

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

EMERSON ELECTRIC CO.

Petitioner,

v.

OLLNOVA TECHNOLOGIES LTD.

Patent Owner.

Case IPR2023-00626

U.S. Patent No. 7,746,887

**DECLARATION OF DEAN P. NEIKIRK IN SUPPORT OF PETITION
FOR *INTER PARTES* REVIEW OF U.S. PATENT NO. 7,746,887**

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I. INTRODUCTION

1. I have been retained by Emerson Electric Co. (“Emerson” or “Petitioner”) to provide my opinions on certain issues related to U.S. Patent No. 7,746,887 (the “’887 patent,” which I understand has been designated as Exhibit 1001) 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, 3-8, 14-15, and 18 of the ’887 patent (“Challenged Claims”) are obvious over the prior art references identified below and as to whether persons interested and ordinarily skilled in the subject matter or art exercising reasonable diligence could have located these references.

2. I understand the ’887 patent is titled “Dynamic Value Reporting for Wireless Automated Systems,” identifies as its named inventor Norman R. McFarland, and is currently owned by Ollnova Technologies Ltd. I have considered the ’887 patent.

3. I understand that the file history of the ’887 patent has been designated as Exhibit 1003. I have considered this file history, and I will refer to it as the “’887 File History” or by its exhibit number.

4. I understand that the ’887 patent was filed as U.S. Patent Application 11/402,743 on April 12, 2006.

5. I have considered the prior art cited in my declaration, including:

1. **U.S. Patent No. 7,528,711** to Kates (“Kates-711”), titled “Portable Monitoring Unit,” filed December 19, 2005 and issued May 5, 2009. I understand that a copy of this patent has been designated as Exhibit 1004.
2. **U.S. Patent Publication No. 2004/0100394** to Hitt (“Hitt”), titled “Distributed Environmental Control in a Wireless Sensor,” filed on October 24, 2003, and published May 27, 2004. I understand that a copy of this publication has been designated as Exhibit 1005.
3. **U.S. Patent Publication No. 2005/0246593** to Littrell (“Littrell”), titled “Methods and Apparatus for Providing Alarm Notification,” filed on April 19, 2004, and published on November 3, 2005. I understand that a copy of this publication has been designated as Exhibit 1006.
4. **U.S. Patent No. 7,102,505** to Kates (“Kates-505”), titled “Wireless Sensor System,” filed May 27, 2004 and issued September 5, 2006. I understand that a copy of this patent has been designated as Exhibit 1022.
5. **U.S. Patent No. 6,513,723** to Mueller (“Mueller”), titled “Method and apparatus for automatically transmitting

temperature information to a thermostat,” filed

September 28, 2000 and issued on February 4, 2003. I

understand that this patent has been designated as Exhibit
1031.

6. I am being compensated by Emerson at my standard hourly consulting rate of \$750 for my time on this matter. My compensation is not dependent on the outcome of this proceeding.

7. As set forth herein, I have concluded that each of Challenged Claims is rendered obvious by the prior art based on the references described below and as explained herein. 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

8. A detailed description of my professional qualifications, including a list of publications, patents, awards, and professional activities, is contained in my curriculum vitae, a copy of which is attached as **Appendix A**.

9. I received a B.S. degree in 1979 in physics from Oklahoma State University, and an M.S. degree and a Ph.D. degree in 1981 and 1984 respectively in applied physics from the California Institute of Technology.

10. Each of my academic degrees involved significant studies in solid state physics, semiconductor devices, electrical engineering, electronic systems, electromagnetics, optics, radio frequency systems, and antennas. For example, courses relating to these fields that I took include two years of study in electromagnetics and optics, one year of study in solid state and semiconductor physics, as well as four years of graduate research in electronic devices, antenna design, antenna fabrication, microwave systems, and optical systems.

11. I am currently a Life Senior Member of the Institute of Electrical and Electronics Engineers (“IEEE”). From March 1991 to October 1994, I served as an Associate Editor for the IEEE publication called “IEEE Transactions on Education.” I also served as a member of the Editorial Board on the IEEE Transactions on Microwave Theory and Techniques in the 1990-2000 timeframe.

12. I have almost 40 years of experience on the faculty of the University of Texas at Austin. My work as a professor began in 1984, when I joined the University of Texas at Austin as an assistant professor. In 1988, I became an associate professor, and became a full professor in 1992.

13. My research over the last forty years has concentrated heavily in the areas of electromagnetics, microwave engineering, microelectronics, semiconductor devices, integrated circuit (IC) fabrication, and new sensors. This research work has been funded by many agencies, focusing on the fabrication and modeling of semiconductor devices, electromagnetic devices and detectors, chemical sensors, temperature sensors, proximity sensors, and pressure sensors, as well as research on the high frequency properties of transmission lines, RF devices, and infrared to terahertz detectors for use in focal plane imaging arrays. My research related to the development of new chemical sensors (an “electronic taste” sensor) was selected for a commercialization venture between The University of Texas and two outside start-up companies.

14. Over the years, I have also taught a variety of electrical engineering courses at the University of Texas. These include Integrated Circuit Fabrication, VLSI Fabrication Techniques, Ultra Large Scale Integrated Circuit Fabrication Techniques, Integrated Circuit Nanomanufacturing Techniques, Electromagnetics in Packaging, Simulation Methods in CAD/VLSI, Micro-Electromechanical Systems,

Electromagnetic Engineering, and Microwave and Radio Frequency Engineering. I have also taught several continuing education courses in these fields.

15. In 1985, I established the Microelectronics Fabrication Teaching Laboratory at The University of Texas at Austin, which continues to this day to provide undergraduate and graduate students with hands-on experience in integrated circuit fabrication. I have taught many courses in integrated-circuit fabrication, microwave devices, integrated circuit packaging, electromagnetics, computer aided design methods for circuit simulation, sensors of all sorts, and micro-electromechanical systems.

16. I conducted research with students and research scientists in the Microelectromagnetics Research Group in the Microelectronics Research Center at The University of Texas at Austin for 37 years. For over ten years, I also served as the Graduate Advisor of the Department of Electrical and Computer Engineering at the University of Texas at Austin, as well as serving for over five years as an Associate Chairman of the Electrical and Computer Engineering Department at The University of Texas at Austin. I also served as Associate Dean of Graduate Studies from 2014 to 2021.

17. Please see my CV, attached hereto as **Appendix A**, for further information.

III. LEGAL UNDERSTANDING

18. In formulating my opinions, I have been informed of certain legal understandings relevant to my opinions. In formulating my opinions, I have relied on the legal understandings I have been provided with as set forth in this declaration.

19. 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

20. I have been informed that patent claims are construed from the viewpoint of a person having 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 having 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).

21. I have further been informed that a person having 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.

22. In interpreting the meaning of the claim language, I understand that a person having 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.

23. I understand that certain claim terms may be interpreted to be “means-plus-function” terms. For these terms, I understand that there must be a

corresponding structure disclosed in the specification in a way that a person of ordinary skill in the art would understand what structure would perform the claimed function. I understand the disclosure may be implicit in the specification if it would have been clear to a person of ordinary skill in the art what structure corresponds to the claimed function. With respect to a computer-implemented function, an algorithm must be disclosed in the specification.

B. My Understanding of Obviousness

24. 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.

25. 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.

26. 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.

27. I have also been advised that in considering whether a claimed invention could be obvious over a combination of prior art references, I may assess whether there are apparent reasons to combine known elements in the prior art in the manner claimed in view of interrelated teachings of multiple prior art references, the effects of demands known to the design community or present in the marketplace, and/or the background knowledge possessed by a person having ordinary skill in the

art. I understand that other principles may be relied on in evaluating whether a claimed invention would have been obvious, and that these principles include the following:

- A combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results;
- When a device or technology is available in one field of endeavor, design incentives and other market forces can prompt variations of it, either in the same field or in a different one, so that if a person having 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 having 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 having ordinary skill will be able to fit the teachings of multiple patents together like pieces of a puzzle;

- A person having ordinary skill in the art is also a person having 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 having 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.

28. I further understand that, in making a determination as to whether the claimed invention would have been obvious to a person having 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.

C. My Understanding of the Doctrine of Equivalents

29. I have been informed that there is a “doctrine of equivalents” in patent law that supports a finding of invalidity if a prior art element is equivalent to a claimed element, even if the prior art element is not identical to the claimed element. Equivalence may be established if the prior art element performs the identical function specified in the claim in substantially the same way and produces substantially the same result.

30. I also understand that insubstantial differences between a prior art element and a claimed element—as understood in light of its specification—will not preclude a finding of invalidity. For example, a difference in a number of parts in a prior art element and the corresponding element disclosed in the patent specification may be an insubstantial difference. Similarly, if a prior art element lacks several components of an overall structure corresponding to a claimed function, that difference may be insubstantial. And, potential advantages of a structure that do not relate to a claimed function should not be considered in an equivalents determination.

31. I understand that the structures, materials, and acts to be considered equivalent or non-equivalent may be described in a patent's specification. A specification may therefore establish a narrow or broad range of equivalents, although an applicant also need not exhaustively describe the full range of equivalents.

IV. BACKGROUND OF THE TECHNOLOGY

32. As discussed in Section V, the purported invention of the '887 patent is a wireless automation device that transmits a sensor reading when a change in a sensed condition is outside a predetermined range. Specifically, claim 1, which is the only independent claim in the '887 Patent, from which each of the other Challenged Claims depends, recites that the wireless automation device includes a "sensor operable to generate a[n] indicator for a sensed condition." "[I]n response to detecting a change in the sensed condition outside of a predetermined range," the wireless automation device utilizes a "transceiver" to "transmit a most recent reading of the indicator stored in memory." If no such change is detected, then "transmission ... is suspended."

33. Based on my experience in the field, however, the functionalities of the '887 patent were well-known in the art prior to the '887 patent's priority date. One example of such prior art is U.S. Patent No. 7,528,711 ("Kates-711"), which identifies Kates as its inventor. I understand that a copy of Kates-711 has been

designated as Exhibit 1004. Kates-711 discloses “a sensor in a ... sensor system for monitoring potentially dangerous or costly conditions ... in a building, or complex.” Kates-711, 1:5-9. The sensor is part of a “sensor system that provides sensor information ... for alerting building or complex management, or other responsible parties, to a potential problem detected by the sensor system.” Kates-711, 1:65-2:2. Such a potential problem occurs when the sensor data is found to be outside a threshold, *e.g.*, “outside an inner range threshold.” Kates-711, 13:19-23. Kates-711 provides that its disclosed sensor system “can operate for an extended period of operability without maintenance or recalibration” by utilizing “an adjustable threshold [that] allows the sensors to adjust to ambient conditions, aging of components, and other operational variations while still providing a relatively sensitive detection capability for hazardous conditions.” Kates-711, 3:62-67.

34. Another relevant prior art reference is U.S. Patent App. No. 2004/0100394, which identifies Hitt as its inventor. I understand that a copy of Hitt has been designated as Exhibit 1005. Hitt discloses a sensor node used to achieve “environmental monitoring and control” where each sensor node includes “a wireless transceiver, a processor, and ... a sensor device.” Hitt, Abstract. As explained in greater detail below in Section IX.B.1, a person having ordinary skill in the art would have been motivated to modify Kates-711 with Hitt’s teachings to advantageously utilize a memory component in a sensor unit to store data

collected by the sensor unit about the sensed condition. Applying Hitt's teachings to Kates-711 yields a system in which recent data about sensed conditions is available in the memory of a sensor unit for further processing and transmission in the environmental monitoring context. None of the features recited in the Challenged Claims of the '887 patent was novel at the time of the alleged invention, and there was nothing novel as to the manner in which the '887 patent combined those features.

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

V. THE '887 PATENT

A. '887 Patent Overview

36. The Challenged Claims are generally directed to a wireless automation device that transmits a sensor reading in response to a sensed condition being outside a predetermined range. '887 patent, Abstract, Claim 1. An embodiment of the wireless automation device described by the Challenged Claims is shown in Figure 2 below (emphasis added):

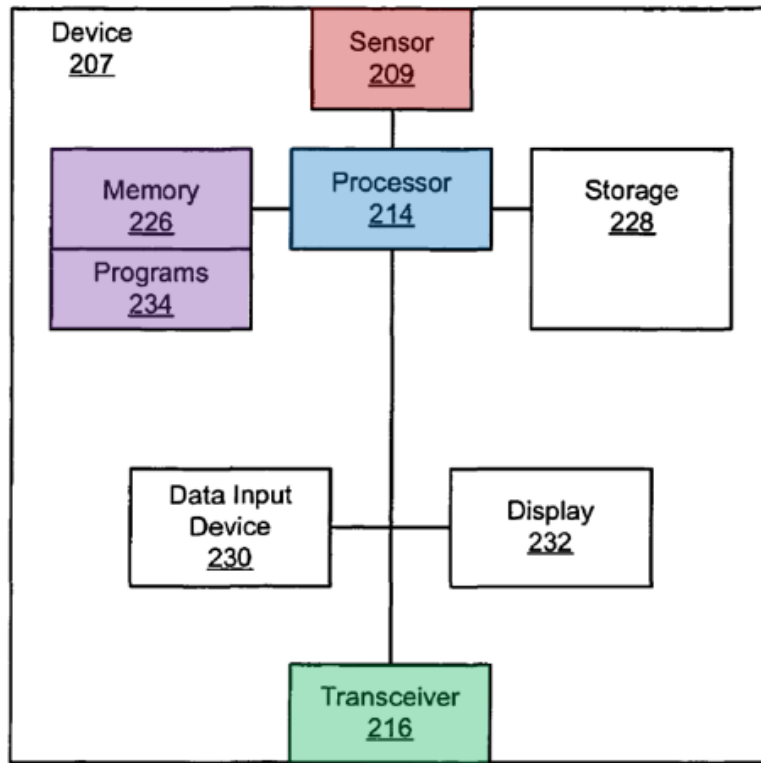


Figure 2

'887 patent, 6:58-65, Fig. 2. As can be seen in the above figure, the wireless automation device comprises several components, including a “**transceiver**,” a “**sensor**,” a “**processor**,” and a “**memory**.” '887, Fig. 2. The **sensor** can include different devices that “sense conditions, parameters, and/or events ... in a building.” '887, 8:46-48. For example, such a sensor may detect the building's temperature, humidity, or both, and can detect other parameters as well. '887, 8:46-65. The sensor then provides the data it has collected about ambient conditions (in the form of sensor readings) to the **processor** for evaluation; these sensor readings can also be stored in the **memory**, which holds a record of prior readings to which

future readings may be compared to detect changes. '887, 7:49-52; 9:51-67, 10:14-16. The **memory** also stores programs that the **processor** executes to process the data it reads from the **sensor**. '887, 7:30-34, 7:65-66, 8:50-51, 9:51-67. Based on this processing, the **processor 214** may determine that the sensed condition has changed such that it is beyond a limit or outside an acceptable range. '887, 7:48-8:56. If the **processor** makes such a determination, it directs the **transceiver 216** to communicate “packets of information” that include, *e.g.*, the triggering event, values or “indicators,” and timing data over a “network.” '887, 10:57-11:44. If, on the other hand, the **processor** determines that the sensed condition does not exceed the threshold or fall outside the permitted range, the processor will not prompt the **transceiver** to communicate with the network. *Id.*

37. The “control algorithm for the system” may dictate adjustments to the limit or range of sensor values against which current sensor data is evaluated to determine whether the **transceiver** should be prompted to transmit information about the sensor value. *Id.*, Abstract, 3:40-44; 12:49-63. Generally, these adjustments are made to ensure the system is not under- or over-sensitive to changes to the sensed conditions. For example, when sensed conditions are observed to not vary much over time, the limit may be reduced or the acceptable range narrowed so smaller changes in the sensed value are detected; on the other hand, when sensed conditions exhibit a large amount of variance, the limit may be increased or the

acceptable range broadened so as to avoid what would otherwise be non-stop notifications. *Id.*, 12:11-13:35.

B. Prosecution History of the '887 Patent

38. 44. In formulating my opinions, I considered the contents of the prosecution history of the '887 patent, a copy of which I understand has been designated as Exhibit 1003. During prosecution, all of the pending claims were rejected by the Examiner as anticipated by U.S. Patent Publication No. 2003/0174070 to Garrod, which I understand has been designated as Ex. 1019. Ex. 1003 ("'877 File History"), 59-71. To overcome this rejection, the Applicant incorporated claim elements from several dependent claims into the independent claims; among the additions were limitations directed to, for example, a memory storing "at least one prior reading of the indicator" and "selectively communicating information ... in response to detecting a change in the sensed condition outside a variable range." '877 File History, 72-83. The Applicant argued that the Garrod reference did not anticipate the claims as modified. *Id.*

39. In the next Office Action, the Examiner maintained most of the previous rejections over Garrod, but indicated dependent claims 7-10, which had not been changed, contained allowable subject matter. '877 File History, 91-103. The Applicant had not previously submitted any arguments defending pending claims 7-10, and the Examiner did not explain why he nonetheless withdrew his previous

anticipation rejection of the claims. The pending claim 7, on which pending claims 8-10 depended, recited “a transmission of the most recent reading of the indicator stored in the memory during a period of the transmission interval is suspended in response to detecting a change in the sensed condition within the predetermined range.” ’877 File History, 74.

40. In response to this office action, the Applicant amended independent claim 1 to incorporate into its final element the aforementioned limitation of pending claim 7 and the limitations of pending claims 4-6. ’877 File History, 116-122. The Applicant canceled all other independent claims and their dependents. *Id.* The Examiner then issued a Notice of Allowance, stating that the Applicant’s addition of the limitation from pending claim 7 was the basis for allowance. ’877 File History, 126-131, 117, 121.

41. I understand that ten years later, the Applicant requested two corrections to the patent: one to amend the word “chance” to “change” in Claim 1, and another one to amend the phrase “information associated reading of the indicator” to “information associated with the reading of the indicator” in Claims 1 and 21. ’877 File History, 153-173. The USPTO granted both requests. ’877 File History, 176.

42. I have been instructed to assume that the word “chance” in the claims has been replaced with the word “change.” I further address the understanding of the second phrase in Section VIII.B below.

VI. THE '887 PATENT PRIORITY DATE

43. I understand the '887 patent was filed on April 12, 2006. I have not formulated any opinion about the correct priority date for the '887 patent. For purposes of this declaration, I was asked to assume, with respect to each of the prior art Grounds discussed in this declaration, that the '887 patent is entitled to the priority date of April 12, 2006. I have been instructed to consider the patent and the prior art from the perspective of a person having ordinary skill in the art as of April 12, 2006.

VII. LEVEL OF ORDINARY SKILL IN THE ART

44. In rendering the opinions set forth in this declaration, I was asked to consider the patent claims and the prior art through the eyes of a person having ordinary skill in the art at the time of the alleged invention. I understand that the factors considered in determining the ordinary level of skill in a field of art include the level of education and experience of persons working in the field; the types of problems encountered in the field, the teachings of the prior art, and the sophistication of the technology at the time of the alleged invention. I understand that a person having ordinary skill in the art is not a specific real individual, but

rather is a hypothetical individual having the qualities reflected by the factors above. I understand that a person having ordinary skill in the art would also have knowledge from the teachings of the prior art, including the art cited below.

45. I have been asked to assume that the '887 patent is entitled to the priority date of April 12, 2006. Upon consideration of these factors, in my opinion, on or before this priority date, a person of ordinary skill in the art, at the time the application that matured into the '887 patent was filed, would have had a minimum of a bachelor's degree in electrical engineering, or a related field, along with at least two years of professional experience in sensors, controls, and/or wireless communications. Additional graduate education could substitute for professional experience, or significant experience in the field could substitute for formal education.

46. I note that in a parallel litigation, PO submitted the declaration of Dr. Erik De La Iglesia, in which he adopted my definition of a person having ordinary skill in the art; I understand this declaration has been designated as Exhibit 1043. Ex. 1043, at 5 ("I have been asked to adopt Dr. Neikirk's proposed standard as to the relevant skill level of a person of ordinary skill in the art.").

47. Well before April 12, 2006, my level of skill in the art was at least that of a person having ordinary skill. I am qualified to opine concerning what a person having ordinary skill in the art would have known and understood at the time of the

'887 patent's purported invention. My analysis and conclusions herein are from the perspective of a person having ordinary skill in the art as of April 12, 2006. Even if that priority date were earlier, however, my opinions would not change as long as the identified prior art were still prior art.

VIII. CLAIM CONSTRUCTION

48. I have been instructed that the Challenged Claims 1, 3-8, 14-15, and 18 of the '887 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 '887 patent.

A. Preambles

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

B. “information associated reading of the indicator” (claim limitation [1.c])

50. I am aware that in the pending Emerson Litigation, the parties dispute whether the phrase “information associated reading of the indicator” requires transmission of (1) the reading of the indicator itself; (2) information associated with the reading of the indicator; or (3) both. Ex. 1009, 2-10; Ex. 1010, 3-8; Ex. 1011, 5-10; Ex. 1012, 4-7. I understand that the parties also dispute whether the issued Certificate of Correction, which requires option (2), is valid. *Id.* For purposes of this declaration, I was instructed to consider whether the prior art meets the claims under each of these three interpretations, and concluded that under any reasonable interpretation, the prior art discloses this limitation because it discloses transmitting both the “reading” and associated “information”—and therefore the Challenged Claims are invalid as obvious over the prior art cited herein, regardless of which of the three options is required. *See* Section IX.A.2(d), IX.D.¹

C. Third-Party Constructions

51. For purposes of this declaration, I was asked to consider several constructions proposed by third-parties and whether they would affect my opinions.

¹ In a related district court litigation, I have opined that the term is indefinite because it is not clear which of these options is required, but regardless of the construction, the prior art discloses each of the three options.

A summary of these constructions that I was instructed to consider are set forth below:

Term	Construction
“wireless automation device” (<i>e.g.</i> , in claim element [1.pre])	Means-plus-function term. ² Function: “to monitor a condition and wirelessly report an event over an automation network in response to detecting a change in the condition” (Ex. 1015, 11-12) Structure: a “general-purpose computer” implementing an algorithm such as, <i>e.g.</i> , the algorithm described in 9:23-11:44 (describing a processor polling a sensor, storing an indicator of a sensed condition in memory, processing the indicator, and controlling a transceiver to communicate information about the sensed condition if, <i>e.g.</i> , the sensed condition has changed beyond a limit or range)

² I understand that the third-party constructions did not identify algorithms for this term (“wireless automation device”) or the other terms identified in this table (“transceiver” and “controller”), and I was instructed to assume that the structures set forth in these constructions are sufficient. I express no opinions on the sufficiency of the corresponding structures.

“transceiver” (<i>e.g.</i>, in claim element [1.a])	Means-plus-function term. Function: “to wirelessly communicate packets of information over a wireless network; to transmit a most recent reading of the indicator stored in the memory during a period of a transmission interval in response to detecting a change in the sensed condition outside a predetermined range; and to suspend transmissions of the most recent reading of the indicator stored in the memory during the period of the transmission interval in response to detecting a change in the sensed condition within the predetermined range” (Ex. 1015, 8-10) Structure: a “general-purpose transceiver” implementing an algorithm such as, <i>e.g.</i>, the algorithm described in 3:16-44 and 10:57-11:12 (describing a transceiver communicating information as packets over a network, the transceiver communicating the information when, <i>e.g.</i>, a change in a sensed condition is beyond a limit or range, and suspending communication of the information when no such change has been identified), the communicated information including a most current indicator associated with the sensed condition, stored in memory, as described in 3:1-15 and 11:45-12:11
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“controller” (<i>e.g.</i>, in claim element [1.c])	Means-plus-function term. Function: “to poll the sensor at a polling interval to read the indicator during a current period of the polling interval, to selectively operate the transceiver to communicate information associated with a reading of the indicator, to store a reading of the indicator during the current period in the memory and reduces the amount of information communicated by the sensor to improve bandwidth” (Ex. 1015, 10-11) Structure: a “generic black box” that “provides general-purpose computing functions” implementing an algorithm such as, <i>e.g.</i>, the algorithm described in 9:23-11:44 (describing a processor polling a sensor, storing an indicator of a sensed condition in memory, processing the indicator, and controlling a transceiver to communicate information about the sensed condition if, <i>e.g.</i>, the sensed condition has changed beyond a limit or range)
“wherein transmission of the most recent reading of the indicator stored in the memory during the period of the transmission interval is suspended in response to detecting a change in the sensed condition within the predetermined range” (<i>e.g.</i>, in claim element [1.e])	“wherein the transmission of the most recent reading of the indicator that would otherwise occur is stopped in response to detecting a change in the sensed condition within the predetermined range” (Ex. 1023, 17-18)

52. I have not adopted any of these third-party constructions as my own, and I express no opinions as to whether any of these constructions should be adopted.

Nonetheless, as set forth below in Section IX, each of these elements is disclosed by the prior art cited herein even under these third-party constructions.

IX. GROUNDS OF UNPATENTABILITY

53. As I explained above in Section IV, the methods for wirelessly reporting sensed conditions claimed in the Challenged Claims were well-known in the art.

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

Name	US Patent/ Publication	Ex.	Priority Date	Filing Date	Published/ Issued
Kates-711	U.S. 7,528,711	1004	12/19/2005	12/19/2005	5/5/2009
Hitt	U.S. 2004/0100394	1005	10/28/2002	10/24/2003	5/27/2004
Littrell	U.S. 2005/0246593	1006	4/19/2004	4/19/2004	11/3/2005
Kates-505	U.S. 7,102,505	1022	5/27/2004	5/27/2004	9/5/2006
Mueller	U.S. 6,513,723	1031	9/28/2000	9/28/2000	2/4/2003

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

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

- a. **Ground 1:** Challenged Claims 1, 3-8, and 18 of the '887 patent are rendered obvious by Kates-711;

- b. **Ground 2:** Challenged Claims 1, 3-8, and 18 of the '887 patent are rendered obvious by Kates-711 in view of Hitt;
- c. **Ground 3:** Challenged Claims 1, 3-8, 14-15, and 18 of the '887 patent are rendered obvious by Kates-711 in view of Littrell;
- d. **Ground 4:** Challenged Claims 1, 3-8, 14-15, and 18 of the '887 patent are rendered obvious by Kates-711 in view of Hitt and Littrell;
- e. **Ground 5:** Challenged Claims 1, 3-8, and 18 of the '887 patent are rendered obvious by Kates-505;
- f. **Ground 6:** Challenged Claims 1, 3-8, and 18 of the '887 patent are rendered obvious by Kates-505 in view of Hitt;
- g. **Ground 7:** Challenged Claims 1, 3-8, 14-15, and 18 of the '887 patent are rendered obvious by Kates-505 in view of Littrell.
- h. **Ground 8:** Challenged Claims 1, 3-8, 14-15, and 18 of the '887 patent are rendered obvious by Kates-505 in view of Hitt and Littrell.
- i. **Ground 9:** Challenged Claims 1, 3-8, and 18 of the '887 patent are rendered obvious by Kates-505 in view of Mueller.

- j. **Ground 10:** Challenged Claims 1, 3-8, and 18 of the '887 patent are rendered obvious by Kates-505 in view of Mueller and Hitt.
- k. **Ground 11:** Challenged Claims 1, 3-8, 14-15, and 18 of the '887 patent are rendered obvious by Kates-505 in view of Mueller and Littrell.
- l. **Ground 12:** Challenged Claims 1, 3-8, 14-15, and 18 of the '887 patent are rendered obvious by Kates-505 in view of Mueller, Hitt, and Littrell.

56. In summary, for **Ground 1**, Kates-711 teaches a sensor system in a building that includes wireless automation devices; the use of memory on such a device would have been obvious. In **Ground 2**, in order to explicitly address the use of memory in a device as required in the Challenged Claims, Hitt affirmatively discloses such memory. For **Grounds 3-4**, I have cited Littrell primarily because the reference provides additional detailed teachings of implementing a band limit threshold and time stamping sensor data. With respect to grounds **Grounds 5-8**, I was asked to consider whether my opinions would have changed to the extent I relied on Kates-505 instead of Kates-711. As set forth in these Grounds 5-8, which otherwise mirror Grounds 1-4, my opinions would not have changed because these two references share the same core critical disclosures. For **Grounds 9-12**, I have

cited Mueller for its disclosures of selectively transmitting a sensor reading when it has changed more than an acceptable amount from a previously sensed reading.

57. It is my opinion that Challenged Claims 1, 3-8, 14-15, and 18 of the '887 patent are unpatentable as explained below. 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 elements of all Challenged Claims containing identical or substantially identical language.

A. Ground 1: Kates-711 (Claims 1, 3-8, and 18)

1. U.S. 7,528,711 (“Kates-711”) Overview

58. Kates-711 discloses “a sensor in a ... wireless sensor system for monitoring potentially dangerous or costly conditions such as... temperature, water, gas and the like ... in a building.” Kates-711, 1:6-11. If the sensor collects information indicative of “a potential problem,” the sensor system detects this and “provides [the] sensor information” to “alert[] building or complex management, or other responsible parties.” Kates-711, 1:65-2:2. In determining which sensed conditions are “anomalous,” the sensors compare the measured sensor value to “an adjustable threshold value.” Kates-711, 3:62-67. The adjustable nature of the threshold allows the sensors to remain sensitive to “hazardous conditions” while accounting for “ambient conditions, aging of components, and other operational variations” and remain “operable for ... extended period[s] ... without maintenance

or recalibration.” *Id.* For example, the threshold can be adjusted to be equal to the average value of sensor readings over a period of time immediately preceding the current measurement. Kates-711, 4:17-34. Upon detection of an anomalous condition by one or more of the sensor units, “the sensor unit communicates with [a] base unit and provides data regarding the anomalous condition;” subsequently, the “base unit ... contact[s] a supervisor or other responsible person.” Kates-711, 4:6-12. *See also* Kates-711, 4:17-6:19. The sensor unit is normally placed in “low-power mode,” during which it “conserves power by not transmitting data that falls within a normal range;” “[i]f an anomalous condition is detected, then the sensor unit ‘wakes up’ and begins communicating with the base unit.” Kates-711, 4:55-64, 13:14-16.

59. Figure 2 below (emphasis added) provides an embodiment of sensor unit 102.

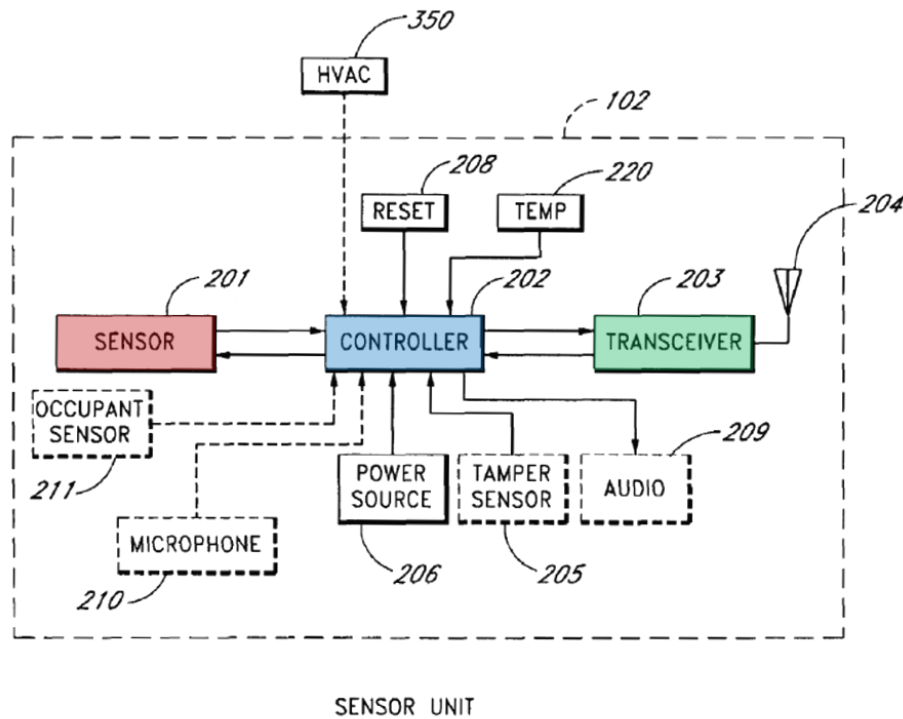


FIG. 2

As shown, sensor unit 102 includes one or more **sensors 201**, **controller 202**, and **transceiver 203**. Kates-711, 12:47-49. **Sensors 201** may be, e.g., a smoke sensor, thermistor, and/or humidity sensor for sensing environmental conditions in a building monitored by the sensor system; the **sensors** transmit the data they collect to **controller 202**. Kates-711, 12:47-13:9. **Controller 202** determines whether to provide the base unit with the sensor data by evaluating the sensor data relative to the adjustable threshold values. Kates-711, 13:9-28. If the sensor data is deemed anomalous (i.e., it falls outside the threshold), “**controller 202** powers up the

transceiver 203” to transmit the “abnormal” sensor data or in response to other commands. Kates-711, 12:47-13:28; 15:10-16:7.

60. Kates-711 provides several examples of threshold values, including both absolute thresholds (*e.g.*, a “high threshold” not to be exceeded or a “low threshold” below which a sensed value should not go) and ranges (*e.g.*, an “inner range threshold” that the sensed value should remain within or an “outer range threshold” that the sensed value should stay outside of). Kates-711, 13:16-23. These threshold values may be dynamically adjusted based on calculations for which the sensed condition is an input; such calculations may include an average, a long-term average, and/or a time-weighted average of sensor measurements. Kates-711, 19:64-20:11.

61. Kates-711 affirmatively discloses and renders obvious that its disclosed sensor unit includes memory to store instructions for the controller and prior sensor values collected by the sensor. For example, Kates-711 teaches that the sensor device performs time weighting of past measurements to dynamically update its threshold values; this not only renders obvious but affirmatively discloses that the past sensed values are stored somewhere in the sensor unit, and a person having ordinary skill in the art would have understood the data to be stored in memory. Kates-711, 4:59-64, 8:43-63, 20:1-6.

62. Moreover, Kates-711 states that the sensor unit is “programmed” to perform sensor measurements—this not only renders obvious, but affirmatively discloses storing such programmed instructions within the sensor unit, and a person having ordinary skill in the art would have understood the program to be stored in memory. Kates-711, 4:59-64, 8:43-63. As further evidence that this would have been obvious to a person of ordinary skill in the art based on Kates-711 alone, Barbacci also discloses that a conventional processor fetches, decodes, and executes instructions stored in memory. Ex. 1046, 2.

63. Kates-711 also teaches implementing its controller using a Field Programmable Gate Array (FPGA) from Xilinx Corp. as the controller. Kates-711, 12:61-66. Xilinx FPGAs were well known by persons of ordinary skill in the art to include and/or use memory. For example, Xilinx filed applications that matured into U.S. Patent No. 7,268,581, which names Trimberger as its first inventor, and U.S. Patent No. 7,254,691, which names Ebeling as its first inventor, that describe the memory components contained in their FPGAs; I understand that the patents have been designated as Exs. 1041 and 1042, respectively. Trimberger discloses that the “general layout of an FPGA” includes “well-known” “block RAMs (BRAMs)” that contain “one or more configurable elements ... that configure [the] FPGA to implement a desired function.” Ex. 1041, 4:9-44. Ebeling describes an FPGA as including “an array of programmable tiles” that include “dedicated random access

memory blocks (BRAMs).” Ex. 1042, 1:9-22. Ebeling further describes that an FPGA may receive “an incoming ... data stream, which may include control information and data” which can be written to and read from BRAMs in the FPGA’s programmable circuitry. Ex. 1042, 1:66-2:14. Taken together, these teachings reflect the well-known understandings of a person having ordinary skill in the art that using a Xilinx FPGA, as in Kates-711, discloses a sensor unit containing a memory component.

64. This understanding that Kates-711’s processor would have at least rendered obvious the use of memory is further confirmed by several other references teaching that similar processors use memory. For example, Littrell discloses storing parameters in a buffer, which is a memory (Littrell, [0006]-[0008], [0030], [0033], [0035]); Ehlers discloses storing a history file, which includes a predetermined number of readings, in memory (Ex. 1007, 8:28-34, 17:41-18:36; Cunningham discloses maintaining current sensor information, as well as a recent history of the same, in the memory of a data collection module (Ex. 1018, 31:59-33:3); Garrod discloses storing “at least” the most recent information from monitored instruments (Ex. 1019, [0029]); and Lareau discloses storing sensor data, including previous readings, in memory (Ex. 1020, [0076]-[0077]).

65. While Kates-711 discloses the features discussed throughout this section as being present in certain “embodiments” of its disclosure, a person having

ordinary skill in the art would have understood, based on these disclosures, that these features comprise optional features that may be combined and included with one another when implementing the disclosed method. Kates-711, 27:57-28:12. At minimum, a person having ordinary skill in the art would have found it obvious to combine such non-mutually-exclusive features to advantageously obtain all of their individual benefits when the disclosures do not provide any reason that such features may not be used in conjunction with one another.

2. Invalidity of Claims 1, 3-8, and 18 Over Kates-711

(a) Element [1.pre]

66. **Element [1.pre]** recites “**A wireless automation device, comprising.**” This element is met by Kates-711.

67. **Kates-711 discloses a wireless automation device** (*e.g.*, a “wireless sensor unit[]” that automatically detects and communicates “anomalous condition[s]”). *See, e.g.*, Kates-711 (emphasis added):

- **Fig. 2:**

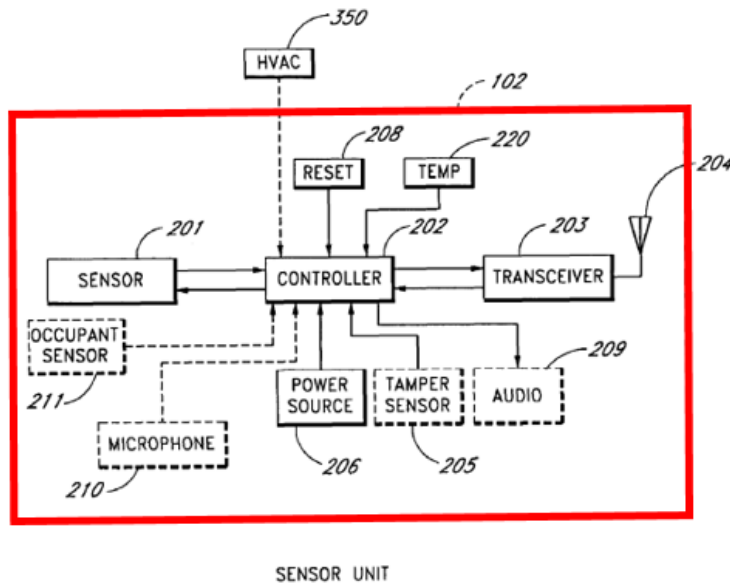


FIG. 2

- **4:35-42** (“In one embodiment, the sensor system includes a number of sensor units located throughout a building that sense conditions and report anomalous results back to a central reporting station. The sensor units measure conditions that might indicate a fire, water leak, etc. The sensor units report the measured data to the base unit whenever the sensor unit determines that the measured data is sufficiently anomalous to be reported.”)
- **5:30-33** (“During normal operation, the repeater only communicates with designated wireless sensor units whose IDs appear in the repeater's database.”)

- **6:6-19** (“In one embodiment, the base unit maintains a database of the health, battery status, signal strength, and current operating status of all of the sensor units and repeater units in the wireless sensor system. In one embodiment, the base unit automatically performs routine maintenance by sending commands to each sensor to run a self-diagnostic and report the results. The base unit collects such diagnostic results. In one embodiment, the base unit sends instructions to each sensor telling the sensor how long to wait between “wakeup” intervals. In one embodiment, the base unit schedules different wakeup intervals to different sensors based on the sensor's health, battery health, location, etc. In one embodiment, the base unit sends instructions to repeaters to route sensor information around a failed repeater.”)
- **7:45-48** (“When the sensor unit 102 detects an anomalous condition (e.g., smoke, fire, water, etc.) the sensor unit communicates with the appropriate repeater unit 110 and provides data regarding the anomalous condition.”)
- **12:47-51** (“FIG. 2 is a block diagram of the sensor unit 102. In the sensor unit 102, one or more sensors 201 and a transceiver 203 are provided to a controller 202. The controller 202 typically provides power, data, and control information to the sensor(s) 201 and the transceiver 202.”)

- **16:56-17:2** (“In one embodiment, a remote shutoff valve 810 is provided, so that the monitoring system 100 can shutoff the water supply to the water heater when a leak is detected. In one embodiment, the shutoff valve is controlled by the sensor unit 102. In one embodiment, the sensor unit 102 receives instructions from the base unit 112 to shut off the water supply to the heater 801. ... Similarly, in one embodiment, the sensor unit 102 controls a gas shutoff valve 811 to shut off the gas supply to the water heater 801 and/or to a furnace (not shown) when dangerous conditions (such as, for example, gas leaks, carbon monoxide, etc.) are detected.”)
- **See also Abstract, 7:45-8:42, 11:7-10, 13:8-28, 15:45-16:35, 18:37-59, 19:35-21:36.**

68. Kates-711 discloses a wireless “sensor unit” that detects and communicates data about anomalous conditions. Kates-711, 5:30-33, 7:45-48, 12:47-51. This “sensor unit” is an automation device because it automatically, e.g., senses, detects, and communicates an “anomalous” environmental conditions as part of a larger system for process control to detect potentially dangerous building conditions. Kates-711, 1:6-11, 1:4:35-48, 1:65-2:2, 7:45-48, 16:36-17:44. These acts by the sensor unit are not described as requiring a prompt from another entity, and so would be considered automated. But even if “automation device” must control another system or function to meet the claim limitation, Kates-711 teaches

an embodiment of the sensor unit in which it “controls a gas shutoff valve 811 to shut off the gas supply to the water heater 801 and/or to a furnace ... when dangerous conditions (such as ... gas leaks, carbon monoxide, etc.) are detected.” Kates-711, 16:56-17:2.

69. Based on a construction proposed by a third party (Ex. 1015, 11-12), which I have not adopted as my own, I have been asked to consider whether this term would be met if it was considered to be a means-plus-function limitation, in which the function includes monitoring a condition and wirelessly reporting an event over an automation network in response to detecting a change in the condition, and the corresponding structure includes, e.g., a computer performing algorithms disclosed in the '887 patent's specification for performing this function. '887, 7:48-63 (“processor 214 implements a control process for the device 207.... processor 214 implements a control process algorithm specific to the sensor 209”), 9:23-11:44 (“processor 214 polls the sensor 209,” “signal $V(t)$ representing the sensed condition may be generated,” “[t]he indicator may be stored in memory,” “[t]he value V_t is processed by the processor 214 ... to identify whether the sensed condition has changed,” and “processor 214 controls the transceiver 216 to selectively communicate information,” for example when “a change in the sensed condition beyond a limit” is detected). Even under such a construction, this limitation would be met by Kates-711. A person having ordinary skill in the art would have

understood Kates-711 to disclose, literally and under the doctrine of equivalents, a processor that meets this claim element; for example, Kates-711 discloses a “programmable microcontroller” that communicates with both a transceiver and a sensor (*see* my discussion for element [1.c]) that performs the claimed function (*see* my discussion of elements [1.a]-[1.e]), in substantially the same way to achieve the same result, since both the Kates-711 apparatus and the claimed invention of the ’887 patent use a sensor component to sense conditions, which upon determining that a sensed condition has changed such that it is outside a threshold, results in the sensed condition’s selective transmission (*see* my discussion of elements [1.a]-[1.c], [1.e]).

(b) Element [1.a]

70. **Element [1.a] recites “a transceiver operable to wirelessly communicate packets of information over a wireless network.”** This element is met by Kates-711.

71. **Kates-711 discloses a transceiver (*e.g.*, “transceiver”) operable to wirelessly communicate packets of information over a wireless network (*e.g.*, sensors communicate “outgoing communication packets” and “receiv[e] wireless data” using “network communication packet[s]”).** *See, e.g.*, Kates-711 (emphasis added):

- **Fig. 2:**

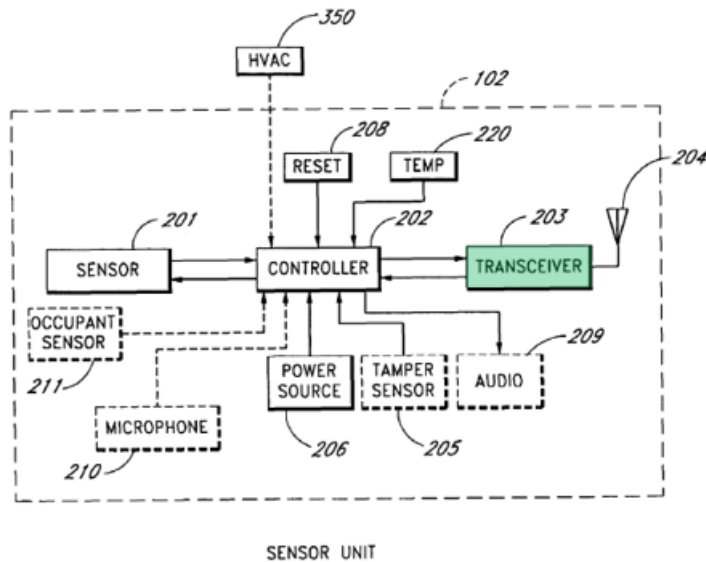


FIG. 2

- **Fig. 5:**

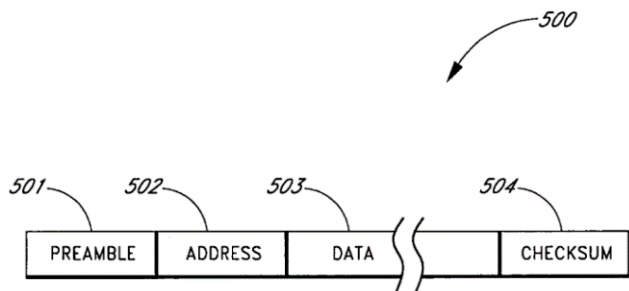


FIG. 5

- **5:21-25** (“In one embodiment, each sensor unit has an Identification code (ID) and the sensor units attaches its ID to outgoing communication packets.”)

In one embodiment, when receiving wireless data, each sensor unit ignores data that is addressed to other sensor units.”)

- **6:29-30** (“FIG. 5 shows a network communication packet used by the sensor units, repeater units, base unit, and PMU.”)
- **11:30-34** (“the sensor units 102-106 and/or the repeater units 110-111 measure the signal strength of the wireless signals received (e.g., the sensor unit 102 measures the signal strength of the signals received from the repeater unit 110...”)
- **12:26-30** (“In one embodiment, the sensor units communicate with the repeater units, base 112, or PMU 125 on the 900 MHz band. This band provides good transmission through walls and other obstacles normally found in and around a building structure.”)
- **12:47-51** (“FIG. 2 is a block diagram of the sensor unit 102. In the sensor unit 102, one or more sensors 201 and a transceiver 203 are provided to a controller 202. The controller 202 typically provides power, data, and control information to the sensor(s) 201 and the transceiver 202.”)
- **See also 13:58-61, 14:15-24, Figs. 1, 3.**

72. Kates-711 discloses that its sensor unit includes a “transceiver” that wirelessly communicates “outgoing” “network communication packets” that contain

“data” over a wireless network to “the repeater units, base 112, or PMU 125.” Kates-711, 12:47-51, 5:21-25, 6:29-30.

73. Based on a construction by a third party (Ex. 1015, 8-10), which I have not adopted as my own, I have also been asked to consider whether this element would have been met under a means-plus function construction in which the function is “wirelessly communicat[ing] packets of information over a wireless network and configured to transmit a most recent reading of the indicator,” and the corresponding structure includes a transceiver. A person having ordinary skill in the art would have understood Kates-711 also to disclose, literally and under the doctrine of equivalents, a transceiver, under this construction for similar reasons. Kates-711 discloses a transceiver that has control information that it uses to selectively communicate sensor data with a network system in response to detecting that the sensor data falls outside a threshold, as I explain in more detail in my discussion of element [1.e]. I conclude that a person having ordinary skill in the art would have understood Kates-711’s disclosures of its transceiver to disclose substantially the same function as the transceiver in the ’887 patent; namely, wirelessly communicating information over a wireless network where the transmitted information is a most recent reading of the indicator of a sensed condition. *See also* [1.pre], [1.e]. A person having ordinary skill in the art would have understood Kates-711 to perform this function in substantially the same way as the ’887 patent, since

both utilize a wireless transceiver (*see* [1.a]), and to achieve the same result, since both selectively communicate information about a sensed condition based on an evaluation of the condition's significance (*see also* [1.e]).

(c) Element [1.b]

74. **Element [1.b] recites “a sensor operable to generate a indicator for a sensed condition.”** This element is met by Kates-711.

75. **Kates-711 discloses a sensor (e.g., “sensor 201”) operable to generate a indicator (e.g., generate “sensor data” including a sensor “reading”) for a sensed condition (e.g., “measur[ing]” “smoke,” “humidity,” and “temperature”).** *See, e.g.,* Kates-711 (emphasis added):

- **Fig. 2:**

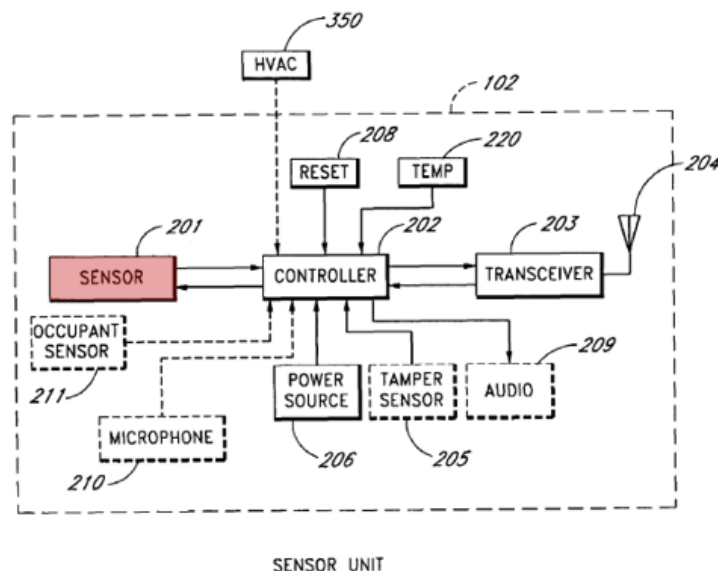


FIG. 2

- **7:13-23** (“The sensor units 102-106 include sensors to measure conditions, such as, for example, smoke, temperature..., humidity, carbon monoxide..., etc. Different sensor units can be configured with different sensors or with combinations of sensors. Thus, for example, in one installation the sensor units 102 and 104 could be configured with smoke and/or temperature sensors while the sensor unit 103 could be configured with a humidity sensor.”)
- **12:47-51** (“FIG. 2 is a block diagram of the sensor unit 102. In the sensor unit 102, one or more sensors 201 and a transceiver 203 are provided to a controller 202. The controller 202 typically provides power, data, and control information to the sensor(s) 201 and the transceiver 202.”)
- **12:66-13:9** (“In one embodiment, the sensor 201 includes an optoelectric smoke sensor with a smoke chamber. In one embodiment, the sensor 201 includes a thermistor. In one embodiment, the sensor 201 includes a humidity sensor. In one embodiment, the sensor 201 includes a sensor, such as, for example, a water level sensor, a water temperature sensor, a carbon monoxide sensor, a moisture sensor, a water flow sensor, natural gas sensor, propane sensor, etc. [¶] The controller 202 receives sensor data from the sensor(s) 201.”)

- **13:7-23** (“The controller 202 receives sensor data from the sensor(s) 201.

Some sensor(s) 201 produce digital data. However, for many types of sensors 201, the sensor data is analog data. Analog sensor data is converted to digital format by the controller 202. In one embodiment, the controller evaluates the data received from the sensor(s) 201 and determines whether the data is to be transmitted to the base unit 112. The sensor unit 102 generally conserves power by not transmitting data that falls within a normal range. In one embodiment, the controller 202 evaluates the sensor data by comparing the data value to a threshold value (e.g., a high threshold, a low threshold, or a high-low threshold). If the data is outside the threshold (e.g., above a high threshold, below a low threshold, outside an inner range threshold, or inside an outer range threshold), then the data is deemed to be anomalous and is transmitted to the base unit 112.”)

- **15:50-16:7** (“FIG. 7 is a flowchart showing one embodiment of operation of the sensor unit 102 wherein periodic monitoring is provided. In FIG. 7, a power up block 701 is followed by an initialization block 702. After initialization, the sensor unit 102 enters a low-power sleep mode.... If no fault occurs during the sleep period, then when the specified sleep period has expired, the process enters a block 706 where the sensor unit 102 takes a sensor reading from the sensor(s) 201. The sensor data is subsequently sent

to the monitoring computer 113 in a report block 707. After reporting, the sensor unit 102 enters a listen block 708 where the sensor unit 102 listens for a relatively short period of time for instructions from monitoring computer 708. If an instruction is received, then the sensor unit 102 performs the instructions, otherwise, the process returns to the sleep block 703. In one embodiment, the sensor 201 and transceiver 203 are normally powered down. The controller 202 powers up the sensor 201 during execution of the block 706. The controller 202 powers up the transceiver during execution of the blocks 705, 707, and 708. The monitoring computer 113 can send instructions to the sensor unit 102 to change the sleep period used in block 703, the listen period used in block 708, etc.”)

- **21:1-5** (“sensor unit 102 obtains a number of sensor data readings from the sensor 201”)
- **See also 4:35-53, 7:60-8:5, 10:61-63, 13:8-14, 16:31-32, 17:42-19:14, 19:46-53, 20:1-49, 21:1-16.**

76. Kates-711 discloses that the sensor unit includes a “sensor 201,” which generates sensor data including a sensor “reading.” Kates-711, 15:50-16:7 21:1-5. Kates-711 specifies that the sensors included in the sensor unit can “measure” a range of conditions, including “smoke, temperature ..., humidity, carbon monoxide ... etc.” Kates-711, 7:13-23. The sensor unit “obtains a number of sensor data

readings” from its sensor(s), which are indicators of the conditions sensed by the sensor. Kates-711, 15:50-16:7 21:1-5.

(d) Element [1.c]

77. **Element [1.c] recites “a controller configured to poll the sensor at a polling interval to read the indicator during a current period of the polling interval and to selectively operate the transceiver to communicate information associated with the reading of the indicator.”** This element is met by Kates-711.

78. **Kates-711 discloses a controller (e.g., “controller”) configured to poll the sensor at a polling interval to read the indicator during a current period of the polling interval (e.g., “powers up the sensor” during “periodic monitoring” and “takes a sensor reading from the sensor(s)”) and to selectively operate the transceiver to communicate information associated reading of the indicator (e.g., “powers up the transceiver” to transmit “sensor data” and “an Identification code (ID)”).** *See, e.g.,* Kates-711 (emphasis added):

• Fig. 2:

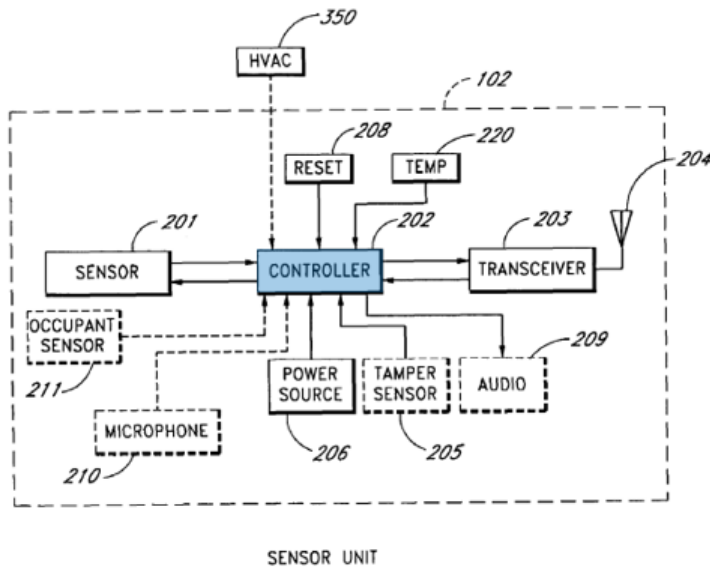


FIG. 2

• Fig. 7:

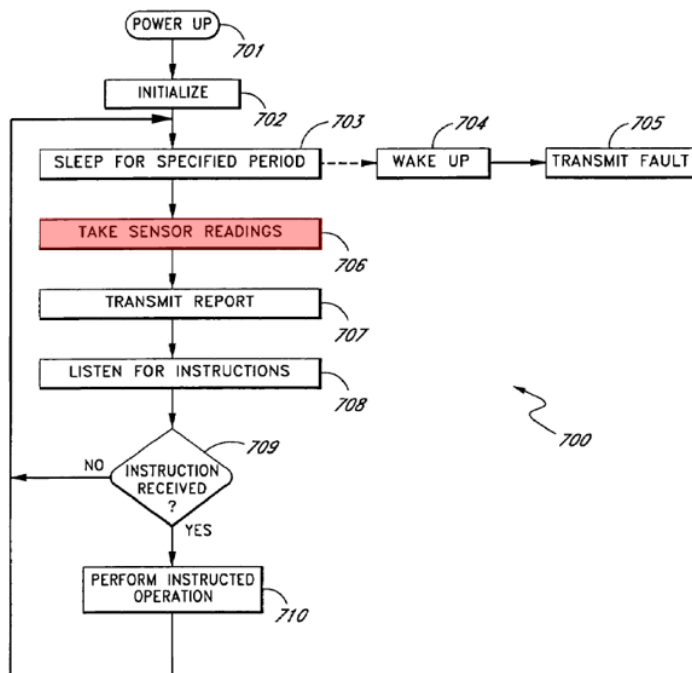


FIG. 7

- **5:18-23** (“In one embodiment, the sensor units use spread-spectrum techniques to communicate with the base unit and/or the repeater units. In one embodiment, the sensor units use frequency-hopping spread-spectrum. In one embodiment, each sensor unit has an Identification code (ID) and the sensor units attaches its ID to outgoing communication packets.”)
- **12:47-51** (“FIG. 2 is a block diagram of the sensor unit 102. In the sensor unit 102, one or more sensors 201 and a transceiver 201 are provided to a controller 202. The controller 202 typically provides power, data, and control information to the sensor(s) 201 and the transceiver 202.”)
- **12:62-66** (“In one embodiment, the controller 202 is a conventional programmable microcontroller. In one embodiment, the controller 202 is based on a Field Programmable Gate Array (FPGA), such as, for example, provided by Xilinx Corp.”)
- **13:7-23** (“The controller 202 receives sensor data from the sensor(s) 201. Some sensor(s) 201 produce digital data. However, for many types of sensors 201, the sensor data is analog data. Analog sensor data is converted to digital format by the controller 202. In one embodiment, the controller evaluates the data received from the sensor(s) 201 and determines whether the data is to be transmitted to the base unit 112. The sensor unit 102 generally conserves power by not transmitting data that falls within a normal

range. In one embodiment, the controller 202 evaluates the sensor data by comparing the data value to a threshold value (e.g., a high threshold, a low threshold, or a high-low threshold). If the data is outside the threshold (e.g., above a high threshold, below a low threshold, outside an inner range threshold, or inside an outer range threshold), then the data is deemed to be anomalous and is transmitted to the base unit 112.")

- **13:57-14:5** ("In one embodiment, the controller 303 includes a table or list of identification codes for wireless sensor units 102. The repeater 303 forwards packets received from, or sent to, sensor units 102 in the list. In one embodiment, the repeater 110 receives entries for the list of sensor units from the computer 113. In one embodiment, the controller 303 determines when a transmission is expected from the sensor units 102 in the table of sensor units and places the repeater 110 (e.g., the transceivers 302, 304) in a low-power mode when no transmissions are expected from the transceivers on the list. In one embodiment, the controller 303 recalculates the times for low-power operation when a command to change reporting interval is forwarded to one of the sensor units 102 in the list (table) of sensor units or when a new sensor unit is added to the list (table) of sensor units.")
- **15:50-16:7** ("FIG. 7 is a flowchart showing one embodiment of operation of the sensor unit 102 wherein periodic monitoring is provided. In FIG. 7, a

power up block 701 is followed by an initialization block 702. After initialization, the sensor unit 102 enters a low-power sleep mode.... If no fault occurs during the sleep period, then when the specified sleep period has expired, the process enters a block 706 where the sensor unit 102 takes a sensor reading from the sensor(s) 201. The sensor data is subsequently sent to the monitoring computer 113 in a report block 707. After reporting, the sensor unit 102 enters a listen block 708 where the sensor unit 102 listens for a relatively short period of time for instructions from monitoring computer 708. If an instruction is received, then the sensor unit 102 performs the instructions, otherwise, the process returns to the sleep block 703. In one embodiment, the sensor 201 and transceiver 203 are normally powered down. The controller 202 powers up the sensor 201 during execution of the block 706. The controller 202 powers up the transceiver during execution of the blocks 705, 707, and 708. The monitoring computer 113 can send instructions to the sensor unit 102 to change the sleep period used in block 703, the listen period used in block 708, etc.”)

- **See also 7:60-8:12, 8:30-42, 9:43-50, 11:16-22, 13:26-28.**

79. See my discussion of elements [1.pre]-[1.b]. Kates-711 also discloses that the sensor unit includes a “controller” that provides control information to the sensor. Kates-711, 12:47-51. As I note in Section VIII.B, under any interpretation,

this element requires, at most, information to be communicated by the transceiver along with the sensor reading. When the sensor unit is operated in “periodic monitoring” mode, the controller “powers up the sensor” “after the specified sleep period has expired” to prompt a sensor measurement of the sensed condition and receive a corresponding sensor reading. Kates-711, 15:50-16:7. The controller evaluates the sensor reading, and if the sensor data is “deemed to be anomalous,” the controller powers up and operates the transceiver to communicate the sensor data and related information, such as the sensor unit’s ID code. Kates-711, 5:18-23, 7:60-8:12, 13:7-23, 15:50-16:7. This ID code is additional information communicated with the packet, and therefore discloses that each packet communicates both information (an ID code) corresponding to the sensor measurement, and the measurement itself, which discloses communicating “information associated reading of the indicator” under any interpretation. However, if the data “falls within a normal range,” “[t]he sensor unit conserves power by not transmitting [the] data.” Kates-711, 13:7-23.

80. Based on a construction proposed by a third party (Ex. 1015, 10-11), which I have not adopted as my own, I have also been asked to consider whether this element would be met under a means-plus-function interpretation in which the controller’s function is to poll the sensor at a polling interval to read the indicator during a current period of the polling interval, to selectively operate the transceiver

to communicate information associated with a reading of the indicator, to store a reading of the indicator during the current period in the memory and reduce the amount of information communicated by the sensor to improve bandwidth, and the corresponding structure is a controller implementing algorithms for performing this function as disclosed in the '887 patent's specification. Applying this construction, a person having ordinary skill in the art would have understood Kates-711 to disclose this term both literally and under the doctrine of equivalents. Kates-711 discloses a "controller," such as a "conventional programmable microcontroller," that provides control information to the sensor and transceiver and causes them to generate and transmit sensor data and other associated information, as I explain in more detail in my discussions above and of elements [1.a]-[1.b] and [1.e]—performing each of these elements using the same algorithmic implementations described in the '887 patent's specification. '887, 7:48-63 ("processor 214 implements a control process for the device 207.... processor 214 implements a control process algorithm specific to the sensor 209"), 9:23-11:44 ("processor 214 polls the sensor 209," "signal $V(t)$ representing the sensed condition may be generated," "[t]he indicator may be stored in memory," "[t]he value V_t is processed by the processor 214 ... to identify whether the sensed condition has changed," and "processor 214 controls the transceiver 216 to selectively communicate information," for example when "a change in the sensed condition beyond a limit" is detected). A person having ordinary skill in the art

would have understood Kates-711's disclosures of its controller to disclose substantially the same function as the controller in the '887 patent; namely, polling the sensor at a polling interval to read the indicator during a current period of the polling interval, selectively operating the transceiver to communicate information associated with a reading of the indicator, storing a reading of the indicator during the current period in the memory and reducing the amount of information communicated by the sensor to improve bandwidth. *See also* [1.pre]-[1.e]. A person having ordinary skill in the art would have understood Kates-711 to perform this function in substantially the same way as the '887 patent, since both utilize a programmable controller to issue and respond to instructions, and to achieve the same result, since both periodically poll the sensor, operate the transceiver to communicate sensor readings and associated information, store readings from the sensor in memory, and reduce the amount of the information communicated through use of the selective transmitting. *See also* [1.pre]-[1.e].

(e) Element [1.d]

81. **Element [1.d] recites “a memory, the controller storing a reading of the indicator during the current period in the memory, where the memory stores at least one prior reading of the indicator, the prior reading of the indicator made during a prior period of the polling interval.”** This element is met by Kates-711.

82. **Kates-711 discloses a memory, the controller storing a reading of the indicator and storing at least one prior reading of the indicator, the prior reading of the indicator made during a prior period of the polling interval** (*e.g.*, “controller” stores both “recent” and “less recent” “sensor measurements” from the “periodic monitoring”). *See, e.g.*, Kates-711 (emphasis added):

- **12:62-66** (“In one embodiment, the controller 202 is a conventional programmable microcontroller. In one embodiment, the controller 202 is based on a Field Programmable Gate Array (FPGA), such as, for example, provided by Xilinx Corp.”)
- **15:50-16:7** (“FIG. 7 is a flowchart showing one embodiment of operation of the sensor unit 102 wherein periodic monitoring is provided. In FIG. 7, a power up block 701 is followed by an initialization block 702. After initialization, the sensor unit 102 enters a low-power sleep mode.... If no fault occurs during the sleep period, then when the specified sleep period has expired, the process enters a block 706 where the sensor unit 102 takes a sensor reading from the sensor(s) 201. The sensor data is subsequently sent to the monitoring computer 113 in a report block 707. After reporting, the sensor unit 102 enters a listen block 708 where the sensor unit 102 listens for a relatively short period of time for instructions from monitoring computer 708. If an instruction is received, then the sensor unit 102 performs the

instructions, otherwise, the process returns to the sleep block 703. In one embodiment, the sensor 201 and transceiver 203 are normally powered down. The controller 202 powers up the sensor 201 during execution of the block 706. The controller 202 powers up the transceiver during execution of the blocks 705, 707, and 708. The monitoring computer 113 can send instructions to the sensor unit 102 to change the sleep period used in block 703, the listen period used in block 708, etc.”)

- **19:64-20:9** (“In one embodiment, the sensor unit 102 is configured as an adjustable-threshold sensor that computes a threshold level. In one embodiment, the threshold is computed as an average of a number of sensor measurements. In one embodiment, the average value is a relatively long-term average. In one embodiment, the average is a time-weighted average wherein recent sensor readings used in the averaging process are weighted differently than less recent sensor readings. In one embodiment, more recent sensor readings are weighted relatively more heavily than less recent sensor readings. In one embodiment, more recent sensor readings are weighted relatively less heavily than less recent sensor readings.”)
- **See also 4:17-34, 4:56-64, 8:43-63, 20:9-49.**

83. Kates-711 discloses that its controller is “a conventional programmable microcontroller” that calculates values such as “a time-weighted average” based on

“recent sensor readings” and “less recent sensor readings.” Kates-711, 12:62-64, 19:64-20:9, 21:1-16. Kates-711 discloses that, absent intervening faults, sensors readings are taken once after every sleep period when operating in periodic monitoring mode. Kates-711, 15:50-60. The “less recent” sensor readings are those taken during periods of periodic monitoring that precede the periods during which the “recent” sensor readings are taken. Kates-711, 15:50-16:7. As discussed in Section IX.A.1, a person having ordinary skill in the art would have understood, or at least found obvious, that storing the data needed to calculate the averages disclosed in Kates-711 would not only render obvious, but affirmatively disclose a memory used by the controller—for example, a conventional programmable microcontroller, or a Xilinx FPGA, which were both well-known in the art to include and/or use memory. Kates, 12:62-66.

84. Taken together, as discussed in Section IX.A.1, Kates-711’s teachings of calculating an average using readings from a current period and from prior periods, optionally assigning different weights to those readings in calculating an average, and using a controller based on the Xilinx FPGA, not only renders obvious, but affirmatively discloses, this element because a person having ordinary skill in the art would have understood that a memory is used by the sensor unit for storage and retrieval of sensor data for use by the processor in those calculations during later periodic monitoring cycles.

(f) Element [1.e]

85. **Element [1.e] recites “wherein the transceiver is configured to transmit a most recent reading of the indicator stored in the memory during a period of a transmission interval in response to detecting a change in the sensed condition outside a predetermined range and wherein transmission of the most recent reading of the indicator stored in the memory during the period of the transmission interval is suspended in response to detecting a change in the sensed condition within the predetermined range.” This element is met by Kates-711.**

86. **Kates-711 discloses wherein the transceiver (*see* [1.a]) is configured to transmit a most recent reading of the indicator stored in the memory (*e.g.*, “sensor data” is stored in memory (*see* [1.d]) and “sent to the monitoring computer”) during a period of a transmission interval (*e.g.*, during a “report block 707” of the “periodic monitoring”) in response to detecting a change in the sensed condition outside a predetermined range (*e.g.*, controller “compar[es] the data value to a threshold value,” including the threshold “for the sensor reading and for the rate of rise,” and transmits “data” that does not “fall[] within a normal range”) and wherein transmission of the most recent reading of the indicator stored in the memory during the period of the transmission interval is suspended in response to detecting a change in the sensed condition within the predetermined range (*e.g.*,**

controller does “not transmit[] data that falls within a normal range” in response to detecting a change by “comparing the data value to a threshold value”). *See, e.g.*, Kates-711 (emphasis added):

- **Fig. 7:**

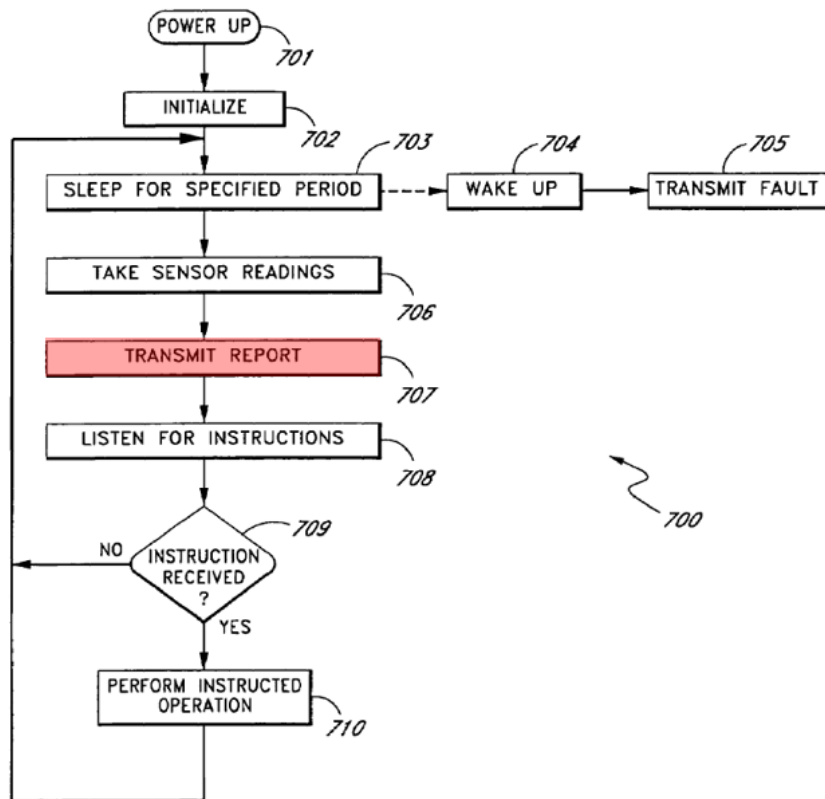


FIG. 7

- **4:6-9** (“When one or more of the sensor units detects an anomalous condition (e.g., smoke, fire, water, etc.) the sensor unit communicates with the base unit and provides data regarding the anomalous condition.”)

- **4:39-42** (“The sensor units report the measured data to the base unit whenever the sensor unit determines that the measured data is sufficiently anomalous to be reported.”)
- **5:12-17** (“In one embodiment, the sensor unit provides two wake-up modes, a first wake-up mode for taking measurements (and reporting such measurements if deemed necessary), and a second wake-up mode for listening for commands from the central reporting station. The two wake-up modes, or combinations thereof, can occur at different intervals”)
- **13:8-23** (“The controller 202 receives sensor data from the sensor(s) 201.... In one embodiment, the controller evaluates the data received from the sensor(s) 201 and determines whether the data is to be transmitted to the base unit 112. The sensor unit 102 generally conserves power by not transmitting data that falls within a normal range. In one embodiment, the controller 202 evaluates the sensor data by comparing the data value to a threshold value (e.g., a high threshold, a low threshold, or a high-low threshold). If the data is outside the threshold (e.g., above a high threshold, below a low threshold, outside an inner range threshold, or inside an outer range threshold), then the data is deemed to be anomalous and is transmitted to the base unit 112.”)

- **15:50-16:4** (“FIG. 7 is a flowchart showing one embodiment of operation of the sensor unit 102 wherein periodic monitoring is provided. In FIG. 7, a power up block 701 is followed by an initialization block 702. After initialization, the sensor unit 102 enters a low-power sleep mode.... If no fault occurs during the sleep period, then when the specified sleep period has expired, the process enters a block 706 where the sensor unit 102 takes a sensor reading from the sensor(s) 201. The sensor data is subsequently sent to the monitoring computer 113 in a report block 707.... The controller 202 powers up the transceiver during execution of the blocks 705, 707, and 708.”)
- **20:9-49** (“When the sensor readings rise above the threshold level, the sensor indicates a notice condition. In one embodiment, the sensor indicates a notice condition when the sensor reading rises above the threshold value for a specified period of time. In one embodiment, the sensor indicates a notice condition when a statistical number of sensor readings (e.g., 3 of 2, 5 of 3, 10 of 7, etc.) are above the threshold level. ...
In one embodiment, the sensor unit 102 computes the notice level according to how far the sensor readings have risen above the threshold and how rapidly the sensor readings have risen. For example, for purposes of explanation, the level of readings and the rate of rise can be quantified as

low, medium, and high. The combination of sensor reading level and rate of rise then can be show as a table, as show in Table 1. Table 1 provides examples and is provided by way of explanation, not limitation.

TABLE 1				
Sensor Reading Level (as compared to the threshold)				
Rate of Rise	High	Warning	Alarm	Alarm
	Medium	Notice	Warning	Alarm
	Low	Notice	Warning	Alarm
		Low	Medium	High

One of ordinary skill in the art will recognize that the notice level N can be expressed as an equation $N=f(t, v, r)$, where t is the threshold level, v is the sensor reading, and r is the rate of rise of the sensor reading. ... In one embodiment, separate thresholds are computed for the sensor reading and for the rate of rise.")

- **See also 7:63-8:5, 8:23-29, 13:23-26, 18:39-41, 19:64-20:9, 20:50-59.**

87. See my discussion of elements [1.pre]-[1.d]. Kates-711 also discloses that during each period in which the sensor unit system remains in “periodic monitoring” mode, “when the specified sleep period has expired,” the sensor unit takes a sensor reading from one or more sensors. Kates-711, 15:50-60. The sensor unit then transmits sensor readings during “report block 707” to a monitoring computer. Kates-711, 15:60-16:4. However, reporting during “reporting block 707” may be suspended; Kates-711 further discloses that the sensor unit conserves battery

power by not transmitting data that falls within a normal range. Kates-711, 4:55-64, 13:8-23. Rather, upon receipt of a sensor reading from the sensor (which is the most recent reading), the controller evaluates the most recent sensor reading to determine whether it should be transmitted to other network components. Kates-711, 13:8-23.

88. Kates-711 provides that the sensor reading is evaluated by the controller against a threshold range that it discloses is a “high-low threshold” or an “inner range threshold.” Kates-711, 13:8-23. Kates-711 further teaches that, in addition to calculating these thresholds based on the value of the sensor reading, thresholds for the sensor unit are also separately and concurrently calculated based on the “rate of rise” of that sensor reading. Kates-711, 20:9-49. Because Kates-711’s analysis of a sensor reading, and also the transmission or suspended transmission thereof, determines both whether the sensor reading exceeds threshold values (*e.g.*, whether a most recent reading is outside a predetermined range) and whether the sensor reading has increased or decreased in comparison to a prior sensor reading (*e.g.*, whether a difference between a most recent reading and a prior reading is outside a predetermined range), Kates-711 not only renders obvious, but affirmatively discloses that Kates-711’s controller will direct the sensor reading to be transmitted if it determines that the sensor data from the reading exhibits a change that falls outside a threshold range. Indeed, the ’887 patent’s disclosure of this element similarly describes detecting such a change based on either detecting a value

outside a range or based on differences between a value and values in a prior interval: “The change may be determined according to detecting a value for the condition outside a variable range. The change may also be determined according to detecting differences in the value from values detected in prior intervals.” ’887, Abstract; *see also id.*, 3:11-15, 3:32-36. The controller determines that the data is “necessary” to transmit because it is “sufficiently anomalous” given that its change is outside the range of the high-low or inner range threshold. Kates-711, 4:39-42, 5:12-16, 13:8-23. If the sensor reading is abnormal to a normal threshold range (either due to a large change in value relative to a prior reading or because it exceeds a threshold value), the controller directs the transceiver to transmit the recent reading. Kates-711 further not only renders obvious but affirmatively discloses that the transmitted sensor reading is the most recent sensor reading, since this data is held in memory for processing and retrieval, as I have discussed with respect to element [1.d] in Section IX.A.2(e), and evaluated to determine whether it is a significant reading that should be transmitted—for example, because it exceeds a rate-of-change threshold or a value threshold. *See id.*

89. The threshold values that define the acceptable range of sensor values are set prior to their use in evaluating whether the most recent sensor reading should be transmitted; the threshold values are therefore predetermined. Kates-711, 13:16-23, 20:9-16. Moreover, Kates-711 discloses setting threshold values in a variety of

ways, all of which not only render obvious, but affirmatively disclose the threshold range being “predetermined” before it is used to evaluate a sensor reading. For example, Kates-711 teaches programming the threshold range against which recent sensor readings are evaluated directly into the sensor unit or via instruction, set based on computations, or, in the case of sensor unit calibration, set during a power up calibration procedure or pre-programmed as a fixed range for use during the calibration period. Kates-711, 13:23-26, 18:39-41, 19:64-20:9, 20:50-59.

90. Based on a construction proposed by a third party (Ex. 1023, 17-18), which I have not adopted as my own, I have also been asked to consider whether this element is met under a claim construction under which the term “where transmission [is suspended]” that appears in this element means “wherein the transmission of the most recent reading of the indicator that would otherwise occur is stopped in response to detecting a change in the sensed condition within the predetermined range.” The element would be met under this construction for the reasons set forth above because the sensor data would have been transmitted but for the determination that it falls within the acceptable threshold of sensor values, due to which its transmission is suspended and, therefore, stopped.

(g) Claim [3]

91. Claim [3] recites “The wireless automation device of claim 1 where an upper limit and a lower limit of the predetermined range may be varied.”

This claim is met by Kates-711.

92. Kates-711 discloses that an upper limit and a lower limit of the predetermined range (e.g., high and low limits of “high-low threshold” or “inner range threshold”) may be varied (e.g., “threshold” values are “adjustable”). See, e.g., Kates-711 (emphasis added):

- **Abstract** (“A sensor system that provides an adjustable threshold level for the sensed quantity is described. The adjustable threshold allows the sensor to adjust to ambient conditions, aging of components, and other operational variations while still providing a relatively sensitive detection capability for hazardous conditions. The adjustable threshold sensor can operate for extended periods without maintenance or recalibration.”)
- **13:16-26** (“In one embodiment, the controller 202 evaluates the sensor data by comparing the data value to a threshold value (e.g., a high threshold, a low threshold, or a high-low threshold). If the data is outside the threshold (e.g., above a high threshold, below a low threshold, outside an inner range threshold, or inside an outer range threshold), then the data is deemed to be anomalous and is transmitted to the base unit 112. In one embodiment, the

data threshold is programmed into the controller 202. In one embodiment, the data threshold is programmed by the base unit 112 by sending instructions to the controller 202.”)

- **19:64-20:9** (“In one embodiment, the sensor unit 102 is configured as an adjustable-threshold sensor that computes a threshold level. In one embodiment, the threshold is computed as an average of a number of sensor measurements. In one embodiment, the average value is a relatively long-term average. In one embodiment, the average is a time-weighted average wherein recent sensor readings used in the averaging process are weighted differently than less recent sensor readings. In one embodiment, more recent sensor readings are weighted relatively more heavily than less recent sensor readings. In one embodiment, more recent sensor readings are weighted relatively less heavily than less recent sensor readings.... The average is used to set the threshold level.”)
- **20:9-49** (“When the sensor readings rise above the threshold level, the sensor indicates a notice condition. In one embodiment, the sensor indicates a notice condition when the sensor reading rises above the threshold value for a specified period of time. In one embodiment, the sensor indicates a notice condition when a statistical number of sensor readings (e.g., 3 of 2, 5 of 3, 10 of 7, etc.) are above the threshold level. ...

In one embodiment, the sensor unit 102 computes the notice level according to how far the sensor readings have risen above the threshold and how rapidly the sensor readings have risen. For example, for purposes of explanation, the level of readings and the rate of rise can be quantified as low, medium, and high. The combination of sensor reading level and rate of rise then can be show as a table, as show in Table 1. Table 1 provides examples and is provided by way of explanation, not limitation.

TABLE 1

Sensor Reading Level (as compared to the threshold)				
Rate of Rise	High	Warning	Alarm	Alarm
	Medium	Notice	Warning	Alarm
	Low	Notice	Warning	Alarm
		Low	Medium	High

One of ordinary skill in the art will recognize that the notice level N can be expressed as an equation $N=f(t, v, r)$, where t is the threshold level, v is the sensor reading, and r is the rate of rise of the sensor reading. ... In one embodiment, separate thresholds are computed for the sensor reading and for the rate of rise.”)

- **See also 4:17-34, 20:51-59, 21:49-53.**

93. See my discussion of elements [1.pre], [1.c], [1.e]. Kates-711 is directed to a system that provides an “adjustable threshold.” Kates-711, Abstract. Kates provides examples of different types of such thresholds that can be adjustable: for

example, Kates-711 characterizes the thresholds against which new sensor measurements are compared by the sensor unit as “high,” “low,” “high-low” or “inner range” thresholds; the last two types of thresholds each have both high and low limit values. Kates-711, 13:16-23, 20:20-49. Kates-711 also discloses adjusting these “adjustable-threshold[s]” by calculating “an average using a number of sensor measurements” that were previously collected; for example, in calculating the average, more recent measurements are given greater weight. Kates-711, Abstract, 19:64-20:9. Taken together, the disclosures in Kates-711, including the disclosures of the “high-low” threshold, the “inner range” threshold, and “adjustable thresholds” would have been understood by a person having ordinary skill in the art to not only render obvious, but affirmatively disclose adjusting one or both of the upper limit and the lower limits of the threshold by increasing or reducing the minimum or maximum threshold sensor values. A person having ordinary skill in the art would have understood that such adjustments advantageously facilitate increasing or reducing the system’s sensitivity to changes in the sensor reading, for example for more accurately determining when to issue alerts caused by large changes in sensor values, or updating the thresholds based on a change to more recent average sensor values. Kates-711, 1:46-54, 3:62-67, 24:7-16.

(h) Claim [4]

94. **Claim [4] recites “The wireless automation device of claim 3 where the upper limit and lower limit may be varied according to an analysis of the most current reading of the indicator and the at least one prior reading of the indicator.”** This claim is met by Kates-711.

95. **Kates-711 discloses that the upper limit and lower limit** (*e.g.*, the upper and lower limit of the “high-low” and “inner range” thresholds) **may be varied according to an analysis of the most current reading of the indicator and the at least one prior reading of the indicator** (*e.g.*, varied according to “an average value of the sensor reading” based on “recent” and “less recent” “sensor readings”).

96. *See* my discussion for claim [3]. Moreover, a person having ordinary skill in the art would have understood that Kates-711 not only renders obvious, but affirmatively discloses, that the upper and lower limit of the predetermined range are automatically varied based on at least one prior reading of the sensor reading. As discussed for claim [3], the sensor unit adjusts the threshold values based on the “average value of the sensor reading” over the current and prior readings, among which are more recent and less recent readings that are prior sensor readings. Kates-711, 4:17-34, 19:64-20:9. Moreover, a person having ordinary skill in the art would have understood this analysis to occur automatically based on both the disclosure

that the sensor unit is “configured” to compute the threshold values as plain or time-weighted average of prior sensor readings in combination with the purported use case of the sensor system in Kates-711: detecting potentially dangerous environmental conditions. *Id.*, Kates-711, 1:6-9. Kates therefore discloses that the calculation (and re-calculation) of a threshold occurs automatically as new sensor readings are made.

(i) Claim [5]

97. **Claim [5] recites “The wireless automation device of claim 1 where the transceiver is configured to transmit the most recent reading of the indicator stored in the memory during a period of the transmission interval in response to detecting a sensed condition beyond a band limit.”** This claim is met by Kates-711.

98. **Kates-711 discloses that the transceiver is configured to transmit the most recent reading of the indicator stored in the memory (e.g., “take[]” and then “sen[d] to the monitoring computer” the “sensor reading”; see [1.d]) during a period of the transmission interval (e.g., during a “report block 707” of the “periodic monitoring”) in response to detecting a sensed condition beyond a band limit (e.g., “controller 202 evaluates the sensor data by comparing the data value to...a high-low threshold,” and “transmitt[ing] to the base unit” the sensor value if**

the data is “above a high threshold, below a low threshold, [or] outside an inner range threshold”).

99. *See* my discussions of elements [1.d]-[1.e] and [3]. As discussed for [1.d]-[1.e] and [3], Kates-711 discloses transmitting the most recent reading of the indicator stored in the memory during the period of the transmission interval in response to detecting a sensed condition outside a predetermined range such as an “inner range threshold” that has upper and lower limits based on either a value or rate-of-change—which discloses a band limit. These thresholds with upper and lower limits are band limits because Kates-711 discloses their use in issuing alerts when sensor values change. Kates-711, 20:20-49. For example, when a rate-of-change is determined to be “low,” “medium,” or “high,” which would have involved the use of three band limits defining the threshold limits for changes being low, medium, and high, a “warning” or “alarm” is triggered. Kates thus discloses a band limit. Indeed, this disclosure from Kates-711 of a band limit calculated by determining the size of a rate of change—i.e., the change between a current sensor measurement and a prior measurement—is similar to the disclosure in the ’887 patent, which explains, for example, that a device uses a “band limit” to detect changes and “extreme conditions” based on a “difference” between a current and prior reading of a sensor value:

The current difference may also be compared to a multiple of the difference limit D_l (e.g., $3 \times D_l$) to identify whether an extreme condition may be present, such as a large temperature increase do to a fire. Where the current difference D_i greater than the difference limit D_l (i.e., $D_i > D_l$) the difference between the current value V_i and the value V_{i-j} in the prior interval may be considered outside a control range or band limit.

'887, 10:23-30; *see also id.*, 3:32-35.

(j) Claim [6]

100. **Claim [6] recites “The wireless automation device of claim 5 where an upper band limit and a lower band limit may be varied.”** This claim is met by Kates-711.

101. **Kates-711 discloses that an upper band limit and a lower band limit may be varied** (*see* [3]).

102. Kates-711 discloses this claim for the same reasons as discussed for claim [3]. As I stated for that claim, Kates-711 discloses an upper limit and lower limit of a predetermined range may be varied based on disclosures about “adjustable threshold[s]”; the only difference between claim 3 and this claim is that this claim refers to an upper and lower *band* limit. As I explained for claim [5], Kates-711 discloses an “inner range threshold” that has upper and lower limits within which a sensor value will not be deemed anomalous; such an “inner range threshold” is a band limit.

(k) Claim [7]

103. **Claim [7] recites “The wireless automation device of claim 5 where the upper band limit and lower band limit may be varied according to an analysis of the most current reading of the indicator and the at least one prior reading of the indicator.”** This claim is met by Kates-711.

104. **Kates-711 discloses that the upper band limit and the lower band limit may be varied according to an analysis of the most current reading of the indicator and the at least one prior reading of the indicator (*see* [4]-[5]).**

105. Kates-711 discloses this claim for the same reasons as discussed for claim [4]. As I explained for that claim, Kates-711 discloses that the upper limit and lower limit may be varied according to an analysis of the most current reading of the indicator and the at least one prior reading of the indicator based on disclosures about “adjustable threshold[s]” that may be adjusted based on calculated averages of past measurements. The only difference between claim [4] and this claim is that this claim refers to an upper and lower *band* limit. As I explained for claim [5], Kates-711 discloses an “inner range threshold” that has upper and lower limits within which a sensor value will not be deemed anomalous; such an “inner range threshold” is a band limit.

(I) Claim [8]

106. **Claim [8] recites “The wireless automation device of claim 1 where the transceiver is configured to transmit the most recent reading of the indicator stored in the memory in response to an externally-received transmission control signal received over the wireless network.”** This claim is met by Kates-711.

107. **Kates-711 discloses that the transceiver is configured to transmit the most recent reading of the indicator stored in the memory (see [1.d]-[1.e]) in response to an externally-received transmission control signal received over the wireless network (e.g., “controller 202 obtains sensor data and transmits the data when commanded by the computer 113,” via a command communicated “through a computer network connection”).** *See, e.g., Kates-711 (emphasis added):*

- **Fig. 1:**

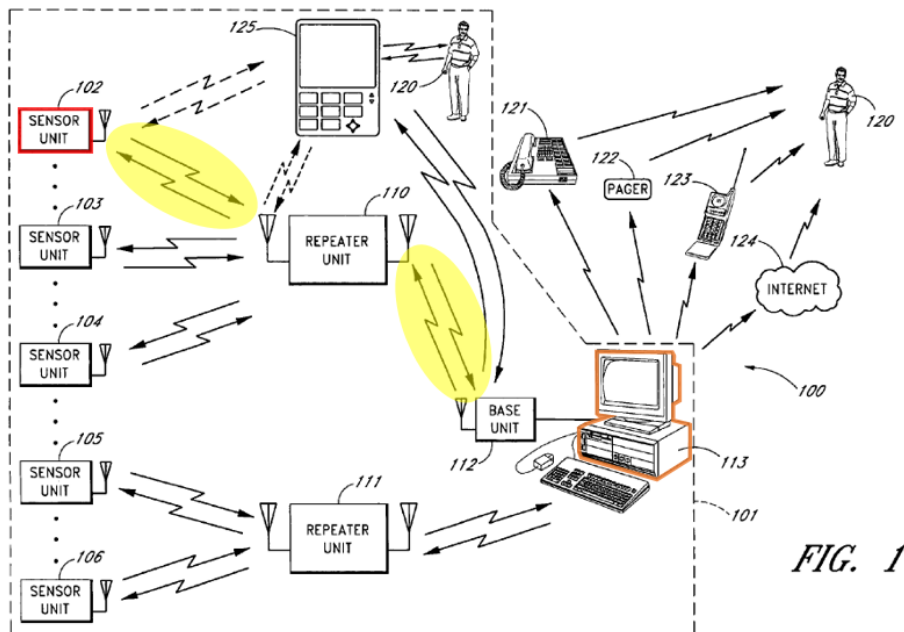


FIG. 1

- **4:56-64** (“In one embodiment, while in the low-power mode, the sensor unit takes regular sensor readings, adjusts the threshold level, and evaluates the readings to determine if an anomalous condition exists. If an anomalous condition is detected, then the sensor unit “wakes up” and begins communicating with the base unit or with a repeater. At programmed intervals, the sensor also “wakes up” and sends status information to the base unit (or repeater) and then listens for commands for a period of time.”)
- **5:12-17** (“In one embodiment, the sensor unit provides two wake-up modes, a first wake-up mode for taking measurements (and reporting such measurements if deemed necessary), and a second wake-up mode for listening for commands from the central reporting station. The two wake-up modes, or combinations thereof, can occur at different intervals”)

- **6:57-63** (“Sensor units 102-104 communicate with the repeater 110. Sensor units 105-106 communicate with the repeater 111. The repeaters 110-111 communicate with the base unit 112. The base unit 112 communicates with a monitoring computer system 113 through a computer network connection such as, for example, Ethernet, wireless Ethernet, firewire port, Universal Serial Bus (USB) port, Bluetooth, etc.”)
- **8:23-29** (“In one embodiment, the sensor unit 102 provides two wake-up modes, a first wake-up mode for taking measurements (and reporting Such measurements if deemed necessary), and a second wake-up mode for listening for commands from the central reporting station. The two wake-up modes, or combinations thereof, can occur at different intervals.”)
- **13:26-28** (“In one embodiment, the controller 202 obtains sensor data and transmits the data when commanded by the computer 113.”)
- **See also 8:5-19, 10:61-65, 16:21-26.**

108. See my discussion of elements [1.pre]-[1.e]. Kates-711 also discloses that its sensor unit performs measurements (that are subsequently transmitted, as discussed for elements [1.a] and [1.e]) in response to both the end of a sleep period in the case of periodic measurements collected during a “first wake-up mode,” and in response to a “command” from computer 113 during a “second wake-up mode.” Kates-711, 8:23-29. The two modes, or “combinations thereof,” may occur at

different intervals for the same sensor system. *Id.* Kates-711 discloses that computer 113 may communicate with the sensor system via, e.g., “wireless Ethernet.” Kates-711, 6:57-63. The computer 113 is therefore external to the sensor unit.

(m) Claim [18]

109. **Claim [18] recites “The wireless automation device of claim 1, where the sensor is configured to sense an environmental condition.”** This claim is met by Kates-711.

110. **Kates-711 discloses that the sensor is configured to sense an environmental condition** (*e.g.*, configured to sense conditions such as “temperature” and “humidity”). *See, e.g.*, Kates-711 (emphasis added):

- **12:66-13:9** (“In one embodiment, the sensor 201 includes an optoelectric smoke sensor with a smoke chamber. In one embodiment, the sensor 201 includes a thermistor. In one embodiment, the sensor 201 includes a humidity sensor. In one embodiment, the sensor 201 includes a sensor, such as, for example, a water level sensor, a water temperature sensor, a carbon monoxide sensor, a moisture sensor, a water flow sensor, natural gas sensor, propane sensor, etc. [¶] The controller 202 receives sensor data from the sensor(s) 201.”)
- **See also 4:3-9, 4:35-39, 4:46-53.**

111. *See* my discussion of element [1.b]. Kates-711 also discloses that the sensors employed in its sensor unit are configured to sense a wide range of environmental conditions including “smoke, temperature, humidity, moisture, water, ... etc.” Kates-711, 4:49-53.

B. Ground 2: Kates-711 in view of Hitt (Claims 1, 3-8, and 18)

1. Overview of Hitt and Motivation to Modify Kates-711 with Hitt’s Teachings

112. Like Kates-711, Hitt discloses a device for use as part of a “wireless sensor system for environmental monitoring and/or control” that comprises “a network of wireless nodes, the wireless nodes includ[ing] an array of sensor nodes and an array of actuator nodes.” Hitt, Abstract, [0003]. Figure 2A below (emphasis added) provides a block diagram of a wireless node that is used as part of the wireless sensor system; this node may be configured as a sensor node or an actuator node by varying component 158 to be a sensor component (e.g., a temperature sensor) or an actuator component (e.g., a component that provides a drive voltage that controls an environmental condition) respectively.

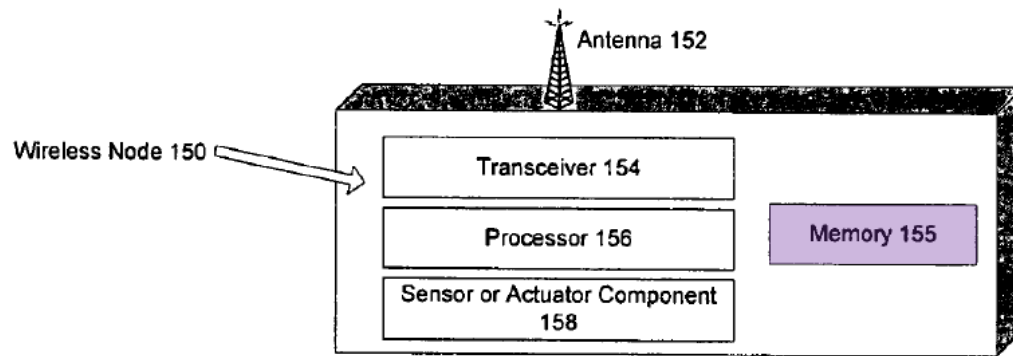


Figure 2A

Hitt, [0046]. In addition to node 158, the wireless node 150 includes an antenna 152, a wireless transceiver 154, and a processor 156. Hitt, [0046]. The processor 156 “controls the operation of the wireless transceiver and the [sensor] node component” by processing and evaluating the sensor data it receives from the sensor node component and directing the transceiver to transmit the sensor data to an actuator node based on its evaluation of the sensor data. Hitt, [0048]. The memory 155 stores instructions that “support[] the operation of each wireless node” that the processor 156 executes to perform “message interpretation,” “transmission,” and other data “processing” such as “[d]ata compression” and “statistical analysis.” Hitt, [0065], [0067], [0068]. The memory 155 also stores periodically sampled sensor data both as it is received from the sensor and after it has been processed; this data can then used for further processing and/or transmitted to other parts of the wireless sensor system. Hitt, [0065], [0067], [0068].

113. Kates-711 and Hitt are in the same field as the '887 patent: sensors, controls, and/or wireless communications. '887, Abstract, 1:6-19 (“relates to remote monitoring of conditions and ... to wirelessly reporting a sensed condition over a wireless communication network”, “process control for [HVAC], environmental air quality, safety and security, fire, hazard prevention, or other processes for a building or facility”), 1:34-49; Kates-711, 1:5-11 (“relates to a sensor in a wired or wireless sensor system for monitoring potentially dangerous or costly conditions”); Hitt, [0003] (“relates ... to systems and methods for an improved environmental monitoring and control system utilizing distributed wireless sensor platforms”), [0019] (discussing exemplary automated systems for security and residential applications). A person having ordinary skill in the art would have also understood Kates-711’s and Hitt’s disclosures to be reasonably pertinent to the alleged problem(s) that the '887’s disclosures purport to address— namely, a need to reduce communications over a wireless system in the context of a sensor system. For example, the '887 patent states that “there is a need for a system for reducing an amount of communication over a wireless automated system;” Kates-711 explains the value of “conserv[ing] power by not transmitting data that falls within a normal range;” and Hitt states “improvements are needed to the sensing systems in order to reduce their overall cost, while enhancing their effectiveness.” '887, Abstract, 1:6-19, 1:34-49; Kates-711, 13:14-16; Hitt, [0018].

114. While, as noted in my discussion in Section IX.A, Kates-711 does not explicitly state that its disclosed device includes “memory,” Hitt expressly teaches that its sensor unit utilizes a “memory” to store and aggregate sensor data that has been collected by the sensor so that the sensor data is available for use in further processing and transmission to other parts of the wireless system. Hitt, [0046], [0049], [0067]-[0068]. Taking these disclosures together, a person having ordinary skill in the art would have been motivated to modify Kates-711’s sensor units with Hitt’s teachings of including a “memory” as part of the sensor node to achieve beneficial and predictable results: the availability of a memory would have enabled secure storage of sensor readings and ensured that prior data was available for future processing.

115. First, Hitt provides more explicit teachings of the memory that a person having ordinary skill in the art would have understood is implicitly disclosed in Kates-711. Kates-711 broadly teaches functions that a person having ordinary skill would have understood to disclose, or at least render obvious, that Kates-711’s sensor unit includes a “memory” in which previously collected sensor data may be stored (and from which it may be later retrieved); for example, Kates-711 discloses that its sensor unit’s controller computes threshold values as “an average of a number of sensor measurements,” “a relatively long-term average,” or “a time-weighted average wherein recent sensor readings ... are weighted differently than less recent

sensor readings.” *See* Kates-711, 19:64-20:9. A person having ordinary skill in the art would have understood that these teachings not only render obvious, but affirmatively disclose that the sensor unit has a memory that stores both the more and less recent sensor data used in those calculations. *See* Section IX.A.1; *see also* Barbacci (“A conventional instruction set processor fetches, decodes, and executes instructions stored in memory.”). Therefore, a person having ordinary skill in the art would have been motivated to modify Kates-711’s implicit disclosure of a memory component in the sensor unit with Hitt’s explicit and detailed teachings of memory to advantageously effectuate Kates-711’s teachings of storing sensor readings (and subsequently calculating threshold values based on these stored readings) by providing the storage medium for doing so.

116. Second, a person having ordinary skill in the art would have understood Hitt’s detailed teachings of using memory to provide a well-known approach to improve the reliability of a wireless sensor system. For instance, Kates-711 discloses that its sensor unit takes sensor readings at periodic intervals, and that the newest sensor reading is compared to prior sensor readings based on calculated averages of prior sensor readings over time; these prior readings are explained to have originated during at least two different sampling periods in the device (e.g., more recent and less recent periods relative to the time of the current sensor reading). Kates-711, 8:1-3, 15:48-50, 19:64-20:19. Hitt provides additional teachings that provide for the

tracking and storage of sensor values in memory such that they are available for calculations. Hitt, [0067]-[0068]. A person having ordinary skill in the art would have known that using memory to store such values advantageously improves the reliability of the system; for instance, U.S. Patent No. 5,696,695 to Ehlers, which I understand has been designated as Exhibit 1007, discloses that storing past data in memory is advantageous to ensure that these values are not unintentionally lost or erased, as may happen in the case of a power outage or other interruptions. Ehlers (Ex. 1007), 9:28-34. Thus, in addition to the fact that Kates-711 alone implicitly discloses, or at least renders obvious, the inclusion a memory in its sensor unit, a person having ordinary skill in the art would have been motivated to modify Kates-711's sensor unit to include a memory that stores previously reported sensor readings as taught by Hitt to improve the reliability of Kates-711's system by ensuring it can withstand expected interruptions like power outages.

117. In light of the above teachings, a person having ordinary skill in the art would also have had a reasonable expectation of success in applying Hitt's teachings of memory to Kates-711's sensor unit. Indeed, Kates-711 discloses that its controller may be a "conventional programmable microcontroller"; such microcontrollers were well-understood to commonly use a memory to, *e.g.*, track data variables used for control applications. As I have explained in Section IX.A.1 above, the prior art is replete with examples of using memory to store sensor information, which is old and

well-known to a person having ordinary skill in the art. *See* Littrell, [0006]-[0008], [0030], [0033], [0035]; Ehlers, 8:28-34, 17:41-18:36; Cunningham, 31:59-33:3; Garrod, [0029]; and Lareau, [0076]-[0077].

2. Invalidity of Claims 1, 3-8, and 18 Over Kates-711 in view of Hitt

(a) Element [1.d]

118. Element [1.d] recites “a memory, the controller storing a reading of the indicator during the current period in the memory, where the memory stores at least one prior reading of the indicator, the prior reading of the indicator made during a prior period of the polling interval.” This element is met by Kates-711 in view of Hitt.

119. In addition to the teachings from Kates-711 that I discussed above in Section IX.A.2(e), **Hitt discloses a memory and storing a reading of the indicator during the current period in the memory** (*e.g.*, storing “sensor data” “in the memory”), **where the memory stores at least one prior reading of the indicator, the prior reading of the indicator made during a prior period of the polling interval** (*e.g.*, “periodically sampl[ing] the sensor” and “aggregat[ing] [the sensor data] into a local memory for processing and/or transmission”). *See, e.g.*, Hitt (emphasis added):

- **Fig. 2A:**

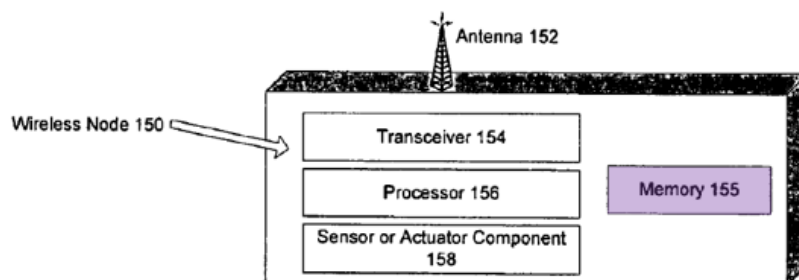


Figure 2A

- [0067] (“In response to the command message, the processor receives the data related to the sensor or the actuator. In one embodiment, the data may be retrieved by initiating a request to the sensor or actuator. In another embodiment, the data may be stored in the memory and the processor retrieves the data from the memory 208.”)
- [0068] (“According to an alternate embodiment of the present invention, a sensor node can periodically sample the sensor and the sensor data is aggregated into a local memory for processing and/or transmission. FIG. 5 is a flow chart illustrating the sensor data processing and routing operation according to one embodiment of the present invention. Referring to FIG. 5, the sensor node is programmed to periodically acquire sensor data (step 502). Then, the sensor data is filtered (step 504) and/or compressed and/or processed (step 506). ... Processing can include statistical analysis (average, median, standard deviation and higher order correlations), linear regression,

linear approximation and other mathematical modeling processes to improve the usability of the data. The processed sensor data is stored in a local memory (step 508).”)

- ***See also* [0046], [0049].**

120. In addition to Kates-711’s teachings, as discussed in Section IX.A.2(e), of the sensor unit performing computations in which “recent” and “less recent” sensor measurements are inputs, Hitt explicitly discloses a “memory” for storing periodically sampled sensor data, which it aggregates in the memory for processing, which may include “statistical analysis,” and transmission to other nodes of the network system. Hitt, [0067]-[0068]. As discussed in Section IX.B.1, a person having ordinary skill in the art would have been motivated to modify Kates-711 with this teaching to advantageously enable the sensor unit device to track prior sensor readings as is needed to carry out Kates-711’s teachings of calculating, e.g., averages using current and prior sensor readings that can then be compared to the current sensor reading. A person having ordinary skill in the art would have further found it obvious to modify Kates-711 with Hitt’s teachings in order to benefit from secure storage of sensor readings from the current period and prior periods that is resilient to possible interruptions like power outages. *See* Section IX.B.1 *supra* (citing Ehlers (Ex. 1007), 9:28-34). *See also* Hitt, [0046], [0049].

(b) Element [1.e]

121. Element [1.e] recites “wherein the transceiver is configured to transmit a most recent reading of the indicator stored in the memory during a period of a transmission interval in response to detecting a change in the sensed condition outside a predetermined range and wherein transmission of the most recent reading of the indicator stored in the memory during the period of the transmission interval is suspended in response to detecting a change in the sensed condition within the predetermined range.” This element is met by Kates-711 in view of Hitt.

122. In addition to the teachings from Kates-711 that I discussed above in Section IX.A.2(f), Hitt discloses a most recent reading of the indicator stored in the memory and retrieved from the memory for processing and/or transmission (*e.g.*, “periodically sampl[ing] the sensor” and “aggregat[ing] [the sensor data] into a local memory for processing and/or transmission”). *See, e.g.*, Hitt (emphasis added):

- **Fig. 2A:**

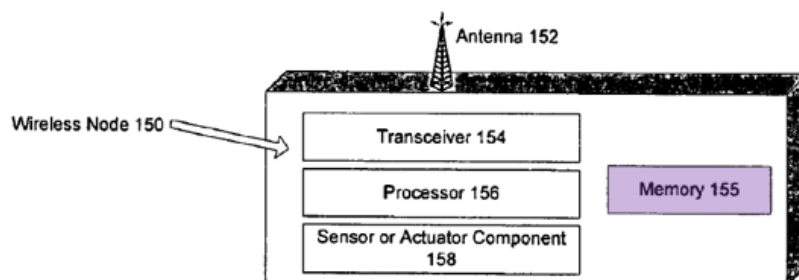


Figure 2A

- [0046] (“In FIG. 2A, a wireless node 150 includes an antenna 152, a wireless transceiver 154, a processor 156 and a node component 158. The wireless transceiver of each wireless node may communicate with a memory 155 that stores a unique transceiver identifier that identifies the wireless network.”)
- [0049] (“In one embodiment, the transceiver circuit, the processor and the memory are integrated in the same housing as the sensor or actuator component.”)
- [0067] (“In response to the command message, the processor receives the data related to the sensor or the actuator. In one embodiment, the data may be retrieved by initiating a request to the sensor or actuator. In another embodiment, the data may be stored in the memory and the processor retrieves the data from the memory 208. The processor may also retrieve the unique address locations of the data from the memory. Then, the processor

formats a transmit signal in response to the command message as described above. *The processor then communicates the transmit signal to the transceiver, which provides the transmit signal to the wireless control system. The transmit signal is then delivered to the intended point*, such as a monitoring node.”)

- [0068] (“According to an alternate embodiment of the present invention, a sensor node can periodically sample the sensor and *the sensor data is aggregated into a local memory for processing and/or transmission.*”)

123. Hitt discloses that sensor data is stored in memory, and the processor retrieves sensor data for processing and/or transmission from that memory. *See* Hitt, [0067]-[0068] and my discussion of element [1.d] above. Because Hitt discloses that all sensor data is stored in the memory, the most recent sensor reading is stored in the memory. As discussed in Section IX.B.1, a person having ordinary skill in the art would have been motivated to modify Kates-711 with Hitt’s teachings of aggregating sensor data in a memory component of the sensor unit for processing and transmission, which would predictably yield a system in which the most recent reading of the indicator is stored in memory before transmission to other parts of the network system if it is found to represent an anomalous condition. As discussed in Section IX.B.1, using memory as a means to store sensor data for later retrieval to be processed and/or transmitted would have been understood by a person having

ordinary skill in the art to advantageously improve the reliability of the sensor system by, for example, protecting against possible data loss in the case of power outages and interruption. *See* Section IX.B.1 *supra* (citing Ehlers (Ex. 1007), 9:28-34).

(c) Claims [5] and [8]

124. **Claim [5] recites “The wireless automation device of claim 1 where the transceiver is configured to transmit the most recent reading of the indicator stored in the memory during a period of the transmission interval in response to detecting a sensed condition beyond a band limit.”** This claim is met by Kates-711 in view of Hitt.

125. **Claim [8] recites “The wireless automation device of claim 1 where the transceiver is configured to transmit the most recent reading of the indicator stored in the memory (*see* [1.e]) in response to an externally-received transmission control signal received over the wireless network.”** This claim is met by Kates-711 in view of Hitt.

126. In addition to the teachings from Kates-711 that I discussed above in Sections IX.A.2(i) and IX.A.2(l), **Hitt further discloses the “most recent reading of the indicator stored in the memory”** in each of these claims for the same reasons that I explained above with respect to claim elements [1.d]-[1.e].

C. Grounds 3-4: Kates-711 in view of Littrell and Kates-711 in view of Hitt and Littrell (Claims 1, 3-8, 14-15, and 18)

1. Overview of Littrell and Motivation to Modify Kates-711 (and Kates-711 in view of Hitt) with Littrell's Teachings

127. Littrell discloses a “method for indicating an alarm condition” to “provide automatic notification[s]” that includes the steps of “measuring a parameter ... that varies over time,” “determining at least one parameter limit as a function of the parameter,” and “comparing the parameter to the parameter limit or limits” so as to “indicate[] an alarm condition when the parameter is outside of a bound set by the parameter limit or limits.” Littrell, Abstract, [0001].

128. Littrell discloses that its parameter limits may be implemented in the form of a band limit that indicates the range of “‘normal’ variation of a parameter” by the provision of an “upper acceptance limit” and “lower acceptance limit” centered around the average value of the parameter. Littrell, [0006], [0015]-[0022]. Littrell further provides that these acceptance limits are calculated (and re-calculated as more data is collected) as a function of measured parameters themselves, using such statistical calculations as averages and standard deviations based on current and prior readings; this accounts for changes in sensor readings over time. Littrell, [0006], [0015]-[0022]; *see also* [0003], [0008], [0023]-[0030]. The functions disclosed by Littrell allow a sensor to differentiate between smaller, normal variations in parameters, which do not need to be transmitted, and a “sudden change”

in values that may indicate “an alarm condition.” Littrell, [0015]. Littrell discloses that the following examples of formulas used to calculate two acceptance limits that together form the band limit within which acceptable parameters fall based on current and prior parameter measurements:

$$“D=average(A)+B\times std_dev(A)+C,” \text{ and}$$

$$“E=average(A)-B\times std_dev(A)-C,”$$

where “A is a value associated with the parameter,” “B” and “C” are constants, “D is a time-varying upper acceptance limit,” “E is a time-varying lower acceptance limit.” Littrell, [0015]-[0022]. “A” may be the parameter value itself or a scaled or offset value of the parameter. Littrell, [0017]. “B” and “C”, the constants, provide configurable variations to the formulas. Littrell, [0018]-[0019], [0024]-[0028]. For example, “B” is the multiplier for the standard deviation of “A” and “affects the sensitivity of the alarm to individual sample variations.” Littrell, [0018], [0024], [0027]-[0028]. In different configurations, “B” may be zero or one. Littrell, [0024], [0028]. “C” is a constant that “controls a minimum acceptable window size” and prevents the window between “D” and “E” from being narrowed to zero. Littrell, [0019], [0025], [0028]. Thus Littrell discloses tracking a band limit in which “D” and “E” are upper and lower limits centered around the average value of the parameter “A”. A person having ordinary skill in the art would have further understood that Littrell’s disclosed band limit varies with time according to an

ongoing dynamic analysis of current and prior readings of the parameter by calculating (and re-calculating) an average and standard deviation of the parameter. Littrell, [0030].

129. Littrell further discloses that its method includes the storage and transmission of timestamps associated with measurements of a parameter from a sensor device to a computer. Littrell, [0032]. Specifically, Littrell discloses that “parameter measurements are time-stamped” at the sensor device when sent to a connected network computer so that, in the case where the computer identifies the measured parameter requires an “alarm indication,” “the time stamp information can be logged” along with such an indication. Littrell, [0032]; Fig. 2. A diagram of a process disclosed by Littrell is shown below in Fig. 1 (emphasis added), where the dashed lines and accompanying parenthetical numbers are included to show the processes and components are attributable to each of: (1) the machine that exhibits operating characteristics subject to alarm conditions when they deviate beyond the acceptable band limit, (2) the sensor and corresponding data acquisition system that sense and acquire parameter measurements representative of the aforementioned operating characteristics, or (3) the computer that processes parameter measurements received from the sensor and data acquisition system to evaluate the measurements with respect to the current alarm limits and raises an alarm when it determines that the alarm limits have been exceeded by the measurements). Littrell,

[0014]-[0022]. The time stamp information would thus have been understood by a person having ordinary skill in the art to be collected as part of the data acquisition process and transmitted from sensor device (2) to computer (3).

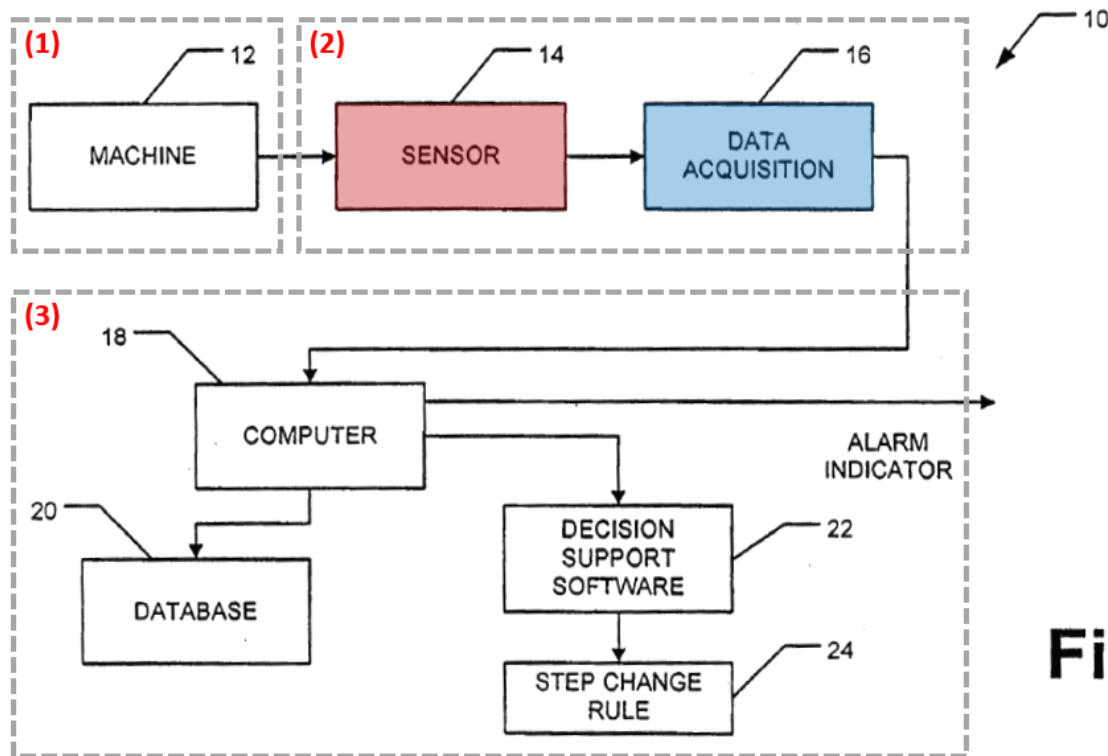
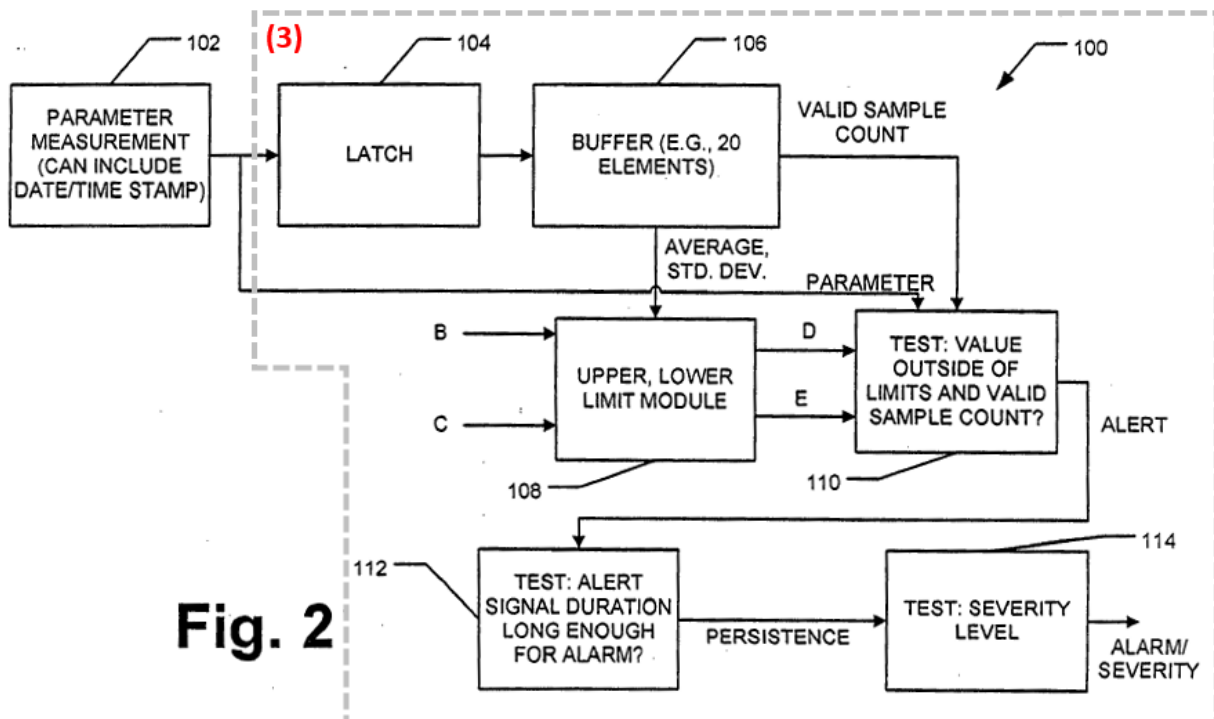


Fig. 1

130. A person having ordinary skill in the art would have understood Littrell's disclosure that "the parameter measurements are timestamped" to further disclose the storage of time-stamps along with their associated measurements when sensor data is measured by sensor 14 and acquired by data acquisition system 16 (which Littrell describes as a "data collection unit" or "computer" that "receives data from one or more sensors 14"). Littrell, [0014]-[0015], [0032], Fig. 2. Moreover, Littrell discloses that the data acquisition system 16 is "networked...to computer

18,” which “executes a program comprising decision support software ... which ... includes a step change rule module 24” that is used to “track a ‘normal’ variation of a parameter” as described above. Littrell, [0014]-[0015]. In the case that computer 18 determines that an alarm should be raised because the data falls outside of the “normal variation” range for the parameter, the computer is disclosed to also “log[]” “the time stamp information” corresponding to the anomalous parameter. Littrell, [0014]-[0015], [0029], [0031]-[0032]. As can be seen in Fig. 2 below (emphasis added), past parameter measurements that are received and latched (i.e., saved) by the computer for use in determining the acceptable range for a parameter includes data and timestamp information. Littrell, [0006]-[0008], [0030].



Taken together, a person having ordinary skill in the art would have understood Littrell as disclosing that the time-stamp information associated with a parameter measurement is included and transmitted with the parameter measurement taken by sensor 14 when transmitted from data acquisition system 16 to computer 18 over the “network.” *Id.*

131. While Littrell discloses the features discussed throughout this section as being present in certain “embodiments” of its disclosure, a person having ordinary skill in the art would have understood, based on these disclosures, that these features comprise optional features that may be combined and included with one another when implementing the disclosed method. Littrell, [0040]. At minimum, a person having ordinary skill in the art would have found it obvious to combine such non-mutually-exclusive features to advantageously obtain all of their individual benefits when the disclosures do not provide any reason that such features may not be used in conjunction with one another.

132. Kates-711, Hitt and Littrell are in the same field as the ’887—sensors, controls, and/or wireless communications; Littrell describes its disclosures as “relat[ing] generally to methods ... that provide automatic notification” in response to measuring a parameter value that is indicative of “problems with machinery ..., manufacturing facilities, and any other appropriate applications.” Littrell, [0001]-[0004],[0039]. *See* Section IX.B.1 (explaining that ’887, Kates-711 and Hitt also

pertain to this field of endeavor). A person having ordinary skill in the art would have also understood Kates-711's, Hitt's and Littrell's disclosures to be reasonably pertinent to the alleged problem(s) identified in the '887—for example, a need to reduce communications over a wireless system. For example, Littrell provides in its disclosures methods by which to “tun[e]... the sensitivity” of the system “to sudden spikes in parameter values.” Littrell, [0039]. *See* Section IX.B.1 (explaining that the '887 patent, Kates-711, and Hitt also address this same problem).

133. While Kates-711 teaches various processes that would teach a person having ordinary skill in the art that the timing data associated with sensed conditions is used, it leaves to the person having ordinary skill in the art the task of determining the details of how to acquire such timing data. For example, Kates-711 discloses that its monitoring computer “maintains a history of humidity readings for various sensor units,” and also that it compares new sensor humidity readings to “a time average of humidity readings,” which must be calculated from stored past measurements. Kates-711, 17:63-67, 17:45-19:14. Kates-711 also discloses that its system can detect water leaks by using a water flow sensor to monitor water flow rates, calculating water usage via these sensed flow rates, and identify “water leaks, by, for example, looking for water flow when there should be little or no flow.” Kates-711, 19:35-55. While, as discussed above in Section IX.A, Kates-711 discloses various thresholds against which to compare new sensor measurements (including

high-low, inner range, and outer range thresholds) and the ability to adjust the thresholds (including by way of particular functions or equations like averaging a number of past sensor readings, which may be optionally time-weighted to give more weight to more recent readings), it leaves to a person having ordinary skill in the art the determination of how specifically to implement such thresholds and adjustments in practice. A person having ordinary skill in the art therefore would have been motivated to modify Kates-711 (and by extension, Hitt) with Littrell.

134. First, a person having ordinary skill in the art would have understood the benefit of improved accuracy of time-based measurements within the system that would result from applying Littrell's teachings of communicating time stamp information along with sensor readings to Kates-711's teachings. As discussed above and in Section IX.A, Kates-711 teaches using a "time history" of past readings collected from a sensor to monitor the relative deviation of current conditions from this history. *E.g.*, Kates-711, 17:45-19:14. Littrell teaches that data collected by a sensor may be time-stamped to indicate the time at which the data was collected and further teaches associating this time-stamp information with the collected data and making it available to computers networked to the sensors and their corresponding data acquisition systems. Littrell, [0014]-[0015], [0029], [0031]-[0032]. Littrell also teaches that parameters are tracked and analyzed for abnormality based on their associated upper and lower limits, which themselves are "time-varying" and "re-

determined” as a statistical function of a certain number of past measurements. Littrell, [0015]-[0022], [0030]-[0031], [0034]-[0038], and Fig. 3 (measuring the length of time a change persists). A person having ordinary skill in the art would have been motivated to use Littrell’s time-related teachings in implementing Kates-711’s time history-based threshold teachings: (1) collecting, storing, and communicating timing data to facilitate computing “time” averages, (2) establishing “time” histories of past measurements of such data, and (3) using these histories in determining when conditions occur that are anomalous in view of past measurements. Indeed, a person having ordinary skill in the art would have understood that storing timing data representative of the time when the sensor data was read was the best way to create and maintain accurate and exact records of sensor data, which would have therefore been useful for providing accurate and exact records for the time histories used in Kates-711 to set thresholds. For example, U.S. Patent Application Publication No. 2005/0270173 to Boaz, which I understand has been designated as Exhibit 1008, discloses methods for remotely reading and collecting data and states that where “data can be data and time stamped,” “an accurate record” may be provided of the monitored data. Boaz, [0019], [0060]. As another example, Ehlers discloses that the maintenance of such an accurate record of historical data is “desirably retained even during power outages and interruptions” and describes several data structures that may be used to store detailed time stamp

information along with measured data. Ehlers, 9:28-34, 13:8-41, *see also* 7:19-24, 7:31-36. Therefore, a person having ordinary skill in the art would have been motivated to, as taught by **Littrell**, maintain and also transmit such timing data and corresponding sensor readings together to beneficially provide accurate time representations of the sensor data for use in Kates-711's disclosed processes.

135. Second, Kates-711 broadly teaches the setting of various thresholds against which measured data is compared to evaluate possible abnormality (including high-low, inner range, outer range, as described above in Section IX.A) and the ability to adjust these thresholds (for example, as an average of a number of sensor readings, including by giving more weight to more recent readings than less recent readings) to determine the existence of anomalous conditions. Kates-711, 13:16-26, 19:64-20:9. *See* Sections IX.A.2(g)-IX.A.2(h). Littrell provides additional mathematical details, including a formula for time-varying range centered around the average value of some number of past sensor readings and the number of past values to include in such an average, that a person having ordinary skill in the art would have found obvious to use in implementing the types of thresholds taught by Kates-711. Littrell, [0015]-[0030]. A person having ordinary skill in the art would have therefore been motivated to modify Kates-711 by using Littrell's provided formula described above (or obvious variations of this formula), to

advantageously implement Kates-711's adjustable thresholds and dynamically calculate upper and lower limits based on a time-based average.

136. Third, adjustable thresholds, like those disclosed by both Kates-711 and Littrell, allow sensors to maintain the right amount of sensitivity to variations in monitored values and “avoid false alarms” that commonly occur when static thresholds are used. Kates-711, Abstract, 1:49-54. This flexibility also allows such a monitoring system to “adjust to ambient conditions, aging of components, and other operational variations while still providing a relatively sensitive detection capability.” Kates-711, 3:62-67. Such dynamic thresholding allows for the thresholds to be tuned “optimally in all conditions” instead of simply recycling a passive threshold throughout the entire monitoring process. Littrell, [0002]. Since Kates-711 does not provide specific formulas for adjusting thresholds, a person having ordinary skill in the art would have turned to Littrell's disclosures of exemplary formulas that may be used to adjust the thresholds and evaluate sensor values for abnormality to effectuate Kates-711's teachings. Such application of a known technique like Littrell's specific formula for adjusting thresholds to a known device like Kates-711's sensor units, which generally refer to the use and adjustment of thresholds) to yield a predictable result (that is, the varying of the sensor value thresholds used to determine whether a sensor reading is anomalous according to

Littrell's disclosed formula) would have been obvious to a person having ordinary skill in the art.

137. In light of the above teachings, a person having ordinary skill in the art also would have had a reasonable expectation of success in applying Littrell's teachings of timing data and adjustable thresholds that are calculated using time-related functions based on a time-varying set of prior collected sensor data to Kates-711's sensor system (alone or in view of Hitt, which further explicitly teaches storing such data in the sensor unit memory). Indeed, Kates-711 already implicitly teaches the use of timing data in its system by disclosing the calculation of "time-weighted" averages, teaching that sensor data is associated with and accompanied by other related information like ID codes of sensor units, and that its sensor unit uses equations to perform calculations of, *e.g.*, averages. Kates-711, 4:20-22, 4:65-5:6, 5:21-23, 8:33-38, 14:33-15:3, 20:1-9, 21:6-9, 21:47-53. As further evidence that this would have been obvious to a person of ordinary skill in the art based on Littrell, Boaz also discloses time stamping sensor data to provide an accurate record (Boaz, [0019], [0060]); Lareau discloses monitoring sensor information against thresholds and, when exceeded, communicating sensor data and timing data (Lareau, [0109]); and Kates-528 discloses evaluating sensor data against various thresholds, which may be pre-programmed and/or received via instructions (Ex. 1021, 9:54-67). A person having ordinary skill in the art would therefore have found it obvious and

straightforward to store and transmit the timing data along with its associated sensor data and to implement Littrell's exemplary equations in dynamically adjusting sensor value thresholds based on collected data.

2. Littrell's Further Disclosures of "Information Associated Reading of the Indicator" in Element [1.e] (Claims 1, 3-8, and 18)

138. To the extent additional disclosure of "information associated with the reading of the indicator" [1.e] is required, Littrell discloses communicating information associated with the reading of the indicator. *See, e.g.,* Littrell (emphasis added):

- [0014] ("A data acquisition system 16 receives data from the one or more sensors 14. Data acquisition system 16 can comprise, for example, networked hardware, a portable data collection unit, an internal computer or controller, or a data acquisition card in a computer system. Data acquisition system 16 is networked in some configurations to a computer 18, which in some configurations, includes or otherwise has access to a database 20.")
- [0015] ("Step change rule module 24 is configured to track a "normal" variation of a parameter. A sudden change in this parameter will cause decision support software 22 to instruct computer 18 to raise an alarm indication. Alarm indication 18, in some configurations of the present invention, activates an audible or visual alarm device or a plurality or

combination of alarm devices. Step change rule module 24 provides an upper and a lower bound for each parameter tracked by the one or more sensors 14. For example, one time-varying parameter is tracked utilizing limits D and E written as follows:

$$D = \text{average}(A) + B \times \text{std_dev}(A) + C, \text{ and}$$

$$E = \text{average}(A) - B \times \text{std_dev}(A) - C,$$

where:

A is a value associated with the parameter (for example, the parameter value itself, or a scaled and/or possibly offset value of the parameter), which in some configurations includes a sample delay;

B is a constant multiplier;

C is a constant added to prevent a width of a window of acceptance between D and E from being narrowed to zero as a result of the standard deviation of A approaching or equaling zero;

D is a time-varying upper acceptance limit; and

E is a time-varying lower acceptance limit; also

average(A) and std_dev(A) are the average value of A over time and a standard deviation of A over time, respectively.”)

- [0029] (“Thus, in some configurations 100 of the present invention and referring to FIG. 2, a parameter measurement 102 is latched by latch 104 at suitable intervals, e.g., once every four seconds, or at any other interval

suitable for observing and monitoring the industrial process. Latch 104 feeds a FIFO (first-in, first-out) buffer 106, which holds a predetermined number of values of the latched parameter. For example, and not by way of limitation, some configurations of the present invention include a 20 element FIFO, which holds the last 20 latched values of the parameter. Other configurations hold a different number of latched values, and in some configurations of the present invention, the size of FIFO buffer 106 is configurable to allow tuning of the sensitivity to sudden spikes in the parameter value. ... In some configurations of the present invention, the statistical functions and alert limits are redetermined each time a new value of the parameter is latched and shifted into buffer 106.”)

- [0032] (“In configurations in which parameter measurements are time-stamped, the time stamp information can be logged when an alarm indication is raised.”)
- [0033] (“Some configurations of the present invention inhibit an alarm signal unless a sufficient number of valid samples of the parameter are held in buffer 106. Also, some configurations of the present invention utilize a value of a parameter latched by latch 104 rather than a current measurement in the test to determine whether the parameter is out of bounds.”)

139. As I explained above in Section IX.C.1 and will further reference below with respect to claims 14 and 15, Littrell discloses that when sensor data is generated, that sensor data is time-stamped with a time stamp corresponding to the time the data was generated. Littrell, [0032]. The time-stamped data is then communicated, together with the time stamp itself, to computers networked to the sensors and their data acquisition systems. Littrell, [0014]-[0015], [0029], [0031]-[0032], Fig. 1. Because both the time stamp, and the corresponding sensor data itself, are communicated, this meets the claim element reciting “information associated reading of the indicator” under any reasonable interpretation because both the “information” (time stamp) and the reading (sensor information that is stamped) are communicated together.

140. As I explained above in Section IX.C.1, a person having ordinary skill in the art would have been motivated to modify Kates-711 with Littrell’s teachings of time-stamping sensor data and communicating such time-stamped sensor data because this would advantageously allow the system to effectuate Kates-711’s teachings of performing time-based processing of data using accurate time information for the sensor data. This combination therefore yields a system in which Littrell’s time stamp information is communicated along with readings of the indicator from Kates-711’s sensor, and such data is used to facilitate more accurate analysis of that data.

141. Accordingly, Kates-711 in view of Littrell, as well as Kates-711 in view of Hitt and Littrell renders obvious claim 1, as well as dependent claims [3]-[8] and [18] that depend therefrom, for the reasons set forth here as well as in Sections IX.A-IX.B.

3. Littrell’s Further Disclosures both that “An Upper Limit and a Lower Limit of the Predetermined Range May Be Varied” and of a “Band Limit” (Claims 3-7)

142. Kates-711, as discussed above in Section IX.A, already discloses varying a threshold against which current measurements are compared based on “an average of a number of sensor measurements,” thus meeting the requirements of Claim 3. *See* Section IX.A.

143. **To the extent additional disclosure is needed, Littrell further discloses that an upper limit** (e.g., “upper acceptance limit”) **and a lower limit** (e.g., “lower acceptance limit”) **of the predetermined range may be varied** (e.g., “redetermin[ing]” limits “utilizing the determined statistical functions to determine one or more alert limits”). *See, e.g.,* Littrell (emphasis added):

- [0003] (“The method includes measuring a parameter of the industrial process that varies over time and determining at least one parameter limit as a function of the parameter and also varying over time. The method further includes comparing the parameter to the parameter limit or limits and indicating an alarm condition when the parameter is outside of a bound set

by the parameter limit or limits when the parameter is compared to the parameter limit or limits.”)

- [0006] (“The method includes measuring a time-varying parameter of the industrial process, latching the parameter and buffering the latched parameter in a FIFO (first-in, first-out) buffer, and determining statistical functions of values of the buffered parameter stored in the FIFO buffer. The method further includes utilizing the determined statistical functions to determine one or more alert limits, comparing value of the parameter to the one or more alert limits; and indicating an alarm dependent upon the parameter being outside a bound set by the one or more alert limits.”)
- [0007] (“Furthermore, some configurations of the present invention provide an apparatus for indicating an alarm condition in an industrial process. The apparatus is configured to latch a varying parameter value of the industrial process and buffer successive latched parameter values in a FIFO (first-in, first-out) buffer, determine statistical functions of values of the buffered parameter stored in the FIFO buffer, and utilize the determined statistical functions to determine one or more alert limits. The apparatus is further configured to compare value of the parameter to the one or more alert limits, and indicate an alarm dependent upon the parameter being outside a bound set by the one or more alert limits.”)

- [0008] (“Some configurations of the present invention provide a medium having recorded thereon machine-readable instructions configured to instruct a computer to latch a varying parameter value of an industrial process and buffer successive latched parameter values in a FIFO (first-in, first-out) buffer and determine statistical functions of values of the buffered parameter stored in said FIFO buffer. The instructions are also configured to instruct a computer to utilize the determined statistical functions to determine one or more alert limits, compare value of the parameter to the one or more alert limits, and indicate an alarm dependent upon the parameter being outside a bound set by the one or more alert limits.”)
- [0015] (“Step change rule module 24 is configured to track a “normal” variation of a parameter. A sudden change in this parameter will cause decision support software 22 to instruct computer 18 to raise an alarm indication. Alarm indication 18, in some configurations of the present invention, activates an audible or visual alarm device or a plurality or combination of alarm devices. Step change rule module 24 provides an upper and a lower bound for each parameter tracked by the one or more sensors 14.”)
- [0029] (“Thus, in some configurations 100 of the present invention and referring to FIG. 2, a parameter measurement 102 is latched by latch 104 at

suitable intervals, e.g., once every four seconds, or at any other interval
suitable for observing and monitoring the industrial process. Latch 104
feeds a FIFO (first-in, first-out) buffer 106, which holds a predetermined
number of values of the latched parameter. For example, and not by way of
limitation, some configurations of the present invention include a 20 element
FIFO, which holds the last 20 latched values of the parameter. Other
configurations hold a different number of latched values, and in some
configurations of the present invention, the size of FIFO buffer 106 is
configurable to allow tuning of the sensitivity to sudden spikes in the
parameter value. (For example, a longer buffer is less sensitive to short
spikes in the parameter value.) Some configurations of the present invention
determine one or more statistical functions (e.g., standard deviation and
average) of the latched values for each interval and provide this information
to a limit module 108, which utilizes the one or more determined statistical
functions to determine one or more alert limits. Module 108 may also utilize
configurable inputs, as described in conjunction with the various equations
disclosed above. In some configurations of the present invention, the
statistical functions and alert limits are redetermined each time a new value
of the parameter is latched and shifted into buffer 106. Also, in some
configurations, the statistical values are not necessarily standard deviation

and mean, but may include other suitable statistical measures, such as median or mode, or another measure of parameter variance.”)

- *See also* [0016]-[0023].

144. For example, Littrell discloses varying a threshold by using “statistical functions” to calculate such “upper” and “lower” “acceptance limits”—which are limits of thresholds—using time-based averages and standard deviations of variations of a “parameter tracked by ... sensors.” Littrell, [0006], [0015]-[0022]. These acceptance limits are calculated as a function of several “latched” values – that is, prior measured values of the parameter – using such statistical calculations as averages and standard deviations; these acceptance limits are “redetermined” as new data is collected and latched and older latched values unlatched. Littrell, [0029]. As I have discussed in Section IX.C.1, Littrell’s disclosure includes a band limit with varying upper and lower limits that allows a sensor to differentiate between smaller, normal variations in parameters, which do not need to be transmitted, and a “sudden change” indicating an alarm condition to be communicated. Littrell, [0015], [0023], [0028].

145. As discussed in Section IX.C.1, a person having ordinary skill in the art would have been motivated to modify Kates-711 with Littrell’s detailed teachings of varying the range of thresholds based on averaging a set of the most recent measurements, understanding that it would be advantageous to adapt to changes in

conditions and maintain proper sensitivity to changes in order to avoid false alarms. Kates-711 in view of Littrell and in view of Hitt and Littrell therefore further render obvious claim 3, and by extension, claims 4-7, which depend from claim 3. *See also* Sections IX.A-IX.B.

4. Claim [14]

146. **Claim [14] recites “The wireless automation device of claim 1 where the memory stores timing data associated with the most recent reading and the at least one prior reading of the indicator.”** This claim is met by both Kates-711 in view of Littrell and Kates-711 in view of Hitt and Littrell.

147. **Kates-711, alone and alternatively in view of Hitt, discloses and at least renders obvious that the memory stores the most recent reading and the at least one prior reading of the indicator.** *See* [1.d] in Sections IX.A.2(e), IX.B.2(a).

148. **Littrell discloses timing data associated with readings of the indicator** (*e.g.*, “parameter measurements are time-stamped”). *See, e.g.*, Litrell (emphasis added):

- **Fig. 1:**

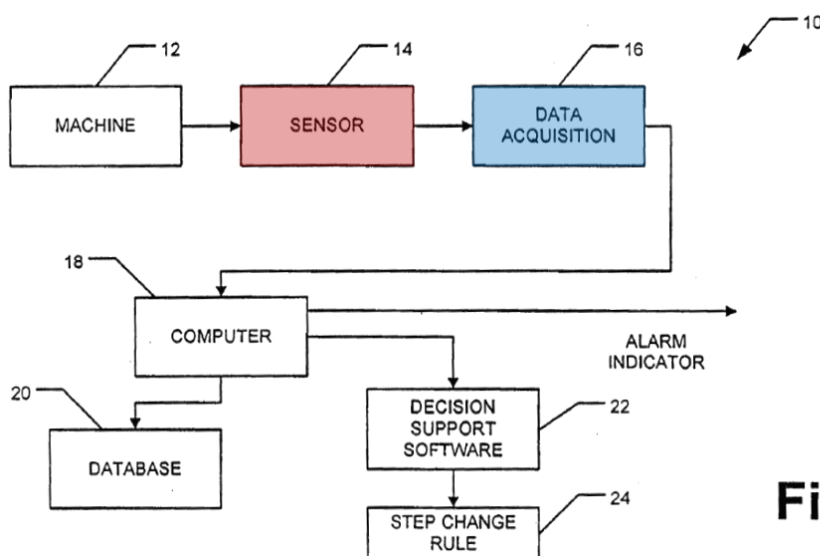


Fig. 1

- [0014] (“In some configurations 10 of the present invention and referring to FIG. 1, an industrial machine or apparatus 12 (hereinafter “machine”) has an operating characteristic that is subject to alarm conditions.... The operating characteristic subject to alarm conditions is sensed by one or more sensors 14. A non-exhaustive list of operating conditions that can be sensed by the one or more sensors 14 include pressure, temperature, position, acceleration, velocity, power, current, and flow.... A data acquisition system 16 receives data from the one or more sensors 14. Data acquisition system 16 can comprise, for example, networked hardware, a portable data collection unit, an internal computer or controller, or a data acquisition card in a computer system. Data acquisition system 16 is networked in some configurations to a computer 18, which in some configurations, includes or otherwise has access to a database 20. Computer 18 executes a program comprising decision

support software or firmware 22, which, in turn, includes a step change rule module 24. In some configurations, database 20 contains variables that can be used for adjusting the sensitivity of step change rule module 24 in accordance with the type of machine 12 being monitored and the time—varying parameter or parameters measured by sensor 14.”)

- **[0015]** (“Step change rule module 24 is configured to track a “normal” variation of a parameter. A sudden change in this parameter will cause decision support software 22 to instruct computer 18 to raise an alarm indication. Alarm indication 18, in some configurations of the present invention, activates an audible or visual alarm device or a plurality or combination of alarm devices. Step change rule module 24 provides an upper and a lower bound for each parameter tracked by the one or more sensors 14. For example, one time-varying parameter is tracked utilizing limits D and E written as follows:”)
- **[0032]** (“In configurations in which parameter measurements are time-stamped, the time stamp information can be logged when an alarm indication is raised.”)

149. In addition to Kates-711’s and Hitt’s teachings of storing recent and prior readings of the indicator in memory discussed above in Sections IX.A-IX.B, Littrell also discloses storing and transmitting timestamps of parameter

measurements along with the measurements themselves. Littrell, [0032]. As discussed in Section IX.C.1, Littrell discloses that time-stamp information associated with a measurement is maintained and stored with the measurement from the time the sensor data is taken by sensor 14 and acquired by data acquisition system 16. Littrell, [0014], [0032], Fig. 2. The time stamp is stored with the associated measurement because it is disclosed that this time stamp is transmitted along with the sensor data to computer 18 for analysis of the data relative to the predetermined normal range for the sensor value. Littrell, [0014]-[0015], [0030], [0032], Fig. 1. When the computer detects an alarm condition (i.e., that the sensor data is outside of the range the system has calculated to be normal), the time stamp associated with this anomalous data reading is logged. Littrell, [0032].

150. As discussed above in Section IX.B.1, a person having ordinary skill in the art would have been motivated to modify Kates-711 in view of Hitt with Littrell's teaching of storing and transmitting timing data associated with a sensor reading, since this would provide accurate time representations of the sensor data to effectuate Kates-711's timing-based processes. Moreover, a person having ordinary skill in the art would have appreciated that this timestamp information is useful to the ultimate goal of these three references, since it would allow the alerted party to understand exactly when the anomalous condition was first detected and understand the duration of a possible unusual or undesirable event

5. Claim [15]

151. **Claim [15] recites “The wireless automation device of claim 1 where the transceiver is configured to transmit the timing data.”** This claim is met by both Kates-711 in view of Littrell and Kates-711 in view of Hitt and Littrell.

152. **Littrell discloses transmitting the timing data** (*e.g.*, “parameter measurements are time-stamped” at sensor 14 and/or data acquisition system 16, and “the time stamp information can be logged when an alarm indication is raised” at computer 18).

153. *See* my discussion for claim [14]. In addition to Kates-711’s teachings of transmitting recent and prior readings of the indicator discussed for element [1.e], Littrell discloses the transmission of associated timestamps along with parameter measurements which may be logged in the case that such measurements are outside of the acceptable range, as discussed in Section IX.C.1. Littrell, [0014]-[0015], [0032]. As discussed for claim [14] and in Section IX.C.1, a person having ordinary skill in the art would have been motivated to modify Kates-711 with this teaching of transmitting the stored timing data associated with a parameter measurement in order to provide accurate time representations of the sensor data in implementing Kates-711’s timing-based processes. Such a transmission of timing data along with sensor data would have been understood by a person having ordinary skill in the art to have the obvious benefit of conveying to the alerted recipient the exact time at which an

anomalous condition began in furtherance of Kates-711's purpose of "alerting ... responsible parties[]" to a potential problem detected by the sensor system." Kates-711, 1:65-2:2.

D. Grounds 5-8: Kates-505 (Claims 1, 3-8, and 18), Kates-505 in view of Hitt (Claims 1, 3-8, and 18), Kates-505 in view of Littrell (Claims 1, 3-8, 14-15, and 18), and Kates-505 in view of Hitt and Littrell (Claims 1, 3-8, 14-15, and 18)

154. I have been asked to consider whether my opinions would change if I relied on Kates-505 instead of Kates-711. Because Kates-505 contains the same core critical disclosures that I rely upon for my opinions, my same opinions rendered above in Sections IX.A-IX.C also apply to grounds based on Kates-505 instead of Kates-711.

1. Kates-505 Contains Substantially Similar Disclosures to Kates-711

155. Both **Kates-711** and **Kates-505** discloses a "wireless sensor system that provides an extended period of operability without maintenance" using "sensor units [that] detect[] an anomalous condition" and "communicate[] with [a] base unit and provide[] data regarding the anomalous condition." Kates-505, 1:41-2:3. Indeed, based on a redline comparison of the specifications of the two references, nearly all of the core critical disclosures that I have cited above with respect to Kates-711 also appear in Kates-505. *See* Ex. 1026 (redline comparison).

156. Each of the disclosures that appear in Kates-711 and not in Kates-505 does not materially impact my opinion that the Challenged Claims are unpatentable. For example, while in Grounds 1-4 I have cited several teachings from Kates-711 relating to an “adjustable threshold,” including certain teachings that do not appear in Kates-505 (I have referred to these teachings below as “Adjustable Threshold Disclosures”), Kates-505 nonetheless already discloses calculating a humidity threshold based on a “time average of humidity readings”:

In one embodiment, the sensor unit 102 transmits humidity data when it determines that the humidity data fails a threshold test. ... In one embodiment, the baseline humidity is computed at least in part as a time average of humidity readings from a number of humidity sensors. In one embodiment, the baseline humidity is computed at least in part as a time average of humidity readings from a humidity sensor.

Kates-505, 15:27-44, *see also* 16:27-42 (describing using water flow measurements over time to detect changes in water flow). Accordingly, while Kates-711 does include additional teachings of, for example, limits of a predetermined range that may be “varied” as recited in claim 3, Kates-505 already includes teachings of varying a threshold, including the above-quoted teaching of calculating such thresholds based on a “time average” of humidity readings; because such readings vary over time, this discloses that the threshold is varied based on the same logic that I explained above in Section IX.A.2. These disclosures are thus sufficient to not

only render obvious, but affirmatively disclose, adjustable thresholds for the same reasons explained above for Grounds 1-4.

157. Additionally, while Kates-711 also explicitly discloses an HVAC unit (*see, e.g.*, Kates-711, Fig. 2) (indicated below as “HVAC Disclosures”), the Challenged Claims are not limited to HVAC applications. Nonetheless, Kates-505 discloses a sensor that measures conditions including “temperature” and “humidity,” including using both rate-of-rise thresholds as well as value-based thresholds. Kates-505, 1:13-36, 1:60-2:8, 3:20-32, 4:54-64, 6:59-64, 8:44-9:1, 13:10-19, 16:7-26. For example, Kates-505 teaches that a high “rate-of-rise” of temperature is used to detect emergency conditions such as a fire, and that sensors therefore will send “temperature rate of rise” information. *Id.* Likewise, in the context of humidity, a humidity sensor used in combination with such a temperature sensor to monitor fungal growth is also used to detect a water leak based on a “relatively sudden increase in humidity as compared to a baseline or reference humidity.” Kates-505, 15:36-16:26. Accordingly, to the extent any of my discussions of Kates-711 above address the use of sensors measuring temperature (*e.g.*, higher or lower temperature thresholds), the same reasoning applies to measurements based on humidity (*e.g.*, higher or lower humidity thresholds) as taught in Kates-505.

158. My reasoning above with respect to the motivation to combine Kates-711 with other references also applies equally to Kates-505. Specifically, a person

having ordinary skill in the art would have been motivated to modify Kates-505 with Hitt (Ground 6) and further with Littrell (Grounds 7-8) for the same reasons as set forth above with respect to Kates-711. Kates-505 is in the same field as Kates-711 (as well as the '887, Hitt, and Littrell)—as reflected in their overlapping disclosures. *See* Kates-505, 9:61-63 (same disclosure of relevant field); Sections IX.A-IX.C. And because of the Kates-711 disclosures that are common with the Kates-505 disclosures, a person having ordinary skill in the art would have been motivated to modify Kates-505 with the same teachings from Hitt and Littrell for the same reasons discussed in Sections IX.B.1 and IX.C.1.

159. Accordingly, as set forth in the next section, Kates-505 alone (Ground 5), in view of Hitt (Ground 6), Littrell (Ground 7), and/or Hitt and Littrell (Ground 8) renders obvious the Claims.

2. Chart Comparing Kates-711 with Kates-505

160. As summarized in the chart below, I conclude that Kates-505 contains disclosures that are substantially identical to the teachings from Kates-711 that are cited in support of Grounds 1-4 (Sections IX.A-IX.C), and the Claims are therefore rendered obvious under Grounds 5-8 by the same reasoning as set forth in the previous sections of this declaration. The last column of the table below addresses differences in cited disclosures between the two references. Differences that have no bearing on the reasoning discussed for Grounds 1-4 are indicated as “Non-Material.”

Grammar and spelling differences are reflected in a redline comparison between the Kates-711 and Kates-505 references, which I understand has been designated as Exhibit 1026, and are not addressed in the chart below.

<u>Claim</u>	<u>Kates-711</u>	<u>Kates-505</u>	<u>Differences</u>
[1.pre]	Fig. 2	Fig. 2	HVAC Disclosures.
	Abstract	Abstract	Non-Material.
	1:6-11	1:6-10	Non-Material.
	4:35-48	1:57-2:3	
	5:30-33	2:54-56	Non-Material.
	6:6-19	3:33-47	
	7:45-48	5:19-22	
	7:45-8:42	5:19-6:16	Non-Material.
	11:7-10	8:52-55	
	12:47-51	9:30-34	
	13:8-28	9:55-10:9	
	15:45-16:35	12:27-13:19	
	16:36-17:44	13:14:31	
	18:37-59	15:27-50	
	16:56-17:2	13:41-55	
	19:35-21:36	16:27-56	Adjustable Threshold Disclosures.
[1.a]	Fig. 1	Fig 1	Non-Material.
	Figs. 2-3	Figs. 2-3	HVAC Disclosures.
	Fig. 5	Fig. 5	
	5:21-25	2:43-48	

	6:29-30	3:58-60	Non-Material.
	11:30-34	9:9-14	
	12:26-30	6:37-40	
	12:47-51	9:30-34	
	13:58-61	10:39-42	
	14:15-24	10:63-11:5	Non-Material.
[1.b]	Fig. 2	Fig 2	HVAC Disclosures.
	4:35-53	1:57-2:8	
	7:13-23	4:54-64	
	7:60-8:5	5:34-46	
	10:61-63	8:38-40	
	12:47-51	9:30-34	
	12:66-13:9	9:46-56	
	13:8-14	9:55-61	
	15:50-16:7	12:32-57	
	16:31-32	13:10-16	
	17:42-19:14	14:29-16:6	
	19:46-53	16:28-33	
	20:1-49, 21:1-5, 21:16	—	Adjustable Threshold Disclosures.
[1.c]	Fig. 2	Fig 2	HVAC Disclosures.
	Fig. 7	Fig. 7	
	5:18-23	2:40-46	
	7:60-8:12	5:34-53	
	8:30-42	6:4-16	
	9:43-50	7:18-25	
	11:16-22	8:62-9:1	

	12:47-51	9:30-34	
	12:62-66	9:42-46	
	13:7-23	9:55-10:3	
	13:26-28	10:7-9	
	13:57-14:5	10:39-53	
	15:50-16:7	12:32-57	
[1.d]	4:17-34	—	Adjustable Threshold Disclosures.
	4:56-64	2:12-20	
	8:43-63	6:17-36	
	12:62-66	9:42-46	
	15:50-16:7	12:32-57	
	19:64-20:49 21:1-16	—	Adjustable Threshold Disclosures.
[1.e]	Fig. 7	Fig. 7	
	4:6-9	1:46-49	
	4:39-42	1:61-64	
	5:12-16	2:34-38	
	7:63-8:5	5:37-46	
	8:23-29	5:64-6:3	
	13:8-23	9:55-10:3	
	13:14-16	9:61-63	
	13:16-23	9:63-10:3	
	13:23-26	10:3-7	
	15:50-16:4	12:32-54	
	18:39-41	15:29-31	
	19:64-20:44 20:50-59	—	Adjustable Threshold Disclosures.

[3]	13:16-26	9:64-10:5	
	Abstract 1:46-54 3:62-67 4:17-34 19:64-20:9 20:51-59 21:49-53	—	Adjustable Threshold Disclosures.
[4]-[7]	19:64-20:9	—	Adjustable Threshold Disclosures.
[8]	Fig. 1	Fig 1	Non-Material.
	4:49-53	2:4-8	
	4:56-64	2:12-20	
	5:12-17	2:34-39	
	6:57-63	4:31-38	
	8:5-9	5:46-50	
	8:13-19	5:54-63	
	8:23-29	5:64-6:3	
	10:61-65	8:38-42	
	13:26-28	10:7-9	
	16:21-26	13:5-9	

[14]- [15]	Abstract	—	Adjustable Threshold Disclosures.
	1:46-54		
	3:62-67		
	4:20-22		
	4:65-5:6		
	19:64-20:9		
	21:6-9		
	21:47-53		
	5:21-23	2:43-46	
	8:33-38	6:7-12	
	13:16-21	9:64-10:5	
	14:33-15:3	11:14-51	
	17:63-67	14:51-55	
	17:45-19:14	14:32-16:6	
	19:35-55	16:27-37	
[18]	4:3-9	1:44-49	
	4:35-39	1:57-61	
	4:46-53	2:1-8	
	12:66-13:7	9:46-56	

E. Grounds 9-12: Kates-505 in View of Mueller (Claims 1, 3-8, and 18), Kates-505 in View of Mueller and Hitt (Claims 1, 3-8, and 18), Kates-505 in View of Mueller and Littrell (Claims 1, 3-8, 14-15, and 18), and Kates-505 in View of Mueller, Hitt, and Littrell (Claims 1, 3-8, 14-15, and 18)

1. Overview of Mueller and Motivation to Modify Kates-505 (and Kates-505 in view of Hitt and/or Littrell) with Mueller's Teachings

161. Mueller discloses the use of “multiple remote sensors [that] transmit[] temperature information to a thermostat.” Mueller, Abstract. Mueller discloses that its sensors automatically transmit temperature information upon “a sensed change in temperature,” which helps in “reducing or eliminating transmission interference and providing increased user control.” Mueller, Abstract, 1:8-11.

162. Mueller discloses one or more remote temperature sensors that are configured to transmit sensed data to a controlling thermostat that displays the transmitted data. Mueller, 3:18-31, 5:19-23, 6:62-7:3, 8:63-66. The sensors take temperature measurements at variable time intervals to randomize data transmission and minimize transmission collisions. Mueller, 8:67-9:6. Moreover, such transmission of data from sensors to the controlling thermostat when “the new sensed temperature is different by a pre-defined amount from a previous transmitted temperature.” Mueller, 2:16-21, 2:37-49, 8:67-9:6, 12:5-7. For example, transmission may only occur if a current sensed temperature is determined to differ

by “more than $\frac{2}{16}^{\circ}$ F” from a previously sensed and transmitted temperature. Mueller, 2:43-49, 9:3-6, 11:61-65.

163. Kates-505, Hitt, Littrell, and Mueller are in the same field as the ’887 – sensors, controls, and/or wireless communications – and reasonably pertinent to the alleged problem(s) identified in the ’887 patent, namely, a need to reduce communications over a wireless system in the context of a sensor system. *See* §§IX.B.1, IX.C.1, IX.D.1; Mueller, 1:40-49, 1:61-2:61 (minimizing wireless transmissions by transmitting “only on a predetermined temperature change”).

164. Kates-505 teaches that detected changed sensor values may be selectively transmitted when they exceed different thresholds (*e.g.*, the value falls outside of a high-low threshold or inner range threshold), and not transmitting when they fall within a normal range (*i.e.*, values that do not differ significantly from previously sensed value). Kates-505, 1:57-2:3 (sending “anomalous” “quantitative measured data (*e.g.*, ... temperature rate of rise, etc.”), 13:16-19 (detecting “rapid temperature rise”), 13:28-32 (detecting a severe leak by “measuring the rate of rise in the water level”), 9:61-10:36, 15:27-29. Mueller further teaches transmitting sensed data to other parts of a network upon detection of a change in sensor value beyond a specified amount. Mueller, 2:43-49, 9:3-6, 11:61-65. A person having ordinary skill in the art would have been motivated to modify Kates-505’s threshold teachings, which describe using value-based thresholds, by adding Mueller’s

teaching of determining whether to transmit data based on a change in a sensor value relative to a prior sensor reading; this results in a system that uses both value-based thresholds and rate-of-change thresholds for a sensor value, for several reasons, discussed below.

165. First, transmitting sensor readings in response to meaningful changes enhances the responsiveness of the automation system to emergency conditions while mitigating the risk of over-notification. Kates-505 teaches that high rates-of-change between measurements may indicate the existence harmful conditions that require immediate attention such as fires and gas leaks or water leaks. Kates-505, 1:57-2:3, 3:20-30, 5:20-33, 13:20-59, 15:51-16:6. A person having ordinary skill in the art would therefore have been motivated to modify Kates-505 to use a change in value—for example, detecting the possibility of a harmful ambient condition when the sensed condition varies more than a predetermined amount from a prior sensed value as taught by Mueller. The result would have been well-understood to be a change-of-value threshold that prompts the sensor to transmit a most recent sensor reading upon detection of such a significant variation in the sensed condition. Together, this combination would have been understood to yield a system that responds both to sensed values that exceed value-based thresholds (for example, temperature setpoints specified by a user) and alerts about the rate-of-change of the sensed condition (for example, temperature rate-of-change thresholds where the

magnitude of change between proximately sensed conditions may indicate an emergency event, such as a fire). By implementing the system using both types of thresholds, the system is therefore able to use the same sensors for the standard operation of the device, as well as to detect anomalous emergency conditions.

166. Second, it was well understood that conditioning the transmission of sensor readings to occur upon detection of a change beyond a predetermined range would improve the reliability of an automation system by reducing wireless noise and interference that would result from excessive communications of non-notable sensor information. Mueller teaches the use of multiple wireless devices, which are much like the multiple sensor units taught by Kates-505, to advantageously reduce installation costs associated with wired devices while allowing for more complex control systems. Mueller, 1:15-49, 2:6-8. However, Mueller also notes that adoption of such a system would ordinarily increase the well-known risk of wireless transmission interference and collisions due to the larger number of transmitting devices within the network. *Id.* Mueller teaches that limiting transmission of sensed conditions to occur upon detection of changes in a sensed condition that exceed a predetermined threshold can mitigate this issue of transmission interference and collisions by reducing network traffic to more meaningful communications. Mueller, 2:16-21, 2:37-49, 8:67-9:6, 11:61-12:7. A person having ordinary skill in the art would therefore have been motivated to modify Kates-505 to transmit a most

recent sensor reading in response to detecting a meaningful change—for example, a change of the kind taught by Mueller in which the most recent sensor reading differs more than a predetermined amount from a prior sensor reading—to mitigate such interference.

167. In light of the above teachings, a person having ordinary skill in the art also would have had a reasonable expectation of success in applying Mueller’s teachings of detecting meaningful changes in the sensed condition based on calculated differences between proximate sensor readings to Kates-505’s sensor system (alone as discussed in Section IX.D or in view of Hitt, which provides further teachings of storing sensor reading data in memory as discussed in Sections IX.B and IX.D, and/or Littrell, which further teaches band limit thresholds and time stamping as discussed in Sections IX.C-IX.D), to selectively transmit sensor data determined to be significantly anomalous such that notification is appropriate. Indeed, Kates-505 already teaches that detecting significant changes between sensor readings is important to identify and promptly react to emergency conditions. Kates-505, 1:57-2:3, 3:20-30, 5:20-33, 13:20-59. And with respect to Hitt’s and Littrell’s teachings, Hitt’s memory-based teachings would store such rate-of-change threshold information in the same way as other sensor information. *E.g.*, Hitt, [0067]-[0068]. And with respect to Littrell, Littrell’s teachings of using averages to allow for adjustments between “normal” and “sudden” changes is consistent with Mueller’s

teachings of monitoring significant changes in rate of rise. *E.g.*, Littrell, [0015]. A POSITA would have therefore found it obvious and straightforward to transmit sensor readings in response to detected changes that exceed a preset threshold, as taught by Mueller.

2. **Mueller’s further disclosures of “transmit[ting] a most recent reading ... in response to detecting a change in the sensed condition outside a predetermined range and ... [suspending transmission] in response to detecting a change in the sensed condition within the predetermined range” ([1.e]) (Claim 1) and a “band limit” (Claim 5)**

168. In addition to the teachings from Kates-505, Hitt, and Littrell that I discussed above in Sections IX.A.2(f), IX.B.2(b), IX.C.2, and IX.D, to the extent any additional disclosure of transmitting “in response to detecting a change in the sensed condition outside a predetermined range” or suspending transmission when “within the predetermined range” in [1.e] is required, **Mueller discloses transmit[ting] a most recent reading ... in response to detecting a change in the sensed condition outside a predetermined range and ... [suspending transmission] in response to detecting a change in the sensed condition within the predetermined range** (*e.g.*, “only transmit[ting] temperature information on a sensed change in temperature,” such as “if the new sensed temperature is different by a pre-defined amount from a previous transmitted temperature.”). And similarly, **Mueller also teaches a “band limit”** as recited in claim 5 (*e.g.*, a limit specified as

a “temperature change” “from a previous transmitted temperature”). *See, e.g.,* Mueller (emphasis added):

- **Abstract** (“A method and device includes the use of multiple remote sensors transmitting temperature information to a thermostat, while reducing or eliminating transmission interference and providing increased user control. Remote temperature sensors of the present invention sense temperature at variable time periods and only transmit temperature information on a sensed change in temperature.”)
- **1:8-11** (“The present invention relates to the field of thermostats, and in particular to a method and apparatus providing automatic transmission of temperature information to a thermostat.”)
- **2:16-21** (“The sensor preferably uses a transmitter (e.g., radio frequency transmitter) to transmit temperature and associated information to a host-controlling thermostat only on a sensed change of temperature. The temperature is also sensed at variable time periods which may vary only minimally.”)
- **2:37-49** (“Specifically, the invention is preferably provided such that a unique serial number and/or channel number information is transmitted along with the temperature information on a variably selected frequency (e.g., random frequency) within a fixed range. Further, sensing of air

temperature may be provided at variable time intervals (e.g., a time offset provided based on a previous sensed temperature) and transmission of the sensed temperature transmitted only on a predetermined temperature change (i.e., comparing the current sensed temperature with a previously transmitted temperature and transmitting only upon a predetermined change). Thus, the possibility of transmission collisions is reduced or eliminated.”)

- **4:26-27** (“All parameters are preferably stored in a non-volatile memory, for example, an EEPROM.”)
- **8:66-9:6** (“The temperature is preferably sensed or measured at a variable time intervals as described in more detail below. This further provides randomization of the data transmission and minimization of transmission collisions. Additionally, as described herein, such transmission shall only occur if the new sensed temperature is different by pre-defined amount from a previous transmitted temperature (e.g., $2/16^{\circ}$ F.).”)
- **11:60-12:9** (“Further, with respect to transmission rate, indoor temperature transmission is preferably provided only if a new sensed temperature including any offset is different from the last transmitted temperature reading by a pre-defined amount, for example more than $2/16^{\circ}$ F. or $1/16^{\circ}$ C. ...

Because transmissions occur only at variable (e.g., ransom) [*sic*] times and only upon a temperature change, a transmission symbol at 122 is preferably provided on the LCD display 102 during each actual transmission of data.”)

169. In addition to the teachings from Kates-505, Hitt, and Littrell that I discussed above in Sections IX.B.2(b), IX.C.2, and IX.D, to the extent additional disclosures of transmitting a sensed value “in response to detecting a change in the sensed condition outside a predetermined range” or suspending transmission when the sensed condition value is “within the predetermined range” is required, Mueller discloses that its sensors “only transmit temperature information on a sensed change in temperature.” Mueller, Abstract, 1:8-11, 2:16-21, 2:37-49, 8:66-9:6, 11:60-12:9. For example, Mueller discloses that its sensors transmit their sensed condition readings to other parts of the system only “if the new sensed temperature is different by a pre-defined amount from a previous transmitted temperature.” Mueller, 8:66-9:6. As I explained in Section IX.E.1, Mueller teaches that its system determines whether to transmit a current temperature reading by comparing it to a previous temperature and transmits the current temperature to other parts of the system only if the difference between the temperatures is, for example, “more than $\frac{2}{16}^{\circ}$ F.” *Id.* Taken together, these teachings from Mueller disclose that sensor values are transmitted in response to detecting a change in the sensed condition that exceeds a predetermined range; otherwise, if the change in temperature is within the

predetermined range, Mueller teaches that the transmission of the sensed value is suspended.

170. Applying Mueller's teachings to Kates-505 also discloses a band limit, as discussed in claim 5, because Mueller teaches that the sensor reading is evaluated by determining a difference between a current and prior temperature. Mueller discloses that its sensors "only transmit temperature information on a sensed change in temperature," as I have discussed in Section IX.E.2. Mueller, Abstract, 1:8-11, 2:16-21, 2:37-49, 8:67-9:6, 11:61-65, 12:5-7. As I explained, Mueller teaches that its system determines whether to transmit a current temperature reading by comparing it to a previous temperature and transmits the current temperature to other parts of the system only if the difference between the temperatures is, for example, "more than $\frac{2}{16}^{\circ}$ F." *Id.* Mueller thus teaches detecting a sensed condition beyond a "band limit" because the determination is made by comparing a current sensed condition to a prior sensed condition. As I discussed previously, this is similar to the '887 patent's own disclosure of such a band limit. *See* §IX.A.2(i).

171. As explained in §IX.E.1, a person having ordinary skill in the art would have been motivated to modify Kates-505's teachings with Mueller's teaching of detecting changes in the sensed condition beyond a preset threshold to advantageously effectuate Kates-505's selective transmissions based on detections of anomalous sensor readings. A person having ordinary skill in the art would have

understood this combination to yield a system in which Mueller's detection of a change exceeding a preset threshold in comparison to a previous measurement causes Kates-505's sensor to selectively transmit sensor readings to other parts of the system, which advantageously allows the system to respond to emergency conditions (in addition to user-based thresholds as taught by Kates-505).

172. Accordingly, I conclude that Kates-505 in view of Mueller, Hitt, and/or Littrell renders obvious claim [1], as well as claims [3]-[8], [14]-[15], and [18] that depend on claim 1, for the reasons set forth here as well as in §§IX.A-IX.D.

X. SECONDARY CONSIDERATIONS

173. I have not seen any evidence in the prosecution history of the '887 patent or any related application that I considered of any arguments regarding secondary considerations exist. Nor have I seen any evidence that any such evidence would have a nexus to any of the Challenged Claims 1, 3-8, 14-15, and 18. Moreover, as shown above with respect to the prior art referenced in Section IX, any alleged solutions to problems or unexpected results in the '887 patent were already well known.

XI. CONCLUSION

174. In summary, I have concluded that the Challenged Claims 1, 3-8, 14-15, and 18 are rendered obvious over the prior art references as discussed above.

Specifically, in my opinion, for at least the reasons above, Challenged Claims 1, 3-8, and 18 of the '887 patent are rendered obvious as follows:

Ground	'887 Patent Claims	Prior Art References
1	1, 3-8, 18	Kates-711
2	1, 3-8, 18	Kates-711 in view of Hitt
3	1, 3-8, 14-15, 18	Kates-711 in view of Littrell
4	1, 3-8, 14-15, 18	Kates-711 in view of Hitt and Littrell
5	1, 3-8, 18	Kates-505
6	1, 3-8, 18	Kates-505 in view of Hitt
7	1, 3-8, 14-15, 18	Kates-505 in view of Littrell
8	1, 3-8, 14-15, 18	Kates-505 in view of Hitt and Littrell
9	1, 3-8, and 18	Kates-505 in View of Mueller
10	1, 3-8, and 18	Kates-505 in View of Mueller and Hitt
11	1, 3-8, 14-15, and 18	Kates-505 in View of Mueller and Littrell
12	1, 3-8, 14-15, and 18	Kates-505 in View of Mueller, Hitt, and Littrell

175. To the extent it is argued that any further disclosure is required for an element in the Challenged Claims 1, 3-8, 14-15, and 18 that I have identified as being disclosed, a person having ordinary skill in the art would certainly have found that element obvious to include based on the same explicit disclosure or inherent disclosures and analysis I have identified above.

176. 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.

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

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

Executed this March 6, 2023, in Dripping Springs, TX.

Respectfully submitted,

A handwritten signature in black ink, appearing to read "Dean Neikirk", written over a horizontal line.

Dr. Dean P. Neikirk, Ph.D.

Appendix A

Dean P. Neikirk

Emeritus Professor, Emeritus Cullen Trust for Higher Education Professorship in Engineering
Department of Electrical and Computer Engineering
Cockrell School of Engineering
The University of Texas at Austin
Austin, TX 78712

Education:

Oklahoma State University (Physics and Mathematics; with Honors)	B.S.	1979
California Institute of Technology (Applied Physics)	M.S.	1981
California Institute of Technology (Applied Physics)	Ph.D.	1984

Professional Experience:

Assistant Professor, University of Texas at Austin, Jan. 1984 - Aug. 1988
Associate Professor, University of Texas at Austin, Sept. 1988- Aug. 1992
Full Professor, University of Texas at Austin, Sept. 1992-Jan. 2021
Associate Dean of Graduate Studies, Aug. 2014 – Jan. 2021
Emeritus Professor, Feb. 2021 - present

Honors and Awards:

- 1984 Marconi International Fellowship Young Scientist Award "for contributions to the development of millimeter wave integrated circuits especially in the areas of detectors and imaging arrays."
- Listed in the Second Edition of Who's Who in Frontiers of Science and Technology, 5th Edition of Who's Who in Technology Today, 1994 American Men & Women of Science; 1985 Outstanding Young Man of America, 1989 Outstanding Young Man of America; 7th Edition of Who's Who in Technology.
- 1984-85 Engineering Foundation Faculty Award, University of Texas at Austin Engineering Foundation Advisory Council.
- 1985-90 General Motors Foundation Centennial Teaching Fellowship, University of Texas at Austin.
- 1985-86 IBM Corporation Faculty Development Award
- 1986 National Science Foundation Presidential Young Investigator.

- 1987 Award for Outstanding Engineering Teaching by an Assistant Professor, College of Engineering, University of Texas at Austin.
- 1990-1992 Temple Foundation Endowed Faculty Fellowship (No. 1), University of Texas at Austin.
- 1992-present Cullen Trust for Higher Education Professorship in Engineering (No. 7), University of Texas.
- 1997 College of Engineering Award for Outstanding Teaching in the Department of Electrical and Computer Engineering, University of Texas at Austin.
- 2003 Department of Electrical and Computer Engineering Gordon T. Lepley IV Endowed Memorial Teaching Award, University of Texas at Austin.
- 2007 Lockheed Martin Aeronautics Company Award for Excellence in Engineering Teaching
 - each year since 1956, Lockheed Martin and its predecessor, has sponsored an award for excellence in engineering teaching to reward one College of Engineering faculty member for exceptional teaching. This prestigious award is given to a faculty member dedicating time and energy in abundance to teaching undergraduate and graduate students. As a result, his or her work leaves a mark of excellence on the entire College of Engineering. Nominations for this award are made by The University of Texas at Austin engineering students and faculty. Final selection is made by a committee composed the five most recent faculty recipients of the award and the student presidents of the Student Engineering Council (SEC) and the Graduate Engineering Council (GEC).
- 2015 Civitatis Award: The University of Texas at Austin Civitatis Award was established in 1997 to recognize outstanding faculty citizenship. The Civitatis Award is conferred upon a member of the faculty in recognition of dedicated and meritorious service to the University above and beyond the regular expectations of teaching, research, and writing. The award is made by the President upon the recommendation of the Faculty Council Executive Committee. Prof. Neikirk was nominated for the award for his “extensive, effective and distinguished service record to his department, college and [the] University of Texas.”

Vita for Dean P. Neikirk:

Dean P. Neikirk received the B.S. degree (1979) in physics from Oklahoma State University, and the M.S. (1981) and Ph.D. (1984) degrees in applied physics from the California Institute of Technology. He joined the faculty of The University of Texas at Austin in 1984, and is currently a Professor in the Department of Electrical and Computer Engineering, holding the Cullen Trust for Higher Education Professorship in Engineering (No. 7). Dr. Neikirk developed the first monolithic, high resolution focal plane detector array for use at wavelengths between 0.1 mm and 1 mm, and in 1984 received the Marconi International Fellowship Young Scientist Award "for contributions to the development of millimeter wave integrated circuits especially in the area of detectors and imaging arrays."

He has also been named a 1986 National Science Foundation Presidential Young Investigator.

Dr. Neikirk's research interests concentrated on the fabrication and modeling of electromagnetic and micromachined sensors and actuators. His work also included projects involving integrated circuit processing and the high frequency properties of transmission lines. His work concentrated on the use of advanced fabrication techniques, including silicon micromachining, for new device and sensor development. Dr. Neikirk developed the teaching laboratory for semiconductor device fabrication at The University of Texas at Austin, and was an active member of The University of Texas at Austin Microelectronics Research Center. Recently Dr. Neikirk's research project related to the development of new chemical sensors (an "electronic taste" sensor) was selected for a commercialization venture between the University of Texas and LabNow, Inc. Dr. Neikirk has also served as the Graduate Advisor of the Department of Electrical and Computer Engineering at UT-Austin, an Associate Chairman of the ECE Department, the Chair of the UT-Austin Graduate Assembly, the Chair of the UT-Austin Faculty Council, the Secretary of the General Faculty at UT-Austin, and as an Associate Dean of the University of Texas at Austin Graduate School.

Professional Societies:

Lifetime Senior Member, Institute of Electrical and Electronics Engineers
• Associate Editor for Solid State and VLSI Electronics, **IEEE Transactions on Education** (March 1991- Oct. 1994)

Commercialization of Technology:

Two companies have been founded based on technology developed by Dr. Neikirk's research group. In both cases the technology was developed at The University of Texas at Austin and licensed to start-ups.

From a University of Texas news release:

Firm commercializing University of Texas technology rounds up \$14 million venture capital investment (October 1, 2004)

AUSTIN, Texas—LabNow Inc. has received \$14 million in first-round venture investment for its point-of-care diagnostic system from the Soros Group, Austin Ventures and other investors.

The money will be used to develop the company's technology and to launch its initial product, CD4Now™, a point-of-care diagnostic tool for HIV/AIDS patients.

The device, which is based on technology developed at The University of Texas at Austin, quickly and accurately analyzes complex fluids such as blood.

Patents

1. US Patent 5,080,870: "Sublimating and Cracking Apparatus," Jan. 14, 1992; Inventors: B. G. Streetman, T. J. Mattord, D. P. Neikirk
2. US Patent 5,408,107: "Semiconductor Device Having Multiple Current-Voltage Curves and Zero-Bias Memory," April 18, 1995;
Inventors: Dean P. Neikirk and Kiran Kumar Gullapalli
3. US Patent 6,589,779: "General signaling protocol for chemical receptors in immobilized matrices," July 8, 2003;
Inventors: McDevitt; John T.; Anslyn; Eric V.; Shear; Jason B.; Neikirk; Dean P.
Assignee: Board of Regents, The University of Texas System (Austin, TX)
4. US Patent 6,602,702: "Detection system based on an analyte reactive particle," August 5, 2003
Inventors: McDevitt; John T. (Austin, TX); Anslyn; Eric V. (Austin, TX); Shear; Jason B. (Austin, TX); Neikirk; Dean P. (Austin, TX)

Assignee: The University of Texas System (Austin, TX)

5. US Patent 6,649,403: "Method of preparing a sensor array," November 18, 2003
Inventors: McDevitt; John T. (Travis, TX); Anslyn; Eric V. (Austin, TX); Shear; Jason B. (Austin, TX); Neikirk; Dean P. (Travis, TX)
Assignee: Board of Regents, The University of Texas Systems (Austin, TX)
6. US Patent 6,680,206, "Sensor arrays for the measurement and identification of multiple analytes in solutions," January 20, 2004
Inventors: McDevitt; John T. (Travis, TX); Anslyn; Eric V. (Austin, TX); Shear; Jason B. (Austin, TX); Neikirk; Dean P. (Travis, TX)
Assignee: Board of Regents, The University of Texas Systems (Austin, TX)
7. US Patent 6,713,298, "Method and apparatus for the delivery of samples to a chemical sensor array," March 30, 2004
Inventors: McDevitt; John T. (Travis, TX); Anslyn; Eric V. (Travis, TX); Shear; Jason B. (Travis, TX); Neikirk; Dean P. (Travis, TX)
Assignee: Board of Regents, The University of Texas System (Austin, TX)
8. US Patent 6,908,770, "Fluid based analysis of multiple analytes by a sensor array," June 21, 2005
Inventors: McDevitt; John T. (Austin, TX); Anslyn; Eric V. (Austin, TX); Shear; Jason B. (Austin, TX); Neikirk; Dean P. (Austin, TX)
Assignee: Board of Regents, The University of Texas System (Austin, TX)
9. US Patent 7,022,517, "Method and apparatus for the delivery of samples to a chemical sensor array," April 4, 2006, filed: July 14, 2000
Inventors: McDevitt; John T. (Austin, TX); Anslyn; Eric V. (Austin, TX); Shear; Jason B. (Austin, TX); Neikirk; Dean P. (Austin, TX); Borich; Damon V. (Austin, TX)
Assignee: Board of Regents, The University of Texas System (Austin, TX)
10. US Patent 7,316,899, "Portable sensor array system," January 8, 2008, filed: January 31, 2001
Inventors: McDevitt; John T. (Austin, TX); Anslyn; Eric V. (Austin, TX); Shear; Jason B. (Austin, TX); Neikirk; Dean P. (Austin, TX)
Assignee: Board of Regents, The University of Texas System (Austin, TX)
11. US Patent 7,491,552, "Fluid based analysis of multiple analytes by a sensor array," February 17, 2009, filed: January 20, 2005
Inventors: McDevitt; John T. (Austin, TX); Anslyn; Eric V. (Austin, TX); Shear; Jason B. (Austin, TX); Neikirk; Dean P. (Austin, TX)
Assignee: Board of Regents, The University of Texas System (Austin, TX)
12. United States Patent 7,651,868, "Method and system for the analysis of saliva using a sensor array," January 26, 2010, Filed: December 13, 2004

Inventors: McDevitt; John T. (Austin, TX), Anslyn; Eric V. (Austin, TX), Shear; Jason B. (Austin, TX), Neikirk; Dean P. (Austin, TX), Christodoulides; Nick J. (Austin, TX)

Assignee: The Board of Regents of The University of Texas System (Austin, TX)

13. United States Patent 8,101,431, "Integration of fluids and reagents into self-contained cartridges containing sensor elements and reagent delivery systems," January 24, 2012, Filed: December 22, 2004

Inventors: McDevitt; John T. (Austin, TX), Ballard; Karri L. (Pflugerville, TX), Floriano; Pierre N. (Austin, TX), Christodoulides; Nick J. (Austin, TX), Neikirk; Dean (Austin, TX), Anslyn; Eric (Austin, TX), Shear; Jason (Austin, TX)

Assignee: Board of Regents, The University of Texas System (Austin, TX)

14. United States Patent 8,105,849, "Integration of fluids and reagents into self-contained cartridges containing sensor elements," January 31, 2012, Filed: December 22, 2004

Inventors: McDevitt; John T. (Austin, TX), Ballard; Karri L. (Pflugerville, TX), Floriano; Pierre N. (Austin, TX), Christodoulides; Nick J. (Austin, TX), Neikirk; Dean (Austin, TX), Anslyn; Eric (Austin, TX), Shear; Jason (Austin, TX)

Assignee: Board of Regents, The University of Texas System (Austin, TX)

15. United States Patent 8,257,967, "Method and system for the detection of cardiac risk factors," September 4, 2012, Filed: April 28, 2003

Inventors: McDevitt; John T. (Austin, TX), Anslyn; Eric V. (Austin, TX), Shear; Jason B. (Austin, TX), Neikirk; Dean P. (Austin, TX), Christodoulides; Nick J. (Austin, TX)

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16. United States Patent 9,291,586, "Passive wireless self-resonant sensor," March 22, 2016, Filing Date: May 5, 2013

Inventors: Neikirk, Dean P. (Austin, TX, US), Pasupathy, Praveenkumar (Austin, TX, US), Zhang, Sheng (Austin, TX, US), Leonhardt, Brad (Austin, TX, US), Ekerdt, John G. (Austin, TX, US), Korgel, Brian A. (Austin, TX, US), Holmberg, Vincent C. (Seattle, WA, US), Shipman, Catherine D. (Reston, TX, US), Bogart, Timothy D. (Oxford, GB), Chockla, Aaron (Chicago, IL, US)

Assignee: Board of Regents, The University of Texas System (Austin, TX, US)

17. United States Patent 9,581,559, "Corrosion detection sensor embedded within a concrete structure with a diffusion layer placed over the sacrificial transducer," February 28, 2017, Filing Date: August 14, 2014

Inventors: Neikirk; Dean P. (Austin, TX), Wood; Sharon L. (Austin, TX), Pasupathy; Praveenkumar (Austin, TX), Yosef; Ali Abu (Austin, TX)

Assignee: Board of Regents, The University of Texas System (Austin, TX)

Publications:

A: Refereed archival journal publications

1. D. P. Neikirk and R. C. Powell, "Laser Time-Resolved Spectroscopy of Host-Sensitized Energy Transfer in $\text{Bi}_4\text{Ge}_3\text{O}_{12}:\text{Er}^{3+}$ Crystals," **J. Lumin.**, vol. 20, 1979, pp. 261-270.
2. R. C. Powell, D. P. Neikirk, J. M. Flaherty, and J. G. Gualtieri, "Lifetime Measurements, Infrared and Photoacoustic Spectroscopy of $\text{NdP}_5\text{O}_{14}$," **J. Phys. Chem. Solids**, vol. 41, 1980, pp. 345-350.
3. R. C. Powell, D. P. Neikirk, and D. Sadar, "Radiationless Decay Processes of Nd^{3+} Ions in Solids," **J. Opt. Soc. Am.**, vol. 70 (5), May 1980, pp. 486-490.
4. D. P. Neikirk, D. B. Rutledge, M. S. Muha, H. Park, and C. X. Yu, "Far-Infrared Imaging Antenna Arrays," **Appl. Phys. Lett.**, vol. 40 (3), 1 February 1982, pp. 203-205.
5. D. P. Neikirk, D. B. Rutledge, M.S. Muha, H. Park, and C. X. Yu, "Progress in Millimeter-Wave Integrated-Circuit Imaging Antenna Arrays," **Proc. Soc. Photo-Opt. Instr. Eng.**, vol. 317, 1981, pp. 206-211.
6. D. P. Neikirk, D. B. Rutledge, P.P. Tong, H. Park, and P. E. Young, "Imaging Antenna Array at $119\mu\text{m}$," **Appl. Phys. Lett.**, vol. (41), 15 August 1982, pp. 329-331.
7. D. P. Neikirk and D. B. Rutledge, "Self-Heated Thermocouples for Far-Infrared Detection," **Appl. Phys. Lett.**, vol. 41, (5), 1 September 1982, pp. 400-402
8. P.P. Tong, D. P. Neikirk, D. Psaltis, D. B. Rutledge, K. Wagner, and P. E. Young, "Tracking Antenna Arrays for Near- Millimeter Waves," **IEEE Trans. Antennas Propagat.**, vol. AP- 31, May, 1983, pp. 512-515.
9. D. P. Neikirk and D. B. Rutledge, "Air-Bridge Microbolometer for Far-Infrared Detection," **Appl. Phys. Lett.** **44**, 15 Jan. 1984, pp. 153-155.
10. P.P. Tong, D. P. Neikirk, D. B. Rutledge, P. E. Young, W. A. Peebles, N. C. Luhmann, Jr., "Imaging Polarimeter Arrays for Near-Millimeter Waves," **IEEE Trans. Microwave Theory Tech. MTT-32**, March 1984, pp. 507-512.
11. D. P. Neikirk, D. B. Rutledge, and W. Lam, "Far-Infrared Microbolometer Detectors," **Int. J. Infrared and Millimeter Waves** **5**, March 1984, pp. 245-277.
12. D. P. Neikirk and D. B. Rutledge, "Far-Infrared Imbedding Impedance Measurements,"

Int. J. Infrared and Millimeter Waves **5**, July 1984, pp. 1017-1026.

13. P. E. Young, D. P. Neikirk, P.P. Tong, D. B. Rutledge, and N. C. Luhmann, Jr., "Multichannel far-infrared phase imaging for fusion plasmas," **Rev. Sci. Instrum.** **56**, Jan. 1985, pp. 81-89.

14. P. E. Young, N. C. Luhmann, Jr., R. J. Taylor, D. P. Neikirk, and D. B. Rutledge, "Far-infrared imaging of tokamak plasma," **Rev. Sci. Instrum.** **56**, May 1985, pp. 903-904.

15. Y. Fukuoka, Q. Zhang, D. Neikirk, and T. Itoh, "Analysis of multilayer interconnection lines for a high speed digital integrated circuit," **IEEE Trans. Microwave Theory Tech. MTT-33**, June 1985, pp. 527-532.

16. N. Song, D. P. Neikirk, and T. Itoh, "Modeling of Ion-implanted GaAs MESFETs by the Finite Element Method," **IEEE Electron Device Lett. EDL-7**, April 1986, pp. 208-210.

17. V. P. Kesan, D. P. Neikirk, B. G. Streetman, and P. A. Blakey, "A New Transit Time Device Using Quantum Well Injection," **IEEE Electron Device Lett. EDL-8**, April 1987, pp. 129-131.

18. A. C. Cambell, V. P. Kesan, G. E. Crook, C. M. Maziar, D. P. Neikirk, and B. G. Streetman, "Impedance Switching Effects in GaAs/AlAs Barrier Structures," **Electronics Letters** **23**, Aug 27, 1987, pp. 926-927.

19. Y. D. Lin, D. P. Neikirk, and T. Itoh, "Coplanar Waveguide Phase Shifter Controlled by a Spatially Periodic Optical Illumination," **Int. J. Infrared and Millimeter Waves** **8**, Sept. 1987, pp. 1027-1036.

20. C. W. Farley, G. E. Crook, V. P. Kesan, T. R. Block, H. A. Stevens, T. J. Mattord, D. P. Neikirk, and B. G. Streetman, "Substrate Rotation and Carbon Generation in a Molecular Beam Epitaxy System," **J. Vac. Science Tech. B**, Sept./Oct. 1987, pp. 1374-1376.

21. V. P. Kesan, D. P. Neikirk, T. D. Linton, P. A. Blakey, and B. G. Streetman, "Influence of Transit Time Effects on the Optimum Design and Maximum Oscillation Frequency of Quantum Well Oscillators," **IEEE Trans. Electron Devices ED-35**, April 1988, pp. 405-413.

22. A. C. Campbell, V. P. Kesan, G. E. Crook, C. M. Maziar, D. P. Neikirk, and B. G. Streetman, "Capacitive Hysteresis Effects in 5.0 nm Single and Double Barrier AlAs Tunneling Structures Grown by MBE," **J. Vac. Science Tech. B** **6**, Mar/Apr 1988, pp. 651-656.

23. V. P. Kesan, A. Mortazawi, D. P. Neikirk, and T. Itoh, "Monolithic Millimeter-Wave Oscillator using a Transmission Line Periodically Loaded by QWITT Diodes," **Electronics Letters**, May 26, 1988, pp. 666-667.

24. T. J. Mattord, V. P. Kesan, G. E. Crook, T. R. Block, A. C. Campbell, D. P. Neikirk, and B. G. Streetman, "Baffle-free Refractory Dimer Source for Molecular Beam Epitaxy," **J. Vac Sci. Technol. B** **6**, Nov./Dec. 1988, pp. 1667-1670.
25. V. P. Kesan, A. Dodabalapur, D. P. Neikirk, and B. G. Streetman, "Growth and Rapid Thermal Annealing of AlGaAs/InGaAs Pseudomorphic Modulation-doped Structures," **Appl. Phys. Lett.** **53**, 22 Aug. 1988, pp. 681-683.
26. T. J. Mattord, V. P. Kesan, D. P. Neikirk, and B. G. Streetman, "A Single-filament Effusion Cell with Reduced Thermal Gradient for Molecular Beam Epitaxy," **J. Vac Sci. Technol. B** **7**, Mar/Apr 1989, pp. 214-216.
27. A. Dodabalapur, V. P. Kesan, T. R. Block, D. P. Neikirk, and B. G. Streetman, "Optical and Electrical Characterization of Pseudomorphic AlGaAs/InGaAs/GaAs Modulation-doped Structures Processed by Rapid Thermal Annealing," **J. Vac Sci. Technol. B** **7**, March/April 1989, pp. 380-383.
28. V. P. Kesan, A. Mortazawi, D. R. Miller, T. Itoh, B. G. Streetman, and D. P. Neikirk, "Microwave Frequency Operation of the Quantum Well Injection Transit Time (QWITT) Diode," **Electronics Letters** **24**, 24 Nov. 1988, pp. 1473-1474.
29. C. S. Kyono, V. P. Kesan, D. P. Neikirk, C. M. Maziar, and B. G. Streetman, "Dependence of Apparent Barrier Height on Barrier Thickness for Perpendicular Transport in AlAs/GaAs Single Barrier Structures Grown by MBE," **Appl. Phys. Lett.** **54**, 6 Feb. 1989, pp. 549-551.
30. R. L. Rogers and D. P. Neikirk, "Use of Broadside Twin Element Antennas to Increase Efficiency on Electrically Thick Dielectric Substrates," **Int. J. Infrared and Millimeter Waves** **9**, Nov. 1988, pp. 949-969.
31. R. L. Rogers and D. P. Neikirk, "Radiation Properties of Slot and Dipole Elements on Layered Substrates," **Int. J. Infrared and Millimeter Waves** **10**, June 1989, pp. 697-728.
32. A. Dodabalapur, V. P. Kesan, D. R. Hinson, D. P. Neikirk, and B. G. Streetman, "Photoluminescence Studies of Pseudomorphic modulation-doped AlGaAs/ InGaAs/ GaAs Quantum Wells," **Appl. Phys. Lett.** **54**, 24 April 1989, pp. 1675-1677.
33. A. C. Campbell, V. P. Kesan, T. R. Block, G. E. Crook, D. P. Neikirk, and B. G. Streetman, "Influence of MBE Growth Temperature on GaAs/AlAs Resonant Tunneling Structures," **Journal of Electronic Materials** **18**, 1989, pp. 585-588.
34. S. M. Wentworth, D. P. Neikirk, and C. R. Brahce, "The High Frequency Characteristics of Tape Automated Bonding (TAB) Interconnects," **IEEE. Trans. Components, Hybrids, and Manufacturing Tech.** **12**, Sept. 1989, pp. 340-347.

35. V. P. Kesan, A. Mortazawi, D. R. Miller, V. K. Reddy, D. P. Neikirk, and T. Itoh, "Microwave and Millimeter Wave QWITT Diode Oscillators," **IEEE Trans. Microwave Theory Tech. MTT-37**, Dec. 1989, pp. 1933-1941.
36. P. Cheung, D. P. Neikirk, and T. Itoh, "A Schottky-Biased, Optically-Controlled Coplanar Waveguide Phase Shifter," **Electronics Letters** **25**, Sept. 14, 1989, pp. 1301-1302.
37. S. M. Wentworth and D. P. Neikirk, "Far Infrared Microbolometers made with Tellurium and Bismuth," **Electronics Letters** **25**, Nov. 9, 1989, pp. 1558-1560.
38. A. Dodabalapur, V. P. Kesan, D. P. Neikirk, and B. G. Streetman, "Photoluminescence and Electoreflectance Studies of Modulation-Doped Pseudomorphic AlGaAs/ InGaAs/ GaAs Quantum Wells," **Journal of Electronic Materials** **19**, 1990, pp. 265-270.
39. P. Cheung, D. P. Neikirk, and T. Itoh, "Optically Controlled Coplanar Waveguide Phase Shifters," **IEEE Trans. Microwave Theory Tech. MTT-38**, May 1990, pp. 586-595.
40. S. M. Wentworth, R. L. Rogers, J. G. Heston, D. P. Neikirk, and T. Itoh, "Millimeter Wave Twin Slot Antennas on Layered Substrates," **Int. J. Infrared and Millimeter Waves** **11**, Feb. 1990, pp. 111-131.
41. J. G. Heston, J. M. Lewis, S. M. Wentworth, and D. P. Neikirk, "Twin slot antenna structures integrated with microbolometer detectors for 94 GHz imaging," **Microwave and Optical Technology Letters** **4**, no. 1, Jan. 5, 1991, pp. 15-19.
42. R. L Rogers, S. M. Wentworth, D. P. Neikirk, and T. Itoh, "A twin slot antenna on a layered substrate coupled to a microstrip feed line," **Int. J. Infrared and Millimeter Waves** **11**, no. 10, October 1990, pp. 1225-1249.
43. T. Y. Chu, D. P. Neikirk, and B. G. Streetman, "Properties and Applications of $\text{Al}_x\text{Ga}_{1-x}\text{As}$ Grown at Low Temperatures," **J. Crystal Growth** **111**, 1991, pp. 26-29.
44. V. K. Reddy, A. J. Tsao, and D. P. Neikirk, "High Peak-to-Valley Current Ratio AlGaAs/AlAs/GaAs Double Barrier Resonant Tunneling Diodes," **Electronics Letters** **26**, Oct. 11, 1990, pp. 1742-1744.
45. A. J. Tsao, V. K. Reddy, and D. P. Neikirk, "Epitaxial Liftoff of AlAs/GaAs Double Barrier Resonant Tunneling Diodes," **Electronics Letters** **27**, March 14, 1991, pp. 484-486.
46. D. R. Miller and D. P. Neikirk, "Simulation of Intervalley Mixing in Double Barrier Diodes Using the Lattice Wigner Function," **Appl. Phys. Lett.** **58**, 17 June 1991, pp. 2803-2805.

47. M.S. Islam, A. J. Tsao, V. K. Reddy, and D. P. Neikirk, "GaAs on Quartz Coplanar Waveguide Phase Shifter," **IEEE Microwave and Guided Wave Letters** **1**, Nov. 1991, pp. 328-330.
48. S. M. Wentworth and D. P. Neikirk, "Composite Microbolometers with Tellurium Detector Elements," **IEEE Trans. Microwave Theory Tech. MTT-40**, no. 2, Feb. 1992, pp. 196-201.
49. T. D. Linton, Jr., P.A. Blakey, and D. P. Neikirk, "The impact of three-dimensional effects on EEPROM cell performance," **IEEE Trans. Electron Devices** **39**, April 1992, pp. 843-850.
50. V. K. Reddy and D. P. Neikirk, "Influence of Growth Interruption on I - V Characteristics of AlAs/GaAs Double Barrier Resonant Tunneling Diodes," **J. Vac. Sci. Technol. B** **10**, Mar/Apr 1992, pp. 1045-1047.
51. A. J. Tsao, V. K. Reddy, D. R. Miller, K. K. Gullapalli, and D. P. Neikirk, "The effect of barrier thickness asymmetries on the electrical characteristics of AlAs/GaAs double barrier resonant tunneling diodes," **J. Vac. Sci. Technol. B** **10**, Mar/Apr 1992, pp. 1042-1044.
52. T. R. Block, D. P. Neikirk, and B. G. Streetman, "Photoluminescence study of the effects of growth interruption on integer and fractional monolayer AlGaAs/GaAs quantum wells," **J. Vac. Sci. Technol. B** **10**, Mar/Apr 1992, pp. 832-834.
53. Emre Tuncer and Dean P. Neikirk, "Highly Accurate Quasi-Static Modeling of Microstrip Lines Over Lossy Substrates," **IEEE Microwave and Guided Wave Letters** **2**, Oct. 1992, pp. 409-411.
54. S. Javalagi, V. Reddy, K. Gullapalli, and D. Neikirk, "High efficiency microwave diode oscillators," **Electronics Letters** **28**, 27 August 1992, pp. 1699-1701.
55. K. K. Gullapalli, A. J. Tsao, and D. P. Neikirk, "Multiple self-consistent solutions at zero bias and multiple conduction curves in quantum tunneling diodes containing $N^- - N^+$ - N^- spacer layers," **Appl. Phys. Lett.** **62**, 7 June 1993, pp. 2971-2973.
56. K. K. Gullapalli, A. J. Tsao, and D. P. Neikirk, "Experimental observation of multiple current - voltage curves and zero-bias memory in quantum well diodes with $N^- - N^+$ - N^- spacer layers," **Appl. Phys. Lett.** **62**, 31 May 1993, pp. 2856-2858.
57. V. K. Reddy and D. P. Neikirk, "High breakdown voltage AlAs/InGaAs quantum barrier varactor diodes," **Electronics Letters** **29**, 4 March 1993, pp. 464-466.
58. T. R. Block, D. P. Neikirk, and B. G. Streetman, "Molecular-beam epitaxial growth condition dependence of reflection high-energy electron diffraction dampening and quantum well photoluminescence," **J. Vac. Sci. Technol. B** **11**, May/June 1993, pp. 791-

59. Y. C. Albert Shih, D. P. Neikirk, B. G. Streetman, and C. W. Magee "Effects of As flux on Si δ -doped GaAs," **J. Vac. Sci. Technol. B** **11**, May/June 1993, pp. 905-907.
60. T. J. Mattord, K. Sadra, A. Srinivasan, A. Tang, T. R. Block, Y. C. Albert Shih, D. P. Neikirk, and B. G. Streetman, "Real-time flux monitoring and feedback control of a valved arsenic source," **J. Vac. Sci. Technol. B** **11**, May/June 1993, pp. 1050-1052.
61. M. Saiful Islam, Emre Tuncer and Dean P. Neikirk, "Calculation of Conductor Loss in Coplanar Waveguide using Conformal Mapping," **Electronics Letters** **29**, 24 June 1993, pp. 1189-1191.
62. Emre Tuncer and Dean P. Neikirk, "Efficient Calculation of Surface Impedance for Rectangular Conductors," **Electronics Letters** **29**, 25 Nov. 1993, pp. 2127-2128.
63. K. Sadra, A. Srinivasan, D. P. Neikirk, and B. G. Streetman, "Speed and Efficiency in Multiple p-i-n Photodetectors," **IEEE J. Lightwave Technol.** **11**, December 1993, pp. 2052-2056.
64. K. K. Gullapalli, D. R. Miller, and D. P. Neikirk, "Simulation of quantum transport in memory-switching double-barrier quantum-well diodes," **Phys. Rev. B (Condensed Matter)** **49**, 15 January 1994, pp. 2622-2628.
65. M. Saiful Islam, Emre Tuncer and Dean P. Neikirk, "Accurate Model for Schottky-Contacted Coplanar Waveguide Including Finite Epilayer Resistance Effects," **Electronics Letters** **30**, 28 April 1994, pp. 712-713.
66. Emre Tuncer, B.-T. Lee, M. S. Islam, and D. P. Neikirk, "Quasi-Static Conductor Loss Calculations in Transmission Lines using a New Conformal Mapping Technique," **IEEE Trans. Microwave Theory Tech.** **42**, September 1994, pp. 1807-1815.
67. Youngmin Kim and D. P. Neikirk, "Micromachined Fabry-Perot Cavity Pressure Transducer," **IEEE Photonics Technology Letters** **7**, Dec. 1995, pp. 1471-1473.
68. Youngmin Kim and Dean P. Neikirk, "Design for Manufacture of Micro Fabry-Perot Cavity-based Sensors," **Sensors and Actuators A** **50**, Jan. 1996, pp. 141-146.
69. I. Busch-Vishniac, C. S. Chu, S. Flagg, V. Gupta, C. Hearn, Y. Kim, P. Koeneman, W. Maddox, D. Masser, D. Neikirk, W. Weldon, H. Wells, and K. Wood, "Smart Hydrodynamic Bearings with Embedded MEMS Devices," *Journal of Tribology*, submitted 3/96, 1996.
70. John J. Lavigne, Steve Savoy, Marvin B. Clevenger, Jason E. Richie, Bridget McDoniel, Seung-Jin Yoo, Eric V. Anslyn, John T. McDevitt, Jason B. Shear, and Dean Neikirk, "Solution-Based Analysis of Multiple Analytes by a Sensor Array: Toward the

Development of an 'Electronic Tongue','" *Journal of the American Chemical Society*, vol. 120, July, 1998, pp. 6429-6430.

71. K. L. Wood, D. Neikirk, I. Busch-Vishniac, W. Weldon, C.-S. Chu, Y. Kim, V. Gupta, W. Maddox, and D. Masser, "MEMs hydrodynamic bearings: Applications to and implications for machine failure prevention," *TriboTest*, vol. 4, pp. 275-288, 1998.

72. R. J. Friar and D. P. Neikirk, "Limitations on the Extraction of Loss Tangent from Submicron Transmission Line Test Structures," *IEEE TRANSACTIONS ON ADVANCED PACKAGING*, vol. 23, p. 393, August 2000.

73. T. Curey, A. Goodey, A. Tsao, J. Lavigne, Y. Sohn, J. McDevitt, E. Anslyn, D. Neikirk, and J. Shear, "Characterization of multicomponent monosaccharide solutions using an enzyme-based sensor array," *ANALYTICAL BIOCHEMISTRY*, vol. 293, June 15, pp. 178-184, 2001.

74. Goodey, Adrian; Lavigne, John J.; Savoy, Steve M.; Rodriguez, Marc D.; Curey, Theodore; Tsao, Andrew; Simmons, Glen; Wright, John; Yoo, Seung-Jin; Sohn, Youngsoo; Anslyn, Eric V.; Shear, Jason B.; Neikirk, Dean P.; McDevitt, John T., "Development of multianalyte sensor arrays composed of chemically derivatized polymeric microspheres localized in micromachined cavities," *JOURNAL OF THE AMERICAN CHEMICAL SOCIETY* 123 (11): pp. 2559-2570 MAR 21 2001.

75. N. Christodoulides, M. Tran, P. Floriano, N. Pierre, M. Rodriguez, A. Goodey, M. Ali, D. Neikirk, and J. McDevitt, "A novel Microchip-based Multi-Analyte Assay System for the Assessment of Cardiac Risk," *Analytical Chemistry* 74 (13), July 1, 2002, pp. 3030-3036.

76. L. Vardapetyan, L. Demkowicz, and D. Neikirk, "hp-Vector finite element method for eigenmode analysis of waveguides," *Comput. Methods Appl. Mech. Engrg.*, vol. 192, Jan. 3, 2003, pp. 185-201.

77. Ali, Mehnaaz F.; Kirby, Romy; Goodey, Adrian P.; Rodriguez, Marc D.; Ellington, Andrew D.; Neikirk, Dean P.; McDevitt, John T.; "DNA hybridization and discrimination of single-nucleotide mismatches using chip-based microbead arrays," *Analytical Chemistry*, v 75, n 18, Sep 15, 2003, p 4732-4739.

78. Sohn, Young- Soo; Goodey, Adrian; Anslyn, Eric V.; McDevitt, John T.; Shear, Jason B.; Neikirk, Dean P., "A micromachined fluidic structure for capillary-based sample introduction into a microbead array chemical sensor," *Sensor Letters*, vol. 2, No. 1, March 1, 2004, pp. 69-72.

79.. Kirby, Romy; Cho, Eun Jeong; Gehrke, Brian; Bayer, Travis; Park, Yoon Sok; Neikirk, Dean P.; McDevitt, John T.; Ellington, Andrew D.; "Aptamer-based sensor arrays for the detection and quantitation of proteins," *Analytical Chemistry*, v 76, n 14, Jul 15, 2004, p 4066-4075.

80. Sang-Wook Han, Jun-Wan Kim, Young-Soo Sohn, and Dean P. Neikirk "Design of Infrared Wavelength-Selective Microbolometers Using Planar Multimode Detectors," IEE Electronics Letters, vol. 40, No. 22, October 28, 2004, pp. 1410-1411.
81. Young-Soo Sohn, Adrian Goodey, Eric V. Anslyn, John T. McDevitt, Jason B. Shear and Dean P. Neikirk, "A microbead array chemical sensor using capillary-based sample introduction: toward the development of an 'electronic tongue'," Biosensors and Bioelectronics, Vol. 21, Aug. 8, 2005, pp. 303-312.
(<http://www.sciencedirect.com/science/article/B6TFC-4DXT7XR-2/2/63c4b30ed5019368cbf0daa18e961915>).
82. Shifeng Li, Pierre N. Floriano, Nicolaos Christodoulides, David Y. Fozdar, Dongbing Shao, Mehnaaz F. Ali, Priya Dharshan, Sanghamitra Mohanty, Dean Neikirk, John T. McDevitt and Shaochen Chen, "Disposable polydimethylsiloxane/silicon hybrid chips for protein detection," Biosensors and Bioelectronics, Vol. 21, No. 4, Oct. 15, 2005, pp. 574-580.
(<http://www.sciencedirect.com/science/article/B6TFC-4F9MTDX-1/2/8723de52f98adafle55f417c04de29cb>)
83. Han, S. W., Park, Y. S., Neikirk, D. P., "Broadband infrared detection using Jaumann absorbers with genetic algorithm," Electronics Letters, v 41, n 24, Nov 24, 2005, pp. 1307-1308.
84. Abu Yousef, A., Wood, S.L., Pasupathy, P., and Neikirk, D.P., "Resonant Sensors for Detecting Corrosion in Concrete Bridges," *Transportation Research Record*, Transportation Research Board, No. 2201, December 2010, pp. 19-26.
85. Sheng Zhang, Praveenkumar Pasupathy, and Dean Neikirk, "Microfabricated self-resonant structure as a passive wireless dielectric constant and conductivity sensor," *Microsystem Technologies*, Springer Berlin / Heidelberg, Issn: 0946-7076, pp. 1-7, <http://dx.doi.org/10.1007/s00542-011-1403-y> , Doi: 10.1007/s00542-011-1403-y.
86. Jong Yeon Park, Praveen Pasupathy and Dean P. Neikirk, "Wavelength Selective Microbolometers with Low Deformation Membranes Using a Planar Self-aligned Process," submitted to be considered for publication in the Journal of Micro/Nanolithography, MEMS, and MOEMS (JM3), April 2012.
87. Jeremiah Fasl, Todd Helwig, Sharon L. Wood, Praveen Pasupathy, Dean P. Neikirk, Frank Raffaelli, "Factors Affecting Wireless Network Communication in Monitoring Systems for Steel Bridges," *Journal of Civil Structural Health Monitoring*, Volume 2, Issue 2, September 2012, pp. 87-95.
88. Joo-Yun Jung, Jong Yeon Park, Sangwook Han, Aniruddha Weling, and Dean P. Neikirk, "Wavelength-selective infrared Salisbury screen absorber," *APPLIED OPTICS*, Vol. 53, No. 11, 10 April 2014, pp. 2431-2436

89. Ignacio F. Gallardo, Praveenkumar Pasupathy, Maxwell Brown, Carol M. Manhart, Dean P. Neikirk, Eric Alani, and Ilya J. Finkelstein, "High-Throughput Universal DNA Curtain Arrays for Single-Molecule Fluorescence Imaging," *Langmuir*, Vol. 31 (37), pp 10310–10317, Sept. 1, 2015. doi: 10.1021/acs.langmuir.5b02416.

90. Shixuan Yang, Ying-Chen Chen, Luke Nicolini, Praveenkumar Pasupathy, Jacob Sacks, Su Becky, Russell Yang, Sanchez Daniel, Yao-Feng Chang, Pulin Wang, David Schnyer, Dean Neikirk and Nanshu Lu, " 'Cut-and-Paste' Manufacture of Multiparametric Epidermal Sensor Systems," *Advanced Materials*, Vol. 27, No. 41, 11/1/2015, pp. 6423-6430.

91. Praveen Pasupathy, Tanuj Trivedi, Brad Leonhardt, Sheng Zhang, John G. Ekerdt, and Dean P. Neikirk, "Miniature Passive Wireless Resonant Platform for Chemical Memory based Threshold Sensing," *IEEE Sensors Journal*, Volume: 17, Issue: 5, March 1, 1 2017, pp. 1209 - 1210; DOI: 10.1109/JSEN.2016.2646686

92. Jung, Joo-Yun; Song, Kyungjun; Choi, Jun-Hyuk; Lee, Jihye; Choi, Dae-Geun; Jeong, Jun-Ho; Neikirk, Dean P., "Infrared broadband metasurface absorber for reducing the thermal mass of a microbolometer," *Scientific Reports*, Vol. 7, No. 430, March 27, 2017, 8 pages, 10.1038/s41598-017-00586-x.

93. Tanuj Trivedi, Anupam Roy, Hema C. P. Movva, Emily S. Walker, Seth R. Bank, Dean P. Neikirk, and Sanjay K. Banerjee, "Versatile Large-Area Custom-Feature van der Waals Epitaxy of Topological Insulators," *ACS Nano*, 2017, 11 (7), pp 7457–7467, DOI: 10.1021/acsnano.7b03894, Publication Date (Web): July 10, 2017.

94. Brad Leonhardt, Praveen Pasupathy, Tanuj Trivedi, Sheng Zhang, Dean P. Neikirk, and John G. Ekerdt, "Functionalized Polycyclic Aromatic Polymers for High Temperature Wireless Chemical Memory Threshold Sensors," submitted to *ACS Ind. Eng. Chem. Res.*, 2017, 56 (19), pp 5479–5482, DOI: 10.1021/acs.iecr.6b04541, Publication Date (Web): May 2, 2017.

95. Tanuj Trivedi, Ye Chen, Ian A. D. Williamson, Praveen Pasupathy, and Dean P. Neikirk, "Group Velocity Estimation and Defect Localization in Magneto-inductive Waveguides," to be published in the *IEEE Transactions on Microwave Theory and Techniques*, Volume 6, April 2021, DOI: 10.1109/TMTT.2021.3055350, pp. 2072-2077.

Praveen Pasupathy, Vivek Subramanian, Ali Abu-Yousef, Sharon Wood, and Dean Neikirk, "Phase Detection of Passive Inductively Coupled Resonant Sensors," to be submitted to *IEEE Sensors Letters*.

Jong Yeon Park, Praveen Pasupathy and Dean P. Neikirk, "Wavelength Selective Microbolometers with Low Deformation Membranes Using a Planar Self-aligned Process," in preparation.

Sheng Zhang, Praveen Pasupathy, Dean Neikirk, "Extension of Interdigitated Capacitor Sensor Model for Conductive Material Measurement," in preparation.

Sheng Zhang, Praveen Pasupathy, Dean Neikirk, "Circuit model for estimating resonant frequency of inductively coupled self resonant sensor," in preparation.

B. Refereed Conference Proceedings

1. D. P. Neikirk, D. B. Rutledge, M.S. Muha, H. Park, and C.-X. Yu, "Progress in Millimeter-Wave Integrated-Circuit Imaging Arrays," SPIE Conf. on Integrated Optics and Millimeter and Microwave Integrated Circuits, Huntsville, Alabama, November, 1981.
2. D. P. Neikirk, D. B. Rutledge, M.S. Muha, H. Park, and C.-X. Yu, "Imaging Antenna Arrays," 6th Int. Conf. on Inf. and Millimeter Waves, Miami Beach, Florida, December, 1981, p. Th-4-1.
3. D. P. Neikirk, D. B. Rutledge, H. Park, C.-X. Yu, W. A. Peebles and N. C. Luhmann, Jr., "Development of Imaging Arrays for Poloidal Field Determination and Holographic Imaging of Plasmas," Proc. of U.S.A. - Japan Workshop on Submillimeter Diagnostic Techniques, Nagoya, US-J FRC-006, p. 60, January, 1982.
4. D. P. Neikirk, D. B. Rutledge, P. E. Young, N. C. Luhmann, Jr., H. Park, W. A. Peebles, and C.-X. Yu, "Far-Infrared Imaging Systems for the Determination of Fusion Plasma Density and Magnetic Field Distributions," Department of Energy Workshop on Magnetic Field Measurements, Oak Ridge, Tennessee, April, 1982.
5. P. Young, Q.-X. Yu, W. A. Peebles, N. C. Luhmann, Jr., D. P. Neikirk, D. B. Rutledge, and P. Tong, "Far-Infrared Imaging," Digest 7th Int. Conf. on Inf. and Millimeter Waves, Marseille, France, February, 1983, p. J3-4.
6. D. P. Neikirk, P.P. Tong, D. B. Rutledge, and P. E. Young, "Progress in Far-Infrared Imaging Arrays," 7th Int. Conf. on Inf. and Millimeter Waves, Marseille, France, February, 1983, p. J3-3.
7. P. E. Young, W. A. Peebles, N. C. Luhmann, Jr., R. J. Taylor, D. P. Neikirk, D. B. Rutledge, and P.P. Tong, "Simultaneous FIR Interferometry/Polarimetry in the UCLA Microtor Plasma," 8th Int. Conf. on Infrared and Millimeter Waves, Miami, Florida, December, 1983.
8. P. E. Young, W. A. Peebles, N. C. Luhmann, Jr., D. P. Neikirk, D. B. Rutledge, and P.P. Tong, "Interferometric FIR Phase Imaging of a Tokamak Plasma," 8th Int. Conf. on Infrared and Millimeter Waves, Miami, Florida, December, 1983.

9. D. P. Neikirk and D. B. Rutledge, "Advances in Microbolometers," 8th Int. Conf. on Infrared and Millimeter Waves, Miami, Florida, December, 1983.
10. P.P. Tong, D. B. Rutledge, and D. P. Neikirk, "Polarization- sensitive imaging arrays," IEEE MTT-S International Microwave Symposium, San Francisco, Ca., May 29- June 1, 1984, pp. 542-544.
11. Y. Fukuoka, Q. Zhang, D. Neikirk, and T. Itoh, "Analysis of multilayer interconnection lines for a high speed digital integrated circuit," IEEE VLSI Multilevel Interconnection Conference, June 21-22, 1984, pp. 246-251.
12. P. Young, D. Neikirk, C. Domier, P. Tong, W. Peebles, D. Rutledge, and N. Luhmann, "Near-millimeter wave imaging," 9th Int. Conf. on Infrared and Millimeter Waves, Takarazuka, Japan, Oct. 22-26, 1984, pp. 250-251.
13. P. Cheung, D. Fun, D. Miller, C.-K. C. Tzuang, D. P. Neikirk, and T. Itoh, "Optically Controlled Coplanar Waveguide Millimeter Wave Phase Shifter," Tenth International Conference on Infrared and Millimeter Waves, Lake Buena Vista, FL, Dec. 9-13, 1985, pp. 303-304.
14. N. U. Song, D. P. Neikirk, and T. Itoh, "Device Modeling and Characterization of Ion-Implanted GaAs MESFET's by the Finite Element Method," 8th Colloquium on Microwave Communication, Budapest, Hungary, August 26-29, 1986.
15. C.-K. Tzuang, P. Cheung, D. P. Neikirk, and T. Itoh, "Analysis of an Optically Controlled CPW Phase Shifter Containing Laterally Non-uniform Lossy Layers, Eleventh International Conference on Infrared and Millimeter Waves, Pisa, Italy, Dec., 1986, pp. 127-129.
16. V. Kesan, D. P. Neikirk, and B G. Streetman, "A Proposed Quantum Well Injection Transit Time Device (QWITT)," Second Topical Meeting on Picosecond Electronics and Optoelectronics, Jan., 1987, pp. 66-68.
17. C.-K. Tzuang, D. Miller, T.-H. Wang, D. P. Neikirk, T. Itoh, P. Williams, and M. Downer, "Picosecond Response of an Optically Controlled Millimeterwave Phase Shifter," Second Topical Meeting on Picosecond Electronics and Optoelectronics, Jan., 1987, pp. 182-184.
18. Y.-D. Lin, D. P. Neikirk, and T. Itoh, "Periodically Illuminated CPW Phase Shifter," 12th International Conference on Infrared and Millimeter Waves, Dec. 14-18, 1987, pp. 93-94.
19. V. P. Kesan, D. P. Neikirk, T. D. Linton, P.A. Blakey, and B. G. Streetman, "Influence of Transit Time Effects on the Optimum Design and Maximum Oscillation Frequency of Quantum Well Oscillators," 12th International Conference on Infrared and Millimeter Waves, Dec. 14-18, 1987, pp. 12-13.

20. P. Cheung, D. P. Neikirk, and T. Itoh, "Measurements of an Optically Controlled Coplanar Waveguide Phase-Shifter," 12th International Conference on Infrared and Millimeter Waves, Dec. 14-18, 1987, pp. 91-92.
21. R. L. Rogers, D. P. Neikirk, and H. Ling, "Planar Matching of Antennas on Electrically Thick Dielectric Substrates," 12th International Conference on Infrared and Millimeter Waves, Dec. 14-18, 1987, pp. 288-289.
22. V. P. Kesan, T. D. Linton, C. M. Maziar, D. P. Neikirk, P.A. Blakey, and B. G. Streetman, "Power-optimized design of quantum well oscillators," 1987 IEEE International Electron Devices Meeting, Dec. 6-9, 1987, pp. 62-65.
23. S. M. Wentworth, D. P. Neikirk, and C. R. Brahce, "High Frequency Characterization of Tape-Automated Bonding (TAB) Interconnects," SPIE Advances in Semiconductors and Superconductors: Physics and Device Applications, Conf. 947: Interconnection of High Speed and High Frequency Devices and Systems, Newport Beach, CA, March 13-18, 1988, pp. 81-84.
24. D. R. Miller, V. P. Kesan, R. L. Rogers, C. M. Maziar, and D. P. Neikirk, "Time Dependent Simulation of the Quantum Well Injection Transit Time Diode," 13th International Conference on Infrared and Millimeter Waves, R. J. Temkin, Editor, SPIE Vol. 1039, Dec. 5-9, 1988, pp. 5-6.
25. P. Cheung, D. P. Neikirk, and T. Itoh, "Experimental Performance of a Periodically Illuminated Optically Controlled Coplanar Waveguide Phase Shifter," 13th International Conference on Infrared and Millimeter Waves, R.J. Temkin, Editor, SPIE Vol. 1039, Dec. 5-9, 1988, pp. 63-64.
26. R. L. Rogers, D. P. Neikirk, H. Ling, and T. Itoh, "Antennas on Electrically Thick Multilayered Substrates," 13th International Conference on Infrared and Millimeter Waves, R. J. Temkin, Editor, SPIE Vol. 1039, Dec. 5-9, 1988, pp. 33-34.
27. A. Mortazawi, V. P. Kesan, D. P. Neikirk, and T. Itoh, "Periodic Monolithic Millimeter-Wave Quantum Well Oscillator," 13th International Conference on Infrared and Millimeter Waves, R. J. Temkin, Editor, SPIE Vol. 1039, Dec. 5-9, 1988, pp. 47-48.
28. V. P. Kesan, A. Mortazawi, D. P. Neikirk, and T. Itoh, "Microwave and Millimeterwave QWITT Diode Oscillator," IEEE MTT-S International Microwave Symposium Digest, Vol. 1, June 13-15, 1989, pp. 487-489.
29. P. Cheung, D. P. Neikirk, and T. Itoh, "An Optically Controlled Coplanar Waveguide Phase-Shifter," IEEE MTT-S International Microwave Symposium Digest, Vol. 1, June 13-15, 1989, pp. 307-309.
30. A. Mortazawi, V. P. Kesan, D. P. Neikirk, and T. Itoh, "A Self Oscillating QWITT

Diode Mixer," 19th European Microwave Conference, London, Engl., Sept. 4-7, 1989, pp. 715-718.

31. R. L. Rogers, D. P. Neikirk, and T. Itoh, "Impedance Measurements and Calculations of a Microstrip-fed Slot Antenna on a Multilayered Electrically Thick Dielectric Substrate," 19th European Microwave Conference, London, Engl., Sept. 4-7, 1989, pp. 167-171.

32. S. M. Wentworth, R. L. Rogers, D. P. Neikirk, and T. Itoh, "A Twin Slot Antenna Structure on a Layered Substrate for Millimeter Wave Imaging Arrays," 14th International Conference on Infrared and Millimeter Waves, M. von Ortenberg, Editor, SPIE Vol. 1240, Oct. 2-6, 1989, pp. 399-400.

33. S. M. Wentworth, R. L. Rogers, J. G. Heston, and D. P. Neikirk, "Twin-slot multi-layer substrate-supported antennas and detectors for terahertz imaging," First International Symposium on Space Terahertz Technology, University of Michigan, Ann Arbor, Mich., March 5-6, 1990, pp. 201-213.

34. D. R. Miller, V. K. Reddy, and D. P. Neikirk, "Realistic Band Structure Effects of GaAs/AlAs Quantum Well Diodes: Theory and Experiment," Proceedings of the SPIE Symposium on Advances in Semiconductors and Superconductors: High Speed Electronics and Device Scaling, SPIE Vol. 1288, San Diego, CA, March 17-21, 1990, pp. 167-176.

35. P. Cheung, M.S. Islam, D. P. Neikirk, and T. Itoh, "Circuit Model of Coplanar Waveguide Phase Shifters on GaAs Substrates," Gallium Arsenide Applications Symposium '90, Rome, Italy, April 19-20, 1990.

36. P. Cheung, D. P. Neikirk, and T. Itoh, "Measurements of an Optically Controlled Coplanar Waveguide Phase Shifter," Microwaves and Optronics Conference and Exhibition on Ultra High Frequency Engineering (MIOP 90), Stuttgart, West Germany, April 24-26, 1990.

37. S. M. Wentworth and D. P. Neikirk, "A Transition Edge Microbolometer (TREMBOL) for Far-Infrared Detection," SPIE Conference on Superconductivity Applications for Infrared and Microwave Devices, SPIE Proceedings Vol. 1292, Orlando, FL, April 19-20, 1990.

38. M.S. Islam, P. Cheung, C.-Y. Chang, D. P. Neikirk, and T. Itoh, "Optically-Controlled Tunable CPW Resonators," IEEE MTT-S International Microwave Symposium Digest, Vol. II, May 8-10, 1990, pp. 949-950.

39. S. M. Wentworth and D. P. Neikirk, "Far-Infrared Composite Microbolometers," IEEE MTT-S International Microwave Symposium Digest, Vol. III, May 8-10, 1990, pp. 1309-1310.

40. J. G. Heston, S. M. Wentworth, R. L. Rogers, D. P. Neikirk, and T. Itoh, "MM Wave /FIR Twin Slot Antenna Structures," AP-S International Symposium and URSI Radio Science Meeting, May, 1990.
41. T. Y. Chu, D. P. Neikirk, and B. G. Streetman, "Properties and Applications of $\text{Al}_x\text{Ga}_{1-x}\text{As}$ Grown at Low Temperatures," Proceedings of the Sixth International Conference on Molecular Beam Epitaxy, Aug. 27-31, 1990, La Jolla, CA, Journal of Crystal Growth, vol. 111, n 1-4, May 2, 1991..
42. A. Mortazawi, D. Miller, D. P. Neikirk, and T. Itoh, "Small Signal Measurements of the Microwave Impedance of QWITT Diodes," 20th European Microwave Conference, Budapest, Hungary, Sept. 10-14, 1990, pp. 715-718.
43. V. K. Reddy, A. J. Tsao, S. Javalagi, D. R. Miller, and D. P. Neikirk, "Quantum Well Injection Transit Time (QWITT) Diode Oscillators," 15th International Conference on Infrared and Millimeter Waves, Richard J. Temkin, Editor, SPIE vol. 1514, Dec. 10-14, 1990, pp. 88-90.
44. M. S. Islam, P. Cheung, D. P. Neikirk, and T. Itoh, "Microwave response of a coplanar waveguide phase shifter to pulsed optical illumination," 15th International Conference on Infrared and Millimeter Waves, Richard J. Temkin, Editor, SPIE vol. 1514, Dec. 10-14, 1990, pp. 484-486.
45. J. M. Lewis, D. P. Neikirk, and S. M. Wentworth, "Low growth temperature GaAs microbolometers," 15th International Conference on Infrared and Millimeter Waves, Richard J. Temkin, Editor, SPIE vol. 1514, Dec. 10-14, 1990, pp. 398-400.
46. C. S. Kyono, P. Cheung, C. J. Pinzone, N. D. Gerrard, T. Bustami, C.M. Maziar, D. P. Neikirk, and R.D. Dupuis, "High gain, high speed InGaAs/InP heterojunction bipolar transistors," 1990 IEEE International Electron Devices Meeting, San Francisco, CA, Dec. 9-12, 1990, pp. 677-680.
47. Nanda Gopal, Dean P. Neikirk, and Lawrence T. Pillage, "Evaluating RC-Interconnect using Moment-Matching Approximations," 1991 IEEE International Conference on Computer-Aided Design Digest of Technical Papers, Conference on Computer-Aided Design - ICCAD-91, Santa Clara, CA, Nov. 10-14, 1991, pp. 74-77.
48. K. K. Gullapalli, D. R. Miller, and D. P. Neikirk, "Hybrid Boltzmann Transport - Schrödinger Equation Model for Quantum Well Injection Transit (QWITT) Diodes," 1991 IEEE International Electron Devices Meeting, Washington, DC, Dec. 8-11, 1991, pp. 18.5.1-18.5.4.
49. Douglas R. Miller and D. P. Neikirk, "Lattice Wigner simulations of double barrier resonant tunneling devices," Third International Symposium on Space Terahertz Technology, The University of Michigan, Ann Arbor, Mich., March 24-26, 1992, pp. 560-574.

50. Youngmin Kim, Wanjun Wang, Dean P. Neikirk, and Ilene J. Busch-Vishniac, "Fabrication and characterization of a clover type position sensitive photodetector," IEEE Instrumentation / Measurement Technology Conference, New York NY, May 12-14, 1992.
51. Nanda Gopal, Emre Tuncer, Dean P. Neikirk, and Lawrence T. Pillage, "Non-uniform lumping models for transmission line analysis," IEEE Topical Meeting on Electrical Performance of Electronic Packaging, Tucson, AZ, April 22-24, 1992, pp. 119-121.
52. K. K. Gullapalli and D. P. Neikirk, "Evaluating space charge resistance in resonant tunneling diodes," 11th Annual Symposium on Electronic Materials, Processing, and Characterization, Richardson, TX, June 1-2, 1992.
53. D. R. Miller and D. P. Neikirk, "Realistic Lattice Wigner simulations of double barrier resonant tunneling devices," 11th Annual Symposium on Electronic Materials, Processing, and Characterization, Richardson, TX, June 1-2, 1992.
54. V. K. Reddy, S. Javalagi, and D. P. Neikirk, "Molecular beam epitaxial growth and characterization of double barrier resonant tunneling diodes for microwave oscillator applications," 11th Annual Symposium on Electronic Materials, Processing, and Characterization, Richardson, TX, June 1-2, 1992.
55. Alwin J. Tsao, M. S. Islam, and D. P. Neikirk, "Epitaxial liftoff of GaAs/AlGaAs thin film device structures for hybrid integration on silicon and quartz substrates," 11th Annual Symposium on Electronic Materials, Processing, and Characterization, Richardson, TX, June 1-2, 1992 (Best Student Paper Award).
56. A. J. Tsao, K. K. Gullapalli, and D. P. Neikirk, "Effect of barrier asymmetries in AlAs/GaAs double barrier resonant tunneling diodes: experiment and numerical simulation," 11th Annual Symposium on Electronic Materials, Processing, and Characterization, Richardson, TX, June 1-2, 1992.
57. K. K. Gullapalli, A. J. Tsao, and D. P. Neikirk, "Observation of zero-bias multi-state behavior in selectively doped two-terminal quantum tunneling devices," 1992 IEEE International Electron Devices Meeting, San Francisco, CA, Dec. 13-16, 1992, pp. 479-482.
58. D. R. Miller and D. P. Neikirk, "Lattice Wigner Simulations of Quantum Devices," 1992 IEEE International Electron Devices Meeting, San Francisco, CA, Dec. 13-16, 1992, pp. 561-564.
59. J. M. Lewis and D. P. Neikirk, "HiTc composite microbolometers using YBCO," 17th International Conference on Infrared and Millimeter Waves, Richard J. Temkin, Editor, SPIE vol. 1929, Dec. 14-17, 1992, pp. 202-203.
60. V. K. Reddy and D. P. Neikirk, "AlAs/InAs heterojunction barrier varactors," 17th

International Conference on Infrared and Millimeter Waves, Richard J. Temkin, Editor, SPIE vol. 1929, Dec. 14-17, 1992, pp. 358-359.

61. A. J. Tsao, M. Saiful Islam, and D. P. Neikirk, "Hybrid integration of millimeter wave devices using the epitaxial lift-off (ELO) technique," 17th International Conference on Infrared and Millimeter Waves, Richard J. Temkin, Editor, SPIE vol. 1929, Dec. 14-17, 1992, pp. 421-422.

62. M. Saiful Islam, Emre Tuncer and Dean P. Neikirk, "Accurate Quasi-Static Model for Conductor Loss in Coplanar Waveguide," 1993 IEEE MTT-S International Microwave Symposium Digest, Vol. II, pp. 959-962.

63. V. K. Reddy, S. Javalagi, and D. P. Neikirk, "AlAs/InGaAs Single Barrier Diodes," 12th Annual Symposium on Electronic Materials, Processing, and Characterization, Austin, TX, June 7-8, 1993.

64. Y. Kim and D. P. Neikirk, "Monolithically integrated optical pressure microsensor," 12th Annual Symposium on Electronic Materials, Processing, and Characterization, Austin, TX, June 7-8, 1993.

65. K. K. Gullapalli and D. P. Neikirk, "Memory Switching Phenomena in Quantum Well Diodes," 12th Annual Symposium on Electronic Materials, Processing, and Characterization, Austin, TX, June 7-8, 1993.

66. E. Tuncer, S. Y. Kim, L. T. Pillage and D. P. Neikirk, "A new, efficient circuit model for microstrip lines including both current crowding and skin depth effects" IEEE 2nd Topical Meeting on Electrical Performance of Electronic Packaging, Monterey, CA, Oct. 20-22, 1993, pp. 85-88.

67. S. Y. Kim, E. Tuncer, R. Gupta, B. Krauter, D. P. Neikirk, and L. T. Pillage, "An Efficient Methodology for Extraction and Simulation of Transmission Lines for Application Specific Electronic Modules," IEEE/ACM International Conference on Computer-Aided Design - 93, Santa Clara, CA, Nov. 7-11, 1993, pp. 58-65.

68. K. K. Gullapalli, D. R. Miller, and D. P. Neikirk, "Wigner-Poisson simulation of memory switching heterostructure tunneling diodes," 1993 IEEE International Electron Devices Meeting, Washington, DC, Dec. 5-8, 1993, pp. 109-112.

69. T. R. Block, K. G. Eyink, D. P. Neikirk, and B. G. Streetman, "Diffraction condition dependence of RHEED dampening during MBE growth," Epitaxial Growth Processes, Proc. SPIE Conf. on Optics, Electro-optics, and Laser Applications, SPIE Vol. 2140, Los Angeles, CA, Jan. 26-27, 1994, pp. 10-24.

70. K. K. Gullapalli and D. P. Neikirk, "Incorporating spatially varying effective-mass in the Wigner-Poisson model for AlAs/GaAs resonant-tunneling diodes," Proceedings of the Third Annual International Workshop on Computational Electronics, Portland, OR, May

18-20, 1994, pp. 171-174.

71. E. Tuncer, Beom-Taek Lee, and D. P. Neikirk, "Interconnect Series Impedance Determination Using a Surface Ribbon Method" IEEE 3rd Topical Meeting on Electrical Performance of Electronic Packaging, Monterey, CA, Nov. 2-4, 1994, pp. 250-252.

72. C. Hearn, W. Maddox, Y. Kim, V. Gupta, D. Masser, P. Koeneman, C. S. Chu, I. Busch-Vishniac, D. Neikirk, W. Weldon, and K. Wood, "Smart Mechanical Bearings Using MEMS Technology," ASME Energy and Environment EXPO '95: Tribology Symposium 1995, editor: H. Masudi, Houston, TX, Jan. 29 - Feb. 1, 1995, pp. 1-10.

73. Y. Kim and D. P. Neikirk, "Fabry Perot Pressure Sensor," *AVS 14th Annual Symposium on Electronic Materials, Processing, and Characterization*, Austin, Texas, June 6-7, 1995.

74. O. Hartin and D. P. Neikirk, "Memory Switching in RTDs," *AVS 14th Annual Symposium on Electronic Materials, Processing, and Characterization*, Austin, Texas, June 6-7, 1995.

75. V. Gupta and D. P. Neikirk, "Design and Fabrication of an Inductive Proximity Sensor using a Two-Coil Planar Transformer on a Micromachined Membrane," *AVS 14th Annual Symposium on Electronic Materials, Processing, and Characterization*, Austin, Texas, June 6-7, 1995.

76. D. P. Neikirk, E. Tuncer, and B.-T. Lee, "The Use of Effective Internal Impedance Approximations in Lossy Transmission Line Modeling," *Progress in Electromagnetics Research Symposium PIERS 95*, The University of Washington, Seattle, Washington, July 24-28, 1995, p. 955.

77. D. P. Neikirk, M. S. Islam, and E. Tuncer, "Accurate Quasi-Static Modeling of Transmission Lines on Semiconducting Substrates," *Progress in Electromagnetics Research Symposium PIERS 95*, The University of Washington, Seattle, Washington, July 24-28, 1995, p. 929.

78. B. Krauter, D. P. Neikirk, and L. T. Pillage, "Sparse Partial Inductance Matrix Formulation," *Progress in Electromagnetics Research Symposium PIERS 95*, The University of Washington, Seattle, Washington, July 24-28, 1995, p. 957.

79. O. Hartin, D. P. Neikirk, A. Anselm, and B. Streetman, "Design and Fabrication of a Three Terminal Quantum Storage Device," Proceedings of the 1995 IEEE/Cornell Conference on Advanced Concepts in High Speed Semiconductor Devices and Circuits, Cornell University, Ithaca, NY, USA, August 7-9, 1995, p. 209-218.

80. K. L. Wood, I. Busch-Vishniac, D. Neikirk, and W. Weldon, "Smart Hydrodynamic Bearing Applications of Micro-Electro-Mechanical Systems," *American Society of Mechanical Engineers' 1995 International Mechanical Engineering Congress and*

Exposition, San Francisco, Nov. 12-17, 1995.

81. B.-T. Lee, E. Tuncer, and D. P. Neikirk, "Efficient 3-D Series Impedance Extraction using Effective Internal Impedance," *IEEE 4th Topical Meeting on Electrical Performance of Electronic Packaging*, Portland, OR, October 1-4, 1995, pp. 220-222.
82. V. Gupta and D. P. Neikirk, "Design of an Eddy-Current Proximity Sensor using a Two-Coil Planar Transformer," in *Micromachined Devices and Components*, Ray Roop, Kevin Chau, Editors, Proc. SPIE 2642, pp. 173-182, Austin, Texas, USA, 23-24 October, 1995.
83. Y. Kim and D. P. Neikirk, "Micromachined Fabry-Perot Pressure Transducer with Optical Fiber Interconnects," in *Micromachined Devices and Components*, Ray Roop, Kevin Chau, Editors, Proc. SPIE 2642, pp. 242-249, Austin, Texas, USA, 23-24 October, 1995.
84. Kristin L. Wood, Dean Neikirk, Ilene Busch-Vishniac, and William Weldon, "MEMS Hydrodynamic Bearings: Applications and Implications to Machine-Failure Prevention," *Proceedings of a Joint Conference on Integrated Monitoring, Diagnostics and Failure Prevention*, Joint Oil Analysis program Technical Support Center, University of Wales, Swansea, Mobile, AL, April 22-26, 1996, pp. 363-372.
85. S. Kim and D. P. Neikirk, "Compact Equivalent Circuit Model for the Skin Effect," 1996 IEEE-MTT-S International Microwave Symposium, San Francisco, California, June 17-21, 1996, pp. 1815-1818.
86. J. Han, D. P. Neikirk, M. Clevenger, and J. T. McDevitt, "Fabrication and characterization of a Fabry-Perot based chemical sensor," SPIE Microelectronic Structures and MEMS for Optical Processing II, M. E. Motamedi and W. Bailey, editors, Proc. SPIE 2881, Austin, Texas, USA, 14-15 October, 1996, pp. 171-178.
87. J. Han and D. P. Neikirk, "Deflection behavior of Fabry-Perot pressure sensors having planar and corrugated membrane," SPIE's Micromachining and Microfabrication '96 Symposium: Micromachined Devices and Components II, R. Roop and K. Chau, Proc. SPIE 2882, Austin, Texas, USA, 14-15 October, 1996, pp. 79-90.
88. B.-T. Lee and D. P. Neikirk, "Minimum Segmentation in the Surface Ribbon Method for Series Impedance Calculations of Microstrip Lines," *IEEE 5th Topical Meeting on Electrical Performance of Electronic Packaging*, Napa, CA, October 28-30, 1996, pp. 233-235.
89. S. -J. Yoo, J. Lavigne, S. Savoy, J. B. McDoniel, E. V. Anslyn, J. T. McDevitt, D. P. Neikirk, J. B. Shear, "Micromachined storage wells for chemical sensing beads in an 'artificial tongue'," SPIE's Micromachining and Microfabrication '96 Symposium: Micromachined Devices and Components III, K. Chau and P. J. French, editors, Proc. SPIE 3224, Austin, Texas, USA, 29-30 September, 1997.

90. Sangwoo Kim and Dean P. Neikirk, "Time Domain Multiconductor Transmission Line Analysis Using Effective Internal Impedance," *IEEE 6th Topical Meeting on Electrical Performance of Electronic Packaging*, San Jose, CA, October 27 - 29, 1997, pp 255-258.
91. S.-J. Yoo, R. Friar, and D. P. Neikirk, "Analytic modeling of monolithic inductors on semiconductor substrates," *IEEE Topical Meeting on Electrical Performance of Electronic Packaging*, , Oct 26-28, 1998, pp. 219-222.
92. S. Savoy, J. J. Lavigne, J. S.-J. Yoo, J. Wright, M. Rodriguez, A. Goodey, B. McDoniel, J. T. McDevitt, E. V. Anslyn, J. B. Shear, A. Ellington, and D. P. Neikirk, "Solution-based analysis of multiple analytes by a sensor array: toward the development of an electronic tongue," *SPIE Chemical Microsensors and Applications*, Vol. 3539, Boston, MA, Nov. 4, 1998, pp. 17-26.
93. J. J. Lavigne, A. Metzger, K. Niikura, L. A. Cabell, S. M. Savoy, J. S. Yoo, J. T. McDevitt, D. P. Neikirk, J. B. Shear, and E. V. Anslyn, "Single-analyte to multianalyte fluorescence sensors," *SPIE Advances in Fluorescence Sensing Technology IV*, S. A. Soper and R. B. Thompson, Vol. 3602, Boston, MA, May, 1999, pp. 220-231.
94. R. J. Friar and D. P. Neikirk, "Experimental Determination of the Importance of Inductance in Sub-Micron Microstrip Lines," *IEEE 1999 International Interconnect Technology Conference*, San Francisco, May 24-26, 1999, pp. 176-177.
95. Eames, Sara J.; Yoo, J. Seung-Jin; Warner, John C.; Neikirk, Dean P.; McDevitt, John Thomas, "Lithographically patterned superconductor bolometer detectors for visible and near-infrared radiation incorporating wavelength-selective light-absorbing elements," *Proc. SPIE-Int. Soc. Opt. Eng.* (1999), 3790 (Engineered Nanostructural Films and Materials), pp. 160-168, July 23, 1999.
96. R. Friar and D. P. Neikirk, "Limitations due to systematic phase errors on the extraction of loss tangent from micron-sized transmission line test structures," *IEEE Topical Meeting on Electrical Performance of Electronic Packaging*, San Diego, CA, October 25-27, 1999, p. 67-70.
97. Youngsoo Sohn, John Levigne, Dr. Yi Deng, Adrian Goodey, Marc Rodriguez, Andrew Tsao, Theodore E. Curey, Dean P. Neikirk, Eric Anslyn, John McDevitt, and Jason Shear, "Micromachined multi-analyte sensors: towards an 'electronic tongue'," *NASA NanoSpace 2000, International Conference on Integrated Nano/Microtechnology for Space Applications*, League City, TX, Jan. 23-28, 2000.
98. Y.-S. Sohn, A. Tsao, E. Anslyn, J. McDevitt, J. B. Shear, and D. P. Neikirk, "Liquid Flow through an Array-based Chemical Sensing System," *Proc. SPIE-Int. Soc. Opt. Eng.* (2000), 4177 (Microfluidic Devices and Systems III), Sept. 18-21, 2000, pp. 212-219.

99. Young-Soo Sohn, Adrian P. Goodey, Eric V. Anslyn, John T. McDevitt, Jason B. Shear, and Dean P. Neikirk, "MEMS Based Microfluidic Structure for Biological and Chemical Sensor Array," TEX MEMS III, Dallas, TX, June 7, 2001, p. 23.
100. S. C. McCleskey, A. P. Goodey, M. D. Rodriguez, J. T. McDevitt, E. V. Anslyn, and D. P. Neikirk, "Development of a multi-component sensor array for the simultaneous detection of various analytes in solution," presented at 222nd ACS National Meeting,, Chicago, IL, 2001.
101. D. Neikirk, Y. Sohn, S. Yoo, B. Park, Y. Park, B. Woo, and S. Wood, "From medical to structural health monitoring: electronic taste chips to electronic structural surveillance tags," presented at International Sensor Conference 2001 (ISC 2001), Seoul, Korea, 2001.
102. Y.-S. Sohn, A. P. Goodey, E. Anslyn, J. McDevitt, J. Shear, and D. P. Neikirk, "Development of a Micromachined Fluidic Structure for a Biological and Chemical Sensor Array," presented at Fifth International Conference on Miniaturized Chemical and Biochemical Analysis Systems, μ TAS 2001, Monterey, California, 2001.
103. S. Wood and D. Neikirk, "Development of a passive sensor to detect cracks in welded steel construction," presented at US-Japan Joint Workshop and Third Grantees Meeting, US-Japan Cooperative Research in Urban Earthquake Disaster Mitigation, Seattle, 2001.
104. T. Postlethwaite, T. Spain-Santanta, P. Zhang, R. Priest, J. McDevitt, J. Shear, D. Neikirk, E. Anslyn, S. McCleskey, and P. Floriano, "Electronic taste chip sensor for the detection of chemical and biological targets," presented at SPIE AeroSense 2002: Conference 4722 Chemical and Biological Sensing III, Orlando, Florida, 2002.
105. Wiskur, Sheryl L.; Metzger, Axel; Lavigne, John J.; Schneider, Stephen E.; Anslyn, Eric V.; McDevitt, John T.; Neikirk, Dean; Shear, Jason B.; "Mimicking the mammalian sense of taste through single-component and multicomponent analyte sensors," ACS Symposium Series, v 825, 2002, p 276-288.
106. Novak, Lisa J.; Grizzle, Kristi M.; Wood, Sharon L.; Neikirk, Dean P., "Development of state sensors for civil engineering structures," Proceedings of SPIE's Vol. 5057 8th Annual International Symposium on NDE for Health Monitoring and Diagnostics: Smart Systems and NDE for Civil Infrastructures, March 3-6, 2003, pp. 358-363.
107. J. W. Kim and D. P. Neikirk, "Infrared wavelength selective micromachined microbolometers," Proceedings of SPIE Vol. 5116 Smart Sensors, Actuators, and MEMS, SPIE's First International Symposium on Microtechnologies for the New Millennium 2003, Maspalomas, Gran Canaria (Canary Islands), Spain, May 19-21, 2003, pp. 514-522.

108. B. H. Park, Y. S. Park, Y.-S. Sohn, and D. P. Neikirk, "Fabrication of bead size sorting chip for chemical array sensor," Proceedings of SPIE Vol. 5116 Smart Sensors, Actuators, and MEMS, SPIE's First International Symposium on Microtechnologies for the New Millennium 2003, Maspalomas, Gran Canaria (Canary Islands), Spain, May 19-21, 2003, pp. 303-313.
109. B. H. Park, Y.-S. Sohn, and D. P. Neikirk, "Development of micro bead size selection chip for a chemical array sensor," μ TAS2003 / microTAS2003: The 7th International Conference on Miniaturized Chemical and BioChemical Analysis Systems, Squaw Valley, California USA, October 5-9 2003, pp. 631-634.
110. Jooyong Kim; Neikirk, D.P.; "Experimental characterization of copper/low-k transmission line interconnects through microwave measurements," IEEE Electrical Performance of Electrical Packaging (IEEE Cat. No. 03TH8710), Princeton, NJ, USA, Oct. 27-29, 2003, p. 93-96.
111. J. T. Simonen, M. M. Andringa, K. M. Grizzle, S. L. Wood, and D. P. Neikirk, "Wireless sensors for monitoring corrosion in reinforced concrete members," Proceedings of SPIE Smart Structures/NDE Joint Conference Vol. #5391, 15-18 March 2004, San Diego, CA, 2004, pp. 587-596.
112. M. M. Andringa, D. P. Neikirk, and S. L. Wood, "Unpowered wireless analog resistance sensor," Proceedings of SPIE Smart Structures/NDE Joint Conference Vol. 5391, 15-18 March 2004, San Diego, CA, 2004, pp. 356-367.
113. Shifeng Li, David Fozdar, Dongbing Shao, Shaochen Chen, Pierre N. Floriano, Nicolaos Christodoulides, Mehnaaz F. Ali, Priya Dharshan, John T McDevitt, Dean Neikirk, "Disposable Polydimethylsiloxane/Silicon Hybrid Chips for Protein Detection," IMECE2004-62170, Proceedings of IMECE: International Mechanical Engineering Congress and Exposition, November 13-19, 2004, Anaheim, California
114. J. W. Kim, Y. Sohn, and D. P. Neikirk, "Microfabrication of a multichannel microfluidic system for use with microbead reagent sources and detectors," SPIE MOEMS-MEMS 2005, MICROFLUIDICS, BIOMEMS AND MEDICAL MICROSYSTEMS III, Proceedings of SPIE Vol. #5718, 25-27 January 2005, pp. 265-271.
115. Nathan P. Dickerson, Jarkko T. Simonen, Matthew M. Andringa, Sharon L. Wood, and Dean P. Neikirk, "Wireless low-cost corrosion sensors for reinforced concrete structures," SPIE: Smart Structures/NDE Joint Conference, Proceedings of SPIE Vol. 5765, 7-10 March 2005, pp. 493-503.
116. S.-W. Han and D. P. Neikirk, "Design of infrared wavelength-selective microbolometers using planar multimode detectors," presented at Proceedings of the SPIE Vol. 5836 Smart Sensors, Actuators, and MEMS II, Microtechnologies for the New Millennium 2005, Seville, Spain, May 9-11, 2005, pp. 549-557.

117. B. Park, Y. S. Park, J. W. Kim, Y.-S. Sohn, and D. P. Neikirk, "MEMS-based method of polymer bead handling for chemical array sensors," Proceedings of the SPIE Vol. 5836 Smart Sensors, Actuators, and MEMS II, Microtechnologies for the New Millennium 2005, Seville, Spain, May 9-11, 2005, pp. 625-633.
118. Sang-Wook Han and D. P. Neikirk, "Design of broadband or wavelength selective planar multi-mode microbolometer infrared detectors," The Joint 30th International Conference on Infrared and Millimeter Waves and 13th International Conference on Terahertz Electronics, IRMMW-THz 2005 Volume 2, 19-23 Sept. 2005, pp. 650 – 651.
119. Sang-Wook Han, Yoon Sok Park, and D. P. Neikirk, "Multilayer Fabry-Perot microbolometers for infrared detection," The Joint 30th International Conference on Infrared and Millimeter Waves and 13th International Conference on Terahertz Electronics, IRMMW-THz 2005 Volume 2, 19-23 Sept. 2005, pp. 646 - 647.
120. Matthew M. Andringa, Dean P. Neikirk, Nathan P. Dickerson, Sharon L. Wood, "Unpowered wireless corrosion sensor for steel reinforced concrete", 4th IEEE International Conference on Sensors, Irvine, Ca, Nov. 1-3, 2005, pp. 155-158.
121. Andringa, Matthew M.; Puryear, John M.; Neikirk, Dean P.; Wood, Sharon L., "Low-cost wireless corrosion and conductivity sensors," Proceedings of SPIE - The International Society for Optical Engineering, v 6174 I, Smart Structures and Materials 2006 - Sensors and Smart Structures Technologies for Civil, Mechanical, and Aerospace Systems, March 2006, p 61740X.
122. Byungki Woo, Matthew Andringa, Sharon Wood, and Dean P. Neikirk, "Development of a Resonant Repeater Tag for the Enhancement of Sensitivity and Specificity in a Wireless Eddy Current Sensing Scheme" Proceedings of SPIE - The International Society for Optical Engineering, v 6174 I, Smart Structures and Materials 2006 - Sensors and Smart Structures Technologies for Civil, Mechanical, and Aerospace Systems, March 2006 [6176-54].
123. Dickerson, Nathan P., Andringa, Matthew M.; Puryear, John M.; Wood, Sharon L.; Neikirk, Dean P., "Wireless threshold sensors for detecting corrosion in reinforced concrete structures," Proceedings of SPIE - The International Society for Optical Engineering, v 6174 I, Smart Structures and Materials 2006 - Sensors and Smart Structures Technologies for Civil, Mechanical, and Aerospace Systems, March 2006, p 61741L.
124. Sangwook Han, Jooyong Kim, and Dean P. Neikirk, "RF Measurement, Characterization, and Verification of Cu/low-k Transmission Line Interconnects," IEEE International Conference on Microelectronic Test Structures, March 6-9, 2006 Hyatt Regency on Town Lake Austin, Texas USA.
125. S. Han and D. P. Neikirk, "Multilayer Fabry-Perot microbolometers for 2-color infrared detection," Proceedings of SPIE - The International Society for Optical

Engineering, v 6206 I, Infrared Technology and Applications XXXII, Orlando, Florida, April 17-21, 2006, p 62061G.

126. A. Weling, P. F. Henning, D. P. Neikirk, and S. Han, "Antenna-coupled microbolometers for multispectral infrared imaging," Proceedings of SPIE - The International Society for Optical Engineering, v 6206 I, Infrared Technology and Applications XXXII, , Orlando, Florida, April 17-21, 2006, p 62061F

127. Dean P. Neikirk, Archie Holmes, Eric V. Anslyn, "Point and Stand-off Sensors for Explosives Detection," The 7th International Symposium on Technology and the Mine Problem, Naval Postgraduate School, Monterey, CA, May 2-5, 2006.

128. Sangwook Han, Rubin Sidhu, Archie Holmes, and Dean P. Neikirk, "Wavelength selective mid and long wave infrared sensor design," 2006 International Symposium on Spectral Sensing Research (ISSSR-2006), organized by the US Army Edgewood Chemical & Biological Center, Bar Harbor, Maine, 29 May – June 2, 2006.

129. Yoon Park, Dean P. Neikirk, and Eric V. Anslyn, "Micromachined Chemiluminescent System for Explosives Detection," Proceedings of SPIE Vol. 6398, Optically-Based Biological and Chemical Detection for Defence III, Monday-Wednesday 11-13 September 2006, Stockholm.

130. Michael D. Engelhardt, Sharon L. Wood, and Dean P. Neikirk, "Challenges for Performance-Based Fire Safety Design of Steel Structures and Opportunities for Sensor Technologies," US-Korea Workshop on Smart Structures Technology for Steel Structures, Prima Hotel, Seoul, Korea, 16-18 November 2006.

131. Yoon S. Park, Matthew M. Andringa, Dean P. Neikirk, Himali S. Hewage, and Eric V. Anslyn, "Smart microplates: integrated photodiodes for detecting bead-based chemiluminescent reactions," 5th IEEE International Conference on Sensors, paper # B1L-E-4, Daegu, Korea, October 22 – 25, 2006.

132. M. M. Andringa, J. M. Puryear, D. P. Neikirk, S. L. Wood, "In situ measurement of conductivity and temperature during concrete curing using passive wireless sensors," SPIE's 14th Annual International Symposium on Smart Structures and Materials & Nondestructive Evaluation and Health Monitoring, Proceedings of SPIE vol 6529 Sensors and Smart Structures Technologies for Civil, Mechanical, and Aerospace Systems, March 2007.

133. J. M. Puryear, M. M. Andringa, S. L. Wood, D. P. Neikirk, "Low-cost wireless sensors for civil infrastructure," SPIE's 14th Annual International Symposium on Smart Structures and Materials & Nondestructive Evaluation and Health Monitoring, Proceedings of SPIE vol 6529 Sensors and Smart Structures Technologies for Civil, Mechanical, and Aerospace Systems, March 2007.

134. J. Jung, S. Han, D. P. Neikirk, A. S. Welington, J. H. Goldie, P. D. Willson, "Wavelength-selective infrared detectors based on patterned resistive sheets," SPIE Defense and Security Symposium 2007, Conference 6542, Infrared Technology and Applications XXXIII, April 9-13, 2007, paper [6542-47].
135. Y. S. Park, H. S. Hewage, D. P. Neikirk, E. V. Anslyn, "Micromachined microfluidic chemiluminescent system for explosives detection," SPIE Defense and Security Symposium 2007, Conference 6554, Chemical and Biological Sensing VIII, April 11-12, 2007, paper [6554-02].
136. Yoon S. Park, P. Pasupathy, and Dean P. Neikirk, "Resonant chemical surveillance tags," SPIE Europe Symposium on Security and Defence, Florence, Italy, 17 - 20 September 2007, Proceedings of SPIE vol. 6739, Electro-Optical Remote Sensing, Detection, and Photonic Technologies and Their Applications, 2007, p. 673916, paper [6739B-43].
137. Joo-Yun Jung, Sangwook Han, Dean P. Neikirk, "Wavelength-selective infrared detectors," SPIE Europe Symposium on Security and Defence, Florence, Italy, 17 - 20 September 2007, Proceedings of SPIE vol. 6737, Electro-Optical and Infrared Systems: Technology and Applications IV, 2007, p. 67370Z, paper [6737-35].
138. Y. Park, M. Andringa, D. Neikirk, H. Hewage, and E. Anslyn, "Smart microplates: Photodiode Within Silicon Pyramidal Cavity for Detecting Bead-Based Chemiluminescence and AC Characterization for RFID-Type Readout," 6th IEEE Conference on Sensors, Atlanta, Georgia, Oct 28-31, 2007, pp. 1189-1192.
139. P. Pasupathy, Dean P. Neikirk, and Sharon L. Wood, "Improved reading techniques for electronic structural surveillance tags," Proc. SPIE Volume 6932 / Wireless Sensors/Networks, Sensors and Smart Structures Technologies for Civil, Mechanical, and Aerospace Systems, March 2008, San Diego, California, USA, 2008693214 (2008), DOI:10.1117/12.776522.
140. Yoon Seok Park, Praveenkumar Pasupathy, Dean P. Neikirk, Eric V. Anslyn, "Micromachined platform for chemiluminescent and phosphorescent vapor detection" (Invited Paper), SPIE Europe Symposium on Security and Defence, Cardiff, Wales, 15 - 18 September 2008, Proceedings of SPIE vol. 7116, Optically Based Biological and Chemical Detection for Defence, paper [7116-27].
141. Puryear, J.M.H., Dickerson, N.P., Wood, S.L., and Neikirk, D.P., "Low-Cost Wireless Sensors for Concrete Bridges," NDE/NDT for Highways and Bridges: Structural Materials Technology, American Society for Nondestructive Testing, Oakland, CA, September 2008.
142. Pasupathy, P., Zhuzhou, M., Neikirk, D.P., Wood, S.L., "Unpowered resonant wireless sensor nets for structural health monitoring," 2008 IEEE Conference on Sensors, Lecce, Italy, Oct 26-29, 2008, pp. 697-700, ISBN: 978-1-4244-2580-8.

143. Wood, S.L. and Neikirk, D.P., "Passive Sensors for Infrastructure Monitoring," Proc. of SPIE Vol. 7292, keynote paper, Sensors and Smart Structures Technologies for Civil, Mechanical, and Aerospace Systems 2009, International Society for Optical Engineering, San Diego, California, 9 March 2009, pp. 729202-1 to 729202-11.
144. Joo-Yun Jung, Jong Yeon Park, and Dean P. Neikirk, "Wavelength-selective infrared detectors based on cross patterned resistive sheets," Proc. SPIE 7298, 72980L (2009), DOI:10.1117/12.818638, SPIE Defense and Security Symposium 2009, Infrared Technology and Applications XXXV, April 13-17, 2009.
145. Praveen Pasupathy, Shasi Munukutla, Dean P. Neikirk, and Sharon L. Wood, "Versatile wireless sacrificial transducers for electronic structural surveillance sensors," 2009 IEEE Conference on Sensors, Christchurch, New Zealand, Oct 25-28, 2009, paper B3L-C2, Oct. 27, IEEE Catalog Number: CFP09SEN-CDR, ISBN: 978-1-4244-5335-1, pp. 979-983.
146. Jun Wan Kim, Praveen Pasupathy, Sheng Zhang, and Dean P. Neikirk, "Measurement of liquid complex dielectric constants using non-contact sensors," 2009 IEEE Conference on Sensors, Christchurch, New Zealand, Oct 25-28, 2009, paper C5L-C5, Oct. 28, IEEE Catalog Number: CFP09SEN-CDR, ISBN: 978-1-4244-5335-1, pp. 2017-2020.
147. Ali Abu Yousef, Praveenkumar Pasupathy, Sharon L. Wood, and Dean P. Neikirk, "Embedded Passive Sensors for Detecting Corrosion in Concrete Bridge Decks," 89th Annual Meeting, Transportation Research Board, Washington, DC, January 2010, Paper #10-3483.
147. Ye Chen, Praveenkumar Pasupathy, Dean P. Neikirk, Sharon L. Wood, "Magneto-inductive waveguide as a passive wireless sensor nets for structural health monitoring," Sensors and Smart Structures Technologies for Civil, Mechanical, and Aerospace Systems, Conference 7647 - Proceedings of SPIE Volume 7647, Date: Thursday 11 March, 2010, San Diego, California, USA.
148. Joo-Yun Jung, Jong Yeon Park, Dean P. Neikirk, Aniruddha S. Weling, William T. Hafer, James H. Goldie, Paul D. Willson, "Skin depth effects in wavelength-selective infrared microbolometers based on lossy frequency selective surfaces," Proceedings of SPIE, Vol. 7660, Infrared Technology and Applications XXXVI, Orlando, Florida, Monday-Friday 5-9 April 2010, paper number 7660-38.
149. Jong Yeon Park, Joo-Yun Jung, Dean P. Neikirk, Aniruddha S. Weling, William T. Hafer, James H. Goldie, Paul D. Willson, "Fabrication of wavelength selective germanium dielectric supported microbolometers," Proceedings of SPIE, Vol. 7660, Infrared Technology and Applications XXXVI, Orlando, Florida, Monday-Friday 5-9 April 2010, paper number 7660-139.

150. Ali Abu Yousef, Praveenkumar Pasupathy, Sharon L. Wood, and Dean P. Neikirk, "Passive Sensors for Detecting Corrosion in Concrete Structures," 3rd Congress of the International Federation for Structural Concrete, Washington, DC, May 2010.
151. Ali Abu Yousef, Praveenkumar Pasupathy, Sharon L. Wood, and Dean P. Neikirk, "Passive Sensors for Detecting Corrosion in Concrete Structures," 5th International Conference on Bridge Maintenance, Safety and Management, Philadelphia, PA, July 2010.
152. Ali Abu Yousef, Praveenkumar Pasupathy, Sharon L. Wood, and Dean P. Neikirk, "Passive Sensors for Detecting Corrosion in Concrete Bridge Decks," 7th International Bridge Engineering Conference Improving Reliability and Safety - Restoration, Renewal and Replacement, San Antonio, Texas, December 2010.
153. JinYoung Kim, Praveenkumar Pasupathy, Chih-Chieh Chou, Sharon L. Wood, and Dean P. Neikirk, "Embedded passive wireless sensors for detecting conductivity within RC structures," Proc. SPIE 7983, 79832L (2011); doi:10.1117/12.880412, SPIE Conference on Nondestructive Characterization for Composite Materials, Aerospace Engineering, Civil Infrastructure, and Homeland Security 2011 Monday 7 March 2011, San Diego, California.
154. Ali E. Abu-Yousef, Praveenkumar Pasupathy, Sharon L. Wood, and Dean P. Neikirk, "Low-Cost, Passive Sensors for Monitoring Corrosion in Concrete Structures," Proc. SPIE 7983, 79831Q (2011); doi:10.1117/12.879893, SPIE Conference on Nondestructive Characterization for Composite Materials, Aerospace Engineering, Civil Infrastructure, and Homeland Security 2011 Monday 7 March 2011, San Diego, California.
155. P. Pasupathy, A. Abu Yousef, D. P. Neikirk, and S. L. Wood, "Wireless Electronic Structural Surveillance Sensors Using Inductively Coupled Sacrificial Transducers," Progress in Electromagnetics Research Symposium, PIERS 2011, Marrakesh. Morocco, March 20-23, 2011, PIERS Online Vol. 7 No. 6 2011 pp: 511-515
156. Ye Chen, Praveen Pasupathy, and Dean P. Neikirk, "The Effects of Defects on Magneto-inductive Waveguide," Progress in Electromagnetics Research Symposium, PIERS 2011, Marrakesh. Morocco, March 20-23, 2011, PIERS Online Vol. 7 No. 6 2011 pp: 506-510
157. Sheng P. Zhang, Praveenkumar Pasupathy, Dean P. Neikirk, "Microfabricated self-resonant structure as a passive wireless chemical sensor," Proc. SPIE 8066, 80661L (2011); doi:10.1117/12.886895, SPIE International Symposium on Microtechnologies, Conference 8066 Smart Sensors, Actuators and MEMS (EMT101), Prague, Czech Republic, 18-20 April 2011, Paper 8066-57.
158. Joo-Yun Jung, Jong Yeon Park, Dean P. Neikirk, Aniruddha S. Weling, Will Hafer, James H. Goldie, and Paul D. Willson, "Experimental LWIR spectral characterization of

wavelength selective microbolometers,” SPIE Defense, Security, and Sensing, Infrared Technology and Applications XXXVII Proceedings of SPIE, paper number 8012-38, 25-29 April 2011, Orlando, Florida.

159. Jong Yeon Park, James E. Gardner, Praveen Pasupathy, Ji Won Suk, Rodney S. Ruoff, and Dean P. Neikirk, “Fabrication and Characterization of Wavelength Selective Microbolometers using a Planar Self-aligned Process for Low Deformation Membranes,” in MOEMS and Miniaturized Systems XI, part of SPIE MOEMS-MEMS, San Francisco, California, 25 Jan 2012, SPIE Paper Number 8252-33, Proc. SPIE 8252, 82520Y (2012); <http://dx.doi.org/10.1117/12.906290> , 7 pages.

160. Ye Chen, Praveen Pasupathy, Tanuj Trivedi, Dean P. Neikirk and Sharon L. Wood, “Improved magneto-inductive waveguide as wireless sensor net for structural health monitoring,” Nondestructive Characterization for Composite Materials, Aerospace Engineering, Civil Infrastructure, and Homeland Security 2012, San Diego, California, USA, Proc. SPIE 8347, 83472H (2012); <http://dx.doi.org/10.1117/12.915227>, Monday 12 March 2012, 8 pages.

161. Ali E. Abu-Yosef, Praveen Pasupathy, Sharon L. Wood and Dean P. Neikirk, “Detection of multiple corrosion thresholds in reinforced concrete structures using passive sensors,” Nondestructive Characterization for Composite Materials, Aerospace Engineering, Civil Infrastructure, and Homeland Security 2012, San Diego, California, USA, Proc. SPIE 8347, 83470J (2012); <http://dx.doi.org/10.1117/12.915164> , Monday 12 March 2012, 7 pages.

162. JinYoung Kim, Praveenkumar Pasupathy, Sharon L. Wood and Dean P. Neikirk, “Enhanced resolution of passive wireless conductivity sensors,” Sensors and Smart Structures Technologies for Civil, Mechanical, and Aerospace Systems 2012, San Diego, California, USA, Proc. SPIE 8345, 83451B (2012); <http://dx.doi.org/10.1117/12.916754> , Monday 12 March 2012, 7 pages.

163. Tanuj Trivedi, Frank Raffaeli, Praveen Pasupathy, Ali E. Abu-Yousef, Ye Chen, Dean Neikirk and Sharon Wood, “A reflectometer-based reader for passive wireless structural surveillance sensors,” Nondestructive Characterization for Composite Materials, Aerospace Engineering, Civil Infrastructure, and Homeland Security 2012, San Diego, California, USA, Proc. SPIE 8347, 83470I (2012); <http://dx.doi.org/10.1117/12.915223> Monday 12 March 2012, 7 pages.

164. Hoo Kim and Dean P. Neikirk, “Three Dimensional Dual-band Stacked Microbolometer Design using resistive dipoles and slots,” SPIE Infrared Technology and Applications XXXIX, edited by Bjørn F. Andresen, Gabor F. Fulop, Charles M. Hanson, Paul R. Norton, Proc. of SPIE Vol. 8704, 870419, 11 June 2013.

165. Dean P. Neikirk, Hoo Kim, Jong Yeon Park, Joo-Yun Jung, “Patterned resistive sheets for use in infrared microbolometers,” SPIE Security + Defence, 25 Sep 2013 4:00 PM - 4:20 PM.

C. Published Abstracts

1. P.E. Young, Q.-X. Yu, W. A. Peebles, N.C. Luhmann, Jr., D. P. Neikirk, and D. B. Rutledge, "Application of Far-Infrared Imaging Arrays to Plasma Density and Magnetic Field Measurements," 4th APS Topical Conference on High Temperature, 1982.
2. P.E. Young, Q.-X. Yu, W.A. Peebles, N.C. Luhmann, Jr., D. P. Neikirk, and D. B. Rutledge, "Demonstration of Far-Infrared Phase Imaging," 24th Annual Meeting, Division of Plasma Physics, New Orleans, La., November, 1982.
3. P. E. Young, W.A. Peebles, N.C. Luhmann, Jr., R.J. Taylor, D. B. Rutledge, D. P. Neikirk, and P.P. Tong, "Current Profile Measurements in a Tokamak Plasma," 25th Ann. APS Meeting, Div. of Plasma Physics, Nov., 1983.
4. D. B. Rutledge, D. P. Neikirk, P.P. Tong, P.E. Young, W.A. Peebles, N.C. Luhmann, Jr., and R.J. Taylor, "Demonstration of a FIR Imaging System as a Multi-Channel Interferometer," 25th Ann. APS Meeting, Div. of Plasma Physics, Nov., 1983.
5. P.E. Young, N.C. Luhmann, Jr., R.J. Taylor, D. P. Neikirk, and D. B. Rutledge, 26th Annual Meeting of the Division of Plasma Physics, Boston, MA, Oct 29- Nov 2, 1984.
6. D.L. Brower, W.A. Peebles, S. Kim, R.L. Savage, Jr., T. Lehecka, N.C. Luhmann, Jr., J. Wagner, D. B. Rutledge, D. P. Neikirk, P.E. Young, and H.K. Park, "Recent advances in multichannel far-infrared collective scattering and interferometry systems," Eleventh Symposium on Fusion Engineering, Austin, TX, Nov. 18-22, 1985.
7. A.C. Campbell, V.P. Kesan, G.E. Crook, C.M. Maziar, D. P. Neikirk, and B. G. Streetman, "Capacitive Hysteresis Effects in 5.0nm single and double barrier AlAs Tunneling Structures," 8th Molecular Beam Epitaxy Workshop, Los Angeles CA, September 9-11, 1987.
8. A.C. Campbell, V.P. Kesan, G.E. Crook, D. P. Neikirk, and B. G. Streetman, "Capacitance Transient Analysis of GaAs/AlAs Tunneling Structures," 1988 Electronics Materials Conference, University of Colorado, Boulder, Colorado, June 22-24, 1988.
9. V.P. Kesan, A. Dodabalapur, D. P. Neikirk, and B. G. Streetman, "Influence of MBE Growth and Rapid Thermal Annealing Conditions on the Electrical Properties of Normal and Inverted AlGaAs/InGaAs Pseudomorphic HEMT Structures," IEEE 46th Annual Device Research Conference, June 20-22, 1988, Boulder, CO.

10. A. Dodabalapur, V.P. Kesan, T.R. Block, D. P. Neikirk, and B. G. Streetman, "Optical and Electrical Characteristics of Normal and Inverted AlGaAs/InGaAs Pseudomorphic HEMT Structures Processed by RTA," 9th Molecular Beam Epitaxy Workshop, West Lafayette, Indiana, September 21-23, 1988.
11. A. Sharif, D. P. Neikirk, and D.R. Diller, "Design and Fabrication of a Multi-Sensor Cryomicroscope Stage using VLSI Technology," Cryo 89, Charleston, SC, June 1989, published in **Physics in Medicine and Biology** 33.
12. A. Dodabalapur, V.P. Kesan, D. P. Neikirk, B. G. Streetman, M.H. Herman, and I.D. Ward, "Photoluminescence and Electreflectance Characterization of Modulation-Doped Quantum Wells," Journal of Electronic Materials 18, July 1989, p. 51.
13. V.K. Reddy and D. P. Neikirk, "Influence of Growth Interruption on I - V Characteristics of AlAs/GaAs Double Barrier Resonant Tunneling Diodes," 11th Annual Molecular Beam Epitaxy Workshop, Austin TX, Sept. 16-18, 1991.
14. A.J. Tsao, V.K. Reddy, D.R. Miller, K.K. Gullapalli, and D. P. Neikirk, "The effect of barrier thickness asymmetries on the electrical characteristics of AlAs/GaAs double barrier resonant tunneling diodes," 11th Annual Molecular Beam Epitaxy Workshop, Austin TX, Sept. 16-18 1991.
15. T.R. Block, D. P. Neikirk, and B. G. Streetman, "MBE growth condition dependence of RHEED dampening and QW photoluminescence," Twelfth North American Conference on Molecular Beam Epitaxy, Ottawa, Canada, Oct. 12-14, 1992.
16. T.J. Mattord, D. P. Neikirk, A. Srinivasan, A. Tang, K. Sadra, Y.C. Shih, and B. G. Streetman, "Real time flux monitoring and feedback control of a valved arsenic source" Twelfth North American Conference on Molecular Beam Epitaxy, Ottawa, Canada, Oct. 12-14, 1992.
17. Y.C. Shih, D. P. Neikirk, and B. G. Streetman, "Effects of As flux on Si δ -doped GaAs," Twelfth North American Conference on Molecular Beam Epitaxy, Ottawa, Canada, Oct. 12-14, 1992.
18. Y. Kim and D. P. Neikirk, "Monolithically integrated optically interrogated pressure microsensor," **J. Acoust. Soc. Am.**, Vol. 92, No. 4 (pt. 2), October 1992, p. 2353.
19. O. Hartin, D. P. Neikirk, A. Anselm, and B. Streetman, "Memory Switching Simulation in Resonant Tunneling Devices," 1997 American Physical Society March Meeting, Kansas City, MO, March 17-21, Bulletin of the American Physical Society, Vol. 42, No. 1, 1997, p. 548.
20. O. Hartin and D. P. Neikirk, "Tight Binding Simulation of Memory Switching in Resonant Tunneling Devices," 1997 American Physical Society International Conference on Computational Physics, University of California, Santa Cruz, Aug. 25, 1997.

21. D. Neikirk, "Embedded Passive Sensors for State Monitoring," presented at NSF Workshop on Exploring the Uses of Autoadaptive Media in Geotechnical Earthquake Engineering, Austin, TX, January 10-12 2001.

22. Lavigne, John J.; Savoy, Steve; Best, Michael; Anslyn, Eric V.; Shear, Jason B.; McDevitt, John T.; Neikirk, Dean, "Toward the development of an 'electronic tongue'," Book of Abstracts, 219th ACS National Meeting, San Francisco, CA, March 26-30, 2000 (2000), AGFD-193.

23. Wood, Sharon; Neikirk, Dean, "Development of a passive sensor to detect cracks in welded steel construction," US-Japan Joint Workshop and Third Grantees Meeting, US-Japan Cooperative Research in Urban Earthquake Disaster Mitigation, Monbu-Kgagku-sho and The National Science Foundation, Seattle, August 15-16, 2001.

24. McCleskey, Shawn C.; Goodey, Adrian P.; Rodriguez, Marc D.; McDevitt, John T.; Anslyn, Eric V.; Neikirk, Dean P., "Development of a multi-component sensor array for the simultaneous detection of various analytes in solution," Abstracts of Papers, 222nd ACS National Meeting, Chicago, IL, United States, August 26-30, 2001.

D. Other Major Publications

V. Kesan and D. P. Neikirk, "Quantum Well Devices," **Microwaves and RF**, vol. 25, July 1986, pp. 93-97.

D. P. Neikirk, P. Cheung, M.S. Islam, and T. Itoh, "Optically Controlled Coplanar Waveguide Phase Shifters," **Microwave Journal**, Dec. 1989, pp. 77-88.

D. P. Neikirk, "Quantum Wells and Other Deep Subjects," **Discovery**, Vol. 11, No. 3, 1989, pp. 5-8.

S. M. Wentworth, J. M. Lewis, and D. P. Neikirk, "Antenna-Coupled Thermal Detectors of mm-Wave Radiation," **Microwave Journal**, Jan. 1993, pp. 94-103.

E. Book Chapter

D. B. Rutledge, D. P. Neikirk, and D. Kasilingam "Integrated- Circuit Antennas," in **Infrared and Millimeter Waves**, vol. 11, editor K.J. Button, 1984.

Nicolaos Christodoulides, Priya Dharshan, Jorge Wong, Pierre N. Floriano, Dean Neikirk and John T. McDevitt, "A Microchip-Based Assay for Interleukin-6," In: *Methods in Molecular Biology*, Volume 385: Microchip-Based Assay Systems, Humana Press, ISBN 978-1-58829-588-0 (Print) 978-1-59745-426-1 (Online), Copyright 2008, pages 131-144.

F. Technical Reports

C-K Tzuang, D. P. Neikirk, and T. Itoh, "Finite Element Analysis of Slow-Wave Schottky Contact Printed Lines," Microwave Laboratory Report No. 87-P-2, AFOSR Grant 86-0036, Feb., 1987.

D. P. Neikirk and T. Itoh, "Monolithic Phase Shifter Study," Microwave Laboratory Report No. 87-P-3, AFOSR Grant 86-0036, Jan., 1987.

V. P. Kesan and D. P. Neikirk, "Quantum Well Devices," Electrical Engineering Research Laboratory Report No. 87-P-8, Joint Services Electronics Program Research Contract AFOSR F49620-86-C-0045, August 7, 1987.

Stuart M. Wentworth and D. P. Neikirk, "High Frequency Characteristics of Tape Automated Bonding (TAB) Interconnects," Microwave Laboratory Report No. 87-P-7, August 26, 1987.

Stuart M. Wentworth and D. P. Neikirk, "Characterization of Tape Automated Bonding (TAB) Interconnects at High Frequency," Microwave Laboratory Report No. 87-P-9, October 23, 1987.

D. P. Neikirk and T. Itoh, "Monolithic Phase Shifter Study," Microwave Laboratory Report No. 90-P-1, Final Technical Report for AFOSR Grant 86-0036, Feb., 1990.

A. Mortazawi, D. Neikirk, and T. Itoh, "Microwave and millimeter wave oscillators and planar power combining structures for QWITT and Gunn diodes," Microwave Laboratory Report No. 90-P-4, Technical Report for ARO Grant DAAL03-88-K-0005 and JSEP Grant F49620-89-0044, Aug., 1990.

Oral Presentations

A. Professional Society Presentation

D. B. Rutledge and D. P. Neikirk, "Imaging Antenna Arrays," Invited Keynote Speakers, Sixth International Conference on Infrared and Millimeter Waves, Miami, Fl., Dec. 7-12, 1981.

D. P. Neikirk and D. B. Rutledge, "Advances in Microbolometers," Invited Keynote Speakers, Eighth International Conference on Infrared and Millimeter Waves, Miami, Fl., Dec. 12-17, 1983.

D. P. Neikirk, "Optically Controlled Coplanar Waveguide Millimeter Wave Phase Shifter," Tenth International Conference on Infrared and Millimeter Waves, Lake Buena Vista, Fl., Dec. 9-13, 1985.

D. P. Neikirk, "Picosecond Response of an Optically Controlled Millimeterwave Phase Shifter," Second Topical Meeting on Picosecond Electronics and Optoelectronics, Jan., 1987.

D. P. Neikirk, "Influence of Transit Time Effects on the Optimum Design and Maximum Oscillation Frequency of Quantum Well Oscillators," 12th International Conference on Infrared and Millimeter Waves, Dec. 14-18, 1987.

D. P. Neikirk, "Measurements of an Optically Controlled Coplanar Waveguide Phase-Shifter," 12th International Conference on Infrared and Millimeter Waves, Dec. 14-18, 1987.

D. P. Neikirk, "High Frequency Characterization of Tape-Automated Bonding Interconnects," 5th Annual Texas Regional Symposium, International Society of Hybrid Manufacturing, April 11, 1988.

D. P. Neikirk, "Time Dependent Simulation of the Quantum Well Injection Transit Time Diode," 13th International Conference on Infrared and Millimeter Waves, Dec. 5-9, 1988.

D. P. Neikirk, "Experimental Performance of a Periodically Illuminated Optically Controlled Coplanar Waveguide Phase Shifter," 13th International Conference on Infrared and Millimeter Waves, Dec. 5-9, 1988.

B. Invited Lectures

1. D. P. Neikirk, "Exotic Heterojunction Devices for Microwave Circuits," NSF Workshop on Future Research Opportunities in Electromagnetics, Arlington, TX., January 29-31, 1986.

2. D. P. Neikirk, "Optical Control of a Monolithic Millimeter Phase Shifter," ARO Workshop on Fundamental Issues in Millimeter and Submillimeter Waves, Los Angeles, Ca., Sept. 15-16, 1986.

3. Dean P. Neikirk, "Quantum Well Oscillators for Millimeter Wave Applications," 1987 Workshop on Compound Semiconductor Microwave Materials and Devices (WOCSEMMAD), Hilton Head Island, S.C., March 2-4, 1987.

4. S.M. Wentworth and D. P. Neikirk, "High Frequency Tape-Automated Bonding (TAB) Interconnect Characterization," IEEE 6th Annual VLSI and GaAs Packaging Workshop, Sept. 14-16, 1987.

5. D. P. Neikirk, "The quantum well injection transit time diode," Engineering Foundation Conference on Advanced Heterostructure Transistors, Keauhou-Kona, Hawaii, Dec. 5-10, 1988.
6. D. P. Neikirk, ""The High Frequency Characteristics of Tape Automated Bonding (TAB) Interconnects," presented to the Microelectronics and Computer Technology Corporation, April 19, 1989.
7. Dean P. Neikirk, "Impedance measurements of quantum well diodes for millimeter wave applications," 1990 Workshop on Compound Semiconductor Microwave Materials and Devices (WOCSEMMAD), San Francisco, CA., Feb. 12-14, 1990.
8. Dean P. Neikirk, "Twin-slot multi-layer substrate-supported antennas and detectors for terahertz imaging," First International Symposium on Space Terahertz Technology, University of Michigan, Ann Arbor, Mich., March 5-6, 1990.
9. Dean P. Neikirk, "Microwave and Millimeterwave Oscillators using Quantum Well Diodes," Joint IEEE MTT/ED Dallas Chapter meeting, Sept. 27, 1990.
10. Dean P. Neikirk, "Quantum Transport Simulations of Resonant Tunneling Diodes," 1991 Workshop on Compound Semiconductor Microwave Materials and Devices (WOCSEMMAD), Ft. Lauderdale, FL., Feb. 18-20, 1991.
11. Dean P. Neikirk, "The Application of Physics in Electrical Engineering (or is it Engineering in Physics?): Electromagnetics in Very High Frequency Semiconductor Devices," Physics Colloquium, Oklahoma State University, March 5, 1992.
12. D. P. Neikirk and B. G. Streetman, "MBE growth of multilayer heterostructures for photonic and high-speed electronic devices," Engineering Foundation Conference on High Speed Optoelectronic Devices and Circuits II, Banff, Alberta, Canada, Aug. 9-13, 1992.
13. L. T. Pillage, D. P. Neikirk, and R. Mercer, "Design automation techniques and algorithms for application specific electronic modules (ASEMs)," ARPA Electronic Packaging & Interconnect Principle Investigator Meeting, Marina del Ray, CA, Feb. 14-18, 1994.
14. D. P. Neikirk, "Micro-sensors - What happens when you make classical devices small?: Integrated Bolometric Radiation Detectors," Texas Instruments, Dallas, Texas, Oct. 20, 1994.
15. Dean P. Neikirk, "Micromachined sensors," Motorola Sensors Steering Committee, Albuquerque, New Mexico, March 28, 1995.
16. D. P. Neikirk, E. Tuncer, and B.-T. Lee, "The Use of Effective Internal Impedance Approximations in Lossy Transmission Line Modeling," *Progress in Electromagnetics*

Research Symposium PIERS 95, The University of Washington, Seattle, Washington, July 28, 1995.

17. D. P. Neikirk, M. S. Islam, and E. Tuncer, "Accurate Quasi-Static Modeling of Transmission Lines on Semiconducting Substrates," *Progress in Electromagnetics Research Symposium PIERS 95*, The University of Washington, Seattle, Washington, July 28, 1995.

18. D. P. Neikirk, "Impact of Finite Metal Conductivity on Inductance Extraction of Interconnects and Packages," Sematech meeting on Electrical Modeling Challenges Faced by Packaging Designers, Austin, Texas, Nov. 19, 1995.

19. D. P. Neikirk, "Micromachined Fabry-Perot Pressure Transducers," Hughes Research Laboratory, Malibu, California, Nov. 21, 1995.

20. D. P. Neikirk, "Classical Devices Made Small; or 'What's the big deal about little machines?'" , Manufacturing 2000, University of Texas at Austin, Feb. 23, 1996.

21. D. P. Neikirk, "Interconnect Inductance Modeling from DC to the Skin Effect Limit," Quad Designs, Camarillo, CA, July 10, 1996.

22. D. P. Neikirk, "Efficient Conductor Boundary Conditions in the dc to Skin Effect Limit," DARPA MAFET Program Review, Fairfax, VA, Oct. 27-31, 1997.

23. Micromachined Array-based Multi-analyte Chemical Sensors: Towards the Fabrication of an "Electronic Tongue" South, Texas Local Section of The Electrochemical Society Meeting, April 17, 1999.

24. D. P. Neikirk, "Resonant Chemical Surveillance Tags," IEEE Electron Device Chapter, Central Texas Section, September 25, 2008.

25. D.P. Neikirk, "Near Borehole Condition Sensing," Nanotechnology Conference and Trade Show - Nanotech 2009, Houston, TX May 3-7, 2009, Nanotech & Cleantech for Oil & Gas Session, (Session chair: Sean Murphy, Advanced Energy Consortium), May 5, 2009.

26. D.P. Neikirk, "Integrated Threshold Nanosensor Systems," Advanced Oil Consortium Microfabricated Sensors Workshop, Houston Research Center, Bureau of Economic Geology, University of Texas at Austin, September 8th-9th, 2010.

27. D. P. Neikirk, "Sensing systems for "harsh" environments," Engineering Challenges for Deepwater Drilling at the "U.S. Offshore Oil Exploration: Managing Risks to Move Forward," James A. Baker III Institute for Public Policy and PFC Energy, Rice University, Houston, TX, February 11, 2011.

C. Other Conference Presentations

Praveen Pasupathy, Mingxiang Zhuzhou, Shasi K. Munukutla, Dean P. Neikirk, and Sharon L. Wood, “Resonant Wireless Sensor Nets for Civil Infrastructure Health Monitoring,” 2009 National Science Foundation Division of Civil, Mechanical and Manufacturing Innovation (CMMI) Engineering Research and Innovation Conference, Honolulu, Hawaii, June 22-25, 2009.

Technical Consulting

Teltech Resource Network (1985-1993)
Ardex, Inc. (1986-88)
University and Polytechnic Grants Committee, Consultancy to examine Equipment Requirements for the Hong Kong University of Science and Technology, July, 1989
E. P. Hamilton Associates, (1987-90)
Burnett Company, Microwave Heating for Secondary Oil Recovery, July, 1990
Microelectronics and Computer Technology Corporation, June, 1990
Microelectronics and Computer Technology Corporation, Oct., 1994 - Sept., 1996
Baker-Hughes

University Committee Assignments

Departmental:

Graduate Student Financial Aid, Sept. 1984- Sept. 1987
Faculty Recruiting, Sept. 1984- Aug. 1985
Microelectronics Jr. Faculty Recruiting, Sept. 1985- Sept. 1987 (chairman)
ECE Safety Committee, Sept. 1985- Aug. 1993 (chairman, 1985-89)
ECE Electronics Shop Coordinating Committee, March 1986- Aug. 1993
Solid State Electronics Area Graduate Advisor, Aug. 1986- Aug. 89
ECE Space Allocation Committee, Sept. 1989-Aug. 1993 (chairman)
ECE Facilities Committee, Sept. 1993- Aug. 1996 (chairman)
ECE Areas Committee, Electromagnetics/Acoustics, Sept. 1993-present
ECE Ad Hoc Committee to Review the Undergraduate Curriculum, Jan. 1995-Aug. 1995
ECE World Wide Web Home Page Committee, Sept. 1995-Aug. 1996
ECE Ad Hoc Committee to Review the Undergraduate Curriculum, Jan. 1997-Aug. 1997
ECE Areas Committee, Materials and Quantum Electronics, Sept. 1993-present; chairman, Sept. 1996-present
Chair of ECE Graduate Studies Committee, May 1998-August 2006
ECE Chair's council, November 1999-2010
ECE Graduate Advisor, Sept. 1999- 2010
ECE Associate Chair, Sept. 2001-Dec. 2010
ECE peer Faculty Annual Review Committee, Sept. 2012-Aug. 2013

College:

Engineering Scholastic Appeals, Sept. 1984- Aug. 1985
Engineering Safety Committee, Sept. 1985- Aug. 1994 (chairman, Sept. 1989-Aug. 1994)

Aerospace Engineering Machine Shop, Sept. 1989-Aug. 1993
College Annual Report Quality Team, Jan. 1994- Aug. 1994
College Multimedia Committee, Sept. 1995-Aug. 2000
Equal Opportunity in Engineering (EOE) Program, 1995-Dec. 1996
Graduate Fellowship Review Committee, Sept. 2011-Aug. 2013

University:

Presidential Ad Hoc Committee on Research Infrastructure Enhancement, Jan. 1988 - Aug. 1994
Research Safety Advisory Committee, Oct. 1991-present (chairman, Sept. 1996-1999)
Ad Hoc Consultative Committee for the Selection of a Dean of the College of Engineering, Nov. 1995-May 1996
Faculty Building Advisory Committee, Sept. 1995-Aug. 2000; Aug. 2003-Aug. 2004
Ad Hoc Project Committee for Parking Garage # 4A, Sept. 1996-Aug. 2000
Faculty Council, Sept. 1996-Aug. 2000; Sept. 2002 - Aug. 2004
Faculty Advisory Committee on the Budget, Sept. 99 - Aug. 2000; Sept. 2008 – Aug. 2011 (vice chair Sept. 2009- Aug. 2010)
Graduate Assembly, April 1997- Aug. 2000; Sept. 2001 - Aug. 2008
Administrative sub-committee of GA, Sept. 1997-Aug. 1998; Sept. 2006-Aug. 2007
Academic sub-committee of GA, Sept. 1998-Aug. 2000; Sept. 2001-Aug. 2006; Sept. 2007-Aug. 2008
Chair, Graduate Assembly, 2004-2005
Academy of Distinguished Teachers selection committee, academic year 1999-2000
Outstanding Graduate Adviser selection committee, academic year 1999-2000
Outstanding Graduate Coordinator selection committee, academic year 1999-2000
Faculty Council, Sept. 2008 – Aug. 2012; Chair-elect Sept. 2009- Aug. 2010; Chair Sept. 2010- Aug. 2011; past chair: Sept. 2011-Aug. 2012
Faculty Council Executive Committee, Sept. 2009 – Aug. 2012
General Faculty Rules and Governance Committee, Sept. 2010 – Aug. 2015 (Chair, Sept. 2011 – Aug. 2013)
Ad Hoc Consultative Committee for the Selection of a Dean of the Graduate School, Nov. 2012 – Sept. 2012
Secretary of the General Faculty and Faculty Council, Sept. 2013 – Aug. 2015
Committee on Undergraduate Degree Program review, Sept. 2013 – Aug. 2015
Faculty Council Executive Committee, Sept. 2013 – Aug. 2015
Faculty Committee on Committees, *ex officio* member, Sept. 2013 – Aug. 2015

UT System:

Task Force on Doctoral Programs and Post-Doctoral Experience, Spring-Fall 2006

University of Texas System Faculty Advisory Council, Sept. 2009- Aug. 2011

State of Texas:

Texas Higher Education Coordinating Board Graduate Education Advisory Committee (GEAC), September 1, 2015 - August 31, 2018.

Evidence of Teaching Effectiveness

Senior Design Projects:

Umer Yousafzai and Venuka Jayatilaka, Spring 1994

Chris Eiting and Sonny Gonzalez, Spring 1994

David Lee and David Onsongo, Fall 1996

Dave Pyle and Aruna Murthy, Spring 1999

Hitesh Mehta and Edward Zhu, Spring 1999, "Giving the electronic tongue a sense of good taste: image analysis tools and GUI"

Gus Espinosa and Donnie Garcia, Spring 1999, "Design and Implementation of a Computer Interfacing Circuit to Control LED's for use with a Chemical Sensor"

Natthanant Pon Skulkaew and Prem Nainani, Spring 2001, "PC-based data acquisition and wireless transmission system"

Matthew Andringa and Allen Hall, Spring 2001, "Non-Invasive RFID Weld Inspection"

Michael Amalfitano and Sapun Parekh, Spring 2002, "Output circuitry for a transmitter used in an Electronic Structural Surveillance system"

Kunal Patel and Jacy Little, Spring 2002, "Swept, high frequency oscillator to work in an Electronic Structural Surveillance (ESS) system"

Dong Pak, Spring 2002, "Automated image-processing software of an electronic chemical sensor"

Rajesh Nerlikar, Jonathan Solomon, Spring 2003, "Wireless Data Acquisition System for Bluetooth-enabled RFID Readers"

Nola Li, Judith Chen, Maria Huang, Fall 2003, "Design and build a tuning network for a swept frequency reader used in structural health analysis"

Tuenlap (Daniel) Chan, Imranul Islam, Derek Choi, Spring 2004, "Design and build an RFID Interrogator Receiver"

John McKee and Terence Man, Spring 2007, "Improved Corrosion Sensors"

Abdulaziz Beayeyz, Sravan Bhagavatula, Rahul Mitra, Shasi Munukutla, Spyder Spann, Fall 2009, "Portable Corrosion Detector"

Jonathan Pham, Po-Han Wu, Josh Schulte, Pritesh Solanki, Mesele Bedasa, Spring 2011- Fall 2011, "Multi-Sensor Robotics Platform"

Raymund Lee, Simon Chow, Connor Landy, Kevin Woo, and Anirudh Kashyap, Fall 2012-Spring 2013, "Variable Frequency RFID Tag and Reader"

Javier Chacon, Joshua Poncik, Joshua Orozco, Sebastian Salomon, Yongcong Zou, Fall 2013-Spring 2014, "Environmental Sensor Monitoring Network"

Organized Classes Taught:

EE 363M Introduction to Microwaves, Spring 1984, # 16455
EE 396K VLSI Fabrication Techniques, Fall 1984, # 16255
EE 379K Integrated Circuit Fabrication, Spring 1985, # 16055
EE 396K VLSI Fabrication Techniques, Fall 1985, # 16275
EE 379K Integrated Circuit Fabrication, Fall 1985, # 16070
EE 396K VLSI Fabrication Techniques, Spring 1986, # 17680
EE 379K Integrated Circuit Fabrication, Spring 1986, # 17450
EE 396K VLSI Fabrication Techniques, Fall 1986, # 15245
EE 379K Integrated Circuit Fabrication, Fall 1986, # 15020
EE 396K VLSI Fabrication Techniques, Spring 1987, # 15205
EE 379K Integrated Circuit Fabrication, Spring 1987, # 14970
EE 396K VLSI Fabrication Techniques, Fall 1987, # 15010
EE 440 Integrated Circuit Fabrication, Fall 1987, # 14545
EE 363M Introduction to Microwaves, Spring 1988, # 14535
EE 396K VLSI Fabrication Techniques, Spring 1988, # 14865
EE 440 Integrated Circuit Fabrication, Spring 1988, # 14390
EE 396K VLSI Fabrication Techniques, Fall 1988, # 15165
EE 440 Integrated Circuit Fabrication, Fall 1988, # 14705
EE 363M Introduction to Microwaves, Spring 1989, # 14525
EE 396K VLSI Fabrication Techniques, Spring 1989, # 14855
EE 396K VLSI Fabrication Techniques, Fall 1989, # 15165
EE 440 Integrated Circuit Fabrication, Fall 1989, # 14705
EE 363M Introduction to Microwaves, Spring 1990, # 14050
EE 396K VLSI Fabrication Techniques, Spring 1990, # 14355, 14360
EE 440 Integrated Circuit Fabrication, Spring 1990, # 13915, 13920
EE 396K VLSI Fabrication Techniques, Fall 1990, # 14630, 14635
EE 440 Integrated Circuit Fabrication, Fall 1990, # 14200, 14205
EE 363M Introduction to Microwaves, Spring 1991, # 14365
EE 396K VLSI Fabrication Techniques, Spring 1991, # 14660, 14665, 14670
EE 440 Integrated Circuit Fabrication, Spring 1991, # 14220, 14225, 14230
EE 396K VLSI Fabrication Techniques, Fall 1991, # 14865, 14860
EE 440 Integrated Circuit Fabrication, Fall 1991, # 14425, 14430
EE 363M Introduction to Microwaves, Spring 1992, # 14270
EE 396K VLSI Fabrication Techniques, Spring 1992, # 14545, 14550, 14555
EE 440 Integrated Circuit Fabrication, Spring 1992, # 14130, 14135
EE 396K VLSI Fabrication Techniques, Fall 1992, # 15095, 15100, 15105
EE 440 Integrated Circuit Fabrication, Fall 1992, # 14670, 14675
EE 397K Microwave Devices, Spring 1993, # 14805
EE 396K VLSI Fabrication Techniques, Fall 1993, # 14800, 14805, 14810
EE 440 Integrated Circuit Fabrication, Fall 1993, # 14385, 14390
EE 363M Introduction to Microwaves, Spring 1994, # 14370
EE 396K VLSI Fabrication Techniques, Fall 1994, # 14365

EE 440 Integrated Circuit Fabrication, Fall 1994, # 13870
 EE 397K Electromagnetics in Packaging, Spring 1995, # 14555
 EE 396K VLSI Fabrication Techniques, Fall 1995, # 14765
 EE 440 Integrated Circuit Fabrication, Fall 1995, # 14260
 EE 397K Electromagnetics in Packaging, Spring 1996, # 14695
 EE 382M Simulation Methods in CAD/VLSI, Spring 1996, # 14500
 EE 396K VLSI Fabrication Techniques, Fall 1996, # 14535
 EE 440 Integrated Circuit Fabrication, Fall 1996, # 14090
 EE 382M Simulation Methods in CAD/VLSI, Spring 1997, # 14325
 EE 363M Introduction to Microwaves, Spring 1997, # 14120
 EE 396K VLSI Fabrication Techniques, Fall 1997, # 15315
 EE 440 Integrated Circuit Fabrication, Fall 1997, # 14820
 EE 363M Introduction to Microwaves, Spring 1998, # 14530
 EE 397K Microwave Devices, Spring 1998, # 14950
 EE 396K VLSI Fabrication Techniques, Fall 1998, # 15475
 EE 440 Integrated Circuit Fabrication, Fall 1998, # 14965
 EE 363M Introduction to Microwaves, Spring 1999, # 14825
 EE 397K Microwave Devices, Spring 1999, # 15260
 EE 396K VLSI Fabrication Techniques, Fall 1999, # 15340
 EE 440 Integrated Circuit Fabrication, Fall 1999, # 14820
 EE 363M Introduction to Microwaves, Spring 2000, # 14755
 EE 396K VLSI Fabrication Techniques, Fall 2000, # 15600
 EE 440 Integrated Circuit Fabrication, Fall 2000, # 15100
 EE 397K Micro-electromechanical Systems (MEMS), Spring 2001, #15170
 EE 396K VLSI Fabrication Techniques, Fall 2001, # 15725
 EE 440 Integrated Circuit Fabrication, Fall 2001, # 15230
 EE 397K Micro-electromechanical Systems (MEMS), Spring 2002, #15330
 EE 396K VLSI Fabrication Techniques, Fall 2002, # 16050
 EE 440 Integrated Circuit Fabrication, Fall 2002, # 15485
 EE 397K Microwave Devices, Spring 2003, # 15110
 EE 396K VLSI Fabrication Techniques, Fall 2003, # 15580
 EE 440 Integrated Circuit Fabrication, Fall 2003, # 15095
 EE 325 Electromagnetic Engineering, Spring 2004, # 14345
 EE 396K VLSI Fabrication Techniques, Fall 2004, # 16250
 EE 440 Integrated Circuit Fabrication, Fall 2004, # 15715
 EE 396K 26-Microelectromechanical Systems, Spring 2005, # 15690
 EE 396K VLSI Fabrication Techniques, Fall 2005, # 16455
 EE 440 Integrated Circuit Fabrication, Fall 2005, # 15930
 EE 396K VLSI Fabrication Techniques, Fall 2006, # 17040
 EE 440 Integrated Circuit Fabrication, Fall 2006, # 16430
 EE 325 Electromagnetic Engineering, Spring 2007, # 15765
 EE 396K VLSI Fabrication Techniques, Fall 2007, # 17425
 EE 440 Integrated Circuit Fabrication, Fall 2007, # 16770
 EE 396K-26 Microelectromechanical Systems, Spring 2008, # 16815
 EE 396K VLSI Fabrication Techniques, Fall 2008, # 17380
 EE 325 Electromagnetic Engineering, Spring 2009, # 16000

EE 396K-24 Microwave Devices, Spring 2010, # 16975
 EE 396K VLSI Fabrication Techniques, Fall 2010, # 17075, 17080, 17085, 17090
 EE 440 Integrated Circuit Fabrication, Fall 2010, # 16540, 16545, 16550, 16555
 EE 396K VLSI Fabrication Techniques, Fall 2011, # 17295, 17300, 17305, 17310
 EE 440 Integrated Circuit Fabrication, Fall 2011# 16760, 16765, 16770, 16775
 EE 396K 26-Microelectromechanical Systems, Spring 2012, #17070
 EE 396K VLSI Fabrication Techniques, Fall 2012, # 17185, 17190, 17195, 17200
 EE 440 Integrated Circuit Fabrication, Fall 2012, # 16640, 16645, 16650, 16665
 EE 363M Introduction to Microwaves, Spring 2013, # 16605
 EE 396K Ultra Large Scale Integrated Circuit Fabrication Techniques, Fall 2013, # 17425, 17430, 17435, 17440
 EE 440 Integrated Circuit Nanomanufacturing Techniques, Fall 2013, # 16790, 16795, 16800, 16805
 EE 396K-24 Microwave Devices. Spring 2014, #17440
 EE 396K Ultra Large Scale Integrated Circuit Fabrication Techniques, Fall 2014, #17525, 17530, 17535, 17540
 EE 440 Integrated Circuit Nanomanufacturing Techniques, Fall 2014, #16960, 16965, 16970, 16975
 EE 363M Microwave and Radio Frequency Engineering, Spring 2015, #16355
 EE 396K Ultra Large Scale Integrated Circuit Fabrication Techniques, Fall 2015, #16965, 16970, 16975
 EE 440 Integrated Circuit Nanomanufacturing Techniques, Fall 2015, #16480, 16485, 16490
 EE 363M Microwave and Radio Frequency Engineering, Spring 2016, #16550
 EE 396K Ultra Large Scale Integrated Circuit Fabrication Techniques, Fall 2016
 EE 440 Integrated Circuit Nanomanufacturing Techniques, Fall 2016
 EE 396K 26-Microelectromechanical Systems, Spring 2017
 EE 363M Microwave and Radio Frequency Engineering, Spring 2018, #15890
 EE 363M Microwave and Radio Frequency Engineering, Spring 2019, #16625
 EE 363M Microwave and Radio Frequency Engineering, Spring 2020, #16695

Continuing Education Courses Taught

"Microelectronics Fabrication - Chemical Aspects," with Isaac Trachtenberg,
 Continuing Engineering Studies, College of Engineering, The University of
 Texas at Austin, June 1-4, 1987.
 "Integrated Circuit Process & Design," with M. R. Mercer, Motorola short course,
 Continuing Engineering Studies, College of Engineering, The University of

Texas at Austin:

- Aug.-Sept., 1987
- Nov.-Dec., 1987
- Nov.-Dec., 1988
- March-April, 1989
- Aug.-Sept., 1989
- Nov.-Dec., 1989
- Feb.-March, 1990
- April, 1990
- Aug., 1990

"Integrated Circuit Processing and Design," with L. T. Pillage, Advanced Micro Devices short course, Continuing Engineering Studies, College of Engineering, The University of Texas at Austin:

- Oct.-Nov., 1990
- June-July, 1991

"Microelectronics Fabrication," for the Fellows of the Senior Service College Fellowship Program, Continuing Engineering Studies, College of Engineering, The University of Texas at Austin, yearly 1993-2003.

Appendix B

LIST OF MATERIALS CONSIDERED

1001	U.S. Patent No. 7,746,887
1003	File History of U.S. Patent No. 7,746,887
1004	U.S. Patent No. 7,528,711 to Kates
1005	U.S. Patent Application Publication No. 2004/0100394 to Hitt
1006	U.S. Patent Application Publication No. 2005/0246593 to Littrell
1007	U.S. Patent No. 5,696,695 to Ehlers
1008	U.S. Patent Application Publication No. 2005/0270173 to Boaz
1009	<i>Ollnova Technologies Ltd. v. Emerson Electric Co.</i> , 4:22-cv-01387 (E.D. Mo.) Defendants' Opening Claim Construction Brief (October 27, 2022)
1010	<i>Ollnova Technologies Ltd. v. Emerson Electric Co.</i> , 4:22-cv-01387 (E.D. Mo.) Plaintiff Ollnova Technologies Ltd.'s Responsive Claim Construction Brief (November 17, 2022)
1011	<i>Ollnova Technologies Ltd. v. Emerson Electric Co.</i> , 4:22-cv-01387 (E.D. Mo.) Defendants' Reply Claim Construction Brief (December 1, 2022)
1012	<i>Ollnova Technologies Ltd. v. Emerson Electric Co.</i> , 4:22-cv-01387 (E.D. Mo.) Plaintiff Ollnova Technologies Ltd.'s Sur-Reply Claim Construction Brief (December 15, 2022)
1013	<i>Ollnova Technologies Ltd. v. Emerson Electric Co.</i> , 4:22-cv-01387 (E.D. Mo.) Joint Claim Construction Statement (December 20, 2022)
1014	<i>Ollnova Technologies Ltd. v. Carrier Global Corp.</i> , 9:22-cv-80388 (S.D. Fla.) Plaintiff Ollnova Technologies Ltd.'s Opening Claim Construction Brief (November 4, 2022)
1015	<i>Ollnova Technologies Ltd. v. Carrier Global Corp.</i> , 9:22-cv-80388 (S.D. Fla.) Carrier Global Corp.'s Responsive Claim Construction and Indefiniteness Brief (November 18, 2022)
1016	<i>Ollnova Technologies Ltd. v. Carrier Global Corp.</i> , 9:22-cv-80388 (S.D. Fla.) Plaintiff Ollnova Technologies Ltd.'s Reply Claim Construction Brief (November 30, 2022)
1017	<i>Ollnova Technologies Ltd. v. Carrier Global Corp.</i> , 9:22-cv-80388 (S.D. Fla.) Joint Claim Construction Chart (December 5, 2022)

1018	U.S. Patent No. 6,124,806 to Cunningham
1019	U.S. Patent Application Publication No. 2003/0174070 to Garrod
1020	U.S. Patent Application Publication No. 2003/0137968 to Lareau
1021	U.S. Patent No. 7,230,528 to Kates
1022	U.S. Patent No. 7,102,505 to Kates
1023	<i>Ollnova Technologies Ltd. v. ecobee Technologies, ULC</i> , 2:22-cv-00072 (E.D. Tex.) P.R. 4-3 Joint Claim Construction and Prehearing Statement (January 10, 2023)
1026	Redline comparison between the specifications of U.S. Patent No. 7,746,887 and U.S. Patent No. 7,102,505
1031	U.S. Patent No. 6,513,723 to Mueller
1041	U.S. Patent No. 7,268,581 to Trimberger
1042	U.S. Patent No. 7,254,691 to Ebeling
1043	<i>Ollnova Technologies Ltd. v. Emerson Electric Co.</i> , 6:22-cv-00358-ADA (W.D. Tex.) Declaration of Erik De La Iglesia in Support of Plaintiff Ollnova Technologies Ltd.’s Responsive Claim Construction Brief
1044	<i>Ollnova Technologies Ltd. v. ecobee Technologies, ULC</i> , 2:22-cv-00072 (E.D. Tex.) Ollnova Technologies Ltd.’s Opening Claim Construction Brief (January 31, 2023)
1046	M. R. Barbacci, C. B. Weinstock and J. M. Wing, “Programming at the processor-memory-switch level,” Proc. [1989] 11th Int. Conf. on Software Eng’g, Singapore, 1988, pp. 19-28