Automated Cable Testing

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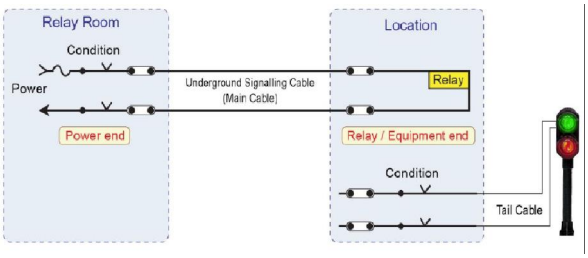
Transmission medium plays vital role in Transmission of information safely from interlocking room to signalling element in the field (like point, signal, LC gate, train detection equipment etc.) and signalling element to interlocking room. Copper cable with PVC insulation is mostly used as transmission medium on IR.

Loss of integrity of transmission medium results in failure of signalling system. Such failures can be on unsafe side also in case of copper cable. To ensure the integrity of copper cable, Signal Engineering Manual stipulates periodical testing of the copper cables. Earth Leakage Detectors are also deployed to detect the cable faults online.

At present, copper cable is tested by meggering. Cable meggering involves disconnection of signalling system which affects the availability of signalling system. Pressure on availability of signalling system is likely to result in non-compliance of testing of signalling cable as per SEM.

A system of cable testing which takes less time and provides evidence of testing is suggested

I. Typical copper cable usage in signalling system

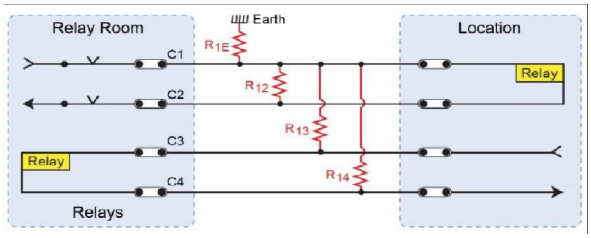


Underground signalling cable of multiple cores is used between relay room and location – which is called main cable. One cable carries multiple elements' controls/status. Disconnection of one cable disables the complete signalling system at the station.

Separate cable is laid between the location in the field and the signalling element – this cable is called tail cable. Disconnection of tail cable affects only that function.

The proposed system helps in testing the main cables in less time compared to the present practice. Tail cables may be tested in conventional way.

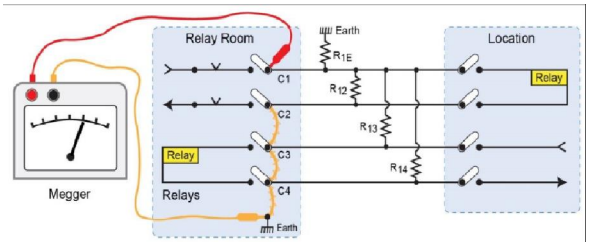
II. Cable failure states



The low resistance failure states of conductor 1 in a four core cable

The conductor can have contact fault with earth or with all other conductors in the cable. While ELD can detect earth fault online – it cannot detect the leakages R12, R13 & R14 which can lead to unsafe failure.

III. Conventional cable testing method



Test connection for conductor 1 in the 4 core cable

In Conventional cable testing each conductor is considered as unit of testing – the insulation with respect to earth [R1E] and all other conductors in the cable [R12, R13 & R14] is measured

Step 1: Functions and supplies connected on both ends of the cable conductors are disconnected by opening the terminal links

Step 2: On testing end, except the conductor under test, i.e. C1 all other conductors are shorted to earth

Step 3: C1 is connected to one terminal of

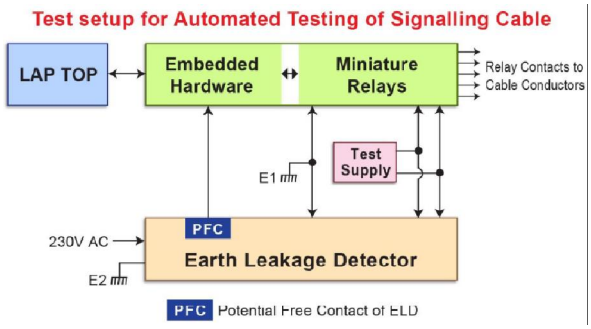
megger and the second terminal of megger is connected to earth

Step 4: Test is conducted by megger and value noted manually. The value of resistance obtained is of RE, R12, R13 & R14 in parallel.

The test is repeated for all the conductors and values noted.

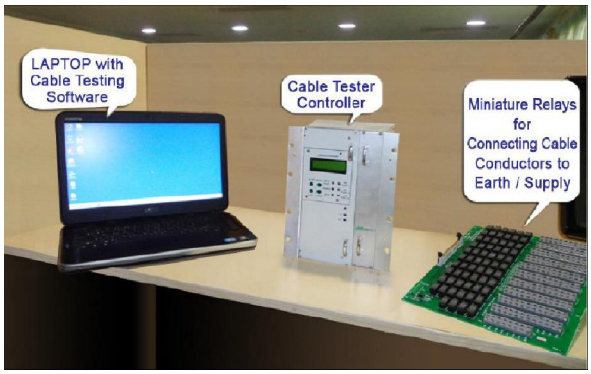
IV. Automated cable Test System:

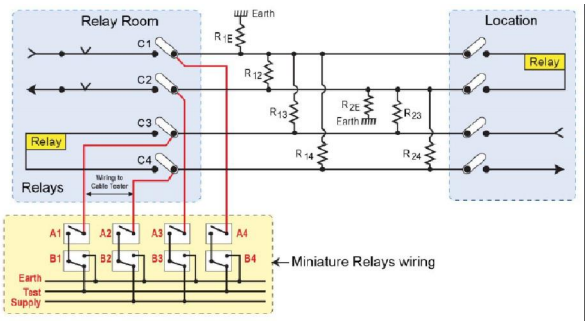
i. Test set up



ii. Test equipment consisting of LAPTOP, Controller & Miniature relays – RDSO approved ELD [not shown in the diagram]

iii. Cable testing circuit diagram:





In automated cable test a pair of conductors in the cable is considered as unit of testing – insulation of each conductor with respect to earth [R1E & R2E] and also with all other conductors [R13, R14, R23 & R24] of the cable is measured. However, insulation between the two conductors in the same pair [R12] cannot be measured in this test. R12, can be measured if C2 & C3 are considered as pair. Hence the test is repeated by making pairs with sliding by one conductor – C2&C3, C4&C1 as pairs

Miniature relay wiring:

A1, A2, A3 & A4: Normally open contacts of these miniature relays are wired to each terminal. These relays when dropped, allows signalling system to function normally even with the test wires terminated on the cable terminals

B1, B2, B3 & B4: Connects Earth or test voltage positive or negative to the conductor under test

Choosing the Test supply: It is better to choose a supply which does not operate a function or relay by accidental closing of cable terminal link

1. ELD is used to test the cable. It is possible to select a value between 2 k ohm to 1 M ohm. It is suggested to select 1 M ohm since one pair only is considered.
2. Test is conducted on a pair of cable at a time - not on each conductor
3. Miniature relays' potential free contacts are wired to the cable terminals in such a way that either test supply or earth is extended to the conductors. When test pair is extended test supply all other conductors are earthed.
4. The sequence of extending supply or earth to each conductor is programmed in the LAPTOP and driven through controller [embedded hardware]
5. Links of terminals on feed end are to be disconnected to ensure galvanic isolation with other cables and equipment
6. The software provided in the LAPTOP drives the miniature relays through embedded hardware [controller] All conductors other than test pair of conductors are earthed. Test supply is applied to the test pair.
7. ELD measures the insulation of the test pair [with respect to earth and also with respect to the other conductors in the cable]. If the value of insulation is less than the set value of one mega ohm - potential free contact of ELD is operated.
8. The test equipment senses the status of potential free contact and declares the test result for the pair of cable under test
9. Test gets repeated for all other remaining pairs

of the cable automatically

10. Test is repeated by changing pairs by sliding one conductor - C2&C3, C4&C1 as pairs
11. A 30 core cable testing may take less than 2 minutes. Value of each pair is recorded in the LAPTOP

V. Proposed testing method

Step1: Connect the test equipment to all the cable conductors with the help of wires with insulated crocodile clips

Step2: Take disconnection of signalling equipment connected by the cable under test. Disconnect terminal links on feed end only. No need to disconnect on function end

Step3: Initiate the test program in the LAPTOP and observe the values displayed for each pair of cable [It takes less than 2 minutes to get the test report]

Step4: Reconnect the terminal links of feed end of each conductor and give reconnection of the signalling equipment

Step5: Remove the crocodile clips

VI. Format of test results [for 8 core cable]

Test results with original pairs:

Test pair	Time stamps of extending supply OR earth				Test result [less/ more than one Mega ohm]
	Pair 1	Pair 2	Pair 3	Pair 4	
Pair 1					
Pair 2					
Pair 3					
Pair 4					

Test result with pair changed

Test pair	conductors	Time stamps of extending supply OR earth				Test result [less/ more than one Mega ohm]
		Pair 1'	Pair 2'	Pair 3'	Pair 4'	
Pair 1'	C2, C3					
Pair 2'	C4, C5					
Pair 3'	C6, C7					
Pair 4'	C8, C1					

Summing up: Automated cable testing saves time of cable meggering which increases availability of signalling system and evidence of test results is available

Annexure

Detecting the defective pair by data logger based on online alarm of ELD

Even though ELD detects earth leakage in the supply, it cannot precisely identify the faulty conductor responsible for the earth fault. The leakage disappears the moment supply is withdrawn from the conductor. By wiring the potential free contact of ELD to the data logger and using special software it is possible to identify precisely the conductor responsible for earth fault.

Detection of leakage by ELD and identification of defective pair of conductors by data logger:

a. If fault occurs to the conductor when it is not carrying power; ELD detects the leakage only after power is applied to the conductor. After power supply to faulty conductors is removed, fault in ELD disappears. Fault reappears in ELD after supply is extended again. This cycle keeps on happening.
b. If fault occurs to the conductors when it is carrying power; ELD detects the leakage immediately. After power supply to faulty conductors is removed, fault in ELD disappears. Fault reappears in ELD after supply is extended again. This cycle keeps on happening until the earth fault is removed.

In both the above cases it is possible to find out the faulty conductors by capturing the behaviour of relays responsible for powering the conductors or relays which are powered by the conductors [HR inducts power into the conductors, TPR is powered by the supply through the conductors]

For example, if ELD generates fault alarm immediately after 12 NWKR is UP and ELD alarm disappears immediately after 12 NWKR Down, it means cable conductors of 12 NWKR are defective. However in case of [b] above, if fault occurs on the conductors which have already power - no relay status change takes place but ELD generates alarm.

For easy analysis, the relays can be divided into two groups, i.e. Up and Down. In each group, they can be listed chronologically.

Typical reports generated by are given below:

Red coloured inputs are responsible for the operation of ELD. In the first example, ELD detected earth fault occurrence, in the second example, ELD detected disappearance of earth fault.

Station	Relay status	Fault Message	Occurred Time
BDPL	S6 RECR UP AT 07:06:04:593 S20 RECR UP AT 08:25:42:890 S18 RECR UP AT 08:29:16:718 S15 RECR UP AT 08:29:36:109 S3RECR UP AT 08:58:48:140 S1 HECR UP AT 09:02:37:265 S1D DECR UP AT 09:02:37:843 S6 DECR DN AT 07:06:04:078 S20 DECR DN AT 08:10:40:546 S20 HECR DN AT 08:25:42:500 S18 HECR DN AT 08:27:46:218 S18 DECR DN AT 08:29:16:218 S15 DECR DN AT 08:29:35:687 S3 HECR DN AT 08:58:47:718 S1 RECR DN AT 09:02:37:390 S1D HECR DN AT 09:02:37:921	Earth Leakage **appeared** in 110V AC Supply	04/23/2013 09:03:36:718

Station	Relay status	Fault Message	Occurred Time
BDPL	S20 UECR DN AT 1:28:46:734	Earth Leakage **disappeared** in 110V AC Supply	04/23/2013 12:23:44:000
	S3 HECR DN AT 11:32:09:156		
	S1 HECR DN AT 11:32:09:984		
	S1 DECR DN AT 11:33:07:546		
	S1D DECR DN AT 11:33:07:562		
	S3 DECR DN AT 11:34:31:843		
	S18 HECR DN AT 1:57:19:250		
	S20 HECR DN AT 11:57:19:906		
	S20 DECR DN AT 1:57:34:921		
	S18 DECR DN AT 1:59:13:328		
	S15 DECR DN AT 1:59:34:578		
	S6 DECR DN AT 12:06:25:375		
	S17 RECR DN AT 12:23:33:890		
	S1D HECR UP AT 1:33:07:968		
	S1 RECR UP AT 11:33:08:109		
	S3RECR UP AT 11:34:32:265		
	S20 RECR UP AT 11:57:35:359		
	S18 RECR UP AT 11:59:13:859		
	S15 RECR UP AT 11:59:34:984		
	S6 RECR UP AT 12:06:25:875		
	S17 HECR UP AT 12.23.33.781		

Note: All relays are not shown in the above reports

Summing up:

i. While ELD can detect the leakage from the supply, Data logger software through its report can identify the defective pair of conductors

ii. Data logger finds out the defective pair of conductors only at the time of supply is given or withdrawn from the defective conductors.

iii. If already supply is there in the conductor when the fault occurred, ELD detects it but defective conductor can be declared by data logger only when supply is withdrawn to the conductors. However a report is immediately generated after fault detection by ELD in which all the conductors carrying power supply at the moment of failure occurrence.