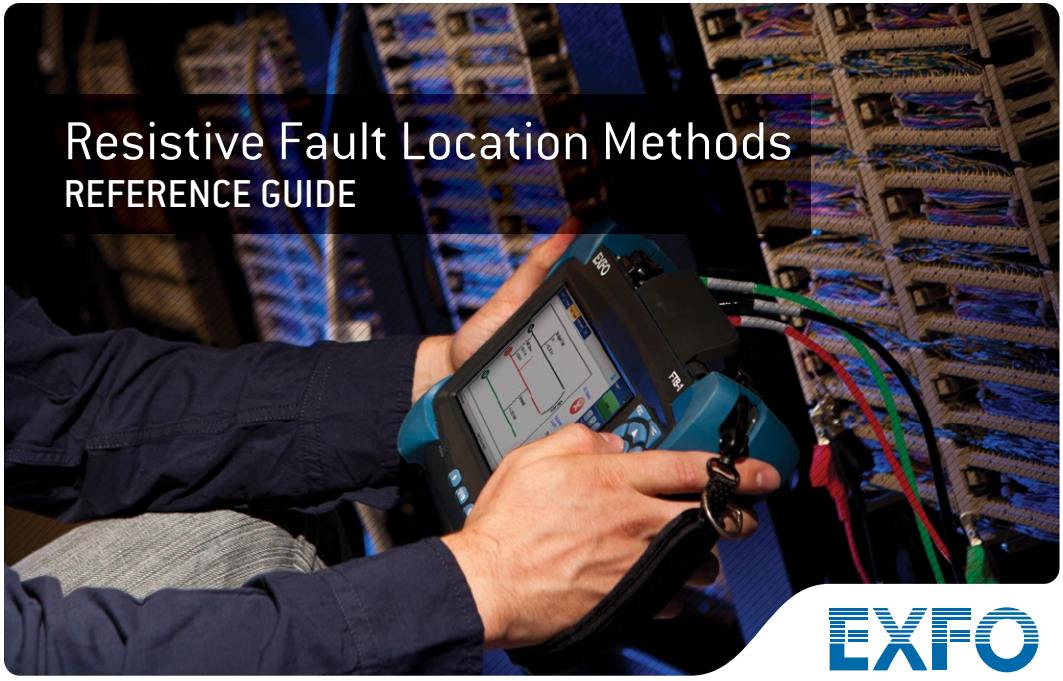
Resistive Fault Location Methods

REFERENCE GUIDE



EXFO

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1. RESISTIVE FAULT LOCATION (RFL)

1.1 What is it?

Resistive fault location (RFL) testing is a powerful measurement that is able to locate high resistive faults in communication cables. High resistive faults are normally caused by damage to or the deterioration of cable insulation or sheath protecting the wires. In most cases, water or moisture is the leading cause of resistive faults. Human and animal interference is usually the reason water or moisture gets into the cable in the first place. There are other methods of determining fault location, such as time domain reflectometry (TDR), however this measurement typically requires a severe low resistance fault (i.e., <100 Ω) to be reliable.

Typically, there are three types of resistive faults: shorts, grounds and crosses.

A short means the A/tip and B/ring have shorted together.

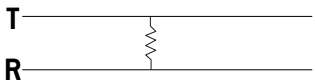


Figure 1. Short between tip and ring

A ground means the A/tip or B/ring has shorted to ground (or sheath).

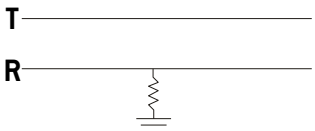


Figure 2. Short between ring and ground

A cross means the A/tip or B/ring has shorted to the B/ring of another pair that is carrying voltage (battery). Not only will there be a resistive fault in this instance, but voltage will be present.

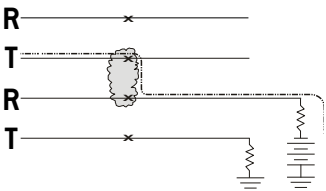
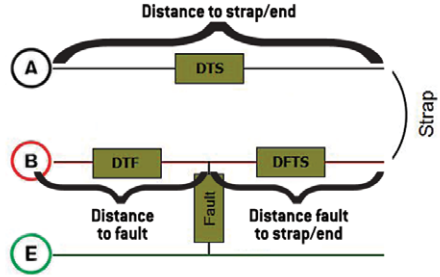


Figure 3. Battery cross

RFL provides a technician with the location of a resistive fault, including its magnitude. This is achieved by applying a voltage to the circuit, and measuring the current and voltage ratio at the fault. Once these measurements are taken, the distance to the fault can be calculated.



The following distance indicators are provided: distance to end, distance to fault, and distance from fault to end. In addition to these distance indicators, an RFL test will give the resistance at the fault location.

The typical rule of thumb is:

- Resistive faults in excess of 10 MΩ are not serious faults (circuits remain stable in excess of 30 MΩ).
- Faults between 3.5 MΩ and 9.9 MΩ are “light resistive faults” that should be fixed before they become too serious.
- Faults under 3.5 MΩ must be repaired as soon as possible, because they affect the customer’s service.

Be sure to check with your engineering group that you are following your company’s established methods and procedures (M&Ps).

1.2 Potential RFL-Related Issues

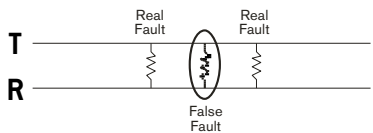
The following issues may cause improper or inconsistent RFL measurements and readings:

- Load coils typically add resistance (4 Ω to 20 Ω) to the distance reading depending on the resistance/kft or resistance/km constant used. Use the EXFO load coil detector to find out how many load coils are present along the line, and then configure the RFL setup by dividing the cable by section, one per load coil (see Chapter 1.4 Test Setup).
- Temperatures play an important role in determining the length of a cable (cable resistance changes with temperature). Temperatures will vary over the length of a cable and the variations can be extreme. Aerial cables in direct sunlight will tend to be at a higher temperature.

If a bridged tap has a fault, the RFL measurement will only indicate the location of the start of the bridged tap.

Different cable gauges have different loop resistances.

The RFL measurement is designed to find a single fault. If multiple faults are present, an incorrect measurement will be given. In this case the loop under test will also have to be sectionalized to narrow down the location of the impairment.



1.3 RFL Test using EXFO MAX/FTB-600 Series

With EXFO's MAX/FTB-600 testers, select the RFL test menu option. The tester will provide measurement results and feedback to the user.

The EXFO tester integrates different types of RFL measurements, referred to as two-wire (2-W), four-wire (4-W) and Küpfmüller.

- 4-W mode is also called the "RFL with separate good pair" or "3 points" test.
- Küpfmüller mode is also called the RFL K-test.

Best Practices

As a first step, best practices recommend performing an isolation resistance (stress/leakage) test on the cable pair to determine whether a fault is present. EXFO's MAX-600 tester includes an isolation resistance test with working voltage from 50V up to 125V. The FTB-600 extends this range up to 500V.

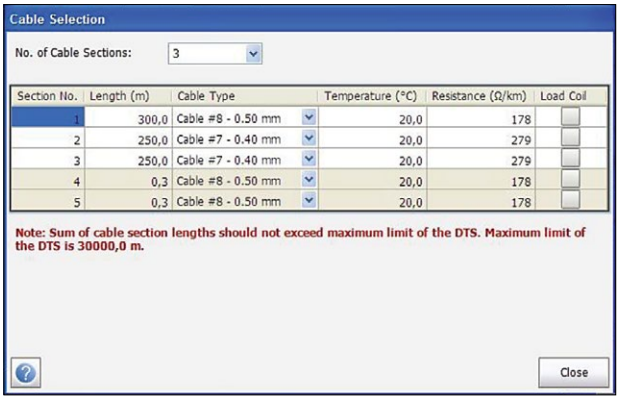
This test will analyze the circuit for insulation breakdown, which signifies a potential resistive fault. When isolation resistance measurements are higher than the configured threshold, the tester will indicate that the circuit is OK and that RFL is not needed. This allows the technician to focus on the real problems in the network.

› When a fault is present (i.e., <3.5 MΩ), the isolation resistance test will show the wires affected by the issue (i.e., between A/T and B/R).

› The RFL Test page will show how to connect the equipment and how to connect the strap. The technician must set up the test environment properly to get an accurate measurement.

1.4 Test Setup

Before the actual RFL test is initiated, the technician must enter critical information in the RFL setup. This information includes wire gauge, temperature (ideally the temperature in each cable section), and whether load coils are present or not.



The MAX/FTB-600 allows a technician to enter this information for up to five cable sections.

Improving Accuracy

Knowing the cable gauge is important because it provides the tester with a basis for the resistance measurement. Indicating the resistance/kft or resistance/km is also important in case the cable being tested has a different value than the default one in the tester. Setting the incorrect wire gauge and/or resistance-per-length value will lead to an incorrect calculation of the respective distances.

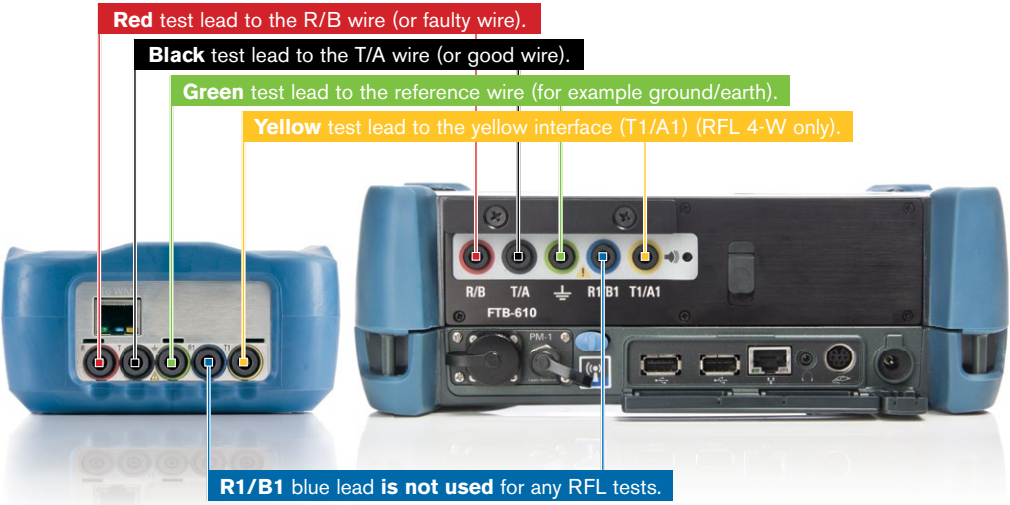
Knowing the lengths and the temperature of all cable sections is very important. Temperature alters resistance: the cooler the cable, the lower the resistance; the hotter the cable, the higher the resistance. Using accurate temperature settings will lead to accurate calculation of the respective distances.

With a proper test setup, the tester will measure the resistance to fault, resistance from fault to end, and resistance to end. With the resistance/kft or resistance/km constant, the distance to the fault, the distance from the fault to the end, and the distance to the end can be calculated. These measurements and calculations allow the technician to identify the exact location of a serious resistive cable fault.

RFL tests require a strap at the far end. This strap is normally created using a piece of spare copper wire, or using the specific cable provided with the tester cable kit; it can also be created using a far-end device (FED) set to short state. In order to obtain the best accuracy, this strap should have a very low resistance value.

Connection Info

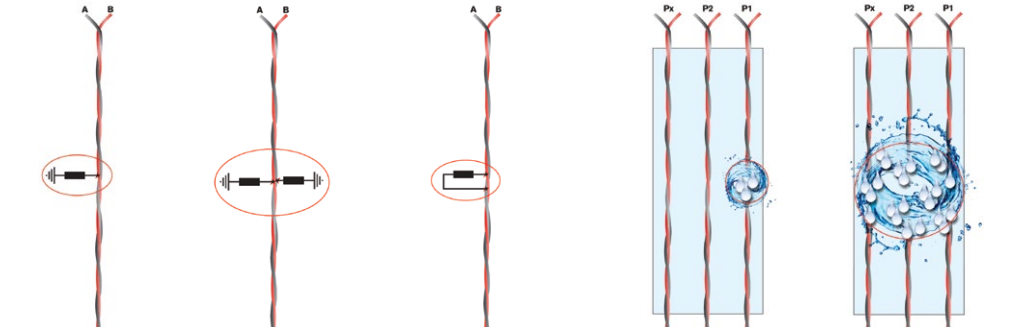
To perform these tests, make the connections as follows:



2. ISOLATION FAULTS

General Isolation Fault Types

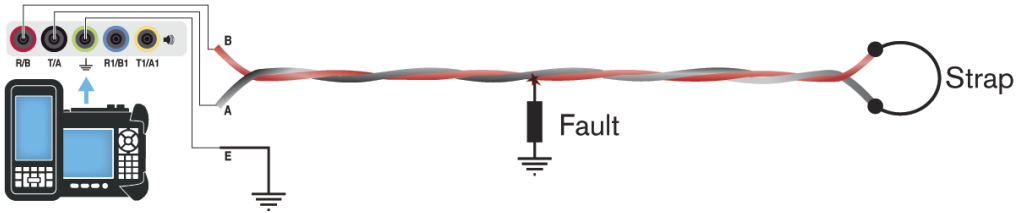
The following examples highlight possible faults, connection modes and results that may be obtained with EXFO's MAX/FTB-600 testers.



Single-wire isolation fault	Two-wire isolation fault	Isolation fault on same-pair wires	Partially flooded binder	Totally flooded binder
RFL 2-W	**K-test**	**RFL 4-W, TDR**	**RFL 4-W, K-test, TDR**	**TDR, RFL 4-W or similar**
Isolation resistance of good wire > 1000 x Rfault	Rfault1 > 2x Rfault2 Rfault1+Rfault2 > 100 x Rloop	Isolation resistance of good pair > 1000 x Rfault. TDR can be used to locate the fault if the Rfault is less than 100 ohms.	Isolation resistance of good pair > 1000 x Rfault	The use of a separate good, dry pair is suggested for best results.

3. FAULT TO GROUND

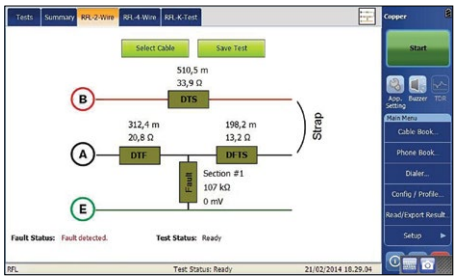
Isolation Fault Type



Single Point of Failure: Murray Method, RFL 2-W

- The two-wire method assumes a single fault is present and that the cable conductors have uniform resistance per unit length.
- The fault contact can be a short to ground or a short to B/ring of another pair.

See page 23 for more details about the Murray Method.



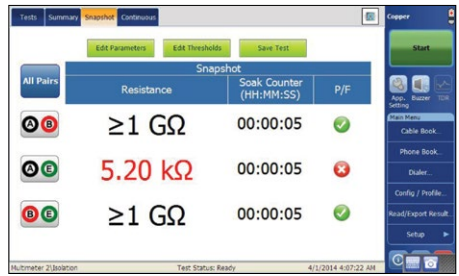
4. RFL 2-W MODE

Example: Fault located 150 m between one wire and the ground

Isolation Test

The isolation test clearly shows that the resistive fault is on the wire connected to the **black** test lead **(T/A)**.

However, the leg connected to the **red** test lead **(R/B)** is very good. This leg could therefore be used as the good wire during the RFL test, or as a spare wire in this cable bundle. If a separate spare wire is used, the wire must have the same length/gauge as the pair under test. If not, accuracy will be poor.



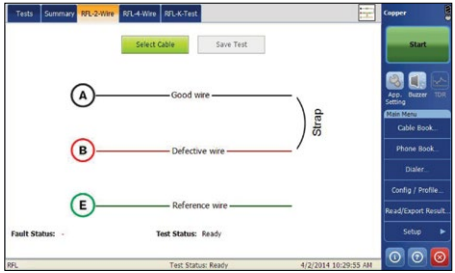
RFL 2-W Test

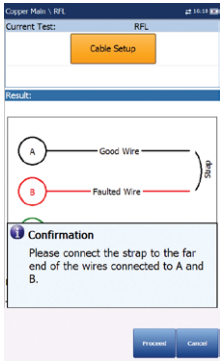
› To perform the test, follow the diagram shown on the screen.

During the isolation test, the wire connected to the **red** test lead **(R/B)** showed good isolation. Connect this wire from the copper pair to the **black** test lead **(T/A)**, and connect the defective wire to the **red** test lead **(R/B)**.

Connect the ground/earth to the **green** test lead (ground interface on the MAX/FTB-600 Series).

Place a strap between your good and bad wires, and launch the test.

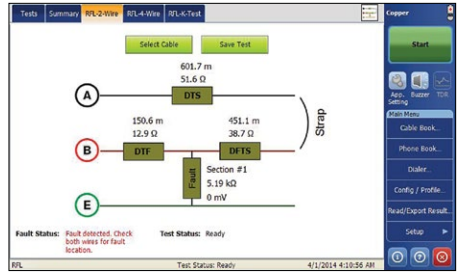


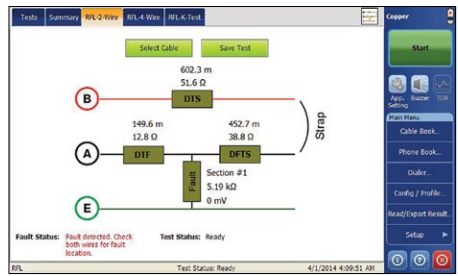


RFL 2-W Results

If the RFL schematic is not respected, and the faulty wire is connected to the **black** test lead **(T/A)** while the good one is connected to the **red** test lead **(R/B)**, the tester will be smart enough to see it. If this happens, the following fault status will be indicated.

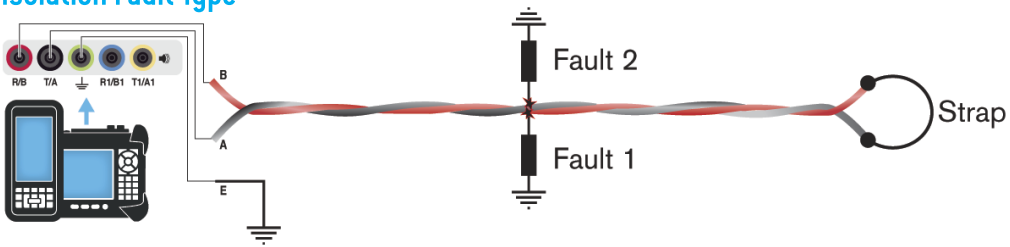
The fault is on the wire connected to the **T/A** test lead.





5. Fault on Both Wires to Ground

Isolation Fault Type



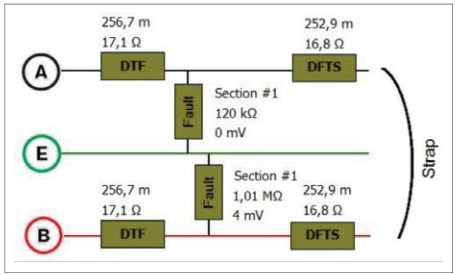
Multiple Points of Failure: Küpfmüller Method, RFL K-test

The Küpfmüller test consists of two measurements:

- One with an open far end
- One with a strap on the far end

Assumptions of the K-test are as follows:

- Rfault1 > 2x Rfault2
- Rfault1+ Rfault2 >100 x Rloop

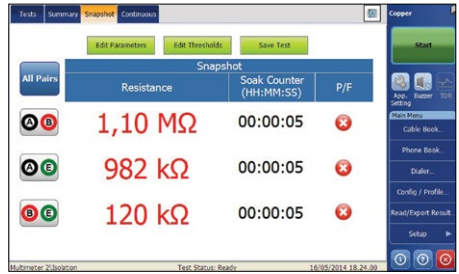


6. RFL K-test Mode

Example: T/A and R/B wires faulty to ground

Isolation Test

When both wires of the same pair have a resistive fault to the ground, and one fault is at least twice as big as the other, the regular RFL test with two or four wires will not work. In that specific situation, the Küpfmüller test, also called the K-test, is required. This test is available on the MAX/FTB-600 solution.



RFL K-test

To perform the test, follow the diagram shown on the screen.

For this test, connect one of the pair's defective wires to the **black** test lead **(T/A)** and the other one to the **red** test lead **(R/B)**. Next, connect the ground to the **green** test lead, and launch the test.

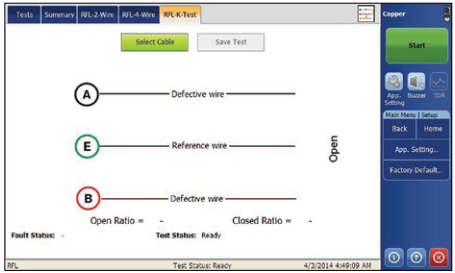
This automatic test has two separate parts:

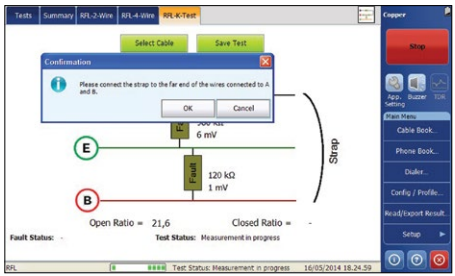
- During the first part of the test, the far end of the pair will remain open.
- In the second part of the test, a short must be created at the far end.

The tester will initiate the first test under the assumption that the pair at the far end is open.

After a moment, the tester will put the test on hold and prompt the technician to place the strap between the two faulty wires at the far end.

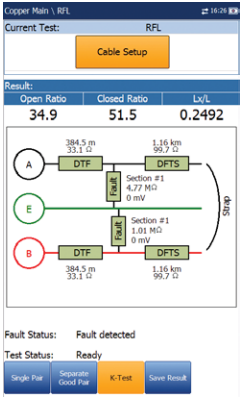
Once the test is complete, the technician must press OK.

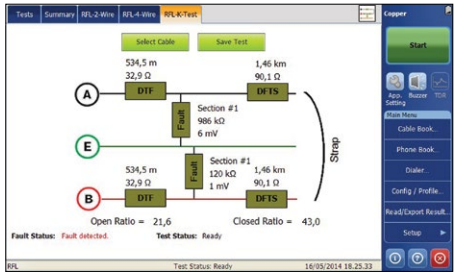




RFL K-test Results

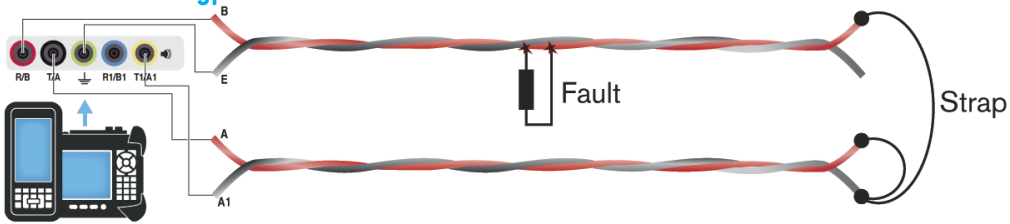
The results will consist of the two ground faults, as well as the distance to the faults and to the strap, as per the RFL two-/four-wire tests.





7. Fault Between the Wires

Isolation Fault Type

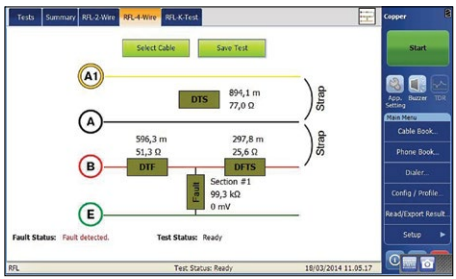


Fault Isolation on Same-Pair Wires: RFL 4-W

The isolation resistance of the good separate pair > 1000 x Rfault.

Both ends of the good separate pair need to be connected to one wire on the faulty pair.

The good separate pair may have a different resistance/ gauge as compared to the faulty one.

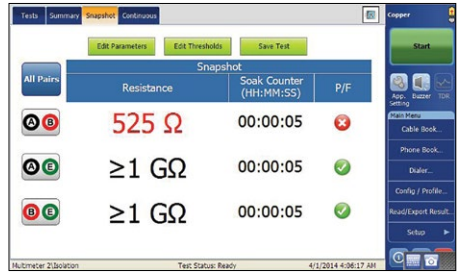


8. RFL 4-W Mode

Example: A short located 150 m between T/A and R/B wires

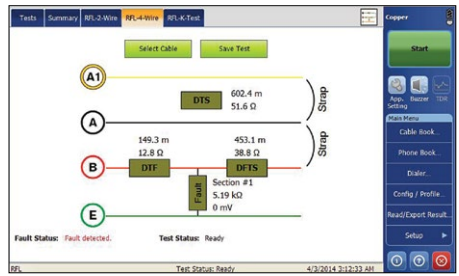
Isolation Test

The isolation test clearly shows that the short is between both wires of the copper pair. Therefore, neither wires can be used as the good wire. In this case, the best practices recommend use of a spare cable as the good wire.



RFL 4-W Test

› To perform the test, the technician simply follows the diagram shown on the screen.



For a short between two wires, the first spare good wire must be connected to the black test lead (T/A), and the second spare good wire must be connected to the **yellow** test lead **(T1/A1)**.

Next, one of the faulty wires must be connected to the **red** test lead **(R/B)**, and the other connected to the **green** test lead.

› A strap must then be placed at the end between the two good wires and the faulty one, after which the test may be launched.

Notes

The RFL 4-W test can also be used to improve the accuracy of the measurement for a wire-to-ground fault, because this method is less affected by the characteristics of the good wire/pair. With RFL 2-W, the good wire must have the same length/gauge as the pair under test. Otherwise, accuracy will be poor.

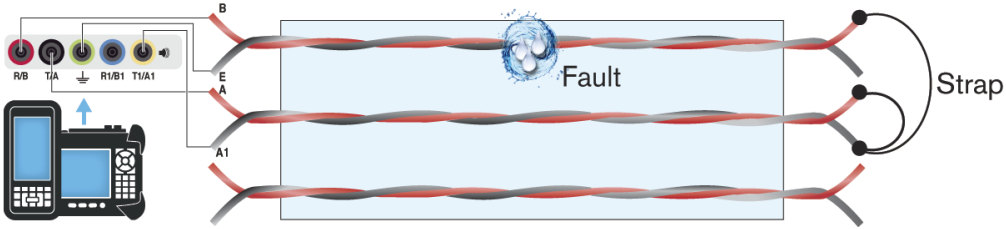
For a resistive fault between one wire and the ground, connect the good wire from the faulty pair to the **black** test lead **(T/A)**, and the spare good wire to the **yellow** test lead **(T1/A1)**.

Connect the faulty wire to the **red** test lead **(R/B)**, and the ground to the **green** test lead.

Next, place a strap at the end between the two good wires and the faulty one, and then launch the test.

9. Wet Faults

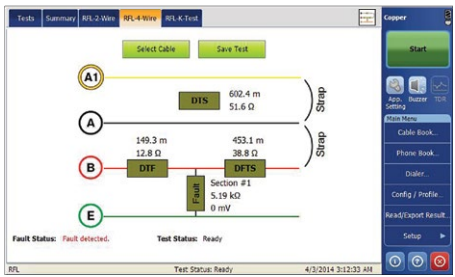
Isolation Fault Type

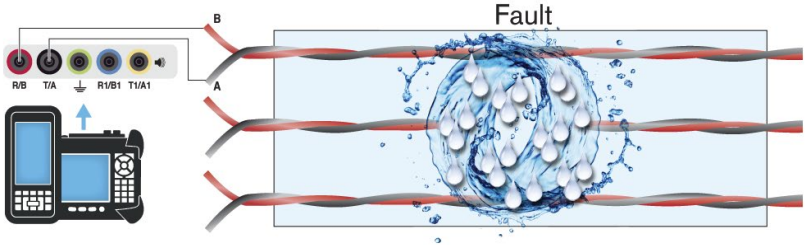


Partially Flooded Binder: RFL 4-W

Use a good separate pair to locate a fault generated by water or moisture.

Depending on the severity of the fault, a TDR may be used as an alternative.

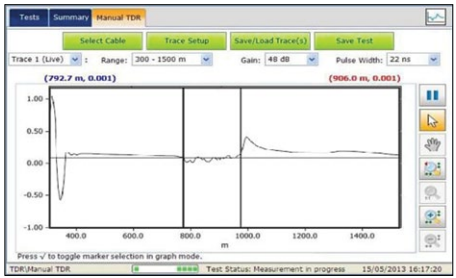




Totally Flooded Binder: TDR

When a fault is very severe, the accuracy of the TDR may be affected.

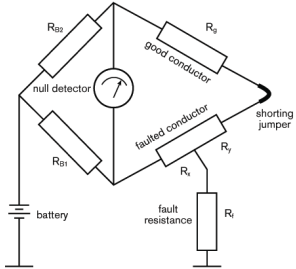
This diagram depicts a water-soaked cable with an open circuit. The water section could have appeared anywhere along the cable. Generally, a noisy reflection is a sign of water. If possible, use a separate good, dry pair and RFL 4-W mode for higher accuracy (see Chapter 8).



10. Additional Notes

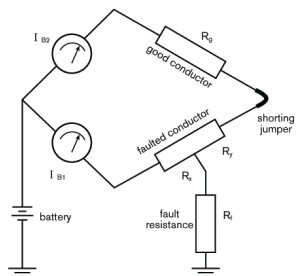
10.1 Murray Method

The RFL tool is based on the Murray Bridge concept, where a circuit measures the current or the voltage in a bridge schema. The real application of the method can vary from test set to test set, but the basic rules and assumptions remain the same. The main assumptions are that the resistance per km/mi of the two wires of the same pair is identical, and that there is only one faulty wire.



Passive

› The passive method requires manual bridge balancing in order to obtain the proper zero of the null detector.

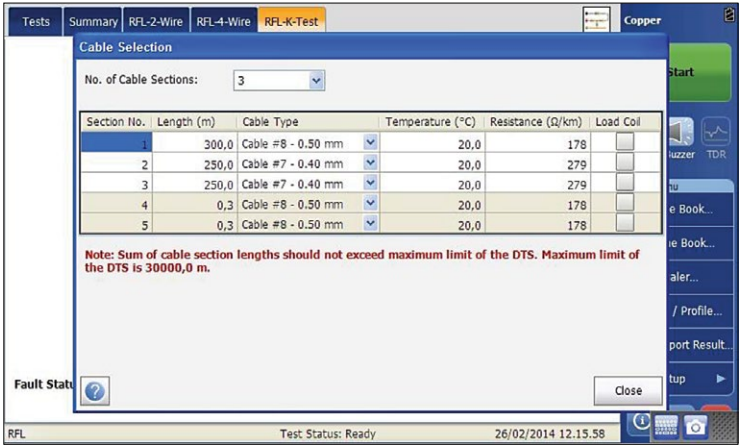


Active

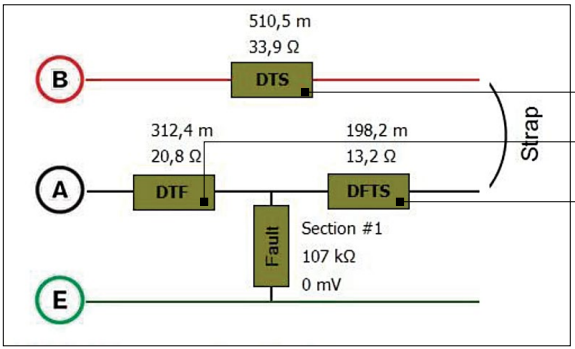
› The active method is more practical for everyday jobs. EXFO's RFL 2-W mode is similar to the Murray Active method.

10.2 RFL Setup

In a multisection cable, each section can be set up for a more precise indication of which section is faulty.



10.3 RFL Result



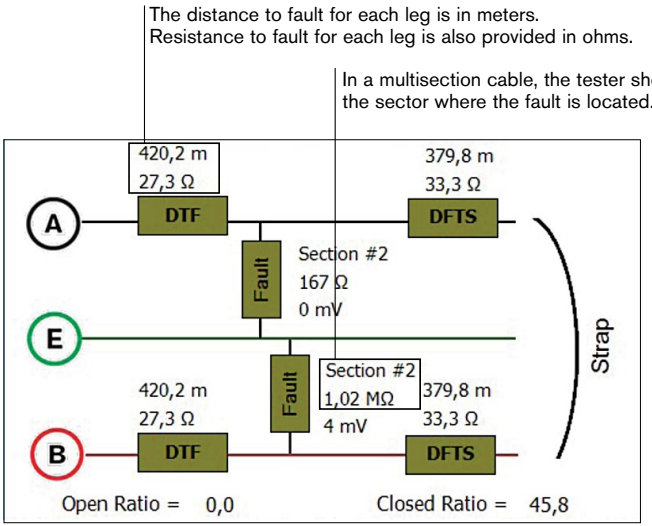
DTS: Distance to end/strap

DTF: Distance to fault

DFTS: Distance fault to end/strap

Example of Test Result

The picture below shows an example of the results returned by the EXFO tester further to an RFL test.



10.4 EXFO Solutions

Access Product Portfolio

Fit for every technician's toolbox, EXFO's wide range of smart, field-portable solutions are designed for installation, activation and maintenance of any type of network.

Visit **www.EXFO.com** for more information.

- MAX-610/635 supports: TDR, RFL 2-W, RFL 4-W, K-test
- FTB-610/635 supports: TDR, RFL 2-W, RFL 4-W, K-test

SmartR™ makes copper testing a whole lot easier.

What is SmartR™?

EXFO's SmartR™ technology enables a unique test approach that delivers intelligent and automated copper fault analysis, enhanced with graphical results and plain-language interpretation.

This feature set automatically runs a series of copper tests, analyzes the results, and provides graphical, color-coded results with clear pass/fail statuses.

The powerful algorithms behind SmartR™ provide the additional capability to accurately locate potential service-affecting faults.

SmartR makes copper troubleshooting much quicker and simpler in comparison with traditional manual methods. In the end, it helps you roll out advanced multiplay services confidently and efficiently–and benefit from significant cost and time savings.

- Speeds up circuit-fault interpretation
- Enables technicians to perform tests beyond their prior skill level
- Implements uniform, repeatable methods

SmartR™ Pair Detective

SmartR™ FaultMapper

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