Japan comments on *China's proposals for High Voltage Safety*

EVS-GTR IWG#18_June, 2019 @ Tokyo

Items

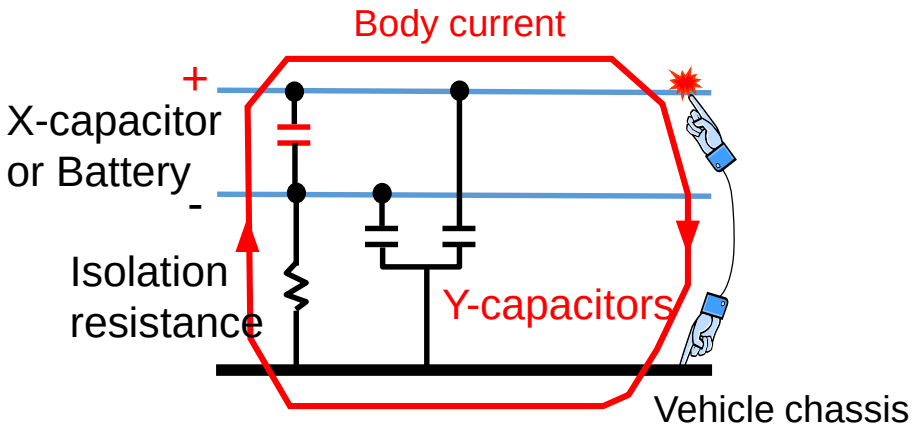
- Japan position on China proposals
- Japan Comments on
  1. Low electrical energy requirements
  2. Isolation resistance test procedures

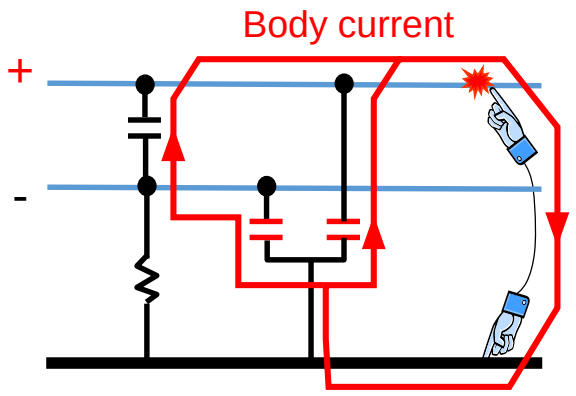
Japan still has several comments to be discussed.

China's proposal	Japan position
Connectors requirements	No comments. (This proposal has already been withdrawn.)
Low electrical energy requirements	Japan has comments to be discussed. • Alternative energy calculation procedures • 10kPa requirement for mechanically robust protections.
Isolation resistance test procedures	Japan has comments to be discussed. • Internal resistance of voltmeters • Alternative resistance calculation formula
Confirmation method for isolation monitoring	No comments.

1,China proposal

The risk by Y-capacitors in single-fault situation need to be managed.



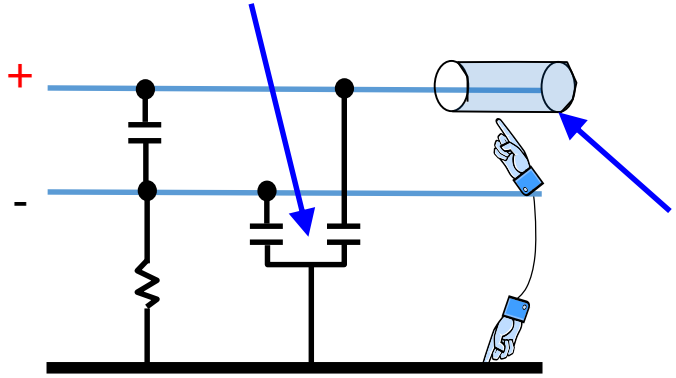


Body current from X-capacitor or battery is limited by the isolation resistance.

Body current from Y-capacitors is not limited by the isolation resistance.

2,Measures to address the risk

Option1_Energy stored in Y-capacitors should be less than 0.2J.



Comments are provided from Japan.

Option2_
Protection that can deal with first fault situation.

- At least two or more layers of insulators or barriers
- Mechanically robust protections (***China proposed 10kPa as a criterion.***)

3,Japan proposal-1

Alternative calculation measure of Y-capacitors' energy should be added in current GTR20 text as an alternative approach.

6.1.6.2.3. Assessment procedure for low electrical energy.

(c) When V1 and V2 (see Figure 8) are measured at a point in time between 10 s and 60 s after the impact and the capacitances of the Y-capacitors (Cy1, Cy2) are specified by the manufacturer, total energy (TEy1, TEy2) shall be calculated according to the following formulas:

$$\mathrm{TEy1} = 0.5 \times \mathrm{Cy1} \times \mathrm{V1}^2 \quad \mathrm{TEy2} = 0.5 \times \mathrm{Cy2} \times \mathrm{V2}^2$$

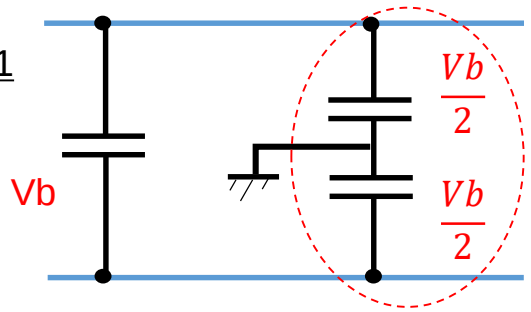
Add an alternative approach.

Alternatively, the calculation of total energy TEy may be conducted according to the formula below with using Vb.

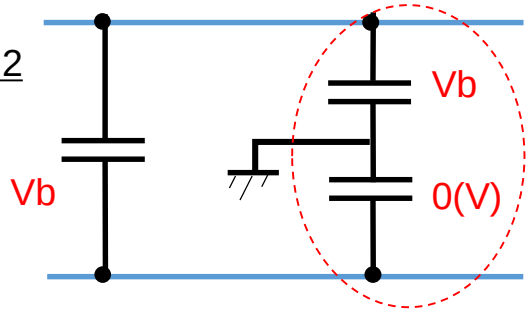
$$\mathrm{TEy} = \mathrm{TEy1} + \mathrm{TEy2} = 0.5 \times \mathrm{Cy} \times \mathrm{Vb}^2$$

Cy: Cy1 or Cy2 whichever is higher

Case 1



Case 2



$$TEy = 0.5 \times Cy \times 2 \times \left(\frac{Vb}{2}\right)^2 = \frac{1}{4} \times Cy \times Vb^2 \quad < \quad TEy = \frac{1}{2} \times Cy \times Vb^2$$

Maximum energy can be calculated with using the battery voltage.

Request of comments from IWG

3,Japan proposal-2

10kPa requirement in China proposal needs to be discussed at EVS-GTR IWG.

➢ *GTR 20 current text*

5.1.1.2.4.2. Electric power train consisting of combined DC- and AC-buses.

- - - if all AC high voltage buses are protected by one of the two following measures, isolation resistance - - - shall have a minimum value of 100 Ω/V of the working voltage:

a. At least two or more layers of solid insulators, electrical protection barriers or enclosures - - -, or

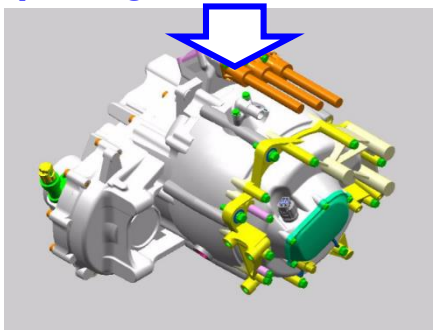
b. Mechanically robust protections that have sufficient durability over vehicle service life such as motor housings, electronic converter cases or connectors.

New approach for quantifying of “mechanically robust protection”

➢ *Text proposed by China*

The class B voltage circuit shall have at least two insulation layers, barriers or enclosures, or placed inside or behind the enclosures, which shall be able to withstand the pressures no less than 10 kPa without significant plastic deformation.

10kPa (=10kg on 10cm*10cm)



➢ *Issues*

- What is the rationale of 10kPa? It seems appropriate because it means putting 10kg weight for the square measuring 10cm by 10cm.
- The evaluation method for 10kPa should be clarified.

Request of comments from China

3,Japan proposal-3

- *Text proposed by China*

6.1.1.2.2.3.2. Second step

Measure the voltages between two terminals of REESS and the electrical chassis simultaneously ~~using two voltmeters with the same internal resistance~~, as shown in figure 1.

No need to require that the internal resistances are equivalent.

6.1.1.2.2.3.3. Third step

A standard known resistance (Ro) is - - - using two voltmeters ~~with the same internal resistance~~.
- - - The electrical isolation (Ri) is calculated according to the following formula:

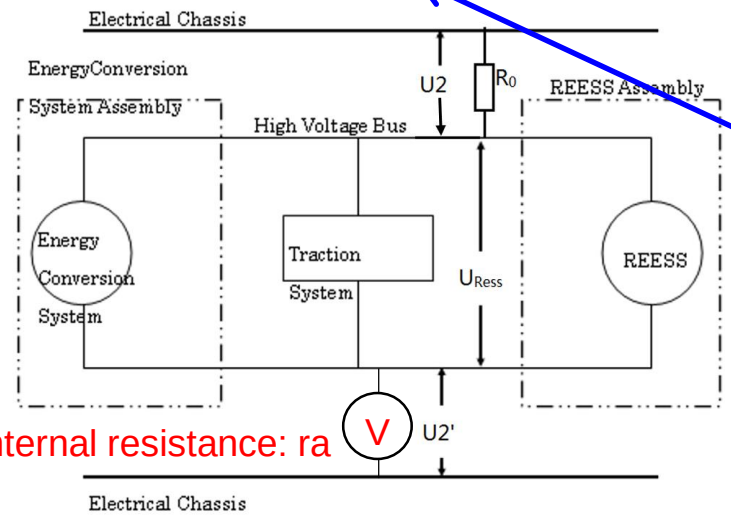
$$Ri = \frac{1}{\frac{1}{R0\left(\frac{U2'}{U2} - \frac{U1'}{U1}\right)} - \frac{1}{\neq \boldsymbol{ra}}}$$

The internal resistance value of the voltmeter connected to U2' side needs to be identified with a high accuracy. The manual or catalog of the voltmeter should be checked beforehand. If there is a deviation specified in a catalog, maximum resistance value should be used for calculation

Revise the formula and add text.

$$Ri = \frac{1}{\frac{1}{R0 \cdot \mathrm{Uress} \cdot \left(\frac{1}{U2} - \frac{1}{U1}\right)} - \frac{1}{\boldsymbol{ra}}}$$

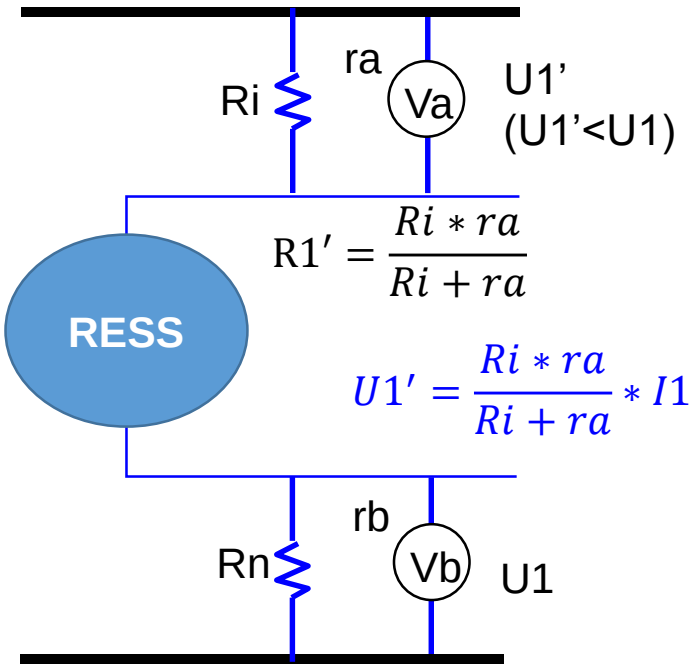
The calculation formula in GTR20 and in China proposal are equivalent.



Internal resistance: ra

The isolation resistance calculation formula proposed by China should be revised.

Derivation of isolation resistance calculation formula



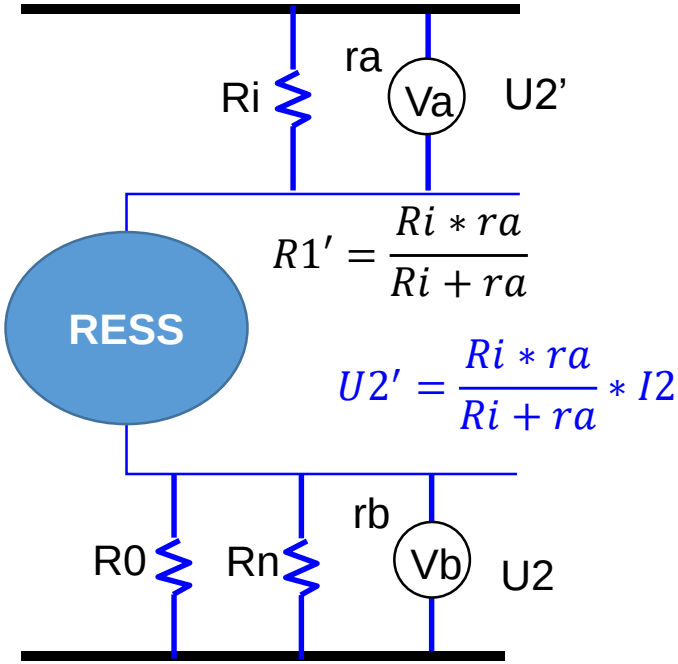
$$R1' = \frac{Ri * ra}{Ri + ra}$$

$$U1' = \frac{Ri * ra}{Ri + ra} * I1$$

$$R1 = \frac{Rn * rb}{Rn + rb}$$

$$U1 = \frac{Rn * rb}{Rn + rb} * I1$$

$$\frac{U1'}{U1} = \frac{\frac{Ri * ra}{Ri + ra}}{\frac{Rn * rb}{Rn + rb}}$$



$$R1' = \frac{Ri * ra}{Ri + ra}$$

$$U2' = \frac{Ri * ra}{Ri + ra} * I2$$

$$R1 = \frac{Rn * R0 * rb}{R0 * rb + Rn * rb + R0 * Rn}$$

$$U2 = \frac{Rn * R0 * rb}{R0 * rb + Rn * rb + R0 * Rn} * I2$$

$$\frac{U2'}{U2} = \frac{\frac{Ri * ra}{Ri + ra}}{\frac{R0 * Rn * rb}{R0 * rb + Rn * rb + R0 * Rn}}$$

Revised calculation

- Supposed condition : ra ≠ rb

ra, rb: internal resistance of voltmeters

$$\frac{U1'}{U1} = \frac{\frac{Ri * ra}{Ri + ra}}{\frac{Rn * rb}{Rn + rb}} = \frac{Ri * ra * (Rn + rb)}{Rn * rb * (Ri + ra)}$$

$$\frac{U2'}{U2} = \frac{\frac{Ri * ra}{Ri + ra}}{\frac{R0 * Rn * rb}{R0 * rb + Rn * rb + R0 * Rn}} = \frac{Ri * ra * (R0 * rb + Rn * rb + R0 * Rn)}{R0 * Rn * rb * (Ri + ra)}$$

$$R0\left(\frac{U2'}{U2} - \frac{U1'}{U1}\right) = \frac{Ri * ra * (R0 * rb + Rn * rb + R0 * Rn)}{Rn * rb * (Ri + ra)} - \frac{R0 * Ri * ra * (Rn + rb)}{Rn * rb * (Ri + ra)}$$

$$= \frac{Rn * Ri * ra * rb}{Rn * rb * (Ri + ra)} = \frac{Ri * ra}{Ri + ra}$$

Correct calculation formula

$$\frac{1}{R0\left(\frac{U2'}{U2} - \frac{U1'}{U1}\right)} - \frac{1}{ra} = \frac{Ri + ra}{Ri * ra} - \frac{1}{ra} = \frac{1}{Ri} \quad \Rightarrow \quad \boldsymbol{Ri = \frac{1}{\frac{1}{R0\left(\frac{U2'}{U2} - \frac{U1'}{U1}\right)} - \frac{1}{ra}}}$$

There is no need to use two voltmeters which have the same internal resistance.

The internal resistance of voltmeter needs to be identified accurately. It should be mentioned in GTR text.

$$Ri\_r = \frac{1}{\frac{1}{R0\left(\frac{U2'}{U2} - \frac{U1'}{U1}\right)} - \frac{1}{ra}}$$

Internal resistance of voltmeter

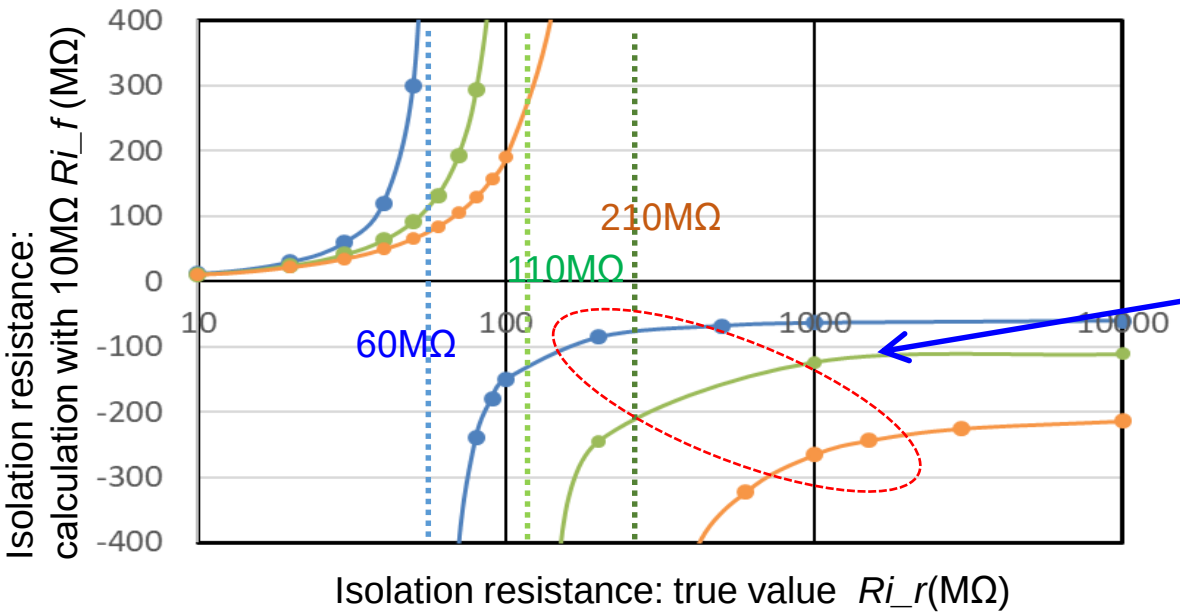
- Current GTR20 text

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

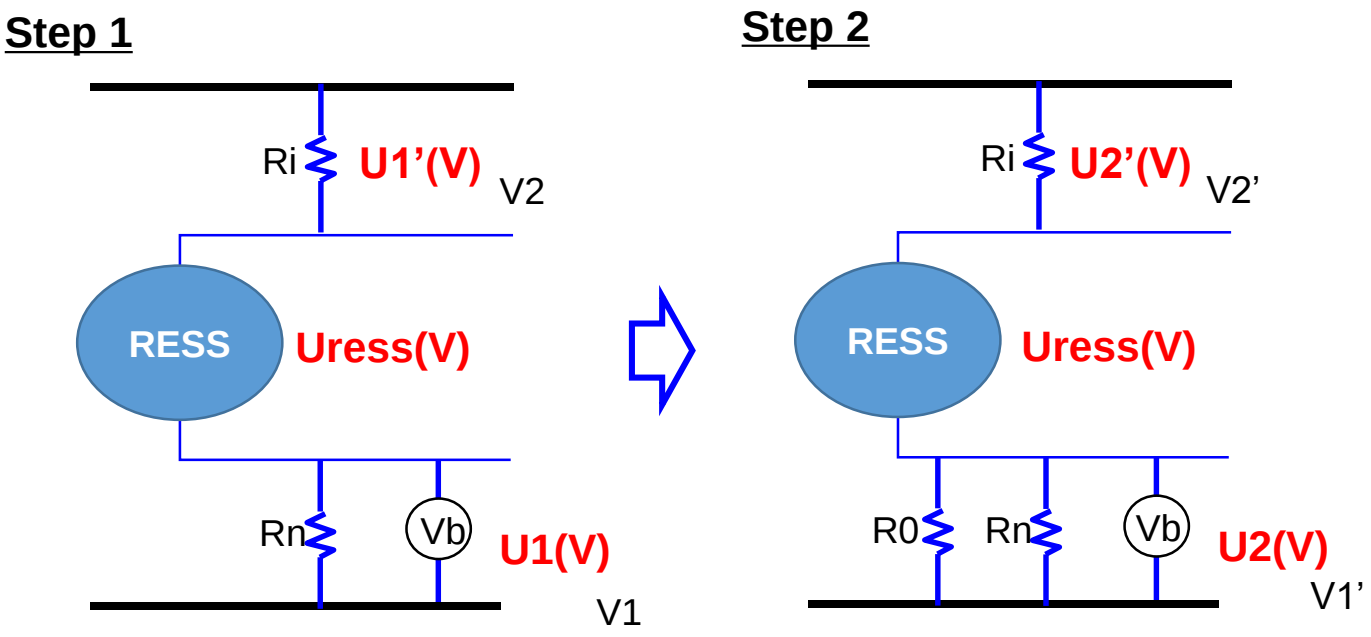
- Calculation with substituting 10Mohms as the internal resistance of voltmeter

$$Ri\_f = \frac{1}{\frac{1}{R0\left(\frac{U2'}{U2} - \frac{U1'}{U1}\right)} - \frac{1}{10M\Omega}}$$

Actual value of internal resistance of voltmeter :ra
ra= 12MΩ 11MΩ 10.5MΩ



Minus values are calculated in the case that the isolation resistance is high.



$$R0 \times \left(\frac{U2'}{U2} - \frac{U1'}{U1}\right) = R0 \times \left(\frac{Uress - U2}{U2} - \frac{Uress - U1}{U1}\right) = R0 \times Uress \times \left(\frac{1}{U2} - \frac{1}{U1}\right)$$

China's formula ⟵ **Equivalent** ⟶ GTR20's formula

Both formulas are equivalent and should be specified in GTR.

China's calculation formula and test procedures

<GTR20 current text>

6.1.1.2.2. Measurement method using the vehicle's own REESS as DC voltage source.
6.1.1.2.2.3. Measurement method.
6.1.1.2.2.3.1. First step.
The voltage is measured as shown in Figure 2 and the **high voltage bus voltage (Vb)** is recorded. Vb shall be equal to or greater than the nominal operating voltage of the REESS and/or energy conversion system as specified by the vehicle manufacturer.

No need in China's procedures

6.1.1.2.2.3.2. Second step.
The voltage (V1) between the negative side of the high voltage bus and the electrical chassis is measured and recorded (see Figure 2).

6.1.1.2.2.3.3. Third step.
The voltage (V2) between the positive side of the high voltage bus and the electrical chassis is measured and recorded (see Figure 2).

The voltage (V2') at another pole needs to be measure in China's proposal

6.1.1.2.2.3.4. Fourth step.
If V1 is greater than or equal to V2, a standard known resistance (Ro) is inserted between the negative side of the high voltage bus and the electrical chassis. With Ro installed, the **voltage (V1')** between the negative side of the high voltage bus and the electrical chassis is measured (see Figure 3).
The electrical isolation (Ri) is calculated according to the following formula:

Ri = Ro*(Vb/V1' – Vb/V1) or Ri = Ro*Vb*(1/V1' – 1/V1)

China's calculation formula

$$\mathbf{Ri} = \mathbf{R0} \times \left(\frac{\mathbf{V2'}}{\mathbf{V1'}} - \frac{\mathbf{V2}}{\mathbf{V1}} \right)$$