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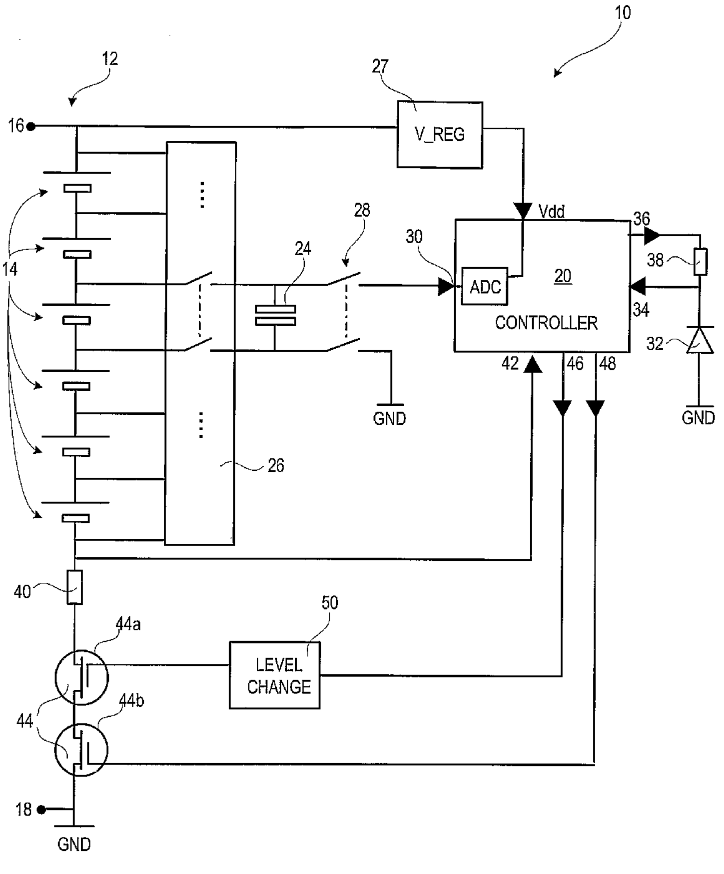
(54) Title: SYSTEM FOR MONITORING CELL VOLTAGE OF A SERIAL CONNECTION OF BATTERY CELLS



(57) Abstract: A Protection Circuit Module (PCM) for a battery comprising at least one cell. The preferred PCM comprises a capacitor that may be selectably connected across one of a plurality of battery cells, or to a voltage measuring device. When connected across a battery cell, the capacitor is charged by an amount depending on the voltage of the cell. When connected to the voltage measuring device, the voltage of the capacitor is measured and used as an indication of the cell voltage.

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SYSTEM FOR MONITORING CELL VOLTAGE OF A SERIAL CONNECTION OF BATTERY CELLS

Field of the Invention

The present invention relates to a voltage monitoring system and in particular to a Protection Circuit Module (PCM) for a battery pack.

Background to the Invention

It is known to provide battery packs, and in particular rechargeable battery packs, with a Protection Circuit Module (PCM). A primary function of the PCM is to monitor the voltage across the, or each, cell of the battery pack and to isolate the battery pack from a load, or from a battery charger, if the measured voltage is outside predetermined limits.

The PCM may be required to measure cell voltages with a relatively high degree of accuracy, for example within a tolerance limit of approximately 0.5 to 1%. Such accuracy can be difficult to achieve especially where the PCM comprises a control unit and the supply, or rail, voltage of the control unit is similar to the individual cell voltage of the battery pack but significantly less than the total battery voltage.

Another common requirement of a PCM is that it draws relatively little power from the battery pack. This requirement can also be difficult to achieve and often conflicts with the requirement for accuracy.

It would be desirable, therefore, to provide a PCM which offers relatively high measurement accuracy while drawing relatively little power from the battery pack.

Summary of the Invention

A first aspect of the invention provides a protection circuit module (PCM) for a battery comprising at least one battery cell, the PCM comprising means for measuring a voltage signal; means for storing electrical charge; and means for selectably connecting the charge storage means across said at least one battery cell such that the charge storage means is charged according to the voltage across said at least one battery cell, or to the voltage measuring means such that the voltage of the charge storage means can be measured.

When connected across a cell, the charge storing means is charged by an amount depending on the potential difference across the cell. When connected to the voltage measuring means, the voltage across the charge storage means can be measured and used as an indication of the voltage of or across the cell.

Preferably, the charge storage means comprises at least one capacitor.

In the preferred embodiment, the charge storage means is connectable across each of a plurality of battery cells in turn, the connecting means being arranged to cause the charge storage means to be connected alternately across one of said battery cells and then to the voltage measuring means, the voltage measuring means being arranged to measure, in turn, the voltage created by the respective stored charge imparted to the charge storage means by each battery cell.

Typically, the system further includes a control unit, the control unit including said voltage measuring means. In order to measure the voltage of the charge storage means, said voltage measuring means may be arranged to compare the voltage of the charge storage means with a first reference voltage.

Advantageously, said first reference voltage comprises a supply voltage to the control unit, the control unit being arranged to calibrate said first reference voltage against a second reference voltage. The second reference voltage may be provided by a diode, for example a reference diode such as a zener diode.

The calibration may be performed occasionally, periodically or before each measurement cycle. Preferably, the control unit is arranged to switch on the reference diode only when the supply voltage is to be calibrated.

Typically, the voltage measuring means includes an Analogue-to-Digital converter (ADC) arranged to receive the voltage of the charge storage means and to receive said first reference voltage as a reference signal.

The connecting means may include at least one switching mechanism operable by the control unit.

In preferred embodiments, the control unit comprises a programmable microprocessor, microcontroller or other data processor.

In typical embodiments, the PCM includes means for isolating the battery from a load depending on the voltage of the charge storage means measured in respect of one or more of said at least one battery cells and/or means for isolating said battery from a charger depending on the voltage of the charge storage means measured in respect of one or more of said at least one battery cells.

Optionally, the PCM may include at least one load that is connectable across said at least one battery cell, and means for selectably connecting the at least one load across said at least one battery cell depending on the voltage of the charge storage means measured in respect of the at least one battery cell.

Alternatively, the PCM may include at least one load in series with a diode, the at least one load and diode being connected across said at least one battery cell, such that the load draws current from the at least one battery cell when the voltage of the cell exceeds the diode voltage.

A second aspect of the invention provides a battery pack comprising a battery having at least one cell, and the PCM of the first aspect of the invention.

A third aspect of the invention comprises a control unit having an input associated with an analogue-to-digital-converter (ADC), the control unit being arranged to receive a supply voltage, wherein the supply voltage provides a reference signal for the ADC and the control unit calibrates the received supply voltage against a supply voltage reference signal.

Some aspects of the invention may be used in other applications other than battery packs. Hence a fourth aspect of the invention provides a voltage monitoring system comprising means for measuring a voltage signal; means for storing electrical charge; and means for selectably connecting the charge storage means across at least one target component such that the charge storage means is charged according to the voltage across said at least one target component, or to the voltage measuring means such that the voltage of the charge storage means can be measured.

It will be understood that voltage may be measured directly or indirectly. Indirect measurement may, for example, be achieved by measuring current or other voltage derivative. Hence, while the invention is described and claimed primarily in the context of voltages, this is intended to embrace equivalent or corresponding characteristics, including current and electrical charge, as would be apparent to a skilled person.

Further advantageous aspects of the invention will become apparent to those ordinarily skilled in the art upon review of the following description of a specific embodiment and with reference to the accompanying drawing.

Brief Description of the Drawings

An embodiment of the invention is now described by way of example and with reference to the accompanying drawing, which is designated as Figure 1 and which presents a block diagram of a voltage monitoring system in the form of a Protection Circuit Module (PCM) embodying the present invention, and a battery pack.

Detailed Description of the Drawings

Referring now to the drawing, there is shown, generally indicated as 10, a preferred embodiment of the voltage monitoring system or PCM. The system 10 is shown coupled to a battery, or battery pack 12. The battery 12 comprises a plurality of cells 14 (6 cells are shown for illustration purposes only) electrically connected in series. In the preferred embodiment, the battery 12 is a rechargeable battery pack and has positive and negative terminals 16, 18 by which the battery pack 12 may, in a discharging mode of operation, supply electrical power to a load (not shown) or may, in a charging mode of operation, be charged or recharged by a battery charger (not shown). The battery 12 may employ any one of a variety of conventional chemical technologies, for example Lithium-Ion (Li-Ion) technology. By way of example, battery 12 may comprise a Li-ion phosphate battery.

The PCM 10 comprises a control unit 20, typically comprising a programmed, embedded microcontroller or other data processor, which receives (at input Vdd) a supply, or rail, voltage from the battery 12 via a voltage regulator 27. In typical applications, the control unit 20 is required to be of a type that consumes relatively little electrical power during use and hence its supply voltage is relatively low. For example, the control unit 20 may comprise a PIC18F1220 IC microcontroller as provided by Microchip Technology Inc (`www.microchip.com`) which requires a nominal 5 volt supply voltage. The voltage regulator 27, which may be a micro-power voltage regulator, delivers the supply voltage to the control unit 20 within product dependent tolerance limits, typically in the order of approximately 5%.

As will be apparent from the following description, the PCM 10 is particularly suited for use in applications where the cell voltage, that is the potential difference across each cell 14 when fully charged to normal capacity, is less than but in the order of, or similar to, the control unit 20 supply voltage. In the present example, the cell voltage is assumed to be approximately 4 volts. Hence, the overall battery voltage, which is approximately 24 volts in the illustrated example, is significantly higher than the control unit supply voltage.

The system 10 further comprises an electrical charge storage device in the form of a capacitor 24 which is connectable across each cell 14 individually by means of a first switching device 26. The switching device 26 may take the form of a multiplexer arranged to connect, in a first switching state, the respective positive and negative terminals of one cell 14 at a time across the capacitor 24 so that the capacitor 24 may be charged by an amount depending on the potential difference across the respective cell 14. The switching device 26 may also adopt a second switching state in which the capacitor 24 is electrically isolated from each of the cells 14 (as illustrated in the drawing). The switch control input (not shown) of the multiplexer 26 is conveniently provided by the control unit 20. The switching device 26 may alternatively take the form of respective individual switches for each cell 14. A second switching device 28 is arranged to selectably connect the capacitor 24 between an input 30 to the control unit 20 and a reference potential, conveniently electrical ground GND. The first and second switching devices 26, 28 may be provided separately or as part of a single switching mechanism. The arrangement is such that, in a capacitor charging mode, the first switching device 26 connects the capacitor 24 across any one of the cells 14, and the second switching device 28 is open to isolate the capacitor 24 from input 30 and from ground GND. Hence, the capacitor 24 is charged by an amount depending on the potential difference across said cell 14. In a capacitor charge measurement mode, the first switching device isolates the capacitor 24 from the cells 14 and the second switching device 28 connects the capacitor 14 between input 30 and ground GND.

In the preferred embodiment, the control unit 20 provides means for measuring a voltage signal, in particular the voltage created by the charged stored on the capacitor 24. Hence, the charge which is stored by, or more specifically the voltage across, the capacitor 24 may be measured by the control unit 20 using the signal at input 30 (with respect to ground in this example).

The control unit 20 may be configured to control the switching of both the first and the second switching devices 26, 28 so that the capacitor 24 is charged by each cell 14 in turn and, after each charge, the stored charge on, or voltage across, the capacitor 24 is measured by the control unit 20. Hence, the control unit 20 is able to measure, indirectly and in turn, the potential difference across each cell 14.

The first and second switching devices 26, 28 and the capacitor 24 may be said to comprise a flying capacitor circuit. The capacitor 24, which may be referred to as a flying capacitor, may, for example, comprise a ceramic storage capacitor and, in the present example, may have a capacitance of approximately 33nF.

Typically, the input 30 is associated with an analogue-to-digital converter (ADC) (not shown) provided internally of the microprocessor 20. The ADC receives an analogue signal via input 30 corresponding to the charge stored on the capacitor 24 and converts the analogue signal into a digital signal which may be processed by the microprocessor 20. Normally, the ADC is provided with a reference signal, usually in the form of a reference voltage, against which the received analogue signal may be measured or calibrated. In some embodiments (not illustrated), the reference voltage for the ADC may comprise the voltage (or a derivative thereof) across a reference diode. Typically, such a reference diode is provided externally of the controller 20 and, during operation of the system 10, is biased (for example by a voltage applied by an output of the control unit 20 or by the control unit supply voltage) so that a relatively precise voltage is developed across the diode. The diode voltage (or derivative) is provided to an input of the control unit 20 for use as an ADC reference voltage. However, for some applications, it is undesirable to employ a reference diode in this manner because of the current that it draws during use. Another disadvantage with this option is that the reference voltage provided by the diode is usually significantly less that the control unit supply voltage and this limits the sensitivity of the ADC. As an alternative, the ADC supply voltage itself (which in the present example may be nominally 5 volts) may be used as the ADC reference voltage. However, as described above, the control unit supply voltage may not be sufficiently accurate for certain applications.

In the preferred embodiment, the control unit supply voltage Vdd provides the ADC reference signal and is calibrated, preferably periodically, by the control unit 20, against a second reference signal. The second reference signal conveniently comprises the voltage (or a derivative thereof) developed across a reference diode, the diode being such that the diode voltage, when turned on, or biased, falls within relatively precise tolerance limits, for example less than 1%. A typical reference diode voltage is accurate to within approximately 0.2%. A reference diode 32 is included in system 10 and the diode voltage is supplied to an input 34 (which is typically associated with a ADC (not shown)) of the control unit 20. The diode 32 may be turned on, or biased, by application of a voltage under the control of the control unit 20. For example, the control unit 20 may apply a voltage to diode via an output 36 (and typically via a current limiting resistor 38). The diode voltage is less than the control unit supply voltage (for example 2.5. volts) and may be used to calibrate the control unit supply voltage Vdd as is now described. The diode 32 is normally switched off (so that it consumes no power) but, during use of the system 10, is occasionally or periodically switched on by application of a biasing voltage by the control unit 20. When the diode 32 is switched on, the control unit 20 measures the diode reference voltage at input 34 and compares the diode reference voltage against the control unit supply voltage received at input Vdd. The control unit 20 may thus determine a relatively accurate value for the supply voltage received at Vdd at the time of measurement. The control unit 20 may thus make a relatively accurate measurement of the signal received by the ADC at input 30 using the determined value of the supply voltage as a reference. Moreover, because the supply voltage is used as a reference for the ADC as opposed to a smaller reference voltage provided by, say, an external reference diode, the sensitivity, or dynamic range, of the ADC is increased and this too contributes to the accuracy of the measurement of the signal received at input 30.

The control unit 20 may, for example, switch on the reference diode 32 for a brief period before each cell voltage measurement, or each round of cell voltage measurements (a round being one cycle of measuring each cell voltage), after which the diode 32 is switched off to minimise power consumption. In the preferred embodiment, in order to preserve power, the control unit 12 enters a low-power “sleep” mode after each measurement cycle and “wakes” itself after a pre-determined period in order to perform a further measurement cycle.

The system 10 may include one or more switches 44 operable, conveniently by the control unit 20, to isolate the battery 12 from a load (not shown), when in discharge mode, or from a charger (not shown)when in charging mode. In the illustrated embodiment, two switches 44a, 44b are provided in series with the battery 12 and are operable by the control unit 20 via outputs 46, 48 respectively.

Each switch 44 may for example comprise a respective power MOSFET (Metal Oxide Semi-conductor Field Effect Transistor). Each MOSFET has an internal “bypass” diode which ensures that it allows current to pass when biased, or connected, the wrong way around (reverse or wrong polarity). By way of example, a MOSFET comprising a Schottky bypass diode may be used. As a result, less voltage is lost and hence less power is dissipated in this mode of operation. In operation, either or both MOSFET’s are turned ‘on’ or ‘off’ by applying suitable gate voltages. Since a MOSFET gate voltage is referenced to its source terminal, a level changing circuit 50 is associated with the gate input for one of the switches 44a. To enable both the charge and discharge modes of operation, both switches 44 are turned 'on': this the normal operational mode. When 'on', a MOSFET appears (electrically) like a low resistance, the "on resistance" being typically 20mΩ in both directions (either polarity connection). When 'off', a MOSFET appears (electrically) like a very high resistance, typically greater than 1MΩ, when connected, or biased, with proper polarity, or looks like a semiconductor diode (e.g. a Schottky diode in the present example) when connected, or biased, with reverse polarity. To enable discharge mode but disable charge mode, only the switch 44b is turned 'on'. To enable charge mode but disable discharge mode, only the switch 44a is turned 'on'. In these cases, the current passes through one 'on' MOSFET, thus incurring typically a 20mΩ insertion loss, in series with a reverse biased 'off' MOSFET, thus incurring typically a 0.5V voltage drop. To monitor for excessive (discharge) current, the voltage drop across resistor 40 is measured. Optionally, resistor 40 may be provided by the implicit "on resistance" of the MOSFET, thus saving an low-ohmic value and a relatively expensive (explicit) resistor.

In the illustrated embodiment, the controller 20 detects the voltage drop across resistor 40 via input 42 and, depending on the detected value, may take appropriate action (e.g. turning the switch 44b off via output 48). Alternatively, a hardware comparator and latching circuit (not shown) may be provided to perform this function, since such hardware acts more quickly as may be required to protect the battery.

During use as a PCM, the control unit 20 periodically (for example several times per second) causes the capacitor 24 to be charged, in turn, by the potential difference across each cell 14. After each charge, the control unit 20 measures, in the manner described above, the charge stored by the capacitor 24, the measured charge being indicative of the potential difference across the respective cell 14.

Should the measured charge of any cell 14 exceed a first, or charge, threshold (when the battery 12 is being charged), then the control unit 20 isolates the battery 12 from the charger. Should the measured charge of any cell 14 drop below a second, or discharge, threshold (when the battery 12 is supplying a load), then the control unit 20 isolates the battery 12 from the load. The control unit 20 may decide to isolate the battery 12 based on a measurement from a single measurement cycle, or may alternatively make a decision based on average measurements taken over several cycles.

The use of a flying capacitor 24 as described above allows the individual cell voltages to be measured to a relatively high level of accuracy without the need for potential divider circuits and high precision resistors (which are undesirable as they add significantly to the cost of the system). It is preferred to use only one storage capacitor 24, although more capacitors may be used if desired. Alternatively, one or more other, conventional electrical energy, or charge, storage devices may be used in place of capacitor 24. By the preferred use of reference diode 32 as described above, the power requirements of the system 10 can be reduced while still maximising the dynamic range of the ADC. Hence, the required level of measurement accuracy can be obtained while using a relatively low precision ADC and while drawing relatively little power.

The PCM function optionally may facilitate "cell balancing" by inclusion of circuitry to deal with the tendency for one or more cells to become more charged than others such that capacity (measured between the first cell to have a voltage below the discharge threshold and the first cell to have a voltage above the charge threshold) is reduced. Differences between cells 14 may lead to differing charging rates and thus to different voltage against time relationships whilst charging. Optionally, the system 10 may employ a "passive-passive" cell balancing technique in which a reference diode, conveniently a zener diode (e.g. 3.9 volts zener diode) and load resistor (e.g. 100 Ohms) in series (not shown) are connected across each cell 14 of the battery 12, such that if one or more cell 14 voltage exceed the voltage of the respective diode, the respective resistor progressively and slowly discharges the cell 14 until the cell voltage drops below the diode voltage. Optionally, "active-passive" cell balancing may be employed in which a respective load resistor (e.g. 100 ohms) is connectable across each cell 14 by means of a switch or respective switch (e.g. a semiconductor switch such as a bipolar or MOSFET transistor), the, or each, switch conveniently being controlled by the controller 20. Each cell 14 may be treated separately. In the preferred embodiment, the controller 20, which measures the cell voltages as described above, decides whether and when to connect the respect load across the respective cell 14 depending on the respective measured cell voltage, and/or on a recorded history of cell voltages in order to balance cell voltages. Either cell balancing option increases the quiescent current of the system 10 and battery 12 combination when the battery 12 is well charged, although with active-passive balancing, the increase can be controlled.

The system 10 may optionally include current sense resistor 40 in series with the battery 12. The voltage across resistor 40 (with respect to electrical ground or other reference) is, for example, supplied to an input 42 (typically associated with an ADC (not shown)) of the control unit 20, or may be measured by any other suitable means. The control unit 20 may monitor the signal received at input 42 and therefore measure the current drawn from the battery 12 when the battery is supplying a load. Depending on the measured current value, e.g. should the detected current exceed the charge threshold value during charging, then the control unit 20 may isolate the battery 12 from the load by means of one or both of switches 44.

The system 10 is particularly, but not exclusively, suitable for use as a PCM and for measuring the potential differences across the cells of a battery. The system may alternatively be used for monitoring the voltage across other target components, including networks. The main embodiment described herein is particularly suited for use with batteries having between 2 and 7 (inclusive) cells, although the invention is not limited to this and may, more generally be used in applications where the battery comprises one or more cells.

In the preferred system 10, the controller 20 comprises a microcontroller, or similar data processor, preferably having a re-programmable non-volatile memory, e.g. a flash memory, and supporting in-circuit programming. Hence, further functionality can be added at zero unit cost. The microcontroller, or other processor, may for example be used to perform one or more of the following tasks: store a product model number and unique product serial number (or other unique identifier) which can be read using a suitable tool via, for example, the processor's serial in-circuit programming port (not shown); store cell chemistry parameters including over-charge and under-charge threshold voltages, and time constants (e.g. how quickly the various switches are switched on or off), in unused code memory where they can be edited after manufacture using a suitable configuration tool without affecting the firmware code or unique serial number; effect application functionality without compromising the PCM function: with due care and honouring rules to ensure that the PCM function gets due priority, spare processing power is available to run one or more related or unrelated applications as may be required by the device into which the system 10 is incorporated, or with which it is associated; include a simple thermometer (not shown) comprising, for example, a low cost thermistor to measure the ambient temperature and hence forbid charging and/or discharging when the temperature is outside predetermined limits; and/or include "debug" firmware code which causes the internally calculated values of each cell voltage, and/or other parameters, to be output, for example in a serial RS232 fashion from the processor's UART output port, so that a suitable software tool (not shown) can read these values via a computer's serial (COM) port and display for debugging or quality control purposes, - hence “self test" firmware is effectively built into the unit at zero additional unit cost.

Some aspects of the invention are not limited to use in the context of a PCM or to the measurement of the voltage across the cells of a battery, as would be apparent to a skilled person, and may more generally be used in a voltage monitoring system for measuring the voltage across one or more target components. Moreover, the invention is not limited to the embodiments described herein which may be modified or varied without departing from the scope of the invention.

CLAIMS:

1. A protection circuit module for a battery comprising at least one cell, the module comprising means for measuring a voltage signal; means for storing electrical charge; and means for selectably connecting the charge storage means across said at least one battery cell such that the charge storage means is charged according to the voltage across said at least one battery cell, or to the voltage measuring means such that the voltage of the charge storage means can be measured.

2. A system as claimed in Claim 1, wherein the charge storage means comprises at least one capacitor.

3. A system as claimed in Claim 1 or 2, wherein the charge storage means is connectable across each of a plurality of battery cells in turn, the connecting means being arranged to cause the charge storage means to be connected alternately across one of said battery cells and then to the voltage measuring means, the voltage measuring means being arranged to measure, in turn, the voltage created by the respective stored charge imparted to the charge storage means by each battery cell.

4. A system as claimed in any preceding claim, further including a control unit, the control unit including said voltage measuring means.

5. A system as claimed in Claim 4, wherein, in order to measure the voltage of the charge storage means, said voltage measuring means is arranged to compare the voltage of the charge storage means with a first reference voltage.

6. A system as claimed in Claim 5, wherein said first reference voltage comprises a supply voltage to the control unit, the control unit being arranged to calibrate said first reference voltage against a second reference voltage.

7. A system as claimed in Claim 6, wherein said second reference voltage is provided by a diode.

8. A system as claimed in any one of Claims 4 to 7, wherein said voltage measuring means includes an Analogue-to-Digital converter (ADC) arranged to receive the voltage of the charge storage means and to receive said first reference voltage as a reference signal.

9. A system as claimed in any one of Claims 4 to 8, wherein the connecting means includes at least one switching mechanism operable by the control unit.

10. A system as claimed in any one of claims 4 to 9, wherein the control unit comprises a programmable microprocessor.

11. A system as claimed in any preceding claim, further including means for isolating the battery from a load depending on the voltage of the charge storage means measured in respect of one or more of said at least one battery cells.

12. A system as claimed in any preceding claim, further including means for isolating said battery from a charger depending on the voltage of the charge storage means measured in respect of one or more of said at least one battery cells.

13. A system as claimed in any preceding claim, further including at least one load that is connectable across said at least one battery cell, and means for selectably connecting the at least one load across said at least one battery cell depending on the voltage of the charge storage means measured in respect of the at least one battery cell.

14. A system as claimed in any preceding claim, further including at least one load in series with a diode, the at least one load and diode being connected across said at least one battery cell, such that the load draws current from the at least one battery cell when the voltage of the cell exceeds the diode voltage.

15. A battery pack including a protection circuit module as claimed in any preceding claim.

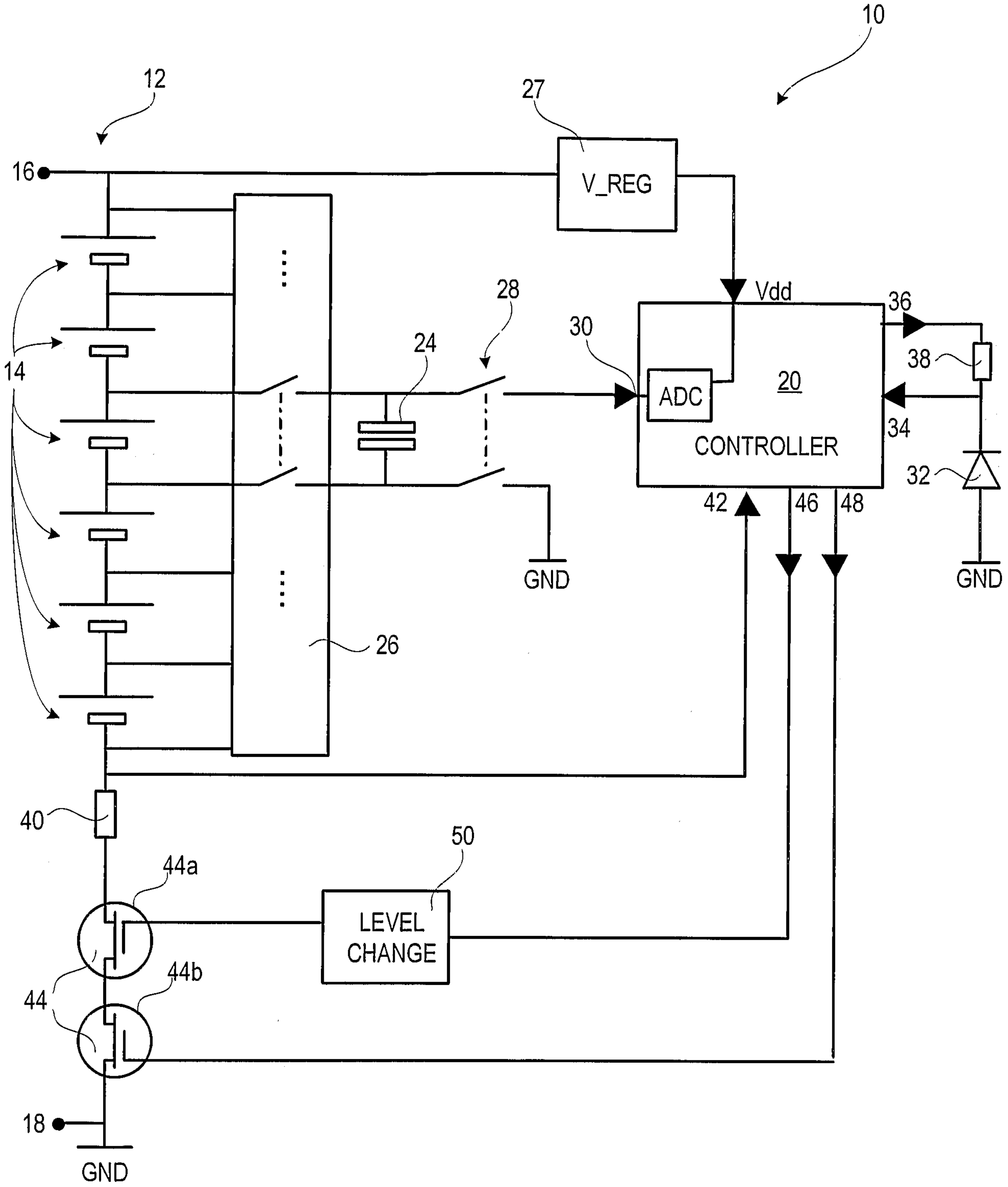
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Fig. 1

INTERNATIONAL SEARCH REPORT

Intern[illegible]nal Application No
PCT/EP2005/005312

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H02J7/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H02J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 992 811 A (HITACHI, LTD) 12 April 2000 (2000-04-12)	1-5
Y	the whole document	6,7
X		8-13
Y		14,15
X	US 2002/017895 A1 (KAWASHIMA SHINGO) 14 February 2002 (2002-02-14) the whole document	1-3
Y	US 5 646 534 A (KOPERA ET AL) 8 July 1997 (1997-07-08) columns 5,6	6
Y	US 5 180 641 A (BURNS ET AL) 19 January 1993 (1993-01-19) the whole document	7,14
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☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

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Date of the actual completion of the international search
2 August 2005

Date of mailing of the international search report
16/08/2005

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	WO 03/088446 A (SANYO ENERGY CORPORATE GMBH; THORSOE, JAN; OEFELE, KARL) 23 October 2003 (2003-10-23) abstract -----	15
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