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Karlgaard

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(54) **MULTI-PORT METER**

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G01R 21/00 (2006.01)
G01R 22/06 (2006.01)

(52) **U.S. Cl.**

CPC ***G01R 21/07*** (2013.01); ***G01R 21/007*** (2013.01); *G01R 22/06* (2013.01)

(58) **Field of Classification Search**

CPC G01R 21/07; G01R 21/007; G01R 22/06
USPC .... 324/140 R
See application file for complete search history.

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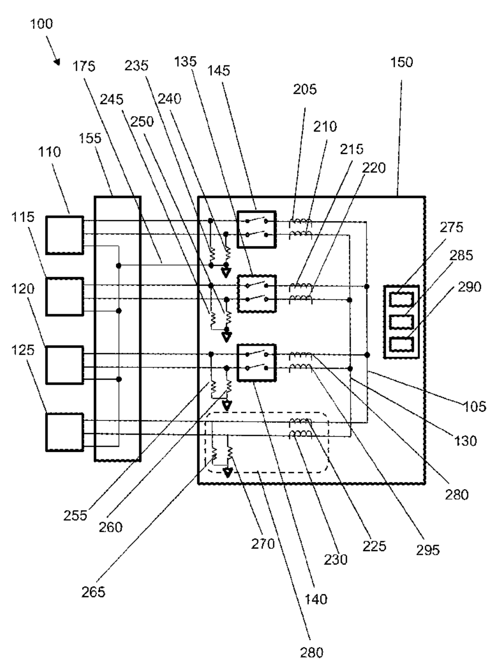
(57) **ABSTRACT**

An electric meter is disclosed. The electric meter comprises a first set of conductive paths configured to connect a first phase of an electric distribution power source, a first phase of a first distributed energy resource device, a first phase of a second distributed energy resource device, and a first phase of a load. The electric meter comprises a second set of conductive paths configured to connect a second phase of the electric distribution power source, a second phase of the first distributed energy resource device, a second phase of the second distributed energy resource device, and a second phase of the load. Also disclosed is a method of use of the electric meter and an electric meter system.

14 Claims, 3 Drawing Sheets



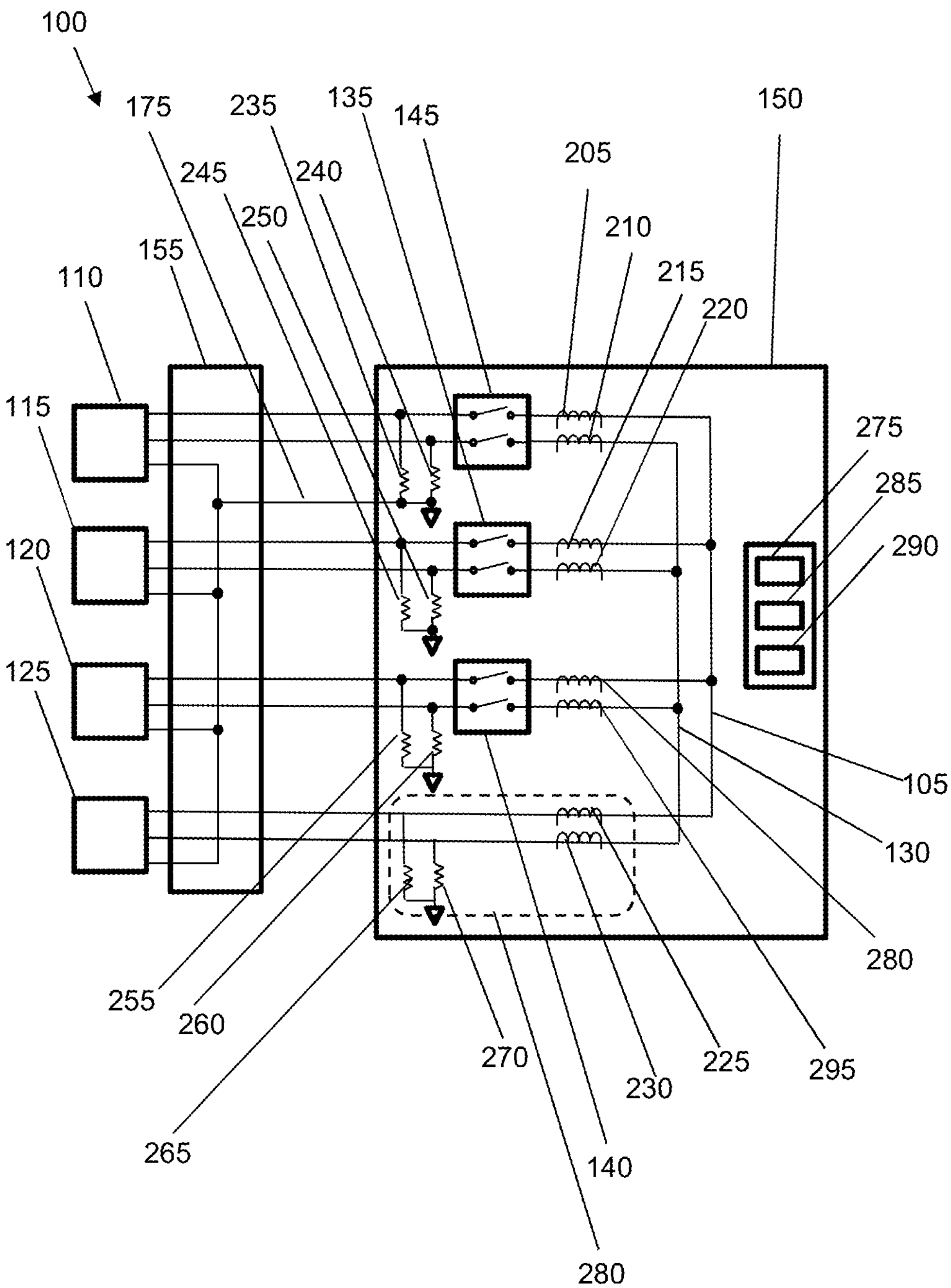

100
175
235
135
145
150
245
240
205
250
210
155
215
110
220
115
275
285
290
120
125
105
130
280
255
260
270
230
225
295
265
140
280

Figure 1

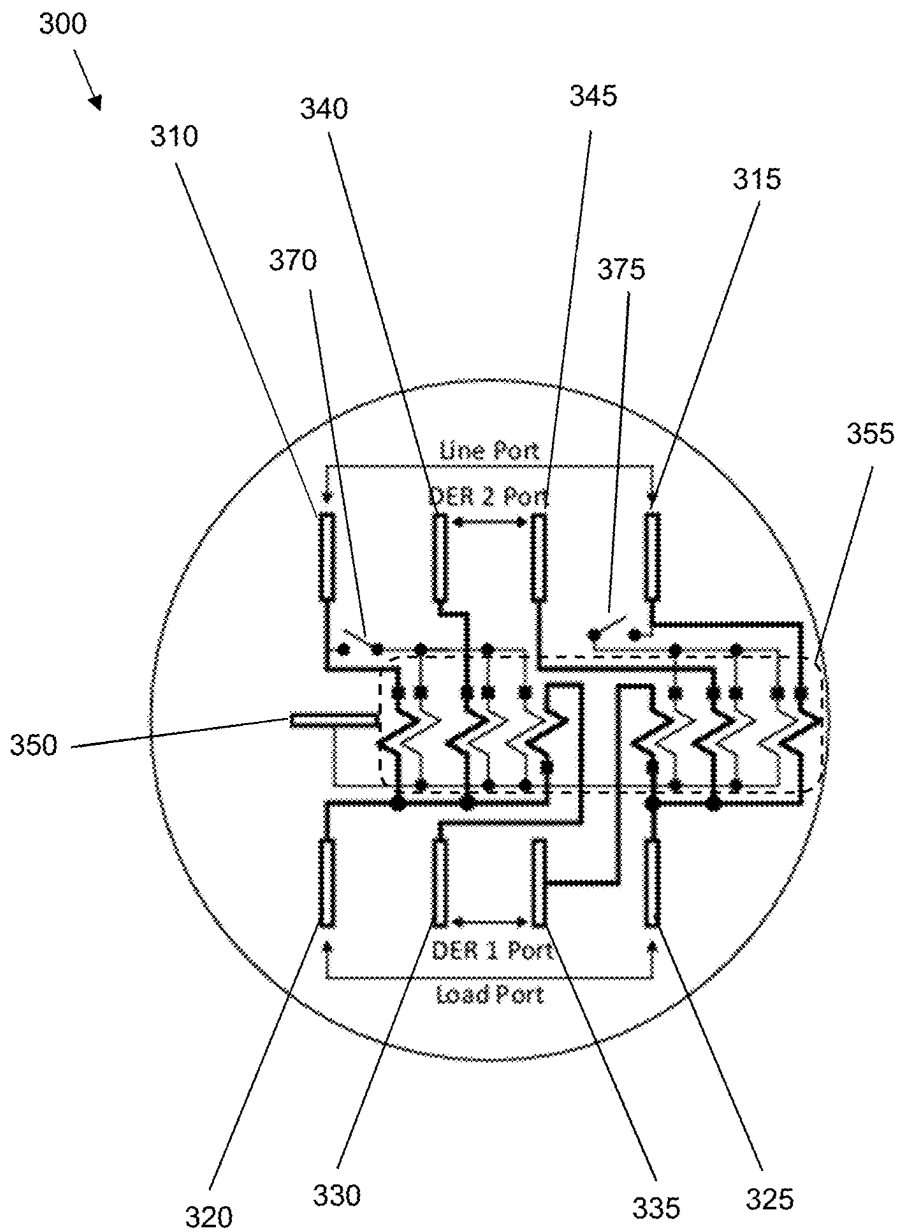

300
310
340
345
315
370
375
355
Line Port
DER 2 Port
350
DER 1 Port
Load Port
320
330
335
325

Figure 2

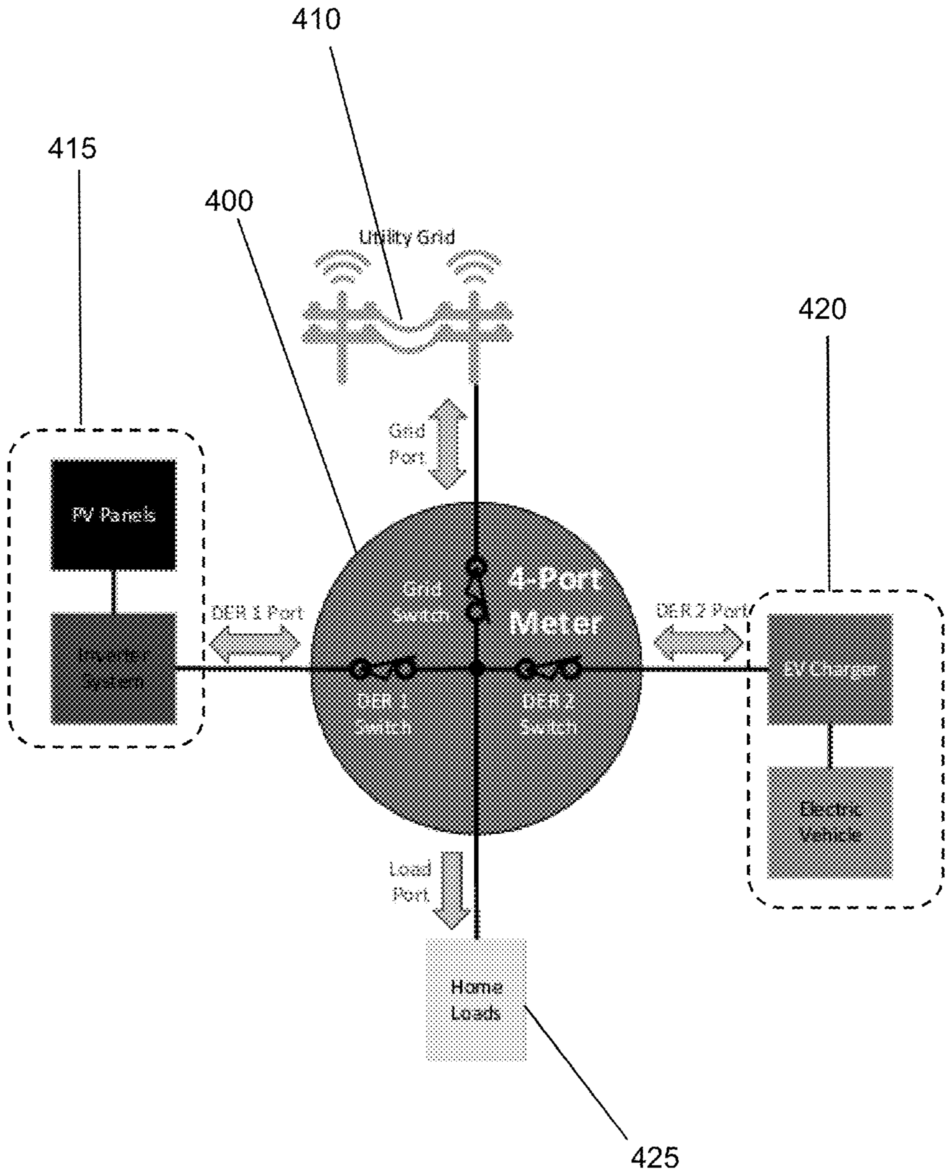

410
415
400
Utility Grid
420
Grid
Port
PV Panels
4-Port
Meter
Grid
Switch
DER 1 Port
DER 2 Port
Inverter
System
EV Charger
DER 1
Switch
DER 2
Switch
Electric
Vehicle
Load
Port
Home
Loads
425

Figure 3

MULTI-PORT METER

FIELD OF INVENTION

The present disclosure is in the field electric meters, and relates in particular to an electric meter for use with multiple distributed energy resources. The disclosure also relates to an associated electric meter system and methods of use of the electric meter.

BACKGROUND TO INVENTION

Distributed Energy Resources may be implemented as relatively small-scale electricity supply or demand resources that may be coupled to the electric grid. Examples of Distributed Energy Resource (DER) devices may include solar panels, generators, turbines, batter energy storage systems, electric vehicle batteries, and the like.

A general use of such DER devices in increasing, in particular by consumers at domestic premises, e.g. residential consumers, due to an increasing adoption of electric vehicles comprising battery storage systems and/or implementation of local energy generation and storage systems such as solar panels with associated battery storage systems.

Connection of DER devices to the electric grid may be complex, expensive, time-consuming and in some cases unsafe. An increase in the range of use cases of DER devices, and in particular to the use of local electricity generation and consumption, has led to increasingly varied use cases and demands on electric meter installations. For example, it may be required to couple multiple DER devices to an electric meter, wherein a flow of energy to be metered may be both to and from such DER devices.

As such, a high degree of flexibility and control in electric meter installation may be required. However, a general lack of standardization of electric meters suitable for use with multiple DER devices may lead to sub-optimal electric meter installation, and may limit a degree of control, metering and possible disaggregation of DER device usage.

It is therefore desirable to provide an electric meter suitable for use with a plurality of DER devices.

It is therefore an aim of at least one embodiment of at least one aspect of the present disclosure to obviate or at least mitigate at least one of the above identified shortcomings of the prior art.

SUMMARY OF INVENTION

The present disclosure is in the field of electric meters, and relates in particular to an electric meter for use with distributed energy resources. The disclosure also relates to an associated electric meter system and methods of use of the electric meter. According to a first aspect of the disclosure, there is provided an electric meter comprising: a first set of conductive paths configured to connect a first phase of an electric distribution power source, a first phase of a first distributed energy resource device, a first phase of a second distributed energy resource device, and a first phase of a load, and a second set of conductive paths configured to connect a second phase of the electric distribution power source, a second phase of the first distributed energy resource device, a second phase of the second distributed energy resource device, and a second phase of the load.

The electric meter may comprise a plurality of blades. The plurality of blades may be arranged to provide a line port comprising connectivity to the first and second phases of the electric distribution power source.

The plurality of blades may be arranged to provide a load port comprising connectivity to the first and second phases of the load.

The plurality of blades may be arranged to provide a first distributed energy resource port comprising connectivity to the first and second phases of the first distributed energy resource device.

The plurality of blades may be arranged to provide a second distributed energy resource port comprising connectivity to the first and second phases of the second distributed energy resource device.

The plurality of blades may be arranged to provide a neutral connection path.

Blades of the first distributed energy resource port may be disposed between blades of the load port.

Blades of the second distributed energy resource port may be disposed between blades of the line port.

The blade of the optional neutral connection path may be disposed substantially between the line port and the load port.

It will be appreciated that the above configuration of blades is provided for purposes of example, and other configurations of blades fall within the scope of the disclosure. For example, a position of the eight blades (or nine if the optional neutral blade is implemented) relative to one another may be different from that described above.

The electric meter may comprise a first controllable electrical disconnect switch configured to selectively connect the first distributed energy resource device to the electric distribution power source, the load and/or the second distributed energy resource device.

The electric meter may comprise a second controllable electrical disconnect switch configured to selectively connect the second distributed energy resource device to the electric distribution power source, the load and/or the first distributed energy resource device.

The electric meter may comprise a third controllable electrical disconnect switch configured to selectively connect the electric distribution power source to the first distributed energy resource device, the load and/or the second distributed energy resource device.

The electric meter may comprise a fourth controllable electrical disconnect switch configured to selectively connect the load to the electric distribution power source, the first distributed energy resource device and/or the second distributed energy resource device.

The electric meter may comprise first electrical metrology components configured to meter one or more voltages and/or currents of the first set of conductive paths.

The electric meter may comprise second electrical metrology components configured to meter one or more voltages and/or currents of the second set of conductive paths.

The electric meter may comprising a housing configured to house at least the first and second electrical metrology components. The housing may comprise a substantially cylindrical shape.

The first electrical metrology components may comprise a first set of current transducers configured to monitor a current on at least one of: the first phase of the electric distribution power source; the first phase of the first distributed energy resource device; the first phase of the second distributed energy resource device; the first phase of the load.

The first electrical metrology components may comprise a first set of voltage transducers configured to monitor a voltage on at least one of: the first phase of the electric distribution power source; the first phase of the first distributed energy resource device; the first phase of the second distributed energy resource device; the first phase of the load.

The second electrical metrology components may comprise a second set of current transducers configured to monitor a current on at least one of: the second phase of the electric distribution power source; the second phase of the first distributed energy resource device; the second phase of the second distributed energy resource device; the second phase of the load.

The second electrical metrology components may comprise a second set of voltage transducers configured to monitor a voltage on at least one of: the second phase of the electric distribution power source; the second phase of the first distributed energy resource device; the second phase of the second distributed energy resource device; the second phase of the load.

The electric meter may comprise a processing and acquisition circuit configured to acquire and process measurements from the first and second electrical metrology components.

The electric meter may comprise a communications module. The communications module may be configured to enable communication with other meters and/or with a utility.

According to a second aspect of the disclosure, there is provided an electric meter system, comprising: an electric meter according to the first aspect; and an electric meter socket comprising a plurality of receptacles configured to receive the electric meter. The electric meter socket may be configured to couple: the first set of conductive paths to the first phase of the electric distribution power source, the first phase of the first distributed energy resource device, the first phase of the second distributed energy resource device, and the first phase of a load; and the second set of conductive paths to the second phase of the electric distribution power source, the second phase of the first distributed energy resource device, the second phase of the second distributed energy resource device, and the second phase of a load.

The socket may comprise at least one neutral connection path configured to form a neutral conductive path between the electric meter and neutral conductors of the electric distribution power source, the first distributed energy resource device, the second distributed energy resource device, and the load.

According to a third aspect of the disclosure, there is provided a method of use of the electric meter according to the first aspect. The method may comprise coupling the meter, via a corresponding meter socket, to an electric distribution power source, a first distributed energy resource device, a second distributed energy resource device, and a load.

The method may comprise a step of configuring a first controllable electrical disconnect switch of the meter to connect the first distributed energy resource device to the load and/or the second distributed energy resource device.

The method may comprise a step of configuring a second controllable electrical connect switch of the meter to connect the second distributed energy resource device to the load and/or the first distributed energy resource device.

The method may comprise a step of configuring a third controllable electrical disconnect switch of the meter configured to disconnect the electric distribution power source from the first distributed energy resource device, the load and/or the second distributed energy resource device.

The method may comprise calculating a power for a port of the electric meter by: multiplying a current of the first phase measured at the port by a measured line voltage for the first phase to determine a power of the first phase at the port; multiplying a current of the second phase measured at the port by a measured line voltage for the second phase to determine a power of the second phase at the port; and adding the power of the first phase to the power of the second phase.

The above summary is intended to be merely exemplary and non-limiting. The disclosure includes one or more corresponding aspects, embodiments or features in isolation or in various combinations whether or not specifically stated (including claimed) in that combination or in isolation. It should be understood that features defined above in accordance with any aspect of the present disclosure or below relating to any specific embodiment of the disclosure may be utilized, either alone or in combination with any other defined feature, in any other aspect or embodiment or to form a further aspect or embodiment of the disclosure.

BRIEF DESCRIPTION OF DRAWINGS

These and other aspects of the present disclosure will now be described, by way of example only, with reference to the accompanying drawings, wherein:

FIG. **1** depicts a representation of an electric meter system according to an embodiment of the disclosure;

FIG. **2** depicts a representation of an electric meter, showing an arrangement of blades, according to an embodiment of the disclosure; and

FIG. **3** depicts a representation of an example use-case of the electric meter of FIG. **1**, according to an embodiment of the disclosure.

DETAILED DESCRIPTION OF DRAWINGS

Currently there is no standard system for connecting multiple DER devices to an electric meter, in a manner that provides suitable control of the individual DER devices and disaggregation capabilities.

An electric meter and associated electric meter system is described herein that provides a means to meter electricity originating from both a plurality of DER devices and the electric grid. For purposes of non-limiting example, such DER devices may include a residential photovoltaic installation with or without associated local energy storage, a residential wind turbine installation with or without associated local energy storage, an electric vehicle battery, or the like.

FIG. **1** depicts a representation of an electric meter system **100** according to an embodiment of the disclosure.

The electric meter system **100** comprises an electric meter **150**. The electric meter system **100** comprises an electric meter socket **155** comprising a plurality of receptacles configured to receive blades of the electric meter **150**, as described in more detail with reference to FIG. **2**.

Also depicted is an electric distribution power source **110**, e.g. the grid, a first distributed energy resource device **115**, a second distributed energy resource device **120**, and a load **125**, all coupled to the electric meter **150** via the meter socket **155**. In some examples, one or more circuit breakers, miniature circuit breakers (MCBs), fuses, residual current devices (RCDs) and/or controllable disconnect switches may be implemented between the socket and one or more of the first distributed energy resource device **115**, the second distributed energy resource device **120** and/or the load.

The electric meter **150** comprises a first set of conductive paths **105** configured to connect a first phase of the electric distribution power source **110**, a first phase of the first distributed energy resource device **115**, a first phase of the second distributed energy resource device **120**, and a first phase of the load **125**.

The electric meter **150** also comprises a second set of conductive paths **130** configured to connect a second phase of the electric distribution power source **110**, a second phase of the first distributed energy resource device **115**, a second phase of the second distributed energy resource device, and a second phase of the load.

In the disclosed example, the electric meter **150** comprises a plurality of controllable electrical disconnect switches **135**, **140**, **145**.

In the disclosed example, the electric meter optionally **150** comprises a first controllable electrical disconnect switch **135** configured to selectively connect the first distributed energy resource device **115** to the electric distribution power source **110**, the load **125** and the second distributed energy resource device **120**.

In the disclosed example, the electric meter optionally **150** comprises a second controllable electrical disconnect switch **140** configured to selectively connect the second distributed energy resource device **120** to the electric distribution power source **110**, the load **125** and the first distributed energy resource device **115**.

In the disclosed example, the electric meter optionally **150** comprises a third controllable electrical disconnect switch **145** configured to selectively connect the electric distribution power source **110** to the first distributed energy resource device **115**, the load **125** and the second distributed energy resource device **120**.

In some example embodiments, the electric meter may optionally **150** comprise a fourth controllable electrical disconnect switch (not shown) configured to selectively connect the load **125** to the first distributed energy resource device **115**, the second distributed energy resource device **120**, and the electric distribution power source **110**.

It will be appreciated that all of the first to fourth controllable electrical disconnect switches are optional, and all embodiments comprising one or more of the controllable electrical disconnect switches fall within the scope of the disclosure.

The example electric meter **150** comprises a plurality of electrical metrology components configured to meter one or more voltages and/or currents of the first and second sets of conductive paths **150**, **130**. Voltages and currents, such as voltages and currents provided by any of the electric distribution power source **110**, the first distributed energy resource device **115** or the second distributed energy resource device **120**, may be measured, or metered, by the plurality of electrical metrology components. The electrical metrology components may measure electrical characteristics of voltage and current waveforms, respectively. A power delivered to/consumed at a port of the electric meter **150** may be calculated based on the voltage and current measurements, as described in more detail below.

A first current transducer **205** is configured to monitor a current on the first phase of the electric distribution power source **110**.

A second current transducer **210** is configured to monitor a current on the second phase of the electric distribution power source **110**.

A third current transducer **215** is configured to monitor a current on the first phase of the first distributed energy resource device **115**.

A fourth current transducer **220** is configured to monitor a current on the second phase of the first distributed energy resource device **115**.

A fifth current transducer **280** is configured to monitor a current on the first phase of the second distributed energy resource device **120**.

A sixth current transducer **295** is configured to monitor a current on the second phase of the second distributed energy resource device **120**.

In some optional embodiments, a seventh current transducer **225** may also be included and is configured to monitor a current on the first phase of the load **125**.

In some optional embodiments, an eighth current transducer **230** may also be included and is configured to monitor a current on the second phase of the load **125**.

Although the seventh current transducer **225** and eighth current transducer **230**, e.g. those associated with the load port, are described as optional, it will be appreciated that in embodiments it may be necessary to measure current on only three of the four ports, e.g. three out of the load port, line port, first distributed energy resource port and the second distributed energy resource port. As such, in some embodiments the current transducers may be removed from a different port than the load port.

That is, in some embodiments instead of the seventh and eighth current transducers **225**, **230** being removed, either the first and second current transducers **205**, **210**, or the third and fourth current transducers **215**, **220**, or the fifth and sixth current transducers **280**, **295** may be removed.

A first voltage transducer **235** is configured to monitor a voltage on the first phase of the electric distribution power source **110**.

A second voltage transducer **240** is configured to monitor a voltage on the second phase of the electric distribution power source **110**.

A third voltage transducer **245** is configured to monitor a voltage on the first phase of the first distributed energy resource device **115**.

A fourth voltage transducer **250** is configured to monitor a voltage rent on the second phase of the first distributed energy resource device **115**.

A fifth voltage transducer **255** is configured to monitor a voltage on the first phase of the second distributed energy resource device **120**.

A sixth voltage transducer **260** is configured to monitor a voltage on the second phase of the second distributed energy resource device **120**.

In some optional embodiments, a seventh voltage transducer **265** is also included, and may be configured to monitor a voltage on the first phase of the load **125**.

In some optional embodiments, an eighth voltage transducer **270** may also be included, and may be configured to monitor a voltage on the second phase of the load **125**.

Although a total of eight voltage transducers and eight current transducers are depicted in the example embodiment of FIG. **1**, it will be appreciated that in other embodiments, fewer than eight current and/or voltage transducers may be implemented. For example, the embodiment of FIG. **2** comprises six current transducers and six voltage transducers. That is, in example embodiments the optional transducers **180** may not be implemented.

The electric meter **150** may comprise a processing circuit **275** and an acquisition circuit **285** configured to acquire and process measurements from the above-described electrical metrology components. For example, said acquisition circuit **285** may comprise one or more analog to digital converters.

Said processing circuit **275** may comprise one or more microprocessors, microcontrollers, or the like.

The processing circuit **275** may be configured to control the first controllable electrical disconnect switch **135**, the second controllable electrical disconnect switch **140**, and/or the third controllable electrical disconnect switch **145**.

In some embodiments, the electric meter **150** may comprise a communications module **290**. The communications module **190** may be configured to enable communication with other meters and/or with a utility. The communications module **190** may be at least partly integrated into or coupled to the processing circuit **275**.

The communications module **190** may be configured to communicate by at least one of: wirelessly; via a cellular network; via power line communications; via a mesh network; using a protocol conforming to a Wireless Smart Utility Network (Wi-SUN) protocol, such as a protocol conforming to an IEEE 802.15.4g standard; or the like. The communications module **190** may be configured to receive communications that include instructions for controlling the first controllable electrical disconnect switch **135**, the second controllable electrical disconnect switch **140**, and/or the third controllable electrical disconnect switch **145**.

The communications module **190** may transmit data related to the operation of the electric meter **150**, such as data corresponding to measurements performed by the above-described electrical metrology components.

In a first example method, which may be a primary method, the processing circuit **275** may be configured to calculate a power for a port of the electric meter **150** by: multiplying a current at a port by a voltage measured at the grid port (per phase). Optionally, in some embodiments, irrespective of which voltage is used for calculating the power, all eight voltages may be measured, e.g. each phase on each of the four described ports.

In a further optional example method, the processing circuit **275** may be configured to calculate a power for a port of the electric meter **150** by: multiplying a current of the first phase measured at the port by a measured line voltage for the first phase to determine a power of the first phase at the port; multiplying a current of the second phase measured at the port by a measured line voltage for the second phase to determine a power of the second phase at the port; and adding the power of the first phase to the power of the second phase.

In an example use case, the first controllable electrical disconnect switch **135** and/or the second controllable electrical disconnect switch **140** may be configured to remain open when the first voltage transducer **235** and the second voltage transducer **240** do not detect a substantial voltage from the electric distribution power source **110**. Furthermore, the first controllable electrical disconnect switch **135** and/or the second controllable electrical disconnect switch **140** may be used to synchronize voltage phases from the first distributed energy resource device **115** and/or the second distributed energy resource device **120** respectively, with the electric distribution power source **110**.

For example, the seventh and eighth voltage transducers **265** and **270** may measure a voltage supplied to the load **125** by the first distributed energy resource device **115** and/or the second distributed energy resource device **120**, while the first and second voltage transducers **235** and **240** measure the voltage supplied by the electric distribution power source **110** and while the third controllable electrical disconnect switch **145** is open. Upon reaching synchronization between the first distributed energy resource device **115** and/or the second distributed energy resource device **120** and the electric distribution power source **110** during a synchronization operation, the third controllable electrical disconnect switch **145** may close. Furthermore, the third controllable electrical disconnect switch **145** may effectively disconnect the electric meter **150** from the electric distribution power source **110**, e.g. the grid. The ability to disconnect the electric meter **150** from the electric distribution power source **110** may enable "islanding," which involves disconnecting the electric meter **150** from the electric distribution power source **110** and supplying power to the load **125** and/or one of the first distributed energy resource device **115** and/or the second distributed energy resource devices **120** from the other of the first distributed energy resource device **115** and/or the second distributed energy resource devices **120**.

The first controllable electrical disconnect switch **135** may effectively connect or disconnect the first distributed energy resource device **115** with the electric meter **150**. In connecting the first distributed energy resource device **115** with the electric meter **150**, the electric meter **150** may measure power production or consumption of the first distributed energy resource device **115** as a separate value to the energy consumed from or sent back to the electric distribution power source **110**. Consumption from the electric distribution power source **110** or production fed back to the electric distribution power source **110** may be metered. Furthermore, the first controllable electrical disconnect switch **135** may connect or disconnect the first distributed energy resource device **115** from the electric distribution power source **110** based on, for example, power production or consumption requirements of the electric distribution power source **110** and first distributed energy resource device **115**.

The second controllable electrical disconnect switch **140** may effectively connect or disconnect the second distributed energy resource device **120** with the electric meter **150**. In connecting the second distributed energy resource device **120** with the electric meter **150**, the electric meter **150** may measure power production or consumption of the second distributed energy resource device **120** as a separate value to the energy consumed from or sent back to the electric distribution power source **110**. Consumption from the electric distribution power source **110** or production fed back to the electric distribution power source **110** may be metered. Furthermore, the second controllable electrical disconnect switch **140** may connect or disconnect the second distributed energy resource device **120** from the electric distribution power source **110** based on, for example, power production or consumption requirements of the electric distribution power source **110** and second distributed energy resource device **120**.

That is, the electric meter **150** may be configured measure and control the electricity delivered to the load **125** via any combination of the electric distribution power source **110**, first distributed energy resource device **115** and the second distributed energy resource devices **120**.

For purposes of example only, an electric meter socket **155** is also depicted. The electric meter socket **155** comprising a plurality of receptacles (not shown) configured to receive the electric meter **150**, e.g. receive corresponding blades of the electric meter **150**.

The electric meter socket **155** may be configured to couple the first set of conductive paths **105** to the first phase of the electric distribution power source **110**, the first phase of the first distributed energy resource device **115**, the first phase of the second distributed energy resource device **120**, and the first phase of a load **125**, depending upon a selected configuration of the plurality of controllable electrical disconnect switches **135**, **140**, **145**.

Similarly, the electric meter socket **155** may be configured to couple the second set of conductive paths **130** to the second phase of the electric distribution power source **110**, the second phase of the first distributed energy resource device **115**, the second phase of the second distributed energy resource device **120**, and the second phase of a load **125**, depending upon a selected configuration of the plurality of controllable electrical disconnect switches **135**, **140**, **145**.

Additionally, for purses of example only, the electric meter socket **155** comprises a neutral connection path **175** configured to form a neutral conductive path between the electric meter **150** and neutral conductors of the electric distribution power source **110**, the first distributed energy resource device **115**, the second distributed energy resource device **120**, and the load **125**. The neutral connection path may be known in the art as a 'ground'. The ability to perform first phase to neutral and second phase to neutral voltage measurements at the DER ports of the first and second distributed energy resource devices **115**, **120**, as well as performing current measurements, may enable effective implementation load disaggregation algorithms. Such load disaggregation algorithms may be executed, at least in part, by the processing circuit **275** and/or by another device, server, cloud based device or the like that the electric meter **150** may communicate with via the communications module **290**.

FIG. **2** depicts a representation of an electric meter **300**, showing an arrangement of blades, according to an embodiment of the disclosure.

As described above, the electric meter **300** is an example of an electric meter comprising six current transducers and six voltage transducers. That is, in example embodiments optional transducers **180** depicted in the example embodiment of FIG. **1** are not implemented in the example embodiment of FIG. **2**.

Each blade is a conductor configured to be received by a corresponding receptacle of the meter socket **155**.

The plurality of blades are arranged to provide a line port, denoted "line port" in FIG. **2**. The line port comprises a first blade **310** corresponding to a first phase of the electric distribution power source **110** and a second blade **315** corresponding to a second phase of the electric distribution power source **110**.

The plurality of blades are arranged to provide a load port, denoted "load port" in FIG. **2**. The load port comprises a third blade **320** corresponding to a first phase of the load **125** and a fourth blade **325** corresponding to a second phase of the load **125**.

The plurality of blades are arranged to provide a first distributed energy resource port, denoted "DER 1 Port" in FIG. **2**. The first distributed energy resource port comprises a fifth blade **330** corresponding to a first phase of the first distributed energy resource device **115** and a sixth blade **335** corresponding to a second phase of the first distributed energy resource device **115**.

The plurality of blades are arranged to provide a second distributed energy resource port, denoted "DER 2 Port" in FIG. **2**. The second distributed energy resource port comprises a seventh blade **340** corresponding to a first phase of the second distributed energy resource device **120** and an eighth blade **345** corresponding to a second phase of the second distributed energy resource device **120**.

The plurality of blades comprise a ninth blade **350** for providing a neutral connection path.

In the example, fifth and sixth blades **330**, **335** of the first distributed energy resource port are disposed between third and fourth blades **320**, **325** of the load port. In the example, seventh and eighth blades **340**, **345** of the second distributed energy resource port are disposed between first and second blades **310**, **315** of the line port.

The ninth blade **350** of the neutral connection path is disposed substantially between the line port and the load port.

Although nine blades are disclosed, it will be understood that embodiments of electric meters **150** and meter sockets **155** according to the present disclosure may include more than or fewer than nine blades and corresponding receptacles respectively. For example, when only one voltage phase is connected fewer than nine blades and receptacles may be included, since blades and receptacles for additional phases are not needed. Similarly, when three voltage phases are connected additional blades and corresponding receptacles may be implemented.

Furthermore, it will be appreciated that the configuration of blades depicted in FIG. **2** is provided for purposes of example, and other configurations of blades fall within the scope of the disclosure. For example, a position of the eight blades (or nine if the optional neutral blade is implemented) relative to one another may be different from that of FIG. **2**.

Also depicted are the metrology components **355**, with voltage transducers depicted with a relatively thin line, and current transducers depicted with a relatively bold line. It can be seen that in the example electric meter **300**, each phase of the line port, the DER 1 Port, and the DER 2 port comprises a corresponding voltage transducer and a corresponding current transducer, e.g. a total of six current transducers and six voltage transducers.

Also depicted is a circular profile **360** of the electric meter **300**, which may correspond to a substantially cylindrical shape of a housing of the electric meter **300**, e.g. a housing for the metrology components **355**.

It will be understood that other form factors of housing may be implemented, such as form-factors having cross-section being rectangular, square, polygonal, or the like.

Also depicted is a first test link **370** and a second test link **375**, also known in the art as "potential links" or even "pot links". Although depicted as opened switches, it will be understood by one of skill in the art that the test links **370**, **275** are for purposes of testing, e.g. in the laboratory or during production for purposes of "phantom loading", and therefore said test links **370**, **375** are typically closed in the field. Furthermore, it will be understood that, although only two test links **370**, **375** are depicted, in other example embodiments more than two test links may be implemented.

FIG. **3** depicts a representation of an example use-case of an electric meter **400**, which may be the electric meter **150** of FIG. **1** or the electric meter **300** of FIG. **2**, according to an embodiment of the disclosure. The electric meter **400** is denoted "4-port meter".

For purposes of example only, a first distributed energy resource **415** is an inverter system coupled to photovoltaic panels. That is, the first distributed energy resource **415** may operate as an energy generator. In some examples, the first distributed energy resource **415** may also operate as an energy consumer, as represented by the bidirectional arrow between the DER 1 Port and the first distributed energy resource **415**. For example, local storage such as a battery system may be provided with the first distributed energy resource **415** and, in some instances, said local storage may receive electricity for charging, wherein the electricity is provided via another port of the electric meter **400**.

For purposes of example only, a second distributed energy resource **420** is an Electric Vehicle (EV) charger coupled to an electric vehicle. That is, the second distributed energy resource **420** may operate primarily as an energy consumer, for charging a battery of the electric vehicle. In some examples, the second distributed energy resource **420** may also operate as an energy provider, as represented by the bidirectional arrow between the DER 2 Port and the second distributed energy resource **420**. As a non-limiting example, the vehicle battery may provide electrical power to a premises at which the electric vehicle charger is installed, via the DER 2 Port, such as in an instance of a failure of the supply to the Grid Port.

Also depicted is a load **425** coupled to the Load Port. The load, which may in a non-limiting example comprise all home loads, which may comprise appliances that consume electrical power such as air conditioning or the like, is a consumer of electrical power, as denoted by the unidirectional arrow between the Load Port and the load **425**.

Also depicted is an electric distribution power source **410**, e.g. the grid, coupled to the Line Port. The electric distribution power source **410** may provide electrical energy, via the meter **400**, to one or more other ports of the meter **400**. The electric distribution power source **410** may also receive electrical energy, via the meter **400**, from one or more other ports of the meter **400**, as represented by the bidirectional arrow between the Line Port and the electric distribution power source **410**.

As described above, the disclosed electric meter **150**, **300**, **400** enables metering and disaggregation of individual distributed energy resource device usage.

Furthermore, the above-described ability to disconnect the electric meter **150**, **300**, **400** from the electric distribution power source **110**, **410** may enable "islanding," which involves disconnecting the electric meter **150**, **300**, **400** from the electric distribution power source **110**, **410** and supplying power to the load **125**, **425** and/or one of the first distributed energy resource device **115**, **415** and/or the second distributed energy resource devices **120**, **420** from the other of the first distributed energy resource device **115**, **415** and/or the second distributed energy resource devices **120**, **415**.

In a first example usage, the meter **400** may be configured such that the first distributed energy resource **415**, which may generate electricity from solar energy, is configured to provide this generated electricity to the second distributed energy resource **420**, to charge the battery of the electric vehicle. Depending upon a configured and/or selected configuration of the meter, the electric distribution power source **410** may be effectively disconnected form the meter **400** by the controllable electrical disconnect switches, e.g. in an example of "islanding".

In a second example usage, the meter **400** may be configured such that any surplus electrical energy generated by the first distributed energy resource **415** that is not required by the second distributed energy resource **420**, may instead be provided to the electric distribution power source **410** via the Grid Port.

In further examples of usage of the disclosed electric meter, a load control device may be coupled to one or both of the distributed energy resource ports. A s a non-limiting example, such a load control device may comprise any of: an electric vehicle charger; an HVAC system; a hot water heater; an air conditioner; a thermostat; a heat pump; a pool pump; a refrigerator; a dryer; a solar inverter; a battery system; or the like.

Although the disclosure has been described in terms of particular embodiments as set forth above, it should be understood that these embodiments are illustrative only and that the claims are not limited to those embodiments. Those skilled in the art will be able to make modifications and alternatives in view of the disclosure, which are contemplated as falling within the scope of the appended claims. Each feature disclosed or illustrated in the present specification may be incorporated in any embodiments, whether alone or in any appropriate combination with any other feature disclosed or illustrated herein.

LIST OF REFERENCE NUMERALS

100 electric meter
105 first set of conductive paths
110 electric distribution power source
115 first distributed energy resource device
120 second distributed energy resource device
125 load
130 second set of conductive paths
135 first controllable electrical disconnect switch
140 second controllable electrical disconnect switch
145 third controllable electrical disconnect switch
150 electric meter
180 optional transducers
190 communications module
205 first current transducer
210 second current transducer
215 third current transducer
220 fourth current transducer
225 seventh current transducer
230 eighth current transducer
235 first voltage transducer
240 second voltage transducer
245 third voltage transducer
250 fourth voltage transducer
255 fifth voltage transducer
260 sixth voltage transducer
265 seventh voltage transducer
270 eighth voltage transducer
275 processing circuit
280 fifth current transducer
285 acquisition circuit
290 communications module
295 sixth current transducer
300 electric meter
310 first blade
315 second blade
320 third blade
325 fourth blade
330 fifth blade
335 sixth blade
340 seventh blade
345 eighth blade
350 ninth blade
355 metrology components
370 first test link
375 second test link
400 electric meter
410 electric distribution power source
415 first distributed energy resource
420 second distributed energy resource
425 load

The invention claimed is:

1. An electric meter comprising:

a first set of conductive paths configured to connect a first phase of an electric distribution power source, a first phase of a first distributed energy resource device, a first phase of a second distributed energy resource device, and a first phase of a load, and

a second set of conductive paths configured to connect a second phase of the electric distribution power source, a second phase of the first distributed energy resource device, a second phase of the second distributed energy resource device, and a second phase of the load,

the meter further comprising a plurality of blades, wherein the plurality of blades are arranged to provide at least:

a line port comprising connectivity to the first and second phases of the electric distribution power source;

a load port comprising connectivity to the first and second phases of the load;

a first distributed energy resource port comprising connectivity to the first and second phases of the first distributed energy resource device; and

a second distributed energy resource port comprising connectivity to the first and second phases of the second distributed energy resource device.

2. The electric meter of claim 1, wherein:

blades of the first distributed energy resource port are disposed between blades of the load port; and

blades of the second distributed energy resource port are disposed between blades of the line port; and optionally

a blade of a neutral connection path is disposed substantially between the line port and the load port.

3. The electric meter of claim 1, comprising at least one of:

a first controllable electrical disconnect switch configured to selectively connect the first distributed energy resource device to the electric distribution power source, the load and/or the second distributed energy resource device;

a second controllable electrical disconnect switch configured to selectively connect the second distributed energy resource device to the electric distribution power source, the load and/or the first distributed energy resource device; and/or

a third controllable electrical disconnect switch configured to selectively connect the electric distribution power source to the first distributed energy resource device, the load and/or the second distributed energy resource device.

4. The electric meter of claim 1, comprising:

first electrical metrology components configured to meter one or more voltages and/or currents of the first set of conductive paths; and

second electrical metrology components configured to meter one or more voltages and/or currents of the second set of conductive paths.

5. The electric meter of claim 4, comprising a housing configured to house at least the first and second electrical metrology components, optionally wherein the housing comprising a substantially cylindrical shape.

6. The electric meter of claim 4, wherein the first electrical metrology components comprise at least one of:

a first set of current transducers configured to monitor a current on at least one of:

the first phase of the electric distribution power source;

the first phase of the first distributed energy resource device;

the first phase of the second distributed energy resource device;

the first phase of the load;

and/or

a first set of voltage transducers configured to monitor a voltage on at least one of:

the first phase of the electric distribution power source;

the first phase of the first distributed energy resource device;

the first phase of the second distributed energy resource device;

the first phase of the load.

7. The electric meter of claim 6, wherein the second electrical metrology components comprise: at least one of:

a second set of current transducers configured to monitor a current on at least one of

the second phase of the electric distribution power source;

the second phase of the first distributed energy resource device;

the second phase of the second distributed energy resource device;

the second phase of the load;

and/or

a second set of voltage transducers configured to monitor a voltage on at least one of:

the second phase of the electric distribution power source;

the second phase of the first distributed energy resource device;

the second phase of the second distributed energy resource device;

the second phase of the load.

8. The electric meter of claim 4, further comprising a processing and acquisition circuit configured to acquire and process measurements from the first and second electrical metrology components.

9. The electric meter of claim 1, further comprising a communications module, wherein the communications module is configured to enable communication with other meters and/or with a utility.

10. A electric meter system, comprising:

an electric meter according to claim 1; and

an electric meter socket comprising a plurality of receptacles configured to receive the electric meter;

wherein the electric meter socket is configured to couple: the first set of conductive paths to the first phase of the electric distribution power source, the first phase of the first distributed energy resource device, the first phase of the second distributed energy resource device, and the first phase of a load; and the second set of conductive paths to the second phase of the electric distribution power source, the second phase of the first distributed energy resource device, the second phase of the second distributed energy resource device, and the second phase of a load.

11. The system of claim 9, wherein the socket comprises at least one neutral connection path configured to form a neutral conductive path between the electric meter and neutral conductors of the electric distribution power source, the first distributed energy resource device, the second distributed energy resource device, and the load.

12. A method of use of the electric meter of claim 1, the method comprising coupling the meter, via a corresponding meter socket, to an electric distribution power source, a first distributed energy resource device, a second distributed energy resource device, and a load.

13. The method of claim **12**, comprising a step of:

configuring a first controllable electrical disconnect switch of the meter to connect the first distributed energy resource device to the load and/or the second distributed energy resource device;

configuring a second controllable electrical connect switch of the meter to connect the second distributed energy resource device to the load and/or the first distributed energy resource device; and

configuring a third controllable electrical disconnect switch of the meter configured to disconnect the electric distribution power source from the first distributed energy resource device, the load and/or the second distributed energy resource device.

14. The method of claim **12**, comprising calculating a power for a port of the electric meter by:

multiplying a current of the first phase measured at the port by a measured line voltage for the first phase to determine a power of the first phase at the port;

multiplying a current of the second phase measured at the port by a measured line voltage for the second phase to determine a power of the second phase at the port;

adding the power of the first phase to the power of the second phase.

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