Testing a domestic wiring installation - location of faults - Remedies

Objectives: At the end of this lesson you shall be able to
- **state the type of test to be carried out in wiring installations and explain the procedure of conducting them**
- **Determine the condition of installation and the method of improving the condition.**

General requirement of inspection and tests (Ref: B.I.S.732-(Part III) 1982.)

Before a completed installation or an addition to the existing installation is put into service, inspection and testing shall be carried out in accordance with the Indian Electricity Rules, 1956. In the event of defects being found, these shall be rectified as soon as practicable, and the installation re-tested.

Periodic inspection and testing shall be carried out in order to maintain the installation in a sound condition after putting it into service.

Items to be inspected in a lighting circuit

Lighting circuits: The lighting circuits shall be checked for ensuring the following.

- Wooden boxes and panels are avoided in factories for mounting the lighting boards and switch controls etc.
- Neutral links are provided in double pole switch-fuses which are used for lighting control, and no fuse is provided in the neutral.
- The plug points in the lighting circuit are all of 3-pin type, the third pin being suitably earthed.
- Tamper-proof interlocked switch sockets and plugs are used for locations easily accessible.
- Lighting wiring in the factory area is taken in enclosed conduits, and conduits are properly earthed, or alternatively, armoured cable wiring is used.
- A separate earth wire is run in the lighting installation to provide earthing for plug points, fixtures and equipment.
- Proper connectors and junction boxes are used wherever joints are to be made in conductors or when cross-over of conductors takes place.
- Cartridge fuse units are fitted with cartridge fuses only.
- Clear and permanent identification marks are painted in all distribution boards, switchboards, sub-main boards and switches as necessary.
- The polarity having been checked, all fuses and single pole switches are connected on the phase conductor only and wiring is correctly connected to the socket-outlets.
- The spare knock-outs provided in distribution boards and switch-fuses are blocked.
- The ends of the conduits enclosing the wiring leads are provided with ebonite or other suitable bushes.
- The fittings and fixtures used for outdoor use are all of weatherproof construction, and similarly, fixtures, fittings and switchgears used in the hazardous area are of flame-proof application.
- Proper terminal connectors are used for termination of wires (conductors and earth leads) and all strands are inserted in the terminals.
- Flat-ended screws are used for fixing conductors to the accessories.
- Use of flat washers backed up by spring washers for making end connections is desirable.
- The number of wires in a conduit conforms to the provisions of Part II of BIS 732.

Testing of installation: After inspection, the following tests shall be carried out, before an installation or an addition to the existing installation is put into service. Any testing of the electrical installation shall commence after obtaining a permit to work from the engineer in-charge and after ensuring the safety provisions.

1 Continuity or open circuit test
2 Polarity test
3 Earth and ground test
4 Insulation and leakage test:
   - between conductors
   - between conductors and earth.

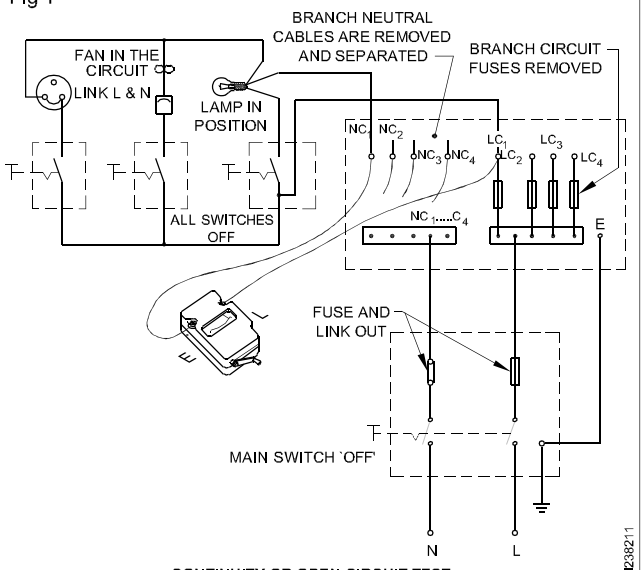
Continuity or open circuit test: This test is carried out to check the continuity of cables in the individual sub-circuits. Before conducting this test, the main and all the distribution circuit fuses should be removed.

The phase and the neutral of the individual circuits should be identified from the distribution board and segregated.

Place all bulbs in position, connect fans to respective ceiling roses, regulators and switches, short all socket outlets by linking the phase and neutral.

Connect the Megger terminals E and L to the individual circuit phase and neutral (Fig 1) and rotate the Megger.

Fig 1



CONTINUITY OR OPEN CIRCUIT TEST

By switching the switches ON and OFF one by one, the Megger should show zero reading and infinity alternatively. The two-way switches may have to be operated alternatively to ensure the correct test results.

If the Megger shows no continuity in the `ON' condition of the switch, then the particular circuit is deemed to be open. On the other hand, if the Megger shows continuity in both the `ON' and `OFF' positions of the switch, this indicates short in the particular circuit.

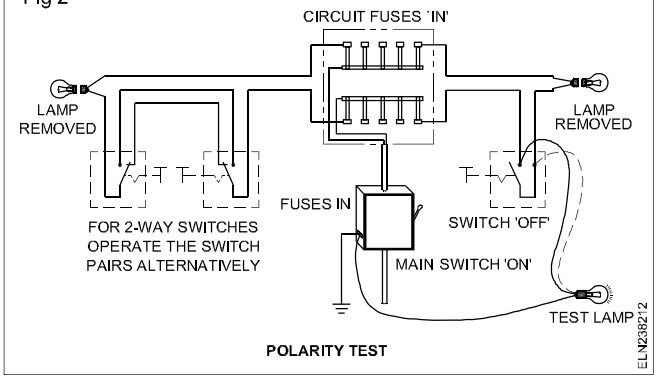
Remember to remove all the shorting links at socket points and to connect the phase to the fuse, and neutral to the link, before switching `ON' the supply.

Polarity test: This test is conducted to check whether switches are connected in phase/live cable or not.

For conducting this test, the lamps are removed from the lamp-holders, the fan regulators are kept in the `OFF' position and the fuses inserted in the main and distribution boards.

Remove the switch covers and switch `ON' the supply. Connect one end of the test lamp to the earth continuity conductor and the other end of the test lamp to the switch terminals alternatively (Fig 2).

Fig 2



POLARITY TEST

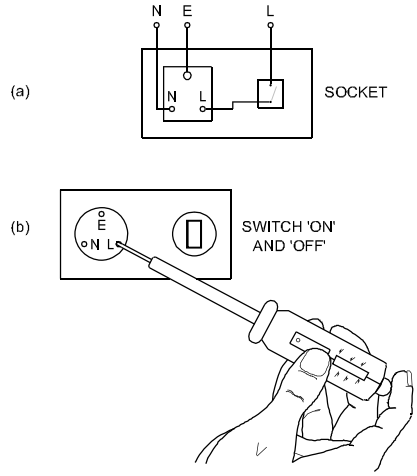
Lighting of the test lamp indicates that the phase or live cable is controlled by the switch.

A further polarity test should be done on the sockets to verify whether

- The phase wire is connected to the right side hole of the socket (Fig 3a).
- The switch controls the phase wire.

  For this test, a neon tester could be inserted in the right side hole of the socket as shown in Fig 3b and the control switch is switched `ON'. Lighting of the neon tester when the switch is `ON' and no light when the switch is `OFF' indicate correct polarity. This test is a must, in all old or new wiring installations as a safety measure.

Fig 3



POLARITY TEST ON SOCKETS

Testing the effectiveness of earth connection: For checking the efficiency of earthing, the following tests are done.

- Testing the continuity of earth continuity conductor (ECC) and measuring its resistance.
- The earth resistance of the electrode shall be measured.

The value of earth electrode resistance should not exceed 5 ohms or to a value such that the protective devices in the circuit operate efficiently in case of earth faults in the circuit.

Insulation tests in wiring installation (BIS 732 (Part II) - 1982.)

The following tests shall be done:

1 The insulation resistance shall be measured by applying the test between the earth and the whole system of the conductor or any section thereof, with all the fuses in place and all the switches closed, and except in earthed concentric wiring, all lamps in position or both poles of installation, otherwise electrically connected together, a DC voltage of not less than twice the working voltage, provided that it does not exceed 500 volts for medium voltage circuits.

2 Where the supply is derived from a three-wire AC or DC or poly-phase system, the neutral pole of which is

connected to earth either direct or through added resistance, the working voltage shall be deemed to be that which is maintained between the outer or phase conductor and the neutral.

3 The insulation resistance in megohms of an installation measured shall not be less than 50 divided by the number of points on the circuit, provided that the whole installation need not be required to have an insulation resistance greater than one megohm.

4 Control- rheostats, heating and power appliances and electric signs, may, if desired, be disconnected from the circuit during the test, but in that event the insulation resistance between the case or framework, and all the live parts of each rheostat, appliance and sign shall be not less than that specified in the relevant Indian Standard Specification, or where there is no such specification, shall be not less than half a megohm.

5 The insulation resistance shall also be measured between all conductors connected to one pole or phase conductor of the supply and all the conductors connected to the middle wire or to the middle wire or to the neutral on to the other pole of the phase conductors of the supply.

6 Such a test shall be made after removing all metallic connections between the two poles of the installation, and in these circumstances the insulation resistance between the conductors of the installation shall be not less than that specified.

On completion of an electrical installation (or an extension to an installation) a certificate shall be furnished by the contractor, countersigned by the certified supervisor under whose direct supervision the installation was carried out. This certificate shall be in the prescribed form as required by the local electric supply authority.

Insulation resistance between conductors and earth:

For this test, put `OFF' the main switch and remove the main fuse-carrier. All distribution fuses should be `IN'; the lamps should be in their holders and all switches for fans and lights should be in the `IN' position. Unplug all the appliances from the sockets, and short the phase and neutral of the sockets with a jumper wire.

Connect the phase and neutral cables at the outgoing terminals of the main switch together, and connect the lead of the Megger terminal to the shorted cables. (Fig 4) Connect the other lead of the Megger to the earth connection and rotate the Megger at its rated speed.

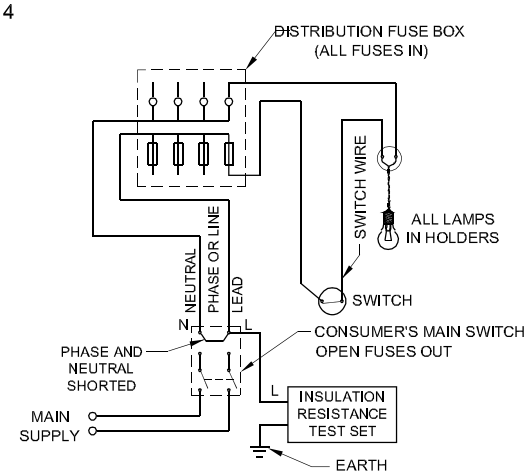
The reading thus obtained should not be lower than the lowest of the values obtained in these three methods.

Method 1 - **Standard value as per B.I.S.**

Standard value of insulation resistance

$$= \frac{50}{\text{No.of points in the circuit}} \text{Mega ohms}$$

Fig 4



INSULATION RESISTANCE TEST BETWEEN CONDUCTORS AND EARTH

where the switch, the lamp-holder and the socket are taken as individual points.

In case, the wiring is done in PVC insulated cables, 50 should be replaced by 12.5.

Method 2 - **I.E. rules state that the leakage current in an installation should not exceed 1/5000th part of the full load current of the installation.**

Applying this, the value of insulation resistance

$$= \frac{\text{Supply voltage in volts}}{\text{Leakage current}} \text{ohms}$$

$$= \frac{\text{Supply voltage in volts x 5000}}{\text{Full load current of the insatallation}}$$

Where leakage current

$$= \text{Full load current of the installation x } \frac{1}{5000}$$

Hence the insulation resistance

$$= \frac{\text{Supply voltage in volts x 5000 x } 10^{-6}}{\text{Full load current of the installation}} \text{Megaohms}$$

Method 3 - **Thumb rule**

The measured insulation resistance of an installation should not be less than one megohm.

Insulation resistance between conductors: For this test, switch off the mains and remove the fuse-carriers.

Remove all lamps from their holders, disconnect all appliances and keep all switches in the ON position.

Keep all the distribution fuses in position.

Connect one test prod of the Megger to the phase cable and the other to the neutral (Fig 5).

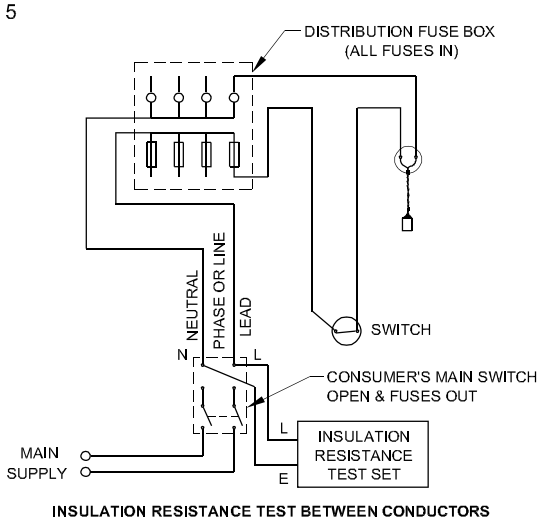
Rotate the Megger and measure the insulation resistance in megohms.

The reading in megohms should not be less than the lowest of the readings obtained in any one of the three methods, stated under `Insulation resistance between conductors and earth.

Inspection, testing and improving the condition of wiring installations

The table given below shows the test results, and the methods to improve the conditions of the wiring installations.

Fig 5



INSULATION RESISTANCE TEST BETWEEN CONDUCTORS

Test Results and Methods for Improving the conditions

S. No.	Test Conducted	Test results	Method of Improvement
1	Continuity or open circuit test	a) Zero reading b) Higher reading in terms of kiloohms or megohms	a) Ok. b) Operate each individual switch in the circuit.Where the reading jumps to a higher value, there will be an open circuit, either by fused bulbs or loose connections at the terminals or break in the wire. After identifying the subcircuit, check the continuity of cables in the smaller zones till the defect is detected and rectified. Where 2-way switches are encountered,operate the switches one by one to detect the fault.
2	Polarity test	a) Polarity was found wrong throughout the installation. b) Polarity found wrong in one or two sockets.	a) Switch off the mains. Remove the fuse-carrier.Interchange the output terminals at ICDP switch or at DB. b) See that the phase is connected to the right side terminal of the socket.
3	Effectiveness of earth connection	a) Discontinuity between earth electrode and one earth pin of the 3- pin socket. b) Indicates voltage drop between phase & the metallic body when tested by test lamp method.	a) Check up the connections and reconnect or replace the earth continuity conductor. b) The earth electrode resistance may be high. ECC may have high resistance. Prepare one more earth electrode and connect the electrodes in parallel. Remove rust and rectify loose connections in ECC connections at all earth terminals including the one at the earth electrode.

S. No.	Test Conducted	Test results	Method of Improvement
4	Insulation test between conductors and earth (or) between the phase and neutral	a) 1 megohm or above	a) Ok. Check the value of the insulation resistance by the formula Megohms = $\frac{50}{\text{No.of outlets}}$ For PVC wired installation replace 50 by 12.5. In case the measured value of insulation resistance is equal to or more than the calculated value, the insulation is OK.
		b) Less than 1 megohm	b) Otherwise locate the fault by sectionalising the zone and replacing the defective cable with a good one. If, however, the values obtained are not sufficiently high, withdraw all the fuses of the distribution fuse-board and test again. This test will include only that portion of the installation between the main switch and the distribution fuse-board. If the fault does not lie in this section,proceed to the distribution fuse-board, and test each branch circuit in turn till the faulty circuit or circuits are discovered.

Testing the industrial wiring installation for faults and their remedies - Flow chart

Objectives: At the end of this lesson you shall be able to
- **explain the different types of faults occur in the industrial**
- **trace and interpret the flow chart for locating the fault.**

Any fault can be found and rectified. It is necessary for the electrician to adopt a method or system based on a sound knowledge of circuitry and electrical theory on experience. The electrician detects to repair a faulty circuit in many ways like a doctor who makes his diagnosis or test using the correct instrument.

The investigation must always be based on an intelligent assessment of the fault and its probable causes, judged from its effects. In many instances, faults arise from installations or circuits. The following are some common installation defects which eventually lead to faults.

1 Fuse protection not matched to the current rating of cables to be protected. This is very often happening due to fitting the fuse-carries with a fuse element of maximum rating than the fuse unit in the protection system.

2 Indiscriminate bunching of too many cables with inadequate connections.

3 Insufficient protection provided for sheathed wiring (e.g.) to switch positions and on joints in roof voids.

4 Incorrect use of materials, not resistant to corrosion, in damp situation (e.g. enameled conduit and accessories)

5 Insufficient attention given to cleaning ends of conduit and/or . Omission of bushings .

6 Incorrect use of PVC insulated and/or sheathed cables and flexible cords instead of heat resistance type, for connections to immersion heating, thermal storage block heaters etc.,

7 Incorrect use of braided and twisted flexible cords for bathroom pendant fittings and similar situations subject to dampness or condensation.

8 Installation of cable of insufficient capacity to carry the starting current of motors, causing excessive voltage drops.

9 Incorrect rating of fuse-element to give protection to the cables connecting the motor.

Segregation of fault

Open circuit fault

Usually the effect of this fault is that the apparatus or lamp in the circuit will not operate. This fault can be located by using the continuity Tester. The fault is of a

a) break in a wire

b) very loose or disconnected terminal or joint connections

c) blown fuse

d) faulty switch contacts.

The fuse should always be checked first for fault finding. Their wirable type can be easily inspected. The cartridge type must be tested for continuity of the fuse element. If it is found not correct replace it. A broken wire or a disconnection will show high resistance in the kiloohm or Megohm ranges in continuity Tester. Before each wire in faulty circuit is tested in turn (live wire, switch-wire, and neutral) all mechanical connections should be inspected like plug, switch, lamp holders, junction box and appliance terminals etc). Make sure that the original connections are restored, once the fault has been found.

Earth Fault

An earth fault between earthed metal work and a live conductor will have the same effect as a direct short-circuit. For this situation the circuit fuse will blow off. To trace the fault, first isolate the live conductor from the neutral by removing all lamps etc.

Keeping all switches in ON position by using insulation resistance Tester, faults are traced. The reading obtained on the instrument will be in low ohms range. It is important to rectify any such fault found, other wise it may cause a shock and fire hazards.

Short circuit fault

Short circuit can occur as the result of damaged insulation, bare wire in junction boxes and fittings or loose terminals contact with a conductor of opposite polarity. The result of a short circuit is a blown fuse. The result will be over heating of the conductors and sparking or arcing at the point of contact. Open all switches, lamps and appliances from the faulty circuit and carry out an insulation resistance test between the live and neutral conductors.

If reading is obtained is satisfactory, close each circuit switch in turn until the fault is located.

High-value series resistance fault

This type of fault is most difficult to trace; it occurs in joint or terminator where it has become loose. Due to this effect the lights will be 'dim or motor will run very slow thereby heating up'. In new wiring wrong connection in a junction box resulting in two or more lamps being connected in series.

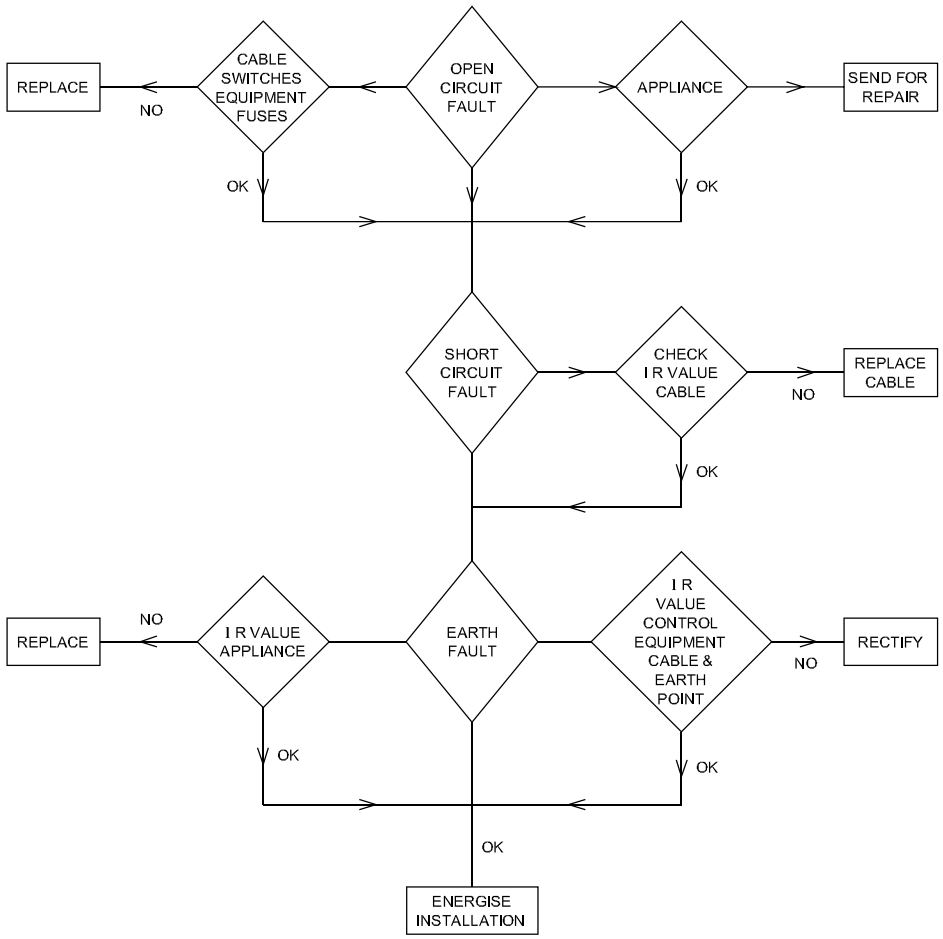
Main faults in new wiring

Wrong connections will either blow a fuse or cause lamps to operate dimly or not at all work. Works only when another circuit switch is switched ON, this indicates wrong connections in looping of wires.

Flow chart of faults

Figure 1 shows the flow chart of each fault kept in chart form.

Fig 1



FLOW CHART FOR LOCATING FAULT IN DOMESTIC WIRING INSTALLATION

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