UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SOLAREDGE TECHNOLOGIES LTD.,
Petitioner,

v.

KOOLBRIDGE SOLAR, INC.,
Patent Owner.

Patent No. 8,937,822
Filing Date: May 8, 2011
Issue Date: January 20, 2015
Title: SOLAR ENERGY CONVERSION AND UTILIZATION SYSTEM

Inter Partes Review No.: IPR2022-00011

**PETITION 5 of 6 FOR *INTER PARTES* REVIEW
UNDER 35 U.S.C. §§ 311-319 AND 37 C.F.R. § 42.100 *et seq*.**

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Ex. 1516:	Certified translation of Ex. 1546, Myrzik, J. Topologische Untersuchungen zur Anwendung von tief/-hochsetzenden Stellern für Wechselrichter, Dissertation zur Erlangung des Grades eines Doktor-Ingenieurs (Dr. ing.) im Fachgebiet Elektrotechnik der Universität Gesamthochschule Kassel (2001, Kassel Univ. Press)
Ex. 1517:	Patel, H., Generalized Techniques of Harmonic Elimination and Voltage Control in Thyristor Inverters: Part I-Harmonic Elimination, IEEE Trans. on Industry Applications, Vol. 1A-9, no. 3 (May/June 1973) (“Patel”)
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Ex. 1544:	Tolbert et al., Multilevel Converters for Large Electric Drives, IEEE Trans. Ind. Apps., Vol 35, No. 1, Jan/Feb 1999
Ex. 1545:	Certified translation of Heribert Schmidt, Bruno Burger, & Klaus Kiefer. Wechselwirkungen zwischen Solarmodulen und Wechselrichtern, Fraunhofer Institute for Solar Power Systems, June 2007. ("Schmidt")

Ex. 1546:	Myrzik, J. Topologische Untersuchungen zur Anwendung von tief/-hochsetzenden Stellern für Wechselrichter, Dissertation zur Erlangung des Grades eines Doktor-Ingenieurs (Dr. ing.) im Fachgebiet Elektrotechnik der Universität Gesamthochschule Kassel (2001, Kassel Univ. Press)
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Ex. 1565:	Ostbayerisches Technologie-Transfer-Institute. V., Power Electronics for Photovoltaics, OTTI International Seminar, May 25-26, 2009

MANDATORY NOTICES

37 C.F.R. § 42.8(b)(1)&(2): Real Parties in Interest & Related Matters.

The real party-in-interest is Petitioner SolarEdge Technologies Ltd. No unnamed entity is funding, controlling, or directing this Petition, or otherwise has had an opportunity to control or direct this Petition or Petitioner's participation in any resulting IPR.

The '822 Patent has been asserted against SolarEdge in the District of Delaware in *Koolbridge Solar, Inc. v. SolarEdge Technologies, Inc.*, No. 1:20-cv-01374-MN (D. Del.). The earliest date of service on Petitioner was October 12, 2020. The Patent Owner, after having been notified of Petitioner's intent to file IPRs against the '822 Patent, voluntarily dismissed its lawsuit without prejudice.

The references relied upon herein were not cited during prosecution. No arguments presented in this Petition were raised during prosecution of the '822 patent.

37 C.F.R. § 42.8(b)(3)&(4): Lead & Back-Up Counsel, and Service Information. Petitioner designates counsel listed below. A power of attorney for counsel is being concurrently filed.

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SolarEdge Technologies Ltd ("Petitioner") petitions for *inter partes* review and cancellation of claims 14-19 of U.S. Patent No. 8,937,822 ("the ’822 patent") (Ex. 1501).

I. INTRODUCTION & RELIEF REQUESTED

The ’822 patent describes a solar energy installation, which includes photovoltaic panels that convert sunlight into direct current (DC) electricity and an inverter that converts the DC electricity into alternating current (AC) electricity for powering a load (such as your home) or for supplying power back to a utility grid. As a byproduct of its internal switching, the inverter used in the installation exhibits an unintended but well-known phenomenon of generating a common-mode AC voltage waveform superimposed on the DC input lines. Ex. 1502, ¶¶ 62-74, 113-120, 126-130.

The ’822 patent further describes the use of a "ground leak detector" in the installation, which detects when there is a fault in the wiring of the installation (*e.g.*, a short to ground), which may pose a safety hazard. Ex. 1502, ¶¶ 121-125. To detect the fault, the ground leak detector relies on the fact that the unintended common mode AC voltage will generate an unusual common mode AC current waveform through the fault, which the ground leak detector senses. Ex. 1502, ¶¶ 75-77.

Independent claim 14 and its dependent claims 15-19 recite aspects of this installation with the ground leak detector, and other well-known and trivial requirements, such as specifying the frequency of the common mode AC voltage waveform, correlating the unusual current to the common mode AC voltage waveform, using current transformers, and including a battery in the solar system installation.

Fujimoto (Japanese unexamined Pat. App. Pub. No. 11-122819, Ex. 1534), which is the primary reference for this petition discloses an example of the same ground leak detector disclosed in the patent and installed similarly in a solar energy installation. As discussed in more detail below, claims 14-19 of the ’822 patent are unpatentable and should be cancelled. Ex. 1502, ¶¶ 88-94, 255-258.

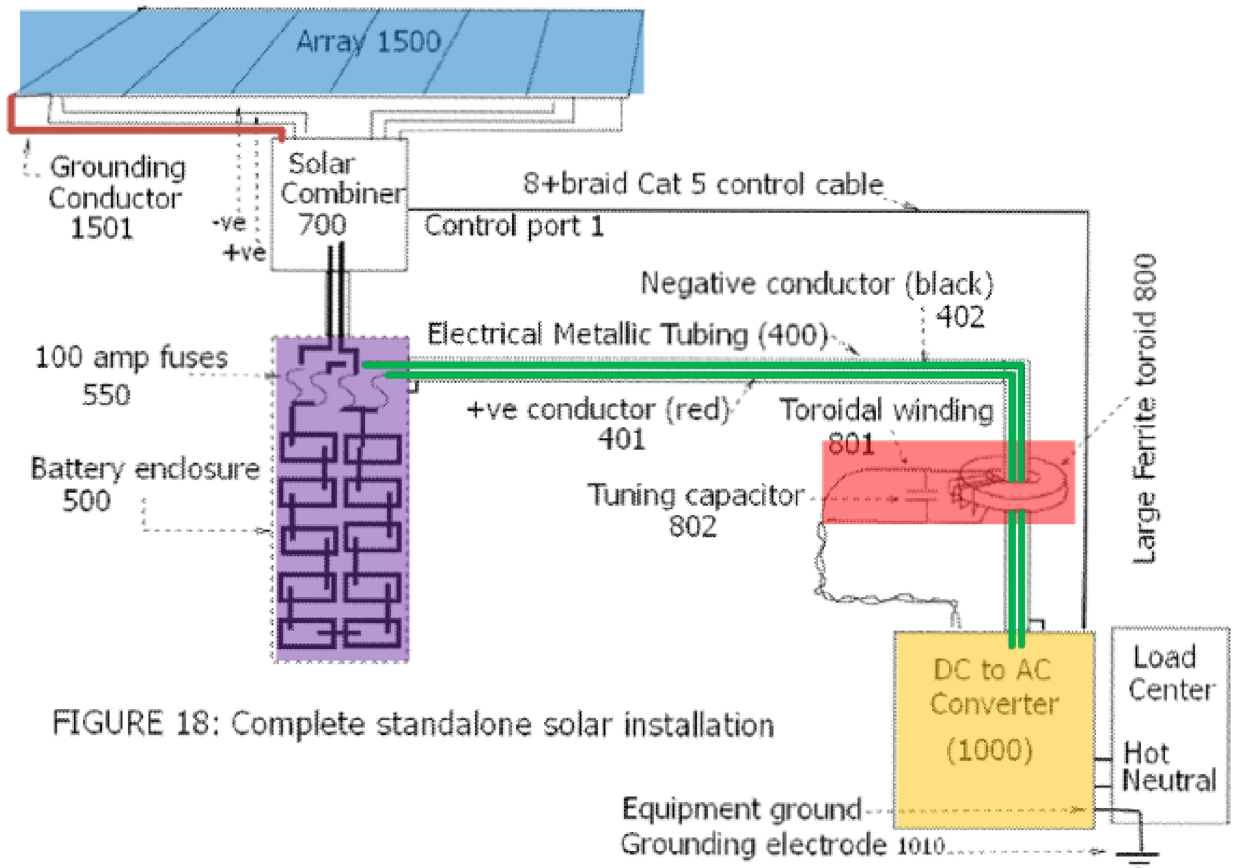
II. GROUNDS FOR STANDING & FEE PAYMENT

Petitioner certifies that the ’822 patent is available for *inter partes* review, and that Petitioner is not barred or estopped from requesting *inter partes* review challenging claims 14-19 on the identified grounds in this Petition. The undersigned authorizes the charge of any required fees to Deposit Account No. 19-0733.

III. OVERVIEW

A. Brief Description of Alleged Invention

An example of the ’822 patent’s solar energy installation implemented with a ground leak detector is illustrated in Figure 18 (annotated below). The solar energy installation comprises a solar array 1500 (**blue**) and a battery 500 (**purple**) connected to positive and negative DC input conductors (**green**) of a DC to AC converter 1000 (**orange**). Ex. 1501, 5:4-6, 30:36-67, 31:35-47, 31:65-67, 35:43-36:9, 36:30-35, 36:49-51, 40:1-9, Fig. 18. The positive and negative DC input conductors are routed from battery 500 and array 1500 (via solar combiner 700) through the ground leak detector (800, 801) (**red**) and to the inverter 1000. *Id.*; Ex. 1502, ¶¶ 75-77.



Ex. 1501, Fig. 18 (annotated).

Toroid 800 of the ground leak detector senses an unusual ground leak current from the common-mode waveform on the positive and negative input conductors, and if the ground leak current exceeds a threshold, the inverter 1000 executes a shutdown (*e.g.*, opens inverter AC output relays and the DC input power and startup relays), thus preventing any further ground leakage current. Ex. 1501, 32:26-32, 35:65-36:3, 36:30-35, 40:29-35; Ex. 1502, ¶¶ 76-77.

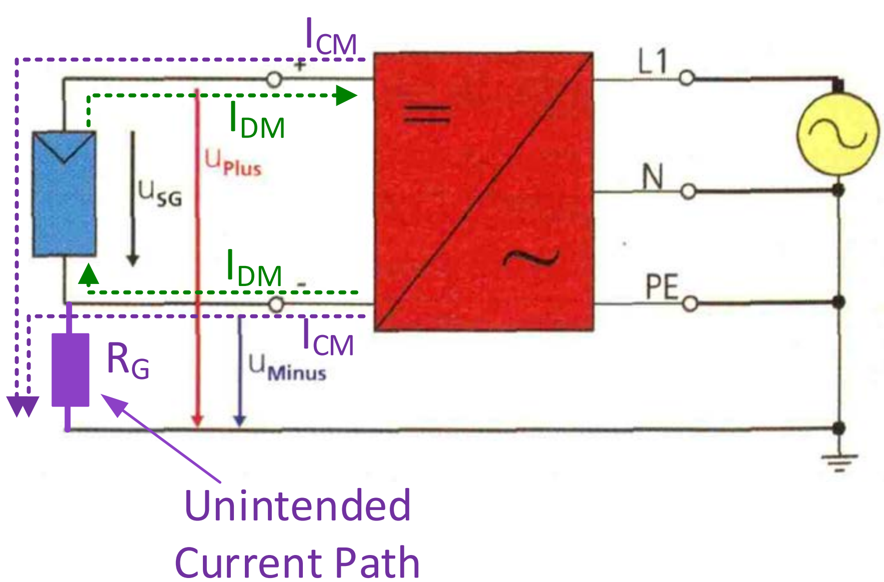
1. Common Mode and Differential Mode Voltage

In the solar energy installation, voltage on the DC side of the system (between the solar array and the inverter) can be described with respect to three terminals—the positive and negative conductors (**green**) connecting the solar array/battery to the input of the inverter, and the neutral terminal, which may be a ground reference of the system. Ex. 1502, ¶¶ 154-156; Ex. 1501, 32:26-32, 35:65-36:3, 36:30-35, 40:29-35. The voltage on the DC side of the system can be described as the sum of two different voltages—a "differential mode" voltage and a "common mode" voltage. Ex. 1502, ¶¶ 152-153. The differential mode voltage is the voltage between the positive and negative conductors resulting from the DC electrical power generated by the power source. *Id.*, ¶ 156. The common mode voltage on the other hand, which is a byproduct of the switching arrangement in the inverter, is a voltage that is the same on both the positive and negative conductors with respect to the neutral. *Id.*, ¶¶ 155, 157-158; Ex. 1543, p. 4; Ex. 1542, p. 4; Ex. 1536, p. 4; Ex. 1545 (certified translation of Ex. 1555), p. 2.

It was well known to a person having ordinary skill in the art ("PHOSITA") that a transformerless inverter that has its outputs connected between the line and neutral (*e.g.*, grounded terminal) of an AC system, may generate a common mode voltage on the DC input terminals that has a frequency that is a multiple of the frequency of the AC output. Ex. 1502, ¶¶ 131-142, 158-159. For a single-phase inverter, the multiple is generally one (*e.g.*, 60Hz), and for a three-phase inverter, the multiple is generally three (*e.g.*, 180 Hz). Ex. 1502, ¶¶ 158-159

2. Common Mode and Differential Mode Current

In addition to being used for voltages, the terms "differential mode" and "common mode" can also be used for electric currents. Differential mode current (**green**), which results from the power generated by the solar array, flows in a closed path from the solar array to the inverter on the positive conductor, and back from the inverter to the solar array on the negative conductor, resulting in equal currents flowing in opposite directions on the positive and negative currents. Ex. 1502, ¶ 160.



Ex. 1545, p. 2, Fig. 1 (annotated).

Common mode current (**purple**) on the other hand is equal and in the same direction on the positive and negative conductors. *Id*. Ideally there is no common mode current, even when there is a common mode voltage, because there is no closed path for the common mode current to flow. *Id.*, ¶ 161. But, the system may have unintended current paths such as stray capacitances and short-circuit faults between components on the DC side of the system (*e.g.*, the solar array or battery) and ground, which create a closed loop through the ground for common mode current to flow. *Id.* In the presence of these unintended current paths, a common mode voltage will cause a common mode current to flow through ground, creating potential shock or fire hazards. *Id*.

For example, in the presence of a resistive ground fault R_G that provides a current path to both the positive and negative DC conductors, the common mode voltage V_{CM} which is equal and in-phase on both of the positive and negative DC conductors will create a corresponding common-mode current I_{CM} that is in-phase on both the positive and negative conductors, with the relation between them given by the formula: $V_{CM} = R_G * I_{CM}$. *Id.*, ¶ 162.

As explained further below, because it was well known that inverters generate common mode voltage at a particular frequency (*e.g.*, 60 Hz or 120 Hz), it was common to detect ground faults by measuring for common mode current caused by, and having the same frequency as, the common mode voltage. *Id.*, ¶¶ 158-159.

B. Prosecution History

The application that led to the ’822 patent was filed May 8, 2011. Ex. 1522, p.128. The claims that would ultimately issue as claims 14-19 (the claims that are the subject of the present petition) were included as claims 14-19 in the initial application. *Id*., pp. 95-96. Claims 14-19 were allowed, as filed, in the first action. *Id*., pp. 306-307; Ex. 1502, ¶¶ 78-79. After prosecution to resolve issues that were unrelated to claims 14-19, the ’822 patent issued on January 20, 2015. Ex. 1501, cover; Ex. 1502, ¶¶ 80-87.

C. Earliest Priority Date for the Claims

The earliest entitled possible priority date for the ’822 patent claims is the filing date of U.S. Patent Application No. 13/103,070—filed May 8, 2011. Ex. 1502, ¶ 61.

D. Scope and Content of the Prior Art[1, 2]

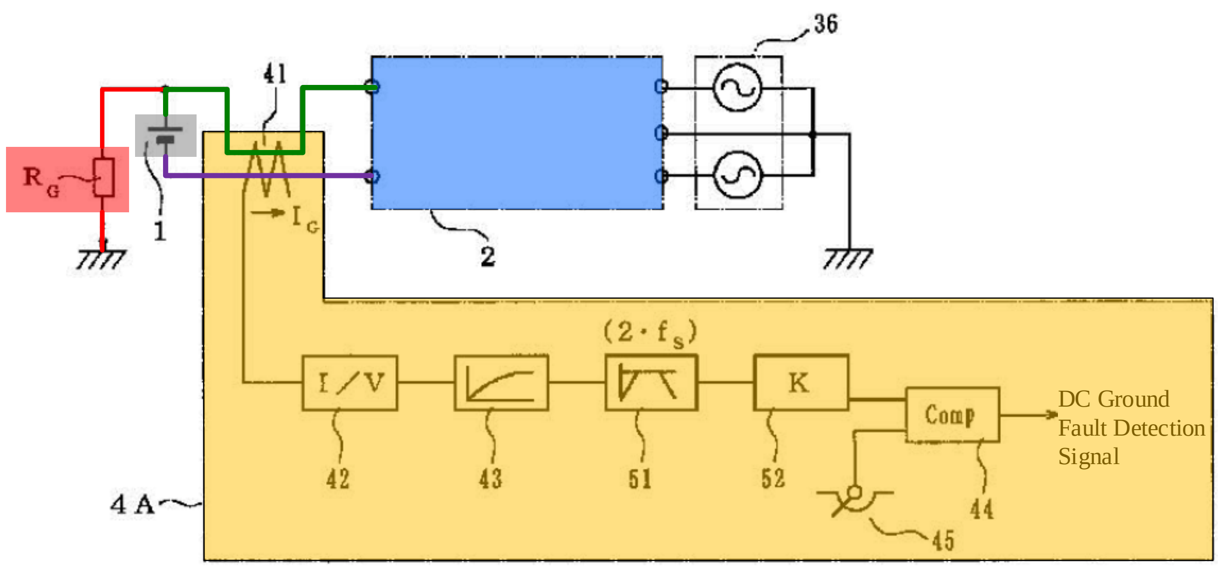
1. Japanese Pat. App. Pub. No. JP 11-122819 (Fujimoto) (Ex. 1533, certified translation Ex. 1534)

Fujimoto (Ex. 1534) is a Japanese Patent that published on April 30, 1999, making it prior art under 35 U.S.C. § 102(b). Ex. 1502, ¶ 163. Fujimoto seeks to

[1] Citations to foreign language prior art will refer to the certified English translations as indicated below.

[2] Citations to 35 U.S.C. §§ 102 and 103 refer to the pre-AIA versions.

reliably detect "a ground fault incident, even when there is an offset due to temperature drift, or the like, when there is a high-resistance ground, and when there is low resistance." Ex. 1534, Abstract. To that end, Fujimoto describes a DC ground fault detector 4 (**red**) having a current transformer 41 through which the positive (**green**) and negative conductors (**purple**) pass between Fujimoto's DC power supply 1 (**grey**) and power converting device 2 (**blue**) that outputs two single phase AC waveforms 36 with respect to a neutral, each at a frequency f_s. Ex. 1534, ¶¶ [0001]-[0002], [0005], [0008], [0010], Abstract, Figs. 1 (annotated), 3; Ex. 1502, ¶¶ 164-166.



Ex. 1534, Fig. 1 (annotated).

In the event of a ground fault—for example, when the ground fault resistance is R_G (**red**)—a "common current" I_G is induced with an AC component (I_{ac}) that is at twice the output frequency ($2f_s$), which is detected by the DC ground fault detector. Ex. 1534, Abstract, ¶¶ [0004]-[0007], [0010]-[0011]; Ex. 1502, ¶¶ 160-162, 166. Fujimoto explains that "the common current I_G, [is] detected by the current transformer 41, [and] is compared to the detection level, to output a DC ground fault detection signal from the comparator 44, to open the circuit breaker 35, to stop the operation of the power converting device, or the like." Ex. 1534, ¶¶ [0005], [0011]. Ex. 1502, ¶ 166.

2. U.S. Patent Application Publication No. 2009/0207543 (Boniface)

Boniface (Ex. 1524) is a U.S. Patent Application Publication published on August 20, 2009, making it prior art under 35 U.S.C. § 102(b).

As shown in Figure 1 (annotated below), Boniface discloses a fault detection system comprising a photovoltaic solar array 101 (**green**) connected to a power conditioning unit, *e.g.*, inverter PCU 115 (**blue**), via connective wiring. Ex. 1524, ¶ [0037]; Ex. 1502, ¶¶ 167-169.

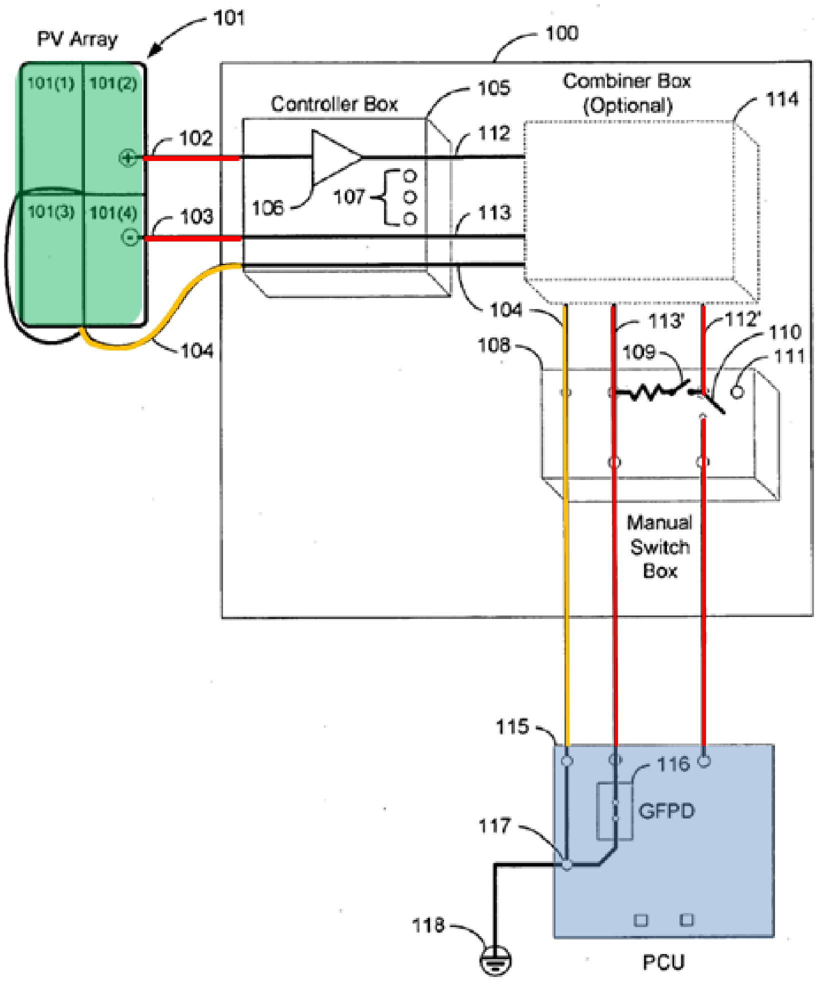


Fig. 1

Ex. 1524, Fig. 1 (annotated).

Boniface discloses that a photovoltaic source positive conductor (102/112/112') and a negative conductor (103/113/113') (**red**) are routed in parallel with an equipment ground conductor 104 (**orange**) connected to earth ground system 118. Ex. 1524, ¶¶ [0037]-[0039], [0048], Figs. 1-2, 6; Ex. 1502, ¶¶ 168-169.

3. U.S. National Electrical Code Handbook (NEC Handbook)

The National Electrical Code® Handbook, Eleventh Edition (Ex. 1519) was published and publicly available in 2008. Ex. 1523, ¶ 80-93 (Section III.C). The NEC Handbook is prior art under pre-AIA 35 U.S.C. § 102(b). The National Electric Code is referenced several times in the ’822 patent but is not recorded as having been reviewed by the Examiner during prosecution. *See, e.g.*, Ex. 1501, 5:21, 10:59, 23:60; Ex. 1502, ¶ 170.

The National Electric Code is promulgated by the National Fire Protection Association and “is intended for use by capable engineers and electrical contractors in the design and/or installation of electrical equipment; by inspection authorities exercising legal jurisdiction over electrical installations; by property insurance inspectors; by qualified industrial, commercial, and residential electricians; and by instructors of electrical apprentices or students.” Ex. 1519, pp. 3, 8; Ex. 1502, ¶ 171.

The Code contains provisions directed to the safe installation of electrical equipment in a variety of settings as well as definitions of terms used in those provisions. Ex. 1519, pp. 7-8; Ex. 1502, ¶ 172. The NEC Handbook includes the Code as well as commentary and supplemental materials regarding the Code. Ex. 1519, p. 3; Ex. 1502, ¶ 172. Among the materials in the NEC Handbook is Article 690 regarding solar photovoltaic systems which includes examples of how such systems including inverters should be installed and connected. Ex. 1519, pp. 21-29; Ex. 1502, ¶ 172.

4. U.S. Patent Application Publication No. 2008/0192519 (Iwata)

Iwata (Ex. 1507) is a U.S. Patent Application Publication published on August 14, 2008, making it prior art under 35 U.S.C. § 102(b). Ex. 1502, ¶ 173.

As shown below, Iwata discloses an inverter similar to that in the ’822 patent. *Compare* Ex. 1501, Fig. 1 *with* Ex. 1507, Fig, 1(a); Ex. 1502, ¶ 174.

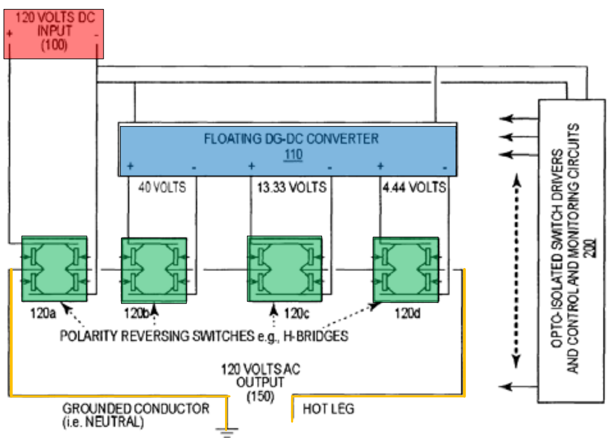
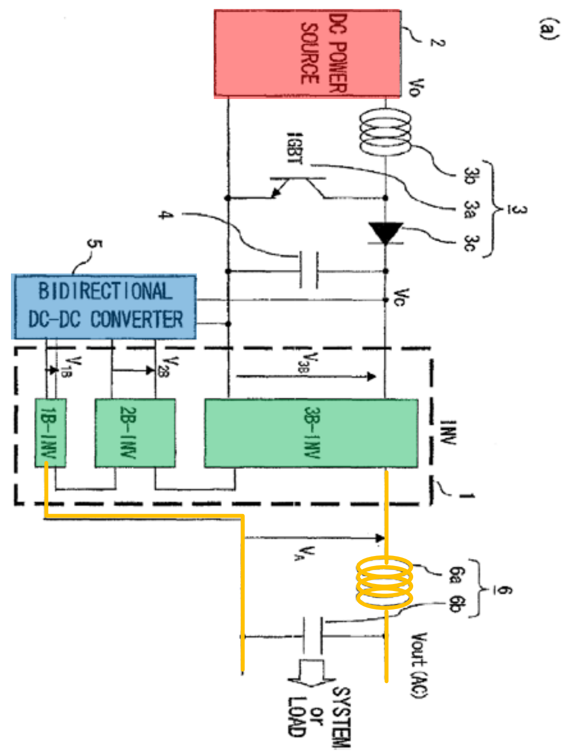


FIG. 1

Ex. 1501, Fig. 1 (annotated)



Ex. 1507, Fig. 1(a) (annotated)

Iwata’s inverter (above right), like that disclosed in the ’822 patent (above left) has a DC power source (**red**), an AC output V_A (**yellow**), and a bidirectional DC-DC converter (**blue**) that converts the DC input V_{3B} into a set of DC voltages V_{1B} and V_{2B}. Ex. 1507, ¶¶ [0045], [0047]-[0048], [0077], [0084], [0097], Fig. 1; Ex. 1502, ¶ 175. The single-phase inverters 1B-INV, 2B-INV and 3B-INV (**green**) have DC input voltages V_{1B} (from the DC to DC converter), V_{2B} (from the DC to DC converter), and V_{3B} (from the DC power source), respectively. Ex. 1507, ¶¶ [0048]-[0051]; Ex. 1502, ¶¶ 175-176.

As shown below, Iwata, like the ’822 patent, discloses that each of the single-phase inverters includes transistors in an H-bridge configuration (**green**). *Compare* Ex. 1501, 7:51-57, Fig. 3 *with* Ex. 1507, ¶ [0046], Fig. 1(b); Ex. 1502, ¶ 177.

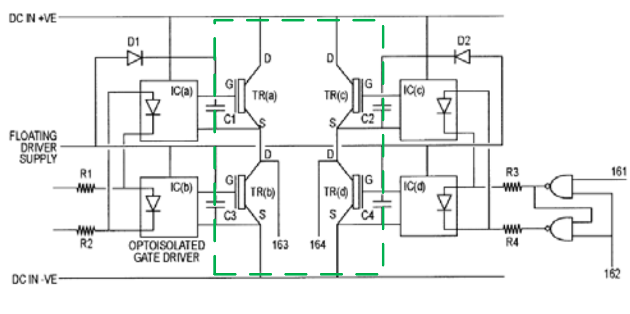
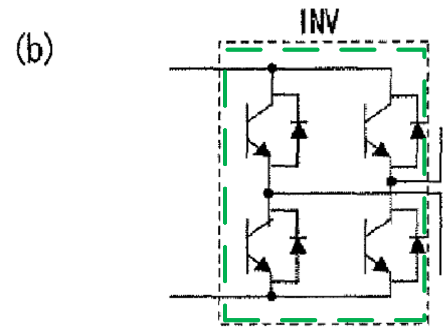


FIG. 3

Ex. 1501, Fig. 3 (annotated)



Ex. 1507, Fig. 1(b) (annotated)

Each single-phase inverter has a different DC supply voltage and is controlled so that, depending on the state of the switching circuit, the inverter will output either the DC supply voltage, the inverse of the DC supply voltage, or zero volts. Ex. 1507, ¶¶ [0047], [0050], [0059]; Ex. 1502, ¶ 178. The switch states can be controlled based on a ternary system with a value of +1 associated with the positive DC voltage, -1 associated with the negative of the DC voltage, and 0 associated with zero voltage. Ex. 1507, ¶ [0050], Fig. 2(a); Ex. 1502, ¶¶ 143-151, 178. As shown below, by controlling the states of the switching devices over time and summing the outputs of the inverters (*i.e.*, 1B-INV, 2B-INV and 3B-INV), an AC output wave is generated.

Ex. 1507, ¶¶ [0007]-[0009], [0047], [0050]-[0051], [0059], [0101], Figs. 2, 4, Abstract, claims 1, 12, 22, 30; Ex. 1502, ¶ 178.

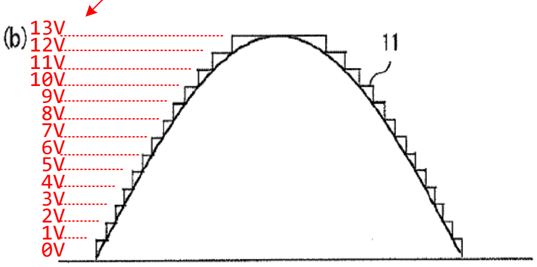
V_A generated by multiplying V_{1B}, V_{2B}, and V_{3B}, each by a ternary-valued state (e.g., -1, 0, or +1) and summing.

(a)

$V_{1B} = 1V$	$V_{2B} = 3V$	$V_{3B} = 9V$		
1	3	9		
V_{1B}	V_{2B}	V_{3B}	V_A LEVEL	
0	0	0	0	+0+0+0 = 0V
1	0	0	1	+1+0+0 = 1V
-1	1	0	2	-1+3+0 = 2V
0	1	0	3	+0+3+0 = 3V
1	1	0	4	+1+3+0 = 4V
-1	-1	1	5	-1-3+9 = 5V
0	-1	1	6	+0-3+9 = 6V
1	-1	1	7	+1-3+9 = 7V
-1	0	1	8	-1+0+9 = 8V
0	0	1	9	+0+0+9 = 9V
1	0	1	10	+1+0+9 = 10V
-1	1	1	11	-1+3+9 = 11V
0	1	1	12	+0+3+9 = 12V
1	1	1	13	+1+3+9 = 13V

V_A

(b)



Ex. 1507, Figs. 2a and 2b (annotated).

Voltages V_{1B}, V_{2B}, and V_{3B} are the DC power source voltage inputs for the 1B-INV, 2B-INV, and 3B-INV H-bridge inverters, respectively, and the states (*i.e.*, +1, 0, -1) of those inverters are shown in the first three columns of Figure 2(a). Ex. 1507, ¶¶ [0050]-[0051], Fig. 2(a); Ex. 1502, ¶ 179. The V_A voltage, which is the sum of the output voltages of 1B-INV, 2B-INV, and 3B-INV, is shown in the fourth column of Figure 2(a) and is also shown graphically in Figure 2(b), approximating a sinewave. Ex. 1507, ¶¶ [0050]-[0051], Fig. 2(b); Ex. 1502, ¶ 179.

IV. IDENTIFICATION OF CHALLENGE PURSUANT TO 37 C.F.R. § 42.104(b)

Petitioner requests review of claims 14–19 on the following grounds and references. Ex. 1502, ¶¶ 180-181.

Grounds	References	Basis	Claims Challenged
1	Fujimoto in view of Boniface	§ 103(a)	14, 15, 18, and 19
2	Fujimoto in view of NEC Handbook	§ 103(a)	14-16 18, and 19
3	Fujimoto in view of Boniface and NEC Handbook	§ 103(a)	16
4 and 5	Fujimoto in view of Boniface / NEC Handbook in further view of Iwata	§ 103(a)	17

The challenged claims are unpatentable based on these grounds as demonstrated by a preponderance of the evidence, including Dr. Baker's expert testimony (*e.g.*, Ex. 1502, ¶¶ 1-60, 132-184), and Dr. Mullins' expert testimony proving authenticity and public availability prior to May 8, 2011 of certain exhibits. Ex. 1523, ¶¶ 1-40, 232-248 (Ex. 1515), 268-285 (Ex. 1517), 80-93 (Ex. 1519), 214-231 (Ex. 1544), 249-267 (Ex. 1546), 332-353 (Ex. 1552), 193-213 (Ex. 1553), 172-192 (Ex. 1554), 155-171 (Ex. 1555), 94-111 (Ex. 1564), 112-129 (Ex. 1565), 354-356.

None of the prior art listed in the table above was before the examiner during prosecution of the ’822 patent. Ex. 1501, cover.

A. Level of Ordinary Skill

At the time of the alleged invention of the ’822 patent, a PHOSITA would have had a bachelor’s degree in electrical engineering or similar discipline, and would have had three years of design experience with power electronics, including experience designing power converters. Ex. 1502, ¶¶ 20-23.

B. Claim Construction

The following terms could be construed as means-plus-function limitations. 37 C.F.R. § 42.104(b)(3). If the Board does not construe these as means-plus-function limitations, they should be construed, along with all other claim terms, according to their ordinary and customary meaning, consistent with the prosecution history, to a skilled artisan at the time of the alleged invention. 37 C.F.R. § 42.100(b). Whether or not these are means-plus-function terms, the prior art discloses these limitations as addressed below. Ex. 1502, ¶¶ 95-97.

1. “DC to AC converter” (Claim 14)

To the extent “DC to AC converter” in claim 14 is a means-plus-function term, it performs the function of: “[having] an AC output having an output waveform with an output repetition frequency [and] creating a common mode AC probe signal waveform [] at a characteristic repetition frequency that is in phase on both said DC positive and negative input conductors." Ex. 1502, ¶¶ 98-99.

The corresponding structures include four different inverter circuits. One inverter circuit, depicted in Figures 1 and 10, includes a plurality of H-bridge switches with series connected outputs and with inputs of each H-bridge switch connected to a different voltage source. Ex. 1501, 6:17-26, Figs. 1, 10; Ex. 1502, ¶¶ 99-103, 107.

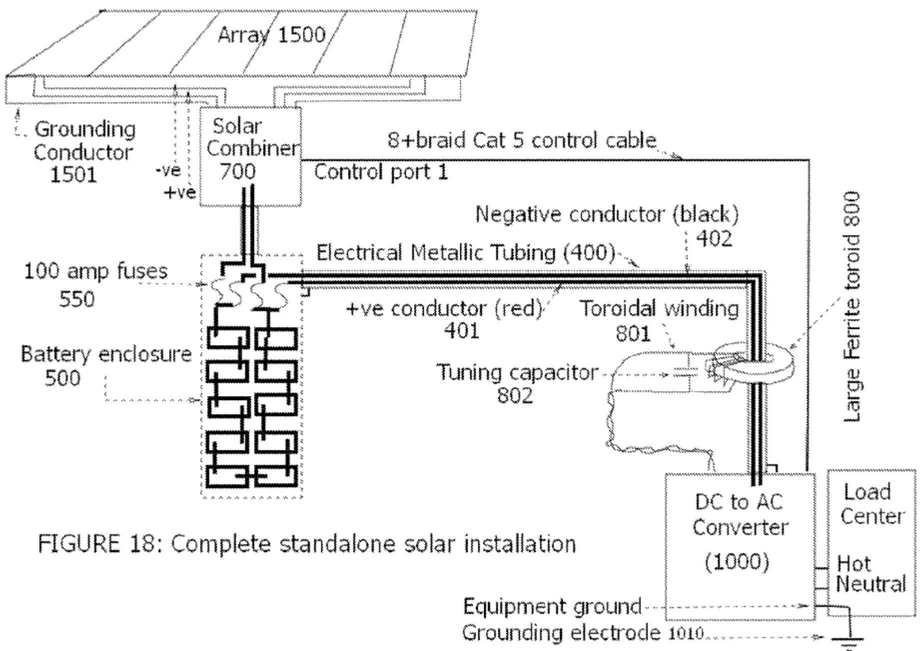
Another corresponding structure, in Figure 15, includes a single H-bridge switch with a single-phase output connected through an inductor. Ex. 1501, 23:27-44, Fig. 15; Ex. 1502, ¶¶ 104-105.

Two other structures are illustrated in Figures 16 and 24 of the '822 patent. Ex. 1502, ¶¶ 105-106. The Figure 16 structure, includes three half-bridge switches with inputs connected across a pair of DC input terminals, and each outputting a voltage phase through a respective inductor. Ex. 1501, Fig. 16; Ex. 1502, ¶ 106. The Figure 24 structure is the same as in Figure 16, but with three additional H-bridge switches, each connected to a different one of the voltage phase outputs. Ex. 1501, 29:25-67, Fig. 24; Ex. 1502, ¶ 106.

2. "detector" (Claim 14)

To the extent "detector" is a means-plus-function term, it performs the function of "detect[ing] an unusual current with said common mode waveform at said characteristic repetition frequency and upon detection of said unusual current providing an indication of the presence of an unwanted ground leak." Ex. 1501, 43:31-35; Ex. 1502, ¶¶ 108-109.

The corresponding structure is a current transformer including toroid 800 with a toroidal winding 801, for example, as shown in Figure 18 below. Ex. 1501, 25:57-59, 31:65-32:20, Fig. 18; Ex. 1502, ¶¶ 109-112.



Ex. 1501, Fig. 18.

V. SPECIFIC GROUNDS FOR UNPATENTABILITY

A. Grounds 1, 2 and 3: Fujimoto-Boniface, Fujimoto-NEC Handbook, Fujimoto-Boniface-NEC Handbook

Ground 1: Fujimoto-Boniface Renders Claims 14-15 and 18-19 Obvious

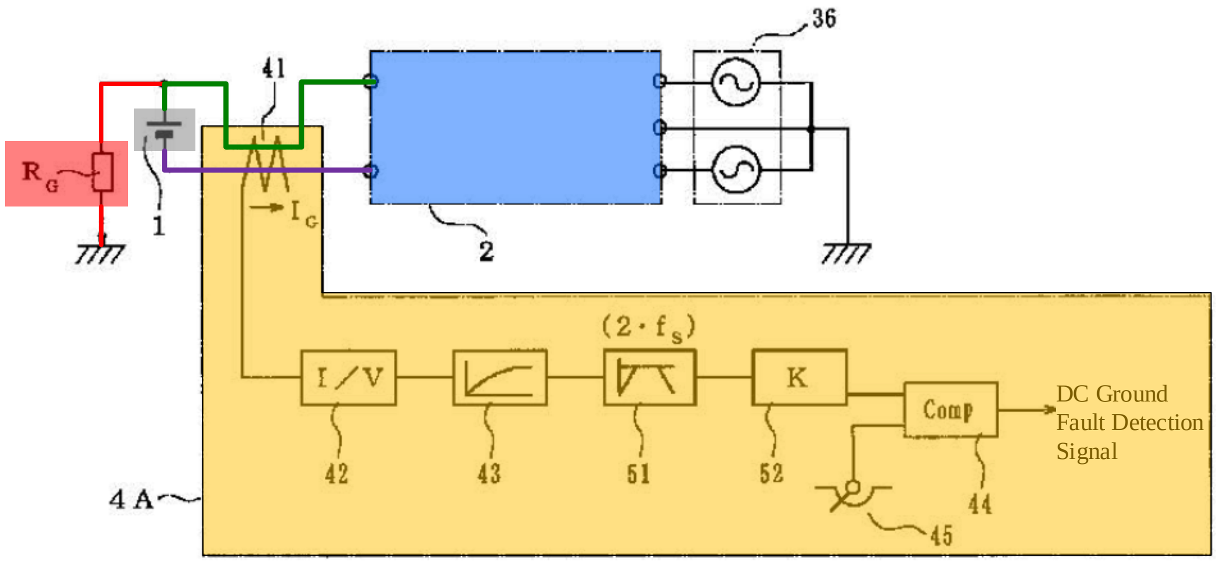
Ground 2: Fujimoto-NEC Handbook Renders Claims 14-16 and 18-19 Obvious

Ground 3: Fujimoto-Boniface-NEC Handbook Renders Claim 16 Obvious

1. Independent Claim 14 (Grounds 1 and 2)

a. "In a solar energy installation comprising a photovoltaic solar array and a DC to AC converter having a DC input with positive and negative conductors routed in parallel with an array grounding conductor and an AC output having an output waveform with an output repetition frequency, a method of detecting a ground leak in the DC wiring to the solar array, comprising:"

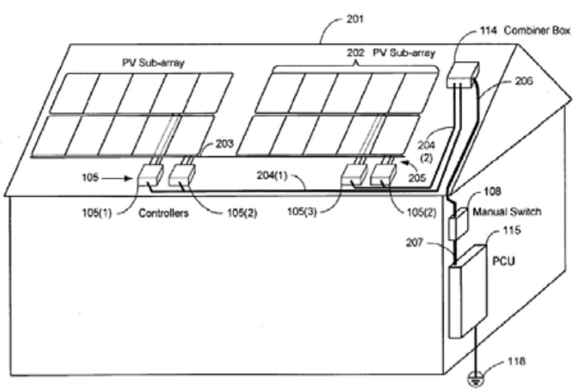
As shown in Figure 1 below, Fujimoto describes a solar power generation system (the claimed "solar energy installation") that includes: an inverter 2 (**blue**) that receives power from DC power supply 1 (**grey**) via positive (**green**) and negative (**purple**) DC conductors and outputs two sine-shaped AC waveforms 36 with frequencies (f_s); and a ground leak detector (**orange**) for detecting a ground leak (**red**) in the wiring of the DC source (the claimed "DC to AC converter having a DC input with positive and negative conductors [] and an AC output having an output waveform with an output repetition frequency, a method of detecting a ground leak in the DC wiring to the solar array"). Ex. 1534, ¶¶ [0001]-[0006], [0008], [0010]-[0011], [0013], Abstract, Claim 1, Figs. 1-4. Ex. 1502, ¶¶ 182-185.



Ex. 1534, Fig. 1 (annotated).

Fujimoto's DC power supply 1 comprises a solar cell or similar DC power source, which a skilled artisan would have understood to include the claimed "photovoltaic solar array," because it was known at the time that solar cells in photovoltaic systems such as the one disclosed in Fujimoto, where packaged in arrays to provide the mechanical packaging and electrical integration for the cells. Ex. 1534, ¶¶ [0001]-[0003], Figs. 1-3, Ex. 1519, pp. 21-22 (Figure 690.1(A), Exhibit 690.2); Ex. 1502, ¶ 186. To the extent Patent Owner contends a photovoltaic solar array is not explicitly disclosed in Fujimoto, it would have been obvious to connect multiple Fujimoto solar cells into arrays, since it was well known at the time that solar cells are arranged and commercially available as solar arrays to produce a higher DC voltage necessary for power conversion. Ex. 1519, pp. 21-24 (Exhibits 690.1-690.4 illustrating photovoltaic arrays connected to an inverter in home installations); Ex. 1506, 4:66-5:2; Ex. 1526, ¶¶ [0029]-[0031]; Ex. 1524, ¶ [0037]; Ex. 1502, ¶ 186. It would also have been obvious to use the photovoltaic solar arrays 101 disclosed in Boniface or photovoltaic solar arrays disclosed in NEC Handbook for the DC power supply 1 of Fujimoto for the same reasons. Ex. 1519, pp. 21-24 (*e.g.*, Exhibits 690.3 and 690.4 illustrating photovoltaic arrays connected to an inverter in home installations); Ex. 1506, 4:66-5:2; Ex. 1526, ¶¶ [0029]-[0031]; Ex. 1507, ¶ [0037]; Ex. 1502, ¶ 187.

Photovoltaic solar arrays were already known and used in the industry as a means of integrating multiple photo cells together for installation (*e.g.*, on the roof of a home) in photovoltaic systems, and there were established safety standards (*e.g.*, the NEC Handbook) for installing such arrays in the US. Ex. 1524, Fig. 2, ¶¶ [0013], [0039]; Ex. 1519, pp. 21-31; Ex. 1502, ¶¶ 187-189.



Ex. 1524, Fig. 2 (annotated)

Ex. 1519, p. 22 (Exhibit 690.1)

As such, this would have been nothing more than combining prior art elements (photovoltaic solar arrays as disclosed in Boniface or the NEC Handbook) according to known methods (established in the industry and specified in the NEC Handbook) to yield a predictable result of a photovoltaic system meeting requisite safety requirements. Ex. 1502, ¶ 190. A PHOSITA have had a reasonable likelihood of success since requirements for installation of such panels was well established (*e.g.*, by the NEC Handbook) and the connection of a photovoltaic solar array to an inverter merely entails an exercise of routine skill. *Id.*, ¶ 191.

Fujimoto does not expressly disclose routing the positive and negative DC conductors "in parallel with an array grounding conductor," but this was a well-known wiring technique as also shown in Boniface—which also includes a solar generation installation—and the NEC Handbook—which sets forth standards of wiring such systems in the United States. Ex. 1524, ¶¶ [0037]-[0039], Figs. 1, 2; Ex. 1519, pp. 8, 21-29; Ex. 1502, ¶ 192.

As shown below in Figure 1, Boniface discloses a fault detection system comprising a photovoltaic solar array 101 (**blue**) connected to a power conditioning unit, *e.g.*, inverter 115 (**orange**), via connective wiring. Ex. 1524, ¶¶ [0037]-[0039], [0048], Figs. 1, 2, 6, 8; Ex. 1502, ¶ 193. Boniface also discloses that a photovoltaic source positive conductor (102/112/112') and a negative conductor (103/113/113') (**green**) are routed in parallel with an equipment ground conductor 104 connected to earth ground system 118. Ex. 1524, ¶¶ [0037]-[0039], [0048], Figs. 1, 2, 6, 8; Ex. 1502, ¶ 193.

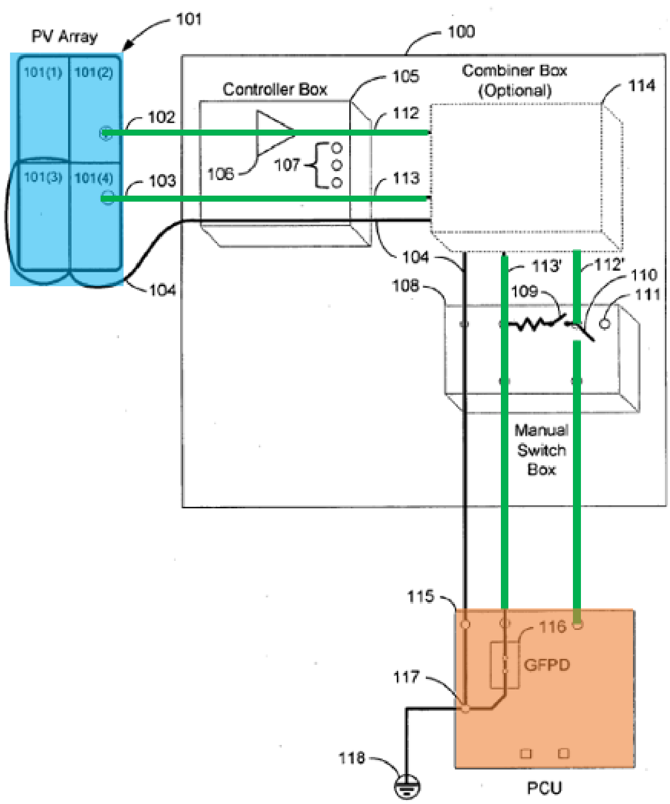


Fig. 1

Ex. 1524, Fig. 1 (annotated).

Boniface's positive and negative conductors, as well as the ground conductor, are fed together into a conduit routed from the PV array output to inverter 115 and earth ground system 118 (the claimed "routed in parallel with an array grounding conductor"). Ex. 1524, ¶¶ [0037], [0039], [0043], [0048], Figs. 1, 2, 3B, 5A-5B, 6, 8; Ex. 1502, ¶¶ 194-195.

Additionally, the NEC Handbook teaches that an "equipment grounding conductor between a PV array and other equipment shall be required" and that "[e]quipment grounding conductors for the PV array . . . shall be contained within the same raceway or cable, or otherwise run with the PV array circuit conductors when those circuit conductors leave the vicinity of the PV array." Ex. 1519, pp. 24, 28-29 ("690.43 Equipment Grounding"); Ex 1502, ¶ 196. The NEC Handbook defines a "raceway" as an "enclosed channel of metal or nonmetallic materials designed expressly for holding wires" including liquidtight flexible conduit, flexible metallic tubing, and flexible metal conduit. Ex. 1519, p. 13; Ex 1502, ¶ 196. Thus, the NEC Handbook also discloses the claimed "routed in parallel with an array grounding conductor." Ex 1502, ¶ 196.

These are the same kind of conduits described in the '822 patent for routing the positive, negative and grounding conductors in parallel through the ground leak detector. Ex. 1501, 25:59-63, 30:46-50, 31:41-45, 31:65-32:3; Ex. 1502, ¶ 196.

A PHOSITA would have been motivated to implement a grounding conductor within Fujimoto's system, in view of the NEC Handbook or Boniface's teaching, and to route Fujimoto's positive and negative conductors in parallel with the frame grounding conductor (*e.g.*, using a conduit) to prevent shock hazards and improve safety. Ex. 1519, p. 7; Ex. 1524, ¶¶ [0001]-[0003], [0039], [0048], [0050]; Ex. 1502, ¶ 197. Specifically, Boniface teaches preventing shock hazards in PV sources by using an equipment ground conductor to connect an entire PV system to PV array equipment or an earth ground system, per the 2008 National Electric Code protocol (NEC Handbook). Ex. 1524, ¶¶ [0001]-[0003], [0038]-[0039], [0048], [0050]; *see*

Ex. 1519, p. 29 ("690.43 Equipment Grounding"); Ex. 1502, ¶ 197. And the NEC Handbook requires a low impedance path for ground fault current back to the load to prevent the ground fault current from flowing through other structures that may create a hazard. Ex. 1519, pp. 24, 29; Ex. 1502, ¶ 197. A PHOSITA would have met these safety requirements by routing the wires through the same conduit (*i.e.*, in parallel) as specified by the NEC. Ex. 1502, ¶¶ 198-199. At the time, the NEC had been adopted by numerous municipalities in the US, thus wiring the Fujimoto system in this manner would indeed have been required. Ex. 1519, pp. 7-8, 29; Ex. 1502, ¶ 199.

Such a combination would thus have been using known techniques (a method of preventing shock hazards by routing positive, negative, and frame ground conductors in parallel through the same conduit, as taught by Boniface and the NEC Handbook) to improve similar devices (the similar PV systems disclosed in Fujimoto, Boniface, and the NEC Handbook) in the same way. Ex. 1534, ¶¶ [0001], [0002]-[0005], [0006]-[0010], Abstract, Claim 1; Ex. 1524, ¶¶ [0001]-[0003], [0037], [0039], Fig. 1; Ex. 1519, pp. 16-17; Ex. 1502, ¶¶ 200-201.

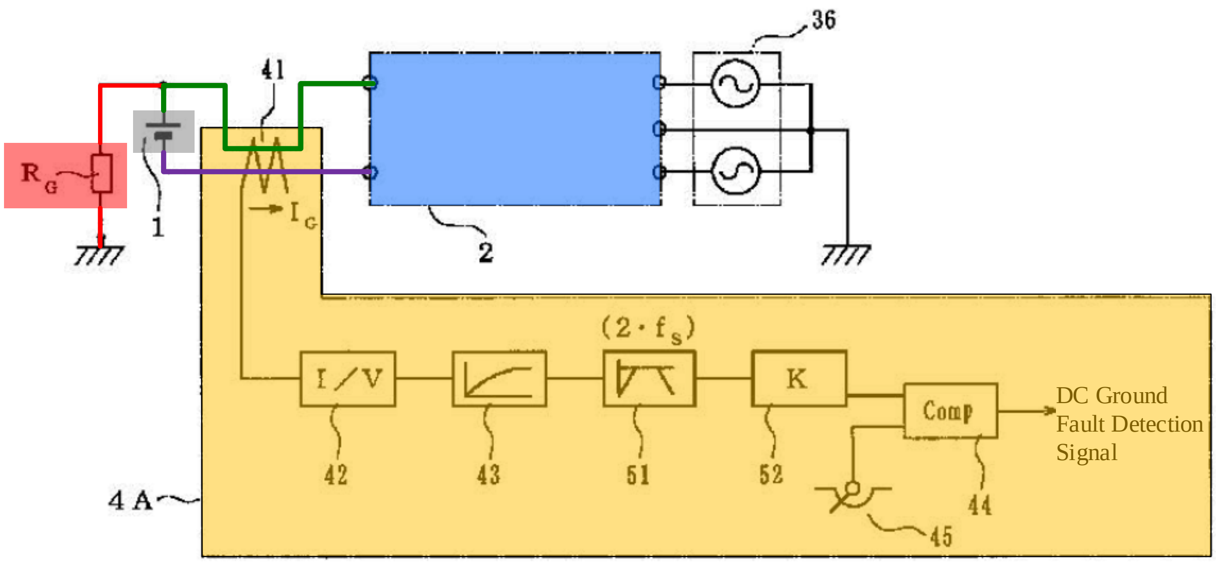
A PHOSITA would have expected success in combining Fujimoto with the photovoltaic arrays and parallel wiring disclosed in Boniface or the NEC Handbook. Ex. 1502, ¶ 202. First Fujimoto, Boniface, and the NEC Handbook describe similar photovoltaic systems sharing similar components and features—for example, they each describe a PV system employing positive and negative conductors running from a DC power source to an inverter. Ex. 1502, ¶ 202. Also, Fujimoto and Boniface both use controlling circuitry to maintain safe operation of their systems, thus increasing the likelihood of compatibility. Ex. 1502, ¶ 202. Furthermore, the NEC Handbook is intended as a guide for the safe installation of electrical systems like that of Fujimoto. Ex. 1519, pp. 7-8; Ex. 1502, ¶ 202. Given that the NEC had been widely adopted in the US, a PHOSITA would have had the skills and knowledge to connect Fujimoto's PV system to an earth ground system, as taught by Boniface and the NEC Handbook, by simply routing via a conduit, a ground conductor in parallel with Fujimoto's DC conductors. Ex. 1524, ¶¶ [0038]-[0039]; Ex. 1519, pp. 7-8, 22; Ex. 1502, ¶ 202.

As discussed above in section IV.B.1, the "DC to AC converter" could be construed as a means-plus-function term. Fujimoto's inverter 2 meets the function of "[having] an AC output having an output waveform with an output repetition frequency" because it outputs two sine-shaped AC waveforms 36 with frequencies (f_s). Ex. 1534, ¶¶ [0006], [0010]; Ex. 1502, ¶¶ 204-205. Fujimoto's inverter 2 also meets the function of "creating a common mode AC probe signal waveform [] at a characteristic repetition frequency that is in phase on both said DC positive and negative input conductors" as discussed below in section V.A.1.c.

Fujimoto also discloses the same or equivalent structure to that disclosed in the ’822 patent. In particular, Fujimoto describes how inverter 2 includes various switching elements (*e.g.*, IGBT transistors) that form two half-bridges 29 and 30, that together form an H-bridge circuit similar to the H-Bridge circuit in Figure 15 of the ’822 patent. Ex. 1534, ¶¶ [0005], [0010], [0012], Fig. 3; Ex. 1501, 23:37-57, Fig. 15; Ex. 1502, ¶ 203. And like the Figure 15 H-bridge circuit in the ’822 patent, Fujimoto’s half-bridges are switched at a high frequency (pulse width modulated) to generate a filtered single phase output and a common mode waveform at the input. Ex. 1534, ¶ [0002]; Ex. 1501, Fig. 15, 23:37-57; Ex. 1502, ¶¶ 203-205.

b. “creating a common mode AC probe signal waveform from said DC to AC converter at a characteristic repetition frequency that is in phase on both said DC positive and negative input conductors”

Fujimoto discloses this limitation. Ex. 1502, ¶¶ 206-210. DC current flow is normally balanced with current in Fujimoto’s positive conductor (**green**) from the DC power supply to the inverter, and the return current in Fujimoto’s negative conductor (**purple**) being equal. Ex. 1531 (certified translation of Ex. 1530), ¶ [0005]; Ex. 1502, ¶ 208; Ex. 1534, Figs. 1, 3 (annotated below). Fujimoto explains that if a ground fault resistance R_G (**red**) exists between the positive conductor and ground, (the claimed “ground leak”), a difference in the positive and negative currents—*i.e.*, a “common current” I_G—is created with an AC component (I_{ac}) having a frequency (the claimed “characteristic repetition frequency”) that is twice the inverter AC output waveform frequency (f_s). Ex. 1534, Abstract, ¶¶ [0004]-[0007], [0010]-[0011], Figs. 1 (annotated), 4; Ex. 1502, ¶¶ 208-209.



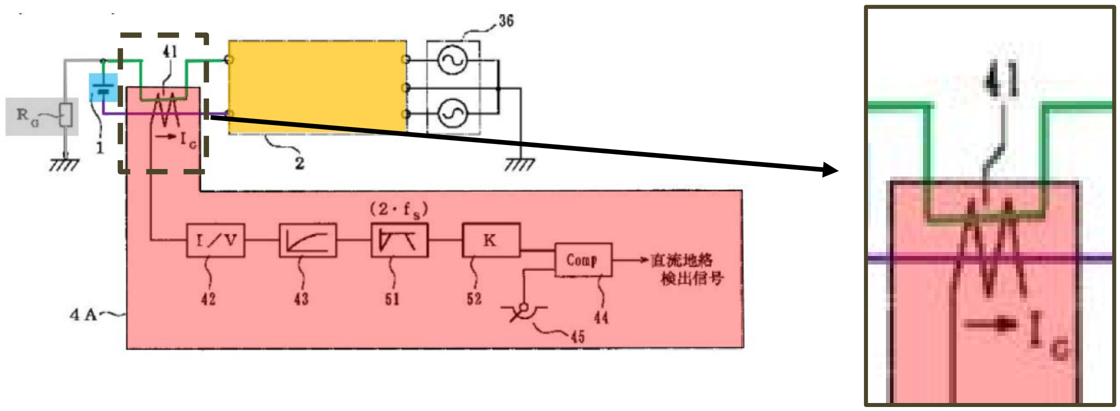
Ex. 1534, Fig. 1 (annotated).

A PHOSITA would have recognized that the equal amounts of current flowing in the positive conductor to the inverter and returning from the inverter is differential mode current, and that the differing amounts of these currents due to the ground leak is common mode current which appears equally and in phase on both conductors. *See* Section III.A.2, *supra*; Ex. 1502, ¶¶ 160-162, 209; Ex. 1534, Abstract, ¶¶ [0004]-[0007]; Ex. 1543, p. 4; Ex. 1542, p. 4; Ex. 1536, p. 4; Ex. 1545, pp. 9-11; Ex. 1564, 302-310; Ex. 1565, 323-338. A PHOSITA would further have understood that this common mode current (I_{ac} with $2f_s$ frequency) is induced on Fujimoto's conductors from a common-mode voltage—having the same in-phase relationship, as determined by $V_{CM} = R_G*I_{ac}$)—generated by the switching arrangement of

Fujimoto's inverter 2 (the claimed "DC to AC converter"). Ex. 1502, ¶ 210; Ex. 1534, ¶¶ [0003]-[0007], [0010]-[0011], Claim 1, Figs. 1, 3-4; *see also* Ex. 1543, p. 4; Ex. 1542, p. 4; Ex. 1536, p. 4; Ex. 1545, pp. 9-11; Section III.A, *supra*. Fujimoto thus discloses the claimed "creating a common mode AC probe signal waveform from said DC to AC converter at a characteristic repetition frequency that is in phase on both said DC positive and negative input conductors." Ex. 1502, ¶ 210.

c. "passing said positive and negative conductors from the array through a detector adapted to detect an unusual current with said common mode waveform at said characteristic repetition frequency and"

Fujimoto discloses this limitation. Ex. 1502, ¶¶ 211-217. Fujimoto's current transformer 41 detects a DC ground fault by measuring the magnitude of a "common current" I_G, "which is the difference between the current that flows from the positive electrode side of the DC power supply 1 ***through the current transformer 41***, and the current that flows into the negative electrode side." Ex. 1534, ¶ [0005] (emphasis added), Figs. 1-3. For example, as shown below in Figure 1 (annotated), Fujimoto's positive conductor (**green**) and negative conductor (**purple**) are passed from Fujimoto's DC power supply 1 through current transformer 41 and ground fault detecting device 4 (**orange**) (the claimed "passing said positive and negative conductors from the array through a detector"). Ex. 1502, ¶ 213; Ex. 1534, ¶ [0005], Abstract, Figs. 1, 3.



Ex. 1534, Fig. 1 (annotated).

Fujimoto's current transformer 41 is a well-known device in which the current-carrying conductors form a primary winding passing through a magnetic core (often a single turn) which inductively induces a proportional smaller current in a secondary winding around the magnetic core that is then used for the measurement. Ex. 1536, p. 5; Ex. 1542, p. 5; Ex. 1543, p. 5; Ex. 1563, Fig. 1A, 1:32-41, 1:47-52, 2:27-44, 3:24-26, 4:8-16, 4:20-25, 4:30-34, 4:38-45, 5:25-28, 5:44-62, 6:10-27; Ex. 1502, ¶ 214. Both Fujimoto's positive and negative DC conductors pass through current transducer 41, which means that current on the positive conductor and equal current returning (in the opposite direction) on the negative conductor, will induce equal, but opposite measurement currents that cancel each other out. Ex. 1502, ¶ 214. As a result, only common-mode currents (*i.e.*, currents traveling in the same direction and in-phase, for example, from Fujimoto's inverter 2 right-to-left to the ground leak R_G) will induce a measurement current that can be detected in current transformer 41. Ex. 1502, ¶ 214; Ex. 1534, ¶¶ [0004]-[0006].

From the common current I_G measured by current transducer 41, Fujimoto's ground fault detecting device 4 extracts, using a band pass filter 51, the common-mode current I_{ac} (the claimed "unusual current") that is twice the AC power supply frequency ($2f_s$) and which is only present in the event of a ground fault R_G, thus disclosing the claimed "detector adapted to detect an unusual current with said common mode waveform at said characteristic repetition frequency." Ex. 1534, ¶¶ [0004]-[0008], [0010]-[0011], Claim 1, Figs. 1, 3-4; Ex. 1502, ¶¶ 214-215; *see also* § III.A, *supra*.

As discussed above in Section IV.B.2, "detector" could be construed as a means-plus-function term. A PHOSITA would have recognized that Fujimoto's current transformer 41 (a well-known device consisting of coils in which a primary current induces a proportional secondary current for measurement) is the same or an insubstantially different structure as the '822 patent's current transformer (toroid 800 and windings 801). Ex. 1502, ¶¶ 216-217; Ex. 1501, 31:65-32:20, 35:66-36:3, Fig. 18; Ex. 1534, ¶¶ [0005], [0008]; Ex. 1536, p. 5; Ex. 1542, p. 5; Ex. 1543, p. 5; Ex. 1563, Fig. 1A, 1:32-41, 1:47-52, 2:27-44, 3:24-26, 4:8-16, 4:20-25, 4:30-34, 4:38-45, 5:25-28, 5:44-62, 6:10-27. Fujimoto's current transformer performs the same function (detecting a difference in the current flowing through the positive conductor and back through the negative conductor) in the same way (coupling to the positive and negative DC input lines) for the same result (outputting a ground fault signal). Ex. 1502, ¶ 217.

d. "upon detection of said unusual current providing an indication of the presence of an unwanted ground leak."

This limitation should be interpreted as conditional language because it is contingent "upon detection of said unusual current." *See Ex parte Schulhauser*, No. 2013-007847, slip op. at 10 (P.T.A.B. April 28, 2016) ("If the condition for performing a contingent step is not satisfied, the performance recited by the step need not be carried out in order for the claimed method to be performed.") Here, if the "unusual current" is not detected, then the claim does not require the limitation to be performed. *Id*.

However, to the extent that this claim limitation is found to be required, Fujimoto discloses this limitation. Ex. 1502, ¶¶ 218-220. Fujimoto describes that, after extracting the common mode I_{ac} with band pass filter 51, the signal is inputted to an amplifier 52, and the amplified signal is compared to a detection level with comparator 44. Ex. 1534, ¶ [0011]; Ex. 1502, ¶ 219. If the filtered and amplified signal exceeds the detection level, DC ground fault detecting device 4 outputs a DC ground fault detection signal to open circuit breaker 35 to stop the operation of Fujimoto's inverter 2 (the claimed "upon detection of said unusual current providing an indication of the presence of an unwanted ground leak."). Ex. 1534, ¶¶ [0001], [0004]-[0005], [0007]-[0008], [0011], Figs. 1, 3; Ex. 1502, ¶¶ 219-220.

2. Dependent Claim 15 (Grounds 1 and 2)

"The method of claim 14 in which the characteristic repetition frequency of said probe signal waveform is 1, 2 or 3 times the AC output repetition frequency of said DC to AC converter".

Claim 15 depends from claim 14, which is taught by Fujimoto in view of Boniface or NEC Handbook, as discussed above. *See* § V.A.1, *supra*. The additional limitations introduced by claim 15 are taught by Fujimoto. Ex. 1502, ¶ 221.

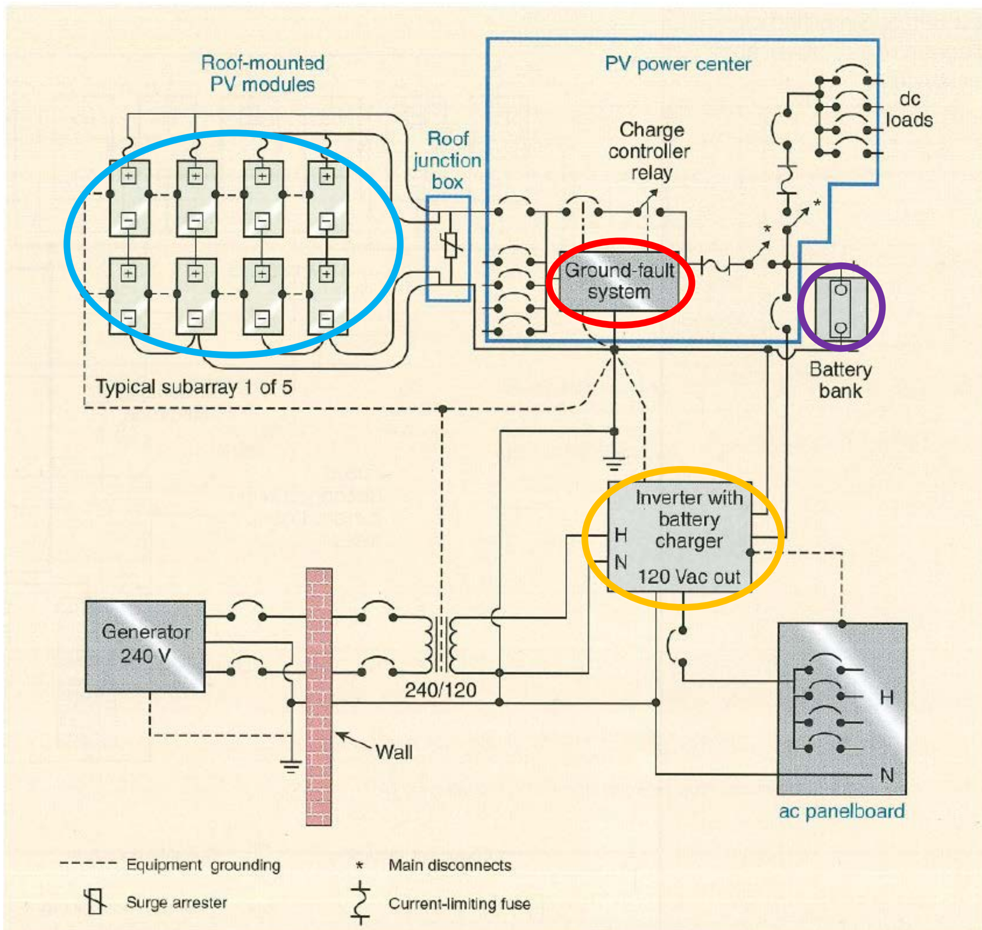
Fujimoto describes that inverter 2 outputs AC power having a frequency (f_s) (the claimed "output repetition frequency"). Ex. 1534, ¶¶ [0006], [0008], [0010]-[0011], [0013], Abstract, Claim 1, Fig. 4; Ex. 1502, ¶ 222. As discussed above, the switching arrangement of Fujimoto's inverter 2 generates a common-mode AC output waveform (the claimed "probe signal waveform"), which causes a "common current" I_G comprising a ground fault current AC component (I_{ac}) with the same frequency to be induced on Fujimoto's positive and negative conductors. Ex. 1502, ¶ 223; *see* §§ III.A.2, V.A.1.b, *supra*. The AC component (I_{ac}) has a frequency that is twice that of the output frequency (f_s), thus disclosing the claimed "characteristic repetition frequency of said probe signal waveform [2] times the AC output repetition frequency of said DC to AC converter." Ex. 1534, ¶¶ [0004]-[0007], [0010]-[0011], Claim 1, Figs. 1, 3-4; Ex. 1502, ¶¶ 223-224; *see* § V.A.1.b, *supra*.

3. Dependent Claim 16 (Grounds 2 and 3)

"The method of claim 15, further comprising a storage battery charged by said solar array, in which said probe signal and unusual current detector also detect unwanted ground leaks from the DC conductors leading to and from said battery."

Claim 16 depends from claim 15, which is taught by Fujimoto in view of Boniface or the NEC Handbook, as discussed above. *See* §§ V.A.1 and V.A.2, *supra*. The combination of Fujimoto and the NEC Handbook, and the combination of Fujimoto, Boniface, and the NEC Handbook teaches the additional subject matter recited by claim 16 for the reasons that follow. Ex. 1502, ¶ 225.

As discussed above, Fujimoto describes a DC power supply 1 which can be a photovoltaic array such as those described in Boniface or the NEC Handbook. *See* Section V.A.1.a, *supra*. The NEC Handbook further describes systems that include a storage battery charged by the photovoltaic array. Ex. 1519, pp. 21 (Figure 690.1(A)), 22 (describing charge controllers for batteries), 23 (Exhibit 690.3), 24 (Exhibit 690.4), 30-32; Ex. 1502 ¶ 226. Exhibit 690.4 of the NEC Handbook illustrates a system where a battery bank (**purple**) is charged using a roof-mounted photovoltaic array (**blue**) that also supplies power to an inverter (**orange**). Ex 1519, p. 24 (Exhibit 690.4); Ex. 1502, ¶ 226. Exhibit 690.4 further shows a ground fault detector (**red**) (as required by NEC section 690.5) positioned to detect ground faults on the DC conductors connected to the storage battery. Ex. 1519, pp. 24-25, *see also* 23 (Exhibit 690.3); Ex. 1502, ¶ 226.



Ex. 1519, p. 24 (Exhibit 690.4) (annotated).

It would have been obvious to modify Fujimoto's and Fujimoto-Boniface's power conversion system to include a storage battery charged by a photovoltaic array, as taught by the NEC Handbook. Ex. 1502, ¶ 227. Furthermore it would have been obvious to have the ground fault detector of Fujimoto detect ground faults on the DC conductors leading to and from the battery. Ex. 1519, pp. 21 (Figure 690.1(A)), 23 (Exhibit 690.3), 24 (Exhibit 690.4); Ex. 1502, ¶ 227. Including a storage battery in Fujimoto's and Fujimoto-Boniface's power conversion system would advantageously provide a back-up power source overnight or whenever sufficient power was not available from the photovoltaic array (*e.g.*, during cloudy weather) and/or when a grid or other external source of AC power is unavailable. Ex. 1502, ¶ 227. This enhanced functionality would be desirable to consumers. *Id.*

Incorporating a storage battery merely involves combining known elements (Fujimoto's and Fujimoto-Boniface's power system and ground leak detector, and the NEC Handbook's rechargeable storage battery) according to known methods (attaching the back-up battery to the DC output connections of the photovoltaic array and the input connections for the inverter) to yield predictable results (DC power from the photovoltaic array may be provided to the battery, and DC power from the battery may be provided to the inverter). *Id.*, ¶ 228. A PHOSITA would have had the skills, knowledge, and motivation to carry out the combination. *Id*.

Additionally, combining Fujimoto and Fujimoto-Boniface with the NEC Handbook would be merely using known techniques to improve similar devices. Ex. 1502, ¶ 229. A back-up power source would have improved Fujimoto's and Fujimoto-Boniface's system, by providing an alternative source for powering the load. *Id.* And, the NEC Handbook discloses a solar power generation system comparable to Fujimoto's system, as both systems include a photovoltaic power source that provides, via conductors, DC electricity to an inverter for conversion to AC electricity to power a load. Ex. 1502, ¶ 229.

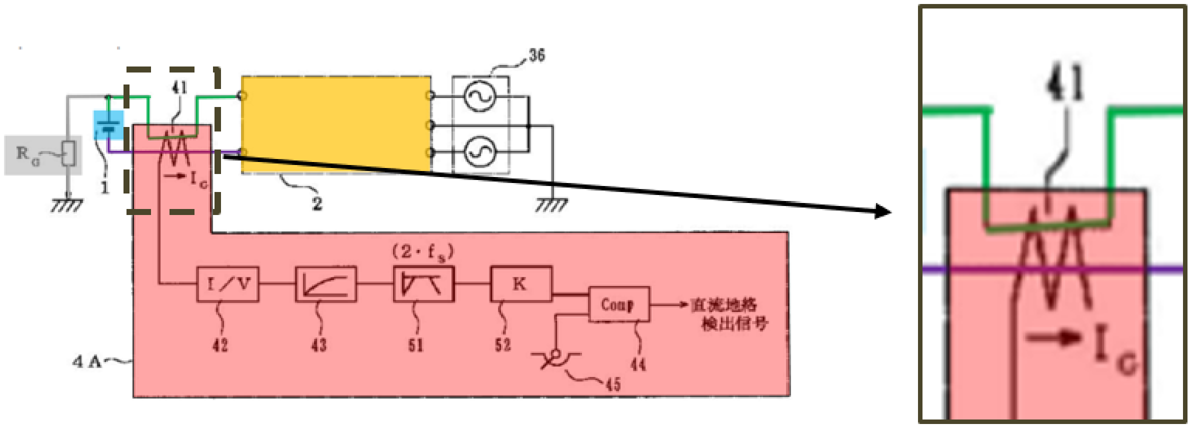
Moreover, in doing so, a PHOSITA would have had a reasonable expectation of success because the proposed implementations of Fujimoto-NEC Handbook and Fujimoto-Boniface-NEC Handbook would be well within the standard skill set of a PHOSITA at the time. Ex. 1502, ¶ 230. And Fujimoto and Fujimoto-Boniface already measure the common mode current at the input of the inverter to detect unwanted ground leaks. *Id*. Thus, unwanted ground leaks from either the photovoltaic array or battery connected to that inverter input would also continue to be detected in the Fujimoto-NEC Handbook and Fujimoto-Boniface NEC Handbook combinations. *Id*.

4. Dependent Claim 18 (Grounds 1 and 2)

> **"The method of claim 14 in which said detection of an unusual current comprises measuring an output signal having said common mode waveform with one or more current transformers encircling either said positive and negative conductors only or encircling said positive and negative conductors and said array grounding conductor".**

Claim 18 depends from claim 14, which is taught by Fujimoto in view of Boniface or the NEC Handbook, as discussed above. *See* § V.A.1, *supra*. The additional limitations introduced by claim 18 are taught by Fujimoto. Ex. 1502, ¶ 231.

Fujimoto's ground fault detecting device 4 detects a common current (I_G) comprising a ground fault current AC component (I_{ac}) (the claimed "unusual current") using current transformer 41, which as discussed above (*see* Section V.A.1.c, *supra*), is a well-known device in which the current carrying conductors form a primary winding passing through a magnetic core which inductively induces a proportional smaller current in a secondary winding around the magnetic core that is then used for the measurement. *See e.g.*, Ex. 1536, p. 5; Ex. 1542, p. 5; Ex. 1543, p. 5; Ex. 1563, Fig. 1A, 1:32-41, 1:47-52, 2:27-44, 3:24-26, 4:8-16, 4:20-25, 4:30-34, 4:38-45, 5:25-28, 5:44-62, 6:10-27; Ex. 1502, ¶¶ 232-233. As also discussed, the AC component (I_{ac}) at twice the AC output frequency (2fs), which is the frequency of the common mode waveform, is measured as the difference between currents in Fujimoto's positive and negative DC conductors that flow "through the current transformer 41" as shown below in Figure 1 (the claimed "measuring an output signal having said common mode waveform with one or more current transformers encircling [] said positive and negative conductors"). Ex. 1534, ¶ [0005], Figs. 1-3, Abstract; *see also* § V.A.1.c, *supra*. Ex. 1502, ¶¶ 233-234.



Ex. 1534, Fig. 1 (annotated).

5. Dependent Claim 19 (Grounds 1 and 2)

"The method of claim 14 in which said detection of an unusual current comprises correlating said common mode waveform with the output signal from one or more current transformers encircling either said positive and negative conductors only or encircling said positive and negative conductors and said array grounding conductor".

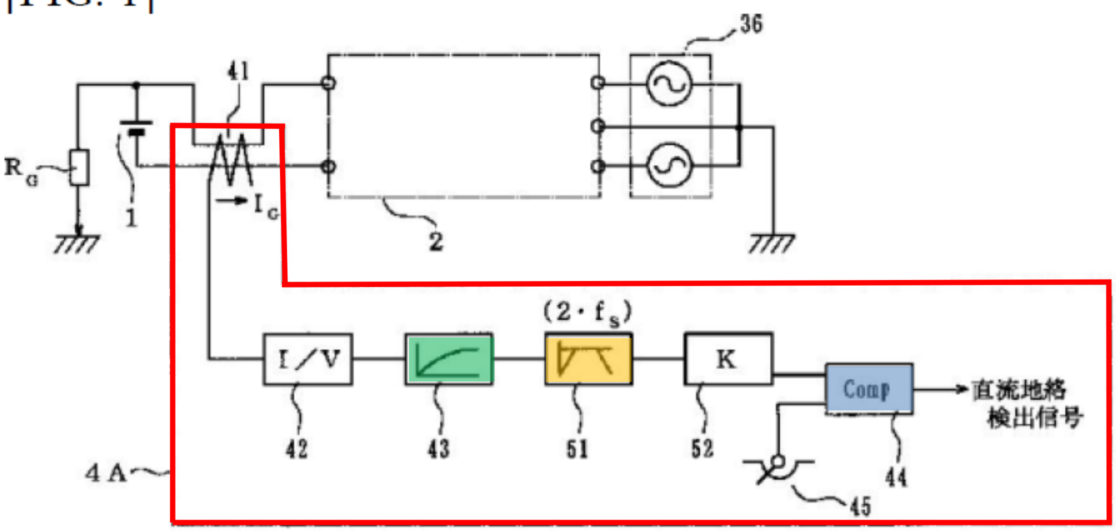
Claim 19 depends from claim 14, which is taught by Fujimoto in view of Boniface or NEC Handbook, as discussed above. *See* § V.A.1, *supra*. The additional limitations introduced by claim 19 are taught by Fujimoto. Ex. 1502, ¶ 235.

As explained above with respect to claim 18, Fujimoto's ground fault detecting device 4 detects a common current (I_G) comprising a ground fault current AC component (I_{ac}) (the claimed "unusual current") using current transformer 41, which encircles the positive and negative DC conductors. *See* Section V.A.3, *supra*. Ex. 1534, ¶ [0005], Abstract, Figs. 1-3; Ex. 1536, p. 5; Ex. 1542, p. 5; Ex. 1543, p.

5; Ex. 1563, Fig. 1A, 1:32-41, 1:47-52, 2:27-44, 3:24-26, 4:8-16, 4:20-25, 4:30-34, 4:38-45, 5:25-28, 5:44-62, 6:10-27; Ex. 1502, ¶ 236.

Additionally, as shown below in Figure 1 (annotated), Fujimoto's current transformer 41 generates an output current signal (the claimed "output signal"), *e.g.*, from a secondary winding, that is converted to a voltage signal by current/voltage converter 42, which is then passed through filter 43 (**green**) for removing high-frequency pulse width modulation (PWM) components (*e.g.*, generated by Fujimoto's inverter 2). Ex. 1534, Figs. 1-3, Abstract, ¶¶ [0005], [0010]-[0012]; Ex. 1502, ¶¶ 237-238. This signal is then input to Fujimoto's band pass filter 51 (**orange**), which extracts only the portion of the signal at a frequency that is twice that of the single-phase AC power supply frequency (f_s). Ex. 1534, Figs. 1-3, Abstract, ¶¶ [0005], [0008], [0010]-[0012], claim 1; Ex. 1502, ¶ 238.

[FIG. 1]



Ex. 1534, Fig. 1 (annotated).

The extracted signal at $2f_s$ frequency is then amplified with amplifier 52 and compared to a detection level to determine if a ground fault current AC component (I_{ac}) (the claimed "unusual current") with a $2f_s$ frequency is present. Ex. 1534, ¶¶ [0005], [0008]-[0011], Claims 1-2; Ex. 1502, ¶ 239. This correlates the output of the current transformer with the common mode waveform as required by claim 19, because it detects whether the output signal has the same $2f_s$ frequency as the common mode waveform (if they are present). Ex. 1502, ¶¶ 239-240.

B. Grounds 4 and 5: Fujimoto in view of Boniface or NEC Handbook in further view of Iwata Renders Claim 17 Obvious

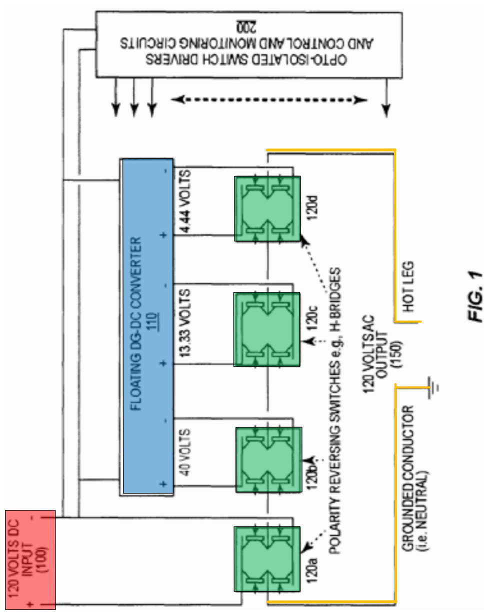
Claim 17: "The method of claim 14 in which said common-mode AC probe signal waveform corresponds to the changing value of a selected digit within a multi-digit number sequence representing said AC output waveform."

Claim 17 depends from claim 14, which is taught by Fujimoto in view of Boniface or the NEC Handbook, as discussed above. *See* § V.A.1, *supra*. Fujimoto-Boniface/NEC Handbook in view of Iwata teaches the additional subject matter recited by claim 17 for the reasons that follow. Ex. 1502, ¶ 241.

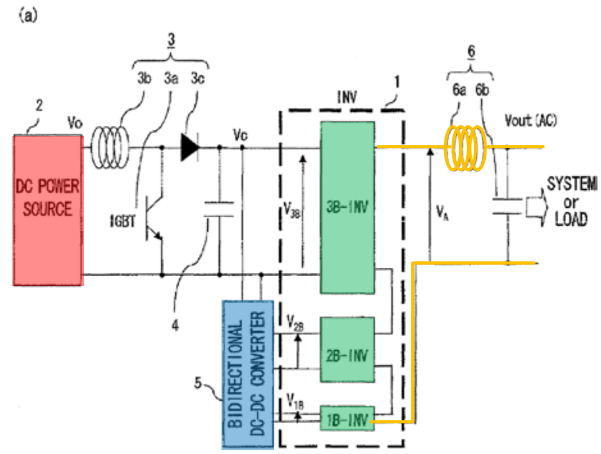
As explained above, Fujimoto's inverter 2 uses a switching circuit 23 and half-bridge inverters 29/30 to produce an AC output waveform having a frequency (f_s) and a common mode waveform with a frequency of $2f_s$ at its inputs. *See* Sections III.A.2, V.A.1.b, *supra*; Ex. 1534, ¶¶ [0002]-[0006], Figs. 1, 3-4; Ex. 1502, ¶¶ 241-242.

Iwata similarly discloses two half-bridges (together referred to as an "H-bridge") as a single phase inverter, which is combined with two other single-phase H-bridge inverters connected in series to form a power conditioner that outputs a single-phase sine wave. Ex. 1507, ¶¶ [0045]-[0046]; Ex. 1502, ¶ 242.

As shown below, Iwata discloses a DC to AC inverter unit 1 that is insubstantially different from that in the '822 patent with a set of series-connected single-phase (H-bridge) inverters (1B-INV, 2B-INV, and 3B-INV) (**green**) that outputs "a substantially sine wave-like output voltage waveform" from the series connection (**orange**) by generating different voltage levels through different combinations of the H-bridge inverter outputs. *Compare* Ex. 1501, 6:16-26, Fig. 1 *with* Ex. 1507, Abstract, ¶¶ [0007]-[0009], [0046]-[0047], [0050]-[0053], [0056], [0059], [0061], [0078], [0090], [0097], [0101], claims 1, 12, 22, 30, Figs. 1, 2, 4, 5, 13, 15; Ex. 1502, ¶¶ 243-244.



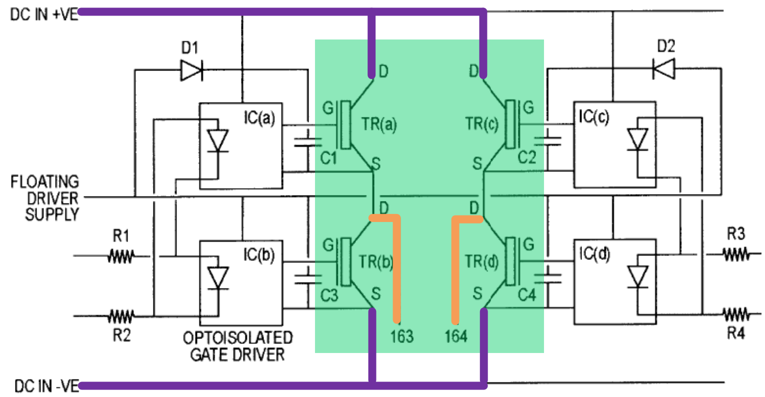
Ex. 1501, Fig. 1 (annotated)



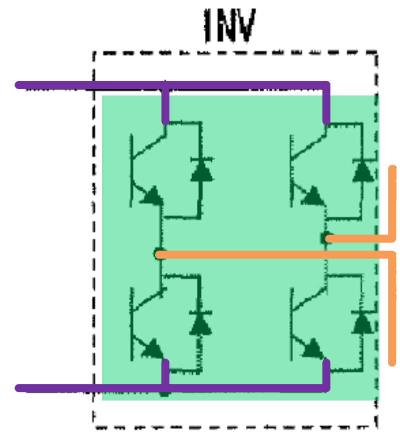
Ex. 1507, Fig. 1(a) (annotated)

In Iwata's embodiment from Figure 1, V_{1B}, V_{2B}, and V_{3B} are the DC power source voltage inputs, respectively, for H-bridge inverters 1B-INV, 2B-INV and 3B-INV. Ex. 1507, ¶ [0049], Fig. 1; Ex. 1502, ¶ 245. Further, V_{1B}, V_{2B}, and V_{3B} are controlled to have predetermined 1:3:9 voltage ratio by the DC-DC converter 5. Ex. 1507, ¶¶ [0048], [0050]-[0051], Figs. 2, 4-5; Ex. 1502, ¶ 245.

Iwata's H-bridge inverters are arranged and controlled identically to the H-bridge switches disclosed in the '822 patent (as shown in the comparison figures below) via a ternary-valued selection signal to operate in three states Iwata refers to as +1, -1, and 0. Ex. 1507, ¶¶ [0046]-[0047], [0050]-[0051], [0059], Fig. 2, 4-5; Ex. 1501, 6:41-46, 7:49-8:3, 10:1-22, 10:35-44, Fig. 3; Ex. 1502, ¶ 246.

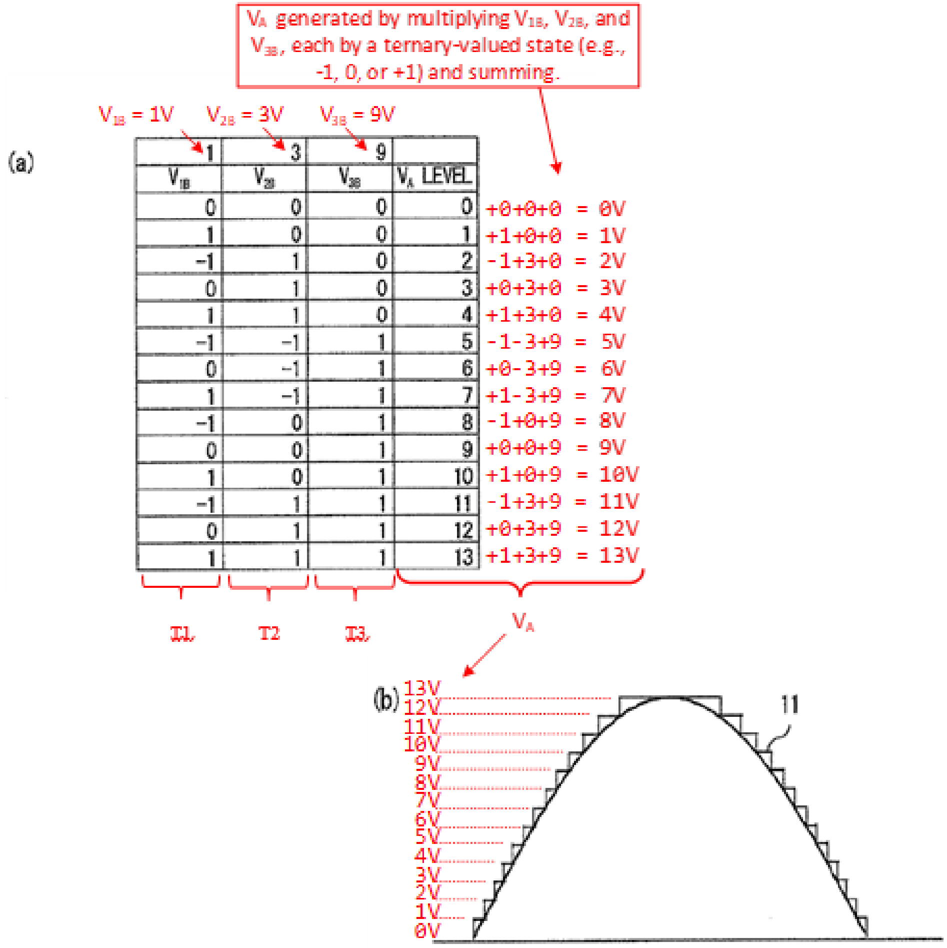


Ex. 1501, Fig. 3 (annotated)



Ex. 1507, Fig. 1(b) (annotated)

Specifically, Iwata's three H-bridge inverters operate to generate a sine wave-like output shown in Figure 2(b) (annotated below) according to a sampled numerical representation (V_A) of the desired AC output waveform, which as shown in Figure 2(a) (annotated below), is expressed in ternary number base with digits (V_{1B}, V_{2B}, and V_{3B}). Ex. 1507, ¶ [0050]; Ex. 1502, ¶¶ 247-248.



Ex. 1507, Figs. 2(a), 2(b) (annotated).

Each ternary digit (labeled T1, T2, and T3 above) determines whether a respective H-bridge inverter is controlled to: (i) a positive state (+1), (ii) a negative state (-1), or (iii) a pass-through state (0). *See* Ex. 1507, ¶ [0050]; Ex. 1502, ¶ 249. In the positive and negative states, the H-bridge inverters output their input voltage with positive or negative polarity, respectively, and in the pass-through state output zero voltage. Ex. 1507, ¶¶ [0047], [0050], Figs. 1-2; Ex. 1502, ¶ 249.

The outputs of Iwata's switches (**green**) are connected in series (**orange**), as shown above in Figure 1(b) (annotated) so that the output V_A is the sum of the outputs of H-bridge inverters 1B-INV, 2B-INV and 3B-INV. Ex. 1507, ¶¶ [0007]-[0009], [0047], [0056], [0059], [0101], [0108]-[0111], Abstract, claims 1, 12, 22, 30; Ex. 1502, ¶ 248. The voltage (V_A) is thus equal to the sum of the input voltages (*e.g.*, 1V, 3V, and 9V), weighted by their respective ternary digits. Ex. 1502, ¶ 250. This can be expressed as a multi-digit number representing the AC output waveform according to the formula: $T_1+3T_2+9T_3$ for input voltages V_{1B} = 1V, V_{2B} = 3V, and V_{3B} = 9V. Ex. 1507, ¶¶ [0009], [0047], [0049]-[0051], Figs. 4-5, claims 1, 13, 25; Ex. 1502, ¶ 250. As shown in Iwata's Figures 2(a) and 2(b) above, the multi digit number (T1, T2, T3) changes in a specific sequence to create output voltage steps from 0V to 13V approximating a sine wave (the claimed "multi-digit number sequence representing said AC output waveform"). Ex. 1507, ¶¶ [0047], [0049]-[0051]; Ex. 1502, ¶ 250.

It was also well known, that this switching of an H-bridge inverter creates common mode voltage waveforms at the H-bridge input, due to the fact that the positive and negative DC input terminals are alternatively connected to each output neutral terminal. Ex. 1502, ¶¶ 150-151, 251; Ex. 1545, pp. 9-11; Ex. 1503, 5:35-55; Ex. 1515, p. 3121, Fig. 5; Ex. 1564, 302-310; Ex. 1565, 323-338. It follows that, because each H-bridge inverter switches according to the changing value of its respective digit, the common mode voltage at the input of each Iwata H-bridge inverter corresponds to the changing value of that H-bridge inverter's respective digit (the claimed "common-mode AC probe signal waveform corresponds to the changing value of a selected digit"). As shown in Figure 2(a), the switching of each Iwata H-bridge inverter into different states corresponds to the changing value of the H-bridge inverter's respective digit. Ex. 1507, ¶¶ [0047], [0049]-[0051]; Ex. 1502, ¶ 251.

Specifically, for each of Iwata's H-bridge inverters, the common mode voltage generated depends on the H-bridge's switching frequency. Ex. 1502, ¶¶ 150-151, 252. For example, as shown in Figure 13 of Iwata, the H-bridge inverter 3B-INV switches from -1 to 0 to +1 cyclically at a frequency that is the same as the output frequency. Ex. 1507, Fig. 13, ¶ [0097]; Ex. 1502, ¶ 252. This is identical to the switching illustrated in Figure 4 of the '822 patent for the H-bridge 120a. Ex. 1501, 6:41-7:45, 10:15-27, Figs. 1, 4 ("Most significant ternary digit"); Ex. 1502, ¶¶ 150, 252. As was well known, and as acknowledged in the '822 patent, this periodic switching creates a common mode square wave voltage generated at the H-bridge input that has the same frequency as the output. Ex. 1501, 10:35-55; Ex. 1502, ¶¶ 150-151, 252.

A skilled artisan would have been motivated to modify the Fujimoto-Boniface system and the Fujimoto-NEC Handbook system by incorporating Iwata's multilevel inverter and its corresponding DC-DC converter and control system into Fujimoto's solar power system. Ex. 1502, ¶ 253. Iwata explains that use of its multilevel inverter is desirable in order to "reduce power loss … and improve conversion efficiency in a power conversion apparatus that converts power from a DC power source such as solar light to AC and outputs AC to a system and load," and such inverters were also known to reduce output filtering requirements. Ex. 1507, ¶¶ [0005]-[0006], [0010]-[0012], [0055]-[0056], [0091], Abstract; Ex. 1531, ¶ [0005], Figs. 1, 14; Ex. 1502, ¶ 253. Such a modification would amount to nothing more than the use of known techniques (the improved multilevel inverter design using multiple H-bridge inverters and associated DC-DC converters and control logic, as taught by Iwata) to improve similar devices (Fujimoto's inverter) in the same way (using multiple-H-bridge designs and associated DC-DC converters and ternary output control logic, as taught by Iwata, to generate an AC output). Ex. 1502, ¶ 253.

Additionally, a PHOSITA making such modifications would have had a reasonable likelihood of success as it merely entails an exercise of routine skill well within the level of ordinary skill in the art. Ex. 1502, ¶ 254. Specifically, a PHOSITA would have understood the modifications entail replacing Fujimoto's inverter 2 and power system 36 with Iwata's inverter 1 and system or load connection (or equivalently, replacing Iwata's DC power source 2 with Fujimoto's

DC power source 1 and DC ground fault detecting device 4). *Id.* A PHOSITA would have further understood that Fujimoto's band-pass filter could easily be adjusted to detect a ground fault with a frequency component such as the common-mode frequency generated by Iwata's H-bridge inverter 3B-INV, which would be connected to Fujimoto's positive and negative DC input conductors in the same manner as Fujimoto's inverter 2 is connected. Ex. 1502, ¶ 254. This would have been a routine matter of tuning Fujimoto's band-pass filter to the frequency of Iwata's common-mode waveform, which was well within the level of ordinary skill in the art. *Id.*

VI. CONCLUSION

For the foregoing reasons, *inter partes* review of claims 14-19 of the '822 patent should be instituted and claims 14-19 should be canceled.

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CERTIFICATION UNDER 37 CFR § 42.24(D)

Under the provisions of 37 CFR § 42.24(d), the undersigned hereby certifies that the word count for the foregoing Petition for Inter Partes Review totals 9,411, which is less than the 14,000 allowed under 37 CFR § 42.24(a)(1)(i). This total includes 9,226 words as counted by the Word Count feature of Microsoft Word and 185 words used in annotations.

Pursuant to 37 C.F.R. § 42.24(a)(1), this count does not include the table of contents, the table of authorities, mandatory notices under § 42.8, the certificate of service, this certification of word count, the claims listing appendix, or appendix of exhibits.

BANNER & WITCOFF, LTD

Dated: October 11, 2021

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CERTIFICATE OF SERVICE

Pursuant to 37 C.F.R. § 42.105, I hereby certify that I caused a true and correct copy of the Petition for *Inter Partes* Review in connection with U.S. Patent No. 8,937,822 and supporting evidence to be served via FedEx. Priority Overnight on October 11, 2021, on the following:

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An electronic courtesy copy is concurrently being e-mailed to the following:

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CLAIM LISTING APPENDIX

U.S. Pat. No. 8,937,822

Designation	Claim Language
Claim 14	
[14A]	14. In a solar energy installation comprising a photovoltaic solar array and a DC to AC converter having a DC input with positive and negative conductors routed in parallel with an array grounding conductor and an AC output having an output waveform with an output repetition frequency, a method of detecting a ground leak in the DC wiring to the solar array, comprising:
[14B]	creating a common-mode AC probe signal waveform from said DC to AC converter at a characteristic repetition frequency that is in phase on both said DC positive and negative input conductors;
[14C]	passing said positive and negative conductors from the array through a detector adapted to detect an unusual current with said common mode waveform at said characteristic repetition frequency and upon detection of said unusual current providing an indication of the presence of an unwanted ground leak.
Claim 15	
15	15. The method of claim 14 in which the characteristic repetition frequency of said probe signal waveform is 1, 2or 3 times the AC output repetition frequency of said DC to AC converter.
Claim 16	
16	16. The method of claim 15, further comprising a storage battery charged by said solar array, in which said probe signal and unusual current detector also detect unwanted ground leaks from the DC conductors leading to and from said battery.
Claim 17	
17	17. The method of claim 14 in which said common-mode AC probe signal waveform corresponds to the changing value of a selected digit within a multi-digit number sequence representing said AC output waveform.
Claim 18	

Designation	Claim Language
18	18. The method of claim 14 in which said detection of an unusual current comprises measuring an output signal having said common mode waveform with one or more current transformers encircling either said positive and negative conductors only or encircling said positive and negative conductors and said array grounding conductor.
Claim 19	
19	19. The method of claim 14 in which said detection of an unusual current comprises correlating said common mode waveform with the output signal from one or more current transformers encircling either said positive and negative conductors only or encircling said positive and negative conductors and said array grounding conductor.