



(51) International Patent Classification:

G01R 27/18 (2006.01) *G01R 31/02* (2006.01)
B60L 3/00 (2006.01)

(21) International Application Number:

PCT/EP2012/004999

(22) International Filing Date:

4 December 2012 (04.12.2012)

(25) Filing Language:

English

(26) Publication Language:

English

(71) Applicant: **VOLVO TRUCK CORPORATION** [SE/SE];
c/o Volvo Business Service AB, Avd. 501842 ARHK5, S-
405 08 Göteborg (SE).

(72) Inventors: **GRUNDBERG, Jan**; Karl Johansgatan 60A,
S-414 55 Göteborg (SE). **PERSSON, Robert**; Norra Hult-
tet 1, S-424 56 Gunnilse (SE). **HJELLE, Tommy**; Tallvä-
gen 8, S-423 53 Torslanda (SE).

(74) Agent: **JÖNRUP, Emil**; Volvo Technology Corporation,
Volvo Corporate Intellectual Property, Dept: BF14100,
M1.7, S-405 08 Göteborg (SE).

(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,

AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,
BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM,
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP,
KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD,
ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI,
NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU,
RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ,
TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA,
ZM, ZW.

(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ,
UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ,
TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK,
EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV,
MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,
TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW,
ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: METHOD FOR ISOLATION MONITORING

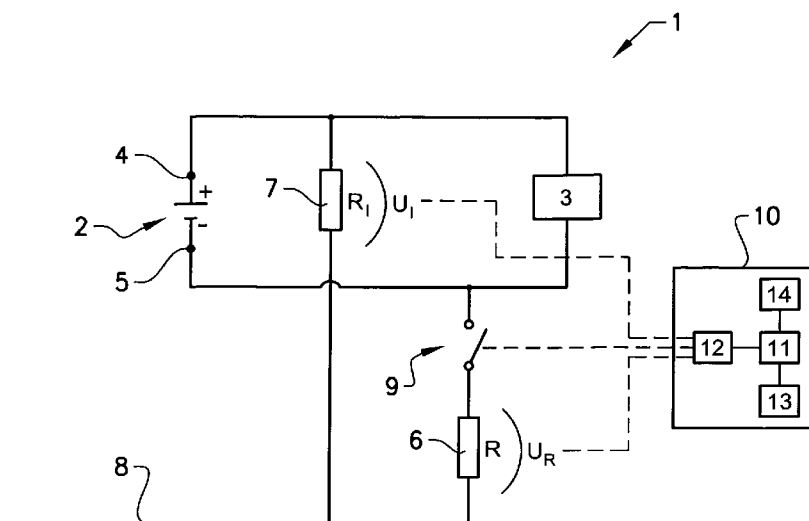


FIG. 1

(57) Abstract: A method for monitoring electrical isolation in an electrical system (1) of a vehicle comprising a high-voltage battery (2) having a positive battery pole (4) and a negative battery pole (5) where the two battery poles are separated from the vehicle chassis (8), where the vehicle comprises a control unit (10) adapted to obtain values that represent the electrical isolation between at least one battery pole and the chassis, comprising the steps of repeatedly obtaining a value that represents the isolation resistance, and saving the value that represents the isolation resistance in a classification table having a plurality of different classification groups. The advantage of the invention is that intermittent faults in a high-voltage system can be detected by using a regular, low speed measurement system.



METHOD FOR ISOLATION MONITORING

TECHNICAL FIELD

The present invention relates to a method for isolation monitoring in electrical system comprising a high-voltage battery. The method is suitable
5 for electric vehicles and hybrid vehicles.

BACKGROUND ART

In electric vehicles, such as electrical automobiles or hybrid electrical automobiles, a high-voltage DC current is used to power an electrical motor. Here, batteries having a voltage of 300 - 600 Volts and more are
10 considered as high-voltage. The electrical system is connected to a high-voltage battery, which is electrically insulated from the body of the vehicle, i.e. the vehicle chassis. However, the negative battery pole in the low-voltage system of the vehicle is connected to chassis ground as is common in vehicles. It is important to keep the two voltage systems
15 separated, and to keep the high-voltage system separated from chassis ground. In order to detect a fault in the high-voltage system, such as an isolation fault, it is important to monitor the insulation of the high-voltage system. In this way, it is possible to detect a deterioration in the high-voltage insulation and in this way prevent a damage to the vehicle. One
20 way is to use a ground detection apparatus arranged to generate a warning when dielectric breakdown occurs between the high-voltage circuit and the vehicle body.

Many conventional power systems utilize some means to protect the system against faults. Faults, such as line-to-line and line-to-ground faults,
25 can cause considerable damage to the power system equipment, and as such, protection against faults is desirable. The results of faults can include damaged electrical components, overheating or even fires.

Faults can be either low-impedance or high-impedance. When a low-impedance fault occurs, current flow in a system can increase substantially, far exceeding the normal load current in the system. In this case, current sensors are often used to detect low-impedance faults.

5 When high-impedance faults occur, such as arc faults, there is not the same increase in current. Often high-impedance faults can generate current levels similar to or less than normal load current. As such, protective devices that merely monitor current will not be able to detect a high-impedance fault condition.

10 Catastrophic damage to system components can result because the fault remains on the system for a substantial duration. In the case of an arc fault, the fault can often remain on the system until the fault burns clear. Since portions of arc faults can reach 6000 degrees Celsius, an arc fault burning clear can involve the vaporization of metal components, fires,
15 smoke, etc. Thus, an apparatus for detecting high-impedance faults, such as arc faults, is desirable.

Such an apparatus must be able to detect actual faults, which dissipates only a fraction of full load power, without generating erroneous fault indications under normal load conditions. Conventional protection devices,
20 such as fuses, breakers, and the like, cannot meet this requirement because these devices only protect against currents exceeding full load. Thus, when high-impedance faults generate less than full load current conventional protection devices do not react and the fault remains in the system. The apparatus must also be able to detect and react to a fault
25 condition quickly to minimize damage to electrical system components. Conventional time-over-current devices may take from seconds to minutes to operate, which is normally too long for an effective protection system. An arc, as compared with a spark, has a relatively stable behaviour, although it may be relatively short. A spark will never show a stable
30 behaviour and is thus more difficult to detect. An arc fault may be shorter

than 100 milliseconds. Since interrupting contactors may take as long as 50 milliseconds to open, detection in the 20 to 50 millisecond range is desirable for an arc fault detection apparatus.

- It is further of advantage to detect deterioration in the insulation before an arc fault occurs. This is especially so for vehicles, where cables and other components vibrate and where an insulation fault may only show temporarily. Such intermittent faults are often very difficult to detect. One way to detect high-impedance fault uses bifurcated wiring. By this, every load wire is split into a pair of wires. If a fault occurs on one wire in the pair, the current on the faulted wire can be compared to the current on the other, unfaulted, parallel wire. A difference in the currents between the two wires indicates that a fault is present. This method is simple and effective for both AC and DC circuits, but splitting each load wire in two is impractical. Further, this method is also not suited for intermittent faults.
- US 6 906 525 B2 discloses a ground detection apparatus for an electric automobile having a high-voltage DC power supply which is electrically insulated from the vehicle body and a three-phase AC motor which is driven by a DC voltage from the high-voltage DC power supply. The apparatus is arranged to detect deterioration in the ground insulation by using a ground detection signal consisting of a square waveform. A measured waveform signal is analyzed in order to detect an abnormal waveform indicative of a fault.

- EP 1930737 A1 shows an insulation resistance detecting apparatus that accurately calculates an insulation resistance value in real time. In the insulation resistance detecting apparatus, an insulation resistance value is calculated from the duty ratio of an output waveform of comparator.

US 2010026276 A1 shows a method and apparatus for detecting a fault condition on a power system. By rectifying power system phase voltages

to produce a rectified waveform, and filtering the rectified waveform, a fault condition on a power system can be identified.

These methods can detect some types of insulation faults in some conditions. There is however a need for an improved isolation monitoring method.

DISCLOSURE OF INVENTION

An object of the invention is therefore to provide an improved isolation monitoring method for a high-voltage system in a vehicle. A further object of the invention is to provide a control apparatus for isolation monitoring of a high-voltage system in a vehicle. A further object of the invention is to provide a computer program and a computer program product to be used with a computer for executing said method.

The solution to the problem according to the invention is described in claim 1 for the method, in claim 13 for the computer program, in claim 14 for the computer program product and in claim 15 for the control apparatus. The other claims contain advantageous further developments of the inventive method.

In the inventive method for monitoring electrical isolation in an electrical system of a vehicle comprising a high-voltage battery having a positive battery pole and a negative battery pole, where the two battery poles are separated from the vehicle chassis, where the vehicle comprises a control unit adapted to obtain values that represent the electrical isolation between at least one battery pole and the chassis, the steps of obtaining a value that represents the isolation resistance, and saving the value that represents the isolation resistance in a classification table having a plurality of different classification groups repeatedly are comprised.

In this method, the electrical isolation in a high-voltage system in a vehicle is monitored over a longer time period by grouping different values

representing the isolation resistance in different classification groups in a classification table. By this method, a statistical analysis of the values can be made and long-term trends can be detected, which are not possible to detect with regular measuring methods. In this way, it is possible to detect
5 an intermittent contact fault that is not detected by the regular detection system. Also damaged insulation that temporarily contacts e.g. chassis ground due to vibrations in the vehicle can be detected in this way. Since such intermittent faults may be present for a longer time in the vehicle without being detected, they may still cause considerably damages to
10 various electrical components, such as the high-voltage batteries.

The values can be obtained continuously by using a predefined sample rate, e.g. by measuring a value every second with a sample rate of 1 Hz. The values may also be obtained at a lower rate and may be measured with a random sampling. It is also possible to measure a series of values
15 during a predetermined time interval, such as during an hour after the vehicle is started. It is further possible to measure a predefined number of values, such as 1000 or 10000, and to store them in the classification table.

It may further be of advantage to temporarily deactivate the measuring of
20 values when at least one predefined condition occurs. Such a condition may e.g. be when an electrical power component is switched on or off. When a power component is e.g. switched on, such as the air condition compressor, it will draw a high peak current as a start current. This may in turn temporarily disturb the electrical system of the vehicle, which could
25 give an erroneous isolation resistance value. By deactivating the measurements during such known disturbances, a more reliable monitoring of the electrical isolation is obtained.

The method is preferably applied to monitor the isolation between the positive battery pole and the vehicle chassis and to monitor the isolation
30 between the negative battery pole and the vehicle chassis simultaneously.

Preferably, the isolation of both battery poles is monitored simultaneously, depending on the type of electrical system.

The value that represents the isolation resistance and that is stored in the classification table can e.g. be the calculated isolation resistance value or the absolute value of the calculated isolation resistance value. It is also possible that the value that represents the isolation resistance is obtained by subtracting the last calculated isolation resistance value from the previously calculated isolation resistance value or the absolute value of the value obtained by subtracting the last calculated isolation resistance value from the previously calculated isolation resistance value.

In an advantageous development of the inventive method, a warning signal is issued by the control system when the number of saved values in a predefined classification group exceeds a predefined share of the total number of obtained values. In this way, the driver of the vehicle can visit the repair shop before the electrical components are damaged.

In an advantageous development of the inventive method, the values are saved in a memory and analyzed when the vehicle is in a work shop for a regular service. In this way, it is possible to detect a fault before it is a problem and to correct it without having to alert the driver of the vehicle.

The obtained values are stored in a classification table having different classification groups. The values of the classification groups are selected depending on the actual values used in the classification table. The values are selected such that normal conditions, i.e. a proper isolation resistance, will place most obtained values in a first group, and that obtained values indicating a faulty condition will be placed in other groups. In this way, it is easy to detect a faulty condition.

When the obtained value is a calculated isolation resistance value, values below e.g. 1 MOhm and preferably below 0.5 MOhm will indicate a faulty

condition and values above 1.0 MOhm or more will indicate a normal condition.

When the obtained value is obtained by subtracting the last calculated isolation resistance value from the previously calculated isolation resistance value, obtained values below e.g. 50 kOhm will indicate a
5 normal condition and values above 100 kOhm or more will indicate a faulty condition.

In an advantageous development of the inventive method, the sample rate is preferably less than 100 Hz, and more preferably less than 10 Hz, and
10 even more preferably less than 2 Hz. In this way, the regular isolation detection system of the vehicle that is used to monitor the isolation resistance of the high-voltage electrical system of the vehicle can be used. Such a system normally uses a relatively slow sample rate, normally in the range around 1 to 10 Hz.

15 BRIEF DESCRIPTION OF DRAWINGS

The invention will be described in greater detail in the following, with reference to the attached drawings, in which

- Fig. 1 shows a schematic first embodiment of an electrical system in a vehicle,
- 20 Fig. 2 shows an example of the voltage behaviour over the test resistor,
- Fig. 3 shows an example of measurements for a correct high-voltage system,
- Fig. 4 shows an example of measurements for a faulty high-voltage
25 system, and
- Fig. 5 shows a flow chart of the inventive method.

MODES FOR CARRYING OUT THE INVENTION

The embodiments of the invention with further developments described in the following are to be regarded only as examples and are in no way to limit the scope of the protection provided by the patent claims.

5 Fig. 1 shows schematically a high-voltage system of an electrical vehicle. The method can of course also be used on other high-voltage systems, but is especially suitably for systems that move, since intermittent faults caused by vibrations can be detected. The system 1 comprises a high-voltage battery 2. The battery may be any type of battery and will
10 preferably comprise a plurality of battery cells or battery modules in order to obtain the required voltage, e.g. 600 volts. Here, batteries having a voltage of 300 - 600 Volts and more are considered as high-voltage batteries. The complete battery assembly is referred to as the high-voltage battery 2. The battery 2 is connected to the high-voltage components 3 of
15 the vehicle. These may include the electrical motor and the voltage/current converters used. The battery comprises a positive battery pole 4 and a negative battery pole 5.

The electrical system further comprises a high resistance resistor 6 that can be connected selectively between the negative battery pole 5 and the
20 chassis ground 8 of the vehicle with a switch 9. The resistor 6, or a similar resistor, may also be connected between the positive battery pole 4 and the chassis ground with another switch. The resistor is connected to the respective pole by the switch element 9, e.g. a semiconductor switch element or a relay. The switch element is controlled by a control unit 10 of
25 the vehicle. The control unit is further adapted to measure the voltage between the positive pole 4 and the chassis ground 8, the voltage between the negative pole 5 and the chassis ground 8, and further the voltage over the resistor 6 when the switch 9 is closed.

The control unit 10 may be a stand-alone control unit or may be integrated in an existing control unit of the vehicle. The control unit comprises a data-processing unit 11 which may comprise, for example, a microcomputer or a central processing unit (CPU) adapted to run a program for performing measurements, calculations and communication with other control units of the vehicle. The control unit further comprises input and output circuitry 12 for measuring voltages and for controlling the switch. The control unit also comprises a nonvolatile memory 13, which may have a first memory part in which a computer program for controlling the control unit is stored, and a second memory part, in which the obtained values can be stored. The control unit also comprises a communication circuitry in the form of a data bus interface 14 for communication with other control units.

Further, the system comprises stray capacitances, both intentional and unintentional, which affects the system and the isolation resistance estimation. Depending on the size of the total capacitance between the positive battery pole and the chassis ground and the total capacitance between the negative battery pole and the chassis ground, the time constant will vary. The time constant is important to consider when measuring the voltage between a battery pole and the chassis ground. If a spark is induced between a battery pole and the chassis ground, the time constant will affect the voltage measured between the battery pole and the chassis ground.

Fig. 2 shows an example of the voltage behaviour over the high resistance resistor acting as a test resistor as a function of time, where the time in the shown example are milliseconds. The continuous line shows the absolute voltage value over the resistor 6 for a properly working high voltage system. When the resistor is connected to the battery pole, the total capacitance between the negative battery pole and the chassis ground has the same voltage value as the battery pole. The voltage is then discharged through the resistor 6 with a time constant depending on the

capacitance. A value representing the isolation resistance is obtained by the control system. The broken line illustrates the voltage behaviour over the resistor when an intermittent fault between the negative battery pole and the chassis ground occurs. In such a case, the capacitance is recharged and the voltage discharges through the resistor again. Now, the measured voltage value will be offset when the control system samples the voltage value over the resistance, which leads to that the obtained isolation resistance value will be faulty. Depending on when the intermittent fault occurs over a sample cycle, the voltage over the resistor when the sample is taken may differ more or less from the proper value. When the isolation resistance is then calculated, the resulting value may be more or less out of range. The resulting value will then be placed in the corresponding classification group.

If the isolation resistance is measured in a conventional way with a slow sample rate, this problem will not be detected. By measuring the isolation resistance constantly or frequently and sorting the measurements in different classification groups over a long time period, the varying measurement values will be possible to detect with the inventive method.

During operation of the electrical vehicle, a control unit of the vehicle constantly or frequently measures the isolation of the high-voltage system, preferably with a predefined sample rate. The sample rate is normally in the region between 1 to 10 Hz. In the described electrical system, both battery poles are separated from chassis ground, such that both the "positive" isolation, i.e. the isolation between the positive pole and chassis ground, and the "negative" isolation, i.e. the isolation between the negative pole and chassis ground, can be measured.

The regular isolation measurement system of the vehicle will only detect direct faults in the high-voltage system that can be directly measured with the control system sampling with a frequency of around 1 Hz, i.e. where the fault is relatively stable. Such faults comprise e.g. short circuits, arc

faults and faulty components. By the use of a classification table, also intermittent faults such as sparks will be detected. The sparks may have a duration in the range between less than one microsecond up to 10 milliseconds. Sparks with such a short duration will not be detected with a regular measuring system. Faults having a duration of less than 20% of the sample frequency can thus be detected with the inventive method.

The positive isolation resistance is measured by connecting the high resistance resistor 6 between the negative battery pole 5 and the vehicle chassis 8. The voltage U_I between the positive battery pole 4 and the vehicle chassis 8, i.e. over the isolation resistance, is measured. At the same time, the voltage U_R over the resistor 6 is measured. The isolation resistance value R_I can now be calculated by using the measured voltage values and the high resistance resistor value. The calculation is preferably done by using

$$R_I = \frac{R \cdot U_I}{U_R}$$

In this way, the estimated isolation resistance can be obtained in an easy and reliable way.

The negative isolation resistance is measured in a similar way, by connecting the high resistance resistor 6 between the positive battery pole 4 and the vehicle chassis 8. The voltage between the battery pole 5 and the vehicle chassis 8 is measured. At the same time, the voltage over the resistor 6 is measured. The isolation resistance value can now be calculated by using the measured voltage values and the high resistance resistor value in the same way as shown above.

The calculated isolation resistance values are thereafter saved in a classification table having different classification groups. Each classification group represents an interval of calculated isolation resistance values. Each calculated isolation resistance value is saved in

the appropriate classification group. The classification table will thus grow for each estimated value, and will comprise several isolation resistance values. Preferably, the values are saved over a longer time period. After a predetermined time interval, the classification table can be analyzed and if
5 the values are correct, the classification table may be reset or saved.

The value representing the isolation resistance can also be obtained by subtracting the last calculated isolation resistance value from the previously calculated isolation resistance value. This subtracted value, or the absolute value of the subtracted value, is saved in a classification table
10 having a plurality of different classification groups.

Depending on the tolerances of the measurement system and on the ambient conditions, a slight variation in the calculated values will occur, even in a correct and stable system. The first classification group is preferably selected such that all values within the tolerances are placed in
15 this group. In Fig. 3, an example of a classification table is shown for subtracted values, where the y-axis shows the number of values and the x-axis shows the different classification groups. The first classification group will comprise all values below 10 kOhm/sample. These values are considered to be correct. It is possible to use one classification table for
20 either the positive or negative isolation type or to use the same classification table for both types. Fig. 3 also shows some values in the second value group comprising values between 10 to 50 kOhm/sample and a few in the third value group comprising values between 50 to 100 kOhm/sample. These values may have been measured when e.g. the
25 motor was switched on or off, which may result in a disturbance in the isolation resistance estimation.

It is also possible to stop the isolation resistance measurements temporarily, e.g. when parts of the electrical high-voltage system are switched on or switched off. Some switching of high-voltage components
30 may create disturbances on the electrical system, which may give

measurements that indicate a fault. Such measurements will thus be placed in one of the following classifications groups. It can thus be of advantage to turn of the measurements off when a component that will give a disturbance is to be activated, e.g. when an AC compressor is switched on or when the electric motor is used during acceleration. When
5 known disturbances are avoided, a better fault estimation can be obtained.

In Fig. 4, an example of a classification table for a faulty isolation is shown. The classification table is the same as for Fig. 3, where the y-axis shows the number of values and the x-axis shows the different classification groups.
10 groups. Here, several values are placed in the fourth classification group comprising values between 100 to 200 kOhm/sample and the fifth group comprising values between 200 to 500 kOhm/sample. These values thus indicate that a number of small sparks has occurred, due to an intermittent contact problem or a damaged insulation. The contact problem may be a
15 grounding screw coming loose. The sparks does not have a high enough energy level to cause the control unit to detect it by a direct measurement, but they can be detected in this way. When the classification table looks like in Fig. 4, a warning message may be given to the driver of the vehicle, prompting him to visit a work shop.

20 Normally, most isolation resistance values will be placed in the first group for a system having problems with intermittent faults. The rate of faulty isolation resistance values can be used to decide how serious the problem is. When the rate of faulty values in one of the higher groups is less than e.g. 5%, it may be decided that the situation is not critical. In one example,
25 most values are in the first group, but a number of values are also placed in e.g. the fourth group. In such a case, there is no immediate cause for concern. In such a case, the classification table which is saved in a memory in the control unit is analyzed in the work shop during e.g. a regular service. With a substantial number of values in one of the higher
30 groups, e.g. group four or five, there is an indication to the work shop that

the system should be measured with e.g. a high frequency measurement system, such as an oscilloscope, in order to find the cause of the abnormal values. If the rate of faulty values is higher than 10% or more, a warning message should be given to the driver.

- 5 For a vehicle with a 600 Volts battery, a typical isolation resistance value may be larger than 1.6 MOhm and preferably larger than 2 MOhm in a correctly functioning system. In this case, values below e.g. 1 MOhm and preferably below 0.5 MOhm can be used to indicate a faulty condition and values above 1 MOhm or more can be seen as representing a normal condition.
- 10 An isolation resistance of 600 kOhm would give a possible current of 1 mA, and such a low isolation resistance value should at least indicate a faulty condition. A lower isolation resistance value could be used to disable the high-voltage system directly in order to avoid hazardous situations.
- 15 When the obtained value is obtained by subtracting the last calculated isolation resistance value from the previously calculated isolation resistance value, obtained values below e.g. 50 kOhm or less will indicate a normal condition and values above 100 kOhm or more will indicate a faulty condition.
- 20 Fig. 5 shows a schematic flow chart of the method for monitoring electrical isolation in an electrical system of a vehicle comprising a high-voltage battery.

- In step 100, a high resistance resistor is connected between one of the battery poles and the vehicle chassis, either between the positive battery pole and the vehicle chassis or between the negative battery pole and the vehicle chassis. The connection of the resistance is controlled by a control unit in the vehicle, and is made by a suitable connection means such as a semiconductor switch.
- 25

In step 110, the voltage over the high resistance resistor is measured with the predefined sample rate by the control unit.

In step 120, the voltage between the other battery pole and the vehicle chassis is measured by the control unit.

- 5 In step 130, a value that represents the isolation resistance value for the measurement is calculated by using the measured voltage values and the high resistance resistor value.

- In step 140, the value that represents the isolation resistance value for the measurement is saved in a corresponding classification group in a
10 classification table. The measurements are repetitively performed when the electrical system of the vehicle is active, i.e. when the vehicle is driving. It is also possible to let the measurements be performed at specific intervals, e.g. a series of measurements every hour or at every 100 km of travel. A series of measurement may be e.g. in the interval of
15 100 to 1000 measurements or more.

- The classification table has a plurality of different classification groups. The number of values in each group will indicate if there is a problem with intermittent faults and on how severe the problem is. The regular isolation measurement system of the vehicle will only detect direct faults in the
20 high-voltage system that can be directly measured with the control system sampling with a frequency of around 1 Hz, i.e. where the fault is relatively stable. Such faults are e.g. short circuits and arc faults. By the use of a classification table, also intermittent faults such as sparks will be detected. The sparks may have a duration in the range between less than one
25 microsecond up to 10 milliseconds. Sparks with such a short duration will not be detected with a regular measuring system.

The value that is used to represent the isolation resistance may be either the calculated isolation resistance value or a value obtained by subtracting the last calculated isolation resistance value from the previously calculated

isolation resistance value. An advantage of subtracting the last calculated isolation resistance value from the previously calculated isolation resistance value is that the difference between the two values is used. The calculated isolation resistance value may vary some between different
5 vehicles and may also vary some over time or depending on outer conditions such as temperature or humidity. By using the difference between two values, this variation can be compensated for.

It is also possible that the stored value is the absolute value of the difference between the two last calculated isolation resistance values.

- 10 The invention is not to be regarded as being limited to the embodiments described above, a number of additional variants and modifications being possible within the scope of the subsequent patent claims.

REFERENCE SIGNS

	1:	Electrical system
	2:	High-voltage battery
	3:	High-voltage components
5	4:	Positive battery pole
	5:	Negative battery pole
	6:	High resistance resistor
	7:	Isolation resistance
	8:	Chassis ground
10	9:	Switch
	10:	Control unit
	11:	Data processing means
	12:	Input and output means
	13:	Memory means
15	14:	Data bus communication means

CLAIMS

1. A method for monitoring electrical isolation in an electrical system
(1) of a vehicle comprising a high-voltage battery (2) having a
positive battery pole (4) and a negative battery pole (5), where the
two battery poles (4, 5) are separated from the vehicle chassis (8),
where the vehicle comprises a control unit (10) adapted to obtain
values that represent the electrical isolation between at least one
battery pole and the chassis, comprising a repetition of the following
steps:
 - obtaining a value that represents the isolation resistance,
- saving the value that represents the isolation resistance
in a classification table having a plurality of different
classification groups.
2. Method according to claim 1, wherein values corresponding to the
electrical isolation between the positive battery pole and the chassis
are stored in one classification table and values corresponding to
the electrical isolation between the negative battery pole and the
chassis are stored in another classification table.
3. Method according to any of the preceding claims, wherein a
warning signal is issued by the control system when the number of
saved values in a predefined classification group exceeds a
predefined share of the total number of obtained values.
4. Method according to claim 3, wherein the warning signal is issued
when the number of saved values in the predefined classification
group exceeds one of; 10%, 25% or 50% of the total number of
obtained values.
5. Method according to any of claims 1 to 4, wherein the values are
saved in a memory and analyzed when the vehicle is in a work
shop for a regular service.

6. A method according to any of the preceding claims, where the value that represents the isolation resistance is obtained by:
- applying a high resistance resistor (6) between one of the battery poles (4, 5) and the vehicle chassis (8),
 - 5 - measuring the voltage over the high resistance resistor (6) with a predefined sample rate,
 - measuring the voltage between the other battery pole (4; 5) and the vehicle chassis(8) with the predefined sample rate,
 - 10 - calculating the value that represents the isolation resistance value by using the measured voltage values and the high resistance resistor value.
7. Method according to claim 6, wherein the sample rate is less than one of the following: 100 Hz, 10Hz or 2Hz.
- 15 8. Method according to any of the preceding claims, wherein the value that represents the isolation resistance is the isolation resistance value.
9. Method according to claim 8, wherein the values in the predefined classification group are less than one of the following: 1 MOhm or
- 20 0.5 MOhm.
10. Method according to any of claims 1 to 6, wherein the value that represents the isolation resistance is obtained by subtracting the last calculated isolation resistance value from the previously calculated isolation resistance value,
- 25 11. Method according to claim 10, wherein the obtained value that represents the isolation resistance is an absolute value.
12. Method according to claim 11, wherein the values in the predefined classification group are larger than one of the following: 5 kOhm or 50kOhm.

- 13.A computer program comprising program code means for performing all the steps of any one of the claims 1 to 12 when said program is run on a computer.
- 5 14.A computer program product comprising program code means stored on a computer readable medium for performing all steps of anyone of the claims 1 to 12 when said program product is run on a computer.
- 10 15.Control apparatus (10) for monitoring the electrical isolation in an electrical system (1) of a vehicle, comprising a memory (13) in which a computer readable program is stored, the program when being executed realizing the steps of the method of any of claims 1 to 12.

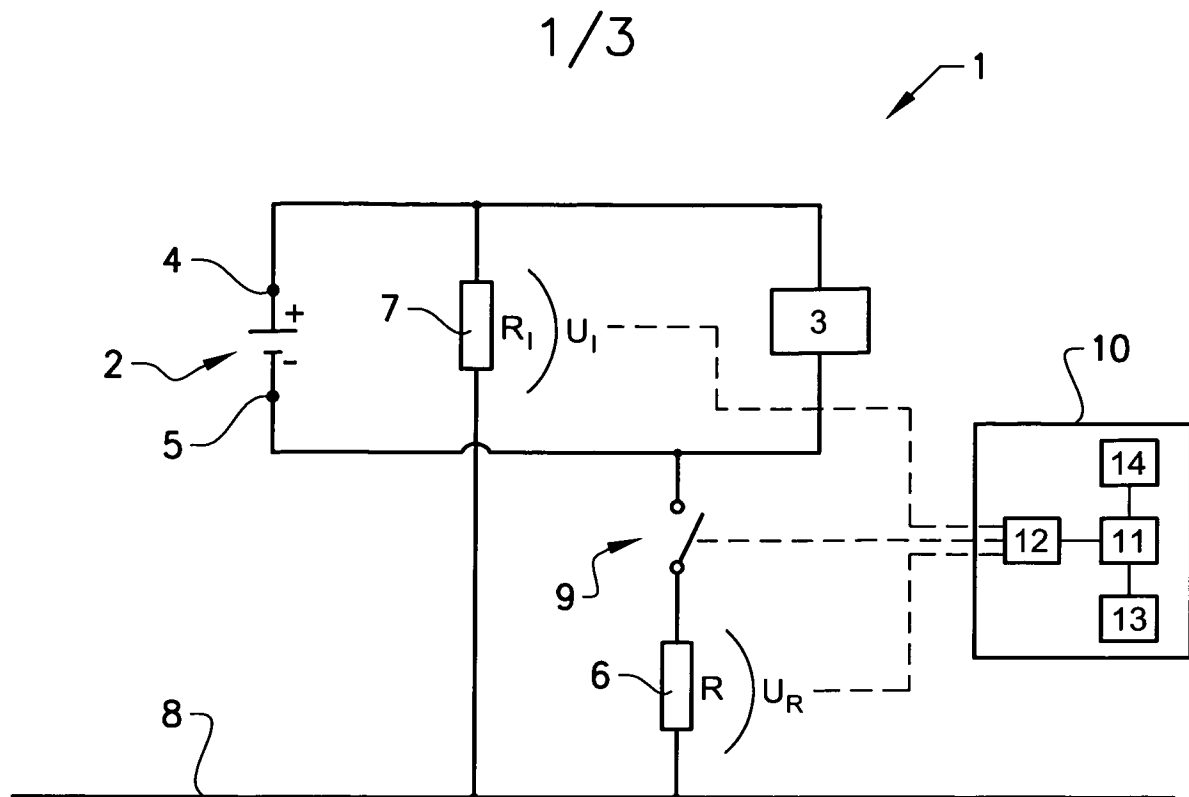


FIG. 1

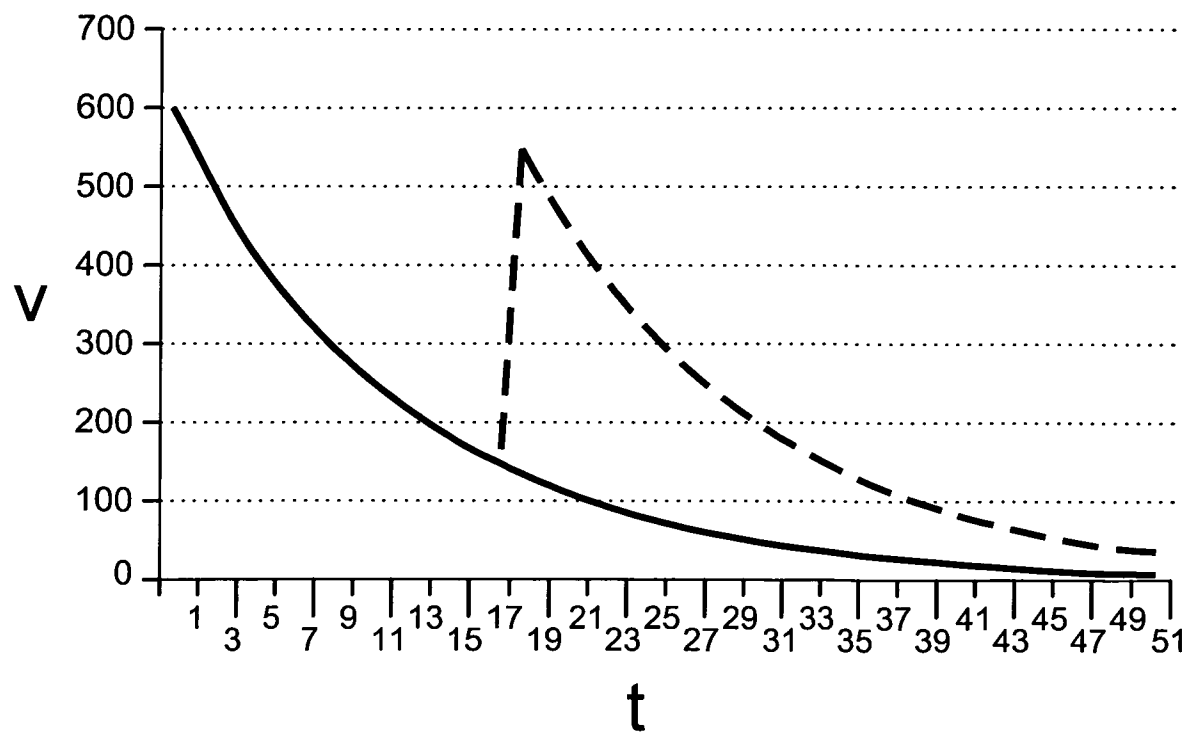


FIG. 2

2/3

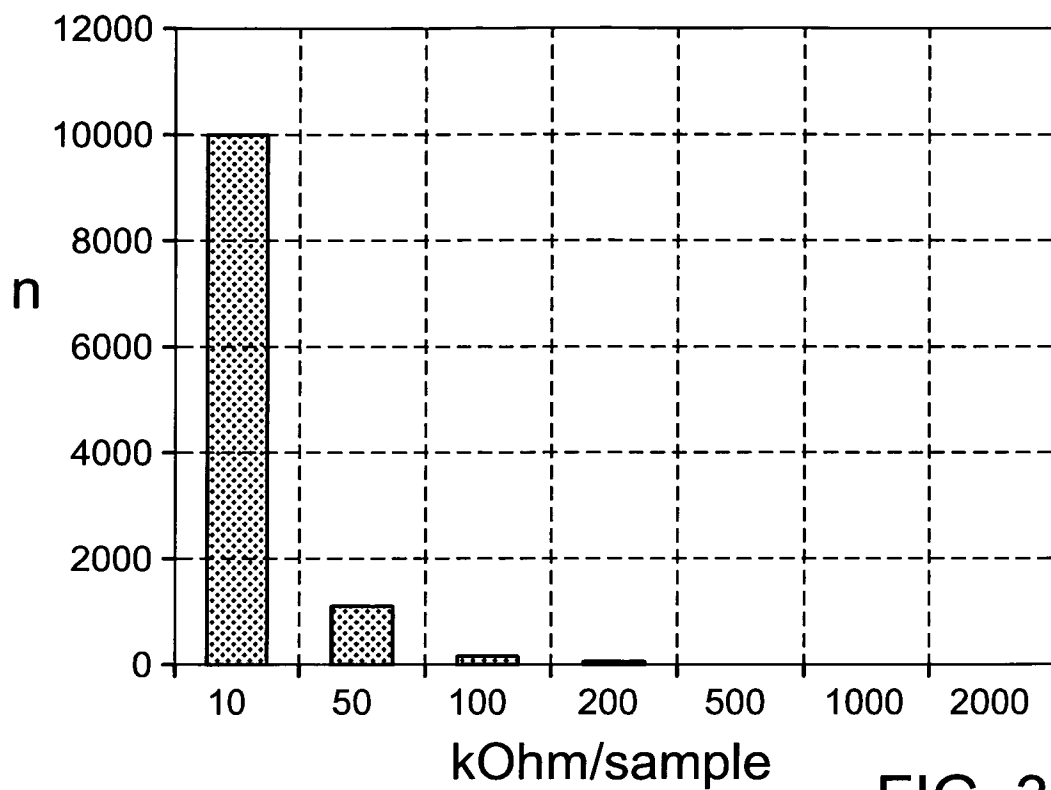


FIG. 3

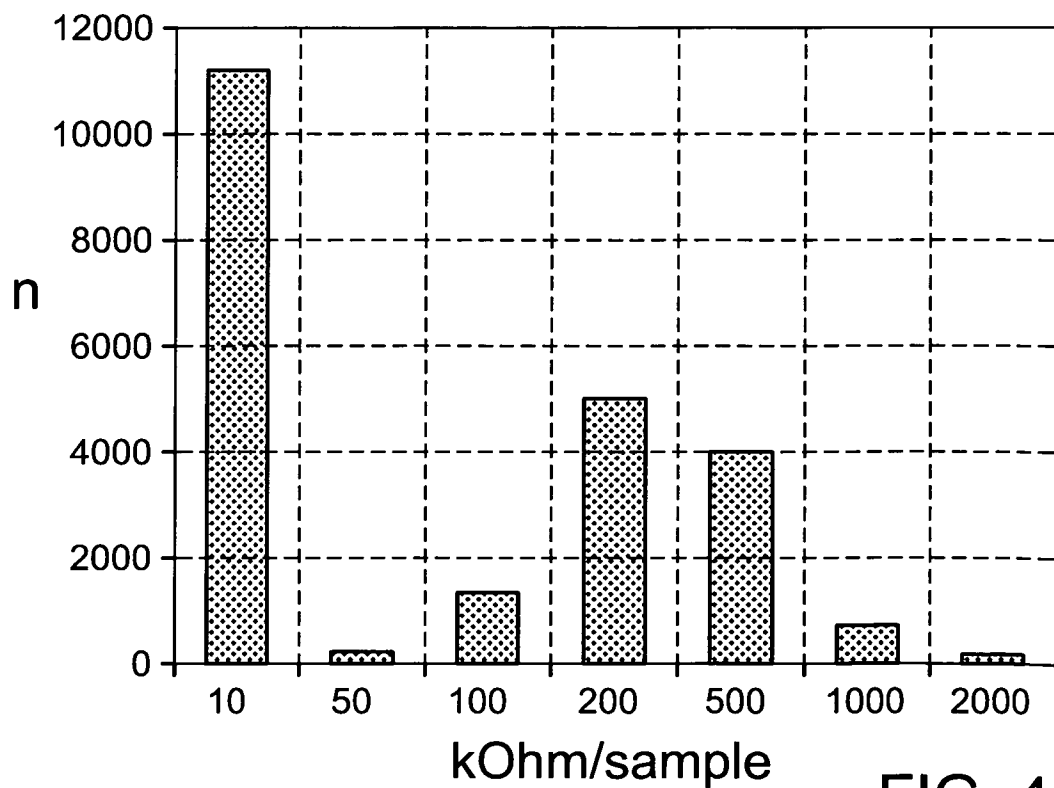


FIG. 4

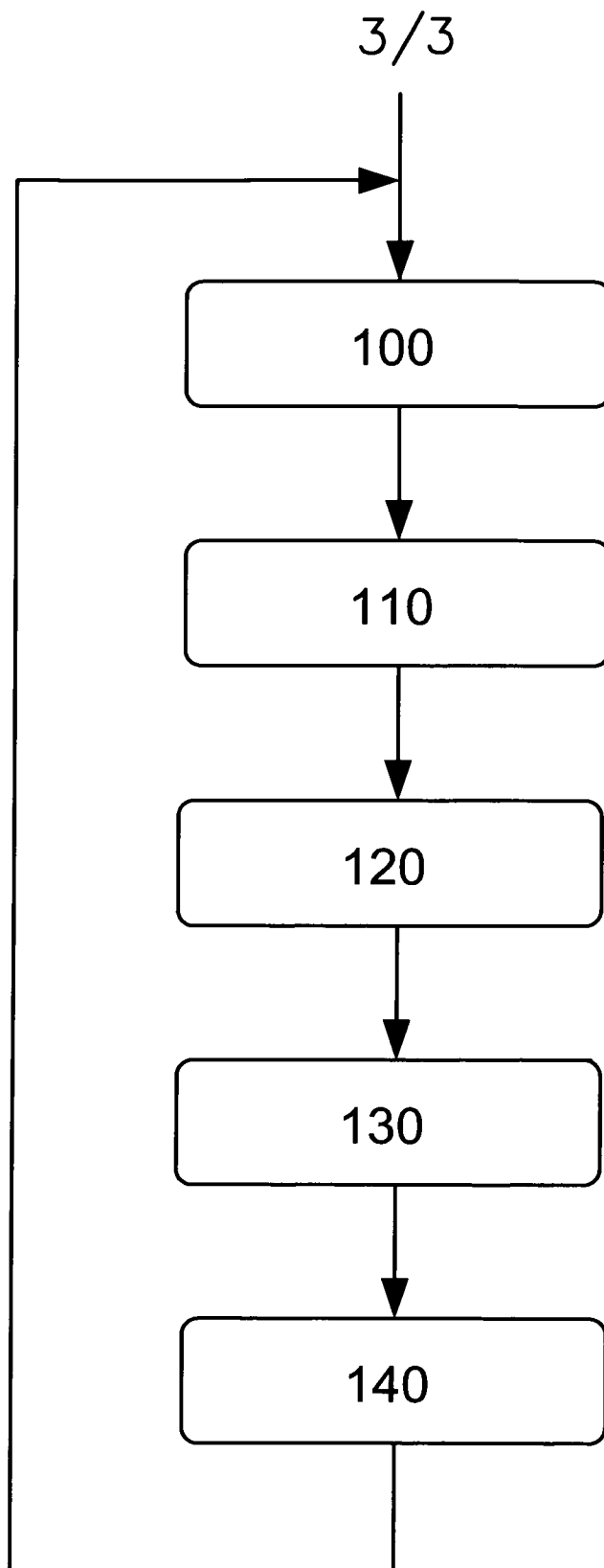


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/004999

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01R27/18 B60L3/00 G01R31/02
ADD.

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)
G01R B60L

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 practicable, 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	DE 10 2010 006108 A1 (BAYERISCHE MOTOREN WERKE AG [DE]) 4 August 2011 (2011-08-04) abstract; figures 1,2 paragraphs [0002], [0005] paragraph [0019] - paragraph [0024] paragraph [0038] - paragraph [0048] paragraph [0059] ----- -/--	1-3,5-15

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

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

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"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

"&" document member of the same patent family

Date of the actual completion of the international search

8 August 2013

Date of mailing of the international search report

19/08/2013

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Ernst, Monika

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2012/004999

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JINGXIN LI ET AL: "Research on Insulation Resistance On-Line Monitoring for Electric Vehicle", ELECTRICAL MACHINES AND SYSTEMS, 2005. ICEMS 2005. PROCEEDINGS OF THE EIGHTH INTERNATIONAL CONFERENCE ON NANJING, CHINA 27-29 SEPT. 2005, PISCATAWAY, NJ, USA, IEEE, vol. 1, 27 September 2005 (2005-09-27), pages 814-817, XP010877521, ISBN: 978-7-5062-7407-4 the whole document -----	1-15
X	US 2011/218745 A1 (HASAN S M NAYEEM [US] ET AL) 8 September 2011 (2011-09-08) abstract; figures 1,2 paragraph [0009] paragraph [0015] - paragraph [0033] -----	1-15
A	EP 2 256 506 A1 (BENDER W GMBH CO KG [DE]) 1 December 2010 (2010-12-01) abstract; figure 1 -----	1-15
A	US 6 906 525 B2 (SUZUKI KOUHEI [JP]) 14 June 2005 (2005-06-14) cited in the application abstract; figures 1,2,7 -----	1-15
A	US 5 561 380 A (SWAY-TIN MIN [US] ET AL) 1 October 1996 (1996-10-01) abstract; figures 1,3-5 -----	1-15

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2012/004999

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 102010006108 A1	04-08-2011	NONE	
US 2011218745 A1	08-09-2011	CN 102193066 A DE 102011012588 A1 US 2011218745 A1	21-09-2011 12-01-2012 08-09-2011
EP 2256506 A1	01-12-2010	EP 2256506 A1 US 2012126839 A1 WO 2010136284 A1	01-12-2010 24-05-2012 02-12-2010
US 6906525 B2	14-06-2005	JP 3678151 B2 JP 2002209331 A US 2002121902 A1	03-08-2005 26-07-2002 05-09-2002
US 5561380 A	01-10-1996	CA 2167440 A1 FR 2734060 A1 JP H08308002 A US 5561380 A	09-11-1996 15-11-1996 22-11-1996 01-10-1996