

ISOLATION OF AN ELECTRICITY METER

FIELD

5 The present disclosure relates to an electricity meter for measuring one or more properties of an electrical input associated with a power supply, and in particular though not exclusively, to an electricity meter for measuring one or more properties of an alternating input voltage, an alternating input current or an alternating input power, wherein the electricity meter is configured to electrically isolate an analogue-to-digital converter (ADC) of the electricity meter from the electrical input.

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BACKGROUND

It is known to use an electricity meter for measuring one or more properties of an electrical input associated with a power supply such as an alternating input voltage, an alternating input current or an alternating input power.

15 However, the reliability of known electricity meters may be too low for some applications. Also, the safety of some electricity meters may be too low for some applications.

SUMMARY

20 According to an aspect of the present disclosure there is provided an electricity meter for measuring one or more properties of an electrical input associated with a power supply, the electricity meter comprising:

- a pair of input terminals for receiving the electrical input;

- an optocoupler arrangement for generating an electrical signal which is based on at least a portion of the electrical input;

- an analogue-to-digital converter (ADC) for generating an ADC output data sequence based on the electrical signal; and

- a processing resource for determining one or more properties of the received electrical input based on the ADC output data sequence,

30 wherein the optocoupler arrangement is configured to electrically isolate the ADC from the input terminals.

In such an electricity meter, the optocoupler arrangement electrically isolates the ADC, and also the processing resource, from the input terminals so that the ADC and the processing resource are electrically isolated from the electrical input. This may be advantageous for the reliability of operation of the ADC and the processing resource

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and therefore also for the reliability of operation of the electricity meter as a whole. This may also be advantageous for the safety of a user of the electricity meter.

Optionally, the optocoupler arrangement comprises an optical source and an optical detector, wherein the optical source and the optical detector are electrically
5 isolated from one another, wherein the optical source is configured to generate an optical signal which is based on at least a portion of the electrical input, and wherein the optical detector is configured to detect the optical signal and generate the electrical signal.

Optionally, the optical source comprises an LED.

10 Optionally, the optical detector comprises a phototransistor or a photodiode.

Optionally, the optocoupler arrangement comprises first and second optocouplers,

wherein the first optocoupler comprises a first optical source and a first optical detector, wherein the first optical source and the first optical detector are electrically
15 isolated from one another, wherein the first optical source is configured to generate a first optical signal based on at least a portion of the electrical input, and wherein the first optical detector is configured to detect the first optical signal,

wherein the second optocoupler comprises a second optical source and a second optical detector, wherein the second optical source and the second optical
20 detector are electrically isolated from one another, wherein the second optical source is configured to generate a second optical signal based on at least a portion of the electrical input, and wherein the second optical detector is configured to detect the second optical signal, and

wherein the optocoupler arrangement is configured so as to generate the
25 electrical signal based on the detected first and second optical signals.

Optionally, the first optical source and the first optical detector are optically isolated from the second optical source and the second optical detector.

Optionally, the optocoupler arrangement is configured so that the first optical source generates the first optical signal when the electrical input is of a first input
30 polarity and the second optical source generates the second optical signal when the electrical input is of a second input polarity opposite to the first input polarity.

Optionally, the optocoupler arrangement is configured so that the first optical detector and the second optical detector generate the electrical signal with a first output
35 polarity when the electrical input is of a first input polarity and the first optical detector and the second optical detector generate the electrical signal with a second output

polarity opposite to the first output polarity when the electrical input is of a second input polarity opposite to the first input polarity.

Optionally, the first input polarity and the first output polarity are the same and the second input polarity and the second output polarity are the same.

5 Optionally, the first input polarity and the first output polarity are different and the second input polarity and the second output polarity are different.

Optionally, the first and second optocouplers comprise first and second unipolar optocoupler devices.

10 Optionally, the first and second unipolar optocoupler devices are housed in first and second housings respectively, the first and second housings being separate from one another.

Optionally, the first and second unipolar optocoupler devices are electrically connected to one another outside of the first and second housings.

15 Optionally, the first and second optocouplers are provided as a bipolar optocoupler device.

Optionally, the first and second optocouplers are housed in separate compartments of a common housing of the bipolar optocoupler device.

Optionally, the first and second optocouplers are electrically connected to one another inside the common housing of the bipolar optocoupler device.

20 Optionally, the first optical source and/or the second optical source comprises an LED.

Optionally, the first optical detector and/or the second optical detector comprises a phototransistor or a photodiode.

Optionally, the electrical input comprises an alternating electrical input.

25 Optionally, the electrical input comprises an input voltage, an input current or an input power.

Optionally, the electrical input comprises an alternating voltage, an alternating current, or an alternating power.

30 Optionally, the electrical input is associated with a phase of a multiple phase power supply.

Optionally, the electricity meter is configured to measure one or more properties of each electrical input of a plurality of electrical inputs, for example wherein each electrical input comprises a voltage such as an alternating voltage, a current such as an alternating current, or a power such as an alternating power and/or wherein each
35 electrical input is associated with a different phase of a multiple phase power supply.

Optionally, the processing resource is configured to determine at least one of a magnitude, a frequency and a phase of the electrical input based on the ADC output data sequence.

5 Optionally, the processing resource is configured to determine whether the electrical input comprises a 50 or 60 Hz alternating electrical input based on the ADC output data sequence.

10 Optionally, the processing resource is configured to determine whether the electrical input comprises a 50 or 60 Hz alternating input voltage, a 50 or 60 Hz alternating input current or a 50 or 60 Hz alternating input power, based on the ADC output data sequence.

Optionally, the processing resource is configured to determine whether the electrical input comprises a constant electrical input based on the ADC output data sequence.

15 Optionally, the processing resource is configured to determine whether the electrical input comprises a constant input voltage of zero Volts or substantially zero Volts, a constant input current of zero Amps or substantially zero Amps, or a constant input power of zero Watts or substantially zero Watts, based on the ADC output data sequence.

20 Optionally, the ADC converts the electrical signal into the ADC output data sequence.

Optionally, the electricity meter comprises an anti-aliasing filter disposed between the optocoupler arrangement and the ADC for filtering the electrical signal to generate a filtered electrical signal, wherein the ADC converts the filtered electrical signal into the ADC output data sequence.

25 According to an aspect of the present disclosure there is provided a method for measuring one or more properties of an electrical input associated with a power supply, the method comprising:

receiving the electrical input at a pair of input terminals;

30 using an optocoupler arrangement to generate an electrical signal which is based on at least a portion of the received electrical input;

using an analogue-to-digital converter (ADC) to generate an ADC output data sequence based on the electrical signal; and

determining one or more properties of the electrical input based on the ADC output data sequence,

35 wherein the optocoupler arrangement electrically isolates the ADC from the input terminals.

It should be understood that any one or more of the optional features of any one of the foregoing aspects of the present disclosure may be combined with any one or more of the other foregoing aspects of the present disclosure or the optional features of any one or more of the other foregoing aspects of the present disclosure.

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BRIEF DESCRIPTION OF THE DRAWINGS

An electricity meter and associated method for measuring one or more properties of an electrical input associated with a power supply will now be described by way of non-limiting example only with reference to the drawings of which:

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FIG. 1 is a schematic of an electricity meter;

FIG. 2 is a circuit diagram of an optocoupler arrangement of the electricity meter of FIG. 1 together with a power supply and a service disconnect switch for selectively connecting the electricity meter to the power supply;

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FIG. 3 is a simulated voltage waveform at an output of the optocoupler arrangement of FIG. 2 when the service disconnect switch is closed; and

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FIG. 4 is a simulated voltage waveform at the output of the optocoupler arrangement of FIG. 2 when the service disconnect switch is open.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring initially to FIG. 1 there is shown an electricity meter generally designated 2 for measuring one or more properties of an electrical input in the form of an input voltage 3 between a voltage phase N input 4 and a neutral input 6 of a power supply such as a power supply on the load side of a service disconnect switch (not shown in FIG. 1). The electricity meter 2 includes a bipolar optocoupler arrangement 10, an anti-aliasing filter 20, an analogue-to-digital converter (ADC) 30 and a processing resource in the form of a microprocessor 40.

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FIG. 2 shows the bipolar optocoupler arrangement 10 in more detail together with an alternating power supply voltage V1 and a service disconnect switch S1 for selectively connecting the alternating power supply voltage V1 to input terminals 11a, 11b of the bipolar optocoupler arrangement 10. The bipolar optocoupler arrangement 10 includes first and second unipolar optocoupler devices U1 and U2 respectively, a network of resistors R1-R3, R5-R9 and capacitors C1-C4, and a bias voltage V2. The

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first unipolar optocoupler device U1 includes a first optical source in the form of a first LED and a first optical detector in the form of a first phototransistor for detecting light emitted by the first LED. The second unipolar optocoupler device U2 includes a second optical source in the form of a second LED and a second optical detector in the form of a second phototransistor for detecting light emitted by the second LED. An anode of the first LED is connected to a cathode of the second LED and a cathode of the first LED is connected to an anode of the second LED. The first optical source and the first optical detector of the first unipolar optocoupler device U1 are optically isolated from the second optical source and the second optical detector of the second unipolar optocoupler device U2. A collector of the first phototransistor and a collector of the second phototransistor are both connected to the bias voltage V2. Resistors R5-R9 are connected in series between an emitter of the first phototransistor and an emitter of the second phototransistor. Moreover, the values of resistors R1, R5, and R7 may be selected to achieve a desired scaling of the input voltage 3 to generate the output voltage 12. Specifically, R1 may be selected so that:

$$R1 \geq \frac{V1 - Vd}{CTR * Irating}$$

where V_d is the diode voltage drop across the first and second LEDs of the optocoupler arrangement 10, CTR is the current transfer ratio of the optocoupler arrangement 10 and I_{rating} is the current rating for the optocoupler arrangement 10.

R5 and R7 may be selected so that:

$$R5 = R7 = \frac{V2 - Vce}{CTR * If}$$

where

$$If = \frac{V1 - Vd}{R1}$$

and

$$Vce = V2 - Vout$$

and where I_f is the current flowing through R5 and R7, and V_{ce} is the collector-emitter voltage drop across the phototransistors of the optocoupler arrangement 10.

In use, the bipolar optocoupler arrangement 10 receives the input voltage 3 across the input terminals 11a, 11b and generates an electrical signal in the form of an output voltage 12 across resistor R9 based on the input voltage 3. As a consequence of the connectivity between the first and second LEDS of the first and second unipolar optocoupler devices U1, U2, the first LED generates the first optical signal when the input voltage 3 is of a first input polarity and the second LED generates the second optical signal when the input voltage 3 is of a second input polarity opposite to the first input polarity. Furthermore, as a consequence of the connectivity between the first and second LEDS of the first and second unipolar optocoupler devices U1, U2 and the connectivity between the first and second phototransistors of the first and second unipolar optocoupler devices U1, U2, the first and second phototransistors generate the output voltage 12 with a first output polarity when the input voltage 3 is of a first input polarity and the first and second phototransistors generate the output voltage 12 with a second output polarity opposite to the first output polarity when the input voltage 3 is of a second input polarity opposite to the first input polarity.

FIG. 3A shows the simulated output voltage 12 generated at the output of the bipolar optocoupler arrangement 10 for the component values shown in FIG. 2 when the service disconnect switch S1 is closed and the bipolar optocoupler arrangement 10 is connected to the alternating power supply voltage V1 via the service disconnect switch S1.

FIG. 3B shows the simulated output voltage 12 generated at the output of the bipolar optocoupler arrangement 10 for the component values shown in FIG. 2 when the service disconnect switch S1 is open and the bipolar optocoupler arrangement 10 is disconnected from the alternating power supply voltage V1 via the service disconnect switch S1.

The anti-aliasing filter 20 filters the output voltage 12 to generate a filtered electrical signal 22. The ADC 30 converts the filtered electrical signal 22 into an ADC output data sequence 32, and the processing resource 40 determines one or more properties of the input voltage 3 based on the ADC output data sequence 32. For example, the processing resource 40 may be configured to determine at least one of a magnitude, a frequency and a phase of the input voltage 3 based on the ADC output data sequence 32. In particular, the processing resource 40 may be configured to determine whether the input voltage 3 comprises a 50 or 60 Hz alternating input voltage based on the ADC output data sequence 32 thereby indicating that the service

disconnect switch S1 is closed or whether the input voltage 3 comprises a constant input voltage 3 of zero Volts or substantially zero Volts based on the ADC output data sequence 32 thereby indicating that the service disconnect switch S1 is open. Accordingly, the processing resource 40 may be configured to determine whether the service disconnect switch S1 is closed or open based on the ADC output data sequence 32. For example, the processing resource 40 may determine whether the service disconnect switch S1 is closed or open based on the ADC output data sequence 32 by performing a Fast Fourier Transform (FFT) on the ADC output data sequence 32 and comparing a magnitude of the frequency component of the ADC output data sequence 32 at 50 or 60 Hz with a threshold value.

From the foregoing description, one of skill in the art will understand that the optocoupler arrangement 10 electrically isolates the anti-aliasing filter 20, and therefore also the ADC 30 and the processing resource 40, from the input terminals 11a, 11b so that the anti-aliasing filter 20, the ADC 30 and the processing resource 40 are electrically isolated from the power supply input voltage 3. This may be advantageous for the reliability of operation of the anti-aliasing filter 20, the ADC 30 and the processing resource 40 and therefore also for the reliability of operation of the electricity meter 2 as a whole. This may also be advantageous for the safety of a user of the electricity meter 2.

One of ordinary skill in the art will also understand that various modifications are possible to the electricity meter 2 described above. For example, although the electricity meter 2 includes a bipolar optocoupler arrangement 10 comprising first and second unipolar optocoupler devices U1, U2, in an alternative embodiment the electricity meter may include a bipolar optocoupler arrangement comprising a single bipolar optocoupler device in which first and second optocouplers are housed in separate compartments of a common housing and in which the first and second optocouplers are electrically connected to one another inside the common housing.

In a further alternative embodiment, the electricity meter may include a single unipolar optocoupler device. One of skill in the art will understand that in such a further alternative embodiment, the unipolar optocoupler device will effectively rectify the input voltage 3 such that the electrical signal generated at the output of the single unipolar optocoupler device will be unipolar. Nevertheless, the processing resource may still determine whether the input voltage 3 comprises a 50 or 60 Hz alternating input voltage based on the ADC output data sequence corresponding to the case when the service disconnect switch S1 is closed or whether the input voltage 3 comprises a constant input voltage 3 of zero Volts or substantially zero Volts based on the ADC

output data sequence 32 corresponding to the case when the service disconnect switch S1 is open based on such a unipolar electrical signal.

In another embodiment, the electricity meter may be configured so that the optocoupler arrangement receives an electrical input which is representative of, for example which is proportional to, the input voltage 3. For example, the electricity meter may be configured so that the optocoupler arrangement receives a portion of the input voltage 3 rather than the whole of the input voltage 3. For example, the electricity meter may comprise a transformer connected between the input voltage 3 and the optocoupler arrangement, wherein the transformer is configured to generate an electrical input which is representative of, for example which is proportional to, the input voltage 3.

Although the electricity meter 2 includes the anti-aliasing filter 20 disposed between the optocoupler arrangement 10 and the ADC 30 for filtering the output voltage 12 to generate the filtered electrical signal 22, wherein the ADC 30 converts the filtered electrical signal 22 into the ADC output data sequence 32, in another embodiment, the anti-aliasing filter 20 may be omitted so that the ADC 30 converts the output voltage 12 into the ADC output data sequence 32.

Although the electrical input is described above as comprising an alternating voltage, in other embodiments of the electricity meter, the electrical input may comprise an alternating current or an alternating power.

The electrical input may be associated with a phase of a multiple phase power supply.

The electricity meter may be configured to measure one or more properties of each electrical input of a plurality of electrical inputs, for example wherein each electrical input constitutes an alternating voltage, an alternating current, or an alternating power and/or wherein each electrical input is associated with a different phase of a multiple phase power supply.

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

features of the embodiments of the present disclosure described above with reference to the drawings may produce effects or provide advantages when used in isolation from one or more of the other features of the embodiments of the present disclosure and that different combinations of the features are possible other than the specific combinations of the features of the embodiments of the present disclosure described above.

The skilled person will understand that in the preceding description and appended claims, positional terms such as 'above', 'along', 'side', etc. are made with reference to conceptual illustrations, such as those shown in the appended drawings.

These terms are used for ease of reference but are not intended to be of limiting nature. These terms are therefore to be understood as referring to an object when in an orientation as shown in the accompanying drawings.

Use of the term "comprising" when used in relation to a feature of an embodiment of the present disclosure does not exclude other features or steps. Use of the term "a" or "an" when used in relation to a feature of an embodiment of the present disclosure does not exclude the possibility that the embodiment may include a plurality of such features.

The use of reference signs in the claims should not be construed as limiting the scope of the claims.

CLAIMS

1. An electricity meter for measuring one or more properties of an electrical input associated with a power supply, the electricity meter comprising:
 - 5 a pair of input terminals for receiving the electrical input;
 - an optocoupler arrangement for generating an electrical signal which is based on at least a portion of the electrical input;
 - an analogue-to-digital converter (ADC) for generating an ADC output data sequence based on the electrical signal; and
 - 10 a processing resource for determining one or more properties of the received electrical input based on the ADC output data sequence,
 - wherein the optocoupler arrangement is configured to electrically isolate the ADC from the input terminals.
- 15 2. The electricity meter as claimed in claim 1, wherein the optocoupler arrangement comprises an optical source and an optical detector, wherein the optical source and the optical detector are electrically isolated from one another, wherein the optical source is configured to generate an optical signal which is based on at least a portion of the electrical input, and wherein the optical detector is configured to detect
20 the optical signal and generate the electrical signal.
3. The electricity meter as claimed in claim 2, wherein the optical source comprises an LED and/or wherein the optical detector comprises a phototransistor or a photodiode.
- 25 4. The electricity meter as claimed in claim 1, wherein the optocoupler arrangement comprises first and second optocouplers,
 - wherein the first optocoupler comprises a first optical source and a first optical detector, wherein the first optical source and the first optical detector are electrically
30 isolated from one another, wherein the first optical source is configured to generate a first optical signal based on at least a portion of the electrical input, and wherein the first optical detector is configured to detect the first optical signal,
 - wherein the second optocoupler comprises a second optical source and a second optical detector, wherein the second optical source and the second optical
35 detector are electrically isolated from one another, wherein the second optical source is

configured to generate a second optical signal based on at least a portion of the electrical input, and wherein the second optical detector is configured to detect the second optical signal, and

wherein the optocoupler arrangement is configured so as to generate the electrical signal based on the detected first and second optical signals.

5 5. The electricity meter as claimed in claim 4, wherein the first optical source and the first optical detector are optically isolated from the second optical source and the second optical detector.

10 6. The electricity meter as claimed in claim 4 or 5, wherein the optocoupler arrangement is configured so that the first optical source generates the first optical signal when the electrical input is of a first input polarity and the second optical source generates the second optical signal when the electrical input is of a second input polarity opposite to the first input polarity.

20 7. The electricity meter as claimed in any one of claims 4 to 6, wherein the optocoupler arrangement is configured so that the first optical detector and the second optical detector generate the electrical signal with a first output polarity when the electrical input is of a first input polarity and the first optical detector and the second optical detector generate the electrical signal with a second output polarity opposite to the first output polarity when the electrical input is of a second input polarity opposite to the first input polarity and, optionally, wherein the first input polarity and the first output polarity are the same and the second input polarity and the second output polarity are the same or wherein the first input polarity and the first output polarity are different and the second input polarity and the second output polarity are different.

25 8. The electricity meter as claimed in any one of claims 4 to 7, wherein at least one of:

30 the first and second optocouplers comprise first and second unipolar optocoupler devices;

 the first and second unipolar optocoupler devices are housed in first and second housings respectively, the first and second housings being separate from one another; or

35 the first and second unipolar optocoupler devices are electrically connected to one another outside of the first and second housings.

9. The electricity meter as claimed in any one of claims 4 to 7, wherein at least one of:
- 5 the first and second optocouplers are provided as a bipolar optocoupler device;
- the first and second optocouplers are housed in separate compartments of a common housing of the bipolar optocoupler device; or
- the first and second optocouplers are electrically connected to one another inside the common housing of the bipolar optocoupler device.
- 10 10. The electricity meter as claimed in any one of claims 4 to 9, wherein one or both of the first optical source and the second optical source comprises an LED and/or wherein one or both of the first optical detector and the second optical detector comprises a phototransistor or a photodiode.
- 15 11. The electricity meter as claimed in any preceding claim, wherein at least one of:
- the electrical input comprises an alternating electrical input;
- the electrical input comprises an input voltage, an input current or an input power;
- 20 the electrical input comprises an alternating voltage, an alternating current, or an alternating power; or
- the electrical input is associated with a phase of a multiple phase power supply.
- 25 12. The electricity meter as claimed in any preceding claim, wherein the electricity meter is configured to measure one or more properties of each electrical input of a plurality of electrical inputs, for example wherein each electrical input comprises a voltage such as an alternating voltage, a current such as an alternating current, or a power such as an alternating power and/or wherein each electrical input is associated with a different phase of a multiple phase power supply.
- 30 13. The electricity meter as claimed in any preceding claim, wherein the processing resource is configured to determine at least one of a magnitude, a frequency and a phase of the electrical input based on the ADC output data sequence.
- 35 14. The electricity meter as claimed in any preceding claim, wherein the processing resource is configured to determine whether the electrical input comprises a 50 or 60 Hz alternating electrical input based on the ADC output data sequence.

15. The electricity meter as claimed in any preceding claim, wherein the processing resource is configured to determine whether the electrical input comprises a 50 or 60 Hz alternating input voltage, a 50 or 60 Hz alternating input current or a 50 or 60 Hz alternating input power, based on the ADC output data sequence.

16. The electricity meter as claimed in any preceding claim, wherein the processing resource is configured to determine whether the electrical input comprises a constant electrical input based on the ADC output data sequence.

17. The electricity meter as claimed in any preceding claim, wherein the processing resource is configured to determine whether the electrical input comprises a constant input voltage of zero Volts or substantially zero Volts, a constant input current of zero Amps or substantially zero Amps, or a constant input power of zero Watts or substantially zero Watts, based on the ADC output data sequence.

18. The electricity meter as claimed in any preceding claim, wherein the ADC converts the electrical signal into the ADC output data sequence.

19. The electricity meter as claimed in any one of claims 1 to 17, comprising an anti-aliasing filter disposed between the optocoupler arrangement and the ADC for filtering the electrical signal to generate a filtered electrical signal, wherein the ADC converts the filtered electrical signal into the ADC output data sequence.

20. A method for measuring one or more properties of an electrical input associated with a power supply, the method comprising:
receiving the electrical input at a pair of input terminals;
using an optocoupler arrangement to generate an electrical signal which is based on at least a portion of the received electrical input;
using an analogue-to-digital converter (ADC) to generate an ADC output data sequence based on the electrical signal; and
determining one or more properties of the electrical input based on the ADC output data sequence,
wherein the optocoupler arrangement electrically isolates the ADC from the input terminals.