UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

TRANSCORE, LP

Petitioner,

v.

HAND HELD PRODUCTS, INC.,

Patent Owner

IPR2024-00982

Patent 10,452,968

PETITION FOR *INTER PARTES* REVIEW OF U.S. PATENT NO. 10,452,968

DECLARATION OF SUMIT ROY, PH. D.

TransCore LP
Exhibit 1003

TABLE OF CONTENTS

I. Introduction And Qualifications 1
A. Qualifications and Experience 2
B. Materials Considered 6
II. Person Of Ordinary Skill In The Art 9
III. Statement Of Legal Principles 11
A. Claim Construction 11
B. Legal Standards for Prior Art 13
C. Anticipation 15
D. Obviousness 15
IV. Technology Background 21
A. RFID Tags 21
B. Modulation 22
C. Signal Modulation by Backscatter RFID Tags 23
D. Powering Backscatter Tags, Reflectance, and Absorption 27
V. The '968 Patent 32
A. The '968 Patent's Prosecution History 37
VI. Overview of the Prior Art References 38
A. Public Availability 38
B. Boyer 39
C. RFID Handbook 43
D. Waldner 44
E. Kapucu 46
F. Hyde 48
VII. Opinions Regarding the '968 Patent's Invalidity 50
VIII. GROUND 1: Claims 11-12, 16-20 were obvious over Boyer in view of RF Handbook. 51

A. Description of Boyer....51

B. The Combined RFID Tag: Modifying Boyer's Section II-C Modulator Impedance....57

C. Motivation for Modifying Boyer's Z_2 Impedance....60

D. Boyer in view of RFID Handbook renders claim 11 obvious....67

1. The combined RFID Tag discloses [11P]: "A radio-frequency identification (RFID) tag"....67

2. The combined RFID Tag discloses [11A]: "a main antenna that receives a radio-frequency (RF) signal from an RFID reader and wirelessly harvests power from the RF signal."....69

3. The combined RFID Tag discloses [11B.1]: "a circuit that is configured to vary a reflection coefficient of the main antenna …"....73

4. The combined RFID Tag discloses [11B.2] "the reflected signal having a first reflectance period and a second reflectance period . . ."....81

5. The combined RFID Tag discloses [11C] "wherein the reflectance of the main antenna is reduced below a predefined amount during the first reflectance period without shorting the main antenna to enable the main antenna to continuously harvest power while transmitting the reflected signal the RFID reader, wherein the reflectance of the main antenna is reduced based on a change in a resonant frequency of the main antenna."....86

E. The combined RFID Tag discloses claim 12....106

F. The combined RFID Tag discloses claim 16....108

G. The combined RFID Tag discloses claim 17....110

H. The combined RFID Tag discloses claim 18....113

I. The combined RFID tag renders claim 19 obvious....115

J. Boyer in view of RFID Handbook renders claim 20 obvious....117

IX. GROUND 2: Claims 1-5, 11-20 were obvious over Boyer in view of RFID Handbook in further view Waldner 118

A. The Combined System of Boyer and RFID Handbook in View of Waldner 118

B. A POSITA would have been motivated to combine Boyer and RFID Handbook with Waldner 122

C. The use of a separate length of antenna as the modulation impedance (Z_{mod}) does not change the reflection property terms 128

D. Claim 13 was obvious over the Combined RFID Tag 130

E. Claim 14 was obvious over the Combined RFID Tag 131

F. Claim 15 was obvious over the Combined RFID Tag 136

1. Main Antenna Interpretation 136

2. Sensor Alternative 138

G. Claim 1 is obvious over the Combined RFID Tag 140

1. The Combined RFID Tag renders [1P] obvious 143

2. The Combined RFID Tag renders [1A] obvious 143

3. The Combined RFID Tag renders [1B] obvious 143

4. The Combined RFID Tag [1C] obvious 144

5. The Combined RFID Tag renders [1D] obvious 146

6. The Combined RFID Tag renders [1E] obvious 148

7. The Combined RFID Tag renders [1F] obvious 149

8. The Combined RFID Tag renders [1G] obvious 150

H. The Combined RFID Tag renders Claim 2 obvious 151

I. The Combined RFID Tag renders Claim 3 obvious 151

J. The Combined RFID Tag renders Claim 4 obvious 153

K. The Combined RFID Tag renders Claim 5 obvious 153

L. The Combined RFID Tag renders Claims 11-12, 16-20 153

X. GROUND 3: Claims 6-10 are obvious over the Boyer in view of RFID Handbook in further view of Kapucu. 154

A. Limitations for Claims 6, 7, 9, and 10 are substantially similar to prior analysis 154

B. Claim limitation [6D] and claim 8 (Duty Cycle) 157

1. The combined system 158

2. A POSITA would have been motivated to modify Boyer and RFID Handbook in view of Kapucu 161

3. Claims 6 and 8 are obvious 163

C. The Combined RFID Tag renders Claim 9 obvious 165

D. The Combined RFID Tag renders Claim 10 obvious 165

XI. Ground 4: Claims 6-10 are obvious over Boyer in view of RFID Handbook, Kapucu, and Waldner under 35 U.S.C. §103. 165

XII. No Secondary Considerations of Non-Obviousness 166

XIII. Conclusion 169

I, Sumit Roy, Ph.D., declare as follows:

I. INTRODUCTION AND QUALIFICATIONS

1. I, Sumit Roy, submit this declaration to state my opinions on the matters described below.

2. I have been retained as an independent expert in this proceeding before the United States Patent and Trademark Office by TransCore, LP.

3. I understand this proceeding involves U.S. Patent No. 10,452,968 ("the '968 patent"), and I have been asked to provide my opinions as to the patentability or unpatentability of the claims of the '968 patent as would have been understood by one of ordinary skill in the art. Specifically, I have been asked to consider the validity of claims 1-20 of the '968 Patent (the "Challenged Claims") in view of prior art, anticipation and obviousness considerations, and understanding of a person of ordinary skill in the art ("POSITA") as it relates to the '968 Patent. I have personal knowledge of the facts and opinions set forth in this declaration, and believe them to be true. If called upon to do so, I would testify competently thereto.

4. This declaration sets forth my opinions, which I have formed based on my study of the evidence; my education, training, research, knowledge, and personal and professional experience; and my understanding as an expert in the field.

5. I am being compensated for my time at the rate of $600 per hour. This compensation is not contingent upon the nature of my findings, the presentation of my findings in testimony, or the outcome of this proceeding. I have no financial interest in the outcome of this matter or on the pending litigation between Petitioner and Patent Owner.

A. Qualifications and Experience

6. I am an expert in the field of wireless networks, including RFID tags, readers, and communications. I have studied, taught practiced, and researched this field for over thirty years. I have summarized in this section my educational background, work experience, and other relevant qualifications. I understand that my *curriculum vitae* (CV) is being filed as Exhibit 1004 in this proceeding. Exhibit 1004 is a true and correct copy of my CV and sets forth the details of my educational history, work history, patents, and other related experience.

7. I earned my Bachelor of Technology degree in Electrical Engineering from Indian Institute of Technology in Kanpur in 1983. In 1985, I earned my Master of Science degree in Electrical Engineering from University of California in Santa Barbara. I earned a Doctor of Philosophy in Electrical Engineering and Master of Arts in Statistics & Applied Probability from University of California in Santa

Barbara in 1988, with my dissertation being on "Estimation Strategies for a Network of Distributed Sensors."

8. While a graduate student, from 1983 through 1988, I worked on various projects related to networked wireless communication and radar systems using a mix of analytical modeling and computer simulation.

9. In July of 1988, I joined the faculty of the University of Pennsylvania as an Assistant Professor in the Department of Electrical Engineering, where I taught upper level undergraduate course called "Communication Systems" and graduate level courses, "Advanced Digital Signal Processing" and "Digital Communications."

10. In January of 1995, I became a tenured Associate Professor in the Division of Engineering at the University of Texas at San Antonio, in San Antonio, Texas. In April of 1998, I transferred to a tenured Associate Professor in the Department of Electrical Engineering in the University of Washington ("UW") in Seattle, Washington and was promoted to Professor in September of 2002. As a faculty member at UW, I have taught courses and directed research in networking and telecommunications, including 802.11 WLAN and cellular technologies. From September 2014 to September of 2019, I received Integrated Systems Term

Professorship at the UW in recognition of my leadership and national stature in this area.

11. I took full-time leave from UW to serve as a Senior Staff Researcher at Intel Labs, Hillsboro, OR from September 2001 to December 2003, where I served as Wireless Systems Architect researching IEEE 802.15.3a Ultra-Wideband PHY layer for Wireless Personal Area Networks and nascent pre-802.11n (MIMO WiFi) technology, with responsibility for representing Intel at IEEE Standards meetings and coordination with other industry partners. My research resulted in several patents relating to the above, including design implementation of MIMO WiFi transceivers.

12. As a result of my academic teaching, research, and industry experience, I have significant knowledge of wireless networking technologies. Since 1988, I have received over ten million dollars in funding from various national and international organizations to support my work on wireless networking.

13. In addition to advising and mentoring students at UW, I have served as external dissertation reviewer for several reputed international universities, such as McGill Univ., Montreal, National University of Singapore, University of Victoria, and Australia National University. At UW and U. Penn., I have advised and supervised over 20 Ph.D. students and visiting scholars.

14. In addition to my academic work, I have remained active in the communication industry through my consulting work. I consulted for Mathworks, a vendor of WLAN toolbox products for design, on current 802.11 designs including MIMO systems. I am also the named inventor on U.S. Patent Nos. 7,782,970 and 8,289,836 titled "An Apparatus and Associated Methods to Introduce Diversity in a Multi Carrier Channel," among others, which are listed in my *curriculum vitae*.

15. I have authored and co-authored over 200 journal publications, conference proceedings, technical papers, book chapters, and technical presentations in a broad array of communications-related technologies, including networking and wireless communication. Indeed, one of the papers I coauthored is discussed as prior art in the current petitions. I have also developed and taught over 10 courses related to communications and computer systems, including several courses on signals and systems, wireless communication, communications systems. These courses included introductory courses on communication systems, as well as more advanced courses on wireless communications. A complete list of my publications and the courses I have developed and/or taught is also contained in my *curriculum vitae*.

16. My professional affiliations include serving in various professional organizations and as a reviewer for a number of technical publications, journals, and conferences. I have also received multiple awards and recognitions, most notably,

elevation to IEEE Fellow in 2007 for "contributions to multi-user communications theory and cross-layer design of wireless networking standards." By IEEE bylaws, only 0.1% of IEEE membership is elevated to Fellow annually. *See* https://www/ieee.org/membership/fellows/steps.html. In addition, I was selected as IEEE Communications Society's Distinguished Lecturer (2014-15, 2017-18), and appointed by Shanghai JiaoTung University as High-end Foreign Expert award (1 month/year, 2014-16), which are listed in my *curriculum vitae*.

17. I have also served as an expert in certain legal proceedings. A list of cases in which I have testified at trial, hearing, or by deposition (including those during the past five years) is provided in my *curriculum vitae*. Over the years, I have been retained by both patent owners as well as petitioners.

B. Materials Considered

18. In reaching the conclusions described in this declaration, I have relied on the documents and materials cited herein as well as those identified in this declaration, including U.S. Patent No. 10,452,968 ("the '968 patent", Ex. 1001), the file history of the '968 patent (Ex. 1002), the prior art references, and information discussed and any other references specifically identified in this declaration, including the materials identified in the chart below. I have also relied on my education, training, research, knowledge, and personal and professional experience

in the relevant technologies and systems that were already in use prior to, and within the timeframe of the earliest priority date of the claimed subject matter in the '968 Patent, which I understand is June 14, 2017.

19. I also reviewed portions of the Manual of Patent Examining procedure, including Sections 2131, 2141–2145. Those sections explain the legal requirements of anticipation, obviousness, and examining procedures relevant to obviousness.

20. Provided below are the Exhibit numbers for documents cited in this declaration:

Exhibit No.	Description
1001	U.S. Patent 10,452,968 to Nikitin, *et al*. ("the '968 patent")
1002	U.S. Patent 10,452,968 File History
1005	Colby Boyer and Sumit Roy, *Backscatter Communication and RFID: Coding, Energy, and MIMO Analysis*, IEEE Transactions on Communications, Vol. 62, No. 3 (March 2014) ("Boyer")
1006	U.S. Publication No. 2005/0237198 ("Waldner")
1007	Pavel V. Nikitin and K. V. S. Rao, *Theory and Measurement of Backscattering from RFID Tags*, IEEE Antennas and Propagation Magazine, Vol. 48, No. 6, December 2006 ("Nikitin")
1008	U.S. Patent 8,022,827 ("Rossman")
1009	K. Kapucu and C. Dehollain, "*Base-station design for passive UHF RFID tags with pulse-width modulated backscattering*," 2014 10th Conference on Ph.D. Research in Microelectronics and Electronics (PRIME), Grenoble, France, 2014, pp. 1-4, doi: 10.1109/PRIME.2014.6872750, ("Kapucu")
1010	K. Kapucu, J. Panades, and C. Dehollain, *Design of a passive UHF RFID tag for capacitive sensor applications*, in 9th Conference on Ph.D Research in Microelectronics and Electronics (PRIME 2013), 2013, pp. 213–216.

Exhibit No.	Description
1011	U.S. Patent 9,471,816 ("Hyde")
1012	Colby Boyer and Sumit Roy, *Backscatter Communication and RFID: Coding, Energy, and MIMO Analysis*, IEEE Transactions on Communications, Vol. 62, No. 3 (March 2014) from Northwestern State University library (April 2, 2014).
1013	Colby Boyer and Sumit Roy, *Backscatter Communication and RFID: Coding, Energy, and MIMO Analysis*, IEEE Transactions on Communications, Vol. 62, No. 3 (March 2014) from Mercer University library (April 2, 2014).
1014	IEEE Webpage (https://ieeexplore.ieee.org/Xplorehelp/ieee-xplore-training/working-with-documents#publication-dates)
1015	Publication Information from IEEE website for Colby Boyer and Sumit Roy, *Backscatter Communication and RFID: Coding, Energy, and MIMO Analysis*, IEEE Transactions on Communications, Vol. 62, No. 3 (March 2014), https://ieeexplore.ieee.org/document/6685977
1016	Publication Information from IEEE website for Pavel V. Nikitin and K. V. S. Rao, *Theory and Measurement of Backscattering from RFID Tags*, IEEE Antennas and Propagation Magazine, Vol. 48, No. 6, December 2006 (https://ieeexplore.ieee.org/document/4118038)
1017	US Patent 7,978,074
1018	IEEE Xplore, 2014 10th Conference on Ph.D. Research in Microelectronics and Electronics (PRIME), Table of Contents, https://ieeexplore.ieee.org/xpl/conhome/6863139/proceeding?isnumber=6872647&sortType=vol-only-seq&pageNumber=1;
1019	IEEE Xplore About Page, https://ieeexplore.ieee.org/Xplorehelp/overview-of-ieee-xplore/about-ieee-xplore
1021	Daniel Dobkin, *The RF in RFID, Passive UHF RFID in Practice*, Elsevier Inc. (2008)
1022	S. Thomas and M. Reynolds, QAM Backscatter of Passive UHF RFID Tags
1023	K. Finkenzeller, RFID Handbook, Third Edition (2010), John Wiley & Sons, Ltd.
1024	G. Marrocco, The Art of UHF RFID Antenna Design: Impedance-Matching and Size-Reduction Techniques
1025	Using Electromagnetic Analysis for RFID Antenna Design, Feb. 2006

Exhibit No.	Description
1026	IEEE, Base-station design for passive UHF RFID tags with pulse-width modulated backscattering

II. PERSON OF ORDINARY SKILL IN THE ART

21. I understand that an assessment of claims of the ’968 patent should be undertaken from the perspective of a person of ordinary skill in the art as of the earliest claimed priority date, which I understand is June 14, 2017. I have also been advised that to determine the appropriate level of a person having ordinary skill in the art, the following factors may be considered: (1) the types of problems encountered by those working in the field and prior art solutions thereto; (2) the sophistication of the technology in question, and the rapidity with which innovations occur in the field; (3) the educational level of active workers in the field; and (4) the educational level of the inventor.

22. The ’968 patent relates to backscatter radio frequency tags. In particular, the ’968 patent describes “[a] radio-frequency identification (RFID) tag with improved sensitivity.” The ’968 patent further describes an RFID tag that includes a circuit for varying the reflection coefficient of the antenna to transmit a reflected signal to the reader according to periods of high reflectance, when a relatively high amount of the RF signal is reflected, and low reflectance, when a

relatively low amount of the RF signal is reflected. The ’968 patent further describes relates to the phenomena that because the RFID tag is not reflecting 100% of the signal during the high period, the RFID tag continuously harvests power during the high reflectance periods.” Ex. 1001, Abstract.

23. A POSITA is someone who understands radio communications and systems (including interrogators/readers, transponders, and signal processing components thereof). In view of the technology described in the ’968 patent, the POSITA would have had a bachelor’s degree in electrical engineering, physics, or an equivalent degree and at least two years of experience in a relevant industry at the time of the ’968 patent’s filing. Additional work or research experience in the field of RFID tags at the time of the ’968 patent’s filing would have been a suitable substitute for less or different education, and vice-versa.

24. My opinions regarding the level of ordinary skill in the art are based on, among other things, my over 30 years of experience in electrical engineering, computer science and RFID system and technology design, my understanding of the basic qualifications that would be relevant to an engineer or scientist tasked with investigating methods and systems in the relevant area, and my familiarity with the backgrounds of colleagues, co-workers, and employees, both past and present.

25. Although my qualifications and experience exceed those of the hypothetical person having ordinary skill in the art defined above, my analysis and opinions regarding the '968 patent have been based on the perspective of a person of ordinary skill in the art as of June 14, 2017.

III. STATEMENT OF LEGAL PRINCIPLES

26. I am not a lawyer. My understanding of legal principles comes from counsel. I have applied the following legal principles in arriving at the opinions set forth in this declaration.

A. Claim Construction

27. I understand that under the legal principles, claim terms are generally given their ordinary and customary meaning, which is the meaning that the term would have to a person of ordinary skill in the art in question at the time of the invention, i.e., as of the effective filing date of the patent application. I further understand that the person of ordinary skill in the art is deemed to read the claim term not only in the context of the particular claim in which a claim term appears, but in the context of the entire patent, including the specification.

28. I am informed by counsel that the patent specification, under the legal principles, has been described as the single best guide to the meaning of a claim term, and is thus highly relevant to the interpretation of claim terms. And I

understand for terms that do not have a customary meaning within the art, the specification usually supplies the best context of understanding the meaning of those terms.

29. I am further informed by counsel that other claims of the patent in question, both asserted and unasserted, can be valuable sources of information as to the meaning of a claim term. Because the claim terms are normally used consistently throughout the patent, the usage of a term in one claim can often illuminate the meaning of the same term in other claims. Differences among claims can also be a useful guide in understanding the meaning of particular claim terms.

30. I understand that the prosecution history can further inform the meaning of the claim language by demonstrating how the inventors understood the invention and whether the inventors limited the invention in the course of prosecution, making the claim scope narrower than it otherwise would be. Extrinsic evidence may also be consulted in construing the claim terms, such as my expert testimony.

31. I have been informed by counsel that, in *Inter Partes* Review (IPR) proceedings, a claim of a patent shall be construed using the same claim construction standard that would be used to construe the claim in a civil action under 35 U.S.C. § 282(b) (the "Phillips" claim construction standard), including construing the claim

in accordance with the ordinary and customary meaning of such claim as understood by one of ordinary skill in the art and the prosecution history pertaining to the patent.

32. I have applied the "Phillips" claim construction standard for purposes of interpreting the claims in this proceeding, to the extent they require an explicit construction. The description of the legal principles set forth above thus provides my understanding of the "Phillips" standard as provided to me by counsel.

B. Legal Standards for Prior Art

33. I understand that a patent or other publication must first qualify as prior art before it can be used to invalidate a patent claim.

34. I understand that a U.S. or foreign patent qualifies as prior art to a patent if the date of issuance of the U.S. or foreign patent is prior to the invention of the patent. I further understand that a printed publication, such as an article published in a magazine or trade publication or a patent application, qualifies as prior art to a patent if the date of publication is prior to the invention of the patent.

35. I understand that, regardless of the date of invention of the patent, a U.S. or foreign patent qualifies as prior art to a patent if the date of issuance of the U.S. or foreign patent is more than one year before the earliest effective filing date of the patent. I further understand that a printed publication, such as an article published in a magazine or trade publication or a patent application, constitutes prior

art to a patent if the publication occurs more than one year before the earliest effective U.S. filing date of the patent, again regardless of the date of invention of the patent.

36. I understand that a U.S. patent or published U.S. application qualifies as prior art to a patent if the application for that patent was filed in the United States before the invention of the patent. My understanding is that, for such prior art references, a patentee may attempt to show that the claimed invention was conceived prior to the filing in the United States of the purported prior art U.S. patent or application. To do so, it is my understanding that patentee must prove with corroborating evidence that the named inventors conceived of the complete claimed invention before the prior art, and were diligent in reducing the claimed inventions to practice.

37. I understand that to qualify as prior art, a reference must contain an enabling disclosure that allows one of ordinary skill to practice the claims without undue experimentation.

38. I understand that documents and materials that qualify as prior art can be used to invalidate a patent claim as anticipated or as obvious. I understand that documents and materials qualify as prior art if they were available to the public or those interested in the technology before the priority date of the ’968 patent.

C. Anticipation

39. I understand that to be granted a patent, the invention must not have been previously disclosed by a reference that is available as prior art. I am not a lawyer, but I have been informed by counsel, that in order to anticipate a patent, the reference must disclose each and every element required by the patent's claims.

40. As part of anticipation, I have been further informed that a prior art reference may anticipate a reference even if it does not disclose all elements of the claim, if those claim elements are inherent. I have been informed that a prior art reference inherently teaches an element if the inherent characteristic necessarily flows from the teachings of the prior art. I further understand that inherency can be demonstrated using extrinsic evidence that makes clear that the missing descriptive matter is necessarily present in what the reference describes.

D. Obviousness

41. I am not a lawyer, and my opinions are limited to my understanding of the relevant field around the time that the inventor conceived the technology behind the '968 patent. Namely, my knowledge of the art at that time, and what that art would have taught and motivated a POSITA at that time. Nevertheless, I have an understanding of obviousness as explained to me by counsel.

42. I have been informed that a claim may be invalid under 35 U.S.C. § 103(a) 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. I have been informed that obviousness is determined from the perspective of a hypothetical POSITA 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.

43. I have been informed that a hypothetical POSITA is assumed to know and to have all relevant prior art in the field of endeavor covered by the claims of the patent.

44. 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 also have 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 also have 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 that, because of the matter with which it deals, logically would have commanded itself to a patentee's attention in considering his problem.

45. I have been informed 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 have been informed as well that a prior art reference should be viewed as a whole.

46. I have been informed that in considering whether an invention for a claimed combination would have been obvious, 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 market place, and/or the background knowledge possessed by a person having ordinary skill in the art. I have been informed that other principles may be relied on in evaluating whether a claimed invention would have been obvious, and that these principles include the following:

- a combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results;
- when a device or technology is available in one field of endeavor,

- design incentives and other market forces can prompt variations of it, either in the same field or in a different one, so that if a person of ordinary skill can implement a predictable variation, the variation is likely obvious;
- if a technique has been used to improve one device, and a person of ordinary skill in the art would recognize that it would improve similar devices in the same way, using the technique is obvious unless its actual application is beyond his or her 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;

- one of the ways in which a patent's subject can be proved obvious is by noting that there existed at the time of invention a known problem for which there was an obvious solution encompassed by the patent's claims;

- any need or problem known in the field of endeavor at the time of invention and addressed by the patent can provide a reason for combining the elements in the manner claimed; "common sense" teaches that familiar items may have obvious uses beyond their primary purposes, and in many cases a person of ordinary skill will be able to fit the teachings of multiple patents together like pieces of a puzzle;

- a person of ordinary skill in the art is also a person of ordinary creativity and is not an automaton;

- a patent claim can be proved obvious by showing that the claimed combination of elements was "obvious to try," particularly when there is a design need or market pressure to solve a problem and there are a finite number of identified, predictable solutions such that a person of ordinary skill in the art would have had good reason to pursue the known options within his or her technical grasp; and

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

47. I also have been informed that, in making a determination as to whether or not the claimed invention would have been obvious to a person of ordinary skill, the Board may consider certain objective factors if they are present, such as: commercial success of products practicing the claimed invention; long-felt but unsolved need; teaching away; unexpected results; copying; and praise by others in the field. These factors are generally referred to as "secondary considerations" or "objective indicia" of nonobviousness. I have been informed, 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 what is claimed and novel in the claim rather than something in the prior art. I have also been informed that even when they are present, secondary considerations may be unable to overcome primary evidence of obviousness (*e.g.*, motivation to combine with predictable results) that is sufficiently strong.

48. In sum, my understanding is that prior art teachings are properly combined where a POSITA at the time of the alleged invention having the understanding and knowledge reflected in the prior art and motivated by the general

problem facing the inventor would have been led to make the combination of elements recited in the claims. Under this analysis, the prior art references themselves, or any need or problem known in the field of endeavor at the time of the invention, can provide a reason for combining the elements of multiple prior art references in the claimed manner.

49. I have been informed and understand that the obviousness analysis requires a comparison of the properly construed claim language to the prior art on a limitation-by-limitation basis.

IV. TECHNOLOGY BACKGROUND

A. RFID Tags

50. RFID technology allows for remote identification of objects and can be used in a variety of applications. A simple RFID system consists of an RFID reader (sometimes referred to as an "interrogator"), which sends an interrogation signal, and one or more RFID tags (sometimes referred to as "transponders"), which receive and respond to the interrogation signal. As indicated by the word "identification," RFID is primarily used for identifying and/or tracking tagged items.

51. One type of tag includes its own power source for generating signals and is referred to as an "active" tag. Another type of tag has no power source and receives power generated by a reader's interrogation signal. This type of tag is

referred to as a "passive" tag. To communicate with a reader, a passive tag receives power from the reader's interrogation signal and reflects back a signal to the reader using a technique called "backscattering." A tag using the backscatter technique modulates the reflected interrogation signal to send the tag's information back to the reader.

52. As compared to active tags, passive RF tags are less complex and primarily operate via power supplied by the reader, thus increasing battery life and reducing associated cost and size. On the other hand, passive tags tend to have a shorter read range, require higher-powered readers as compared to active tags, have lower reliability as compared to an active system, and have greater susceptibility to electrical interference due to their lower signal levels.

B. Modulation

53. RFID tags communicate with readers by backscattering modulated signals. Modulation is the process by which information is imparted onto an analog signal, *e.g.*, carrier wave (typically a sinusoidal signal, very often a complex sinusoid) by varying one or more of its parameters such as its amplitude, phase, or frequency in accord with the information. When antennas at the receiver receive the transmitted signal, the receiver can demodulate the signal and recover the transmitted sequence of bits.

54. Various modulation techniques can be used to impart digital information onto a transmitted wave. Digital modulation is based on transmission of a discrete set of symbols, usually with the set of symbols being a power of 2, with two-valued binary modulation, *i.e.* 2 being the simplest. A first order modulation technique transfers one of two discrete symbols. One of the simplest forms of digital modulation is known as amplitude-shift keying (ASK). In ASK, "one of the amplitudes is zero; that is, one binary digit is represented by the presence, at constant amplitude, of the carrier, the other by the absence of the carrier."

C. Signal Modulation by Backscatter RFID Tags

55. Modulating RF signals is a well-known science. Passive RFID tags receive an RF signal from an RF reader. The tag absorbs some of the energy from the RF signal and reflects (e.g., backscatters) the rest back to the reader as a modulated signal. The relationship between the amount of power reflected versus absorbed is also well known.

56. In his book, *The RF in RFID*—which in my well-known and widely used textbooks—Daniel Dobkin explains the mechanics between reflecting and absorbing power. Dobkin describes antenna reflectance according to three states: normal, open, and short-circuited.

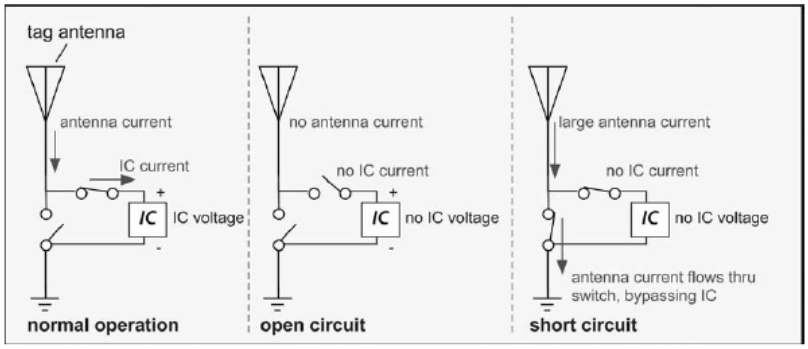


Figure 5.15: Elements of Simple Backscatter Modulation Schemes. Single-ended Antenna Connections are Shown for Simplicity.

As Dobkin explains, when in "normal operation" the IC is matched to the antenna. Dobkin at 210. In a matched state, the Antenna and the IC are connected, and their relative values of resistance is matched, to absorb the greatest amount of power. *Id.* at 210, 212; *see also* Boyer at 774. In the open condition, since no current can flow through either the IC or to ground, no current is absorbed or backscattered. Dobkin at 211. During a short condition, the current flows readily to ground, which results in the highest reflected signal. *Id.*

57. Modulation typically happens by switching between two states, where one state is the matched condition. For example, as Dobkin explains, one form of modulation is based on switching between the normal (matched) condition and the open condition and another is based on switching between the normal (matched) condition and the short-circuit condition. Dobkin at 213. Under ideal assumptions, during the matched condition, the tag absorbs the same amount of power as it reflects. During the open condition, the tag neither absorbs nor reflects any power.

And during the short-circuit condition, the tag reflects all the power, absorbing none. Dobkin at 213.

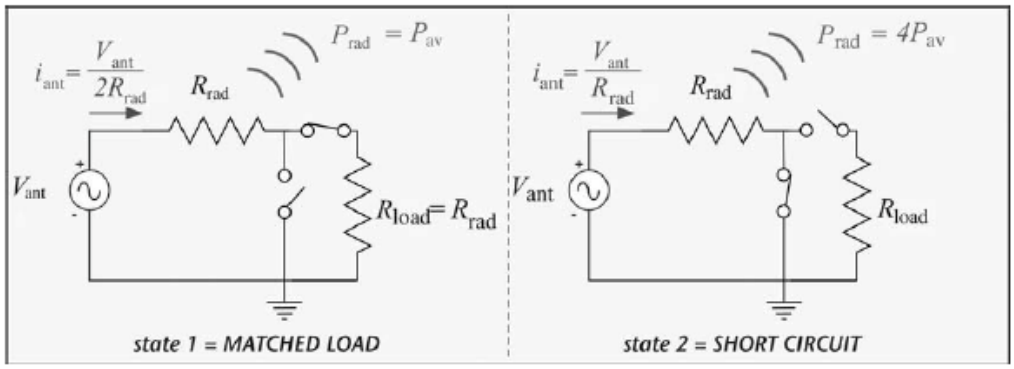


Figure 5.18: Modulating the Backscattered Signal by Switching Between a Matched Load and a Short Circuit.

58. Pavel V. Nikitin, one of the named inventors published an article in IEEE outlining these well-known principles over a decade before filing for the '968 patent. *See* Ex-1007 (Nikitin). Nikitin's article even recites many of the fundamental and conventional concepts that appear in the claims of the '968 patent, including the use of different impedance loads connected to the antenna to modulate the reflected (backscatter signals) by creating high and low reflectance periods.

59. As Nikitin explained, a "typical passive tag consists of an antenna and an application specific integrated circuit (ASIC) chip, both with complex impedances." *Id.*, 212. As shown in Nikitin's Figure 1 reproduced below, the "chip [**yellow**] obtains power from the RF signal [**green**] transmitted by the RFID reader

[**blue**].” *Id*. “The tag sends data back by switching its input impedance [**red**] between two states and thus modulating the backscattered signal [**orange**].” *Id.*

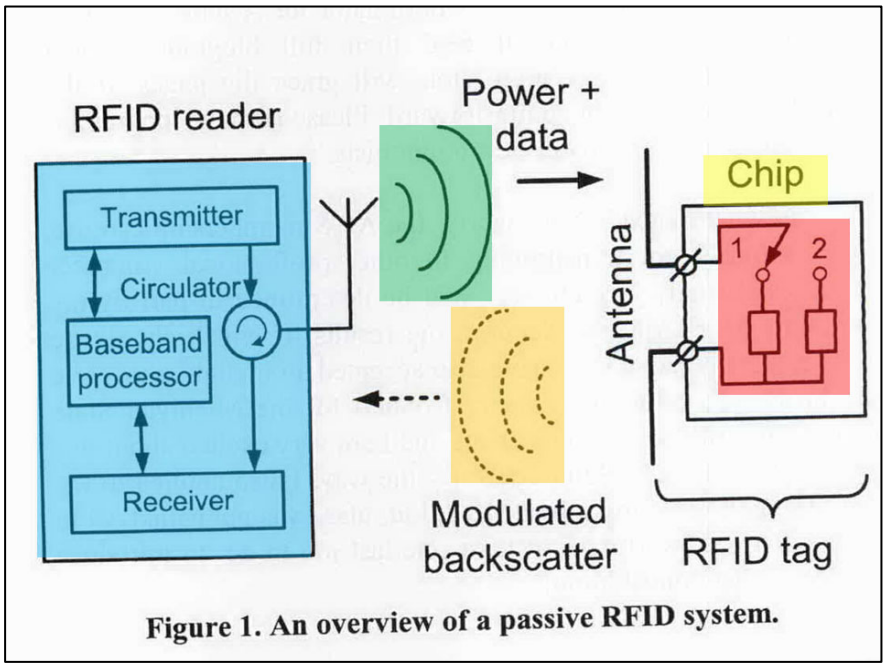


Figure 1. An overview of a passive RFID system.

60. The impedance states—*i.e.*, when the switch connects impedance “1” or “2” (in **red**) to the antenna in Figure 1 above—present a certain radar cross section, with one impedance state “usually high and another is low to provide a significant difference in the backscattered signal.” Ex-1007, 212. This is how the backscattered signal is modulated (*i.e.*, the encoding of 1’s and 0’s representing the data that is received by the reader).

61. Nikitin illustrates the forward link (reader to tag) and reverse link (tag to reader) signals in a passive RFID system in Figure 2 reproduced below. *Id*., 213.

"The signal transmitted on the forward link (from the reader to the tag [shown in **red**]) contains both continuous wave (CW) and modulated commands." *Id.*, 212. "On the reverse link (from the tag to the reader [shown in **orange**]), the data is sent back during one of the CW periods, when the tag impedance modulates the backscattered signal." *Id.*

62. In other words, the modulated signal reflected from the tag to the reader includes high reflectance periods (*e.g.*, when impedance "1" is connected to the antenna and represents a high value, in **blue**) and low reflectance periods (*e.g.*, when impedance "2" is connected to the antenna and represents a low value, in **red**).

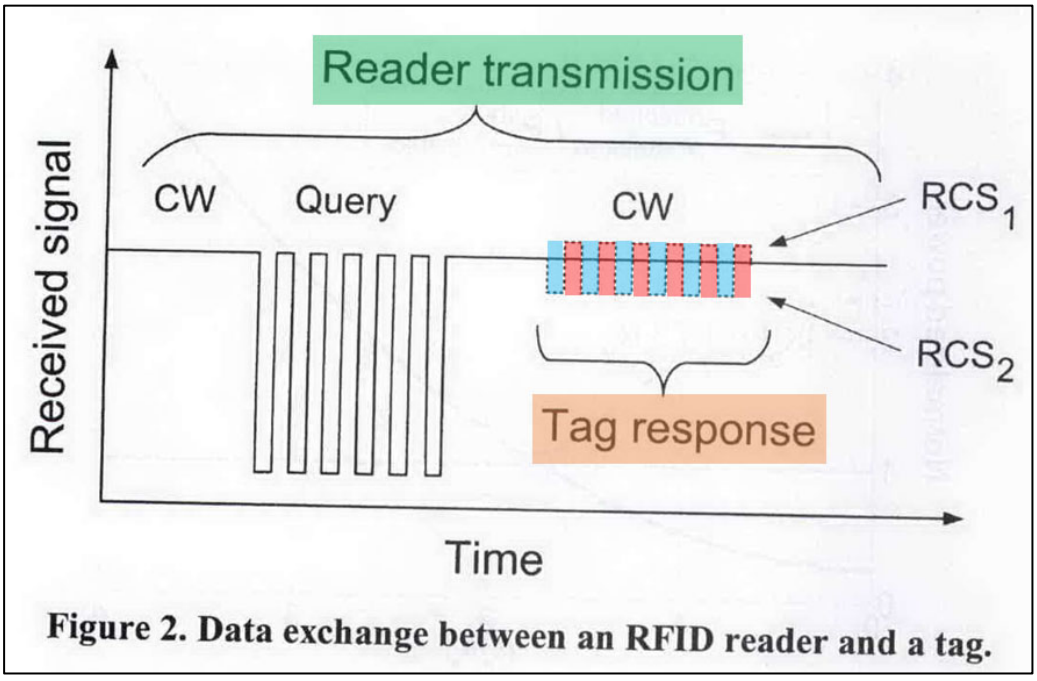


Figure 2. Data exchange between an RFID reader and a tag.

Id., 213.

D. Powering Backscatter Tags, Reflectance, and Absorption

63. As I mentioned earlier, backscatter RFID tags do not have their own batteries and must, instead, rely on harvesting power from the signal sent by the RFID reader. When the RFID tag receives the signal, it harvests a portion and reflects a portion.

64. The strength of the signal reflected and the amount of power harvested is a function of the tag's antenna's impedance relative to the IC's impedance. The tag's antenna has an impedance value and the tag's integrated circuit ("IC") has an impedance value. Backscattering happens by matching and unmatching the antenna's and IC's impedance.

65. The amount of energy reflected, the tag's reflection coefficient, is represented by the following equation:

$$\Gamma = \frac{(z_i - z_a^*)}{(z_i + z_a^*)}$$

Ex. 1005, 772.

66. Where z_a is the antenna impedance and z_i is the IC impedance. '968 patent, 4:62-67; Ex-1005, 772.[1] The reflection coefficient determines the amount of Electric field that is backscattered ($\vec{\varepsilon}_{\text{scat}}$) by the RF tag to the reader:

$$\vec{\varepsilon}_{\text{scat}} = \vec{\varepsilon}^{\text{M}}_{\text{scat}} - \Gamma I_{\text{M}} \frac{\vec{\varepsilon}_a}{I_a}$$

Ex. 1005, 772.

67. Under ideal assumptions, whatever remaining power is not reflected back to the reader is absorbed by the tag's IC. In the real world, some power is lost to efficiency.

68. Returning to Dobkin's explanation, we see that tags that modulate between a "matched" condition and an open or a short condition only absorb power during the "matched" condition. Dobkin explains that when the load resistance (*e.g.*, IC inductance) is very small compared to the radiation resistance (*e.g.*, antenna impedance), there is little voltage across the load and little power is delivered to the

[1] The equation recited in the '968 patent includes a typographical error. The denominator should reflect the ***sum*** of the antenna's and integrated circuit's impedance, not the difference.

load. But during the matched condition, the matched antenna "*scatters as much power as it receives*." Ex. 1021 at 212 (emphasis in original).

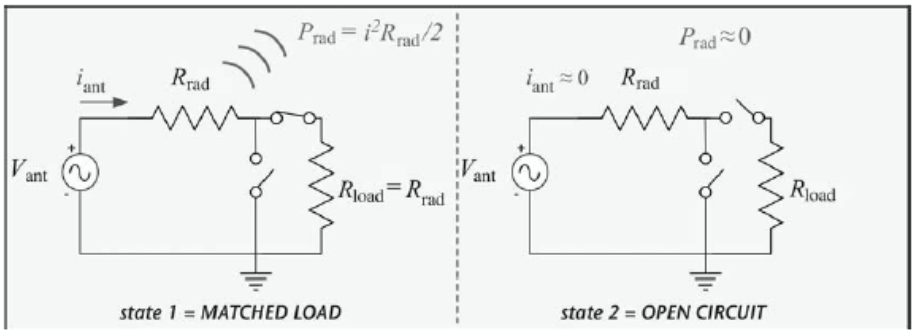


Figure 5.17: Modulating the Backscattered Signal by Switching Between a Matched Load and an Open Circuit Load.

Ex. 1021 at 213.

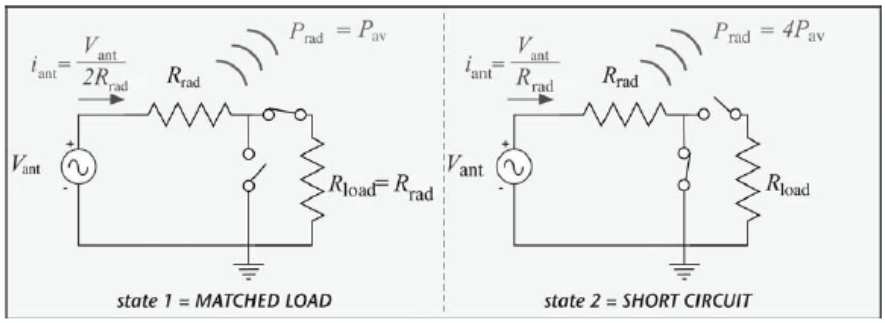


Figure 5.18: Modulating the Backscattered Signal by Switching Between a Matched Load and a Short Circuit.

69. Because the matched condition is the only period of the tag's modulation cycle during which power is harvested, Dobkin teaches an alternative arrangement wherein the IC maintains some resistance during both modulation periods.

70. The ratio of the antenna's impedance compared to the IC's impedance yields different levels of reflection to absorption.

71. Dobkin explains that in early designs, a tag "would start its reply to a reader and then run out of juice in the middle of transmitting its ID." *Id*., 214. It then proposes a solution: "it is helpful to consider trading off some backscattered signal for more tag power." *Id*.

72. Dobkin than analyzes two different binary modulators: one in which a "resistance in series with the load" (*i.e*., the IC) in Figure 5.19 and the other when capacitance is placed in parallel shown in Figure 5.20.

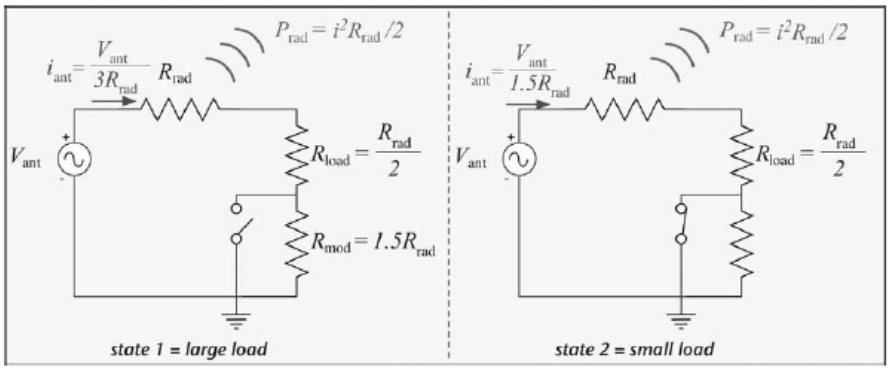


Figure 5.19: Modulation Using a Resistive Circuit in Place of a Short (Resistive Amplitude-Shift Keying).

Id., 215.

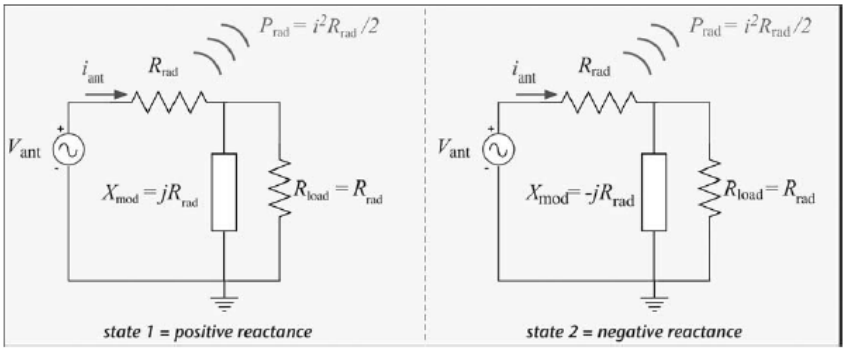


Figure 5.20: Modulation Using Reactance Rather than Resistance.

Id., 216.

73. Dobkin summarizes the results shown increased power harvesting and decreased signal strength in these two modulators in comparison to a "short" or "open circuit:

Table 5.1: Modulation Approaches.

	Approach	Backscattered Power	IC Power
	Match <=> Open	$P_{av}/2$	$P_{av}/2$
Short Circuit	Match <=> Short	$P_{av}/2$	$P_{av}/2$
Alternative Impedances	Resistive ASK	$0.22\ P_{av}$	$0.55\ P_{av}$
	Reactive PSK	$0.32\ P_{av}$	$0.8\ P_{av}$

Ex-1021, 218.

V. THE '968 PATENT

74. The '968 patent purports to improve passive RFID systems by "sacrific[ing] backscatter signal strength in order to provide additional received power to the tag 100." Ex-1001, 4:18-24. Of course, as shown below, the paper I coauthored with Mr. Boyer years earlier applied this principal, which was already well-known by that time.

75. In any event, the ’968 patent first sets out the conventional features of prior art RFID backscatter systems:

1) RFID “tags include[] a main antenna that receives a radio-frequency (RF) signal from an RFID reader and wirelessly harvests power from the RF signal.” *Id*., 1:49-52.
2) RFID “tags typically consist of an integrated circuit (IC) connected to an antenna,” wherein the IC is “often a low power device, powered purely by RF energy harvested from the reader signal.” *Id*., 1:8-9;
3) “The tag responds to the reader by varying its input impedance (and reflectance) and thus modulating the backscattered signal.” *Id*., 1:9-11;
4) Varying the input impedance modulates the signal because “it switches [the tag antenna] between two reflectance states”—“power harvesting” and “close to a short-circuit, in order to provide maximum backscatter.” *Id*., 3:50-54.

It is the final point where the ’968 patent purports to improve the prior art using modulator impedance values (during backscatter) that are ***less*** than a short circuit.

76. The ’968 asserts that the prevailing belief in the prior art was “that a reduction in tag transmission performance would reduce the range of the tag. Thus, solutions that improve tag range by sacrificing tag transmission performance have

not been explored." *Id*., 1:40-45. It further contends that in prior art RFID tags, the backscatter "signal is designed to have the ***maximum*** strength to maximize the range of the tag 100"—*i.e*., a short circuit or close to it. *Id*.

77. But according to the '968 patent, the inventors discovered that power harvesting, not backscatter signal strength, is the limiting factor in passive RFID performance. Therefore, the prior art systems all suffer from the same limiting problem: during backscattering with a short circuit, "the tag shorts (or approximately shorts) its antenna port (and hence its RF power supply) approximately 50% of the time (duty cycle of a typical tag-to-reader data signal), thus losing up to 3 dB of the incoming RF power (the tag IC cannot harvest RF power when the input terminals are shorted)." *Id*., 3:60-65. The '968 patent contends that "Modern RFID tags still follow this backscattering scheme, even though modern RFID readers are much more sensitive than they used to be and can successfully detect and decode weak tag signals. The result is that at the fringes of the tag range, the tag will intermittently lose power while attempting to communicate with the reader. This results in failed communication with the reader and shrinks the useable range of tag transmission." *Id*., 4:9-17.

78. As a result, the '968 patent contends that the "inventors have determined several embodiments that counter the basic assumptions in the art and

sacrifice tag transmission performance in order to increase its range." *Id*., 4:18-23. The '968 patent proposes "sacrific[ing] backscatter signal strength in order to provide additional received power to the tag 100." *Id*. This reduction in signal strength takes the form of reduced amplitude in the reflected backscatter signal, as shown in Figure 3. In particular, Figure 3 "shows how the amplitude a1 or depth of backscatter 102 is reduced to a2 in order to increase charging of the RFID tag 100. This allows for steady transmission of a (weakened) signal 102' at the fringes of the tag range, which modern readers are able to read." *Id*., 4:23-28.

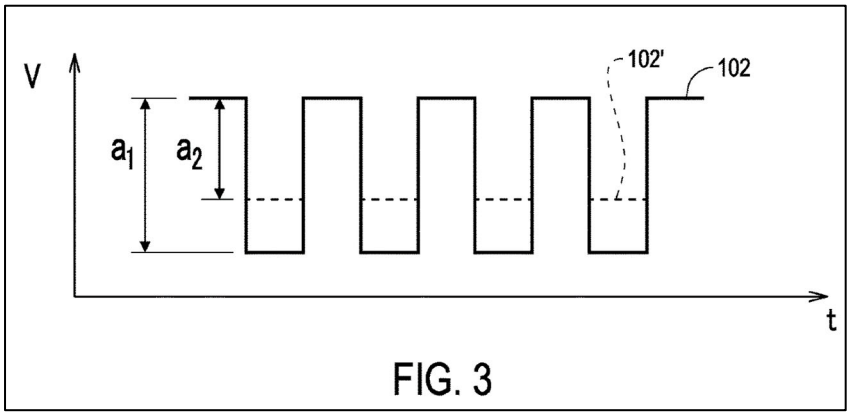


FIG. 3

79. The result is that rather than "antenna 104 reflecting substantially all of the signal and substantially none of the signal during different transmission periods, antenna 104 has periods of relatively high reflectance and relatively low reflectance. In other words, in the periods of high reflectance, the antenna has reflectance higher than a predetermined amount, and in the periods of low reflectance, the antenna has reflectance lower than a predetermined amount." *Id*., 4:24-34. The '968 patent

contends this change "expands the useable range of the tag, by allowing the antenna to continuously harvest power while transmitting the reflected signal 102'. Several embodiments use existing CMOS integrated circuits, and can nevertheless have significant sensitivity improvement (e.g. 3 dB)." *Id*., 4:47-51.

80. To achieve the above power harvesting at the expense of backscatter signal strength, the '968 employs well-known concepts of adjusting the load impedance values used to modulate the reflected signal. Specifically, the principal that the tag's reflectance (and power harvesting) is a function of the antenna's impedance compared to the IC's impedance. The '968 patent "adds or subtracts one or more impedances 620 from antenna 104," the result is that it "changes the resonant frequency and reflectance properties without shorting the antenna 104." *Id*., 5:43-59.

81. As such, the '968 includes the same conventional RFID backscatter design with a binary modulator that varies the reflection coefficient of the main antenna, including by changing the tag's resonant frequency. The '968 patent describes a "physical" means involving "[a] shared antenna [that] can have a modulator . . . that only slightly changes antenna resonant frequency (by engaging/disengaging extra antenna length)." *Id*., 5:41-47. Figure 5, below, illustrates the "physical" embodiment.

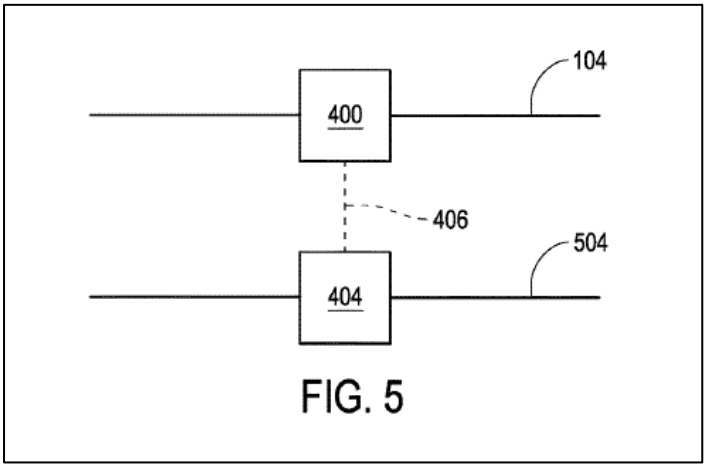


FIG. 5

82. The ’968 patent also describes an “electrical” means, involves “an ASIC or processor [that] controls one or more switches 610 to add or subtract one or more impedances 620 from antenna 104.” *Id*., 5:51-57. Figure 7, below, illustrates the “electrical” embodiment.

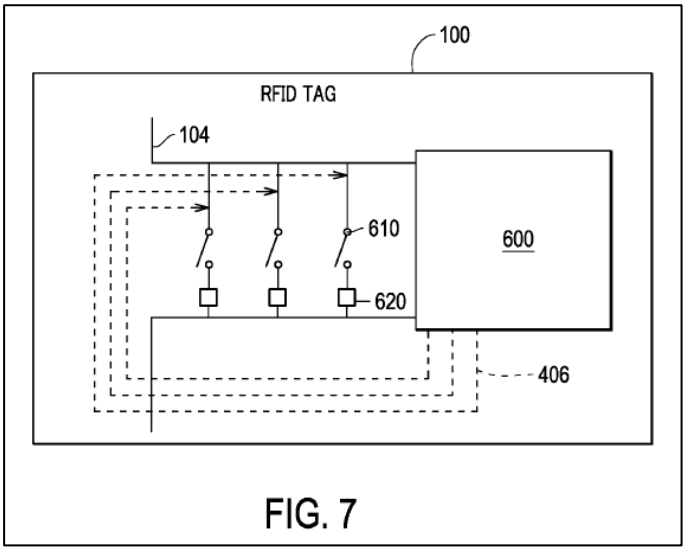


FIG. 7

A. The ’968 Patent’s Prosecution History

83. During prosecution, the Applicant distinguished the prior art primarily based on amendments that required that the reflectance of the main antenna is reduced "without shorting the main antenna." Ex-1002, 34-36. The notice of allowance contended "[t]he prior art of record does not fairly teach or suggest … that the reflectance of the main antenna is reduced due to controlled switching during high reflectance periods without shorting the main antenna" and that Wang "cannot accomplish that the reflectance of the main antenna is reduced due to controlled switching during high reflectance periods without shorting the main antenna." Ex-1002, 13-14.

VI. OVERVIEW OF THE PRIOR ART REFERENCES

84. As shown below, the references (Boyer, the RFID Handbook, Dobkin) do not short the antenna during modulation to reflect a signal from the reader. Instead, the references switch the load on the antenna using different impedances to change the resonant frequency of the antenna (changing its reflection coefficient and the amount of the RF signal it reflects and absorbs) and, thereby, changing the amount of the incoming signal that reflected and absorbed. Because neither shorts the antenna, a POSITA would have understood that power harvesting occurs continuously throughout backscatter.

A. Public Availability

85. ***Boyer:*** Colby Boyer and Sumit Roy, *Backscatter Communication and RFID: Coding, Energy, and MIMO Analysis*, IEEE Transactions on Communications, Vol. 62, No. 3 (March 2014) ("Boyer"). I am a co-author on the Boyer reference, which was published in March 2014 in the IEEE journal on Transactions on Communications, Vol. 62, No. 3. This is a well-known and widely circulated industry journal, and I consult articles and papers that are published here routinely as part of my research. It is considered reliable and the dates indicated are widely accepted dates of publication.

86. I have personal knowledge that Boyer was published on or about the date indicated on the document (March 2014) because I recall writing the paper with Mr. Boyer and when it was approved for publication. Moreover, I confirmed that it is available through the IEEE website.

87. I am also a fellow of the IEEE, and I am familiar with its publishing. In a single volume year, for example volume 62 published in 2014, the IEEE Xplore releases 12 digital/online issues.

B. Boyer

88. Boyer was published two years before the '968 patent and recognizes that since "backscatter modulation and on-tag power harvesting efficiency are coupled" it is necessary to re-examine notions of power and spectral efficiency from

an energy-constraint perspective." Ex-1005, 770. Boyer explains that "[t]he amount of energy a tag can harvest on average is affected by numerous factors, depending on if the tag is idle or backscattering." *Id*. Boyer recognizes that "[d]uring the active state, the choice of tag modulation and coding influences the amount [of power] harvested." *Id*.

89. Boyer recognized the well-known problem that the '968 patent purports to have discovered—that reduced availability from insufficient power harvesting is a limiter of passive RFID tag performance. In this regard, Boyer explains the importance of power harvesting to passive tags: "if the average harvested energy is less than the average energy expenditure, tags undergo duty-cycling, between an active communication ('on') state and an idle ('off') state that is used largely for energy harvesting and storage." *Id*., 771. As a result, "(passive/semipassive) tags are primarily downlink limited, whereby tag availability is limited by the amount of energy they harvest while not communicating." *Id*. Boyer notes that this cycling between active and idle states "impacts the amount of data [the tag] can transmit on the uplink when it is active, since the tag duty cycle ('on' portion) must be judiciously balanced against the modulation/code rate used." *Id*.

90. Boyer explains this principle using a "simple 2-state model: the tag is either active and backscattering information or the tag is in a sleep state and no

backscatter occurs. If the (average) power harvested by the tag is greater than the (average) power consumed in its active state, then the tag is operational 100 percent of the time. If not, the tag undergoes a duty cycling behavior between an active state and a sleep state; ***clearly this reduces availability for backscatter and reduces uplink throughput***." *Id*., 775, 776. This reduction in uplink throughput caused by the RFID tag powering down is the same issue the '968 patent purports to have discovered.

91. In view of the above, Boyer explores this principle in several embodiments, including two-state and four-state modulation schemes, to maximize tag performance by power harvesting throughout the entire active state (when the RFID tag is modulating the reflected signal)—exactly as discussed in the '968 patent. In other words, years before the '968 patent was filed, Boyer already taught that by varying the modulation impedances such that the antenna reflectance is less than 1 (*i.e*., less than a short-circuited antenna) for both the high and low modulation periods, better performance is achieved through continual power harvesting because the tag remains "available." *Id*., 775-776 (Section II-C). Indeed, Boyer expressly states that the modulation impedance, Z_2, is "***between*** an open ($Z_2 = \infty$) and ***short state*** ($Z_2 = 0$)" and that as the value approaches a short circuit, the "harvested power during backscatter P_{back} decreases." *Id*., 775.

92. Boyer models optimal performance in comparison to reflectivity values, demonstrating that peak performance (measured as "Goodput"—*i.e.* the amount of useful data transmitted over time) at reflectances below the conventional "short-circuited" antennas (*i.e.* a reflectance (G_2) of 1 during the high period of backscatter modulation, shown all the way on the right of the graph below, at least where the second state has a reflectance (G_1) at or near full absorption—*i.e.*, 0):

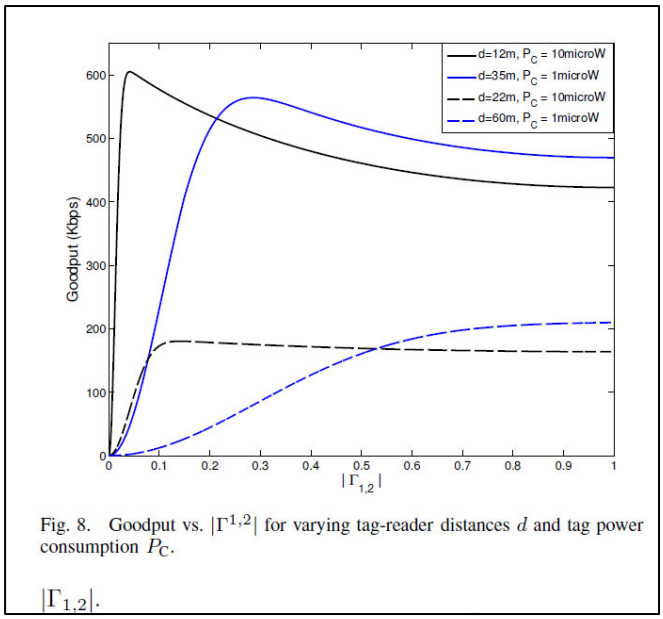


Fig. 8. Goodput vs. $|\Gamma^{1,2}|$ for varying tag-reader distances d and tag power consumption P_C.

$|\Gamma_{1,2}|$.

Id., 776.

93. Boyer concludes that while increasing the reflectance increases the signal strength (reflected by the bit error rate "BER"), it reduces the amount of power harvested (P_{back}) and reduces the amount of time the tag remains available to transmit data ("D_{cycle}"), which in turn reduces data throughput and ultimately limits the range

of the tag. *Id*. ("[b]y increasing $|\Gamma_{1,2}|$ the BER improves, but P_{back} and the corresponding tag duty cycle D_{cycle} decreases."); Ex-1005, 776.

C. RFID Handbook

94. RFID Handbook is a well-known textbook published 7 years before the '968 patent was filed. I was familiar with this textbook before my involvement in this case.

95. It provides the fundamental of RFID passive tags and backscatter transmission. Ex. 1023, 22-23, 39-40, 47-48, 114-124, 127-137, 139-141.

96. With regard to "modulated backscatter," the RFID Handbook explains that the reflected signal depends "on the relationship between Z_T [input impedance of the antenna] and Z_A [input impedance of the antenna]." *Id*., 139. During modulation, the "input impedance Z_T of the transponder is altered in time with the data stream to be transmitted by the switching on and off of an additional impedance Z_{mod} in time with the data stream to be transmitted. As a result, the scatter aperture σ, and thus the power P_S reflected by the transponder, is changed in time with the data, i.e. it is modulated." *Id*.

97. Figure 4.89 depicts the modulator impedance structure for several conventional binary modulators, as well as the absorbed and reflected signals, including:

1. an impedance modulator (4.89(d) using impedance Z_{mod});

2. an ohmic modulator (4.89(e) using a resistor R_{mod}); and

3. a capacitive modulator (4.89(f) using a capacitor C_{mod}).

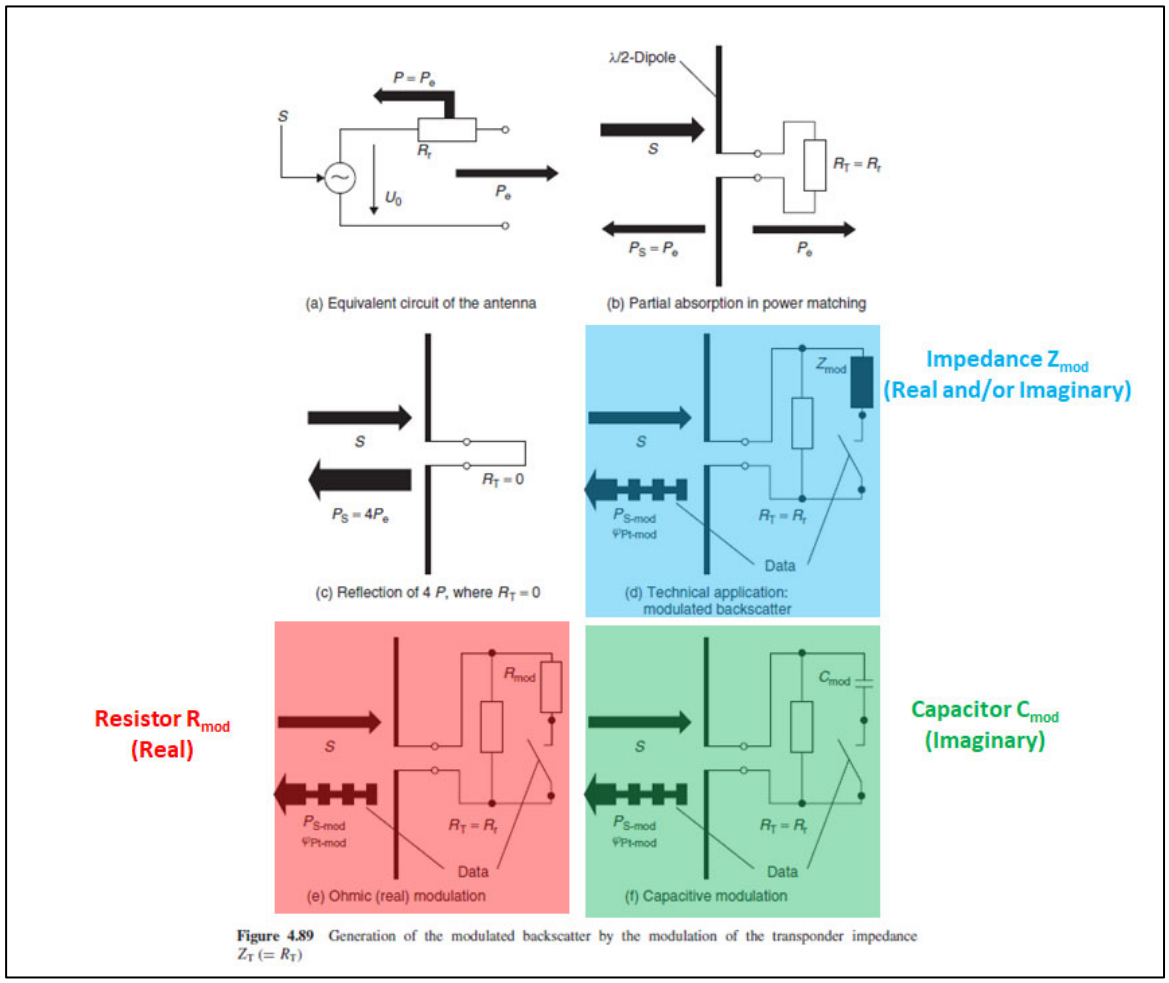


Figure 4.89 Generation of the modulated backscatter by the modulation of the transponder impedance $Z_T (= R_T)$

Id., 140.

D. Waldner

98. Waldner discloses an RFID tag capable of dynamically adjusting its resonant frequency to reduce or eliminate the potential effects of electromagnetic

"tag-to-tag coupling." Ex-1006, Abstract; ¶21. In other words, Waldner teaches various ways that an RFID tag can adjust its antenna's reflectance by changing the resonant frequency. This includes adjusting the impedance loads connected to the antenna.

99. One well-known approach to adjusting the resonant frequency of an antenna is to change the length of the antenna itself. As shown in Figure 3, Waldner teaches that an RFID tag is "capable of dynamically adjusting its resonant frequency" by switching in additional lengths (e.g., loops) of antenna. *Id.*, ¶43.

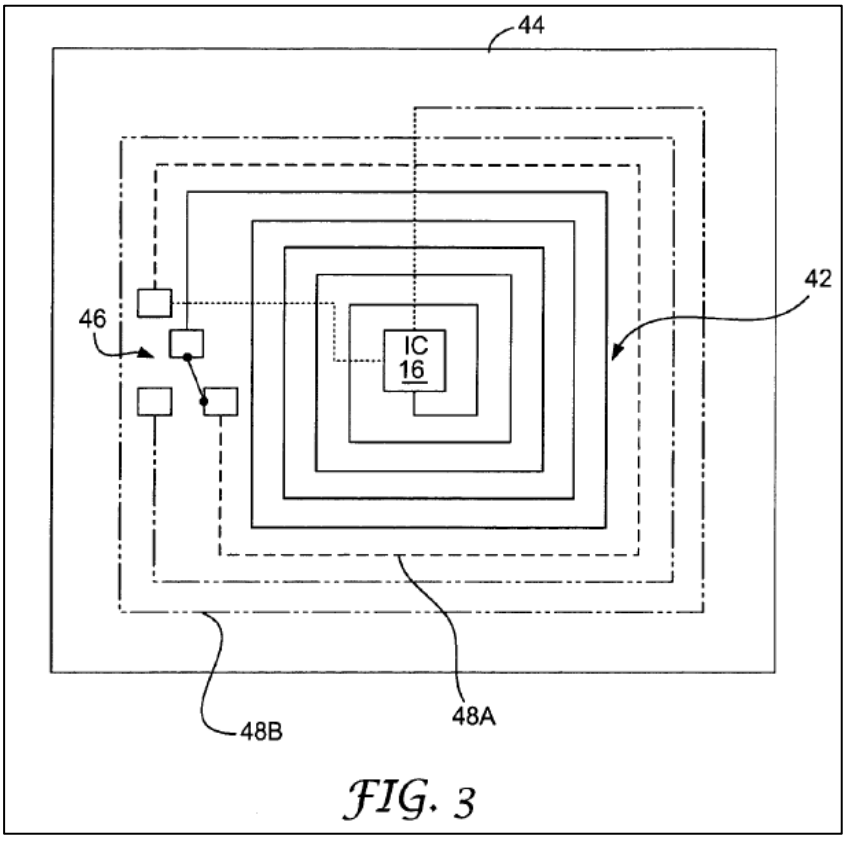


FIG. 3

100. Waldner further teaches that "switch 46 … switches between inductive elements 48A and 48B in order to selectively include inductive elements 48A and 48B as additional loops for an antenna 42." *Id.*, ¶37. Waldner teaches that inductive elements 48A and 48B can be switched around periods of absorption and reflection, including to operate at different resonant frequencies. *Id.*, ¶¶43-44.

E. Kapucu

101. Kapucu discloses a base-station design "for passive UHF RFID tags that use pulse-width modulation (PWM) in backscattering communication." Ex-1009, 1. Kapucu specifically addresses RFID tags that include a "phase-locked loop (PLL) based sensor interfaces [that] can be used in RFID tags with capacitive sensors to reduce the power consumption of the tags." *Id.*[2] Kapucu describes such a device in which "the output of the sensor interface is a pulse train whose duty cycle is proportional to the variation in the sensor capacitance value." *Id*. Kapucu explains that "[t]he pulse train signal controls the backscattering switches that short the antenna terminals. This way the sensor value information is pulse-width modulated and sent to the base station (reader) by backscattering." *Id*.

[2] Kapucu cites to a companion article, Ex-1010, which describes the RFID and sensor interface in more detail.

102. Figure 4 below shows a model of this RFID tag, where the PWM signal (orange) is used to control the switch (green) between the short circuit (**high reflectance period**) and the modulated impedance Z_L (**low reflectance period**):

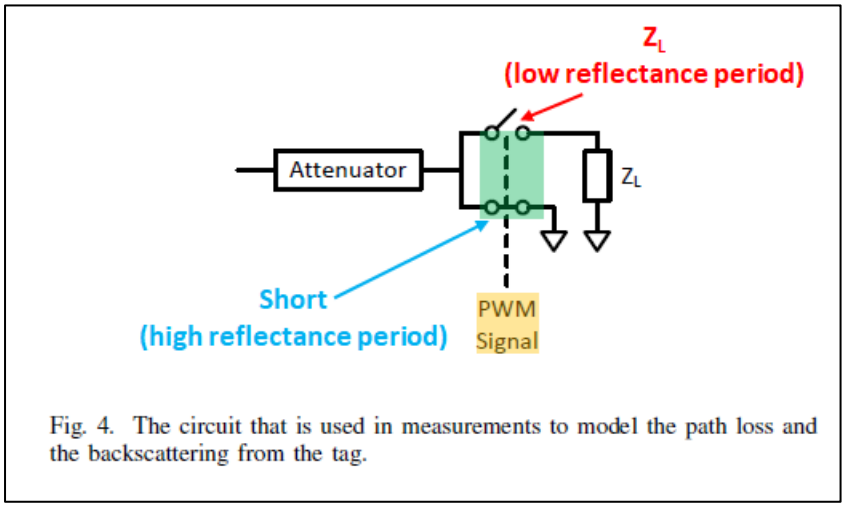


Fig. 4. The circuit that is used in measurements to model the path loss and the backscattering from the tag.

103. Kapucu then models the duty-cycle of the PWM signal controlling the RF switch, and hence the duty cycle of the backscattered sign, "from 20% to 80% with 5% steps." *Id.*, 4. The receipt of the reflected signal at the reader is shown in Figure 5, along with an example of a received signal having a 35% duty cycle shown in Figure 6.

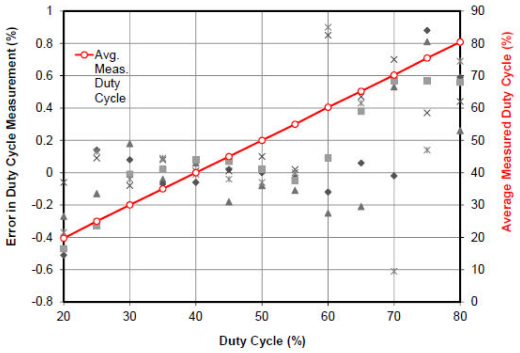


Fig. 5. The results of the duty-cycle measurements. The error in each measurement and the average measured duty-cycle are plotted with respect to the actual duty-cycle of the control signal which is swept from 20% to 80% with 5% steps.

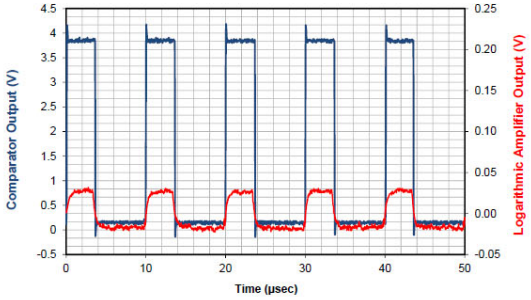


Fig. 6. The measured voltage waveforms at the output of the log-amp (red) and at the output of the comparator (blue) for a 100 kHz PWM signal with 35% duty-cycle. The $50\,mV_{p-p}$ signal at the output of the logarithmic amplifier is amplified to a rail-to-rail signal by the comparator.

Id. at 4.

F. Hyde

104. Hyde also does not short circuit the antenna during backscatter. EX-1011, 6:20-23. Hyde teaches an RFID tag that includes a tuning circuit for adjusting the impedance match between the antenna and the Integrated Circuit, thereby adjusting the amount of signal reflected versus absorbed. As shown in Figure 9 below, Hyde's RFID front end includes tuning element 908, which "includes a number of different capacitors C1, C2, C3, and C4 arranged in parallel" that are "switched into or out of the overall tuning element 908, thereby modifying the effective impedance of the tuning element 908." *Id.*, 12:9-13.

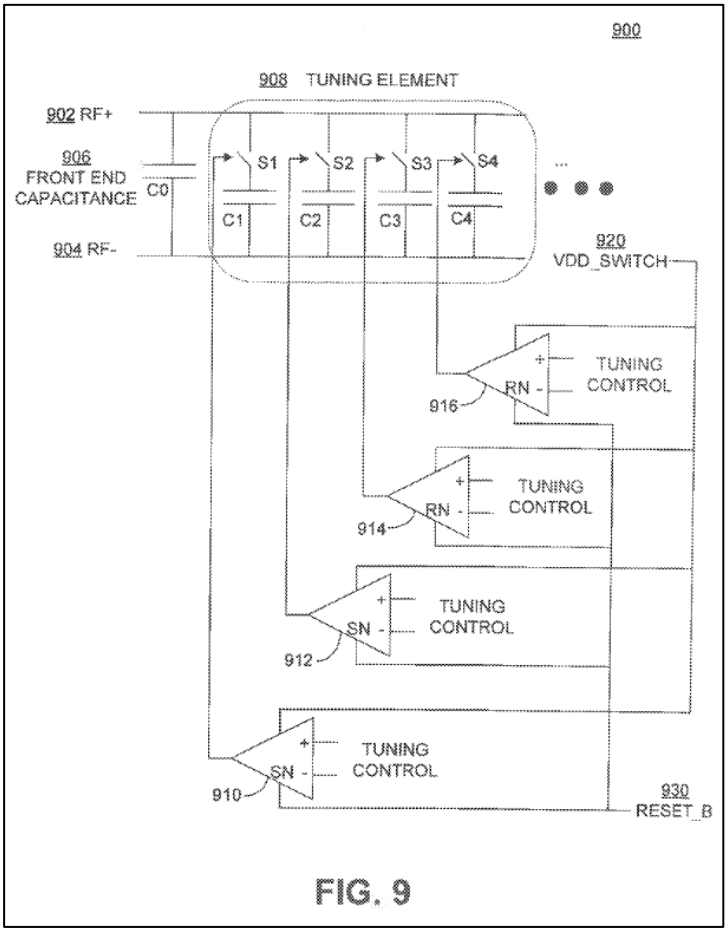


FIG. 9

Id., FIG. 9.

105. As shown in Hyde's Figure 7, below, switching in different capacitors results in a different period of reflection and absorption. Hyde also illustrates the well-known concept that, in general, the portion of the RF signal that is not reflected is absorbed (power harvested) by the tag.

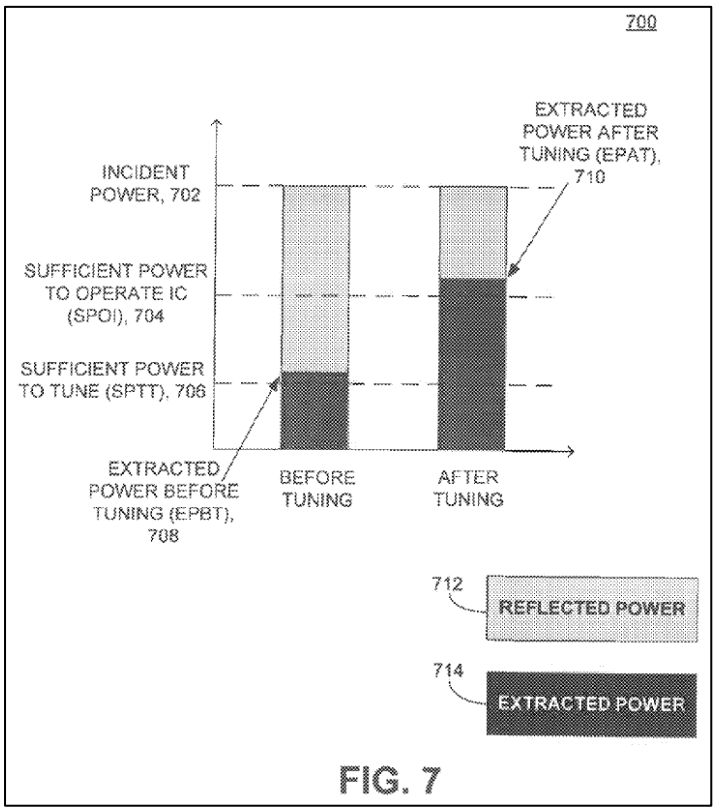


FIG. 7

Id., FIG. 7.

106. In this way Hyde mismatches the impedances through switching capacitors C1 through C4 in and out of connection rather than shorting the antenna. *Id.*, 6:20-23.

VII. OPINIONS REGARDING THE '968 PATENT'S INVALIDITY

107. I have reviewed and analyzed the prior art references and materials cited herein. In my opinion the claims of the '968 patent are rendered obvious based on the following prior art:

- **GROUND 1:** Claims 11-12, 16-20 are obvious over Boyer in view of RFID Handbook under 35 U.S.C. §103.
- **GROUND 2:** Claims 1-5, 11-20 are obvious over Boyer in view RFID Handbook in further view of Waldner under 35 U.S.C. §103.
- **GROUND 3:** Claims 6-10 are obvious over Boyer in view of RFID Handbook in further view of Kapucu under 35 U.S.C. §103.
- **GROUND 4:** Claims 6-10 are obvious over Boyer in view of RFID Handbook, Kapucu and in further view of Waldner under 35 U.S.C. §103.

VIII. GROUND 1: CLAIMS 11-12, 16-20 WERE OBVIOUS OVER BOYER IN VIEW OF RF HANDBOOK.

A. Description of Boyer

108. I Coauthored *Backscatter Communication and RFID: Coding, energy, and MIMO analysis* (which I hereinafter refer to as "Boyer") with Dr. Colby Boyer, while he was a student of mine.[3] Part of the paper's purpose was to educate the reader

[3] As noted above, I have personal knowledge that Dr. Boyer's and my paper, *Backscatter Communication and RFID: Coding, energy, and MIMO analysis* was published online in IEEE Xplorer's on or around March 2014 edition. Boyer & Roy,

about RFID and "re-examine notions of power and spectral efficiency" since "backscatter modulation and on-tag harvesting efficiency are coupled." *Ex.* 1005 at 770. In this paper, Dr. Boyer and I described principles relating to RFID power harvesting and reflectance. It is these same well-known principles that the inventors of the '968 patent claim to have discovered.

109. Boyer describes the science behind how a backscatter RFID tag can switch between two inductive elements, Z_1 and Z_2, to change the reflection coefficient and, thus, the amount of power that the tag reflects versus absorbs. *See, e.g.*, Ex. 1005 at 772. For example, Boyer's system level diagram, Figure 2, illustrates a switch optionally connecting the tag's antenna to Z_1 and Z_2. *Id.*

Backscatter Communication and RFID Coding, Energy, and MIMO Analysis, 62 IEEE Xplore 3 770 (March 2014).

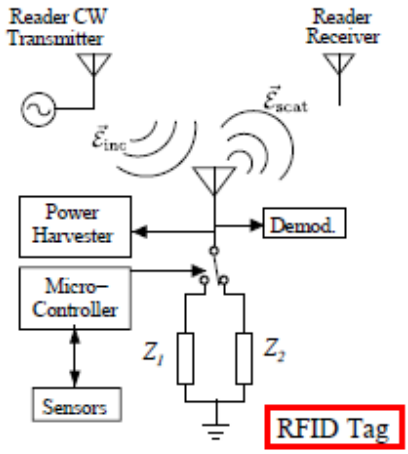
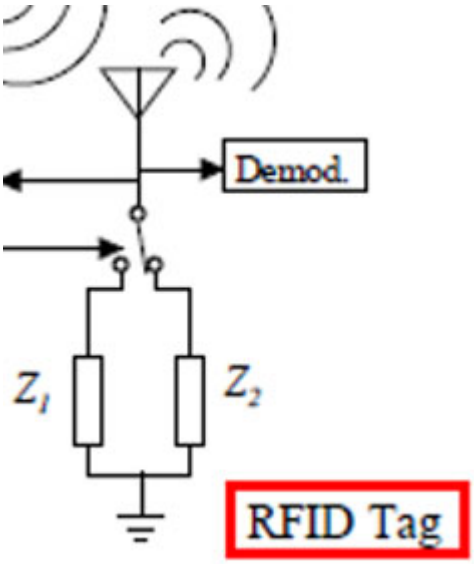
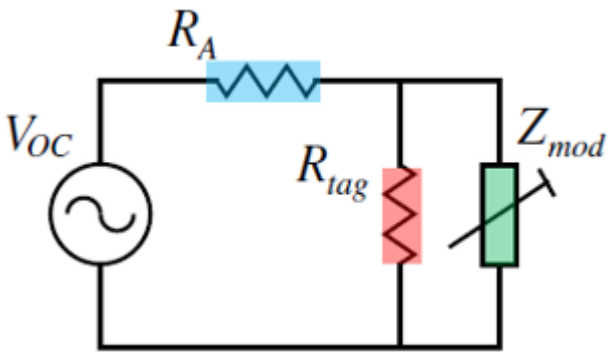


Fig. 2. System level diagram of an RFID tag with two modulator states. $\vec{\mathcal{E}}_{inc}$ represents the incident E-field generated by the reader's CW at the tags antenna. $\vec{\mathcal{E}}_{scat}$ represents the backscatter E-field propagating back to the reader's receiver. To modulate $\vec{\mathcal{E}}_{scat}$, the on-tag microcontroller logic switches the backscatter modulator between two impedance states Z_1 and Z_2. Additionally, the microcontroller processes any sensory data. The demodulator (demod.) block decodes the reader to tag communication. The power harvester captures part of the energy in the incident RF $\vec{\mathcal{E}}_{inc}$ for use by the tag.

110. I regularly discuss and cite to figure 2 and figure 6 throughout my discussion of Boyer. While these two figures look different and, indeed offer a different perspective of the RFID tag (figure 2 is a system level diagram and figure 6 represents the Thevenin equivalent circuit) these two figures represent the same RFID tag. *See id.* at 775 (explaining that "Z_{mod} (as in Fig. 6) has two states Z_1 and Z_2, which are strictly resistive"). A POSITA would have therefore recognized that these two diagrams describe the same RFID tag—at least, one in which the antenna and front end are matched.



Ex. 1005, Fig. 2.



Ex. 1005, Fig. 6.

111. As shown on the left, Figure 2 switches between impedance state Z_1 and Z_2. As shown on the right, Figure 6 represents the switching as Z_{mod}. For Figure 6, the load impedance Z_L is split into its constituent components comprising the impedance of the tag front end (R_{tag} since its complex conjugates are matched with the antenna) and backscatter modulator (Z_{mod}) impedances, which are connected in parallel. As such, it is appropriate that whenever I discuss a concept with reference to one figure, that discussion applies equally with reference to the other.

112. Figure 3 shows an equivalent circuit (called a "Thevinin" circuit) for analyzing RFID tags like the switched modulator in Figure 2 (*i.e.*, Z_L is shown as varying).

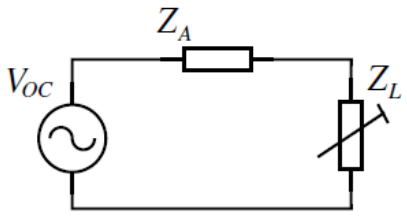


Fig. 3. Thevenin equivalent circuit of an RFID tag. V_{OC} is the voltage induced by the reader's CW, Z_A is the tag antenna's equivalent impedance, and Z_L is the combined impedance of the tag front end and backscatter modulator.

113. In Figure 6,[4] the circuit is assumed to be in a "matched" state such that the reactive (imaginary) components of the antenna and integrated circuit (IC) impedances are complex conjugates and cancel, leaving only the resistive (real) components to consider. Ex-1005, fn. 7. ("the inductive and capacitive components of antenna and tag IC are tuned out by matching.") The "modulator impedance Z_{mod} is placed in parallel to the tag IC with equivalent resistance R_{tag}, and the antenna has equivalent resistance R_A."[5]

[4] Ex-1005, 774.

[5] In the Figure 6 Thevenin equivalent circuit, the load impedance Z_L is split into its constituent components comprising the impedance of the tag front end (R_{tag} since its complex conjugates are matched with the antenna) and backscatter modulator (Z_{mod}) impedances, which are connected in parallel.

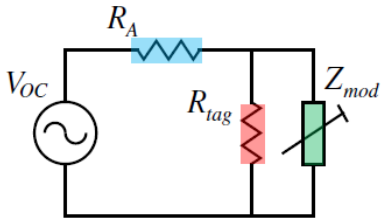
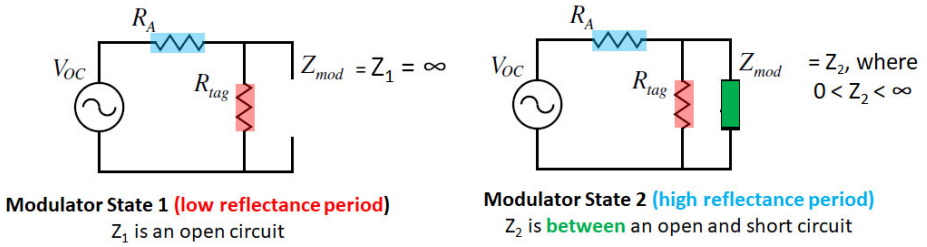


Fig. 6. Thevenin equivalent circuit of an RFID tag with the modulator impedances separated from rest of the tag IC. Reproduced from [24].

114. Boyer then describes a specific example of this embodiment in Section II-C, "where Z_{mod} (as in Fig. 6) has two states Z_1 and Z_2, which are strictly resistive." *Id.*, 775. "One modulator state remains in the matched condition (*i.e.*, Z_1 is an open circuit) and the other state has the value Z_2," which can be varied "between an open ($Z_2 = \infty$) and short state ($Z_2 = 0$)." *Id.* This embodiment of the binary modulation RFID tag system is illustrated in the modified figures below by their Thevenin equivalent circuits shown in its two states:



Boyer Figure 6 (annotated, duplicated, and modified to show two modulation states).

B. The Combined RFID Tag: Modifying Boyer's Section II-C Modulator Impedance

115. The combined RFID tag comprises a simple substitution of a capacitor (C_{mod}) for Boyer's resistive modulator impedance (Z_2) in the Section II-C embodiment.

116. Boyer's Section II-C embodiment provides an example of a conventional binary modulator in which the modulation impedances Z_{mod} "are strictly resistive." Ex-1003, 775. Since Z_1 is an open circuit and Z_2 is resistive, Boyer's modulator is therefore a basic "Ohmic" or "Real" modulation circuit as shown in the RFID Handbook below. Ex-1023, 140 (Figure 4.89(e), shown in red).

117. However, it would have been obvious to a POSITA to use any suitable impedance in Boyer's conventional binary modulator, including an impedance with reactance (imaginary components). The RFID Handbook describes two other conventional and well-known modulators (in addition to the Ohmic modulator):

1. an impedance modulator (4.89(d) using impedance Z_{mod}) in blue; and
2. a capacitive modulator (4.89(f) using a capacitor C_{mod}) in green.

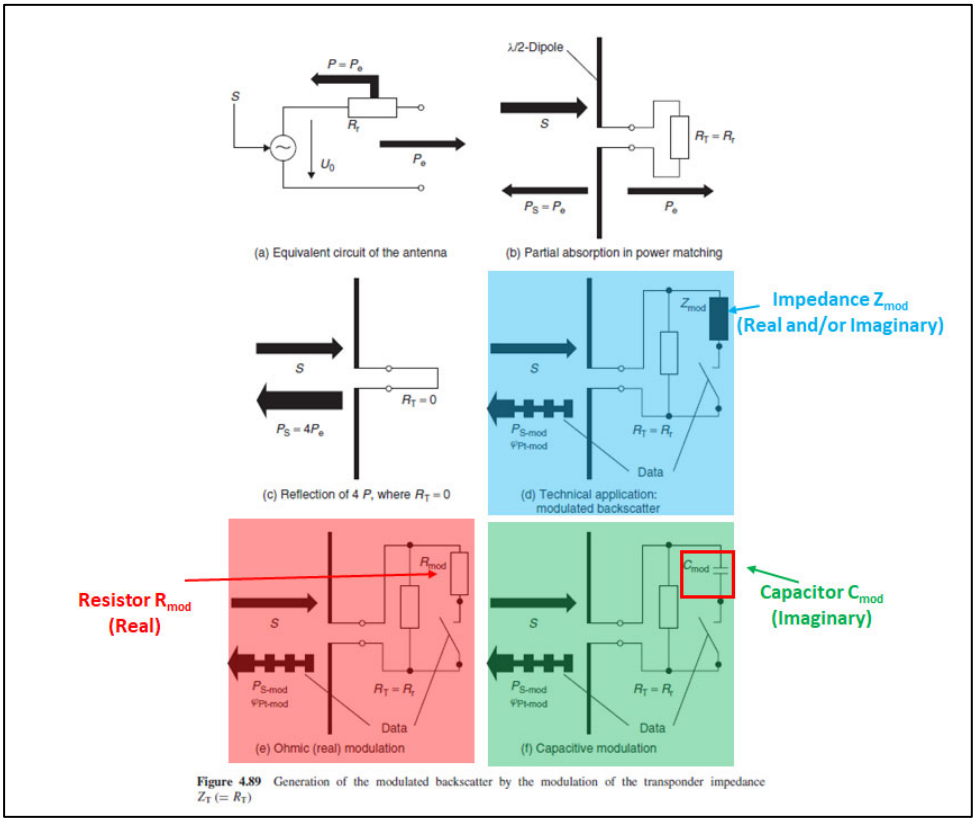


Figure 4.89 Generation of the modulated backscatter by the modulation of the transponder impedance $Z_T (= R_T)$

Id., 140

118. While the general impedance embodiment (Figure 4.89(d), blue) can apply to any underlying electrical components (resistor, inductor, capacitor, or a combination) and the analysis would be the same, the combined system will substitute the RFID Handbook's capacitor C_{mod} from the "capacitive modulation" circuit shown in Figure 4.89(f) for Boyer's Z_2 impedance in its Section II-C embodiment. No other changes are needed.

119. Therefore, in the combined system, impedance Z_1 remains an open circuit and impedance Z_2 is still varied between an "open" and a "short" circuit.

120. The reflection coefficient (G) of the RFID tag is given by the following equation:

$\Gamma = \frac{Z_L - Z_A^*}{Z_L + Z_A^*}$ is the (complex) reflection coefficient between the antenna and load;

Ex-1005, 772.

121. In the modulation state for Z_1 (switch is open), G_1 is 0 because the circuit is in a matched condition ($Z_L = Z_A^*$) and therefore the numerator in the above equation is 0.

122. In the modulation state for Z_2, G_2 varies ***between*** 0 (*i.e.*, open circuit matched condition) and 1 (short circuit, where $Z_L = 0$ and $G = Z_A^*/Z_A^* = 1$).

123. The following table provides a summary of the RFID tag for the analysis below:

Reflectance Period	Modulation Impedance (Z_{mod})	Modulation Impedance |Value|	Reflection Coefficient (G)
State 1: First (High)	$Z_2 = C_{mod}$	Between short and open circuit ($0 < Z_2 < \infty$)	$0 < G_2 < 1$
State 2: Second (Low)	Open switch	Open circuit (∞)	$G_1 = 0$

C. Motivation for Modifying Boyer's Z_2 Impedance

124. In my opinion, a POSITA would have been motivated to use a complex impedance—such as modulation capacitor C_{mod} as taught in RFID Handbook—in place of Boyer's "resistive" Z_2 in the Section II-C embodiment.

125. First, both Boyer's resistive Z_2 and a conventional C_{mod} impedance, as described in the RFID Handbook, are used for the same purpose and perform the same function: they are switched on and off in an RFID passive tag to modulate the backscatter signal by mismatching the antenna and load impedances. As such, both circuit elements were well-known and conventionally used in these types of circuits. Indeed, RFID Handbook expressly shows both configurations ***side-by-side*** as conventional binary modulation circuits:

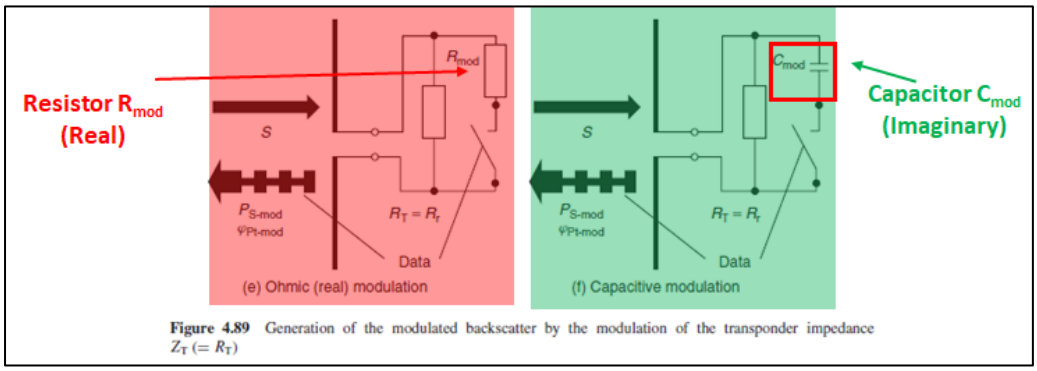


Figure 4.89 Generation of the modulated backscatter by the modulation of the transponder impedance $Z_T (= R_T)$

Ex-1023, 140. Accordingly, a POSITA would have at least found it obvious to try implementing Boyer's resistive Z_2 as using C_{mod}. A POSITA likewise would have predictably expected the combination to yield a tag that modulates and backscatters

an RF wave through C_{mod}.

126. A POSITA would have recognized that no other changes to Boyer's circuit would have been required to operate for its intended purpose if the modulation impedance has a complex value. The binary modulator will still operate as described (switching states based on the data and modulation scheme) to modulate the reflected signal—a POSITA would simply select the values of the impedance to operate within the system parameters. Therefore, while I am discussing the use of a capacitive load here, it would have been just as obvious and within the skill of a POSA to use an impedance with real and imaginary components. Indeed, we taught such embodiments (where the modulation impedance had complex values) in Boyer by showing the various constellations that are not located on the real (Re) or imaginary (IM) axis, such as Figures 5 and 7. Boyer, 773-774. Choosing the circuit elements and their values are simply design choices when designing the modulator. And as the RFID Handbook shows, a POSITA was already aware of different circuits that could be used (along with a matched state as the second state).

127. Therefore, the combined system would have represented a simple substitution of one known element [*i.e.*, a conventional capacitive modulation impedance C_{mod}] for another [Boyer's conventional resistive modulation impedance Z_2] to obtain predictable results [*i.e.*, a conventional capacitive modulator circuit,

just as shown in RFID Handbook Figure 4.89(f), that is switched on/off to change the reflective characteristics of the RFID tag to modulate the reflected signal, with no changes to how Boyer currently operates.].

128. Second, Boyer motivates the modification. Throughout Boyer, Z_{mod} is described in terms of a general impedance, teaching that backscatter modulation is achieved via modulation of a complex load impedance. It is never suggested that a resistive modulation impedance is required to take advantage of the underlying principle: *i.e.*, optimizing tag performance by sacrificing transmission power for more power harvesting. Thus, like the RFID Handbook Figure 4.89(d) disclosure of a modulation impedance of "Z_{mod}," a POSITA would have understood that the designer of the circuit would choose—based on the design parameters and system purpose—what type of impedance to use, including impedances with at least some reactance. Indeed, that is a common design process and a POSITA would have been aware of at the time—testing and trying out different circuit elements to see which ones work for a particular application. A POSITA reading our work would have taken away the key (and well-known principle) that some impedance should be used in the second modulation state (Z_2) such that not all of the incident signal power was reflected (so some current would pass through the IC). We sought to demonstrate that this principle was sounds with the Figure 8 analysis showing where how power

harvesting translated to better performance. We never suggested that only a real impedance provided those results, and a POSITA would have known, particularly in view of Dobkin's analysis of capacitive modulators to illustrate this principle (Ex-1021, 216), that reactive impedance (capacitors or inductors) that such circuits elements could be used in these modulators.

129. In fact, Boyer teaches "that switching between symbols [impedance modulation states] by ***changing only the real component*** of η [corresponding to the resistive part of the modulation impedances] ***tends to be less efficient in terms of power harvesting than changing the imaginary component*** of η [corresponding to the reactive components of the modulation impedances]."[6] *Id*., 774. A POSITA would have therefore understood that the selection of Z_2 as "strictly resistive" was primarily for illustration purposes—*i.e.*, to demonstrate the trade-off between power harvesting and increasing uplink efficiency or equivalently tag range. However, a POSITA and would have been readily motivated by Boyer to investigate the use of complex impedances for the same purpose. Resistors, capacitors, and inductors are the basic circuit elements, and POSITAs in the field would have known that,

[6] Boyer introduced a design parameter, η, which "corresponds to Z_{mod} value." Ex-1003, 774.

particularly since the equations for reflectivity and power harvesting both take into account resistance and reactance, that anyone of those variables could be varied to change the reflective properties of the RFID tag.

130. In fact, Boyer's Figure 7 shows that for a 4-state modulator, maximum power harvesting (P_{tag}) for a quadrature amplitude constellation is achieved by the set marked "optimal," each point of which corresponds to a different and unique load of impedances. It is clear that each point in the "optimal" modulation constellation has both non-zero (the value along the x-axis, highlighted in blue) and imaginary (value along the y-axis, highlighted in red) components.

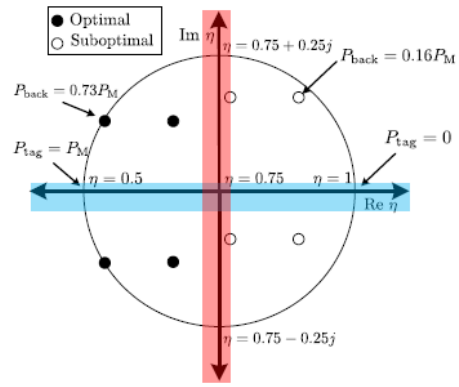


Fig. 7. Two 4-QAM constellation with identical detection error by the reader, but with different P_{back} values. One constellation uses the optimal η values, while the other constellation is arbitrarily placed. The solid-lined circle is the boundary of the set W, the feasible η values. The P_{tag} values are given for the match ($\eta = 0.5$) and short ($\eta = 1$) state. P_{back} is give for the optimal constellation design and for the arbitrarily placed constellation. Reproduced from [24].

Id., 774.

131. Boyer also explains that "detection performance depends on the Euclidean distance between the two reflection coefficients states via $|\Gamma_{1,2}| = |\Gamma_1| - |\Gamma_2|$ . . . ." Ex-1005, 772. This is a basic concept when working with alternating currents since the currents will have both amplitude and phase. And as taught by Boyer, RFID Handbook and Dobkin, a POSITA would have known that readers operate to detect the differences in the reflected signal coming from the RFID tag—and those differences can be in both phase or amplitude (or both). Thus, the more different the reflected signal (in absolute terms), the higher the read rates and the lower the error rates. In fact, Figure 8 shows tag performance based on the absolute value (magnitude) of the difference in the reflectance values $|\Gamma_{1,2}|$, which by definition is a complex value. Thus, a POSITA would have known from these teachings that the impedances are typically complex, and would have been strongly motivated to try them as it would *enable additional degrees of design freedom* to meet the desired condition on the magnitude of the difference in reflection $|\Gamma_{1,2}|$, in pursuit of enhanced RFID tag performance.

132. Further, the textbooks confirm that a POSITA would have possessed the necessary background of backscatter modulation using variable complex load impedances and the benefits thereof. For example, when addressing the same transmission power/power harvesting trade-off, Dobkin showed that a binary

modulator circuit where Z_{mod} is only capacitive has better power harvesting and backscatter transmission than a strictly resistive binary modulator. Ex-1021, 214-218 (Table 5.1, comparing modulators in Figures 5.19 and 5.20). While Dobkin's Figure 5.20 modulator performed phase shift keying (PSK) between the first and second modulator states (*i.e.*, two capacitors without opposite imaginary components), a POSITA would have recognized that a capacitive modulator could switch between a matched state and unmatched state created by connecting and disconnecting one capacitor, as shown in RFID Handbook (page 140, Figure 4.89(d) and (f)) and Boyer Section II-C. While this configuration may reduce the difference in power between states 1 and 2 (as compared to switching between two capacitors), it would have increased power harvesting (since more power can be harvested in the matched state), which is one of the primary teachings of Boyer and Dobkin. It also would have potentially required fewer circuit elements (*i.e.*, one capacitor instead of two), which would have been beneficial from a cost and manufacturing perspective. Thus, a POSITA would have been motivated to use a reactive load, whether by connecting capacitors or inductors.

133. Therefore, the combined system would have represented a use of known technique to improve similar devices (methods, or products) in the same way. At the very least, a POSITA would have recognized this as a design choice and found

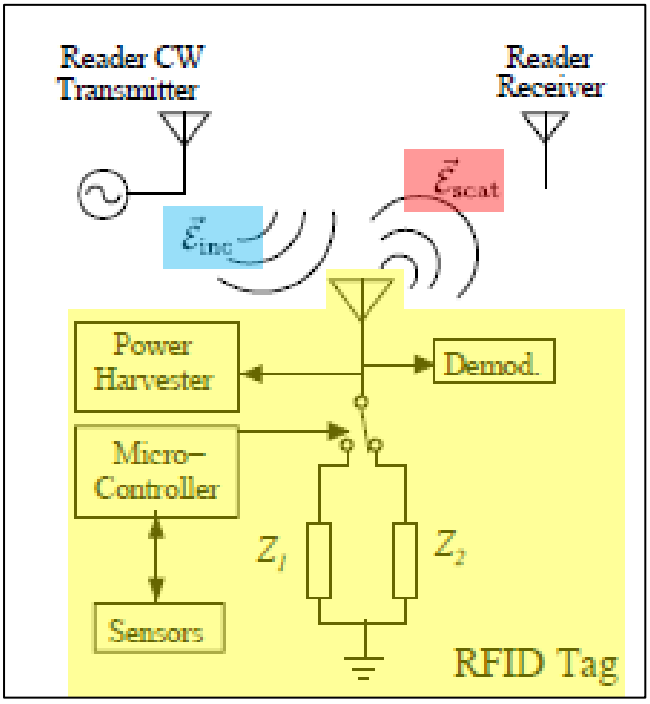
it obvious to try a complex modulation impedance since there are only a finite number of choices—strictly resistive, strictly reactive, or a combination of the two. A capacitor is certainly one well-known impedance for modulating a backscattered signal, as taught in both Dobkin and RFID Handbook. And as noted above, Boyer itself shows that complex impedances are used for modulating backscattered signals.

D. Boyer in view of RFID Handbook renders claim 11 obvious

1. The combined RFID Tag discloses [11P]: "A radio-frequency identification (RFID) tag"

134. Boyer is about Radio Frequency Identification (RFID) tags. Ex. 1005 at 770 (Abstract). Boyer teaches that "backscatter communication system consists of two components: ***a RFID tag*** (backscatter node) and a RFID reader (transmitter/receiver)." Ex-1005 772.

135. Figure 2, reproduced below, shows a "system level diagram of ***an RFID tag***" (shown in yellow), which includes "microcontroller logic [that] switches the backscatter modulator between two impedance states Z_1 and Z_2" to modulate the backscattered signal $\vec{\varepsilon}_{scat}$ (shown in red). The incident signal from the reader ($\vec{\varepsilon}_{inc}$) is shown in blue:



Boyer Figure 2

Id.

136. Figure 6 shows the Thevenin equivalent circuit for an embodiment of the "RFID tag" with a binary backscatter modulator analyzed herein.

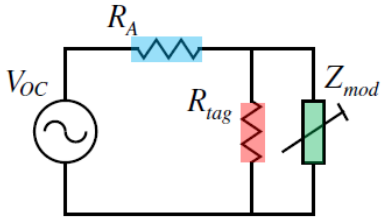
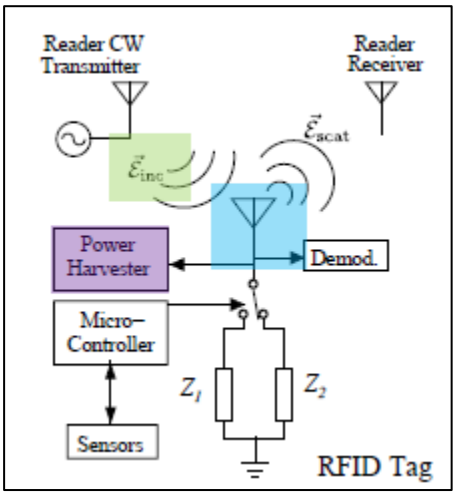


Fig. 6. Thevenin equivalent circuit of an RFID tag with the modulator impedances separated from rest of the tag IC. Reproduced from [24].

2. The combined RFID Tag discloses [11A]: "a main antenna that receives a radio-frequency (RF) signal from an RFID reader and wirelessly harvests power from the RF signal."

137. Boyer discloses "*a main antenna that receives a radio-frequency (RF) signal from an RFID reader."* The RFID tag includes at least the antenna (blue) that receives the RF signal $\vec{\varepsilon}_{inc}$ (green) from the RFID reader ("Reader CW Transmitter) in Figure 2 below.



Boyer, 772.

138. Boyer explains that the main antenna "*receives a radio-frequency (RF) signal from an RFID reader" (*$\vec{\varepsilon}_{inc}$ shown in blue in Figure 2 above) and *"wirelessly harvests power from the RF signal.*" For example, in describing the RFID system in Figure 2, Boyer states that "$\vec{\varepsilon}_{inc}$ represents the incident E-field generated by the reader's CW at the ***tags [sic] antenna***." *Id*., 772. The generated E-field is indeed a

radio frequency (RF) signal as it operates within the radio frequency spectrum and is an integral part of electromagnetic wave used for RFID communication. In particular, the frequency of the E-field is the same as the frequency of the RF signal emitted by the reader. As the RFID reader transmits the CW RF signals, it generates an oscillating electric field (E-field) and magnetic field (H-field) around the reader's antenna. These fields, i.e., E-field and H-field, propagate through space as electromagnetic waves. As soon as an RFID tag enters the reader's coverage range or field, the tag's antenna captures the oscillating E-field and uses the captured energy to power the tag's circuitry. Boyer further explains that "[t]he power harvester," shown in purple in Figure 2 above, "captures part of the energy in the incident RF $\vec{\varepsilon}_{inc}$ for use by the tag." *Id*.

139. Boyer discloses *a main antenna that … wirelessly harvests power from the RF signal*. Boyer describes the fundamental concept that the power reflected is inversely proportional to the amount of power absorbed by the IC. Boyer explains that in backscatter RFID systems, "[a]ny tag within range of the reader's downlink CW signal will backscatter a portion back to the source (the reader), while the remainder ***is harvested*** to assist powering the on-tag integrated circuit (IC)." *Id*., 771; 772 ("In this example, a tag is illuminated with an incident RF electrical field $\vec{\varepsilon}_{inc}$, part of which is backscattered as the field $\vec{\varepsilon}_{scat}$. The remaining power is

assumed harvested by the tag."); 775 ("Passive RFID tags must rely on harvesting a portion of the reader's CW incident energy in order to be operational for backscatter."). While in a real-world implementation, some of that non-reflected power may be lost (e.g., to resistive heating), a POSITA would have understood that additional power can be harvested if more power is available to harvest (*i.e.*, rather than reflected).

140. Again, that the tag's antenna harvests power from the incident antenna is a fundamental principle of RFID. In addition to the description from Boyer, a POSITA would have understood how the relative impedance match between the antenna and the IC defines how much power the tag harvests. Dobkin is one example textbook that describes this phenomena. Dobkin explains that when the load resistance (e.g., IC inductance) is mismatched to the radiation resistance (e.g., antenna inductance), very little voltage or current flows across the Tag's IC. Ex. 1021 at 212. However, the matched condition represents the optimum power transfer. *Id.* During the matched condition the load resistance and the radiation resistance are matched. *Id.* Dobkin explains that "as a consequence [of] the matched condition, the power dissipated in the load is equal to the power dissipated in the radiation resistance—that is, a matched antenna *scatters as much power as it receives*. *Id.*

141. As a more visual representation, the prior art reference Hyde illustrates how adjusting the relative impedance match between the tag's antenna and IC results in a different ratio of power reflected versus absorbed.

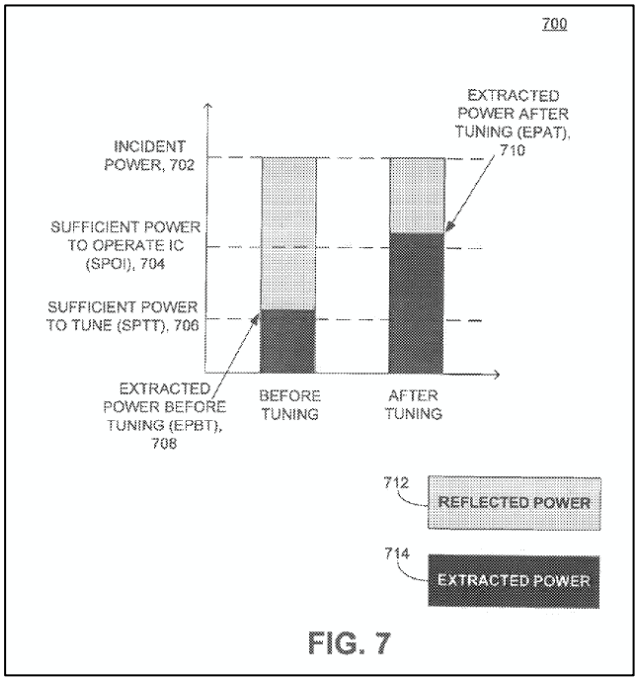


FIG. 7

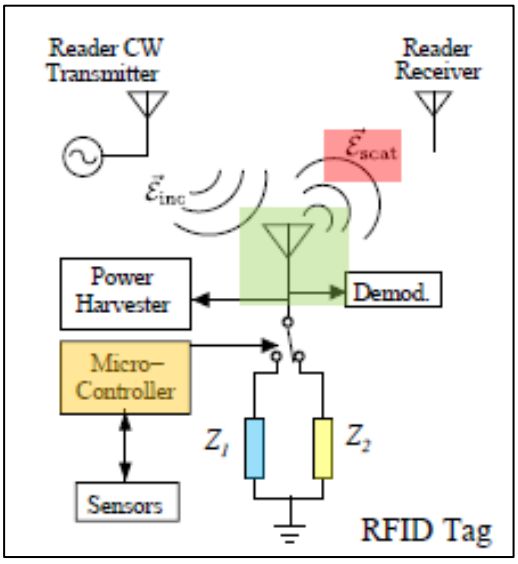
Ex. 1011, Fig. 7.

142. As Boyer describes the well-known principle that the tag absorbs whatever energy from the RF signal is not reflected, and as other references confirm this principle, a POSITA would understand Boyer to teach *a main antenna that receives a radio-frequency (RF) signal from an RFID reader and wirelessly harvests power from the RF signal*.

3. The combined RFID Tag discloses [11B.1]: "a circuit that is configured to vary a reflection coefficient of the main antenna …"

143. Boyer discloses "*a circuit that is configured to vary a reflection coefficient of the main antenna to transmit a reflected signal to the RFID reader*" [11B.1]. As explained below, Boyer discloses that the "integrated **circuit**" (IC) includes a microcontroller that modulates the backscattered signal by "controlling the frontend impedance" (Z) on the antenna, thereby changing its reflection coefficient (Γ). *Id*., at 771, 772.

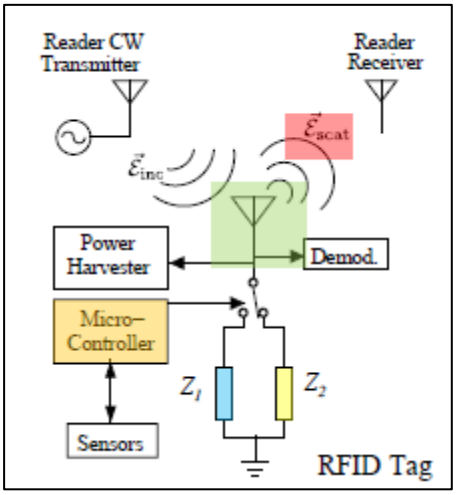
144. As illustrated in Figure 2, for example, Boyer discloses that the RFID has a "Microcontroller." Figure 2 generally shows the microcontroller being connected to, and hence, a part of the IC (e.g., the "circuit").



Ex. 1005, Fig. 2.

145. The microcontroller includes logic that "switches the backscatter modulator between two impedance states Z_1 and Z_2" to modulate the backscattered signal $\vec{\varepsilon}_{scat}$. *Id*., 772; 771 ("***IC*** modulates information onto the backscattered CW by controlling the front-end impedance loading."). A POSITA would have understood that the IC includes the microcontroller, and that both constitute a "circuit" because they must comprise circuit elements to perform logic—including the switching needed to perform modulation. Indeed, it was well-known in these types of modulating circuits that there must be some logic (and therefore some circuity) that controls the state that the RFID tag (and specifically the modulating circuitry) is in so that the reflected signal includes information on the data that is being sent. Otherwise, there would be no information conveyed with the reflected signal.

146. Boyer further explains that "the tag"—via the IC and microcontroller—"switches the modulator impedance between Z_1 and Z_2 resulting in the ***corresponding reflection coefficients Γ_1 and Γ_2***, respectively." *Id*., 772. In other words, switching the load impedance Z_L between Z_1 and Z_2 changes the reflection coefficient of the main antenna (which, in turn, changes the portions of the incident signal that are either reflected or absorbed for power harvesting).



147. Indeed, Figure 6 shows the Thevenin equivalent model of the RFID tag having a variable impedance Z_{mod}, where the binary backscatter modulator switches between the two states by changing the modulation impedance between Z_1 (open circuit for the matched condition embodiment) and Z_2 (having a value between an open and short circuit). *Id.*, 775.

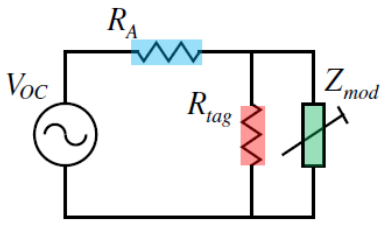


Fig. 6. Thevenin equivalent circuit of an RFID tag with the modulator impedances separated from rest of the tag IC. Reproduced from [24].

148. The reference to Z_1 being an "open circuit" is not the same as the entire circuit being open such that no current flows. Instead, because the modulation impedance Z_{mod} is in parallel with the IC impedance (here, because the complex

component of the IC impedance and antenna impedance are matched, only their resistances are shown), when Zmod is an open circuit, current still flows through the antenna (R_A) and the IC (R_{tag}).

149. The '968 patent confirms that reflection coefficient Γ in Boyer is the same *reflection coefficient* recited in the claims. Boyer sets forth the well-known relationship between the antenna load impedance (Z_L, corresponding to the combination of the chip impedance plus either Z_1 or Z_2, whichever is connected at the time) and the reflection coefficient of the antenna:

> $\Gamma = \frac{Z_L - Z_A^*}{Z_L + Z_A^*}$ is the (complex) reflection coefficient between the antenna and load;

Id., 772.[7]

150. The '968 patent provides the ***same*** equation for its reflection coefficient, where Z_L and Γ in Boyer are the same as Z_i and r in the '968 patent, respectively:

[7] Where Z_A^* is equal to the complex conjugate of the antenna's impedance, Z_A.

explained in the following equations (1)-(4) and Table 1. The reflection coefficient ρ is described according to equation (1).

$$\rho_i=(z_i-z_a^*)/(z_i-z_a^*), \quad (1)$$

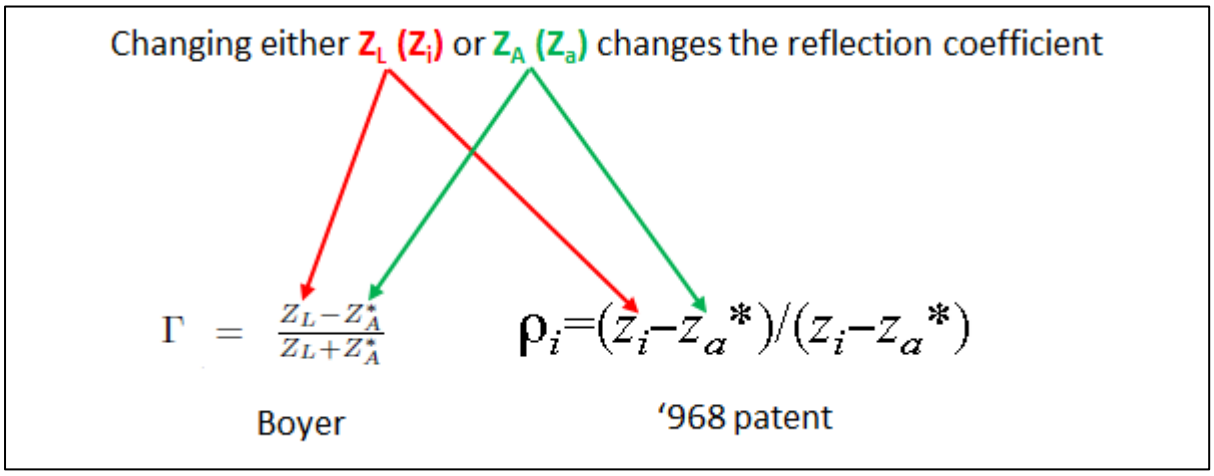
where z_a is the antenna impedance.

'968 patent, 5:64-67.[8]

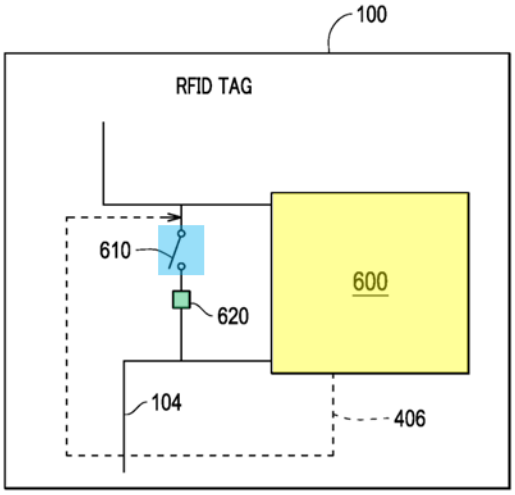
151. That the equation in the '968 patent for the "*reflection coefficient*" of the "*main antenna*" expressly considers ***both*** the antenna impedance (Z_a) and the load impedance (Z_i) confirms the understanding of a POSITA that the "*reflection coefficient of the antenna*" is affected by changes in the load, which in turn is affected by changing modulating impedances like Boyer's Z_1/Z_2. Indeed, it is not uncommon to refer to the reflectance properties of an RFID tag as properties of the antenna, since the antenna is sometimes thought of as the component that receives and radiates the RF signals. But the reflectance properties (*e.g.*, reflectance, resonant frequency, etc.) of the RFID antenna (and hence the tag) are affected by the load impedance, which the '968 patent confirms. Said another way, if the same conductor

[8] As noted above, the '968 patent includes a typographical error. Otherwise, the numerator and denominators would be the same. And of course, we had the correct formula in Boyer, which would have been well-known to a POSITA.

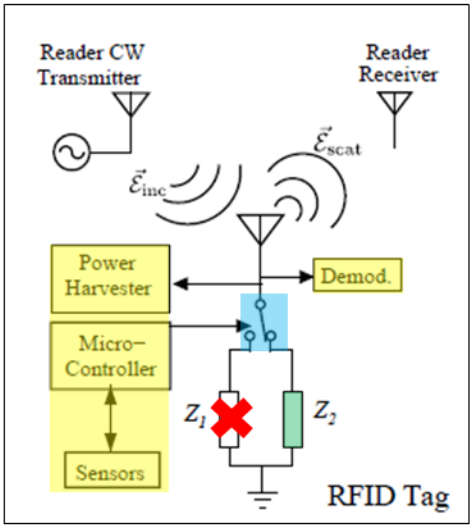
(*e.g.*, same material, length, etc.) is connected to two different loads, it will have a different reflection coefficient.



The '968 patent confirms that changing the modulating impedance connected to the antenna as taught by Boyer changes the "reflectance properties" of the "*main antenna*." In the "electrical" embodiment, the '968 patent explains that "Electrical-reduced backscatter signal strength and increased tag power efficiency are achieved and controlled via choosing a ***different modulating impedance within tag circuitry***." '968 patent, 5:51-54. "In these embodiments, an ASIC or processor 600 controls one or more switches 610 to ***add or subtract one or more impedances 620 from antenna 104. This changes the resonant frequency and reflectance properties without shorting the antenna 104***." *Id.*, 5:55-59. This describes the binary modulator in Boyer, which shows Z_1 (open circuit) and Z_2 (green) connected directly to the antenna by the switch (blue), just like Figure 6 from the '968 patent.



'968 Patent, Figure 6



Boyer, Figure 2

The claims confirm that the '968 patent uses "*main antenna*" and the combination of the antenna and IC (or tag circuit) interchangeably for these concepts. For example, claim element [11A] recites the "*main antenna*" "*harvests power from the RF signal*." *See also* [11C.2]. Of course, a POSITA would have understood that power harvesting (rectification, *i.e.*, conversion of RF to DC) can only be done in the IC (*e.g.*, through Boyer's "power harvester"); power harvesting cannot be done by the antenna alone. Ex-1023, 129-137.

152. Indeed, were this to mean something other than the reflection coefficient set forth in the above equation (*e.g.*, antenna, IC, modulation impedance), it would not be grounded in anything technical since the equation takes into account both the antenna and the load. It is, after all, the load modulation that is responsible

for the changes in the reflectance, resonant frequency, etc. It is a property of the whole tag, since the causative agent of the effects is clearly the IC circuit. There is no technical distinction between a) changing the load (hence R & C that characterizes the tag input impedance and/or a part of the antenna (*e.g.*, length of coil and hence the inductance) and the impact on b) reflectance G (via match/mismatch). In the Thevenin circuit equivalent, the antenna contributes a component (the voltage, the inductance, and antenna resistance) and the tag IC provides the rest (load impedance); and effects like reflectance and resonant frequency result from analyzing the circuit as a whole. A POSITA would not consider a "reflectance" or "resonance" with only the antenna inductance without considering the IC contributions (*i.e.*, the resonance property belongs to the entire tag). Hence, changing the IC load (*e.g.*, capacitance, inductance, complex) changes the reflectance and resonant frequency of the antenna/tag.

153. In Section II-C, impedances Z_1 ("open circuit") and Z_2 ("between an open ($Z_2 = \infty$) and short state ($Z_2 = 0$)") are different, resulting in different reflectance coefficients $|\Gamma_1|$ and $|\Gamma_2|$, respectively ($G_1 = 0$; $0 < |G_2| < 1$). Boyer, 775. This analysis does not change whether Z_2 is a resistor, a capacitor (as in the modified system), an inductor, or a combination thereof. The reflection coefficient equation is agnostic as to the circuit elements themselves, and simply considers how the circuit element

affects the Z_{load}. And the equation takes into account both the real and imaginary components. This makes logical sense because, if the imaginary components of the load and antenna are not complex conjugates (*i.e.*, not in the matched condition), then the tag reflects more of the incident RF signal. Therefore, if the antenna and IC are matched, using a load impedance that mismatches the reactance (such that they are no longer complex conjugates) would have the same effect.

154. Finally, as explained below for element [11B.2], the reflection coefficient (Γ) determines the reflected E-field at the reader ($\vec{\varepsilon}_{scat}$). Therefore, the IC and microcontroller are *"configured to vary a reflection coefficient of the main antenna to transmit a reflected signal to the RFID reader"* [11B.1].

4. The combined RFID Tag discloses [11B.2] "the reflected signal having a first reflectance period and a second reflectance period . . ."

155. Boyer further discloses "the reflected signal having a **first reflectance period** and a **second reflectance period** when an amount of reflectance by the main antenna of the RF signal is different than during the **first reflectance period**" [11B.2].

156. With reference first to Figure 2 discussed above, Boyer explains that "[a]n example of backscatter modulation is switching the tag impedance between two values, Z_1 and Z_2, to achieve binary modulation (*e.g.* on-off keying)." *Id.*, 772.

The ***first*** and ***second*** *reflectance periods* of the backscattered signal correspond to the ON (high reflectance) and OFF (low reflectance) periods of the modulated reflected signal ($\vec{\varepsilon}_{scat}^{M}$) when Z_1 and Z_2 are the "modulator impedances," respectively. These reflectance periods must be different to obtain a modulated signal.

157. In particular, Boyer explains the well-known concept that "[b]y altering the tag's antenna impedance loading" (*i.e.*, switching between load impedances Z_1 and Z_2), "a return signal with different phase and amplitude is backscattered to the reader." *Id.*, 772. As shown above for element [11B.1], Boyer teaches that the "tag switch[ing] the modulator impedance between Z_1 and Z_2 result[s] in the corresponding reflection coefficients Γ_1 and Γ_2, respectively." *Id.*, 772. As a result, the RFID tag backscatters a signal with different phase and amplitude to the reader and the reader uses the received signal to estimate different modulation states at the tag. Specifically, and as an example, the tag backscatters a signal at a fixed amplitude and frequency, representing a binary "1" (On). In contrast, an absence of the backscattered signal may represent a binary "0" (Off). On-Off Keying is a straightforward and efficient modulation technique used in various communication systems, especially well-suited for passive RFID tags, which have no internal power source and rely on the energy harvested from the reader's signal to operate.

158. Boyer teaches that the reflected E-field changes according to the two-different states of the reflection coefficient. As shown in the equation below, from Boyer, the reflected E-field "signal at the reader," $\vec{\varepsilon}_{scat}$, is a function of the reflection coefficient Γ.

$$\vec{\varepsilon}_{scat} = \vec{\varepsilon}^{M}_{scat} - \Gamma I_{\mathrm{M}} \frac{\vec{\varepsilon}_a}{I_a}$$

Id., 772 (equation (1)). This is the "*reflected signal*."

159. Recall that Γ is a function of the antenna's impedance compared to the IC's impedance, as set forth in the equation below:

$\Gamma = \frac{Z_L - Z_A^*}{Z_L + Z_A^*}$ is the (complex) reflection coefficient between the antenna and load;

Id., 772.[9] Accordingly, when the IC's (load) impedance switches between state Z_1 and Z_2, Z_L changes and, with it, Γ.

160. Therefore, Γ_2 and Γ_1 are the antenna reflectance corresponding to the periods when the IC (via the microcontroller) switches the modulator impedances

[9] Where Z_A^* is equal to the complex conjugate of the antenna's impedance, Z_A.

between Z_2 and Z_1.[10] This in turn provides the ***first reflectance period*** (*i.e.*, high reflectance corresponding to Γ_2 and an ON period) *and the* ***second reflectance period*** (*i.e.* low reflectance period corresponding to Γ_1 and an OFF period); *i.e.* the respective periods of the resulting backscattered electric field at the reader to achieve ON-OFF keying:

$$\vec{\varepsilon}_{scat} = \vec{\varepsilon}^{M}_{scat} - \Gamma_1 I_{\mathrm{M}} \frac{\vec{\varepsilon}_a}{I_a} ; \vec{\varepsilon}_{scat} = \vec{\varepsilon}^{M}_{scat} - \Gamma_2 I_{\mathrm{M}} \frac{\vec{\varepsilon}_a}{I_a}$$

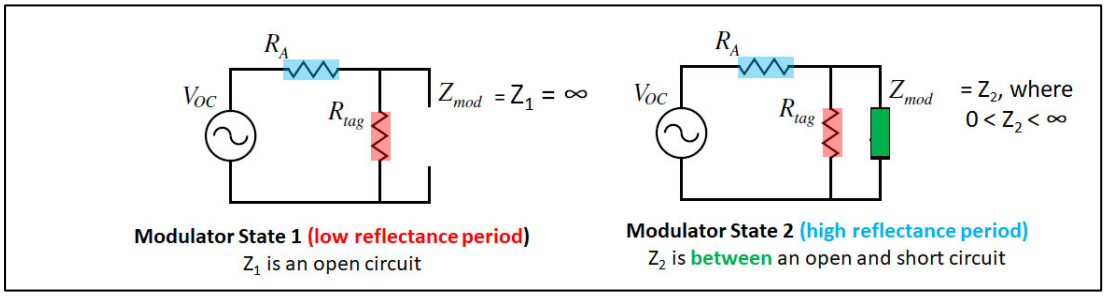
**Reflected Signal During Second (Γ_2 and Z_2) /
First (Γ_1 and Z_1) Reflectance Periods**

Id., 772.

161. Indeed, Boyer's embodiment corresponding to Figure 6 and Section II-C shows a variable impedance Z_{mod}, where the binary backscatter modulator switches between the two states by changing the modulation impedance between Z_1

[10] As discussed below for element [11C.1], the Figure 6 embodiment discussed herein sets "Z_1 [as] an open circuit" corresponding to the OFF or "***low reflectance period***" and allows Z_2 to be varied "between an open" and "short state" corresponding to the ON or ***high reflectance period***. *Id.*, 775 (Section II-C). I have therefore mapped Z_2 to the first (high) reflectance period and Z_1 to the second (low) reflectance period.

(open circuit for the **low reflectance** matched condition, where $\Gamma_1 = 0$) and Z_2 (having a value between an open and short circuit for the **high reflectance period**, where $|\Gamma_2|$ is greater than 0 but less than 1). *Id.*, 775.



Boyer Figure 6 (annotated and modified to show the two modulation states). Since Γ_1 and Γ_2 are different, the "*amount of reflectance of the RF signal*," which is proportional to the reflection coefficient as shown above, is therefore varied to modulate the signal.

162. The '968 patent confirms that the ***first*** (high) and ***second*** (low) *reflectance periods* includes the ON and OFF periods of the backscatter signal as shown in Boyer.

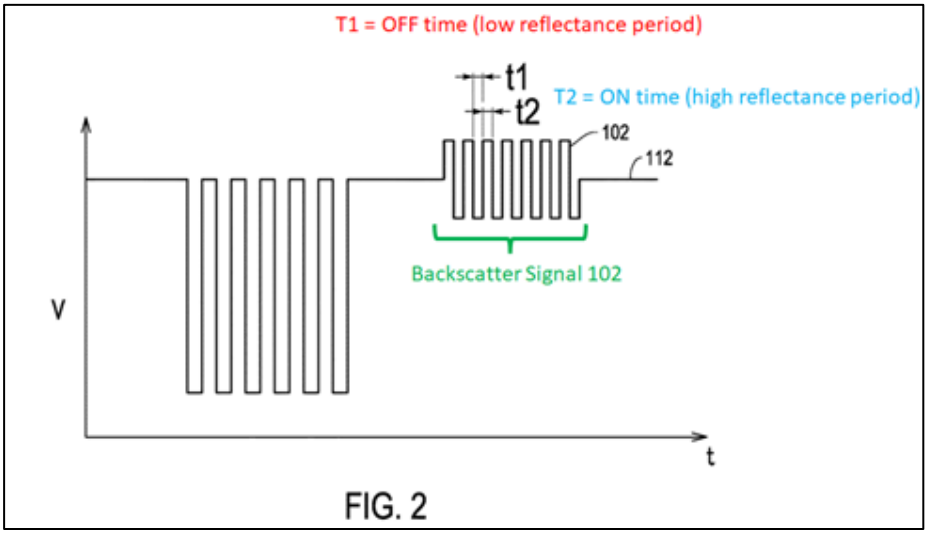


FIG. 2

'968 patent, 3:65-4:3 ("FIG. 2 shows waveforms of reader signal 112 and backscatter signal 102 . . . where t_1 is the length of the OFF time (low reflectance period) for each period of the signal and t_2 is the length of ON time (high reflectance period) for each period.")

5. The combined RFID Tag discloses [11C] "wherein the reflectance of the main antenna is reduced below a predefined amount during the first reflectance period without shorting the main antenna to enable the main antenna to continuously harvest power while transmitting the reflected signal the RFID reader, wherein the reflectance of the main antenna is reduced based on a change in a resonant frequency of the main antenna."

163. Boyer discloses "*wherein the reflectance of the main antenna is reduced below a predefined amount during the* ***first reflectance period*** *without shorting the main antenna to enable the main antenna to continuously harvest power while transmitting the reflected signal to the RFID reader, wherein the reflectance*

of the main antenna is reduced based on a change in a resonant frequency of the main antenna" [11C]. For ease of explanation, I break this limitation into three various concepts and organize them under sections below [11C.1] – [11C.3].

a) [11C.1] "wherein the reflectance of the main antenna is reduced below a predefined amount during the first reflectance period without shorting the main antenna"

164. As I explained before, the fact that RFID tags receive downlink signals from an RF reader, reflect back some of the signal and absorb the rest is a well-known science in RFID tags. Boyer describes this fundamental concept. Boyer explains that "[a]ny tag within range of the reader's downlink CW signal will backscatter a portion back to the source (the reader), ***while the remainder is harvested to assist powering the on-tag integrated circuit (IC)***." *Id*., 771.

165. As explained above, Boyer discloses an embodiment of the "binary backscatter modulator where Z_{mod} has two states Z_1 and Z_2," in which:

1) "[o]ne modulator state remains in the matched condition (*i.e*., Z_1 is an open circuit)"; and
2) "the other state has the value Z_2," where the value of Z_2 is varied "***between*** an open ($Z_2 = \infty$) and ***short state*** ($Z_2 = 0$)."

Boyer, 775.

166. As explained for elements [11B.1] and [11B.2], a binary system that switches modulator impedances Z_{mod} between Z_1 and Z_2 provides different antenna reflection coefficients, Γ_1 and Γ_2. This in turn yields different levels of reflected electric field, $\vec{\varepsilon}_{scat}$, during different periods of the reflected signal (*e.g.*, for ON-OFF keying). Boyer, 771-773.

167. Boyer recognizes that if a passive RFID tag cannot harvest enough power, it enters a sleep state where it is not available at all—*i.e.*, it cannot transmit any data, which "reduces uplink throughput."

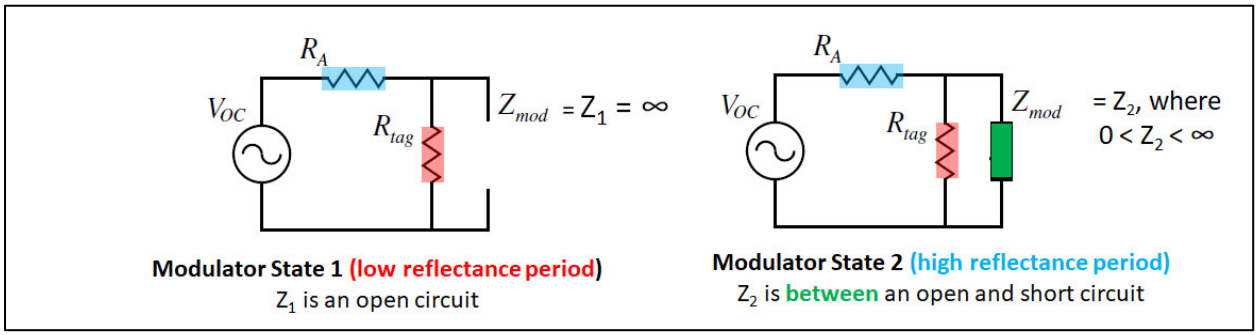
> Passive RFID tags must rely on harvesting a portion of the reader's CW incident energy in order to be operational for backscatter. Consider a simple 2-state model: the tag is either active and backscattering information or the tag is in a sleep state and no backscatter occurs. If the (average) power harvested by the tag is greater than the (average) power consumed in its active state, then the tag is operational 100 percent of the time. If not, the tag undergoes a *duty cycling* behavior between an active state and a sleep state; clearly this reduces *availability* for backscatter and reduces uplink throughput. In this sub-section, we further explore this aspect.

Id., 775.

168. In recognition of this limitation, Boyer teaches that tag performance is optimized by setting the antenna reflectance Γ for the ***high reflectance period*** (*i.e.*, the "ON" phase of the modulated backscatter signal) at values less than 1, which means at a reflectance Γ that is less than the reflectance that shorting the antenna

would yield. This enables power to be harvested "during backscatter." *Id*., 775 (Section II-C titled "Duty Cycle-Capacity Tradeoff").

169. For example, the embodiment corresponding to Figure 6 and Section II-C shows a variable impedance Z_{mod}, where the binary backscatter modulator switches between the two states by changing the modulation impedance between Z_1 (open circuit for the **low reflectance** matched condition, where $\Gamma_2 = 0$) and Z_2 (having a value between an open and short circuit for the **high reflectance period**, where Γ_1 is less than 1). *Id*., 775.



Boyer Figure 6 (annotated and modified to show the two modulation states). As Z_{mod} is in parallel with R_{tag}, there remains some current through the IC during both state 1 and state 2. Accordingly, the tag's IC continues to receive and harvest power in both states, and the antenna is never shorted to ground.

170. Considering the values for state Z_2 in more detail, Figure 8, below models a range of antenna reflectance values $|\Gamma|$[11] that are less than 1 (*i.e.*, less than the reflectance of a short-circuited antenna) to demonstrate the increased performance obtained by trading some backscatter signal strength for the additional power harvested while backscattering.

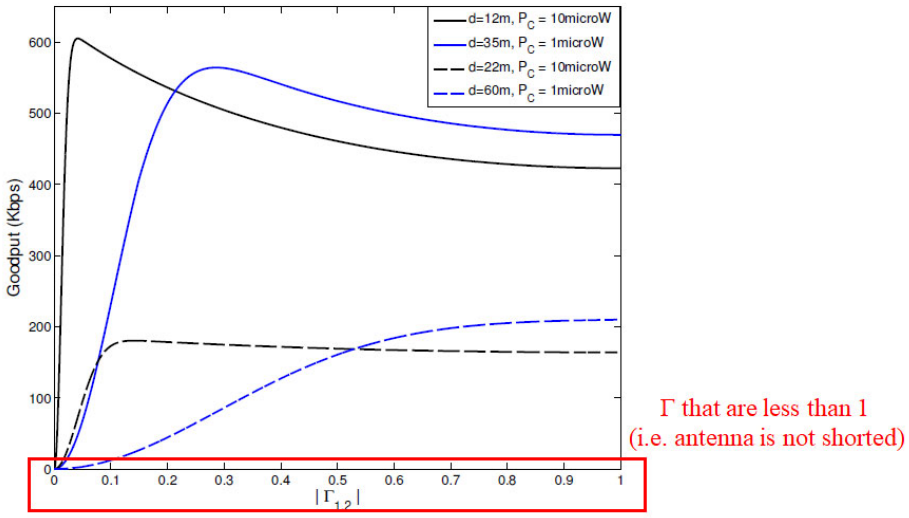


Fig. 8. Goodput vs. $|\Gamma^{1,2}|$ for varying tag-reader distances d and tag power consumption P_C.

Boyer, 776.

[11] The term $|\Gamma_{1,2}|$ is the difference between $|\Gamma_1|$ and $|\Gamma_2|$ ($|\Gamma_1 - \Gamma_2|$). Boyer, 772. Therefore, in the example embodiment corresponding to Figure 6 and Section II-C where Z_L is matched for Z_1 (and $\Gamma_1 = 0$), a POSITA would have understood $|\Gamma_{1,2}|$ is equal to $|\Gamma_2|$.

171. Since in the embodiment in Figure 6 and Section II-C has one state (when $Z_{mod} = Z_1$) set to a "matched condition" (*i.e.*, Z_L is equal to Z_A), a POSITA would have understood that the state corresponding to the Z_1 modulator impedance is the ***second* (low) *reflectance period*** when 1) maximum power harvesting and minimal reflection occurs; and 2) Γ_1 is equal to 0, as set forth in this equation from above:

$\Gamma = \frac{Z_L - Z_A^*}{Z_L + Z_A^*}$ is the (complex) reflection coefficient between the antenna and load;

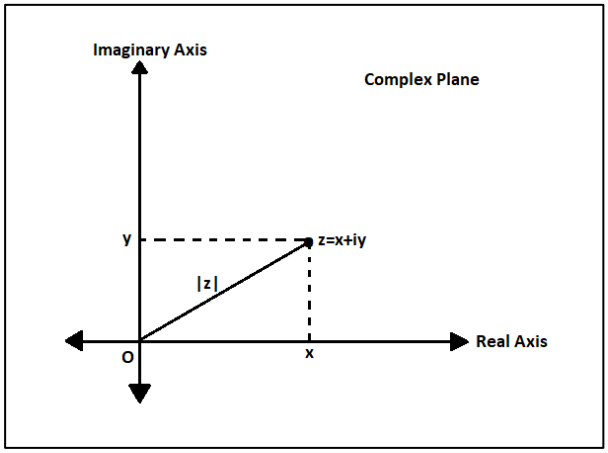
172. When the load impedance Z_L is matched to the antenna impedance Z_A, by its complex conjugate, the reflection coefficient becomes zero because all of the power from the source (e.g., RFID reader) is being transferred to the load without any being reflected back by the RFID tag. When these two impedances are equal, $Z_A = Z_A$, this condition eliminates reflection at the load and results in a reflection coefficient of zero, $\Gamma_1 = 0$.

173. A zero reflection coefficient means that there is no standing waves or reflected power in the transmission line. Thus, all (or at least substantially all) the power is harvested and delivered to the antenna of the RFID tag. In practice, achieving a reflection coefficient of zero means that the RFID tag is perfectly tuned,

allowing for the most efficient transmission and reception of signals, and maximum power harvesting.

174. Similarly, since setting $Z_{mod} = Z_2$ determines the reflectance of the antenna in the ***first* (high) *reflectance period***, a POSITA would have understood that the reference to a "short state" is a short circuit of the antenna. For example, applying the same equation for Γ_2, if the IC impedance is 0 (e.g., shorted), then the reflection coefficient is 1 (the antenna's impedance divided by the antenna's impedance). Therefore, a POSITA would have understood that selecting a value for $Z_{mod} = Z_2$ "between" an "open" and "short state" means 1) antenna reflection coefficient $|\Gamma_2|$ will be greater than 0 and less than 1; 2) the antenna will ***not*** be shorted since Z_2 is ***between*** an open ***and a short***; and 3) since the antenna is not shorted, $|\Gamma_2|$ can be chosen to be below a "*predefined amount*" (for example, less than 1, but also any amount within the disclosed range of 0 to 1).

175. Although in the combined system Γ_2 will have a complex value, it will still be greater than 0 and less than 1. Moreover, the magnitude of a complex number is given by: $|z| = |x + jy| = \sqrt{x\text{^}2 + y\text{^}2}$ (*i.e.*, the vector from the origin to the point in the complex plane):

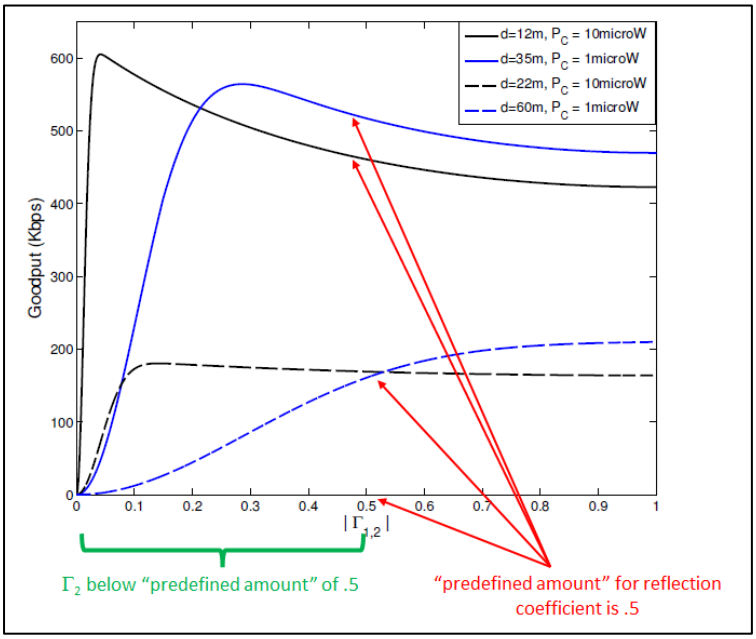


176. Therefore, since $Z_2 = C_{mod}$ in the modified RFID tag, it has corresponding reactance value and a non-zero magnitude, and the same analysis applies.

177. Finally, because Boyer's state Z_2 is ***between*** an open ***and a short*** (rather than being shorted), the state at Z_2 is below a "*predefined amount*" (for example, less than 1, but also any amount within the disclosed range of 0 to 1). That the reflectance Γ_2 is less than a "*predefined amount*" and the antenna is not shorted is confirmed in Figure 8, which models reflectance values for Γ_1/Γ_2 that range from 0 to 1, and hence include instances where Γ_2 is below a *predefined amount* (*i.e.* less than 1, less than .1, less than .2, less than .3, etc.).[12] Examples are highlighted below with "*predefined*

[12] As explained above, for the Figure 6 and Section II-C embodiment, a POSITA would have understood $|\Gamma_{1,2}|$ is equal to Γ_2, since $\Gamma_1 = 0$.

amounts" between 0 and .5 in green and a "*predefined amount*" equal to .5 in red for the Figure 6 embodiment.



Boyer, 775-776.

b) [11C.2] " . . . to continuously harvest power while transmitting the reflected signal to the RFID reader"

178. Boyer further discloses that the reflectance is reduced below a predefined level "*to enable the main antenna to continuously harvest power while transmitting the reflected signal to the RFID reader"* [11C.2]. As I explained above, Boyer is expressly directed to applying the principal of reducing backscatter transmission power to increase power harvesting during backscatter.

179. As explained below, and continuing with the Section II-C embodiment in which $Z_{mod} = Z_2$ and is varied "***between*** an open ($Z_2 = \infty$) and ***short state*** ($Z_2 = 0$)," since the modulation impedance Z_2 is not a "short state" and therefore $|\Gamma_2|$ is less than 1, a POSITA would have understood that at least some of the incident RF field that is not reflected is harvested for power. Boyer, 775-776. It's a fundamental principle that when there is some current on the antenna and IC, whatever power is not reflected is absorbed and available for harvesting. Indeed, Boyer expressly states in its "Fundamentals" section that while part of the incident RF electrical field is backscattered, "***[t]he remaining power is assumed harvested by the tag***, i.e. dissipated by the modulator impedances Z_1, Z_2." Boyer, 771. This relationship between signal reflection and power harvesting was already a well-known concept to a POSITA even at the time Boyer was published. While in a real-world implementation, some of that non-reflected power may be lost (e.g., to resistive heating), a POSITA would have understood that additional power can be harvested if more power is available to harvest (*i.e.*, rather than reflected).

180. For example, as a visual representation of the inverse relationship between signal reflected versus absorbed, Hyde illustrates that the relative amount of antenna inductance compared to IC inductance results in different ratios of reflectance to absorption.

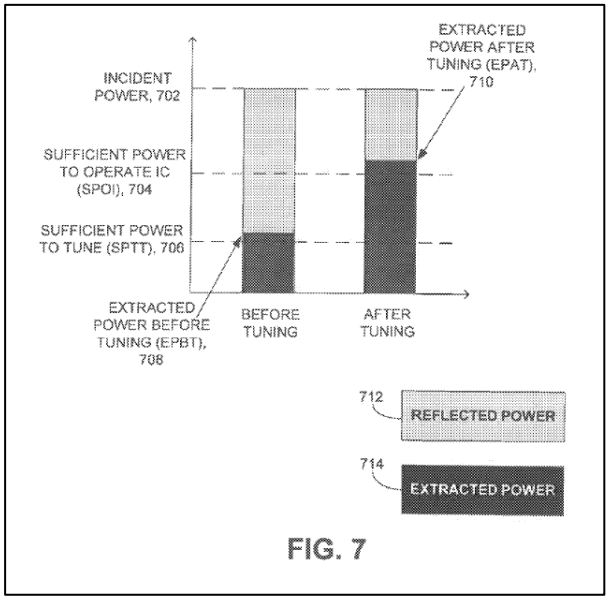


FIG. 7

Ex. 1011, Fig. 7. According to Hyde, as the Tag's IC's inductance changes relative to the antenna, to arrive closer to a match condition, the result is that more power is harvested (extracted) and less is reflected.

181. Returning to Boyer, Boyer explains that backscatter tags operate around two states: "the tag is either active and backscattering information or the tag is in a sleep state and no backscatter occurs." Boyer, 775. Boyer explains that tags that harvest more power than they consume are "operational 100 percent of the time," but that other tags must "undergo[] a duty cycling behavior between an active state and a sleep state." *Id*. Boyer represents a tag's duty cycle according to the following equation:

$$D_{cycle} = \frac{P_{\mathrm{M}}}{P_{\mathrm{M}} + P_{\mathrm{C}} - P_{\mathrm{back}}}$$

where P_M represents the energy harvested during the sleep state, P_C represents the power consumed, and P_{back} represents the power harvested ***during backscatter***. Boyer, 775.

182. Boyer teaches that the amount of power harvested, P_{back}, is a function of the impedance load during the entire backscatter period. Referring back to the "binary backscatter modulator where Z_{mod} has two states Z_1 and Z_2," Boyer teaches that when "[o]ne modulator state remains in the matched condition (i.e., Z_1 is an open circuit) and the other state has the value Z_2," "[b]y varying the value of Z_2 between an open ($Z_2 = \infty$) and short state ($Z_2 = 0$), ***the harvested power during backscatter P_{back} decreases but link reliability improves***." Ex-1005 776. A POSITA would therefore have understood that the selection of Z_2 affects the amount of power harvested during backscatter in the ***first* (high) *reflectance period*** because as the reflectance increases (approaches a short circuit), the P_{back} decreases (*i.e.*, there is less signal to harvest when Z_2 is connected to modulate the signal). And of course, if no power was harvested during the ***first* (high) *reflectance period***, then the impedance of Z_2 would have no impact on P_{back}.

183. To explain this concept, Boyer represents the power harvested during backscatter mathematically as:

$$P_{\text{back}} = P_{\text{M}} \frac{1 + (1 - |\Gamma_{1,2}|)^2}{2}$$

where the constraints of Z_1 and Z_2 translate to $|\Gamma_{1,2}| \leq 1$ in the Figure 6 embodiment described in Section II-C.[13] Boyer, 775-776. Boyer explains that as the reflectance difference $|\Gamma_{1,2}|$ increases, P_{back} decreases. Boyer, 776. In other words, the further from a short state ($Z_2 = 0$), the more power the tag will harvest during backscatter. In this way, Boyer teaches not shorting the antenna during the ***first* (high) *reflectance period*** *"to continuously harvest power while transmitting the reflected signal to the RFID reader*."

184. Again, with reference to Figure 8 and the modeling of different antenna reflectance values, Boyer states that "[b]y increasing $|\Gamma_{1,2}|$, the BER improves, ***but*** $\boldsymbol{P_{back}}$ and the corresponding tag duty cycle D_{cycle} decreases." Boyer, 776. Boyer then identifies the optimum performance values for different distances and tag power consumption levels, all but one of which corresponds to a difference in reflectivity $|\Gamma_{1,2}|$ less than 1 (where the antenna is short circuited).

[13] As explained above, for the Figure 6 and Section II-C embodiment, $|\Gamma_{1,2}|$ is equal to Γ_2.

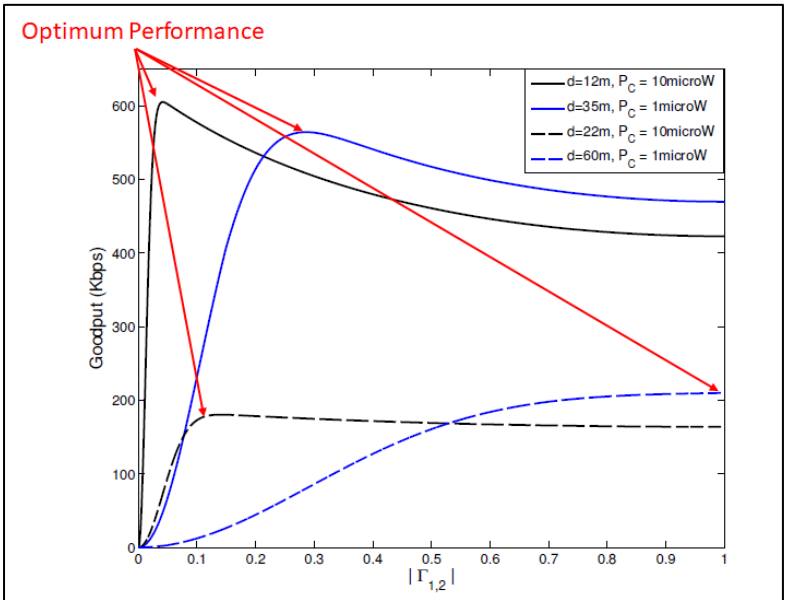


Fig. 8. Goodput vs. $|\Gamma^{1,2}|$ for varying tag-reader distances d and tag power consumption P_C.

Boyer, 776 ("The first three curves in Fig. 8 are in the modulation limited regime. Increasing link reliability via $|\Gamma_{1,2}|$ provides only a marginal increase in CBSC, but the decrease in D_{cycle} offsets any capacity gains. . . . The last curve represents the power limited regime, because $|\Gamma_{1,2}| = 1$ is required to maximize goodput").

185. That a POSITA would have understood that a power harvesting is performed during backscatter when the antenna is not shorted is confirmed by textbooks, which demonstrate that a POSITA knew "it is helpful to consider trading off some backscattered signal for more tag power." Ex-1021, 214. Dobkin specifically analyzes the power harvested in both resistive and a capacitive modulation circuit in Figures 5.19 and 5.20, respectively, and shows power

harvesting occurs during backscatter in both states. Ex-1021, 214-218. Indeed, Dobkin concludes:

> We have used very specific examples of ASK and PSK component values for simplicity. ***In the general case where the component values are allowed to vary from those corresponding to a very small modulated signal to the limit of open and short circuits***, it is found that the general conclusions we have arrived at are still applicable: at moderate backscattered power, PSK provides substantially better power delivery to the IC load than ASK, but the backscattered power is always lower than in the extreme case where the load is varied from an open to a short circuit.

Ex-1021, 218.

c) [11C.3] "wherein the reflectance of the main antenna is reduced based on a change in a resonant frequency of the main antenna"

186. As explained above for elements [11B.1] and [11B.2], Boyer varies the reflection coefficient of the main antenna by switching the modulating impedance Z_{mod} between Z_1 and Z_2. It was well-known to a POSITA that changing an antennas reflectance by "coupling electrical elements, such as capacitive elements, inductive elements, or combinations thereof, [would] vary the ***resonant frequency*** of the RFID tag." Ex-1005, Abstract (switching circuitry "may selectively couple electrical

elements, such as capacitive elements, inductive elements, or combinations thereof, to vary the ***resonant frequency*** of the RFID tag.")

187. In the modified RFID tag, Z_2 has a reactive component (*e.g.*, it is capacitor C_{mod}). Since resonant frequency is "inversely proportional to the product of inductance and capacitance," (Ex-1021, 217), a POSITA would have known that adding (or subtracting) a reactance from the RFID tag changes the resonant frequency:

$$\omega_{\text{res}} L = \frac{1}{\omega_{\text{res}} C} \longrightarrow \omega_{\text{res}} = \sqrt{\frac{1}{LC}}.$$

Ex-1021, 473 (resonant frequency of a circuit).

188. The performance of an RFID tag largely depends on the resonant frequency of its antenna, which should be precisely tuned to match the operating frequency of the RFID system. The resonant frequency is determined by the antenna's electrical elements, such as capacitive elements, inductive elements, or combinations thereof.

189. For example, assume that an RFID tag contains an LC circuit. The LC circuit is also called resonant circuit that is an electric circuit consisting of an inductor ("L") and a capacitor ("C"). Another way of representing the resonant frequency of the RFID tag can be written as:

$$f_{res} = \frac{1}{2\pi\sqrt{LC}}$$

where f_{res} is the frequency in Hz, L is the value of inductance in *Henries*, and C is the capacitance in *Farads*. Ex-1021, 136. By adjusting the capacitance, such as adding or removing capacitive elements, the resonant frequency of the RFID tag will be adjusted accordingly. Similarly, by adjusting the inductance, such as adding or removing inductive elements, the resonant frequency of the RFID tag will be adjusted accordingly.

190. For the same reasons I explained for limitation [11B.1], a POSITA would understand that changing the reactance of the load (either the IC or the modulation impedance) changes the resonant frequency "*of the main antenna*."

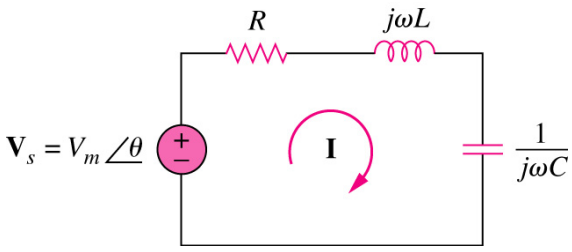
191. Traditionally RFID tag IC impedances are designed for the center frequencies of operation assigned (e.g. North America 915 MHz). Typical IC impedance has a resistive (real) and strongly capacitive (imaginary) component (*e.g.*, a typical measured IC impedance value is 20 - j200 Ohms). Ex-1024.

192. However, the IC impedance is hardly constant – it depends on a number of factors like the system frequency, IC packaging (material, dimension, etc.) and the substrate (i.e., object) to which the tag is attached. Ex-1025.

193. Hence, achieving 'conjugate matching' of the antenna impedance to the chip impedance for resonance must be adaptive (i.e., antenna impedance is to be modified to conjugate match the imprecisely known IC impedance). This may be achieved by various approaches – including a) inclusion of an intermediate matching circuit, or b) means of antenna layout.

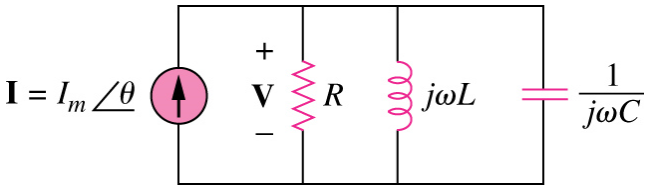
194. For UHF-RFID systems, the antenna sub-system is modelled as RLC tank circuit; changing the impedance of antenna sub-system is achieved by adjusting variable capacitor inserted into the antenna sub-system and/or by modifying the inductance. Depending on the Thevenin Equivalent circuit, model, the RFL can be in series or in parallel, BOTH show equivalent resonance features as explained below.

RLC Series Resonance



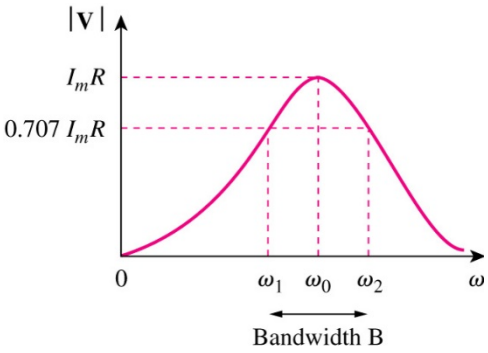
$Z_s(\omega) = 1/j\omega C + j\omega L = (1-\omega^2 CL)/j\omega C$ is the reactive component of the impedance and the resonance frequency is thus $\omega_o = 1/(LC)^{1/2}$.

RLC Parallel Resonance



195. The combined parallel reactive $Z_p(\omega)$ is

$Z_p(\omega) = (j\omega C + 1/j\omega L)^{-1} = j\omega L/(1 - \omega^2 LC)$ again leading to resonance freq. $\omega_o = 1/(LC)^{1/2}$.



As a result for the parallel RLC circuit, the tag response shows a peak at resonance freq. ω_0 corr. to matched condition (min. reflectance, max power harvested). Any changes to the L, C in the equivalent circuit would de-tune the tag response, i.e., change the resonance freq. ω_0 and thus alter the reflectance in the corresponding tag state.

196. As noted above, it is not unusual to refer to the reflection properties of an RFID tag as properties of the antenna, since that ultimately is the component that receives the incipient (downlink) and re-radiates the backscattered RF signals. Of course, the reflective properties (e.g., reflectance, resonant frequency) of the RFID antenna are affected by the load impedance. Indeed, when connected as an RFID tag, the antenna and tag have the same resonant frequency. Ex. 1021, 477.

197. Of course, the reflective properties (e.g., reflectance, resonant frequency) of the RFID antenna (and hence the tag) are affected by the load impedance, which the '968 patent confirms. It is, after all, the load modulation that is responsible for the changes in the reflectance, resonant frequency, etc. It is a property of the whole tag, since the causative agent of the effects is clearly the IC circuit. There is no technical distinction between a) changing the load (hence R & C that characterizes the tag input impedance and/or a part of the antenna (*e.g.*, length of coil and hence the inductance) and the impact on b) reflectance G and resonant frequency (via match/mismatch). In the Thevenin circuit equivalent, the antenna contributes a component (the voltage, the inductance, and antenna resistance) and the tag IC provides the rest (load impedance); and effects like reflectance and resonant frequency result from analyzing the circuit as a whole. A POSITA would not consider a "reflectance" or "resonance" with only the antenna inductance without considering the IC contributions (*i.e.*, the resonance property belongs to the entire tag). Hence, changing the IC load (here, the capacitance) changes the reflectance and resonant frequency of the antenna/tag.

198. The '968 patent confirms that changing the modulating impedance connected to the antenna as taught by Boyer changes the resonant frequency of the main antenna. In the "electrical" embodiment, the '968 patent explains that

"Electrical-reduced backscatter signal strength and increased tag power efficiency are achieved and controlled via choosing a ***different modulating impedance within tag circuitry***." '968 patent, 5:51-54. The patent continues on to state that, "In these embodiments, an ASIC or processor 600 controls one or more switches 610 to ***add or subtract one or more impedances 620 from antenna 104. This changes the resonant frequency and reflectance properties without shorting the antenna 104***." *Id*., 5:55-59. This is the exact embodiment in Boyer and the RFID Handbook, which switch modulation impedances.

199. The combined RFID tag therefore discloses "*wherein the reflectance of the main antenna is reduced based on a change in a resonant frequency of the main antenna*" [11C.3].

E. The combined RFID Tag discloses claim 12

200. Claim 12 depends from claim 11 and further requires "*the circuit changes the resonant frequency of the main antenna to generate the first and second reflectance period*." As explained above for element [11B.1] and [11B.2], Boyer discloses that IC with microcontroller (the circuit) "*changes the resonant frequency of the main antenna to generate the first and second reflectance period*." In brief, the IC via microcontroller switches the modulation impedances Z_{mod} between Z_1 and Z_2, which changes the tag's reflection coefficient, Γ_1 and Γ_2, and, with it, creates the

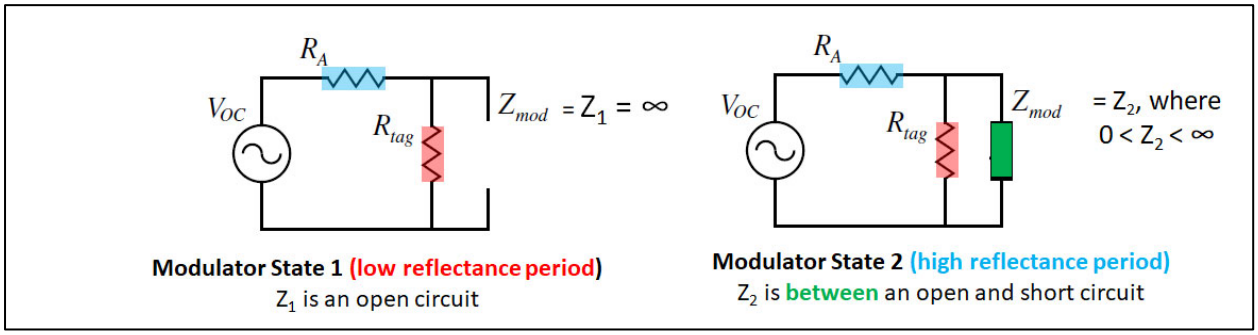
first (high or ON) and ***second*** (low or OFF) reflectance periods of the reflected signal:

$$\vec{\varepsilon}_{scat} = \vec{\varepsilon}^{M}_{scat} - \Gamma_1 I_M \frac{\vec{\varepsilon}_a}{I_a} ; \vec{\varepsilon}_{scat} = \vec{\varepsilon}^{M}_{scat} - \Gamma_2 I_M \frac{\vec{\varepsilon}_a}{I_a}$$

**Reflected Signal During Second (Γ_2 and Z_2) /
First (Γ_1 and Z_1) Reflectance Periods**

Boyer, 772.

201. Again, these states (corresponding to $Z_{mod} = Z_1$ or Z_2) are illustrated by the two states of Figure 6:



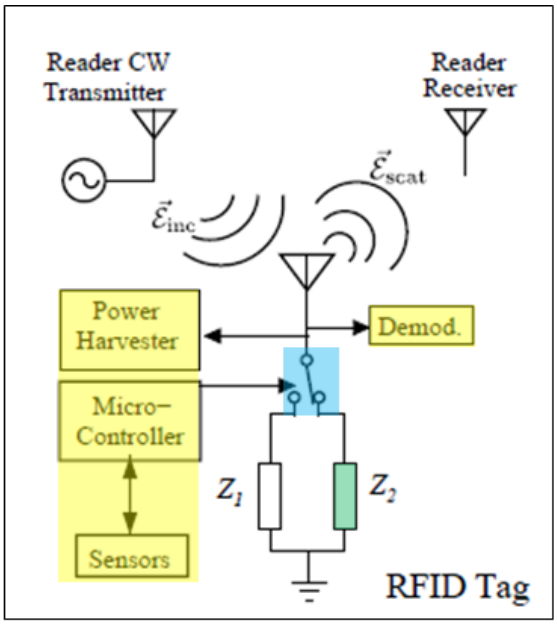
Boyer Figure 6 (annotated and modified to show the two modulation states).

202. And as explained for element [11C], changing an antennas reflectance by "coupling electrical elements, such as capacitive elements, inductive elements, or combinations thereof" to the antenna "var[ies] the resonant frequency of the RFID tag," exactly as described in the '968 patent. Waldner, Abstract; '968 patent, 5:55-59.

F. The combined RFID Tag discloses claim 16

203. Claim 16 depends from claim 11 and further requires "*a switch controlled by the circuit that connects an RF impedance to the main antenna during the first reflectance period*." As explained for element [11B.1] and claim 12 above, Boyer's discloses RFID passive tags with a binary backscatter modulator (Figure 2), which includes an IC with a microcontroller (shown in yellow below) that controls a switch (shown in blue) connecting modulation impedances (Z_{mod}) Z_1 and Z_2 to the main antenna. Boyer, 772 ("the on-tag microcontroller logic switches the backscatter modulator between two impedance states Z_1 and Z_2.").

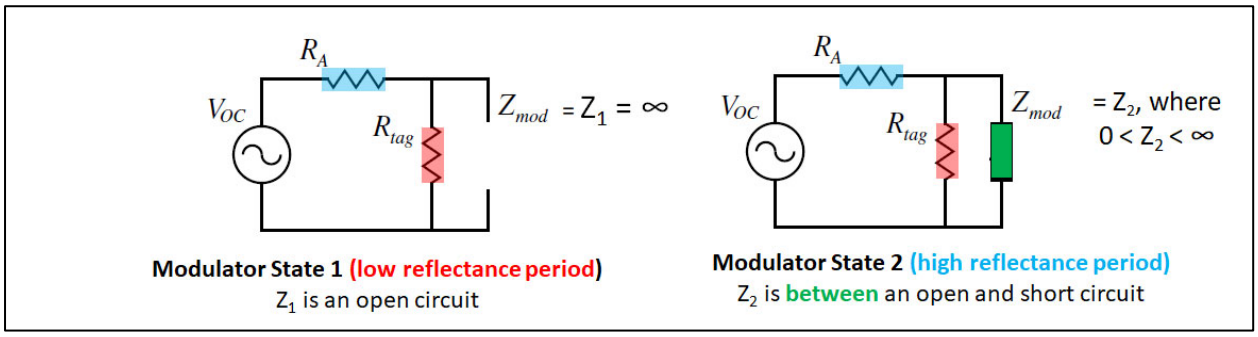
204. As explained for element [11B.2], Z_2 (shown in green) is connected during the ***first reflectance period***—*i.e*. during the ON modulation of the backscatter period. A POSITA would have understood that impedance Z_2 is an "*RF impedance*" because when it is connected to the antenna, it affects the RF properties of the antenna.



Boyer, Figure 2

Ex-1005, Fig. 2 (annotated).

205. Again, the ***first reflectance period*** corresponds to $Z_{mod} = Z_2$ in the embodiment illustrated in Boyer's Figure 6 and Section II-C. The modified figure below shows the switching between $Z_{mod} = Z_1$ and $Z_{mod} = Z_2$:



Boyer Figure 6 (annotated and modified to show the two modulation states).

G. The combined RFID Tag discloses claim 17

206. Claim 17 depends from claim 11 and further requires "wherein the amount of reflectance by the main antenna of the RF signal is greater than the predetermined amount during the **first reflectance period**, and the amount of reflectance by the main antenna of the RF signal is lower than the predetermined amount during the **second reflectance period**." To the extent this claim is understandable, Boyer discloses this limitation.

207. As explained above for elements [11C.1] and [11C.2], Boyer discloses embodiments for Figure 6 and Section II-C in which "[o]ne modulator state remains in the matched condition (*i.e.*, Z_1 is an open circuit) and the other state has the value Z_2," where the value of Z_2 is varied "***between*** an open ($Z_2 = \infty$) and ***short state*** ($Z_2 = 0$)." And as explained for elements [11B.1] and [11B.2], a binary modulation system that switches the modulator impedance Z_{mod} between Z_1 and Z_2 provides different antenna reflection coefficients, Γ_1 and Γ_2. Boyer, 771-773.

208. Since Z_1 corresponds to a "matched condition" (*i.e.*, Z_L is equal to Z_A) in the Figure 6 and Section II-C embodiment, a POSITA would have understood that $Z_{mod} = Z_1$ corresponds to the ***second* (low) *reflectance period*** when 1) maximum power harvesting and minimal reflection occurs; and 2) Γ_1 is equal to 0, as set forth in this equation from above:

$\Gamma = \frac{Z_L - Z_A^*}{Z_L + Z_A^*}$ is the (complex) reflection coefficient between the antenna and load;

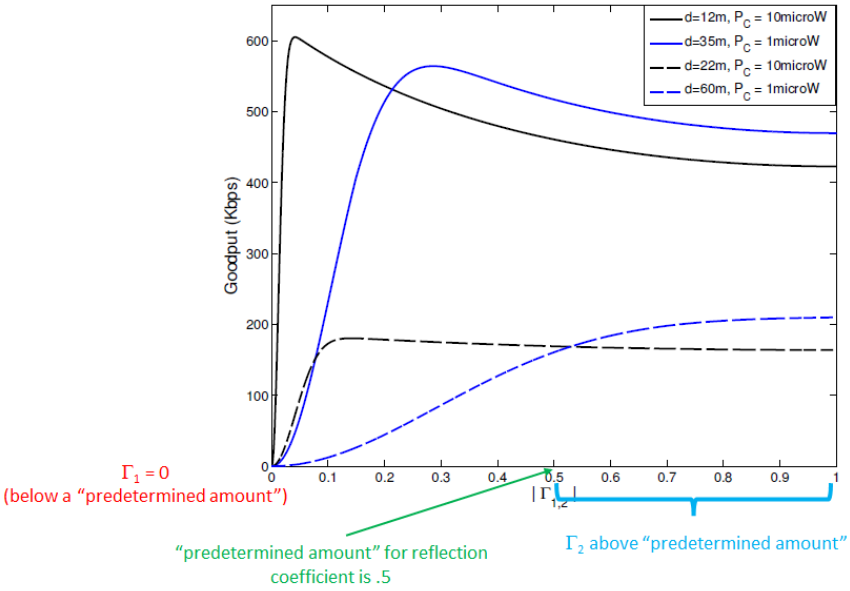
Since $Z_{mod} = Z_1$ maintains the "matched" phase where $Z_L = Z_a$, $\Gamma_1 = 0$. Therefore, whatever the "*predetermined amount*" is, "*the amount of reflectance by the main antenna of the RF signal is lower than the predetermined amount during the* ***second reflectance period***" since 0 is the lowest reflectance. And as shown below, Figure 8 provides a continuum of Γ values greater than 0 that are still less than the reflectance in the ***second*** **(low)** ***reflectance period***.

209. Similarly, since $Z_{mod} = Z_2$ determines the reflectance of the antenna in the ***first*** **(high)** ***reflectance period***, a POSITA would have understood that the reference to a "short state" is a short circuit of the antenna. Therefore, a POSITA would have understood that selecting a value for Z_2 "between" an "open" and "short state" means that antenna reflectance $|\Gamma_2|$ will be greater than zero but less than 1.

210. Thus, a POSITA would have understood that there is a reflectivity between $Z_{mod} = Z_1$ ($|\Gamma_1| = 0$) and $Z_{mod} = Z_2$ ($|\Gamma_2|$ is greater than 0 but less than 1)—*i.e.*, a *predetermined amount*—such that *"the amount of reflectance by the main antenna of the RF signal is greater than the predetermined amount during the* ***first reflectance period***," while also being greater than 0—such that it is *lower than the predetermined amount during the* ***second reflectance period***.

211. Boyer's Figure 8, which models reflectance values that range from 0 to 1, and hence include instances where $|\Gamma_1|$ is below a *predetermined amount* and $|\Gamma_2|$ is greater than that same *predetermined amount* (*i.e.*, .1, .2, .3, etc.) are shown.[14] Each of the values on the x-axis provides a "*predetermined amount*" at least because the designers had to select the antenna, chip impedance, and Z_1/Z_2 values to set the desired reflectances for each period of the modulated backscatter signal, including the value during the high reflectance period corresponding to $|\Gamma_2|$. Examples are highlighted below with "*predetermined amounts*" between 0 and .5 in green and a "*predetermined amount*" equal to .5 in red.

[14] As noted above, since in Boyer's Figure 6 and Section II-C embodiment, Z_1 is an open circuit and the tag is in a matched condition (*i.e.*, Γ_1 is 0), $|\Gamma_{1,2}|$ is equal to Γ_2. (*i.e.*, $|\Gamma_1 - \Gamma_2| = |\Gamma_2|$.)



Boyer, 776.

212. Each of the values on the x-axis provides a "*predetermined amount*" at least because the designers had to select the antenna, chip impedance, and Z_1/Z_2 values to set the desired reflectance coefficients for each period of the modulated backscatter signal, including the value during the **high** and **low** reflectance period corresponding to Γ_1 and Γ_2.

H. The combined RFID Tag discloses claim 18

213. Claim 18 depends from claim 11 and further requires "*the amount of reflectance of the main antenna of the RF signal during* ***the first reflectance period*** *is of greater magnitude to the amount of reflectance of the main antenna of the RF signal during the* ***second reflectance period***."

214. For the same reasons discussed above for claim 17, since Boyer discloses a range of embodiments for Figure 6 and Section II-C that optimize the reflectance values for the two reflectance periods, and there exists a "*predetermined amount*" that is less than the reflectivity in the first period but greater than the reflectivity in the second period, then by definition the "*amount of reflectance of the main antenna of the RF signal during the first reflectance period* must be of *greater magnitude to the amount of reflectance of the main antenna of the RF signal during the second reflectance period*." Again $\Gamma_1 = 0$ and Γ_2 is greater than 0 but less than 1 in Boyer's embodiment in Figure 6 and Section II-C: Duty Cycle-Capacity Tradeoff. Boyer, 775-776.

215. Figure 8 shows a continuum of such example embodiments, where Γ_2: $> \Gamma_1$.

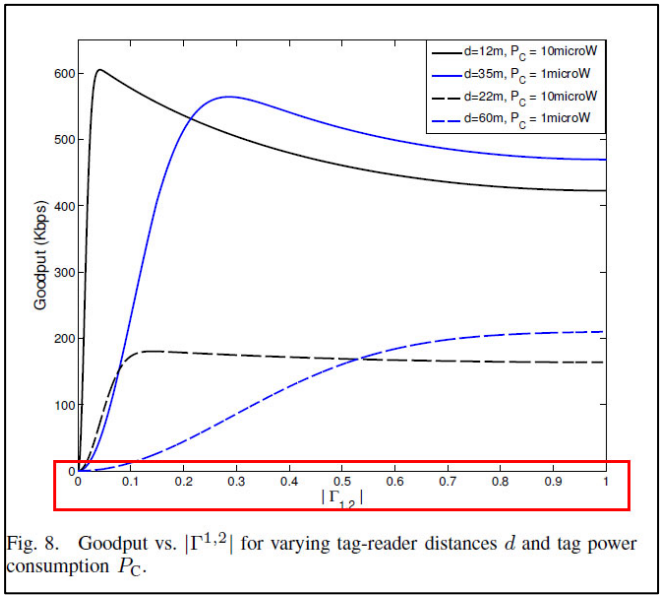


Fig. 8. Goodput vs. $|\Gamma^{1,2}|$ for varying tag-reader distances d and tag power consumption P_C.

Boyer, 775-776.

I. The combined RFID tag renders claim 19 obvious.

216. Claim 19 depends on claim 11 and further recites "*wherein the circuit is an application-specific integrated circuit (ASIC)*." Boyer discloses an RFID tag with a binary backscatter modulator that includes an ***integrated circuit (IC)***, which "modulates information onto [a] backscattered [carrier wave] by controlling the front-end impedance loading." Boyer, 771.

217. While Boyer does not expressly refer to IC as an ASIC, it would have been obvious to use an ASIC for Boyer's IC. First, it was common to use ASICs for RFIDs, including backscatter passive RFID tags. Ex. 1021, 195. Even the inventor recognized years earlier that "***typical*** passive tag consists of an antenna and an ***application specific integrated circuit (ASIC) chip***." Ex. 1007, 212 (Nikitin). Thus,

including an ASIC as Boyer's IC would have involved nothing more than a simple substitution of one known element for another to obtain predictable results or, at the very least, use of known technique to improve similar devices in the same way.

218. Second, a POSITA would have been motivated to use an ASIC as taught by RFID Handbook so that the tag could be used in a wide range of applications.

Table 3.6 Overview of the power consumption of various RFID-ASIC building blocks (Atmel, 1994). The minimum supply voltage required for the operation of the microchip is 1.8 V, the maximum permissible voltage is 10 V (Atmel, 1994)

	Memory (bytes)	Write/read distance(cm)	Power consumption	Frequency	Application
ASIC#1	6	15	10 µA	120 kHz	Animal ID
ASIC#2	32	13	600 µA	120 kHz	Goods flow, access check
ASIC#3	256	2	6 µA	128 kHz	Public transport
ASIC#4	256	0.5	<1 mA	4 MHz*	Goods flow, public transport
ASIC#5	256	<2	~1 mA	4/13.56 MHz	Goods flow
ASIC#6	256	100	500 µA	125 kHz	Access check
ASIC#7	2048	0.3	<10 mA	4.91 MHz*	Contactless chip cards
ASIC#8	1024	10	~1 mA	13.56 MHz	Public transport
ASIC#9	8	100	<1 mA	125 kHz	Goods flow
ASIC#10	128	100	<1 mA	125 kHz	Access check

*Close-coupling system.

Ex-1023, 42; *id*., xiii (defining "ASIC").

219. Moreover, a POSITA would have known of benefits of using an ASIC, rather than for example, a general processor, because of the size and cost restraints on RFID tags. ASICs could be manufactured at scale for much less cost and size than general processors because they were designed for a specific purpose, providing both size and cost advantages. Ex. 1021, 195 ("The expense of creating such an

application-specific integrated circuit (ASIC) implies that only large volume usage can provide an economic return to the company responsible for it.")

J. Boyer in view of RFID Handbook renders claim 20 obvious

220. Claim 20 requires "*wherein the main antenna is a linearly polarized antenna*." Boyer discloses an RFID tag with a main antenna. Boyer, 772, Figure 2. While Boyer does not expressly describe the antenna, it would have been obvious to include such an antenna.

221. First, linearly polarized antennas were well-known and conventional in the art at the time the '968 patent was filed. One example is a dipole antenna, which "is a linear polarised antenna in which the electric field lines run parallel to the dipole axis." Ex-1023, 114; U.S. Pat. No. 7,324,058 (filed Feb. 8, 2006); Ex.-1007, 216 (using a "linearly polarized transmitting antenna" for the measurements of the RFID chip.) RFID Handbook even shows that the antennas in its modulation circuits shown in Figure 4.89(a)-(f) are "l/2 Dipole." Ex-1023, 140. Even the '968 patent admits that such RFID tags were "prevailing on RFID market." '968 patent, 5:32-35.

222. Because Boyer is agnostic as to the details of the antenna, a POSITA would have selected any suitable antenna for Boyer's RFID tag, including a conventional "linearly polarized antenna." A POSITA would have also known of the

benefits of using a linearly polarized antenna, such as increased energy transfer when the antennas have the same direction. Ex-1023, 114. Therefore, this modification would have been a simple substitution of one known element for another to obtain predictable results" or, at the very least, "use of known technique to improve similar devices in the same way.

IX. GROUND 2: CLAIMS 1-5, 11-20 WERE OBVIOUS OVER BOYER IN VIEW OF RFID HANDBOOK IN FURTHER VIEW WALDNER

223. Claims 1-5, 13-15 are similar to claim 11 except they claim the use of "*separate length of antenna*" as the impedance that is switched onto the antenna. However, as shown below, this was a well-known technique to vary the load impedance (and therefore the reflectivity) of an RFID tag antenna.

A. The Combined System of Boyer and RFID Handbook in View of Waldner

224. As explained above for claim 11, the combined system of Boyer in view of RFID Handbook is an RFID tag with "binary backscatter modulator" that includes an impedance Z_2 having a reactance—in the example for claim 11, a capacitance C_{mod}.

225. However, as explained above, a POSITA would have known that the modulation impedance Z_{mod} could have any value depending on the system design. Indeed, as noted above, Boyer refers throughout to Z_{mod}, without reference to its

components until the specific Section II-C embodiment to illustrate the results. And RFID Handbook discloses a modulator with impedance Z_o (blue) alongside the Ohmic (red) and capacitive (green) modulation circuits.

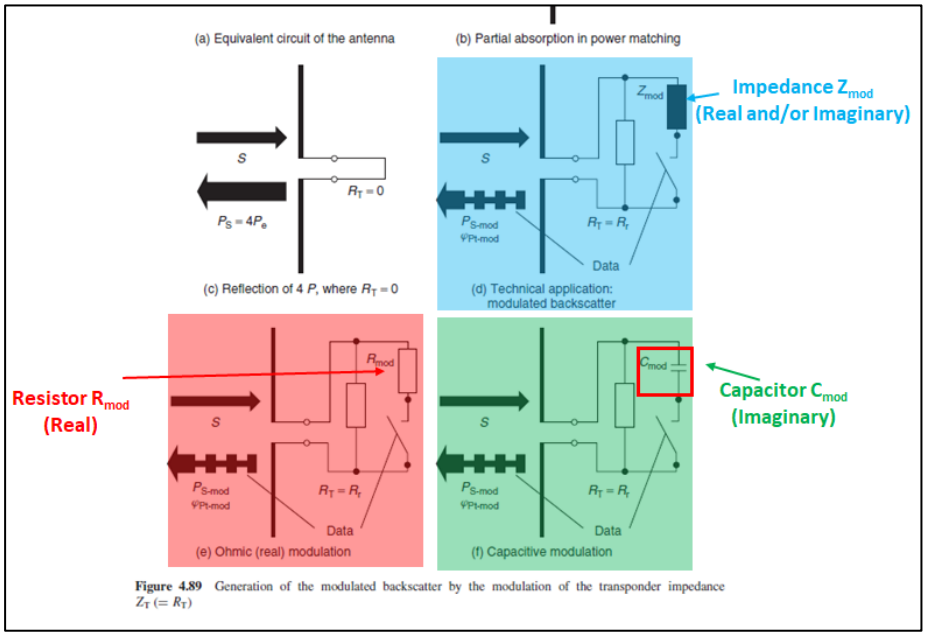


Figure 4.89 Generation of the modulated backscatter by the modulation of the transponder impedance $Z_T (= R_T)$

226. Since Boyer and RFID Handbook teach the actual implementation of the modulation impedances (Z_{mod}) can vary to optimize RFID performance, a POSITA would have therefore looked to any suitable teaching of impedances that can be switched (connected) to an antenna to change its reflectance (*i.e.*, by changing the antenna's resonant frequency). Such techniques were well-known in the art.

227. One such example is shown in Waldner. (Ex. 1006). Waldner is directed to a passive RFID tag that "includes a main antenna tuned to a first resonant frequency, and switching circuitry that dynamically changes the ***resonant frequency***

of the main antenna." Waldner, Abstract. Waldner specifically teaches that its switching circuitry "may selectively couple electrical elements, such as capacitive elements, inductive elements, or combinations thereof, ***to vary the resonant frequency of the RFID tag***." *Id*.

228. Waldner teaches examples of an impedance that could be used with reference to Figure 3, reproduced below, where the tag operates switch 46 to alternate between two inductive elements 48A and 48B. Waldner, ¶37. Waldner teaches that "[i]nductive elements 48A and 48B comprise portions of conductive traces fabricated to form ***additional loops of antenna*** 42" but that "inductive elements 48A and 48B could be any component with an inductance, or completely ***separate antennas***." Waldner, ¶38.

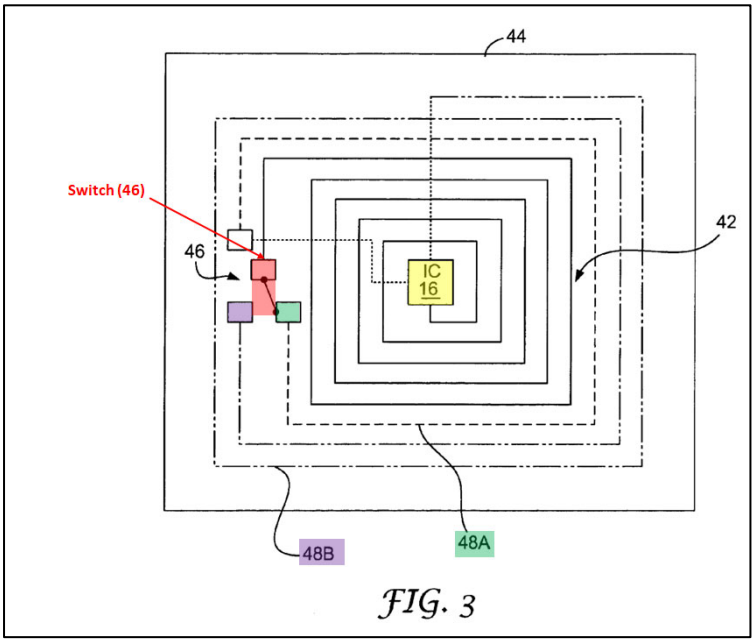
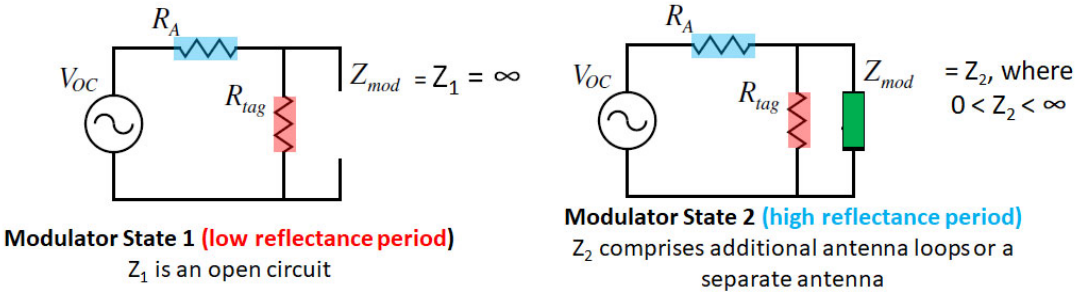
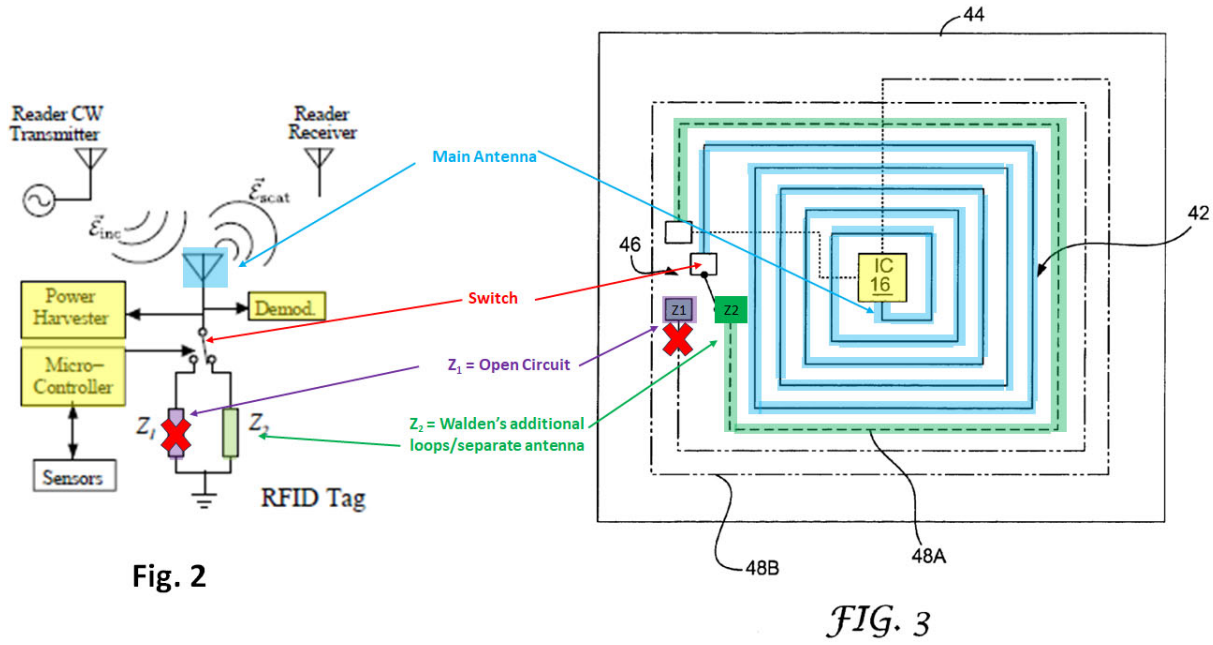


FIG. 3

229. For the combined system, Boyer's embodiment in Section II-C—in which the modulator impedance Z_{mod} "has two states Z_1 and Z_2"—as further modified by RFID Handbook to have a reactive impedance, is further combined with Waldner's teaching of circuit elements that can be used as such an impedance, including the use of "additional loops" of the main antenna or a "completely separate antenna." Waldner, Abstract; ¶38. Waldner's circuit components are specifically used for the impedance Z_2 (since Z_1 is an open circuit). Boyer, 775.



Boyer, Figure 6 (further modified to show Z_2 as antenna loops/separate antenna).



Boyer Figure 2 (left) and Waldner Figure 3 (right) (annotated to show how additional antenna loops/antenna would have been implemented as Boyer's Z_2).

230. In addition, Waldner's switch 46 and control line from IC 16 could replace Boyer's corresponding switch and connection to "micro-controller."

B. A POSITA would have been motivated to combine Boyer and RFID Handbook with Waldner

231. A POSITA would have been motivated to use Waldner's "additional loops" of antenna, or an entirely "separate antenna" as taught by Waldner, as the additional impedance Z_2 of Boyer's binary backscatter modulator in Section II-C.

232. First, Boyer, RFID Handbook, and Waldner are directed to the same field and address similar functionality—switching connections to impedances to

change the antenna reflectance in RFID backscatter tags. Waldner, ¶¶7 ("… by changing the resonant frequency at which the RFID tag ***backscatters*** radio frequency energy"); 23 ("***backscatters RF energy***"). Further, like Boyer and RFID Handbook, Waldner's tag includes "switching circuitry that dynamically changes the resonant frequency of the main antenna . . . [by] selectively coupl[ing] electrical elements, such as capacitive elements, inductive elements, or combinations thereof, to vary the resonant frequency of the RFID tag." *Id*., Abstract, ¶¶8, 10, 23-36, 37 ("switch 46 that switches between inductive elements 48A and 48B in order to selectively include inductive elements 48A and 48B as additional loops for an antenna 42. In this manner, switch 46 is able to vary the frequency at which RFID tag 44 resonates."), 38-39, 44 ("automatically adjust the resonant frequency of RFID tag 44").

233. Therefore, a POSITA studying Boyer and the RFID Handbook would look towards teachings of impedances that can be switchably connected to the antenna to change its reflectivity (*i.e*., by changing the resonant frequency), and found Waldner. At the very least, the combined system would have represented a simple substitution of one known element [*i.e.*, Waldner's switchable impedances comprising antenna loops or separate antennas] for another [Boyer's switchable

impedance Z_2] to obtain predictable results [*i.e.*, a switchable impedance that connects to an RFID backscatter tag antenna to change its reflectivity.]

234. Second, even though Waldner selectively couples/decouples its additional impedances to tune the antenna frequencies to address interference from other tags (or other sources), a POSITA would still recognize that Waldner's switchable impedances would have been a suitable implementation in Boyer's binary backscatter modulator. Specifically, a POSITA would have recognized that Waldner's inductance elements 48A and 48B, with additional lengths of antenna, capacitive components, inductive components, or combinations, thereof each result in a different impedance load (Z_2) and therefore different reflectance (Γ_2), as taught by Boyer. Waldner, ¶¶37, 44.

235. The fact that Boyer switches impedances to change the antenna reflectivity for modulation, whereas Waldner changes the impedances for tuning, would not have dissuaded a POSITA from utilizing Waldner's teaching of impedances in modulation. Boyer switches impedances to change the reflection coefficient of the antenna. That is precisely what Waldner teaches its electrical elements (capacitive, inductive, or combinations) are used for. Indeed, a POSITA would have known that any suitable impedance could be used in Boyer that would change the reflection coefficient and enable continuous power harvesting. And an

additional loop of antenna, or a separate antenna, as well as any other inductance elements (or capacitive elements for that matter), would have been suitable for that purpose. Waldner itself teaches the interchangeability of load impedances to change resonant frequency. Ex-1006, ¶36 ("capacitive element in parallel/series," "short out a capacitive element," "switch in an inductive element in either series or parallel," "or combinations thereof, to change the resonant frequency of main antenna.")

236. Indeed, the specification does not provide any evidence or indication as to why using a separate antenna length or antenna was not obvious, or any specific benefits that are obtained over other impedances. '968 patent, 5:38-61. At the very least, Waldner's use of dynamically switchable antenna lengths to change the reflective properties of the antenna would have constituted "known work" in the RFID backscatter field that would have prompted variations of it for use in other aspects of the RFID tag, including as an impedance in a modulator circuit.

237. Third, a POSITA would have been motivated to use an additional length of antenna or separate antenna for the Z_2 impedance in Boyer because it would have provided known advantages over other known impedance components. For example, using additional antenna loops/separate antenna would have provided the known benefit of increasing the amount of the RF signal that could be received, thereby increasing power harvesting at the RFID tag. RFID Handbook, 119

(discussing radar cross-section and power density). Moreover, a POSITA would have known that an additional antenna loop/separate antenna would have been relatively simple to manufacture on an RFID, since the main antenna components would also have to be fabricated at the same time.

238. Further, as taught by Waldner, using antenna loops or a separate antenna would have provided a level fidelity for tuning the impedances to optimize the performance and the relevant frequencies (as taught by Boyer's Figure 8), that a capacitive or conductive load alone may not have provided. Therefore, using Waldner's switchable antenna loops or separate antennas in place of Boyer's generic switchable Z_2 impedance would have constituted applying a known technique to a known device (method, or product) ready for improvement to yield predictable results.

239. A POSITA would also have known that using a separate antenna or antenna loop would have provided the benefit of changing both the real and imaginary components of the antenna reflectance, since they comprise both an inductance and resistance as shown by their equivalent circuits. Ex-1023, 119 (Figure 4.65). Boyer teaches that "switching between symbols [corresponding to impedances] by changing ***only the real*** component of η tends to be less efficient in terms of power harvesting than changing the imaginary component of η." Ex-1005,

774. Therefore, using an antenna or antenna loop is an efficient means by which additional design freedom is provided—*i.e.*, the ability to vary both resistance and reactance of the antenna.

240. The length of an antenna is an important factor in determining its resonant frequency and impedance characteristics since it affects the antenna's electrical length and its resonance. The electrical length of an antenna is a dimensionless parameter equal to the physical length of the antenna divided by the wavelength of a signal at a given frequency travelling through the antenna. When the physical length of the antenna is changed, it effectively changes the point at which the signal reflects within the antenna structure, which in turn alters the impedance of the antenna.

241. Finally, a POSITA would have found it obvious to try implementing an additional loop of antenna (or a sperate antenna) as taught by Waldner as the switchable Z_2 impedance in Boyer. POSITAs in the RFID field routinely experiment with different impedance loads on the antenna through some combination of inductive and/or capacitive elements to arrive at different values and RF behaviors. Nikitin, 214. There are only a finite number of ways to achieve these different results, and one way is conductive traces that form antennas, like taught in Waldner.

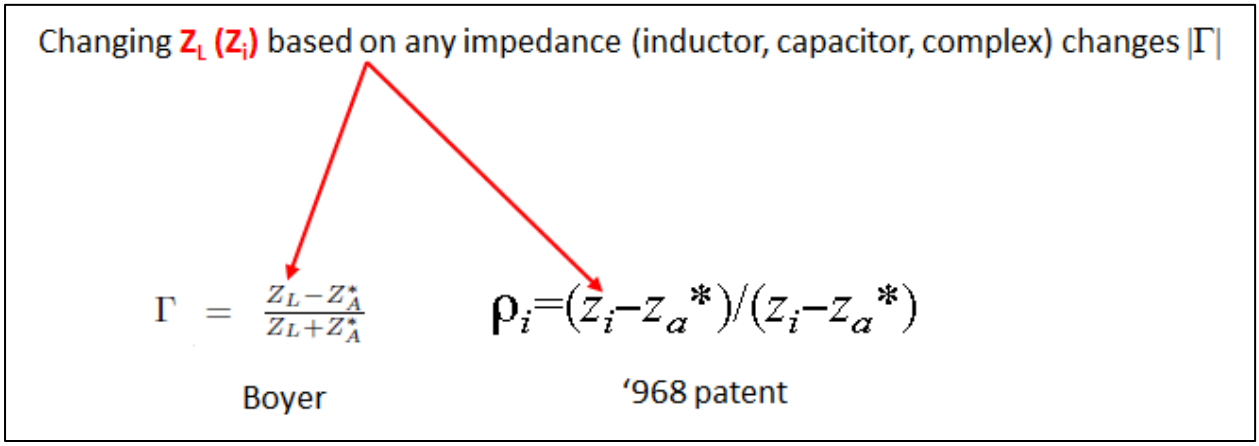
C. The use of a separate length of antenna as the modulation impedance (Z_{mod}) does not change the reflection property terms

242. The claims recite various reflective properties "of" or "by" the "*main antenna."* Although the analysis for Ground 1 used as an example a capacitor (C_{mod}) as the modulation impedance, the anlaysis is the same if a length of antenna is connected/disconnected to the antenna (as taught in Waldner) to modulate the signal.[15]

243. As explained above, in the combined system for Ground 2, Z_2 is Waldner's separate length of antenna. The equations analyzing the reflective properties "*of/by the antenna*" are all agnostic as to the specifics of the impedance used—including where or how it is connected to the antenna—as are Boyer's and Dobkin's teachings of power harvesting throughout the backscatter communication.

244. As to terms 1) "reflection coefficient" [11B.1]/[1D]/[6B]; 2) "amount of reflectance" [11B]/[1D]/[6B]; and 3) "reflectance" [11C.1]/[1D]/[6C], those values are all provided by the reflection coefficient equation (or at the very least are proportional to it) provided below:

[15] A POSITA would have understood an antenna length will have a reactive impedance (inductance) and perhaps a resistive component.



245. Thus, since $Z_{mod} = Z_2$ has an inductive value (or is complex), the reflection coefficient $|G_2|$ will be different than $|G_1|$ (which remains 0 for the matched condition in Boyer), and $|G_2|$ will be between 0 and 1 since it does not short the antenna.

246. Similarly, for "*resonant frequency*" [11C.3]/[1G]/[6C], that value is provided by the equation below, which will again change regardless of whether Z_2 is a capacitive, inductive, or complex (*e.g.*, Waldner's length of antenna), as any reactive load will change the L or C values. This will in turn change the reflection properties:

$$f_{res} = \frac{1}{2\pi\sqrt{LC}}$$

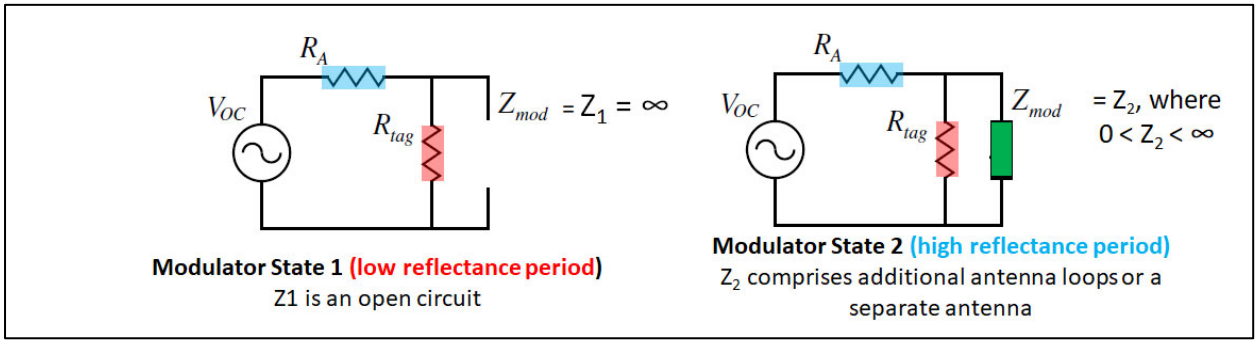
247. The remaining analysis is equally applicable since none of claims 11-12, 16-20 (or as we will see later, claims 6-10) have limitations that depend on the type of reactive modulation impedance used (other than the requirement in some

claims to use a separate length of antenna) nor the location of the switch that modulates the signal (so long as it connects to the antenna). And as explained above, a POSITA would have understood that Z_2 is not confined to a resistive (Ohmic) modulator; it was simply an example of a conventional modulator used for illustration purposes.

D. Claim 13 was obvious over the Combined RFID Tag

248. Claim 13 depends from claim 11 and further requires "*the circuit adds a separate length of antenna to the main antenna during the **first reflectance period***." As explained above, in the combined system of Boyer as modified by Waldner, impedance Z_2 comprises "portions of conductive traces fabricated to form additional loops of antenna 42" or "completely separate antennas," either of which is a "*separate length of antenna*." Waldner, ¶38. Thus, the circuit (Boyer's IC with microcontroller that controls the switch between impedances Z_1 and Z_2 as shown in Figure 2) adds the "*separate lengths of antennas*" (as taught by Waldner) when Z_2 is connected (*i.e.*, in the **first (high) reflectance period**). *See* the discussion claim [11B.2] above.

249. The **first (high) reflectance period** is shown on the right of the modified version of Boyer's Figure 6 showing the different modulation periods, here with the impedance Z_2 as taught by Waldner:

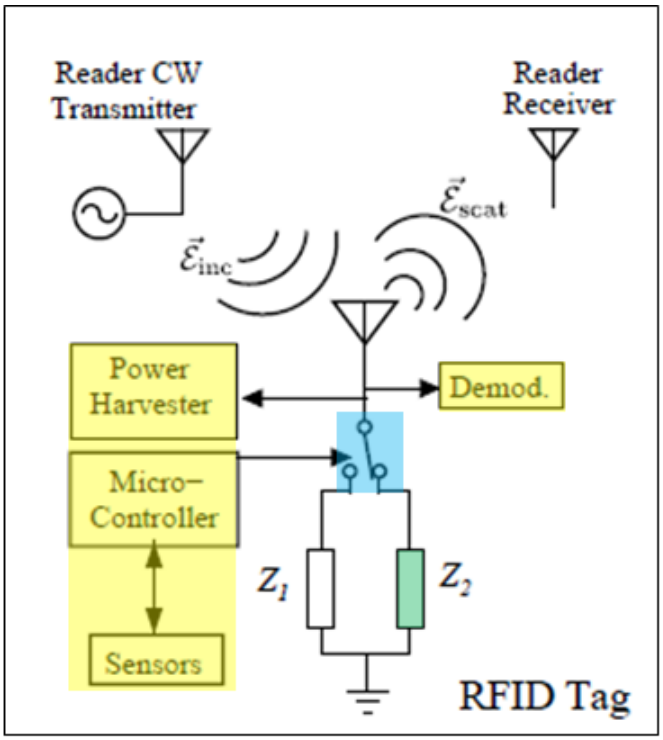


Boyer, Figure 6 (further modified to show Z_2 as antenna loops/separate antenna).

E. Claim 14 was obvious over the Combined RFID Tag

250. Claim 14 depends from claim 13 and further requires "*a switch that adds the separate length of antenna by connecting the separate length of antenna to the main antenna during the* ***first reflectance period****, the switch being located on a first portion of the main antenna and the circuit being located on a second portion of the main antenna, wherein the first portion of the main antenna is different than the second portion of the main antenna*." The combined RFID tag renders this claim obvious.

251. As discussed above for claim 16, Boyer discloses *a switch* (*i.e.*, the switch shown in Figure 2 in blue below) that is "*controlled by the circuit that connects an RF impedance to the main antenna during the first reflectance period*" (*i.e.*, the switch is controlled by the IC via microcontroller and "switches the backscatter modulator between two impedance states Z_1 and Z_2").

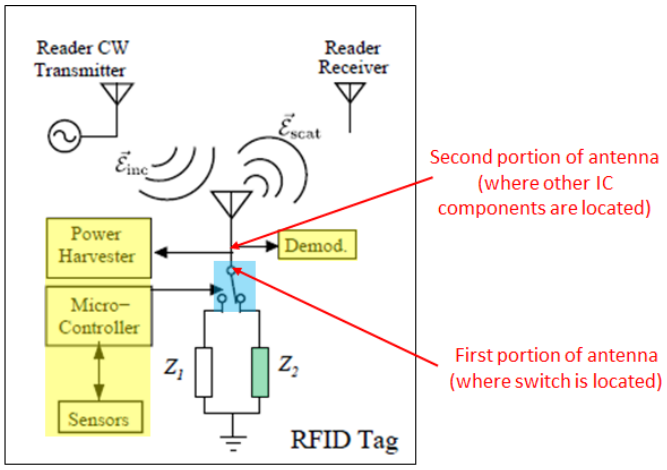


Boyer Figure 2.

252. Moreover, as explained for claim 13, in the combined system of Boyer in view of Waldner, the impedance Z_2 (shown in green above) comprises either additional loops of antenna or a separate antenna (either of which would comprise a *"separate length of antenna"*). As further explained for claim 13, the switch connects Z_2 to the main antenna during the ***first reflectance period***—*i.e.*, during the high period of the backscatter modulation.

253. In the combined system, Boyer also discloses "*the switch being located on a first portion of the main antenna and the circuit being located on a second portion of the main antenna, wherein the first portion of the main antenna is different*

than the second portion of the main antenna." First, in Figure 2, Boyer discloses that its IC includes additional components—such as power harvester ("rectifier"), sensors, and demodulator—that are connected to the antenna in different locations (and hence different "portions") than the switch (which is controlled by the microcontroller):



Boyer Figure 2 (annotated).

Boyer, 770.

254. Indeed, a POSITA would have understood that Boyer's rectifier circuit (*i.e.*, power harvester) would have a separate connection to the antenna because it needs to operate in both the active and idle state for the RFID to harvest power. As an example, Dobkin shows a conventional RFID tag with separate components (power supply, signal detection, modulation), connecting to the antenna in different

locations. At the very least it would have been obvious based on the teachings in Boyer, 770 (Figure 2).

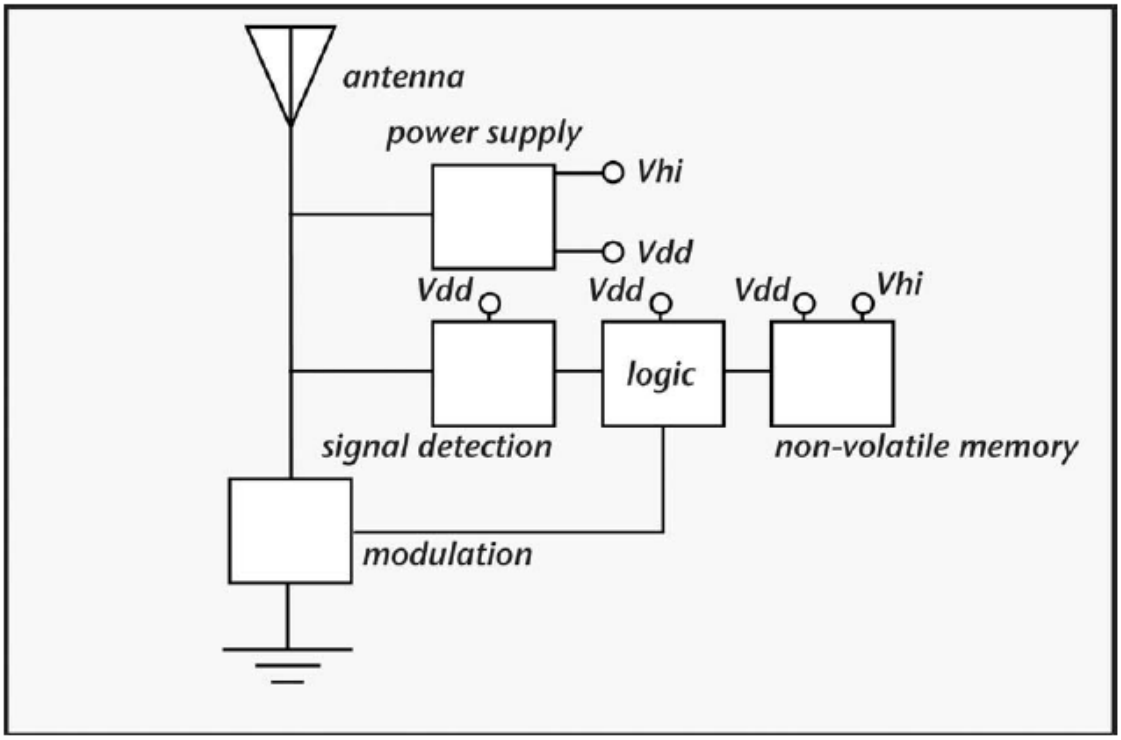
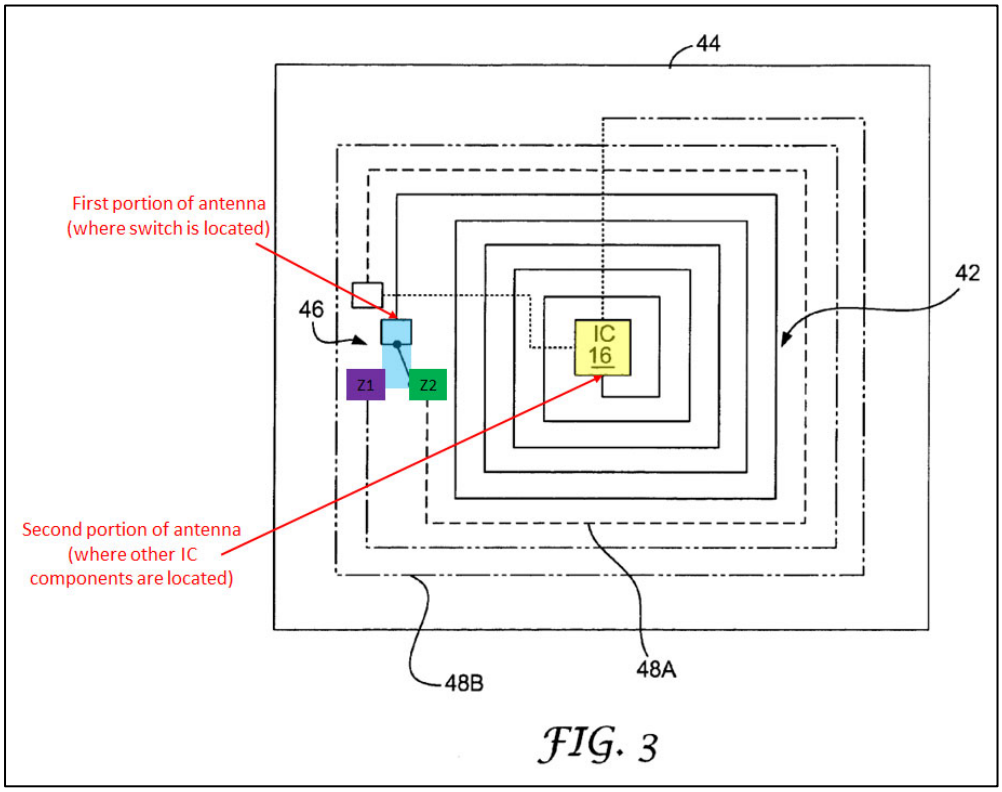


Figure 5.1: Elements of a Passive UHF Tag.

Ex-1021, 196.

255. Second, Waldner expressly teaches how to implement a switch and variable load impedances comprising additional loops of antenna/separate antenna in Figure 3, reproduced below. Therefore, as explained above, in the combined system, Waldner's extra loops of antenna may be implemented in the same way in Boyer's RFID tag. As shown, Waldner's IC 16 (yellow) is connected to a second

portion of the antenna, and the switch (blue) that connects additional loops (Z_2, green) is connected to a first portion of the antenna.



Waldner Figure 3.

256. Waldner therefore teaches the switch and IC are connected to different parts of the antenna when using additional loops of antenna as load impedance to change the resonant frequency of the main antenna. For the same reasons explained above for why a POSITA would have been motivated to implement the impedances in Waldner into Boyer's modulator impedances, a POSITA would have been equally motivated to implement those impedance in the same way taught by Waldner.

257. In the alternative, it would have been obvious in the combined system of Boyer in view of Waldner to connect the IC and switch to different portions of the main antenna. First, it would have been a simple design choice since 1) the IC in Boyer's RFID passive tag must be connected to the antenna somewhere so that it can harvest power and demodulate the incoming signal; and 2) there are only two options: connect at the same or to different portions of the main antenna. With only two choices, it would have been obvious to try both. At the very least, it would have been a design choice as to where to connect the IC to the antenna.

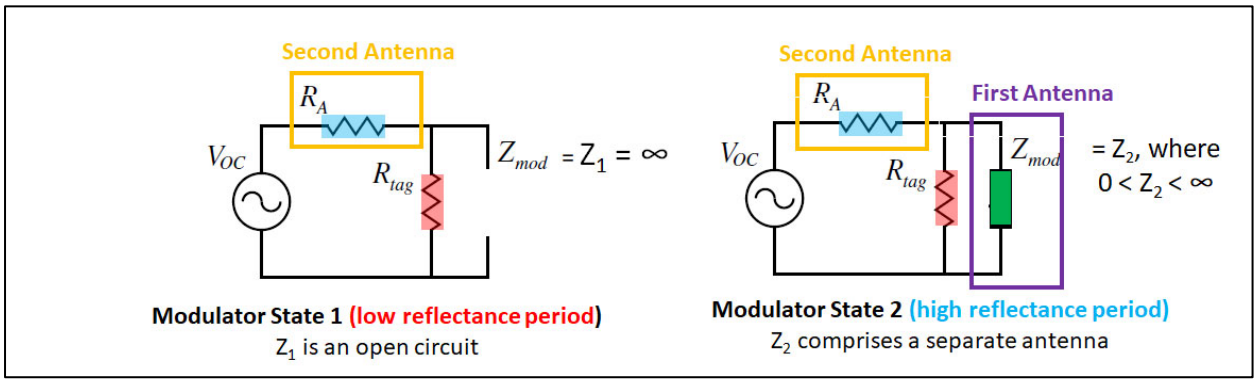
F. Claim 15 was obvious over the Combined RFID Tag

258. As discussed above for claims 13 and 14, the combined RFID tag renders obvious "*the main antenna includes a first antenna for receiving the RF signal, and a second antenna for receiving power, and the second antenna continues to absorb a portion of the RF signal during the* ***first reflectance period*** *and the* ***second reflectance period*** *to generate a low reflectance to enable wireless power harvesting during both the* ***first reflectance period*** *and the* ***second reflectance period***."

1. Main Antenna Interpretation

259. First, the main antenna and the additional length of antenna (or separate antenna) for Z_2 represent the first and second antennas.

260. With regard to the "*second antenna*" of the "*main antenna*," this is the portion of the main antenna corresponding to the impedance (R_A, shown in blue below) in the combined system that remains connected to the chip in both the second (**low**) and first (**high**) reflectance periods.



261. The "*second antenna*" is also shown in Figure 3 of Waldner (in blue):

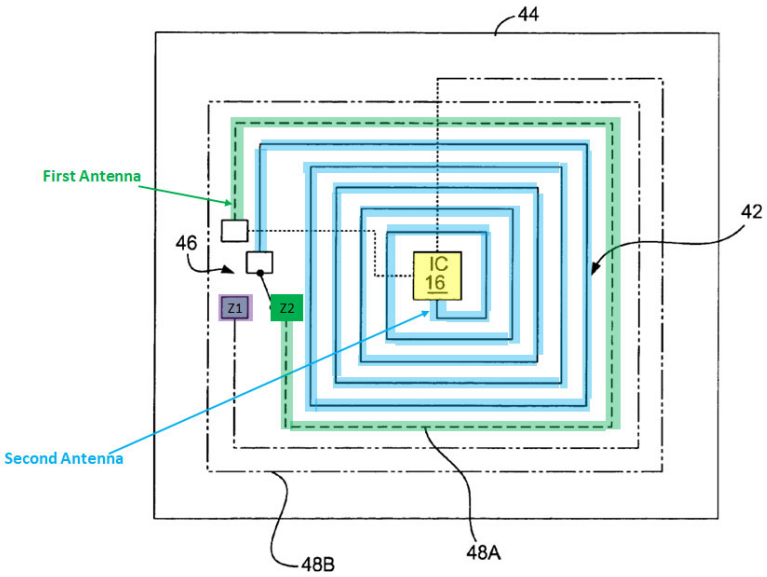
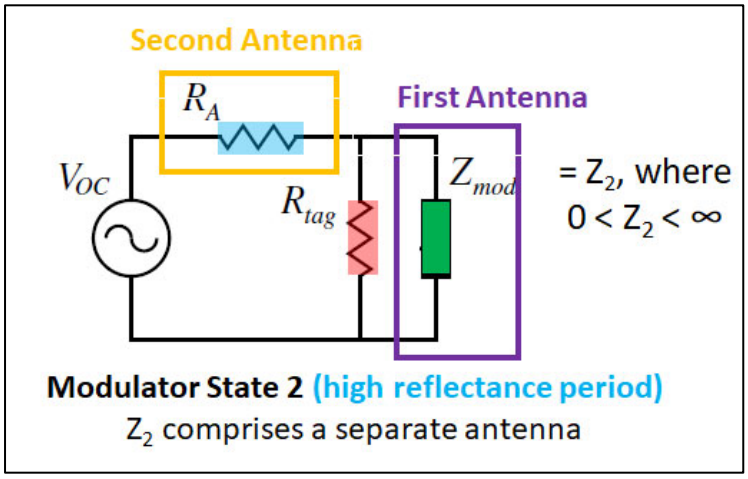


FIG. 3

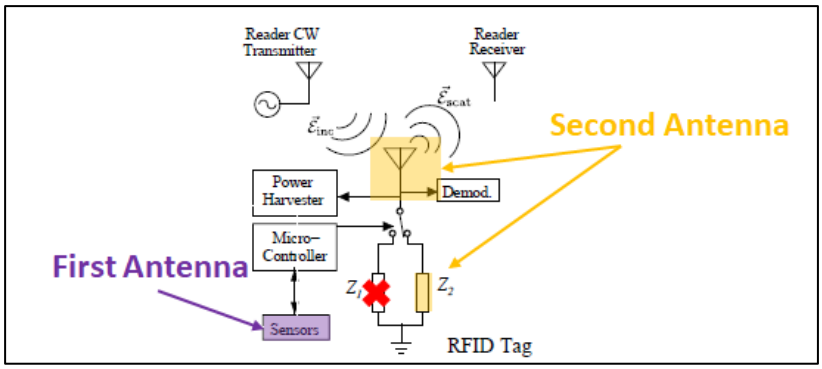
262. As explained for claim [11C], Boyer harvests power in both the high and low periods of the backscatter signal, and this portion of the tag antenna (whether connected to Z_2, shown in green, above or not) continues to receive the reader signal, which the tag harvests.

263. With regard to "*first antenna*" of the "*main antenna*" that is *"for receiving the RF signal,"* this is at least the separate antenna providing the modulation impedance Z_2, shown in green above, in the combined system of Boyer and Waldner. That separate antenna, Z_2, receives the RF signal at least when connected to the main antenna during the high reflectance period (shown in the right in the above figure), and reflects a portion of the signal back while power harvesting the remaining portion of RF signal.



2. Sensor Alternative

264. In the alternative, Boyer's "sensors" in Figure 2 are modified to include the "sensing" antenna in Waldner. Ex. 1006, Abstract ("The RFID tag may include a sensing circuit that determines when to selectively couple the electrical element to the main antenna to adjust the resonant frequency of the main antenna"); Figure 1 (element 20).



Boyer, Figure 2 (modified to show Z1 is an open circuit; labels for antennas)

265. Such a modification to Boyer would have been obvious because Boyer is agnostic about the sensors that may be included. A POSITA would therefore have included any useful and well-known sensors, including Waldner's sensing antenna, which can be used to determine if there is interference and allow the tag to make any necessary adjustments. Ex-1006, ¶ 25 ("sensing antenna 20 may be viewed as determining or sensing whether there is tag-to-tag coupling.") Although Waldner uses the sensing antenna to tune the antenna, a POSTIA would have known that it could be used for other purposes, such as to detect movement relative to the reader

or measure signal strength. This would have constituted use of a known technique to improve similar devices in the same way and/or applying a known technique to a known device ready for improvement to yield predictable results.

266. The "*first antenna*" is *"for receiving the RF signal."* Waldner explains that "sensing antenna 20 may be tuned to the operating frequency of the RFID system." Ex. 1006, ¶ 25;

267. The "*second antenna*" is the combination of the main antenna (R_A, shown in blue) and the modulation impedance (Z_2,), which combined both receive the reader signal and harvest power throughout both states (*i.e.*, when Z_2 is connected and disconnected). *See* claim [11C.1]-[11C.3].

G. Claim 1 is obvious over the Combined RFID Tag

268. Claim 1 of the '968 patent includes claim elements that are essentially the same as, or broader than, claims 11, 13, and 14 analyzed above. As such, the sections below demonstrate how each claim element in claim 11 corresponds to one or more claim elements in the claims addressed above. The same support and arguments set forth above apply to each of these claim limitations.

1[pre] A radio-frequency identification (RFID) tag comprising:	11[pre] A radio-frequency identification (RFID) tag comprising:
1[A] a main antenna that receives a radio-frequency (RF) signal from an RFID reader and wirelessly harvests	11[A] a main antenna that receives a radio-frequency (RF) signal from an RFID reader and wirelessly harvests

power from the RF signal;	power from the RF signal; and
1[B] a switch connected to a first portion of the main antenna and a separate length of antenna;	14 The RFID tag of claim 13, further comprising: a switch that adds the separate length of antenna by connecting the separate length of antenna to the main antenna during the first reflectance period, the switch being located on a first portion of the main antenna and the circuit being located on a second portion of the main antenna, wherein the first portion of the main antenna is different than the second portion of the main antenna.
1[C] a circuit connected to a second portion of the main antenna, wherein the second portion of the main antenna is different than the first portion of the main antenna, the circuit being configured to:	14 The RFID tag of claim 13, further comprising: a switch that adds the separate length of antenna by connecting the separate length of antenna to the main antenna during the first reflectance period, the switch being located on a first portion of the main antenna and the circuit being located on a second portion of the main antenna, wherein the first portion of the main antenna is different than the second portion of the main antenna.
1[D] vary a reflection coefficient of the main antenna to transmit a reflected signal to the RFID reader, the reflected signal having high reflectance periods when an amount of reflectance by the main antenna of the RF signal is greater than a predetermined amount, and low reflectance periods when an amount of reflectance by the main antenna of the RF signal is lower than the predetermined amount;	11[B] a circuit that is configured to vary a reflection coefficient of the main antenna to transmit a reflected signal to the RFID reader, the reflected signal having a first reflectance period and a second reflectance period when an amount of reflectance by the main antenna of the RF signal is different than during the first reflectance period; 17 The RFID tag of claim 11, wherein the amount of reflectance by the main antenna of the RF signal is greater than

	the predetermined amount during the first reflectance period, and the amount of reflectance by the main antenna of the RF signal is lower than the predetermined amount during the second reflectance period.
1[E] control the switch to intermittently connect the separate length of antenna to the main antenna;	Claim 16 depends from claim 11 and further requires "a switch controlled by the circuit that connects an RF impedance to the main antenna during the first reflectance period." 13 The RFID tag of claim 12, wherein the circuit adds a separate length of antenna to the main antenna during the first reflectance period.
1[F] change a resonant frequency of the main antenna, based on the controlled switching, to generate a high reflectance period and a low reflectance period; and	12 The RFID tag of claim 11, wherein the circuit changes the resonant frequency of the main antenna to generate the first and second reflectance period. 13 The RFID tag of claim 12, wherein the circuit adds a separate length of antenna to the main antenna during the first reflectance period.
1[G] reduce a reflectance of the main antenna below a predefined amount during the high reflectance period without shorting the main antenna to enable the main antenna for continuous wireless power harvesting while transmitting the reflected signal to the RFID reader, wherein the reflectance of the main	11[C] wherein a reflectance of the main antenna is reduced below a predefined amount during the first reflectance period without shorting the main antenna to enable the main antenna to continuously harvest power while transmitting the reflected signal to the RFID reader, wherein the reflectance of the main

antenna during the high reflectance period is reduced based on the change in the resonant frequency of the main antenna.	antenna is reduced based on a change in a resonant frequency of the main antenna.

1. The Combined RFID Tag renders [1P] obvious

269. Both claim limitations [1P] and [11P] recite "*[a] radio-frequency identification (RFID) tag*." *See* Claim [11P] above.

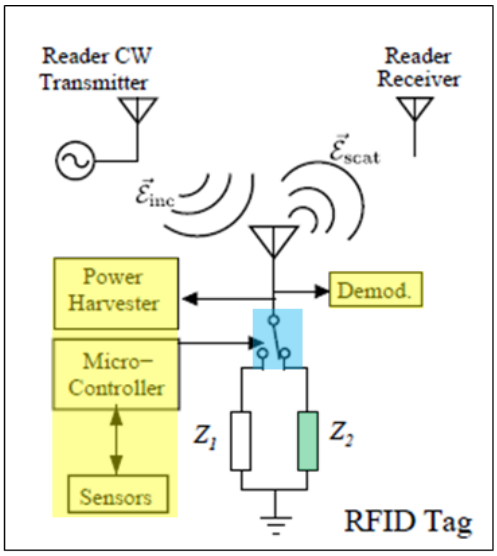
2. The Combined RFID Tag renders [1A] obvious

270. Both claim limitations [1A] and [11A] recite "a main antenna that receives a radio-frequency (RF) signal from an RFID reader and wirelessly harvests power from the RF signal." *See* Claim [11A] above.

3. The Combined RFID Tag renders [1B] obvious

271. Claim limitation [1B] recites "a switch connected to a first portion of the main antenna and a separate length of antenna." I showed above for claim 14 why Boyer in view of Waldner discloses "a **switch** that adds the separate length of antenna **by connecting the separate length of** antenna to the main antenna during the first reflectance period, **the switch being located on a first portion of the main antenna** …." The same analysis applies for this claim limitation, where the switch (in blue) shown in Figure 2 below 1) "switches the backscatter modulator between two impedance states Z_1 and Z_2"—*i.e.*, connects a first portion of the main

antenna to Z_2; and 2) in the combined system of Boyer in view of Waldner, the impedance Z_2 (shown in green below) comprises either additional loops of antenna or a separate antenna (either of which would comprise a "separate length of antenna").



Boyer Figure 2.

4. The Combined RFID Tag [1C] obvious

272. Claim limitation [1C] recites "*a circuit connected to a second portion of the main antenna, wherein the second portion of the main antenna is different than the first portion of the main antenna*." The analysis for claim 14 applies, where a POSA would have understood that if a circuit is "*located on*" a portion of the main antenna, it is also "*connected to*" that portion. The '968 patent does not explain what "located on" means, and only mentions it twice in the specification in language that

essentially copies the claim language. There is no explanation or definition provided. At most, "*located on*" is used consistent with the "connected to" in the '968 patent.

273. I showed above for claim 14 why Boyer in view of Waldner discloses "the circuit [i.e., the IC shown in yellow in Figure 2 below] being located on a second portion [i.e., the portions connected to the power harvester, demodulator, etc.] of the main antenna, wherein the first portion of the main antenna is different than the second portion of the main antenna."

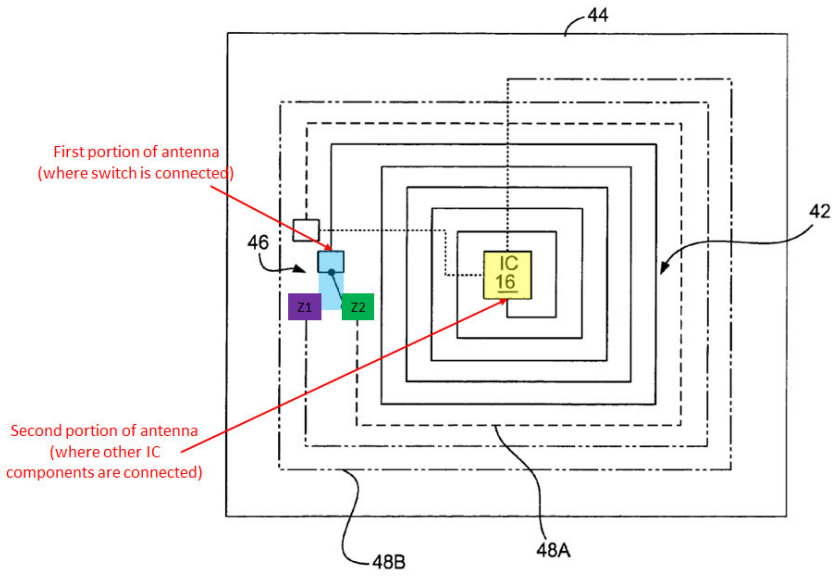
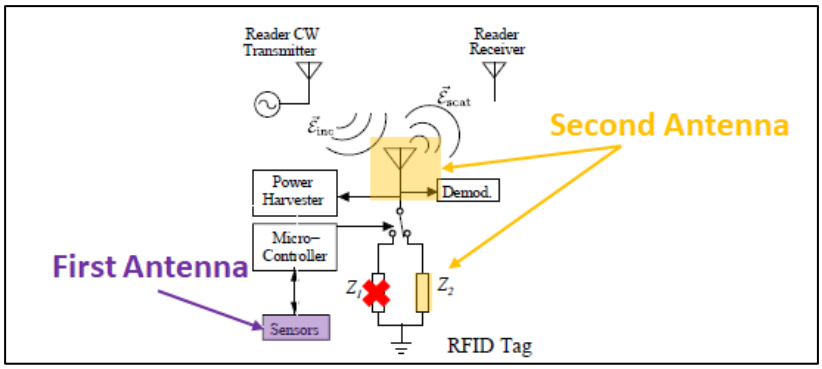


FIG. 3

Waldner, Figure 3 (annotated)

274. Separately, the analysis for claim 16 applies, where the combined system has a main antenna with a "first" and "second" antenna, including for example, Waldner's sensory antenna as one of Boyer's "sensors." A POSA would have understood that the IC would have had a separate connection to the sensory antenna (as well as any other sensors as shown in Figure 2).



Boyer, Figure 2 (modified to show Z1 is an open circuit; labels for antennas)

5. The Combined RFID Tag renders [1D] obvious

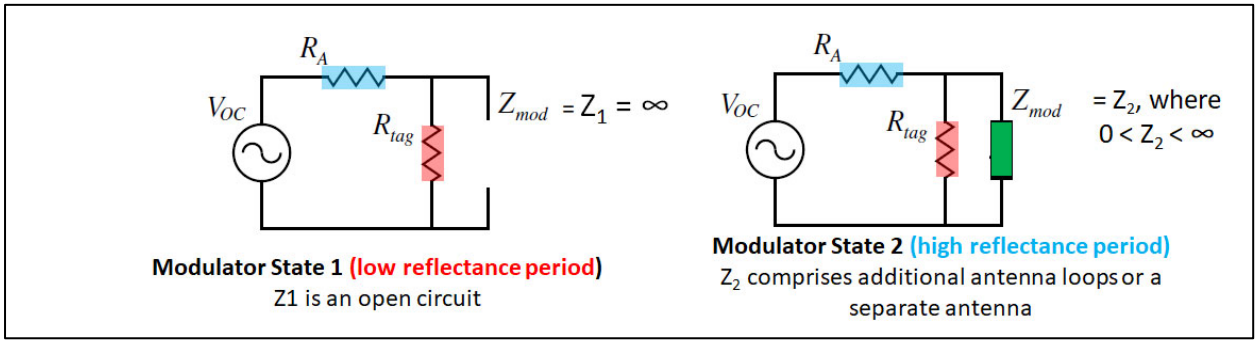
275. Claim limitation [1D] recites that the circuit is further configured to "vary a reflection coefficient of the main antenna to transmit a reflected signal to the RFID reader, the reflected signal having **high reflectance periods** when an amount of reflectance by the main antenna of the RF signal is greater than a predetermined amount, and **low reflectance periods** when an amount of reflectance by the main antenna of the RF signal is lower than the predetermined amount."

276. I showed above for claim limitation [11B] that Boyer discloses the circuit is "*configured to vary a reflection coefficient of the main antenna to transmit a reflected signal to the RFID reader, the reflected signal having a* ***first reflectance period*** *and a* ***second reflectance period*** *when an amount of reflectance by the main antenna of the RF signal is different than during the first reflectance period*."

277. I also showed for claim 17 that in Boyer "*the amount of reflectance by the main antenna of the RF signal is greater than the predetermined amount during the* ***first reflectance period****, and the amount of reflectance by the main antenna of the RF signal is lower than the predetermined amount during the* ***second reflectance period***."

278. My analyses of claim limitation [11B] and claim 17 apply to limitation [1D] as well.

279. While claims 11 and 17 did not recite "high" and "low" reflectance periods, I showed above that the ***first reflectance period***, when Z_1 (an open circuit) is connected is the ***low reflectance period*** because it is the "matched" condition, and the ***second reflectance period***, when Z_2 (which has an impedance between an open and short circuit) is connected is the ***high reflectance period*** because that is when the reflectance is greater than 0.



Boyer, Figure 6 (further modified to show Z_2 as antenna loops/separate antenna)

6. The Combined RFID Tag renders [1E] obvious

280. Claim limitation [1E] recites that the circuit is further configured to "*control the switch to intermittently connect the separate length of antenna to the main antenna*."

281. I showed above for claim 16 that Boyer discloses the circuit has "*a switch controlled by the circuit that connects an RF impedance to the main antenna during the first reflectance period.*" And as discussed above for limitation [1B], and previously for claim 13, the I showed that in the system of Boyer as modified by Waldner, "*the circuit adds a separate length of antenna to the main antenna during the first reflectance period*"—*i.e.*, the impedance Z_2 can be "portions of conductive traces fabricated to form additional loops of antenna 42" or "completely separate antennas," either of which is a "separate length of antenna." Waldner, ¶38. Therefore, the same analysis applies to this claim limitation.

282. The switching that connects Z_2 to the main antenna is "*intermittent*" at least because it is part of the backscatter modulation process, in which the switch (controlled by the IC) connects and disconnects Z_2 to modulate the signal—*i.e.*, to create the first (high) and second (low) reflectance periods—in accordance with the data and modulating scheme chosen. For binary (two state) modulation, the rate at which Z_2 is modulated (i.e. changes value via connecting and disconnecting impedances) depends on the specific binary sequence to be transmitted. While on average the proportion of binary '0' and '1' symbols may be expected to be equal for a sufficiently long information sequence, their proportions will vary, in a specific sub-sequence, thus leading to varying and intermittent modulation ('switching') rates.

7. The Combined RFID Tag renders [1F] obvious

283. Claim limitation [1F] recites that the circuit is further configured to "*change a resonant frequency of the main antenna, based on the controlled switching, to generate a* ***high reflectance period*** *and a* ***low reflectance period***."

284. I showed above for claim limitations [11C.3] that "*the reflectance of the main antenna is reduced based on a change in a resonant frequency of the main antenna*" based on the ***circuit*** (Boyer's IC, which includes the microcontroller) controlling the switch that connects the impedances between Z_1 and Z_2.

285. I also showed for claim 16 that Boyer discloses the circuit has "a switch controlled by the circuit that connects an RF impedance to the main antenna during the **first reflectance period**," for claim 12 that the "circuit changes the resonant frequency of the main antenna to generate the **first** and **second** reflectance period," and for claim 13 that "the circuit adds a separate length of antenna to the main antenna during the first reflectance period." The same analysis applies to this claim.

8. The Combined RFID Tag renders [1G] obvious

286. Claim limitation [1G] recites that the circuit is further configured to "*reduce a reflectance of the main antenna below a predefined amount during the **high reflectance period** without shorting the main antenna to enable the main antenna for continuous wireless power harvesting while transmitting the reflected signal to the RFID reader, wherein the reflectance of the main antenna during the **high reflectance period** is reduced based on the change in the resonant frequency of the main antenna*." This limitation is substantively identical to claim limitation [11C] addressed above, where the "*first reflectance period*" is the "*high reflectance period*"—*i.e.*, the period when the switch connects the impedance Z_2, and the main antenna has reflectance Γ_2.

H. The Combined RFID Tag renders Claim 2 obvious

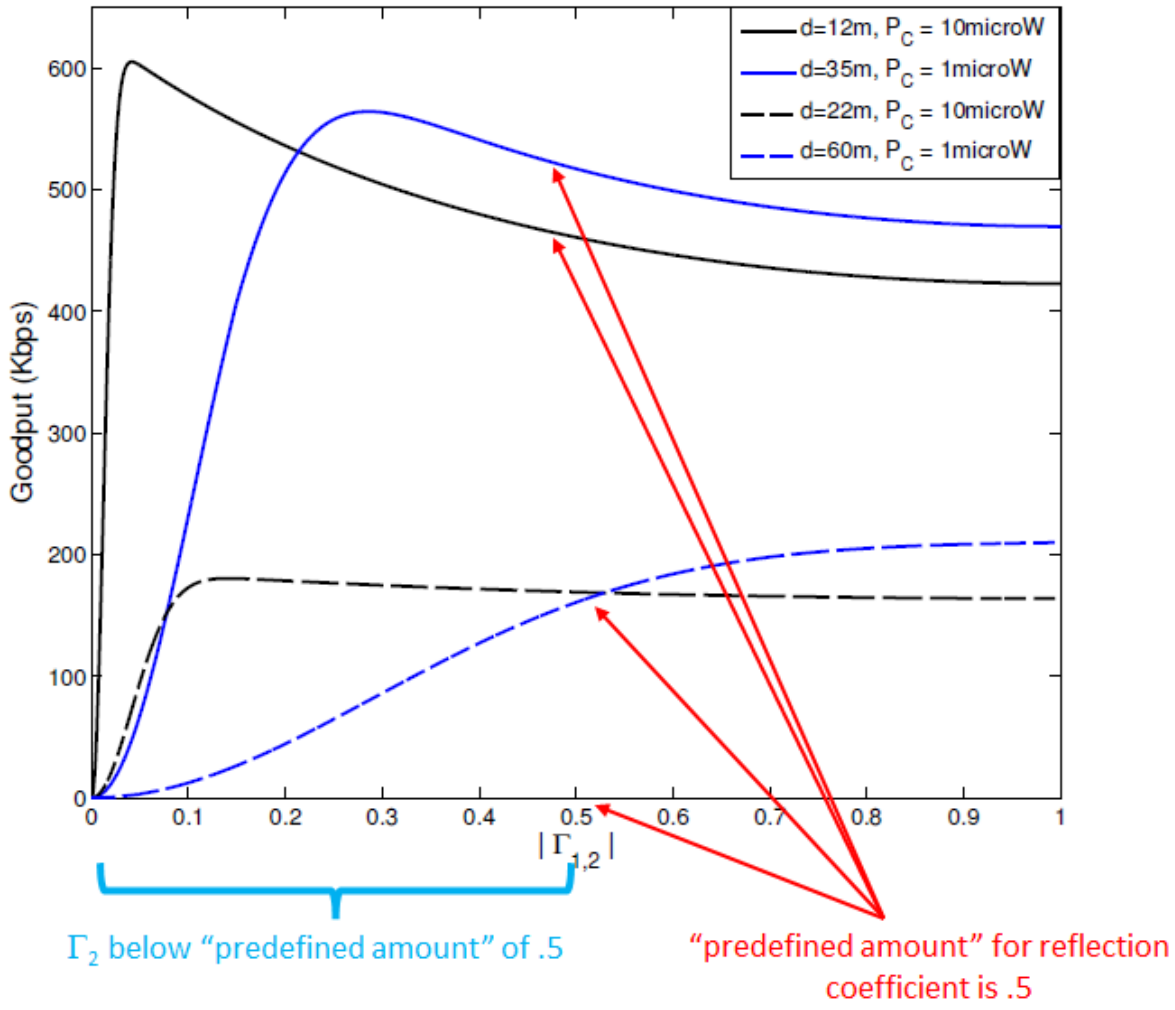
287. Claim 2 requires "*the predetermined amount is a reflection coefficient magnitude of between 0 and 0.5*." The analysis for limitation [1D] and claim 17 applies. Although claim 17 did not specify the "*predetermined amount*," Boyer discloses that Z_2 (corresponding to the ***high reflectance period***) can have a reflectance magnitude $|G_2|$ anywhere between 0 and 1, which a POSA would have understood includes values equal to or greater than .5. Since Γ_1 (when Z_1 is connected during the **low reflectance period**) is 0, it will be lower than any "*predetermined amount*" in that range. And as explained for limitation [11C.1], the fact that the impedance is reactive (here inductive rather than capacitive) does not change the analysis because it will still have a non-zero magnitude.

I. The Combined RFID Tag renders Claim 3 obvious

288. Claim 3 requires "*the predefined amount is a reflection coefficient magnitude of 0.5*." The analysis for limitations [11C.1] and [11C.2] applies. Boyer also discloses or at least renders obvious this limitation since $|G_2|$ can be varied between 0 and 1. Indeed, Boyer expressly states that the modulation impedance, Z_2, is "***between*** an open ($Z_2 = \infty$) and ***short state*** ($Z_2 = 0$)" and that as the value

approaches a short circuit, the "harvested power during backscatter P_{back} decreases."

Id., 775. Therefore, as shown in Figure 8, there are instances when $|\Gamma_2|$ is below .5:[16]



Boyer, 776.

[16] As explained above, since Z_1 is an open circuit and the tag is in a matched condition (*i.e.*, Γ_1 is 0), $|\Gamma_{1,2}|$ is equal to $|\Gamma_2|$.

J. The Combined RFID Tag renders Claim 4 obvious

289. Claim 4 depends on claim 1 and further requires "*the circuit is an application-specific integrated circuit (ASIC)*." *See* claim 19 above.

K. The Combined RFID Tag renders Claim 5 obvious

290. Claim 5 depends on claim 1 and further requires "*wherein the main antenna is a linearly polarized antenna*." *See* claim 20 above.

L. The Combined RFID Tag renders Claims 11-12, 16-20

Although as shown above in Section VI, claims 11-12 and 16-20 are rendered obvious over Boyer in view of RF Handbook alone, to the extent Patent Owner argues that these claims require that a separate antenna or separate length of antenna must be used to vary the "*reflection coefficient*" [11B.1]/[1D]/[6B]; 2) "amount of reflectance" [11B]/[1D]/[6B]; and 3) "*reflectance*" [11C.1]/[1D]/[6C], and 4) "*resonant frequency*" [11C.3]/[1G] of/by the "*main antenna*," then those claims would have been obvious in the combined system (Boyer in view of RFI Handbook, in further view of Waldner) as described above for Claims 1-5 and 13-15. As explained above in Section VI.C, Z_2 is Waldner's separate antenna or separate length of antenna, and the analysis of these reflection properties is the same regardless of the reactive (or complex) value of the impedance.

X. GROUND 3: CLAIMS 6-10 ARE OBVIOUS OVER THE BOYER IN VIEW OF RFID HANDBOOK IN FURTHER VIEW OF KAPUCU.

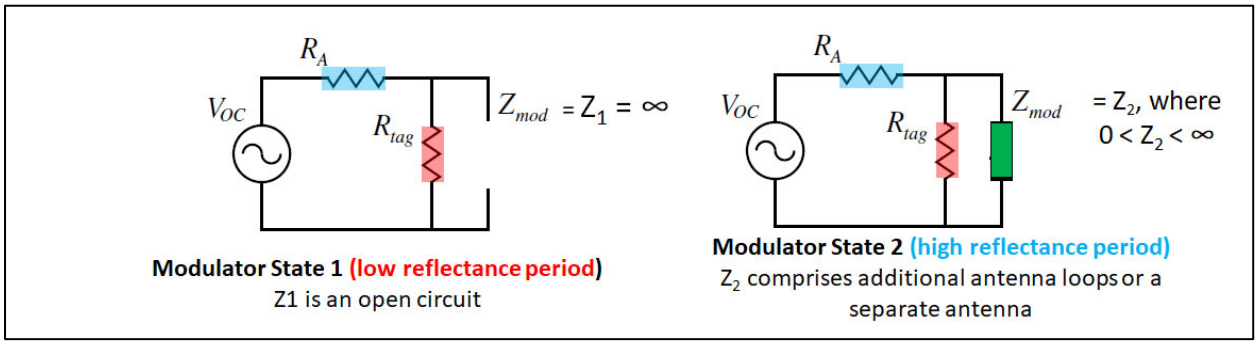
A. Limitations for Claims 6, 7, 9, and 10 are substantially similar to prior analysis

291. As shown in the chart below, claims 6, 7, 9 and 10 are substantially the same as claims 2, 3, 11, 17, 19, and 20, except as highlighted and discussed below. Therefore, I incorporate and apply the analysis of those prior claim limitations to those claims.

Claims 6, 7, 9, and 10	Claim Limitations Analysis Incorporated by Reference
[6P] A radio-frequency identification (RFID) tag comprising:	11[pre] A radio-frequency identification (RFID) tag comprising:
[6A] a main antenna that receives a radio-frequency (RF) signal from an RFID reader and wirelessly harvests power from the RF signal; and	11[A] a main antenna that receives a radio-frequency (RF) signal from an RFID reader and wirelessly harvests power from the RF signal; and
[6B] a circuit that is configured to vary a reflection coefficient of the main antenna to transmit a reflected signal to the RFID reader, the reflected signal having a ***high*** reflectance period when an amount of reflectance by the main antenna of the RF signal is greater than a predetermined amount, and a ***low*** reflectance period when an amount of reflectance by the main antenna of the RF signal is lower than the predetermined amount,	11[B] a circuit that is configured to vary a reflection coefficient of the main antenna to transmit a reflected signal to the RFID reader, the reflected signal having a ***first*** reflectance period and a ***second*** reflectance period when an amount of reflectance by the main antenna of the RF signal is different than during the first reflectance period; 17 The RFID tag of claim 11, wherein the amount of reflectance by the main antenna of the RF signal is greater than the predetermined amount during the first reflectance period, and the amount

Claims 6, 7, 9, and 10	Claim Limitations Analysis Incorporated by Reference
	of reflectance by the main antenna of the RF signal is lower than the predetermined amount during the second reflectance period.
[6C] wherein a reflectance of the main antenna is reduced below a predefined amount during the high reflectance period without shorting the main antenna to enable the main antenna for continuous wireless power harvesting while transmitting the reflected signal to the RFID reader, wherein the reflectance of the main antenna ***during the high reflectance period*** is reduced based on a change in a resonant frequency of the main antenna	11[C] wherein a reflectance of the main antenna is reduced below a predefined amount during the first reflectance period without shorting the main antenna to enable the main antenna to continuously harvest power while transmitting the reflected signal to the RFID reader, wherein the reflectance of the main antenna is reduced based on a change in a resonant frequency of the main antenna.
[6D] See below	
7. The RFID tag of claim 6, wherein the predetermined amount is a reflection coefficient magnitude of between ***0.25 and 1.***	2. The RFID tag of claim 1, wherein the predetermined amount is a reflection coefficient magnitude of between ***0 and 0.5.*** 3. The RFID tag of claim 1, wherein the predefined amount is a reflection coefficient magnitude of 0.5.
9. The RFID tag of claim 6, wherein the circuit is an application-specific integrated circuit (ASIC).	19. The RFID tag of claim 11, wherein the circuit is an application-specific integrated circuit (ASIC).
10. The RFID tag of claim 6, wherein the main antenna is a linearly polarized antenna	20. The RFID tag of claim 11, wherein the main antenna is a linearly polarized antenna.

292. For limitation [6B], and similar to the discussion above for claim [1D], the claim limitation recites "high" and "low" reflectance periods rather than "first" and "second" reflectance periods. However, I showed above that the ***second reflectance period***, when Z_1 (an open circuit) is connected, is the ***low reflectance period*** because it is the "matched" condition and the reflectance is 0, and the ***first reflectance period***, when Z_2 (which has an impedance between an open and short circuit) is connected, is the ***high reflectance period*** because that is when the reflectance is greater than 0.

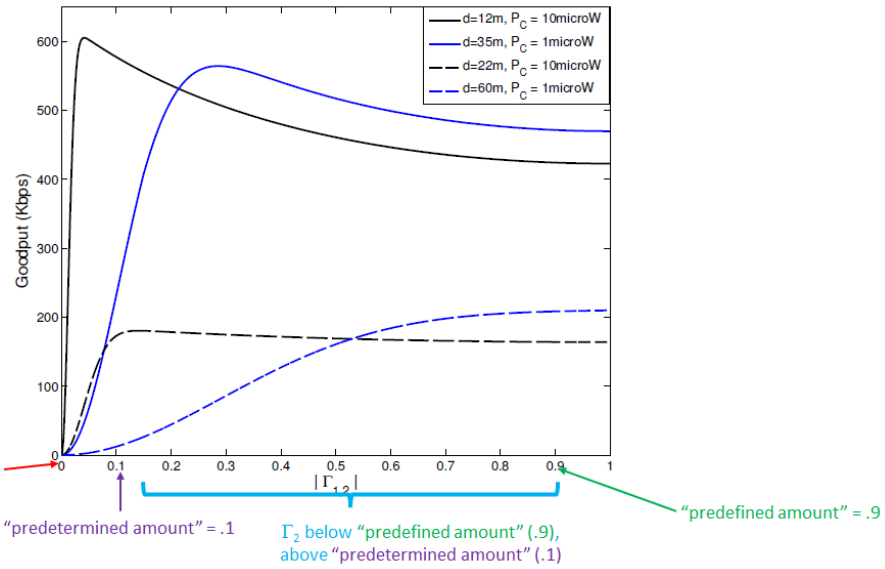


Boyer, Figure 6 (further modified to show Z_2 as antenna loops/separate antenna).

293. Limitation [6C] recites "*during the high reflectance period*." However, the analysis in [11C] applies since the reflectance $|\Gamma_2|$ is the antenna reflectance throughout ("*during*") the **first** (**high**) reflectance period.

294. In addition, the combination of [6B] and [6C] requires $|\Gamma_2|$ greater than a "*predetermined amount*" but below a "*predefined amount*," and $|\Gamma_1|$ to be below

the "*predetermined amount*." As explained above, a POSITA would have chosen any value of Γ_2 for their system, which would have met the "*predefined*" and "*predetermined*" limitations, such as the following example:



295. In addition, claim 7 recites that "*the predetermined amount is a reflection coefficient magnitude of between* ***0.25 and 1.***" Claim 2 recited the "*predetermined amount*" is between 0 and .5. Since the ranges overlap, the same analysis applies—*i.e.*, Boyer teaches coefficients within the range of limitation [6C] for the same reasons discussed for claims 2 and 3.

B. Claim limitation [6D] and claim 8 (Duty Cycle)

296. Claim limitation [6D] recites "*wherein the circuit increases a duty cycle of the low reflectance periods and decreases a duty cycle of the high reflectance periods to increase a time period of wireless power transmission*." Claim

8 further recites "*wherein the circuit increases the duty cycle of the low reflectance periods to greater than 50%.*" As explained below, these claims are obvious over Boyer in view of Kapucu.

1. The combined system

297. As discussed above, Boyer discloses a passive RFID backscatter tag that uses a binary modulator to switch between periods of high and low reflectance by varying the modulation impedance (Z_{mod}), thereby changing the reflectance of the antenna. While Boyer does not expressly discuss the duty cycles of the high and low reflectance periods, Kapucu discloses a "passive UHF RFID tags that use pulse-width modulation (PWM) in backscattering communication." Ex-1009, 1 (Abstract). It would have been obvious to modify Boyer to include this feature.

298. Kapucu describes RFID tags that have a "phase-locked loop (PLL) based sensor interface" to work "with capacitive sensors to reduce the power consumption of the tags." *Id*. Kapucu explains that the "output of the sensor interface is a pulse train whose duty cycle is proportional to the variation in the sensor capacitance value" and that the "pulse train signal controls the backscattering switches that short the antenna terminals." *Id*. "This way the sensor value information is pulse-width modulated and sent to the base station (reader) by backscattering." *Id*. Kapucu shows an example of a pulse-train that has an "arbitrary

duty-cycle," but that still shows that the high reflectance period is a shorter than the low reflectance period. *Id*. at 2.

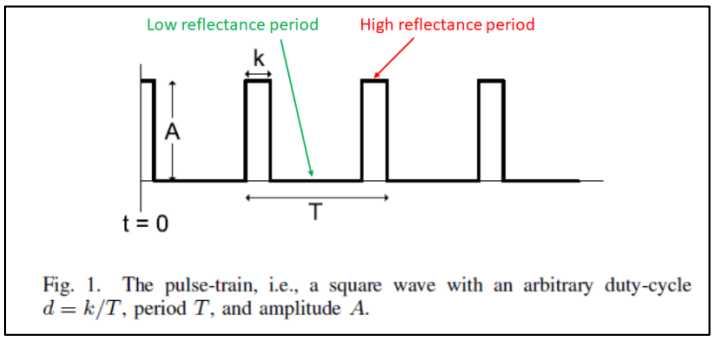


Fig. 1. The pulse-train, i.e., a square wave with an arbitrary duty-cycle $d = k/T$, period T, and amplitude A.

299. Kapucu further teaches how the PWM RFID tag operates using a model of the behavior. "The PWM signal from the waveform generator"—which models the signals received from capacitor sensors—"controls the RF switch, which changes the load seen by the cable between short circuit and the impedance Z_L." *Id*. at 4. This concept is illustrated in the model circuit shown in Figure 4, with a binary modulation switch (green) just as in Boyer:

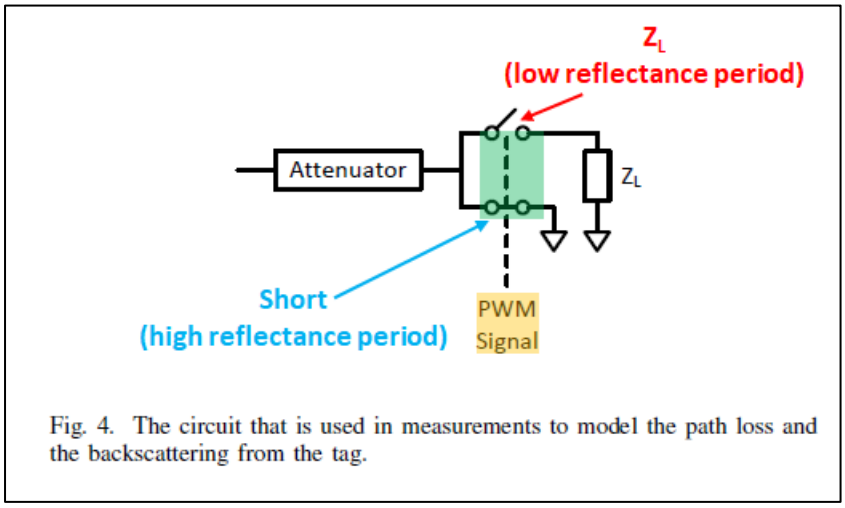


Fig. 4. The circuit that is used in measurements to model the path loss and the backscattering from the tag.

300. In the modified system, Kapucu's capacitive sensors are used as Boyer's "sensors" (shown in blue in the modified Figure 2 below), and Kapucu's PLL interface is used along with the microcontroller (grey) to control the binary modulator switch (green) between the modulator impedances (Z_1 and Z_2) [17] based on the pulse train (PWM, orange) to create the PWM backscattered signals, as taught by Kapucu.

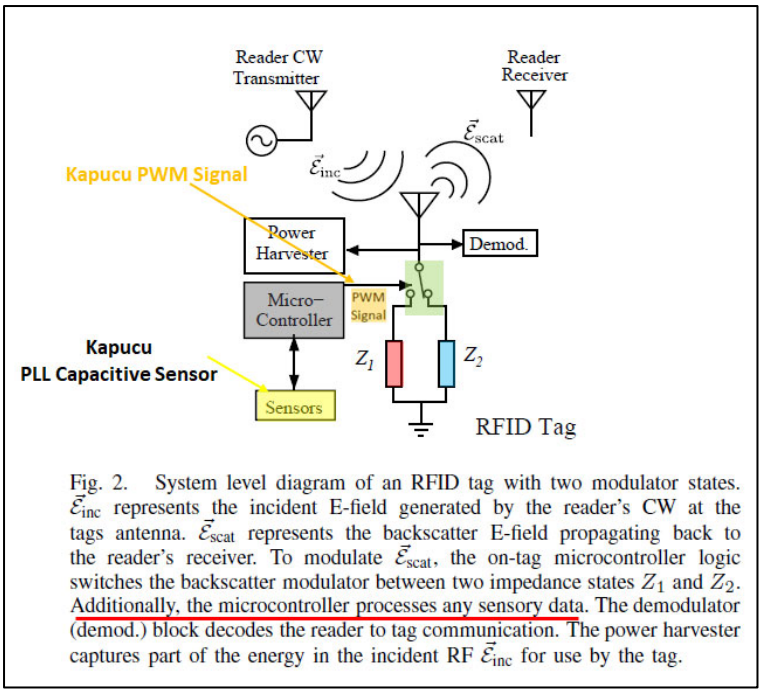


Fig. 2. System level diagram of an RFID tag with two modulator states. $\vec{\mathcal{E}}_{inc}$ represents the incident E-field generated by the reader's CW at the tags antenna. $\vec{\mathcal{E}}_{scat}$ represents the backscatter E-field propagating back to the reader's receiver. To modulate $\vec{\mathcal{E}}_{scat}$, the on-tag microcontroller logic switches the backscatter modulator between two impedance states Z_1 and Z_2. Additionally, the microcontroller processes any sensory data. The demodulator (demod.) block decodes the reader to tag communication. The power harvester captures part of the energy in the incident RF $\vec{\mathcal{E}}_{inc}$ for use by the tag.

[17] Continuing with Boyer's Figure 6 and Section II-C embodiment, Z_1 remains an open circuit (for the matched condition) and Z_2 has a value between an open circuit and a short circuit.

2. A POSITA would have been motivated to modify Boyer and RFID Handbook in view of Kapucu

301. A POSITA would have been motivated to modify Boyer's RFID tag with a reactive impedance (C_{mod}) from RFID Handbook with Kapucu's teachings of PWM of the backscatter communications—including its PLL-based capacitive sensor interface—at least for use with capacitive sensors.

302. First, Kapucu itself motivates the combination by explaining the benefits of integrating PLL sensors into RFID tags like Boyer's Figure 6 and Section II-C embodiment. Kapucu explains that "integration of sensors with passive UHF RFID tags extends the application of RFID technology to many new fields such as environmental monitoring, healthcare, and food quality monitoring." Kapucu, 1. Thus, a POSITA would have been motivated to modify Boyer's RFID tags so that it can operate in these fields and have wider applicability. And when doing so, a POSITA using Boyer's RFID tag would have looked to the art to discover how to implement such an RFID tag and found Kapucu's teachings of using PWM when using sensors.

303. In addition, Kapucu explains that "phase-locked loop (PLL) based sensor interfaces can be used in RFID tags with capacitive sensors to ***reduce*** the power consumption of the tags." Kapucu, 1. As shown above, Boyer teaches that

power was a limiting factor in RFID performance such that increasing power harvesting increased tag performance and range. Thus, a POSITA would have been motivated to include additional techniques that would either harvest more power or, as taught by Kapucu, reduce power consumption to further improve the RFID performance.

304. Second, Boyer is already capable of, and configured to, work with Kapucu's components and teachings. For example, as illustrated in the modified Figure 2 above, Kapucu, like Boyer, includes "sensors," a microcontroller to process the sensor data, and a "switch" is used to modulate the backscattered signal. And like Kapucu, Boyer's RFID backscattering is achieved by varying the load impedance on the antenna to change between the high and low reflectance states. Thus, modifying Boyer would result in an RFID tag that would function in the same way, although improved with Kapucu's lower power and PLL sensors. Therefore, modifying Boyer's Figure 6 and Section II-C RFID passive tag with Kapucu's PWM embodiment (and PLL sensors) would have constituted use of a known technique to improve similar devices in the same way and/or applying a known technique to a known device ready for improvement to yield predictable results.

3. Claims 6 and 8 are obvious

305. Limitation [6D] requires "*wherein the circuit increases a duty cycle of the low reflectance periods and decreases a duty cycle of the high reflectance periods to increase a time period of wireless power transmission." Claim 8 requires "the duty cycle of the low reflectance periods to greater than 50%.*"

306. In the combined system, the duty cycle for the **high** and **low** reflectance periods of the modulated of the backscattered signal are varied based on the sensor data as taught by Kapucu. Specifically, "the output of the sensor interface is a pulse train whose duty cycle is proportional to the variation in the sensor capacitance value." *Id*. Kapucu explains that "[t]he pulse train signal controls the backscattering switches that short the antenna terminals. This way the sensor value information is pulse-width modulated and sent to the base station (reader) by backscattering." *Id*.

307. Kapucu specifically shows that the duty cycle of the **high reflectance period** can be decreased in comparison to the low reflectance period, resulting in a duty cycle of greater than 50% for the **low reflectance period** as shown in the figure below:

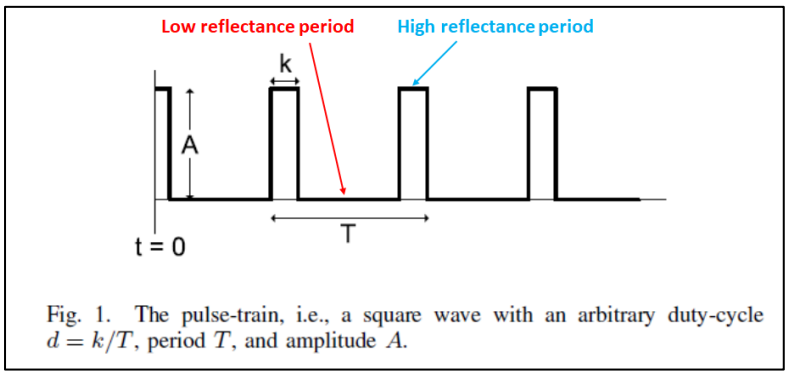


Fig. 1. The pulse-train, i.e., a square wave with an arbitrary duty-cycle $d = k/T$, period T, and amplitude A.

308. Kapucu further discloses how the PWM can vary the duty cycle in through modeling: "The duty-cycle of the PWM signal controlling the RF switch is swept from 20% to 80% . . . . " *Id*., 4. Kapucu shows a specific example in Figure 6 of the "voltage waveforms recorded during the measurements for a 100 kHz PWM signal with ***35% duty cycle***." A POSITA would have therefore understood that in some embodiments, the duty cycle could be any value within the modeled range—i.e. between 20% and 80%.

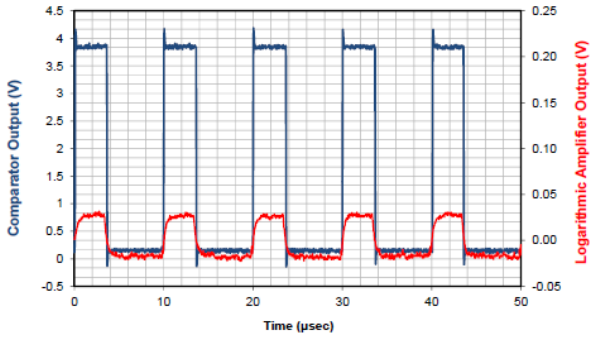


Fig. 6. The measured voltage waveforms at the output of the log-amp (red) and at the output of the comparator (blue) for a 100 kHz PWM signal with 35% duty-cycle. The $50\,mV_{p-p}$ signal at the output of the logarithmic amplifier is amplified to a rail-to-rail signal by the comparator.

309. Therefore, the combined system shows "*wherein the circuit increases a duty cycle of the low reflectance periods and decreases a duty cycle of the high reflectance periods to increase a time period of wireless power transmission*" [6D] and "*the duty cycle of the low reflectance periods to greater than 50%*" [8].

310. Moreover, to the extent someone argues that that duty cycle must be increased "*to increase a time period of wireless power transmission*"—*i.e.*, that this is more than an intended use or outcome—that is disclosed in the combined system as well. As taught by Boyer, the low reflectance period harvests more power and hence a system in which the duty cycle of the low reflectance period is longer increases power harvesting and hence the time of power transmission.

C. The Combined RFID Tag renders Claim 9 obvious

311. *See* claim 19 above.

D. The Combined RFID Tag renders Claim 10 obvious

312. *See* claim 20 above.

XI. GROUND 4: CLAIMS 6-10 ARE OBVIOUS OVER BOYER IN VIEW OF RFID HANDBOOK, KAPUCU, AND WALDNER UNDER 35 U.S.C. §103.

313. Although as shown above in Section VIII, claims 6-10 are rendered obvious over Boyer in view of RF Handbook and Kapucu, to the extent Patent Owner argues that these claims require that a separate antenna or separate length of antenna

must be used to vary the "*reflection coefficient*" [11B.1]/[1D]/[6B]; 2) "*amount of reflectance*" [11B]/[1D]/[6B]; 3) "*reflectance*" [11C.1]/[1D]/[6C], and 4) "*resonant frequency*" [11C.3]/[1G]/[6C] of/by the "*main antenna*," then those claims would have been obvious in the combined system (Boyer in view of RFI Handbook and Kapucu, in further view of Waldner). As explained above in Section VI.C, Z_2 is Waldner's separate antenna or separate length of antenna, and the analysis of these reflectance properties is the same regardless of the reactive (or complex) value of the impedance.

XII. NO SECONDARY CONSIDERATIONS OF NON-OBVIOUSNESS

314. I understand from counsel that the Patent Owner in the underlying district court litigation has not yet identified any evidence with respect to secondary considerations of non-obviousness.

315. To the extent the Patent Owner cites any evidence of sales or any praise or any industry recognition of products that the Patent Owner asserts to implement the claimed invention, I am not aware of any information demonstrating that any increased sales, commercial success, praise, or any other secondary factor (that the Patent Owner may assert) was a result of the particular features recited in the '968 patent's claims. Because the Patent Owner has not yet identified any evidence of secondary considerations, the Patent Owner cannot demonstrate that the limitations

of the claimed invention in particular, as opposed to other features of the products at issue, were the factors that caused any increased sales, praise, or any other asserted secondary considerations.

316. Thus, based on my review of the evidence to date, I can summarize my opinions regarding any alleged secondary considerations of non-obviousness relating to the ’968 patent, as follows:

317. *No commercial success of the claimed invention*. The Patent Owner has not cited any evidence of particular commercial success of products embodying the ‘968 patent as opposed to products that do not embody the ‘968 patent. The Patent Owner has not cited any evidence that any commercial success of any products is particularly a result of the claimed inventions recited in the ‘968 patent’s claims and not due to any other facts.

318. *No long-felt but unsolved need*. The Patent Owner has not cited any evidence of any long-felt need that remained unsolved in the prior art before the ‘968 patent. To the contrary, as discussed above, the prior art solved the problems that the ‘968 patent purports to address.

319. *No failure of others*. The Patent Owner has not cited any evidence of anyone who tried, but failed, to solve the problems addressed by the ‘968 patent. As

shown by my analysis above, there existed prior art references that successfully disclosed and rendered obvious the subject matter claimed by the '968 patent.

320. *No copying of the claimed invention.* The Patent Owner has not cited any evidence that any other party (including TransCore or third parties) ever copied from the '968 patent and its claimed invention.

321. *No unexpected results of the claimed invention*. The Patent Owner has not cited any evidence of unexpected results achieved by the '968 patent's claimed invention. To the contrary, the prior art disclosed the predictable, expected results that show why the '968 patent's claims are obvious as discussed in my Declaration.

322. *No praise for the claimed invention*. The Patent Owner has not cited any evidence of praise for the claimed invention recited in the '968 patent.

323. *No surprise or skepticism at the claimed invention*. The Patent Owner has not cited any evidence that observers were surprised by, or skeptical of, the claimed invention recited in the '968 patent.

324. *No departure from the wisdom of the prior art*. The Patent Owner has not cited any evidence that the claimed inventions of the '968 patent departed from the wisdom of the prior art. The '968 patent claims subject matter that was already present in the prior art, including in the references discussed in my Declaration.

325. Moreover, with respect to the considerations discussed above, I also refer to and incorporate my opinions stated throughout this Declaration, including my analysis showing that the '968 patent is directed to techniques known in the prior art and does not provide any inventive technology.

326. To the extent the Patent Owner at a later date cites or provides any other evidence regarding secondary considerations, including any expert opinions, I reserve the right to supplement my analysis and opinions to comment on it.

XIII. CONCLUSION

327. For at least the preceding reasons, in my opinion, claims 1–20 of the '968 patent would have been obvious to a person of ordinary skill in the art based on the prior art references that I have cited and analyzed above.

328. 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 this proceeding. If required, I will appear for cross-examination at the appropriate time. I reserve the right to offer opinions relevant to the invalidity of the '968 patent claims at issue and/or offer testimony in support of this Declaration.

I hereby declare that all statements made herein of my own knowledge are true and that all statements are 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 18 U.S.C. § 1001.

Dated: May 30, 2024

Respectfully submitted,

Sumit Roy, Ph.D.