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### Measuring apparatus for measuring a voltage over an isolation barrier and household appliance having the measuring apparatus

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#### Abstract

A measuring apparatus ascertains measurement information relating to an input voltage. The measuring apparatus contains an operational amplifier having first and second inputs, and an output for providing the measurement information. The measuring apparatus further has a first input node for coupling to a first pole of the input voltage, and a first isolation resistor which connects the first input node to the first input of the operational amplifier. Moreover, the measuring apparatus contains a second input node for coupling to a second pole of the input voltage, and a second isolation resistor which connects the second input node to the second input of the operational amplifier. The measuring apparatus further has a feedback resistor which connects the output of the operational amplifier to the first input of the operational amplifier, and a reference resistor which connects the second input of the operational amplifier to a reference potential.

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## Background/Summary

## CROSS-REFERENCE TO RELATED APPLICATION

(1) This application claims the priority, under 35 U.S.C. § 119, of German Patent Application DE 10 2022 205 116.5, filed May 23, 2022; the prior application is herewith incorporated by reference in its entirety.

## FIELD AND BACKGROUND OF THE INVENTION

(2) The invention relates to an apparatus, in particular a switching arrangement, for measuring a voltage, in particular an AC voltage or a DC voltage (e.g. the intermediate circuit voltage of a switched-mode power supply or of motor electronics).

(3) A household appliance, such as, e.g., a washing machine or a dishwasher, typically has a grid connection, in particular a switched-mode power supply, with which the household appliance can be connected to an AC supply grid. The grid voltage or supply voltage provided by a supply grid can have fluctuations with regard to the voltage amplitude and/or with regard to the frequency. Such fluctuations can lead to overvoltage situations and/or to fluctuations in the power consumption in a household appliance and therefore possibly to impairments of the operation of the household appliance.

## SUMMARY OF THE INVENTION

(4) The present application is concerned with the technical object of enabling efficient and precise measurement of the grid voltage or supply voltage of an electrical appliance, in particular of a household appliance, in order to ensure reliable and stable operation of the electrical appliance even in the event of fluctuations in the supply voltage. In this case, the measurement should also be made possible over an isolation barrier.

(5) The object is achieved by the subject matter of the independent patent claim. Advantageous embodiments are in particular defined in the dependent patent claims, described in the following description or illustrated in the appended drawing.

(6) According to one aspect of the invention, a measuring apparatus for ascertaining measurement information relating to an input voltage, in particular relating to an alternating current (AC) input voltage or relating to a direct current (DC) input voltage, is described. The measuring apparatus can in particular be configured to provide one or more measurement voltages for the input voltage which can be read by a microprocessor (via an analog-to-digital converter) in a reliable and efficient manner in a Safety Extra Low Voltage (SELV) or a Protective Extra Low Voltage (PELV) environment. The input voltage, in particular the AC input voltage, can be, e.g., a 230 volt (V) supply voltage.

(7) The measuring apparatus contains an operational amplifier having a first input (e.g. having an inverting and/or minus input) and having a second input (e.g. having a non-inverting and/or plus input), and having an output for providing the measurement information. The operational amplifier (and the optional comparator described in this document) can be operated, e.g., between an operating voltage (e.g. 10V or less, or 5V or less) and a reference voltage or a reference potential (e.g. ground). Alternatively, the operational amplifier (and optionally the comparator) can be operated between a positive and a negative operating voltage (which encompasses the reference potential). In a further example, the operational amplifier (and optionally the comparator) can be operated between two voltages which form a voltage range which comprises the subrange between the operating voltage and the reference potential (or another target range for the output voltage of the operational amplifier (or of the comparator)).

(8) In addition, the measuring apparatus contains a first input node for coupling to a first pole (e.g. to the minus pole, to a phase conductor or to the neutral conductor) of the input voltage, and a first (ohmic) isolation resistor which connects the first input node (directly) to the first input of the operational amplifier. Moreover, the measuring apparatus contains a second input node for coupling to a second pole (in a complementary manner to the first pole e.g. to the plus pole, to the neutral conductor or to the phase conductor) of the input voltage, and a second (ohmic) isolation

resistor which connects the second input node (directly) to the second input of the operational amplifier.

(9) The input voltage can be part of a first voltage reference system. The input voltage can have, e.g., an amplitude of 100V or more. The first voltage reference system can be, e.g., a supply voltage (e.g. a 230V supply voltage) or an intermediate circuit voltage (for instance of a switched-mode power supply or of electronics for a BLDC motor, i.e. for a brushless DC motor). Conversely, the operating voltage and/or the reference potential can be part of a second voltage reference system, in particular of an SELV or of a PELV voltage reference system. The measurement information and/or the operating voltage can have, e.g., an amplitude of 50V or less. An isolation barrier can be arranged between the two voltage reference systems, which isolation barrier is provided in particular by the isolation resistors of the measuring apparatus. A measurement of the input voltage from another voltage reference range can therefore be made possible (at the output of the operational amplifier) in an efficient and reliable manner.

(10) The measuring apparatus further contains a feedback resistor which connects the output of the operational amplifier (directly) to the first input of the operational amplifier. In addition, the measuring apparatus contains a reference resistor which connects the second input of the operational amplifier (directly or via an offset unit) to the reference potential (e.g. to ground). Measurement information relating to the input voltage can thus be provided at the output of the operational amplifier in a particularly precise way.

(11) The first isolation resistor and the second isolation resistor can each have such a high resistance value that the first isolation resistor and the second isolation resistor achieve galvanic isolation with a leakage current which is less than a predefined (within a regulation, for instance the SELV standard) leakage current threshold value. Alternatively or in addition, the first isolation resistor and/or the second isolation resistor can each have a plurality of resistor elements arranged in series. An isolation barrier between the first voltage reference range and the second voltage reference range can thus be provided in a particularly efficient manner.

(12) The resistance values of the first isolation resistor and of the second isolation resistor are preferably identical or deviate from one another by no more than 5%. Furthermore, the resistance values of the feedback resistor and of the reference resistor are preferably identical or deviate from one another by no more than 5%. Particularly precise and efficient measurement of the input voltage can thus be made possible via the output voltage at the output of the operational amplifier.

(13) The measuring apparatus can comprise an offset unit (e.g. a voltage source) which is configured to shift the reference potential by an offset voltage in order to generate a modified reference potential. The reference resistor can then be arranged in such a way that the reference resistor connects the second input of the operational amplifier (directly) to the modified reference potential.

(14) The input voltage can have different polarities at different times. The input voltage can be, e.g., an AC voltage. The offset voltage can be so high that the differential voltage between the first input and the second input of the operational amplifier has a uniform polarity at each of the different times (preferably between 0V and the operating voltage). Alternatively or in addition, the offset voltage can be so high that the output voltage at the output of the operational amplifier has a uniform polarity at each of the different times (preferably between 0V and the operating voltage).

(15) The output voltage at the output of the operational amplifier can be configured to assume values from a possible voltage range, and/or measuring and/or evaluation electronics downstream of the operational amplifier can be configured to measure measurement values from the possible voltage range. The offset voltage can then correspond to half of the possible voltage range. In a preferred example, the offset voltage corresponds to half of the voltage difference between the operating voltage and the reference potential, or deviates by no more than 5% therefrom. In this case, the output voltage can be measured between the output of the operational amplifier and the reference potential (e.g. ground) (and passed to an analog-to-digital converter).

- (16) Provision can therefore be made for an offset unit which makes it possible to provide, at the output of the operational amplifier, an output voltage (relative to the reference potential) which has no change in polarity, even when measuring an AC input voltage. Particularly efficient and precise measurement of the input voltage can thus be made possible.
- (17) The measuring apparatus can therefore be designed to provide, as measurement information at the output of the operational amplifier, an output voltage as a measurement of the input voltage, which output voltage corresponds to a scaled and/or shifted version of the input voltage. In this case, the output voltage can have an amplitude of 50V or less (even if the input voltage has an amplitude of 100V or more). Particularly efficient measurement of the input voltage can therefore be made possible.
- (18) The measuring apparatus can comprise a comparator which is configured to compare the output voltage at the output of the operational amplifier with a comparison potential derived from the reference potential. In this case, the comparison potential can be the modified reference potential which corresponds to the reference potential shifted by the offset voltage. The comparator can therefore be configured to indicate a change in polarity and/or a zero crossing of the input voltage as an output signal of the comparator. Providing a comparator can allow efficient and precise measurement of the zero crossing and/or of the frequency of an (AC) input voltage.
- (19) The measuring apparatus can comprise an analog-to-digital converter which is configured to convert the output voltage at the output of the operational amplifier or a voltage derived therefrom (e.g. the output voltage or the output signal of the comparator) into a digital measurement voltage.
- (20) In addition, the measuring apparatus can contain a processor which is configured to use the digital measurement voltage as a basis for ascertaining, as measurement information, a measurement value for the input voltage, in particular a measurement value for the amplitude or for the entire signal form of the input voltage. Alternatively or in addition, a change in polarity and/or a zero crossing of the input voltage can be detected, and/or the frequency of the input voltage can be ascertained (if the digital measurement voltage indicates the output signal of the comparator). Efficient and precise use of the measurement information can therefore be made possible.
- (21) According to a further aspect, a household appliance (e.g. a washing machine, a dishwasher, an oven, a stove, a kitchen appliance, a vacuum cleaner, a dryer, a refrigerator, etc.) which includes the measuring apparatus described in this document is described. The household appliance can in particular contain a grid connection for connecting the household appliance to an AC supply voltage. The measuring apparatus can be configured to use the AC supply voltage as a basis for ascertaining measurement information relating to the supply voltage.
- (22) The household appliance can further comprise a control unit which is configured to operate a function of the household appliance depending on the measurement information, in particular depending on a measurement value of the amplitude of the supply voltage. For example, the power of the household appliance can be controlled or regulated depending on the measurement information. Particularly safe and reliable operation of the household appliance can thus be made possible.
- (23) It should be noted that any aspects of the measuring apparatus described in this document can be combined with one another in a variety of ways. In particular, the features of the patent claims can be combined with one another in a variety of ways.
- (24) Other features which are considered as characteristic for the invention are set forth in the appended claims.
- (25) Although the invention is illustrated and described herein as embodied in a measuring apparatus for measuring a voltage over an isolation barrier, it is nevertheless not intended to be limited to the details shown, since various modifications and structural changes may be made therein without departing from the spirit of the invention and within the scope and range of equivalents of the claims.
- (26) The construction and method of operation of the invention, however, together with additional

objects and advantages thereof will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings.

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## Description

### BRIEF DESCRIPTION OF THE FIGURES

- (1) FIG. 1 is a block diagram of an exemplary household appliance;
- (2) FIG. 2 is block diagram of an exemplary measuring apparatus for measuring a voltage;
- (3) FIG. 3A is a basic circuit diagram based on an operational amplifier;
- (4) FIG. 3B is a circuit diagram of the exemplary measuring apparatus having the operational amplifier;
- (5) FIG. 3C is a circuit diagram of a further exemplary measuring apparatus having the operational amplifier;
- (6) FIG. 4A is a circuit diagram of the exemplary measuring apparatus for measuring the amplitude of an AC input voltage; and
- (7) FIG. 4B is a circuit diagram of an exemplary measuring apparatus for measuring the zero crossing and/or the frequency of an AC input voltage.

### DETAILED DESCRIPTION OF THE INVENTION

(8) As stated above, the present document is concerned with enabling stable and reliable operation of a household appliance in an efficient manner even in the event of fluctuations in the supply voltage. Referring now to the figures of the drawings in detail and first, particularly to FIG. 1 thereof, there is shown an exemplary household appliance **100**, e.g. a washing machine, having a grid connection **102**, in particular having a switched-mode power supply, via which the household appliance **100** can be connected to an AC supply voltage **103**. The household appliance **100** contains a measuring apparatus **110** which is configured to measure one or more measurement signals relating to the supply voltage **103**. The one or more measurement signals (e.g. the output voltage of an operational amplifier and/or the output signal of a comparator) can be evaluated by a control unit **101**, e.g. by a microprocessor, of the household appliance **100**, in particular in order to match the operation of the household appliance **100** to a respectively present characteristic, e.g. amplitude and/or frequency, of the supply voltage or grid voltage **103**. Stable and reliable operation of the household appliance **100** can thus be enabled even in the event of fluctuations in the supply voltage **103**.

(9) FIG. 1 therefore shows a household appliance **100** which can be connected to the public electricity grid via a power plug and can thus be supplied with electrical energy. The public electricity grid can be considered to be “voltage reference system A”. Live parts in and on the household appliance **100** which have a connection to this voltage reference system typically have to be electrically isolated and protected from being touched by a user of the household appliance **100**. Electric shocks caused by the relatively high voltage of this voltage reference system can thus be avoided in a reliable manner. Such isolation is potentially not possible or associated with relatively high complexity in a household appliance **100**, for example in the region of the user interface, or in the case of accessories such as a meat thermometer, for example.

(10) For this reason, a household appliance **100** typically has its own power supply, which can be referred to as “voltage reference system B” and which has a lower (operating) voltage (also referred to as VDD in this document) with respect to the grid voltage **103**, by way of which electric shocks for a user can be reliably avoided. Components of the household appliance **100** which cannot be isolated can be safely supplied with electrical energy within the voltage reference system B.

(11) One pole of the public electricity grid is typically connected to ground, which makes it necessary to galvanically isolate the voltage reference system A and the voltage reference system B

from one another. The galvanic separation can be achieved by a so-called isolation barrier. Energy can be transmitted between the two voltage reference systems magnetically by means of a transformer (as part of the isolation barrier).

(12) An isolation barrier usually has a maximum permissible discharge current (which is also referred to as leakage current) and/or one or more further isolation characteristics, such as, e.g., a particular geometrical spacing and/or a particular dielectric strength. The electrically defined relationship of the two voltage reference systems, which are galvanically separated from one another by the isolation barrier, with respect to one another is usually lost through an isolation barrier. If the voltage of the voltage reference system A is intended to be measured within the voltage reference system B, it is therefore typically necessary to transmit this relative voltage information to the voltage reference system B without deactivating the isolation barrier in this case.

(13) An example of a voltage measurement over an isolation barrier is the measurement of the grid voltage **103**. Measured information relating to the grid voltage **103** can, e.g., be used to activate a protective function in the household appliance **100** or to optimize, in terms of energy, one or more processes, such as, for example, the defrosting of a refrigerator by means of heaters.

(14) In this document, a measuring apparatus **110** for measuring a voltage **103** over an isolation barrier is described, which measuring apparatus satisfies a maximum permissible leakage current stipulated for the isolation barrier and/or satisfies one or more further isolation characteristics or isolation requirements.

(15) FIG. 2 shows a circuit diagram of an exemplary measuring apparatus **110**. The measuring apparatus **110** is configured to clearly determine the potential difference **103** between the points **211** and **221** (i.e. the input voltage **103**) using the difference between the measurement voltages **219** (between the first measurement point **217** and the reference potential **202**) and **229** (between the second measurement point **227** and the reference potential **202**).

(16) The offset resistors **214** and **224** establish a connection of the measurement points **217** and **227** to the operating voltage **201** of the second voltage reference system B **232**. The operating voltage **201** can have a fixed value in relation to the reference potential **202**. An offset voltage can thus be added to each of the measurement voltages **219** and **229**, which offset voltage makes it possible to keep each of the measurement voltages **219**, **229** solely in the positive range. This is advantageous for receiving each of the individual measurement voltages **219**, **229** via a unipolar analog-to-digital converter in a microprocessor.

(17) The resistors **212**, **214** and **215** and the resistors **222**, **224** and **225** each form a voltage divider **213**, **223** between the voltage **218** and the first measurement voltage **219** and between the voltage **228** and the second measurement voltage **229**, respectively.

(18) The potential difference between the input nodes **211** and **221** constitutes the input voltage **103**. In this case, the potential differences or voltages **218** and **228** are typically not significant in absolute terms. Interference, common-mode voltages or additional impedances between the input nodes **211** and **221** and the reference potential **202** cancel each other out when the difference is formed and only the input voltage **103** remains as the result. It is thus possible, in a system in which one point is set as potential reference point ("GND") (with the reference potential **202**), to measure a voltage between two input nodes **211**, **221** independently of the respective absolute potential differences **218**, **228** of the individual input nodes **211**, **221** in relation to the potential reference point of the system. A high-impedance connection of the two input nodes **211**, **221** to the measuring apparatus **110** is thus made possible.

(19) The capacitors **216** and **226** can be used for the low-pass filtering of the measurement voltage. If no low-pass filtering is required, the capacitors **216**, **226** can be dispensed with.

(20) By using relatively high resistance values of the isolation resistors **212** and **222** and by way of a corresponding limitation of the electrical currents via the isolation resistors **212**, **222**, a voltage measurement over an isolation barrier between the first voltage reference system A **231** and the second voltage reference system B **232** is made possible.

(21) Typically, the higher the chosen resistance value of the isolation resistors **212** and **222**, the greater the interference influence of parasitic capacitances on the absolute voltages **218** and **228**. By way of the differential voltage measurement, however, these interference influences completely cancel each other out as part of the difference formation such that precise measurement of the input voltage **103** using the difference of the measurement voltages **219**, **229** is made possible even when reducing the leakage currents of the isolation barrier by increasing the resistance value of the isolation resistors **212** and **222**. In this case, the measuring apparatus **110** illustrated in FIG. 2 uses only passive components and therefore allows particularly efficient implementation.

(22) In the case of the measuring apparatus **110** illustrated in FIG. 2, the two measurement voltages **219**, **229** have to be measured virtually at the same time, which typically requires the use of at least two analog-to-digital converter inputs and sampling of the two inputs at times which are as close together as possible. If a sufficient number of analog-to-digital converter inputs are unavailable and/or if virtually simultaneous sampling is not possible, the measuring apparatus **110** from FIG. 2 can thus typically not be used.

(23) FIG. 3A shows an exemplary operational amplifier basic circuit **300** having the function of a subtracter. The circuit **300** is configured to subtract the two input voltages “U.sub.E2” **221** and “U.sub.E1” **211** from one another, and delivers, based thereon, a result as output voltage “U.sub.A” at the output node **305** (relative to the reference potential **202**). The two input voltages **211**, **221** are routed via resistors **212**, **222** to the inverting input **311** and to the non-inverting input **312**, respectively, of an operational amplifier **310**. The output **313** of the operational amplifier **310** is coupled to the inverting input **311** via a feedback resistor **302**. The non-inverting input **312** is coupled to the reference potential **202** via a reference resistor **304**.

(24) For an ideal operational amplifier **310**, the relationship between the output voltage and the input voltages **211**, **221** can be described as

$$(25) \quad U_A = U_{E2} * \frac{R1+R2}{R1} * \frac{R4}{R3+R4} - U_{E1} * \frac{R2}{R1}. \quad (a)$$

(26) By setting the following conditions for the resistance values of the resistors **212**, **222**, **302**, **304**:  $R1=R3$  and  $R2=R4$ , the relationship can be illustrated by the following formula:

$$(27) \quad U_A = \frac{R2}{R1} * (U_{E2} - U_{E1}). \quad (a)$$

(28) As can be seen from this formula, a voltage measurement between the points “E1” and “E2” can be made possible by means of the circuit **300**. The absolute voltages between the points “E1” **211** and “E2” **221** to the point “GND” (with the reference potential **202**) no longer play a role in this case. Only the potential difference **103** between the points “E1” **211** and “E2” **221** is evaluated.

(29) The circuit principle from FIG. 3A can be used to measure a voltage over an isolation barrier in a household appliance **100**, such as illustrated by way of example in FIG. 3B. The values of the resistors “R1” and “R3” and also “R2” and “R4” are preferably identical in order to eliminate the absolute voltage reference between the two voltage reference systems “A” **231** and “B” **232**. As a consequence thereof, still only the potential difference **103** between the points “E1” **211** and “E2” **221** is relevant.

(30) In the electronic circuits **102** installed in a household appliance **100**, usually only a positive operating voltage **201** is available (for operating the operational amplifier **310**). Furthermore, an analog-to-digital converter usually carries out a voltage measurement only in the positive voltage range. For this reason, the measuring apparatus **110** can comprise an offset unit **330** (e.g. an (ideal) voltage source) which is configured to effect an offset voltage **333**, by way of which an output voltage **340** which lies solely in the positive range in relation to the reference potential **202** is achieved at the output point **305** (see FIG. 3C). By subtracting the offset voltage **333** from this output voltage **340**, a measurement value **320** which can be positive and negative and can therefore represent both polarities of the voltage **103** that is to be measured is therefore obtained (see FIG. 3B), e.g. in order to detect the zero crossing of the voltage **103** that is to be measured. In order to allow the greatest possible modulation in both voltage directions, the offset voltage **333** preferably



corresponds to half the voltage of the entire measurement range (which typically corresponds to the difference between the operating voltage **201** and the reference potential **202**). In the case of a measurement range of 0V to 3.3V, e.g. an offset voltage “U.sub.OFFSET” **333** of approximately 1.65V can be chosen. Generally, half the supply voltage or operating voltage **201** can be used as the offset voltage **333**. The offset unit **330** can be arranged between the reference potential **202** and the reference resistor **304** such that a modified reference potential **332**, which corresponds to the reference potential **202** shifted by the offset voltage **333**, can be provided at the connection point **331** between the reference resistor **304** and the offset unit **330**. The output voltage **320** can be provided relative to the modified reference potential **332**.

(31) The isolation resistors “R1” **212** and “R3” **222** constitute the resistors which reach over the isolation barrier between the voltage reference systems **231**, **232**. These resistors are preferably designed in such a way that the isolation resistors **212**, **222** do not impair the characteristics of the isolation between the voltage reference systems “A” **231** and “B” **232**. For this purpose, the resistance values of the isolation resistors **212**, **222** typically do not fall below a known minimum resistance value. Alternatively or in addition, the isolation resistors **212**, **222** preferably comply with a known standard and/or each consist of a plurality of resistor elements connected in series.

(32) The differential measurement principle of the measuring apparatus **110** allows virtually any resistance value of “R1” **212** and “R3” **222** to be chosen. The two voltage reference systems “A” **231** and “B” **232** can therefore be separated from one another at very high impedance such that isolation therebetween is not impaired. The output voltage “U.sub.A” **320** of the measuring apparatus **110** from FIG. 3B can be ascertained by the following formula:

$$(33) U_A = \frac{R_2^2}{R_1} * (-U_{E\_diff}).$$

(34) FIGS. 3B and 3C show no components for filtering the measurement signal (i.e. the output voltage **320**) and/or for protecting the circuitry but these components can be added as required (without changing the basic functionality of the circuit **110** and the measurement of voltages over an isolation barrier).

(35) FIG. 4A illustrates the application of the measuring apparatus **110** for measuring the grid voltage in a household appliance **100**. The terminals “E1” **211** and “E2” **221** can be connected to the two terminals “PHASE” and “NEUTRAL” of the electricity supply grid. For safety reasons, the isolation resistors “R1” and “R3” **212**, **222** can each be implemented by two resistors connected in series (“R1” comprising “R1\_1” and “R1\_2”, and “R3” comprising “R3\_1” and “R3\_2”). The resistance value should be chosen to be high enough to maintain the isolation barrier. The output voltage “U.sub.ADC” **340** at the point “ADC” **305** (relative to the reference potential **202**) constitutes the divided, measured grid voltage provided with an offset “U.sub.OFFSET” **333**. The zero point is located at the voltage value “U.sub.OFFSET”. It is therefore possible to measure both polarities of the input voltage, in this case of the grid voltage, without having to measure a negative voltage with an analog-to-digital converter (ADC). The grid voltage “U.sub.Netz” can be calculated from the measured voltage “U.sub.ADC” **340** using the following formula:

$$(36) U_{Net} = \frac{R_1}{R_2} * (U_{OFFSET} - U_{ADC}).$$

(37) A further application is the detection of the zero crossing of the grid voltage, such as illustrated by way of example in FIG. 4B. The detection of the zero crossing can be used, for example, for the grid-voltage-synchronous switching of actuators in a household appliance **100**. The measurement of the grid frequency as clock is a further application of such a zero-crossing detection.

(38) In order to detect a zero crossing, the polarity of the output voltage “U.sub.A” of the operational amplifier **310** can be evaluated. A comparator **410** can be used for this purpose. The comparator **410** converts the polarity of the signal into a digital signal having the two states high and low. This output signal of the comparator **410** can then be tapped at the output point **405** of the comparator **410**. The state of the signal at the output point **405** therefore indicates the respectively present polarity of the grid voltage. A change in the state of the signal at the output point **405** therefore corresponds to a zero crossing of the grid voltage “U.sub.Netz”.

(39) The measuring apparatus **110** described in this document has a relatively low component expenditure and space requirement. Furthermore, it is sufficient to measure a single voltage and so only one single analog-to-digital converter input is required. In addition, the output impedance of the circuit **110** is relatively low on account of the operational amplifier **310**, which allows relatively fast sampling of the measured voltage. The measuring apparatus **110** allows grid voltage measurement and/or zero-crossing detection in appliances **100** in which no grid-potential-related measurement circuit is provided or possible.

(40) The measuring apparatus **110** primarily has passive components in the form of resistors such that interference influences can be effectively calculated and compensated for by component tolerances. In a first approximation, the components have linear behavior, which allows simple calibration of the circuit **110** during the manufacturing process.

(41) The present invention is not limited to the exemplary embodiments shown. In particular, it should be noted that the description and the figures are only intended to illustrate the principle of the proposed measuring apparatus.

## Claims

1. A household appliance, comprising: a grid connection for connecting the household appliance to an AC supply voltage; a measuring apparatus for ascertaining measurement information relating to an input voltage, said measuring apparatus including: an operational amplifier having a first input, a second input, and an output for providing the measurement information; a first input node for coupling to a first pole of the input voltage; a first isolation resistor connecting said first input node to said first input of said operational amplifier; a second input node for coupling to a second pole of the input voltage; a second isolation resistor connecting said second input node to said second input of said operational amplifier; a feedback resistor connecting said output of said operational amplifier to said first input of said operational amplifier; a reference resistor connecting said second input of said operational amplifier to a reference potential; an analog-to-digital converter configured to convert an output voltage at said output of said operational amplifier or a voltage derived therefrom into a digital measurement voltage; and a processor configured to use the digital measurement voltage as a basis for: ascertaining, as the measurement information, a measurement value for the input voltage; detecting a change in polarity and/or a zero crossing of the input voltage; and/or ascertaining a frequency of the input voltage; said measuring apparatus configured to use the AC supply voltage as a basis for ascertaining the measurement information relating to the AC supply voltage; and a controller configured to operate a function of the household appliance depending on the measurement information.
2. The measuring apparatus household appliance according to claim 1, wherein said first isolation resistor and said second isolation resistor each have a resistance value such that said first isolation resistor and said second isolation resistor achieve galvanic isolation with a leakage current which is less than a predefined leakage current threshold value.
3. The household appliance according to claim 1, wherein: the input voltage is part of a first voltage reference system; and/or an operating voltage and/or the reference potential for operating said operational amplifier are part of a second voltage reference system.
4. The household appliance according to claim 1, wherein said first isolation resistor and/or said second isolation resistor each have a plurality of resistor elements disposed in series.
5. The household appliance according to claim 1, wherein: resistance values of said first isolation resistor and of said second isolation resistor being identical or deviating from one another by no more than 5%; and/or resistance values of said feedback resistor and of said reference resistor being identical or deviating from one another by no more than 5%.
6. The household appliance according to claim 1, further comprising an offset unit configured to shift the reference potential by an offset voltage to generate a modified reference potential; and

wherein said reference resistor connecting said second input of said operational amplifier to the modified reference potential.

7. The household appliance according to claim 6, wherein: the input voltage has different polarities at different times; and the offset voltage is so high that: a differential voltage between said first input and said second input of said operational amplifier has a uniform polarity at each of the different times; and/or an output voltage at said output of said operational amplifier has a uniform polarity at each of the different times.

8. The household appliance according to claim 6, wherein: said operational amplifier is operated between an operating voltage and the reference potential; and the offset voltage corresponds to half of a voltage difference between the operating voltage and the reference potential, or deviating by no more than 5% therefrom.

9. The household appliance according to claim 6, wherein: an output voltage at said output of said operational amplifier assuming values from a possible voltage range, and/or from measuring and/or from evaluation electronics downstream of said operational amplifier and configured to measure measurement values from the possible voltage range; and the offset voltage corresponding to half of the possible voltage range.

10. The household appliance according to claim 1, wherein: the measuring apparatus is configured to provide, as the measurement information at said output of said operational amplifier, an output voltage as a measurement of the input voltage; and the output voltage corresponding to a scaled and/or shifted version of the input voltage.

11. The household appliance according to claim 10, wherein: the input voltage has an amplitude of at least 100V; and the output voltage has an amplitude of 50V or less.

12. The household appliance according to claim 1, further comprising a comparator configured to compare an output voltage at said output of said operational amplifier with a comparison potential derived from the reference potential.

13. The household appliance according to claim 12, wherein: said comparator is configured to indicate a change in polarity and/or a zero crossing of the input voltage as an output signal of said comparator; said operational amplifier and said comparator are operated between an operating voltage and the reference potential or between a positive and a negative operating voltage; and the comparison potential being a modified reference potential which corresponds to the reference potential shifted by an offset voltage.

14. The household appliance according to claim 3, wherein: the first voltage reference system is an electricity supply grid or of an intermediate circuit of an electrical appliance; and/or the second voltage reference system is a safety extra low voltage, or a protective extra low voltage of a voltage reference system.

15. The household appliance according to claim 1, wherein the digital measurement voltage is a basis for a measurement value for an amplitude or an entire signal form of the input voltage.

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