

ELECTRICITY METER AND ASSOCIATED METHOD

FIELD

5 The present disclosure relates to an electricity meter and associated method for measuring one or more properties of an electrical input associated with a power supply, and in particular though not exclusively, for measuring one or more properties of an alternating current, an alternating voltage or an alternating power such as an alternating current, an alternating voltage or an alternating power associated with a phase of a multiple phase power supply.

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BACKGROUND

It is known to use an electricity meter to measure one or more properties of an electrical input such as an alternating electric current as associated with a phase of a multiple phase power supply by sampling a voltage signal which is representative of the alternating electric current to thereby generate an output data sequence during a time period and by determining the one or more properties of the alternating electric current during the time period based on the output data sequence.

However, the generated output data sequence may include noise as a result of the sampling operation resulting in a signal-to-noise ratio (SNR) which is too high for some applications, especially when the alternating electric current is low. This may lead to a lack of precision in the measured value(s) of the one or more properties of the alternating electric current resulting in a lack of measurement repeatability and/or a limited dynamic range.

25 SUMMARY

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:

30 a first ADC configured to receive an ADC input signal which is representative of the electrical input and to generate, from the ADC input signal, a first ADC output data sequence which is representative of the electrical input during a time period;

a second ADC configured to receive the ADC input signal which is representative of the electrical input and to generate, from the ADC input signal, a second ADC output data sequence which is representative of the electrical input during the time period; and

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a processing resource configured to determine a cross-correlated average data sequence corresponding to the time period based on the first and second ADC output data sequences and to determine the one or more properties of the electrical input during the time period based on the cross-correlated average data sequence
5 corresponding to the time period.

Determining a cross-correlated average data sequence corresponding to the time period based on the first and second ADC output data sequences and determining the one or more properties of the electrical input during the time period based on the cross-correlated average data sequence corresponding to the time period may serve to
10 cancel, or at least reduce, any uncorrelated noise which is included with the first and second ADC output data sequences. Such uncorrelated noise may be thermal and may originate from the sample and hold stages of the first and second ADCs. In theory, use of the first and second ADCs and cross-correlated averaging in this way may result in up to half of the noise included in each of the first and second ADC output
15 data sequences being cancelled. In effect, this may improve the precision with which the electrical input may be measured and/or may improve repeatability of the measurement of the electrical input by up to a factor of two. This may also lead to an increase in the dynamic range of the electricity meter. Any harmonic distortion which is correlated with the electrical input may remain unaffected by the cross-correlated
20 averaging.

Optionally, determining the cross-correlated average data sequence corresponding to the time period based on the first and second ADC output data sequences comprises:

reversing in time the order of the data of the first ADC output data sequence
25 and multiplying the time-reversed first ADC output data sequence by the second ADC output data sequence to generate a product data sequence or reversing in time the order of the data of the second ADC output data sequence and multiplying the first ADC output data sequence by the time-reversed second ADC output data sequence to generate a product data sequence; and

30 determining a square root of the data of the product data sequence.

Optionally, determining the cross-correlated average data sequence corresponding to the time period based on the first and second ADC output data sequences comprises:

performing one or more conditioning operations on the first and second ADC
35 output data sequences to generate first and second conditioned data sequences respectively;

reversing in time the order of the data of the first conditioned data sequence and multiplying the time-reversed first conditioned data sequence by the second conditioned data sequence to generate a product data sequence or reversing in time the order of the data of the second conditioned data sequence and multiplying the first
5 conditioned data sequence by the time-reversed second conditioned data sequence to generate a product data sequence; and

determining a square root of the data of the product data sequence.

Optionally, the one or more conditioning operations comprise a calibration adjustment operation and/or a resampling operation.

10 Optionally, the calibration adjustment operation comprises adjusting the first and second ADC output data sequences according to calibration data measured by the electricity meter for one or more known electrical inputs, each known electrical input having a corresponding known amplitude, a corresponding known frequency and a corresponding known phase.

15 Optionally, the resampling operation comprises one or more of interpolation, image rejection filtering, anti-aliasing filtering and decimation.

Optionally, determining the one or more properties of the electrical input during the time period comprises determining one or more of an amplitude, a frequency and a phase of the electrical input during the time period based on the cross-correlated
20 average data sequence corresponding to the time period.

Optionally, determining the one or more properties of the electrical input during the time period comprises:

performing one or more conditioning operations on the cross-correlated average data sequence corresponding to the time period to generate a conditioned
25 cross-correlated average data sequence; and

determining one or more properties of the electrical input during the time period based on the conditioned cross-correlated average data sequence corresponding to the time period.

Optionally, performing one or more conditioning operations on the cross-correlated average data sequence corresponding to the time period to generate the conditioned cross-correlated average data sequence comprises referencing a phase of the cross-correlated average data sequence to a zero-crossing of the alternating
30 electric current.

Optionally, referencing the phase of the cross-correlated average data sequence to the zero-crossing of the alternating electric current comprises performing
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a phase-locked loop (PLL) operation followed by a fast Fourier transform (FFT) operation.

Optionally, determining the one or more properties of the electrical input during the time period comprises determining one or more of an amplitude, a frequency and a phase of the electrical input during the time period based on the conditioned cross-correlated average data sequence corresponding to the time period.

Optionally, the electricity meter is configured to generate the ADC input signal based on the electrical input.

Optionally, the electricity meter comprises a transformer, wherein generating the ADC input signal based on the electrical input comprises using the transformer to transform the electrical input to a transformed electrical input.

Optionally, the transformer comprises a current step-down transformer. Optionally, the current step-down transformer has a turns ratio in the range 1:100 to 1:10,000, 1:1000, to 1:3000, approximately 1:2000, or 1:2000.

Optionally, the electricity meter comprises a voltage divider.

Optionally, generating the ADC input signal based on the electrical input comprises passing the electrical input or the transformed electrical input through the voltage divider to generate a voltage signal or applying the electrical input or the transformed electrical input to the voltage divider to generate a voltage signal.

Optionally, the voltage divider comprises a plurality of resistors connected in series.

Optionally, the ADC input signal comprises the voltage signal.

Optionally, the electricity meter comprises an anti-aliasing filter.

Optionally, generating the ADC input signal based on the electrical input comprises using the anti-aliasing filter to filter the voltage signal.

Optionally, the ADC input signal comprises the filtered voltage signal.

Optionally, wherein the time period corresponds to one or more line cycles of the alternating electric current. A shorter time period corresponding to fewer line cycles would allow the electrical input to be measured with greater resolution for each line cycle, while a longer time period corresponding to more line cycles would allow for more averaging to further improve the signal-to-noise ratio.

Optionally, the electrical input comprises an alternating electrical input.

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.

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.

5 Optionally, 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.

Optionally, each electrical input is associated with a different phase of a multiple phase power supply.

10 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, at a first ADC, an ADC input signal which is representative of the electrical input and using the first ADC to generate, from the ADC input signal, a first ADC output data sequence which is representative of the electrical input during a time period;

15 receiving, at a second ADC, the ADC input signal which is representative of the electrical input and using the second ADC to generate, from the ADC input signal, a second ADC output data sequence which is representative of the electrical input during the time period; and

20 determining a cross-correlated average data sequence corresponding to the time period based on the first and second ADC output data sequences; and

25 determining the one or more properties of the electrical input during the time period based on the cross-correlated average data sequence corresponding to the time period.

Optionally, determining the cross-correlated average data sequence corresponding to the time period based on the first and second ADC output data sequences comprises:

30 reversing in time the order of the data of the first ADC output data sequence and multiplying the time-reversed first ADC output data sequence by the second ADC output data sequence to generate a product data sequence or reversing in time the order of the data of the second ADC output data sequence and multiplying the first ADC output data sequence by the time-reversed second ADC output data sequence to generate a product data sequence; and

35 determining a square root of the data of the product data sequence.

Optionally, determining the cross-correlated average data sequence corresponding to the time period based on the first and second ADC output data sequences comprises:

5 performing one or more conditioning operations on the first and second ADC output data sequences to generate first and second conditioned data sequences respectively;

reversing in time the order of the data of the first conditioned data sequence and multiplying the time-reversed first conditioned data sequence by the second conditioned data sequence to generate a product data sequence or reversing in time
10 the order of the data of the second conditioned data sequence and multiplying the first conditioned data sequence by the time-reversed second conditioned data sequence to generate a product data sequence; and

determining a square root of the data of the product data sequence.

Optionally, the one or more conditioning operations comprise a calibration
15 adjustment operation and/or a resampling operation.

Optionally, adjusting the first and second ADC output data sequences according to calibration data measured by the electricity meter for one or more known electrical inputs, each known electrical input having a corresponding known amplitude, a corresponding known frequency and a corresponding known phase.

20 Optionally, the resampling operation comprises one or more of interpolation, image rejection filtering, anti-aliasing filtering and decimation.

Optionally, determining the one or more properties of the electrical input during the time period based on the cross-correlated average data sequence corresponding to the time period comprises:

25 performing one or more conditioning operations on the cross-correlated average data sequence corresponding to the time period to generate a conditioned cross-correlated average data sequence; and

determining one or more properties of the electrical input during the time period based on the conditioned cross-correlated average data sequence corresponding to
30 the time period.

Optionally, performing one or more conditioning operations on the cross-correlated average data sequence corresponding to the time period to generate the conditioned cross-correlated average data sequence comprises referencing a phase of the cross-correlated average data sequence to a zero-crossing of the electrical input.

Optionally, referencing the phase of the cross-correlated average data sequence to the zero-crossing of the electrical input comprises performing a phase-locked loop (PLL) operation followed by a fast Fourier transform (FFT) operation.

5 Optionally, determining the one or more properties of the electrical input during the time period comprises determining one or more of an amplitude, a frequency and a phase of the electrical input during the time period based on the conditioned cross-correlated average data sequence corresponding to the time period.

Optionally, the electrical input comprises an alternating electrical input.

10 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.

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

15 Optionally, the electricity meter is configured to measure one or more properties of each electrical input of a plurality of electrical inputs.

Optionally, 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.

20 Optionally, each electrical input is associated with a different phase of a multiple phase power supply.

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
25 any one or more of the other foregoing aspects of the present disclosure.

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
30 by way of non-limiting example only with reference to the drawings of which:

FIG. 1 is a schematic of a first electricity meter; and

FIG. 2 is a schematic of a second electricity meter.

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DETAILED DESCRIPTION OF THE DRAWINGS

Referring initially to FIG. 1 there is shown a first electricity meter generally designated 2 for measuring one or more properties 4 of an electrical input associated with a power supply in the form of an alternating electric current 6, the electricity meter 2 comprising a voltage divider in the form of a plurality of series-connected burden resistors 8, first and second analogue-to-digital converters (ADCs) in the form of first and second delta-sigma ADCs 10a and 10b respectively, and a processing resource in the form of a microprocessor 12. The alternating electric current 6 may be a phase N load current and the one or more properties 4 of the alternating electric current 6 may be one or more energy metrics for metrology.

The first and second ADCs 10a and 10b are each configured to receive an ADC input signal in the form of a voltage signal 18 which is representative of the electric current 6 flowing through the burden resistors 8. The first and second ADCs 10a and 10b are configured to generate first and second ADC output data sequences 20a, 20b respectively which are representative of the electric current 6 flowing through the burden resistors 8 during a time period such as one or more line cycles of the alternating electric current 6. The microprocessor 12 is configured to perform a cross-correlated averaging operation 30 of the first and second ADC output data sequences 20a, 20b to determine a cross-correlated average data sequence 40 corresponding to the time period. One of ordinary skill in the art will understand that the cross-correlated average data sequence 40 corresponding to the time period may be considered to constitute a phase N current vector output 40 which corresponds to the phase N load current 6 during the time period. The microprocessor 12 is configured to determine the one or more properties 4 of the phase N load current 40 during the time period based on the phase N current vector output 40. For example, the microprocessor 12 may be configured to determine one or more of an amplitude, a frequency and a phase of the phase N current vector output 40 during the time period.

In use, the alternating electric current 6 is passed through the burden resistors 8 to generate the voltage signal 18 which is representative of the electric current 6. The first ADC 10a receives the voltage signal 18 and generates the first ADC output data sequence 20a which is representative of the electric current 6 during the time period. The second ADC 10b also receives the voltage signal 18 and generates a second ADC output data sequence 20b which is representative of the electric current 6 during the time period. The microprocessor 12 determines one or more properties of the electric current 4 during the time period based on the first and second ADC output data sequences 20a, 20b. Specifically, the microprocessor 12 determines a phase N current vector output 40 corresponding to the time period by performing a cross-

correlated averaging operation 30 on the first and second ADC output data sequences 20a, 20b to generate the cross-correlated average data sequence 40 corresponding to the time period and then determining one or more properties of the cross-correlated average data sequence 40 to generate the one or more energy metrics for metrology 4.

- 5 The microprocessor 12 determines the cross-correlated average data sequence 40 corresponding to the time period based on the first and second ADC output data sequences 20a, 20b by reversing in time the order of the data of the first ADC output data sequence 20a and multiplying the time-reversed first ADC output data sequence by the second ADC output data sequence 20b to generate a product data sequence
10 and by determining a square root of the data of the product data sequence to determine the cross-correlated average data sequence 40.

- Determining the phase N current vector output 40 corresponding to the time period by determining a cross-correlated average data sequence corresponding to the time period based on the first and second ADC output data sequences 20a, 20b and
15 then determining the one or more properties of phase N current vector output 40 to generate the one or more energy metrics for metrology 4 in this way serves to cancel, or at least reduce, any uncorrelated noise which is included with the first and second ADC output data sequences 20a, 20b. Such uncorrelated noise is generally thermal and originates from the sample and hold stages of the first and second delta-sigma
20 ADCs 10a, 10b. One of skill in the art will understand that the cross-correlated averaging operation 30 is analogous to a matched filter operation which rejects the uncorrelated noise present in the first and second ADC output data sequences 20a, 20b. In theory, use of the first and second ADCs 10a, 10b and the cross-correlated averaging operation 30 may result in up to half of the noise included with the first and
25 second ADC output data sequences 20a, 20b being cancelled. In effect, this may lead to an improvement in measurement precision of the phase N current vector output 40 and an improvement in measurement repeatability of the phase N current vector output 40 by up to a factor of two. This also leads to an increase in the dynamic range of the electricity meter 2. Any harmonic distortion which is correlated with the 50 or 60 Hz
30 phase N load current 6 remains unaffected by the cross-correlated averaging operation 30.

- Referring now to FIG. 2 there is shown a second electricity meter generally designated 102 for measuring one or more properties 104 of an alternating electric current 106, the electricity meter 102 comprising a current step-down transformer 107,
35 a voltage divider in the form of a plurality of series-connected burden resistors 108, an anti-aliasing filter 109, first and second analogue-to-digital converters (ADCs) in the

form of first and second delta-sigma ADCs 110a and 110b respectively, and a processing resource in the form of a microprocessor 112. The alternating electric current 106 may be a phase N load current and the one or more properties 104 of the alternating electric current 106 may be one or more energy metrics for metrology. The current step-down transformer 107 may have a turns ratio of 1:2000.

The first and second ADCs 110a and 110b are each configured to receive an ADC input signal in the form of a voltage signal 119 at the output of the anti-aliasing filter 109. The voltage signal 119 is representative of the electric current 106. The first and second ADCs 110a and 110b are configured to generate first and second ADC output data sequences 120a, 120b respectively which are representative of the electric current 106 during a time period such as one or more line cycles of the alternating electric current 106.

The microprocessor 112 is configured to perform one or more conditioning operations on the first and second ADC output data sequences 120a, 120b to generate first and second conditioned data sequences 126a, 126b respectively. Specifically, the microprocessor 112 is configured to perform a calibration adjustment operation 122 followed by a resampling operation 124 to generate the first and second conditioned data sequences 126a, 126b from the first and second ADC output data sequences 120a, 120b respectively. The calibration adjustment operation 122 may comprise adjusting the first and second ADC output data sequences 120a, 120b according to calibration data measured by the electricity meter 102 for one or more known alternating electric currents, each known alternating electric current having a corresponding known amplitude, a corresponding known frequency, and a corresponding known phase. The resampling operation 124 may comprise the use of one or more of interpolation, an image rejection filter, an anti-aliasing filter and decimation.

The microprocessor 112 is further configured to perform a cross-correlated averaging operation 130 of the first and second conditioned data sequences 126a, 126b to generate a cross-correlated average data sequence 132 corresponding to the time period.

The microprocessor 112 is further configured to perform one or more conditioning operations on the cross-correlated average data sequence 132 corresponding to the time period to generate a conditioned cross-correlated average data sequence 140. Specifically, the microprocessor 112 is configured to reference a phase of the cross-correlated average data sequence 132 to a zero-crossing of the alternating electric current 106 by performing a phase-locked loop (PLL) operation 134

followed by a fast Fourier transform (FFT) operation 136 to generate the conditioned cross-correlated average data sequence 140.

One of ordinary skill in the art will understand that the conditioned cross-correlated average data sequence 140 corresponding to the time period may be considered to constitute a phase N current vector output 140 which corresponds to the phase N load current 106 during the time period. The microprocessor 112 is configured to determine the one or more properties 104 of the phase N load current 140 during the time period from the phase N current vector output 140. For example, the microprocessor 112 may be configured to determine one or more of an amplitude, a frequency and a phase of the phase N current vector output 140 during the time period.

In use, the alternating electric current 106 constitutes a primary alternating electric current of the current transformer 107. The current transformer 107 transforms the alternating electric current 106 into a secondary alternating electric current which is passed through the burden resistors 108 to generate an initial voltage signal 118. The initial voltage signal 118 is applied to an input of the anti-aliasing filter 109 to generate a voltage signal 119 which is representative of the electric current 106.

The first ADC 110a receives the voltage signal 119 and generates the first ADC output data sequence 120a which is representative of the electric current 106 during the time period. The second ADC 110b also receives the voltage signal 119 and generates a second ADC output data sequence 120b which is representative of the electric current 106 during the time period. The microprocessor 112 determines one or more properties of the electric current 104 during the time period based on the first and second ADC output data sequences 120a, 120b. Specifically, the microprocessor 112 performs the calibration adjustment operation 122 followed by the resampling operation 124 on the first and second ADC output data sequences 120a, 120b to generate the first and second conditioned data sequences 126a, 126b respectively.

The microprocessor 112 then performs the cross-correlated averaging operation 130 on the first and second conditioned data sequences 126a, 126b respectively to generate the cross-correlated average data sequence 132. More specifically, the microprocessor 112 determines the cross-correlated average data sequence 132 corresponding to the time period based on the first and second conditioned data sequences 126a, 126b by reversing in time the order of the data of the first conditioned data sequence 126a and multiplying the time-reversed first conditioned data sequence by the second conditioned data sequence 126b to generate

a product data sequence and by determining a square root of the data of the product data sequence to determine the cross-correlated average data sequence 132.

5 The microprocessor 112 then performs the PLL operation 134 followed by the FFT operation 136 on the cross-correlated average data sequence 132 corresponding to the time period to generate the phase N current vector output 140 which corresponds to the phase N load current 106 during the time period. The microprocessor 112 determines the one or more properties of the phase N current vector output 140 to generate the one or more energy metrics for metrology 104.

10 Determining the phase N current vector output 140 corresponding to the time period by determining a cross-correlated average data sequence 132 corresponding to the time period based on the first and second ADC output data sequences 120a, 120b and then determining the one or more properties of phase N current vector output 140 to generate the one or more energy metrics for metrology 104 in this way serves to cancel, or at least reduce, any uncorrelated noise which is included with the first and second ADC output data sequences 120a, 120b. Such uncorrelated noise is generally thermal and originates from the sample and hold stages of the first and second delta-sigma ADCs 110a, 110b. One of skill in the art will understand that the cross-correlated averaging operation 130 is analogous to a matched filter operation which rejects the uncorrelated noise present in the first and second ADC output data sequences 120a, 120b. In theory, use of the first and second ADCs 110a, 110b and the cross-correlated averaging operation 130 may result in up to half of the noise included with the first and second ADC output data sequences 120a, 120b being cancelled. In effect, this may lead to an improvement in measurement precision of the phase N current vector output 140 and an improvement in measurement repeatability of the phase N current vector output 140 by up to a factor of two. This also leads to an increase in the dynamic range of the electricity meter 102. Any harmonic distortion which is correlated with the 50 or 60 Hz phase N load current 106 remains unaffected by the cross-correlated averaging operation 130.

25 One of ordinary skill in the art will also understand that various modifications are possible to any of the electricity meters 2, 102 described above. For example, as an alternative to determining the cross-correlated average data sequence 40 corresponding to the time period based on the first and second ADC output data sequences 20a, 20b by reversing in time the order of the data of the first ADC output data sequence 20a and multiplying the time-reversed first ADC output data sequence by the second ADC output data sequence 20b to generate a product data sequence and by determining a square root of the data of the product data sequence to

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determine the cross-correlated average data sequence 40, the cross-correlated average data sequence 40 corresponding to the time period may be determined by reversing in time the order of the data of the second ADC output data sequence 120b and multiplying the first ADC output data sequence 120a by the time-reversed second conditioned data sequence to generate the product data sequence and by determining a square root of the data of the product data sequence to determine the cross-correlated average data sequence 40.

Similarly, as an alternative to determining the cross-correlated average data sequence 132 corresponding to the time period based on the first and second conditioned data sequences 126a, 126b by reversing in time the order of the data of the first conditioned data sequence 126a and multiplying the time-reversed first conditioned data sequence by the second conditioned data sequence 126b to generate a product data sequence and by determining a square root of the data of the product data sequence to determine the cross-correlated average data sequence 132, the cross-correlated average data sequence 132 corresponding to the time period may be determined by reversing in time the order of the data of the second conditioned data sequence 126b and multiplying the first conditioned data sequence 126a by the time-reversed second conditioned data sequence to generate the product data sequence and by determining a square root of the data of the product data sequence to determine the cross-correlated average data sequence 132.

Although the first and second ADCs 10a, 110a and 10b, 110b respectively are described as delta-sigma ADCs, in other embodiments, the first and second ADCs 10a, 110a and 10b, 110b respectively may be ADCs of any kind, for example the first and second ADCs 10a, 110a and 10b, 110b respectively may be a Wilkinson ADC, a direct conversion or flash ADC, a successive-approximation ADC, a ramp compare ADC, an integrating ADC, a delta-encoded or counter-ramp ADC or a pipelined ADC a time-interleaved ADC or the like.

The alternating electric current 6, 106 may constitute a phase of a multiple phase power supply.

The alternating electric current 6, 106 may constitute a phase A of a multiple phase power supply.

The electricity meter 2, 102 may be configured to measure one or more properties of each alternating electric current of a plurality of alternating electric currents such as a plurality of phases of a multiple phase power supply according to any of the methods described above.

Optionally, the current step-down transformer may have a turns ratio in the range 1:100 to 1:10,000, 1:1000, to 1:3000, approximately 1:2000, or 1:2000.

Although the electricity meters 2, 102 are described above as being configured to measure one or more properties of an electrical input associated with a power supply in the form of an alternating electrical current, in an alternative embodiment, the electricity meter may be configured to measure one or more properties of a different kind of electrical input associated with a power supply. For example, the electricity meter may be configured to measure one or more properties of a different kind of alternating electrical input associated with a power supply.

The electricity meter may be configured to measure one or more properties of an electrical input comprising an input voltage, an input current or an input power.

The electricity meter may be configured to measure one or more properties of an electrical input comprising an alternating voltage, an alternating current, or an alternating power.

The electricity meter may be configured to measure one or more properties of an electrical input which is 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 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.

Although the electricity meters 2, 102 have 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.

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 first ADC configured to receive an ADC input signal which is representative of the electrical input and to generate, from the ADC input signal, a first ADC output data sequence which is representative of the electrical input during a time period;
 - a second ADC configured to receive the ADC input signal which is representative of the electrical input and to generate, from the ADC input signal, a second ADC output data sequence which is representative of the electrical input during
10 the time period; and
 - a processing resource configured to determine a cross-correlated average data sequence corresponding to the time period based on the first and second ADC output data sequences and to determine the one or more properties of the electrical input
15 during the time period based on the cross-correlated average data sequence corresponding to the time period.
2. The electricity meter as claimed in claim 1, wherein determining the cross-correlated average data sequence corresponding to the time period based on the first
20 and second ADC output data sequences comprises:
 - reversing in time the order of the data of the first ADC output data sequence and multiplying the time-reversed first ADC output data sequence by the second ADC output data sequence to generate a product data sequence or reversing in time the order of the data of the second ADC output data sequence and multiplying the first
25 ADC output data sequence by the time-reversed second ADC output data sequence to generate a product data sequence; and
 - determining a square root of the data of the product data sequence.
3. The electricity meter as claimed in claim 1, wherein determining the cross-correlated average data sequence corresponding to the time period based on the first
30 and second ADC output data sequences comprises:
 - performing one or more conditioning operations on the first and second ADC output data sequences to generate first and second conditioned data sequences respectively;

reversing in time the order of the data of the first conditioned data sequence and multiplying the time-reversed first conditioned data sequence by the second conditioned data sequence to generate a product data sequence or reversing in time the order of the data of the second conditioned data sequence and multiplying the first
5 conditioned data sequence by the time-reversed second conditioned data sequence to generate a product data sequence; and

determining a square root of the data of the product data sequence.

4. The electricity meter as claimed in claim 3, wherein the one or more
10 conditioning operations comprise a calibration adjustment operation and/or a resampling operation.

5. The electricity meter as claimed in claim 4, wherein the calibration adjustment operation comprises adjusting the first and second ADC output data sequences
15 according to calibration data measured by the electricity meter for one or more known electrical inputs, each known electrical input having a corresponding known amplitude, a corresponding known frequency and a corresponding known phase.

6. The electricity meter as claimed in claim 4 or 5, wherein the resampling
20 operation comprises one or more of interpolation, image rejection filtering, anti-aliasing filtering and decimation.

7. The electricity meter as claimed in any preceding claim, wherein determining the one or more properties of the electrical input during the time period comprises
25 determining one or more of an amplitude, a frequency and a phase of the electrical input during the time period based on the cross-correlated average data sequence corresponding to the time period.

8. The electricity meter as claimed in any one of claims 1 to 6, wherein
30 determining the one or more properties of the electrical input during the time period based on the cross-correlated average data sequence corresponding to the time period comprises:

performing one or more conditioning operations on the cross-correlated average data sequence corresponding to the time period to generate a conditioned
35 cross-correlated average data sequence; and

determining one or more properties of the electrical input during the time period based on the conditioned cross-correlated average data sequence corresponding to the time period.

- 5 9. The electricity meter as claimed in claim 8, wherein performing one or more conditioning operations on the cross-correlated average data sequence corresponding to the time period to generate the conditioned cross-correlated average data sequence comprises referencing a phase of the cross-correlated average data sequence to a zero-crossing of the electrical input.
- 10 10. The electricity meter as claimed in claim 9, wherein referencing the phase of the cross-correlated average data sequence to the zero-crossing of the electrical input comprises performing a phase-locked loop (PLL) operation followed by a fast Fourier transform (FFT) operation.
- 15 11. The electricity meter as claimed in any one of claims 8 to 10, wherein determining the one or more properties of the electrical input during the time period comprises determining one or more of an amplitude, a frequency and a phase of the electrical input during the time period based on the conditioned cross-correlated
- 20 average data sequence corresponding to the time period.
12. The electricity meter as claimed in any preceding claim, wherein the electricity meter is configured to generate the ADC input signal based on the electrical input.
- 25 13. The electricity meter as claimed in any preceding claim, comprising a transformer, wherein generating the ADC input signal based on the electrical input comprises using the transformer to transform the electrical input to a transformed electrical input.
- 30 14. The electricity meter as claimed in claim 12 or 13, comprising a voltage divider, wherein generating the ADC input signal based on the electrical input comprises passing the electrical input or the transformed electrical input through the voltage divider to generate a voltage signal or applying the electrical input or the transformed electrical input to the voltage divider to generate a voltage signal.

15. The electricity meter as claimed in claim 14, wherein the voltage divider comprises a plurality of resistors connected in series.

16. The electricity meter as claimed in claim 14 or 15, wherein the ADC input signal
5 comprises the voltage signal.

17. The electricity meter as claimed in claim 14 or 15, comprising an anti-aliasing filter, wherein generating the ADC input signal based on the electrical input comprises using the anti-aliasing filter to filter the voltage signal, and wherein the ADC input signal
10 comprises the filtered voltage signal.

18. 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
15 power;
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.

19. 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
20 with a different phase of a multiple phase power supply.

20. A method for measuring one or more properties of an electrical input associated with a power supply, the method comprising:
receiving, at a first ADC, an ADC input signal which is representative of the
30 electrical input and using the first ADC to generate, from the ADC input signal, a first ADC output data sequence which is representative of the electrical input during a time period;
receiving, at a second ADC, the ADC input signal which is representative of the electrical input and using the second ADC to generate, from the ADC input signal, a
35 second ADC output data sequence which is representative of the electrical input during the time period;

determining a cross-correlated average data sequence corresponding to the time period based on the first and second ADC output data sequences; and

determining the one or more properties of the electrical input during the time period based on the cross-correlated average data sequence corresponding to the time period.