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.: IPR2022-00009

PETITION 3 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. 1104:	Certified Translation of Ex. 1120, Japanese Patent Pub. No. 2006-238630A ("Mori")
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Ex. 1116:	Certified translation of Ex. 1146, 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. 1117: 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”)

Ex. 1118: U.S. Patent Application Pub. No. 2007/0278988 (“De”)

Ex. 1119: Mark W. Earley Ed., *National Electrical Code ® Handbook*, Eleventh Edition, 2008

Ex. 1120: Japanese Patent Application Publication No. 2006-238630 (“Mori”)

Ex. 1121: Q. Liu, S. Wang, A. C. Baisden, F. Wang and D. Boroyevich, EMI Suppression in Voltage Source Converters by Utilizing dc-link Decoupling Capacitors, IEEE Transactions on Power Electronics, vol. 22, no. 4, pp. 1417-1428, July 2007 (“Liu”)

Ex. 1122: Certified File History of U.S. Patent No. 8,937,822

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Ex. 1130: Japanese Pat. App. Pub. No. P2004-7941A (“Suzuki”)

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Ex. 1132-1134: Reserved

Ex. 1135: U.S. Patent No. 6,112,158 (“Bond”)

Ex. 1136: Excerpts from the Modern Dictionary of Electronics, 6th Edition, 1992

Ex. 1137-1141: Reserved

Ex. 1142: McGraw-Hill Dictionary of Electrical and Electronic Engineering, 1984

Ex. 1143: Excerpts of IEEE: The Authoritative Dictionary of IEEE Standard Terms, Seventh Edition, IEEE Press 2000

Ex. 1144: Tolbert et al., Multilevel Converters for Large Electric Drives, IEEE Trans. Ind. Apps., Vol 35, No. 1, Jan/Feb 1999 (“Tolbert”)

Ex. 1145: Certified translation of Ex. 1155, Heribert Schmidt, Bruno Burger, & Klaus Kiefer. Wechselwirkungen zwischen Solarmodulen und Wechselrichtern, Fraunhofer Institute for Solar Power Systems, June 2007 (“Schmidt 2007”)

Ex. 1146: 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. 1147: U.S. Patent No. 7,082,040 (“Raddi”)

Ex. 1148: U.S. Patent No. 4,320,449 (“Carroll”)

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Ex. 1150: U.S. Patent No. 5,285,372 (“Huynh”)

Ex. 1151: Certified translation of Ex. 1158, PCT Publication No. WO 2010/082265 (“Mori ’265”)

Ex. 1152: Keith H. Billings, *Switchmode Power Supply Handbook*, McGraw Hill, 1989

Ex. 1153: Marty Brown, *Power Supply Cookbook*, Butterworth-Heinemann, 1994

Ex. 1154: U.S. Department of Commerce. International Trade Administration, *Electric Current Abroad*, 1998 Edition, reprinted Feb. 2002 ("ECA 1998/2002")

Ex. 1155: Heribert Schmidt, Bruno Burger, & Klaus Kiefer. Wechselwirkungen zwischen Solarmodulen und Wechselrichtern. English translation: Interaction between Solar Modules and DC/AC Inverters, 2007

Ex. 1156: Math H. Bollen, Irene Gu, *Signal Processing of Power Quality Disturbances*, Wiley-IEEE Press, 2006

Ex. 1157: Symmetrical components, Wikipedia, https://en.wikipedia.org/wiki/Symmetrical_components, downloaded September 29, 2021

Ex. 1158: PCT Publication No. WO 2010/082265 ("Mori '265")

Ex. 1159-1163: Reserved

Ex. 1164: Ostbayerisches Technologie-Transfer-Institute. V., Power Electronics for Photovoltaics, OTTI International Seminar, June 7-8, 2010

Ex. 1165: 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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I. INTRODUCTION & RELIEF REQUESTED

U.S. Patent No. 8,937,822 ('822 patent) describes various configurations of well-known DC-AC converters (also referred to as an inverter) that convert direct current (DC) electrical power such as from a solar panel to alternating current (AC) electrical power using reversing switches arranged as: (1) a single-phase inverter with an H-bridge switch; (2) a single-phase inverter with multiple H-bridge switches in series; or (3) a three-phase inverter with half-bridge switches. Ex. 1102, ¶¶ 91-95. The '822 patent's claims add merely trivial requirements to these embodiments based on intrinsic properties of DC-AC inverters, such as common-mode AC waveforms appearing on the DC input lines, or well-known components like bidirectional DC-DC converters, switching controllers, a ground leak detector, and a common-mode filter. Schmidt (Ex. 1103), which discloses a single-phase inverter with an H-bridge switch, alone and in combination with the additional secondary references in this petition disclose these additional limitations. Claims 1-13 and 20 of the '822 patent are unpatentable and should be cancelled.

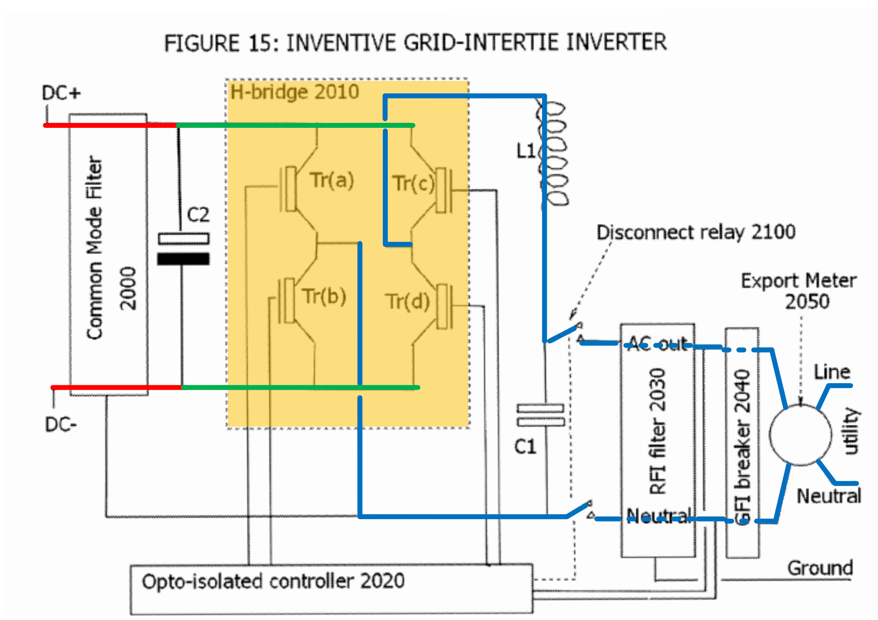
II. GROUNDS FOR STANDING & FEE PAYMENT

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 1-13 and 20 on the identified grounds. The undersigned authorizes the charge of any required fees to Deposit Account No. 19-0733.

III. OVERVIEW

A. Brief Description of Alleged Invention

The ’822 patent describes multiple well-known inverters, one of which is a single-phase H-bridge switch (**orange**), which generates an AC output (**blue**) by switching Tr(c) and Tr(d) at a high switching frequency (*e.g.*, 200 kHz) while switching Tr(b) and Tr(a) at a “60 Hz repetition rate” in a “synchronized” manner with the “utility grid.” Ex. 1101, Abstract, 3:51-4:7, 5:58-59, 17:50-51, 23:37-24:13, 35:58-59.



Ex. 1101, Fig. 15 (annotated)

The switching of Tr(b) and Tr(a) alternatively connects the DC+ and DC- inputs to the neutral output causing a common-mode 60 Hz square waveform at each DC input terminal. *Id.*, 4:3-8, 4:46-50, 23:49-57, 27:10-11, 35:54-58; Ex. 1102, ¶¶ 61-79.

B. Prosecution History

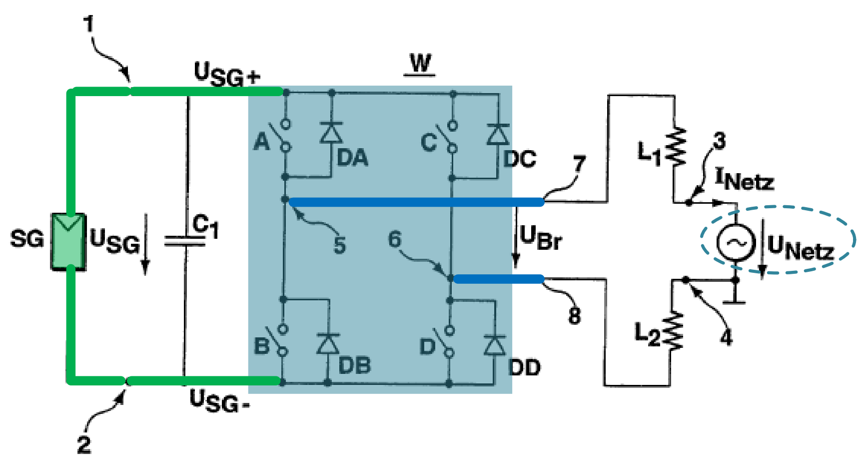
The application that led to the ’822 patent was filed May 8, 2011. Ex. 1122, p. 128. Claims 1 and 6 were rejected as obvious over U.S. Patent Nos. 7,082,040 (Raddi) and 4,320,449 (Carroll). *Id.*, pp. 303-308. In response, the applicant amended claim 1 to recite “wherein the second repetition frequency is a multiple equal to the same said number N of said first repetition frequency,” purportedly incorporating then-allowable claim 3 “to overcome the examiner’s rejection of claim 1.” *Id.*, pp. 318-319. The applicant distinguished the amendment from claim 3: “Rather than specify N to be 1, 2 or 3[,] I have left it equal to the number of unique phases recited in claim 1.” *Id.* The examiner allowed the claims based on the prior art allegedly lacking the feature “wherein the second repetition frequency is multiple equal to the same said number N of said first repetition frequency.” *Id.*, pp. 357-361. The examiner materially erred as this limitation is found throughout the inverter prior art as explained in this Petition and the concurrently filed petitions. Moreover, none of the prior art in this Petition was cited during prosecution, and none is cumulative to the prior art relied upon by the examiner. Schmidt, the primary reference, describes an inverter with a floating source, which is fundamentally different from Raddi’s AC-AC converter with an uninterrupted neutral from input to output that prevents the DC supply from floating, and fundamentally different from Carroll’s cycloconverter connected to the outputs of an inverter for conditioning the outputs for reactive loads. Ex. 1102, ¶¶ 80-90; Ex. 1101, cover; Ex. 1147, Abstract; Ex. 1148, Fig. 1, 1:19-34.

C. Scope and Content of the Prior Art

1. U.S. Patent No. 7,046,534 (Schmidt) (Ex. 1103)

Schmidt, a U.S. Patent issued on May 16, 2006, is prior art under 35 U.S.C. § 102(b).[1]

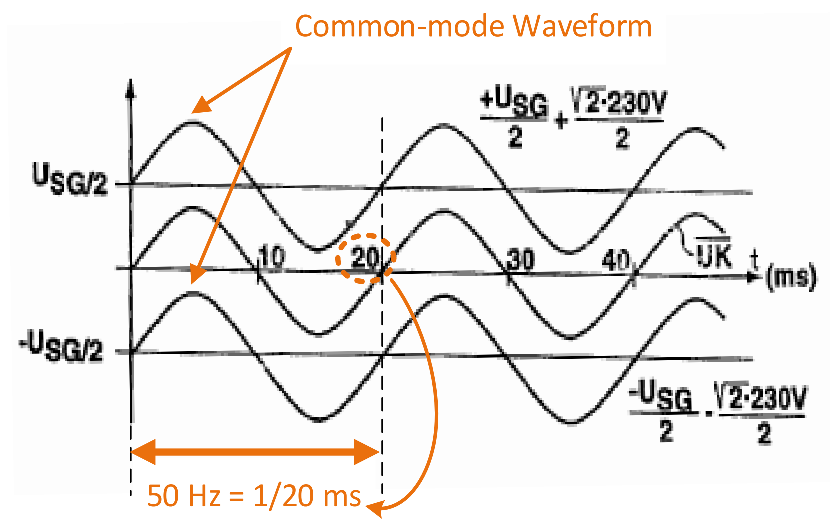
Schmidt describes an H-bridge with switches (A/B/C/D) (also referred to as a full-bridge) (**blue**) controlled to convert power from a DC source (SG) (**green**) to an AC output (U_{Netz}) connected to a public grid or an independent island grid with a stable voltage and frequency (*e.g.*, 50 or 60 Hz). Ex. 1103, 1:9-44, 1:50-55, 2:7-4:12, 4:41-5:51, 9:14-62.



Ex. 1103, Fig. 2 (annotated)

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

Shown below, the H-bridge switch also causes common-mode voltage waveforms to appear at the DC input terminals at the same frequency as the AC output (*e.g.*, 50 or 60 Hz). Ex. 1103, 4:4-10, 9:56-62; Ex. 1102, ¶¶ 184-191.

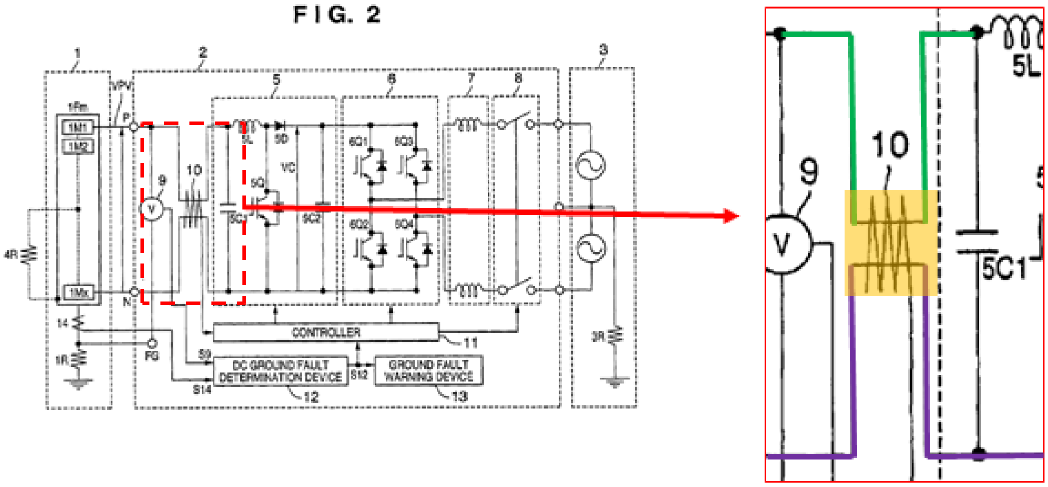


Ex. 1103, Fig. 6 (annotated)

2. U.S. Patent No. 6,927,955 (Suzui) (Ex. 1106)

Suzui, a U.S. Patent issued on August 9, 2005, is prior art under 35 U.S.C. § 102(b).

Suzui describes a current detector 10 (**orange**), on the input to an inverter, which detects a ground fault by sensing an imbalance current at the DC input of an inverter:



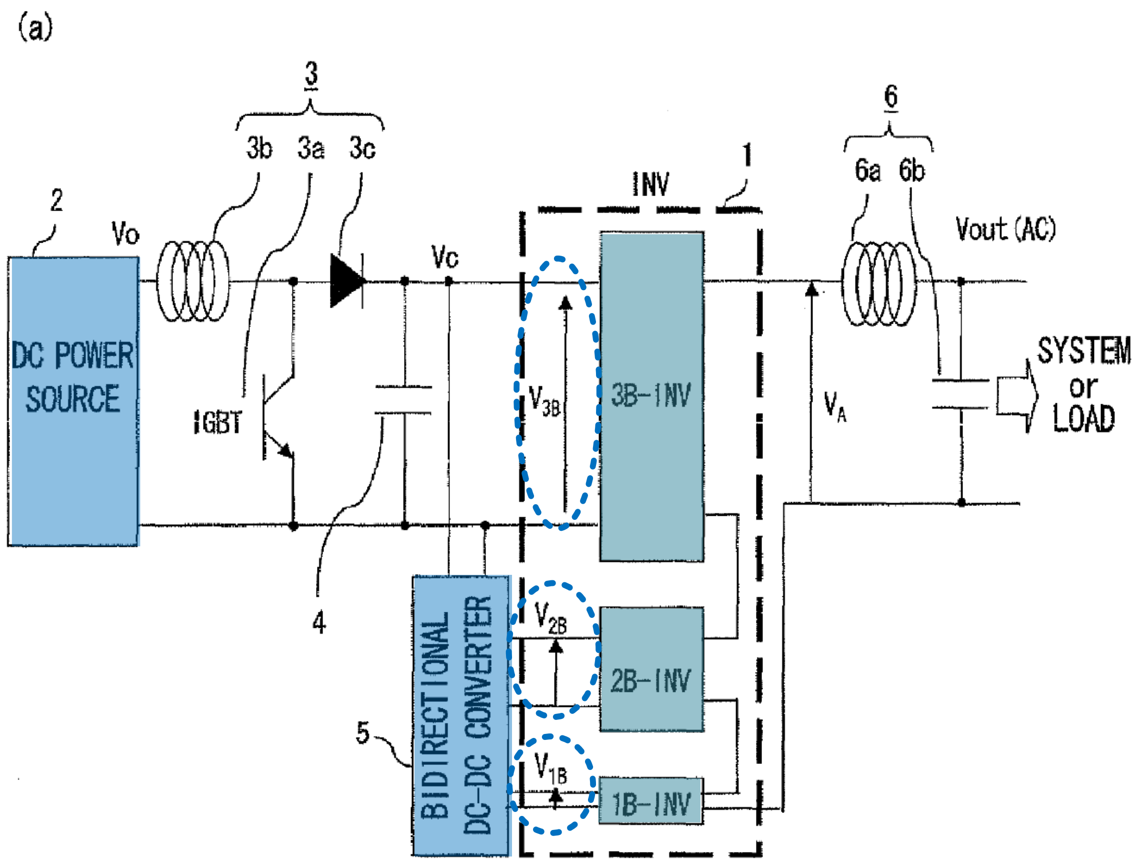
Ex. 1106, Fig. 2 (annotated).

If a ground fault is detected, Suzui's current detector 10 outputs a ground fault signal [*S10*] causing the inverter to disconnect from the commercial system 3. Ex. 1106, 1:34-38, 1:56-61, 4:28-36, 5:47-62, Figs. 2, 9, 9B; Ex. 1102, ¶¶ 192-193.

3. U.S. Patent Application Publication No. 2008/0192519 (Iwata) (Ex. 1107)

Iwata, a U.S. Patent Application Publication published on August 14, 2008, is prior art under 35 U.S.C. § 102(b).

Iwata describes a DC-AC converter with multiple, series connected H-bridge switch inverters 1B-INV, 2B-INV, and 3B-INV having respective input voltages V_{1B}, V_{2B}, V_{3B}, which are successive powers of 3 ("1:3:9"), and which are generated from DC Power Source 2 and bidirectional DC-DC converter 5. Ex. 1107, ¶¶ [0003], [0007]-[0009], [0045], [0050], Fig. 1b; Ex. 1102, ¶¶ 194-195.



Ex. 1107, Fig. 1a (annotated)

The outputs of the inverters are connected in series to generate a sum voltage V_A as a number of voltages steps producing a "substantially sine wave-like output Voltage waveform 11" as shown in Figure 2(b):

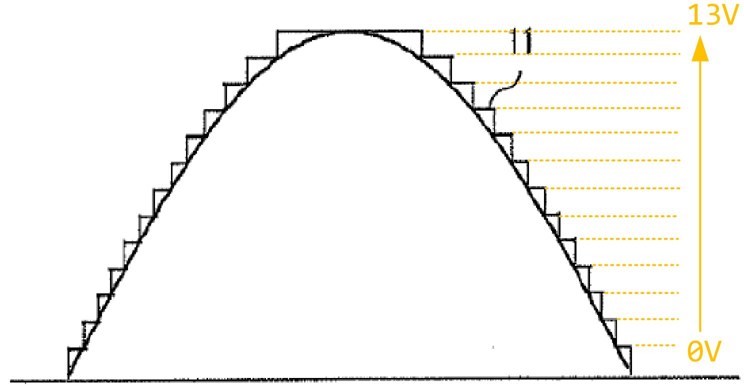
"Output DC Voltages"

(a)

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

"Ternary States"

(b)



Ex. 1107, Fig. 2a (top) and Fig 2.b (bottom) (annotated).

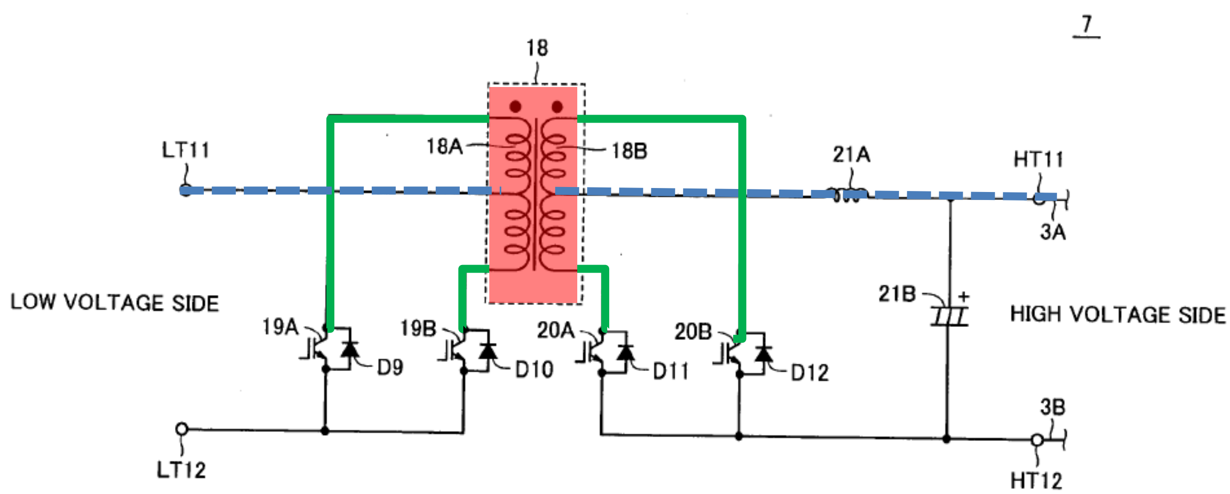
As shown in Figure 2(a), the sum voltage V_A is expressed in ternary number base with three digits (V_{1B}, V_{2B}, and V_{3B}), with each digit determining whether a respective H-bridge switch is controlled to one of the three output states: (a) a positive polarity state (1), (b) an inverse polarity state (-1), and (c) a pass-through state (0). Ex. 1107, ¶ [0050]; Ex. 1102, ¶¶ 194-197.

4. U.S. Patent Application Publication No. 2009/0086520 (Nishimura) (Ex. 1108)

Nishimura, a U.S. Patent Application Publication published on April 2, 2009, is prior art under 35 U.S.C. § 102(b).

Nishimura describes a bidirectional DC-DC converter with an equivalent structure to that in Figure 2 of the ’822 patent. including a center-tapped windings (**red**) that are connected to the positive terminal of the DC input or output (**blue**) with ends of the windings connected to the drains of N-Type MOSFET pairs (**green**):

FIG.4

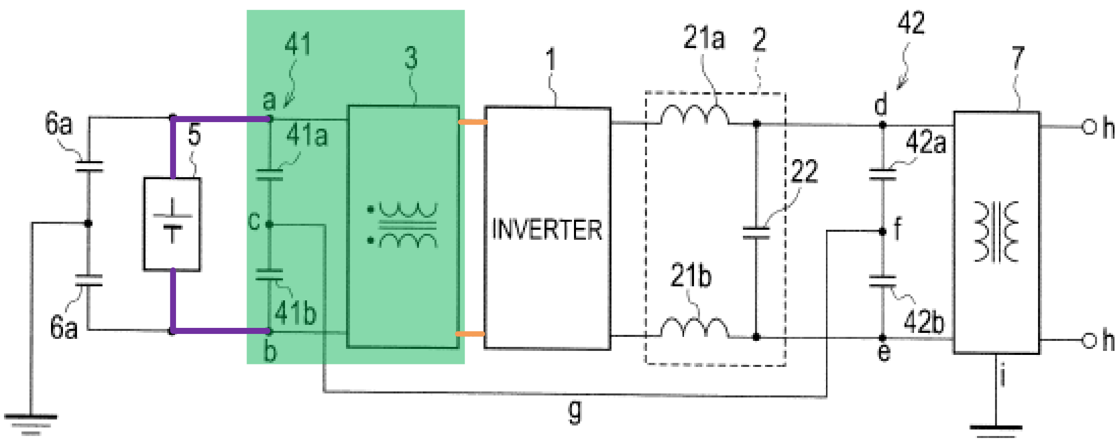


Ex. 1108, Fig. 4 (annotated), [0091]-[0101]; Ex. 1101, 18:34-47, Fig. 2; Ex. 1102, ¶ 198.

5. **PCT Pub. No. WO 2010/055713 (Koyama) (Ex. 1127, Ex. 1109)**

Koyama (Ex. 1127, certified translation of Ex. 1109), a PCT patent application publication published on May 20, 2010, is prior art under 35 U.S.C. § 102(a).

Koyama describes a common-mode filter (**green**), including a common-mode choke coil 3a and capacitors 41a, 41b, between DC input terminals of an inverter 1 (**orange**) and positive and negative terminals of DC power source 5 (**purple**). Ex. 1109, ¶¶ [0002]-[0008], [0012], [0016]-[0021], [0024]-[0027], [0030]-[0031], [0036]-[0038], Figs. 1-4; Ex. 1102, ¶¶ 199-201.



Ex. 1109, Fig. 5 (annotated)

6. **Ahmed, "Passive Filter Design for Three-Phase Inverter Interfacing in Distributed Generation, Compatibility in Power Electronics," CPE 2007, IEEE, 2007 (Ahmed) (Ex. 1110)**

Ahmed, an article published by the IEEE and publicly available since 2007, is prior art under 35 U.S.C. § 102(b). Ex. 1123, ¶¶ 41-65 (Section III.B).

Ahmed discloses a low-pass LC filter for reducing switching frequency harmonics of inverters. Ex. 1102, ¶¶ 202-203.

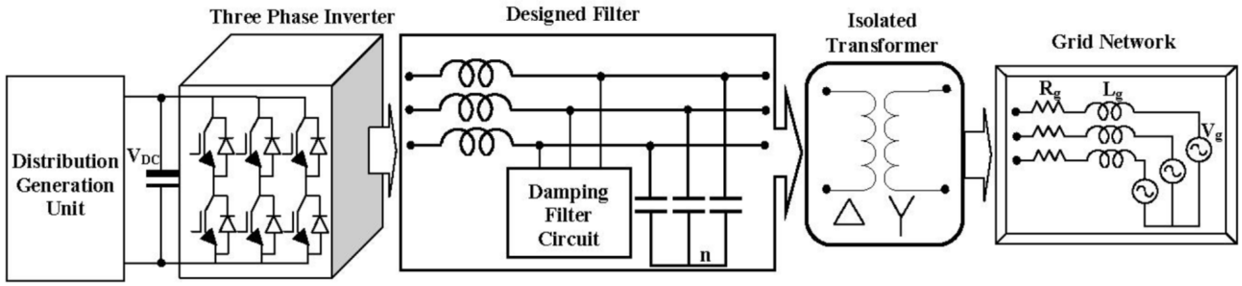


Fig. 1. Block diagram of the proposed interfacing system

Ex. 1110 at 1, Fig. 1

7. Mohan, N., Power Electronics: Converters Applications and Design (2nd Ed. John Wiley & Sons. Inc.) (Mohan) (Ex. 1112)

Mohan, a textbook on power electronics published and publicly available since 1995, is prior art under 35 U.S.C. § 102(b). Ex. 1123, ¶¶ 66-79 (Section III.B); Ex. 1112 at iv. Mohan is referenced by Schmidt (as Ref. 3) for its switch timing, which is further evidence of its publication and public accessibility. Ex. 1103, 1:41-44, 3:22-25, 4:41-64. Mohan describes several switch timings for an H-bridge inverter (*id.*, Figs. 8-11), including unipolar pulse width modulated (PWM) switching and voltage cancellation. Ex. 1102, ¶ 204.

Unipolar PWM Switching. Mohan describes alternating between four switch states for an H-bridge switch, producing a pattern of three output states (positive, negative, and two pass-through states), that when filtered produces a sine wave output:

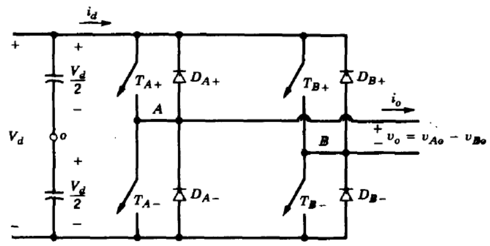
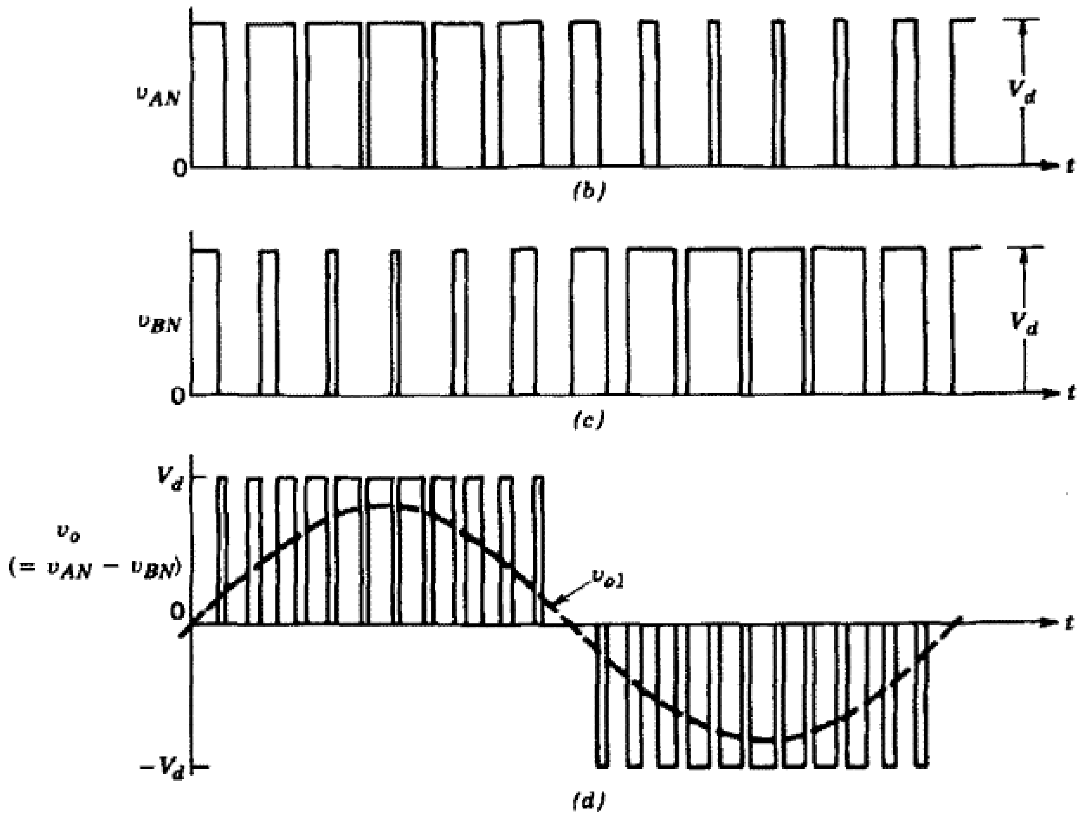


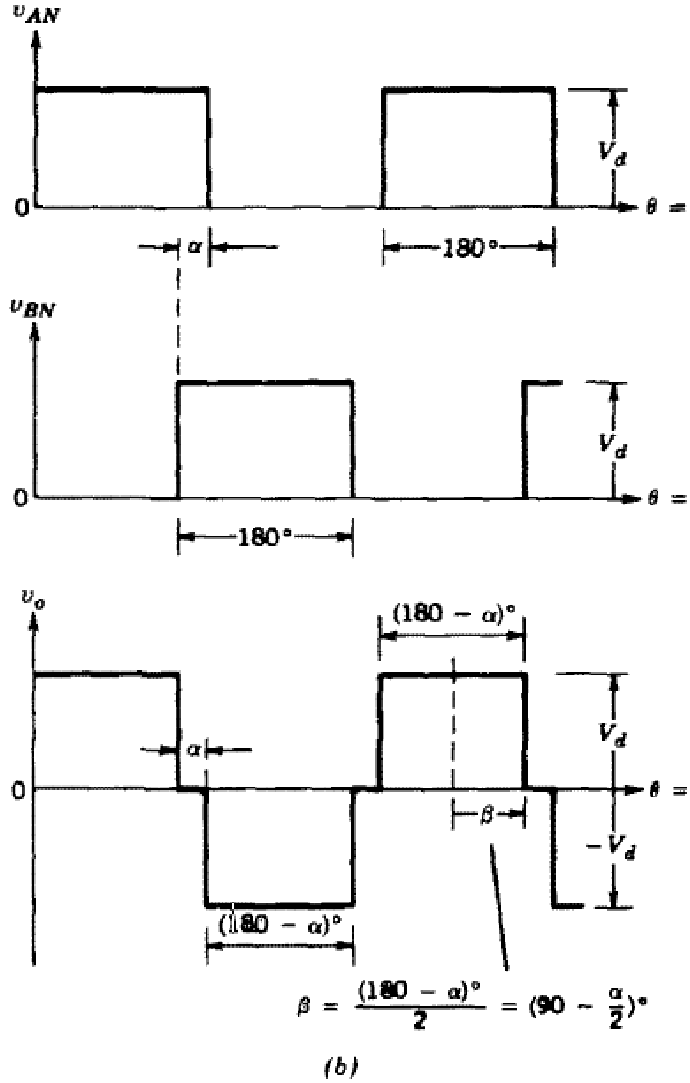
Figure 8-11 Single-phase full-bridge inverter.

1. T_{A+}, T_{B-} on: $v_{AN} = V_d$, $v_{BN} = 0$; $v_o = V_d$
2. T_{A-}, T_{B+} on: $v_{AN} = 0$, $v_{BN} = V_d$; $v_o = -V_d$
3. T_{A+}, T_{B+} on: $v_{AN} = V_d$, $v_{BN} = V_d$; $v_o = 0$
4. T_{A-}, T_{B-} on: $v_{AN} = 0$, $v_{BN} = 0$; $v_o = 0$



Ex. 1112, pp. 215-218, Figs. 8-11, 8-15(a)-(d), 8-31; Ex. 1102, ¶¶ 205-206. Pass-through states are created when both output terminals are simultaneously connected to a single DC input terminal, producing V_0=0. *Id*.

Voltage Cancellation. Voltage cancellation is a specific type of unipolar PWM voltage switching. Ex. 1112, p. 218. In voltage cancellation, the switches have a set duty cycle of 0.5. *Id.* This results in both pass-through states being alternately utilized to produce v_0=0:



Ex. 1112, p. 219; Ex. 1102, ¶ 207.

8. U.S. Patent No. 7,576,449 (Becker) (Ex. 1125)

Becker, a U.S. Patent that issued on August 18, 2009, is prior art under 35 U.S.C. § 102(b).

Becker describes a three-phase inverter implemented with a group of three single-phase inverters (*e.g.*, 14, 15, and 16) (**orange**) connected in a wye arrangement at a "service tap to [the] supply mains" (**purple**) such that one output terminal of each single-phase inverter connects respectively to one of three AC phase outputs L1, L2, and L3 (**green**), and the other output terminal is connected to a central neutral terminal N (**blue**). Ex. 1125, 1:18-20, 2:49-51, 2:56-62, 3:43-4:21, 4:45-48, 5:22-28; Ex. 1102, ¶ 208.

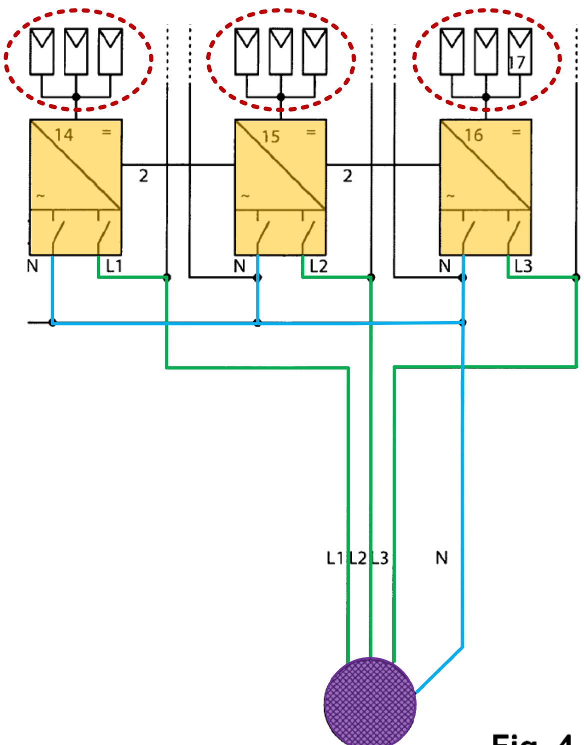


Fig. 4

Ex. 1125, Fig. 4 (annotated)

9. U.S. Patent Publication No. 2002/0171436 (Russell) (Ex. 1126)

Russell, a U.S. Patent Application Publication published on November 21, 2002, is prior art under 35 U.S.C. § 102(b).

Russell describes a photovoltaic array 102 that supplies DC power to an DC-AC converter (inverter 106) through a watt-hour metering device 4 to an electric utility service connection 118 using a 3-phase 120/208 Volt AC service. Ex. 1126, Abstract, ¶¶ [0003]-[0007], [0018]-[0019], [0027]-[0031], [0033], Figs. 1, 7; Ex. 1102, ¶ 209.

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

Petitioner requests review of claims 1-13 and 20 on these grounds:

Grounds	References	Basis	Claims Challenged
1-2	Schmidt	102/103	1-3, 8-10
3	Schmidt in view of Suzui	103	4, 11
4	Schmidt in view of Iwata and Nishimura	103	5, 12-13
5	Schmidt in view of Koyama and Ahmed	103	6, 20
6	Schmidt in view of Becker and Russell	103	7
7	Schmidt in view of Mohan	103	2

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. 1102, ¶¶ 1-60, 131-183, 210-211, 419-422), and Dr. Mullins' expert testimony proving authenticity and public availability prior to May 8, 2011 of certain exhibits. Ex. 1123, ¶¶ 1-40, 41-65 (Ex. 1110), 66-79 (Ex. 1112), 232-248

(Ex. 1115), 268-285 (Ex. 1117), 80-93 (Ex. 1119), 286-307 (Ex. 1121), 214-231 (Ex. 1144), 249-267 (Ex. 1146), 332-353 (Ex. 1152), 193-213 (Ex. 1153), 172-192 (Ex. 1154), 155-171 (Ex. 1155), 308-331 (Ex. 1156), 94-111 (Ex. 1164), 112-129 (Ex. 1165), 354-356.

A. Level of Ordinary Skill

At the time of the alleged invention of the ’822 patent, a person having ordinary skill in the art (“PHOSITA”) would have had a bachelor’s degree in electrical engineering or a similar discipline and three years of design experience with power electronics, including experience designing power converters. Ex. 1102, ¶¶ 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 PHOSITA 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. 1102, ¶¶ 59, 96-98.

1. "DC to AC converter" (Claim 1)

To the extent "DC to AC converter" is found to be a means-plus-function term, it performs the function of:

> caus[ing] (1) an AC output waveform at said first repetition frequency and having a voltage relative to one of said at least one ground, neutral or reference potential terminals to appear with a unique phase at each of a number N at least equal to one of said set of live AC output terminals, and (2) a common-mode voltage waveform at a second repetition frequency to appear relative to one of said at least one ground, neutral or reference potential terminals and in the same phase on both of said positive and negative terminals of said DC power source, wherein the second repetition frequency is a multiple equal to the same said number N of said first repetition frequency.

Ex. 1101, claim 1; Ex. 1102, ¶ 99.

The corresponding structures include four different inverter circuits:

- Depicted in Figures 1 and 10, one inverter includes a plurality of H-bridge switches with series connected outputs and each input of the H-bridge switches connected to a different voltage source. Ex. 1101, 6:17-26, Figs. 1, 10; Ex. 1102, ¶¶ 100-104.
- Depicted in Figure 15, another inverter includes a single H-bridge switch with a single-phase output connected through an inductor. Ex. 1101, 23:37-44, Fig. 15; Ex. 1102, ¶ 105.

- Depicted in Figure 16, a third inverter 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. 1101, Fig. 16; Ex. 1102, ¶ 106.
- Depicted in Figure 24, the fourth inverter 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. 1101, 29:26-67, Fig. 24; Ex. 1102, ¶¶ 107-108.

2. "A switch[ing] controller" (Claims 2 and 5)

To the extent "switch[ing] controller" in claims 2 and 5 is construed to be a means-plus function term, the claim 2 function is:

> [controlling a] first electronic switch . . . to connect said positive DC input terminal to the instantaneously most positive of said set of AC output terminals and said at least one ground, neutral or reference potential terminal alternating with connecting said negative DC input terminal to the instantaneously most negative of said set of AC output terminals and said at least one ground, neutral or reference potential terminal,

and the claim 5 function is:

> for controlling the three-state electronic switches according to a sampled numerical representation of the desired AC output waveform expressed in a ternary number base.

Ex. 1101, claims 2, 5; Ex. 1102, ¶ 119.

The corresponding structures for both switch controllers include (1) "a microcontroller" with "memory"; or (2) "a crystal reference oscillator," "15-bit divider," and Read Only Memory (ROM) containing precomputed waveforms. Ex. 1101, 12:26-51, 24:8-12; Ex. 1102, ¶¶ 120-124.

3. "AC ground leak detector" (Claim 4)

To the extent "AC ground leak detector . . ." is construed to be a means-plus-function term, it performs the function of:

> detect[ing] an imbalance current at said second frequency and [] thereby provid[ing] a detection signal indicative of an unwanted leakage impedance from a DC conductor to ground.

Ex. 1101, claim 4.

The corresponding structure is a current transformer including toroid 800 with a toroidal winding 801. Ex. 1101, 25:57-59, 31:65-32:20, 35:66-36:3, 41:21-22, Figs. 18; Ex. 1102, ¶¶ 109-113.

4. "bidirectional DC-to-DC converter" (Claims 5 and 13)

To the extent "bidirectional DC-to-DC converter" in claims 5 and 13 is construed to be a means-plus-function term, the claim 5 function is:

> converting the input voltage from said DC power source to a number of floating supplies of voltages equal to the input voltage divided or multiplied by successive powers of 3,

and the claim 13 function is:

> to form, along with the DC source voltage, a set of floating DC supplies of voltages having voltage ratios of successive powers of 3.

Ex. 1101, claims 5, 13.

The corresponding structure for both claims is one or more transformers with windings that have turn ratios in proportion to the voltage ratios being output, where each winding corresponding to a floating supply is center tapped (or an equivalent structure). Ex. 1101, 15:29-34, 18:34-47, 19:5-23, Figs. 2, 10; Ex. 1102, ¶¶ 125-130.

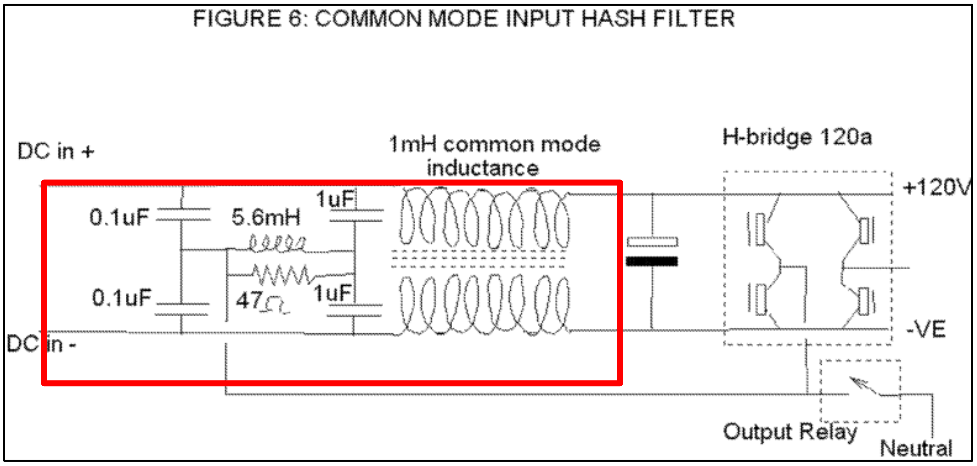
5. "common-mode filter" (Claim 6)

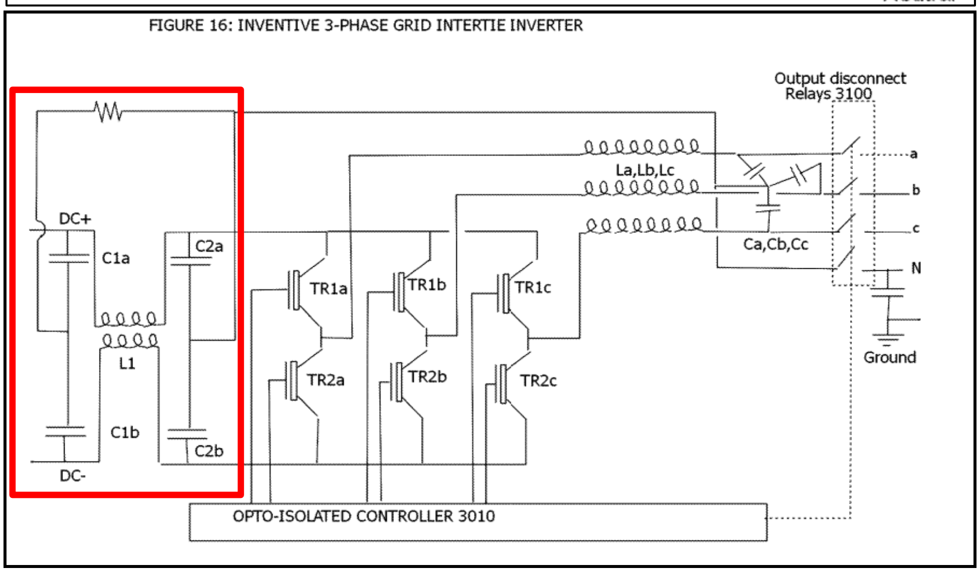
To the extent "common mode filter" is a means-plus-function term, it performs the claimed function of:

> (1) preventing high frequency components of the DC to AC converter internal waveforms being exported to said DC source and (2) minimizing overshoot of said common-mode waveform in order to minimize peak voltages on said positive and negative terminals.

Ex. 1101, claim 6; Ex. 1102, ¶¶ 114-115.

The corresponding structure is a filter comprising capacitors, inductors, and resistors arranged as shown in Figures 6 and 16. Ex. 1101, 18:18-33; Ex. 1102, ¶¶ 116-118.





Ex. 1101, Figs. 6 (top, annotated), 16 (bottom, annotated)

V. SPECIFIC GROUNDS FOR UNPATENTABILITY

A. Grounds 1-2: Schmidt Anticipates or Renders Obvious Claims 1-3 and 8-10

1. Independent Claim 1

a. [1A]: "A DC to AC conversion apparatus for converting power from a DC source to produce an power output waveform at a first repetition frequency, comprising"

To the extent the preamble is limiting, Schmidt discloses this element. Ex. 1102, ¶¶ 212-216. As shown in Figure 2, Schmidt describes a single-phase, transformerless "DC/AC converter" (**blue**) that converts a DC voltage source (solar generator SG) to a 50 or 60 Hz alternating current (AC) voltage (the claimed "produc[ing] a[] power output waveform at a first repetition frequency"). Ex. 1103, 1:11-27, 2:40-60, 3:5-17, 7:37-8:24, Fig. 1; Ex. 1102, ¶¶ 212-216.

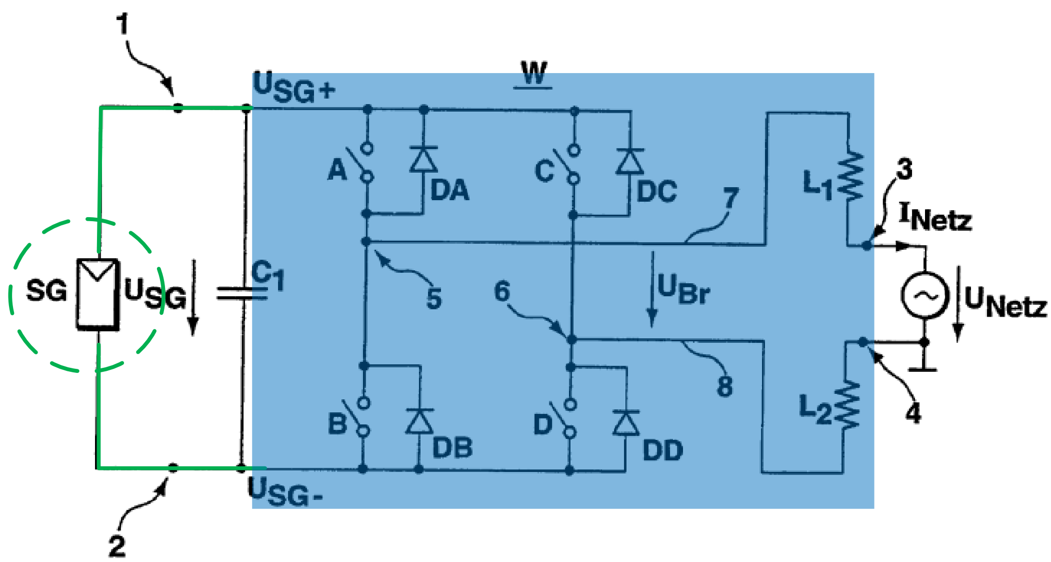
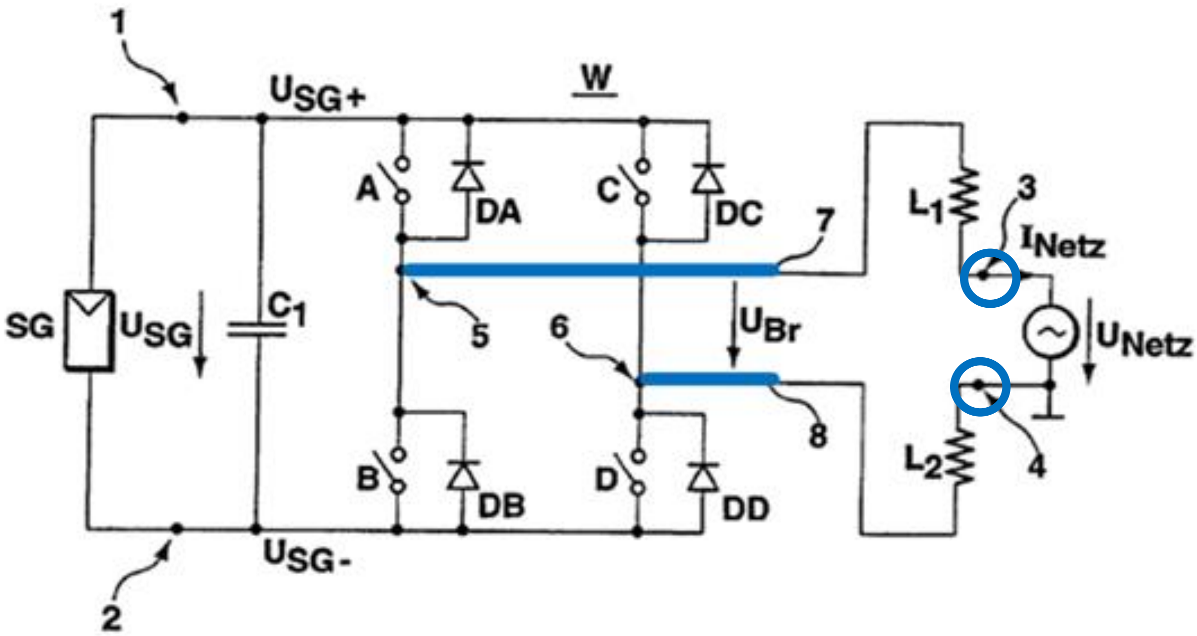


Fig. 2

Ex. 1103, Fig. 2 (annotated)

b. [1B-1C]: "a set of at least one live AC output terminals, at least one output terminal designated as a ground, neutral or reference potential terminal"

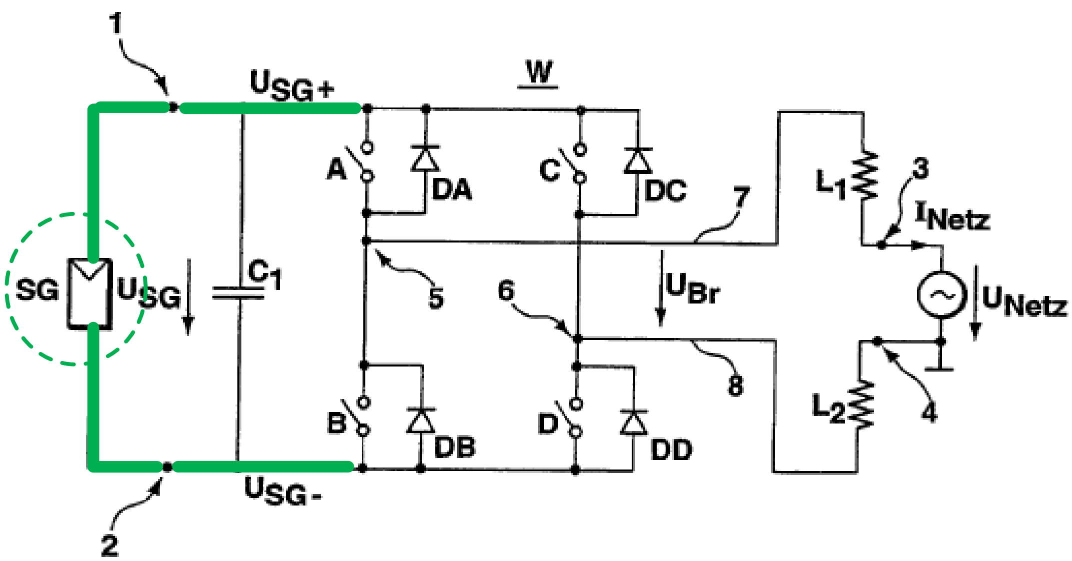
Schmidt's inverter has a live AC output terminal (terminal 3), outputting AC voltage (U_{Netz}) relative to a neutral terminal (terminal 4 connected to ground) (**blue** circles). Ex. 1103, 2:61-67, 3:5-18, 5:48-54, 7:37-58, Figs. 1-2; Ex. 1102, ¶¶ 217-220.



Ex. 1103, Fig. 2 (annotated)

c. [1D]: "a floating DC power source having a positive and a negative terminal connected respectively to the positive and negative DC input terminals of a DC to AC converter"

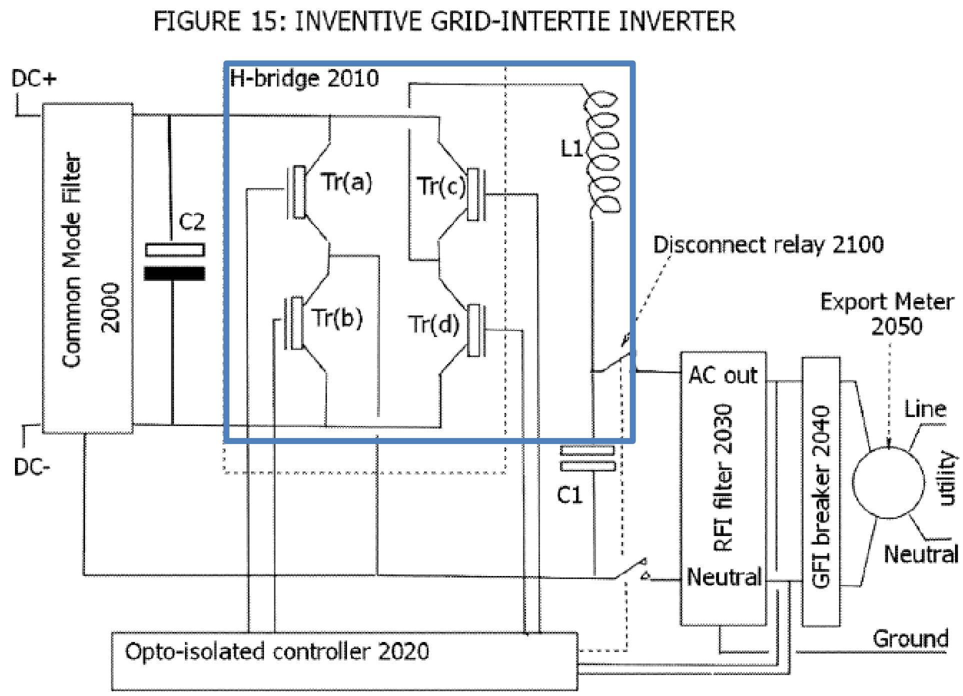
Schmidt's "solar generator SG is connected as the DC voltage source" with positive and negative terminals connected respectively to positive and negative DC input terminals (1 and 2) of the DC-AC converter. Ex. 1103, 1:11-15, 2:40-60, 5:48-51, Figs. 1-2; Ex. 1102, ¶ 221.



Ex. 1103, Fig. 2 (annotated)

Schmidt's DC power source is floating because (as described in the '822 patent) neither terminal is permanently connected to neutral line. 4. Ex. 1101, 23:37-42, Fig. 15; Ex. 1102, ¶ 222; *see also* Ex. 1113, Figs. 1, 5, ¶ [0016].

The structure of Schmidt's DC/AC converter in Figure 2 is identical or equivalent to the structure disclosed in the '822 patent for the "DC-AC converter" of claim 1. Ex. 1102, ¶¶ 223-230. Both inverters have a set of four MOSFET switches (A/C/B/D and Tr(a)/Tr(b)/Tr(c)/Tr(d)) in an H-bridge configuration and inductor smoothing of the output. *Compare* Ex. 1101, Fig. 15 (below), 23:37-44, 24:18-22, 29:4-6 *with* Ex. 1103, 2:40-3:18, Fig. 2; Ex. 1102, ¶¶ 223-228; *see also* Ex. 1113, Fig. 1, ¶ [0004]; Ex. 1114, ¶¶ [0004]-[0007], Fig. 2.



Ex. 1101, Fig. 15 (annotated)

Schmidt's Figure 1 embodiment is also equivalent, because though it includes additional switches E and F, these switches avoid "jumps in high-frequency voltage" but do not otherwise change the performance by switches H-bridge switches of the functions of elements [1E] and [1F] below. Ex. 1102, ¶ 229; Ex. 1103, Fig. 6, 7:46-55, 9:14-21, 9:34-38, 9:56-62; Ex. 1145 (certified translation of Ex. 1155) at 9-11; *Odetics, Inc. v. Storage Technology Corp.*, 185 F.3d 1259, 1267-68 (Fed. Cir. 1999) (a component-by-component correspondence not required for equivalence). Similarly, Schmidt's use of series connected two smoothing inductors (rather than one) and recovery diodes do not create a substantial difference between the two structures and are unnecessary to perform the claimed function. Ex. 1102, ¶¶ 223-

230. Thus, the differences between the ’822 patent’s DC-AC converter structures and Schmidt’s DC/AC converter structure in Figures 1 and 2 are insubstantial as Schmidt’s DC/AC converters are similarly controlled to produce the AC output waveform from a floating DC input. *Id*. Schmidt’s DC/AC converter also performs the same function (converting power from a floating DC source to AC power) in the same way (switching a single H-bridge) for the same result (an AC output waveform and a common-mode waveform at the DC inputs, *see* Sections V.A.1.d-V.A.1.e, *infra*). Ex. 1102, ¶¶ 225-229.

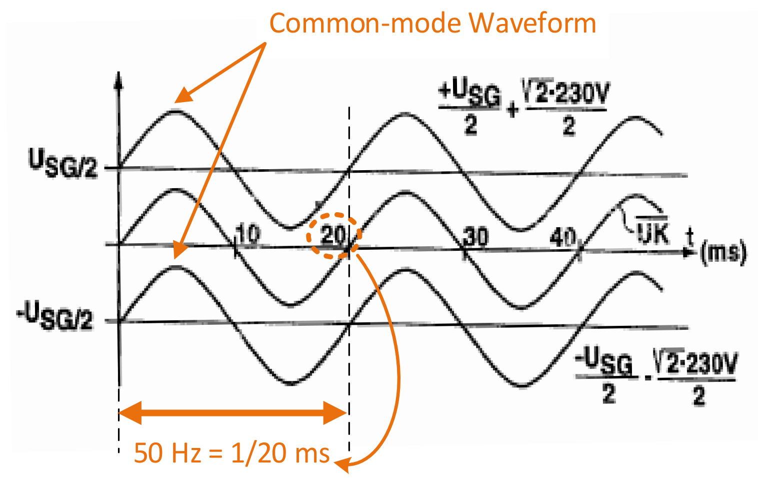
d. [1E]: “wherein the DC to AC converter causes: (1) an AC output waveform at said first repetition frequency and having a voltage relative to one of said at least one ground, neutral or reference potential terminals to appear with a unique phase at each of a number N at least equal to one of said set of live AC output terminals”

Schmidt’s DC/AC converter has only one AC output terminal 3 (*i.e.*, “N” is 1) on which the converter produces one unique phase of a 50 Hz sine-shaped AC output waveform (U_{Netz}) relative to neutral terminal 4 (the claimed “AC output waveform at said first repetition frequency and having a voltage relative to one of said at least one ground, neutral or reference potential terminals to appear with a unique phase”). Ex. 1103, 1:17-27, 2:40-3:18, 5:48-51, Figs. 1, 2, 6; Ex. 1102, ¶¶ 231-233.

e. [1F]: "[wherein the DC to AC converter causes:] (2) a common-mode voltage waveform at a second repetition frequency to appear relative to one of said at least one ground, neutral or reference potential terminals and in the same phase on both of said positive and negative terminals of said DC power source, wherein the second repetition frequency is a multiple equal to the same said number N of said first repetition frequency."

Schmidt teaches three different switching patterns that create the claimed common-mode voltage—"symmetrical timing" (also called bipolar switching) "unsymmetrical timing" (also called unipolar switching), and "single-phase chopping"—each of which periodically alternate connecting the positive and negative terminals of the DC source to the grid neutral via switches C and D, causing the voltages at the DC terminals to fluctuate together with respect to the neutral. Ex. 1103, Figs. 3-6, 4:5-10, 5:15-20, 5:48-55, 9:14-62; Ex. 1102, ¶¶ 170-183, 234-236.

As shown below, the symmetrical and unsymmetrical timing causes "time-synchronized" waveforms "fluctuating with a low-frequency of 50 Hz" (which is the same as the output frequency) to appear respectively on the DC power source terminals (U_{SG+}, U_{SG-}), and these waveforms are symmetrically centered at +/- $U_{SG}/2$ volts relative to the neutral grid output terminal (the claimed "common-voltage waveform at a second repetition frequency [] relative to one of said at least one ground, neutral or reference potential terminals and in the same phase on both of said positive and negative terminals of said DC power source, wherein the second repetition frequency is a multiple equal to the same said number N of said first repetition frequency," consistent with the claimed "N" equal to 1). Ex. 1102, ¶¶ 172, 236-238; Ex. 1103, 1:17-21, 2:40-60, 3:5-18, 3:50-4:10, 5:15-20, 5:48-55, 9:56-62.



Ex. 1103, Fig. 6 (annotated)

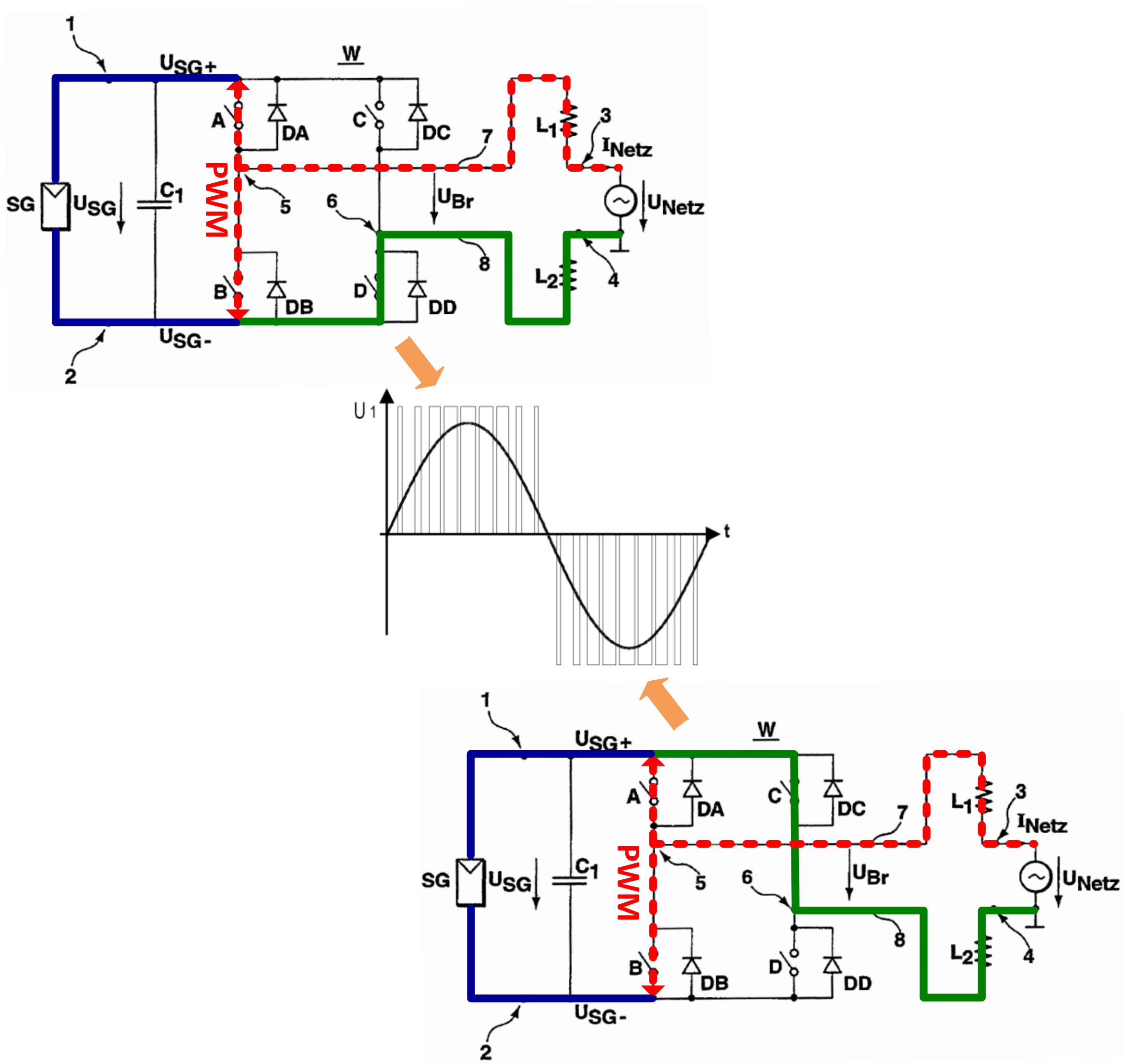
Single-phase chopping also causes common-mode voltages, but as a 50 or 60 Hz square wave. Ex. 1102, ¶¶ 172, 237-238; Ex. 1145, pp. 9-11; Ex. 1103, 5:35-55; Ex. 1115, p. 3121, Fig. 5; Ex. 1116 (certified translation of Ex. 1146), p. 32.

Such generation of common-mode waveforms at the DC inputs of these H-bridge inverter circuits was well known, as shown in Schmidt and in other publications by Schmidt's inventors and others describing the operation of these type of circuits. Ex. 1102, ¶¶ 239-244; Ex. 1113, Figs. 1 (depicting an identical circuit), 5 (depicting a common-mode voltage waveform), ¶¶ [0004], [0016] ("FIG. 5 shows the voltage of the solar generator to ground in the single-phase transformerless DC/AC converters described based on FIGS. 1, 3 and 4."); *see* Ex. 1114, Fig. 2 (depicting Schmidt's Figure 2 in Schmidt's German equivalent); Ex. 1115, p. 3121, Figs. 4-5, 10; Ex. 1145, pp. 9-11; *Realtime Data, LLC v. Iancu*, 912 F.3d 1368, 1372-73 (Fed. Cir. 2019) (second references may be used to understand primary reference without a motivation to combine).

2. Claim 2

> **"The apparatus of claim 1 wherein said DC to AC converter further comprises: A first electronic switch controlled by a switching controller to connect said positive DC input terminal to the instantaneously most positive of said set of AC output terminals and said at least one ground, neutral or reference potential terminal alternating with connecting said negative DC input terminal to the instantaneously most negative of said set of AC output terminals and said at least one ground, neutral or reference potential terminal"**

To generate its AC output sine wave, Schmidt describes controlling the H-bridge circuit ("first electronic switch") using "single-phase chopping" in which "a bridge branch, for example the switches C, D, is only switched periodically with grid frequency (50 or 60 Hz), whereas the other bridge branch is timed sine-modulated (PWM) with a high frequency." Ex. 1103, 2:61-67, 3:5-21, 5:35-51; *compare with* Ex. 1101, 23:65-24:8; Ex. 1102, ¶¶ 245-247; *see* Sections V.A.1.a, V.A.1.b, *supra*. This switching is illustrated below, in which the top and bottom figures are Schmidt's Figure 2 annotated to respectively show the switch states during the positive and negative halves of the sine wave, and the middle figure is a diagram reproduced from the Myzrik dissertation referenced in Schmidt for showing the inverter output before (pulse waves U_{Br}) and after (sine wave U_{Netz}) filtering by the output inductors. Ex. 1103, 5:35-55; Ex. 1116, pp. 31-32; Ex. 1102, ¶¶ 248-250, 255-256.



Ex. 1103, Fig. 2 (annotated); Ex. 1116, Fig. 2.15a

In the top figure, switch D is closed, connecting negative DC input terminal 2 to neutral terminal 4 (**green**), while switches A and B are alternatively switched at a high frequency to modulate (**red**) AC output terminal 3 between the positive and negative DC input terminals, producing a pre-filtered pulse train between 0 and $+U_{SG}$

(U1 in the Myzrik diagram), which after filtering produces the positive half of the output sine wave. Ex. 1103, Figs. 4a-d. 2, 5:35-51; Ex. 1116, pp. 31-32, Fig. 2.15a; Ex. 1102, ¶¶ 248-250, 255-256.

In the bottom figure, switch C is closed, connecting positive DC input terminal 1 to neutral terminal 4 (**green**), while switches A and B modulate (**red**) AC output terminal 3 between the positive and negative DC input terminals, producing a pre-filtered pulse train between 0 and $-U_{SG}$, which after filtering produces the negative half of the output sine wave. Ex. 1103, Figs. 2, 4a-d, 5:35-51; Ex. 1116, pp. 31-32, Fig. 2.15a; Ex. 1102, ¶¶ 250-252, 255-256.

During the positive half-cycle, neutral terminal 4 is the "most negative" output terminal—thus, statically connecting it to the negative DC terminal satisfies "connecting said negative DC input terminal to the instantaneously most negative of said set of AC output terminals and said at least one ground, neutral or reference potential terminal." Ex. 1102, ¶¶ 253-254, 257. During the negative half-cycle, neutral terminal 4 is the "most positive" output terminal—thus, statically connecting it to the positive DC input terminal during the negative half-cycle satisfies "alternating with connecting said negative DC input terminal to the instantaneously most negative of said set of AC output terminals and said at least one ground, neutral or reference potential terminal." *Id.*

Schmidt discloses a switching controller, such as the pulse width modulator of switches A-D and control unit 13, which may be "an additional unit within an inverter [or] an add-on of the conventional control unit" for switches E and F, and "other elements shown in the disclosed converter circuit" (*e.g.*, switches A-D). Ex. 1103, 7:53-67, 10:32-34, 10:52-54, 12:35, Fig. 1; Ex. 1102, ¶ 258. To the extent Patent Owner argues Schmidt does not disclose the claimed switching controller for operating the H-bridge using single-phase chopping, a PHOSITA would have understood that a switching controller was present to operate the Schmidt's switches, and it would also have been obvious and trivial for a PHOSITA to operate Schmidt's H-bridge with single-phase chopping using Schmidt's pulse width modulator or control unit 13 because only simple changes to adjust the pulse timing would have been required, which was well within the ordinary skill in the art. Ex. 1102, ¶¶ 258-259; *see* Ex. 1104 (certified translation of Ex. 1120), Fig. 4, ¶¶ [0015]-[0019] (CPU 10 and PLD 11 controlling H-bridge switches); Ex. 1112, pp. 703-707, Figs. 28-8, 28-10; Ex. 1111, Abstract, 3:53-67, 4:1-28, 4:36-46, Fig. 2 (control circuit 16); *Bos. Sci. Scimed, Inc. v. Cordis Corp.*, 554 F.3d 982, 991 (Fed. Cir. 2009) ("Combining...embodiments disclosed adjacent to each other in a prior art patent does not require a leap of inventiveness.").

To the extent "switching controller" is a means-plus-function term, Schmidt's control unit may be a digital signal processor (DSP), which a PHOSITA would understand to include a "microcontroller" and "memory," the same structure as the "switching controller" described in the '822 patent. Ex. 1103, 7:62-64; Ex. 1101, 12:26-51, 24:8-12; Ex. 1102, ¶ 260. Any differences between the '822 patent's "switching controller" structures and Schmidt's control unit structure are insubstantial. Ex. 1102, ¶ 260. Further, a component-by-component correspondence is not required for equivalence. *Odetics,* 185 F.3d at 1267-68. Schmidt's controller performs the same functions (as in claim 2) in the same way (controlling half-bridge switches using drive signals) for the same result (periodically connecting the different DC input terminals to the instantaneously most positive and negative of the AC output terminals and neutral). Ex. 1102, ¶¶ 260-261.

3. Independent Claim 8

a. [8A]: "A method of converting power from a direct current source with improved efficiency to provide AC output power at a standard voltage and frequency and to a number of output terminals corresponding to the number of phases required, comprising:"

To the extent the preamble is limiting, Schmidt discloses it. Schmidt describes a "DC/AC converter" that converts power from a DC source ("solar generator," SG) into a "conventional" single-phase 50/60 Hz sine-shaped grid voltage U_{Netz} (*e.g.*, 230V public electricity grid voltage) on output terminal 3 relative to grid neutral terminal 4 (the claimed "converting power from a direct current source … to provide AC output power at a standard voltage and frequency and to a number of output terminals corresponding to the number of phases required”). *See* Section V.A.1.a, *supra*; Ex. 1103, 1:17-27, 2:40-66, 3:5-18, 9:56-62, 16:3-18, 16:32-33, Figs. 2, 6; Ex. 1102, ¶¶ 266-268. Schmidt’s converter has “high conversion efficiency and low volume and weight” (the claimed “improved efficiency”) compared to other converters (*e.g.*, buck-boost converters). Ex. 1103, 1:50-2:19; Ex. 1102, ¶ 267.

b. [8B]: “configuring said direct current source to be floating”

As explained, Schmidt’s solar generator SG is a floating DC power source just as in the ’822 Patent as neither terminal is permanently connected to ground or the neutral line. *See* Section V.A.1.c, *supra*; Ex. 1103, 2:40-60, 5:48-51; Ex. 1101, 23:37-42, Fig. 15; Ex. 1113, ¶ [0016]; Ex. 1102, ¶¶ 221-222, 269-270.

c. [8C]: “connecting the negative line from said direct current source to a first output terminal required to be instantaneously negative relative to all other output terminals

while deriving from the direct current source positive voltage line the instantaneous voltages required to be output from the other output terminals relative to said first terminal,

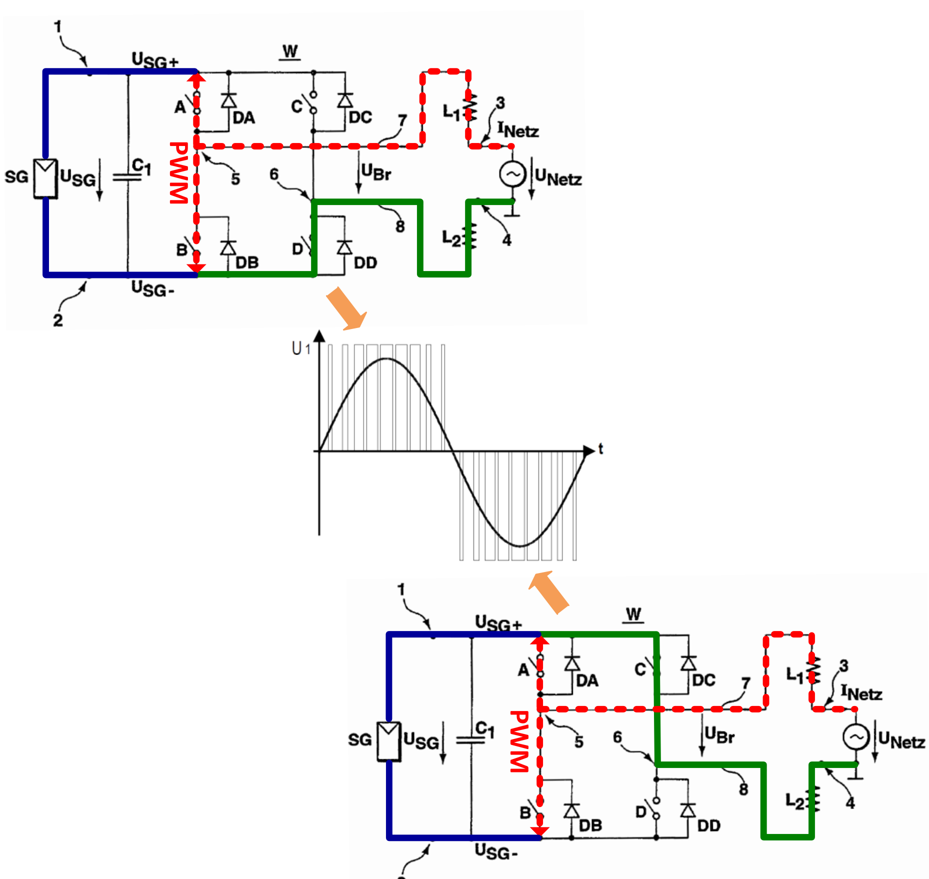
in a rotating sequence with connecting the positive line from said direct current source to a next-in-sequence output terminal required to be instantaneously positive relative to all other output terminals

while deriving from the negative line of the direct current source the instantaneous voltages relative to said next-in-sequence terminal required to be output from the other terminals”

As discussed, Schmidt’s converter has positive and negative DC source terminals, a live AC output terminal, and a neutral terminal connected to ground. *See*

Section V.A.1.c-V.A.1.d, *supra*; Ex. 1103, 2:61-67, 3:5-18, 5:48-51, Fig. 2; Ex. 1102, ¶¶ 217-222, 271. As also explained (and shown below), Schmidt describes "single-phase chopping." *See* Section V.A.2, *supra*; Ex. 1103, 5:35-55; Ex. 1116, pp. 31-32, Fig. 2.15a; Ex. 1102, ¶¶ 247, 255, 271.

During the positive half of the sine wave (top left), the negative DC input terminal (**green**) is connected to the neutral output terminal (the "first output terminal") through switch D, which is "instantaneously negative relative to all other output terminals [the output terminal 3 (**red**)]." Ex. 1103, Fig. 2, 5:35-51; Ex. 1116, pp.31-32, Fig. 2.15a; Ex. 1102, ¶¶ 248-250, 255-256, 272-273.



Ex. 1103, Fig. 2 (annotated); Ex. 1116, Fig. 2.15a

During the negative half of sine wave (bottom left) (*i.e.*, “in a rotating sequence”), the positive DC input terminal is connected to the ground output terminal (**green**) through switch C, which is the “next-in-sequence output terminal required to be instantaneously positive relative to all other output terminals.” Ex. 1103, Fig. 2,4a-d, 5:35-51; Ex. 1116, pp. 31-32, Fig. 2.15a; Ex. 1102, ¶¶ 249-250, 255-256, 274-275.

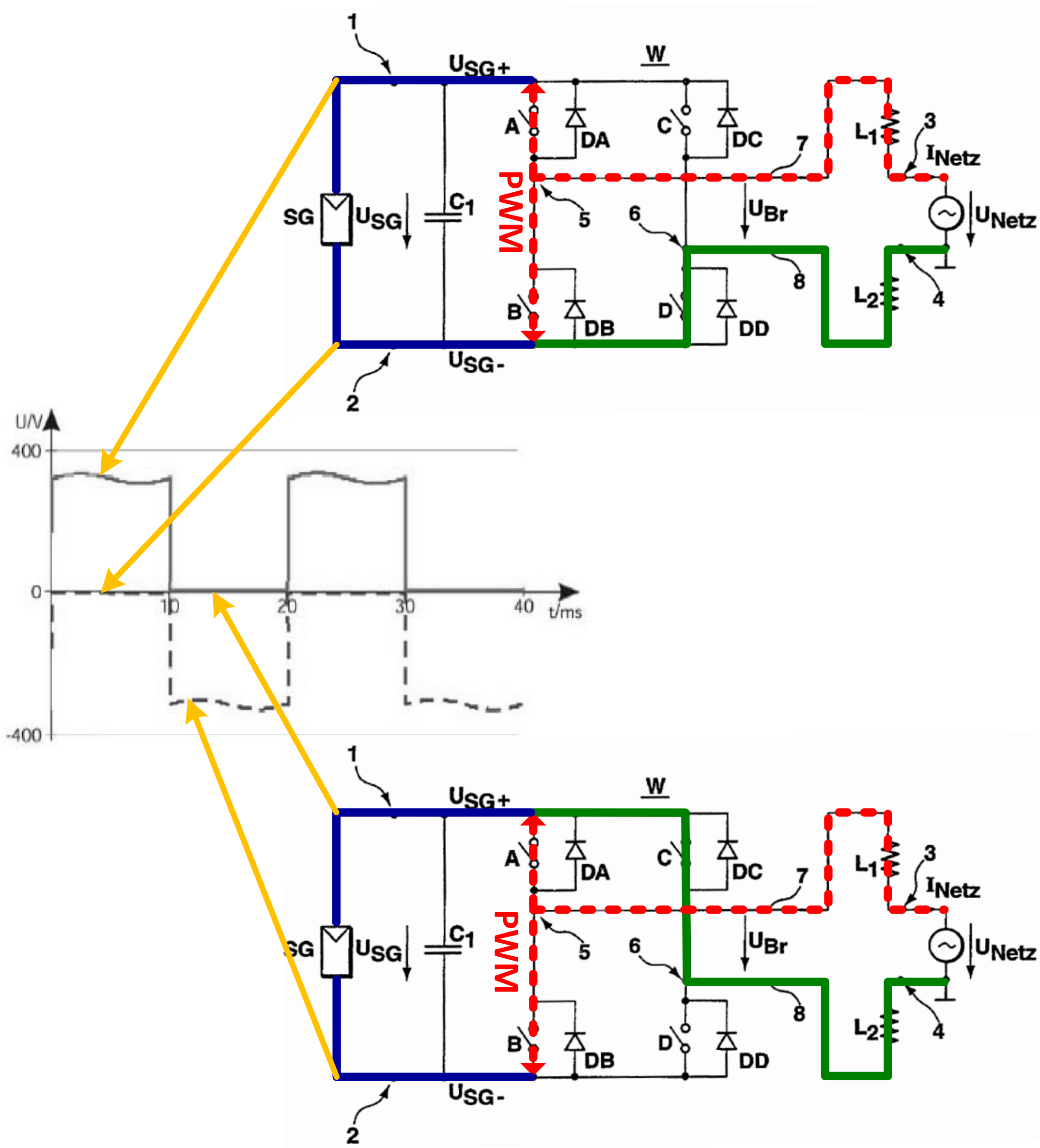
As explained, during both halves of the sine wave, switches A and B pulse width modulate to generate (after filtering) the positive sine wave voltage (the claimed “deriving from the direct current source [positive/negative] voltage line the instantaneous voltages required to be output from the other output terminals”). *See* Section V.A.2, supra; Ex. 1103, 1:33-36, 1:60-63, 5:35-55, Figs. 2, 4a-d; Ex. 1102, ¶¶ 276-277; Ex. 1116, pp. 31-32, Figs. 2-15.

This is no different than the description of the claimed switching in the ’822 patent. Ex. 1101, 23:65-24:15; Ex. 1102, ¶ 273.

d. [8D]: “selecting the timing of said rotating sequence such that a common mode waveform with a characteristic repetition frequency appears in phase on both the direct current source positive and negative lines.”

As described, Schmidt discloses its DC-AC converter causing a common-mode voltage waveform as recited in element [8D]. *See* Sections V.A.1.e, V.A.3.c, *supra*; Ex. 1103, 1:17-21, 2:40-60, 3:5-18, 5:7-20, 5:48-55, 9:56-62, Fig. 6; Ex. 1113, ¶ [0016]; Ex. 1102, ¶ 278. For single-phase chopping, Schmidt’s inverter periodically alternates connecting the positive or the negative terminal of the solar generator to the grid's neutral conductor with the grid frequency (50 or 60 Hz) so that "the potential of the solar generator leaps periodically by the level of the solar generator." *See* Sections V.A.1.e, V.A.3.c, *supra*; Ex. 1103, 5:35-55; Ex. 1145, pp. 9-11; Ex. 1115, pp. 3121, Fig. 5; Ex. 1102, ¶¶ 174-176, 238, 279.

The potentials of the solar generator sources lines are shown below in a diagram (middle figure) reproduced from a paper by the Schmidt inventors and published in 2007, along with Schmidt's Figure 2 as previously annotated to show the switch states respectively during the positive and negative halves of the sine wave. Ex. 1145, pp. 10-11 (Figure 13); Ex. 1164, 307-310; Ex. 1165, 323-337; Ex. 1103, Fig. 2; Ex. 1102, ¶ 280.



Ex. 1145 at 11 (Figure 13); Ex. 1103, Fig. 2 (annotated)

During the positive half of the sine wave (upper figure), the negative DC source line is connected to neutral terminal 4 (**green**), which corresponds to the voltage on the negative DC source line (middle figure, dashed curve) equaling 0 volts between 0 and 10ms, and during the negative half of the sign wave (lower figure), the positive DC source line is connected to neutral terminal 4 (**green**), which corresponds to the voltage on the positive DC source line (middle figure, solid curve) equaling 0 volts between 10 and 20 ms. Ex. 1145, pp. 10-11 (Figure 13); Ex. 1103, 5:35-55; Ex. 1102, ¶¶ 281-282. The DC source lines not connected to neutral terminal are offset by the U_{SG} volts output by the DC source, resulting in an in-phase 50 or 60 Hz square wave on both DC source lines, which a PHOSITA would understand to be the claimed "selecting the timing of said rotating sequence such that a common-mode waveform with a characteristic repetition frequency appears in phase on both the direct current source positive and negative lines." Ex. 1145, pp. 10-11 (Figure 13); Ex. 1103, 5:35-55; Ex. 1102, ¶¶ 281-286; *see also* Ex. 1115, pp. 3121, 3124, Figs. 4-5, 10; Ex. 1143 at 4; Ex. 1142 at 4; Ex. 1136 at 4.

4. Claims 3 and 9

[3]: "The DC to AC conversion apparatus of claim 1 wherein said second repetition frequency is a multiple equal to the same said number N of said first repetition frequency and said number N is equal to 1, 2 or 3."

[9]: "The method of claim 8 in which said characteristic frequency is a multiple of 1, 2 or 3 times the AC output power frequency."

Schmidt's inverter has one live AC output terminal, so "N" is 1, and Schmidt's common-mode voltage waveform (depicted in Figure 6) has a repetition frequency (the "second repetition frequency" of claim 3 and "characteristic frequency" of claim 9) equal to (a "multiple" of 1) its AC output's frequency (the claimed "first repetition frequency" of claim 3 and "AC output power frequency" of claim 9). *See* Sections V.A.1.b, V.A.1.d-V.A.1.e, *supra*; Ex. 1102, ¶¶ 262-265, 287-290; Ex. 1103, 1:17-

21, 2:40-60, 3:5-18, 4:4-10, 5:48-51, 9:14-62, Fig. 6; Ex. 1113, Figs. 1, 5, ¶¶ [0004], [0016]; Ex. 1114, Fig. 2.

5. Claim 10

"The method of claim 8 in which said step of deriving instantaneous voltages from the direct current source positive line or negative line comprises using one of . . . (b) a pulse-width modulator."

As discussed with respect to claim 8, to derive the instantaneous voltages from the DC source positive and negative lines using single-phase chopping, Schmidt's inverter pulse width modulates switches A and B at a high frequency, thus operating as a "pulse-width modulator" of claim 10. *See* Sections V.A.2 (claim 2), V.A.3.c ([8C]), *supra*; Ex. 1103, 3:32, 5:35-47 ("sine-modulated (PWM)"), 7:53-67, 10:53-54 ("pulse-width-modulator (PWM)" controlling switches A-D); Ex. 1116, pp. 31-32; Ex. 1112, pp. 216-217, 219; Ex. 1102, ¶¶ 291-295.

B. Ground 3: Schmidt in View of Suzui Renders Claims 4 and 11 Obvious

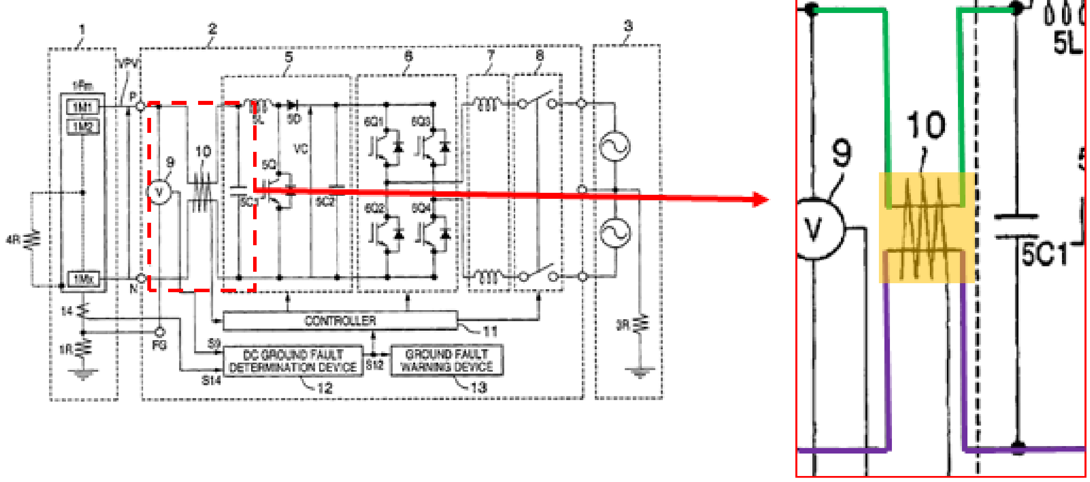
1. Dependent Claims 4 and 11

[4]: "The apparatus of claim 1 further comprising an AC ground leak detector inserted in the positive and negative conductors between said DC source and said DC to AC converter, the AC ground leak detector being adapted to detect an imbalance current at said second frequency and to thereby provide a detection signal indicative of an unwanted leakage impedance from a DC conductor to ground."

[11]: "The method of claim 8 in which an unwanted leakage impedance to ground from a line of either polarity of said direct current source is detected by detecting a common-mode current with said common mode waveform at said characteristic repetition frequency."

Suzui discloses these claims. Ex. 1102, ¶¶ 296-309. As shown below, Suzui teaches current detector 10 (**orange**) (claimed "AC ground leak detector") inserted in a positive conductor (**green**) and a negative conductor (**purple**) between Suzui's solar battery 1 and converter circuit 5 of Suzui's inverter 2 (claimed "detector inserted in the positive and negative conductors between said DC source and said DC to AC converter" in claim 4). Ex. 1106, Fig. 9B, 1:56-61, 5:47-51; Ex. 1102, ¶¶ 297, 306.

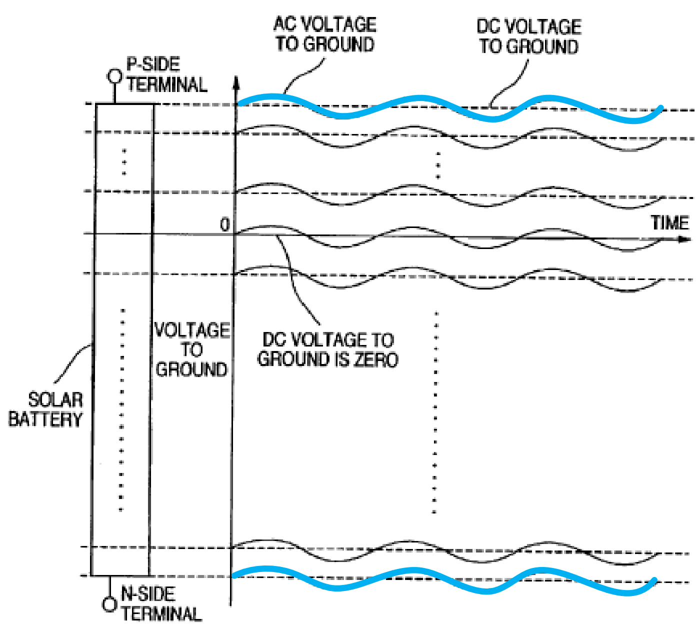
FIG. 2



Ex. 1106, Fig. 2 (annotated)

A PHOSITA would have recognized that detector 10 is a current transformer, which is the same or insubstantially different structure for the toroidal winding detector disclosed in the '822 patent. Ex. 1101, 31:65-32:20, 35:66-36:3, Fig. 18; Ex. 1102, ¶ 301. Suzui's detector performs the same function (detecting a zero-phase or common-mode current) in the same way (by the positive and negative DC input lines passing through a toroid) for the same result (outputting a ground fault signal). Ex. 1102, ¶ 301.

Suzui's detection scheme is applicable to transformerless inverters, such as the one disclosed in Schmidt, which generates a common-mode AC waveform (**blue**) on the inverter's positive and negative input terminals matching the inverter's output frequency (claim 4's "second frequency" and claim 11's "characteristic repetition frequency"). Ex. 1106, 1:41-43, 1:56-62, 3:26-30, 4:28-40, 5:47-51, 6:58-64, 7:54-60, 9:28-33, 10:33-39, 11:31-37, 13:13-16, 13:47-50; Ex. 1102, ¶¶ 298, 306.



Ex. 1106, Fig 10 (annotated)

In the event of a DC ground fault (an "unwanted leakage impedance"), the common-mode AC voltage generated by the inverter causes an imbalance current (*i.e.*, zero-phase or common-mode current)—at the same frequency as the common-mode AC voltage—to flow on the DC input terminals, which is detected by current detector 10. Ex. 1106, 1:34-38, 1:56-61, 4:28-36, 5:47-51; Ex. 1102, ¶¶ 299, 307. Suzui thus discloses both claim 4's "detector being adapted to detect an imbalance current at the said second frequency," and claim 11's "detecting a common-mode current with said common-mode waveform at said characteristic repetition frequency." *Id*.

After detecting a current in the DC conductors that satisfies a predetermined threshold value, Suzui's current detector 10 outputs a ground fault signal [S10] (the claimed "provide a detection signal indicative of an unwanted leakage impedance from a DC conductor to ground"), causing the inverter to disconnect from commercial system 3. Ex. 1106, 5:47-62, Fig. 2; Ex. 1102, ¶ 300.

A PHOSITA would have been motivated to modify Schmidt's DC/AC converter to detect a DC ground fault current and disconnect from the commercial power system (*e.g.*, grid) as taught by Suzui to prevent shock hazards and comply with government safety standards, such as the 2008 National Electric Code. Ex. 1106, 1:34-38, 1:56-61, 5:47-51, 9:52-56; Ex. 1119, pp. 7-9, 18-21; Ex. 1124, ¶¶ [0039], [0048], [0050]; Ex. 1102, ¶¶ 301, 308. Since Suzui's detector is specific to transformerless inverters with common-mode input voltage, such as Schmidt's inverter, such a modification would have been no more than applying a known technique (Suzui's ground fault detection) to improve a similar device (Schmidt's transformerless inverter generating a common-mode AC input voltage) in the same way (detecting a common-mode current at the DC inputs of Schmidt's inverter). Ex. 1102, ¶¶ 302, 308.

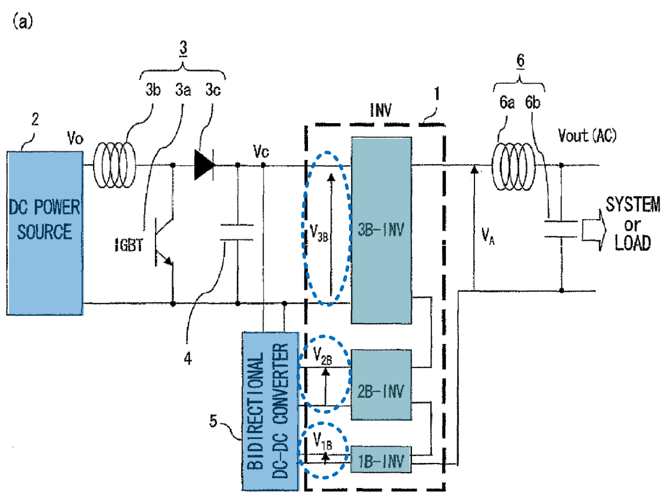
A PHOSITA would have easily made the combination, yielding the predictable and reasonably expected result. *Id.* at ¶¶ 303, 308. While Suzui discusses specific embodiments of detecting a DC ground fault for a 120-Hz component (twice the commercial frequency 60 Hz), a PHOSITA would have understood that a ground fault could also be detected based on any desired frequency, such as the 50 or 60 Hz common-mode frequency of Schmidt's inverter. *Id*. This would have been a routine matter of routing the positive and negative conductors connected to the DC/AC converter through the current detector and configuring Schmidt's switch controller (*e.g.*, control unit 13 or Schmidt's pulse width modulator) to receive ground fault signals from the current detector.

C. Ground 4: Schmidt in View of Iwata and Nishimura Renders Claims 5, 12, and 13 Obvious

1. A PHOSITA Would Have Been Motivated to Combine Schmidt with Iwata and Nishimura

Schmidt describes a single-phase, single H-bridge DC-AC converter that discloses all elements of claims 1 and 8. Claims 5, 12, and 13 add additional requirements to claims 1 and 8 not expressly described in Schmidt, including a bidirectional DC-to-DC converter generating floating supplies with a specific voltage ratio, multiple H-bridge switches connected in series, and expressing a desired voltage with a ternary number system. While Schmidt does not expressly describe these elements, Iwata and Nishimura do.

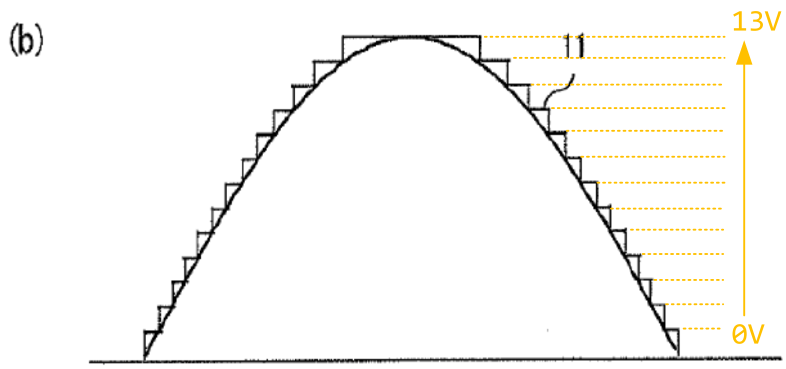
Iwata discloses bidirectional DC-to-DC converter 5 that converts input voltage V_{3B} from DC power source 2 to several floating supplies of voltage V_{1B} and V_{2B} with voltages at successive powers of 3 as inputs to three H-bridge switch inverters (3B-INV, 2B-INV, and 1B-INV) that are connected in series. Ex. 1107, ¶¶ [0003], [0007]-[0009], [0045], [0049] ("[T]he relation between V_{1B}, V_{2B}, and V_{3B} is 1:3:9."), Fig. 1(b); Ex. 1102, ¶¶ 310-312.



Ex. 1107, Fig. 1a (annotated)

Nishimura provides a specific structure for the bidirectional DC-DC converter in the '822 patent identical to the structure to '822 patent Figure 2. Ex. 1108, ¶¶ [0091]-[0101], Fig. 4; Ex. 1101, 18:34-47, Fig. 2; Ex. 1102, ¶ 317.

Iwata's three inverters operate to generate a sine wave-like output shown in Figure 2(b) according to a sampled numerical representation (V_A) of the desired AC output waveform, which as shown in Figure 2(a), is expressed in ternary number base with digits (V_{1B}, V_{2B}, and V_{3B}). Ex. 1107, ¶ [0050]; Ex. 1102, ¶¶ 313-314.



"Output DC Voltages"

(a)

"Ternary States"

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

Ex. 1107, Figs. 2b (annotated top), 2a (annotated bottom)

Each ternary digit determines the output state of each respective H-bridge: (a) first polarity (+1), (b) inverse polarity (-1), and (c) pass-through (0). Ex. 1107, ¶

[0050] ("1 represents generation of a positive voltage, -1 represents generation of a negative voltage, and 0 represents generation of zero voltage."). Output waveform (V_A) is the sum of the three inverter outputs at any given moment. Ex. 1107, ¶¶ [007]-[009], [0047]-[0053]; Ex. 1102, ¶ 315.

A PHOSITA would have been motivated to arrange three of Schmidt's H-bridge converters in the same manner as Iwata's H-bridge switches, controlling them with Iwata's switch timing, and using Iwata's bidirectional DC-DC converter (using a structure like Nishimura's bidirectional DC-DC converter) to produce additional floating voltage sources. Ex. 1102, ¶ 318. As Iwata explains, using "plural single-phase inverters . . . connected in series" instead of a conventional power conditioner's single, four switch inverter (like Schmidt) enables "gradational output voltage control," producing smaller voltage steps requiring less output filtering and improving approximation of a sine wave, and reducing power loss and increases efficiency. Ex. 1107, ¶¶ [0005]-[0006], [0009]-[0010], [0055]-[0056]; *see also* Ex. 1104, ¶ [0012]; Ex. 1102, ¶ 318. Further, Iwata's bidirectional DC-DC converter beneficially "keeps the voltage ratio of the DC power sources V1B, V2B, and V3B of the inverters at a constant value and also allows them to supply excess energy to compensate for insufficiency among them." Ex. 1107, ¶ [0077]; Ex. 1102, ¶ 319.

This combination amounts to combining prior art elements according to known methods (arranging multiple Schmidt's DC/AC converters in the same manner as Iwata, controlling them using Iwata's switch timing, and using Iwata's bidirectional DC-to-DC converter to supply additional floating voltages) to yield predictable results (an AC output waveform that requires less filtering). Ex. 1102, ¶ 320.

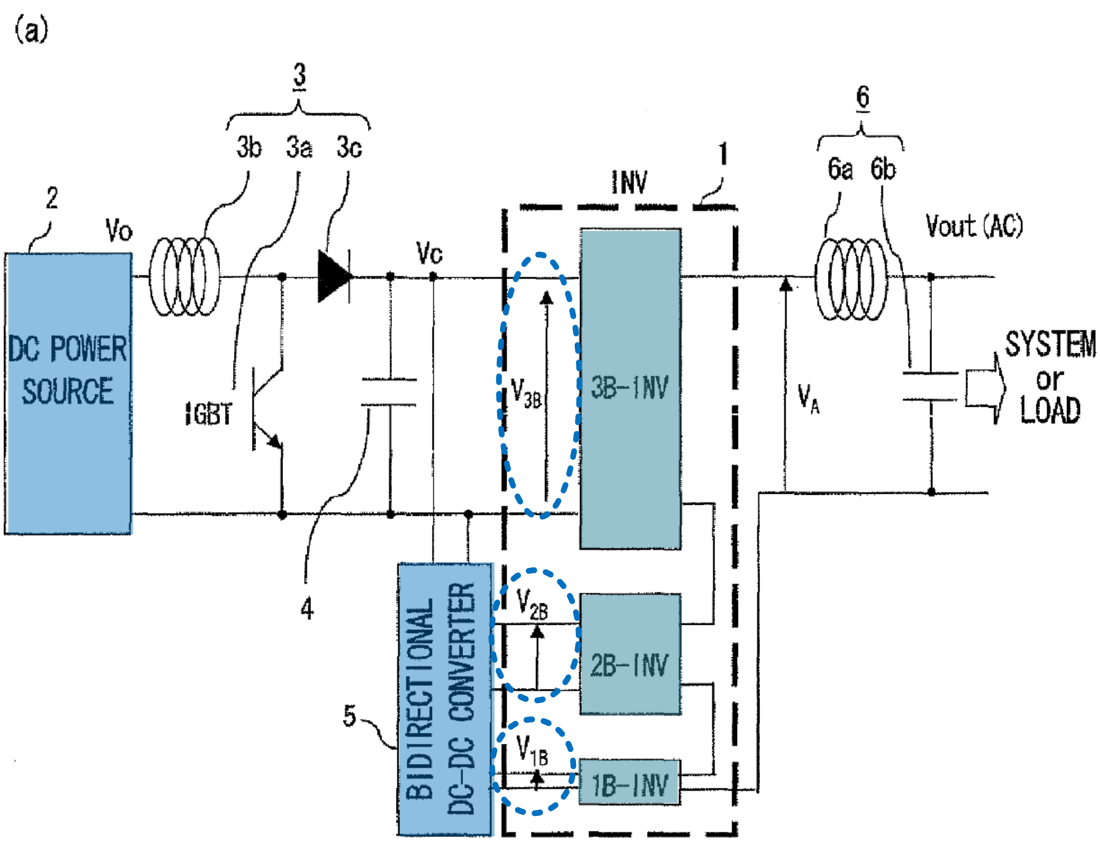
A PHOSITA would also have been motivated to use Nishimura's DC-to-DC converter with Schmidt and Iwata because it performs the bidirectional DC-DC power conversion required in Iwata, and because the split inductor coupling in this design requires only two transistors for each coil (*e.g.*, as compared to a full bridge design) and less drive power supplies for powering the control signals of these transistors (reducing size, cost and weight), and the use of the MOSFET transistors (*e.g.*, instead of using diodes as in Figures 2 and 5) improves efficiency of the converter. Ex. 1108, ¶¶ [0098], [0108]-[0109]; Ex. 1102, ¶¶ 316-317, 321. Using Nishimura's DC-DC converter in this manner is a simple substitution of one known (Iwata's bidirectional DC-DC converter) with another known element (Nishimura's DC-DC converter) for a predictable result. Ex. 1102, ¶ 322.

A PHOSITA would have reasonably expected success in combining these elements as the combination merely requires inserting additional components (the additional switches and bidirectional DC-DC converter) and adjusting the switch timing to operate those switches, which was well within the level of ordinary skill in the art. Ex. 1102, ¶ 323.

2. Claim 5

a. [5A]: "The DC to AC conversion apparatus of claim 1 in which said DC to AC converter further comprises: A bidirectional DC-to-DC converter for converting the input voltage from said DC power source to a number of floating supplies of voltages equal to the input voltage divided or multiplied by successive powers of 3"

Iwata discloses bidirectional DC-to-DC converter 5 that converts input voltage V_{3B} from DC power source 2 to floating voltage supplies V_{1B} and V_{2B}, which are equal to the input voltage divided by successive powers of 3. Ex. 1107, ¶ [0049] ("[T]he relation between V_{1B}, V_{2B}, and V_{3B} is 1:3:9."); Ex. 1102, ¶¶ 324-326.

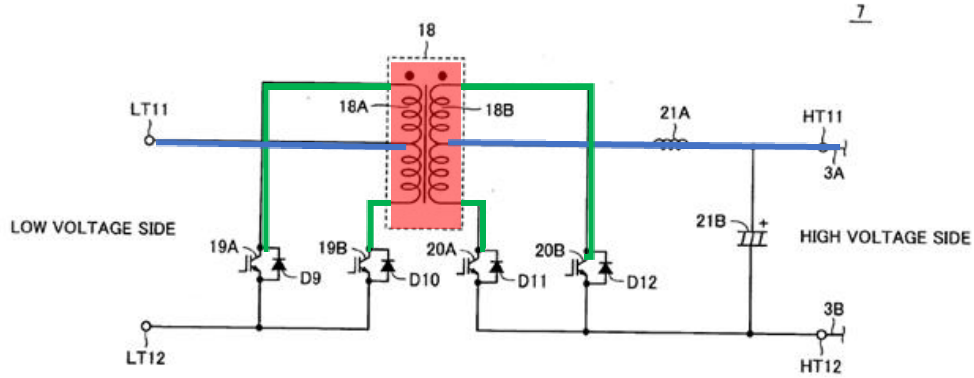


Ex. 1107, Fig. 1a (annotated)

V_{1B}, $V_{2B,}$ and V_{3B} are the DC power source voltage inputs for inverters 1B-INV, 2BINV, and 3B-INV. Ex. 1107, ¶ [0049]. V_{1B}, V_{2B} , and V_{3B} are floating because, like the ’822 Patent, none of these supplies are permanently connected to ground or the neutral line. Ex. 1102, ¶ 326; Ex. 1101, 3:22-24, 6:23-26, 7:8-15, 8:6-14, 23:37-42.

To the extent the claimed “bidirectional DC-DC converter” is found to be a means-plus-function term, Nishimura discloses an identical or equivalent (insubstantially different) structure to ’822 patent Figure 2. Ex. 1102, ¶ 328. As shown below, Nishimura, in Figure 4 (top), depicts a bidirectional converter for a grid connected power supply, which includes with center-tapped windings (**red**) that are connected to the positive terminal of the DC input or output (**blue**) with ends of the windings connected to the drains of N-Type MOSFET pairs (**green**) just like the ’822 patent (bottom). *See id*.

FIG.4



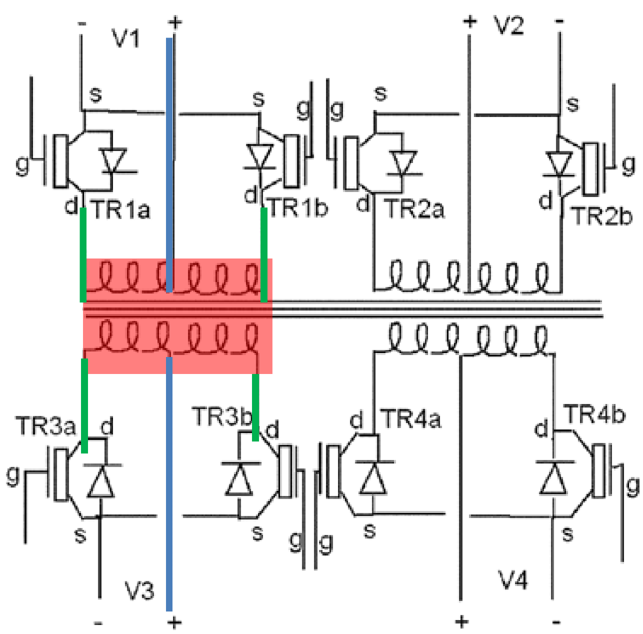


FIGURE 2: BIDIRECTIONAL DC-DC CONVERTER

Ex. 1108, Fig. 4 (annotated, top); Ex. 1101, Fig. 2 (annotated, bottom)

The ’822 patent merely duplicates this structure (either on a common transformer winding as shown in Figure 2, or as multiple individual converter for each output voltage) to enable more than one voltage output (V2, V3, and V4) if the input is V1. Ex. 1101, 18:34-65, 19:8-17; Ex. 1102, ¶ 329.

As explained in Section V.C.1, *supra*, a PHOSITA would have been motivated to arrange three of Schmidt H-bridge DC-to-AC converters in the same manner as Iwata's H-bridge switches and apply Iwata's switch timing with Nishimura's bidirectional DC-DC converter with a reasonable expectation of success. Ex. 1102, ¶¶ 318-323, 327, 330-332.

b. [5B]: "a number of three-state electronic switches each in the form of an H-bridge, each with a pair of input terminals connected to one of the DC power source and said floating voltage supplies from said bidirectional DC to DC converter, and a pair of output terminals, the outputs terminals of said electronic H-bridge switches being directly connected in series and one end of the series connected output terminal pairs being connected to at least one of said set of AC output terminals"

Schmidt discloses a single, three-state H-bridge (with smoothing inductors) (**blue**) with a pair of input terminals (1,2) connected to a floating DC power source (SG) and with AC output terminals (3,4) directly connected to an AC output (U_{Netz}). Ex. 1103, 2:40-66; Ex. 1102, ¶ 333.

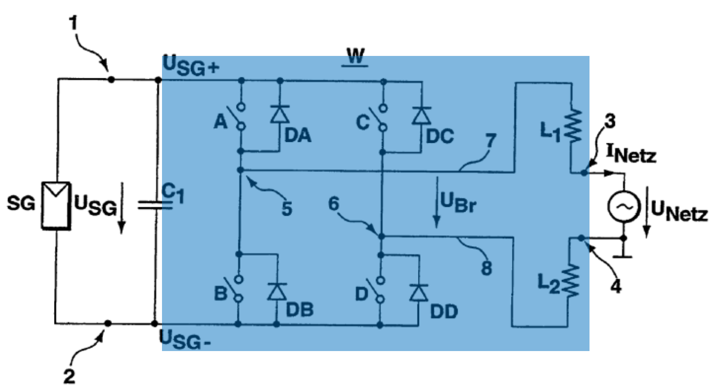
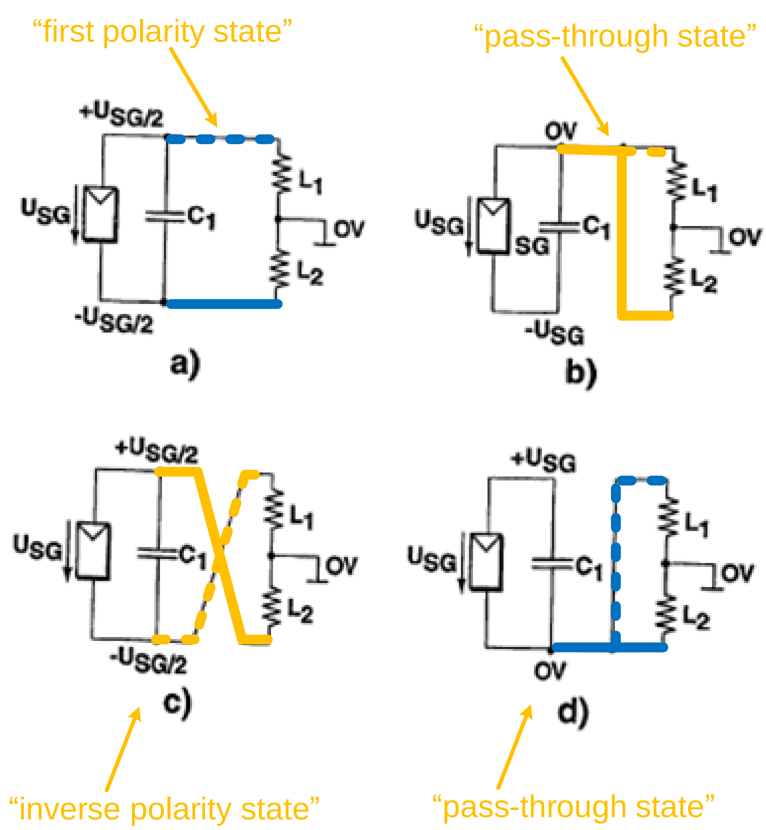


Fig. 2

Ex. 1103, Fig. 2 (annotated)

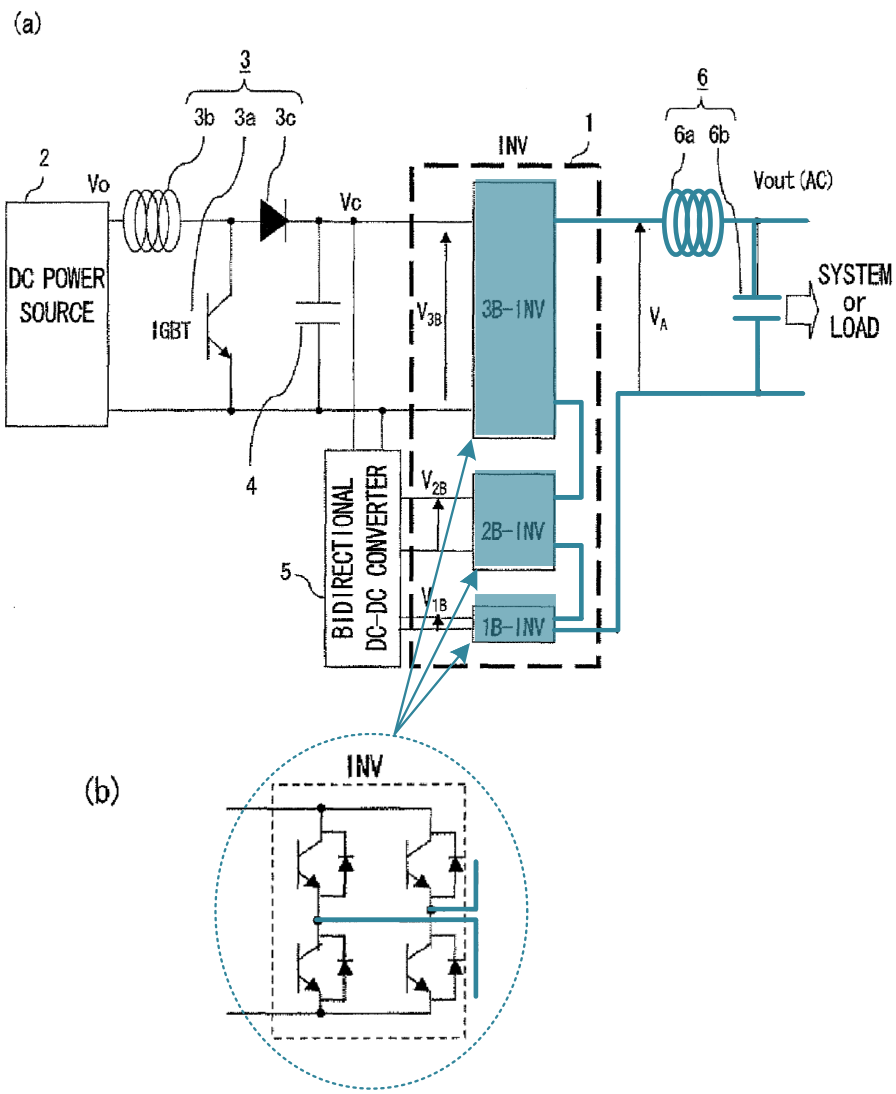
Schmidt's switches have three output states based on four switch states "useful for obtaining an alternating waveform across the load." Ex. 1102, ¶ 334; Ex. 1117 at 311, Fig. 4 (one positive, one negative, and two zero states); Ex. 1112, pp. 215-217. Figure 4 of Schmidt below depicts these states, which includes a first polarity state, an inverse polarity state, and two pass-through states. *See* Ex. 1102, ¶ 334.



Ex. 1103, Fig. 4 (annotated)

But Schmidt does not describe "a number of three-state electronic switches" connected in series with a bidirectional DC to DC converter. But Iwata does.

Iwata discloses connecting a plurality of H-bridge switches in series, with one bridge connected to the DC power source and the other two connected to floating voltage supplies from a bidirectional DC to DC converter. Ex. 1102, ¶¶ 335-336; Ex. 1107, ¶¶ [0003], [0007]-[0009]; *See* Section V.C.1, *supra*. For example, Iwata's Figure 1(a) shown below has three inverters (3B-INV, 2B-INV, and 1B-INV) that are H-bridge switches, as shown in Figure 1(b), with the H-bridge outputs connected in series and with the output terminals at the series ends connected to the AC output terminals. *See* Ex. 1102, ¶¶ 336-337.



Ex. 1107, Figs. 1(a)-1(b) (annotated)

As shown in Figure 2(a), Iwata, like Schmidt, discloses that its H-bridge switches have three output states (+1, -1, 0) that generate positive, negative, and zero voltages, respectively. Ex. 1107, ¶¶ [0045]-[0049], Fig. 4; Ex. 1102, ¶ 337.

"Output DC Voltages"

(a)

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

"Ternary States"

Ex. 1107, Fig. 2(a) (annotated)

As explained in Section V.C.1, *supra*, a PHOSITA would have been motivated to arrange three of Schmidt H-bridge DC-to-AC converters in the same manner as Iwata's H-bridge switches and apply Iwata's switch timing with a reasonable expectation of success. Ex. 1102, ¶¶ 318-320, 323, 327, 338-340.

c. [5C]: "a switch controller for controlling said three-state electronic switches according to a sampled numerical representation of the desired AC output waveform expressed in a ternary number base, each ternary digit of a numerical sample determining whether a respective switch is controlled to one of the three output states (a) first polarity state, (b) inverse polarity state and (c) pass-through state, wherein the pass through state allows current flow in the H-bridge output circuit without

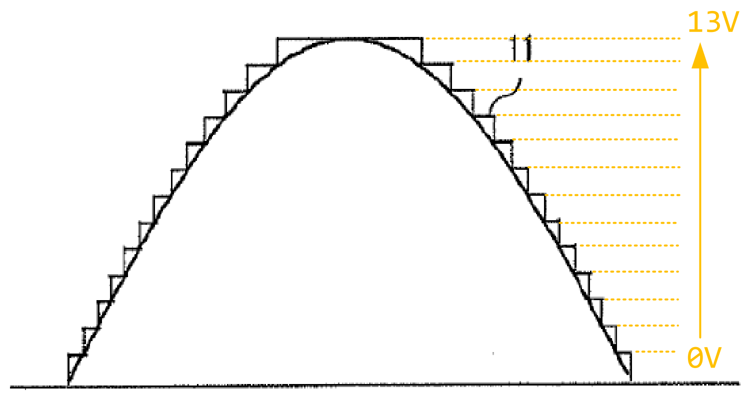
connecting the DC input voltage in series with the H-bridge output terminals, the first polarity state causes the [] DC input voltage to be connected in series with the H-bridge output terminals with a first polarity and the inverse polarity state causes the DC input voltage to be connected in series with the H-bridge output terminals with an opposite polarity to the first polarity state."

As discussed, Schmidt discloses controlling its three-state electronic switch with three output states: first polarity, inverse polarity, and pass-through. *See* Section V.C.2.b, *supra*; Ex. 1103, Fig. 4; Ex. 1102, ¶ 341. Iwata also discloses H-bridge switches that would have been understood as using the same three output switching states. Ex. 1107, Figs. 1(b), 2(a); Ex. 1102, ¶ 341.

Schmidt does not expressly disclosure using a sampled numerical representation of the desired AC output waveform expressed in a ternary number base to control its switch, but Iwata does. Ex. 1102, ¶ 342.

Iwata's inverters operate to generate a sine wave-like output shown in Figure 2(b) according to a sampled numerical representation (V_A) of the desired AC output waveform, which as shown in Figure 2(a), is expressed in ternary number base with digits (V_{1B}, V_{2B} , and V_{3B}). Ex. 1107, ¶ [0050]; Ex. 1102, ¶¶ 342-343.

(b)



“Output DC Voltages”

(a)

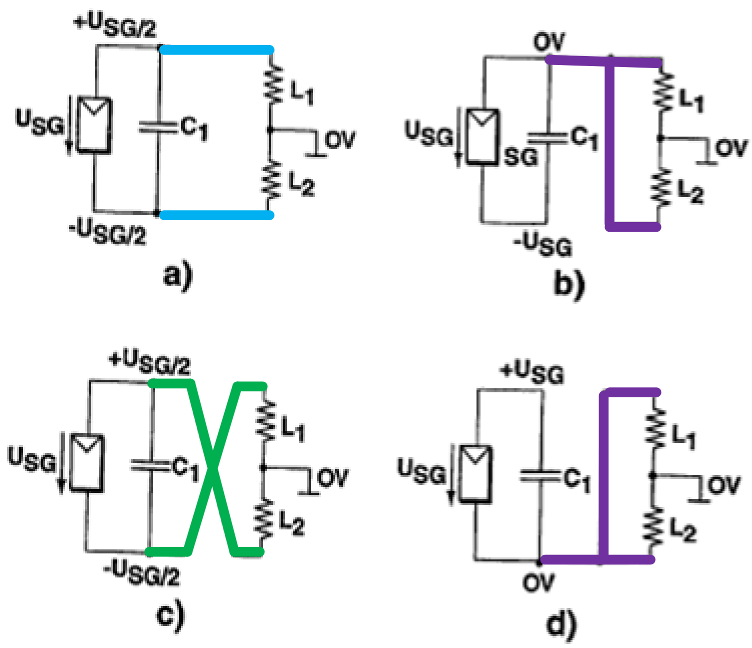
1	3	9	
V_{1B}	V_{2B}	V_{3B}	V_A LEVEL
0	0	0	0
1	0	0	1
-1	1	0	2
0	1	0	3
1	1	0	4
-1	-1	1	5
0	-1	1	6
1	-1	1	7
-1	0	1	8
0	0	1	9
1	0	1	10
-1	1	1	11
0	1	1	12
1	1	1	13

“Ternary States”

Ex. 1107, Fig. 2(b) (annotated top) Fig. 2(a) (annotated bottom)

Each ternary digit of a numerical sample determines the state of H-bridge switch: (a) first polarity (+1), (b) inverse polarity (-1), or (c) pass-through (0). *See* Ex. 1107, ¶ [0050]; Ex. 1102, ¶ 344.

Figure 4 of Schmidt below illustrates the equivalent circuit of Schmidt’s Figure 2 H-bridge for different switch configurations providing the three output states, which a PHOSITA would have understood also apply to Iwata’s H-bridges, since all H-bridges provide these three states the same way. Ex. 1103, 4:65-5:14; Ex. 1117, p. 311; Ex. 1102, ¶¶ 154-160, 345-347.



Ex. 1103, Fig. 4 (annotated)

In the pass-through states, switches A and C are closed (top right) or B and D are closed (bottom right), which shorts (**purple**) the outputs so current flows in the H-bridge output circuit without connecting the DC input voltage in series with the H-bridge output terminals. Ex. 1102, ¶ 346; Ex. 1117, p. 311. In the first polarity state (top left), switches A and D are closed causing the DC input voltage to be connected in series (**blue**) with the H-bridge output terminals with a first polarity, and in the inverse polarity state, switches B and C are closed causing the DC input voltage to be connected in series with the H-bridge output terminals with an opposite polarity (**green**) to the first polarity state. *Id*.

As discussed, Schmidt expressly discloses switch controllers. *See* Section V.A.2, *supra*; Ex. 1103, 7:53-67, 10:32-34, 10:52-54, 12:35; Ex. 1102, ¶¶ 258, 348-349. To the extent Patent Owner argues Schmidt-Iwata does not disclose switch controllers for Schmidt's or Iwata's H-bridges, a PHOSITA would have understood that a switch controller is necessarily present to generate control signals for the switch states in Iwata or would otherwise have been obvious and trivial to implement, as explained. *See* Section V.A.2, *supra*; Ex. 1102, ¶¶ 258-259, 349; *see* Ex. 1104, [0015]-[0019] (CPU 10 and PLD 11 controlling H-bridge switches), Fig. 4; Ex. 1112, pp. 703-705, 706-707, Figs. 28-8, 28-10; Ex. 1111, Abstract, 3:53-67, 4:1-28, 4:36-46, Fig. 2 (control circuit 16).

To the extent the "switch controller" is a means-plus-function term, Schmidt's control unit may be a DSP, which a PHOSITA would understand to include a "microcontroller" and "memory," the same structure as the "switch controller" described in the '822 patent. Ex. 1103, 7:62-64; Ex. 1101, 12:26-51, 24:8-12; Ex. 1102, ¶¶ 260, 350. Any differences between the '822 patent's "switch controller" structures and Schmidt's control unit structure are insubstantial, and Schmidt's switch controller performs the same function (as in claim 5) in the same way (controlling H-bridge switches using drive signals) for the same result (producing the desired waveform according to a sampled numerical representation). Ex. 1102, ¶¶ 260-261, 350.

This combination amounts to combining prior art elements according to known methods (programing Schmidt's switch controller, that already controls Schmidt's H-bridge DC-to-AC converters, to control a series of H-bridge DC-to-AC converters arranged in the same manner of Iwata's H-bridges switches and using Iwata's ternary digit-based switch timing with a bidirectional DC-DC converter) to yield predictable results (an AC output waveform that requires less filtering). Ex. 1102, ¶¶ 351-352. A PHOSITA would have a reasonable expectation of success because the switch controller allows the "gradational output voltage control." Ex. 1107, ¶¶ [0005]-[0006], [0010], [0055]-[0056]; Ex. 1102, ¶¶ 351-353.

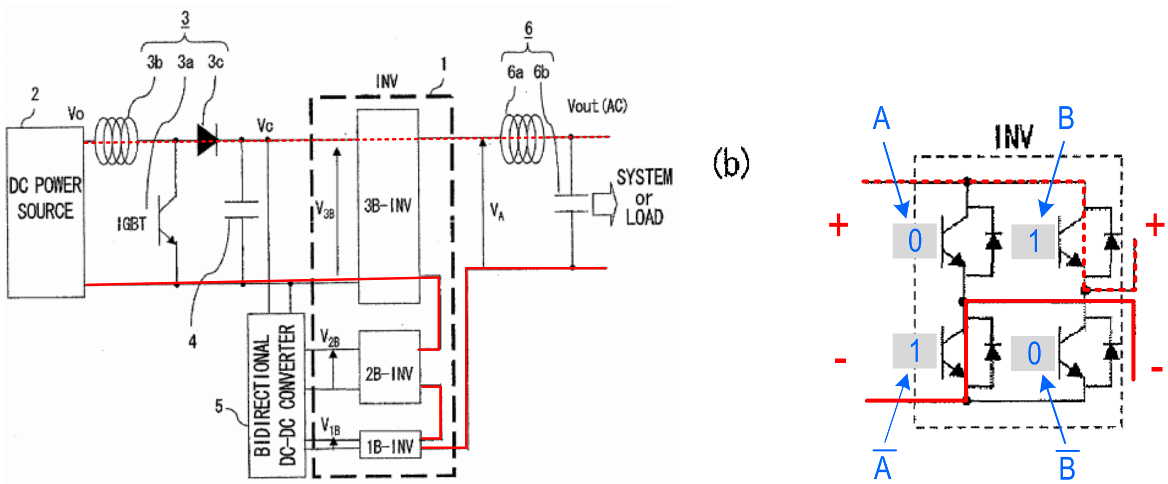
3. Claim 12

> **"The method of claim 8 in which said step of deriving instantaneous voltages from the direct current source positive line or negative line comprises expressing a desired voltage using a finite number of digits (T(n), T(n-1), T(n-2) . . . T3,T2,T1) in a ternary number system such that the instantaneously desired voltage is equal to 3^m[T(n)+T(n−1)/3+T(n−1)/9+. . . T1/3(n−1) or 3T(n)+T(n−1)+T(n−1)/3+. . . T1/3(n−)]times the voltage from said direct current source, where the power m may be zero."**

Schmidt-Iwata teaches this claim. Ex. 1102, ¶¶ 354-366. As explained, one method of deriving instantaneous voltage for a single H-bridge inverter is "single-phase chopping," which alternates connecting the positive or the negative terminal of the Solar generator DC input to the grid's neutral conductor via switches C and D with the grid frequency (50 or 60 Hz). *See* Section V.A.3.c, *supra*; Ex. 1103, 5:35-51; s*ee also* Ex. 1103, 1:33-36, 1:60-63, 5:35-55, Fig. 2; Ex. 1116, pp. 31-32; Ex. 1102, ¶¶ 354-355. Iwata teaches another method of deriving instantaneous voltage using multiple inverters, which has equivalent switching to the previously discussed "single-phase chopping." Ex. 1102, ¶ 355.

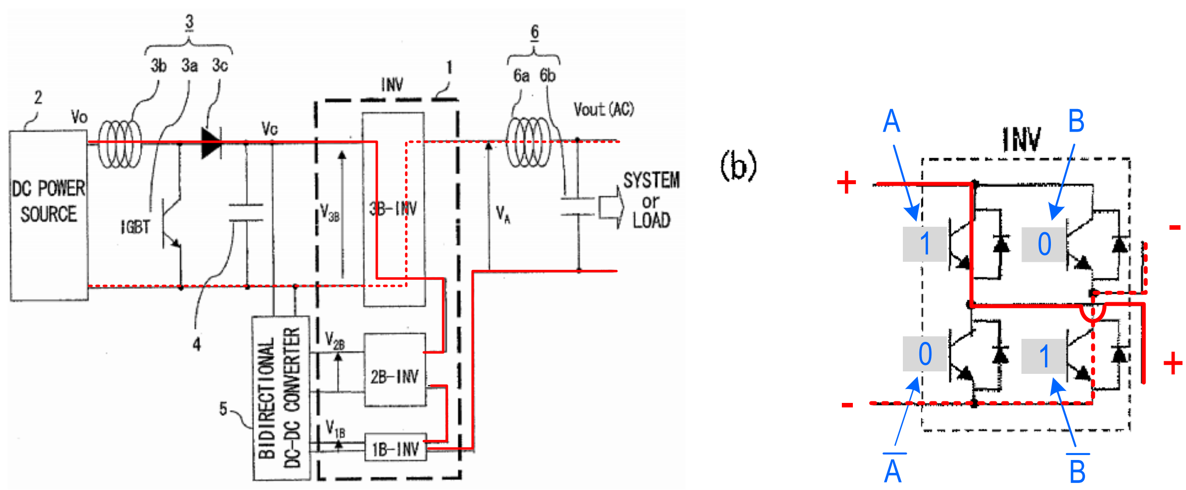
As explained, Iwata discloses connecting a plurality of H-bridge switches (3B-INV, 2B-INV, and 1B-INV) in series, with one bridge connected to the DC power source and the other two connected to floating voltage supplies from a bidirectional DC-to-DC converter. Ex. 1107, ¶¶ [0003]-[0008], [0045]-[0046], Figs. 1a-1b; *see* Section V.C.1, *supra.* And, as also explained, Iwata discloses expressing the desired voltage (V_A) in normalized gradations (0 to 13) in a ternary number system using three digits for the polarity states (1, -1, 0) for inverters 1B-INV, 2BINV, and 3B-INV. *See* Section V.C.1, *supra*; Ex. 1107, ¶ [0050], Figs. 2a-2b (annotated added); Ex. 1102, ¶ 356. The instantaneously desired voltage (V_A) is equal to weighted sum of these values in successive powers of 3, each multiplied by the input voltage: $V_A=V_{1B}+V_{2B}+V_{3B}$. Ex. 1107, ¶ [0051]; Ex. 1102, ¶ 357. This can be expressed in the ternary digit value (T) for each inverter as $T_{1B}+3T_{2B}+9T_{3B}$ or, $3^2[T_{3B}+T_{2B}/3+T_{1B}/9]$. which is substantially similar to the supply ratios discussed in the '822 patent with successive powers of three. Ex. 1101, 6:39-60, 9:65-10:14; Ex. 1102, ¶ 357.

Just as with single-phase chopping in Schmidt (Section V.A.3.c), during the positive half of the AC output sine wave (shown in Figures 2(a)-2(b)), the negative DC input terminal is connected to the ground output terminal (the "first output terminal") through V_{3B} when V_{3B} is +1, which, at that time, is "instantaneously negative" relative to the other output terminal, the AC live output (as in claim 8). Ex. 1107, Figs. 1(a)-1(b) (annotated below); Ex. 1103, 5:36-40; Ex. 1102, ¶ 358.



Ex. 1107, Figs. 1(a)-1(b) (annotated)

And like single-phase chopping, next in the sequence and shown below, during the negative half of the AC output sine wave, the positive DC input terminal is connected to the output ground through V_{3B} when V_{3B} is -1, which, at that time, is the "next-in-sequence output terminal required to be instantaneously positive relative to all other output terminals." Ex. 1107, Figs. 1(a)-1(b) (annotated below); Ex. 1103, 5:36-40; Ex. 1102, ¶ 359.



Ex. 1107, Figs. 1(a)-1(b) (annotated)

Throughout both halves of the sine wave, the inverters are controlled to output the desired sine wave voltage through using the previously mentioned ternary number system and, optionally as shown in Figures 3, 13, and 15, PWM (the claimed "deriving from the direct current source [positive/negative] voltage line the instantaneous voltages required to be output from the other output terminals"). *See* Ex. 1107, ¶¶ [0015], [0025], [0027], Figs. 3, 13, 15; *see also id.*, ¶¶ [0050], [0097], [0103], claims 10, 20, 28; Ex. 1102, ¶ 360. The only difference between single-phase chopping and PWM is the frequency at which the switches connecting the DC input to the "deriving" terminal are modulated. Ex. 1102, ¶ 360.

The equations in claim 12, however, deviate from a pure successive power of three for each switch state regarding the instantaneously desired voltage. Ex. 1102, ¶ 361. Instead, as indicated in **bold** below, claim 12 appears to require weighting some switch states twice **(T(n-1))** and the equations appear unfinished ($T1/3^{(n-)}$):

instantaneously desired voltage "equal to 3^m[T(n)+T(**n−1**)/3+T(**n−1**)/9+...T1/$3^{(n-1)}$ **or** 3T(n)+T(**n−1**)+T**(n−1**)/3+. . . **T1/$3^{(n-)}$]** times the voltage, where the power m may be zero."[2]

Varying the weighting would have been obvious to a PHOSITA. Ex. 1102, ¶ 362. Specifically, Iwata expressly notes that the "relation between V_{1B}, V_{2B} and V_{3B} may be other than 1:3:9" and provides ten examples of different weighting, as shown in Figure 4. Ex. 1107, ¶ [0051], Fig. 4; Ex. 1102, ¶ 362. This mere change in proportions or quantity do not render claims nonobvious. *Gardner v. TEC Systems, Inc*., 725 F.2d 1338, 1346, 1349 (Fed. Cir. 1984) (dimensional formulae "made the application sound like something unique and inventive but had no real function" and did not render claim nonobvious); *Iron Grip Barbell Co., Inc. v. USA Sports, Inc.*, 392 F.3d 1317, 1320-23 (Fed. Cir. 2004) (three openings for gripping barbell weight were obvious in view of prior art with two and four openings). Furthermore, choosing an alternative weighting would have been nothing more than combining of prior art elements (three of Schmidt's H-bridge DC-to-AC converters arranged in the same manner as Iwata's H-bridge switches using multiple DC voltages) according to known methods (Iwata's teaching of how different voltage ratios lead

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[2] Petitioner reserves its right to argue that such mathematical claims are not patentable under 35 U.S.C. § 101 and that this claim is indefinite.

to different numbers and levels of voltage gradations to obtain a desired waveform and a PHOSITA's understanding of how to select the desired waveform optimized for a particular application) to obtain a predictable result (an inverter optimized for a particular application and filtering requirement). Ex. 1102, ¶ 362; *See Ecolab, Inc. v. FMC Corp.*, 569 F.3d 1335 (Fed Cir. 2009). Choosing an alternative weighting would have been obvious to try as there are a finite number of potential weighting ratios that must add up predictably to the desired output voltage, and implementing such alternative weighting ratios would have been within the level of ordinary skilled in the art with a reasonable expectation of success, as evidence by Iwata's disclosure of numerous variations on weighting in Figure 4. Ex. 1102, ¶¶ 363-364.

Finally, as explained above in Section V.C.1, *supra*, a PHOSITA would have been motivated to arrange three of Schmidt H-bridge DC-to-AC converters in the same manner as Iwata's H-bridge switches and apply Iwata's alternative weighting ratios and switch timing with a reasonable expectation of success. Ex. 1102, ¶¶ 365-366.

4. Claim 13

a. [13A-13B]: "The method of claim 8 in which said step of deriving instantaneous voltages from the direct current source positive and negative lines comprises the steps of: using a bidirectional DC-to-DC converter to form, along with the DC source voltage, a set of floating DC supplies of voltages having voltage ratios of successive powers of 3"

As explained, Schmidt-Iwata teaches "deriving instantaneous voltages from the direct current source positive and negative lines." *See* Ex. 1102, ¶ 367; Section V.C.3, *supra*. And as explained for claim 5, Schmidt-Iwata-Nishimura teaches a bidirectional DC-to-DC converter for converting the voltage from a DC power source to several floating supplies of voltages equal to the input voltage divided or multiplied by successive powers of 3. *See* Section V.C.2.a, *supra*. For the same reasons, Schmidt-Iwata-Nishimura also teaches "using a bidirectional DC-to-DC converter to form, along with the DC source voltage, a set of floating DC supplies of voltages having voltage ratios of successive powers of 3." Ex. 1102, ¶ 368; Ex. 1107, ¶ [0050] (The "relation between V_{1B}, $V_{2B,}$ and V_{3B} is 1:3:9."), Figs. 1(a), 2(a)-2(b); Ex. 1108, Fig. 4. Moreover, to the extent "bidirectional DC-to-DC converter" in claim 13 is a means-plus-function term, Nishimura teaches the identical or equivalent claim 13 structure for the same reasons discussed above with respect to claim 5, since the structure disclosed in'822 patent for both of these claims is the same (Figure 2) or equivalent (*e.g.,* insubstantially different). *See* Section V.C.2.a, *supra*; Ex. 1102, ¶ 369. Finally, as explained above in Sections V.C.1V.C.2.a, *supra*, a PHOSITA would have been motivated to arrange three of Schmidt H-bridge DC-to-AC converters in the same manner as Iwata's H-bridge switches and apply Iwata's switch timing with a reasonable expectation of success, and a PHOSITA would have been motivated to substitute Schmidt-Iwata's bidirectional DC-to-DC converter with Nishimura's DC-to-DC converter with a reasonable amount of success. Ex. 1102, ¶¶ 370-371.

b. [13C]: "selecting one or more of said floating DC supplies to be directly connected in series to an AC output, with or without a polarity reversal, such that the algebraic sum of the selected voltages and polarities equals the desired instantaneous voltage of the AC output."

As explained, Schmidt-Iwata teaches multiple floating DC supply voltages (V_{1B}, $V_{2B,}$ and V_{3B}) as inputs to three inverters (1B-INV, 2BINV, and 3B-INV) with outputs connected in series to an AC output. Ex. 1103, 2:40-60, 5:48-51, Fig. 2; Ex. 1107, ¶¶ [0045]-[0048], Fig. 1(a); *see* Ex. 1102, ¶ 372; Ex. 1101, 3:22-24, 6:23-26, 7:8-15, 8:6-14, 23:37-42.

Iwata discloses directly connecting in series one or more of the floating DC supplies to an AC output, as claimed. Ex. 1102, ¶ 373. Specifically, Iwata describes expressing the desired voltage (V_A) (normalized) a "substantially sine wave-like output Voltage waveform 11" (Figure 2(b)) expressed in a ternary number system using three digits (V_{1B}, $V_{2B\,,}$ and V_{3B}) (Figure 1(a)). Ex. 1107, ¶ [0050]; Ex. 1102, ¶ 373.

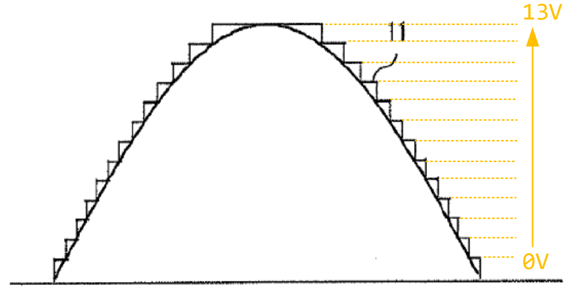
“Output DC Voltages”

(a)

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

“Ternary States”

(b)

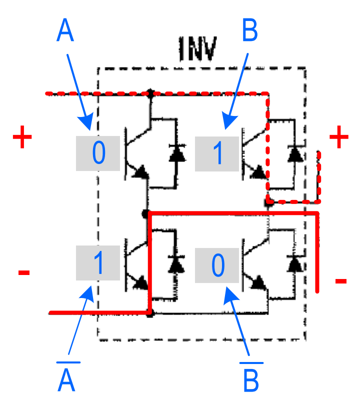


Ex. 1107, Figs. 2(a)-2(b) (annotated)

Each digit determines the state of each respective switch: (a) first polarity (+1), (b) reverse polarity (-1) and (c) pass-through (0) for a desired voltage output. *See* Ex. 1107, ¶ [0050]; Ex. 1102, ¶ 374.

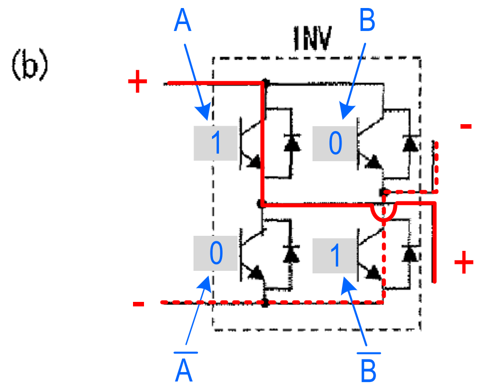
The first polarity state causes the DC input voltage to be connected in series with the H-bridge output terminals “without a polarity reversal.” *See* Ex. 1102, ¶¶ 345-347, 358, 375-376.

(b)



Ex. 1107, Fig. 1(b) (annotated)

And Iwata's inverse polarity state causes the DC input voltage to be connected in series with the H-bridge output terminals with "a polarity reversal." *See* Ex. 1102, ¶¶ 345-347, 359, 377-378.



Ex. 1107, Fig. 1(b) (annotated)

The desired instantaneous voltage of the AC output (V_A) is equal to the sum of voltages V_{1B}, V_{2B}, and V_{3B} (the DC power source voltage inputs for inverters 1B-INV, 2BINV, and 3B-INV), which have a voltage ratio of successive powers of 3 based on the voltage of the direct current source (*i.e.*, 1:3:9). Ex. 1107, ¶¶ [0050]-[0051], Figs. 1(a) (serially connected outputs), 2(a); Ex. 1102, ¶¶ 379-381.

D. Ground 5: Schmidt in View of Koyama and Ahmed Renders Claims 6 and 20 Obvious

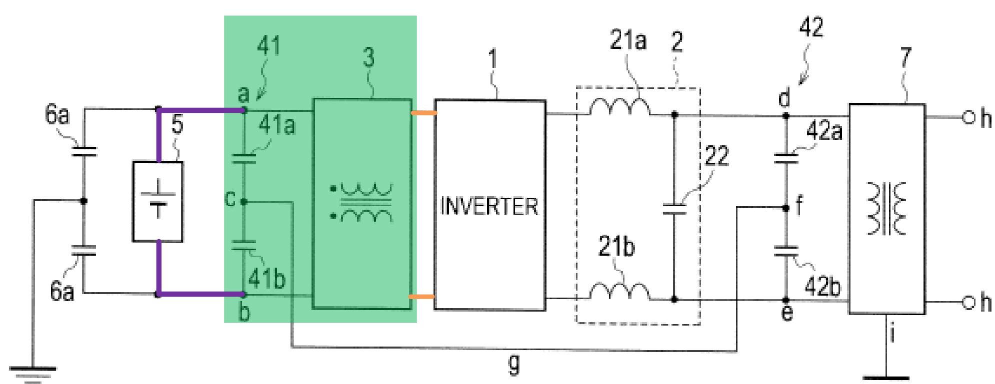
1. Claim 6

[6A]: "The DC to AC conversion apparatus of claim 1, further comprising a common-mode filter connected between said DC to AC converter DC input terminals and said positive and negative terminals of said DC source, the common-mode filter being configured both"

[6B]: "to prevent high frequency components of the DC to AC converter internal waveforms being exported to said DC source and"

[6C]: "to minimize overshoot of said common-mode waveform in order to minimize peak voltages on said positive and negative terminals."

Schmidt does not describe this limitation, but Koyama does. Ex. 1102, ¶¶ 382-383. Koyama describes a "common-mode filter [**green**] connected between said DC to AC converter DC input terminals [**orange**] and said positive and negative terminals of said DC source [**purple**]" as recited in claim 6. Ex. 1109, ¶¶ [0005]-[0008], [0012], [0024]-[0026], [0030]-[0031], [0036]-[0038], Figs. 1, 4; Ex. 1102, ¶ 383.

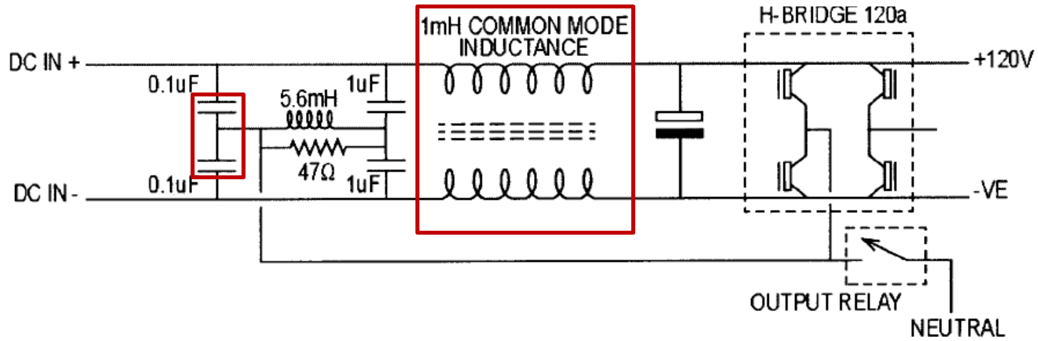


Ex. 1109, Fig. 5 (annotated)

Koyama's inverters using PWM generate high-frequency, common-mode current and voltage, and Koyama's common-mode filter (choke 3 and capacitors 41a, 41b) prevent these high-frequency waveforms from flowing to the DC power sources. Ex. 1109, ¶¶ [0002]-[0003], [0012-0013], [0016]-[0018], [0026], Figs. 2-3; Ex. 1102, ¶ 384; *see* Section V.A.2, *supra;* Ex. 1103, 1:33-36, 1:60-63, 5:35-55; Ex. 1116, pp. 31-32, Fig. 2.15; Ex. 1118, ¶ [0001].

A PHOSITA would have understood that Koyama's capacitors also control overshoot. Ex. 1121 at 1417 (comparing a similar capacitor-based filter for "damping and filtering high-frequency switching transients" to "other device voltage overshoot suppression schemes."); Ex. 1102, ¶ 385.

Koyama's common-mode filter components (common-mode choke 3 and capacitors 41) are equivalent to and insubstantially different from the '822 patent's disclosed common-mode filter structure of a "common mode inductance" and .1uF capacitors illustrated in Figure 6, which perform the same function (filtering) in the same way (using passive filtering) for the same result (reducing high frequency components and preventing overshoot). *See* Ex. 1102, ¶ 386.



Ex. 1101, Fig. 6 (annotated)

With similar DC sources and a similar switching scheme, a PHOSITA would have recognized the common-mode noise problem described in Koyama would apply equally to Schmidt—and thus, a PHOSITA would have been motivated to combine Schmidt and Koyama, because capacitor-based common-mode filters are "simpler to implement, less, lossy, and less expenses" than "other device voltage overshoot suppression schemes such as active and passive snubbers" and are "normally used" in switching voltage-source converters to reduce voltage stress due to interconnect parasitics and control voltage overshoot. Ex. 1103, 1:45-59, 2:40-48, 2:67-3:4, 3:19-25, 4:41-49, 5:35-40; Ex. 1109, ¶¶ [0008], [0027], Figs. 2-3; Ex. 1121, p. 1417; Ex. 1102, ¶ 387. Koyama's common-mode filter inserted between Schmidt's solar generator DC power source (similar to Koyama's solar cell) and Schmidt's inverter (similar to Koyama's inverter) would also beneficially minimize the hazards caused by the inverter-generated high frequency common-mode leakage and to improve the electromagnetic compatibility of the inverter with other system components. Ex. 1109, ¶¶ [0002], [0019]-[0021]; Ex. 1118, ¶ [0001]; Ex. 1102, ¶

387. Doing so would have been nothing more than the use of a known technique (inserting Koyama's common-mode filter between a power source and inverter) to improve a similar device (Schmidt's solar generator and inverter) in the same way (by suppressing the common-mode current emitted by Schmidt's inverter). Ex. 1102, ¶ 388. Finally, a PHOSITA would have reasonably expected success in combining these elements as the combination merely requires inserting additional filter components, and adjusting component values, which was well within the level of ordinary skill in the art. *Id*.

To the extent Patent Owner argues that Koyama does not disclose an equivalent structure because it lacks the overshoot damping circuit structure of the '822 patent, Ahmed does. Ex. 1102, ¶ 389. Koyama's filter has a resonance between the inductors and capacitors, which may lead to ringing, voltage overshoot, and instability. Ex. 1110, Abstract, p. 6; Ex. 1121, pp. 1420-1422; Ex. 1102, ¶ 390. Ahmed teaches to minimize overshoot with a filter having one of several damping circuits, including an LC filter with a parallel connected resistor and inductor pair in series with a capacitor (**green**). *See* Ex. 1102, ¶ 390.

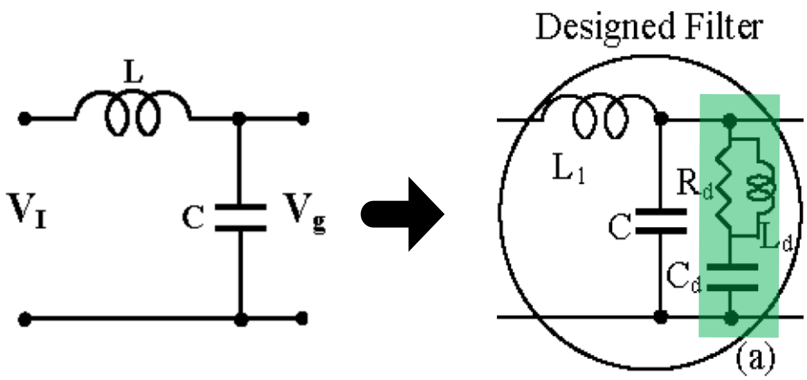
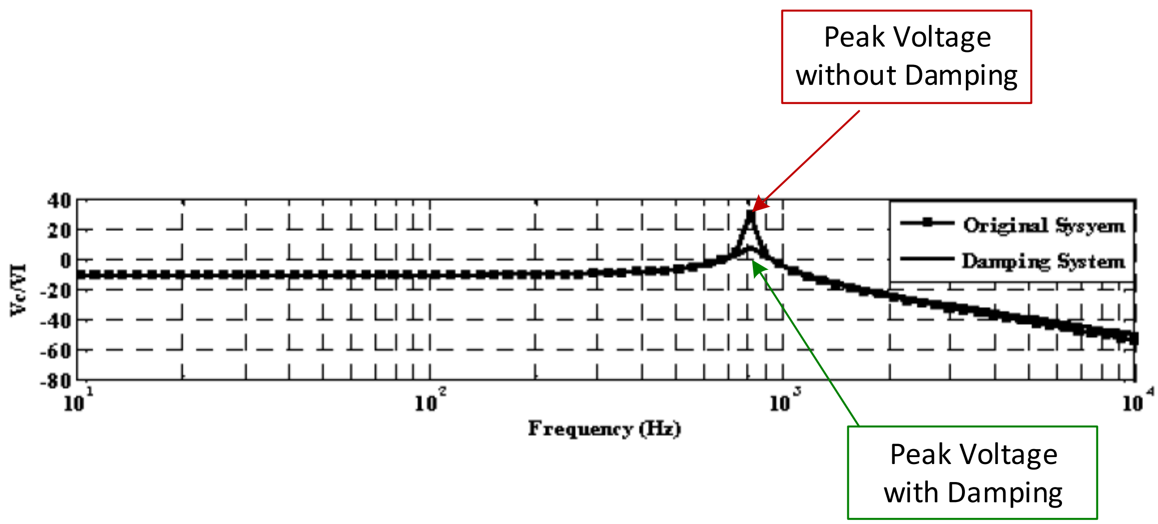


Fig. 2(b) (excerpt)

Fig. 15(a) (excerpt)

Ex. 1110, Figs. 2(b), 15(a) (excerpted and annotated)

As shown in Figure 14(b), Ahmed's damping circuit reduces the peak voltage and minimizes overshoot at the resonant frequency. *See* Ex. 1102, ¶ 391.



Ex. 1110, Fig. 14(b) (annotated)

The addition of the inductor in parallel with a damping resistor would reduce power dissipation of the damping circuit more than just the resistor alone. Ex. 1110, pp. 7, 9; Ex. 1102, ¶ 392. And adding Ahmed to Schmidt and Koyama would have been nothing more than the obvious use of a known technique (inserting Ahmed's damping circuits in an LC filter) to improve a similar device (Koyama's common-mode LC filter) in the same way (by suppressing the resonance between the choke and capacitors and reducing power dissipation of the damping resistor). Ex. 1102, ¶ 392. A PHOSITA would have been very familiar with designing and implementing passive LC filter circuits like Ahmed's LC filter and would have had the skills to do so, resulting in a reasonable expectation of success. Ex. 1102, ¶¶ 392-393.

2. Claim 20

[20A]: "The method of claim 8 in which connecting the positive line of said DC source to the instantaneously most positive of all output terminals alternating in a rotating sequence with connecting the negative line of said DC source to the most positive of all output terminals comprises connecting the DC source terminal to the selected output terminal through a common mode filter in order"

[20B]: "to prevent high frequency components of said common-mode waveform being exported to said DC source and"

[20C]: "to minimize overshoot of said common mode waveform in order to minimize peak voltages on said positive and negative terminals."

As explained above, Schmidt teaches claim 8, including the clamed "connecting . . ." step, and Schmidt-Koyama-Ahmed teaches a common-mode filter between the DC-AC converter input terminals and the DC source terminals that prevents high frequency components of the DC-AC converter internal waveforms being exported to the DC source minimizes overshoot of the common-mode waveform in order to minimize peak voltages on said positive and negative terminals. *See* Sections V.A.3.c, V.D.1, *supra*; Ex. 1102, ¶¶ 394-396. For the same reasons, Schmidt-Koyama-Ahmed teaches claim 20.

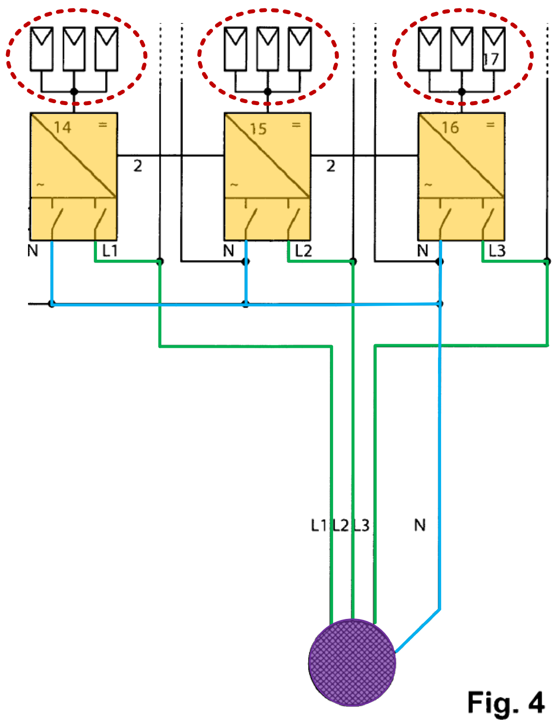
E. Ground 6: Schmidt in View of Becker and Russell Renders Claim 7 Obvious

> **"A three-phase grid-interactive inverter operating according to claim 1 in which said set of AC output terminals comprises three terminals that deliver current at unique phases spaced relatively 0, 120 and 240 degrees apart through a watt-hour metering device to the three legs of a wye-connected 120/208-volt, three-phase, electric utility company service connection and said at least one ground, neutral or reference potential terminal is the neutral terminal at the center of the wye-connection."**

Schmidt describes its DC/AC converters supplying energy to a public electricity grid and its DC/AC converters being applied to three-phase converters that output three periodic current/voltage curves, each phase-shifted by 120 degrees (the claimed "three-phase grid-interactive inverter operating according to claim 1" with "three terminals that deliver current at unique phases spaced relatively 0, 120 and 240 degrees apart [to an] electric utility company service connection"). Ex. 1103, 1:9-21, 2:32-40, 2:43-47; Ex. 1101, 4:40-45; Ex. 1102, ¶¶ 397-398. Schmidt does not expressly disclose how its DC/AC converters are arranged as a three-phase inverter; however, Becker does.

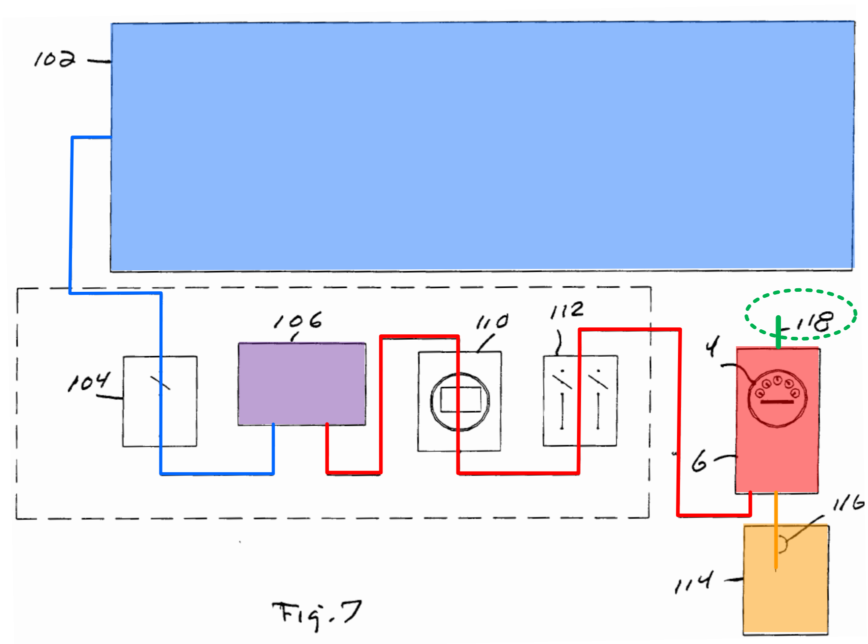
Becker describes a three-phase inverter implemented with a group of three single-phase inverters (*e.g.*, 14, 15, and 16) (**orange**) like Schmidt's single-phase inverter. Ex. 1125, 1:18-20, 2:49-51, 2:56-62, 3:43-4:21, 4:45-48, 5:22-28; Ex. 1102,

¶ 399. The outputs of the single-phase inverters are connected to a "service tap to [a] supply mains" (**purple**) in a wye arrangement such that one output terminal of each single-phase inverter is connected to one of three AC phase outputs L1, L2, and L3 (**green**), and the other output terminal is connected to a central neutral terminal N (**blue**) (the claimed "three legs of a wye-connected [ ], three-phase, electric utility company service connection and said [neutral] terminal is the neutral terminal at the center of the wye-connection"). Ex. 1125, 2:43-45, 3:48-51; Ex. 1102, ¶¶ 399-401.



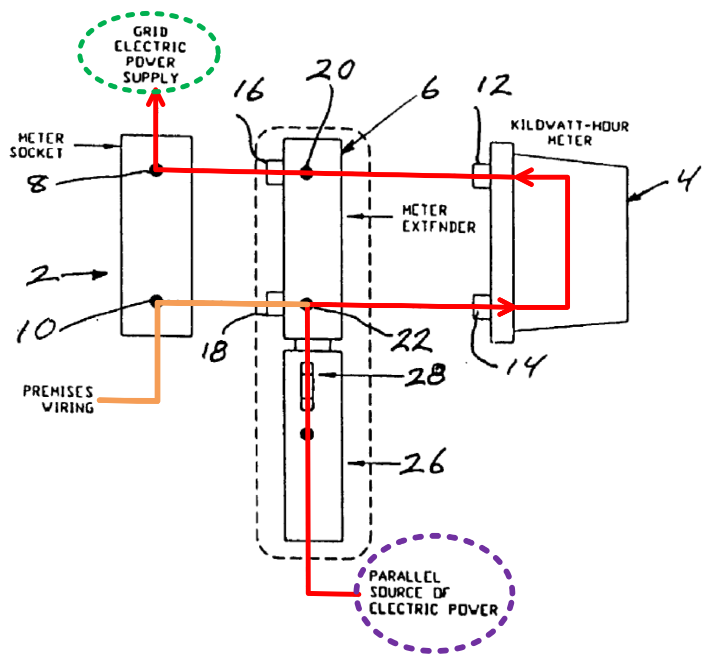
Ex. 1125, Fig. 4 (annotated)

Russell discloses the claimed "watt-hour metering device" and an "electric utility company service connection" that is "120/208-volt." Ex. 1102, ¶ 402. Russell's photovoltaic array 102 (**blue**) supplies DC power to an DC-AC converter (inverter 106) (**purple**) through a watt-hour metering device 4 (**red**) to an electric utility service connection 118 (**green**), which may be a 3-phase 120/208 Volt AC service. Ex. 1126, Abstract, ¶¶ [0003]-[0007], [0018]-[0019], [0029]-[0030], [0033], Figs. 1, 7; Ex. 1102, ¶ 402.



Ex. 1126, Fig. 7 (annotated)

Russell's inverter 106 is connected to the watt-hour meter 4 using a prewired "meter extender" 6 inserted between the meter 4 and a meter socket 2, as shown below. Ex. 1126, ¶¶ [0018]-[0019], [0027]-[0028], [0030]-[0031], [0033]. This connects the inverter's AC power output (**purple**) directly to the wiring of a premises (**orange**) and to the electrical grid (**green**) through the meter (**red**). *Id.*; Ex. 1102, ¶ 403.



Ex. 1126, Fig. 1 (annotated)

A PHOSITA would have been motivated to arrange Schmidt's single-phase inverters as in Becker's group of wye connected single-phase inverters. As Becker expressly teaches, this arrangement achieves a higher efficiency and lower cost for high output applications as compared to other three-phase inverters and also increases the quality and quantity of current supply. Ex. 1125, 1:18-31, 1:41-55, 2:16-30; 3:1-31, 3:39-42, 3:51-52, 4:15-21; Ex. 1102, ¶ 404. Doing so would have been nothing more than the application of known techniques (Becker's inverter interconnection and control arrangement) to a known device ready for improvement (Schmidt's inverters) to yield a predictable result (Schmidt's three-phase inverter arranged as in Becker). Ex. 1102, ¶ 404.

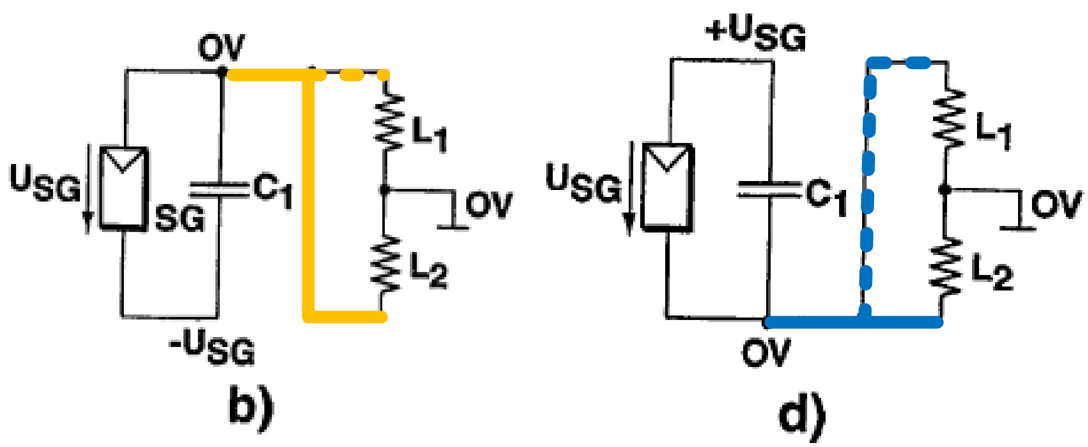
And a PHOSITA would have been motivated to connect the Schmidt-Becker three-phase inverter as described above using Russell's "net metering" configuration with an electric utility company service connection to power loads in a building, to feedback excess power to the grid, to track the net power consumed and generated at the building for billing purposes. Ex. 1126, ¶¶ [0003], [0030], [0033]; Ex. 1102, ¶ 405. This modification would have been nothing more than the combination of prior art elements (Schmidt-Becker's photovoltaic source/three-phase wye-connected inverter and Russell's watthour meter and three-phase 120V/208V utility service) according to known methods (inserting Russell's wired meter extender) to yield predictable results (measuring total consumed/generated 3-phase power at a building). Ex. 1102, ¶ 405.

A PHOSITA would have a reasonable expectation of success in making the Schmidt-Becker-Russell combination because the combination requires only routine wiring of known components (*e.g.*, photovoltaic panels, inverters, connectors, and meters) as schematically described in the references with standardized and conventional meters and meter sockets, which was well within the ability of a person of ordinary skill in the art. Ex. 1126, ¶¶ [0003], [0019]; Ex. 1135, 1:10-51; Ex. 1102, ¶¶ 406-407.

F. Ground 7: Schmidt in View of Mohan Renders Claim 2 Obvious Under an Alternative Reading

To the extent Patent Owner contends that claim 2 is directed to alternating between two pass-through states, such a configuration lacks written description support in the specification. Even so, Mohan illustrates just such an arrangement. Ex. 1102, ¶¶ 408-409.

Two states of Schmidt's single-phase, single H-bridge inverter are pass-through states in Figures 4b and 4d. *See* Ex. 1102, ¶ 410; Ex. 1117, p. 311, Fig. 4.



Ex. 1103, Fig. 4(b), 4(d) (annotated)

Schmidt describes using "unipolar voltage switching" specifically for alternating these zero-voltage circuit states in Figure 4b and 4d (the pass-through states). Schmidt references Mohan (called "Ref. 3") for this. Ex. 1103, 3:22-25, 4:41-64. The individual transistor switch states for these H-bridge pass-through states are shown below. Ex. 1112, p. 217; Ex. 1102, ¶ 411.

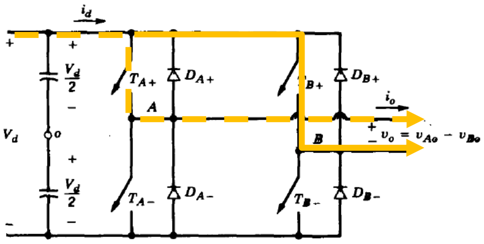


Figure 8-11 Single-phase full-bridge inverter.

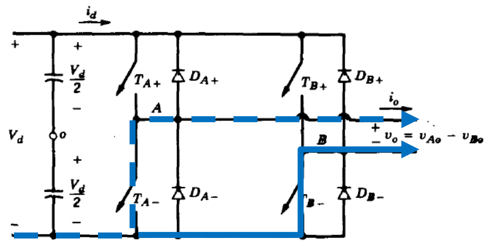
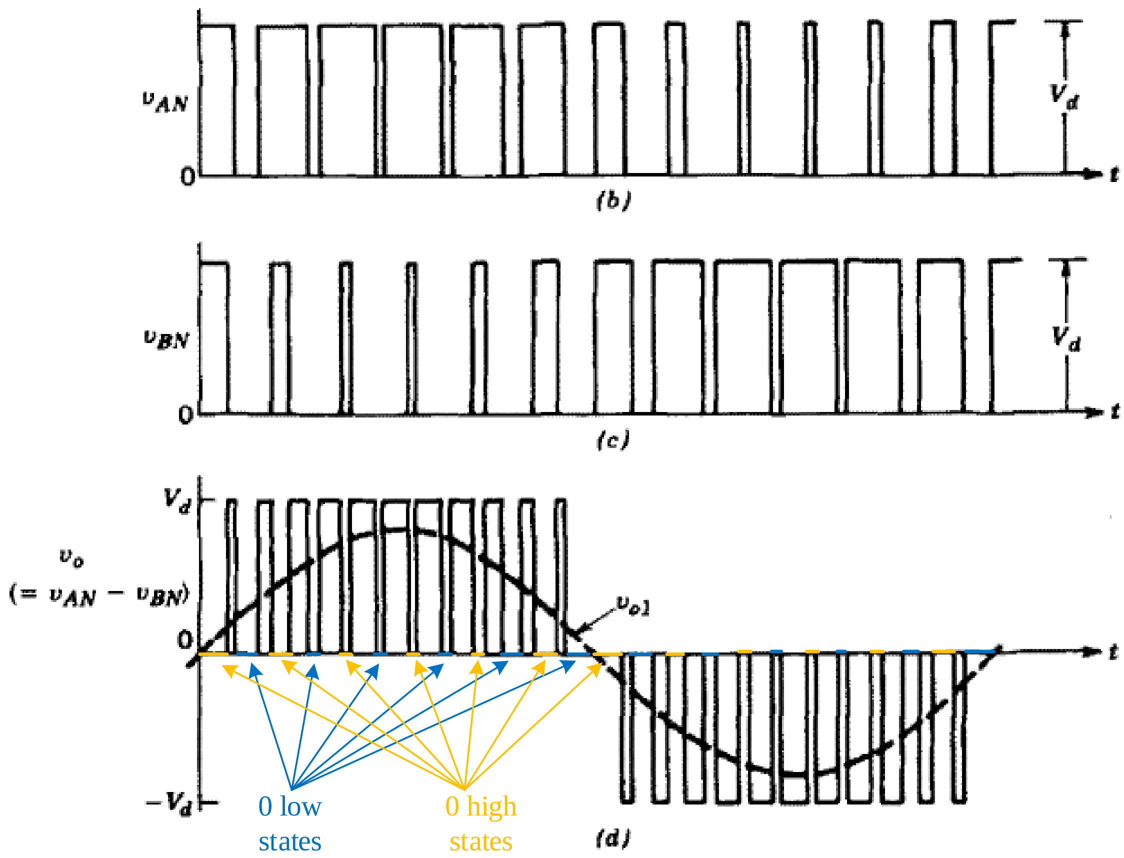


Figure 8-11 Single-phase full-bridge inverter.

1. T_{A+}, T_{B-} on: $v_{AN} = V_d, \quad v_{BN} = 0; \quad v_o = V_d$
2. T_{A-}, T_{B+} on: $v_{AN} = 0, \quad v_{BN} = V_d; \quad v_o = -V_d$
3. T_{A+}, T_{B+} on: $v_{AN} = V_d, \quad v_{BN} = V_d; \quad v_o = 0$
4. T_{A-}, T_{B-} on: $v_{AN} = 0, \quad v_{BN} = 0; \quad v_o = 0$

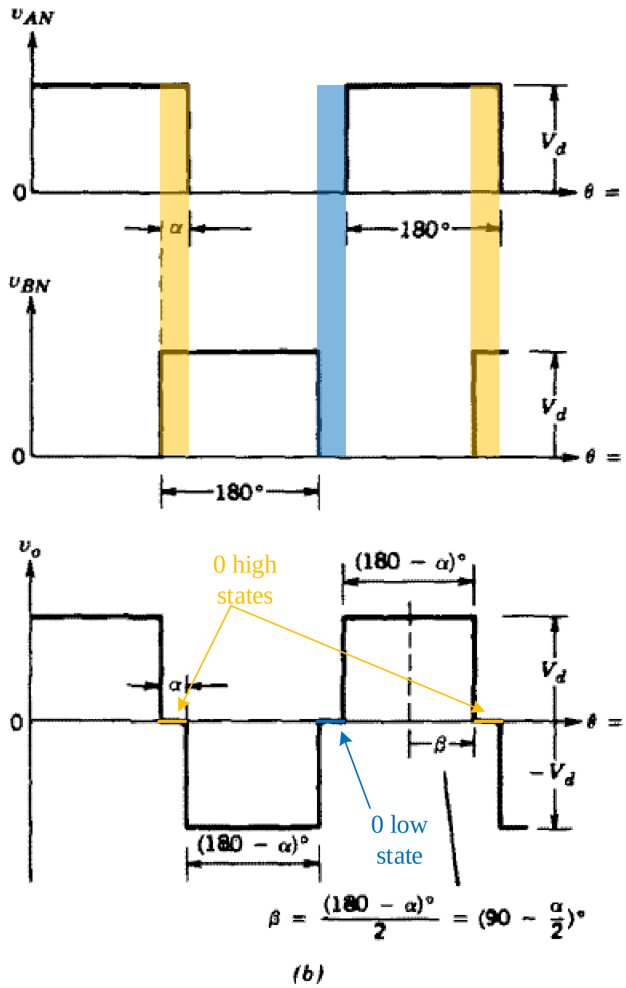
Ex. 1112, Fig. 8-11 (annotated)

Mohan illustrates alternating between these two pass-through states during the intervening zero phases. Ex. 1112, pp. 215-218; Ex. 1102, ¶ 412.



Ex. 1112, Fig. 8-15(b)-(d)

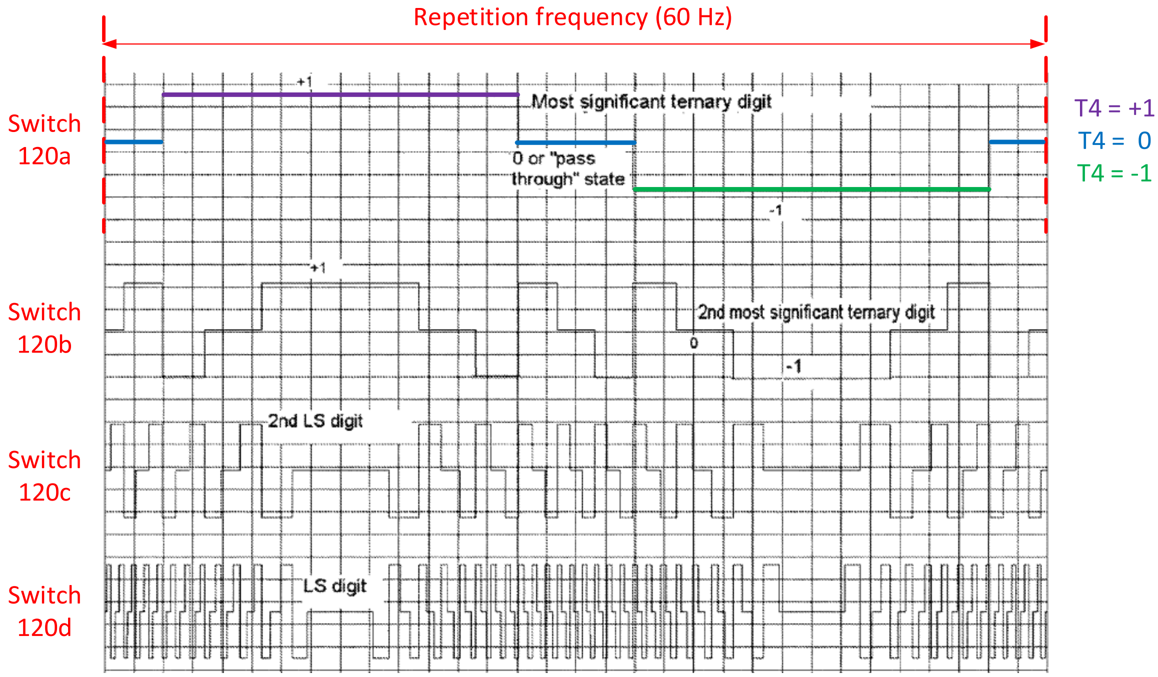
Shown below, Mohan also describes voltage cancellation control, which is based on unipolar PWM voltage switching and uses the same switching states but has a set duty cycle of 0.5 with an overlap angle of α that creates the pass-through states. Ex. 1112, pp. 218-219; Ex. 1102, ¶ 413. During the zero (pass-through) states, Mohan alternates between connecting the positive and ground terminals to the AC output and the negative ground terminals to the AC output. Ex. 1112, p. 219; Ex. 1102, ¶ 413.



Ex. 1112, Fig. 8(b) (annotated)

Common-mode waveforms were well-known to occur when switching a full-bridge inverter using unipolar switching, including in other patents filed by Schmidt. *See* Section V.A.1.e, *supra*; Ex. 1113, ¶¶ [0004], [0016] ("FIG. 5 shows the voltage of the solar generator to ground in the single-phase transformerless DC/AC converters described based on FIGS. 1, 3 and 4."), Figs. 1 (depicting an identical circuit), 5 (depicting a common-mode voltage waveform); Ex. 1114, Fig. 2 (depicting the same circuit as Schmidt Figure 2 in the German equivalent of Schmidt); Ex. 1115, pp.

3121, 3124, Figs. 4-5, 10; Ex. 1102, ¶ 415; *Realtime Data*, 912 F.3d at 1372-73. Moreover, Mohan's voltage cancellation control has an identical waveform as switch 120a as disclosed in the '822 patent that also generates common-mode waveforms. *See* Ex. 1102, ¶ 414.



Ex. 1101, Fig. 4 (annotated)

A PHOSITA would have been motivated to utilize either switching pattern to output an AC waveform in Schmidt. First, PWM with unipolar voltage switching in Mohan is expressly referenced in Schmidt as providing advantages by enabling this same "zero-voltage period" and improved efficiency and electromagnet compatibility through reduced current fluctuations (ripples) in the inductors and output current. Ex. 1103, 4:51-64. Second, the voltage cancellation control in Mohan is based on that same unipolar voltage switching and maximizes the fundamental output magnitude. Ex. 1112, p. 219. Each amounts to a simple substitution of one known switching pattern for another (PWM with unipolar voltage switching and voltage cancellation control) to obtain predictable results (an AC output waveform). Ex. 1102, ¶ 416.

A PHOSITA would have had a reasonable expectation of success in implementing PWM with unipolar voltage switching or voltage cancellation control into Schmidt's converter because Schmidt expressly describes using PWM with unipolar voltage switching and because voltage cancellation control is based on that same switching and is "feasible" in a "single-phase, full-bridge inverter circuit," like Schmidt's circuit. Ex. 1112, p. 218. Both switching patterns were within the level of ordinary skill to implement, merely requiring a change in the timing of the switch controller. Ex. 1102, ¶¶ 417-418.

VI. CONCLUSION

For the foregoing reasons, claims 1-13 and 20 of the '822 patent should be cancelled.

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 13,898, which is less than the 14,000 allowed under 37 CFR § 42.24(a)(1)(i). This total includes 13,762 words as counted by the Word Count feature of Microsoft Word and 136 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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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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Dated: October 11, 2021

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CLAIM LISTING APPENDIX

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

Designation	Claim Language
Claim 1	
[1A]	1. DC to AC conversion apparatus for converting power from a DC source to produce an power output waveform at a first repetition frequency, comprising
[1B]	a set of at least one live AC output terminals,
[1C]	at least one output terminal designated as a ground, neutral or reference potential terminal;
[1D]	a floating DC power source having a positive and a negative terminal connected respectively to the positive and negative DC input terminals of a DC to AC converter, wherein the DC to AC converter causes:
[1E]	(1) an AC output waveform at said first repetition frequency and having a voltage relative to one of said at least one ground, neutral or reference potential terminals to appear with a unique phase at each of a number N at least equal to one of said set of live AC output terminals, and
[1F]	(2) a common-mode voltage waveform at a second repetition frequency to appear relative to one of said at least one ground, neutral or reference potential terminals and in the same phase on both of said positive and negative terminals of said DC power source, wherein the second repetition frequency is a multiple equal to the same said number N of said first repetition frequency.
Claim 2	
2	2. The apparatus of claim 1 wherein said DC to AC converter further comprises: A first electronic switch controlled by a switching controller to connect said positive DC input terminal to the instantaneously most positive of said set of AC output terminals and said at least one ground, neutral or reference potential terminal alternating with connecting said negative DC input terminal to the instantaneously most negative of said set of AC output terminals and said at least one ground, neutral or reference potential terminal.
Claim 3	

Designation	Claim Language
3	3. The DC to AC conversion apparatus of claim 1 wherein said second repetition frequency is a multiple equal to the same said number N of said first repetition frequency and said number N is equal to 1, 2 or 3.
Claim 4	
4	4. The apparatus of claim 1 further comprising an AC ground leak detector inserted in the positive and negative conductors between said DC source and said DC to AC converter, the AC ground leak detector being adapted to detect an imbalance current at said second frequency and to thereby provide a detection signal indicative of an unwanted leakage impedance from a DC conductor to ground.
Claim 5	
[5A]	5. The DC to AC conversion apparatus of claim 1 in which said DC to AC converter further comprises:
[5B]	A bidirectional DC-to-DC converter for converting the input voltage from said DC power source to a number of floating supplies of voltages equal to the input voltage divided or multiplied by successive powers of 3;
[5C]	A number of three-state electronic switches each in the form of an H-bridge, each with a pair of input terminals connected to one of the DC power source and said floating voltage supplies from said bidirectional DC to DC converter, and a pair of output terminals, the outputs terminals of said electronic H-bridge switches being directly connected in series and one end of the series connected output terminal pairs being connected to at least one of said set of AC output terminals;
[5D]	A switch controller for controlling said three-state electronic switches according to a sampled numerical representation of the desired AC output waveform expressed in a ternary number base, each ternary digit of a numerical sample determining whether a respective switch is controlled to one of the three output states (a) first polarity state, (b) inverse polarity state and (c) pass-through state, wherein the pass through state allows current flow in the H-bridge output circuit without connecting the DC input voltage in series with the H-bridge output terminals, the first polarity state causes the the DC input voltage to be connected in series with the H-bridge

Designation	Claim Language
	output terminals with a first polarity and the inverse polarity state causes the DC input voltage to be connected in series with the H-bridge output terminals with an opposite polarity to the first polarity state.
Claim 6	
[6A]	6. The DC to AC conversion apparatus of claim 1, further comprising a common-mode filter connected between said DC to AC converter DC input terminals and said positive and negative terminals of said DC source, the common-mode filter being configured both
[6B]	to prevent high frequency components of the DC to AC converter internal waveforms being exported to said DC source and
[6C]	to minimize overshoot of said common-mode waveform in order to minimize peak voltages on said positive and negative terminals.
Claim 7	
7	7. A three-phase grid-interactive inverter operating according to claim 1 in which said set of AC output terminals comprises three terminals that deliver current at unique phases spaced relatively 0, 120 and 240 degrees apart through a watt-hour metering device to the three legs of a wye-connected 120/208-volt, three-phase, electric utility company service connection and said at least one ground, neutral or reference potential terminal is the neutral terminal at the center of the wye-connection.
Claim 8	
[8A]	8. A method of converting power from a direct current source with improved efficiency to provide AC output power at a standard voltage and frequency and to a number of output terminals corresponding to the number of phases required, comprising
[8B]	Configuring said direct current source to be floating;
[8C]	connecting the negative line from said direct current source to a first output terminal required to be instantaneously negative relative to all other output terminals while deriving from the direct current source positive voltage line the instantaneous voltages required to be output from the other output terminals

Designation	Claim Language
	relative to said first terminal, in a rotating sequence with connecting the positive line from said direct current source to a next-in-sequence output terminal required to be instantaneously positive relative to all other output terminals while deriving from the negative line of the direct current source the instantaneous voltages relative to said next-in-sequence terminal required to be output from the other terminals;
[8D]	selecting the timing of said rotating sequence such that a common mode waveform with a characteristic repetition frequency appears in phase on both the direct current source positive and negative lines.
Claim 9	
9	9. The method of claim 8 in which said characteristic frequency is a multiple of 1, 2 or 3 times the AC output power frequency.
Claim 10	
10	10. The method of claim 8 in which said step of deriving instantaneous voltages from the direct current source positive line or negative line comprises using one of (a) a delta-sigma approximator having a high switching frequency; (b) a pulse-width modulator; or (c) approximations to said instantaneous voltages based on a finite number of digits in a ternary number system.
Claim 11	
11	11. The method of claim 8 in which an unwanted leakage impedance to ground from a line of either polarity of said direct current source is detected by detecting a common-mode current with said common mode waveform at said characteristic repetition frequency.
Claim 12	
12	12. The method of claim 8 in which said step of deriving instantaneous voltages from the direct current source positive line or negative line comprises expressing a desired voltage using a finite number of digits (T(n), T(n-1), T(n-2) . . . T3,T2,T1) in a ternary number system such that the instantaneously desired voltage is equal to 3^m[T(n)+T(n−1)/3+T(n−1)/9+. . . T1/$3^{(n-1)}$ or

Designation	Claim Language
	3T(n)+T(n−1)+T(n−1)/3+. . . T1/$3^{(n-)}$]times the voltage from said direct current source, where the power m may be zero.
Claim 13	
[13A]	13. The method of claim 8 in which said step of deriving instantaneous voltages from the direct current source positive and negative lines comprises the steps of:
[13B]	using a bidirectional DC-to-DC converter to form, along with the DC source voltage, a set of floating DC supplies of voltages having voltage ratios of successive powers of 3;
[13C]	selecting one or more of said floating DC supplies to be directly connected in series to an AC output, with or without a polarity reversal, such that the algebraic sum of the selected voltages and polarities equals the desired instantaneous voltage of the AC output.
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	

Designation	Claim Language
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	
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.
Claim 20	
[20A]	20. The method of claim 8 in which connecting the positive line of said DC source to the instantaneously most positive of all output terminals alternating in a rotating sequence with connecting the negative line of said DC source to the most positive of all output terminals comprises connecting the DC source terminal to the selected output terminal through a common mode filter in order
[20B]	to prevent high frequency components of said common-mode waveform being exported to said DC source and
[20C]	to minimize overshoot of said common-mode waveform in order to minimize peak voltages on said positive and negative terminals.