

## What is RFL?

### Introduction

Technicians use a measurement technique called resistive fault locate (RFL) to quickly and accurately determine where faults such as shorts, grounds, or battery crosses are located. RFL involves strapping a good wire or pair (shorted) to the faulted (bad) wire and then performing a series of ohmmeter measurements. After analyzing the results of the ohmmeter measurements and performing an ohms-to-feet conversion, the technician can determine the size and location of a fault.

Typically, RFL is the last test performed because other measurements such as DC volts, ohmmeter, or opens should be run first to detect problems. However, once a fault has been identified as a resistive fault less than 20 Meg ohms and the faulted wire is located, RFL can help pinpoint the fault location.

Although a TDR may be used to help determine the presence and location of a fault, an RFL measurement often is more accurate. There are several key factors that separate RFL from the TDR, including:

- The more resistance a fault presents, the less likely the TDR is able to verify that it exists, and
- The TDR only uses tip and ring; consequently, it may not see a fault from tip or ring to ground.

Given the limitations of test tools, such as the TDR, it is apparent that RFL is an important measurement that can provide information that is unavailable through other sources.

### Need for RFL

Highly resistive faults can be difficult to verify and correct during initial testing. It is not uncommon for a circuit to pass initial testing and then fail at a later time. With a very limited supply of copper pairs in good condition, RFL provides a reliable and accurate means for locating faults so that the pairs are fixed before new services are provisioned

### How RFL works

A technician places a strap or short from the faulted wire to a good wire or pair and performs RFL using a series of precise resistance (ohmmeter) measurements to accurately determine the resistance to a fault. During this test, the resistance to the strap (short) is determined along with the fault size. After these measurements, both the temperature and gauge of the copper wire are taken into consideration and an ohms-to-feet conversion is performed. The results provide information such as DTF (distance to fault), DTS (distance to strap), and DSTF (distance strap to fault).

### The RFL test performed with the HST-3000

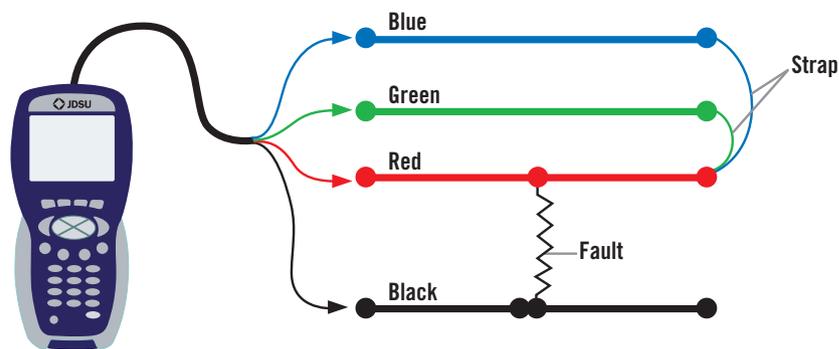
When using an HST-3000 for an RFL test, the terms tip, ring, and ground are not used. Instead, the connections are as follows:

- HST-3000 green test lead connected to the “good” wire (green to good)
- HST-3000 red test lead connected to the “faulted” or bad wire (red to bad)
- HST-3000 black test lead connected to the “reference” wire, which is typically ground or shield (black to reference)

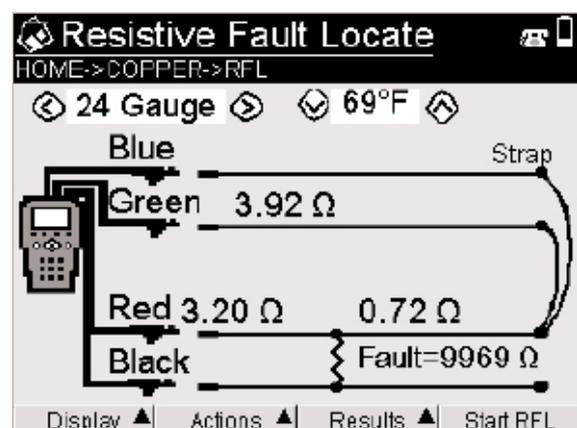
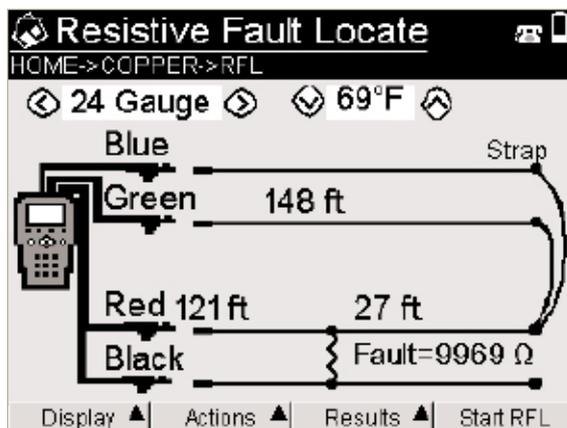
For separate pair RFL measurement, the HST-3000 blue test lead and the HST-3000 green test lead are connected to a known “good” pair

### Two methods for performing an RFL test

#### Separate pair method

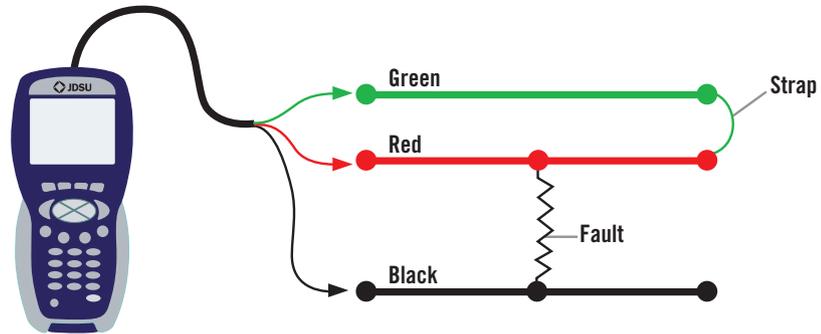


The separate pair method is preferred because it is the only method that can be used for a double-sided fault (both wires in a pair are faulted). In this case, the user locates a known good pair, or if the distance to the strap is not too long, lays out a separate pair of wires across the ground to use as the known good pair. A strap is placed from each lead of the known good pair to the faulted lead, or the known good pair is strapped together and then strapped to the faulted wire. After these straps are placed, the loop is ready for RFL separate pair testing.

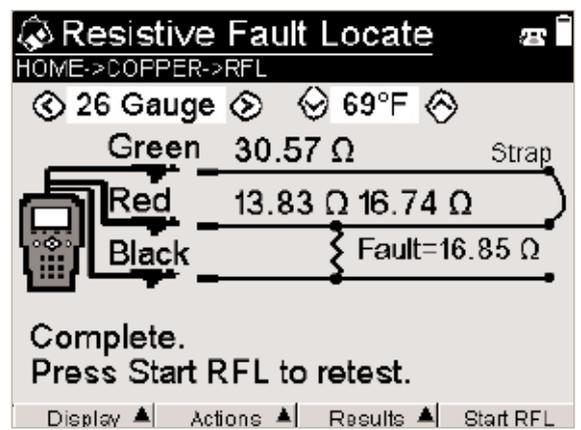
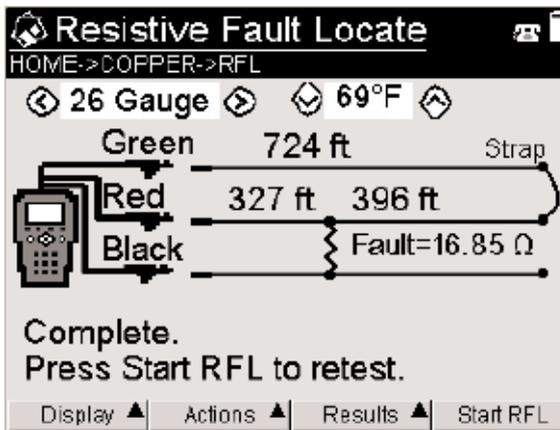


**Single pair method**

Single pair testing should be used only if the separate pair method is not an option. This situation occurs when there is no known good pair and if only one side (lead) of the pair under test is faulted. To perform single pair RFL testing, the technician straps the good wire in the pair under test to the faulted (bad) wire



It is important to note that RFL testing takes approximately 30 to 40 seconds. Arrows indicating the paths that are being tested will be displayed on the HST-3000's screen. Once the test is completed, each result will be shown in either ohms or feet.



## Temperature and gauge

The temperature and gauge of the wires must be entered into the HST-3000 before an accurate distance conversion can be performed.

### Temperature

As the wires' temperature changes, so does their resistance. For example, the higher the temperature is, the greater the resistance. Because RFL determines the location of the fault through a series of resistance measurements, the accuracy of the distance conversion is skewed in proportion to the difference between the temperature setting and the actual temperature.

### Gauge

Gauge affects distance conversion because different gauge wires have different levels of resistance. (See Table 1 below.) The higher the gauge is; the greater the resistance.

19 gauge/.8mm	16.09 Ohms/1000 feet (305m)
22 gauge/.6mm	32.4 Ohms/1000 feet (305m)
24 gauge/.4mm	51.32 Ohms/1000 feet (305m)
26 gauge/.4mm	82.01 Ohms/1000 feet (305m)

Table 1. Typical ohms-per-foot/meter values

It is possible to have more than one gauge of wire over the length of the cable. There are different methods for adjusting the temperature and gauge when performing RFL testing on multi-gauge and single-gauge cable spans.

### Single-gauge cable span

It is easy to adjust the temperature and gauge displayed on the HST-3000's RFL testing screen. Before or after the test is complete, push the up arrow to raise the temperature and the down arrow to lower it. Push the left and right arrow keys to increase or decrease the gauge of the wire.

### Multi-gauge cable span

A technician uses the multi-gauge setup option to accurately measure a pair containing sections of multiple gauges and/or cable with different temperatures (buried and aerial). Because these variables affect the resistance of the pair, the accuracy of the conversion also is affected. Therefore, the HST-3000 must be configured to closely reflect the true conditions of the pair. The larger the error for cable gauge or temperature is, the greater the impact these variables will have on the accuracy of the measurements.

To prevent any discrepancies that can cause a distance conversion to be inaccurate, enter the gauge, temperature, and distance for each section of cable by following these steps:

1. Press the **Configure** action key
2. Press the **Display** soft key
3. Select “Display Multi-Cable Setup”

To add new sections of cable, press the **Add** soft key. When prompted, enter the gauge, temperature, and length of the cable section. If the **Delete** soft key is pressed, it will delete the last section listed. Once each section of cable is entered, press the **Home** or **Cancel** button.

Gauge	Temp	Distance
124 Gauge	69°F	????
224 Gauge	69°F	1000 ft
326 Gauge	50°F	5000 ft
4	----	----
5	----	----
6	----	----
		Total: ????

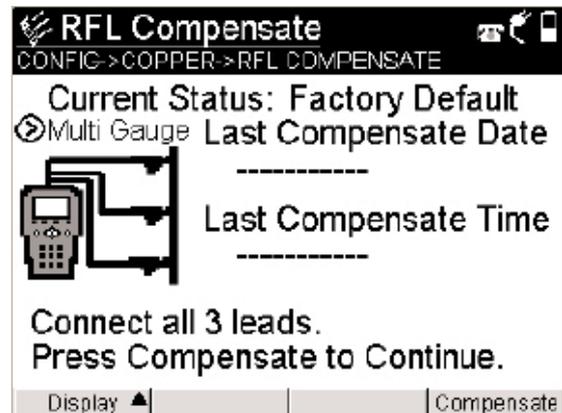
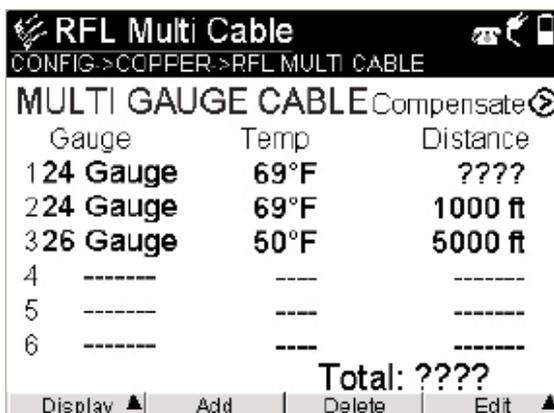
To enter an unknown value for temperature or distance on one section of cable, type #. The HST will calculate the value of this missing field.

### Cord compensation

There is a different compensation for single and separate pairs.

For the most accurate results, JDSU recommends compensating the RFL measurement to remove possible effects of the test leads by taking the following steps:

1. Press the **Display** soft key
2. Select the appropriate mode (Single Pair Manual Strap or Separate Pair Manual Strap) and press okay. (The number of the selection can also be pressed.)
3. Press the **Configure** navigation key.
4. Follow the instructions on the screen and connect the HST-3000 test leads to the test cable



5. Press the **Compensate** soft key

The compensation stops automatically when finished, and the result is displayed. The date and time are recorded if it was successful.

6. Press the **Home** navigation key to return to the RFL

### Distance to strap (DTS)

During RFL testing, it is important to keep DTS as short as possible because of distributed leakage; small amounts of leakage that occurs even over a good wire. More of this leakage is present over longer distances. Therefore, to keep DTS as short as possible, technicians can sectionalize the cable by using the HST-3000's ohmmeter to locate the section of cable that contains the fault, then stop and test just that section.

### The good pair and leakage

Before performing RFL, it is important to verify that the good pair or wire is actually good by using the HST-3000's Leakage mode ohmmeter. If leakage is present, the leakage should be 500 times greater than the fault size on the bad wire or the results will be affected. Once there is confirmation that the pair has little or no leakage, the leads can be strapped to the faulted wire and RFL testing performed.

### Testing from both ends

Performing RFL testing from both ends and comparing the results to see if they agree can help pinpoint the location of the fault. If the results conflict, this may indicate other problems and/or an inaccurate conversion.

### Connections and ohms

It is important to take into consideration that the wires, adapter, or screws that connect the HST-3000 to the pair also may introduce levels of resistance. For example, if the technician connects the clips to corroded screws, this will add resistance and cause an inaccurate measurement.

### Testing multiple pairs

It is important to test multiple pairs if there is more than one faulted pair in a count or binder. Typically, the faults found using RFL are located in the same area as other faults; however, the distance to each fault may vary slightly due to the make up of the cable. Additionally, as more pairs are tested, the severity of the faults can provide insight as to when it is time to repair the cable.

Because unusual line conditions can change and affect RFL, the same pairs should be tested multiple times to validate results and ensure accuracy.

### Load coils

Load coils can make the pair's distance appear longer by a range of 91 feet to more than 480 feet. To derive the correct distance, technicians must subtract the designated amount (See Table 2.), which is based on a 5-foot stub at 70° F. It is important to know the load's location so that the correct amount is subtracted from the correct section.

Code	19 AWG	22 AWG	24 AWG	26 AWG	OHMS
632	470	235	147	91	4.14
652	484	242	150	94	4.17
662	480	240	149	96	4.25

Table 2. Load coil corrective distance

### Tips

#### Ohms in strap

It is important that the strap attached to the end of the wires under test has the least amount of resistance as possible to maintain the accuracy of the RFL. The greater the strap's resistance, the more inaccurate the measurement.

#### Use ground or ring as reference

If using ground as a reference to locate a battery cross does not give a good result, the ring lead of a working POTS line can be used as a reference.

#### Error messages

Fault Size > 20 Meg ohms

Loop > 7000 ohms

## Definitions

### Battery cross

A fault that occurs when the bad wire is shorted with the ring lead of a working pair

### DTF

Distance to fault (the distance from the HST to the fault)

### DTS

Distance to strap (the distance from the HST to the strap)

### DSTF

Distance strap to fault (the distance from the strap at the far end of the pair to the fault)

### Double-sided fault

A condition where both wires in the pair are faulted. When this occurs, the pair must be tested using the separate pair method. Normally, the fault occurs on both wires at the same place; therefore, using either wire as the “bad” wire will locate the fault.

### Reference pair

The pair or conductor that the test set uses in conjunction with the faulted wire to accurately calculate the distance to the fault.

## Warnings

### Multiple faults

RFL cannot accurately determine the location of multiple faults on a pair. Because distance is based on the assumption that resistance is caused by a single fault in one location, multiple faults cause errors in the resistance measurement, which, in turn, cause errors when converting resistance to a distance.

For example, if a pair is 1000 feet long and there are two faults of equal resistance on the pair at 25 feet and 75 feet, then RFL results will indicate there is a fault at 50 feet. If the faults are equal, RFL results will show one larger fault located between the two faults.

### Cross

If the pair under test is crossed with a working pair with a higher voltage than POTS (plain old telephone system), such as HDSL, then the voltage on the pair could be 190 volts or more.

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