

## OICA Draft Proposal for the ELSA Meeting July 22-24 in Bonn

### ELECTRICAL SAFETY PROVISIONS FOR VEHICLES IN USE

#### 1. **Scope General**

This module shall apply to the drive train of electric vehicles, hybrid vehicles and fuel cell vehicles high voltage components and systems which are galvanically connected to the high voltage bus of vehicles including the coupling system for connecting to the mains.

#### 2. **Definitions**

For the purpose of this regulation the following definitions apply:

##### 2-1 "Traction battery"

the electrical power storage units which are electrically connected, and its assembly, for the supply of energy of the power.

##### 2-1 "Rechargeable energy storage system RESS"

system that stores energy for delivery of electric energy and which is rechargeable

##### 2-2 "Passenger compartment"

the space for occupant accommodation, bounded by the roof, floor, side walls, doors, window glass, front bulkhead and rear bulkhead, or rear gate, as well as by the barriers and enclosures provided for protecting the power train from direct contact with live parts.

##### 2-3 "Luggage compartment"

the space in the vehicle for luggage accommodation, bounded by the roof, hood, floor, side walls, as well as by the barrier and enclosure provided for protecting the power train from direct contact with live parts, being separated from the passenger compartment by the front bulkhead or the rear bulk head.

##### 2-4 "Direct contact"

the contact of persons with live parts.

##### 2-5 "Live parts"

any conductive part(s) intended to be electrically energized in normal use.

##### 2-6 "Indirect contact"

the contact of persons with exposed conductive parts.

2-7 “Protection degree IPXXB” and “Protection degree IPXXD”

refer to those defined in ISO 20653 (2006??), Road vehicles - Degrees of protection (IP-Code) - Protection of electrical equipment against foreign objects, water and access

2-8 “Exposed conductive part”

conductive part which can be touched without using any tools, and which is not normally alive, but which may become electrically energized under insulation failure conditions.

2-8-1 “Exposed conductive part”

conductive part which can be touched under the provisions of the applicable protection degree (see 2.7), and which is not normally alive, but which may become electrically energized under any failure conditions.

2-8-2 “Non-exposed conductive part”

Conductive part which cannot be touched under the provisions of the applicable protection degree (see 2.7)]

2-9 “Electrical circuit”

an assembly of connected live parts through which an electric current is designated to be electrically energized pass in normal operation conditions.

2-10 “Working voltage”

the highest value of an electrical circuit voltage, specified by the manufacturer, which may occur between any conductive parts in open circuit conditions or under normal operation condition.

2-11 “Electrical chassis”

a set made of conductive parts electrically linked together, whose potential is taken as reference.

2-12 “Solid insulator”

insulating coating of wiring harnesses provided in order to cover and protect the live parts against direct contact from any direction of access; covers for insulating the live parts of connectors; and varnish or paint for the purpose of insulation.

2-13 “Barrier”

the part providing protection against direct contact to the live parts from any direction of access.

2-14 “Enclosure”

the part enclosing the internal units and providing protection against direct contact from any usual direction of access.

2-15 “Service plug”

the device for shutting off the electrical circuit when conducting checks and services of the traction battery, fuel cell stack, etc.

2 - 16 "High Voltage"

classification of an electric component or circuit, if its maximum working voltage is > 60 V and ≤ [1500 V d.c.] or > 30 V and ≤ [1000 V a.c.] respectively

2 - 17 "High Voltage Bus"

electric circuit, including the vehicle coupling system, that operates on high voltage

2 - 18 "Active driving possible mode"

vehicle mode when application of pressure to the accelerator pedal (or activation of an equivalent control) will cause the drive train to move the vehicle.

**3. Requirements for Protection against Electrical Shock** -not connected

[3-1 General

These electrical safety requirements apply to high voltage buses which are not galvanically connected to external high voltage power supplies.]

3-2 Protection against direct contact

The protection against direct contact with live parts shall comply with paragraphs 3-2-1 and 3-2-2. These protections (solid insulator, barrier, enclosure, etc.) shall be reliably secured and sturdy, and they shall not be able to be opened, disassembled or removed without the use of tools.

However, connectors of the high voltage bus may be separated without the use of tools, provided that they comply with the requirements of paragraphs 3-2-1 and 3-2-2 when separated. ~~under a condition that their connection is separated.~~ This requirement is fulfilled if other components must be removed with the use of tools in order to separate the connector.

3-2-1 For protection of live parts inside the passenger compartment or luggage compartment, the protection degree IPXXD shall be provided.

3-2-2 For protection of live parts in areas other than the passenger compartment or luggage compartment, the protection degree IPXXB must be satisfied.

3-2-3 Service plug

~~In the case of the live parts of an outlet whose electrical circuit is insulated galvanically by the transformer, etc. from the high voltage bus, as well as~~

For the service plug which can be opened, disassembled or removed without tools, it is acceptable if protection degree IPXXB is satisfied under a condition where it is opened, disassembled or removed without tools.

[3-2-4 Vehicle inlet

However, ~~this the provision requirements of §§ 3-2-1 and 3-2-2 shall not apply to the vehicle inlet where the voltage of the live parts becomes equal or below DC 60V or equal or below AC 30V (r.m.s.) immediately after the connection to the external power supply is released.]~~

3-2-4-5 Marking

The symbol shown in Figure 1 shall appear near high voltage electric energy sources as RESS and fuel cell stacks.  
The same symbol shall be visible on enclosures, which, when removed expose live parts of high voltage circuits and/or basic insulation.

[Accessibility and removability of barriers / enclosures should be considered for the necessity of the symbol.]

The symbol background shall be yellow, the bordering and the arrow shall be black.

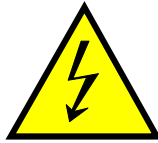


Figure 1 — Marking of high voltage equipment

The outer covering of cables and harness for high voltage circuits, not within enclosures shall be identified by orange color.

NOTE 1 High voltage connectors may be identified by the harnesses to which the connector is attached.

3-3 Protection against indirect contact

3-3-1 For protection against electrical shock which could arise from indirect contact, the exposed conductive parts, such as the conductive barrier and enclosure, shall be galvanically connected securely to the electrical chassis by connection with electrical wire or ground cable, or by welding, or by connection using bolts, etc. so that no dangerous potentials are produced.

3-3-2 The resistance between all exposed conductive parts and the electrical chassis shall be lower than 0.1 ohm when there is current flow of at least 0.2 amperes.

The said resistance shall be regarded as lower than 0.1 ohm when it is clearly evident that the DC electrical connection has been established adequately and securely by such means as welding.

[3-3-3 In the case of motor vehicles which are connected to the external power supply through the conductive connection, a device for galvanical connection of the electrical chassis to the earth ground must be provided.]

3-4 Insulation Resistance

Electrical isolation between the high voltage bus and the electrical vehicle chassis conducting structure shall be > [100] ohms/volt for DC buses, and > [500] ohms/volt for AC buses.

The measurement shall be conducted according to Attached Sheet 1 "Insulation Resistance Measurement Method" or a method equivalent to it.

~~4 Requirements for Protection against Electrical Shock – connected~~

~~4-1 General~~

These electrical safety requirements apply to high voltage buses which are galvanically connected to external high voltage power supplies.

#### 4-2 Protection against direct contact

The protection against direct contact with live parts shall comply with Paragraphs 4-2-1 and 4-2-2. These protections (solid insulator, barrier, enclosure, etc.) shall be reliably secured and sturdy, and they shall not be able to be opened, disassembled or removed without the use of tools. However, connectors of the electrical circuit of the power train may be separated without the use of tools, provided that they comply with the requirements of Paragraphs 4-2-1 and 4-2-2 under a condition that their connection is separated.

This requirement is fulfilled if other components must be removed with the use of tools in order to separate the connector.

4-2-1 For protection of live parts inside the passenger compartment or luggage compartment, the protection degree IPXXD shall be provided.

4-2-2 For protection of live parts in areas other than the passenger compartment or luggage compartment, the protection degree IPXXB must be satisfied.

However, this provision shall not apply to the vehicle inlet where the voltage of the live parts becomes below DC 60V or below AC 30V (r.m.s.) immediately after the connection to the external power supply is released.

#### 4-3 Protection against indirect contact

4-3-1 For protection against electrical shock which could arise from indirect contact, the exposed conductive components, such as the conductive barrier and enclosure, shall be galvanically connected securely to the electrical chassis by connection with electrical wire or ground cable, or by welding, or by connection using bolts, etc. so that no dangerous potentials are produced.

4-3-2 The resistance between all exposed conductive parts and the electrical chassis shall be lower than 0.1 ohm when there is current flow of at least 0.2 amperes. The said resistance shall be regarded as lower than 0.1 ohm when it is clearly evident that the DC electrical connection has been established adequately and securely by such means as welding.

4-3-3 In the case of motor vehicles which are connected to the external power supply through the conductive connection, a device for galvanical connection of the electrical chassis to the earth ground must be provided.

### 5. Requirements for traction batteries

The battery shall be equipped with a protective device (such as fuses or circuit breakers) in order to prevent excessive current. However, this provision shall not apply to cases where there is no likelihood of dangerous effects resulting from excessive currents in the wires and the traction battery. This shall be demonstrated by calculation.

## **[6. Requirements for Functional Safety**

At least a momentary indication must be given to the driver either :

- (a) when the vehicle is in "active driving possible mode" or,
- (b) when one further action is required to place the vehicle in "active driving possible mode".

However, this provision does not apply under conditions where an internal combustion engine provides directly or indirectly the vehicle's propulsion power.]

## Attached Sheet 1

### INSULATION RESISTANCE MEASUREMENT METHOD

#### 1. General

The insulation resistance for each high voltage bus of the vehicle shall be measured or shall be determined by calculation using measurement values from each part or component unit of a high voltage bus (hereinafter referred to as the “divided measurement”).

#### 2. Measurement Method

The insulation resistance measurement shall be conducted by selecting an appropriate measurement method from among those listed in Paragraphs 2–1 through 2–3, depending on the electrical charge of the live parts or the insulation resistance, etc.

The range of the electrical circuit to be measured shall be clarified in advance, using electrical circuit diagrams, etc.

Moreover, modification necessary for measuring the insulation resistance may be carried out, such as removal of the cover in order to reach the live parts, drawing of measurement lines, change in software, etc.

In cases where the measured values are not stable due to the operation of the on-board insulation resistance monitoring system, etc., necessary modification for conducting the measurement may be carried out, such as stopping of the operation of the device concerned or removing it. Furthermore, when the device is removed, it must be proven, using drawings, etc., that it will not change the insulation resistance between the live parts and the electrical chassis.

Utmost care must be exercised as to short circuit, electric shock, etc., for this confirmation might require direct operations of the high-voltage circuit.

#### 2–1 Measurement method using DC voltage from off-vehicle sources

##### 2–1–1 Measurement instrument

An insulation resistance test instrument capable of applying a DC voltage higher than the maximum working voltage of the high voltage bus shall be used.

##### 2–1–2 Measurement method

2–1–2–1 An insulator resistance test instrument shall be connected between the live parts and the electrical chassis. Then, the insulation resistance shall be measured by applying a DC voltage higher than the maximum working voltage of the high voltage bus and coupling system for charging, respectively.

#### 2–2 Measurement method using the vehicle’s own RESS as DC voltage source

##### 2–2–1 Test vehicle conditions

The HV-bus shall be energized by the vehicle’s own RESS and the voltage level throughout the test shall be at least the nominal operating voltage as specified by the vehicle manufacturer..

##### 2–2–2 Measurement instrument

The voltmeter used in this test shall measure DC values and shall have an internal resistance of at least 10 MΩ.

### 2-2-3 Measurement method

#### 2-2-3-1 First step

The voltage is measured as shown in Figure 1 and the HV Bus voltage ( $V_b$ ) is recorded.  $V_b$  shall be must be equal to or greater than the nominal operating voltage as specified by the vehicle manufacturer.

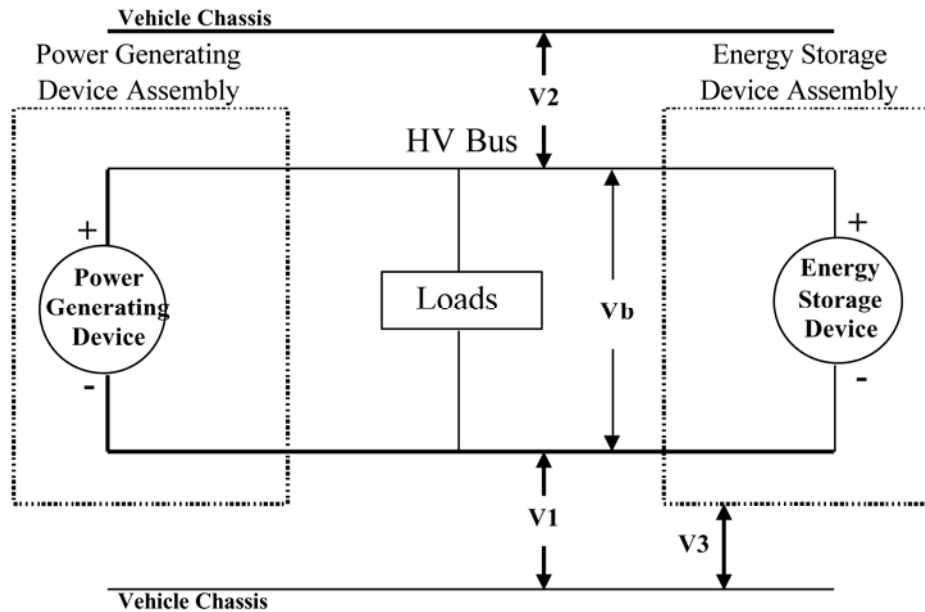


Figure 1: Measurement of  $V_b$ ,  $V_1$ ,  $V_2$

#### 2-2-3-2 Second step

Measure and record the voltage ( $V_1$ ) between the negative side of the high voltage bus and the vehicle chassis (see Figure 1):

#### 2-2-3-3 Third step

Measure and record the voltage ( $V_2$ ) between the positive side of the high voltage bus and the vehicle chassis (see Figure 1):

#### 2-2-3-4 Fourth step

If  $V_1$  is greater than or equal to  $V_2$ , insert a standard known resistance ( $R_0$ ) between the negative side of the high voltage bus and the vehicle chassis. With  $R_0$  installed, measure the voltage ( $V_1'$ ) between the negative side of the high voltage bus and the vehicle chassis (see Figure 2).



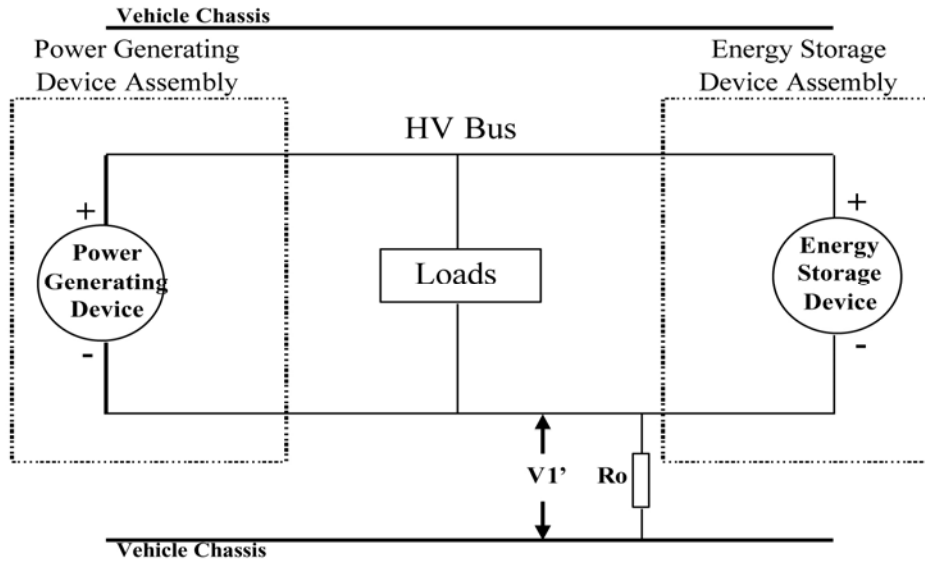


Figure 2: Measurement of V1'

Calculate the electrical isolation (Ri) according to the following formula:

$$Ri = Ro * (Vb/V1' - Vb/V1) \text{ or } Ri = Ro * Vb * (1/V1' - 1/V1)$$

If V2 is greater than V1, insert a standard known resistance (Ro) between the positive side of the high voltage bus and the vehicle chassis. With Ro installed, measure the voltage (V2') between the positive side of the high voltage bus and the vehicle chassis. (See Figure 3). Calculate the electrical isolation (Ri) according to the formula shown. Divide this electrical isolation value (in ohms) by the nominal operating voltage of the high voltage bus (in volts).

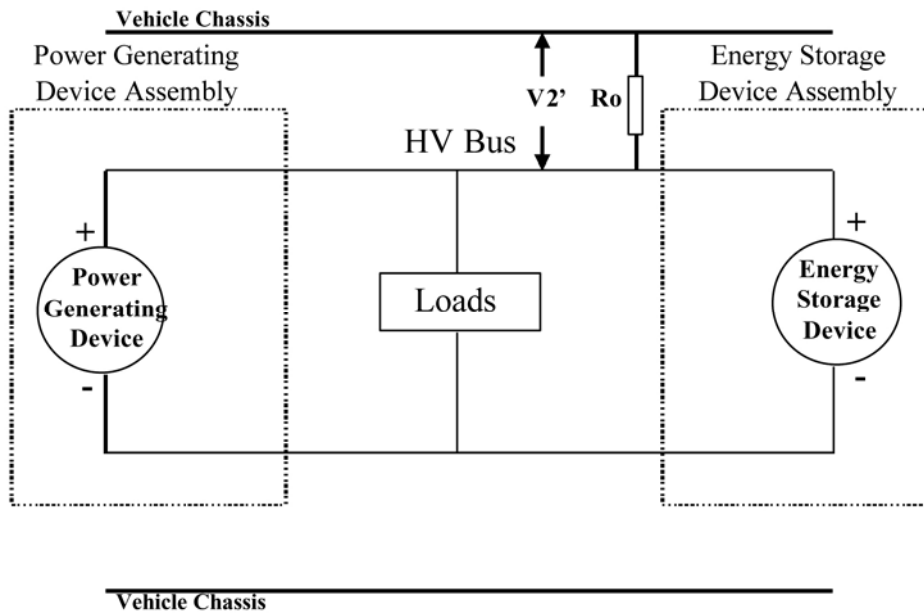


Figure 3: Measurement of V2'

Calculate the electrical isolation (Ri) according to the following formula:

$$R_i = R_o \cdot (V_b / V_2' - V_b / V_2) \quad \text{or} \quad R_i = R_o \cdot V_b \cdot (1 / V_2' - 1 / V_2)$$

2-2-3-5 Fifth step

The electrical isolation value Ri (in ohms) divided by the maximum operating voltage of the high voltage bus (in volts) shall be equal to or greater than 100 Ω/V for high voltage d.c. electric circuits or 500 Ω/V for high voltage a.c. electric circuits.

NOTE 1: The standard known resistance Ro (in ohms) should be approximately 500 times the nominal operating voltage of the vehicle (in volts). Ro is not required to be precisely this value since the equations are valid for any Ro; however, an Ro value in this range should provide good resolution for the voltage measurements.

## 2-3 Measurement method by an on-board insulation resistance monitoring system

### 2-3-1 Measurement instrument

The on-board insulation resistance monitoring system shall be capable of monitoring the insulation resistance between the live parts and the electrical chassis and of giving a warning before it drops to 100 Ω/V for high voltage d.c. electric circuits or 500 Ω/V for high voltage a.c. electric circuits. Its function shall be confirmed by the method indicated in Paragraphs 2-3-1-1 through 2-3-1-2 or a method equivalent to it.

#### 2-3-1-1 Example of confirmation method in which a resistor is inserted in parallel in the high-voltage circuit

Warning of the driver shall be given when a resistor is inserted which makes the combined insulation resistance between the terminal being monitored and the electrical chassis 100 Ω/V for high voltage d.c. electric circuits or 500 Ω/V for high voltage a.c. electric circuits.

### 2-3-1-2 Example of confirmation method in which a pseudo signal is inputted

In cases where the relationship between the input value and output voltage of the sensor is clear warning shall be given when a pseudo voltage corresponding to the output voltage equivalent to 100  $\Omega/V$  for high voltage d.c. electric circuits or 500  $\Omega/V$  for high voltage a.c. electric circuits is applied instead of the output of the sensor concerned.

### 2-3-2 Measurement method

Confirm that no warning is given under a condition that the on-board insulation resistance monitoring system is operating. In this case, confirmation as to whether or not the insulation resistance drop monitor is operating may be performed by means of the initial check function of the warning lamp when the motor vehicle is started.

If no warning is given, the insulation resistance shall be regarded as more than 100  $\Omega/V$  for high voltage d.c. electric circuits or 500  $\Omega/V$  for high voltage a.c. electric circuits.]

[Attached Sheet 2 (for information)]

**FUNCTION CONFIRMATION METHOD OF POWER SUPPLY SHUT-OFF AT TIME OF ELECTRIC LEAKAGE**

The following shall prescribe the function confirmation method and requirements of power supply shut-off at time of electric leakage.

1. Confirmation method for functions of power supply shut-off at time of electric leakage

Paragraph 1-1 shows an example of the confirmation method in which leakage of electric current is caused by the resistor. Paragraph 1-2 gives an example of the confirmation method in which pseudo signal is added.

This confirmation requires the operation of the high-voltage circuit directly. Therefore, utmost care must be exercised as to short circuit, electrical shock, etc.

1-1 Example of confirmation method in which leakage of electric current is caused by resistor

An appropriate resistor shall be inserted between the terminal for which the leaking electric current is monitored and the electrical chassis. At this time, the relationship between the electric current flowing in the resistor and the time elapsed until the shutting-off, shall be measured. The measurement shall be conducted with various electric currents by changing the resistance of the resistor connected.

1-2 Example of confirmation method using a pseudo signal

In cases where the relationship between the input value and output voltage of the sensor is clear through the submitted data of characteristics of the sensor being used, etc., the relationship between the pseudo voltage being applied and the time elapsed until the shutting-off shall be measured when a pseudo voltage corresponding to the output voltage equivalent to the shutting-off limitation is applied instead of the output of the sensor concerned.

2. Requirements of power supply shut-off at time of electric leakage

The shut-off requirements shall be prescribed according to the leaking electric current and continuation time. Shutting-off shall take place below 200 mA when the continuation time is 10 msec or less; below the electric current determined from the following formula according to the continuation time when the continuation time is between 10 msec and 2 seconds; and below 26 mA when the continuation time is 2 seconds or more.

$$I=10-0.38507 \log_{10} t+2.6861$$

where:

I : Leaking electric current (mA)

t : Continuation time (msec)

Leaking electric current I (mA)