

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.,

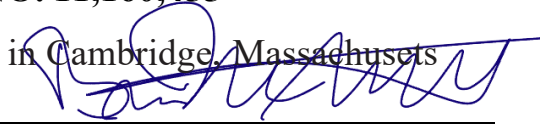
Patent Owner.

Case IPR2025-01252

Patent No. 11,160,455

**DECLARATION OF BRIAN W. ANTHONY IN SUPPORT
OF PETITION FOR *INTER PARTES* REVIEW
OF U.S. PATENT NO. 11,160,455**

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. 11,160,455 (“the ’455 patent”) in connection with the above-captioned *inter partes* review (“IPR”) proceeding. In particular, I have been asked to provide my insights, analysis, and opinions regarding whether claims 1-20 of the ’455 patent (“Challenged Claims”) are obvious over the prior art references identified below.

2. I understand that the ’455 patent is titled “Multi-wavelength wearable device for non-invasive blood measurements in tissue,” names as an inventor Mohammed N. Islam, and is currently owned by Omni Medsci Inc. I have considered the ’455 patent. I understand that the ’455 patent has been provided as Ex. 1001.

3. I understand that the file history of the ’455 patent has been provided as Ex. 1002. I have considered this file history, and I will refer to it as “the ’455 Patent File History” or by its exhibit number.

4. I understand that the ’455 patent 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.

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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/IS2013/075700 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, 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, 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 as application No. PCT/US2013/075767 on Dec. 17, 2013, 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.

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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 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 '455 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. 61/747,485, 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

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Jan. 21, 2013. For the purposes of rendering my opinions in this Declaration, I have been asked to assume that the Challenged Claims are entitled to the December 31, 2012 filing dates of the earliest filed provisional applications for the purposes of rendering my opinions in this declaration. I have not been asked to opine on whether the Challenged Claims of the '455 patent are entitled to this 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 as long as the identified prior art were still prior art.

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 to opine concerning what a person of ordinary skill in the art would have known and understood during that time. Before December 31, 2012, 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 '455 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 31, 2012.

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

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earliest claimed priority date for the '455 patent; my own knowledge and experiences gained from my work experience in the field of the '455 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 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.

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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 I discuss below, certain claim limitations challenged in those proceedings are identical and/or substantially identical to the Challenged Claims of the ’455 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 ’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 five 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 (1) **Lisogurski** alone renders obvious Challenged Claims 1, 8, and 11 of the '455 patent (Ground 1, see my discussion in Section IX.A); (2) **Lisogurski** in view of **LeBoeuf** renders obvious Challenged Claims 2-4, 9-10, and 15-17 of the '455 patent (Ground 2, see my discussion in Section IX.B); (3) **Lisogurski** in view of **Tran** renders obvious Challenged Claims 1, 8, 12, and 15 of the '455 patent (Grounds 3-4, see my discussion in Section IX.C); and (4) **Lisogurski** in view of **LeBoeuf** and **Tran** renders obvious Challenged Claims 5-7, 13-14, and 18-20 of the '455 patent (Grounds 3-4, see my discussion in +Section IX.C). To the extent that claim limitations [1.c], [8.c], and [15.c] require explicit disclosure of "lenses," and Challenged Claims 7, 14, and 20 require further disclosure of increasing pulse rate of a light source to increase signal-to-noise ratio, it is also my opinion that Grounds 1-4 in further view of **Carlson** additionally render obvious Claims 1-20

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(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. involving the ’455 patent. I also understand that the ’484 patent, which is related to the ’455 patent, is also 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 I discuss 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 *inter partes* 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 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

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include the following:

- A combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results;
- When a device or technology is available in one field of endeavor, design incentives and other market forces can prompt variations of it, either in the same field or in a different one, so that if a person of ordinary skill can implement a predictable variation, the variation is likely obvious;
- If a technique has been used to improve one device, and a person of ordinary skill in the art would recognize that it would improve similar devices in the same way, using the technique is obvious unless its actual application is beyond their skill;
- An explicit or implicit teaching, suggestion, or motivation to combine two prior art references to form the claimed combination may demonstrate obviousness, but proof of obviousness does not depend on or require showing a teaching, suggestion, or motivation to combine;
- Market demand, rather than scientific literature, can drive design trends and may show obviousness;
- In determining whether the subject matter of a patent claim would have been obvious, neither the particular motivation nor the avowed purpose of the named inventor controls whether the claim is obvious;
- One of the ways in which a patent's subject can be proved obvious is by noting that there existed at the time of invention a known problem for which there was an obvious solution encompassed by the patent's claims;
- Any need or problem known in the field of endeavor at the time of invention and addressed by the patent can provide a reason for combining the elements in the manner claimed;
- "Common sense" teaches that familiar items may have obvious uses beyond their primary purposes, and in many cases a person of ordinary skill will be able to fit the teachings of multiple patents together like pieces of a puzzle;

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- 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-Anthony, ¶¶37-56 (discussing the same).

41. As I discussed in Section V, the '455 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 ratio of such signals. '455 patent, 21:36-57 (describing technique for “measuring a particular blood constituent” and “methods of improving the ability to discriminate between different constituents”), 36:18-37:56 (describing “the physiological measurement device that ... communicate[s] over a first communication link ... to a receiver in a smart phone[or] tablet cell phone” “which ... operate[s] through the use of one of many wireless technologies”), 59:4-25 (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”), 71:21-40 (same), 80:29-35 (describing that in order to “permit higher signal-to-noise levels,” a “higher intensity or brightness of light sources may be used”).

42. In my opinion, and as further discussed below, the ’455 patent recites claim limitations that are identical and/or substantially identical to those in 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 ’455 patent’s priority date. ’533-Anthony, ¶¶37-56; ’484-Anthony, ¶¶37-56.

43. While the ’455 patent claims include additional limitations, they at most recite (1) a common location to place a wearable device, (2) a generic driver and associated driver circuitry for light sources, (3) a generic measurement or comparison technique using multiple wavelengths, common configurations and characteristics for light sources and detectors, and (4) common analytical methods for data processing/analysis (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 ’455 PATENT

A. ’455 Patent Overview

44. Figure 24 of the ’455 patent, annotated and reproduced below, shows an embodiment of the physiological measurement system to which the ’455 patent

is directed:

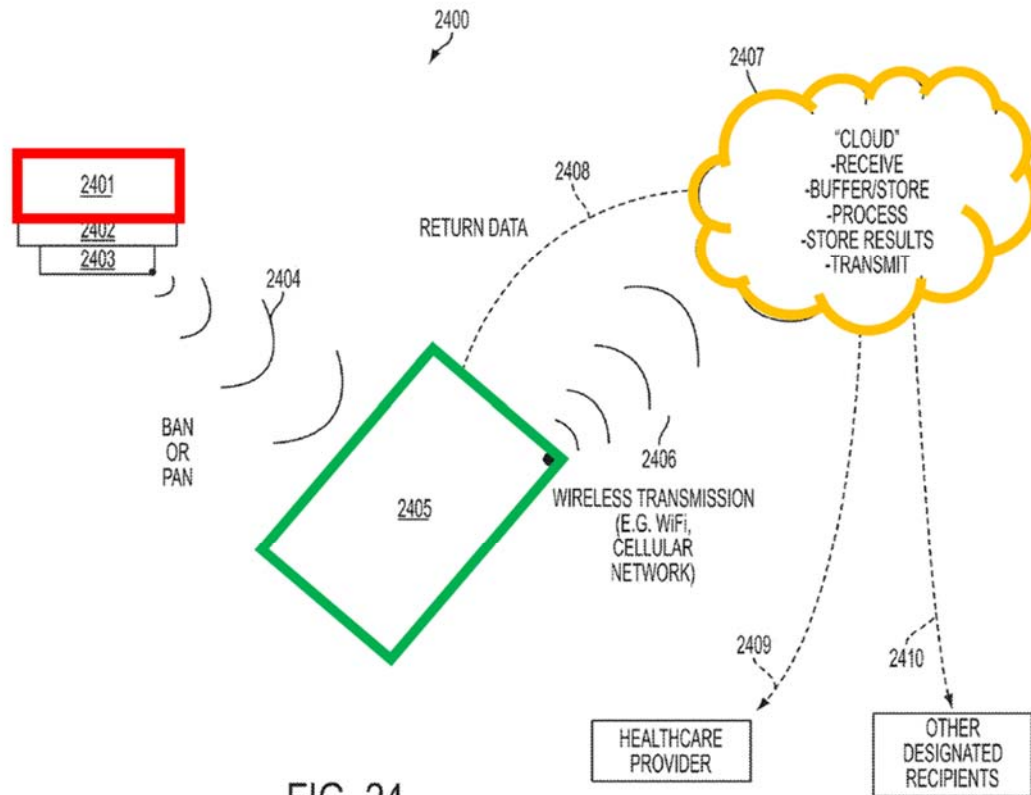


FIG. 24

'455 patent, 36:19-37:57 (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.**” '455 patent, 36:18-38. 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 ’455 patent, 36:39-37:51 (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).

45. The **wearable device 2401** “measure[s] one or more physiological parameters,” can be placed on a user’s body (i.e., “placed on teeth, a wrist, or an ear of a user”), and includes a plurality of semiconductor sources such as LEDs that generate an output optical light with a plurality of optical wavelengths and a “driver.” ’455 patent, 8:29-36. 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. ’455 patent, 8:36-41. 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.” ’455 patent, 8:44-47, 9:47-50.

46. The ’455 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 ’455 patent describes that using a “higher light level or intensity [of light to] may improve the signal-to-noise ratio for the measurements.” ’455 patent, 21:36-57; *see also*

'455 patent, 80:29-35 (disclosing that using “higher intensity or brightness of light sources” to “permit higher signal-to-noise levels”). As another example, the '455 patent describes “improv[ing] the signal-to-noise ratio” by “us[ing] 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. '455 patent, 59:4-25; *see also* '455 patent, 71:21-40.

B. The Prosecution History

47. In formulating my opinions, I considered the contents of the '455 Patent File History, a copy of which I understand has been designated as Exhibit 1002.

48. The '455 patent issued from U.S. Pat. App. 17/078,771, which was filed on October 23, 2020. The Applicant filed a preliminary amendment to the claims on January 14, 2021, and filed a terminal disclaimer on June 7, 2021 in view of the '484 patent, among others. '455 Patent File History, 276-275, 378-383, 396. The pending claims were then allowed (Examiner issued a Notice of Allowance on June 16, 2021). '455 Patent File History, 386-395. The Applicant made further claim amendments subsequent to the allowance, and the claims were again allowed without a rejection. '455 Patent File History, 601-609, 638-645.

49. In both Notices of Allowance, the Examiner noted that the prior art does

not disclose various limitations, including: (1) “detection system ... synchronized to the light source,” (2) “detection system comprises a plurality of detectors that are spatially separated from each other,” (3) “at least one analog to digital converter ... coupled to at least one of the spatially separated detectors,” (4) “output signal ... configured to be transmitted over a wireless transmission link,” (5) “output signal is indicative of one or more of the physiological parameters,” (6) “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,” (7) “increase the signal-to-noise ratio by comparing the first signal [responsive to light when LEDs are off] and the second signal [responsive to light when a LED is on],” (8) “six light emitting diodes,” and (9) “the plurality of semiconductor sources and the plurality of spatially separated detectors are located on one or more arcs,” and (10) “wherein the output optical light comprises wavelengths between 600nm and 1000nm to monitor a level of oxy-hemoglobin and deoxyhemoglobin.”¹ ’455 Patent File History, 386-395,

¹ In the second Notice of Allowance, the Examiner noted that the prior art does not disclose the following limitations of claim 1: “wherein the plurality of optical wavelengths comprises three optical wavelengths for measuring or calibrating at least a portion of the one or more of the physiological parameters, wherein the optical wavelengths comprise near infrared or visible wavelengths” and “wherein at least a

639-645.

50. For the reasons I discuss in more detail below, **Lisogurski** alone or in view of **LeBoeuf**, **Tran**, and/or **Carlson** discloses each such 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.

part of the output optical light is configured to be scattered after striking an irregular surface.” ’455 Patent File History, 639-645. However, based on my review of the ’455 patent claims, these terms do not appear in claim 1.

Declaration of Brian W. Anthony in Support of
Petition for *Inter Partes* Review, U.S. Patent No. 11,160,455

52. I have been asked to assume the Challenged Claims are entitled to the December 31, 2012 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 '455 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 31, 2012, 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 '455 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 31, 2012. 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 '455 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 '455 patent.

A. Board's Constructions in the Prior IPRs

1. "light source" limitations ([7], [14], [20])

56. In the '533 patent final written decision, I understand that the Board construed "a light source comprising a plurality of semiconductor sources that are light emitting diodes ... configured to increase signal-to-noise ratio by ... increasing a pulse rate of at least one of the plurality of semiconductor sources" to mean "a light source containing two or more light emitting diodes (semiconductor sources), wherein at least one of the light emitting diodes is capable of having its pulse rate increased to increase a signal-to-noise ratio." '533-FWD, 10-12. For the reasons I

discuss below, the prior art discloses this limitation under the Board’s construction, which is also consistent with the plain and ordinary meaning of the term. (Sections IX.C.3.e.[7], h.[14], k.[20]; IX.D.3.b).

2. “to detect an object” Limitation ([19])

57. In the ’484 patent final written decision, I understand that the Board construed “to detect an object” to mean “to discover or notice the existence or presence of something.” ’484-FWD, 8-10; ’484-RFWD, 3. For the purposes of this Declaration, I have been instructed to adopt the Board’s construction. For the reasons I discuss below, the prior art discloses this limitation under the Board’s construction, which is also consistent with the plain and ordinary meaning of the term. (Section IX.C.3.j.[19]).

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. In the prior ’533 IPR, I further opined that a person of ordinary skill in the art would have understood the term “pulse rate” to mean “number of pulses of light per unit of time.” ’533-Anthony, ¶66.

60. I understand that in the prior ’533 IPR, the petitioner proposed

construing “plurality of lenses,” and “pulse rate,” which the Board declined to construe. ’533-FWD, 9-10.

61. In the prior ’484 IPR, I did not opine on the meaning of “plurality of lenses,” 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.

62. 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.

63. The Board in ’533 and ’484-IPRs did not construe any other claim present in the ’455 patent.

64. 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.c-e.[1.b]-[1.d], q-s.[8.b]-[8.d]; IX.B.3.h-j.[15.b]-[15.d]; IX.C.3.e.[7], h.[14], k.[20]; IX.D.3.a-b).

C. Prior District Court Constructions

65. 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.)—involving related patents to the ’455 patent, including the ’533 patent, the district court (in its decisions that I understand have been designated as Exhibits 1018 and 1019, respectively) 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”).

66. For the purposes of this Declaration, and consistent with the Board’s prior decision not to construe the term, 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. (Section IX.A.3.d-e.[1.c]-[1.d], r-s.[8.c]-[8.d]; IX.B.3.i-j.[15.c]-[15.d]; IX.D.3.a).

D. Terms at Issue in Texas Case

67. I understand that in their 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 Challenged Claims 1-2, 8-9, and 15 as potentially indefinite:

- “spatially separated detectors” (claims 1, 2, 8, 9, 15),
- “a plurality of detectors that are spatially separated from each other” (claims 1, 8, 15),
- “wherein the detection system is configured to be synchronized to the light source” (claims 1, 8, 15),
- “increase the signal-to-noise ratio by comparing the first signal and the second signal” (claims 1, 8, 15),
- “the plurality of semiconductor sources configured to generate an output optical light having a plurality of optical wavelengths” (claim 1),
- “the wearable device configured to increase the signal-to-noise ratio by increasing light intensity of at least one of the semiconductor sources from an initial light intensity” (claim 1),
- “the plurality of semiconductor sources and the plurality of spatially separated detectors are located on one or more arcs” (claims 2, 9, 15),
- “the light emitting diodes configured to generate an output optical light having one or more optical wavelengths” (claims 8 and 15).

Ex.1023, at 240-241.

68. 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 I discuss below in Sections IX.A-B, 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

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

70. In this section, I will explain why the teachings or combinations of teachings from the following references render obvious each limitation 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.

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

- **Ground 1:** Challenged Claims 1, 8, and 11 of the '455 patent are rendered obvious by **Lisogurski**.
- **Ground 2:** Challenged Claims 2-4, 9-10, and 15-17 of the '455 patent are rendered obvious by **Lisogurski** in view of **LeBoeuf**.
- **Ground 3:** Challenged Claims 1, 8, 12, and 15 of the '455 patent are rendered obvious by **Lisogurski** in view of **Tran**.
- **Ground 4:** Challenged Claims 5-7, 13-14, and 18-20 of the '455 patent are rendered obvious by **Lisogurski** in view of **LeBoeuf** and **Tran**.
- **Grounds 5-8:** Challenged Claims 1-20 of the '455 patent are rendered obvious by Grounds 1-4, optionally in further view of **Carlson**.

IX. SPECIFIC GROUNDS FOR CHALLENGE

72. It is my opinion that Challenged Claims of the '455 patent are unpatentable as explained below. As I explain above in Section IV, although the '455 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.

73. In this section, I explain why claims 1-20 of the '455 patent are rendered obvious by the teachings of **Lisogurski**, **LeBoeuf**, **Tran**, and **Carlson**. Regarding all Grounds, **Lisogurski** teaches a physiological measurement system that is worn by a user and is for use with a smart phone or tablet, the measurement system including a light source that outputs light having multiple wavelengths, lenses, and detection system, and where the measurement system includes means for improving signal-noise-ratios. Regarding Ground 2, **LeBoeuf** further teaches a

physiological measurement system including reflective surfaces to direct the output of the light source to a patient's tissue, and the arrangement of optical emitters and detectors in arcs. Regarding Grounds 3 and 4, **Tran** further teaches the use of a physiological monitoring system for use with a smart phone, and the use of various signal processing methodologies, including artificial intelligence for pattern recognition and classification and regression methodologies. Regarding Grounds 5-8, **Carlson** further teaches the use of lenses in a physiological monitoring system and increasing the pulse rate of a light source to increase signal-to-noise ratio.

74. I note that in this discussion, I may focus on the particular language in the specific claim limitations, 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

75. **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 “a patient's pulse rate and blood pressure.” Lisogurski, 4:3-5. 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.

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

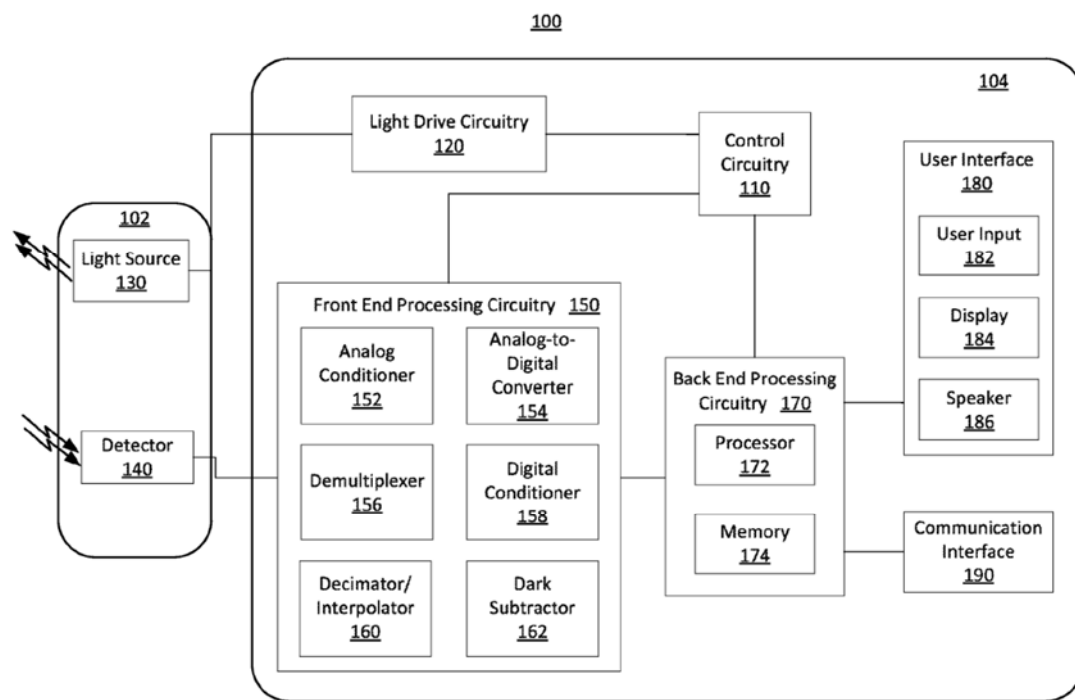


FIG. 1

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. Light source 130 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[]” them 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 at the priority date of the '455 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 may be 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, 11:50-54. '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.

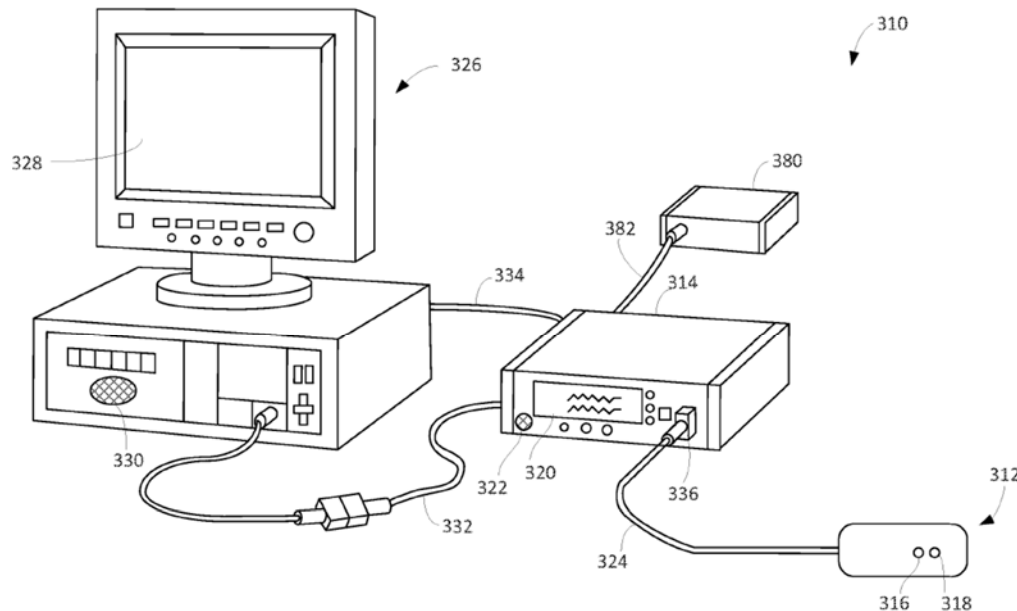
82. “User interface 180” includes various components, including “user input 182, display 184, and speaker 186,” and may include “a keyboard, a mouse, a touch screen, buttons, switches, [and] a microphone[,] ... or any other suitable input device.” Lisogurski, 15:19-22. ’533-FWD, 17; ’484-FWD, 16-17.

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 that 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: “For 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.



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 286 and IR ‘on’ period 290”, 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, 17:8-10, 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.

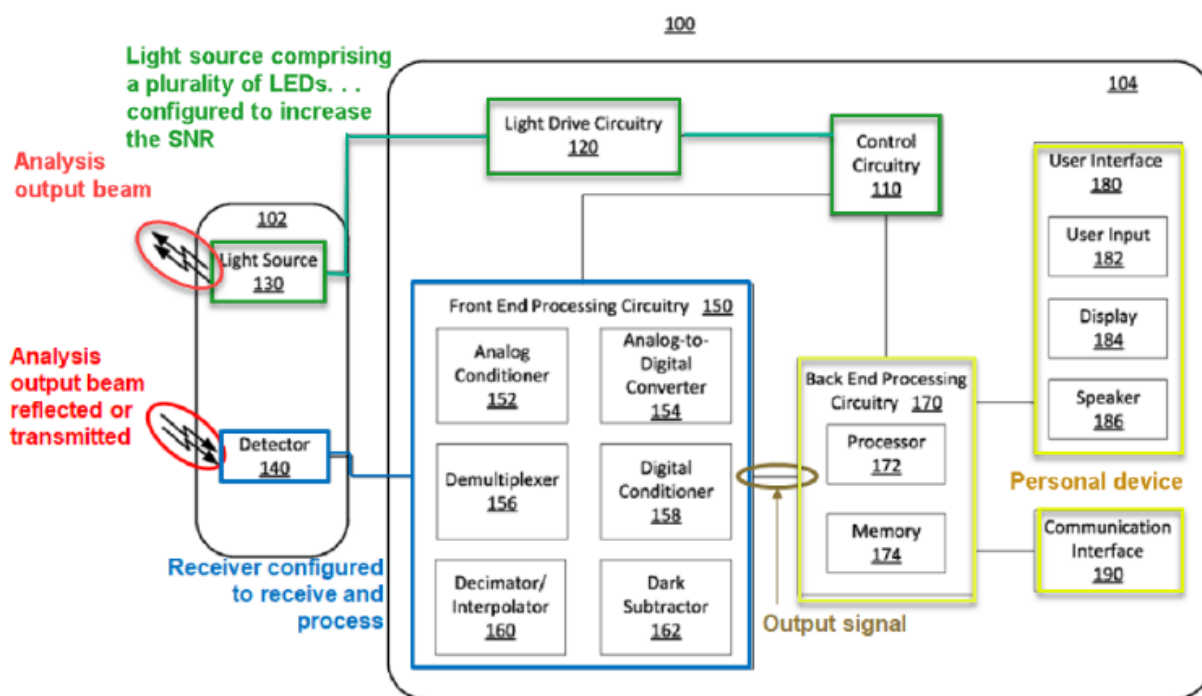


FIG. 1

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. And, 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 trade-off consideration.

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, 8, and 11 Over Lisogurski

108. As I discuss below, Claims 1, 8, and 11 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, 8, and 11.

a. Element [1.pre]

109. Element [1.pre] recites: “**A system for measuring one or more physiological parameters and for use with a smart phone or tablet, the system**

comprising.² This element is met by **Lisogurski**.

110. Regarding an identical limitation in the prior '484 IPR, I understand that the Board determined that the petitioner demonstrated “Lisogurski [] disclos[es] a system for measuring one or more physiological parameters for use with a smart phone or tablet....” '484-FWD, 13, 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).

111. Regarding a substantially identical limitation in the prior '533 IPR reciting “**A measurement system comprising,**” I understand that the Board

² I have added certain emphasis to the '455 patent's claim limitations throughout my declaration. **Green** emphasis indicates '455 patent claim limitations that are identical to those addressed in the prior '533 patent and '484 patent IPRs, **black** emphasis indicates '455 patent claim limitations that differ from, but are substantially identical to, those addressed in the prior '533 patent and '484 patent IPRs, **blue** emphasis indicates limitations similar to '455 patent claim limitations that I discuss earlier in my declaration, **all other** emphases show new limitations in the '455 patents not addressed in the prior '533 patent and '484 patent IPRs.

determined that “Petitioner demonstrates that Lisogurski’s system 100/310, including sensor 102/312 for measuring blood oxygen saturation, meets this limitation,” and that “[s]ensor 102/312 is a pulse oximeter.” ’533-FWD, 25. 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, ¶88 (citing Lisogurski, Abstract, 3:43-46, 3:61-4:3, 4:52-62, Figs. 1 & 3).

112. ’455 patent element [1.pre] is 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 and for use with a smart phone or tablet, the system comprising.**” Thus, my opinions regarding the ’484 patent term apply equally to ’455 patent element [1.pre]. ’484-Anthony, ¶¶89-95.

113. A portion of the ’455 patent element [1.pre] is also substantially identical to the corresponding limitation in the ’533 patent on which I previously opined, which recites: “**A measurement system comprising.**” Both limitations recite a “system,” and that the system is used for measurement (i.e., the ’533 patent’s use of “measurement system” and the ’455 patent’s use of a “system for measuring”). At least as to that portion, my opinion regarding the ’533 patent apply equally to ’455 patent element [1.pre]. ’533-Anthony, ¶88.

114. As further support for this limitation, **Lisogurski** discloses that its

“sensor unit 312 may be connected to monitor 314 as shown,” and “may be powered by an internal power source, e.g., a battery” or “may draw power from monitor 314.” Lisogurski, 17:55-59.

b. Element [1.a]

115. Element [1.a] recites: “**a wearable device adapted to be placed on teeth, a wrist, or an ear of a user, and.**” This element is met by **Lisogurski**.

116. 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 [] disclos[es a] system [that] 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).

117. ’455 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 difference between the two limitations is that the ’455 patent’s use of “**teeth,**” which is appended to an otherwise identical ‘or’-separated list as recited in the

corresponding limitation of the '484 patent. A person having ordinary skill in the art would have understood that **Lisogurski** discloses placing its sensor on either the wrist or ear of a user (Lisogurski, 4:6-20), which is sufficient to satisfy element [1.a] of the '455 patent. The differences between the two terms do not change my analysis, and thus my opinions regarding the '484 patent term apply equally to '455 patent element [1.a]. '484-Anthony, ¶¶89-95, 96-97.

118. As further support for this limitation, **Lisogurski** discloses that embodiments of its system include wearable device (“sensor 102” or “sensor 312”) which are placed, for example, on the ear of a patient. Lisogurski, 4:6-20, 10:44-46, 17:30-36. 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 patient.

c. Element [1.b]

119. Element [1.b] recites: “**including a light source comprising a driver and a plurality of semiconductor sources, the plurality of semiconductor sources configured to generate an output optical light having a plurality of optical wavelengths.**” This element is met by **Lisogurski**.

120. Regarding a substantially identical limitation in the prior '533 IPR reciting “**including 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 that 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).

121. 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** disclosed “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).

122. '455 patent element [1.b] is substantially identical to the corresponding limitation in the '533 patent on which I previously opined, which recites: “**including 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;” (ii) the '533 patent's use of “optical beam” as opposed to the '455 patent's use of “optical light,” and; (iii) the '455 patent's addition of “a light source comprising a driver” (which I address in more detail below). **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 '455

patent's use of "optical light." These differences between the two terms do not change my analysis. Thus, my opinions regarding the '533 patent term apply equally to '455 patent element [1.b]. '533-Anthony, ¶¶92-94.

123. '455 patent element [1.b] 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 differences between the two limitations are: (i) the '484 patent's additional use of "semiconductor sources that are light emitting diodes," and; (ii) the '455 patent's addition of "a light source comprising a driver" (which I address in more detail below). 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 '455 patent element [1.b]. '484-Anthony, ¶¶98-101.

124. Regarding the '455 patent's additional recitation of "**a light source comprising a driver**," Lisogurski discloses that its sensor including light source, as modified (Section IX.A.2), includes a driver ("light drive circuitry 120") that generates a light drive signal (an electrical signal), that controls the light source.

Lisogurski discloses that its “monitor 104 includes control circuitry 110, [and] light drive circuitry 120.” Lisogurski, 11:28-31; 10:42-46. Light drive circuitry 120 generates “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. Light drive circuitry 120 is also “configured to generate a light drive signal that is provided to light source 130 of sensor 102,” which, for example, controls “the intensity of light source 130 and the timing of when light source 130 is turned on and off,” and “the operation of each wavelength of light” when “light source 130 is configured to emit two or more wave lengths of light.” Lisogurski, 11:50-60. “The light drive signal may comprise a single signal or may comprise multiple signals (e.g., one signal for each wavelength of light).” Lisogurski, 11:50-60. A person of ordinary skill in the art would have recognized that **Lisogurski’s** light drive circuitry is consistent with common industry practice in optical medical monitoring devices. Specifically, the use of dedicated driver circuitry, i.e. electronics, to control the timing, intensity, and modulation of LED-based light sources was well-understood in the field and important for accurate physiological measurements, such as pulse oximetry. The explicit teaching by **Lisogurski** of using multiple signals to independently control different wavelengths was well known by a person of ordinary skill in the art at the relevant time, aimed at optimizing device performance and enhancing measurements.

125. As I discuss above in Section IX.A.2, a person having ordinary skill in the art would have understood (or at least found obvious) that a driver (i.e., light drive circuitry 120) and control circuitry 110 would be located within **Lisogurski's** light source 130. This is because the light drive circuitry 120, control circuitry 110, and light source 130 are operationally interdependent components: the light drive circuitry 120 and control circuitry 110 are both responsible for generating the drive signals that control the operation of the light source 130. Given that the drive and control circuitry work together to control the electrical current applied to the light source, it would have been routine design practice to integrate the two components within a common device. Combining driver and control circuitry with the optical sources reduces electrical noise and interference, enhances reliability, simplifies device architecture, and facilitates more efficient manufacturing. These were standard design goals well known in the art and would have been pursued by a person of ordinary skill in the art at the time of the claimed invention to improve the overall responsiveness of **Lisogurski's** system.

126. I understand that Defendants identified a portion of this limitation—**“the plurality of semiconductor sources configured to generate an output optical light having a plurality of optical wavelengths”**—as potentially indefinite in the Texas Case. Ex. 1023, 240-241.

127. Regardless, of its interpretation (e.g., (1) **each** of the plurality of

semiconductor sources is configured to generate light having multiple wavelengths, or (2) **together**, the plurality of semiconductor sources are configured to generate light having multiple wavelengths), however, and without opining on whether or not it has adequate written description support, **Lisogurski** meets this term under either interpretation.

128. For example, as the Board found in the prior '533 IPR, **Lisogurski** at least discloses two light emitting diodes that **each** generate an output beam of light having one or more wavelengths (e.g., an LED that emits red light and an LED that emits infrared light). '533-FWD, 25-26 (citing Lisogurski, 10:48-52, 10:56-63). **Lisogurski** discloses that “the Red wavelength may be between about 600 nm and about 700 nm, and the IR wavelength may be between about 800 nm and about 1000 nm,” such that each LED emits a wavelength band. Lisogurski, 10:56-58. Indeed, LEDs were known to have a bandwidth such that a single-colored LED emits light having more than one wavelength as shown in U.S. Patent No. 7,029,628, which I understand has been designated as Exhibit 1030. Ex. 1030, 9:57-62 (“40 nm bandwidth is representative of current LED sources in the red to near infrared range, and about 20 nm bandwidth is representative for the lower visible wavelengths.”). A person of ordinary skill in the art would have understood, or at least found it obvious, that the red LED emits a range of wavelengths in the red spectrum and the infrared LED emits a range of wavelengths in the infrared

spectrum. *See, e.g.*, Ex. 1030, 9:57-62 (“40 nm bandwidth is representative of current LED sources in the red to near infrared range, and about 20 nm bandwidth is representative for the lower visible wavelengths.”).

129. To the extent this term requires the light emitted from each of the red and infrared LEDs to be combined, a person of ordinary skill in the art would have understood, or at least found it obvious, that this is met by **Lisogurski**. **Lisogurski** discloses that its light source 130, collectively comprising LEDs, can “emit photonic signals having one or more wavelengths of light (e.g., Red and IR) into a subject’s tissue.” **Lisogurski**, 10:49-52. Further, to the extent further disclosure is required, a person of ordinary skill in the art would have at minimum found it obvious to implement **Lisogurski** to combine both the Red light and IR light emitted from the two LEDs into a single output beam of light having two wavelengths (red, infrared) to increase light intensity. For example, U.S. Patent Publication No. 2006/0184040, U.S. Patent Nos. 5,497,769, 5,827,182, and 7,764,982, which I understand have been designated as Exhibits 1077, 1059, 1060, and 1061, respectively, teach that it was well-known to combine light from different light sources to achieve various benefits, such as to: provide additional intensity for a light source, ensure sufficient optical power for measuring blood oxygenation, bolster the brightness at a wavelength, and boost a wavelength spectrum and equalize signal attenuation, respectively. *See e.g.*, Ex. 1077, [0089] (“light ... can be injected into or combined with the light from the

main light source” to “provide additional intensity” for a “light source.”); Ex. 1059, 2:20-29 (a tissue spectrometer incorporated “four different laser diodes” as light sources to ensure sufficient optical power for measuring blood oxygenation); Ex. 1060, 3:26-63 (“a first emitter [infrared] and second and third emitters [red]” operated together in an oximeter sensor to bolster the brightness at that wavelength); Ex. 1061, 8:63-9:12 (an array of same-wavelength LEDs activated simultaneously “boost[s] at least a portion of the [red] wavelength spectrum” and equalizes signal attenuation).

d. Element [1.c]

130. Element [1.c] recites: “**the wearable device comprising** 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.**” This element is met by **Lisogurski**.

131. Regarding a substantially identical limitation in the prior ’533 IPR reciting “**the wearable measurement device comprising** 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 “Petitioner 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).

132. Regarding a substantially identical limitation in the prior ’484 IPR reciting “**the wearable device comprising 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).

133. '455 patent element [1.c] is substantially identical to the corresponding limitation in the '533 patent on which I previously opined, which recites: “**the wearable measurement device comprising a plurality of lenses configured to receive a portion of the output optical beam and to deliver** an analysis output beam to a sample.”

134. Aside from differing turns of phrases, the main differences between the two limitations are: (i) the '533 patent's use of “the wearable measurement device” as opposed to the '455 patent's use of “the wearable device,” (ii) the '533 patent's use of “output optical beam” or “output beam” as opposed to the '455 patent's use of “output optical light” or “output light,” (iii) the '533 patent's use of “to deliver an analysis output” as opposed to the '455 patent's use of “to deliver a lens output,” and (iv) the '533 patent's use of “to deliver ... to a sample” as opposed to the '455 patent's use of “deliver ... to tissue.”

135. **First**, as I discussed above (Sections IX.A.3.a-b.[1.pre]-[1.a]), a person of ordinary skill in the art would have understood that **Lisogurski's** device is specifically a measurement device. **Second**, again as I explained above (Section IX.A.3.c.[1.b]), 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 '455 patent's use of “optical light.” **Third**, 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 '455 patent 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). **Fourth**, 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 '455 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.a.[1.pre]). Thus, the differences between the two terms do not change my analysis, and my opinions regarding the '533 patent term apply equally to '455 patent element [1.c]. '533-Anthony, ¶¶123-129.

136. '455 patent element [1.c] is also substantially identical to the corresponding limitation in the '484 patent on which I previously opined, which recites: “**the wearable device comprising 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.**”

137. The main differences between the two limitations are: (i) the '455 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 '455 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 refer 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 '455 patent element [1.c]. '484-Anthony, ¶¶102-109.

e. Element [1.d]

138. Element [1.d] recites: "**the wearable device further comprising 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**.

139. 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 "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. I further understand the Board determined that the petitioner demonstrated this.

140. Regarding a substantially identical limitation in the prior '533 IPR reciting "**the wearable measurement device further comprising** 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,” that “Petitioner 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).

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

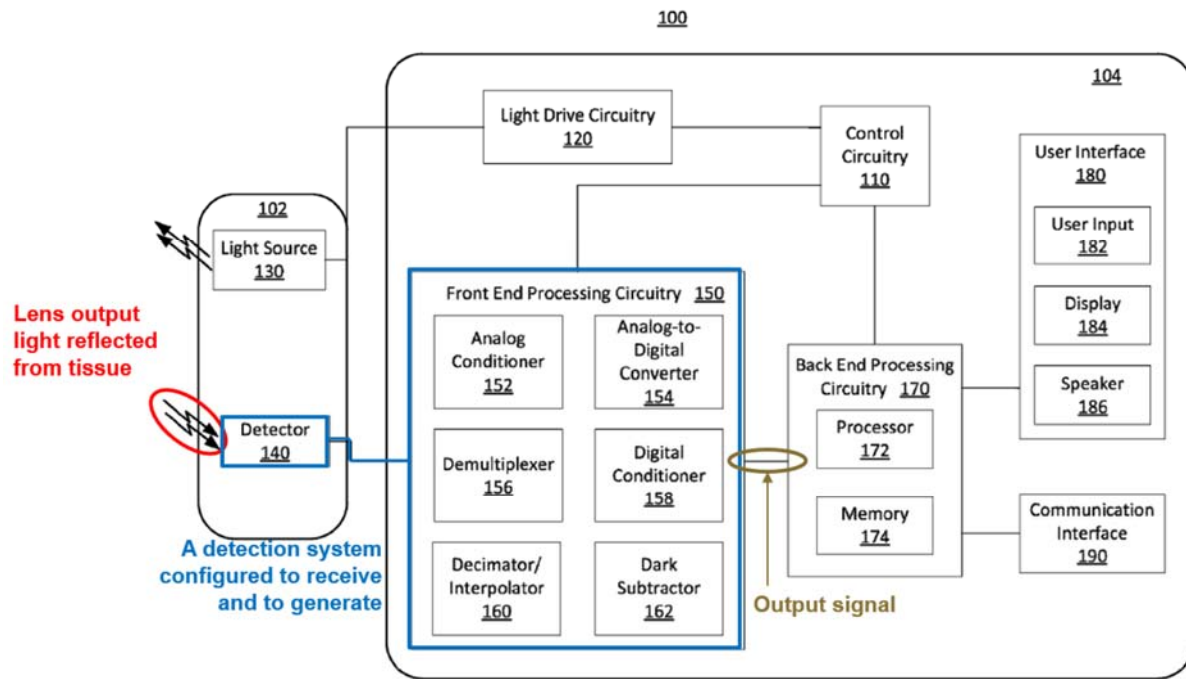


FIG. 1

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

142. '455 patent element [1.d] is identical to the corresponding limitation in the '484 patent on which I previously opined, and which recites: “**the wearable device further comprising 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 '455 patent element [1.d]. '484-Anthony, ¶¶115-117.

143. '455 patent element [1.d] is substantially also identical to the corresponding limitation in the '533 patent on which I previously opined, which recites: “**the wearable measurement device further comprising** 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.**” Aside from differing turns of phrases, the main differences between the two limitations are as listed, and each is immaterial to my analysis: (i) the '533 patent's use of “wearable measurement device” as opposed to the '455 patent's use of “wearable device”; (ii) the '533 patent's use of “comprising a receiver configured to receive and process” as opposed to the '455 patent's “comprising a detection system configured to receive; (iii) the '533 patent's use of “at least a portion of the analysis output beam” as opposed to the '455 patent's use of “at least a portion of the lens output light”; (iv) the '533 patent's additional use of “reflected or transmitted” as opposed to the '455 patent's use of “reflected.”

144. **First**, as I explained above, a person of ordinary skill in the art would have understood that **Lisogurski's** device is specifically a measurement device (Section IX.A.3.d.[1.c]). **Second**, 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 ’455 patent element [1.d], just like “receiver” in the ’533 patent, is used to “process” the “portion of the lens output light” as it “generate[s] an output signal” based on this light. **Third**, 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 and that the claim terms “analysis output” and “lens output” refer to the light that is received by the lenses. **Fourth**, 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—standard aspects of optical interactions with biological tissue. 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 ’455 patent’s reference to “reflected” light. A person of ordinary skill in the art would have recognized that the identified wording differences between the ’455 and ’533 patent limitations do not represent substantial technical distinctions. Thus, the differences between the two terms do not change my analysis, and my opinions regarding the ’533 patent term apply equally to ’455 patent element [1.d]. ’533-Anthony, ¶¶136-146.

f. Element [1.e]

145. Element [1.e] recites: “**wherein the detection system is configured to**

be synchronized to the light source.” 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 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).

147. 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.

148. ’455 patent element [1.e] 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 ’455 patent element [1.e]. ’484-Anthony, ¶¶118-127.

149. ’455 patent element [1.e] 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 ’455 patent’s use of “receiver” as

opposed to the '484 patent's use of "detection system." As I discuss above regarding claim limitation [1.d] (Section IX.A.3.e.[1.d]), 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 and processing the same. Thus, the differences between the two terms do not change my analysis, and my opinions regarding the '484 patent term apply equally to '455 patent element [1.e]. '533-Anthony, ¶¶136-146, 171.

150. 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" portion 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.

151. 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, 240-241.

152. 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 ’455 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.e] at least

includes such embodiments. *See, e.g.*, '455 patent, 44:62-67.

153. 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.

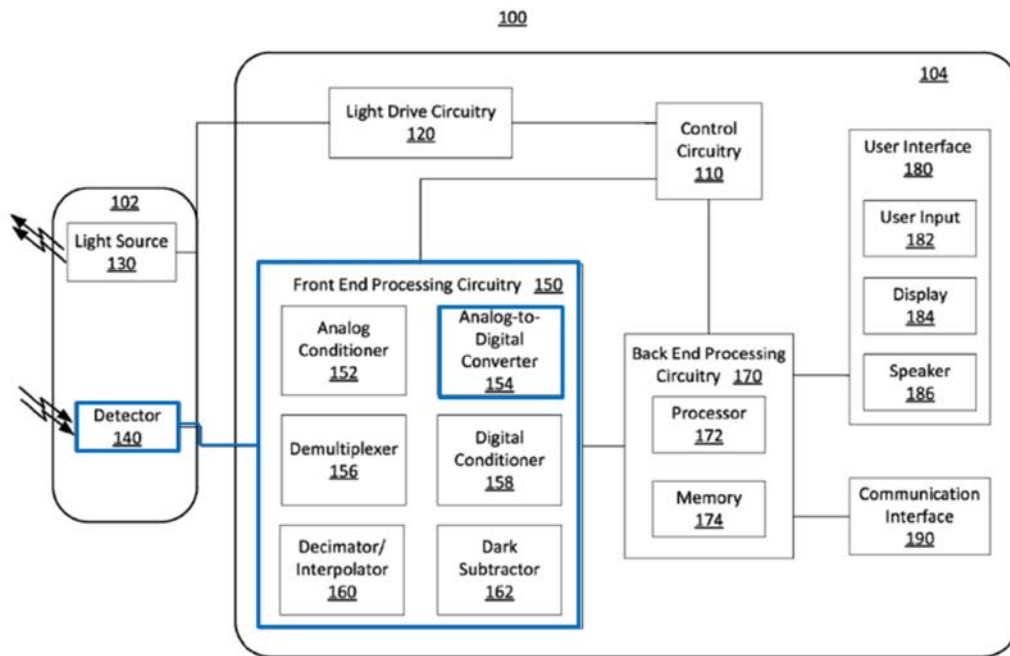
154. As I discussed above, a person of ordinary skill in the art would have been motivated to combine the front end processing circuitry 150, which includes analog to digital converter (Lisogurski 13:7-12), into **Lisogurski's** detection system and would have been further motivated to put light drive 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.

g. Element [1.f]

155. Element [1.f] 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 spatially separated detectors.**” This element is met by **Lisogurski**.

156. 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).

157. The detectors and the front-end processing circuitry, each depicted in the annotated Figure 1 below, are collectively the claimed “detection system.” ’484-Anthony, ¶130.



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

158. '455 patent element [1.f] 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”), these terms are identical. Thus, my opinions regarding the '484 patent term apply equally to '455 patent element [1.f]. '484-Anthony, ¶¶128-131.

159. I understand that Defendants identified these limitations—“**a plurality**

of detectors that are spatially separated from each other,” and “spatially separated detectors”—as potentially indefinite in the Texas Case. Ex. 1023, 240-241.

160. 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 '455 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.f] at least includes such embodiments:

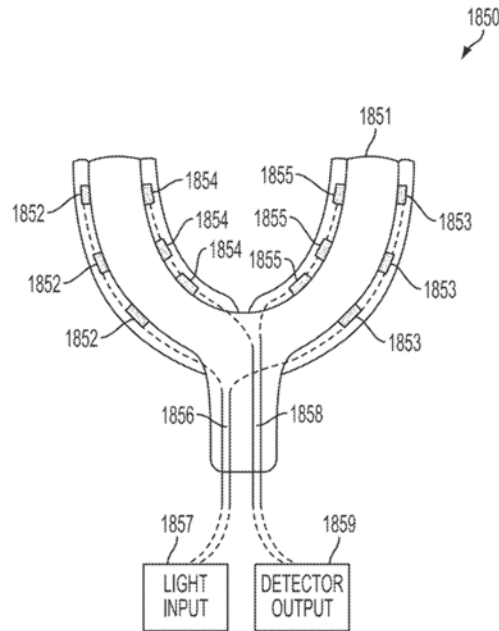


FIG. 18B

See, e.g., '455 patent, 28:16-53.

161. 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.

h. Element [1.g]

162. Element [1.g] recites: “**the smart phone or tablet comprising a wireless receiver, a wireless transmitter, a display, a speaker, a voice input module, a microprocessor and a touch screen, the smart phone or tablet configured to receive and process at least a portion of the output signal, wherein**

the smart phone or tablet is configured to store and display the processed output signal, and wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link.” This element is met by **Lisogurski**.

163. Regarding a substantially identical limitation in the prior '484 IPR reciting **“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, the smart phone or tablet configured to receive and process at least a portion of the output signal, wherein the smart phone or tablet is configured to store and display the processed output signal, and wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link,”** 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).

164. 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,** the personal device **configured to receive and process at least a portion of the output signal, wherein** the personal device **is configured to store and display the processed output signal, and wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link,”** 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 “Petitioner 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).

165. ’455 patent element [1.g] is substantially 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, the smart phone or tablet configured to receive and process at least a portion of the output signal, wherein the smart phone or tablet is configured to store and display the processed output signal, and wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link.**” The only difference between the two limitations is the '484 patent's addition of “one or more buttons or knobs,” which only adds an additional component to the smart phone or tablet. Thus, the differences between the two terms do not change my analysis, and my opinions regarding the '484 patent term apply equally to '455 patent element [1.g]. '484-Anthony, ¶¶136-142.

166. '455 patent element [1.g] 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,** the personal device **configured to receive and process at least a portion of the output signal, wherein** the personal device **is configured to store and display the processed output signal, and wherein at least a portion of the processed output signal is configured to be transmitted**

over a wireless transmission link.” 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 ’455 patent’s use of a “smartphone or tablet”; and (ii) the ’533 patent’s use of a “microphone” as opposed to the ’455 patent’s use of “a voice input module,” and (iii) the ’533 patent’s addition of “one or more buttons or knobs.” **First**, a person having ordinary skill in the art would have understood that smartphones and tablets are both 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. **Third**, the ’533 patent’s addition of “one or more buttons or knobs,” only adds an additional component to the personal device. Thus, the differences between the two terms do not change my analysis, and my opinions regarding the ’533 patent term apply equally to ’455 patent element [1.g]. ’533-Anthony, ¶¶147-153.

167. 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 ’455 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).

168. 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 includes 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.

169. 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.

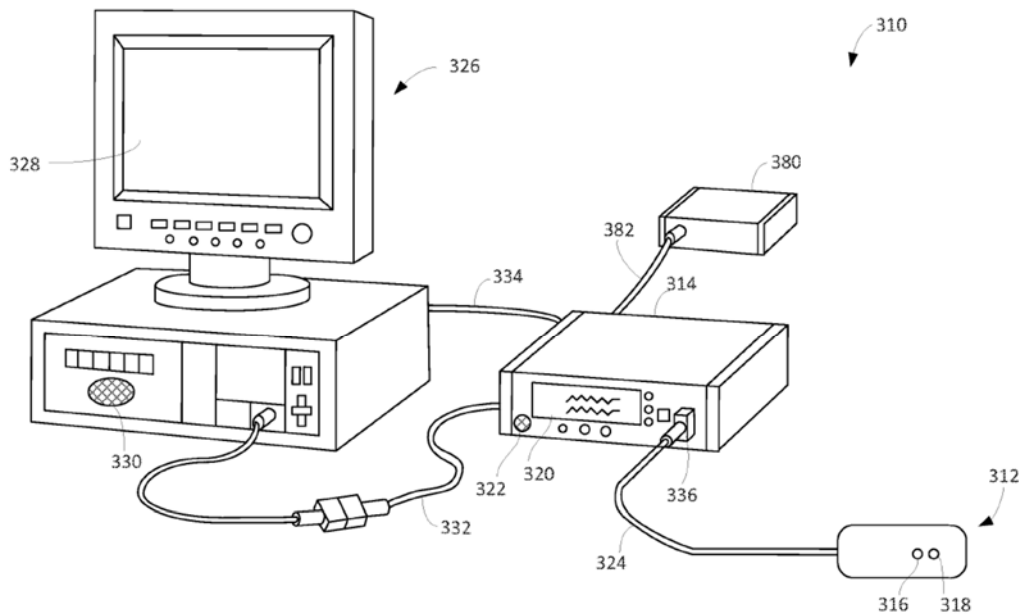


FIG. 3

i. Element [1.h]

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

171. Regarding an identical limitation in the prior ’484 IPR, 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. '455 patent element [1.h] is 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.**” Thus, my opinions regarding the '484 patent term apply equally to '455 patent element [1.h]. '484-Anthony, ¶¶148-154.

173. As further support for this limitation, **Lisogurski** discloses measuring 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 or 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 detection[s] received from one or 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 “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. **Lisogurski’s** processed data (*i.e.*, output signal) thus at least includes or is indicative of physiological parameters.

j. Element [1.i]

175. Element [1.i] recites: “**the wearable device configured to increase the signal-to-noise ratio by increasing light intensity of at least one of the**

semiconductor sources from an initial light intensity.” 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 the “[p]etitioner 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).

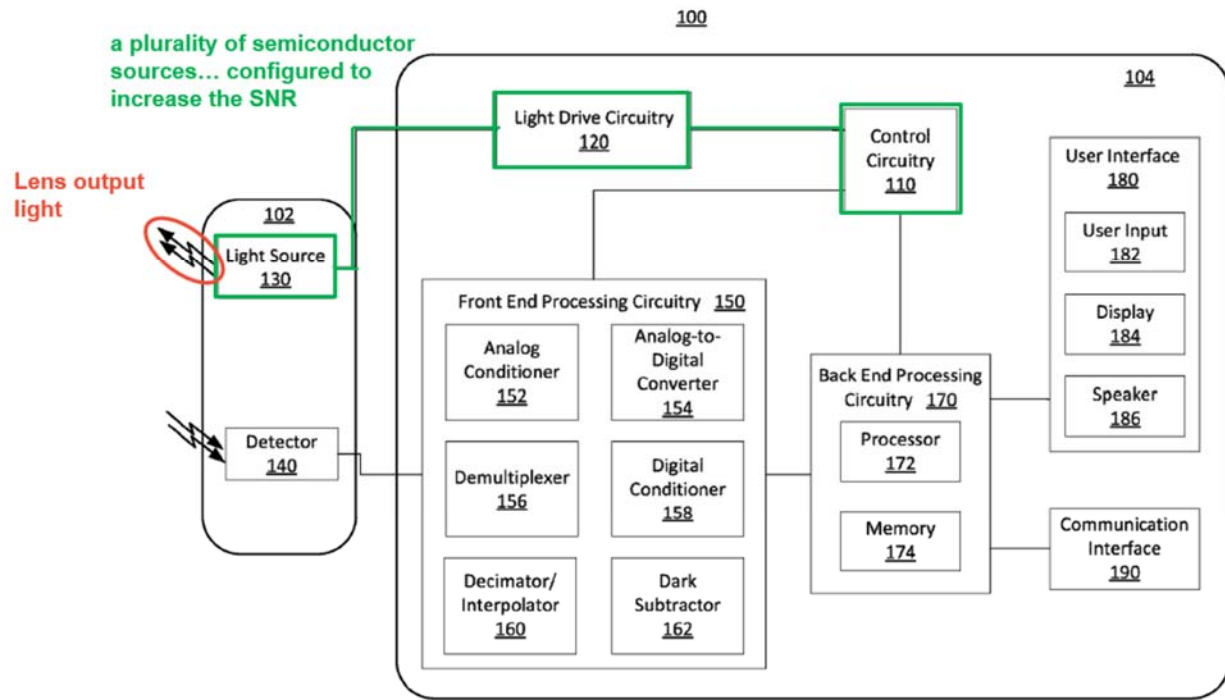


FIG. 1

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

179. '455 patent element [1.i] is substantially identical to the 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 only difference is the differing turns of phrases (e.g., the '455 patent adds “at least one of the semiconductor sources” as opposed to the '484 patent that uses “at least one of the plurality of semiconductor sources”). Thus, the differences between the two terms do not change my analysis, and my opinions regarding the '484 patent term apply equally to '455 patent element [1.i].

'484-Anthony, ¶¶155-171.

180. '455 patent element [1.i] is substantially identical to the corresponding limitation in the '533 patent on which I previously opined, which recites: “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 each is immaterial to my analysis: (i) the '533 patent's use of “the light source configured to increase signal-to-noise ratio” as opposed to the '455 patent's use of “the wearable device configured to increase signal-to-noise ratio”; and (ii) the '455 patent's addition of “from an initial light intensity.” **First**, a person having ordinary skill in the art would have understood that Lisogurski's wearable device (see my discussion of limitation [1.a] reciting “the wearable device adapted to be placed on teeth, a wrist, or an ear of a user”) includes a light source (see my discussion of limitation [1.b] reciting that the wearable device “includ[es] a light source”) and because the timing and activation of this light source is controlled by drive signals generated by light drive circuitry 120 (see 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 have understood that increasing a signal-to-noise ratio involves increasing it 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 '455 patent element [1.i]. '533-Anthony, ¶¶95-109.

181. I understand that Defendants identified portions of this limitation—**“the wearable device configured to increase the signal-to-noise ratio by increasing light intensity of at least one of the semiconductor sources from an initial light intensity”**—as potentially indefinite in the Texas Case. Ex. 1023, 240-241.

182. Regardless, of its interpretation (e.g., by increasing light intensity, increasing the signal-to-noise ratio of (1) to-be-generated output signals or (2) already-generated output signals based on the antecedent basis of “signal-to-noise ratio”), however, and without opining on whether or not it has adequate written description support, **Lisogurski** meets this term under either interpretation because it is a matter of timing. For example, **Lisogurski** discloses that, from an initial light intensity, its “system may increase the brightness of the light sources in response to the noise to improve the signal-to-noise ratio,” such that the signal-to-noise ratio of a to-be-capture signal is increased. **Lisogurski**, 9:46-60. Further, **Lisogurski** discloses that “the system may increase brightness ***throughout the cardiac cycle*** because the system may require increased signal amplitudes to differentiate between

fiducial and other points of interest related to physiological parameters and those related to noise or motion.” Lisogurski, 9:46-60 (emphasis my own). A person of ordinary skill in the art would thus have understood that Lisogurski teaches increasing brightness of the light source (i.e., intensity) preemptively and that an already-generated output signal would have increased signal-to-noise ratio.

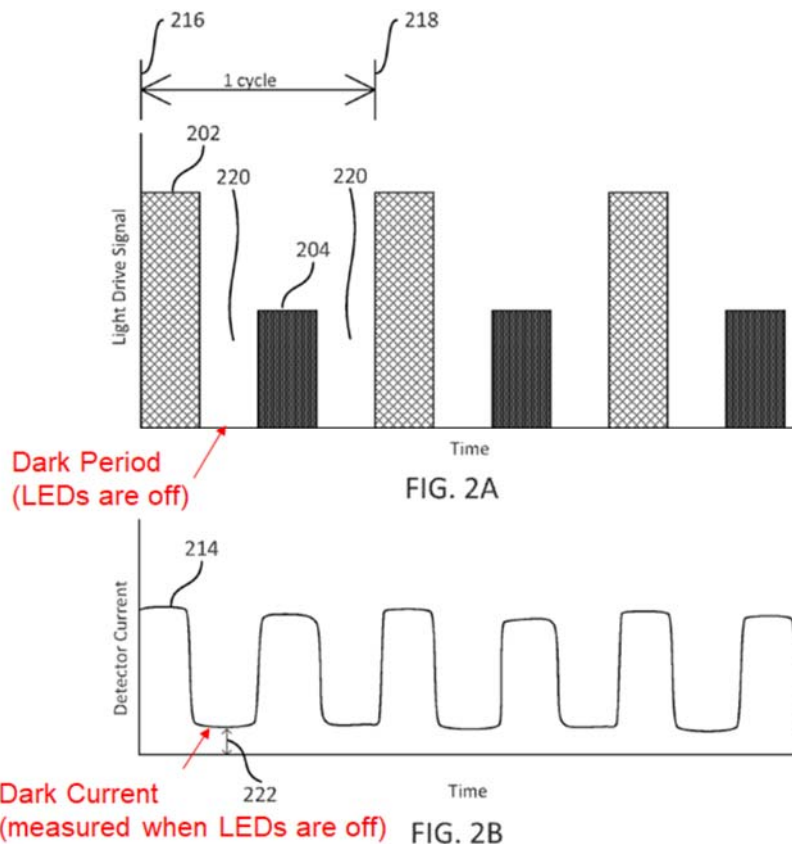
k. Element [1.j]

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

184. Regarding a substantially identical limitation in the prior ’484 IPR reciting **“the detection system further configured to: generate a first signal responsive to light received while the light emitting diodes are off,”** I understand the Board determined that 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).

185. **Lisogurski’s** Figures 2A and 2B are reproduced below with

annotations to explain **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.

186. '455 patent element [1.j] is substantially 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.**” The main difference between

the two limitations is the '484 patent's use of "light emitting diodes" as opposed to the '455 patent's use of "semiconductor sources." As I discussed above regarding claim limitation [1.b] (Section IX.A.3.c.[1.b]), 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 '455 patent element [1.j]. '484-Anthony, ¶¶193-198.

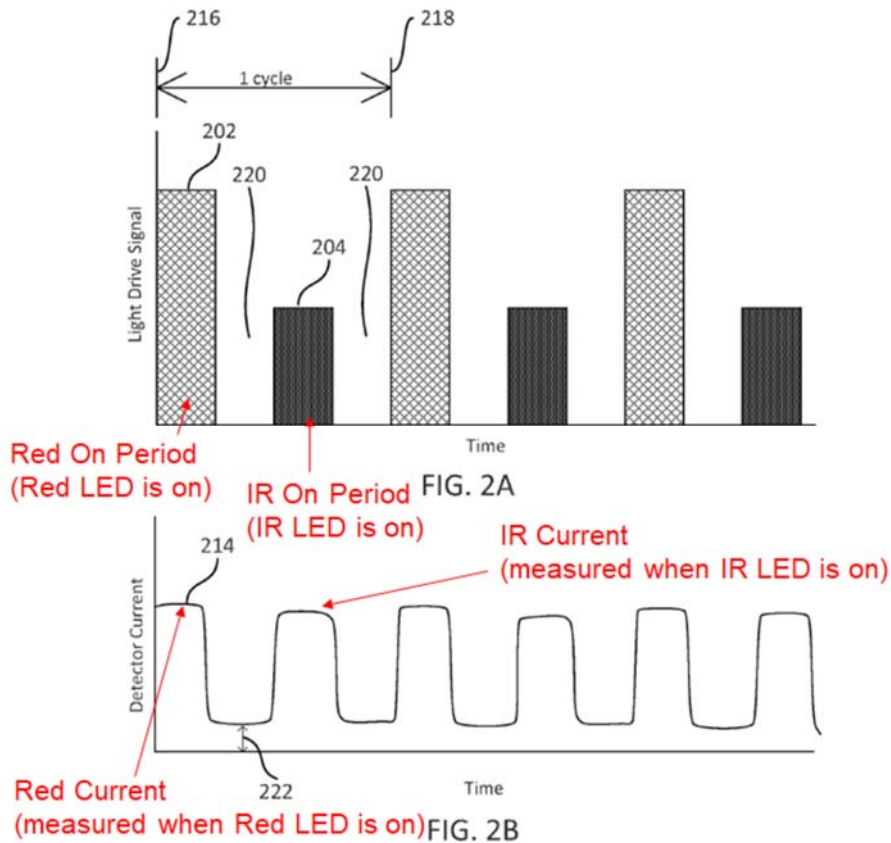
I. Element [1.k]

187. **Element [1.k] recites: "generate a second signal responsive to light received while at least one of the semiconductor sources is on; and."** This element is met by **Lisogurski**.

188. Regarding a substantially identical limitation in the prior '484 IPR reciting "**generate a second signal responsive to light received while at least one of the light emitting diodes is on,**" 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).

189. 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.

190. '455 patent element [1.k] is substantially 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.**” The main difference between the two limitations is the ’484 patent’s use of “light emitting diodes” as opposed to the ’455 patent’s use of “semiconductor sources.” As I discussed above regarding claim element [1.b] (Section IX.A.3.c.[1.b]), 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 ’455 patent element [1.k]. ’484-Anthony, ¶¶199-202.

m. Element [1.l]

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

192. 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).

193. '455 patent element [1.1] 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 [1.1] of '455. See '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 '455 patent element [1.1]. '484-Anthony, ¶¶203-206.

194. I understand that Defendants identified portions of 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, 240-241.

195. 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 '455 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.” '455 patent, 59:4-25. A person of ordinary skill in the art would have understood that limitation [1.1] at least includes such embodiments.

196. 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.”). Therefore, **Lisogurski** discloses subtracting (e.g., differencing) two signal to improve signal-to-noise ratio.

n. Element [1.m]

197. Element [1.m] recites: “**wherein the plurality of optical wavelengths comprises three optical wavelengths for measuring at least a**

portion of the one or more of the physiological parameters, wherein the optical wavelengths comprise near infrared or visible wavelengths.” This element is met by **Lisogurski**.

198. As I discussed above, the majority of this limitation is met by **Lisogurski**. See my discussions of claim elements [1.b], [1.pre], and [1.h] above. Sections IX.A.3.c.[1.b] (reciting “**plurality of optical wavelengths**”); IX.A.3.a.[1.pre] (reciting, in portion, “**measuring one or more physiological parameters**”) & IXA.3.i.[1.h] (reciting “**measuring at least a portion of the one or more of the physiological parameters**”).

199. Regarding the ’455 patent’s additional recitation of “**the plurality of optical wavelengths comprises three optical wavelengths**,” **Lisogurski** discloses that its light source 130/316 is configured to: (1) “emit photonic signals having one or more wavelengths of light (e.g., Red and IR [infrared]),” and (2) “include any number of light sources with any suitable characteristics.” **Lisogurski**, 10:48-60. Further to this point, **Lisogurski** reiterates that its sensor unit 312 “may include one or more light source 316 for emitting light at one or more wavelengths into a subject’s tissue.” **Lisogurski**, 17:17-39. Multiple wavelengths were commonly used in physiological monitoring applications (such as pulse oximetry and advanced optical sensing methods) to improve accuracy, provide additional physiological information, and enhance reliability of measurements. A person of ordinary skill in

the art would have understood (or at least found obvious) that **Lisogurski** thus discloses using multiple (e.g., three or more) wavelengths. Indeed, Lisogurski discloses that its reference to light includes “any suitable wavelength of electromagnetic radiation [that] may be appropriate for use with the present techniques.” Lisogurski, 10:65-11:6. A person of ordinary skill in the art would have found it both practical and obvious to employ at least three optical wavelengths.

200. 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, 24:58-25:5. A person of ordinary skill in the art would have understood that leveraging multiple wavelengths to measure blood oxygen saturation (such as red and infrared) is a foundational principle in the art. Each wavelength’s different absorption characteristics allow for precise discrimination blood constituents based

on differential concentrations.

201. 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].

202. 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.

203. From the perspective of a person of ordinary skill in the art, using multiple (three 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.

204. Regarding the '455 patent's additional recitation of “**wherein the optical wavelengths comprise near infrared or visible wavelengths**,” **Lisogurski** discloses the use of at least red light in the range of 600 nanometers (nm) to 700 nm and the use of infrared (IR) light in the range of 800 nm to 1000 nm. Lisogurski,

10:56-58. Also as illustrated in U.S. Patent Nos. 6,662,033 and 5,028,787, which I understand have been designated as Exhibits 1046 and 1047, respectively, it was well-known in the art that (1) red light falls within the visible portion of the electromagnetic spectrum, typically ranging from approximately 600 nm to 800 nm; and (2) near infrared light corresponds to the region of the electromagnetic spectrum, typically spanning from about 800 nm to 1000 nm. *E.g.*, Exs. 1046, 1:54-61 (“[W]avelength in the near red part of the visible spectrum [is] near 660 nanometers (nm), and one in the near infrared part of the spectrum [is] in the range of 880 nm-940 nm... As used herein, ‘red’ wavelengths or ‘red’ spectrum will refer to the 600-800 nm portion of the electromagnetic spectrum; “near red” [will refer to] the 600-700 nm portion; ... and “infrared” or “near infrared” [will refer to] the 800-1000 nm portion.”); 1047, claim 1 (reciting in part, “a near-infrared detector for detecting near-infrared energy within the range of about 600 to 1110 nanometers”). A person of ordinary skill in the art would, therefore, have understood that the red light and IR light disclosed in **Lisogurski** falls within the visible and near infrared ranges, respectively.

o. Element [8.pre]

205. Element [8.pre] recites: “**A system for measuring one or more physiological parameters and for use with a smart phone or tablet, the system comprising.**” This element is met by **Lisogurski**.

206. For the reasons I discussed above in element [1.pre], **Lisogurski’s** “optical physiological monitoring system” meets this limitation (Section IX.A.3.a.[1.pre]).

207. ’455 patent element [8.pre] is identical to ’455 patent element [1.pre], which recites: “**A system for measuring one or more physiological parameters and for use with a smart phone or tablet, the system comprising.**” Thus, my opinions regarding the term in the ’455 patent element [1.pre] apply equally to ’455 patent element [8.pre] (Section IX.A.3.a.[1.pre]).

p. Element [8.a]

208. Element [8.a] recites: “**a wearable device adapted to be placed on a wrist or an ear of a user.**” This element is met by **Lisogurski**.

209. For the reasons I discussed above in element [1.a], **Lisogurski’s** sensor meets this limitation (Section IX.A.3.b.[1.a]).

210. ’455 patent element [8.a] is substantially identical to the ’455 patent element [1.a], which recites: “**a wearable device adapted to be placed on teeth, a wrist, or an ear of a user.**” The only difference between the two limitations is element [1.a]’s use of “teeth” in the otherwise identical ‘or’-separated list. Thus, the differences between the two terms do not change my analysis, and my opinions regarding the term in ’455 patent element [1.a] applies equally to ’455 patent element [8.a] (Section IX.A.3.b.[1.a]).

q. Element [8.b]

211. Element [8.b] recites: **“including a light source comprising a driver and a plurality of semiconductor sources that are light emitting diodes, the light emitting diodes configured to generate an output optical light having one or more optical wavelengths.”** This element is met by **Lisogurski**.

212. For the reasons I discussed above in element [1.b], **Lisogurski’s** sensor with light source meets this limitation (Section IX.A.3.c.[1.b]).

213. ’455 patent element [8.b] is substantially identical to the ’455 patent element [1.b], which recites: **“including a light source comprising a driver and a plurality of semiconductor sources, the plurality of semiconductor sources configured to generate an output optical light having a plurality of optical wavelengths.”** Aside from differing turns of phrases, the main difference between the two limitations is the element [8.b]’s additional use of “semiconductor sources that are light emitting diodes.” As I discussed above in Section IX.A.3.c.[1.b], a person of ordinary skill in the art would have understood that light emitting diodes are semiconductor light sources. E.g., Ex. 1039, 2:6-9 (“The LED is a semiconductor diode that emits incoherent narrow-spectrum light....”). Thus, the differences between the two terms do not change my analysis, and my opinions regarding the term in ’455 patent element [1.b] term apply equally to ’455 patent element [8.b] (Section IX.A.3.c.[1.b]).

214. I understand that Defendants identified a portion of this limitation—**“the light emitting diodes configured to generate an output optical light having one or more optical wavelengths”**—as potentially indefinite in the Texas Case. Ex. 1023, 240-241. As I discussed above (Section IX.A.3.c.[1.b]), regardless of its outer bounds, however, and without opining on whether or not it has adequate written description support, **Lisogurski** meets this term because **Lisogurski’s** LEDs, individually or together as a group, meet this limitation.

r. Element [8.c]

215. Element [8.c] recites: **“the wearable device comprising 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.”** This element is met by **Lisogurski**.

216. For the reasons I discussed above in element [1.c], **Lisogurski’s** sensor with light source meets this limitation. (Section IX.A.3.d.[1.c]).

217. ’455 patent element [8.c] is identical to ’455 patent element [1.c], which recites: **“the wearable device comprising 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.”** Thus, my opinions regarding the term in the ’455 patent element [1.c] apply equally to ’455 patent element [8.c] (Section IX.A.3.d.[1.c]).

s. Element [8.d]

218. Element [8.d] recites: **“the wearable device further comprising 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**.

219. For the reasons I discussed above in element [1.d], **Lisogurski’s** detector and front end processing circuitry meet this limitation (Section IX.A.3.e.[1.d]).

220. ’455 patent element [8.d] is identical to ’455 patent element [1.d], which recites: “**the wearable device further comprising 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 term in the ’455 patent element [1.d] apply equally to ’455 patent element [8.d] (Section IX.A.3.e.[1.d]).

t. Element [8.e]

221. Element [8.e] recites: “**wherein the detection system is configured to be synchronized to the light source.**” This element is met by **Lisogurski**.

222. For the reasons I discussed above in element [1.e], **Lisogurski’s** front end processing circuitry meets this limitation (Section IX.A.3.f.[1.e]).

223. ’455 patent element [8.e] is identical to ’455 patent element [1.e], which recites: “**wherein the detection system is configured to be synchronized to the light source.**” Thus, my opinions regarding the term in the ’455 patent element [1.e]

apply equally to '455 patent element [8.e] (Section IX.A.3.f.[1.e]).

224. I understand that Defendants identified a portion of this limitation—**“wherein the detection system is configured to be synchronized to the light source”**—as potentially indefinite in the Texas Case. Ex. 1023, 240-241. As I discussed above (Section IX.A.3.f.[1.e]), regardless of its outer bounds, however, and without opining on whether or not it has adequate written description support, **Lisogurski** meets this term because **Lisogurski** discloses and renders obvious the indisputable scope of the limitation.

u. Element [8.f]

225. Element [8.f] 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 spatially separated detectors.”** This element is met by **Lisogurski**.

226. For the reasons I discussed above in element [1.f], **Lisogurski’s** detector meets this limitation (Section IX.A.3.g.[1.f]).

227. '455 patent element [8.f] is identical to '455 patent element [1.f], which 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 spatially separated detectors.”** Thus, my opinions regarding the term in the '455 patent element [1.f] apply equally to

'455 patent element [8.f] (Section IX.A.3.g.[1.f]).

228. I understand that Defendants identified portions of this limitation—**“a plurality of detectors that are spatially separated from each other,”** and **“spatially separated detectors”**—as potentially indefinite in the Texas Case. Ex. 1023, 240-241. As I discussed above (Section IX.A.3.g.[1.f]), regardless of its outer bounds, however, and without opining on whether or not it has adequate written description support, **Lisogurski** meets this term because **Lisogurski** discloses and renders obvious the indisputable scope of the limitations.

v. Element [8.g]

229. Element [8.g] recites: **“the smart phone or tablet comprising a wireless receiver, a wireless transmitter, a display, a microphone, a speaker, a microprocessor and a touch screen, the smart phone or tablet configured to receive and process at least a portion of the output signal, wherein the smart phone or tablet is configured to store and display the processed output signal, and wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link.”** This element is met by **Lisogurski**.

230. For the reasons I discussed above in element [1.g], **Lisogurski's** monitor meets this limitation (Section IX.A.3.h.[1.g]).

231. '455 patent element [8.g] is substantially identical to the '455 patent

element [1.g], which recites: **“the smart phone or tablet comprising a wireless receiver, a wireless transmitter, a display, a speaker, a voice input module, a microprocessor and a touch screen, the smart phone or tablet configured to receive and process at least a portion of the output signal, wherein the smart phone or tablet is configured to store and display the processed output signal, and wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link.”** Aside from the reordering of the listed components, the main difference between the two limitations is the element [8.g]’s use of “a microphone” as opposed to [1.g]’s use of “a voice input module.” As I explained above regarding claim limitation [1.g] (Section IX.A.3.h.[1.g]), 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 term in ’455 patent element [1.g] applies equally to ’455 patent element [8.g] (Section IX.A.3.h.[1.g]).

w. Element [8.h]

232. Element [8.h] recites: **“wherein the output signal is indicative of one or more of the physiological parameters.”** This element is met by **Lisogurski**.

233. For the reasons I discussed above in element [1.h], **Lisogurski’s** data (i.e., an output signal, transmitted to a server, monitor, or remote device) meets this

limitation (Section IX.A.3.i.[1.h]).

234. '455 patent element [8.h] is identical to '455 patent element [1.h], which recites: “**wherein the output signal is indicative of one or more of the physiological parameters.**” Thus, my opinions regarding the term in the '455 patent element [1.h] apply equally to '455 patent element [8.h] (Section IX.A.3.i.[1.h]).

x. Element [8.i]

235. Element [8.i] 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; and.**” This element is met by **Lisogurski**.

236. For the reasons I discussed above in element [1.i], **Lisogurski's** sensor meets this limitation (Section IX.A.3.j.[1.i]).

237. '455 patent element [8.i] is substantially identical to the '455 patent element [1.i], which recites: “**the wearable device configured to increase the signal-to-noise ratio by increasing light intensity of at least one of the semiconductor sources from an initial light intensity.**” The only difference between the two limitations is the differing turns of phrases (i.e., element [8.i]'s use of “at least one of the plurality of semiconductor sources” as opposed to element [1.i]'s use of “at least one of the semiconductor sources”). Thus, the

differences between the two terms do not change my analysis, and my opinions regarding the term in '455 patent element [1.i] term apply equally to '455 patent element [8.i] (Section IX.A.3.j.[1.i]).

y. Element [8.j]

238. Element [8.j] 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**.

239. For the reasons I discussed above in element [1.j], **Lisogurski’s** front end processing circuitry meets this limitation (Section IX.A.3.k.[1.j]).

240. '455 patent element [8.j] is substantially identical to the '455 patent element [1.j], which recites: **“the detection system further configured to: generate a first signal responsive to light received while the semiconductor sources are off.”** The main difference between the two limitations is element [1.j]’s use of “semiconductor sources” as opposed to element [8.j]’s use of “light emitting diodes.” As I discussed above regarding claim element [1.b] (Section IX.A.3.c.[1.b]), a person of ordinary skill in the art would have understood that light emitting diodes are semiconductor light sources. *E.g.*, Ex. 1039, 2:6-9 (“The LED is a semiconductor diode that emits incoherent narrow-spectrum light....”). Thus, the differences between the two terms do not change my analysis, and my opinions regarding the term in '455 patent element [1.j] applies equally to

'455 patent element [8.j] (Section IX.A.3.k.[1.j]).

z. Element [8.k]

241. Element [8.k] 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**.

242. For the reasons I discussed above in element [1.k], **Lisogurski's** front end processing circuitry meets this limitation (Section IX.A.3.1.[1.k]).

243. '455 patent element [8.k] is substantially identical to the '455 patent element [1.k], which recites: “**generate a second signal responsive to light received while at least one of the semiconductor sources is on; and.**” The main difference between the two limitations is element [1.k]'s use of “semiconductor sources” as opposed to element [8.k]'s use of “light emitting diodes.” As I discussed above regarding claim element [1.b] (Section IX.A.3.c.[1.b]), a person of ordinary skill in the art would have understood that light emitting diodes are semiconductor light sources. *E.g.*, Ex. 1039, 2:6-9 (“The LED is a semiconductor diode that emits incoherent narrow-spectrum light....”). Thus, the differences between the two terms do not change my analysis, and my opinions regarding the term in '455 patent element [1.k] applies equally to '455 patent element [8.k] (Section IX.A.3.1.[1.k]).

aa. Element [8.l]

244. Element [8.l] recites: “**increase the signal-to-noise ratio by**

comparing the first signal and the second signal; and.” This element is met by **Lisogurski**.

245. For the reasons I discussed above in element [1.1], **Lisogurski’s** front end processing circuitry meets this limitation (Section IX.A.3.m.[1.1]).

246. ’455 patent element [8.1] is identical to ’455 patent element [1.1], which recites: **“increase the signal-to-noise ratio by comparing the first signal and the second signal; and.”** Thus, my opinions regarding the term in the ’455 patent element [1.1] apply equally to ’455 patent element [8.1] (Section IX.A.3.m.[1.1]).

247. I understand that Defendants identified portions of 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, 240-241. As I discussed above (Section IX.A.3.m.[1.1]), regardless of its outer bounds, however, and without opining on whether or not it has adequate written description support, **Lisogurski** meets this term because **Lisogurski** discloses and renders obvious the indisputable scope of the limitation.

bb. Element [8.m]

248. Element [8.m] recites: **“wherein the plurality of semiconductor sources comprises six light emitting diodes.”** This element is met by **Lisogurski**.

249. The majority of this claim limitation is met by **Lisogurski** for the same reasons I discussed above in regarding elements [1.b] and [8.b].

Sections IX.A.3.c.[1.b] (reciting, in portion, “**plurality of semiconductor sources**”), IX.A.3.q.[8.b] (reciting, in portion, “**a plurality of semiconductor sources that are light emitting diodes**”).

250. Regarding the '455 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).

251. Further, for the reasons I discussed in connection with element [1.m], it was well-known in the art that adding additional lights—particularly three or more—enhance 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. This is because each wavelength interacts differently with tissue, penetrating to different depths and exhibiting varying sensitivities to specific compounds. Section IX.A.3.n.[1.m]. Moreover, as also explained in the discussion above relating to element [1.m], the use of multiple wavelengths was a routine and effective solution to overcome a known limitation in the prior art—namely, that using two wavelengths was insufficient to quantify the concentration of each absorber and determine blood oxygen concentration accurately. Section IX.A.3.n.[1.m]. A

person of ordinary skill in the art would have understood that the use of multiple optical wavelengths was a conventional solution for addressing limitations inherent in simpler dual-wavelength systems. Multiple wavelengths and multiple LEDs enable improved differentiation of multiple physiological absorbers, as well as improved accuracy, improved signal to noise ratio and provided redundancy. Accordingly, a person of ordinary skill in the art would thus have understood (or at least found it obvious) that **Lisogurski's** system comprises multiple number of LEDs for the same reasons discussed in element [1.m].

252. 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.*, Ex. 1033, [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.”).

cc. Claim [11]

253. Claim 11 recites: “**The system of claim 8, wherein the output optical light comprises wavelengths between 600 nm and 1000 nm to measure a level of oxy-hemoglobin and deoxy-hemoglobin, and wherein the output signal corresponding to at least one of the optical wavelengths is used to improve**

measurement of the one or more physiological parameters using the output signal corresponding to the other two optical wavelengths.” This additional limitation is met by **Lisogurski**.

254. **Lisogurski** discloses that **the output optical light** (e.g., light emitted from “multiple LEDs” “direct[ed]...toward a subject’s tissue”; Section IX.A.3.c.[1.b]) **comprises wavelengths between 600 nm and 1000 nm to measure a level of oxy-hemoglobin and deoxy-hemoglobin** (e.g., comprises wavelengths “between about 600 nm and about 700 nm” and “between about 800 nm and about 1000 nm” to measure “high” and “low” “blood oxygen saturation”) **and wherein the output signal** (e.g., “processed signal”; Section IX.A.3.e.[1.d]) **corresponding to at least one of the optical wavelengths is used to improve measurement of at least one of the one or more physiological parameters using the output signal corresponding to the other two optical wavelengths** (e.g., “monitoring” “activity with the more sensitive available wavelength” to compensate for different sensitivities to different wavelengths). **Lisogurski**, 10:48-64, 11:6-8, 12:42-48 17:43-54, 24:58-25:5.

255. Regarding “**wavelengths between 600 nm and 1000 nm to measure a level of oxy-hemoglobin and deoxy-hemoglobin**,” as I discussed above in connection with element [1.m], **Lisogurski** discloses using multiple light sources: i.e., that light source 130 has three or more LEDs emitting at least red and IR lights

with wavelengths between about 600 nm and 700 nm and between about 800 nm and 1000 nm, respectively. Section IX.A.3.n.[1.m] (reciting, in portion, “three optical wavelengths”); Lisogurski, 10:48-64 (“[T]he Red wavelength may be between about 600 nm and about 700 nm, and the IR wavelength may be between about 800 nm and about 1000 nm”). Further, using those LEDs, Lisogurski discloses measuring “blood oxygen saturation” including the “concentration of oxyhemoglobin” and the “concentration of deoxyhemoglobin.” Lisogurski, 24:58-25:5.

256. Regarding “**corresponding to at least one of the optical wavelengths is used to improve measurement of at least one of the one or more physiological parameters using the output signal corresponding to the other two optical wavelengths,**” Lisogurski discloses using “light source 130” including “any number of light sources” and “multiple ... detectors,” which detect signals emitted by the “multiple light sources,” which are thereafter reflected by or traveled through a user’s tissue. Lisogurski, 10:58-60, 17:43-54. See also my discussion of claim element [1.f]. Section IX.A.3.g.[1.f] (reciting, in portion, “a plurality of detectors”). Lisogurski further discloses that after detecting these signals, the detectors can then provide multiple output signals. Lisogurski, 12:42-48 (discussing front end processing circuitry providing “one or more processed signals” to back end processing circuitry 170). Further, Lisogurski teaches the use of multiple

wavelengths of light, with each wavelength selected based on its sensitivity to the specific physiological parameters being measured, to compensate for different sensitivities to different wavelengths. For example, **Lisogurski** explains that, in the context of measuring blood oxygen saturation, it is advantageous to use both red and infrared (IR) light: “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. Thus, it may be desired to monitor activity with the more sensitive available wavelength.” Lisogurski, 24:58-25:5. See also my discussion of claim element [1.m]. Section IX.A.3.n.[1.m] (reciting, in portion, “three optical wavelengths”). This teaching from **Lisogurski** highlights that using both red and IR light allows the system to more accurately distinguish between different oxygen saturation levels, leveraging each wavelength’s greater sensitivity to a particular oxygenation state to improve measurements taken with lights having different wavelengths. In summary, **Lisogurski** discloses the use of multiple light sources—that emit wavelengths of

light selected to complement one another in sensitivity to the physiological parameters being measured—as well as multiple detectors that generate multiple output signals.

257. Furthermore, a person of ordinary skill in the art would have understood (or at least found obvious) that the detectors of **Lisogurski's** system output signals that each correspond to at least one of the wavelengths emitted by the multiple light sources. This is because **Lisogurski's** optical physiological monitoring system (see my discussion in Section IX.A.3.a.[1.pre]) includes detectors that receive reflected or transmitted light at specific wavelengths in order to extract data about a physiological parameter. Lisogurski, 11:6-8 (“Detector 140 may be chosen to be specifically sensitive to the chosen targeted energy spectrum of light source 130.”). Moreover, as I discussed above in connection with element [1.m], a person of ordinary skill in the art would have understood (or at least found obvious) that **Lisogurski's** use of multiple wavelengths serves two purposes: first, to enable the measurement of a broader range of physiological parameters, and second, to improve the accuracy of those measurements. Section IX.A.3.n.[1.m]. To this end, a person of ordinary skill would have understood that **Lisogurski** includes an output signal corresponding to at least one of the optical wavelengths to improve measurement of the one or more physiological parameters based on the output signal corresponding to the other (multiple more) optical wavelengths. See *e.g.*, Ex. 1033, [0033]-[0034],

[0035] (“....when only two wavelengths are used but there are more than two significant absorbers in the patient’s tissue, the system may be underdetermined. Therefore, adding wavelengths sensitive to additional significant absorbers can help the system compensate for the additional significant absorbers and enable more accurate calculation of the concentration of each absorber and the blood oxygen saturation. For example, an eight wavelength physiological monitor utilizes an eight-dimensional calibration curve, which provides eight degrees of freedom to compensate for various physiologically-related parameters. Such parameters can include, for example, noise, motion, various hemodynamic parameters, and/or blood constituent concentrations and/or levels....”), [0036] (“Furthermore, traditional physiological monitors that utilize two light sources to derive a patient’s plethysmographic signal generally require one light source’s wavelength to fall in the red spectrum and the other light source’s wavelength to fall in the infrared spectrum. However, a multi-wavelength physiological monitor advantageously provides the ability to utilize all infrared wavelength light sources and/or other non-red infrared light sources to derive an accurate plethysmographic waveform. One advantage of utilizing non-red wavelength light sources (for example, all infrared wavelength light sources) is that the multi-wavelength physiological monitor can be further configured to determine several blood constituent concentrations based upon signals measured from just the non-red light sources....”), [0037] (“The ability to

measure a physiological parameter with a multi-dimensional system allows the system to compensate and account for the presence of other conditions that may affect the particular physiological parameter being measured....”). A person of ordinary skill in the art would have further understood (or at least found obvious) that **Lisogurski’s** system is able to realize these benefits by using the output signal corresponding to the other multiple (e.g., two or more) optical wavelengths because each signal carried information that is indicative of one or more of the physiological parameters of interest. Section IX.A.3.i.[1.h].

B. GROUND 2: Lisogurski in view of LeBoeuf (Claims 2-4, 9-10, and 15-17):

1. Overview of LeBoeuf

258. **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].

259. **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.

260. **Earbud housing 16** is “at least partially reflective to scatter light [from **optical emitters 24**] within the cavity defined by the **earbud housing 16**.” LeBoeuf, [0125]. **LeBoeuf** explains that an “advantage of this configuration is so that light ... can be focused on a particular region of the ear where a particular physiological activity may be located.” LeBoeuf, [0125]; *see also* LeBoeuf, [0017] (“In some embodiments, a light reflective material is on at least a portion of one or

both of the inner and outer surfaces of the light-guiding cover.”), [0123], Fig. 8C.

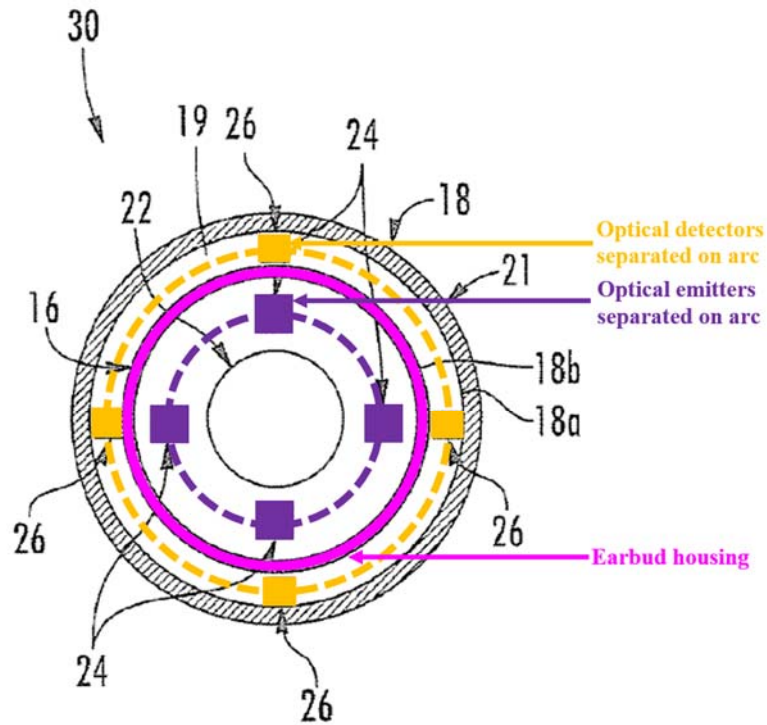


FIG. 8B

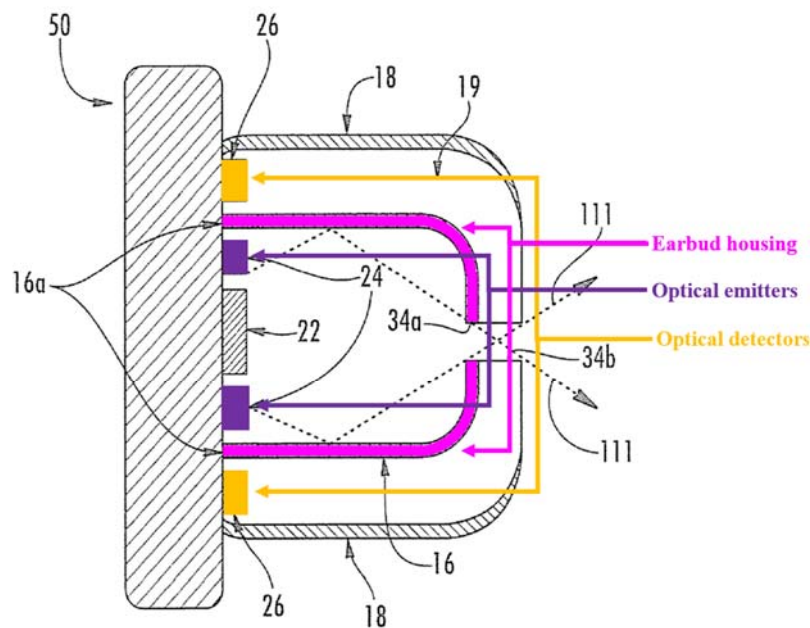


FIG. 8C

2. Motivation to Combine Lisogurski and LeBoeuf

261. **Lisogurski** and **LeBoeuf** are both in the same field as the '455 patent—which includes physiological monitoring—and are reasonably pertinent to the problems addressed by the '455 patent—e.g., improving optical physiological monitoring. '455 patent, 8:29-9:9; Lisogurski, 1:10-11; LeBoeuf, Abstract, [0025], [0026].

262. 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.

263. 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 I understand has been designated as Exhibit 1045, is directed to a pulse oximeter and 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.

264. A person of ordinary skill in the art would have had a reasonable expectation of success in applying **LeBoeuf’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].

265. With respect to **LeBoeuf’s** reflective surface teachings, a person of ordinary skill in the art would also have been motivated to apply **LeBoeuf’s** reflective surface teaching to **Lisogurski’s** system to receive and redirect at least some of the output optical light to improve the performance of **Lisogurski’s** physiological monitoring system. **LeBoeuf** discloses an “earbud,” with “earbud housing 16” that is “at least partially reflective to scatter light within the cavity.” LeBoeuf, [0125]. **LeBoeuf** teaches that this configuration offers two advantages: (1) it would help “focus [the light generated by optical emitters 24] on a particular region of the ear where a particular physiological activity may be located” and (2) it “reduce[s] unwanted optical signals from regions that may not be relevant to the

physiological activity of interest.” LeBoeuf, [0125]. Such advantages were well understood in the art as shown in U.S. Patent Pub. No. 2012/0197093, which I understand has been designated as Exhibit 1041. Ex. 1041, [0152] (a sensor surrounded by a “reflective” material may “help[] direct light to and/or from the sensor module [] and a blood flow region [i.e., measurement site] within the body part”). Thus, by controlling the emitted light and confining it to physiologically meaningful regions, the reflective material enhances the efficiency of light delivery and collection. This, in turn, improves the signal-to-noise ratio by increasing the proportion of relevant signal relative to background or stray signals, resulting in more accurate and reliable physiological measurements.

266. A person of ordinary skill in the art would have understood that reflective surfaces used to guide and redirect optical signals within wearable physiological monitors were well known and routinely implemented at the relevant time. Such reflective surfaces reduce optical losses, improve signal strength, enhance the signal-to-noise ratio, and minimize interference from irrelevant background signals. By specifically confining emitted optical signals to targeted, physiologically meaningful regions, reflective surfaces enhance the accuracy and precision of physiological measurements. Accordingly, a person of ordinary skill in the art would have been motivated to apply **LeBoeuf’s** reflective surface teachings to **Lisogurski’s** wearable device to enhance signal measurement quality.

267. A person of ordinary skill in the art would have had a reasonable expectation of success in applying **LeBeouf’s** reflective surface to **Lisogurski’s** system. Both references teach applying their respective physiological measurement systems to the ear: **Lisogurski** describes placing its oximeter on the “earlobe” of a user or “around or in front of the ear” and **LeBoeuf**, similarly, describes its system is “attached to the ear of a person.” *Lisogurski*, 4:6-20; *LeBoeuf*, [0006]; *see also* *LeBoeuf*, [0010], [0025], [0026]. Accordingly, a person of ordinary skill in the art would have found it straightforward and advantageous to apply **LeBoeuf’s** reflective surface to **Lisogurski’s** system, including when implemented on a patient’s earlobe. Moreover, a person of ordinary skill in the art would have understood that modifying **Lisogurski’s** measurement system would involve only routine changes that were already well-known in the art—specifically, incorporating reflective surfaces. 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.

268. Indeed, it was common technique to use reflective surfaces to control the path of light such as to concentrate the delivery of light to a desired target area while minimizing light exposure to surrounding, non-targeted areas. For example, U.S. Pat. Pub. 2012/0197093 (“Valencell-093”) discloses a “sensor module 700, 800” that includes a “a reflector”—made of materials such as “a metal, metallic

alloy, mylar, mica, reflective plastic, reflective textile, or the like”—to “help direct light to and/or from the sensor module 700, 800 and a blood flow region [, which is the specific region intended to be measured].” Ex. 1041, [0152]. Additionally, **LeBoeuf** has substantially similar disclosures with Valencell-093, a patent publication considered by the Board in the ’484-IPR. ’484-FWD, 55-58. As the Board recognized in the ’484-IPR, a person of ordinary skill in the art would have been motivated to combine the teachings of **Lisogurski** with those of **Valencell-093** “because they both concern analogous miniaturized pulse oximetry devices having the same applications.” ’484-FWD, 58-59 (citing at ’484-Pet. at 73). **LeBoeuf** similarly also concerns a miniaturized pulse oximetry devices and a person of ordinary skill in the art would therefore also have been motivated to combine the teachings of Lisogurski with those of LeBoeuf.” Likewise, U.S. Pat. No. 8,821,397, which I understand has been designated as Exhibit 1032, discloses using a mirror (“splitting mirror 660,” which “includes many smaller reflective components that are angled in different directions) to direct the emitted light (either toward the emission detector 260 or toward “aperture 670”). Ex. 1032, 16:23-57, FIGS. 4C, 4E.

3. Invalidity of Claims 2-4, 9-10, and 15-17 Over Lisogurski in view of LeBoeuf

269. As I discuss below, Claims 2-4, 9-10, and 15-17 are rendered obvious

by **Lisogurski** in view of **LeBoeuf**. In addition to my discussion in Section IX.B.1-2, the following discussion identifies example disclosures that each disclose Challenged Claims 2-4, 9-10, and 15-17.

a. Claim [2]

270. Claim 2 recites: “**The system of claim 1, wherein the plurality of semiconductor sources comprises six light emitting diodes, and wherein the plurality of semiconductor sources and the plurality of spatially separated detectors are located on one or more arcs.**” This additional limitation is met by **Lisogurski** in view of **LeBoeuf**.

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

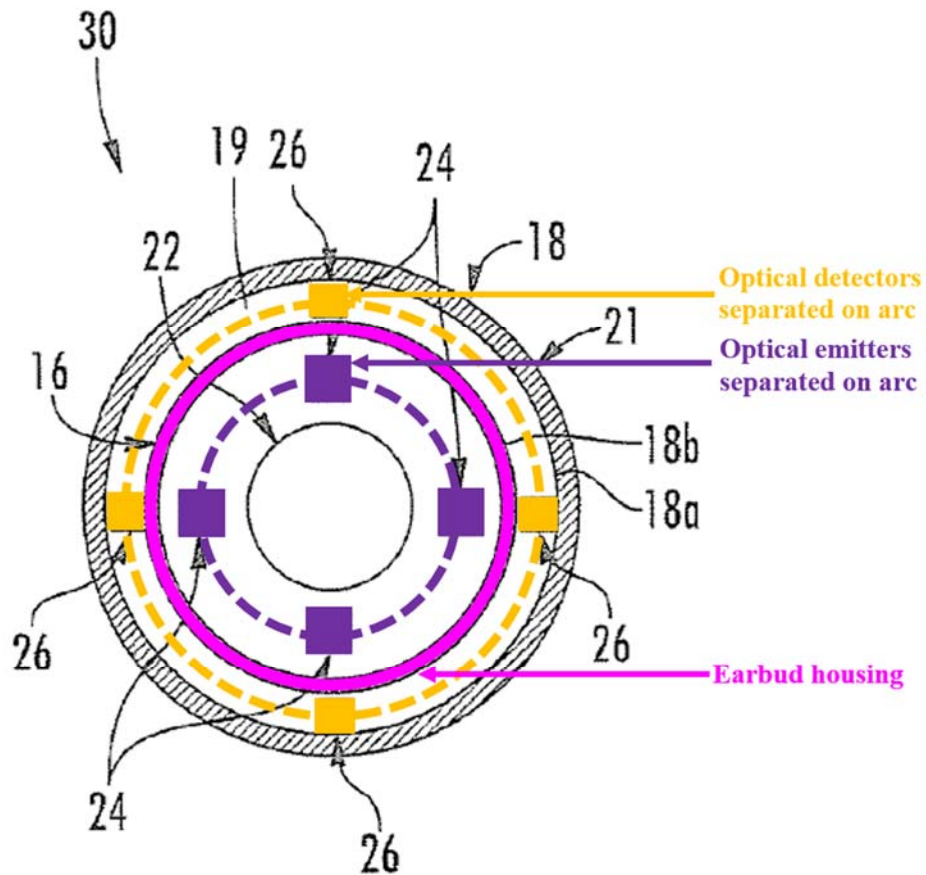
272. As I discussed above, **Lisogurski** discloses that the **plurality of semiconductor sources comprises six light emitting diodes** (*e.g.*, six “light sources” that are LEDs; Section IX.A.3.bb.[8.m]) ... **and the plurality of spatially separated detectors** (*e.g.*, “multiple...detectors, which may be spaced apart”; Section IX. A.3.g.[1.f]).

273. **LeBoeuf** discloses **the plurality of semiconductor sources** (*e.g.*, “optical emitters 24” that are “light-emitting diode[s]”) **and the plurality of spatially separated detectors** (*e.g.*, “optical detectors 26”) **are located on one or more arcs** (*e.g.*, spatially separated in an arc). **LeBoeuf**, [0048]-[0050], [0092],

[0123], FIGS. 8A-8B.

274. 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.

275. **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.



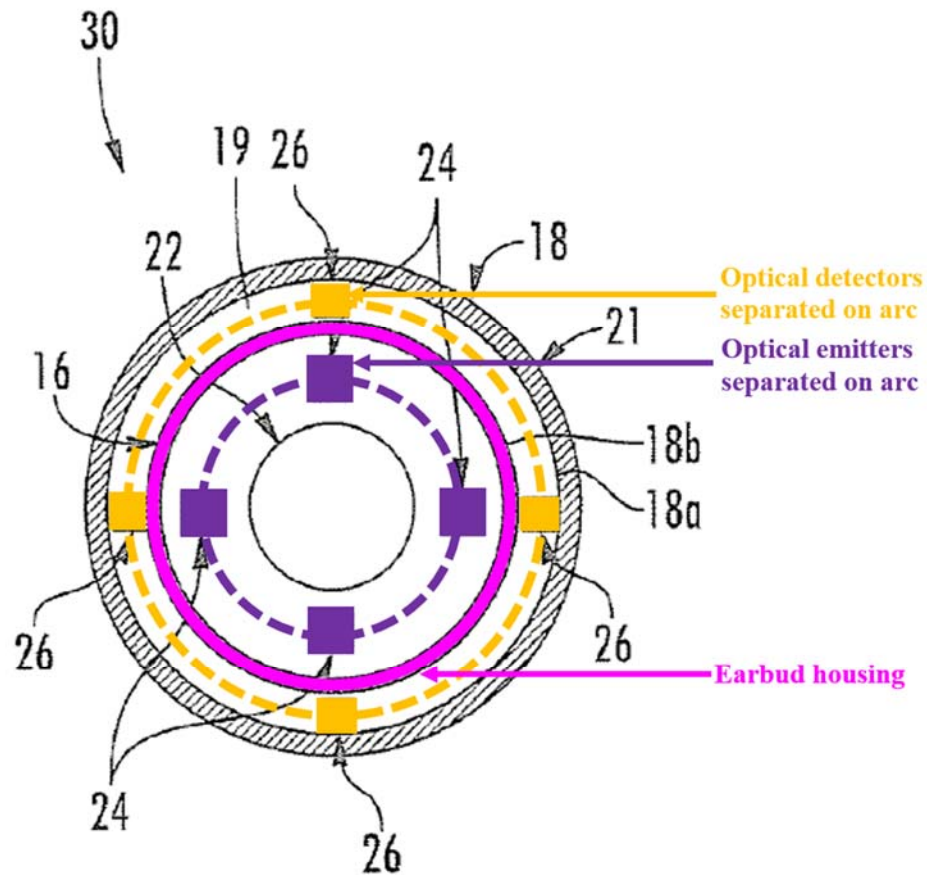
276. As I discuss in Section IX.B.2, a person of ordinary skill in the art would have been motivated to apply **LeBoeuf's** teachings to **Lisogurski's** system—specifically, to arrange the plurality of semiconductor sources so that they are spatially separated from each another and, likewise, to arrange 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.B.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.

277. I understand that Defendants identified portions of this limitation—**“spatially separated detectors”** and **“the plurality of semiconductor sources and the plurality of spatially separated detectors are located on one or more arcs”**—as potentially indefinite in the Texas Case. Ex. 1023, 240-241.

278. Regarding **“spatially separated detectors,”** as I discussed above regarding claim limitation [1.f] (Section IX.A.3.g.[1.f]), regardless of its outer bounds, however, and without opining on whether or not it has adequate written description support, **Lisogurski** meets the term because **Lisogurski** discloses and renders obvious the indisputable scope of the limitation.

279. Regarding **“located on one or more arcs,”** 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, **LeBoeuf** 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:



b. Claim [3]

280. Claim 3 recites: “**The system of claim 2, wherein the output optical light comprises wavelengths between 600 nm and 1000 nm to measure a level of oxy-hemoglobin and deoxy-hemoglobin.**” This additional limitation is met by **Lisogurski**.

281. For the reasons I discussed above in claims 2 and 11, **Lisogurski’s** system meets this limitation (Sections IX.B.3.a.[2] and IX.A.3.cc.[11]).

282. ’455 patent claim 3 is identical to a portion of the ’455 patent claim 11,

which recites: “...wherein the output optical light comprises wavelengths between 600 nm and 1000 nm to measure a level of oxy-hemoglobin and deoxy-hemoglobin...” Thus, my opinions regarding the term in the ’455 patent claim 11 apply equally to ’455 patent claim 3 (Section IX.A.3.cc.[11]).

c. Claim [4]

283. Claim 4 recites: “The system of claim 3, wherein the output signal corresponding to at least one of the optical wavelengths is used to improve measurement of at least one of the one or more physiological parameters using the output signal corresponding to the other two optical wavelengths.” This additional limitation is met by **Lisogurski**.

284. For the reasons I discussed above in claims 3 and 11, **Lisogurski**’s system meets this limitation (Sections IX.B.3.b.[3] and IX.A.3.cc.[11]).

285. ’455 patent claim 4 is substantially identical to a portion of the ’455 patent claim 11, which recites: “...wherein the output signal corresponding to at least one of the optical wavelengths is used to improve measurement of the one or more physiological parameters using the output signal corresponding to the other two optical wavelengths.” Aside from differing turns of phrases (“at least one of the one or more physiological parameters” vs. “of the one or more physiological parameters”), these terms are identical. Thus, my opinions regarding the term in the ’455 patent claim 11 apply equally to ’455 patent claim 4

(Section IX.A.3.cc.[11]).

d. Claim [9]

286. Claim 9 recites: “**The system of claim 8, wherein the plurality of semiconductor sources and the plurality of spatially separated detectors are located on one or more arcs.**” This additional limitation is met by **Lisogurski** in view of **LeBouef**.

287. For the reasons I discussed above in claims 2 and 8, **Lisogurski’s** system modified by the teachings of **LeBouef** meets this limitation (Sections IX.B.3.a.[2] and IX.A.3.p-bb.[8.a]-[8.m]).

288. ’455 patent claim 9 is identical to a portion of the ’455 patent claim 2, which recites: “...**wherein the plurality of semiconductor sources and the plurality of spatially separated detectors are located on one or more arcs.**” Thus, my opinions regarding the term in the ’455 patent claim 2 apply equally to ’455 patent claim 9 (Section IX.B.3.a.[2]).

289. I understand that Defendants identified portions of this limitation—**“spatially separated detectors”** and **“the plurality of semiconductor sources and the plurality of spatially separated detectors are located on one or more arcs”**—as potentially indefinite in the Texas Case. Ex. 1023, 240-241. As I discussed above regarding claim 2 (Section IX.B.3.a.[2]), regardless of its outer bounds, however, and without opining on whether or not it has adequate written description support,

Lisogurski and **LeBouef** respectively meet these terms because **Lisogurski** and **LeBouef** disclose and render obvious the indisputable scope of the limitations.

e. Claim [10]

290. Claim 10 recites: “**The system of claim 9, wherein the output optical light comprises three optical wavelengths for measuring at least a portion of the one or more of the physiological parameters, and wherein the optical wavelengths comprise near infrared and visible wavelengths.**” This additional limitation is met by **Lisogurski**.

291. For the reasons I discussed above in claim element [1.m] and claim 9, **Lisogurski’s** system modified by the teachings of **LeBoeuf** meets this limitation. (Sections IX.A.3.n.[1.m] and IX.B.3.d.[9]).

292. ’455 patent claim 10 is substantially identical to ’455 patent element [1.m], which recites: “**wherein the plurality of optical wavelengths comprises three optical wavelengths for measuring at least a portion of the one or more of the physiological parameters, wherein the optical wavelengths comprise near infrared or visible wavelengths.**” The main differences between the two limitations are as listed, and with each difference being immaterial to my analysis: (i) claim 10’s use of “wherein the output optical light comprises three wavelengths” as opposed to element [1.m]’s use of “wherein the plurality of optical wavelengths comprises three optical wavelengths”; and (ii) claim 10’s use of “near infrared and

visible wavelengths” as opposed to element [1.m]’s use of “near infrared or visible wavelengths.” These differences are a matter of phrasing or the use of disjunctive versus conjunctive lists. Thus, the differences between the two terms do not change my analysis, and my opinions regarding the ’455 patent element [1.m] term apply equally to ’455 patent claim 10 (Section IX.A.3.n.[1.m]).

f. Element [15.pre]

293. Element [15.pre] recites: “**A system for measuring one or more physiological parameters and for use with a smart phone or tablet, the system comprising.**” This element is met by **Lisogurski**.

294. For the reasons I discuss above in element [1.pre], **Lisogurski’s** “optical physiological monitoring system” meets this limitation (Section IX.A.3.a.[1.pre]).

295. ’455 patent element [15.pre] is identical to ’455 patent element [1.pre], which recites: “**A system for measuring one or more physiological parameters and for use with a smart phone or tablet, the system comprising.**” Thus, my opinions regarding the term in the ’455 patent element [1.pre] apply equally to ’455 patent element [15.pre] (Section IX.A.3.a.[1.pre]).

g. Element [15.a]

296. Element [15.a] recites: “**a wearable device adapted to be placed on teeth, a wrist, or an ear of a user.**” This element is met by **Lisogurski**.

297. For the reasons I discuss above in element [1.a], **Lisogurski’s** sensor meets this limitation (Section IX.A.3.b.[1.a]).

298. ’455 patent element [15.a] is identical to ’455 patent element [1.a], which recites: “**a wearable device adapted to be placed on teeth, a wrist, or an ear of a user.**” Thus, my opinions regarding the term in the ’455 patent element [1.a] apply equally to ’455 patent element [15.a] (Section IX.A.3.b.[1.a]).

h. Element [15.b]

299. Element [15.b] recites: “**including a light source comprising a driver and a plurality of semiconductor sources that are light emitting diodes, the light emitting diodes configured to generate an output optical light having one or more optical wavelengths.**” This element is met by **Lisogurski**.

300. For the reasons I discuss above in element [8.b], **Lisogurski’s** sensor with light source meets this limitation (Section IX.A.3.q.[8.b]).

301. ’455 patent element [15.b] is identical to ’455 patent element [8.b], which recites: “**including a light source comprising a driver and a plurality of semiconductor sources that are light emitting diodes, the light emitting diodes configured to generate an output optical light having one or more optical wavelengths.**” Thus, my opinions regarding the term in the ’455 patent element [8.b] apply equally to ’455 patent element [15.b] (Section IX.A.3.q.[8.b]).

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

“the light emitting diodes configured to generate an output optical light having one or more optical wavelengths”—as potentially indefinite in the Texas Case. Ex. 1023, 240-241. As I discussed above (Section IX.A.3.c.[1.b]), regardless of its outer bounds, however, and without opining on whether or not it has adequate written description support, **Lisogurski** meets this term because **Lisogurski’s** LEDs, individually or together as a group, meet this limitation.

i. Element [15.c]

303. Element [15.c] recites: **“the wearable device comprising 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.”** This element is met by **Lisogurski**.

304. For the reasons I discuss above in element [1.c], **Lisogurski’s** sensor with light source meets this limitation (Section IX.A.3.d.[1.c]).

305. ’455 patent element [15.c] is identical to ’455 patent element [1.c], which recites: **“the wearable device comprising 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.”** Thus, my opinions regarding the term in the ’455 patent element [1.c] apply equally to ’455 patent element [15.c] (Section IX.A.3.d.[1.c]).

j. Element [15.d]

306. Element [15.d] recites: **“the wearable device further comprising 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**.

307. For the reasons I discuss above in element [1.d], **Lisogurski’s** detector and front end processing circuitry meets this limitation (Section IX.A.3.e.[1.d]).

308. ’455 patent element [15.d] is identical to ’455 patent element [1.d], which recites: **“the wearable device further comprising 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 term in the ’455 patent element [1.d] apply equally to ’455 patent element [15.d] (Section IX.A.3.e.[1.d]).

k. Element [15.e]

309. Element [15.e] recites: **“wherein the detection system is configured to be synchronized to the light source.”** This element is met by **Lisogurski**.

310. For the reasons I discuss above in element [1.e], **Lisogurski’s** front end processing circuitry meets this limitation (Section IX.A.3.f.[1.e]).

311. ’455 patent element [15.e] is identical to ’455 patent element [1.e], which recites: **“wherein the detection system is configured to be synchronized to the light source.”** Thus, my opinions regarding the term in the ’455 patent element [1.e] apply equally to ’455 patent element [15.e] (Section IX.A.3.f.[1.e]).

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

“wherein the detection system is configured to be synchronized to the light source”—as potentially indefinite in the Texas Case. Ex. 1023, 240-241. As I discussed above regarding claim element [1.e] (Section IX.A.3.f.[1.e]), regardless of its outer bounds, however, and without opining on whether or not it has adequate written description support, **Lisogurski** meets this term because **Lisogurski** discloses and renders obvious the indisputable scope of the limitation.

I. Element [15.f]

313. Element [15.f] 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 spatially separated detectors.”** This element is met by **Lisogurski**.

314. For the reasons I discuss above in element [1.f], **Lisogurski’s** detector meets this limitation (Section IX.A.3.g.[1.f]).

315. ’455 patent element [15.f] is identical to ’455 patent element [1.f], which 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 spatially separated detectors.”** Thus, my opinions regarding the term in the ’455 patent element [1.f] apply equally to ’455 patent element [15.f] (Section IX.A.3.g.[1.f]).

316. I understand that Defendants identified portions of this limitation—**“a**

plurality of detectors that are spatially separated from each other,” and **“spatially separated detectors”**—as potentially indefinite in the Texas Case. Ex. 1023, 240-241. As I discussed above regarding claim element [1.f] (Section IX.A.3.g.[1.f]), regardless of its outer bounds, however, and without opining on whether or not it has adequate written description support, **Lisogurski** meets this term because **Lisogurski** discloses and renders obvious the indisputable scope of the limitations.

m. Element [15.g]

317. Element [15.g] recites: **“the smart phone or tablet comprising a wireless receiver, a wireless transmitter, a display, a microphone, a speaker, a microprocessor and a touch screen, the smart phone or tablet configured to receive and process at least a portion of the output signal, wherein the smart phone or tablet is configured to store and display the processed output signal, and wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link”** This element is met by **Lisogurski**.

318. For the reasons I discuss above in element [8.g], **Lisogurski’s** monitor meets this limitation (Section IX.A.3.v.[8.g]).

319. ’455 patent element [15.g] is identical to ’455 patent element [8.g], which recites: **“the smart phone or tablet comprising a wireless receiver, a**

wireless transmitter, a display, a microphone, a speaker, a microprocessor and a touch screen, the smart phone or tablet configured to receive and process at least a portion of the output signal, wherein the smart phone or tablet is configured to store and display the processed output signal, and wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link.” Thus, my opinions regarding the term in the ’455 patent element [8.g] apply equally to ’455 patent element [15.g] (Section IX.A.3.v.[8.g]).

n. Element [15.h]

320. Element [15.h] recites: “**wherein the output signal is indicative of one or more of the physiological parameters.**” This element is met by **Lisogurski**.

321. For the reasons I discuss above in element [1.h], **Lisogurski’s** data (i.e., an output signal, transmitted to a server, monitor, or remote device) meets this limitation (Section IX.A.3.i.[1.h]).

322. ’455 patent element [15.h] is identical to ’455 patent element [1.h], which recites: “**wherein the output signal is indicative of one or more of the physiological parameters.**” Thus, my opinions regarding the term in the ’455 patent element [1.h] apply equally to ’455 patent element [15.h] (Section IX.A.3.i.[1.h]).

o. Element [15.i]

323. Element [15.i] 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; and.**” This element is met by **Lisogurski**.

324. For the reasons I discuss above in element [8.i], **Lisogurski’s** sensor meets this limitation (Section IX.A.3.x.[8.i]).

325. ’455 patent element [15.i] is identical to ’455 patent element [8.i], which recites: “**the wearable device configured to increase the signal-to-noise ratio by increasing light intensity of at least one of the semiconductor sources from an initial light intensity.**” Thus, my opinions regarding the term in ’455 patent element [8.i] term apply equally to ’455 patent element [15.i] (Section IX.A.3.x.[8.i]).

p. Element [15.j]

326. Element [15.j] 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**.

327. For the reasons I discuss above in element [8.j], **Lisogurski’s** front end processing circuitry meets this limitation (Section IX.A.3.y.[8.j]).

328. ’455 patent element [15.j] is identical to ’455 patent element [8.j], which recites: “**the detection system further configured to: generate a first signal**

responsive to light received while the semiconductor sources are off.” Thus, my opinions regarding the term in ’455 patent element [8.j] applies equally to ’455 patent element [15.j] (Section IX.A.3.y.[8.j]).

q. Element [15.k]

329. Element [15.k] 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**.

330. For the reasons I discuss above in element [8.k], **Lisogurski’s** front end processing circuitry meets this limitation (Section IX.A.3.z.[8.k]).

331. ’455 patent element [15.k] is identical to ’455 patent element [8.k], which recites: “**generate a second signal responsive to light received while at least one of the semiconductor sources is on; and.**” Thus, my opinions regarding the term in ’455 patent element [8.k] applies equally to ’455 patent element [15.k] (Section IX.A.3.z.[8.k]).

r. Element [15.l]

332. Element [15.l] recites: “**increase the signal-to-noise ratio by comparing the first signal and the second signal; and.**” This element is met by **Lisogurski**.

333. For the reasons I discussed above in element [1.l], **Lisogurski’s** front end processing circuitry meets this limitation (Section IX.A.3.m.[1.l]).

334. '455 patent element [15.l] is identical to '455 patent element [1.l], which recites: **“increase the signal-to-noise ratio by comparing the first signal and the second signal; and.”** Thus, my opinions regarding the term in the '455 patent element [1.l] apply equally to '455 patent element [15.l] (Section IX.A.3.m.[1.l]).

335. I understand that Defendants identified portions of 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, 240-241. As I discussed above regarding claim element [1.l] (Section IX.A.3.m.[1.l]), regardless of its outer bounds, however, and without opining on whether or not it has adequate written description support, **Lisogurski** meets this term because **Lisogurski** discloses and renders obvious the indisputable scope of the limitation.

s. **Element [15.m]**

336. Element [15.m] recites: **“wherein the plurality of semiconductor sources comprises six light emitting diodes.”** This element is met by **Lisogurski**.

337. For the reasons I discuss above in element [8.m], **Lisogurski's** front end processing circuitry meets this limitation (Section IX.A.3.bb.[8.m]).

338. '455 patent element [15.m] is identical to '455 patent element [8.m], which recites: **“wherein the plurality of semiconductor sources comprises six light emitting diodes.”** Thus, my opinions regarding the term in the '455 patent

element [8.m] apply equally to '455 patent element [15.m]
(Section IX.A.3.bb.[8.m]).

t. Element [15.n]

339. Element [15.n] recites: **“wherein the plurality of semiconductor sources comprises six light emitting diodes, and wherein the plurality of semiconductor sources and the plurality of spatially separated detectors are located on one or more arcs; and.”** This element is met by **Lisogurski** in view of **LeBoeuf**.

340. For the reasons I discuss above in claim 2, **Lisogurski’s** system as modified by the teachings of **LeBoeuf** meets this limitation (Section IX.B.3.a.[2]).

341. '455 patent element [15.n] is identical to a portion of '455 patent claim 2, which recites: **“...wherein the plurality of semiconductor sources comprises six light emitting diodes, and wherein the plurality of semiconductor sources and the plurality of spatially separated detectors are located on one or more arcs.”** Thus, my opinions regarding the term in the '455 patent claim 2 apply equally to '455 patent element [15.n] (Section IX.B.3.a.[2]).

342. I understand that Defendants identified a portion of this limitation—**“spatially separated detectors”** and **“the plurality of semiconductor sources and the plurality of spatially separated detectors are located on one or more arcs”**—as potentially indefinite in the Texas Case. Ex. 1023, 240-241. As I discussed above

regarding claim 2 (Section IX.B.3.a.[2]), regardless of its outer bounds, however, and without opining on whether or not it has adequate written description support, **Lisogurski** and **LeBouef** respectively meet these terms because **Lisogurski** and **LeBouef** disclose and render obvious the indisputable scope of the limitations.

u. Element [15.o]

343. Element [15.o] recites: “**wherein the output optical light comprises wavelengths between 600 nm and 1000 nm to measure a level of oxy-hemoglobin and deoxy-hemoglobin.**” This element is met by **Lisogurski**.

344. For the reasons stated in claim 3, **Lisogurski’s** system meets this limitation (Section IX.B.3.b.[3]).

345. ’455 patent element [15.o] is identical to a portion of ’455 patent claim 3, which recites: “**...wherein the output optical light comprises wavelengths between 600 nm and 1000 nm to measure a level of oxy-hemoglobin and deoxy-hemoglobin.**” Thus, my opinions regarding the term in the ’455 patent claim 3 apply equally to ’455 patent element [15.o] (Section IX.B.3.b.[3]).

v. Claim [16]

346. Claim 16 recites: “**The system of claim 15, wherein the output optical light comprises three optical wavelengths for measuring at least a portion of the one or more of the physiological parameters, and wherein the output signal corresponding to at least one of the optical wavelengths is used to**

improve measurement of at least one of the one or more physiological parameters using the output signal corresponding to the other two optical wavelengths.” This additional limitation is met by **Lisogurski**.

347. For the reasons I discuss above in element [1.m], claim 4, and claim 15, **Lisogurski’s** system meets this limitation (Sections IX.A.3.n.[1.m], IX.B.3.c.[4], IX.B.3.f-u.[15.pre]-[15.o]).

348. ’455 patent claim 16 is substantially identical to a portion of ’455 patent element [1.m], which recites: “**wherein the plurality of optical wavelengths comprises three optical wavelengths for measuring at least a portion of the one or more of the physiological parameters...**” The main difference between the relevant portion of element [1.m] and claim 16 is element [1.m]’s use of “wherein the plurality of optical wavelengths comprises three optical wavelengths” as opposed to claim 16’s use of “wherein the output optical light comprises three optical wavelengths.” For reasons I discuss above regarding claim 10 (Section IX.B.3.e.[10]), these differences are a matter of phrasing. Thus, my opinions regarding the term in the ’455 patent element [1.m] apply equally to ’455 patent claim 16 (Section IX.A.3.n.[1.m]).

349. ’455 patent claim 16 is also identical to a portion of ’455 patent claim 4, which recites: “**...wherein the output signal corresponding to at least one of the optical wavelengths is used to improve measurement of at least one of the**

one or more physiological parameters using the output signal corresponding to the other two optical wavelengths.” Thus, my opinions regarding the term in the ’455 patent claim 4 apply equally to ’455 patent claim 16 (Section IX.B.3.c.[4]).

w. Claim [17]

350. Claim 17 recites: “The system of claim 16, wherein the wearable device further comprises a reflective surface to receive and redirect at least some of the output optical light from the plurality of semiconductor sources.”

This additional limitation is met by **Lisogurski** in view of **LeBoeuf**.

351. See my discussion of claim 16 above (Section IX.B.3.v.[16]).

352. **LeBoeuf** discloses that the wearable device further comprises a reflective surface (e.g., “partially reflective” “earbud housing 16” attached to “base 50”) to receive and redirect at least some of the output optical light from the plurality of semiconductor sources (e.g., “focus[light] on a particular region of the ear”). **LeBoeuf**, [0017], [0123], [0125]; FIG. 8C.

353. **LeBoeuf** discloses that “[e]arbud housing 16” is “partially reflective to scatter light within the cavity defined by the earbud housing 16.” **LeBoeuf**, [0123], [0125]; FIG. 8C; see also **LeBoeuf**, [0017] (“[A] light reflective material is on at least a portion of one or both of the inner and outer surfaces of the light-guiding cover.”). An advantage of this configuration is that it allows the light emitted from optical emitters 24 to “be focused on a particular region of the ear where a particular

art would have been motivated to apply **LeBoeuf’s** teachings to **Lisogurski’s** system to enhance the efficiency with which light is delivered to the target tissue.

C. GROUND 3-4: Grounds 1-2 in further view of Tran (Claims 1, 5-8, 12-15, 18-20):

1. Overview of Tran

356. **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).

357. **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.

358. **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.

359. 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, 11:1-13. **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.

360. **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 cell phone,” 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 (alone or in view of LeBoeuf) and Tran

361. Like **Lisogurski** and **LeBoeuf**, **Tran** is analogous art, in the same field as the ’455 patent—including physiological monitoring—and is reasonably pertinent to the problems addressed by the ’455 patent—e.g., improving optical physiological monitoring. ’455 patent, 8:29-9:9; Lisogurski, 1:10-11; LeBoeuf, Abstract, [0025], [0026]; Tran, 1:10-33, 2:66-67, 4:30-36, 36:62-37:12.

362. 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.

363. 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. 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. 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, ¶¶215-216 (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).

364. 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**.

365. 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.

366. 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.

367. 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.

368. 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, 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.

369. With respect to **Tran’s** pattern identification or classification and data regression teachings, a person of ordinary skill in the art would have been motivated to apply **Tran’s** teachings of pattern identification, classification, or regression signal processing methodologies to **Lisogurski’s** system to improve the accuracy and reliability of data analysis of physiological information and improve the overall robustness of these analyses. Accordingly, I understand that the Board found that “a person of ordinary skill would have looked to Tran for a slightly different purpose,

i.e., to improve how the data obtained by Lisogurski's device is stored and analyzed." '484-FWD, 46-47. A person of ordinary skill in the art would have understood the significant advantages of employing advanced data analysis methods such as neural networks, Hidden Markov Models, and regression analyses in wearable physiological monitoring devices. These analytical methodologies were well known in the art as effective at identifying physiological patterns, classifying physiological states, flagging irregularities, and improving real-time decision-making capabilities in health monitoring systems. For example, as I discussed above, **Tran** teaches the use of artificial neural networks for the purpose of identifying patterns in physiological data ("a patient's vital signs") that are associated with potentially dangerous conditions, thus making the identification more accurate and reliable. '484-Anthony, ¶227 (citing Tran, 11:1-8, 9:23-54, 11:16-19, 12:4-16, 23:39-50, 24:45-18, 80:24-8:1); Tran, 9:23-54, 11:1-8, 12:4-16, 11:16:19; 23:39-50. **Tran** further explains that neural networks are "**quite robust** at recognizing user habits or patterns," which enables the system to improve the ability to flag irregularities that may signal clinically important conditions. '484-Anthony, ¶227 (citing Tran, 11:1-8, 9:23-54) (emphasis my own). **Tran** also explains that its data analysis technique also includes a Hidden Markov Model to "derive a set of reference pattern templates, each template is representative of an identified pattern in a vocabulary set of reference treatment patterns." '484-Anthony, ¶227 (citing

Tran, 24:45-25:18, 80:24-8:3). **Tran** explains that the Hidden Markov Model can be used together with a neural network: “[t]he addition of a neural network at the front end of the HMM in an embodiment provides the capability of representing states with dynamic values.” 484-Anthony, ¶227 (citing Tran, 24:58-60). A person of ordinary skill in the art would have understood that **Tran’s** neural network and HMM perform pattern identification or classification and allow identification of certain conditions more reliable and accurate. Lastly, **Tran** also discloses using “regression methods” for the same purpose: to analyze physiological signals. Tran, 22:24-31. Accordingly, a person of ordinary skill in the art would be motivated to apply **Tran’s** data analysis techniques to **Lisogurski’s** system to enhance its health monitoring capabilities by improving the robustness of extracting clinically relevant insights from sensor data.

370. Moreover, a person of ordinary skill in the art would have been further motivated to apply **Tran’s** pattern identification or classification and data teachings to **Lisogurski’s** system for more accurate identification and analysis of conditions of interests. Accordingly, I understand that the Board determined that **Tran’s** pattern identification and classification analyze certain vital signs of patients “to track and flag patterns in a patient’s vital signs to recognize possibly dangerous conditions.” ’484-FWD, at 52-53. **Lisogurski** already discloses using an “algorithm ... to determine” physiological parameters including, for example, “a regression

based algorithm.” Lisogurski, 9:36-45. Accordingly, because **Lisogurski** contemplates using various computational approaches to interpret sensor data, including regression methods, a person of ordinary skill in the art would have been motivated to incorporate well-established data analysis methods—such as those disclosed in **Tran**—to improve the efficiency, accuracy, and reliability of how data is processed by **Lisogurski’s** device, as explained above.

371. A person of ordinary skill in the art would have understood that data analysis techniques—pattern identification or classification and signal regression taught by **Tran**—were well-known in the art, recognized as standard tools for extracting meaningful insights from physiological signals, and easily implemented and/or applied to **Lisogurski’s** system. For example, pattern identification or classification techniques were already being used in analyzing physiological data for the detection of conditions such as sleep apnea or sepsis, as shown in U.S. Patent Nos. 8,862,196, 8,412,655, and 5,511,553, which I understand have been designated as Exhibits 1042-1044, respectively. See Ex. 1042, 17:10-37, 35:1-36:12; see also Ex. 1043, 28:9-29:40, 31:29-53; Ex. 1044, 8:3-11, 45:6-11, 45:65-46:12. Also, as shown in U.S. Patent No. 6,931,269, which I understand has been designated as Exhibit 1051, pattern identification or classification techniques were already being used to “classify different patterns of pulse and plethysmographic waveforms that can occur under different physiological conditions.” Ex. 1051, 2:21-4:36. As also

shown in U.S. Patent No. 8,364,226, which I understand has been designated as Exhibit 1050, signal regression techniques were also commonly used to analyze measured signals in order to calculate physiological parameters of a monitored patient, such as oxygen saturation and respiration rate. Ex. 1050, 24:1-12, 25:16-32:61.

372. A person of ordinary skill in the art would have had a reasonable expectation of success in applying **Tran's** artificial intelligence and other data analysis technique to **Lisogurski's** system. As I discussed above, data analysis techniques such as pattern identification, classification, and signal regression, and use of artificial intelligence to perform these techniques 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 ¶¶ 368 and 371. 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.

373. **LeBoeuf's** teaching regarding the spatial configuration of the light sources and detectors as well as the physical configuration of **Lisogurski's** sensor unit (Section IX.B) pertain to different aspects of **Lisogurski's** system (i.e., the monitor and/or software within the monitor) where **Tran's** teaching would be applicable. A person of ordinary skill in the art would have understood that implementing spatial detector configurations and the use of reflective surfaces (as

taught by **LeBoeuf**) and advanced data analysis techniques (as taught by **Tran**) address separate but complementary system components. As such, the motivation to incorporate **Tran’s** data analysis techniques into **Lisogurski’s** system—and the reasonable expectation of success in doing so—would remain the same for **Lisogurski’s** system applying **LeBoeuf’s** teaching.

3. Invalidity of Claims 1-20 Over Lisogurski in view of LeBoeuf and Tran

374. As I discuss below, Claims 1-20 are rendered obvious by **Lisogurski** in view of **LeBoeuf** and **Tran**. In addition to my discussion in Sections IX.C.1-2, the following discussion identifies example disclosures that each disclose Challenged Claims 1-20.

a. Elements [1.pre], [8.pre], [15.pre]

375. Elements [1.pre], [8.pre], and [15.pre] (collectively, the “smart phone or tablet” limitations) each recite: “**A system for measuring one or more physiological parameters and for use with a smart phone or tablet, the system comprising.**” These elements are disclosed and rendered obvious by **Lisogurski**, for the reasons I discuss above in connection with ’455 patent elements [1.pre], [8.pre], and [15.pre] (Sections IX.A.3.a.[1.pre], IX.A.3.o.[8.pre], IX.B.3.f.[15.pre]).

376. To the extent additional disclosure is required for the “**smart phone or 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, 33:58-34:40).

b. Element [5.a]

377. Element [5.a] recites: “**The system of claim 4, wherein the system is configured to use artificial intelligence to process some of the at least a portion of the output signal; and.**” This additional limitation is met by **Lisogurski** in view of **Tran**.

378. See my discussion of claim 4 above (Section IX.B.3.c.[4]).

379. Regarding a substantially identical limitation in the prior ’484 IPR reciting “wherein the wearable device **is configured to use artificial intelligence** in

making decisions associated with **at least a portion of the output signal,**” 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).

380. ’455 patent element [5.a] is substantially identical to a corresponding limitation in the ’484 patent on which I previously opined, and which recites: “wherein the wearable device **is configured to use artificial intelligence** in making decisions associated with **at least a portion of the output signal.**” Aside from

differing turns of phrases, the main differences between the two limitations are (1) the '484 patent's use of "the wearable device" as opposed to the '455 patent element [5.a]'s use of "the system," and (2) the '484 patent claim use of "in making decisions associated with" and '455 patent element [5.a]'s use of "to process."

381. **First**, as I discuss above in relation to claim elements [1.pre] and [1.a], **Lisogurski's** wearable device is part of its system (Sections IX.A.3.a-b.[1.pre]-[1.a]). Second, a person of ordinary skill in the art would have understood (or at least found it obvious) that **Tran** teaches using artificial intelligence to process an output signal, as it discloses using a "statistical analyzer such as a neural network" to "process[]" "data received by [a] server." Tran 11:6-30. Thus, the differences between the two terms do not change my analysis, and my opinions regarding the '484 patent term apply equally to '455 patent element [5.a]. '484-Anthony, ¶¶217-219.

382. As I have discussed in Section IX.C.2, a person of ordinary skill in the art would have been motivated to apply **Tran's** artificial intelligence teachings to **Lisogurski's** system (either alone or as modified by **LeBoeuf**) such as to enable **Lisogurski's** system to acquire more accurate physiological measurements and, to analyze the collected data to, for example, more effectively detect and flag clinically significant conditions.

c. Element [5.b]

383. Element [5.b] recites: “**wherein the system is configured to perform pattern identification or classification, or wherein the system is configured to apply one or more regression signal processing methodologies to at least a part of the output signal.**” This additional limitation is met by **Lisogurski** in view of **Tran**.

384. **Lisogurski** in view of **Tran** renders obvious “**wherein the system is configured to perform pattern identification or classification.**”

385. Regarding a substantially identical limitation in the prior ’484 IPR reciting “wherein the wearable device is **configured to perform pattern identification or classification,**” 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.” ’484-FWD, 46-47. Moreover, I understand that the Board determined that the petitioner demonstrated (1) “Tran [] disclos[es] neural networks are used to recognize patterns”; (2) “Tran uses neural networks to track and flag patterns in a patient’s vital signs to recognize possibly dangerous conditions”; and (3) “Tran teaches using the neural network with a Hidden Markov Model (a derived

set of reference pattern templates) to perform pattern matching and pattern identification or classification.” ’484-FWD, 52-53. 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, ¶¶226-227 (citing Tran, 9:23-54, 11:1-8, 11:16-19, 12:4-16, 23:39-50, 24:45-60, 80:24-81:3).

386. ’455 patent element [5.b] is substantially identical to the corresponding limitation in the ’484 patent on which I previously opined, and which recites: “wherein the wearable device is **configured to perform pattern identification or classification.**” The main difference between the two limitations is the ’484 patent’s use of a “the wearable device” as opposed to the ’455 patent element [5.b]’s use of “the system.” As I discuss above in relation to claim [5.a], **Lisogurski**’s wearable device is part of its system (Section IX.C.3.b.[5.a]). Thus, my opinions regarding the ’484 patent term apply equally to ’455 patent element [5.b]. ’484-Anthony, ¶¶228-229 (referring to ’484-Anthony, ¶¶226-227).

387. **Lisogurski** discloses the system is **configured to apply one or more regression signal processing methodologies** (e.g., “regression based algorithm”) **to at least a part of the output signal.** Lisogurski, 5:25-47, 9:36-45.

388. A person of ordinary skill in the art would have understood that cardiac cycle modulation techniques, such as explicitly taught by **Lisogurski**, were standard, established methodologies in optical physiological monitoring. Detecting different

portions of the cardiac cycle was well-known and routinely employed. Regression-based algorithms provided enhanced accuracy and reliability in deriving clinically significant physiological parameters, such as blood oxygen saturation. For example, **Lisogurski** discloses using “cardiac cycle modulation,” which refers generally to “the modulation techniques generally correlated to the cardiac cycle” and “related to ... physiological parameters.” Lisogurski, 5:25-47. **Lisogurski** also teaches “vary[ing] the algorithm used to determine a physiological parameter based, in part, on the cardiac cycle modulation [CCM] technique.” Lisogurski, 9:36-38. The CCM technique may detect either just the peaks and valleys of the cardiac pulse cycle or the entire pulse cycle, and the choice of algorithm—such as for determining blood oxygen saturation—depends on which portion of the cycle is detected. Lisogurski, 9:38-45. When the entire pulse is detected, **Lisogurski** teaches using a “regression based algorithm” to determine blood oxygen saturation. Lisogurski, 9:42-45.

389. To the extent additional disclosure is required, **Tran** also discloses the system configured to **apply one or more regression signal processing methodologies** (e.g., apply “regression methods”) **to at least a part of the output signal** (e.g., “data”). Tran, 3:64-65, 21:58-60, 22:23-28, 50:16-54:34, 86:48-51.

390. A person of ordinary skill in the art would have understood that employing advanced analytical models, including regression-based techniques, to analyze physiological data was well-established, was standard practice in the

physiological monitoring and healthcare fields. Consistent with that understanding, for example, **Tran** discloses employing “data driven analyzers” to “track [a] patient’s habits” (such as their “eating and drinking habits, sleeping habits, or exercise habits”) and to “track the patient’s risk of stroke or heart attack.” *Tran*, 22:23-28, 54:35-40, 3:64-65. **Tran** further discloses that: “[t]hese data driven analyzers may incorporate a number of models such as parametric statistical models, non-parametric statistical models, clustering models, nearest neighbor models, regression methods, and engineered (artificial) neural networks.” *Tran*, 54:35-40; *see also* *Tran*, 22:23-28. The models, including regression methods, are applied to the output data (i.e., signals data detected by **Tran’s** system). For example, to “monitor and predict stroke attack,” **Tran** teaches using its system detect various types of physiological data, such as pressure and flow of fluids (including blood) in the brain, tomographic imaging of cranial tissue, and EEG signals. *Tran*, 50:16-54:34 (detailing additional physiological data collected for stroke monitoring and prediction); *see also* *Tran*, 54:6-13 (“[T]o detect heart attack, the system detects discomfort in the center of the chest that lasts more than a few minutes, or that goes away and comes back. Symptoms can include pain or discomfort in one or both arms, the back, neck, jaw or stomach. The system can also monitor for shortness of breath which may occur with or without chest discomfort. Other signs may include breaking out in a cold sweat, nausea or lightheadedness.”), 86:48-51 (“[F]or

detecting heart attacks or stroke attacks, ... the detection and classification of ventricular complexes from the ECG data is can be used for rhythm and various types of arrhythmia to be recognized.”), 21:58-60 (“[T]o determine whether the user is experiencing muscle weakness reflective of a stroke,” the system “tracks typical arm and leg movements.”). A person of ordinary skill in the art would have understood that **Tran** teaches applying its “regression methods” for the analyzing of output data constitutes a type of regression signal processing methodology because it involves (1) mathematical analysis—in particular, regression analysis, which is a statistical method used to analyze correlation between parameters—and (2) transformation of detected signals to extract useful information—here, the onset of a stroke.

391. As I discuss above in Section IX.C.2, a person of ordinary skill in the art would have been motivated to apply **Tran’s** pattern identification or classification teachings and regression signal processing teachings to **Lisogurski** either alone or in view of **LeBoeuf** as to enable **Lisogurski’s** system to acquire more accurate measurements and conduct more accurate analyses. Indeed, from the perspective of a person of ordinary skill in the art, pattern identification, classification, and regression-based analyses would have been recognized as common analytical tools that significantly improve decision-making, accuracy, and physiological parameter reliability.

d. Claim [6]

392. Claim 6 recites: “**The system of claim 5, wherein the wearable device further comprises a reflective surface to receive and redirect at least some of the output optical light from the plurality of semiconductor sources.**” This additional limitation is met by **Lisogurski** in view of **LeBouef** for the reasons I discuss above in connection with ’455 patent claims 5 and 17 (Sections IX.C.3.b-c.[5.a]-[5.b], IX.B.3.w.[17]).

393. ’455 patent claim 6 is identical to a portion of ’455 claim 17, which recites: “**...wherein the wearable device further comprises a reflective surface to receive and redirect at least some of the output optical light from the plurality of semiconductor sources.**” Thus, my opinions regarding the ’455 patent claim 17 apply equally to ’455 patent claim 6 (Section IX.B.3.w.[17]).

e. Claim [7]

394. Claim 7 recites: “**The system of claim 6, wherein the wearable device is further configured to increase the signal-to-noise ratio by increasing a pulse rate of at least one of the semiconductor sources from an initial non-zero pulse rate.**” This additional limitation is met by **Lisogurski**.

395. Regarding two substantially identical limitations in the prior ’484 IPR reciting (1) “**the wearable device configured to increase the signal-to-noise ratio**” and (2) “**by increasing a pulse rate of at least one of the plurality of**

semiconductor sources from an initial pulse rate,” I understand the Board determined that the petitioner demonstrated that “Lisogurski teaches regulating a light drive signal, i.e., electric current applied to LEDs and that LEDs can be modulated by controlling ‘drive cycle parameters’ such as light intensity, duty cycle, and light source firing rate.” ’484-FWD, 27-29. I understand that the Board determined that the petitioner advanced two arguments that include that, **one (the sampling rate argument)**, a “skilled person would have recognized that a light source must have an initial firing rate (‘initial pulse rate’) that the system can later change,” and that “Lisogurski teaches this feature by describing embodiments in which the pulse rate of the LED is correlated to the sampling rate of an analog-to-digital converter in the detector,” and that “by increasing firing rate from an initial rate to correlate the firing rate to the sampling rate of an analog-to-digital (A-D) converter, Lisogurski improves signal-to-noise ratio by spreading the noise across more samples.”; and, **two (the CCM argument)**, “cardiac cycle modulation (CCM) varies the light drive signal to remain synchronous with a subject’s heart rate, thereby increasing the pulse rate as the subject’s heart rate increases and reducing noise by 1–4%.” ’484-FWD, 29-30.

396. I understand that the Board determined “based on its **sampling rate argument**, [p]etitioner ha[d] demonstrated Lisogurski teaches the pulse rate limitation,” and that “Petitioner’s argument is consistent with its assertion that

‘Lisogurski explains that varying the drive cycle parameters can increase signal-to-noise ratio of the device when interference is encountered,’” and that “[p]etitioner’s argument is consistent with its assertion that ‘Lisogurski explains that varying the drive cycle parameters can increase signal-to-noise ratio of the device when interference is encountered.’” ’484-FWD, 30-32.

397. I understand that the Board determined “Petitioner ha[d] demonstrated that Lisogurski discloses the application of **CCM** alone improves signal-to-noise ratio and teaches the pulse rate limitation,” and that “Lisogurski discloses a system that may alter the CCM technique based on noise or ambient light and may be used with or without other forms of modulation,” and that Lisogurski discloses CCM techniques that “may provide improved performance” “in the presence of moderate noise.” ’484-FWD, 32-36.

398. The Board’s findings and conclusions are 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, ¶¶48-56, 155-164 (citing Lisogurski, 1:19-21, 1:44-46, 1:67-2:3, 5:55-6:6, 9:46-52, 9:57-60, 10:48-49, 11:38-41, 11:50-54, 14:49-55, 16:2-9, 17:55-59, 18:16-31, 25:49-55, 31:11-24, 31:39-55, Fig. 1), 172-183 (citing ’484 patent, 25:66-26:4, 26:29-30, 28:23-26; Lisogurski, 1:22-25, 2:1-2, 8:29-35, 9:46-52, 11:43-46, 11:52-55, 25:46-61, 27:44-52, 33:56-58, 35:5-9, 35:27-31, 37:6-22).

399. Regarding two substantially identical limitations in the prior '533 IPR reciting (1) “**the light source configured to increase signal-to-noise ratio**” and (2) “**by increasing a pulse rate of at least one of the plurality of semiconductor sources,**” I understand the Board determined that “[p]etitioner has demonstrated how Lisogurski alone teaches” this limitation, and that (1) “[p]etitioner argues that Lisogurski teaches the pulse rate limitation because the LED firing rate and detector sampling rate are correlated and ‘increasing the sampling rate ‘may result in more accurate and reliable physiological information.’”; and (2) that [p]etitioner contends that “‘when a person’s heart rate increases’ Lisogurski ‘increase[s] the sampling rate and emitter firing rate to become or remain synchronous with [the] cardiac cycle [, which] ... allows Lisogurski to obtain ‘more accurate and reliable physiological information,’ which a person skilled in the art would have understood occurs ‘because [the] SNR is higher.’” ’533-FWD, 26-29. Moreover, I understand the Board determined that (1) “Lisogurski teaches correlating LED pulse rate and cardiac cycle rate, for example, by increasing LED pulse rate to match an increased cardiac cycle rate”; (2) “Lisogurski teaches that noise contributes ‘variations of 2.6%, 1.9%, and 3.8% to the computed pulse amplitudes of PPG signal 2602, systole period modulated PPG signal 2604, and diastole period modulated PPG signal 2606.’ ... Thus, increasing the LED firing rate to become synchronous with the systole period of an increased cardiac cycle rate can result in a physiological

measurement having less noise (1.9%), and, therefore, an increased signal-to-noise ratio. Lisogurski also teaches that modulating an LED drive signal to match ‘particular segments of a respiratory cycle *may* provide an increased signal-to-noise ratio’”; and (3) “a light source is ‘configured’ to increase signal-to-noise by increasing LED pulse rate when it is ‘capable’ of doing so, i.e., when the increased pulse rate allows the device to operate in a frequency range having less environmental noise. This is true, even if the device does not always do so.” ’533-FWD, 29-30. 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, ¶¶48-56, 110-116 (citing ’533 patent, 19:37-42, 19:67-20:2, 21:55-59; Lisogurski, 1:22-25, 2:1-2, 8:29-35, 9:46-52, 11:43-46, 11:52-55, 25:49-55, 27:44-52, 33:47-49, 35:5-9, 33:56-58, 35:27-31, 37:6-22).

400. ’455 patent claim 7 is substantially identical to the corresponding limitations in the ’484 patent on which I previously opined, and which recite: (1) “**the wearable device configured to increase the signal-to-noise ratio**” and (2) “**by increasing a pulse rate of at least one of the plurality of semiconductor sources from an initial pulse rate.**” Aside from differing turns of phrases, the main difference between the limitations is the ’455 patent’s use of “increasing a pulse rate ... from an initial pulse rate” as opposed to the ’455 patent’s use of “increasing a pulse rate ... from an initial non-zero pulse rate.” As I explain below, **Lisogurski**

teaches or at least renders obvious an increase from an initial non-zero pulse rate. Thus, my opinions regarding the '484 patent terms apply equally to '455 patent claim 7. '484-Anthony, ¶¶48-56, 155-164, 172-192.

401. '455 patent claim 7 is substantially identical to the corresponding limitations in the '533 patent on which I previously opined, and which recite: (1) “the light source configured to increase **signal-to-noise ratio**” and (2) “**by increasing a pulse rate of at least one of the plurality of semiconductor sources.**” Aside from differing turns of phrases, the main difference between the limitations is the '455 patent's additional use of “increasing a pulse rate ... from an initial non-zero pulse rate.” For the reasons I explain below, **Lisogurski** teaches or at least renders obvious an increase from an initial non-zero pulse rate. Thus, my opinions regarding the '533 patent terms apply equally to '455 patent claim 7. '533-Anthony, ¶¶48-56, 95-103, 110-122, 167.

402. Regarding the '455 patent's recitation of “**from an initial non-zero pulse rate,**” **Lisogurski** discloses improving signal-to-noise ratio (SNR) using various techniques, including: (1) by correlating sampling rate and LED firing (pulse) rate, and (2) by using cardiac cycle modulation (CCM) to vary the light drive signal to remain synchronous with a subject's heart rate. '484-Anthony, ¶¶172-183 (citing the '484 patent, 25:66-26:4, 26:29-30, 28:23-26; Lisogurski, 1:22-25, 2:1-2, 8:29-35, 9:46-52, 11:43-46, 11:52-55, 25:46-61, 27:44-52, 33:47-49, 33:56-58,

35:5-9, 35:27-31, 37:6-22,); '533-Anthony, ¶¶110-116 (citing the '533 patent, 19:37-42, 19:67-20:2, 21:55-59; Lisogurski, 1:22-25, 2:1-2, 8:29-25, 9:46-52, 9:57-60, 11:43-46, 11:52-55, 25:49-55, 27:44-52, 33:47-49, 33:56-58, 35:5-9, 35:27-31, 37:6-22).

403. Regarding the first technique (*i.e.*, correlating sampling rate and LED firing (pulse) rate), **Lisogurski** discloses that the light sources in its system—*i.e.*, LEDs have a firing (pulse) rate. *See, e.g.*, Lisogurski, 35:16-17 (“firing rate of the emitters”), 35:28 (“emitter firing rate”), claim 7 (“light source firing rate”). **Lisogurski** further discloses increasing the LED firing rate. *E.g.*, Lisogurski, 35:30 (“increasing the emitter firing rate”). Taken together, a person of ordinary skill in the art would have understood that **Lisogurski** contemplates increasing the LED’s firing rate from an initial non-zero firing (pulse) rate value to a higher non-zero firing (pulse) rate value. For at least this reason, Lisogurski teaches or at least renders obvious that the firing rate of its LEDs are increased from a non-zero pulse rate.

404. Regarding the second CCM technique, **Lisogurski** discloses that its cardiac cycle modulation entails “generat[ing a] light drive signal such that a parameter of the emitted one or more photonic signals varies substantially synchronously with physiological pulses of the subject.” Lisogurski, 25:46-52. As I explain in my '484 patent Declaration, a person of ordinary skill in the art would have understood this to mean that **Lisogurski’s** system adjusts the LED firing

(pulse) rate to stay in sync (i.e., “substantially synchronous[]”) with a subject’s heart rate. Therefore, as the subject’s heart rate increases, the system correspondingly increases the LED firing (pulse) rate to maintain synchronization. ’484-Anthony, ¶¶181-182 (citing Lisogurski, 25:46-61). A person of ordinary skill would have understood that because a living subject’s heart rate is non-zero, **Lisogurski** teaches or at least renders obvious increasing the LED firing (pulse) rate from an initial, non-zero pulse value.

f. Claim [12]

405. Claim 12 recites: “**The system of claim 11 wherein the system is configured to use artificial intelligence in making decisions associated with some of the at least a portion of the output signal; and wherein the system is configured to perform pattern identification or classification, or wherein the system is configured to apply one or more regression signal processing methodologies to at least a part of the output signal.**” This additional limitation is disclosed and rendered obvious by **Lisogurski** in view of **Tran** for the reasons I discuss above in connection with ’455 patent elements [5.a]-[5.b] and claim 11 (Sections IX.C.3.b-c.[5.a]-[5.b], IX.A.3.cc.[11]).

406. A portion of ’455 patent claim 12 is substantially identical a corresponding limitation in the ’484 patent, which recites: (1) “...wherein 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 ’455 patent claim 12 and the corresponding ’484 patent limitation is the ’484 patent’s use of “the wearable device” as opposed to the ’455 patent claim 12’s use of “the system.” However, as I discuss above in relation to claim elements [1.pre] and [1.a], **Lisogurski’s** wearable device is part of its system (Sections IX.A.3.a-b.[1.pre]-[1.a]). Thus, the differences between the two terms do not change my analysis, and my opinions regarding the ’484 patent term apply equally to ’455 patent claim 12. ’484-Anthony, ¶¶217-219.

407. A portion of ’455 patent claim 12 is identical to ’455 patent element [5.b], which recites: “**wherein the system is configured to perform pattern identification or classification, or wherein the system is configured to apply one or more regression signal processing methodologies to at least a part of the output signal.**” Thus, my opinions regarding the ’455 patent element [5.b] apply equally to ’455 patent claim 12 (Section IX.C.3.c.[5.b]).

g. Claim [13]

408. Claim 13 recites: “**The system of claim 12, wherein the wearable device further comprises a reflective surface positioned to receive and redirect at least some of the output optical light from the plurality of semiconductor sources.**” This additional limitation is met by **Lisogurski** in view of **LeBouef** for the reasons I discuss above in connection with ’455 patent claims 12 and 17

(Sections IX.C.3.f.[12], IX.B.3.w.[17]).

409. '455 patent claim 13 is substantially identical to a portion of '455 patent claim 17, which recites: "...**wherein the wearable device further comprises a reflective surface to receive and redirect at least some of the output optical light from the plurality of semiconductor sources.**" The main difference between the limitations is the '455 patent claim 13's use of "a reflective surface positioned to receive and redirect". A person of ordinary skill in the art would have understood that for a reflective surface to receive light and subsequently redirect, it is positioned in a manner that allows it to receive the light. Thus, the differences between the terms do not change my analysis, and my opinions regarding the '455 patent claim 17 apply equally to '455 patent claim 13 (Section IX.B.3.w.[17]).

h. Claim [14]

410. Claim 14 recites: "**The system of claim 13, wherein the wearable device is further configured to increase the signal-to-noise ratio by increasing a pulse rate of at least one of the semiconductor sources from an initial non-zero pulse rate.**" This additional limitation is met by **Lisogurski** for the reasons I discuss in connection with '455 patent claims 7 and 13 (Section IX.C.3.e.[7], IX.C.3.g.[13]).

411. '455 patent claim 14 is identical to a portion of '455 patent claim 7, which recites: "...**wherein the wearable device is further configured to increase the signal-to-noise ratio by increasing a pulse rate of at least one of the**

semiconductor sources from an initial non-zero pulse rate.” Aside from the differing claims they depend from, the two claims are otherwise identical. Thus, the differences between the terms do not change my analysis, and my opinions regarding the ’455 patent claim 7 apply equally to ’455 patent claim 14 (Section IX.C.3.e.[7]).

i. Claim [18]

412. Claim 18 recites: “**The system of claim 17, wherein the system is configured to use artificial intelligence in making decisions associated with some of the at least a portion of the output signal; and wherein the system is configured to perform pattern identification or classification, or wherein the system is configured to apply one or more regression signal processing methodologies to at least a part of the output signal.**” This additional limitation is met by **Lisogurski** in view of **Tran** for the reasons I discuss above in connection with ’455 patent elements [5.a]-[5.b] and claim 17. (Sections IX.C.3.b-c.[5.a]-[5.b], IX.B.3.w.[17]).

413. ’455 patent claim 18 is substantially identical to the combination of ’455 elements [5.a] and [5.b], which recite, respectively: (1) “**...wherein the system is configured to use artificial intelligence to process some of the at least a portion of the output signal; and**” and (2) “**wherein the system is configured to perform pattern identification or classification, or wherein the system is configured to apply one or more regression signal processing methodologies to at least a part**

of the output signal.” The main difference between the limitations is the ’455 patent claim 18’s use of “artificial intelligence in making decisions associated with some of the at least a portion of the output signal” and the ’455 patent element [5.a]’s use of “artificial intelligence to process some of the at least a portion of the output signal.” For the reasons I discuss above regarding claim 12 (Section IX.C.3.f.[12]), a person of ordinary skill in the art would have understood that using artificial intelligence to make decisions associated with some part of a signal entails processing that signal—specifically, analyzing the physiological data (i.e., at least a portion of the output signal) to extract information from it. Thus, the differences between the terms do not change my analysis, and my opinions regarding the ’455 patent elements [5.a] and [5.b] apply equally to ’455 patent claim 18 (Sections IX.C.3.b-c.[5.a]-[5.b]).

j. Claim [19]

414. Claim 19 recites: “**The system of claim 18, wherein the system is at least in part configured to detect an object, and a property of at least some of the output signal is compared by at least one of the wearable device, the smart phone, and the tablet to a threshold.**” This additional limitation is met by **Lisogurski**.

415. Regarding substantially identical limitation in the prior ’484 IPR reciting “...**wherein the wearable device is at least in part configured to detect**

an object,” and a limitation identical to a portion of the ’455 claim 19 reciting, “...and a property of at least some of the output signal is compared by at least one of the wearable device, the smart phone or tablet to a threshold,” I understand the Board determined that it “agree[s] with [p]etitioner that Lisogurski discloses that the wearable device is configured to detect an object,” and that (1) “Lisogurski discloses the device can identify an object, such as an ear or a wrist, because it can distinguish when it has fallen off (probe off error).”; (2) “Lisogurski [] disclos[es] comparing a detected signal to a threshold or target value and using the outcome to change the operational mode of the device”; and (3) “Lisogurski compares the output signal to thresholds that identify portions of interest for further processing or to change light source modulation, e.g., by comparing changes in ambient light and noise to a threshold to determine changes in noise level.” ’484-FWD, 49-52. Such disclosures, in combination, indicate that **Lisogurski** is configured to detect an object, such as a target sample and target signal from a physiological measurement. 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, ¶¶220-222 (citing Lisogurski, 9:46-52, 24:41-57, 36:66-37:2, 37:8-14, 40:42-41:39). Moreover, I understand the Board determined that the claim was unpatentable on remand. ’484-RFWD, 4-7.

416. A portion of ’455 patent claim 19 is substantially identical to a portion

of the corresponding claim in the '484 patent on which I previously opined, and which recites: "...wherein the wearable device is at least in part configured to detect an object..." The main difference between the claims is '455 patent claim 19's use of "wherein the system" and the '484 patent's use of "wherein the wearable device." As I discuss above regarding claim element [5.a], **Lisogurski's** wearable device is part of its system (Section IX.C.3.b.[5.a]).

417. A portion of '455 patent claim 19 is identical to a portion of the corresponding claim in the '484 patent on which I previously opined, and which recites: "...and a property of at least some of the output signal is compared by at least one of the wearable device, the smart phone or tablet to a threshold." Thus my opinions regarding the '484 patent terms apply equally to '455 patent claim 19. '484-Anthony, ¶¶220-222.

418. As further support for this limitation, **Lisogurski** discloses, for example, comparing blood oxygen saturation "to a threshold or target value, such as threshold 830," and changing the device's mode of operation based on the results. Lisogurski, 24:41-57; *see also* Lisogurski, 9:46-52, 37:8-14, 40:42-41:39 (disclosing additional comparison analyses). A person of ordinary skill would have understood that this comparison would be executed by the processor 172 in the monitor 104 that "receive[s] and process[es] physiological signals" and "determine[s] one or more physiological parameters based on the received physiological signals." Lisogurski,

10:42-46, 11:28-32, 14:56-64, Fig. 1.

k. Claim [20]

419. Claim 20 recites: “**The system of claim 19, wherein the wearable device is further configured to increase the signal-to-noise ratio by increasing a pulse rate of at least one of the semiconductor sources from an initial non-zero pulse rate.**” This additional limitation is met by **Lisogurski**.

420. For the reasons I discuss above in claims 7 and 19, **Lisogurski** meets this limitation (Sections IX.C.3.e.[7], IX.C.3.j.[19]).

421. Claim 20 is identical to a portion of claim 7, which recites: “**...wherein the wearable device is further configured to increase the signal-to-noise ratio by increasing a pulse rate of at least one of the semiconductor sources from an initial non-zero pulse rate.**” Thus, my opinions regarding the ’455 patent claim 7 apply equally to ’455 patent claim 20 (Section IX.C.3.e.[7]).

D. GROUNDS 5-8: Grounds 1-4 in further view of Carlson (Claims 1-20):

1. Overview of Carlson

422. **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]. An example of the “ear clip 1” is depicted in Figure 2, which is reproduced below. **Carlson**, [0033], Fig. 2.

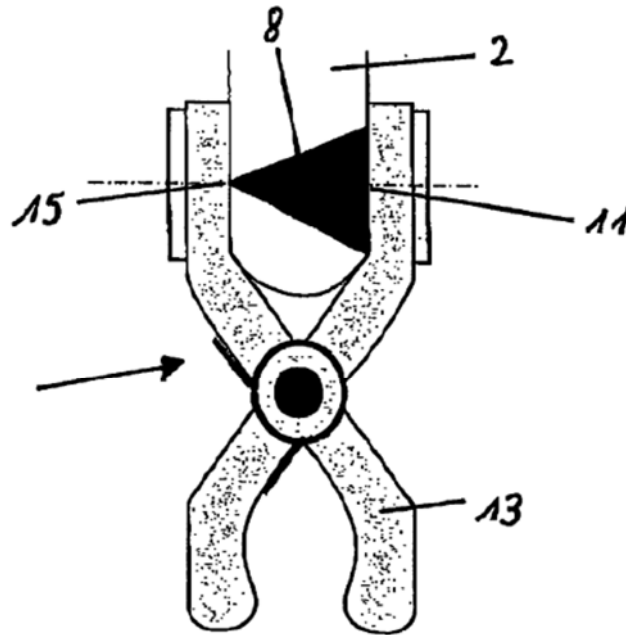


Figure 2

423. **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 is a light detector that 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.

424. **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.

425. **Carlson** discloses that it is an objective of the invention to provide “optical and/or electronic means for increasing the Signal-to-Noise ratio (S/N) ... in rough (optical) environmental conditions,” such as by emitting pulsed light (as opposed to “continuous light”) from its LEDs. Carlson, [0010], [0069]. For example, **Carlson** discloses that its system “temporarily modulate[s] the optical radiation of the LED at the carrier frequency f_c in order to shift the power spectrum of the pulsoximeter signals into a higher frequency range where environmental optical radiation is unlikely.” Carlson, [0065]. Temporary modulation frequency f_c is “chosen in such a way that it is outside the frequency spectrum of sunlight and of

ambient light.” Carlson, [0069]. This allows for the pulsoximeter signals to be “readily discriminated from electronic and parasitic contributions of environmental optical radiation” (i.e., environmental signals, such as sunlight and ambient light) and, thus, “increas[es] significantly the Signal-to-Noise and Signal-to-Background ratio.” Carlson, [0069]. ’533-FWD, 18-20.

2. Motivation to Combine

426. Like **Lisogurski**, **LeBoeuf**, and **Tran**, **Carlson** is analogous art, in the same field as the ’455 patent—including physiological monitoring—and is reasonably pertinent to the problems addressed by the ’455 patent—e.g., improving optical physiological monitoring. ’455 patent, 8:29-9:9; 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 ’455 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 discussions 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.

427. 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.

428. 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.

429. 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-Anthony, ¶112 (citing Carlson, [0010], [0014]; Lisogurski, 6:3-6, 9:49-60, 13:60-14:10, 14:40-55, 37:6-20); '533-Anthony, ¶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-Anthony, ¶112 (citing Carlson, [0010], [0014]; Lisogurski, 6:3-6, 9:49-60, 13:60-14:10, 14:40-55, 37:6-20); ’533-Anthony, ¶133 (citing Carlson, [0010], [0014]; Lisogurski, 6:3-6, 9:49-60, 13:60-14:10, 14:40-55, 37:6-20).

430. 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-Anthony, ¶113; ’533-Anthony, ¶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.

431. With respect to **Carlson’s** higher frequency light modulation teachings, the Board found in the prior ’533 IPR that a person of ordinary skill in the art would have been motivated to apply **Carlson’s** technique of “us[ing] a light source modulation to temporarily modulate the optical radiation of the LED” at a frequency that “is chosen in such a way that it is outside the frequency spectrum of sunlight and of ambient light,” “given that Lisogurski teaches that the firing rate of the LEDs

can be adjusted in response to changes in environmental conditions.” ’533-FWD, 33-35 (citing ’533-Pet. 35, 37-38; Lisogurski, 25:49-55, 27:44-52, 37:6-22; Carlson, ¶69). As the Board noted, both **Carlson** and **Lisogurski** “recognize the problem of ambient light noise ‘and the need to offset its negative impact on the signal-to-noise ratio’” such that a person of ordinary skill in the art “would have found it obvious to configure Lisogurski to increase the firing rate (frequency) of LEDs as taught by Carlson.” ’533-FWD, 31-34 (citing ’533-Pet., 38-39; Lisogurski, 9:46-60; Carlson, [0067]-[0069]); *see also* Lisogurski, 1:67-2:3, 9:46-60, 37:6-18; Carlson, [0068]-[0069], [0064]. 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, ¶¶84-86, 117-122 (Claim 13), ¶¶167-169 (Claim 5). Indeed, a person of ordinary skill in the art would have understood that higher-frequency modulation of LEDs to reduce ambient interference was a common and well-known industry technique. This technique, for example, provides a greater number of measurements within a given time frame, generates a known signal pattern distinct from ambient signals, improves the discrimination of the measurement signal from environmental noise, and shifts the measurement signal to higher frequency ranges where filtering and detection techniques can be more effectively and easily applied. The explicit teachings in both **Carlson** and **Lisogurski** clearly indicate the technical compatibility and practicality of this combination. A person of ordinary skill in the

art would have immediately recognized the benefit of this simple substitution and would anticipate successful implementation in the system of **Lisogurski**.

432. Further, the Board in the prior '484 IPR "[r]ecogniz[ed] that firing rate is among [Lisogurski's] light drive signal parameters that can be adjusted, [and] a person of ordinary skill would have had reason to employ Carlson's technique that temporarily increases the firing rate (or pulse rate of the LED) to a range that mitigates the effect of noise arising from transient ambient conditions, while avoiding excess battery power drain." '484-FWD, 37. 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, ¶¶184-192.

433. A person of ordinary skill in the art would have had a reasonable expectation of success in applying **Carlson's** teaching of increased firing rate of LEDs to **Lisogurski's** system. As the Board already found, **Lisogurski** teaches "(1) taking a physiological measurement in cardiac cycle modulation mode using LEDs modulated at a 1Hz pulse rate, (2) exiting the cardiac cycle modulation mode upon detecting ambient light noise, and (3) taking the measurement in a second mode that varies any combination of LED brightness, duty cycle, or firing rate, and **Carlson** teaches (4) taking a physiological measurement using an LED modulated at a 1000 Hz pulse rate to reduce ambient light noise." '533-FWD, 33-34 (citing '533-Pet., 35, 37 (citing Lisogurski, 25:49-55, 27:44-52, 37:6-22; Carlson [0069])).

As the Board explained, this “proposed combination of Lisogurski and Carlson is the simple ‘substitution of one element for another known in the field’ to achieve a predictable result.” ’533-FWD, 35 (internal quotations omitted). Therefore, both references teach techniques for changing the operation of their light sources to reduce the effects of ambient light and noise, and a person of ordinary skill in the art would have understood that any one of these techniques is a common substitute for another, and 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. A person of ordinary skill in the art would have appreciated the simplicity and predictability of substituting one known modulation method for another to enhance overall system performance. 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, ¶¶84-86, 121-122 (Claim 13), ¶¶167-169 (Claim 5).

434. **Carlson’s** teaching concern the modulation of **Lisogurski’s** light source, **LeBouef’s** teaching address the spatial configuration of the multiple light sources and multiple detectors as well as address the physical arrangement of **Lisogurski’s** sensor unit (Section IX.B), and **Tran’s** teachings pertain to **Lisogurski’s** monitor and/or software within the monitor (Section IX.C). 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 1-20 Over Lisogurski in view of LeBoeuf, Tran, and Carlson

435. As I discuss below, Claims 1-20 are rendered obvious by **Lisogurski** in view of **LeBoeuf**, **Tran**, and **Carlson**. In addition to my discussion in Sections IX.D.1-2, the following discussion identifies example disclosures that each disclose Challenged Claims 1-20.

a. Elements [1.c], [8.c], [15.c]

436. Elements [1.c], [8.c], and [15.c] (collectively, the “lens” limitations) are identical and each recite: “**the wearable device comprising 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.**” These elements are disclosed and rendered obvious by **Lisogurski**, for the reasons I discussed above in connection with ’455 patent elements [1.c], [8.c], and [15.c] (Sections IX.A.3.d.[1.c], IX.A.3.r.[8.c], IX.B.3.i.[15.c]).

437. To the extent additional disclosure is required for the “lens” limitations, **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”).

438. Regarding the “lens limitations” in the prior ’484 IPR reciting “**the wearable device comprising 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 that the Board determined 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,” 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).

439. Regarding the “lens limitations” in the prior ’533 IPR reciting “**the wearable measurement device comprising 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 that the Board determined “[p]etitioner

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). A person of ordinary skill in the art would have understood that the motivation to incorporate lenses into a wearable sensor device (e.g. to focus emitted optical radiation into human tissue to increase optical power, enhance signal-to-noise ratio, and improve measurement reliability, etc.) is clearly taught by **Carlson**, aligned with well-established industry practice, and supported by **Lisogurski**.

440. 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.d.[1.c], IX.A.3.r.[8.c], IX.B.3.i.[15.c]).

441. 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.

442. For the reasons I discuss in Section IX.D.2, a person of ordinary skill in the art would have 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**.

b. Claims [7], [14], [20]

443. Claims 7, 14, and 20 (collectively, the “pulse rate” limitations) are identical, aside from the claims they depend from and each recite: “**The system of claim [6 / 13 / 19], wherein the wearable device is further configured to increase the signal-to-noise ratio by increasing a pulse rate of at least one of the semiconductor sources from an initial non-zero pulse rate.**” These additional limitations are disclosed and rendered obvious by **Lisogurski**, for the reasons I have

provided in connection with '455 patent claims 7, 14, and 20 (Section IX.C.3.e.[7], IX.C.3.h.[14], IX.C.3.k.[20]).

444. To the extent additional disclosure is required for the “pulse rate” limitations, **Carlson discloses wherein the wearable device is further configured to increase the signal-to-noise ratio** (*e.g.*, “increase[] significantly the Signal-to-Noise and Signal-to-Background ratio”) **by increasing a pulse rate of at least one of the semiconductor sources from an initial non-zero pulse rate** (*e.g.*, “shift[ing] the frequency of the emitted light” so it is “substantially outside of frequency of noise and/or environmental signals”).

445. Regarding the “pulse rate” limitations in the prior '484 IPR reciting “the wearable device configured to increase the signal-to-noise ratio” and “by increasing a pulse rate of at least one of the plurality of semiconductor sources from an initial pulse rate,” I understand the Board “conclude[d] that the combined teachings of **Lisogurski** and **Carlson** would have disclosed or suggested the pulse rate limitation to a person of ordinary skill in the art.” '484-FWD, 43. Specifically, I understand that the Board determined that “Carlson [] expressly disclos[es] shifting the frequency of emitted light during operation from a first frequency to a second frequency, so it is substantially outside the frequency of noise and environmental signals,” and that “in view of Carlson’s recognition that sunlight interference is temporary and can occur at different frequencies, a person of ordinary skill would

have recognized that the pulse frequency can vary,” and that “a person of ordinary skill would have had reason to combine the teachings of Lisogurski and Carlson because both references identify and address the same problem, i.e., the negative impact of ambient light on signal-to-noise ratio.” ’484-FWD, 36. Moreover, I understand that the Board determined that “Lisogurski teaches a system that may vary the parameters that characterize the light drive signal in a way that is correlated to some physiological measurement, such as heart rate,” and that “the intensity or firing rate may change from a first value to a second value synchronously with heartrate.” ’484-FWD, 36-43. 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, ¶¶184-192 (citing Lisogurski, 1:67-2:3, 5:55-61, 9:46-60, 9:50-52, 9:57-60, 37:6-18; Carlson, [0002], [0020], [0067]-[0069], claims 10-11).

446. Regarding the “pulse rate” limitations in the prior ’533 IPR reciting “the light source configured to increase **signal-to-noise ratio**” and “**by increasing a pulse rate of at least one of the plurality of semiconductor sources**,” I understand the Board determined that “[p]etitioner has demonstrated that the combination of Lisogurski and Carlson teaches a light source configured to increase signal-to-noise by increasing LED pulse rate,” and that “a skilled person would have found it obvious to configure Lisogurski to increase the firing rate (frequency) of

LEDs as taught by Carlson, given that Carlson teaches that increasing the modulation frequency of the pulsed LEDs improves the signal-to-noise.” ’533-FWD, 30-31, 35. Moreover, I understand that the Board specifically found that “[p]etitioner cites sufficient evidence to persuasively demonstrate how Lisogurski teaches (1) modulating an LED by pulsing it at a 1 Hz rate that matches a cardiac cycle, (2) detecting ambient light noise, and (3) changing the LED modulation to operate in a second mode by changing one or more of the LED brightness, duty cycle (on time per cycle), or firing rate” and that the Board agreed that “Carlson teaches ‘pulsing the LEDs reduces the effects of ambient light including sunlight’ when ‘the pulse frequency (*‘pulse rate’*) is ‘chosen in such a way that it is outside the frequency spectrum of sunlight and of ambient light.’” ’533-FWD, 32-33. Lastly, I understand that the Board agreed that “Lisogurski ‘can readily be modified to incorporate the Carlson technique, given that Lisogurski teaches that the firing rate of the LEDs can be adjusted in response to changes in environmental conditions, such as changes in background noise or ambient light.’” ’533-FWD, 32-34. 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, ¶¶117-122 (citing Lisogurski, 1:67-2:3, 5:55-61, 9:46-60, 9:57-60, 37:6-18; Carlson, [0067]-[0069]).

447. For the reasons I discuss above, the “pulse” 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 “pulse rate” limitations (Section IX.C.3.e.[7], IX.C.3.h.[14], IX.C.3.k.[20]).

448. 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 offset the problem of ambient light noise, thereby advantageously improving **Lisogurski’s** systems’ signal-to-noise ratio. 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

449. I have found no evidence in either the '455 patent’s prosecution history or elsewhere that supports any secondary considerations arguments, or evidence of nexus to any challenged claim. *See generally* '455FH. Indeed, as I have discussed in connection to the prior art referenced herein, any purported solutions to problems or unexpected results in the '455 patent were already well-known in the art.

450. 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

451. In summary, I have concluded that the Challenged Claims are rendered

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obvious over the prior art references as I discussed above. Specifically, in my opinion, for at least the reasons above, the Challenged Claims of the '455 patent is obvious.

452. 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.

453. 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.

454. 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.

455. 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

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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., Frigala, 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.

- 2.36 Xiang Zhang, Jonathan Fincke, Charles Wynn, Matthew Johnson, Robert Haupt, and Brian Anthony. Full Noncontact Laser Ultrasound: First Human Data. *Nature, Light: Science & Applications*. 2019 (Accepted)
- 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.
- 2.46 Benjamin, Alex; Ely, Gregory; Fincke, Jonathan; Anthony BW. Reflection Ultrasound Tomography Using Localized Freehand Scans. *IEEE Int Symp Biomed Imaging*. 2020.
- 2.47 Ozturk A, Zubajlo RE, Dhyanani 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.
- 2.50 Fincke J, Zhang X, Shin B, Ely G, Anthony BW. Quantitative Sound Speed Imaging of Cortical Bone and Soft Tissue: Results from Observational Data Sets. *IEEE Trans Med Imaging*. 2021;PP(X):1–1.
- 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.
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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

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Magana-Salgado	Uriel	<i>Tenative: Muscle Health monitoring</i>	MechE	2023	expected
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	

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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. 11,160,455 (“’455 patent”)
1002	File History of U.S. Application No. 17/078,771 (“’455 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”)
1026	U.S. Patent Pub. No. 2010/0217102 (“LeBoeuf”)

Exhibit No.	DESCRIPTION
1027	U.S. Patent No. 8,108,036 (“Tran”)
1028	U.S. Patent Pub. No. 2005/0049468A1 (“Carlson”)
1030	U.S. Patent No. 7,029,628 (“Tam”)
1031	U.S. Patent No. 8,050,730 (“Zhang”)
1032	U.S. Patent No. 8,821,397 (“Al-Ali”)
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	Joseph D. Bronzino, The Biomedical Engineering Handbook (1995)
1039	U.S. Patent No. 8,079,735 (“Vakil”)
1041	U.S. Patent Pub. No. 2012/0197093 (“Valencell-093”)
1042	U.S. Patent No. 8,862,196 (“Lynn”)
1043	U.S. Patent No. 8,412,655 (“Colman”)
1044	U.S. Patent No. 5,511,553 (“Segalowitz”)
1045	U.S. Patent No. 6,801,799 (“Mendelson”)
1046	U.S. Patent No. 6,662,033 (“Casciani”)
1047	U.S. Patent No. 5,028,787 (“Rosenthal”)
1048	U.S. Pat. No. 9,239,951 (“Hoffberg”)

Exhibit No.	DESCRIPTION
1049	U.S. Pat. Pub. 2007/0194939 (“Alvarez”)
1050	U.S. Patent No. 8,364,226 (“Diab”)
1051	U.S. Patent No. 6,931,269 (“Terry”)
1059	U.S. Patent No. 5,497,769 (“Gratton”)
1060	U.S. Patent No. 5,827,182 (“Raley”)
1061	U.S. Patent No. 7,764,982 (“Dalke”)
1064	U.S. Patent No. 5,554,273 (“Demmin”)
1065	U.S. Patent No. 5,953,713 (“Behbehani”)
1077	U.S. Patent Publication No. 2006/0184040 (“Keller”)
1081	U.S. Patent No. 9,651,533 (“’533 patent”)
1082	U.S. Patent No. 10,517,484 (“’484 patent”)

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