Calculation of Maximum Earth Loop Impedance Z_s

For a TN system, section 411.4.5 of BS7671:2008+A3:2015 defines the maximum earth fault loop impedance based on the following condition being met:

$$Zs < \frac{Uo\ Cmin}{Ia}$$

Where:

Z_s maximum earth fault loop impedance.

U_o minimum voltage factor to take account of voltage variations depending on time and place, changing of transformer taps and other considerations
U0 is the nominal a.c. rms line voltage to Earth.
e.g. For a 400V 3 phase system this is 230V

I_a current causing operation of the protective device within the specified time.
e.g. For motor starters this is 0.4 seconds. This time is taken from tables in BS 7671

C_{min} minimum voltage factor to take account of voltage variations depending on time and place, changing of transformer taps and other considerations.

Note: For a low voltage supply given in accordance with
Electricity Safety, Quality and Continuity Regulations (ESQCR),
Cmin (V) is given the value 0.95.

The requirement is that the measures value of Z_s is lower than the calculated figure

Example of calculated maximum Z_s value for a device

$$Z_s = \frac{U_o\ x\ C_{min}}{I_a}$$

e.g. for a GV2P07

I_a = 40.2A U_o = 230V C_{min} =0.95

$$Z_s = \frac{230 \times 0.95}{40.2}$$

Z_s = 5.44Ω (ohms)

Therefore, if the measured value of Impedance is below 5.44 Ω the Earth loop impedance of the circuit is acceptable.

For Motor rated devices with Thermal and Magnetic Protection

In practice, the thermal setting also scales the magnetic setting and therefore the above values are the maximum. If the measured earth fault loop impedance is above the values in the table, it may be possible that it meets the requirements of the lEE Regulations if the thermal setting is lowered.

Important Note: Where an installation has been specified on the basis of Z_s value calculated from a less than maximum short circuit trip level (as described in the previous paragraph) it is necessary to ensure that no unauthorized or inadvertently upward adjustment of the thermal setting is possible. If it isn't practical to do so, then the Z_s values for the maximum trip current.

Measured values of Zs

When Zs values are measured at ambient temperature, account needs to be taken of the increase in resistance of the conductors with increasing temperature due to load current, as explained in Appendix 14 of BS 7671, before the measured values can be checked for compliance against the maximum values of Zs referred to in BS 7671.