TIDA-01513 insulation resistance calculation formula

- Get both resistance of HV positive to chassis ground(Risop) and HV negative to chassis ground(Rison)

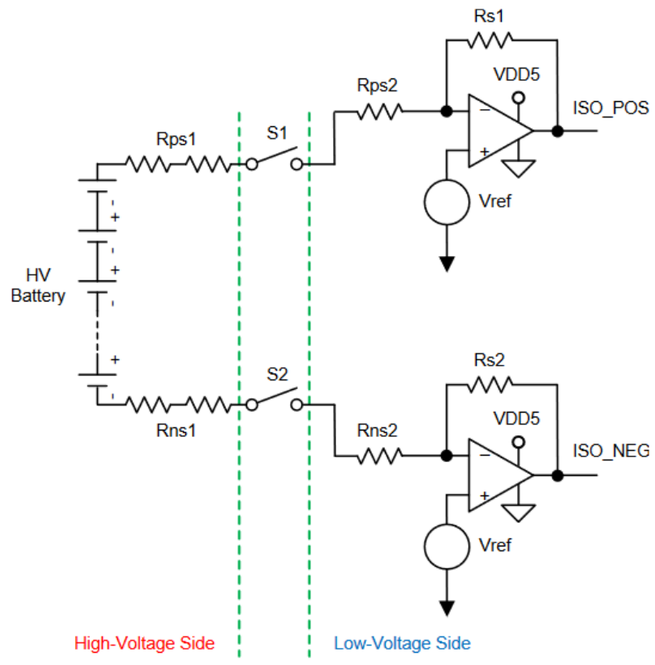


Figure 6. HEV and EV Isolation

Status 1: Close S1 and remain S2 open, ISO_POS and HV_BATT1(Simultaneous with ISO_POS) can be read by the ADC while ISO_NEG remains equal to Vref.
For simplify, α is stipulated as below.

$$\alpha = V_{ref} \cdot \left(1 + \frac{R_{ps}}{R_s}\right) - \frac{R_{ps}}{R_s} \cdot ISO\_POS$$

Then equation 1 can be got.

$$\frac{\frac{V_{ref}}{R_{ps}} + \frac{HV\_BATT1}{R_{ison}}}{\frac{1}{R_{ps}} + \frac{1}{R_{ison}} + \frac{1}{R_{isop}}} = \alpha \qquad \text{equation 1}$$

Status 2: Close S2 and open S1, ISO_NEG and HV_BATT2(Simultaneous with ISO_NEG) can be read by the ADC while ISO_POS remains equal to Vref.
For simplify, β is stipulated as below.

$$\beta = V_{ref} \cdot \left(1 + \frac{R_{ps}}{R_s}\right) - \frac{R_{ps}}{R_s} \cdot ISO\_NEG$$

Then equation 2 can be got.

$$\frac{\frac{V_{ref}}{R_{ps}} - \frac{HV\_BATT2}{R_{isop}}}{\frac{1}{R_{ps}} + \frac{1}{R_{ison}} + \frac{1}{R_{isop}}} = \beta \qquad \text{equation 2}$$

Here, Rps=Rps1+Rps2=Rns1+Rns2, Rs=Rs1=Rs2.

By these two equations, Risop and Rison can be got separately.

$$R_{isop} = \frac{HV\_BATT1 \cdot HV\_BATT2 \cdot R_{ps} + HV\_BATT1 \cdot R_{ps} \cdot \beta - HV\_BATT2 \cdot R_{ps} \cdot \alpha}{HV\_BATT1 \cdot V_{ref} - HV\_BATT1 \cdot \beta + V_{ref} \cdot \beta - V_{ref} \cdot \alpha}$$

$$R_{ison} = -\frac{HV\_BATT1 \cdot HV\_BATT2 \cdot R_{ps} + HV\_BATT1 \cdot R_{ps} \cdot \beta - HV\_BATT2 \cdot R_{ps} \cdot \alpha}{HV\_BATT2 \cdot V_{ref} - HV\_BATT2 \cdot \alpha + V_{ref} \cdot \beta - V_{ref} \cdot \alpha}$$

Double check Risop and Rison with simulation

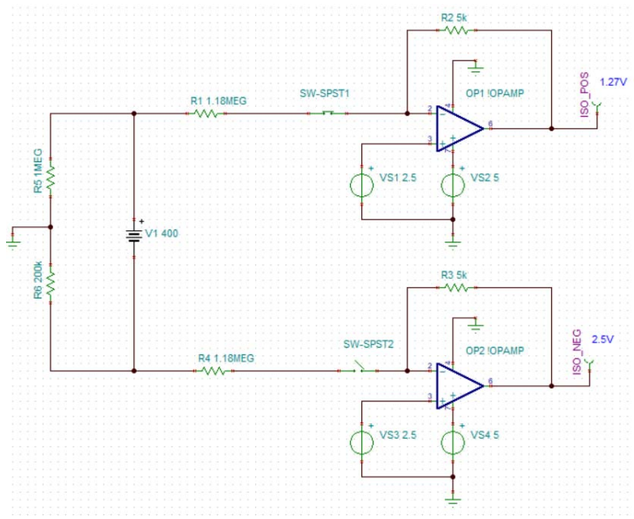
$R_{ps} := 1.18 \cdot 10^6$

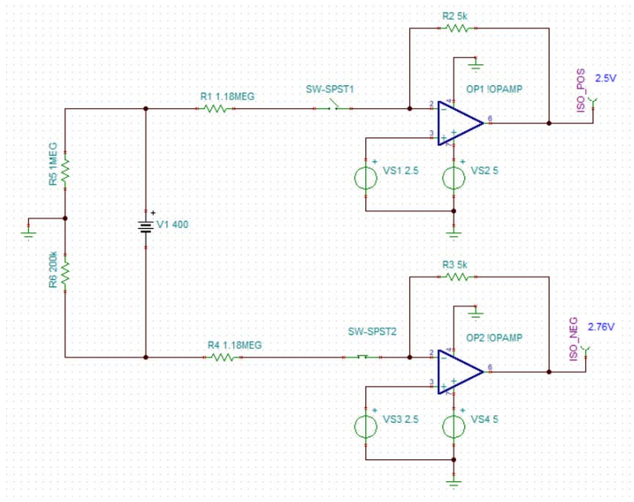
$R_s := 5000$

$HV\_BATT1 := 400$

$HV\_BATT2 := 400$

$V_{ref} := 2.5$





$ISO\_POS := 1.27$

$$\alpha := V_{ref}\cdot\left(1 + \frac{R_{ps}}{R_s}\right) - \frac{R_{ps}}{R_s}\cdot ISO\_POS = 292.78$$

$ISO\_NEG := 2.76$

$$\beta := V_{ref}\cdot\left(1 + \frac{R_{ps}}{R_s}\right) - \frac{R_{ps}}{R_s}\cdot ISO\_NEG = -58.86$$

$$R_{isop} := \frac{HV\_BATT1\cdot HV\_BATT2\cdot R_{ps} + HV\_BATT1\cdot R_{ps}\cdot\beta - HV\_BATT2\cdot R_{ps}\cdot\alpha}{HV\_BATT1\cdot V_{ref} - HV\_BATT1\cdot\beta + V_{ref}\cdot\beta - V_{ref}\cdot\alpha} = 9.645\times 10^{5}$$

$$R_{ison} := -\frac{HV\_BATT1\cdot HV\_BATT2\cdot R_{ps} + HV\_BATT1\cdot R_{ps}\cdot\beta - HV\_BATT2\cdot R_{ps}\cdot\alpha}{HV\_BATT2\cdot V_{ref} - HV\_BATT2\cdot\alpha + V_{ref}\cdot\beta - V_{ref}\cdot\alpha} = 1.951\times 10^{5}$$

Get ISO_POS and ISO_NEG from known Risop and Rison

Status 1: Close S1 and remain S2 open, ISO_POS and HV_BATT1(Simultaneous with ISO_POS) can be read by the ADC while ISO_NEG remains equal to Vref. The formula of getting ISO_POS is the reverse calculation of equation 1.

$$ISO\_POS = \left[V_{ref}\cdot\left(1 + \frac{R_{ps}}{R_s}\right) - \frac{\frac{V_{ref}}{R_{ps}} + \frac{HV\_BATT1}{R_{ison}}}{\frac{1}{R_{ps}} + \frac{1}{R_{ison}} + \frac{1}{R_{isop}}}\right]\cdot\frac{R_s}{R_{ps}}$$

Status 2: Close S2 and open S1, ISO_NEG and HV_BATT2(Simultaneous with ISO_NEG) can be read by the ADC while ISO_POS remains equal to Vref. The formula of getting ISO_POS is the reverse calculation of equation 2.

$$ISO\_NEG = \left[V_{ref}\cdot\left(1 + \frac{R_{ps}}{R_s}\right) - \frac{\frac{V_{ref}}{R_{ps}} - \frac{HV\_BATT2}{R_{isop}}}{\frac{1}{R_{ps}} + \frac{1}{R_{ison}} + \frac{1}{R_{isop}}}\right]\cdot\frac{R_s}{R_{ps}}$$

Status 3: Close both S1 and S2, ISO_POS, ISO_NEG and HV_BATT2(Simultaneous with ISO_POS and ISO_NEG) can be read by the ADC. Equation 3 and equation 4 represent ISO_POS and ISO_NEG with known Risop and Rison.

$$ISO\_POS = \frac{R_{ps}^{2}\cdot R_{ison}\cdot V_{ref} + R_{ps}^{2}\cdot R_{isop}\cdot V_{ref} - HV\_BATT\cdot R_s\cdot R_{ps}\cdot R_{isop} - HV\_BATT\cdot R_s\cdot R_{ison}\cdot R_{isop} + R_s\cdot R_{ps}\cdot R_{ison}\cdot V_{ref} + R_s\cdot R_{ps}\cdot R_{isop}\cdot V_{ref} + 2\cdot R_{ps}\cdot R_{ison}\cdot R_{isop}\cdot V_{ref}}{R_{ps}^{2}\cdot R_{ison} + R_{ps}^{2}\cdot R_{isop} + 2\cdot R_{ps}\cdot R_{ison}\cdot R_{isop}}$$ equation 3

$$ISO\_NEG = \frac{R_{ps}^{2}\cdot R_{ison}\cdot V_{ref} + R_{ps}^{2}\cdot R_{isop}\cdot V_{ref} + HV\_BATT\cdot R_s\cdot R_{ps}\cdot R_{ison} + HV\_BATT\cdot R_s\cdot R_{ison}\cdot R_{isop} + R_s\cdot R_{ps}\cdot R_{ison}\cdot V_{ref} + R_s\cdot R_{ps}\cdot R_{isop}\cdot V_{ref} + 2\cdot R_{ps}\cdot R_{ison}\cdot R_{isop}\cdot V_{ref}}{R_{ps}^{2}\cdot R_{ison} + R_{ps}^{2}\cdot R_{isop} + 2\cdot R_{ps}\cdot R_{ison}\cdot R_{isop}}$$ equation 4

Double check ISO_POS and ISO_NEG by simulation

$R_{ps} := 1.18\cdot 10^{6}$

$R_s := 5000$

$HV\_BATT1 := 400$

$HV\_BATT2 := 450$

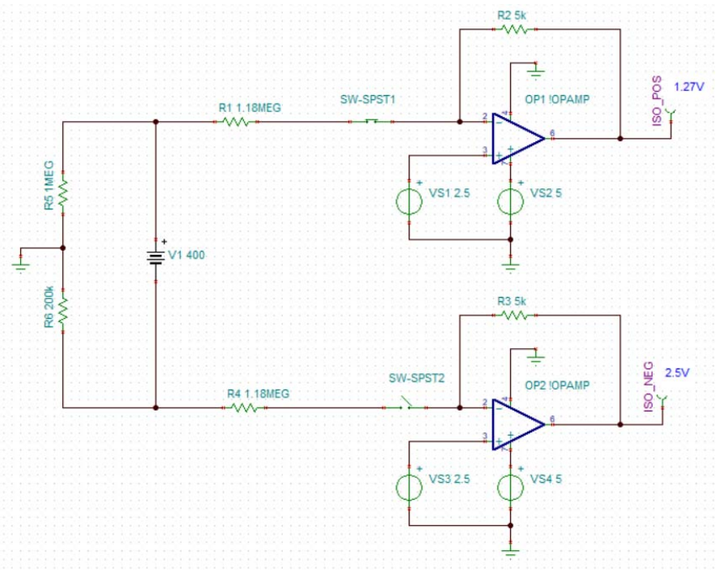
$V_{ref} := 2.5$

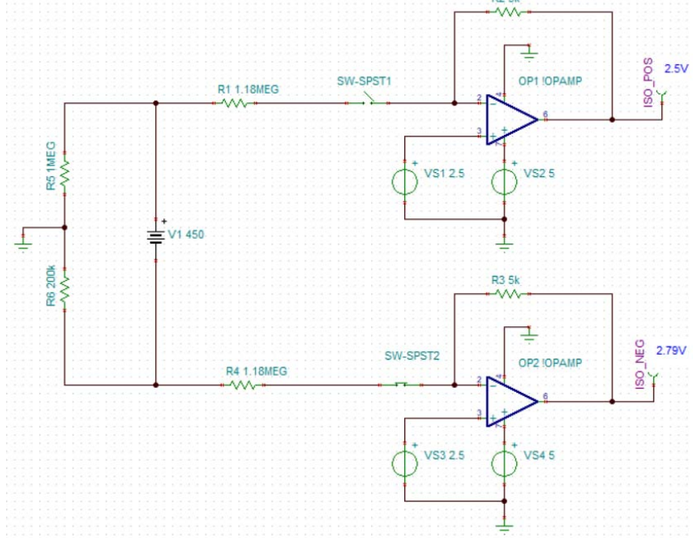
$R_{isop} := 1\cdot 10^{6}$

$R_{ison} := 200\cdot 10^{3}$

$$ISO\_POS := \left[V_{ref}\cdot\left(1 + \frac{R_{ps}}{R_s}\right) - \frac{\frac{V_{ref}}{R_{ps}} + \frac{HV\_BATT1}{R_{ison}}}{\frac{1}{R_{ps}} + \frac{1}{R_{ison}} + \frac{1}{R_{isop}}}\right]\cdot\frac{R_s}{R_{ps}} = 1.272$$

$$ISO\_NEG := \left[V_{ref}\cdot\left(1 + \frac{R_{ps}}{R_s}\right) - \frac{\frac{V_{ref}}{R_{ps}} - \frac{HV\_BATT2}{R_{isop}}}{\frac{1}{R_{ps}} + \frac{1}{R_{ison}} + \frac{1}{R_{isop}}}\right]\cdot\frac{R_s}{R_{ps}} = 2.788$$





$R_{ps} := 1.18 \cdot 10^{6}$

$R_{s} := 5000$

HV_BATT := 500

$V_{ref} := 2.5$

$R_{isop} := 500 \cdot 10^{3}$

$R_{ison} := 200 \cdot 10^{3}$

$$ISO\_POS := \frac{R_{ps}^{2} \cdot R_{ison} \cdot V_{ref} + R_{ps}^{2} \cdot R_{isop} \cdot V_{ref} - HV\_BATT \cdot R_{s} \cdot R_{ps} \cdot R_{isop} - HV\_BATT \cdot R_{s} \cdot R_{ison} \cdot R_{isop} + R_{s} \cdot R_{ps} \cdot R_{ison} \cdot V_{ref} + R_{s} \cdot R_{ps} \cdot R_{isop} \cdot V_{ref} + 2 \cdot R_{ps} \cdot R_{ison} \cdot R_{isop} \cdot V_{ref}}{R_{ps}^{2} \cdot R_{ison} + R_{ps}^{2} \cdot R_{isop} + 2 \cdot R_{ps} \cdot R_{ison} \cdot R_{isop}} = 1.084$$

$$ISO\_NEG := \frac{R_{ps}^{2} \cdot R_{ison} \cdot V_{ref} + R_{ps}^{2} \cdot R_{isop} \cdot V_{ref} + HV\_BATT \cdot R_{s} \cdot R_{ps} \cdot R_{ison} + HV\_BATT \cdot R_{s} \cdot R_{ison} \cdot R_{isop} + R_{s} \cdot R_{ps} \cdot R_{ison} \cdot V_{ref} + R_{s} \cdot R_{ps} \cdot R_{isop} \cdot V_{ref} + 2 \cdot R_{ps} \cdot R_{ison} \cdot R_{isop} \cdot V_{ref}}{R_{ps}^{2} \cdot R_{ison} + R_{ps}^{2} \cdot R_{isop} + 2 \cdot R_{ps} \cdot R_{ison} \cdot R_{isop}} = 3.202$$