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WO 2008/042483 A1 **WO 1993/024842 A1**
JP 2001298877 A **US 20050083206 A1**

(58) Field of Search:
INT CL **G01R**
Other: **WPI & EPODOC**

(54) Abstract Title**: Multi-circuit electricity metering**

(57) A multi-circuit electricity metering apparatus to be used for metering the power and energy consumption in the branch circuits of an electricity distribution system within a premises provides a plurality of non-contact current sensors connected to a plurality of compact metering devices each of which comprises only the electronic components necessary for metering the power and energy consumption in the circuits being metered. The said plurality of metering devices are interconnected via a multi-wire bus with each other and with a common low-voltage power-supply apparatus and with a common AC voltage-sensing apparatus and with a common data-logging apparatus. Preferably the said non-contact current sensors are miniature Rogowski coils. Advantageously the said non-contact current sensors are multi-turn coiled Rogowski coils. Preferably each of the said metering devices together with the said current sensors connected to is of sufficiently small size that it can be supported by the conductors of the circuits that is being used to meter. The said multi-circuit metering apparatus provides means of communicating with a remote computer system for the purposes of transmitting recorded data to the remote computer and for the purpose of receiving configuration data or updated control programmes from the remote computer.

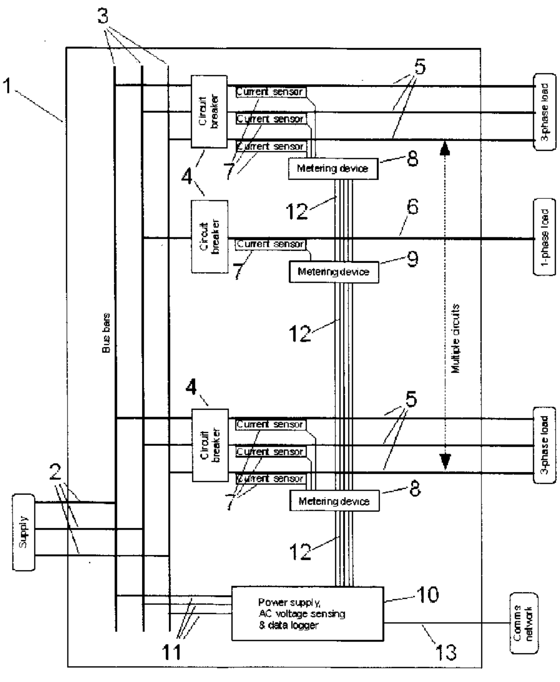

Figure 1

GB 2 452 989 A

Original Printed on Recycled Paper

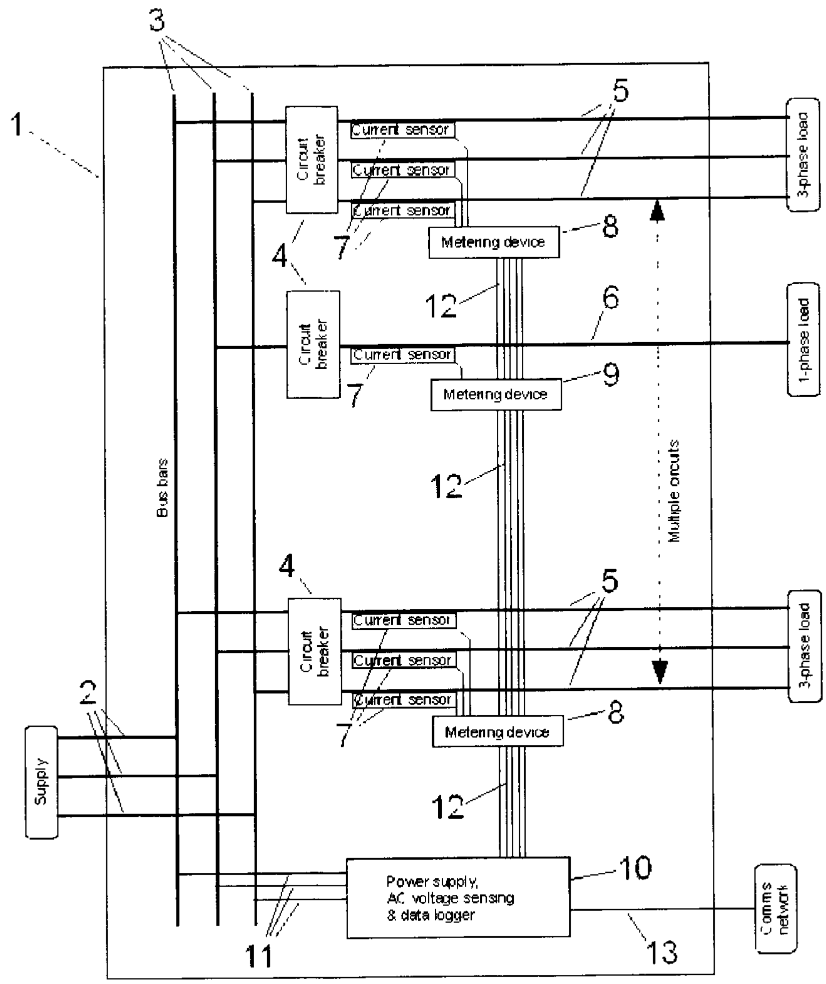
3
1
5
Circuit breaker
Current sensor
Current sensor
Current sensor
3-phase load
4
7
Metering device
8
12
6
Circuit breaker
Current sensor
1-phase load
7
Metering device
9
Bus bars
12
Multiple circuits
4
5
Circuit breaker
Current sensor
Current sensor
Current sensor
3-phase load
2
7
Metering device
8
Supply
12
Power supply,
AC voltage sensing
& data logger
10
Comms network
11
13

Figure 1

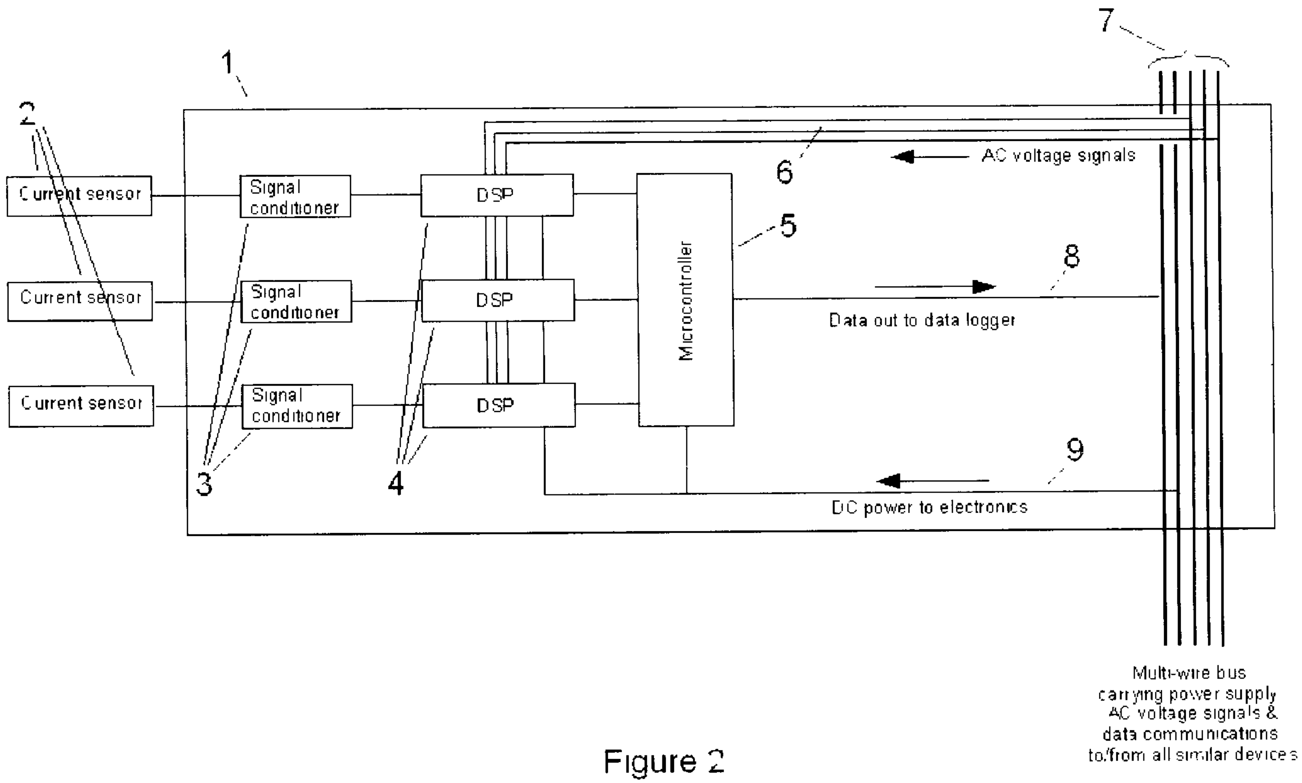
1
2
Current sensor
Current sensor
Current sensor
Signal conditioner
Signal conditioner
Signal conditioner
3
DSP
DSP
DSP
4
Microcontroller
5
6
AC voltage signals
7
8
Data out to data logger
9
DC power to electronics
Multi-wire bus
carrying power supply
AC voltage signals &
data communications
to/from all similar devices

Figure 2

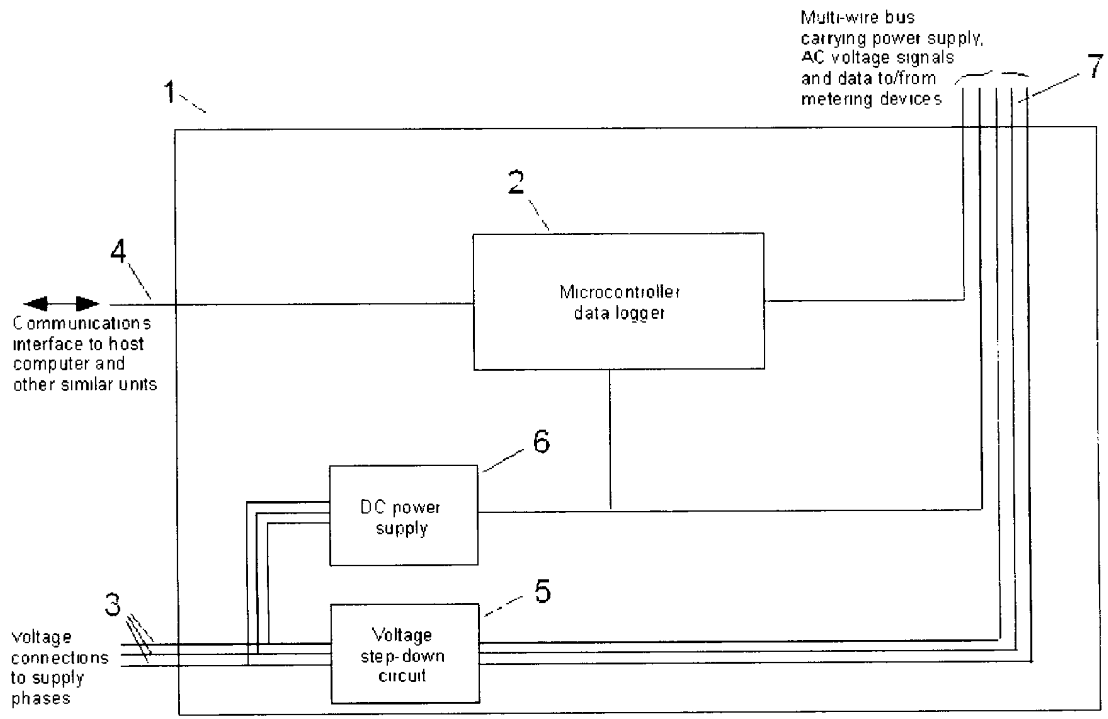
Multi-wire bus carrying power supply, AC voltage signals and data to/from metering devices
7
1
2
Microcontroller data logger
4
Communications interface to host computer and other similar units
6
DC power supply
3
5
Voltage step-down circuit
voltage connections to supply phases

Figure 3

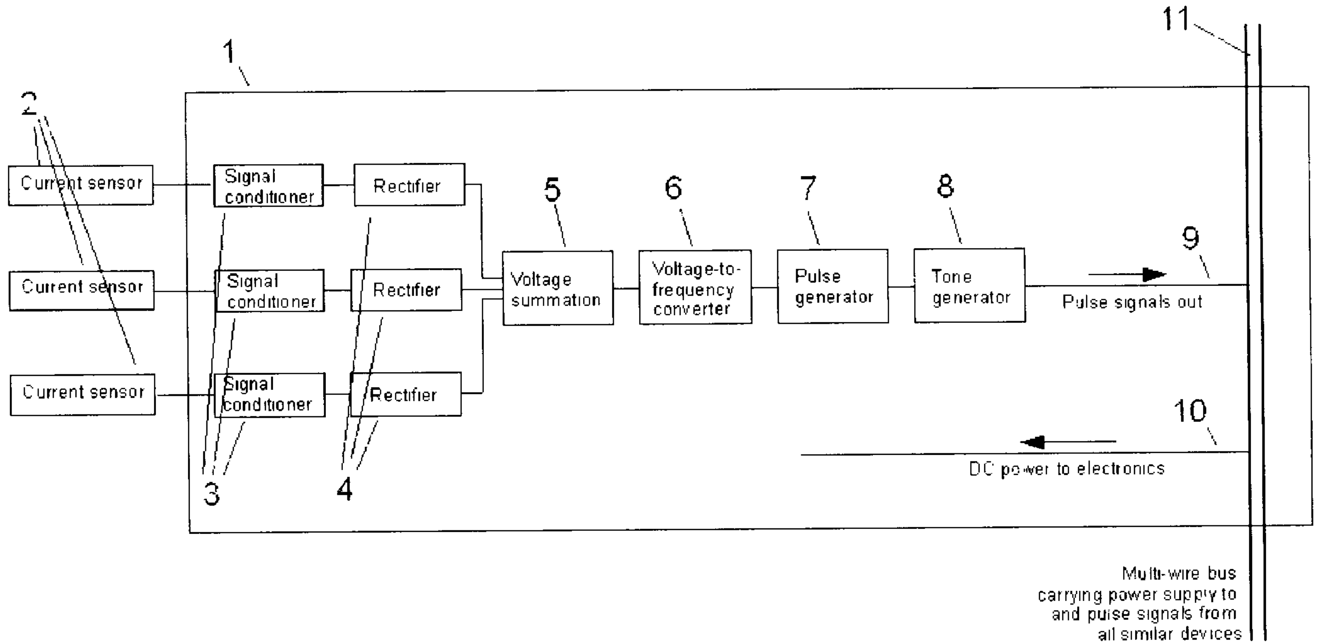
1
2
Current sensor
Current sensor
Current sensor
Signal conditioner
Signal conditioner
Signal conditioner
3
Rectifier
Rectifier
Rectifier
4
5
Voltage summation
6
Voltage-to-frequency converter
7
Pulse generator
8
Tone generator
9
Pulse signals out
10
DC power to electronics
11
Multi-wire bus carrying power supply to and pulse signals from all similar devices

Figure 4

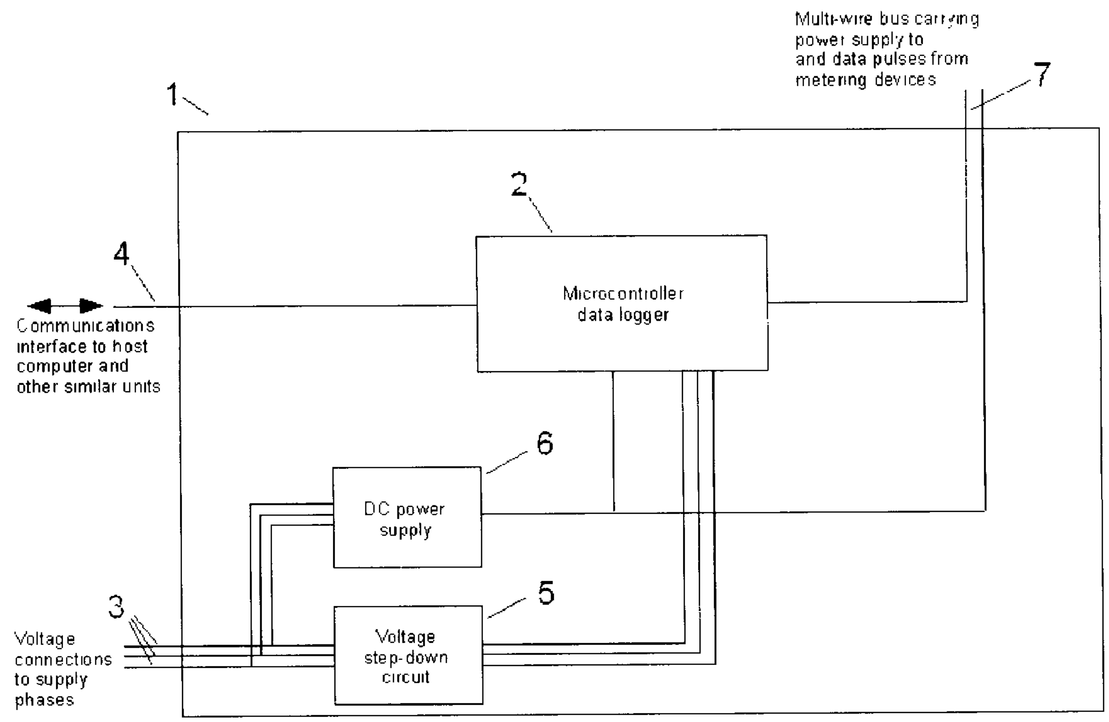
1
2
Microcontroller
data logger
4
Communications
interface to host
computer and
other similar units
Multi-wire bus carrying
power supply to
and data pulses from
metering devices
7
6
DC power
supply
5
Voltage
step-down
circuit
3
Voltage
connections
to supply
phases

Figure 5

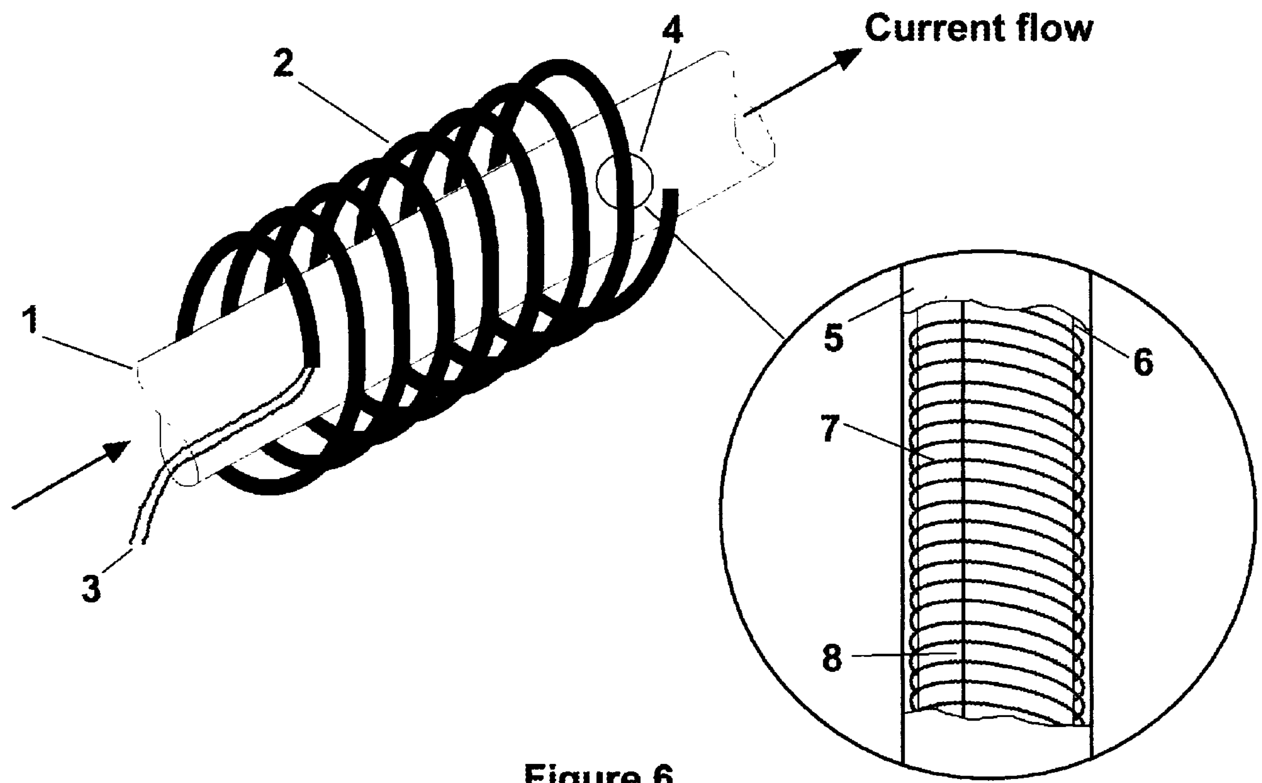

Figure 6

Apparatus and method for electricity metering

Field of the invention

This invention relates to the metering of power and energy consumption in electrical circuits.

Background

The power flowing in an electric circuit and the consequent consumption of energy in that circuit is usually determined by means of an electricity meter connected to the circuit. An alternating current (AC) electric circuit as commonly used for electrical power distribution comprises one or more phase conductors and usually a neutral conductor.

In order to measure the power flowing in an AC circuit it is generally necessary to measure the voltage of and the current flowing in each phase of the circuit. One technique that is used in modern electricity meters involves the measurement of these voltages and currents at a frequency greater than the frequency of the AC voltage, then calculating the instantaneous power for each set of measurements and integrating the instantaneous power values with respect to time to determine the average power flowing in the circuit and the energy consumed over a period of time.

Electricity consumption in a premises or other installation is conventionally metered using a single electricity meter installed on the main electrical incomer to the premises. Such meters are read periodically by the electricity supplier for the purposes of billing the customer and of providing the customer with information about the amount of electricity consumed.

However, in order to gain better understanding of how, where and when electrical energy is being consumed so that energy consumption may appropriately be managed, additional meters, sometimes referred to as sub-meters, may be installed on various branch circuits of the electrical distribution system within the premises.

Conventional sub-metering techniques usually require the installation of individual electricity meters within distribution panels or at other points on the circuits to be metered. Each meter requires as inputs the current and voltage from each phase conductor of the circuit to be metered. This requirement is usually met by the use of current transformers mounted on each individual phase conductor of the circuit and voltage-sensing wires connected to each conductor of the circuit.

Meters used for sub-metering typically provide a pulse output, whereby electrical pulses are created in correspondence to the amount of energy consumed. The pulses from such meters are typically recorded by a data logger and subsequently transmitted to a computer system for analysis and presentation to the users of the system.

Some types of meter can provide additional information about the current, voltage, power factor, harmonics and other data. These meters use a communication interface such as RS485 serial communication, Ethernet or wireless for transmission of the data to a computer system.

It is often desirable to install a sub-metering system into an electrical distribution panel, where a number of circuits to be metered are located close together. The most widely-used conventional sub-metering technique would necessitate the installation of multiple electricity meters, together with current transformers and voltage-sensing wires for each circuit to be metered. This technique has several disadvantages:

- the cost of multiple meters and current transformers is often high in relation to the value of the electricity to be metered;
- there is often insufficient space to accommodate the meters within the distribution panel;
- there is often insufficient space for the current transformers;
- the time taken to install the equipment and make the necessary connections gives rise to high installation costs;
- the electricity supply to the premises must usually be disconnected during installation, and the duration of the supply interruption is often unacceptably long for the customer.

The present invention overcomes these disadvantages by reducing the size and cost of the metering apparatus and by simplifying the installation procedure.

Statement of invention

An objective of the present invention is provide a metering apparatus that is small enough that it can be supported by the conductors of the circuit that it is being used to meter.

A second objective of the present invention is to provide a metering apparatus that can be attached quickly and easily to the circuit that it is being used to meter.

A third objective of the present invention is to provide a multi-circuit metering apparatus that does not require contact connections to each individual circuit.

A fourth objective of the present invention is to provide a multi-circuit metering apparatus that is capable of recording for each of the plurality of circuits being metered any or all of the following parameters: current, voltage, real power, reactive power, energy consumed.

A fifth objective of the present invention is to provide a multi-circuit metering apparatus that is capable of transmitting recorded data to a remote computer system, via communications protocols such as Ethernet, RS485, Modbus, wireless or powerline communication.

A sixth objective of the present invention is to provide a multi-circuit metering apparatus that is capable of being configured from a remote computer system, via communications protocols such as Ethernet, RS485, Modbus, wireless or powerline communication.

These objectives are achieved, in accordance with the principles of a preferred embodiment of the invention, by replacing the conventional electricity meter with a simplified metering device comprising only the components necessary for metering the power and energy consumption in a single-phase or multi-phase circuit. One or more non-contact current sensors, one for each phase of the circuit being metered, are attached to the phase conductors of the said circuit and connected to the said metering device. The plurality of said metering devices are interconnected, via a multi-wire cable, with each other and with a common low-voltage power supply apparatus and with a common data-logging apparatus and with a common AC voltage-sensing apparatus. The said simplified metering devices utilise a communication protocol that is adapted for communication via a common communication bus so that each said metering device can transmit data to the said data-logging apparatus via the said multi-wire cable. The low-voltage power needed for operation of each said metering device is provided from the said common power supply apparatus via the said multi-wire cable. The AC voltage signals required for proper determination of power in the said circuits are transmitted from the said common voltage-sensing apparatus via the said multi-wire cable to each of the said metering devices.

In a preferred embodiment of the invention, the said metering device comprises means for conditioning the signals received from the said current sensors; one or more digital signal processing (DSP) devices, such as for example the Microchip MCP3909 Energy Metering IC, one for each phase of the circuit being metered, adapted for the measurement of power and energy consumption in electric circuits; a microcontroller for computation of the power and energy consumption in the circuit being metered and for generation of the data signals for transmission to the data-logging apparatus.

In a preferred embodiment of the invention, the said non-contact current sensors are miniature Rogowski coils, and the said signal conditioning means in each of the said metering devices is designed to perform the integration required for the signals from Rogowski coils.

In another preferred embodiment of the invention, each of said non-contact current sensors comprises a multi-turn coiled Rogowski coil that encircles the phase conductor multiple times so as to increase the amplitude of the signal generated by the said current sensor.

In another preferred embodiment of the invention the said multi-turn coiled Rogowski coil current sensor is manufactured in a manner such that it maintains a coiled-coil form suitable for close attachment to an electrical conductor wire and such that it may be attached to the said conductor simply by manipulating the pre-formed coiled-coil such that each turn of the coiled-coil then tightly encircles the said electrical conductor wire.

In another preferred embodiment of the invention each of the said metering devices is manufactured with the associated current sensors pre-connected to it and is provided with simple attachment clips that provide means of quickly attaching the said metering device together with said current sensors to an electrical circuit.

In another preferred embodiment of the invention each of the said metering devices is provided with multi-contact electrical connectors such that the said multi-wire cable may quickly and easily be connected to each of the said metering devices.

In another preferred embodiment of the invention each of the said metering devices is provided with multi-contact electrical connectors for connection of the said multi-wire cable and with a pre-connected multi-wire cable in the form of a fly-lead that simplifies the task of connecting multiple metering devices together in a "daisy chain" fashion.

In a simplified embodiment of the invention, each of the said metering devices comprises electronic circuitry that processes the signals from the attached current sensors to produce pulse signals at a rate which is in proportion to the sum of the currents flowing in the phases of the circuit being metered. The said electronic circuitry then converts each pulse to a short burst of alternating voltage (a tone burst) for transmission to the data-logging apparatus via the said multi-wire cable. The frequency of the tone bursts generated by each said metering device is set so that a different tone frequency is used by each of the said metering devices installed in a given installation. The said data-logging apparatus is adapted to detect tone-burst pulse signals in a manner such that it is able to determine the identity of the metering device from which each pulse is received. The said data-logging apparatus is also adapted to calculate the power and energy consumption in each circuit being metered, using the voltage signals from the said common voltage-sensing apparatus and the pulse signals received from each metering device. A characteristic of this simplified embodiment of the invention is that it is not capable of correctly metering power in circuits wherein the power factor is not equal to unity, but that for many practical applications, where the power factor is known or expected to be close to unity, the accuracy of the power measurement is sufficiently good for the purposes of energy sub-metering.

Description

The invention will now be described in detail, with reference to the following drawings:

Figure 1 is a schematic diagram illustrating the principal components of a multi-circuit electricity metering system.

Figure 2 is a schematic diagram illustrating the principal components of a metering device based on digital signal processing and microcontroller technology.

Figure 3 is a schematic diagram illustrating the principal components of an apparatus that combines the functions of low-voltage power supply, AC voltage-sensing and data logging.

Figure 4 is a schematic diagram illustrating the principal components of a simplified metering device that meters only the current in a circuit.

Figure 5 is a schematic diagram illustrating the principal components of an apparatus that combines the functions of low-voltage power supply, AC voltage-sensing and data logging for use with the simplified metering device shown in Figure 5.

Figure 6 is a diagram illustrating the principle of construction of a multi-turn coiled Rogowski coil current sensor.

As shown in Figure 1, a typical electrical distribution panel **1** contains equipment for distribution of the incoming 3-phase electrical supply **2** via bus bars **3** and circuit breakers **4** to each of a plurality of 3-phase branch circuits **5** and a plurality of single-phase branch circuits **6**. A plurality of non-contact current sensors **7** are each attached to or located in suitable close proximity to one of the phase conductors of the circuits **5** and **6** to be metered. Each of the said current sensors for each 3-phase circuit is connected to a 3-phase metering device **8**, and the said current sensor for each single-phase circuit is connected to a single-phase metering device **9**.
A combined power-supply, voltage-sensing and data-logging apparatus **10** is located in a suitable position in or near the distribution panel and is connected to the said bus bars or to other suitable points on the conductors of the electrical system by means of

voltage-sensing connections **11**, and provides low-voltage DC power and AC voltage signals to each of the said metering devices via a multi-wire cable **12** that is connected to all of the metering devices that form part of the metering installation.
Each of the plurality of said metering devices generates signals that are indicative of the power and energy consumption in the respective circuit being monitored and transmits these signals from time to time via the multi-wire cable **12** to the said data-logging apparatus. The communication link **13** provides a means of communicating with one or more remote computer systems for the purposes of transmitting data to the said remote computers or for the purpose of receiving configuration data or control programmes from said remote computers, using communication protocols such as but not limited to Ethernet, RS485, Modbus, wireless or powerline communication.

A preferred embodiment of the said metering device is illustrated in Figure 2. The metering device **1** comprises a number of signal conditioning means **3**, one for each current sensor **2**; a corresponding number of digital signal processing (DSP) devices **4**, a microcontroller **5**; AC voltage signal connections **6** from the multi-wire bus **7** to each of the said DSP devices; a signal output **8** from the microcontroller to the multi-wire bus; and a DC power connection **9** from the multi-wire bus to the electronic components of the metering device.
In a preferred embodiment of the invention the current sensor is a Rogowski coil or a multi-turn coiled Rogowski coil, and each said signal conditioner provides the necessary integration of the signal from the said sensor. Other types of signal conditioner may be used for other types of current sensor.
The said DSP devices process the AC current and voltage signals to calculate the power and energy consumption for each of the phases of the circuit being metered. There are on the market a number of suitable DSP devices: for example the Microchip MCP3909 Energy Metering IC may be used, although those skilled in the art will know that other suitable devices are available. The output signals from the said DSP devices are transmitted to the said microcontroller, which calculates the total power and energy consumption and provides a means of communicating the calculated parameters via the said multi-wire bus to the said data-logging apparatus.

A preferred embodiment of the said power-supply, voltage-sensing and data-logging apparatus is illustrated in Figure 3. While not essential for the functioning of the present invention, it is convenient to provide the power-supply, voltage-sensing and data-logging apparatus within a single combined enclosure **1**. A microcontroller **2** provides the functions of logging the data obtained from the said plurality of metering devices via the multi-wire bus **7**, and of communicating with one or more remote computers via the communications interface **4**. The voltage-sensing connections **3** are connected to the bus bars or other suitable points on the conductors of the electrical distribution system being metered, and in turn provide power to the DC power supply apparatus **6** and voltages to the voltage step-down unit **5**. The said DC power supply apparatus provides low-voltage DC power to the microcontroller and other components of the data-logging apparatus and to the plurality of said metering devices via the said multi-wire bus. The said voltage step-down apparatus reduces each AC voltage signal to a level suitable for direct input to the said DSP devices in the said metering devices, and at the same time beneficially reduces the AC voltage signals to a level that is safe for transmission via the said multi-wire bus.

A simplified embodiment of the said metering device, suitable for use when the power factor in the circuits to be monitored is known or expected to be close to unity, is shown in Figure 4. The metering device **1** has one or more signal conditioners **3**, one for each current sensor **2** connected to the said metering device. The said signal conditioners are adapted to process the signals in a manner appropriate to the type of said current sensor. In the case of Rogowski coils or multi-turn coiled Rogowski coils being used as the current sensors, the said signal conditioners provide the necessary integration function. The conditioned signal is rectified by the rectifiers **4**, and then summed by the voltage summation unit **5**. The summed voltage which is representative of the sum of the currents flowing in the phase conductors of the circuit being metered is then converted to a frequency by the voltage-to-frequency converter **6**. The pulse generator **7** then generates a stream of pulses at the frequency of the output from the said voltage-to-frequency converter. The said pulses are then converted by the tone generator **8** into short bursts of alternating voltage (tone bursts) at a frequency and amplitude suitable for transmission via connection **9** and via the multi-wire cable **11** to a data-logging apparatus adapted to receive such tone-burst signals. The frequency of the tone generated by the said tone generator is defined so that each said simplified metering device installed in a given multi-circuit metering system is identifiable by the frequency of the tone in the tone bursts. The low-voltage DC power required for operation of the components of the said metering device is obtained via the connection **10** to the said multi-wire bus.

Figure 5 shows an alternative embodiment of the combined power-supply, voltage-sensing and data-logging apparatus for use with the simplified metering device previously described and shown in Figure 4. While not essential for the functioning of the present invention, it is convenient to provide the power-supply, voltage-sensing and data-logging apparatus within a single combined enclosure **1**. A microcontroller **2** provides the functions of logging the data obtained from the said plurality of simplified metering devices via the multi-wire bus **7**, and of communicating with one or more remote computers via the communications interface **4**. The voltage-sensing connections **3** are connected to the bus bars or other suitable points on the conductors of the electrical distribution system being metered, and in turn provide power to the DC power supply apparatus **6** and voltages to the voltage step-down unit **5**. The said DC power supply apparatus provides low-voltage DC power to the microcontroller and other components of the data-logging apparatus and to the plurality of said metering devices via the said multi-wire cable. The said voltage step-down apparatus reduces each AC voltage signal to a level suitable for direct input to the analogue-to-digital inputs of the said microcontroller. In this embodiment, the said microcontroller also calculates the power and energy consumption in each of the circuits being metered using the pulse data from each of the said simplified metering devices and from the said reduced AC voltage signals.

A preferred embodiment of the said current sensor is shown in Figure 6. A outer coil **2** is wound a number of times around the current-carrying conductor **1** that forms one of the phase conductors of the circuit being metered. The construction of the outer coil is shown in detail in the enlarged drawing of a small section **4** of the said outer coil. The outer coil which in effect is itself a Rogowski coil comprises an evenly-spaced inner coil **7** of a small diameter insulated conductor wire wound along the length of a flexible non-magnetic former **6** and covered by a flexible non-magnetic cover **5**. One end of the said inner coil is fed back **8** through the inside of the said inner coil so that both connections

3 to the said inner coil are located at one end of the said outer coil.

In a preferred embodiment of the said coiled Rogowski coil current sensor, the materials and process used for manufacture of the said coiled Rogowski coil current sensor provide a sensor that is pre-formed to a shape and size that permits it to fit tightly around an electrical conductor of a specified diameter or range of diameters, and permits the said sensor to be attached to the said electrical conductor simply by manipulating the coil so that each turn of the said sensor becomes encircled tightly around the said conductor, and such that when the said coil has been attached to the said electrical conductor it will be capable of supporting its own weight and the weight of the metering device to which it is connected without moving from the position in which it was attached.

Claims

1. An electricity metering system comprising:

- a plurality of metering devices, each mounted in proximity to a circuit that is to be metered, wherein each metering device comprises
  - means for metering one or more of the current, real power, reactive power and energy consumption in each phase of the said circuit and one or more of the total current, total real power, total reactive power and total energy consumption in the whole circuit
  - means for generating electrical signals indicative of at least one of the said current, real power, reactive power and energy consumption
  - means for sending said electrical signals to a data-logging apparatus

  and wherein each of the said metering devices obtains the low-voltage power necessary for its operation from a power supply apparatus which is common to all of the said plurality of metering devices;
- a plurality of non-contact current sensors, each attached to or mounted close to one phase conductor of a circuit to be metered in a manner such that the said current sensor generates a signal indicative of the current flowing in the said phase conductor and connected to the metering device that is being used to meter the said circuit;
- a power supply apparatus the input of which is connected to at least two of the conductors in the electrical distribution system that is being metered and the output of which is used to supply low-voltage power to each of the plurality of said metering devices;
- an AC voltage-sensing apparatus which senses the voltage from each of the conductors in the circuit supplying electricity to the electrical distribution system and which reduces each of the sensed AC voltages to a low level suitable for connection to the input of a digital signal processing device or to an analogue input of a microcontroller;
- a data-logging apparatus that provides a means of recording the electrical signals generated by the said metering devices and a means of communicating the recorded data to a remote computer system using of a suitable

communications medium such as but not limited to Ethernet, RS485 serial communications, wireless, power line communication;

- a multi-wire bus that interconnects all of the said metering devices with the power-supply apparatus and with the data-logging apparatus in a manner such that it is capable of supplying low-voltage power to all of the said metering devices and to the said data-logging apparatus and of communicating the electrical signals from each of the said metering devices to the said data-logging apparatus.

2. An electricity metering system as claimed in claim 1, wherein the said AC voltage-sensing apparatus is connected to the said multi-wire bus so that the reduced level voltage signals can be transmitted to each of the plurality of said metering devices, and wherein the plurality of said metering devices each comprises:
   - one or more signal conditioning means each adapted to condition the signal from a non-contact current sensor;
   - one or more digital signal processing (DSP) devices, each of said DSP devices being adapted to the measurement of electric power and energy consumption using the current signal from one of the said signal conditioning means and an AC voltage signal from the said AC voltage-sensing apparatus via the said multi-wire bus;
   - a microcontroller which takes the output signals from the said DSP devices and calculates the total power and energy consumption of the said circuit that is being metered and which generates signals for transmission to the said data-logging apparatus.

3. An electricity metering apparatus as claimed in claim 1, wherein the plurality of said metering devices each comprises:
   - one or more signal conditioning means each adapted to condition the signal from a non-contact current sensor;
   - one or more signal rectification means;
   - a signal summation means;
   - a voltage-to-frequency conversion means;
   - a pulse generation means;

- a tone generation means

such that the said metering device generates a stream of pulses, at a rate proportional to the sum of the currents flowing in each phase of the circuit being metered, in the form of tone bursts and where the frequency of the tone used in the tone bursts is defined for each said metering device such that each pulse signal received by the data-logging apparatus can be identified as being from a particular metering device, and wherein the said data-logging apparatus is adapted to receive and decode the said tone-burst pulse signals via the said multi-wire bus.

4. An electricity metering apparatus as claimed in claim 1 wherein the plurality of current sensors are miniature Rogowski coils.

5. An electricity metering apparatus as claimed in claim 1 wherein the plurality of current sensors are multi-turn coiled Rogowski coils.

6. An electricity metering apparatus as claimed in claim 1 wherein the plurality of current sensors are current transformers.

7. An electricity metering apparatus as claimed in claim 1 wherein the plurality of current sensors are Hall-effect current transducers.

8. An electricity metering apparatus as claimed in claim 1 wherein each of the plurality of metering devices together with the current sensors connected to it is small enough in physical size to be supported by the conductors of the circuit that is being metered.

9. An electricity metering apparatus as claimed in claim 2 wherein the plurality of current sensors are miniature Rogowski coils.

10. An electricity metering apparatus as claimed in claim 2 wherein the plurality of current sensors are multi-turn coiled Rogowski coils.

11. An electricity metering apparatus as claimed in claim 2 wherein the plurality of current sensors are current transformers.

12. An electricity metering apparatus as claimed in claim 2 wherein the plurality of current sensors are Hall-effect current transducers.

13. An electricity metering apparatus as claimed in claim 2 wherein each of the plurality of metering devices together with the current sensors connected to it is small enough in physical size to be supported by the conductors of the circuit that is being metered.

14. An electricity metering apparatus as claimed in claim 3 wherein the plurality of current sensors are miniature Rogowski coils.

15. An electricity metering apparatus as claimed in claim 3 wherein the plurality of current sensors are multi-turn coiled Rogowski coils.

16. An electricity metering apparatus as claimed in claim 3 wherein the plurality of current sensors are current transformers.

17. An electricity metering apparatus as claimed in claim 3 wherein the plurality of current sensors are Hall-effect current transducers.

18. An electricity metering apparatus as claimed in claim 3 wherein each of the plurality of metering devices together with the current sensors connected to it is small enough in physical size to be supported by the conductors of the circuit that is being metered.

INTELLECTUAL
PROPERTY OFFICE

15

Application No: GB0718567.1 **Examiner:** Daniel Voisey
Claims searched: 1 to 18 **Date of search:** 14 January 2009

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1, 6 and 7	WO 93/24842 A1 (CENTRO DE PESQUISAS DE ENERGIA ELETRICA) see particularly the abstract, page 1 lines 3 to 15, page 12 line 22 to page 14 line 34, page 16 line 22 to page 20 line 3, page 21 line 16 to page 22 line 2, page 25 lines 8 to 15, and figures 1 to 3.
X,E	1	WO 2008/042483 A1 (GENERAL ELECTRIC) see particularly the abstract, page 1 paragraphs 2 and 3, page 2 paragraphs 3 and 4, page 4 paragraph 2 to page 5 paragraph 2, and figure 1.
X	1	US 2005/0083206 A1 (COUCH) see particularly the abstract, paragraphs [0003] to [0007], and figure 1.
X	1 and 6	JP 2001298877 A (SHIBAURA MECHATRONICS) see particularly the abstract, and figures 1 and 2.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art
Y	Document indicating lack of inventive step if combined with one or more other documents of same category	P	Document published on or after the declared priority date but before the filing date of this invention
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

G01R

The following online and other databases have been used in the preparation of this search report

WPI & EPODOC

International Classification:

Subclass	Subgroup	Valid From
G01R	0022/06	01/01/2006