TT systems: right wa

Bill Allan follows up inquiries on the NAPIT Helpline and looks in detail at the demands of BS7671 on this line of work

Enquiries regarding electrical installations forming part of TT systems continue to keep the NAPIT Technical Helpline busy. We covered the topic in a general way in last issue's *Ask Eddie* but in this article I'll go into more detail and review the requirements of BS 7671 for such installations, answering typical questions in the process.

TT systems

Electrical installations forming part of a TT system are commonly found in older properties and areas of low population density and may be supplied by overhead cables or underground cables. No earth is provided from the source of supply and consequently, premises have their own earth electrode.

Exposed-conductive-parts within the installation are connected via protective conductors to the main earthing terminal (MET) and from the MET to the earth electrode. In the event of a phase to earth fault occurring in the installation, the earth fault current flows back to the source as shown in Fig. 1.

TT systems are also used in electrical installations where the designer considers it inadvisable to use the earthing facility provided by the electricity supplier, particularly if the earthing facility is provided from a PME network. Examples are: swimming pools and remote buildings with extraneous-conductive-parts.

Automatic disconnection

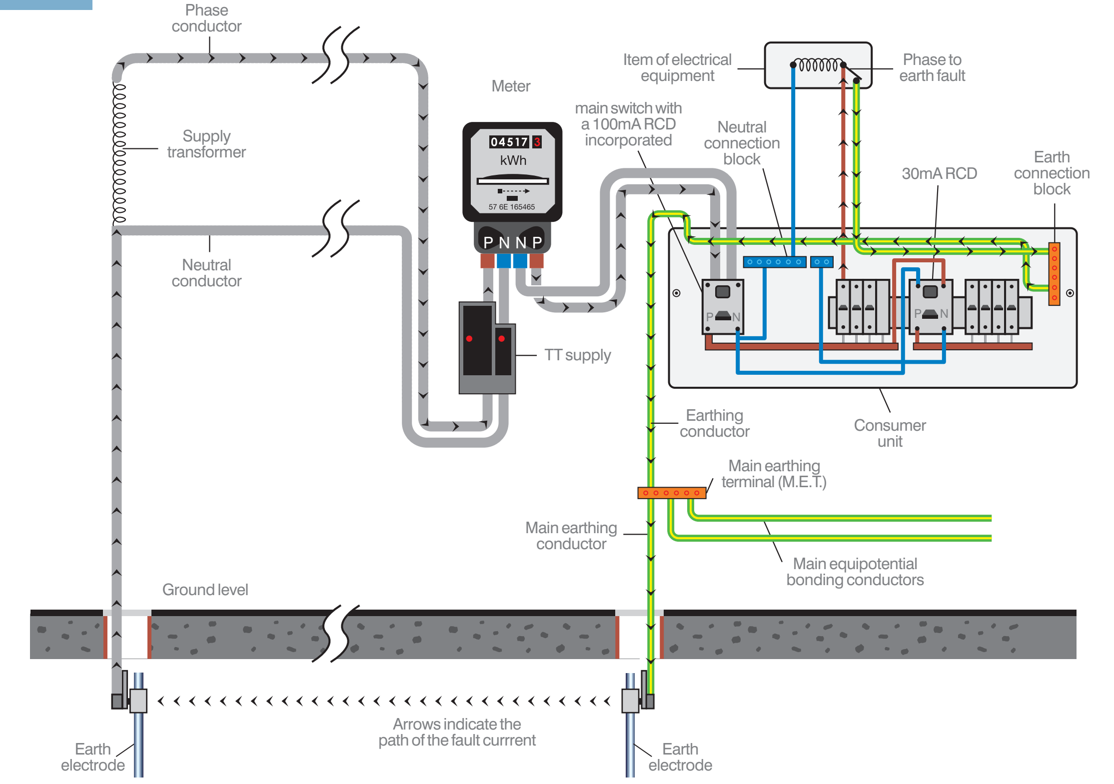
Regulation 413-02-19 of BS 7671 states that while overcurrent protective devices may be used, RCDs are preferred. This is because the earth fault loop impedance (Z_S) values for each circuit are unlikely to be less than the maximum Z_S values related to the various types and ratings of overcurrent devices in Tables 41B1, 41B2 and 41D of BS 7671.

Therefore automatic disconnection by overcurrent devices within 0.4 or 5 seconds cannot be guaranteed. The requirement for each circuit in installations forming part of TT systems is given in Regulation 413-02-20:

$$R_A I_a \leq 50 \text{ V}$$

where: R_A is the sum of the resistances of the earth electrode and the protective conductor(s) connecting it to the exposed-conductive-part.
I_a is the current causing automatic operation of the

Fig 1



...y to design and test

protective device within 5 seconds.

Where the protective device is an RCD, I_a in the (below left) formula is the rated residual operating current $I_{\Delta n}$ of the RCD.

It should be noted that the 50 volt value is modified for certain locations in Part 6 of BS 7671. Therefore, while automatic disconnection in installations forming part of TT systems is not specifically stated in terms of maximum time (e.g. 0.4 or 5 seconds), from the above formula it may be taken to be either five seconds (where overcurrent protective devices are used) or, where RCDs are used, the $I_{\Delta n}$ of the RCD (i.e. 0.03 seconds for a 30 mA RCD or 0.1 seconds for a 100 mA RCD).

Maximum values of earth electrode resistance

The maximum permissable resistance values of the earth electrode may be taken from Table 1, reproduced from Table 2.3 in IEE Guidance Note 3, Inspection and Testing.

The values in Table 1 are based on the formula in Regulation 413-02-20: $R_A I_a \leq 50$ V.

For example, where a 30 mA RCD is used in a normal dry location, the maximum value of the earth electrode resistance, R_A will be as follows:

$$R_A I_a \leq 50\ \text{V}$$

Therefore: $$R_A \leq \frac{V}{I_a} \leq \frac{50}{0.03} \leq 1666.6$$

(the corresponding value in the table below has been rounded down slightly)

Table 1: Maximum values of earth electrode resistance for TT installations

RCD rated residual operating current I_n	Maximum values of earth electrode resistance, R_A normal dry locations	constructions sites, agricultural and horticultural premises
30 mA	1660 Ω	830 Ω
100 mA	500 Ω	250 Ω
300 mA	160 Ω	80 Ω
500 mA	100 Ω	50 Ω

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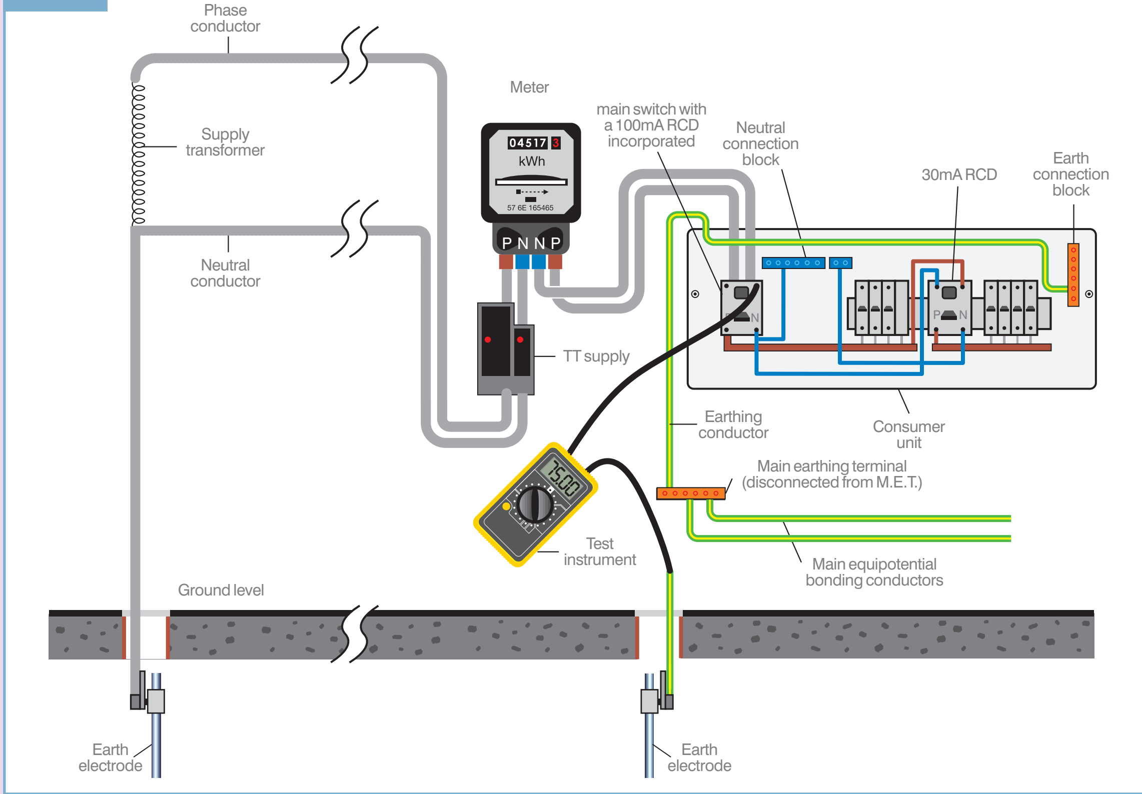
Fig 2



Designing and testing TT systems

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Measuring earth electrode resistance

Two methods are given in IEE Guidance Note 3, Inspection and Testing for measuring the resistance of installation earth electrodes:

- test method 1, in which only the resistance of the electrode and the earthing conductor connected to it are measured, is used where a high level of accuracy is important and where low values of electrode resistance to earth are required, as in electrodes used in the earthing of sub-stations, generators and transformers. Test method 1 involves the use of a proprietary test instrument.

- test method 2, in which the impedance of the whole earth fault current path is measured and is taken to be the resistance of the electrode. This method is used where a high level of accuracy is not strictly required and involves the use of a standard earth loop impedance tester.

It is more usual for test method 2 to be used to measure electrode resistance in TT systems as the electrode under test is used in conjunction with an RCD, which is likely to provide automatic disconnection in the event of a fault, even with a relatively high value of electrode resistance. Consequently, this article will deal only with test method 2.

Prior to starting the test, the installation must be isolated from the supply and the earthing conductor to the earth electrode must be disconnected at the main earthing terminal so that the reading is not affected by parallel paths. The earth loop impedance tester is connected between the incoming live phase conductor and the earthing conductor to the electrode (Fig. 2). As the resistance of the electrode is likely to be significantly higher than the other components of the earth fault current path, the reading is taken to be R_A. The electrical resistance to earth (R_A) is recorded in the space provided on the certificate.

In order to allow for dry weather causing a rise in soil resistance, IEE Guidance Note 3 advises that resistance values of earth electrode should be below 200 ohms. However, as BS 7430: Code of Practice for Earthing recommends that the resistance value should not exceed 100 ohms, this lower value is preferable.

Recording values

Questions have been asked on the NAPIT Technical Helpline such as: “Do I also need to insert a value for Z_e?” and “Is Z_e the same as R_A in TT systems?” Reference to Fig. 1 shows that this test is clearly different to a Z_e test in a TN-S or TN-C-S system. However, the measurement (which is taken to be R_A) could be considered to be the equivalent of Z_e in TN – S and TN-C-S systems.

As it is a requirement of Regulation 313-01-01 that the value of Ze be determined, **the value of R_A should also be recorded on the certificate as Z_e**.

Table 1 shows that the use of RCDs for automatic disconnection permits much higher values of R_A (Z_e), and therefore of Z_s, than could be allowed when using overcurrent protective devices for indirect shock protection. Consequently, some have asked the question: “Is it necessary to carry out Z_s tests on TT installations?”

It is a requirement of Regulation 713-11-01 that Z_s be determined. No exceptions are made for TT systems. Therefore, where installations which form part of TT systems are being tested and certificated, Z_s tests should still be carried out and recorded on the certificate, even if the values exceed the maximum Z_s values in Tables 41B1, 41B2 and 41D of BS 7671.

Advantages to measuring Z_s are that the continuity of the circuit protective conductor is confirmed and deterioration can be assessed on subsequent PIRs.

In a typical splitboard consumer unit for TT system, the socket-outlet circuits are protected by a downstream 30 mA RCD, which is required by Regulation 471-08-06 (this regulation should be studied for the full requirements). The other circuits are protected by an upstream time-delay (S type) 100 mA RCD.

Is the 100 mA RCD necessary? Yes, if the Z_s values for those other circuits are too high to permit disconnection within the required time.

Conclusion

As the role of RCDs are vital in ensuring protection against electric shock in TT systems, it is of the utmost importance that they are properly tested in accordance with BS 7671. Further information on RCDs can be found in IEE Guidance Note 1, Selection and Erection (Section 3.6), while the topic of automatic disconnection is covered in some detail in IEE Guidance Note 8, Earthing and Bonding (Chapter 7). See also story on Pages 22 and 23.