Description

This invention relates to methods and devices for measuring the impedance of batteries and battery components.

Secondary batteries in stationary applications are used at electric generating stations, substations, and industrial plants to perform the vital functions of circuit breaker tripping and automatic switching, to provide for the orderly shutdown of generating units in an emergency, including the starting of emergency diesel-generators, and to power other similar tasks. Applications requiring a longer-term delivery of battery energy include emergency lighting for plants and hospitals, and supplying uninterrupted power for computer and communication equipment. Batteries must be ready to deliver their stored energy on demand to accomplish these tasks. Although batteries are reliable, a failure to supply the required energy would often result in serious consequences.

Battery systems used for these applications are often made up of individual, series-connected cells; electric utility installations generally consist of 24, 60, or 120 individual 2-volt cells connected together to provide 48, 120, or 240 VDC. The normal, steady-state load of sensors, indicating lights, relay coils, and electronic apparatus is supplied by a charger connected to the battery terminals. The charger also maintains the battery in a fully-charged state (i.e., electrolyte specific gravity of 1.230 for a typical lead-acid battery). This is known as float-charge operation. The normal load supplied by these batteries is complex, and varies with time. It is often not possible to disconnect these loads for test purposes without interrupting the main circuits they control.

The battery terminal voltage or the specific gravity of each cell making up a battery are indicators which have been used to determine battery state-of-charge. It is standard industry practice to take periodic specific gravity measurements and to conduct visual and other checks. However, specific gravity readings do not entirely indicate a battery's ability to supply power. For example, the specific gravity of each cell in a battery may indicate a fully-charged ready state, but a high impedance in one intercell connection can prevent the battery from functioning as intended.

Load discharge tests can be used to prove a battery's ability to perform. A discharge test is specified by the Nuclear Regulatory Commission (NRC) Regulations 0123 (BWR) and 0452 (PWR) for each critical battery of a nuclear generating unit. The test must be performed each time a unit is refueled. Each discharge reduces the remaining service life of a battery and may cause deterioration which can impair the battery's ability to function next time in an on-line situation. A load discharge test may indicate trouble, but it will often not locate it.

It is important to have an in-service indication that a battery is able to deliver its stored electrochemical energy when required, and also a means for locating an abnormal condition while the battery remains in service. Routine visual inspections, specific gravity readings, voltage readings, and periodic equalizing charge are all used to keep the battery ready to perform. Measurement and testing devices have been developed for relatively simple systems which give indications of a battery's ability to deliver its stored energy.

One example described in U.S. Patent No. 3,873,911 to Champlin utilizes an AC method at 100 Hz and low current (milliamperes) to obtain a measurement of what the patent defines as dynamic resistance. Dynamic resistance as defined by Champlin is inversely proportional to the dynamic power -- an indicator of the battery's condition and state-of-charge. The disclosed method is primarily designed for testing a single automotive battery. In the disclosed Champlin system the battery to be tested is isolated from any external electrical load since a determination of the dynamic resistance/power is dependent on a measurement made using the battery's own open-circuit voltage. For this reason, any significant load on the battery during the test can distort the measurement.

U.S. Patent No. 3,676,770 to Sharaf describes a system for indicating the charge remaining in a battery, specifically a battery for a fork lift truck, while the battery is supplying a load. For the first 75% of the battery's energy discharge, the charge level is indicated by an expanded-scale voltmeter. This measurement is used due to low initial values of battery resistance. For the remaining 25% of the charge, the battery's internal resistance increases sufficiently so that it can be compared to a reference resistance. The measurement system uses short-duration pulses of voltage or current spaced seconds apart and is powered by the battery. Typical stationary batteries on float-charge service are characterized by lower resistance and larger capacitance than those typically encountered in fork lift truck batteries. These differences reduce the reliability of measurements made in the manner described by Sharaf. Also, the charging system normally used in stationary applications produces a ripple current that contains harmonics which interact with the additional capacitance of connected cables and filters. Such additional capacitance can distort pulses, introduce spurious signals and noise, and interfere with the use of pulse timing to measure low values of battery resistance.

Another example is described by U.S. Patent No. 3,753,094 to Furuishi which utilizes a 100 Hz AC signal at low current to measure battery internal impedance. The Furuishi patent, like the Champlin patent, provides no suggestion as to how to measure the resistance of a battery which is simultaneously connected to an active load and a battery charger.

Rather, Furuishi discloses the use of blocking capacitors to prevent a flow of direct current from the battery. The object of the Furuishi device is to provide a means for checking the impedance and hence quality of a battery during the manufacturing process.

Any system that measures battery impedance must contend with the cell-to-cell variations of this characteristic. Each individual cell in a battery has a unique electrical impedance caused by manufacturing variations. For critical applications, individual cell impedances are measured when manufactured and those which closely match are selected for a battery. Normally, individual cell impedances fall within a relatively narrow range of values. This variation in individual cell impedance makes it desirable to secure a "signature" initial value of cell impedance and later to use this value to detect changes. The impedance of the entire battery varies with the sum of individual cell impedances and can be treated in a similar manner. During the service life of an individual cell, its impedance may increase, but the overall change in battery impedance may be quite small. Impedance changes may be due to reduction in charge state or may indicate a developing defect which could impair battery performance.

In measuring the impedance of a stationary secondary battery, the measuring system must contend with large capacitance values. In their September, 1959 IEEE paper entitled "Battery Impedance: Farads, Milliohms, Microhenrys", Willinganz and Rohner report that the apparent capacitance values range from 1 farad to several hundred farads, depending on battery size and test frequency. The resistance will be 0.1 to 10 milliohms, while the inductance will be less than 0.1 microhenry. It is important to consider the magnitude of these quantities when using impedance changes to determine battery condition.

US4433294 (Windebank) discloses a battery monitor comprising:

a) an AC signal generator adapted to generate an AC signal at a selected frequency;

b) means for applying the AC signal across a first pair of contacts of a battery; and

c) means for determining first and second ohms-law related parameters indicative of impedance across a second pair of contacts of the battery, said determining means comprising first means for supplying a first input signal indicative of the first ohms-law related parameter

It is an object of the present invention to locate a defect in an individual cell of a multicell secondary storage battery, including during periods when the battery is on float charge and connected to an active electrical load.

It is another object of the present invention to locate electrical connections external to the individual cells that have impedances much greater than the statistical norm, including during periods when the battery is on float charge and connected to an active electrical load.

It is still a further object of the invention to provide a test apparatus and procedure for determining and predicting a secondary storage battery's ability to supply power to a load, including during test periods when the storage battery is on float charge and connected to an active load.

According to a first aspect of the invention there is provided a battery monitor comprising:

a) an AC signal generator adapted to generate an AC signal at a selected frequency;

b) means for applying the AC signal across a first pair of contacts of a battery;

c) means for determining first and second Ohms-law-related parameters indicative of impedance across a second pair of contacts of the battery, said determining means comprising first means for supplying a first input signal indicative of the first Ohms-law-related parameters, the battery monitor being characterized in that said determining means further comprises first filter means coupled to the first supplying means for passing components of the first input signal at the selected frequency and for attenuating at least components of the first input signal in a first attenuation frequency range greater than the selected frequency, said first filter means operating to generate a first filtered output signal; and

first means for measuring said first filtered output signal to determine said first Ohms-law-related parameter.

In the embodiments described below, the two Ohms-law-related parameters are current and voltage, but in alternative embodiments other parameters, such as dissipated power across a resistor, may well be substituted.

This invention is particularly useful in monitoring the condition of a battery while the battery is connected both to a battery charger and to an active electrical load. Typically, such a charger and active load will cause AC currents to flow through the battery at a number of characteristic frequencies, such as harmonics and subharmonics of the AC source which powers the charger. Preferably, the selected frequency of the AC signal generator is spaced from these characteristic frequencies, and the filter operates to block the characteristic frequencies while passing the selected frequency. In this way, the measurement of the Ohms-law-related parameter is made substantially independent of currents in the battery resulting from the charger and the active load.

A further object of the present invention is to detect changes in the overall impedance of a multicell secondary storage battery, including the intercell connectors, by the continuous measurement and monitoring of the terminal to terminal impedance while the battery is float charged and connected to an active

load.

According to a second aspect of the present invention there is provided a method for comparing the impedance of a plurality of components of a battery while said battery is electrically connected to a charger and an active load, said battery comprising a pair of battery output terminals and a plurality of cells electrically connected between the battery output terminals each of said components comprising a pair of electrical contacts, said method comprising the steps of:

a) passing an AC current of a known magnitude through the battery across the battery output terminals, said AC current having a selected frequency, characterized in that the method includes the following steps:

b) obtaining a first voltage signal indicative of the AC voltage across the pair of electrical contacts of a first one of the components;

c) passing the first voltage signal through a filter operative to pass components of the first voltage signal at the selected frequency and to attenuate components of the first voltage signal in an attenuation frequency range which includes frequencies greater than the selected frequency;

d) measuring the first voltage signal as filtered in step (c) to obtain a first voltage measurement;

e) combining the first voltage measurement with the known magnitude of the current to obtain a first impedance value;

f) repeating steps (b) through (e) with a second voltage signal indicative of the AC voltage across the pair of electrical contacts of a second one of the components to obtain a second impedance value; and

g) comparing the first and second impedance values.

This method allows the impedance of individual components of the battery to be measured and assessed while the battery is connected to both a charger and an active load. As with the apparatus of this invention, the use of a filter which passes signals at the selected frequency of the AC current and attenuates other frequencies allows an accurate measurement to be obtained without removing the battery from service.

The invention itself, together with further objects and attendant advantages, will best be understood by reference to the following detailed description, taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

FIGURE 1 is a schematic circuit diagram of a first presently preferred embodiment of the battery condition monitor of this invention, which measures and continuously monitors the impedance of a multicell secondary storage battery, terminal-to-terminal.

FIGURE 1a is a schematic circuit diagram of the capacitor and switching circuit of Figure 1.

FIGURE 2 is a schematic circuit diagram of a second preferred embodiment of the battery condition monitor of this invention, which utilizes a computer to calculate and record battery impedance automatically.

FIGURE 3 is a schematic circuit diagram of a third preferred embodiment which can be used as a diagnostic tool to measure the impedance of individual battery components.

FIGURE 4 is a partial perspective view of the battery diagnostic tool of Figure 3 connected to measure the overall impedance of a battery cell.

FIGURE 5 is a partial perspective view of the battery diagnostic tool of Figure 3 connected to measure the impedance of a single electrical connection of an intercell connector.

DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EMBODIMENTS

The preferred embodiments described below are designed for use in two modes of operation. The first mode is that of a battery condition monitor used to monitor the impedance of a multicell secondary battery continuously in order to measure its ability to deliver stored energy to a connected load, and also to give a warning of developing trouble. The second mode is that of a diagnostic tool used to determine the location of a high impedance individual cell or intercell connection of the battery. In both modes of operation, the battery under test preferably remains connected to a battery charger which continues to supply the normal electrical load and to maintain the battery at float charge level. All of the embodiments described below utilize an AC signal generator having a specially selected frequency for measuring the impedance of the battery and its components.

The embodiments of Figures 1 and 2 operate as a battery condition monitor to measure and display the battery impedance at all times while the battery is on float charge and connected to an active load. Typically, a 2% increase in total battery impedance may signal developing trouble, and further testing of individual cells and connections of the battery should be performed to determine the cause of any such increase in total battery impedance.

Referring to Figure 1, the first preferred embodiment of this invention is used the measure the total impedance of a battery 6 while it is connected in circuit with a battery charger 4 and an active electrical load 8. The charger 4 is powered by an AC supply source (not shown) which typically operates at either 60 or 50 Hz. For this reason, the DC current supplied by the charger 4 will typically have a ripple current component which often ranges between 3 and 5% of the amplitude of the DC voltage. This ripple current

component of the voltage supplied by the charger 4 is largely distributed at harmonics and subharmonics of the fundamental frequency of the AC supply source. The load 8, depending upon its particular electrical characteristics, can create further AC components on the voltage placed across the battery 6 by the charger 4. For example, commonly utilized frequencies such as 400 or 1000 Hz may often be associated with the electrical load 8. In the circuit of Figure 1, the charger is both supplying current to the electrical load 8, as well as maintaining the battery 6 in a float charge condition.

The embodiment of Figure 1 includes an AC sine wave generator 2 which generates an AC signal that is supplied across the battery 6 via a capacitor and switching circuit 10. In this embodiment, the amperage of this AC signal is regulated by the AC generator 2 to preferably within 0.5% of the desired value. Furthermore, the frequency of the signal supplied by the AC generator 2 is held constant, in this embodiment at 25 Hz. Because the battery 6 presents an extremely low impedance path as compared to that of the charger 4 and the load 8, a large majority of the current supplied by the AC generator 2 flows through the battery 6. For this reason, any measurement of the voltage across the battery 6 at the frequency of the generator 2 is consistently proportional to the impedance of the battery 6.

Figure 1b shows a detailed schematic diagram of the capacitor and switching circuit 10 of Figure 1a. This circuit 10 includes first and second inputs 12,14 and first and second outputs 16,18. The first and second inputs 12,14 receive the AC signal generated by the AC generator 2, and the first and second outputs 16,18 are connected across the output terminals of the battery 6.

The circuit 10 includes first and second switches 20,22. The common pole of the first switch 20 is connected via a fuse 24 with the first output 16, and the common pole of the second switch 22 is connected via the series combination of a second fuse 26 and a capacitor 28 with the second output 18. A neon bulb 30 is connected in parallel across the capacitor 28.

When the switches 20,22 are in the central position shown in Figure 1b, the inputs 12,14 are isolated from the outputs 16,18, and the outputs 16,18 are isolated from each other. When the switches 20,22 are moved to a first position (to the right as shown in Figure 1a) the first and second outputs 16,18 are interconnected via a resistor 32, the capacitor 28, and the fuses 24,26. When the switches 20,22 are moved to a second position (to the left as shown in Figure 1b), the first input 12 is interconnected with the first output 16 via the first fuse 24, and the second input 14 is interconnected with the second output 18 via the capacitor 28 and the second fuse 26.

From the foregoing description it should be apparent that the AC generator 2 and the capacitor and switching circuit 10 can be used to pass an AC signal of a regulated amplitude and a known frequency through the battery 16.

The embodiment of Figure 1 includes an ammeter 34 which operates to measure the amperage of the AC signal supplied by the AC generator 2. This ammeter 34 includes a shunt resistor 36 interconnected between the second input 14 of the circuit 10 and the AC generator 2. The voltage drop across this shunt resistor 36 is amplified by an amplifier 38, and the resulting signal is supplied as an input to a bandpass filter 40. This bandpass filter 40 is tuned to the same frequency as that of the AC generator 2, and it operates to pass signals at the selected frequency while blocking signals having frequencies either above or below the selected frequency. The amplitude of the resulting filtered signal is then measured with a meter 42.

The embodiment of Figure 1 also includes a voltmeter 44 connected to measure the voltage across the first and second outputs 16,18. This voltmeter 44 includes an amplifier 46, a filter 48, and a meter 50 which operate similarly to the corresponding components of the ammeter 34.

The following information is provided merely by way of example in order better to define the best mode of this invention. The AC generator 2 of Figure 1 can be implemented with a wide variety of circuits. The power frequency converter supplied by Diego Power (San Diego, California) as Model 1011-9 has been found to be suitable. In this embodiment, the AC generator 2 is adjusted to supply a current of 1 amp at a frequency of 25 Hz. The capacitor 28 in this embodiment is preferably a 6000 microfarad capacitor rated for a working voltage of 300 VDC. The fuses 24,26 in this embodiment are 10 amp fuses, and the resistor 32 is a 10 K Ohms, 12 watt resistor. In this embodiment the shunt 38 is preferably a 50 amp, 50 millivolt shunt, and the amplifier 38, filter 40, and meter 42 can be obtained as a single unit identified by General Radio of Concord, Mass., as Model No. 1564. General Radio Model No. 1564 can also be used for the amplifier 46, the filter 48 and the meter 50. Preferably, the filters 40,48 are both centered at 25 Hz in this embodiment, and the filters 40,48 provide more than 40 dB attenuation for all frequencies below 12.5 Hz or greater than 50 Hz. The amplifiers 38,46 should of course be capable of withstanding the DC voltage of the battery 6.

The frequency distribution of harmonic signal components normally present in the charger-load combination should be considered carefully when selecting the frequency of the generator 2 and the filters 40,48. This is because the amplitude of such harmonic components typically varies in time. For this reason, any harmonic components flowing through the battery 6 and having a frequency close to that of the generator 2 will contribute to errors in the impedance measurement.

In this embodiment the frequency of the AC current supplied by the generator 2 has been selected to avoid harmonics or subharmonics originating in the output of the charger 4, and also those frequencies which are commonly used in the electrical load 8, such as 400 and 1000 Hz. The frequency of the AC generator 2 for any particular charger-load combination can be selected after first analyzing the power spectrum of the voltage across the battery 6. The AC generator 2 should then be tuned to operate at a frequency characterized by consistently low power. In most applications, when the charger 4 is powered by a 60 Hz AC power source, a frequency of 11-14,21-29 or 91-109 Hz can be used for the AC generator 2 and the filters 40,48. At present, a frequency of 25 Hz is preferred for these applications. When the charger 4 is powered by an AC power source operating at 50 Hz, it is often preferable to set the AC generator 2 and the filters 40,48 for 30 or 120 Hz.

In this preferred embodiment the current supplied by the generator 2 to the battery 6 is preferably limited to 1 ampere to avoid undesirable effects on the battery 6, yet to provide a sufficient current to allow an accurate and precise measurement of the impedance across the battery 6. A regulated current of exactly 1 ampere has one important benefit, in that any voltage reading obtained with the voltmeter 44 will equal the impedance of the battery in Ohms. The capacitor 28 is provided to isolate the AC generator 2 from direct current supplied by the battery 6. In alternative embodiments, where the current regulation of the AC generator 2 is sufficiently reliable, the ammeter 34 can be eliminated. Preferably, the voltmeter 44 should be sufficiently accurate and sensitive to display measurements in the low millivolt range and to indicate changes of as little as 1 or 2 millivolts, which may be indicative of developing problems with the battery 6.

In operation, the embodiment of Figure 1 is used as follows. First, the switches 20,22 are placed in the central position as shown in Figure 1b, and the outputs 16,18 are connected across the output terminals of the battery 6, as shown in Figure 1a. Because the outputs 16,18 are isolated from one another and from the AC generator 2 when the switches 20,22 are in the central position, the possibility of arcing is minimized. Once the outputs 16,18 have been connected across the battery 6, the switches 20,22 are then moved to the first position (to the right as shown in Figure 1a). This establishes a current path between the outputs 16,18 through the resistor 32 and the capacitor 28, thereby charging the capacitor 28 to the working voltage of the battery 6. A sufficient charge on the capacitor 28 is indicated by the neon bulb 30. Once the capacitor 28 has been charged, the switches 20,22 can be moved to the second position (to the left as shown in Figure 1a). In this second position the AC generator 2 applies a sinusoidal AC current across the battery 6. As explained above, this current is preferably regulated at a magnitude of 1 ampere. The meter 50 of the voltmeter 44 can then be read directly to determine the impedance of the battery 6.

It is important to recognize that this impedance measurement is made while the battery 6 is interconnected with both the charger 4 and the active load 8. Because the filter 48 is tuned to the same frequency as that of the signal supplied by the AC generator 2, and because this frequency is selected to avoid characteristic frequencies in the power spectrum of the charger 4 and the load 8, a reliable measurement of battery impedance is obtained. The ammeter 34 can be used to check the amperage of the AC signal supplied by the AC generator 2 to allow adjustment of this amperage if necessary.

Figure 2 shows a schematic diagram of a second preferred embodiment of this invention which is similar in many respects to the first preferred embodiment described above. Corresponding reference numerals have been used for corresponding elements in the two embodiments. Because elements 2-50 of the two embodiments are identical, they will not be described again here. Rather, the following discussion will focus only on the differences between the two embodiments.

In the embodiment of Figure 2 the filtered signal supplied by the filter 40 to the meter 42 of the ammeter 34 is sampled and digitized by a transducer 52, and then supplied as an input to a computer 56. Similarly, the filtered signal supplied by the filter 48 to the meter 50 in the voltmeter 44 is also sampled and digitized by a transducer 54 and supplied as a second input to the computer 56. Thus, the computer is supplied with a digitized measurement of the measured AC current at the selected frequency by the transducer 52, and of the measured voltage across the battery 6 at the selected frequency by the transducer 54. The computer 56 is programmed to divide the voltage measurement by the current measurement and to print the resulting impedance value on a printer 58 on a regular basis. Thus, the computer 56 repeatedly measures and displays the impedance of the battery 6. Because the embodiment of Figure 2 divides the voltage measurement by the current measurement, it is not necessary for the AC generator to provide a regulated current as described above. Simply by way of example, the signal sampling and digitizing system marketed by Keithley as Model No. 197 can be used for the transducers 52,54.

The first and second embodiments of Figures 1 and 2 provide a substantially continuous indication of the condition of the battery 6, while the battery 6 is connected to both the charger 4 and the load 8. These embodiments may be used to supplement the standard industry practice of periodic visual and other checks of the condition of a secondary battery. These embodiments can be used to detect developing trouble in the battery 6, whether it results from increased

impedance of an individual cell, or increased impedance of an intercell connection. As described below, the third embodiment of Figure 3 can then be used to locate the particular cell or intercell connection that has resulted in an increase in battery impedance, again without requiring that the battery 6 be isolated from the charger 4 or the load 8.

Figure 3 shows the third preferred embodiment of this invention adapted to locate the particular cell or interconnection of the battery 6 characterized by a high impedance. Elements 2-50 of this preferred embodiment can be identical with the corresponding elements of the first preferred embodiment of Figure 1, and will not be described again here.

As shown in Figure 3, the battery 6 includes a plurality of individual battery cells 60a,60b...60n. Each battery cell defines two output terminals 64,66, and adjacent battery cells are interconnected by an intercell conductor 62. In the embodiment of Figure 3, the two inputs to the amplifier 46 are connected to respective probes 68,70. These probes 68,70 are preferably of the type having spring-loaded contact points which twist as they are pushed against the metal terminals. This approach assures a consistent, low resistance probe contact. Probes supplied by James G. Biddle Company of Plymouth Meeting, Pennsylvania as Model No. 241001-7 have been found suitable. Preferably, the voltmeter 44 should be adjusted to provide a fast response and settling time and should be capable of displaying values as low as 100 microvolts.

In use, the embodiment of Figure 3 operates to measure impedances having lower values than those of the entire battery 6. For this reason, it has been found preferable to increase the magnitude of the AC current supplied by the generator 2 to about 10 amperes for tests involving individual cells 60 and terminals 64,66. Impedance values of individual 2-volt cells 60 range from about typical values of about 10 milliohms for the type of battery used in many substations to about 0.3 milliohms for large batteries of the type used in stations. The impedance of battery connections is typically on the order of 10 to 200 microhms. When the amperage of the AC signal generated by the AC generator 2 is maintained at 10 amperes, voltage readings of the voltmeter 44 typically vary in the range of 3-100 millivolts for cell impedances and in the range of 0.1-2 millivolts for intercell connections. As suggested above, the current output of the generator 2 can be regulated in order to minimize calculations required to convert the reading of the voltmeter 44 to an impedance value. Alternately, an unregulated AC generator 2 can be used and the reading of the voltmeter 44 can simply be divided by the reading of the ammeter 34, either manually or automatically.

Figures 4 and 5 illustrate a method for testing the impedance of the individual cells 60 and the individual intercell connections of the battery 6. In order to measure the impedance of an individual cell 60 such as the cell 60c of Figure 4, the probes 68,70 are pushed against the terminals 64,66, respectively. Then the current and voltage measurements of the ammeter 34 and the voltmeter 44 are noted and recorded and used to determine the impedance of the cell 60c.

The impedance of the intercell connection between adjacent cells 60c,60d can then be measured simply by moving the probe 68 from the position shown in solid lines in Figure 4 to the position shown in dotted lines in Figure 4, leaving the other probe 70 in place on the terminal 66 of the cell 60c. The measured values of current and voltage as indicated by the ammeter 34 and the voltmeter 44 are then noted and recorded in order to determine the impedance of the intercell connection.

The above procedure is then repeated for each individual cell and each intercell connection. To obtain the next measurement of cell impedance, the probe 70 is moved from the terminal 66 of the cell 60c to the terminal 66 of the cell 60d. Readings are then recorded as previously described. Of course, in the event a regulated generator 2 is used, it may not be necessary to record the current measured by the ammeter 34 for each test.

Once impedances have been calculated for each individual cell 60 and each intercell connection, the arithmetic mean impedance for the cells 60 is determined along with the arithmetic mean impedance for the intercell connections. Cells or intercell connections having impedances that differ from the corresponding arithmetic mean by more than 15% should preferably be investigated further to determine the cause of the increased impedance, such a cell deterioration or intercell connection corrosion.

In the event the impedance of an intercell connection between adjacent cells is more than 15% greater than the arithmetic mean, the cause is likely to be at one or both of the electrical interconnections between the terminals 64,66 and the intercell conductor 62. Figure 5 illustrates the use of the probes 68,70 to measure the impedance of such an electrical interconnection. One of the probes 68 is placed on the corresponding terminal 64 of the cell 60 and the other of the probes 70 is placed on the intercell conductor 62. The measured impedance of any one of these electrical interconnections is then compared with identical interconnections at other cells to determine which connection is causing the measured increase in intercell impedance. Of course, other measurement procedures can be used depending upon the physical layout of the battery installation and its connections.

From the foregoing, it should be apparent that an improved apparatus and method have been described for monitoring and diagnosing the condition of a battery. In all embodiments, an AC generator is

used to generate an AC current at a selected frequency which does not correspond to any characteristic frequency of the charger-load circuit in which the battery to be tested is connected. Voltage and current measurements are then made via respective bandpass filters which are tuned to the frequency of the AC generator and which block AC signals at the characteristic frequencies of the charger-load circuit. In this way, a reliable measure of battery impedance can be obtained simply and quickly, while the battery remains connected to both the charger and the load.

In the embodiments described above, the filters 40,48 have been described as bandpass filters. It should be understood that it is not necessary in all applications that bandpass filters be used. As an alternative, in the event the frequency of the AC generator is sufficiently low, and in the event there are no significant frequencies of the charger-load circuit below the frequency of the AC generator, then a low-pass filter may be substituted for the bandpass filters described above. Of course, the particular apparatus used to measure voltage or current, the particular AC generator, and the particular structure of the capacitor and switching circuit can all be modified as appropriate for the particular application. Furthermore, it is not critical in all applications that the measured parameters correspond directly to voltage and current. Any other Ohms-law-related parameter which varies as a function of the impedance of the battery being tested, such as dissipated power across a resistance for example, can be substituted as desired.

It is therefore intended that the foregoing detailed description be regarded as illustrative rather than limiting, and that it be understood that it is the following claims, including all equivalents, which are intended to define the scope of this invention.

Claims

1. A battery monitor comprising:
a) an AC signal generator (2) adapted to generate an AC signal at a selected frequency;
b) means (10, 16, 18) for applying the AC signal across a first pair of contacts of a battery (6);
c) means (34, 44) for determining first and second Ohms-law-related parameters indicative of impedance across a second pair of contacts of the battery, said determining means comprising first means (46 or 38) for supplying a first input signal indicative of the first Ohms-law-related parameter, the battery monitor being characterized in that said determining means further comprises:

first filter means (48 or 40) coupled to the first supplying means (46 or 38) for passing components of the first input signal at the selected frequency and for attenuating at least components of the first input signal in a first attenuation frequency range greater than the selected frequency, said first filter means (46 or 38) operating to generate a first filtered output signal; and

first means (50 or 42) for measuring said first filtered output signal to determine said first Ohms-law-related parameter.

2. The invention of Claim 1 wherein a battery charger (4), and an electrical load (8) are electrically connected to said battery (6), wherein said battery charger (4) and said electrical load (8) cause AC currents in said battery (6) at a plurality of characteristic frequencies, and wherein the first attenuation frequency range includes the plurality of characteristic frequencies.

3. The invention of Claim 2 wherein the battery charger (4) and the load (8) are connected in parallel with one another across the battery (6).

4. The invention of Claims 1, 2 or 3 wherein said first and second Ohms-law-related parameters correspond to voltage and current, respectively, wherein said first input signal corresponds to voltage across said second pair of contacts, and wherein the first measuring means (50) measures the voltage of the input signal as filtered by the first filter means (48).

5. The invention of Claim 4 wherein the determining means (34, 44) regulates the second Ohms-law-related parameter to a predetermined value.

6. The invention of any one of Claims 1 to 5 wherein the determining means (34, 44) further comprises:

second means (46 or 38) for supplying a second input signal indicative of said second Ohms-law-related parameter;

second filter means (40 or 48) connected to said second supplying means (46 or 38) for passing components of the second input signal at the selected frequency and for attenuating at least components of the second input signal in a second attenuation frequency range greater than the selected frequency, said second filter means (40 or 48) operating to generate a second filtered output signal; and

second means (42 or 50) for measuring said second filtered output signal to determine said second Ohms-law-related parameter.

7. The invention of Claim 6 wherein said first and second attenuation frequency ranges are identical.

8. The invention of Claims 6 or 7 further comprising:

means (56) for automatically combining the first and second Ohms-law-related parameters to determine said impedance.

9. The invention of any one of the preceding Claims wherein the first pair of contacts is one and the same with the second pair of contacts.

10. The invention of any one of the preceding Claims wherein the battery (6) comprises a pair of output contacts (16, 18) wherein the battery (6) comprises a plurality of cells (60a to 60n), each having a

used to generate an AC current at a selected frequency which does not correspond to any characteristic frequency of the charger-load circuit in which the battery to be tested is connected. Voltage and current measurements are then made via respective bandpass filters which are tuned to the frequency of the AC generator and which block AC signals at the characteristic frequencies of the charger-load circuit. In this way, a reliable measure of battery impedance can be obtained simply and quickly, while the battery remains connected to both the charger and the load.

In the embodiments described above, the filters 40,48 have been described as bandpass filters. It should be understood that it is not necessary in all applications that bandpass filters be used. As an alternative, in the event the frequency of the AC generator is sufficiently low, and in the event there are no significant frequencies of the charger-load circuit below the frequency of the AC generator, then a low-pass filter may be substituted for the bandpass filters described above. Of course, the particular apparatus used to measure voltage or current, the particular AC generator, and the particular structure of the capacitor and switching circuit can all be modified as appropriate for the particular application. Furthermore, it is not critical in all applications that the measured parameters correspond directly to voltage and current. Any other Ohms-law-related parameter which varies as a function of the impedance of the battery being tested, such as dissipated power across a resistance for example, can be substituted as desired.

It is therefore intended that the foregoing detailed description be regarded as illustrative rather than limiting, and that it be understood that it is the following claims, including all equivalents, which are intended to define the scope of this invention.

Claims

1. A battery monitor comprising:
a) an AC signal generator (2) adapted to generate an AC signal at a selected frequency;
b) means (10, 16, 18) for applying the AC signal across a first pair of contacts of a battery (6);
c) means (34, 44) for determining first and second Ohms-law-related parameters indicative of impedance across a second pair of contacts of the battery, said determining means comprising first means (46 or 38) for supplying a first input signal indicative of the first Ohms-law-related parameter, the battery monitor being characterized in that said determining means further comprises:

first filter means (48 or 40) coupled to the first supplying means (46 or 38) for passing components of the first input signal at the selected frequency and for attenuating at least components of the first input signal in a first attenuation frequency range greater than the selected frequency, said first filter means (46 or 38) operating to generate a first filtered output signal; and

first means (50 or 42) for measuring said first filtered output signal to determine said first Ohms-law-related parameter.

2. The invention of Claim 1 wherein a battery charger (4), and an electrical load (8) are electrically connected to said battery (6), wherein said battery charger (4) and said electrical load (8) cause AC currents in said battery (6) at a plurality of characteristic frequencies, and wherein the first attenuation frequency range includes the plurality of characteristic frequencies.

3. The invention of Claim 2 wherein the battery charger (4) and the load (8) are connected in parallel with one another across the battery (6).

4. The invention of Claims 1, 2 or 3 wherein said first and second Ohms-law-related parameters correspond to voltage and current, respectively, wherein said first input signal corresponds to voltage across said second pair of contacts, and wherein the first measuring means (50) measures the voltage of the input signal as filtered by the first filter means (48).

5. The invention of Claim 4 wherein the determining means (34, 44) regulates the second Ohms-law-related parameter to a predetermined value.

6. The invention of any one of Claims 1 to 5 wherein the determining means (34, 44) further comprises:

second means (46 or 38) for supplying a second input signal indicative of said second Ohms-law-related parameter;

second filter means (40 or 48) connected to said second supplying means (46 or 38) for passing components of the second input signal at the selected frequency and for attenuating at least components of the second input signal in a second attenuation frequency range greater than the selected frequency, said second filter means (40 or 48) operating to generate a second filtered output signal; and

second means (42 or 50) for measuring said second filtered output signal to determine said second Ohms-law-related parameter.

7. The invention of Claim 6 wherein said first and second attenuation frequency ranges are identical.

8. The invention of Claims 6 or 7 further comprising:

means (56) for automatically combining the first and second Ohms-law-related parameters to determine said impedance.

9. The invention of any one of the preceding Claims wherein the first pair of contacts is one and the same with the second pair of contacts.

10. The invention of any one of the preceding Claims wherein the battery (6) comprises a pair of output contacts (16, 18) wherein the battery (6) comprises a plurality of cells (60a to 60n), each having a

pair of output contacts (64, 66), wherein the first pair of contacts corresponds to the output contacts of the battery (16, 18), and wherein the second pair of contacts corresponds to the output contacts (64, 66) of one of the cells (60a to 60n).

11. The invention of any one of the preceding Claims further comprising means (28) for blocking DC current flow through a circuit comprising the battery (6) and the AC signal generator (2).

12. The invention of any one of the preceding Claims wherein said selected frequency is in the range of 11-14 Hz.

13. The invention of any one of Claims 1 to 11 wherein said selected frequency is in the range of 21-29 Hz.

14. The invention of any one of Claims 1 to 11 wherein said selected frequency is in the range of 91-109 Hz.

15. The invention of any one of the preceding Claims wherein said first filter means (48 or 40) comprises a bandpass filter centered at the selected frequency and operative to attenuate signals having frequencies above and below the selected frequency.

16. The invention of any one of the preceding Claims wherein the AC signal is sinusoidal in waveform.

17. The invention of Claim 2 wherein said first supplying means (46) first filter means (48) and first measuring means (50) comprise an ammeter (42) coupled to said applying means (10, 16, 18) to generate a current measurement indicative of the magnitude of the AC current applied to the battery (6) at said selected frequency, said ammeter comprising:

means (30), coupled to the applying means (10, 16, 18) for developing a first input signal indicative of the magnitude of current applied to the battery (6) by the AC signal generator (2);

a first bandpass filter (40) centered on said selected frequency and operative to pass components of the first input signal at said selected frequency and to attenuate components in an attenuating range which extends above and below said selected frequency range and which includes said plurality of characteristic frequencies; and

means (42) for measuring the magnitude of the first input signal as filtered by the first bandpass filter (40); and

wherein said determining means (34, 44) further comprises a voltmeter (44) coupled to said battery (6) to generate a voltage measurement indicative of the magnitude of the AC voltage across a second pair of contacts of the battery, said voltmeter (44) comprising:

means (44), coupled to the second pair of contacts, for developing a second input signal indicative of the voltage across the second pair of contacts;

a second bandpass filter (48) centered on said selected frequency and operative to pass components of said second input signal at said selected frequency and to attenuate components in said attenuating frequency range; and

means (50) for measuring the magnitude of the second input signal as filtered by the second bandpass filter (48).

18. A method for comparing the impedance of a plurality of components (60a to 60n, 62) of a battery (6) while said battery (6) is electrically connected to a charger (4) and an active load (8), said battery (6) comprising a pair of battery output terminals (16, 18) and a plurality of cells (60a to 60n) electrically connected between the battery output terminals (16, 18), each of said components (60a to 60n, 62) comprising a pair of electrical contacts (64, 66), said method comprising the steps of:

a) passing an AC current of a known magnitude through the battery (6) across the battery output terminals (16, 18), said AC current having a selected frequency, characterized in that the method includes the following steps:

b) obtaining a first voltage signal indicative of the AC voltage across the pair of electrical contacts (64, 66) of a first one of the components (60a to 60n, 62);

c) passing the first voltage signal through a filter (48) operative to pass components of the first voltage signal at the selected frequency and to attenuate components of the first voltage signal in an attenuation frequency range which includes frequencies greater than the selected frequency;

d) measuring the first voltage signal as filtered in step (c) to obtain a first voltage measurement;

e) combining the first voltage measurement with the known magnitude of the current to obtain a first impedance value;

f) repeating steps (b) through (e) with a second voltage signal indicative of the AC voltage across the pair of electrical contacts (64, 66) of a second one of the components (60a to 60n, 62) to obtain a second impedance value; and

g) comparing the first and second impedance values.

19. The method of Claim 18 wherein each of the components (60a to 60n, 62) comprises a respective cell (60a to 60n), and wherein the first and second impedance values correspond to the impedance of the respective cells (60a to 60n).

20. The method of Claim 18 wherein each of the components (60a to 60n, 62) comprises a respective intercell conductor (62), and wherein the first and second impedance values correspond to the impedance of respective intercell connections.

21. The method of Claim 18 wherein each of the components (60a to 60n, 62) comprises a respective eletrical connection, and wherein the first and second impedance values correspond to the impedance of the respective electrical connections.

22. The method of any one of Claims 18 to 21 wherein said selected frequency is in the range of 11-14 Hz.

23. The method of any one of Claims 18 to 21 wherein said selected frequency is in the range of 21-29 Hz.

24. The method of any one of Claims 18 to 21 wherein said selected frequency is in the range of 91-109 Hz.

25. The method of any one of Claims 18 to 24 wherein the filter (48) of step (c) is a bandpass filter (48) centered at the selected frequency and wherein the attenuation frequency range extends above and below the selected frequency.

26. The method of any one of Claims 18 to 25 wherein the charger (4) and the active load (8) cause additional AC currents at characteristic frequencies to pass through the battery (6), wherein the characteristic frequencies are spaced from the selected frequency, and wherein the filter (48) of step (c) attenuates all of the characteristic frequencies.

27. The method of any one of Claims 18 to 26 wherein the AC current is sinusoidal in waveform.

Patentansprüche

1. Batterieüberwachungsgerät, enthaltend:
a) einen Wechselspannungs-Signalgenerator (2) zur Erzeugung eines Wechselspannungssignals bei einer ausgewählten Frequenz;
b) eine Einrichtung (10, 16, 18) zum belegen des Wechselspannungssignals über ein erstes Kontaktpaar einer Batterie (6);
c) eine Einrichtung (34, 44) zum Bestimmen erster und zweiter auf das Ohm'sche Gesetz bezogener Parameter, die die Impedanz über ein zweites Kontaktpaar der Batterie angeben, wobei die Bestimmungseinrichtung eine erste Einrichtung (46 oder 38) zum Abgeben eines ersten Eingangssignals, das für den ersten auf das Ohm'sche Gesetz bezogenen Parameter kennzeichnend ist, dadurch gekennzeichnet, daß die Bestimmungseinrichtung weiterhin enthält:

eine erste Filtereinrichtung (48 oder 40), die mit der ersten Zuführungseinrichtung (46 oder 38) verbunden ist, um Komponenten des ersten Eingangssignals bei der ausgewählten Frequenz durchzulassen und wenigstens Komponenten des ersten Eingangssignals in einem ersten Dämpfungsfrequenzbereich stärker zu dämpfen, als die ausgewählte Frequenz, wobei die erste Filtereinrichtung (46 ode 38) zur Erzeugung eines ersten gefilterten Ausgangssignals arbeitet; und

eine erste Einrichtung (50 oder 42) zum Messen des ersten gefilterten Ausgangssignals, um den ersten, auf das Ohm'sche Gesetz bezogenen Parameter zu bestimmen.

2. Die Erfindung von Anspruch 1, wobei ein Batterielader (4) und eine elektrische Last (8) elektrisch mit der Batterie (6) verbunden sind, wobei der Batterielader (4) und die elektrische Last (8) Wechselströme in der Batterie (6) bei mehreren charakteristischen Frequenzen verursachen, und wobei der erste Dämpfungsfrequenzbereich die Vielzahl charakteristischer Frequenzen enthält.

3. Die Erfindung von Anspruch 2, wobei der Batterielader (4) und die Last (8) parallel zueinander über die Batterie (69 geschaltet sind.

4. Die Erfindung der Ansprüche 1, 2 oder 3, bei der die ersten und zweiten auf das Ohm'sche Gesetz bezogenen Parameter der Spannung bzw. dem Strom entsprechen, wobei das erste Eingangssignal der Spannung über dem zweiten Kontaktpaar entspricht und die erste Meßeinrichtung (50) die Spannung des Eingangssignals, wie von der ersten Filtereinrichtung (48) gefiltert, mißt.

5. Die Erfindung von Anspruch 4, bei der die Bestimmungseinrichtung (34, 44) den zweiten auf das Ohm'sche Gesetz bezogenen Parameter auf einen vorbestimmten Wert regelt.

6. Die Erfindung nach einem der Ansprüche 1 bis 5, bei der die Bestimmungseinrichtung (234, 44) weiter enthält:

eine zweite Einrichtung (46 oder 38) zum Abgeben eines zweiten Eingangssignals, das für den zweiten auf das Ohm'sche Gesetz bezogenen Parameter kennzeichnend ist;

eine zweite Filtereinrichtung (40 oder 48), die mit der zweiten Zuführungseinrichtung (46 oder 38) verbunden ist, um Frequenzen des zweiten Eingangssignals bei der ausgewählten Frequenz durchzulassen und wenigstens Komponenten des zweiten Eingangssignals in einem zweiten Dämpfungsfrequenzbereich stärker als die ausgewählte Frequenz zu dämpfen, wobei die zweite Filtereinrichtung (40 oder 48) zur Erzeugung eines zweiten gefilterten Ausgangssignals arbeitet; und

eine zweite Einrichtung (42 oder 50) zum Messen des zweiten gefilterten Ausgangssignals zur Bestimmung des zweiten auf das Ohm'sche Gesetz bezogenen Parameters.

7. Die Erfindung von Anspruch 6, bei der die ersten und zweiten Dämpfungsfrequenzbereiche identisch sind.

8. Die Erfindung der Ansprüche 6 oder 7, weiterhin enthaltend

eine Einrichtung (56) zum automatischen Kombinieren der ersten und zweiten auf das Ohm'sche Gesetz bezogenen Paramter zur Bestimmung der Impedanz.

9. Die Erfindung nach einem der vorhergehenden Ansprüche, bei der das erste Kontaktpaar und das zweite Kontaktpaar ein und dasselbe ist.

10. Die Erfindung nach einem der vorhergehenden Ansprüche, bei der die Batterie (6) ein Paar Aus-

gangskontakte (6, 18) aufweist, wobei die Batterie (6) mehrere Zellen (60a - 60n) enthält, die jeweils ein Ausgangskontaktpaar (64, 66) aufweisen, wobei das erste Kontaktpaar den Ausgangskontakten der Batterie (16, 18) entspricht und das zweite Kontaktpaar den Ausgangskontakten (64, 66) einer der Zellen (60a bis 60n) entspricht.

11. Die Erfindung nach einem der vorhergehenden Ansprüche, weiterhin enthaltend eine Einrichtung (28) zum Blockieren eines Gleichstrom durch eine Schaltung, die die Batterie (6) und den Wechselspannungssignalgenerator (2) enthält.

12. Die Erfindung nach einem der vorhergehenden Ansprüche, bei der die ausgewählte Frequenz im Bereich zwischen 11 und 14 Hz liegt.

13. Die Erfindung nach einem der Ansprüche 1 bis 11, bei der die ausgewählte Frequenz im Bereich von 21 bis 29 Hz liegt.

14. Die Erfindung nach einem der Ansprüche 1 bis 11, bei der die ausgewählte Frequenz im Bereich von 91 bis 109 Hz liegt.

15. Die Erfindung nach einem der vorhergehenden Ansprüche, bei der die erste Filtereinrichtung (48 oder 40) ein Bandpaßfilter enthält, dessen Mittenfrequenz auf der ausgewählten Frequenz liegt und das dazu dient, Signale zu dämpfen, die Frequenzen oberhalb und unterhalb der ausgewählten Frequenz haben.

16. Die Erfindung nach einem der vorhergehenden Ansprüche, bei der das Wechselspannungssignal sinusförmig ist.

17. Die Erfindung nach Anspruch 2, bei der die erste Zuführeinrichtung (46), die erste Filtereinrichtung (48) und die erste Meßeinrichtung (50) ein Ampèremeter (42) enthalten, das mit der Anlegeeinrichtung (10, 16, 18) verbunden ist, um eine Strommessung zu erzeugen, die für die Stärke des an die Batterie (6) bei der augewählten Frequenz angelegten Wechselstroms kennzeichnend ist, enthaltend:

eine Einrichtung (30), die mit der Anlegeeinrichtung (10, 16, 18) verbunden ist, um ein erstes Eingangssignal zu entwickeln, das für die Stärke des von dem Wechselspannungssignalgenerator (2) an die Batterie (6) angelegten Stroms kennzeichnend ist;

ein erstes Bandpaßfilter(40), dessen Mittenfrequenz in der ausgewählten Frequenz liegt und dazu dient, Komponenten des ersten Eingangssignals bei der ausgewählten Frequenz durchzulassen und Komponenten in einem Dämpfungsbereich zu dämpfen, der sich oberhalb und unterhalb des ausgewählten Frequenzbereichs erstreckt und das mehrere charakteristische Frequenzen aufweist; und

eine Einrichtung (42) zum Messen der Stärke des ersten Eingangssignals, wie durch das erste Bandpaßfilter (40) gefiltert; und

wobei die Bestimmungseinrichtung (34, 44) weiterhin ein Voltmeter (44) enthält, das mit der Batterie (6) verbunden ist, um eine Spannungsmessung zu erzeugen, die für die Stärke der Wechselspannung über einem zweiten Kontaktpaar der Batterie kennzeichnend ist, enthaltend:

eine Einrichtung (44), die mit dem zweiten Kontaktpaar verbunden ist, um eine zweites Eingangssignal zu entwickeln, das für die Spannung über dem zweiten Kontaktpaar kennzeichnend ist;

ein zweites Bandpaßfilter (48), dessen Mittenfrequenz in der ausgewählten Frequenz liegt und dazu dient, Komponenten des zweiten Eingangssignals bei der ausgewählten Frequenz durchzulassen, und Komponenten in dem Dämpfungsfrequenzbereich zu dämpfen; und

eine Einrichtung (50) zum Messen der Stärke des zweiten Eingangssignals, wie durch das zweite Bandpaßfilter (48) gefiltert.

18. Verfahren zum Vergleichen der Impedanz mehrerer Komponenten (60a bis 60n, 62) einer Batterie (6), während die Batterie (6) elektrisch mit einem Lader (4) und einer aktiven Last (8) verbunden ist, wobei die Batterie (6) ein Paar Batterieausgangsanschlüsse (16, 18) und mehrere Zellen (60a bis 60n) aufweist, die elektrisch zwischen die Batterieausgangsanschlüsse (16, 18) geschaltet sind, wobei jede der Komponenten (60a bis 60n, 62) ein Paar elektrischer Kontakte (64, 66) aufweist, enthaltend die folgenden Schritte

a) Durchleiten eines Wechselstroms bekannter Amplitude durch die Batterie (6) über die Batterieausgangsanschlüsse (16, 18), wobei der Wechselstrom eine ausgewählte Frequenz aufweist, dadurch gekennzeichnet, daß das Verfahren die folgenden Schritte umfaßt:

b) Erhalten eines ersten Spannungssignals, das für die Wechselspannung über das Paar elektrischer Kontakte (64, 66) einer ersten der Komponenten (60a bis 60n, 62) kennzeichnend ist;

c) Durchleiten des ersten Spannungssignals durch ein Filter (48), das dazu dient, Komponenten des ersten Spannungssignals bei der ausgewählten Frequenz durchzulassen und Komponenten des ersten Spannungssignals in einem Dämpfungsfrequenzbereich, der Frequenzen gröber als die ausgewählte Frequenz umfaßt, zu dämpfen;

d) Messen des ersten Spannungssignals, wie es im Schritt (c) gefiltert wurde, um eine erste Spannungsmessung zu erhalten;

e) Kombinieren der ersten Spannungsmessung mit der bekannten Amplitude des Stroms, um einen ersten Impedanzwert zu erhalten;

f) Wiederholen der Schritte (b) bis (e) mit einem zweiten Spannungssignal, das für die Wechselspannung über das Paar elektrischer Kontakte (64, 66) einer zweiten der Komponenten (60a bis 60n, 62) kennzeichnend ist, um einen zweiten Spannungswert zu erhalten; und

g) Vergleichen der ersten und zweiten Impedan-

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zwert.

19. Verfahren nach Anspruch 18, bei dem jede der Komponenten (60a bis 60n, 62) eine entsprechende Zelle (60a bis 60n) enthält, und wobei die ersten und zweiten Impedanzwerte der Impedanz der jeweiligen Zellen (60a bis 60n) entspricht.

20. Verfahren nach Anspruch 18, bei dem jede der Komponenten (60a bis 60n, 62) einen entsprechenden Leiter (62) zwischen den Zellen enthält und wobei die ersten und zweiten Impedanzwerte der Impedanz der jeweiligen Verbindungen zwischen den Zellen entsprechen.

21. Verfahren nach Anspruch 18, bei dem jede der Komponenten (60a bis 60n, 62) eine jeweilige elektrische Verbindung enthält und wobei die ersten und zweiten Impedanzwerte der Impedanz der jeweiligen elektrischen Verbindung entsprechen.

22. Verfahren nach einem der Ansprüche 18 bis 21, bei dem die ausgewählte Frequenz im Bereich von 11 bis 14 Hz liegt.

23. Verfahren nach einem der Ansprüche 18 bis 21, bei dem die ausgeäwhlte Frequenz im Bereich von 21 bis 29 Hz liegt.

24. Verfahren nach einem der Ansprüche 18 bis 21, bei dem die ausgewählte Frequenz im bereich von 91 bis 109 Hz liegt.

25. Verfahren nach einem der Ansprüche 18 bis 24, bei dem das Filter (48) vom Schritt (c) ein Bandpaßfilter (48) ist, dessen Mittenfrequenz auf der ausgesuchten Frequenz liegt und wobei der Dämpfungsfrequenzbereich sich oberhalb und unterhalb der ausgewählten Frequenz erstreckt.

26. Verfahren nach einem der Ansprüche 18 bis 25, bei dem der Lader (4) und die aktive Last (8) das Hindurchleiten von zusätzlichen Strömen bei charakteristischen Frequenzen durch die Batterie (6) bewirken, wobei die charakteristischen Frequenzen von der ausgewählten Frequenz Abstand haben und das Filter (48) vom Schritt (c) alle charakteristischen Frequenzen dämpft.

27. Verfahren nach einem der Ansprüche 18 bis 26, bei dem der Wechselstrom sinusförmig ist.

Revendications

1. Appareil de contrôle de batterie comprenant :
a) un générateur (2) de signaux alternatifs destiné à créer un signal alternatif à une fréquence choisie,
b) un dispositif (10, 16, 18) destiné à appliquer un signal alternatif à une première paire de contacts d'une batterie (6),
c) un dispositif (34, 44) destiné à déterminer un premier et un second paramètres liés à la Loi d'Ohm et représentatifs de l'impédance entre une seconde paire de contacts de la batterie, le dispositif de détermination comprenant un premier dispositif (46 ou 38) destiné à transmettre un premier signal d'entrée représentatif du premier paramètre lié à la Loi d'Ohm, l'appareil de contrôle de batterie étant caractérisé en ce que le dispositif de détermination comporte en outre :

un premier dispositif de filtrage (48 ou 40) couplé au premier dispositif d'alimentation (46 ou 38) et destiné à transmettre des composantes du premier signal d'entrée à la fréquence choisie et à atténuer au moins les composantes du premier signal d'entrée qui sont comprises dans une première plage de fréquences d'atténuation supérieures à la fréquence choisie, le premier dispositif de filtrage (46 ou 38) assurant la création d'un premier signal filtré de sortie, et

un premier dispositif (50 ou 42) destiné à mesurer le premier signal filtré de sortie et à déterminer le premier paramètre lié à la Loi d'Ohm.

2. Invention selon la revendication 1, dans laquelle un chargeur de batterie (4) et une charge électrique (8) sont connectés électriquement à la batterie (6), et le chargeur (4) et la charge électrique (8) provoquent la création de courants alternatifs dans la batterie (6) à plusieurs fréquences caractéristiques, et la première plage de fréquences d'atténuation comprend ces fréquences caractéristiques.

3. Invention selon la revendication 2, dans laquelle le chargeur de batterie (4) et la charge (8) sont connectés en parallèle l'un avec l'autre aux bornes de la batterie (6).

4. Invention selon la revendication 1, 2 ou 3, dans laquelle le premier et le second paramètres liés à la Loi d'Ohm correspondent à une tension et à un courant, respectivement, et le premier signal d'entrée correspond à une tension appliquée à la seconde paire de contacts, et le premier dispositif de mesure (50) assure la mesure de la tension du signal d'entrée filtré dans le premier dispositif de filtrage (48).

5. Invention selon la revendication 4, dans laquelle le dispositif (34, 44) de détermination régule le second paramètre lié à la Loi d'Ohm à une valeur prédéterminée.

6. Invention selon l'une quelconque des revendications 1 à 5, dans laquelle le dispositif de détermination (34, 44) comporte en outre :

un second dispositif (46 ou 38) destiné à transmettre un second signal d'entrée représentatif du second paramètre lié à la Loi d'Ohm,

un second dispositif de filtrage (40 ou 48) connecté au second dispositif d'alimentation (46 ou 38) et destiné à transmettre des composantes du second signal d'entrée à la fréquence choisie et à atténuer au moins des composantes du second signal d'entrée qui sont comprises dans une seconde plage de fréquences d'atténuation supérieure à la fréquence choisie, le second dispositif de filtrage (40 ou 48) assurant la création d'un second signal filtré de sortie, et

un second dispositif (42 ou 50) de mesure du

second signal filtré de sortie, destiné à déterminer le second paramètre lié à la Loi d'Ohm.

7. Invention selon la revendication 6, dans laquelle la première et la seconde plages de fréquences d'atténuation sont identiques.

8. Invention selon la revendication 6 ou 7, comprenant en outre un dispositif (56) de combinaison automatique du premier et du second paramètres liés à la Loi d'Ohm afin que l'impédance soit déterminée.

9. Invention selon l'une quelconque des revendications précédentes, dans laquelle la première paire de contacts est confondue avec la seconde paire de contacts.

10. Invention selon l'une quelconque des revendications précédentes, dans laquelle la batterie (6) a une paire de contacts de sortie (16, 18), la batterie (6) a plusieurs cellules (60a à 60n) ayant chacune une paire de contacts de sortie (64, 66) la première paire de contacts correspond aux contacts de sortie de la batterie (16, 18), et la seconde paire de contacts correspond aux contacts de sortie (64, 66) de l'une des cellules (60a à 60n).

11. Invention selon l'une quelconque des revendications précédentes, comprenant en outre un dispositif (28) destiné à arrêter la circulation du courant continu dans un circuit comprenant la batterie (6) et le générateur (2) de signaux alternatifs.

12. Invention selon l'une quelconque des revendications précédentes, dans laquelle la fréquence choisie est comprise entre 11 et 14 Hz.

13. Invention selon l'une quelconque des revendications 1 à 11, dans laquelle la fréquence choisie est comprise entre 21 et 29 Hz.

14. Invention selon l'une quelconque des revendications 1 à 11, dans laquelle la fréquence choisie est comprise entre 91 et 109 Hz.

15. Invention selon l'une quelconque des revendications précédentes, dans laquelle le premier dispositif de filtrage (48 ou 40) est un filtre passe-bande centré à une fréquence choisie et destiné à atténuer des signaux ayant des fréquences supérieures et inférieures à la fréquence choisie.

16. Invention selon l'une quelconque des revendications précédentes, dans laquelle le signal alternatif a une forme d'onde sinusoïdale.

17. Invention selon la revendication 2, dans laquelle le premier dispositif d'alimentation (46), le premier dispositif de filtrage (48) et le premier dispositif de mesure (50) constituent un ampèremètre (42) couplé au dispositif (10, 16, 18) d'application de manière qu'il crée une mesure de courant représentative de l'intensité du courant alternatif appliqué à la batterie (6) à la fréquence choisie, l'ampèremètre comprenant

un dispositif (30) couplé au dispositif d'application (10, 16, 18) et destiné à créer un premier signal d'entrée représentatif de l'intensité du courant appliqué à la batterie (6) par le générateur (2) de signaux alternatifs,

un premier filtre passe-bande (40) centré sur la fréquence choisie et destiné à laisser passer les composantes du premier signal d'entrée à la fréquence choisie et à atténuer les composantes dans une plage d'atténuation qui est placée au-dessus et au-dessous de la plage de fréquence choisie et qui comprend plusieurs fréquences caractéristiques, et

un dispositif (42) destiné à mesurer l'amplitude du premier signal d'entrée filtré par le premier filtre passe-bande (40), et

dans laquelle le dispositif (34, 44) de détermination comporte en outre un voltmètre (44) couplé à la batterie (6) et destiné à créer une mesure de tension représentative de l'amplitude de la tension alternative entre les contacts de la seconde paire de la batterie, le voltmètre (44) comprenant :

un dispositif (44) couplé à la seconde paire de contacts et destiné à créer un second signal d'entrée représentatif de la tension entre les contacts de la seconde paire,

un second filtre passe-bande (48) centré sur la fréquence choisie et destiné à laisser passer les composantes du second signal d'entrée à la fréquence choisie et à atténuer les composantes de la plage des fréquences d'atténuation, et

un dispositif (50) de mesure de l'amplitude du second signal d'entrée filtré par le second filtre passe-bande (48).

18. Procédé de comparaison de l'impédance de plusieurs éléments constituants (60a à 60n, 62) d'une batterie (6) alors que la batterie (6) est connectée électriquement à un chargeur (4) et à une charge active (8), la batterie (6) contenant une paire de bornes de sortie (16, 18) et plusieurs cellules (60a à 60n) qui sont connectées électriquement entre les bornes de sortie (16, 18) de la batterie, chacun des éléments constituants (60a à 60n, 62) comportant une paire de contacts électriques (64, 66), le procédé comprenant les étapes suivantes :

a) le passage d'un courant alternatif d'intensité connue dans la batterie (6) entre les bornes de sortie (16, 18) de la batterie, le courant alternatif ayant une fréquence choisie, caractérisé en ce que le procédé comprend les étapes suivantes :

b) l'obtention d'un premier signal de tension représentatif de la tension alternative entre les contacts électriques de la paire (64, 66) d'un premier des éléments constituants (60a à 60n, 62),

c) le passage du premier signal de tension dans un filtre (48) destiné à laisser passer des composantes du premier signal de tension à la fréquence choisie et à atténuer des composantes du premier signal de tension dans une plage de fréquences d'atténuation qui contient des fréquences supérieures à la fréquence choisie,

d) la mesure du premier signal de tension filtré

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dans l'étape (c) afin qu'une première mesure de tension soit obtenue,

e) la combinaison de la première mesure de tension à l'intensité connue du courant afin qu'une première valeur d'impédance soit obtenue,

f) la répétition des étapes (b) à (e) avec un second signal de tension représentatif de la tension alternative entre les contacts électriques de la paire (64, 66) d'un second des éléments constituants (60a à 60n, 62) afin qu'une seconde valeur d'impédance soit obtenue, et

g) la comparaison de la première et de la seconde valeurs d'impédance.

19. Procédé selon la revendication 18, dans lequel chacun des éléments constituants (60a à 60n, 62) est un accumulateur respectif (60a à 60n), et la première et la seconde valeurs d'impédance correspondent à l'impédance des accumulateurs respectifs (60a à 60n).

20. Procédé selon la revendication 18, dans lequel chacun des éléments constituants (60a à 60n, 62) est un conducteur respectif (62) reliant des accumulateurs, et la première et la seconde valeurs d'impédance correspondent à l'impédance des connexions respectives formées entre les accumulateurs.

21. Procédé selon la revendication 18, dans lequel chacun des éléments constituants (60a à 60n, 62) est une connexion électrique respective, et la première et la seconde valeurs d'impédance correspondent à l'impédance des connexions électriques respectives.

22. Procédé selon l'une quelconque des revendications 18 à 21, dans lequel la fréquence choisie est comprise entre 11 et 14 Hz.

23. Procédé selon l'une quelconque des revendications 18 à 21, dans lequel la fréquence choisie est comprise entre 21 et 29 Hz.

24. Procédé selon l'une quelconque des revendications 18 à 21, dans lequel la fréquence choisie est comprise entre 91 et 109 Hz.

25. Procédé selon l'une quelconque des revendications 18 à 24, dans lequel le filtre (48) de l'étape (c) est un filtre passe-bande (48) centré à la fréquence choisie, et la plage des fréquences d'atténuation est disposée au-dessus et au-dessous de la fréquence choisie.

26. Procédé selon l'une quelconque des revendications 18 à 25, dans lequel le chargeur (4) et la charge active (8) provoquent le passage de courants alternatifs supplémentaires à des fréquences caractéristiques dans la batterie (6), et les fréquences caractéristiques sont séparées de la fréquence choisie, et le filtre (48) de l'étape (c) atténue toutes les fréquences caractéristiques.

27. Procédé selon l'une quelconque des revendications 18 à 26, dans lequel le courant alternatif a une forme d'onde sinusoïdale.