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ABSTRACT

A system for controlling an electrical appliance enables a single unit to be configured for a wide range of harmonic load control channels, protocols and Demand Response Operational Instructions, and is also compatible with current harmonic load control channels used by the electricity suppliers. The system includes a processing unit electrically connected to a mains electricity supply, the processing unit including a memory and a processor, the memory including program code instructions configured to cause the processor to: filter the mains electricity supply to extract one or more harmonic load control channels selected from a plurality of harmonic load control channels; and convert the one or more harmonic load control channels to one or more electricity demand response operational instructions, for controlling an electricity demand or supply, selected from a plurality of electricity demand response operational instructions.

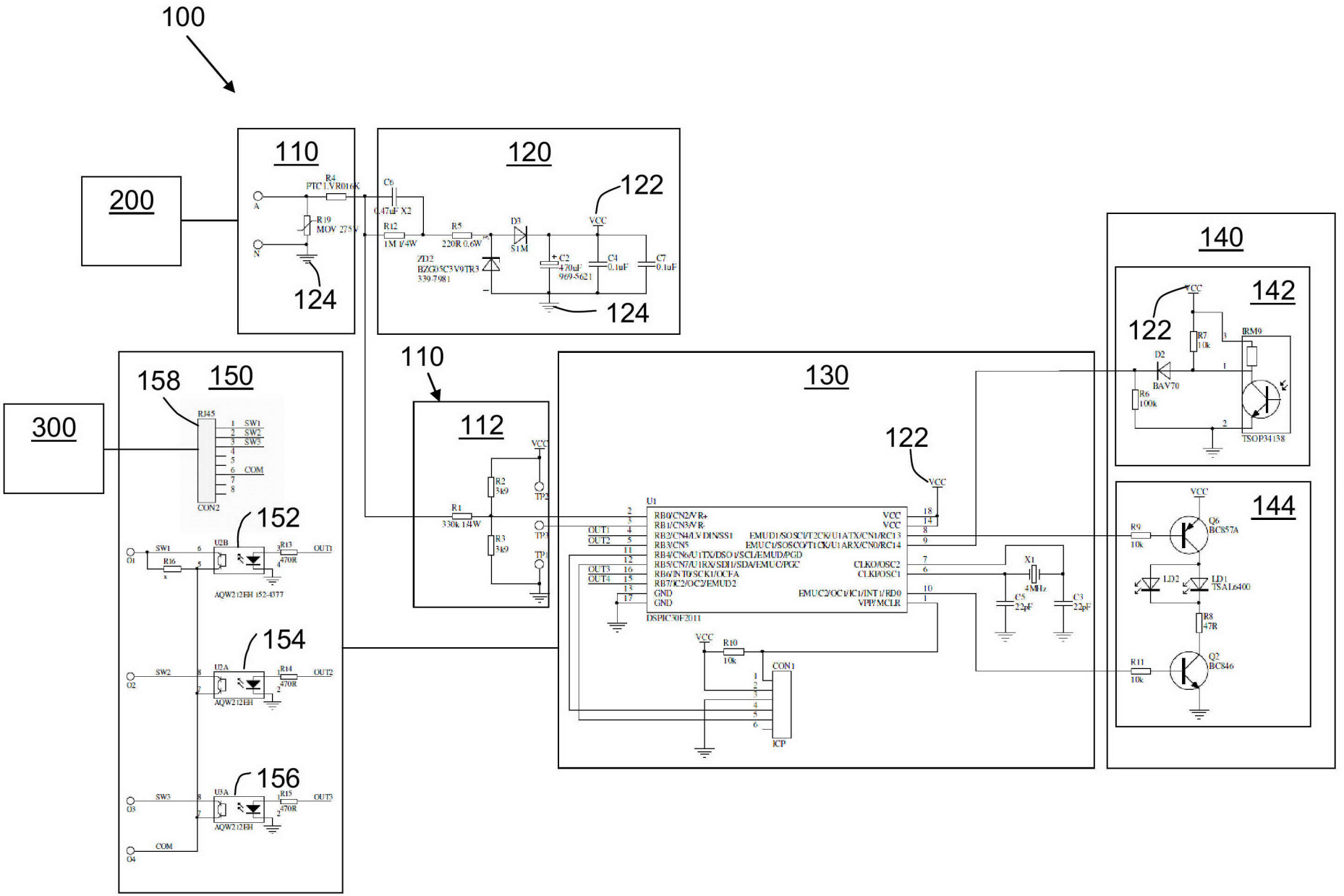
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FIG. 1

TITLE

A METHOD AND SYSTEM FOR CONTROLLING AN ELECTRICAL LOAD OR SUPPLY

FIELD OF THE INVENTION

[0001] This invention relates generally to a method and system of controlling an electrical load or supply, and in particular to controlling the power usage or power delivery of an appliance.

BACKGROUND TO THE INVENTION

[0002] Electricity demand peaks are often caused by consumers' habitual use of electricity. For example, peaks often occur in the morning as consumers use electricity to boil a kettle to make tea or coffee, and in the evening as consumers prepare an evening meal and switch on the television. In addition, demand for electricity is often increased during hot or cold weather when there is a greater use of air conditioners and electric heaters. In the industry such appliances are considered to be essential appliances as they are required on-demand. Other examples of essential appliances include televisions and computers.

[0003] In order to reduce power consumption at peak usage times, electricity distribution network operators are sometimes able to switch on or switch off non-essential appliances. Non-essential appliances are defined as appliances which are not required on-demand, such as hot water storage systems and swimming pool pumps. As these appliances can equally be used at other times of the day, time shifting their operation can be effective in reducing peak electricity demands and increasing electricity use during reduced demand periods.

[0004] In order to switch off non-essential appliances, electricity suppliers have conventionally superimposed a voltage harmonic on the electricity supply. A demand response switch is connected between the electricity supply and the non-essential appliance which senses the voltage harmonic and, in response, the demand response switch turns the appliance off. When the power consumption reduces, the electricity

distribution network operator sends out a different voltage harmonic signal to turn the non-essential appliances back on.

[0005] Some modern appliances (for example air conditioning units, pool pump controllers, solar hot water units, electric vehicle chargers, and grid connected photovoltaic cell inverter units) are fitted with a control connection which is defined in Australian Standard (AS) 4755. This control connection allows the immediate power consumption to be controlled remotely. In the case of grid connected photovoltaic cell inverter units, the control connection can signal the inverter to feed electricity back to the distribution grid.

[0006] However, the harmonic signals currently present on the electricity network are not compatible with the control interface specified in AS4755. The electrical requirements of the two interfaces are vastly different. Harmonic signals operate at mains voltage (240VAC, 50Hz fundamental for the Australian system) while the interface specified in AS4755 is a set of voltage free contacts operating at extra low voltage (34.5V or less, AC or DC).

[0007] Additionally, harmonic load control signals often contain only two pieces of information, a channel number, and an ON or an OFF operation. Each demand response switch is programmed to receive a single channel, and use the ON or OFF portion of the signal to turn the supply to its output circuit on or off, respectively. The states specified in AS4755 (defined as Demand Response Modes, or DRMs) are more complex than the simple on-off signals sent out using harmonic signalling systems. AS4755 defines up to 10 different states (NO DRM, and DRM0 to DRM8) for a single appliance. Some manufacturers combine up to 3 load control relays in a single physical enclosure, however these load control relays can only respond to one harmonic and can only switch the appliance on or off. These “multichannel” units are operationally identical to 3 separate load control relays. In addition, harmonic signalling systems vary in frequency and protocol, and are often specific to a single suburb, or substation grid area.

[0008] In other circumstances, with the proliferation of residential rooftop solar and photovoltaic (PV) inverter installations, electricity generators around the world are finding that "maximum operational demand" conditions, such as on hot summer days with high air conditioning demand, are becoming less frequent. That is generally due to the greater portion of peak load supplied by PV inverters. However, during periods of low electricity demand, where there are, for example, clear skies, warm temperatures and/or low economic activity (such as on a public holiday), excess PV electricity generation may flood into a grid, causing the grid to reach full capacity. And such oversupply of electricity in a grid also can be problematic for electricity generators.

[0009] The steady increase in PV electricity generation over the last several years has caused a decrease in the "minimum operational demand" of many grid networks. When such minimum operational demand gets too low, that can cause various problems, including for example problems with grid instability, network voltage management, and frequency control. Further, in severe cases, drops in minimum operational demand can necessitate emergency frequency control schemes and system restarts.

[0010] Electricity networks are traditionally designed as a one-way system. Energy flows from the generator at one end to the consumer at the other. Control and protection systems are installed with the assumption that energy flow will be unidirectional. As such traditional electricity networks have no means of compensating for excess generation at the consumer end of the grid. The only option available to network operators when grid stability is threatened is to isolate the area of the network where the generation is occurring.

[0011] However, isolating those areas of the network disconnects all generation equipment and appliances from electricity supply. This can result in widespread blackouts. Thus disconnecting areas of the community from electricity supply is not a feasible operational procedure to regulate consumer-connected generation systems.

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[0012] There is therefore a need for an improved method and system of controlling an electrical load or supply.

[0013] The reference to any prior art in this specification is not, and should not be taken as, an acknowledgement or any form of suggestion that the prior art forms part of the common general knowledge in Australia or elsewhere.

OBJECT OF THE INVENTION

[0014] It is an object, of some embodiments of the present invention, to provide consumers with improvements and advantages over the above described prior art, and/or overcome and alleviate one or more of the above described disadvantages of the prior art, and/or provide a useful commercial choice.

SUMMARY OF THE INVENTION

[0015] In one form, although not necessarily the only or broadest form, the invention resides in a system for controlling an electrical appliance including:

a processing unit electrically connected to a mains electricity supply, the processing unit including a memory and a processor, the memory including program code instructions configured to cause the processor to:

filter the mains electricity supply to extract a sequence of harmonic load control channels selected from a plurality of harmonic load control channels in order to activate one or more functions for controlling the appliance; and

convert the sequence of harmonic load control channels to one or more electricity demand response operational instructions, for controlling an electricity demand or supply, selected from a plurality of electricity demand response operational instructions that conform to an industry standard.

[0016] Preferably, the sequence of harmonic load control channels is decoded before being converted to the one or more electricity demand response operational instructions.

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[0017] Preferably, the electricity demand response operational instructions conform to Australian Standard 4755.

[0018] Preferably, the system further including a power supply module for powering the system.

[0019] Preferably, the power supply module includes power rails including a reference and a supply.

[0020] Preferably, the system further including an input interface to attenuate the mains electricity supply.

[0021] Preferably, the input interface includes a biasing circuit which biases the attenuated mains electricity supply between the reference and the supply.

[0022] Preferably, the system further including an output interface connected to the processing unit.

[0023] Preferably, the output interface includes one or more switches for controlling an electricity demand response mode of the appliance.

[0024] Preferably, the appliance is a photovoltaic (PV) inverter or other appliance associated with an electricity supply.

[0025] Preferably, an output interface connected to the processing unit includes one or more switches for controlling the electricity supply response mode of the appliance.

[0026] Preferably, the system further including a communications module for configuring the system.

[0027] Preferably, the communications module includes an infra-red transceiver.

[0028] According to another form, the invention resides in a method for controlling an electrical appliance including the steps of:

filtering a mains electricity supply to extract a sequence of harmonic load control channels selected from a plurality of harmonic load control channels in order to activate one or more functions for controlling the appliance; and

converting the sequence of harmonic load control channels to one or more electricity demand response operational instructions, for controlling an electricity demand or supply, selected from a plurality of electricity demand response operational instructions that conform to an industry standard.

[0029] Preferably, the harmonic load control channels are decoded before being converted to the one or more demand response operational instructions.

[0030] Preferably, wherein the harmonic load control channels are decoded before being converted to the one or more demand response operational instructions.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031] An embodiment of the invention will be described with reference to the accompanying drawings in which:

FIG. 1 illustrates a combined block diagram and schematic diagram of a system for controlling an electrical load according to an embodiment of the present invention; and

FIG. 2 illustrates a flow diagram of a method of controlling an electrical load according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0032] Elements of the invention are illustrated in concise outline form in the drawings, showing only those specific details that are necessary to understanding the embodiments of the present invention, but so as not to clutter the disclosure with excessive detail that will be obvious to those of ordinary skill in the art in light of the present description.

[0033] In this patent specification, adjectives such as first and second, left and right, front and back, top and bottom, etc., are used solely to define one element from another element without necessarily requiring a specific relative position or sequence that is described by the adjectives. Words such as “comprises” or “includes” are not used to define an exclusive set of elements or method steps. Rather, such words merely define a minimum set of elements or method steps included in a particular embodiment of the present invention. It will be appreciated that the invention may be implemented in a variety of ways, and that this description is given by way of example only.

[0034] FIG. 1 illustrates a combined block diagram and schematic of a system 100 for controlling an electrical load, and FIG. 2 illustrates a flow diagram 400 of a method for controlling an electrical load according to an embodiment of the present invention.

[0035] Referring to FIG. 1, the system 100 is connected between a mains electricity supply 200 and an appliance 300. A separate system 100 is required for each appliance 300. However, it should be appreciated that the present invention may be adapted to control a plurality of appliances 300.

[0036] Referring to FIG. 2, at step 410, the system 100 filters the mains electricity supply 200 to extract one or more harmonic load control channels selected from a plurality of harmonic load control channels. Optionally, the system 100 may decode the selected harmonic load control channel. The system 100, at step 220, converts the selected harmonic load control channel to one or more electricity demand

response operational instructions selected from a plurality of electricity demand response operational instructions . The electricity demand response operational instructions (OI) may be compatible with Australian Standard AS 4755. An advantage of the present system 100 over the prior art, is that a single unit can be configured for a wide range of harmonic load control channels, protocols and operational instructions.

[0037] Referring to FIG. 1, the mains electricity supply 200 may be a single phase or a three phase supply at a voltage such as 100Vac, 110Vac, 230Vac, 415Vac at 50Hz or 60Hz, or any other applicable voltage and frequency.

[0038] The appliance 300 may be any device that is connected to the mains electricity supply 200, such as a water heater and an air conditioner, but is not limited to such devices. In addition, the appliance 300 includes a Demand Response (DR) input. The appliance 300 adjusts an amount of power consumed from the mains electricity supply 200 in response to a signal on the DR input. In one embodiment, the DR input conforms to Australian Standard AS 4755.

[0039] The system 100 includes an input interface 110, a power supply module 120, a processing unit 130, a communications module 140, and an output interface 150.

[0040] The input interface 110 is connected between the mains electricity supply 200 and the processing unit 130, and between the mains electricity supply 200 and the power supply module 120. The purpose of the input interface 110 is to reduce the mains electricity supply 200 to an attenuated mains electricity supply at a suitable voltage level to the processing unit 130. For example, the input interface 110 may reduce the mains electricity supply 200 from 230Vac to 5Vp-p. In addition, the input interface 110 provides a link to the power supply 120. The input interface 110 may also include a biasing circuit 112, in order to bias the attenuated mains electricity supply between power rails of the power supply 120.

[0041] The power supply module 120 provides power to the processing unit 130, the communications module 140 and the output interface 150 via the power rails. The power rails include a supply 122 and a reference 124. In one embodiment, the reference 124 is derived from a neutral line of the mains electricity supply 200. The power supply 120 may provide one or more voltages between the supply 122 and the reference 124 such as 3.3Vdc, 5Vdc, and 12Vdc but is not limited to these values. The power supply module 120 may be any suitable internal (as shown in FIG. 1) or external (not shown) power supply.

[0042] The processing unit 130 may include a processor, such as a microcontroller, coupled to a memory such as Random Access Memory (RAM) and Read Only Memory (ROM). The memory includes instructions in the form of software and/or firmware to cause the processor to carry out the method of the present invention. In addition, the microcontroller may include an analogue to digital converter to receive the attenuated mains electricity supply. A person skilled in the art will realise that the microprocessor and the memory may be a single unit, as in the embodiment shown in FIG. 1, or the microprocessor and the memory may be constructed from individual components.

[0043] The processing unit 130, receives the attenuated mains electricity supply, from the input interface 110, and filters the attenuated mains electricity supply to extract a selected harmonic load control channel. If present, the processing unit 130 converts the selected harmonic load control channel to one or more demand response operational instructions (OI) which are provided to the output interface 150. If the selected harmonic load control channel is encoded, the processing unit 130 decodes the selected harmonic load control channel.

[0044] The communications module 140 is connected to the processing unit 130, and allows a technician to communicate with, and programme the system 100, for example to adjust parameters or to update firmware or software. In one embodiment, the communications module 140 is an infra-red transceiver, including an infra-red receiver 142, and an infra-red transmitter 144, as shown in FIG. 1 and may

be configured using an infra-red remote control unit. It should be appreciated that any suitable communications module 140 may be used, either wireless or wired, such as wireless Local Area Network, Bluetooth®, Ethernet, Zigbee®, Universal Serial Bus and RS232 connections. In addition, it should be appreciated that the communications module 140 may be connected to the Internet or use a cellular connection to allow the system to be configured remotely.

[0045] The output interface 150 is connected between the processing unit 130 and the appliance 300 to provide the DRM signals to the appliance 300. In one embodiment, the output interface 150 includes one or more switches 152, 154, 156, such as opto-couplers, which isolate the mains electricity supply 200 from the appliance 300.

[0046] Outputs from the switches 152, 154, 156 connect to the appliance 300 and are controlled by the processing unit 130 connected to inputs of the switches 152, 154, 156. The output interface 150 may also include a port 158, such as an RJ45 port, connected to a suitable cable, which connects the system 100 to the appliance 300.

[0047] In one embodiment, the switches 152, 154, 156 set electricity Demand Response Modes (DRMs) on the appliance 300 according to Australian Standard AS 4755. For example, if no switches are closed (no DRM), the appliance operates normally. If the first switch 152 only is closed, the appliance 300 is set to DRM 1, which reduces the power consumed by the appliance 300 by 100%; i.e. the appliance 300 or parts of the appliance 300 switch off, with an allowance of 5% to operate essential parts of the appliance 300 such as cooling fans. If the second switch 152 only is closed, the appliance 300 is set to DRM 2, which reduces the power consumed by the appliance 300 by at least 50%; i.e. the power usage of the appliance 300 is no greater than 50% of a maximum power consumption of the appliance 300. If a third switch 156 only is closed, the appliance 300 is set to DRM 3, which reduces the power consumed by the appliance 300 by at least 25%; i.e. the power usage of the appliance 300 is no greater than 75% of the maximum power consumption of the appliance 300. Although

three DRMs are described, it should be appreciated that the present invention may be adapted for any future DRMs of AS 4755.

[0048] It should also be appreciated that although it is possible to have more than one DRM state asserted at once at the output module 300, the processing unit 130 is configured to ensure that no two DRM states are asserted at any given time unless such a combination is appropriate for the appliance 300. In addition, the processing unit 130 may receive a sequence of harmonic load control channels, and in response, the processing unit 130 may perform other functions such as implement delay timers, or provide a failsafe operation in the event of missed signals from harmonic load control channels.

[0049] In use the system 100 is installed by an electrician between the mains electricity supply 200 and the appliance 300. The system 100 is pre-configured by the electricity distribution network operator with a harmonic load control channel selected from a plurality of harmonic load control channels to filter. In addition, the system 100 is pre-configured for a selection of operational instructions, selected from a plurality of operational instructions, to be asserted at the output interface 150. For example, the network operator may specify a harmonic load control channel operating at 217Hz to control an operational instruction 2 at the output interface 150. In addition, if the harmonic load control channel is encoded, the network operator may specify a decoding protocol.

[0050] If required, the system 100 may be reconfigured by the network operator for a different harmonic load control channel and DRM. For example, the network operator may install a new signalling system which uses a different harmonic load control channel operating at 425Hz. In this case, a technician may be deployed to re-configure system 100 using a computer, such as laptop or tablet connected to the system 100 via the communications module 140. Alternatively, if the system is connected to the Internet or uses cellular communications, the system 100 may re-configured remotely.

[0051] In another embodiment, the present invention enables a reduction in the supply of electricity to a grid, so as for example to improve grid management related to minimum operational demand. Thus, for example, an analogous system of the above system 100 is connected between the mains electricity supply 200 and a power supply appliance such as a PV inverter of a residential solar power system. The system is preconfigured to assert a selected operational instruction in response to a selected harmonic signal. During periods of minimum operational demand the network operator can send harmonic signals to a selected subset of devices. Upon receiving the harmonic signal from the network operator the system closes the appropriate output contacts to assert operational instruction 0 (OI0) which instructs the inverter to apply DRM0 and disconnect from the electricity grid. The result is fewer generation appliances connected to the grid, which in turn increases demand on base load generation keeping it in a stable operating condition.

[0052] In summary, the method and system of controlling an electrical load or supply provides, according to some embodiments, the following advantages:

1) The system of the present invention allows a single unit to be configured for a wide range of harmonic load control channels, protocols and DRMs;

2) The system is compatible with current harmonic load control channels used by electricity suppliers; and

3) The system allows electricity suppliers to improve power grid management by immediately reducing either electricity demand from or electricity supply to a power grid, as required in real time.

[0053] The above description of various embodiments of the present invention is provided for purposes of description to one of ordinary skill in the related art. It is not intended to be exhaustive or to limit the invention to a single disclosed embodiment. As mentioned above, numerous alternatives and variations to the present invention will be apparent to those skilled in the art of the above teaching. Accordingly, while some alternative embodiments have been discussed specifically, other embodiments will be apparent or relatively easily developed by those of ordinary skill in the art.

Accordingly, this patent specification is intended to embrace all alternatives, modifications and variations of the present invention that have been discussed herein, and other embodiments that fall within the spirit and scope of the above described invention.

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CLAIMS

1. A system for controlling an electrical appliance including:

a processing unit electrically connected to a mains electricity supply, the processing unit including a memory and a processor, the memory including program code instructions configured to cause the processor to:

filter the mains electricity supply to extract a sequence of harmonic load control channels selected from a plurality of harmonic load control channels in order to activate one or more functions for controlling the appliance; and

convert the sequence of harmonic load control channels to one or more electricity demand response operational instructions, for controlling an electricity demand or supply, selected from a plurality of electricity demand response operational instructions that conform to an industry standard.

2. The system of claim 1 wherein the sequence of harmonic load control channels is decoded before being converted to the one or more electricity demand response operational instructions.

3. The system of claim 1 wherein the electricity demand response operational instructions conform to Australian Standard 4755.

4. The system of any preceding claim further including a power supply module for powering the system.

5. The system of claim 4 wherein the power supply module includes power rails including a reference and a supply.

6. The system of any preceding claim further including an input interface to attenuate the mains electricity supply.

7. The system of claim 6 wherein the input interface includes a biasing circuit which biases the attenuated mains electricity supply between the reference and the supply.

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8. The system of any preceding claim further including an output interface connected to the processing unit.

9. The system of claim 8 wherein the output interface includes one or more switches for controlling an electricity demand response mode of the appliance.

10. The system of claim 1, wherein the appliance is a photovoltaic (PV) inverter or other appliance associated with an electricity supply.

11. The system of claim 10 wherein an output interface connected to the processing unit includes one or more switches for controlling the electricity supply response mode of the appliance.

12. The system of any preceding claim further including a communications module for configuring the system.

13. The system of claim 12 wherein the communications module includes an infra-red transceiver.

14. A method for controlling an electrical appliance including the steps of:

filtering a mains electricity supply to extract a sequence of harmonic load control channels selected from a plurality of harmonic load control channels in order to activate one or more functions for controlling the appliance; and

converting the sequence of harmonic load control channels to one or more electricity demand response operational instructions, for controlling an electricity demand or supply, selected from a plurality of electricity demand response operational instructions that conform to an industry standard.

15. The method of claim 14 wherein the harmonic load control channels are decoded before being converted to the one or more demand response operational instructions.

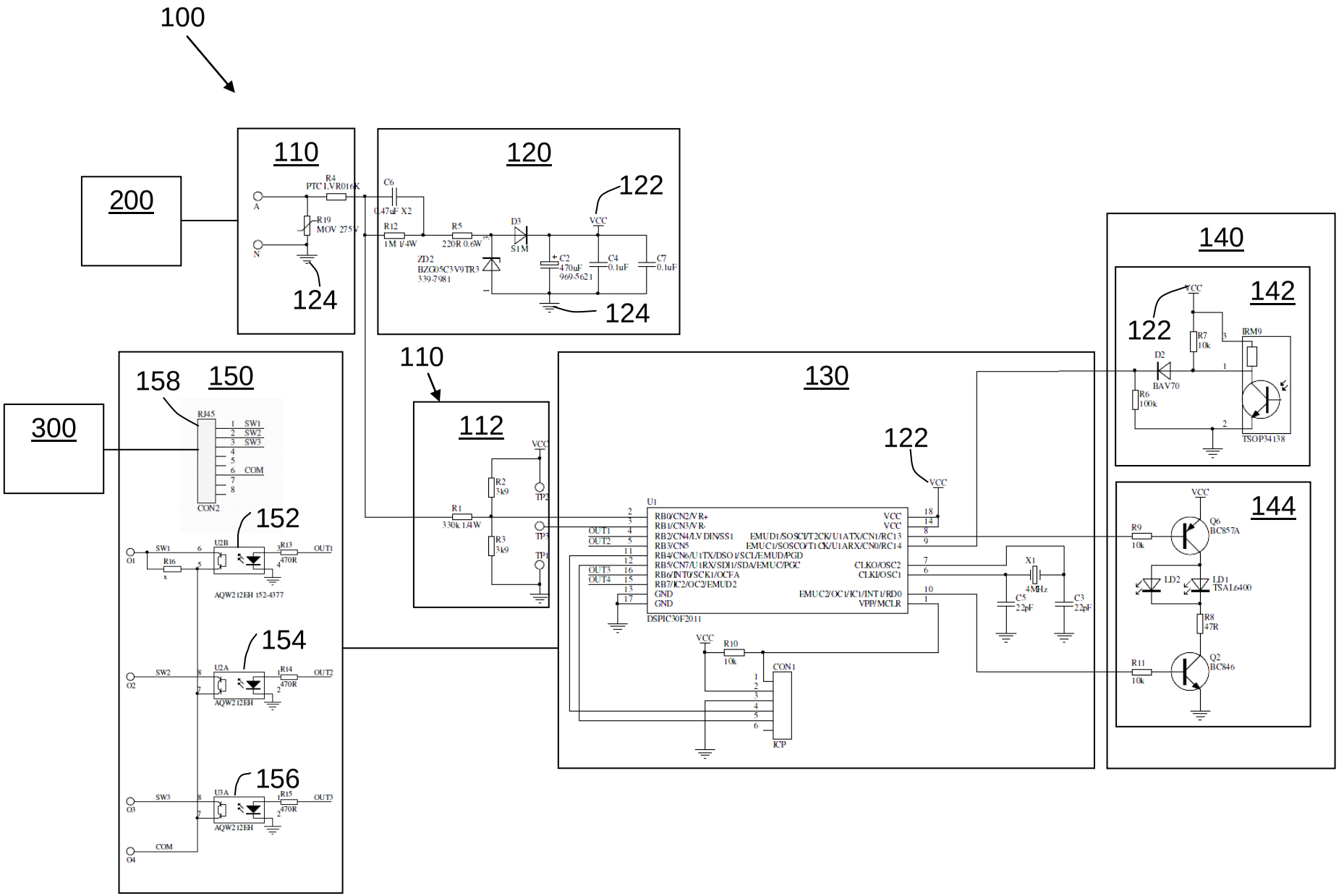
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FIG. 1

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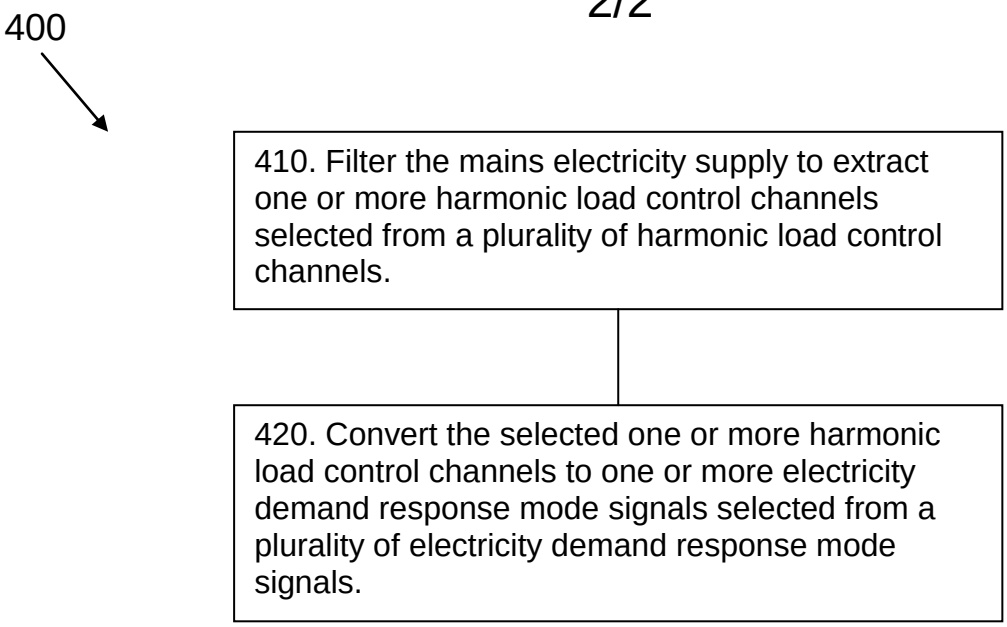

FIG. 2