., Ma, D., Kimerling, L., Agarwal, A., & Anthony, B. W. “Chemical Characterization of Aerosol Particles Using On-chip Photonic Cavity Enhanced Spectroscopy”. *ACS Sensors*. 2018
- 2.31 Feigin, M., Ranger, B., Anthony, B., “Probabilistic Framework for Maximal Consensus Image Registration with Application to Medical Ultrasound Imaging” *IEEE Transactions on Biomedical Engineering*, (submitted) 2019.
- 2.32 X. Du, D. Hardt, and B. Anthony, “Real Time Imaging of Invisible Micron-Scale Monolayer Patterns on a Moving Web Using Condensation Figures,” *IEEE Trans. Ind. Electron.*, pp. 1–1, 2019.
- 2.33 B. J. Ranger, M. Feigin, X. Zhang, K. M. Moerman, H. Herr, and B. W. Anthony, “3D Ultrasound Imaging of Residual Limbs With Camera-Based Motion Compensation,” *IEEE Trans. Neural Syst. Rehabil. Eng.*, vol. 27, no. 2, pp. 207–217, Feb. 2019.
- 2.34 M. Feigin-Almon, D. Freedman, and B. W. Anthony, “A Deep Learning Framework for Single-Sided Sound Speed Inversion in Medical Ultrasound,” *IEEE Trans. Biomed. Eng.*, pp. 1–1, 2019.
- 2.35 R. Singh, D. Ma, L. Kimerling, A. M. Agarwal, and B. W. Anthony, “Chemical Characterization of Aerosol Particles Using On-Chip Photonic Cavity Enhanced Spectroscopy,” *ACS Sensors*, vol. 4, no. 3, pp. 571–577, Mar. 2019.

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- 2.37 M. Feigin, M. Zwecker, D. Freedman, and B. W. Anthony, “Detecting muscle activation using ultrasound speed of sound inversion with deep learning,” Submitted Oct. 2019.
- 2.38 S. Kim, D. D. Kim, and B. Anthony, “Dynamic Control of a Fiber Manufacturing Process using Deep Reinforcement Learning,” Submitted Nov. 2019.
- 2.39 R. Singh, Y. Nie, A. M. Agarwal, and B. W. Anthony, “Inverse Design of Photonic Metasurface Gratings for Beam Collimation in Opto-fluidic Sensing,” Submitted Oct. 2019.
- 2.40 Benjamin A, Chen M, Li Q, Chen L, Dong Y, Carrascal CA, et al. Renal Volume Estimation Using Freehand Ultrasound Scans: An Ex Vivo Demonstration. *Ultrasound Med Biol*. 2020 Jul;46(7):1769–82.
- 2.41 Chrzanowski S, Tresansky AP, Nagy J, Rutkove S, Anthony B. Muscle Imaging – MRI. *Neuromuscul Disord*. 2020 Oct;30:S95.
- 2.42 Singh R, Agarwal A, W Anthony B. Mapping the design space of photonic topological states via deep learning. *Opt Express*. 2020 Sep 14;28(19):27893.
- 2.43 Lee JH, Traverso G, Ibarra-Zarate D, Boning DS, Anthony BW. Ex Vivo and In Vivo Imaging Study of Ultrasound Capsule Endoscopy. *J Med Device*. 2020 Jun 1;14(2).
- 2.44 Singh R, Agarwal A, Anthony BW. Design of optical meta-structures with applications to beam engineering using deep learning. *Sci Rep*. 2020 Dec 16;10(1):19923.
- 2.45 Yang H, Carrascal CA, Xie H, Shamdasani V, Anthony BW. 2-D Ultrasound Shear Wave Elastography With Multi-Sphere-Source External Mechanical Vibration: Preliminary Phantom Results. *Ultrasound Med Biol*. 2020 Sep;46(9):2505–19.
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- 2.47 Ozturk A, Zubajlo RE, Dhyan M, Grajo JR, Mercaldo N, Anthony BW, et al. Variation of Shear Wave Elastography With Preload in the Thyroid: Quantitative Validation. *J Ultrasound Med*. 2021 Apr 20;40(4):779–86.
- 2.48 Kang HED, Kim D, Kim S, Kim DD, Cheon JH, Anthony BW. Homomorphic Encryption as a secure PHM outsourcing solution for small and medium manufacturing enterprise. *J Manuf Syst*. 2021 Oct;61:856–65.
- 2.49 Kim S, Kim DD, Anthony B. Dynamic Control of a Fiber Manufacturing Process using Deep Reinforcement Learning. *IEEE/ASME Trans Mechatronics [Internet]*. 2021;4435(c):1–1.
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- 2.51 Singh R, Nie Y, Gao M, Agarwal AM, Anthony BW. Inverse design of photonic meta-structure for beam collimation in on-chip sensing. *Sci Rep*. 2021 Dec 5;11(1):5343.
- 2.52 Benjamin A, Ely G, Anthony BW. 2D speed of sound mapping using a multilook reflection ultrasound tomography framework. *Ultrasonics*. 2021 Jul;114:106393.
- 2.53 Hahm KS, Anthony BW. In-home Health Monitoring using Floor-based Gait Tracking. *Internet of Things (Netherlands) [Internet]*. 2022 Aug;19:100541.
- 2.54 Goryachev I, Tresansky AP, Ely GT, Chrzanowski SM, Nagy JA, Rutkove SB, et al. Comparison of Quantitative Ultrasound Methods to Classify Dystrophic and Obese Models of Skeletal Muscle. *Ultrasound Med Biol*. 2022 Sep;48(9):1918–32.
- 2.56 Jaffe AT, Zubajlo RE, Daniel L, Anthony BW. Automated Force-Coupled Ultrasound Method for Calibration-Free Carotid Artery Blood Pressure Estimation. *Ultrasound Med Biol*. 2022 Sep;48(9):1806–21.
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- 2.59 Wang YJ, Chai LA, Zubajlo RE, Anthony BW. Sequencing waves in single-transducer acoustophoretic patterning of microspheres. *Appl Phys Lett*. 2022 Dec 12;121(24):244106.
- 2.60 Silva L, Dias M, Folgado D, Nunes M, Namburi P, Anthony B, et al. Respiratory Inductance Plethysmography to Assess Fatigability during Repetitive Work. *Sensors*. 2022 Jun 2;22(11):4247.
- 2.62 Magana-Salgado U, Namburi P, Feigin-Almon M, Pallares-Lopez R, Anthony B. A comparison of point-tracking algorithms in ultrasound videos from the upper limb. *Biomed Eng*. 2023 May 24;22(1):52.
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- 2.69 Ranger BJ, Moerman KM, Anthony BW, Herr HM. Constitutive parameter identification of transtibial residual limb soft tissue using ultrasound indentation and shear wave elastography. *J Mech Behav Biomed Mater* []. 2023 Jan;137:105541.
- 2.70 Wang, J; Anthony B. Absolute Magnitude of the Acoustic Radiation Force in a Multi-Wavelength Patterning Device Before and After Pattern Formation. *Proc ASME 2024*. 2024;1–10.
- 2.71 Camacho J de J, Aguirre B, Ponce P, Anthony B, Molina A. Leveraging Artificial Intelligence to Bolster the Energy Sector in Smart Cities: A Literature Review. *Energies* []. 2024 Jan 10;17(2):353.
- 2.72 Ponce P, Anthony B, Bradley R, Maldonado-Romo J, Méndez JI, Montesinos L, et al. Developing a virtual reality and AI-based framework for advanced digital manufacturing and nearshoring opportunities in Mexico. *Sci Rep* []. 2024 May 16;14(1):11214.
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- 2.74 Lee JH, Nathanson LA, Burke RC, Anthony BW, Shapiro NI, Dagan AS. Assessment of respiratory rate monitoring in the emergency department. *JACEP Open* []. 2024 Jun 8;5(3).
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 - 2.79 Mata O, Ponce P, Perez C, Ramirez M, Anthony B, Russel B, et al. Digital twin designs with generative AI: crafting a comprehensive framework for manufacturing systems. *J Intell Manuf* []. 2025 Feb 20.
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3. Proceedings of Refereed Conferences:
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 - 3.10. Anthony, B. W., Namvari, K., "Dimensional variation of polymer substrate electrode production," *Proceedings of SPIE Vol. 8251, 82510G* (2012).
 - 3.11. Selvakumar, S., Linares, R., Oppenheimer, A., Anthony, B., "Variation analysis of flow rate delivered using a blister pump," *Proceedings of SPIE Vol. 8251, 82510I* (2012).
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 - 3.16. Sun, S.-Y, Gilbertson, M., Anthony, B. W. "6-DoF Probe Tracking via Skin Mapping for Freehand 3D Ultrasound". 2013 IEEE International Symposium on Biomedical Imaging (ISBI), (2013).

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- 3.18. Inamdar, T., Anthony, B. W., "Characterizing fluidic seals for on-board reagent delivery," Proceedings of SPIE (2013).
- 3.19. Zakrzewski, A., Anthony, B. W. "Quantitative Elastography and its Application to Blood Pressure Estimation: Theoretical and Experimental Results". 2013 IEEE Engineering in Medicine and Biology Society (EMBS), (2013).
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Theses Supervised by Brian W. Anthony

Summary:

	<u>Total</u>	<u>Completed</u>	<u>In Progress</u>
Bachelor's	5	5	0
Master's	42	35	7
MEng	29	17	12
Engineer's			
<u>Doctoral</u>			
As Supervisor	26	15	11
As Reader	4	3	1

Last	First	Title	Department	Year	
Bachelor's Theses					
Syverud	Brian	<i>Robotic ultrasound manipulator: calibration of position and orientation measurement system</i>	MechE	2009	
Johnson	Michael	<i>Design of a precise X-Y-Theta nanopositioning optical sensor</i>	MechE	2009	
Chai	Lauren	<i>Design of mechanical arterial simulator</i>	MechE	2012	
Ramos	Javier	<i>Design of Force Measurement Probe</i>	MechE	2012	
Mireault	Alfred Norman	<i>Mechanical design of an ultrasonic tomographic imaging system</i>	MechE	2016	

Master's Theses					
Fitriani		<i>Multiscale Dynamic Time and Space Warping</i>	CDO	2008	
Zarrouati	Nadège	<i>A precision manipulation system for polymer microdevice production</i>	MechE	2010	
Gilbertson	Matthew Wright	<i>Handheld force-controlled ultrasound probe</i>	MechE	2010	
Sun	Shih-Yu	<i>Deformation correction in ultrasound imaging in an elastography framework</i>	EECS	2010	
Zakrzewski	Aaron	<i>Multi-scale quantitative elastography and its application to blood pressure estimation</i>	MechE	2013	
Koppaka	Sisir	<i>Imaging Biomarkers for Duchenne Muscular Dystrophy</i>	CDO	2015	
Zhang	Xiang (Shawn)	<i>Design of a single element 3D ultrasound scanner</i>	MechE	2015	
Primack	Willow	<i>Analysis and Productivity Improvement of an Automated Material Handling System through Simulation</i>	LGO	2015	

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Churchill	Hugh E.	<i>Cycle-time Analysis and Improvement Using Lean Methods within a Retail Distribution Center</i>	LGO	2015	
Sazdanoff	Nicholas	<i>Evaluation of postponement in the Drug Product supply chain</i>	LGO	2015	
Kojimoto	Nigel Costello	<i>Ultrasonic inspection methods for defect detection and process control in roll-to-roll flexible electronics manufacturing</i>	MechE	2015	
Kundu	Ina Annesha	<i>Imaging platforms for detecting and analyzing skin features and Its stability : with applications in skin health and in using the skin as a body-relative position-encoding system</i>	MechE	2015	
Conover	Susan	<i>Imaging platforms for detecting and analyzing skin features and Its stability : with applications in skin health and in using the skin as a body-relative position-encoding system</i>	SDM	2015	
Hess	Tylor	<i>Algorithm deployment platform</i>	MechE	2016	
Lee	Kang Qi lan	<i>Computational tools for enabling longitudinal skin image analysis</i>	CDO	2016	
Huang	Athena Yeh	<i>May the force be with you : a medical ultrasound system with integrated force measurement</i>	MechE	2017	
Benjamin	Alex	<i>The (travel) times they are a changing : a computational framework for the diagnosis of non-alcoholic fatty liver disease (NAFLD)</i>	CDO	2017	
Yang	Heng	<i>Ultrasound shear wave elastography imaging with external mechanical vibration</i>	MechE	2017	
Zubajlo	Rebecca	<i>Quantitative biomarkers for tissue characterization</i>	MechE	2017	
Benjamin	Rishon Robert	<i>Silence of the lamb waves</i>	CDO	2017	
Haidar	Samer	<i>Supply chain network strategy for consumer medical device introduction</i>	LGO	2016	
Al-Meer	Mariam	<i>Reducing heart failure admissions through improved care systems and processes</i>	LGO	2017	
Sandford	Michael	<i>Application of 3D printing in medical devices New Product Development</i>	LGO	2017	

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Graule	Moritz Alexander	<i>Towards force-correlated ultrasound volume elastography</i>	MechE	2017	
Sun	Mingxiu	<i>Education and practice factory : from factory design to first product delivery</i>	MechE	2018	
Singh	Robin	<i>Whispering photons : on-chip biophotonic integrated circuits for point-of-care diagnostics</i>	MechE	2018	
Beaudoin	Judy	<i>Quantifying dermatology : method and device for user-independent ultrasound measurement of skin thickness</i>	MechE	2018	
DiAndreth	Chris	<i>Optimization of Downstream Supply Chain Product Flow based on an Integrated Cost-to-Deliver Perspective</i>	LGO	2019	
Puppo	Manuel Martinez	<i>Replenishment in an integrated stock world</i>	LGO	2019	
Lu	Shirley Suet-Ning	<i>Design of dynamically controlled desktop fiber accumulator with tension feedback as part of smart manufacturing educational kit</i>	MechE	2020	
Kim	Sangwoon	<i>Model-free tracking control of an optical fiber drawing process using deep reinforcement learning</i>	MechE	2020	
Chen	Hongling (Holly)	<i>Vascular Imaging System for Longitudinal Registration and Mapping of Superficial Vessels with Quantitative Analysis</i>	IDM	2020	
Chavez	Yasmin	<i>System identification and control of a miniature external mechanical vibration device towards clinical ultrasound shear wave elastography</i>	MechE	2020	
Koeppen	Ryan	<i>Design of Electromechanical Attachments for Improved Ultrasound Imaging Repeatability</i>	MechE	2021	
Goryachev	Ivan	<i>Kiosks for Non-Contact Vital Sign Detection</i>	MechE	2021	
Adiwijaya	Zenia	<i>Tenative: ML for Process control</i>	SDM	2023	expected
Chen	George	<i>Tenative: ML for Process control</i>	MechE	2022	expected
Deshpande	Aniruddha	<i>Tenative: Food manufacturing - ML models</i>	EECS	2023	expected
Dhar	Shreya	<i>Tenative: Education Kit</i>	MechE	2023	expected
Espinoza	Victor Reyes	<i>Tenative: ML for Process control</i>	EECS	2022	expected
Justiniano	Eugenio Caraballo	<i>Tenative: Sound and Light on Cells</i>	MechE	2023	expected

Theses Supervised by Brian W. Anthony

Magana-Salgado	Uriel	<i>Tenative: Muscle Health monitoring</i>	MechE	2023	expected
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Master Eng. Theses					
Su	Xiangyong	<i>Optimization of labor allocation at a syringe production facility : design proposals</i>	MechE	2008	
Liaw	Sze Sen	<i>Optimization of labor allocation at a syringe production facility using computer simulation</i>	MechE	2008	
Ng	Gar Yan	<i>Optimization of labor allocation at a syringe production facility : work study</i>	MechE	2008	
Linares	Rodrigo	<i>Manufacturability of lab on a chip devices: tolerance analysis and requirements establishment</i>	MechE	2010	
Selvakumar	Sivesh	<i>Manufacturing of Lab-On-a-Chip devices : variation analysis of liquid delivery using blister packs</i>	MechE	2010	
Namvari	Kasra	<i>Manufacturability of lab-on-chip devices : dimensional variation analysis of electrode foils using visual technology</i>	MechE	2011	
Donoghue	Linda	<i>Design of a micro-interdigitated electrode for impedance measurement performance in a biochemical assay</i>	MechE	2011	
Holmes	Jacklyn	<i>Robustness and repeatability of interdigitated electrodes on a substrate tested in an aqueous environment</i>	MechE	2011	
Judge	Benjamin	<i>Thermoplastic bonding of microfluidic substrates</i>	MechE	2012	
Jain	Nikhil	<i>A comprehensive study and validation of high-throughput microscale electrode production using thermal transfer printing techniques</i>	MechE	2012	
Inamdar	Tejas Satish	<i>Manufacturing of lab-on-a-chip devices : characterizing seals for on-board reagent delivery</i>	MechE	2013	
Saber	Aabed Saud	<i>Manufacturability of lab on chip devices : reagent-filled reservoirs bonding process and its effect on reagents flow pattern</i>	MechE	2013	

Theses Supervised by Brian W. Anthony

Nguyen	Khanh Huy	<i>Hot embossing as a method for rapid prototyping microfluidic devices</i>	MechE	2013	
Ragosta	Nicholas Hiroshi	<i>Design and measurement analysis of hot embossing system for high aspect ratio microfluidics</i>	MechE	2013	
Kalsekar	Viren Sunil	<i>Design and process optimization of a hot embossing machine for microfluidics with high aspect ratios</i>	MechE	2013	
Xue	Elise	<i>Sensorless ultrasound probe 6DoF pose estimation through the use of CNNs on image data</i>	EECS	2018	
DiAndreth	Christopher	<i>Optimization of downstream supply chain product flow based on an integrated cost-to-deliver perspective</i>	LGO	2019	
Cherna	Samuel	<i>External virbarion on Butterfly Probes</i>	EECS	2022	expected
Sawant	Nilay Sanjay	<i>Tenative: ML for Process Control</i>	MechE	2022	expected
Othman	Mohamed Ayman Mohamed	<i>Tenative: ML for Process Control</i>	MechE	2022	expected
Sardet	Maelle Jade	<i>Tenative: ML for Process Control</i>	MechE	2022	expected
Li	Rui	<i>Tenative: Design and Manufacture of Education Kit</i>	MechE	2022	expected
Rojrungsasithorn	Tanach	<i>Tenative: Design and Manufacture of Education Kit</i>	MechE	2022	expected
Levi	Aviva Jesse	<i>Tenative: Design and Manufacture of Education Kit</i>	MechE	2022	expected
Bradley	Russel	<i>Tenative: Design and Manufacture of Education Kit</i>	MechE	2022	expected
Smith	Carly Madeleine	<i>Tenative: Clinical Trial Monitoring Kit Design</i>	MechE	2022	expected
Aitmbiriq	Imane	<i>Tenative: Clinical Trial Monitoring Kit Design</i>	MechE	2022	expected
Noh	Joyce	<i>Tenative: Clinical Trial Monitoring Kit Design</i>	MechE	2022	expected
Lin	Ryan Shao-Wei	<i>Tenative: Clinical Trial Monitoring Kit Design</i>	MechE	2022	expected

Doctoral Theses, Supervisor					
Ljubicic	Dean	<i>High Speed Instrumentation for Inspection of transparent parts</i>	MechE	2013	
Gilbertson	Matthew Wright	<i>Electromechanical systems to enhance the usability and diagnostic capabilities of ultrasound imaging</i>	MechE	2014	
Sun	Shih-Yu	<i>Ultrasound probe localization by tracking skin features</i>	EECS	2014	

Theses Supervised by Brian W. Anthony

Zakrzewski	Aaron	<i>Arterial blood pressure estimation using ultrasound</i>	MechE	2017	
Roberts	Megan	<i>Design and fabrication of a flexible membrane ultrasound transducer</i>	MechE	2018	
Lee	John Haeseon	<i>Measuring the absolute concentration of particles in suspension using high frequency B-mode ultrasound imaging</i>	EECS	2015	
Fincke	Jonathan Randall	<i>Non-contact quantitative imaging of limbs, bone and tissue, using ultrasound tomographic techniques</i>	MechE	2018	
Ranger	Bryan	<i>Ultrasonic imaging methods for quantitative musculoskeletal tissue assessment and improved prosthetic interface design</i>	HST	2018	
Kundu	Ina Annesha Kundu	<i>Imaging skin structures for health, body mapping, and identification (under the Tucson Skin)</i>	MechE	2018	
Kim	David Donghyun Kim	<i>Design and development of desktop fiber and fabric manufacturing system for advanced materials</i>	MechE	2020	
Wang	Jenny Wang	<i>Formation Process of Acoustophoretic Patterns</i>	MechE	2022	
Pigula	Anne Pigula	<i>Statistical analysis of ultrasound signals for tissue characterization : the Homodyned K Distribution</i>	HST	2020	
Zhang	Xiang Zhang	<i>Non-contact ultrasound</i>	MechE	2019	
Benjamin	Alex Benjamin	<i>3D organ property mapping using freehand ultrasound scans</i>	MechE	2020	
Singh	Robin Singh	<i>Integrated bio-photonic devices : sensors, imagers, and beyond</i>	MechE	2021	
Chen	Melinda Chen	<i>Liver Vascular Health Imaging</i>	HST	2022	
Jaffe	Alex	<i>Venous and Blood Pressure in the extremities</i>	EECS	2022	
Hahm	Katie	<i>Ambient Gait Analysis</i>	MechE	2022	
Chai	Lauren	<i>Tentative: Radiation Force Manufacturing</i>	MechE	2022	expected
Zubajlo	Rebecca Zubajlo	<i>Tentative: Physical Measurement of Cells</i>	MechE	2022	expected
Lange	April	<i>Tentative: Volume US - Squishy slam</i>	MechE	2023	expected
Zhang	Zhuorui	<i>Tentative: Large Aperture Wearable</i>	MechE	2024	expected
Gao	Mingye	<i>Tentative: Integrated Photonics for Biosensing</i>	EECS	2024	expected

Theses Supervised by Brian W. Anthony

Lin	QiAn	<i>Tenative: US Path Planning</i>	MechE	2024	expected
Kang	David Ha Eun	<i>Tenative: Homomorphic Encryption and ML</i>	MechE	2023	expected
Tripathy	Soumya	<i>Tenative: Integrated Photonics for US</i>	Media	2024	expected

Doctoral Theses, Reader

Shi	Chuan	<i>Efficient buffer design algorithms for production line profit maximization</i>	MechE	2011	
Petrzelka	Joe	<i>Contact region fidelity, sensitivity, and control in roll-based soft lithography</i>	MechE	2012	
Smyth	Katherine	<i>Piezoelectric micro-machined ultrasonic transducers for medical imaging</i>	EECS	2016	
Athanassiadis	Athanasios G.	<i>Optical breakdown acoustics : transduction and sensing underwater</i>	MechE	2019	

Postdoctoral Associates and Fellows Supervised by Brian W. Anthony

Current Postdocs

<i>Name</i>	<i>Dates of Appointment</i>	<i>PhD Granting Institution</i>
Jenny Wang	2022 -	MIT
Melinda Chen	2022 -	MIT
David Lee	2024-	

Previous Postdocs

<i>Name</i>	<i>Current Title</i>	<i>Current Employer</i>
Vannah, Bill	Scientist	Mary Free Bed Rehabilitation Hospital
Victor Lempitsky	Head of AI	Samsung
Javier J. Gonzalez	May 2013 – 2015	University of Madrid
Matthew Gilbertson	Senior Electro-Optical Engineer	Lockheed Martin
Xian, Du	Professor	UMass (2018)
David Ibarra	Professor	Monterery Tec
Micha Feigin	Research Scientist	MIT
Ian Butterworth	Biomedical Research Engineer	MIT
Carlos Castro-Gonzalez		
	Co-Founder and CEO	Leuko
Berta Martí Fuster	Head of Communications	Oncoheroes Biosciences
Bonghun (Bruce) Shin	Senior Scientist	University Waterloo
Megan Roberts	Director of Product Development	Med Tech Co.
Greg Ely	Senior Algorithm Engineer	Imaging Co.
David Kim	Scientist	Sandia Labs
Shawn Zhang	Scientist	MIT
Praneeth Namburi	Scientist	MIT

APPENDIX B (LIST OF MATERIALS CONSIDERED)

Exhibit No.	DESCRIPTION
1001	U.S. Patent No. 12,268,475 (“’475 patent”)
1002	File History of U.S. Application No. 18/927,698 (“’475 Patent File History”)
1004	Declaration of Brian Anthony in Support of Petition for Inter Partes Review of U.S. Patent No. 9,651,533 submitted in IPR2019-00916, Ex. 1003 (“’533-Anthony”)
1005	<i>Apple Inc. v. Omni Medsci, Inc.</i> , No. IPR2019-00916, Paper 1 (P.T.A.B. Apr. 10, 2019) (“’533-Pet.”)
1008	<i>Apple Inc. v. Omni Medsci, Inc.</i> , No. IPR2019-00916, Paper 39 (P.T.A.B. Oct. 14, 2020) (“’533-FWD”)
1009	<i>Omni MedSci, Inc. v. Apple Inc.</i> , No. 21-01229, ECF 69 (Fed. Cir. June 8, 2022)
1010	Declaration of Brian Anthony in Support of Petition for Inter Partes Review of U.S. Patent No. 10,517,484 submitted in IPR2021-00453, Ex. 1003 (“’484-Anthony”)
1011	<i>Apple Inc. v. Omni Medsci, Inc.</i> , No. IPR2021-00453, Paper 1 (P.T.A.B. Jan. 22, 2021) (“’484-Pet.”)
1013	<i>Apple Inc. v. Omni Medsci, Inc.</i> , No. IPR2021-00453, Paper 7 (P.T.A.B. Aug. 6, 2021) (“’484-Inst.”)
1015	<i>Apple Inc. v. Omni Medsci, Inc.</i> , No. IPR2021-00453, Paper 22 (P.T.A.B. Aug. 3, 2022) (“’484-FWD”)
1016	<i>Apple Inc. v. Omni Medsci, Inc.</i> , No. IPR2021-00453, Paper 26 (P.T.A.B. Feb. 14, 2025) (“’484-RFWD”)
1018	<i>Omni MedSci, Inc. v. Apple Inc.</i> , 2:18-cv-00134-RWS, Dkt. No. 211 (E.D. Tex. June 24, 2019)
1019	<i>Omni MedSci, Inc. v. Apple Inc.</i> , 2:18-cv-00429-RWS, Dkt. No. 152 (E.D. Tex. Aug. 14, 2019)
1023	Defendants’ Supplemental Invalidity and Subject Matter Eligibility Contentions, July 18, 2025. <i>Omni MedSci, Inc. v. Samsung Electronics Co., Ltd. et al.</i> , No. 2:24-cv-01070-JRG-RSP (E.D. Tex.)
1025	U.S. Patent No. 9,241,676 (“Lisogurski”)

Exhibit No.	DESCRIPTION
1026	U.S. Patent Pub. No. 2010/0217102 (“LeBoeuf”)
1027	U.S. Patent No. 8,108,036 (“Tran”)
1028	U.S. Patent Pub. No. 2005/0049468A1 (“Carlson”)
1031	U.S. Patent No. 8,050,730 (“Zhang”)
1033	U.S. Patent Pub. No. 2011/0237911 (“Lamego”)
1034	U.S. Patent No. 5,942,749 (“Takeuchi”)
1035	U.S. Patent No. 5,822,473 (“Magel”)
1036	US Patent 5,592,124 (“Mullins”)
1037	E.F. Schubert, Light-Emitting Diodes (Cambridge Univ. Press, 2nd ed. reprinted 2014)
1038	“The Biomedical Engineering Handbook,” by Joseph D. Bronzino (1995)
1039	U.S. Patent No. 8,079,735 (“Vakil”)
1044	U.S. Patent No. 5,511,553 (“Segalowitz”)
1045	U.S. Patent No. 6,801,799 (“Mendelson”)
1048	U.S. Pat. No. 9,239,951 (“Hoffberg”)
1049	U.S. Pat. Pub. 2007/0194939 (“Alvarez”)
1052	U.S. Patent No. 8,996,088 (“Dasco”)
1053	U.S. Patent Pub. No. 2007/0149868 (“Blank”)
1054	U.S. Patent No. 8,852,103 (“Rothberg”)
1057	U.S. Patent No. 8,922,788 (“Addison”)
1058	JP3552090 (“Denso”) (Certified English Translation)

Exhibit No.	DESCRIPTION
1059	JP3552090 (“Denso”)
1064	U.S. Patent No. 5,554,273 (“Demmin”)
1065	U.S. Patent No. 5,953,713 (“Behbehani”)
1081	U.S. Patent No. 9,651,533 (“’533 patent”)
1082	U.S. Patent No. 10,517,484 (“’484 patent”)
1083	Declaration of Brian Anthony in Support of Petition for Inter Partes Review of U.S. Patent No. 9,861,286 submitted in IPR2019-00914, Ex. 1003

*I also considered any additional materials referenced in my declaration.