

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SOLAREGE TECHNOLOGIES LTD.,
Petitioner,

v.

KOOLBRIDGE SOLAR, INC.,
Patent Owner.

IPR2022-00013
Patent 10,784,710 B2

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

BOUCHER, *Administrative Patent Judge*.

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

In response to a Petition (Paper 2, “Pet.”) filed by SolarEdge Technologies Ltd. (“Petitioner”), we instituted an *inter partes* review of claims 1–17 of U.S. Patent No. 10,784,710 B2 (Ex. 1001, “the ’710 patent”). Paper 10 (“Dec.”). During the trial, Koolbridge Solar, Inc. (“Patent Owner”) filed a Response (Paper 14, “PO Resp.”), to which Petitioner filed a Reply (Paper 17, “Reply”) and Patent Owner filed a Sur-reply (Paper 19, “Sur-reply”). An oral hearing was held with the parties, and a copy of the transcript was entered into the record. Paper 26 (“Tr.”).

We have jurisdiction under 35 U.S.C. § 6. This Decision is a Final Written Decision under 35 U.S.C. § 318(a) as to the patentability of the claims on which we instituted trial. Based on the record before us, Petitioner has shown, by a preponderance of the evidence, that claims 1–17 are unpatentable.

I. BACKGROUND

A. *The ’710 Patent*

1. *Overview*

The ’710 patent “relates generally to DC-to-AC convert[e]rs for electric power systems, and in particular to a transformerless inverter operative to approximate an AC output by selectively switching the positive, negative, or zero values of a plurality of differently-valued DC sources and summing the switch outputs.” Ex. 1001, 1:18–23. Figure 1 of the ’710 patent is reproduced below.

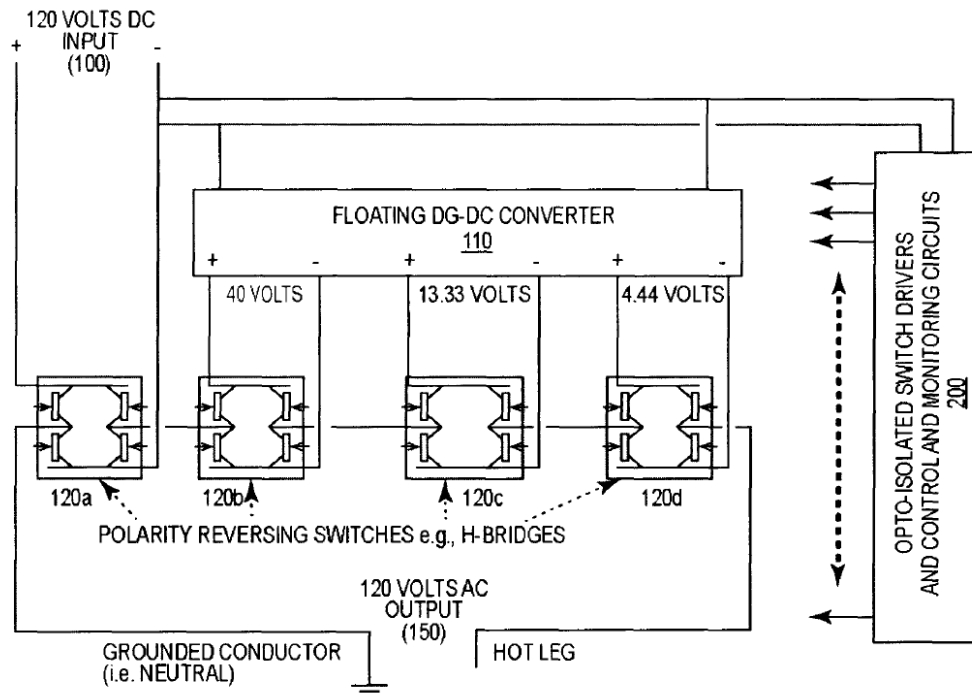


FIG. 1

Figure 1 is a block diagram of a DC-to-AC load converter. *Id.* at 5:66–67. The DC-to-AC converter has input 100 for a floating DC power source and a pair of output terminals 150 for the AC output. *Id.* at 6:65–7:7. Bidirectional DC-DC converter 110 converts DC input 100 to a number of floating DC output voltages applied to a set of reversing switches 120, controlled by opto-isolated driver circuit 200. *Id.* Each switch 120 can be controlled based on an n-ary control signal to apply a multiplier to the input voltage. *Id.* at 7:23–28, 7:51–54. The outputs of switches 120 are connected in series to AC output 150 to generate a sum voltage, depending on the state of the n-ary control signals for each switch 120. *Id.* at 7:60–65. By appropriate control switches 120, any voltage within a certain range can be produced at specific steps. *Id.* at 8:5–7.

The '710 patent illustrates this by focusing on a ternary system with four switches 120, such that each numerical sample value is expressed with

four digits in the ternary number system, e.g. (T4, T3, T2, T1). *See id.* at 7:23–31. Each digit T_i ($i = 1, 2, 3, \text{ or } 4$) can only take on one of the three values $-1, 0, \text{ or } +1$, such that the voltage provided by each switch is bypassed or is contributed in either positive or negative polarity to the sum voltage. *Id.* For such a ternary system, the floating DC output voltages are generated with the ratios $1:\frac{1}{3}:\frac{1}{9}:\frac{1}{27}$, in correspondence with the place significance of the different ternary digits. *Id.* at 7:28–31.

The '710 patent provides further illustration with a specific numerical example in which input 100 provides 120 volts DC from ten 12-volt rechargeable batteries connected in series. *See id.* at 6:65–7:7. In such a case, floating DC supplies generated by converter 100 are therefore 40 V ($\frac{1}{3} \times 120 \text{ V}$), 13.33 V ($\frac{1}{9} \times 120 \text{ V}$), and 4.44 V ($\frac{1}{27} \times 120 \text{ V}$). *Id.* at 7:31–35. The peak voltage that could be generated at AC output 150 occurs when $T_1 = T_2 = T_3 = T_4 = 1$, and is $120 + 40 + 13.33 + 4.44 = 177.77 \text{ V}$, which corresponds to a useful sine wave output voltage of 125.7 V RMS. *Id.* at 7:35–39; *see id.* at 7:65–67. More generally, the voltage generated at AC output 150 may take any of the $3^4 = 81$ values of $120T_4 + 40T_3 + 13.33T_2 + 4.44T_1 \text{ V}$ that result from the three possible values of T_i , in steps of 4.44 V between -177.77 V and $+177.77 \text{ V}$. *Id.* at 7:60–65, 8:5–7. For instance, if T_1 is instead set to 0, the voltage at AC output 150 would be 173.33 V; if T_1 is instead set to -1 , the voltage at AC output 150 would be 168.88 V; and so on. *Id.* at 7:65–8:5.

“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 $-[1]77.77$ to $+177.77$ volts and back again,

repetitively in the proper sequence and at the proper times.” *Id.* at 8:21–25. This is illustrated with Figure 12 of the ’710 patent, which is reproduced below.

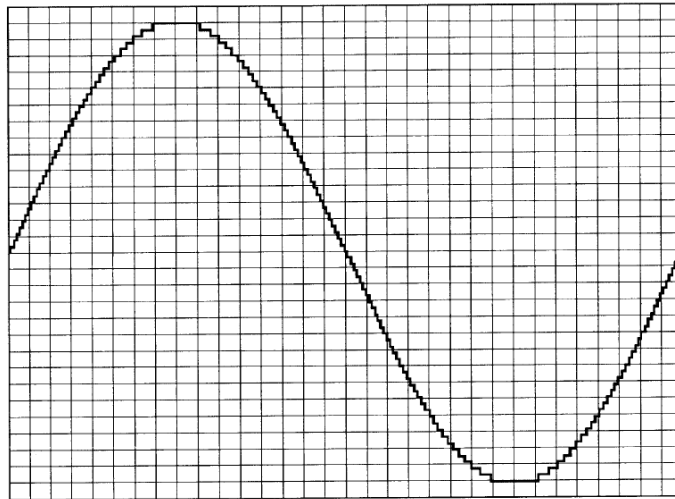


FIG. 12

Figure 12 “shows the output sinusoidal waveform from the converter produced by controlling the switches in the proper sequence.” *Id.* at 10:31–35.

2. Illustrative Claim

Independent claim 1 (the ’710 patent’s only independent claim) is illustrative of the challenged claims and is reproduced below.

1. A DC to AC converter having a transformerless output, and operative to convert DC power to an AC power having a desired voltage and waveform, and to output the AC power between hot and neutral output terminals, the DC to AC converter comprising:

a plurality of controlled switches, each having a power input connection operative to accept DC power from an associated DC power source at an associated DC voltage, and each controlled switch further having a power output connection operative to output a selected one of: (a) the

associated DC voltage, (b) the associated DC voltage having an inverted polarity, and (c) zero voltage, in response to an associated ternary-valued selection signal representing the multiplier values +1, -1, or 0 respectively, the power output connections of the plurality of switches being directly connected in series to output a sum voltage approximating the desired AC output voltage and waveform.

Ex. 1001, 42:50–67.

3. *Prosecution History*

Two aspects of independent claim 1 were added by amendment during prosecution, namely the preamble recitation of the recited AC to DC converter “having a transformerless output” and the requirement in the body of the claim that the power output connections of the plurality of switches be “directly” connected in series to output the sum voltage. Ex. 1003, 286. Such amendments were presented by the Applicant after the Examiner rejected independent claim 1, among others, for obviousness over U.S. Patent No. 4,180,853 (“Scorso”) in view of U.S. Patent No. 5,373,433 (“Thomas”). *Id.* at 261–268.

In distinguishing the amended claim from the combination, the Applicant argued that “Thomas clearly teaches three transformers hooked together to form the output” and that “the outputs of [certain] switches . . . are not directly connected at all.” *Id.* at 295–296. The Examiner subsequently allowed the claims, referring to a failure of the searched prior art to teach output of ternary-controlled switches directly connected in series to output a voltage approximating a desired waveform. *Id.* at 313.

B. Evidence

Petitioner relies on the following references:

Iwata	US 2008/0192519 A1	Aug. 14, 2008	Ex. 1004
Mori '630	JP 2006-238630 A	Sept. 7, 2006	Ex. 1006 ¹
Mori '265	WO 2010/082265 A1	July 22, 2010	Ex. 1007 ²
Flanagan	US 5,400,237	Mar. 21, 1995	Ex. 1008
Tracy	US 7,088,601 B2	Aug. 8, 2006	Ex. 1009
Bower	US 6,750,391 B2	June 15, 2004	Ex. 1011
Koyama	WO 2010/055713 A1	May 20, 2010	Ex. 1013 ³
Nishimura	US 2009/0086520 A1	Apr. 2, 2009	Ex. 1014
Phadke	US 8,576,591 B2	Nov. 5, 2013	Ex. 1015

K. H. Ahmed, S. J. Finney, and B. W. Williams, *Passive Filter Design for Three-Phase Inverter Interfacing in Distributed Generation*, CPE 2007 (IEEE 2007) (Ex. 1012) (“Ahmed”)

In addition, Petitioner relies on Declarations by R. Jacob Baker, Ph.D., P.E. Exs. 1002, 1074. Dr. Baker was cross-examined by Patent Owner, and a transcript of his deposition was entered into the record. Exs. 2007 (deposition transcript), 2008 (exhibit to deposition transcript). Patent Owner relies on a Declaration by Daniel Foty, Ph.D. Ex. 2006. Dr. Foty was cross-examined by Petitioner, and a transcript of his deposition

¹ Exhibit 1006 is a certified English translation of JP 2006-238630. The original Japanese version of the reference was filed into the record by Petitioner as Exhibit 1005.

² Exhibit 1007 is a certified English translation of WO 2010/082265 A1. The original Japanese version of the reference was filed into the record by Petitioner as Exhibit 1016.

³ Exhibit 1013 is a certified English translation of WO 2010/055713 A1. The original Japanese version of the reference was filed into the record by Petitioner as Exhibit 1017.

was entered into the record. Exs. 1075 (deposition transcript), 1081 (exhibit to deposition transcript).

C. Instituted Grounds of Unpatentability

We instituted review of claims 1–17 on the following grounds.

Dec. 27; Pet. 20–21.

Claim(s) Challenged	35 U.S.C. §⁴	References
1–3, 5, 7, 8, 10–12	103(a)	Iwata, Bower
4, 7, 8, 12	103(a)	Iwata, Bower, Mori ’630
6	103(a)	Iwata, Bower, Mori ’265
9	103(a)	Iwata, Bower, Flanagan
9	103(a)	Iwata, Bower, Mori ’630, Flanagan
10, 11	103(a)	Iwata, Bower, Tracy
10, 11	103(a)	Iwata, Bower, Nishimura
10, 11	103(a)	Iwata, Bower, Tracy, Nishimura
13	103(a)	Iwata, Bower, Koyama
13	103(a)	Iwata, Bower, Tracy, Koyama
14, 15	103(a)	Iwata, Bower, Koyama, Ahmed
14, 15	103(a)	Iwata, Bower, Tracy, Koyama, Ahmed
14, 15	103(a)	Iwata, Bower, Mori ’630, Koyama, Ahmed
14, 15	103(a)	Iwata, Bower, Tracy, Mori ’630, Koyama, Ahmed
16	103(a)	Iwata, Bower, Ahmed

⁴ The Leahy-Smith America Invents Act (“AIA”), Pub. L. No. 112-29, 125 Stat. 284, 287–88 (2011), amended 35 U.S.C § 103(a). Petitioner contends that “[t]he earliest possible priority date for the ’710 patent claims is the filing date of U.S Patent Application No. 13/103,070, May 8, 2011.” Pet. 8 (citing Ex. 1002 ¶ 116). Patent Owner does not contest that the pre-AIA version of § 103(a) accordingly applies.

Claim(s) Challenged	35 U.S.C. § ⁴	References
17	103(a)	Iwata, Bower, Phadke

D. Real Parties in Interest

The parties identify only themselves as real parties in interest. Pet. 1; Paper 5, 2.

E. Related Matters

Both parties identify *Koolbridge Solar, Inc. v. SolarEdge Technologies, Inc.*, No. 1:20-cv-01374 (D. Del.), which has been dismissed without prejudice, as involving the '710 patent. Pet. 1; Paper 5, 2.

Although the '710 patent was also challenged by Petitioner in IPR2022-00014 and IPR2022-00015, we did not institute *inter partes* review in either of those proceedings. See Dec. 12 (“we otherwise exercise our discretion under 35 U.S.C. § 314(a) to deny the additional petitions challenging the '710 patent”). Petitioner also challenged U.S. Patent No. 8,937,822 B2 (“the '822 patent”), owned by Patent Owner, in each of IPR2022-00007, IPR2022-00008, IPR2022-00009, IPR2022-00010, IPR2022-00011, and IPR2022-00012, with the Board instituting *inter partes* review only in IPR2022-00007 and IPR2022-00010. See *SolarEdge Techs. Ltd. v. Koolbridge Solar, Inc.*, IPR2022-00007, Paper 10 at 9–13 (PTAB Apr. 19, 2022) (finding separate petitions for two claim groups of the '822 patent justified).

II. ANALYSIS

A. *Legal Principles*

A claim is unpatentable for obviousness under 35 U.S.C. § 103(a) if the differences between the claimed subject matter and the prior art are “such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains.” *KSR Int’l Co. v. Teleflex Inc.*, 550 U.S. 398, 406 (2007). The question of obviousness is resolved on the basis of underlying factual determinations, including: (1) the scope and content of the prior art; (2) any differences between the claimed subject matter and the prior art; (3) the level of skill in the art; and (4) when in evidence, objective indicia of nonobviousness, i.e., secondary considerations.⁵ *Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966).

Additionally, the obviousness inquiry typically requires an analysis of “whether there was an apparent reason to combine the known elements in the fashion claimed by the patent at issue.” *KSR*, 550 U.S. at 418 (citing *In re Kahn*, 441 F.3d 977, 988 (Fed. Cir. 2006) (requiring “articulated reasoning with some rational underpinning to support the legal conclusion of obviousness”)); see *In re Warsaw Orthopedic, Inc.*, 832 F.3d 1327, 1333 (Fed. Cir. 2016) (citing *DyStar Textilfarben GmbH & Co. Deutschland KG v. C.H. Patrick Co.*, 464 F.3d 1356, 1360 (Fed. Cir. 2006)).

⁵ The parties do not address objective indicia of nonobviousness, which accordingly do not form part of our analysis.

B. Level of Ordinary Skill in the Art

In determining whether an invention would have been obvious at the time it was made, we consider the level of ordinary skill in the pertinent art at the time of the invention. *Graham*, 383 U.S. at 17. “The importance of resolving the level of ordinary skill in the art lies in the necessity of maintaining objectivity in the obviousness inquiry.” *Ryko Mfg. Co. v. Nu-Star, Inc.*, 950 F.2d 714, 718 (Fed. Cir. 1991). The “person of ordinary skill in the art” is a hypothetical construct, from whose vantage point obviousness is assessed. *In re Rouffet*, 149 F.3d 1350, 1357 (Fed. Cir. 1998). “This legal construct is akin to the ‘reasonable person’ used as a reference in negligence determinations” and “also presumes that all prior art references in the field of the invention are available to this hypothetical skilled artisan.” *Id.* (citing *In re Carlson*, 983 F.2d 1032, 1038 (Fed. Cir. 1993)).

Petitioner proposes that a person of ordinary skill in the art “would have had a bachelor’s degree in electrical engineering or a similar discipline, and three years of design experience with power electronics, including experience designing power converters.” Pet. 21 (citing Ex. 1002 ¶¶ 20–23). Patent Owner neither expressly addresses Petitioner’s proposal nor proffers its own articulation of the level of ordinary skill in the art. But Patent Owner’s expert, Dr. Foty, states that he “do[es] not dispute the Petitioner’s proposed level of ordinary skill in the art.” Ex. 2006 ¶ 43.

Because we find Petitioner’s proposal reasonable, consistent with the level of skill reflected by the prior art, and supported by the testimony of Dr. Baker, we adopt it for purposes of this Decision. *See Okajima v. Bourdeau*,

261 F.3d 1350, 1355 (Fed. Cir. 2001) (the prior art may reflect an appropriate level of skill in the art).

C. Dr. Baker's Testimony

Patent Owner suggests that exclusion of Dr. Baker's testimony is "warranted" as including "in-depth explanations and supporting documentary evidence" that is improperly incorporated into the Petition. PO Resp. 6–7; *see* 37 C.F.R. §§ 42.6(a)(3) ("Arguments must not be incorporated by reference from one document into another document"), 42.104(b)(5) ("The Board may exclude or give no weight to the evidence where a party has failed to state its relevance or to identify specific portions of the evidence that support the challenge"). According to Patent Owner, such improper incorporation occurs "repeatedly," such that there are "numerous examples" in which Dr. Baker's testimony includes "arguments found nowhere in the Petition itself" but relied on "to support a conclusory argument in the Petition." PO Resp. 7. Patent Owner adds that, "in many cases, the relevance of the cited portions of the expert declaration or other evidence is unexplained." *Id.*

We disagree with Patent Owner's characterization and discern insufficient basis to exclude Dr. Baker's testimony. Addressing an earlier presentation of Patent Owner's argument based on the preliminary record, we were "not persuaded that the Petition improperly relies on incorporation of arguments from Dr. Baker's Declaration" and invited Patent Owner "to elaborate on its argument by providing additional examples that explain how the Petition is deficient in this respect." Dec. 26.

We have considered Patent Owner’s reiterated argument, and note that the only specific example Patent Owner identifies relates to whether Iwata’s series-connected inverters include transformers. *See* PO Resp. 9–10. Below, we discuss the propriety of Petitioner’s reliance on Dr. Baker’s testimony within the specific context of that example. *See infra* § II.E.2.a. More generally, we disagree with Patent Owner’s broader implication that there must be perfect alignment between a petition and a supporting expert declaration because “[m]erely repeating an argument from the Petition in the declaration of a proposed expert does not give that argument enhanced probative value.” *Kinetic Techs, Inc. v. Skyworks Solutions, Inc.*, IPR2014-00529, Paper 8 at 15 (PTAB Sept. 23, 2014); *see also Xerox Corp. v. Bytemark, Inc.*, IPR2022-00624, Paper 9 at 15–17 (PTAB Aug. 24, 2022) (precedential) (according “little weight” to declaration testimony that contains a *verbatim* restatement of a petition’s arguments without additional supporting evidence or reasoning).

Indeed, expert discussion of evidence with technical reasoning to support conclusions is a valuable and important part of expert testimony that our regulations expect to be included in a declaration. *See* 37 C.F.R. § 42.65(a) (“Expert testimony that does not disclose the underlying facts or data on which the opinion is based is entitled to little or no weight.”); *Upjohn Co. v. Mova Pharm. Corp.*, 225 F.3d 1306, 1311 (Fed. Cir. 2000) (“Lack of factual support for expert opinion to factual determinations, however, may render the testimony of little probative value in a validity determination.”) (quoting *Ashland Oil, Inc. v. Delta Resins & Refractories, Inc.*, 776 F.2d 281, 294 (Fed. Cir. 1985)); *Carella v. Starlight Archery & Pro Line Co.*, 804 F.2d 135, 138 (Fed. Cir. 1986) (“Although in some

circumstances unsupported oral testimony can be sufficient to provide prior knowledge or use, it must be regarded with suspicion and subjected to close scrutiny.”).

D. Claim Construction

The Board uses “the same claim construction standard that would be used to construe the claim in a civil action under 35 U.S.C. § 282(b), including construing the claim in accordance with the ordinary and customary meaning of such claim as understood by one of ordinary skill in the art and the prosecution history pertaining to the patent.” 37 C.F.R. § 42.100(b) (2019); *see Phillips v. AWH Corp.*, 415 F.3d 1303, 1312–13 (Fed. Cir. 2005) (en banc). The specification may reveal a special definition given to a claim term by the patentee. *Phillips*, 415 F.3d at 1316. If an inventor acts as his or her own lexicographer, the definition must be set forth in the specification with reasonable clarity, deliberateness, and precision. *Renishaw PLC v. Marposs Societa’ per Azioni*, 158 F.3d 1243, 1249 (Fed. Cir. 1998).

Petitioner contends that “[a]ll claim terms herein should be given their ordinary and customary meaning to a [person of ordinary skill in the art], consistent with the prosecution history, as they would be given in a civil action.” Pet. 21 (citing 37 C.F.R. § 42.100(b)). Patent Owner states that it “does not believe any explicit claim construction is required to resolve the issues presented in the Petition.” PO Resp. 2. We agree with the parties and do not find it necessary expressly to construe any term. *See Nidec Motor Corp. v. Zhongshan Broad Ocean Motor Co.*, 868 F.3d 1013, 1017 (Fed. Cir. 2017) (“[W]e need only construe terms ‘that are in controversy, and

only to the extent necessary to resolve the controversy.” (quoting *Vivid Techs., Inc. v. Am. Sci. & Eng’g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999))).⁶

E. Scope and Content of the Prior Art

1. Iwata

Iwata “relates to a power conversion apparatus that converts DC power to AC power.” Ex. 1004 ¶ 1. Figure 1(a) of Iwata is reproduced below.

⁶ In advocating that we accord all claim terms their “ordinary and customary meaning,” Petitioner specifically “does not contend for this IPR that the claims include any means-plus-function limitations,” but addresses two terms “in case the Board finds them to be means-plus-function elements.” Pet. 21–22. Although Patent Owner cursorily asserts that “[i]t is Petitioner’s affirmative burden to establish any proposed construction of a challenged claim, something Petitioner here does not even try and undertake,” Patent Owner appears not to have accepted our earlier invitation “to challenge *more specifically* Petitioner’s position that all claim terms should be accorded their ordinary and customary meaning.” PO Resp. 3; Dec. 16 (emphasis added). Herein, we do not resort to 35 U.S.C. § 112 ¶ 6 for the construction of any claim term.

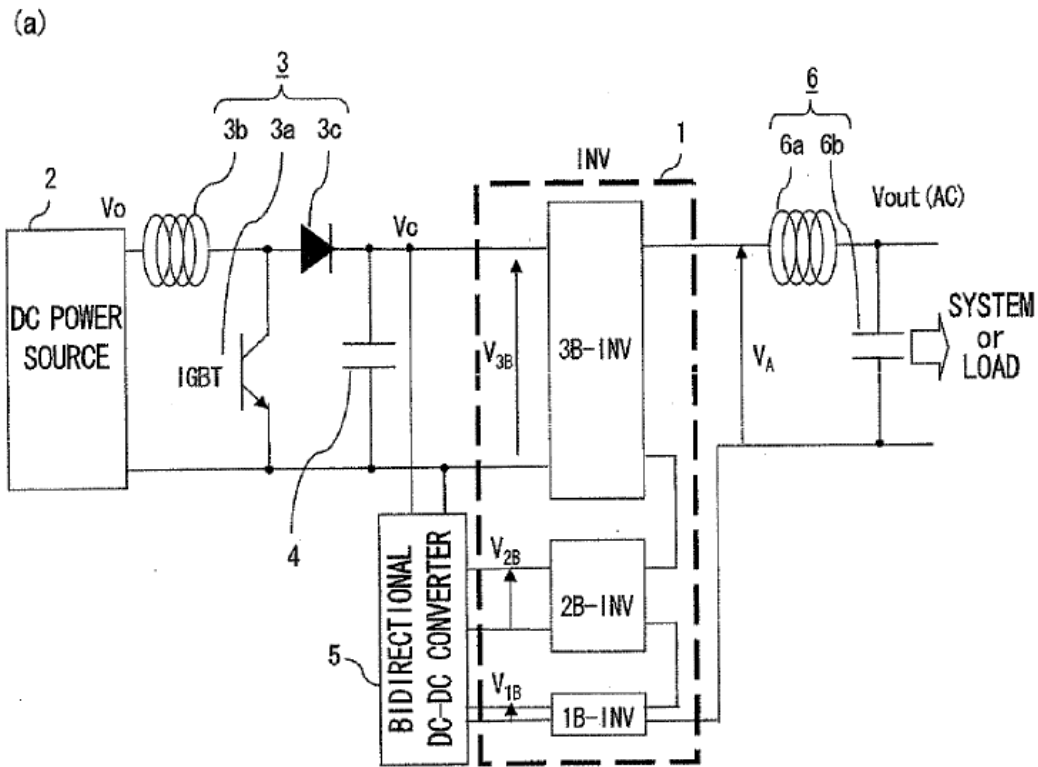


Figure 1(a) provides a schematic view of a power conditioner. *Id.* ¶ 45. Input voltage V_O is provided by DC power source 2 and AC voltage V_A is output to smoothing filter 6 (which includes inductor 6a and capacitor 6b) so that AC voltage V_{out} may be supplied to a system or load. *Id.* ¶¶ 45, 47. Bidirectional DC-DC converter 5 converts the DC input into a set of DC voltages V_{1B} and V_{2B} so that single-phase inverters 1B-INV, 2B-INV, and 3B-INV respectively have DC input voltages V_{1B} , V_{2B} , and V_{3B} . *Id.* ¶¶ 46, 48. Single-phase inverters 1B-INV, 2B-INV, and 3B-INV “can generate positive, negative and zero voltages,” and are connected in series to output AC voltage V_A “as the sum of these generated voltages combined.” *Id.* ¶ 47.

Figure 1(b) of Iwata is reproduced below.

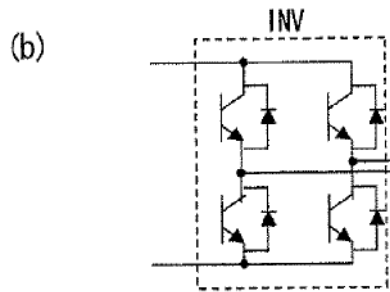


Figure 1(b) shows that “[e]ach of the single-phase inverters 3B-INV, 2B-INV and 1B-INV includes plural self-turn-off semiconductor switching devices such as [insulated-gate bipolar transistors] with diodes connected in inverse-parallel.” *Id.* ¶ 46.

Iwata discusses an example in which “the relation between V_{1B} , V_{2B} and V_{3B} is 1:3:9.” *Id.* ¶ 50. By applying the positive, negative, or zero contribution from each inverter in various combinations, “output voltages of 14 gradational levels . . . can be selected as the output voltage V_A of the inverter unit.” *Id.* Thus, as illustrated in Figure 2(b) of Iwata, reproduced below, output voltage V_A may have “a substantially sine wave-like output voltage waveform.” *Id.*

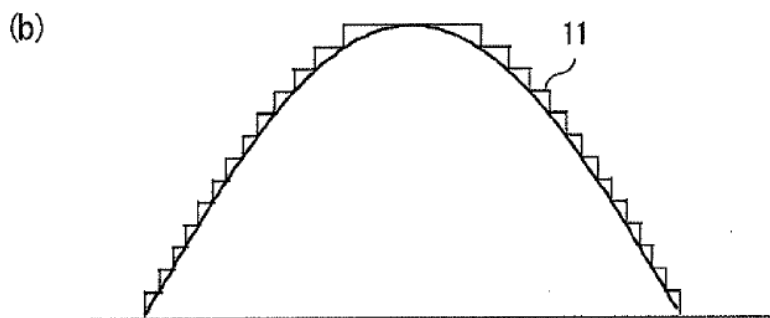


Figure 2(b) shows an output voltage waveform produced by the multiple single-phase inverters. *Id.* ¶ 14.

2. Bower

Bower “provides a fully integrated and self-contained alternating current (‘AC’) photovoltaic (‘PV’) Building Block device.” Ex. 1011, 1:21–25. Bower includes a description of “common electrical configurations” in residential settings where its described Building Block device may be applied. *See id.*, 10:10–15. Figure 3 of Bower is reproduced below.

AC PV Building Block Electrical Interconnect for the Basic Residential Utility-Interactive Configuration Using One-Phase, Grounded Output at Supplied Line Voltage and Frequency

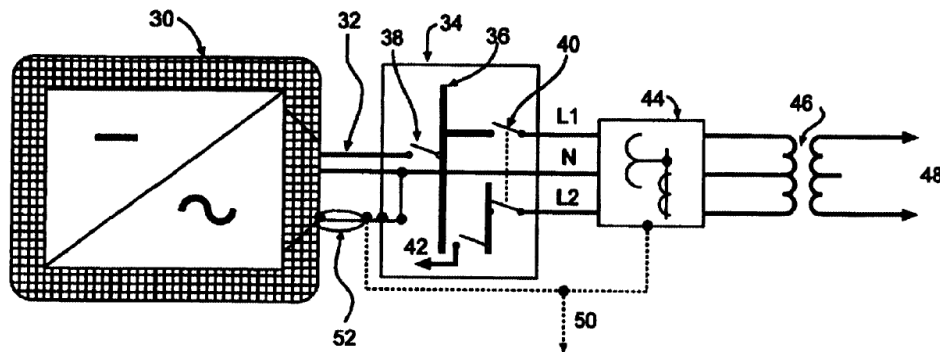


Fig. 3

Figure 3 “shows the most common application for residential applications interconnections” where Bower’s Building Block device may be used. *Id.* at 10:16–18. Bower explains:

In the United States, the majority of the residential dwellings are wired with single-phase 240V, 60 Hz power. The 240V is further centertapped to provide what is referred to as two-phase power. Most household circuits are 120V in the United States . . . and are connected on either side of the center tap to balance the load as best possible.

Id. at 10:18–24.

All exposed metal parts 52 are connected to equipment ground circuit 50, “as required by the National Electrical Code in the US.” *Id.* at 10:30–34. Also in accordance with the National Electrical Code, Bower’s Building Block device is installed on branch circuit 32. *Id.* at 10:34–38. “Additional components are service entrance panel 34, comprising main bus 36, branch 38, and mains 40, output 42 to loads . . . , meter 44, distribution transformer 46, and AC utility grid 48.” *Id.* at 10:43–46.

3. Mori ’630

Mori ’630 relates to “a power conversion device capable of obtaining the desired output waveform by gradation control by combining a plurality of inverters.” Ex. 1006 ¶ 1. Figure 1 of Mori ’630 is reproduced below.

[FIGURE 1]

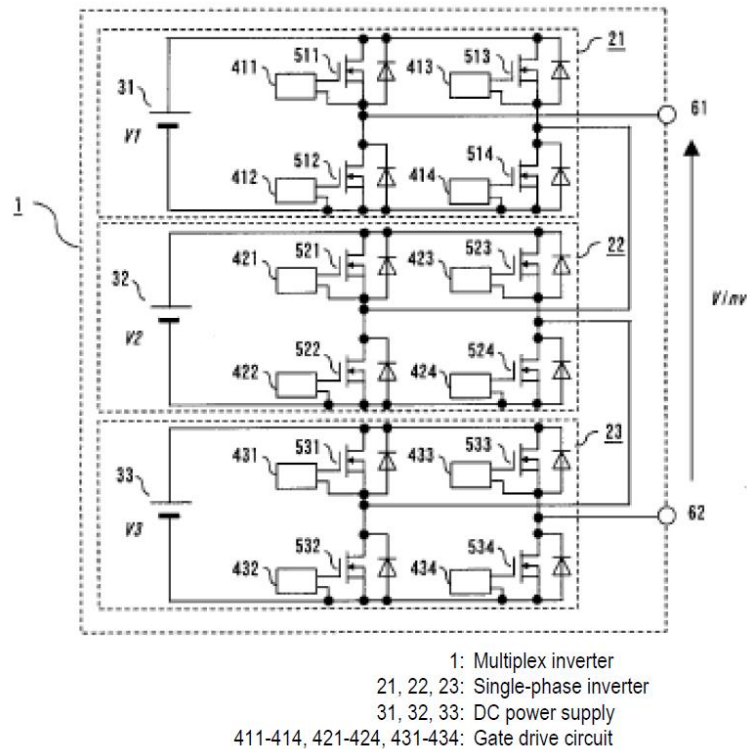


Figure 1 shows “the main circuit configuration of a power conversion device.” *Id.* ¶ 9. The drawing illustrates AC sides of single-phase inverters 21–23 having different DC power supplies 31–33, connected in series to form multiplex inverter 1. *Id.* Each single-phase inverter is composed of switching elements, such as MOSFETs, in an H-bridge configuration controlled by ternary-valued signals produced by a control circuit. *Id.* ¶¶ 9–11.

4. Mori '265

Mori '265 “relates to control of a power converting apparatus having an alternating current/direct current conversion function.” Ex. 1007 ¶ 1. Figure 14 of Mori '265 is reproduced below.

[Fig. 14]

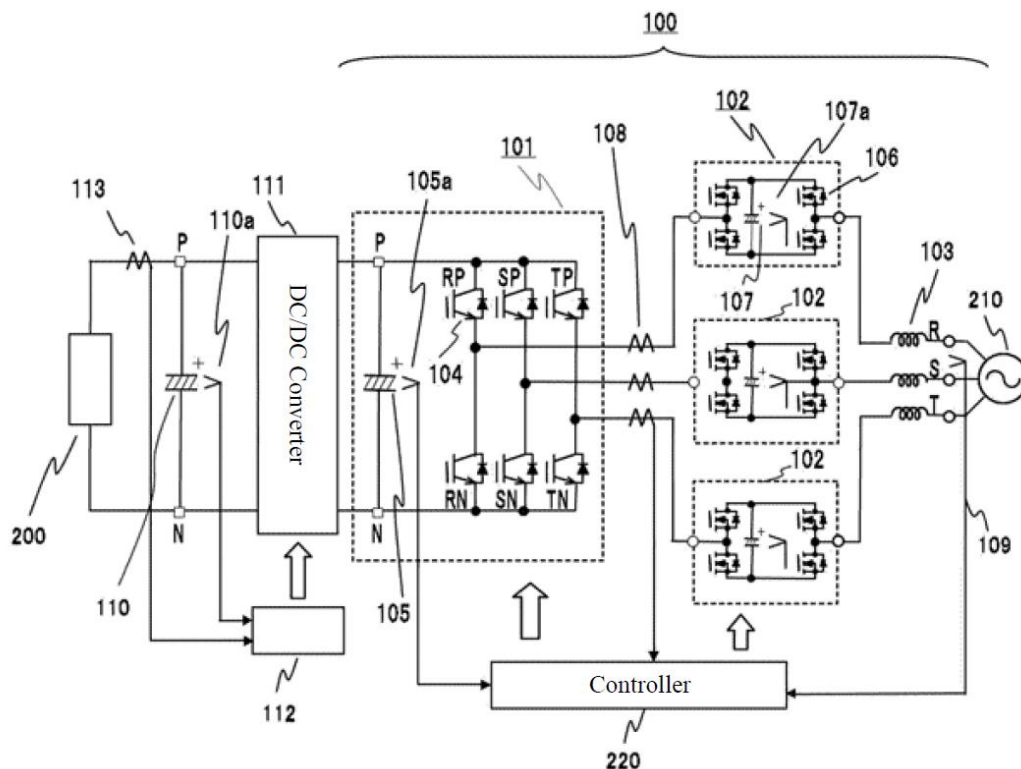


Figure 14 illustrates a power-converting apparatus that includes multiple sub-inverters 102, each with switching elements 106 (“such as a plurality of MOSFETs”) in an H-bridge configuration. *Id.* ¶ 48. Each sub-inverter 102 outputs voltage levels of $-V$, 0, or $+V$ by using current control signals RX and RY. *Id.* ¶¶ 11, 31–32. Figure 11, reproduced below, illustrates four possible patterns for these two bits.

[Fig. 11]

SW		A	B	C	D
RX →	XP	1	0	1	0
	XN	0	1	0	1
RY →	YP	0	1	1	0
	YN	1	0	0	1
Suboutput		+	−	0	0

Notably, the bottom row of Figure 11, reproduced above, shows that one bit combination places a switch into the $+1$ state, another places the switch into the -1 state, and the remaining two combinations place the switch into the 0 state. *See id.* ¶ 32.

5. Flanagan

Flanagan “relates generally to an inverter and inverter controller and, more particularly, to a pulse width modulation (PWM) controller for operating an inverter.” Ex. 1008, 1:6–9. The disclosure focuses on “the context of a three-phase system” in which the inverter comprises three pairs

of inverter switches, illustrated in Figure 2 of Flanagan, reproduced below.
Id. at 4:59–68.

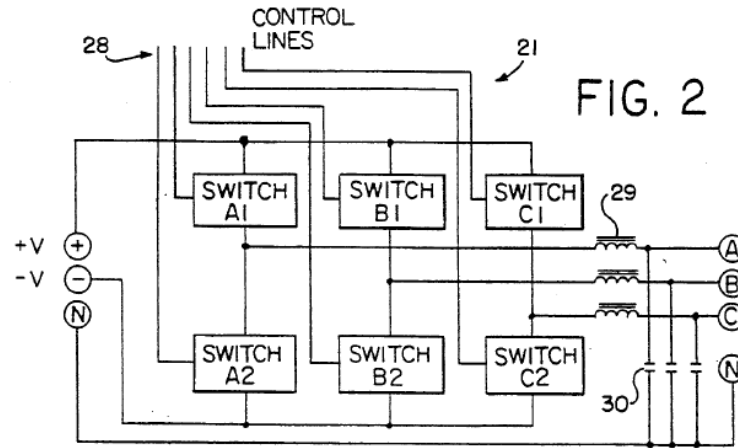


Figure 2 shows inverter 21 as a full-bridge, three-phase inverter that includes three complementary pairs of inverter switches A1/A2, B1/B2, and C1/C2. *Id.* at 4:64–68. A PWM controller (not shown) supplies an appropriate gating-signal sequence on control lines 28 to the inverter switches to generate a desired three-phase AC inverter output. *Id.* at 5:17–20. The inverter output includes line inductors 29 and filter capacitors 30 for smoothing the inverter output signal. *Id.* at 5:20–23.

Flanagan describes the PWM controller as having a memory that stores a series of drive data words, each including “a driveword for controlling the inverter switch states and a drivetime word for providing relative timing information within the PWM sequence.” *Id.* at 5:26–35. To control the inverter to produce a desired output voltage at a desired time, a procedure is followed in which a first driveword and corresponding drivetime word are retrieved from memory and output onto data buses. *Id.* at 5:55–6:35. As an address counter is progressively incremented, subsequent drivewords and corresponding drivetime words in the sequence are retrieved and output onto the data buses. *Id.*

6. Tracy

Tracy “relates to power conversion apparatus and methods, and more particularly, to power conversion apparatus and methods in which a polyphase AC output is generated from a DC link.” Ex. 1009, 1:6–9.

Figure 3 of Tracy is reproduced below.

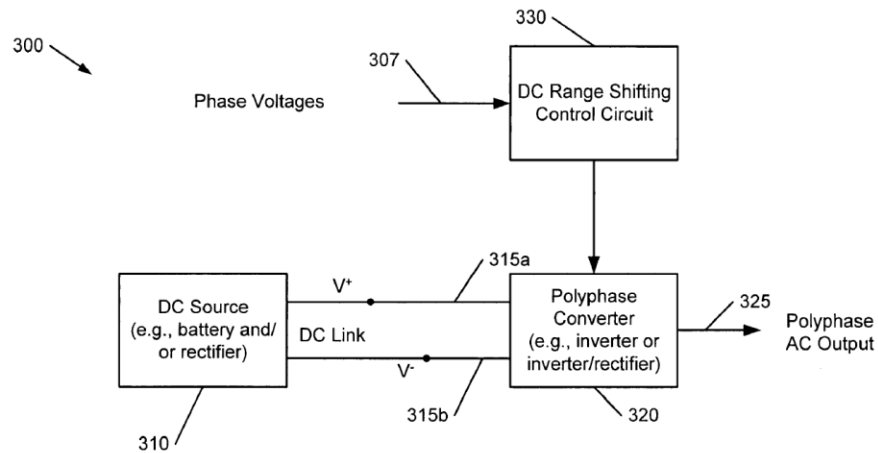


FIG. 3

Figure 3 illustrates the power conversion apparatus, notably showing battery 310 as a DC source of uninterruptable power for an inverter. *Id.* at 4:50–5:16. As Tracy states, uninterruptible power supplies like batteries were known to be used as DC power sources for inverters “to provide conditioned and/or auxiliary power.” *Id.* at 1:10–16.

7. Koyama

Koyama “relates to a grid-tie inverter that converts output from a direct current power supply into alternating current and connects the

poor power quality.” *Id.* at 1. The drawing illustrates a solution to a problem identified by Ahmed of resonance between the inductor and capacitor components by adding a damping circuit, which includes a resistor with an additional capacitor and/or inductor. *Id.* at 7–8.

9. Phadke

Phadke “relates to photovoltaic power systems, DC/DC converters and DC/AC inverters for use in such systems.” Ex. 1015, 1:14–16. Figure 6 of Phadke is reproduced below.

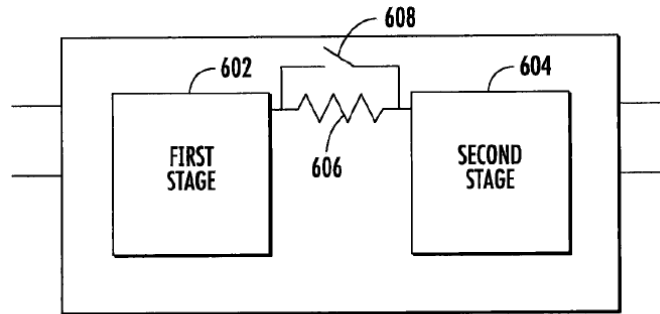


FIG. 6

Figure 6 is a block diagram of an example two-stage DC/DC converter. *Id.* at 2:31–32. First power stage 602 is coupled to second power stage 604 by resistor 606, with switch 608 connected in parallel with resistor 606 for selectively bypassing resistor 606. *Id.* at 6:64–7:1. To protect the circuit during startup, switch 608 is held open so that the resistor limits the amount of current flowing to second stage 604. *Id.* at 7:1–8. Once a certain threshold has been reached, switch 608 is closed to remove any impedance between the two stages 602, 604.

F. Independent Claim 1

Petitioner challenges independent claim 1 as unpatentable under 35 U.S.C. § 103(a) over Iwata and Bower. Pet. 23–34. In doing so, Petitioner relies primarily on Iwata, except for the requirement that the recited “DC to AC converter” be operative “to output the AC power between hot and neutral output terminals,” for which Petitioner relies additionally on Iwata. *See generally id.*

1. Summary of Petitioner’s Argument

Petitioner contends that the structure illustrated in Figure 1(a) of Iwata shows a “DC to AC converter having a transformerless output,” as recited in claim 1’s preamble, and that the structure is “operative to convert DC power to an AC power having a desired voltage and waveform.” *Id.* at 23–24; see Ex. 1001, 42:50–52. This is so, Petitioner explains, because “Iwata’s inverter outputs a desired voltage and waveform by generating different voltage levels through different combinations of the outputs of inverters 1B-INV, 2B-INV, and 3B-INV to produce ‘a substantially sine wave-like output voltage waveform 11’ as generally shown in Figure 2(b), which may have, for example, an AC output of 200V.” Pet. 24 (quoting Ex. 1004 ¶ 50; citing Ex. 1004 ¶¶ 50–53, 61, 78, 90, 97, 119, Figs. 2, 4, 5, 13, 15; Ex. 1002 ¶ 136). This characterization is supported by Dr. Baker’s testimony. See Ex. 1002 ¶ 136. In addition, Petitioner expressly addresses the requirement that the “DC to AC converter” have “a transformerless output” by noting that Iwata’s inverter “does not include a transformer between the series-connected inverters 1B-INV, 2B-INV, and 3B-INV (H-bridge switches) and

the output V_{out} (AC), and thus the output is ‘transformerless.’” Pet. 25; see Ex. 1001, 42:50.

For the “plurality of controlled switches” recited in the claim, Petitioner identifies Iwata’s single-phase inverters 1B-INV, 2B-INV, and 3B-INV. Pet. 29; see Ex. 1001, 42:55. Petitioner contends that they “each hav[e] a power input connection operative to accept DC power from an associated DC power source at an associated DC voltage,” as the claim recites, by virtue of their connection either to DC power source 2 (in the case of inverter 3B-INV) or to bidirectional DC-DC converter 5 (in the case of inverters 2B-INV and 1B-INV). Pet. 30 (citing Ex. 1004 ¶¶ 46, 48, 49, 77, 83, 84, 97, 100, 103–111, Figs. 1, 14, 16–18; Ex. 1002 ¶ 147); see Ex. 1001, 42:55–58. As Petitioner observes, Iwata discloses that V_{1B} , V_{2B} , and V_{3B} are the DC power source voltage inputs respectively for inverters 1B-INV, 2B-INV, and 3B-INV. *Id.* (citing Ex. 1004 ¶ 49, Fig. 1; Ex. 1002 ¶ 147).

The claim also requires that “each controlled switch further hav[e] a power output connection operative to output a selected one of: (a) the associated DC voltage, (b) the associated DC voltage having an inverted polarity, and (c) zero voltage, in response to an associated ternary-valued selection signal representing the multiplier values +1, –1, or 0 respectively.” Ex. 1001, 42:58–64. For this limitation, Petitioner contends that “Iwata’s inverters are arranged and controlled identically to the H-bridge switches disclosed in the ’710 patent . . . via a ternary-valued selection signal to operate in three states Iwata refers to as +1, -1, and 0.” Pet. 30–31 (citing Ex. 1004 ¶¶ 46, 50, 51, 59, Figs. 2, 4, 5; Ex. 1001, 7:23–28, 8:33–54, 9:58–64, 11:5–13, 11:26–35, Fig. 3; Ex. 1002 ¶ 149). As Petitioner explains, Iwata’s “1B-INV, 2B-INV, and 3B-INV inverters can each output either a

positive or negative (*i.e.*, ‘inverted polarity’) voltage of their respective input voltage (*e.g.*, V_{1B} , V_{2B} , or V_{3B}), or a zero voltage based on whether the inverter’s respective switches are controlled to be in the +1, -1, or 0 state.” *Id.* at 31 (citing Ex. 1004 ¶¶ 47, 50, Figs. 1, 2; Ex. 1002 ¶ 150).

To address the claim’s recitation that “the power output connections of the plurality of switches [are] directly connected in series to output a sum voltage approximating the desired AC output voltage and waveform,” Petitioner observes that Iwata’s inverters “are directly connected in series.” *Id.* at 33. Thus, the output V_A is the sum of the outputs of inverters 1B-INV, 2B-INV, and 3B-INV. *See id.* (citing Ex. 1004, Abstr., ¶¶ 7–9, 47, 56, 59, 101; Ex. 1002 ¶ 153). In addition, because Iwata provides a set of different DC power source voltage inputs V_{1B} , V_{2B} , V_{3B} , such as the 1:3:9 ratio discussed above, Petitioner further observes that Iwata teaches an example of producing a substantially sinewave-like output voltage waveform. *Id.* at 34 (citing Ex. 1004, Abstr., ¶¶ 7–9, 47, 50, 51, 53, 59, 61, 101, Figs. 2, 4, 5; Ex. 1002 ¶ 155). Such an example is illustrated in Figure 2 of Iwata, reproduced above.

The only remaining recitation of independent claim 1 is that the “DC to AC converter . . . output the AC power between hot and neutral output terminals.” Ex. 1001, 42:50–53. Petitioner addresses this limitation in the alternative. First, Petitioner contends that a person of ordinary skill in the art “would have found it obvious that Iwata’s inverter would output AC power between hot and neutral terminals.” Pet. 25. Supported by Dr. Baker’s testimony, Petitioner points to Iwata’s express illustration of outputting AC power across a pair of terminals connected to “a system or load.” *Id.* at 26 (citing Ex. 1004, Abstr., ¶¶ 6, 47, 59, 101, 119, Figs. 1, 14, 16–18; Ex. 1002

¶ 139); Ex. 1004 ¶ 47. Petitioner reasons that a person of ordinary skill in the art “would understand a ‘system’ in Iwata to include an AC electrical grid” and that “a residential single-phase AC electrical grid input would include three wires: two hot (or line) wires and one neutral wire.” Pet. 26 (citing Ex. 1002 ¶ 139; Ex. 1001, 25:5–9, 32:8–11, 33:4–6; Ex. 1018, 7–8, 11–12; Ex. 1039 ¶¶ 66–79). According to Petitioner, meeting the claim limitation “would have been obvious as one of only two choices” presented by industry safety standards. *Id.* at 26–27 (citing Ex. 1018, 24; Ex. 1002 ¶ 141).

Alternatively, Petitioner contends that the limitation “would have been obvious in view of Bower.” *Id.* at 25. Supported by Dr. Baker’s testimony, Petitioner characterizes Figure 3 of Bower, reproduced above, as showing that the AC output of Bower’s Building Block “can provide AC power across a hot terminal [(L1)] and a neutral terminal [(N)] in accordance with the NEC 2008 standards, including having the neutral terminal connected to ground circuit 50.” *Id.* at 27 (citing Ex. 1011, 10:21–38, 11:11–18, Figs. 3, 7, 11; Ex. 1002 ¶ 142). Petitioner reasons that “[i]t was obvious to use a known technique (attaching the AC outputs of a two terminal inverter to an AC electrical grid so that one terminal is hot and the other is neutral as taught in Bower) to improve a similar device (Iwata’s inverter) in the same way (connecting the output terminals of an inverter to an AC electrical grid).” *Id.* at 28 (citing Ex. 1002 ¶ 143). Petitioner supports this reasoning with Dr. Baker’s testimony, which includes the following statement regarding the knowledge and skill possessed by a person of ordinary skill in the art:

A [person of ordinary skill in the art] would also have been familiar with connecting the output terminals of an inverter to an AC electrical grid so that one terminal was hot and the other was neutral, and the [person of ordinary skill in the art] would have had the requisite skills to do so, resulting in an expectation of success. As noted above, connecting the two outputs of an inverter to a hot and a neutral terminal was well known and understood as one of only two choices (connecting to hot and hot, or connecting to hot and neutral).

Ex. 1002 ¶ 143.

We find Petitioner's reasoning sufficient. In particular, Dr. Baker's testimony provides rational underpinning for Petitioner's reasoning to combine the teachings of Iwata and Bower as proposed. Patent Owner disputes limited aspects of Petitioner's analysis, which we consider below.

2. Patent Owner's Arguments

Patent Owner's arguments disputing the sufficiency of Petitioner's analysis are directed only at recitations that appear in the preamble to independent claim 1, not to limitations that are recited in the claim's body. For purposes of this Decision, we treat the preamble as limiting, which neither party disputes. *See* Tr. 12:4–5 (Petitioner agreeing that it did not affirmatively argue the preamble was not limiting), 17:24–18:9 (Patent Owner asserting that Petitioner did not argue the preamble was not limiting). We also note that Patent Owner's arguments directed at the preamble of independent claim 1 are the only arguments made by Patent Owner on the merits. That is, Patent Owner does not dispute the sufficiency of Petitioner's showing for any of dependent claims 2–17 outside of the arguments we address directly below.

a. “transformerless output”

Contrary to Petitioner’s position, Patent Owner asserts that Iwata “does not” disclose a DC to AC converter “having a transformerless output,” as independent claim 1 recites. PO Resp. 8. According to Patent Owner, Petitioner’s position is flawed because “the Petition identifies no bounds of what Petitioner is pointing to as the ‘DC-to-AC converter’ such that Patent Owner or the Board can[not] determine whether other components of the Dc-to-AC converter include a transformer.” *Id.* at 10. “At best,” Patent Owner says, “Iwata discloses a discrete portion of an incomplete circuit that does not include a transformer.” *Id.* at 8.

It is undisputed that Iwata lacks any express disclosure of a transformer. *See* Reply 1 (Petitioner stating that Patent Owner “cannot point to where Iwata discloses a transformer in its output because Iwata undisputedly does not do so”); PO Resp. 8 (Patent Owner stating that “Iwata discloses a discrete portion of an incomplete circuit that does not include a transformer”). And, as Petitioner asserts, Patent Owner “does not actually argue that Iwata discloses, illustrates, or discusses having a transformer in its output.” Reply 1. Instead, Patent Owner “argues that Iwata *could have* an *undisclosed* transformer in its output.” *Id.*

Patent Owner makes this point in multiple ways. For example, Patent Owner suggests that Iwata’s H-bridge switches (which Petitioner identifies as part of the “DC to AC converter”) “may have been pre-conditioned,” presumably with some circuitry that includes a transformer. PO Resp. 9. “Just as importantly,” Patent Owner adds, “only in the cited portions of the Baker Declaration does Petitioner’s expert explain why the H-Bridge to

Vout terminals portion of the circuit does not include a transformer.” *Id.* at 9–10. According to Patent Owner, Dr. Baker’s testimony was “necessary to explain that this section of the circuit did not include a transformer” because “Iwata discloses a smoothing filter located between the inverters and the output, which is not a transformer, and that the inverters also do not include a transformer.” *Id.* at 10.

We do not agree with Patent Owner that the Petition is accordingly deficient. *See id.* (“Since the analysis appears nowhere in the Petition, the Board should not credit what appears only in the Baker Declaration, meaning the Petition cannot be sustained.”). As Petitioner points out, it is readily apparent that Iwata contains no disclosure of a transformer—a point Patent Owner does not dispute—such that “Iwata speaks for itself in this regard and no elaborate analysis is needed.” Reply 4. Dr. Baker supports this observation by confirming that Iwata’s circuit does not include a transformer in the circuit portion identified by Petitioner, and by noting that the smoothing filter described at that portion “is not a transformer.”

Ex. 1002 ¶ 137. That a smoothing filter is not a transformer is an elementary observation that would be manifestly apparent to a person of ordinary skill in the art, i.e., to a person who notably holds a degree in electrical engineering and has design experience with power electronics.

Patent Owner also faults Petitioner for “identif[ying] no bounds of what Petitioner is pointing to as the ‘DC-to-AC converter’ such that Patent Owner or the Board can determine whether other components of the DC-to-AC converter include a transformer.” PO Resp. 10. More specifically, Patent Owner criticizes the Petition for failing to argue that portions of Iwata’s circuit after its output terminals are “not connected to a

transformer,” or that a transformer is not part of the system or load to which Iwata teaches supplying its output voltage. *Id.* at 11–17. Patent Owner’s argument loses sight of the fact that the claim specifically requires that the “output” of the DC to AC converter be transformerless. *See* Ex. 1001, 42:50.

Both the Petition and Dr. Baker clearly identify the output of Iwata’s inverter. *See* Pet. 9 (Iwata’s Figure 1 annotated by Petitioner with yellow coloring to identify “Iwata’s inverter [with] AC output V_A ”); Ex. 1002 ¶¶ 135–136 (similarly annotated version of Iwata’s Figure 1). And both the Petition and Dr. Baker correctly point out that the identified output has no transformer. *See* Pet. 25 (“Iwata’s inverter . . . does not include a transformer between the series-connected inverters 1B-INV, 2B-INV, and 3B-INV (H-bridge switches) and the output V_{out} (AC), and thus the output is ‘transformerless.’”); Ex. 1002 ¶ 137 (same).

Iwata thus clearly and unambiguously teaches a transformerless output, and both the Petition and Dr. Baker’s supporting Declaration identify where such a transformerless output is taught. It is of no moment that a person of ordinary skill in the art might, as Petitioner asserts, also “readily imagine inserting a transformer into the output of Iwata,” which would merely “render both transformerless outputs and transformed outputs obvious.” Reply 4. We accordingly find that Petitioner presents sufficient evidence to support its position that Iwata meets the claim’s recitation of a DC to AC converter “having a transformerless output.”

b. “hot and neutral output terminals”

Patent Owner disputes the sufficiency of Petitioner’s arguments regarding claim 1’s requirement that the “DC to AC converter . . . output the AC power between hot and neutral output terminals.” PO Resp. 17–24; Ex. 1001, 42:50–54. As we summarize above and as Patent Owner correctly asserts, “Petitioner does not argue that Iwata discloses this element,” but instead contends that “it would have been obvious to connect Iwata’s inverter outputs to the hot and neutral output terminals of a power grid or, alternatively, that it would have been obvious in view of Bower.” PO Resp. 17–18 (citing Pet. 25). Patent Owner specifically disputes Petitioner’s reasoning that a person of ordinary skill in the art “would understand a ‘system’ in Iwata to include an AC electrical grid.” *Id.* at 18 (“Petitioner never provides any support for its conclusory statement that a [person of ordinary skill in the art] would have understood a ‘system’ in Iwata to include an AC electrical grid.”). In addition, Patent Owner disputes Petitioner’s reasoning that a person of ordinary skill in the art would have connected Iwata’s inverter to “hot and neutral output terminals” as the claim requires. *Id.* at 24 (“A [person of ordinary skill in the art] would thus understand that Iwata is providing a ‘hot’ line and an ‘anti-hot’ line and neither of those can be connected to neutral.”).

We disagree that Petitioner’s reasoning is deficient in either respect. First, Iwata expressly teaches that the “output voltage V_A . . . is supplied to a system or load.” Ex. 1004 ¶ 47. Petitioner supports its reasoning that a person of ordinary skill in the art would understand such a “system” to include an AC electrical grid with Dr. Baker’s testimony. Ex. 1002 ¶ 139. Both Petitioner and Dr. Baker make specific reference to an example of such

an AC electrical grid as “one in compliance with the National Fire Protection Association (NFPA) 70 National Electrical Code 2008 Edition (NEC 2008) that is cited repeatedly in the ’710 patent and was the most widely adopted installation code in the United States.” Pet. 26; see Ex. 1002 ¶ 139.

Patent Owner’s contention that “Petitioner never provides any support for its conclusory statement that a [person of ordinary skill in the art] would have understood a ‘system’ in Iwata to include an AC electrical grid” insufficiently credits the evidentiary value of Dr. Baker’s testimony. See Prelim. Resp. 18. Notably, Patent Owner was afforded opportunities to test the strength of this testimonial evidence through cross-examination of Dr. Baker, and to provide its own evidence in the form of testimony by its own declarant. Indeed, Patent Owner took advantage of both of these opportunities. See Exs. 2006 (Declaration of Dr. Foty), 2007 (transcript of deposition of Dr. Baker).

In supporting Patent Owner’s position, Dr. Foty testifies that a person of ordinary skill in the art “would recognize that some inverters can be tied to the AC grid (because they are specifically designed to be able to do so), while some cannot (as they are not designed to be able to meet the requirements associated with connection to an AC grid).” Ex. 2006 ¶ 59. Dr. Foty points to disclosure in the ’710 patent that he contends “recognizes this critical difference.” *Id.* Dr. Baker agrees with this point, but clarifies that a person of ordinary skill in the art “would have understood that Iwata’s reference to supplying a load means that Iwata’s inverter can act as a load inverter and Iwata’s reference to supplying a system means that Iwata’s inverter can act as a grid-tied inverter.” Ex. 1074 ¶ 8. As Petitioner notes in

replying to Patent Owner’s argument, Patent Owner “offers no other explanation for what a ‘system’ is, if not the grid.” Reply 12.

Petitioner’s argument is persuasive, particularly accounting for the level of skill possessed by an ordinarily skilled artisan. Although Patent Owner contends that Petitioner’s argument in reply is improper, we disagree. See Sur-reply 10–11 (“Allowing Petitioner to now argue it is only an AC grid and to belatedly present argument about **why** a [person of ordinary skill in the art] would have this understanding is improper, especially because Patent Owner is precluded from offering any evidence to rebut it at this point.”). Patent Owner was afforded an opportunity to cross-examine Dr. Baker’s Reply Declaration, but evidently chose not to do so. See 37 C.F.R. §§ 42.51(b)(1)(ii) (authorizing cross-examination of affidavit testimony as routine discovery), 42.23(b) (noting a sur-reply may be accompanied by “deposition transcripts of the cross-examination of any reply witness).

We find Petitioner’s evidence and argument submitted in reply to be properly responsive to the argument raised by Patent Owner in its Response and supported by Dr. Foty’s testimony. See *Ericsson Inc. v. Intellectual Ventures I LLC*, 901 F.3d 1374, 1380 (Fed. Cir. 2018) (“[T]he Board has discretion to determine whether a petition for *inter partes* review identified the specific evidence relied on in a reply and when a reply contention crosses the line from the responsive to the new.”). And the Office’s policy limiting evidence submitted with a sur-reply appropriately accounts for the fact that petitioners bear the burden of showing unpatentability of challenged claims. *Harmonic Inc. v. Avid Tech., Inc.*, 815 F.3d 1356, 1363 (Fed. Cir. 2016) (“In an IPR, the petitioner has the burden from the onset to show with particularity why the patent it challenges is unpatentable.”).

Second, Dr. Baker and Dr. Foty disagree whether a person of ordinary skill in the art would understand Iwata to be capable of functioning with hot-neutral connections. *See* Ex. 2006 ¶ 60 (Dr. Foty testifying that “Iwata is incapable of functioning under the second choice [of hot-neutral connections]”); Ex. 1074 ¶ 12 (Dr. Baker testifying that he “disagree[s] with Dr. Foty that Iwata’s inverter is producing ‘output waveforms’ on both of its outputs in a manner that precludes it from being connected hot-hot”). We need not resolve this technical disagreement because of Petitioner’s alternative position that relies on the combination with Bower.

As we note above, Bower expressly shows connection of AC output across hot and neutral terminals, and Dr. Baker explains that a person of ordinary skill in the art would have reason and skill to combine the teachings of Iwata and Bower as Petitioner proposes. *See* Ex. 1011, 10:21–38, 11:11–18; Ex. 1002 ¶ 143. Although Dr. Foty expresses some disagreement with this combination, he does so only because “Petitioner has failed to provide an explanation as to why a [person of ordinary skill in the art] would believe that the inverter of Iwata could ever be connected to an AC grid at all—beyond the unexplained (and unsupported) contention that the term ‘system’ in Iwata refers to an ‘AC grid.’” Ex. 2006 ¶ 67. As we explain above, Petitioner properly developed the evidence on this point in response to Dr. Foty’s testimony and Patent Owner’s related arguments. And, as we also explain above, we determine that the evidence on the fully developed record sufficiently supports Petitioner’s position under the standard we apply.

3. Summary

For these reasons, we conclude that Petitioner shows, by a preponderance of the evidence, that independent claim 1 is unpatentable under 35 U.S.C. § 103(a) over Iwata and Bower.

G. Dependent Claims 2 and 5

Claims 2 and 5 depend directly from independent claim 1 and respectively recite that “at least some of the DC voltages associated with the plurality of controlled switches have different values” and that “each associated DC voltage differs from another DC voltage nominally by a factor of 3.” Ex. 1001, 43:1–3, 43:13–15. Petitioner challenges these claims as unpatentable under 35 U.S.C. § 103(a) over Iwata and Bower. Pet. 35. Specifically, Petitioner observes that “Iwata discloses its DC voltages (*i.e.*, V_{1B} , V_{2B} , and V_{3B}) having voltages that differ from one another by a factor of 3, *e.g.*, having a 1:3:9 ratio (*e.g.*, $V_{1B}=1V$, $V_{2B}=3V$, and $V_{3B}=9V$).” Pet. 35 (citing Ex. 1004, Abstr., ¶¶ 50–51, 53, 60–61, 79, 85, 94, Figs. 2, 4; Ex. 1002 ¶¶ 159, 162). This identification is sufficient to meet the additional limitations of both claims.

We conclude that Petitioner shows, by a preponderance of the evidence, that dependent claims 2 and 5 are unpatentable under 35 U.S.C. § 103(a) over Iwata and Bower.

H. Dependent Claim 3

Claim 3 depends directly from independent claim 1 and recites that “the desired voltage is a voltage of a standard household electricity supply and the desired waveform is sinusoidal at a standard household electricity

supply frequency.” Ex. 1001, 43:4–7. Petitioner challenges this claim as unpatentable under 35 U.S.C. § 103(a) over Iwata and Bower, identifying disclosure from either Iwata or Bower as meeting the additionally recited limitations. Pet. 35–37.

With respect to the former, Petitioner asserts that “Iwata discloses that its inverter can be connected to a system or load or applied to an uninterruptible power supply[, which] provides, among other things, emergency power to buildings when power grids fail.” Pet. 36 (citing Ex. 1004, Abstr., ¶¶ 47, 59, 101, 119; Ex. 1002 ¶ 166). Petitioner supports this assertion, as well as its assertion that Iwata’s disclosure of 200 V for an AC waveform “is a standard household voltage for Japan,” with uncontroverted testimony by Dr. Baker. Ex. 1002 ¶ 166; Pet. 36 (citing Ex. 1004 ¶¶ 5, 53, 61, 85).

With respect to the latter, Petitioner notes that “Bower outputs single-phase 240V, 60Hz AC power or ‘power at 120V or any other single-phase voltage with one terminal grounded that is intended to be connected to the neutral conductor in the house.’” Pet. 36 (citing Ex. 1011, 10:16–26; Ex. 1002 ¶¶ 167–168). Bower expressly states that, “[i]n the United States, the majority of the residential dwellings are wired with single-phase 240V, 60 Hz power.” Ex. 1011, 10:18–20. Petitioner adequately reasons, with Dr. Baker’s supporting testimony, that “[i]t was obvious to use a known technique (producing an AC waveform with the voltage and frequency used in a standard household) to improve a similar device (Iwata’s inverter) in the same way (Iwata produces AC power for a standard household).” Pet. 36 (citing Ex. 1002 ¶¶ 169–170).

Petitioner's reliance for dependent claim 3 on either Iwata or Bower is sufficient. We conclude that Petitioner shows, by a preponderance of the evidence, that dependent claim 3 is unpatentable under 35 U.S.C. § 103(a) over Iwata and Bower.

I. Dependent Claim 4

Claim 4 depends directly from independent claim 1 and recites that “the controlled switches are MOSFETs connected in H-bridge configurations, and the associated DC power sources are floating relative to each other and relative to the DC to AC converter hot and neutral output terminals.” Ex. 1001, 43:8–12. Petitioner challenges claim 4 as unpatentable under 35 U.S.C. § 103(a) over Iwata, Bower, and Mori '630. Pet. 44–49.

As indicated in our discussion of independent claim 1 above, we agree that Petitioner sufficiently shows that Iwata's switches are connected in H-bridge configurations like those described in the '710 patent. *See supra* § II.E.1; Pet. 44–45. Petitioner additionally reasons that the associated DC power sources in Iwata are “floating,” both relative to each other and relative to the hot and neutral output terminals, in light of the statement made during prosecution of the '710 patent that “[a]s well known in the art, a ‘floating’ output of a power supply is one that is not referenced to a set voltage, such as chassis or earth ground.” Pet. 47. In particular, Petitioner observes that Iwata's power sources are not grounded, and that the specific operation of DC power source V_C across capacitor 4 as shown in Figure 1(a) of Iwata (reproduced above) requires that it be floating with respect to the output and with respect to the other DC power sources. *Id.* at 46–47. Petitioner's

reasoning is supported by Dr. Baker’s uncontroverted testimony. Ex. 1002 ¶¶ 204–206. Petitioner thus makes a sufficient showing with respect to these aspects of the claim.

Petitioner relies on Mori ’630’s disclosure of single-phase inverters composed of MOSFETs to meet the claim’s additional aspect that the recited controlled switches be “MOSFETs.” Pet. 49. In addition to thus identifying this disclosure in Mori ’630, Petitioner articulates sufficient reason to combine that teaching with the Iwata-Bower combination because Dr. Brown supports Petitioner’s assertion that “MOSFETs had been used in switches for decades, and Mori ’630 teaches how to connect and control MOSFETs in an H-bridge configuration.” *Id.* (citing Ex. 1006 ¶¶ 9–10; Ex. 1002 ¶¶ 210).

We conclude that Petitioner shows, by a preponderance of the evidence, that dependent claim 4 is unpatentable under 35 U.S.C. § 103(a) over Iwata, Bower, and Mori ’630.

J. Claim 6

Claim 6 depends directly from independent claim 1 and recites that “the ternary-valued selection signals comprise pairs of binary bits, each bit pair having in total four combinations of possible values, of which two of the four combinations represent the zero multiplier value.” Ex. 1001, 43:16–20. Petitioner challenges claim 6 as unpatentable under 35 U.S.C. § 103(a) over Iwata, Bower, and Mori ’265. Pet. 59–64. Petitioner acknowledges that “Iwata does not explicitly disclose that the ternary-valued selection signals [used to control switch states within Iwata’s inverters] comprise pairs of binary bits as recited in claim 6.” *Id.* 60 (citing Ex. 1002 ¶ 239).

Supported by Dr. Baker’s uncontroverted testimony, Petitioner relies for this limitation on Mori ’265’s disclosure of such two-bit control signals, as illustrated in Figure 11 of Mori ’265, reproduced above. *Id.* (citing Ex. 1002 ¶ 239); *see supra* § II.D.4. Dr. Baker testifies that a person of ordinary skill in the art would have been motivated to use Mori’s two-bit control signal encoding “because that encoding is efficient and eliminates superfluous control logic that would have been required by other encoding schemes for Iwata’s ternary-valued control signal.” Ex. 1002 ¶ 244. Petitioner’s reliance on this testimony provides rational underpinning for its position that it would have been obvious to effect the combination, which Dr. Baker further testifies would achieve predictable results in a known manner. Pet. 64; Ex. 1002 ¶ 244. In particular, the combination meets the claim requirement of each bit pair having four combinations of values, of which two represent a zero multiplier value, as explicitly illustrated in the bottom row of Mori ’265’s Figure 11, reproduced above. *See supra* § II.D.4.

We conclude that Petitioner shows, by a preponderance of the evidence that dependent claim 6 is unpatentable under 35 U.S.C. § 103(a) over Iwata, Bower, and Mori ’265.

K. Dependent Claims 7 and 8

Petitioner challenges claims 7 and 8 as (1) unpatentable under 35 U.S.C. § 103(a) over Iwata and Bower; and (2) unpatentable under 35 U.S.C. § 103(a) over Iwata, Bower, and Mori ’630. Pet. 37–40, 49–55. Those claims depend directly from independent claim 1 and recite “a switch selection signal generator operative to produce the ternary-valued selection signals.” Ex. 1001, 43:21–23, 43:29–31. For this limitation, Petitioner

relies on Iwata’s description of using ternary-valued selection signals to control the H-bridge switches. Pet. 37–40. In particular, Petitioner observes that Iwata describes a “gradational output voltage control operation” that is applied to control the sum voltage output waveform with a set of ternary-valued selection signals sent to each of the H-bridge switches at different times. *Id.* at 37 (citing Ex. 1004 ¶¶ 47–50). In addition, Petitioner notes that Iwata also describes applying pulse-width modulation control (“PWM control”) to improve voltage-waveform accuracy. *Id.* (citing Ex. 1004 ¶¶ 50–51). Dr. Baker provides uncontroverted testimony that a person of ordinary skill in the art “would have understood that ‘gradational’ and ‘PWM’ control in Iwata would have included a signal generator (*i.e.*, a ‘switch selection signal generator’) generating the ternary valued control signals sent to the H-bridge switches to create the desired sum output.” Ex. 1002 ¶ 175. Dr. Baker thus supports Petitioner’s position that the limitation is taught by Iwata.

In the case of claim 7, “the switch selection signal generator [is] configured to produce sets of switch selection signals, at given time instants, such that the sum voltage output is momentarily the best approximation to the instantaneous voltage values of the desired waveform at the given instants.” *Id.* at 43:23–28. In the case of claim 8, “the switch selection signal generator [is] configured to produce sequential sets of switch selection signals, and [is] configured to produce each new set of switch selection signals at a time instant at which the new set of switch selection signals would cause the sum voltage to be a better approximation to an instantaneous voltage value of the desired waveform at that time instant than

the immediately previously output set of switch selection signals.” *Id.* at 43:31–40.

According to Petitioner, and supported by Dr. Baker’s uncontroverted testimony, Figures 2(b) and 3 of Iwata illustrate “sequential time instants at which each new set of switch selection signals produce a sum output voltage that approximates ‘the instantaneous voltage values of the desired waveform.’” Pet. 39 (citing Ex. 1002 ¶ 177). Petitioner reasons, and we agree, that such sum output voltages at the time instants are the “best approximation . . . at the given instants,” as recited in claim 7, and also “a better approximation . . . at that time instant than the immediately previously output set of switch selection signals,” as recited in claim 3. *Id.* (citing Ex. 1002 ¶ 177). We thus determine that Petitioner makes a sufficient showing under its Iwata-Bower challenge.

We also determine that Petitioner makes a sufficient showing under its alternative challenge that implements Mori ’630’s control circuit within the Iwata-Bower combination. *See* Pet. 49–55. As Petitioner observes, Mori ’630 resembles Iwata in its teaching of an inverter comprising series-connected individual single-phase inverters that consist of H-bridges attached to respective DC power sources. *Id.* at 49–50 (citing Ex. 1006 ¶¶ 9–10, claim 1, Fig. 1; Ex. 1002 ¶ 215). In addition, Mori ’630 describes gate drive circuitry that Petitioner identifies with the “switch selection signal generator” recited in the claims because it applies a predetermined voltage for turning each switch on and off based on a gate drive signal generated by a control circuit. *See id.* at 50–51 (citing Ex. 1006 ¶¶ 10–11, 15–33, Figs. 1, 4, 9, 10, 13, 15; Ex. 1002 ¶ 216). And Mori ’630 teaches that such gate control circuitry provides a set of ternary-valued selection signals to control

the H-bridge switches at given time instants so that the sum output approximates the instantaneous waveform voltage values. *See id.* at 51–52 (citing Ex. 1006 ¶¶ 9, 11–12, 15, 18–22, 29, Abstr.; Ex. 1002 ¶ 217).

Dr. Baker supports Petitioner’s contention that implementing Iwata with Mori ’630’s control circuit was “an obvious combination of prior art elements . . . according to known methods . . . to yield predictable results.” *Id.* at 52; Ex. 1002 ¶ 218. This is because, Dr. Baker testifies, Iwata requires the H-bridge switches to receive control signals to create the three possible states for each H-bridge, and Mori ’630 generates “that same type of control signal.” Ex. 1002 ¶ 218. Dr. Baker describes Figure 8 of Mori (not reproduced here) as showing “the target waveform . . . and basic gradation output . . . , which changes at each time instant . . . to a new value . . . that equals the target voltage, from a previous value . . . that is less than the target voltage” so that “sum output voltage is changed to the target voltage at each time instant and further using PWM control to improve the approximation.” *Id.* ¶ 222. As Dr. Baker testifies, and Petitioner argues, such a procedure meets the respective requirements for configuration of the switch selection signal generator recited in claims 7 and 8. *Id.*; Pet. 55.

We conclude that Petitioner shows, by a preponderance of the evidence that claims 7 and 8 are (1) unpatentable under 35 U.S.C. § 103(a) over Iwata and Bower, and (2) unpatentable under 35 U.S.C. § 103(a) over Iwata, Bower, and Mori ’630.

L. Dependent Claim 9

Claim 9 depends from claim 8 and recites,
where the desired waveform is repetitive:

memory operative to store precomputed sequential sets of switch selection signals and the associated time instants at which each set is to be output; and

wherein the switch selection signal generator is operative to retrieve the precomputed sequential sets of switch selection signals and associated time instants from the memory, and to output the switch selection signals at the associated times.

Ex. 1001, 43:41–50. Petitioner challenges claim 9 as (1) unpatentable under 35 U.S.C. § 103(a) over Iwata, Bower, and Flanagan; and (2) unpatentable under 35 U.S.C. § 103(a) over Iwata, Bower, Mori ’630, and Flanagan.

Pet. 64–67. For both its proposed Iwata-Bower and Iwata-Bower-Mori ’630 combinations, Petitioner contends that a person of ordinary skill in the art “would have been motivated . . . to include the memory and functionality of Flanagan’s programmed PWM controller because using a series of precomputed signals reduces or eliminates the need for processing power dedicated to calculating the signals in real time.” *Id.* at 66. Flanagan’s PWM controller meets the limitations additionally recited in claim 9, and Petitioner’s reasoning for further effecting the combination of that teaching is supported by Dr. Baker’s uncontroverted testimony, including that the modification represents a combination of prior-art elements in a known manner, with predictable results, and with a reasonable expectation of success. Ex. 1002 ¶¶ 256–257.

In this way, Petitioner makes a sufficient showing such that we conclude that Petitioner shows, by a preponderance of the evidence, that claim 9 is (1) unpatentable under 35 U.S.C. § 103(a) over Iwata, Bower, and Flanagan; and (2) unpatentable under 35 U.S.C. § 103(a) over Iwata, Bower, Mori ’630, and Flanagan.

M. Claims 10 and 11

Claim 10 depends directly from claim 1 and recites that “the DC power source having the highest voltage value is a battery and the DC power sources having lower voltages [*sic*] values comprise bi-directional DC-DC conversion circuitry operative to derive the lower voltage values from the battery.” Ex. 1001, 43:51–55. Claim 11 also depends directly from claim 1 and similarly recites that “the DC power source supplying the highest mean power is a battery and the DC power sources supplying lower mean power comprise bi-directional DC-DC conversion circuitry operative to derive the lower mean power from the battery.” *Id.* at 43:56–44:2. That is, claims 10 and 11 are identical, except that claim 11 recites “mean power” instead of “voltage value.” Because mean power is the product of voltage and current, the “mean power” recited in claim 11 is directly proportional to the “voltage value” recited in claim 10, as Dr. Baker testifies. Ex. 1002 ¶ 188.

Petitioner challenges claims 10 and 11 as (1) unpatentable under 35 U.S.C. § 103(a) over Iwata and Bower; (2) unpatentable under 35 U.S.C. § 103(a) over Iwata, Bower, and Tracy; (3) unpatentable under 35 U.S.C. § 103(a) over Iwata, Bower, and Nishimura; and (4) unpatentable under 35 U.S.C. § 103(a) over Iwata, Bower, Tracy, and Nishimura. Pet. 40–42, 67–70. For its challenges over Iwata and Bower alone, Petitioner addresses the limitations of claim 10 by observing that Iwata provides an example that uses a solar battery as its DC power source, and that Iwata’s inverter is used in an “uninterruptible power supply.” Pet. 40–41 (citing Ex. 1004 ¶¶ 1–3, 119). Dr. Baker’s provides uncontroverted testimony that “[i]t was well known to a [person of ordinary skill in the art] that a[n uninterruptible power supply] typically includes a battery to provide uninterrupted power as the

backup power source, when the primary power source . . . was inoperative.” Ex. 1002 ¶ 182. In further addressing the limitations of claim 11, Petitioner adds that Iwata’s DC power source (V_{3B}) is taught to have a voltage higher than the other two power sources (V_{1B} and V_{2B}), with the switches controlled such that the mean power of the V_{3B} source is higher than the mean power (proportion to voltage) of the V_{1B} and V_{2B} sources. Pet. 42. We agree with this analysis.

Petitioner alternatively relies on Tracy “to the extent [Patent Owner] argues the ‘battery’ of claims 10 and 11 is not taught by Iwata-Bower.” *Id.* at 67. Supported by Dr. Baker’s uncontroverted testimony, Petitioner reasons that “[t]he use of Tracy’s battery as an uninterruptible DC power source in Iwata’s inverter was obvious as the simple substitution of one known element (Tracy’s battery as an uninterruptible DC power source) for another (Iwata’s uninterruptible power source) to yield predictable results (the battery serves as a reliable uninterruptible DC power source having the highest voltage value).” *Id.* at 68. Petitioner thereby provides rational underpinning to effect the combination and makes a sufficient showing.

Petitioner alternatively relies on Nishimura in combination with either Iwata and Bower alone or in further combination with Tracy, “[t]o the extent that the ‘bi-directional DC-DC conversion circuitry’ of claims 10 and 11 is a means-plus-function term.” *Id.* at 69. Because we have not construed that term in that manner, we do not reach these additional challenges.

We conclude that Petitioner shows, by a preponderance of the evidence, that claims 10 and 11 are (1) unpatentable under 35 U.S.C. § 103(a) over Bower and Iwata; and (2) unpatentable under 35 U.S.C. § 103(a) over Bower, Iwata, and Tracy.

N. Claim 12

Claim 12 depends directly from independent claim 1 and recites that “one of the power output connections of the controlled switch having the associated DC power source of the highest associated DC voltage is one of the end terminals of the series connection, and is connected to the neutral output terminal.” Ex. 1001, 44:3–7. Petitioner challenges claim 12 as (1) unpatentable under 35 U.S.C. § 103(a) over Iwata and Bower; and (2) unpatentable under 35 U.S.C. § 103(a) over Iwata, Bower, and Mori ’630. Pet. 42–44, 56–58.

First, for the Iwata-Bower challenge, because it would have been obvious for one of Iwata’s inverter output terminals to be neutral, as discussed above, Petitioner reasons that it would similarly have been specifically obvious for Iwata’s 3B-INV inverter to be connected to neutral as one of only two possibilities. *Id.* at 42–43. Dr. Baker supports this reasoning by testifying that connecting the 3B-INV inverter (which has the highest DC voltage) to neutral may advantageously reduce common mode voltage and electromagnetic interference. Ex. 1002 ¶ 195. We credit Dr. Baker’s uncontroverted testimony on this point.

Second, Petitioner alternatively contends that, to the extent Patent Owner argues that it would not have been obvious with the Iwata-Bower combination alone to connect the AC output power of the inverter across a pair of terminals with the bottom output terminal hot and the top output terminal neutral, such a configuration would have been obvious in view of Mori ’630. Pet. 56. Patent Owner does not so argue. Nevertheless, we agree with Petitioner’s alternative reasoning. Supported by Dr. Baker’s

uncontroverted testimony, Petitioner reasons that a person of ordinary skill in the art “would have been motivated to connect the single-phase inverter as taught by Iwata-Bower . . . with the output of the highest voltage inverter (INV-3B in Iwata) connected to neutral as taught by Mori ’630, in order to expand the capability of the Iwata-Bower designs to three phase AC systems.” *Id.* at 57–58; Ex. 1002 ¶ 230. We also credit Dr. Baker’s testimony on this point.

We accordingly conclude that Petitioner shows, by a preponderance of the evidence, that dependent claim 12 is (1) unpatentable under 35 U.S.C. § 103(a) over Iwata and Bower; and (2) unpatentable under 35 U.S.C. § 103(a) over Iwata, Bower, and Mori ’630.

O. Claim 13

Claim 13 depends directly from independent claim 1 and recites that (1) “the associated DC power source of one of the controlled switches is a battery,” and (2) the DC to AC converter “further compris[es] a common-mode filter interposed between the battery and the controlled switch.” Ex. 1001, 44:8–12. Petitioner challenges claim 13 as (1) unpatentable under 35 U.S.C. § 103(a) over Iwata, Bower, and Koyama; and (2) unpatentable under 35 U.S.C. § 103(a) over Iwata, Bower, Tracy, and Koyama. Pet. 70–72. Petitioner relies on its analysis of claims 10 and 11 in contending that Iwata and Bower alone or in further combination with Tracy meet the requirement that the associated DC power source be a battery. *Id.* at 70–71; *see supra* § II.L.

For the further limitation of a common-mode filter, Dr. Baker testifies that the first common mode choke coil 3a and capacitors 41a, 41b of

Koyama, shown in Figure 5 of Koyama, reproduced above, is a “common-mode filter,” which the drawing shows interposed between battery 5 and inverter 1. Ex. 1002 ¶ 277. Supported by Dr. Baker’s uncontroverted testimony, Petitioner reasons that a person of ordinary skill in the art “would have been motivated to add Koyama’s common mode filter between the floating battery (*e.g.*, of Iwata’s or Tracy’s [uninterruptible power supply] battery and other DC power sources) and Iwata’s inverter (including the 3B-INV H-bridge) to suppress common-mode currents and minimize [electromagnetic interference].” Pet. 72 (citing Ex. 1013 ¶¶ 12–13, 19–21; Ex. 1002 ¶ 184). Petitioner thus provides rational underpinning to support its contention that it would have been obvious to include Koyama’s common-mode filter with the Iwata-Bower or Iwata-Bower-Tracy combinations.

We conclude that Petitioner shows, by a preponderance of the evidence, that dependent claim 13 is (1) unpatentable under 35 U.S.C. § 103(a) over Iwata, Bower, and Koyama; and (2) unpatentable under 35 U.S.C. § 103(a) over Iwata, Bower, Tracy, and Koyama.

P. Claims 14 and 15

Claim 14 is recited as depending from claim 12 and recites that the common mode filter comprises:

- a capacitor connected between DC power input terminals of the controlled switch;
- a common-mode choke connected between the battery and the DC power input terminals of the controlled switch;
- a first pair [of] capacitors connected respectively from positive and negative terminals of the battery to the neutral output terminal;

a damping resistor connected to the neutral output terminal; and

a second pair of capacitors connected respectively from the positive and negative terminals of the battery to the other end of the damping resistor than the neutral terminal.

Ex. 1001, 44:13–29.⁷ Claim 15 depends from claim 14 and recites “an inductor connected in parallel with said damping resistor.” *Id.* at 44:30–32. Petitioner challenges claims 14 and 15 as (1) unpatentable under 35 U.S.C. § 103(a) over Iwata, Bower, Koyama, and Ahmed; (2) unpatentable under 35 U.S.C. § 103(a) over Iwata, Bower, Tracy, Koyama, and Ahmed; (3) unpatentable under 35 U.S.C. § 103(a) over Iwata, Bower, Mori ’630, Koyama, and Ahmed; and (4) unpatentable under 35 U.S.C. § 103(a) over Iwata, Bower, Tracy, Mori ’630, Koyama, and Ahmed. Pet. 72–78. Such various combinations result from Petitioner’s contentions regarding claims discussed above, with Koyama applied for the structure of the recited “common mode filter” modified to include a damping circuit as taught by Ahmed. *Id.* at 73–78.

Specifically, Petitioner identifies the “capacitor connected between DC power input terminals of the controlled switch” with capacitor 4 shown in Figure 1(a) of Iwata; identifies the recited “common-mode choke” and “first pair [of] capacitors” with the common-mode filter structures shown in Figure 5 of Koyama; and identifies the recited “damping resistor” and

⁷ As Petitioner observes, claim 12 does not provide antecedent basis for a “common mode filter” or for a “battery.” See Pet. 72–73. Claim 14 is thus presumably meant to depend from claim 13, which does provide such antecedents. Regardless, Petitioner refers to its analysis of claim 13 to support its position that such features would have been obvious, even if claim 14 is meant to depend from claim 12. See *id.* at 73.

“second pair of capacitors” with Ahmed’s LC damping filter. *Id.* at 73–76. As Petitioner points out, Ahmed’s damping filter may include an inductor in parallel with its damping resistor as illustrated in Figure 15(a) of Ahmed. *Id.* at 76; Ex. 1012, 8 (Figure 15(a)).

Dr. Baker’s uncontroverted testimony supports these identifications, as well as Petitioner’s rationale for effecting the combination of Koyama and Ahmed with Iwata. See Ex. 1002 ¶¶ 295–298. Dr. Baker testifies that a person of ordinary skill in the art “would have understood how to apply [Ahmed’s] damping techniques to the equivalent common mode versions of [Koyama’s] filters,” and provides specific illustrations of the modifications that were within the scope of ordinary skill. *Id.* at 299–300. Petitioner relies on such testimony in reasoning that “[u]sing Ahmed’s damping circuits . . . to modify Koyama’s common mode filter would reduce resonance in the filter,” and that “[t]he addition of the inductor in parallel with [the] damping resistor provides the additional benefit of reducing power dissipation of the damping circuit.” Pet. 77 (citing Ex. 1012, 7, 9; Ex. 1002 ¶ 302). Dr. Baker’s testimony further supports Petitioner’s contention that such combinations, which disclose all of the features of claims 14 and 15, “represent the obvious use of a known technique (inserting Ahmed’s damping circuits in an LC filter) to improve a similar device (Koyama’s common mode LC filter) in the same way (by suppressing the resonance between the choke and capacitors and reducing power dissipation of the damping resistor).” Pet. 77–78; Ex. 1002 ¶¶ 302–303.

We accordingly conclude that Petitioner shows, by a preponderance of the evidence, that dependent claims 14 and 15 are (1) unpatentable under 35 U.S.C. § 103(a) over Iwata, Bower, Koyama, and Ahmed; (2) unpatentable

under 35 U.S.C. § 103(a) over Iwata, Bower, Tracy, Koyama, and Ahmed;
(3) unpatentable under 35 U.S.C. § 103(a) over Iwata, Bower, Mori '630,
Koyama, and Ahmed; and (4) unpatentable under 35 U.S.C. § 103(a) over
Iwata, Bower, Tracy, Mori '630, Koyama, and Ahmed.

Q. Claim 16

Claim 16 depends directly from independent claim 1 and recites
a low-pass output filter comprising:
 an inductor connected between the sum voltage at the end
of the series connection of switches and the hot output terminal;
 a first capacitor connected across the hot and neutral
output terminals;
 a damping resistor connected to the neutral output
terminal; and
 a second capacitor connected from the hot output
terminal to the other end of the damping resistor than the
neutral terminal.

Ex. 1001, 44:33–44. Petitioner challenges claim 16 as unpatentable under
35 U.S.C. § 103(a) over Iwata, Bower, and Ahmed. Pet. 78–81. In doing
so, Petitioner observes that Figure 1(a) of Iwata illustrates a low-pass
smoothing filter that comprises inductor 6a and capacitor 6b connected as
required by the first two elements of claim 16 when the top output terminal
is hot, as discussed above in connection with independent claim 1. *Id.* at 78–
79; *see* Ex. 1004 ¶ 47. Petitioner additionally relies on Ahmed to modify
Iwata's low-pass smoothing filter to include the remaining two elements of
claim 16 to reduce unwanted resonance effects. Pet. 80. Petitioner supports
its contention that the combination would have been effected by one of
ordinary skill in the art as using a known technique to improve a similar
device with a reasonable expectation of success with Dr. Baker's

uncontroverted testimony regarding the familiarity of such filtering techniques to such a skilled artisan. *Id.* at 80–81; Ex. 1002 ¶¶ 312–313.

We accordingly conclude that Petitioner shows, by a preponderance of the evidence, that dependent claim 16 is unpatentable under 35 U.S.C. § 103(a) over Iwata, Bower, and Ahmed.

R. Claim 17

Claim 17 depends directly from independent claim 1 and recites a start-up in-rush current limiting circuit interposed between at least one of the controlled switches and its associated DC power source, the start-up in-rush current limiting circuit comprising:

one or more switches operative to insert a series impedance between the DC power source and the controlled switch when the DC to AC converter is initially powered on and no electrical load is connected to an AC output, and further operative to remove the series impedance and connect the DC power source to the controlled switch when the in-rush current has dropped below a threshold.

Ex. 1001, 44:45–57. Petitioner challenges claim 17 as unpatentable under 35 U.S.C. § 103(a) over Iwata, Bower, and Phadke. Pet. 81–83. Petitioner acknowledges that Iwata does not disclose the recited “start-up in-rush current limiting circuit,” and relies on Phadke’s disclosure of such a circuit. *Id.* at 81. In particular, Petitioner contends that a person of ordinary skill in the art would be motivated to use Phadke’s switch 608, shown in Figure 6 of Phadke, reproduced above, to protect the circuit during startup. *Id.* at 82–83. Specifically, Petitioner contends that it would have been obvious “to use Phadke’s startup circuit between one of Iwata’s power sources and the controlled H-bridge switches”: “This would have been combining known

elements (Phadke’s startup circuit and Iwata power sources providing power to its H-bridge switches) according to known methods (inserting the startup circuit between the power source and inverter as taught in Phadke) to yield predictable results (protecting Iwata’s H-bridge circuitry by limiting the amount of current entering the switches during startup).” *Id.* at 83.

Petitioner supports this reasoning with Dr. Baker’s uncontroverted testimony, which we credit. Ex. 1002 ¶¶ 320–324.

We accordingly conclude that Petitioner shows, by a preponderance of the evidence, that dependent claim 17 is unpatentable under 35 U.S.C. § 103(a) over Iwata, Bower, and Phadke.

III. CONCLUSION

The table below summarizes our conclusions as to the challenged claims.⁸

⁸ 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).

Claims	35 U.S.C. §	References	Claims Shown Unpatentable	Claims Not Shown Unpatentable
1–3, 5, 7, 8, 10–12	103(a)	Iwata, Bower	1–3, 5, 7, 8, 10–12	
4, 7, 8, 12	103(a)	Iwata, Bower, Mori '630	4, 7, 8, 12	
6	103(a)	Iwata, Bower, Mori '265	6	
9	103(a)	Iwata, Bower, Flanagan	9	
9	103(a)	Iwata, Bower, Mori '630, Flanagan	9	
10, 11	103(a)	Iwata, Bower, Tracy	10, 11	
10, 11 ⁹	103(a)	Iwata, Bower, Nishimura		
10, 11 ⁹	103(a)	Iwata, Bower, Tracy, Nishimura		
13	103(a)	Iwata, Bower, Koyama	13	
13	103(a)	Iwata, Bower, Tracy, Koyama	13	
14, 15	103(a)	Iwata, Bower, Koyama, Ahmed	14, 15	
14, 15	103(a)	Iwata, Bower, Tracy, Koyama, Ahmed	14, 15	
14, 15	103(a)	Iwata, Bower, Mori '630, Koyama, Ahmed	14, 15	
14, 15	103(a)	Iwata, Bower, Tracy, Mori '630, Koyama, Ahmed	14, 15	
16	103(a)	Iwata, Bower, Ahmed	16	
17	103(a)	Iwata, Bower, Phadke	17	
Overall Outcome			1–17	

⁹ For the reasons discussed above, we do not reach these challenges. See *supra* § II.M.

IV. ORDER

It is

ORDERED that claims 1–17 of U.S. Patent No. 10,784,710 B2 have been shown, by a preponderance of the evidence, to be unpatentable; and

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

IPR2022-00013
Patent 10,784,710 B2

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