matter as the procedure adopted for phase relays in Table 9.3. Either the above factors must be taken into account with the errors calculated for each current level, making the process much more tedious, or longer grading margins must be allowed. However, for other types of relay, the procedure adopted for phase fault relays can be used.

9.16.3 Sensitive Earth-Fault Protection

LV systems are not normally earthed through an impedance, due to the resulting overvoltages that may occur and consequential safety implications. HV systems may be designed to accommodate such overvoltages, but not the majority of LV systems.

However, it is quite common to earth HV systems through an impedance that limits the earth-fault current. Further, in some countries, the resistivity of the earth path may be very high due to the nature of the ground itself (e.g. desert or rock). A fault to earth not involving earth conductors may result in the flow of only a small current, insufficient to operate a normal protection system. A similar difficulty also arises in the case of broken line conductors, which, after falling on to hedges or dry metalled roads, remain energised because of the low leakage current, and therefore present a danger to life.

To overcome the problem, it is necessary to provide an earth-fault protection system with a setting that is considerably lower than the normal line protection. This presents no difficulty to a modern digital or numerical relay. However, older electromechanical or static relays may present difficulties due to the high effective burden they may present to the CT.

The required sensitivity cannot normally be provided by means of conventional CT's. A core balance current transformer (CBCT) will normally be used. The CBCT is a current transformer mounted around all three phase (and neutral if present) conductors so that the CT secondary current is proportional to the residual (i.e. earth) current. Such a CT can be made to have any convenient ratio suitable for operating a sensitive earth-fault relay element. By use of such techniques, earth fault settings down to 10% of the current rating of the circuit to be protected can be obtained.

Care must be taken to position a CBCT correctly in a cable circuit. If the cable sheath is earthed, the earth connection from the cable gland/sheath junction must be taken through the CBCT primary to ensure that phase-sheath faults are detected. Figure 9.17 shows the correct and incorrect methods. With the incorrect method, the fault current in the sheath is not seen as an unbalance current and hence relay operation does not occur.

The normal residual current that may flow during healthy

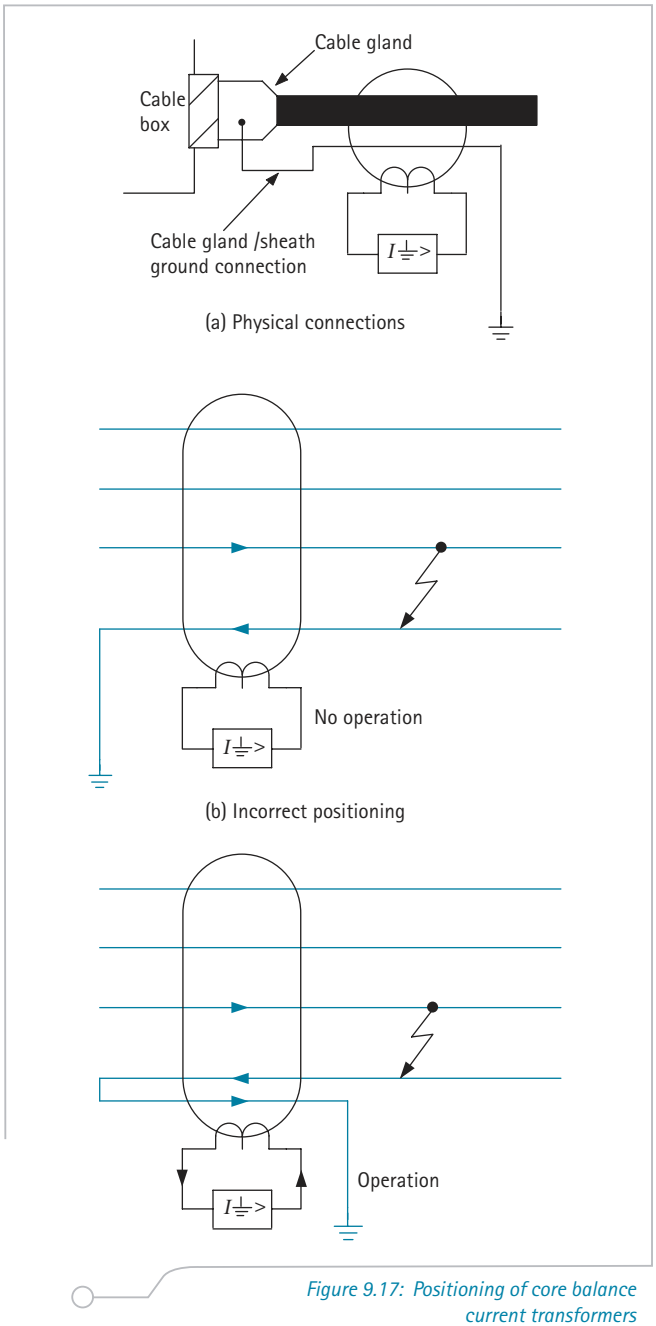

Figure 9.17: Positioning of core balance current transformers

conditions limits the application of non-directional sensitive earth-fault protection. Such residual effects can occur due to unbalanced leakage or capacitance in the system.

9.17 DIRECTIONAL EARTH-FAULT OVERCURRENT PROTECTION

Directional earth-fault overcurrent may need to be applied in the following situations:

i. for earth-fault protection where the overcurrent protection is by directional relays

ii. in insulated-earth networks

iii. in Petersen coil earthed networks

iv. where the sensitivity of sensitive earth-fault protection is insufficient – use of a directional earth-fault relay may provide greater sensitivity