

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

DELTA ELECTRONICS, INC.
Petitioners,

v.

VICOR CORPORATION
Patent Owner

Case IPR2024-00134

U.S. Patent No. 10,199,950

**DECLARATION OF DOUGLAS CHARLES HOPKINS, PH.D. IN
SUPPORT OF PETITION FOR *INTER PARTES* REVIEW**

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DECLARATION OF DOUGLAS CHARLES HOPKINS, PH.D.

1. I, Douglass Charles Hopkins, make this declaration in connection with the proceedings identified above.

2. I have been retained on behalf of Petitioner Delta Electronics, Inc. (“Delta”) to offer my expert opinions in connection with the above-captioned proceeding relating to U.S. Patent No. 10,199,950 (“the ’950 Patent”).

3. I am being compensated for my time in connection with this *inter partes* review (IPR) at my standard consulting rate. No part of my compensation depends on the outcome of this proceeding.

4. I have been asked to provide my opinions as to whether claims 1, 2, 5-10, 13-17, 19, and 21-40 of the ’950 Patent (the “Challenged Claims”) are invalid to a person having ordinary skill in the art at the time of the alleged invention.

5. In preparing this declaration, I have reviewed the ’950 Patent (Ex. 1001),¹ the file history of the ’950 Patent (Ex. 1002), various pieces of prior art (Exs. 1005-1008), and all other materials referenced in this declaration.

6. In forming the opinions expressed in this declaration, I relied upon my education, training, knowledge, and experience in the art, and have considered the viewpoint of an ordinary artisan at the time of the invention.

¹ All citations to exhibit numbers in this declaration are to the exhibits attached to the accompanying IPR Petition for the ’950 Patent.

I. BACKGROUND AND QUALIFICATIONS

7. I summarize in this section my educational background, career history, and other relevant qualifications. My full resume is attached as Exhibit A to this declaration.

8. I earned a Bachelor of Science in Electrical Engineering and a Master of Science in Electrical Engineering from the State University of New York at Buffalo in 1975 and 1977, respectively. I earned a Ph.D. in Electrical Engineering from Virginia Polytechnic Institute and State University (Virginia Tech) in 1989, with a focus on Power Electronics and Energy Systems.

9. I am currently a Professor in the Department of Electrical and Computer Engineering at North Carolina State University—a position I've held since August 2011 to the present. I have also served as Director of the Laboratory for Packaging Research in Electronic Energy Systems at North Carolina State University since September 2011 to the present.

10. Prior to my position at North Carolina State University, I was a Professor in the Electrical Engineering Department of the State University of New York at Buffalo, from 1997 to 2011. I was also Director of the Electronic Power and Energy Research Laboratory at the the State University of New York at Buffalo during that same timeframe. In 2008, during my time at the State University of New York at Buffalo, I founded a company called DensePower, LLC (involved in

developing power control modules for power supplies), and I served as its President from 2008 until 2014.

11. From 1994-1998, I was an Assistant Professor in the Department of Electrical Engineering at the State University of New York at Binghamton, and my teaching and research were in the area of electronic energy systems and electronic packaging. Prior to that, from 1993-1994, I was a Research Assistant Professor at the State University of New York Research Foundation in Binghamton, New York, with research in the area of electronic energy systems.

12. From 1988 to 1992, I was an Assistant Professor in the Department of Electrical Engineering at Auburn University. In that role, my teaching and research were in the area of power electronics and power packaging.

13. From 1983 to 1988, while I was a Doctoral Student at Virginia Tech, I was also an Instructor in the Department of Electrical Engineering at Virginia Tech.

14. Prior to my time in academia, and before I began pursuit of my Ph.D. in 1983, I worked as an Electrical Engineer in the Corporate Research and Development Center at General Electric Company from 1977-1982. I also worked as a Senior Engineer in the Research and Development Center at Carrier Corporation from 1982-1983.

15. I have been a Senior Member of the Institute of Electrical and Electronics Engineers (“IEEE”) since 1992, and have participated in a number of the

IEEE Societies, including the Components, Packaging and Manufacturing Technology Society, the Electron Devices Society, the Industry Applications Society, the Industrial Electronics Society, the Power Electronics Society, the Power & Energy Society, and the Vehicular Technology Society. I am also a Fellow of the International Microelectronics and Packaging Society.

II. LEGAL STANDARDS

16. I am not a lawyer or legal expert, and I do not offer any opinions regarding applicable legal standards. Below, I set forth my understanding of the law as it has been explained to me, and I have applied this understanding in forming my opinions in this declaration.

A. Priority Date and Prior Art

17. I am informed that for these proceedings, the prior art to the challenged patent includes patents and printed publications in the relevant art that predate the priority date of the patent.

18. The '950 Patent issued on February 5, 2019 from U.S. Patent Application No. 13/933,252 filed on July 2, 2013. Ex. 1001, Cover. The '950 Patent is not a continuation or divisional of any earlier application.

19. I understand that the '950 Patent claims priority to July 2, 2013. I understand that the '950 Patent was filed after the America Invents Act became

effective on March 16, 2013, and therefore Patent Owner is unable to claim an earlier priority date than the date on which the patent was filed.

B. Claim Interpretation

20. I understand that in construing or interpreting a patent claim, the words of the claim are generally given their ordinary and customary meaning, which is the meaning that words would have had to a person of ordinary skill in the art in question at the time of the invention. The person of ordinary skill in the art is deemed to read the claim term in the context of not only the particular claim in which the disputed term appears, but also in the context of the entire patent, including the other claims and the specification, as well as the prosecution history of the patent. For purposes of this proceeding, I understand the claim terms of the '481 Patent to have their ordinary and customary meaning.

C. Anticipation

21. To invalidate a patent claim as anticipated in the context of IPR, the petitioner bears the burden of showing by a preponderance of the evidence that a single prior art reference discloses every element required by the claim.

22. An element need not be expressly disclosed if it is inherent in the prior art, but the allegedly inherent characteristic must necessarily flow from the teachings of the applied prior art—in other words, the fact that a certain result or

characteristic may occur or be present in the prior art is not sufficient to establish the inherency of that result or characteristic.

D. Obviousness

23. To invalidate a patent claim as obvious in the context of an IPR proceeding, the petitioner bears the burden of showing by a preponderance of the evidence that the differences between the invention and the prior art are such that the subject matter as a whole would have been obvious to a person of ordinary skill in the art to which the subject matter pertains at the time the claimed invention was made. Factors relevant to the determination of obviousness include (1) the scope and content of the prior art, (2) the level of ordinary skill in the art at the time of the invention, (3) differences between the claimed invention and the prior art, and (4) “secondary considerations” or objective evidence of obviousness or nonobviousness.

24. I am informed that some non-exclusive rationales that may support a conclusion of obviousness include:

- Combining prior art elements according to known methods to yield predictable results;
- Simple substitution of one known element for another to obtain predictable results;
- Use of known technique to improve similar devices (methods, or products) in the same way;
- Applying a known technique to a known device (method, or product) ready for improvement to yield predictable results;

- “Obvious to try” – choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success;
- Known work in one field of endeavor may prompt variations of it for use in either the same field or a different one based on design incentives or other market forces if the variations are predictable to one of ordinary skill in the art;
- Some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention.

25. **Reason to Combine.** Obviousness can be established by showing that a person of ordinary skill in the art would have combined or modified the teachings of the prior art to produce the claimed invention and would have had a reasonable expectation of success in achieving the claimed subject matter. There is no requirement that the prior art provide an express teaching, suggestion, or motivation to combine elements of the prior art, but a determination of obviousness requires more than showing that each element of a patent claim was independently known in the prior art. Rather, the petitioner in an IPR must identify some apparent reason why a person of ordinary skill in the art would have combined the elements or concepts from the prior art in the same way as in the claimed invention when considered as a whole. The motivation to combine may be implicit and may be found in the knowledge of a person of ordinary skill in the art, from the nature of the problem to be solved, market demand, or common sense.

26. **Hindsight.** A determination regarding obviousness must be based on the knowledge possessed by a person of ordinary skill in the art at the time when the invention was made, and one should not consider in hindsight what is known today or what is learned from the teachings of the patent. Thus, it is inappropriate to use hindsight reconstruction of references to reach the claimed invention without any explanations as to how or why the references would be combined to produce the claimed invention.

27. **Analogous Art.** An obviousness analysis cannot be based on nonanalogous art. The rationale behind this rule is that when art is directed to a different purpose than a claimed invention, an inventor would have less motivation or occasion to consider it. Art is analogous when it is from the same field of endeavor as the claimed invention, or if the art is not from the same field of endeavor, when it is reasonably pertinent to the particular problem faced by the inventor. To be “reasonably pertinent,” art must “logically commend itself” to an inventor’s attention in considering his problem.

III. PERSON OF ORDINARY SKILL IN THE ART

28. I have been advised that there are multiple factors relevant to determining a person having a level of ordinary skill in the pertinent art, including the educational level of active workers in the field at the time of the alleged

invention, the sophistication of the technology, the type of problems encountered in the art, and the prior art solutions to those problems.

29. I have been informed that Patent Owner has contended in a related ITC proceeding that a person of ordinary skill in the art with respect to the '950 Patent would have at least a Masters degree in electrical engineering and two or more years of work experience relating to power electronics and the design of switching power converters, with more experience potentially substituting for education or vice versa. I have adopted this understanding of the level of skill in the art for purposes of this Declaration.

30. I have been qualified as at least a person of ordinary skill in the art since well before 2013, and each of my opinions set forth in this declaration are presented from the standpoint of one skilled in the art. Thus, where I specify in the analysis below that I am rendering my opinion, it should be understood that my opinion is from the perspective of a person having the level of ordinary skill in the art that I have described at the time of the invention.

IV. OVERVIEW OF THE '950 PATENT

31. The '950 Patent issued on February 5, 2019 from U.S. Application No. 13/933,252, filed on July 12, 2013. Ex. 1001, Cover. The '950 Patent only claims priority to the 13/933,252 application. *Id.*

32. The '950 Patent describes and claims DC-DC power and/or bus converters including “an input circuit and output circuit” wherein the converter “is adapted to convert power from the input circuit to the output circuit at a substantially fixed voltage transformation ratio” and wherein the “input circuit and at least a portion of the output circuit are connected in series across the source.” Ex. 1001, Abstract.

33. The described and claimed power/bus converters comprise an inductive component and one or more power switches in either the input circuit, the output circuit, or both. *See, e.g., id.*, claim 1. A charge flowing in the inductive component charges and discharges capacitances in the converter so that a voltage across one or more of the switches is reduced prior to turning on said one or more switches. *Id.* The '950 Patent also claims is a power distribution bus containing such a power converter and “a plurality of regulators” connected to the output of the converter and the input of a load. *Id.*

34. The '950 Patent does not identify or claim to solve any particular problem in the art, and discusses nothing more than obvious and well-known bus converter and DC-DC converter functionality and structure.

35. I have reviewed the file history of the '950 Patent. I understand that the claims of the '950 Patent were only substantively rejected once as being anticipated

and obvious over U.S. Patent Application No. 2008/0211304 to Farrington et al. (“Farrington”). Ex. 1002, 77-83.

36. The applicant distinguished the pending claims from Farrington on the basis that Farrington did not disclose an “input of the bus covered and at least a portion of the output circuit of the bus converted are connected in series across the source.” *Id.*, 99-100 (emphasis in original). As noted by the applicant, Farrington disclosed an output circuit that is galvanically isolated from the source because “the input circuit is connected to the output circuit via magnetic coupling between the primary winding 309 and the secondary windings 210 and 211 of the isolation transformer.” *Id.*, 100 (emphasis in original). On the same basis, the applicant argued that Farrington did not disclose “the primary and secondary transformer winding are galvanically connected in series, wherein the bus converter is configured to provide power to a power distribution bus that is not galvanically isolated from the source.” *Id.*, 103.

37. The claims were thereafter allowed, and were not again rejected. *See* Ex. 1002, 114. However, the applicant filed numerous requests for continued examination/amendments after allowance, amending the specification (*id.*, 139-142), adding hundreds of prior art references to the record (*id.*, 147-205, 359-421, 588-598, 776-780), and amending existing claims or adding new claim (*id.*, 517-529, 546-555, 561-570, 623-669). Each time, the application was allowed without

rejection. *Id.*, 298, 450, 539, 558-560, 580-582, 610, 674, 793. The issue notification was finally entered on January 16, 2019, and the '950 Patent issued on February 5, 2019. *Id.*, 811.

V. OVERVIEW OF THE PRIOR ART

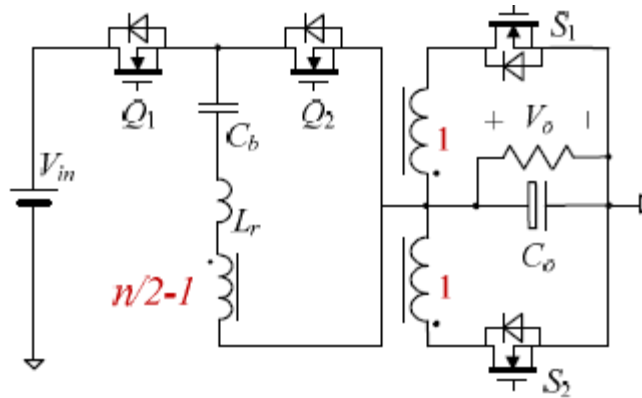
A. Huang (Ex. 1005)

38. Huang is a conference paper entitled “Novel Non-isolated LLC Resonant Converters” presented at the 2012 Twenty-Seventh Annual IEEE Applied Power Electronics Conference and Exposition (APEC) in February 2012. Ex. 1005. It was published by at least March 9, 2012. Ex. 1009, ¶¶ 39-45, 48.

39. The paper identifies Daocheng Huang as the co-author along with Xinke Wu and Fred. C. Lee. None of the named inventors or Patent Owner are listed as co-authors of Huang.

40. Huang proposes “novel non-isolated LLC resonant converters” that can achieve zero voltage switching, reduce the number of turns in the transformer, and reduce the current through the secondary transformer winding. Ex. 1005, 1373.

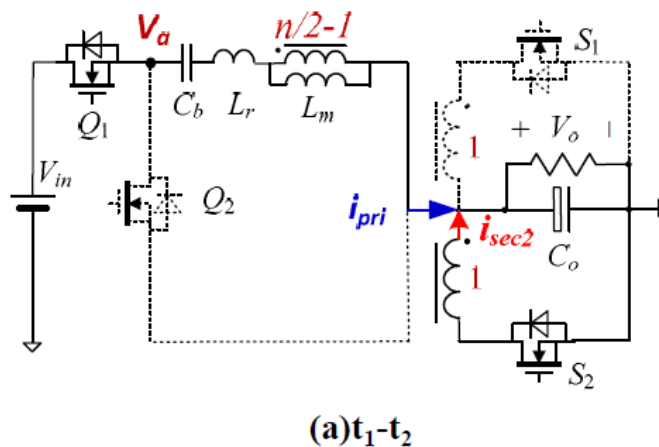
41. One of these topologies is a half-bridge, non-isolated resonant converter depicted in Figure 12(b):



Id., Figure 12(b).

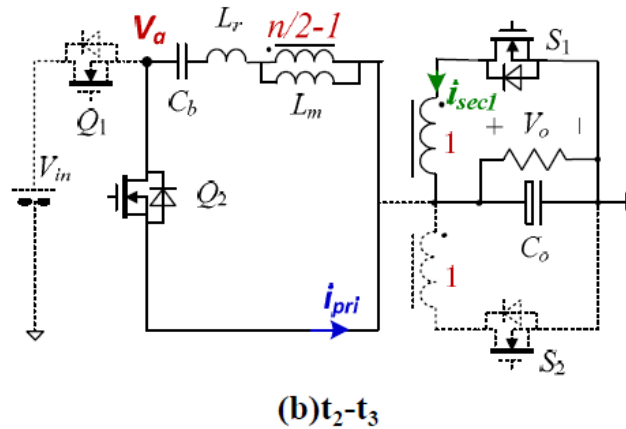
42. Huang's converters are capable of zero-voltage switching. *Id.*, 1373. Zero-voltage switching, in which switches are not turned ON/closed until the voltage across the body diode of the switch is zero or near-zero, allows for operation at a higher frequency and higher input voltages without sacrificing efficiency.

43. Figures 14(a) and 14(b) depict equivalent circuits for the operation of Huang's 12(b) converter at two different time intervals. *Id.*, 1378. During t_1 to t_2 , the current is delivered from the source to the resonant tank and the transformer (Q_1 is closed/on and Q_2 is open/off).



Ex. 1005, Figure 14(a), 1378.

44. During t_2 to t_3 , the remaining power stored in the resonant tank is transferred to the transformer with current flowing in the opposing direction as in time t_1 to t_2 (Q_1 is open/off and Q_2 is closed/on).



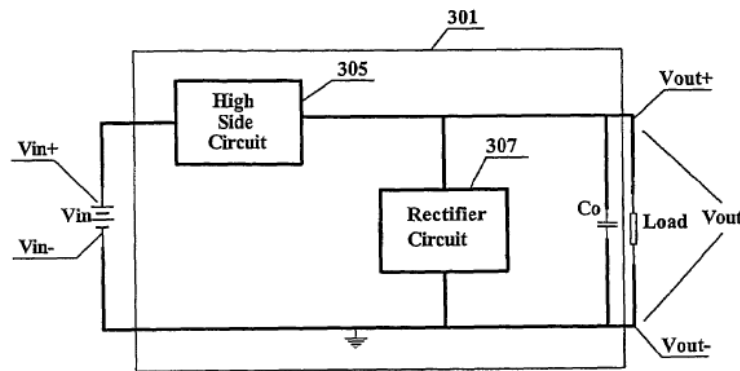
Ex. 1005, Figure 14(b), 1378.

45. Zero-voltage switching occurs between these two time periods as well as directly after t_2 to t_3 . During zero-voltage switching, current from the LLC tank (which includes the transformer primary winding) flows through the antiparallel diode of the switch (e.g., Q_2 between t_1 to t_2 and t_2 to t_3 , Q_1 after t_2 to t_3) which causes the voltage across the transistor to drop until it reaches a value close to zero (limited by the small voltage drop of the diode). Because this occurs when both gate signals are low, i.e., the switches are both off/open, by the time the circuit transitions from both switches being off to one being on, the voltage across the transistor of the switch to be turned on is close to zero.

B. Liu (Ex. 1006)

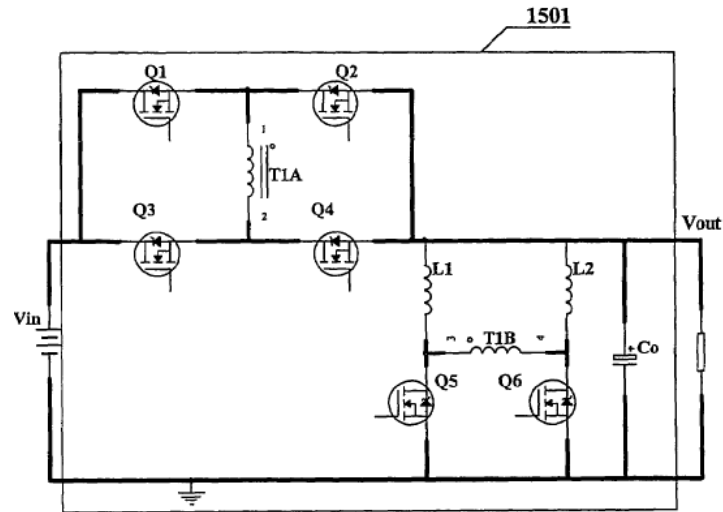
46. Liu is a United States patent that was filed on August 16, 2006 and issued on December 11, 2007. Ex. 1006, Cover. Liu claims priority to a provisional application filed on December 9, 2002. *Id.*

47. Liu discloses a first high-level converter topology shown in Figure 3 comprising a high-side circuit, rectifier circuit, and output capacitor:



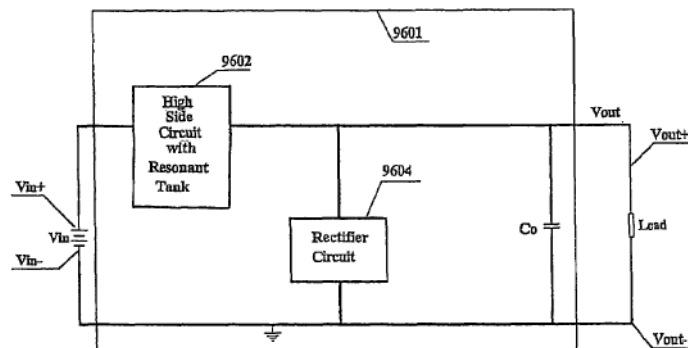
Ex. 1006, Figure 3.

48. Figure 15 is a specific embodiment of the configuration shown in Figure 3, comprising a full-bridge high-side circuit comprising primary switches that control the flow of current through the transformer primary winding and a half-bridge rectifier circuit with two switches controlling the flow of current through the transformer secondary winding and two inductors L1 and L2:



Ex. 1006, Figure 15, 16:16-18:16.

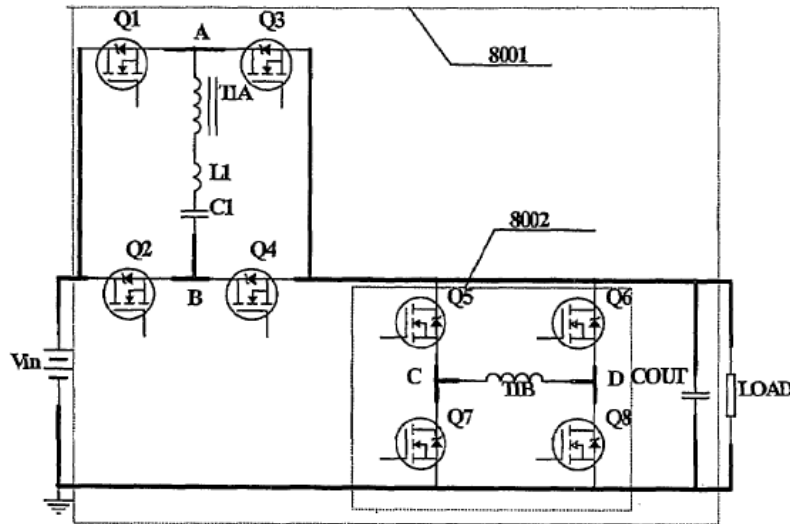
49. Liu discloses a second topology depicted in Figure 68A that is similar to Figure 3 except the high-side circuit includes a resonant tank:



Ex. 1006, Figure 68A.

50. Figure 80 is a specific embodiment of the configuration shown in Figure 68A, comprising a full-bridge high-side circuit with four primary switches that control the flow of current through an LLC series resonant tank including the transformer primary winding, inductor $L1$, and capacitor $C1$. *Id.*, Figure 80, 32:53-

33:7. It further comprises a full-bridge rectifier circuit with four primary switches that control the flow of current through the transformer secondary winding. *Id.*



Id., Figure 80

51. Liu discloses that the disclosed converter topologies are advantageously capable of zero voltage switching among other efficiencies. Ex. 1006, 18:21-31, 36:20-33. Zero-voltage switching operates by lowering the voltage across a switch's antiparallel/body diode to zero or near-zero before turning the switch on or closing the switch by, for example, reversing current direction in the transformer windings.

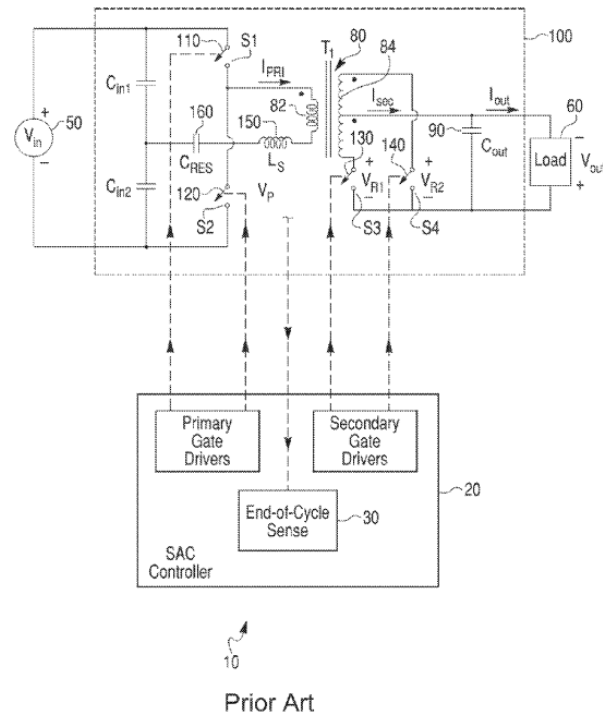
C. The '481 Patent (Ex. 1007)

52. The '481 Patent relates to a method for “digital control of resonant zero-current and zero-voltage switching resonant power converters.” Ex. 1007, 1:6-9.

53. The specification describes one implementation of the invention as “a method of synchronously operating a power converter in a series of converter operating cycles includes providing an oscillator for generating clock signals at an oscillator frequency and generating timing control signals for each of a plurality of events based upon the clock signals in a standard converter operating cycle having a standard operating period and frequency. The timing and control signals may turn a primary switch ON and OFF at times when essentially zero voltage is impressed across and essentially zero resonant current is flowing in the primary switch and turn a secondary switch ON and OFF at times when essentially zero current is flowing in and essentially zero voltage is impressed across the secondary switch.” *Id.* 2:26-41.

54. The '481 Patent explains that resonant power converters with zero-current and zero voltage switching capabilities were known in the art at the time of invention (the '481 Patent was filed on March 14, 2013). *See* Ex. 1007, 1:13-2:7; Figure 1. The '481 Patent claims to have invented a digital controller to replace the prior art controller, though states that the circuitry of the claimed digital controller is “essentially the same as” the prior art controller. *Id.*, 4:29-35. Thus, both the prior art controller and the claimed digital controller “controls the turning ON and OFF of switches within the power conversion circuitry” to control the timing of power transfer and energy recycling intervals. *Id.*, 1:22-59. “Each converter operating cycle comprises two power transfer intervals of equal length and two energy recycling

intervals of equal length.... Each power transfer interval is substantially equal to one-half of the characteristic period” *Id.*, 1:47-53; *see also id.*, 8:22-26. (normal converter operation may be defined by power transfer intervals being on half of the characteristic resonant period). During a power transfer interval, primary switches (e.g., S1 in the figure below) are closed which causes a flow of resonant current in the transformer primary winding, *i.e.*, power is transferred from the input of the circuit to the output via the transformer. *Id.*, 1:22-47.



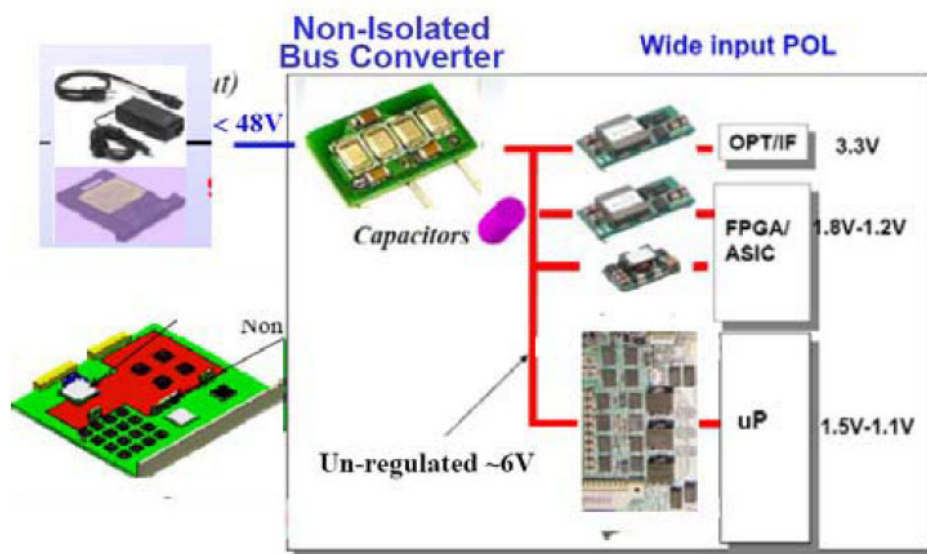
Id., Figure 1.

D. Lee (Ex. 1008)

55. Lee is an article entitled “Design Challenges for Distributer Power Systems” published in the Asian Power Electronics Journal, Volume 1, No. 1. Ex. 1008, 1. It was published no later than August 31, 2007. Ex. 1009, ¶¶46-48.

56. The paper identifies as authors Fred C. Lee (also a named author of Huang), Ming Xu, Shuo Wang, and Bing Lu. *Id.* None of the named inventors or Patent Owner are listed as co-authors of Lee.

57. Lee discusses technological advancements, challenges, and opportunities for development in distributed power systems. Ex. 1008, 1. One specific proposal is a non-isolated intermediate bus architecture, depicted below. *Id.*, 12, Figure 43. This architecture includes a non-isolated bus converter designed to minimize switching losses and body diode losses at high switching frequencies and increase circuit efficiency. *Id.*, 11-12.



Ex. 1008, Figure 43.

VI. THE CHALLENGED CLAIMS ARE UNPATENTABLE

58. It is my opinion that a person of ordinary skill in the art would have considered the Challenged Claims of the '950 Patent unpatentable over: (A) Huang; (B) Huang and the '481 Patent; (C) Huang alone or in combination with the '481 Patent, in view of Lee; (D) Liu; and/or (E) Liu in view of Lee. I explain my opinions in detail below, on a claim-by-claim basis.

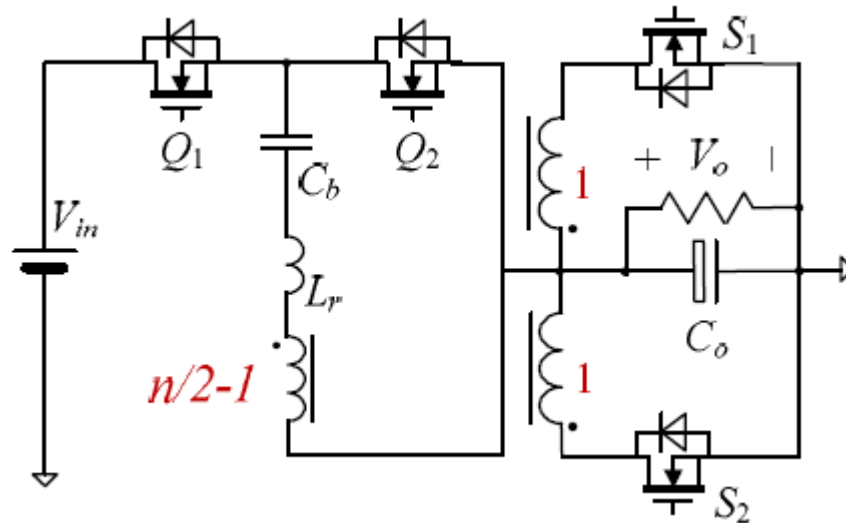
A. Ground I: Claims 1, 5-7, 9, 13-16, 19, and 21-40 Are Obvious Over Huang

59. It is my opinion that Huang (Ex. 1005) renders obvious claims 1, 5-7, 9, 13-16, 19, and 21-40 of the '950 Patent.

1. Independent Claim 1

- a. Limitation 1(a): An apparatus comprising:*
- b. Limitation 1(b): a power distribution system comprising a source for providing power at a DC source voltage V_S*

60. Huang discloses a number of full- and half-bridge, non-isolated LLC resonant converters (for example, those shown in figures 2, 6, 7, 8, 12), including the half-bridge converter depicted in Figure 12(b):



Ex. 1005, Figure 12(b).

61. The Figure 12(b) converter “receive[s] power from a power distribution system comprising a source for providing power at a DC source voltage V_s ” indicated by “ V_{in} ” (“voltage in”) on the left. It is clear reading Huang that this source is a DC source: when explaining the problem to be addressed in the paper, Huang notes the benefits and detriments of existing DC-DC converters and proposes an alternative solution. Ex. 1005, 1373. A POSITA would have therefore understood the proposed solution to be in the same area, i.e., DC-DC converters. Moreover, the converter prototype made to verify the proposals made in Huang was a DC-DC converter. *Id.*, 1379. As a POSITA would have known, DC-DC converters both receive and output DC voltage.

- c. *Limitation 1(c): a bus converter comprising an input circuit and an output circuit, the bus converter being adapted to convert power from the input circuit to the output circuit at a substantially fixed voltage*

transformation ratio, K_{DC} , at an output current, wherein an input voltage V_{IN} is applied to the input circuit and an output voltage V_{OUT} is produced by the output of the bus converter, and wherein the substantially fixed voltage transformation ratio can be represented as $K_{DC}=V_{OUT}/V_{IN}$;

62. The '950 Patent acknowledges, as it must, that the Intermediate Bus Architecture (“IBA”) was known in the art at the time of invention. Ex. 1001, 1:13-35 (describing IBA configuration as prior art). Specifically, the '950 Patent depicts “a prior art power distribution system 1 such as an Intermediate Bus Architecture” in Figure 1, reproduced below. *Id.*, 1:13-14. IBA systems included a DC power source supplying power to a bus converter. *Id.*, 1:13-16. The bus converter included, for example, a DC transformer to provide voltage transformation, *e.g.*, a DC-DC converter such as that disclosed by Huang. *Id.*, 1:20-24, Figure 12(b).

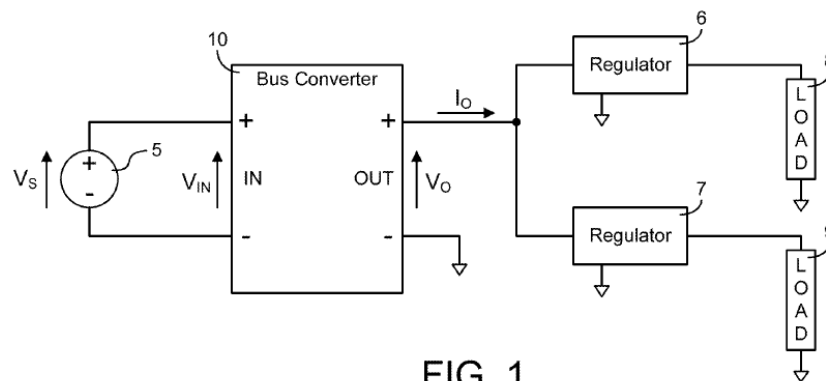


FIG. 1

Ex. 1005, Figure 1.

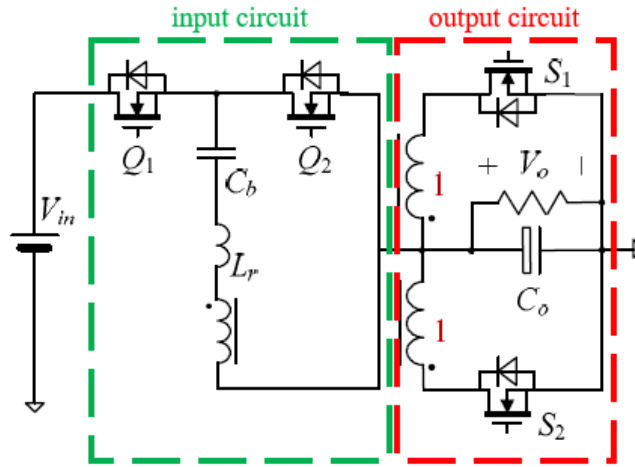
63. A POSITA would have understood a power converter to be a component that converts electrical energy, for example, AC into DC or DC into AC. Power converters can also change the voltage, current and frequency of the voltage

or current. For example, DC-DC converters either step down or step up the voltage, e.g., from 48V to 3.3V. A POSITA would have further known that a bus converter is a DC-DC power conversion module intended to step down or step up voltage. A POSITA would have therefore known that a bus converter is or contains a power converter.

64. A POSITA would also have known to use a DC-DC converter such as Huang's as the bus converter or part of the bus converter where the input and output of the converter both need to be DC, as is the case where the input to the converter is DC and the electronics downstream from the converter also use DC.

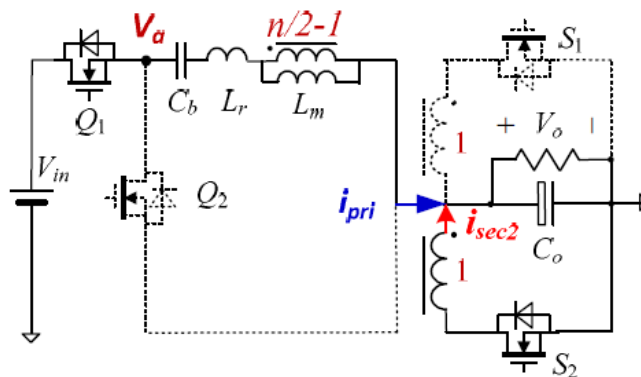
65. A POSITA would have also known that, in the case of IBA, the bus converter should both be efficient and low cost. Huang's converter increases efficiency of the converter and the overall system by, for example, achieving zero voltage switching, low turn off loss for switches, reduction in transformer turns, and reduction of current through transformer secondary windings. *See* Ex. 1005, 1373. Huang would thus be an attractive option to a POSITA seeking a high efficiency converter.

66. Huang's Figure 12(b) converter converts power from the input circuit to the output circuit, which are indicated in green and red, respectively:



Ex. 1005, Figure 12(b) (annotations added).

67. As depicted in Huang's Figure 12(b), the input voltage to the converter is V_{in} and the output voltage of the converter is V_o . The input voltage of the input circuit, corresponding to the claimed V_{IN} , is the voltage to the converter, V_{in} , less the output voltage, V_o : $V_{IN} = V_{in} - V_o$. This can be seen in Figure 14(a), which depicts an equivalent circuit of Figure 12(b) when switches Q_2 and S_1 are off (open), and Q_1 and S_2 are on (closed):



Ex. 1005, Figure 14(a). The output voltage, V_o , corresponds to the claimed V_{OUT} . *Id.*

68. The power conversion performed by Huang's Figure 12(b) converter is performed at a substantially fixed voltage transformation ratio that can be represented as $K_{DC} = \frac{V_{OUT}}{V_{IN}}$. **First**, Huang discloses that the switching frequency of the converter may be at the resonant frequency. Ex. 1005, 1378. In LLC converters, the impedance of the resonant tank is zero when the switching frequency is at the resonant frequency. Because the impedance of the resonant tank is zero, the voltage gain is fixed for all load conditions when the switching frequency is at the resonant frequency because the impedance is not interfering with the voltage. Thus, the transformation ratio (which is the voltage gain, as noted by the '950 Patent, Ex. 1001, 4:57-60), is fixed and only affected by the transformer turns ratio when the switching frequency is at the resonant frequency. The transformer turns ratio is physically fixed in the circuit and, therefore, the transformation ratio is likewise fixed.

69. **Second**, that the power conversion performed by Huang's Figure 12(b) converter is performed at a substantially fixed voltage transformation ratio that can be represented as $K_{DC} = \frac{V_{OUT}}{V_{IN}}$ can also be demonstrated mathematically. The transformation ratio value K_{DC} for Huang's Figure 12(b) converter can be represented in terms of the transformer turns ratio. Because the turns in a transformer are fixed for a circuit, the transformation ratio is therefore necessarily fixed.

70. As discussed above, $V_{IN} = V_{in} - V_o$ and $V_{OUT} = V_o$ for the converter of Figure 12(b). Therefore, the voltage transformation ratio for the converter is $K_{DC} = \frac{V_{OUT}}{V_{IN}} = \frac{V_o}{V_{in}-V_o}$. Huang further notes that the transformer turns ratio of Figure 12(b) circuit, which for clarity will be referred to as K_t herein, is $\frac{(V_{in}/2)-V_o}{V_o}$. Ex. 1005, 1378. Using the voltage transformation ratio, $K_{DC} = \frac{V_{OUT}}{V_{IN}} = \frac{V_o}{V_{in}-V_o}$, and the transformer turns ratio, $K_t = \frac{(V_{in}/2)-V_o}{V_o}$, we can see that the voltage transformation ratio K_{DC} is equal to $\frac{1}{(2K_t+1)}$:

$$K_t = \frac{(V_{in}/2)-V_o}{V_o}$$

Multiply both sides by two:

$$2K_t = \frac{V_{in}-2V_o}{V_o}$$

Add one to both sides:

$$2K_t + 1 = \frac{V_{in}-2V_o+V_o}{V_o}$$

Simplify:

$$2K_t + 1 = \frac{V_{in}-V_o}{V_o}$$

Transpose:

$$\frac{1}{2K_t+1} = \frac{V_o}{V_{in}-V_o}$$

Substitute:

$$\frac{1}{2K_t+1} = K_{DC}$$

71. Thus, the converter shown in Figure 12(b) of Huang is adapted to convert power from the input circuit to the output circuit at the fixed voltage transformation ratio, $\frac{1}{2K_t+1} = K_{DC}$, where K_t is the transformer turns ratio $\frac{(V_{in}/2)-V_o}{V_o}$.

Because the transformer turns ratio is physically fixed for a circuit, and the transformation ratio is dependent upon the transformer turns ratio, the transformation ratio is therefore likewise fixed.

- d. Limitation 1(d): a power distribution bus connected to distribute power from the output circuit of the bus converter at the output voltage V_{OUT} ; and*

72. Huang explains that the area of application for the disclosed converters, including the Figure 12(b) converter, is as point-of-load and voltage regulator converters for use in processors. Ex. 1005, 1373. A POSITA would have known that Huang's Figure 12(b) converter output would be connected to a power distribution bus to distribute power from the output circuit, as the purpose of such converters is to provide power to downstream components, e.g., regulators that in turn provide power to loads.

- e. Limitation 1(e): a plurality of regulators, wherein each regulator comprises a regulator input connected to the power distribution bus to receive power from the output circuit of the bus converter and a regulator output connected to supply power to a respective load, the plurality of regulators each being separated by a distance from the bus converter;*

73. As I discuss in more detail above, the '950 Patent acknowledges that the use of an IBA, wherein a bus converter supplies power to one or more downstream regulators, was known at the time of invention. Ex. 1001, 1:13-35. As the

'950 Patent shows, the IBA configuration included a bus converter supplying power to one or more down-stream regulators (highlighted in yellow):

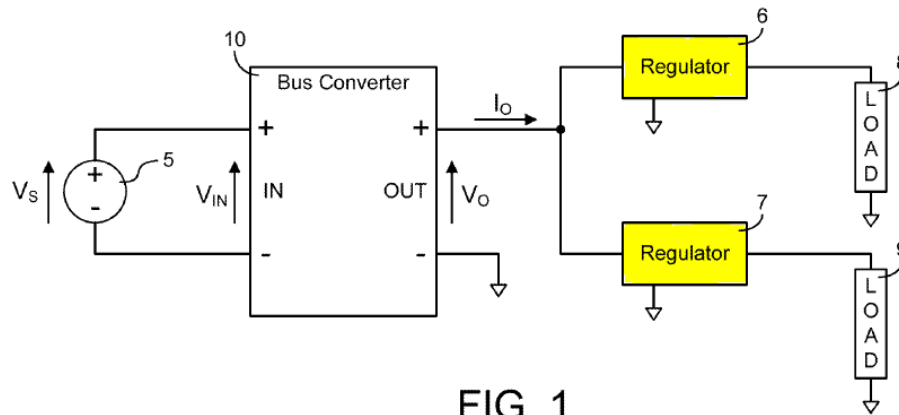


FIG. 1

Ex. 1005, Figure 1 (annotations added). In this configuration, the input of the regulators is attached to a power distribution bus to which the output of the bus converter is also attached, such that the regulators are receiving power from the output of the bus converter. *Id.*, 1:13-35, Figure 1. The regulators would then provide regulated power/voltage to their respective loads. *Id.* A POSITA would have further known that regulators would be separated by a distance from the bus converter. For example, as the '950 Patent explains:

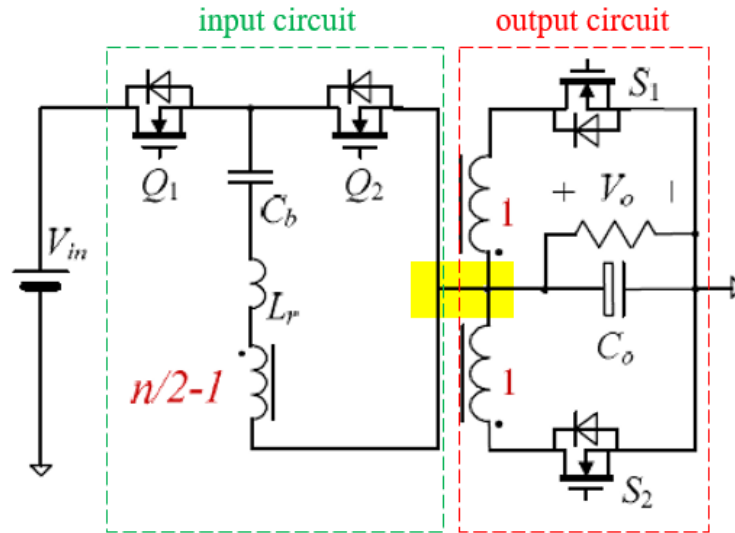
[I]n a typical system, one or more system circuit boards housed in a common enclosure may each include one or more bus converters, preferably located near the edge of, or other location on, the board where power connections are made to the board. A down-stream regulator receiving power from the bus converter(s) may be preferably located adjacent to the circuitry, e.g. a processor, ASIC, or other circuitry, to which it or they supply power. The physical distance separating the bus converter and a respective down-stream regulator in such an example may range from as much as a dimension of the system circuit board,

i.e. a diagonal dimension where the bus converter and regulator located at opposite corners, a length or width dimension where they are located at opposite edges, a half-length or width where one is situated closer to the middle and the other is at an edge, etc. In another example, a bus converter may be located off of the system board in which case the electrical distance could be greater than a dimension of the system board. Naturally, the distance separating the bus converter and a respective down-stream regulator will depend on the system layout. However, a bus converter housed in a self-contained assembly adapted to be installed as a unit at a location remote from the down-stream regulator(s) may be separated by a distance from a down-stream regulator regardless of their respective mounting locations at the system level.

Ex. 1005, 3:53-2:13.

f. Limitation 1(f): wherein the input circuit of the bus converter and at least a portion of the output circuit of the bus converter are galvanically connected in series across the source such that an absolute value of the input voltage V_{IN} applied to the input circuit is approximately equal to the absolute value of the DC source voltage V_S minus a number N times the absolute value of the output voltage V_{OUT} , where N is at least 1;

74. The input circuit and output circuit of Huang's Figure 12(b) converter are galvanically connected in series across the source. A series connection between the input circuit and the output circuit is shown in Figure 12(b), highlighted in yellow below.



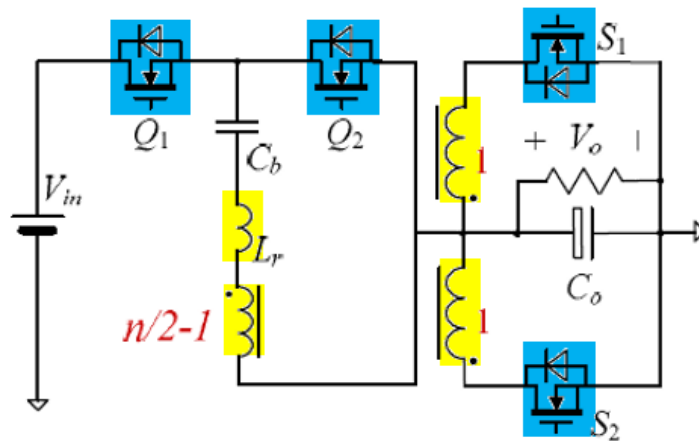
Ex. 1005, Figure 12(b) (annotations added).

75. Galvanic connection refers to whether there is direct electrical charge connection between functional sections of the system, *i.e.*, the input and output circuit. Specifically, galvanic contact requires that there not be electrical charge isolation between the contact points. Because the input circuit and output circuit are serially connected by an electrical conductor, *i.e.* non-isolated, they are galvanically connected. *Id.*

76. Further, as discussed above, the voltage V_{IN} applied to the input circuit is $V_{in} - V_o$, where V_{in} is the DC source voltage V_S . In other words, the voltage applied to the input circuit, V_{IN} , is equal to the DC source voltage, V_S , less the output voltage, V_{OUT} . Thus, the input voltage, V_{IN} , is equal to the DC source voltage, V_S , minus a number N times the output voltage, V_{OUT} , where N is exactly 1. *Id.*

- g. *Limitation 1(g): wherein the bus converter comprises an inductive component and one or more power switches in the input circuit, the output circuit, or both; and*

77. Huang discloses that both the input circuit and output circuit of the Figure 12(b) converter have inductive components, specifically the resonant inductor (L_r) and the transformer windings highlighted in yellow in the image below. Huang's input circuit and output circuit also both comprise power switches, Q_1 , Q_2 , S_1 , and S_2 , highlighted in blue below.



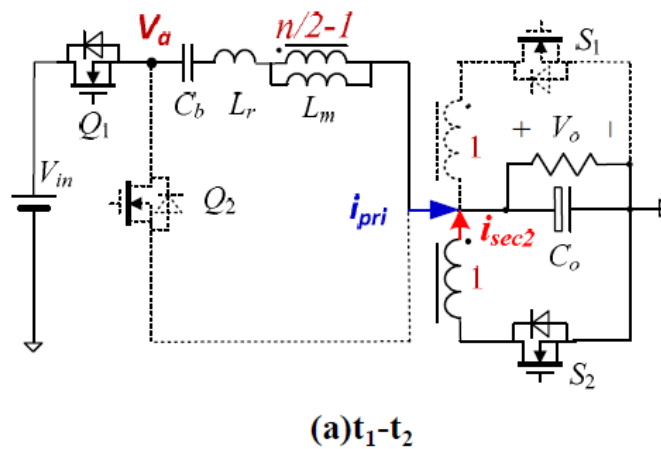
Ex. 1005, Figure 12(b) (annotations added).

- h. *Limitation 1(h): wherein a current flowing in the inductive component charges and discharges capacitances in the bus converter reducing a voltage across said one or more switches prior to turning ON said one or more switches.*

78. Zero-**current** switching (“ZCS”) is when switching occurs when the **current** is approximately zero; zero-**voltage** switching (“ZVS”) is when switching occurs when the **voltage** is approximately zero. As Huang explains, LLC resonant

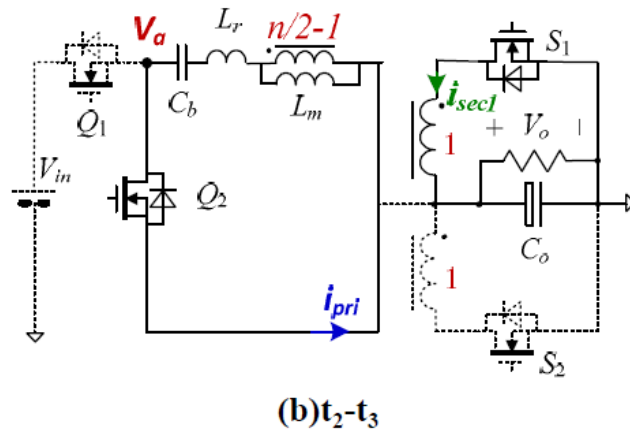
converters, including the one depicted in Figure 12(b), can achieve both zero-voltage switching and zero-current switching. Ex. 1005, 1373, 1379.

79. Figures 14(a) and 14(b) depict equivalent circuits for the operation of the converter of Figure 12(b) at two different time intervals. *Id.*, 1378. During t_1 to t_2 , the current is delivered from the source (V_{in}) to the resonant tank and the transformer (Q_1 is closed/on and Q_2 is open/off).



Ex. 1005, Figure 14(a), 1378.

80. During t_2 to t_3 , the remaining power stored in the resonant tank is transferred to the transformer with current flowing in the opposing direction as in time t_1 to t_2 (Q_1 is open/off and Q_2 is closed/on).



Ex. 1005, Figure 14(b), 1378.

81. Zero-voltage switching occurs between these two time periods as well as directly after t_2 to t_3 . During zero-voltage switching, current from the LLC tank (which includes the transformer primary winding) flows through the antiparallel diode of the switch (e.g., Q_2 between t_1 to t_2 and t_2 to t_3 , Q_1 after t_2 to t_3) which causes the voltage across the transistor to drop until it reaches a value close to zero (limited by the small voltage drop of the diode). Because this occurs when both gate signals are low, i.e., the switches are both off/open, by the time the circuit transitions from both switches being off to one being on, the voltage across the transistor is close to zero.

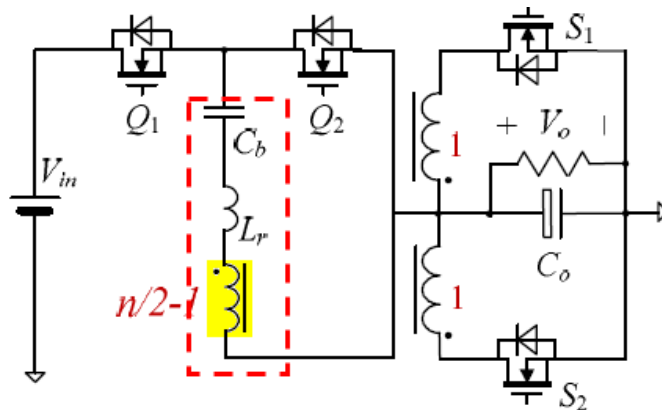
82. Thus, current flowing into the inductive components, specifically the transformer windings, of Huang's Figure 12(b) converter charges and discharges capacitances in the bus converter reducing a voltage across said one or more switches prior to turning ON said one or more switches.

2. Dependent Claim 5

- a. *Limitation 5(a): The apparatus of claim 1, wherein the bus converter comprises: a transformer, and a resonant circuit including the transformer having a characteristic resonant frequency and period, the input circuit including two or more primary switches connected to drive the resonant circuit and the output circuit being connected to receive power from the transformer; and*

83. For the reasons I discuss above, Huang renders obvious claim 1. Huang further renders obvious the additional limitations of Claim 5.

84. The transformer in Figure 12(b) is highlighted in yellow below, and the resonant circuit of which it is a part is outlined in red:

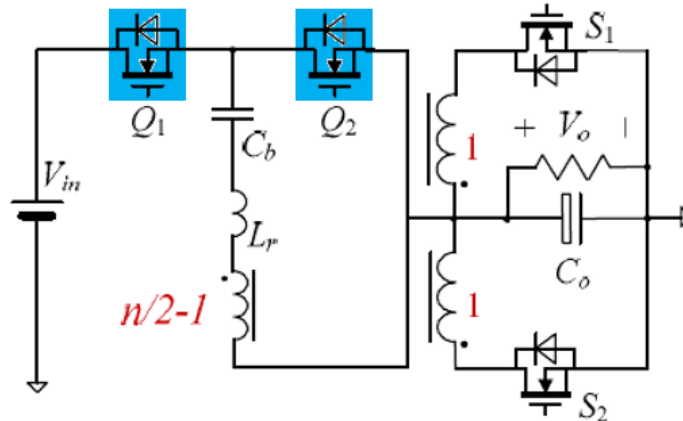


Ex. 1005, Figure 12(b) (annotations added).

85. Resonant converters, like the Figure 12(b) converter, are circuits made up of inductors and capacitors that oscillate at a specific frequency, called the resonant frequency, wherein the impedances of circuit elements cancel each other out causing the impedance of the circuit to be at a minimum and the current to be at a maximum. Thus, by virtue of disclosing that the converter depicted in Figure 12(b)

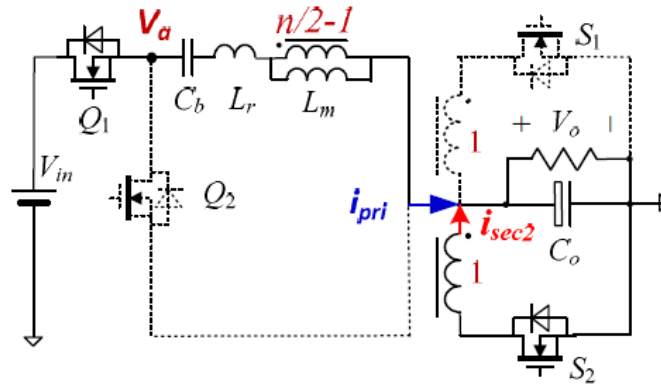
is an LLC resonant converter, Huang discloses that the resonant circuit has a characteristic resonant frequency and period. All circuits have a “period,” which is the time it takes for it to complete a “cycle.” For Huang’s Figure 12(b) converter, the period encompasses each of the states I explained above for claim limitation 1(h).

86. The input circuit of the Huang’s Figure 12(b) converter comprises two primary switches that are connected to drive the resonant circuit, highlighted blue in the image below.



Ex. 1005, Figure 12(b) (annotations added).

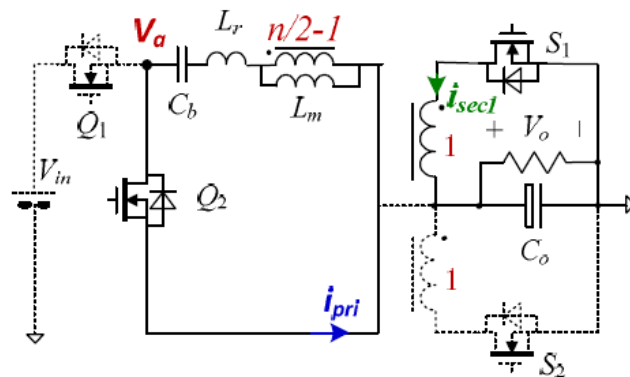
87. As I discussed above with respect to limitation 1(h), the switches drive the resonant circuit: When Q_1 is closed/on and Q_2 is open/off, current is delivered from the source to the resonant tank and the transformer, as shown in Figure 14(a):



(a) t_1-t_2

Ex. 1005, Figure 14(a), 1378.

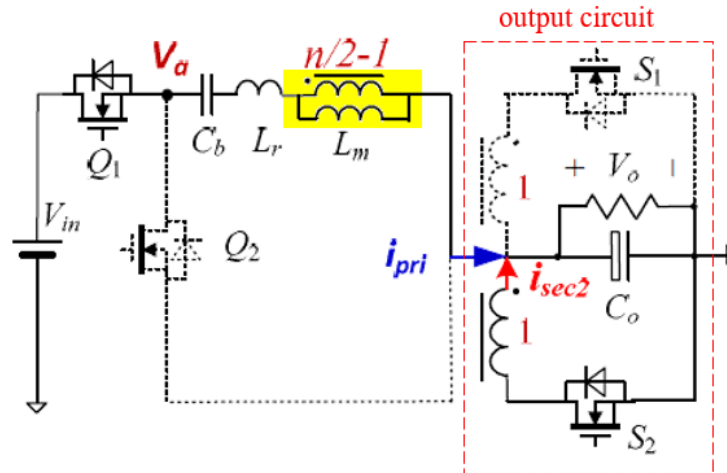
88. When Q_1 is open/off and Q_2 is closed/on, the remaining power stored in the resonant tank is transferred to the transformer with current flowing in the opposing direction as when Q_1 is closed/on and Q_2 is open/off, as shown in Figure 14(b).



(b) t_2-t_3

Ex. 1005, Figure 14(b), 1378.

89. As can also be seen in Figure 14(a), where the solid lines indicate active portions of the circuit, the output circuit (outlined in red dashed lines) receives power from the transformer (highlighted in yellow):



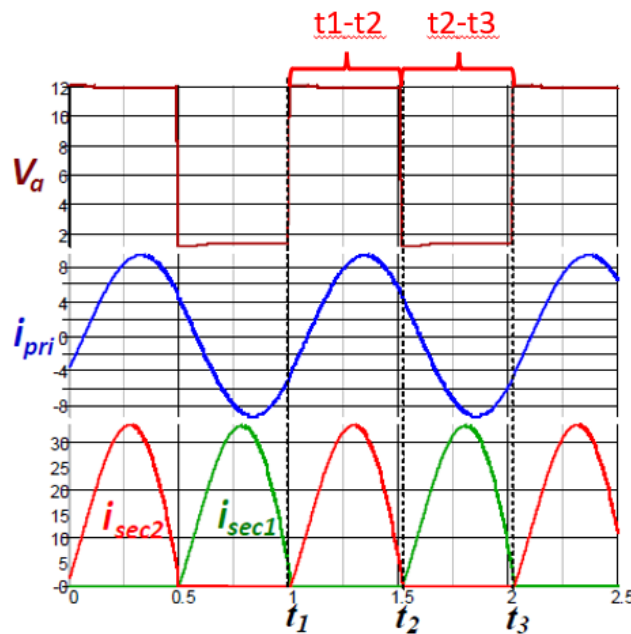
Ex. 1005, Figure 14(a), 1378.

- b. *Limitation 5(b): a switch controller adapted to operate the primary switches in a series of converter operating cycles, each converter operating cycle characterized by two power transfer intervals of essentially equal duration each interval having a duration less than the characteristics resonant period, during which one or more of the primary switches are ON and power is transferred from the input to the output via the transformer.*

90. As I explained above with respect to limitations 1(h) and 5(a), Huang's Figure 12(b) converter operates in converter operating cycles where (1) at time t_1 to t_2 Q_1 is closed/on and Q_2 is open/off and current is delivered from the source to the resonant tank and the transformer, (2) Q_1 and Q_2 are both open/off and current flows through the body diode of Q_2 causing the voltage across the transistor to drop until it reaches a value close to zero, (3) at time t_2 to t_3 Q_1 is open/off and Q_2 is closed/on and the remaining power stored in the resonant tank is transferred to the transformer with current flowing in the opposing direction as in time t_1 to t_2 , and (4) Q_1 and Q_2 are both open/off and current flows through the body diode of Q_1 causing the voltage

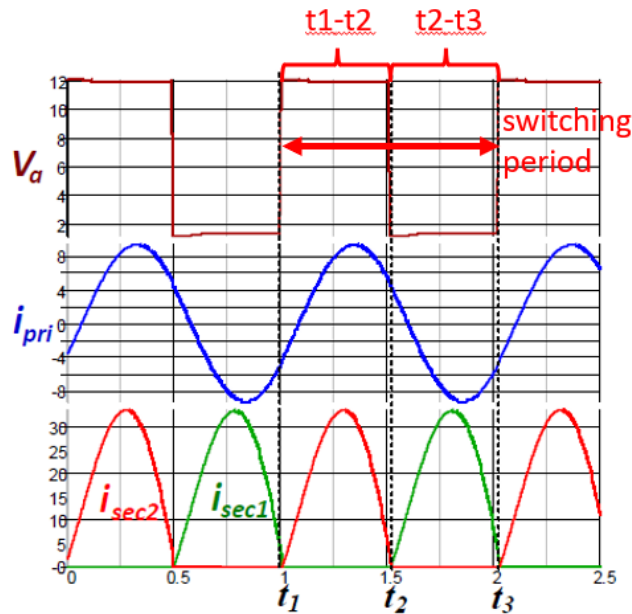
across the transistor to drop until it reaches a value close to zero . Ex. 1005, Figures 14(a), 14(b), 1378. Steps (1) and (3) above are power transfer intervals because current/power is being transferred between components of the circuit. A POSITA would have known that the opening and closing of Q_1 and Q_2 was operated by a switch controller.

91. Huang also discloses that these power transfer intervals are of essentially equal duration, each less than the characteristic resonant period. The durations of the step (1) (corresponding to t_1 to t_2) and step (3) (corresponding to t_2 to t_3) intervals are shown in Figure 14(c), demonstrating that they are essentially the same length (half of a time unit):



Ex. 1005, Figures 14(c) (annotations added), 1378.

92. The interval across which all the above steps are performed is the switching period. For Huang's Figure 12(b) converter, the period is t_1 to t_3 (steps 2 and 4 are essentially instantaneous).

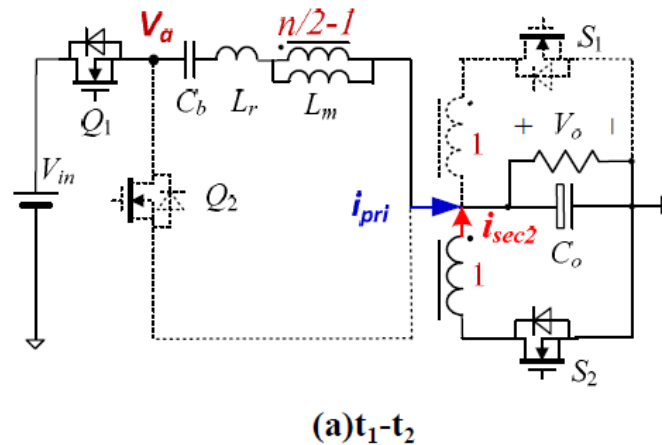


Ex. 1005, Figure 14(c) (annotations added), 1378.

93. In describing the operation of Figure 12(b) converter, Huang discloses that the switching frequency for the converter is at or above the resonant frequency. Ex. 1005, 1378. It is a known property of circuits that the switching frequency is the inverse of the switching period, and similarly the resonant frequency is the inverse of the resonant period. Huang's disclosure that the switching frequency of the Figure 12(b) converter may be at or above the resonant frequency means that the switching period of Huang is equal to or less than the resonant period. Because each power transfer interval is shown by Huang to be about half of the switching period (which

is equal to or less than the resonant period) each power transfer interval is also less than the resonant period.

94. During the converter operating cycle, when switch Q_1 is closed/on, power is transferred from the input to the output via the transformer, as can be seen in Figure 14(a):



Ex. 1005, Figure 14(a), 1378.

3. Dependent Claim 6

The apparatus of claim 1, wherein the bus converter is a self-contained assembly adapted to be installed as a unit.

95. As I discussed above, Huang renders obvious claim 1. And, as explained above in limitation 1(c), the '950 Patent acknowledges that IBA was known in the art at the time of invention. Ex. 1001, 1:13-35. IBA included a bus converter that included, for example, a DC-DC converter such as that disclosed by Huang. *Id.*; Ex. 1005, Figure 12(b). As previously explained, a POSITA would have known to use a DC-DC converter such as Huang's where the input to the converter

and output of the converter are both DC. Moreover, it was known that bus converters would comprise self-contained assemblies adapted to be installed as units into, for example, computing systems. *Id.*

4. **Dependent Claim 7**

The apparatus of claim 1, further comprising a circuit board, wherein the bus converter and at least one regulator are assembled to the circuit board, and the regulator is configured to supply power to an integrated circuit.

96. As explained above, Huang renders obvious claim 1. Moreover, it was known at the time of the alleged invention that bus converters and regulators could be assembled onto a circuit board with one another. And, as claimed in claim 1, it was known in the art at the time of the alleged invention that regulators would provide power to a load. When the regulator was mounted to the same circuit board as the bus converter, rather than the same circuit board as the load, the regulator would necessarily provide power to the integrated circuit as the load.

5. **Independent Claim 9**

- a. *Limitation 9(a): An apparatus comprising:*
- b. *Limitation 9(b): a power converter comprising an input circuit and an output circuit, wherein the power converter is configured to receive power from a power distribution system comprising a source for providing power at a DC source voltage V_S , the power converter being adapted to convert power from the input circuit to the output circuit at a substantially fixed voltage transformation ratio, K_{DC} , at an output current, wherein an input voltage V_{IN} is applied to the input circuit and an output voltage V_{OUT} is*

produced by the output of the power converter, and wherein the substantially fixed voltage transformation ratio can be represented as $K_{DC}=V_{OUT}/V_{IN}$, wherein the power converter further comprises:

97. Huang renders obvious this claim limitation for the same reasons I discuss above for claim limitations 1(b) and 1(c).

- c. Limitation 9(c): a series connection between the input circuit of the power converter and at least a portion of the output circuit of the power converter across the source, such that an absolute value of the input voltage V_{IN} applied to the input circuit is approximately equal to the absolute value of the DC source voltage V_S minus a number N times the absolute value of the output voltage V_{OUT} , where N is at least 1;*

98. Huang renders obvious this claim limitation for the same reasons I discuss above for claim limitation 1(f).

- d. Limitation 9(d): wherein the power converter comprises an inductive component and one or more power switches in the input circuit, the output circuit, or both; and*

99. Huang renders obvious this claim limitation for the same reasons I discuss above for claim limitation 1(g).

- e. Limitation 9(e): wherein a current flowing in the inductive component charges and discharges capacitances in the power converter reducing a voltage across said one or more switches prior to turning ON said one or more switches.*

100. Huang renders obvious this claim limitation for the same reasons I discuss above for claim limitation 1(h).

6. Dependent Claim 13

- a. Limitation 13(a): The apparatus of claim 9, wherein the power converter comprises: a transformer, and a resonant circuit including the transformer having a characteristic resonant frequency and period, the input circuit including two or more primary switches connected to drive the resonant circuit and the output circuit being connected to receive power from the transformer; and*

101. As I explained above, Huang renders obvious claim 9. Huang renders obvious the additional limitations of this claim for the same reasons I discussed above for claim limitation 5(a).

- b. Limitation 13(b): a switch controller adapted to operate the primary switches in a series of converter operating cycles, each converter operating cycle characterized by two power transfer intervals of essentially equal duration each interval having a duration less than the characteristics resonant period, during which one or more of the primary switches are ON and power is transferred from the input to the output via the transformer*

102. Huang renders obvious this claim limitation for the same reasons I discussed above for claim limitation 5(b).

7. Dependent Claim 14

The apparatus of claim 9, wherein the power converter is part of a bus converter that is a self-contained assembly adapted to be installed as a unit.

103. As explained above, Huang renders obvious claim 9. Further, as I discussed above in detail regarding claim limitation 1(c), the '950 Patent acknowledges that IBA was known in the art at the time of invention. Ex. 1001,

1:13-35 (describing IBA configuration as prior art). IBA included a bus converter that included, for example, a DC transformer to provide voltage transformation, *e.g.*, a DC-DC converter such as that disclosed by Huang. *Id.*; Ex. 1005, Figure 12(b). A POSITA would have known that a DC-DC converter like Huang's Figure 12(b) converter may be used alone or as part of a bus converter. A POSITA would have further known that bus converters were commonly provided in self-contained assemblies to be installed into, for examples, computing systems as a unit.

8. Dependent Claim 15

The apparatus of claim 9, further comprising a circuit board, and wherein the power converter is configured to supply power to a plurality of regulators over a power distribution bus, the regulators disposed at a distance to the power converter, and wherein at least one of the regulators is assembled to the circuit board and configured to supply power to an integrated circuit.

104. For the reasons discussed above, Huang renders obvious claim 9. Huang also renders obvious this claim for the same reasons discussed above for claim limitations 1(d), 1(e), and 7.

9. Independent Claim 16

- a. Limitation 16(a): An apparatus comprising:*
- b. Limitation 16(b): a bus converter comprising an input circuit and an output circuit, wherein the bus converter is configured to receive power from a power distribution system comprising a source for providing power at a DC source voltage V_S , the bus converter being adapted to convert power from the input circuit to the output circuit at a substantially fixed voltage transformation ratio, K_{DC} ,*

at an output current, wherein an input voltage V_{IN} is applied to the input circuit and an output voltage V_{OUT} is produced by the output of the bus converter, and wherein the substantially fixed voltage transformation ratio can be represented as $K_{DC}=V_{OUT}/V_{IN}$;

105. Huang renders obvious this claim limitation for the same reasons I discussed above for claim limitations 1(b) and 1(c).

c. Limitation 16(c): a power distribution bus connected to distribute power from the output circuit of the bus converter at the output voltage V_{OUT} ; and

106. Huang renders obvious this claim limitation for the same reasons I discussed above for claim limitation 1(d).

d. Limitation 16(d): a plurality of regulators, wherein each regulator comprises a regulator input connected to the power distribution bus to receive power from the output circuit of the bus converter and a regulator output connected to supply power to a respective load, the plurality of regulators each being separated by a distance from the bus converter;

107. Huang renders obvious this claim limitation for the same reasons I discussed above for claim limitation 1(e).

e. Limitation 16(e): wherein the input circuit of the bus converter and at least a portion of the output circuit of the bus converter are connected in series across the source such that an absolute value of the input voltage V_{IN} applied to the input circuit is approximately equal to the absolute value of the DC source voltage V_S minus a number N times

the absolute value of the output voltage V_{OUT} , where N is at least 1;

108. Huang renders obvious this claim limitation for the same reasons I discussed above for claim limitation 1(f).

f. Limitation 16(f): wherein the bus converter comprises an inductive component and one or more power switches in the input circuit, the output circuit, or both; and

109. Huang renders obvious this claim limitation for the same reasons I discussed above for claim limitation 1(g).

g. Limitation 16(g): wherein a current flowing in the inductive component charges and discharges capacitances in the bus converter reducing a voltage across said one or more switches prior to turning ON said one or more switches.

110. Huang renders obvious this claim limitation for the same reasons I discussed above for claim limitation 1(h).

10. Dependent Claim 19

The apparatus of claim 16, wherein the bus converter is a self-contained assembly adapted to be installed as a unit.

111. Huang renders obvious claim 16 for the reasons stated above. Huang also renders obvious this claim limitation for the same reasons discussed above for claim 6.

11. Dependent Claim 21

a. Limitation 21(a): The apparatus of claim 16, wherein the bus converter comprises: a transformer, and a resonant circuit including the transformer having a characteristic

resonant frequency and period, the input circuit including two or more primary switches connected to drive the resonant circuit and the output circuit being connected to receive power from the transformer; and

112. Huang renders obvious claim 16 for the reasons discussed above.

Huang also renders obvious this claim limitation for the same reasons I discussed above for claim limitation 5(a).

b. Limitation 21(b): a switch controller adapted to operate the primary switches in a series of converter operating cycles, each converter operating cycle characterized by two power transfer intervals of essentially equal duration each interval having a duration less than the characteristics resonant period, during which one or more of the primary switches are ON and power is transferred from the input to the output via the transformer.

113. Huang renders obvious this claim limitation for the same reasons I discuss above for claim limitation 5(b).

12. Independent Claim 22

a. Limitation 22(a): An apparatus comprising:

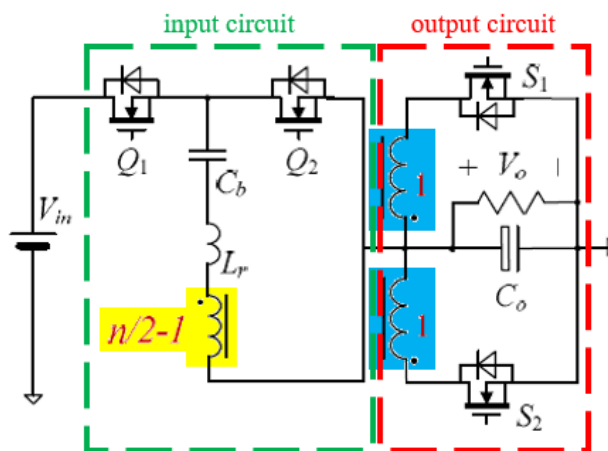
b. Limitation 22(b): an intermediate bus architecture power distribution system for an electrical system comprising a source for providing power at a DC source voltage;

114. Huang renders obvious this claim limitation for the same reasons I discussed above for claim limitation 1(b). Further, as the '950 Patent acknowledges, IBA was known in the art at the time of invention. Ex. 1001, 1:13-35 (describing IBA configuration as prior art).

- c. *Limitation 22(c): a circuit board comprising a bus converter, the bus converter comprising an input circuit, the input circuit comprising a primary transformer winding, the bus converter further comprising an output circuit, the output circuit comprising a secondary transformer winding, wherein the primary and secondary transformer windings are galvanically connected in series, and wherein the bus converter is configured to provide power to a power distribution bus that is not galvanically isolated from the source; and*

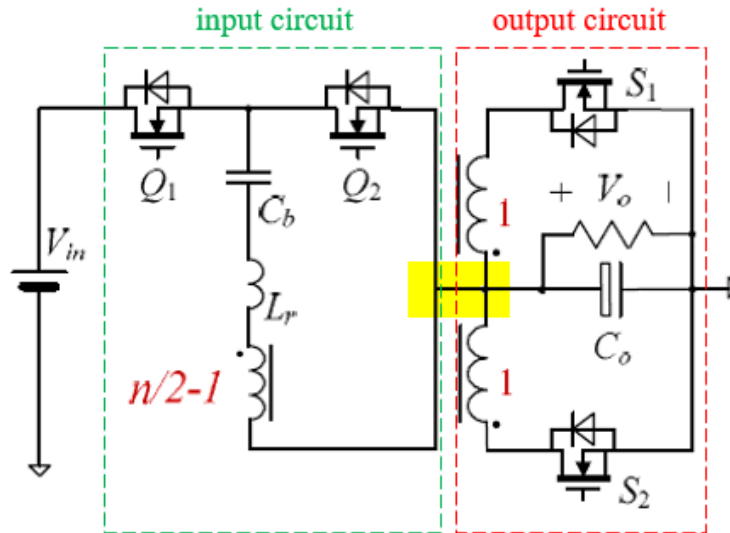
115. As I discussed above regarding limitation 1(c), a POSITA would have known that Huang's Figure 12(b) converter could be used as part of a bus converter and would have been motivated to do so due to the efficiencies gained by Huang's converter.

116. Huang's input and output circuits are outlined in green and red, respectively, below. Huang's primary transformer winding within the input circuit is highlighted in yellow while the secondary windings within the output circuit are highlighted in blue.



Ex. 1005, Figure 12(b) (annotations added).

117. Further, the input and output circuits are galvanically connected in series, as can be seen by the direct connection between them (yellow):



Ex. 1005, Figure 12(b) (annotations added).

118. Huang's Figure 12(b) converter is therefore also configured to provide power to a power distribution bus that is not galvanically isolated from the source because it does not provide galvanic isolation between the source (V_{in}) and the power provided to the power distribution bus (V_o).

- d. *Limitation 22(d): the circuit board further comprising a plurality of regulators, wherein each regulator comprises a regulator input connected to the power distribution bus to receive power from the output circuit of the bus converter and a regulator output connected to supply power to a respective load, the plurality of regulators each being separated by a distance from the bus converter.*

119. Huang renders obvious this claim limitation for the same reasons I discussed above for claim limitation 1(e).

13. **Dependent Claim 23**

- a. *Limitation 23(a): The apparatus of claim 22, wherein the bus converter is adapted to convert power from the input circuit to the output circuit at a substantially fixed voltage transformation ratio, K_{DC} , at an output current, wherein an input voltage V_{IN} is applied to the input circuit and an output voltage V_{OUT} is produced by the output of the bus converter, and wherein the substantially fixed voltage transformation ratio can be represented as $K_{DC}=V_{OUT}/V_{IN}$; and*

120. For the reasons I discussed above, Huang renders obvious claim 22.

Huang also renders obvious this claim limitation for the same reasons discussed above for claim limitation 1(c).

- b. *Limitation 23(b): wherein the input circuit of the bus converter and at least a portion of the output circuit of the bus converter are connected such that an absolute value of the input voltage V_{IN} applied to the input circuit is approximately equal to the absolute value of the DC source voltage V_S minus a number N times the absolute value of the output voltage V_{OUT} , where N is at least 1.*

121. Huang renders obvious this claim limitation for the same reasons I discussed above for claim limitation 1(f).

14. **Dependent Claim 24**

The apparatus of claim 22, wherein the bus converter is a self-contained assembly adapted to be installed as a unit.

122. For the reasons I discussed above, Huang renders obvious claim 22.

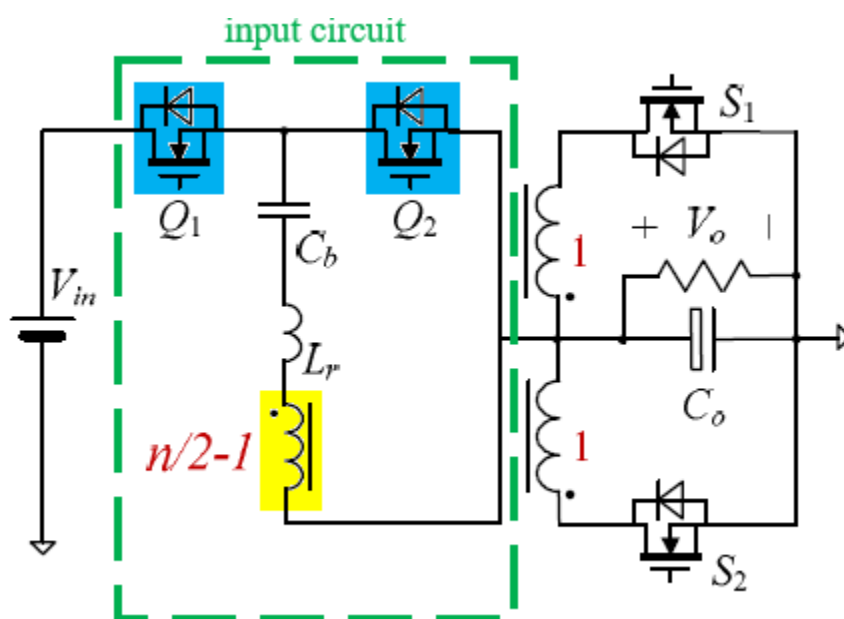
Huang also renders obvious this claim limitation for the same reasons I discussed above for claim 6.

15. Dependent Claim 25

The apparatus of claim 1 wherein the input circuit comprises a primary winding and switches connected to the primary winding, the output circuit comprises a secondary winding and secondary switches connected to the secondary winding, and a controller for operating the switches in a series of converter operating cycles, wherein the primary and secondary windings are connected in series during at least a portion of each converter operating cycle.

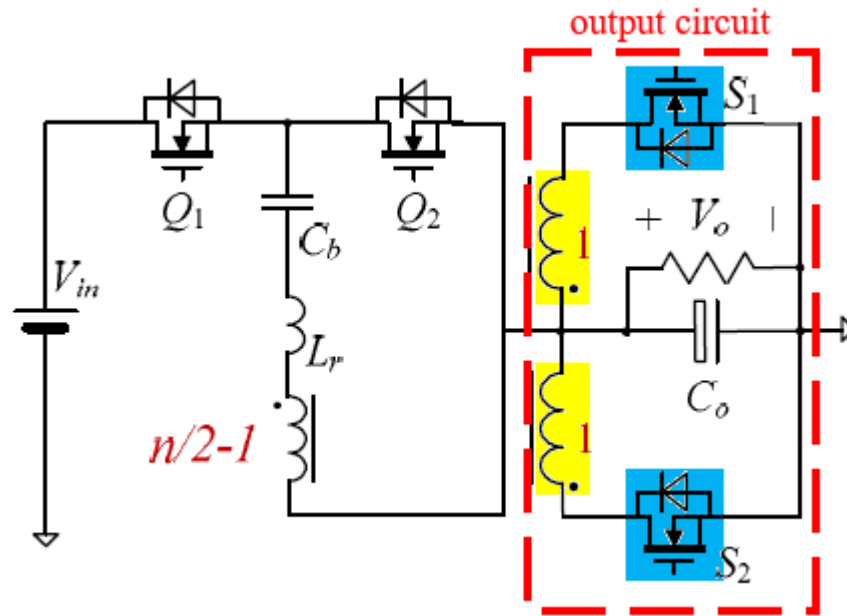
123. For the reasons I discussed above, Huang renders obvious claim 1.

Below, the input circuit of Huang's Figure 12(b) converter is outlined in green, with the primary winding highlighted in yellow and the primary switches connected to the primary winding highlighted in blue:



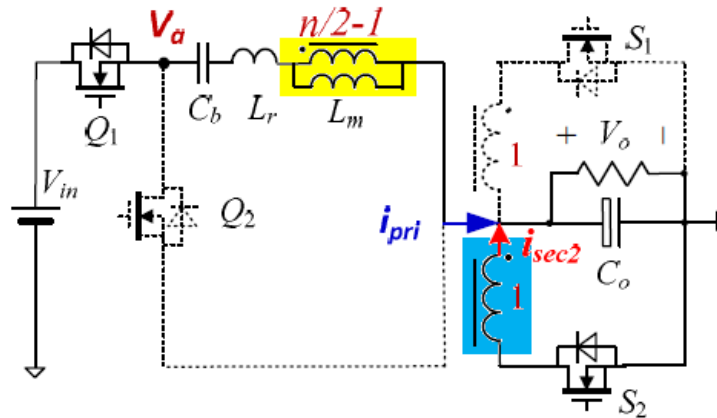
Ex. 1005, Figure 12(b) (annotations added).

124. The output circuit of Huang's Figure 12(b) converter is outlined in red below, with the secondary winding highlighted in yellow and the secondary switches connected to the secondary winding highlighted in blue:



Ex. 1005, Figure 12(b) (annotations added).

125. As I explained in more detail above for claim limitation 5(b), a switch controller operates the primary and secondary switches in a series of operating cycles, each comprising two power transfer intervals. During the converter operating cycle, when switch Q_1 is closed/on, the primary winding (yellow) is connected in series to the secondary winding (blue), as can be seen in Figure 14(a):



Ex. 1005, Figure 14(a) (annotations added).

16. Dependent Claim 26

The apparatus of claim 9 wherein the input circuit comprises a primary winding and switches connected to the primary winding, the output circuit comprises a secondary winding and secondary switches connected to the secondary winding, and a controller for operating the switches in a series of converter operating cycles, wherein the primary and secondary windings are connected in series during at least a portion of each converter operating cycle.

126. For the reasons I explained above, Huang renders obvious claim 9.

Huang also renders obvious this claim limitation for the same reasons I discussed above for claim 25.

17. Dependent Claim 27

The apparatus of claim 16 wherein the input circuit comprises a primary winding and switches connected to the primary winding, the output circuit comprises a secondary winding and secondary switches connected to the secondary winding, and a controller for operating the switches in a series of converter operating cycles, wherein the primary and secondary windings are connected in

series during at least a portion of each converter operating cycle.

127. For the reasons I explained above, Huang renders obvious claim 16. Huang also renders obvious this claim limitation for the same reasons discussed I above for claim 25.

18. Dependent Claim 28

The apparatus of claim 1 wherein the voltage across said one or more power switches is reduced to essentially zero volts prior to turning ON said one or more switches.

128. For the reasons I explained above, Huang renders obvious claim 1. Huang also renders obvious this claim limitation for the same reasons discussed I above for claim limitation 1(h).

19. Independent Claim 29

- a. Limitation 29(a): An apparatus comprising:*
- b. Limitation 29(b): a power distribution system comprising a source for providing power at a DC source voltage V_S ;*

129. Huang renders obvious this claim limitation for the same reasons I discussed above for claim limitation 1(b).

- c. Limitation 29(c): a bus converter comprising an input circuit and an output circuit, the bus converter being adapted to convert power from the input circuit to the output circuit at a substantially fixed voltage transformation ratio, K_{DC} , at an output current, wherein an input voltage V_{IN} is applied to the input circuit and an output voltage V_{OUT} is produced by the output of the bus*

converter, and wherein the substantially fixed voltage transformation ratio can be represented as $K_{DC}=V_{OUT}/V_{IN}$;

130. Huang renders obvious this claim limitation for the same reasons I discussed above for claim limitation 1(c).

d. Limitation 29(d): a power distribution bus connected to distribute power from the output circuit of the bus converter at the output voltage V_{OUT} ; and

131. Huang renders obvious this claim limitation for the same reasons I discussed above for claim limitation 1(d).

e. Limitation 29(e): a plurality of regulators, wherein each regulator comprises a regulator input connected to the power distribution bus to receive power from the output circuit of the bus converter and a regulator output connected to supply power to a respective load, the plurality of regulators each being separated by a distance from the bus converter;

132. Huang renders obvious this claim limitation for the same reasons I discussed above for claim limitation 1(e).

f. Limitation 29(f): wherein the input circuit of the bus converter and the output circuit of the bus converter are galvanically connected; and

133. Huang renders obvious this claim limitation for the same reasons I discussed above for claim limitation 1(f).

- g. Limitation 29(g): wherein the bus converter comprises an inductive component and one or more switches in the input circuit or output circuit or both; and*

134. Huang renders obvious this claim limitation for the same reasons I discussed above for claim limitation 1(g).

- h. Limitation 29(h): where in a current flowing in the inductive component charges and discharges capacitances in the converter reducing a voltage across said one or more switches prior to turning ON said one or more switches.*

135. Huang renders obvious this claim limitation for the same reasons I discussed above for claim limitation 1(h).

20. Dependent Claim 30

The apparatus of claim 29 wherein the voltage across one or more switches is reduced to essentially zero volts prior to turning ON said one or more switches.

136. For the reasons I explained above, Huang renders obvious claim 29. Huang also renders obvious this claim for the same reasons I discussed above for claim limitation 1(h).

21. Independent Claim 31

- a. Limitation 31(a): An apparatus comprising:*
- b. Limitation 31(b): a power distribution system comprising a source for providing power at a DC source voltage V_S ;*

137. Huang renders obvious this claim for the same reasons I discussed above for claim limitation 1(b).

- c. *Limitation 31(c): a bus converter comprising an input circuit and an output circuit, the bus converter being adapted to convert power from the input circuit to the output circuit at a substantially fixed voltage transformation ratio, K_{DC} , at an output current, wherein an input voltage V_{IN} is applied to the input circuit and an output voltage V_{OUT} is produced by the output of the bus converter, and wherein the substantially fixed voltage transformation ratio can be represented as $K_{DC}=V_{OUT}/V_{IN}$;*

138. Huang renders obvious this claim for the same reasons I discussed above for claim limitation 1(c).

- d. *Limitation 31(d): a power distribution bus connected to distribute power from the output circuit of the bus converter at the output voltage V_{OUT} ; and*

139. Huang renders obvious this claim for the same reasons I discussed above for claim limitation 1(d).

- e. *Limitation 31(e): a plurality of regulators, wherein each regulator comprises a regulator input connected to the power distribution bus to receive power from the output circuit of the bus converter and a regulator output connected to supply power to a respective load, the plurality of regulators each being separated by a distance from the bus converter;*

140. Huang renders obvious this claim for the same reasons I discussed above for claim limitation 1(e).

- f. *Limitation 31(f): wherein the input circuit comprises a winding having a first number of turns, wherein the output circuit comprises a winding having a second number of turns, and wherein the voltage transformation ratio is a*

function of a ratio of the first number of turns to the second number of turns; and

141. Huang renders obvious this claim for the same reasons I discussed above for claim limitation 1(c).

- g. Limitation 31(g): wherein the input circuit of the bus converter and at least a portion of the output circuit of the bus converter are connected in series across the source such that an absolute value of the input voltage V_{IN} applied to the input circuit is approximately equal to the absolute value of the DC source voltage V_S minus a number N times the absolute value of the output voltage V_{OUT} , where N is at least 1.*

142. Huang renders obvious this claim for the same reasons I discussed above for claim limitation 1(f).

22. Independent Claim 32

- a. Limitation 32(a): An apparatus comprising:*
- b. Limitation 32(b): a power distribution system comprising a source for providing power at a DC source voltage V_S ;*

143. Huang renders obvious this claim for the same reasons I discussed above for claim limitation 1(b).

- c. Limitation 32(c): a bus converter comprising an input circuit and an output circuit, the bus converter being adapted to convert power from the input circuit to the output circuit at a substantially fixed voltage transformation ratio, K_{DC} , at an output current, wherein an input voltage V_{IN} is applied to the input circuit and an output voltage V_{OUT} is produced by the output of the bus*

converter, and wherein the substantially fixed voltage transformation ratio can be represented as $K_{DC}=V_{OUT}/V_{IN}$;

144. Huang renders obvious this claim for the same reasons I discussed above for claim limitation 1(c).

d. Limitation 32(d): a power distribution bus connected to distribute power from the output circuit of the bus converter at the output voltage V_{OUT} ; and

145. Huang renders obvious this claim for the same reasons I discussed above for claim limitation 1(d).

e. Limitation 32(e): a plurality of regulators, wherein each regulator comprises a regulator input connected to the power distribution bus to receive power from the output circuit of the bus converter and a regulator output connected to supply power to a respective load, the plurality of regulators each being separated by a distance from the bus converter;

146. Huang renders obvious this claim for the same reasons I discussed above for claim limitation 1(e).

f. Limitation 32(f): wherein the input circuit comprises a winding having a first number of turns, wherein the output circuit comprises a winding having a second number of turns, and wherein the voltage transformation ratio is a function of a ratio of the first number of turns to the second number of turns; and

147. Huang renders obvious this claim for the same reasons I discussed above for claim limitation 1(c).

- g. *Limitation 32(g): wherein the input circuit of the bus converter and the output circuit of the bus converter are galvanically connected.*

148. Huang renders obvious this claim for the same reasons I discussed above for claim limitation 1(f).

23. Independent Claim 33

- a. *Limitation 33(a): An apparatus comprising:*
- b. *Limitation 33(b): a bus converter comprising an input circuit and an output circuit, the bus converter being adapted to convert power from the input circuit to the output circuit at a substantially fixed voltage transformation ratio, K_{DC} , at an output current, wherein an input voltage V_{IN} is applied to the input circuit and an output voltage V_{OUT} is produced by the output of the bus converter, and wherein the substantially fixed voltage transformation ratio can be represented as $K_{DC}=V_{OUT}/V_{IN}$;*

149. Huang renders obvious this claim limitation for the same reasons I discussed above with respect to claim limitation 1(c).

- c. *Limitation 33(c): wherein the input circuit of the bus converter and the output circuit of the bus converter are galvanically connected; and*

150. Huang renders obvious this claim limitation for the same reasons I discussed above with respect to claim limitation 1(f).

- d. *Limitation 33(d): wherein the bus converter comprises an inductive component and one or more power switches in the input circuit or output circuit or both; and*

151. Huang renders obvious this claim limitation for the same reasons I discussed above with respect to claim limitation 1(g).

- e. *Limitation 33(e): wherein a current flowing in the inductive component charges and discharges capacitances in the converter reducing a voltage across said one or more switches prior to turn ON said one or more switches.*

152. Huang renders obvious this claim limitation for the same reasons I discussed above with respect to claim limitation 1(h).

24. Dependent Claim 34

- a. *Limitation 34(a): The apparatus of claim 33, wherein the bus converter comprises: a transformer, and a resonant circuit including the transformer having a characteristic resonant frequency and period, the input circuit including two or more primary switches connected to drive the resonant circuit and the output circuit being connected to receive power from the transformer; and*

153. For the reasons I discussed above, Huang renders obvious claim 33. Huang also renders obvious this claim limitation for the same reasons I discussed above with respect to claim limitation 5 (a).

- b. *Limitation 34(b): a switch controller adapted to operate the primary switches in a series of converter operating cycles, each converter operating cycle characterized by two power transfer intervals of essentially equal duration each interval having a duration less than the characteristics resonant period, during which one or more of the primary switches are ON and power is transferred from the input to the output via the transformer.*

154. Huang renders obvious this claim limitation for the same reasons I discussed above with respect to claim limitation 5(b).

25. Dependent Claim 35

The apparatus of claim 33 wherein the voltage across said one or more switches is reduced to essentially zero volts prior to turn ON of said one or more switches.

155. For the reasons I discussed above, Huang renders obvious claim 33.

Huang renders obvious this claim for the same reasons I discussed above for claim 28.

26. Dependent Claim 36

The apparatus of claim 33 wherein the input circuit of the bus converter and at least a portion of the output circuit of the bus converter are connected in series across the source such that an absolute value of the input voltage V_{IN} applied to the input circuit is approximately equal to the absolute value of the DC source voltage V_S minus a number N times the absolute value of the output voltage V_{OUT} , where N is at least 1.

156. For the reasons I discussed above, Huang render obvious claim 33.

Huang also renders obvious this claim for the same reasons discussed above with respect to claim limitation 1(f).

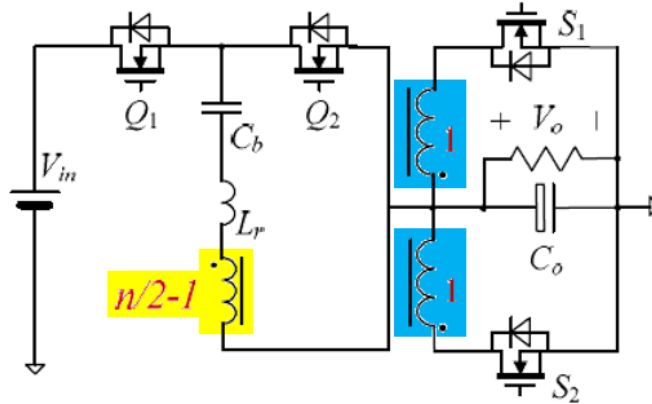
27. Dependent Claim 37

The apparatus of claim 33, wherein the input circuit comprises a first winding having a first number of turns, wherein the output circuit comprises a second winding having a second number of turns, and wherein the voltage transformation ratio is a function of a ratio of the first number of turns to the second number of turns.

157. For the reasons I discussed above, Huang renders obvious claim 33.

The input circuit of Huang's Figure 12(b) converter, as indicated in the circuit

diagram, comprises a first transformer winding having a first number of turns, $\frac{n}{2} - 1$ (yellow), and two second windings each having one turn (blue).



Ex. 1005, Figure 12(b) (annotations added).

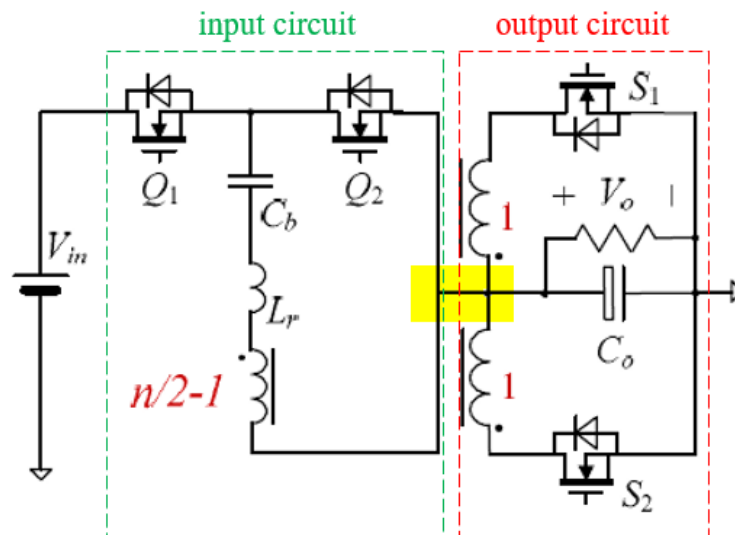
158. As I explained above for claim limitation 1(c), the voltage transformation ratio of Huang's Figure 12(b) converter is a function of the transformer turns ratio of that converter, which is the ratio of the number of turns of the second winding to the number of turns of the first winding.

28. Dependent Claim 38

The apparatus of claim 37, wherein at least a portion of the input circuit of the bus converter is connected in series with at least a portion of the output circuit of the bus converter such that an absolute value of a voltage applied to the first winding is approximately equal to the absolute value of the input voltage, V_{IN} , minus a number N times the

absolute value of the output voltage V_{OUT} , where N is at least 1.

159. For the reasons I discussed above, Huang renders obvious claim 37. A series connection between the input circuit and the output circuit is shown in Figure 12(b), highlighted in yellow below.



Ex. 1005, Figure 12(b) (annotations added).

160. Galvanic connection refers to whether there is direct electrical connection between functional sections of the system, *i.e.*, the input and output circuit. Specifically, galvanic contact requires that there not be isolation between the components. Because the input circuit and output circuit are serially connected and non-isolated, they are galvanically connected. *Id.*

161. As discussed above in claim limitation 1(c), using the voltage transformation ratio ($K_{DC} = \frac{V_{OUT}}{V_{IN}} = \frac{V_o}{V_{in}-V_o}$) and the transformer turns ratio provided by Huang ($K_t = \frac{(V_{in}/2)-V_o}{V_o}$), one can derive that $K_{DC} = \frac{1}{2K_t+1}$.

162. It is a known property in the field that the voltage at the transformer primary winding is equal to the transformer turns ratio multiplied by the voltage occurring at the transformer secondary winding. Here, we know the voltage at the transformer secondary winding is V_{OUT} . *Id.* Thus, the voltage across the transformer primary winding, V_{PRI} is equal to $K_t * V_{OUT}$. *Id.*

163. Using the fact that $K_{DC} = \frac{1}{2K_t+1}$ and $K_{DC} = \frac{V_{OUT}}{V_{IN}}$, one knows that $\frac{V_{OUT}}{V_{IN}} = \frac{1}{2K_t+1}$. Using this relation, we can show that $V_{PRI} = K_t * V_{OUT} = V_{IN} - (K_t + 1) * V_{OUT}$:

$$\frac{V_{OUT}}{V_{IN}} = \frac{1}{2K_t+1}.$$

Cross multiply:

$$V_{IN} = (2K_t + 1) * V_{OUT}$$

Multiply out right side:

$$V_{IN} = 2K_t V_{OUT} + V_{OUT}$$

Subtract $K_t V_{OUT}$ from both sides:

$$V_{IN} - K_t V_{OUT} = K_t V_{OUT} + V_{OUT}$$

Subtract V_{OUT} from both sides:

$$V_{IN} - K_t V_{OUT} - V_{OUT} = K_t V_{OUT}$$

Simplify by factoring out V_{OUT}

$$V_{IN} - (K_t + 1) * V_{OUT} = K_t V_{OUT}$$

164. Thus, the voltage applied to the first winding, V_{PRI} or $K_t * V_{OUT}$, is approximately equal to the absolute value of the input voltage, V_{IN} , minus a number N times the absolute value of the output voltage, V_{OUT} , where N is $K_t + 1$. We also know that $K_t + 1$ is greater than 1 because the transformer turns ratio must be a positive number — there cannot be a negative number of windings — and any positive number plus one is greater than one.

29. Dependent Claim 39

The apparatus of claim 22 wherein the bus converter comprises an inductive component and one or more power switches in the input circuit, the output circuit, or both, and wherein a current flowing in the inductive component charges and discharges capacitances in the bus converter reducing a voltage across said one or more switches prior to turning ON said one or more switches.

165. For the reasons I discussed above, Huang renders obvious claim 22. Huang renders obvious this claim for the same reasons I discussed above for claim limitations 1(g) and 1(h).

30. Dependent Claim 40

The apparatus of claim 22 wherein at least one of the regulators is assembled to the circuit board and configured to supply power to an integrated circuit.

166. For the reasons I discussed above, Huang renders obvious claim 22. Huang renders obvious this claim for the same reasons I discussed above for claim 7.

B. Ground II: Claims 5, 13, 21, 25-27, and 34 Are Obvious Over Huang In View Of The '481 Patent

1. Motivation to Combine

167. A POSITA would have been motivated to combine Huang and the '481 Patent. Huang discloses a number of novel, non-isolated LLC DC-DC resonant converters that can achieve zero voltage switching, low turn off loss for switches, reduction in transformer turns, and reduction of current through transformer secondary windings. *See* Ex. 1005, 1373. The '481 Patent is directed to a method for “digital control of resonant zero-current and zero-voltage switching resonant power converters,” such as the resonant circuits disclosed in Huang. *See* Ex. 1007, 1:6-9.

168. Modifying the resonant converter disclosed in Huang to utilize the digital control circuitry disclosed in the '481 Patent would have been obvious to a POSITA. **First**, as the '481 Patent states, prior art power converters using resonant processes to efficiently transfer energy from an input source to a load (e.g., the converters disclosed in Huang) were known to include controllers to control “the turning ON and OFF of switches within the power conversion circuitry.” Ex. 1007, 1:13-25. It would have been obvious to a POSITA to try using the digital control circuitry described in the '481 Patent with the converters disclosed in Huang: there were a limited number of controller types compatible with resonant circuits, and a POSITA would have had a reasonable expectation of success in using the '481 Patent's circuitry with the converters disclosed in Huang. The '481 Patent even

confirms that the disclosed digital power conversion circuitry is “essentially the same” as what existed in the prior art. Ex. 1007, 4:29-35.

169. **Second**, a POSITA would have specifically been interested in enhancing efficiency considering Huang’s focus on improving existing converter design to reduce switching and transformer losses. *See, e.g.*, Ex. 1005, 1373. Both Huang and the ’481 Patent indicate that a motivation to implement their disclosed inventions is to improve the efficiency of existing circuit design. *See, e.g., id.*; Ex. 1007, 7:29-35. A POSITA would therefore have been motivated to improve the efficiency of the circuit design in other ways, such as including digital control circuitry to improve the energy efficiency of the converter.

170. **Third**, use of the digital control circuitry in the ’481 Patent with the resonant converters disclosed in Huang would have involved mere substitution of one known element (existing control circuitry) for another (the specific digital control circuitry disclosed in the ’481 Patent) to obtain predictable results (the efficient control of the resonant converter). A POSITA would have recognized using the circuitry disclosed in the ’481 Patent to be an easy modification or addition to make to Huang’s converters, and such modification or addition would only require using standard techniques known in the art.

2. Dependent Claim 5

- a. Limitation 5(a): The apparatus of claim 1, wherein the bus converter comprises: a transformer, and a resonant*

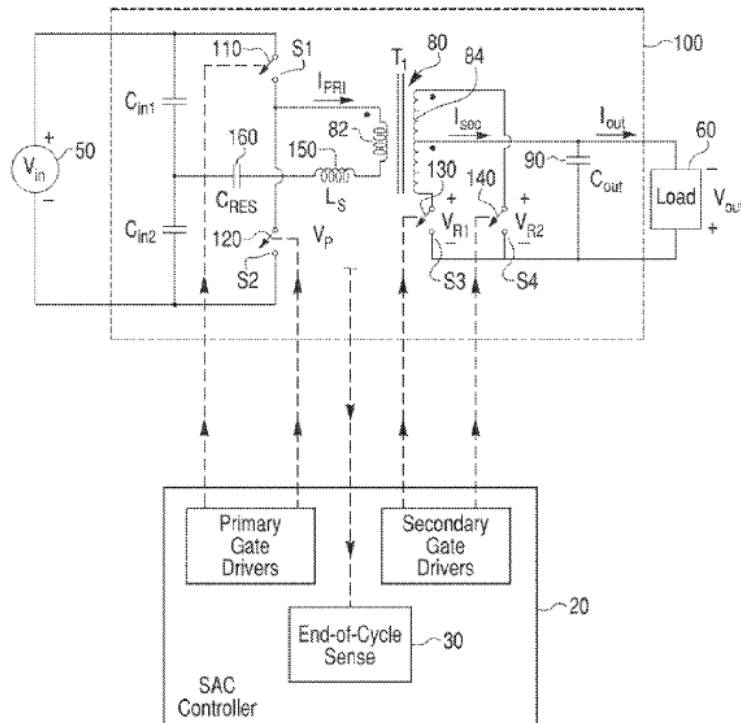
circuit including the transformer having a characteristic resonant frequency and period, the input circuit including two or more primary switches connected to drive the resonant circuit and the output circuit being connected to receive power from the transformer; and

171. Huang, alone or in view of the '481 Patent, renders this limitation obvious for the reasons I discussed above for claim 1 and claim limitation 5(a) (Ground I). The '481 Patent further discloses that the disclosed circuitry is intended to control a resonant circuit (including a transformer) that comprises a characteristic resonant frequency and period. *See, e.g.,* Ex. 1007, 1:32-36, 4:29-45, 6:21-24, claim 1.

b. Limitation 5(b): a switch controller adapted to operate the primary switches in a series of converter operating cycles, each converter operating cycle characterized by two power transfer intervals of essentially equal duration each interval having a duration less than the characteristics resonant period, during which one or more of the primary switches are ON and power is transferred from the input to the output via the transformer.

172. Huang modified to operate with the control circuitry disclosed by the '481 Patent renders this limitation obvious. The '481 Patent discloses a “method of synchronously operating a power converter in a series of converter operating cycles.” Ex. 1007, Abstract. The switch controller “controls the turning ON and OFF of switches within the power conversion circuitry” to control the timing of power transfer and energy recycling intervals. *Id.*, 1:22-59. “Each converter operating cycle comprises two power transfer intervals of equal length and two energy recycling

intervals of equal length.... Each power transfer interval is substantially equal to one-half of the characteristic period” *Id.*, 1:47-53; *see also id.*, 8:22-26 (normal converter operation may be defined by power transfer intervals being one half of the characteristic resonant period). During a power transfer interval, primary switches (e.g., S1 in Figure 1, reproduced below) are closed which causes a flow of resonant current in the transformer primary winding, *i.e.*, power is transferred from the input of the circuit to the output via the transformer. *Id.*, 1:22-47.



Ex. 1007, Figure 1 (admitted prior art).

3. Dependent Claim 13

- a. *Limitation 13(a): The apparatus of claim 9, wherein the power converter comprises: a transformer, and a resonant circuit including the transformer having a characteristic*

resonant frequency and period, the input circuit including two or more primary switches connected to drive the resonant circuit and the output circuit being connected to receive power from the transformer; and

173. Huang, alone or in view of the '481 Patent, renders this limitation obvious for the reasons I discussed above for claim 9 and claim limitation 5(a) (Grounds I and II).

b. Limitation 13(b): a switch controller adapted to operate the primary switches in a series of converter operating cycles, each converter operating cycle characterized by two power transfer intervals of essentially equal duration each interval having a duration less than the characteristics resonant period, during which one or more of the primary switches are ON and power is transferred from the input to the output via the transformer.

174. Huang, alone or in view of the '481 Patent, renders this limitation obvious for the reasons I discussed above for claim limitation 5(b) (Grounds I and II).

4. Dependent Claim 21

a. Limitation 21(a): The apparatus of claim 16, wherein the bus converter comprises: a transformer, and a resonant circuit including the transformer having a characteristic resonant frequency and period, the input circuit including two or more primary switches connected to drive the resonant circuit and the output circuit being connected to receive power from the transformer; and

175. Huang, alone or in view of the '481 Patent, renders this limitation obvious for the reasons I discussed above for claim 16 and claim limitation 5(a) (Grounds I and II).

- b. *Limitation 21(b): a switch controller adapted to operate the primary switches in a series of converter operating cycles, each converter operating cycle characterized by two power transfer intervals of essentially equal duration each interval having a duration less than the characteristics resonant period, during which one or more of the primary switches are ON and power is transferred from the input to the output via the transformer.*

176. Huang, alone or in view of the '481 Patent, renders this limitation obvious for the reasons I discussed above for claim limitation 5(b) (Grounds I and II).

5. Dependent Claim 25

The apparatus of claim 1 wherein the input circuit comprises a primary winding and primary switches connected to the primary winding, the output circuit comprises a secondary winding and secondary switches connected to the secondary winding, and a controller for operating the switches in a series of converter operating cycles, wherein the primary and secondary windings are connected in series during at least a portion of each converter operating cycle.

177. Huang, alone or in view of the '481 Patent, renders this limitation obvious for the reasons I discussed above for claims 1 and 25 (Ground I) and claim 5 (Grounds I and II).

6. Dependent Claim 26

The apparatus of claim 9 wherein the input circuit comprises a primary winding and primary switches connected to the primary winding, the output circuit comprises a secondary winding and secondary switches connected to the secondary winding, and a controller for operating the switches in a series of converter operating

cycles, wherein the primary and secondary windings are connected in series during at least a portion of each converter operating cycle.

178. Huang, alone or in view of the '481 Patent, renders this limitation obvious for the reasons I discussed above for claims 9 and 26 (Ground I) and claim 5 (Grounds I and II).

7. Dependent Claim 27

The apparatus of claim 16 wherein the input circuit comprises a primary winding and primary switches connected to the primary winding, the output circuit comprises a secondary winding and secondary switches connected to the secondary winding, and a controller for operating the switches in a series of converter operating cycles, wherein the primary and secondary windings are connected in series during at least a portion of each converter operating cycle.

179. Huang, alone or in view of the '481 Patent, renders this limitation obvious for the reasons I discussed above for claims 16 and 27 (Ground I) and claim 5 (Grounds I and II).

8. Dependent Claim 34

- a. Limitation 34(a): The apparatus of claim 33, wherein the bus converter comprises: a transformer, and a resonant circuit including the transformer having a characteristic resonant frequency and period, the input circuit including two or more primary switches connected to drive the*

resonant circuit and the output circuit being connected to receive power from the transformer; and

180. Huang, alone or in view of the '481 Patent, renders this limitation obvious for the reasons I discussed above claims 33 and 34 (Ground I) and claim limitation 5(a) (Grounds I and II).

b. Limitation 34(b): a switch controller adapted to operate the primary switches in a series of converter operating cycles, each converter operating cycle characterized by two power transfer intervals of essentially equal duration each interval having a duration less than the characteristics resonant period, during which one or more of the primary switches are ON and power is transferred from the input to the output via the transformer.

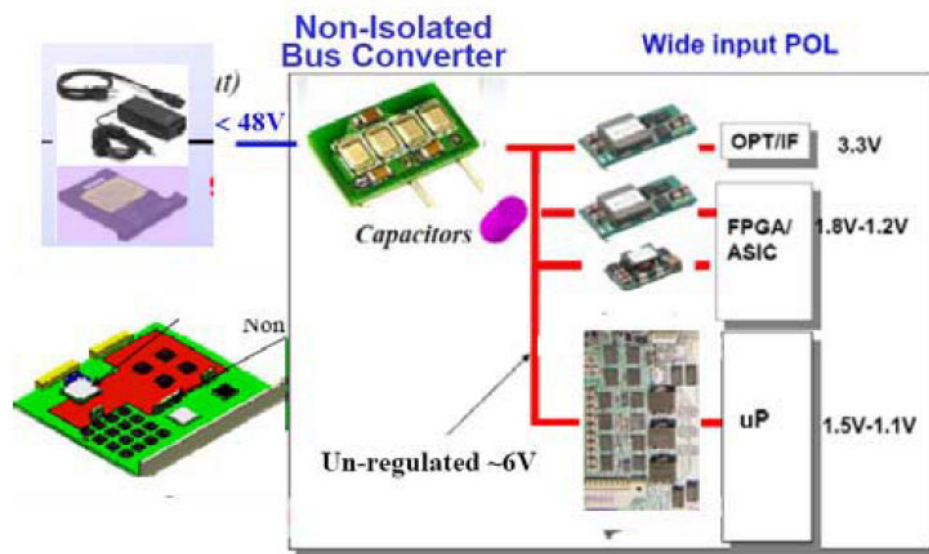
181. Huang, alone or in view of the '481 Patent, renders this limitation obvious for the reasons I discussed above for claim limitation 5(b) (Grounds I and II).

C. Grounds III and IV: Claims 1, 5-7, 14-16, 19, and 21-40 Are Obvious Over Huang, Alone Or In Combination With The '481 Patent, In View Of Lee

1. Motivation to Combine

182. A POSITA would have been motivated to combine Huang, alone or in combination with the '481 Patent, and Lee. Huang discloses a number of novel, non-isolated LLC DC-DC resonant converters that can achieve zero voltage switching, low turn off loss for switches, reduction in transformer turns, and reduction of current through transformer secondary windings. *See* Ex. 1005, 1373. Lee discusses design challenges and opportunities for a variety of power supply applications,

including DC-DC converters. Ex. 1008, 1. Opportunities discussed include cost savings, performance improvements, and chip size. *Id.* Lee proposes a non-isolated intermediate bus architecture, depicted below, as one method of increasing performance. *Id.*, 12, Figure 43. This architecture includes a non-isolated bus converter designed to minimize switching losses and body diode losses at high switching frequencies and increase circuit efficiency. *Id.*, 11-12.



Ex. 1008, Figure 43.

183. Lee discusses using a “voltage divider” DC-DC converter that can achieve high power density and “ultra-high efficiency in the whole load range with capability to handle over load conditions” as the non-isolated bus converter in Lee’s architecture. *Id.* at 12.

184. It would have been obvious to a POSITA to use the resonant converters disclosed in Huang, as is or as modified by the ’481 Patent, in the intermediate bus

architecture disclosed in Lee in place of Lee's "voltage divider." **First**, a POSITA would understand that the "non-isolated bus converter" of Lee's proposed architecture is a power converting circuit that could take many forms, including the DC-DC converter disclosed by Huang.

185. **Second**, Huang contemplates the use of the disclosed converters in point-of-load (POL) and voltage regulator applications where high power density and high efficiency are desired—a use case for Lee's non-isolated bus converter. Ex. 1005, 1373. And it would have been obvious to a POSITA to try Huang's high power density and high efficiency converters as the non-isolated bus converter in the non-isolated intermediate bus architecture proposed by Lee in place of Lee's DC-DC "voltage divider": there were limited options for non-isolated converters, and Huang's non-isolated LLC resonant converters were specifically designed for the same purpose as Lee's voltage divider, namely, increasing overall circuit efficiency. *Compare* Ex. 1005, 1373, 1378-79, *with* Ex. 1008, 12. A POSITA would have had a reasonable expectation of success in using Huang's converters in the intermediate bus architecture disclosed in Lee because, as shown in Lee Figure 43, it was contemplated that the non-isolated bus converter would be a modular, and thus replaceable, component.

186. **Third**, a POSITA would have specifically been interested in enhancing efficiency considering both Lee and Huang's focus on improving existing converter

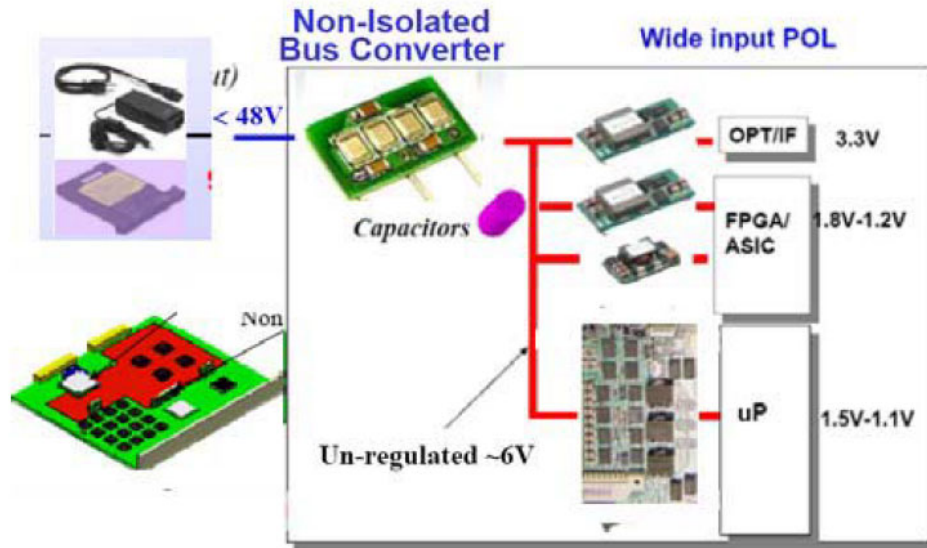
design to reduce switching and transformer losses. *See, e.g.*, Ex. 1005, 1373; Ex. 1008, 11-12. Both Huang and Lee indicate that a motivation to implement their disclosed inventions is to improve the efficiency of existing circuit design. *See, e.g., id.* Thus, a POSITA would be motivated to improve the efficiency of the circuit design in other ways, such as including Huang's improved converters in Lee's improved architecture design to improve the overall power conversion efficiency.

187. ***Fourth***, use of Lee's intermediate bus architecture with the resonant converters disclosed in Huang would have involved mere substitution of one known element (Lee's "voltage divider" as the non-isolated bus converter shown in Figure 43) for another (Huang's non-isolated LLC resonant converters as the non-isolated bus converter) to obtain predictable results (more efficient power conversion). A POSITA would have recognized using Huang's Figure 12(b) converter to be an easy modification to make to Lee's intermediate bus architecture using standard techniques known in the art.

2. Independent Claim 1

- a. Limitation 1(a): An apparatus comprising:*
- b. Limitation 1(b): a power distribution system comprising a source for providing power at a DC source voltage V_S ;*

188. Lee's proposed intermediate bus architecture (a power distribution system) includes a 48V DC source voltage, as shown in Figure 43:

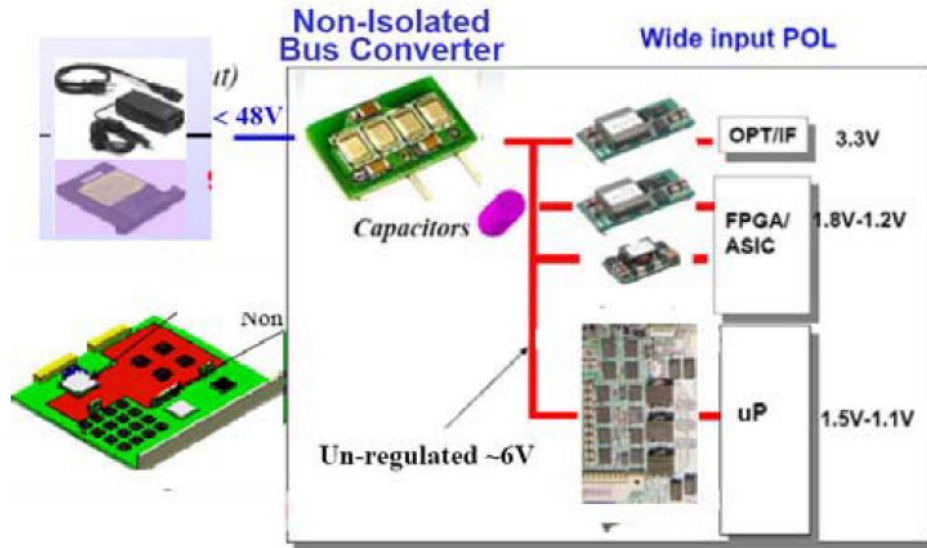


Ex. 1008, Figure 43. Lee also explains that the “voltage divider” used as a non-isolated bus converter is a DC-DC converter. *Id.*, 11-12.

189. Huang likewise discloses this claim limitation for the reasons I discussed above for Ground I.

- c. *Limitation 1(c): a bus converter comprising an input circuit and an output circuit, the bus converter being adapted to convert power from the input circuit to the output circuit at a substantially fixed voltage transformation ratio, K_{DC} , at an output current, wherein an input voltage V_{IN} is applied to the input circuit and an output voltage V_{OUT} is produced by the output of the bus converter, and wherein the substantially fixed voltage transformation ratio can be represented as $K_{DC} = V_{OUT}/V_{IN}$;*

190. As I discussed above, Huang’s Figure 12(b) converter would operate as the non-isolated bus converter Lee’s intermediate bus architecture (depicted in Figure 43, reproduced below) in the combination of Huang and Lee.

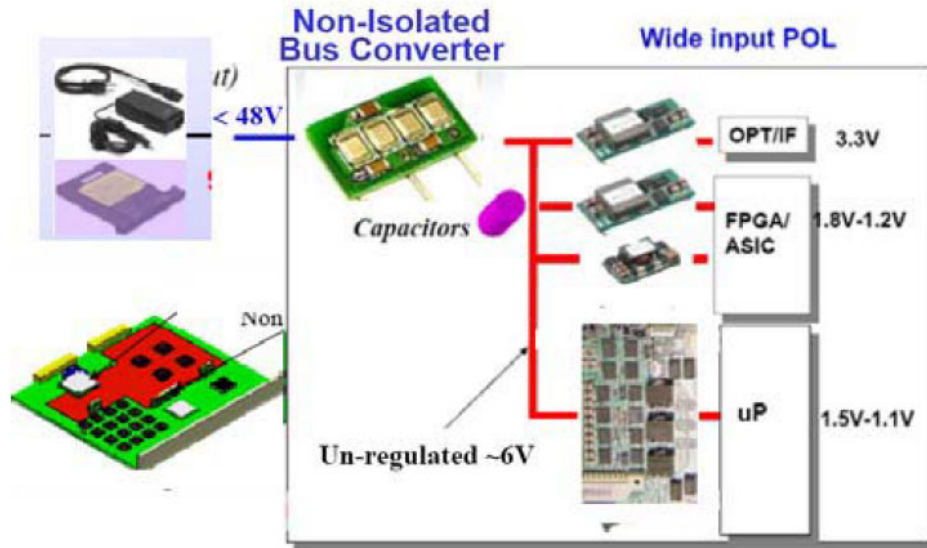


Ex. 1008, Figure 43.

191. Huang renders obvious the remainder of this limitation for the reasons I discussed above for Ground I.

d. Limitation 1(d): a power distribution bus connected to distribute power from the output circuit of the bus converter at the output voltage V_{OUT} ; and

192. Lee's intermediate bus architecture includes a power distribution bus (red lines in Figure 43, below) connected to distribute power from the output circuit of the non-isolated bus converter (Huang's Figure 12(b) converter in the combination) at the output voltage V_{OUT} . See Ex. 1008, Figure 43. I incorporate by reference my discussion of this limitation in Ground I above.



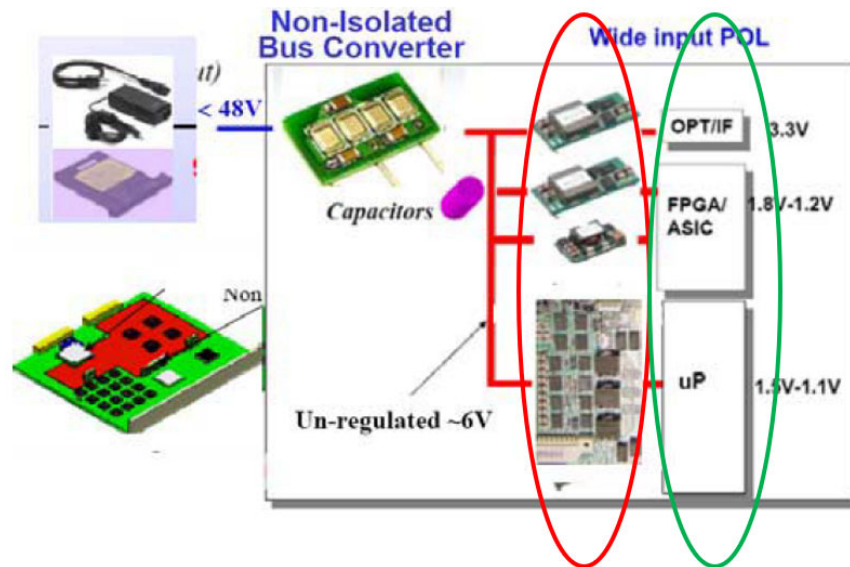
Ex. 1008, Figure 43.

- e. *Limitation 1(e): a plurality of regulators, wherein each regulator comprises a regulator input connected to the power distribution bus to receive power from the output circuit of the bus converter and a regulator output connected to supply power to a respective load, the plurality of regulators each being separated by a distance from the bus converter;*

193. Lee's intermediate bus architecture includes a plurality of regulators, each regulator comprising an input connected to receive power from the output circuit of the bus converter (Huang's Figure 12(b) circuit in the combination) and an output connected to supply power to a load. Ex. 1008, 11-12. The circuits circled in red in Figure 43 below are the regulators, what Lee refers to as "wide input POLs," or point-of-load DC-DC converters. Ex. 1008, 8, 11-12. The white boxes circled in green in Figure 43 below are the loads; for example, the center load is an FPGA or

ASIC, two types of integrated circuits that are ordinarily off-the-shelf components.

Id.



Ex. 1008, Figure 43 (annotations added).

194. A POSITA would have recognized the regulators to be distanced from the bus converter for a number of reasons, including at least because the bus converter is a separate component from the point-of-load DC-DC converters and the point-of-load DC-DC converters would have been part of the circuit boards comprising the loads themselves (i.e., the point-of-load converters were local to the load, not the bus converter).

- f. Limitation 1(f): wherein the input circuit of the bus converter and at least a portion of the output circuit of the bus converter are galvanically connected in series across the source such that an absolute value of the input voltage V_{IN} applied to the input circuit is approximately equal to the absolute value of the DC source voltage V_S minus a*

number N times the absolute value of the output voltage V_{OUT} , where N is at least 1;

195. The combination of Huang, alone or in combination with the '481 Patent, and Lee renders obvious this limitation for the reasons I discussed above for Ground I.

g. Limitation 1(g): wherein the bus converter comprises an inductive component and one or more power switches in the input circuit, the output circuit, or both; and

196. The combination of Huang alone or in combination with the '481 Patent, and Lee renders obvious this limitation for the reasons I discussed above for Ground I.

h. Limitation 1(h): wherein a current flowing in the inductive component charges and discharges capacitances in the bus converter reducing a voltage across said one or more switches prior to turning ON said one or more switches.

197. The combination of Huang alone or in combination with the '481 Patent, and Lee renders obvious this limitation for the reasons I discussed above for Ground I.

3. Dependent Claim 5

Limitation 5(a): The apparatus of claim 1, wherein the bus converter comprises: a transformer, and a resonant circuit including the transformer having a characteristic resonant frequency and period, the input circuit including two or more primary switches connected to drive the

resonant circuit and the output circuit being connected to receive power from the transformer; and

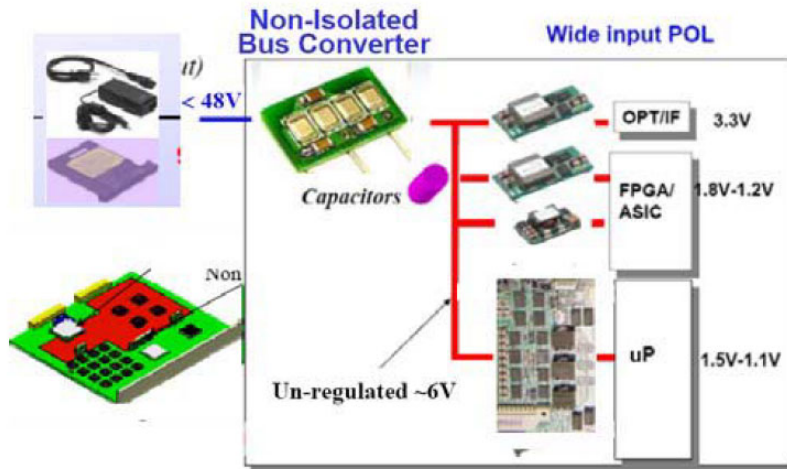
Limitation 5(b): a switch controller adapted to operate the primary switches in a series of converter operating cycles, each converter operating cycle characterized by two power transfer intervals of essentially equal duration each interval having a duration less than the characteristics resonant period, during which one or more of the primary switches are ON and power is transferred from the input to the output via the transformer.

The combination of Huang, alone or in combination with the '481 Patent, and Lee renders obvious these claims for the reasons I discussed above for claims 1 (Grounds I, II, III, and IV) and 5 (Grounds I and II).

4. Dependent Claim 6

The apparatus of claim 1, wherein the bus converter is a self-contained assembly adapted to be installed as a unit.

198. For the reasons I discussed above, Huang, alone or in combination with the '481 Patent, renders obvious claim 1. As is depicted in Figure 43 of Lee, the non-isolated bus converter of Lee's proposed intermediate bus architecture is a self-contained assembly adapted to be installed as a unit:

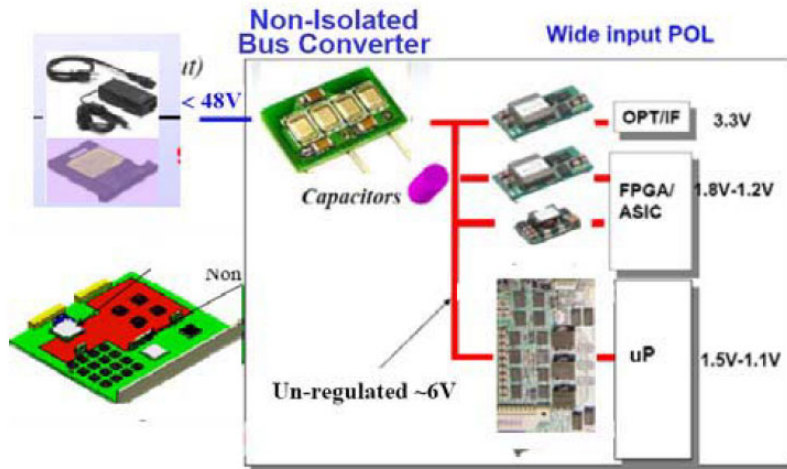


Ex. 1008, Figure 43.

5. Dependent Claim 7

The apparatus of claim 1, further comprising a circuit board, wherein the bus converter and at least one regulator are assembled to the circuit board, and the regulator is configured to supply power to an integrated circuit.

199. For the reasons I discussed above, Huang, alone or in combination with the '481 Patent, renders obvious claim 1. As depicted in Figure 43 of Lee, the non-isolated bus converter and the regulators are assembled to circuit boards in Lee's proposed intermediate bus architecture:



Ex. 1008, Figure 43.

200. At least one regulator in Lee is configured to supply power to an integrated circuit; specifically, the regulators are shown connected to an FPGA or ASIC, which is a type of integrated circuit.

6. Dependent Claim 14

The apparatus of claim 9, wherein the power converter is part of a bus converter that is a self-contained assembly adapted to be installed as a unit.

201. For the reasons I discussed above, Huang, alone or in combination with the '481 Patent, renders obvious claim 9. The combination of Huang and Lee renders obvious this claim for the reasons I discussed above for claim 9 (Ground I) and claim 6 (Grounds I, III, and IV).

7. Dependent Claim 15

The apparatus of claim 9, further comprising a circuit board, and wherein the power converter is configured to supply power to a plurality of regulators over a power distribution bus, the regulators disposed at a distance to

the power converter, and wherein at least one of the regulators is assembled to the circuit board and configured to supply power to an integrated circuit.

202. The combination of Huang alone or in combination with the '481 Patent, and Lee renders obvious this claim for the reasons I discussed above for claim limitation 1(e) (Grounds I, III, and IV), claim 7 (Grounds I, III, and IV), and claim 9 (Ground I).

8. Independent Claim 16

- a. Limitation 16(a): An apparatus comprising:*
- b. Limitation 16(b): a bus converter comprising an input circuit and an output circuit, wherein the bus converter is configured to receive power from a power distribution system comprising a source for providing power at a DC source voltage V_S , the bus converter being adapted to convert power from the input circuit to the output circuit at a substantially fixed voltage transformation ratio, K_{DC} , at an output current, wherein an input voltage V_{IN} is applied to the input circuit and an output voltage V_{OUT} is produced by the output of the bus converter, and wherein the substantially fixed voltage transformation ratio can be represented as $K_{DC}=V_{OUT}/V_{IN}$;*

203. The combination of Huang alone or in combination with the '481 Patent, and Lee renders obvious this limitation for the reasons I discussed above for claim limitations 1(b) and 1(c) (Grounds I, III, and IV).

- c. *Limitation 16(c): a power distribution bus connected to distribute power from the output circuit of the bus converter at the output voltage V_{OUT} ; and*

204. The combination of Huang alone or in combination with the '481 Patent, and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(d) (Grounds I, III, and IV).

- d. *Limitation 16(d): a plurality of regulators, wherein each regulator comprises a regulator input connected to the power distribution bus to receive power from the output circuit of the bus converter and a regulator output connected to supply power to a respective load, the plurality of regulators each being separated by a distance from the bus converter;*

205. The combination of Huang alone or in combination with the '481 Patent, and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(e) (Grounds I, III, and IV).

- e. *Limitation 16(e): wherein the input circuit of the bus converter and at least a portion of the output circuit of the bus converter are connected in series across the source such that an absolute value of the input voltage V_{IN} applied to the input circuit is approximately equal to the absolute value of the DC source voltage V_S minus a number N times the absolute value of the output voltage V_{OUT} , where N is at least 1;*

206. The combination of Huang alone or in combination with the '481 Patent, and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(f) (Grounds I, III, and IV).

- f. Limitation 16(f): wherein the bus converter comprises an inductive component and one or more power switches in the input circuit, the output circuit, or both; and*

207. The combination of Huang alone or in combination with the '481 Patent, and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(g) (Grounds I, III, and IV).

- g. Limitation 16(g): wherein a current flowing in the inductive component charges and discharges capacitances in the bus converter reducing a voltage across said one or more switches prior to turning ON said one or more switches.*

208. The combination of Huang alone or in combination with the '481 Patent, and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(h) (Grounds I, III, and IV).

9. Dependent Claim 19

The apparatus of claim 16, wherein the bus converter is a self-contained assembly adapted to be installed as a unit.

209. The combination of Huang, alone or in combination with the '481 Patent, and Lee renders obvious this limitation for the reasons I discussed above for claims 6 and 16 (Grounds I, III, and IV).

10. Dependent Claim 21

- a. Limitation 21(a): The apparatus of claim 16, wherein the bus converter comprises: a transformer, and a resonant circuit including the transformer having a characteristic resonant frequency and period, the input circuit including two or more primary switches connected to drive the*

resonant circuit and the output circuit being connected to receive power from the transformer; and

210. Huang, alone or in view of the '481 Patent, in combination with Lee renders this limitation obvious for the reasons I discussed above for claims 16, 21, and claim limitation 5(a) (Grounds I and II).

b. Limitation 21(b): a switch controller adapted to operate the primary switches in a series of converter operating cycles, each converter operating cycle characterized by two power transfer intervals of essentially equal duration each interval having a duration less than the characteristics resonant period, during which one or more of the primary switches are ON and power is transferred from the input to the output via the transformer.

211. Huang, alone or in view of the '481 Patent, in combination with Lee renders this limitation obvious for the reasons I discussed above for claim limitation 5(b) (Grounds I and II).

11. Independent Claim 22

a. Limitation 22(a): An apparatus comprising:

b. Limitation 22(b): an intermediate bus architecture power distribution system for an electrical system comprising a source for providing power at a DC source voltage;

212. The combination of Huang alone or in combination with the '481 Patent, and Lee renders obvious this limitation for the reasons I discussed above for claim limitations 1(b) and 22(b) (Grounds I, III, and IV).

c. Limitation 22(c): a circuit board comprising a bus converter, the bus converter comprising an input circuit, the input circuit comprising a primary transformer

winding, the bus converter further comprising an output circuit, the output circuit comprising a secondary transformer winding, wherein the primary and secondary transformer windings are galvanically connected in series, and wherein the bus converter is configured to provide power to a power distribution bus that is not galvanically isolated from the source; and

213. The combination of Huang alone or in combination with the '481 Patent, and Lee renders obvious this limitation for the reasons I discussed above for claim limitations 1(c) and 22(c) (Grounds I, III, and IV).

d. Limitation 22(d): the circuit board further comprising a plurality of regulators, wherein each regulator comprises a regulator input connected to the power distribution bus to receive power from the output circuit of the bus converter and a regulator output connected to supply power to a respective load, the plurality of regulators each being separated by a distance from the bus converter

214. The combination of Huang alone or in combination with the '481 Patent, and Lee renders obvious this limitation for the reasons I discussed above for claim limitations 1(e) and 22(d) (Grounds I, III, and IV).

12. Dependent Claim 23

Limitation 23(a): The apparatus of claim 22, wherein the bus converter is adapted to convert power from the input circuit to the output circuit at a substantially fixed voltage transformation ratio, K_{DC} , at an output current, wherein an input voltage V_{IN} is applied to the input circuit and an output voltage V_{OUT} is produced by the output of the bus converter, and wherein the substantially fixed voltage

transformation ratio can be represented as $K_{DC}=V_{OUT}/V_{IN}$; and

Limitation 23(b): wherein the input circuit of the bus converter and at least a portion of the output circuit of the bus converter are connected such that an absolute value of the input voltage V_{IN} applied to the input circuit is approximately equal to the absolute value of the DC source voltage V_S minus a number N times the absolute value of the output voltage V_{OUT} , where N is at least 1.

215. For the reasons I discussed above, Huang, alone or in combination with the '481 Patent, renders obvious claim 1. The combination of Huang, alone or in combination with the '481 Patent, and Lee renders obvious this claim for the reasons I discussed above for claim 23 (Ground I).

13. Dependent Claim 24

The apparatus of claim 22, wherein the bus converter is a self-contained assembly adapted to be installed as a unit.

216. The combination of Huang, alone or in combination with the '481 Patent, and Lee renders obvious this limitation for the reasons I discussed above for claim 6 and claim 22 (Grounds I, III, and IV).

14. Dependent Claims 25-28

217. The combination of Huang, alone or in combination with the '481 Patent, and Lee renders obvious these claims for the reasons I discussed above for claims 1, 9, and 16 (Grounds I, II, III, and IV) and claims 25-28 (Grounds I and II).

15. Independent Claim 29

- a. Limitation 29(a): An apparatus comprising:*
- b. Limitation 29(b): a power distribution system comprising a source for providing power at a DC source voltage V_S ;*

218. The combination of Huang, alone or in combination with the '481 Patent, and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(b) (Grounds I, II, III, and IV).

- c. Limitation 29(c): a bus converter comprising an input circuit and an output circuit, the bus converter being adapted to convert power from the input circuit to the output circuit at a substantially fixed voltage transformation ratio, K_{DC} , at an output current, wherein an input voltage V_{IN} is applied to the input circuit and an output voltage V_{OUT} is produced by the output of the bus converter, and wherein the substantially fixed voltage transformation ratio can be represented as $K_{DC}=V_{OUT}/V_{IN}$;*

219. The combination of Huang, alone or in combination with the '481 Patent, and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(c) (Grounds I, II, III, and IV).

- d. Limitation 29(d): a power distribution bus connected to distribute power from the output circuit of the bus converter at the output voltage V_{OUT} ; and*

220. The combination of Huang, alone or in combination with the '481 Patent, and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(d) (Grounds I, II, III, and IV).

- e. Limitation 29(e): a plurality of regulators, wherein each regulator comprises a regulator input connected to the*

power distribution bus to receive power from the output circuit of the bus converter and a regulator output connected to supply power to a respective load, the plurality of regulators each being separated by a distance from the bus converter;

221. The combination of Huang alone or in combination with the '481 Patent, and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(e) (Grounds I, II, III, and IV).

f. Limitation 29(f): wherein the input circuit of the bus converter and the output circuit of the bus converter are galvanically connected; and

222. The combination of Huang alone or in combination with the '481 Patent, and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(f) (Grounds I, II, III, and IV).

g. Limitation 29(g): wherein the bus converter comprises an inductive component and one or more power switches in the input circuit or output circuit or both; and

223. The combination of Huang alone or in combination with the '481 Patent, and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(g) (Grounds I, II, III, and IV).

h. Limitation 29(h): wherein a current flowing in the inductive component charges and discharges capacitances in the converter reducing a voltage across

said one or more switches prior to turn ON of said one or more switches.

224. The combination of Huang alone or in combination with the '481 Patent, and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(h) (Grounds I, II, III, and IV).

16. Dependent Claim 30

The apparatus of claim 29 wherein the voltage across one or more switches is reduced to essentially zero volts prior to turning ON said one or more switches.

225. The combination of Huang alone or in combination with the '481 Patent, and Lee renders obvious this claim for the reasons I discussed above for claim 30 (Ground I).

17. Independent Claim 31

- a. Limitation 31(a): An apparatus comprising:*
- b. Limitation 31(b): a power distribution system comprising a source for providing power at a DC source voltage V_S ;*

226. The combination of Huang alone or in combination with the '481 Patent, and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(b) (Grounds I, II, III, and IV).

- c. Limitation 31(c): a bus converter comprising an input circuit and an output circuit, the bus converter being adapted to convert power from the input circuit to the output circuit at a substantially fixed voltage transformation ratio, K_{DC} , at an output current, wherein an input voltage V_{IN} is applied to the input circuit and an output voltage V_{OUT} is produced by the output of the bus*

converter, and wherein the substantially fixed voltage transformation ratio can be represented as $K_{DC}=V_{OUT}/V_{IN}$;

227. The combination of Huang alone or in combination with the '481 Patent, and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(c) (Grounds I, II, III, and IV).

d. Limitation 31(d): a power distribution bus connected to distribute power from the output circuit of the bus converter at the output voltage V_{OUT} ; and

228. The combination of Huang alone or in combination with the '481 Patent, and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(d) (Grounds I, II, III, and IV).

e. Limitation 31(e): a plurality of regulators, wherein each regulator comprises a regulator input connected to the power distribution bus to receive power from the output circuit of the bus converter and a regulator output connected to supply power to a respective load, the plurality of regulators each being separated by a distance from the bus converter;

229. The combination of Huang alone or in combination with the '481 Patent, and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(e) (Grounds I, II, III, and IV).

f. Limitation 31(f): wherein the input circuit comprises a winding having a first number of turns, wherein the output circuit comprises a winding having a second number of turns, and wherein the voltage transformation ratio is a

function of a ratio of the first number of turns to the second number of turns; and

230. The combination of Huang alone or in combination with the '481 Patent, and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(c) (Grounds I, II, III, and IV) and claim 37 (Ground I).

- g. Limitation 31(g): wherein the input circuit of the bus converter and at least a portion of the output circuit of the bus converter are connected in series across the source such that an absolute value of the input voltage V_{IN} applied to the input circuit is approximately equal to the absolute value of the DC source voltage V_S minus a number N times the absolute value of the output voltage V_{OUT} , where N is at least 1.*

231. The combination of Huang alone or in combination with the '481 Patent, and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(f) (Grounds I, II, III, and IV).

18. Independent Claim 32

- a. Limitation 32(a): An apparatus comprising:*
- b. Limitation 32(b): a power distribution system comprising a source for providing power at a DC source voltage V_S ;*

232. The combination of Huang alone or in combination with the '481 Patent, and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(b) (Grounds I, II, III, and IV).

- c. Limitation 32(c): a bus converter comprising an input circuit and an output circuit, the bus converter being adapted to convert power from the input circuit to the output circuit at a substantially fixed voltage*

transformation ratio, K_{DC} , at an output current, wherein an input voltage V_{IN} is applied to the input circuit and an output voltage V_{OUT} is produced by the output of the bus converter, and wherein the substantially fixed voltage transformation ratio can be represented as $K_{DC}=V_{OUT}/V_{IN}$;

233. The combination of Huang alone or in combination with the '481 Patent, and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(c) (Grounds I, II, III, and IV).

d. Limitation 32(d): a power distribution bus connected to distribute power from the output circuit of the bus converter at the output voltage V_{OUT} ; and

234. The combination of Huang alone or in combination with the '481 Patent, and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(d) (Grounds I, II, III, and IV).

e. Limitation 32(e): a plurality of regulators, wherein each regulator comprises a regulator input connected to the power distribution bus to receive power from the output circuit of the bus converter and a regulator output connected to supply power to a respective load, the plurality of regulators each being separated by a distance from the bus converter;

235. The combination of Huang alone or in combination with the '481 Patent, and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(e) (Grounds I, II, III, and IV).

f. Limitation 32(f): wherein the input circuit comprises a winding having a first number of turns, wherein the output circuit comprises a winding having a second number of turns, and wherein the voltage transformation ratio is a

function of a ratio of the first number of turns to the second number of turns; and

236. The combination of Huang alone or in combination with the '481 Patent, and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(c) (Grounds I, II, III, and IV) and claim 37 (Ground I).

g. Limitation 32(g): wherein the input circuit of the bus converter and the output circuit of the bus converter are galvanically connected.

237. The combination of Huang alone or in combination with the '481 Patent, and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(f) (Grounds I, II, III, and IV).

19. Independent Claim 33

a. Limitation 33(a): An apparatus comprising:

b. Limitation 33(b): a bus converter comprising an input circuit and an output circuit, the bus converter being adapted to convert power from the input circuit to the output circuit at a substantially fixed voltage transformation ratio, K_{DC} , at an output current, wherein an input voltage V_{IN} is applied to the input circuit and an output voltage V_{OUT} is produced by the output of the bus converter, and wherein the substantially fixed voltage transformation ratio can be represented as $K_{DC}=V_{OUT}/V_{IN}$;

238. The combination of Huang alone or in combination with the '481 Patent, and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(c) (Grounds I, II, III, and IV).

- c. Limitation 33(c): wherein the input circuit of the bus converter and the output circuit of the bus converter are galvanically connected; and*

239. The combination of Huang alone or in combination with the '481 Patent, and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(f) (Grounds I, II, III, and IV).

- d. Limitation 33(d): wherein the bus converter comprises an inductive component and one or more power switches in the input circuit or output circuit or both; and*

240. The combination of Huang alone or in combination with the '481 Patent, and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(g) (Grounds I, II, III, and IV).

- e. Limitation 33(e): wherein a current flowing in the inductive component charges and discharges capacitances in the converter reducing a voltage across said one or more switches prior to turn ON said one or more switches.*

241. The combination of Huang alone or in combination with the '481 Patent, and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(h) (Grounds I, II, III, and IV).

20. Dependent Claims 34-39

242. The combination of Huang alone or in combination with the '481 Patent, and Lee renders obvious these claims for the reasons I discussed above for claims 34-39 (Grounds I and II).

21. Dependent Claim 40

The apparatus of claim 22 wherein at least one of the regulators is assembled to the circuit board and configured to supply power to an integrated circuit.

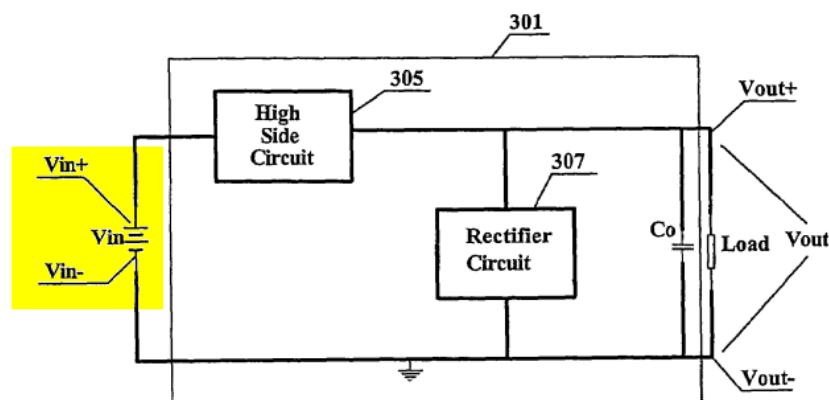
243. The combination of Huang alone or in combination with the '481 Patent, and Lee renders obvious this limitation for the reasons I discussed above for claims 7 and 22 (Grounds I, II, III, and IV).

D. **Ground V: Claims 1, 2, 6-10, 14-17, 19, 22-33, 35-37, and 39-40 Are Obvious Over Liu**

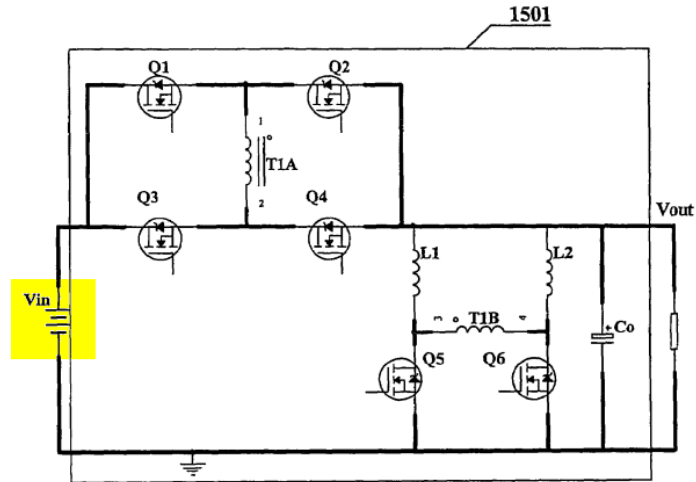
1. Independent Claim 1

- a. *Limitation 1(a): An apparatus comprising:*
- b. *Limitation 1(b): a power distribution system comprising a source for providing power at a DC source voltage V_S ;*

244. Liu discloses a variety of DC-DC converters, all of which receive as input a DC source voltage V_{in} . A first generalized embodiment of these converters is provided in Figure 3, of which Figure 15 is a particular embodiment:

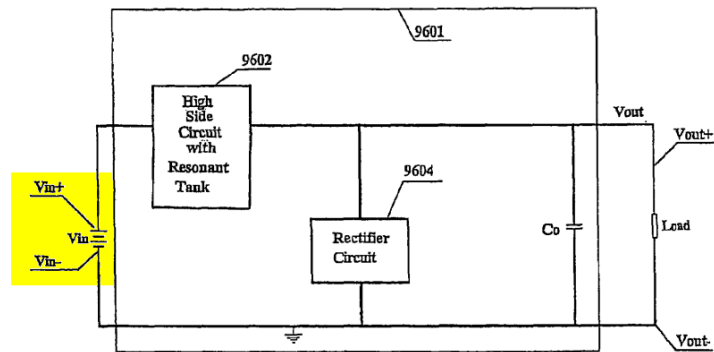


Ex. 1006, Figure 3 (annotation added).

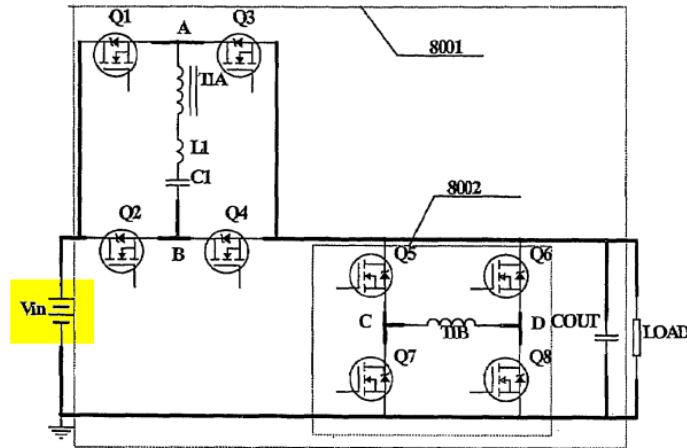


Ex. 1006, Figure 15 (annotation added).

245. A second generalized embodiment of the disclosed converters is provided in Figure 68A, of which Figure 80 is a particular embodiment:



Id., Figure 68A (annotation added).



Id., Figure 80 (annotation added).

246. Liu describes the input voltage as DC. *See, e.g.*, Ex. 1006, 2:64-3:2; 6:63-65. A POSITA would have known that the DC source comes from a power distribution system comprising the source.

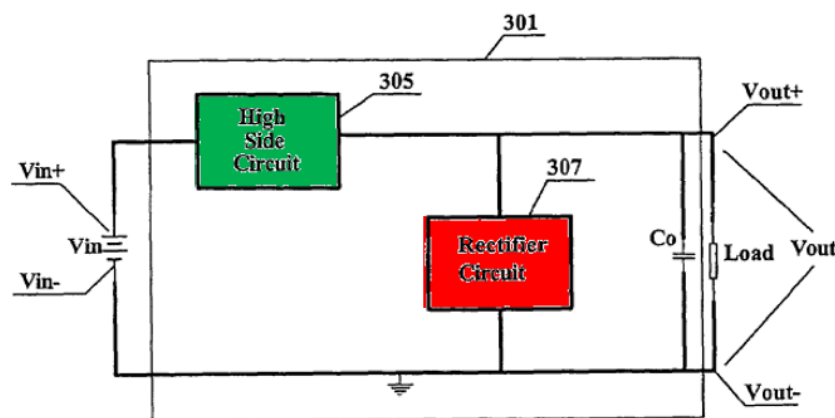
- c. Limitation 1(c): a bus converter comprising an input circuit and an output circuit, the bus converter being adapted to convert power from the input circuit to the output circuit at a substantially fixed voltage transformation ratio, K_{DC} , at an output current, wherein an input voltage V_{IN} is applied to the input circuit and an output voltage V_{OUT} is produced by the output of the bus converter, and wherein the substantially fixed voltage transformation ratio can be represented as $K_{DC} = V_{OUT}/V_{IN}$;*

247. As I discussed above with respect to Huang (Ground I) for this limitation, the '950 Patent acknowledges that IBA was known in the art at the time of invention. Ex. 1001, 1:13-35. The '950 Patent describes "a prior art power distribution system 1 such as an Intermediate Bus Architecture" in Figure 1, reproduced below. *Id.*, 1:13-14. IBA systems included a DC power source supplying

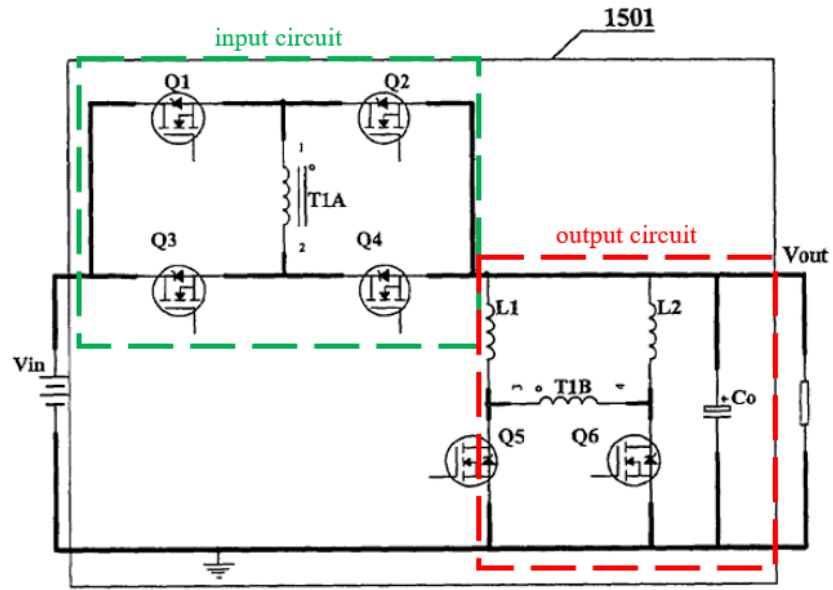
power to a bus converter. *Id.*, 1:13-16. The bus converter included, for example, a DC-DC converter such as that disclosed by Liu. *Id.*; Ex. 1006, Figures 3, 15, 68A, 80.

248. A POSITA would have known to use a DC-DC converter such as Liu's as the bus converter or part of the bus converter when the input and output of the converter both need to be DC because the input to the converter is DC and the electronics downstream from the converter also use DC. A POSITA would have also known that, in the case of IBA, the bus converter should both be efficient and low cost. Liu's converters increase efficiency by, for example, achieving zero voltage switching. *See* Ex. 1006, 36:20-33. Liu's converters would thus be an attractive option to a POSITA.

249. The converters embodying the Figure 3 configuration convert power from the input circuit to the output circuit, which are indicated in green and red, respectively:

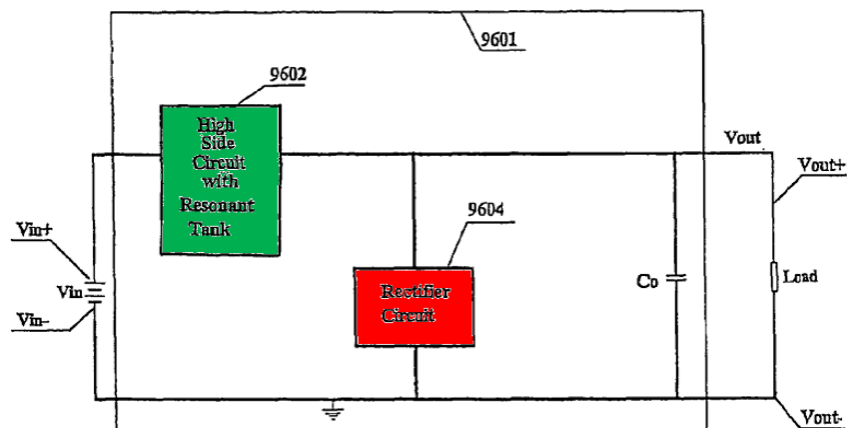


Ex. 1006, Figure 3 (annotations added).

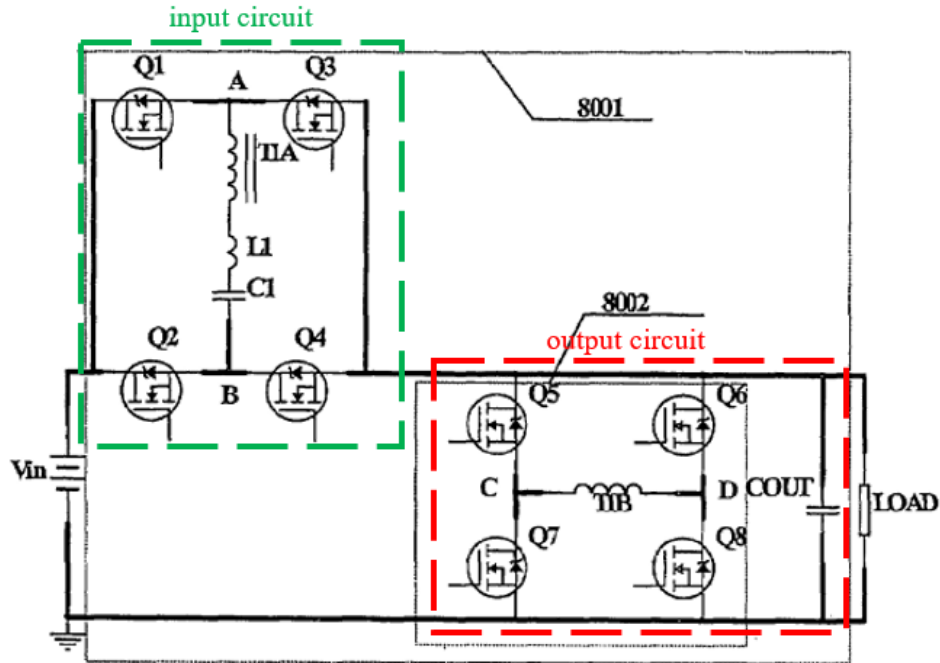


Ex. 1006, Figure 15 (annotations added).

250. The converters embodying the Figure 68A configuration likewise convert power from the input circuit to the output circuit, which are indicated in green and red, respectively:



Id., Figure 68A (annotations added).



Id., Figure 80 (annotations added).

251. The power conversion is performed at a substantially fixed voltage transformation ratio that can be represented as $K_{DC} = \frac{V_{OUT}}{V_{IN}}$. In the circuits of Figures 15 and 80, the output circuit produces an output voltage, V_{out} , referred to in the '950 claim as V_{OUT} . The input voltage to the input circuit, V_{IN} , is the voltage into the converter (V_{in}) less the output voltage (V_{out}): $V_{IN} = V_{in} - V_{out}$. Thus, the voltage transformation ratio is $K_{DC} = \frac{V_{OUT}}{V_{IN}} = \frac{V_{out}}{V_{in} - V_{out}}$.

252. Further, the values of V_{out} and V_{in} can be represented in terms of the transformer turns ratio. *See* Ex. 1006, 17:5-15, 18:36-46. For example, Liu discloses that the relationship between V_{out} and V_{in} for Figure 15 is shown in the equation

$$V_{out} = \frac{V_{in} * N * D}{(2 + N * D)}$$

where N is the transformer turns ratio and D is the total duty cycle.

Ex. 1006, 18:36-46. Using this equation, we can derive K_{DC} based on the transformer turns ratio and total duty cycle:

$$V_{out} = \frac{V_{in} * N * D}{(2 + N * D)}$$

Multiply by $(2+N*D)$: $(2 + N * D) * V_{out} = V_{in} * N * D$

Multiply out left side: $2 * V_{out} + N * D * V_{out} = V_{in} * N * D$

Subtract $N*D*V_{out}$: $2 * V_{out} = V_{in} * N * D - N * D * V_{out}$

Simplify right side: $2 * V_{out} = N * D(V_{in} - V_{out})$

Divide by $V_{in}-V_{out}$: $\frac{2*V_{out}}{V_{in}-V_{out}} = N * D$

Divide by 2: $\frac{V_{out}}{V_{in}-V_{out}} = \frac{N*D}{2}$

Substitute: $K_{DC} = \frac{N*D}{2}$

253. For a duty cycle of 50%, which Liu describes as desirable because it optimizes performance of the converter (*see* Ex. 1006, 17:5-15), the voltage transformation ratio becomes $K_{DC} = \frac{0.5*N}{2}$, which can be simplified to $K_{DC} = \frac{N}{4}$. Thus, K_{DC} is fixed because the transformer turns ratio is physically fixed for the circuit.

254. The circuit depicted in Figure 80 is a series resonant LLC circuit. When the switching frequency of the circuit depicted in Figure 80 is at the resonant frequency, the voltage across the primary winding (as well as inductor L1 and

capacitor C1) is $V_{in} - V_{out}$. The voltage across the secondary winding is equivalent to V_{out} . As is known in the art, the turns ratio of a transformer is equal to the voltage across the secondary winding divided by the voltage across the primary winding. Therefore, the turns ratio of the transformer, N , in Figure 80 is $\frac{V_{out}}{V_{in}-V_{out}}$. The voltage transformation ratio of the circuit shown in Figure 80 is $K_{DC} = \frac{V_{out}}{V_{in}-V_{out}}$. Thus, $K_{DC} = N$ and is therefore fixed by the fixed physical transformer turns ratio N .

- d. Limitation 1(d): a power distribution bus connected to distribute power from the output circuit of the bus converter at the output voltage V_{OUT} ; and*

255. Liu discloses that the disclosed converters can be used in computing applications, more specifically as part of the power distribution bus taking AC voltage from a wall outlet, converting the AC to DC, and then converting the DC voltage to lower voltages required by, for example, CPUs. Ex. 1006, 1:21-48. A POSITA would have understood the output of the DC-DC converters disclosed in Liu to be connected to the power distribution bus to distribute power from the output circuit, as this is the purpose of such converters.

- e. Limitation 1(e): a plurality of regulators, wherein each regulator comprises a regulator input connected to the power distribution bus to receive power from the output circuit of the bus converter and a regulator output connected to supply power to a respective load, the*

plurality of regulators each being separated by a distance from the bus converter;

256. As discussed above in my discussion of Huang (Ground I), the '950 Patent acknowledges that the use of an IBA, wherein a bus converter supplies power to one or more down-stream regulators, was known at the time of invention. Ex. 1001, 1:13-35. As the '950 Patent shows, the IBA configuration included a bus converter supplying power to one or more down-stream regulators (highlighted in yellow):

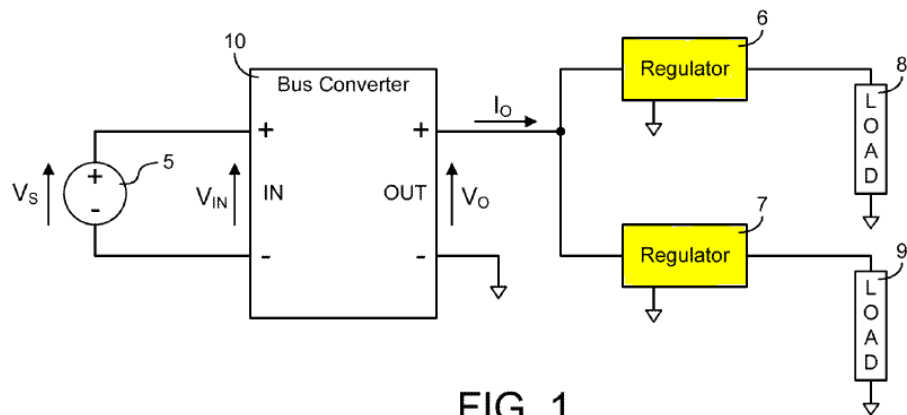


FIG. 1

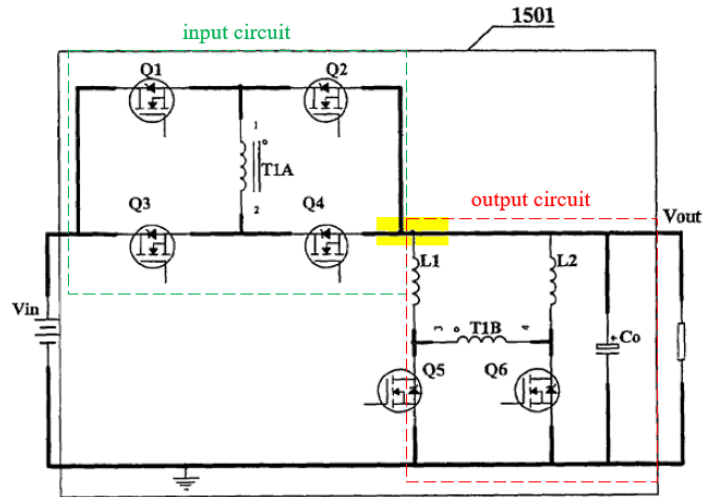
Ex. 1005, Figure 1 (annotations added). In this configuration, the input of the regulators is attached to a power distribution bus to which the output of the bus converter is also attached, such that the regulators are receiving power from the output of the bus converter. *Id.* The regulators would then provide regulated power/voltage to their respective loads. *Id.* A POSITA would have further known that regulators would be separated by a distance from the bus converter. For example, as the '950 Patent explains:

[I]n a typical system, one or more system circuit boards housed in a common enclosure may each include one or more bus converters, preferably located near the edge of, or other location on, the board where power connections are made to the board. A down-stream regulator receiving power from the bus converter(s) may be preferably located adjacent to the circuitry, e.g. a processor, ASIC, or other circuitry, to which it or they supply power. The physical distance separating the bus converter and a respective down-stream regulator in such an example may range from as much as a dimension of the system circuit board, i.e. a diagonal dimension where the bus converter and regulator located at opposite corners, a length or width dimension where they are located at opposite edges, a half-length or width where one is situated closer to the middle and the other is at an edge, etc. In another example, a bus converter may be located off of the system board in which case the electrical distance could be greater than a dimension of the system board. Naturally, the distance separating the bus converter and a respective down-stream regulator will depend on the system layout. However, a bus converter housed in a self-contained assembly adapted to be installed as a unit at a location remote from the down-stream regulator(s) may be separated by a distance from a down-stream regulator regardless of their respective mounting locations at the system level.

Ex. 1005, 3:53-2:13.

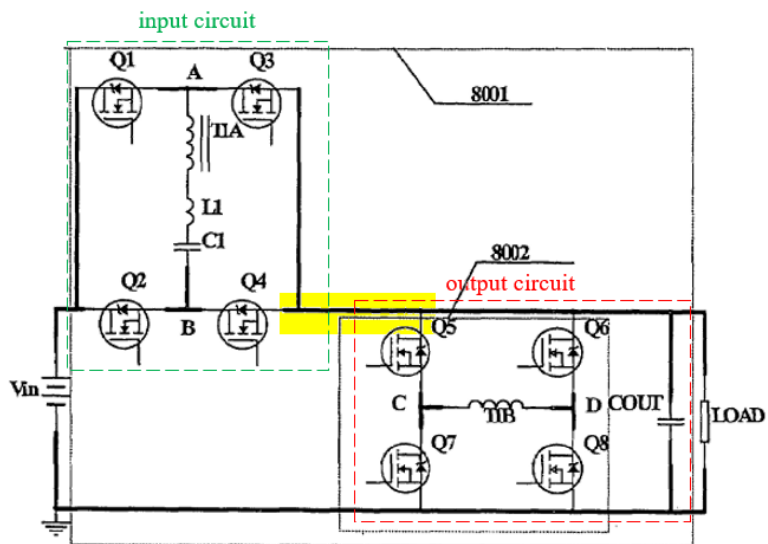
- f. Limitation 1(f): wherein the input circuit of the bus converter and at least a portion of the output circuit of the bus converter are galvanically connected in series across the source such that an absolute value of the input voltage V_{IN} applied to the input circuit is approximately equal to the absolute value of the DC source voltage V_S minus a number N times the absolute value of the output voltage V_{OUT} , where N is at least 1;*

257. A series connection between the input circuit (green) and the output circuit (red) in Figure 15 of Liu is highlighted in yellow below:



Ex. 1006, Figure 15 (annotations added).

258. A series connection between the input circuit (green) and the output circuit (red) in Figure 80 of Liu is highlighted in yellow below:



Ex. 1006, Figure 80 (annotations added).

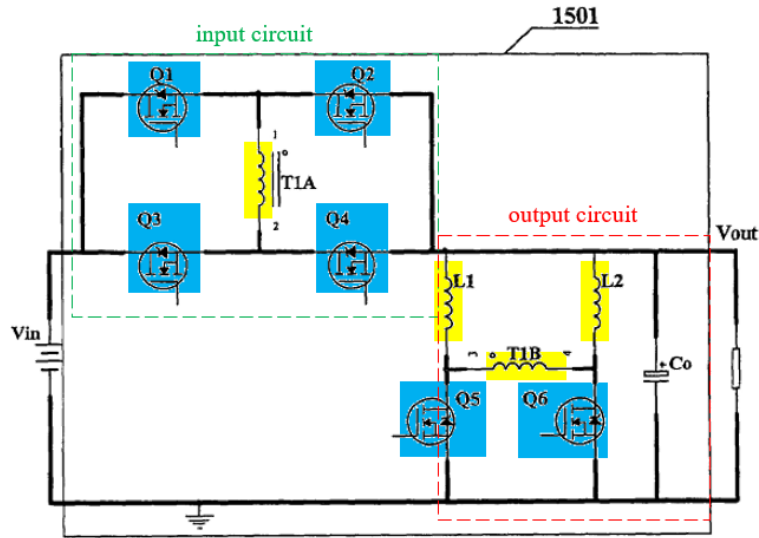
259. Galvanic connection refers to whether or not there is a direct electrical charge connection between functional sections of the system, *i.e.*, the input and

output circuit. Specifically, galvanic contact requires that there not be isolation between the components. Because the input circuit and output circuit are serially connected and non-isolated, they are galvanically connected.

260. Further, as discussed above, the voltage V_{IN} applied to the input circuit is $V_{in} - V_{out}$, where V_{in} is the DC source voltage, V_S . In other words, the voltage applied to the input circuit (V_{IN}) is equal to the DC source voltage (V_S) less the output voltage V_{OUT} . Thus, the input voltage V_{IN} is equal to the DC source voltage V_S minus a number N times the output voltage V_{OUT} , where N is exactly 1. *Id.*

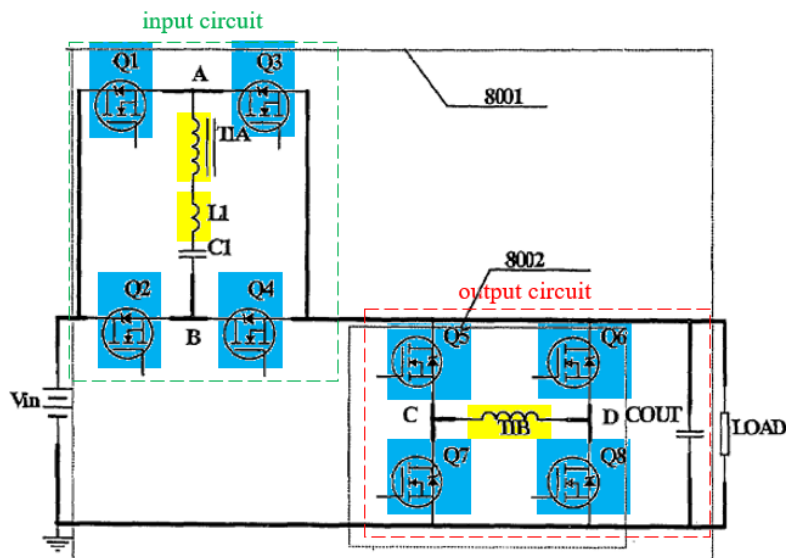
g. Limitation 1(g): wherein the bus converter comprises an inductive component and one or more power switches in the input circuit, the output circuit, or both; and

261. Liu discloses that both the input circuit and output circuit of the converter depicted in Figure 15 have inductive components, namely primary transformer winding T1A in the input circuit and secondary transformer winding T1B and inductors L1 and L2 in the output circuit, all highlighted in yellow below. The input and output circuits also comprise power switches, highlighted in blue.



Ex. 1006, Figure 15 (annotations added), 16:18-44.

262. Both the input circuit and output circuit of Figure 80 also have inductive components, namely primary transformer winding T1A and inductor L1 in the input circuit and secondary transformer winding T1B in the output circuit, all highlighted in yellow below. The input and output circuits also comprise power switches, highlighted in blue.



Ex. 1006, Figure 80 (annotations added), 32:55-33:7.

- h. Limitation 1(h): wherein a current flowing in the inductive component charges and discharges capacitances in the bus converter reducing a voltage across said one or more switches prior to turning ON said one or more switches.*

263. Like Huang, Liu discloses that an advantage of the disclosed converters is that they can operate in zero voltage switching mode. Ex. 1006, 18:20-31, 36:30-33. As a person of ordinary skill in the art would understand, zero voltage switching means that the switches turn ON once the voltage across them reaches near zero. With respect to the converter shown in Figure 15, Liu specifically notes that ZVS “for Q1, Q2, Q3, and Q4 can be achieved by *the leakage inductance of the transformer T1* and by the load current” by using phase-shift PWM control, such as the phase-shift PWM control gate drive scheme depicted in Figure 20. Ex. 1006, 18:24-28 (emphasis added). Using these phase-shift PWM controls, there is a time when Q1 will be turned OFF while Q4 is still on. At this time, the current reflected from the secondary side (i.e., the current flowing through the primary winding) charges the capacitance of Q1. At the same time, the antiparallel diode of the off-switch, Q2, provides a path for the current which in turn discharges the capacitance of Q2, reducing the voltage across Q2 to near zero. Q2 is then turned on, achieving zero voltage turn on. After Q2 is turned on, and while Q5 is still on, the secondary side of the transformer is shorted, causing the primary and secondary sides of the transformer to be decoupled, i.e., electrical energy is prevented from transferring

between the windings of the transformer. Q4 is then turned off, and switch Q2 is still on. In this configuration, the leakage inductance of the transformer will charge the capacitance of Q4 and discharge the capacitance of Q3, reducing the voltage across Q3 to near zero. Q3 is then turned on, achieving zero voltage turn on.

264. With respect to the converter shown in Figure 80, a POSITA would have known that ZVS would be achieved using the resonant tank in the high-side circuit. Specifically, when switches are OFF, the resonant tank (including the transformer) resonates. This traverses the voltage across the OFF switches from zero to their peak, and then back down again to zero. The OFF switches are then turned ON, when their voltage is zero.

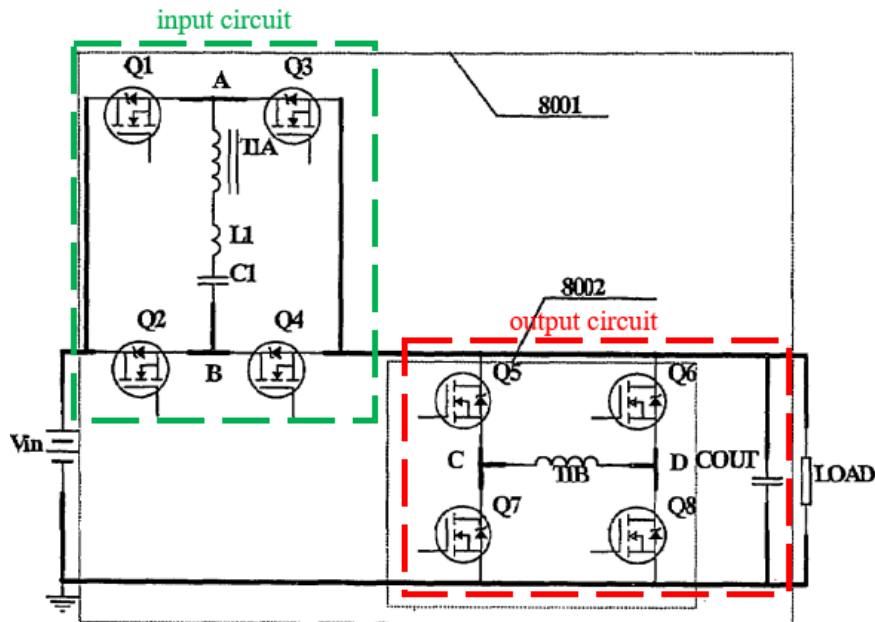
265. Thus, the transformers in both Liu's Figure 15 and 80 circuits charges and discharges capacitances in the bus converter reducing a voltage across said one or more switches prior to turning ON said one or more switches.

2. Dependent Claim 2

The apparatus of claim 1, wherein both the input circuit and the output circuit comprise full-bridge circuits, wherein the input circuit comprises a winding having a first number of turns, wherein the output circuit comprises a winding having a second number of turns, and wherein

the voltage transformation ratio is a function of a ratio of the first number of turns to the second number of turns.

266. For the reasons I discussed above, Liu renders obvious claim 1. As can be seen below, the input and output circuits of Liu's Figure 80 converter comprise full-bridge circuits, which can be seen in their use of four switches each.



Ex. 1006, Figure 80 (annotations added).

267. The input circuit comprises transformer primary winding T1A, and the output circuit has transformer secondary winding T1B. T1A and T1B each have a number of turns. *See, e.g., 17:5-15* (noting possibility of 2 turns in secondary winding and 3 in primary). As discussed above for claim limitation 1(c), the the voltage transformation ratio is a function of a ratio of the first number of turns to the second number of turns, N.

3. **Dependent Claim 6**

The apparatus of claim 1, wherein the bus converter is a self-contained assembly adapted to be installed as a unit.

268. For the reasons discussed above, Liu renders obvious claim 1. And as discussed previously, the '950 Patent acknowledges that IBA was known in the art at the time of invention. Ex. 1001, 1:13-35. IBA included a bus converter that included, for example, a DC-DC converter such as that disclosed by Liu. *Id.*; Ex. 1005, Figure 12(b). As previously discussed for claim limitations 1(c) and 1(d), a POSITA would have known that a DC-DC converter such as Liu's may be used alone or as part of a bus converter. Moreover, it was known that bus converters would comprise self-contained assemblies adapted to be installed as units into computing systems. *Id.*

4. **Dependent Claim 7**

The apparatus of claim 1, further comprising a circuit board, wherein the bus converter and at least one regulator are assembled to the circuit board, and the regulator is configured to supply power to an integrated circuit.

269. For the reasons discussed above, Liu renders obvious claim 1. Moreover, it was known at the time of the alleged invention that bus converters and regulators could be assembled onto a circuit board with one another. And, as claimed in claim 1, it was known in the art at the time of the alleged invention that regulators would provide power to a load. When the regulator was mounted to the same circuit

board as the bus converter, rather than the same circuit board as the load, the regulator would necessarily provide power to the integrated circuit as the load.

5. Dependent Claim 8

The apparatus of claim 1, further comprising a clamp circuit connected to prevent the output voltage, V_{OUT} , from exceeding a predetermined level.

270. For the reasons discussed above, Liu renders obvious claim 1. Liu discloses that a snubber circuit may be added to the output circuit (rectifier circuit) to reduce power dissipation. Ex. 1006, 15:24-26. A POSITA would have known that snubber circuits act as protection by limiting or stopping voltage spikes. For example, a snubber circuit may switch voltage amplitude and the rate of its rise, thereby reducing the total power dissipation. In other words, snubber circuits operate by *clamping* the voltage spikes. Therefore, a POSITA would have understood Liu to disclose connecting a snubber circuit to prevent the output voltage from exceeding a predetermined level. Alternatively, a POSITA would have known that the switch controller could be used to monitor the output voltage and, e.g., turn on one synchronous rectifier transistor to short the output capacitor gathering the leakage current or otherwise switch the circuit to prevent the output voltage from exceeding a predetermined level. In this case, the controller is operating as a “clamp circuit.”

6. Independent Claim 9

- a. *Limitation 9(a): An apparatus comprising:*
- b. *Limitation 9(b): a power converter comprising an input circuit and an output circuit, wherein the power converter is configured to receive power from a power distribution system comprising a source for providing power at a DC source voltage V_S , the power converter being adapted to convert power from the input circuit to the output circuit at a substantially fixed voltage transformation ratio, K_{DC} , at an output current, wherein an input voltage V_{IN} is applied to the input circuit and an output voltage V_{OUT} is produced by the output of the power converter, and wherein the substantially fixed voltage transformation ratio can be represented as $K_{DC}=V_{OUT}/V_{IN}$, wherein the power converter further comprises:*

271. Liu renders obvious this claim limitation for the same reasons I discussed above for claim limitations 1(b) and 1(c).

- c. *Limitation 9(c): a series connection between the input circuit of the power converter and at least a portion of the output circuit of the power converter across the source, such that an absolute value of the input voltage V_{IN} applied to the input circuit is approximately equal to the absolute value of the DC source voltage V_S minus a number N times the absolute value of the output voltage V_{OUT} , where N is at least 1;*

272. Liu renders obvious this claim limitation for the same reasons I discussed above for claim limitation 1(f).

- d. *Limitation 9(d): wherein the power converter comprises an inductive component and one or more power switches in the input circuit, the output circuit, or both; and*

273. Liu renders obvious this claim limitation for the same reasons I discussed above for claim limitation 1(g).

- e. *Limitation 9(e): wherein a current flowing in the inductive component charges and discharges capacitances in the power converter reducing a voltage across said one or more switches prior to turning ON said one or more switches.*

274. Liu renders obvious this claim limitation for the same reasons I discussed above for claim limitation 1(h).

7. **Dependent Claim 10**

The apparatus of claim 9, wherein both the input circuit and the output circuit comprise full-bridge circuits, wherein the input circuit comprises a winding having a first number of turns, wherein the output circuit comprises a winding having a second number of turns, and wherein the voltage transformation ratio is a function of a ratio of the first number of turns to the second number of turns.

275. For the reasons discussed above, Liu renders obvious claim 9. Liu renders obvious this claim limitation for the same reasons I discussed above for claim 2.

8. Dependent Claim 14

The apparatus of claim 9, wherein the power converter is part of a bus converter that is a self-contained assembly adapted to be installed as a unit.

276. For the reasons discussed above, Liu renders obvious claim 9. Liu renders obvious this claim limitation for the same reasons I discussed above for claim 6.

9. Dependent Claim 15

The apparatus of claim 9, further comprising a circuit board, and wherein the power converter is configured to supply power to a plurality of regulators over a power distribution bus, the regulators disposed at a distance to the power converter, and wherein at least one of the regulators is assembled to the circuit board and configured to supply power to an integrated circuit.

277. For the reasons discussed above, Liu renders obvious claim 9. Liu renders obvious this claim limitation for the same reasons I discussed above for claim limitations 1(d) and 1(e) and claim 7.

10. Independent Claim 16

- a. *Limitation 16(a): An apparatus comprising:*
- b. *Limitation 16(b): a bus converter comprising an input circuit and an output circuit, wherein the bus converter is configured to receive power from a power distribution system comprising a source for providing power at a DC source voltage V_S , the bus converter being adapted to convert power from the input circuit to the output circuit at a substantially fixed voltage transformation ratio, K_{DC} , at an output current, wherein an input voltage V_{IN} is applied to the input circuit and an output voltage V_{OUT} is*

produced by the output of the bus converter, and wherein the substantially fixed voltage transformation ratio can be represented as $K_{DC}=V_{OUT}/V_{IN}$;

278. Liu renders obvious this claim limitation for the same reasons I discussed above for claim limitations 1(b) and 1(c).

- c. Limitation 16(c): a power distribution bus connected to distribute power from the output circuit of the bus converter at the output voltage V_{OUT} ; and*

279. Liu renders obvious this claim limitation for the same reasons I discussed above for claim limitation 1(d).

- d. Limitation 16(d): a plurality of regulators, wherein each regulator comprises a regulator input connected to the power distribution bus to receive power from the output circuit of the bus converter and a regulator output connected to supply power to a respective load, the plurality of regulators each being separated by a distance from the bus converter;*

280. Liu renders obvious this claim limitation for the same reasons I discussed above for claim limitation 1(e).

- e. Limitation 16(e): wherein the input circuit of the bus converter and at least a portion of the output circuit of the bus converter are connected in series across the source such that an absolute value of the input voltage V_{IN} applied to the input circuit is approximately equal to the absolute value of the DC source voltage V_S minus a number N times the absolute value of the output voltage V_{OUT} , where N is at least 1;*

281. Liu renders obvious this claim limitation for the same reasons I discussed above for claim limitation 1(f).

f. Limitation 16(f): wherein the bus converter comprises an inductive component and one or more power switches in the input circuit, the output circuit, or both; and

282. Liu renders obvious this claim limitation for the same reasons I discussed above for claim limitation 1(g).

g. Limitation 16(g): wherein a current flowing in the inductive component charges and discharges capacitances in the bus converter reducing a voltage across said one or more switches prior to turning ON said one or more switches.

283. Liu renders obvious this claim limitation for the same reasons I discussed above for claim limitation 1(h).

11. Dependent Claim 17

The apparatus of claim 16, wherein both the input circuit and the output circuit comprise full-bridge circuits, wherein the input circuit comprises a winding having a first number of turns, wherein the output circuit comprises a winding having a second number of turns, and wherein the voltage transformation ratio is a function of a ratio of the first number of turns to the second number of turns.

284. For the reasons discussed above, Liu renders obvious claim 16. Liu renders obvious this claim limitation for the same reasons I discussed above for claim 2.

12. Dependent Claim 19

The apparatus of claim 16, wherein the bus converter is a self-contained assembly adapted to be installed as a unit

285. For the reasons discussed above, Liu renders obvious claim 16. Liu renders obvious this claim limitation for the same reasons I discussed above for claim 6.

13. Independent Claim 22

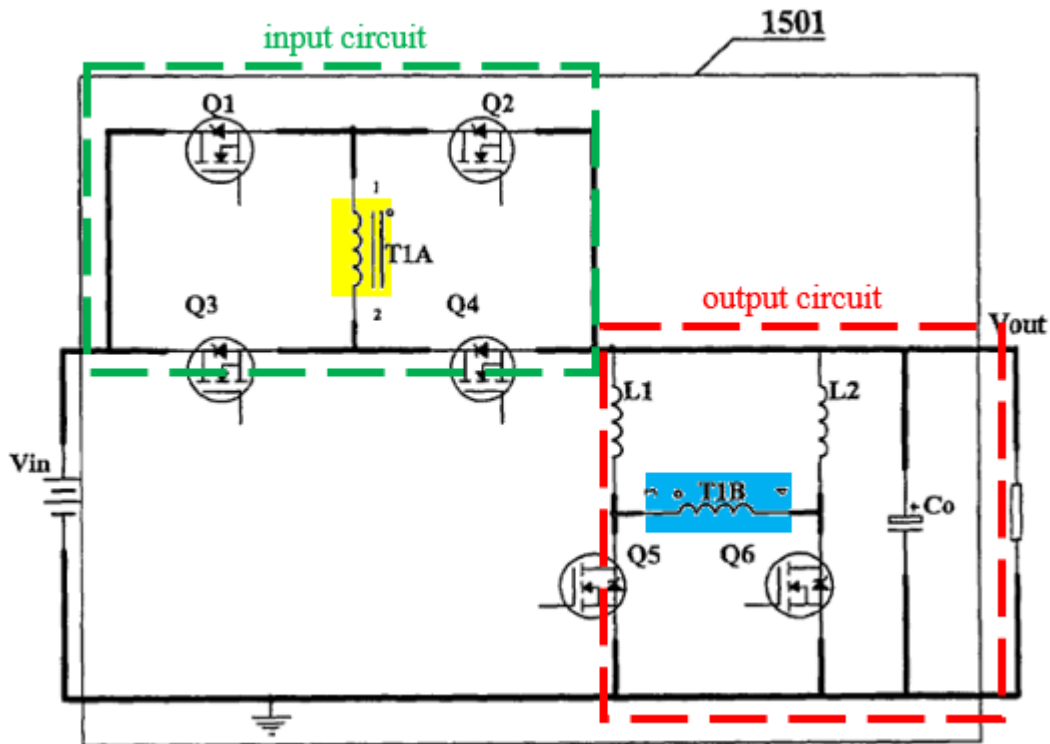
- a. Limitation 22(a): An apparatus comprising:*
- b. Limitation 22(b): an intermediate bus architecture power distribution system for an electrical system comprising a source for providing power at a DC source voltage*

286. Liu renders obvious this claim limitation for the same reasons discussed above for claim limitation 1(b). And, as the '950 Patent acknowledges, IBA was known in the art at the time of invention. Ex. 1001, 1:13-35 (describing IBA configuration as prior art).

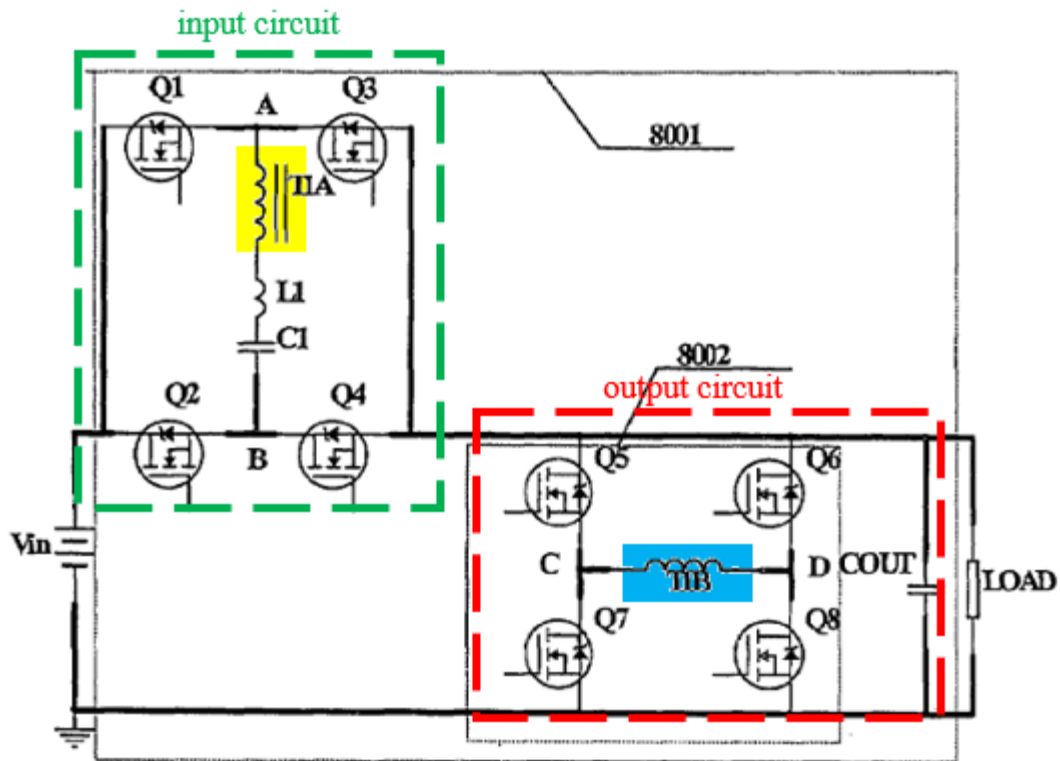
- c. Limitation 22(c): a circuit board comprising a bus converter, the bus converter comprising an input circuit, the input circuit comprising a primary transformer winding, the bus converter further comprising an output circuit, the output circuit comprising a secondary transformer winding, wherein the primary and secondary transformer windings are galvanically connected in series, and wherein the bus converter is configured to provide power to a power distribution bus that is not galvanically isolated from the source; and*

287. As discussed above for claim limitation 1(c), a POSITA would have known that Liu's converters could be used as part of a bus converter.

288. The input and output circuits are outlined in green and red, respectively, for both the Figure 15 and Figure 80 converters of Liu below. The primary transformer winding within the input circuit is highlighted in yellow while the secondary winding is highlighted in blue:

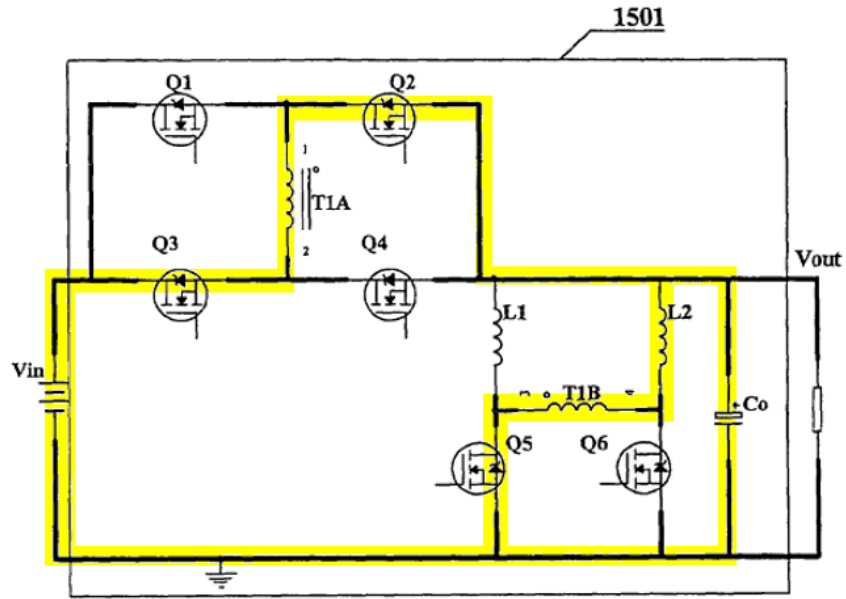


Ex. 1006, Figure 15 (annotations added).

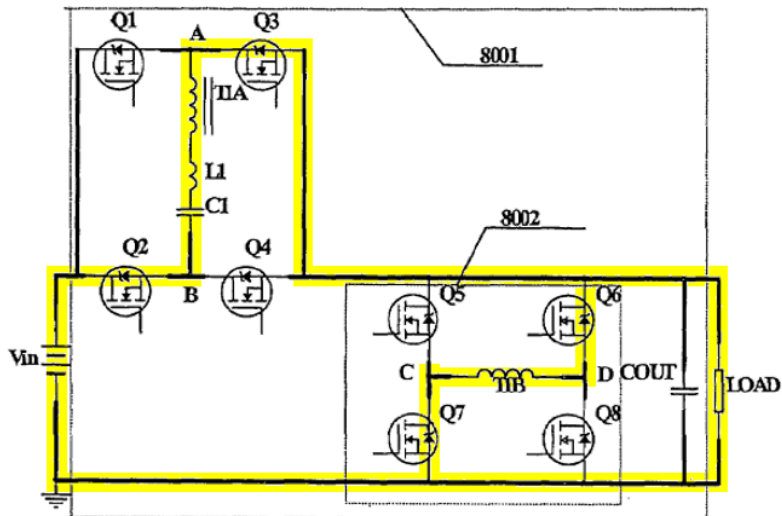


Ex. 1006, Figure 80 (annotations added).

289. Further, the input and output circuits are galvanically connected in series, as can be seen by the direct connection between them (yellow):



Ex. 1006, Figure 15 (annotations added).



Ex. 1006, Figure 80 (annotations added).

290. Liu's Figure 15 and Figure 80 converters are therefore also configured to provide power to a power distribution bus that is not galvanically isolated from

the source because they do not provide galvanic isolation between the source (V_{in}) and the power provided to the power distribution bus (V_o).

- d. *Limitation 22(d): the circuit board further comprising a plurality of regulators, wherein each regulator comprises a regulator input connected to the power distribution bus to receive power from the output circuit of the bus converter and a regulator output connected to supply power to a respective load, the plurality of regulators each being separated by a distance from the bus converter.*

291. Liu renders obvious this claim limitation for the same reasons I discussed above for claim limitation 1(e).

14. **Dependent Claim 23**

- a. *Limitation 23(a): The apparatus of claim 22, wherein the bus converter is adapted to convert power from the input circuit to the output circuit at a substantially fixed voltage transformation ratio, K_{DC} , at an output current, wherein an input voltage V_{IN} is applied to the input circuit and an output voltage V_{OUT} is produced by the output of the bus converter, and wherein the substantially fixed voltage transformation ratio can be represented as $K_{DC}=V_{OUT}/V_{IN}$; and*

292. For the reasons discussed above, Liu renders obvious claim 22. Liu also renders obvious this claim limitation for the same reasons I discussed above for claim limitation 1(c).

- b. *Limitation 23(b): wherein the input circuit of the bus converter and at least a portion of the output circuit of the bus converter are connected such that an absolute value of the input voltage V_{IN} applied to the input circuit is approximately equal to the absolute value of the DC*

source voltage V_S minus a number N times the absolute value of the output voltage V_{OUT} , where N is at least 1.

293. Liu renders obvious this claim limitation for the same reasons I discussed above for claim limitation 1(f).

15. Dependent Claim 24

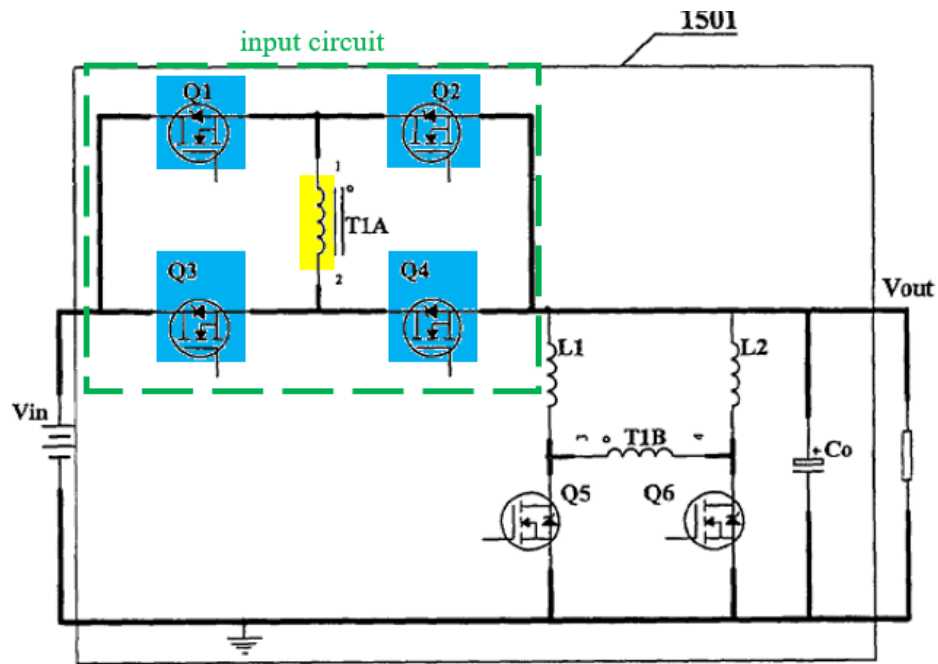
The apparatus of claim 22, wherein the bus converter is a self-contained assembly adapted to be installed as a unit.

294. For the reasons discussed above, Liu renders obvious claim 22. Liu renders also obvious this claim limitation for the same reasons I discussed above for claim 6.

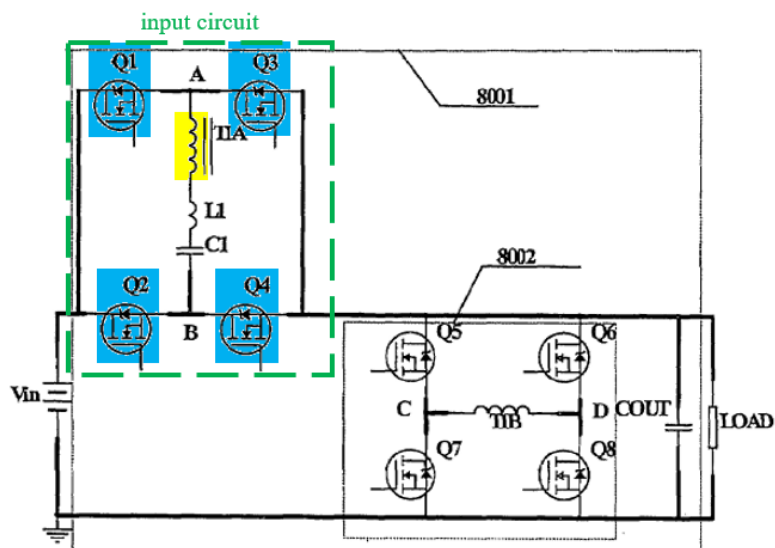
16. Dependent Claim 25

The apparatus of claim 1 wherein the input circuit comprises a primary winding and primary switches connected to the primary winding, the output circuit comprises a secondary winding and secondary switches connected to the secondary winding, and a controller for operating the switches in a series of converter operating cycles, wherein the primary and secondary windings are connected in series during at least a portion of each converter operating cycle.

295. For the reasons discussed above, Liu renders obvious claim 1. Below, I have outlined the input circuits of Liu's Figure 15 and Figure 80 converters in green, with the transformer primary winding highlighted in yellow and the primary switches connected to the transformer primary winding highlighted in blue:

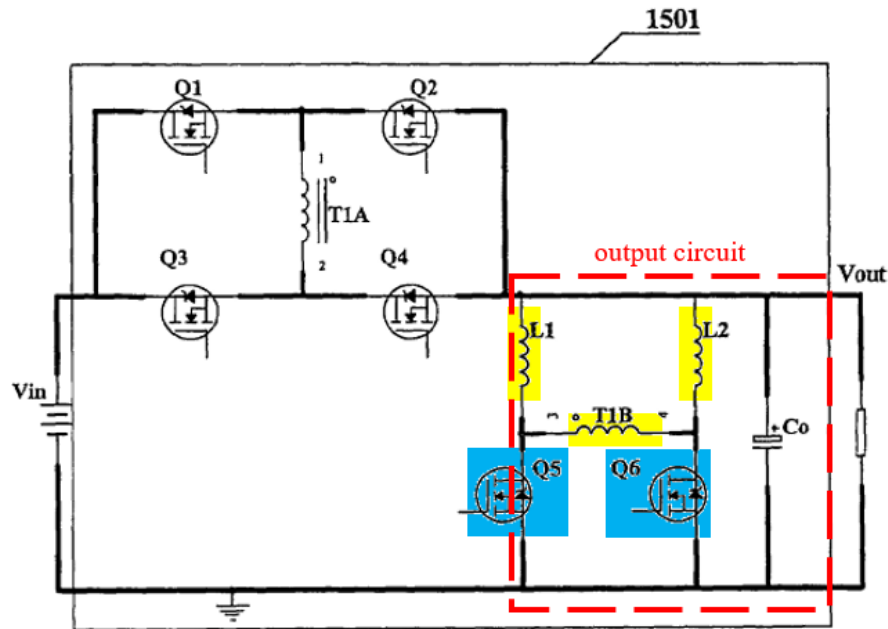


Ex. 1006, Figure 15 (annotations added).

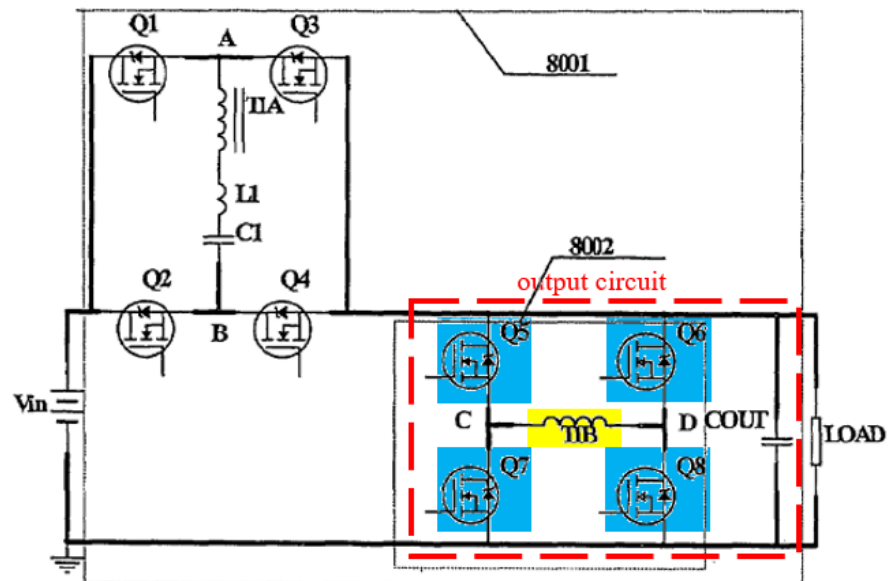


Ex. 1006, Figure 80 (annotations added).

296. I have outlined the output circuits in red below, with the transformer secondary windings highlighted in yellow and the secondary switches connected to the secondary winding highlighted in blue:

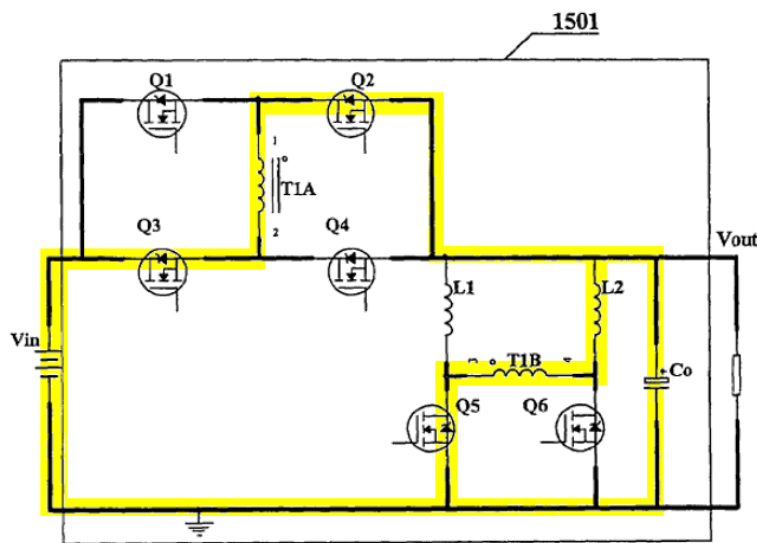


Ex. 1006, Figure 15 (annotations added).

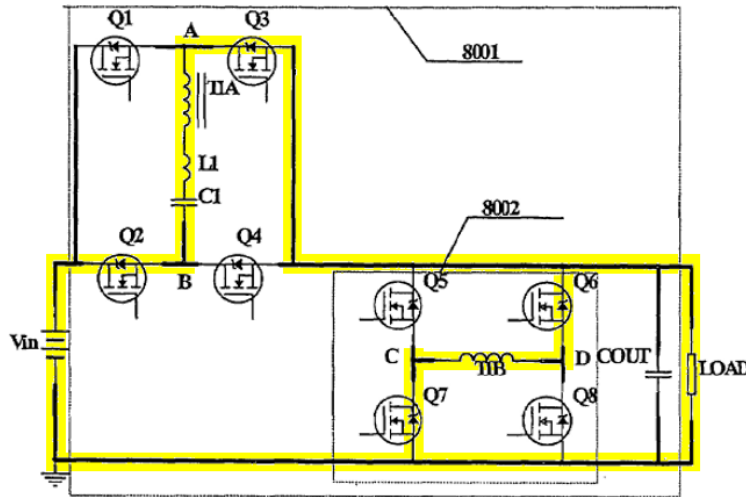


Ex. 1006, Figure 80 (annotations added).

297. As I have discussed in greater detail above for claim limitation 1(h), the primary and secondary switches are operated (i.e., switched on or off, closed or open). A POSITA would have understood that operation of the switches and converter would require a controller. In Figure 15, the primary and secondary windings are connected in series when either of Q1, Q4, and Q6 or Q2, Q3, and Q5 are on/closed. In Figure 80, the primary and secondary windings are connected in series when either of Q1, Q4, Q5, and Q8 or Q2, Q3, Q6, and Q7 are on/closed.



Ex. 1006, Figure 15 (annotations added).



Ex. 1006, Figure 80 (annotations added).

17. Dependent Claim 26

The apparatus of claim 9 wherein the input circuit comprises a primary winding and primary switches connected to the primary winding, the output circuit comprises a secondary winding and secondary switches connected to the secondary winding, and a controller for operating the switches in a series of converter operating cycles, wherein the primary and secondary windings are connected in series during at least a portion of each converter operating cycle.

298. For the reasons discussed above, Liu renders obvious claim 9. Liu also renders obvious this claim limitation for the same reasons I discussed above for claim 25.

18. Dependent Claim 27

The apparatus of claim 16 wherein the input circuit comprises a primary winding and primary switches connected to the primary winding, the output circuit comprises a secondary winding and secondary switches connected to the secondary winding, and a controller for

operating the switches in a series of converter operating cycles, wherein the primary and secondary windings are connected in series during at least a portion of each converter operating cycle.

299. For the reasons discussed above, Liu renders obvious claim 16. Liu also renders obvious this claim limitation for the same reasons I discussed above for claim 25.

19. Dependent Claim 28

The apparatus of claim 1 wherein the voltage across said one or more power switches is reduced to essentially zero volts prior to turning ON said one or more switches

300. For the reasons discussed above, Liu renders obvious claim 1. Liu also renders obvious this claim limitation for the same reasons I discussed above for claim limitation 1(h).

20. Independent Claim 29

- a. Limitation 29(a): An apparatus comprising:*
- b. Limitation 29(b): a power distribution system comprising a source for providing power at a DC source voltage V_S ;*

301. Liu renders obvious this claim limitation for the same reasons I discussed above for claim limitation 1(b).

- c. Limitation 29(c): a bus converter comprising an input circuit and an output circuit, the bus converter being adapted to convert power from the input circuit to the output circuit at a substantially fixed voltage transformation ratio, K_{DC} , at an output current, wherein an input voltage V_{IN} is applied to the input circuit and an output voltage V_{OUT} is produced by the output of the bus*

converter, and wherein the substantially fixed voltage transformation ratio can be represented as $K_{DC}=V_{OUT}/V_{IN}$;

302. Liu renders obvious this claim limitation for the same reasons I discussed above for claim limitation 1(c).

d. Limitation 29(d): a power distribution bus connected to distribute power from the output circuit of the bus converter at the output voltage V_{OUT} ; and

303. Liu renders obvious this claim limitation for the same reasons I discussed above for claim limitation 1(d).

e. Limitation 29(e): a plurality of regulators, wherein each regulator comprises a regulator input connected to the power distribution bus to receive power from the output circuit of the bus converter and a regulator output connected to supply power to a respective load, the plurality of regulators each being separated by a distance from the bus converter;

304. Liu renders obvious this claim limitation for the same reasons I discussed above for claim limitation 1(e).

f. Limitation 29(f): wherein the input circuit of the bus converter and the output circuit of the bus converter are galvanically connected; and

305. Liu renders obvious this claim limitation for the same reasons I discussed above for claim limitation 1(f).

- g. *Limitation 29(g): wherein the bus converter comprises an inductive component and one or more power switches in the input circuit or output circuit or both; and*

306. Liu renders obvious this claim limitation for the same reasons I discussed above for claim limitation 1(g).

- h. *Limitation 29(h): wherein a current flowing in the inductive component charges and discharges capacitances in the converter reducing a voltage across said one or more switches prior to turn ON of said one or more switches.*

307. Liu renders obvious this claim limitation for the same reasons I discussed above for claim limitation 1(h).

21. Dependent Claim 30

The apparatus of claim 29 wherein the voltage across said one or more switches is reduced to essentially zero volts prior to turn ON of said one or more switches.

308. For the reasons discussed above, Liu renders obvious claim 29. Liu also renders obvious this claim limitation for the same reasons I discussed above for claim limitation 1(h).

22. Independent Claim 31

- a. *Limitation 31(a): An apparatus comprising:*
- b. *Limitation 31(b): a power distribution system comprising a source for providing power at a DC source voltage V_S ;*

309. Liu renders obvious this claim for the same reasons I discussed above for claim limitation 1(b).

- c. *Limitation 31(c): a bus converter comprising an input circuit and an output circuit, the bus converter being adapted to convert power from the input circuit to the output circuit at a substantially fixed voltage transformation ratio, K_{DC} , at an output current, wherein an input voltage V_{IN} is applied to the input circuit and an output voltage V_{OUT} is produced by the output of the bus converter, and wherein the substantially fixed voltage transformation ratio can be represented as $K_{DC}=V_{OUT}/V_{IN}$;*

310. Liu renders obvious this claim for the same reasons I discussed above for claim limitation 1(c).

- d. *Limitation 31(d): a power distribution bus connected to distribute power from the output circuit of the bus converter at the output voltage V_{OUT} ; and*

311. Liu renders obvious this claim for the same reasons I discussed above for claim limitation 1(d).

- e. *Limitation 31(e): a plurality of regulators, wherein each regulator comprises a regulator input connected to the power distribution bus to receive power from the output circuit of the bus converter and a regulator output connected to supply power to a respective load, the plurality of regulators each being separated by a distance from the bus converter;*

312. Liu renders obvious this claim for the same reasons I discussed above for claim limitation 1(e).

- f. *Limitation 31(f): wherein the input circuit comprises a winding having a first number of turns, wherein the output circuit comprises a winding having a second number of turns, and wherein the voltage transformation ratio is a*

function of a ratio of the first number of turns to the second number of turns; and

313. Liu renders obvious this claim for the same reasons I discussed above for claim limitation 1(c).

- g. Limitation 31(g): wherein the input circuit of the bus converter and at least a portion of the output circuit of the bus converter are connected in series across the source such that an absolute value of the input voltage V_{IN} applied to the input circuit is approximately equal to the absolute value of the DC source voltage V_S minus a number N times the absolute value of the output voltage V_{OUT} , where N is at least 1.*

314. Liu renders obvious this claim for the same reasons I discussed above for claim limitation 1(f).

23. Independent Claim 32

- a. Limitation 32(a): An apparatus comprising:*
- b. Limitation 32(b): a power distribution system comprising a source for providing power at a DC source voltage V_S ;*

315. Liu renders obvious this claim for the same reasons I discussed above for claim limitation 1(b).

- c. Limitation 32(c): a bus converter comprising an input circuit and an output circuit, the bus converter being adapted to convert power from the input circuit to the output circuit at a substantially fixed voltage transformation ratio, K_{DC} , at an output current, wherein an input voltage V_{IN} is applied to the input circuit and an output voltage V_{OUT} is produced by the output of the bus*

converter, and wherein the substantially fixed voltage transformation ratio can be represented as $K_{DC}=V_{OUT}/V_{IN}$;

316. Liu renders obvious this claim for the same reasons I discussed above for claim limitation 1(c).

d. Limitation 32(d): a power distribution bus connected to distribute power from the output circuit of the bus converter at the output voltage V_{OUT} ; and

317. Liu renders obvious this claim for the same reasons I discussed above for claim limitation 1(d).

e. Limitation 32(e): a plurality of regulators, wherein each regulator comprises a regulator input connected to the power distribution bus to receive power from the output circuit of the bus converter and a regulator output connected to supply power to a respective load, the plurality of regulators each being separated by a distance from the bus converter;

318. Liu renders obvious this claim for the same reasons I discussed above for claim limitation 1(e).

f. Limitation 32(f): wherein the input circuit comprises a winding having a first number of turns, wherein the output circuit comprises a winding having a second number of turns, and wherein the voltage transformation ratio is a function of a ratio of the first number of turns to the second number of turns; and

319. Liu renders obvious this claim for the same reasons I discussed above for claim limitation 1(c).

- g. *Limitation 32(g): wherein the input circuit of the bus converter and the output circuit of the bus converter are galvanically connected.*

320. Liu renders obvious this claim for the same reasons I discussed above for claim limitation 1(f).

24. Independent Claim 33

- a. *Limitation 33(a): An apparatus comprising:*
- b. *Limitation 33(b): a bus converter comprising an input circuit and an output circuit, the bus converter being adapted to convert power from the input circuit to the output circuit at a substantially fixed voltage transformation ratio, K_{DC} , at an output current, wherein an input voltage V_{IN} is applied to the input circuit and an output voltage V_{OUT} is produced by the output of the bus converter, and wherein the substantially fixed voltage transformation ratio can be represented as $K_{DC}=V_{OUT}/V_{IN}$;*

321. Liu renders obvious this claim limitation for the same reasons I discussed above with respect to claim limitation 1(c).

- c. *Limitation 33(c): wherein the input circuit of the bus converter and the output circuit of the bus converter are galvanically connected; and*

322. Liu renders obvious this claim limitation for the same reasons I discussed above with respect to claim limitation 1(f).

- d. *Limitation 33(d): wherein the bus converter comprises an inductive component and one or more power switches in the input circuit or output circuit or both; and*

323. Liu renders obvious this claim limitation for the same reasons I discussed above with respect to claim limitation 1(g).

- e. *Limitation 33(e): wherein a current flowing in the inductive component charges and discharges capacitances in the converter reducing a voltage across said one or more switches prior to turn ON said one or more switches.*

324. Liu renders obvious this claim limitation for the same reasons I discussed above with respect to claim limitation 1(h).

25. Dependent Claim 35

The apparatus of claim 33 wherein the voltage across said one or more switches is reduced to essentially zero volts prior to turn ON of said one or more switches.

325. For the reasons discussed above, Liu renders obvious claim 33. Liu also renders obvious this claim for the same reasons I discussed above for claim 28.

26. Dependent Claim 36

The apparatus of claim 33 wherein the input circuit of the bus converter and at least a portion of the output circuit of the bus converter are connected in series across the source such that an absolute value of the input voltage V_{IN} applied to the input circuit is approximately equal to the absolute value of the DC source voltage V_S minus a number N times the absolute value of the output voltage V_{OUT} , where N is at least 1.

326. For the reasons discussed above, Liu renders obvious claim 33. Liu renders obvious this claim for the same reasons I discussed above with respect to claim limitation 1(f).

27. Dependent Claim 37

The apparatus of claim 33, wherein the input circuit comprises a first winding having a first number of turns,

wherein the output circuit comprises a second winding having a second number of turns, and wherein the voltage transformation ratio is a function of a ratio of the first number of turns to the second number of turns.

327. For the reasons discussed above, Liu renders obvious claim 33. Liu also renders obvious this claim for the same reasons I discussed above with respect to claim 2.

28. Dependent Claim 39

The apparatus of claim 22 wherein the bus converter comprises an inductive component and one or more power switches in the input circuit, the output circuit, or both, and wherein a current flowing in the inductive component charges and discharges capacitances in the bus converter reducing a voltage across said one or more switches prior to turning ON said one or more switches.

328. For the reasons discussed above, Liu renders obvious claim 22. Liu also renders obvious this claim for the same reasons I discussed above for claim limitations 1(g) and 1(h).

29. Dependent Claim 40

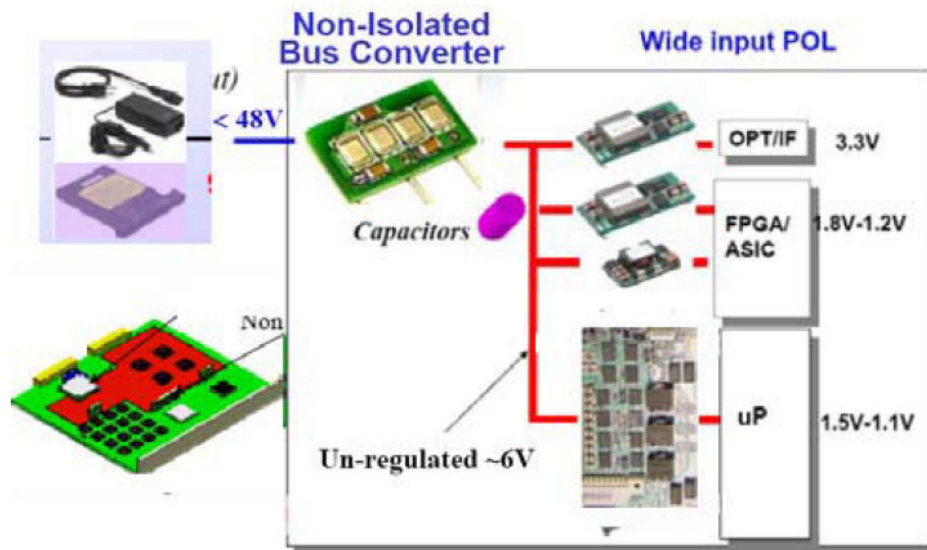
The apparatus of claim 22 wherein at least one of the regulators is assembled to the circuit board and configured to supply power to an integrated circuit.

329. For the reasons discussed above, Liu renders obvious claim 22. Liu renders obvious this claim for the same reasons I discussed above for claim 7.

E. Ground VI: Claims 1, 2, 6-8, 10, 14-17, 19, 22-33, 35-37, and 39-40 Are Obvious Over Liu In View Of Lee

1. Motivation to Combine

330. A POSITA would have been motivated to combine Liu and Lee. Liu discloses a number of DC-DC converters that can achieve zero voltage switching and other efficiencies. *See* Ex. 1006, 36:20-33. Lee discusses design challenges and opportunities for a variety of power supply applications, including DC-DC converters. Ex. 1008, 1. Opportunities discussed include cost savings, performance improvements, and chip size. *Id.* Lee specifically proposes a non-isolated intermediate bus architecture, depicted below in Figure 43. *Id.*, 12, Figure 43. This architecture includes a non-isolated bus converter designed to minimize switching losses and body diode losses at high switching frequencies and increase circuit efficiency. *Id.*, 11-12.



Ex. 1008, Figure 43.

331. Lee discloses using a “voltage divider” DC-DC converter that can achieve high power density and “ultra-high efficiency in the whole load range with capability to handle over load conditions” as the non-isolated bus converter in Lee’s architecture. *Id.* at 12.

332. It would have been obvious to a POSITA to use the DC-DC converters disclosed in Liu in the intermediate bus architecture disclosed in Lee. **First**, a POSITA would understand that the “non-isolated bus converter” of Lee’s proposed architecture is a power converting circuit that could take many forms, including the DC-DC converter disclosed by Liu.

333. **Second**, Liu contemplates the use of the disclosed converters in, for example, personal computer applications. *See, e.g.*, Ex. 1006, 1:37-47, 13:3-6. It would have been obvious to a POSITA to try Liu’s higher efficiency converters as the non-isolated bus converters in the non-isolated intermediate bus architecture proposed by Lee in place of Lee’s DC-DC “voltage divider”: there were limited options for non-isolated converters, and Liu’s non-isolated DC-DC converters were specifically designed for the same purpose as Lee’s voltage divider, i.e., to improve operating efficiency. Ex. 1006, 36:20-33; Ex. 1008, 12. A POSITA would have had a reasonable expectation of success in using Liu’s converters in the intermediate bus architecture disclosed in Lee because, as shown in Lee Figure 43, it was

contemplated that the non-isolated bus converter would be a modular, and thus replaceable, component.

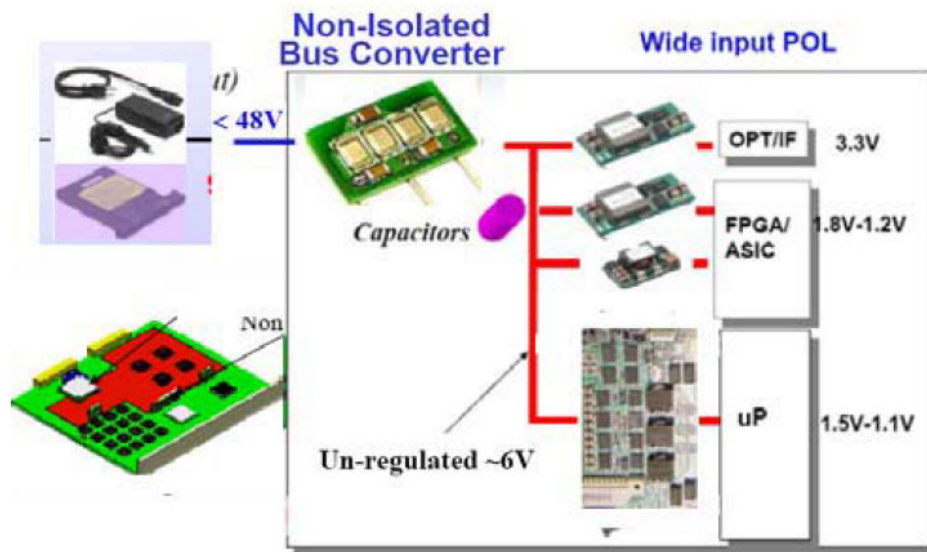
334. **Third**, a POSITA would have specifically been interested in enhancing efficiency considering both Lee and Liu's focus on improving existing converter design to reduce switching and transformer losses. *See, e.g.*, Ex. 1006, 36:20-33; Ex. 1008, 11-12. Both Liu and Lee indicate that a motivation to implement their disclosed inventions is to improve the efficiency of existing circuit design. *See, e.g., id.* Thus, a POSITA would have been motivated to improve the efficiency of the circuit design in other ways, such as including Liu's improved converters in Lee's improved architecture design to improve the overall power conversion efficiency.

335. **Fourth**, use of Lee's intermediate bus architecture with the DC-DC converters disclosed in Liu would have involved mere substitution of one known element (Lee's "voltage divider" as the non-isolated bus converter shown in Figure 43) for another (Liu's DC-DC converters as the non-isolated bus converter) to obtain predictable results (more efficient power conversion). A POSITA would have recognized using the Liu's converters to be an easy modification to make to Lee's intermediate bus architecture using standard techniques known in the art.

2. Independent Claim 1

- a. *Limitation 1(a): An apparatus comprising:*
- b. *Limitation 1(b): a power distribution system comprising a source for providing power at a DC source voltage V_S ;*

336. Lee's proposed intermediate bus architecture (a power distribution system) includes a 48V DC source voltage, as can be seen in Figure 43:



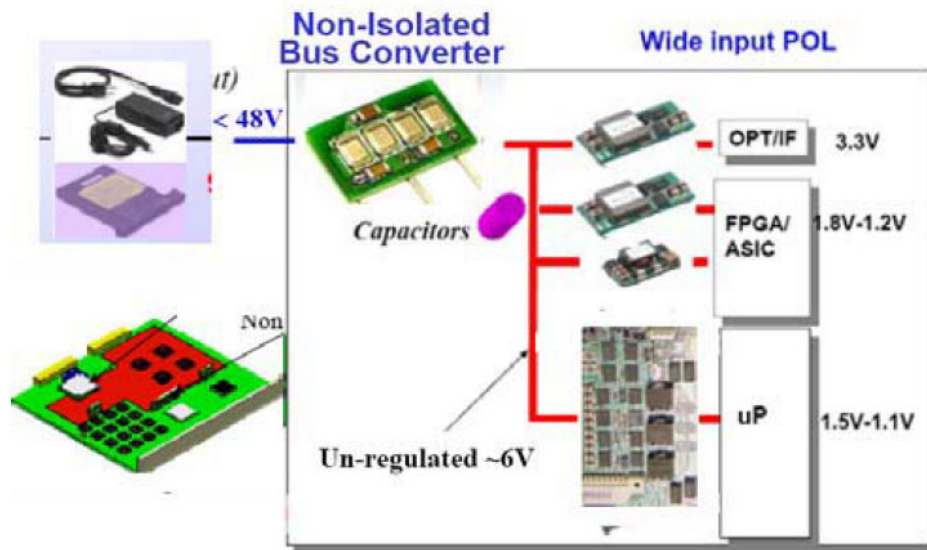
Ex. 1008, Figure 43; *see also id.*, 11-12 (voltage divider disclosed by Lee as a non-isolated bus converter is a DC-DC converter).

337. Liu likewise discloses this claim limitation for the reasons I discussed above for Ground V.

- c. *Limitation 1(c): a bus converter comprising an input circuit and an output circuit, the bus converter being adapted to convert power from the input circuit to the output circuit at a substantially fixed voltage transformation ratio, K_{DC} , at an output current, wherein an input voltage V_{IN} is applied to the input circuit and an output voltage V_{OUT} is produced by the output of the bus*

converter, and wherein the substantially fixed voltage transformation ratio can be represented as $K_{DC} = V_{OUT}/V_{IN}$;

338. Liu's Figure 15 and 80 converters would operate as the non-isolated bus converter Lee's intermediate bus architecture in the combination of Liu and Lee. Lee discloses that the non-isolated bus converter is unregulated, meaning that the transformation ratio of the converter is fixed. Ex. 1008, Figure 43. When Liu's non-isolated converter is substituted into Lee's architecture as the bus converter, the transformation ratio ($\frac{V_{OUT}}{V_S}$) is therefore fixed. Because for Liu's converters $V_{in} = V_S - V_{OUT}$, $\frac{V_{OUT}}{V_{IN}}$ is necessarily also fixed as it depends on other fixed values.

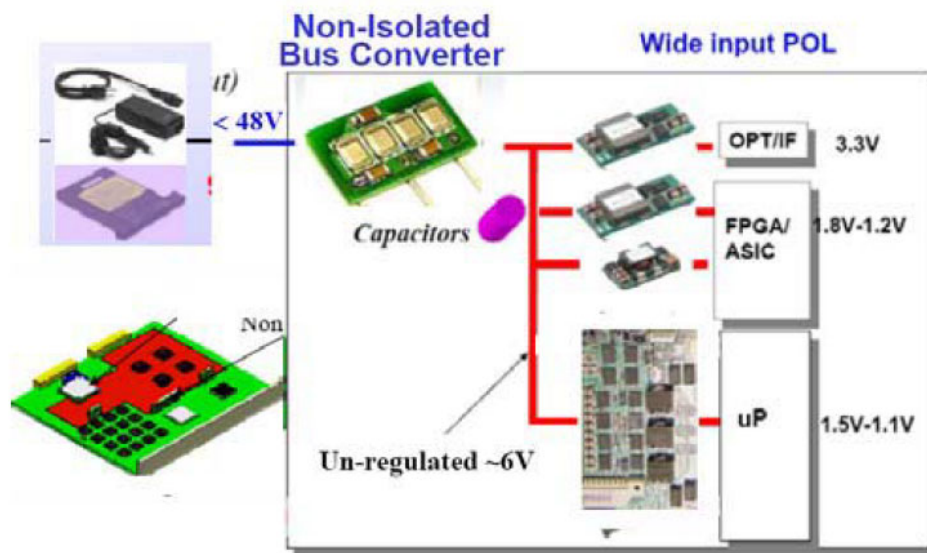


Ex. 1008, Figure 43.

339. Liu's converter comprises the remainder of this limitation as discussed above for Ground V.

- d. *Limitation 1(d): a power distribution bus connected to distribute power from the output circuit of the bus converter at the output voltage V_{OUT} ; and*

340. Lee's intermediate bus architecture includes a power distribution bus (red lines in Figure 43, below) connected to distribute power from the output circuit of the non-isolated bus converter (Liu's Figure 15 or 80 converter) at the output voltage V_{OUT} .

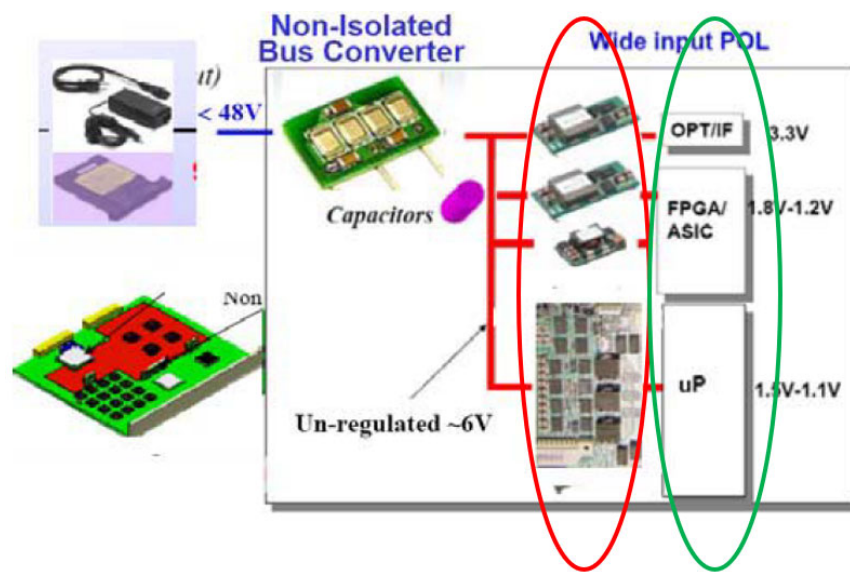


Ex. 1008, Figure 43.

- e. *Limitation 1(e): a plurality of regulators, wherein each regulator comprises a regulator input connected to the power distribution bus to receive power from the output circuit of the bus converter and a regulator output connected to supply power to a respective load, the plurality of regulators each being separated by a distance from the bus converter;*

341. Lee's intermediate bus architecture includes a plurality of regulators, each regulator comprising an input connected to receive power from the output

circuit of the bus converter and an output connected to supply power to a load. Ex. 1008, 11-12. The circuits circled in red in Figure 43 below are the regulators, what Lee refers to as “wide input POLs,” or point-of-load DC-DC converters. Ex. 1008, 8, 11-12. The white boxes circled in green in Figure 43 below are the loads; for example, the center load is an FPGA or ASIC, two types of integrated circuits that ordinarily are off-the-shelf components. *Id.*



Ex. 1008, Figure 43 (annotations added).

342. A POSITA would have recognized the regulators to be distanced from the bus converter for a number of reasons including at least because the bus converter is a separate component from the point-of-load DC-DC converters and the point-of-load DC-DC converters would have been part of the circuit boards comprising the loads themselves (i.e., the point-of-load converters were local to the load, not the bus converter).

- f. Limitation 1(f): wherein the input circuit of the bus converter and at least a portion of the output circuit of the bus converter are galvanically connected in series across the source such that an absolute value of the input voltage V_{IN} applied to the input circuit is approximately equal to the absolute value of the DC source voltage V_S minus a number N times the absolute value of the output voltage V_{OUT} , where N is at least 1;*

343. The combination of Liu and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(f) (Ground V).

- g. Limitation 1(g): wherein the bus converter comprises an inductive component and one or more power switches in the input circuit, the output circuit, or both; and*

344. The combination of Liu and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(g) (Ground V).

- h. Limitation 1(h): wherein a current flowing in the inductive component charges and discharges capacitances in the bus converter reducing a voltage across said one or more switches prior to turning ON said one or more switches.*

345. The combination of Liu and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(h) (Ground V).

3. Dependent Claim 2

The apparatus of claim 1, wherein both the input circuit and the output circuit comprise full-bridge circuits, wherein the input circuit comprises a winding having a first number of turns, wherein the output circuit comprises a winding having a second number of turns, and wherein

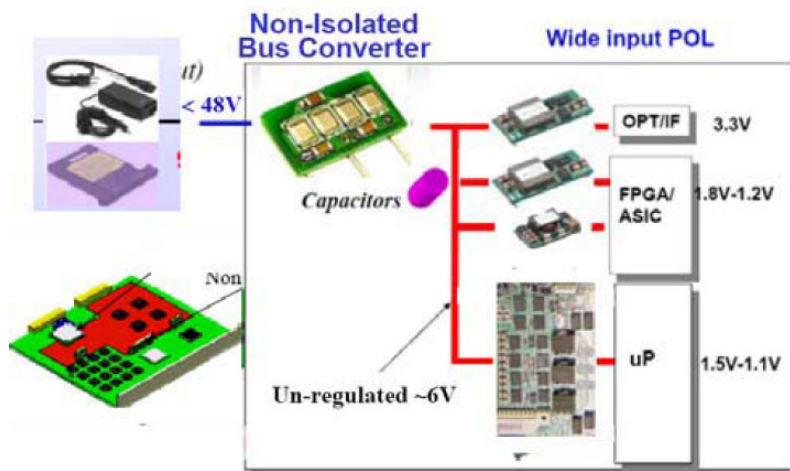
the voltage transformation ratio is a function of a ratio of the first number of turns to the second number of turns.

346. The combination of Liu and Lee renders obvious this claim for the reasons discussed above for claim 1 (Grounds V and VI) and claim 2 (Ground V).

4. **Dependent Claim 6**

The apparatus of claim 1, wherein the bus converter is a self-contained assembly adapted to be installed as a unit.

347. For the reasons I discussed above, Liu renders obvious claim 1 (Grounds V and VI). Liu further renders obvious this claim in combination with Lee. As seen in Figure 43 of Lee, the non-isolated bus converter of the proposed intermediate bus architecture is a self-contained assembly adapted to be installed as a unit:



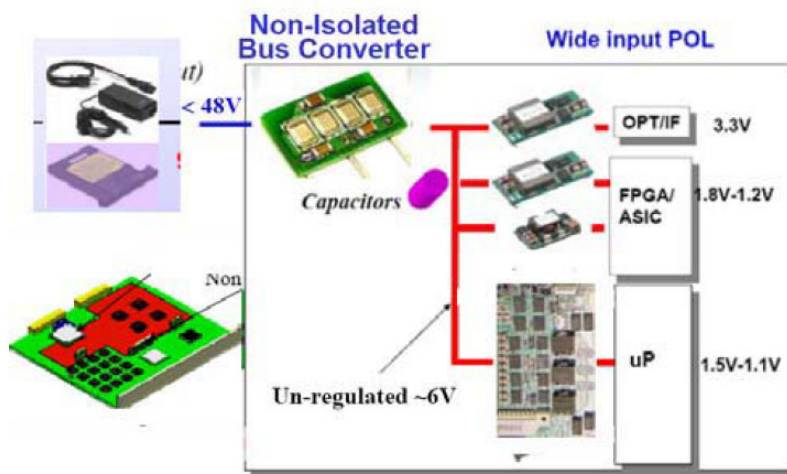
Ex. 1008, Figure 43.

5. **Dependent Claim 7**

The apparatus of claim 1, further comprising a circuit board, wherein the bus converter and at least one

regulator are assembled to the circuit board, and the regulator is configured to supply power to an integrated circuit.

348. For the reasons I discussed above, Liu renders obvious claim 1 (Grounds V and VI). Liu further renders obvious this claim in combination with Lee. As seen in Figure 43 of Lee, the non-isolated bus converter and the regulators are assembled to circuit boards in the proposed intermediate bus architecture:



Ex. 1008, Figure 43.

349. At least one regulator in Lee is configured to supply power to an integrated circuit; specifically, the regulators are shown connected to an FPGA or ASIC, which is a type of integrated circuit.

6. Dependent Claims 8 and 10

350. For the reasons I discussed above, Liu, alone or in combination with Lee, renders obvious claims 1 (Grounds V and VI) and 9 (Ground V). Liu further renders obvious this claim in combination with Lee. The combination of Liu and

Lee renders obvious these claims for the reasons I discussed above for claims 8 and 10 (Ground V).

7. Dependent Claim 14

The apparatus of claim 9, wherein the power converter is part of a bus converter that is a self-contained assembly adapted to be installed as a unit.

351. The combination of Liu and Lee renders obvious this claim for the reasons I discussed above for claims 6 (Ground V and VI) and claims 9 and 14 (Ground V).

8. Dependent Claim 15

The apparatus of claim 9, further comprising a circuit board, and wherein the power converter is configured to supply power to a plurality of regulators over a power distribution bus, the regulators disposed at a distance to the power converter, and wherein at least one of the regulators is assembled to the circuit board and configured to supply power to an integrated circuit.

352. The combination of Liu and Lee renders obvious this claim for the reasons I discussed above for claim limitation 1(e) and claim 7 (Grounds V and VI) and claims 9 and 15 (Ground V).

9. Independent Claim 16

- a. *Limitation 16(a): An apparatus comprising:*
- b. *Limitation 16(b): a bus converter comprising an input circuit and an output circuit, wherein the bus converter is configured to receive power from a power distribution system comprising a source for providing power at a DC source voltage V_s , the bus converter being adapted to*

convert power from the input circuit to the output circuit at a substantially fixed voltage transformation ratio, K_{DC} , at an output current, wherein an input voltage V_{IN} is applied to the input circuit and an output voltage V_{OUT} is produced by the output of the bus converter, and wherein the substantially fixed voltage transformation ratio can be represented as $K_{DC}=V_{OUT}/V_{IN}$;

353. The combination of Liu and Lee renders obvious this limitation for the reasons I discussed above for claim limitations 1(b) and 1(c) (Grounds V and VI).

- c. Limitation 16(c): a power distribution bus connected to distribute power from the output circuit of the bus converter at the output voltage V_{OUT} ; and*

354. The combination of Liu and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(d) (Grounds V and VI).

- d. Limitation 16(d): a plurality of regulators, wherein each regulator comprises a regulator input connected to the power distribution bus to receive power from the output circuit of the bus converter and a regulator output connected to supply power to a respective load, the plurality of regulators each being separated by a distance from the bus converter;*

355. The combination of Liu and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(e) (Grounds V and VI).

- e. Limitation 16(e): wherein the input circuit of the bus converter and at least a portion of the output circuit of the bus converter are connected in series across the source such that an absolute value of the input voltage V_{IN} applied to the input circuit is approximately equal to the absolute value of the DC source voltage V_S minus a number N times*

the absolute value of the output voltage V_{OUT} , where N is at least 1;

356. The combination of Liu and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(f) (Grounds V and VI).

f. Limitation 16(f): wherein the bus converter comprises an inductive component and one or more power switches in the input circuit, the output circuit, or both; and

357. The combination of Liu and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(g) (Grounds V and VI).

g. Limitation 16(g): wherein a current flowing in the inductive component charges and discharges capacitances in the bus converter reducing a voltage across said one or more switches prior to turning ON said one or more switches.

358. The combination of Liu and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(h) (Grounds V and VI).

10. Dependent Claim 17

The apparatus of claim 16, wherein both the input circuit and the output circuit comprise full-bridge circuits, wherein the input circuit comprises a winding having a first number of turns, wherein the output circuit comprises a winding having a second number of turns, and wherein the voltage transformation ratio is a function of a ration of the first number of turns to the second number of turns.

359. The combination of Liu and Lee renders obvious this claim for the reasons I discussed above for claim 16 (Grounds V and VI) and claim 17 (Ground V).

11. Dependent Claim 19

The apparatus of claim 16, wherein the bus converter is a self-contained assembly adapted to be installed as a unit.

360. The combination of Liu and Lee renders obvious this limitation for the reasons I discussed above for claims 6, 16, and 19 (Grounds V and VI).

12. Independent Claim 22

a. *Limitation 22(a): An apparatus comprising:*

b. *Limitation 22(b): an intermediate bus architecture power distribution system for an electrical system comprising a source for providing power at a DC source voltage;*

361. The combination of Liu and Lee renders obvious this limitation for the reasons I discussed above for claim limitations 1(b) and 22(b) (Grounds V and VI).

c. *Limitation 22(c): a circuit board comprising a bus converter, the bus converter comprising an input circuit, the input circuit comprising a primary transformer winding, the bus converter further comprising an output circuit, the output circuit comprising a secondary transformer winding, wherein the primary and secondary transformer windings are galvanically connected in series, and wherein the bus converter is configured to provide power to a power distribution bus that is not galvanically isolated from the source; and*

362. The combination of Liu and Lee renders obvious this limitation for the reasons I discussed above for claim limitations 1(c) and 22(c) and claim 7 (Grounds V and VI).

d. *Limitation 22(d): the circuit board further comprising a plurality of regulators, wherein each regulator comprises a regulator input connected to the power distribution bus*

to receive power from the output circuit of the bus converter and a regulator output connected to supply power to a respective load, the plurality of regulators each being separated by a distance from the bus converter

363. The combination of Liu and Lee renders obvious this limitation for the reasons I discussed above for claim limitations 1(e) and 22(be) (Grounds V and VI).

13. Dependent Claim 23

Limitation 23(a): The apparatus of claim 22, wherein the bus converter is adapted to convert power from the input circuit to the output circuit at a substantially fixed voltage transformation ratio, K_{DC} , at an output current, wherein an input voltage V_{IN} is applied to the input circuit and an output voltage V_{OUT} is produced by the output of the bus converter, and wherein the substantially fixed voltage transformation ratio can be represented as $K_{DC}=V_{OUT}/V_{IN}$; and

Limitation 23(b): wherein the input circuit of the bus converter and at least a portion of the output circuit of the bus converter are connected such that an absolute value of the input voltage V_{IN} applied to the input circuit is approximately equal to the absolute value of the DC source voltage V_S minus a number N times the absolute value of the output voltage V_{OUT} , where N is at least 1.

364. The combination of Liu and Lee renders obvious this claim for the reasons I discussed above for claim 22 (Grounds V and VI) and claim 23 (Ground V).

14. Dependent Claim 24

The apparatus of claim 22, wherein the bus converter is a self-contained assembly adapted to be installed as a unit.

365. The combination of Liu and Lee renders obvious this limitation for the reasons I discussed above for claims 22 and 6 (Grounds V and VI).

15. Dependent Claims 25-28

366. The combination of Liu and Lee renders obvious these claims for the reasons I discussed above for claims 1, 9, and 16 (Grounds V and VI) and claims 25-28 (Ground V).

16. Independent Claim 29

- a. Limitation 29(a): An apparatus comprising:*
- b. Limitation 29(b): a power distribution system comprising a source for providing power at a DC source voltage V_S ;*

367. The combination of Liu and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(b) (Grounds V and VI).

- c. Limitation 29(c): a bus converter comprising an input circuit and an output circuit, the bus converter being adapted to convert power from the input circuit to the output circuit at a substantially fixed voltage transformation ratio, K_{DC} , at an output current, wherein an input voltage V_{IN} is applied to the input circuit and an output voltage V_{OUT} is produced by the output of the bus converter, and wherein the substantially fixed voltage transformation ratio can be represented as $K_{DC}=V_{OUT}/V_{IN}$;*

368. The combination of Liu and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(c) (Grounds V and VI).

- d. *Limitation 29(d): a power distribution bus connected to distribute power from the output circuit of the bus converter at the output voltage V_{OUT} ; and*

369. The combination of Liu and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(d) (Grounds V and VI).

- e. *Limitation 29(e): a plurality of regulators, wherein each regulator comprises a regulator input connected to the power distribution bus to receive power from the output circuit of the bus converter and a regulator output connected to supply power to a respective load, the plurality of regulators each being separated by a distance from the bus converter;*

370. The combination of Liu and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(e) (Grounds V and VI).

- f. *Limitation 29(f): wherein the input circuit of the bus converter and the output circuit of the bus converter are galvanically connected; and*

371. The combination of Liu and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(f) (Grounds V and VI).

- g. *Limitation 29(g): wherein the bus converter comprises an inductive component and one or more power switches in the input circuit or output circuit or both; and*

372. The combination of Liu and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(g) (Grounds V and VI).

- h. *Limitation 29(h): wherein a current flowing in the inductive component charges and discharges capacitances in the converter reducing a voltage across*

said one or more switches prior to turn ON of said one or more switches.

373. The combination of Liu and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(h) (Grounds V and VI).

17. Dependent Claim 30

The apparatus of claim 29 wherein the voltage across said one or more switches is reduced to essentially zero volts prior to turn ON of said one or more switches.

374. The combination of Liu and Lee renders obvious this claim for the reasons I discussed above for claim 28 and 29 (Grounds V and VI).

18. Independent Claim 31

- a. Limitation 31(a): An apparatus comprising:*
- b. Limitation 31(b): a power distribution system comprising a source for providing power at a DC source voltage V_S ;*

375. The combination of Liu and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(b) (Grounds V and VI).

- c. Limitation 31(c): a bus converter comprising an input circuit and an output circuit, the bus converter being adapted to convert power from the input circuit to the output circuit at a substantially fixed voltage transformation ratio, K_{DC} , at an output current, wherein an input voltage V_{IN} is applied to the input circuit and an output voltage V_{OUT} is produced by the output of the bus converter, and wherein the substantially fixed voltage transformation ratio can be represented as $K_{DC}=V_{OUT}/V_{IN}$;*

376. The combination of Liu and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(c) (Grounds V and VI).

- d. *Limitation 31(d): a power distribution bus connected to distribute power from the output circuit of the bus converter at the output voltage V_{OUT} ; and*

377. The combination of Liu and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(d) (Grounds V and VI).

- e. *Limitation 31(e): a plurality of regulators, wherein each regulator comprises a regulator input connected to the power distribution bus to receive power from the output circuit of the bus converter and a regulator output connected to supply power to a respective load, the plurality of regulators each being separated by a distance from the bus converter;*

378. The combination of Liu and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(e) (Grounds V and VI).

- f. *Limitation 31(f): wherein the input circuit comprises a winding having a first number of turns, wherein the output circuit comprises a winding having a second number of turns, and wherein the voltage transformation ratio is a function of a ratio of the first number of turns to the second number of turns; and*

379. The combination of Liu and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(c) (Grounds V and VI) and claim 37 (Ground V).

- g. *Limitation 31(g): wherein the input circuit of the bus converter and at least a portion of the output circuit of the bus converter are connected in series across the source such that an absolute value of the input voltage V_{IN} applied to the input circuit is approximately equal to the absolute value of the DC source voltage V_S minus a number N times*

the absolute value of the output voltage V_{OUT} , where N is at least 1.

380. The combination of Liu and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(f) (Grounds V and VI).

19. Independent Claim 32

- a. Limitation 32(a): An apparatus comprising:*
- b. Limitation 32(b): a power distribution system comprising a source for providing power at a DC source voltage V_S ;*

381. The combination of Liu and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(b) (Grounds V and VI).

- c. Limitation 32(c): a bus converter comprising an input circuit and an output circuit, the bus converter being adapted to convert power from the input circuit to the output circuit at a substantially fixed voltage transformation ratio, K_{DC} , at an output current, wherein an input voltage V_{IN} is applied to the input circuit and an output voltage V_{OUT} is produced by the output of the bus converter, and wherein the substantially fixed voltage transformation ratio can be represented as $K_{DC}=V_{OUT}/V_{IN}$;*

382. The combination of Liu and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(c) (Grounds V and VI).

- d. Limitation 32(d): a power distribution bus connected to distribute power from the output circuit of the bus converter at the output voltage V_{OUT} ; and*

383. The combination of Liu and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(d) (Grounds V and VI).

- e. *Limitation 32(e): a plurality of regulators, wherein each regulator comprises a regulator input connected to the power distribution bus to receive power from the output circuit of the bus converter and a regulator output connected to supply power to a respective load, the plurality of regulators each being separated by a distance from the bus converter;*

384. The combination of Liu and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(e) (Grounds V and VI).

- f. *Limitation 32(f): wherein the input circuit comprises a winding having a first number of turns, wherein the output circuit comprises a winding having a second number of turns, and wherein the voltage transformation ratio is a function of a ratio of the first number of turns to the second number of turns; and*

385. The combination of Liu and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(c) (Grounds V and VI) and Claim 37 (Ground V).

- g. *Limitation 32(g): wherein the input circuit of the bus converter and the output circuit of the bus converter are galvanically connected.*

386. The combination of Liu and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(f) (Grounds V and VI).

20. Independent Claim 33

- a. *Limitation 33(a): An apparatus comprising:*
- b. *Limitation 33(b): a bus converter comprising an input circuit and an output circuit, the bus converter being adapted to convert power from the input circuit to the output circuit at a substantially fixed voltage*

transformation ratio, K_{DC} , at an output current, wherein an input voltage V_{IN} is applied to the input circuit and an output voltage V_{OUT} is produced by the output of the bus converter, and wherein the substantially fixed voltage transformation ratio can be represented as $K_{DC}=V_{OUT}/V_{IN}$;

387. The combination of Liu and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(c) (Grounds V and VI).

c. Limitation 33(c): wherein the input circuit of the bus converter and the output circuit of the bus converter are galvanically connected; and

388. The combination of Liu and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(f) (Grounds V and VI).

d. Limitation 33(d): wherein the bus converter comprises an inductive component and one or more power switches in the input circuit or output circuit or both; and

389. The combination of Liu and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(g) (Grounds V and VI).

e. Limitation 33(e): wherein a current flowing in the inductive component charges and discharges capacitances in the converter reducing a voltage across said one or more switches prior to turn ON said one or more switches.

390. The combination of Liu and Lee renders obvious this limitation for the reasons I discussed above for claim limitation 1(h) (Grounds V and VI).

21. Dependent Claims 35-37, 39

391. The combination of Liu and Lee renders obvious these claims for the reasons I discussed above for claims 33 and 22 (Grounds V and VI) and claims 35-37 and 39 (Ground V).

22. Dependent Claim 40

The apparatus of claim 22 wherein at least one of the regulators is assembled to the circuit board and configured to supply power to an integrated circuit.

392. The combination of Liu and Lee renders obvious this limitation for the reasons I discussed above for claims 7 and 22 (Grounds V and VI).

VII. SECONDARY CONSIDERATIONS

393. I am not aware of any secondary considerations of non-obviousness with a nexus to the alleged invention of the '950 Patent.

VIII. CONCLUSION

394. Based on the above, it is my opinion that the Challenged Claims of the '950 Patent are invalid and unpatentable. Each of the claims was anticipated or obvious over the prior art, and a POSITA would have readily appreciated that the claims were not inventive.

I hereby declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct, and that all statements made of my own knowledge are true and that all statements made on information and belief are believed to be true. I understand that willful false statements are punishable by fine or imprisonment or both. *See* 18 U.S.C. § 1001.

Date: November 1, 2023

Respectfully submitted,



Douglas Charles Hopkins, Ph.D.