

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent of: Dae-Young Kim
U.S. Patent No.: 10,469,119 Attorney Docket No. 50095-0305IP1
Issue Date: November 5, 2019
Appl. Serial No.: 15/989,033
Filing Date: May 24, 2018
Title: MAGNETIC MOUNT FOR ELECTRONIC DEVICES

DECLARATION OF DR. REGAN ZANE

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(i)	Element [12]: The case of claim 1, further comprising a soft protective cover which comprises a back panel to cover a back portion of the electronic device, and a side wall extending from a top surface of the back panel along edges of the back panel, wherein the hard protective cover is constructed to removably mount over the soft protective cover.	122
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LISTING OF CLAIMS

Claim 1	
[1pre]	A case for an electronic device wherein the electronic device has a receiver coil for wireless charging constructed within the electronic device and the receiver coil is formed in between an inner boundary and an outer boundary, the case comprising:
[1a]	a hard protective cover constructed to receive the electronic device therein wherein the hard protective cover has a recess which faces the electronic device and the hard protective cover is external with respect to the electronic device; and
[1b]	a metal plate constructed to be received in the recess of the hard protective cover,
[1c]	wherein the metal plate is constructed to enable magnetic retention or attachment of the case to a support having a magnet,
[1d]	wherein the metal plate has a rounded concave edge,
[1e]	wherein the metal plate received in the recess is positioned to substantially allow magnetic waves to pass through the area formed by the inner boundary.
Claim 2	
[2]	The case of claim 1, wherein the metal plate does not overlap with an orthographic parallel projection of the area formed by the inner boundary onto a projection plane of the metal plate.
Claim 3	
[3]	The case of claim 1, wherein the inner boundary and the outer boundary are substantially circular.

Claim 4	
[4]	The case of claim 1, wherein the rounded concave edge substantially symmetrically aligns to respective orthographic parallel projections of the inner boundary and the outer boundary onto a projection plane of the metal plate.
Claim 6	
[6]	The case of claim 4, wherein the rounded concave edge is placed outside an orthographic parallel projection of the outer boundary onto a projection plane of the metal plate.
Claim 7	
[7a]	The case of claim 1, wherein the metal plate is substantially rectangular with a first side having the rounded concave edge,
[7b]	wherein the metal plate has third and fourth sides that are substantially parallel to each other and has a second side that is substantially parallel to the first side.
Claim 8	
[8]	The case of claim 7, wherein the metal plate has rounded corners.
Claim 10	
[10]	The case of claim 1, wherein the metal plate is attached to the hard protective cover by an adhesive.
Claim 11	
[11]	The case of claim 1, wherein the hard protective cover further comprises a surrounding recess which surrounds the recess and slopes away from a flat surface of the hard protective cover towards the recess forming a cavity.
Claim 12	

[12]	The case of claim 1, further comprising a soft protective cover which comprises a back panel to cover a back portion of the electronic device, and a side wall extending from a top surface of the back panel along edges of the back panel, wherein the hard protective cover is constructed to removably mount over the soft protective cover.
Claim 13	
[13pre]	A metal plate for magnetically mounting an electronic device or a case with an electronic device installed therein wherein the electronic device has a receiver coil for wireless charging constructed within the electronic device and the receiver coil is formed in between an inner boundary and an outer boundary, the metal plate comprising:
[13a]	a rounded concave edge,
[13b]	wherein the metal plate is constructed to be attachable to the electronic device or the case,
[13c]	wherein the metal plate is constructed to enable magnetic retention or attachment of the electronic device to a support having a magnet,
[13d]	wherein the metal plate attached to the electronic device or the case is positioned to substantially allow magnetic waves to pass through the area formed by the inner boundary.
Claim 14	
[14]	The case of claim 13, wherein the metal plate does not overlap with an orthographic parallel projection of the area formed by the inner boundary onto a projection plane of the metal plate.
Claim 15	
[15]	The case of claim 13, wherein the inner boundary and the outer boundary are substantially circular.
Claim 16	

[16]	The case of claim 13, wherein the rounded concave edge, the inner boundary, and the outer boundary are substantially symmetrical with respect to a same line
Claim 18	
[18]	The case of claim 16, wherein the rounded concave edge is placed outside an orthographic parallel projection of the outer boundary onto a projection plane of the metal plate.
Claim 19	
[19a]	The case of claim 13, wherein the metal plate is substantially rectangular with a first side having the rounded concave edge, and
[19b]	the metal plate has rounded corners,
[19c]	wherein the metal plate has third and fourth sides that are substantially parallel to each other and has a second side that is substantially parallel to the first side.

I, Regan Zane, Ph.D., declare as follows:

I. INTRODUCTION

1. I have been retained as a technical expert by counsel on behalf of Apple Inc. (“Apple”/“Petitioner”). I understand that Apple is requesting that the Patent Trial and Appeal Board institute an *inter partes* review (“IPR”) proceeding with respect to U.S. Patent No. 10,469,119 (“the ’119 patent”) (EX1001).

2. I have been asked to provide my independent analysis of the ’119 patent in light of certain prior art publications, and I have done so based on my personal knowledge and experience.

3. I am not, and never have been, an employee of Apple. I received no compensation for this Declaration beyond my normal hourly compensation based on my time actually spent analyzing the ’119 patent, the prior art publications cited below, and various issues related thereto. I will not receive any added compensation based on the outcome of any IPR or other proceeding involving the ’119 patent.

II. QUALIFICATIONS

4. In formulating my opinions, I have relied on my knowledge, training, and experience in the relevant field. My education and experience are described more fully in the attached curriculum vitae (Appendix A). For ease of reference, I have highlighted certain information below.

5. I have more than 25 years of experience in industry and academia as an electrical engineer in the field of power electronics. My work over the years includes extensive experience developing wireless charging solutions for electronic devices and systems, and I am recognized internationally as a leading expert in the field. For example, I was selected by the U.S. National Science Foundation as the Founding Director of the NSF ASPIRE Engineering Research Center, a program with more than \$150M in research funding for wireless charging of electric vehicles, I recently served the General Chair for the IEEE Wireless Power Transfer Conference and Expo (WPTCE), the world's premier conference for wireless charging of electronic devices, and I have been contracted by numerous companies and government agencies to lead or support development and hardware validation of devices with wireless charging.

6. I received my Bachelor of Science degree in Electrical Engineering (BSEE) from the University of Colorado at Boulder in 1996. In 1998, I received a Master of Science degree in Electrical Engineering (MSEE) from the University of Colorado at Boulder. In 1999, I received a Doctor of Philosophy (Ph.D.) degree in electrical engineering from the University of Colorado at Boulder. My Ph.D. dissertation research focused on the design of low-cost, high performance custom integrated circuit (IC) controllers and gate drives for isolated AC-to-DC power converters and power management circuitry. In 1999, I joined the Corporate

Research and Development Center at General Electric (GE) as a Senior Research Scientist. At GE, I developed and commercialized custom integrated circuits for a wide range of power applications including multiple generations of integrated power controllers for compact fluorescent and high intensity discharge lamps and portable medical devices. These designs included gate drive and control circuits for primary and secondary side controllers. In 2001, I joined the Department of Electrical, Computer, and Energy Engineering at the University of Colorado at Boulder as an Assistant Professor. I received tenure and was promoted to Associate Professor in 2008. In 2012, I became a Full Professor with a USTAR endowment in the Department of Electrical and Computer Engineering at Utah State University. There, I founded and continue to direct the Electric Vehicle & Roadway (EVR) Research Facility and Test Track, the USU Power Electronics Lab (UPEL), and the Battery Limits and Survivability Test (BLAST) lab. In 2016, I formed and launched the multi-campus industry sponsored Center for Sustainable Electrified Transportation (SELECT), and in 2020, I led the team to receive the National Science Foundation's (NSF's) highest award for international center level research and became the Director of the NSF Engineering Research Center for Advancing Sustainability through Powered Infrastructure for Roadway Electrification (ASPIRE ERC). The ASPIRE ERC includes 10 universities, more than 80 faculty and 250 students, and over 70 industry and innovation sponsors from automotive OEMs, Tier 1 component

suppliers, utilities, battery manufacturers, national laboratories, and a wide range state, government, and non-profit agencies. In 2018, I received the David G. and Diann L. Sant Endowed Professorship at Utah State University. Since 2006, I have served as an Associate Editor with IEEE Transactions on Power Electronics. In addition, since 2013 I have served as an Associate Editor for the IEEE Journal of Emerging and Selected Topics in Power Electronics. I have served as conference chairman, co-chair, session chair, and committee member for numerous professional conferences in power electronics over the past 20 years and maintained active participation as a journal article reviewer and elected professional society leader. I have served as a member of multiple standards committees through the IEEE and the Society of Automotive Engineers (SAE), and currently serve as co-chair of the SAE J2954/3 subteam on wireless power transfer for battery charging on electric vehicles. In 2025, I was elected an IEEE Fellow, which is the highest grade of membership offered by the IEEE. This distinction recognizes individuals who are among the top one-tenth of one percent (0.1%) of IEEE membership for extraordinary accomplishments in the field of electrical engineering. I also received Inventor of the Year and Researcher of the Year awards for my work related to wireless charging and power electronics.

III. LEGAL PRINCIPLES

7. In forming my analysis and conclusions expressed in this Declaration, I have applied the legal principles described in the following paragraphs, which were provided to me by counsel for the Petitioner.

A. Person of Ordinary Skill in the Art

8. I understand that the factors considered in determining the ordinary level of skill in a field of art include: the level of education and experience of persons working in the field; the types of problems encountered in the field; the teachings of the prior art regarding solutions to such problems; and the sophistication of the technology at the time of the alleged invention. I understand that a person of ordinary skill in the art (“POSITA”) is not a specific real individual, but rather is a hypothetical individual having the qualities reflected by the factors above and knowledge of all relevant prior art references, including the references I cite below.

B. Obviousness

9. I have been informed that a patent claim is invalid as “obvious” in light of one or more prior art references if it would have been obvious to a POSITA at the time of the alleged invention, taking into account (1) the scope and content of the prior art, (2) the differences between the prior art and the claims, (3) the level of ordinary skill in the art, and (4) any so called “secondary considerations” of non-

obviousness, which include: (i) “long-felt but unresolved need” for the claimed invention, (ii) commercial success attributable to the claimed invention, (iii) unexpected results of the claimed invention, and (iv) “copying” of the claimed invention by others.

10. While I do not know the exact date that the alleged invention of the ’119 patent was made, I do know that the ’119 patent’s earliest claimed priority date is May 25, 2017. For purposes of my obviousness analysis, I have applied a date of May 25, 2017 as the date of the alleged invention (“Critical Date”), although in many cases the same analysis would hold true even if the date of the alleged invention were earlier or later.¹

11. I have been informed that a claim can be obvious in light of a single prior art reference or multiple prior art references. To be obvious in light of a single prior art reference or multiple prior art references, there must be a reason that would have prompted a POSITA to modify or supplement the single prior art reference, or to combine two or more references, in a manner that provides the elements of the claimed invention. This reason may come from a teaching, suggestion, or

¹ Note, however, that I do not concede that the ’119 patent is entitled to its earliest claimed priority date.

motivation to combine, or may come from the reference(s) themselves, the knowledge or “common sense” of a POSITA, or from the nature of the problem to be solved, and this reason may be explicit or implicit from the prior art as a whole. I have been informed that, under the law, the combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results. I also understand it is improper to rely on hindsight in making the obviousness determination.

12. I understand that an obviousness determination also requires that a POSITA would have had a reasonable expectation of success. This concept has been explained to me as relating to the relative likelihood or predictability—from the perspective of a POSITA—of successfully modifying the prior art in a manner that would meet the claimed limitations of the patent being challenged (here the ’119 patent). I understand that the expectation of success need only be “reasonable” and, thus, does not require the absolute certainty gleaned from physically creating the proposed prior art modification.

C. Claim Interpretation

13. I understand that, for purposes of my analysis in this *inter partes* review proceeding, the terms appearing in the patent claims should be interpreted according to their “ordinary and customary meaning.” In determining the ordinary and

customary meaning, I understand that the words of a claim are first given their plain meaning that those words would have had to a person of ordinary skill in the art at the time of the alleged invention. I also understand that the structure of the claims, the specification and file history may be used to better construe a claim. Moreover, I understand that even treatises and dictionaries may be used, albeit under limited circumstances, to determine the meaning attributed by a person of ordinary skill in the art to a claim term.

IV. MATERIALS CONSIDERED

14. My analysis in this Declaration is based on my knowledge and experience. Based on my above-described qualifications in Section II, the Patent Trial and Appeal Board should consider me to be an expert in the field. Also, based on my experiences, I understand and know of the capabilities of persons of ordinary skill in this field.

15. As part of my independent analysis for this Declaration, I have considered the following: the '119 patent (EX1001) and its prosecution history (EX1002); the background knowledge/technologies that were commonly known to persons of ordinary skill; my own knowledge and experience gained from my work in the field; my experience in teaching and advising others in this field; and my

experience working with others involved in this field. In addition, I have analyzed the following publications and materials:

EX1004	U.S. Patent Pub. No. 2016/0294427 (“Wojcik”)
EX1005	U.S. Patent Pub. No. 2016/0003270 (“Franklin”)
EX1006	MobileReviewsEh, Spigen Thin Fit Hybrid Review (YouTube, Feb. 28, 2016), https://www.youtube.com/watch?v=fzymdpDZ1kc (“Spigen”)
EX1007	U.S. Patent Publication No. 2011/0050164 (“Partovi”)
EX1008	Wikipedia Contributors, Neodymium (Wikipedia, Mar. 11, 2016), https://web.archive.org/web/20160311013603/https://en.wikipedia.org/wiki/Neodymium
EX1009	3M Double Coated Tape 9448A Data Sheet (2013)
EX1010	U.S. Patent Publication No. 2014/0265767 (“Fathollahi”)
EX1011	U.S. Provisional Patent Application No. 62/511,280
EX1012	U.S. Patent Pub. No. 2013/0093388 (“Partovi ’388”)
EX1013	U.S. Patent Publication No. 2012/0235636 (“Partovi ’636”)
EX1014	U.S. Patent Publication No. 2014/0354218 (“Kaynar”)
EX1015	U.S. Patent Publication No. 2011/0192857 (“Rothbaum”)
EX1016	U.S. Patent Publication No. 2012/0151973 (“Cheung”)
EX1017	U.S. Patent Publication No. 2011/0228458 (“Richardson”)
EX1029	System Description Wireless Power Transfer, Vol. 1, Pt. 1, v. 1.0.1 (October 2010)

16. Note that my citations to non-patent literature throughout this Declaration reference the absolute page number added to the exhibit (as opposed to the original pagination of the document). For patent literature, I’ve used the column/line numbers or paragraph numbers. Note also that, unless I’ve indicated otherwise, all emphasis in any quoted text are ones I have added.

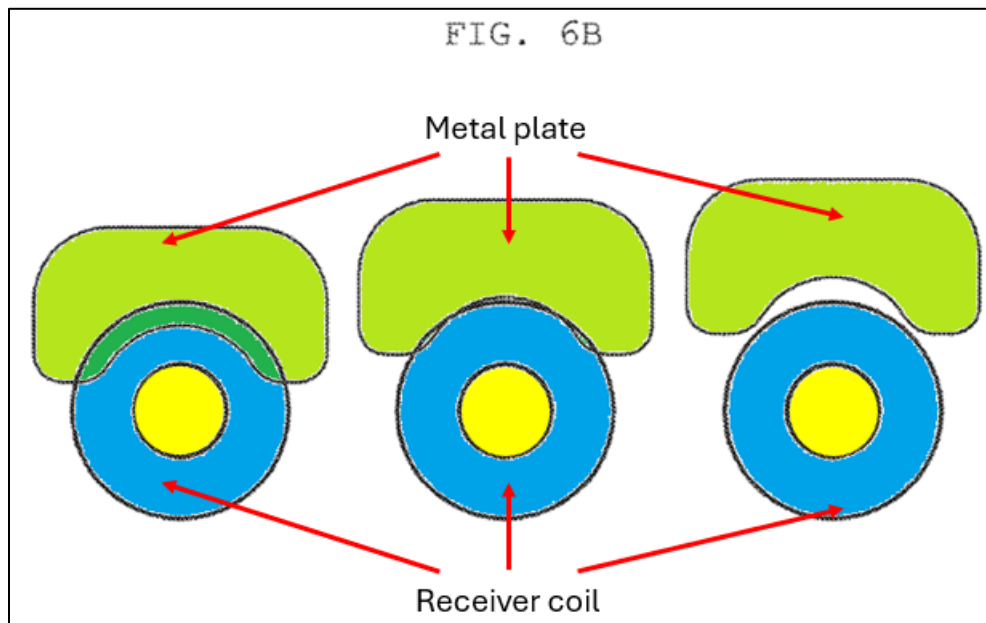
17. Although I cite and quote to selected portions of various references in this Declaration, the reader should understand that these citations are representative examples. A POSITA would have viewed each reference in its entirety and in combination with other references. Accordingly, I intend the references identified in this Declaration to be viewed as incorporated in their entireties.

V. THE '119 PATENT

A. Pertinent Disclosure

18. The '119 Patent purportedly provides “a case for an electronic device wherein the electronic device has a receiver coil for wireless charging and the receiver coil is formed in between an inner circle and an outer circle,” the case including “a hard protective frame constructed to receive the electronic device therein wherein the hard protective frame faces the electronic device; and a metal plate constructed to be received in the recess.” EX1001, Abstract.

19. The '119 Patent explains that the “metal plate is constructed to enable magnetic retention or attachment of the case to a support having a magnet.” EX1001, Abstract. Various configurations of the metal plate, including its shape and position relative to the receiver coil of the electronic device, are contemplated. EX1001, Abstract, FIGs. 1A-1D, 2A-2B, 3A-3C, 4A-4C, 6B, 12, 15, 16, 18. For instance, as shown in Figure 6B below. EX1001, 2:57-58, FIG. 6B.



EX1001, FIG. 6B.

20. Figure 6B, as highlighted above, shows three possible metal plate-receiver coil configurations where the metal plate is highlighted light green, the receiver coil is highlighted blue, and the interior of the receiver coil is highlighted yellow. EX1001, 2:54-55, FIG. 6B. At left, a rounded concave edge of the metal plate “may be placed in between the inner boundary [] and the outer boundary []” of the receiver coil. EX1001, 4:26-29. In the middle, the “rounded concave edge [] [of the metal plate] may overlap with the outer boundary” of the receiver coil. EX1001, 4:29-31. At right, the “rounded concave edge [] [of the metal plate] may be placed outside the outer boundary” of the receiver coil. EX1001, 4:31-32.

21. With respect to the benefits of such a configuration, the '119 Patent explains:

The metal plate [] of the present invention helps a case with an electronic device installed therein that is magnetically attracted and retained by the support having a magnet, and at the same time, the case having the metal plate [] does not substantially impede or prevent wireless charging of the electronic device. In addition, the metal plate does not substantially impede or prevent wireless charging of the electronic device, and thus a user does not have to remove the metal plate for wireless charging.

EX1001, 6:31-39.

B. Prosecution History

22. The '119 Patent issued November 5, 2019, from U.S. Patent Application No. 15/989,033, which was filed May 24, 2018. EX1001, Cover.

23. During prosecution, Examiner Trandai issued a first non-final Office action on August 6, 2018, rejecting the majority of claims as obvious over a combination of U.S. Patent Publication No. 2011/0050164 (EX1007) ("Partovi") and U.S. Patent Publication No. 2012/0235636 (EX1013) ("Partovi '636"), and the remaining claims as obvious over the same Partovi and Partovi '636 combination, further in view of U.S. Patent Publication No. 2012/0151973 (EX1016) ("Cheung") or U.S. Patent Publication No. 2011/0228458 (EX1017) ("Richardson"). EX1002, 81-92.

24. Responsive to the rejections, the Applicant argued alleged distinctions, and the Examiner then issued a January 17, 2019 final Office action rejecting the claims based at least on a new combination of U.S. Patent Publication No. 2014/0354218 (EX1014)(“Kaynar”) and U.S. Patent Publication No. 2011/0192857 (EX1015)(“Rothbaum”). EX1002, 113-125, 127-137.

25. The Applicant subsequently argued that the identified prior art references failed to teach or suggest “wherein the metal plate has a rounded concave edge, wherein the metal plate received in the recess is positioned to substantially allow magnetic waves to pass through the area formed by the inner boundary.” EX1002, 156-171. The Examiner allowed the claims on June 17, 2019, and in doing so failed to offer an express statement of reasons for allowance. EX1002, 180-184.

26. The features argued by the Applicant, which apparently provided the basis for the unexplained allowance, are plainly disclosed by U.S. Patent Application Publication No. 2016/0003270A1 (“Franklin”).

27. And both Wojcik and Franklin were of record during prosecution, but were apparently overlooked by the Examiner. *See, e.g.*, EX1002, 91 (citing Wojcik and Franklin), 93 (citing Wojcik), 94 (citing Franklin). And, as demonstrated below, a POSITA would have found the subject matter of at least the ’119 Patent’s independent claims obvious over their predictably combined disclosures. For at least

these reasons, in my opinion, the '119 Patent issued as a consequence of material error.

C. Claim Construction

28. I have been asked to provide my interpretation of the following terms of the '119 patent set forth below. In providing the following interpretations, I have carefully considered and applied the claim construction standard referred to in §III.C above. Below, I offer my analysis of how a POSITA would have construed certain claim features of the '119 patent:

Claim Term	Construction
“A case for an electronic device wherein the electronic device has a receiver coil for wireless charging constructed within the electronic device and the receiver coil is formed in between an inner boundary and an outer boundary, the case comprising:” (Claims 1-4, 6-8, 10-12)	The preamble is limiting.
“A metal plate for magnetically mounting an electronic device or a case with an electronic device installed therein wherein the electronic device has a receiver coil for wireless charging constructed within the electronic device and the receiver coil is formed in between an inner boundary and an outer boundary, the metal plate comprising:” (Claims 13-16, 18-19)	The preamble is limiting.

VI. PERSON OF ORDINARY SKILL IN THE ART

29. A person of ordinary skill in the art (“POSITA”) relating to the subject matter of the ’119 Patent as of the Critical Date would have had (1) at least a bachelor’s degree in electrical engineering or a related field, and (2) at least two years of industry experience in consumer electronics or similar systems. Additional graduate education could substitute for professional experience, and *vice versa*.

30. My analysis and conclusions expressed in this Declaration are based on the perspective of a POSITA having this level of knowledge and skill. My education, technical expertise and personal knowledge discussed in Section II shows that I meet the qualifications of a POSITA.

VII. OVERVIEW OF CONCLUSIONS FORMED

31. This Declaration explains the conclusions that I have formed based on my independent analysis. To summarize those conclusions: Based upon my knowledge and experience, and my review of the materials listed above, I believe that Claims 1-4, 6-8, 10, 13-16, and 18-19 are obvious in view of Wojcik-Franklin (Ground 1), that Claims 1-4, 6-8, 10-11, 13-16, and 18-19 are obvious in view of Spigen-Partovi (Ground 2A), and that Claim 12 is obvious in view of Spigen-Partovi-Fathollahi (Ground 2B).

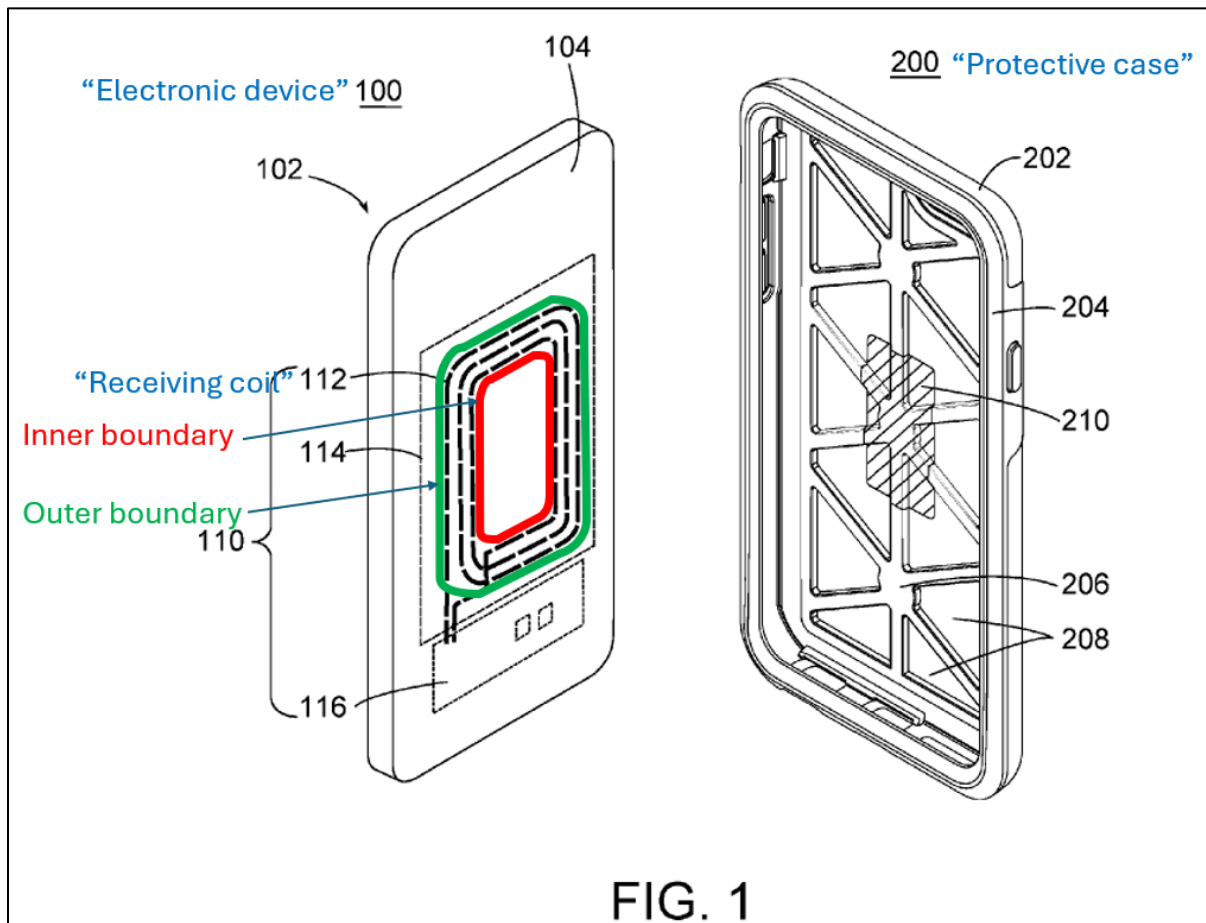
VIII. GROUND 1: Wojcik-Franklin Renders Obvious Claims 1-4, 6-8, 10, 13-16, and 18-19

A. Wojcik (EX1004)

32. Wojcik discloses an “[e]lectronic [d]evice [c]ase with [i]nductive [c]oupling [f]eatures.” EX1004, Title. Specifically, Wojcik describes a “protective case” that “includes a shell for receiving and at least partially covering an electronic device.” EX1004, Abstract; *see id.*, claim 1, [0022], [0023], FIGs. 1, 4A. Wojcik explains that the case includes a core that “is affixed to the back portion of the shell at a location that coincides with a center region of the wireless charging coil of the wireless charging circuitry of the installed electronic device.” EX1004, Abstract; *see id.*, claim 1 (“protective case for an electronic device having wireless charging circuitry and a wireless charging coil proximate a back surface of the electronic device”).

33. As shown in Wojcik’s FIG. 1 (reproduced below), the “electronic device 100” has a “receiving coil 112” that is formed in between an inner boundary (shown in red) and an outer boundary (shown in green). EX1004, FIG. 1. The “receiving coil 112” is part of a “wireless charging circuit 110” that “allows electronic device 100 to be charged and/or powered from an external device (not pictured) without having to attach a cable or other type of electromechanical connector between electronic device 100 and the external device.” EX1004, [0022]

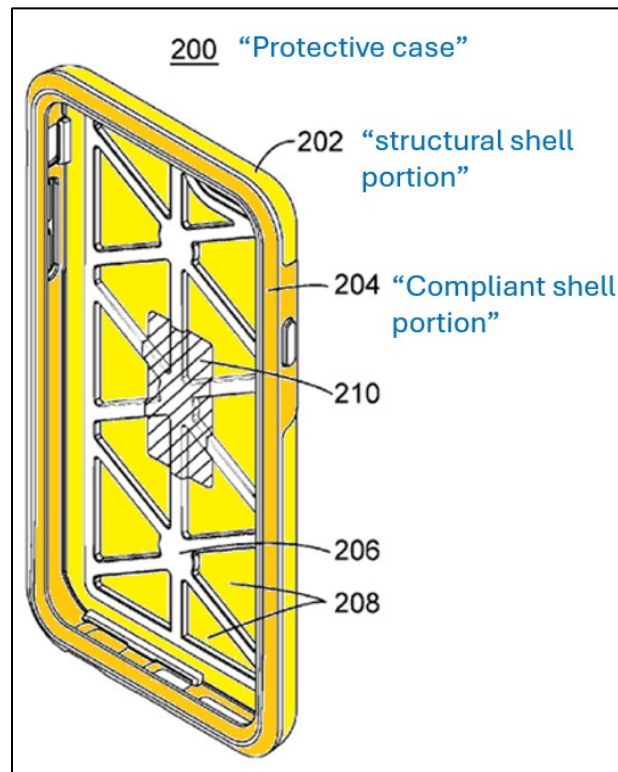
(Wireless charging circuit 110 may include a receiving coil 112 having a ferrite backing 114, and a printed circuit board 116 inside a housing 102 of electronic device 100).



EX1004 (Wojcik), FIG. 1 (annotated, highlighted).

34. The “protective case 200” includes a “structural shell portion 202 and a compliant shell portion 204,” where the shell portion 202 “provide[s] some degree of stiffness or rigidity to protective case 200 and may also provide some resistance to abrasion,” as illustrated below in excerpted Figure 1. EX1004, [0023]. “Protective case 200 may further include, but does not require, an internal cushion

layer 206 which may provide a softer or more compliant surface against one or more surfaces of the electronic device 100 rests when electronic device 100 is inserted in protective case 200.” EX1004, [0023].



EX1004 (Wojcik), FIG. 1 (annotated, highlighted, excerpted); *see also id.*, FIG. 2.

35. Wojcik’s “protective case 200” further includes a “a high magnetic permeability material, such as ferrite 210, disposed to correspond to a center of the receiving coil 112.” EX1004, [0025], FIG. 1. Wojcik explains that “[a] high magnetic permeability material, such as a ferrite (or another material having ferromagnetic properties), may thus be applied as a sheet backing to the antenna/coil in a wireless power transfer circuit to prevent effects of the magnetic field on other

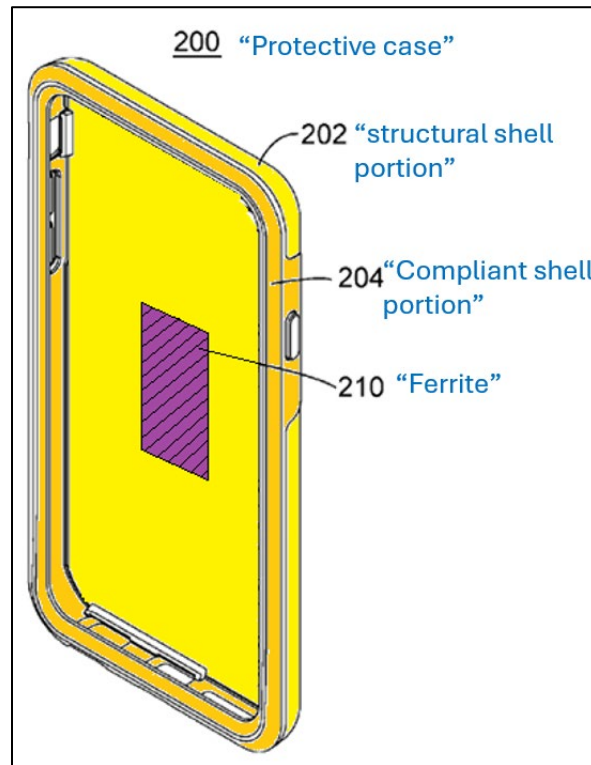
circuitry, and vice versa.” EX1004, [0016]. “[A] ferrite material may also be used as a core (e.g., in or near the center of) a power transmitting coil”; this “placement concentrates, and to a degree directs or steers the magnetic flux, increasing the magnetic coupling efficiency or the efficiency of the magnetic induction power transfer, between the transmitting and receiving coils.” EX1004, [0016].

36. Wojcik explains that, “[i]n FIG. 1, ferrite 210 is implemented in part of the rigid shell portion 202 and in part of cushion layer 206,” such that the ferrite is received in between the protective cover (rigid shell portion 202) and the electronic device. EX1004, [0027], FIG. 1. Wojcik further explains that “[f]errite 210 may be affixed to, adhered to, attached to, and/or *embedded in any portion of protective case 200*,”² adding that “[i]n some situations, ferrite 210, or another material having high magnetic permeability relative [to] other components of protective case 200, may be molded into, molded with, or *molded inside of one of the components of protective case 200 such that it is not externally visible on protective case 200*.” EX1004, [0028].

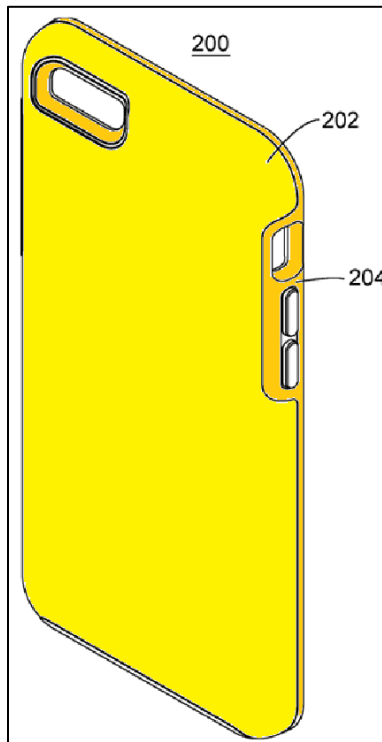
37. Thus, as modified by Wojcik’s own description of its alternative embodiment, ferrite 210 is molded inside one of the components of the protective

² Unless otherwise indicated, emphases throughout this Declaration are added.

case (e.g., the rigid shell portion 202), “such that it is not externally visible on protective case 200.” *Id.* This is illustrated below, where optional cushion layer 206 is not shown (or not included), per Wojcik. EX1004, [0023] (“Protective case 200 may further include, but does not require, an internal cushion layer 206”).



EX1004, FIG. 1 (annotated excerpt, modified per Wojcik at [0023]).



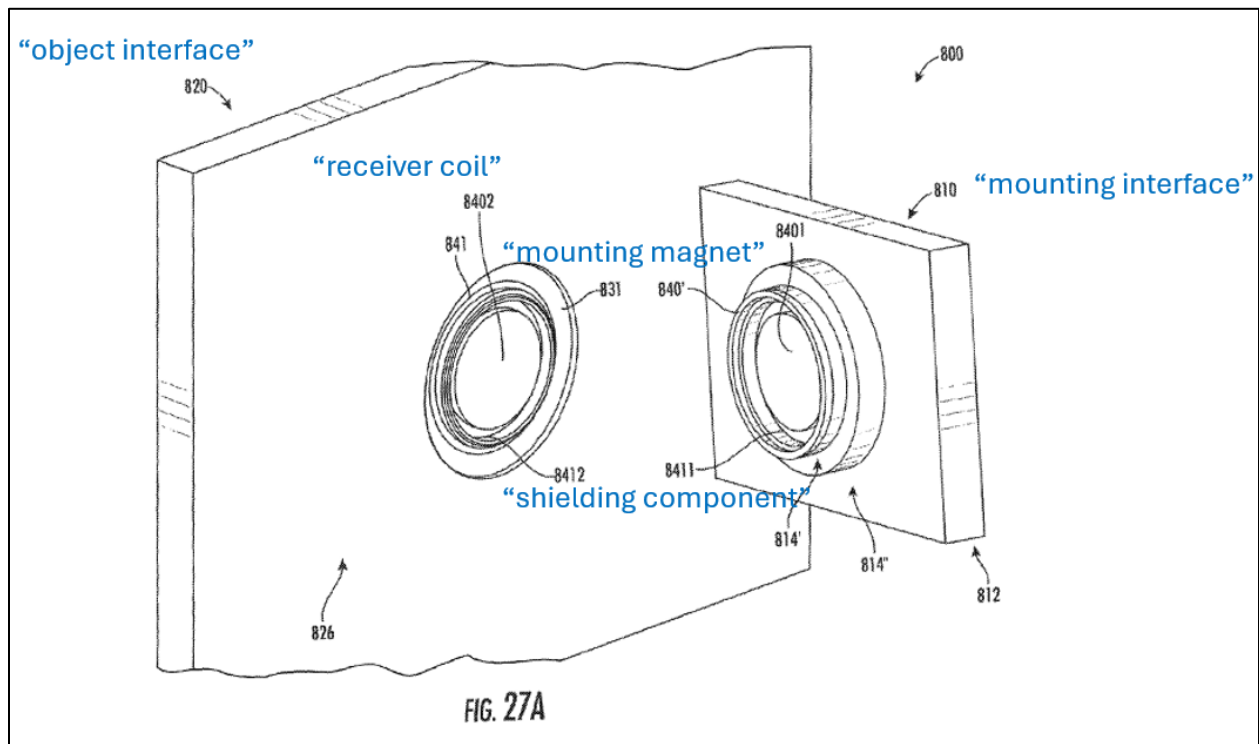
EX1004 (Wojcik), FIG. 3 (annotated, highlighted, modified).

38. Wojcik further invites the inclusion of additional magnetic material within its protective case to enhance magnetic coupling for wireless charging, stating for example that the “protective case may also include a ferrite core, *or other high magnetic permeability material insert*, core, material, or region *co-molded or otherwise formed in a back wall of the protective case to enhance magnetic coupling of the wireless charging circuitry.*” EX1004, [0038]; *see also id.*, [0039] (“The central ferrite, or other high magnetic permeability material, and/or side portion ferrites may also *enhance magnetic coupling with such external device by increasing the magnetic coupling factor...*”), [0040] (“The central ferrite, or other high magnetic permeability material, and/or side portion ferrites may also enhance

magnetic coupling with such external device by increasing the magnetic coupling factor, concentrating the magnetic flux, and/or constraining or steering the magnetic field”).

B. Franklin (EX1005)

39. Franklin describes an apparatus for mounting an electronic device that allows for wireless charging through the mount. EX1005, Abstract, [0184]. As illustrated in FIGs. 27A-27B (FIG. 27A reproduced below), Franklin discloses (1) an object interface 820 with magnets 831, 841 and receiver coil 8402 and (2) a mounting interface 810 with magnet 840' and transmitter coil 8401. EX1005, [0336]-[0338], [0342]-[0344], FIGs. 27A-27B.



EX1005 (Franklin), FIG. 27A (annotated); *see also id.*, FIG. 27B.

40. Like Wojcik, Franklin describes a system that allows for wireless charging of an electronic device using a receiver coil included within the device. EX1005, [0334]-[0336], [0342] (describing “an inductive charging relationship” established between the transmitter coil 8401 and the receiver coil 8402, with “an engagement force produced between the [magnets]” maintaining the position of the receiver coil 8402 “within the charging range of the transmitter coil” 8401), [0054] (“The term ‘magnet’ refers to any material or component that responds to a magnetic field”); EX1004, Abstract (“The core is affixed to the back portion of the shell at a location that coincides with a center region of the wireless charging coil of the wireless charging circuitry of the installed electronic device,” which “increases

magnetic coupling between the wireless charging coil of the installed electronic device and a source charging coil when the protective case is placed in proximity to the source charging coil”), [0038] (“The protective case may also include a ferrite core, or other high magnetic permeability material insert, core, material, or region co-molded or otherwise formed in a back wall of the protective case to enhance magnetic coupling of the wireless charging circuitry”), [0039], [0040]. Franklin further describes simultaneously using magnets to adhere and promote correct alignment between the electronic device and a charger. EX1005, [0334]-[0336], [0342], [0054].

41. Franklin expresses a concern, however, that “ferromagnetic components ... may interfere with the wireless charging field.” EX1005, [0344]; *see also id.*, [0349] (“a mounting apparatus and/or an object interface may be configured (e.g., via the configuration of shielding materials, flux guides, caps, etc.) so that interference from ferromagnetic components and/or magnetic fields comprised by the mounting apparatus and/or the object interface may be substantially prevented”).

42. To address this concern, Franklin explains that both the object interface 820 and the mounting interface 810 include respective magnets to achieve an engagement force and respective shielding components 8412, 8411 that are

“configured so that the enclosure comprised by the second shielding component 8412 and the first shielding component 8411 may be configured to guide, block, divert, etc. magnetic fields and/or lines associated with ferromagnetic components of the mounting apparatus (e.g., a mounting magnet, etc.) that may interfere with the wireless charging field” between the receiver coil 8402 of the object interface 820 and the mounting interface 810. EX1005, [0344].

43. Franklin describes, for example, that “the second shielding component 8412 may be configured to agree with the first shielding component 8411 so that the receiver coil component 8402 and the transmitter coil component 8401 may be substantially fully enclosed by the second shielding component 8412 and the first shielding component 8411 when the object interface 820 is fully engaged with the mounting apparatus 810,” as shown in FIGS. 27A and 27B. EX1005, [0344]. Franklin adds that “[s]ubstantially fully enclosing the receiver coil component 8402 and the transmitter coil component 8401 within an enclosure comprised by the second shielding component 8412 and the first shielding component 8411 may isolate a wireless charging field (e.g., a magnetic field) that is associated with the wireless charging relationship relative to other ferromagnetic components and/or magnetic fields supported by or associated with the mounting apparatus 810 and/or the object interface 820.” EX1005, [0344].

44. This solution isolates the wireless charging fields from the additional components for mounting, and the design and shielding components not only avoid interference, they directly support flux paths by shaping and enhancing the coupling of fields for wireless charging. This is consistent with Wojcik’s teachings. *See* EX1004, [0016], [0038] (“ferrite core, or other high magnetic permeability material insert, ... to enhance magnetic coupling”), [0039], [0040].

45. “Thus, the enclosure comprised by the second shielding component 8412 and the first shielding component 8411 may protect the integrity of the wireless charging field associated with the wireless charging relationship.” EX1005, [0344], [0349] (explaining that components can be configured relative to a charging device “so that the wireless charging field is undisturbed” and “[a]lternatively or additionally, a mounting apparatus and/or an object interface may be configured (e.g., via the configuration of shielding materials, flux guides, caps, etc.) so that interference from ferromagnetic components and/or magnetic fields comprised by the mounting apparatus and/or the object interface may be substantially prevented.”).

C. The Wojcik-Franklin Combination

1. Analogous Art

46. Wojcik and Franklin are analogous art to the ’119 Patent, which is generally directed to “a case having a metal plate for magnetically mounting the case

with an electronic device installed therein to a support having a magnet, and more particularly, to a metal plate having a rounded concave edge.” EX1001, 1:13-19 (Field of the Invention).

47. Wojcik discloses an “[e]lectronic [d]evice [c]ase with [i]nductive [c]oupling [f]eatures.” EX1004, Title. Specifically, Wojcik describes a “protective case” that “includes a shell for receiving and at least partially covering an electronic device,” and that includes a core that “is affixed to the back portion of the shell at a location that coincides with a center region of the wireless charging coil of the wireless charging circuitry of the installed electronic device.” EX1004, Abstract; *see also id.*, claim 1 (“protective case for an electronic device having wireless charging circuitry and a wireless charging coil proximate a back surface of the electronic device”), [0022], [0023], FIGS. 1, 4A.

48. Similar to Wojcik, Franklin describes an apparatus for mounting an electronic device that allows for wireless charging through the mount using a receiver coil included within the device, while simultaneously using magnets to adhere and promote correct alignment between the electronic device and a charger. EX1005, Abstract, [0038], [0039], [0040], [0054], [0334]-[0336], [0342]-[0344]; FIGS. 27A-27B.

49. Accordingly, Wojcik and Franklin are both directed to the same field of endeavor as the '119 Patent, at least insofar as they both describe magnetically mounting a case/apparatus with an installed electronic device to support wireless charging of the installed electronic device. *See, e.g.*, EX1004, [0022] (“rear surface 104 may include or conceal magnets or other structures for attaching/aligning the rear surface 104 to/with the wireless power charger”). And, for at least that reason, Wojcik and Franklin are analogous art to the '119 Patent.

50. Moreover, Wojcik and Franklin are also reasonably pertinent to the problem the '119 Patent purports to solve, for example, that a “metal plate may impede or prevent wireless charging of a cell phone because the metal plate blocks electromagnetic field for wireless charging.” EX1001, 1:20-44; *see also id.*, 1:44 (“This invention is directed to solve this problem”). For example, both Wojcik and Franklin disclose systems that enable wireless charging of a cell phone or other electronic device in which the electromagnetic field is not blocked by a metal plate. EX1004, Abstract; *see also id.*, claim 1 (“protective case for an electronic device having wireless charging circuitry and a wireless charging coil proximate a back surface of the electronic device”), [0022], [0023], FIGS. 1, 4A; EX1005, Abstract, [0038], [0039], [0040], [0054], [0334]-[0336], [0342]-[0344]; FIGS. 27A-27B.

51. And, for at least that additional reason, Wojcik and Franklin are analogous art to the '119 Patent.

2. Reasons to Combine

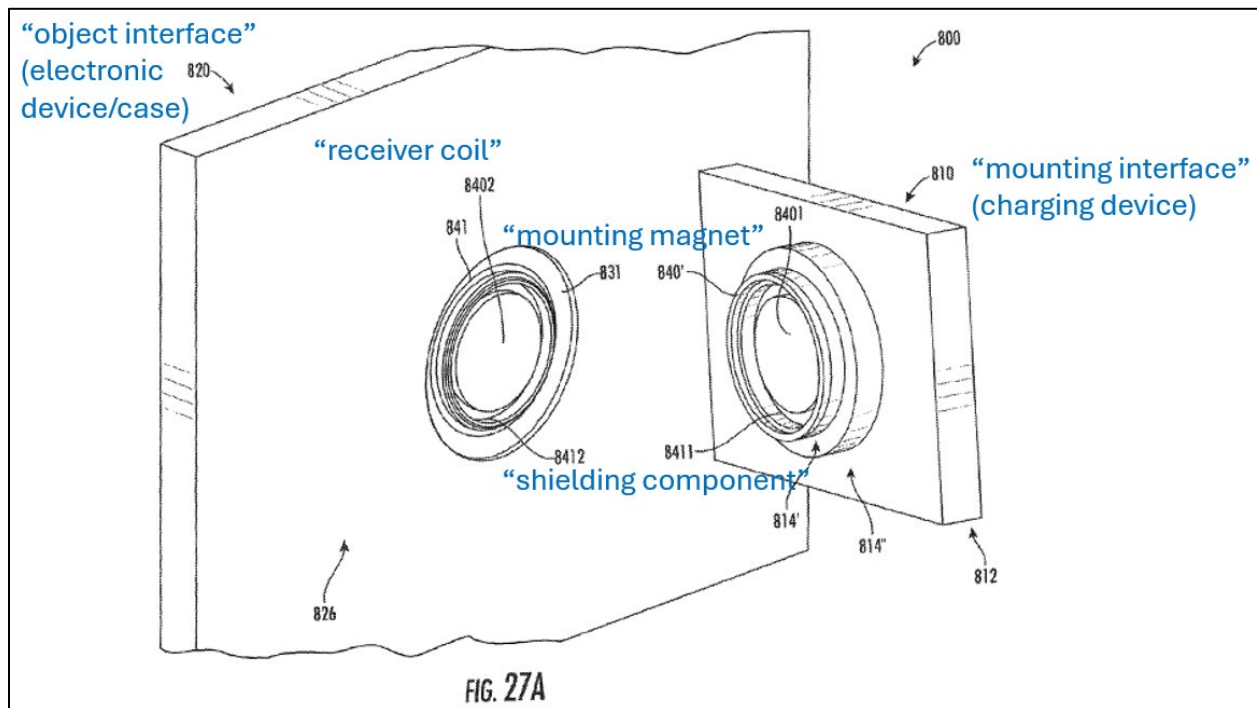
52. Franklin explains that “mounting interface 810 may comprise a wireless charging device” that “may comprise a transmitter coil component 8401,” and “object interface 820 may be a case for a mobile electronic device (e.g., a tablet computer, etc.) that is not configured to participate in a wireless charging relationship.” EX1005, [0336], [0338].

53. Additionally, Franklin explains that “an object interface may be configured to attach to a coil object ... so that a compatible wireless charging component comprised by the object may be positioned within a charging range of ... the mounting apparatus.” EX1005, [0057]. Further, a POSITA would have understood a “coil object” to include, for example, a cell phone with a receiver coil for wireless charging, like the electronic device of Wojcik’s FIG. 1. EX1005, [0057] (“The term “coil object” refers to an object (as defined above) that comprises a wireless charging component that is configured to participate in a wireless charging relationship (i.e., a wireless charging device, such as a wireless charging base station, a mobile device capable of being charged wirelessly, etc.).”), [0346].

54. A POSITA would have further noted the similarities between Wojcik and Franklin. For example, FIGS. 1-3 of Wojcik depicting a receiver coil in a phone and FIG. 4 of Wojcik show nearly identical coil designs in a case, offering an option for the coil in both the phone and the case. EX1004, FIGS. 1-4. Similarly, Franklin describes options for the coil to reside in a case or in a coil object attached to the case. EX1005, [0332]-[0352].

55. As such, a POSITA would have been motivated to combine Wojcik with Franklin to apply Franklin's solutions to Wojcik's similar system in order to be compatible with a cell phone that includes wireless charging.

56. In such a configuration, a POSITA would have understood that the object interface 820 of Franklin may comprise, for instance, Wojcik's protective case 200 when electronic device 100 is installed in protective case 200, such that object interface 820 comprises a mobile electronic case with mounting magnets and a shielding component and a receiver coil attached to the case (e.g., a cell phone with a receiver coil for wireless charging installed in the case). EX1004, [0023], EX1005, [0336], [0338].



EX1005, FIG. 27A (annotated)

57. Consistent with the teachings of both references, a POSITA would have been motivated by Franklin to modify Wojcik's case to include additional mounting magnets (e.g., magnets "including a ferrous metal") surrounding areas corresponding to the electronic device's receiver coil. The resulting combination would improve wireless charging through two complementary and independent mechanisms:

58. The added mounting magnets, as taught by Franklin, would provide an engagement force that maintains alignment of the electronic device's receiver coil within charging range of an external transmitter coil (EX1004, [0019], [0022]; EX1005, [0342]);

59. The inclusion of the high magnetic permeability material (i.e., Wojcik's ferrite) would concentrate and steer the magnetic flux between the coils (EX1004, [0016], [0025], [0043]).

60. These features would independently increase the magnetic coupling between the receiver and transmitter coils and, in turn, the efficiency of the magnetic induction power transfer between the coils. EX1004, [0016], [0025].

61. Regarding the flux concentration mechanism, *see* EX1004, [0005] (“The coupling region increases or improves magnetic inductive coupling between the wireless charging coil of the installed electronic device and a source charging coil that is external to the cover when the cover with the installed electronic device is placed in proximity to the source charging coil”), [0016] (noting that magnetic material placed “in or near the center of” a “power transmitting coil” may “increase[] the magnetic coupling efficiency or the efficiency of the magnetic induction power transfer, between the transmitting and receiving coils”), [0038] (the “*protective case may also include a ... high magnetic permeability material insert ... co-molded or otherwise formed in a back wall of the protective case to enhance magnetic coupling of the wireless charging circuitry*”), [0039] (“*The central ... high magnetic permeability material ... may also enhance magnetic coupling with such external device* by increasing the magnetic coupling factor...”), [0040] (“The central

... high magnetic permeability material ... may also enhance magnetic coupling with such external device by increasing the magnetic coupling factor, concentrating the magnetic flux, and/or constraining or steering the magnetic field”); EX1005, [0054], [0334]-[0336], [0342] (“The wireless charging relationship established between the transmitter coil component 8401 and the receiver coil component 8402 may be an inductive charging relationship, and *an engagement force produced between the [magnets] may maintain the position of the receiver coil component 8402 within the charging range of the transmitter coil component 8401*”).

62. In particular, while it is desirable to have a case to protect the electronic device, the case is positioned between the electronic device (and its receiver coil) and a charging device (and its transmitter coil), which could, in the absence of one or more mounting magnets (per Franklin) in the case, limit the adherence and alignment of the electronic case to the charging device.

63. Moreover, Wojcik itself recognizes that an electronic device may have separate magnets for alignment and notes that “the thickness of the case often limits how closely the electronic device can be placed to a ... charging surface.” EX1004, [0022], [0017] (“The thickness of case material between the wireless power transfer antenna or coil and any wireless power transmitter can reduce the efficiency or even

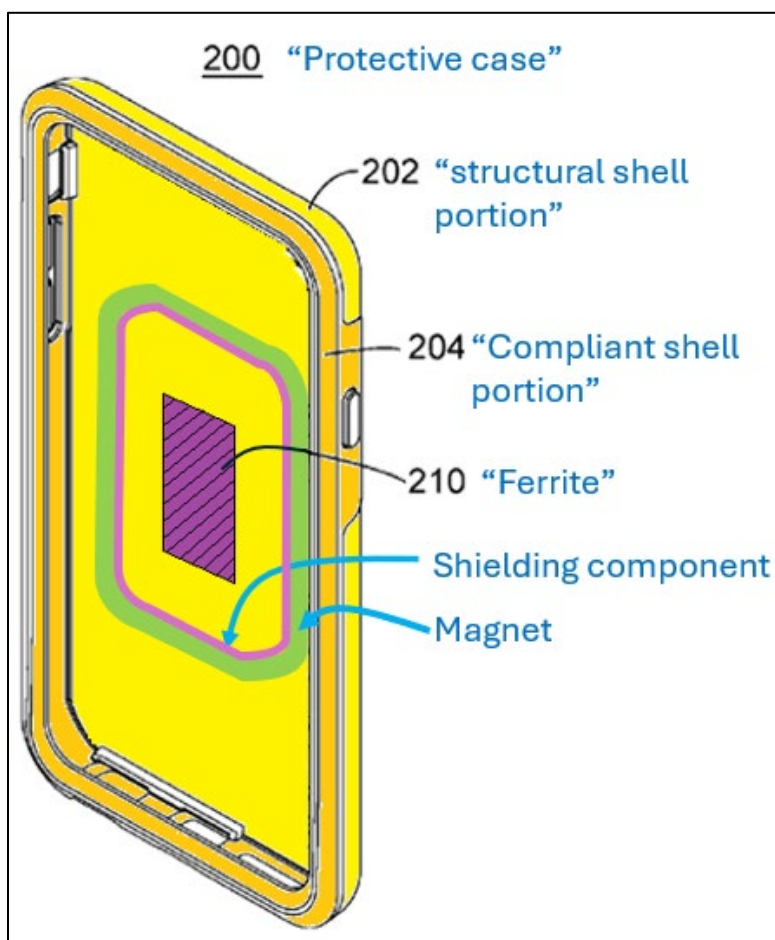
prevent the power transfer from taking place. In addition, the case material may cause a shielding or blocking effect and further limit the power transfer between the devices.”).

64. As such, a POSITA would have been motivated to apply the teachings of Franklin to maintain the magnetic coupling relationship between the device and its charger by preserving the closeness between the electronic device and the charger and further helping to align the receiver and transmitter coils. EX1004, [0022] (discussing “magnets or other structures for attaching/aligning the rear surface 104 [of the case] to/with the wireless power charger”); EX1005, [0336] (discussing a wireless charging device as the mounting apparatus).

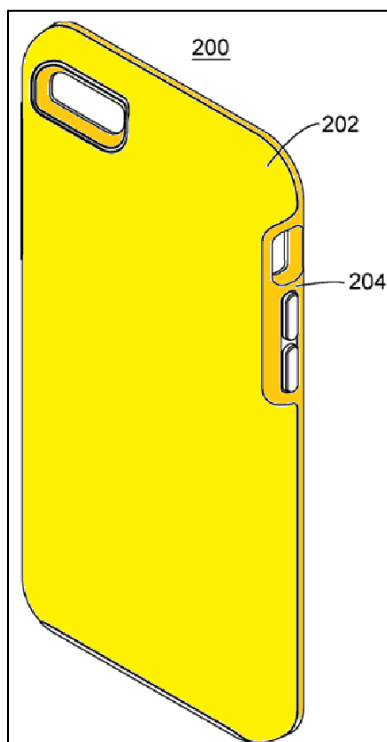
65. A POSITA would have been further motivated to modify Wojcik’s case so that the magnets do not “interfere with the wireless charging field” created by the receiver coil of Wojcik’s electronic device 100, which Franklin highlights as a potential concern when ferromagnetic components are included in the case. EX1005, [0344], [0349]. In particular, a POSITA would have been motivated to modify Wojcik’s case to add a magnet and shielding component to “guide, block, divert, etc. magnetic fields and/or lines associated with ferromagnetic components” of Wojcik’s protective case (i.e., magnet). EX1005, [0344], A POSITA, reviewing Franklin, would have found obvious that the modification to include the magnet and

shielding component would “protect the integrity of the wireless charging field associated with the wireless charging relationship,” per Franklin (i.e., with the shielding component), while retaining the protective functionality of Wojcik’s case and furthering Wojcik’s goal of “enhancing magnetic coupling of the wireless charging circuitry” (i.e., with the magnet). EX1005, [0344]; EX1004, [0038].

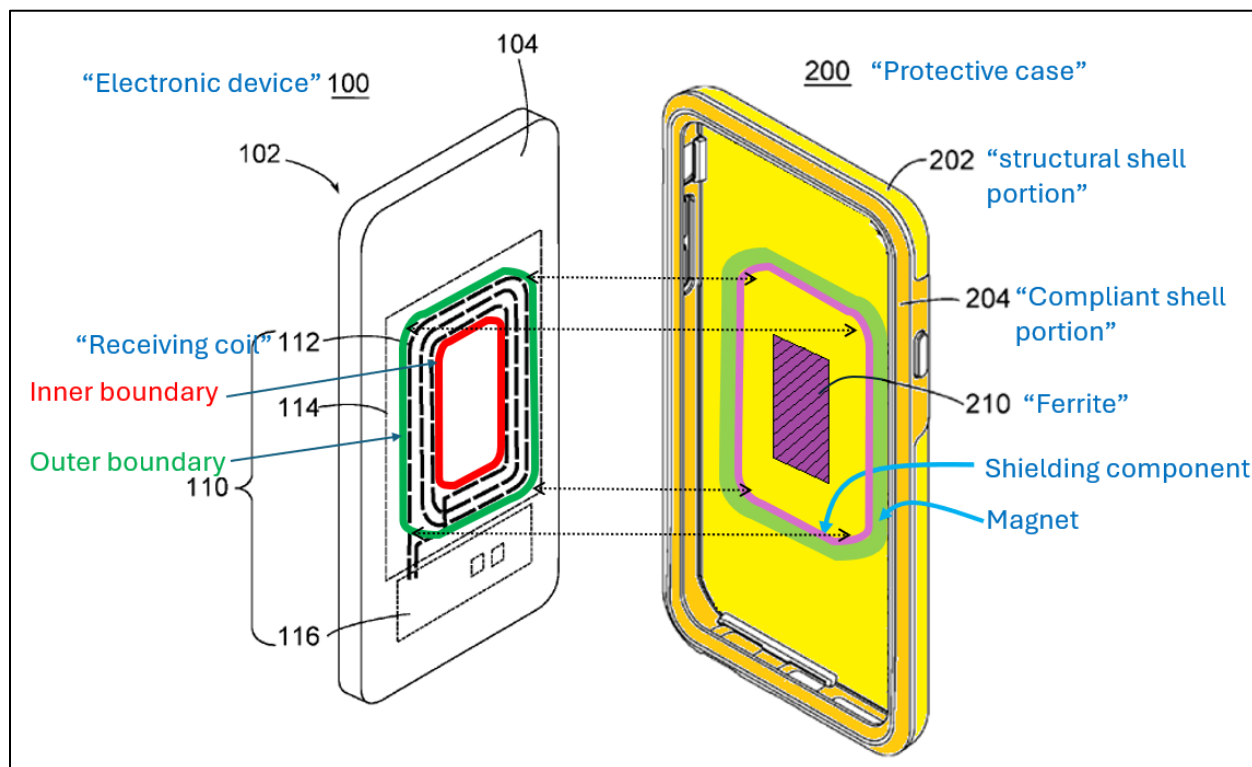
66. Thus, as enhanced based on Franklin’s teachings, and as shown below in modified FIGs. 1 and 3, Wojcik’s case would retain the advantages of protection and resistance to abrasion and “increasing the magnetic coupling efficiency or the efficiency of the magnetic induction power transfer, between the transmitting and receiving coils” offered by Wojcik’s ferrite core, while further benefitting from an additional “engagement force produced between” magnets on the protective case with magnets on a charging device (e.g., mounting interface) that help to “maintain the position of the receiver coil” of the electronic device within charging range of a respective transmitter coil, without interfering with electromagnetic power transfer. EX1004, [0016], [0023], [0038]; EX1005, [0342], [0344].



EX1004, FIG. 1 (annotated, highlighted, excerpted, modified to omit optional cushion layer 206 and add Franklin's shielding component and magnet); *see also* EX1005, FIG. 27A.



EX1004, FIG. 3 (annotated, highlighted, modified).



Wojcik-Franklin Combination.

3. Reasonable Expectation of Success

67. Modifying Wojcik's case and electronic device to leverage Franklin's teachings would have required only routine knowledge well within the skill of a POSITA prior to the earliest effective filing date. Indeed, the modification would have amounted to nothing more than the use of a known technique to improve similar devices – in each instance an electronic device employing induction charging with another device (case or mount) – in a similar way, combining prior art elements to known methods to yield the predictable results described above.

68. Furthermore, the elements of the resulting combination would each perform functions they had been known to perform prior to the combination – electronic device 100 would continue to perform the function of inductive charging and protective case 200 would continue to employ the functions of partially covering and protecting electronic device 100 without interfering with the magnetic field employed for induction charging, but, as taught by Franklin, would leverage mounting magnets and shielding components to promote adherence and correct alignment between electronic device 100 and its charger without interfering with the wireless charging field. Accordingly, a POSITA would have more than reasonably expected success when incorporating Franklin's teachings into Wojcik to achieve the motivating advantages described above.

D. Claim Element Analysis

1. Claim 1

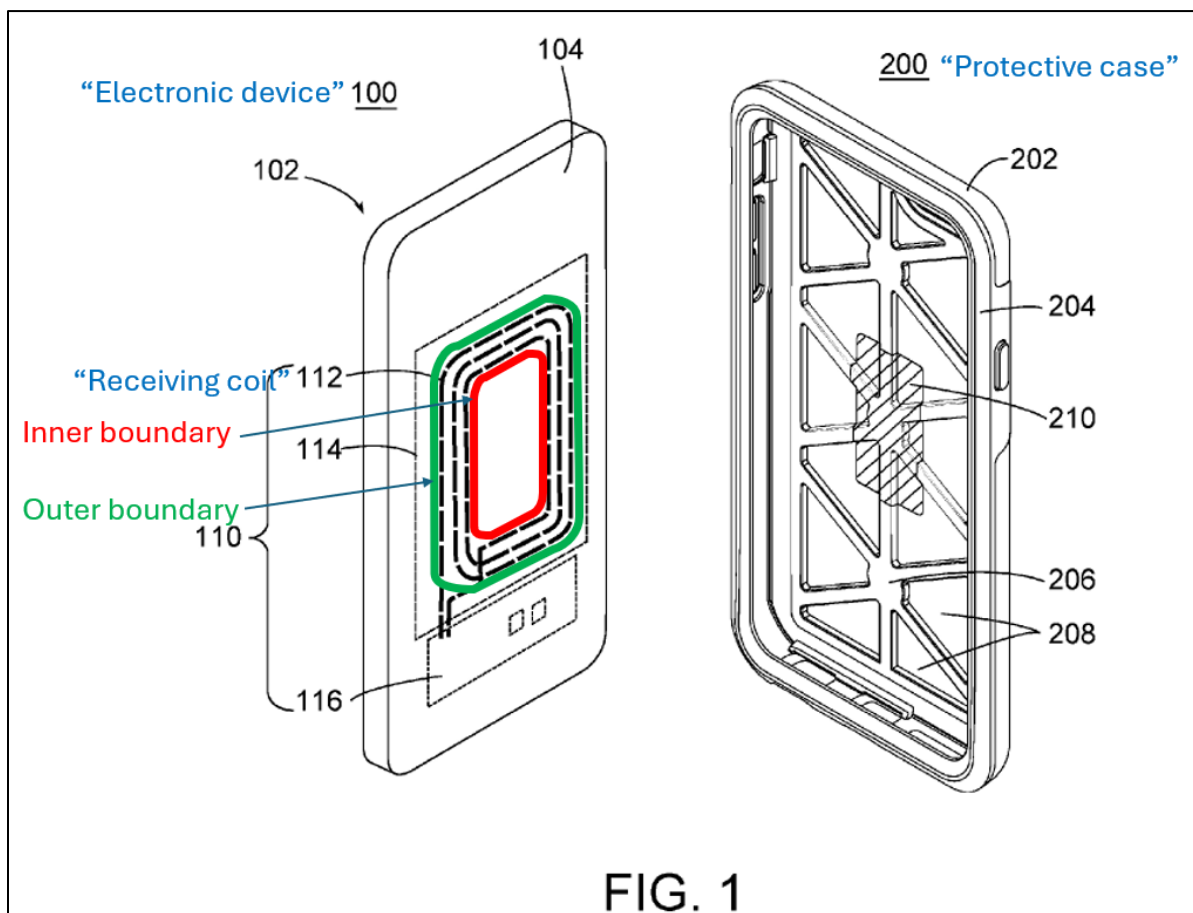
- (i) *Element [1pre]: A case for an electronic device wherein the electronic device has a receiver coil for wireless charging constructed within the electronic device and the receiver coil is formed in between an inner boundary and an outer boundary, the case comprising:*

69. Wojcik discloses an “[e]lectronic [d]evice [c]ase with [i]nductive [c]oupling [f]eatures.” EX1004, Title. Specifically, Wojcik describes a “protective case includes a shell for receiving and at least partially covering an electronic device.” EX1004, Abstract; *see id.*, claim 1, [0022], [0023], FIGs. 1, 4A.

70. Wojcik explains that the case includes a core that “is affixed to the back portion of the shell at a location that coincides with a center region of the wireless charging coil of the wireless charging circuitry of the installed electronic device.” EX1004, Abstract; *see id.*, claim 1 (“protective case for an electronic device having wireless charging circuitry and a wireless charging coil proximate a back surface of the electronic device”).

71. As shown in FIG. 1 (reproduced below), the “electronic device 100” has a “receiving coil 112” that is formed in between an inner boundary (shown in red) and an outer boundary (shown in green). EX1004, FIG. 1. The “receiving coil 112” is part of a “wireless charging circuit 110” that “allows electronic device 100 to

be charged and/or powered from an external device (not pictured) without having to attach a cable or other type of electromechanical connector between electronic device 100 and the external device.” EX1004, [0022] (Wireless charging circuit 110 may include a receiving coil 112 having a ferrite backing 114, and a printed circuit board 116 inside a housing 102 of electronic device 100).



EX1004, FIG. 1 (annotated).

- (ii) *Element [1a]: a hard protective cover constructed to receive the electronic device therein wherein the hard protective cover has a recess which faces the electronic device and the hard protective cover is external with respect to the electronic device; and*

72. Wojcik explains that “protective case 200” includes a “structural shell portion 202 and a compliant shell portion 204,” where the shell portion 202 “provide[s] some degree of stiffness or rigidity to protective case 200 and may also provide some resistance to abrasion.” EX1004, [0023]. “Protective case 200 may further include, but does not require, an internal cushion layer 206 which may provide a softer or more compliant surface against one or more surfaces of the electronic device 100 rests when electronic device 100 is inserted in protective case 200.” EX1004, [0023]. Thus, the case includes a protective cover (structural shell portion 202 alone or in combination with compliant shell portion 204) constructed to receive the electronic device 100 therein.



EX1004, FIG. 1 (annotated, highlighted, excerpted); *see also id.*, FIG. 2.

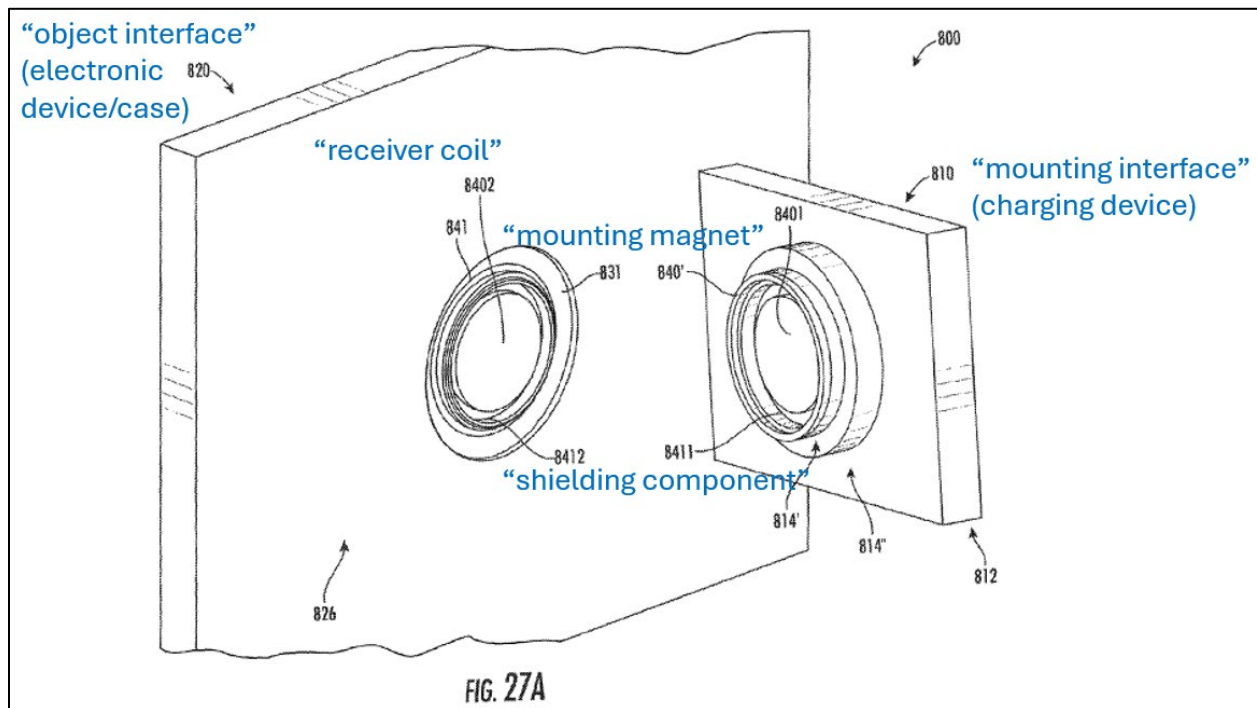
73. Wojcik explains that the structural shell portion 202 “may provide some degree of stiffness or rigidity to protective case 200 and may also provide some resistance to abrasion.” EX1004, [0023]. Wojcik further explains that “the term ‘compliant’, when referring to shell material, is to be interpreted as referring to the comparative rigidity of the material with respect to the term ‘rigid.’” EX1004, [0030] (“A compliant shell material may be formed from one or more substances having a shore A hardness less than about 50. In some protective cases, a compliant

shell portion may have a shore A hardness in the range of about 15 to 30, about 10 to 35 or about 10 to 45.”).

74. Moreover, as shown in FIG. 1 (above), protective case 200 has a recess that faces electronic device 100 that it covers and protects the device 100 when in use. EX1004, FIG. 1, [0025] (“electronic device 100 typically fits into protective case 200 snugly”) (“electronic device 100 is installed in protective case 200”). The hard protective cover (e.g., structural shell portion 202) is external with respect to the electronic device, as shown in FIG. 1. EX1004, FIG. 1.

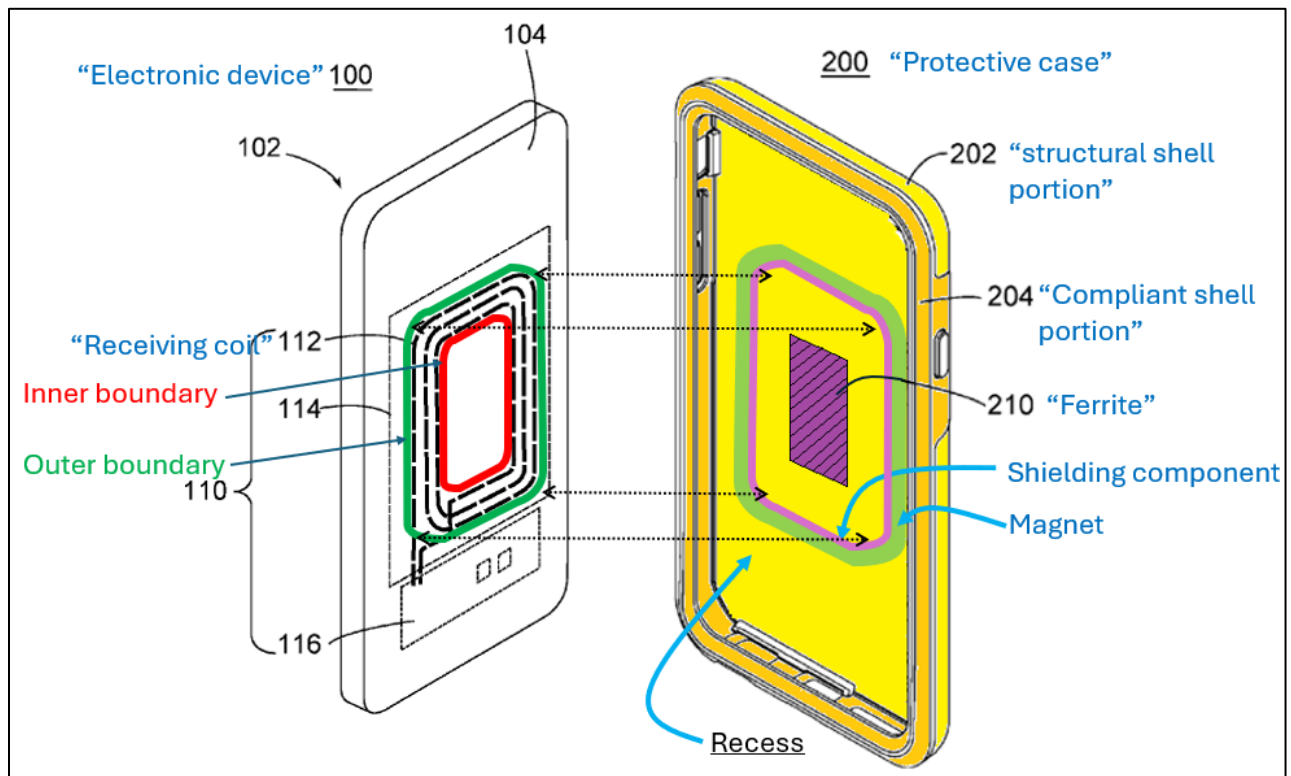
(iii) *Element [1b]: a metal plate constructed to be received in the recess of the hard protective cover,*

75. Franklin teaches that mounting magnet, which is a combination of magnet 831 and magnet 841, is included in object interface 820. EX1005, [0338] (“the third mounting magnet may comprise a plurality of magnets, 831 and 841”), [0342], FIGs. 27A-27B. In this way, the mounting magnet is a metal plate. Franklin further explains that “[m]agnet 831 may comprise a round, ferrous *metal plate* with a center opening (i.e., a hole in the center of the plate)),” and “magnet 841 may be a permanent ring magnet that is configured to be attached to the ferrous metal plate.” EX1005, [0338] (emphasis added).



EX1005, FIG. 27A (annotated).

76. As discussed and shown in the combination section (§VIII.C) and shown below, in the Wojcik-Franklin Combination, the magnet (metal plate) is received in the recess of the protective cover. This is illustrated in the image below.



Wojcik-Franklin Combination.

77. Moreover, a POSITA would have found it obvious for the Wojcik-Franklin Combination case to include a magnet embedded in the recess of the case at least in view of Wojcik’s teaching that its ferrite could be “affixed to, adhered to, attached to, and/or *embedded in* any portion of protective case.” EX1004, [0028].

- (iv) *Element [1c]: wherein the metal plate is constructed to enable magnetic retention or attachment of the case to a support having a magnet,*

78. Franklin explains that “[m]agnet 831 may comprise a round, ferrous metal plate,” and “magnet 841 may be a permanent ring magnet that is configured to be attached to the ferrous metal plate.” EX1005, [0338]. As such, a POSITA

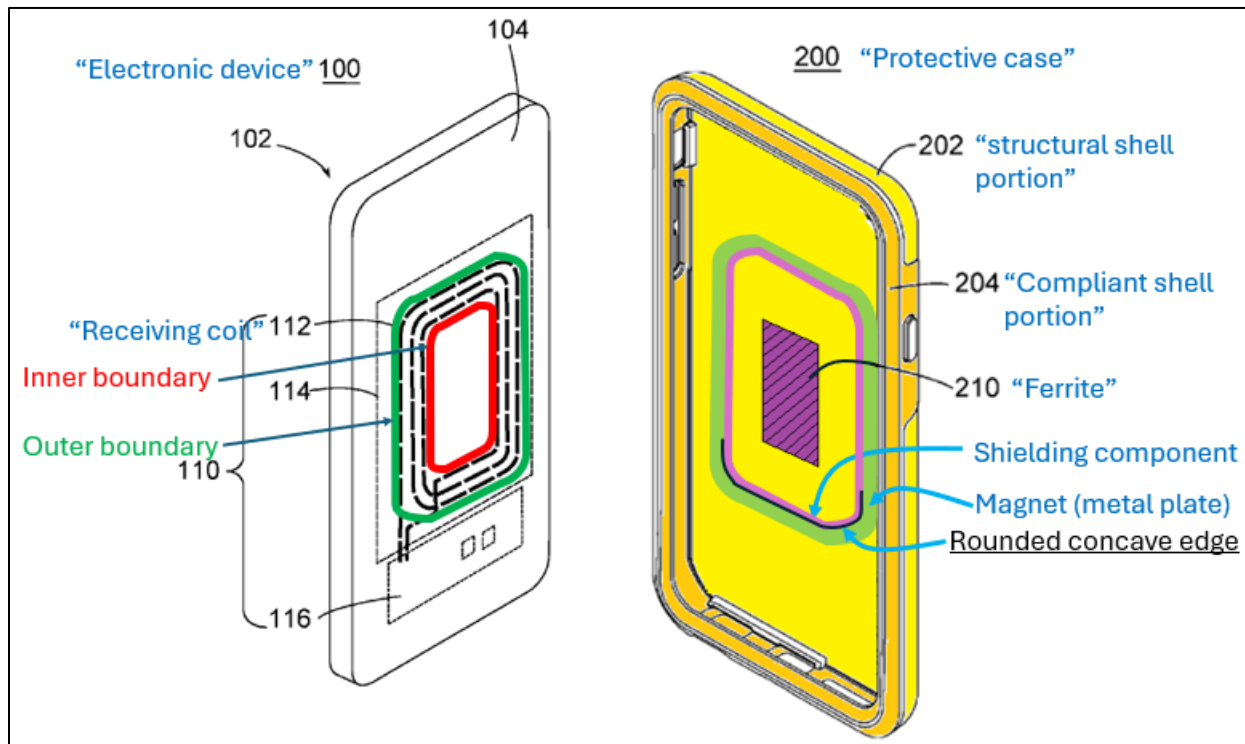
would have understood and/or found obvious that the mounting magnet (combination of magnet 831 and magnet 841) comprises a metal plate that comprises a permanent magnet and thus constructed to enable magnetic retention or attachment of the case to a support having a magnet. That is, with the magnet 831/841 in the recess of the case, the case would be magnetically retained or attached to a support that also has a magnet.

79. This is further disclosed in Franklin, which explains that “[m]agnet 831 may be configured relative to magnets 830 and magnets 840” so that an attraction force may be produced between magnet 831 and magnets 830 and 840” when the object interface 820 is brought into proximity with the mounting apparatus 810, and magnet 841 may be configured relative to magnet 840’ so that an attraction force may be produced between magnet 841 and magnet 840’ when the object interface 820 is brought into proximity with the mounting apparatus 810,” as shown in FIG. 27B. EX1005, [0342] (“Therefore, as shown in FIG. 27B, an attraction force produced between the second mounting magnet 840’ (one of a plurality of second mounting magnets in this embodiment) and the third mounting magnet (specifically, magnet 841 in this embodiment) may cause engagement between the second mounting magnet 840’ and the third mounting magnet, and a depth defined by the engagement member 814’ may be configured relative to a charging range defined by the transmitter coil component 8401 so that the receiver coil component 8402

may be within the charging range of the transmitter coil component 8401 when the second mounting magnet 840' and the third mounting magnet are engaged.”).

(v) *Element [1d]: wherein the metal plate has a rounded concave edge,*

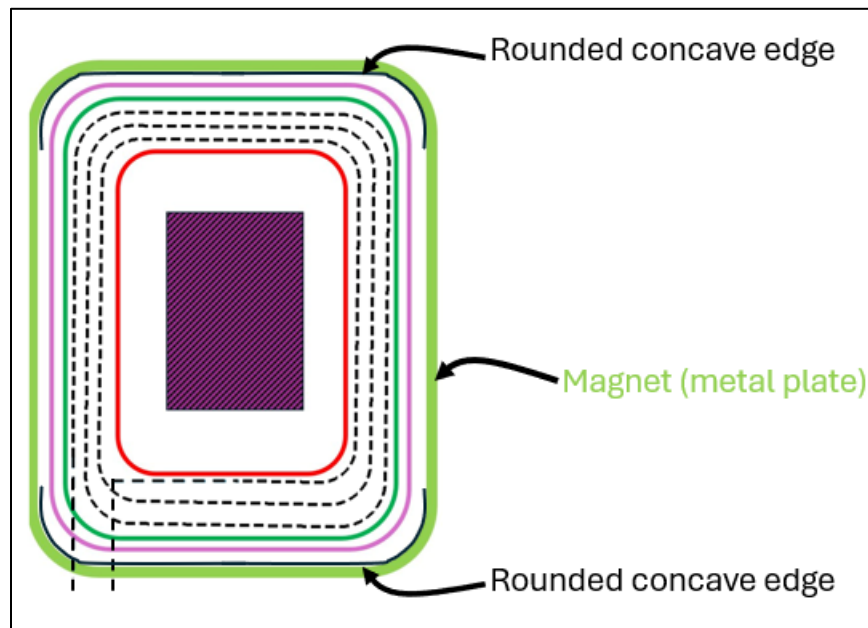
80. As illustrated below, a POSITA would have found it obvious to implement the magnet (metal plate) of the Wojcik-Franklin Combination with a rounded concave edge.



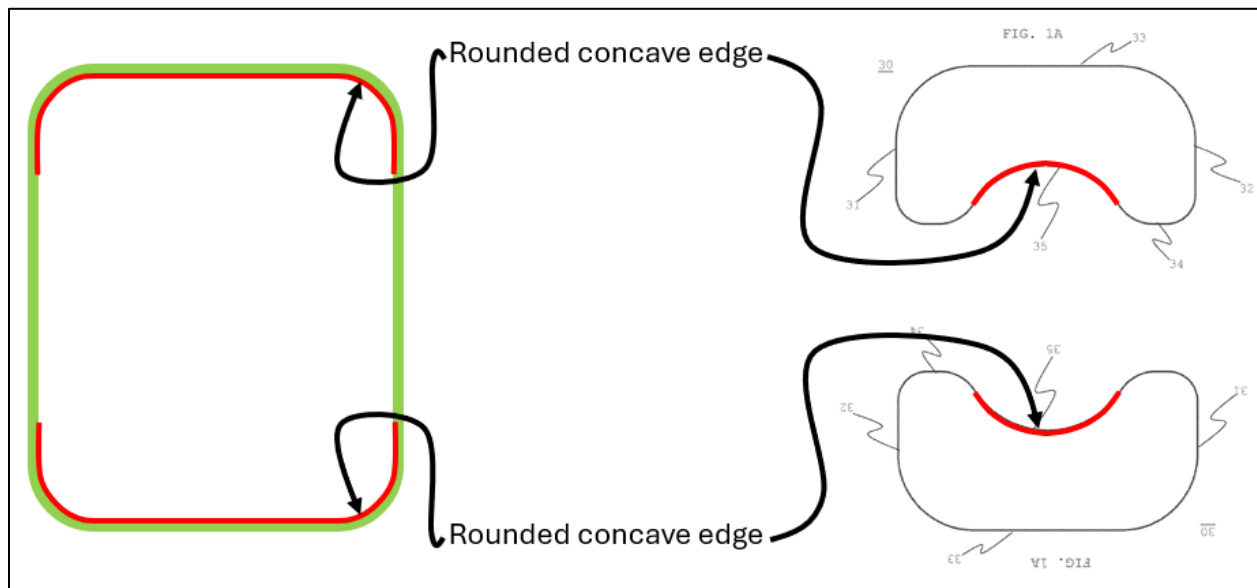
Wojcik-Franklin Combination.

81. For instance, the mounting magnet disclosed in Franklin is a hollow ring that is shaped to fit the outer boundary of the coil. EX1005, FIG. 27A, [0338]. In particular, Franklin discloses a circular magnet that matches the outer boundary

of the circular receiver coil. *Id.*, FIG. 27A, [0338] (“Magnet 831 may comprise a round, ferrous metal plate with a center opening (i.e., a hole in the center of the plate)”). A POSITA would have found obvious that one natural inclusion of Franklin’s mounting magnet in Wojcik’s case would be to use a mounting magnet that matches the shape of Wojcik’s receiver coil. The image below illustrates a representation of a plan view of the metal plate (magnet) of the Wojcik-Franklin Combination case with a projection of the inner and outer boundaries of the receiver coil and the receiver coil, where the metal plate (magnet) has rounded concave edges/corners. As can be seen in the image below, the metal plate is shaped to match the outer boundary of the receiver coil, and in that regard features rounded concave edges/corners.



Either of these rounded concave edges is consistent at least with the '119 Patent's example of an alleged rounded concave edge on its metal plate, as shown below in the side-by-side comparison of the Wojcik-Franklin Combination's metal plate and the '119 Patent's example metal plate (in either its original or vertically flipped configuration).



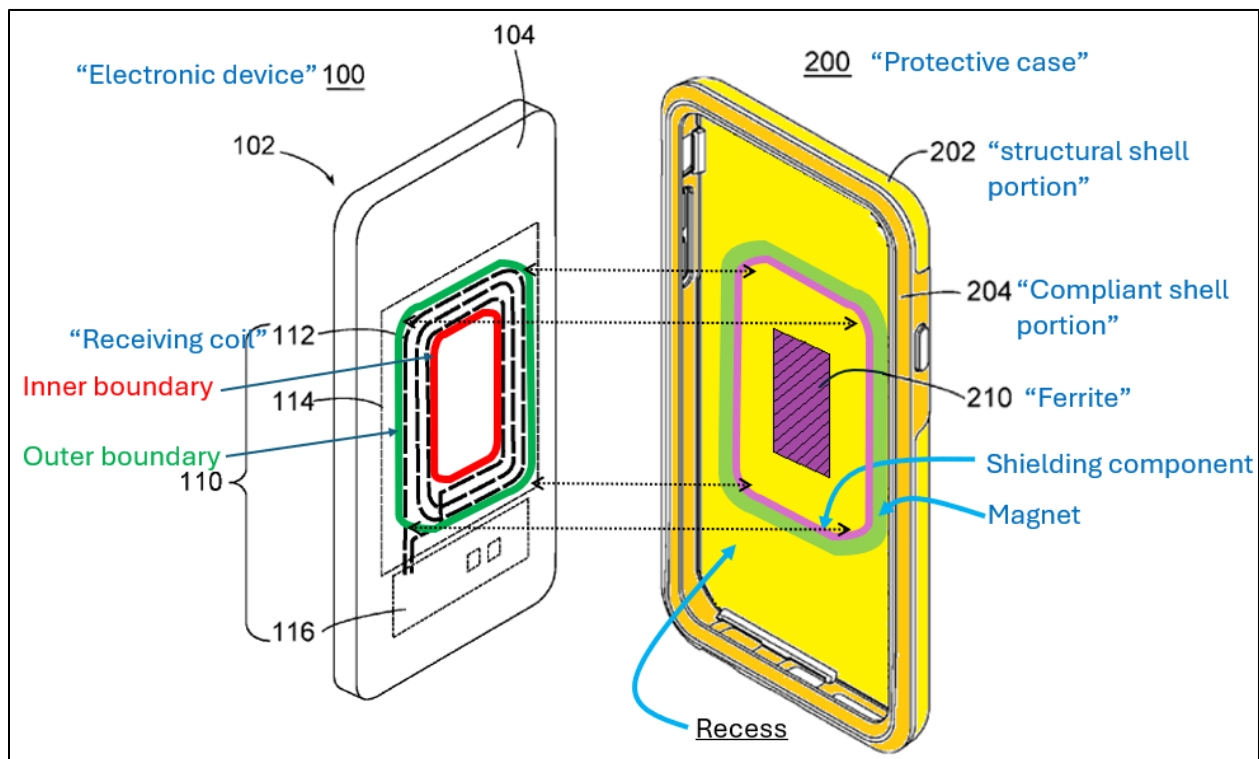
(comparison to EX1001, FIG. 1A (highlighted, rotated)).

- (vi) *Element [1e]: wherein the metal plate received in the recess is positioned to substantially allow magnetic waves to pass through the area formed by the inner boundary.*

82. As discussed and shown in the combination section above, in the Wojcik-Franklin Combination, the metal plate (magnet) received in the recess is positioned such that it does not overlap with an orthographic parallel projection of the receiver coil of an electronic device positioned in the case.

83. Further, a shielding component is positioned in the Wojcik-Franklin Combination case on the inside boundary of the magnet that further acts to “guide, block, divert, etc. magnetic fields and/or lines associated with” ferrite to “protect the integrity of the wireless charging field associated with the wireless charging relationship,” per Franklin. EX1005, [0344]. Thus, Franklin’s solution isolates the

wireless charging fields from the additional components for mounting. EX1005, [0344]. In the Wojcik-Franklin Combination, application of Franklin's teaching results in a design and shielding components that not only avoid interference, but further directly support flux paths that maintain and, as would be understood from the teachings of Wojcik, channel and enhance coupling of fields for wireless charging. EX1005, [0344].



Wojcik-Franklin Combination.

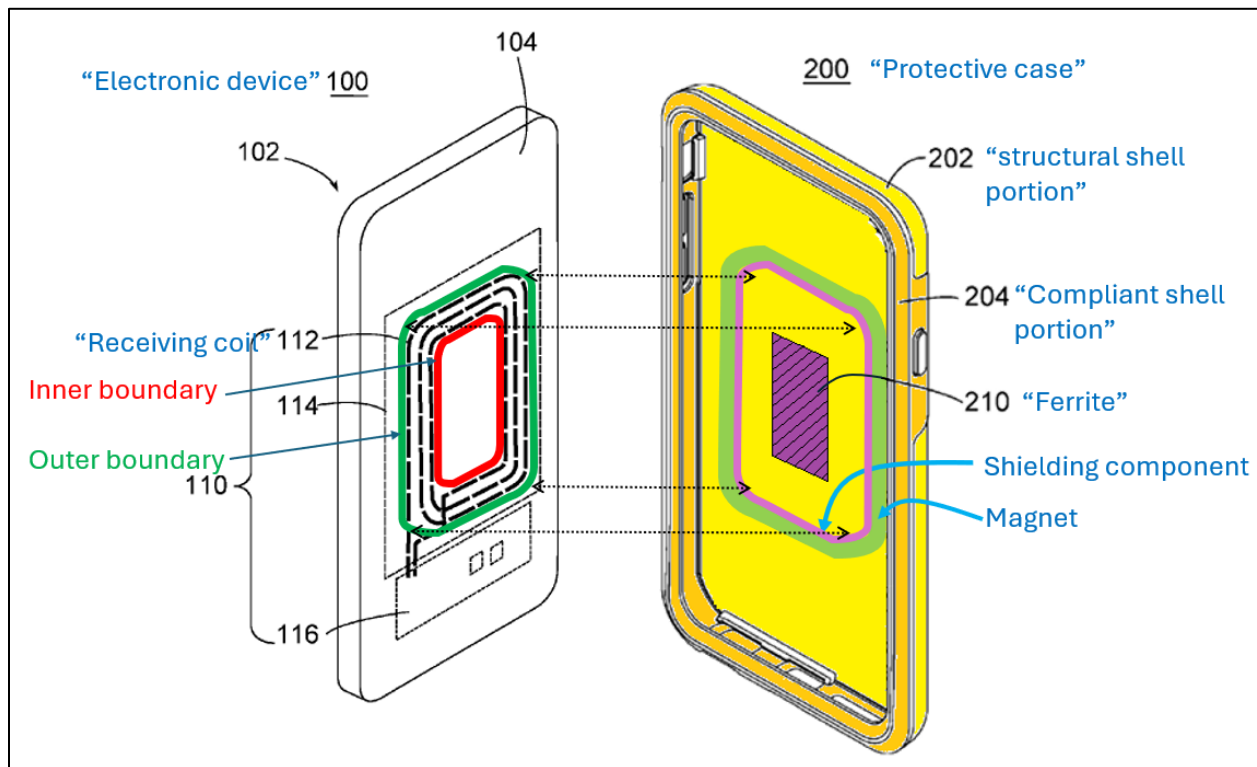
84. For at least these reasons, a POSITA would have understood that the metal plate received in the recess in the Wojcik-Franklin Combination is positioned

to substantially allow magnetic waves to pass through the area formed by the inner boundary.

2. Claim 2

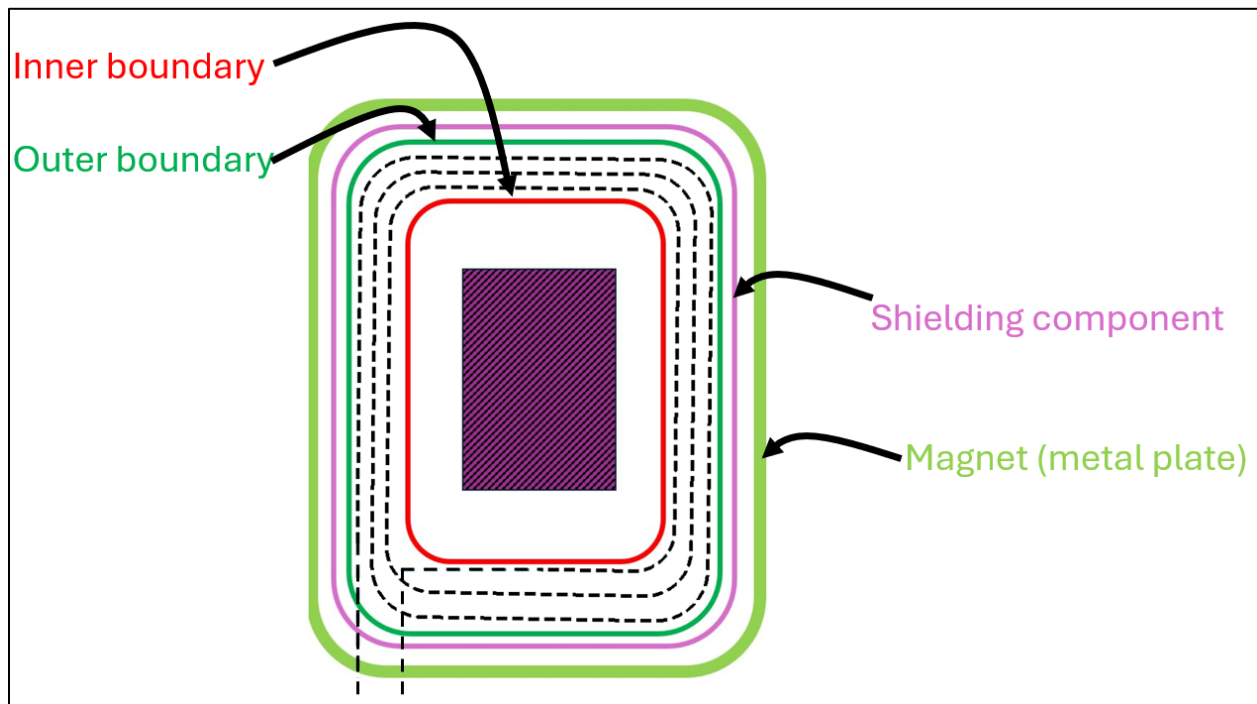
- (i) *Element [2]: The case of claim 1, wherein the metal plate does not overlap with an orthographic parallel projection of the area formed by the inner boundary onto a projection plane of the metal plate.*

85. As discussed and shown in the combination section, in the Wojcik-Franklin Combination, the magnet (metal plate) received in between the protective cover and the electronic device is positioned such that it does not overlap with an orthographic parallel projection of the receiver coil of an electronic device positioned in the case.



Wojcik-Franklin combination.

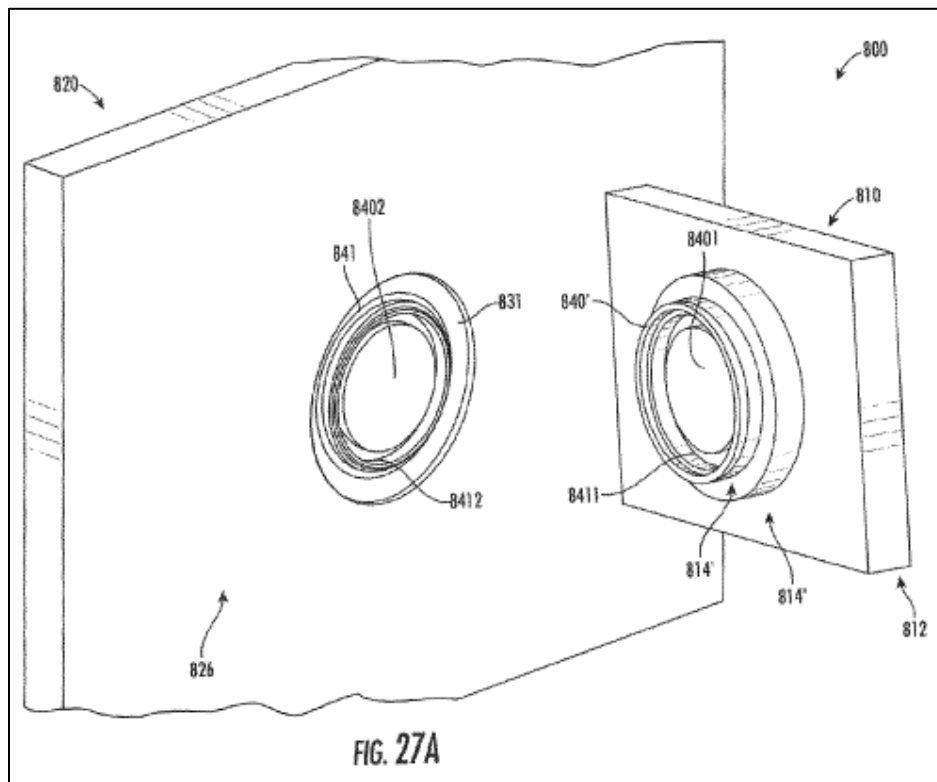
86. This is shown in the image below illustrating a representation of a plan view of the metal plate (magnet) of the Wojcik-Franklin Combination case with a projection of the inner and outer boundaries of the receiver coil and the receiver coil.



3. Claim 3

- (i) *Element [3]: The case of claim 1, wherein the inner boundary and the outer boundary are substantially circular.*

87. As illustrated in FIGs. 27A-27B, Franklin discloses (1) an object interface 820 (e.g., phone device) with magnet 831/841 and receiver coil 8402, where the inner boundary and the outer boundary of the receiver coil 8402 are substantially circular.

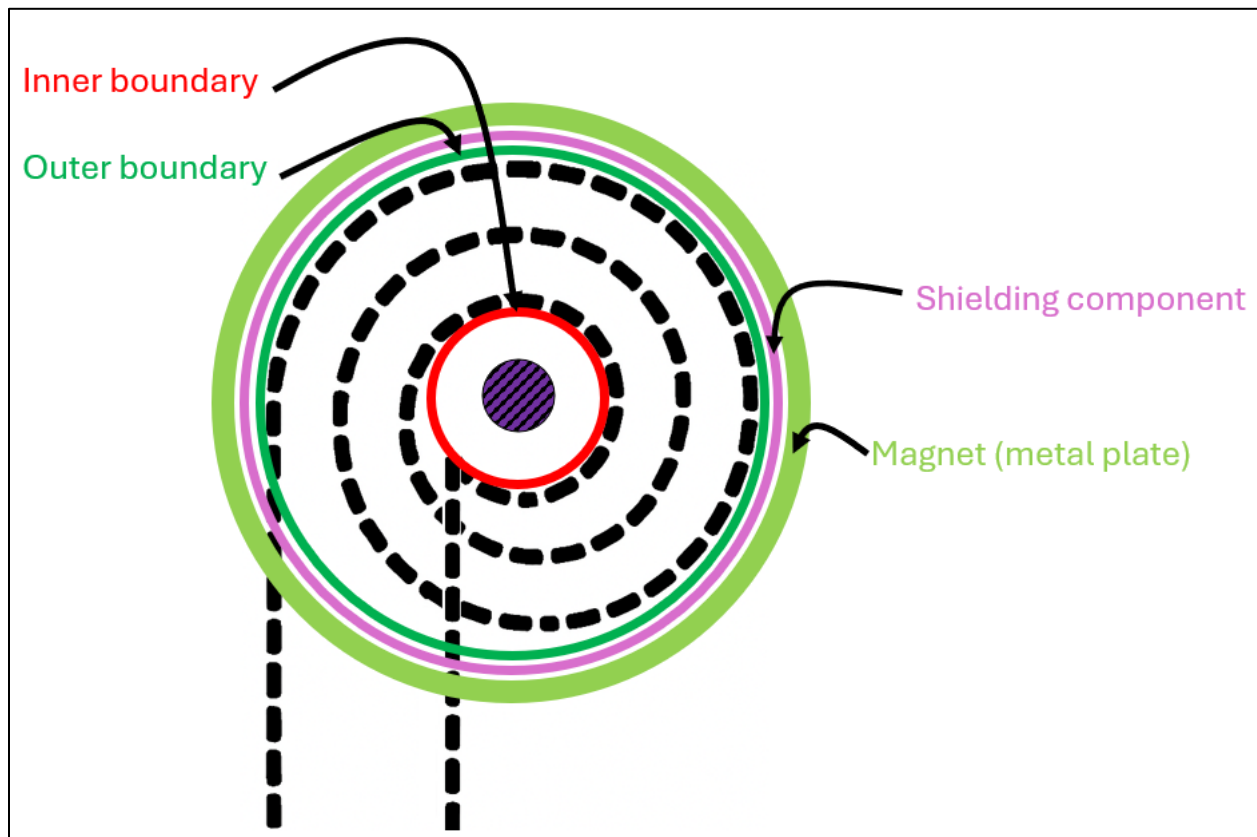


EX1005, FIG. 27A

88. While the receiver coil of the electronic device described in Wojcik is shown to be substantially rectangular, a POSITA would have recognized that other shapes, such as square and circle, would also be useful for the receiver coil. EX1004, [0015] (“wireless transfer of electrical power is accomplished using electromagnetic induction techniques. Wireless power transfer circuitry and antennae may utilize one or standard or proprietary wireless power transfer protocols, such as those published and promoted by Qi, PMA (Power Matters Alliance), A4WP (Alliance for Wireless Power), and/or others.”); EX1005, [0340] (“For example, each wireless charging device may be configured according to a wireless charging specification (e.g., Qi,

Powermat, etc.) to ensure compatibility.”). The Qi standard establishes a number of different power receiver configurations, including a rectangular shape and a circular shape. EX1029, 69, 72.

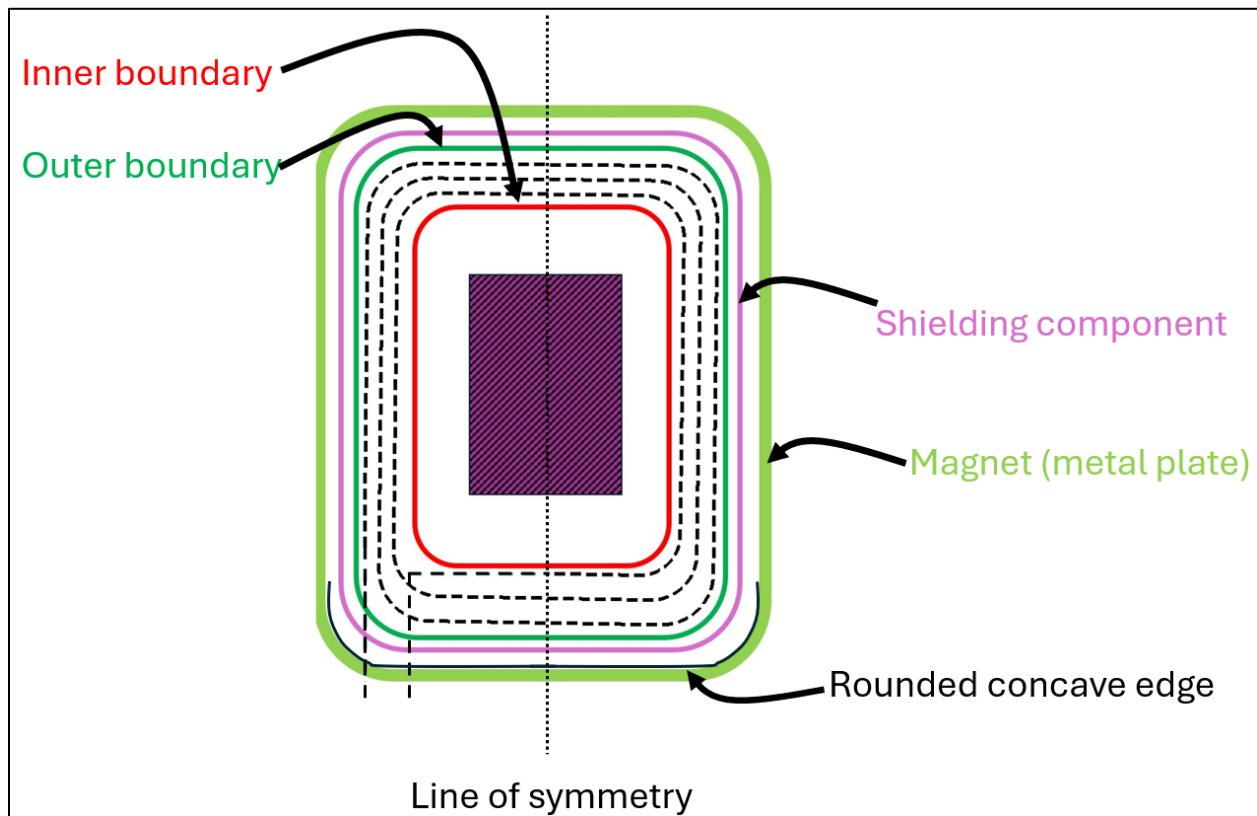
89. For instance, Franklin discloses a circular receiver coil 8402, with correspondingly-shaped surrounding shielding components and magnets. EX1005, FIG. 27A. Thus, it would have at least been obvious to include, in the electronic device, a circular receiver coil, which would therefore have substantially circular inner and outer boundaries. This is shown in the image below illustrating a representation of a plan view of the metal plate (magnet) of this variation of the Wojcik-Franklin Combination case with a projection of the inner and outer boundaries of the receiver coil and the receiver coil.



4. Claim 4

- (i) *Element [4]: The case of claim 1, wherein the rounded concave edge substantially symmetrically aligns to respective orthographic parallel projections of the inner boundary and the outer boundary onto a projection plane of the metal plate.*

90. As shown in the image below illustrating a representation of a plan view of the metal plate (magnet) of the Wojcik-Franklin Combination case with a projection of the inner and outer boundaries of the receiver coil and the receiver coil, the rounded concave edge substantially symmetrically aligns to respective orthographic parallel projections of the inner boundary and the outer boundary onto a projection plane of the metal plate.

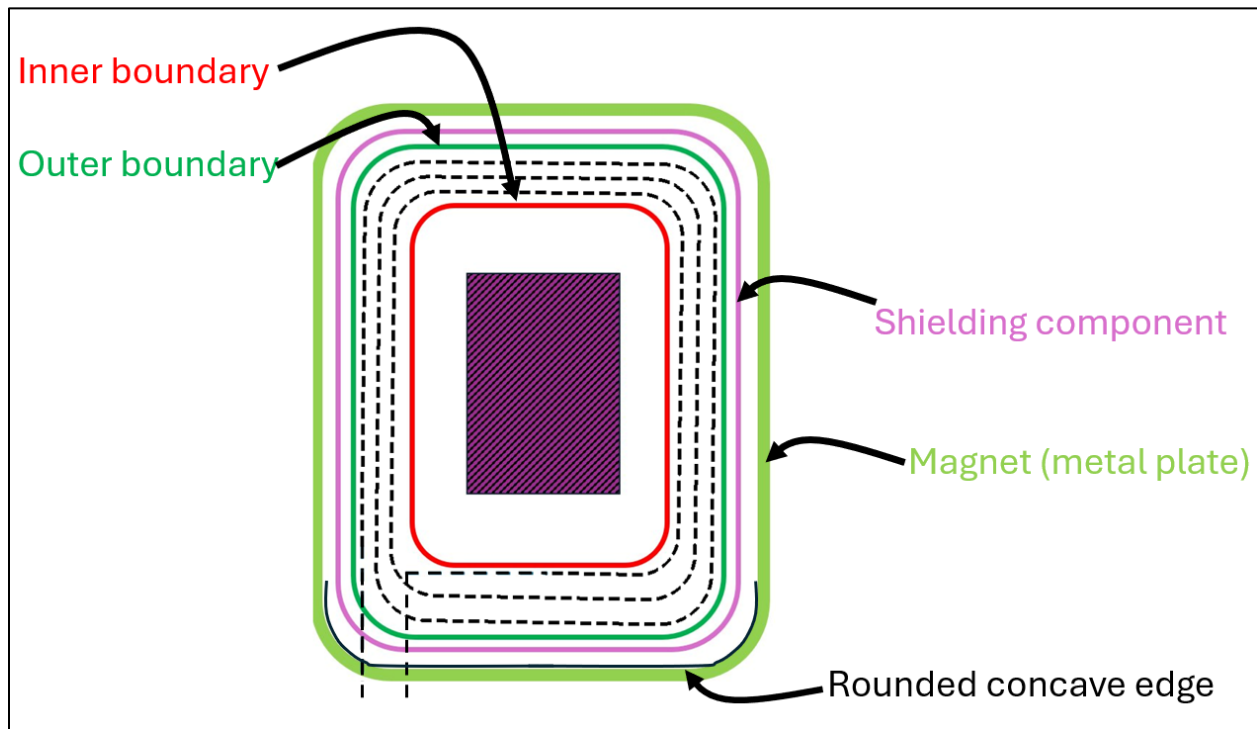


5. Claim 6

- (i) *Element [6]: The case of claim 4, wherein the rounded concave edge is placed outside an orthographic parallel projection of the outer boundary onto a projection plane of the metal plate.*

91. As shown in the image below illustrating a representation of a plan view of the metal plate (magnet) of the Wojcik-Franklin Combination case with a projection of the inner and outer boundaries of the receiver coil and the receiver coil, the rounded concave edge is outside an orthographic parallel projection of the outer boundary onto a projection plane of the metal plate. Franklin explicitly discloses such a configuration where the object interface 820 with mounting magnet 831/841 has a rounded concave edge that is outside an orthographic parallel projection of the

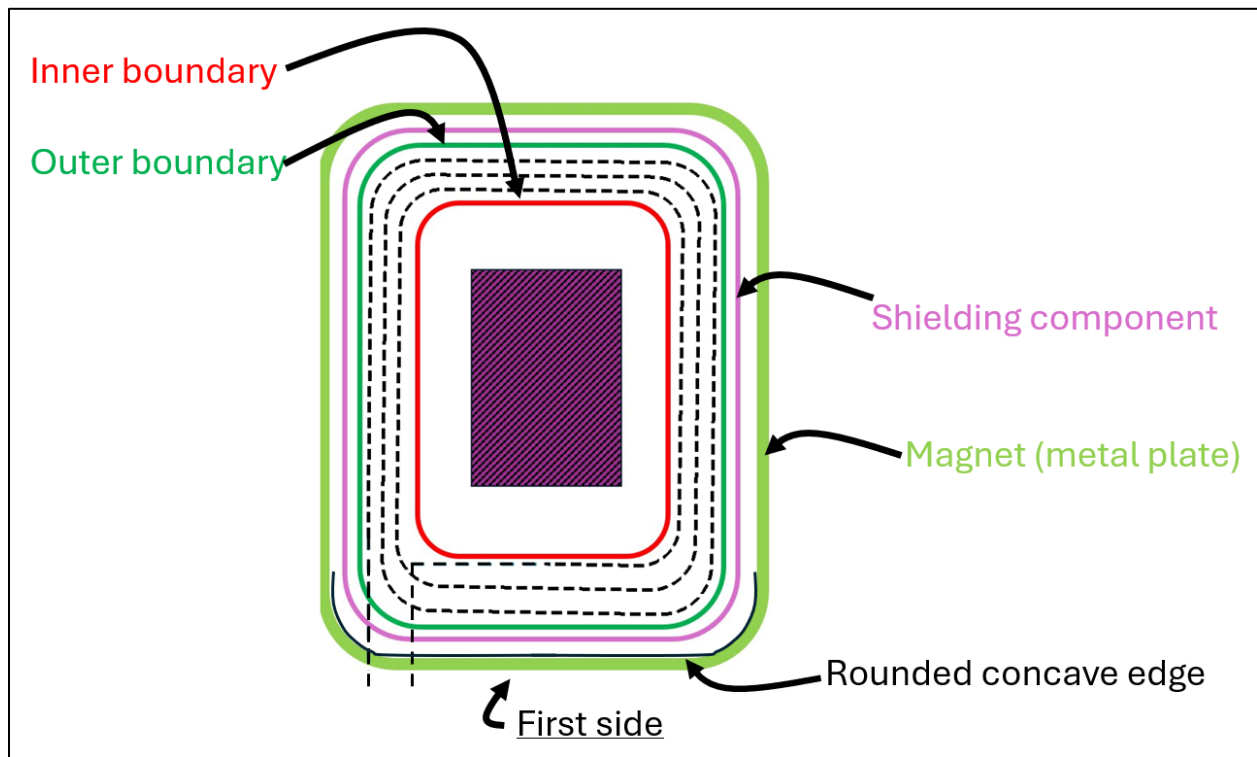
outer boundary onto a projection plane of the metal plate (i.e., the rounded edge of mounting magnet 831/841 is outside of the receiver coil 8402). EX1005, FIGs. 27A-27B.



6. Claim 7

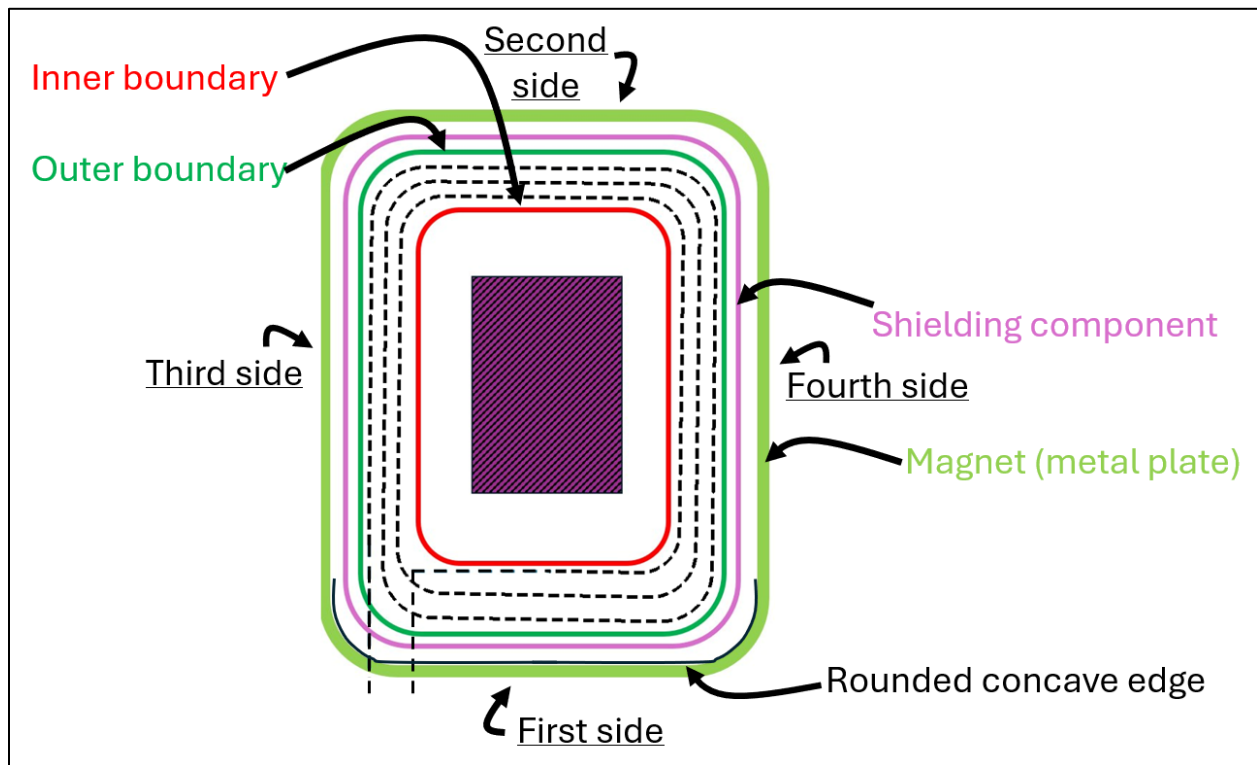
- (i) *Element [7a]: The case of claim 1, wherein the metal plate is substantially rectangular with a first side having the rounded concave edge,*

92. As shown in the image below illustrating a representation of a plan view of the metal plate (magnet) of the Wojcik-Franklin Combination case with a projection of the inner and outer boundaries of the receiver coil and the receiver coil, the metal plate (magnet) is substantially rectangular and has a first side having a rounded concave edge. *see also* discussion of claim [8], *infra*.



- (ii) *Element [7b]: wherein the metal plate has third and fourth sides that are substantially parallel to each other and has a second side that is substantially parallel to the first side.*

93. As shown in the image below illustrating a representation of a plan view of the metal plate (magnet) of the Wojcik-Franklin Combination case with a projection of the inner and outer boundaries of the receiver coil and the receiver coil, the metal plate (magnet) has third and fourth sides that are substantially parallel to each other and a second side that is substantially parallel with the first side.



7. Claim 8

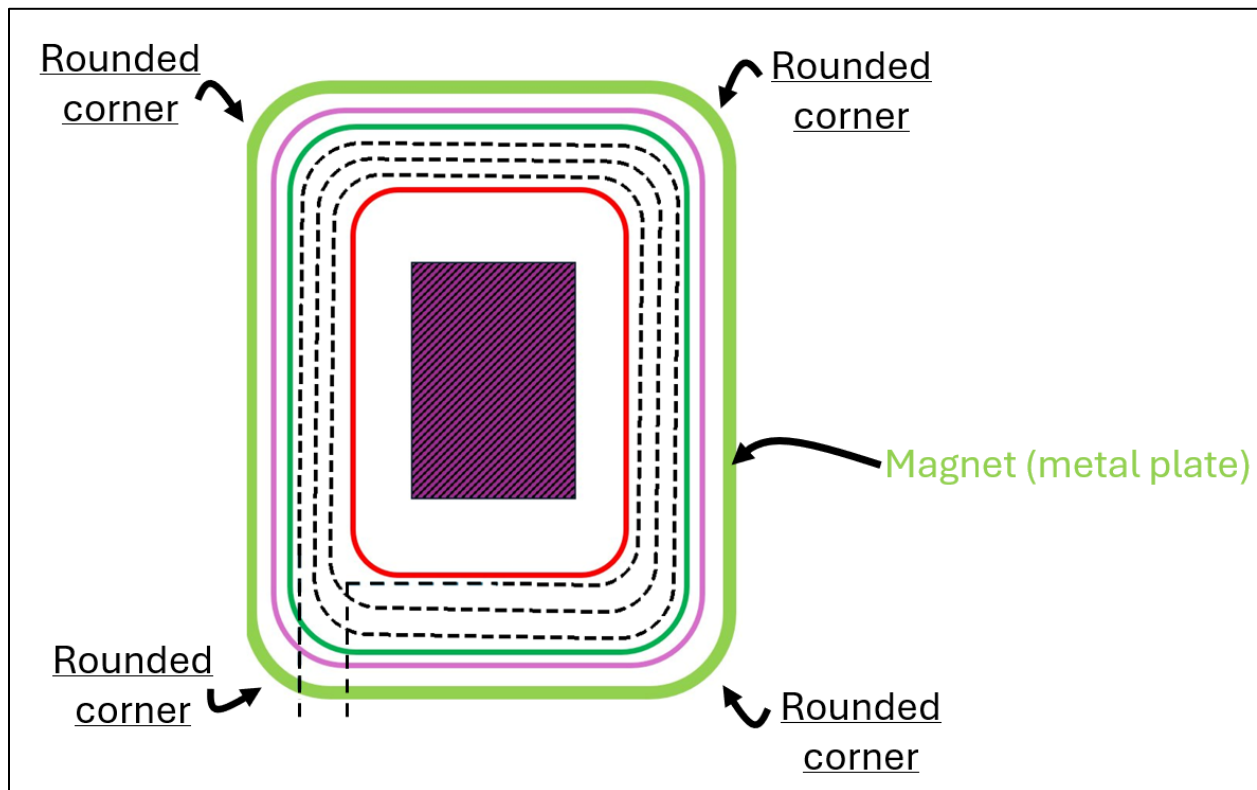
- (i) *Element [8]: The case of claim 7, wherein the metal plate has rounded corners.*

94. A POSITA would have found obvious to include, in the Wojcik-Franklin Combination, a metal plate with rounded corners. The mounting magnet disclosed in Franklin is a hollow ring that is shaped to fit the outer boundary of the coil. EX1005, FIG. 27A. In particular, Franklin discloses a circular magnet that matches the outer boundary of the circular receiver coil. *Id.* A POSITA would have found obvious that one natural inclusion of Franklin's mounting magnet³ in

³ A POSITA would have found that another natural inclusion of Franklin's

Wojcik's case would be to use a mounting magnet that matches the shape of Wojcik's receiver coil. The image below illustrates a representation of a plan view of the metal plate (magnet) of the Wojcik-Franklin Combination case with a projection of the inner and outer boundaries of the receiver coil and the receiver coil, where the metal plate (magnet) has rounded corners. As can be seen in the image below, the metal plate is shaped to match the outer boundary of the receiver coil.

mounting magnet in Wojcik's case would be to leverage Franklin's teaching of a circular receiver coil and its corresponding circular mounting magnet and shielding component, as shown and discussed regarding claim 3 above.



8. Claim 10

- (i) *Element [10]: The case of claim 1, wherein the metal plate is attached to the hard protective cover by an adhesive.*

95. Franklin does not explicitly describe how the mounting magnets are attached to the protective cover. However, Franklin explains that mounting magnets may be removable, replaceable, or modular. EX1005, [0058] (describing “modular components” that are “removable, detachable, and/or replaceable”), [0364] (“second mounting magnet 940 may be removable”), [0366] (the first mounting magnet 930 may be removable via the first top opening 991, and, correspondingly, the first mounting magnet 930 may be configured to be a modular component of the mounting apparatus 910”).

96. A POSITA would have therefore considered other references, such as Wojcik, to gain further implementation details that allow the magnets to be mechanically supported and fixed relative to the device structure. For example, Wojcik explains that its “[f]errite 210 may be affixed to, **adhered to**, attached to, and/or embedded in any portion of protective case.” EX1004, [0028]. Thus, it would have been obvious to a POSITA to similarly adhere mounting magnets to the protective case in a similar fashion – that is, using an adhesive to provide adherence, at least because both Wojcik’s ferrite 210 and Franklin’s mounting magnets (e.g., mounting magnet 831/841) comprise ferrous/magnetic materials that are attached to the device. EX1005, [0338] (“Magnet 831 may comprise a round, ferrous metal plate with a center opening”).

9. Claim 13

- (i) *Element [13pre]: A metal plate for magnetically mounting an electronic device or a case with an electronic device installed therein wherein the electronic device has a receiver coil for wireless charging constructed within the electronic device and the receiver coil is formed in between an inner boundary and an outer boundary, the metal plate comprising:*

97. As discussed with respect to claim 1, the Wojcik-Franklin Combination renders this element obvious. See discussion of [1pre], [1b], [1c].

(ii) *Element [13a]: a rounded concave edge,*

98. *Supra*, analysis of [1d].

(iii) *Element [13b]: wherein the metal plate is constructed to be attachable to the electronic device or the case,*

99. *Supra*, analysis of [10].

(iv) *Element [13c]: wherein the metal plate is constructed to enable magnetic retention or attachment of the electronic device to a support having a magnet,*

100. The metal plate (magnet) of the Wojcik-Franklin Combination, which is included in a recess of the case with an electronic device installed therein, enables retention or attachment of the electronic device to a support having a magnet for the same reasons discussed above with respect to [1c]. *See* discussion of [1c]. In particular, because the magnet enables magnetic retention or attachment of the case to a support having a magnet, the magnet similarly enables magnetic retention or attachment of the electronic device because the electronic device is installed in the case.

(v) *Element [13d]: wherein the metal plate attached to the electronic device or the case is positioned to substantially allow magnetic waves to pass through the area formed by the inner boundary.*

101. *Supra*, analysis of [1e].

10. Claim 14

- (i) *Element [14]: The case of claim 13, wherein the metal plate does not overlap with an orthographic parallel projection of the area formed by the inner boundary onto a projection plane of the metal plate.*

102. *Supra*, analysis of [2].

11. Claim 15

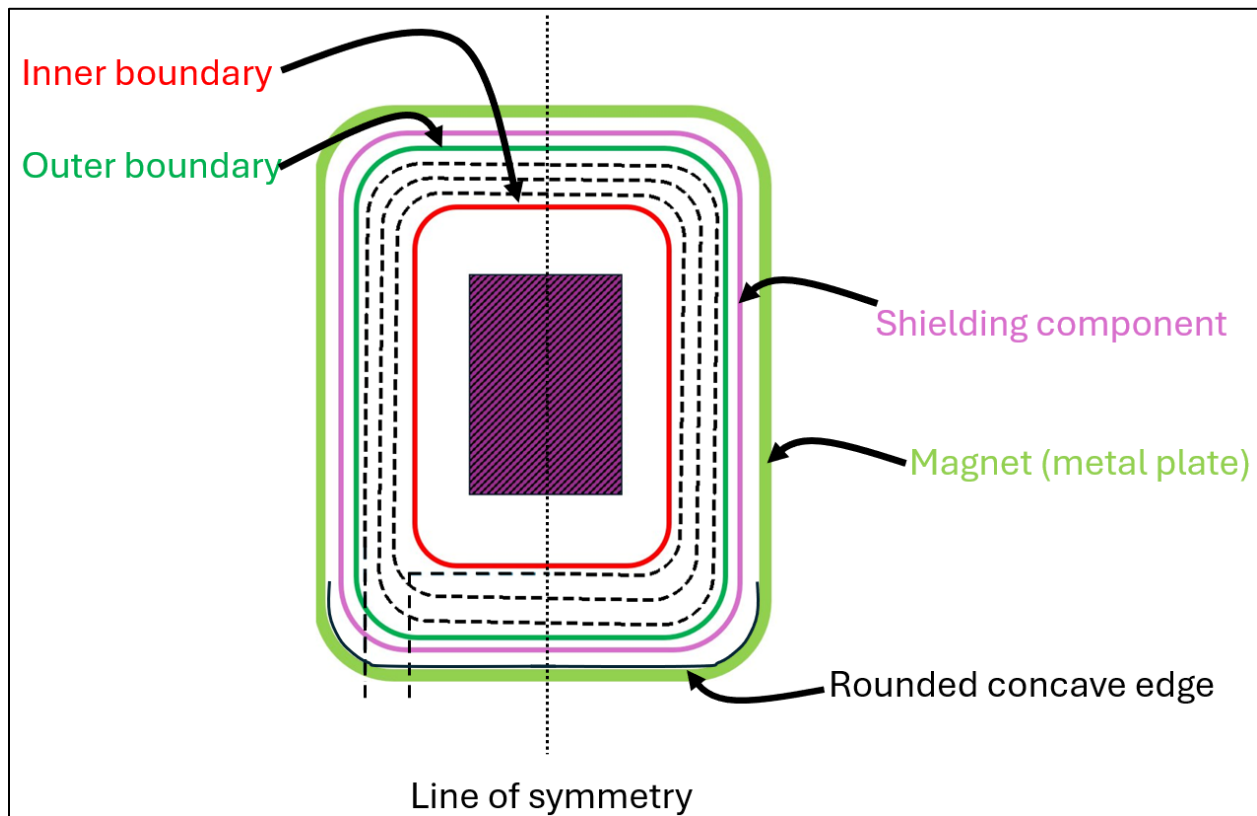
- (i) *Element [15]: The case of claim 13, wherein the inner boundary and the outer boundary are substantially circular.*

103. *Supra*, analysis of [3].

12. Claim 16

- (i) *Element [16]: The case of claim 13, wherein the rounded concave edge, the inner boundary, and the outer boundary are substantially symmetrical with respect to a same line.*

104. As shown in the image below illustrating a representation of a plan view of the metal plate (magnet) of the Wojcik-Franklin Combination case with a projection of the inner and outer boundaries of the receiver coil and the receiver coil, the rounded concave edge, the inner boundary, and the outer boundary are substantially symmetrical with respect to a same line (labeled line of symmetry, below).



13. Claim 18

- (i) *Element [18]: The case of claim 16, wherein the rounded concave edge is placed outside an orthographic parallel projection of the outer boundary onto a projection plane of the metal plate.*

105. *Supra*, analysis of [6].

14. Claim 19

- (i) *Element [19a]: The case of claim 13, wherein the metal plate is substantially rectangular with a first side having the rounded concave edge, and*

106. *Supra*, analysis of [7a].

(ii) *Element [19b] the metal plate has rounded corners,*

107. *Supra*, analysis of [8].

(iii) *Element [19c]: wherein the metal plate has third and fourth sides that are substantially parallel to each other and has a second side that is substantially parallel to the first side.*

108. *Supra*, analysis of [7b].

IX. GROUND 2A: Spigen-Partovi Renders Obvious Claims 1-4, 6-8, 10-11, 13-16, and 18-19

A. Spigen (EX1006)

109. Spigen discloses a protective case (“Thin Fit Hybrid” case) for a mobile device that includes an embedded metal plate to facilitate magnetic mounting. EX1006, 0:15-1:15; EX1024⁴, (Appendix YouTube4). Spigen’s case includes a rear housing having an inner recess that receives a rectangular metal plate. *Id.*, 1:15-2:10.

⁴ Appendix YouTube4 to the Declaration of June Munford is a transcript of the Spigen audio. Parallel citations to Appendix YouTube4 are provided for particular aspects of my analysis.



EX1006, 0:38 and 1:57 (annotated).

When seated within the recess of the case, the metal plate facilitates mounting of the mobile device within the protective case to an external magnetic base, such as a magnetic car mount. *Id.* The solid, rectangular metal plate spans across a portion of the central rear face of the mobile device when the mobile device is received by the case. EX1006, 1:40-2:01.

110. I note that Spigen is a YouTube video.⁵ Based on my experience, YouTube includes keyword search functionality for users to locate and view videos

⁵ I have accessed the version of Spigen submitted as EX1006

(<https://www.youtube.com/watch?v=fzymdpDZ1kc>) and compared it to the website at

<https://web.archive.org/web/20160303000430/https://www.youtube.com/watch?v=f>

of interest. I note that Spigen includes a text description including common terms that a POSITA would have used when looking to identify and view a video such as Spigen. For example, a POSITA would have performed a keyword search using terms such as case, magnet, mount, and plate, for example, all of which aligns with terms in the description of the YouTube video text caption, such that the video was readily accessible via such keyword searching.

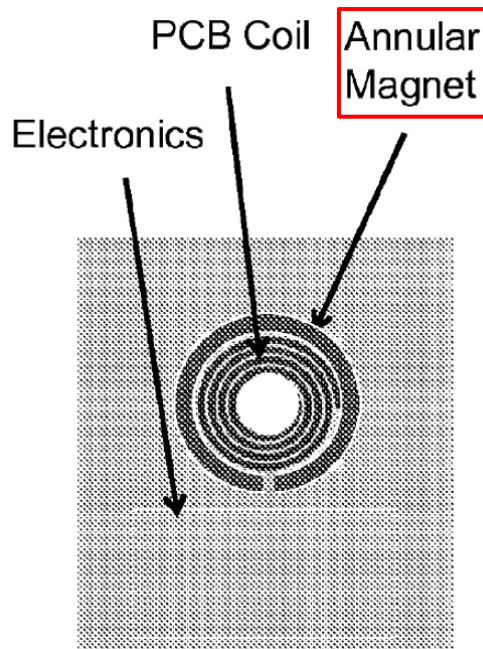
B. Partovi (EX1007)

111. Partovi describes systems for wireless power transfer that utilize magnetic elements to facilitate alignment and securement between a mobile device or its case and a charging station, and to enhance transfer of wireless power. EX1007, Abstract, [0003], [0078], [0081], [0155] (“Use of the magnets is especially beneficial in cases where the charger and/or power supply is integrated or attached to a moving platform such as in a car where it is important to keep the mobile device stationary while the car is moving.”), [0195] (“skin” or “case”); FIGS. 5, 10. Partovi

zymdpDZ1kc&gl=US&hl=en as archived by the Internet Archive (referenced in the affidavits submitted as EX1024 (as Appendix YOUTUBE03) and EX1025 (as Exhibit A), and I can confirm that the videos provided at both URLs appear to me to be identical.

describes the receiver coil as being located within the mobile device and as interacting with a charger coil external to the mobile device. *See, e.g.*, EX1007, [0077], FIGs. 7, 10, 19, 20, 44-45.

112. To prevent interference with the inductive charging field while still securely mounting the device, Partovi teaches shaping these magnetic elements (for example, plates or alignment magnets) to accommodate the mobile device's receiver coil and a complementary charge coil. *Id.*, [0081]-[0082]. For example, Partovi discloses utilizing magnetic elements having a "ring" shape or "arc magnets, square magnets, or one or more magnetic discs or other shapes" to allow the magnetic plate to be positioned proximate the coil to "provide minimal or no effect on performance of a wireless charger" while securing the device in place. Partovi, [0081], [0182]; *see also id.* [0155], [0201].



EX1007, FIG. 10 (partial, annotated), FIG. 4.

C. The Spigen-Partovi Combination

1. Analogous Art

113. Spigen and Partovi are analogous art to the '119 patent, which is generally directed to “a case having a metal plate for magnetically mounting the case with an electronic device installed therein to a support having a magnet, and more particularly, to a metal plate having a rounded concave edge.” EX1001, 1:13-19 (Field of the Invention).

114. Spigen discloses a protective case for a mobile device that includes an embedded metal plate to facilitate magnetic mounting. EX1006, 0:15-2:10; EX1024, (Appendix YouTube4). Partovi similarly describes systems for wireless power transfer that utilize magnetic elements to facilitate alignment and securement

between a mobile device and a charging station, with enhanced wireless power transfer. EX1007, Abstract, [0003], [0078], [0081]-[0082], [0155], [0201]; FIGS. 5, 7, 10.

115. Accordingly, Spigen and Partovi are both directed to the same field of endeavor as the '119 Patent, at least insofar as Spigen describes a protective case featuring a metal plate for magnetic mounting of an electronic device, and Partovi describes magnetic mounting and alignment between an electronic device and a charger. For at least that reason, Spigen and Partovi are analogous art to the '119 Patent.

116. Both references are also reasonably pertinent to a common core engineering problem that the '119 Patent purports to solve, including magnetic attachment with an external support using a metal plate while accommodating wireless charging. EX1001, 1:14-18, 20-44; *see also id.*, 1:44 (“This invention is directed to solve this problem”); *supra*, §IX.A-B, *infra*, §IX.D (Application of Spigen and Partovi). *Id.*

117. For at least that additional reason, Spigen and Partovi are analogous art to the '119 Patent.

2. Reasons to Combine

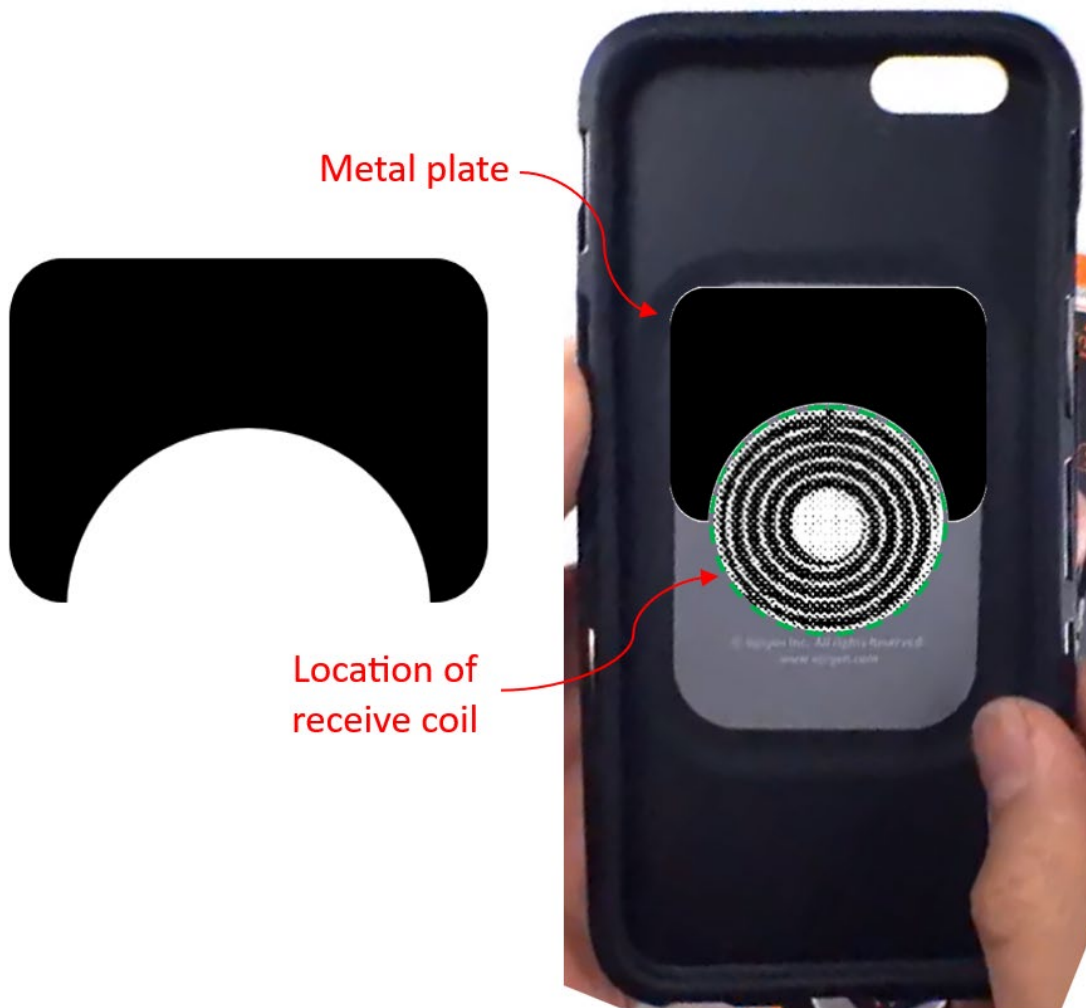
118. For reasons I describe in more detail below, and based on my knowledge and experience in the field and my review of Spigen and Partovi, a POSITA would have enhanced Spigen's mobile device case based on Partovi's teachings to, among other things, accommodate wireless inductive charging while providing secure attachment to a mount.

119. Spigen notably already provides a mobile device case featuring a rectangular metal plate that is positioned in a recess within the case to facilitate magnetic mounting (e.g., to a magnetic car mount). EX1006, 0:35-0:41, 1:05-1:20, 1:50-2:05. Based on my knowledge and experience in the field, the shape of a plate was a readily selectable design consideration, based on holding force, available space, aesthetics, and other considerations, and a POSITA would have found obvious that Spigen's metal plate would be predictably shaped to accommodate inductive mobile phone charging. *Id.*

120. For example, Partovi discloses known techniques for configuring magnetic elements to accommodate and follow the perimeter of a receiver coil, so as not to interfere with inductive charging. EX1007, [0182], [0201]. Partovi discloses utilizing magnetic elements having a "ring," "arc," or annular shape to allow the magnetic plate to be positioned proximate the coil to "provide minimal or

no effect on performance of a wireless charger” while securing the device in place. EX1007, [0081], [0155], [0182], [0201], FIG. 10 (illustrating an annular magnet surrounding a PCB coil), FIG. 44.

121. In accordance with Partovi’s teachings, the POSITA would have shaped Spigen’s metal plate to accommodate a mobile device utilizing wireless/inductive charging, by including a curved edge corresponding to the curvature of the receiving coil of the mobile device. EX1007, [0077] (“the receiver shown in FIGS. 1-4 can be built into... a mobile device such as a mobile phone.”), [0149] (“the [r]eceiver in the mobile device... can be integrated by the manufacturer in to the device.”), [0206], FIG. 20). The curvature of the lower edge would feature a profile that mimics the arcuate shape of the receiver coil such that the plate would be positioned proximate the coil when the mobile device is received in the case. Doing so would have predictably facilitated alignment and promoted wireless charging performance without meaningful interference from the metal plate. EX1007, [0155], [0201].



122. For example, a POSITA would have been prompted to achieve multiple advantages by shaping the Spigen-Partovi Combination's metal plate to include a concave lower edge, as shown above. Based on my knowledge and experience in the field, a POSITA would have, in at least some implementations, maintained the overall generally rectangular shape of Spigen's original metal plate, to promote magnetic holding strength consistent with Spigen's mounting objectives while avoiding impact to the receiver coil and wireless power transfer. *Id.* Adjusting the

shape of the plate by accommodating space overlying the coil location and retaining the balance of Spigen's generally rectangular plate, and/or expanding slightly, would have promoted desired holding strength. A POSITA would have recognized from Partovi's description that the material in the upper rectangular section (e.g., of Spigen's original plate shape) would not interfere with wireless power transfer and would promote the magnetic mounting objective. *Id.*

123. As another example, and as an alternative to the concave lower edge shown above, a POSITA would have similarly found it obvious to shape the Spigen-Partovi Combination's metal plate as a ring with a cutout, as expressly described and shown within Partovi. EX1007, [0178] ("The ring is used here as an example and other geometries of thin magnets such as a square, rectangle, triangle, etc. shape can also be used."), FIGS. 5, 10-11, 19, 20, 43-45.

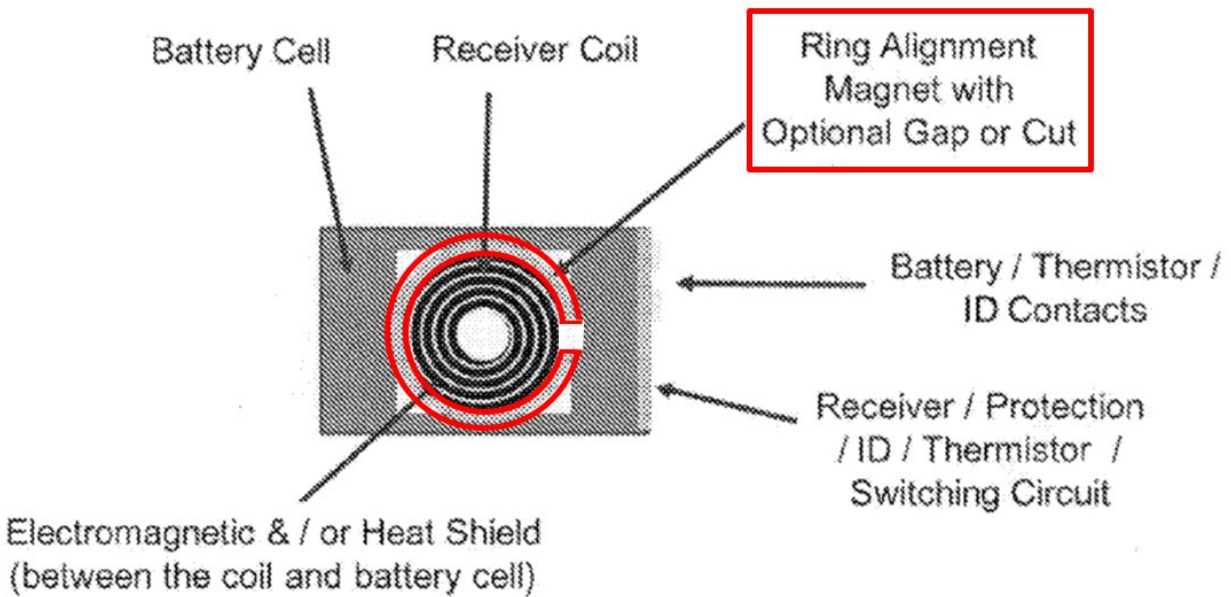
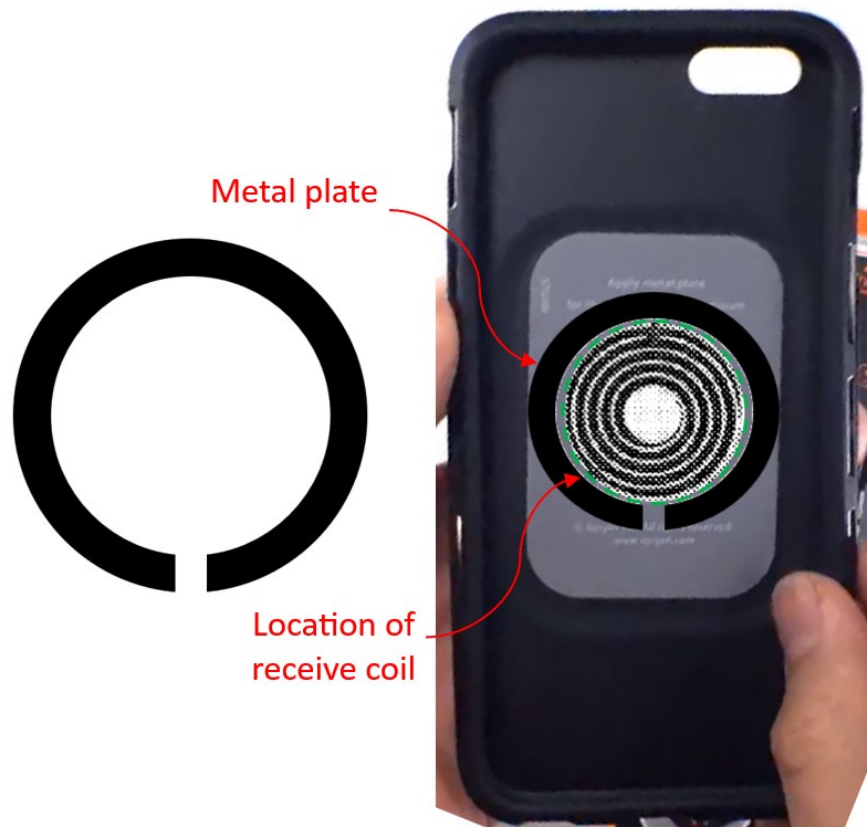


Figure 44

124. For instance, a POSITA would have utilized a ring shape to facilitate magnetic engagement with a support, and alignment of receiving and charging coils, in scenarios in which it would have been further beneficial to accommodate rotation of the device relative to a support/charger. EX1007, [0152] (“The magnets can be mounted such that they allow rotation of the receiver coil and thus the mobile device and/or battery with respect to the charger and/or power supply while maintaining charging capability.”); [0178] (“rotationally invariant alignment”). In that regard, the POSITA would have found it obvious to implement the Spigen-Partovi Combination’s metal plate with a ring shape that surrounds or nearly surrounds a projection of the mobile device receiver coil.



125. A POSITA would have readily implemented the metal plate to package in a space-efficient manner and limiting potential interference with wireless charging. For example, a POSITA would have predictably configured the metal plate such that the metal plate does not overlap with a projection of the area formed by the inner boundary onto the metal plate, does not overlap with a projection of the area formed by the outer boundary on the metal plate, or overlaps slightly with a projection of the area formed by the outer boundary on the metal plate, promoting space-efficiency and without meaningful impact to wireless charging. EX1007, FIGs. 5, 10, 11, 20, 43-45; *id.*, FIG. 19 (illustrating slight overlap).

126. A POSITA would have been motivated to utilize a metal plate having a curved edge in accordance with Partovi's suggestions in Spigen's mobile device case for multiple reasons.

127. *First*, a POSITA would have been motivated to combine Spigen and Partovi to enhance the functionality and applicability of Spigen's case by accommodating a device that utilizes wireless charging. Prior to the time of the '119 patent, mobile devices utilizing wireless charging were common and widely known. *Id.* (EX1007, Abstract, [0077], FIG. 20). Mobile devices benefited from the protection of case like that disclosed by Spigen, regardless of the type of charging system used. *Id.* Spigen provides a magnetic mounting solution for its case but does not expressly account for wireless charging. Based on my knowledge and experience in the field, I note that a solid rectangular metal plate interposed between a receiver coil and an external transmitter coil attenuates and diverts the charging field, and so was understood to interfere with inductive charging. EX1004, [0017] ("the case material may cause a shielding or blocking effect and further limit the power transfer between the devices"). Partovi describes an arrangement that addresses this problem by arranging magnetic elements in shapes that follow the perimeter of a receiver coil. Partovi, [0054], [0082]. EX1007, [0081]-[0082], [0182]. Partovi describes an arrangement that addresses this problem by arranging magnetic elements in shapes that follow the perimeter of a receiver coil. Partovi,

[0054], [0082]. EX1007, [0081]-[0082], [0182]. A POSITA would have recognized, based on Partovi, that adjusting the shape of the metal plate would promote wireless charging without interference, facilitating use of Spigen's case with mobile devices that utilize wireless charging, such as mobile devices described by Partovi. EX1007, [0178], [0196].

128. ***Second***, a POSITA would have been motivated to combine Spigen and Partovi to promote wireless charging efficiency through alignment of the receiver coil and the charging coil. EX1007, [0080] ("maximum efficiency and power transfer"), [0152], [0155]. Partovi expressly describes and illustrates a magnetic element having a curved edge that mimics the curved profile of the receiver coil in order to facilitate alignment with a corresponding magnetic component in a support/charger. EX1007, [0178], [0196], FIGS. 5, 10-11, 19, 20, 43-45. Based on my knowledge and experience in the field, I note that coil-to-coil alignment impacts the coupling between the transmitter and receiver coils, such that applying a curved profile in accordance with Partovi to the plate described by Spigen would have predictably promoted precise magnetic alignment between the device and the charger, enhancing charging efficiency.

129. ***Third***, a POSITA would have been prompted to combine Spigen and Partovi to utilize a plate having a rounded concave edge, based on Partovi's

suggestions, in order to promote a compact, space-efficient geometry. Partovi addressed spatial constraints using a curved edge of the plate that mimics the curved profile of the receiver coil for positioning proximate the coil without interference. EX1007, [0178]. Based on Partovi's description, a POSITA would have implemented a similar geometry in the metal plate to efficiently utilize the limited physical footprint on the rear of the mobile device, positioning the plate in close proximity around a portion of the perimeter of the coil, thereby effectuating its mounting function in a space-efficient geometry. *Id.*

130. ***Fourth***, in some implementations, a POSITA would have been motivated to combine the references to utilize a ring shape to promote rotationally invariant alignment. Partovi expressly teaches that utilizing “a ring” shape for the magnetic alignment element promotes “rotationally invariant alignment.” EX1007, [0196]. A POSITA would have recognized the functional benefit and enhanced flexibility and convenience for magnetically mounting the device to a charger mount to facilitate effective alignment for charging regardless of its orientation, and/or to facilitate positioning of the phone screen in a desired orientation (e.g., portrait, landscape, or an intermediate orientation).

3. Reasonable Expectation of Success

131. Modifying Spigen's case to leverage Partovi's teachings would have required only routine knowledge well within the skill of a POSITA prior to the earliest effective filing date. Indeed, the modification would have amounted to the use of a known technique (per Partovi, curving magnetic alignment components to magnetically secure a device with a charger/mount) to improve a known system (Spigen's phone case mounting system) ready for improvement to yield predictable results (including the benefits articulated above).

132. A POSITA would have had a reasonable expectation of success in making the proposed modifications, especially based on the similarity of the systems, and the simplicity of adjusting the shape of the existing metal plate of Spigen. Indeed, as described by Partovi, the use of magnetic components of a variety of shapes was known and predictably implemented. A POSITA would have readily utilized the same materials and manufacturing techniques as Spigen's original solution to implement the metal plate of the Spigen-Partovi Combination, with minimal or no additional cost. *Id.*

133. A POSITA would have recognized from Spigen and Partovi that modifying the shape of the Spigen plate to include a curved edge or ring shape is readily included in the mobile device case without hindering Spigen's intended

functionality in attaching with a mount. The Spigen-Partovi Combination case retains Spigen's functionality of providing a metallic component for secure magnetic mounting, while simultaneously facilitating the passage of inductive charging fields, in accordance with Partovi. *Id.*

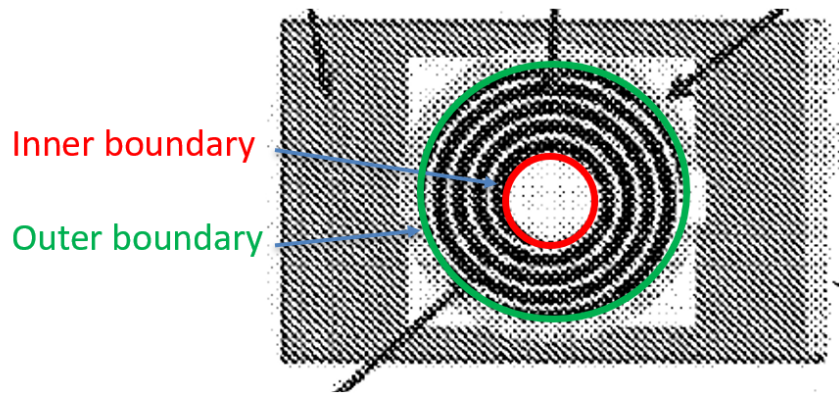
D. Claim Element Analysis

1. Claim 1

- (i) *Element [1pre]: A case for an electronic device wherein the electronic device has a receiver coil for wireless charging constructed within the electronic device and the receiver coil is formed in between an inner boundary and an outer boundary, the case comprising:*

134. The Spigen-Partovi Combination renders obvious this element. Spigen discloses a protective case for an electronic device (e.g., mobile phone). EX1006, Title ("iPhone 6(s+) cases"), 0:00-0:15 ("one of the best two-piece cases"); *see also* EX1024 (Appendix YouTube4, 0:00).

135. And, as explained above, the POSITA would have included a receiver coil within the Spigen-Partovi Combination electronic device for wireless charging. For instance, as shown in Partovi's FIG. 44 (reproduced below), Partovi describes a mobile phone having a "receiver coil" that is formed in between an inner boundary and an outer boundary. EX1007, Abstract, [0003], [0077]-[0078], FIGs. 7, 10, 19, 20, 44-45.



(EX1007, FIG. 44 (partial, annotated))

136. Consistent with Partovi’s teachings, the POSITA would have formed the Spigen-Partovi Combination receiver coil in between an inner boundary and an outer boundary and positioned in the mobile device. EX1007, Abstract, [0003], [0077]-[0078], FIGs. 7, 10, 19, 20, 44-45.

- (ii) *Element [1a]: a hard protective cover constructed to receive the electronic device therein wherein the hard protective cover has a recess which faces the electronic device and the hard protective cover is external with respect to the electronic device; and*

137. Consistent with Spigen, the Spigen-Partovi Combination case, which is external with respect to the electronic device, includes a hard protective cover constructed to receive the electronic device in a recess which faces the electronic device.

138. Spigen discloses a case having a “dual-layered structure for extra protection” that includes a hard protective cover and an inner cushion portion.

EX1006, 0:17-0:22 (text shown on box). The case has structure and rigidity sufficient to receive and retain the electronic device.⁶



EX1006, [0:19] (annotated).

⁶ Notably, the hard protective cover and relatively softer inner cushion disclosed by Spigen is just like that described by the '119 Patent. EX1001, 8:22-25 ("The soft protective cover (10) is made of soft material and the hard protective frame (20) is made of hard material."); EX1006, 0:17-0:22.

139. Spigen's hard protective cover features a recess that faces the electronic device. EX1006, 0:19. The mobile device is received within the recess such that the hard protective cover is external with respect to the electronic device. *Id.*

(iii) *Element [1b]: a metal plate constructed to be received in the recess of the hard protective cover,*

140. The Spigen-Partovi Combination includes a metal plate (e.g., Spigen's "neodymium" plate) constructed to be received in the recess of the hard protective cover. EX1006, 1:42-1:50 ("the back plate area has an area that's recessed that allows you to fit the Quad Neo dynamin dynamin [sic] [neodymium] magnet easily"); EX1024 (Appendix YouTube4, 1:42-1:50); EX1006, 0:17 ("Apply metal plate" text in case recess); EX1008 ("metal"); EX1001, 9:18-26.

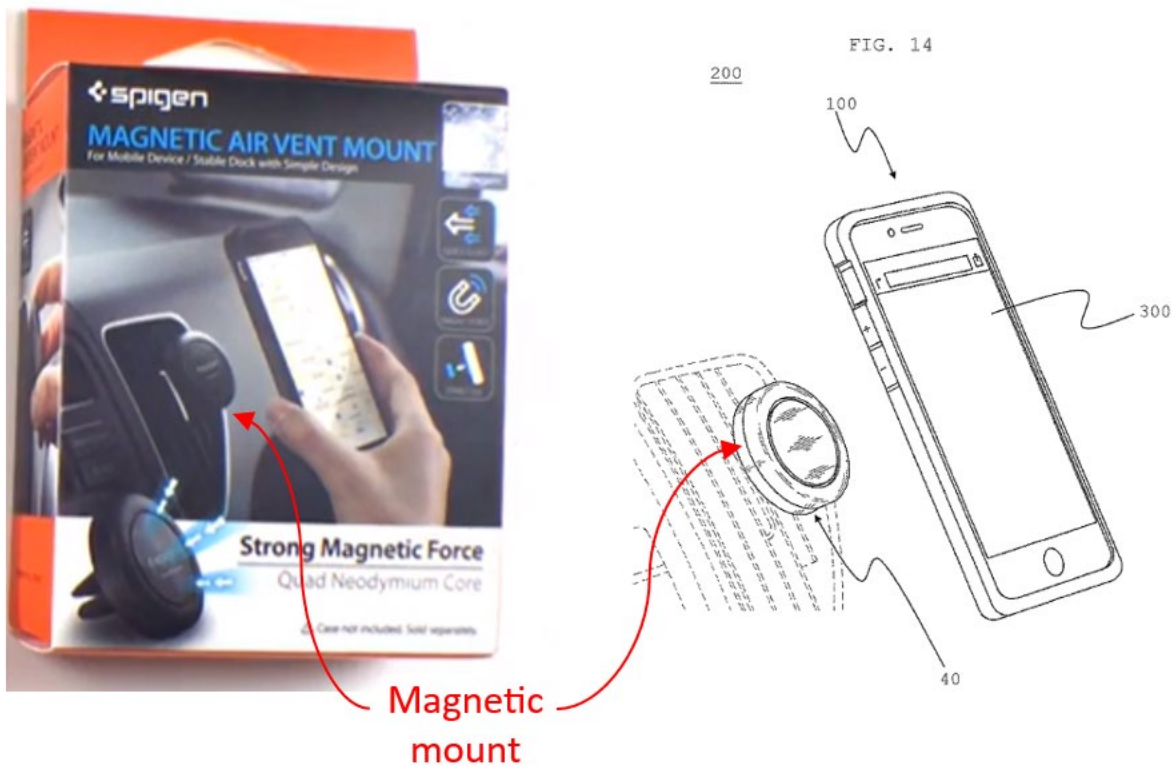


EX1006, 0:38 and 1:57(annotated).

- (iv) *Element [1c]: wherein the metal plate is constructed to enable magnetic retention or attachment of the case to a support having a magnet,*

141. In the Spigen-Partovi Combination, the metal plate is constructed to enable magnetic retention or attachment of the case to a support having a magnet (e.g., Spigen’s “magnetic air vent mount”), in accordance with Spigen and Partovi’s teachings. For example, the metal plate in the case enables magnetic retention or attachment to a support such as a “magnetic air vent mount” disclosed by Spigen, or other similar mounts *Id.*; EX1006, 0:35-0:41 (text shown on box); *id.* 1:08-1:10, 1:11-1:20; 1:40-2:05; EX1007, [0080], [0097], [0176]-[0178], [0195]-[0196].⁷

⁷ I note that the metal plate resulting from the application of Partovi’s teachings to Spigen, which enables magnetic retention of the case to a support featuring a magnet, is just like the metal plate described by the ’119 Patent. EX1001, Abstract (“the hard protective frame has a ... a metal plate constructed to be received in the recess. The metal plate is constructed to enable magnetic retention or attachment of the case to a support having a magnet.”); EX1006, 0:17-0:22.



EX1006, 0:38 (annotated, with Spigen at left and the '119 Patent at right).

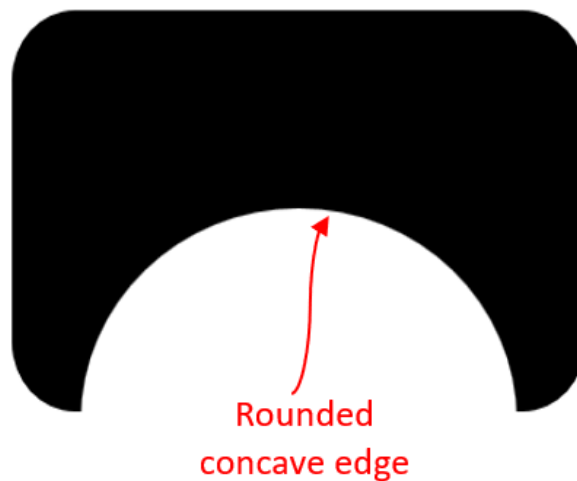
- (v) *Element [1d]: wherein the metal plate has a rounded concave edge,*

142. The Spigen-Partovi Combination features a metal plate that has a rounded concave edge, in accordance with Partovi's suggestions. *supra*, §IX.C (Spigen-Partovi Combination).

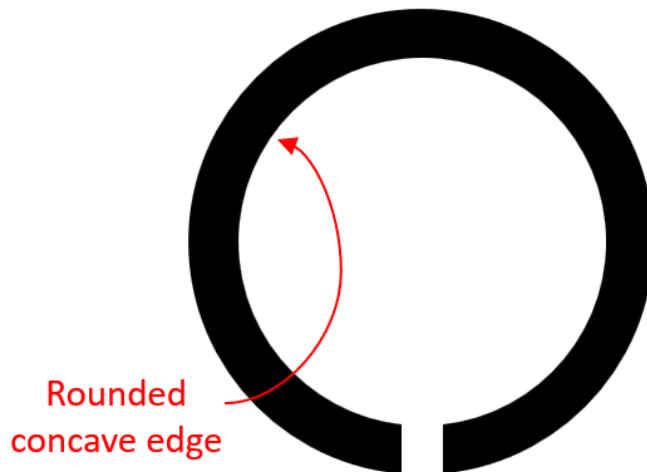
143. As described above, a POSITA would have found obvious multiple shapes for the metal plate, each of which includes a rounded concave edge that mimics and accommodates the profile of the receiver coil of the mobile device housed within the protective case. Partovi explains that an "example of a type of

magnet that can be used for this purpose is a ring or arc magnet that will provide minimal or no effect on performance of a wireless charger.” EX1007, [0178]; *see also* EX1007, [0183], [0195]-[0197] (placed “around the coil,” magnet geometries can include “arc magnets” or “other shapes.”). The magnets are mounted to “maintain[] charging capability” by not interfering with the inductive charging of the coils. *Id.*

144. According to a first example predictable implementation, an arc shape cutout is provided in the rectangular metal plate disclosed by Spigen, to accommodate the geometry of a circular receiver coil described by Partovi. *Supra*, §IX.C (Spigen-Partovi Combination).



145. According to a second example predictable implementation, the metal plate is shaped in the form of a ring (e.g., such as a ring having a cutout), in accordance with Partovi’s suggestions. *See, e.g.*, EX1007, FIG. 44.



146. To be clear, a POSITA would have recognized and found obvious, from Spigen and Partovi, that the geometry of the cavity that accommodates the metal plate in the case has a geometry compatible with the metal plate. A POSITA would have nested the modified plate within the existing cavity, and/or similarly modified the geometry of the cavity to accommodate the shape of the Spigen-Partovi Combination's plate. *Id.*

- (vi) ***Element [1e]: wherein the metal plate received in the recess is positioned to substantially allow magnetic waves to pass through the area formed by the inner boundary.***

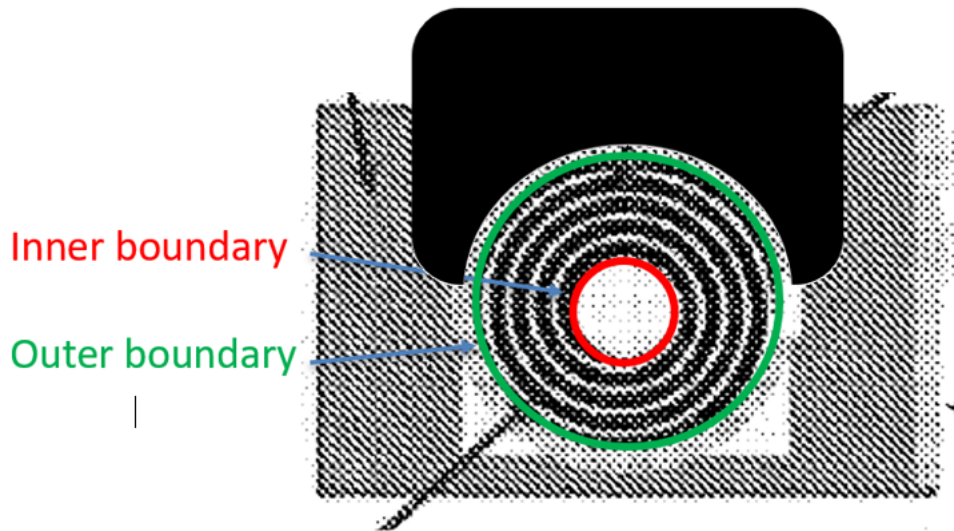
147. Consistent with Partovi's express teachings, the POSITA would have found it obvious to position the metal plate received in the Spigen-Partovi recess to substantially allow magnetic waves to pass through the area formed by the inner boundary. *supra*, §IX.C (Spigen-Partovi Combination).

148. For instance, Partovi expressly indicates magnet configurations that “provide minimal or no effect on performance of a wireless charger.” EX1007, [0178]; *see also* EX1007, [0183], [0195]-[0197] (placed “around the coil,” magnet geometries can include “arc magnets” or “other shapes.”); *see also, infra*, Analysis of Claims 2 and 6.

2. Claim 2

- (i) ***Element [2]: The case of claim 1, wherein the metal plate does not overlap with an orthographic parallel projection of the area formed by the inner boundary onto a projection plane of the metal plate.***

149. As discussed above (§IX.C – Spigen-Partovi Combination), in the combination, the metal plate is positioned in accordance with Partovi’s suggestions such that it does not overlap with an orthographic parallel projection of the area formed by the inner boundary of the receiver coil of an electronic device positioned in the case. EX1007, FIGs. 5, 10, 11, 20, 43-45. Indeed, the rounded concave edge of the metal plate has a curvature that tracks near an outer boundary of the receiver coil and is spaced apart from an inner boundary of the receiver coil. *Id.*



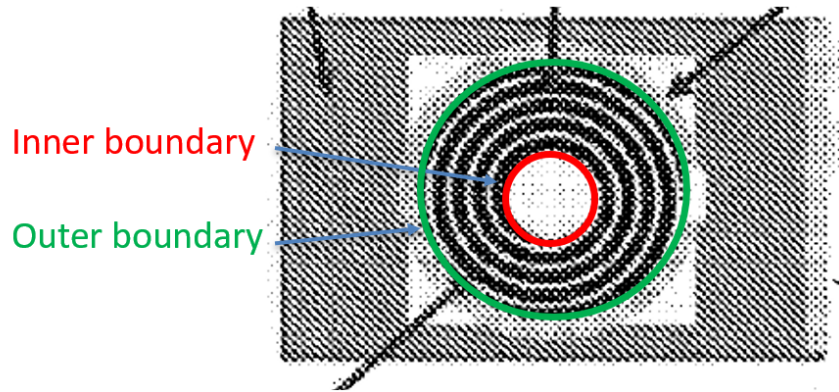
150. Likewise, according to the second exemplary predictable implementation in which the metal plate is implemented in the form of a ring (*supra*, Analysis of Element 1d), the rounded concave edge of the metal plate has a curvature that tracks near an outer boundary of the receiver coil and is spaced apart from an inner boundary of the receiver coil. The metal plate does not overlap with an orthographic parallel projection of the area formed by the inner boundary onto a projection plane of the metal plate such that the plate provides “minimal or no effect on performance of a wireless charger.” EX1007, [0178].

3. Claim 3

- (i) ***Element [3]: The case of claim 1, wherein the inner boundary and the outer boundary are substantially circular.***

151. In the combined system, the inner boundary and the outer boundary of the “receiver coil” are substantially circular, in accordance with Partovi’s

suggestions. EX1007, FIG. 44; *see also*, EX1007, FIGS. 5, 7-13, 19-25, 36-37, 41, 43-47.

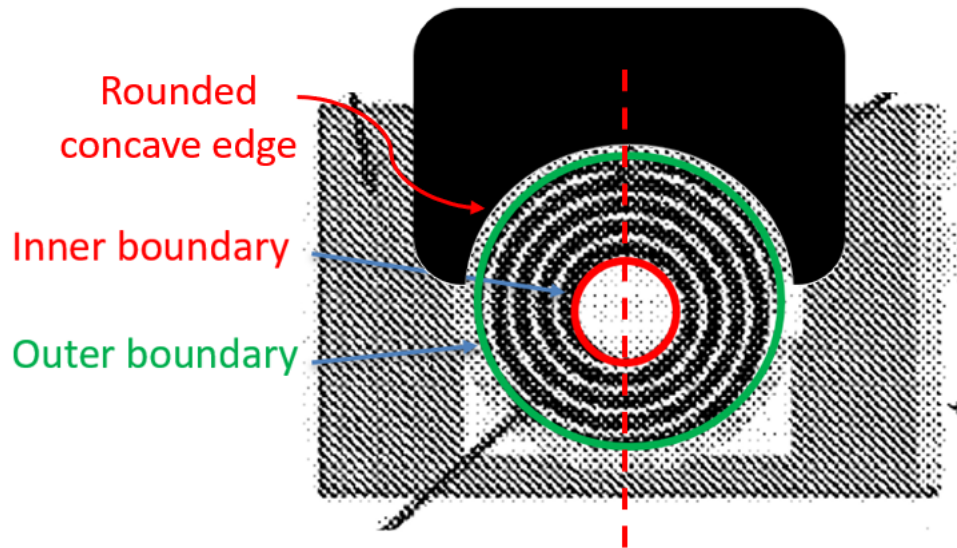


(EX1007, FIG. 44 (partial, annotated))

4. Claim 4

- (i) ***Element [4]: The case of claim 1, wherein the rounded concave edge substantially symmetrically aligns to respective orthographic parallel projections of the inner boundary and the outer boundary onto a projection plane of the metal plate.***

152. In the combination, the rounded concave edge substantially symmetrically aligns to respective orthographic parallel projections of the inner boundary and the outer boundary onto a projection plane of the metal plate. *see also* EX1001, 4:18-25; 5:21-27.



5. Claim 6

- (i) *Element [6]: The case of claim 4, wherein the rounded concave edge is placed outside an orthographic parallel projection of the outer boundary onto a projection plane of the metal plate.*

153. As shown below, in the Spigen-Partovi Combination, the rounded concave edge is placed outside an orthographic parallel projection of the outer boundary onto a projection plane of the metal plate. EX1007, FIGs. 5, 10, 11, 20, 43-45; *see also, supra*, Analysis of Claim 2.

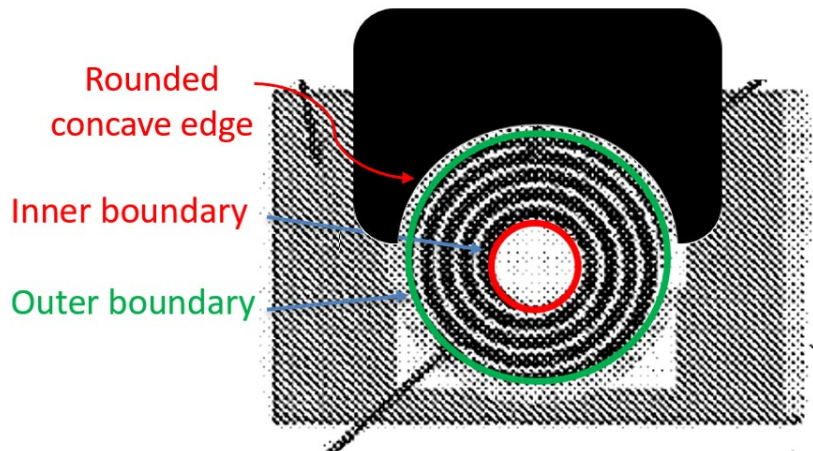


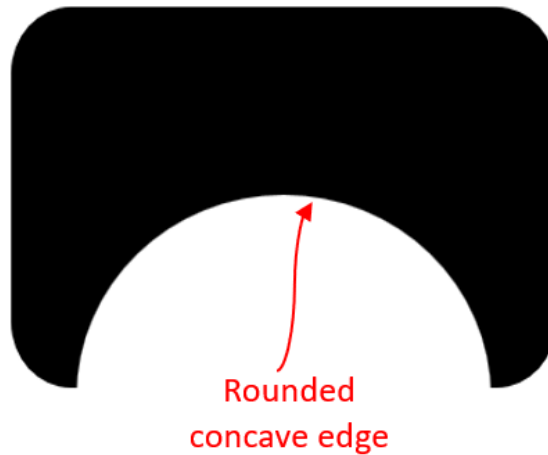
FIG. 6B

154. Likewise, according to the second example predictable implementation in which the metal plate is implemented in the form of a ring (*supra*, Analysis of Element 1d), the metal plate is positioned similarly relative to the receiver coil such that the rounded concave edge is outside an orthographic parallel projection of the outer boundary onto a projection plane of the metal plate, for the reasons discussed above.

6. Claim 7

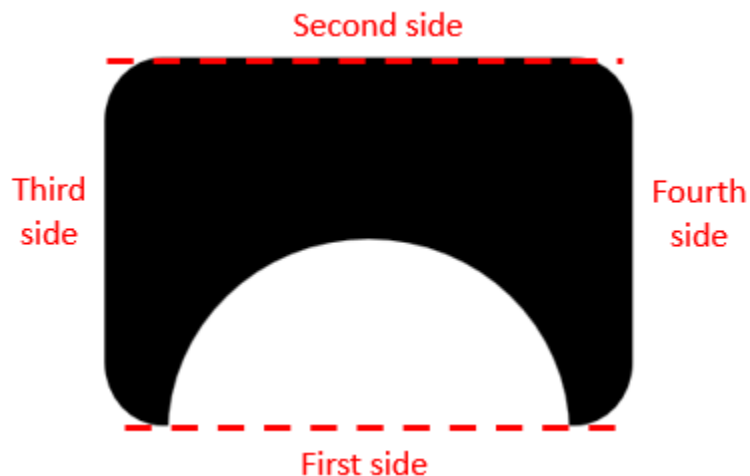
- (i) *Element [7a]: The case of claim 1, wherein the metal plate is substantially rectangular with a first side having the rounded concave edge,*

155. As shown below, in the first example predictable implementation of the Spigen-Partovi Combination, the metal plate is substantially rectangular and has a first side having a rounded concave edge. *See also* discussion of claim [8], *infra*.

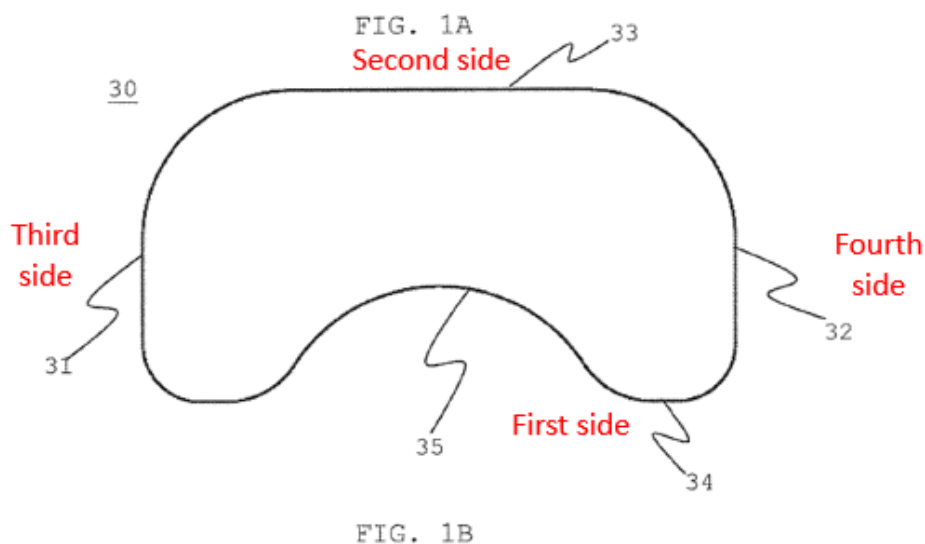


- (ii) *Element [7b]: wherein the metal plate has third and fourth sides that are substantially parallel to each other and has a second side that is substantially parallel to the first side.*

156. In the first exemplary predictable implementation of the Spigen-Partovi Combination, the metal plate has third and fourth sides that are substantially parallel to each other and a second side that is substantially parallel with the first side.



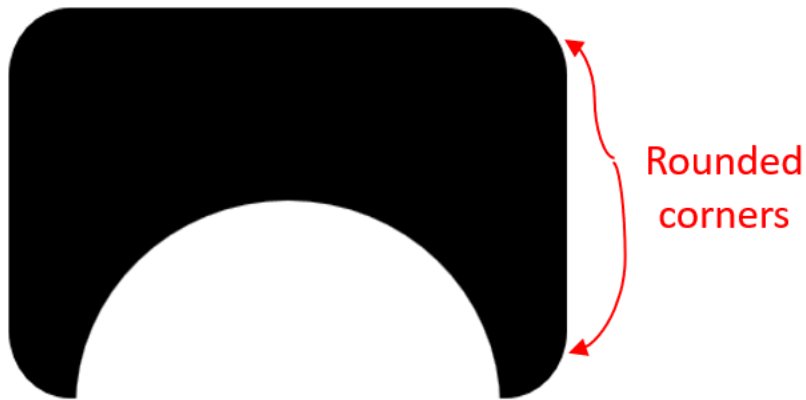
157. Here again, the Spigen-Partovi Combination's metal plate is like the example depicted by the '119 Patent.



7. Claim 8

- (i) *Element [8]: The case of claim 7, wherein the metal plate has rounded corners.*

158. In the combination, the metal plate has rounded corners, in accordance with Spigen and Partovi's suggestions. (EX1006, 1:50-2:02).



8. Claim 10

- (i) *Element [10]: The case of claim 1, wherein the metal plate is attached to the hard protective cover by an adhesive.*

159. In the Spigen-Partovi Combination, the metal plate is attached to the hard protective cover by an adhesive. For example, Spigen discloses an adhesive tape on a surface of the metal plate that adheres the metal plate to the hard protective cover. EX1006, 1:57-2:03.



(EX1006, 1:58 (annotated))

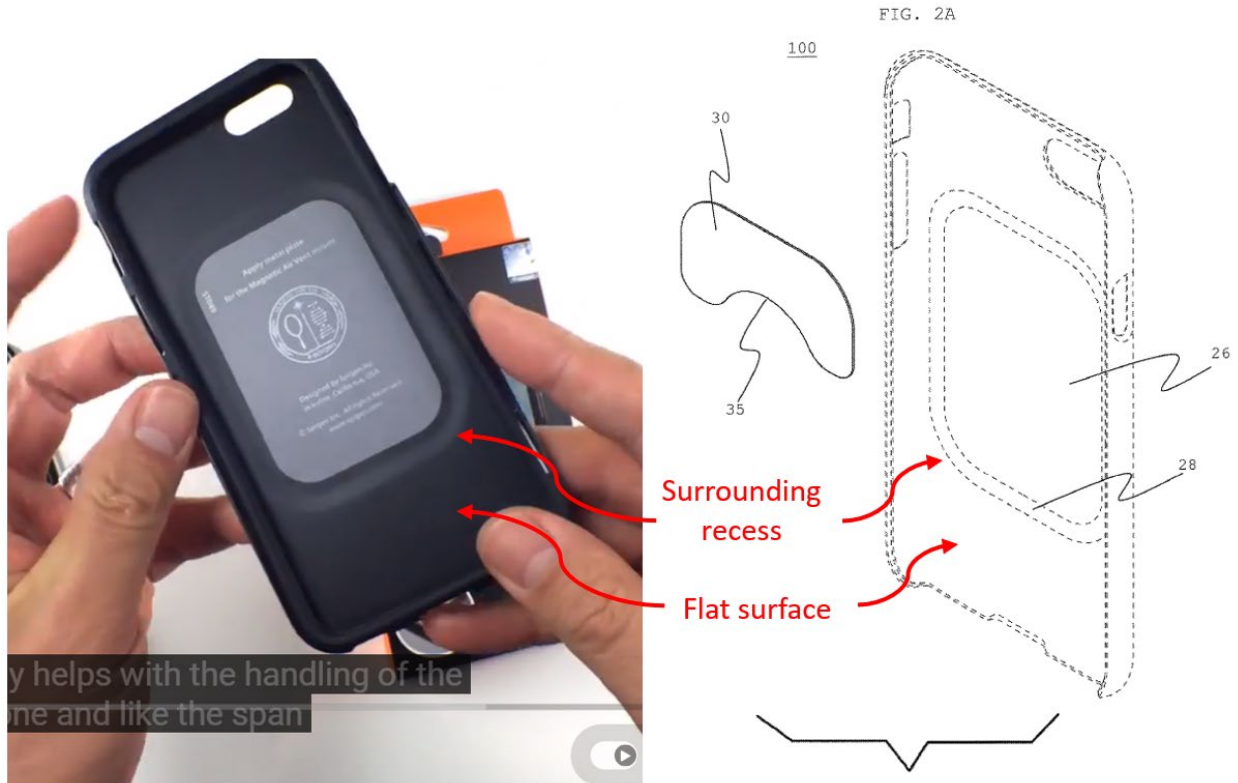
9. Claim 11

- (i) *Element [11]: The case of claim 1, wherein the hard protective cover further comprises a surrounding recess which surrounds the recess and slopes away from a flat surface of the hard protective cover towards the recess forming a cavity.*

160. The hard protective cover of the Spigen-Partovi Combination includes a surrounding recess which surrounds the recess and slopes away from a flat surface of the hard protective cover towards the recess forming a cavity, in accordance with Spigen.

Spigen

'119 Patent



(EX1006, 0:17, EX1001, FIG. 2A (annotated)).

161. The shape and configuration of the surrounding recess of Spigen is just like the '119 patent itself.

162. Similarly, according to the second exemplary predictable implementation in which the metal plate is implemented in the form of a ring (*supra*, Analysis of Element 1d), the surrounding recess which surrounds the recess and slopes away from a flat surface of the hard protective cover towards the recess forming a cavity, consistent with Spigen's suggestion. Indeed, consistent with

Spigen's surrounding recess depicted above, a POSITA would have readily modified the shape to likewise surround a ring shaped metal plate.

10. Claim 13

- (i) *Element [13pre]: A metal plate for magnetically mounting an electronic device or a case with an electronic device installed therein wherein the electronic device has a receiver coil for wireless charging constructed within the electronic device and the receiver coil is formed in between an inner boundary and an outer boundary, the metal plate comprising:*

163. The Spigen-Partovi Combination renders this element obvious. *Supra*, Analysis of [1pre], [1b], [1c].

- (ii) *Element [13a]: a rounded concave edge,*

164. *Supra*, Analysis of [1d].

- (iii) *Element [13b]: wherein the metal plate is constructed to be attachable to the electronic device or the case,*

165. *Supra*, Analysis of Claim [10].

- (iv) *Element [13c]: wherein the metal plate is constructed to enable magnetic retention or attachment of the electronic device to a support having a magnet,*

166. The metal plate of the Spigen-Partovi Combination, included in a recess of the case with an electronic device installed therein, enables retention or attachment of the electronic device to a support having a magnet for the same reasons

discussed above with respect to [1c]. *Supra*, Analysis of [1c]. The magnet enables magnetic retention or attachment of the case to a support having a magnet, and similarly enables magnetic retention or attachment of the electronic device installed in the case.

- (v) *Element [13d]: wherein the metal plate attached to the electronic device or the case is positioned to substantially allow magnetic waves to pass through the area formed by the inner boundary.*

167. *Supra*, Analysis of [1e].

11. Claim 14

- (i) *Element [14]: The case of claim 13, wherein the metal plate does not overlap with an orthographic parallel projection of the area formed by the inner boundary onto a projection plane of the metal plate.*

168. *Supra*, Analysis of Claim [2].

12. Claim 15

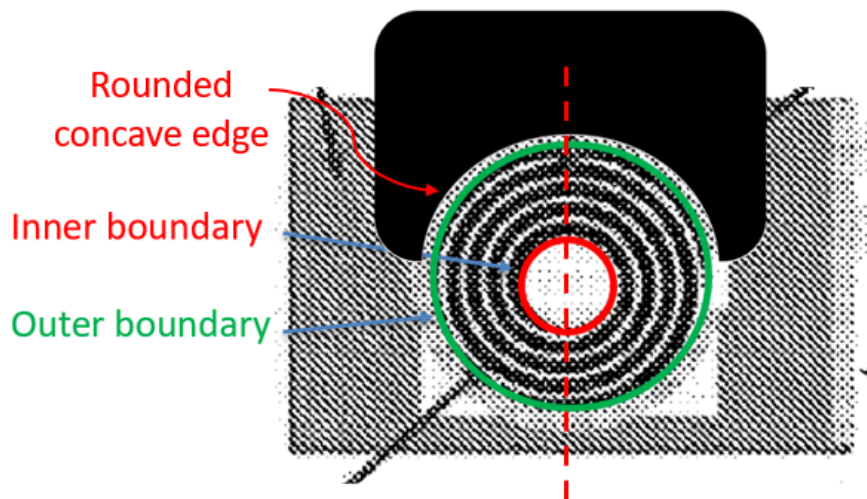
- (i) *Element [15]: The case of claim 13, wherein the inner boundary and the outer boundary are substantially circular.*

169. *Supra*, Analysis of Claim [3].

13. Claim 16

- (i) *Element [16]: The case of claim 13, wherein the rounded concave edge, the inner boundary, and the outer boundary are substantially symmetrical with respect to a same line.*

170. In the Spigen-Partovi Combination, the rounded concave edge, the inner boundary, and the outer boundary are substantially symmetrical with respect to a same line (labeled line of symmetry, below). *see also, supra* Analysis of Claim 4.



14. Claim 18

- (i) *Element [18]: The case of claim 16, wherein the rounded concave edge is placed outside an orthographic parallel projection of the outer boundary onto a projection plane of the metal plate.*

171. *Supra*, Analysis of Claim [6].

15. Claim 19

- (i) *Element [19a]: The case of claim 13, wherein the metal plate is substantially rectangular with a first side having the rounded concave edge, and*

172. *Supra*, Analysis of Claim [7a].

- (ii) *Element [19b]: the metal plate has rounded corners,*

173. *Supra*, Analysis of Claim [8].

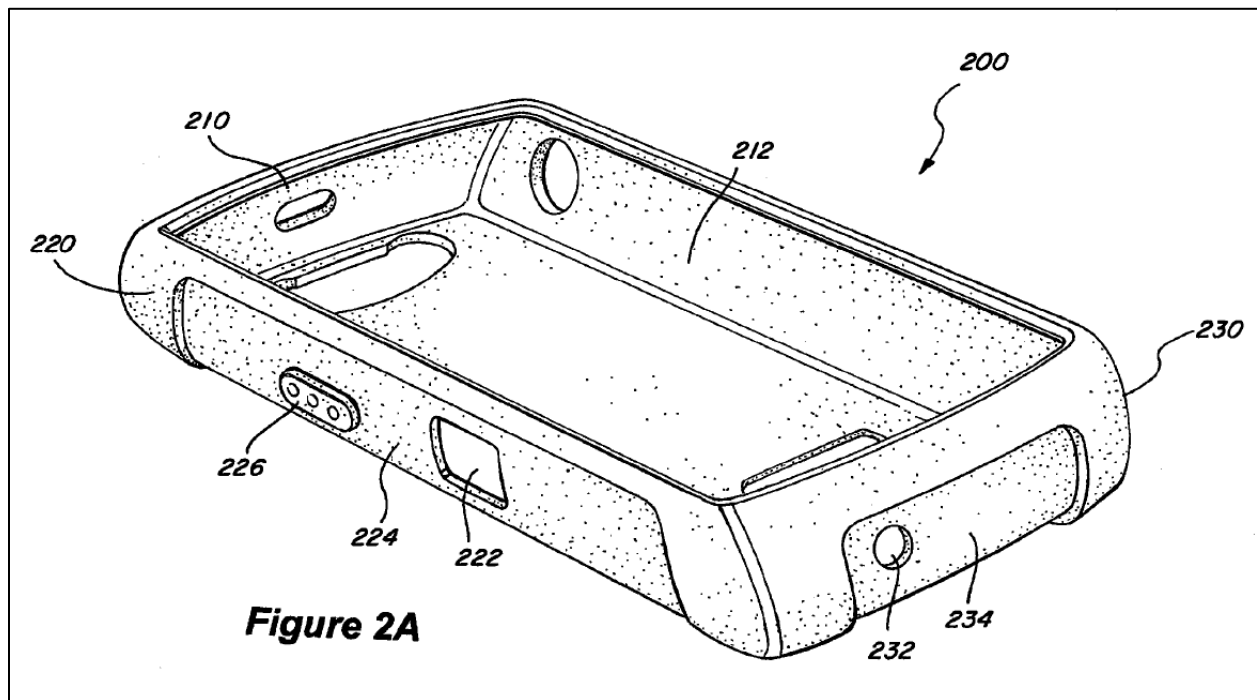
- (iii) *Element [19c]: wherein the metal plate has third and fourth sides that are substantially parallel to each other and has a second side that is substantially parallel to the first side.*

174. *Supra*, Analysis of Claim [7b].

X. GROUND 2B: Spigen-Partovi-Fathollahi Renders Obvious Claim 12

A. Fathollahi (EX1010)

175. Fathollahi describes “a protection device for a mobile device” that includes a combination of a flexible inner sleeve and a rigid shell. EX1010, Abstract, [0003], [0010]-[0012], [0030]-[0038], [0039]-[0043], [0045]-[0047], cl. 1, FIGS. 2A-2B, 3A-5, 7A-7C. The flexible inner sleeve “encapsulates” a mobile device. *Id.*



EX1010, FIG. 2A.

B. The Spigen-Partovi-Fathollahi Combination

1. Analogous Art

176. Fathollahi is analogous art to the '119 patent. Fathollahi is in the same field of endeavor, and is reasonably pertinent to the same core engineering problems involving mobile device case construction. *Id.* Indeed, Fathollahi is directed to mobile device case construction, and provides teachings a POSITA would have found pertinent to case construction and configurations. *Id.*; *infra*, §X.B-C.

2. Reasons to Combine

177. A POSITA would have improved the Spigen-Partovi Combination's mobile device case based on Fathollahi's teachings regarding a flexible inner sleeve component that includes a back portion that extends across the mobile phone. EX1010, [0012] ("backing portion"), cl. 1 ("back surface"); FIG. 2A (showing back surface of "flexible inner sleeve"). The resulting case would in accordance with Spigen include hard and flexible portions, and the flexible portion would include a back that extends across the back of a mobile phone received in the case. *Id.*

178. A POSITA would have been motivated to combine Spigen-Partovi with Fathollahi in order to enhance protection of a mobile device within the case, in accordance with the express objectives of both Spigen and Partovi. EX1006, 2:04-2:15; EX1010, [0003], [0010]-[0011], [0030] (the elasticity of the flexible inner sleeve "protects against accidental dropping or other damages to the underlying mobile device."), FIG. 2A. Fathollahi expressly describes encapsulating the mobile device with a flexible inner sleeve. Based on that related disclosure, a POSITA would have been motivated to provide cushioning across the back of the mobile device, in addition to around the perimeter, to afford additional protection. *Id.*

3. Reasonable Expectation of Success

179. A POSITA would have reasonably expected success when combining Spigen-Partovi and Fathollahi, as doing so would have required nothing more than routine knowledge well within the skill of a POSITA prior to the earliest effective filing date. For example, the application of known techniques (use of a hard outer shell and flexible inner sleeve having a back portion to provide protection to a mobile device) to a known system (Spigen-Partovi's phone case mounting system that includes a hard outer portion and a flexible inner portion) ready for improvement to yield predictable results (benefits articulated above). A POSITA would have had a reasonable expectation of success in making the proposed modifications, especially based on the similarity of the case constructions, and the simplicity of including a back material to the existing flexible cushion described by Spigen.

C. Claim Element Analysis

1. Claim 12

- (i) *Element [12]: The case of claim 1, further comprising a soft protective cover which comprises a back panel to cover a back portion of the electronic device, and a side wall extending from a top surface of the back panel along edges of the back panel, wherein the hard protective cover is constructed to removably mount over the soft protective cover.*

180. Spigen-Partovi-Fathollahi combination renders obvious Claim 12. The system includes a soft protective cover. *See*, EX1006, 0:17-22, 2:04-2:15. In the

combined system, the soft protective cover includes a back panel to cover a back portion of the electronic device, in accordance with Fathollahi. EX1010, FIG. 2A, [0010]-[0011]; *supra*, §X.B (Spigen-Partovi-Fathollahi Combination).



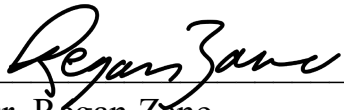
181. The soft protective cover includes a side wall extending from a top surface of the back panel along edges of the back panel, in accordance with Spigen and Fathollahi's teachings. *See, e.g.*, EX1006, 0:17-22, 2:04-2:15; EX1010, FIG. 2A.

182. Consistent with Spigen, the hard protective cover is constructed to removably mount over the soft protective cover. EX1006, 0:17-22, 2:04-2:15.

XI. CONCLUSION

183. I declare that all statements made in this Declaration of my own knowledge are true and that all statements made on information and belief are believed to be true. I further declare that these statements are made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both (under Section 1001 of Title 18 of the United States Code).

Executed this 15th day of September, 2026.



Dr. Regan Zane

APPENDIX A



Dr. Regan A. Zane

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Department of Electrical and Computer Engineering

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SHORT BIO

Dr. Regan Zane is the founding Director of the Center for Advancing Sustainability through Powered Infrastructure for Roadway Electrification (ASPIRE), an NSF sponsored engineering research center involving 10 universities, 4 national labs, more than 85 faculty and staff, more than 300 students, and more than 60 industry and innovation partners. He holds the David G. and Diann L. Sant Endowed Professor position at Utah State University in the Department of Electrical and Computer Engineering, where he founded the USU Power Electronics Lab (UPEL), the Electric Vehicle and Roadway (EVR) research facility and test track, and the Battery Limits and Survivability Test (BLAST) lab.

Dr. Zane is an IEEE Fellow and has published more than 250 peer-reviewed articles, served as co-inventor on more than 40 issued patents, received international and institutional recognition in research, teaching and innovation, and raised more than \$190 million in research, development and demonstration funding. His programs maintain a strong emphasis on collaboration with academic, government and industry partners to develop and transition innovative technologies into the marketplace.

Dr. Zane has made significant contributions to the design, modeling, and application of resonant converters and to the development of advanced control techniques for modular power converters in a wide range of applications. His current programs cover key aspects of electrified transportation, from battery, vehicle, and charging systems to grid integration, smart charge management, demand response and distributed energy resources. Additional topics include wireless power transfer, medium voltage grid-tied power converters, control of modular scalable series and parallel input and output converters, high efficiency, high frequency, high power density, and high performance dc-dc, ac-dc, dc-ac power converters, ac and dc microgrids, battery management systems, drivers for LEDs and discharge lamps in energy efficient lighting systems, active stability control and adaptive tuning in multi-input, multi-output converter systems, active converter and system health monitoring, power integrated circuit design, and low-power energy harvesting.

EMPLOYMENT

- 2020 – present **Director**, NSF Advancing Sustainability through Powered Infrastructure for Roadway Electrification (ASPIRE) Engineering Research Center, College of Engineering, Utah State University.
- 2012 – present **Full Professor**, *Department of Electrical and Computer Engineering*, Utah State University. **David G. and Diann L. Sant Endowed Professor** (since 2018) and **USTAR Professor** (2012 – 2018). Founding Director of the Center for Sustainable Electrified Transportation (SELECT), Electric Vehicle & Roadway (EVR) Research Facility and Test Track and USU Power Electronics Lab (UPEL).
- 2008 – 2016 **Associate Professor**, *Department of Electrical, Computer, and Energy Engineering*, University of Colorado at Boulder.
- 2001 – 2008 **Assistant Professor**, *Department of Electrical and Computer Engineering*, University of Colorado at Boulder.
- 1999 – 2001 **Senior Research Scientist**, *Electronic Power Conversion*, Corporate Research & Development Center, General Electric, Niskayuna, NY. Principle researcher in area of custom integrated circuits for power management applications within GE businesses with an emphasis on miniature controllers for energy efficient lighting systems.

EDUCATION

Institution	Degree	Year	Field of Study
University of Colorado at Boulder Dissertation title , “ <i>Development, analysis, and implementation of an ASIC controller for single-phase power factor correction.</i> ”	Ph.D. (GPA: 4.0)	1999	Electrical Engineering
University of Colorado Boulder	M.S. (GPA: 4.0)	1998	Electrical Engineering
University of Colorado Boulder	B.S. (GPA: 4.0)	1996	Electrical Engineering

HONORS AND AWARDS

2025	IEEE Fellow
2021	Campus Researcher of the Year Award, Utah State University
2020	Utah Clean Cities Sustainability Partner of the Year (for SELECT & ASPIRE Centers)
2019	Utah Innovation Award in Clean Technology and Energy for “Robust and Efficient Battery Management System,” sponsored by Utah Governor’s Office of Economic Development
2018	David G. and Diann L. Sant Endowed Professor, Utah State University
2017	Department Researcher of the Year Award, ECE Department, Utah State University
2015	Inaugural Director of the USU Electric Vehicle and Roadway (EVR) Research Facility and Test Track
2011	Selected member of the 2012-2013 Defense Sciences Study Group (DSSG), Institute for Defense Analyses (IDA), US Defense Advanced Research Projects Agency (DARPA)
2011	Holland Teaching Award, University of Colorado
2009	IEEE Power Electronics Society Transaction Prize Letter Award
2008	IEEE Power Electronics Society Richard M. Bass Outstanding Young Power Electronics Engineer Award
2008	Coleman Institute Faculty Sabbatical Fellowship
2008	John and Mercedes Peebles Innovation in Teaching Award, University of Colorado
2007	IEEE Power Electronics Society Transaction Prize Letter Award
2007	Senior Member, IEEE
2006	Provost Faculty Achievement Award, University of Colorado
2006	Inventor of the Year Award, Technology Transfer Office, University of Colorado
2006	IEEE MTT Microwave Prize for best journal paper
2004	NSF Faculty Early Career Development (CAREER) Program Award Recipient
2001	Six-Sigma Green Belt Certificate, GE Corporate Research and Development
2001	Manager’s Award, General Electric Corporate Research and Development

PUBLICATION RECORD**Books** (published or in press)

- [1] L. Corradini, D. Maksimovic, P. Mattavelli, R. Zane, *Digital control of high-frequency switched-mode power converters*, Hoboken, NJ: Wiley, 2015.

Journals (published or in press)

- [1] S. Gurudiwan, A. Zade, H. Wang and R. Zane, "Optimized Timing Control for Leading-Edge Aligned Modulation of a T-Type Bridge in Unfolding-Based AC–DC Converters," in *IEEE Transactions on Power Electronics*, vol. 40, no. 4, pp. 4716–4721, April 2025, doi: 10.1109/TPEL.2024.3514819.
- [2] T. Newbolt, M. Waite, P. Mandal, H. Wang and R. Zane, "Load Demand Modeling of Large-Scale Charging Infrastructure for Electric Vehicles In-Motion," in *IEEE Access*, vol. 12, pp. 175550–175562, 2024, doi: 10.1109/ACCESS.2024.3496656.
- [3] A. Zade, S. Gurudiwan, D. Maksimović and R. Zane, "High-Bandwidth Control of a 20-kW Single-Stage Unfolding-Based AC–DC Converter Using the Extra Element Theorem and Current Emulation Technique," in *IEEE Transactions on Power Electronics*, vol. 39, no. 11, pp. 14411–14429, Nov. 2024, doi: 10.1109/TPEL.2024.3423705.
- [4] S. Gurudiwan, A. Zade, H. Wang and R. Zane, "Accurate ZVS Analysis of a Full-Bridge T-Type Resonant Converter for a 20-kW Unfolding-Based AC-DC Topology," in *IEEE Open Journal of Power Electronics*, vol. 5, pp. 692–708, 2024, doi: 10.1109/OJPEL.2024.3400256.
- [5] S. Inoue et al., "50 kW Reflexive Tuning Networks With Low Uncoupled Transmitter Currents for Dynamic Inductive Power Transfer Systems," in *IEEE Open Journal of Power Electronics*, vol. 5, pp. 436–451, 2024, doi: 10.1109/OJPEL.2024.3379846.
- [6] M. Rasheed et al., "Active Reconditioning of Retired Lithium-Ion Battery Packs From Electric Vehicles for Second-Life Applications," in *IEEE Journal of Emerging and Selected Topics in Power Electronics*, vol. 12, no. 1, pp. 388–404, Feb. 2024, doi: 10.1109/JESTPE.2023.3325251.
- [7] A. Zade et al., "A 21-kW Unfolding-Based Single-Stage AC–DC Converter for Wireless Charging Applications," in *IEEE Journal of Emerging and Selected Topics in Power Electronics*, vol. 12, no. 1, pp. 8–27, Feb. 2024, doi: 10.1109/JESTPE.2023.3309588.
- [8] R. Hassan, H. Wang and R. Zane, "A New Online Continuous Stability Monitoring Method for DC Microgrids," in *IEEE Transactions on Power Electronics*, vol. 38, no. 9, pp. 10739–10749, Sept. 2023, doi: 10.1109/TPEL.2023.3284512.
- [9] T. Newbolt, P. Mandal, H. Wang and R. Zane, "Sustainability of Dynamic Wireless Power Transfer Roadway for In-Motion Electric Vehicle Charging," in *IEEE Transactions on Transportation Electrification*, vol. 10, no. 1, pp. 1347–1362, March 2024, doi: 10.1109/TTE.2023.3262202.
- [10] H. Wang, M. Rasheed, R. Hassan, M. Kamel, S. Tong and R. Zane, "Life-extended Active Battery Control for Energy Storage Using Electric Vehicle Retired Batteries," in *IEEE Transactions on Power Electronics*, vol. 38, no. 6, pp. 6801–6805, June 2023, doi: 10.1109/TPEL.2023.3252362.
- [11] S. Inoue, D. Goodrich, S. Saha, R. Nimri, A. Kamineni, N. Flann, R. Zane, "Fast Design Optimization Method Utilizing a Combination of Artificial Neural Networks and Genetic Algorithms for Dynamic Inductive Power Transfer Systems," in *IEEE Open Journal of Power Electronics*, vol. 3, pp. 915–929, 2022, doi: 10.1109/OJPEL.2022.3224422.
- [12] T. Saha, A. C. Bagchi, H. Wang and R. Zane, "Bidirectional LCL–T Resonant DC–DC Converter for Priority Loads in Undersea Distribution Networks," in *IEEE Transactions on Power Electronics*, Jun. 2022, doi: 10.1109/TPEL.2022.3187133.
- [13] M. Kamel, M. M. U. Rehman, F. Zhang, R. A. Zane and D. Maksimović, "Differential Input Current Regulation in Parallel Output Connected Battery Power Modules," in *IEEE Transactions on Power Electronics*, vol. 37, no. 4, pp. 3854–3864, April 2022, doi: 10.1109/TPEL.2021.3120365.
- [14] D. Trinko, N. Horesh, R. Zane, Z. Song, A. Kamineni, T. Konstantinou, K. Gkritza, C. Quinn, T. H. Bradley, J. C. Quinn, "Economic feasibility of in-motion wireless power transfer in a high-density traffic corridor," *eTransportation*, Volume 11, Feb. 2022, doi: 10.1016/j.etrans.2021.100154.
- [15] H. Alan Mantooth, R. Zane and M. Manjrekar, "Guest Editorial Special Section on Cybersecurity of Power Electronics Through Hardware Hardening," in *IEEE Journal of Emerging and Selected Topics in Power Electronics*, vol. 10, no. 1, pp. 1255–1257, Feb. 2022, doi: 10.1109/JESTPE.2021.3133857.

- [16] M. Kamel, V. Sankaranarayanan, R. Zane, D. Maksimovic, “State-of-Charge Balancing with Parallel and Series Output Connected Battery Power Modules,” *IEEE Transactions on Power Electronics*, vol. 37, no. 6, pp. 6669 – 6677, Jan. 2022, doi: 10.1109/TPEL.2022.3143835.
- [17] M. Kamel, R. Zane, D. Maksimovic, “Voltage sharing with series output connected battery modules in a plug-and-play dc microgrid,” *IEEE Transactions on Power Electronics*, vol. 3, no. 11, pp. 13118 – 13127, Nov. 2021, doi: 10.1109/TPEL.2021.3076475.
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- [21] T. Saha, A. Bagchi, R. Zane, “Analysis and Design of an LCL-T Resonant DC-DC Converter for Underwater Power Supply,” *IEEE Transactions on Power Electronics*, Early Access, pp. 1 – 13, Oct. 2020.
- [22] P. Thummala, D. Yelaverthi, R. Zane, Z. Ouyang, M. Anderson, “A 10-MHz GaNFET-Based-Isolated High Step-Down DC-DC Converter: Design and Magnetics Investigation,” *IEEE Transactions on Industry Applications*, vol. 55, no. 4, pp. 3889 – 3900, Mar. 2019.
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- *Received IEEE Power Electronic Society 2009 Prize Transactions Letter Award
- [54] M. Shirazi, J. Morroni, A. Dolgov, R. Zane, D. Maksimovic, “Integration of frequency response measurement capabilities in digital controllers for DC-DC converters,” *IEEE Trans. Power Electron.*, vol. 23, no. 5, pp. 2524 – 2535, Sep. 2008.
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Full Conference Papers with Peer Review (published or in press)

- [1] H. Ahmed, R. Zane, A. Kamineni and Y. Liu, "Partial Inductance Analysis for PCB Litz Coils in Wireless Power Transfer Systems," *2025 IEEE Wireless Power Technology Conference and Expo (WPTCE)*, Rome, Italy, 2025, pp. 1-6, doi: 10.1109/WPTCE62521.2025.11062268.
- [2] D. Goodrich, A. Zade, S. Gurudiwan, M. Mansour, R. Zane and H. Wang, "Small-Signal Modeling and Damping Design of Unfolding-Based Single Stage AC-DC Converter Using the Extra Element Theorem," *2025 IEEE Applied Power Electronics Conference and Exposition (APEC)*, Atlanta, GA, USA, 2025, pp. 719-726, doi: 10.1109/APEC48143.2025.10977164.
- [3] A. Zade and R. Zane, "Accurate Small-Signal Phasor Transformation-Based Modeling of Secondary-Side Diode-Bridge Rectifiers for Battery Charging Applications," *2025 IEEE Applied Power Electronics Conference and Exposition (APEC)*, Atlanta, GA, USA, 2025, pp. 1004-1011, doi: 10.1109/APEC48143.2025.10977532.
- [4] A. Zade, S. Gurudiwan and R. Zane, "Small-Signal Phasor Modeling of T-Type Bridge-Based Single-Sided and Double-Sided LCC Resonant Converters for WPT Applications," *2025 IEEE Applied Power Electronics Conference and Exposition (APEC)*, Atlanta, GA, USA, 2025, pp. 2194-2201, doi: 10.1109/APEC48143.2025.10977075.
- [5] S. Gurudiwan, A. Zade, H. Wang and R. Zane, "Nonlinear Capacitance-Based Accurate ZVS Analysis for Full-Bridge T-Type Resonant Converters," *2024 IEEE Energy Conversion Congress and Exposition (ECCE)*, Phoenix, AZ, USA, 2024, pp. 3288-3295, doi: 10.1109/ECCE55643.2024.10860915.
- [6] T. Newbolt, P. Mandal, H. Wang and R. Zane, "Feasibility of Dynamic Wireless Power Transfer to Mitigate Load Demands Under Resiliency Events," *2024 IEEE Power & Energy Society General Meeting (PESGM)*, Seattle, WA, USA, 2024, pp. 1-5, doi: 10.1109/PESGM51994.2024.10761075.
- [7] S. D. Niafenderi, P. Mandal, H. Wang and R. Zane, "DER-Integrated Grid Operations Under Extreme Weather Events Incorporating DWPT System," *2024 56th North American Power Symposium (NAPS)*, El Paso, TX, USA, 2024, pp. 1-6, doi: 10.1109/NAPS61145.2024.10741701.
- [8] T. Newbolt, P. Mandal, H. Wang and R. Zane, "DWPT-Integrated Microscopic Traffic Flow for Distribution Grid Voltage Stability Analysis," *2024 56th North American Power Symposium (NAPS)*, El Paso, TX, USA, 2024, pp. 1-6, doi: 10.1109/NAPS61145.2024.10741859.
- [9] M. Gulzar, R. M. Raja, R. Zane and H. Wang, "A Novel Direct Duty-to-Current Control for DC Bias Mitigation in Dual Active Bridge Converters for Enhanced EV Applications," *2024 IEEE Workshop on Control and Modeling for Power Electronics (COMPEL)*, Lahore, Pakistan, 2024, pp. 1-6, doi: 10.1109/COMPEL57542.2024.10613974.
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Patents, Filed, Pending

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- [2] N. Roberts, J. Mullen, R. Zane, A. Kamineni, B. Varghese, M. Halling, “Static heat exchanger for wireless power transfer pad,” US Patent Appl. No.: 17/023865, filed Sep 17, 2020, published Mar 2021 20210082613 A1.
- [3] B. Varghese, J. Mermigas, A. Kamineni, R. Zane, “Inductive wireless charging pad for electric vehicles reinforced with non-conductive elements,” US Patent Appl. No.: 17/023026, filed Sep 16, 2020, published Mar 2021 20210078425 A1.
- [4] R. Hassan, H. Wang, R. Zane, “A Power Electronic Instrument for Continuously Monitoring Stability and stabilizing a dc microgrid,” Disclosure submitted Dec. 2019, US patent application pending, US20210293893A1.
- [5] R. Hassan, H. Wang, R. Zane, “A Power Electronic Apparatus for Active Stability Regulation of Interconnected Converters Using Dynamic Virtual Impedance,” Disclosure submitted Dec. 2019, US patent application pending.
- [6] B. Riar, D. Thrimawithana, R. Zane, V. Wang, “A multi-level modular converter,” US Patent Appl. No.: 16/964948, filed Jan 2019, published Feb 2021, 20210044216 A1.
- [7] D. Maksimović, K. Afridi, R. Zane, G. Plett, M.S. Trimoli, “Heterogeneous Energy Storage System and Method of Controlling a Heterogeneous Energy Storage System,” US patent application filed Feb. 2017.

Invited Presentations and Seminars

- [1] R. Zane, keynote speaker, “The Future of Electrified Transportation — Power Electronics to the Rescue!,” IEEE COMPEL 2025, Knoxville, TN, Jun 2025.
- [2] R. Zane, invited speaker, “Advanced EV charging infrastructure: supporting the grid of the future,” GE Electrification Forum, Niskayuna, NY, Oct. 2023.
- [3] R. Zane, invited speaker, “ASPIRE Overview and the Future of Electrified Transportation in Utah,” Utah AFL-CIO Annual Convention, West Valley City, UT, Jun. 2023.

- [4] R. Zane, invited speaker, “ASPIRE pilots and State of Utah Transportation Electrification Initiative,” Salt Lake City Infrastructure Committee meeting, Salt Lake City, UT, Apr. 2023.
- [5] R. Zane, invited speaker and panelist, “Cross-agency, Coordinated Multi-modal Electrification Plan,” UTA Electrification Forum, Salt Lake City, UT, Sep. 2022.
- [6] R. Zane, invited speaker and panelist, “Status and Future of Wireless Charging,” IEEE International Transportation Electrification Conference, ITEC 2022, Anaheim, CA, Jun. 16, 2022.
- [7] R. Zane, invited plenary dinner presentation, “A Perspective on the Future of Electrified Transportation and its Demand for Copper,” Rio Tinto Customer Day, Salt Lake City, UT, Jun. 1, 2022.
- [8] R. Zane, invited public talk, “Electric Avenues – The Future of Electrified Transportation,” USU Science Unwrapped series, Logan, UT, Apr. 1, 2022. <https://www.youtube.com/watch?v=Kb7yXprPNhM>.
- [9] R. Zane, invited talk, “Launching your Engineering Career – Electrified Transportation,” USU Launch your Engineering Career series for engineering students, Logan, UT, Mar. 30, 2022.
- [10] R. Zane, invited webinar, “Impact of wireless charging on battery requirements for EVs,” Stanford StorageX International Symposium, August 27, 2021. <https://energy.stanford.edu/storagex-initiative/events/past-events>.
- [11] R. Zane, invited webinar, “An Electric Future for Transportation,” Center for Transportation, Environment, and Community Health (CTECH), Impacts of Transportation and Urban Systems on Health and the Environment Webinar Series, Apr. 6, 2021. https://vod.video.cornell.edu/media/CTECH+Webinar+Series+-+An+Electric+Future+for+Transportation.CC1/I_rgf9l39m
- [12] R. Zane, invited speaker and panelist, “ASPIRE NSF Engineering Research Center and UTA Intermodal Hub Project,” Utah Institute of Transportation Engineers (ITE), UPA UT, WTS Panel Workshop, Feb. 16, 2021.
- [13] R. Zane, invited roundtable moderator, “An EV Future webinar: Designing the Infrastructure,” US DOE Office of Electricity An EV Future Initiative webinar, Dec. 9, 2020.
- [14] R. Zane, “Electric Road Studies: Utility Power Requirements and Upgrade Costs,” invited presentation, US Department of Energy (DOE) and International Energy Agency (IEA) Hybrid Electric Vehicle (HEV) Task 45 Electrified Roadways committee webinar, Nov. 18, 2020.
- [15] R. Zane, invited roundtable moderator, “An EV Future webinar: Managing Load,” US DOE Office of Electricity An EV Future Initiative webinar, Nov. 5, 2020.
- [16] R. Zane, C. Fawson, invited breakout speaker, Energy Technology and Innovation Outlook panel, Utah Economic & Energy Summit, Oct. 26, 2020.
- [17] R. Zane, “Advancing Sustainability through Powered Infrastructure for Roadway Electrification,” invited presentation, NSF POETS ERC Annual Meeting, Oct. 2020.
- [18] R. Zane, “Utah’s future in electrified transportation,” invited interview, Live Electric series podcast, hosted by Rocky Mountain Power, Oct. 2, 2020.
- [19] J. Campbell, R. Zane, A. Graul, Z. Song, T. Molloy, B. Grunkemeyer, “Western Smart Plug-in Electric Vehicle Community Partnership Lessons Learned,” invited panelists, webinar hosted by Rocky Mountain Power, Sep. 10, 2020.
- [20] R. Zane, “Electrified roadways,” invited radio interview, USU INSTEAD podcast series, Episode 36, Aug. 2020.
- [21] R. Zane, “Microgrid demonstration project, smart charge management, and electrified transportation,” invited presentation, UK delegation on electric utilities, hosted by Rocky Mountain Power, Salt Lake City, UT, Dec. 2019.
- [22] R. Zane, “Electric roadways – technology overview,” invited keynote presentation, Charging Ahead – SELECT Thought Leadership Series, West Lafayette, IN, Oct. 2018.
- [23] R. Zane, A. Kamineni, “Practical challenges in designing a dynamic wireless charging system,” invited presentation, IEA HEV-TCP Task 26 Workshop 9 on Wireless Charging, Detroit, MI, Nov. 6-7, 2018.
- [24] R. Zane, invited Future of Transportation Keynote Speaker, Utah Clean Cities 25th Anniversary celebration, Salt Lake City, UT, Nov. 2, 2018.

- [25] R. Zane, two-week invitation as a visiting professor at the University of Cantabria, Spain. Provided guest seminars on “Electric roads – a vision for the future of transportation,” “Electric bike design,” “Vehicle controller design,” and a tutorial on “Basics of inductive charging systems.” Santander, Spain, May 2018.
- [26] R. Zane, one-week invitation as a visiting professor at India Institute of Technology, Kharagpur. Provided an IEEE society Talk on “Challenges and opportunities in transportation electrification,” a seminar on “Electric vehicle charging infrastructure,” and guest lectures on “Vehicle controller design,” “Electric bike design,” and “Life balancing active battery management systems.” Kharagpur, India, March 2018.
- [27] R. Zane, Live Electric Week, invited guest panelist on RadioActive, KRCL 90.9fm Salt Lake City radio, Sep. 2017.
- [28] R. Zane, invited speaker and panelist, “Transportation Solutions for Improved Air Quality,” The Governor’s Utah Energy Development Summit, Salt Lake City, UT, May 2017.
- [29] R. Zane, “A sustainable (electrified) future for roadway transportation,” Clean Energy Institute invited seminar, University of Washington, Seattle, WA, Apr. 2017.
- [30] R. Zane, “Autonomy and electrification,” invited guest lunch speaker, Federal Highway Administration (FHWA) Western Administrators Annual Meeting, Salt Lake City, UT, Mar. 2017.
- [31] R. Zane, “Charging infrastructure for electric vehicles,” Rocky Mountain Power Electric Vehicle Technology Workshop, Salt Lake City, UT, Jan. 2017.
- [32] R. Zane, “Electric roadways,” invited guest interview, Cool Science Radio hosted by Lynn Ware Peek and Chris Cherniak, KPCW NPR radio, Dec. 2016.
- [33] R. Zane, “Modular battery systems,” IEEE ESARS / International Transportation Electrification Conference, Toulouse, France, Nov 2-4, 2016.
- [34] R. Zane, “Technologies to accelerate electric vehicle adoption,” SAGE Westin Roundtable Series, University of Wisconsin-Madison, WI, Nov. 2016.
- [35] R. Zane, “Wireless EV charging systems for electrified roadways,” Electric Vehicle Technology Conference (EVTC), Cocoa, FL, Oct. 2016.
- [36] R. Zane, “Center for Sustainable Electrified Transportation (SELECT),” invited presentation, Federal Highway Administration (FHWA), Salt Lake City, UT, Aug. 2016.
- [37] R. Zane, “Electrification: Sustainability for transportation systems,” invited presentation, Ben-Gurion University of the Negev, Ben-Gurion, Israel, Jul 2016.
- [38] R. Zane, “Electrification: Towards a sustainable future for our transportation system,” USU Sunrise Session, Salt Lake City, UT, Jan. 2016
- [39] R. Zane, “Sustainable electrified transportation,” Institute of Transportation Engineers (ITE) Annual Conference, Salt Lake City, UT, Jan. 2016.
- [40] R. Zane, “Center for Sustainable Electrified transportation Systems (SELECT),” USTAR confluence annual conference, Salt Lake City, UT, Sept. 2015.
- [41] R. Zane, “Rush Hour. Transportation solutions for a sustainable urban Salt Lake,” invited panelist, public event at The Leonardo, Salt Lake City, Aug. 2015.
- [42] R. Zane, “USTAR advanced transportation institute,” USTAR confluence annual conference, Salt Lake City, UT, Nov. 3-4, 2014.
- [43] R. Zane, “Vehicle power management: research advances for cost and weight reduction,” Battery Show and Electric & Hybrid Vehicle Technology Conference, Novi, MI, Sep. 15 – 17, 2014.
- [44] R. Zane, “Research directions at the USU Power Electronics Lab (UPEL),” invited presentation, University of Cantabria, Santander, Spain, Jun. 26, 2014.
- [45] R. Zane, “Advances in electrified transportation and power electronics at the USU Power Electronics Lab (UPEL),” USU Foundation Board Meeting, Park City, May 7, 2014.

- [46] R. Zane, “High efficiency energy conversion for next generation energy systems and electronic loads,” National Academy of Engineering (NAE), EU-US Frontiers of Engineering (FOE) Symposium, Beckman Center, Irvine, CA, Nov. 3 – 5, 2011.
- [47] R. Zane, Z. Popovic, “Low power RF energy harvesting,” invited presentation, MIT MTL/MITEI Workshop on Next Generation u-Energy Systems, Cambridge, MA, Dec. 2010.
- [48] Z. Popovic, R. Zane, “Integrated design of power management and RF powering,” invited presentation, *Energy challenges in RFIDs and wireless sensors, European microwave conference*, Paris, France, Sep. 2010.
- [49] R. Zane, D. Maksimovic, “Digital control of SMPS,” invited industry short course, Analog Devices, Inc., Shanghai, China and San Jose, CA, Aug. 2010.
- [50] R. Zane, “Energy harvesting & power electronics,” invited presentation and panel session on energy harvesting, *IEEE Appl. Power Electron. Conf. Expo.*, Palm Springs, CA, Feb. 2010.
- [51] R. Zane, Z. Popovic, “RF energy harvesting: what, where, why and how,” invited presentation, *IDTechEx Energy Harvesting & Storage USA*, Denver, CO, Nov. 2009.
*Hosted an invited laboratory tour for the conference at UCB.
- [52] R. Zane, “Efficient low power energy harvesting for miniature wireless devices,” invited presentation, *CMOS Emerging Technologies Workshop*, Vancouver, BC, Sep. 2009.
- [53] R. Zane, “Efficient power management for low power energy harvesting,” invited presentation, *Darnell nanoPower Forum*, San Jose, CA, May 2009.
- [54] R. Zane, D. Maksimovic, J. Morroni, “Digital control of SMPS,” invited industry short course, Lockheed Martin, Grand Prairie, TX, Mar. 2009.
- [55] R. Zane, “Low Power Energy Harvesting -- Making the Difference with Efficient Power Management,” invited presentation, Future of DC-DC Conversion, IEEE Applied Power Electronics Specialists Conference (APEC), Washington D.C., Feb. 2009.
- [56] R. Zane, “Towards externally powered telemetric chronic neural implants,” invited seminar as part of the NSF international collaboration travel grant, Towards a Dynamic Brain Clamp, Federal University of Ceara, Sobral, Brazil, Jan 2009.
- [57] R. Zane, “Low power energy harvesting for wireless sensors,” Grainger invited seminar series, University of Illinois, Champaign-Urbana, Dec. 2008.
- [58] R. Zane, “Digital control in SMPS,” invited industry short course, On-semiconductor, Toulouse, France, May 2008.
- [59] Z. Popovic, R. Zane, “RF energy harvesting,” invited presentation, *Darnell nanoPower Forum*, San Jose, CA, Jun. 2008.
- [60] R. Zane, “Digital auto-tuning and adaptive techniques for SMPS,” invited seminar, IEEE PELS-IES joint technical session, Santander, Spain, Apr. 2008.
- [61] J. Shin, R. Zane, Z. Popovic, “Batteryless microPower sensors for context aware technologies,” invited presentation, RESNA 2007, sponsored by NSF Emerging Technology – Tools for the Future, Phoenix, AZ, Jun. 2007.
- [62] R. Zane, Z. Popovic, “Efficient low power RF energy harvesting and power management,” invited presentation, *Darnell nanoPower Forum*, San Jose, CA, Jun. 2007.
- [63] R. Zane, “CAREER: Modeling, control and design of energy-efficient lighting systems,” invited presentation, NSF 2004 Grantees workshop, Reno, NV, Apr. 2007.
- [64] R. Zane, D. Maksimović, “Digital control of switch-mode power supplies,” on-site invited industry short course, Analog Devices Inc., San Jose, CA, Jul. 2006.
- [65] R. Zane, D. Maksimović, “Digital control of switched-mode power supplies,” professional educational seminar, *IEEE Applied Power Electronics Conference and Exposition*, Dallas, TX, Mar. 2006.

- [66] R. Zane, Z. Popovic, “Harvesting ambient energy for low power sensors,” invited presentation, *IEEE Presents Innovation and Technology in Colorado*, Colorado Technology Week, Denver, CO, Oct. 2005.
- [67] R. Zane, Z. Popovic, “Batteryless MicroPower Sensors for Context Aware Technologies,” invited presentation, *Annual Coleman Institute Meeting*, Oct. 2005.
- [68] R. Zane, D. Maksimović, B. Miao, “Active identification and automated digital controller design in DC-DC power converters,” invited presentation, *Annual AFRL Space Power Workshop*, Apr. 2005.
- [69] T. Zhao, J. Israel, R. Zane, Z. Popovic, “Electronics for wireless neural sensors,” poster presentation, *Coleman Institute Annual Conference*, Oct. 2004.
- [70] R. Zane, “Digital control in switch mode power supplies,” on-site invited industry tutorial, Artesyn Technologies, Framingham, MA, May 2004.
- [71] D. Maksimović, A. Prodic, R. Zane, “Digital control of high-frequency switching power converters,” professional educational seminar, *IEEE Applied Power Electronics Conference and Exposition*, Anaheim, CA, Feb. 2004.
- [72] D. Restrepo, D. Finch, R. Zane, A. Sharp, “CEMS-based chronic brain implants,” poster presentation, *Coleman Institute Annual Conference*, Oct. 2003.
- [73] R. Zane, D. Maksimović, “Custom IC blocks for enabling digital control in switching power converters,” invited lecture series, *IEEE Solid-State Circuits Society*, Denver chapter, Jul. 2003.
- [74] R. Zane, D. Maksimović, “Digital control in switching converters,” *Annual AFRL Space Power Workshop*, Apr. 2003.
- [75] D. Restrepo, D. Finch, R. Zane, M. Stowell, A. Sharp, “CEMS-based chronic brain implants,” poster presentation, *Coleman Institute Annual Conference*, October 2002.
- [76] D. Maksimović, R. Zane, “Scalable digital control for switching power converters,” invited presentation, *Intel Technology Symposium*, Seattle, Aug. 2002.
- [77] R. Zane, D. Maksimović “Intelligent control in power converters and systems” *DARPA workshop on integrated smart power*, Arlington, VA, Nov. 2002.

RESEARCH GRANTS & CONTRACTS

Research Grants and Contracts Awarded

- Department of Energy, “SuperCharge: Sustainable Utilization of Power Infrastructure Enabling Rapid and Replicable MHDVs Charging through Hybrid AC/DC Distribution Networks and Renewable Grid Energy Integration,” USU Total: \$22M. Role: PI. Oct. 2025 – Sep. 2028.
- Department of Energy, “Wasatch Front Multi-Modal Corridor Electrification Plan,” USU total: \$1.12M. Role: PI. Oct. 2023 – Mar 2025.
- State of Utah, “Statewide Strategic Planning for Transportation Electrification Infrastructure,” \$2.1M per year ongoing state appropriation, USU total over first 5 years: \$10.5M. Role: PI. Jul 2023 – June 2028.
- State of Utah, “Freight Logistics Electrification Demonstration Project,” One-time State appropriation, USU total: \$15M. Role: PI. Jul 2022 – June 2025.
- State of Utah, “Battery Electric Trainset Development,” One-time State appropriation, Total: \$24M. Role: PI. Partnered with Stadler Rail. Jul 2022 – June 2026.
- Department of Energy, “Utility Managed Distributed Energy Resources Intelligent Community, UDERMS iCommunity,” total prime DOE share to Rocky Mountain Power: \$6.42M; USU subaward DOE share total: \$2.4M. Role: USU PI, program Co-PI. Jan 2021 – Dec 2024.
- National Science Foundation, “High School Creative Design Course Supplement: Engineering Research Center for Advancing Sustainability through Powered Infrastructure for Roadway Electrification (ASPIRE),” USU total: \$378k. Role: PI & Director. Sep 2021 – Aug 2023. Investigators: R. Zane (PI, USU), K. Gkritza (Purdue), Q. Lv (CU-Boulder), S. Nazarian (UTEP), G. Covic (Univ. of Auckland).

National Science Foundation, “2021 NSF Internship Supplements: Engineering Research Center for Advancing Sustainability through Powered Infrastructure for Roadway Electrification (ASPIRE),” USU total: \$231k. Role: PI & Director. Sep 2021 – Aug 2023. Investigators: R. Zane (PI, USU), K. Gkritza (Purdue), Q. Lv (CU-Boulder), S. Nazarian (UTEP), G. Covic (Univ. of Auckland).

State of Utah, “Freight Logistics Electrification Demonstration Pre-pilot,” One-time State appropriation, USU total: \$5M. Role: PI. June 2021.

National Science Foundation, “Engineering Research Center for Advancing Sustainability through Powered Infrastructure for Roadway Electrification (ASPIRE),” USU total: \$26M. Role: PI & Director. Sep 2020 – Aug 2025 (renewable for 10 years, \$50.6M total). Investigators: R. Zane (PI, USU), K. Gkritza (Purdue), Q. Lv (CU-Boulder), S. Nazarian (UTEP), G. Covic (Univ. of Auckland).

Department of Energy, “Western Smart Regional EV Adoption and Infrastructure at Scale (WSEV@Scale),” total prime DOE share to Rocky Mountain Power: \$6.6M; USU subcontract DOE share: \$3.3M. Role Co-PI, USU lead. Oct. 2020 – Sep. 2023.

Department of Energy, “eMosaic: Electrification Mosaic Platform for Grid-Informed Smart Charging Management,” total prime DOE share to ABB, Inc.: \$4.9M; USU subcontract DOE share: \$1.5M. Role Co-PI, USU lead. Oct. 2020 – Dec. 2024.

Department of Energy, “Increasing Affordability, Energy Efficiency, and Ridership of Transit Bus Systems through Large-Scale Electrification,” total prime DOE share to USU: \$1.75M. Role: Co-PI. Oct 2020 – Dec. 2023. USU Investigators: Z. Song (PI), R. Zane (Co-PI), A. Graul (Co-PI).

Department of Energy, “Resilient-Interoperable-Smart Charge Management Control Systems Architecture for EVs at scale,” total prime DOE share to Dream Team Co LLC: \$4.76M, USU subcontract DOE share \$1.1M. Role: Co-PI. Oct. 2020 – Dec. 2024. USU Investigators: A. Kamineni (PI, USU), R. Zane (USU).

State of Utah, “Electrified Transportation, Support for SELECT Center and ASPIRE ERC Growth,” One-time State appropriation, USU total: \$3M. Role: PI. June 2020.

Pacificorp, “Power Balance and Demand Response for a Charging Intermodal Hub,” USU total: \$1.9M. Role: PI. Dec 2019 – Dec 2021. Investigators: R. Zane (PI, USU), J. Gunther (USU).

CBMM North America, Inc., “Nanocrystalline cores in wireless chargers,” USU total: \$100k. Role: Co-PI. Dec 2019 – Dec 2010. Investigators: A. Kamineni (PI, USU), R. Zane (USU).

Tokef LLC, “Hybrid Energy Storage for UTVs – Milestone 2,” USU total: \$111k. Role: PI. Sep 2019 – Sep 2020. Investigators: R. Zane (USU, PI).

Toyota Motor North America, “Augmentation to Phase 2 and Phase 3: Design, Development and Testing of a Dynamic Wireless Power Transfer System for Electric Vehicles,” USU total: \$133k. Jan 2019 – Dec 2019. Investigators: R. Zane (USU, PI), A. Kamineni (USU).

Toyota Motor North America, Visiting Scientist PhD program agreement for Shuntaro Inoue, USU total: \$267k. Aug 2019 – Jul 2023. Investigators/co-advisors: R. Zane (USU, PI), A. Kamineni (USU).

Department of Energy, “Long-range battery electric vehicle with megawatt wireless charging,” total prime DOE share: \$5M; USU subcontract DOE share: \$960,000. Role: Project Co-PI, USU lead. Oct 2019 – Sep 2022. Investigators: B. Lindgren (Kenworth), R. Zane (USU), M. Masquelier (WAVE), M. Casteel (UPS), S. Kiliccote (eIQ), E. Smalley (Seattle City Light), L. Whittemore (PGE).

DOE ARPA-E, “Low-cost, easy-to-integrate, and reliable grid energy storage system with 2nd life lithium batteries,” total prime DOE ARPA-E share: \$2M; USU subcontract total DOE share: \$631,645. Role: Project Co-PI, USU lead. May 2019 – June 2021. Investigators: A. Tong (UCSD), R. Zane (USU), J. Quinn (CSU).

Idaho National Laboratory / Battelle, “WPT technical support for cyber security research,” USU total: \$31k. Role: PI. Feb 2019 – Jan 2020. Investigators: R. Zane (USU, PI), A. Kamineni (USU).

Toyota Motor North America, Inc., “Characterization of the Evatran PLUGLESS 7.2 kW System,” USU total: \$62k. Role: PI. Jan 2019 – Apr 2020. Investigators: R. Zane (USU, PI), A. Kamineni (USU).

AECOM Technical Services, Inc., “Illinois tollway pre-pilot feasibility study,” USU total: \$280k. Role: PI. Jan 2019 – Dec 2019. Investigators: R. Zane (PI, USU), A. Kamineni (USU), M. Halling (USU), N. Roberts (USU).

US DOT Federal Transit Administration (FTA), “Electric Bus Corridor Model,” USU total: \$50k. Role: Co-PI. Jan 2019 – Mar 2020. Investigators: Z. Song (PI, USU), R. Zane (USU).

USTAR Industry Partnership Program, “Development of an integrated thermal management and optimized concrete enclosure for stationary wireless charging systems,” USU total: \$363k, Jan. 2019 – Apr 2020. Investigators: N. Roberts (PI, USU), R. Zane (USU), M. Halling (USU).

Department of Energy, “Enabling secure and resilient XFC: A software/hardware security co-design approach,” Virginia Tech prime contractor, total DOE share \$2.5M; USU subcontract total DOE share: \$577,213. Role: Project Co-PI, USU lead. Oct. 2018 – Dec 2020. Investigators: R. Gerdes (VT), S. Rahman (VT), K. Heaslip (VT), R. Zane (USU), A. Paaso (ComEd), C. Rodine (ChargePoint), P. Jonathan (OnBoard Security), K. Vamvoudakis (Georgia Tech), M. Pipattanasomporn (VT), S. Bogosyan (Istanbul Tech).

Department of Energy, “High power wireless extreme fast charging development and deployment for electric trucks,” WAVE prime contractor, total DOE share: \$4.3M, USU total: \$636,364. Role: Project Co-PI, USU lead. Aug. 2018 – Jul. 2021. Investigators: M. Masquelier (WAVE), R. Zane (USU), K. Aron (Schneider Electric), J. Kreese (Cummins), T. Williamson (TTSI).

Raytheon Integrated Defense Systems, “Analysis and design of the series resonant converter and parallel resonant converter and wireless power transfer,” USU total: \$74,799. Role: PI. May 2018 – Dec 2018. Investigators: R. Zane (PI, USU).

TransChill, LLC, “Battery energy storage system for transport chillers,” USU total: \$99,949. Role: PI. Jan. 2018 – Aug. 2018. Investigators: R. Zane (PI, USU).

Tokef LLC, “Hybrid energy storage for electric trucks,” USU total: \$19,916. Role: PI. Apr. 2018 – Jul. 2018. Investigators: R. Zane (PI, USU).

Tokef LLC, “Feasibility study for electric roadway paint,” USU total: \$23,455. Role: Co-PI. Apr. 2018 – Sep. 2018. Investigators: R. Christensen (PI, USU), R. Zane (Co-PI, USU).

PacifiCorp, “Advancing smart inverter integration in Utah,” USU, total \$99,997. Role: PI. Jan. 2018 – Dec. 2018. Investigators: R. Zane (PI, USU).

PacifiCorp, “Development and demonstration of a microgrid system at the USU EVR,” USU, total \$189,999. Role: PI. Jan 2018 – Jun. 2020. Investigators: R. Zane (PI, USU).

DOE ARPA-E, “Feasibility analysis of electric roadways through localized traffic, cost, adoption, and environmental impact modeling,” USU, total \$498,170. Role: PI. Oct. 2017 – Sep. 2018. Investigators: R. Zane (PI, USU), Z. Song (Co-PI, USU), J. Quinn (Co-PI CSU), N. Gkritza (Co-PI Purdue).

USTAR, “Thermal management test lab for high reliability energy storage systems,” USU total: \$694,514. Role: PI. May 2017 – Feb 2017. Investigators: R. Zane, (PI, USU).

NASA, “Active battery management system with physics based life modeling,” EP Systems prime contractor, subcontract to USU. USU total: \$29,252. Role: PI. Jun 2017 – Nov 2017. Investigators: R. Zane (PI, USU).

Raytheon Integrated Defense Systems, “Power system control,” USU total: \$25,522. Role: PI. May 2017 – Sep 2017. Investigators: R. Zane (PI, USU).

Electric Power Systems LLC, “Development of a passive battery management system for a silicon nanowire battery,” USU total: \$15,078. Role: PI. Mar 2017 – Aug 2017. Investigators: R. Zane (PI, USU).

Department of Energy, “WestSmartEV: Western Smart Plug-in Electric Vehicle Community Partnership,” Rocky Mountain Power (RMP) prime contractor, total prime DOE share: \$4M; total DOE share subcontract to USU: \$1.2M. Role: Co-PI. Jan 2017 - Dec 2019. Investigators: Z. Song (PI, USU), R. Zane (Co-PI, USU).

Raytheon Integrated Defense Systems, “Analysis and design of series resonant converter (SRC) prototype with digital control,” USU total \$149,998. Role: PI, Jan 2017 – Dec 2017. Investigators: R. Zane (PI, USU).

Colorado DOT, “Phase 1: Planning study for electric roadway pilot project,” AECOM prime contractor, subcontract to USU. Role: PI. Jan 2017 – May 2017. USU Total: \$90k. R. Zane (PI, USU).

USTAR Engineering Research Triangle, “Automated monitoring and control of electric vehicle charging infrastructure,” USU total: \$40k. Role: Co-PI. Jan 2017 – Dec 2017. Investigators: M. Parvania (UofU), R. Zane (USU), J. Salmon (BYU).

NIDILRR, “Energy management system for battery powered mobility devices based on wireless power transfer concept to promote community living and participation,” USU total: \$599,077. Role: Co-PI. Sep 2016 – Sep 2019. Investigators: Z. Pantic (PI, USU), R. Zane (Co-PI, USU), C. Bodine (Co-PI, UC-Denver), C. Coopmans (Co-PI, USU).

Raytheon Integrated Defense Systems, “CHIPS: research, magnetics design, and breadboard,” USU total \$73,080. Role: PI, Oct 2016 – Mar 2017. Investigators: R. Zane (PI, USU).

ONR, “Robust plug-and-play expeditionary battery system,” Utah State University (USU). Total: \$737,217. Role: PI, Sep 2016 – Dec 2018. Investigators: R. Zane (PI, USU), K. Smith (Co-PI, NREL), S. Trimboli (Co-PI, UCCS), D. Maksimovic (Co-PI, CU-Boulder), J. Pinon (Co-PI, HDS).

FTA Lo-No, “Utah’s Public/Public/Private Partnership for the Deployment of Electric Bus Technology: Downtown to the University Connection,” Utah Transit Authority prime contract, subcontract to USU. USU total: \$78k. Investigators: R. Zane (PI, USU), Z. Song (Co-PI, USU), J. Quinn (Co-PI, CSU).

Raytheon Integrated Defense Systems, “Analysis and design of series resonant converter (SRC) prototype with digital control,” USU total \$149,044. Role: PI, Jun 2016 – Dec 2016. Investigators: R. Zane (PI, USU).

Department of Energy (DOE), ARPA-E AMPED, “Hybrid energy storage demonstration plus-up, advanced control of large battery packs,” Utah State University (USU). Total: \$500k. Role: PI, Jan. 2016 – Mar. 2017. Investigators: R. Zane (PI, USU), S. Trimboli (UCCS), D. Maksimovic (UCB), K. Smith (NREL).

USTAR, “Center for Sustainable Electrified Transportation Systems (SELECT),” Utah State University (USU). Total: \$750k. Role: PI, Jul. 2015 – Jun. 2016. Investigators: R. Zane (PI, USU), Z. Pantic (USU), J. Quinn (USU), R. Gerdes (USU), R. Sharma (USU), P. Barr, (USU).

Department of transportation, “Advance Radar based low ground clearance vehicle detection and warning system,” Intelligent Automation Inc (IAI) prime contractor, subcontract to USU. Role: PI, Sep. 2015 to Mar 2016. USU Total: \$10,350.

Peery Foundation, “Bidirectional three phase power inverter for dual purpose grid tied and grid forming applications,” USU total: \$150,000. Role: PI, Jan 2015 – Dec 2017. Investigators: R. Zane (PI, USU).

Utah State University, “Electric Vehicle and Roadway (EVR) Research Facility and Test Track,” R. Zane received \$2.4M award for EVR facility construction and selected as inaugural EVR Director. Construction Aug 2014 – Mar 2015.

Raytheon Integrated Defense Systems, “Analysis and design of series resonant converter (SRC) prototype with digital control,” USU total \$91,927. Role: PI, Jan 2015 – Dec 2015. Investigators: R. Zane (PI, USU).

Department of Energy (DOE), ARPA-E AMPED, “Tech-to-market plus-up, advanced control of large battery packs,” Utah State University (USU). Total: \$170k. Role: PI, Jan. 2015 – Dec. 2015.

- Investigators: R. Zane (PI, USU), S. Trimboli (UCCS), D. Maksimovic (UCB), K. Smith (NREL), D. Anderson (Ford).
- Office of Naval Research, “Phase I: Hybrid Energy Storage Modules (HESM), Advanced Bi-Directional Power Conversion (BDPC) System,” subcontract to Raytheon, USU Total: \$110K.
Role: PI, Aug 2014 – Jul 2015.
Investigators: R. Zane (PI, USU).
- Department of Transportation, “A Novel Multi-Sensor Wireless Network for Bridge Structural Health Monitoring,” subcontract to Intelligent Automation, Inc. (IAI), USU total: \$25K. Jan 2014 – May 2015.
Investigators: R. Zane (PI, USU).
- National Institute on Disability Rehabilitation Research, RERC-ACT, “Wireless power system for socially interactive robots,” subcontract to University of Colorado, USU total: \$106K. Nov. 2013 – Dec. 2014.
Investigators: R. Zane (PI, USU), Z. Pantic (USU), R. Baktur (USU).
- Raytheon Integrated Defense Systems, “High Power Series Resonant Converter (SRC) 32 kW prototype,” USU total \$99K. May 2013 – Dec. 2013.
Investigators: R. Zane (PI, USU).
- Raytheon Integrated Defense Systems, “High Power Series Resonant Converter (SRC) Proof of Concept,” USU total \$30K. May 2013 – Dec. 2013.
Investigators: R. Zane (PI, USU).
- DARPA, “Hydraulic actuation for micro-scale robots (HAMR),” subcontract to MIT, USU total: \$252K. Role: Co-PI, Mar 2013 – Aug 2015.
Investigators: A. Hosoi (PI, MIT), K. Iagnemma (MIT), R. Zane (USU).
- Department of Energy (DOE), ARPA-E AMPED, “Robust cell-level modeling and control of large battery packs,” Utah State University (USU) lead, team members: National Renewable Energy Labs (NREL), University of Colorado Boulder and Colorado Springs, Ford. Total: \$3.4M.
Role: PI, Jan. 2013 – Dec. 2015.
Investigators: R. Zane (PI, USU), S. Trimboli (UCCS), D. Maksimovic (UCB), K. Smith (NREL), D. Anderson (Ford).
- Office of Naval Research, “Support integration and test of power management controller (PMC) for Phase II compact power conversion technology (CPCT) program,” subcontract to Raytheon, USU Total: \$167K.
Role: PI, Aug 2012 – Apr 2013.
Investigators: R. Zane (PI, USU).
- Department of Energy (DOE), ARPA-E Solar ADEPT, “Wafer-Level Sub-Module Integrated DC/DC Converter,” CU-Boulder (lead), team members Nuvotronics LLC, National Renewable Energy Labs (NREL), Total: \$1.3M.
Role: Co-PI, Nov. 2011 – Oct. 2014.
Investigators: D. Maksimovic (Program PI, UCB), Z. Popovic (Co-PI, UCB), R. Zane (Co-PI, UCB), Jean Marc Rollin (Co-PI, Nuvotronics), F. Patrick McCluskey (Co-PI, NREL).
- Office of Naval Research, “Compact Power Conversion Technologies (CPCT) ONR Phase II: Bidirectional Power Converter,” subcontract to Raytheon, Total: \$542K. Program split between UCB and USU in 2012.
Role: PI, May 2011 – Dec 2012.
Investigators: R. Zane (PI, USU), D. Maksimovic (UCB).
- Office of Naval Research, “Support on power converter controls: Compact Power Conversion Technologies (CPCT) ONR Phase I PROGRAM,” subcontract to Raytheon, Total: \$54K.
Role: PI, Jan 2010 – Jun 2010.
Investigators: R. Zane (PI, ECE, UCB), R. Erickson (ECE, UCB), D. Maksimovic (ECE, UCB).
- Texas Instruments, “Power control and management for ultra high efficiency data servers,” \$264K:
Role: Co-PI, Colorado Power Electronics Center (CoPEC), Jun 2010 – May 2013.
Investigators: D. Maksimovic (PI, ECE, UCB), R. Zane (Co-PI, ECE, UCB).

Analog Devices, Inc., “Specifications-driven design space boundaries for point-of-load converters,” Total award: \$44K:
Role: PI, Colorado Power Electronics Center (CoPEC), Jan 2010 – Dec. 2010.
Investigators: R. Zane (PI, ECE, UCB), D. Maksimovic (ECE, UCB).

Raytheon Integrated Defense Systems, “Cascade operation of bi-directional power converter (BDPC) using digital control and power factor corrected (PFC) rectifier,” Total: \$18k.
Role: PI, Colorado Power Electronics Center (CoPEC), Jun 2010 – Dec 2010.
Investigators: R. Zane (PI, ECE, UCB), D. Maksimovic (ECE, UCB)

Raytheon Integrated Defense Systems, “Power converter controls for 3-phase DC-AC inverter,” Total: \$50k.
Role: PI, Colorado Power Electronics Center (CoPEC), Jan 2010 – Dec 2010.
Investigators: R. Zane (PI, ECE, UCB), R. Erickson (ECE, UCB), D. Maksimovic (ECE, UCB)

Department of Education, National Institute on Disability Rehabilitation Research, RERC-ACT, “Non-linear context-aware prompting system for adults with cognitive disabilities in the workplace,” Total: \$1.1M.
Role: co-PI, subcontract to UCD, RERC-ACT “Rehabilitation Engineering Research Center on the Advancement of Cognitive Technologies,” program period: Jan 2010 – Dec 2015.
Investigators: M. Melonis (PI, UCB), R. Zane (co-PI, ECE, UCB), Z. Popovic (co-PI, ECE, UCB), A. Mihailidis (co-PI, UCD), S. Van Vuuren (Co-PI, UCB). Prime contract: C. Bodine (PI, Assistive Technology Partners Director, Physical Medicine and Rehabilitation, UCHSC), M. Lightner (ECE, UCB).

Department of Transportation, “A novel multi-sensor wireless network for bridge structural health monitoring,” Total: \$35K, subcontract to Intelligent Automation, Inc.
Role, PI, Jun. 2010 – Jul. 2011.
Investigators: R. Zane (ECE, UCB).

Northrop Grumman, “RF energy harvesting system miniaturization,” Total: \$22k.
Role: PI, Colorado Power Electronics Center (CoPEC), Jan 2009 – Dec 2009.
Investigators: R. Zane (PI, ECE, UCB), Z. Popovic (ECE, UCB).

On-Semiconductor, “Digitally controlled Class-D audio amplifiers for portable applications,” Total: \$44k
Role: PI, Colorado Power Electronics Center (CoPEC), Jan 2009 – Dec 2009.
Investigators: R. Zane (PI, ECE, UCB), L. Corradini (ECE, UCB), R. Erickson (ECE, UCB).

NSF, “Towards a Dynamic Brain Clamp,” International collaboration travel grant, Total: \$30K.
Role: Co-PI; travel grant lead by PI D. Restrepo, UCHSC, UC-Denver; Travel to Federal University of Ceara, Sobral, Brazil, Jan 2009.

Coleman Institute, “Low-power energy harvesting in cognitive disability applications,” Total: \$77K
Sabbatical Faculty Fellowship, Fall 2008 – Spring 2009.
Investigators: R. Zane (Co-PI, ECE, UCB), Z. Popovic (Co-PI, ECE, UCB).

MSI/DARPA, “PPeC: Parasitically Powered embedded Communication,” Total: \$88K
Role: Co-PI, subcontract to MicroSat Systems (MSI), Jan 2008 – Dec. 2008.
Investigators: R. Zane (Co-PI, ECE, UCB), Z. Popovic (Co-PI, ECE, UCB).

NASA, “Wireless Ultrasonic Transducer Network for Airframe Structure Health Management,” Total: \$100K, subcontract to Intelligent Automation, Inc.
Role, PI, Jan. 2008 – Dec. 2010.
Investigators: R. Zane (ECE, UCB).

NSF, “IREE: Modeling, control and design of energy efficient lighting systems,” Total: \$44.5K
Role: PI, International Research and Education in Engineering (IREE) supplement on NSF CAREER grant. Sep. 2007 – Jun. 2008.
Investigators: R. Zane (PI, ECE, UCB).

NSF CNS, “NOSS: An integrated power aware sensor-simulation network system for long-term performance assessment of concrete infrastructures,” Total: \$600K:
Role, Co-PI, Sep. 2007 – Aug. 2010.

- Investigators: X.C. Cai (PI, CS, UCB), R. Zane (ECE, UCB), Y. Xi (Civil, UCB).
- DOE, “Miasolé Solar America Initiative, SAI,” Total: \$1,049,874 (Awarded by DOE, but later withdrawn by Miasole)
Role: Co-PI, DOE SAI, subcontract to Miasolé, Aug. 2007 – Jul. 2010.
Investigators: M. Brandemuehl (PI, CEAE, UCB), R.W. Erickson (ECE, UCB), R. Zane (ECE, UCB).
- On-Semiconductor, “LED drives for general lighting applications,” Total award: \$88K:
Role: PI, Colorado Power Electronics Center (CoPEC), Jan. 2007 – Dec. 2008.
Investigators: R. Zane (PI, ECE, UCB).
- National Semiconductor, “System IC controls for backlighting in LCD HDTV,” Total: \$326K:
Role: PI, Colorado Power Electronics Center (CoPEC), Aug. 2003 – July. 2009.
Investigators: R. Zane (PI, ECE, UCB).
- Powercast Corp., “Integrated design of rectenna and power management circuit,” Total: \$44K:
Role: PI, Colorado Power Electronics Center (CoPEC), Aug. 2007 – July. 2008.
Investigators: R. Zane (PI, ECE, UCB), Z. Popovic (ECE, UCB).
- Analog Devices, Inc., “Digital control loops in SMPS,” Total award: \$176K:
Role: PI, Colorado Power Electronics Center (CoPEC), Oct. 2006 – Dec. 2009.
Investigators: R. Zane (PI, ECE, UCB).
- NASA Glenn, “Spacecraft Power Converter Health Monitoring and Prognostics,” Total: \$137K:
Role: PI, program period: Apr. 2006 – Mar. 2009.
Investigators: R. Zane (PI, ECE, UCB), D. Maksimović (ECE, UCB).
- Astec / Artesyn Technologies, “Auto-tuning controller for POL converters” Total: \$88K
Role: PI, Colorado Power Electronics Center (CoPEC), Jan. 2006 – Dec. 2007.
Investigators: R. Zane (PI, ECE, UCB), D. Maksimović (ECE, UCB).
- Luna Innovations, “Phase II SBIR: RF Power Scavenging for Wireless Sensors,” Total: \$100K
Role: Co-PI, subcontract to Luna Innovations on US Navy/Air Force SBIR Contract No. N00164-05-C-6088, program period: Nov. 2005 – Mar. 2007.
Investigators: Z. Popovic (PI, ECE, UCB), R. Zane (ECE, UCB).
- CU TTO, “Energy harvesting for maintenance free operation of wireless devices,” Total: \$100K:
Role: PI, Proof-of-Concept (POC) competition, program period: July 2006 – May 2007.
Investigators: R. Zane (PI, ECE, UCB), Z. Popovic (ECE, UCB).
- DARPA, “Planer Integrated Power Processor (PIPP),” Total: \$320K:
Role: PI, Phase I: Robust Integrated Power Electronics (RIPE), subcontract to General Electric, program period: Sep. 2005 – Aug. 2009.
Investigators: R. Zane (PI, ECE, UCB), D. Maksimović (ECE, UCB).
- Intel, “High-frequency digital multi-phase controller and modulator,” Total: \$186K
Role: Co-PI, Colorado Power Electronics Center, program period: Jan 2005 – Dec 2006.
Investigators: D. Maksimović (PI, ECE, UCB), R. Zane (ECE, UCB).
- Department of Education, “Batteryless power supplies for sensor technologies,” Total: \$150K:
Role: PI, subcontract to UCHSC, RERC-ACT “Rehabilitation Engineering Research Center on the Advancement of Cognitive Technologies,” program period: Jan 2005 – May 2007.
Investigators: Subcontract: R. Zane (PI, ECE, UCB). Prime contract: C. Bodine (PI, Assistive Technology Partners Director, Physical Medicine and Rehabilitation, UCHSC), M. Lightner (ECE, UCB).
- NSF Faculty Early Career Development (CAREER) Program, “CAREER: Modeling, Control, and Design of Energy-Efficient Lighting Systems,” Total: \$400K + \$6K REU:
Role: PI, program period: Feb. 2004 – Jan. 2010.
Investigators: R. Zane (PI, ECE, UCB).
- NSF, “SENSORS: Collaborative Research: Self-Configuring In Situ Wireless Sensor Networks for Prescribed Fire Management,” Total: \$300K:

Role: Co-PI, program period: Sept 2003 – May 2007.

Investigators: R. Han (PI, CS, UCB), R. Zane (ECE, UCB), L. Queen (School of Forestry, University of Montana), C. Seielstad (School of Forestry, University of Montana).

NASA Glenn Research Center, “Stability Control in PMAD Systems through Power Converter Modules with Direct Digital Control,” Total: \$74K,

Role: PI, program period: Aug 2003 – Nov. 2005.

Investigators: R. Zane (PI, ECE, UCB), D. Maksimović (ECE, UCB).

Artesyn Technologies, “Digital control in multiphase converters” Total: \$74K

Role: PI, Colorado Power Electronics Center (CoPEC), Jan. 2003 – Dec. 2005.

Investigators: R. Zane (PI, ECE, UCB), D. Maksimović (ECE, UCB)

Coleman Institute, “Feasibility study for CEMS-based chronic brain implants,” Total: \$370K:

Role: Co-PI, program period: Jan 2001 – Dec 2004.

Investigators: D. Restrepo (PI, Cell and Developmental Biology, Director Neuroscience, UCHSC), R. Zane (ECE, UCB), A. Sharp (Integrative Physiology, UCB), D. Finch (Mechanical Engineering, UCB).

DOE, “Modeling and IC-Control of High Frequency Electronic Ballasts,” Total: \$154K:

Role: PI, subcontract to General Electric, program period: Aug 2001 – Jul 2004.

Investigators: R. Zane (PI, ECE, UCB).

CoPEC associate memberships, various companies, Total: \$133K:

Role: Co-PI, Zilker Labs, 2003 – 2007, Intersil, 2003 – 2004, Northrop Grumman, 2005 – 2007.

Investigators: R. Erickson, D. Maksimović, R. Zane (all Co-PIs, ECE, UCB).

Philips Research, “Development of Solid-State LED Power Supply,” Total: \$30K:

Role: Co-PI, Colorado Power Electronics Center, Aug 2001 – Jul 2002.

Investigators: R. Erickson (PI, ECE, UCB), R. Zane (ECE, UCB).

TEACHING ACCOMPLISHMENTS

Educational development and research grants

Department of Energy (DOE), “GATE Center of Excellence, in Innovative Drivetrains in Electric Automotive Technology Education (IDEATE),” joint program with University of Colorado Colorado Springs, Total: \$954K.

Role: PI (for CU-Boulder campus), Oct. 2011 – Sep. 2016.

Investigators: G. Plett (Program PI, UCCS), **R. Zane** (sub-contract PI, UCB/USU), D. Maksimovic (UCB).

Teaching – Courses Taught at Utah State University

- Electrified Transportation Systems (aka ASPIRE 101), ECE-MAE-CEE 5930
 - Spring 2022, 2023, and 2024: created new multi-campus, cross-disciplinary course on electrified transportation systems.
- Fundamentals of Electric Power Systems, ECE 5110, 3 credits.
 - Spring 2020: introduced new course materials on electric utility modeling and simulation
- Power Electronics for Electric Drive Vehicles, 3 credits.
 - Fall 2018: introduced as regular course, ECE 5150/6150.
 - Fall 2017, 2016, 2014, 2013, 2012: new course co-developed with CU-Boulder as part of the DOE IDEATE GATE Center. Course was offered via distance learning with lectures, assignments and materials shared between USU and CU-Boulder campuses. Offered as special topics, ECE 5930/6930.
- Electric Vehicles Design Lab, ECE 5930/6930, 3 credits (pre-requisite is Power Electronics for Electric Drive Vehicles theory course).
 - Spring 2018, 2017 and 2013: new laboratory course co-developed with visiting instructor, Daniel Costinett. Redesigning course in Spring 2017 for new lab designs in Spring 2018.
- Modeling and control of power electronics systems, ECE 7170
 - Spring 2020, 2021, 2022, 2023
 - Fall 2018, ECE 7170, introduced as regular course.
 - Summer 2017, Spring 2017, Spring 2015, independent study, ECE 7930

- Digital control of high frequency switched mode power supplies
 - Spring 2022, 2023, Summer 2021, Fall 2019, Fall 2016, taught as independent study, ECE 7930
- Resonant and soft switching techniques in power electronics, ECE 7180
 - Spring 2019, Summer 2017, Spring 2016; introduced as new regular course.
- Power electronics for grid-connected systems
 - Fall 2014, Independent study, ECE 7930
- Undergraduate introduction to engineering, ENGR 1500
 - Spring 2019

Teaching – Courses Taught at CU-Boulder

- Electronics Design Laboratory, ECEN 2830, 3 credits.
 - Spring 2011: co-developed and co-taught this new sophomore level laboratory as part of a new undergraduate curriculum development at CU-Boulder. 70 students.
 - Fall 2011: continued course development and taught course. 31 students.
- Renewable Sources and Efficient Electrical Energy Systems, ECEN 2060.
 - Spring 2008: co-developed and co-taught this new sophomore level course as a first step in developing a new curriculum in energy and energy efficiency.
- Circuits / Electronics III, Introduction to Microelectronic Circuits, ECEN 3250, 5 credits, combined lecture and laboratory required core undergraduate course.
 - Fall 2006: 20 undergraduate.
 - Fall 2007: 33 undergraduate enrolled.
 - Received the 2008 John and Mercedes Peebles Innovation in Teaching Award, University of Colorado
 - Fall 2011: 51 students. Developed and taught course as the first version within new undergraduate curriculum as a 3 credit theory course.
- Introduction to Power Electronics, dual-listed ECEN 4797/5797 + online CAETE remote delivery
 - Fall 2001: 19 undergraduate, 20 graduate
 - Fall 2009: 21 undergraduate, 54 graduate
- Power Electronics Laboratory, dual-listed ECEN 4517/5517
 - Spring 2004: 54 undergraduate (lecture included 10 graduate)
 - Spring 2005: 10 graduate
 - Spring 2006: 46 undergraduate (lecture included 16 graduate)
 - Spring 2007: 42 undergraduate and 10 graduate
 - Spring 2008: Co-developed and co-taught a major modification to the laboratory, with the new name: Power Electronics and Photovoltaic Power Systems Laboratory
 - Developed a mobile solar power system cart and re-designed the laboratory experiments to focus on power electronic components in the solar power system.
- Analog IC Design, dual-listed ECEN 4228/5228 – now ECEN 4827/5827 + online CAETE
 - Spring 2002: 12 undergraduate, 22 graduate
 - Spring 2003: 26 undergraduate, 37 graduate
 - Spring 2004: 22 undergraduate, 27 graduate
 - Developed detailed course notes, additional assignments, and adjusted course content to create a two-semester sequence, with Analog IC as a prerequisite for Mixed-Signal IC.
 - Fall 2004: 14 undergraduate, 9 graduate
 - Detailed course notes posted online in place of a formal textbook. Additional changes made to syllabus to coordinate with mixed-signal IC design. Submitted formal course proposals for the two-semester IC design sequence.
 - Fall 2010: 3 undergraduate, 27 graduates
- Mixed-Signal IC Design (new course developed in 2002), ECEN 5018 – Now ECEN 5837

- Fall 2002: 15 graduate
 - Developed new course in Fall 2002, including detailed course notes (see website, ece.colorado.edu/~ecen5007), assignments, on-line tutorials for Cadence tools, and final project designs. Course notes are used in place of a formal text book.
- Fall 2003: 22 graduate
- Spring 2005: 21 graduate
 - Developed new on-line tutorials and two-week design assignments integrating theory and extensive use of CAD tools for complete custom IC design.
- Spring 2006: 16 graduate
- Spring 2008: 16 graduate
- Spring 2010: 5 graduate
- Digital Control in SMPS, Industry Short Course, University of Colorado, Boulder, CO, July 2005, August 2006, August 2007. Enrolled 28 industry participants in two sessions three days each. Instructors: R. Zane, D. Maksimović, B. Miao.
 - Materials on digital control of SMPS from this course have now been integrated into ECEN 5807: Modeling and control of power electronic systems, with detailed notes, tutorials and simulation models posted online: <http://ece-www.colorado.edu/~ecen5807>
- Student evaluations on Faculty Course Questionnaire (FCQ) results for Instructor to date
 - a. *Fall 2006 and on:* 6.0, 5.7, 5.5, 5.4, 5.2, 4.9, 4.3, 4.2 (out of 6)
 - b. *Spring 2006 and before:* 1 A+, 2 A, 1 A-, 4 B+, 3 B

Graduate Final Thesis Examinations – Serving as Primary Advisor

1. Marium Rasheed, Ph.D., “Architectural Design of Hybrid Battery Energy Storage Systems with Integrated Active Balancing and Reconditioning Control,” May 2023. Currently at Ford Motor Company, Dearborn, MI.
2. Shuntaro Inoue, Ph.D., “Architectural Design of Hybrid Battery Energy Storage Systems with Integrated Active Balancing and Reconditioning Control,” Dec 2022. Currently at Toyota Central R&D Labs, Inc., Japan.
3. Chakridhar Reddy, Ph.D., “AC-AC Converter Topologies for Wireless Charging Applications,” May 2022. Currently at Lucid Motors, Newark, CA.
4. Mahmoud Mansour, M.S., “Power factor correction and multi-cell control for a medium-voltage three-phase unfolding input-series output-parallel AC-DC converter,” Dec 2021. Currently a Research Engineer III at USU-ASPIRE, Logan, UT.
5. Rees Hatch, M.S., “Analysis and design of 3-phase unfolding based AC-DC battery chargers,” June 2021. Currently a Research Engineer III at USU-ASPIRE, Logan, UT.
6. Joshua Wooten, M.S., “Control of series connected battery powered modules,” June 2021. Currently an engineer at Northrup Grumman, Ogden, UT.
7. Benny Varghese, Ph.D., “Roadway-embedded transmitters and multi-pad receivers for high power dynamic wireless power transfer,” May 2021. Currently Research Scientist at Idaho National Laboratory, Idaho Falls, ID.
8. Rohail Hassan, Ph.D., “Active stability monitoring and stability control of DC microgrids using incremental continuous injection,” April 2021. Currently Research Scientist at General Electric Global Research Center, Niskayuna, NY.
9. Mohamed Ahmed Kamel, Ph.D., “Analysis and control of parallel and series connected modular battery systems,” Nov 2020. Currently at General Motors.
10. Dorai Yelaverthi, Ph.D., “Three-phase unfolding based soft DC-link converter topologies for AC to DC applications,” Aug 2020. Currently Research Scientist at ABB US Corporate Research Center, Raleigh, NC.
11. Anindya Bagchi, Ph.D., Emerging works on wireless inductive power transfer: AUV charging from constant current distribution and analysis of controls in EV dynamic charging, Aug 2020. Currently at Advanced Energy.
12. Tarak Saha, Ph.D., “Soft-switched resonant DC-DC converter in underwater DC power distribution network,” Jul. 2020. Currently Research Scientist at General Electric Global Research Center, Niskayuna, NY.
13. Hongjie Wang, Ph.D., “Design and control of series resonant converters for DC current power distribution applications,” May 2018. Currently Assistant Professor at Utah State University in Logan, UT.

14. Muhammed Muneeb Ur Rehman, Ph.D., “Modular, scalable battery systems with integrated cell balancing and dc bus power processing,” March 2018. Currently at Amazon, Seattle, WA.
15. Weilun (Warren) Chen, Ph.D., “Bidirectional three-phase ac-dc power conversion using dc-dc converters and a three-phase unfold,” Nov 2017. Currently at United Technologies Research Center in Hartford, CT.
16. Hien Ngyuen, Ph.D., “Design and Control of a Modular Resonant DC-DC Converter for Point-of-Load Applications,” July 2014. Currently at a start-up solar company in CA.
17. Daniel Seltzer, Ph.D., “Modeling and Control of the Dual Active Bridge Series Resonant Converter,” May 2014. Currently employed at Space-X in Los Angeles, CA.
18. Daniel Costinett, Ph.D., “Analysis and Design of High Efficiency, High Conversion Ratio, DC-DC Power Converters,” June 2013. Currently an Assistant Professor of ECE at University of Tennessee, Knoxville.
19. Qingcong Hu, Ph.D., “Techniques to improve LED drivers by reducing voltage stress and required energy storage,” Sep. 2011. Current employed at CREE Semiconductor, Durham, NC.
20. Thurein Paing, Ph.D., “Power management techniques for micropower energy scavenging,” May, 2011. Currently employed at Maxim Integrated, Fremont, CA.
21. Ryan Schnell, Ph.D., “Digital control of LFSW HID lamp drivers with soft saturation magnetic materials and integrated resonant lamp ignition,” August, 2010. Currently employed at Analog Devices, Longmont, CO.
22. Jeffery Morroni, Ph.D., “Adaptive tuning and monitoring of digitally controlled switched mode power supplies,” October, 2009. Currently employed at Texas Instruments, Santa Clara, CA and Longmont, CO.
23. Mariko Shirazi, Ph.D., “Embedded frequency response measurement capability for monitoring and tuning of system dynamics in digitally-controlled DC-DC converters,” September, 2009. Currently employed at the National Renewable Energy Lab (NREL), Golden, CO.
24. Montu Doshi, Ph.D., “Power control architectures for CCFL and HBLED based light sources,” August, 2009. Currently employed at Texas Instruments, Longmont, CO.
25. Arseny Dolgov, M.S. Thesis, “Power management system for online low power RF energy harvesting optimization,” May 2009. Currently employed at Ball Aerospace, Boulder, CO.
26. Yang Zhang, Ph.D., “Digital control in modular masterless multiphase microprocessor power supplies,” August, 2006. Currently employed at Texas Instruments in Santa Clara, CA.
27. Yan Yin, Ph.D., “Modeling and IC control of electronic ballasts,” June 2004. Currently employed at Texas Instruments in Longmont, CO.
28. Preeti Bhandarkar, M.S. Thesis, “Design of a low-power sigma-delta A/D converter for chronic brain implants,” April 2004.

Current Graduate Students – Serving as Primary Advisor (paid as RA or Fellowship)

1. Abdullah Baig, Ph.D. candidate, entered Aug. 2023.
2. Azmeer Zahid, Ph.D. candidate, entered Aug. 2023.
3. Haris Ahmed, Ph.D. candidate, entered Aug. 2023.
4. Mayank Chawla, Ph.D. candidate, entered Aug. 2021.
5. Sanat Poddar, Ph.D. candidate, entered Aug. 2021.
6. Aditya Zade, Ph.D. candidate, entered Aug. 2021.
7. Shubhangi Gurudiwan, Ph.D. candidate, entered Aug. 2021.
8. Jackson Morgan, Ph.D. candidate, entered Jan 2021 (BS to PhD).

Past Graduate Students, Non-Thesis MS – Serving as Primary Advisor

1. Aaron Mattmiller, M.S. graduate, Aug. 2010.
2. Jieyeon Choi, M.S. graduate, May 2010.
3. Jim Patterson, M.S. graduate, May 2008.

4. Jeffrey Israel, M.S. graduate, May 2007.
5. Michael Weimer, M.S. graduate, May 2006.
6. Tony Carosa, M.S. graduate, Spring 2006.
7. Kevin Lybarger, M.S., expected graduation: May 2007.
8. Steve Scroggs, M.S. graduate, Fall 2005.
9. Sandra Johnson, M.S. graduate, Spring 2004.
10. Jonathan Gray, M.S. graduate, Fall 2002.

Undergraduate Students Advised and Independent Study

1. Brian Hobbs, BS student, EURP research student.
2. Forrest Nichols, BS student, EURP research student. Entering BS/MS program 2024.
3. Jennifer Hinton, BS student, research on AC/DC power converters, Aug 2020 – Dec 2021.
4. Brooks Maughan, BS student, research on EV charging systems, May 2020 – May 2021.
5. Jackson Morgan, BS student, research on impacts of EV charging and renewable energy on electric grids, Aug. 2019 – Dec 2020.
6. Joshua Zaugg, BS student, research on DC-DC converter modeling and hardware design, Jan 2019 – May 2020.
7. Ian Colbert, BS student, research on battery systems and grid modeling for electric vehicle charging, Mar. 2018 – May 2019.
8. Mahmoud Mansour, BS student, research on microgrid and energy management systems and high power electric vehicle charging, Mar. 2018 – May 2019.
9. Rees Hatch, BS student, research on battery systems, transport chillers, and wireless power transfer systems, Mar. 2018 – May 2019.
10. Daniel Bosco, BS student, research on solar inverters, microgrid, and grid modeling. Jan. 2018 – May 2020.
11. Shaun Bartschi, BS student, research on electric transportation and RFID tags for autonomous vehicle alignment, Sep 2017 – Jan 2019.
12. Matthew Hansen, BS student, research on electric vehicle dynamic modeling, charging infrastructure, and electric roadways, Jan 2017 – Aug 2020.
13. Jacob Alder, BS student, research on solar power installation and support of SELECT research center, Oct 2016 – May 2019.
14. Justin Jones, BS student, research on bidirectional power supplies, Jan 2014 – 2015.
15. William Balling, BS student, research on high voltage, low power, pulse generation circuit for piezoelectric structural health monitoring systems, Jan 2014 – 2015.
16. Justin Cox, BS student, research on high voltage, low power pulse power supply design for solid-state pumps and valves, May 2013 – present.
17. Kelly Hathaway, MS/BS student, research on bidirectional DC-DC converter modules for battery management systems in electric vehicles. May 2013 – 2015.
18. Kevin Kennedy, BS student, research on digital control of bidirectional resonant power converters, Aug 2012 – 2105.
19. Douglas Bloomquist, BS student, research on low power wireless sensor networks and energy harvesting, DLC apprentice, Aug. 2009 – Aug. 2010. Continued on as a graduate research assistant.
20. Daniel Costinett, BS student, research on low power energy harvesting for wireless sensors, DLC apprentice, Aug. 2008 – 2009. Continued as a Ph.D. student.
21. Daniel Seltzer, MS/BS student, research on low power piezo-electric element drive circuit for aircraft wing integrity monitoring, Mar. 2008 – 2009. Continued as a Ph.D. student.

22. Adam Bierman, MS/BS student, research on energy efficient lighting systems, Sep 2007 – present. Sponsored by NSF REU and IREE supplements, including international exchange in Spain.
23. Ryan Dolan, MS/BS student, research on lighting electronics, Jun 2007 – Dec. 2007.
24. Carey Davis, BS student, research on energy efficient lighting systems, DLC apprentice, Jan 2007 – May 2008.
25. Michael Weimer, MS/BS student, independent study in 2005 on harvesting power and electronics design for NSF Sensors project: Fire sensors.
26. Arseny Dolgov, B.S. candidate, research work on an NSF REU project in lighting electronics and on a Coleman Foundation project on wireless sensors, graduation: May 2007.
 - a. Received the **Dean's Outstanding Graduate for Research** award, May 2007.
27. Eric Hicks, independent study project, "A/D converter design and Cadence software tutorial development," Fall 2002.
28. Deirdre Lynch, independent study project, "Electronics 4 laboratory," Fall 2002.
29. Andrew Kowles, independent study project, "Analysis of resonant LCC circuits," Spring 2002.

Postdoctoral Researchers Advised

1. Dr. Yingying Zhang, Mar 2020 – Aug 2020.
2. Dr. Hongjie Wang, Jun 2018 – Jul 2019.
3. Dr. Abhilash Kamineni, Aug 2017 – Jul 2019.
4. Dr. Prasanth Thummala, Nov 2016 – Jun 2017.
5. Dr. Baljit Riar, Sep 2016 – Dec 2019.
6. Dr. Shijie Zhou, Jun 2015 – May 2016.
7. Dr. Mehmed Celebi, Sep 2015 – Aug 2016.
8. Dr. Michael Evzelman, Sep 2013 – Sep 2016.
9. Dr. Tuba Yilmaz, Nov 2013 – Dec 2014.
10. Dr. Sara Dadras, Nov 2012 – Jun 2013.
11. Dr. Victor Manuel Lopez Martin, Jun 2012 – Dec 2012.
12. Dr. Luca Corradini, Jun 2009 – Dec 2011.
13. Dr. Botao Miao, Jun 2004 – Dec 2006.

SERVICE ACTIVITIES

Service – Editorial staff, conference, society and standards committees

1. Conference General Chair, IEEE Wireless Power Technologies Conference and Exhibit, WPTCE 2023, San Diego, CA, Jun. 2023.
2. Society for Automotive Engineers (SAE) standards committee member, SAE J2954/2, Wireless power transfer of heavy duty plug-in electric vehicles and positioning communication, Dynamic Wireless Power Transfer sub-team chair, Jun. 2017 – present.
3. IEEE PELS Cyber-Physical Security Initiative Steering Committee member, Jan. 2018 – Dec. 2021.
4. IEEE Workshop on Cybersecurity of Power Electronic Systems (CyberPELS), organizing committee member, Treasurer, 2019.
5. Guest Editor, IEEE Journal of Emerging and Selected Topics in Power Electronics, Special Section on Cybersecurity of Power Electronics through Hardware Hardening, 2018 – 2019.
6. Associate Editor, IEEE Transactions on Power Electronics, Jan. 2006 – present.
7. Associate Editor, IEEE Journal of Emerging and Selected Topics in Power Electronics, 2013 – present.

8. General Co-Chair, Conference on Electric Roads and Vehicles, 2015, 2016, 2018, 2020, 2023, 2025.
9. IEEE Power Electronics Society (PELS), Administrative Committee (AdCom), 2008 – 2014.
10. IEEE Applied Power Electronics Conference and Exposition (APEC) conference committee member (2001 – 2012) and Topic Chair (2005-2006)
11. IEEE Power Electronics Specialists Conference (PESC) committee member (2001 – 2010)
12. IEEE Power Electronics Society (PELS) Simulation, Modeling, and Control Committee vice-chair 2006
13. IEEE Workshop on Control and Modeling for Power Electronics (COMPEL), Program Chair & Treasure, COMPEL 2014, University of Oviedo, Spain; Program Chair, COMPEL 2010, hosted at the University of Colorado, Boulder, CO
14. IEEE Energy Conversion Congress & Exposition (ECCE), Topic Chair, 2016 – present.
15. IEEE Standards Committee, PAR 1789, “Recommending practices for modulating current in High Brightness LEDs for mitigating health risks to viewers,” Dec. 2008 – 2012.

Service – Major Internal, Utah State University

- Engineering Dean search committee, 2023 – present
- Faculty search committee chair, power / power electronics, 2018 – 2019.
- College of Engineering undergraduate research committee, 2013 – 2016.
- ECE department graduate studies committee, 2013 – present.
- Faculty search committee member, computer engineering, 2016-2017.
- Workshop organizer, Engineering State, Summer 2017, 2018, 2019.
- Director, USU Power Electronics Lab (2012-2020), Electric Vehicle and Roadway (EVR) Test Track and Research Facility (2015 – present), and Battery Limits and Survivability (BLAST) Lab, 2018 – present.
- Director, Center for Sustainable Electrified transportation (SELECT), 2015 – 2020.
- Faculty search committee chair, power / power electronics, 2012 – 2013.

Service – Major Internal, University of Colorado Boulder

- Faculty search committee chair, 2011 – 2012
 - a. Led faculty search for energy engineering area faculty in the ECEE department.
- Undergraduate curriculum committee, 2010 – 2012
 - a. Participate in weekly department committee meetings and provide materials and updates on curriculum for circuits, electronics and power courses.
- Curriculum development
 - a. Participated in new curriculum development teams for analog courses (3 core circuits courses, new sophomore Electronics Design Lab, and sophomore elective on renewable energy)
- Course assessment teams, 2004 – 2008
 - a. Team member, ECEN 3250, Circuits III
 - b. Team member, ECEN 3100 Digital Logic
- Internal review committee, 2003
 - a. Participated in department review meetings, reviewed final committee report, participated in discussions with external review board
- Graduate studies committee, 2001-2010
 - a. Participate annually in graduate student admissions, departmental teaching assistant (TA) offers and fellowships; periodic meetings on graduate studies and curriculum
- Chairman, power area Ph.D. preliminary examination committee
 - a. Committee chairman in 2002, 2005, 2007; committee member in 2003, 2004, 2006.
- Colorado power electronics center (CoPEC) faculty member
 - a. Assist in hosting annual CoPEC industry sponsor meeting and laboratory exposition and coordinate weekly group meetings with student presentations
 - b. Participate in student recruiting, curriculum development, and lab management

Service – Journal and Conference Paper Reviews

- IEEE Journal of Emerging and Selected Topics in Power Electronics (~2 papers per year)
- IEEE Transactions on Power Electronics (full papers and letters) (~ 6 papers per year)
- IEEE Journal of Solid-State Circuits (~ 2 papers per year)
- IEEE Transactions on Circuits and Systems, Parts I & II (~ 2 papers per year)
- IEEE Industrial Applications Society Transactions (~ 1 paper per year)
- IEEE Transactions on Industrial Electronics (~1 paper per year)
- IEEE Transactions on Microwave Theory and Techniques (~1 paper per year)
- IEEE Energy Conversion Congress & Exposition (ECCE) (~ 10 papers per year)
- IEEE Applied Power Electronics Conference (APEC) (~ 10 papers per year)
- IEEE Transportation Electrification Conference & Expo, ITEC (~10 papers per year)
- IEEE Workshop on Control and Modeling for Power Electronics (COMPEL) (~10 papers per year)
- IEEE International Symposium on Circuit and Systems (ISCAS) (~ 10 papers per year)
- IEEE International Symposium on Industrial Electronics (ISIE) (~ 2 papers per year)

Service – Consulting Positions

- Jul 2025 – present. Cooley LLP. Patent consultant and expert witness.
- Apr 2025 – present. DLA Piper LLP (US). Patent consultant and expert witness.
- Sep 2023 – present. Faegre Drinker Biddle & Reath, LLP. Patent consultant and expert witness.
- Jul 2023 – Nov 2024. Knobbe, Martens, Olson & Bear, LLP. Patent consultant and expert witness.
- Feb 2022 – present. Bond Shoeneck & King. Patent consultant and expert witness.
- May 2021 – Apr 2022. Holland & Knight LLP. Patent consultant and expert witness.
- Apr 2021 – Aug 2024. Paul Hastings LLP. Patent consultant and expert witness.
- Sep 2020 – Dec 2020. Akin Gump Strauss Hauer & Feld LLP. Patent consultant and expert witness.
- Nov 2019 – Feb 2025. Alston & Bird LLP. Patent consultant and expert witness.
- July 2019 – May 2021. Radulescu LLP. Patent consultant and expert witness.
- Sep 2018 – Oct 2019, Dec 2021 – present. Baker Botts LLP. Patent consultant and expert witness.
- May 2018 – Aug 2018. Bookoff McAndrews, PLLC. Patent consultant and expert witness.
- Aug 2016 – Dec 2017. Bristows LLP. Patent consultant and expert witness.
- Jul 2016 – present. Friedman, Suder & Cooke. Patent consultant and expert witness.
- Feb 2016 – Nov 16. Jenner & Block, LLP. Patent consultant and expert witness.
- Jan 2015 – present. Finnegan, Henderson, Farabow, Garrett & Dunner, L.L.P. Patent consultant and expert witness.
- Jan 2012 – Dec 2013. Institute for Defense Analysis (IDA). Selected as member of the 2012-2013 Defense Sciences Study Group (DSSG), US Defense Advanced Research Projects Agency (DARPA).
- Feb 2010 – Aug. 2011. Friedman, Suder & Cooke, patent consultant. Served as an expert witness on electronic ballast case, including expert report, deposition, and testimony at trial.
- May 2008 – Dec 2014: Intelligent Automation Inc., low power piezo-electric driver design consultant.
- Nov 2008 – Nov 2009: Cymbet Corporation, low power energy harvesting design consultant.
- Jun. 2006 – Nov 2009: Telegen / Vu1, electronic ballast design consultant.
- Oct. 2005 – Mar. 2007: Luna Innovations, low power management design consultant.
- Aug. 2005 – Dec. 2005: Intertainment, low power management design consultant.
- June 2005 – Dec. 2006: Intelligent Automation Inc., power converter design consultant.
- Dec. 2004 – May 2005: Cooley Godward LLP, patent consultant.
- Nov. 2004 – Jan 2005: ITU Ventures, technology consultant.

- Nov. 2004 – Dec. 2006: Winstead Sechrest & Minick P.C., patent consultant.
- May 2004: Zilker Labs, consultant on digital control and custom IC design in power converters.
- May 2004: Artesyn Technologies, 3-day short course on digital control in switching power converters.
- 2002 – 2005: Jet Propulsion Labs, University of Washington, Neptune Project Power Group Review Committee
- 2001 – 2005: General Electric Global Research, consulting on application of digital and custom mixed-signal IC controls in lighting electronics and related applications