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(71) Applicant: **VICWOOD PROSPERITY TECHNOLOGY LIMITED** [CN/CN]; 19/F, 188 Des Voeux Road Central, Hong Kong, Hong Kong (CN).

(72) Inventors: **CHENG, Ka Wai Eric**; Department of Electrical Engineering, the Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong, Hong Kong (CN). **NG, Hin Hung**; 19/F, 188 Des Voeux Road Central, Hong Kong, Hong Kong (CN). **LAW, Man Yau**; 19/F, 188 Des Voeux Road Central, Hong Kong, Hong Kong (CN). **WONG, Kwok Shing**; 19/F, 188 Des Voeux Road Central, Hong Kong, Hong Kong (CN).

(74) Agent: **YOU YI INTERNATIONAL INTELLECTUAL PROPERTY SERVICES LIMITED**; Suite 1602, 16/F, Tower 1, China Hong Kong City, 33 Canton Road, Tsim Sha Tsui, Kowloon, Hong Kong, Hong Kong (CN).

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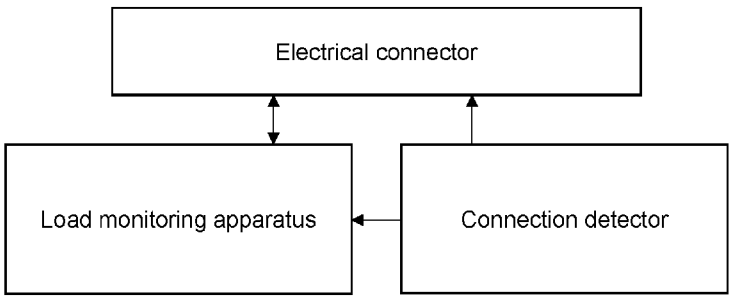


Fig. 8

(57) Abstract: An load monitoring apparatus for monitoring an electrical apparatus, the load monitoring apparatus comprising a controller(142) which is configured to capture and process voltage and current data of the electrical apparatus, which is electrically connected with a power supply, to obtain electrical parameters of the electrical apparatus, to store the electrical parameters as measured electrical parameters, to compare the measured electrical parameters with a set of pre-stored electrical parameters, to determine whether the measured electrical parameters match with the stored electrical parameters, and to operate a power switch to turn off power supply to the electrical parameters if the measured electrical parameters do not match with the stored electrical parameters.

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METHOD AND APPARATUS FOR LOAD MONITORING

Field

[001] The present disclosure relates to method and apparatus for monitoring of power-operated devices and apparatus, and more particularly to automated monitoring of power-operated devices and apparatus by electronic circuitry.

Background

[002] The modern world is full of appliances and equipment which are powered by electricity. Appliances and equipment which are operated by electricity are referred to collectively as power-operated apparatus herein. Monitoring of electrical properties and/or characteristics of power-operated apparatus during operation provide useful information, and such information may be used to enhance safety of operation and/or may mitigate unauthorized use. However, automated monitoring of power-operated apparatus, especially at a general-purpose power outlet, can be difficult, since different power-operated apparatus have different electrical properties and/or characteristics and different power-operated apparatus can be connected to the power outlet alternatively.

Summary of disclosure

[003] There is disclosed method of and apparatus for monitoring an electrical apparatus, the electrical apparatus having a plurality of electrical parameters by a load monitoring apparatus comprising a controller. The method may comprise the load monitoring apparatus capturing and processing voltage and current data of the electrical apparatus to obtain electrical parameters of the electrical apparatus, and storing the electrical parameters as measured electrical parameters, comparing the measured electrical parameters with a set of pre-stored electrical parameters, determining whether the measured electrical parameters match with the stored electrical parameters, operating a power switch to turn off power supply to the electrical parameters if the measured electrical parameters do not match with the stored electrical parameters.

[004] There is disclosed a load monitoring apparatus for monitoring electrical parameters of an electrical load. The apparatus may comprise a controller, a power switch operable by the controller, a data acquisition device operable, voltage and current sensors configured to feed voltage and current information to the data acquisition device and a data storage device. The controller may be configured to perform methods disclosed herein.

[005] More specifically, the controller may be configured to capture and process voltage and current data of an electrical apparatus, which may be electrically connected with a power supply, to obtain electrical parameters of the electrical apparatus, to store the electrical parameters as measured electrical parameters, to compare the measured electrical parameters with a set of pre-stored electrical parameters, to determine whether the measured electrical parameters match with the stored electrical parameters, and to operate a power

switch to turn off power supply to the electrical parameters if the measured electrical parameters do not match with the stored electrical parameters.

[006] There is also disclosed a load monitoring apparatus, also known as power supply control apparatus. The load monitoring apparatus may comprise a controller, a load current monitor and power connection circuitry operable by the controller for controlling power supply from a power source to a load. The power connection circuitry may comprise a switchable power connection path between a source side and a load side, and the power connection path is switchable to operate in a first operation state or an on-state in which state impedance between the source side and the load side is very low to permit flow of operation current from the power source to the load through the power connection path, or a second operation state or an off-state in which state impedance between the source side and the load side is very high to impede flow of operation current through the power connection path. The controller may operate to receive an identification number from a load and to use the identification number to retrieve a set of stored reference electrical parameters of the load from a set of databases, to measure operational electrical parameters of the load, to compare measured electrical parameters with the reference electrical parameters, and to determine whether the load is fit for power supply with reference to outcome of comparison between the measured electrical parameters and the reference electrical parameters.

[007] The controller may operate to detect or receive an identification number from a load upon detection of signals representing the load making a request for power supply.

[008] The set of stored reference electrical parameters of the load may comprise operational electrical parameters of a reference load in a plurality of operation states, and the controller may operate the load current monitor to measure operational electrical parameters of the load during the plurality of operational states, and may compare measured operational electrical parameters with the stored operational electrical parameters of a reference load of the plurality of operational states, and may generate a signal to indicate whether the load is fit for power supply according to outcome of comparison.

[009] The plurality of operation states may comprise a power-up state and a steady state.

[0010] The operational electrical parameters of the load to be measured during the power-up state may include peak current amplitude at the first and subsequent cycles of the power supply.

[0011] The plurality of operation states may comprise a switching state, the switching state comprising a plurality of switchable states. The reference operational electrical parameters of a first switchable state may comprise operational electrical parameters of the first switchable state and operational electrical parameters of a second switchable state.

[0012] The load may be classified into a plurality of load types, the load types comprising an AC load, a DC load and a complex load. The controller may operate to measure and determine the operational electrical parameters of the load according to the load type of the load.

[0013] The identification number may comprise information on the load type of the load. The controller may operate to measure the operational electrical parameters of the load according to the load type contained in the identification number.

[0014] The identification number may comprise a serial number of an appliance and each appliance may have a unique pre-assigned serial number.

[0015] The reference operational electrical parameters may include one or more of peak current, peak currents, peak current range, first cycle peak current at start-up, power factor, power factor variation, power factor range, switching time, real power, apparent power.

[0016] The databases may contain a list of black listed identification numbers and a load having a black-listed identification number is prohibited from receiving power supply.

[0017] The databases may contain a list of white listed identification numbers and a load having a black-listed identification number is to receive power supply from the power source after a request for power supply has been acknowledged by the controller. The controller may monitor the operational electrical parameters of the load after power supply to the load has begun.

[0018] The controller may operate the load current monitor to measure operational electrical parameters of the load during a plurality of operational states, and may compare measured operational electrical parameters with the stored operational electrical parameters. The operational electrical parameters to be measured at different operational states may be different.

[0019] The controller may operate the load current monitor to measure operational electrical parameters of the load. The measure operational electrical parameters of the load may include peak currents and their trend of change.

[0020] The controller may operate to measure operational electrical parameters of the load when the controller fails to receive an identification number from the load and or when the received identification number is an unregistered identification number which fails to return a set of stored reference electrical parameters from the databases. The controller may compare measured electrical parameters with a set of pre-stored reference electrical parameters, may determine whether the load is fit for power supply with reference to outcome of comparison between the measured electrical parameters and the reference electrical parameters, and may operate the power connection circuitry to supply operation power to the load upon detection of a successful outcome of comparison.

[0021] The load may have an unregistered identification number controller and the controller is to save the unregistered identification number to become a registered identification number and to save the measured electrical parameters as reference electrical parameters associated with the registered identification number.

[0022] There is also disclosed a method of a controller operating a load monitoring apparatus, also known as power supply control apparatus. The method may control flow of power from a power source to a load. The load monitoring apparatus comprises a load current monitor and power connection circuitry operable by the controller. The power connection circuitry may comprise a switchable power connection path between a source side and a load side. The power connection path may be switchable to operate in a first operation state or an on-state in which state impedance between the source side and the load side is very low to permit flow of operation current from the power source to the load through the power connection path, or a second operation state or an off-state in which state impedance between the source side and the load side is very high to impede flow of operation current through the power connection path. The method may comprise the controller executing stored instructions to receive an identification number from a load, to use the identification number to retrieve a set of stored reference electrical parameters of the load from a set of databases, to measure operational electrical parameters of the load, to compare measured electrical parameters with the reference electrical parameters, and to determine whether the load is fit for power supply with reference to outcome of comparison between the measured electrical parameters and the reference electrical parameters.

[0023] The controller may operate to detect or receive an identification number from a load upon detection of signals representing the load making a request for power supply.

[0024] The set of stored reference electrical parameters of the load may comprise operational electrical parameters of a reference load in a plurality of operation states, and wherein the controller is to operate the load current monitor to measure operational electrical parameters of the load during the plurality of operational states, and to compare measured operational electrical parameters with the stored operational electrical parameters of a reference load of the plurality of operational states, and to generate a signal to indicate whether the load is fit for power supply according to outcome of comparison.

[0025] The plurality of operation states may comprise a power-up state and a steady state. The controller may measure different operational electrical parameters of the load at the power-up state and at the steady state.

Figures

[0026] Example and example embodiments will be described with reference to the accompanying Figures, in which:

Figure 1 is a block diagram of an example electrical system comprising a power supply control device of the present disclosure,

Figure 1A is a block diagram of an example a power supply control device of the present disclosure,

Figure 1B is a block diagram of an example control device of the power supply control device of Figure 1A,

Figure 1C is a flow diagram depicting an example flow of operations of the example the power supply control device of Figure 1A,

Figure 2A is a block diagram of an example a power supply control device of the present disclosure,

Figure 2A1 is an example hybrid block and circuit diagram of an example implementation of the power supply control device of Figure 2A,

Figure 2B is a block diagram of an example control device of the power supply control device of Figure 2A,

Figures 2B1 and 2B2 are schematic diagrams depicting example signal collection devices of Figure 2A1,

Figure 2C is a flow depicting an example flow of operations of the power supply control device of Figure 2A,

Figure 3 is a flow diagram showing partial example flow of operation of the power supply control device,

Figure 3A is a schematic diagram depicting living body contact on the load side,

Figure 4 is a schematic circuit diagram of an example load current monitor circuit,

Figures 5A, 5B and 5C are example load current waveforms of example AC loads,

Figure 6A shows example supply voltage and load current relationships of an example DC load,

Figures 6B and 6C show example supply voltage and load current relationships of example DC loads,

Figure 7 shows example supply voltage and load current relationships of an example complex load,

Figure 8 is a schematic diagram of an example power connection interface,

Figures 9 and 10 are flows chart showing example operation flows of a controller of an example load monitoring apparatus, and

Figure 11 is a schematic diagram of example network connection comprising a load monitor apparatus according to the disclosure.

Description

[0027] An example power supply control device **100** includes a first device side (or a source side **S**) which is for connection to a power source and a second device side (or a load side **L**) which is for connection to an electrical load, as depicted in Figure 1.

[0028] The power supply control device **100** comprises a switching circuitry **110**, a control device **140**, a power connection circuitry and a power circuit **160**, as depicted in Figure 1A.

[0029] The power connection circuitry includes a first current conduction portion **P1** which is connected to the first device side **S**, a second current conduction portion **P2** which is

connected to the second device side **L**, and a power switching device **SW1** which is intermediate or which interconnects the first **P1** and the second **P2** current conduction portions. The power switching device **SW1** is switchable between a first operation state of very low impedance and a second operation state of very high impedance. When the power switching device **SW1** is in the very low impedance first operation state (or "ON state"), a very low impedance current conduction path is established between the first device side **S** and the second device side **L**. This current conduction path is to facilitate flow of operation current or operation power between the first device side **S** and the second device side **L** and forms a power connection path. When in this ON state, the first device side **S** and the second device side **L** are operationally connected for load operation, and operational current or operational power will flow through the power supply control device **100**. When the power switching device **SW1** is in the very high impedance second operation state (or "OFF state"), there is very high impedance between the first device side **S** and the second device side **L**. When in this OFF state, the first device side **S** and the second device side **L** are operationally disconnected, flow of operational current between the first device side **S** and the second device side **L** will be impeded. Where there is a current flow across the power supply control device **100** during this OFF-state, the current will be limited by the very high OFF-state impedance of the power switching device **SW1** and the current will be limited to a non-operational load current or a non-hazardous current which is negligible and/or below a safety limit. An operational load current herein means a current of a magnitude which is intended or designated for a specific or designated load. For an electrical load, the operational load current may be the rated current or rated operation current of the load. The term "ON state" is interchangeably used with the terms "ON-state", "on state", "on-state", "closed state" and the term "OFF state" is interchangeably used with the terms "OFF-state", "off state", "off-state" or "open state" herein.

[0030] The control device **140** comprises a controller **142** and a memory device **144**, as depicted in Figure 1B. The controller **142** is to operate to control switching operations of the power switching device **SW1** and the memory device **144** is for storing data and instructions for use by the controller **142**. The controller **142** may be a processor, a microprocessor or a microcontroller which is to execute stored instructions to operate to switch the path interconnecting the source side **S** and the load side **L** from a very high impedance off-state to a very low impedance on-state and vice versa. The controller **142** comprises a plurality of control ports, data output ports and data output ports.

[0031] In example embodiments, the power supply control device **100** is operable in a 'standby mode' or a 'power supply mode'. When in the standby mode, the power switching device **SW1** is in the off-state and the first current conduction portion **P1** and the second current conduction portion **P2** form a non-conductive path in so far as operation current is concerned. When in the power supply mode, the power switching device **SW1** is in the on-state and the first current conduction portion **P1** and the second current conduction portion **P2** form a conductive path in so far as operation current is concerned.

[0032] Referring to Figure 1C, the power supply control device **100** is set in the standby mode when at an initial state **1100**. At **1110**, the controller **142** operates to monitor conditions on the load side **L** and determine whether a request for power supply condition has occurred. If a request for power supply condition has occurred and is detected by the controller **142**, the controller **142** will at **1120** make enquiries to the load side to investigate whether the load on the load side is an admissible or acceptable load. To make the enquiries, the controller **142** will send one or more enquiry signals to the load side and await response signals from the load side **L**. At **1130**, the controller will upon receipt of response signals of the load side determine whether the load connected to the load side is an admissible or acceptable load. If the load is found to be unacceptable or non-admissible, the controller **142** will refuse power supply to the load and return to the initial state and the power switching device **SW1** is maintained in the off-state **1100**. Alternatively, if the load is found to be admissible or acceptable, the controller **142** will at **1140** operate to switch on the power switching device **SW1** to supply power to the load side **L**. When a power use cycle has ended at **1150**, the controller will reset the power supply control device **100** to the initial state **1100** and await the next request for power supply. As an option, the controller **142** may operate to generate an alarm to alert users that the load is not-admissible or not-acceptable.

[0033] To determine whether there is a request for power supply condition on the load side, the controller **142** may continuously monitor the load side **L** and determine whether a change in electrical property representing a request for power supply condition has occurred on the load side **L**. For example, a sudden drop in load side impedance, indicating a switching on of a load on the load side, or connection of a switched-on load to the load side, may be taken as a request for power supply condition. Alternatively, a request for power supply may be made by way of a protocol communication between the controller **142** and a counterpart controller of the load. For example, protocol data of the protocol communication may be sent through the second current conduction portion **P2** or by wireless transmission.

[0034] To determine whether the load on the load side is eligible, that is, admissible or acceptable for power supply, the controller will send one or more enquiry signals to the load side **L** and then determine whether the corresponding response signals received by the controller **142** contain information indicating eligibility of the load to receive power supply from the power source. For example, the controller **142** may send enquiry signals with an aim to determining whether the load is a target load, an acceptable load, a non-excluded load, an unacceptable load, or an excluded or prohibited load.

[0035] If the load is a target load, an acceptable load or a non-excluded load, the controller **142** may operate to switch on the power switching device **SW1**. Alternatively, if the load is an unacceptable load or an excluded or prohibited load, the power switching device **SW1** will stay in the off-state and return to the initial state or standby state until a next request for power supply condition is detected. The controller may generate an alarm if a condition of non-admissibility or non-acceptability of load is detected, so that the load may be removed for repair or disposal, or security alerted.

[0036] To determine whether a load is eligible (that is, admissible or acceptable) for power supply, one or more eligibility criteria may be used.

[0037] An example criterion of eligibility is by way of identification enquiry. When this identification criterion is used, the controller **142** will obtain identification data of the load and check whether the identity of the load corresponds to the identity of a target load or an acceptable load. To obtain identification data of the load, the controller **142** may send a 'request for identification' by way of communication protocol to the load side and await load side response. A counterpart controller on the load connected to the load side will then send its identity data to the controller **142** and the controller will then verify acceptability. Alternatively, the counterpart controller on the load may be set to transmit identification data to the source side **S** upon connection or upon making a power supply request. The identification data may be sent to controller **142** the through the second current conduction portion **P2** or by wireless transmission. In some embodiments, the controller **142** will determine eligibility of the target load with reference to the received identification information, for example, by determining whether the received identification information matches with identification information of a pre-stored eligible or target load.

[0038] In example embodiments, the power supply control device **100** is a built-in part of a general purpose power outlet, for example a general purpose power socket or wall outlet, the power supply control device **100** may operate to supply power to one or more eligible loads, for example, loads having identification data corresponding to particular or pre-determined electrical specifications or electrical characteristics such as power factor, current rating, voltage rating, temperature rating, safety rating, ingress protection ("IP") rating, or the like; or loads having pre-determined status, such as approval status, security status, safety status, class status, performance status, or the like. The identification criterion by way of identity matching would provide useful protection against misuse, unsafe or unauthorized use of tools, apparatus or equipment. The identification information of an admissible load or admissible loads may be pre-stored for subsequent verification at production, or may be subsequently downloaded by way of update from time to time after installation.

[0039] To obtain identification information of a target load, an acceptable load, a non-excluded load, an unacceptable load, an excluded or prohibited load, or other update data, the control device **140** may include a first communication interface **COM 1** for data communication between the controller **142** and a data source via the first current conduction portion **P1**. To obtain identification data of a load, the control device **140** may include a second communication interface **COM 2** for data communication between the load side counterpart controller and the controller **142** via the second current conduction portion **P2**.

[0040] The first communication interface **COM 1** may comprise a power line communication ("PLC") modem to enable data communication through the first current conduction portion **P1** which operate as a power supply line, or as an alternative or an additional option, by means of a wireless frontend such as a WiFi frontend, as depicted in Figure 2B.

[0041] The second communication interface **COM 2** may comprise a simple switch to facilitate direct data communication between the controller **142** and the counterpart controller on the load side **L** via the second current conduction portion **P2**, or may comprise a power line communication ("PLC") modem to enable data communication between the controller **142** and the counterpart controller on the load side **L** via the second current conduction portion **P2,** or as an alternative or an additional option, by means of a wireless frontend such as a WiFi frontend, as depicted in Figure 2B. Where the controller **142** is required to perform pre-supply check via the second communication interface **COM 2**, the simple switch would suffice. Where the controller **142** is required to perform update checks via the second communication interface **COM 2**, for example, when power is being supplied to the load, the option of a PLC modem or a wireless frontend would be preferred for data communication since power isolation. As an example, the PLC modem may perform data communication with data modulated at say 10kHz for transmission to the source side and at say 100Hz or 250Hz for transmission to the load side.

[0042] An example criterion of eligibility is by way of electrical characteristics enquiry. When this identification criterion is used, the controller **142** will obtain reference data of one or more electrical characteristics of the load and check whether the one or more electrical characteristics of the load on the load side correspond to the reference data.

[0043] In example applications of the electrical characteristics enquiry, electrical characteristics may be pre-stored in the load and retrievable by the controller **142** through cooperation with the counterpart controller of the load, for example, through data communication via the second communication interface **COM 2**. When a request for power supply condition has been detected, the controller **142** will operate to retrieve the pre-stored electrical characteristics from the load, for example, non-volatile memory of the load, for comparative evaluation.

[0044] In example applications, electrical characteristics of the load may be pre-stored in the own memory device **144** of the control device **140** and the controller **142** is to retrieve the pre-stored electrical characteristics for comparative evaluation when a request for power supply from the load side is detected and the identity of the load determined.

[0045] In example applications, electrical characteristics of the load are stored out of the power supply control device **100** but are retrievable by the controller **142** with reference to identification information of the load, for example, through data communication with an external data source.

[0046] The one or more electrical characteristics of the load that may be used for comparative evaluation may include: impedance, impedance-voltage variation, impedance-current variation, impedance-frequency variation, voltage-current variation, voltage-frequency variation, current-frequency variation, voltage-time variation, current-time variation, pulse response, step signal response, phase shift, time constants, or the like.

[0047] To determine the one or more electrical characteristics of the load for comparative evaluation with the reference data, the power supply control device **100** may additionally include a probing signal source **130** and a load monitor **120**, as depicted in Figure 2A. In example operations, the controller **142** is to operate the probing signal source **130** to generate probing signals and to transmit probing signals to the load side **L** by closing the switch **SW2**, for example, when the power switching device **SW1** is OFF. Where the probing signal is a high frequency AC (alternate current) signal, a coupling capacitor may be connected in series with or to replace the switch **SW2**.

[0048] A probing signal may include one or more of: DC (direct current) voltage or current, of constant amplitude or variable amplitudes; AC voltage or current, of specific or variable frequencies and of constant amplitude or variable amplitudes; pulse signals or trains, of specific or variable periods and of constant amplitude or variable amplitudes; step signals, of specific or variable rise times and of constant amplitude or variable amplitudes. The probing source may include a sinusoidal signal generator or a signal generator which can be set to selectively generate square, sinusoidal or saw tooth probing signals without loss of generality.

[0049] The load monitor **120** is to collect responsive signals on the load side which are generated in response to the probing signals and comprises responsive signal collection devices. The responsive signal collection devices may include voltage and/or current sensing devices to collect voltage and/or current information on the load side.

[0050] In example operations as depicted in Figure 2C, the controller **142** would operate the probing signal source **130** to transmit one of more probing signals or one or more types of probing signals to the load side at **1182**, to collect data coming in from the load monitor **120** and representing responsive signals at **1184**, to evaluate one or more electrical characteristics of the load using the collected responsive information at **1185**, and to determine whether the one or more electrical characteristics of the load as determined from the collected responsive information match with the reference data of corresponding electrical characteristics at **1186**. If the comparison at **1186** confirms matching, the controller **142** will close the power switching device **SW1** to facilitate power flow to the load side at **1188**. On the other hand, if the matching comparison fails, the controller **142** will return the power supply control device to the initial state of **1180** and maintain the power switching device **SW1** in the off-state. At end of power use cycle at **1189**, the controller **142** will return the power supply control device to the initial or reset state of **1180**

[0051] Referring to Figure 2A, the probing signal source **130** is for generating probing signals. The probing signal source **130** is operable to generate probing signals and is connected to the load side **L** by a probing signal switch **SW2**. The probing signal switch **SW2** is switchable between a low impedance ON-state and a high impedance OFF-state. When the probing signal switch **SW2** is closed, the probing signal switch **SW2** is in the ON-state and probing signals generated by the probing signal source will flow to the load side **L**. When the probing

signal switch **SW2** is opened, the probing signal switch **SW2** is in the OFF-state and probing signals generated by the probing signal source will not flow to the load side **L**.

[0052] So that the controller can obtain and process information or data to determine electrical characteristics on the load side, the controller will perform load probing operations. In example, load probing operations, the controller will operate the probing signal source to generate load probing signals to the load side and evaluate a response signal or a plurality of responsive signals received from the load side in response to the probing signal to determine one or more electrical characteristics of the load. During load probing operations, the probing signal switch **SW2** is closed and the power switching device **SW1** is opened, a probing signal path is established between the probing signal source **130** and the second current conduction portion **P2**, and probing signals generated by the probing signal source **130** flows to the load side **L**. During non-probing operations, the probing signal switch **SW2** is opened, the probing signal path between the probing signal source **130** and the second current conduction portion **P2** is disconnected to isolate the probing signal source **130** from the second current conduction portion **P2**, and probing signals generated by the probing signal source **130** do not flow to the load side **L**. In some examples, the probing signal switch **SW2** can be part of the probing signal source **130**.

[0053] The load monitor device **120** comprises detection circuitry which is arranged to collect electrical signals, in particular responsive signals, from the load side **L**. The detection circuitry may comprise signal processing circuitry such as shaping circuitry, amplification circuitry, filtering circuitry and other useful circuitry to process electrical signals collected from the load side **L** for subsequent output. In some embodiments, the detection circuitry may comprise decision circuitry to provide a decision output or a plurality of decision outputs upon receiving signals from the signal processing circuitry. In some embodiments, the detection circuitry comprises devices for collecting responsive signals on the load side. A responsive signal is one which is generated in response to a probing signal.

[0054] The control device **140** comprises control circuitry. The control circuitry comprises control device and/or control circuit arrangements which are arranged to manage and/or control operations of the power supply control device **100**. The control circuitry may comprise a microprocessor, memory and peripheral circuitry such as input, output and control ports. The control device **140** is connected to the load monitor device **120** for receiving electrical signals originated from the load side **L**. The control device **140** is connected to control switching operations of both the power switching device **SW1** and the probing signal switch **SW2**.

[0055] In example applications, the switching circuitry **110** comprising the power switching device **SW1** and the probing signal switch **SW2** is operatively controlled by the control device **140**. For example, the control device **140** may operate or control the power switching device **SW1** and the probing signal switch **SW2** either individually or oppositely in synchronisation so that when one is turned on, the other is turned off. In some embodiments, the control device

140 may be connected to the probing signal source **130** to control its signal generation operations. Each of the power switching device **SW1** and the probing signal switch **SW2** may be implemented as solid state relays using MOSFET, thyristor or SCRs.

[0056] The power circuit **160** comprises power circuitry for supplying operation power to various components of the power supply control device **100**. The power circuitry comprises power circuit arrangements such as transformers and power regulators which are arranged to supply regulated power supply to the power consuming components of the power supply control device **100** such as the load monitor device **120**, the probing signal source **130** and/or the control device **140**. An input of the power circuit **160** is connected to the first device side **S** and output of the power circuit **160** is connected to the power consuming components.

[0057] In example applications, the power supply control device **100** is connected to a power supply or a power source, with the first device side **S** connected to a power supply such as AC mains and the second device side **L** connected to a load, as depicted in Figure 1. The load can be any electrical powered apparatus, appliance, equipment or tools. In example applications, the power supply control device **100** may be a built-in part of the power supply apparatus, for example, a general purpose power supply apparatus**.** In some example, the power supply control device **100** may be operated by a power source which is independent of the source side power supply.

[0058] In use, the power supply control device **100** is initially set to be in a stand-by mode. The power supply control device **100** will be subsequently set into a power operation mode when conditions on the load side **L** are found or determined to correspond to prescribed operation conditions or eligible admission conditions.

[0059] When in the standby mode, no current exceeding a safety threshold in time period and in amplitude is allowed to flow through the power supply control device **100** from the source side **S** to the load side **L**. To facilitate this, the power switching device **SW1** is set into the OFF state when in the stand-by mode, and only to be switched into the operational mode subsequently after satisfactory determination of prescribed operation or admission conditions on the load side. When in the power operation mode, normal operational current exceeding the safety threshold time and current will be allowed to flow from the source side **S** to the load side **L**, and through the power supply control device **100**. To facilitate this operation to allow flow of operational currents, the power switching device **SW1** is set into the ON state when in the power operation mode.

[0060] In typical or example configurations, the power supply control device **100** is set into the standby mode each time when the power supply control device **100** is connected to an active power source and will remain in the standby mode until actuated to operate in the operational mode.

[0061] In typical or example configurations, the power supply control device **100** is reset into the standby mode after each use or completion of a cycle of power operation. A cycle of power operation means an operation current has flowed through the power supply control device **100**

for a minimum operation duration and followed by a period of no operation current flow exceeding a predetermined threshold pausing period. An example threshold pausing period may be set to a few second or a few minutes.

[0062] When in the standby mode, the control device **140** will operate in a pre-power operation mode. During the pre-power operation mode, load side **L** electrical conditions are monitored and evaluated to determine whether there is a request for power supply condition. When a request for power supply condition has been detected, the control device **140** will operate to collect electrical signals from the load side and determine whether the collected electrical signals represent conditions of eligible admission on the load side. The pre-power operation is also referred herein as a pre-actuation mode or a monitoring mode.

[0063] In example or typical monitoring operations, the power switching device **SW1** is in the OFF state, the probing signal switch **SW2** is in the ON state and probing signals generated by the probing signal source will be transmitted to the load side as probing signals and to the control device **140** as reference signals. The control device **140** on evaluating the collected probing signal and upon comparison with or with respect to the reference signals would be able to determine whether electrical properties on the load side correspond to electrical properties of eligible operations.

[0064] While the power circuit **160** is connected to the source side **S** to obtain mains power supply for operation when in use, the power supply control device **100** may be DC operated, for example, by battery operation. Where the power supply control device **100** is DC operated, the power circuit may include DC-DC converters and/or DC-AC converters. In some applications, the power supply control device **100** may be dually both battery and mains operated without loss of generality.

[0065] An example power supply control device **200** of Figure 2A1 comprises switching circuitry **210**, a load monitor device **220**, a probing signal source **230**, a control device **240** and a power circuit **260**. The power supply control device **200** includes the same functional components of the power supply control device **100** of Figure 1A and the description thereon is incorporated herein mutatis mutandis where appropriate and with reference numerals increased by 100.

[0066] In the example power supply control device **200**, the power circuit **260** comprises two 220v-to-9v transformers which are connected in series to form a 220v-to-18v transformer. Rectified output of the transformer is voltage regulated by a power regulation arrangement **262** comprising voltage regulators. The transformer output comprises two output paths, namely, a first output path of 18v AC to serve as probing signals and a second output path connected to a full wave rectifier to supply DC power to operate components of the power supply control device **200**. As shown in the circuit diagrams Figure 2A and 2A1, the rectified output is connected to a first voltage regulator **7808**. The first voltage regulator **7808** comprises two outputs, namely, a first voltage output of 8V DC output for driving operational amplifiers

(Op-amp) and a second voltage output connected to a second voltage regulator **7805** to provide a voltage output of 5V DC output for microprocessor and peripheral devices operation.

[0067] The load monitor device **120** comprises two current transformers **222a**, **222b** as example of signal collection devices. Connection of the current transformers **222a**, **222b** is depicted in more detail in Figures 2B1 and 2B2. Each of the current transformers **222a**, **222b** has a transformer ratio and rating of 5A/5mA.

[0068] The current transformer **222a** (or first current transformer) is for detection of current flowing through the second current conduction portion **P2**. Although a single wire is shown in Figures 1 and 2, each of P1 and P2 actually comprises a live and neutral wire as depicted in Figures 2B1 and 2B2. The current transformer **222b** (or second current transformer) is for detection of imbalanced current flowing through the second current conduction portion **P2** and its associated neutral wire portion **N**. Hall effect transducers or other transducers may be used alternatively.

[0069] To facilitate automated monitoring of electrical apparatus, electrical apparatus may be categorized into a plurality of different load types, for example, according to load characteristics. For example, electrical apparatus may be categorized with reference to their load current characteristics when connected to a power supply. Power supply herein means an alternating electrical power supply having a sinusoidal supply voltage of a constant frequency and a constant amplitude unless the context requires otherwise. Typical power supplies for powering electrical apparatus are main power supply or power supplies that comply with standards of mains power supply. The prevailing mains power supplies of different countries or territories are either at a sinusoidal frequency of 50Hz or 60Hz and at a nominal voltage of between 100V and 240V.

[0070] In example embodiments, an electrical apparatus may be classified as a first load type if the current of the electrical apparatus follows the supply voltage of the power supply when the electrical apparatus is electrically connected to the power supply; as a second load type if the current of the electrical apparatus does not follow the supply voltage of the power supply when the electrical apparatus is electrically connected to the power supply, but has current which is characteristic of an electronic power converter which converts AC power into DC power; and as a third load type if the current of the electrical apparatus does not follow the supply voltage of the power supply and does not exhibit the current characteristics of an electronic power converter when the electrical apparatus is electrically connected to the power supply. An electrical apparatus is electrically connected to the power supply herein means a state in which operation power is to flow from the power supply to the electrical apparatus unimpeded or unimpeded by an open switch.

AC Load

[0071] The first load type comprises electrical apparatus having a load current which follows the supply voltage of the power supply when the electrical apparatus is connected to a sinusoidal power supply. The first load type may be divided into a plurality of load subtypes.

[0072] An example subtype of load of the first type has a full-wave sinusoidal current flow when connected to a full-wave sinusoidal power supply. The voltage-current relationship of a light bulb having a tungsten filament as an example of a load of this subtype (first subtype herein) is shown in Figure 5A.

[0073] Another example subtype of load of the first type has a half-wave sinusoidal current flow when connected to a full-wave sinusoidal power supply. A half-wave sinusoidal current is one which flows for half of a sinusoidal cycle or for 180 degrees out of 360 degrees of a sinusoidal cycle and which does not flow for the remaining half of the sinusoidal cycle. A half-wave sinusoidal current typically flows in the first half or the second half of a sinusoidal cycle. The first-half of a sinusoidal cycle corresponds to 0-180 degrees of the sinusoidal cycle and the second half of a sinusoidal cycle corresponds to 180-360 degrees of the sinusoidal cycle. A load having a half-wave sinusoidal current is characteristic of a diode circuit or rectifier circuit, but other loads, for example, switched loads, may also exhibit a half-wave sinusoidal characteristic. A load has a half-wave sinusoidal current flow if the current in the non-conductive half of a sinusoidal cycle is zero or negligible. The voltage-current relationship of a hair blower (Philips branded 1300 Airport 600/1200W) as an example of a load of this subtype (second subtype herein) is shown in Figure 5B.

[0074] A further example subtype of load of the first type has a phase cut current flow characteristic when connected to a full-wave sinusoidal power supply. A load having a phase cut current flow characteristic generally follows the sinusoidal waveform of the supply voltage, but has a non-conductive portion having no or negligible current followed by an abrupt change portion which returns the current flow to follow the sinusoidal waveform of the supply voltage. The phase cut can be represented by a characteristic phase-cut angle, and the phase-cut angle is less than 180 degrees, and usually less than 90 degrees. A load having a phase cut current flow characteristic is typical of a circuit having a switchable device such as a thyristor, SCR, triac, thyratron, or other gated devices. The switchable device is operated by a gating circuit or a firing circuit to control the phase cut angle and the phase cut angle determines the conductive portion during a sinusoidal supply voltage cycle. The voltage-current relationship of a Lightwave oven (Proluxury brand model SDTA0201, 1200W-1400W) as an example of a load of this subtype (third subtype herein) is shown in Figure 5C. The circular mark on Figure 5C is to show a region where phase cutting occurs. The example phase cutting occurs in the first half cycle of the sinusoidal current waveform, or more specifically in the first quadrant and between zero and thirty degrees. The first load type is conveniently referred to as an AC load herein.

DC Load

[0075] The second load type comprises electrical apparatus having a load current which is characteristic of an electronic power converter. An electronic power converter is to operate to convert AC to DC. Switched power supplies and rectifying circuitry are example of electronic power converters. A switched power supply, also known as switched-mode power supply, typically comprises a switching circuit which operates to convert AC power to DC power. The current input of an example switched-mode power supply in operation has an arcuate profile in the time domain, as shown in Figure 6A. Referring to Figure 6A, the load current to the power converter has an arch shape comprising a first current side, a second current side and a vertex portion interconnecting the first current side and the second current side. The load current has a duration which is shorter than the sinusoidal half cycle during which the load current flows. The load current duration is typically determined by the duty ratio of a power conversion circuitry of the power converter. The power conversion circuitry may comprise a half-H-bridge or a full H-bridge. The duty ratio of a DC power converter is usually in the range of between 10% and 90%, and more particularly between 20%-30%. The first current side and the second current side are symmetrical about an axis of symmetry which passes through the vertex, the axis of symmetry is parallel to the current axis (Y-axis) and orthogonal to the time axis (X-axis) of Figure 6A. The first current side has a slope of a first polarity, the second current side has a slope of a second polarity opposite to the first polarity, and inflexion occurs at the vertex of the load current which is intermediate the first current side and the second current side. The slope of a current side generally follows the polarity or trend of the driving sinusoidal supply voltage. As shown in Figure 6A, the load current when driven by the first half sinusoidal cycle of the supply voltage has a first current side of a positive or rising slope, a second current side of a negative or falling slope, and a vertex portion having a zero slope. The load current when driven by the second half sinusoidal cycle of the supply voltage has a first current side of a negative or falling slope, a second current side of a positive or rising slope, and a vertex portion having a zero slope. The first and the second half sinusoidal cycles are, respectively, positive and negative half cycles in the example of Figure 6A. The load current and supply voltage relationship of an example electrical apparatus (Midea brand fan, model FTS35-13BR at 50Hz supply voltage) having an electronic power supply as depicted in Figure 6B has a current arch width which is approximately 20% of the voltage arch width of the corresponding supply voltage half cycle.

[0076] The supply voltage and load current relationship of an example electrical apparatus is shown in Figure 6C. The example electrical apparatus is a 7W LED lamp having a rectifying circuit which is to convert AC supply into DC power for LED operation. The rectifying circuit comprises a bridge rectifier and a parallel RC (resistance-capacitance) bridge connected to the input node of the bridge rectifier.

[0077] Similar to the load current characteristics of the example electrical apparatus having a switched mode power supply, each load current cycle of this example electrical apparatus has

a first current side having a first slope of a first polarity, a second current side having a second slope of a second polarity opposite to the first polarity, and a vertex portion containing an inflexion point of zero slope. In this example, the first slope is an abrupt slope having a gradient which is significantly higher than the slope of the second slope, and the second current side has a significantly higher duration than the duration of the first current side. The load current has a conduction window having a width (in time domain) which is smaller than the half-cycle width of the supply voltage. In this example, the load current duration is approximately 50% of the supply voltage half-cycle width. In general, the load current duration may be around 40%-75%, or between 50%-60%, of the supply voltage half-cycle width.

[0078] The second load type is conveniently referred to herein as a DC load, since the output of the power conversion circuitry is direct current (DC).

Complex Load

[0079] An electrical apparatus having load current characteristics what are not defined hereinabove is classified as a third load type or as a third type of load. An electrical apparatus of the third type comprises more complicated circuitry compared to the AC load and the DC load. The third load type is conveniently referred to herein as a complex load. The load current of a complex load herein does not usually have a dominant fundamental frequency and its complex frequency domain characteristics may be analyzed by techniques such as FFT. Apparatuses comprising motors, inverters etc., are typical example of complex load.

[0080] The supply voltage and load current relationship of an example third type of load (Samsung brand refrigerator, model RB34K6252) is shown in Figure 7.

[0081] While electrical apparatuses are classified into an example plurality of three types of loads, the types of loads are non-exhaustive and are to increase when load current characteristics which are definitive of an additional load type or additional load types are available.

Operation modes and states

[0082] Many electrical apparatuses have different operation states and have different load current requirements or characteristics at the different operation states. For example, some electrical apparatuses begin operation at a cold state and proceed to a warm state after the cold state. Electrical apparatus having a cold state typically draw a large load current from the power supply when starting up from the cold state, and the load current is to fall to a rated current after completion of starting up. The load current at starting up from the cold state is typical multiple times the magnitude of the rated current at the warm state. The start-up current may appear as a current surge or a current spike when compared with the rated current at the warm state which is also referred to as a steady state. For example, a surge current at start-up of an electrical apparatus in the cold state may be 3 times to 10 times or more, typically between 3 times and 5 times the magnitude of the rated current. The rated current is a steady-state current which may vary within a small range during steady state operations. When an

electrical apparatus is at a cold state, it usually means that the electronic circuitry of the electrical apparatus is not pre-biased. To mitigate the magnitude of current surge and/or shorten start up time, many electrical apparatuses have a standby mode which draws a standby current that is substantially smaller than the rated current of the electrical apparatus. An electrical apparatus at standby mode usually has its electrical or electronic circuitry pre-biased to facilitate quick start-up and or start-up with reduced or minimum current surge.

[0083] When an electrical apparatus (for example, a refrigerator having a mechanical compressor) begins operation from a cold state, the initial current, also known as power up current or cold start current, may appear as a current surge and the operation current will subside to or towards a steady-state current, usually gradually. When the electrical apparatus is operating at the steady state current, the electrical apparatus is said to be in the warm state. The change from a spiky start-up current to the rated current represents a transition from a cold state to a cold start state and then the steady state. A stand-by mode is classified as a steady-state mode in this disclosure. When in the stand-by mode, the appliance is in a warm-state and is ready for steady-state operations.

[0084] Many electrical apparatuses can operate in a plurality of steady-states. For example, an electrical apparatus may operate in a plurality of steady states according to load requirements, user selection, schedules, etc. The switching between various steady-states may be automatic, for example in response to sensor feedback, according to preset times or time schedules, by user control or election, or according to other criteria or means without loss of generality.

[0085] Appliances may be classified according to their expected use conditions. For example, electrical appliances such as hair dryers, hand blowers, vacuum cleaners, washing machines, may be classified as a short-use duration appliance. Appliances such as refrigerators, computer servers, air conditioners and lighting equipment may be classified as a long-duration appliance.

[0086] To facilitate automated monitoring of electrical apparatus, electrical apparatus may be categorized into a plurality of operation states, for example, a power-up state, a steady state, a switching state, or other states as and when appropriate.

Start-up state

[0087] To facilitate automated determination of the type of loads, the load monitoring apparatus may be configured to capture load current characteristics of the electrical apparatus during an initial period of electrical connection when the electrical apparatus is first electrically connected to the power supply. An electrical apparatus is first electrically connected to a power supply if the electrical apparatus changes from a state of non-electrical connection with the power supply to a state of electrical connection with the power supply. When the electrical apparatus is electrically connected to the power supply, load current is to flow from the power supply to the electrical apparatus.

[0088] In example embodiments, the load monitoring apparatus is configured to capture load current characteristics of the electrical apparatus for a plurality of supply voltage cycles during an initial period of first electrical connection. The initial period may comprise, for example, 5-15 voltage cycles after first electrical connection of the electrical apparatus with the power supply. In practice, load current characteristics of 8 to 10 supply voltage cycles may be captured for controller processing. After the current characteristics of the electrical apparatus for a plurality of supply voltage cycles have been captured, the load monitoring apparatus is to analyze which type of load is the electrical apparatus. To facilitate determination of the type of load to which electrical apparatus belong or to be classified, the load monitoring apparatus, or more specifically the controller of the load monitoring apparatus, is configured to compare the load current characteristics of the electrical apparatus with the load current characteristics of the different types of loads herein.

[0089] After the load type has been determined, the load monitoring apparatus, or more specifically the controller of the load monitoring apparatus, is configured to and is to operate to extract pertinent electrical parameters of the electrical apparatus for subsequent or future use.

[0090] In example embodiments, the electrical parameters to be captured, extracted, and/or processed on startup when an AC load has been detected include one or more of: first cycle peak current value, maximum peak current value and minimum peak current value during the initial period, power factor, and rms current during one of the voltage cycles, for example, the last voltage cycle during the initial period.

[0091] In addition, the load monitoring apparatus, or more specifically the controller of the load monitoring apparatus, is configured to and is to operate to determine the subtype of AC load to which the electrical apparatus belong.

[0092] In example embodiments such as the present, AC load type is assigned a numerical code zero “0”, the first AC load subtype (AC full wave) is assigned a subtype number zero (“0”), the second AC load subtype (AC half wave) is assigned a subtype number one (“1”), and the third subtype (AC phase-cut) is assigned a subtype number two (2). The subtype numbers are elected as a matter of convenience and are not intended to be limiting. Where an electrical apparatus is switchable between AC full wave and AC half wave, the electrical apparatus will be assigned the subtype number 2, or alternatively, a subtype number 4, as a matter of convenience. The extracted pertinent parameters may be set out in table form, for example in the example form of Table 1 below:

[0093] Table 1

1	2	3	4	5	6
AC Load (Code =0)	First Peak current	Full-wave (Code = 0)	Max. peak Min. peak	power factor (In displacement	Current (Last cycle,

	value	Half-wave (including Half-wave/ full-wave switchable) (Code = 1)	(current value)	angle, θ)	RMS value)
		Phase cutting (code=2)			

[0094] In example embodiments, the electrical parameters to be captured, extracted, and/or processed on startup when a DC load has been detected include one or more of: peak current of the first cycle, peak current of the last cycle, rms current of the last cycle, average real power of the last cycle, apparent power of the last cycle, all of the initial period. The extracted pertinent parameters may be set out in a table form, for example in the example form of Table 2 below:

[0095] Table 2

1	2	3	4	5	6
DC Load (Code =1)	First cycle peak current	Last cycle peak current	Last cycle rms current	average real power over a full cycle (last cycle)	apparent power over a full cycle (last cycle)

[0096] In example embodiments, the electrical parameters to be captured, extracted, and/or processed on startup when a complex load (third load type) has been detected include one or more of: first cycle peak current value, maximum peak current value and minimum peak current value during the initial period, power factor, and rms current during one of the voltage cycles, for example, the last voltage cycle during the initial period. The extracted pertinent parameters may be set out in a table form, for example in the example form of Table 3 below:

[0097] Table 3

1	2	3	4	5	6
Complex Load (Code =2)	First cycle peak current	Last cycle peak current	Last cycle rms current	average real power over a full cycle (last cycle)	apparent power over a full cycle (last cycle)

Steady state

[0098] Where an electrical apparatus is operable in a plurality of different steady states having different power requirements, pertinent electrical parameters of the electrical apparatus at the different steady states may be obtained, for example, from captured voltage and current data which are saved and processed to obtain the electrical parameters. Pertinent electrical parameters herein include peak current or current peak, power including real power and apparent power, and power factor which may be obtained from read power and apparent power.

[0099] Where the load is an AC load, the pertinent steady-state electrical parameters may include one or more of maximum peak current, minimum peak current, power factor. Power factor may be recorded in radian or displacement angle. The pertinent electrical parameters of each steady state (where there is more than one steady state), identified for example by a steady state number, may be set out in table form, for example in the example form of Table 4 below:

[00100] Table 4

1	2	3	4
Steady state Number (#)	Maximum peak current (I)	Minimum peak current (I)	Power factor

[00101] Where the load is a DC load, the pertinent steady-state electrical parameters may include one or more of: maximum peak current, minimum peak current, maximum root-mean-square (rms) current, minimum rms (root-mean-square) current, average real power over a full supply voltage cycle, average apparent power over a full supply voltage cycle, power factor. Power factor may be obtained by the relationship $power\ factor = \frac{Average\ real\ power\ over\ a\ full\ cycle}{Apparent\ power\ over\ a\ full\ cycle}$ and expressed as displacement angle Φ or cosine Φ. The pertinent electrical parameters may be set out in table form, for example in the example form of Table 5 below:

[00102] Table 5

1	2	3	4	5	6	7	8
Steady state Number (#)	Max peak I	Min peak I	Max rms current	Min rms current	average real power over a full cycle	apparent power over a full cycle	Power factor

[00103] Where the load is a complex load, the pertinent steady-state electrical parameters may include one or more of: maximum peak current, minimum peak current, maximum root-mean-square (rms) current, minimum rms (root-mean-square) current, average real power over a full supply voltage cycle, average apparent power over a full supply voltage cycle, power factor.

Switched states

[00104] Where an electrical apparatus is switchable between a plurality of different operational states, additional pertinent parameters may be extracted and saved, and set out in a table form, for example in the example form of Table 5 below:

1	2	3	4
Switching state	Switching time in	Peak current in a	Peak current in a

Number (##)	milliseconds (ms) (maximum)	first switching state (maximum)	second switching state (maximum)

[00105] The extracted pertinent parameters may be saved in the local storage of the load monitoring apparatus, for example, on an on-board memory.

[00106] Automated monitoring of electrical apparatus by machine to enhance operational safety and/or security may be realized by use of a load monitoring apparatus which comprises electronic circuitry. The electronic circuitry may comprise detection circuitry, decision circuitry, control circuitry, data acquisition device, data storage device, and sensors.

[00107] An example load monitoring apparatus may comprise a controller as control and decision circuitry, a power switch connected to a power supply and operable by the controller, sensors such as electrical sensors, and a data acquisition device operable by the controller to facilitate capture of pertinent data such as voltage and current data. The controller may be a solid-state controller such as a microprocessor-based controller or a gate-logic-array-based controller. The power switch may be a semiconductor power switch or a electromechanical switch such as a relay.

[00108] The load monitoring apparatus is configured to capture voltage and current data of the electrical apparatus when power flows from the power supply to the electrical apparatus.

[00109] In example embodiments, the load monitoring apparatus, or more specifically the controller, is configured to capture voltage and current data of the electrical apparatus when the electrical apparatus enters into electrical connection with the power supply. An electrical apparatus enters into a state of electrical connection or a state of power connection with the power supply means that the electrical apparatus changes from a state of non-electrical connection to a state of connection with the power supply. When an electrical apparatus changes from a state of non-electrical connection to a state of electrical connection with the power supply, the electrical apparatus changes from a state of no power flow from the power supply to the electrical apparatus to a state of power flow from the power supply to the electrical apparatus.

[00110] In example embodiments, the controller is configured to begin capture and is to begin capture of electrical data resulting from the power flow upon detection of entry of electrical connection between the electrical apparatus and the power supply.

[00111] In example embodiments, the controller is configured to perform data communication with a load and is to begin data communication with the electrical apparatus to make data enquiries with the electrical apparatus upon detection of entry of electrical connection between the electrical apparatus and the power supply. Where the electrical apparatus is a smart apparatus having a data communication frontend, a data storage device and a data controller, the data controller of the smart apparatus will return with apparatus data requested by the load monitoring apparatus. The smart apparatus data may include one or

more of: apparatus identification (load ID), pertinent electrical parameters of the smart apparatus, load type. The pertinent electrical parameters include the pertinent electrical parameters described herein and may include one or more additional data such as rate current, rated voltage, rated frequency, maximum allowable current, maximum allowable voltage, maximum allowable power, maximum temperature. The pertinent electrical parameters may include one or more sets of pertinent electrical parameters on start-up, on steady-state operations, and on the different switched states as described herein.

[00112] In example operations, the load monitoring apparatus is configured to and is to operate to capture data on voltage and start-up current when the electrical apparatus enters into electrical connection with the power supply, to process the voltage and current data to obtain pertinent electrical parameters, and to determine whether the obtained electrical parameters are within an acceptable range defined by a set of stored pertinent electrical parameters. If the outcome is positive, that is, the obtained electrical parameters are within the acceptable range, electrical connection is maintained. Otherwise, electrical connection is broken and an alarm may be set.

[00113] The stored pertinent electrical parameters may be retrieved from a smart apparatus, from a database of pertinent electrical parameters when the load ID of the electrical apparatus is known, or by machine learning of the load monitoring apparatus if the electrical apparatus is electrically connected to the power supply for a first time and no useable data is retrieved from the electrical apparatus.

[00114] In some embodiments, the load monitoring apparatus is configured to and is to operate to machine learn pertinent electrical parameters of an electrical apparatus. To machine learn the pertinent electrical parameters of an electrical apparatus, the controller of the monitoring apparatus is configured to and is to operate to capture voltage and current data on start-up, during steady-state operations, and at different switched states of the electrical apparatus, to process the captured voltage and current data to obtain the pertinent electrical parameters, and to save the pertinent electrical parameters, for example, locally or on a database accessible by other load monitoring apparatus of a network, for example, a local network.

[00115] When the electrical apparatus is electrically reconnected with physical disconnection, the load monitoring apparatus will monitor the load conditions of the electrical using the learned and stored pertinent electrical parameters.

[00116] The controller is configured to and is to operate to set an acceptable range of the pertinent electrical parameters when the pertinent electrical parameters have been leaned and stored, and to subsequently use the acceptable range to form the pertinent electrical parameters for subsequent use or applications. The acceptable range may be set according to safety requirements and may be set according to a prestored margin algorithms.

[00117] Where the electrical apparatus being learned has an apparatus identity or apparatus identification information ("**ID**") such as Mac address, Bluetooth (TM) ID, Wi Fi ID,

RFID, power-on-ethernet (PoE) or other electronic ID (wireless or wired) which is detectable by the load monitoring apparatus, the controller of the load monitoring apparatus upon detection of new electrical connection of the electrical apparatus with the power supply will operate to retrieve the stored pertinent electrical parameters to facilitate load monitoring of the electrical apparatus. A new electrical connection herein means the electrical apparatus changes from a state of non-electrical connection to a state of electrical connection, after a previous electrical connection. The load monitoring apparatus may be equipped with a wireless frontend and/or optical frontend to facilitate electronic equipment ID recognition and/or detection.

[00118] The load monitoring apparatus is configured to and is to operate to perform load monitoring on start-up, during steady-state operations, and/or at different switched states using, respectively the start-up pertinent electrical parameters, the steady-state pertinent electrical parameters , and/or the switched states pertinent electrical parameters, whether the electrical parameters were learned from the electrical apparatus or retrieved from database or data storage.

[00119] Where the electrical apparatus has no apparatus or equipment ID which is detectable or recognizable by the controller, the load monitoring apparatus may have to relearn the pertinent electrical parameters on next re-connection, which may be physical or electrical re-connection.

[00120] The power supply may comprise an electrical connector for making detachable physical and electrical connection with an electrical apparatus. To facilitate detachable physical and electrical connection with an electrical apparatus, the electrical apparatus would need to have a counterpart electrical connector which is mechanically complementary to the electrical connector of the power supply.

[00121] In some embodiments, the power supply may comprise a power connection interface comprising a load monitoring apparatus, an electrical connector, a connection detector and a rigid main housing, as shown in Figure 8. The load monitoring apparatus, the connection detector and the electrical connector may be housed inside the main housing and the electrical connector has a connection port exposed on the main housing.

[00122] In example embodiments, the power supply comprising a load monitoring apparatus, an electrical connector and a connection detector is configured in the form of a power outlet, wall socket, power plug, or other suitable forms of electrical power connection interface.

[00123] To facilitate detection of physical connection between an electrical apparatus and a power supply or detection of physical disconnection of an electrical apparatus from a power supply, the power supply or the electrical connector of the power supply may comprise a connection detector or a connection sensor which is configured to detect physical connection between the electrical apparatus and the power supply. The connection sensor and the load monitoring apparatus may comprise a contact sensor which is configured to detect physical

or mechanical connection between the electrical apparatus and the power supply. The contact sensor has a signal output which is to out detection signals to the load monitoring apparatus and the controller of the load monitoring apparatus is configured to determine whether there is physical connection which is sufficient to establish electrical connection between the electrical apparatus and the power supply.

[00124] Where the power supply or the electrical connector of the power supply comprises a connection detector or a connection sensor which is configured to detect whether physical connection suitable for electrical power transfer is made between the electrical apparatus and the power supply, the controller of the load monitoring apparatus may be configured to determine with reference to signals of the connection detector or a connection sensor whether an electrical apparatus is physically removed and disconnected from the power supply or the power connector. If no removal or disconnection of the electrical apparatus is detected, the load monitoring apparatus may perform using the last saved pertinent electrical parameters to perform load monitoring of the electrical apparatus. If physical removal or physical disconnection of the electrical apparatus is detected, the load monitoring apparatus may need to re-perform learning of pertinent electrical parameters upon detection of a new physical and electrical connection of an electrical apparatus where the electrical apparatus is neither a smart apparatus nor an apparatus having a machine detectable ID.

[00125] Example operation flow of a load monitoring apparatus in cooperation with a power connection interface which comprises an electrical connector having a port for detachable electrical connection with a complementary electrical connector and a connection detector is shown in Figure 9.

[00126] Example operation flow of a load monitoring apparatus is shown in Figure 10.

[0100] Mains power supply (or ‘mains power’ or ‘main supply’ in short) herein means the general-purpose alternating-current (AC) electric power supply which is also known as household power, household electricity, house current, power-line, domestic power, wall power, line power, AC power, city power, street power, grid power, etc. Most mains power in the world either operate at a standard frequency of 50Hz (Europe) or 60Hz (US) sinusoid.

[00127] Electrical appliances typically comprise electrical circuit assemblies which are connected to the load side of a power source to obtain operation power. The electrical circuits of modern electrical appliances are complex and their electrical properties or electrical characteristics as an electrical load are non-constant, but can be variable according to operation time and/or operation states.

Load current monitoring

[00128] In example embodiments, a load monitor may be connected to the load or the power outlet to monitor load current conditions and a controller is to operate the load monitor to capture an example plurality of load current samples for determination of load current

properties and/or load current characteristics. The load current samples may be samples of load current amplitudes with respect to time. The captured current amplitude and time data may be stored in a storage device of the monitor circuit. The storage device may comprise volatile memory devices such as RAM and non-volatile memory devices such as flash memories. A controller, for example, an integrated circuit or solid-state microprocessor-based controller is to operate to analyze the captured current and time to determine the load current properties and load current characteristics at materials times.

[00129] An example load current monitor comprises a current sensor which is connected across the first input terminal A and a second input terminal com, as depicted in Figure 4. The current monitor is for monitoring current which flows through a load, which is connected to an AC power source, and the AC power source comprises a live terminal L and a neutral terminal N. The current sensing path comprises a low resistance path formed by a fusible link and a current sensing resistor. The current sensing resistor has an example very low resistance of 0.01Ω and the example fusible link has an example fusing rating of 5A. The current which flows through the current sensing resistor is monitored by a resistor ladder network. The resistor ladder network comprises a first terminal which is connected to a first terminal of the current sensing resistor and a second terminal which is connected to a negative input terminal of an amplifier LTC1050. The resistor ladder network comprises a plurality of switchable resistor links to control gain of the voltage amplifier. The positive input terminal of the voltage amplifier LTC1050 is tied to a reference voltage, which in the present example embodiment is set to be at 1.6V by a set of biasing resistors when the amplifier output is to swing between 0 and 3.3 volt when the power supply to the load current monitor is at 5V DC. The current monitor comprises a third input terminal which is for connection to the live terminal of the AC voltage to monitor the AC supply voltage. The load current monitor comprises a first output terminal which is an output terminal of the voltage amplifier. The load current monitor comprises a second output terminal which is a line voltage terminal V for outputting the AC line voltage, down converted. The load current monitor comprises a third output terminal zero which is a reference voltage terminal for outputting voltage at the com terminal or the neutral terminal. The first input terminal A is connected to an upstream end of the low resistance path and the second terminal com is connected to the neutral terminal of an AC source and the downstream end of the low resistance path.

[00130] The load characteristics of some appliances change according to the operation states. In example embodiments, load characteristics are determined during different operation states and the outcomes of determination may be used as stand-alone criteria or in combination.

[00131] In some embodiments, the frequency contents of the load current are obtained by using Fast Fourier Transforms (FFT), and the characteristic frequency spectrum of the load current is stored as pertinent parameters.

[0101] The same symbols and conventions are used herein where appropriate unless the context requires otherwise or unless specified.

[0102] In example embodiments, a load monitor apparatus is to execute stored instructions to operate the load monitor circuit to monitor load-side conditions and to determine whether the connected appliance is fit for operation. The load monitor circuit may comprise the load current monitor circuit of Figure 4, which may be incorporated or built-in as part of the load monitor 120 of Figure 1, and the device, including the load monitor 120, of Figure 2A may also function as the load monitor apparatus.

[0103] The appliance may have an identification code which is stored on the appliance. For example, the identification code may be stored in a data storage device, such as a non-volatile memory, of the appliance or stored in an RFID tag attached to the appliance. Where the identification code is stored in a data storage device on the appliance, the appliance may comprise a data communication frontend to facilitate export of the identification code. The data communication frontend may be wired data communication port or a wireless data communication frontend.

[0104] When the appliance is to request for power supply, the load monitor apparatus, or more specifically the controller or the load monitor apparatus, is to obtain the identification code of the appliance. An appliance may be treated as to request for power when the appliance is first connected to the power source or when a connected appliance is switched on from an off-state.

[0105] After the identification code of the appliance has been obtained by the load monitor apparatus, the controller is to retrieve stored electrical characteristics of the appliance with reference to the identification code. The electrical characteristics, for example, comprising the pertinent parameters hereinabove, are pre-stored in databases of stored electrical characteristics of appliances. The databases may be stored on-board the load monitor apparatus or outside. Where the databases are stored outside of the load monitor apparatus, the load monitor apparatus may retrieve the stored electrical characteristics through its data communication frontend, as depicted in Figure 8.

[0106] During operations of the appliances, the load monitor apparatus is to compare the retrieved pertinent parameters and the real time measured data and to determine whether the appliance is fit for operation.

[0107] In example embodiments, the database may include a white list, a grey list and a black list. A white list may contain electrical characteristics of a plurality of appliances which is approved for immediate connection, together with their pertinent parameters. A black list may contain identification numbers of a plurality of appliances which are prohibited from connection. A grey list may contain types of appliances which are not prohibited from connection or partial parameters, subject to verification of their pertinent electrical characteristics and parameters.

[0108] The databases may be contributed by manufacturers and assembled as centralized databases.

[0109] The databases may be contributed by end-users and saved on the load monitor apparatus.

[0110] The databases may follow the formats of the pertinent parameters set out herein as examples, but other formats are of course possible.

[0111] To build the databases, sample electrical appliances of various types and associated electrical characteristics are measured and stored as reference data for subsequent use. Due to variation and tolerances, ranges of associated electrical characteristics are measured may be included in the database so that the load monitor apparatus may determine whether the electrical characteristics and parameters are within an acceptable range or ranges representing fitness for operation. For example, an appliance may be fit for operation when new but its electrical characteristics and parameters degrade to outside the acceptable range or ranges and become no longer fit for operation. When the load monitor apparatus has determined that the electrical characteristics and parameters of an approved appliance are no longer with an acceptable range representing fit for operation, the specific appliance having a specific identification number will become black listed, locally or centrally.

[0112] The load monitor apparatus may include a set of local databases of frequently used appliances to expedite approval for power connection.

[0113] As the electrical characteristics and pertinent parameters of various appliances can fluctuate within a reasonable range, a manufacture may define acceptable range or ranges of the electrical characteristics and parameters of appliances, for example, by measuring the electrical characteristics and parameters of a pool of samples of appliances.

[0114] Where an appliance has no identification number or has an identification number which is not on the databases, the load monitor apparatus may include an option for a user to selectively approve an appliance by going through initial measurements to measure the operating electrical characteristics and parameters at one or all or the operations states and to determine whether the appliance should be approved for power connection. The measured operating electrical characteristics and parameters of an approved appliance are then stored locally for future reference. Where the appliance has no built-in identification number, the approval procedure may be repeated every time when the appliances makes a request for power connection. Where an appliance has an identification number which is not previously stored in the databases, the databases may be updated with the new identification number and the associated electrical characteristics and parameters as those of an approved appliance.

[0115] In example embodiments, a plurality of load monitor apparatus is connected separately to a plurality of individual power outlets. The updated local databases may be distributed to

the plurality of load monitor apparatus within the locality for use by the plurality of load monitor apparatus within the same locality. A locality may be a home, an office, a building or a street without loss of generality.

[0116] In some embodiment, each locality may have a centralized load monitor apparatus which controls operation of a plurality of power outlets and the databases of pertinent electrical characteristics and parameters of approved appliances of the locality are stored on the centralized load monitor apparatus.

[0117] The identification number may be specific to individual appliances so that each appliance can be uniquely identified by its identification number. The identification number may include a serial number of an appliance, which is assigned for example by manufacturer.

[0118] The identification number may include a code portion to represent the load type. For example, an identification number may include a type code portion which indicates whether the appliance is an AC load (for example, type code=0), a DC load (for example, type code=1), a complex load (for example, type code=2) etc.

[0119] The pertinent or reference electrical characteristics and parameters may be stored according to the operations state. For example, the power-up state may be given a state-code of 0, the switching-state may be given a state-code of 1, and the steady-state may be given a state-code of 2. The switching-state may have a two-digit format to provide space for sub-switching states.

[0120] In operation, the load monitor apparatus may monitor the operation electrical characteristics and parameters at each and/or every operation state. If the measured electrical characteristics and parameters commensurate with the pre-stored reference electrical characteristics and parameters, the load monitor apparatus is to determine that the connected appliance is fit for operation and power connection is to continue. Otherwise, the power connection is to cease and an alert or alarm may be generated to attract user or security attention.

[0121] While the disclosure is made with reference to example and embodiments, it should be appreciated that the embodiments and example herein are to facilitate better understanding and are not intended to be restrictive.

Claims

1. A method of monitoring an electrical apparatus having a plurality of electrical parameters by a load monitoring apparatus comprising a controller, the method comprising the load monitoring apparatus:

- capturing and processing voltage and current data of the electrical apparatus to obtain electrical parameters of the electrical apparatus, and storing the electrical parameters as measured electrical parameters,
- comparing the measured electrical parameters with a set of pre-stored electrical parameters,
- determining whether the measured electrical parameters match with the stored electrical parameters,
- operating a power switch to turn off power supply to the electrical parameters if the measured electrical parameters do not match with the stored electrical parameters.

2. The method of claim 1, wherein the method comprises the load monitoring apparatus:

- obtaining electrical parameters of the electrical apparatus on start-up of the electrical apparatus and storing measured start-up electrical parameters of the electrical apparatus on the load monitoring device,
- comparing the measured start-up electrical parameters with a set of pre-stored start-up electrical parameters,
- determining whether the measured start-up electrical parameters match with the stored start-up electrical parameters,
- operating a power switch to turn off power supply to the electrical parameters if the measured start-up electrical parameters do not match with the stored start-up electrical parameters.

3. The method of claims 1 or 2, wherein the method comprises the load monitoring apparatus:

- obtaining electrical parameters of the electrical apparatus when the electrical apparatus is operating in a steady state and storing measured steady-state electrical parameters of the electrical apparatus on the load monitoring device,
- comparing the measured steady-state electrical parameters with a set of pre-stored steady-state electrical parameters,
- determining whether the measured steady-state electrical parameters match with the stored steady-state electrical parameters,
- operating a power switch to turn off power supply to the electrical parameters if the measured steady-state electrical parameters do not match with the stored steady-state electrical parameters.

4. The method according to any preceding claim, wherein the electrical apparatus is switchable to operate in a plurality of switched operating modes, and the method comprises the load monitoring apparatus:

- obtaining electrical parameters of the electrical apparatus when the electrical apparatus is operating in a switched operating mode and storing measured electrical parameters of the electrical apparatus in the switched operating mode on the load monitoring device,

- comparing the measured electrical parameters of the switched operating mode with a set of pre-stored electrical parameters of the switched operating mode,

- determining whether the measured electrical parameters of the switched operating mode match with the stored electrical parameters of the switched operating mode,

- operating a power switch to turn off power supply to the electrical parameters if the measured electrical parameters of the switched operating mode do not match with the stored electrical parameters of the switched operating mode.

5. The method according to any preceding claim, wherein the electrical apparatus is switchable to operate in a plurality of switched operating modes, and the method comprises the load monitoring apparatus:

- measuring switching time when the electrical apparatus operating in a steady state is switched between a first operating mode and a second operating mode, and storing the switching time;

- determining whether the measured switching time matches with a stored switching time,

- operating a power switch to turn off power supply to the electrical parameters if the measured switching time does not match with the stored switching time.

6. The method according to any preceding claim, wherein the method comprises the load monitoring apparatus:

- capturing voltage and current data of the electrical apparatus and storing the captured voltage and current data of the electrical apparatus,

- determining load type of the electrical apparatus according to the captured voltage and current data,

- processing the captured voltage and current data to obtain electrical parameters of the electrical apparatus;

- determining whether the obtained electrical parameters of the electrical apparatus match with stored electrical characteristics of that load type.

7. The method according to any preceding claim, wherein the electrical apparatus has a load type identification data containing load type information of the electrical apparatus, and the method comprises the load monitoring apparatus:

- capturing voltage and current data of the electrical apparatus and storing the captured voltage and current data of the electrical apparatus,

- processing the captured voltage and current data to obtain electrical parameters of the electrical apparatus;

- determining whether the obtained electrical parameters of the electrical apparatus are consistent with electrical parameters which are characteristics of that load type.

8. The method according to any preceding claim, wherein the electrical apparatus has an apparatus identification data which is readable or detectable by the load monitoring apparatus, and the method comprises the load monitoring apparatus:

- retrieving electrical parameters of the electrical apparatus using the apparatus identification data;

- capturing voltage and current data of the electrical apparatus and storing the captured voltage and current data of the electrical apparatus,

- processing the captured voltage and current data to obtain electrical parameters of the electrical apparatus;

- determining whether the obtained electrical parameters of the electrical apparatus are consistent with retrieved electrical parameters of the electrical apparatus.

9. The method according to any preceding claim, wherein the electrical apparatus has a load type identification containing load type information of the electrical apparatus, and the method comprises the load monitoring apparatus:

- capturing voltage and current data of the electrical apparatus on start-up and storing the captured start-up voltage and current data of the electrical apparatus,

- processing the captured voltage and current data to obtain start-up electrical parameters of the electrical apparatus;

- determining whether the obtained electrical parameters of the electrical apparatus are consistent with start-up electrical parameters of the load type.

10. The method according to any preceding claim, wherein the electrical apparatus has an apparatus identification data which is detectable by the load monitoring apparatus, wherein the method comprises the load monitoring apparatus:

- capturing voltage and current data of the electrical apparatus and storing the captured voltage and current data of the electrical apparatus,

- processing the captured voltage and current data to obtain electrical parameters characteristic of the electrical apparatus in operation and devising a set of parameters for load monitoring;

- storing the apparatus identification data and the set of parameters;

- retrieving the set of parameters to perform load monitoring when new electrical connection between the electrical apparatus and the power supply is detected.

11. A load monitoring apparatus for monitoring electrical parameters of an electrical load when the load electrical is electrically connected to a power supply, the apparatus comprising a controller, a power switch operable by the controller, a data acquisition device operable, voltage and current sensors configured to feed voltage and current information to the data acquisition device and a data storage device; wherein the controller is configured to perform the method according to any preceding claims.

12. The load monitoring apparatus of claim 11, wherein the power switch is for making breakable electrical connection between the power supply and an electrical load, wherein the controller is configured to operate the data acquisition device to acquire voltage and current data through the voltage and current sensors when load current flows through the power switch; and wherein electrical characteristics of different types of load are stored on the load monitoring apparatus and the controller is configured to determine type load of an electrical load which is connected to the power source and to apply a set of monitoring criteria according to the load type.

13. The load monitoring apparatus of claims 11 or 12, wherein the controller is configured to learn electrical parameters of an electrical load using voltage and current data captured by the data acquisition device when a load is electrically connected to the power supply, and to stored learned electrical parameters for subsequent monitoring of the load when the load is reconnected to the power supply after electrical connection.

14. The load monitoring apparatus according to any preceding claims, wherein load current characteristics of a plurality of load types and electrical parameters for monitoring the plurality of load types are stored on the data storage device, wherein the controller is configured and to operate to assign a load type to a load according to measured voltage and current data of the load, and wherein the controller is configured and is to operate to apply monitoring electrical parameters to perform load monitoring of the load using the electrical parameters.

15. The load monitoring apparatus according to any preceding claims, further comprising a detection arrangement for detecting physical disconnection of a load from the power supply.

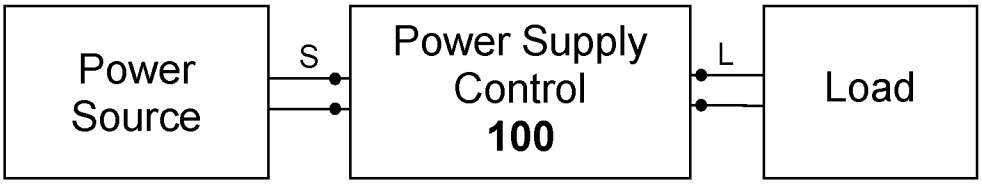


Fig. 1

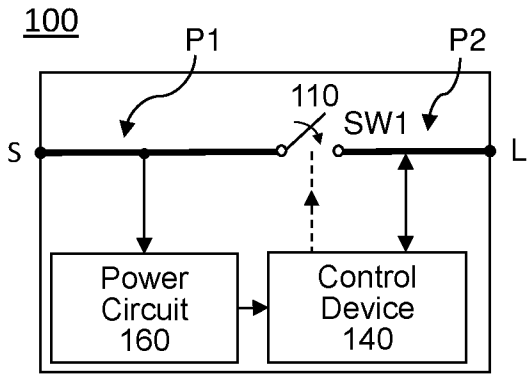


Fig. 1A

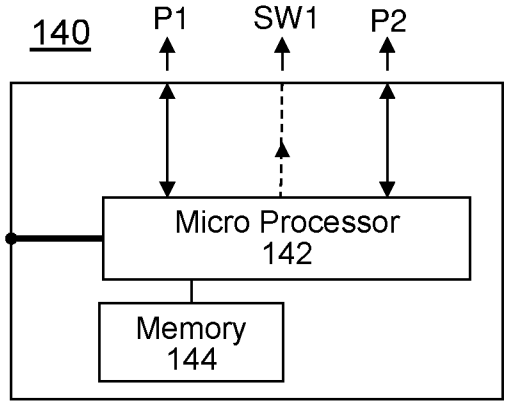


Fig. 1B

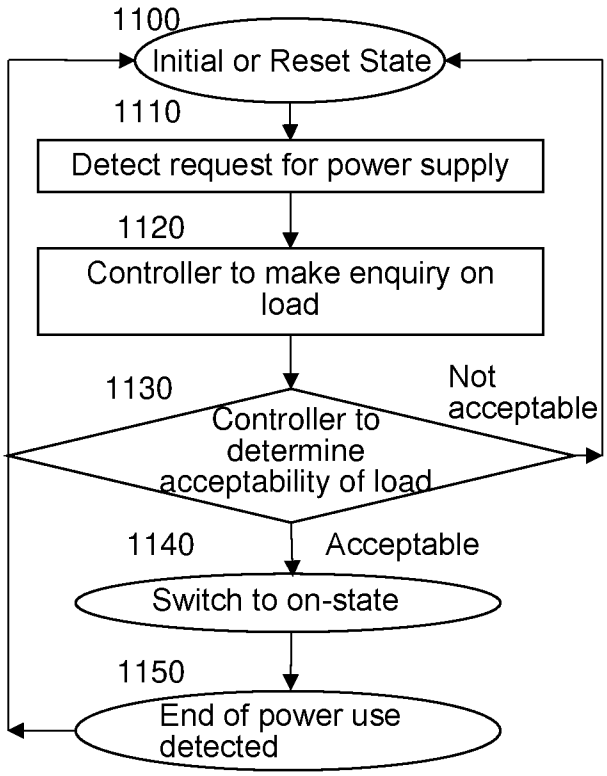


Fig. 1C

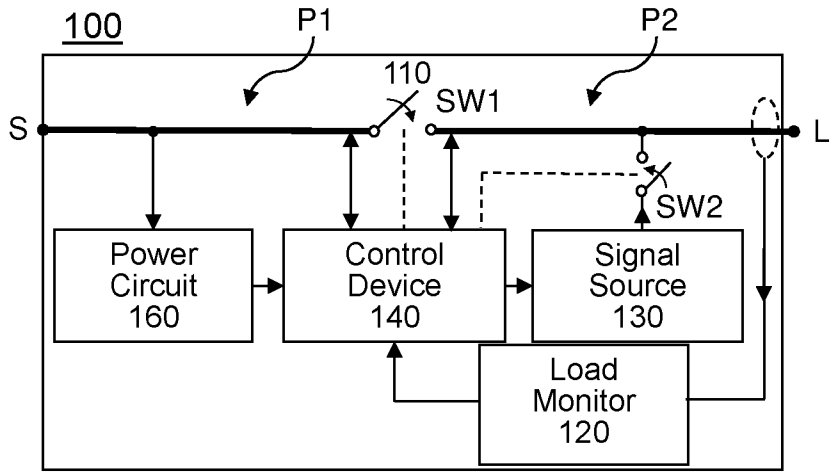


Fig. 2A

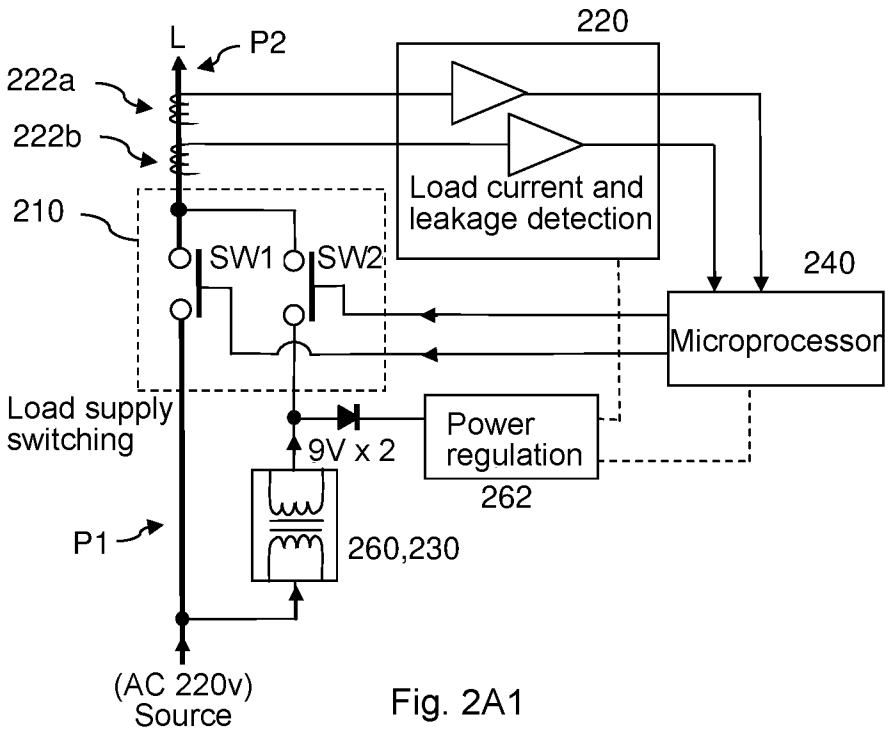


Fig. 2A1

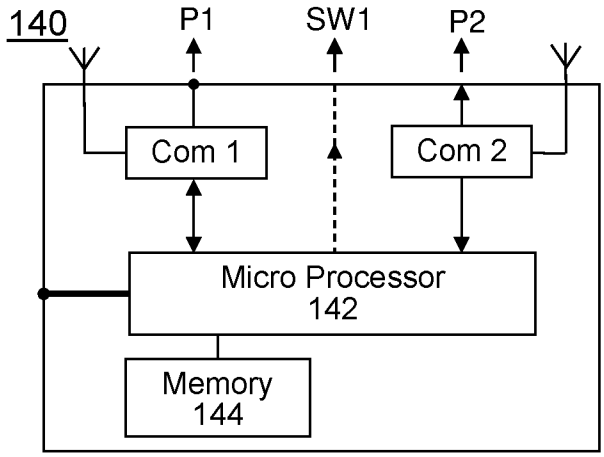


Fig. 2B

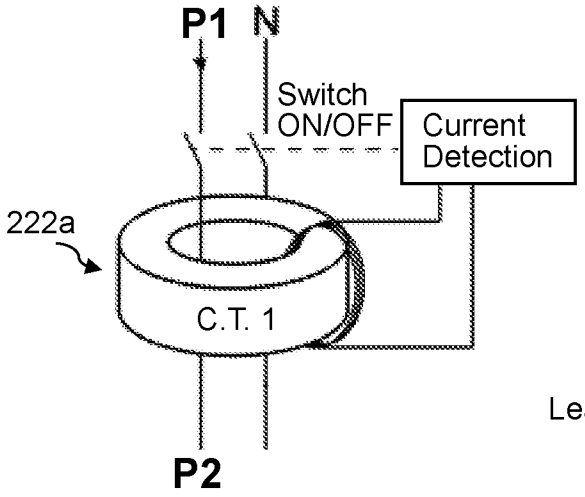


Fig. 2B1

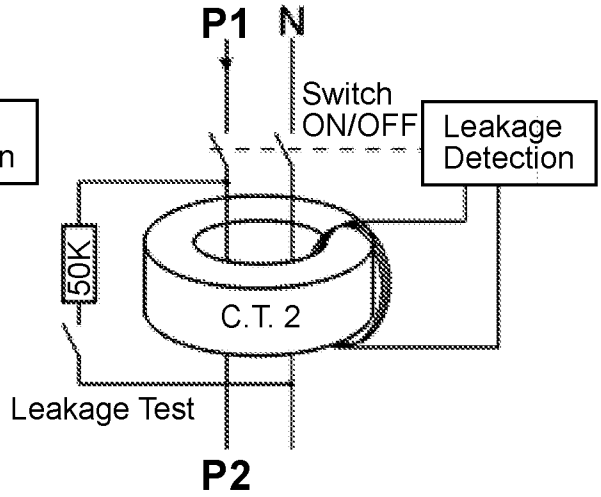


Fig. 2B2

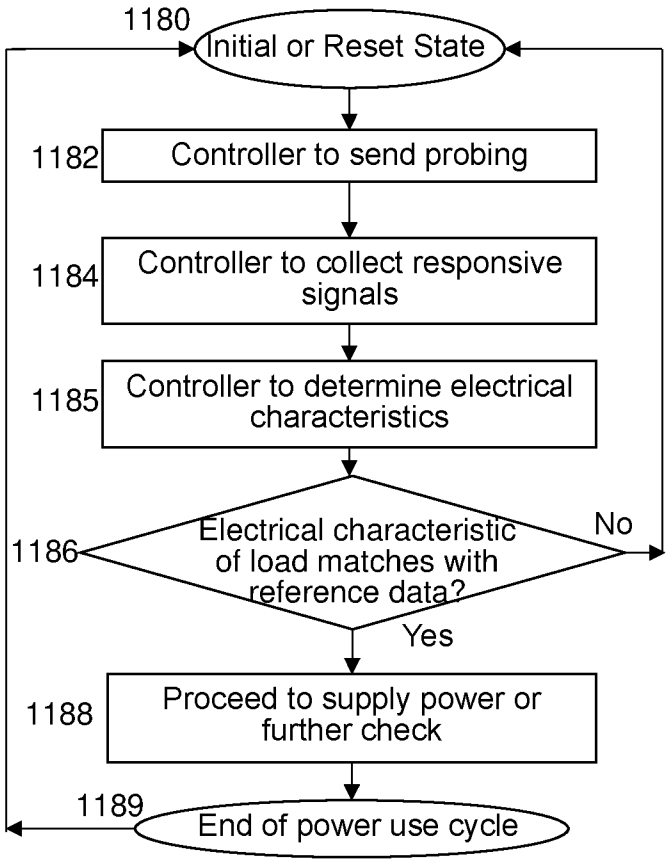


Fig. 2C

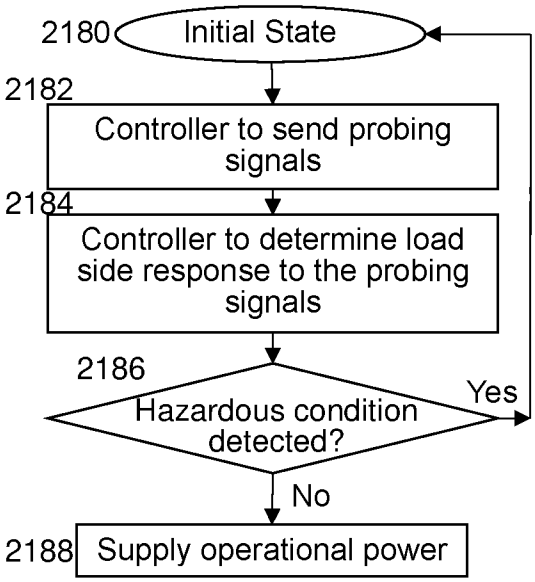


Fig. 3

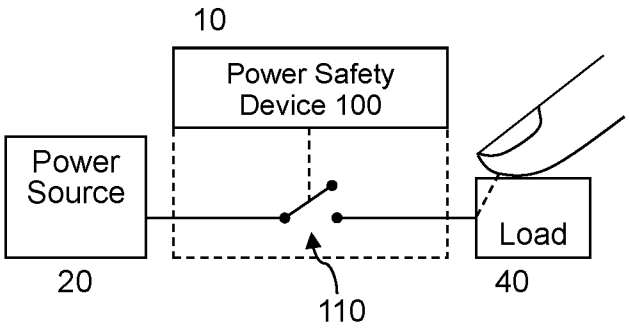


Fig. 3A

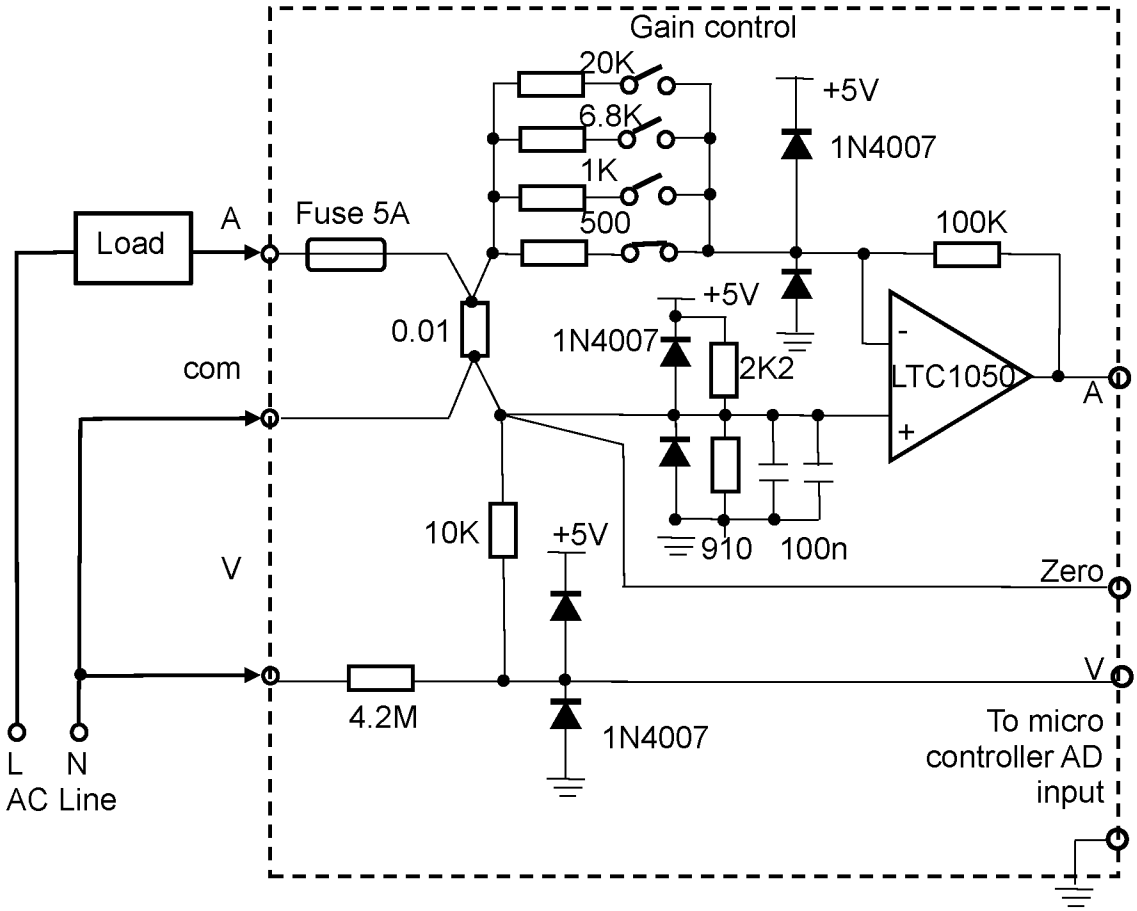

Gain control
20K
6.8K
1K
500
+5V
1N4007
100K
Load
A
Fuse 5A
0.01
com
+5V
1N4007
2K2
LTC1050
A
10K
+5V
910
100n
V
Zero
V
4.2M
1N4007
To micro
controller AD
input
L
N
AC Line

Fig. 4

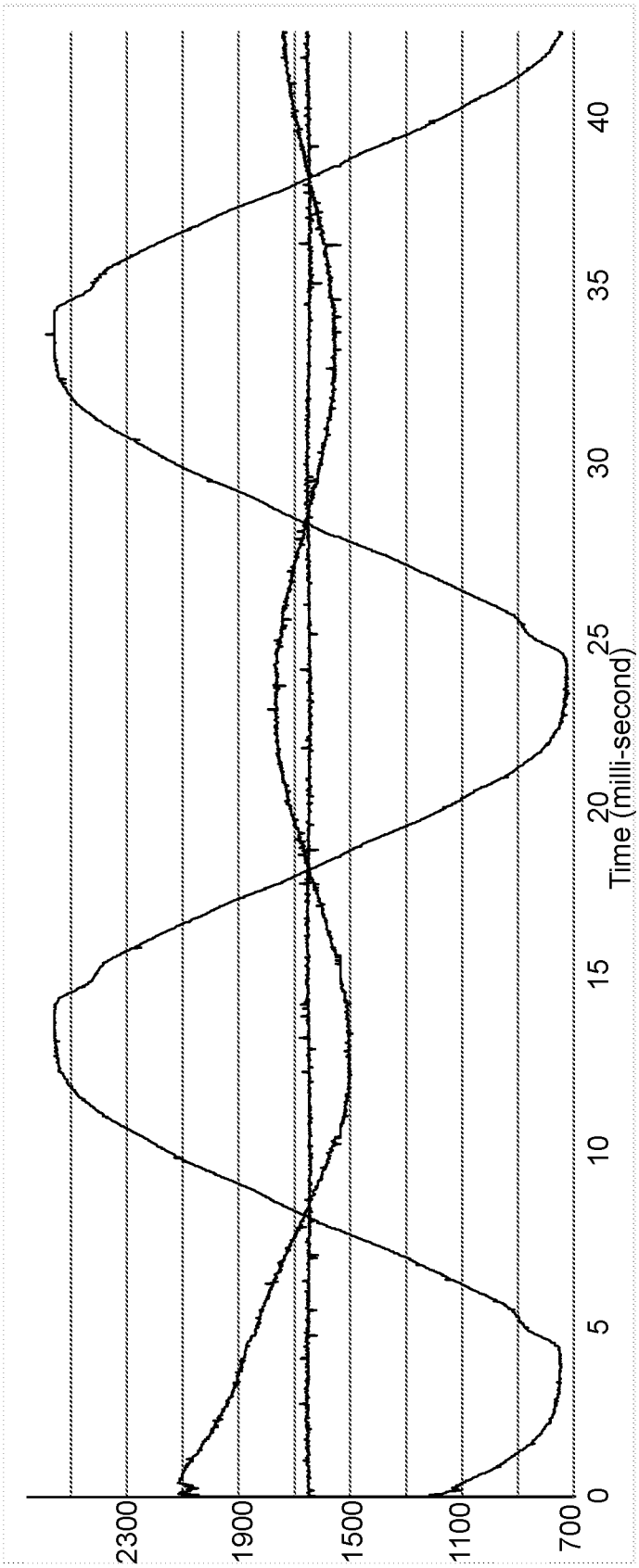

2300
1900
1500
1100
700
0
5
10
15
20
25
30
35
40
Time (milli-second)

Fig. 5A

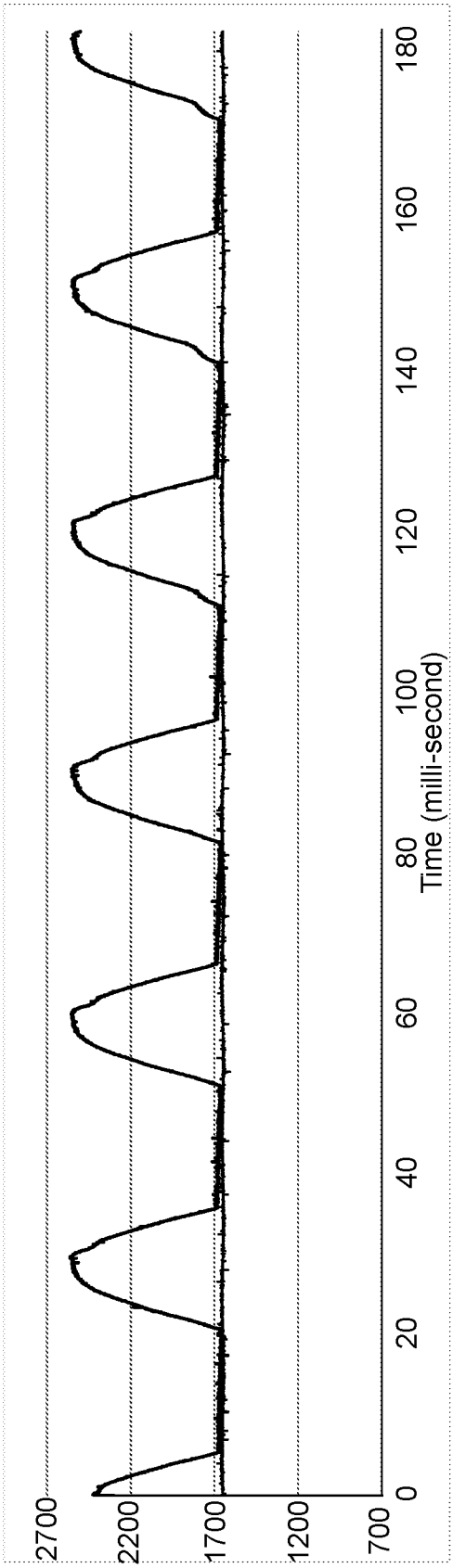

2700
2200
1700
1200
700
0
20
40
60
80
100
120
140
160
180
Time (milli-second)

Fig. 5B

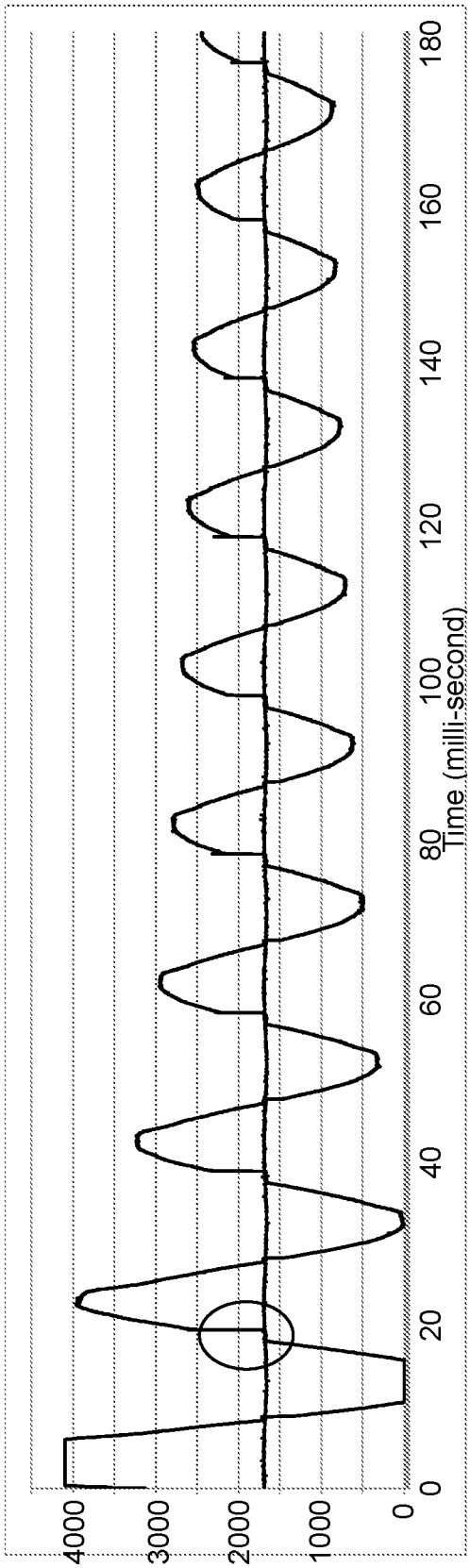

4000
3000
2000
1000
0
0
20
40
60
80
100
120
140
160
180
Time (milli-second)

Fig. 5C

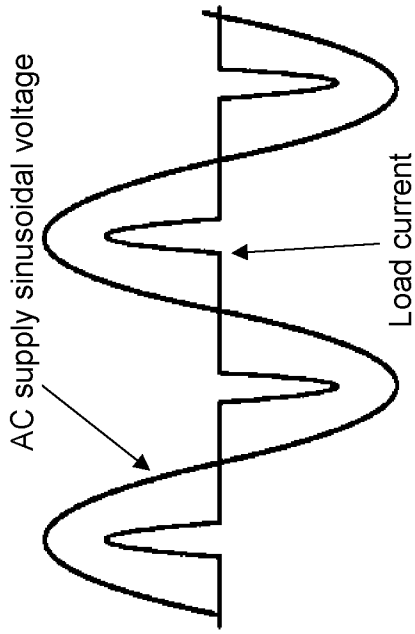

AC supply sinusoidal voltage
Load current

Fig. 6A

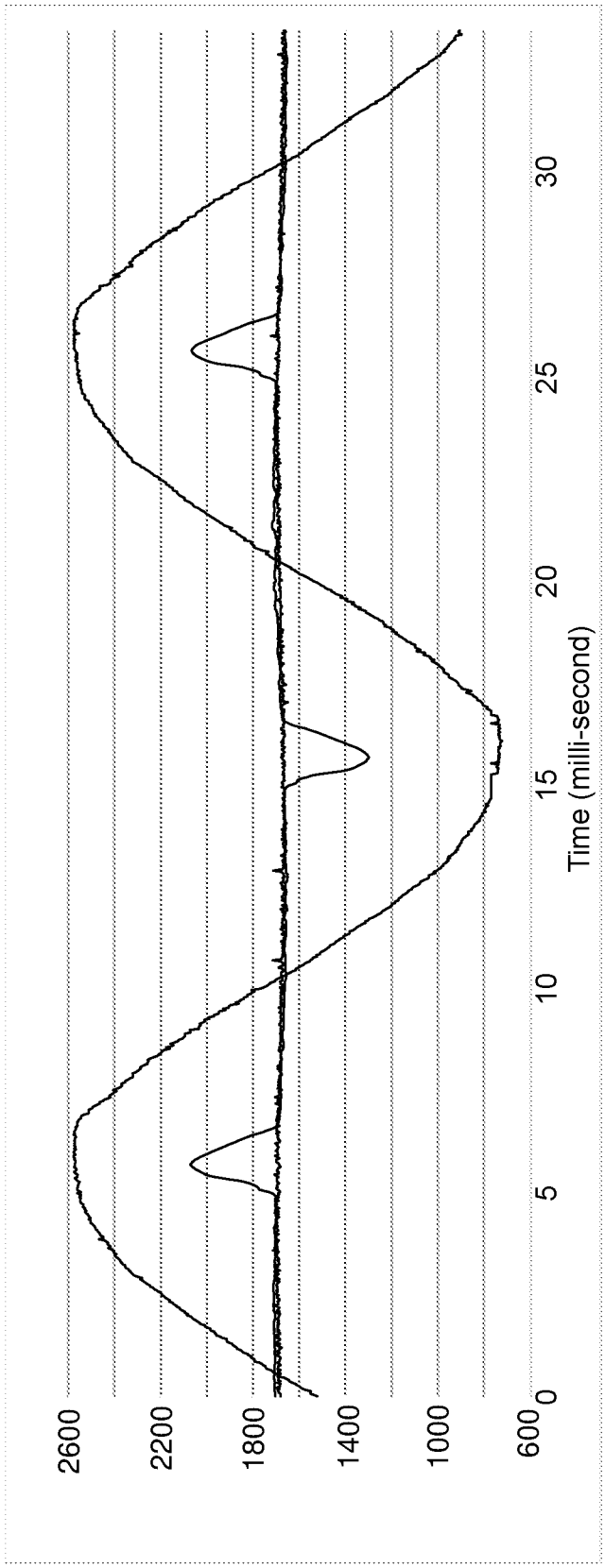

2600
2200
1800
1400
1000
600
0
5
10
15
20
25
30
Time (milli-second)

Fig. 6B

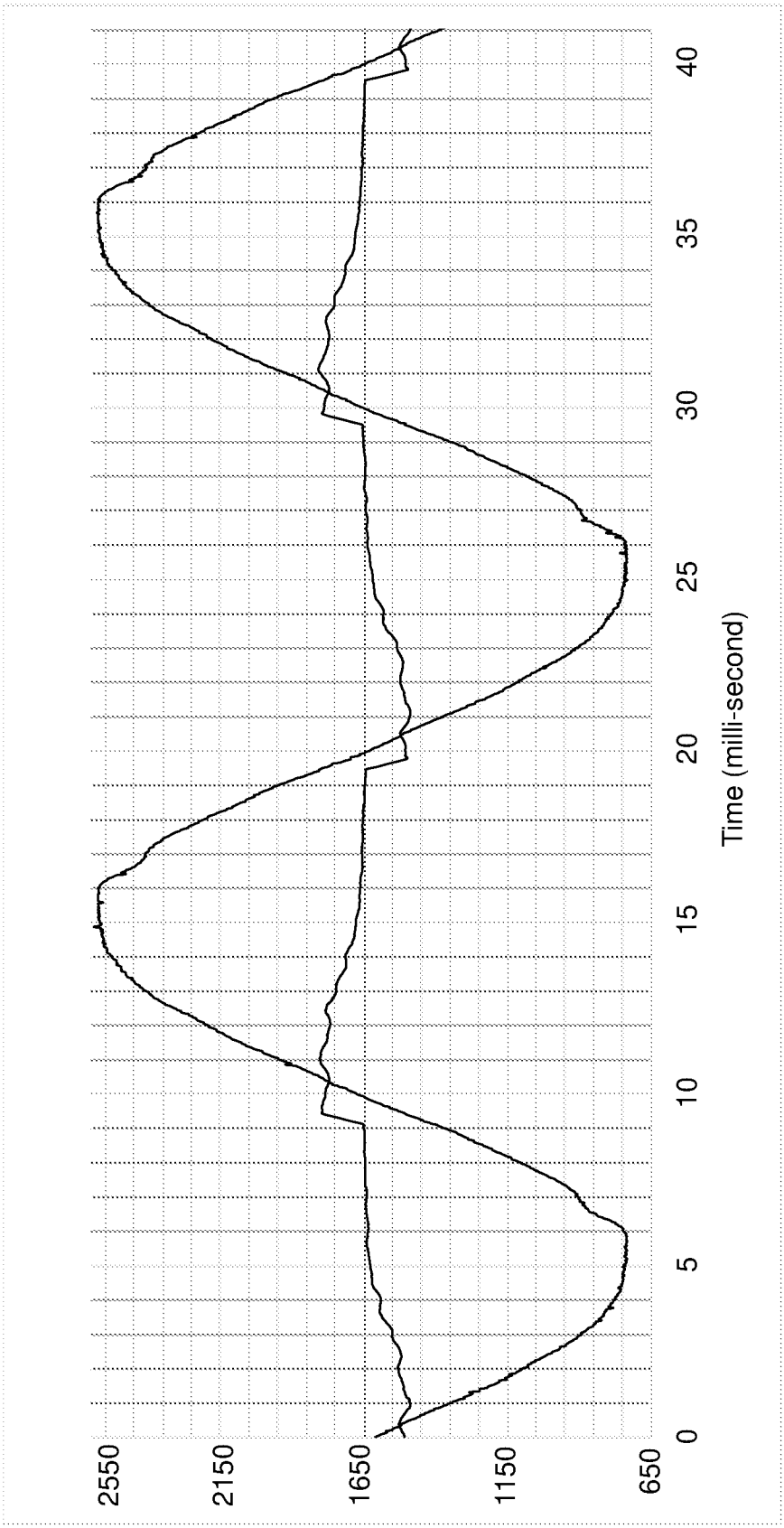

2550
2150
1650
1150
650
0
5
10
15
20
25
30
35
40
Time (milli-second)

Fig. 6C

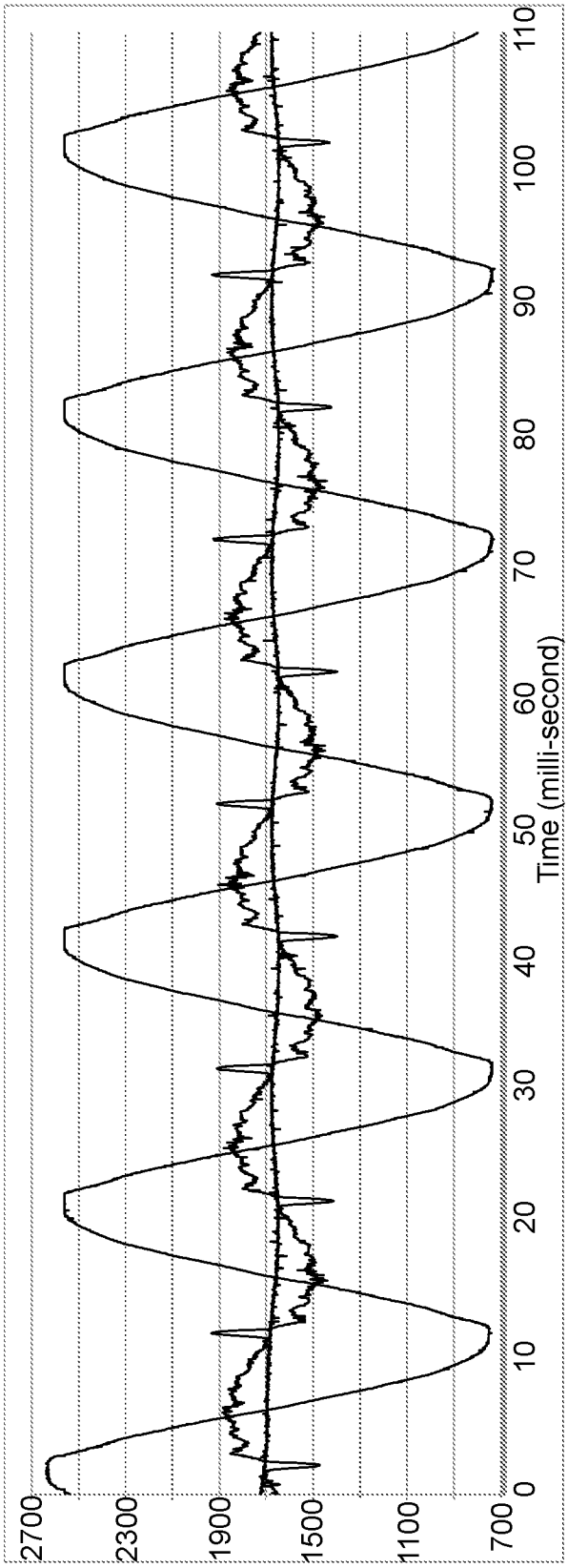

2700
2300
1900
1500
1100
700
0
10
20
30
40
50
60
70
80
90
100
110
Time (milli-second)

Fig. 7

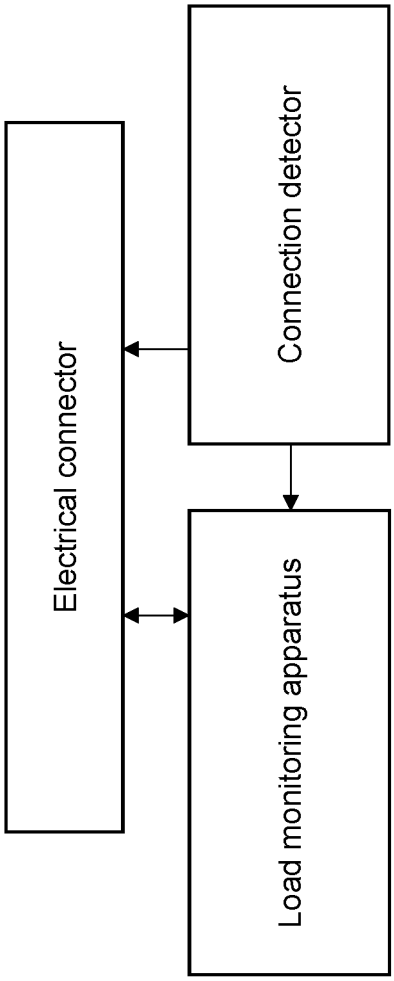

Electrical connector
Connection detector
Load monitoring apparatus

Fig. 8

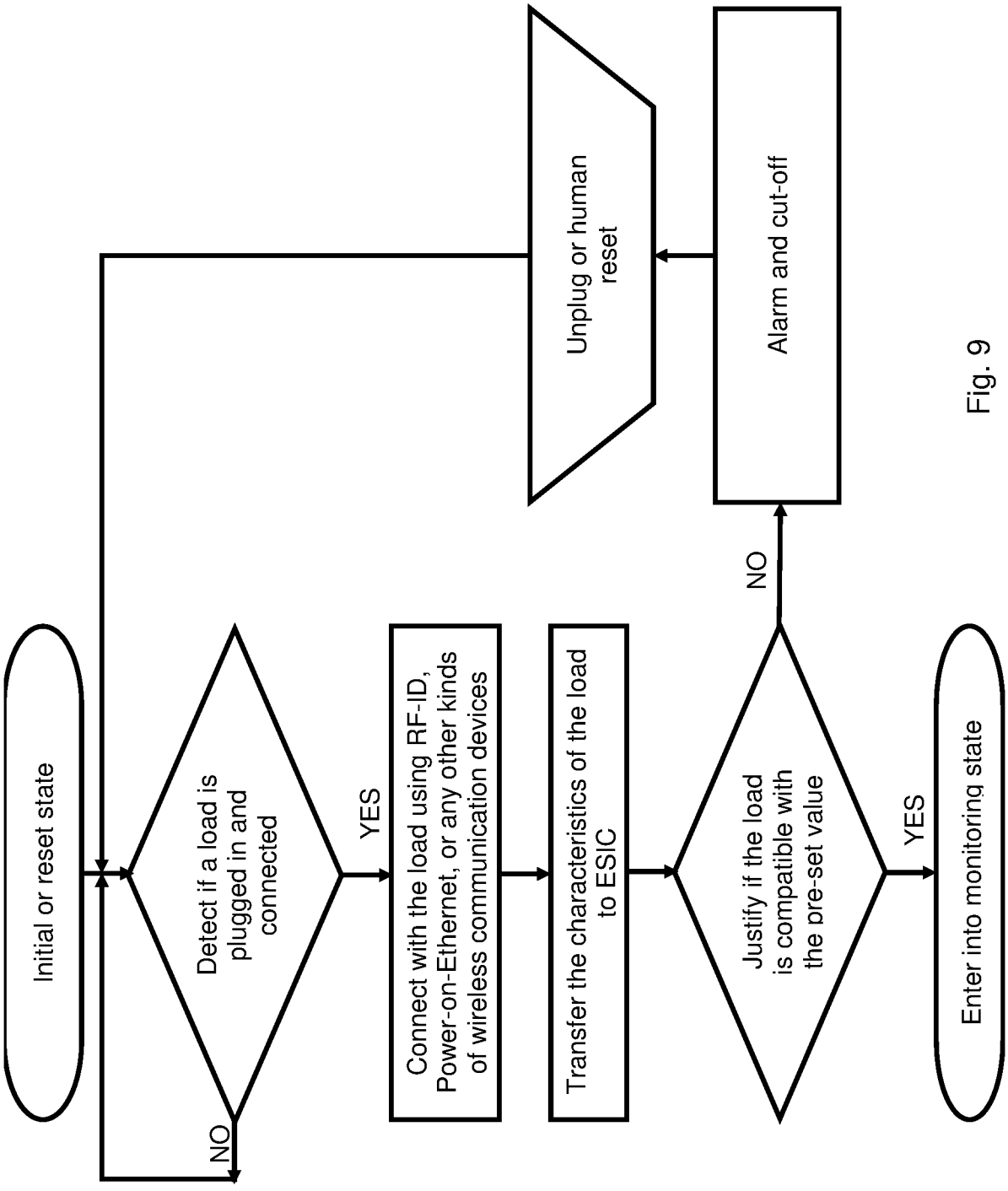

Initial or reset state
Detect if a load is plugged in and connected
NO
YES
Connect with the load using RF-ID, Power-on-Ethernet, or any other kinds of wireless communication devices
Transfer the characteristics of the load to ESIC
Justify if the load is compatible with the pre-set value
NO
YES
Alarm and cut-off
Unplug or human reset
Enter into monitoring state

Fig. 9

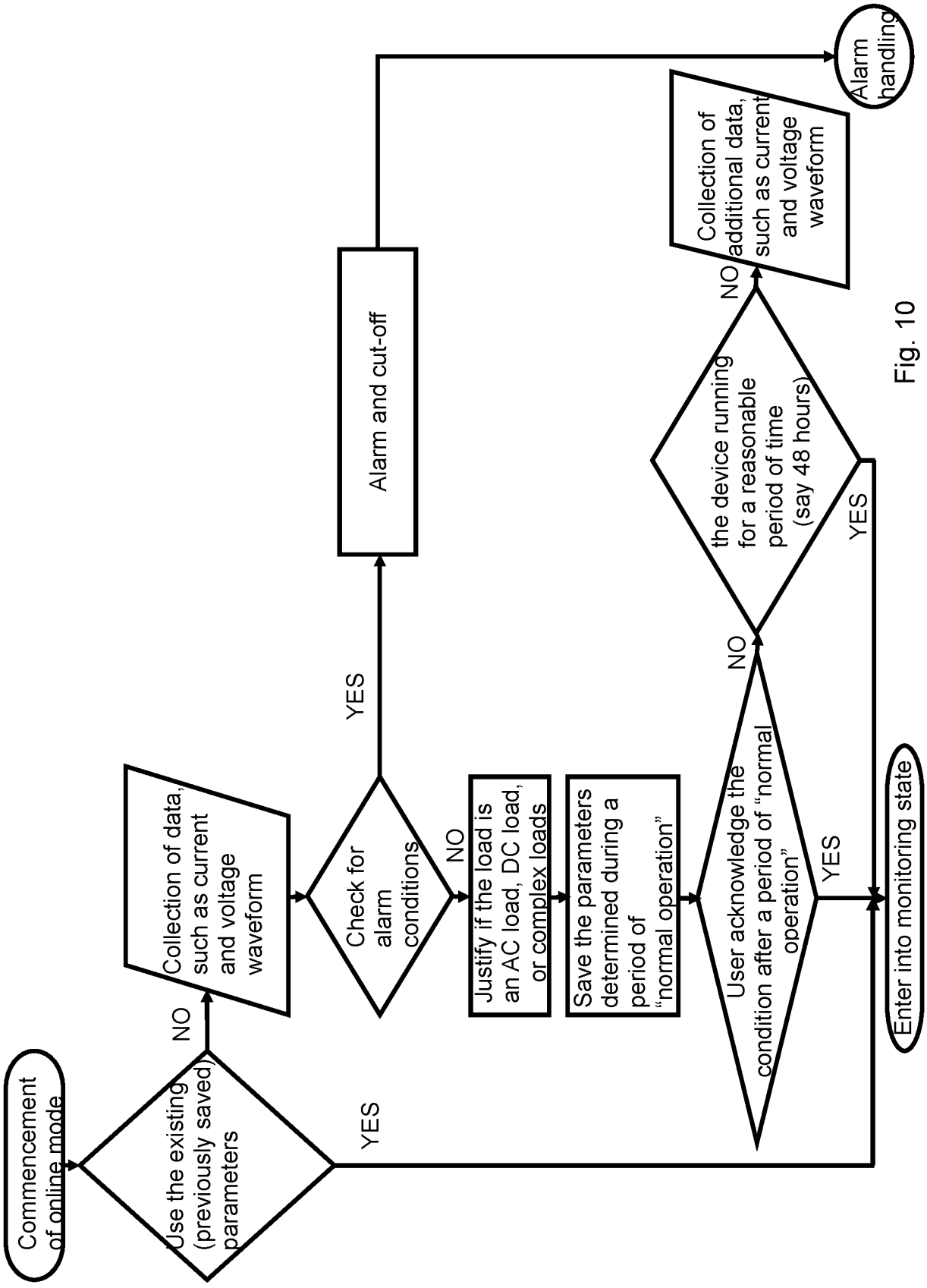

Commencement of online mode
Use the existing (previously saved) parameters
NO
YES
Collection of data, such as current and voltage waveform
Check for alarm conditions
YES
Alarm and cut-off
NO
Justify if the load is an AC load, DC load, or complex loads
Save the parameters determined during a period of "normal operation"
User acknowledge the condition after a period of "normal operation"
NO
YES
the device running for a reasonable period of time (say 48 hours)
NO
Collection of additional data, such as current and voltage waveform
YES
Alarm handling
Enter into monitoring state

Fig. 10

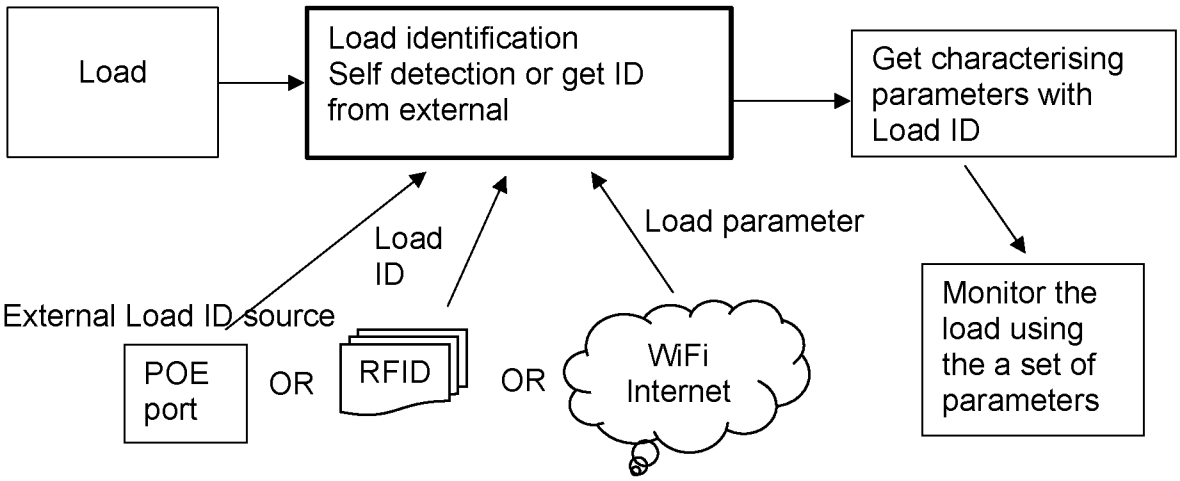

Load
Load identification
Self detection or get ID
from external
Get characterising
parameters with
Load ID
Load
ID
Load parameter
External Load ID source
POE
port
OR
RFID
OR
WiFi
Internet
Monitor the
load using
the a set of
parameters

Fig. 11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2020/051364

A. CLASSIFICATION OF SUBJECT MATTER

G01R 31/00(2006.01)i; G01R 19/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G01R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNPAT,EPODOC,WPI,CNKI: load, voltage, current, parameter, switch, status, mode, threshold, preset, compare+, storage, controller, start-up, start, steady, type, characteristics

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 107155352 A (TATSUMI RYOKI CO., LTD.) 12 September 2017 (2017-09-12) see claims 1-10, description paragraphs [0038]-[0069],[0084]-[00134],[0185]-[00190] and figures 1-13	1-15
X	CN 102468643 A (ZHANG, Yucheng) 23 May 2012 (2012-05-23) see description paragraphs [0012]-[0017] and figure 1	1,3
A	CN 102116836 A (YAMATAKE CORP.) 06 July 2011 (2011-07-06) the whole document	1-15
A	CN 103513128 A (INDUSTRIAL TECHNOLOGY RESEARCH INSTITUTE) 15 January 2014 (2014-01-15) the whole document	1-15
A	CN 104638768 A (HARBIN RESEARCH INSTITUTE OF ELECTRICAL INSTRUMENTS) 20 May 2015 (2015-05-20) the whole document	1-15
A	US 2018080992 A1 (APPLE INC.) 22 March 2018 (2018-03-22) the whole document	1-15

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 May 2020	**01 July 2020**
Name and mailing address of the ISA/CN **National Intellectual Property Administration, PRC** **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088** **China** Facsimile No. **(86-10)62019451**	Authorized officer **XU,Zexin** Telephone No. **86-（10）-53962570**

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IB2020/051364

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CN	104638768	A	20 May 2015		None		
US	2018080992	A1	22 March 2018		None		