



सत्यमेव जयते

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS



Pamphlet on

MEASUREMENT & APPLICATION OF EARTH FAULT LOOP IMPEDANCE

CAMTECH/ EL/ 2021-22/ Earth Fault Loop/ 1.0

END USER

Electrical Engineers and Technicians
Dealing with LV Installations

अभ्यास RDS
रेल अग्रदूत Transforming Railways



Indian Railways
Centre for Advanced Maintenance Technology

MAHARAJPURA, GWALIOR - 474005

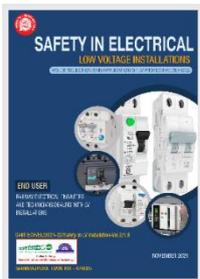
Earth Fault Loop Impedance

(Ref: - Para 3.64 of IS 732:2019)

The impedance of the earth current fault loop (phase to earth loop) starting and ending at the point of earth fault. This impedance is denoted by the symbol Z_s . The earth fault loop comprises the following, starting at the point of earth fault:

- The circuit protective conductor (earth conductor);
- The consumer's earthing terminal and earthing conductor, and for TN systems, The metallic return path;
- For TT and IT systems, the earth return path;
- The path through the earth neutral point of the transformer;
- The transformer winding; and
- The line conductor from the transformer to the point of fault.

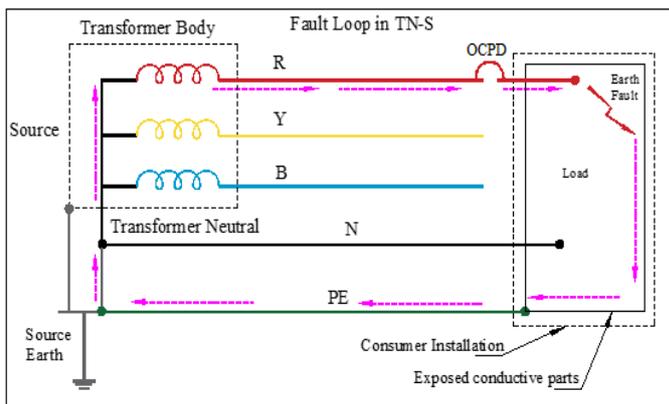
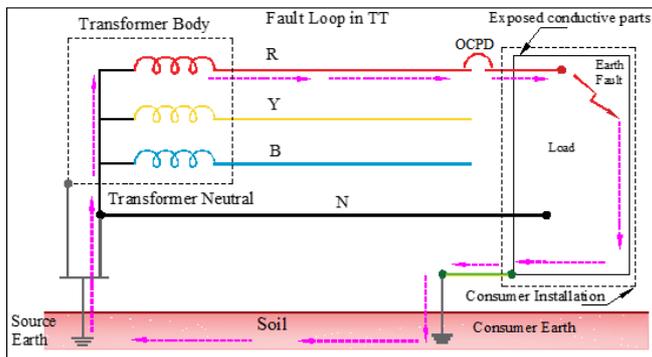
Earth Fault Loop Paths in Different Earthing System



Different Earthing systems has different earth fault path as shown below. (Type of system Earthing already discussed in the Para 6 of CAMTECH Book: "Safety in Electrical Low Voltage Installation" Vol-1 Basic of LV Earthing system)

⇨ TT system

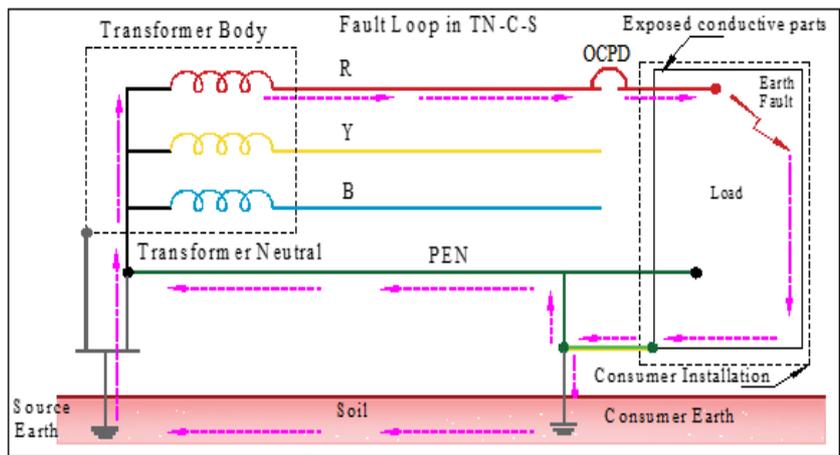
Earth Loop Path due to Earth Fault in TT system



⇨ TNS system

Earth Loop Path due to Earth Fault in TNS system

⇒ TN-C-S system

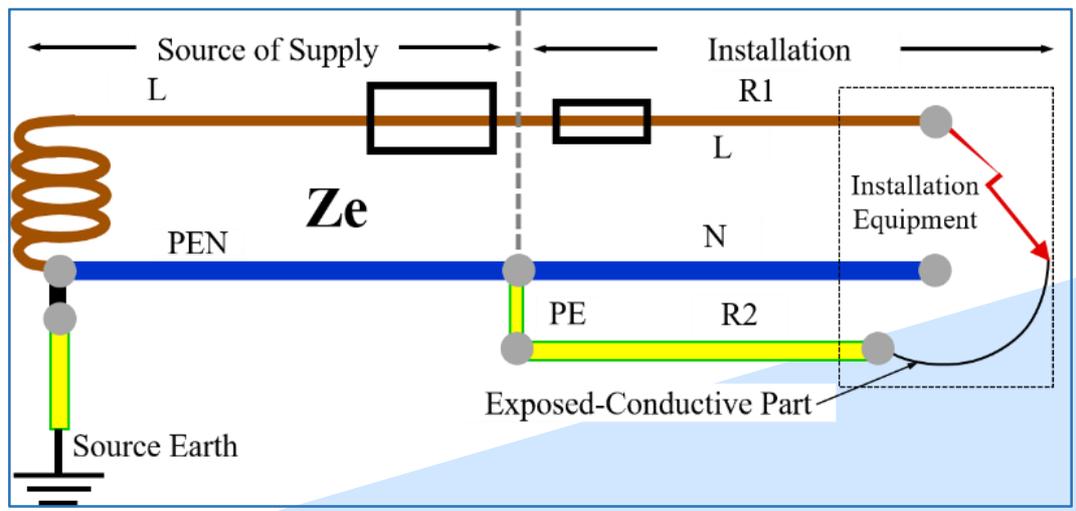


Earth Loop Path due to Earth Fault in TN-C-S system

Note: The value of earth fault loop impedance is lowest in TN-C-S system & highest in TT system as path of fault loop is metallic in case of TN-C-S

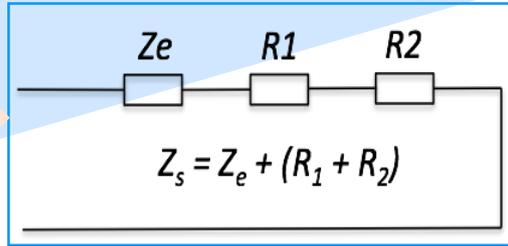
Calculation of Earth fault loop impedance in TN-C-S

The circuit shows the earth fault current path when there is a earth fault in the installation. The resistors indicate the different resistance and impedances that exist in the installation and external supply. All wires/cables have resistance and its depends on the Cross sectional Area & length of the conductors



Calculation of Earth Fault Loop Impedance in TN-S

Earth Fault Loop Impedance Showing Individual Impedance



Z_s = Total earth fault loop impedance.

Z_e = The external loop impedance. i.e. the impedance from source upto the start of installation(Main distribution board) including transformer winding.

R_1 = The resistance of the line conductor from MDB to the fault point.

R_2 = The resistance of the protective conductor from fault point to MDB.

Measurement of Fault Loop Impedance

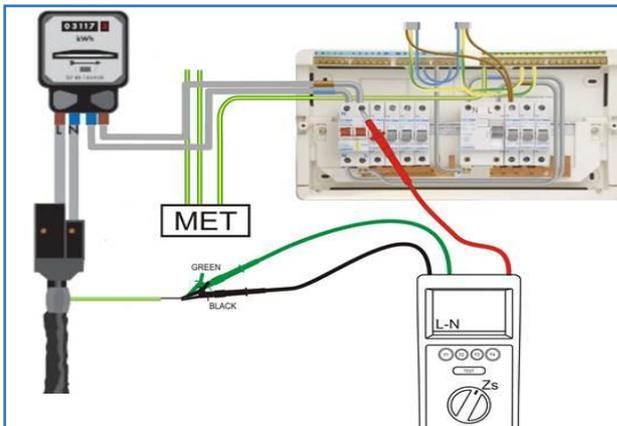
Measurement of the fault loop impedance by voltage drop method

(Ref:- Method LL2 of Annexure-LL of IS 732 : 2019)

The above method for measurement of Earth Fault Loop Impedance already explain in Annexure-1 of CAMTECH Book: "Safety in Electrical Low Voltage Installation" Vol-2:Selection and Application of LV Protective Devices.

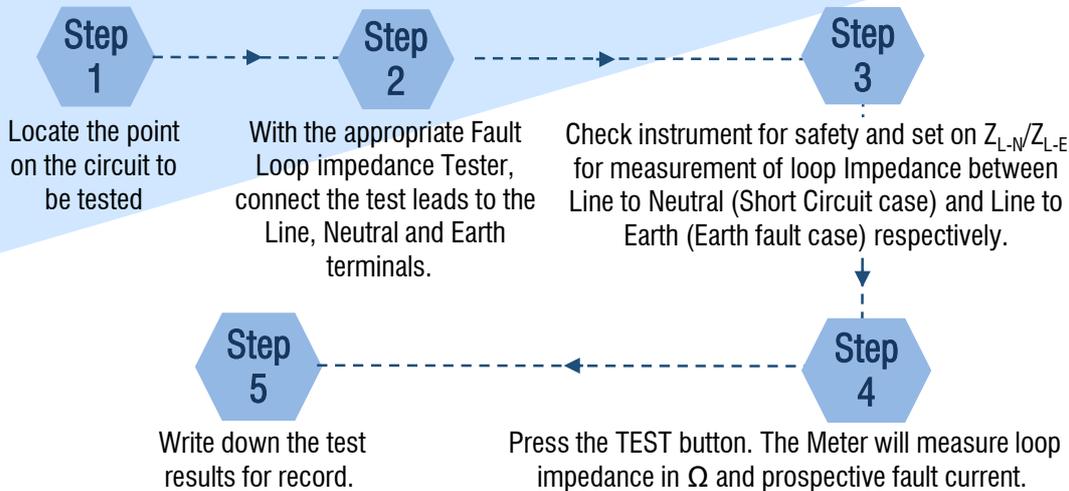
Measurement of Fault Loop Impedance Using Fault Loop Impedance Tester (Commonly used method)

Fault loop testers are used to measure fault loop impedance between Phase to Neutral and Phase to Earth. This equipment also gives prospective fault current to decide suitable protective device for the system.



Measurement of Fault loop Impedance using fault loop impedance tester

Fault Loop Impedance Test Sequence



NOTE: If the circuit is RCD protected than you will have to select the “No trip” function of the Megger to avoid nuisance tripping of the RCD. If your tester does not have this option then you will have to Bypass the RCD for testing.

Estimation of Earth Fault/ short circuit Loop Impedance for Design purpose

The Approximate value of earth fault loop impedance can also be calculated theoretically during design stage based on the method already discussed in para 2.8.2 of booklet “Safety in electrical Low Voltage Installations”, Vol.2: Selection and Application of LV protective Devices published by CAMTECH.

Selection of Type (B/C/D) of MCB

(Ref: Para MM 6.2.3.6.2 of Annexure-MM of IS 732: 2019)

The tripping of MCB during Earth fault depends on the value of Earth Fault Loop Impedance encountered by the fault current. The relation between tripping current (I_t) of MCB and the maximum earth fault loop impedance (Z_s) of the concern circuit are as given:

$$Z_s \leq \frac{2}{3} \left(\frac{U_0}{I_a} \right)$$

Where

Z_s = The maximum earth fault loop impedance in (Ω) of the concern circuit.

I_a = The current in amperes (Amp.) causing the automatic operation of the disconnecting device (MCB) within the required time.

U_0 = The line conductor to earthed neutral voltage (V).

The maximum earth fault loop impedance in the above formula is reduced by a fraction of 2/3 because when earth fault happens the voltage at that point of fault is reduced to lower value than the nominal supply voltage. This reducing factor will ensure that MCB is tripping instantaneously even if voltage is further reduced to lower values.

Accordingly, a table has been derived using above formula for calculation of the maximum earth fault loop impedance for standard current ratings and types of MCB available in the market to ensure Tripping during Earth fault. This table can be used a ready reckoner for selection of MCB for different current ratings based on earth fault/short circuit loop impedance of the circuit.

Type of MCB	MCB rating in Amps	6	10	16	20	25	32	40	50	63	80	100	125
B	$Z_s(\ln \text{ Ohms}) = (2/3 \times (U_0 / I_a))$	5.11	3.07	1.92	1.53	1.23	0.96	0.77	0.61	0.49	0.38	0.31	0.25
C	$Z_s(\ln \text{ Ohms}) = (2/3 \times (U_0 / I_a))$	2.56	1.53	0.96	0.77	0.61	0.48	0.38	0.31	0.24	0.19	0.15	0.12
D	$Z_s(\ln \text{ Ohms}) = (2/3 \times (U_0 / I_a))$	1.28	0.77	0.48	0.38	0.31	0.24	0.19	0.15	0.12	0.10	0.08	0.06

Example: Type of MCB for any circuit can be found out with the help of the above table. This can be explained by an example as below

One Number sockets are connected to the final circuit through 6A MCB in the residential quarter. The value of earth fault loop impedance at that socket is 3 Ohm.

What type of MCB is to be used?

As per Chart given in table 2, required maximum earth fault loop impedance for 6A type(B/C/D) MCB are as below: -

Type B: - 5.11 Ohm

Type C: -2.56 Ohm

Type D: - 1.28 Ohm

As per given data type B MCB is suitable for above circuit, as given earth fault loop impedance (3 Ohm) is lower only in type B MCB therefore ensuring correct tripping during earth fault.

Disclaimer:

It is clarified that this pamphlet does not supersede any existing provisions laid down by Indian Standards, Railway Board, RDSO or Zonal Railways. The pamphlet is for guidance only and it is not a statutory document.

*If you have any suggestion or comment, please write to:
Dy. Director (Electrical), CAMTECH, Maharajpur, Gwalior (M.P.) – 474 005*