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.: IPR2022-00007

PETITION 1 of 6 FOR *INTER PARTES* REVIEW
UNDER 35 U.S.C. §§ 311-319 AND 37 C.F.R. § 42.100 *et seq*.

TABLE OF CONTENTS

MANDATORY NOTICES i
I. INTRODUCTION & RELIEF REQUESTED 1
II. GROUNDS FOR STANDING & FEE PAYMENT 1
III. OVERVIEW 2
A. Brief Description of Alleged Invention 2
B. Prosecution History 4
C. Scope and Content of the Prior Art 5
1. U.S. Patent No. 7,088,601 (“Tracy”) (Ex. 1005) 5
2. Japanese Pat. App. Pub. No. P2004-7941A (“Suzuki”) (Ex. 1030, Ex. 1031) 9
3. Japanese Pat. App. Pub. No. JP 11-122819 (“Fujimoto”) (Ex. 1033, Ex. 1034) 11
4. U.S. Pat. App. Pub. No. 2007/0278988 (“De”) (Ex. 1018) 12
5. U.S. Patent No. 6,112,158 (“Bond”) (Ex. 1035) 13
6. U.S. Patent No. 5,029,064 (“Ball”) (Ex. 1032) 14
IV. IDENTIFICATION OF CHALLENGE PURSUANT TO 37 C.F.R. § 42.104(b) 16
A. Level of Ordinary Skill 17
B. Claim Construction 17
1. “DC to AC converter” (Claim 1) 17
2. “A switch[ing] controller” (Claims 2 and 5) 19
3. “AC ground leak detector” (Claim 4) 19
4. “bidirectional DC-to-DC converter” (Claims 5 and 13) 20
5. “common-mode filter” (Claim 6) 20
V. SPECIFIC GROUNDS FOR UNPATENTABILITY 22
A. Grounds 1 and 2: Tracy Anticipates or Renders Obvious Claims 1-3, 8-10 22
1. Independent Claim 1 22

2. Independent Claim 8 28
3. Dependent Claim 2 35
4. Dependent Claims 3 and 9 38
5. Dependent Claim 10 39
B. Ground 3: Tracy in View of Fujimoto Renders Claims 4 and 11 Obvious 39
1. Dependent Claims 4 and 11 39
C. Ground 4: Tracy in view of De Renders Claims 6 and 20 Obvious, ...43
1. Claims 6 43
2. Claim 20 47
D. Ground 5: Tracy in View of Bond Renders Claims 7 Obvious 49
1. Dependent Claim 7 49
E. Ground 6: Tracy in view of Suzuki and Ball Renders Claims 5, 12, and 13 Obvious 53
1. A PHOSITA Would Have Been Motivated to Modify Tracy with Suzuki 53
2. A PHOSITA Would Have Been Motivated to Modify Tracy-Suzuki with Ball 62
3. Dependent Claim 5 66
4. Dependent Claim 12 74
5. Dependent Claim 13 78
F. CONCLUSION 81
CERTIFICATION UNDER 37 CFR § 42.24(d) 82
CERTIFICATE OF SERVICE 83
CLAIM LISTING APPENDIX 84

EXHIBITS

Ex. 1001:	U.S. Patent No. 8,937,822 ("the '822 patent")
Ex. 1002:	Expert Declaration of Dr. R. Jacob Baker
Ex. 1003:	U.S. Patent No. 7,046,534 ("Schmidt")
Ex. 1004:	Reserved
Ex. 1005:	U.S. Patent No. 7,088,601 ("Tracy")
Ex. 1006:	Reserved
Ex. 1007:	U.S. Patent Application Publication No. 2008/0192519 ("Iwata")
Ex. 1008:	U.S. Patent Application Pub. No. 2009/0086520 ("Nishimura")
Ex. 1009:	Certified Translation of Ex. 1027, PCT Pub. No. WO 2010/055713 ("Koyama")
Ex. 1010:	K. H. Ahmed, S. J. Finney and B. W. Williams, *Passive Filter Design for Three-Phase Inverter Interfacing in Distributed Generation*, *Compatibility in Power Electronics*, CPE 2007, IEEE, pp. 1-9, 2007 ("Ahmed")
Ex. 1011:	Reserved
Ex. 1012:	Mohan, N., Power Electronics: Converters Applications and Design (2nd Ed. John Wiley & Sons. Inc.) ("Mohan")
Ex. 1013:	U.S. Patent Application Pub. No. 2011/0255316 ("Burger")
Ex. 1014:	Reserved
Ex. 1015:	Araújo, S. Highly Efficient Single-Phase Transformerless Inverters for Grid-Connected Photovoltaic Systems, IEEE Trans. on Industrial Elecs, vol. 57, no. 9 (Sept. 2010)
Ex. 1016:	Certified translation of Ex. 1046, 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. 1017: 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. 1018: U.S. Patent App. Pub. No. 2007/0278988 ("De")

Ex. 1019: Mark W. Earley Ed., National Electrical Code ® Handbook, Eleventh Edition, 2008

Ex. 1020: Reserved

Ex. 1021: Reserved

Ex. 1022: Certified Prosecution History for the U.S. Patent No. 8,937,822

Ex. 1023: Declaration of James Mullins

Ex. 1024: U.S. Patent App. Pub. No. 2009/0207543 ("Boniface")

Ex. 1025-1026: Reserved

Ex. 1027: PCT Pub. No. WO 2010/055713 ("Koyama")

Ex. 1028-1029: Reserved

Ex. 1030: Japanese Pat. App. Pub. No. P2004-7941A ("Suzuki")

Ex. 1031: Certified Translation of Ex. 1030, Japanese Pat. App. Pub. No. P2004-7941A ("Suzuki")

Ex. 1032: U.S. Patent No. 5,029,064 ("Ball")

Ex. 1033: Japanese Pat. App. Pub. No. JP 11-122819 ("Fujimoto")

Ex. 1034: Certified Translation of Ex. 1033, Japanese Unexamined Pat. App. Pub. No. JP 11-122819 ("Fujimoto")

Ex. 1035: U.S. Patent No. 6,112,158 ("Bond")

Ex. 1036: Excerpts from the Modern Dictionary of Electronics, 6th Edition, 1992

Ex. 1037: U.S. Patent No. 8,643,985 (“West ’985”)

Ex. 1038: U.S. Patent App. Pub. No. 2010/0275823 (“Pahls”)

Ex. 1039: U.S. Patent No. 7,710,752 (“West ’752”)

Ex. 1040: U.S. Patent No. 7,746,003 (“Verfuerth”)

Ex. 1041: J. G. Tracy and H. Pfitzer, “Achieving high efficiency in a double conversion transformerless UPS,” 31st Annual Conference of IEEE Industrial Electronics Society, 2005. (“Tracy-IEEE 2005”)

Ex. 1042: McGraw-Hill Dictionary of Electrical and Electronic Engineering, 1984

Ex. 1043: Excerpts of IEEE: The Authoritative Dictionary of IEEE Standard Terms, Seventh Edition, IEEE Press 2000

Ex. 1044: Tolbert et al., Multilevel Converters for Large Electric Drives, IEEE Trans. Ind. Apps., Vol 35, No. 1, Jan/Feb 1999

Ex. 1045: Certified translation of Ex. 1055, Heribert Schmidt, Bruno Burger, & Klaus Kiefer. Wechselwirkungen zwischen Solarmodulen und Wechselrichtern, Fraunhofer Institute for Solar Power Systems, June 2007. (“Schmidt”)

Ex. 1046: 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. 1047: U.S. Patent No. 7,082,040 (“Raddi”)

Ex. 1048: U.S. Patent No. 4,320,449 (“Carroll”)

Ex. 1049: U.S. Patent App. Pub. No. 2007/0295590 (“Weinberg”)

Ex. 1050: U.S. Patent No. 5,285,372 (“Huynh”)

Ex. 1051: Certified translation of Ex. 1058, PCT Publication No. WO 2010/082265 ("Mori '265")

Ex. 1052: Keith H. Billings, *Switchmode Power Supply Handbook*, McGraw Hill, 1989

Ex. 1053: Marty Brown, *Power Supply Cookbook*, Butterworth-Heinemann, 1994

Ex. 1054: U.S. Department of Commerce. International Trade Administration, *Electric Current Abroad*, 1998 Edition, reprinted Feb. 2002. ("ECA 1998/2002")

Ex. 1055: Heribert Schmidt, Bruno Burger, & Klaus Kiefer. Wechselwirkungen zwischen Solarmodulen und Wechselrichtern. English translation: Interaction between Solar Modules and DC/AC Inverters, 2007

Ex. 1056: Math H. Bollen, Irene Gu, *Signal Processing of Power Quality Disturbances*, Wiley-IEEE Press, 2006

Ex. 1057: Symmetrical components, Wikipedia, https://en.wikipedia.org/wiki/Symmetrical_components, downloaded September 29, 2021

Ex. 1058: PCT Publication No. WO 2010/082265 ("Mori '265")

Ex. 1059-1063: Reserved

Ex. 1064: Ostbayerisches Technologie-Transfer-Institute. V., Power Electronics for Photovoltaics, OTTI International Seminar, June 7-8, 2010

Ex. 1065: 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 SolarEdge 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 (the "'822 patent") describes various configurations of well-known DC-AC inverters 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; and (3) a three-phase inverter with half-bridge switches. Ex. 1002, ¶¶ 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 bi-directional DC-DC converters, switching controllers, a ground leak detector, and a common-mode filter. *Id.* Tracy (Ex. 1005), which teaches a three-phase inverter with half-bridge switches, alone and in combination with the additional secondary references in this petition, disclose these limitations. Claims 1-13 and 20 of the '822 patent should be cancelled.

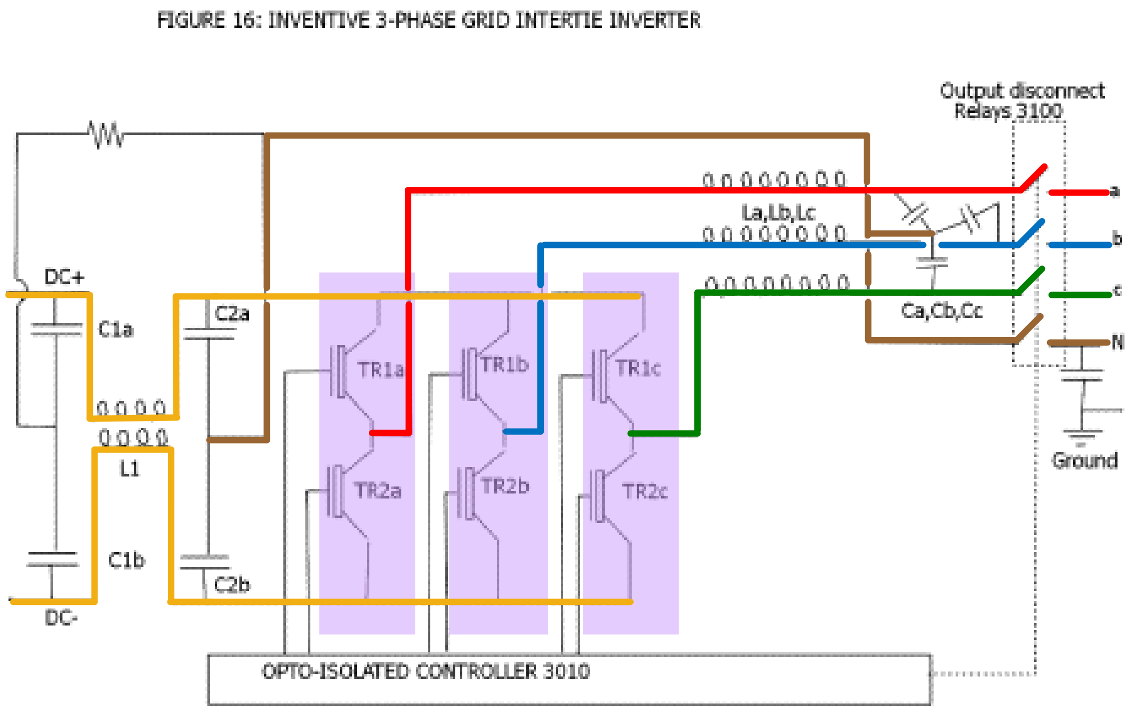
II. GROUNDS FOR STANDING & FEE PAYMENT

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

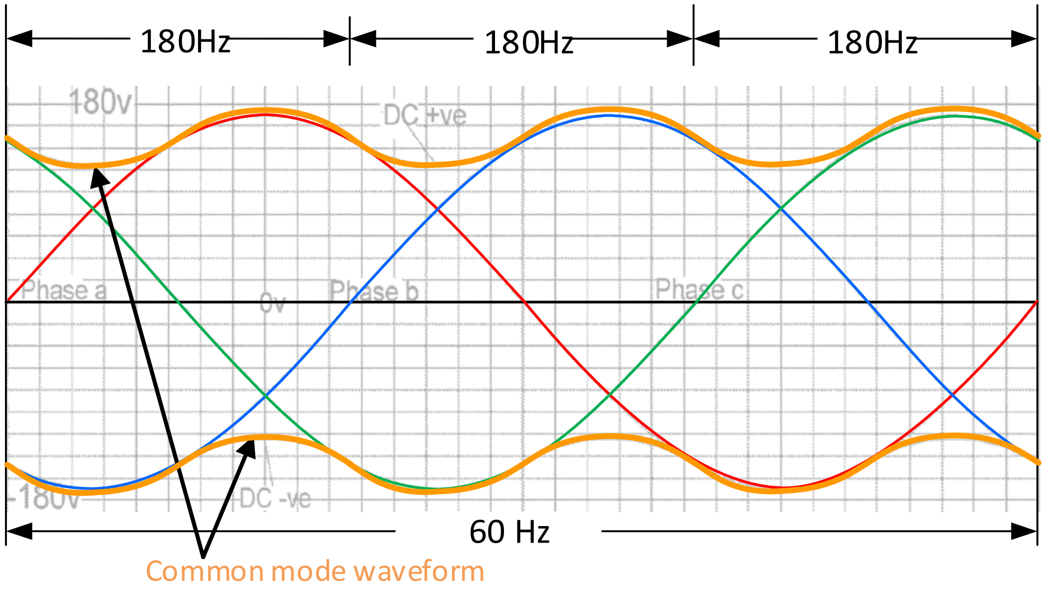
A. Brief Description of Alleged Invention

The ’822 patent describes multiple well-known inverters, one of which is a three-phase inverter including three half-bridge switches (**purple**) that convert a floating DC input source (**orange**) to three-phase AC outputs (**red**, **blue**, **green**) relative to a neutral terminal (**brown**):



Ex. 1001, Fig. 16 (annotated)

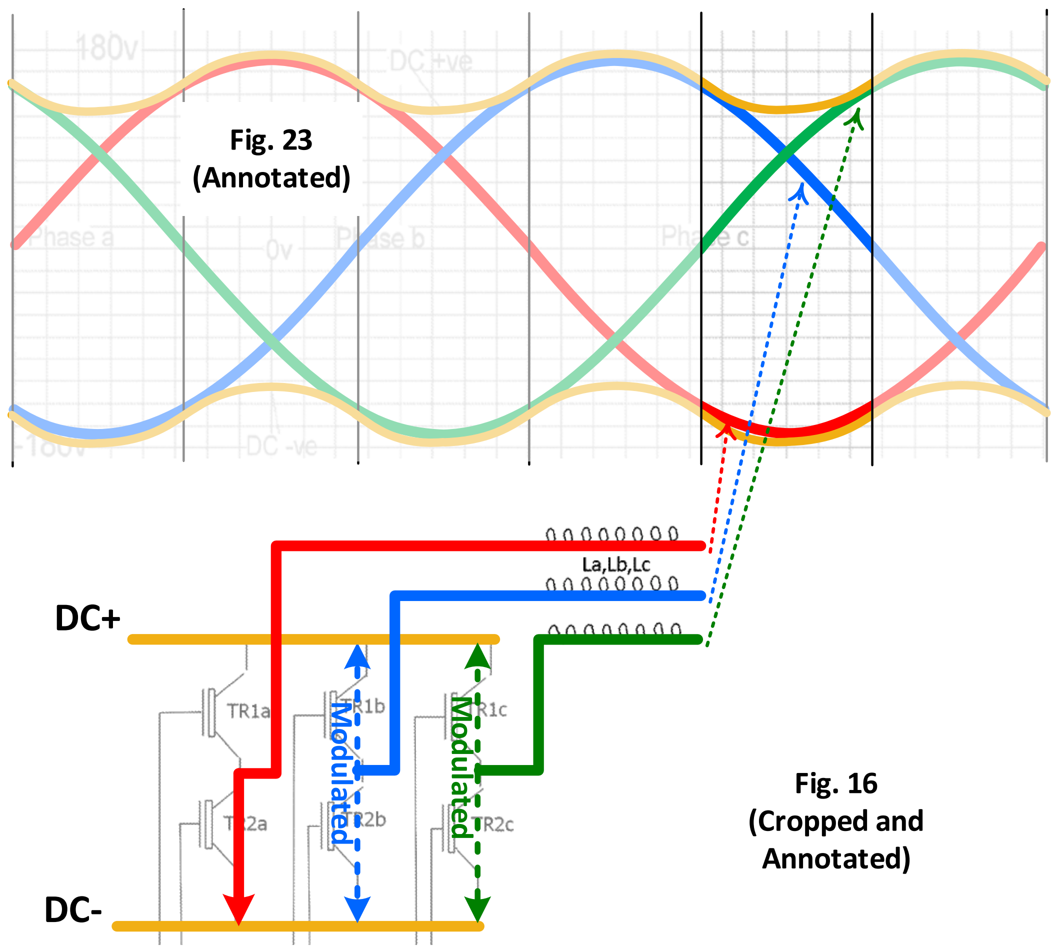
Id., Fig. 23, 4:25-56, 26:34-27:43; Ex. 1002, ¶¶ 61-74. The half-bridge switches connect the positive and negative input terminals to the three outputs in a pattern thereby generating three AC voltages (**red**, **blue**, and **green**) having unique phases (0/120/240 degrees):



Ex. 1001, Fig. 23 (annotated)

Id., 4:40-45, 26:56-27:11. The connection of the DC inputs to the AC phase outputs produces a common-mode voltage (**orange**) on both DC inputs at three times the frequency of the AC phase outputs. *Id.*, 4:46-52, 27:5-9, 27:31-36, Abstract.

The switching pattern (claims 2 and 8) is shown below in the highlighted interval, in which phase **a** is connected to the DC- input (**red** and **orange**), while phases **b** (**blue**) and **c** (**green**) (having opposite polarities of phase **a**) are modulated between DC+ and DC-. The pattern rotates every successive interval, so for example in the next interval, phase **c** and the DC+ input (**green** and **orange**) are connected, while phases **a** (**red**) and **b** (**blue**) are modulated. *Id.*, 4:26-33, 26:57-27:34; Ex. 1002, ¶¶ 75-79.



Ex. 1001, Fig. 23 (annotated), Fig. 16 (cropped and annotated)

B. Prosecution History

The application that led to the ’822 patent was filed May 8, 2011. Ex. 1022, 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. 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

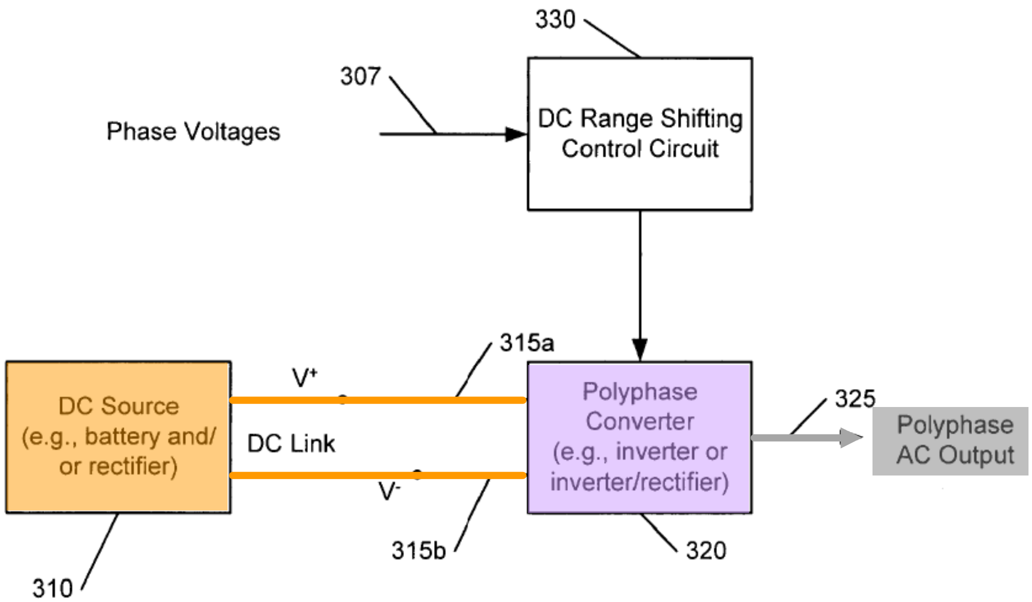
N to be 1, 2 or 3[,] I have left it equal to the number of unique phases recited in claim 1." *Id.* The examiner allowed the claims based on the prior art allegedly lacking the feature "wherein the second repetition frequency is multiple equal to the same said number N of said first repetition frequency." *Id.*, pp. 357-361. The prior art cited herein was not cited during prosecution, and none is cumulative to the art relied upon by the examiner. Tracy, the primary reference relied on herein, discloses an inverter with a floating DC supply voltage, 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 outputs of an inverter for conditioning the outputs for reactive loads. Ex. 1002, ¶¶ 80-90; Ex. 1001, cover; Ex. 1047, Abstract; Ex. 1048, Fig. 1, 1:19-34.

C. Scope and Content of the Prior Art

1. U.S. Patent No. 7,088,601 ("Tracy") (Ex. 1005)

Tracy issued on August 8, 2006, making it prior art under 35 U.S.C. § 102(b).[1] Tracy describes a three-phase inverter (*e.g.*, 320) (**purple**) that converts power from a DC source (a rectifier or battery) (**orange**) to an AC output (**grey**).

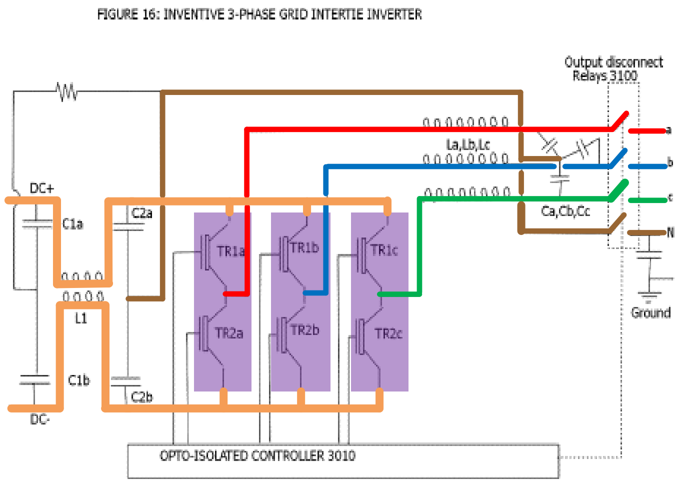
[1] Citations to 35 U.S.C. §§ 102 and 103 refer to pre-AIA versions.



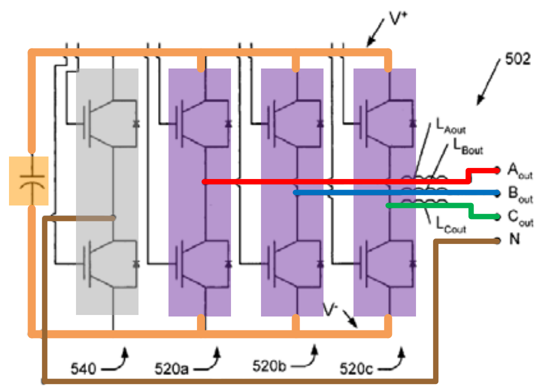
Ex. 1005, Fig. 3 (annotated)

Id., Fig. 5, Abstract, 1:26-3:35, 4:50-5:16, 5:41-7:61, 9:12-10:60; Ex. 1002, ¶¶ 184-186. Tracy, like the '822 patent, uses three half-bridge circuits (520a, 520b, 520c) (**purple**) to output an AC output (Aout, Bout, Cout) (**red**, **blue**, **green**) relative to a neutral terminal (N) (**brown**).[2] *Compare* Ex. 1005, 5:53-6:58 *with* Ex. 1001, 26:22-28:14; Ex. 1002, ¶ 187.

[2] Tracy also discloses an optional additional half-bridge 540 (**grey**) connected to neutral.

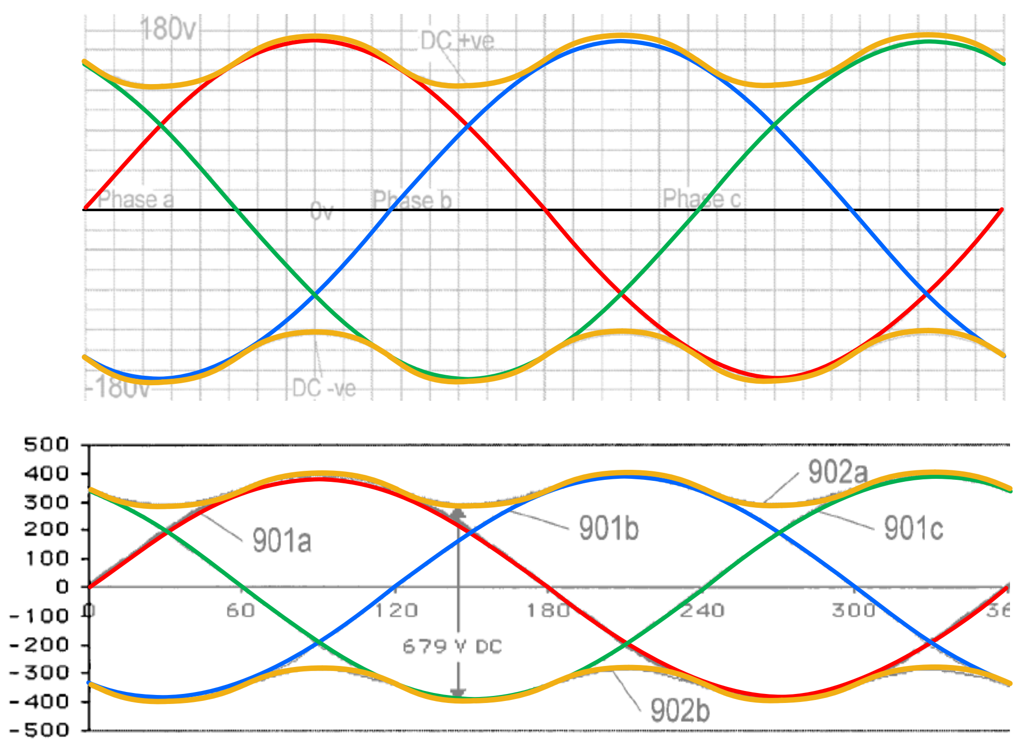


Ex. 1001, Fig. 16 (annotated)



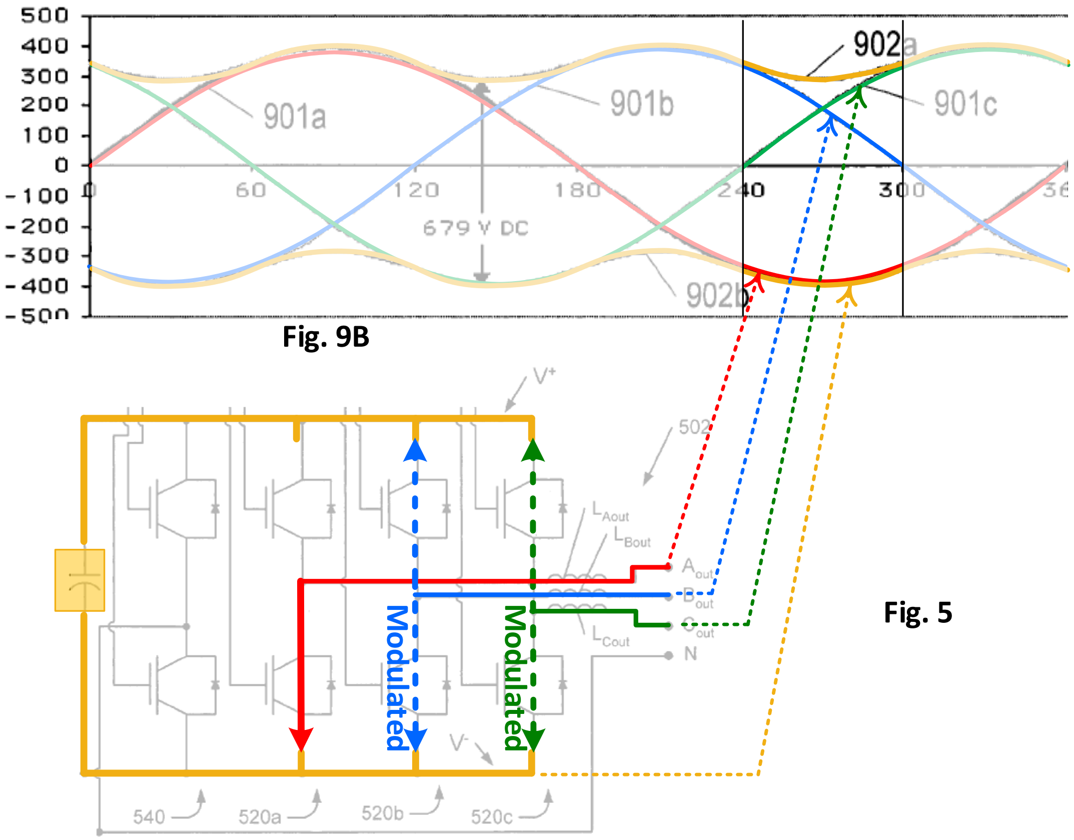
Ex. 1005, Fig. 5 (annotated)

Tracy's inverter generates the same three phase outputs (**red**, **blue**, and **green**) having unique phases (0/120/240 degrees), and the same common-mode voltage (**orange**) on both DC inputs, as the '822 patent inverter. Ex. 1005, 5:44-7:61, 9:12-10:60; Ex. 1001, 26:22-28:14, 4:46-52, Abstract; Ex. 1002, ¶ 188.



Ex. 1001, Fig. 23 (top); Ex. 1005, Fig. 9B (bottom) (annotated)

Tracy and the ’822 patent disclose the same switching pattern, which Tracy describes as adding a “zero sequence (common-mode)” offset to the DC voltages. Ex. 1005, Fig. 9B, 7:8-61, 8:58-10:28, 10:42-57; Ex. 1045, p. 943; Ex. 1056, pp. 39-40; 1057, pp. 1-2; Ex. 1064, 51-57, 302-310; Ex. 1065, 51-57, 323-337, 385-398. To add the offset, Tracy applies “discontinuous modulation” (*e.g.*, as shown in the 240-300 degree interval below) so that “one phase is held continuously to one of the DC voltage busses” (*e.g.*, Aout (**red**) connected to DC- (**orange**)) while the other two phases (*e.g.*, Bout (**blue**) and Cout (**green**)) are modulated between the DC inputs. Ex. 1005, 10:25-27; Ex. 1002, ¶ 189.

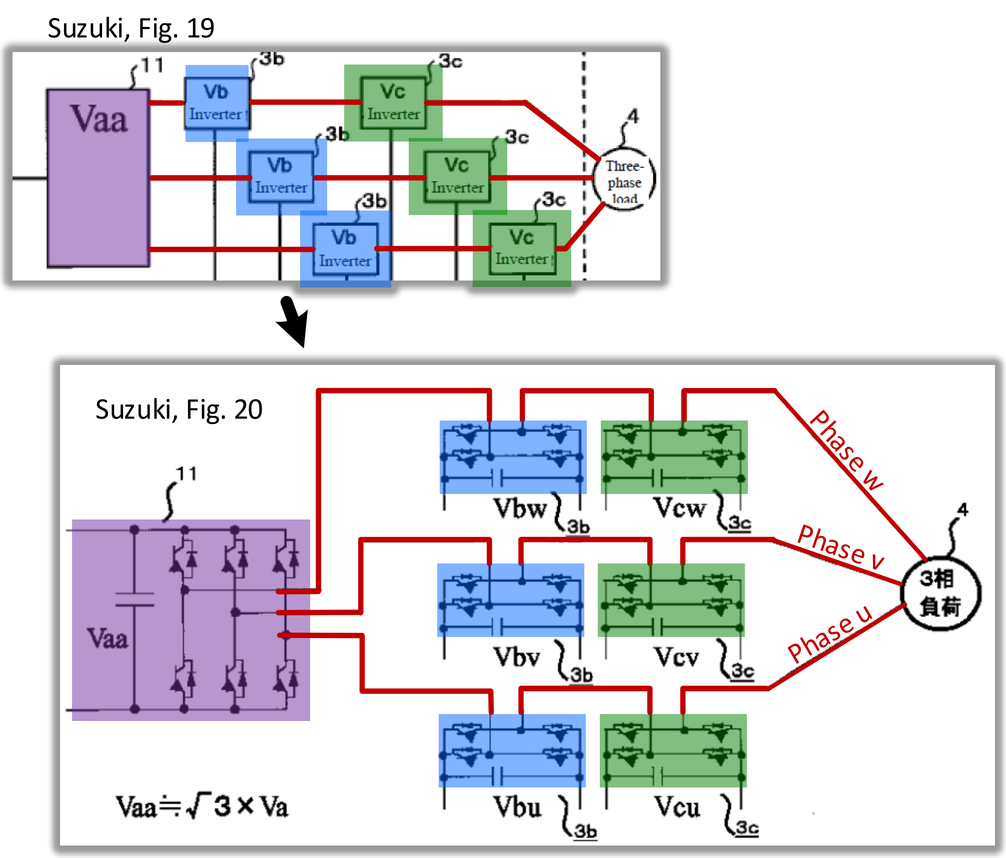


Ex. 1005, Figs. 9B (top), 5 (bottom) (cropped and annotated)

The pattern rotates every successive 60 degree interval, so for example, in the next interval phase Cout (**green**) is connected to the DC+ input while Aout and Bout are modulated. Ex. 1002, ¶ 190; *see* Section III.A, *supra*.

2. Japanese Pat. App. Pub. No. P2004-7941A ("Suzuki") (Ex. 1030, Ex. 1031)

Suzuki (Ex. 1030, certified translation Ex. 1031) is a Japanese Patent Application published on January 8, 2004, making it prior art under 35 U.S.C. § 102(b). Suzuki discloses multiple variations of single-phase and three-phase "multiplex" power inverters that are built from multiple individual inverters with outputs that are connected in series:



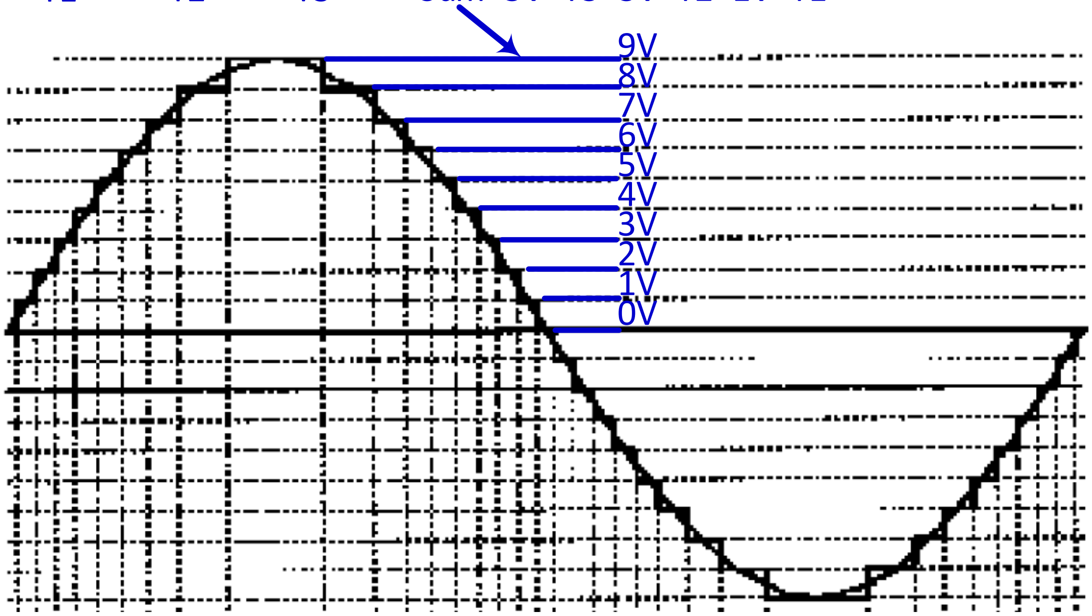
Ex. 1031, Figs. 19 (annotated), 20 (annotated)

Id., ¶¶ [0016]-[0019], [0031]-[0032]; Ex. 1002, ¶¶ 191-193.

One version includes a three-phase half-bridge inverter (**purple**), with each of its phase outputs (u, v, w) connected in series **(red**) with the outputs of two H-bridge inverters (**blue** and **green**). Ex. 1031, ¶¶ [0016]-[0019], [0031]-[0032]. Each inverter generates a different output voltage (Va, Vb, and Vc), which are multiplied by ternary digits—+1, -1, and 0 for outputting a positive, negative, and zero DC voltage, respectively. Ex. 1031, ¶¶ [0016]-[0019], Fig 4. The output voltages are scaled to different values (e.g., 1V, 3V, 5V), and combined to generate a sequence of steps approximating an AC output waveform.

1	3	5	
Va	Vb	Vc	Gradation level
0	0	0	0
1	0	0	1
-1	1	0	2
0	1	0	3
1	1	0	4
0	0	1	5
1	0	1	6
-1	1	1	7
0	1	1	8
1	1	1	9

T1 T2 T3 Sum=5V*T3+3V*T2+1V*T1

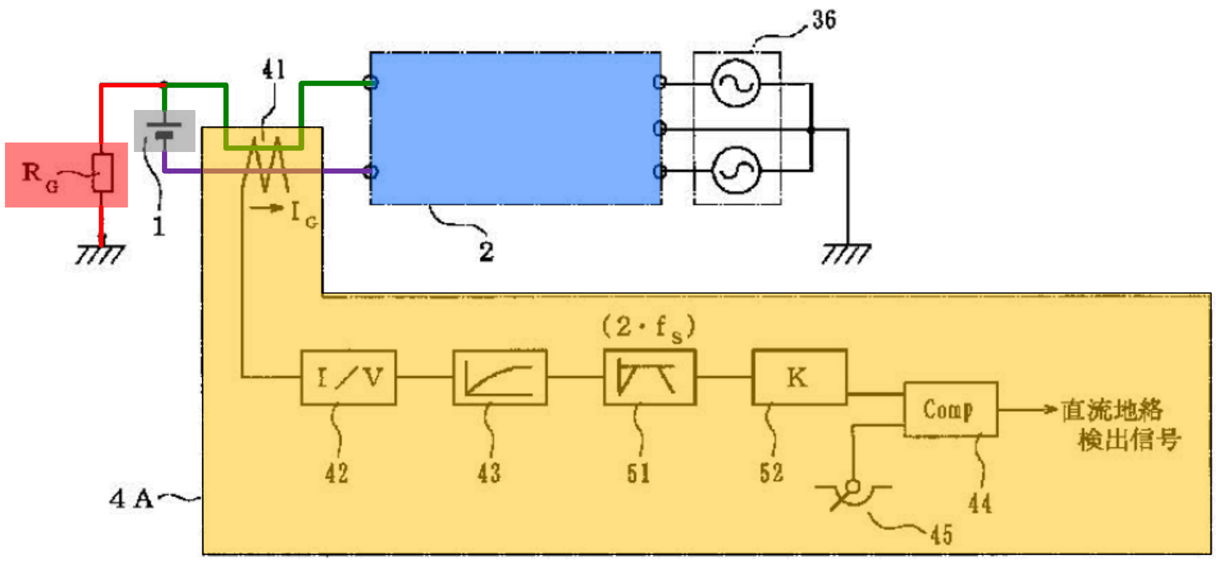


Ex. 1031, Fig. 4G (annotated), 5(b) (annotated).

Id., ¶¶ [Summary], [0018]-[0019]; Ex. 1002, ¶¶ 194-195.

3. Japanese Pat. App. Pub. No. JP 11-122819 (“Fujimoto”) (Ex. 1033, Ex. 1034)

Fujimoto (Ex. 1033, certified translation Ex. 1034) is a Japanese patent publication that published on April 30, 1999, making it prior art under 35 U.S.C. § 102(b). Fujimoto describes a DC ground fault detector (**orange**) inserted at current transformer 41 in the positive (**green**) and negative conductors (**purple**) between Fujimoto's DC power supply 1 (**grey**) and inverter 2 (**blue**):



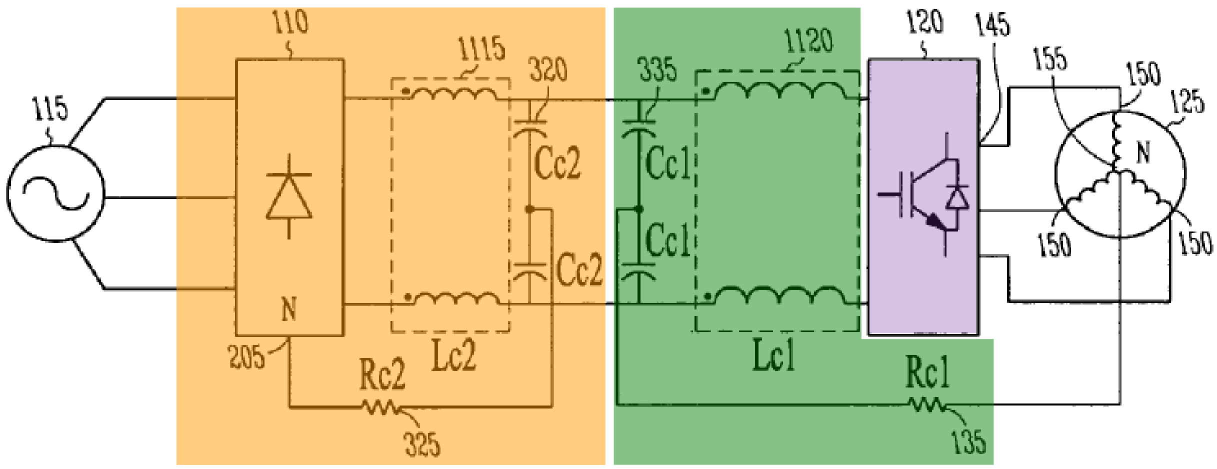
Ex. 1034, Fig. 1 (annotated)

Id., ¶¶ [0005], [0008], [0010], Fig. 3; Ex. 1002, ¶¶ 196-198. In the event of a ground fault R_G (**red**), a "common current" I_G is induced with an AC component (I_{ac}) at twice the frequency of the AC output waveform of the inverter, which is detected by the DC ground fault detector. Ex. 1034, ¶¶ [0004]-[0007], [0010]-[0011]; Ex. 1002, ¶ 199.

4. U.S. Pat. App. Pub. No. 2007/0278988 ("De") (Ex. 1018)

De, published on December 6, 2007, is prior art under 35 U.S.C. § 102(b).

De discloses a common-mode filter (**green**), including a common-mode inductor 1120 and capacitors 335, connected between DC input terminals of an inverter 1 (**purple**) and positive and negative terminals of DC power source 5 (**orange**). Ex, 1018, ¶¶ [0020], [0033]-[0034], Figs. 11-12; Ex. 1002, ¶¶ 200-203.



Ex. 1018, Fig. 12 (annotated)

5. U.S. Patent No. 6,112,158 ("Bond") (Ex. 1035)

Bond issued on August 29, 2000, making it prior art under 35 U.S.C. § 102(b).

Bond discloses a watt-hour metering device 10 (**yellow**) with a utility120V/208V four-wire wye service-type connection with neutral at the center of the wye, and with power lines 12 (**blue**), 14 (**red**), and 16 (**green**)) delivering current Ia (**blue**), Ib (**red**), and Ic (**green**) at unique phases spaced 0, 120 and 240 degrees apart:

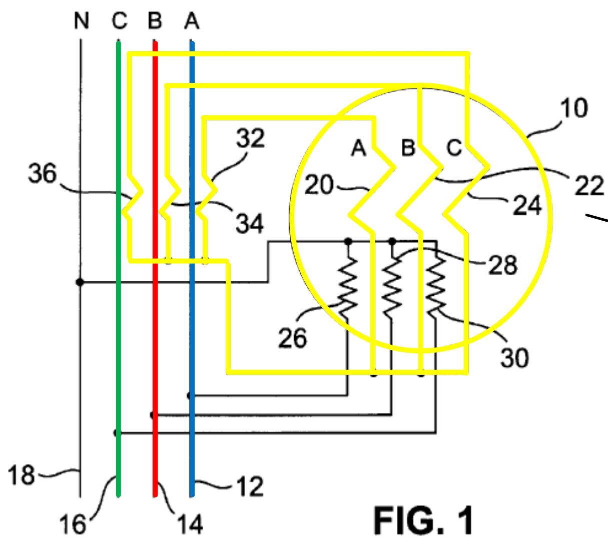
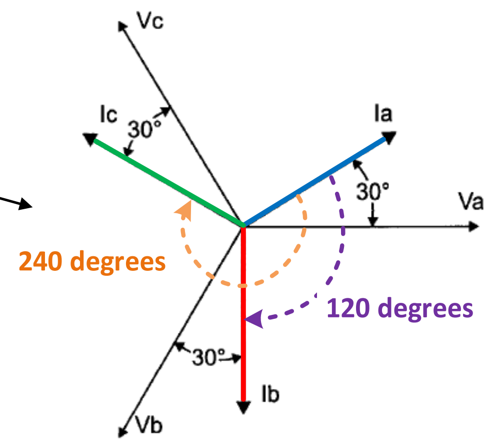


FIG. 1



Ex. 1035, Figs. 1, 1a (annotated)

Id., 1:10-22, 1:26-49, 2:55-58, 3:16-23, 3:41-49, 4:4-11, 4:27-58 (table 2), 10:9-11; Ex. 1002, ¶¶ 204-208.

6. U.S. Patent No. 5,029,064 ("Ball") (Ex. 1032)

Ball issued on July 2, 1991, making it prior art under 35 U.S.C. § 102(b). Ball discloses a bidirectional power converter (two examples shown below) with a single transformer (**orange**) that transfers power between multiple bi-directional ports that include one fixed DC voltage port (**blue**) and any combination of other fixed DC (**blue**), variable DC (**green**), AC (**red**), and AC/DC combination (**purple**) voltage ports:

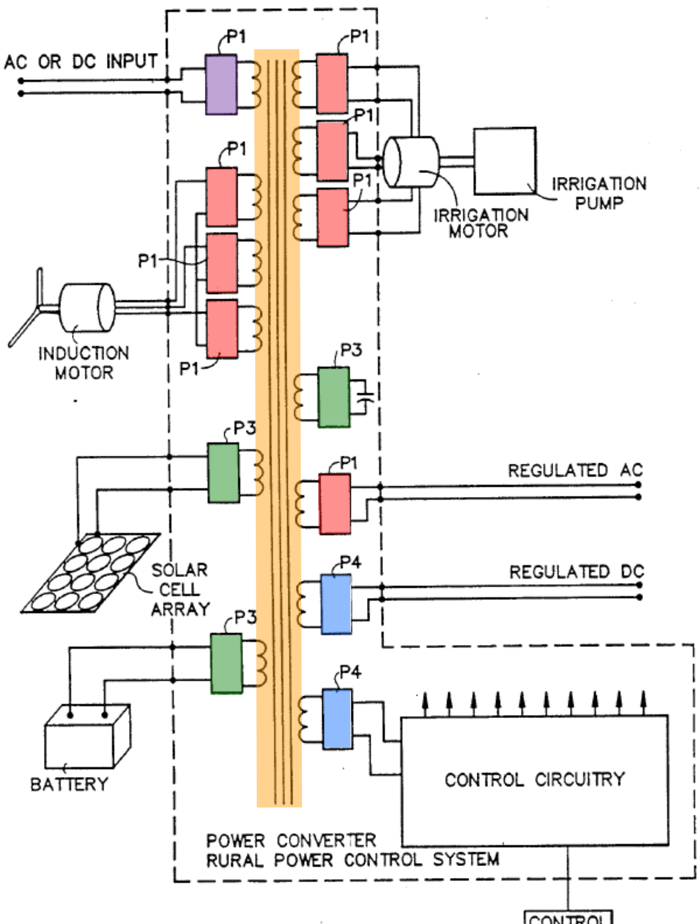


FIG. 22

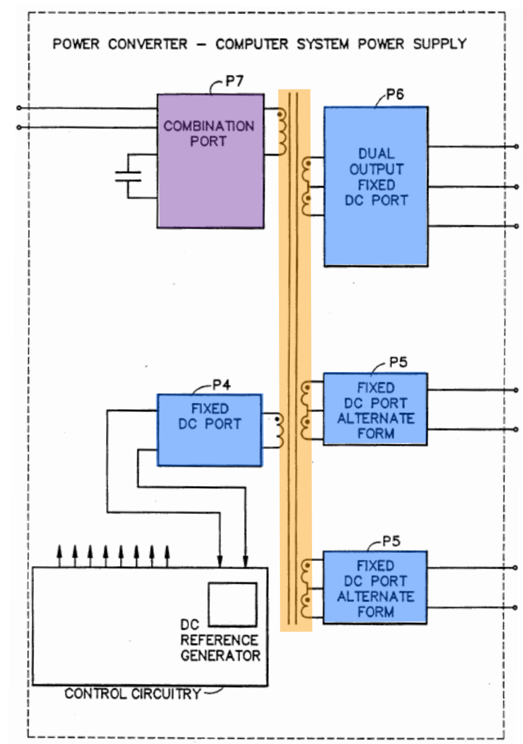


FIG. 20

Ex. 1032, Figs. 22 (left, annotated), 20 (right, annotated)

Id., 11:65-12:4, 19:52-61, 21:20-65, 36:64-68, 37:17-20, 40:41-46, 42:7-52, 50:20-30, 53:20-26; Ex. 1002, ¶¶ 209-211.

The fixed DC voltage port, which is connected to a DC power source (a battery), generates an equal-duty-cycle square wave within the transformer, and each remaining port locks on to this square wave to convert power (AC, DC, or both) at its port terminals to/from the square wave at the transformer winding. Ex. 1032, 12:5-27, 13:9-23, 22:12-48, 31:44-32:11, 32:52-33:8, 34:43-35:4, 43:31-38, 44:34-60, 52:22-32, 52:53-62; Ex. 1002, ¶¶ 212-213.

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

Petitioner requests review of claims 1–13 and 20 on the following grounds and references.

Grounds	References	Basis	Claims Challenged
1	Tracy	102	1-3, 8-10
2	Tracy	103	1-3, 8-10
3	Tracy-Fujimoto	103	4, 11
4	Tracy-De	103	6, 20
5	Tracy-Bond	103	7
6	Tracy-Suzuki-Ball	103	5, 12, 13

Unpatentability of the challenged claims is demonstrated by a preponderance of the evidence, including Dr. Baker's expert testimony (*e.g.*, Ex. 1002, ¶¶ 1-60, 131-183, 214-215, 381-384), and Dr. Mullins' expert testimony proving authenticity and public availability prior to May 8, 2011 of certain exhibits. Ex. 1023, ¶¶ 1-40, 41-65 (Ex. 1010), 66-79 (Ex. 1012), 232-248 (Ex. 1015), 268-285 (Ex. 1017), 80-93 (Ex. 1019), 130-154 (Ex. 1041), 214-231 (Ex. 1044), 249-267 (Ex. 1046), 332-353 (Ex. 1052), 193-213 (Ex. 1053), 172-192 (Ex. 1054), 155-171 (Ex. 1055), 308-331 (Ex. 1056), 94-111 (Ex. 1064), 112-129 (Ex. 1065), 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. 1002, ¶¶ 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. 1002, ¶¶ 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. 1001, cl. 1; Ex. 1002, ¶ 99.

The corresponding structures include four different inverter circuits. One inverter circuit, depicted in Figures 1 and 10, includes a plurality of H-bridge switches with series-connected outputs and with inputs of each H-bridge switch connected to a different voltage source. Ex. 1001, 6:17-26, Figs. 1, 10; Ex. 1002, ¶¶ 100-104.

Another, in Figure 16, 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. 1001, Fig. 16; Ex. 1002, ¶ 106.

Two other structures are illustrated in Figures 15 and 24. Ex. 1002, ¶¶ 105, 107-108. Figure 15 includes a single H-bridge switch with a single-phase output connected through an inductor. Ex. 1001, 23:27-44, Fig. 15. The Figure 24 structure is the same as in Figure 16, but with three additional H-bridge switches, each connected to a different one of the voltage phase outputs. Ex. 1001, 29:25-67, Fig. 24.

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. 1001, cls. 2, 5; Ex. 1002, ¶ 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. 1001, 12:26-51, 24:8-12; Ex. 1002, ¶¶ 119-124.

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. 1001, cl. 4; Ex. 1002, ¶ 109. The corresponding structure is a current transformer including toroid 800 with a toroidal winding 801. Ex. 1001, 25:57-59, 31:65-32:20, 35:66-36:3, 41:21-22, Fig. 18; Ex. 1002, ¶¶ 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.

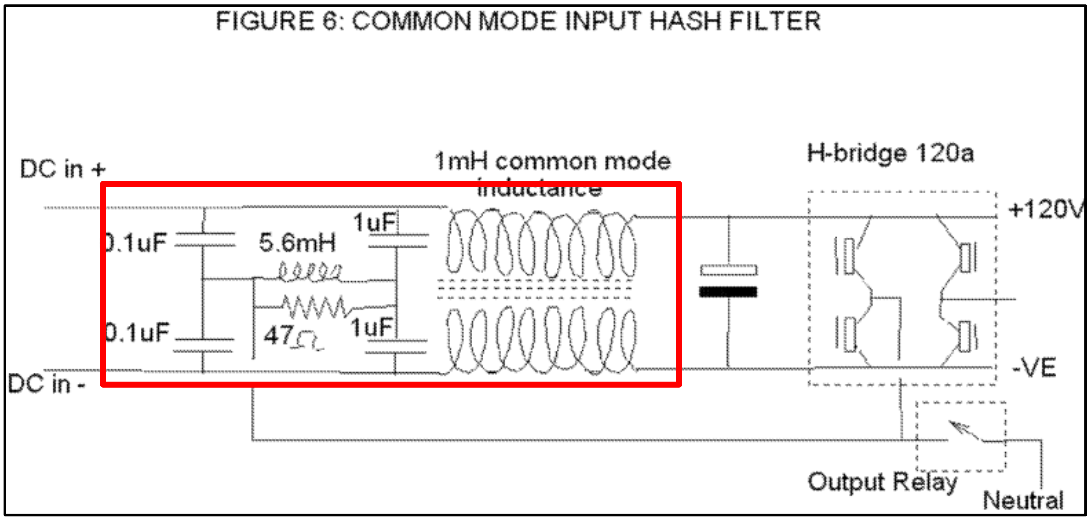
Ex. 1001, cls. 5, 13.

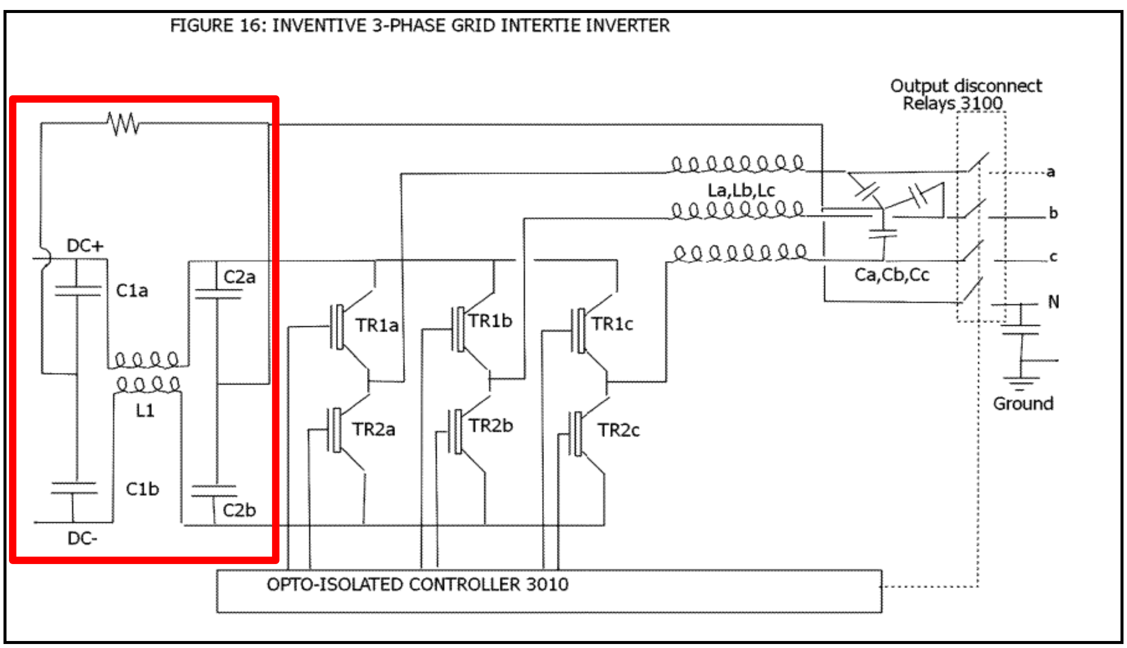
The corresponding structure for both claims is one or more transformers with windings that have turn ratios in proportion to the voltage ratios being output, where each winding corresponding to a floating supply is center tapped (or an equivalent structure). *Id.*, 15:29-34, 18:34-47, 19:5-23, Figs. 2, 10; Ex. 1002, ¶¶ 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. 1001, cl. 6; Ex. 1002, ¶¶ 114-116. The corresponding structure is a filter comprising capacitors, inductors, and resistors arranged as shown in Figures 6 and 16 of the patent:





Ex. 1001, Figs. 6 (annotated), 16 (annotated), 18:18-33; Ex. 1002, ¶¶ 115-118.

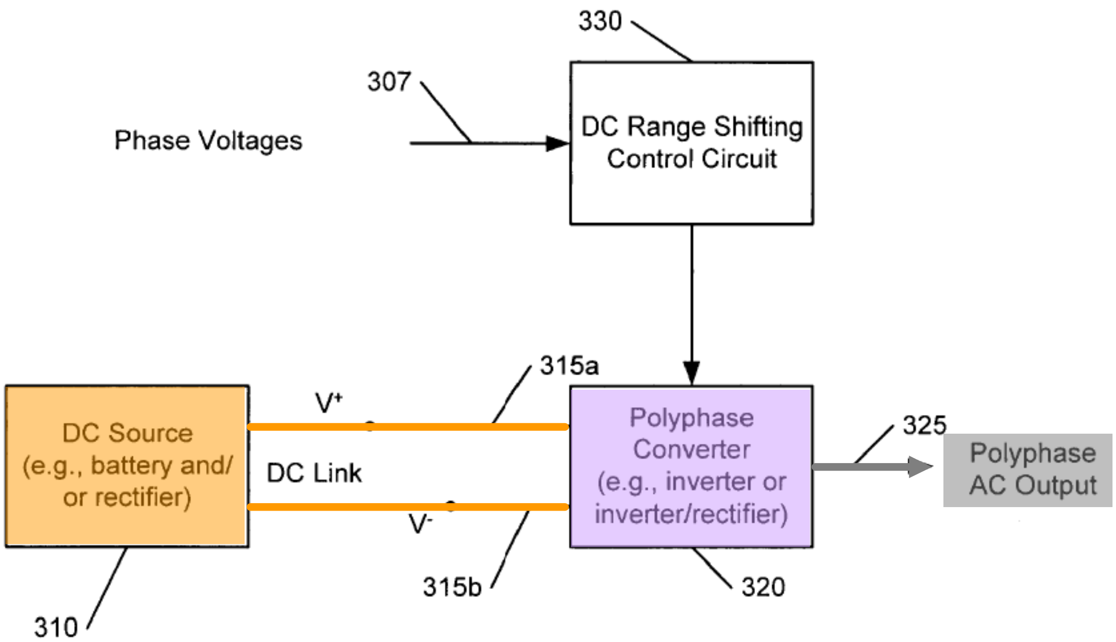
V. SPECIFIC GROUNDS FOR UNPATENTABILITY

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

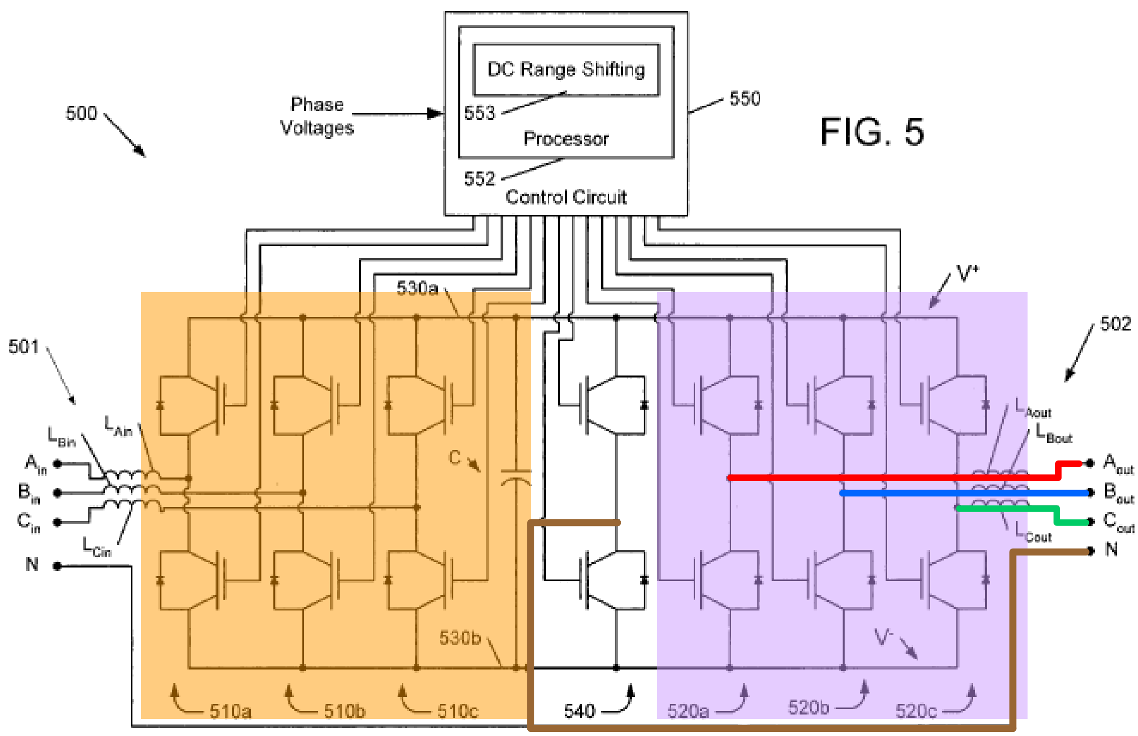
1. Independent Claim 1

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"

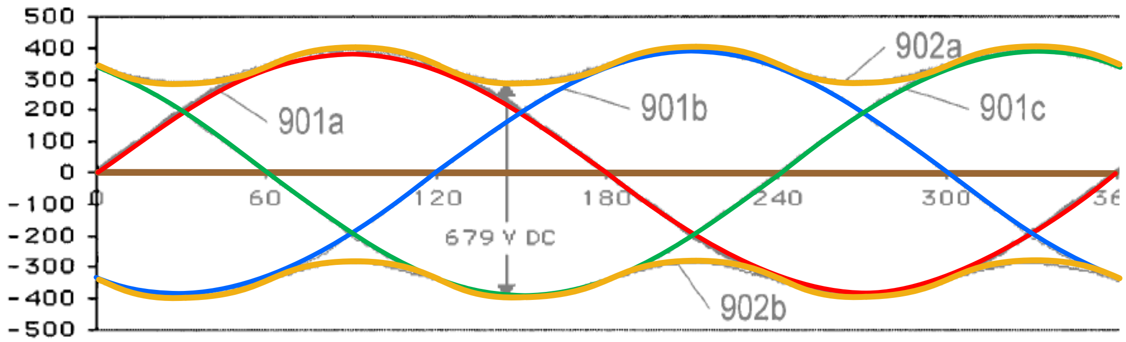
To the extent the preamble is limiting, Tracy discloses it. Ex. 1002, ¶¶ 216-218. Tracy describes a three-phase DC/AC converter (*e.g.*, 320) (**purple**) that converts power from a DC source (*e.g.*, 310) (**orange**) to a polyphase AC output (**grey**) as shown in Figures 3, 5, and 9B annotated below. Ex. 1005, Abstract, 1:26-3:35, 4:4-5:16, 5:44-7:61, 9:12-10:60, Figs. 3-5, 9B; Ex. 1002, ¶¶ 218-219. The output includes three phase outputs (Aout, Bout, Cout) (**red**, **blue**, **green**) (each a claimed "power output waveform at a first repetition frequency") relative to a neutral terminal (**brown**). *Id.*; Ex. 1002, ¶¶ 218-221.



Ex. 1005, Fig. 3 (annotated)



Ex. 1005, Fig. 5 (annotated)



Ex. 1005, Fig. 9B (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"

Tracy discloses three live AC output terminals Aout, Bout, Cout, (**red**, **blue**, **green**), and an output terminal designated as neutral N (**brown**). Ex. 1005, Abstract, 1:55-64, 4:59-67, 5:6-13, 5:24-26, 5:64-6:6, 7:8-14, 10:49-57, Figs. 3-5, 9B; Ex. 1002, ¶¶ 222-225.

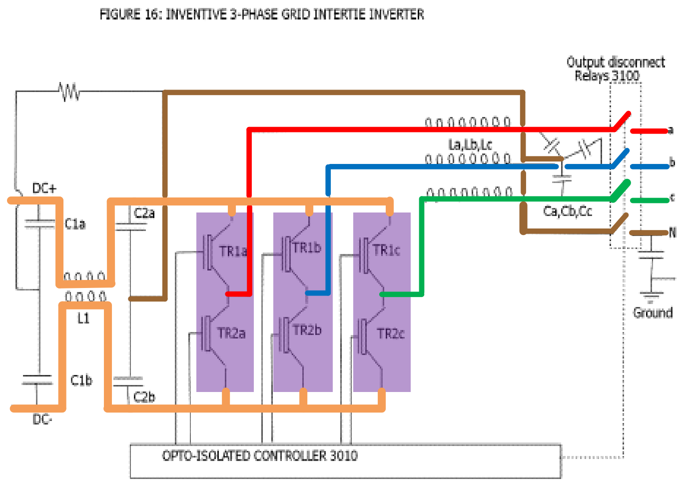
c. [1D]: "a floating DC power source having a positive and a negative terminal connected respectively to the positive and negative DC input terminals of a DC to AC converter"

Tracy's DC source (*e.g.*, Battery 310) has positive and negative terminals connected respectively to positive and negative DC input terminals of the inverter, and Tracy's DC source is floating because its terminals are connected only to the inputs of the half-bridge switches (*e.g.*, 315a/b, 520a-c, 540) and are isolated (not "permanently connected" as described in the '822 patent) from any established potential such as the neutral terminal N (**brown**). Ex 1005, 4:52-59, 5:11-16, 5:55-

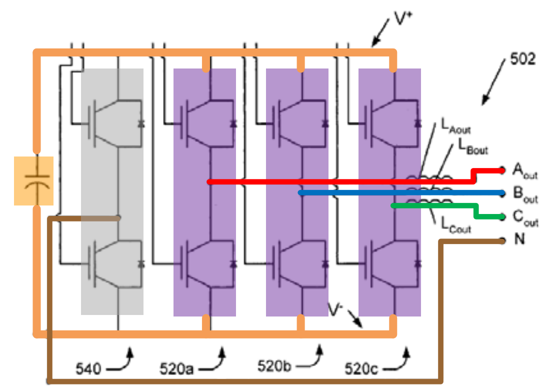
6:3, 23:38-41; Ex. 1001, 23:38-41, Figs. 3, 5; Ex. 1036, 6; Ex. 1042, 6; Ex. 1002, ¶¶ 226-228.

To the extent Patent Owner argues that Tracy does not disclose a "floating" DC source, this would have been obvious, since connecting the DC source to a ground (other than through Tracy's H-bridges) would have created a ground fault for common-mode current caused by Tracy's common-mode voltage waveform (*see* Section V.A.1.e, *infra*), resulting in electromagnetic interference and potential fire hazards, and incompatibility with ground fault protection and grounding requirements of government safety standards. Ex. 1019, pp. 14-15; Ex. 1024, ¶¶ [0039], [0048], [0050]; Ex. 1034, ¶¶ [0004]-[0005]; Ex. 1041, pp. 943; Ex. 1010, pp. 1-2; Ex. 1002, ¶ 229.

To the extent "DC to AC converter" is a means plus function term, Tracy's inverter is identical to or insubstantially different from the '822 patent's inverter structure (compared below), because both convert DC power (**orange**) using three half-bridge circuits (**purple**) to output three phases (**red**, **blue**, **green**) relative to a neutral terminal (N) (**brown**). *Compare* Ex. 1005, 5:53-6:58 *with* Ex. 1001, 26:22-28:14; Ex. 1002, ¶ 231.



Ex. 1001, Fig. 16

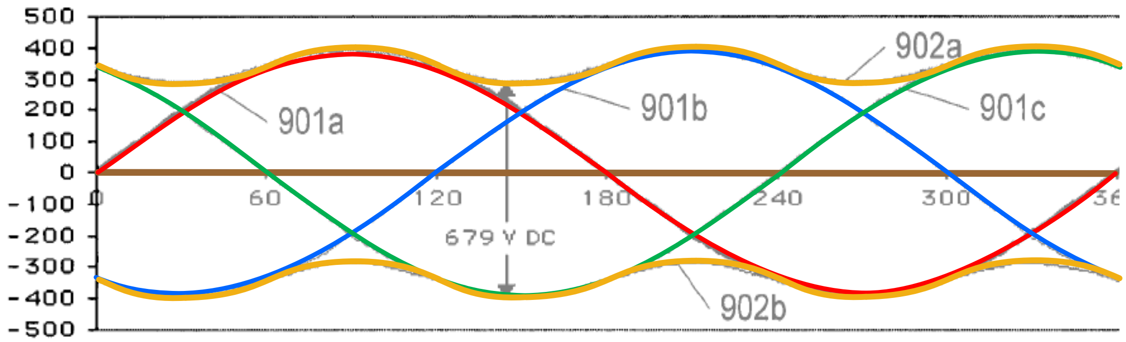


Ex. 1005, Fig. 5

As discussed below (*see* Sections V.A.1.d-V.A.1.e, *infra*), Tracy's inverter performs the same function recited in elements [1E] and [1F] in the same way (using half-bridge switches) for the same result (an AC sinewave output and a common-mode waveform on the input). Ex. 1002, ¶¶ 230-231.

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, and"

Tracy discloses this element. Ex 1005, Figs. 7, 9B, 7:8-61, 10:42-60. Tracy's inverter generates three sine wave voltages (**red**, **blue**, and **green**) (an "AC output waveform at said first repetition frequency") relative to neutral (**brown**) with unique phases (0/120/240 degrees) to appear at each of the three ("N" = 3) live AC output terminals.

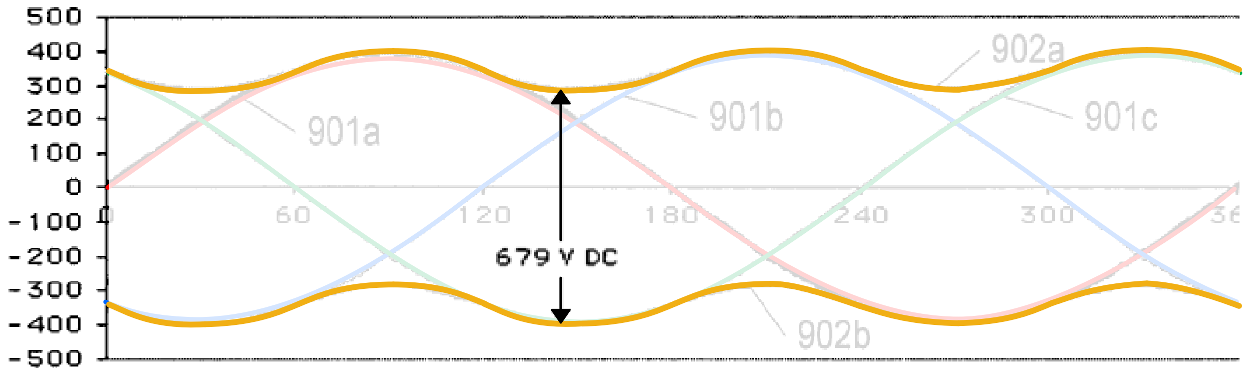


Ex. 1005, Fig. 9B (annotated)

Ex. 1002, ¶¶ 232-233; Ex. 1005, 5:64-6:3, 6:11-20, 6:34-49, 10:42-60.

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."

Tracy discloses this element. The control circuit of Tracy conforms the voltages on the DC input lines to an envelope (**orange**) defined by the positive and negative extrema of the three-phase voltages by reducing the voltage between the DC input lines from two times the AC output voltage relative to neutral (*e.g.*, 784V) to the maximum difference (*e.g.*, 679V) between the phase voltages and adding a "zero sequence (*i.e.*, common mode)" reference with respect to the neutral N terminal.



Ex. 1005, Fig. 9B (cropped and annotated)

Id., 7:8-17; *see also* Ex. 1005, 2:52-3:14, 6:50-7:61, 8:58-65, 10:42-57; Ex. 1056 at 23-26; Ex. 1057 at 1-6; Ex. 1064, 51-57; Ex. 1065, 51-57; Ex. 1002, ¶¶ 181-182, 234-235.

In every 60 degree interval, "one phase is held continuously to one of the DC voltage busses," which causes the common-mode waveform to undulate with a second repetition frequency that is three times (for "N" =3) the first repetition frequency of each voltage phase (due to the voltage phases being offset 120 degrees). The common-mode waveform appears with the same phase on both DC input lines. Ex. 1005, Fig. 9B, 5:64-6:3, 6:11-20, 6:34-49, 10:42-60; Ex. 1002, ¶¶ 236-237.

2. 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, Tracy discloses it. As previously explained (*see* Section V.A.1.a, *supra*), Tracy describes an inverter that converts power from a DC source (*e.g.*, a battery or rectifier) to AC output power with three phases on three output terminals (the claimed "number of output terminals corresponding to the number of phases required"). Ex. 1005, Abstract, 1:26-3:35, 4:50-5:16, 5:44-7:61, 9:12-10:60, Figs. 3-5, 9A-E; Ex. 1002, ¶¶ 247-255.

Tracy's inverter "improve[s] conversion efficiency" and is interfaced to a "480/227 Y" three-phase output in a "conventional" uninterruptible power supply connected to a utility grid. Ex. 1005, 1:10-47, 3:38-42, 5:11-24, 10:42-11:28, 12:5-8; Ex. 1002, ¶¶ 251-252. A PHOSITA would have understood that a utility grid operates at a standard voltage and frequency and that "480/227 Y" refers to the same standard referred to in the '822 patent, which is a three-phase interface for utility grids in the United States operating at a 60Hz frequency with voltages of 480 volts between any two phases and 227 volts between each phase and the neutral (the claimed "standard voltage and frequency"). Ex. 1002, ¶ 252; Ex. 1001, 37:38-43 ("US 277/480-volt service"), 17:51-52 ("60 Hz AC (in the US)"); Ex. 1037, Fig. 1, 2:43-57; Ex. 1038, ¶ [0057]; Ex. 1039, Figs. 1, 4-5, 1:25-29, 3:9-18; Ex. 1040, Fig. 3, 1:40-57, 5:42-44, 6:13-18; Ex. 1049, ¶¶ [0145], [0148].

To the extent Tracy does not disclose a standard 60Hz frequency and standard 480/227 Y voltage, this would have been obvious, since any utility grid's voltage and frequency are standards by which all systems connected to the grid must operate, and because, as the '822 patent admits, this voltage and frequency is known to be used in the United States. Ex. 1002, ¶ 253; Ex. 1001, Fig. 9A, 17:35-65 ("60 Hz AC (in the US)"), 37:38-43 ("US 277/480-volt service").

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

Tracy's DC source (*e.g.*, battery 310) is floating (or would obviously be floating) because its terminals are connected only to the inputs of the half-bridge switches (*e.g.*, 315a/b, 520a-c, 540) in the inverter and are isolated (not "permanently connected" as described in the '822 patent) from any established potential such as the neutral terminal. *See* Section V.A.1.c, *supra*; Ex 1005, Fig. 3 (battery 310), 5:11-16; Ex. 1001, 23:38-41; Ex. 1036, p. 6; Ex. 1002, ¶¶ 256-258.

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

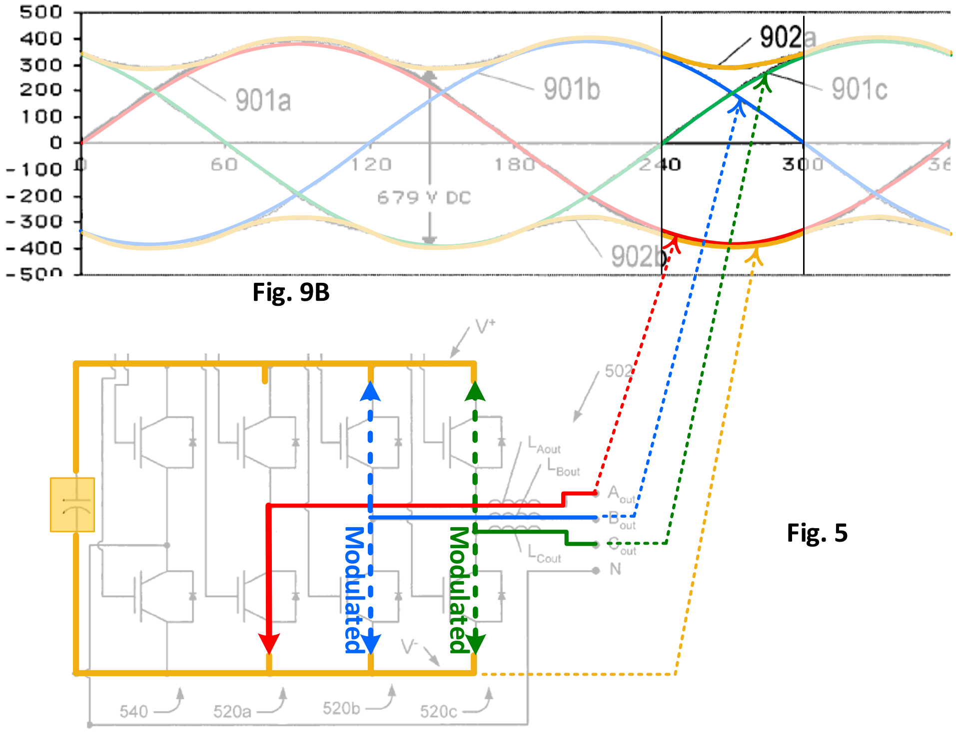
while deriving from the negative line of the direct current source the instantaneous voltages relative to said next-in-sequence terminal required to be output from the other terminals"

Tracy discloses this limitation. As previously discussed , Tracy's inverter generates three voltage outputs with unique phases, and a common-mode voltage waveform (a "zero sequence" offset) on the DC input lines (902a-b). *See* Section

V.A.1.d, V.A.2.d, *supra*; Ex. 1005, Fig. 9B, 2:52-3:14, 5:64-6:3, 6:11-20, 6:34-7:61, 8:58-65, 10:42-60; Ex. 1002, ¶¶ 259-261.

As previously discussed (Section V.A.1.e ([1d]), *supra*), the control circuit of Tracy reduces the voltages on the DC input lines to the maximum difference (*e.g.*, 679V) between the phase voltages, and shifts the DC voltages with a common-mode offset so that the DC+ and DC- voltages conform to an envelope of the three phase voltages, such that one of the output phases equals the positive or negative DC input lines in each 60 degree interval. Ex. 1005, 2:48-51, 10:49-60; Ex. 1002, ¶¶ 261-264.

For example, in the interval between 240 and 300 degrees as shown below, Tracy's signal generator circuit 730 applies "discontinuous modulation" to half bridge 520a so that "one phase is held continuously to one of the DC voltage busses" (*e.g.*, the most negative phase Aout (**red**) is connected to DC- (**orange**)):

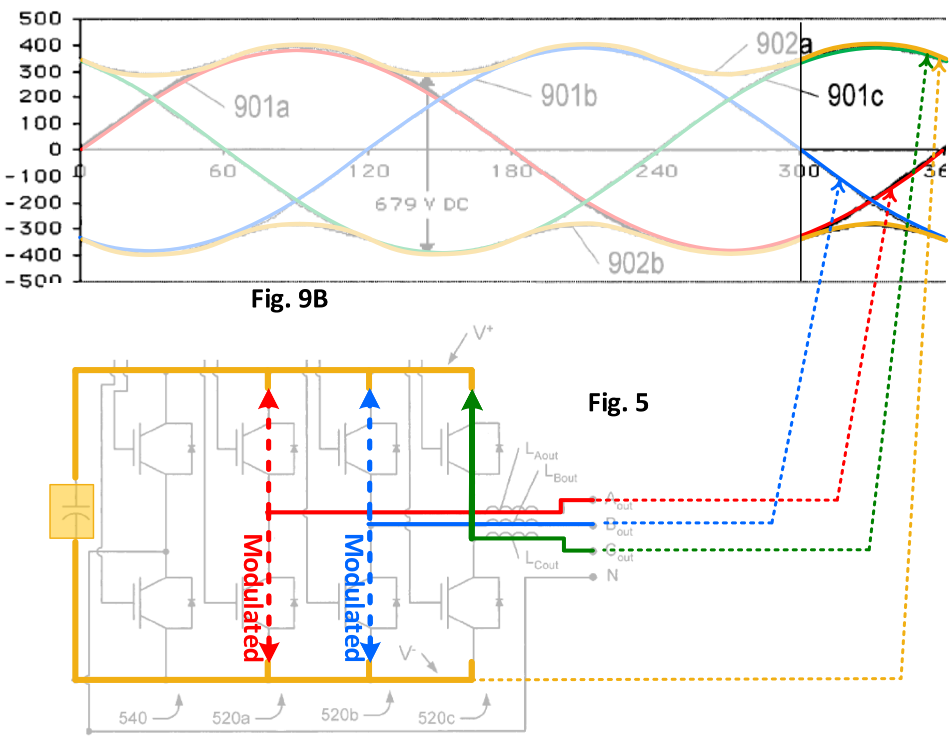


Ex. 1005, Figs. 5 (bottom, annotated), 9B (top, annotated)

Id., 2:10-15, 7:7-20, 10:6-28, 12:50-55, 14:46-51, 15:21-22; Ex. 1002, ¶¶ 261-264; *compare* Section III.A.2, *supra*. Tracy thus discloses "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." Ex. 1002, ¶ 264.

Signal generator circuit 730 generates the instantaneous voltages of other two phase outputs (Bout (**blue**) and Cout (**green**)) by pulse-width-modulating half-bridges 520b and 520c between the DC+ and DC- inputs, thus disclosing "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." Ex. 1002, ¶¶ 263-264; Ex. 1005, Figs. 5, 9B, 8:58-9:11; *see also* Ex. 1005, 2:1-15, 2:59-3:20, 7:21-61, 8:16-29, 9:12-10:5, 13:41-14:2, 14:43-45, 16:17-20.

The pattern rotates every successive 60 degree interval through the entire waveform by connecting (discontinuously modulating) the next phase in the sequence to the opposite DC input terminal. Ex. 1002, ¶ 265. For example, in the next interval between 300 and 360 degrees as shown below, phase Cout (**green**) is connected to the DC+ input while phases Aout (**red**) and Bout (**blue**) are pulse-width-modulated between the DC+ and DC- inputs:



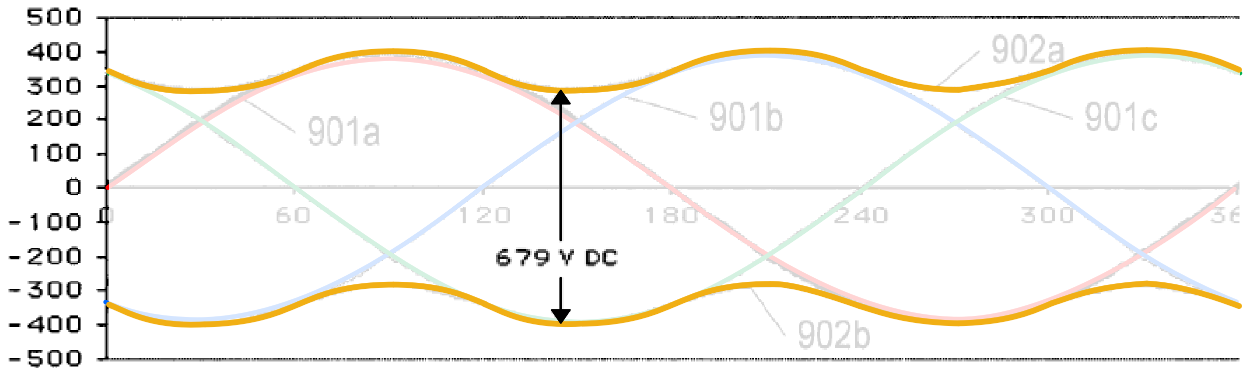
Ex. 1005, Figs. 5 (bottom, annotated), 9B (top, annotated)

Ex. 1002, ¶¶ 265-266; Ex. 1005, 2:1-15, 2:59-3:20, 7:7-61, 8:16-29, 8:58-10:28, 12:50-55, 13:41-14:2, 14:43-51, 15:21-22, 16:17-20. Tracy thus discloses "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." Ex. 1002, ¶¶ 266-267.

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."

Tracy discloses this limitation. As previously explained (*see* Sections V.A.1.e ([1d]), V.F.1.c ([8c]), *supra*), Tracy's inverter reduces the voltages on the DC input lines to the maximum difference (*e.g.*, 679V) between the phase voltages, and shifts the DC voltages with a common-mode ("zero sequence") offset so that the DC+ and DC- voltages conform to an envelope of the three phase voltages, with the positive or negative DC input lines alternatively equaling one of the output phases in a rotating sequence every 60 degrees. Ex. 1005, Figs. 7, 9B, 2:48-3:14, 5:64-6:3, 6:11-20, 6:34-7:61, 8:58-65, 10:49-60; Ex. 1002, ¶¶ 268-269.

The sequence is such that a common-mode waveform (**orange**) appears with the same phase (*i.e.*, is "in phase") on both DC input lines and has a characteristic frequency (which is 3 times the frequency of each phase due to the phases being offset 120 degrees).



Ex. 1005, Fig. 9B (cropped and annotated)

Id., 5:64-6:3, 6:11-20, 6:34-49, 10:42-60; Ex. 1043, p. 4; Ex. 1042, p. 4; Ex. 1036, p. 4; Ex. 1002, ¶¶ 269-271.

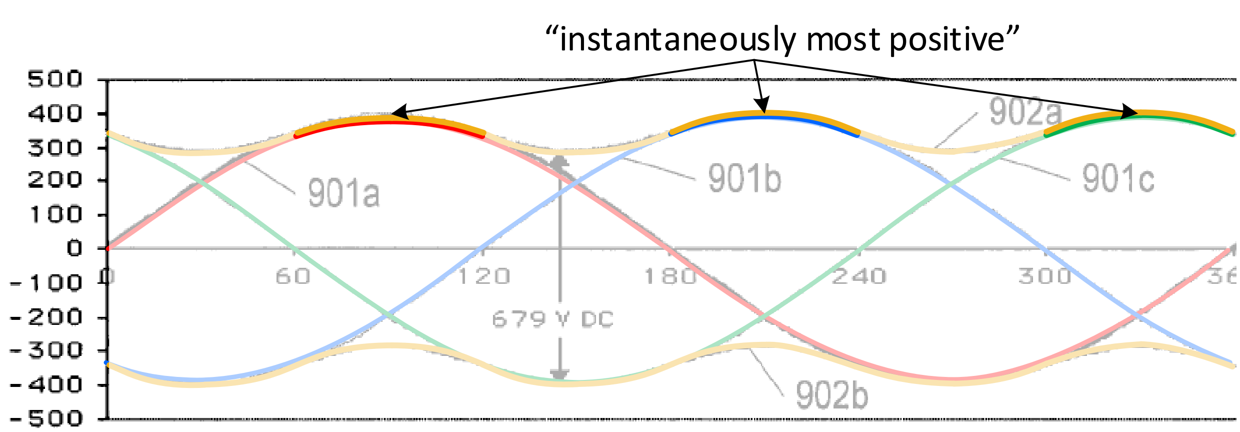
3. Dependent Claim 2

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

Tracy discloses this limitation. As previously explained *(see* Sections V.A.1.d, V.A.1.e, *supra*) Tracy's inverter generates three voltage phase outputs with unique phases and a common-mode voltage waveform (a "zero sequence" offset) on the DC input lines (902a-b). Ex. 1005, Fig. 9B, 2:48-3:14, 5:64-6:3, 6:11-20, 6:34-7:61, 8:58-65, 10:42-60; Ex. 1002, ¶¶ 238-239.

Tracy's inverter generates this common-mode voltage with a control circuit (*e.g.*, 330) (a "switching controller") that controls three half-bridges ("a first electronic switch") so that in every 60 degree interval, one of the phases equals either the positive or negative DC input lines (referred to as "discontinuously modulating"). Ex. 1005, Fig. 9B, 2:48-3:14, 5:64-6:3, 6:11-20, 6:34-7:61, 8:58-65, 10:42-60; Ex. 1002, ¶¶ 238-239. The pattern alternates every successive 60 degree interval by connecting the next phase in the sequence to the opposite DC input terminal. Ex. 1002, ¶¶ 239-242; *see also* Sections V.A.2.c, V.A.2.d (describing elements 8C and 8D).

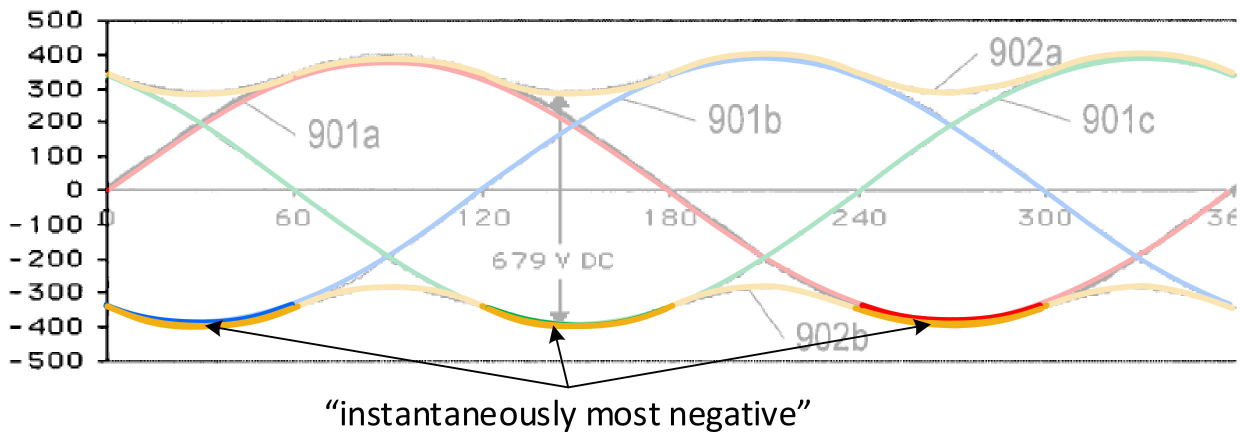
During the 60-120, 180-240, and 300-360 degree intervals, the controller causes the switch to connect the positive input terminal 902a to the instantaneously most positive of said set of AC output terminals 901a, 901b, or 901c, and said at least one ground, neutral or reference potential terminal.



Ex. 1005, Fig. 9B (annotated)

Ex. 1002, ¶ 240.

And during the 0-60, 120-180, 240-300 degree intervals, the controller alternates with connecting said negative DC input terminal 902B to the instantaneously most negative of said set of AC output terminals 901a, 901b, 901c and said at least one ground, neutral or reference potential terminal.



Ex. 1005, Fig. 9B (annotated)

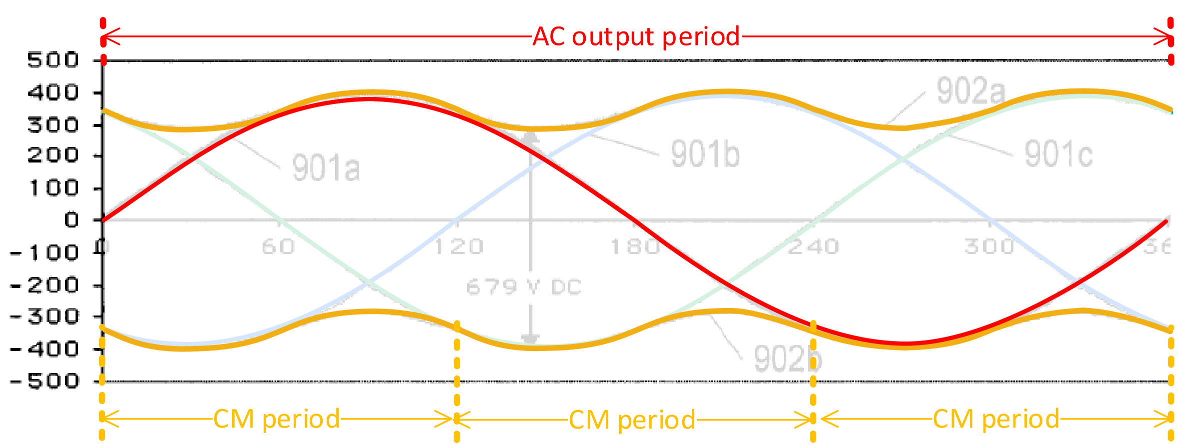
Ex. 1002, ¶ 241. Tracy thus discloses the function claim 2's "switching controller."

The corresponding structure of the "switching controller" includes "a microcontroller" with "memory." Ex. 1001, 12:26-51, 24:8-12; *see* Section IV.B.2, *supra*. Tracy's control circuit that performs the claim 2 function, is similarly described as "drive circuits controlled by a processor such as a microprocessor or microcontroller" storing program instructions. Ex. 1005, 4:20-45, 6:7-11, 6:34-39; Ex. 1002, ¶ 243. A PHOSITA would have understood that these program instructions were stored in memory. Ex. 1002, ¶ 243. Both controllers are insubstantially different and perform the same functions (as in claim 2) in the same way (controlling half-bridge switches using drive signals) for the same result (connecting the positive and negative DC input terminals to the instantaneously most positive and negative of the AC output terminals and neutral). *Compare* Ex. 1005, 4:20-24, 6:21-43, 7:64-8:2, 8:61-65, 10:42-60, Figs. 5, 9B *with* Ex. 1001, 12:26-51, 24:8-12, 26:56-28:21, Figs. 16, 23; Ex. 1002, ¶¶ 243-244.

4. Dependent Claims 3 and 9

> **Claim 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 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.**

The period of Tracy's common-mode waveform is 1/3 the period of the AC output phase. Ex. 1005, Fig. 9B; Ex. 1002, ¶¶ 245-246, 272-273. The common-mode waveform thus has a characteristic frequency (which is 1/period) of 3 times the frequency of each AC output phase as required by claims 3 (N=3) and 9.



Ex. 1005, Fig. 9B (annotated)

Ex. 1002, ¶¶ 245-246, 272-273; Ex. 1005, 10:49-57.

5. Dependent 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.

Tracy discloses (*see* Section V.A.2.c ([8C]), *supra*) using pulse-width-modulation via the signal generator circuit 730 (claimed "pulse width modulator") to control the half bridges circuits 520a, 520b, and 520c to perform element [8C]'s step of "deriving instantaneous voltages from the direct current source positive line or negative line." Ex. 1005, Figs. 5, 7, 9B, 7:8-61; Ex. 1002, ¶¶ 274-276. *See* Section V.A.2.c ([8c]), *supra*.

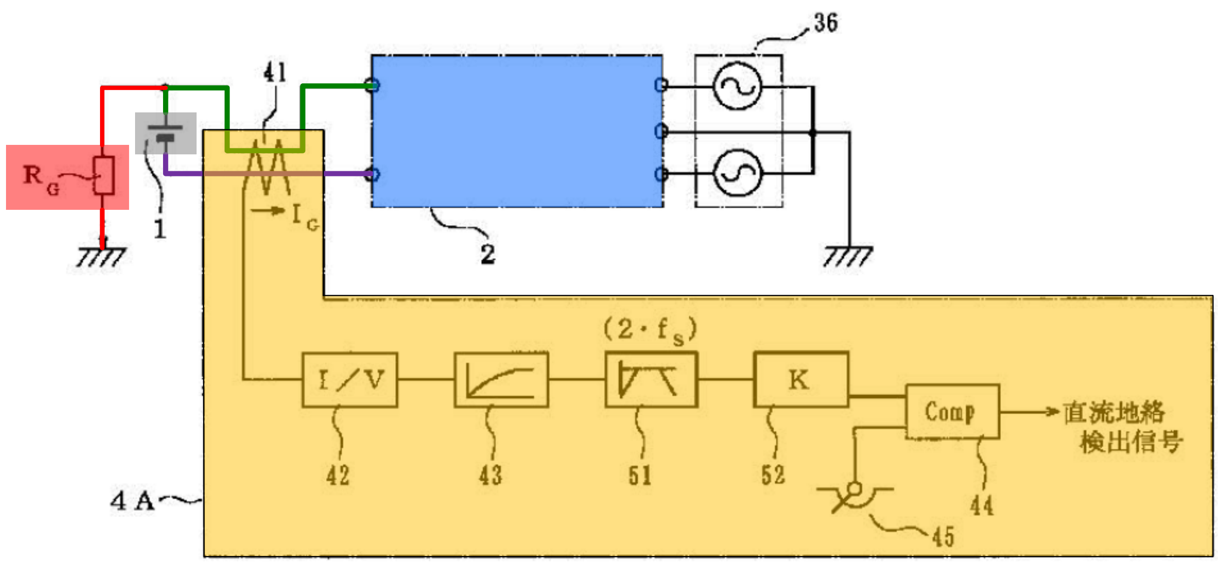
B. Ground 3: Tracy in View of Fujimoto Renders Claims 4 and 11 Obvious

1. Dependent Claims 4 and 11

Claim 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 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.

Tracy does not disclose these claims, but Fujimoto does. Fujimoto's inverter (**blue**) converts power from a DC power supply (**grey**) to an AC power output to a three-wire power system 36 with a grounded center neutral point. Fujimoto includes a DC ground fault detector (**orange**) with a current transformer 41 inserted in the positive (**green**) and negative (**purple**) DC conductors (the "AC ground leak detector inserted in the positive and negative conductors between said DC source and said DC to AC converter" in claim 4).



Ex. 1034, Fig. 1 (annotated)

Ex. 1002, ¶¶ 277-279, 290-291; Ex. 1034, Abstract, ¶¶ [0001]-[0005], [0008], [0010]-[0011], Fig. 3.

DC current flow is normally balanced with current in the positive conductor (**green**) from the power source to the inverter, and the return current in the negative conductor (**purple**) being equal. Ex. 1034, ¶ [0005]; Ex. 1002, ¶¶ 279, 291. If a ground fault resistance R_G (**red**) exists between the positive conductor and ground (the claims 4 and 11 "unwanted leakage impedance"), a difference in the positive and negative currents—*i.e.*, a "common current" I_G—is created with an AC component (I_{ac}) at twice the inverter AC output waveform frequency (the claim 4 "imbalance current at the said second frequency" and claim 11 "common-mode current with said common mode waveform at said characteristic repetition frequency"). Ex. 1034, Abstract, ¶¶ [0005]-[0007], [0010]-[0011], Fig. 4; Ex. 1002, ¶¶ 279-280, 291-292.

Fujimoto's detector isolates and amplifies (via band-pass filter 51 and amplifier 52) the AC component I_{ac} at two times the system frequency and compares it to a prescribed detection level 45 to indicate a fault (the claim 4 "detection signal" and claim 11 "detecting"). Ex. 1034, Abstract, ¶¶ [0007], [0010]-[0011], Figs. 1-2; Ex. 1002, ¶¶ 280, 291-292.

A PHOSITA would have understood that in the presence of R_G, the common mode current I_{ac} would be induced from a common-mode voltage generated by Fujimoto's (transformerless) inverter with the grounded center neutral point, and that Fujimoto's detector could easily be applied to Tracy's three-phase transformerless inverter, which similarly generates a common-mode voltage waveform on the DC input line with respect to neutral. Ex. 1002, ¶¶ 281-285, 292;

Ex. 1034, Fig. 3, Abstract, ¶¶ [0004], [0008]; Ex. 1005, Fig. 9B (annotated), 10:49-57; *see* Section V.A.4 (claims 3, 9), *supra*.

A PHOSITA would have been motivated to modify Tracy's inverter to detect a leakage impedance and stop operation of the inverter as taught in Fujimoto to prevent hazards (*e.g.*, fire) and to comply with government safety standards for ground fault protection. Ex. 1019, pp. 14-15; Ex. 1024, ¶¶ [0039], [0048], [0050]; Ex. 1034, ¶¶ [0004]-[0005]; Ex. 1002, ¶¶ 281-283, 292. Since Tracy's and Fujimoto's inverters are similar and would produce similar common-mode currents through a DC ground fault, such a modification would have been no more than applying a known technique (Fujimoto's ground fault detection) to improve a similar device (Tracy's transformerless inverter generating a common-mode AC input voltage) in the same way (as Fujimoto's transformerless inverter generating a common-mode AC input voltage). Ex. 1002, ¶¶ 284-286, 292.

A PHOSITA would have reasonably expected success in combining Tracy and Fujimoto, yielding a predictable result of Tracy's inverter with Fujimoto's detector to indicate a DC ground fault. Ex. 1002, ¶¶ 286-287, 292. A PHOSITA would have understood that Fujimoto's band-pass filter could easily be adjusted to detect a ground fault with a three-times frequency component such as the common-mode frequency disclosed in Tracy (as opposed to two-times in Fujimoto). *Id.* This would have been a routine matter of tuning Fujimoto's band-pass filter to the frequency of Tracy's common-mode waveform, which was well within the level of ordinary skill in the art. *Id.*

A PHOSITA would have recognized that Fujimoto's current transformer 41 (a well-known device in which a primary current induces a proportional secondary current for measurement) is the same or an insubstantially different structure as the '822 patent's current transformer (toroid 800 and windings 801). Ex. 1002, ¶ 288; Ex. 1001, 31:65-32:20, 35:66-36:3, Fig. 18; Ex. 1034, ¶¶ [0005], [0008]; Ex. 1036, p. 5; Ex. 1042, p. 5; Ex. 1043, p. 5. Fujimoto's current transformer performs the same function (detecting a difference in the current flowing through the positive conductor and back through the negative conductor) in the same way (by coupling to the positive and negative DC input lines) for the same result (outputting a ground fault signal). Ex. 1002, ¶¶ 288-289.

C. Ground 4: Tracy in view of De Renders Claims 6 and 20 Obvious,

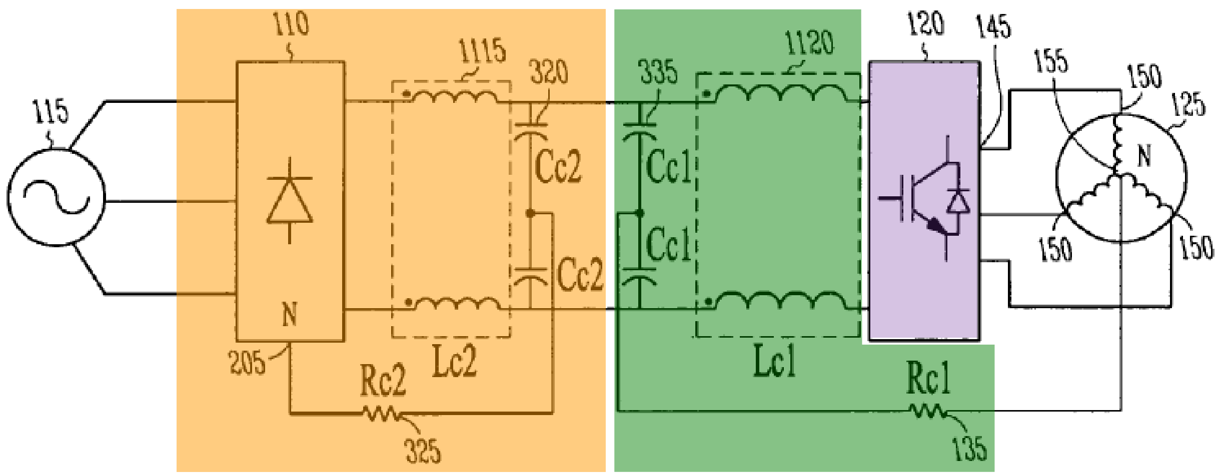
1. Claims 6

[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."

Tracy does not disclose this claim, but De does. De discloses a common-mode filter (Lc1, Cc1, Rc1) (**green**) connected between DC input terminals of an inverter (**purple**) and the positive and negative terminals of a DC source (rectifier circuit 110 with an output filter) (**orange**) as recited by element [6A].



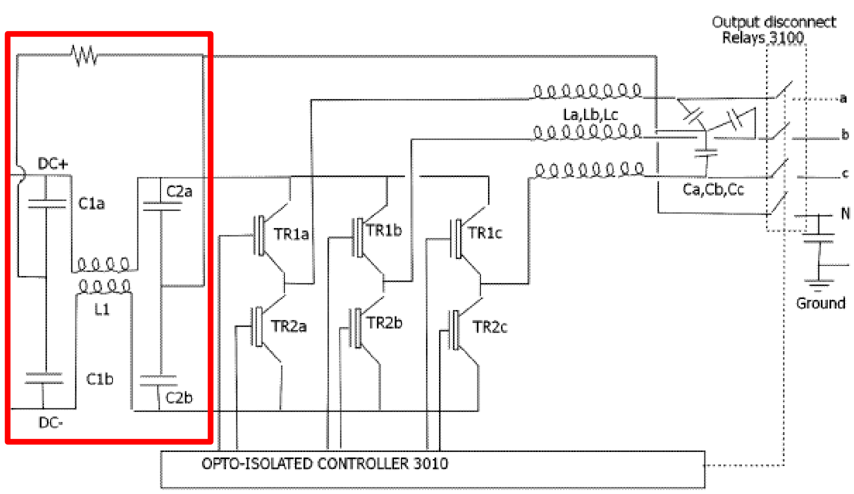
Ex. 1018, Fig. 12 (annotated)

Id., Figs. 11, ¶¶ [0020], [0033]-[0034]; Ex. 1002, ¶¶ 293-297.

De's inverter (like Tracy's inverter) is a source of electromagnetic interference (EMI) in the form of common-mode noise, which a PHOSITA would have understood to be caused by high frequency internal switching within the inverter. Ex. 1018, Abstract, ¶¶ [0001]-[0022]; Ex. 1041, p. 943; Ex. 1010, pp. 1-2; Ex. 1002, ¶¶ 295, 298, 305. De's filter prevents this common-mode noise from being exported to the DC source, because De's inductor (Lc1) and capacitor (Cc1) form a low-pass common-mode filter loop with a resonant frequency (which is the cutoff frequency above which waveforms are attenuated) selected to be one-third to one-half of the inverter's internal switching frequency. Ex. 1018, ¶¶ [0021]-[0022]; Ex. 1002, ¶¶ 298, 305. De's filter thus "prevent[s] high frequency components of the DC to AC converter internal waveforms being exported to said DC source" (element [6B]). Ex. 1002, ¶ 305.

Further, De's resistor (Rc1) "ensure[s] proper damping of the common mode filter loop," which a PHOSITA would have understood to minimize common-mode voltage overshoot caused by the L-C filter resonating, and thus minimize peak voltages on the positive and negative inverter terminals as required in element [6C]. Ex. 1018, ¶ [0022]; Ex. 1010, pp. 6-9 (describing resistor for reducing overshoot at filter resonant frequency), Figs. 11-17; Ex. 1002, ¶ 306.

De's and the '822 patent's (Figure 16, below) common-mode filters are both second-order, low-pass L-C filters with equivalent structures.



Ex. 1001, Fig. 16 (annotated)

Ex. 1002, ¶ 302.

The exact multiples, values and arrangements of L, C, and R in De's common-mode filter are selected by a "designer with average skill" depending upon particular inverter parameters (*e.g.*, switching frequency), and thus any differences between the two filters would be insubstantial. Ex. 1018, ¶ [0022]; Ex. 1010, 6-9 (illustrating equivalent arrangements of L, C, and R for damping filter overshoot), Figs. 11-17; Ex. 1002, ¶ 303. The two filters perform the same function (filtering) in the same way (using passive components arranged as a second order filter) for the same result (reducing high frequency components and preventing overshoot). Ex. 1002, ¶¶ 303-304.

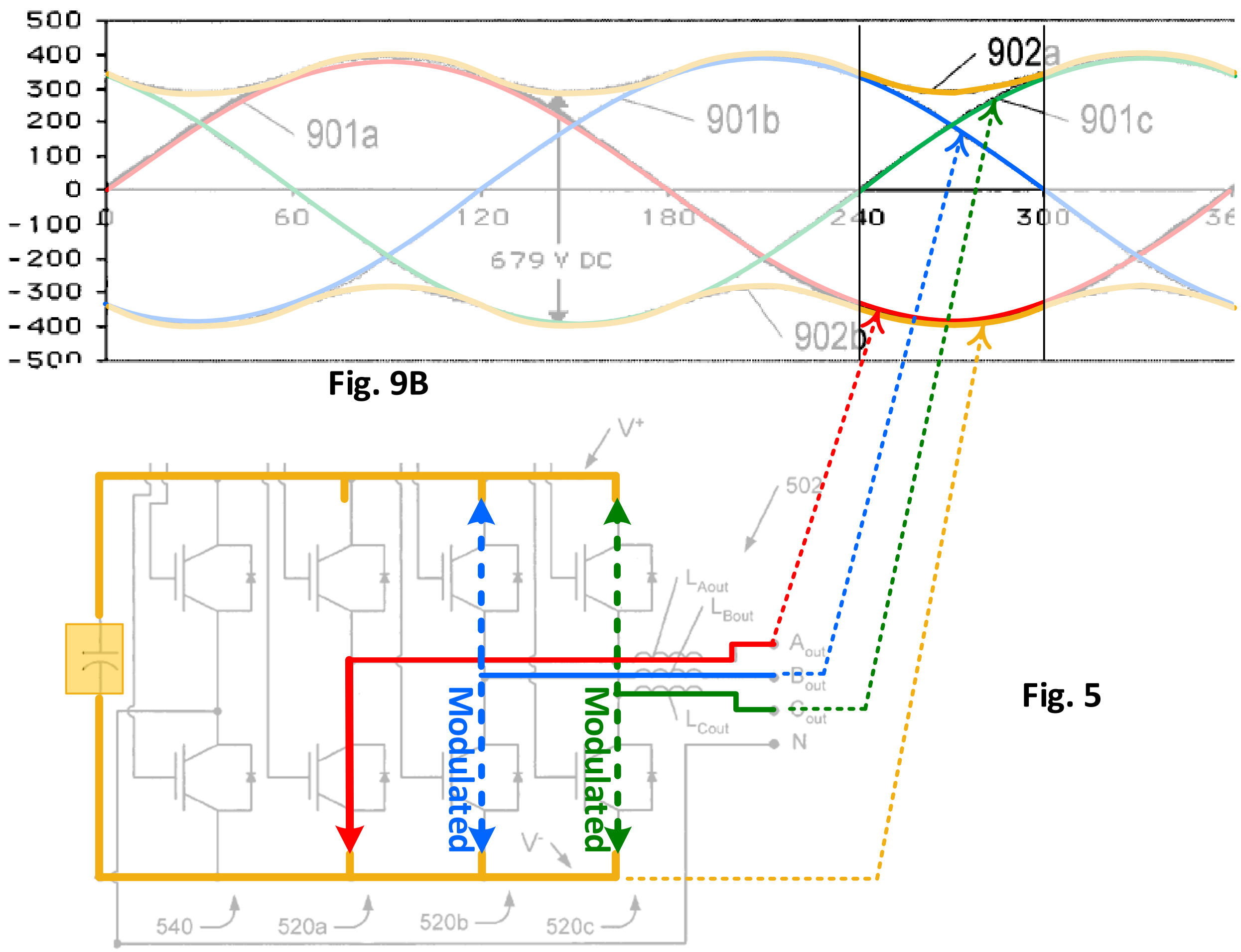
With similar DC sources and similar switching schemes, a PHOSITA would have recognized that De's common-mode noise problem would apply equally to Tracy, thus motivating a PHOSITA to insert De's common-mode filter between Tracy's DC power source and inverter (similar to De's) for the benefit of minimizing hazards caused by the inverter-generated high frequency common-mode leakage and to improve the electromagnetic compatibility of the inverter with other components in the system. *Id.*, ¶ 298; Ex. 1018, Abstract, ¶¶ [0001], [0021]-[0022]; Ex. 1009 (certified translation of Ex. 1027), ¶¶ [0002], [0019]-[0022]; Ex. 1041, p. 943 (explaining that Tracy's inverters high PWM frequencies create harmonic content that must be filtered); Ex. 1010, pp. 1-2. Doing so would have been the obvious use of a known technique (inserting De's common-mode filter between a power source and inverter) to improve a similar device (Tracy's DC power source and inverter) in the same way (by suppressing the common-mode current emitted by Tracy's inverter). Ex. 1002, ¶¶ 299-300.

A PHOSITA would have reasonably expected success, 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. Ex. 1018, ¶ [0022]; Ex. 1002, ¶ 301.

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."**

Tracy-De teaches this claim. Element [20A] purportedly refers to element [8C] for connecting the positive and negative lines of the DC source in a rotating sequence to the "most positive" output terminal, but element [8C] recites a different limitation of connecting to the "most positive" and "most negative" output terminals in a rotating sequence. As previously explained (*See* Section V.A.2.c ([8C]), *supra*), Tracy discloses connecting the positive and negative inputs in a rotating sequence respectively to the instantaneously "most positive" and "most negative" output terminals (**red**) as in element [8C], while also pulse-width-modulating the other output phases (**blue**, **green**):



Ex. 1005, Figs. 5 (bottom, annotated), 9B (top, annotated)

Ex. 1002, ¶¶ 307-311.

This pulse-width-modulating (*e.g.*, by half-bridge 520c) alternatively connects (*i.e.*, in a rotating sequence) both DC lines to the "most positive" output terminal (*e.g.*, the **green** phase in the second half of the 240 to 300 degree interval above), thus disclosing element [20A]. Section V.A.2.c ([8C]), *supra*); Ex. 1005, Figs. 5, 9B, 2:1-15, 2:59-3:20, 7:21-61, 8:58-10:5; Ex. 1002, ¶¶ 310-315.

Tracy-De, as explained above, further teaches a common-mode filter between the inverter input terminals and the DC source terminals that prevents high frequency components of the inverter internal waveforms being exported to the DC source and that minimizes common-mode voltage overshoot, which minimizes positive and negative terminal peak voltage, thus disclosing elements [20B] and [20C]. *See* Section V.C.1 (Claim 6), *supra*); Ex. 1002, ¶¶ 315-317.

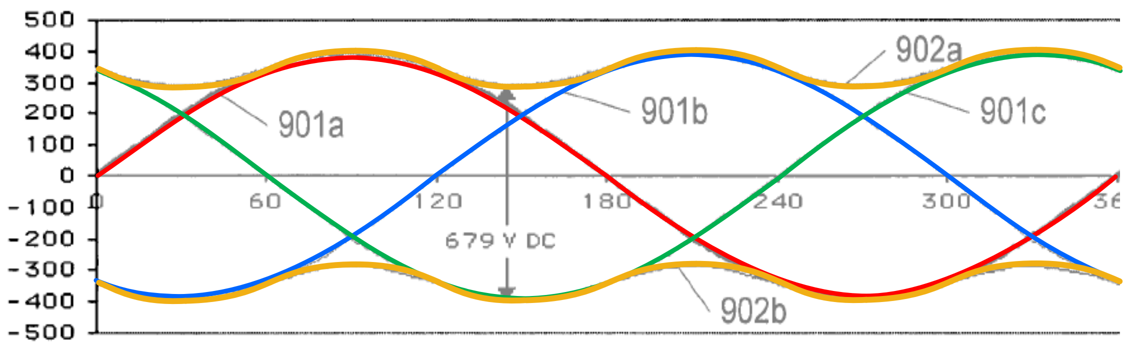
D. Ground 5: Tracy in View of Bond Renders Claims 7 Obvious

1. Dependent Claim 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.

Tracy and Bond teach this claim. Tracy discloses a "line interactive" three-phase inverter connected to a utility grid in an uninterruptable power supply (UPS) (the claim 7 "three-phase grid-interactive inverter"). Ex. 1005, 1:10-47, 5:1-13, 10:42-45, Figs. 2-5, 9B; Ex. 1002, ¶¶ 318-320. As previously discussed, Tracy's inverter operates according to claim 1. *See* Section V.A.1, *supra*.

Tracy's inverter includes "three terminals [Aout (901a) (**red**), Bout (901b) (**blue**), and Cout (901c) (**green**)] that deliver current at unique phases spaced relatively 0, 120, and 240 degrees apart" as further recited in claim 7.



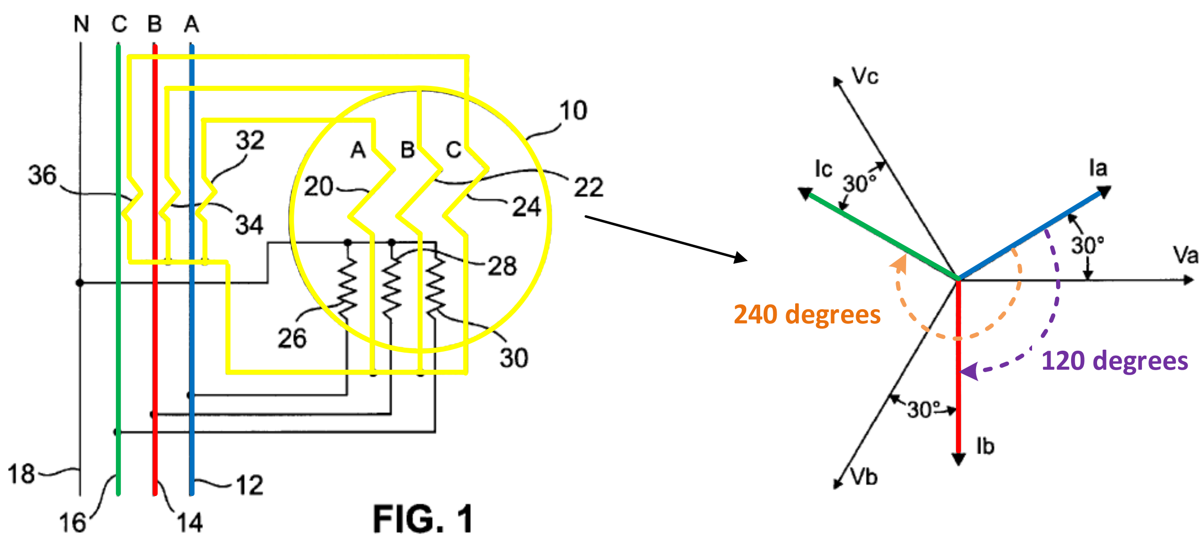
Ex. 1005, Fig. 9B (cropped and annotated)

Id., 5:1-13, 10:42-45, Figs. 2-5; Ex. 1002, ¶¶ 319-320.

In "line interactive" applications, Tracy's AC output terminals Aout, Bout, and Cout, and its neutral terminal N, are connected with "an actual load neutral (in 'Y' connected output configurations)" (the claimed "three legs of a wye-connected [], 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"). Ex. 1005, 5:1-17; Ex. 1002, ¶ 320.

Tracy does not disclose "a watt-hour metering device" or that the wye connection is "120/208-volt," but Bond does. Like Tracy, Bond describes "three terminals" (power lines 12 (**blue**), 14 (**red**), and 16 (**green**)) with current phases "approximately 120°" apart (Ia (**blue**), Ib (**red**), and Ic (**green**) for phases A, B, and

C respectively) as recited in claim 7. Ex. 1035, 3:41-49, 4:4-11, 10:9-11, Figs. 1 (annotated), 1a (annotated); Ex. 1002, ¶¶ 321-322.



Ex. 1035, Figs. 1 (left, annotated), 1a (right, annotated)

Bond additionally teaches delivering these currents "through a watt-hour metering device" 10 (yellow) with a utility four-wire wye service type connection with neutral center and with a 120-volt (line-to-neutral) (resulting in 208-volt (line-to-line)) output voltage (the claimed "the three legs of a wye-connected 120/208-volt, three-phase, electric utility company service connection and . . . neutral terminal at the center of the wye-connection"). Ex. 1035, 1:10-22, 1:26-49, 2:55-58, 3:16-23, 3:41-49, 4:4-11, 4:27-58, 10:9-11, 12:32-43, Figs. 1, 1a; Ex. 1002, ¶ 323.

A PHOSITA would have been motivated to combine Tracy's three-phase wye-connected inverter with Bond's 120/208 wye-connected meter to enable monitoring of energy usage. Tracy teaches connecting its inverter to a utility grid (*e.g.*, Ex. 1005, Fig. 2), and Bond teaches utility service providers using its meter to monitor energy usage by customers connected to the grid for billing, resource allocation planning, power factor tracking, and for error diagnostics. Ex 1005, 1:10-47; Ex. 1035, 1:10-16, 1:27-40, 2:4-20, 3:16-23, 3:41-48, 4:4-11, 4:27-58, 9:15-19, 10:8-11, 14:7-9, Fig. 6 (4WY-120V); Ex. 1002, ¶ 324. Bond's 120/208V wye configuration is a "commonly used service type[] [that is] standardized and [] well known to those of ordinary skill in the art." Ex. 1035, 1:34-36.

This is simply combining prior art elements (three-phase inverter output and a watt-hour meter) according to known methods (coupling terminals to a meter and grid as taught by Bond) to yield predictable results (measuring output current of the three phases, phases A, B, and C, with a watt-hour meter in a standardized utility connection). Ex. 1002, ¶¶ 324-326.

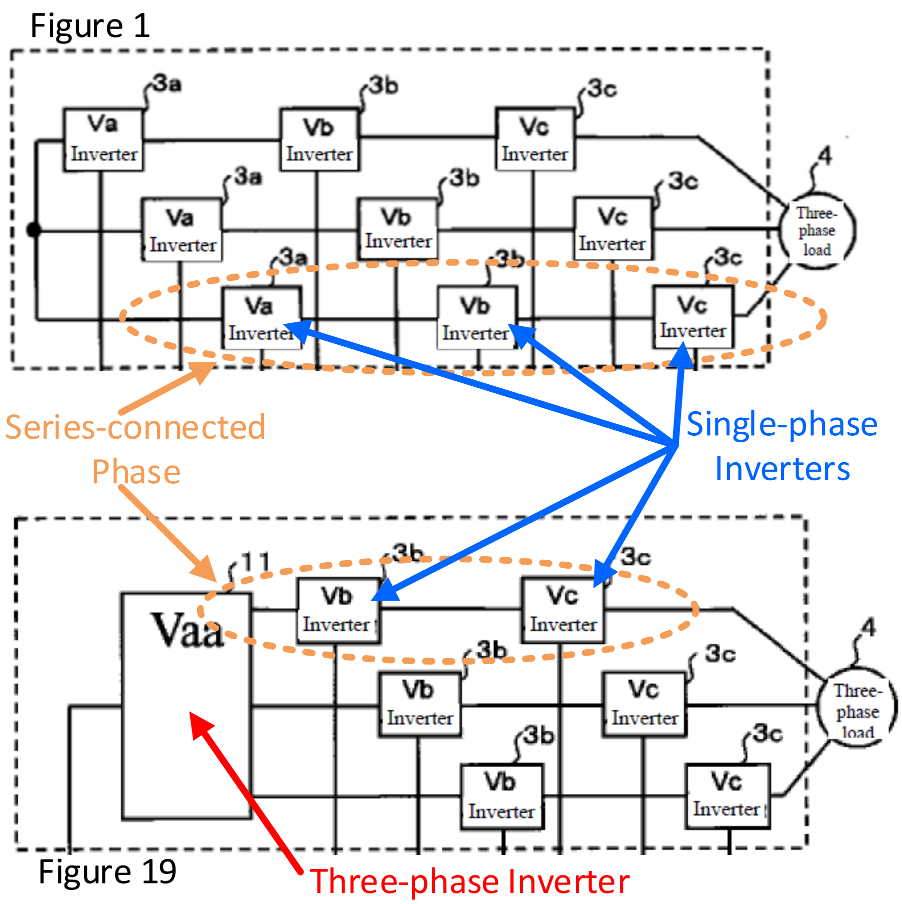
A PHOSITA would have reasonably expected success, as the combination merely require connecting a UPS (including an inverter) and a utility meter that is *standardized* and well within the level of ordinary skill in the art. Ex. 1035, 1:35-37; Ex. 1002, ¶ 327.

E. Ground 6: Tracy in view of Suzuki and Ball Renders Claims 5, 12, and 13 Obvious

1. A PHOSITA Would Have Been Motivated to Modify Tracy with Suzuki

Tracy describes a three-phase inverter that discloses all elements of claims 1 and 8. *See* Sections V.A.1-V.A.2, *supra*. Claims 5, 12, and 13 add additional elements, including a bidirectional DC-to-DC converter that generates floating supplies with specific voltage ratios, and expressing a desired voltage with a ternary number system. While Tracy does not expressly describe these elements, Suzuki and Ball do. Ex. 1002, ¶ 328.

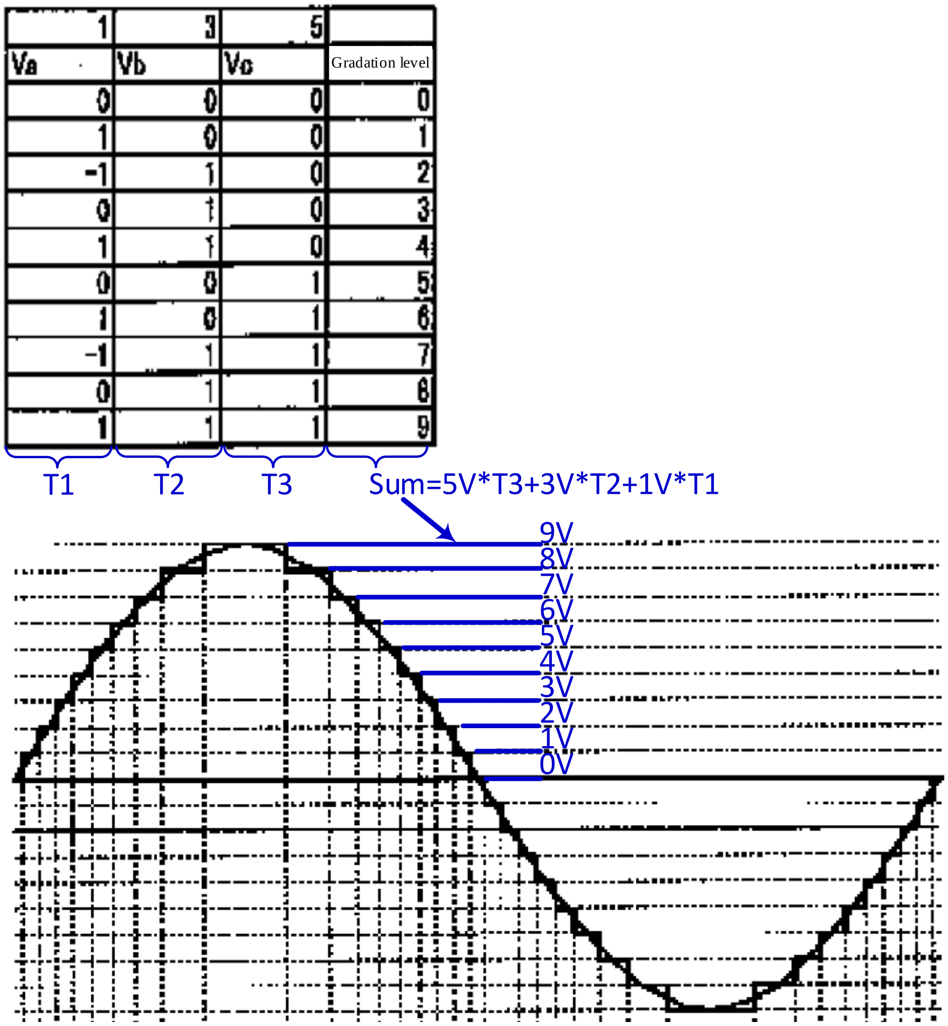
Suzuki improves upon conventional three-phase inverters by connecting, for each phase output, a number of single-phase and three-phase inverters together in series to produce a smoother AC voltage waveform, requiring less filtering than prior inverters.



Ex. 1031, Figs. 1 (top, annotated), 19 (bottom, annotated)

Id., Abstract, ¶¶ [0002]-[0006]; Ex. 1002, ¶¶ 328-329.

The voltages from each of Suzuki's series-connected inverters (Va, Vb, and Vc) are multiplied by a respective ternary digit (T3, T2, and T1) having a value of -1, 0, or +1 and summed together: Vc*T3+Vb*T2+Va*T1. Ex. 1031, Fig. 4, ¶¶ [0018]-[0019], [0031]-[0032]; Ex. 1002, ¶ 330. The ternary digits are controlled to generate a sequence of small voltage gradations approximating a smooth AC output waveform.



1	3	5	
Va	Vb	Vc	Gradation level
0	0	0	0
1	0	0	1
-1	1	0	2
0	1	0	3
1	1	0	4
0	0	1	5
1	0	1	6
-1	1	1	7
0	1	1	8
1	1	1	9

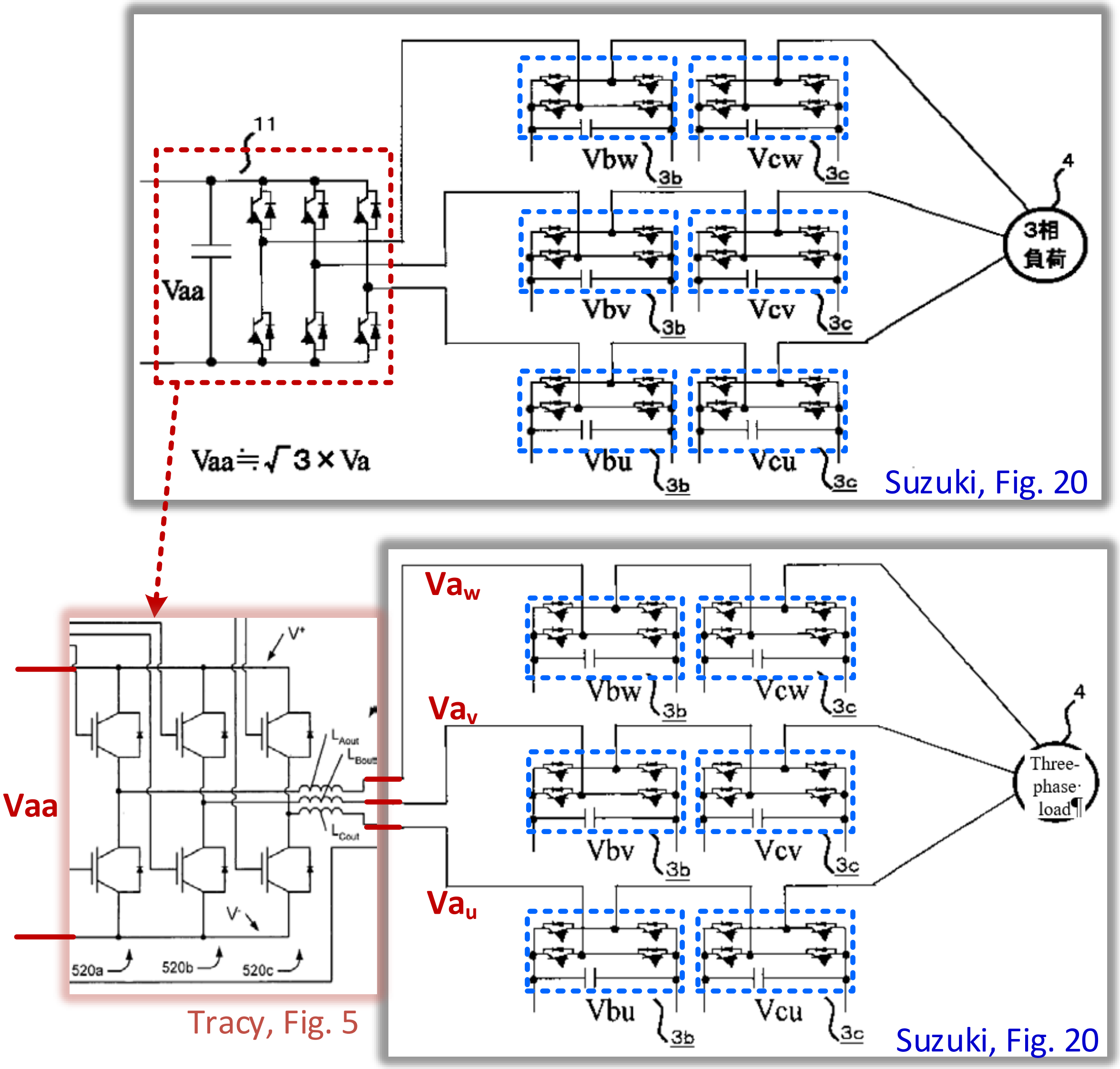
Ex. 1031, Figs. 4C (top, annotated), 5b (bottom, annotated)

Ex. 1002, ¶ 330; Ex. 1031, Figs. 19, 20, 28, ¶¶ [0017]-[0022], [0031], [0039].

Suzuki teaches multiple design variations to generate different sets of gradation levels, including: replacing three single-phase inverters 3a with one three-phase inverter 11 (*compare* Figure 1 *with* Figure 19); setting the voltages in increasing or decreasing order (*compare* Figures 1, 19 *with* Figures 6, 28); changing the number of inverters connected in series (*compare* Figure 1 *with* Figure 10); selecting different voltage ratios (*e.g.*, Va:Vb:Vc = 1:2:4, 1:3:4, 1:3:5, 1:3:6, 1:3:7, 1:3:8, 1:3:9 in Figure 4); modifying any of these ratios by increasing Va ≥ 1; and pulse-width-modulating the output of each inverter to scale the voltage magnitude anywhere between 0 to Va, 0 to Vb, and 0 to Vc. Ex. 1031, Figs. 1, 6, 10, 18-20, 28, ¶¶ [0016], [0018]-[0022], [0024]-[0025], [0031]-[0032], [0039]; Ex. 1002, ¶ 331.

A PHOSITA would have been motivated to apply one or more of these different combinations of features disclosed in Suzuki to Tracy's inverter in a manner that teaches claims 5, 12, and 13. *See* Sections V.E.3.a, V.E.4, V.E.5, *infra*; Ex. 1002, ¶¶ 331-340.

For example, to generate smoother AC phase voltages (requiring less filtering) from Tracy's inverter, a PHOSITA would have been motivated to connect Tracy's inverter arranged as the three-phase inverter 11 (**red**) in Suzuki, with each phase output of Tracy's inverter connected to one or more series-connected single-phase inverters (*e.g.*, H-bridge circuits 3b and 3c) (**blue**):



Ex. 1005, Fig. 5 (annotated); Ex. 1031, Fig. 20 (annotated)

Ex. 1002, ¶ 332; Ex. 1005, 3:3-7, 5:64-6:15; Ex. 1031, Figs. 19, 28, Abstract, ¶¶ [0016], [0031]-[0032], [0039].

Suzuki teaches that the input voltages to H-bridge switches 3b and 3c are respectively equal to the output voltages Vb and Vc. Ex. 1002, ¶ 333; Ex. 1031, Fig. 4, ¶¶ [0015], [0018]-[0019]. Tracy teaches that the input voltage (Vaa) to its three-phase inverter stage is between $\sqrt{3}$ and 2 times the phase output voltage (Va) depending on the amplitude of the common-mode waveform generated by Tracy's zero-sequence modulation (*e.g.*, between 679V and 784V in Figures 9B and 9A, respectively). Ex. 1005, 10:42-57, 11:13-25, Figs. 9a- 9b; Ex. 1002, ¶ 333; *see* Section V.A.1.e, *supra*. Thus, for the Va:Vb:Vc output voltage ratios specified in Suzuki (*see* Ex. 1031, Figure 4), the corresponding input voltages in Tracy-Suzuki are given by Vaa:Vb:Vc, where Vaa is between $\sqrt{3}$*Va and 2*Va. Ex. 1002, ¶ 348. Similarly, if the output voltages are in the opposite sequence Vc:Vb:Va, the corresponding input voltages would be Vcc:Vb:Va, where Vcc is between $\sqrt{3}$*Vc and 2*Vc. *Id.*

Suzuki teaches a Va:Vb:Vc ratio of (≥1):3:9, which in the Tracy-Suzuki combination corresponds to a Vaa:Vb:Vc input voltage ratio of (≥1.73):3:9, with Vaa ≥ $\sqrt{3}$*Va. Ex. 1002, ¶ 334; Ex. 1031, ¶¶ [0021], [0031], Fig. 4. This range of input voltage ratios includes 3:3:9 (or $1{:}1{*}3^0{:}1{*}3^1$), which meets the claim 5 "floating supplies of voltages equal to the input voltage [] multiplied by successive powers of 3." Ex. 1002, ¶ 334; Section V.E.3.a, *infra*.

Similarly, Suzuki teaches a Vc:Vb:Va ratio of 5:3:1, which in the Tracy-Suzuki combination corresponds to an input voltage ratio Vcc:Vb:Va of (8.66 to 10):3:1, where Vcc is between ($\sqrt{3}$*Vb) to (2*Vb). Ex. 1002, ¶ 335; Ex. 1005, 10:42-57, 11:13-25; Ex. 1031, ¶¶ [0021], [0031], Fig. 4. The input voltage ratio of 9:3:1 (or $1:1*3^{-1}:1*3^{-2}$) is within this (8.66 to 10):3:1 range of ratios—thus, Tracy-Suzuki also teaches the claim 5 "floating supplies of voltages equal to the input voltage divided [] by successive powers of 3". Ex. 1002, ¶ 335; Ex. 1005, 10:42-57, 11:13-25; Ex. 1031, ¶¶ [0021], [0031], Fig. 4.

As another example, a single Suzuki H-bridge inverter in series with each of Tracy's inverter phase outputs and with Suzuki's Va:Vb ratio of 1:3 would disclose the formula for the "instantaneously desired voltage" recited in claim 12. Ex. 1031, ¶¶ [0020], [0024]-[0025]; Ex. 1002, ¶ 336; Section V.E.4, *infra*. And the Tracy-Suzuki combination with Vb and Vc set to 3 and 9 (in the Va:Vb:Vc ratio of 1:3:9 shown in Figure 4G of Suzuki) would disclose the claim 13 "set of floating DC supplies of voltages having voltage ratios of successive powers of 3." Ex. 1031, Fig. 4, ¶¶ [0018]-[0019]; Ex. 1002, ¶ 336; Section V.E.5, *infra*.

Each of these modifications reduces the size of the filter required at each phase output. Ex. 1031, ¶¶ [0002]-[0005], [0018]-[0019], [0024]-[0025]; Ex. 1002, ¶ 337. Further, some of these modifications, such as using two instead of three series connected inverters and replacing three single-phase inverters with one three-phase inverter, simplifies device configuration and reduces cost by having fewer devices to control. Ex. 1031, ¶¶ [0024]-[0025], [0032], Figs. 10, 19-20; Ex. 1002, ¶ 337.

Based on these advantages, a PHOSITA would have been motivated to add one or more H-bridge inverters connected in series according to Suzuki to each phase output of Tracy's inverter, with the specific voltage ratios described above. Ex. 1002, ¶ 338; *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."). Doing so would have been the obvious use of known techniques (adding one or more series connected H-bridge converters to each phase output with different voltage scaling) to improve a similar device (Tracy's three-phase inverter) in the same ways as taught in Suzuki (for example, with Suzuki's improved inverter structure shown in Figures 10, 20, or 28). Ex. 1002, ¶ 338.

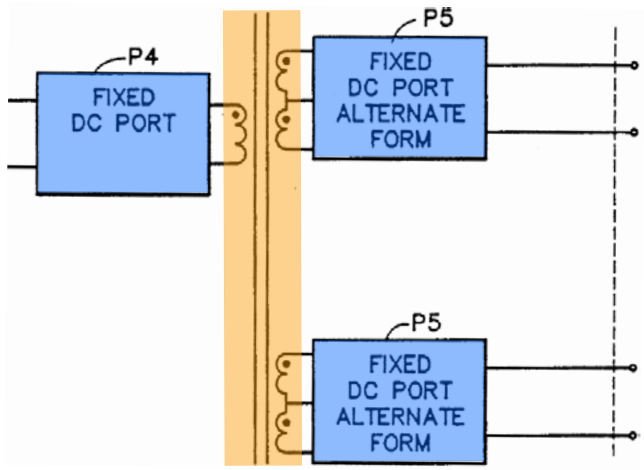
Moreover, varying the weighting of the voltage multipliers to values other than the examples expressly disclosed in Suzuki would have been obvious to a PHOSITA in view of Tracy-Suzuki and a PHOSITA's technical ability. *Id.*, ¶ 339. Suzuki expressly notes that "V_a, $V_{b,}$ and V_c" may "have a relationship" other than 1:3:9, including six additional examples in Figure 4 (including where Va is any value greater than the value listed in the table), and even more example ratios of the inverter output voltages with respect to Figure 40. Ex. 1031, Figs. 4, 40-42, ¶¶ [0020]-[0021], [0040]-[0056]. The '822 patent does not describe its claimed weighting as novel or nonobvious or having any technical benefit over simply weighting by consecutive powers of three. Unsurprisingly, mere changes in proportions or quantity do not render claims nonobvious. *Gardner v. TEC Systems,* *Inc*., 725 F.2d 1338, 1346, 1349 (Fed. Cir. 1984) (dimensional formula "made the application sound like something unique and inventive but had no real function"); *Iron Grip Barbell Co., Inc. v. USA Sports, Inc.*, 392 F.3d 1317, 1320-23 (Fed. Cir. 2004) (a barbell weight having three openings for gripping was obvious in view of two and four openings prior art). Furthermore, choosing an alternative weighting would have been nothing more than the obvious combining of prior art elements (Suzuki's inverter using multiple DC voltages) according to known methods (Suzuki's teaching of how different voltage ratios lead 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). *Ecolab, Inc. v. FMC Corp.*, 569 F.3d 1335, 1350 (Fed Cir. 2009). Ex. 1002, ¶ 339.

A PHOSITA would have reasonably expected success in combining Tracy and Suzuki, since Suzuki explains how to connect the H-bridge inverters to a three-phase inverter which is schematically the same as Tracy's inverter and describes how to control such a circuit to generate the output waveforms with small gradations, and because Tracy's inverter with zero-sequence modulation would be compatible with Suzuki's control to provide the phase output voltage (Va or Vc) based on an input voltage of two to $\sqrt{3}$ times the output voltage. Ex. 1002, ¶ 340; Ex. 1005, 10:42-57, 11:13-25, Figs. 9a-9b; Ex. 1031, ¶¶ [0018]-[0022], [0024]-[0025], [0031]-[0032], Figs. 19-20, 28. Moreover, Suzuki teaches that any of the series connected individual inverters may be modulated with "PWM control or chopper control," which is compatible with the PWM control of the three-phase inverter taught in Tracy. Ex. 1005, 2:1-15, 2:59-3:20, 7:21-61, Fig. 9B; Ex. 1031, ¶¶ [0020]-[0022]; Ex. 1002, ¶ 340. Making the circuit connections and applying the control of Tracy and Suzuki as described above are basic engineering skills of a PHOSITA. Ex. 1002, ¶ 340. Additionally, implementing alternative weighting ratios would have easily been within the level of ordinary skilled in the art and performed with a reasonable expectation of success, as evidenced by Suzuki's disclosure of over 10 variations on weighting in Figure 4. *Id.*

2. A PHOSITA Would Have Been Motivated to Modify Tracy-Suzuki with Ball

While Suzuki teaches using AC-to-DC converters to derive the additional DC voltage inputs to the H-bridge circuits from an AC power source, a PHOSITA would have recognized that when the source is a DC battery, as it is for Tracy's inverter, the additional Suzuki voltages would instead have to be derived through DC-to-DC conversion. Ex. 1002, ¶ 341. Ball discloses such an arrangement.

Ball discloses a universal converter with a single transformer (**orange**) that transfers power, *inter alia*, between two or more bi-directional fixed DC voltage ports (**blue**).

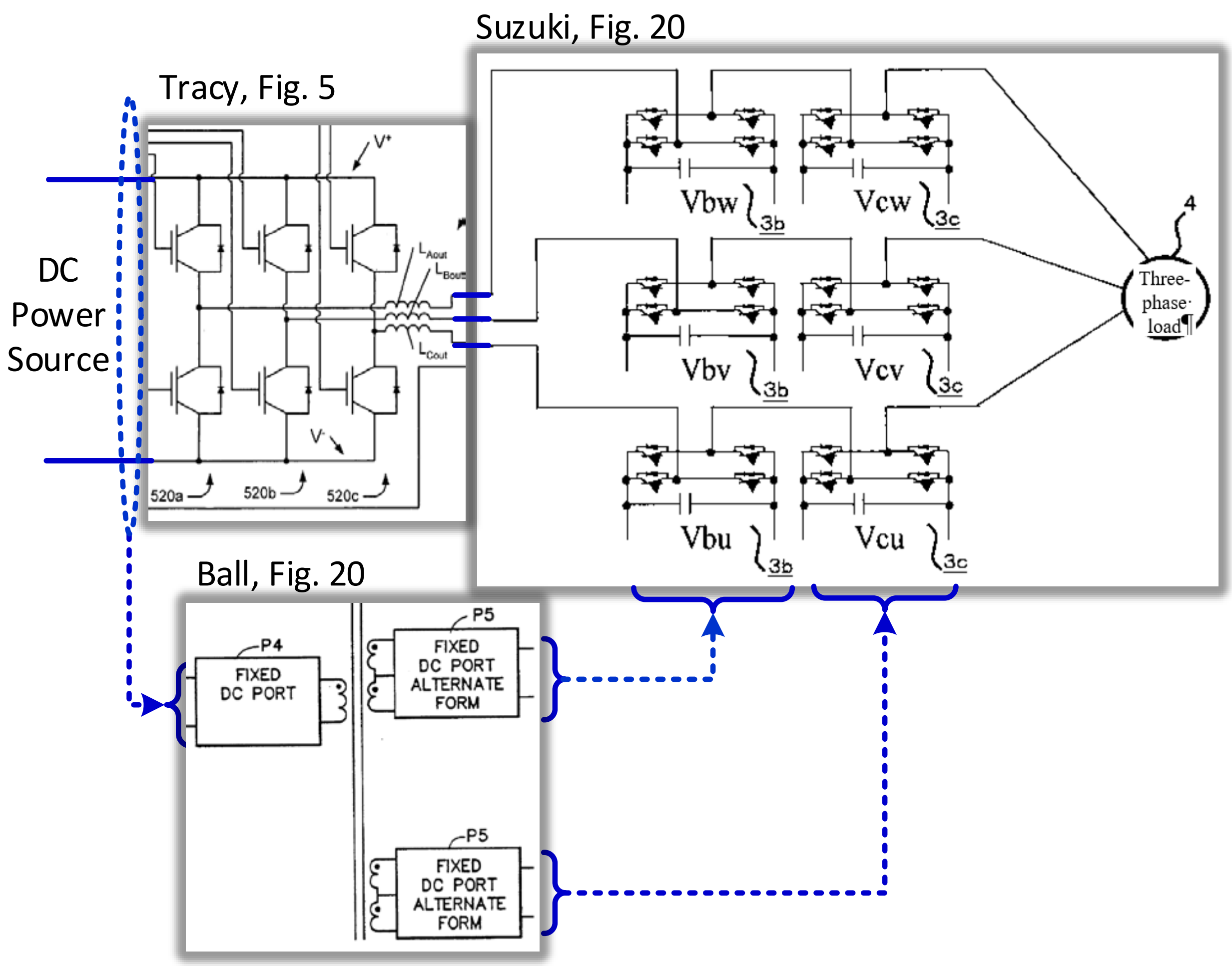


Ex. 1032, Fig. 20 (cropped and annotated)

Ex. 1002, ¶ 342; Ex. 1032, Fig. 22, Abstract, 12:5-27, 25:58-61, 36:64-68, 42:5-36, 50:20-28. One of Ball's fixed DC voltage ports is connected to a battery and controlled to generate a high frequency, equal duty cycle, square wave on its transformer winding with an amplitude equal to the voltage output by the battery. Ex. 1032, 12:5-27, 13:9-23, 21:20-65, 22:12-27, 22:37-48, 31:44-32:11, 34:43-35:4, 43:31-38, 44:34-42, 52:22-32, 52:53-62; Ex. 1002, ¶ 343. The other ports lock onto this square wave through their transformer windings to transfer power bi-directionally between the ports, where the ratio of DC voltages between the ports is determined by the ratio of turns on the transformer. Ex. 1032, 32:52-33:8, 42:8-52, 44:52-60, 53:20-26; Ex. 1002, ¶ 343. Each port is floating with respect to the other ports because the power transformer coupling the coils isolates each port, because control transformers isolate the control signals of the ports, and because the ports are not permanently connected to any established potential such as a neutral terminal.

Ex. 1032, 39:3-17, Figs. 2b, 3b; Ex. 1001, 23:38-41; Ex. 1036, p. 6; Ex. 1042, p. 6; Ex. 1002, ¶ 343.

A PHOSITA would have been motivated to use Ball's DC-to-DC converter with Tracy-Suzuki to convert the DC voltage source to the floating DC voltages for Suzuki's additional H-bridges as shown below:



Ex. 1005, Fig. 5; Ex. 1031, Fig. 20; Ex. 1032, Fig. 20 (annotated)

Ex. 1002, ¶ 344. Ball's DC-DC converter, with a single transformer, is not only capable of providing any number of floating DC voltages required, but is also over

95% efficient, uses lower cost and fewer components then other prior art DC-to-DC converters, and eliminates or reduces the size, cost, and weight of filtering components needed for the ports. Ex. 1032, 3:20-26, 15:34-51, 19:51-53, 19:66-20:29, 40:17-19, 40:30-36, 42:15-18, 42:26-36; Ex. 1008, ¶¶ [0018]-[0024]; Ex. 1002, ¶ 345. Such a combination would have been nothing more than the simple substitution of one known element (Suzuki's AC-to-DC converters that derive the DC voltage inputs from an AC source) for another (Ball's DC-to-DC converters that derive the DC voltage inputs from Tracy's DC source) to obtain predictable results (Suzuki's H-bridge switches powered from Tracy's DC source rather than an AC source). Ex. 1002, ¶ 345.

A PHOSITA would have reasonably expected success in combing Tracy-Suzuki with Ball. Ex. 1002, ¶ 346. Ball uses the same DC source (a battery) as Tracy, and provides the same multiple DC voltage outputs as Suzuki. *Id*. Ball describes both how its circuit is structured with schematics and how to adjust the transformer winding ratio to set the voltages of the ports to achieve the ratios described by Suzuki (*e.g.*, 1:3:9). *Id*. Making the circuit connections of Ball's DC voltage ports to Tracy's DC power source and Suzuki's H-bridge voltage inputs as described above are basic engineering skills of a PHOSITA. Ex. 1005, 4:50-55, Fig. 3; Ex. 1031, ¶ [0023], Fig. 5; Ex. 1002, ¶ 346.

3. Dependent Claim 5

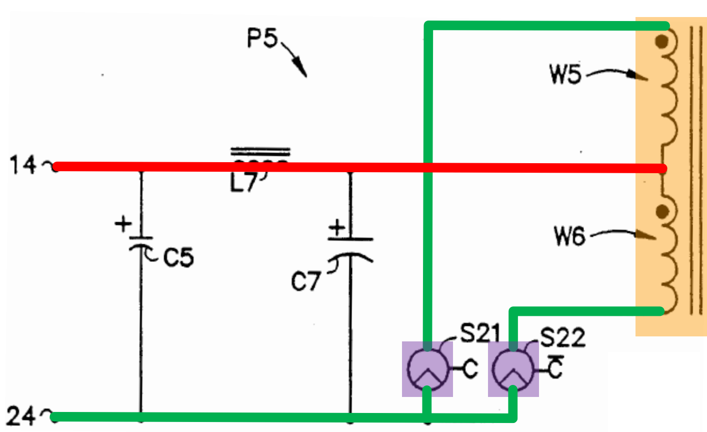
a. "The DC to AC conversion apparatus of claim 1 in which said DC to AC converter further comprises: a bidirectional DC-to-DC converter for converting the input voltage from said DC power source to a number of floating supplies of voltages equal to the input voltage divided or multiplied by successive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

Tracy-Suzuki-Ball as previously described discloses this limitation. As illustrated above, Ball discloses a bidirectional DC-DC converter that converts the input voltage from Tracy's DC power source to a number of Suzuki floating supply voltages. Ex. 1032, Figs. 2b, 3b, 8, 20, 12:5-27, 13:9-23, 25:58-61, 39:3-17, 42:5-36, 50:20-28, 53:20-25; Ex. 1002, ¶¶ 347-348; *see* Sections V.E.1, V.E.2, *supra*.

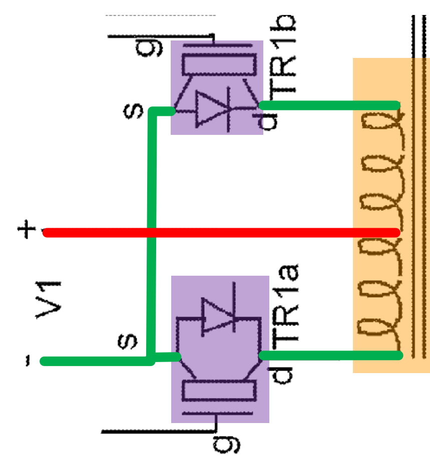
Tracy-Suzuki further discloses setting Vaa (the DC power source) and Vb and Vc (the floating voltages) to 3V:3V:9V or 9V:3V:1V (a ratio of $1:3^0:3^1$ or $1:3^{-1}:3^{-2}$, the claim 5 "floating supplies of voltages equal to the input voltage divided or multiplied by successive powers of 3"), based on Suzuki's Va:Vb:Vc ratios of (≥1V):3V:9V and 5V:3V:1V with Tracy's input voltage of $\sqrt{3}$*Va and 1.8*Va, respectively. *See* Section V.E.1, *supra*; Ex. 1002, ¶ 349; Ex. 1031, ¶¶ [0021], [0031], Fig. 4; Ex. 1005, 10:42-57, 11:13-25, Figs. 9a, 9b.

As explained (Section V.E.1, *supra*), a PHOSITA would have been motivated to modify Tracy's inverter having a DC voltage input range of $\sqrt{3}$ to 2 times its output voltage with Suzuki's multiple H-bridge switches with output voltage ratios (*e.g.*, (≥1V):3V:9V and 5V:3V:1V as shown in Figure 4) and with Ball's bidirectional DC-DC converter with a reasonable expectation of success. Ex. 1002, ¶ 350.

To the extent claim 5's "bidirectional DC-to-DC converter" is construed to be a means-plus-function term, the structure of Ball's converter is identical to, or insubstantially different from, that of the '822 patent's bidirectional DC-to-DC converter, with each port having a coil (**orange**) coupled to a central transformer, a center tap connected to a positive terminal (**red**), and the coil ends coupled to a negative terminal (**green**) through respective MOSFET switches (**purple**), and with coil turn ratios in proportion to the voltage ratios between the ports.



Ex. 1032, Fig. 8 (annotated)



Ex. 1001, Fig. 2 (annotated)

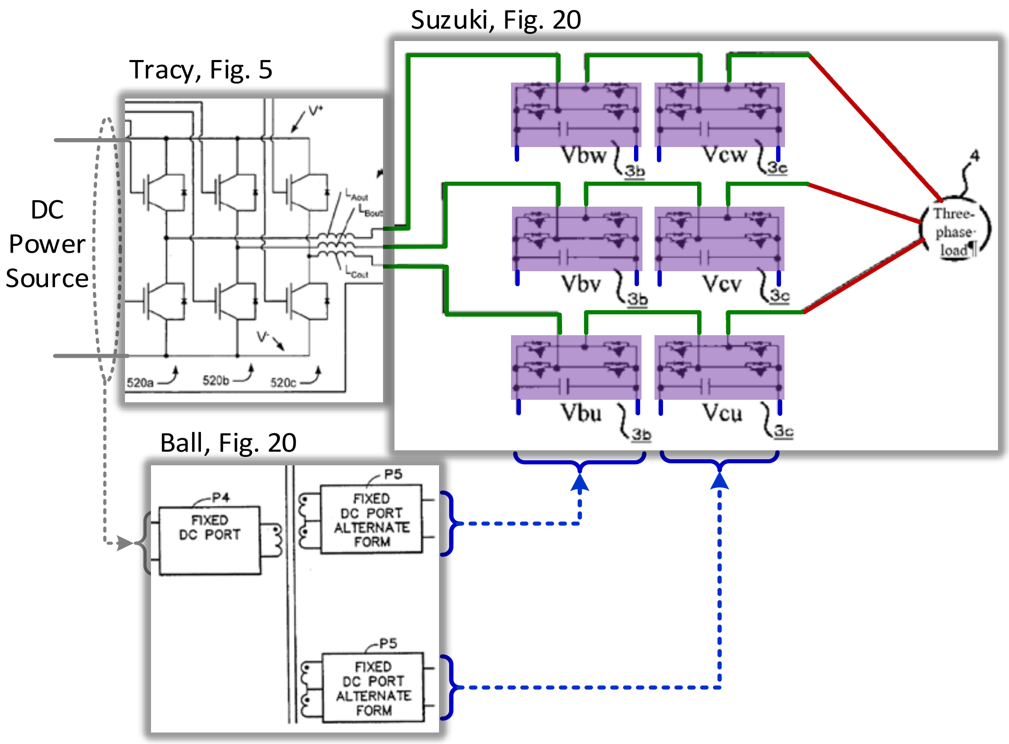
Ex. 1001, 18:34-66; Ex. 1032, 38:60-39:17, 39:29-40, 39:67-40:7, 40:17-19, 42:7-36, 44:52-60, 53:20-26, Figs. 2, 3, 13; Ex. 1002, ¶ 351.

Each DC port is controlled with similar high-frequency square-wave signals driving respective gates of the two MOSFET switches (*e.g.*, S21/S22 in Ball or Tr1a/Tr1b in the '822 patent). Ex. 1001, 18:37-66, Fig. 2; Ex. 1032, 22:12-20, 34:59-35:4, 40:30-36, 40:48-51, 42:8-12, 44:34-42, 44:52-60, 46:8-14, 53:20-26, Figs. 8, 12, 13; Ex. 1002, ¶ 352.

Both bi-directional converters perform the same function (converting the input voltage from the DC power source to several floating supplies of voltages) in the same way (using the same structure and control) for the same result (generating different floating voltages with a constant voltage ratio in, e.g., successive powers of 3). Ex. 1002, ¶ 352.

b. "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;"

In the Tracy-Suzuki-Ball combination (Sections V.E.1-V.E.2), Suzuki discloses three-state H-bridge switches (**purple**), each with input terminal pairs connected to a floating voltage (**blue**) from Ball's bidirectional DC-DC converter, and each with output terminals directly connected in series (**green**), and one end of the series-connected output terminal pairs connected to an AC output (**red**) as recited in this element:



Ex. 1005, Fig. 5; Ex. 1031, Fig. 20; Ex. 1032, Fig. 20 (annotated)

Ex. 1002, ¶ 353; Ex. 1031, Figs. 4G, 5 (illustrating +V, -V, 0 voltage levels), ¶¶ [0015]-[0019], [0021], [0022], [0069], [Claim 27].

As explained above in Sections V.E.1, V.E.2, *supra*, a PHOSITA would have been motivated to connect the outputs of one or more of Suzuki's H-bridge switches in series between Tracy's inverter phase outputs and the AC phase output terminals and connect the H-bridge switch inputs to Ball's bi-directional DC-DC converter with a reasonable expectation of success. Ex. 1002, ¶ 354.

c. "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,

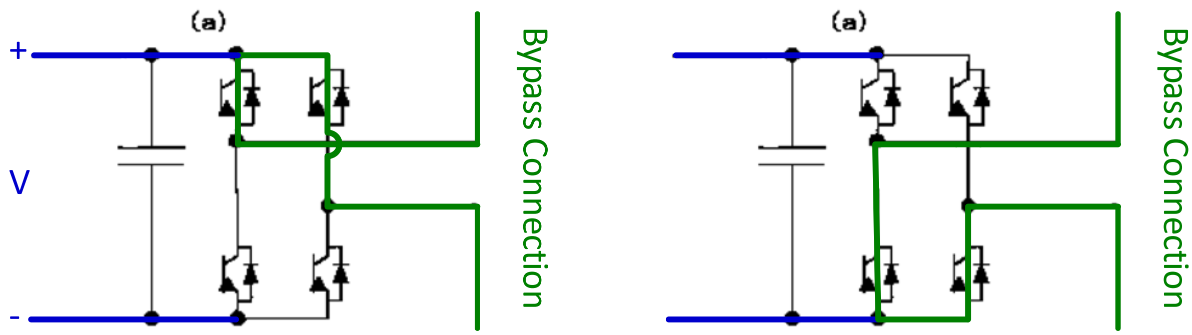
wherein the pass through state allows current flow in the H-bridge output circuit without connecting the DC input voltage in series with the H-bridge output terminals, the first polarity state causes the the DC input voltage to be connected in series with the H-bridge output terminals with a first polarity 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."

Suzuki (combined with Tracy and Ball, *see* Section V.E.1, V.E.2, *supra*) teaches using series-connected H-bridge output terminals (*see* Section V.E.3.b, *supra*) to approximate a sine wave (claimed "desired AC output waveform") as a sequence of steps expressed as predetermined combinations of ternary digits ("bit[s]") (claimed "ternary number base"), where each step is the sum of the individual inverter voltages (*e.g.*, Vc, Vb, and Va) multiplied respectively by the ternary digits: Vc*T3+Vb*T2+Va*T1. Ex. 1002, ¶¶ 355-356; Ex. 1031, Figs. 4, 5, 19, 20, 28, ¶¶ [0015]-[0022], [0031], [0039], [0069].

Each H-bridge switch is controlled to be in either a first polarity (ternary digit=+1) state, an inverse polarity (ternary digit=-1) state, or one of two pass-through (ternary digit=0) states. Ex. 1002, ¶¶ 356, 361; Ex. 1031, Figs. 4, 5, 20, ¶¶

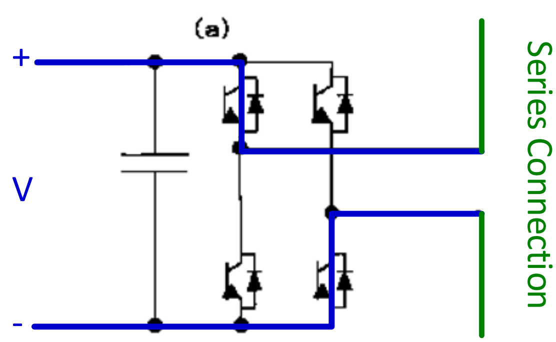
[0015]-[0022], [Claim 27]; Ex. 1017, p. 311 (identifying the only four states "useful for obtaining an alternating waveform across the load"), Fig. 4; Ex. 1012, pp. 215-217; Ex. 1044, pp. 37-38, Fig. 2b; Ex. 1003, 4:65-5:14; Ex. 1007, ¶ [0050].

In the pass-through states (outputting zero voltage), current flows in the H-bridge output circuit without connecting the DC input voltage in series with the H-bridge output terminals:



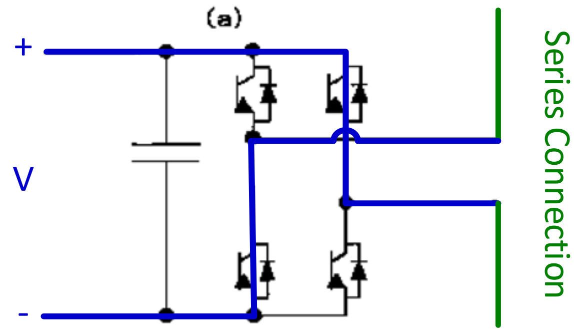
Ex. 1031, Fig. 3(a) (annotated)

Ex. 1017, p. 311, Fig. 4; Ex. 1002, ¶ 362; Ex. 1012, pp. 215-217. In the first polarity state, the DC input voltage is connected in series with the H-bridge output terminals with a first polarity.



Ex. 1031, Fig. 3(a) (annotated)

Ex. 1017, p. 311, Fig. 4; Ex. 1002, ¶ 363; Ex. 1012, pp. 215-217. And in the inverse polarity state, the DC input voltage is connected in series with the H-bridge output terminals with an opposite polarity.



Ex. 1031, Fig. 3(a) (annotated)

Ex. 1017, p. 311, Fig. 4; Ex. 1002, ¶ 364; Ex. 1012, pp. 215-217.

As explained above in Sections V.E.1, V.E.2, *supra*, a PHOSITA would have been motivated to modify Tracy's inverter to use Suzuki's H-bridge switches and ternary number base (using ternary digits) to control the H-bridge switches and Ball's bi-directional DC-DC converter with a reasonable expectation of success. Ex. 1002, ¶¶ 337-340, 345-346, 365.

Further, Tracy additionally discloses a control circuit (*e.g.*, 330, 430, 550) (claimed "switch controller") for controlling the inverter's switches. Ex. 1005, Fig. 9B, 2:48-3:14, 5:64–6:3, 6:11-20, 6:34-7:61, 8:58-65, 10:42-60; Ex. 1002, ¶ 357. Using Tracy's control circuit to control the added H-bridge circuits would have been obvious because both Suzuki and Tracy (with its control circuit) teach controlling half-bridges (sets of three half-bridges in Tracy's inverter and Suzuki's inverter 11, and pairs of half-bridges in each Suzuki H-bridge), and both provide similar PWM control. Ex. 1005, Fig. 5, 5:53-6:6; Ex. 1031, ¶¶ [0006]-[0010], [0017]; Ex. 1002, ¶¶ 357-359. Moreover, like Suzuki's use of a sampled numerical representation as described above, Tracy's control circuit uses a desired sine wave reference 701 "indicative of a desired voltage for the AC output." Ex. 1005, 7:22-37; Ex. 1031, Figs. 4, 5, ¶¶ [0018]-[0019], [0031]-[0032]; Ex. 1002, ¶ 357. Additionally, both references represent these outputs in terms of counts ("gradation levels" in ternary "bit[s]" in Suzuki, and 0-1000 "counts" in Tracy). Ex. 1005, 8:58-10:28; Ex. 1031, ¶¶ [0018]-[0019], [0031]-[0032], Figs. 4, 5; Ex. 1002, ¶ 357.

Based on these similarities, and for the simplicity and efficiency of using a single control circuit for all switches in the previously described Tracy-Suzuki-Ball inverter (*see* Sections V.E.1, V.E.2, *supra*), a PHOSITA would have been motivated to utilize Tracy's control circuit as a ready solution for implementing Suzuki's control of its H-bridge circuits (claimed "three state electronic switches"). Ex. 1002, ¶¶ 357-359. Doing so would have been the obvious combination of prior art elements (Tracy's control circuit implementing Suzuki's control scheme) according to known methods (connecting Tracy's control circuit to Suzuki's H-bridges and programming Tracy's controller with computer program instructions) to yield predictable results (the previously described Tracy-Suzuki-Ball inverter controlled with Tracy's control circuit). *Id.*

A PHOSITA would have reasonably expected success in combining these elements as the combination merely requires wiring Tracy's controller to Suzuki's transistors in the H-bridge switches through conventional driver circuits and configuring Tracy's control circuit with routine programming, which were well within the level of ordinary skill in the art. Ex.1031, ¶ [0022]; Ex. 1002, ¶ 360.

The '822 patent's corresponding structure of the "switching controller includes "a microcontroller" with "memory." Ex. 1001, 12:26-51, 24:8-12; *see* Section IV.B.2, *supra*. Tracy's control circuit (*e.g.*, 330, 430, 550) that performs the claim 5 function, is similarly described as "drive circuits controlled by a processor such as a microprocessor or microcontroller" storing program instructions. Ex. 1005, 4:20-45; Ex. 1002, ¶ 366. A PHOSITA would have understood that these program instructions were stored in memory and it would have otherwise been obvious to store such program instructions in memory. Ex. 1002, ¶ 366. Moreover, both controllers are insubstantially different from and perform the same functions (as in claim 5) in the same way (controlling H-bridge switches based on a sampled numerical representation) for the same result (producing the desired waveform). *Id.*

4. Dependent 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**

> **$3T(n)+T(n-1)+T(n-1)/3+\ldots T1/3^{(n-)}$] times the voltage from said direct current source, where the power m may be zero.**

The combination of Tracy, Suzuki, and Ball as previously described (Section V.E.1, *supra*) discloses this limitation. As previously explained, Tracy discloses the claim 8 elements, including "said step of deriving instantaneous voltages from the direct current source positive line or negative line." *See* Section V.A.2.c, *supra*; Ex. 1005, 3:3-7, 5:64-6:15, 6:21-30, 7:21-30, 10:50-60, Figs. 5, 7, 9B; Ex. 1002, ¶¶ 367-368. And as also explained with respect to the Tracy-Suzuki-Ball combination, Suzuki teaches expressing the desired voltage using two or three ternary digits (-1, 0, +1) (the claimed "finite number of digits … in a ternary number system"). *See* Sections V.E.1, V.E.3.c, *supra*; Ex. 1031, Fig. 4 (annotated), ¶¶ [0018]-[0019], [0031]-[0032]; Ex. 1002, ¶ 368.

Claim 12 further recites that the instantaneously desired voltage is equal to either of two recited formulas—one of which is reproduced and annotated below—times the voltage from the DC source:

$$\mathbf{3^{m}[\ T(n) + T(n-1)/3 + T(n-1)/9 + \ldots T1/3^{(n-1)}]}.$$

Ex. 1001, 42:66-43:7. A PHOSITA would have understood this formula as intended to represent a weighted sum of the ternary digits, with the multiplier (the weight) for each digit defined by a sequence, the beginning and end of the sequence given by the weights for T(1) and T(n), and the middle expression (**blue**) providing a pattern for the weights of the intermediate digits. Ex. 1002, ¶¶ 369-370. However, for n ≥ 3, this middle expression has no discernible pattern, and thus cannot be understood. *Id*.

But for n=2, no intermediate digits exist, and thus, a PHOSITA would understand the formula to simplify down to just the first and last digit expressions (irrespective of what pattern the middle expression was intended to show for other values of n). *Id.*, ¶ 371. Multiplying the formula by "the voltage from said direct current source," the formula for N=2 can be rewritten as:

$$\mathbf{V_{DC} * 3^{m} * [T2 + T1/3]}$$

Id., ¶ 371. This formula is disclosed by Tracy-Suzuki-Ball as previously described (*see* Section V.E.1) with one Suzuki H-bridge connected to each phase output of the three-phase Tracy inverter, and with the inverters outputting ±3V and ±1V respectively, such that each instantaneous phase voltage is 3*T2+1*T1. Ex. 1031, Figs. 4, 10, 19, 20, 28, ¶¶ [0005], [0018]-[0019], [0024]-[0025], [0031]-[0032], [0044], [0048]; Ex. 1002, ¶ 371. This matches the above formula with "m" scaled for whatever the voltage V_{DC} (Vaa in the Tracy-Suzuki-Ball combination) is set to at the input of Tracy's three-phase inverter. Ex. 1031, Figs. 4, 10, 19-20, 28, ¶¶ [0005], [0018]-[0019], [0024]-[0025], [0031]-[0032], [0044], [0048]; Ex. 1002, ¶ 371. The Tracy-Suzuki-Ball combination as described above thus teaches claim 12.

As explained above in Section V.E.1, *supra*, a PHOSITA would have been motivated to modify Tracy to use Suzuki's multiple H-bridge switches and switch timing and Ball's bi-directional DC-DC converter with a reasonable expectation of success to provide a smoother output waveform than produced by Tracy alone, thus reducing filtering requirements. Ex. 1002, ¶¶ 337-340, 345-346, 372-373.

Moreover, varying the weighting of the multipliers to other ratios covered by claim 12 would have been obvious to a PHOSITA in view of the Tracy/Suzuki combination and a PHOSITA's technical ability. *Id.*, ¶ 373. As discussed (Section V.E.1, *supra*), in addition to the 1:3:9 ratio, Suzuki discloses a large variety of other voltage weightings, and does not describe these as novel or nonobvious or having any technical benefit over simply weighting by consecutive powers of three. *Id.*; Ex. 1031, Figs. 4, 40-42, ¶¶ [0020]-[0021], [0040]-[0056]. Choosing an alternative weighting would have been nothing more than combining of prior art elements (Suzuki's inverter using multiple DC voltages) according to known methods (Suzuki's teaching of how different voltage ratios lead 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. 1002, ¶ 373; *Ecolab, Inc. v. FMC Corp.*, 569 F.3d 1335, 1350 (Fed Cir. 2009); *see also Gardner v. TEC Systems, Inc.*, 725

F.2d 1338, 1346, 1349 (Fed. Cir. 1984); *Iron Grip Barbell Co., Inc. v. USA Sports, Inc.*, 392 F.3d 1317, 1320-23 (Fed. Cir. 2004). Implementing such alternative weighting ratios would have easily been within the level of ordinary skilled in the art with a reasonable expectation of success, as evidence by Suzuki's disclosure of over 10 variations on weighting in Figure 4. Ex. 1002, ¶ 373.

5. Dependent Claim 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:

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;

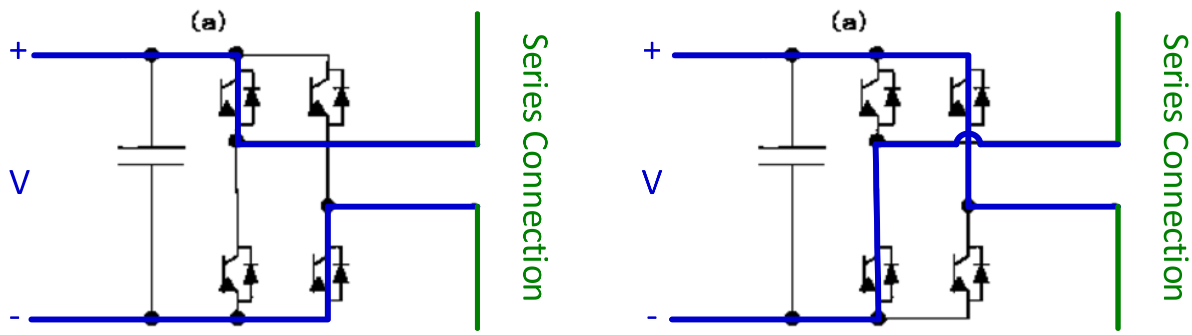
selecting one or more of said floating DC supplies to be directly connected in series to an AC output, with or without a polarity reversal, such that the algebraic sum of the selected voltages and polarities equals the desired instantaneous voltage of the AC output.

Tracy-Suzuki-Ball as described above (Sections V.E.1-V.E.2, *supra*) discloses this claim. As explained, Tracy discloses claim 8, including "deriving instantaneous voltages from the direct current source positive line or negative line." *See* Section V.A.2.c; Ex. 1005, 3:3-7, 5:64-6:15, 6:21-30, 7:21-30, 10:50-60, Figs. 5, 7, 9B; Ex. 1002, ¶ 374. And as explained (*see* Section V.E.2, *supra*), Ball discloses the claimed "bidirectional DC-to-DC converter" that converts Tracy's DC power source voltage (the claimed "DC source voltage") to a number of Suzuki H-bridge floating input voltages. Ex. 1002, ¶ 375; Ex. 1005, Fig. 5; Ex. 1031, Fig. 20; Ex. 1032, Figs. 2b, 3b, 8, 20, 12:5-27, 13:9-23, 25:58-61, 39:3-17, 42:5-36, 50:20-28, 53:20-25; *see* Sections V.E.1, V.E.2, *supra*. To the extent "bidirectional DC-to-DC converter" is a means-plus-function term, Ball teaches the identical or equivalent structure for the same reasons discussed above with respect to claim 5, since the '822 patent discloses the same structure for both of these claims. *See* Section V.E.3.a, *supra*; Ex. 1001, 18:34-66, Fig. 2; Ex. 1032, Figs. 2b, 3b, 8, 12:5-27, 13:9-23, 39:3-28, 42:5-36, 53:20-25; Ex. 1002, ¶ 377.

Suzuki discloses that the floating supply voltages Vb and Vc may be 3V and 9V (3^1 and 3^2) respectively—the claimed "set of floating DC supplies of voltages having voltage ratios of successive powers of 3." *See* Section V.E.1, *supra*; Ex. 1031, Figs. 4G, 19, 20, 28, ¶¶ [0018]-[0019], [0031]-[0032]; Ex. 1002, ¶ 376.

As described, Suzuki's H-bridge switches 3b and 3c have outputs connected in series to each AC output phase, with the desired instantaneous voltage of each phase being the sum of inverter voltages (*e.g.*, Vc, Vb, and Va) each multiplied by a respective ternary digit (annotated as T3, T2, and T1): Vc*T3+Vb*T2+Va*T1. Ex. 1031, Fig. 4 (annotated), ¶¶ [0018]-[0019], [0031]-[0032]; Ex. 1002, ¶ 378.

For ternary digit T2 = -1, the Vb floating source is in reverse polarity, thus outputting -3V (3V x -1) in series with the voltage phase output (the claimed "selecting one or more of said floating DC supplies to be directly connected in series to an AC output, with [] a polarity reversal”). Ex. 1031, Fig. 4 (annotated), ¶¶ [0018]-[0019], [0031]-[0032]; Ex. 1002, ¶ 379. For ternary digit T3 = 1, the Vc floating source is connected in forward polarity to output 9V (9V x 1) in series with the voltage phase output (the claimed “selecting . . . without a polarity reversal.” Ex. 1031, Fig. 4 (annotated), ¶¶ [0018]-[0019], [0031]-[0032]; Ex. 1002, ¶ 379. The H-bridge switch circuit paths in forward and reverse polarities are illustrated below.



Ex. 1031, Fig. 3a (annotated)

Ex. 1017, p. 311 (identifying the only two states outputting input voltage with or without reverse polarity), Fig. 4; Ex. 1012, pp. 215-217; Ex. 1002, ¶ 379. The sum instantaneous phase output is thus -3V+9V = 6V, thereby teaching “the algebraic sum of the selected voltages and polarities equals the desired instantaneous voltage of the AC output,” as claimed. Ex. 1002, ¶ 380.

F. CONCLUSION

For the foregoing reasons, *inter partes* review of claims 1-13 and 20 of the ’822 patent should be instituted and these claims should be canceled.

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CERTIFICATION UNDER 37 CFR § 42.24(D)

Under the provisions of 37 CFR § 42.24(d), the undersigned hereby certifies that the word count for the foregoing Petition for Inter Partes Review totals 13,862, which is less than the 14,000 allowed under 37 CFR § 42.24(a)(1)(i). This total includes 13,720 words as counted by the Word Count feature of Microsoft Word and 142 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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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,
[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, 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: 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;
[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;
[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 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, 2 or 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.