

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.,

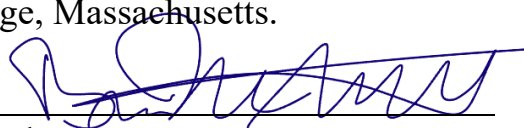
Patent Owner.

Case IPR2025-01251

Patent No. 10,874,304

**DECLARATION OF BRIAN W. ANTHONY IN SUPPORT
OF PETITION FOR *INTER PARTES* REVIEW
OF U.S. PATENT NO. 10,874,304**

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. 10,874,304 (“the ’304 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 1-6, 11-16, 19-22, 26-27 of the ’304 patent (“Challenged Claims”) are obvious over the prior art references identified below.

2. I understand that the ’304 patent is titled “Semiconductor source based near infrared measurement device with improved signal-to-noise ratio,” names as an inventor Mohammed N. Islam, and is currently owned by Omni Medsci Inc. I have considered the ’304 patent. I understand that the ’304 patent has been provided as Ex. 1001.

3. I understand that the file history of the ’304 patent has been provided as Ex. 1002. I have considered this file history, and I will refer to it as “the ’304 Patent File History” or by its exhibit number.

4. I understand that the ’304 patent is a continuation of application No. 16/284,514, filed on Feb. 25, 2019, now abandoned, which is a continuation of

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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, and application No. 16/669,794, which is a continuation of application No. 16/506,885, filed on Jul. 9, 2019, now Pat. No. 10,517,484, which is a continuation of application No. 16/272,069, filed on Feb. 11, 2019, now abandoned, which is a continuation of application No. 16/029,611, filed on Jul. 8, 2018, now Pat. No. 10,201,283, which is a continuation of application No. 15/888,052, filed on Feb. 4, 2018, now Pat. No. 10,136,819, which is a continuation of application No. 15/212,549, filed on Jul. 18, 2016, now Pat. No. 9,885,698, which is a continuation of application No. 14/650,897, filed as application No. PCT/US2013/075700 on Dec. 17, 2013, now Pat. No. 9,494,567, said application No. 16/506,885 is a continuation of application No. 16/004,359, filed on Jun. 9, 2018, 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.

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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. 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.

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PCT/US2013/075736 on Dec. 17, 2013, now Pat. No. 9,500,635. I have considered this file history.

5. I understand that the '304 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 Jan. 21, 2013. For the purposes of 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 '304 patent are entitled to this priority date, and do not provide any opinion on that subject for the purpose of this Declaration.

6. My analysis and conclusions set forth in this declaration are based on my educational background and experiences in the field (see 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 in the art. 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 '304 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 earliest claimed priority date for the '304 patent; my own knowledge and experiences gained from my work experience in the field of the '304 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.

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- **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 Tran are to Exhibit 1028.
- **U.S. Patent No. 7,139,076 (“Marbach”)** to Ralf Marbach, titled “Stable optical diffuse reflection measurement,” filed on August 8, 2003, published on November 21, 2006, and granted on August 10, 2006. I understand that a copy of this reference has been designated as Exhibit 1029. Throughout my declaration, references to Marbach are to Exhibit 1029.

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, respectively. *See* Ex. 1004 (Declaration of Brian Anthony, Ph.D. Regarding U.S. Patent No. 9,651,533, herein “’533-Anthony”); 1010 (Declaration of Brian Anthony, Ph.D. Regarding U.S. Patent No. 10,517,484, herein “’484-Anthony”). As discussed below, certain claim limitations challenged in those proceedings are identical and/or substantially identical to the Challenged Claims of the ’304 patent. Accordingly, for

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purposes of this Declaration, I refer to my declaration submitted in the prior '533 IPR, as my "Prior '533 Declaration," and my declaration submitted in the prior '484 IPR as my "Prior '484 Declaration," as applicable. Additionally, in this Declaration, I refer to the Board's Final Written Decision in the prior '533 IPR as "'533-FWD," which I understand has been designated as Exhibit 1008, and the Final Written Decision and Final Written Decision on Remand in the prior '484 IPR as "'484-FWD" and "'484-RFWD," which I understand have been designated as Exhibits 1015 and 1016, respectively.

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

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Lisogurski Figure 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 ("Valencell-093"), 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 four 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 Figure 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 Section IX.A, it is my opinion that (1) **Lisogurski** alone renders obvious Challenged Claims 1, 3, 11, 19, and 20 of the '304 patent (Ground 1, *see* Section IX.A); (2) **Lisogurski** in view of **LeBoeuf** renders

obvious Challenged Claims 2, 4-6, 14-16, 21-22, and 27 of the '304 patent (Ground 2, *see* Section IX.B); and (3) **Lisogurski** in view of **LeBoeuf** and **Tran** renders obvious Challenged Claims 1-6, 11-16, 19-22, and 26-27 of the '304 patent (Grounds 3-4, *see* Section IX.C). To the extent that claim limitations [1.c], [11.c], and [19.c] require additional disclosure for the “receive” and “deliver” an output/input beam limitations and Challenged Claims 13 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 1-6, 11-16, 19-22, and 26-27 (Grounds 5-8, *see* Section IX.D). To the extent that Challenged Claims 12-13 and 26 require further disclosure of improving a signal-to-noise ratio by applying regression signal processing methodologies or multivariate techniques, it is also my opinion that Grounds 3 and 7 in further view of **Marbach** additionally render obvious Claims 12-13 and 26 (Grounds 9-10, *see* Section IX.E).

13. I understand that there are pending district court litigations between 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”) and Omni Medsci, Inc. in *Omni Medsci, Inc. v. Samsung Electronics Co., Ltd. et al.*, 2:24-cv-01070-JRG-RSP (E.D. Tex) (“Texas Case”), as well as between Omni MedSci, Inc. and Whoop, Inc.

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involving the '304 patent in *Omni MedSci, Inc. v. Whoop, Inc.*, 1:25-cv-00140-JLH (D. Del.). I also understand that the '484 patent, which is related to the '304 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 discussed below, each document is a type that experts in my field would have reasonably relied upon when forming their opinions. Further, experts in my field would have had access to each document either through the applicable patent offices and/or well-known libraries, conferences, or publications in the field. My opinions are also based upon my personal and professional experience.

II. QUALIFICATIONS

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

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

18. I earned a Bachelor of Science in Engineering from Carnegie Mellon University in 1994 and a Master's degree in Engineering from MIT in 1998. My thesis topic related to anisotropic wave guides and acoustic non-destructive testing. In 2006, I earned my Ph.D. in Engineering from MIT. My research focused on high-performance computation, signal processing, and electro-mechanical system design.

19. In 1997, I co-founded Xcitex Inc., a company that specialized in video-acquisition and motion-analysis software. I served as the Chief Technology Officer and directed and managed product development until 2006. Our first demo product was an optical ring for human motion measurement used to capture user hand motion in order to control the user's interaction with a computer. Many of the structural elements of our optical ring addressed the same system issues as those described and claimed in the patent at issue. For example, our optical ring included multiple light emitting diodes, multiple photodetectors, techniques for modulation and

synchronization, noise reduction algorithms, and optical components for light blocking, light redirection, and light capture, and structural components for holding and geometrically arranging the various components. We estimated human hand-motion based on how that motion changed the detected light. In our application we did not try to eliminate motion artifact, we tried to measure it. In developing our ring, we considered well-known problems such as ambient light and noise, which are, unsurprisingly, also mentioned in the patent at issue. Motion Integrated Data Acquisition System (MiDAS) was our flagship video and data acquisition product which relied upon precise synchronization of multiple clocks for optical sensor and video acquisition, data acquisition, and external illumination.

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

21. In 2011, I co-founded MIT's Medical Electronic Device Realization Center ("MEDRC") and currently serve as co-director. The MEDRC aims to create and deploy revolutionary medical technologies by collaborating with clinicians, the microelectronics, and medical devices industries. We combine expertise in

computation; communications; optical, electrical, and ultrasound sensing technologies; and consumer electronics. We focus on the usability and productivity of medical devices using, for example, image and signal processing combined with intelligent computer systems to enhance practitioners' diagnostic intuition. Our research portfolio includes low power integrated circuits and systems, big data, micro electro-mechanical systems, bioelectronics, sensors, and microfluidics. Specific areas of innovation include wearable, non-invasive and minimally invasive optical biosensor devices, medical imaging, laboratory instrumentation, and the data communication from these devices and instruments to healthcare providers and caregivers. My experience with these devices is directly applicable to the technology in the patent at issue. For example, in one current project related to this work, we use a patient-mounted mobile near infrared (NIR) camera to image and characterize the surface and subsurface structures of the skin.

22. I am also the Associate Director of MIT.nano, MIT's new 200,000 sq-ft nanofabrication and characterization facility. One of the major research initiatives with MIT.nano focuses on sensors and sensing systems. Our research in sensing science and sensing engineering is targeting innovations in advanced manufacturing, healthcare, environmental remediation, smart infrastructure, and the creation of advanced machines and materials. I also co-founded the Center for Polymer Micro-fabrication at MIT. The Center's research focuses on polymer-based manufacturing

processes and the large-scale commercialization of micro fluidic devices for chemical, biomedical, and photonic applications. My experience under these initiatives is directly applicable to the technology in the patent at issue. We develop optical sensors to noninvasively monitor soft flexible materials during the manufacturing process.

23. Furthermore, my research focuses on computational instrumentation, including the development of instrumentation and measurement solutions for manufacturing systems and medical devices. Additionally, my teaching interests include the design and modeling of large-scale systems in a wide variety of decision-making domains and developing optimization algorithms and software for analyzing and designing such systems. I teach or have taught courses in Electrical Engineering, Controls, Optics, and Signal Processing, all pertinent subject matter to the patent at issue.

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

III. LEGAL UNDERSTANDING

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

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

27. I have been informed that in *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 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

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same field or in a different one, so that if a person of ordinary skill can implement a predictable variation, the variation is likely obvious;

- If a technique has been used to improve one device, and a person of ordinary skill in the art would recognize that it would improve similar devices in the same way, using the technique is obvious unless its actual application is beyond their skill;
- An explicit or implicit teaching, suggestion, or motivation to combine two prior art references to form the claimed combination may demonstrate obviousness, but proof of obviousness does not depend on or require showing a teaching, suggestion, or motivation to combine;
- Market demand, rather than scientific literature, can drive design trends and may show obviousness;
- In determining whether the subject matter of a patent claim would have been obvious, neither the particular motivation nor the avowed purpose of the named inventor controls whether the claim is obvious;
- One of the ways in which a patent's subject can be proved obvious is by noting that there existed at the time of invention a known problem for which there was an obvious solution encompassed by the patent's claims;
- Any need or problem known in the field of endeavor at the time of invention and addressed by the patent can provide a reason for combining the elements in the manner claimed;
- "Common sense" teaches that familiar items may have obvious uses beyond their primary purposes, and in many cases a person of ordinary skill will be able to fit the teachings of multiple patents together like pieces of a puzzle;
- A person of ordinary skill in the art is also a person of ordinary creativity, and is not an automaton;
- A patent claim can be proved obvious by showing that the claimed combination of elements was "obvious to try," particularly when there is a design need or market pressure to solve a problem and there are a finite number of identified, predictable solutions such that a person of ordinary

skill in the art would have had good reason to pursue the known options within his or her technical grasp; and

- One should be cautious of using hindsight in evaluating whether a claimed invention would have been obvious.

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.

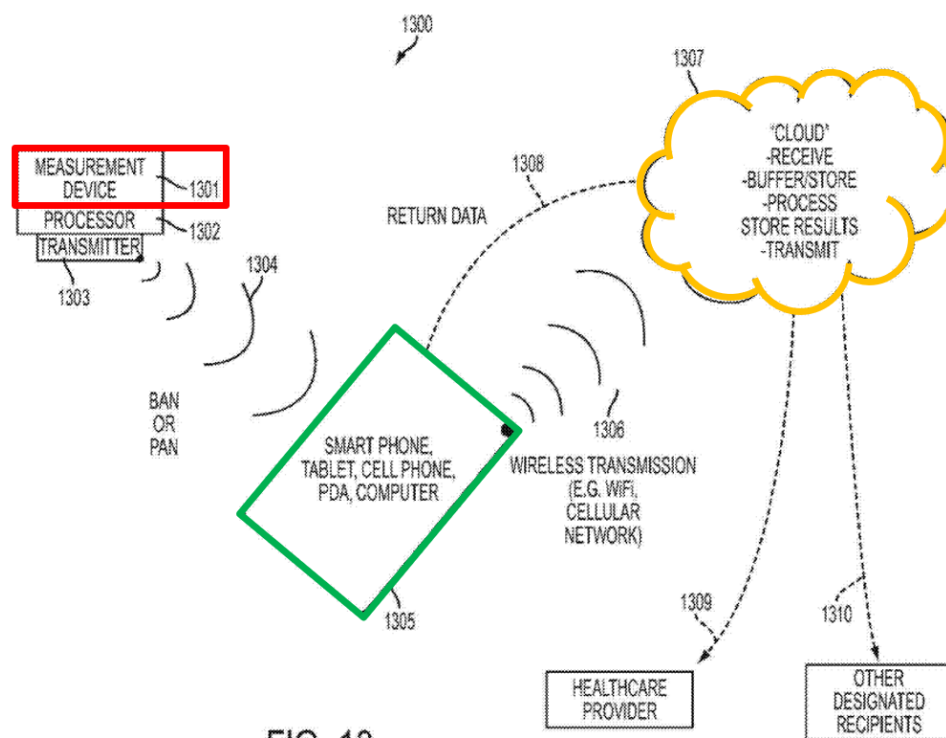
IV. BACKGROUND OF THE TECHNOLOGY

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 discussed in Section V, the ’304 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. ’304 patent, 20:5-25 (describing technique for “measuring a particular blood constituent” and “methods of improving the ability to discriminate between different constituents”), 33:45-57 (describing the “measurement device” that “communicate[s] over a first communication link,” to “a smart phone, tablet, [or] cellphone” which “operate[s] through the use of one of many wireless technologies”), 30:27-45 (describing the advantages of “us[ing] ... an active illuminator,” which includes, *inter alia*, “subtract[ing] out” the “sun light changes” 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”), 35:31-33 (“a higher light level or intensity may improve the signal-to-noise ratio for the measurement”).

42. Figure 13 (which I annotated below) is reproduced below with annotations identifying components I’ve described.



'304 patent, Fig. 13 (including my annotations).

43. In my opinion, and as further discussed below, the '304 patent recites claim limitations that are identical and/or substantially identical to those in the '533 patent and the '484 patent. Section IX.A-D. As I opined in the '533 and '484 IPRs, such wearable measurement system and devices were well known in the art prior to the '304 patent's priority date. '533-Anthony, ¶¶37-56, '484-Anthony, ¶¶37-56.

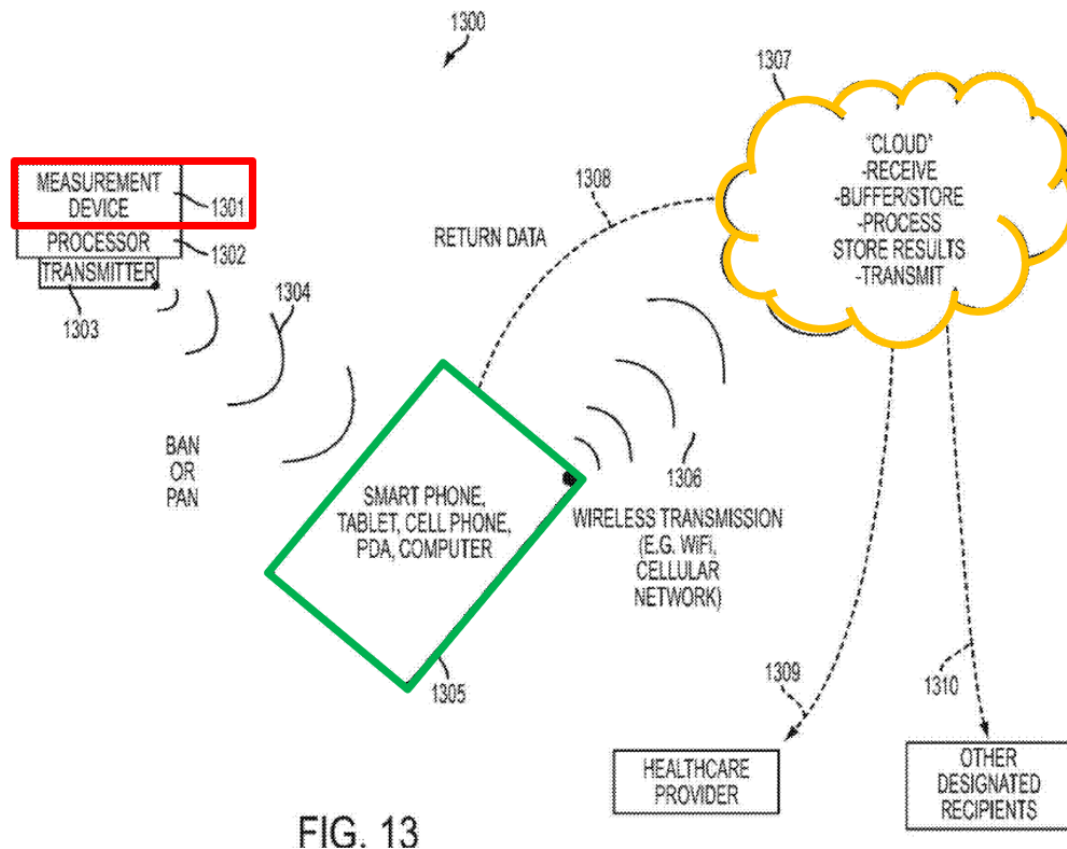
44. While the '304 patent claims to include additional limitations, they at most recite (1) common ways to increase light intensity, (2) common configurations and characteristics for light sources and detectors, (3) generic methods of generating optical beams by modulating semiconductor sources, (4) a generic reflective surface to improve detection, and (5) common analytical methods to improve measurement

of physiological parameters. *See* my discussion in Section IX below. For the reasons I have further discussed below, all such additional limitations were well-known in the art. *See* my discussions in Sections IX.A-E below.

V. THE '304 PATENT

A. '304 Patent Overview

45. Figure 13 of the '304 patent, which I annotated and reproduced below, shows an embodiment of the physiological measurement system to which the '304 patent is directed:



'304 patent, 33:45-35:16 (describing “a particular embodiment 1300” of “the non-invasive measurement device”); Fig. 13 (including my annotations). The wearable

measurement device 1301 comprises “a processor 1302 to process some of the measured data” and “a transmitter 1303 to communicate [measurements] over a first communication link 1304 ... to a receiver in a **smart phone**” or “**tablet 1305.**” ’304 patent, 33:45-34:7. An “application [or] software program” in **smart phone or tablet 1305** “receive[s] and process[es]” the measurements, and transmits “the processed data” to **cloud based server 1307**, which “processes the data” by using, e.g., pattern matching algorithms, regression, and multivariate techniques. ’304 patent, 34:7-28, 35:17-23, 35:30-39.

46. The **wearable device 1301** which “**measure[s] one or more physiological parameters,**” can be placed on a user’s body (i.e., “placed on a wrist or an ear of a user”) and includes a plurality of semiconductor sources that generate an output optical light with a plurality of optical wavelengths. ’304 patent, 5:4-18, 5:41-50. The **wearable device 1301** further comprises “one or more lenses” that receive 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. ’304 patent, 5:50-51. The ’304 patent describes several techniques, which are common and well-known in the art, in order to improve signal processing to select the constituents of interest, including using increased light intensity, modulation, increased pulse rate, and dark subtraction techniques. ’304 patent, 5:23-

30, 6:3-8, 24:45-52. For example, the '304 patent describes using a “higher light level or intensity [to] improve the signal-to-noise for the measurement[s].” '304 patent, 35:30-32. In another example, the '304 patent further describes “improv[ing] the signal-to-noise ratio” by “usi[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. '304 patent, 30:27-45.

B. The Prosecution History

47. In formulating my opinions, I considered the contents of the '304 Patent File History, a copy of which I understand has been designated as Exhibit 1002.

48. The '304 patent issued from application U.S. Pat. App. 16/669,794, which was filed October 31, 2019. There were no prior art rejections issued during prosecution, and the pending claims were allowed on November 25, 2020 after the Applicant agreed to incorporate the Examiner's proposed amendments, which further recited “increasing a light intensity relative to an initial light intensity” and “generate an output signal representing at least in part a non-invasive measurement on blood contained within the sample.” Ex.1002, 266, 273, 275-76, 287 (amendments underlined). For the reasons I set forth below, **Lisogurski** discloses these limitations. Section IX.A.3.

VI. LEVEL OF ORDINARY SKILL IN THE ART

49. In rendering the opinions set forth in this declaration, I was asked to consider the patent claims and the prior art through the eyes of a person of ordinary skill in the art at the time of the alleged invention. I understand that the factors considered in determining the ordinary level of skill in a field of art include the level of education and experience of persons working in the field; the types of problems encountered in the field, the teachings of the prior art, and the sophistication of the technology at the time of the alleged invention. I understand that a person of ordinary skill in the art is not a specific real individual, but rather is a hypothetical individual having the qualities reflected by the factors above. I understand that a person of ordinary skill in the art would also have knowledge from the teachings of the prior art including the art cited below.

50. 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 '304 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.

51. 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.

52. Well 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 '304 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. A different priority date would not change my opinions as long as the identified prior art were still prior art.

VII. CLAIM CONSTRUCTION

53. I have been instructed that, unless otherwise noted herein, the Challenged Claims of the '304 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 '304 patent.

A. Board's Constructions in the Prior Related IPRs

1. "light source" limitations ([1], [11])

54. 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 (emphases added). For the reasons I discuss below in Section IX.A.3 the prior art discloses this limitation under the Board's construction, which is also consistent with the plain and ordinary meaning of the term. See my discussion in Sections IX.A.3.[1.a], [1.g], [3], [11.a], [11.b], [11.g], [19.a], [20]; IX.C.3.[13].

2. "to identify an object" limitation ([12])

55. In the '484 patent final written decision, I understand that the Board construed "to identify an object" to mean "to recognize or establish an object as

being a particular thing,” which is, one, consistent with the plain and ordinary meaning of the term, and, two, which I understand the Federal Circuit affirmed on appeal designated as Exhibit 1017 herein. ’484-FWD, 8-10; ’484-Remand-FWD, 3; Ex. 1017, 7-10. For the purposes of this Declaration, I have been instructed to adopt the Board’s construction. For the reasons I discuss below in Section IX.B.3, the prior art discloses this limitation under the Board’s construction, which is also consistent with the plain and ordinary meaning of the term. *See* my discussion in Section IX.C.3.[12.b].

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

56. In the prior ’533 IPR, I opined that a person of ordinary skill in the art would have understood the term “beam” to mean “photons or light transmitted to a particular location in space.” ’533-Anthony, ¶62.

57. 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.

58. I understand that in the prior ’533 IPR, the petitioner proposed construing “beam,” and “pulse rate,” which the Board declined to construe. ’533-FWD, 9-10.

59. In the prior ’484 IPR, I opined that the term “cloud” be given its plain and ordinary meaning, which that a person of ordinary skill in the art would have

understood to mean “a remote device (or network of devices) hosted on a network and used to store, manage, or process data.” ’484-Anthony, ¶65.

60. In the prior ’484 IPR, I understand that the petitioner proposed construing “cloud,” patent owner Omni did not propose any construction for this term, and the Board declined to construe it. ’484-FWD, 7-8.

61. The Board in ’533 and ’484-IPRs did not construe any other terms present in the ’304.

62. 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.[1.a], [1.c], [1.e], [1.i], [1.l], [3], [11.a], [11.c], [11.e], [11.i], [11.l], [19.b]-[19.d], [19.f], [20]; IX.B.3.[2], [4]; IX.C.3.[13]; IX.D.3.b).

C. Prior District Court Constructions

63. I also 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.) (“Related EDTX Cases”)—involving the ’533 and related patents that share substantially similar specifications to the ’304 patent, the district court (in its decisions that I understand

have been designated as Exhibits 1018 and 1019, respectively) construed the following terms that appear in the Challenged Claims of the '304 patent here.

1. “beam” limitations ([1]-[3], [11], [14], [19], [20])

64. I understand that prior to the Board’s final written decision in the prior '533 IPR, in the Related EDTX Cases, the term “beam” was construed as “photons or light transmitted to a particular location in space.” *See* Ex.1018, 7-9; Ex.1019, 10-12. Though the Patent Owner subsequently raised this construction in its Preliminary Response in the '533 IPR, I understand that the Board nevertheless concluded that no construction of “beam” was necessary. '533-POPR, 10-11; '533-Inst., 9; '533-FWD, 9-10. For the reasons I discuss below in Sections IX.A.3 and IX.B.3, the prior art discloses this limitation under the district court’s construction and under the plain and ordinary meaning of the term, to the extent there are any differences between them.

2. “modulating”/“modulation” limitations ([19])

65. I understand that in the Related EDTX Cases, the district court also construed the term “modulating at least one of the LEDs” to mean “varying the amplitude, frequency, or phase of the light produced by at least one of the LEDs to include information.” *See* Ex.1018, 13-16; Ex.1019, 15-19. In a related IPR (IPR2019-00914), I understand that the petitioner proposed the same construction, and I adopted that construction in providing my opinion. Ex 1083, ¶66. I understand

that the Board adopted the same construction. *Apple Inc. v. Omni Medsci, Inc.*, IPR2019-00914, Paper 13 at 9-11 (Nov. 6, 2019). Note, the '533 and '484 patents do not recite this “modulating” term, and thus there was no need for the Board to construe this term in the '533 and '484 IPRs. For the reasons I discuss below in Section IX.A.3, the prior art discloses this limitation also under the district court’s construction previously adopted by the Board.

D. Terms at Issue in the Texas Case

66. I understand that in Defendants’ Supplemental Invalidity and Subject Matter Eligibility Contentions served in the Texas Case, which I understand has been designated as Exhibit 1023, Petitioners identified the following limitations of the '304 patent as potentially indefinite:

- 1) **“a receiver configured to: ... synchronize to the light source”** (cls. 1, 11)
- 2) **“the light source configured to increase signal-to-noise ratio by increasing a light intensity relative to an initial light intensity from at least one of the plurality of semiconductor sources”** (cls. 1, 11)
- 3) **“wherein the measurement system is at least in part configured for selection or identification of an object”** (cl. 12)
- 4) **“wherein the measurement system is configured to use artificial intelligence in making decisions”** (cl. 12),
- 5) **“wherein the light source is configured to further increase the signal-to-noise ratio by increasing a pulse rate of at least one of the plurality of semiconductor sources from an initial non-zero pulse rate”** (cl. 13),
- 6) **“the receiver comprises a plurality of detectors arranged along a first arc, and wherein the plurality of semiconductor sources are arranged along a second arc that is offset from the first arc.”** (cls. 4, 5, 15, 21),

- 7) **“wherein the first arc and the second arc are concentric”** (cls. 6, 16, 22),
- 8) **“a receiver configured to: ... synchronize to the modulation of the at least one of the semiconductor sources”** (cl. 19),
- 9) **“the measurement device further configured to improve a signal-to-noise ratio of the input optical beam reflected from the tissue by: differencing the first signal and the second signal, and increasing the light intensity relative to the initial light intensity from at least one of the semiconductor sources”** (cl. 19),
- 10) **“wherein the light source is configured to further improve the signal-to-noise ratio of the input optical beam reflected from the tissue by increasing a pulse rate of at least one of the plurality of semiconductor sources from an initial non-zero pulse rate”** (cl. 20).

Ex.1023, 236-238.

67. For the purposes of this Declaration, I do not take a position on whether these terms are indefinite. And, regardless of the outer bounds of these limitations, for the reasons discussed below in Sections IX.A-C, these limitations are still disclosed and rendered obvious by the prior art because the prior art discloses and renders obvious embodiments within the indisputable scope of these limitations. *See* my discussion below of [1.a], [1.g], [11.b], [11.g], [19.e], [19.g], [20], [4], [5], [6], [15], [16], [21], [22], [12.pre], [12.b], [13], [13], [20].

VIII. GROUNDS OF UNPATENTABILITY

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

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

Name	Ex.	Publication	Filed	Published/ Issued
Lisogurski	1025	US 9,241,676	5/31/2012	1/26/2016
LeBoeuf	1026	US 2010/0217102	1/21/2010	8/26/2010
Tran	1027	US 8,108,036	6/18/2009	1/31/2012
Carlson	1028	US 2005/0049468	9/3/2003	3/3/2005
Marbach	1029	US 7,139,076	8/8/2003	11/21/2006

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

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

Ground	Claim(s)	References
1	1, 3, 11, 19, 20	Lisogurski
2	2, 4-6, 14-16, 21-22, 27	Lisogurski in view of LeBoeuf
3	1, 3, 11-13, 19, 20, 26	Lisogurski in view of Tran
4	2, 4-6, 12-16, 21-22, 26-27	Lisogurski in view of LeBoeuf and Tran
5-8	See claims for Grounds 1-4, respectively	Grounds 1-4 in view of Carlson
9	1, 3, 11-13, 19, 20, 26	Lisogurski in view of Tran and Marbach

10	Lisogurski in view of Tran, Carlson and Marbach
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IX. SPECIFIC GROUNDS FOR CHALLENGE

71. It is my opinion that Challenged Claims of the '304 patent are unpatentable as explained below. As I explain above in Section IV, although the '304 patent purports to have invented an optical physiological measurement system, such devices were well-known in the art. As described below, the cited prior art provides these teachings.

72. In this section, I explain why claims 1-6, 11-16, 19-22, 26-27 of the '304 patent are rendered obvious by the teachings of **Lisogurski, LeBoeuf, Tran, Carlson**, and/or **Marbach**. Regarding all Grounds, **Lisogurski** teaches a physiological measurement system for use with a smart phone or tablet, the measurement system including a light source and detection system, and where the measurement system includes means of 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 an arc. 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

threshold comparison 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. Regarding Grounds 9-10, **Marbach** further teaches the use of multivariate techniques to improve the signal-to-noise ratio for the physiological measurement system.

73. I note that, in this discussion, I may focus on the particular language in specific claims, but it should be understood that my analysis applies to the corresponding limitations of all claims containing identical or substantially identical language.

A. GROUND 1: Lisogurski (Claims 1, 3, 11, 19, and 20)

1. Overview of Lisogurski

74. **Lisogurski** discloses a “medical device,” specifically a “physiological monitoring system [that] monitor[s] one or more physiological parameters of a patient[by] ... using one or more physiological sensors,” such as a “pulse oximeter [that] non-invasively measure[s] the oxygen saturation of a patient’s blood.” Lisogurski, 3:44-46, 3:62-64. The physiological parameters may include “a patient’s pulse rate and blood pressure.” Lisogurski, 4:3-5. Moreover, the pulse oximeter includes a “light sensor that is placed at a site on a patient, typically a fingertip, toe, forehead, [] earlobe, ... or ... a foot.” Lisogurski, 4:6-8. ’533-FWD, 13; ’484-FWD, 12-13. The light sensor emits “one or more wavelengths [of light]

that are attenuated by the blood in an amount representative of the blood constituent concentration,” including “Red and infrared (IR) wavelengths” of light. Lisogurski, 4:42-51. A person of ordinary skill in the art would have understood such disclosures as being consistent with standard, established physiological monitoring techniques and sensor placements.

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

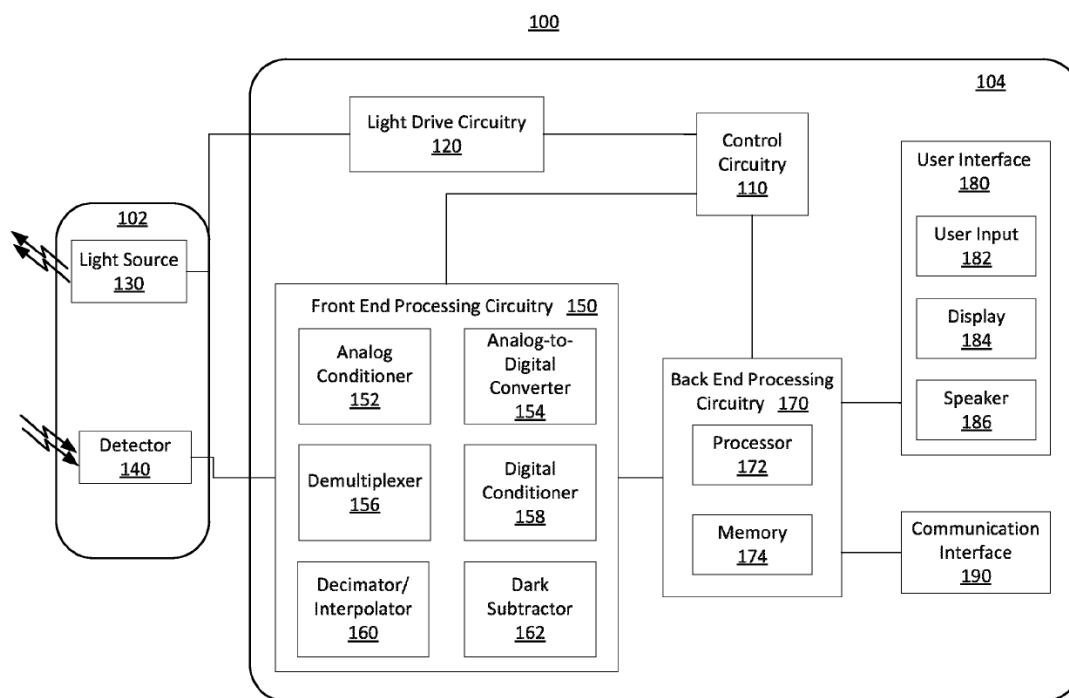


FIG. 1

76. **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, 17:39-45 (“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 '304 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.

77. 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.

78. “Light drive circuitry 120 ... generate[s] a light drive signal, which [is] used to turn on and off light source 130, based on the timing control signals.” Lisogurski, 11:38-54. “Light drive circuitry 120” also controls the intensity of light

source 130 and the “timing of when the light source 130 is turned on and off.”
Lisogurski, 11:50-54. ’533-FWD, 16; ’484-FWD, 16.

79. “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, 11:43-46, 12:42-45. ’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.

80. “[B]ackend processing circuitry 170” includes “processor 172 and memory 174.” Lisogurski, 14:56-57. “[B]ack end 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 promoting user interactions and data integration with other systems.

81. “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, 15:19-23. ’533-FWD, 17; ’484-FWD, 16-17.

82. “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. 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.

83. **Lisogurski** further discloses that “the components of physiological monitoring system 100 ... are shown and described as separate components ... for

illustrative purposes only” and that: ... (1) “the functionality of some of the components may be combined in a single component” and (2) “the functionality of some of the components ... may be divided over multiple components.” Lisogurski, 15:66-16:9. **Lisogurski** goes on to explain that: “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, 17;’484-FWD, 15, 17.

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

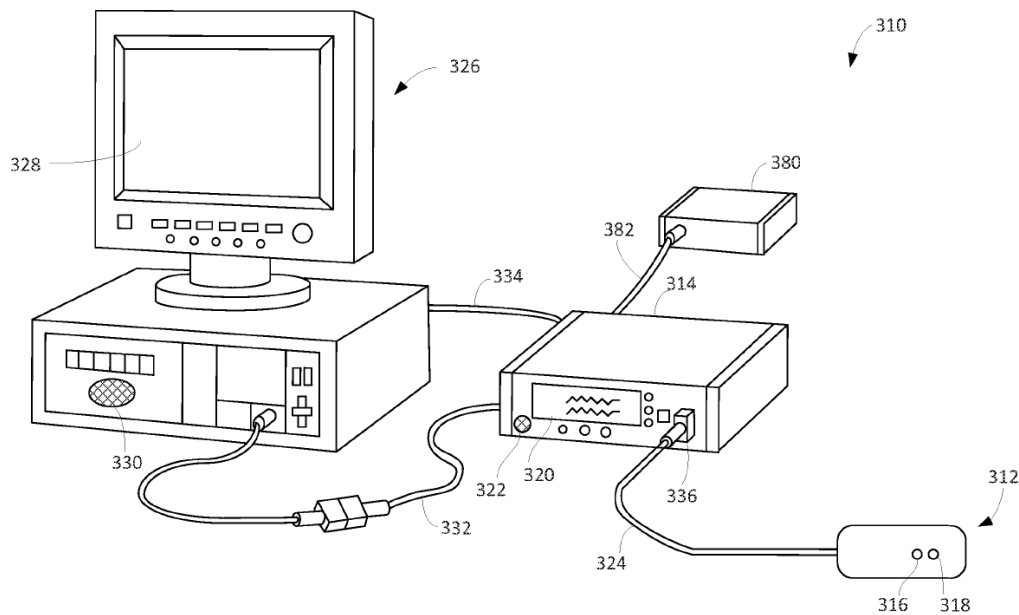


FIG. 3

85. **Lisogurski** discloses several embodiments of its physiological monitoring system, two of which are depicted in the block diagram of Figure 1 (2:11-13; element labelled “100”) and the perspective view of Figure 3 (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.

86. **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.

87. Monitor 314 is “communicatively coupled to” and “communicate[s] wirelessly” with MPPM 326. Lisogurski, 18:58-65. MPPM 326 “calculate[s] physiological parameters based at least in part on data relating to light emission ... received from one or more sensor units such as sensor unit 312,” “provide[s] a display 328 for information from monitor 314,” and is “coupled to a network to enable the sharing of information with servers or other workstations (not shown).” Lisogurski, 17:59-62, 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.

88. MPPM 326 may “be configured to calculate physiological parameters and ... provide a display 328 for information from monitor 314.” 18:49-52. Monitor 314 and MPPM 326 are “coupled to a network to enable the sharing of information with servers or other workstations.” 18:62-65. The servers may “be used to determine physiological parameters,” and may display the parameters on a remote display, a “local display” such as display 320 of monitor 314, or display 328 of MPPM 326. 20:53-57. The servers may also “publish the data to a server or website,” or otherwise “make the parameters available to a user by any other suitable technique.” 20:58-60.

89. **Lisogurski** further discloses various methods for improving signal-to-noise ratio. For example, **Lisogurski** discloses: (1) modulating the light drive signal to have a “period the same as or closely related to the period of [a] cardiac cycle, thus generating a cardiac cycle modulation,” (2) using a dark subtraction process to remove noise from the ambient light by “subtract[ing] the background or dark level from the levels received during red ‘on’ portion 274 and IR ‘on’ period 278”, and (3) varying parameters related to the light drive signal, including “drive current or light brightness, duty cycle, firing rate, modulation parameters, other suitable parameters, or any combination thereof.” *Lisogurski*, 6:7-19, 9:46-60, 13:60-14:10, 16:33-54, 25:49-55. ’533-FWD, 17; ’484-FWD, 17. A person of ordinary skill in the art would have understood these disclosed methods (cardiac-cycle modulation,

dark subtraction, varying drive parameters) as common and well-understood strategies for improving signal-to-noise ratio and accuracy in photoplethysmography-based physiological wearable or ambulatory monitoring systems.

2. Motivation to Modify Lisogurski

90. A person of ordinary skill in the art would have been motivated to modify **Lisogurski's** “physiological monitoring system 100” in order to place several components located within monitor 104—namely, **control circuitry 110**, **light drive circuitry 120**, and **front end processing circuitry 150**—to sensor 102 where **light source 130** is located. Figure 1 is reproduced below with annotations highlighting some of the components I’ve described. ’533-FWD, 22-25 (including annotated Fig. 1 below); ’484-FWD, 24-25.

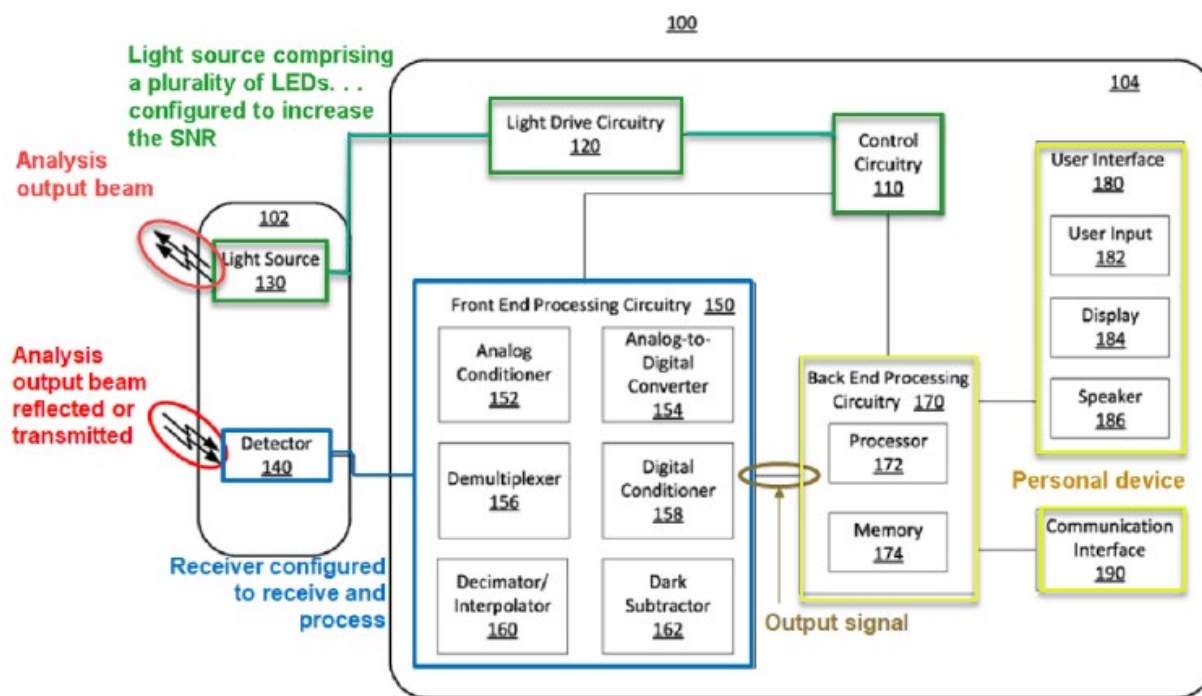


FIG. 1

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 requirements considerations (trade-offs), 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 capability of wearable sensors for use in sports and personal fitness applications and wireless 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 either necessary or at least obvious to include the control

circuitry 110 and light drive circuitry 120 to be located alongside the light source 130 within sensor 102. '533-Anthony, ¶101 (citing Lisogurski, 11:38-41, 11:50-54, 25:52-55); '484-Anthony, ¶162 (citing Lisogurski, 11:38-41, 11:50-54, 25:52-55). A person of ordinary skill in the art would have further understood that integrating control and drive circuitry directly with the LEDs is advantageous to maintaining precise synchronization and optimal signal integrity. Indeed, given the limitations in transmitting accurate electrical signals without introducing noise or timing errors, a person of ordinary skill in the art would have found such integration technically and practically advantageous.

95. Moreover, a person of ordinary skill in the art would have understood that adding the light drive and control circuitry directly to sensor 102 would not have negatively impacted the operation of **Lisogurski's** system. For example, a person of ordinary skill in the art would have appreciated that modern electronic components such as control and drive circuits are designed with compactness, power efficiency, and ease of integration in mind, making them well-suited for integration within the form factor of a wearable sensor. Their small size would not add significant bulk or weight, and their efficient power consumption helps maintain the device's overall battery life. As a result, a person of ordinary skill in the art would have found the integration of the light drive circuitry and control circuitry into sensor 102 both practical, feasible and advantageous, enhancing both performance and

usability in physiological monitoring applications without compromising system performance. '533-Anthony, ¶102 (citing Lisogurski, 16:2-9); '484-Anthony, ¶163 (citing Lisogurski, 16:2-9).

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

97. Additionally, as the Board further found, a person of ordinary skill in the art would have been motivated to modify monitor 104 to be a personal device “includ[ing] only backend processing circuitry 170, user interface 180, and communication interface 190.” '533-FWD, 39-40 (citing '533-Pet., 49-53; Lisogurski, Fig. 1). As the Board explained, and as I noted above, “Lisogurski’s express suggestion and 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* 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. 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 typically 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 understand that this relocation as an obvious step, consistent with established industry practices for design, manufacturing, function, and usability trade-offs. Integrating light drive circuitry and associated control components directly into sensor assemblies minimizes interference, enhances operational efficiency, 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, ¶52, 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, ¶52, 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 with 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. 7-8. 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 measurements” 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, ¶52, Fig. 4 (showing front end analog signal conditioning circuitry 330 in sensor 300); Ex. 1034, Abstract (“a photodetector with 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, 3, 11, 19, and 20 Over Lisogurski

108. As I discuss below, Claims 1, 3, 11, 19, and 20 are rendered obvious by **Lisogurski**. In addition to my discussion in Sections IX.A.1-2, the following discussion identifies example disclosures.

a. Element [1.pre]

109. Element [1.pre] recites: “**A measurement system comprising.**” This element is met by **Lisogurski**.

110. The Board previously found this identical limitation was met by **Lisogurski** in the prior ’533 IPR. In particular, to meet “**A measurement system**” (recited in claims 5 and 13 of the ’533 patent), the Board relied on “Lisogurski’s [physiological monitoring] system 100/310, including sensor 102/312 for measuring blood oxygen saturation.” ’533-FWD, 25 (discussing claim 13) (citing ’533-Pet., 28), 42-43 (applying analysis of claim 13 to claim 5); Lisogurski, 4:6-20, 17:55-59, *see also* Figs. 1, 3, 3:44-46, 3:61-4:3, 10:42-46, 17:30-32. 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, ¶¶88-91.

b. Element [1.a]

111. Element [1.a] recites: “a light source comprising a plurality of semiconductor sources that are configured to generate an output optical beam with one or more optical wavelengths, the light source configured to increase signal-to-noise ratio by increasing a light intensity relative to an initial light intensity from at least one of the plurality of semiconductor sources;”¹ This element is met by Lisogurski.

112. The Board previously found a substantially identical limitation was met by Lisogurski in the prior '533 IPR. In particular, to meet “a light source that includes a plurality of semiconductor sources that are light emitting diodes configured to generate an output optical beam with one or more optical wavelengths” (recited in claims 5 and 13 of the '533 patent), the Board relied on Lisogurski's disclosure of a “[s]ensor 102/312,” which includes “light source 130.” '533-FWD, 25-26 (discussing claim 13) (citing '533-Pet. 29-31), 42-43 (applying analysis of claim 13 to claim 5); Lisogurski, 10:48-64, 17:37-45, Figs. 1, 3. For example, as the Board found, Lisogurski's “sensor 102/312 [] contain[s] multiple LEDs that emit and direct light toward a subject's tissue [thus, output

¹ For readability, color-coding has been used to clarify the mapping of certain claim language to prior art.

optical beam], 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 (citing ’533-Pet., 29-30); Lisogurski, 4:42-45, 7:38-8:3, 10:48-52, 10:56-63, 17:37-45, 19:25-31, Figs. 1, 3). This is consistent with my opinions regarding this ’533 limitation, which I incorporate by reference as if fully set forth herein. ’533-Anthony, ¶¶92-94. Additionally, as discussed above in Section VII.C.1, I understand that in the Related EDTX Cases, the district court construed the term “beam” to mean “photons or light transmitted to a particular location in space.” See Ex.1018, 7-9; Ex.1019, 10-12. As discussed above, **Lisogurski** discloses LEDs that emit and direct light toward a subject’s tissue, which are “photonic signal[s] interacting with the tissue” at “a site on a patient, typically a fingertip, toe, forehead or earlobe” or “foot.” See, e.g., 4:6-45. Thus, **Lisogurski** teaches and at minimum renders obvious “beam” under the district court’s prior construction.

113. The language in the above-referenced limitation in the ’533 on which I previously opined, and which recites: “**a light source that includes 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,**” (claims 5/13) is a subset of the language in the corresponding limitation in ’304 [1.a] (“**a light source comprising a plurality of semiconductor sources that are configured to generate an output optical beam with one or**

more optical wavelengths”). In particular, the above-referenced ’533 limitation further specifies that the claimed “plurality of semiconductor sources” are “light emitting diodes.” But, it was well known in the art 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 (Vakil), 2:6-9 (“The LED is a semiconductor diode that emits incoherent narrow-spectrum light...”). Thus, the differences between the two limitations do not change my analysis, and my opinions regarding the above-referenced ’533 limitation apply equally to the corresponding limitation in ’304 [1.a]. ’533-Anthony, ¶¶92-94.

114. To meet “**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**” (recited by claims 5 and 13 of the ’533 patent), the Board (applying its construction of “light source...configured to increase signal-to-noise ratio...,” *see* Section VII.A.1) found that light source 130 of Lisogurski’s modified system (see my discussion in Section IX.A.2) “**increase[s] the brightness of the light sources in response to ... noise to improve the signal-to-noise ratio.**” ’533-FWD, 26 (discussing claim 13) (citing ’533-Pet. 29-39), 42-43 (applying analysis of claim 13 to claim 5); 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, 35:5-9; ’533-Anthony ¶¶95-98. This is

consistent with my opinions regarding this '533 limitation, which I incorporate by reference as if fully set forth herein. '533-Anthony, ¶¶92-94.

115. Though the '533 limitations do not recite increasing a light intensity “**relative to an initial light intensity**,” as recited in this '304 limitation, the Board found a substantially identical limitation met by the same embodiment of **Lisogurski** in the prior '484 IPR.

116. In particular, to show **Lisogurski** “increas[es] light intensity of at least one of the plurality of semiconductor sources **from an initial light intensity**” ('484 claim 1), the Board relied on **Lisogurski's** disclosures “that by increasing light intensity the system may **increase the brightness of light sources** in response to noise to improve signal to noise ratio,” thus increasing from a non-zero light intensity to an increased light intensity. '484-FWD, 27 (citing '484-Pet., 45-48); **Lisogurski**, 1:19-21, 1:44-46, 1:67-2:3, 5:55-6:6, 9:46-60, 10:48-49, 11:38-41, 11:50-54, 14:49-55, 25:49-55; 31:11-24, 31:39-55, 35:5-9, 37:6-22); '533-FWD, 26. The Board also relied on **Lisogurski's** disclosure of “**brightness (light intensity)** as a parameter of the light drive signal, i.e., the signal that drives the LED” generated by light drive circuitry within sensor 102/312 as modified (see my discussion in Section IX.A.2). '484-FWD, 27 (citing '484-Pet., 45-48); 533 FWD, 26. This is consistent with my opinions regarding this '484 limitation, which I incorporate by reference as if fully set forth herein. '484-Anthony, ¶¶165-171.

117. Thus, the differences between the above-discussed '533 and '484 limitations and this '304 limitation do not change my analysis, and my opinions regarding the '533 and '484 limitations apply equally to '304 patent element [1.a]. '533-Anthony, ¶¶92-94; '484-Anthony, ¶¶165-171.

118. I understand that Defendants identified “the light source configured to increase signal-to-noise ratio by increasing a light intensity relative to an initial light intensity from at least one of the plurality of semiconductor sources” as potentially indefinite in the Texas case. Ex. 1023, 238.

119. 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.

120. 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 using the already-increased light intensity would thus have increased signal-to-noise ratio.

c. Element [1.b]

121. Element [1.b] recites: “**a measurement device configured to.**” This element is met by **Lisogurski**.

122. The Board previously found a substantially identical limitation was met by **Lisogurski** in the prior ’533 IPR. In particular, to meet “**a wearable measurement device**” (recited in claims 5 and 13 of the ’533 patent), the Board relied on **Lisogurski’s** disclosure of “[s]ensor 102/312 for measuring blood oxygen saturation.” ’533-FWD, 25 (discussing claim 13) (citing ’533-Pet., 28), 42-43 (applying analysis of claim 13 to claim 5); Lisogurski, 4:6-20, 4:15-20, 17:55-59, *see also* Figs. 1, 3, 3:6-4:5, 4:21-64. This is consistent with my opinions regarding this ’533 limitation, which I incorporate by reference as if fully set forth herein. ’533-Anthony, ¶¶89-91.

123. ’304 patent element [1.b] is substantially similar to the corresponding limitation in the ’533 patent on which I previously opined, and which recites: “**a**

wearable measurement device” (claims 5/13). The main difference between these limitations is the inclusion of an additional modifier in the ’533 patent limitation (i.e., “wearable”). A **wearable measurement device** (’533 claims 5 and 13) is still a **measurement device** (’304, [1.b]), such that the differences between the two limitations do not change my analysis, and my opinions regarding the ’533 patent term apply equally to ’304 patent element [1.b]. ’533-Anthony, ¶¶89-91.

d. Element [1.c]

124. Element [1.c] recites: “receive a portion of the output optical beam, and deliver an analysis output beam to a sample.” This element is met by Lisogurski.

125. The Board previously found a substantially identical limitation was met by **Lisogurski** in the prior ’533 IPR. **Lisogurski** discloses that its “sensor 102” includes “LEDs,” and to meet “a plurality of lenses configured to **receive a portion of the output optical beam and to deliver an analysis output beam to a sample**” (recited in claims 5 and 13 of the ’533 patent), the Board determined that “a [person of ordinary skill in the art] would have known that LEDs are often covered by lensing encapsulants, and would have selected such LEDs for [Lisogurski’s] 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.” ’533-FWD, 35-37 (discussing claim 13) (citing ’533-Pet., 39-40), 42-43 (applying analysis of claim 13 to claim 5); Lisogurski, 7:38-8:3, 10:48-56, 19:25-31;

see also '484-FWD, 23, 26-27. Such LEDs thus include lensing encapsulants to receive and deliver the light to a sample (i.e., output optical beam). 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 (Light Emitting Diodes), 97-98, 191-99, 266-67; Ex. 1038 (Biomedical Engineering Handbook), 765).

126. '304 patent element [1.c] is substantially identical to the corresponding limitation in the '533 patent on which I previously opined, which recites: “a plurality of lenses configured to **receive a portion of the output optical beam and to deliver an analysis output beam to a sample**” (claims 5, 13). The main difference between these limitations is the inclusion of “a plurality of lenses” in the '533 patent limitation. Given that the '533 limitation merely specifies one way to perform the same limitation recited in '304 [1.c] (i.e., using “a plurality of lenses” to “receive a portion of the output optical beam and deliver an analysis output beam to a sample”), the disclosure from **Lisogurski** relied upon by the Board to meet the '533 limitation also satisfies '304 patent element [1.c]. Thus, the differences between the two terms do not change my analysis, and my opinions regarding the '533 patent term apply equally to '304 patent element [1.c]. '533-Anthony, ¶¶123-129.

127. '304 patent element [1.c] is substantially identical to the [1.b] limitation in the '484 patent on which I previously opined, which recites: “one or more lenses configured to **receive a portion of at least one of the output optical lights and to direct a lens output light to tissue**” (claim 1). The main difference between these limitations is the inclusion of “one or more lenses” in the '484 patent limitation. As I discussed above, a person of ordinary skill in the art would have understood that lenses are one mechanism through which light can be received and delivered to a sample. Thus, the differences between the two terms do not change my analysis, and my opinions regarding the '484 patent term apply equally to '304 patent element [1.c]. '484-Anthony, ¶¶102-109.

128. As further support for this limitation, **Lisogurski** discloses that its “sensor” 102/312 includes “LEDs”. Lisogurski, 7:38-8:3, 10:48-56, 19:25-31. As I previously opined for the '533 patent and '484 patent, and as the Board agreed, LEDs are typically “encapsulated in glass or another medium which is called an encapsulant” and “a person of ordinary skill in the art designing a system based on **Lisogurski** would have recognized that **Lisogurski** was describing a device that would benefit from selecting an LED that uses an encapsulant” because “lenses on the LEDs can be used to direct all of the emitted light” to the tissue, which improves power efficiency for the battery-powered sensor 102/312. '533-Anthony, ¶¶123-129; '484-Anthony, ¶¶102-109; '533-FWD, 35; *see also* '484-FWD, 23, 26-27

(finding that **Lisogurski** meets “**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**” limitation).

e. Element [1.d]

129. Element [1.d] recites: “**a receiver configured to.**” This element is met by **Lisogurski**.

130. The Board previously found an identical limitation was met by **Lisogurski** in the prior ’533 IPR. In particular, to meet “**receiver**” (recited in claims 5 and 13 of the ’533 patent), the Board relied on **Lisogurski’s** disclosure of “detector 140/318 and front end processing circuitry 150” in **Lisogurski’s** modified system (*supra*, Section IX.A.2). ’533-FWD, 37-39 (discussing claim 13) (citing ’533-Pet. 45-49), 42-43 (applying analysis of claim 13 to claim 5); *Lisogurski*, 11:9-27, 11:41-46, 12:42-45, 17:40-42, Figs. 1, 3; *see also* 7:39-42, 10:48-49, 16:2-9. This is consistent with my opinions regarding this ’533 limitation, which I incorporate by reference as if fully set forth herein. ’533-Anthony, ¶¶136-138.

f. Element [1.e]

131. Element [1.e] recites: “**receive** and **process** at least a portion of the analysis output beam reflected or transmitted from the sample.” This element is met by **Lisogurski**.

132. The Board previously found an identical limitation was met by **Lisogurski** in the prior '533 IPR. In particular, to show that **Lisogurski's** receiver is configured to “**receive and process at least a portion of the analysis output beam reflected or transmitted from the sample**” (as identically recited in claims 5 and 13 of the 33 patent), the Board found that **Lisogurski's** “detector 140/318” of the receiver (*see* my discussion in Section IX.A.3.[1.d]), as modified (*see* my discussion in Section IX.A.2)) “**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.**” '533-FWD, 37-39 (discussing claim 13) (citing '533-Pet. 44-45), 42-43 (applying analysis of claim 13 to claim 5); **Lisogurski**, 17:39-42, 11:14-17, Figs. 1, 3; *see also* 11:9-10, 11:20-27, 11:41-46, 11:50-54. This is consistent with my opinions regarding this '533 limitation, which I incorporate by reference as if fully set forth herein. '533-Anthony, ¶¶136-138.

g. Element [1.f]

133. Element [1.f] recites: “**generate an output signal representing at least in part a non-invasive measurement on blood contained within the sample.**” This element is met by **Lisogurski**.

134. This limitation includes language that was already determined unpatentable by the Board in the '533-IPR (“**generate an output signal**”) and new language that was not previously considered (“**representing at least in part a non-**

invasive measurement on blood contained within the sample”). *See* ’533-FWD, 37-39.

135. In particular, to meet the identical “**generate an output signal**” limitation in the prior ’533 IPR (as recited in claims 5 and 13 of the ’533 patent), the Board relied on **Lisogurski**’s disclosure that “detector 140” of the receiver (*see* my discussion in Section IX.A.3.[1.d]) generates a “detection signal,” and front end processing circuitry 150, within detector 140 of **Lisogurski**’s modified system (*see* my discussion in Section IX.A.2) receives and processes the detection signal to “provide” these “one or more processed signals to back end processing circuitry 170,” or the depicted “**output signal**” in Fig. 1 below. ’533-FWD, 37-39 (discussing claim 13) (citing ’533-Pet. 48-49), 42-43 (applying analysis of claim 13 to claim 5); **Lisogurski**, 11:9-10, 11:20-27, 11:41-46, 11:50-54, 12:42-45, Fig. 1. This is consistent with my opinions regarding this ’533 limitation, which I incorporate by reference as if fully set forth herein. ’533-Anthony, ¶¶136-138.

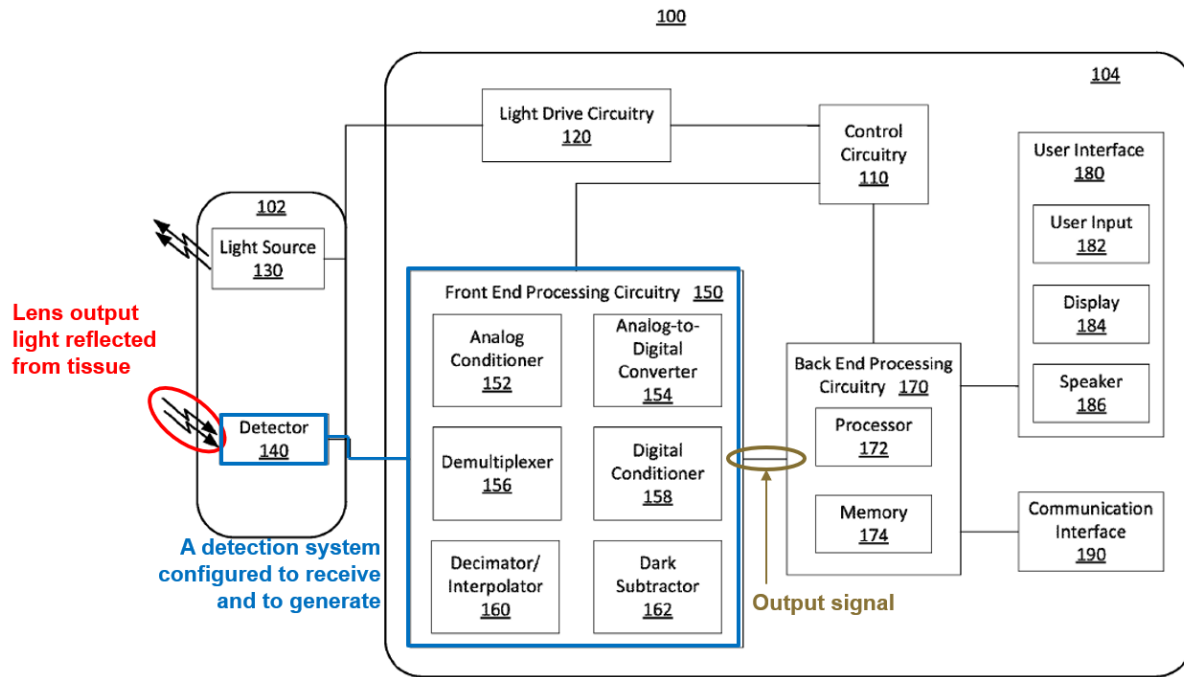


FIG. 1

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

136. Regarding this '304 limitation's additional recitation of the output signal "**representing at least in part a non-invasive measurement on blood contained within the sample,**" Lisogurski discloses that "the detection signal" generated by "detector 140" "may be processed" by front end processing circuitry 150 and, from the processed signal, "physiological parameters may be determined (e.g., based on the absorption of the Red and IR wavelengths in the subject's tissue)." Lisogurski, 11:13-27. As Lisogurski teaches, these absorption levels in the subject's tissue are used by detector 140 to "**non-invasively measure the oxygen saturation of a patient's blood**" to perform pulse oximetry. Figs. 1, 3, 3:61-4:62,

10:46-49, 17:55-59. Thus, the processed detection signal, or the processed signal, is an **output signal generated** by detector 140, as modified (see my discussion in Section IX.A.2), and **represents at least in part a non-invasive measurement on blood contained within the subject's tissue.**

h. Element [1.g]

137. Element [1.g] recites: “**synchronize to the light source.**” This element is met by **Lisogurski**.

138. The Board previously found this identical limitation was met by **Lisogurski** in the prior '533 IPR. In particular, to meet “**synchronized to the light source**” (recited in claim 5 of the '533 patent), the Board relied on **Lisogurski's** disclosure that the “front end processing circuitry” 150 of the receiver (*see* my discussion in Section IX.A.3.[1.d]), as modified (*see* my discussion in Section IX.A.2), “use[s] 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, 39 (discussing claim 13) (citing '533-Pet. 44-45); Lisogurski, 11:41-46, 11:50-54. As discussed in further detail in connection with [19.b] below (see my discussion in Section IX.A.3.[19.b]), Lisogurski discloses light drive circuitry 120 synchronizes the light source 130 by operating in “continuous modulation.” Lisogurski, 11:50-54. This is consistent with my opinions regarding

this '533 limitation, which I incorporate by reference as if fully set forth herein. '533-Anthony, ¶¶136-146.

139. As further support for this limitation, **Lisogurski** discloses that its “front end processing circuitry 150” of its detector 140/318, as modified in the manner I discussed in Section IX.A.2, “use[s] the timing control signals to operate synchronously with light drive circuitry 120,” which controls operation of the light source. Lisogurski, 11:41-46, 11:50-54. Light drive circuitry 120 “generate[s] a light drive signal that is provided to light source 130 of sensor 102,” which “control[s] the intensity of light source 130 and the timing of when light source 130 is turned on and off.” Lisogurski, 11:50-54. To this end, Lisogurski teaches that the drive cycle of the light source includes a sequence of “on” and “off” portions, where a signal is generated during the “off” portion to determine, for example, the level of ambient light, noise, or dark current to be subtracted from the “on” signals. *See* Lisogurski, 16:67-17:2. 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, as I discuss in Section IX.A.3.k.[1.j] below.

140. '304 patent element [1.g] is substantially identical to language in the corresponding limitation in the '533 patent on which I previously opined, which recites: “**synchronized to pulses of the light source.**” The only difference between

the two limitations is the '533's addition of "pulses of." A person of ordinary skill in the art would have understood that synchronizing to the pulses of the light is just one method for synchronizing to a light source and that synchronizing to the light source would include synchronizing to the pulses of the light source. Thus, the differences between the two terms do not change my analysis, and my opinions regarding the '533 patent term apply equally to '304 patent element [1.g]. '533-Antony, ¶¶136-146.

141. I understand that Defendants identified this limitation ("**a receiver configured to: ... synchronize to the light source**") as potentially indefinite in the Texas case. Ex. 1023, 238. Regardless of its outer bounds (e.g., extent of synchronization), 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. For example, embodiments of the '304 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.*, '304 patent, 18:24-29. 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.

142. As 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** light source (see my discussion in 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 explicitly ensure that the detection system, comprising the front-end processing circuitry 150 and associated ADC, 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.

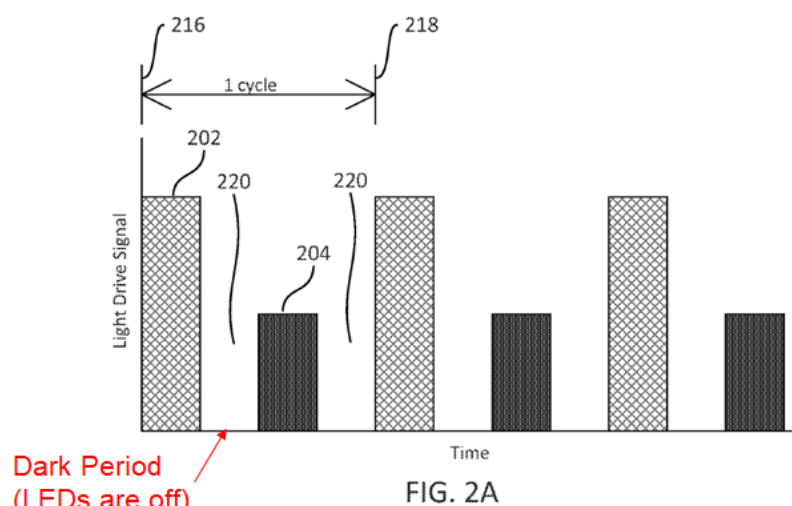
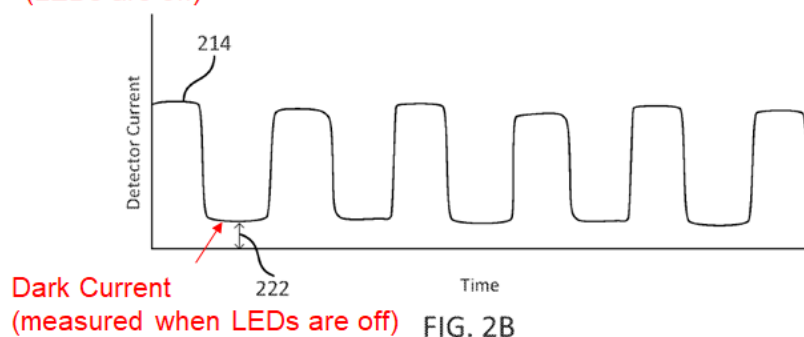
i. Element [1.h]

143. Element [1.h] recites: “capture light while the semiconductor sources are off and convert the captured light into a first signal.” This element is met by **Lisogurski**.

144. The Board previously found a substantially similar limitation was met by **Lisogurski** in the prior '484 IPR. In particular, to meet a detection system configured to “**generate a first signal responsive to light received while the semiconductor diodes are off**” (recited in claim 1 of the '484 patent), the Board relied on **Lisogurski**'s disclosure that “the front end processing [circuitry 150]” of the receiver (see my discussion in Section IX.A.3.[1.d]), as modified (see my discussion in Section IX.A.2) “uses the current measured when the LEDs are off to generate a dark signal representative of ambient light.” '484-FWD, 43-44 (citing '484-Pet. 54-55); Lisogurski, Figs. 2A-B, 6:12-19, 11:14-16, 12:59-13:6, 13:31-41, 13:67-14:6; '484-Anthony ¶¶197-198. This is consistent with my opinions regarding this '484 limitation, which I incorporate by reference as if fully set forth herein. '484-Anthony, ¶¶193-198.

145. '304 patent element [1.h] is substantially similar to the corresponding limitation in the '484 patent on which I previously opined, and which recites: “**generate a first signal responsive to light received while the light emitting diodes are off**” (claim 1). Aside from differing turns of phrases, the main differences between the two limitations are: (i) the '484's use of “generate a first signal” as opposed to the '304's use of “convert the captured light into a first signal” and (ii) the '484's use of “light received” as opposed to the '304's use of “capture light.” Though the limitations use slightly different language, they cover

substantially the same concept, and the disclosure from **Lisogurski** relied upon by the Board to meet the '484 limitation also satisfies '304 patent element [1.h]. Consistent with the Board's findings (discussed above), **Lisogurski's** detector receives and captures ambient light during "off" periods when the LEDs are off and converts that captured light into or generate a "dark signal" by measuring the current when the LEDs are off. Lisogurski, 13:60-14:10, 16:48-53, Figs. 2A-B. Thus, the differences between the two terms do not change my analysis, and my opinions regarding the '484 patent term apply equally to '304 patent element [1.h]. '484-Anthony, ¶¶193-198.



j. Element [1.i]

146. Element [1.i] recites: “capture light while at least one of the semiconductor sources is on and convert the captured light into a second signal, the captured light including at least a part of the at least a portion of the analysis output beam reflected or transmitted from the sample, and.” This element is met by Lisogurski.

147. This limitation includes language similar to that which was already determined unpatentable by the Board in the 484-IPR (“generate a second signal responsive to light received while at least one of the light emitting diodes is on”) and new language that was not previously considered (“the captured light including at least a part of the at least a portion of the analysis output beam reflected or transmitted from the sample”). See ’484-FWD, 43-44 (finding that Lisogurski’s “front end processing circuitry” meets “generat[ing] a second signal responsive to light while at least one of the [LEDs] is on”).

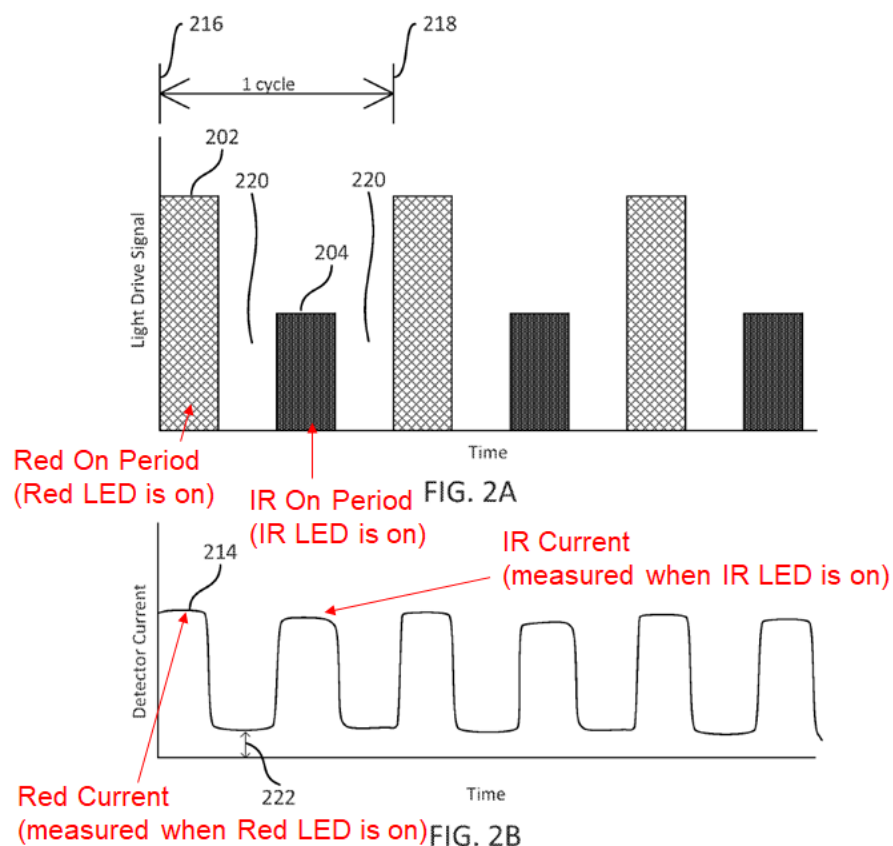
148. The Board previously found a substantially identical limitation was met by Lisogurski in the prior ’484 IPR. In particular, to meet “generate a second signal responsive to light received while at least one of the semiconductor diodes is on” (’484 claim 1), the Board relied on Lisogurski’s disclosure that “the front end processing circuitry measur[es] the signal when at least one LED is on to capture a portion of the optical beam, e.g., a red signal and an IR signal, reflected from the

tissue.” ’484-FWD, 43-44 (citing ’484-Pet. 55-56); Lisogurski, Figs. 2A-B, 6:12-19, 8:16-23, 11:12-20, 13:35-41, 13:67-14:2, 16:52-53, 17:8-10, 17:40-42. This is consistent with my opinions regarding this ’484 limitation, which I incorporate by reference as if fully set forth herein. ’484-Anthony, ¶¶199-202.

149. As further support for this limitation, **Lisogurski** discloses that “front end processing circuitry 150” of its detector 140/318, as modified in the manner I discussed in Section IX.A.2, uses the current measured during a “‘on’ periods” for the LEDs to capture a “red signal” and an “IR signal” reflected from the tissue. For example, **Lisogurski** discloses detector 140 “detect[s] the light that is reflected by or has traveled through the subject’s tissue” **when at least one LED is on** and “front end processing circuitry 150” will then “**generate a Red signal [and] an IR signal**” based on the light detected. Lisogurski, Figs. 2A-B, 6:12-19, 8:16-23, 11:12-20, 13:35-42, 13:67-14:2, 16:52-53, 17:8-10, 17:39-42.

150. The “**capture light while at least one of the semiconductor sources is on and convert the captured light into a second signal**” language in ’304 patent element [1.i] 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**” (claim 1). As with [1.h] above, the main differences between the two limitations are: (i) the ’484’s use of “generate” as opposed to the ’304’s use of “convert” and (ii)

the '484's use of "light received" as opposed to the '304's use of "captured light." As I explained for [1.h] above and reproduce below, these differences do not change my analysis in the context of the limitations. Though the limitations use slightly different language, they cover substantially the same concept, and the disclosure from **Lisogurski** relied upon by the Board to meet the '484 limitation also satisfies '304 [1.i]. Consistent with the Board's findings (discussed above), **Lisogurski's** detector captures, or receives, light emitted by the LEDs and reflected by or transmitted from subject's tissue during "on periods" and converts that captured light into, or generates, "Red and IR signals" by measuring the current when the LEDs are on. Lisogurski, 13:60-14:10, 16:48-53, 17:39-42, Figs. 2A-B. Thus, the differences between the two terms do not change my analysis, and my opinions regarding the '484 patent term apply equally to '304 patent element [1.i]. '484-Anthony, ¶¶199-202.



151. Regarding the '304 patent's additional recitation of the “**captured light including at least a part of the at least a portion of the analysis output beam reflected or transmitted from the sample,**” **Lisogurski** discloses that detector 140 “detect[s] the light that is reflected by or has traveled through the subject’s tissue” when at least one light source, such as an LED is “on.” **Lisogurski**, 7:58-61, 8:16-23, 17:39-42. As I discussed for [1.c] above, **Lisogurski** teaches that the “light” emitted from an LED “into the tissue of a subject to generate physiological signals” is the claimed “analysis output beam.” 10:52-56. *See* my discussion in Section IX.A.3.[1.c]. Thus, the light that is detected by detector 140 includes at least a

portion of the light that is emitted by the LED diode which “is reflected by or has traveled through the subject’s tissue.” Lisogurski, 17:39-42.

k. Element [1.j]

152. Element [1.j] recites: “the **measurement system** further configured to **improve the signal-to-noise ratio by differencing the first signal and the second signal.**” This element is met by Lisogurski.

153. As I discussed in [1.pre], Lisogurski discloses the **measurement system**. See my discussion in Section IX.A.3.[1.pre].

154. Additionally, the Board previously found a substantially identical limitation was met by Lisogurski in the prior ’484 IPR. In particular, to meet “the detection system **further configured to:... increase the signal-to-noise ratio by comparing the first signal and the second signal**” (’484 claim 1), the Board relied on Lisogurski’s disclosure of a “dark subtractor 162” (of front end processing circuitry 150) that performs “a ‘dark subtraction’ technique that **subtracts the dark signal**” (see my discussion in Section IX.A.3.[1.h]) “from **the red and IR signals,**” thus differencing the red/IR and dark signals (see my discussion in Section IX.A.3.[1.i]) “**to generate adjusted red and IR signals with noise removed, thereby improving signal-to-noise ratio.**” ’484-FWD, 43-44 (citing ’484-Pet. 54, 57); Lisogurski, Fig. 1, 6:7-19, 13:60-14:10, 16:33-54; ’484-Anthony ¶¶194, 204-206.

This is consistent with my opinions regarding this '484 limitation, which I incorporate by reference as if fully set forth herein. '484-Anthony, ¶¶203-206.

155. '304 patent element [1.j] is substantially identical to the corresponding limitation in the '484 patent on which I previously opined, which recites: “**increase the signal-to-noise ratio by comparing the first signal and the second signal.**” The main differences between the two limitations are: (i) the '304's use of “differencing the first signal and the second signal” as opposed to the '484's “comparing” the signals and [ii] the '304's use of “improve the signal-to-noise ratio” as opposed to the '484's “increase the signal-to-noise ratio.” Though the limitations use slightly different language, they cover substantially the same concept, and the disclosure from **Lisogurski** relied upon by the Board to meet the '484 limitation also satisfies '304 [1.j]. Consistent with the Board's findings (discussed above), **Lisogurski** uses a “dark subtractor” that differences the “dark signal” portions of the detected signals and the “Red and IR signals” to generate adjusted red and IR signals with noise removed, thereby improving signal-to-noise ratio. Lisogurski, 13:60-14:10, 16:33-54. Thus, the differences between the two terms do not change my analysis, and my opinions regarding the '484 patent term apply equally to '304 patent element [1.j]. '484-Anthony, ¶¶203-206.

I. Element [1.k]

156. Element [1.k] recites: “**a smart phone or tablet** 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 smart phone or tablet configured to: **receive and process at least a portion of the output signal, store and display the processed output signal, and transmit at least a portion of the processed output signal over a wireless transmission link**; and.” This element is met by Lisogurski.

157. The Board previously found a substantially identical limitation was met by **Lisogurski** in the prior ’484 IPR. In particular, to meet “**smart phone or tablet**” (’484 claim 1), the Board relied on **Lisogurski’s** disclosure that “its sensor is designed to be used with **a monitor that may be a portable, battery powered system.**” ’484-FWD, 25-27 (citing ’484-Pet., 40-42 (“a skilled person would have considered **Lisogurski** to disclose, or at least to render obvious, implementing Lisogurski’s monitor as a tablet or smartphone”)); Lisogurski, Figs. 1, 3, 1:16-18, 15:20-23, 15:19-23, 15:49-56, 18:65-66; ’484-Anthony ¶138. As the Board found, a person of ordinary skill in the art would have found that **Lisogurski’s monitor 104, which is “portable,” “battery powered,” and having a “user interface 180” with “a touch screen,” would include a smart phone or tablet.** ’484-FWD, 25-27 (citing ’484-Pet. at 41-42); Lisogurski, Fig. 1, 1:16-18, 15:20-27, 18:65-66. This is

consistent with my opinions regarding this '484 limitation, which I incorporate by reference as if fully set forth herein. '484-Anthony, ¶¶136-142.

158. To show that **Lisogurski's** monitor 104 (as modified, *see* my discussion in Section IX.A.2) comprises a “**wireless receiver, a wireless transmitter, a display, a speaker, a microphone, one or more buttons or knobs, a microprocessor and a touch screen**” ('533 claims 5/13, *see also* '484 claim 1²), the Board relied on **Lisogurski's** disclosure of monitor 104 includes “communication interface 190” (which “include[s] one or more receivers” and “transmitters” “configured to allow...wireless communication”), user interface 180 (which includes a “display 184,” “speaker 186,” and user input 182 which includes a “microphone,” “buttons,” and “touch screen”), and “backend processing circuitry 170” (which “includes microprocessor 172”). '533-FWD, 40 (discussing claim 13) (citing '533-Pet., 50-51), 42-43 (applying analysis of claim 13 to claim 5); '484-FWD, 16-17, 25-27 (citing '484-Pet. 40-42); Lisogurski, 14:60-15:16, 15:19-23, 15:30-35, 15:43-57, 18:11-15, 18:49-65, 26:55-60, 27:31-36, Fig. 1.

² Claim 1 of the '484 patent is almost identical to the corresponding limitation of claims 5 and 13 of the '533 patent, except that claim 1 of the '484 patent recites a “voice input module” instead of a “microphone” (as claimed in the '533 limitation).

159. To show that **Lisogurski’s** monitor 104 (as modified, *see* my discussion in Section IX.A.2) is 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” (’533, claims 5/13, ’484 claim 1), the Board relied on **Lisogurski’s** disclosure that “**processor 172 in back end processing circuitry 170**” of monitor 104 (as modified, *see* my discussion in Section IX.A.2) “**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.’**” ’533-FWD, 41 (citing ’533-Pet., 50-53); ’484-FWD, 25-26 (citing ’484-Pet, 40-41); Lisogurski, 14:56-64, Fig. 1. As the Board further explained, “[m]onitor 104/314 **displays the processed output signal (i.e., a determined physiological parameter) because it includes display 184/320, which can ‘display, for example, an estimate of a subject’s blood oxygen saturation generated by monitor 104.’**” ’533-FWD, 41 (discussing claim 13) (citing ’533-Pet., 50-53), 42-43 (applying analysis of claim 13 to claim 5); ’484-FWD, 25-26 (citing ’484-Pet, 40-41); Lisogurski, 15:30-35, Figs. 1, 3; ’484-FWD, 25-26 (citing ’484-Pet, 40-41) (discussing claim 1, which has identical limitation language). Furthermore, the Board explained that “[m]onitor 104/314 **stores the processed**

output signal because it includes memory 174, which can store “historical information [measured in] previous cardiac cycles.” ’533-FWD, 41 (citing ’533-Pet., 50-53); Lisogurski, 14:64-15:16, 27:31-36, Fig. 1.

160. And, as the Board further found, “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,” such as “WiFi, IR, WiMax, BLUETOOTH, UWB or other standards.” ’533-FWD, 41-42 (discussing claim 13) (citing ’533-Pet., 50-53), 42-43 (applying analysis of claim 13 to claim 5); Lisogurski, 15:43-57, 18:11-15, 18:49-65, 26:55-60, Figs. 1, 3.

161. ’304 patent element [1.k] is substantially identical to the corresponding limitations in the ’484 and ’533 limitations, on which I previously opined:

- ’484, claim 1: “**a 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**”

- '533, claims 5, 13: “**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.**”

162. Aside from reordering of the listed components, the main difference between '304 [1.k] and the prior similar '484 limitation is the '304's use of a “microphone” as opposed to the '484's use of “a voice input module.” However, the Board already found that **Lisogurski** discloses a “microphone” when it found that **Lisogurski** met the claimed “microphone” term of the similar '533 limitation based on the same embodiment relied upon by the Board to meet the “voice input module” of the '484 limitation. '533-FWD, 39-40; Lisogurski, 15:20-23. Thus, the differences between '304 patent element [1.k] and the substantially identical limitations in the '484 and '533 patents do not change my analysis, and my opinions regarding the '484 and '533 patent terms apply equally to '304 patent element [1.k]. '484-Anthony, ¶¶136-142; '533-Anthony, ¶¶147-153.

m. Element [1.l]

163. **Element [1.l] recites: “a cloud configured to.”** This element is met by **Lisogurski**.

164. The Board previously found an identical limitation was met by **Lisogurski** in the prior ’484 IPR. In particular, to meet **“a cloud configured to”** (’484 claim 1), the Board relied on **Lisogurski’s** disclosure that “multi-parameter physiological monitor (MPPM 326)” is “coupled to a network to enable sharing of information with servers or other workstations, i.e., a cloud based server.” ’484-FWD, 26-27 (citing ’484-Pet. 42-43); Lisogurski, 15:55-57, 18:49-53, 18:63-65. 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, ¶¶143-147.

n. Element [1.m]

165. **Element [1.m] recites: “receive, over the wireless transmission link, an output status comprising the at least a portion of the processed output signal.”** This element is met by Lisogurski.

166. The Board previously found an identical limitation was met by **Lisogurski** in the prior ’484 and ’533 IPR. In particular, to meet the same limitation (’484 claim 1, ’533 claims 5/13), the Board relied on **Lisogurski’s** disclosure that “physiological parameters and other data may be wirelessly transmitted to a server

or a multi-parameters physical monitor (MPPM 326).” ’484-FWD, 26 (citing ’484-Pet. 42-43); ’533-FWD, 42 (discussing claim 13) (citing ’533-Pet. 53-55), 42-43 (applying analysis of claim 13 to claim 5); Lisogurski, 15:43-48, 18:49-53, 18:58-62, 20:8-13, 26:51-60. For example, **Lisogurski** discloses that “processor 172” of “front end processing circuitry” 150 “determine[s] one or more physiological parameters based on the received physiological signals,” which “communication interface 190” transmits to “a network, a server or other workstations,” including MPPM 326. 14:61-64, 15:43-57. And as **Lisogurski** teaches, these physiological parameters indicate a physiological status of the patient, such as “pulse rate, blood pressure, blood oxygen saturation (e.g., arterial, venous, or both), hemoglobin concentration (e.g., oxygenated, deoxygenated, and/or total).” 17:63-67. As such, the physiological parameters received by MPPM 326 constitute the **claimed “output status”** comprising at least a portion of the physiological signals (**claimed “processed output signal”**; see my discussion in Section IX.A.3.[1.k]). This is consistent with my opinions regarding these ’484 and ’533 limitations provided in my Prior ’484 and ’533 Declarations, which I incorporate by reference as if fully set forth herein. ’484-Anthony, ¶¶143-147; ’533-Anthony, ¶¶154-157.

o. Element [1.n]

167. **Element [1.n] recites: “process the received output status to generate processed data, and store the processed data.”** This element is met by **Lisogurski**.

168. The Board previously found an identical limitation was met by **Lisogurski** in the prior ’484 and ’533 IPRs. In particular, to meet the same limitation (’533 claims 5, 13, ’484 claims 1, 7, 15), the Board found that **Lisogurski’s** MPPM 326 “process[es] the received output status” (e.g., “pulse rate, blood pressure, blood oxygen saturation ..., hemoglobin concentration”, *see* my discussion in Section IX.A.3.[1.m]) “to generate processed data, and ... store[s] the processed data” because MPPM 326 “monitor 104/314 can ‘publish the data,’ and thus MPPM 326 “would need to process the data and then store it” in order to “publish” it.” ’533-FWD, 42-43 (citing ’533-Pet. 53-55); ’533-Anthony ¶155; ’484-FWD, 26 (citing ’484-Pet., 44); Lisogurski, 15:43-48, 18:49-53, 18:58-62, 20:8-13, 19:1-19, 26:55-60. At minimum, it would have been obvious to do so. This is consistent with my opinions regarding these ’484 and ’533 limitations provided in my Prior ’484 and ’533 Declarations, which I incorporate by reference as if fully set forth herein. ’484-Anthony, ¶¶143-147; ’533-Anthony, ¶¶154-157.

p. **Claim 3**

169. Claim 3 recites: “The measurement system of claim 1, wherein **the light source is further configured to increase the light intensity from the plurality of semiconductor sources by spatially coupling the optical output beam from at least two of the plurality of semiconductor sources.**” This claim is met by **Lisogurski**.

170. As I discussed above for Claim 1 (*see* my discussion in Section IX.A.3.[1.pre]-[1.n]), **Lisogurski’s** “physiological monitoring system,” which includes “**light source 130**” within “sensor 102/103,” meets the **the light source is further configured to increase the light intensity from the plurality of semiconductor sources** limitation. In particular, **Lisogurski** discloses a “**sensor**” 102/103 including “**light source 130**” that “**increase[s] the brightness**” of “**multiple LEDs,**” as I discussed in [1.a] above (*see* Section IX.A.3.[1.a]). **Lisogurski**, 10:48-64, 9:50-52, 11:50-54.

171. Additionally, **Lisogurski** teaches and renders obvious increasing light intensity by **spatially coupling multiple LEDs**. For example, **Lisogurski** discloses that when performing blood oxygen measurements, its physiological monitoring system “may operate a **first light source**” such as an “**(IR) LED,**” “at full or regular brightness,” and “**the brightness of a light source may be... increased during a more important period**” by “**power[ing] additional light sources,**” such as “**red LEDs**”

during “periods of interest.” 5:4-7, 7:40-64; *see also* 17:37-39, 19:24-31, 25:36-43.

A person of ordinary skill in the art would have understood that increasing brightness using additional light sources would have been done by spatially combining the output beams from each of the multiple LEDs (e.g., “(IR) LED” and “red LED”) into one beam. Indeed, it was a well-known way to increase brightness of a light source, as illustrated by e.g., U.S. Patent Publication No. 2006/0184040, which I understand has been designated as Exhibit 1077, as further discussed below. For example, Keller explains that “light ... can be injected into or combined with the light from the main light source” to “provide additional intensity” for a “light source.” Ex. 1077 (Keller), ¶89. Similarly, U.S. Patent No. 5,497,769, which I understand has been designated as Exhibit 1059, discloses a tissue spectrometer that incorporated “four different laser diodes” as light sources to ensure sufficient optical power for measuring blood oxygenation. Ex. 1059 (Gratton), 2:16-23. U.S. Patent No. 5,827,182, which I understand has been designated as Exhibit 1060, also discloses oximeter sensor in which “a first emitter [infrared] and second and third emitters [red]” are operated together to bolster the brightness at a given wavelength. Ex. 1060 (Raley), 3:26-47. Further, U.S. Patent No. 7,764,982, which I understand has been designated as Exhibit 1061, describes activating an array of same-wavelength LEDs simultaneously to “boost at least a portion of the red wavelength spectrum” and equalize signal attenuation. Ex. 1061 (Dalke), 8:53-9:12. Thus,

increasing the brightness of a light source by spatially coupling beams from multiple light sources would have been well-known (and at least obvious) to a person of ordinary skill in the art.

q. Element [11.pre]

172. Element [11.pre] recites: “**A measurement system comprising.**” This element is met by **Lisogurski**.

173. ’304 patent element [11.pre] is identical to ’304 patent element [1.pre], which recites: “**A measurement system comprising.**” Thus, my opinions regarding the term in the ’304 patent element [1.pre] apply equally to ’304 patent element [11.pre].

174. Thus, for the reasons stated in element [1.pre], **Lisogurski’s** “optical physiological monitoring system” meets this limitation. *See* my discussion in Section IX.A.3.[1.pre].

r. Element [11.a]

175. Element [11.a] recites: “**a wearable measurement device for measuring one or more physiological parameters, including a light source comprising a plurality of semiconductor sources that are configured to generate an output optical beam with one or more optical wavelengths.**” This element is met by **Lisogurski**.

176. The Board previously found a substantially identical limitation was met by **Lisogurski** in the prior '533 IPR. In particular, to meet “**a wearable measurement device for measuring one or more physiological parameters, 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**” ('533 claim 13), the Board relied on **Lisogurski's** disclosure of a “**sensor 102/312 for measuring blood oxygen saturation,... [which may be] mounted on a user's fingertip, toe, earlobe, wrist, or thigh.**” '533-FWD, 25 (citing '533-Pet. 28); **Lisogurski**, 1:10-25, 3:43-46, 4:6-20, 17:55-59; *see also* '484-FWD, 23 (citing '484-Pet. 27-28) (discussing similar grounds for substantially similar limitation recited in claims 1, 7, and 15: “a wearable device adapted to be placed on a wrist or an ear of a user, and including a light source comprising a plurality of semiconductor sources, each of the semiconductor sources configured to generate an output light having one or more optical wavelengths”). For example, **Lisogurski** discloses that sensor 102/312 “**include[s] light source 130,**” which “**may include LEDs**” emitting light “**of multiple wavelengths, for example, a red LED and an IR LED.**” **Lisogurski**, 10:48-57, 3:43-46, 17:55-59, 19:20-31. This is consistent with my opinions regarding the '533 limitation (and substantially similar limitation in the '484 patent), which I incorporate by reference as if fully set forth herein. '533-Anthony, ¶¶89-94; '484-

Anthony, ¶¶96-101. *See also* my discussion in Element [1.a] above (“**a light source comprising a plurality of semiconductor sources that are configured to generate an output optical beam with one or more optical wavelengths**”).

177. ’304 patent element [11.a] is substantially identical to language in the corresponding limitation in the ’533 patent on which I previously opined, and which recites: “**wearable measurement device for measuring one or more physiological parameters, 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**” (’533 claim 13). The only difference between the two limitations is the ’533 patent’s inclusion of “light emitting diodes” as a type of “plurality of semiconductor sources.” As discussed above in [1.a], it was well known in the art that light emitting diodes are semiconductor sources such that the differences between the two terms do not change my analysis, and my opinions regarding the ’533 patent term apply equally to ’304 patent element [11.a]. ’533-Anthony, ¶¶89-94. *See* my discussion in Section IX.A.3.[1.a].

s. Element [11.b]

178. Element [11.b] recites: “**the light source configured to increase signal-to-noise ratio by increasing a light intensity relative to an initial light**

intensity from at least one of the plurality of semiconductor sources.” This element is met by **Lisogurski**.

179. '304 patent element [11.b] is a subset of '304 patent element [1.a], which recites: “**a light source comprising a plurality of semiconductor sources that are configured to generate an output optical beam with one or more optical wavelengths, the light source configured to increase signal-to-noise ratio by increasing a light intensity relative to an initial light intensity from at least one of the plurality of semiconductor sources**” (language identical to [11.b] underlined for readability). Thus, my opinions regarding the term in '304 patent element [1.a] term apply equally to '304 patent element [11.b].

180. Thus, for the reasons stated in element [1.a], **Lisogurski's** sensor with a light source meets this limitation. *See* my discussion in Section IX.A.3.[1.a].

181. I understand that Defendants identified “the light source configured to increase signal-to-noise ratio by increasing a light intensity relative to an initial light intensity from at least one of the plurality of semiconductor sources” as potentially indefinite in the Texas case. Ex. 1023, 238. As discussed above in [1.a] (Section IX.A.3.[1.a]), however, and 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”), and without opining on whether or not it has adequate written

description support, **Lisogurski** meets this term because **Lisogurski** discloses the indisputable scope of the limitations.

t. Element [11.c]

182. Element [11.c] recites: **“the wearable measurement device configured to receive a portion of the output optical beam, and to deliver an analysis output beam to a sample.”** This element is met by **Lisogurski**.

183. As discussed above in connection with [1.b], **Lisogurski** discloses the claimed **“measurement device configured to.”** For example, as discussed in Section [1.b], the Board relied on **Lisogurski’s** disclosure of a “sensor 102/312 for measuring blood oxygen saturation” to meet **“a measurement device”** (recited in claims 5 and 13 of the ’533 patent). ’533-FWD, 25 (discussing claim 13)(citing ’533-Pet., 28), 42-43 (applying analysis of claim 13 to claim 5); **Lisogurski**, 4:6-20, 4:15-20, 17:55-59, *see also* Figs. 1, 3, 3:6-4:5, 4:21-64.

184. Additionally, as discussed in Section [1.c], to meet **“receive a portion of the output optical beam, and deliver an analysis output beam to a sample”** (recited in claims 5 and 13 of the ’533 patent), the Board relied on **Lisogurski’s** disclosure that “sensor 102” includes “LEDs,” which, as the Board determined, “a [person of ordinary skill in the art] would have known that LEDs are often covered by lensing encapsulants” to “direct more of the light produced by the LED outward toward the tissue.” ’533-FWD, 35-37 (discussing claim 13) (citing ’533-Pet., 39-

40), 42-43 (applying analysis of claim 13 to claim 5); Lisogurski, 7:38-8:3, 10:48-56, 19:25-31.

185. Furthermore, for the reasons discussed in [11.a], **Lisogurski’s** measurement device (e.g., “sensor 102/312 for measuring blood oxygen”) is a “**wearable measurement device**” (as claimed in [11.a]) because as the Board already found in the prior ’533 IPR, **Lisogurski** discloses that the “sensor 102/312” is mounted on a user’s fingertip, toe, earlobe, wrist, or thigh. ’533-FWD, 25 (citing ’533-Pet. 53-55); Lisogurski, 4:6-20.

186. Thus, for the reasons discussed in [1.b], [1.c], and [11.a], **Lisogurski** meets this element. *See* my discussion in Sections IX.A.3.[1.b], [1.c], and [11.a].

u. Element [11.d]

187. Element [11.d] recites: “**the wearable measurement device further comprising a receiver configured to.**” This element is met by **Lisogurski**.

188. As discussed above in connection with [1.d], **Lisogurski** discloses the claimed “**receiver configured to,**” which is substantially identical to the language recited in [11.d]. For example, as discussed in [1.d], to show that **Lisogurski** renders obvious the claimed “receiver” (recited in claims 5 and 13 of the ’533 patent) the Board relied on **Lisogurski’s** disclosure of “detector 140/318 and front end processing circuitry 150” in **Lisogurski’s** modified system (*supra*, Section IX.A.2). ’533-FWD, 37-39 (discussing claim 13) (citing ’533-Pet. 45-49), 42-43

(applying analysis of claim 13 to claim 5); Lisogurski, 11:9-27, 11:41-46, 12:42-45, 17:40-42, Figs. 1, 3; *see also* 7:39-42, 10:48-49, 16:2-9.

189. Moreover, **Lisogurski’s** receiver (e.g., “detector 140/318 and front end processing circuitry 150” in **Lisogurski’s** modified system (*supra*, Section IX.A.2)) is included in **Lisogurski’s** wearable measurement device (e.g., “sensor 102/312 for measuring blood oxygen saturation, [which may be] mounted on a user’s fingertip, toe, earlobe, wrist, or thigh,” *see* [11.pre]). Lisogurski, 4:6-20.

190. Thus, for the reasons stated in elements [1.d] and [11.pre], Lisogurski’s detector and front end processing circuitry meets this limitation. *See* Sections IX.A.3.[1.d] and [11.pre].

v. Element [11.e]

191. Element [11.e] recites: “**receive and process at least a portion of the analysis output beam reflected or transmitted from the sample.**” This element is met by **Lisogurski**.

192. As discussed above in connection with [1.d] and [1.e], **Lisogurski** discloses “a receiver configured to: **receive and process at least a portion of the analysis output beam reflected or transmitted from the sample,**” which is identical to [11.d] and [11.e]. Additionally, as discussed in connection with [11.d], **Lisogurski’s** receiver is part of **Lisogurski’s** wearable measurement device.

193. Thus, for the reasons stated in elements [1.d], [1.e], and [11.d], Lisogurski's detector and front end processing circuitry meet this limitation. *See* my discussion in Sections IX.A.3.[1.d], [1.e], and [11.d].

w. Element [11.f]

194. Element [11.f] recites: “**generate an output signal representing at least in part a non-invasive measurement on blood contained within the sample.**” This element is met by **Lisogurski**.

195. As discussed above in connection with [1.d] and [1.f], **Lisogurski** discloses “a receiver configured to: **generate an output signal representing at least in part a non-invasive measurement on blood contained within the sample,**” which is identical to [11.d] and [11.f]. Additionally, as discussed in connection with [11.d], **Lisogurski's** receiver is part of **Lisogurski's** wearable measurement device.

196. Thus, for the reasons stated in elements [1.d], [1.f], and [11.d], Lisogurski's detector and front end processing circuitry meet this limitation. *See* my discussion in Sections IX.A.3.[1.d], [1.f], and [11.d].

x. Element [11.g]

197. Element [11.g] recites: “**synchronize to the light source.**” This element is met by **Lisogurski**.

198. As discussed above in connection with [1.d] and [1.g], **Lisogurski** discloses “a receiver configured to: **synchronize to the light source,**” which is

identical to [11.d] and [11.g]. Additionally, as discussed in connection with [11.d], **Lisogurski's** receiver is part of **Lisogurski's** wearable measurement device.

199. Thus, for the reasons stated in element [1.d], [1.g], and [11.d], **Lisogurski's** detector and front end processing circuitry meet this limitation. *See* my discussion in Sections IX.A.3.[1.d], [1.g], and [11.d].

200. I understand that Defendants identified this limitation (“**a receiver configured to: ...synchronize to the light source**”) as potentially indefinite in the Texas case. Ex. 1023, 238. As discussed above in [1.g], however, and regardless of its outer bounds (e.g., extent of synchronization) and without opining on whether or not it has adequate written description support, this term is met by **Lisogurski** because **Lisogurski** discloses and renders obvious the indisputable scope of the limitation. *See* my discussion in Section IX.A.3.[1.g].

y. **Element [11.h]**

201. Element [11.h] recites: “**capture light while the semiconductor sources are off and convert the captured light into a first signal.**” This element is met by **Lisogurski**.

202. As discussed above in connection with [1.d] and [1.h], **Lisogurski** discloses “a receiver configured to: **capture light while the semiconductor sources are off and convert the captured light into a first signal,**” which is identical to

[11.d] and [11.h]. Additionally, as discussed in connection with [11.d], **Lisogurski's** receiver is part of **Lisogurski's** wearable measurement device.

203. Thus, for the reasons stated in element [1.d], [1.h], and [11.d], **Lisogurski's** detector and front end processing circuitry meet this limitation. See my discussion in Sections IX.A.3.[1.d], [1.h], and [11.d].

z. Element [11.i]

204. Element [11.i] recites: “**capture light while at least one of the semiconductor sources is on and convert the captured light into a second signal, the captured light including at least a part of the at least a portion of the analysis output beam reflected or transmitted from the sample, and.**” This element is met by **Lisogurski**.

205. As discussed above in connection with [1.d] and [1.i], **Lisogurski** discloses “a receiver configured to: **capture light while at least one of the semiconductor sources is on and convert the captured light into a second signal, the captured light including at least a part of the at least a portion of the analysis output beam reflected or transmitted from the sample, and,**” which is identical to [11.d] and [11.i]. Additionally, as discussed in connection with [11.d], **Lisogurski's** receiver is part of **Lisogurski's** wearable measurement device.

206. Thus, for the reasons stated in element [1.d], [1.i], and [11.d], Lisogurski's detector and front end processing circuitry meet this limitation. *See* my discussion in Sections IX.A.3.[1.d], [1.i], and [11.d].

aa. Element [11.j]

207. Element [11.j] recites: **“wherein the measurement system further configured to improve the signal-to-noise ratio by differencing the first signal and the second signal.”** This element is met by Lisogurski.

208. '304 patent element [11.j] is almost identical to the '304 patent element [1.j], which recites: **“the measurement system further configured to improve the signal-to-noise ratio by differencing the first signal and the second signal.”** The only difference is that [11.j] adds “wherein” before the otherwise same limitation in [1.j], which is an immaterial difference. Thus, and my opinions regarding the term in '304 patent element [1.j] applies equally to '304 patent element [11.j].

bb. Element [11.k]

209. Element [11.k] recites: **“a smart phone or tablet 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 smart phone or tablet configured to: receive and process at least a portion of the output signal, store and display the processed output signal, and transmit at**

least a portion of the processed output signal over a wireless transmission link; and.” This element is met by **Lisogurski**.

210. For the reasons stated in element [1.k], **Lisogurski’s** monitor meets this limitation. *See* my discussion Section IX.A.3.[1.k].

211. ’304 patent element [11.k] is identical to the ’304 patent element [1.k], which recites: **“a smart phone or tablet 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 smart phone or tablet configured to: receive and process at least a portion of the output signal, store and display the processed output signal, and transmit at least a portion of the processed output signal over a wireless transmission link; and.”** Thus, and my opinions regarding the term in ’304 patent element [1.k] applies equally to ’304 patent element [11.k].

cc. Element [11.l]

212. Element [11.l] recites: **“a cloud configured to receive over the wireless transmission link an output status comprising the at least a portion of the processed output signal, to process the received output status to generate processed data and to store the processed data, and wherein the cloud is capable of storing a history of at least a portion of the received output status over a specified period of time.”** This element is met by Lisogurski.

213. As I discussed above in connection with [1.l], [1.m], and [1.n], **Lisogurski discloses and renders obvious “a cloud configured to”** (as recited by [1.l]), **“receive, over the wireless transmission link, an output status comprising the at least a portion of the processed output signal”** (as recited by [1.m]) to **“process the received output status to generate processed data”** (as recited by [1.n]). See my discussion in Sections IX.A.3.[1.l]-[1.n].

214. Regarding the remainder of this limitation (**“wherein the cloud is capable of storing a history of at least a portion of the received output status over a specified period of time”**), the Board previously found substantially identical limitations were met by **Lisogurski** in the prior ’484 and ’533 IPRs. In particular, to meet **“the cloud is configured to store a history of at least a portion of the one or more physiological parameters over a specified period of time”** (’484 claim 1) and **“wherein the remote device is capable of storing a history of at least a portion of the received output status over a specified period of time”** (’533 claims 5/13), the Board found that **Lisogurski’s** cloud (e.g., **“MPPM 326,”** see [1.l]) **“is configured to calculate physiological parameters, and ... can perform historical analysis or prior cardiac cycles and calculate statistical information.”** ’484-FWD, 26-27 (citing ’484-Pet., 44); ’533-FWD, 42-43 (citing ’533-Pet., 53-55 (citing Lisogurski, 15:43-48, 18:49-53, 18:58-62, 20:8-13, 26:51-60)); Lisogurski, 15:43-48, 18:49-53, 18:58-62, 19:1-19, 20:8-13, 26:51-60, 26:55-60. And, as the Board

agreed, a person of ordinary skill in the art would have understood that “to calculate historical statistical information, the [physiological monitoring] system must store the historical physiological data (*‘history of at least a portion of the one or more of the physiological parameters’*) over the specified period of time (e.g., a certain number of cardiac cycles or a certain period of time).” ’484-FWD, 26-27 (agreeing with ’484-Pet. 43-44 (emphasis in original)); ’484-Anthony, ¶¶150-154; *see also* ’533-FWD, 42 (citing ’533-Pet. 53-55) (finding that **Lisogurski** discloses **storing a history of at least a portion of the received output status over a specified period of time** because MPPM 326 “can perform statistical analysis on a history of physiological parameter measurements”); Lisogurski, 20:8-13, 26:51-60. At minimum, it would have been obvious to do so. This is consistent with my opinions regarding these ’484 and ’533 limitations, which I incorporate by reference as if fully set forth herein. ’484-Anthony, ¶¶148-154; ’533-Anthony, ¶¶158-163.

215. ’304 patent element [11.1] is substantially identical to language in the corresponding limitation in the ’533 patent on which I previously opined, and which recites: “**wherein the remote device is capable of storing a history of at least a portion of the received output status over a specified period of time**” (claims 5, 13). The main difference between the two limitations is the ’304’s limitation is performed by a “cloud” as opposed to the ’533’s limitation being performed by a “remote device.” But, the disclosure from **Lisogurski** relied upon by the Board to

meet the claimed “remote device” in the ’533 limitation (e.g., MPPM 326) is a cloud, as the Board found in the prior ’484 FWD. ’533-FWD, 42-43 (citing ’533-Pet. 53-55); ’484-FWD, 26-27 (citing ’484-Pet., 44); Lisogurski, 15:43-48, 18:49-53, 18:58-62, 20:8-13, 26:51-60. Thus, the disclosure from **Lisogurski** relied upon by the Board to meet the ’533 limitation for “remote device” also satisfies ’304 [1.c]. Thus, the differences between the two terms do not change my analysis, and my opinions regarding the ’533 patent term apply equally to ’304 patent element [11.l]. ’533-Anthony, ¶¶158-163.

dd. Element [19.pre]

216. Element [19.pre] recites: “**A wearable device for use with a smart phone or tablet, the wearable device comprising.**” This element is met by **Lisogurski**.

217. As I discussed above in Element [11.a], **Lisogurski** discloses “**a wearable device**” (e.g., “**sensor 102/312 for measuring blood oxygen saturation, [which may be] mounted on a user’s fingertip, toe, earlobe, wrist, or thigh.**”). ’533-FWD, 25 (citing ’533-Pet. 53-55); Lisogurski, 1:10-25, 3:43-46, 4:6-20, 17:55-59; *see also* ’484-FWD, 23 (citing ’484-Pet. 27-28). See my discussion in Section IX.A.3.[11.a].

218. Furthermore, the Board also previously found that **Lisogurski’s** sensor 102/312 (which meets the claimed “**wearable device**”) is **for use with a smart**

phone or tablet in the '484-IPR. '484-FWD, 23 (citing '484-Pet. 27-28 (citing Lisogurski, 1:10-25, 3:43-46, 4:6-20)). For example, to meet “**a system for measuring one or more physiological parameters and for use with a smart phone or tablet, the system comprising**” ('484 patent, claims 1, 7, 15), the Board found that **Lisogurski** teaches and renders obvious that **sensor 102/312** (as modified, *see* Section IX.A.2) includes “**front end processing circuitry 150**” that “**receive[s] a detection signal from detector 140 and provide[s] one or more processed signals to back end processing circuitry 170**” of **monitor 104**. Lisogurski, 12:42-45; '484-FWD, 23-24 (citing '484-Pet. 27-28, 33-34 (citing Lisogurski, 1:10-25, 3:43-46, 4:6-20, 11:14-22, 12:42-45, 17:40-42)). As I discussed (*see* my discussion in Section IX.A.3.[1.k]), and as the Board found, a person of ordinary skill in the art would have understood **monitor 104** to meet “**a smart phone or tablet**” and **sensor 102/312** is used with **monitor 104** because it transmits the processed detection signals to the back end processing circuitry 170 of **monitor 104**, thus allowing **monitor 104** to store and process the measurements from **sensor 102/312**. This is consistent with my opinions regarding this '484 limitation, which I incorporate by reference as if fully set forth herein. '484-Anthony, ¶¶89-95.

ee. Element [19.a]

219. Element 19.a recites: “**a measurement device including a light source comprising a plurality of semiconductor sources for measuring one or more physiological parameters.**” This claim is met by **Lisogurski**.

220. As discussed above in connection with [11.a], **Lisogurski** discloses the claimed “wearable **measurement device for measuring one or more physiological parameters, including a light source comprising a plurality of semiconductor sources,**” which satisfies this limitation because it merely reorders the claim language without any change in meaning (i.e., “for measuring one or more physiological parameters” is after “measurement device” in [11.a] instead of after “plurality of semiconductor sources”). *See* my discussion in Section IX.A.3.[11.a] above. Thus, for the reasons stated in [11.a], **Lisogurski** also discloses [19.a].

ff. Element [19.b]

221. Element 19.b recites: “**the measurement device configured to: generate, by modulating at least one of the semiconductor sources having an initial light intensity, an input optical beam having one or more optical wavelengths, and.**” This claim is met by **Lisogurski**.

222. As I discussed in [1.a] (Section IX.A.3.[1.a]) above, **Lisogurski** discloses that its “sensor 102/312” (*see* my discussion in Sections IX.A.3.[19.a] & [1.b]) includes **a plurality of semiconductor sources** (e.g., “multiple LEDs”) with

an **initial light intensity** (e.g., “brightness”) that are configured to **generate an output optical beam with one or more optical wavelengths** (e.g., “an LED that emits red light, and an LED that emits infrared light having a wavelength between 800 and 1000 nm”). *See* my discussion in Section IX.A.3.[1.c] (**receive a portion of the output optical beam, and deliver an analysis output beam to a sample**) and Section IX.A.3.[1.e] (**at least a portion of the analysis output beam reflected or transmitted from the sample**).

223. Additionally, the output optical beam **Lisogurski** discloses, as discussed in [1.a] above (*see* Section IX.A.3.[1.a]), functions as the claimed “input optical beam” because light source 130 in its sensor 102/312 “include[s] a Red light emitting light source and an IR light emitting light source, e.g., Red and IR light emitting diodes (LEDs), for emitting light into the tissue of a subject to generate physiological signals” in which “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.” **Lisogurski**, 10:53-63, 4:42-45, 7:38-8:3, 10:48-52, 17:37-45, 19:25-31, Figs. 1, 3. Thus, the light emitted by **Lisogurski’s** LEDs is consistent with the claimed “input optical beam” with “one or more optical wavelengths” which, as [19.c] (*see* Section IX.A.3.[19.c]) below explains, is “delivered to the tissue” and then is “reflect[ed]” by the tissue.

224. **Lisogurski** further discloses such **multiple LEDs operate in “continuous modulation,”** which is driven by the light drive signal for the light source’s “on” and “off” periods or “high and low output states” to produce outputs of differing intensities. 11:61-12:9. Thus, the input beam is modulated, as the “light sources are driven in this manner ... [to] emit pulses of light at their respective wavelengths into the tissue of a subject.” 12:3-14; *see also* 6:19-26 (“drive cycle modulation may be implemented using time division multiplexing as described above, code division multiplexing, ... any other suitable technique, or any combination thereof”).

225. Additionally, as discussed above in Section VII.C.2, I understand that in the Related EDTX Cases, the district court construed the term “modulating at least one of the LEDs” to mean “varying the amplitude, frequency, or phase of the light produced by at least one of the LEDs to include information.” *See* Ex.1018, 13-16; Ex.1019, 15-19. As the district court further remarked, “under the customary meaning of ‘modulating,’ pulsing may add information by turning the light on and off, presumably in some predetermined pattern or sequence.” Ex.1018, 16. Because **Lisogurski’s** modulation of LEDs includes information by, e.g., pulsing the light to turn the light on and off at a certain frequency (as discussed above), **Lisogurski** teaches “modulating” under the district court’s prior construction.

gg. Element [19.c]

226. Element [19.c] recites: “**receive and to deliver a portion of the input optical beam to tissue, wherein the tissue reflects at least a portion of the input optical beam delivered to the tissue.**” This claim is met by **Lisogurski**.

227. As discussed above in connection with [1.c] and [1.e], **Lisogurski** discloses “**receive a portion of the output optical beam, and deliver an analysis output beam to a sample**” (as recited by [1.c]) and **at least a portion of the analysis output beam reflected or transmitted from the sample** (as recited by [1.e]). *See* my discussion in Sections IX.A.3.[1.c] and [1.e].

228. For the same reasons discussed in connection with [19.b] above, the “output optical beam” recited in [1.c] satisfies the “input optical beam” recited in [19.c].

hh. Element [19.d]

229. Element 19.d recites: “**the measurement device further comprising a receiver configured to: capture light while the semiconductor sources are off and convert the captured light into a first signal, and capture light while at least one of the semiconductor sources is on and convert the captured light into a second signal, the captured light including at least a portion of the input optical beam reflected from the tissue.**” This claim is met by **Lisogurski**.

230. As discussed above in connection with [1.d], [1.h], and [1.i], **Lisogurski discloses “[a measurement system comprising] a receiver** (as recited by [1.d]), “[a receiver configured to:] **capture light while the semiconductor sources are off and convert the captured light into a first signal**” (as recited by [1.h]), and “[a receiver configured to:] **capture light while at least one of the semiconductor sources is on and convert the captured light into a second signal, the captured light including** at least a part of the **at least a portion of the analysis output optical beam reflected** or transmitted **from the** sample” (as recited by [1.i]). *See* my discussion in Sections IX.A.3.[1.d], [1.h], and [1.i].

231. As I discussed in [1.i] above, Lisogurski’s output optical beam reflected from the sample (e.g., “**light that is reflected by or has traveled through the subject’s tissue**”) is an input optical beam reflected from “tissue.” Lisogurski, 17:39-42.

ii. Element [19.e]

232. Element [19.e] recites: “**synchronize to the modulation of the at least one of the semiconductor sources.**” This claim is met by **Lisogurski**.

233. As discussed above in connection with [1.a], and [1.g], **Lisogurski discloses** “a light source comprising a plurality of **semiconductor sources...**” (as recited by [1.a]) and “[a receiver configured to:] **synchronize to the light source**” (as recited by [1.g]). *See* my discussions in Sections IX.A.3.[1.a], and [1.g].

234. Additionally, **Lisogurski** further discloses that the synchronization occurs **to the modulation** of the at least one of the semiconductor sources. For example, **Lisogurski** teaches that “detector 140/318” and “front end processing circuitry 150,” as modified in the manner I discussed above in Section IX.A.2 (*see also* my discussion in Section IX.A.3.[1.d]), operate synchronously with the light sources’ “continuous modulation.” *See* my discussion in Sections IX.A.3.[1.b] & [19.b]; Lisogurski, 11:61-12:9.

235. I understand that Defendants identified **“a receiver configured to:...synchronize to the modulation of the at least one of the semiconductor sources”** as potentially indefinite in the Texas case. Ex. 1023, 238. As discussed above (Section IX.A.3.[1.g]), however, and regardless of its outer bounds 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 this limitation.

jj. Element [19.f]

236. Element [19.f] recites: **“the measurement device further configured to improve a signal-to-noise ratio of the input optical beam reflected from the tissue by: differencing the first signal and the second signal, and.”** This claim is met by **Lisogurski**.

237. As I discussed above in [1.b], [1.i], and [1.j], **Lisogurski** discloses **a measurement device** (e.g., “sensor” 102/312; [1.b]) **further configured to improve the signal-to-noise ratio by differencing the first signal and the second signal** (e.g., “subtract dark values from the Red and IR ... to generate adjusted Red and IR signals”; [1.j]), where the **improved signal ratio is of the input optical beam reflected from the tissue** (e.g., “light that is reflected by or has traveled through the subject’s tissue”; [1.i]). *See* Sections IX.A.3.[1.b] & [1.i] & [1.j].

238. As the Board already noted, **Lisogurski** discloses a “dark subtraction” technique that “subtracts the dark signal from the red and IR signals to generate adjusted red and IR signals with noise removed, thereby improving signal-to-noise ratio.” ’484-FWD, 44 (citing ’484-Pet., 54 57 (citing Lisogurski, 6:7-19, 13:60-14:10, 14:46-55, 16:33-54)). 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, ¶¶90-94.

kk. Element [19.g]

239. Element [19.g] recites: “**increasing the light intensity relative to the initial light intensity from at least one of the semiconductor sources.**” This element is met by **Lisogurski**.

240. For the reasons stated in element [1.a], **Lisogurski’s** sensor with a light source meets this limitation. *See* my discussion in Section IX.A.3.[1.a].

241. '304 patent element [19.g] is a subset of and substantially identical to the '304 patent element [1.a], which recites: **“a light source comprising a plurality of semiconductor sources that are configured to generate an output optical beam with one or more optical wavelengths, the light source configured to increase signal-to-noise ratio by increasing a light intensity relative to an initial light intensity from at least one of the plurality of semiconductor sources.”** '304 patent element [19.g] is a subset of the '304 patent element [1.a] and, with the exception of [1.a]'s initial discussion of the plurality of semiconductor sources, contains identical language to [1.a]. Thus, the differences between the two terms do not change my analysis, and my opinions regarding the term in '304 patent element [1.a] term apply equally to '304 patent element [19.g].

242. I understand that Defendants identified “the measurement device further configured to improve a signal-to-noise ratio of the input optical beam reflected from the tissue by: ...increasing the light intensity relative to the initial light intensity from at least one of the semiconductor sources” as potentially indefinite in the Texas case. Ex. 1023, 238. As discussed above in [1.a] (see Section IX.A.3.[1.a]), 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 because **Lisogurski** discloses and renders obvious the indisputable scope of the limitation.

ll. Element [19.h]

243. Element [19.h] recites: “**the measurement device further configured to generate an output signal representing at least in part a non-invasive measurement on blood contained within the tissue.**” This element is met by **Lisogurski**.

244. As discussed above in connection with [1.b], [1.d], and [1.f], **Lisogurski** discloses “a **measurement system** [comprising]” (as recited by [1.b]), “a receiver **configured to**” (as recited by [1.d]) “**generate an output signal representing at least in part a non-invasive measurement on blood contained within the sample**” (as recited by [1.f]). *See* my discussion in Sections IX.A.3.[1.b], [1.d], and [1.f].

mm. Element [19.i]

245. Element [19.i] recites: “**the wearable device configured to communicate with the smart phone or tablet, the smart phone or tablet comprising a wireless receiver, a wireless transmitter, a display, a voice input module, a speaker, and a touch screen; and.**” This element is met by **Lisogurski**.

246. For the reasons stated in elements [1.k] and [19.pre] above, **Lisogurski's** sensor and monitor meets this limitation. *See* my discussion in [1.k], Sections IX.A.3.[1.k], [19.pre].

247. As discussed above in connection with [19.pre] and [1.k], **Lisogurski** discloses “**A wearable device for use with a smart phone or tablet**” (as recited by [19.pre]), the “**smart phone or tablet 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**” (as recited by [19.pre]). *See* my discussion in Sections IX.A.3.[1.k] and [19.pre]. Additionally, as the Board found in the '484 IPR, and as discussed above in in [1.k], **Lisogurski** discloses a “**voice input module**” in the same embodiment as relied upon for the rest of the language in [19.i]. *See* my discussion in Section IX.A.3.[1.k]; '484-FWD, '484-FWD, 25-27 (citing '484-Pet. 40-42); Lisogurski, 14:60-15:16, 15:19-23, 15:30-35, 15:43-57, 18:11-15, 18:49-65, 26:55-60, 27:31-36, Fig. 1.

nn. Element [19.j]

248. Element [19.j] recites: “**the smart phone or tablet configured to: receive and to process at least a portion of the output signal, store and display the processed output signal, and transmit at least a portion of the processed output signal over a wireless transmission link.**” This element is met by **Lisogurski**.

249. For the reasons stated in element [1.k], **Lisogurski**'s monitor meets this limitation. *See* my discussion in Section IX.A.3.[1.k].

250. '304 patent element [19.j] is a subset of and substantially identical to the '304 patent element [1.k], which recites: “**a smart phone or tablet 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 smart phone or tablet configured to: receive and process at least a portion of the output signal, store and display the processed output signal, and transmit at least a portion of the processed output signal over a wireless transmission link**” (language identical to [19.j] underlined). Since '304 patent element [19.j] is a subset of the '304 patent element [1.k], the differences between the two terms do not change my analysis, and my opinions regarding the term in '304 patent element [1.k] term apply equally to '304 patent element [19.j].

oo. Claim 20

251. Claim 20 recites: “**The wearable device of claim 19, wherein the **light source** is configured to further **improve the signal-to-noise ratio of the input optical beam reflected from the tissue by increasing a pulse rate of at least one of the plurality of semiconductor sources from an initial non-zero pulse rate.**”** This claim is met by **Lisogurski**. *See* my discussion for claim 19 in Sections IX.A.3.[19.pre]-[19.j].

252. As I discussed above in [19.a], **Lisogurski** discloses that the wearable device of claim 19 includes a **light source** (e.g., “sensor” 102/312 “include[s] light source 130”). See my discussion in Section IX.A.3.[19.a].

253. The Board previously found a substantially identical limitation was met by **Lisogurski** in the prior ’484 IPR. In particular, to meet the light source being configured to “**improve the signal-to-noise ratio...by increasing a pulse rate of at least one of the plurality of semiconductor sources from an initial non-zero pulse rate**” (’484 claim 1), the Board relied on two separate rationales, namely **Lisogurski’s** disclosure of improving signal-to-noise ratio by: (1) correlating sampling rate and **LED firing (pulse) rate** and (2) using cardiac cycle modulation (CCM) varying the light drive signal to remain synchronous with a **subject’s heart rate**. ’484-FWD, 27-35 (citing ’484-Pet. 45, 48-51, ’484-Pet.-Reply, 5-7).

254. As to the “sampling rate” rationale, the Board agreed that **Lisogurski** teaches “correlat[ing] sampling rate and **LED firing (pulse) rate**,” explaining that “decreasing the duration of the ‘off’ periods (i.e., **increasing the emitter firing rate**) relates to an increased sampling rate.” ’484-FWD, 31-32 (citing ’484-Pet., 22, 49-51; ’484-Pet.-Reply, 5); **Lisogurski**, 35:24-31, Fig. 2A, *see also* 2:1-2, 5:55-6:6, 8:29-35, 9:46-52, 11:43-46, 11:52-55, 25:46-55, 27:44-52, 33:47-49, 33:56-58, 35:7-9, 37:6-22. Further, “**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.” ’484-FWD, 30 (citing ’484-Pet. 49-51); Lisogurski, 9:46-52, 37:6-22; ’484-Anthony, ¶¶156-164, 173-183. Because **Lisogurski** discloses LEDs with a firing (pulse) rate (*i.e.*, a duration of the “off” periods), which a person of ordinary skill in the art would have understood, or at minimum found obvious, to be non-zero, and increasing that firing rate (*i.e.*, decreasing that duration), **Lisogurski** teaches or at least renders obvious that the firing rate of its LEDs are increased from an initial non-zero pulse rate. ’484-Anthony, ¶¶156-164, 173-183. This is consistent with my opinions regarding the ’484 limitation, which I incorporate by reference as if fully set forth herein. ’484-Anthony, ¶¶156-164, 173-183.

255. With respect to the “CCM” rationale, the Board found that **Lisogurski** discloses that “the application of CCM [cardiac cycle modulation] alone improves signal-to-noise.” ’484-FWD, 30-36 (citing ’484-Pet., 50-51, ’484-Pet.-Reply, 6-8); Lisogurski, 9:57-60, 25:46-61, 25:50-61, 31:11-24, 31:39-55, 41:40-42:58; *see also* ’533 FWD, 26-30. According to the Board, “**Lisogurski** teaches correlating LED pulse rate and cardiac cycle rate, for example by increasing LED pulse rate to match an increased cardiac cycle rate.” ’533-FWD, 29; Lisogurski, 25:46-61 (light drive parameters, such as “firing rate,” are “varie[d] with a period the same as or closely related to the period of the cardiac cycle, thus generating a cardiac cycle modulation”). By increasing the pulse rate as the subject’s heart rate increases,

Lisogurski teaches **improving SNR by reducing noise by 1-4%**. '484-FWD, 30 (citing '484-Pet. 50-51; '484-Anthony ¶¶181-82); Lisogurski, 42:55-58 (“cardiac cycle modulation techniques may provide improved performance” “in the presence of moderate noise”), 25:46-26:14 (“particular segments of a respiratory cycle may provide an increased signal to noise ratio...it may be desired to correlate a modulation technique with...both respiration variations and cardiac pulses”); *see also* '533-FWD, 27-30. '484-Anthony, ¶¶156-164, 173-183; '533-Anthony, ¶¶95-103, 110-116. Because **the pulse rate synchronizes with the subject’s non-zero heart rate, and increases as the subject’s heart rate increases**, **Lisogurski** teaches or at least renders obvious **increasing the pulse rate from an initial non-zero pulse rate**. '484-Anthony, ¶¶156-164, 173-183; '533-Anthony, ¶¶95-103, 110-116.

256. '304 patent claim 20 is substantially identical to the corresponding limitations in the '484 patent on which I previously opined, and which recite: **“the wearable device configured to increase the signal-to-noise ratio by increasing a pulse rate of at least one of the plurality of semiconductor sources from an initial pulse rate.”** ('484 claims 1, 7, 15). Though the limitations use slightly different language, they cover substantially the same concept, and the disclosure from **Lisogurski** relied upon by the Board to meet the '484 limitation also satisfies '304 [20]. Consistent with the Board’s findings (discussed above), the light source in **Lisogurski’s** wearable measurement device increases the firing rate, or

pulse rate, of its output light from an initial non-zero rate to decrease the noise of its measurements, thus improving the signal-to-noise ratio of the measurements.

Lisogurski, 9:46-52, 25:46-26:14, 37:6-22, 42:50-54.

257. Regarding the remaining language in this limitation, **Lisogurski** also discloses that it is **the input optical beam reflected from the tissue** for which the signal-to-noise ratio is improved by increasing the firing rate. **Lisogurski** discloses that “the [physiological monitoring] system ... receive[s] a signal,” and that the physiological monitoring system can receive these signals “using a ... detector,” which, as discussed in [1.e]) above, “**detect[s] the light that is reflected by or has traveled through the subject’s tissue.**” See my discussion in Section IX.A.3.[1.e]; Lisogurski, 26:26-29, 33:65-67; see also my discussion in Section IX.A.3.[19.f] (**Lisogurski** discloses the input optical beam reflected from the tissue in [19.f]).

258. I understand that Defendants identified “wherein the light source is configured to further improve the signal-to-noise ratio of the input optical beam reflected from the tissue by increasing a pulse rate of at least one of the plurality of semiconductor sources from an initial non-zero pulse rate” as potentially indefinite in the Texas case. Ex. 1023, 238. Regardless of its interpretation (e.g., by increasing pulse rate, increasing the signal-to-noise ratio of (1) to-be-generated reflected input optical signals or (2) already-generated input optical signals based on the antecedent basis of “signal-to-noise ratio”) 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.

259. Consistent with this embodiment, as the Board found in the prior '484 IPR, **Lisogurski** discloses “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.” '484-FWD, 30 (citing '484-Pet. 49-51 (citing Lisogurski, 9:46-52, 37:6-22)). The Board also found in the prior '484 IPR that Lisogurski discloses because “particular segments of a respiratory cycle may provide an increased signal to noise ratio...it may be desired to correlate a modulation technique with...both respiration variations and cardiac pulses” '484-FWD, 34 (citing '484-Pet. 50-51 (citing Lisogurski, 42:50-54, 25:46-26:14)). **Lisogurski** further discloses that “the system may sample a signal at different rates *throughout a cardiac cycle*” such that “increasing the sampling rate for a portion of the cardiac cycle may result in more accurate and reliable physiological information.” Lisogurski, 33:42-58. A person of ordinary skill in the art would thus have understood that **Lisogurski** teaches increasing the pulse rate preemptively and that an already-generated output signal using the already-increased pulse rate would thus have increased signal-to-noise ratio.

B. GROUND 2: Lisogurski in view of LeBoeuf (Claims 2, 4-6, 14-16, 21-22, 27):

1. Overview of LeBoeuf

260. **LeBoeuf** discloses “light guiding earbud 30,” includes “earbud housing 16” which has “a **cover 18**” with “**cladding material 21** [which] may be reflective material.” ¶¶107, 115, 123. Specifically, “**cover 18** includes a **cladding material 21** on the **outer surface 18a** thereof.” ¶123, FIG. 8A (including my annotations). Light guiding earbud 30 also includes “optical detector[s] 26” and “optical emitter[s] 24,” which may be LEDs. ¶92. Optical detectors 26 and optical emitters 24 may be disposed in an arc formation. FIG. 8B (including my annotations). **Cover 18** “serves as a light guide” for “scattered light ... from an ear region and ... guides the light to the optical detector 26” such that the detector 26 can receive the light emitted by the optical emitter 24 that has “interrogate[d] the surface of the ear, penetrate[d] the skin of the ear, and generate[d] a scattered light response.” ¶¶103, 105; FIG. 8C (including my annotations); *see also* Fig. 3.

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** teachings to **Lisogurski's** sensor to include a plurality of optical emitters and detectors arranged along offset concentric arcs to increase detection of scattered light, thus improving accuracy of physiological measurements. Both **Lisogurski** and **LeBoeuf** disclose physiological monitoring devices that can be worn on different parts of the body, including the ear, and which operate by emitting light into biological tissue. *Lisogurski*, 4:6-20, 11:9-27; *LeBoeuf*, ¶¶6, 10. Further, **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.

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 (“The light intensity may be directly related to the absorbance and/or reflectance of light in the tissue. That is, when more light at a certain wavelength is absorbed or reflected, less light of that wavelength is received from the tissue by detector 140.”); *LeBoeuf*, ¶105. Accordingly, a person of ordinary skill in the art would have also recognized that a linear or closely grouped arrangement of detectors would be insufficient to capture

much of the angularly scattered light, as illustrated by e.g., U.S. Patent No. 6,801,799, which I understand has been designated as Exhibit 1045, as further discussed below. Ex. 1045 (Mendelson), 4:14-65 (“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.”). Accordingly, a person of ordinary skill in the art would have been motivated to look to a reference like **LeBoeuf** that teaches optical emitters and detectors arranged along arcs to improve the detection. A person of ordinary skill in the art would have recognized that **LeBoeuf’s** detector arrangement enhances the amount of scattered light from biological tissue 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 **LeBoeuf’s** teaching to arrange spatially separate detectors and light sources on one or more arcs to improve the detection of scattered light from biological tissue and increase the signal-to-noise ratio of **Lisogurski’s** wearable device.

264. A person of ordinary skill in the art would have had a reasonable expectation of success in applying **Lebeouf’s** arc arrangement teaching to **Lisogurski’s** system. Both references teach an optical-based measurement system that employs multiple emitters and multiple detectors and disclose that “any suitable” or “various configurations” may be used to arrange those emitters and detectors.

Lisogurski, 17:37-45; LeBoeuf, ¶¶6, 123, 125. Indeed, using an arc arrangement to increase signal-to-noise ratio was also well known in the art. For example, Mendelson, 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 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” and “sensor unit 312 may include multiple light sources and detectors, which may be spaced apart,”), LeBoeuf, ¶¶ 6, 123, 123.

265. With respect to **LeBoeuf’s** reflective material teachings, a person of ordinary skill in the art would also have been motivated to apply **LeBoeuf’s** reflective material teaching to **Lisogurski’s** system to receive and redirect at least some of the light emitted from the semiconductor sources and reflected by the tissue sample to improve the signal measurement quality of **Lisogurski’s** physiological monitoring system. LeBoeuf, ¶¶103, 105. Specifically, LeBoeuf teaches the use of

reflective surfaces to receive the light reflected from the tissue sample and deliver or redirect the light to the detectors. LeBoeuf, ¶105. A person of ordinary skill in the art would have understood that **LeBoeuf’s** reflective surface material enhances the efficiency of the light delivery from the light reflected from or transmitted through the tissue to the detectors in the sensor, minimizing loss of light intensity due to scattering. LeBoeuf, ¶125 (“An advantage of this configuration is ... this configuration may reduce unwanted optical signals from regions that may not be relevant to the physiological activity of interest.”). 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. 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, as illustrated by e.g., U.S. Patent No. 6,343,223 and W.O. Patent Pub. No. 2000/013003, which I understand have been designated as Exhibits 1062 and 1063, respectively, as further discussed below. *See, e.g.*, Ex. 1062 (Chin), 3:28-33, 7:46-57 (disclosing a pulse oximetry sensor which includes “at least one reflecting surface for redirecting light back to the blood-perfused tissue” which “improve[s] performance over a sensor without such a reflector” by “provid[ing] a significant improvement in the amount of light reaching the detector”). Ex. 1063 (Colvin), 8:24-25, 51:28-52:8, Fig. 23D (disclosing a “common LED chip mounted within a reflector cup,” which increases an LED’s effective brightness). Additionally, **LeBoeuf** has substantially similar disclosures with U.S. Patent Publication No. 2012/0197093 (“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**.

266. 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, ¶¶6, 10, 25-26; *see also* LeBoeuf, ¶¶103, 105, 107, 115. Thus, it would have been straightforward and advantageous to apply **LeBoeuf’s** earbud sensor teachings to **Lisogurski’s** sensor on patients’ earlobes. Lisogurski, 4:6-20; LeBoeuf, ¶¶25-26. Both references teach optical physiological measurement systems including multiple emitters and detectors spaced apart and emitters/light sources directing light towards a subject’s tissue. Lisogurski, 17:37-45; LeBoeuf, ¶¶6, 123, 125. Using different configurations for the light sources and detectors were well known in the art. Lisogurski, 17:42-45, LeBoeuf, ¶124. Likewise, use of reflective materials to focus light output was well known in the art, as illustrated in U.S. Patent No. 6,662,033,

which I understand has been designated as Exhibit 1046. E.g., Ex.1046 (Casciani), 16:23-57, FIGS. 4C, 4E. Accordingly, a person of ordinary skill in the art would have found it straightforward and advantageous to apply **LeBoeuf's** reflective surface and arc arrangement teachings 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.

267. 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, which I understand has been designated as Exhibit 1041, 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, ¶152. 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, 16:27-40.

3. Invalidity of Claims 2, 4-6, 14-16, 21-22, and 27 Over Lisogurski in view of LeBoeuf

268. As I discuss below, Claims 2, 4-6, 14-16, 21-22, and 27 are rendered obvious by **Lisogurski in view of LeBoeuf**. In addition to my discussion in Sections IX.A.1-2, the following discussion identifies example disclosures that each disclose Challenged Claims 2, 4-6, 14-16, 21-22, and 27.

a. Claim 2

269. Claim 2 recites: “The measurement system of claim 1, **wherein the plurality of semiconductor sources comprises at least one of: light emitting diodes (LEDs), laser diodes (LD's), tunable LD's, and super-luminescent laser diodes (SLDs),** and wherein the measurement system further **comprises a reflective surface to receive and redirect** at least some of the **at least a portion of the analysis output beam reflected or transmitted from the sample.**” This claim is met by **Lisogurski** in view of **LeBoeuf**.

270. As discussed in connection with claim 1, **Lisogurski** renders obvious the **claimed measurement system of claim 1**. See Sections IX.A.3[1.pre]-[1.n].

271. As I discussed in [1.a] above, **Lisogurski's plurality of semiconductor sources (e.g., “multiple LEDs”) are light emitting diodes**. See Section IX.A.3.[1.a].

As I discussed in [1.c] and [1.i], **Lisogurski** teaches the “light” produced “outward toward the tissue” is then “reflected by or has traveled through the subject’s tissue.” 10:52-56, 17:39-42; *see* Sections IX.A.3.[1.c] & [1.i].

272. **LeBoeuf** further discloses a **reflective surface** (*e.g.*, “a cover 18” with “cladding material 21 [which] may be reflective material”) to **receive and redirect light reflected or transmitted from the sample** (*e.g.*, “serves as a light guide that... collects light external to the earbud housing 16 and delivers the collected light to the optical detector 26”). **LeBoeuf**, ¶¶103, 105, 107, 115.

273. **Further, LeBoeuf** discloses light-guiding earbud 30 has a “cover 18” with a “cladding material 21 [which] may be reflective material.” ¶¶107, 115. **LeBoeuf** further discloses the cover 18 “serves as a light guide that... collects light external to the earbud housing 16 and delivers the collected light to the optical detector 26” and thus receives and redirects the light. ¶103. Specifically, **LeBoeuf** discloses the “optical detector 26 detects scattered light 110 from an ear region and the light guiding region 19 of the light guide 18 guides the light to the optical detector 26,” and this scattered light is generated when light emitted by the optical emitter 24 “interrogates the surface of the ear, penetrates the skin of the ear, and generates a scattered light response 110,” which thus includes light transmitted to or reflected by the ear. **LeBoeuf**, ¶105.

274. As discussed in Section IX.B.2, a person of ordinary skill in the art would have been motivated to modify **Lisogurski's** measurement system with **LeBoeuf's** reflective surface teachings to advantageously enhance the quality of signal measurements.

b. Claim 4

275. Claim 4 recites: “**The measurement system of claim 1, wherein the receiver comprises a plurality of detectors arranged along a first arc, and wherein the plurality of semiconductor sources are arranged along a second arc.**” *See* Section IX.A.3.[1.pre]-[1.n]. This claim is met by **Lisogurski** in view of **LeBoeuf**.

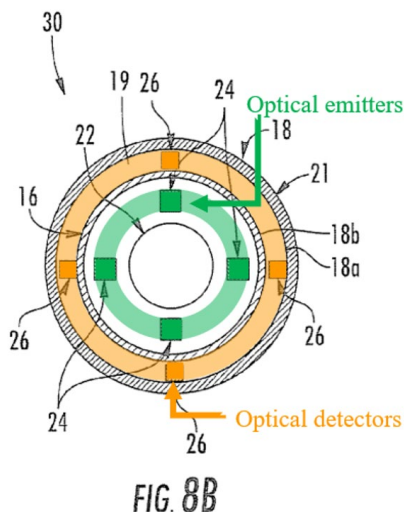
276. As discussed in connection with claim 1, **Lisogurski** renders obvious the **claimed measurement system of claim 1**. *See* Section IX.A.3[1.pre]-[1.n].

277. As I discussed above in [1.d], **Lisogurski renders obvious the receiver** (*e.g.*, “detector” 140 coupled to “front end processing circuitry” 150; [1.d]). **Lisogurski**, 11:9-27, 11:41-46, 12:42-45, 17:40-42, Figs. 1, 3; *see* Section IX.A.3.[1.d].

278. **LeBoeuf discloses a plurality of detectors arranged along a first arc** (*e.g.*, “optical detectors 26” arranged in the orange circle, *see* annotated Fig. 8B), **and wherein the plurality of semiconductor sources are arranged along a**

second arc (e.g., “optical emitters 24” arranged in the green circle, *see* Fig. 8B).

LeBoeuf, Fig. 8B, ¶123.

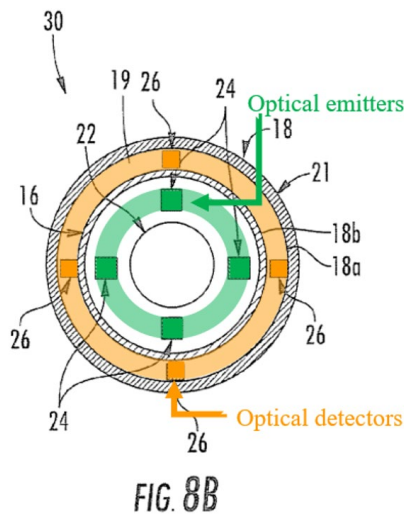


279. **LeBoeuf discloses**, in Fig. 8B, **optical detectors 26 arranged along a first circle (outlined in orange)**, and **optical emitters 24 are arranged along a second circle (outlined in green)**. Fig. 8B, ¶123. As shown, the first orange circle is offset from the second green circle, and the two circles are concentric.

280. As described in Section IX.B.2, a person of ordinary skill in the art would have been motivated to implement the arc arrangement teachings of **LeBoeuf** to **Lisogurski’s** detector 140/318 (as modified per my discussion in Section IX.A.2) to advantageously improve the detection of scattered light from biological tissue, and increase the signal-to-noise ratio.

281. I understand that Defendants identified “the receiver comprises a plurality of detectors arranged along a first arc, and wherein the plurality of

semiconductor sources are arranged along a second arc that is offset from the first arc” as potentially indefinite in the Texas case. Ex. 1023, 238. Regardless of its outer bounds (e.g., requiring full circular arcs or more broadly encompassing any degree of curvature), however, and without opining on whether or not it has adequate written description support, **LeBoeuf** discloses the indisputable scope of this limitation. Indeed, **LeBoeuf** discloses a plurality of optical emitters 24 in a completely circular arc (i.e., arranged along a full circle) and a plurality of optical detectors 26 in another completely circular arc (same) as shown in the annotated Figure 8B below:



c. Claim 5

282. Claim 5 recites: “**The measurement system of claim 4, wherein the first arc is offset from the second arc.**” This claim is met by **Lisogurski** in view of **LeBoeuf**.

283. As discussed in connection with claim 4, **Lisogurski** renders obvious the **claimed measurement system of claim 4**. *See* my discussion in Section IX.A.3.[4].

284. As I discussed in Claim 4 above, Lisogurski's physiological monitoring system modified by the teachings of LeBoeuf meets this limitation. *See* my discussion in Section IX.B.3.[4]. For example, **LeBoeuf** discloses an arrangement in Fig. 8B in which "optical emitters 24" are arranged in a smaller circle within a larger circle of "optical detectors 26" such that the first circle of detectors is offset from the second circle of emitters. LeBoeuf, Fig. 8B, ¶123.

285. I understand that Defendants identified "the receiver comprises a plurality of detectors arranged along a first arc, and wherein the plurality of semiconductor sources are arranged along a second arc that is offset from the first arc" as potentially indefinite in the Texas case. Ex. 1023, 238. As discussed above, regardless of its outer bounds (e.g., requiring full circular arcs or more broadly encompassing any degree of curvature), however, and without opining on whether or not it has adequate written description support, **LeBoeuf** meets this term because **LeBoeuf** discloses the indisputable scope of the limitations. *See* my discussion in Section IX.B.3.[4].

d. Claim 6

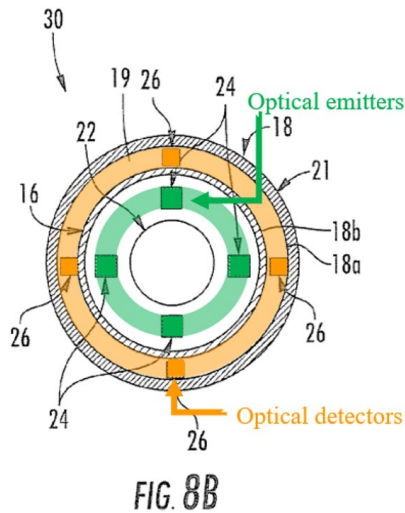
286. Claim 6 recites: “**The measurement system of claim 4, wherein the first arc and the second arc are concentric.**” This claim is met by **Lisogurski** in view of **LeBoeuf**.

287. As discussed in connection with claim 4, **Lisogurski** in view of **LeBoeuf** renders obvious the claimed measurement system of claim 4. *See* Section IX.A.3.[4].

288. For the reasons I discussed in Claim 4 above, **Lisogurski’s** physiological monitoring system modified by the teachings of **LeBoeuf** meets this limitation. *See* Section IX.B.3.[4]. For example, **LeBoeuf** discloses an arrangement in Fig. 8B in which “optical emitters 24” are arranged in a smaller circle within a larger circle of “optical detectors 26” such that the first circle of detectors shares a center point and is thus concentric to the second circle of emitters. **LeBoeuf**, Fig. 8B, ¶123.

289. I understand that Defendants identified “wherein the first arc and the second arc are concentric” as potentially indefinite in the Texas case. Ex. 1023, 238. Regardless of its interpretation (e.g., requiring full circular arcs or more broadly encompassing any degree of curvature, as in claim 4), however, and without opining on whether or not it has adequate written description support, **LeBoeuf** discloses the indisputable scope of this limitation. Indeed, **LeBoeuf** discloses in Fig. 8B, a first

circle of optical detectors 26 which shares the same center with a second circle of optical emitters 24. LeBoeuf, Fig. 8B, ¶123. **LeBoeuf** discloses a plurality of optical emitters 24 in a smaller circular arc within a larger circular arc consisting of a plurality of optical detectors 26 as shown in the annotated Figure 8B below:



e. **Claim 14**

290. Claim 14 recites: “**The measurement system of claim 11, wherein the plurality of semiconductor sources comprises at least one of: light emitting diodes (LEDs), laser diodes (LD's), tunable LD's, and super-luminescent laser diodes (SLDs), and the measurement system further comprising a reflective surface to receive and redirect at least some of the at least a portion of the analysis output beam reflected or transmitted from the sample.**” This claim is met by **Lisogurski**.

291. As discussed in connection with claim 11, **Lisogurski** renders obvious the **claimed measurement system of claim 11**. *See* my discussion in Section IX.A.3.[11].

292. Aside from the preamble, (which recites “[t]he measurement system of claim 11,” instead of “[t]he measurement system of claim 1,” as recited in claim 2), claim 11 recites the same dependent limitation as claim 2.

293. For the reasons I discussed in Claim 2 above, **Lisogurski’s** physiological monitoring system modified by the teachings of **LeBoeuf** meets this limitation. *See* my discussion in Section IX.B.3.[2].

f. Claim 15

294. Claim 15 recites: “**The measurement system of claim 11, wherein the receiver comprises a plurality of detectors arranged along a first arc, and wherein the plurality of semiconductor sources are arranged along a second arc that is offset from the first arc.**” *See* Sections IX.A.3.[11]. This claim is met by **Lisogurski** in view of **LeBoeuf**.

295. As discussed in connection with claim 11, **Lisogurski** renders obvious the claimed measurement system of claim 11. *See* my discussion in Section IX.A.3.[11].

296. Claim 15 depends from Claim 11 and additionally recites language that is substantively identical to the limitations recited in Claims [4] (“**wherein the**

receiver comprises a plurality of detectors arranged along a first arc, and wherein the plurality of semiconductor sources are arranged along a second arc”) and [5] (“the first arc is offset from the second arc”).

297. For the reasons I discussed in Claims [4] and [5] above, Lisogurski’s physiological monitoring system modified by the teachings of **LeBoeuf** meets this limitation. *See* my discussion in Section IX.B.3.[4]-[5].

298. I understand that Defendants identified “the receiver comprises a plurality of detectors arranged along a first arc, and wherein the plurality of semiconductor sources are arranged along a second arc that is offset from the first arc” as potentially indefinite in the Texas case. Ex. 1023, 238. As discussed above (Section IX.B.3.[4]), regardless of its outer bounds (e.g., requiring full circular arcs or more broadly encompassing any degree of curvature), however, and without opining on whether or not it has adequate written description support, **LeBoeuf** meets this term because **LeBoeuf** discloses the indisputable scope of the limitations.

g. Claim 16

299. *See* Section IX.B.3.[15].

300. Claim 16 recites: “**The measurement system of claim 15, wherein the first arc and the second arc are concentric.**” This claim is met by **Lisogurski** in view of **LeBoeuf**.

301. As discussed in connection with claim 15, **Lisogurski** renders obvious the **claimed measurement system of claim 15**. See my discussion in Section IX.A.3.[15].

302. Aside from the preamble, (which recites “[t]he measurement system of claim 15,” instead of “[t]he measurement system of claim 4,” as recited in claim 6), claim 16 recites the same dependent limitation as claim 6.

303. For the reasons I discussed in Claim 6 above, **Lisogurski’s** physiological monitoring system modified by the teachings of LeBoeuf meets this limitation. See my discussion in Section IX.B.3.[6].

304. I understand that Defendants identified “wherein the first arc and the second arc are concentric” as potentially indefinite in the Texas case. Ex. 1023, 238. As discussed above, regardless of its outer bounds (e.g., requiring full circular arcs or more broadly encompassing any degree of curvature), and without opining on whether or not it has adequate written description support, **LeBoeuf** meets this term because **LeBoeuf** discloses the indisputable scope of the limitations. See my discussion in Section IX.B.3.[6].

h. Claim 21

305. Claim 21 recites: “**The wearable device of claim 20, wherein the receiver comprises a plurality of detectors arranged along a first arc, and wherein the plurality of semiconductor sources are arranged along a second arc**”

that is **offset from the first arc.**” This claim is met by **Lisogurski** in view of **LeBoeuf**.

306. As discussed in connection with claim 20, **Lisogurski** renders obvious the **claimed wearable device of claim 20**. *See* my discussion in Section IX.A.3.[20].

307. Aside from the preamble, (which recites “[t]he wearable device of claim 20,” instead of “[t]he measurement system of claim 11,” as recited in claim 15), claim 21 recites the same dependent limitation as claim 15.

308. For the reasons I discussed in Claim 15, **Lisogurski’s** measurement system (e.g., “physiological monitoring system 100/310,” including “sensor 102/312,” *see* Section IX.A.3.[1.pre], as modified by LeBoeuf) is a wearable device. For example, the Board relied on **Lisogurski’s** disclosure of a “sensor 102/312 for measuring blood oxygen saturation, [which may be] mounted on a user’s fingertip, toe, earlobe, wrist, or thigh” to determine that **Lisogurski’s** measurement device (e.g., “sensor 102/312 for measuring blood oxygen”) is a wearable measurement device because **Lisogurski** discloses that the “sensor 102/312” is mounted on a user’s fingertip, toe, earlobe, wrist, or thigh. ’533-FWD, 25 (citing ’533-Pet. 53-55); *Lisogurski*, 4:6-20. Thus, for the reasons discussed in claim 15, **Lisogurski’s** physiological monitoring system modified by the teachings of **LeBoeuf** also meets claim 21. *See* my discussion in Sections IX.B.3.[4]-[5].

309. I understand that Defendants identified “the receiver comprises a plurality of detectors arranged along a first arc, and wherein the plurality of semiconductor sources are arranged along a second arc that is offset from the first arc” as potentially indefinite in the Texas case. Ex. 1023, 238. As discussed above, regardless of its outer bounds (e.g., requiring full circular arcs or more broadly encompassing any degree of curvature), however, and without opining on whether or not it has adequate written description support, **LeBoeuf** meets this term because **LeBoeuf** discloses the indisputable scope of the limitations. See my discussion in Section IX.B.3.[4].

i. Claim 22

310. Claim 22 recites: “**The measurement system of claim 21, wherein the first arc and the second arc are concentric.**” This claim is met by **Lisogurski** in view of **LeBoeuf**.

311. As discussed in connection with claim 21, **Lisogurski** in view of **LeBeouf** renders obvious the **claimed measurement system of claim 21**. See Section IX.A.3.[21].

312. Aside from the preamble, (which recites “[t]he measurement system of claim 21,” instead of “[t]he measurement system of claim 4,” as recited in claim 6), claim 16 recites the same dependent limitation as claim 6. For the reasons I discussed in Claim 6 above, **Lisogurski’s** physiological monitoring system modified

by the teachings of **LeBoeuf** meets this limitation. *See* my discussion in Section IX.B.3.[6].

313. I understand that Defendants identified “wherein the first arc and the second arc are concentric” as potentially indefinite in the Texas case. Ex. 1023, 238. As discussed above, 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. *See* my discussion in Section IX.B.3.[6].

j. Claim 27

314. Claim 27 recites: “**The wearable device of claim 19, wherein the measurement device further comprises a reflective surface configured to receive and redirect at least a portion of light reflected from the tissue.**” This claim is met by **Lisogurski** in view of **LeBoeuf**.

315. As discussed in connection with claim 19, **Lisogurski** renders obvious the **claimed wearable device of claim 19**. *See* my discussion in Section IX.A.3.[19].

316. Aside from the preamble, (which recites “[t]he wearable device of claim 19, instead of “[t]he measurement system of claim 11,” as recited in claim 14), claim 27 recites a substantially identical limitation to claim 14. For the reasons I discussed in Claim [11.a] above, **Lisogurski’s** including “sensor 102/312,” *see* Section IX.A.3.[1.pre]) is a wearable device. For example, the Board relied on

Lisogurski's disclosure of a “sensor 102/312 for measuring blood oxygen saturation, [which may be] mounted on a user's fingertip, toe, earlobe, wrist, or thigh” to determine that **Lisogurski's** measurement device (e.g., “sensor 102/312 for measuring blood oxygen”) is a wearable measurement device because **Lisogurski** discloses that the “sensor 102/312” is mounted on a user's fingertip, toe, earlobe, wrist, or thigh. '533-FWD, 25 (citing '533-Pet. 28; Lisogurski, 4:6-20).

317. Thus, for the reasons discussed in claim 14, and because the differences between claims 27 and 14 do not change my analysis (as discussed above), **Lisogurski's** physiological monitoring system modified by the teachings of **LeBoeuf** also meets claim 27. *See* my discussion in Section IX.B.3.[14].

C. GROUNDS 3-4: Grounds 1-2 in further view of Tran (Claims 1-6, 11-16, 19-22, 26-27):

1. Overview of Tran

318. **Tran** discloses a “heart monitoring system for a patient” that includes a wearable monitoring device (e.g., “wearable appliance,” such as a “wristwatch”) for detecting heart attacks and stroke attacks. *Tran*, Abstract, 2:66-67, 3:6-13. The wearable appliance collects and communicates patient health data to a server, and the server feeds the data to a “statistical analyzer” that analyzes the data. *Tran*, 3:6-13, 8:28-53, 9:23-54, 11:1-31, 5:36-43, 26:17-29, 36:62-37:13, 46:25-42, 54:14-57:13, 60:58-61:37, 74:29-67. When the “wearable appliance” is outside the normal

network range and cannot send data to the server by itself, the wearable appliance searches for a “cell phone that is mesh network compatible,” such as a “smart phone[],” which provides data to the server using a cellular connection. Tran, 33:50-34:40. The data can include “pulse oximetry” measurements collected by the monitoring device to “characterize the patient’s cardiac condition.” Tran, 25:36-43, 26:17-29, 36:62-37:13, 46:25-42, 60:58-61:37, 74:29-67.

319. **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.

320. **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. These "artificial neural networks," are used to analyze patient data to "flag potentially dangerous conditions," which "can be specified as an event or a pattern that can cause physiological...damage to the patient." Tran, 11:6-19, 22:24-28, 74:45-46, 75:18-20, 87:33-37, 85:60-61, 88:48-50, 90:58-61.

321. Like all neural networks and artificial intelligence, the statistical analyzer "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, 11:1-31. **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 sounds 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.

322. **Tran** further discloses that its system may include “providing remote diagnostic capability so that a remote healthcare provider (such as a doctor, nurse, therapist or caregiver) can visually communicate with the patient in performing remote diagnosis.” Tran, 5:36-43. **Tran** also discloses that, while the wearable device is outside a mesh network range, “the device searches for a cellphone,” such as a “smart phone[],” and if it detects one, it will communicate “with the cell phone and provide[] information to the server 200 using the cellular connection.” Tran, 33:50-34:40. **Tran** further discloses that the server hosts a webpage that includes a list of “recently measured blood pressure data,” “graphs that plot the systolic and diastolic blood pressure data,” and “tables and graphs corresponding to a different data measured by the wearable device such as calorie consumption/dissipation,

ambulation pattern, sleeping pattern, heart rate, pulse oximetry, and temperature.”

Tran, 26:17-29.

2. Motivation to Combine Lisogurski (alone or in view of LeBoeuf) and Tran

323. Like **Lisogurski** and **LeBoeuf**, **Tran** is analogous art, in the same field as the '304 (including physiological monitoring), and is reasonably pertinent to the alleged problems addressed by the '304 (including improving optical physiological monitoring). *See* my discussion in Section IX.B.2; Tran, 1:10-33 (“This invention relates generally to methods and systems for monitoring a person...”), 2:66-67 (“Early detection and treatment of stroke is essential to recovery from a stroke”), 3:3-5 (“In one aspect, a monitoring system for a person includes one or more wireless nodes and a stroke sensor coupled to the person and the wireless nodes to determine a stroke attack”); 4:30-36 (“Advantages of the system may include one or more of the following. The system detects the warning signs of stroke and prompts the user to reach a health care provider within 2 hours of symptom onset. The system enables patent to properly manage acute stroke, and the resulting early treatment might reduce the degree of morbidity that is associated with first-ever strokes”), 36:62-37:12.

324. With respect to **Tran’s** “smart phone” teachings, a person of ordinary skill in the art would have been motivated to apply **Tran’s** smart phone teachings 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 discusses 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. *Tran*, 34:4-25, 33:58-34:3, 34:25-40; '484-Anthony, ¶¶215-16. Furthermore, I understand that in the prior '484 IPR, the Board found that “a person of ordinary skill would have recognized **Tran's** smart phone 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, ¶¶211-216. Moreover, it was well-known in the art that tablets and smartphones could be used in wearable physiological monitoring systems, and there was a general trend in the industry to develop such devices. '484-Anthony, ¶¶216 (citing *Tran*, 33:58-34:40), 48-56. Smartphones provide significant practical benefits, such as mobile connectivity, portability, and ease of integration. Accordingly, a person of ordinary skill would have recognized that **Lisogurski's** monitor could be implemented to use or include a smart phone as

taught in **Tran**, and that doing so would have allowed **Lisogurski's** monitor 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). 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**.

325. Additionally, a 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.

326. With respect to **Tran’s** artificial intelligence teachings, a person of ordinary skill in the art would have been motivated to apply **Tran’s** teachings of an artificial intelligence-driven “statistical analyzer” to **Lisogurski’s** wearable sensor 102/312 (as modified, *see* my discussion in Section IX.B.2) to improve how data obtained by **Lisogurski’s** sensor is stored and analyzed for making decisions based on the data. Specifically, in the prior ’484 IPR, I understand that the Board found that “a person of ordinary skill would have looked to **Tran** ... 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 “using [an] artificial neural network to analyze such data and provide warnings,” such as “us[ing] neural networks to track and flag patterns in a patient’s vital signs to recognize possibly dangerous conditions,” to “classify patient risk” and determine when to “provide warnings.” ’484-FWD, 46-47, 52-53. Additionally, as the Board found, **Lisogurski’s** system “process[es] its collected data to track patient status,” and a person of ordinary skill in the art “would have been motivated to seek additional ways to use” such data. ’484-FWD, 46-47; Tran, 22:23-28, 36:62-37:13; Lisogurski, 15:43-65, 18:58-65, 10:48-64. This is consistent with my opinions in my prior ’484 Declaration and my opinions herein. ’484-Anthony, ¶¶218-219.

327. Additionally, 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 and making decisions based on 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 decision-making in medical diagnosis and health monitoring, as illustrated by e.g., U.S. Patent Nos. 5,554,273 and 5,953,713, which I understand have been designated as Exhibits 1064 and 1065, respectively, as further discussed below. *See, e.g.*, Ex. 1064 (Demmin), 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 (Behbehani), 2:25-39 (“an artificial neural network trained to recognize patterns characterizing sleep disorder breathing” enables automated, real-time diagnosis of sleep apnea). 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.

328. 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 (Hoffberg), 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 (Alvarez), ¶148. 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.

329. With respect to **Tran’s** pattern recognition teachings, a person of ordinary skill in the art would have been motivated to apply these teachings to **Lisogurski’s** system to improve the accuracy and reliability of data analysis of physiological information and improve the overall robustness of these analyses. A person of ordinary skill in the art would have understood the significant advantages of employing advanced data analysis methods such as **Tran’s** 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, 23:40-42) (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, 80:24-81:3). **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. Accordingly, a person of ordinary skill in the art would been motivated to apply **Tran's** data analysis techniques to **Lisogurski's** system to enhance its health monitoring and notification capabilities by improving the robustness of extracting clinically relevant insights from sensor data.

330. Moreover, a person of ordinary skill in the art would have been further motivated to apply **Tran’s** pattern recognition teachings to **Lisogurski’s** system for more accurate identification and analysis of conditions of interests. **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.

331. A person of ordinary skill in the art would have understood that data analysis techniques—pattern recognition 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 recognition 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. 1065 (Behbehani), 2:25-39 (“an artificial neural network trained to recognize patterns

characterizing sleep disorder breathing” enables automated, real-time diagnosis of sleep apnea); Ex. 1042 (Lynn), 17:10-37, 35:1-36:12 (“The degree and pattern of divergence from the predetermined normal range may serve to indicate the presence of a malady such as sleep apnea or sepsis.”); *see also* Ex. 1043 (Colman), 28:9-29:40, 30:28-34, 31:29-53 (“The medical recommendations may be deduced from analysis of at least some of the individual parameter's values and patterns and comparison of the measured values and patterns to the known ranges and patterns of the individual parameters”); Ex. 1044 (Segalowitz), 8:3-11, 45:6-11, 45:65-46:12 (“artificial intelligent programming of microchips within said strip-patch device-system enables safe, effective, rapid and economical method for optimal ‘on-site’ (‘on-patient’) portable clinical judgement assessment of the patient, in real time”). Pattern recognition techniques were already being used to “classify different patterns of pulse and plethysmographic waveforms that can occur under different physiological conditions,” as shown in U.S. Patent No. 6,931,269, which I understand has been designated as Exhibit 1051. Ex.1051 (Terry), 2:21-4:36.

332. 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 discussed above, pattern recognition techniques to perform data analysis, 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. 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.

333. **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** teachings 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 smart phone use, pattern recognition, and AI-driven 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 1-6, 11-16, 19-22, and 26-27 Over **Lisogurski** in view of **LeBoeuf** and **Tran**

334. As I discuss below, Claims 1-6, 11-16, 19-22, and 26-27 are rendered obvious by **Lisogurski** in view of **LeBoeuf** and **Tran**. In addition to my discussion

in Sections IX.C.1-IX.C.2 the following discussion identifies example disclosures that each disclose Claims 1-6, 11-16, 19-22, and 25-27.

a. Claims 1-6, 11-16, 19-22, and 26-27

335. Claims 1-6, 11-16, 19-22, and 26-27 each recite or depend on a claim which recites: “**a smart phone or tablet.**” These elements are taught and rendered obvious by **Lisogurski**, for the reasons I’ve provided in connection with ’304 elements [1.k]. *See* my discussion in Section IX.A.3.[1.k].

336. To the extent additional disclosure is required for the “**smart phone or tablet**” limitation, for the reasons stated in my Prior ’484 Declaration, which I incorporate by reference as if fully stated herein, **Lisogurski** in view of **Tran** discloses these 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” (relevant to ’304, [1.k] and [11.k]); and alternatively, (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” (relevant to ’304, [19.pre], [19.i], and [19.j]). ’484-FWD, 47-48. For example, “If the wearable appliance detects a cell phone,” including “smart phones,” it “communicates with the cell phone and provides information to the server 200 using the cellular connection.” Tran, 34:4-25. Thus, as discussed in Section IX.C.2, a person of ordinary skill in the art would have been motivated to apply **Tran’s** smart phone teachings to **Lisogurski’s** monitor 104 (alone or as modified by **LeBoeuf**, see my discussion in Section IX.C.2) to enhance the versatility and connectivity of **Lisogurski’s** monitor. 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, ¶¶48-56, 215-216 (citing Tran, 34:4-25, 33:58-34:3, 34:25-40).

b. Element [12.pre]

337. Element [12.pre] recites: “**The measurement system of claim 11, wherein the measurement system is configured to use artificial intelligence in making decisions.**” This element is met by **Lisogurski** in view of **Tran**.

338. As discussed in connection with claim 11, **Lisogurski** renders obvious the **claimed measurement system of claim 11**. See my discussion in Sections IX.A.3.[11.pre]-[11.i].

339. The Board previously found a substantially identical limitation was met by **Lisogurski** in view of **Tran** in the prior ’484 IPR. In particular, to meet “**the**

wearable device is configured to use artificial intelligence in making decisions...

(’484 claims 2/18), the Board found that “**Tran** discloses feeding data from a wearable patient monitoring device such as those disclosed by **Lisogurski** to a statistical analyzer” that incorporates “engineered (artificial) neural networks,” which is a form of artificial intelligence (AI). ’484-FWD, 48-49 (citing ’484-Pet., 61); ’484-RFWD, 11; Tran, 3:6-13, 11:6-30, 22:24-30, 9:23-54, 85:60-61, 87:33-37, 88:48-50, 90:58-61. **Tran** discloses using AI to make decisions, such as determining when to warn a patient about potentially dangerous medical conditions. For example, as the Board found, **Tran’s** AI-driven statistical analyzer “analy[zes] patient data [to] flag potentially dangerous conditions that can be specified as an event or pattern that can harm the patient.” ’484-FWD, 48-49 (citing ’484-Pet., 61); Tran, 11:16-19, 9:23-54, 87:33-37, 85:60-61, 88:48-50, 90:58-61. For example, the AI-driven “statistical analyzer is trained with training data where certain signals are determined to be undesirable for the patient, given his age, weight, and physical limitations, among others.” Tran, 11:10-13. “For example, the patient’s glucose level should be within a well established range, and any value outside of this range is flagged by the statistical analyzer as a dangerous condition.” Tran, 13-16. When such dangerous conditions are detected, **Tran** discloses “display[ing] a warning to a patient and connect[ing] the patient to the appropriate emergency response authority.” Tran, 87:33-37; *see also* 85:60-61, 88:48-50, 90:58-61. ’484-Pet., 61. Furthermore,

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, which I incorporate by reference as if fully set forth herein. ’484-Anthony, ¶¶210-219.

340. ’304 patent element [12.pre] is substantially identical to the corresponding limitation in the ’484 patent on which I previously opined, and which recites: “**The system of claim 1, wherein the wearable device is configured to use artificial intelligence in making decisions associated with at least a portion of the output signal**” (claims 2, 18). The main difference between the two limitations is the ’484’s use of “the wearable device” as opposed to the ’304 element [12.pre]’s use of “the measurement system.” **Lisogurski’s** wearable device (e.g., “sensor

102/312” which is mounted on a user’s fingertip, toe, earlobe, wrist, or thigh) is part of its measurement system (e.g., “physiological monitoring system 100/310,” including “sensor 102/312”). *See, e.g.*, Section IX.A.3.[11.a] (for Lisogurski’s disclosure of “sensor 102/312” which can be placed on a user’s “fingertip, toe, forehead or earlobe”). Thus, the differences between the two terms do not change my analysis, and my opinions regarding the ’484 patent term apply equally to ’304 patent element [12.pre]. ’484-Anthony, ¶¶210-219.

341. As I discussed above in Section IX.C.2, the Board found that a person of ordinary skill in the art would have been motivated to apply **Tran’s** teachings of an AI-driven statistical analyzer to **Lisogurski’s** physiological monitoring system (either alone or as modified by **LeBoeuf**) to advantageously acquire more accurate physiological measurements and improve analysis of the collected physiological measurement data to, for example, more effectively detect and flag clinically significant conditions and determine when a patient should be alerted to dangerous health conditions.

342. I understand that Defendants identified “**wherein the measurement system is configured to use artificial intelligence in making decisions**” as potentially indefinite in the Texas case. Ex. 1023, 238. Regardless of its outer bounds (e.g., what constitutes “making decisions”), however, and without opining on whether or not it has adequate written description support, this term is met by

Tran because **Tran** discloses and renders obvious the indisputable scope of this limitation. For example, an embodiment of the '304 patent discusses using built-in “artificial intelligence” to make decisions on how to respond to real-time data. '304 patent, 32:46-58. A person of ordinary skill in the art would have understood that the limitation [12.pre] at least includes this embodiment contemplating analyzing physiological measurements.

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

c. Element [12.a]

344. Element [12.a] recites: “**wherein the measurement system is configured to perform pattern identification or classification, and wherein the measurement system is configured to apply a threshold function to a**

comparison with a stored data set; and.” This element is met by **Lisogurski** in view of **Tran**.

345. As discussed in connection with claim 11, **Lisogurski** renders obvious the **claimed measurement system of claim 11**. See Sections IX.A.3.[11.pre]-[11.l].

346. Additionally, to meet “**configured to perform pattern identification or classification**” (’484 claims 4/12/21), the Board relied on **Tran’s** disclosure that “neural networks are used to recognize patterns.” ’484-FWD, 53 (citing ’484-Pet., 64; Tran, 9:23-54, 11:1-8, 11:16-19, 22:23-59, 23:4-16, 23:39-50, 24:45-48, 24:58-60, 80:24-81:3; ’484-RFWD, 11-12. The Board also relied on **Tran’s** teachings of “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, 53 (citing ’484-Pet., 64-65); Tran, 9:23-54, 11:1-8, 11:16-19, 22:23-59, 23:4-16, 23:39-50, 24:45-48, 24:58-60, 80:24-81:3; ’484-RFWD, 11-12 (agreeing that limitation was met based on ’484-FWD, 53). As **Tran** teaches, “The hidden Markov model is used to derive a set of reference pattern templates, each template representative of an identified pattern in a vocabulary set of reference treatment patterns.... During recognition, the unknown pattern can then be identified as the reference pattern with the highest probability in the likelihood calculator.” Tran, 24:45-55. **Tran** discusses that “module 52” of the server 20 “monitors the patient ambulatory pattern and generates warnings should the patient’s

patterns indicate that the patient has fallen or is likely to fall.” Tran, 11:37-39. For example, the analyzer may use various “statistical models,” “regression methods,” and “engineered (artificial) neural networks” to “track the patient’s habits.” “Prior to operation, data driven analyzers or models of the patient’s habits or ambulation patterns are built using one or more training sessions.” Tran, 22:23-31. “The user’s habits and movements can be determined by the system for stroke detection.” 13:42-18:31.

347. Furthermore, 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). Moreover, I understand the Board determined that the claim was unpatentable on remand. '484-RFWD, 11. This is consistent with my opinions regarding this '484 limitation, which I incorporate by reference as if fully set forth herein. '484-Anthony, ¶¶210-223, 226-229.

348. '304 patent element [12.a] (“**wherein the measurement system is configured to perform pattern identification or classification**”) 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 based on at least a part of the output signal**” (claims 4, 12, 21). The main difference between the two limitations is the '484's use of “the wearable device” as opposed to the '304 element [12.pre]'s use of “the measurement system.” **Lisogurski's** wearable device (e.g., “sensor 102/312” which is mounted on a user's fingertip, toe, earlobe, wrist, or thigh) is part of its measurement system (e.g., “physiological monitoring system 100/310,” including “sensor 102/312”). *See, e.g.*, Section IX.A.3.[11.a]. (for Lisogurski's disclosure of “sensor 102/312” which can be placed on a user's “fingertip, toe, forehead or earlobe”). Thus, the differences between the two terms do not change

my analysis, and my opinions regarding the '484 patent term apply equally to '304 patent element [12.a]. '484-Anthony, ¶¶210-223, 226-229.

349. Additionally, the Board previously found a substantially identical limitation was met by **Lisogurski** in the prior '484 IPR. In particular, to meet “compare a property of at least some of the output signal to a threshold” ('484 claims 3/8/16), the Board relied on **Lisogurski's** disclosure of “comparing a detected signal to a threshold or target value.” '484-FWD, 50 (citing '484-Pet., 63 (citing **Lisogurski**, 24:41-57)). Specifically, the Board also relied on **Lisogurski's** teachings of “compar[ing] the output signal to thresholds that identify portions of interest for further processing or to change light source modulation.” '484-FWD, 50 (citing '484-Pet., 63 (citing **Lisogurski**, 9:46-52, 37:8-14)); *see also* **Lisogurski**, 40:42-41:39. For example, **Lisogurski** teaches that the received signal is sampled and used to determine “region[s] of interest” by using “threshold crossings” based on these samples. 33:65-67, 40:42-47. Because the received signals are sampled, a person of ordinary skill in the art would have understood that **Lisogurski's** measurement system stores the received signal to select them as sample points. **Lisogurski**, 40:42-47, 41:15-25; Fig. 25. At minimum, it would have been obvious to do so. This is consistent with my opinions regarding this '484 limitation, which I incorporate by reference as if fully set forth herein. '484-Anthony, ¶¶210-223, 226-229.

350. '304 patent element [12.a] (“**wherein the measurement system is configured to apply a threshold function to a comparison with a stored data set**”) is substantially identical to the corresponding limitation in the '484 patent on which I previously opined, and which recites: “**wherein the wearable device is at least in part configured to identify an object, and to compare a property of at least some of the output signal to a threshold**” (claims 3, 8, 16). The main differences between the two limitations is (i) the '484's use of “the wearable device” as opposed to the '304 element [12.a]'s use of “the measurement system,” (ii) the '484's use of a “compare ... to a threshold” as opposed to the '304 element [12.a]'s use of “apply a threshold function to a comparison,” and (iii) the '484's use of “a property of at least some of the output signal” as opposed to the '304 element [12.a]'s use of “a stored data set.” Though the limitations use slightly different language, they cover substantially the same concept, and the disclosure from **Lisogurski** relied upon by the Board to meet the '484 limitation also satisfies '304 [12.a]. As discussed in [11.pre] and [11.a] above, **Lisogurski's** physiological measurement system contains a wearable device and thus functions performed by the wearable device are performed by the system. Additionally, consistent with the Board's findings (discussed above), **Lisogurski** discloses “comparing a detected signal to a threshold or target value” which involves applying a function to the data to determine “region[s] of interest” in the stored data of the physiological

measurements. Lisogurski, 24:41-57, 40:42-47. Thus, the differences between the two terms do not change my analysis, and my opinions regarding the '484 patent term apply equally to '304 patent element [12.a]. '484-Anthony, ¶¶210-223, 226-229.

351. As I discussed above in Section IX.C.2, the Board found that a person of ordinary skill in the art would have been motivated to apply **Tran's** teachings of an AI-driven statistical analyzer to **Lisogurski's** physiological monitoring system (either alone or as modified by **LeBoeuf**) to advantageously acquire more accurate physiological measurements and improve analysis of the collected physiological measurement data to, for example, more effectively detect and flag clinically significant conditions and determine when a patient should be alerted to dangerous health conditions.

d. Element [12.b]

352. Element [12.b] recites: “wherein the **measurement system** is at least in part configured for **selection or identification of an object**, and wherein the measurement system is configured to **improve a signal-to-noise ratio** of the selection or identification by **applying regression signal processing methodologies or multivariate techniques**.” This element is met by **Lisogurski** in view of **Tran**.

353. This limitation includes language similar to language that was already determined unpatentable by the Board in the '484-IPR (“**detect**” or “**identify an object**”) and new language that was not previously considered (**improve a signal-to-noise ratio of the selection or identification by applying regression signal processing methodologies or multivariate techniques**). See '484-FWD, 49-52; '484-Remand-FWD, 4-7.

354. As discussed in connection with claim 11, **Lisogurski** renders obvious the **claimed measurement system of claim 11**. See Sections IX.A.3.[11.pre]-[11.l].

355. The Board previously found a substantially identical limitation was met by **Lisogurski** in the prior '484 IPR. In particular, to meet “**wherein the wearable device is at least in part configured to identify an object**” ('484 claim 3/8), the Board found that **Lisogurski's** sensor 102/312 “**calculat[es] an amount of a blood constituent, e.g., oxyhemoglobin**” in a tissue sample, and thus **Lisogurski** “**teaches identifying an object, i.e., the blood constituent oxyhemoglobin.**” '484-Remand-FWD, 6-7 (citing '484-Pet.-Reply, 24); **Lisogurski**, 4:36-51. Specifically, as the Board explained, **Lisogurski** discloses identifying an object by measuring “the light intensity or the amount of light absorbed” by “the tissue” “to calculate any of a number of physiological parameters, including an amount of a blood constituent (e.g., oxyhemoglobin) being measured.” '484-Remand-FWD, 4-7; **Lisogurski**, 4:36-62. Thus, the Board found that “[a]s **Lisogurski** discloses a method of measuring oxygen

saturation that uses different wavelengths to distinguish hemoglobin from oxygen carrying hemoglobin, i.e., oxyhemoglobin, Lisogurski teaches identifying an object, i.e., the blood constituent oxyhemoglobin.” 484-Remand-FWD, 4-7; Lisogurski, 4:36-62. In other words, **Lisogurski’s** calculation and measurement of the amount of oxyhemoglobin exists in blood includes distinguishing and identifying the oxyhemoglobin blood constituent. This is consistent with my opinions regarding this ’484 limitation, which I incorporate by reference as if fully set forth herein. ’484-Anthony, ¶¶210-223.

356. ’304 patent element [12.b] (“**wherein the measurement system is at least in part configured for selection or identification of an object**”) is substantially identical to the corresponding limitation in the ’484 patent on which I previously opined, and which recites: “**wherein the wearable device is at least in part configured to identify an object.**” (claims 3, 8). The main differences between the two limitations is (i) the ’484’s use of “the wearable device” as opposed to the ’304 element [12.b]’s use of “the measurement system” and (ii) the ’304 element [12.b]’s addition of the optional “selection of an object.” First, **Lisogurski’s** wearable device (e.g., “sensor 102/312” which is mounted on a user’s fingertip, toe, earlobe, wrist, or thigh) is part of its measurement system (e.g., “physiological monitoring system 100/310,” including “sensor 102/312”). *See, e.g.*, Section IX.A.3.[11.a] (for **Lisogurski’s** disclosure of “sensor 102/312” which can

be placed on a user's "fingertip, toe, forehead or earlobe"). Second, **Lisogurski's** disclosure of "identify[ing] an object" (as recited in '484 claims 3, 8) meets "selection or identification of an object (as recited in '304 [12.b]) because "selection" is recited as an alternative to "identification," and thus [12.b] is met by **Lisogurski's** identification alone. Thus, the differences between the two terms do not change my analysis, and my opinions regarding the '484 patent term apply equally to '304 patent element [12.b]. '484-Anthony, ¶¶210-223.

357. Additionally, **Lisogurski** further discloses **improving a signal-to-noise ratio**. For example, **Lisogurski** discloses that in response to "background noise" caused by patient motion," its physiological monitoring "system may increase the brightness of the light sources...to **improve the signal-to-noise ratio**" (SNR). **Lisogurski**, 9:49-52. A person of ordinary skill in the art would have understood, or at minimum found it obvious, that **Lisogurski's** teachings of improving SNR are applied to its identification of certain blood constituents (e.g., oxyhemoglobin) in tissue, because improving SNR would also improve the accuracy of measuring the amount of, and thus identifying, blood constituents (e.g., oxyhemoglobin) is in a tissue sample, as illustrated by e.g., U.S. Patent Nos. 6,587,704 and 6,397,092, which I understand have been designated as Exhibits 1066 and 1067, respectively, as further discussed below. *See, e.g.*, Ex. 1066 (Fine), 2:30-35 ("greater signal-to-noise ratio... enables constituents in blood to be detected at concentration levels below

those previously detectable in a non-invasive system.”); Ex. 1067 (Norris), 3:12-35 (taking multiple rapid samples and averaging them “increases the signal to noise ratio of the digital signal under analysis” and “also increases the dynamic range...allowing use of [a lower-bit] converter” and “improves consistency of the measurements.”).

358. Further, a person of ordinary skill in the art would have found it obvious to use **multivariate techniques** to implement **Lisogurski’s** “improve[ment] [of] signal-to-noise ratios” because **multivariate techniques** are commonly used methods to clean up and improve the accuracy of data, as illustrated by e.g., U.S. Patent No. 5,360,004, which I understand has been designated as Exhibit 1068, as further discussed below. *See, e.g.,* Marbach, 12:19-27 (performing “measurement algorithms” on “multivariate input data” of measurement signals “better[s] the measurement accuracy a.k.a. SNR” because “noise correlated between the different pieces of multivariate input data can be subtracted out in the measurement algorithm” to produce the “user-desired output”); *see also* 11:57-63; Ex. 1068 (Purdy), 6:1-9 (“various techniques of multivariate analysis are known in the chemical arts,” and partial least squares (PLS) as a preferred technique. In practice, after such pretreatment, the “pretreated data is then subject to multivariate analysis” to yield the analyte value and is an obvious solution for improving SNR and accuracy”).

359. I understand that Defendants identified “wherein the measurement system is at least in part configured for selection or identification of an object” as potentially indefinite in the Texas case. Ex. 1023, 238. Regardless of its outer bounds (e.g., what constitutes an “object”), however, and without opining on whether or not it has adequate written description support, this term is met by **Lisogurski** because **Lisogurski** discloses and renders obvious the indisputable scope of this limitation. For example, an embodiment of the ’304 patent discusses that blood constituents “may be detected and identified.” ’304 patent, 28:58-62. A person of ordinary skill in the art would have understood that the limitation [12.b] at least includes this embodiment contemplating identifying blood constituents.

360. Consistent with this embodiment, and as the Board previously found, **Lisogurski** discloses “the light intensity or the amount of light absorbed” by “the tissue” to “calculate any of a number of physiological parameters, including an amount of a blood constituent (e.g., oxyhemoglobin)” in the tissue sample. *Lisogurski*, 4:36-51; ’484-RFWD, 5-7 (finding “[a]s **Lisogurski** discloses a method of measuring oxygen saturation that uses different wavelengths to distinguish hemoglobin from oxygen carrying hemoglobin, i.e., oxyhemoglobin, **Lisogurski** teaches identifying an object, i.e., the blood constituent oxyhemoglobin.”).

e. **Claim 13**

361. Claim 13 recites: **“The measurement system of claim 12, wherein the light source is configured to further increase the signal-to-noise ratio by increasing a pulse rate of at least one of the plurality of semiconductor sources from an initial non-zero pulse rate.”** This claim is met by **Lisogurski**.

362. As discussed in connection with claim 12, **Lisogurski** renders obvious the **claimed measurement system of claim 12**. See my discussion in Sections IX.C.3.[12.pre]-[12.b].

363. ’304 patent claim [13] is substantially identical to ’304 patent claim [20] which I discussed above, and which recites: **The wearable device of claim 19, wherein the light source is configured to further improve the signal-to-noise ratio of the input optical beam reflected from the tissue by increasing a pulse rate of at least one of the plurality of semiconductor sources from an initial non-zero pulse rate.**” See Section IX.C.3.[12.pre]-[12.b]. The main difference between the two limitations is Claim [13] use of a “measurement system” as opposed to Claim 20’s use of “the wearable device.” As I discussed in [11.pre] and [11.a] above, the “wearable device” is a part of the “measurement system” and thus the light source contained within the wearable device is also contained within the measurement system. See Sections IX.A.3.[11.pre], [11.a]. Thus, the differences between the

terms do not change my analysis, and my opinions regarding '304 patent claim 20 apply equally to '304 patent claim 13.

364. I understand that Defendants identified “the light source is configured to further increase the signal-to-noise ratio by increasing a pulse rate of at least one of the plurality of semiconductor sources from an initial non-zero pulse rate” as potentially indefinite in the Texas case. Ex. 1023, 238. As discussed above in connection with claim 20, regardless of its interpretation (e.g., by increasing pulse rate, increasing the signal-to-noise ratio of (1) to-be-generated reflected input optical signals or (2) already-generated input optical 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. See my discussion in Section IX.A.3.[20].

f. Claim 26

365. Claim 26 recites: “[26.pre] **The wearable device of claim 19, wherein the wearable device is configured to use artificial intelligence in making decisions; [26.a] wherein the wearable device is configured to perform pattern identification or classification, and wherein the wearable device is configured to apply a threshold function to a comparison with a stored data set; and [26.b] wherein the wearable device is at least in part configured for selection or**

identification of an object, and wherein the wearable device is configured to improve a signal-to-noise ratio of the selection or identification by applying regression signal processing methodologies or multivariate techniques.” This claim is met by **Lisogurski**.

366. As discussed in connection with claim 19, **Lisogurski** renders obvious the **claimed wearable device of claim 19**. See my discussion in Sections IX.A.3.[19.pre]-[19.j].

367. ’304 patent claim [26] is substantially identical to ’304 patent claim [12] which I discussed above, and which recites: “[12.pre] **The measurement system of claim 11, wherein the measurement system is configured to use artificial intelligence in making decisions; [12.a] wherein the measurement system is configured to perform pattern identification or classification, and wherein the measurement system is configured to apply a threshold function to a comparison with a stored data set; and [12.b] wherein the measurement system is at least in part configured for selection or identification of an object, and wherein the measurement system is configured to improve a signal-to-noise ratio of the selection or identification by applying regression signal processing methodologies or multivariate techniques.”** See Section IX.C.3.[12.pre]-[12.b]. The main difference between the two limitations is Claim [26] use of “the wearable device” as opposed to Claim [12]’s use of “the measurement system.” For the

reasons I discussed in Claim [11.a] above, Lisogurski’s measurement system (e.g., Lisogurski’s “physiological monitoring system 100/310,” including “sensor 102/312,” *see* Section IX.A.3.[1.pre]) is a wearable device. ’533-FWD, 25 (citing ’533-Pet. 53-55); Lisogurski, 4:6-20. Thus, the differences between the two terms do not change my analysis, and my opinions regarding ’304 patent element [12] apply equally to ’304 patent element [26].

368. Additionally, a person of ordinary skill in the art would have been motivated to implement **Tran’s** AI teachings in **Lisogurski’s** wearable sensor 102/312 (as modified, *see* Section IX.C.2) to improve how the data obtained is stored and analyzed by the device without needing to involve an external device to avoid latency.

D. GROUNDS 5-8: Grounds 1-4 in further view of Carlson (Claims 1-6, 11-16, 19-22, 26-27):

1. Overview of Carlson

369. **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, ¶2; *see also* Carlson, ¶49. An example of the “ear clip 1” is depicted in Figure 2, which I’ve reproduced below. Carlson, ¶33, Fig. 2.

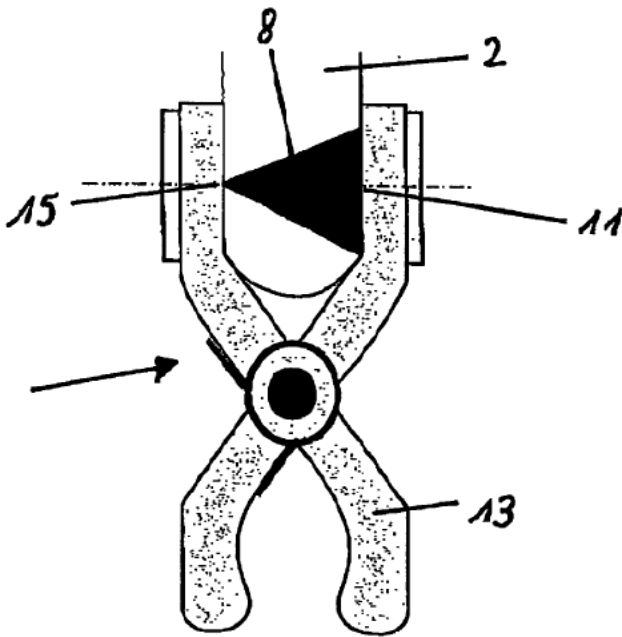


Figure 2

370. **Carlson** discloses that “ear clip 1” (also referred to in Carlson as “ear sensor 1”; see ¶¶48-49) 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, ¶49. 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, ¶50. **Carlson** teaches that the configuration of light source 15 includes having “two light emitting sources” (i.e., “two LEDs”). Carlson, ¶50. **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, ¶62. ’533-FWD, 18-20.

371. **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 “influence[s] the measurement of the pulsoximeter sensor.” Carlson, ¶¶4, 68. 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, ¶15, ’533-FWD, 18-20.

372. **Carlson** discloses that it is an objective of the invention to provide “optical and/or electronic means for increasing 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, ¶¶10, 69. **Carlson’s** LEDs emit light “not as a current or continuous light but as pulsed light.” ¶69. 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, ¶65. 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, ¶69. 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, ¶69; ’533-FWD, 18-20.

2. Motivation to Combine Lisogurski (alone or in view of LeBoeuf and/or Tran) and Carlson

373. Like **Lisogurski**, **LeBoeuf**, and **Tran**, **Carlson** is analogous art, in the same field as the ’304 patent—including physiological monitoring—and is reasonably pertinent to the problems addressed by the ’304 patent—e.g., improving optical physiological monitoring. ’304 patent, 5:4-5:40; Lisogurski, 1:10-11; LeBoeuf, Abstract, ¶¶25, 26; Carlson, ¶¶2, 4, 6-8, 10. 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 ’304 patent. Lisogurski, 9:46-60, 14:40-55, 26:5-14; Carlson, ¶54. A person of ordinary skill in the art would have understood that both **Lisogurski** and **Carlson** are within the relevant technical field, addressing similar problems as the 304 patent, and, therefore, are compatible. The

explicit discussion in both references about mitigating similar technical challenges would have made their combination straightforward and logical from a person of ordinary skill in the art's perspective.

374. 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. Thus, a person of ordinary skill in the art would have applied **Carlson's** lenses teachings to **Lisogurski's** sensor 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, ¶¶10, 14; Lisogurski, 6:3-6, 9:49-60, 13:60-14:10, 14:40-55, 37:6-20). This is consistent with my opinions in my Prior '484 Declaration and my opinions herein. '484-Anthony, ¶¶111-114.

375. Additionally, in the prior '533 IPR, I understand that the Board agreed, determining that a person skilled in the art would have applied Carlson's lenses teachings to Lisogurski's wireless sensor 102/312 to "increase the optical signal power without increasing the actual power used by the system," thereby "increasing the Signal/Noise ... ratio" and that "Lisogurski teaches the importance of both reducing power consumption and increasing signal-to-noise ratio" such that a person

of ordinary skill in the art would have applied Carlson's lens teaching to Lisogurski's wireless sensor 102/312. '533-FWD, 37; Carlson, ¶¶10, 14; Lisogurski, 14:40-55, 37:6-20; '533-Anthony, ¶133 (citing Carlson, ¶¶10, 14; Lisogurski, 6:3-6, 9:49-60, 13:60-14:10, 14:40-55, 37:6-20). This is consistent with my opinions in my Prior '533 Declaration and my opinions herein. '533-Anthony, ¶¶131-134.

376. 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, ¶14; *see also* Carlson ¶10. Accordingly, a person of ordinary skill in the art would have been motivated to apply **Carlson's** lenses teachings to **Lisogurski's** system to further its own goals of improving the signal-to-noise ratio of the measured optical signal and increasing its optical signal power without increasing its actual power. '484-Anthony, ¶112 (citing Carlson, ¶¶10, ¶14; Lisogurski, 6:3-6, 9:49-60, 13:60-14:10, 14:40-55, 37:6-20); '533-Anthony, ¶133 (citing Carlson, ¶¶10, 14; Lisogurski, 6:3-6, 9:49-60, 13:60-14:10, 14:40-55, 37:6-20).

377. 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. Lisogurski, 1:10-11, 10:48-56, 17:37-45; Carlson ¶54. 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, ¶14; *see also* ¶54. 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.

378. 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, such as changes in background noise or ambient light.” ’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, ¶¶67-69); *see also* Lisogurski, 1:67-2:3, 9:46-60, 37:6-18; Carlson, ¶¶68-69, 64. 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. 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**.

379. 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.

380. 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, both references teach techniques for changing the operation of their light sources to reduce the effects of ambient light and noise because **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 ¶69)). 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).

381. **Carlson’s lens and light modulation** teachings concern the mechanisms within and the operation of **Lisogurski’s** light source, **LeBoeuf’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 (see my discussion in Section IX.B), and **Tran’s** teachings pertain to **Lisogurski’s**

monitor and/or software within the monitor (see my discussion in 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 1-6, 11-16, 19-22, and 26-27 Over Lisogurski in view of LeBoeuf, Tran, and Carlson

382. As I discuss below, Claims 1-6, 11-16, 19-22, and 26-27 are rendered obvious by **Lisogurski** in view of **LeBoeuf, Tran, and Carlson**. In addition to my discussion in Section IX.D.1-2, the following discussion identifies example disclosures that each disclose Challenged Claims 1-6, 11-16, 19-22, and 26-27.

a. Elements [1.c], [11.c], [19.c]

383. Element [1.c] recites: “**receive a portion of the output optical beam, and deliver an analysis output beam to a sample.**”

384. Element [11.c] recites: “**the wearable measurement device configured to receive a portion of the output optical beam, and deliver an analysis output beam to a sample.**”

385. Element [19.c] recites: “**receive and to deliver a portion of the input optical beam to tissue, wherein the tissue reflects at least a portion of the input optical beam delivered to the tissue.**”

386. As I discussed above in Elements [1.c], [11.c], [19.c], **Lisogurski** teaches and at least renders obvious the “receive” and “deliver” an output/input beam limitation. *See* my discussion in Sections IX.A.3.[1.c], [11.c], [19.c].

387. **To the extent additional disclosure is required for the “receive” and “deliver” an output/input beam limitation, Carlson discloses receiving the optical beam** (e.g., “two lenses 21 that receive light beams 8 emitted by LEDs 15”) **and delivering an analysis beam to a sample** (e.g., “deliver light bundles or beams 12 to sample 2”). Carlson, ¶¶45, 54, 62.

388. Regarding the “receive” and “deliver” an output/input beam 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 that the Board noted that “[a]ccording to Petitioner, a person of ordinary skill would have had reason to employ lenses as taught by **Carlson** in **Lisogurski**’s sensor to focus light from the LED onto a person’s skin and in doing so, increase optical power and improve signal to noise ratio,” and that “**Carlson** discloses ... lenses and that ... can be diffractive or refractive and direct the emitted optical radiation into human or animal tissue.” ’484-FWD, 23, 26-27. This is consistent with my opinions regarding this ’484 limitation provided in my Prior ’484 Declaration, which I incorporate by reference as if fully set forth herein. ’484-Anthony, ¶¶48-56, 81-87 (citing

Lisogurski, 1:4-6, 1:16-18, 3:50-53, 4:15-20, 4:63-67, 9:46-52, 14:50-55, 17:51-58, 37:8-11; Carlson, ¶¶2, 10, 48, 52), 110-114 (citing Carlson, ¶¶10, 13, 14, 24, 54, 62, Fig. 4; Lisogurski, 6:3-6, 9:49-60, 13:60-14:10, 14:40-55, 37:6-20; Ex. 1038 (Biomedical Engineering Handbook), 765).

389. 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 “Petitioner demonstrate[d] that a person skilled in the art would have included lenses in **Lisogurski’s** wireless sensor 102/312 because **Carlson** teaches the advantages of doing so,” and that “**Carlson** teaches lenses 21 ‘increase the optical signal power without increasing the actual power used by the system, thereby ‘increasing the Signal/Noise . . . ratio.’” ’533-FWD, 36-37. This is consistent with my opinions regarding this ’533 limitation provided in my Prior ’533 Declaration, which I incorporate by reference as if fully set forth herein. ’533-Anthony, ¶¶48-56, (citing Ex. 1041 (“Valencell-093”), ¶3), 84 (citing Lisogurski, 4:15-20, 17:51-58; Carlson, ¶¶48, 52), 119 (citing Carlson, ¶¶67-69), 130-135 (citing Carlson, ¶¶10, 13, 14, 24, 54, 62, Fig. 4; Lisogurski, 6:3-6, 9:49-60, 13:60-14:10, 14:40-55, 37:6-20; Ex. 1038 (Biomedical Engineering Handbook), 765).

390. For the reasons I discuss above, the “receive” and “deliver” an output/input beam 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 “receive” and “deliver” an output/input beam limitations. See my discussion in Sections IX.A.3.[1.c], [11.c], [19.c].

391. 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, ¶2. 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, ¶35; *see also* Carlson, Fig. 4.

392. 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 **Lisgourski** 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 13, 20

393. Claim 13 recites: “The measurement system of claim 12, wherein the light source is configured to further increase the signal-to-noise ratio by increasing a pulse rate of at least one of the plurality of semiconductor sources from an initial non-zero pulse rate.” Claim 20 likewise recites: “The wearable device of claim 19, wherein the light source is configured to further improve the signal-to-noise ratio of the input optical beam reflected from the tissue by increasing a pulse rate of at least one of the plurality of semiconductor sources from an initial non-zero pulse rate.” ’304 patent, Claim 20 (language identical to claim 13 underlined for readability).

394. Claims 13 and 20 (collectively, the “pulse rate” limitations) are disclosed and rendered obvious by **Lisogurski**, for the reasons I’ve provided in connection with ’304 claims 13 and 20. *See* my discussion in Sections IX.C.3.[13], IX.A.3.[20].

395. To the extent additional disclosure is required for the “pulse rate” limitations, **Carlson discloses wherein the light source is configured to further 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 plurality of 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”). Carlson, ¶¶ 62-69, claim 11.

396. Regarding the “pulse rate” limitations in the prior ’484 IPR reciting **“the wearable device configured to increase the signal-to-noise ratio by increasing a pulse rate of at least one of the plurality of semiconductor sources from an initial pulse rate,”** I understand the Board “concluded 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 “Petitioner cites **Carlson** as expressly disclosing 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,” that “Petitioner contends 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 “Petitioner contends 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, ¶¶2, 20, 67-69, claims 10-11).

397. Regarding the “pulse rate” limitations in the prior ’533 IPR reciting **“the light source configured to increase signal-to-noise ratio by increasing a pulse rate of at least one of the plurality of semiconductor sources,”** I understand the Board determined that “Petitioner 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 “Petitioner argues, ‘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. Additionally, the Board found **Lisogurski in view of Carlson** render obvious this limitation because “both references recognize the problem of ambient light noise ‘and the need to offset its negative impact on the signal-to-noise ratio.’” See ’533-FWD, 30-35, 42-43; see also ’484-FWD, 36-43. Moreover, I

understand that the Board specifically found that “Petitioner 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. Specifically, the Board found that **Carlson** teaches “various means to improve a pulsoximeter’s signal-to-noise,” including “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...in the range of above approximately 1000 Hz.” ’533-FWD, 33, 42-43; Carlson, ¶¶62-69; *see also* ’484-FWD, 36-43. As **Carlson** further discloses, in addition to selecting a frequency of “1000 Hz which of course is a frequency far outside of any indoor light source,” the pulse rate could be “chosen at any other frequency, [such] as e.g. 2000 Hz or even higher,” such that the pulsoximeter could proactively generate higher pulse rates to avoid the influence of any ambient light. Carlson, ¶69. 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, ¶67-69).

398. 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. See my discussions in Sections IX.C.3.[13], IX.A.3.[20].

399. 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**.

400. I understand that Defendants identified “wherein the light source is configured to further 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” as potentially indefinite in the Texas case. Ex. 1023, 238. Regardless of its

interpretation (e.g., by increasing pulse rate, increasing the signal-to-noise ratio of (1) to-be-generated reflected input optical signals or (2) already-generated input optical 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, this term is met by **Carlson** because **Carlson** meets this term under either interpretation because it is a matter of timing.

401. For example, as the Board found in the prior ’484 IPR, **Carlson** discloses “various means to improve a pulsoximeter’s signal-to-noise” which “include ‘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 . . . in the range of above approximately 1000 Hz.’” ’533-FWD, 33 (citing Carlson, ¶¶ 62–69). The Board also found in the prior ’533 IPR 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 (citing ’533-Pet. 37-38 (citing Carlson, ¶69)). **Carlson** further discloses that in addition to selecting a frequency of “1000 Hz which of course is a frequency far outside of any indoor light source,” the pulse rate could be “chosen at any other frequency, [such] as e.g. 2000 Hz or even higher,” such that the pulsoximeter could proactively generate higher pulse rates to avoid the

influence of any ambient light. Carlson, ¶69. A person of ordinary skill in the art would thus have understood that **Carlson** teaches increasing the pulse rate of the light source preemptively and that an already-generated output signal using the already-increased pulse rate would thus have increased signal-to-noise ratio.

E. Grounds 9-10: Grounds 3 and 7 in view of Marbach (Claims 12-13, 26)

402. As I discussed above, **Lisogurski** in view of **Tran** (either alone or in further view of LeBeouf) renders obvious claims 12-13 and 26. See my discussion in Sections IX.C.3.[12.pre]-[12.b], [13], [26]. To the extent further disclosure of **improving a signal-to-noise ratio by applying regression signal processing methodologies or multivariate techniques** is required (claims 12-13, 26), **Marbach** discloses **improving a signal-to-noise ratio by applying multivariate techniques** (e.g., “measurement algorithms” using “multivariate input data” “better[s] the measurement accuracy a.k.a. SNR”). Marbach, 11:57-63, 12:19-27.

403. **Marbach** discloses performing “measurement algorithms” on “multivariate input data” of measurement signals in order to “better the measurement accuracy a.k.a. SNR.” Marbach, 12:19-27; *see also* 11:57-63. Specifically, the “noise correlated between the different pieces of multivariate input data can be subtracted out in the measurement algorithm” to produce the “user-desired output.” Marbach, 12:19-27; *see also* 11:57-63.

404. Like **Lisogurski, Tran, and Carlson, Marbach** is analogous art, in the same field as the '304 (including physiological monitoring), and is pertinent to the alleged problems addressed by the '304 (including improving optical physiological monitoring). *See* my discussion in Sections IX.C.2, IX.D.2; Marbach, 3:35-50, 5:53-60, 6:14-19.

405. A person of ordinary skill in the art would have been motivated to apply **Marbach's** teachings regarding multivariate techniques to improve SNR, to advantageously enhance the accuracy and stability of blood glucose measurements in **Lisogurski's** measurement system. Marbach, 3:36-67, 5:53-6:19. **Lisogurski** discloses techniques for reducing noise, including removing "ambient and background signals" to "improve the signal-to-noise ratio" and "improve the quality of the determined physiological parameter[s]." Lisogurski, 6:7-19, 9:46-60. For example, **Lisogurski** discloses "increas[ing] the brightness of the light sources in response to the noise to improve the signal-to-noise ratio" and subtracting "dark values" from "Red and IR signals" to reduce the effects of ambient light. Lisogurski, 9:46-52, 13:60-14:10. **Marbach** specifically emphasizes that combined analysis of multiple signals enables more accurate quantification of analytes like glucose; accordingly, a person of ordinary skill in the art would have been motivated to apply **Marbach's** teachings of multivariate techniques to further improve the SNR of the

physiological measurements taken by the sensor in **Lisogurski's** measurement system, as explicitly contemplated by **Lisogurski**.

406. A person of ordinary skill in the art would have had a reasonable expectation of success in applying **Marbach's** teaching to **Lisogurski's** physiological monitoring system that improves SNR (either alone or in view of **Tran**). Both **Lisogurski** and **Marbach** teach optical physiological measurement systems utilizing LEDs as light sources. Lisogurski, 10:48-56; Marbach 3:36-67, 5:53-6:19, 7:17-32. Furthermore, using multivariate techniques to improve SNR was well known in the art. For example, Fine notes that “greater signal-to-noise ratio... enables constituents in blood to be detected at concentration levels below those previously detectable in a non-invasive system.” Fine, 2:30-35. Additionally, Norris explains that taking multiple rapid samples and averaging them “increases the signal to noise ratio of the digital signal under analysis” and “also increases the dynamic range...allowing use of [a lower-bit] converter” and “improves consistency of the measurements.” Norris, 3:12-35. Thus, a person of ordinary skill in the art would have found it routine, straightforward, and advantageous to apply **Marbach's** multivariate techniques to **Lisogurski's** optical physiological measurements. Lisogurski, 10:48-56; Marbach 3:36-67, 5:53-6:19, 7:17-32. 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.

407. **Marbach's** teachings concern the improving the SNR of the light signal detected by **Lisogurski's** sensor, **Tran's** teachings as applied concern the monitor and/or software within the monitor (Section IX.C), and **Carlson's** teachings as applied concern the mechanisms within and the firing rate of **Lisogurski's** light source (Section IX.D), such that the above-discussed motivations and reasonable expectation of success would remain the same for **Lisogurski's** physiological monitoring system alone or in view of **Tran and/or Carlson**. The combined approach would predictably lead to significant gains in both the robustness and precision of physiological monitoring, consistent with the explicit disclosures and objectives shared between these references. The person of ordinary skill in the art would thus expect, with a high degree of confidence, that the integration would reliably produce the anticipated improvements in system performance.

X. SECONDARY CONSIDERATIONS

408. I have found no evidence in either the '304 patent's prosecution history or elsewhere that supports any secondary considerations arguments, or evidence of nexus to any challenged Claim. *See generally* '304FH. Indeed, as I have discussed in connection to the prior art referenced herein, any purported solutions to problems or unexpected results in the '304 patent were already well-known in the art.

409. 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

410. In summary, I have concluded that the Challenged Claims are rendered obvious over the prior art references as discussed above. Specifically, in my opinion, for at least the reasons above, the Challenged Claims of the '304 patent obvious.

411. 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.

412. 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.

413. 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

Declaration of Brian W. Anthony in Support of
Petition for *Inter Partes* Review, U.S. Patent No. 10,874,304

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.

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

APPENDIX A

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
School of Engineering Faculty Personnel Record

Date: November 20, 2024

Name:

Brian W. Anthony

Department: Mechanical Engineering / Institute of Medical Engineering and Science

1. Date of Birth: July 1972

2. Citizenship: USA

3. Education:

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

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

5. Principal Fields of Interest:

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

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

Harry Asada, Professor

Ian Hunter, Professor

Kamal Youcef-Toumi, Professor

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

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

8. History of MIT Appointments:

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

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

9. Consulting Record:

Engagements greater than 3 months.

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

10. Professional Service

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

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

11. Awards Received:

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

12. Current Organization Membership:

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

13. Patents and Patent Applications Pending:

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

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

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

14. Professional Registration:

N/A.

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

See next.

1. Books:

Smart Manufacturing On-line course, deployed 2019 and 2020

2. Papers in Referred Journals:

- 2.1. B. Anthony, A. Abbate, D. Klimek, P. Kotidis., "Analysis of Ultrasonic Waves in Arbitrarily Oriented or Rotating Anisotropic Thin Materials", *Quantitative Nondestructive Evaluation*. Vol 18. pgs 215 - 222. (1999).
- 2.2. A. Abbate, B. Anthony, D. Klimek, P. Kotidis., "Analysis of Dispersive Ultrasonic Signals by the Ridges of the Analytic Wavelet Transform", *Quantitative Nondestructive Evaluation*. Vol 18. pgs 703 - 710. (1999).
- 2.3. Dan Klimek, Brian Anthony, Agostino Abbate, Petros Kotidis, "Laser Ultrasonic Instrumentation for Accurate Temperature Measurement of Silicon Wafers in Rapid Thermal Processing Systems", *Rapid Thermal and Integrated Processing VII*, Materials Research Society, Volume 525, pg 135. (1999)
- 2.4. Hardt, D.E., Anthony, B.W., Tor S.B., "A teaching factory for polymer microfabrication - μ Fac," *International Journal of Nanomanufacturing*, 2010, Vol. 6, No.1/2/3/4, pp. 137 - 151.
- 2.5. Shih-Yu Sun, Matthew Gilbertson, and Brian W. Anthony, "Probe Localization for Freehand 3D Ultrasound by Tracking Skin Features", Book Section, *Medical Image Computing and Computer-Assisted Intervention - MICCAI 2014*, Springer, 2014, Vol. 8674. *Lecture Notes in Computer Science*, Pages 365-372.
- 2.6. Xian Du, Brian W. Anthony, Nigel C. Kojimoto, "Grid-based matching for full-field large-area deformation measurement", *Optics and Lasers in Engineering*, Volume 66, March 2015, Pages 307-319.
- 2.7. Xian Du, Nigel C. Kojimoto, Brian W. Anthony, "Concentric circular trajectory sampling for super-resolution and image mosaicing", *Journal of the Optical Society of America A*, Volume 32, No. 2, February 2015, Pages 293-304.
- 2.8. M. Gilbertson, B. Anthony. "A Force and Position Control System for Freehand Ultrasound", *IEEE Transactions on Robotics*, Volume 31, Issue 4. 2015.
- 2.9. Andrey Kuzmin, Aaron Zakrzewski, Brian Anthony, Victor Lempitsky, "Multi-frame Elastography Using Handheld Force-Controlled Ultrasound Probe". *Transactions on Ultrasonics, Ferroelectrics, and Frequency Control*, Volume 62, Issue 8, Pages 1486 – 1500, 2015.
- 2.10. Xian Du and Brian Anthony, "Concentric circle scanning system for large-area and high-precision imaging," *Optics Express*, Vol 23, Issue 15, Pages 20014-20029, 2015.
- 2.11. Du, X., Anthony, B., "Controlled angular and radial scanning for super resolution concentric circular imaging," *Opt. Express* 24(20), 22581, United States (2016).
- 2.12. Jimenez, X., Shukla, S. K., Ortega, I., Illana, F. J., Castro-González, C., Marti-Fuster, B., Butterworth, I., Arroyo, M., Anthony, B., et al., "Quantification of Very Low Concentrations of Leukocyte Suspensions In Vitro by High-Frequency Ultrasound," *Ultrasound Med. Biol.* 42(7), 1568–1573, England (2016).
- 2.13. Koppaka, S., Shklyar, I., Rutkove, S. B., Darras, B. T., Anthony, B. W., Zaidman, C. M., Wu, J. S., "Quantitative Ultrasound Assessment of Duchenne Muscular Dystrophy Using Edge Detection Analysis," *J. Ultrasound Med.* 35(9), 1889–1897, United States (2016).
- 2.14. Lee, J., Boning, D., Anthony, B., "Measuring the Absolute Concentration of Microparticles in Suspension using High Frequency B-mode Ultrasound Imaging", *Ultrasound in Medicine and Biology*, 2018.
- 2.15. Correa-de-Araujo, R., Harris-Love, M., Miljkovic, I., 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.
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- 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, Dhyan M, Grajo JR, Mercaldo N, Anthony BW, et al. Variation of Shear Wave Elastography With Preload in the Thyroid: Quantitative Validation. *J Ultrasound Med*. 2021 Apr 20;40(4):779–86.
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- 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.
- 2.53 Hahm KS, Anthony BW. In-home Health Monitoring using Floor-based Gait Tracking. *Internet of Things (Netherlands) [Internet]*. 2022 Aug;19:100541.
- 2.54 Goryachev I, Tresansky AP, Ely GT, Chrzanowski SM, Nagy JA, Rutkove SB, et al. Comparison of Quantitative Ultrasound Methods to Classify Dystrophic and Obese Models of Skeletal Muscle. *Ultrasound Med Biol*. 2022 Sep;48(9):1918–32.
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- 2.60 Silva L, Dias M, Folgado D, Nunes M, Namburi P, Anthony B, et al. Respiratory Inductance Plethysmography to Assess Fatigability during Repetitive Work. *Sensors*. 2022 Jun 2;22(11):4247.
- 2.62 Magana-Salgado U, Namburi P, Feigin-Almon M, Pallares-Lopez R, Anthony B. A comparison of point-tracking algorithms in ultrasound videos from the upper limb. *Biomed Eng*. 2023 May 24;22(1):52.
- 2.63 Jaffe A, Goryachev I, Sodini C, Anthony BW. Central venous pressure estimation with force-coupled ultrasound of the internal jugular vein. *Sci Rep*. 2023;13(1).
- 2.64 Ponce P, Anthony B, Deshpande AS, Molina A. A Low-Cost Microcontroller-Based Normal and Abnormal Conditions Classification Model for Induction Motors Using Self-Organizing Feature Maps (SOFM). *Energies*. 2023 Oct 30;16(21):7340.
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- 2.66 Feigin M, Freedman D, Anthony BW. Computing Speed-of-Sound From Ultrasound: User-Agnostic Recovery and a New Benchmark. *IEEE Trans Biomed Eng* []. 2023;accepted:1–11.
- 2.67 Medina, A., Bradley, R., Xu, W., Ponce, P., Anthony, B. and Molina, A., 2024. Learning manufacturing computer vision systems using tiny YOLOv4. *Frontiers in Robotics and AI*, 11, p.1331249.
- 2.68 Wang YJ, Anthony BW. Using Local Concentration to Model the Progress of Acoustophoretic Assembly of Microspheres in Planar Standing Waves. *J Micro- Nano-Manufacturing* []. 2023 Dec 1;11(4).
- 2.69 Ranger BJ, Moerman KM, Anthony BW, Herr HM. Constitutive parameter identification of transtibial residual limb soft tissue using ultrasound indentation and shear wave elastography. *J Mech Behav Biomed Mater* []. 2023 Jan;137:105541.
- 2.70 Wang, J; Anthony B. Absolute Magnitude of the Acoustic Radiation Force in a Multi-Wavelength Patterning Device Before and After Pattern Formation. *Proc ASME 2024*. 2024;1–10.
- 2.71 Camacho J de J, Aguirre B, Ponce P, Anthony B, Molina A. Leveraging Artificial Intelligence to Bolster the Energy Sector in Smart Cities: A Literature Review. *Energies* []. 2024 Jan 10;17(2):353.
- 2.72 Ponce P, Anthony B, Bradley R, Maldonado-Romo J, Méndez JI, Montesinos L, et al. Developing a virtual reality and AI-based framework for advanced digital manufacturing and nearshoring opportunities in Mexico. *Sci Rep* []. 2024 May 16;14(1):11214.
- 2.73 Ranger BJ, Moerman KM, Feigin M, Herr HM, Anthony BW. 3D Ultrasound Shear Wave Elastography for Musculoskeletal Tissue Assessment Under Compressive Load: A Feasibility Study. *Ultrason Imaging* []. 2024 May 21.
- 2.74 Lee JH, Nathanson LA, Burke RC, Anthony BW, Shapiro NI, Dagan AS. Assessment of respiratory rate monitoring in the emergency department. *JACEP Open* []. 2024 Jun 8;5(3).
- 2.75 Krbec BA, Zhang X, Chityat I, Brady-Mine A, Linton E, Copeland D, et al. Emerging innovations in neonatal monitoring: a comprehensive review of progress and potential for non-contact technologies. *Front Pediatr* []. 2024 Oct 14;12(October):1–13.
- 2.76 Kang DHE, Kim D, Song Y, Lee D, Kwak H, Anthony BW. Harnessing the potential of shared data in a secure, inclusive, and resilient manner via multi-key homomorphic encryption. *Sci Rep* []. 2024 Jun 13;14(1):13626.
- 2.77 Hahm KS, Anthony BW. Machine learning-based gait health monitoring for multi-occupant smart homes. *Internet of Things* []. 2024 Jul;26(February):101154.

- 2.78 Pérez Briceño C, Ponce P, Robinson Fayek A, Anthony B, Bradley R, Molina A. Discrete event simulation for photovoltaic integration in sustainable manufacturing– A review and future directions. *Renew Sustain Energy Rev* []. 2025 Jul;216(March):115676.
- 2.79 Mata O, Ponce P, Perez C, Ramirez M, Anthony B, Russel B, et al. Digital twin designs with generative AI: crafting a comprehensive framework for manufacturing systems. *J Intell Manuf* []. 2025 Feb 20.
- 2.80 Jaffe AT, Pallarès-López R, Raines JK, Aguirre AD, Anthony BW. Noninvasive Quantitative Compression Ultrasound Central Venous Pressure: A Clinical Pilot Study. *BME Front* []. 2025 Jan 19;6:1–12.

3. Proceedings of Refereed Conferences:

- 3.1. Dipen N. Sinha, Brian W. Anthony, David C. Lizon, "Swept Frequency Acoustic Interferometry Techniques for Chemical Weapons Verification and Monitoring", Third International Conference On-Site Analysis, (1995).
- 3.2. David E. Hardt, Brian W. Anthony and Shu Beng Tor, "A Teaching Factory for Polymer Microfabrication – muFac", Proc. 5th International Symposium on Nano-Manufacturing (ISNM), Athens, November 12-15, 2008.
- 3.3. Gilbertson, M., Anthony, B., and Sun, S.Y., "Handheld Force Controlled Ultrasound Probe", *J. Med. Devices* 4, 027540 (2010)
- 3.4. Ljubicic, D. M., Anthony, B., "Development of a high-speed profilometer for manufacturing inspection," *Proceedings of SPIE Vol. 7767, 776705* (2010).
- 3.5. Sun, S., Anthony, B. W., Gilbertson, M. W., "Trajectory-based deformation correction in ultrasound images," *Proceedings of SPIE Vol. 7629, 76290A* (2010).
- 3.6. Anthony, B. W., Hardt, D. E., Hale, M., et al., "A research factory for polymer microdevices: muFac," *Proceedings of SPIE Vol. 7593, 75930A* (2010).
- 3.7. Gilbertson, M. W., Anthony, B. W., "Impedance-controlled ultrasound probe," *Proceedings of SPIE Vol. 7968, 796816* (2011).
- 3.8. Ljubicic, D. M., Anthony, B. W., "3D high-speed profilometer for inspection of micro-manufactured transparent parts," *Proceedings of SPIE Vol. 8082, 808211* (2011).
- 3.9. Anthony, B.W, Hardt, D.E., "Revitalizing US Manufacturing to Capitalize on Innovation – Through Education" 119th ASEE Annual Conference, San Antonio TX, June 10-13, (2012)
- 3.10. Anthony, B. W., Namvari, K., "Dimensional variation of polymer substrate electrode production," *Proceedings of SPIE Vol. 8251, 82510G* (2012).
- 3.11. Selvakumar, S., Linares, R., Oppenheimer, A., Anthony, B., "Variation analysis of flow rate delivered using a blister pump," *Proceedings of SPIE Vol. 8251, 82510I* (2012).
- 3.12. Donoghue, L., Anthony, B. W., "Design for manufacture of a micro-interdigitated electrode for impedance measurement in a biochemical assay," *Proceedings of SPIE Vol. 8251, 82510Y* (2012).
- 3.13. Holmes, J., Anthony, B. W., "Robustness and repeatability test of interdigitated electrodes on a polymer substrate in an aqueous environment," *Proceedings of SPIE Vol. 8251, 825110* (2012).
- 3.14. Sun, S.-Y, Anthony, B. W. "Freehand 3D ultrasound volume imaging using a miniature-mobile 6-DOF camera tracking system". 2012 IEEE International Symposium on Biomedical Imaging (ISBI), 2-5 May, (2012).
- 3.15. Gilbertson, M.W., Anthony, B.A., 2012. "Ergonomic Controls Strategies for a Handheld Force-Controlled Ultrasound Probe," 2012 IEEE/RSJ Intelligent Robots and Systems (IROS) Conference. Vilamoura, Portugal. (2012)
- 3.16. Sun, S.-Y, Gilbertson, M., Anthony, B. W. "6-DoF Probe Tracking via Skin Mapping for Freehand 3D Ultrasound". 2013 IEEE International Symposium on Biomedical Imaging (ISBI), (2013).

- 3.17. Sun, S.-Y, Gilbertson, M., Anthony, B. W. "Computer-Guided Ultrasound Probe Realignment by Optical Tracking". 2013 IEEE International Symposium on Biomedical Imaging (ISBI), (2013).
- 3.18. Inamdar, T., Anthony, B. W., "Characterizing fluidic seals for on-board reagent delivery," Proceedings of SPIE (2013).
- 3.19. Zakrzewski, A., Anthony, B. W. "Quantitative Elastography and its Application to Blood Pressure Estimation: Theoretical and Experimental Results". 2013 IEEE Engineering in Medicine and Biology Society (EMBS), (2013).
- 3.20. Gilbertson, M. Anthony, B.W., "An Ergonomic, Instrumented Ultrasound Probe for 6-Axis Force/Torque Measurement". 2013 IEEE Engineering in Medicine and Biology Society (EMBS), (2013).
- 3.21. Dhyani, M, Gilbertson, M., Samir, A., Anthony, B.W., "Precise Quantification of Sonographic Forces: A First Step Toward Reducing Ergonomic Injury", 2014 AIUM Annual Convention, (2014).
- 3.22. Koppaka, S., Gilbertson, M., Wu, J., Rutkove, S., Anthony, B. W. "Assessing Duchenne Muscular Dystrophy With Force-controlled Ultrasound". 2014 IEEE International Symposium on Biomedical Imaging (ISBI), (2014).
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- 3.25. Zhang, Xiang; Fincke, Jonathan; Kuzmin, Andrey; Lempitsky, Victor; Anthony, Brian, "A single element 3D ultrasound tomography system," in Engineering in Medicine and Biology Society (EMBC), 2015 37th Annual International Conference of the IEEE , vol., no., pp.5541-5544, 25-29 Aug. 2015.
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- 3.28. Lee, John H.; Jimenez, Javier; Butterworth, Ian R.; Castro-Gonzalez, Carlos; Shukla, Shiva K.; Marti-Fuster, Berta; Elvira, Luis; Boning, Duane S.; Anthony, Brian W., "Measurement of very low concentration of microparticles in fluid by single particle detection using acoustic radiation force induced particle motion", IEEE International, Ultrasonics Symposium (IUS), 2015.
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- 3.32. Pigula, A. J., Wu, J. S., Gilbertson, M. W., Darras, B. T., Rutkove, S. B., Anthony, B. W., "Force-controlled ultrasound to measure passive mechanical properties of muscle in Duchenne muscular dystrophy," 2016 38th Annu. Int. Conf. IEEE Eng. Med. Biol. Soc., 2865–2868, IEEE (2016).

- 3.33. Ranger, B. J., Feigin, M., Zhang, X., Mireault, A., Raskar, R., Herr, H. M., Anthony, B. W., "3D optical imagery for motion compensation in a limb ultrasound system," Proc. SPIE 9790, N. Duric and B. Heyde, Eds., 97900R (2016).
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- 3.37. Zakrzewski, A. M., Dhyani, M., Samir, A. E., Anthony, B. W., "Non-Invasive, Non-Occlusive Blood Pressure Estimation Using Ultrasound: Clinical Results (I)," 38th Annu. Int. Conf. IEEE Eng. Med. Biol. Soc. (2016).
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- 3.39. Anthony, et al, "Non-Invasive Diagnosis of Non-Alcoholic Fatty Liver Disease (NAFLD) using Ultrasound Image Echogenicity", 2017 39th Annu. Int. Conf. IEEE Eng. Med. Biol. Soc., accepted (2017).
- 3.40. Anthony, et al, "Camera-tracking vs. image-based motion compensation in a tomographic limb ultrasound system", 2017 39th Annu. Int. Conf. IEEE Eng. Med. Biol. Soc., (2017).
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- 3.43. A. Benjamin et al., "Non-invasive diagnosis of non-alcoholic fatty liver disease (NAFLD) using ultrasound image echogenicity," 2017 39th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), Seogwipo, 2017,
- 3.44. H. Yang, A.Benjamin, B. Anthony, "Simulation of multi-source external mechanical vibration for shear wave elastography," The Journal of the Acoustical Society of America, 142, 2017
- 3.45. Singh, R., Ma, D., Agarwal, A., & Anthony, B. W. (2018). On-chip photonic particle senso. Presented at the SPIE BiOS, San Francisco, CA.
- 3.46. Kundu, I., & Anthony, B. W. . "Imaging the superficial vascular structure for mapping and identification." |SPIE Smart Structures and Materials + Nondestructive Evaluation and Health Monitoring, Denver, Colorado. (2018)
- 3.47. Kundu, I., Du, X., & Anthony, B. W. (2018). "Imaging platforms for registering and analyzing the skin microrelief structure." Presented at the SPIE Smart Structures and Materials + Nondestructive Evaluation and Health Monitoring, Denver, Colorado. (2018)
- 3.48. Zakrzewski, A. M., & Anthony, B. W. (2018). Pre-and-Post Exercise Blood Pressure Estimation from Force-Measured Ultrasound: First Results. Presented at the 2018 40th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), Honolulu, HI.
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- 3.50. Chen, M., Li, Q., Karimian, N., Yeh, H., Duan, Y., Fontan, F., ... Samir, A. E. (2018). Contrast-Enhanced Ultrasound to Quantify Perfusion in a Machine-Perfused Pig Liver. Presented at the 2018 40th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), Honolulu, HI.

- 3.51. Wang, Y. J., & Anthony, B. W. (2018). Characterization of wave fields using transient motion of microspheres under acoustic radiation force. Presented at the 21st International Symposium on Nonlinear Acoustics, Santa Fe, NM.
- 3.52. Yang, H., Carrascal, C., Xie, H., Shamdasani, V., Anthony, B.W., “Design and Experimental Validation of Miniature External Mechanical Vibrators towards Clinical Ultrasound Shear Wave Elastography”, IUS, 2018.
- 3.53. Singh, Robin; Ma, Danhao; Kimerling, Lionel; Agarwal, Anuradha; Anthony, Brian, “Microscale photoacoustic spectroscopy using integrated photonics for lab-on-chip applications”, Spie BIOS, (accepted), 2018.
- 3.54. J. B. Frontin and B. W. Anthony, “Quantifying Dermatology: Method and Device for User-Independent Ultrasound Measurement of Skin Thickness,” in 2019 41st Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), 2019, pp. 5743–5748.
- 3.55. A. Benjamin et al., “Renal volume reconstruction using free-hand ultrasound scans,” J. Acoust. Soc. Am., vol. 145, no. 3, pp. 1922–1922, Mar. 2019.
- 3.56. A. Y. Huang and B. W. Anthony, “An Instrumented Ultrasound Probe for Shear Wave Elastography With Uneven Force Distribution,” in 2019 41st Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), 2019, pp. 6208–6211.
- 3.57. Feigin M, Zwecker M, Freedman D, Anthony BW. Detecting muscle activation using ultrasound speed of sound inversion with deep learning. Proc Annu Int Conf IEEE Eng Med Biol Soc EMBS. 2020 Oct 20;2020-July:2092–5.
- 3.58. Li Y, Kim DD, Anthony B. HapticWall - An Ecountered-type Two-Dimensional Vertical System for Virtual Reality. Dyn Syst Control Conf. 2020;1–9.
- 3.59. Feigin M, Zwecker M, Freedman D, Anthony BW. Detecting muscle activation using ultrasound speed of sound inversion with deep learning. In: 2020 42nd Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC). IEEE; 2020. p. 2092–5.
- 3.60. Feigin M, Makovsky Y, Freedman D, Anthony BW. High-frequency full-waveform inversion with deep learning for seismic and medical ultrasound imaging. In: SEG Technical Program Expanded Abstracts 2020. Society of Exploration Geophysicists; 2020. p. 3492–6.
- 3.61. Singh R, Agarwal A, Anthony BW. Ultra-high sensitive all-optical photoacoustic transducers. In: Oraevsky AA, Wang L V., editors. Photons Plus Ultrasound: Imaging and Sensing 2020. SPIE; 2020. p. 35.
- 3.62. Singh R, Agarwal A, Anthony BW. Leveraging Integrated Photonics for Ultrasound Sensing Applications. In: Imaging and Applied Optics Congress. Washington, D.C.: OSA; 2020. p. JW5A.7.
- 3.63. Singh R, Su P, Agarwal A, Anthony BW. Integrated Mid-IR Photonics for Gas and Aerosol Sensors. In: Imaging and Applied Optics Congress. Washington, D.C.: OSA; 2020. p. JW5C.7.
- 3.64. Ely G, Fincke J, Zhang X, Anthony BW. Optimizing Transducer Acquisition Scheme for Rapid Ultrasound Tomography of Limbs. In: 2020 IEEE International Ultrasonics Symposium (IUS). IEEE; 2020. p. 1–4.
- 3.65. Cuiffi JD, Wang H, Heim J, Anthony BW, Kim S, Kim DD. Factory 4.0 Toolkit for Smart Manufacturing Training. In: 2021 ASEE Virtual Annual Conference Content Access. 2021.
- 3.66. Hahm KS, Chase AS, Dwyer B, Anthony BW. Indoor Human Localization and Gait Analysis using Machine Learning for In-home Health Monitoring. In: 2021 43rd Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC). IEEE; 2021. p. 6859–62
- 3.67. Hong MS. Teaching Process Data Analytics and Machine Learning at MIT. Chem Eng Educ. 2022;56(4).
- 3.68. Ranger B, Hira A, Smith B, Zhang X, Anthony B. Work in progress: cost-effective table-top ultrasound systems as platform for biomedical engineering education. In: 2022 ASEE Annual Conference & Exposition. 2022.

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	

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

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

Theses Supervised by Brian W. Anthony

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

Theses Supervised by Brian W. Anthony

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

Doctoral Theses, Reader

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

Postdoctoral Associates and Fellows Supervised by Brian W. Anthony

Current Postdocs

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

Previous Postdocs

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

APPENDIX B (LIST OF MATERIALS CONSIDERED)

Exhibit No.	DESCRIPTION
1001	U.S. Patent No. 10,874,304 (“’304”)
1002	File History of U.S. Application No. 16/669,794 (“’304FH”)
1004	Declaration of Brian Anthony in Support of Petition for <i>Inter Partes</i> 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.”)
1007	<i>Apple Inc. v. Omni Medsci, Inc.</i> , No. IPR2019-00916, Paper 16 (P.T.A.B. Oct. 18, 2019) (“’533-Inst.”)
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. 2021-1229, 2022 WL 2062168 (Fed. Cir. June 8, 2022)
1010	Declaration of Brian Anthony in Support of Petition for <i>Inter Partes</i> 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.”)
1014	<i>Apple Inc. v. Omni Medsci, Inc.</i> , No. IPR2021-00453, Paper 11 (P.T.A.B. Feb. 4, 2022) (“’484-Pet.-Reply”)
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”)
1017	<i>Apple Inc. v. Omni MedSci, Inc.</i> , No. 2023-1034, 2024 WL 3084509 (Fed. Cir. June 21, 2024), ECF No. 44
1018	<i>Omni MedSci, Inc. v. Apple Inc.</i> , 2:18-cv-00134-RWS, Dkt. No. 211 (E.D. Tex. June 24, 2019) (“CC Order”)
1019	<i>Omni MedSci, Inc. v. Apple Inc.</i> , 2:18-cv-00429-RWS, Dkt. No. 152 (E.D. Tex. Aug. 14, 2019)

Exhibit No.	DESCRIPTION
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. 2010/0217102A1 ("LeBoeuf")
1027	U.S. Patent No. 8,108,036 ("Tran")
1028	U.S. Patent Pub. No. 2005/0049468A1 ("Carlson")
1029	U.S. Patent Pub. No. 7,139,076 ("Marbach")
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, <i>Light-Emitting Diodes</i> (Cambridge Univ. Press, 2nd ed. reprinted 2014)
1038	"The Biomedical Engineering Handbook," by Joseph D. Bronzino (1995)
1039	U.S. Patent No. 8,079,735 ("Vakil")
1041	U.S. Patent Pub. No. 2012/0197093 A1 ("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")

Exhibit No.	DESCRIPTION
1046	U.S. Patent No. 6,662,033 (“Casciani”)
1048	U.S. Pat. No. 9,239,951 (“Hoffberg”)
1049	U.S. Pat. Pub. 2007/0194939 (“Alvarez”)
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”)
1062	U.S. Patent No. 6,343,223 (“Chin”)
1063	W.O. Patent Pub. No. 2000/013003 (“Colvin”)
1064	U.S. Patent No. 5,554,273 (“Demmin”)
1065	U.S. Patent No. 5,953,713 (“Behbehani”)
1066	U.S. Patent No. 6,587,704 (“Fine”)
1067	U.S. Patent No. 6,397,092 (“Norris”)
1068	U.S. Patent No. 5,360,004 (“Purdy”)
1077	U.S. Patent Publication No. 2006/0184040 (“Keller”)
1081	US. Patent No. 9,651,533 (“533”)
1082	U.S. Patent No. 10,517,484 (“484”)
1083	Declaration of Brian Anthony in Support of Petition for Inter Partes Review of U.S. Patent No. 9,861,286 submitted in IPR2019-00914, Ex. 1003
1085	<i>Apple Inc. v. Omni Medsci, Inc.</i> , No. IPR2019-00916, Paper 10 (P.T.A.B. July. 22, 2019) (“533-POPR”)

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