

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE PATENT TRIAL AND APPEAL BOARD

ALTENERGY POWER SYSTEM USA, INC.,
Petitioner

v.

CYBOENERGY, INC.
Patent Owner

Case IPR2024-00360

U.S. Patent No. 8,786,133

DECLARATION OF MLADEN KEZUNOVIC

TABLE OF CONTENTS

	Page
I. INTRODUCTION	1
II. QUALIFICATIONS.....	1
III. SUMMARY OF OPINIONS.....	3
IV. DOCUMENTS AND THINGS REVIEWED.....	5
V. MY UNDERSTANDING OF THE LEGAL PRINCIPLES.....	5
A. Anticipation under 35 U.S.C. § 102.....	5
B. Obviousness under 35 U.S.C. § 103(a).....	6
C. Obviousness of a combination of prior art elements	8
VI. PERSON OF ORDINARY SKILL IN THE ART	9
VII. THE '133 PATENT.....	11
VIII. SCOPE AND CONTENT OF THE PRIOR ART	20
IX. CLAIM CONSTRUCTION	41
X. OPINIONS AND OBSERVATIONS REGARDING THE FILE HISTORY.....	42
XI. INVALIDITY OPINIONS	52
A. Ground 1: Kondo and Nishi.....	52
B. Ground 2: Kondo and Fornage	73
C. Ground 3: Fornage and Kondo	81
D. Additional Opinions Regarding Nishi and Kondo.....	98
E. Opinions Regarding Claims 17 and 21.....	98
F. Secondary Considerations of Nonobviousness.....	102

I, Dr. Mladen Kezunovic, do hereby declare as follows:

I. INTRODUCTION

[0001] I, Dr. Mladen Kezunovic, a citizen of the United States of America, have been retained by Quarles & Brady LLP, counsel for Petitioner Altenergy Power System USA, Inc. (“APsystem”) to provide expert testimony in the *inter partes* review of United States Patent No. 8,786,133 to Cheng et al. (hereinafter “the ’133 Patent”).

II. QUALIFICATIONS

[0002] My qualifications are discussed in this section of this report, and my CV is attached as Appendix 1.

[0003] I graduated from the University of Sarajevo, Sarajevo, Bosnia, in 1974 with a Bachelor of Science degree in Electrical Engineering.

[0004] I received my Master of Science in Electrical Engineering from the University of Kansas in 1977, and was awarded my Ph.D. in Electrical Engineering, also from the University of Kansas, in 1980.

[0005] I currently serve in a variety of academic and professional roles. In the academic realm, I have worked at Texas A&M University (“TAMU”) since 1992 when I became the director of TAMU’s Power Systems Control and Protection Laboratory. I became a tenured professor at TAMU in 1996, and currently teach there. From 2012 until 2019 I also served as director of TAMU’s Smart Grid Center.

From 1997 until 2006 I served as the director of TAMU's Electric Power and Power Electronics Institute.

[0006] In the professional realm, I have been a site director for the Power Systems Engineering Research Center, originally a part of the National Science Foundation I/UCRC, since 2000.

[0007] I am the President, CEO, and Principal consultant of Test Laboratories International, Inc., d.b.a. XpertPower Associates, a company I started in 1992.

[0008] I have been a registered professional engineer in the state of Texas under the Texas Board of Professional Engineers since 1993. My license number is 76824.

[0009] Prior to my current professional employments, I was an engineer and project leader at Energoinvest Company from 1980 until 1987, and prior to that role I was a systems engineer in the Industry Systems division of Westinghouse Electric Corporation from 1979 until 1980.

[0010] I am an active member of The Institute of Electrical and Electronic Engineers (IEEE) since 1980 and have held a variety of roles in IEEE since 1990.

[0011] A list of my publications is attached as Appendix 2. I have not testified or been deposed in any litigation matter within the last four years.

[0012] Based on the above qualifications I am considered an expert in the field of power system protection and control, interfacing of renewables (including solar panels and other solar sources) to power sources and data analytics for fault analysis

and power system operation. The subject matter of the '133 patent is squarely within my expertise.

[0013] I have been retained by Petitioner's counsel to determine whether the claims of the '133 Patent are valid, and I am being paid \$395.00 per hour to review the patent at issue, various prior art references, and to provide the opinions set forth in this declaration. I have no connection with CyboEnergy, Inc. and do not have a stake, financial or otherwise, in whether the claims of the '133 Patent are affirmed or canceled.

[0014] I have read and am familiar with the '133 Patent, its prosecution history and the prior art references as detailed in the petition.

III. SUMMARY OF OPINIONS

[0015] I was asked to analyze whether claims 15-24 of the '133 Patent are anticipated by or obvious in view of the prior art and to provide my opinions on that analysis. As a result, I reviewed the references that are quoted in the text below. and listed in Appendix 3.

[0016] My opinions and bases for the claims being obvious are included in this report, including exhibits that summarize and support them. Broadly stated, it is my opinion that claims 15-24 of the '133 patent recite obvious combinations of prior art elements of DC to AC inverters, particularly the sort of inverters that are used in solar power installations. Independent claims 15 and 19 are directed to inverters that

are connected in a “daisy chain” through AC inputs and outputs, and that also have more than one DC input. Inverters with more than one DC input were disclosed in the prior art before the relevant date of the ’133 patent. This idea is shown in U.S. Patent Publication No. 2005/0105224 (“Nishi”) and U.S. Patent Application No. 2009/0020151 (“Fornage”). The idea of connecting more than one inverter in a “daisy chain” was also in the prior art. This idea was shown in U.S. Patent Application No. 2002/0038667 (“Kondo”). In my opinion, it would have been obvious to combine Kondo’s daisy chained inverters with Fornage or Nishi’s disclosure of multi-input, shared inverters. A person of ordinary skill would be motivated to do this to enhance the scalability of Kondo’s system, while reducing component count and cost while creating a system that could perform maximum power point tracking on connected sources individually. This modification to Kondo would result in a more scalable, cost effective, reliable and efficient system by reducing the number of required components for cost reduction and increase in efficiency but not jeopardizing reliability. It would also have been obvious to start with Fornage’s (or Nishi’s) multi-input inverter architecture and add the ability to add additional inverters by incorporating Kondo’s daisy-chain connection arrangement. A person of ordinary skill would do this because daisy chaining the inverters is a simple and easy way to increase the scale of the system, and also gives each inverter the capability to detect and mitigate overcurrent on the combined AC

connection, as taught in Kondo. The claims that depend on claims 15 and 24 recite typical elements of inverter systems and are also obvious.

IV. DOCUMENTS AND THINGS REVIEWED

[0017] In forming my opinions, I relied upon my education and experience in the relevant field, and I considered the viewpoint of a person having ordinary skill in the relevant art, as of July 16, 2009 (the earliest priority date listed on the '133 Patent).

[0018] A list of all documents considered by me in forming my opinions is attached as Appendix 3.

V. MY UNDERSTANDING OF THE LEGAL PRINCIPLES

[0019] I am not an attorney and do not expect to offer any opinions at trial or depositions regarding the law. I have, however, been informed of certain legal principles that I relied upon and used as a framework in reaching the opinions set forth in this report. These are summarized below.

A. Anticipation under 35 U.S.C. § 102

[0020] I understand that invalidity by anticipation requires that the four corners of a single, prior art document describe every element of the claimed invention. Further, I understand that, for an alleged prior art reference to anticipate a patent claim, the reference must disclose, within the reference itself, all of the limitations of the claim arranged or combined in the same way as recited in the claim.

[0021] I also understand that, for an alleged prior art reference to anticipate a patent claim, the reference must enable a person of ordinary skill in the art to make and use the claimed invention.

[0022] I understand that a claim limitation may be present in an alleged prior art reference either expressly or inherently, but inherency may be established only if such limitation is necessarily present in the reference. I understand inherency cannot be established by probabilities or possibilities, and the mere fact that a certain thing may result from a given set of circumstances is not sufficient to establish inherency.

B. Obviousness under 35 U.S.C. § 103(a)

[0023] I am informed that a patent claim is invalid as obvious if, at the time the claimed invention was made, the differences between the prior art and the claimed invention as a whole would have been obvious to a person of ordinary skill in the art. I am informed that the following factors are considered in determining whether a claimed invention is invalid as obvious over the prior art: (1) the scope and content of the prior art (i.e., the devices, technology, knowledge and practices that pre-existed the invention), (2) the level of ordinary skill in the art, (3) the differences between the claimed invention and the prior art, and (4) any real-world facts, sometimes referred to as “secondary considerations” or “objective indicia,” that indicate the invention was obvious or not obvious, for example:

- commercial success of the invention, causally related to the invention itself rather than to companion factors, such as advertising or attractive packaging;
- copying of the invention by competitors as distinguished from their independent development;
- the invention's satisfaction of a long-felt but hitherto unsatisfied need, despite the availability of the elements of the invention;
- acquiescence by the industry to the patent's validity by honoring the patent through taking licenses;
- failed attempts by those skilled in the art to make the invention or achieve the objectives of the invention;
- praise for the invention, such as recognition of the invention as an advancement over the prior art by technically competent peers; and
- any other real-world facts that indicate the invention was obvious or not obvious.

[0024] At this point in the dispute between the parties, I understand that counsel has not received any evidence of secondary considerations from the Patent Owner.

I reserve the right to supplement my opinion if the Patent Owner provides evidence of secondary considerations.

C. Obviousness of a combination of prior art elements.

[0025] I am informed that, in determining whether a combination of prior art elements renders a patent claim obvious, the proper inquiry is whether the combination would have been obvious to a person of ordinary skill in the art who was familiar with the prior art in the field and analogous prior art from other fields. I am informed that a claim composed of several elements is not proved obvious just by demonstrating that each element existed somewhere in the prior art. I understand that there must be a reason why one of ordinary skills would have combined elements from different prior art references, or something else that would have prompted such a person to consider combining prior art elements. I understand that any need, design consideration or problem known in the field at the time of the alleged invention could provide a reason or motive to combine prior art elements in the claimed manner. I understand that the reason to combine an element from the prior art may derive from the fact that it is well known or commonly used in the art. I also understand that the reason to combine references may come from the background knowledge possessed by a person having ordinary skill in the art. I understand that a person of ordinary skill is also a person of ordinary creativity, and

that the common sense of one skilled in the art may also provide a reason or motive to combine prior art elements to arrive at the claimed matter.

[0026] I am informed that combining known elements according to known methods is likely to be obvious when it does nothing more than yield predictable results. That is, when a claimed invention is simply an arrangement of prior art elements in which each element performs the function it was known to perform and provides the benefits that it provided in prior art devices, the claimed combination is obvious. I am also informed that choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success, is also likely to be obvious.

VI. PERSON OF ORDINARY SKILL IN THE ART

[0027] In my opinion, a person of ordinary skill in the art (“POSITA”) of the technology of the ’133 Patent is a person having a bachelor’s degree in electrical engineering and five years of experience designing grid connected photovoltaic systems. The technology described in the ’133 Patent is not complex, and the ’133 Patent itself does not provide much detailed description of the circuitry disclosed therein. Indeed, the system of the claims described in independent claims 15 and 24 is depicted as an arrangement of literal “black boxes” in, for example, FIG. 5, which shows a number of “Power Inverter[s]” designated by numeral 90, that are daisy chained together in parallel and have more than one DC input. The “Power

Inverter[s]” themselves are depicted, for example, in FIG. 9, schematically, as a collection black box components (DC-DC Boost Converter, 183; DC-AC Inverter, 186, etc.). See, ’133 patent, 6:44-46 (“FIG. 9 is a block diagram illustrating a smart dual-input power inverter that inverts the DC power from two DC sources to single-phase AC power.”) and generally 6:46-7:17 (describing the components of FIG. 9). These components are described in the body of the ’133 patent in terms of their functionality, rather than their circuit structure. For example, in describing the “DC-AC Inverter 186”, the ’133 patent says “The total combined DC power is inverted to AC power with voltage larger than 240V AC by the DC-AC inverter 168.” 6:56-58. I note that the ’133 patent does not include any actual board-level circuit diagrams, which would include components like Application-specific Integrated Circuit (ASICs), transformers, capacitors, sensors and the like. Given the conceptual, high-level at which the devices of the ’133 patent are described, I have concluded that level of skill in the art of the ’133 Patent is not particularly high.

[0028] This definition is based on my understanding of the sorts of problems encountered in the art, prior art solutions to those problems, including solutions present in the prior art, the pace of innovation in the art area, the sophistication of the technology, and education level of workers who are active in the field. Based on my education and my experience, I have at least the level of ordinary skill in the art, and I had at least the level of ordinary skill in 2009, at the time of the filing of the

application that matured into the '133 patent. I understand that, although I may be considered a person of greater than ordinary skill in the art, I will render my analysis from the perspective of one of ordinary skill in the art. If the level of ordinary skill in the art of the '133 patent is greater than the level I have identified, my ultimate opinion on the obviousness of claims 15-24 would not change. Indeed, those claims would be more clearly obvious to a person of higher skill than they are to a person of the level I have identified.

VII. THE '133 PATENT

[0029] The '133 Patent relates to inverters for DC sources, such as photovoltaic (PV) solar panels. The '133 patent says, “The subject of this patent relates to direct current (DC) to alternating current (AC) power inverters that invert DC power from single or multiple DC power sources to single-phase or three-phase AC power, where the DC power source includes but is not limited to photovoltaic (PV) solar modules, fuel cells, batteries, and other DC power generators.” 1:7-13.

[0030] An inverter is an electronic device that changes a direct current (DC) electrical signal into an alternating current (AC) electrical signal. In a DC circuit, the current moves in one direction along a conductor (e.g., a wire). In an AC system, the polarity of the power alternates over a period of the sinusoidal voltage and current signal. If one were to measure the magnitude of power flow at a point along a wire carrying an AC signal, the measurement would typically take the form of a

sine wave, where the magnitude of the current flow increases first from zero to some maximum in a positive direction, drops back to zero, and then increases next to some maximum in the negative direction. The voltage of an AC signal is also generally a sine wave, out of phase with the current waveform.

[0031] AC electrical signals are typically used to transmit electrical power (i.e., the product of voltage and current) over long distances. This is because AC electrical power experiences less losses on long distance electrical transmission lines that operate at high voltage and relatively low current when transferring the same power. The electrical power supplied by one's local electric utility through the "grid" (i.e., the network of electrical power transmission lines and distribution feeders that bring power to an electric utility's customers) is AC. Long distance electrical power transmission occurs at high AC voltages which are reduced by a series of transformers by the time the power reaches a utility customer. By the time this power reaches a residential customer in the United States, for example, the electrical power supplied by the utility is 110V-240V AC depending on the type of connection (single phase vs three phase, and whether three phase has three or four circuits). Because of this, the electrical appliances and other electrical loads in an American home are designed to accept 110V-240V AC power. A typical plug voltage in a single-phase circuit connection is 110V AC, and it is available at the wall sockets in American households.

[0032] A photovoltaic solar module (“PV module”) (also called a solar cell, photovoltaic module, or solar module) is a device that converts solar radiation (i.e., light) into electrical energy. PV modules are sometimes provided in assemblies called “solar panels”, which themselves might be referred to as “modules”. As the ’133 patent says, PV module interfaces are DC sources – they generate DC electrical power having an electrical signal that has unidirectional current flow. In order for this power to be usable by, for example, household appliances, it must be converted into AC power, ideally, AC power with about the same voltage that household appliances are designed to use (for example 110V AC). An inverter is a device that performs this function – it takes a DC signal and transforms it into an AC signal.

[0033] The claims of the ’133 patent that I have been asked to consider describe a particular sort of arrangement of inverters for DC sources. Claim 15, for example, recites a “plurality of power inverters” each with “single DC-AC inverter” with “at least two DC power input ports”. Each inverter has “an AC power input port” and “an AC power output port”. Claim 15 says “said AC power output port of each power inverter being connected in a daisy chain to the AC power input port of the next power inverter, except for the AC power input port of the first power inverter being left open”. Claim 15 also recites DC power sources with output ports connected to the inverters, and the AC output port of the last power inverter being connected a “power service panel” of the power grid. Claim 19, which is a method

claim, involves connecting inverter in a daisy chain of the sort contemplated in claim 15. FIG. 5 of the '133 patent shows the inverter architecture contemplated by claims 15 and 19.

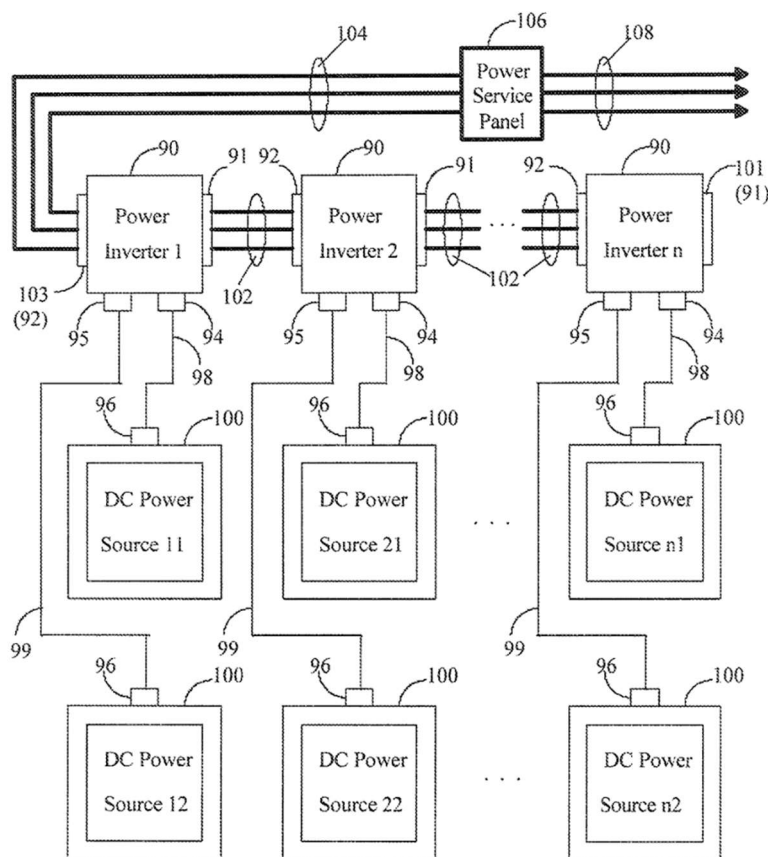


Fig. 5

[0034] The language of claims 15 and 19 is shown in the chart below. Some of the sub-elements of the method claim, claim 19, have been moved around to match up with corresponding elements from claim 15, which is the apparatus claim. Also, there are dependent claims below claim 19 that correspond to sub-elements of claim 15, but I will address these in the specific Grounds, below.

15p1: A scalable DC to AC power inversion system for providing AC power to a power grid	19p: A method of making a DC to AC power conversion system incrementally scalable, comprising:
15p2: from a plurality of individual DC power sources each having a DC power output port, comprising:	19a1: a) providing a plurality of DC power sources
15a1: a) a plurality of power inverters, each of said power inverters including a single DC-AC inverter,	19a2: and a plurality of DC to AC power inverters, said DC to AC power inverters each having a single DC-AC inverter,
15a2: at least two DC power input ports coupled to the single DC-AC inverter,	19a4: and at least two DC input ports coupled to the single DC-AC inverter;
15a3: an AC power input port, and an AC power output port coupled to the single DC-AC inverter,	19a3: an AC input port coupled to the single DC-AC inverter, an AC output port coupled to the single DC-AC inverter,
15a4: each of said DC power input ports having one DC power source connected thereto;	19b1: b) connecting at least one of said DC power sources, respectively, to each of said DC input ports; and

15b1: b) said AC power output port of each power inverter being connected in a daisy-chain to the AC power input port of the next power inverter,	
15b2: except for the AC power input port of the first power inverter being left open,	
15b3: and the AC power output port of the last power inverter being connected to a power service panel of the power grid;	19c: c) providing AC power to the power grid.
15c: c) whereby said system is incrementally scalable by adding or subtracting DC power sources and daisy-chained inverters.	

[0035] An important aspect of solar inverters that is particularly relevant to my opinions is “maximum power point tracking” or “MPPT”. One of the fundamental laws of electrical engineering is “Ohm’s Law”, which sets forth the relationship between voltage, current and resistance. Ohm’s law provides that $V = IR$, where V

is voltage (electrical potential), I is current (the flow of electrical charge), and R is resistance. The behavior of electricity, particularly in the DC domain, is often analogized to the behavior of water. Voltage, or potential, represents potential electric energy. It is a measure of the pushing force that causes charge to flow in a wire. By analogy, voltage is like the height of water stored in an elevated water tank, or the downward slope of a water pipe or a river. Current, or the rate of flow, is the measure of the amount of charge moving in a conductor, like the amount of water flowing in a river, or over a waterfall. Resistance refers to the forces that tend to resist the flow of electricity, like rocks in a river, or a water pipe being constricted. Ohm's law provides that when there is more resistance, more force (or voltage) will be required to push the same amount of current. Electrical power, the rate of electrical energy transferred per unit time, is the product of voltage and current.

[0036] The voltage and current output from a PV module can be plotted on an I-V curve for a given load (i.e., a given resistance). An example set of I-V curves for a PV modular under various illumination conditions, taken from another one of Patent Owner's Patents¹, is reproduced below this paragraph.

¹ U.S. Patent No. 9,331,489

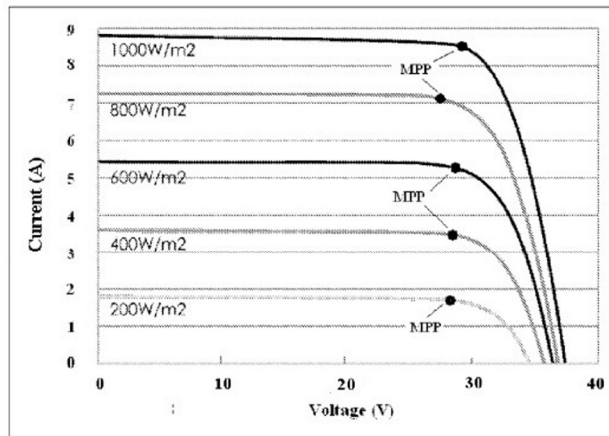


Fig. 1 (Prior Art)

[0037] There are several things to notice about this set of I-V curves. First, the point at which maximum power (the product of voltage and current) can be extracted from a PV module will occur around the “elbow” of the I-V curve, before the current begins dropping precipitously. This point is marked “MPP” for “maximum power point” on the curves. Second, the location of this maximum power point changes with the illumination on the panel. The illumination of the panels in the figures above is reflected by the irradiance values on the left (e.g., 1000W/m²). As the illumination, or the amount of light on the panel, falls, the maximum power point moves in terms of both current and voltage. The MPP of a PV module will also change with its temperature and with the age of the panel, and for a given set of environmental conditions, different panels will have different MPPs just because of differences in manufacturing conditions for the panels.

[0038] In order to extract maximum power from a PV module, that module should “see” an electrical load or impedance that is equal to the panel’s own internal resistance at the MPP, which is V/I at the MPP. This is equivalent to presenting a “bias voltage” to the output terminals of a PV module that is equal to the output voltage of the module at the MPP point. Prior art U.S. Patent Publication No. US2009/0000654 (“Rotzoll ’654”) discusses this ideal load or bias voltage when it says “The MPPT process evaluates the PV module string output current-voltage curve on a continuous or sampled basis to determine the correct load voltage thus maximizing the string output power calculated as the string output voltage times current.” [0008]. Similarly, U.S. Patent Publication No. 2009/0020151 (“Fornage”) says “The cell should be biased at the Maximum Power Point (MPP) in order to extract the maximum power”. [0007]. Therefore, solar inverters will often have bias voltage or impedance matching circuit, that presents the ideal bias voltage to the PV module on the circuit’s input, while providing a different DC output voltage on the output to drive the circuit that converts DC to AC. This impedance matching function is generally provided by a DC-DC converter. The use of a DC-DC converter to do MPPT tracking is suggested by the ’133 patent when it says “The MFA microcontroller performs real-time control and optimization functions for the smart and scalable power inverter, in which Model-Free Adaptive (MFA) controllers are used to control the DC-DC boost converter, and MFA optimizers provide

maximum power point tracking (MPPT) to allow the power inverter to achieve optimal power production.” 5:57-63.

VIII. SCOPE AND CONTENT OF THE PRIOR ART

[0039] The system and method disclosed in claims 15-24 of the '133 Patent were obvious in view of the state of the art on July 16, 2009. As I stated above, the challenged claims are a combination of two well-known inverter architectures: shared inverters, and inverters connected in parallel in a “daisy chain”.

[0040] The 2005 IEEE paper by Kjaer, Pederson and Blaabjerg, *A Review of Single-Phase Grid-Connected Inverters for Photovoltaic Modules*, (2005) (“Kjaer”) does a good job of laying out various solar inverter topologies that were known prior to 2009. FIG. 3 of Kjaer is reproduced below. As Kjaer makes clear, early on, a solar power installation had a single central inverter, shown in a). PV modules (i.e., solar panels) were connected in series, and also in parallel, and their combined DC output was fed to a single inverter, shown by the box labeled DC/AC. Later, string inverters were developed, shown in b), where a series-connected string of PV panels is connected to an inverter. Later, “multi-string technology” emerged, shown in c). In a multi-string topology, multiple strings of panels are each connected to their own DC/DC converter, and the outputs of those DC/DC converters are provided to a single DC/AC inverter, which would have multiple (in this case 2) DC inputs. The shared inverter can produce 1 or 3 phase AC power, as indicated in the figure below.

Later, as shown in d), “AC-Modules” were developed, where each connected solar panel had its own inverter.

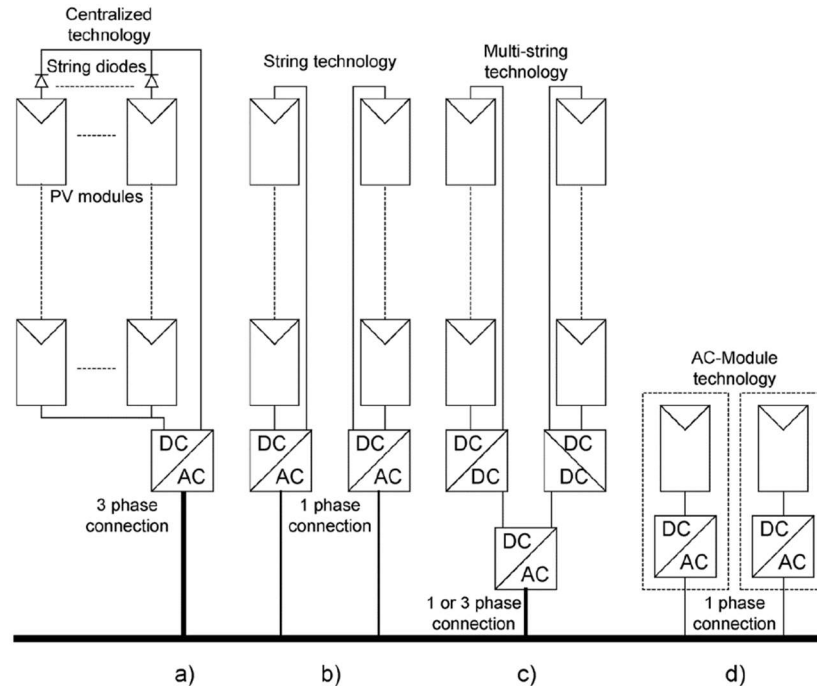


Fig. 3. Historical overview of PV inverters. (a) Past centralized technology. (b) Present string technology. (c) Present and future multi-string technology. (d) Present and future ac-module and ac cell technologies.

[0041] Kjaer recognizes two important advantages of a multi-string topology where the inverter can accept input from multiple DC sources: individual control and scalability/flexibility. The paper says:

The multi-string inverter depicted in Fig. 3(c) is the further development of the string inverter, where several strings are interfaced with their own dc–dc converter to a common dc–ac inverter [7], [28]. This is beneficial, compared with the centralized system, since every string can be controlled individually. Thus, the operator may start his/her own PV power plant with a few modules. Further enlargements are easily achieved since a new

string with dc–dc converter can be plugged into the existing platform. A flexible design with high efficiency is hereby achieved.

Kjaer, pg. 1296. Here, Kjaer is saying that with a multi-string inverter, with more than one DC input, the user can start out with one string of panels in the installation, and plug in additional strings later, as needed, in order to expand power production capacity. Efficiency is maintained because this can be done up to a point, without having to incur the expense of another inverter. Also, when Kjaer refers to individual control, it is referencing the ability to bias each string differently so that each string is run at its Maximum Power Point, which increases overall efficiency. This is made possible by providing a DC/DC converter for each connected panel or string. The ability to do MPPT on each string individually is advantageous because each string may be of a different size, different type, experience its own unique irradiation conditions (e.g., due to shading, inclination angle, dirt or the like), and therefore, the optimum bias voltage for each string will be different. By controlling each connected string of panels at the string's optimum power point, overall power production can be maximized, which would not be the case if all strings were connected to the same inverter without the ability to individually control each string. In that sort of arrangement, all strings would be driven at something like an average power point, which would be suboptimal regarding system efficiency. Rotzoll '654 discusses the efficiency disadvantage of trying to control all panels on a house roof at the same bias point, since each panel experiences different illumination conditions. Rotzoll '654, [0008] ("Due to the nature of residential rooftops, the

string design results in MPPT performance at the levels of the least power producing modules in the photovoltaic (PV) array. This degrades the AC power harvest for the entire array.”)

[0042] I would also note here that there is another reason why the person of ordinary skill would be motivated to choose a multi-input (i.e., a multi-string) inverter. Such a configuration reduces overall component cost as compared to, for example, an AC module configuration of the sort shown in FIG. 3(d), above. In an AC module, there is one inverter per string. In a multi-string inverter, there is more than one string per inverter, so in this topology, the number of inverters is reduced because an inverter is being shared between more than one string. Kjaer notes that the cost of the inverter was a significant consideration to operators of PV generating facilities near the time of the invention, noting “The cost of the grid-connected inverter is, therefore, becoming more visible in the total system price. A cost reduction per inverter watt is, therefore, important to make PV-generated power more attractive [4].” Kjaer, pg. 1292. Rotzoll ’118 makes this same point – that the cost of the inverter is something to be considered when designing a system: “...there can be up to 1000 components in an inverter resulting in significant cost per unit energy.” Rotzoll ’118, [0006]. The multi-string inverter topology, then, saves costs as compared to having one inverter per string, while at the same time, preserving the ability to do MPPT on each string individually. It is, in effect, a happy medium

between AC modules, each of which have their own inverter (which is expensive) and centralized inverters (which are inexpensive but jeopardize system reliability as a single point of failure and do not have the ability to do MPPT on each connected panel for improved efficiency).

[0043] For these reasons, it is my opinion that the person of ordinary skill would have been motivated to incorporate multi-input inverters, of the sort shown in Kjaer, Nishi and Fornage, into other daisy chained inverter systems, such as the one shown in Kondo. I discuss these systems below.

Fornage

[0044] Shared inverters, and their advantages, were also recognized by other prior art references that I analyze in this report. Fornage, for example, in FIG. 5, shows an inverter 300, with multiple DC inputs, each of which has its own DC Boost converter (508n), the outputs of which are tied together and provided to a DC/AC inverter 510. Fornage's DC inputs are connected to DC sources, i.e., solar panels 102, shown in FIG. 3. I have included FIG. 5 figure below.

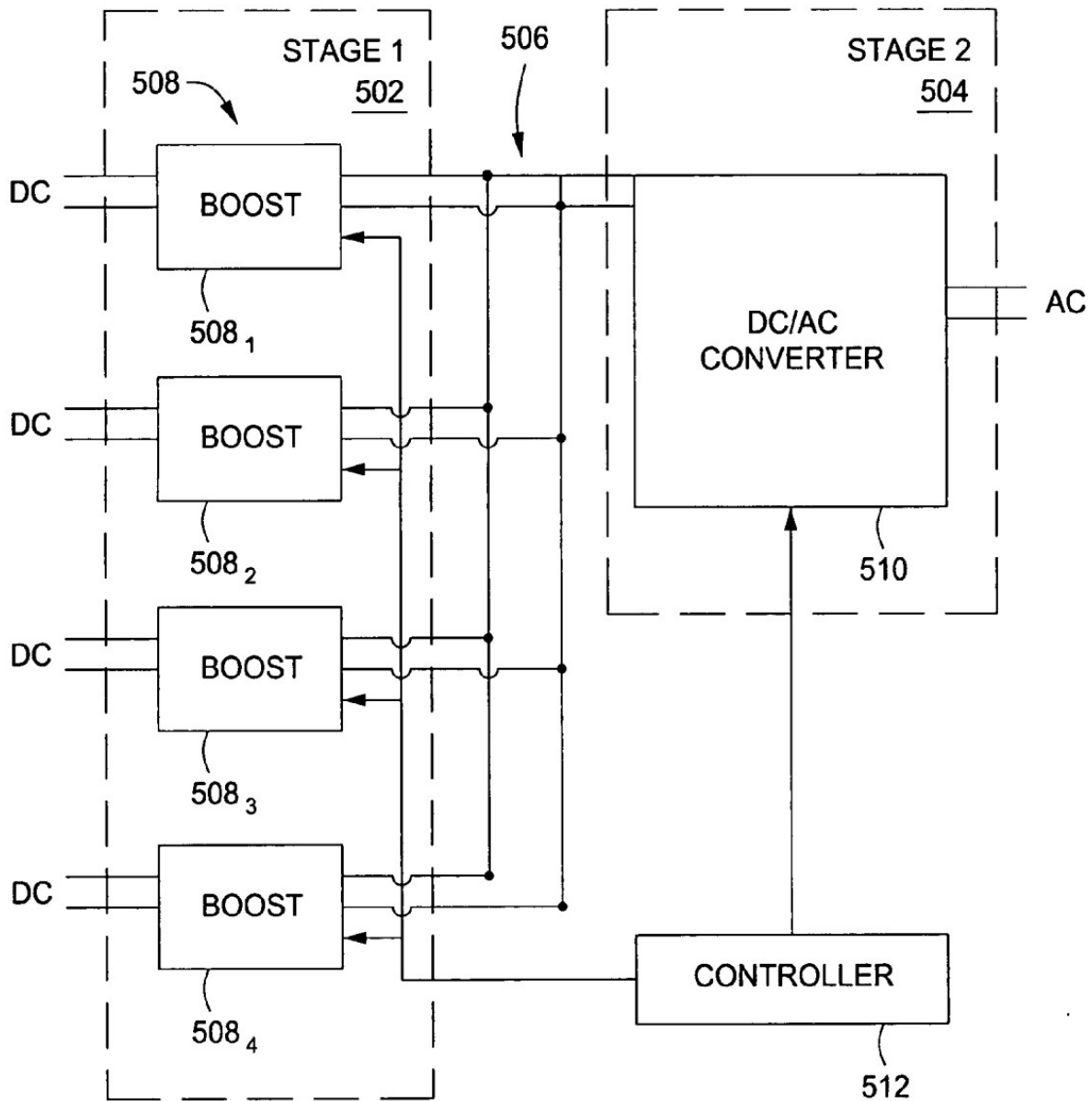


FIG. 5

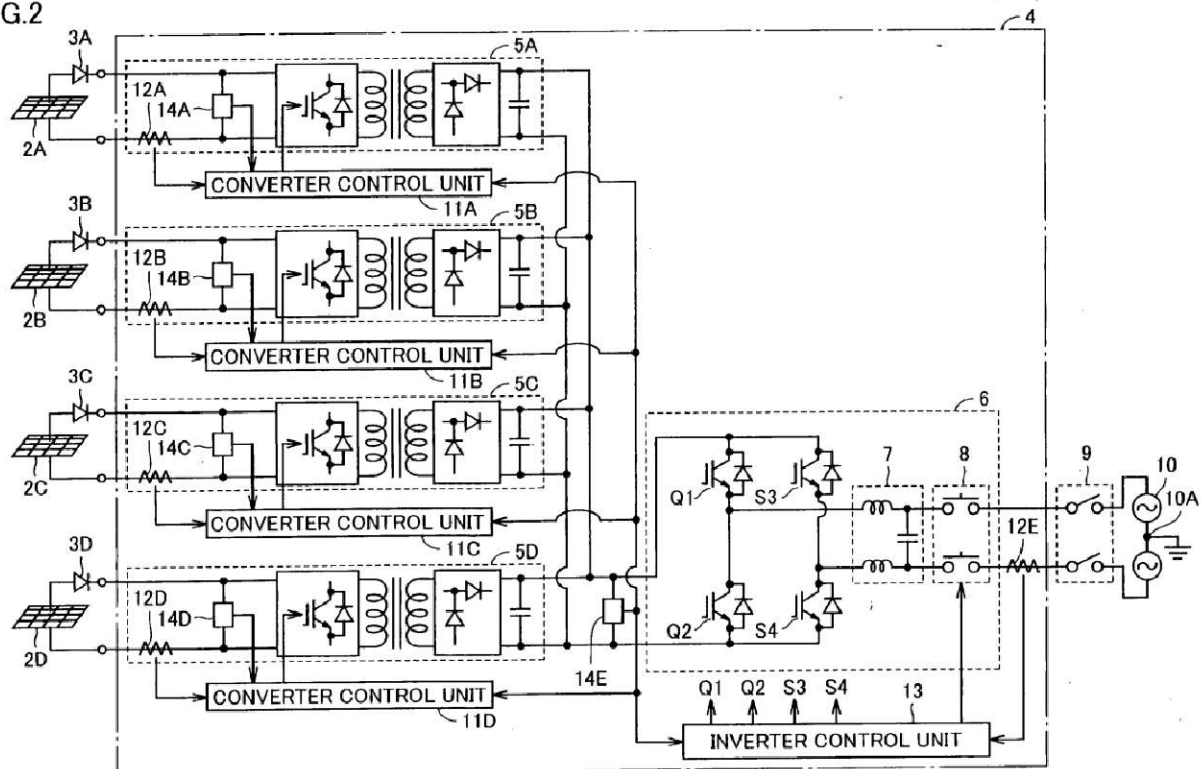
[0045] Fornage recognized the advantages of having a single inverter with multiple DC inputs, in that such an arrangement enables each connected solar panel

(or segments of a panel, like rows of individual solar cells) to be biased individually at its maximum power point. That application says “A controller 512 provides an individual control signal to each boost circuit 508 to ensure that the rows of cells coupled thereto operates at the row’s MPP. The boost circuits 508 are coupled by a DC bus 506...The bus 506 couples the combined DC outputs of the boost circuits, 508 to the DCAC converter switching to convert DC to AC”. [0033].

Nishi

[0046] U.S. Patent Publication No. 2005/0105224 (“Nishi”) also recognizes this same advantage of a multi-string inverter. That application shows in FIG. 2 an inverter 4 with multiple DC inputs from solar panels 2A-2D. The DC inputs are supplied to respective DC-DC converters 5A-5C, the outputs of which are tied together in a common DC bus. The DC bus is connected to a DC-AC inverter 6, which is then connected to the utility grid 10. I have included FIG. 2 from Nishi below.

FIG.2



[0047] Like Fornage, Nishi recognizes that one advantage to providing separate DC inputs on a shared inverter is the ability to run each connected solar power individually to maximize power production. Nishi says, “Here, converter control units 11A-11D each calculate an output power of respective solar cell arrays 2A-2D based on corresponding input voltage detection value and input current detection value, and control respective converters 5A-5D so that the output power of respective solar cell arrays 2A-2D becomes maximum.” [0077]

[0048] The ability to extract maximum power from each connected panel (or panel segment) is especially useful when those panels are differently sized or experiencing

different irradiation conditions, such as when they are installed on different-facing roof sections of a home, as is shown in Nishi's FIG. 1. Nishi notes that a large, south facing roof panel might have a higher output voltage than smaller east and west facing panels. [0028]. Nishi also says "it is desirable that the inverter apparatus receiving a DC power from each of a plurality of DC power sources can address a plurality of DC power sources with different output voltage ranges in order to perform efficient power generation." [0029].

[0049] Nishi points out another advantage to having a multi-input inverter system. Such a system can combine DC power generated by different sorts of DC sources, not just photovoltaic modules. Nishi calls these "hybrid systems", and the application illustrates one in FIG. 6, where the inverter 6 takes DC power from a fuel cell 16, as well as connected solar panels 2A-2D. [0110] A fuel cell is a device that converts energy from a chemical reaction (e.g., oxidizing hydrogen) into DC electricity. Nishi teaches that providing an inverter system with multiple inputs is advantageous because these sorts of sources can be incorporated alongside solar panels while sharing the same inverter: "a dispersed power-source system of a hybrid type can easily be structured with low costs and without reduction of efficiency." [0115]

[0050] So, the prior art recognized that solar inverters could be provided that had multiple DC inputs to accept DC power from more than one attached photovoltaic

module. The prior art also recognized that such arrangements were advantageous because they are easily scalable by adding more solar panels, they enable MPPT tracking on individual panels that might be experiencing different irradiation conditions while using the same inverter, and they allow for the easy incorporation of other sorts of DC sources for home or commercial power generation.

Kondo

[0051] The other portion of the alleged invention of claims 15 and 19, inverters connected together in a “daisy chain” through AC input and output ports, was also known in the art. U.S. Patent Publication No. 2002/0038667 (“Kondo”) discloses these sorts of inverters. That patent application shows several solar inverters that are daisy chained together through AC input and output ports, that is to say, that each inverter has an AC input port to accept AC power generated by an upstream connected inverter, and an AC output port to output the combined input power and power generated by the inverter. FIGs. 1 and 2 showing this arrangement are below.

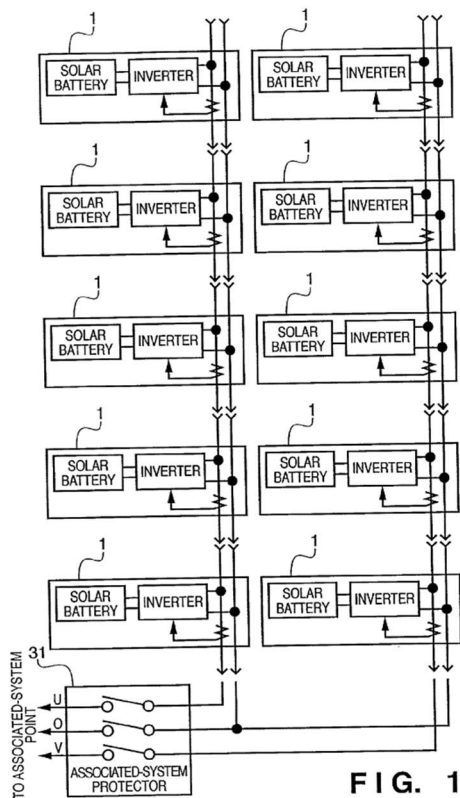


FIG. 1

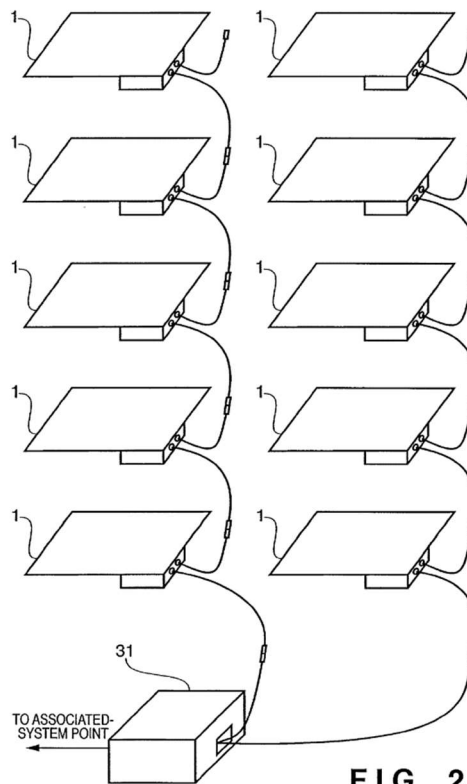
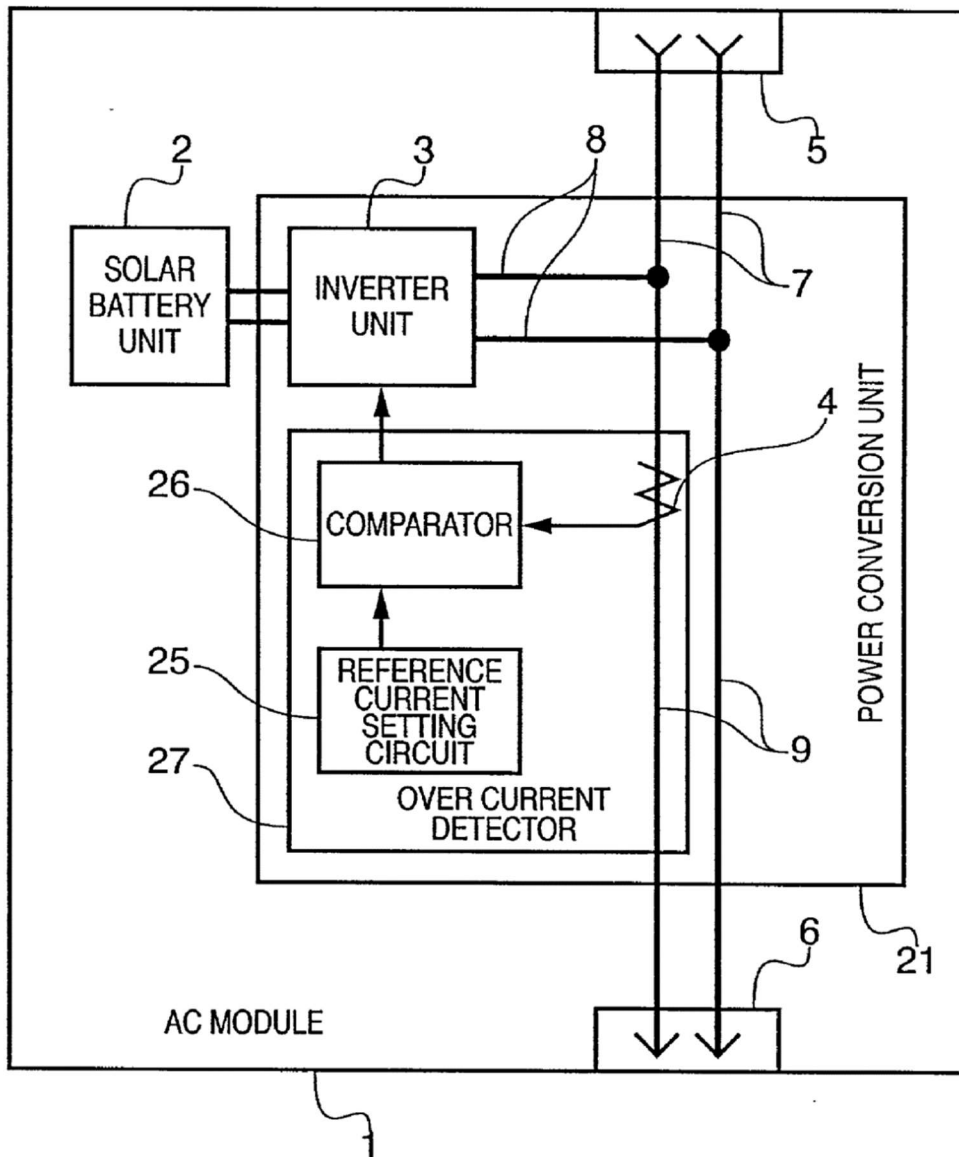


FIG. 2

[0052] The AC input and output ports from Kondo can be more clearly seen in FIG. 3 (below), which is a detailed view of an “AC module” 1, shown in FIGs. 1 and 2 above. Kondo’s AC module includes a “solar battery” (i.e., a PV module or solar cell, which Kondo also calls a “photoelectronic transducer” – [0031]) and an inverter, as shown. In FIG. 3, Kondo shows that each of its AC modules has a power inverter (“Power Conversion Unit” 21, described at [0033], which includes a DC-AC inverter (“Inverter Unit” 3 in FIG. 3, shown in detail in FIG. 5, and described at [0035]-[0040]), an AC power input port 5 and an AC power output port 6. Kondo describes the function of these ports as follows: “The converted AC power is collected together with AC power, which is inputted from an input connector 5, and

then outputted to an output connector 6.” This means that Kondo’s inverters (FIG. 3, 21) are receiving AC power generated by upstream modules at their AC input port 5, adding their own AC power, and then presenting the combined AC power on the output port 6 for passing to inverters farther down the line, as shown in FIGs. 1 and 2. Kondo confirms this when it says “The DC power generated by the solar battery unit 2 is converted to AC power by the inverter unit 3, sent through the current path 8, collected together with the power, which is generated by other AC modules 1, and inputted from the input connector 5, then sent through the current path 9, and outputted to the output connector 6.” [0051].

FIG. 3



[0053] Kondo also discloses other elements of claims 15 and 19. For example, in the daisy chain arrangement shown in FIGs. 1-2, Kondo recognizes that the first

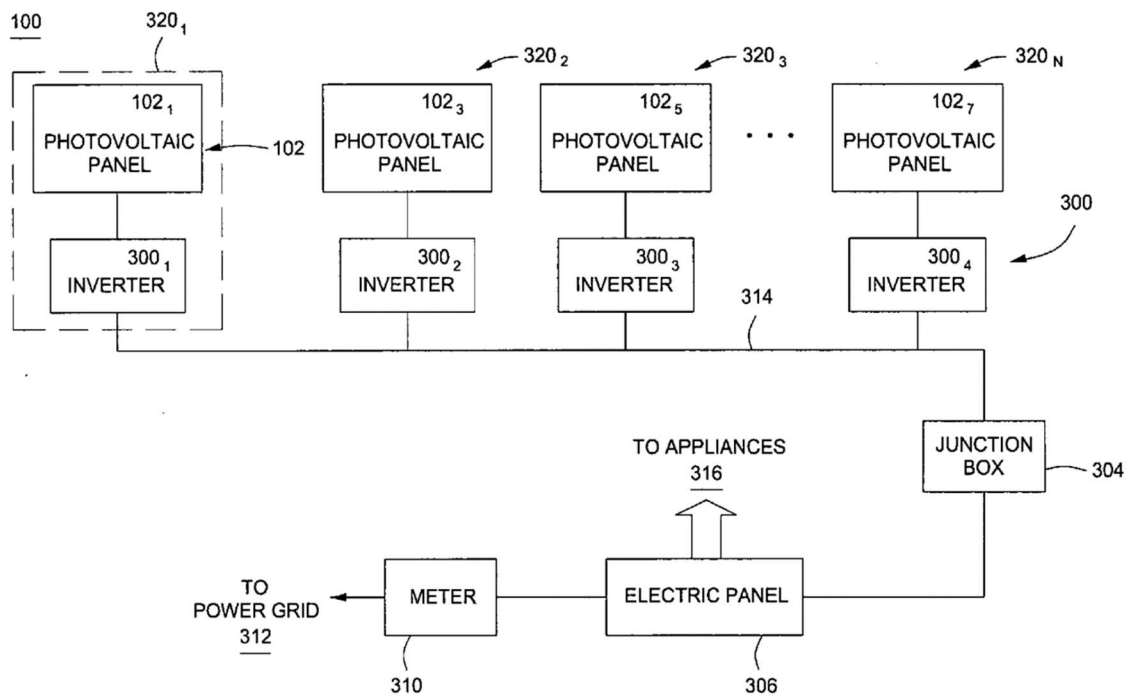
inverter in the chain would have nothing connected to its AC power input port, which would remain open. Kondo says “As shown in FIG. 1, the input connector 5 of the AC module 1, which is connected at the end of the cascade connection, is unconnected. Therefore, a receptacle that does not allow easy contact with the electrically activated portion is used for the input connector 5...” [0048]. Additionally, Kondo’s system is connected to the power grid, which Kondo calls the “commercial-use power system”. Kondo says “An associated-system protector 31, comprising a switch and a system abnormality detector, is provided between the AC module 1 and a commercial-use power system (hereinafter simply referred to as the system).” [0026].

[0054] I would point here that Kondo does not use the claim term “daisy chain” to describe the manner in which its inverters are connected. Instead, Kondo describes the inverter connections as a “parallel” “cascade” or “sequentially repeating cascade” connection: “AC module, integrating a solar battery and an inverter, can easily be connected with other plural AC modules in parallel by way of cascade connections.” (Abstract) and also see claims 8 and 9, [0003], [0004] and [0048]. In my view, the person of skill in the art would understand this as a “daisy chain” connection. As is seen in FIGs. 1-2, Kondo’s inverters are connected, one to the next, so that all the connected inverters are connected electrically in parallel (i.e., all are operating at the same voltage), and the current they supply is added to the

combined connection. This is exactly how the inverters described in the '133 patent are connected, as shown above in FIG. 5. Indeed, while the '133 patent does not define “daisy chain”, it does say “Although we say the power inverters daisy chain, where the output port of each power inverter is connected to the input port of the next power inverter, the actual connection of the inverters is pass-through. That means, the generated AC power from each power inverter is added in parallel onto the AC powerline.” '133 patent, 3:61-66. So, if the '133 patent shows daisy chained inverters, so does Kondo – both documents describe inverters connected, one to the next, electrically in parallel, such that their power and current is added. I would also note here that Rotzoll '118, which I discuss further below, describes exactly this same sort of sequential connection of inverters through AC inputs and outputs as a “daisy chain” connection. See Rotzoll '118, [0015] (“There are, according to one embodiment, two inverter mounting bracket AC connections to support daisy-chain connections between multiple AC modules.”)

[0055] Kondo discloses a number of advantages to daisy chaining inverters through AC input and output ports. First, Kondo says that by providing AC inputs and AC outputs for its inverters, the number of inverters in the system can be easily increased for increased power. Kondo says “Therefore, each AC module 1 has a 100V single-phase output. Connecting the input connector with the output connector of the AC module 1 as shown in FIGS. 1 and 2 enables to

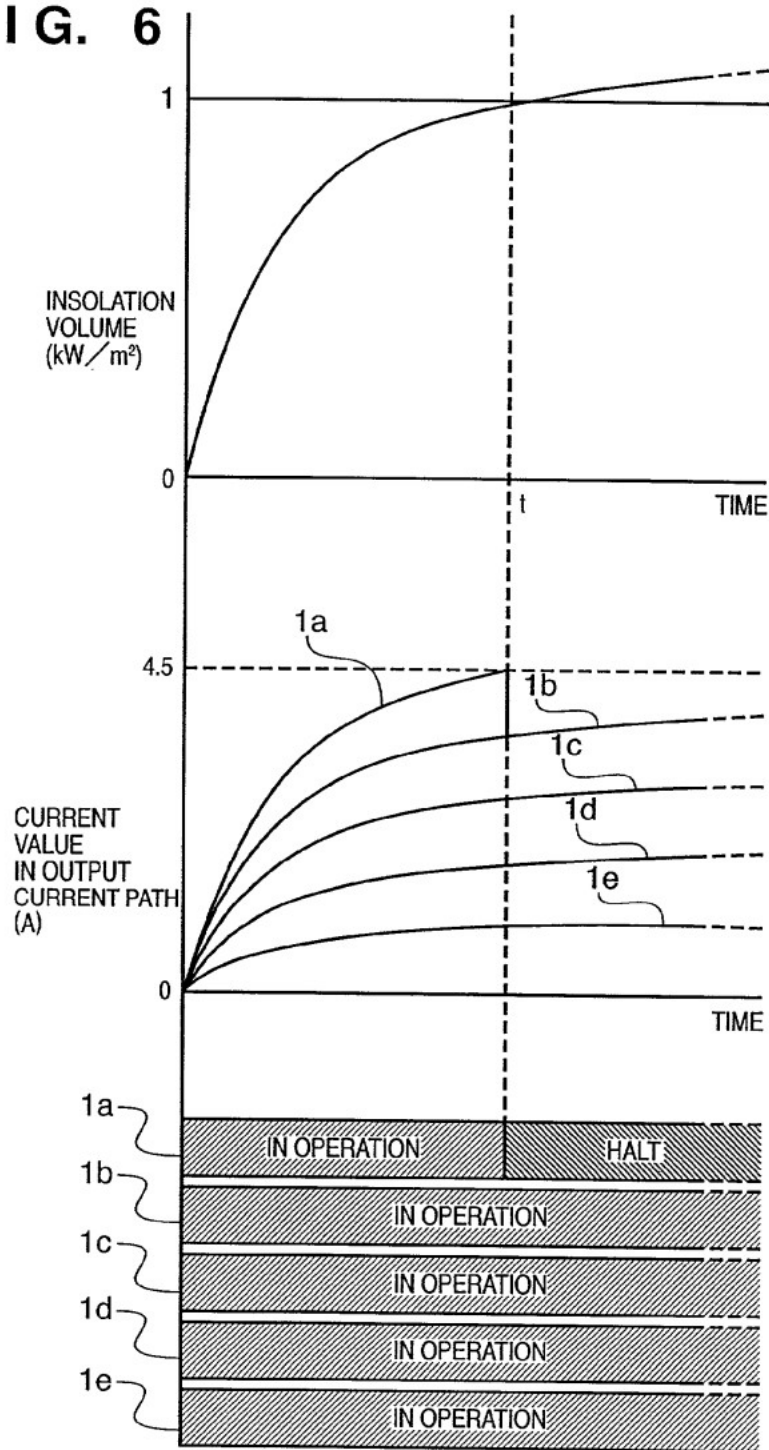
increase the number of parallel connection of the AC module 1.” [0025]. Kondo also says “AC module, integrating a solar battery and an inverter, can easily be connected with other plural AC modules in parallel by way of cascade connections.” [Abstract]. One might ask, if a user wanted to increase total power output by increasing the number of inverters and connected solar panels in an installation, why not just provide inverters with an AC output connected to a common bus? This sort of arrangement is shown in FIG. 3 of Fornage, which I have included below.



[0056] One disadvantage of simply bringing AC power from a number of inverters out to an external bus is recognized by Kondo. In a parallel inverter arrangement

with many inverters and panels, there is a risk that too much current might be supplied to the bus, especially under unexpectedly bright illumination conditions. Kondo says “...an improvident increase of the number of connections causes the current in a connector or current path of the AC module to exceed the rated current.” [0004] and Abstract. Kondo’s second advantage is a solution to this problem. Each of Kondo’s AC’s modules includes an overcurrent detector (27 in FIG. 3) which senses the current level on “current path” 9 with a current detector 4. See [0042]-[0046]. When the current running through one of Kondo’s AC modules exceeds a “set value” ([0046]), the inverter unit 3 in the module that senses overcurrent is shut off, such that it no longer supplies additional current to the daisy chain of inverters. See [0046]. Kondo provides an example of how this works in FIG. 6, which I have included below.

FIG. 6



[0057] Speaking of FIG. 6, above, suppose there is a daisy chain arrangement of parallel connected modules (inverters plus connected solar panels) like is shown in

FIG. 1. These would be 1a-1e. Over time, the amount of sunlight falling on the solar panels may increase (i.e., as the sun moves from the horizon in the morning to overhead at mid-day). This is shown by the “insolation volume” curve in FIG. 6, which shows irradiance (optical power per unit area) in kilowatts per meter squared. As the amount of sun on the connected solar panels increases, so does the amount of electrical power generated by each panel – and as power increases, so does the amount of current output by each panel. Because the modules are connected in parallel to a common current path, their output currents are being added together on the current path. Kondo says “As shown in FIG. 6, the collected current value of each of the AC modules 1 (i.e., current value in the current path 9) increases as the insulation rises”. [0054] and see [0055] and [0051] (which refers to the AC power being collected together). One sees the accumulated current in the middle pane of FIG. 6, where each inverter is contributing the same low level of current. When a preset threshold is reached, in this case 4.5A, one inverter (inverter 1a) shuts itself off.

[0058] Kondo says that, in the prior art, the problem of too much current being delivered by a solar system was handled at the “associated system protector 31”, which would disconnect the system entirely from the grid in the event of a current spike. See [0026] (“When the associated-system protector 31 detects a voltage increase of the system, a frequency abnormality, a power failure or the like, it turns

off the switch to disconnect the photovoltaic power generation apparatus from the system.”) and [0057]. The beauty of Kondo’s alternative system is that, in the event of an overcurrent condition caused, for example, by a sudden rise in sunlight, the photovoltaic generation system remains connected to supply power to the grid. Only those inverters that are contributing current that push the total collected current above the preset maximum are shut off. The remaining inverters remain in operation and can continue supplying power near the maximum current rating of the system. Kondo says “Meanwhile, when the insolation is 1.0 kw/m², the AC modules 1b to 1e respectively have collected current values of 0.9A, 1.8A, 2.7A, and 3.6A; thus the operation of inverter circuit 13 continues. In other words, the power collected from five AC modules 1 is supplied to the system until time t, and the power collected from four AC modules 1 is supplied to the system after time t.” [0056] and see [0057] (“power conversion of the AC module 1 is halted sequentially from the one closest to the associated-system point.”).

[0059] This is a significant advantage over prior art systems. It allows for a connected system to remain in operation at close to its current maximum (and power), as some inverters are taken offline and brought back online depending on the amount of illumination. It is important to point that that this system is made possible by Kondo’s daisy chain architecture, with an internal AC bus created by AC inputs and outputs. Rather than having a connection to an external AC bus as in

Fornage, above, Kondo essentially routes the AC bus carrying the combined current *through* each inverter, via each inverter's AC inputs and outputs. That gives every inverter in the chain the ability to sample the amount of accumulated current on the bus (e.g., with the over current detector 27 shown in FIG. 3), so that only the inverters that contribute excess current that exceeds some threshold need be shut down. Essentially, because the AC bus is connected to each inverter, any inverter can act as an overcurrent protective device for the entire bus. In an arrangement with an external AC bus, like that shown in Fornage's FIG. 3, the inverters do not know how much current is being carried on the bus and so cannot perform this function. The solution in the pre-Kondo prior art is to sense total current at the grid connection, and to disconnect the entire photovoltaic system when there is overcurrent. Kondo's system is a significant improvement over this.

[0060] As I describe below, and as I have foreshadowed in this section, the Fornage, Nishi and Kondo, together, include all of the elements of the challenged independent claims. These elements, chiefly, inverters that could be daisy chained together and inverters with multiple DC inputs, are conventional elements well-known in the industry. These elements could be combined in a predictable matter to increase reliability, reduce cost and/or achieve higher power efficiency with a high chance for success, and indeed, as I explain later in this report, the references themselves suggest why the person of ordinary skill would combine them.

IX. CLAIM CONSTRUCTION

[0061] I understand that claims in an IPR are given their ordinary and customary meaning as understood by one of ordinary skill in the art considering the specification and prosecution history.

[0062] I understand that the Petitioner and the Patent Owner may have different constructions for several terms, but in the underlying dispute, the parties have both agreed that the claims of the '133 patent are to be construed in terms of their plain and ordinary meaning, and neither party has proposed any special construction for any claim term. I agree with this approach. The claim terms of the '133 patent are easily understandable, and would have been easily understood by the person of ordinary skill as I have defined that person without the need for any special definitions of terms.

[0063] I also understand that neither the Patent Trial and Appeal Board (PTAB), nor the District Court, has not yet construed any terms of the '133 patent. In the event that the PTAB or the District Court provides an explicit construction for some term of the '133 patent, I reserve the right to perform additional analyses based on any such construction.

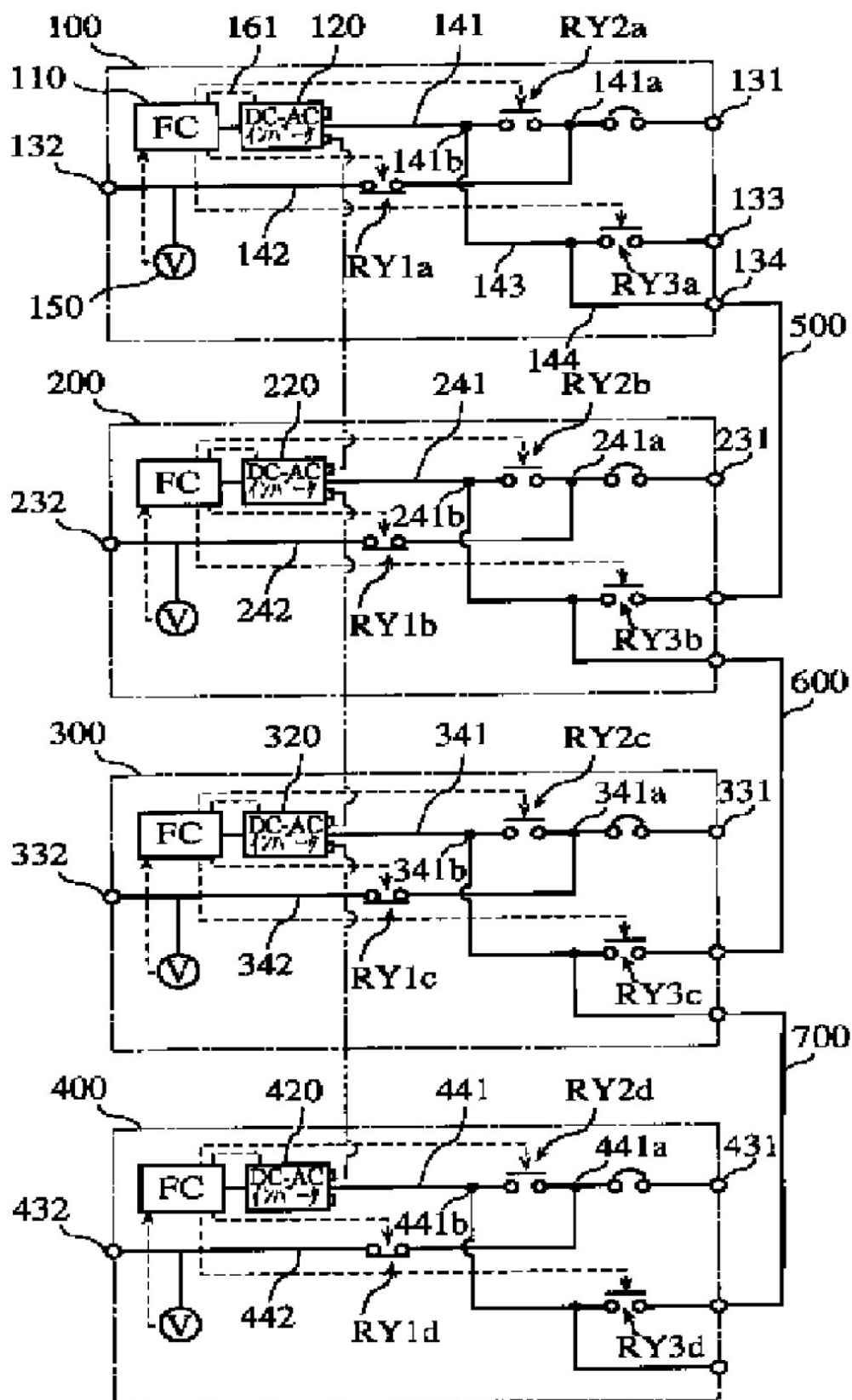
[0064] I have reviewed the file history of the '133 patent, and I saw nothing that would lead me to conclude that the patentee applied any special definition to any

claim term that I consider in this report, other than that term's ordinary and customary meaning.

X. OPINIONS AND OBSERVATIONS REGARDING THE FILE HISTORY

[0065] As I mentioned earlier, I have reviewed the file history of the '133 patent, which I understand is the record of negotiation between the patentee and the Patent Office.

[0066] I understand that the initial versions of claims 15 and 19 were rejected over a Japanese patent application JP09275637. This reference is referred to in the file history documents as both "Ishizawa" and "Aoki", who I would assume are the two inventors listed on the patent application. I will call this patent application "Aoki". While I have not reviewed an English translation of that patent application, I do note that there is a Japanese copy of it in the file history, which includes a figure showing an inverter apparatus. I have reproduced that figure below.



[0067] In considering Aoki, the Examiner noted that it disclosed a plurality of inverters, each with a DC input port. See June 12, 2013 Office Action, pgs. 3-4. The DC sources in Aoki would be the fuel cells marked “FC”, each of which is connected to a DC-AC inverter (120, 220, etc., marked “DC-AC”). The Examiner also noted that each of Aoki’s devices (100, 200, etc.) included an AC output port and an AC input port. The Examiner called the AC input ports “respective input ports 333, fig1” and the AC output ports “respective output ports 134, fig1”. Id. I think there is a typo here, and the Examiner meant to identify input ports 133, rather than “333”. Looking at the arrangement above, it is clear, and I agree with the examiner, that 134, and the corresponding terminals in the other devices, are AC output ports. I say this because they are connected to the DC-AC inverters. Also, I agree with what the Examiner was trying to say, in that 133, and the corresponding terminals on the other inverters, are AC input ports. I know this because these terminals are connected to the AC output ports of the next device upstream in the chain. For example, AC output port 134 of device 100 is connected to the terminal on device 200 that corresponds to terminal 133 on device 100. Thus, these devices are arranged in a daisy chain, which each device connected to a next device, through AC inputs and outputs.

[0068] The Examiner also made some pertinent observations relevant to other claim elements. In particular, the Examiner noted that a power generation system

connected to the grid through a “power service panel” was generally known in the art and would have been obvious to incorporate with a power generation system.

The Examiner stated:

Official Notice is taken that both the concept and advantages of providing a power service panel connection from a supplemental utility grid co-generation system and providing power to the utility grid are well known and expected in the art. It would have been obvious to have included the power service panel in Aoki as these panels are known to provide known and desirable power connections from a co-generation system for use on the utility grid.

Office Action of June 12, 2013, pg. 4.

[0069] I agree with the Examiner’s analysis here. Home or other non-utility solar power generation facilities (which the Examiner here calls “co-generation” systems) connected to the commercial electrical grid through a service panel were well-known prior to the ’133 patent and would have been obvious to add to any solar power generation system. Indeed, in a typical home solar power setup, the inverters are connected to a service panel (i.e., a home circuit breaker panel) and then to the grid. This allows the home to receive solar power through its service panel, just like it receives power from the grid through the service panel. This is advantageous because the service panel include circuit breakers than can disconnect household circuits from the power source (the grid or the solar system) when the current being drawn by those circuits gets too high. In times of surplus, when the solar panels are generating more power than the home is using, power can be supplied back into the

grid (often for payment from the utility), where it can be used by other users. Alternatively, all the solar power can be sold to the grid, and the homeowner receives a credit for the use of grid power for the home. Fornage shows a solar system connected through a service panel (“electric panel 306”) to the power grid in FIG. 3, above and describes these sorts of sell-back arrangements when it says

The electric panel **306** connects the power from the junction box **304** to the power grid **312** and, in some applications, to appliances **316** within a user's facility. For example, in a home, the electric panel **306** is a well-known AC distribution hub comprising various circuit breakers and/or fuses to distribute electricity to various circuits within the home. The electric panel **306** is coupled through the electric meter **310** to the power grid **312**. The meter **310** determines the amount of power supplied to the grid **312**, such that the owner of the system **100** can be compensated for supplying electricity to the grid **312**.

[0027] and see [0005] (“The inverter converts the DC to AC and supplies the AC to the power grid. The user uses power from the grid in a typical fashion; however, their cost is offset by the amount of electricity the photovoltaic generation system supplies to the grid.” Fornage, [0005].

[0070] The Examiner also took official notice of the obviousness of building an inverter system that outputs either single-phase or three-phase AC. The Examiner stated

Official Notice is taken that both the concept and advantages of providing for single or three phases power in power inversion systems are well known and expected in the art. It would have been obvious to have included the desirable number of phases (single or three) in Aoki's inverter system as the number of phases are known to be readily chosen depending on the needs of the connected grid/load.

Office Action of June 12, 2013, pg. 5.

[0071] I agree with the Examiner's conclusion here. Both single-phase and three-phase power and their advantages have been known for more than a century. In a single-phase system, power is transmitted on one conductor, and the current and voltage waveform is one sine wave. In a three-phase system, three wires are used, and the voltage and current waveforms are also sine waves, but they are shifted 120 degrees relative to one another. Single-phase power is used, generally, in homes, which use 110V AC single-phase here in the United States. Three-phase power is used in industrial and commercial settings, because it enables the transmission of more power using fewer conductors. As the Examiner suggests, it would have been obvious for the POSA to configure an inverter system to output either single-phase or three-phase AC depending on, for example, whether the inverter was being employed in a residential or industrial/commercial setting.

[0072] Returning to the file history, the applicant amended the claims that would mature into claims 15 and 19 to recite "a plurality of power inverters, each of said

power inverters having at least two DC power input ports”. Response and Amendment in response to June 12, 2013 Office Action, pg. 11 (amendment to claim 21). I believe that this amendment was filed on August 15, 2013. The applicant then argued that Aoki’s (Ishizawa’s) inverters each had just one DC power input port:

Ishizawa et al. is directed to a system in which a number of fuel cells are operated in parallel. Although the system of Ishizawa et al. includes a plurality of power inverters, only one power inverter is provided for each fuel cell. Nowhere in Ishizawa et al. is there any teaching or suggestion as to how a single power inverter might have multiple DC power input ports.

Id. at pg. 15.

[0073] It’s my opinion that Aoki’s figure, above, doesn’t show two or more DC input ports for each DC-AC inverter. The figure shows just one connection between a fuel cell and the DC-AC inverter for each device. However, there were certainly examples in the art of DC-AC inverters with multiple DC inputs. Fornage and Nishi are two such examples. Adding multiple inputs to an inverter that was already set up to be daisy chained in parallel would have been obvious for the reasons I will describe below.

[0074] This multiple DC input argument apparently convinced the Examiner that the subject claims of the ’133 patent were allowable over Aoki. When the Examiner eventually allowed the patent application, he said:

Claims 26-32 in the application are deemed to be directed to a nonobvious improvement over the prior art of record, particularly Erickson, JR. et al. US 2012/0025618; Stren US 2010/0237703; Dennis et al. US 2011/0273022; Rotzoll et al. US 2008/0283118; and Bower et al. US 2003/0111103 teach systems for providing AC power to a grid from a plurality of sources/converters.

The primary reason for allowance of the claims is the inclusion of the particular port configuration further comprising both an AC input port coupled to the single DC-AC inverter and the AC output port coupled to the single DC-AC inverter.

Notice of Allowance, April 4, 2014.

[0075] With due respect to the Patent Office, the Examiner's reasons for allowance do not make sense, and his reasoning here is flat wrong. The Examiner stated that he allowed the patent because the claims recited "both an AC input port coupled to the single DC-AC inverter and the AC output port coupled to the single DC-AC inverter". But the Examiner had already found a reference that disclosed those features in Aoki. The AC input and output ports (133 and 134) coupled to a single DC-AC inverter (DC-AC 120) are plainly visible in the figure from Aoki in this report above. See [0066], above. Those claim elements were rejected over Aoki, and the applicant never contested the Examiner's finding that Aoki showed an inverter with an AC input and AC output ports that was daisy chained together with

other inverters. Instead, the applicant argued that the claims were allowable because Aoki's inverters only had one DC input port.

[0076] Moreover, the Examiner had another reference that obviously showed an inverter with an AC input port and an AC output port, such that they could daisy chain connected. U.S. Patent Publication No. 2008/0283118 ("Rotzoll '118"), which the Examiner said he considered in the reasons for allowance, discloses these features. These features are shown in FIG. 2 of Rotzoll '118, which I have reproduced below. That figure shows a number of modules 202, 222 each of which has a solar panel (i.e., a DC source) 210, 230, and an inverter 204, 224. Each inverter has a pair of connectors (e.g., 205, 208). Rotzoll '118 says

Referring to FIG. 2, an array **201** of PV modules **202, 222, 242** including PV module-mounted inverters **204, 224, 244** as known in the prior art is shown. In the configuration shown, connector **205** is connected to the grid. As referred to herein the grid will be recognized by one skilled in the art of electrical generation and local electric grid systems. This grid includes not only the ability to use the power produced by the PV modules locally, for example to power a commercial enterprise or residence, but also to sell back excess or unused power to a community electric grid. The AC grid voltage appears at connector the **208** and is passed to the inverter **224** of the PV module **222** via another connector **225**, which is mated with a receiving connector **208**. Similarly, the same AC voltage is now available at a similar inverter **244** via the mating of a like connector **228** to another receiving connector **245**. This sequence can continue until the maximum current rating of all cables **206, 207, 226, 227, 246, 247** and **266** has been exhausted.

[0008]

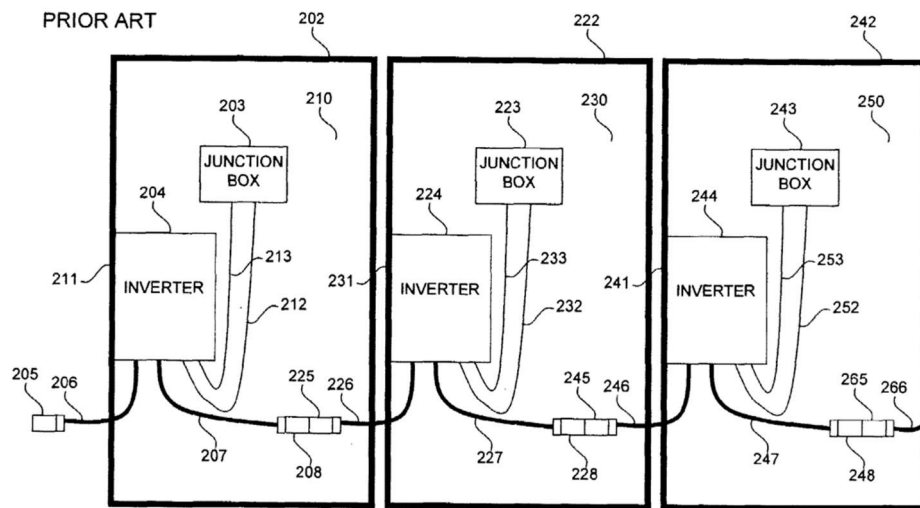


FIG. 2

[0077] Here, Rotzoll '118 is discussing the daisy chain arrangement of the claims. Indeed, the application refers explicitly calls this arrangement a “daisy chain”: “There are, according to one embodiment, two inverter mounting bracket AC connections to support daisy-chain connections between multiple AC modules.” [0015]. The discussion of FIG. 2, above, makes it clear that each inverter in the chain is adding its own AC power on the chain “until the maximum current rating of all cables...has been exhausted”. So, Rotzoll '118 already disclosed an arrangement of daisy chained inverters, where each device was receiving AC power from an upstream inverter, adding its own power, and outputting the combined power on an AC output. In view of this, the Examiner’s statement that features were not in the art was a mistake, in my opinion. They were clearly in the art, as

shown by Aoki and Rotzoll '118. As I describe in my report, these features were also in Kondo.

XI. INVALIDITY OPINIONS

A. Ground 1: Kondo and Nishi

[0078] It is my opinion that claims 15–16, 18–20 and 22–24 of the '133 patent are unpatentable because they are obvious over the combination of Kondo and Nishi. In this combination, I am taking Kondo as the starting point, and pointing out that it would have been obvious to modify it with teachings from Nishi. As I laid out above, Kondo describes a system of inverters connected to solar panels where each inverter has an AC power input port and an AC power output port such that they can be connected in a daisy-chain. It would have been obvious to make Kondo's inverters multi-input inverters such that they could accept DC input from more than one connected DC source, which is shown in Nishi. This change would have been motivated by an interest in providing more flexibility regarding reliability, reduction in cost and/or improvement in efficiency, all offering scalability for the system, while reducing total component count by sharing inverters.

[0079] I will now walk through the claim elements and explain how the various claim elements are present in the references.

15p1: A scalable DC to AC power inversion system for providing AC power to a power grid

19p: A method of making a DC to AC power conversion system incrementally scalable, comprising:

[0080] Kondo's system has shown in FIGs. 1-6 (power conversion unit 21 shown in detail in FIG. 3) is a DC to AC inversion system, which is to say, a system that converts DC to AC. Kondo says "The power conversion unit 21 converts DC power supplied from the solar battery unit 2 to 50/60 Hz and 100V AC power." [0033] Kondo's system is incrementally scalable because it permits additional "AC modules" to be added, as shown in FIGs. 1 and 2. Kondo says "AC module, integrating a solar battery and an inverter, can easily be connected with other plural AC modules in parallel by way of cascade connections." [Abstract]. Kondo's system supplies AC power to the grid. Kondo refers to the grid as the "commercial-use power system" and its connection to the grid is shown FIG. 1 ("TO ASSOCIATED SYSTEM POINT"). See FIG. 1 and [0026] and [0002] (referring generally to photovoltaic generation systems supplying power to the commercial use power system). I would also note here that, as the Examiner stated, connecting a solar power generation system to the grid is obvious and would have been obvious to add, for example, so that that system owner could sell surplus power to the grid.

15p2: from a plurality of individual DC power sources each having a DC power output port, comprising:

19a1: a) providing a plurality of DC power sources

[0081] Kondo's FIGs. 1 and 3-4 show a plurality of individual DC power sources, "solar batteries" 2. The person of skill would understand these "solar batteries" to be photovoltaic cells – a silicon semiconductor device that turn solar energy into DC electrical energy. Kondo confirms this: "As shown in FIG. 4, the solar battery unit 2 accounts for the most part of the AC module 1. Preferably used as the solar battery unit 2 is one employing amorphous silicon, or polycrystalline silicon or crystalline silicon in its photoelectronic transducer. DC power is outputted from an electrode (not shown) of the solar battery unit 2. Note when the insolation is 1 kW/m², the rated output of the solar battery unit 2 in the first embodiment is: the rated voltage, 25V; rated current, 4 A; and rated power, 100 W." [0031]. Each of Kondo's solar batteries must have some sort of output port to get the DC power to the inverter. Kondo refers above to an "electrode of the solar battery unit 2", which is not shown, but which would be an output port. This electrode would be electrically connected to the "DC input terminal 18" to Kondo's power inverter 3, which is shown on FIG. 5. See [0036].

15a1: a) a plurality of power inverters, each of said power inverters including a single DC-AC inverter,

19a2: and a plurality of DC to AC power inverters, said DC to AC power inverters each having a single DC-AC inverter,

[0082] Kondo's power inverters are the "inverters" pictured in the AC modules 1 shown in FIG. 1 and the "POWER CONVERSION UNIT" 21 shown in FIG. 3. See

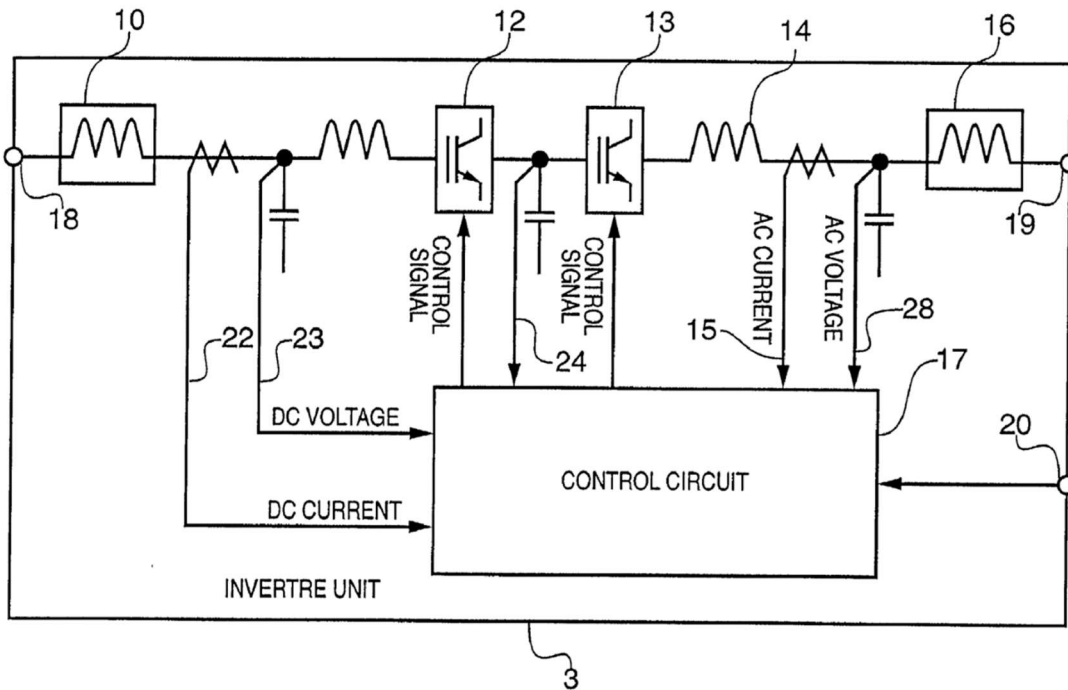
[0033]. Each power inverter (power conversion unit 21) contains a single DC-AC inverter, which is “inverter unit 3”, shown in FIG. 3. Kondo says “The power conversion unit 21 comprises an inverter unit 3, an over current detector 27, and current paths 7, 8 and 9. The power conversion unit 21 converts DC power supplied from the solar battery unit 2 to 50/60 Hz and 100V AC power.” [0033]. The DC-AC inverter 3 is also shown in more detail in FIG. 5.

15a2: at least two DC power input ports coupled to the single DC-AC inverter,

19a4: and at least two DC input ports coupled to the single DC-AC inverter;

[0083] Kondo’s DC-AC inverters have a single DC power input port. That is “DC input terminal 18” (FIG. 5 and [0036]). DC input port 18 (of DC-AC inverter 3) receives DC power from solar battery 2, which can be seen in FIG. 3. I have reproduced FIG. 5 from Kondo here.

FIG. 5

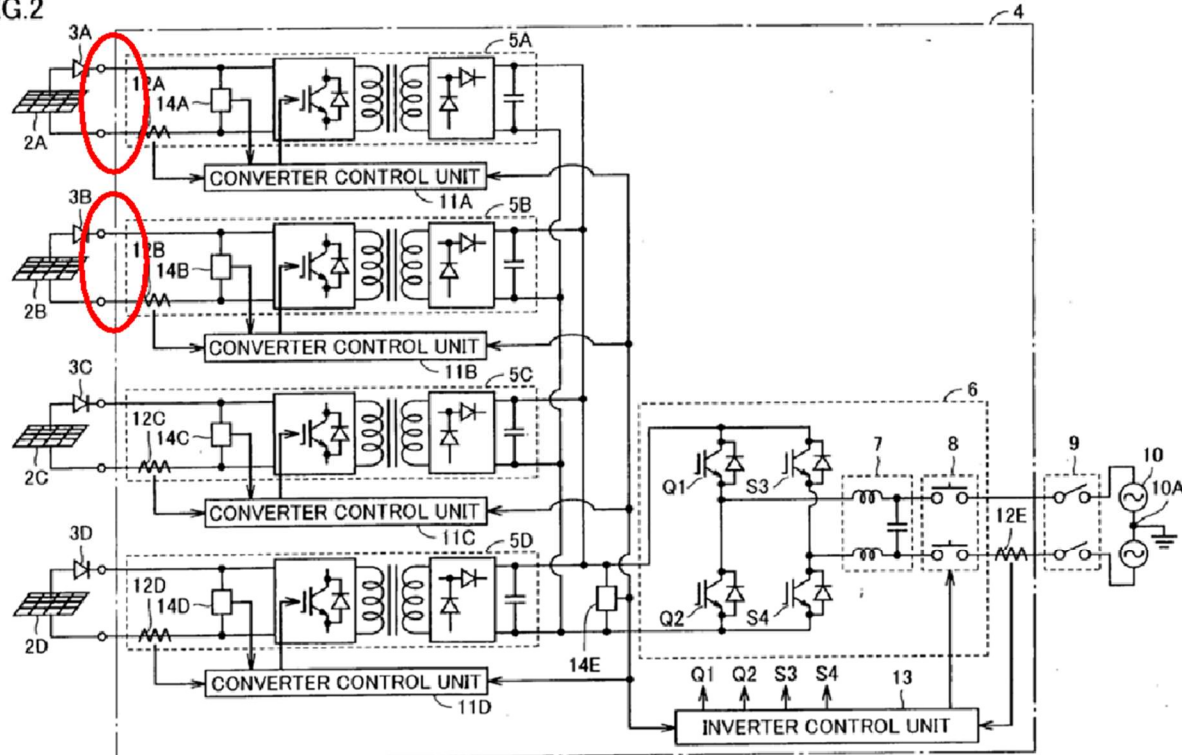


[0084] FIG. 5 of Kondo shows that in the DC-AC inverter of Kondo (3) DC power received through input port 18 is supplied to a boost circuit 12. Paragraph [0036] says, “The DC voltage, about 25V, which is inputted to the DC input terminal 18, is converted to 160V DC voltage by the booster circuit 12 which includes a boost chopper.”. Control of the boost circuit 12 enables Kondo’s inverters to do MPPT: “At this stage, the control circuit 17 performs the well-known optimum operation point tracking control based on DC current 22 and DC voltage 23.” [0036].

[0085] Nishi, in FIGs. 1-2, discloses a power inverter (“inverter apparatus 4”), which is described in paragraphs [0038], [0068] and [0070]. Nishi’s power inverter

also contains a single DC-AC inverter, which is “inverter 6”, also shown in FIGs. 1-2 and described at [0038] and [0067]. Referring now to FIG. 2, Nishi’s power inverter 4 has four DC power input ports that take DC input from attached photovoltaic modules 2A-2C. Two of the DC input ports are marked in red on FIG. 2, below. We know that these are DC power input ports because they are receiving input from “solar cell arrays” 2A-2D, which are DC sources. See [0063]. Each of Nishi’s DC power input ports is connected to a DC/DC converter (5A-5C – see [0065]), the outputs of which are combined on a DC bus, which is connected to Nishi’s power inverter, 6. Nishi says “Inverter 6 receives a DC power, which is a combined DC power of every DC power outputted from each of converters 5A-5D”. [0067].

FIG.2



[0086] It would have been obvious to incorporate Nishi's arrangement for providing multiple DC inputs to an inverter with Kondo's arrangement for daisy-chaining inverters through their AC outputs. The person of skill would have been motivated to incorporate Nishi's shared inverter arrangement because it permits the inverter to optimize the DC power output of more than one connected string of PV modules, operating under different conditions, while sharing the inverter, thereby saving cost. Nishi provides in reference to the embodiment of FIGs 1 and 2 "Here, converter control units 11A-11D each calculate an output power of respective solar cell arrays 2A-2D based on corresponding input voltage detection value and

input current detection value, and control respective converters 5A–5D so that the output of respective solar cell arrays 2A–2D becomes maximum.” [0077]. One advantage of maximizing input power on each attached string is that overall power is maximized when each string has different irradiation conditions, and therefore operates at a different voltage. See [0061]–[0063] (stating that different solar arrays receiving different amounts of sun will have different output voltage) and [0065] (stating that parallel DC/DC converters can adjust solar cell output voltage of all cells to maximize power).

[0087] Additionally, the person of skill would have been motivated to add multiple DC inputs to Kondo’s inverters, as shown in Nishi, in order enable the incorporation of other DC sources, such as fuel cells. In its second embodiment, shown in FIG. 6, Nishi shows an inverter 4A, with a DC-AC inverter 6, accepting DC input from solar panels 2A-D as well as fuel cell 16. Having the capability to accept DC power from multiple sources is highlighted as an advantage in Nishi, which says: “Considering the diversification of the DC power sources of practical use, it is highly advantageous to structure a dispersed-power-source system of, a hybrid type that is higher in efficiency and lower in costs.” [0035] and see [0047] (emphasizing the advantages of receiving power from different kinds of power sources). By enabling a single shared inverter to have multiple DC inputs, Nishi

provides the ability to incorporate different sorts of DC sources while reducing total component costs by using a single DC-AC inverter.

[0088] Also, using Nishi's shared inverter arrangement in the inverter of Kondo would be a simple substitution of one known element for another, yielding predictable results. Kondo already discloses one DC input (18 in FIG. 5, above), a DC/DC boost converter ("boost circuit 12"), and a controller ("control circuit 17") for performing MPPT. See [0036] ("At this stage, the control circuit 17 performs the well-known optimum operation point tracking control based on DC current 22 and DC voltage 23). Modifying Kondo with Nishi's shared inverter arrangement into Kondo would simply involve providing additional DC inputs and additional boost circuits controlled by Kondo's existing controller, and then collecting the total DC output of the boost circuits on a DC bus, and providing it to Kondo's DC-AC inverter (13 in FIG. 5, see [0036]). This would not be difficult for the person of ordinary skill to do in view of the disclosure in Nishi. The wiring is elementary, and simply involves replicating Kondo's components (input port 18 and boost circuit 12), tying the outputs from the boost circuits to a common DC bus, and then connecting that bus to Kondo's DC-AC inverter 13. See FIG. 5.

[0089] Alternatively, the person of ordinary skill could simply substitute Nishi's inverter 4 for Kondo's inverter (power conversion unit), while retaining Kondo's AC input and output ports in order to retain Kondo's flexibility and its

ability to detect over current conditions. Indeed, if the person of skill was attempting to increase the number of DC inverter inputs, as in Nishi, the person of skill would recognize the risk of an overcurrent condition and would be further motivated to keep Kondo's daisy chain arrangement, under which every inverter in the daisy chain can sense and address over current.

15a3: an AC power input port, and an AC power output port coupled to the single DC-AC inverter,

19a3: an AC input port coupled to the single DC-AC inverter, an AC output port coupled to the single DC-AC inverter,

[0090] Kondo's power inverters (21 in FIG. 3) have an AC power input port (5) and an AC power output port (6), both of which are coupled directly to the DC/AC inverter (inverter unit 3), respectively through "current paths" 8 and 9 in FIG. 3. Kondo says "The DC power generated by the solar battery unit 2 is converted to AC power by the inverter unit 3, sent through the current path 8, collected together with the power, which is generated by other AC modules 1 and inputted from the input connector 5, then sent through the current path 9, and outputted to the output connector 6." [0051] and see [0006] (referring to input and output connectors and [0033] ("The converted AC power is collected together with AC power, which is inputted from an input connector 5, and then outputted to an output connector 6.")). In FIG. 4, Kondo shows that the AC input/output ports 5 and 6 can also be connectors.

15a4: each of said DC power input ports having one DC power source connected thereto;

19b1: b) connecting at least one of said DC power sources, respectively, to each of said DC input ports; and

[0091] As I explain above, both Kondo and Nishi show DC power input ports (terminal 18 in FIG. 5 of Kondo, or the connections shown above in FIG. 2 of Nishi) that are connected to DC sources, which would be Kondo's solar batteries 1 and Nishi's photovoltaic panels 2A-2D, or fuel cell 16.

15b1: b) said AC power output port of each power inverter being connected in a daisy-chain to the AC power input port of the next power inverter,

22(a): The method of claim 19 further comprising daisy-chaining at least two of said DC to AC power inverters, said AC power output port of each DC to AC power inverter being connected in a daisy-chain to the AC power input port of the next DC to AC power inverter,

[0092] As I state in [0051]-[0059], above, Kondo discloses a daisy chain arrangement of inverters connected, one to the next, through their AC power input and AC power output ports. This arrangement is shown in both FIG. 1 and 2.

15b2: except for the AC power input port of the first power inverter being left open,

22(b): except for the AC power input port of the first DC to AC power inverter being left open,

[0093] As I state in paragraph [0053], in Kondo's daisy chain arrangement, the AC input port of the upstream-most inverter in the chain is unconnected, or left open. This is visible in FIG. 2 (the uppermost left hand inverter) and Kondo says as much at paragraph [0048].

15b3: and the AC power output port of the last power inverter being connected to a power service panel of the power grid;

19c: c) providing AC power to the power grid.

22(c): and the AC power output port of the last DC to AC power inverter being connected to a power service panel of the power grid.

[0094] Kondo discloses a grid connection through a service panel, or at least, such a connection would have been obvious, as indeed the Examiner pointed out during prosecution. Kondo shows the last power inverter being connected to an "associated system point" through an "associated system protector" 31 (i.e., a breaker panel illustrated as including breaker switches. This is shown in FIG. 1 and 2. The associated system would have been understood as a power grid because Kondo refers to this as the "commercial use power system", which is the utility grid. See [0002] and [0026] and [0006] (referring generally to grid-connected solar system or a "photovoltaic power generation system[]") that "supplies a commercial-use power". The associated system protector shows switches of the sort that would be present in utility customer's service panel, and Kondo describes the associated system protector as having the same function as a service panel, which is isolation between

the customer and the grid. Kondo suggests this when it says “An associated-system protector 31, comprising a switch and a system abnormality detector, is provided between the AC module 1 and a commercial-use power system (hereinafter simply referred to as the system).” [0026].

[0095] Even if Kondo does not explicitly disclose a “grid” and a “service panel”, these would have been obvious to add to the combination, for example, from Nishi. In Nishi’s FIG. 2, the inverter 4 is connected to a breaker 9, and then to “commercial power system 10”, i.e., the grid. See [0097] (“Inverter 6 transforms a DC power outputted from each of converters 5A–5D into an AC power and outputs the AC power. The AC power outputted from inverter 6 is supplied to commercial power system 10 and household loads, which are not shown, via leakage breaker 9.”); [0067], [0016]. [0005] and [0003]. Here again, an associated system breaker would be understood as a utility customer’s service panel, which includes circuit breakers that can isolate the customer’s home from the grid.

[0096] Even if Nishi does not disclose these elements, they would have been obvious to incorporate from, for example, Fornage. That reference explicitly disclose a service panel, “electric panel 306” in FIG. 3, which is connected to the “power grid 312”. Fornage recognizes the advantage of this arrangement, which is that enables the owner of a photovoltaic system to sell surplus power to the utility or at least to offset the cost of power from the utility with generated power. I discuss

this in paragraph [0068], above, and Fornage discusses selling power to the grid in [0005] and [0027]. Fornage's teaching of this ability to sell power to the grid, while still being able to drive home loads connected to the service panel would motivate the incorporation of these elements into the combination of Kondo and Nishi.

15c: c) whereby said system is incrementally scalable by adding or subtracting DC power sources and daisy-chained inverters.

[0097] Kondo's system is scalable, in that a user can add or subtract daisy chained inverters through their AC input/output ports. Kondo confirms this when it says that a cascade connection of the sort described "enables to increase the number of parallel-connected AC modules by sequentially repeating cascade connection".

[0003] Kondo also suggests that this sort of connection "enables easy parallel connection of plural AC modules by way of cascade connection". [0004]. Now, these disclosures are directly related to different patent applications, but in the Abstract, Kondo is clear that its own daisy chain scheme is an easily scalable "cascade" arrangement: "AC module, integrating a solar battery and an inverter, can easily be connected with other plural AC modules in parallel by way of cascade connections." Claims 8 and 9 and [0048] also refer to the connection scheme as being a "cascade". This means that the disclosures above, where Kondo refers to this sort of connection as allowing for increases in the number of parallel connected modules" and that such connections are "easy" to apply just as well to Kondo. Moreover, simply as a matter of common sense, the easy way Kondo's inverters can

be connected in parallel through AC input and output ports (seen in FIGs. 1-2) demonstrates that the design is incrementally scalable by adding or subtracting inverters. Indeed, Kondo's overcurrent limitation functionality is in place in case a user adds too many inverters.

[0098] Additionally, Nishi's system is incrementally scalable by adding or subtracting DC power sources to the shared inverter. Nishi says "Thus, inverter apparatus 4 in the dispersed-power-source system includes a plurality of converters having different input voltage ranges, and therefore it can transform a DC power outputted from each of a plurality of DC power sources having different output voltage ranges into a commercial AC power, without providing a booster circuit at a front stage or imposing limit on a number of solar cell modules to be connected for constituting an solar cell array." [0068] and see [0003] (referring to a "plurality of DC sources"); [0043] (referring to a "plurality of converters" each connected to a DC source). Additionally, Nishi states that its system may include "at least one first DC power source" and "at least one second DC power source" in the plurality of sources. These disclosures suggest that Nishi is contemplated an arbitrary number of plural sources, i.e., may be more than two, which suggests that sources can be added or subtracted. See [0038].

[0099] In my opinion, it would have been obvious to take Kondo's already scalable system and enhance it with the additional ability to add or subtract panels or panel strings to a single inverter. As I state above, this would create a system that could perform MPP tracking on more than one panel while sharing an inverter, thereby reducing component count by requiring fewer inverters. It would also permit different sorts of sources (like photovoltaic panels and fuel cells) to share a single inverter, which is an advantage emphasized by Nishi. See [0115] ("a dispersed-power-source system of a hybrid type can easily be structured with low costs and without reduction of efficiency.")

16. The system of claim 15, in which the output of each of the said power inverters is single phase AC.

20. The method of claim 19, in which the output of each of said power inverters is single phase AC.

[00100] Kondo's inverters output single phase AC. Kondo says "each AC module 1 has a 100V single-phase output". [0025].

18. The system of claim 15 further comprising a first DC power source connected to one of said DC power input ports of one of said power inverters and a second DC power source different in kind from said first DC power source connected to another of said DC power input ports of said one power inverter.

24. The method of claim 19 further comprising: a) connecting a first DC power source to one of said DC power input ports of one of said power inverters; and b) connecting a second DC power source, different in kind from said first DC power source, to another of said DC power input ports of said one power inverter.

[00101] Nishi discloses providing DC power sources of different kinds to different inputs of power inverter, and it would be obvious to include this capability in the modified device of Kondo. In its first embodiment, Nishi discloses that solar panels arranged at different inclination angles will have different output voltage and different output power because they will experience different levels of irradiation. Specifically, Nishi observes that the south-facing panels shown in FIG. 1 (2A and 2B) will have higher output voltage and power than the east- and west-facing panels (2C and 2D). This is described at [0061]-[0063] and [0068]. Nishi summarizes “solar cell arrays 2A, 2B and solar cell arrays 2C, 2D are different in output voltage range output power range.” Nishi teaches (and shows in FIGs. 1 and 2) the outputs of all these different sorts of sources being provided to input ports of the same power inverter 4.

[00102] As I have already opined, this arrangement is advantageous because it allows maximum power point tracking on each panel, individually, to maximize overall power production, while sharing the same DC-AC inverter, thereby reducing overall cost as compared to providing multiple inverters as in Kondo. Nishi emphasizes this advantage of individual MPP tracking at [0072]-[0079]. At [0077], Nishi says specifically that its “control units 11A-11D each control the pulse width of PFM control signal so that the output power of respective solar cell arrays 2A-2D becomes maximum...” The person of ordinary skill would have been motivated to

incorporate the ability to take DC input from different sorts of sources because it enables the connection of panels experiencing differing illumination conditions, while maximizing power and reducing overall component count and cost. This capability is especially advantageous in a situation like that shown in FIG. 1, where rooftop solar panels are facing in different directions and experience different illumination levels. This situation is one that the person of ordinary skill would easily foresee while installing a solar system.

[00103] Additionally, in its second embodiment, Nishi teaches providing DC outputs from non-solar DC sources to the DC inputs of its shared inverter. In [0047], Nishi says “Additionally, the inverter apparatus and the dispersed-power-source system according to the present invention can be applied to a home power generation system that transforms a DC power from a plurality of DC power sources constituted of solar batteries, fuel cells, generators or the like into a commercial AC power and outputs this AC power to a household load, and that allows the AC power to reversely flow into the commercial power system.” This arrangement is shown in FIG. 6, where DC outputs from a number of solar panels (2A-2D) as well as a fuel cell 16 are provided to power inverter 4A, and then to DC-AC inverter 6. Nishi describes this: “In a second embodiment, a dispersed-power-source system of the hybrid type in which solar cell arrays and fuel cells are used as DC power sources is shown”. [0108].

[00104] As I set forth above and in connection with claim 15, the person of ordinary skill would have been motivated to modify Kondo's inverters to have multiple DC inputs, as shown in Nishi, to gain the advantage of being able to optimize power output of a collection of solar panels operating under unlike conditions. Additionally, the person of skill would have recognized the efficiency benefit of being able to share an inverter between solar cell and non-solar DC sources such as the fuel cell shown in FIG. 6 of Nishi. Nishi teaches the advantages of this type of "hybrid" system, when it states "a dispersed-power-source system of a hybrid type can easily be structured with low costs and without reduction of efficiency". [0115]. Also, Nishi teaches that providing an inverter capable of excepting inputs from unlike sources would have been a simple modification within the level of ordinary skill. Specifically, Nishi suggests that the only modification required to the arrangement of FIG. 1 is to provide a DC-DC converter with a different input voltage range for the fuel cell's DC converter 5E. (30-60V DC for the fuel cell versus 80-320V or 50-160V for solar panels). See [0066], [0111]-[0112].

23. The method of claim 19 where the providing of AC power includes producing a total AC power that is the summation of the AC power supplied by each said DC to AC power inverter.

[00105] In Kondo's daisy-chain arrangement of FIG. 1, the power of all the connected inverters is collected (i.e., summed), and provided to the grid (i.e., the "commercial use power system"). The combined power is summed onto "current

path” 9 shown in FIG. 3, which runs through all the connected inverters of FIG. 1 as an AC bus. Kondo makes this clear when it says “The DC power generated by the solar battery unit 2 is converted to AC power by the inverter unit 3, sent through the current path 8, collected together with the power, which is generated by other AC modules 1 and inputted from the input connector 5, then sent through the current path 9, and outputted to the output connector 6.” [0051]. This AC bus, that combines the current, and therefore the power, from all the connected AC modules and their inverters in the chain, is marked in red on FIG. 1 below.

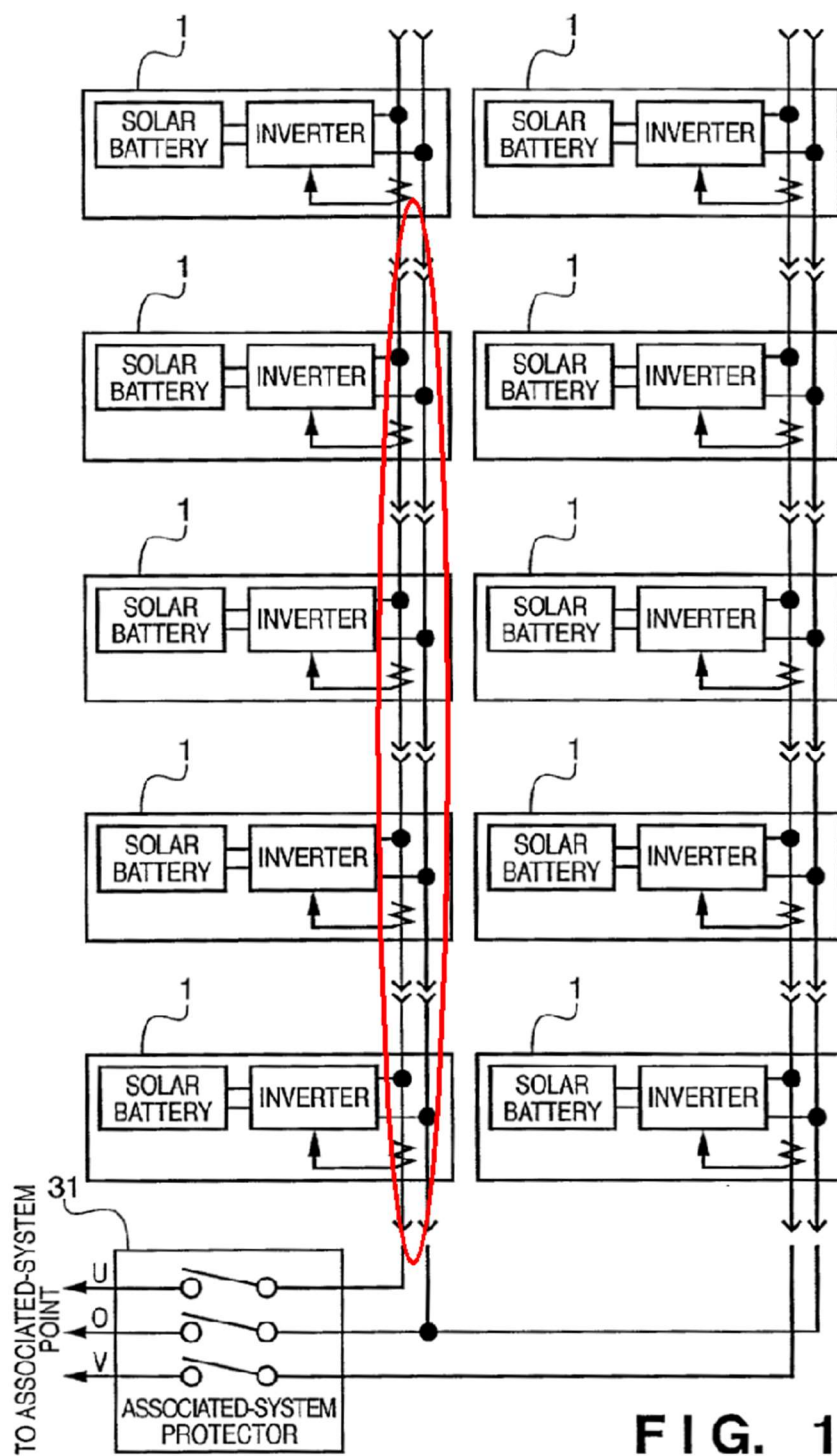


FIG. 1

[00106] Indeed, Kondo's innovation (providing each inverter with the ability to sense overcurrent and shut its inverter down) is to deal with a potential problem of

too much power being summed onto this bus, which might happen when illumination on the connected panels rapidly increases. FIG. 6 in Kondo shows the summation of AC current (i.e., power) contributed by all the connected inverters in the chain as sunlight on the panels increases. *See* [0053] (referring to the “collected current values of the AC modules 1 connected in common phase”) and [0056] (referring to the current added by each module contributing 0.9A). Since each AC module 1 has an output of 100V AC ([0025]), the summation of the currents shown in FIG. 6 shows a total AC power that is the summation of the AC power outputted by each module in the daisy-chain.

B. Ground 2: Kondo and Fornage

[00107] It is my opinion that claims 15–16, 18–20 and 22–24 of the ’133 patent are unpatentable because they are obvious over the combination of Kondo and Fornage. In this combination, I am again mentioning Kondo as the starting point, and pointing out that it would have been obvious to modify it with teachings from Fornage. In my analysis that follows, I will not repeat my analysis regarding Kondo’s disclosures that I set forth above under Ground 1. Specifically, as to claim elements 15p1, 19p, 15p2, 19a1, 15a1, 19a2, 15a3, 19a3, 15b1, 22(a), 15b2, 22(b), 15b3, 19c, 22(c), 15c, 16, 20, and 23, my opinion is that all these claim elements are disclosed in Kondo, for the reasons set forth above in Ground 1. I will now make some specific

observations about Fornage, how it applies to specific claim elements, and why combining it with Kondo would be obvious.

15a2: at least two DC power input ports coupled to the single DC-AC inverter,

19a4: and at least two DC input ports coupled to the single DC-AC inverter;

[00108] It is my opinion that Fornage discloses multiple DC input power ports connected to a single inverter. This arrangement is shown in FIG. 5, which shows multiple inputs marked “DC”, each of which is connected to a DC/DC boost circuit 508. The DC outputs of the boost circuits are combined on a DC bus 506, and the combined DC is provided to a DC/AC inverter (“DC/AC converter 510). See [0033]. The entirety of the arrangement of FIG. 5, which Fornage calls a “dual stage inverter” is usable as one of the inverters shown in FIG. 3. Fornage states, “FIG. 5 is a block diagram of an exemplary embodiment of a dual stage inverter 500 that may be used as an inverter 300 within a power generator 320 in accordance with the present invention.” [0032]. Thus, Fornage discloses a parallel connected inverter arrangement in FIG. 3, with multiple power inverters 300n, each of which may accept multiple DC inputs as shown in FIG. 5, and each of which includes a DC-AC inverter. See [0034] (“DC/AC converter 510...The DC/AC converter converts the DC to AC”).

[00109] It would have been obvious to incorporate Fornage's arrangement for providing multiple DC inputs to an inverter with Kondo's arrangement for daisy-chaining inverters through their AC outputs/inputs. This combination would involve modifying Kondo's DC-AC inverter (21 in FIG. 3) to accept DC input from more than one DC source (e.g., more than one solar cell or "solar battery", to use Kondo's term.) The POSA would have been motivated to incorporate Fornage's multi-input inverter arrangement because it permits the inverter to optimize the DC power output of more than one connected solar module or string of modules, while using the same shared inverter (510) and controller (512) (corresponding to Kondo's inverter 3 and control circuit 17 – see Kondo, [0036]-[0038]).

[00110] The advantage of and motivation for this modification, like the modification to Kondo discussed in Ground 1 earlier, is that it enables a plurality of connected solar panels (or segments of panels) to be operated at their respective maximum power points while sharing a single inverter, thereby reducing component count and cost. Fornage notes that for close packed installations like the sort shown in its FIG. 1, certain portions of solar panels will be shaded during certain times of the day. See FIG. 1 and [00018] ("The shaded-areas 106₁ and 106₂ are subjected to a shadow from a neighboring panel and are exposed to less light; thus, the shaded areas 106₁ and 106₂ may produce less DC than the areas exposed to direct sun.") This means that different portions of a panel will have different maximum power

points depending on the level of illumination. See [0018] (“the cells in the lit-area 104₁ have a different MPP as compared to the MPP of the cells in the shaded area 106₁.”) Also, panel specific factors such as “temperature, incident light level and aging” and “manufacturing tolerances” will impact the MPP of an individual solar cell array. [0007]. Fornage’s solution to these problems is to do MPPT on each connected panel individually, or each panel segment such as a row of cells, so that “a maximum amount of power can be extracted from the panel when fully illuminated or when shaded.” [0018]. Fornage’s multi-input architecture of FIG. 5 accomplishes this by driving each panel or panel segment connected to a DC input at its MPP by appropriately controlling DC to DC boost circuits with a controller. See [0033] (“A Controller 512 provides an individual control signal to each boost circuit 508 to ensure that the rows of cells coupled thereto operates [sic] at the row’s MPP.”) [0033].

[00111] Also, Fornage teaches the person of ordinary skill that its multi-input capability provides for a more flexible and scalable system, where the user could add panels without having to add inverters. Fornage highlights this scalability advantage in describing the system of FIG. 3, which recall includes the multi-input inverters of FIG. 5, as “scalable and flexible to fit any user’s needs.” [0025]. Kondo also recognizes the advantage of flexibility and scalability when Kondo highlights the advantage of its system which “enables to increase the number of parallel-

connected AC modules by sequentially repeating cascade connection.” [0003] and see [0004] (“enables easy parallel connection of plural AC modules by way of cascade connection”). In view of these teachings, the person of ordinary skill would recognize the advantage of scalability, and would also realize that additional scalability could be provided in Kondo’s system with the addition of Fornage’s multi-input inverter.

[00112] Incorporating Fornage’s shared inverter arrangement into the inverters of Kondo would be a simple substitution of one known element for another, yielding predictable results. Kondo, like Fornage, already provides for one DC input (18 in FIG. 5), a DC/DC boost converter (“boost circuit 12”), a controller (“control circuit 17”) for performing MPPT. See Kondo, [0036] (“At this stage, the control circuit 17 performs the well-known optimum operation point tracking control based on DC current 22 and DC voltage 23). Incorporating Fornage’s shared inverter arrangement into Kondo would simply involve providing additional DC inputs and additional boost circuits controlled by Kondo’s existing controller (or separate controllers) and then collecting the total DC output of the boost circuits on a DC bus (Fornage, FIG. 5, 506 described at [0033]), and providing it to Kondo’s inverter (13 in FIG. 5, see [0036]). This modification would be, essentially, a simple wiring problem, which is within the skill of the person of ordinary skill.

15b3: and the AC power output port of the last power inverter being connected to a power service panel of the power grid;

19c: c) providing AC power to the power grid.

22(c): and the AC power output port of the last DC to AC power inverter being connected to a power service panel of the power grid.

[00113] As I set forth above in my opinions regarding Kondo in Ground 1, Kondo already includes these elements, when it discloses connection “commercial-use power system” through a system protector 31, as shown in FIG. 1 and described in [0026]. However, if Kondo does not explicitly disclose a power grid or power service panel, it would have been obvious to connect Kondo’s system, as modified with Fornage’s multi-input inverters, to a grid through a power service panel. This sort of connection is disclosed in Fornage (POWER GRID 312 and ELECTRIC PANEL 306 in FIG. 3). The person of ordinary skill would understand that connecting a photovoltaic installation to the grid through a service panel was advantageous because it would enable the solar system to be used to power appliances (316 in FIG. 3) through the service panel, and also, to sell power back to the utility by supplying it to the grid. Fornage describes this at [0027].

15c: c) whereby said system is incrementally scalable by adding or subtracting DC power sources and daisy-chained inverters.

[00114] As I note above in Ground 1, Kondo is already incrementally scalable by adding or subtracting DC power sources and daisy-chained inverters. Kondo allows AC modules, which include both a DC power source (“solar battery”) and an inverter to added to subtracted to its daisy chain topology. See FIGs. 1 and 2, [0003], [0004]

(referring to “easy parallel connection of plural AC modules by way of cascade connection”) and Kondo’s Abstract (“AC module, integrating a solar battery and an inverter, can easily be connected with other plural AC modules in parallel by way of cascade connections.”)

[00115] Fornage’s system, again shown in FIGs. 3 and 5, is also incrementally scalable. In those two figures Fornage discloses a system where any number of inverters n are coupled together in parallel along an AC bus 314. Fornage says “The inverters $300_1, 300_2 \dots 300_n$ couple the output AC to an AC bus 314.” [0025]. Fornage continues, “Using such an AC bus **314** and discrete power generators **320_N**, the system **100** is scalable and flexible to fit any user's needs. The structures of the inverters **300₁, 300₂ . . . 300_n** are discussed below (See FIG. 5 and FIG. 6).” [0025]. So, Fornage discloses a “scalable and flexible” system by which an arbitrary number of inverters can be added or subtracted from an AC bus. Fornage also discloses that any of its inverters can be a multi-input inverter of the sort shown in FIG. 5. See [0032]. In describing FIG. 5’s multi-input inverter, Kondo says that it can have an arbitrary number of boost circuits 508: “The first stage [of inverter 500] comprises a plurality of boost circuits 508, which include $508_1, 508_2 \dots 508_n$ ”. [0033] and see [0034] (“In this embodiment, the boost circuits $508_1, 508_2 \dots 508_n$ share a single DC/AC converter 510.” Each of Fornage’s boost circuits 508 is connected to a DC source: “The boost circuit 508 receives DC from a DC source, such as, rows 404,

columns 406, solar cell 402.” [0033]. From this I conclude that Fornage is teaching the person of ordinary skill that an arbitrary number (n) DC sources (i.e., PV panels) may be connected to the inverter of FIG. 5, which is to say that DC sources may be added and subtracted. Fornage confirms this in paragraph [0023] when it says “the system 100 may include any number of the photovoltaic panels 102”. My conclusion here is further confirmed by Fornage’s teaching that its system is “scalable and flexible”.

[00116] In my opinion, it would have been obvious to enhance Kondo’s scalability with Fornage’s additional ability to add or subtract strings of panels to a single inverter. Such a modification would be motivated by Fornage’s interest in a system that is “scalable and flexible”. Fornage’s multi-input inverter adds an additional level of scalability to Kondo’s parallel, daisy-chain inverter arrangement, and enables a user to add panels as needed, without having to add an additional inverter. If more generation capacity is needed, additional inverters can be added. As I set forth above, the desirability to scale up a system with more panels as a user’s needs grow was already recognized in the art, for example, in Kjaer, pg. 1296.

[00117] Additionally, I would note that this additional scalability would be inherent after incorporating Fornage’s multiple input functionality into Kondo’s inverters. As I set forth above, one reason to do this would be make a system that allows MPPT on individual panel connections while sharing an inverter having multiple inputs.

Such a system is inherently scalable because panels can be plugged into or removed from the inverter as needed. It would just be a matter of connecting or disconnecting inverters to the DC inputs already shown in Fornage's FIG. 5.

C. Ground 3: Fornage and Kondo

[00118] It is my opinion that claims 15–16, 18–20 and 22–24 of the '133 patent are unpatentable because they are obvious over the combination of Fornage and Kondo. In Ground 2 earlier, I explained why the person of ordinary skill would have been motivated to modify Kondo's daisy-chained inverters so that its inverters had multiple DC inputs, as shown in Fornage. Here, I explain why it would also have been obvious to go the other direction. The person of ordinary skill starting with a parallel arrangement of multi-input inverters, which Fornage discloses in FIGs. 3 and 5, would also have found it obvious to daisy-chain those inverters together through AC input and output ports, as taught by Kondo. One motivation for this modification would be to take advantage of Kondo's ability to detect and address overcurrent conditions, which is possible when the combined AC bus is routed through the inverters as shown in Kondo. I will now address each of the claim limitations in turn.

15p1: A scalable DC to AC power inversion system for providing AC power to a power grid

19p: A method of making a DC to AC power conversion system incrementally scalable, comprising:

[00119] As I discuss in Ground 2, 15c above, Fornage discloses an incrementally scalable system, in that Fornage contemplates connecting an arbitrary number of inverters in parallel on an AC bus (as in FIG. 3), and also an arbitrary number of DC sources to each inverter, as shown in FIG. 5. Fornage explicitly says that its system is “scalable and flexible to fit any user’s needs”. [0025] Fornage also discloses that it’s system supplies power to the grid. See [0026]-[0027].

15p2: from a plurality of individual DC power sources each having a DC power output port, comprising:

19a1: a) providing a plurality of DC power sources

[00120] As I note above, Fornage’s system includes a plurality of DC power sources, namely, the photovoltaic panels 102n shown in FIG. 3, and the panels that would be connected to the DC inputs (“DC”) shown in FIG. 5. See [0023]-[0024]. Each of those panels would have some DC output port capable of being plugged into the inverters shown in FIG. 3 and the DC inputs shown in FIG. 5. I would note here also that Kondo discloses that its photovoltaic panels (“solar batteries”) have an “electrode” that provides DC out. See Kondo, [0031]. To the extent that some sort of explicit disclosure of a structure that provides DC power out of the solar panels is required, it would have been obvious to incorporate Kondo’s electrode to allow power to be obtained from the solar panels.

15a1: a) a plurality of power inverters, each of said power inverters including a single DC-AC inverter,

19a2: and a plurality of DC to AC power inverters, said DC to AC power inverters each having a single DC-AC inverter,

[00121] Fornage discloses a plurality of power inverters (inverters 300_n, shown in FIG. 3), which are described in [0022] and [0024]-[0025]. Each of Fornage's power inverters 300 includes a single DC-AC inverter, DC-AC Converter 510, or alternatively, second inverter stage 504, both shown in FIG. 5. See [0032] (explaining that FIG. 5 depicts a two-stage inverter than can be used as the inverters 300 of FIG. 3), [0033] ("The second stage 504 comprises a DC/AC converter 510") and [0034] (describing how the shared DC-AC Converter 510 converts DC to AC). The person of ordinary skill would understand that both second stage 504 or its included DC-AC Converter 510 are DC-AC inverters because they convert DC to AC. Note that the '133 patent speaks of "inverters" broadly as devices that convert AC to DC. See '133 patent, 1:7-10 ("The subject of this patent relates to direct current (DC) to alternating current (AC) power inverters that invert DC power from single or multiple DC power sources to single-phase or three-phase AC power...")

15a2: at least two DC power input ports coupled to the single DC-AC inverter,

19a4: and at least two DC input ports coupled to the single DC-AC inverter;

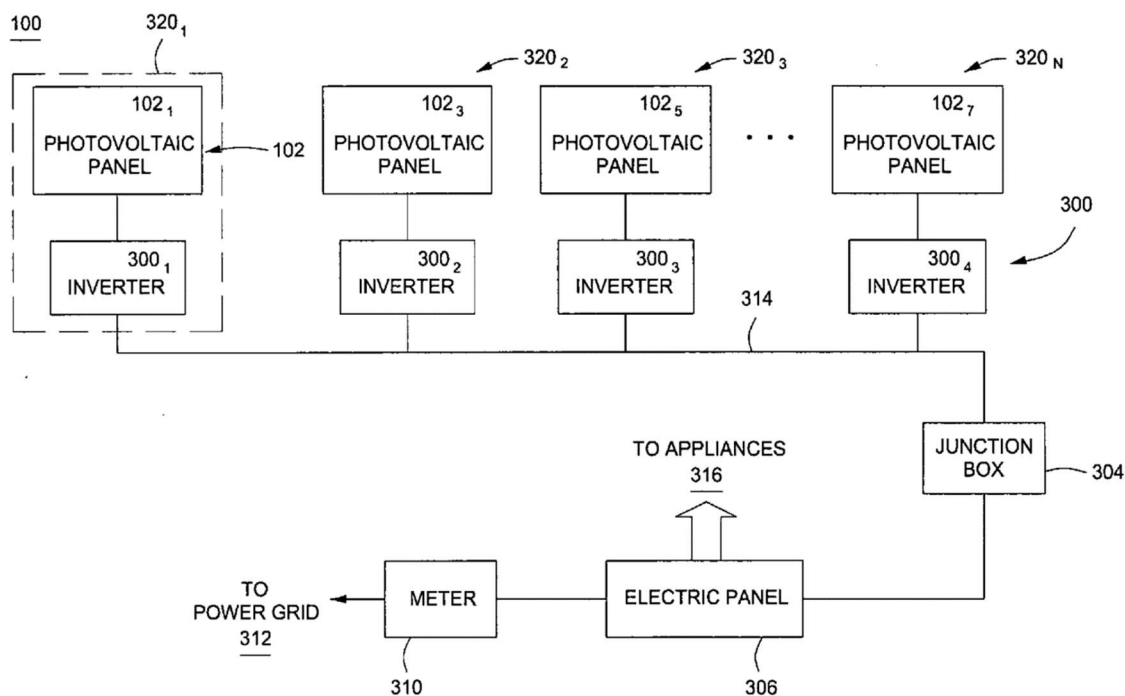
[00122] Fornage's power inverters (300 in FIG. 3 and 5) contain at least two DC input ports coupled to the single DC-AC inverter. Looking at FIG. 5, one sees 4 DC

input ports, marked “DC”, but as I set forth above, Fornage contemplates an arbitrary number of DC sources and connected boost circuits 508. These input ports are connected via DC bus 506 to the single DC-AC inverter, 504/510, which outputs AC. See [0033] and [0034].

15a3: an AC power input port, and an AC power output port coupled to the single DC-AC inverter,

19a3: an AC input port coupled to the single DC-AC inverter, an AC output port coupled to the single DC-AC inverter,

[00123] In my view, Fornage already discloses a daisy chain inverter arrangement. Referring to FIG. 3 (below), Fornage shows each inverter connected in parallel to the next inverter, where each inverter’s AC power output is combined on an AC bus 314. Fornage says “The inverters $300_1, 300_2 \dots 300_n$ couple the output AC to an AC bus 314.” [0025]. This arrangement necessarily requires that each of Fornage’s inverters include at least an AC output, and indeed, such an output is marked “AC” as coming out of DC-AC inverter (converter 510), shown in FIG. 5.



[00124] In my opinion, it would have been obvious to modify Fornage's arrangement shown in FIGs. 3 and 5 such that every inverter had an AC input port and an AC output port, such that the AC bus essentially runs through every inverter, all as shown in Kondo. As I explain above, Kondo, in connection with FIGs. 1-6, shows a daisy-chained inverter arrangement where inverters are connected through AC input/output ports. Referring to Kondo's FIG. 3, the modification to Fornage's arrangement of FIG. 3 would be to route the bus through each inverter, such that Fornage's AC bus 314 runs along Kondo's "conduction path" (7 and 9 in FIG. 3). This modification would involve providing each of Fornage's inverters 300 with an AC input port and AC output port (5,6) as shown in Kondo's FIG. 3.

[00125] There are several scalability reasons why the person of ordinary skill would have been motivated to make this modification. First, providing AC input and output ports would have been a straightforward way to permit the user to scale the system by plugging additional inverters into a chain as shown in Kondo. Kondo says that its daisy-chain arrangement allows for easy chaining of inverters, through AC input and output ports. This is shown above in Kondo's FIG. 2 and Kondo emphasizes that its arrangement allows inverters to be connected "easily": "AC module, integrating a solar battery and an inverter, can easily be connected with other plural AC modules in parallel by way of cascade connections." Kondo, Abstract. Incorporating Kondo's easy inverter connection scheme would make the addition of more inverters easy, and would advance Fornage's interest in a system that is "scalable and flexible to fit any user's needs". [0025]

[00126] Additionally, the person of ordinary skill would have been motivated to do this to solve the overcurrent problem that is recognized in Kondo. As I explain above in my overview of Kondo, Kondo is concerned with what happens when an installation has too many inverters in a string, or when the amount of sunlight on the inverters quickly increases. Under these conditions, the amount of current on an AC bus may exceed a maximum rating, and the result is complete disconnection of the solar system from the grid. See Abstract and [0004] (discussing overcurrent conditions where there is an "improvident increase of the number of connections");

[0057] (describing over current when “insolation [i.e., the amount of sunlight] becomes extremely intense); and [0057] (describing prior art configurations “where the associated-system protector 31 [i.e., a breaker] detects an over current and disconnects the switch therein”).

[00127] I acknowledge that when Kondo discusses overcurrent conditions in paragraph 0004, it may be contemplating an arrangement of daisy chain inverters that that already have AC input and output ports. However, the person of ordinary skill would appreciate that combining the outputs of inverters onto an external AC bus (like bus 314 of Fornage) has the same risks of overcurrent. Bus 314 in Fornage would necessarily have some maximum current rating, and connectors on that bus (e.g., to form connections at the junction box 304, the service panel 306, the meter 310, etc.), would also have maximum current ratings. So, it is my opinion that the person of skill would appreciate that Kondo’s teachings of the risk of too much current being supplied to an AC bus would apply to situations where the bus was external to the inverters (as in Fornage), just as they apply to an internal bus (as in Kondo). In short, the person of ordinary skill would understand that the current generated by the inverters must go somewhere, regardless of whether the bus is internal to the inverters or external, and so an overcurrent condition is a problem in either configuration.

[00128] As I explain above, in view of Kondo's teachings of the risk of too much current being supplied by connected inverters, the person of skill would have been motivated to adopt Kondo's solution to the problem, which is to bring the AC bus through each connected inverter assembly shown in Fig 1 so that each inverter can measure its current and combination of currents from other inverters contributing to the accumulated current on the bus with an overcurrent detector (element 27 in Kondo's FIG. 3, described at [0042]-[0046]). As Kondo describes in those paragraphs and in connection with FIG. 6, and as I discuss above, the inverter closest to the panel connection using its overcurrent detector, compares the accumulated current on the bus to a reference ("reference value" set by circuit 25, which may be at or below the maximum current rating of the bus itself, "conduction path" 9). See [0044]-[0045] ("The reference current setting circuit 25 sets a reference value to be compared with the current value, detected by the current detector 4...Note in the following description, the rated value of the output connector 6 and the current path is set as the reference value.") As is described in connection with FIG. 6, if the amount of current on conduction path 9 (i.e., the portion of the AC bus running through each inverter) exceeds the reference, the inverter detecting the overcurrent condition shuts off, so that it is no longer adding current to the bus. See [0055] (discussing the "inverter halt signal" sent when current above 4.5A is detected).

[00129] As I explain above, this system has a number of advantages. It permits the user to install many inverters without the risk of overcurrent, even under changing irradiation conditions. Additionally, as Kondo points out, this system allows the photovoltaic generation system to stay connected to the grid, with some subset of the inverters producing a total power associated with a current near the maximum rating of the system. Only some inverters need be shut down, since only those inverters are adding excess current. So, the entire system stays connected, and keeps producing power, under a variety of illumination conditions. Kondo recognizes this at [0057]: “even in a case where a sudden increase is found in insolation, AC modules 1 other than the one closest to the associated-system point can continue their operation because power conversion of the AC module 1 is halted sequentially from the one closest to the associated-system point”. Again, as Kondo recognizes, this is an advantage over prior art systems where the entire generation system is disconnected from the grid if current gets too high. See [0057] (contrasting with prior art system: “Unlike the configuration where the associated-system protector 31 detects an over current and disconnects the switch therein”).

[00130] For the reasons just stated, and in view of Kondo’s disclosure, the person of ordinary skill would recognize that Fornage’s system of parallel connection of inverters along an external AC bus was ready for improvement to address the risk of too much current, and that it could be improved with Kondo’s system. Kondo’s

system addresses the problem by bringing the AC bus through each inverter, where the total current (including the current being added by any given inverter) could be measured with an overcurrent detector, like that shown in Kondo. This sort of measurement is made easy and simple by routing the bus through each inverter using AC inputs and outputs. In this configuration (Kondo's) each inverter can sample current and shut itself off if it determines that its contribution will push the total current on the bus over the limit. This sampling and corrective action cannot be achieved in the configuration of Fornage's FIG. 3, where the AC bus is external to the inverters, and the inverters are simply pushing current onto the bus. In this configuration, the inverters do not know how much current the bus is carrying, and corrective action would have to be taken at some other point, such as Fornage's junction box 304, electric panel 306 or meter 310. While the entire AC feed in the bus could be disconnected from the grid at these points (as discussed in connection with Kondo's associated-system protector), that has a disadvantage in that the system would no longer be supplying any power to the grid. Kondo's configuration eliminates this disadvantage, and so, the person of ordinary skill would be motivated to improve Fornage by using it.

[00131] I would emphasize here again that modifying Fornage's FIG. 3 external bus configuration with Kondo's internal bus arrangement would also further Fornage's interest in a system that is "scalable and flexible to fit any user's needs".

Fornage, [0025]. Kondo's daisy chain arrangement with current monitoring enables inverters to be added without concern that the system will be shut down entirely in the event of overcurrent produced by high light conditions. Scaling Kondo's system is also simple as a matter of wiring - additional inverters can simply be plugged into inverters already connected to the grid. Also, recall that Fornage expresses a general interest in efficiency and maximizing power generation. See Fornage, [0020]. This is common sense – the person of ordinary skill would want their system operating at maximum power and efficiency, so that they had the lowest or no-cost electricity they could have. Modifying Fornage with Kondo's configuration results in more power generation and less down-time because it keeps the system connected to the grid operating at near-maximum current, which allows for more power to be used to drive household loads and/or sold back to the grid.

[00132] Finally, I would note here that modifying Fornage with Kondo as I have proposed would be simple, predictable, and well within the level of skill of the person of ordinary skill. Kondo provides blueprint for the modification in FIGs. 1-3. Fornage's external bus of FIG. 3 would simply be modified such that the bus ran through each inverter in the chain, as shown in FIGs. 1–3 of Kondo. This could be accomplished by adding Kondo's AC input and output ports and current paths (7 and 9) to the second stage (504) shown in Fornage's FIG. 5. The POSA would also add Kondo's overcurrent detector 27, such that Fornage's existing controller 512 was

directed to stop the inverter from producing power if the current on the internal bus portion exceeded a reference.

15a4: each of said DC power input ports having one DC power source connected thereto;

19b1: b) connecting at least one of said DC power sources, respectively, to each of said DC input ports; and

[00133] As I explained above, Fornage shows four DC input ports to its inverter, marked “DC” in FIG. 5, any of which may be attached to a DC power source (panels 102n), as shown in FIG. 3. Fornage says “The boost circuit 508 receives DC from a DC source, such as rows 404, columns 406, solar cell 402, portions thereof and the like.” [0034].

15b1: b) said AC power output port of each power inverter being connected in a daisy-chain to the AC power input port of the next power inverter,

22(a): The method of claim 19 further comprising daisy-chaining at least two of said DC to AC power inverters, said AC power output port of each DC to AC power inverter being connected in a daisy-chain to the AC power input port of the next DC to AC power inverter,

[00134] As I explain above, Kondo discloses a daisy-chain arrangement of inverters with each inverter’s AC output port connected to an AC input port of the next inverter. This arrangement is shown in FIGs. 1-6 of Kondo, and particular in FIGs. 1-3. For the reasons explained above, it would have been obvious to modify Fornage’s arrangement of FIG. 3 with Kondo’s daisy chain arrangement in order to

bring the bus through each inverter, such that each inverter could measure the total current on the bus to sense and correct an overcurrent condition.

15b2: except for the AC power input port of the first power inverter being left open,

22(b): except for the AC power input port of the first DC to AC power inverter being left open,

[00135] In my opinion, Kondo discloses this element, and it would have been obvious to add to Fornage. In Kondo's arrangement, every inverter has an AC input and an AC output. For the reasons stated above, this arrangement would have been obvious to use to modify Fornage's arrangement of inverters connected along an AC bus. In such an arrangement, the upstream most inverter (i.e., inverter 300₁ in Fornage's FIG. 3) would necessarily have an open AC input port. Kondo makes this clear in [0048], where the first input connector 5 of the first AC module in the cascade of FIG. 1 is described as "unconnected". This is actually shown in FIG. 2 of Kondo where the uppermost inverters (e.g., the one at the top left) has an open AC input port that is not connected to anything. Again, this is a natural consequence of Kondo's advantageous way of connecting inverters, and it would be present in the combination of Kondo and Fornage. The only reason this would not be the case is if the first (most upstream) inverter was different in kind than other inverters, but the person of ordinary skill would have no reason to do this as it would be more

expensive, would add needless complexity, and would be counter to Fornage's interest in easy flexibility and scalability.

15b3: and the AC power output port of the last power inverter being connected to a power service panel of the power grid;

19c: c) providing AC power to the power grid.

22(c): and the AC power output port of the last DC to AC power inverter being connected to a power service panel of the power grid

[00136] As I noted in Ground 2, above, Fornage discloses this limitation. FIG. 3 shows the last inverter in the chain (300₄ in FIG. 3) connected to the power grid 312 through a service panel 306. See Fornage, [0022] and [0027]. I also agree with the Examiner of the '133 patent that connecting a photovoltaic generation system to the electric grid through a service panel is generally known in the art and would be obvious to add to any solar generation system where there was an interest in supplying power to household loads and selling surplus power to the grid. See Fornage [0027].

15c: c) whereby said system is incrementally scalable by adding or subtracting DC power sources and daisy-chained inverters.

[00137] As I explained above and in Ground 2, Fornage already discloses that its system is "scalable and flexible". [0025] And indeed, in Fornage's system, solar panels may be added to or disconnected from the multiple DC inputs shown in FIG. 5, and inverters can be added to or disconnected from the AC bus 314 shown in FIG. 3. Fornage is explicit in saying that its system can accept any number of DC sources

(e.g., solar panels) and any number of inverters. See [0032] (“system 100 may include any number of inverters 300...”) and [0017] (“Although three panels are shown, the photovoltaic panel system 100 may include any number of panels 102.”) The addition of the overcurrent protection scheme from Kondo actually enhances Fornage’s flexibility and scalability because it guards against a problem that may occur if too many inverters are added to the chain.

16. The system of claim 15, in which the output of each of the said power inverters is single phase AC.

20. The method of claim 19, in which the output of each of said power inverters is single phase AC

[00138] Fornage says that its inverters will supply output in whatever phase is used by the connected AC grid. Fornage says “The inverters **300** of the present invention may produce current that is in-phase with the AC grid current and generate such current with low distortion.” [0024]. Kondo says that its inverters output single phase AC. Kondo, [0025]. The person of ordinary skill would understand that if the grid was supplying single phase AC, the photovoltaic system would supply single phase AC in order to sync to the grid 312 and to drive the loads connected to Fornage’s electric panel 306. Rotzoll ’654, which I will discuss further below in Ground 4, teaches that “Residential systems commonly utilize single phase AC, while commercial systems most often use three phase AC.”) [0007]. So, if the

person of ordinary skill was configuring Fornage's system to interface with residential loads, it would output single phase AC, and if it were interfacing with industrial loads, or the high voltage, transmission sections of the grid, it would output three phase AC. Both are possible and within the level of ordinary skill. Indeed, Kjaer, whom I cite above, depicts in FIG. 3 (above) that a multi-input, inverter of the sort depicted in Fornage can output 1 or 3 phase power. I also agree with the Examiner of the '133 Patent who took official notice that it was known in the art and obvious to generate single or three phase power depending on the needs of the connected grid or load.

18. The system of claim 15 further comprising a first DC power source connected to one of said DC power input ports of one of said power inverters and a second DC power source different in kind from said first DC power source connected to another of said DC power input ports of said one power inverter.

24. The method of claim 19 further comprising: a) connecting a first DC power source to one of said DC power input ports of one of said power inverters; and b) connecting a second DC power source, different in kind from said first DC power source, to another of said DC power input ports of said one power inverter

[00139] Fornage discusses different-in-kind DC sources being connected to its multi-input inverter (shown, e.g., in FIG. 5). Fornage says that photovoltaic cells have different Maximum Power Points due to “temperature, incident light level and aging” and “manufacturing tolerances” such that “all solar cells have slightly different characteristics that vary the MPP from cell to cell”. [0007]. In particular,

Fornage discloses a condition where certain rows of individual solar cells on a panel will be shaded by adjacent panels, so that, on a given panel, some rows will be fully irradiated and others will be shaded. This is discussed at [0017]-[0019]. Fornage also says that the panels described in the embodiment of FIG. 3 may be “of any size or shape”. [0023] By providing multiple DC inputs to an inverter, Fornage’s system can optimize production of various areas of the panel (e.g., rows of cells) by operating each row at its specific MPP: “each inverter is controlled to bias the inverters associated row of cells at the Maximum Power Point (MPP) for the row. In this manner, as the MPP varies for rows that are shadowed, the optimal bias may be applied to rows in full sun and rows in shade.” [0031].

23. The method of claim 19 where the providing of AC power includes producing a total AC power that is the summation of the AC power supplied by each said DC to AC power inverter.

[00140] In Fornage’s system, shown in FIG. 3, the AC power outputs of all inverters are collected, i.e., summed together, on the AC bus 314, where the combined power is fed to the junction box 304. Fornage says “The junction box 304 generally connects together the outputs from all the inverters $300_1, 300_2 \dots 300_n$ to form a single AC feed to the electric panel 106.” [0026]. This summation of power is a necessary consequence of Kirchoff’s current law, which requires that the current be added together. The same result would occur in the Fornage’s FIG. 3, as modified by Kondo, it is just that the current (and therefore the power) from all inverters is

added to an internal, rather than an external bus). As I note above in Ground 1, Kondo discusses this accumulation of current (and therefore power) in connection with FIG. 6, which shows the currents from all connected inverters being added onto the internal bus.

D. Additional Opinions Regarding Nishi and Kondo.

[00141] In my opinions regarding Ground 3, above, I focus on the combination of Fornage’s multiple-DC input inverter with Kondo’s daisy chained inverter, using AC inputs and outputs. It is my opinion that any other multiple, DC-input inverter could also be combined with Kondo in the same manner as Fornage. For example, Nishi, discussed above in Ground 1, also discloses a multiple input inverter. It would have been just as obvious to combine Nishi and Kondo, with Nishi as the starting reference, to result in a system having the claim elements discussed above in Ground 3. The motivation here would be the same – to provide Kondo’s method for detecting and stopping an overcurrent condition, and to add additional scalability to Nishi.

E. Opinions Regarding Claims 17 and 21.

[00142] Claims 17 and 21 correspond to claims 16 and 20, but claims 17 and 21 recite “the output of each of said power inverters is three-phase AC”. In my opinion, these claims are obvious for the same reasons 16 and 20 are obvious, which I set forth above, in Ground 3. As the Examiner indicated in the file history, the phase of

the AC output of an inverter can be single phase or three phase, in order to match the phase of the grid or to drive loads (e.g., appliances) with electricity of the appropriate phase. As Kjaer demonstrates in FIG. 3 (above) it was known in the art to provide a multi-input inverter that could output one or three-phase AC power. U.S. Patent Publication No. 2009/0000654 (“Rotzoll ’654”) confirms that single and three phase power are in common use, for residential and commercial systems, respectively: “Residential systems commonly utilize single phase AC, while commercial systems most often use three phase AC.”. Rotzoll, ’654, [0007].

[00143] Rotzoll ’654 discloses a solar inverter system in FIG. 6 (below), which is very similar to multi-string/multi-input inverter systems discussed above from Nishi and Fornage. In Rotzoll ’654’s system, a power inverter (marked 620 and labeled “Distributed Inverter” on FIG. 6, and see [0063] calling a corresponding structure a “distributed inverter”) is provided. Multiple DC sources (PV Modules, 602), are connected through multiple “DC output wire[s]” (605, 606 and 615, 616 and) to a DC-AC inverter 624. See Rotzoll, ’654, [0064]. The AC output of inverter 624 is connected to “Other Inverters” through AC wiring 625 (i.e., an AC bus, like that shown in Fornage, FIG. 3). See Rotzoll, ’654, [0066].

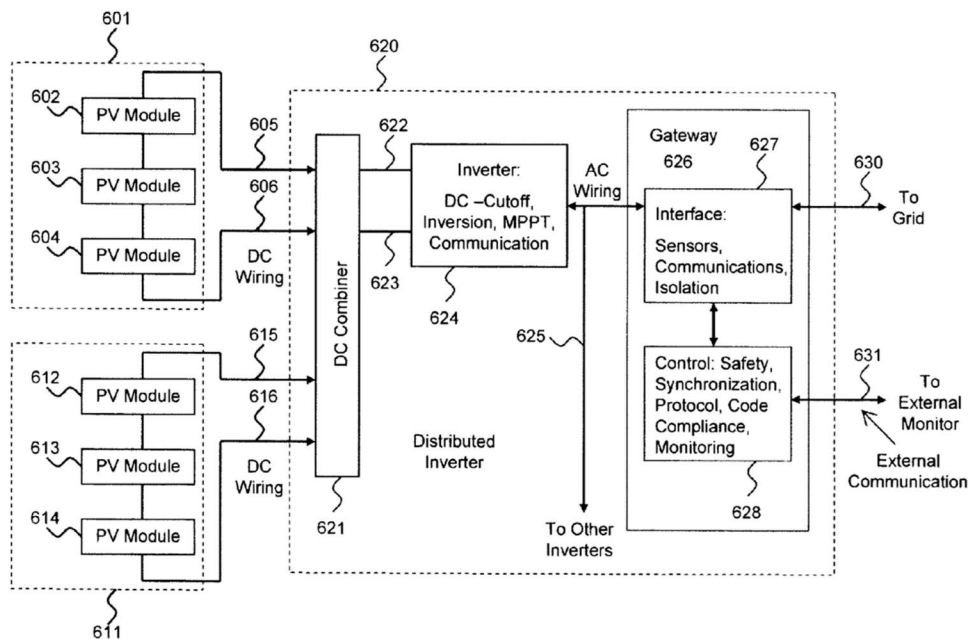


FIG. 6

[00144] Throughout the patent application, Rotzoll '654 emphasizes that its inverters can produce AC output power with any appropriate phase. The application says “Without loss of generality, the output of the microinverters can be single-phase AC, split-phase AC or multi-phase AC.” [0071]. The application also says “The power inversion unit converts DC power from the associated PV module to AC power. The AC power may be generated in single-phase or multi-phase form.” The application also says “A multiphase microinverter has the additional advantage of delivering substantially balanced multiphase AC power.” [0011].

[00145] In my opinion, the person of ordinary skill would understand, in light of these disclosures, that solar inverters of the sort disclosed in Rotzoll '654 could output three-phase power (which is a species of multi-phase power) as an alternative to single-phase power. This means that it would have been obvious to modify or configure any of the art combinations discussed above, including the ones in Grounds 1-3, to output three-phase AC power instead of single-phase AC power. The person of ordinary skill would have been motivated to make such a modification if the system were being designed for an industrial setting where three-phase equipment was being used, and/or for supplying a three-phase electric grid. As Rotzoll '654 says, "Residential systems commonly utilize single phase AC, while commercial systems most often use three phase AC." [0007].

[00146] Additionally, this would have been an easy modification, having predictable results, that would have been well within the skill of the person of ordinary skill. As Kjaer, above, demonstrates, it was known to provide solar inverters that could output either three-phase or single-phase power in architectures similar to the one of the '133 patent. Indeed, Rotzoll '654 shows, in FIG. 6, a multi-input inverter connected to an AC bus, while discussing three-phase output and its advantages. Accordingly, I conclude that the person of ordinary skill could easily make this modification, simply by including a three-phase AC inverter in the combination.

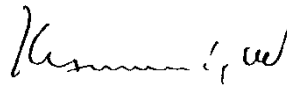
F. Secondary Considerations of Nonobviousness.

[00147] I understand that the Patent Owner has not submitted any evidence of secondary considerations of nonobviousness yet in this proceeding or in connection with this dispute generally.

[00148] I reserve the right to supplement my opinion if the Patent Owner provides exhibits or arguments related to secondary considerations in this proceeding.

[00149] The undersigned declares that all statements made herein of his own knowledge are true, and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under §1001 of Title 18 of the United States Code. I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

Executed on: Dec 21, 2023

A handwritten signature in black ink, appearing to read "K. M. ...", is written above a horizontal line.

APPENDIX 1

APPENDIX 2

APPENDIX 3

List of Materials Considered

I have reviewed the following materials to prepare this report:

- a. United States Patent No. 8,786,133 to Cheng *et al.*
- b. File History of the '133 Patent
- c. Fornage (2009/0020151)
- d. Rotzoll '118 (2008/0283118)
- e. Kondo (2002/0038667)
- f. Nishi (2005/0105334)
- g. Rotzoll '654 (2009/0000654)
- h. Kjaer (A Review of Single-Phase Grid-Connected Inverters for Photovoltaic Modules, Kjaer, Pedersen and Blaabjerg, IEEE TRANSACTIONS ON INDUSTRY APPLICATIONS, VOL. 41, NO. 5, SEPTEMBER/OCTOBER 2005)
- i. United States Patent No. 9,331,489