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.: IPR2022-00012

PETITION 6 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. 1604:	Certified Translation of Ex. 1620, Japanese Patent Publication No. 2006-238630 to Mori *et al*. (“Mori”)
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Ex. 1615:	Araújo, S. Highly Efficient Single-Phase Transformerless Inverters for Grid-Connected Photovoltaic Systems, IEEE Trans. on Industrial Elecs, vol. 57, no. 9 (Sept. 2010)
Ex. 1616:	Certified translation of Ex. 1646, 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. 1617:	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. 1644:	Tolbert et al., Multilevel Converters for Large Electric Drives, IEEE Trans. Ind. Apps., Vol 35, No. 1, Jan/Feb 1999
Ex. 1645:	Certified translation of Ex. 1655, Heribert Schmidt, Bruno Burger, & Klaus Kiefer. Wechselwirkungen zwischen Solarmodulen und Wechselrichtern, Fraunhofer Institute for Solar Power Systems, June 2007 ("Schmidt")

Ex. 1646:	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. 1647:	U.S. Patent No. 7,082,040 ("Raddi")
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Ex. 1651:	Certified translation of Ex. 1658, PCT Publication No. WO 2010/082265 ("Mori '265")
Ex. 1652:	Keith H. Billings, *Switchmode Power Supply Handbook*, McGraw Hill, 1989
Ex. 1653:	Marty Brown, *Power Supply Cookbook*, Butterworth-Heinemann, 1994
Ex. 1654:	U.S. Department of Commerce. International Trade Administration, *Electric Current Abroad*, 1998 Edition, reprinted Feb. 2002 ("ECA 1998/2002")
Ex. 1655:	Heribert Schmidt, Bruno Burger, & Klaus Kiefer. Wechselwirkungen zwischen Solarmodulen und Wechselrichtern. English translation: Interaction between Solar Modules and DC/AC Inverters, 2007
Ex. 1656-57:	Reserved
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Ex. 1665:	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*.**

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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. 1601).

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. Ex. 1602, ¶¶ 62-74. 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. 1602, ¶¶ 113-130.

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. 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.

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.

Mirafzal (U.S. Patent Application Publication No. 2008/0080106, Ex. 1628), which is the primary reference for this petition, discloses an example of the same ground leak detector disclosed in the patent. As discussed in more detail below, claims 14-19 of the ’822 patent are unpatentable and should be cancelled.

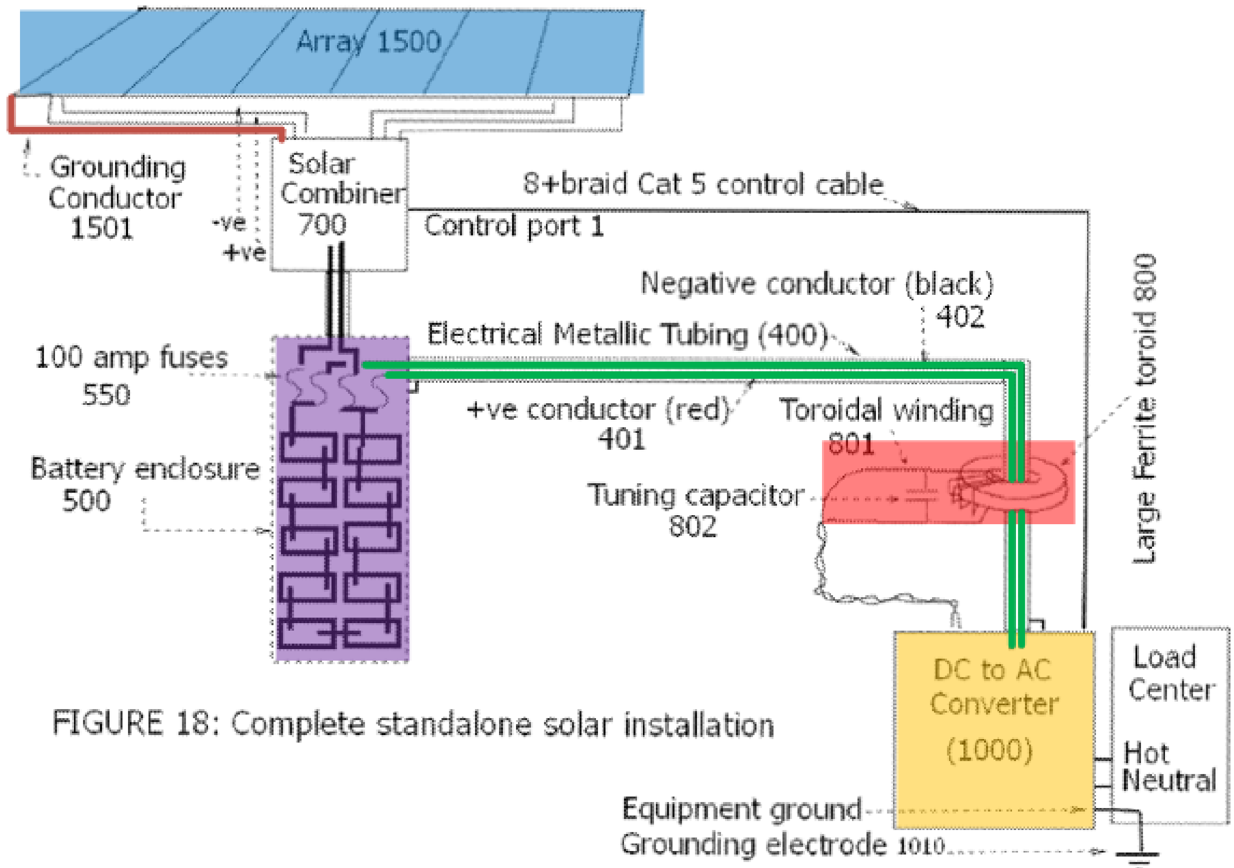
II. GROUNDS FOR STANDING & FEE PAYMENT

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 comprising 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. 1601, 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. 1602, ¶¶ 75-76.



Ex. 1601, 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. 1601, 32:26-32, 35:65-36:3, 36:30-35, 40:29-35; Ex. 1602, ¶ 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. 1602, ¶ 156; Ex. 1601, 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. 1602, ¶¶ 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. Ex. 1602, ¶ 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. Ex. 1602, ¶¶ 154-155; Ex. 1643, p. 4; Ex. 1642, p. 4; Ex. 1636, p. 4; Ex. 1645, p. 2; Ex. 1664, pp. 307-310; Ex. 1665, pp. 323-337.

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. 1602, ¶¶ 157-159. 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. 1602, ¶ 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, 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. 1602, ¶ 160.

Common mode current on the other hand is equal and in the same direction on the positive and negative conductors. Ex. 1602, ¶ 160. 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. 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. 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. Ex. 1602, ¶ 161.

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 $V_{CM} = R_G * I_{CM}$. Ex. 1602, ¶ 162.

As explained further below, because it was well known that inverters generate common mode voltage at a particular frequency, it was known to detect ground faults by measuring for common mode current caused by, and having the same frequency as, the common mode voltage.

B. Prosecution History

The application that led to the ’822 patent was filed May 8, 2011. Ex. 1622, 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. 1602, ¶¶ 78-79. After prosecution to resolve issues that were unrelated to claims 14-19, the ’822 patent issued on January 20, 2015. Ex. 1601, cover; Ex. 1602, ¶¶ 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. 1602 ¶ 61.

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

1. U.S. Patent Application Publication No. 2008/0080106 (Mirafzal)

Mirafzal (Ex. 1628) is a U.S. Patent Application that published on April 3, 2008. Mirafzal is prior art under pre-AIA 35 U.S.C. § 102(b). Ex. 1602, ¶ 163.

As shown in Figure 1 below, Mirafzal describes a power conversion system 10 including a power source 14 (**blue**), an inverter 18 (**orange**), and an integrated DC link inductor and current sensor winding 12 ("ICSW") (**red**). Ex. 1628, ¶¶ [0016]-[0017], Fig. 1; Ex. 1602, ¶ 164. Mirafzal further states that the ICSW may be alternatively referred to as a ground fault detector. Ex. 1628, ¶ [0020]; Ex. 1602, ¶ 164.

As illustrated in Figure 1, power source 14 is an alternating current (AC) power source which provides alternating current to a rectifier 16 which converts it to direct current. This direct current flows along current paths 38 and 40 (**green**)

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[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.

through ICSW 12 to inverter 18. Ex. 1628, ¶¶ [0018]-[0020]; Ex. 1602, ¶ 165. Mirafzal further discloses that power source 14 may be a direct current (DC) power source, in which case rectifier 16 may be omitted. Ex. 1628, ¶¶ [0018]-[0019]. Inverter 18 outputs AC power at an appropriate frequency and waveform. Ex. 1628, ¶¶ [0021], [0027]. Inverter 18 may also shape the AC waveform using pulse width modulation. Ex. 1628, ¶¶ [0021], [0031]; Ex. 1602, ¶ 165.

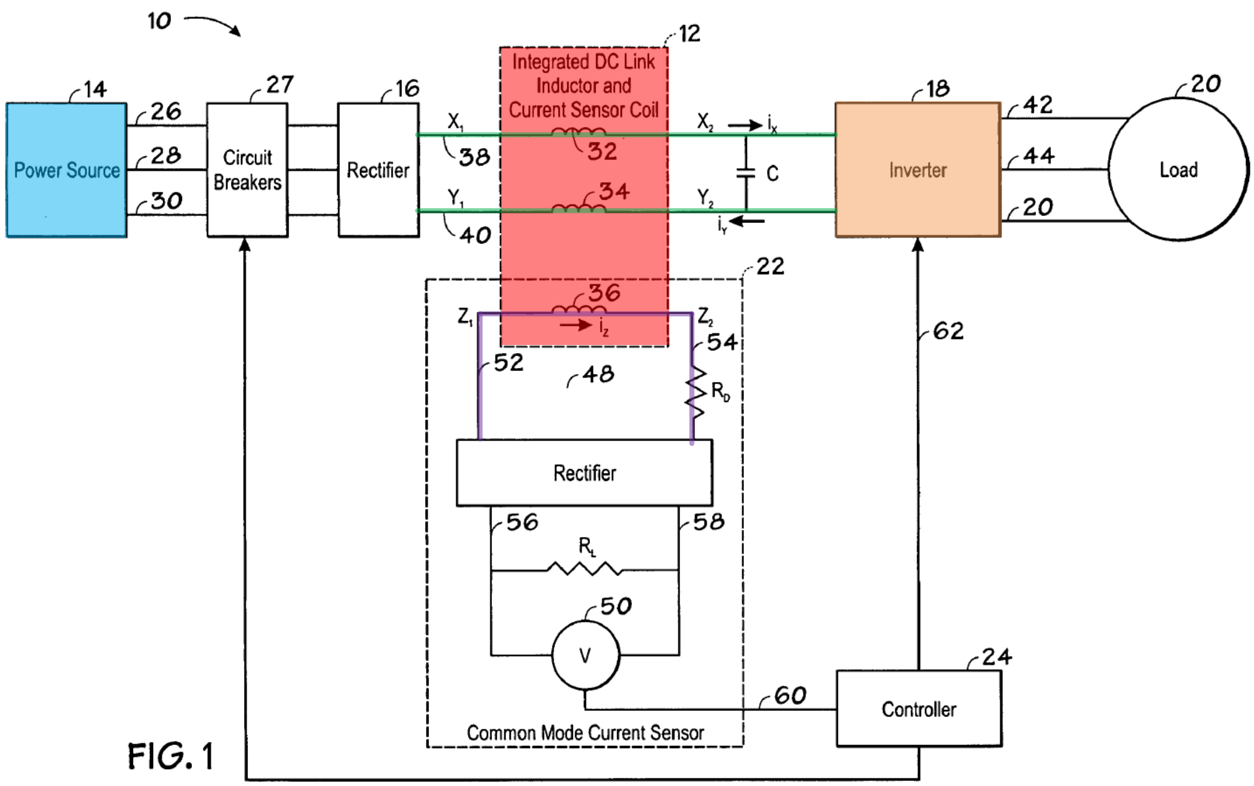


FIG. 1

Ex. 1628, Fig. 1 (annotated)

The ICSW (*i.e.*, ground fault detector) is further shown in Figure 2 below where current paths 38 and 40 (**green**) are wound around legs 66 and 70 of monolithic core 64. Ex. 1628, ¶¶ [0020], [0023]-[0024], [0032], Fig. 2; Ex. 1602, ¶

166. Current sensor winding 36 (**purple**) is wound around leg 68 and connected to inputs 52 and 54 to common mode current sensor 22. Ex. 1628, ¶¶ [0023]-[0024], [0032]-[0033], Figs. 1-2; Ex. 1602, ¶ 166.

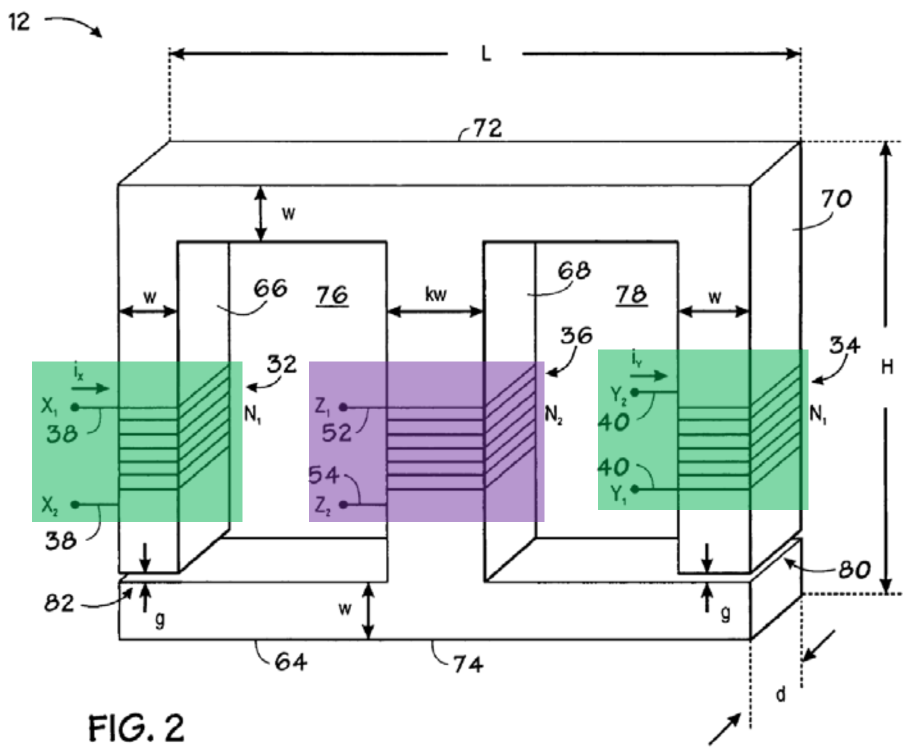


FIG. 2

Ex. 1628, Fig. 2 (annotated)

In both the ’822 patent and Mirafzal, the ground fault detector is shown having the positive and negative DC inputs running in parallel through a winding. *Compare* Ex. 1601, Fig. 18 *with* Ex. 1628, Figs. 1-2; Ex. 1602, ¶ 167. Mirafzal’s positive and negative conductors 38 and 40 (**green**), connecting the power source to the inverter, are shown routed in parallel. *Compare* Ex. 1628, ¶¶ [0020], [0032]-[0033] *with* Ex. 1601, 30:36-67; Ex. 1602, ¶ 167.

The common mode current sensor of Mirafzal identifies a ground fault by detecting an imbalance in magnitude of the currents on current paths 38 and 40. Ex. 1628, ¶¶ [0012], [0023]; Ex. 1602, ¶ 168. As shown above in Figure 1, ICSW 12 is located on the positive current path 38 and the negative current path 40 between Mirafzal's power source 14 and inverter 18. Ex. 1628, ¶¶ [0028]-[0029], Fig. 1. As a result of the currents i_X and i_Y flowing through current paths 38 and 40, ICSW 12 produces a current i_Z indicative of the difference in magnitude between i_X and i_Y (i.e., a common mode current). Ex. 1628, ¶¶ [0029]-[0030], [0038]-[0039], Fig. 4; Ex. 1602, ¶ 168. After detecting that the common mode current exceeds a predetermined value, Mirafzal's common mode current sensor 22 sends controller 24 a signal indicating a ground fault has occurred. Ex. 1628, ¶¶ [0012], [0026], [0041], Fig. 3. Controller 24 then signals circuit breaker 27 to open one or more breakers and stop delivery of power to the load 20. Ex. 1628, ¶¶ [0026], [0041], Fig. 3; Ex. 1602, ¶ 168.

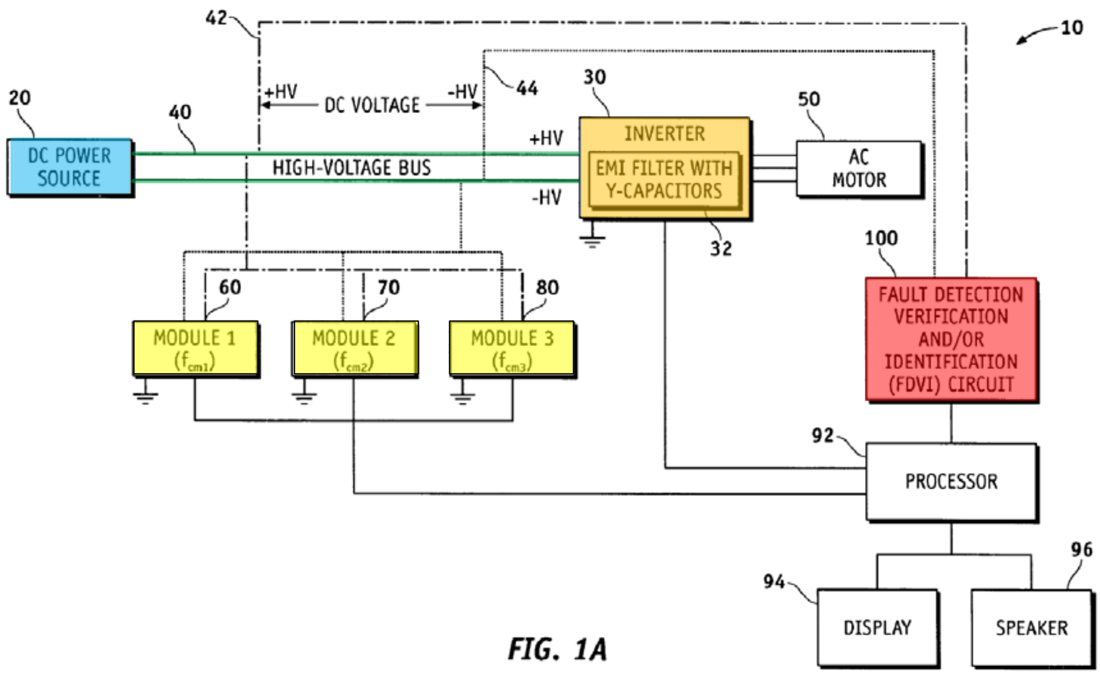
2. U.S. Patent No. 7,649,360 (Ivan)

Ivan (Ex. 1629) is a U.S. Patent that issued on January 19, 2010. Ivan is prior art under pre-AIA 35 U.S.C. § 102(b). Ex. 1602, ¶ 169.

Ivan describes a system for detecting and identifying the source of alternating current faults (*i.e.*, ground faults) on the DC bus of a hybrid electric vehicle using a common mode voltage detector circuit. Ex. 1629, 1:8-12, 2:3-19; Ex. 1602, ¶ 170.

Ivan further notes that its fault detection circuit can be implemented in a variety of applications and is not limited to use in hybrid vehicles. Ex. 1629, 5:46-52, 8:8-15; Ex. 1602, ¶ 170.

As shown in Figure 1A below, Ivan describes a fault detection system including a DC power source 20 (**blue**), an inverter module 30 (**orange**), and a fault detection verification and identification (FDVI) circuit (**red**). Ex. 1629, 4:21-30, Fig. 1A; Ex. 1602, ¶ 171. The DC power source 20 is, for example, one or more batteries. Ex. 1629, 4:21-22. The inverter module 30 converts DC power to AC power and is coupled to an AC motor 50. Ex. 1629, 4:39-42. A high voltage DC bus 40 (**green**) with positive and negative terminals 42 and 44 made of a conductive material connects the DC power source and inverter 30. Ex. 1629, 4:21-36, Fig. 1A; Ex. 1602, ¶ 171. Also coupled to DC bus 40 are additional modules/devices/circuits 60-80 (**yellow**) which can be, for example, a DC-DC converter, an engine cooling fan, or other modules. Ex. 1629, 4:21-25, 4:67-5:16; Ex. 1602, ¶ 172. Ivan further states that inverter 30 and modules 60-80 each have an identifiable, fundamental operating switching frequency associated therewith. Ex. 1629, 4:67-5:16; Ex. 1602, ¶ 172.



Ex. 1629, Fig. 1A (annotated)

Ivan's FDVI module (also referred to in Ivan as a fault detection circuit (FDC), fault detection and verification circuit (FDVC), or fault detection, verification and identification circuit (FDVIC)) is coupled to DC bus 40 and generates a DC signal between DC bus terminals 42 and 44 that is input to the FDC. Ex. 1629, 5:52-56, 6:61-64, 8:15-19, Figs. 2A, 2D, 2E; Ex. 1602, ¶ 173. The FDC uses a common mode voltage detector to remove a differential mode DC voltage component from the input signal to determine a common mode AC voltage. Ex. 1629, 5:57-66, 6:65-7:3, 8:24-25. The magnitude of the common mode AC voltage signal is then measured and compared to a fault detection threshold voltage. Ex. 1629, 6:6-12, 6:65-7:3, 8:24-25; Ex. 1602, ¶ 173. When the measured magnitude of the common mode AC voltage is equal to or greater than the threshold voltage, a signal is output indicating an AC fault has been detected. Ex. 1629, 6:32-40, 7:4-40, 8:26-35; Ex. 1602, ¶ 173.

In the FDVIC implementation, Ivan further describes how the frequency of the common mode voltage signal can be used to identify the module causing the AC fault. Ex. 1629, 9:18-40, Fig. 2E; Ex. 1602, ¶ 174. In particular, frequency detector 160 determines the frequency of the common mode AC voltage signal and generates a frequency identification signal that indicates the center frequency of the common mode AC voltage signal. Ex. 1629, 9:19-25. A module identification unit 170 then compares the frequency of the common mode AC voltage signal with the fundamental operating frequencies of the modules (inverter 30 and modules 60-80) to identify the module that is the source of the AC fault. Ex. 1629, 9:26-39. Processor 92 can then generate a signal which stops or disconnects the identified module. Ex. 1629, 9:50-55, Fig. 1A; Ex. 1602, ¶ 174.

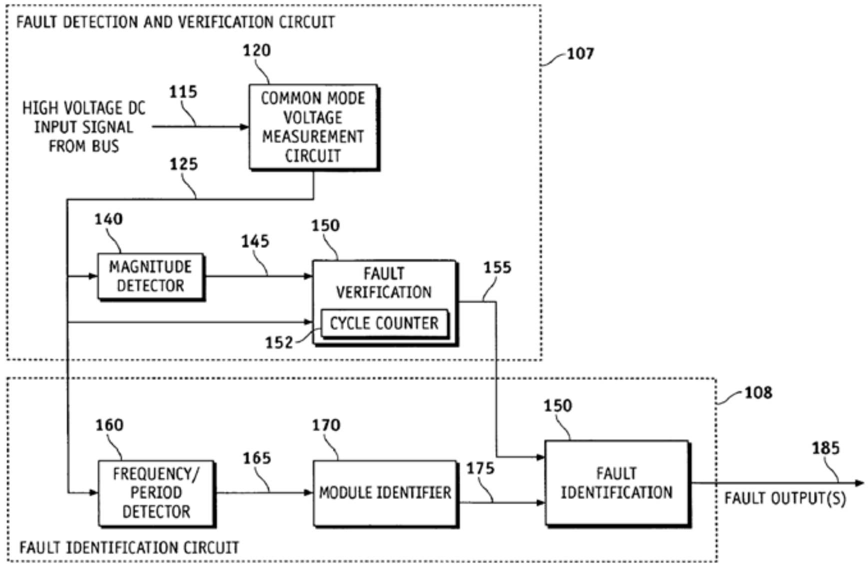


FIG. 2E

Ex. 1629, Fig. 2E

3. National Electrical Code Handbook (NEC Handbook)

The National Electrical Code® Handbook, Eleventh Edition (Ex. 1619) was published and publicly available to a PHOSITA in 2009. Ex. 1623, ¶¶ 81-93 (Section III.C). The NEC Handbook is prior art under pre-AIA 35 U.S.C. § 102(b).[3] Ex. 1602, ¶ 175.

The National Electric Code is promulgated by the National Fire Protection Association and "is intended for use by is intended for use by capable engineers and

[3] 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. 1601, 5:21, 10:59, 23:60; Ex. 1602, ¶ 175.

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. 1619, p. 8; Ex. 1602, ¶ 176.

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. 1619, pp. 7-8. The NEC Handbook includes the Code as well as commentary and supplemental materials regarding the Code. Ex. 1619, p. 3. 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. 1619, pp. 21-29; Ex. 1602, ¶ 177.

4. Japanese Patent Publication No. 2006-238630 (Mori)

Mori (Ex. 1620)[4], a Japanese Laid-Open Patent Publication entitled "Power Conversion Device," was filed on February 25, 2005, and published on September 7, 2006. Mori is prior art under pre-AIA 35 U.S.C. § 102(b). Ex. 1602, ¶ 178.

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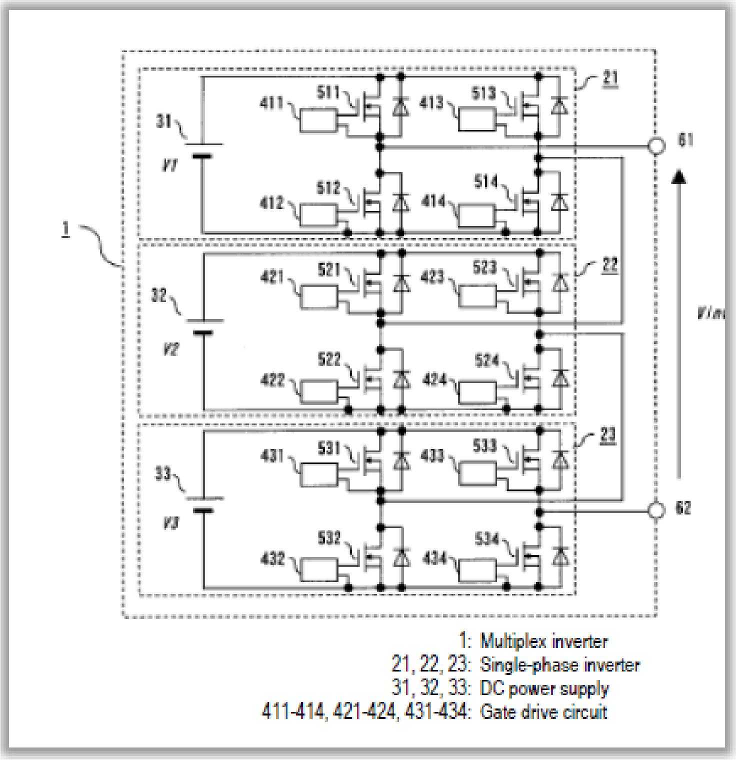
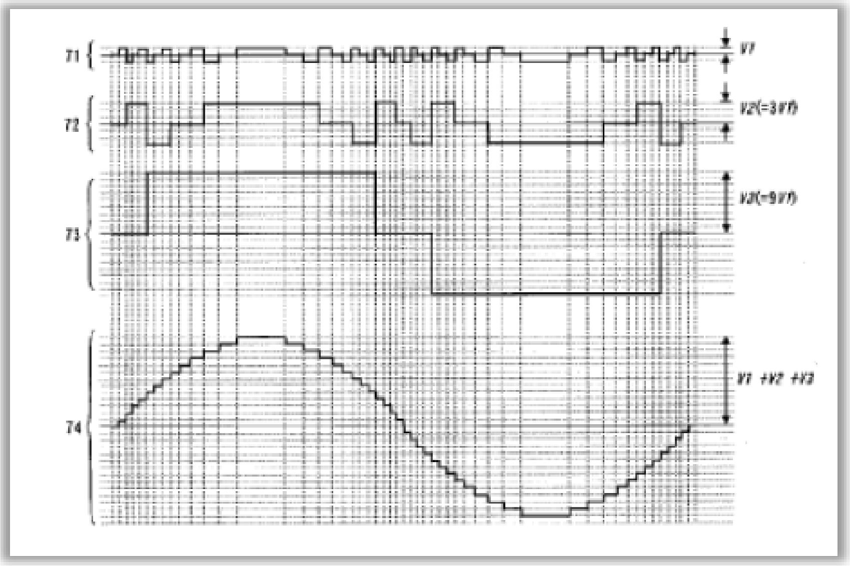
[4] A certified English language translation of the Japanese language Mori reference has been provided as Ex. 1604.

Mori provides "a power conversion device in which a plurality of AC sides of a single-phase inverter. . . are connected in series." Ex. 1604, Abstract. To do so, Mori combines "gradational control and [pulse width modulation] PWM control without increasing the processing load on a CPU, in order to obtain a highly accurate output voltage." *Id*. Mori discloses a multiplex inverter 1 formed from "a plurality of single-phase inverters 21-23 having different DC power supplies 31-33." Ex. 1604, ¶ [0009], Fig. 1; Ex. 1602, ¶ 179.



Ex. 1604, Fig. 1.

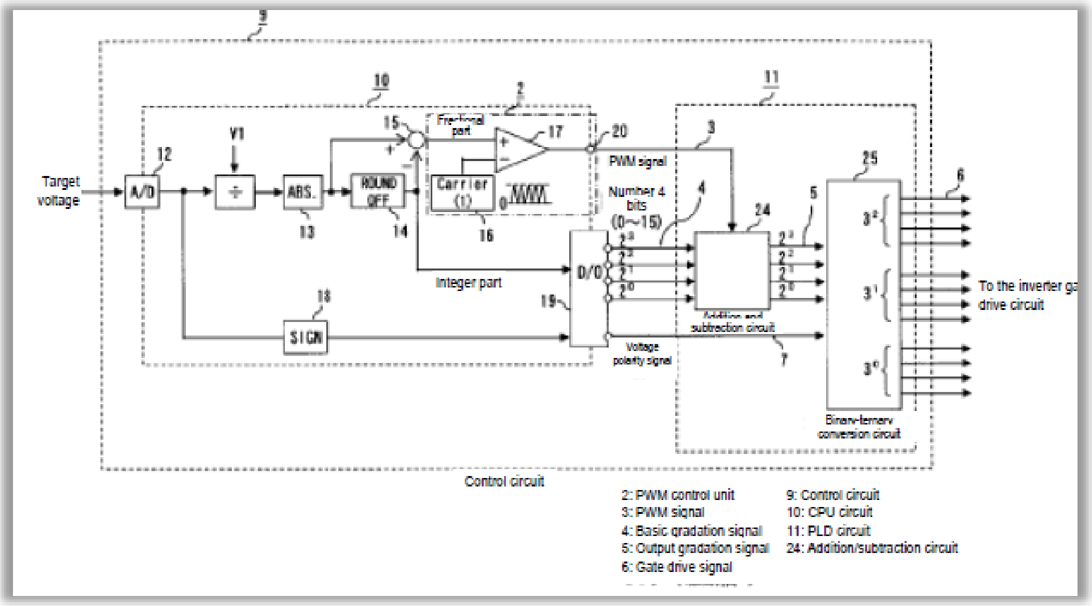
Each of the single-phase inverters 21-23 “can generate positive and negative and zero voltages as outputs,” which are shown in Mori’s Figure 2 (reproduced below). Ex. 1604, ¶ [0011]; Ex. 1602, ¶ 180.



Ex. 1604, Fig. 2.

Mori’s “multiplex inverter 1 uses a control circuit . . . to perform PWM control in combination with gradation control of each single-phase inverter 21-23.” Ex. 1604, ¶ [0011]; Ex. 1602, ¶ 181.

Mori also describes converting a binary control signal (*i.e.*, gradation signal 5) “into a ternary number. . . since the voltages V1-V3 of the DC power supplies 31-33 of the single-phase inverters 21-23 have a ternary relationship, here V1:V2:V3 = 1:3:9.” Ex. 1604, ¶ [0019]; Ex. 1602, ¶ 182. Thus, Mori explains that its “output signals (output gradation levels) of the single-phase inverters 21, 22, and 23 are indicated by 3^0, 3^1, and 3^2.” Ex. 1604, [0019], Fig. 4 (reproduced below); Ex. 1602, ¶ 182.



Ex. 1604, Fig. 4.

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.

Grounds	References	Basis	Claims Challenged
1	Mirafzal in view of Ivan and NEC Handbook	§ 103(a)	14, 15, 16, 18, and 19
2	Mirafzal-Ivan-NEC Handbook in view of Mori	§ 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. 1602, ¶¶ 1-60, 88-94, 131-184, 214-215, 253), and Dr. Mullins' expert testimony proving authenticity and public availability prior to May 8, 2011 of certain exhibits. Ex. 1623, ¶¶ 1-40, 232-248 (Ex. 1615), 268-285 (Ex. 1617), 80-93 (Ex. 1619), 214-231 (Ex. 1644), 249-267 (Ex. 1646), 332-353 (Ex. 1652), 193-213 (Ex. 1653), 172-192 (Ex. 1654), 155-171 (Ex. 1655), 94-111 (Ex. 1664), 112-129 (Ex. 1665), 354-356.

None of the prior art listed in the table above was before the examiner during prosecution of the '822 patent. Ex. 1601, 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. 1602, ¶¶ 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. 1602, ¶¶ 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. 1601, claim 14; Ex. 1602, ¶ 98.

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. 1601, 6:17-26, Figs. 1, 10; Ex. 1602, ¶¶ 99-103.

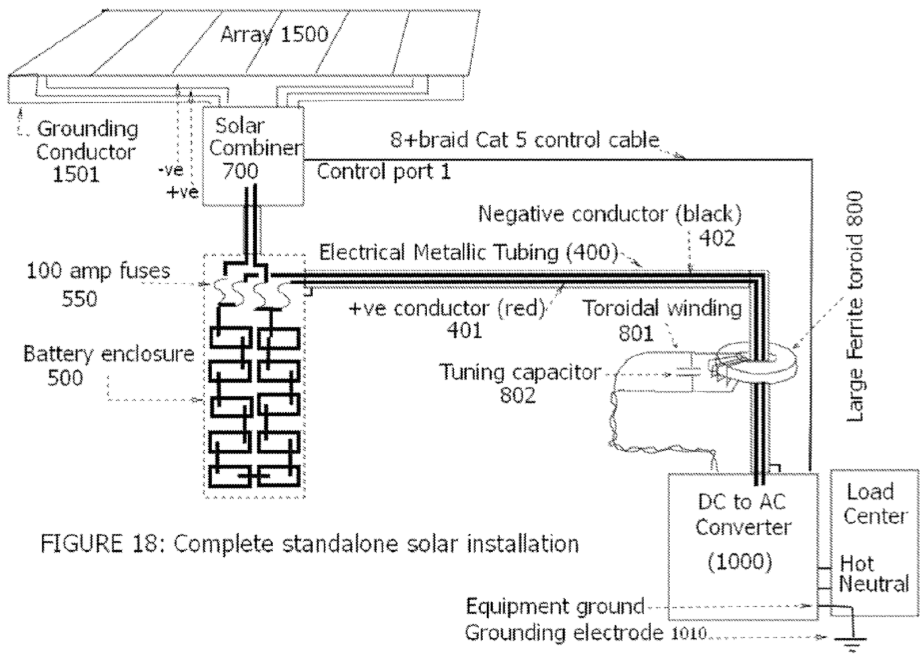
Another corresponding structure, in Figure 15, includes a single H-bridge switch with a single-phase output connected through an inductor. Ex. 1601, 23:27-44, Fig. 15; Ex. 1602 ¶ 104.

Two other structures are illustrated in Figures 16 and 24. Ex. 1602, ¶¶ 105-107. 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. 1601, Fig. 16; Ex. 1602, ¶ 105. 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. 1601, 29:25-67, Fig. 24; Ex. 1602, ¶ 106.

2. "detector" (Claim 14)

To the extent "detector" in claim 14 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. 1601, claim 14; Ex. 1602, ¶ 108.

The corresponding structure is a current transformer including toroid 800 with a toroidal winding 801, for example, as shown in Figure 18 below. Ex. 1601, 25:57-59, 31:65-32:20; Ex. 1602, ¶¶ 109-112.



Ex. 1601, Fig. 18.

V. SPECIFIC GROUNDS FOR UNPATENTABILITY

A. Ground 1: Mirafzal in view of Ivan and NEC Handbook Renders Claims 14, 15, 16, 18, and 19 Obvious

1. Independent Claim 14

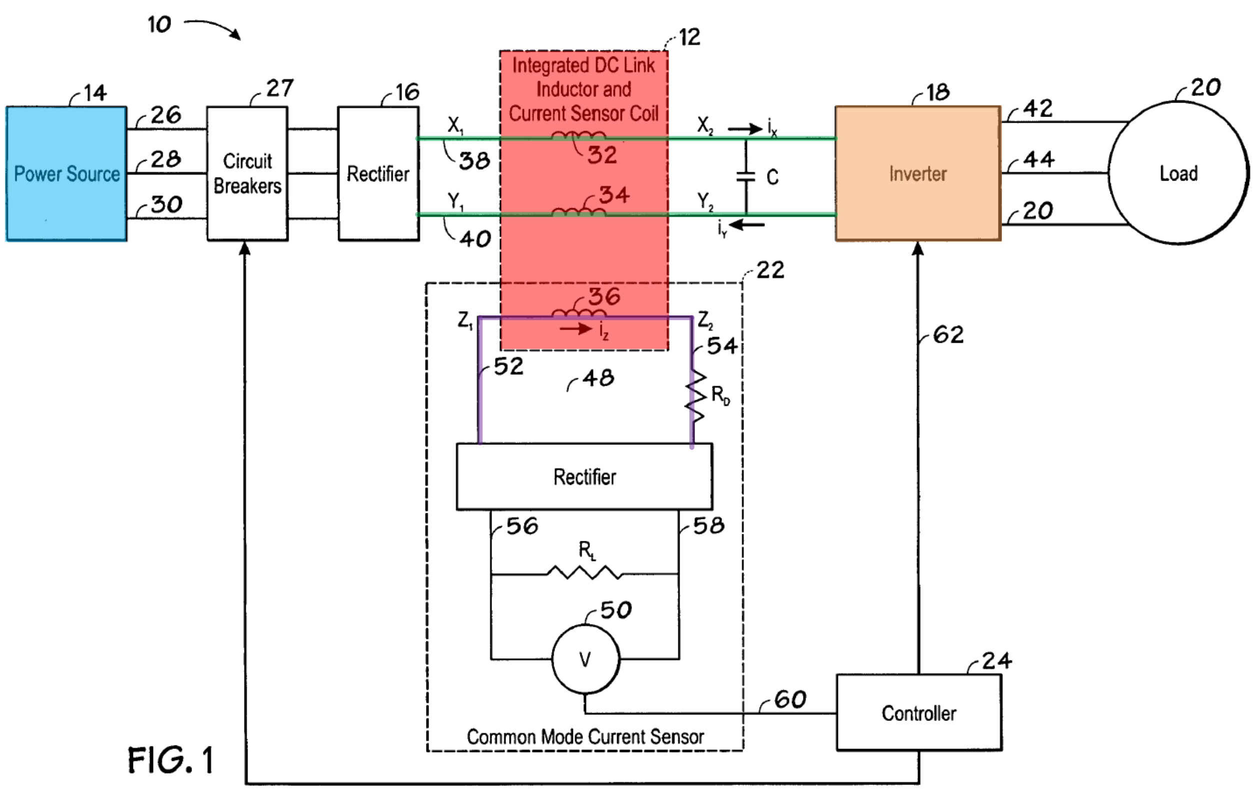
a. "In a solar energy installation comprising a photovoltaic solar array and a DC to AC converter having a DC input with positive and negative conductors routed in parallel with an array grounding conductor and an AC output having an output waveform with an output repetition frequency, a method of detecting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

Mirafzal describes a power conversion system including an inverter 18 (the claimed "DC to AC converter") which is "configured to receive DC power and output AC power having an appropriate frequency and waveform" (the claimed “waveform with an output repetition frequency”). Ex. 1628, [0017], [0021]. The inverter may also shape the waveform using pulse width modulation. Ex. 1628, ¶¶ [0021], [0031]; Ex. 1602, ¶¶ 185-186.

As discussed above in Section IV.B.1, the “DC to AC converter” could be construed as a means-plus-function term. Mirafzal’s inverter 18 meets the function of “[having] an AC output having an output waveform with an output repetition frequency” because it is “configured to . . . output AC power having an appropriate frequency and waveform.” Ex. 1628, ¶ [0021]; Ex. 1602, ¶ 187. Mirafzal’s inverter 18 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.b.

Mirafzal also discloses the same or equivalent structure to that disclosed in the ‘822 patent. In particular, Mirafzal describes how inverter 18 may include various solid state switching devices (*e.g.*, transistors), and that these switches may be used to output three phase AC power by “selectively temporarily closing circuit paths coupling various combinations of the phase paths 42, 44, and 46 with the DC current paths 38 and 40.” Ex. 1628, ¶¶ [0021], [0031]; Ex. 1602, ¶ 188. This arrangement is the same or equivalent to the structure shown in Figure 16 of the ’822 patent where the DC input is applied to half-bridges of transistors that can connect either the positive (DC+) or negative (DC-) to each of the three-phase outputs (a, b, c). Ex. 1601, 26:35-39, Fig. 16; Ex. 1602, ¶ 188.

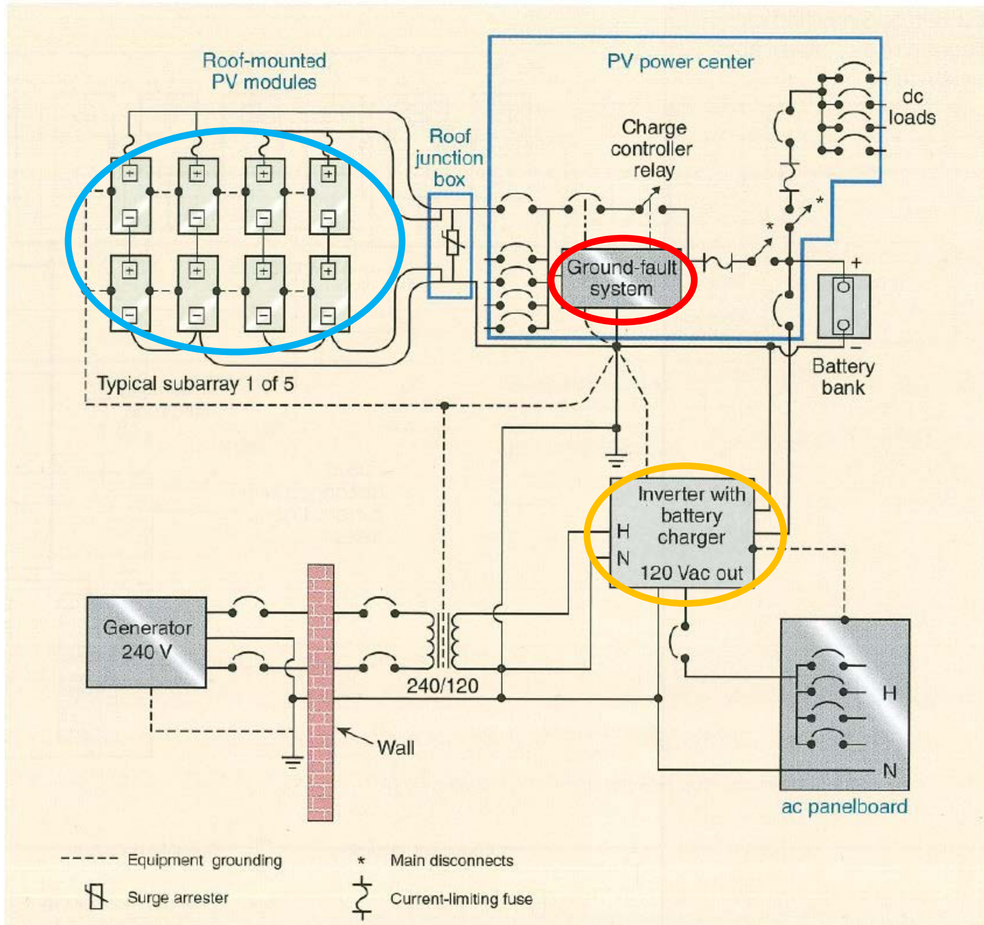
As shown in Figure 1 below, Mirafzal's inverter (**orange**) is powered by a power source 14 (**blue**) connected to the inverter using positive and negative DC current paths 38 and 40 (**green**) (the claimed "positive and negative conductors"). Ex. 1628, ¶¶ [0017]-[0020]; Ex. 1602, ¶ 189. While illustrated as an AC power source with a rectifier for conversion to DC current, Mirafzal states that the power source 14 can be a DC power source and the rectifier may be omitted. Ex. 1628, ¶¶ [0018]-[0019]; Ex. 1602, ¶ 189.



Ex. 1628, Fig. 1 (annotated)

Mirafzal also discloses "a method of detecting a ground leak in the DC wiring." Ex. 1602, ¶ 190. For example, Mirafzal describes using an integrated DC link inductor and current sensor winding 12 ("ICSW") (**red**) as a ground fault detector. Ex. 1628, ¶¶ [0016], [0020], [0023], [0030]; Ex. 1602, ¶ 190.

While Mirafzal does not describe a "solar energy installation" using a "photovoltaic solar array" as a power source, use of photovoltaic arrays as DC power sources was known to a PHOSITA as taught by the NEC Handbook. Ex. 1602, ¶¶ 191-192. For example, the NEC Handbook includes circuit diagrams illustrating photovoltaic arrays as the DC power source to an inverter. Ex. 1619, pp. 23-24 (Exhibits 690.3 and 690.4); Ex. 1602, ¶ 191. In particular, Exhibit 690.4 in the NEC Handbook shows a photovoltaic installation including photovoltaic modules (**blue**) connected via a ground-fault system (**red**) to provide DC power to an inverter (**orange**) which produces 120 VAC output:



Ex. 1619, p. 24 (Exhibit 690.4) (annotated)

A PHOSITA would have known that the DC power source of Mirafzal could be implemented using a photovoltaic array thus forming the claimed "solar energy installation" including a "photovoltaic solar array" of claim 14. Ex. 1602, ¶ 192.

A PHOSITA would have been motivated to replace the power source of Mirafzal with a photovoltaic array because that would allow the use of Mirafzal in a system that is not dependent on grid power or the use of a generator. Ex. 1602, ¶ 193. Furthermore, Mirafzal specifically suggests the use of DC power sources (Ex. 1628, ¶ [0018]) and a PHOSITA would have known that a photovoltaic array is a potential DC power source. Ex. 1602, ¶ 193. Also, combining the photovoltaic array of the NEC Handbook with Mirafzal would be merely using known techniques (using a photovoltaic array as a DC power source) to improve similar devices (the similar power conversion systems disclosed in Mirafzal and the NEC Handbook) in the same way. Ex. 1602, ¶ 194. A PHOSITA also would have expected success in replacing the power source of Mirafzal with a photovoltaic array. Replacing the generic DC power source taught in Mirafzal with a DC photovoltaic array would have been within the skill and knowledge of a PHOSITA as confirmed by the teaching in the NEC Handbook. Ex. 1602, ¶ 194.

Although the positive and negative current paths of Mirafzal are routed in parallel (for example, as shown by Figure 1, and the fashion in which they pass through the ICSW of Figure 2), Mirafzal does not describe them as being routed "in parallel with an array grounding conductor" (a grounding conductor is not shown in Figures 1 and 2 of Mirafzal). However, routing wires in parallel (for instance in the same conduit) was a well-known wiring technique, and the NEC Handbook teaches it. Ex. 1602, ¶ 195. The NEC Handbook states that an "equipment grounding conductor between a PV array and other equipment shall be required" and that "[e]uipment 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. 1619, p. 29 ("690.43

Equipment Grounding"); Ex 1602, ¶ 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. 1619, p.13. 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. 1601, 25:59-25:63, 30:46-50, 31:41-45, 31:65-32:3; Ex. 1602, ¶ 196. A PHOSITA would have known to route current paths 38 and 40 in parallel with an array grounding conductor as required by the NEC. Ex. 1602, ¶ 196.

A PHOSITA would have been motivated, in view of the NEC Handbook's teaching, to route Mirafzal's positive and negative conductors in parallel with a grounding conductor (e.g., using a conduit) to prevent shock hazards and improve safety and additionally because routing the wires in parallel (*e.g.*, in the same conduit) would also be easier and more convenient. Ex. 1602, ¶ 197. The NEC Handbook teaches preventing shock hazards in PV sources by using an equipment ground conductor, per the NEC. Ex. 1619, p. 29; Ex. 1602, ¶ 197. As a PHOSITA would have understood at the time, a low impedance path is required 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. 1602, ¶ 197. A PHOSITA would have known that the safety requirements of the NEC could be met by routing the wires through the same conduit (*i.e.*, in parallel). Ex. 1602, ¶ 197.

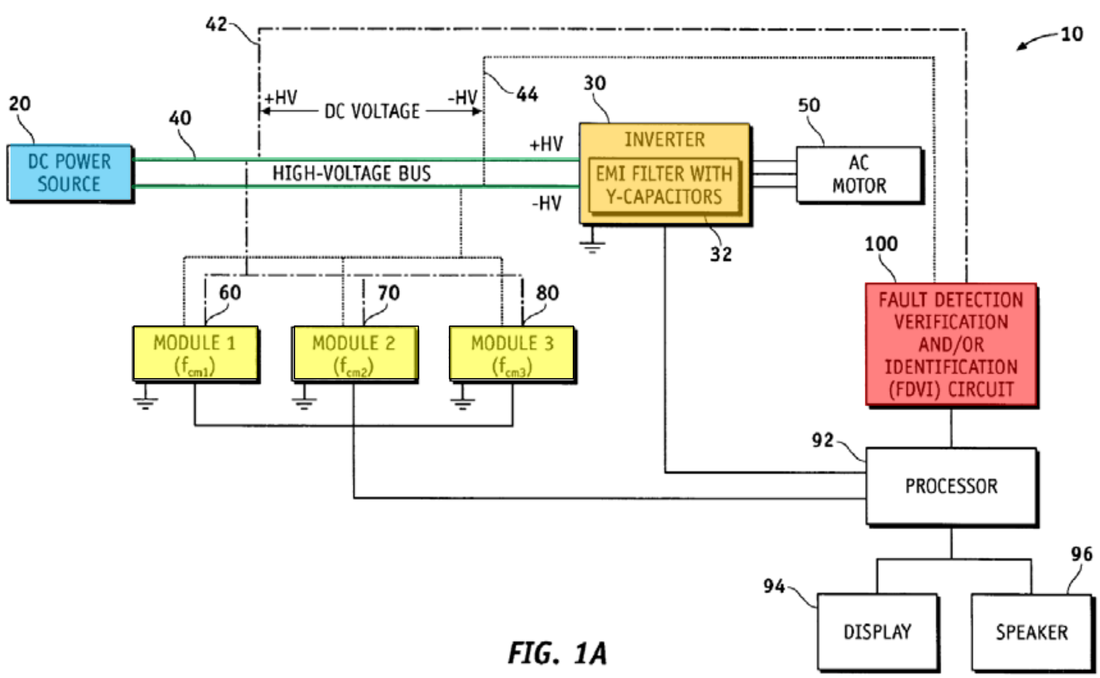
Also, combining the NEC Handbook's wire routing techniques with Mirafzal would be merely using known techniques (the NEC Handbook's method of preventing shock hazards by routing these wires in parallel through the same conduit) to improve similar devices (the similar power conversion systems disclosed in Mirafzal and the NEC Handbook) in the same way. Ex. 1602, ¶ 198. The NEC Handbook teaches a power conversion system comparable to (and compatible with) Mirafzal's system—*e.g.*, they both include positive and negative conductors for connecting a power source to an inverter, as well as ground fault protection. Ex. 1619, pp.23-24; Ex. 1602, ¶ 198. Further, the NEC Handbook's safety and protection techniques for using an equipment ground conductor routed in parallel with positive and negative conductors connecting system components would have improved Mirafzal's system to make it safer by, as a result of routing the wires in parallel in the same conduit, providing a low impedance path for ground fault current back to the inverter to prevent the ground fault current from creating a shock hazard. Ex. 1602, ¶ 198. Additionally, a PHOSITA would have found it both convenient and easier to route the wires together in a single conduit. Ex. 1602, ¶ 198. And the NEC Handbook's disclosure of routing the positive and negative conductors in parallel with the equipment ground conductor for ground fault protection could be implemented in Mirafzal in the same way as in the NEC Handbook. Ex. 1602, ¶ 198.

A PHOSITA would have expected success in combining Mirafzal with the wiring techniques taught by the NEC Handbook. Ex. 1602, ¶¶ 199. First, the NEC Handbook is intended as a guide for the safe installation of electrical systems like that of Mirafzal. Ex. 1619, pp. 7-8; Ex. 1602, ¶ 199. Second, a PHOSITA would have had the skills and knowledge to connect Mirafzal's system to an earth ground system, as taught by the NEC Handbook. *Id*. A PHOSITA, therefore, would have understood that the NEC Handbook's teachings would have been able to be combined with Mirafzal's system simply by routing a ground conductor to run in parallel with Mirafzal's positive and negative conductors. *Id*.

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"

Mirafzal discloses that its inverter produces a common mode voltage that results in a common mode current flowing between the system and ground (the claimed "creating a common-mode AC probe signal waveform from said DC to AC converter at a characteristic repetition frequency"). Ex. 1628, ¶¶ [0012]-[0013]; Ex. 1602, ¶¶ 200-201. Mirafzal further discloses that this common mode current can be sensed on DC current paths 38 and 40 (the claimed "DC positive and negative input conductors") using the current sensor winding 36 that is part of the ICSW 12 and common mode current sensor 22. Ex. 1628, ¶¶ [0023]-[0024], [0029]-[0030], Figs. 1, 2; Ex 1602, ¶ 201.

While Mirafzal does not disclose that the common mode signal waveform would be "at a characteristic repetition frequency that is in phase on both said DC positive and negative input conductors," Ivan does disclose this limitation. In particular Ivan describes that modules, including inverter 30, (**yellow** and **orange**, respectively) attached to DC bus 40 (**green**), each have a fundamental operating switching frequency. Ex. 1629, 4:67-5:16; Ex. 1602, ¶ 202.



Ex. 1629, Fig. 1A (annotated)

These modules cause common mode AC voltage signals on the DC bus at this operating frequency (the claimed "characteristic repetition frequency") such that the module causing the common mode AC voltage signal can be identified by comparing its operating frequency to the frequency of the common mode AC voltage signal. Ex. 1629, 9:18-39, 11:10-22, 12:8-55; Ex. 1602, ¶ 203. Furthermore, Ivan discloses that the common mode AC voltage signal is in phase on both the positive bus 42 and negative bus 44. Ex. 1629, 5:22-29, Fig. 1B; Ex. 1602, ¶¶ 203-204.

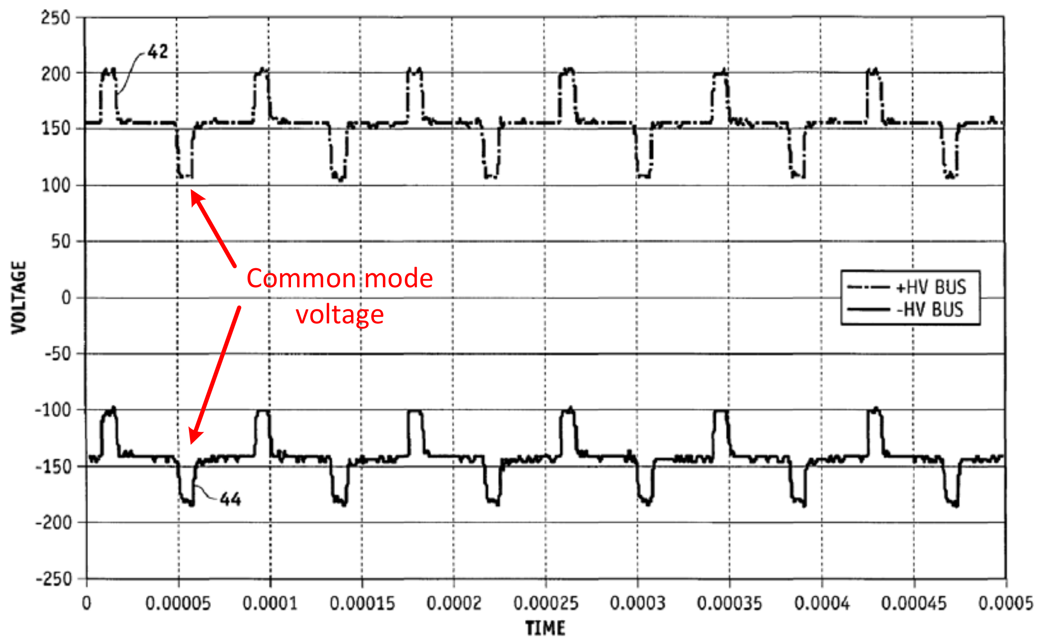


FIG. 1B

Ex. 1629, Fig. 1B (annotated)

While Mirafzal describes measuring common mode signals in the context of current and Ivan describes measuring common mode signals in the context of voltage, a PHOSITA would have known that the frequency of these signals would be the same whether measured as current or voltage. Ex. 1602, ¶ 205.

A PHOSITA would have been motivated to combine the teachings of Mirafzal and Ivan because they both describe using measurement of common mode signals to detect ground faults in power conversion systems. Ex. 1602, ¶ 206. In particular, as shown above in Fig 1A, similar to Mirafzal, Ivan includes a DC power source (**blue**), a DC bus (**green**), an inverter (**orange**), and a circuit for detecting ground faults (**red**). Ex. 1629, 4:21-36, Fig. 1A; Ex. 1602, ¶ 206. Mirafzal acknowledges that the fast switching in an inverter results in a high frequency common mode current. Ex. 1628, ¶ [0013]; Ex. 1602, ¶ 206. A PHOSITA would have known that the techniques in Ivan used for comparing the operating frequency of the inverter to the frequency of the common mode AC voltage signal on the DC bus would be equally applicable to the common mode current measured in Mirafzal. *See* Sections III.A.1 and 2, *supra*. Ex. 1602, ¶ 206. A PHOSITA further would have realized the benefit of confirming the source of a common mode signal on the DC bus. Ex. 1602, ¶ 206.

Also, combining Ivan's frequency comparison techniques with Mirafzal would be merely using known techniques (Ivan's frequency measurement and comparison) to improve similar devices (the similar ground fault protection systems disclosed in Mirafzal and Ivan) in the same way. Ex. 1602, ¶ 207. Ivan's frequency comparison techniques require only a few additional components (e.g., a frequency detector) that would have been familiar to a PHOSITA. Ex. 1629, 9:18-39, Fig. 2E; Ex. 1602, ¶ 207.

A PHOSITA would have expected success in combining Mirafzal with the frequency comparison techniques taught by Ivan. Ex. 1602, ¶ 208. Mirafzal already includes a detector for measuring the common mode signal on the DC bus. Ex. 1628, ¶ [0023]. Adding a frequency detector like that of Ivan to Mirafzal's common mode current sensor was well within the skills and knowledge of a PHOSITA. Ex. 1602, ¶ 208. A PHOSITA, therefore, would have understood that the frequency measurement and comparison techniques of Ivan would have been able to be combined with Mirafzal's system simply by adding a few well-known components. *Id*.

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"

Mirafzal discloses passing its positive and negative conductors through a detector adapted to detect common mode currents. As shown in Figure 2 below, the positive and negative current paths 38 and 40 (**green**) pass through ICSW 12 (**red**) and are wound around the legs of ICSW 12 to form inductors 32 and 34 (the claimed "passing said positive and negative conductors from the array through a detector"). Ex. 1628, ¶¶ [0020], [0032]-[0033], Fig 2; Ex. 1602, ¶¶ 209-210. Current sensor winding 36 (which is wound around the center leg of ICSW 12 (**purple**)) is used by the common mode current sensor 22 to detect a common mode current that arises in current paths 38 and 40 (the claimed "a detector adapted to detect an unusual current"). Ex. 1628, ¶¶ [0023]-[0024], [0030], [0033]-[0037], Figs. 2, 4; Ex. 1602, ¶ 210.

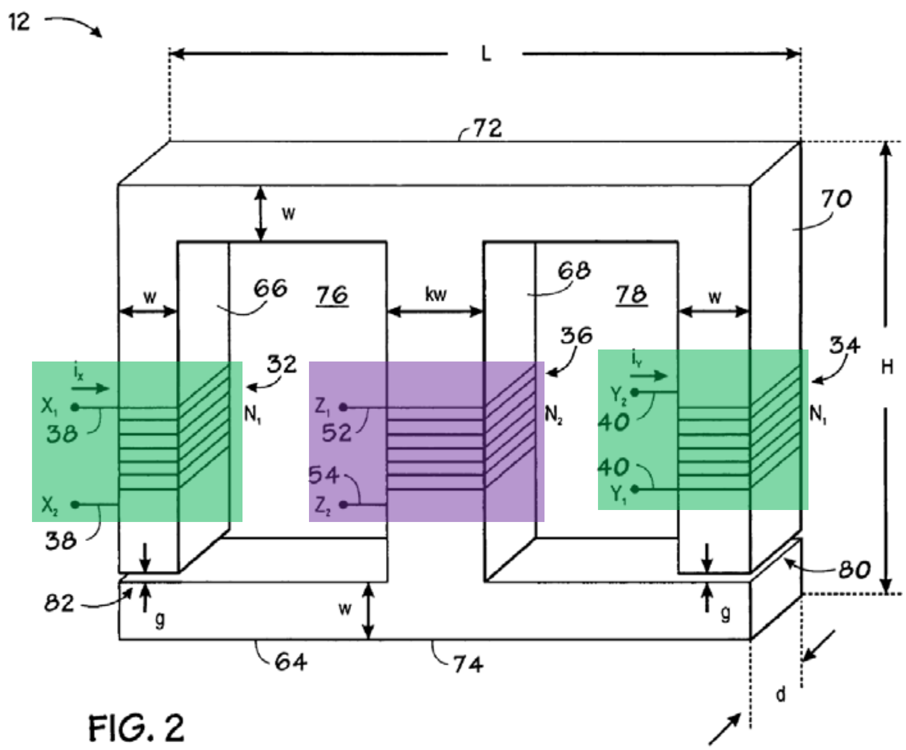


FIG. 2

Ex. 1628, Fig. 2 (annotated)

As discussed above in Section IV.B.2, "detector" could be construed as a means-plus-function term, and it is disclosed by the Mirafzal-Ivan-NEC Handbook combination. Mirafzal's ICSW 12 and common mode current sensor 22 meets the function of "detect[ing] an unusual current with said common mode waveform" because current sensor winding 36 detects whether a common mode current is present in current paths 38 and 40. Ex. 1628, ¶¶ [0023]-[0024], [0030], [0033]-[0037], Figs. 2, 4; Ex. 1602, ¶ 211. As explained in Section V.A.1.d below, the common mode current sensor 22 meets the function of "upon detection of said unusual current providing an indication of the presence of an unwanted ground leak" by terminating delivery of power to the load 20 when a ground leak is detected.

A PHOSITA would have recognized that Mirafzal also discloses the same or equivalent structure to that disclosed in the '822 patent. In particular, Mirafzal describes how when a common mode current arises on current paths 38 and 40 (*i.e.*, i_X and i_Y) a flux occurs in current sensor winding 36, thus inducing a current i_Z indicating a common mode current is present. Ex. 1628, ¶¶ [0029]-[0030]; Ex. 1602, ¶ 212. The windings 32, 34, and 36 on ICSW 12 are the same or equivalent to the '822 patent's toroid 800 and toroidal winding 801. Ex. 1601, 35:66-36:2, Fig. 18; Ex. 1602, ¶ 212.

While Mirafzal does not expressly describe that the common mode current detected by the common mode current sensor is at the characteristic repetition frequency, Ivan discloses that the common mode signals generated on the DC bus by an inverter will have such a frequency.[5] Ex. 1602, ¶ 213. In particular, Ivan describes a frequency detector that determines the frequency of the common mode AC voltage signal and then compares that frequency to the fundamental operating frequency of the inverter that is the source of the common mode signal (the claimed

[5] As discussed above, the common mode current and common mode voltage in a circuit would have the same frequency. *See* Sections III.A.1 and 2.

"with said common mode waveform at said characteristic repetition frequency"). Ex. 1629, 9:18-39; Ex. 1602, ¶ 213.

As discussed above in Section V.A.1.b, a PHOSITA would have been motivated to combine the teachings of Mirafzal and Ivan, combining Mirafzal with Ivan would be merely using known techniques to improve similar devices, and would have expected success in combining Mirafzal with Ivan. Ex. 1602, ¶ 214.

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, Mirafzal-Ivan-NEC Handbook discloses it. Ex. 1602, ¶ 216. Mirafzal describes that, after detecting a current exceeding a certain magnitude, common mode current sensor 22 outputs a ground fault signal to controller 24 indicating the presence of a ground fault, thereby causing the controller to terminate delivery of power to the load 20 by signaling circuit breaker 27 (the claimed "upon detection of said unusual current providing an indication of the presence of an unwanted ground leak.”). Ex. 1628, ¶¶ [0023]-[0026], [0040]-[0041], Figs. 1, 3; Ex. 1602, ¶ 216. Mirafzal also describes that the magnitude of the measured common mode current may be stored in memory or displayed. Ex. 1628, ¶ [0041].

Alternatively, Ivan describes that after detection of an AC fault, in addition to turning off or disconnecting the module that caused the fault, a display 94 can visually display the identity of the module or a speaker 96 can provide an audible indicator of the fault. Ex. 1629, 9:50-67; Ex. 1602, ¶ 217.

2. **Claim 15**

“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 Mirafzal-Ivan-NEC Handbook, as discussed above. *See* Section V.A.1, *supra*. The additional limitations introduced by claim 15 are taught by Mirafzal. Ex. 1602, ¶ 218.

Mirafzal describes an inverter that produces AC power of a frequency and amplitude that is controlled through the use of solid state switching devices. Ex. 1628, ¶ [0021]; Ex. 1602, ¶ 219. In particular, Mirafzal describes how its inverter uses these switches to form a three phase AC current by selectively closely circuit paths that couple phase paths 42, 44, and 46 with the DC current paths 38 and 40. Ex. 1628, ¶ [0031], Fig 1; Ex. 1602 ¶ 219. A PHOSITA would have known that

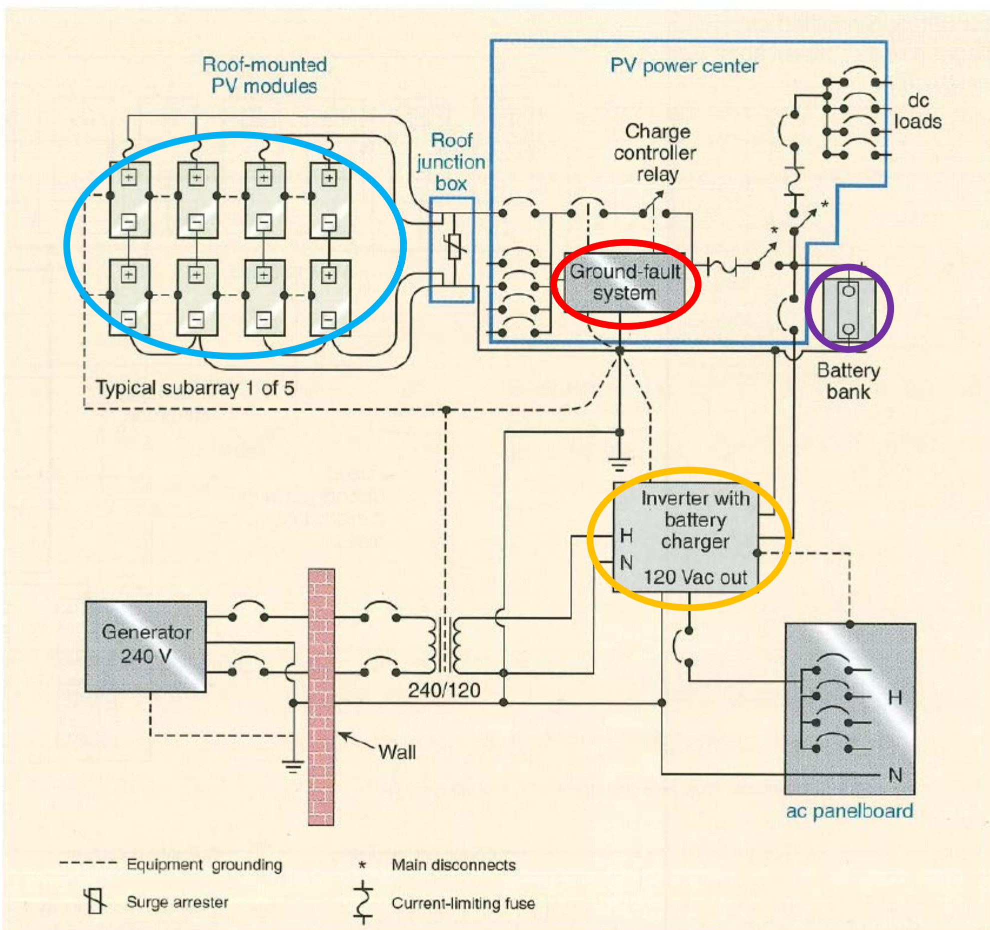
Mirafzal's inverter thus creates a common-mode AC probe signal waveform on the DC current paths due to the voltage step changes resulting from this switching. *See* Sections III.A.1 and 2, *supra*; Ex. 1602, ¶ 219. A PHOSITA would also know that because Mirafzal's inverter is outputting a three phase AC signal the "characteristic repetition frequency of said probe signal" would be 3 times the "AC output repetition frequency." Ex. 1645, p. 2; Ex. 1602, ¶ 219.

3. **Claim 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 16 depends from claim 15 which depends from claim 14, both of which are taught by Mirafzal-Ivan-NEC Handbook, as discussed above. *See* Section V.A.2, *supra*. The combination also teaches the additional subject matter recited by claim 16 for the reasons that follow. Ex. 1602, ¶ 220.

As discussed above, Mirafzal describes a DC power source which can be a photovoltaic array such as those described in 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. 1619, pp. 21 (Figure 690.1(A)), 22 (describing charge controllers for batteries), 23 (Exhibit 690.3), 24 (Exhibit 690.4); Ex. 1602, ¶ 221. For example, Exhibit 690.4 of the NEC Handbook illustrates a system where a battery bank (**purple**) can be charged using a roof-mounted photovoltaic array (**blue**) that also supplies power to an inverter (**orange**). Ex. 1619, p. 24; Ex. 1602, ¶ 221. 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. 1619, pp. 24-25, *see also* 23 (Exhibit 690.3); Ex. 1602, ¶ 221.



Ex. 1619, p. 24 (Exhibit 690.4) (annotated)

It would have been obvious to modify Mirafzal's power conversion system to include a storage battery charged by a photovoltaic array, as taught by the NEC

Handbook. Ex. 1602, ¶ 222. Furthermore, it would have been obvious to have the ground fault detector of Mirafzal detect ground faults on the DC conductors leading to and from the battery. Ex. 1619, pp. 21 (Figure 690.1(A)), 23 (Exhibit 690.3), 24 (Exhibit 690.4); Ex. 1602, ¶ 222. Including a storage battery in Mirafzal'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. 1602, ¶ 222. This enhanced functionality would be desirable to consumers. *Id.*

Incorporating a storage battery merely involves combining known elements (Mirafzal'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). Ex. 1602, ¶ 223. A PHOSITA would have had the skills, knowledge, and motivation to carry out the combination. Ex. 1602, ¶ 223.

Additionally, combining Mirafzal with the NEC Handbook would be merely using known techniques to improve similar devices. Ex. 1602, ¶ 224. A back-up power source would have improved Mirafzal's system, by providing an alternative source for powering the load. Ex. 1602, ¶ 224.

Moreover, in doing so, a skilled artisan would have had a reasonable expectation of success because the proposed implementations of Mirafzal-Ivan-NEC Handbook would be well within standard skill set of a PHOSITA at the time. Ex. 1602, ¶ 225. And Mirafzal already measures the common mode current at the input of the inverter to detect unwanted ground leaks. Ex. 1602, ¶ 225. Thus, unwanted ground leaks from either the photovoltaic array or battery connected to that inverter input would continue to be detected in the Mirafzal-Ivan-NEC Handbook combination. Ex. 1602, ¶ 225.

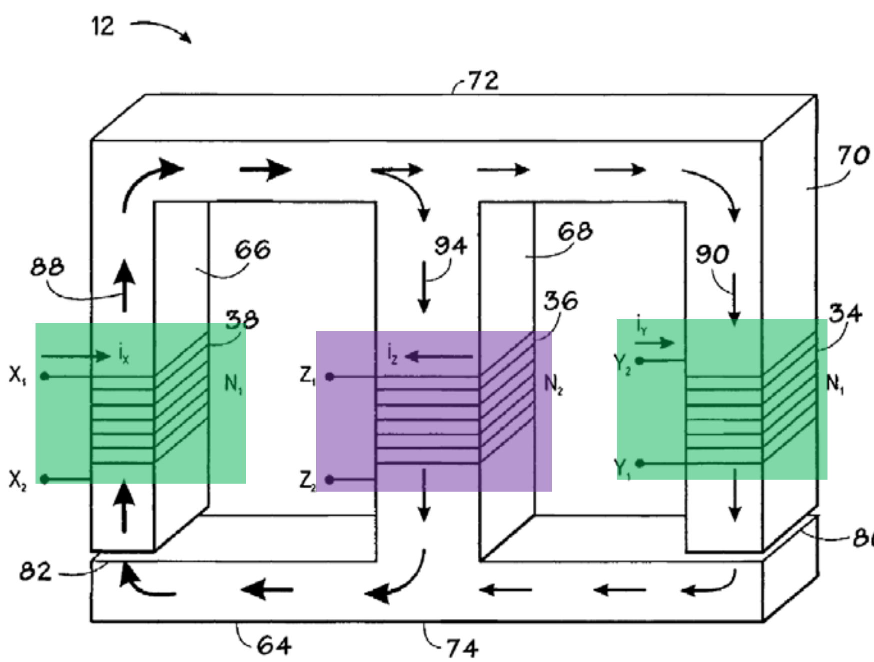
4. **Claim 18**

> **"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 18 depends from claim 14, which is taught by Mirafzal-Ivan-NEC Handbook, as discussed above. *See* Section V.A.1, *supra*. The additional limitations introduced by claim 18 are taught by Mirafzal. Ex. 1602, ¶¶ 226-227.

The ground fault detector of Mirafzal (ICSW 12), as shown in Figure 4 below, has current paths 38 and 40 (**green**) passing through and wound around legs 66 and 70 of monolithic core 64. Ex. 1628, ¶¶ [0020], [0023]-[0024], [0032], Figs. 2, 4;

Ex. 1602, ¶ 228. Current sensor winding 36 (**purple**) is wound around leg 68 and connected to common mode current sensor 22. Ex. 1628, ¶¶ [0023]-[0024], [0032]-[0033], Figs. 2, 4; Ex. 1602, ¶ 228. The magnetic fluxes induced in the core by the currents i_X and i_Y result in a flux in the middle leg 68 due to the difference in those currents (*i.e.*, the common mode current). Ex. 1628, ¶¶ [0037]-[0040], Fig. 4. This flux induces a current i_Z in winding 36 which is measured as the common mode current by common mode sensor 22. Ex. 1628, ¶¶ [0023], [0037]-[0040], Figs. 1, 4; Ex. 1602, ¶ 228.



Ex. 1628, Fig. 4 (annotated)

ICSW 12 thus constitutes a current transformer encircling current paths 38 and 40 measuring the common mode output signal to detect an unusual current. Ex.

1602, ¶¶ 229-230. With regard to the array grounding conductor, as discussed above, a PHOSITA would have known to route current paths 38 and 40 in parallel with an array grounding conductor as required by the NEC. *See* Section V.A.1.a, *supra*. However, claim 18 allows for the array conductor to be encircled by or not be encircled by the current transformer so the precise position of the array ground conductor in the Mirafzal-Ivan-NEC Handbook is not pertinent here.

5. **Claim 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."**

Claim 19 depends from claim 14, which is taught by Mirafzal-Ivan-NEC Handbook, as discussed above. *See* Section V.A.1, *supra*. The combination also teaches the additional subject matter recited by claim 19 for the reasons that follow. Ex. 1602, ¶¶ 231-233.

As discussed above in regard to claim 18, the ICSW 12 of Mirafzal constitutes a current transformer that encircles the positive and negative current paths and produces an output signal. *See* Section V.A.4, *supra*.

The output signal produced by Mirafzal's ICSW may be correlated to a common mode waveform using the process described in Ivan. In particular, Ivan describes measuring the common mode frequency of the output signal. This common mode frequency is then compared to the fundamental operating frequency of the inverter (*i.e.*, the frequency of the common mode waveform) to determine if the inverter is the source of the ground fault. Ex. 1629, 9:18-39, 11:10-22, 12:8-55; Ex. 1602 ¶ 234. Thus, A PHOSITA would understand Ivan's process for comparing the frequency of the output signal to the fundamental operating frequency of the inverter to correspond to the claimed "correlating said common mode waveform with the output signal from one or more current transformers encircling. . . said positive and negative conductors." Ex. 1602, ¶ 234.

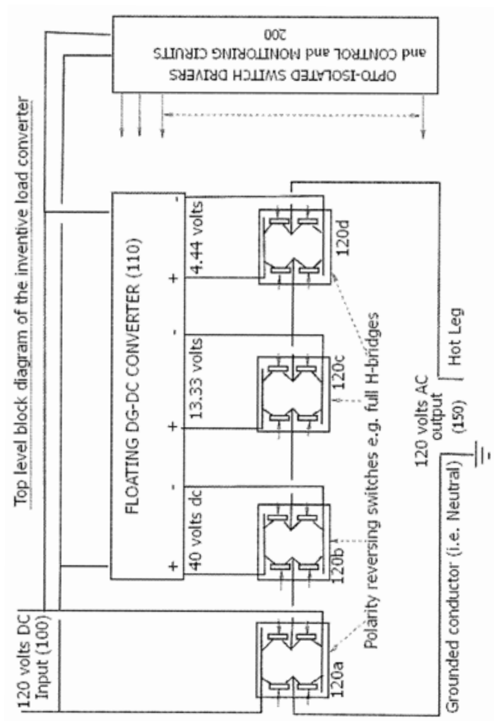
With regard to the array grounding conductor, as discussed above, a PHOSITA would have known to route current paths 38 and 40 in parallel with an array grounding conductor as required by the NEC. *See* Section V.A.1.a, *supra*. However, claim 19 allows for the array conductor to be encircled by or not be encircled by the current transformer so the precise position of the array ground conductor in the Mirafzal-Ivan-NEC Handbook is not pertinent here. Ex. 1602, ¶¶ 235-236.

B. Ground 2: Mirafzal in view of Ivan and the NEC Handbook and further in view of Mori Renders Claim 17 Obvious

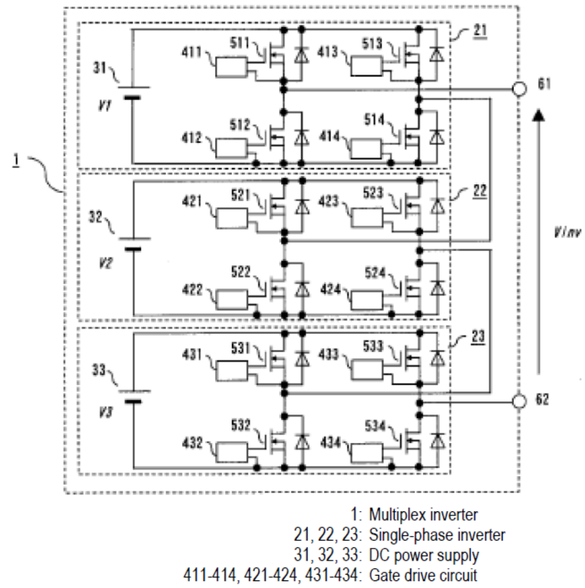
Claim 17: "The method of claim 14 in which said common-mode AC probe signal waveform corresponds to the changing value of a selected digit within a multi-digit number sequence representing said AC output waveform."

Mirafzal-Ivan-NEC Handbook discloses claim 14 as described above. *See* Section V.A.1, *supra*. Mirafzal-Ivan-NEC Handbook in combination with Mori teaches this additional limitation. Ex. 1602, ¶¶ 237-238.

Like the ’822 patent, Mori uses multiple H-bridge circuits (21, 22, 23) to form its multiplex inverter 1. Ex. 1604, ¶¶ [0002]-[0012], [0015]-[0016], [0019]-[0021], [0034]; Ex. 1602, ¶ 239. In Mori, each of the H-bridges within multiplex inverter 1 receive DC voltage from a source (V1, V2, or V3), and these inputs may differ by a successive power of 3 (*e.g.*, 1V, 3V, 9V). Ex. 1604, ¶¶ [0002]-[0012], [0015]-[0016], [0019]-[0021], [0034]; Ex. 1602, ¶ 239. In Mori, as in the ’822 patent, the H-bridge switch outputs are connected in series to generate an AC output (Vinv) at a first repetition frequency. *Compare* Ex. 1604, ¶¶ [0009]-[0012], Fig. 1 *with* Ex. 1601, 6:16-9:40, Fig. 1; Ex. 1602, ¶ 239. The switching structures differ only in the number of voltage sources/H-bridge switches (four in the ’822 patent Figure 1 (below), and three in Mori Figure 1 (below)). Ex. 1604, ¶ [0011], Fig. 1; Ex. 1601, 6:25-26, Fig. 1; Ex. 1602, ¶ 239.

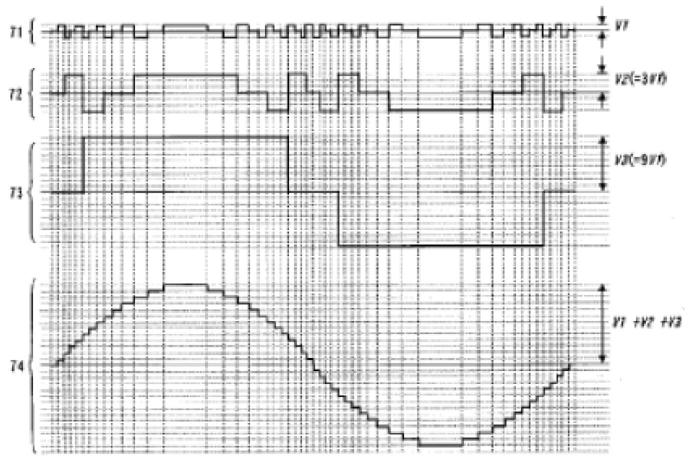


Ex. 1601, Fig. 1



Ex. 1604, Fig. 1

Mori discloses that control of the multiplex inverter 1 (formed from "a plurality of single-phase inverters 21-23 having different DC power supplies 31-33") is accomplished using control signals for each of the H-bridge switches (*i.e.*, 21, 22, and 23). Ex. 1604, ¶¶ [0009]-[0011], Fig. 1; Ex. 1602, ¶ 240. To that end, Mori describes converting a binary control signal (*i.e.*, gradation signal 5) "into a ternary number. . . since the voltages V1-V3 of the DC power supplies 31-33 of the single-phase inverters 21-23 have a ternary relationship, here V1:V2:V3 = 1:3:9." Ex. 1604, ¶ [0019], Figs. 4, 6; Ex. 1602, ¶ 240. Mori's three H-bridge switches each can operate to output: (1) its input voltage V; (2) the negative of its input voltage (-V); or (3) zero volts. Ex. 1602, ¶ 240; Ex. 1604, ¶¶ [0011]-[0012], [0019], Figs. 2, 6. By placing each of the H-bridges into one of these three states (+, 0, -) and then varying those states, the total of the outputs from the bridges will approximate a sine wave, which is shown in Mori's Figure 2 (reproduced below). *Id.*



Ex. 1604, Fig. 2

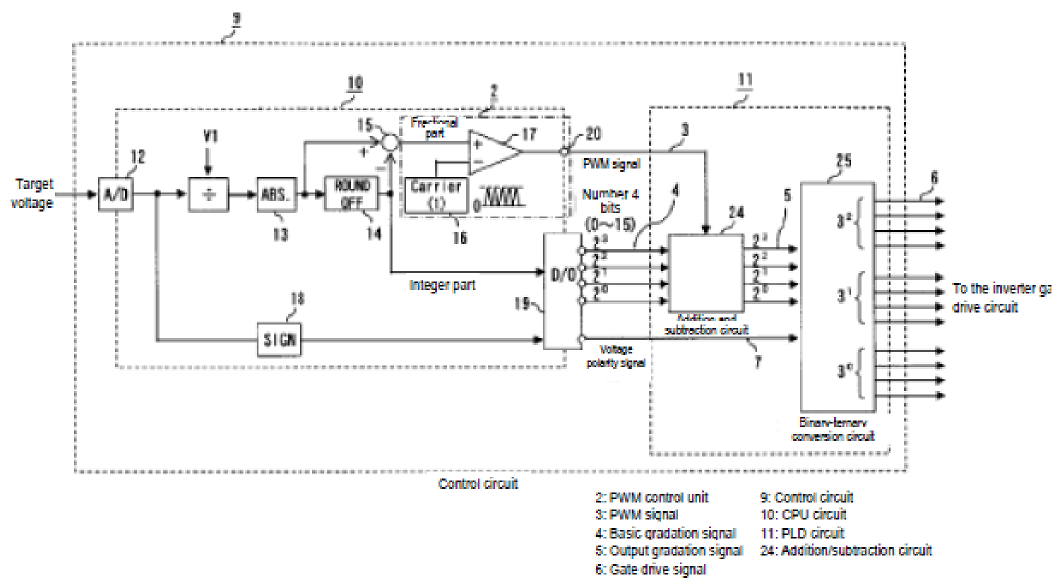
To accomplish the control, Mori's "multiplex inverter 1 uses a control circuit . . . to perform PWM control in combination with gradation control of each single-phase inverter 21-23." Ex. 1604, ¶ [0011]; Ex. 1602, ¶ 241.

Further, the ternary states of each of Mori's H-bridges can be thought of as a digit in a multi-digit number (one digit for each H-bridge) that represents the AC output waveform (the recited "multi-digit number sequence representing said AC output waveform"). Ex. 1602, ¶ 242. This is because the output waveform at any given time comprises the sum of the state of the H-bridge (-1, 0, 1) times the input voltage for that H bridge (*e.g.*, 1V, 3V, 9V). The output can be represented by the formula T1(V1)+T2(V2)+T3(V3) where T1 is the state of the first H-bridge (labeled 21 in Mori), T2 is the state of the second H-bridge (22), and T3 is the state of the third H-bridge (23). Ex. 1604, ¶ [0019], Fig. 6; Ex. 1602, ¶ 242. The multi-digit number T1 T2 T3 (with each of those digits changing as the states of the H-bridges are changed) represents the output waveform. This is because as the states of the H-bridges (or digits of the multi-digit number) change, so does the output voltage. Ex. 1604, ¶ [0019], Fig. 6; Ex. 1602, ¶ 242. Thus, the multi H-bridge inverter of Mori teaches the claimed "multi digit number sequence" that "represents said output waveform." Ex. 1602, ¶ 242.

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 terminal. Ex. 1602, ¶ 243; Ex. 1645, pp. 9-11; Ex. 1603, 5:35-55; Ex. 1615, p. 3121, Fig. 5. It follows that the common mode voltage at the input of each of Mori's H-bridges corresponds to the changing value of the H-bridge inverter's respective digit (the claimed "common-mode AC probe signal waveform corresponds to the changing value of a selected digit").

Specifically, for each of Mori's H-bridge inverters, the common mode voltage generated depends on the H-bridge's switching frequency. Ex. 1602, ¶ 244. For example, as shown in Figure 2, the third bridge 23 (at voltage V3) switches from +1 to 0 to -1 cyclically at a frequency that is the same as the output frequency. Ex. 1604, Fig. 2, ¶ [0012]; Ex. 1602, ¶ 244. This is identical to the switching illustrated in Figure 4 of the '822 patent for the H-bridge 120a. Ex. 1601, 6:41-7:45, 10:15-27, Figs. 4, 5 ("Most significant ternary digit"); Ex. 1602, ¶ 244. 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. 1601, 10:35-55; Ex. 1602, ¶ 244.

Mori also explicitly describes converting a binary control signal (*i.e.*, gradation signal 5) "into a ternary number. . . since the voltages V1-V3 of the DC power supplies 31-33 of the single-phase inverters 21-23 have a ternary relationship, here V1:V2:V3 = 1:3:9." Ex. 1604, ¶ [0019]; Ex. 1602, ¶ 245. Thus, Mori explains that its "output signals (output gradation levels) of the single-phase inverters 21, 22, and 23 are indicated by 3^0, 3^1, and 3^2." Ex. 1604, ¶ [0019] and Fig. 4 (below); Ex. 1602, ¶ 245.



Ex. 1604, Fig. 4

A PHOSITA would have been motivated to modify Mirafzal's inverter by incorporating Mori's multiplex inverter 1 and its corresponding control system. Ex. 1602, ¶ 246. Indeed, Mori explains that use of its three-stage multiplex inverter 1 is desirable in order to "obtain a highly accurate output voltage waveform" even while using inexpensive control circuitry. Ex. 1604, ¶ [0008]; Ex. 1602, ¶ 246. Mirafzal discloses that its inverter may use "various solid state switching devices" to produce an AC waveform at the output of the inverter by selectively closing circuit paths connecting various combinations of the output paths with DC current paths 38 and 40. Ex. 1628, ¶¶ [0021], [0031]; Ex. 1602, ¶ 246. One method of switching between DC sources is to use an H-bridge like those used in Mori. Such a modification would amount to little more than the use of known techniques (the improved inverter design using multiple H-bridges and associated control system of Mori) to improve similar devices (Mirafzal's inverter) in the same way (by incorporating Mori's multiple H-bridge design and associated ternary output control signals). Ex. 1602, ¶ 246.

Additionally, a PHOSITA making such modifications would have had a reasonable likelihood of success as it merely entails an exercise of routine skill to incorporate multiple H-bridges into an inverter and generate the appropriate control signals because the modification merely requires the implementation of known components being operated for their known uses, which was well within the level of ordinary skill in the art. Ex. 1602, ¶ 247. In particular, Mirafzal discloses that its inverter solid-state switching devices to output an AC waveform by selectively closing circuit paths connecting various combinations of the output paths with DC current paths 38 and 40. Ex. 1628, ¶¶ [0021], [0031]; Ex. 1602, ¶ 247. The H-bridges of Mori's inverter operate similarly except each of Mori's three H-bridges is powered by an individual DC voltage source with a different voltage (*e.g.*, 1V, 3V, 9V) instead of the one DC voltage source of Mirafzal's inverter. Ex. 1604, ¶ [0009]; Ex. 1628, ¶ [0021]; Ex. 1602, ¶ 247. In Mori, each DC voltage source is powered by AC power that has been rectified using a transformer and smoothed with a capacitor. Ex. 1604, ¶ [0002]; Ex. 1602, ¶ 247. In replacing Mirafzal's inverter with Mori's multiple H-bridge inverter, a PHOSITA would recognize that because the inverter of Mirafzal is already being supplied with DC power (through current paths 38 and 40), a rectifying transformer would not be required and instead a DC-to-DC converter connected to current paths 38 and 40 could be used to provide the three different voltage levels required by Mori's H-bridges. Ex. 1628, ¶¶ [0021], [0031], Fig. 1; Ex. 1602, ¶ 247. DC-to-DC converters were known in the art at the time as evidenced by, for example, Ivan's disclosure of a DC-to-DC converter as being a potential module 60 connected to Ivan's high voltage DC bus 40. Ex. 1629, 5:8-16; Ex. 1602, ¶ 247. A PHOSITA would have the necessary skill to make the necessary circuit connections to incorporate Mori's inverter into the Mirafzal-Ivan-NEC Handbook combination.

In the combined Mirafzal-Ivan-NEC Handbook-Mori system, the ground fault detection system taught by Mirafzal-Ivan-NEC Handbook and detailed above (*see* Section V.A.1) will still work as intended. This is because the switching of each of Mori's H-bridge switches (each of which represents the recited "changing of a selected digit" of a multi-digit number, as explained immediately above) causes associated common mode voltage signals (each a recited "common-mode AC probe signal waveform correspond[ing] to the changing value") on the DC input lines, in the same fashion as the switching in Mirafzal's inverter (and Ivan's inverter) caused a common mode signal that is used for ground fault detection. Ex. 1602, ¶ 248. Thus, in the combined system, the common-mode AC probe signal waveform that is used for ground fault detection is formed on the DC input to the inverter, which corresponds to the changing value of a selected digit within a multi-digit number sequence representing the AC output waveform. Ex. 1602, ¶ 248. This is also the way that the system described in the '822 patent works. Ex. 1601, 6:41-67, 9:51-10:14, 10:65-11:59; Ex. 1602, ¶ 248. In the combination of Mirafzal-Ivan-NEC Handbook-Mori, the frequency detector of Ivan would be configured to identify and compare the frequency of the common mode waveform to the fundamental operating frequency of Mori's inverter rather than Mirafzal's. Ex. 1602, ¶ 248.

Thus, the combination of Mirafzal-Ivan-NEC Handbook with Mori teaches this feature. Ex. 1602, ¶ 249.

C. 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. Ex. 1602, ¶¶ 250-252.

Dated: October 11, 2021

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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 10,250, which is less than the 14,000 allowed under 37 CFR § 42.24(a)(1)(i). This total includes 10,247 words as counted by the Word Count feature of Microsoft Word and 3 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.

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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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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.