

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SOLAREGE TECHNOLOGIES LTD.,
Petitioner,

v.

KOOLBRIDGE SOLAR, INC.,
Patent Owner.

IPR2022-00007
Patent 8,937,822 B2

Before THU A. DANG, BRIAN J. McNAMARA,
and PATRICK M. BOUCHER, *Administrative Patent Judges*.

McNAMARA, *Administrative Patent Judge*.

JUDGMENT
Final Written Decision
Determining All Challenged Claims Unpatentable
35 U.S.C. § 318(a)

I. BACKGROUND

In response to a Petition (Paper 2, “Pet”), we instituted an *inter partes* review of claims 1–13, and 20 of U. S. Patent No. 8,937,822 B2 (“the ’822 patent”). See Paper 10 (“Dec. to Inst.”). Patent Owner filed a Patent Owner Response (Paper 14, “PO Resp.”), Petitioner filed a Petitioner Reply (Paper 17, “Pet. Reply”) and Patent Owner filed a Sur-reply (Paper 19, “PO Sur-Reply”). A transcript of an oral hearing held on January 19, 2023 (Paper 27, “Hr’g. Tr.”) has been entered into the record.

We have jurisdiction under 35 U.S.C. § 6. This Final Written Decision is issued pursuant to 35 U.S.C. §318(a). We base our decision on the preponderance of the evidence. 35 U.S.C. § 316(e); 37 C.F.R. § 42.1(d).

Having reviewed the arguments of the parties and the supporting evidence, we conclude that Petitioner has demonstrated by a preponderance of the evidence that the challenged claims are unpatentable.

II. THE ’822 PATENT

The ’822 patent relates to DC to AC converters for electric power systems that may be of particular interest in solar energy systems. Ex. 1001, 1:5–9. The ’822 patent describes a first implementation in which a waveform generator is based on expressing the desired output voltage waveform as a series of numerical samples in a number base. *Id.* at 3:17–20. Each sample is expressed as a plurality of digits in the number base. *Id.* at 3:20–22. One or more high frequency, bi-directional, isolating DC to DC converters converts input DC power at a first voltage to a series of relatively floating DC output voltages. *Id.* at 3:22–24. The floating DC output voltages are in the same ratio to one another as powers of the number base. *Id.* at 3:24–26. Switches connected to each of the floating DC supplies are controlled according to a corresponding digit of the numerical sample to

generate a corresponding floating output voltage waveform. *Id.* at 3:26–29. The floating output waveforms are then directly connected in series to form the desired power output waveform having the desired repetition frequency, thereby eliminating the need for low-frequency transformers or other weighting means. *Id.* at 3:26–33.

Figure 1 of the '822 patent is reproduced below.

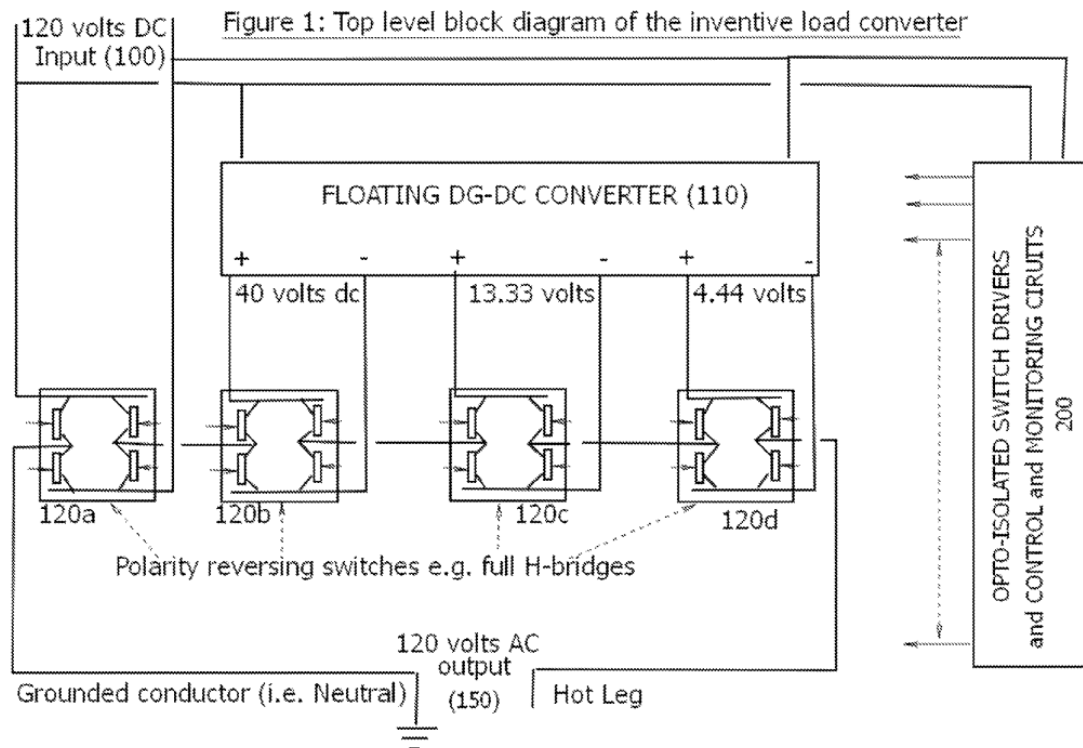


Figure 1 is a block diagram of one implementation the DC-AC load converter of the '822 patent. Ex. 1001, 5:33–34, 6:17–18. As an example, ten, 12 volt rechargeable batteries connected in series can be used to form 120 V DC input 100. *Id.* at 6:18–20. The apparatus of Figure 1 generates a 120 V AC output at terminals 150; one of these terminals may be connected to a grounded conductor or neutral of the AC load. *Id.* at 6:20–23.

As shown in Figure 1, bi-directional DC-DC converter 110 converts DC input 100 to a number of floating DC output voltages. *Id.* at 6:23–24.

The inverter AC output waveform to be generated is represented as a sequence of numerical samples. *Id.* at 6:41–43. Each numerical sample value is expressed with four digits in the ternary number system, T_1 – T_4 , where T_i ($i=1 \dots 4$) can take on only one of three values (-1, 0, or +1). Therefore, in addition to the DC input, floating DC-DC converter 110 generates 3 corresponding DC floating supplies with ratios of 1:1/3:1/9:1/27, resulting in floating DC voltages of 40 volts (120/3), 13.33 volts (120/9), and 4.44 volts (120/27), when the source is 120 Volts DC. *Id.* at 6:41–52. As the sum of the DC input and all the outputs of the DC-DC converter is 177.77 (i.e., $120+40+13.33+4.44$), the peak AC output is 177.77 volts, which corresponds to a useful sine wave output of 125.7 volts rms. *Id.* at 6:54–57. Other scaling is possible. *See id.* at 6:60–7:6.

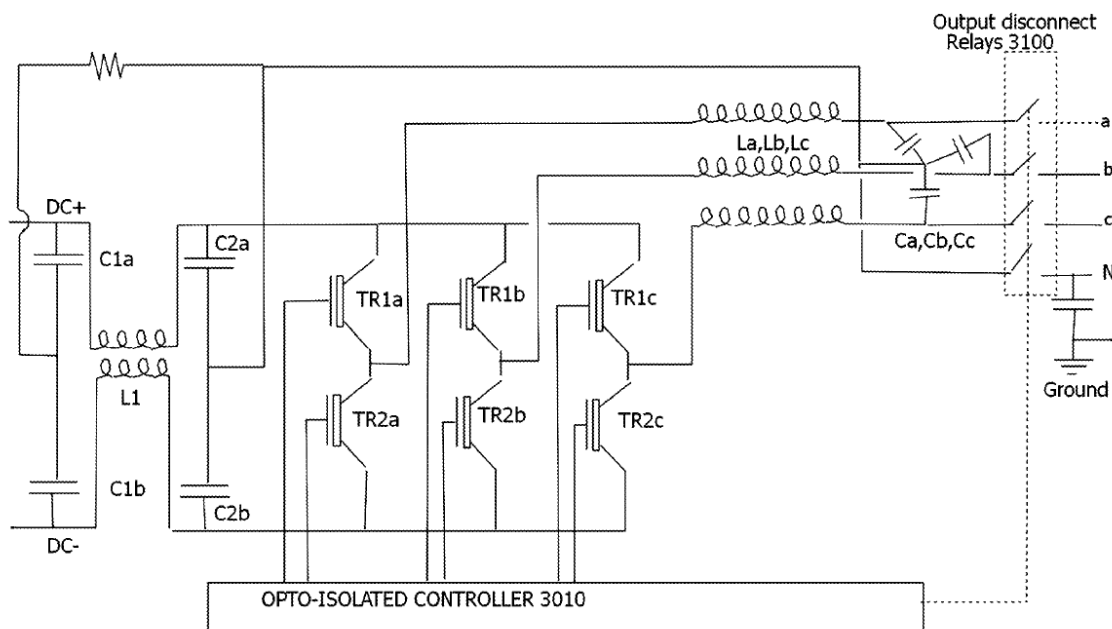
The floating DC input and the floating DC outputs from converter 110 each feed respective polarity reversing switches 120a-120d that are directly connected in series to AC output 150 and controlled by opto-isolated driver 200, so that “by either inverting the selected polarity of each DC supply or not, or not selecting it, in accordance with a respective one of the ternary digits T_4, T_3, T_2, T_1 , the series-connected output can be any of the 81 values ($120T_4+40T_3+13.33T_2+4.44T_1$) volts.” *See id.* at 6:25–30, 7:7–16. “In order to generate a 60 Hz step-approximation to a 125.7 volt rms sinewave, the switches are controlled to select sequentially among the $3^4=81$ possible voltage levels from -177.77 to +177.77 volts and back again, repetitively in the proper sequence and at the proper times,” i.e. $2 \times 81 \times 60 = 9720$ level changes per second. *Id.* at 7:39–45; 8:38–41.

A common characteristic among the embodiments of the invention is that “a common-mode AC signal is created in-phase on both the positive and negative DC input terminals and on all DC conductors.” Ex. 1001, 4:46–49.

In a single-phase application, the common-mode AC signal is at the same frequency as the output frequency; in a three-phase application, the common mode frequency is three times the output frequency; in a quadrature case, the common mode frequency is twice the AC output frequency. *Id.* at 4:49–53. The '822 patent notes that a ground leakage fault in the DC circuit can be detected by detecting AC leakage current at the common mode frequency, because that is easier than detecting a DC leakage current. *Id.* at 4:53–56.

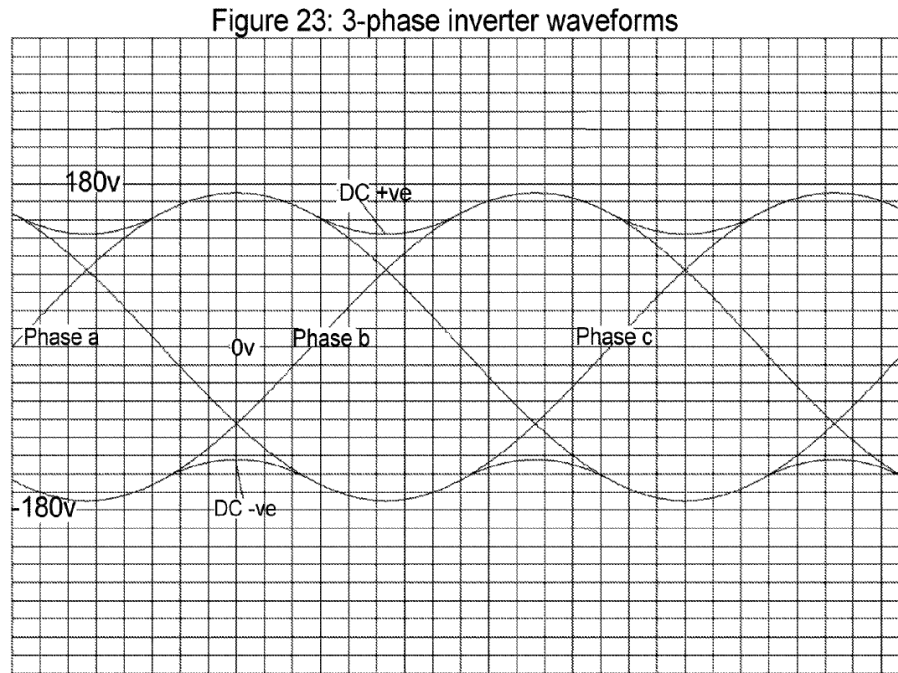
Figure 16 of the '822 patent reproduced below shows a 3-phase grid inverter. Ex. 1001, 5:60–61, 26:35–36.

FIGURE 16: INVENTIVE 3-PHASE GRID INTERTIE INVERTER



In Figure 16, the DC input is applied to three half-bridges that connect either DC+ or DC- through an LC smoothing filter to each of three-phase outputs a, b, and c, e.g., a 120/208 utility connection with a neutral, preferably a utility transformer with a Y-configured secondary to accommodate RFI filter capacitors to decouple RF interference to neutral rather than to ground. *See id.* at 26:36–46.

Figure 23 reproduced below shows the inverter voltage waveforms at the output to the utility and on the input DC+ and DC- lines. *Id.* at 26:57–58.



Operating the switches according to specific logic “causes a common-mode AC signal to appear in-phase on DC terminals with a frequency of three times the AC output frequency of the inverter, that is 180 Hz for an output frequency of 60 Hz.” *See id.* at 26:57–27:8 (describing the specific switching logic for operating the half-H bridges). The 180 Hz common mode signal is almost a sine wave. *Id.* at 27:59; *see also, id.* at 27:20–28:21 (discussing details of grid tie operation). The presence of an AC component on the DC terminals “facilitates detection of ground leakage faults on the DC side,” e.g., “[i]f the inverter is connected to the utility via a regular two-pole AC GFI breaker, any leakage path on the DC side will result in a 60 Hz imbalance current between neutral and hot on the AC side, thus tripping the breaker.” *See id.* at 25:42–48.

III. ILLUSTRATIVE CLAIM

Claim 1, reproduced below with the paragraph designations used in the Petition, is representative of the subject matter of the challenged claims of the '822 patent

- 1[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
 - [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;
 - [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] [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.

IV. CLAIM CONSTRUCTION

In the Decision to Institute we declined to treat any of the claim terms as mean-plus-function terms because the terms have an ordinary and customary meaning. Dec. to Inst. 14–15. Neither party has proposed any other claim constructions. We apply the plain and ordinary meaning in this Decision.

V. GROUNDS OF INSTITUTION

We instituted trial on all the challenged claims on all grounds asserted in the Petition, as listed below:

Claim(s) Challenged	35 U.S.C. §	Reference(s)/Basis
1–3, 8–10	102 ¹	Tracy ²
1–3, 8–10	103	Tracy
4, 11	103	Tracy, Fujimoto ³
6, 20	103	Tracy, De ⁴
7	103	Tracy, Bond ⁵
5, 12, 13	103	Tracy, Suzuki, ⁶ Ball ⁷

In addition to '822 patent, the references, and other documents, the record before us includes the following testimonial evidence:

Declaration of R. Jacob Baker, Ph.D., P.E. in Support of Petitioner Solaredge Technologies Ltd.'s Petition 1 of 6 for Inter Partes Review of U.S. Pat. No. 8,937,822. Ex. 1002 ("Baker Decl.").

Reply Declaration of R. Jacob Baker, Ph.D., P.E. Ex. 1074 ("Baker Reply Decl.").

Transcript of Deposition of Dr. Daniel Foty taken on September 12, 2022. Ex. 1075 ("Foty Depo. Tr.").

¹ See The Leahy-Smith America Invents Act ("AIA"), Pub. L. No. 112–29, 125 Stat. 284, 287–88 (2011), amended 35 U.S.C. §§ 102, 103, and 112. Because the application of the '822 patent was filed before March 16, 2013 (the effective date of the relevant amendments), the pre-AIA versions of §§ 102, 103, and 112 apply

² U.S. Patent No. 7,088,601 (Ex. 1005).

³ Japanese Pat. App. Pub. No. JP H11-122819 (Ex. 1034).

⁴ U.S. Patent App. Pub. No. 2007/0278988 (Ex. 1018).

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

⁶ Japanese Pat. App. Pub. No. P2004-7941A (Ex. 1030; English Translation Ex. 1031).

⁷ U.S. Patent No. 5,029,064 (Ex. 1032).

Declaration of Dr. Daniel Foty submitted in *Intel Corp. v. Qualcomm Inc.*, IPR2019-00049. Ex. 1080 (“Foty Intel Decl.”).

Supplemental Declaration of Daniel Foty, dated August 1, 2022. Ex. 1082 (“Foty Supp. Decl.”), also labeled on the document as Ex. 2010.⁸

Declaration of Dr. Daniel Foty. Ex. 2006 (“Foty Decl.”).

Transcript of Deposition of R. Jacob Baker, Ph.D., P.E. Ex. 2007 (“Baker Depo. Tr.”).

Exhibit 2 to Transcript of Deposition of R. Jacob Baker, Ph.D., P.E. Ex. 2008.

Petitioner argues that Dr. Foty offers testimony outside his area of expertise. Pet. Reply 24–26; *see also* Paper 15 (Petitioner’s Objections to Exhibits in Patent Owner’s Response); Ex. 1082, (Foty Supp. Decl.). Patent Owner disputes Petitioner’s contentions concerning Dr. Foty’s qualifications. PO Sur-Reply 17–19. Both parties filed objections to evidence. Paper 15 (Petitioner’s Objections to Exhibit 2006 (Foty Decl.) in Patent Owner’s Response); Paper 18 (Patent Owner’s Objections to Evidence (objecting to Exhibits 1074–1081)). As no motions to exclude evidence have been filed, we give due weight to all the evidence before us.

VI. ANALYSIS OF PRIOR ART CHALLENGES

A. Claims 1–3 and 8–10 As Anticipated By or Obvious Over Tracy

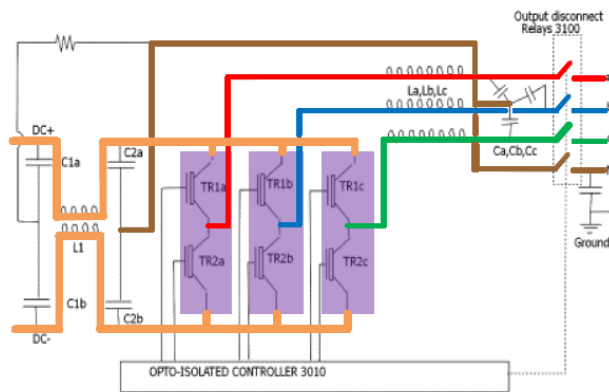
1. Tracy (Ex. 1005)

Tracy concerns a power conversion apparatus connected to first and second DC busses that generates a polyphase AC output. Ex. 1005, 1:7–9. Tracy uses a control circuit to shift a DC voltage range of the first and second DC busses relative to a reference voltage based on a relationship

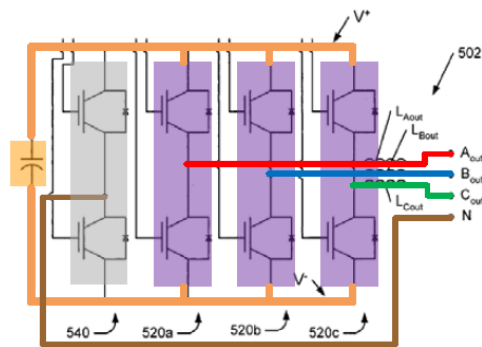
⁸ Ex. 2010 in the record is Patent Owner’s oral hearing demonstratives.

among phase components associated with the AC output. *Id.* at 1:51–61, Fig. 3. The reference voltage for the polyphase AC output may be an actual or synthetic neutral derived from the phases. *Id.* at 1:61–64.

To demonstrate the similarities between the '822 patent and Tracy, the Petition includes an annotated comparison of Figure 16 of the '822 patent, as shown below on the left, and Figure 5 of Tracy, as shown below on the right.

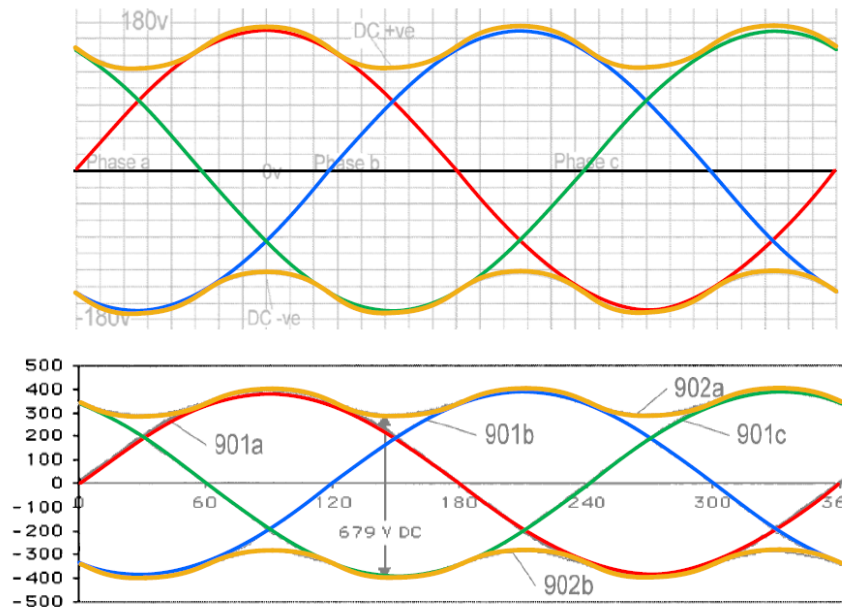


Ex. 1001, Fig. 16 (annotated)



Ex. 1005, Fig. 5 (annotated)

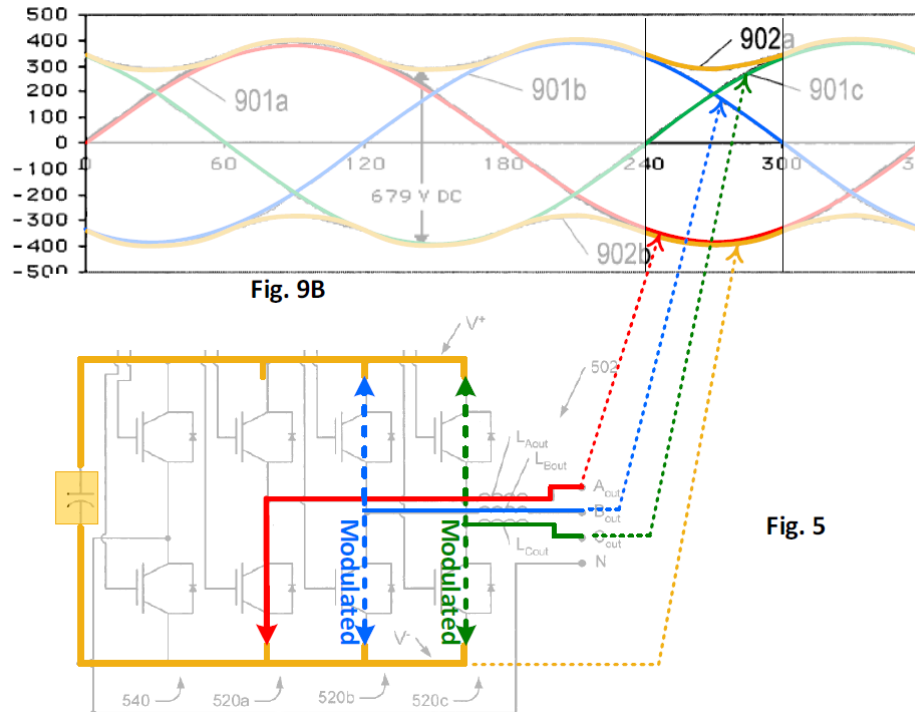
Pet. 7. Comparing its annotated Figure 16 of the '822 patent and Figure 5 of Tracy, Petitioner observes that both figures show three half-bridge circuits (shaded purple) that produce three-phase AC outputs of 0, 120 and 240 degrees (Aout (red), Bout (blue), Cout (green)) relative to a neutral terminal (brown) and the same common mode voltage (orange) on both DC inputs. *Id.* at 6–7. Further demonstrating the similarities between the '822 patent and Tracy, the Petition includes an annotated figure comparing the waveforms of Figure 23 of the '822 patent (shown on top) and the waveforms in Figure 9B of Tracy, shown on the bottom. *Id.* at 7. Petitioner's annotated figure is shown immediately below.



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

Pet. 7. Petitioner observes that both Figure 23 of the '822 patent and Figure 9B of Tracy illustrate the same three-phase outputs (0, 120, and 240 degrees) and the same common mode voltage on the DC terminals. *Id.*

Petitioner also asserts that Tracy and the '822 patent use the same switching pattern, which Tracy describes as adding a “zero sequence (common-mode)” offset to the DC voltages by applying “discontinuous modulation” so that one phase is held continuously to one of the DC voltage busses, while the other two phases are modulated between the DC inputs. *See* Pet. 8. To illustrate the point, Petitioner provides an annotated version of Figure 9B above Figure 5 of Tracy, as shown immediately below.



Id. The Petition states that the above annotated figure shows Tracy’s discontinuous modulation in the 240–300 degree interval, where Aout (red) is connected to DC- (orange) and Bout (blue) and Cout (green) are modulated between the DC inputs. *Id.* (citing Ex. 1005, 10:25–27; Ex. 1002, Baker Decl. ¶ 189). According to Petitioner, “[t]he 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.” *Id.* at 9 (citing Ex. 1003, Baker Decl. ¶ 190).

2. Claim 1

a) Claim Limitation 1A

Petitioner identifies the preamble of claim 1 as claim limitation 1A. Claim limitation 1A recites 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.” Ex. 1001, 41:1–4. Petitioner notes that Tracy describes a three-phase DC/AC converter that converts

power from a DC source to a poly-phase AC output. Pet. 22–24 (citing Ex. 1005, (code 57) 1:26–3:35, 4:4–5:16, 5:44–7:61, 9:12–10:60, Figs. 3, 5, 9B; Ex. 1002, Baker Dec. ¶¶ 218–219).

Patent Owner does not respond specifically to Petitioner’s contentions concerning this limitation. Having considered the evidence and arguments of record, we find that Petitioner has demonstrated Tracy discloses this limitation.

b) Claim Limitations 1B–1C

Petitioner identifies as claim limitations 1B–1C the recitation “a set of at least one live AC output terminals, at least one output terminal designated as a ground, neutral or reference potential terminal.”

Petitioner cites Tracy’s live AC output terminals and its neutral terminal as disclosing these limitations. Pet. 24 (citing Ex. 1005, (code 57), 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, Baker Decl. ¶¶ 222–225).

Patent Owner does not respond specifically to Petitioner’s contentions concerning limitation 1B and 1C. Having considered the evidence and arguments of record, we find that Petitioner has demonstrated Tracy discloses these limitations.

c) Claim Limitation 1D

Petitioner identifies as claim limitation 1D the recitation “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.”

Petitioner cites Tracy’s disclosure of battery 310 with positive and negative terminals connected to respective positive and negative DC input terminals of the inverter as disclosing claim limitation 1D. Pet. 24–25.

Patent Owner contends that the Petition does not indicate what part of Tracy corresponds to the claimed positive and negative terminal. PO Resp. 5 (acknowledging that in paragraphs 226 and 227 of his declaration Petitioner's expert explains that first and second DC voltage busses 315a, 315b are the positive and negative terminals of DC source 310, but arguing that we should disregard this testimony because the argument does not appear in the Petition); Ex. 1002, Baker Decl. ¶¶ 226–227; *see also* PO Sur-Reply 6–7.

Petitioner points out that Patent Owner fails to mention the discussion in the Petition stating that Tracy's battery is floating because its terminals are connected only to the inputs of half-bridge switches 315a/b, 520a–c, and 540 and are isolated from (not permanently connected to) any established potential such as the neutral terminal. Pet. Reply 1–2, (citing Pet. 24, discussing 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, Baker Decl. ¶¶ 226–228). Petitioner further points to the annotated version of Figure 3 in the Petition in which the terminals are highlighted in orange. *Id.* at 2 (citing Pet. 22–23, 25–26).

Referencing the same text Petitioner cited on page 24 of the Petition, Patent Owner replies that the Petition “only indicates that Petitioner believes Tracy has positive and negative DC input terminals, not what they are” and argues that Petitioner's citations to the Baker declaration in the Petitioner Reply “multiply the procedural issues.” PO Sur-Reply 6–7.

Patent Owner's arguments on this point are unavailing. The Petition argues that Tracy discloses a floating DC power source with positive and negative terminals connected to respective positive and negative terminals of a DC to AC converter, as recited in claim limitation 1D, explicitly citing

specific terminals of Figure 3 of Tracy. The Petition includes an annotated version of Figure 3 illustrating a DC source connected to polyphase converter 320 via V^+ bus 315a and V^- bus 315b and specifically cites relevant portions of Tracy. Pet. 23 (citing Ex. 1005, 4:52–59, 5:11–16, 5:55–6:3, 23:38–41). The discussion in the Baker Declaration is similar. Ex. 1002, Baker Decl. ¶ 226. Dr. Baker’s statement that the first and second DC voltage busses 315a, 315b in Tracy are the positive and negative DC output terminals of the DC source, as well as the positive and negative DC input terminals of the polyphase DC to AC converter 320, merely articulates what is already shown in annotated Figure 3 in the Petition. Ex. 1002, Baker Decl. ¶ 226; Pet. 23–24.

Patent Owner next asserts that Tracy does not disclose the claimed “floating DC power source” because Tracy discloses that the DC voltage busses are controlled with respect to a reference voltage, such as a neutral. *See* PO Resp. 6–16. Petitioner notes that Patent Owner’s expert (Dr. Foty) describes “floating” as meaning either that the voltage is indeterminate, which is not how the ’822 patent uses the term, or the difference between two voltage values is fixed (regardless of the actual voltage values). Pet. Reply 2–3 (citing Ex. 1082, Foty Supp. Decl. ¶ 19). Petitioner’s expert, Dr. Baker agrees with Dr. Foty’s second description of “floating.” *See* Ex. 1074, Baker Reply Decl. ¶¶ 9–10 (“[a] PHOSITA would understand that this second definition is consistent with both the ’822 Patent and with Tracy.”). Dr. Baker emphasizes Figure 23 of the ’822 patent shows that, although the difference between the actual values referenced to the 0V neutral is fixed, their actual values can vary widely and that “[t]his ability to vary is made possible by the fact that the DC terminals are not permanently connected to

any established potential, such as neutral.” Ex. 1024, Baker Reply Decl. ¶ 10.

The Petition states that Tracy’s DC source is floating because its terminals are connected only to the inputs of half bridge switches 315a/b, 520 a–c, and 540, and are isolated from any established potential such as neutral terminal N, i.e., the DC source’s terminals are not permanently connected to neutral terminal N. Pet. 24; Pet. Reply 3–4 (citing Ex. 1002, Baker Decl. ¶ 151 for the proposition that for the DC power source to be floating, its positive and negative terminals must not be permanently connected to the ground reference of the AC input or any other ground reference other than through the inverter); *see also* Ex. 1074, Baker Reply Decl. ¶ 10 (“Tracy’s DC voltage is allowed to vary with respect to neutral – this could not happen if either terminals 902a, 902b were permanently connected to neutral.”). Petitioner cites Figure 23 of the ’822 patent and Figure 9B of Tracy as illustrating that the difference between DC terminal voltages can remain fixed, although the actual values referenced to neutral (0V) can vary widely because the DC terminals are not permanently connected to any established potential such as neutral. Pet. Reply 4–5 (citing Ex. 1001, 26:34–27:8, Figs. 16, 23; Ex. 1005, 10:42–11:12, Figs. 5, 9B; Ex. 1002, Baker Decl. ¶¶ 75, 188; Ex. 1074, Baker Reply Decl. ¶¶ 9–10); *see also* Pet. 7–8 (comparing Fig. 23 of the ’822 patent and Fig. 9B of Tracy).

Arguing that a voltage is not “floating” if it is attached to any established potential such as the neutral terminal, Patent Owner disputes that Tracy supports Petitioner’s assertions for the following reasons: (i) Tracy repeatedly discusses a reference voltage (PO Resp. 6–7), (ii) Tracy discloses that the voltage busses are coupled to the neutral terminal (*id.* at 7–11), (iii)

Tracy discloses that the rectifier is coupled to an AC power source (*id.* at 11–12), and (iv) Petitioner’s theory is inconsistent with the disclosure in Tracy (*id.* at 12–14). We address each of these arguments.

i. Tracy repeatedly discusses a reference voltage

According to Patent Owner’s expert “th[e] appearance of ‘reference voltage’ (repeatedly) in Tracy clearly serves to indicate that Tracy’s circuitry is *not* floating – but instead makes (conventional-style) use of a reference voltage for the definition of voltages V+ and V-.” Ex. 2006, Foty Decl. ¶ 62; *see also id.* ¶ 65. Patent Owner argues that, unlike Tracy, in the ’822 patent, the DC voltage busses are not controlled with respect to a reference voltage; Patent Owner contends that Tracy does not disclose a floating power source, as that term is used in the ’822 patent, because in Tracy “the DC voltage busses are instead controlled with respect to a reference voltage.” PO Resp. 6. Noting that Tracy “involves controlling the difference (a phase-controlled rectifier) between V+ and V-,” Dr. Foty states “[t]he control of both V+ and V- in Tracy is a fundamental aspect of Tracy’s invention – and is the exact opposite of having a floating DC source” because “Tracy is modulating the circuitry so as to decide what V+ and V- will be, thus the DC power source cannot be floating in this situation” (Ex. 2006 ¶¶ 63–64). *See* PO Resp. 6–7.

Petitioner responds that Patent Owner’s assertions are inconsistent with the claim and the specification and are internally contradictory. Pet. Reply 5–10. According to Petitioner, Patent Owner’s argument that in the ’822 patent the DC power source cannot be controlled with respect to a reference voltage contradicts the claim, because the claim recites that the DC to AC converter causes a common mode voltage waveform to appear

relative to one of at least the ground, neutral, or reference potential on positive and negative terminals of the DC power source. *Id.* at 6.

Petitioner also contends that Patent Owner's arguments are inconsistent with the '822 patent Specification because Figure 23 of the '822 patent "clearly shows that the 'DC +ve' and 'DC -ve' voltages at the DC terminals are controlled to vary with respect to neutral (0V)." *Id.* (citing Ex. 1074, Baker Reply Decl. ¶ 22). Petitioner notes the discussion in the '822 patent of a solar charged battery configured to allow its terminals to be alternately interchanged so that the positive and negative terminals are connected to the grounded neutral connector. Pet. Reply 8 (citing Ex. 1001, 3:39–44).

According to Patent Owner, "Petitioner acknowledges a voltage source is not floating if it is connected to 'any established potential such as a neutral terminal.'" PO Resp. 6 (quoting Pet. 24). Petitioner emphasizes that Patent Owner omits an important aspect of Petitioner's argument, i.e., that both Tracy and the '822 patent rely on temporarily connecting DC terminals to a neutral terminal for generating the common mode voltage waveform. Pet. Reply 7–8 (citing PO Resp. 6). As Petitioner points out, "[t]he '822 patent is replete with statements that one of the 'floating' DC source's terminals is temporarily connected to neutral." *Id.* at 8 (citing Ex. 1001, 23:47–48 ("[t]he DC- is connected to the neutral when the AC output is required momentarily to be positive, and the DC+ is connected to neutral when the AC output is momentarily required to be negative"), 23:48–52 ("[t]his switching is synchronized with the utility grid so that the two solar array terminals are alternately grounded at a 60 Hz repetition rate"), 3:52–60, 4:27–40, 10:44–47, 11:1–7, 11:25–28; *see also* Ex. 1074, Baker Reply Decl. ¶ 12).

Patent Owner argues that, unlike the circuits of Tracy, the circuits in the '822 patent connect the neutral line to the H-bridges, not the DC input terminals, and that Petitioner does not explain the relevance of the different Tracy circuit to the claimed invention. Pet. Reply 8.

Patent Owner's argument on this point is unavailing. Petitioner's arguments are focused on and responsive to Patent Owner's assertions that Tracy does not teach a floating DC source. Patent Owner's contention that Petitioner cannot make affirmative arguments in the Reply because Patent Owner can no longer present evidence about whether a person of ordinary skill would find the differences in the circuit is also unavailing. Petitioner's arguments merely respond to Dr. Foty's testimony concerning the meaning of a DC floating voltage. Pet. Reply 2–10 (citing, e.g., PO Resp. 6; Ex. 1082, Foty Supp. Decl. ¶19). Indeed, Patent Owner's expert executed two declarations, one with its Patent Owner Response (Ex. 2006) and another (Ex. 1082) in response to Petitioner's objections to evidence (Paper 15).⁹ Petitioner's Reply addresses issues raised in both of Dr. Foty's declarations.

Petitioner further notes that Dr. Foty on the one hand states that a reference is a way of saying that something *is not* floating, as the voltages are referenced to a known, fixed DC voltage, but on the other hand relies on a reference voltage (ground) to describe a voltage that *is* floating, saying that, while the difference between two voltages is fixed, e.g., a 9V battery, the actual values referenced to ground can vary widely, as long as the difference remains 9V, e.g. 29V and 20V. Pet. Reply 6–7 (citing Ex. 1082, Foty Supp. Decl. ¶ 19). Petitioner states that a person of ordinary skill

⁹ Patent Owner did not preserve its objections with a Motion to Exclude.

would not have adopted Dr. Foty’s statement as defining a floating DC power source. *Id.* at 7 (citing Ex. 1074, Baker Reply Decl. ¶ 11). Petitioner points to extrinsic dictionary evidence cited by Patent Owner that defines “floating” as “[t]he condition wherein a device or circuit is not grounded and not tied to an established voltage supply.” *Id.* at 9 (citing PO Resp. 6; *see also* Ex. 1042, 6).

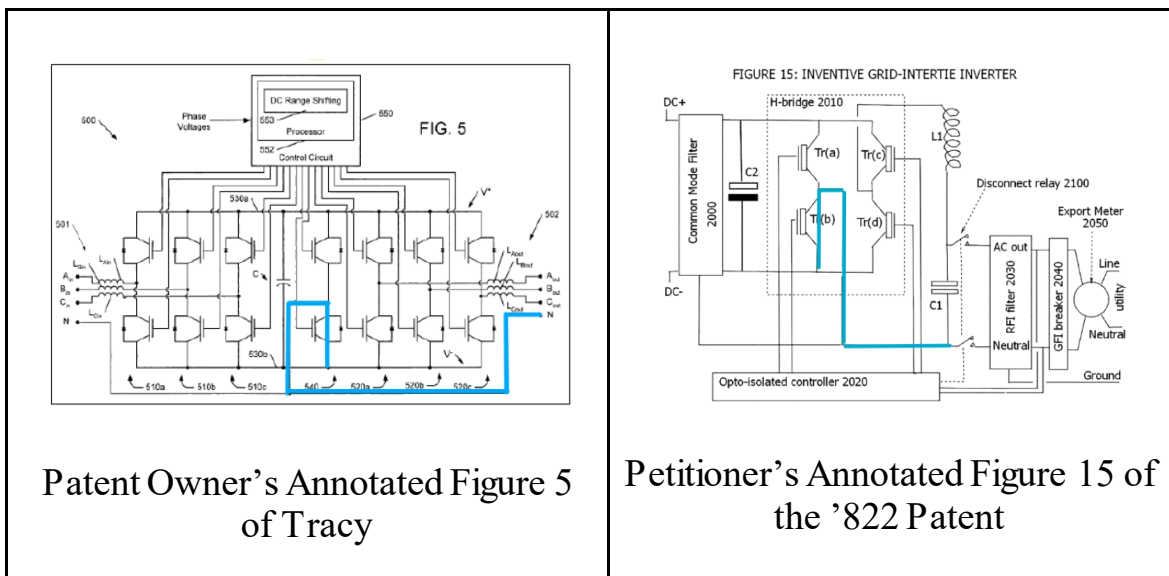
We agree with Petitioner that Patent Owner unrealistically reads this definition to mean there can never be a connection to ground or neutral, because Patent Owner ignores the disclosure in the ’822 patent of temporarily connecting one or the other of the floating DC sources to neutral, as discussed above. *Id.* at 9–10 (citing Ex. 1001, 3:52–60, 4:27–40, 10:44–47, 11:1–7, 11:25–28, 23:47–52; Ex. 1074, Baker Reply Decl. ¶¶ 12–13).

ii. Tracy discloses that the voltage busses are coupled to the neutral terminal

The Petition states that the DC power 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.” Pet. 24; *see* PO Resp. 7–8. According to Patent Owner, the DC “terminals of the DC source in Tracy are connected to an established potential . . . namely, neutral terminal N.” PO Resp. 8. Patent Owner cites its annotated version of Figure 5 of Tracy as expressly illustrating a connection between neutral terminal N and lower voltage bus 530b. PO Resp. 8–9. Patent Owner also cites the text of Tracy as disclosing that the voltage busses are connected to neutral through half-bridge 540, as well as testimony of Dr. Baker agreeing that half-bridge 540 provides a neutral

connection. *Id.* at 9 (citing Ex. 1005, 6:3–6; Ex. 2007, Baker Depo. Tr. 81:15–21).

Petitioner’s reply again focuses on the nature of the connection as being temporary, rather than permanent, in both the ’822 patent and in Tracy. Pet. Reply 10–13. Petitioner’s Reply includes a reproduction of Patent Owner’s annotated Figure 5 of Tracy (reproduced below on the left) and Petitioner’s annotated Figure 15 of the ’822 patent (reproduced below on the right).



Id. at 11–12. Referring to Patent Owner’s annotated Figure 5 of Tracy (shown above on the left), Petitioner notes that Patent Owner’s blue line annotation passes through a switch in half bridge circuit 540, such that the connection to neutral is not permanent, but exists only when the lower switch is closed. *Id.* at 10–11. Petitioner points out that its blue line annotation of Figure 15 of the ’822 patent (shown above on the right) demonstrates that the ’822 patent similarly relies on connecting one or the other of the DC terminals to neutral. *Id.* at 11. We agree with Petitioner that

these figures illustrate that Tracy's DC source is floating in the same way the '822 patent's DC source is floating. *Id.*

iii. Tracy discloses that the rectifier is coupled to an AC power source

According to Patent Owner, another reason Petitioner's effort to characterize Tracy's Figure 5 as disclosing a floating DC power source fails is that Petitioner ignores the alleged DC power source includes a rectifier that includes half bridge circuits 510a, 510b, and 510c that must be attached to an associated AC power source. PO Resp. 11 (citing Ex. 1002, Baker Decl. ¶ 186). Patent Owner notes Tracy discloses a rectifier "receives AC power from an AC power source 10, such as a utility grid" and that "Figure 5 of Tracy shows a three-phase AC input that provides AC power to the rectifier." *Id.* (citing Ex. 1005, 1:19–22, 5:55–60). According to Patent Owner, "[t]he only AC source for the rectifier that is disclosed in Tracy is the utility grid" (*id.* at 12 (citing Ex. 1005 1:19–22, 5:17–24)) and "[a] POSITA would recognize that the AC power grid is not a 'floating' power source" (*id.* at 12 (citing Ex. 2006, Foty Decl. ¶ 66; Ex. 2007, Baker Depo. Tr. 62:11–19)).

Petitioner replies that Patent Owner's argument relies on the incorrect premise that the utility grid is always grounded and a floating DC source must never be connected to ground. Pet. Reply 13. Petitioner states that the existence of an AC grid would not permanently connect terminals 530a, 530b to ground or neutral and would not prevent Tracy's DC power source 310 from floating. *Id.* at 13–14. Petitioner further notes Patent Owner ignores that Tracy discloses alternatives for DC source 310 include a battery, which does not require the utility connection argued by Patent Owner. *Id.* at 14 (citing Ex. 1005, 4:25–53; Ex. 1074, Baker Reply Decl. ¶ 25).

According to Patent Owner, Petitioner does not explain why the AC grid would not permanently connect either of terminals 530a, 530b to ground or neutral and why the AC grid would not prevent Tracy's power source from floating. PO Sur-Reply 8 (also arguing that we should not consider Dr. Baker's testimony in support of Petitioner's argument because Dr. Baker's testimony is not articulated in Petitioner's Reply). Dr. Baker's testimony is responsive to Patent Owner's characterization of Dr. Baker's testimony as stating that "the AC grid is always grounded." PO Resp. 12. Dr. Baker limited his testimony that the AC grid is always grounded, stating "to the extent we limit the scope to the AC grid of a building or that we recognize that all grounds aren't at the same potential." Ex. 2007, Baker Depo. Tr. 62:11–19 (further noting that because each building has its own ground, one cannot run communication cables between adjacent buildings). Dr. Baker's Reply Declaration states "[a]s I have consistently said, and as the '822 Patent has said, the DC source is floating because neither of its terminals is permanently connected to ground, the neutral line or a reference voltage." Ex. 1074, Baker Reply Decl. ¶ 24. Dr. Baker explains:

through Tracy's control circuit, only the voltage *difference* between V+ and V- is fixed. Even if the Tracy rectifier is coupled to an (undisclosed) AC utility grid to the left of Fig. 5, the fact remains that the voltages V+ and V- are allowed to vary, and neither of them is permanently connected to a neutral voltage. Looking at Tracy's Fig. 5, even if the A/B/C/N lines on the left come from a utility grid that is grounded, it is clear that none of those lines A/B/C/N is permanently connected to the terminals 530a, 530b. Ex. 1005, Fig. 5. They are only connected if a switch 510a, 510b, 510c, 540 is closed, and as discussed above, this kind of temporary connection does not prevent the terminal voltages V+ and V- from varying, is used by the '822 Patent as well, and does not render the DC source to be not floating.

Id.

Patent Owner also argues that Petitioner's battery argument fails because a battery can be floating or non-floating, depending upon the configuration of the circuit in which the battery sits. PO Sur-Reply 9. Petitioner notes, however that the battery example does not require the utility grid connections that PO identifies in its argument. Pet. Reply 14 (citing Ex. 1074, Baker Reply Decl. ¶ 25).

Dr. Baker's testimony is persuasive evidence that Tracy discloses the claimed floating DC power source, as Tracy's terminals are not permanently connected to the neutral.

iv. Petitioner's theory is inconsistent with the disclosure in Tracy

Referencing its cross-examination concerning Figure 9D of Tracy, a figure not discussed in the Petition or Dr. Baker's declaration, Patent Owner argues that Dr. Baker was unable to reconcile the constant DC voltages Patent Owner highlights in blue. *See* Ex. 2007, 120:4–121:9. Tracy states that in Figure 9D “input phase voltages 921a, 921b, and 921c and the output phase voltages 922a, 922b, and 922c[,] have substantially the same magnitude but are shifted in phase (around 60°) with respect to one another,” leading to “a difference between the positive and negative DC bus voltages 927a, 923b to be around 784 volts.” Ex. 1005, 10:67–11:6.

Patent Owner's argument on this point is also unavailing. Although Tracy does not provide a detailed explanation of Figure 9D, it is not inconsistent with a finding that the DC power source is floating. Figures 9B–9E and the corresponding portions of Tracy discuss the DC voltages on the busses “according to [the] embodiments of the invention configured along the lines of the converter 500 of FIG. 5.” *See* Ex. 1005, 10:42–49,

10:60–64, 10:67–11:6, 11:6–12. As discussed above, Petitioner and Patent Owner’s experts agree that a floating voltage is characterized by a constant voltage difference, regardless of the magnitude of the voltage. *See*, Exs. 1082/2010, Foty Resp. Decl. ¶ 19; Ex. 1074, Baker Reply Decl. ¶¶ 9–10; Pet. Reply 3–4. Figure 9A of Tracy illustrates a conventional system in which the voltage on the DC busses is relatively constant with respect to the output neutral, hence the difference in the voltage is constant. Ex. 1005, 10:29–41, Fig. 9A. Patent Owner cites Figure 9D for the proposition that Dr. Baker was unable to explain how the DC voltages highlighted in blue are fixed. PO Resp. 13–14 (citing Ex. 2007, Baker Depo. Tr, 117:15–121:9). However, in Figures 9B, 9C, and 9E, which illustrate different input conditions for the converter shown in Figure 5, the DC voltage on each of the DC busses varies, but forms an envelope characterized by the difference between the voltages being constant. *See*, Ex. 1005, 10:29–11:39, Table V, Figs. 9A–9E. Notwithstanding that he did not use or cite Tracy’s Fig. 9D in his direct testimony, when cross-examined, Dr. Baker characterized Fig. 9D stating “[i]t’s just illustrating the difference in voltages of 784 and then as discussed in the text it says that’s still less than what you have in a conventional system.” Ex. 2007, 120:14–121:2. Thus, all the examples in Figure 9, i.e., Figs 9A–9E illustrate that the difference in the voltage is constant.

Having considered the evidence of record, we find that Petitioner has demonstrated that Tracy discloses claim limitation 1D.

v. Claim limitation 1D obviousness arguments

Petitioner further contends that, to the extent Patent Owner argues Tracy does not disclose a floating DC source, this feature would have been obvious because “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 created by Tracy's common-mode voltage waveform," resulting in hazardous conditions that would fail to comply with government standards. Pet. 25 (citing Ex. 1019, pp. 14–15; Ex. 1024 ¶¶ 39, 48, 50; Ex. 1034 ¶¶ 4–5; Ex. 1041, p. 943; Ex. 1010, 1–2; Ex. 1002, Baker Decl. ¶ 229).

Although Patent Owner asserts it is unclear what Petitioner refers to when stating “this” would have been obvious, taken in context, and as recognized in the Decision to Institute, Petitioner contends that to the extent Patent Owner contends Tracy does not disclose it, the claimed floating DC source would have been obvious. *See* Pet. 25; Dec. to Inst. 23. Patent Owner contends that Petitioner's obviousness argument is based on the understanding that connecting the DC source to a ground would have created a ground fault. Patent Owner asserts three reasons that Petitioner's obviousness contentions are wrong.

First, Patent Owner contends that “[c]ircuitry is regularly connected to ground without incident to provide a reference voltage” and “Tracy discloses using a neutral reference for precisely this purpose.” PO Resp. 15 (citing Ex. 2006, Foty Decl. ¶ 62). Second, Patent Owner contends that Figure 9D of Tracy contradicts Petitioner because Tracy's Figure 9D shows a balanced voltage, i.e., voltage that are equal on either side of a neutral on the DC voltage busses. Third, Patent Owner argues that testimony by Petitioner's expert that equipment designers often intentionally introduce electric current that flows from a hot wire to ground to reduce EMI contradicts Petitioner's assertion that connecting the DC source to ground would result in EMI and create a fire hazard. *Id.* at 16.

Petitioner contends that these statements are largely divorced from Tracy and do not support Patent Owner's argument that Tracy's source is

non-floating. Pet. Reply 15. In response to Patent Owner’s first and third arguments, Petitioner explains that regular connections to ground are not proof of a “non-floating” source in the context of the ’822 patent, because the ’822 patent discloses temporarily connecting one of the terminals of its floating DC source to ground. *Id.* (citing Ex. 1001, 3:45–50). Petitioner further notes that introducing leakage current “says nothing about whether this is found in Tracy, or whether it would prevent the DC voltage from varying.” *Id.* Petitioner states that Patent Owner’s Figure 9D argument fails because Patent Owner incorrectly “assumes that if a varying waveform can only be created with a floating source, and if a non-floating source creates a flat waveform, that all flat waveforms must have been created with a non-floating source.” Pet. Reply 14. Noting that Patent Owner does not dispute that the waveforms in Figures 9B, 9C, and 9E are not flat, and that Patent Owner does not rebut Petitioner’s explanation of how the Figure 9B waveform shows that DC voltage for a floating source is controlled to vary with respect to neutral, Petitioner notes that Figures 9B–9E exemplify what can be done with Tracy’s system by controlling the circuits differently. *Id.* at 14.

Having considered the arguments and evidence of record, we find that, even if Tracy did not disclose claim limitation 1D as discussed above (*see* Sections VI.A.2.c.i–iv), Tracy would have disclosed or suggested claim limitation 1D to a person of ordinary skill under 35 U.S.C. § 103.

d) Claim Limitation 1E

Petitioner identifies as claim limitation 1E the recitation “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.”

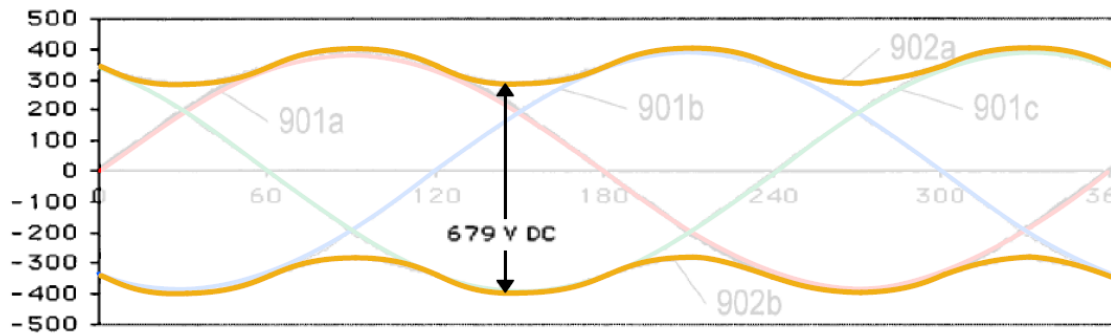
Petitioner cites Tracy as disclosing an inverter that generates three sine wave voltages relative to a neutral with 0, 120, and 240 degree phases that appear at each of three (N=3) live AC output terminals. Pet. 26 (citing Ex. 1005, 5:64–6:3, 6:11–20, 6:34–49; 7:8–61, 10:42–60, Figs. 7, 9B; Ex. 1002, Baker Decl. ¶¶ 232–233).

Patent Owner does not explicitly address Petitioner’s arguments concerning claim limitation 1.E. Having considered all the arguments and evidence of record, we find that Petitioner has demonstrated that Tracy discloses the subject matter recited in claim limitation 1E.

e) Claim Limitation 1F

Petitioner identifies as claim limitation 1F the recitation “[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.”

Petitioner cites Tracy’s control circuit as disclosing claim limitation 1F. Pet. 27–28. Petitioner refers to another annotated version of Figure 9B that we reproduce immediately below.



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

Id. at 28. Petitioner argues that Tracy’s control circuit

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.

Id. at 27 (citing Ex. 1005, 8–17, 2:52–3:14, 6:50–7:61, 8:58–65, 10:42–57; Ex. 1056, 23–26; Ex. 1057, 1–6; Ex. 1064, 51–57; Ex. 1065, 51–57; Ex. 1002, Baker Decl. ¶¶ 181–182, 234–235). Petitioner further notes that Tracy discloses that in each 60 degree interval, one phase is held continuously to one of the DC voltage busses, causing the common-mode voltage to undulate at a second repetition frequency that is three times the first repetition frequency, *i.e.*, the repetition frequency of each voltage phase (for N=3 and the voltage phases being 120 degrees apart). *Id.* 28. Petitioner further notes that the common-mode voltage appears with the same phase on both DC input lines. *Id.* (citing Ex. 1005, 5:64–6:3, 6:11–20, 6:34–49, 10:42–60, Fig. 9B; Ex. 1002, Baker Decl. ¶¶ 236–237).

Patent Owner contends that the Petition does not identify exactly what Petitioner contends discloses the common-mode voltage waveform. PO Resp. 16, PO Sur-Reply 12. Patent Owner states that, instead Petitioner

points to lines 902a and 902b in Figure 9B, identified as an envelope, but also mentions a zero sequence (common mode) reference signal. PO Resp. 17 (citing Petition 27). Patent Owner acknowledges that the direct testimony of Petitioner's expert Dr. Baker clarifies "that it is the waveform 902a, 902b which is claimed to be the 'common-mode voltage waveform,'" but argues we should not consider this testimony because it is not discussed in the Petition. PO Resp. 17 (citing Ex. 1002 ¶ 131). We decline Patent Owner's suggestion that we not consider Dr. Baker's direct testimony on this issue, as the Petition's arguments concerning claim limitation 1F cite to paragraph 234 of the Baker Declaration that again identifies "common mode voltage waveform 902a, 902b (orange) on each of the DC busses." Pet. 27 (citing Ex. 1002, Baker Decl. ¶ 234 ("the common mode voltage waveforms 902a, 902b are the claimed 'common-mode voltage waveform'"), ¶ 235 ("the common-mode voltage waveforms 902a, 902b, each oscillate at a frequency (claimed 'second repetition frequency') that is different from the frequency of the AC phase outputs 901a, 901b, 901c.")).

Patent Owner argues that Petitioner's only explanation for why waveforms 902a, 902b are common-mode is that they were created by adding a zero sequence (common mode reference) with respect to the N-terminal. PO Sur-Reply 13. Patent Owner contends Petitioner is wrong because Tracy does not add the zero sequence (common mode) reference to the DC voltages, but instead uses the zero sequence reference to generate pulse width modulated signals that control the half-bridge circuits. PO Resp. 19 (citing Ex. 1005, 7:8–11, 8:2–37). Patent Owner acknowledges that Tracy discloses the zero sequence reference "may be used as a reference vector that may be added to the other reference vectors." *Id.* at 19. Nevertheless, Patent Owner asserts that, because Tracy does not add the zero

sequence reference to the DC bus voltages, the zero sequence reference is used merely to regulate the DC bus voltages V^+ and V^- , and Petitioner has not shown Tracy discloses claim limitation 1F. *Id.*

Patent Owner's argument is unavailing. As Petitioner notes, claim limitation 1F does not recite a zero sequence reference or adding a zero sequence reference to a DC voltage. Pet. Reply 16. The Petition states that Tracy's control circuit conforms the voltages on the DC input lines to an envelope, as illustrated and highlighted in orange (waveforms 902a, 902b) at a constant separation of 679 Volts. Pet. 27–28 (citing Ex. 1002, Baker Decl. ¶¶ 181–182, 234–235); *see also, id.* at 28 (Petitioner's annotated Figure 9B of Tracy). As Dr. Baker further argues, even if not anticipated, claim limitation 1F would have been obvious over Tracy. Dr. Baker testifies

Tracy's DC to AC converter circuit (*e.g.*, inverter 320 or three IGBT half-bridge circuits 520a-c) is structurally identical to, or substantially the same as, the transformerless structure of the "DC to AC converter" of the '822 patent and is being controlled in an identical, or substantially the same, manner to produce a common-mode voltage waveform on the DC inputs.

Ex. 1002 ¶ 237 (comparing Figures 5, 9B of Tracy to Figures 16, 23 of the '822 patent). Noting that in both Tracy and the '822 patent the common-mode voltage results from controlling the half-bridge switches to modulate the DC voltages on the DC inputs using the phase inputs, Dr. Baker testifies that a person of ordinary skill would have known that the voltages, frequencies, and phases produced by Tracy's DC to AC converter circuit could have easily been modified by adjusting the switching timing of the half bridge switches. *Id.*

Having considered the arguments and evidence of record, we find that Petitioner has demonstrated that Tracy discloses the subject matter recited in claim limitation 1F.

f) Claim 1 Conclusion

Having considered the evidence and arguments of record, we find that Petitioner has demonstrated that Tracy discloses all the limitations of claim 1 and we conclude that Petitioner has shown by a preponderance of the evidence that claim 1 is unpatentable under 35 U.S.C. § 102 as anticipated by Tracy or under 35 U.S. C. § 103 as obvious over Tracy.

3. Independent Claim 8

a) Claim Limitation 8A

Petitioner identifies as claim limitation 8A the preamble of claim 8, which recites “[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.”

In addition to citing its discussion of claim limitation 1A, Petitioner notes that Tracy’s inverter improves conversion efficiency and interfaces with a “480/227 Y” three-phase output in a conventional uninterruptible power supply connected to a utility grid. Pet. 29 (citing Ex. 1005, 1:10–47, 3:38–42, 5:11–24, 10:42–11:28, 12:5–8; Ex. 1002, Baker Decl. ¶¶ 251–252). Petitioner notes that a person of ordinary skill would have understood that a utility grid operates at a standard voltage and frequency and that Tracy’s discussion of a “480/227 Y” voltage refers to the same standard discussed in the ’822 patent, i.e., a three-phase interface utility for U.S. utility grids operating at 60 Hz with 480 volts between any two phases and 227 volts between each phase and the neutral. *Id.* at 29 (citing Ex. 1002, Baker Decl.

¶ 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 ¶ 57; 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 ¶¶ 145, 148)). Petitioner further asserts that, to the extent Tracy does not disclose a standard 60 Hz and standard 480/227 Y voltage, this feature would have been obvious to a person of ordinary skill. *Id.*

b) Claim Limitation 8B

Petitioner identifies as claim limitation 8B the recitation “[c]onfiguring said direct current source to be floating.” Petitioner notes that Tracy discloses a floating source as to claim 8 for the same reasons articulated in its discussion of claim 1. Pet. 30.

c) Claim Limitation 8C

Petitioner identifies as claim limitation 8C the recitation “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.”

Petitioner refers to its discussion of claim 1 demonstrating that Tracy’s inverter generates three voltage outputs with unique phases and a common-mode voltage waveform on the DC lines. Pet. 30. Petitioner further notes its earlier discussion of Tracy’s control circuit

reduc[ing] the voltages on the DC input lines to the maximum difference (e.g., 679V) between the phase voltages, and shift[ing] 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.

Id. (citing Ex. 1005, 2:48–51, 10:49–60; Ex. 1002, Baker Decl. ¶¶ 261–264).

Referring to a duplicate of the annotated version of Figures 5 and 9B of Tracy discussed above, Petitioner again notes that, in the interval between 240 and 300 degrees 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 is connected to DC-). *Id.* Petitioner states that the pattern rotates every successive 60 degrees through the entire waveform by connecting the next phase in the sequence to the opposite DC input terminal. *Id.* at 33 (showing a similar annotated version of Figures 5 and 9B in which Cout is connected to the DC+ input, while Aout (red) and Bout (blue) are pulse-width modulated between the DC+ and DC- inputs); *see also* Ex. 1002, Baker Decl. ¶¶ 266–267.

Arguing that Petitioner relies on the same arguments it advanced concerning claim 1, i.e. that waveforms 902a and 902b show the claimed common mode waveform, Patent Owner asserts, without further explanation, that waveforms 902a, 902b do not show the claimed feature. PO Resp. 21. We find that Petitioner has demonstrated Figure 9B of Tracy shows common mode voltage 902a, 902b in phase on both DC input lines with a characteristic frequency and discloses all the limitations recited in claim 8.

Having reviewed the arguments and evidence of record, we conclude that Petitioner has shown by a preponderance of the evidence that claim 8 is

unpatentable under 35 U.S.C. § 102 as anticipated by Tracy or under 35 U.S.C. § 103 as obvious over Tracy.

4. *Claim 2*

Claim 2 depends from claim 1 and further recites “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.”

Petitioner cites Tracy’s disclosure of generating a common-mode voltage with control circuit 330 controlling three half-bridges (i.e., electronic switches) so that in every 60° interval, one of the phases equals the positive or negative DC input line. Pet. 36 (citing 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, Baker Decl. ¶¶ 238–239). Petitioner states that Tracy discloses the function of the “switching controller” recited in claim 2 as follows: “[d]uring 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 set of AC output terminals 901a, 901b, or 901c, and said at least one ground, neutral or reference potential terminal” 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 set of AC output terminals 901a, 901b, 901c and at least one ground, neutral or reference potential terminal.” *Id.* at 36–37 (citing Ex. 1002, Baker Decl. ¶ 240). Petitioner also cites Tracy as disclosing a switching controller

structure that includes a micro-controller and memory, noting that a person of ordinary skill would have understood program instructions were stored in the memory. *Id.* at 37–38.

Patent Owner cites the arguments it advanced concerning independent claim 1, but does not respond specifically to Petitioner’s contentions concerning the additional limitations recited in claim 2. PO Resp. 21. Based on the arguments and evidence previously discussed in our analysis of claims 1 and 8 and on Petitioner’s discussion of the additional limitations recited in claim 2, we find that Petitioner has demonstrated that Tracy discloses all the limitations recited in claim 2.

Having reviewed the arguments and evidence of record, we conclude that Petitioner has shown by a preponderance of the evidence that claim 2 is unpatentable under 35 U.S.C. § 102 as anticipated by Tracy or under 35 U.S.C. § 103 as obvious over Tracy.

5. *Claims 3 and 9*

Claims 3 and 9 depend from claims 1 and 8, respectively. Claim 3 recites that the second repetition frequency is a multiple equal to the same number N of the first repetition frequency and N is 1, 2, or 3 (claim 3); claim 9 recites that the characteristic frequency is a multiple of 1, 2, or 3 times the AC output frequency.

Petitioner notes that the common mode waveform and Tracy have a characteristic frequency that is three times the frequency of each AC output phase, as required by claim 3 ($N=3$) and claim 9. Pet. 38.

Patent Owner cites the arguments it advanced concerning independent claims 1 and 8, but does not respond specifically to Petitioner’s contentions concerning the additional limitations recited in claims 3 and 9. PO Resp. 21. Based on the arguments and evidence previously discussed in our analysis of

claims 1 and 8 and on Petitioner's discussion of the additional limitations recited in claims 3 and 9, we find that Petitioner has demonstrated Tracy discloses the limitations of claim 3 and 9.

Having reviewed the arguments and evidence of record, we conclude that Petitioner has shown by a preponderance of the evidence that claims 3 and 9 are unpatentable under 35 U.S.C. 102 as anticipated by Tracy or under 35 U.S.C. § 103 as obvious over Tracy.

6. *Claim 10*

Claim 10 depends from claim 8 and further recites "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."

Referencing its discussion of claim limitation 8C, Petitioner cites Tracy as disclosing the use of pulse width modulation via signal generator circuit 730 control half breach circuits 520a, 520b and 520c to derive instantaneous voltages from the direct current source positive or negative line. Pet. 39.

Patent Owner cites the arguments it advanced concerning independent claims 1 and 8, but does not respond specifically to Petitioner's contentions concerning the additional limitations recited in claim 10. PO Resp. 21. Based on the arguments and evidence previously discussed in our analysis of claims 1 and 8 and on Petitioner's discussion of the additional limitations recited in claim 10, we find that Petitioner has demonstrated that Tracy discloses the limitations of claim 10.

Having reviewed the arguments and evidence of record, we conclude that Petitioner has shown by a preponderance of the evidence that claim 10 is unpatentable under 35 U.S.C. § 102 as anticipated by Tracy or under 35 U.S.C. § 103 as obvious over Tracy.

B. Claims 4 and 11 as obvious over Tracy and Fujimoto

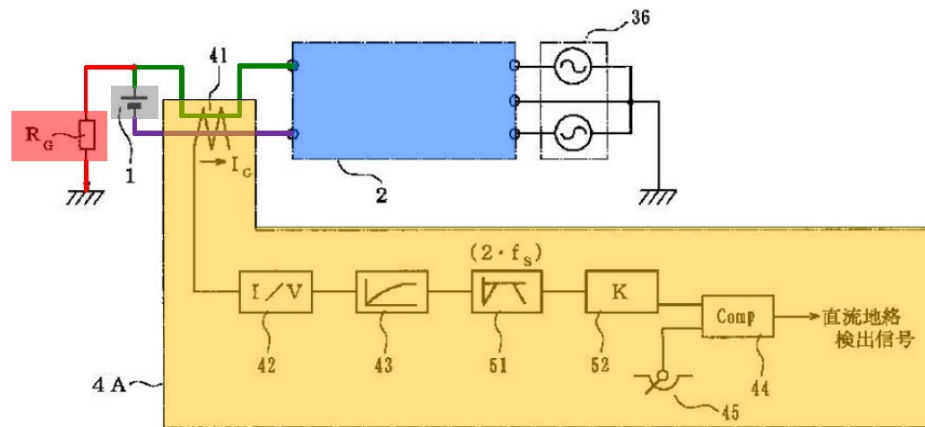
1. Fujimoto (Ex. 1033, English Translation Ex. 1034)

Fujimoto concerns “a DC ground fault detecting device for detecting a DC ground fault that is connected to a power converting device that converts DC power of a DC power supply into AC power, and that is connected to a neutral point ground single-phase three wire-type power system.” Ex. 1034 ¶ 8. When a ground fault current flows from the DC power supply through a neutral point, Fujimoto’s device recognizes the ground fault by detecting, as a “common current,” the difference between the current that flows through the positive electrode of the DC power supply and the current that flows through the negative electrode. *Id.* The common current (I_G) has a DC component and an AC component. *Id.* ¶ 4. Figure 4 of Fujimoto shows the ground fault DC component (I_{dc}), the common current (I_G), and ground fault AC component (I_{ac}), which is at a frequency that is twice the frequency (f_s) of the single-phase power supply. *Id.* ¶ 6.

2. Claims 4 and 11

Claim 4 depends from claim 1 and further recites that the apparatus comprises “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 depends from claim 8 and further recites “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.” We address claim 4 as representative of the subject matter of claims 4 and 11.

An annotated version of Figure 1 of Fujimoto from the Petition is reproduced below.



Ex. 1034, Fig. 1 (annotated)

Pet. 40. Referencing annotated Figure 1, Petitioner cites Fujimoto as disclosing a DC ground fault detector inserted at current transformer 41 in the positive and negative conductors between DC power supply 1 and inverter 2. *Id.* at 11–12 (citing Ex. 1034 ¶¶ 4–7, 10–11, Figs 1, 3; Ex. 1002 ¶¶ 196–198). Petitioner notes that “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,” but

[i]f 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”).

Id. at 40–41 (citing Ex. 1034, Abstract, ¶¶ 5–7, 10–11, Fig. 4; Ex. 1002, Baker Decl. ¶¶ 279–280, 291–292). Petitioner further notes that Fujimoto

includes band-pass filter 51 and amplifier 52 to facilitate comparing common mode current I_{ac} to detection level 45 to indicate a fault, i.e., the claimed “detection signal” signal in claim 4 and the claimed “detecting” recited in claim 11. *Id.* at 41 (citing Ex. 1034, Abstract, ¶¶ 7, 10–11, Figs. 1–2; Ex. 1002, Baker Decl. ¶¶ 280, 291–292).

Acknowledging that Tracy does not disclose the limitations of claim 4 and 11, Petitioner asserts that a person of ordinary skill would have understood that a common-mode current would have been induced in the presence of a leakage resistance generated by Fujimoto’s transformerless inverter and, thus, to avoid hazards and comply with safety standards, would have had reason to combine the teachings of Tracy with those of Fujimoto to stop Tracy’s similar transformerless inverter from operating, as taught by Fujimoto, e.g., by adjusting the bandpass filter to detect a ground fault with a three-times frequency component (the common-mode current in Tracy). *See* Pet. 41–43. Petitioner further argues that adjusting the bandpass filter frequency range is well within the capability of a person of ordinary skill, that the combination yields a predictable result, and that a person of ordinary skill would have had a reasonable expectation of success. *Id.*

Patent Owner contends that a person of ordinary skill would understand a distinction exists between a “ground fault” and a “ground leak.” PO Resp. 22. According to Patent Owner an ordinarily skilled artisan would know that the term “ground fault” refers to a failure of the system (often a destructive failure induced by corrosion, etc.) that causes catastrophic shunting of the system to ground, but that the term “ground leak” refers to a non-catastrophic shunting of the system that causes a hazard to personnel, such that a ground is provided through a person’s body to ground. *Id.* Patent Owner contends that the distinction between the terms is

recognized in the art, and that Petitioner does not explain why a person of ordinary skill would look to Fujimoto because, unlike the '822 patent, which concerns a ground leak, Fujimoto concerns a ground fault. *Id.* at 21–22; PO Sur-Reply 15–16.

As Petitioner points out, claim 4 recites that the ground leak detector is adapted to detect an imbalance at the second frequency and provide a detection signal indicative of an unwanted leakage impedance from a DC conductor to ground. Pet. Reply 20. Claim 4 is not limited to leakages that are minor or not catastrophic, but recites only that the leakage is unwanted. *Id.* Petitioner further notes that, in a blog post, Patent Owner's expert, Dr. Foty referred to personnel hazards as a "ground fault," and that the standard in the National Electrical Code (NEC) is the same for detecting a ground leak (6mA). *Id.* (citing Ex. 2009, 99; Ex. 1074 ¶¶ 40, 43–44; Ex. 1075, 70:9–71:18, 116:12–118:1, 144:7–13).

Even if the two terms are distinguished in the art, we do not read claim 4 to be limited to certain types of ground leaks that are minor or non-catastrophic. As Petitioner points out, the '822 patent states that it is useful for detecting ground faults and discusses detection of ground faults using an AC ground leak detector. Pet. Reply 18 (citing Ex. 1001, code 57, 3:44–45). Based on the claim language, the use of the terms in the '822 patent, and the NEC standards being same for detecting a ground leak and a ground fault, we find that Petitioner has demonstrated that a person of ordinary skill would have had reason to consider references using either term and that Fujimoto discloses the ground leak detector as recited in claim 4. For similar reasons we reach the same conclusion as to claim 11.

We find that Petitioner has demonstrated that a person of ordinary skill would have had reason to combine the teachings of Tracy and Fujimoto

and that their combined teachings would have disclosed the limitations recited in claims 4 and 11 to an ordinarily skilled artisan.

Having reviewed the arguments and evidence of record, we conclude that Petitioner has shown by a preponderance of the evidence that claims 4 and 11 are unpatentable under 35 U.S.C. § 103 as obvious over Tracy and Fujimoto.

C. Claims 6 and 20 as obvious over Tracy and De

1. De (Ex. 1018)

De discloses that an induction motor driven by an inverter injects a common mode voltage into the motor, causing a common-mode current to flow through the motor, inverter and a system ground. Ex. 1018 ¶ 1. As the common-mode current creates noise arising from the AC/DC converter and the DC/AC inverter, common-mode suppression filters are used. Petitioner notes that a person of ordinary skill would have understood that, like Tracy's inverter, De's inverter is a source of EMI in the form of common-mode noise, caused by high frequency internal switching within the inverter. Pet. 44.

2. Claim 6

a) Claim limitation 6A

Claim 6 depends from claim 1. Petitioner identifies as claim limitation 6A the recitation "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 [to]."

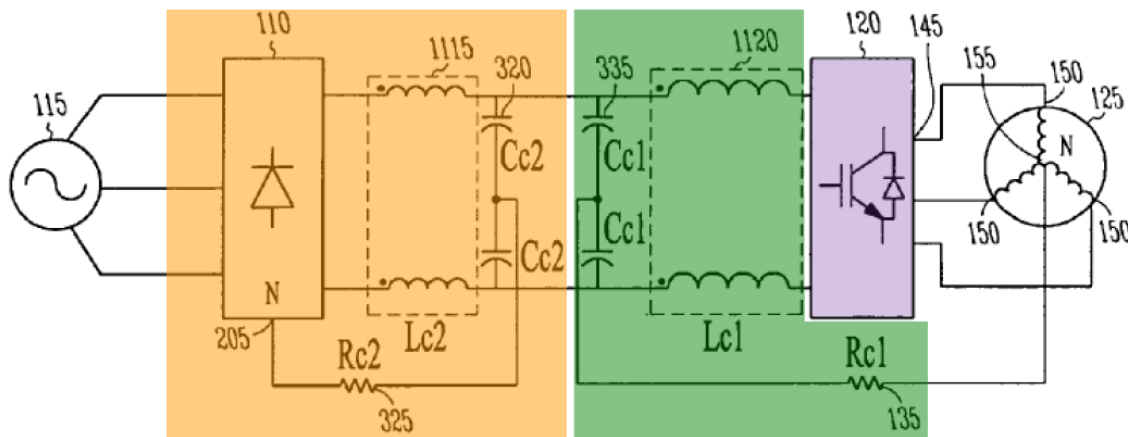
b) Claim limitation 6B

Petitioner identifies as claim limitation 6B the recitation “to prevent high frequency components of the DC to AC converter internal waveforms being exported to said DC source.”

c) Claim limitation 6C

Petitioner identifies as claim limitation 6C the recitation “to minimize overshoot of said common-mode waveform in order to minimize peak voltages on said positive and negative terminals.”

Petitioner addresses all three limitations of claim 6 together. Petitioner’s annotated version of Figure 12 of De is reproduced immediately below.



Ex. 1018, Fig. 12 (annotated)

Pet. 44. Referencing annotated Figure 12, Petitioner cites De as disclosing “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].” *Id.* at 44. Petitioner further states that De’s filter prevents the common-mode noise from being exported to the DC source, as recited in claim limitation 6B, because inductor Lc1 and capacitor

Cc1 form a low pass common-mode filter loop whose resonant frequency, i.e. a cutoff frequency above which waveforms are attenuated) is selected to be one-half the inverter's internal frequency, thereby disclosing claim limitation 6B. *Id.* at 44–45. As to claim limitation 6C, Petitioner notes resistor Rc1 in De “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].” *Id.* at 45 (citing Ex. 1018 ¶ 22; Ex. 1010, 6–9 (as describing a resistor for reducing overshoot at the filter resonant frequency), Figs. 11–17; Ex. 1002, Baker Decl. ¶ 306).

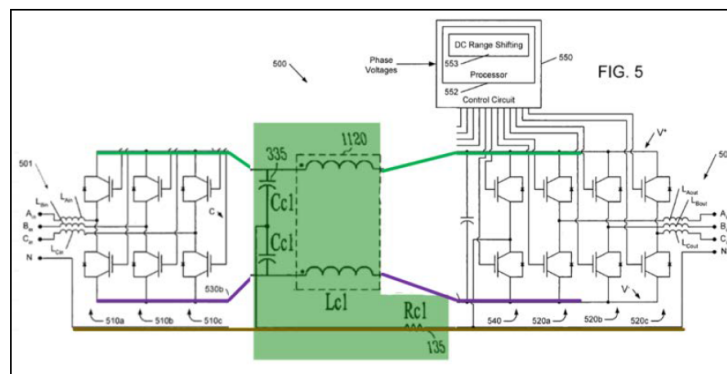
d) Motivation to Combine

Petitioner contends that a person of ordinary skill would have recognized that Tracy and De use similar DC sources and switching schemes and would have understood that De's common-mode noise problem would apply equally to Tracy. Pet. 46. Petitioner further argues that the common-mode filters in De and the '822 patent are both second-order low pass L-C filters with equivalent structures performing the same functions and that a designer with average skill would select the values of L, C, and R depending upon the inverter parameters. *Id.* at 46.

Patent Owner contends that Petitioner “fails to consider how inserting the identified common-mode filter into the circuit of Tracy affects the other limitations of this claim—including the requirement that the DC to AC conversion apparatus include a floating DC power source.” PO Resp. 23–24. According to Patent Owner, inserting De's between Tracy's DC power source and inverter results in the output lines of the DC power source being connected to neutral through a capacitor and the input lines of the inverter

being connected to neutral through a capacitor and an inductor, contravening Petitioner's description of a floating DC power source. PO Resp. 24–25 (citing Ex. 1018, Fig. 12). Patent Owner cites a figure in Dr. Baker's Declaration showing the DC power source connected to neutral and argues that Petitioner does not describe why this combination still discloses the required "floating" power source, as the DC terminals are always connected to the neutral through the capacitor, and is therefore not floating. *Id.* at 25 (citing Ex. 1002, Baker Decl. ¶ 296); PO Sur-Reply 17. Patent Owner further argues that a person of ordinary skill would have assumed that the additional elements from De would change the common mode waveform after it traversed the filter, a topic not addressed by Petitioner. *Id.*

The figure from paragraph 296 of Dr. Baker's declaration, reproduced below, is an annotated version of Figure 5 of Tracy showing how a common mode filter from Figure 12 De would have been included.



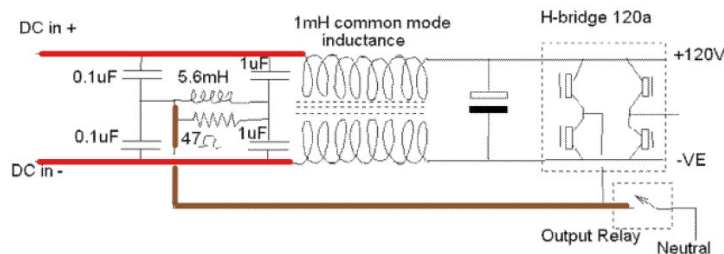
Ex. 1005, Fig. 5 (annotated) combined with part of Ex. 1018, Fig. 12 (green box)

Ex. 1002, Baker Decl. ¶ 296; *see* PO Resp. 25; Pet. Reply 21. The addition of De's filter is shown in the center box highlighted in green. Petitioner notes that neither Patent Owner nor its expert suggests the addition of the De filter with capacitor CC1 would prevent Tracy's DC voltages from varying as Petitioner asserts. Pet. Reply 22. Petitioner further points out that De discloses a low pass filter that blocks high frequency signals, e.g., noise

resulting from the high frequency internal switching within the inverter, but allows the lower frequency common mode waveform to pass through and would not have permanently fixed a terminal voltage to ground or prevented a terminal voltage from varying in the manner described in the '822 patent. *Id.* (citing Pet. 43–47, Ex. 1074, Baker Reply Decl. ¶¶ 45–51).

Patent Owner's argument that Petitioner has changed the test of defining a floating source is unavailing. PO Sur-Reply 17. As Petitioner notes, Figure 6 of the '822 patent shows the same type of connection that results from combining the teaching of Tracy and De. Figure 6 of the '822 patent, as annotated by Petitioner, is shown below.

FIGURE 6: COMMON MODE INPUT HASH FILTER



Pet. Reply 23. Petitioner points to the filter on the DC input, and notes that the neutral line (colored brown) is connected to the DC+/- terminals (colored in red) by capacitors (1μF) and inductors 5.6mH. *Id.* at 22–23. Petitioner notes that the DC source still floats because at the operating frequencies of the common mode waveform at the DC input terminals in the '822 patent, those capacitors appears as an open circuit to those terminal voltages. *Id.* at 23.

Based on the arguments and evidence of record, we find that Petitioner has demonstrated a person of ordinary skill would have had reason to combine the teachings of Tracy and De and that their combined teachings

would have disclosed the limitations of claim 6 to an ordinarily skilled artisan.

Having reviewed the arguments and evidence of record, we conclude that Petitioner has shown by a preponderance of the evidence that claim 6 is unpatentable under 35 U.S.C. § 103 as obvious over Tracy and De.

3. *Claim 20*

a) *Claim limitation 20A*

Claim 20 depends from claim 8. Petitioner identifies as claim limitation 20A the recitation “[t]he 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 [to].”

b) *Claim limitation 20B*

Petitioner identifies as claim limitation 20B the recitation “to prevent high frequency components of said common-mode waveform being exported to said DC source and.”

c) *Claim limitation 20C*

Petitioner identifies as claim limitation 20C the recitation “to minimize overshoot of said common mode waveform in order to minimize peak voltages on said positive and negative terminals.”

Petitioner addresses all three limitations of claim 20 together. Petitioner notes that claim limitation 20A appears to reference claim limitation 8C for connecting the positive and negative lines of the DC source and a rotating sequence to the “‘most positive’ output terminal,” but that claim limitation 8C recites connecting the “most positive” and “most

negative” output terminals in a rotating sequence. Pet. 47. Petitioner asserts that Tracy discloses this limitation, connecting the positive and negative inputs in a rotating sequence to the instantaneously most positive and most negative output terminals, while also pulse-width-modulating the other output phases. *Id.* at 48 (citing Ex. 1002 ¶¶ 307–311). In particular, Petitioner cites Tracy as disclosing half-bridge circuits, e.g. 502c, that alternately connect both DC lines to the most positive output terminal, thus disclosing claim limitation 20A. *Id.* at 48–49. Petitioner asserts that a person of ordinary skill would have had reason to combine the teachings of Tracy and De in the same manner as discussed above relative to claim limitations 6B and 6C. *Id.* at 49.

Patent Owner does not address claim 20 explicitly. Having reviewed the arguments and evidence of record, we find the Petitioner has demonstrated a person of ordinary skill would have had reason to combine the teachings of Tracy and De and that their combined teachings would have disclosed the limitations of claim 20 to an ordinarily skilled artisan.

We conclude that Petitioner has shown by a preponderance of the evidence that claim 20 is unpatentable under 35 U.S.C. § 103 as obvious over Tracy and De.

D. Claim 7 as obvious over Tracy and Bond

1. Bond

Bond discloses that electric utilities employ a number of commonly used service types (a nominal voltage and wiring configuration) to provide polyphase AC electrical power on a plurality of supply lines in which the voltage on each line has a unique phase angle. Ex. 1035, 1:10–36. Wiring configurations are defined by the number of wires and the wiring relationship between the phases (wye or delta), e.g., 120-volt four-wire wye

service. *Id.* at 1:30–37. Bond also states notes that different watt-hour meter types are used to measure power consumption for the various service types. Petitioner relies on Figure 1 of Bond, which “shows an overview of an electrical utility meter wired for metering three phase electrical power service.” Pet. 13–14, 51–52; Ex. 1035, Fig. 1.

2. *Claim 7*

Claim 7 depends from claim 1 and recites “[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.”

Referencing its discussion of claim 1, Petitioner cites Tracy as disclosing a line interactive three-phase inverter connected to utility credit in and on interruptible power supply that includes three terminals (Aout (901a), Bout (901b), and Cout (901c)) that deliver current at unique phases spaced relatively 0, 120, 240, degrees apart, as recited in claim 7. Pet. 49–50.

Petitioner also notes that Tracy’s AC output terminals and its neutral terminal are connected with an actual load neutral in “Y” connected output configurations, which Patent Owner states are 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.” *Id.* at 50 (citing Ex. 1005, 5:1–17; Ex. 1002, Baker Decl. ¶ 320).

Petitioner relies on Bond to disclose the claimed “watt-hour metering device.” *Id.* According to Petitioner, Bond teaches three terminals (power lines 12, 14, and 16) that deliver current at phases approximately 120 degrees apart (Ia, Ib, Ic) through a watt-hour metering device with a utility four-wire wye service type connection with neutral center and a 120-volt line-to-neutral, which results in a 208-volt (line-to-line) output voltage, i.e., the claimed “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”. Pet. 50–51 (citing 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, Baker Decl. ¶ 323).

Petitioner notes that Tracy teaches connecting its inverter to a utility grid and Bond teaches a utility service provider using its meter to monitor energy usage by customers connected to the grid for multiple purposes, including billing, resource allocation, power factor tracking, and error diagnosis. Pet. 52. Petitioner argues a person of ordinary skill would have reasonably expected successfully combining the teachings of these references to achieve predictable results. *Id.*

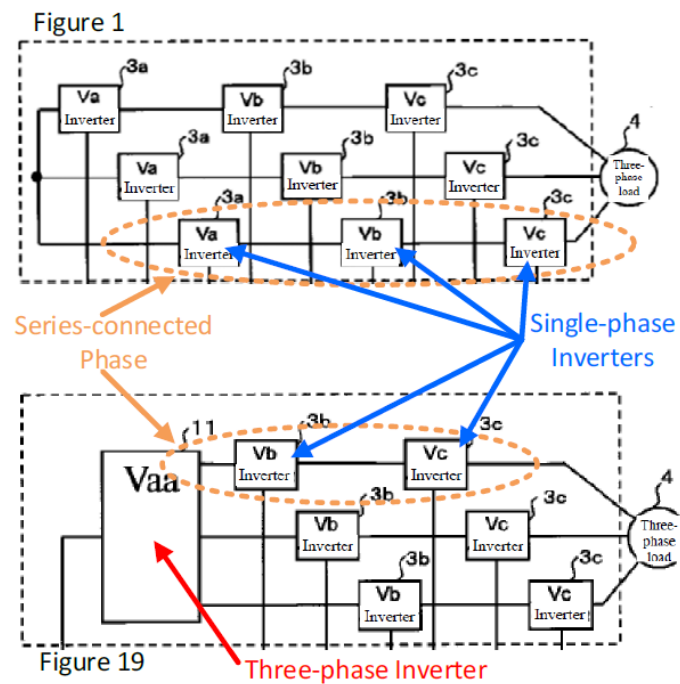
Patent Owner does not address claim 7 explicitly. Having reviewed the evidence and arguments of record, we find the Petitioner has demonstrated a person of ordinary skill would have had reason to combine the teachings of Tracy and Bond and that their combined teachings would have disclosed the limitations of claim 7 to an ordinarily skilled artisan.

We conclude that Petitioner has shown by a preponderance of the evidence that claim 7 is unpatentable under 35 U.S.C. § 103 as obvious over Tracy and Bond.

E. Claim 5, 12, and 13 as obvious over Tracy, Suzuki, and Ball

1. Suzuki

Petitioner cites Suzuki as disclosing multiple variations of single-phase and three-phase multiplex inverters are built from individual inverters with outputs connected in series. Pet. 10, 53. Petitioner's annotated version of Figure 1 (top) and Figure 19 (bottom) of Suzuki is shown below.



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

Pet. 54. Petitioner cites Suzuki as disclosing that voltages from each of its series connected inverters (Va, Vb, Vc) are multiplied by a respective digit T3, T2, T1 having a value of -1, 0, or +1; and the voltages are summed together to generate a sequence of small voltage gradations approaching a smooth AC output waveform, as shown in Figures 4C and 5B of Suzuki. *Id.* at 54–55 (citing Ex. 1031 ¶¶ 17–22, 31–32, 39, Figs. 1, 4, 5, 19; Ex. 1002, Baker Decl. ¶ 330). Petitioner further notes that Suzuki discloses multiple design variations to generate different gradation levels and argues that a

person of ordinary skill would have had reason to apply one or more of these different combinations in a manner that teaches claims 5, 12, and 13.

Id. at 56.

a) Motivation to Combine Tracy and Suzuki

Referring to its annotated version of Figs 1 and 19 of Suzuki, discussed above, Petitioner contends that in order to generate smoother AC phase voltages, a person of ordinary skill would have had reason to connect Tracy's inverter, arranged as Suzuki's three phase inverter 11 (red), with each phase output of Tracy's inverter connected to one or more series connected single phase inverters, e.g. H-bridge circuits 3b, 3c (blue).
Pet. 56, 59–60.

Noting that (i) in Suzuki input voltages to H-bridge switches equal output voltages V_b and V_c and (ii) Tracy teaches the input voltage V_{aa} to its three-phase inverter is between $\sqrt{3}$ and 2 times the phase output voltage (depending on the amplitude of the common-mode waveform generated by Tracy's zero-sequence modulation), Petitioner observes that for the $V_a:V_b:V_c$ ratio in Suzuki, the corresponding voltage in the combination of Tracy and Suzuki would be $V_{aa}:V_b:V_c$, where V_{aa} is between $\sqrt{3}*V_a$ and $2*V_a$ (and that the same would be true for output voltage in the opposite sequence $V_{cc}:V_b:V_c$). *Id.* at 57–58 (citing Ex. 1005, 10:42–57, 11:13–25). As Suzuki teaches a $V_a:V_b:V_c$ ratio of $(\geq 1):3:9$, with $V_{aa} \geq \sqrt{3}*V_a$ ($V_{aa} \geq 1.73V_a$), the input voltage ratio of the Tracy-Suzuki combination includes 3:3:9, which satisfies the limitation in claim 5 that “floating supplies of voltages equal to the input voltage [] multiplied by successive powers of 3.” *Id.* at 58. Petitioner makes a similar argument for Suzuki's teaching of a $V_c:V_b:V_a$ ratio of 5:3:1, as corresponding to $V_{cc}:V_b:V_a$. *Id.* at 58–59.

As other examples, Petitioner states that a single Suzuki H-bridge inverter in series with each of Tracy's inverter phase outputs with Suzuki's ratio of 1:3 would disclose the formula for "instantaneously desired voltage" in claim 12 and with Vb and Vc set to 3 and 9 (the Va:Vb:Vc ratio of 1:3:9) would disclose the claim 13 "set of floating DC supplies of voltages having voltage ratios of successive powers of 3." Pet. 59 (Ex. 1031 ¶¶ 24–25, 32, Figs. 10, 19–20; Ex. 1002, Baker Decl. ¶ 337).

According to Petitioner, a person of ordinary skill would have known how to connect Suzuki's H-bridges to each phase output of Tracy's inverter with the ratios discussed above to achieve desired advantages, because (i) Suzuki explains how to connect the H-bridge inverters to a three-phase inverter that is schematically the same as Tracy's inverter, (ii) Suzuki describes how to control such a circuit to generate the output waveforms, and (iii) Tracy's inverter with zero-sequence modulation would be compatible with Suzuki's control of phase output voltage based on input voltage 2 or $\sqrt{3}$ times output voltage. *Id.* at 61 (citing Ex. 1002, Baker Decl. ¶ 340; Ex. 1005, 10:42–57, 11:13–25, Figs. 9a–9b; Ex. 1031 ¶¶ 18–22, 24–25, 31–32, Figs. 19–20, 28).

2. *Ball*

Ball concerns phase controlled reversible power converters that simultaneously, bidirectionally couple any number of electrical potentials having any waveform to any number of other electrical potentials having any waveform through a single high frequency transformer. Ex. 1032, 1:33–38. In particular, Petitioner cites Ball as disclosing a bidirectional power converter with a single transformer that transfers power between multiple bidirectional ports that include one fixed DC voltage port and any combination of other fixed DC and variable, AC and AC/DC voltage ports. Pet. 14–15

(citing Ex. 1033, 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, Figs. 20, 22; Ex. 1002, Baker Decl. ¶¶ 209–211). Petitioner observes that Ball’s fixed DC voltage port (connected to a DC power source) generates an equal-duty-cycle square wave within the transformer that each remaining port locks onto in order to convert power (AC, DC, or both) at its port terminals to/from the square wave transformer winding. *Id.* at 15–16 (citing 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, Baker Decl. ¶¶ 212–213).

a) Motivation to Combine Tracy, Suzuki and Ball

Petitioner contends that a person of ordinary skill would have had reason to combine the teachings of Tracy and Suzuki with those of Ball’s DC-DC converter to convert the DC voltage source to floating DC voltages for Suzuki’s additional H-bridges. Pet. 64 (citing Ex. 1002, Baker Decl. ¶ 344). Petitioner notes that Ball’s single transformer DC-DC converter can provide any number of DC floating voltages, is highly efficient, and reduces the size, weight, and cost of filtering components needed for ports. *Id.* at 65. According to Petitioner, a person of ordinary skill reasonably would have expected success in combining Tracy and Suzuki with Ball because Ball uses the same DC source as Tracy, provides the same multiple of DC voltages as Suzuki and is a simple substitution of one known element (Suzuki’s AC-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). *Id.* (citing Ex. 1002, Baker Decl. ¶ 345).

3. *Claim 5*

Claim 5 depends from claim 1. Petitioner identifies as limitation (a) the recitation “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.”

Petitioner cites its earlier discussion of reasons a person of ordinary skill would have had reason to combine the teachings of Tracy and Suzuki as disclosing setting V_{aa} (the DC power source) and V_b (the floating voltages) to 3V:3V:9V or 9V:3V:1V (a ratio of $1:3^0:3^1$ or $1:3^{-1}:3^{-2}$), based on Suzuki’s $V_a:V_b:V_c$ ratios of $(\geq 1V):3V:9V$ and $5V:3V:1V$ with Tracy’s input of $\sqrt{3}*V_a$ and $1.8*V_a$, respectively. Pet. 66. Thus, the combined teachings of Tracy and Suzuki disclose the claim 5a limitation the “floating supplies of voltages equal to the input voltage divided or multiplied by successive powers of 3.” *Id.* Petitioner further references its explanation that a person of ordinary skill would have had reason to combine Ball’s bi-directional DC-DC converter, whose structure is insubstantially different from that of the DC-DC converter in the ’822 patent. *Id.* at 67.

Petitioner identifies as limitation (b) the recitation “[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.”

As to claim limitation 5b, Petitioner cites Suzuki's three-state H-bridges each with terminal pairs connected to a floating voltage from Ball's DC-DC converter; each of the output terminals is connected in series, and one end of the series-connected output terminals is connected to an AC output, as recited in limitation 5b.

Petitioner identifies as limitation (c) the recitation "[a] switch controller for controlling said three-state electronic switches according to a sampled numerical representation of the desired AC output waveform expressed in a ternary number base, each ternary digit of a numerical sample determining whether a respective switch is controlled to one of the three output states (a) first polarity state, (b) inverse polarity state and (c) pass-through state, wherein the pass through state allows current flow in the H-bridge output circuit without connecting the DC input voltage in series with the H-bridge output terminals, the first polarity state causes the . . . DC input voltage to be connected in series with the H-bridge output terminals with a first polarity and the inverse polarity state causes the DC input voltage to be connected in series with the H-bridge output terminals with an opposite polarity to the first polarity state."

Petitioner states that the combined teachings of Suzuki, Tracy and Ball teach using series-connected H-bridge output terminals to approximate a sine wave (the claimed AC output waveform) where each step of a sequence is the sum of individual inverter voltages multiplied by ternary digits controlling each H-bridge switch to be in a first polarity, inverse polarity, of one of two pass-through states (ternary digits +1, -1, 0, respectively). *See* Pet. 70–71. Petitioner notes that 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; in the first and inverse polarity states, the DC input voltage is connected in series with the H-bridge output terminals with a first polarity and an inverse polarity respectively. *Id.* 72. According to Petitioner, using Tracy's control circuit to control the added H-bridge circuits would have been obvious because (i) Suzuki and Tracy both teach controlling half-bridges and both provide pulse width modulation control, (ii) like Suzuki's use of a sampled representation, Tracy's control circuit uses a sine wave reference indicating a desired voltage for the AC output, and (iii) both Tracy and Suzuki represent these outputs in terms of "counts." *See id.* at 72–73.

Patent Owner does not respond specifically to Petitioner's contentions concerning the limitations recited in claim 5. Having reviewed the arguments and evidence of record, we find the Petitioner has demonstrated a person of ordinary skill would have had reason to combine the teachings of Tracy, Suzuki and Ball and that their combined teachings would have disclosed the limitations of claim 5 to an ordinarily skilled artisan.

We conclude that Petitioner has shown by a preponderance of the evidence that claim 5 is unpatentable under 35 U.S.C. § 103 as obvious over Tracy, Suzuki, and Ball.

4. *Claim 12*

Claim 12 depends from claim 8 and further recites "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 ($T(n)$, $T(n-1)$, $T(n-2)$. . . T_3, T_2, T_1) in a ternary number system such that the instantaneously desired voltage is equal to $3^m [T(n) + T(n-1)/3 + T(n-1)/9 + \dots T_1/3^{(n-1)}$ or $3T(n) + T(n-1) + T(n-1)/3 + \dots T_1/3^{(n-1)}$] times the voltage from said direct current source, where the power m may be zero."

Petitioner cites its previous discussion of claim 8 demonstrating that Tracy discloses deriving instantaneous voltages from the direct current source positive or negative line, and its discussion of Tracy, Suzuki, and Ball as teaching expressing the desired voltage using two or three ternary digits. Pet. 75. Petitioner notes that a person of ordinary skill would have understood the first formula in claim 12 “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” i.e., $T(n-1)/3 + T(n-1)/9 + \dots$ “providing a pattern for the weights of the intermediate digits.” *Id.* at 75–76 (citing Ex. 1001, 42:66–43:7). Petitioner further notes that for $n \geq 3$, there is no discernable pattern for the middle expression and, for $n=2$, no intermediate terms exist, such that the expression becomes $V_{DC} * 3^m * [T_2 + T_1/3]$. Petitioner asserts that the combined teachings of Tracy, Suzuki and Ball disclose this formula with one Suzuki H-bridge connected to each phase output of Tracy’s three-phase inverter outputting plus and minus 3V and plus and minus 1V, respectively, such that each instantaneous phase voltage is $3 * T_2 - 1 * T_1$. *Id.* at 76 (citing Ex. 1031, Figs. 4, 10, 19, 20, 28, ¶¶ 5, 18–19, 24–25, 31–32, 44, 48; Ex. 1002, Baker Decl. ¶ 371). Petitioner notes that with “m” scaled to voltage V_{DC} (V_{aa} in the Tracy, Suzuki, Ball combination) this formula matches the formula in claim 12. Petitioner also argues that a person of ordinary skill would have had reason to combine the teachings of Tracy, Suzuki and Ball to arrive at claim 12 for reasons similar to those discussed above. *Id.* at 76–77.

Patent Owner does not respond specifically to Petitioner’s contentions concerning the limitations recited in claim 12. Having reviewed the arguments and evidence of record, we find the Petitioner has demonstrated a

person of ordinary skill would have had reason to combine the teachings of Tracy, Suzuki and Ball and that their combined teachings would have disclosed the limitations of claim 12 to an ordinarily skilled artisan.

We conclude that Petitioner has shown by a preponderance of the evidence that claim 12 is unpatentable under 35 U.S.C. § 103 as obvious over Tracy, Suzuki, and Ball.

5. *Claim 13*

Claim 13 depends from claim 8 and further recites
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.

Petitioner cites its previous discussion of claim 8 demonstrating that Tracy discloses deriving instantaneous voltages from the direct current source positive or negative line and its discussion of Ball as disclosing the claimed bidirectional DC-to-DC converter that converts Tracy's power source (the claimed DC source voltage) to a number of Suzuki's H-bridge floating input voltages. *See* Pet. 78–79. Petitioner further notes its previous discussion of Suzuki as demonstrating that Suzuki discloses “floating supply voltages V_b and V_c 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.’” *Id.* at 79 (citing Ex. 1031, Figs. 4G, 19, 20, 28, ¶¶ 18–19, 31–32; Ex. 1002, Baker Decl. ¶ 376). Noting that “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.*, V_c , V_b , and V_a) each multiplied by a respective ternary digit (annotated as T_3 , T_2 , and T_1):

$V_c * T_3 + V_b * T_2 + V_a * T_1$,” Petitioner observes as follows:

[f]or ternary digit $T_2 = -1$, the V_b floating source is in reverse polarity, thus outputting $-3V$ ($3V \times -1$) in series with the voltage phase output (the claimed “selecting one or more of said floating DC supplies to be directly connected in series”[]).

Pet. 79–80 (citing Ex. 1034 ¶¶ 18–19, 31–32; Ex 1002, Baker Decl. ¶ 379); and

[f]or ternary digit $T_3 = 1$, the V_c floating source is connected in forward polarity to output $9V$ ($9V \times 1$) in series with the voltage phase output (the claimed “selecting . . . without a polarity reversal.”[]).

Id. at 80 (citing Ex. 1031, Fig. 4 (annotated), ¶¶ 18–19, 31–32; Ex. 1002, Baker Decl. ¶ 379).

Thus, according to Petitioner “[t]he 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.” *Id.*

Patent Owner does not respond specifically to Petitioner’s contentions concerning the limitations recited in claim 13. Having considered the arguments and evidence of record, we find the Petitioner has demonstrated a person of ordinary skill would have had reason to combine the teachings of Tracy, Suzuki and Ball and that their combined teachings would have disclosed the limitations of claim 13 to an ordinarily skilled artisan.

We conclude that Petitioner has shown by a preponderance of the evidence that claim 13 is unpatentable under 35 U.S.C. § 103 as obvious over Tracy, Suzuki, and Ball.

VII. CONCLUSION¹⁰

Having considered the arguments and evidence of record, we conclude that Petitioner has demonstrated by a preponderance of the evidence that challenged claims 1–13 and 20 are unpatentable.

In summary:

Claim(s)	35 U.S.C. §	Reference(s)/Basis	Claim(s) Shown Unpatentable	Claim(s) Not shown Unpatentable
1–3, 8–10	102	Tracy	1–3, 8–10	
1–3, 8–10	103	Tracy	1–3, 8–10	
4, 11	103	Tracy, Fujimoto	4, 11	
6, 20	103	Tracy, De	6, 20	
7	103	Tracy, Bond	7	
5, 12, 13	103	Tracy, Suzuki, Ball	5, 12, 13	
Overall Outcome			1–13, 20	

¹⁰ Should Patent Owner wish to pursue amendment of the challenged claims in a reissue or reexamination proceeding subsequent to the issuance of this decision, we draw Patent Owner’s attention to the April 2019 *Notice Regarding Options for Amendments by Patent Owner Through Reissue or Reexamination During a Pending AIA Trial Proceeding*. See 84 Fed. Reg. 16,654 (Apr. 22, 2019). If Patent Owner chooses to file a reissue application or a request for reexamination of the challenged patent, we remind Patent Owner of its continuing obligation to notify the Board of any such related matters in updated mandatory notices. See 37 C.F.R. § 42.8(a)(3), (b)(2).

VIII. ORDER

In consideration of the above it is:

ORDERED that claims 1–13 and 20 are unpatentable; and

FURTHER ORDERED that that, because this is a Final Written Decision, parties to the proceeding seeking judicial review of the decision must comply with the notice and service requirements of 37 C.F.R. § 90.2.

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