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13 Measuring Resistance with Model M3

PRELIMINARY NOTE: This section applies only to Users who have purchased CableEye Model M3 testers. Model M3 has internal electronics enabling the measurement of resistance whereas Model M2-Basic, M2, and older models do not.

13.1 Model M3 Overview

Customers have three models of CableEye to choose from when purchasing a system. Model M2-Basic (Item 810) provides a fixed resistance threshold of about 46 kΩ and is limited to cables of 64 or fewer conductors (128 test points total). M2-Basic is not expandable beyond 128 test points, but is our lowest cost system and suffices for many applications. Model M2 (Item 811) also has a fixed resistance threshold of 46 kΩ but is expandable to over 1000 test points for large cables and wiring harnesses. Both M2-Basic and M2 are excellent when you need to check only for opens, shorts, and miswires. With the high 46 kΩ threshold, these models will detect very low-level short circuits between conductors. Model M3 (Item 821) has all the capabilities of Model M2, but also offers two adjustable resistance thresholds between 0.5 Ω and 10 MΩ, and also will measure discrete resistors within this range that may be embedded in a cable. M3 would be used in applications where connection quality and isolation must also be checked (e.g.: medical electronics, high-current applications), or embedded resistors are present.

We provide this section for customers purchasing our Model M3 tester, or for existing CableEye users upgrading from the M2 to the M3 system. Section 13.2 starting on the next page applies specifically to those who are upgrading their existing M2 tester to an M3 tester or who will be using a mix of M2 and M3 testers. Customers purchasing a new M3 tester for the first time may skip directly to Section 13.3 in which we describe those software functions not described previously in this User's Guide that apply specifically to M3.

13.2 Hardware Differences between CableEye Models M3 and M2

Externally, Models M3 and M2 appear almost identical. Both use the same aluminum housing, both connect to the computer's serial port using a supplied DB9 M/F cable, both have an external power module, both can accept the same CB interface boards and accessories, and both use the same software. The electronic circuit board in M3 and its electrical operating characteristics, however, are entirely different. If you have used the M2 tester previously, you should be aware of the following essential differences:

1 – M3 applies test voltages between 0v and +10v at a maximum of 1ma to the unit under test. M2 applies test voltages between 0v and +5v at a maximum of 0.33ma to the unit under test.

2 – M3 requires a different power module than M2. We include the proper power module with all new units. If you upgrade from M2 to M3, you *must* return your M2 power module with the base unit when we perform the upgrade, and we will return a proper module to you with the upgraded equipment. For M3, the module's output is 15v DC, unregulated, at 400 to 500ma. If you are using both M2 and M3 testers in your facility, it is ***very*** important that the M2 and M3 power modules not be interchanged. The DC plug will fit both types.

3 – If you need more test points than are provided on the M3 base unit, you may purchase expansion modules for it in increments of 128 test points. One wall power module will suffice for a base unit. If any expansion modules are used, a separate regulated desktop power supply is provided in place of the wall module. M2 and M3 expansion modules are ***not*** interchangeable. If you require an expansion module for M3, you must purchase the expansion module specifically designed for it (Item 822 or 823).

4 – Two separate M2 base units may be connected together so that the 2nd unit acts as an expansion module. M3 base units cannot be connected in this manner due to M3's more complex internal electronics. If you need to expand to M3 base unit beyond 152 test points, you need to purchase an M3 expansion module (Item 822 or 823).

5 – When you measure a cable with M2, the Pass, Fail, and Ready lights flicker, indicating that a measurement is in progress, and would stop flickering when the measurement completes. These lights *do not flicker* on M3. Instead, the Pass, Fail, and Ready lights will turn off and a yellow ***Busy*** light will turn on and remain on constantly (will not flicker) during the measurement. The Busy light will turn off when the measurement finishes, and Pass or Fail will illuminate appropriately if Match Data is available for comparison. If Match data is not loaded, neither Pass or Fail will be on.

6 – A miniDIN8 Remote Control socket accessible from the rear of the tester functions similarly to that on the M2 tester, but in addition, it offers an output drive signal for an external relay or lamp capable of sinking up to 200ma. You control this signal with a special Macro instruction, however, we do not plan to implement this instruction until we release software version v4.1 in the spring of 2001.

7 – The DB15 *female* ***Expansion Out*** connector accessible from the rear of M2 is replaced by a DB26HD female connector on M3. This offers the 11 additional signal pins necessary for the M3 detached expansion module.

In place of the DB15 *male* connector found on M2 is a 24-pin IDC header intended as the *Expansion Out* connector for the *M3 Attached Expansion Modul*e (AEX), Item 823. You may connect either the Attached Expansion Module (Item 823) to this 24-pin header, or the separate expansion module (Item 822) to the DB26HD connector. However, *never connect both types of expansion module at the same time;* doing so may damage the circuitry.

13.3 Resistance Measurement and Thresholds

CableEye Model M3 offers a high-speed resistance scanning circuit not found on previous CableEye models. This new capability permits you to check the *quality of a connection* in addition to basic wiring correctness. For most cables, you do not need to measure the actual resistance of each wire. Rather, you would like to confirm that the resistance of a good connection does not exceed a maximum limit, and that the isolation between unconnected wires does not fall below a minimum limit. We refer to these two limits as *thresholds.*

Whenever you test a cable, the thresholds you have chosen in the *Resistance Limits* preferences are applied automatically. Wires that fail the limits test appear in the wire list with a *resistance value* and will cause any comparison made with Match Data to fail unless a corresponding resistance appears in the Match Data wire list.

You may also measure the *actual resistance value* of one or more resistors that may be embedded in a cable. This will happen automatically whenever a cable is tested if the resistor value falls between the two resistance thresholds. Alternatively, you may issue commands to measure resistance between two specific pins with a Macro instruction (explained in a later section).

13.3.1 – Checking for Good Connections

Wire connections in a cable that exceed your maximum resistance threshold will be flagged as defective. High-resistance connections like this may be caused by incomplete crimps, by insufficient mating between the knife-pin and wire conductor in IDC flat cables, or by cold solder joints in soldered connections. These marginal connections may then result in circuit misoperation, intermittent connections, or physical heating in the cable if enough current flows through that connection. In a properly managed cable assembly shop, high resistance connections occur rarely. However, resistance testing is needed to ensure that absolutely no bad cables make their way into a customer's product. You may set CableEye Model M3 to check for an acceptable connection resistance of as little as 0.5 ohms.

13.3.2 – Checking for Good NON-Connections

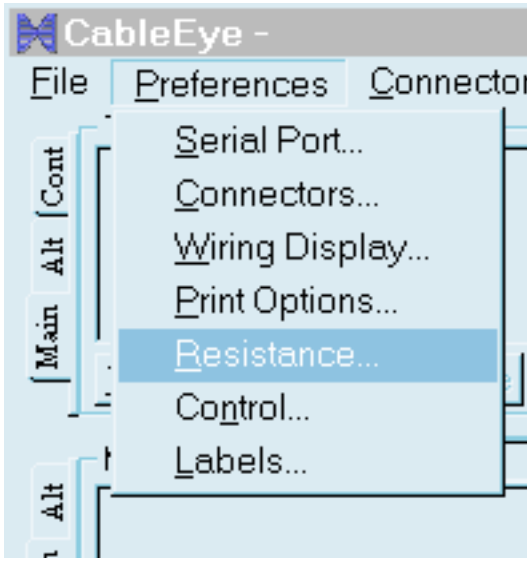
In addition to certifying that a wire connection passes a low resistance test, we must also ensure that internal short circuits do not exist. While this seems obvious, we need to define exactly what constitutes a short circuit. To certain sensitive electronic devices, especially in medical applications, a "short circuit" may exist in a cable when as much as a one Megohm (or higher) resistance path appears between two pins. In contrast, the high output drive capability of present-day CMOS digital circuits can easily maintain the logic '1' minimum voltage across a short circuit of as small as several hundred ohms. Ideally, we would like an infinite resistance between isolated conductors. As a practical matter, though, a lesser amount will be quite adequate for most applications. We recommend a minimum isolation threshold of one Megohm for general purposes, although you may set the isolation threshold to be as high as 10 Meghoms with CableEye Model M3.

13.3.3 – Resistance Measurement Capabilities

Unlike a benchtop multimeter which measures resistance across a single set of probes, CableEye must measure the resistance between every possible combination at least 128 different test points, and must do so very quickly (in less than a second). Consequently, CableEye's measurement characteristics are quite different from a typical multimeter. The following subsections itemize important information about how to set thresholds, how to measure resistors, and what you can and cannot measure.

Setting Thresholds

Choose the *Resistance Limits* tab in the *Preferences* menu, shown on the right, to access CableEye's resistance control panel. Refer to Figure 13-1 on the next page as we discuss this panel. You will set all resistance parameters under your control from the resistance control panel.



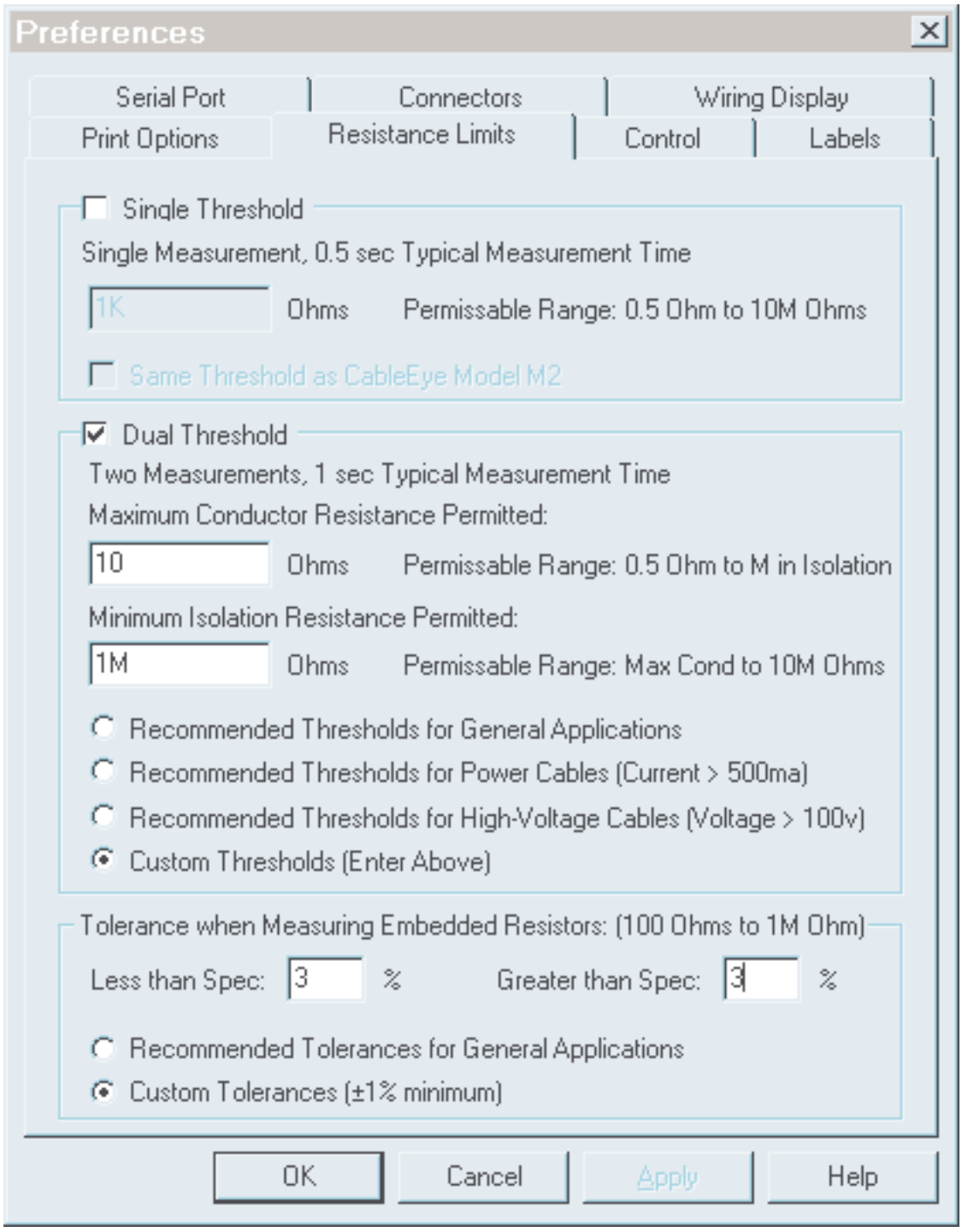


Figure 13-1 *Set resistance thresholds and tolerances using this Resistance Limits tab in CableEye's Preferences menu.*

For our purposes, a "threshold" is simply a resistance value that separates decision regions. If you choose a *Single Threshold*, you are dividing the entire range of conductor resistance, from zero ohms (a perfect conductor) to an infinitely high resistance (a perfect insulator) into two regions. Values below the threshold signify an acceptable conductor, and values above it signify acceptable isolation between conductors. When you use a single threshold, the measurement time will be faster, but you will not be able to detect embedded resistors nor will you be able to test the quality of a connection. The single threshold option was provided for applications where you need to configure Model M3 to behave exactly like our simpler Model M2 tester, or for special applications. *Example:* if you choose a threshold of 1000 Ω, all connections below that value qualify as *acceptable* wire connections, and all connections above that value are considered "open circuits". Typically, good wire connections have a resistance of less than 10 ohms (often only a fraction of an ohm), and isolated conductors offer a resistance of 1 Megohm or greater (typically 10's of Megohms, depending on humidity).

For most purposes, you would select the *Dual Threshold* option in the Resistance Control Panel. In this case, we divide the entire range of conductor resistance into three regions. As in the single threshold option, the lower region contains all acceptable resistance values for a "good" connection (a wire), and the upper region contains all acceptable resistance values for isolated wires where no connection exists. We also have a *middle* region which represents either questionable connections, or discrete resistors that may be embedded in a cable. Refer to Figure 13-2 below.

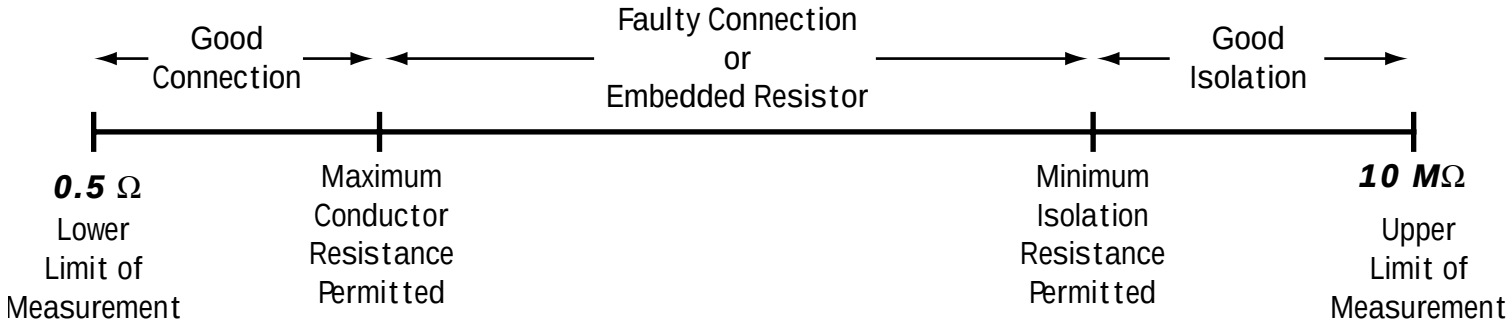


Figure 13-2 *Dual resistance thresholds divide the range of sensitivity into three regions.*

The *Maximum Conductor Resistance Permitted* sets the highest value of resistance acceptable for a "good" connection. For most applications, we recommend a value of 10 ohms, but it could be set to as little as one-half an ohm. If you set this value for less than five ohms, the measurement time may increase by a factor of two or more due to the increased sensitivity you are asking for, and you may pick up marginally higher resistance values that will have no effect on the function of the cable. Use the smallest threshold of 0.5 ohms only when you test power cables or any cables that are expected to carry significant current (20 gauge or thicker wire).

The *Minimum Isolation Resistance Permitted* sets the lowest value of isolation resistance acceptable for unconnected wires. For most applications, we recommend a value of one Megohm, but it could be set to as high as ten Megohms during automatic scanning. Note that you may make discrete measurements between specific conductors using the Macro instruction "TEST RESISTANCE . . .", or the *Resistance Tool* in the wiring display window.

Note that contact the resistance of dry human skin is about two or three Megohms. To minimize the probability of false negatives during production testing, we recommend setting the isolation threshold above one Megohm *only* when you are testing cables that will be used in a high voltage or extremely low current application. It is interesting to observe that you would need to apply 1000 volts across a one Megohm resistor to create a current flow of one milliamp.

Measuring Resistors Automatically

CableEye measures embedded resistors automatically when the resistor's value falls *between* the high and low thresholds. When you save a cable in the database, the resistance values associated with any embedded resistors are saved along with the wire list and other cable information. Thus, embedded resistors become one of the characteristics of the stored cable and must be present in a test cable to successfully match against the saved data. When you compare two cables that contain embedded resistors, the resistance values measured in the unit under test must fall with the tolerances you set in the *Resistor Limits* preferences you see in at the bottom of the Resistance Control Panel. Missing resistors, misconnected resistors, or resistors that are present but fall outside of the tolerance range, will flag an error when the cables are compared.

Threshold Violations

The thresholds you set, whether in the single or dual threshold mode, function automatically every time you test a cable. Threshold violations, if any are found, appear in a *Characteristics* column on the wirelist, as shown in Figure 13-3. The wiring diagram cor-

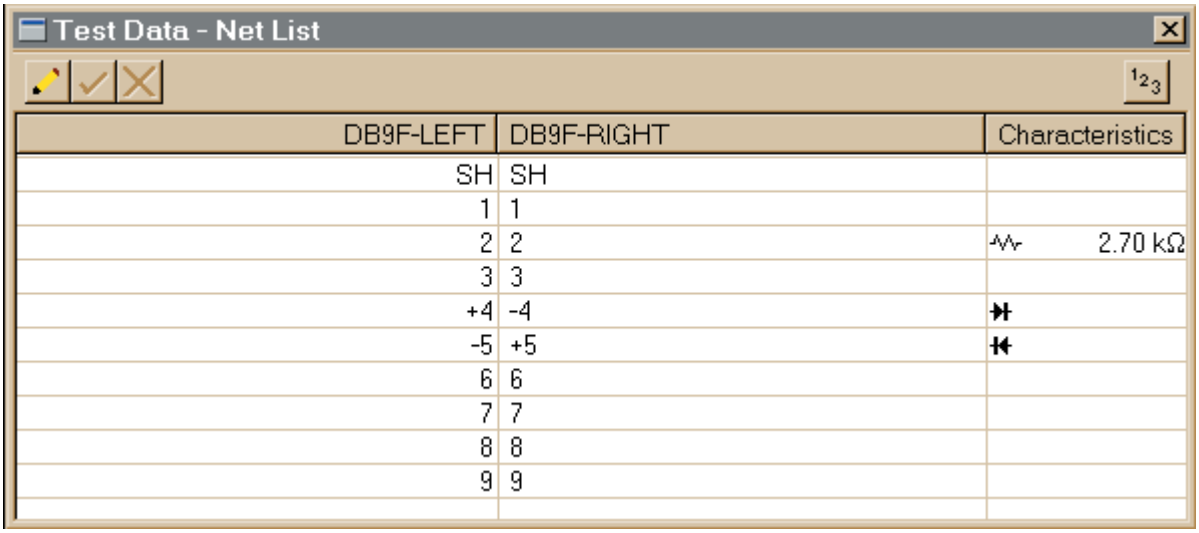


Figure 13-3 *Threshold violations appear in the Characteristics column of the Net List. This cable contains two diodes as well.*

responding to this Net List appears in Figure 13-4. Note that a threshold violation may be caused either by a faulty connection or by an embedded resistor. CableEye cannot know how to interpret the Test Data *unless* you have loaded Match Data. A resistor pre-

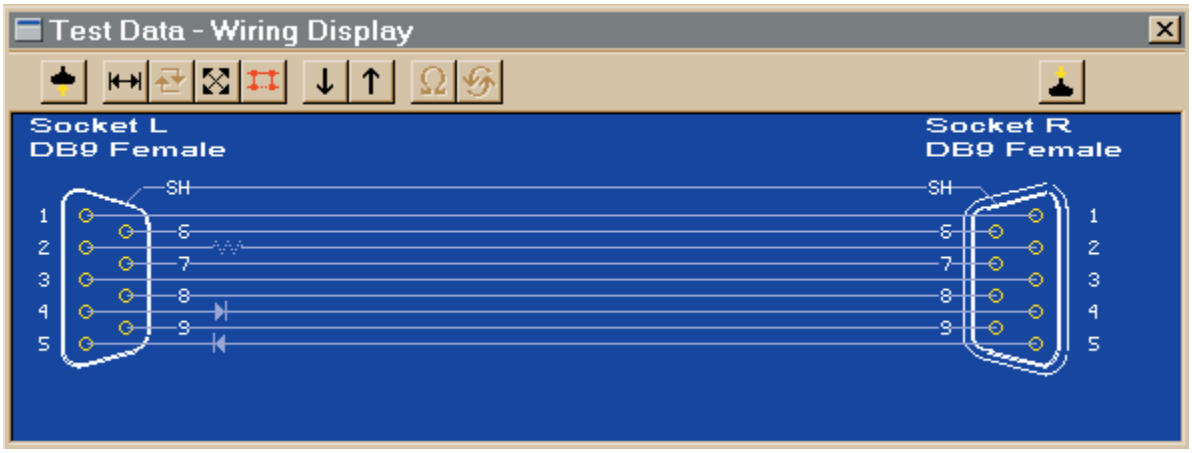


Figure 13-4 *This wiring schematic corresponds to the wire list of Figure A3 and shows either a threshold violation or an embedded resistor in the cable, as well as two diodes.*

sent in the Match Data netlist requires that a corresponding resistor appear in the Test Data netlist and fall within the resistance tolerance specified in the Resistance Control Panel in order that a *Pass* condition be achieved.

Comparing Two Cables

Match data need not be loaded to detect simple threshold violations. As seen in the previous figures, you may refer to the wire list to see any violations detected. However, in order to generate a *Pass* or *Fail* condition and cause the appropriate indicator lamp to light, Match Data *must be present*. The Match Data you load specifies what constitutes a "good" cable. To achieve a *Pass* condition, the following requirements must be met after you measure a cable:

1 – The wiring topology must match perfectly.
2 – The connector types and genders must be identical
3 – The presence or absence of a shield must match.
4 – Any diodes embedded in the cable must be present and properly oriented.
5 – There must be no resistance threshold violations.
6 – Any embedded resistors present in the Match Data must also be present in the Test Data and found to be within the tolerance range specified in *Resistor Preferences* panel.

We report the results of this comparison in the *Differences List* window. Unlike previous versions of the CableEye software, the Differences List now has a *Characteristics* column in which resistance errors are detailed.

Note that you may specify two or more *different* low thresholds in a cable if desired. This might be necessary if you have a combination of power and signal lines in which the current-carrying conductors have a more stringent low resistance requirement, or if you are measuring a multi-headed cable or wiring harness in which one of the legs involves much longer run of wire than the other. As an example, assume you need to set a threshold for signal lines to 20 ohms, and for two power conductors (heaver gauge wire) in the same cable for 0.5 ohms. First, set the low threshold in Resistance Preferences to the highest value, 20 ohms in this case. Then, manually enter resistance values of 0.5 ohms using the Netlist Editor (described in Section x.x.x) for those conduc-

tors which are to have lower thresholds. Finally, set the resistance tolerance in the Resistance Preferences to +0% and –100%. In this way, any defined resistors a guaranteed to have values at or below the value you choose.

The Test Data shown in Figure 13-5 has four threshold violations. In this case, we had set the low threshold at 10 ohms and the resistance tolerance at 20%. Because the connections L-44 to R-44 and L-46 to R-46 do not show resistors defined in corresponding positions of the Match Data, they must be faulty connections and thus appear in the Differences List. The connection L-48 to R-48 does have a corresponding resistor in the Match Data. Although the resistances are not exactly equal, they are within the 20% tolerance we specified, so no error is flagged for the connection L-48 to R-48. Finally, the connection L-49 to R-49 has a corresponding resistor in the Match Data, but the value measured in Test Data exceeds the tolerance and thus is reported as an error. Note that in this case we report the *difference* between the measured resistance and the Match Data value in the Differences List.

A *Pass* condition exists only when no errors appear in the Differences List. At that time, the PASS lamp will light on the tester, a large green box with a yellow checkmark will appear on the computer's screen, and any Macro that may be executing will process the test as a "match". If the Differences List show any entries at all, a *Fail* condition will be asserted, causing the FAIL lamp to light, a large red box with a black X to appear on the computer's screen, and the "no match" situation processed in a Macro.

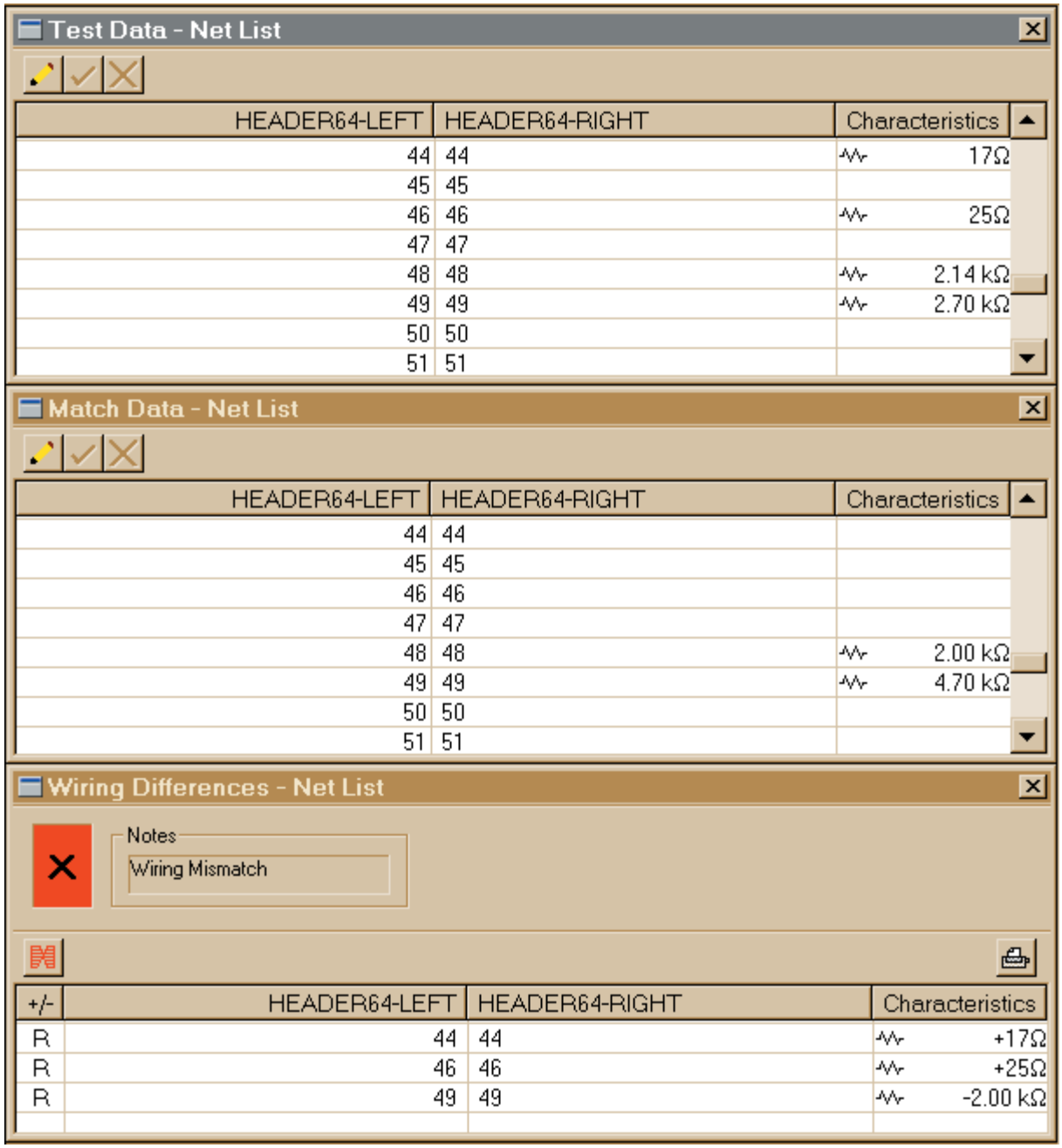


Figure 13-5 *Here you see Test Data with threshold violations reported, Match Data with two defined resistors, and the Differences List showing only those connections in the test cable which violate the Match Data. In this case, the resistance tolerance was set at ±20%, so one connection passed and the other failed.*

Measuring Resistors by Direct Control and With Macros

Occasionally, you may need to measure a resistor whose value falls within either the good connection or good isolation resistance range (for example, measuring a five ohm resistor with the low threshold set at 10 ohms). This will not normally happen automatically when you use Test Cable. However, you may accomplish this in one of three other ways:

1 – If Match Data has been loaded and contains one or more embedded resistors in the net list, resistors that are expected but not found in the Test Data trigger individual measurement cycles on the specific test points between which the resistor appears in the Match Data. If these targeted measurements fail to detect a resistor, or detect one that is outside of the tolerance you specified, an error will be flagged.

2 – To manually test the resistance of any specific connection, display the schematic wiring diagram and use the Up- or Down-Arrow keys to highlight a connection of interest. Once you have highlighted the desired connection, a *Group Netlist* window pops up showing the resistor's value. click the *Resistance* tool ("Ω" symbol) in the menu bar to measure the resistance of that connection once, or the *Continuous Resistance* tool (circulating arrows symbol) to measure constantly; pressing the Continuous Resistance tool again stops the remeasuring cycle. See Figure 13-6.

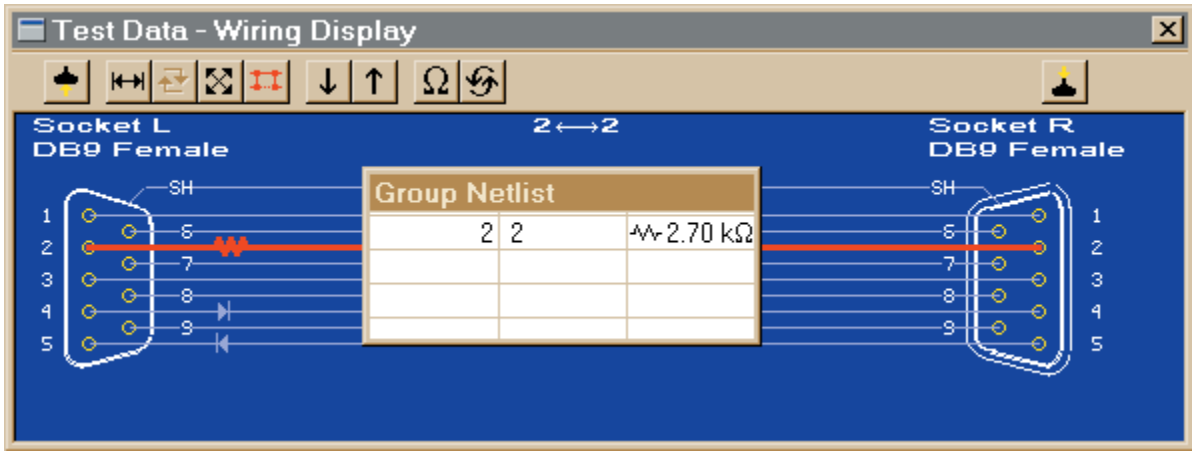


Figure 13-6 *Highlight a resistive connection to produce a pop-up window with the details.*

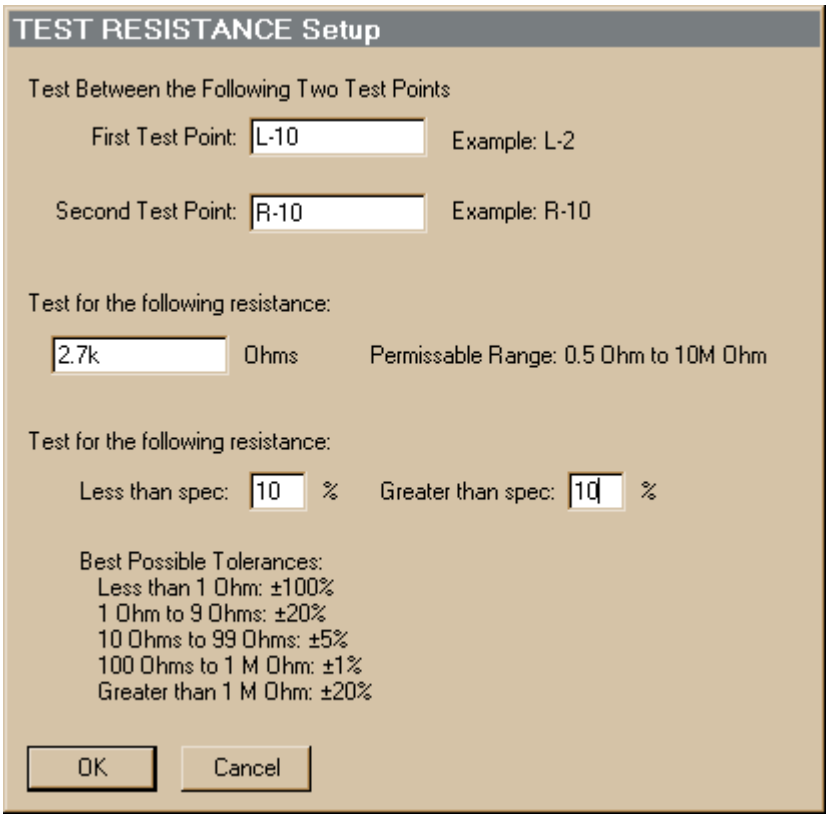
3 – Use the "Test Resistance" Macro instruction during an automatic test sequence. This Macro instruction takes the following form:

TEST RESISTANCE (Pin 1) (Pin 2) (Expected Value) (+Tolerance) (–Tolerance)

When you choose "Test Resistance . . ." from the instruction list, a setup screen appears which lets you enter easily all of the needed values.

Example:

Test for a 2.7 kΩ resistor between pins L-10 and R-10, allowing a ±10% tolerance. Here is the setup screen that will appear showing the values you would enter:



Upon clicking "OK", the window will close and the following instruction will appear in the Macro list:

TEST RESISTANCE L-10, R-10, 2.7kΩ, +10%, –10%

When this instruction executes, the result will be True or False, so you would then follow this instruction with

`IF MATCH THEN . . .` or **`IF NOMATCH THEN . . .`**

At this point, you may sound a tone, print a report, print a label, or take other appropriate action. If you are unfamiliar with CableEye Macros, refer to Section Six in the CableEye User's Guide, *Automatic Testing*, for more information.

Resistance Accuracy

Unlike a digital multimeter, CableEye's resistance measurements vary in precision over the measurement range. This means, simply, the the most accurate measurements occur in the middle of the range where you might expect to find embedded resistors. Fewer digits of precision are offered at the extremes where we are simply checking against performance thresholds. This characteristic results from designing a resistance thresholding circuit that operates at the highest possible speed. The table below summarizes the ranges and precisions offered.

Resistance Range	Digits of Precision	Accuracy	Numeric Examples
0.5 Ω to .9 Ω	1	±0.1 ohms	0.7 Ω,
1 Ω to 9 Ω	1	±1 ohm	3 Ω
10 Ω to 99 Ω	2	±10%	83 Ω
100 Ω to 999 kΩ	3	±1%	586 Ω,, 1.39 kΩ
1 MΩ to 2.9 MΩ	2	±10%	1.5 MΩ, 2.1 MΩ
3 MΩ to 10 MΩ	1	±20%	4 MΩ, 8 MΩ

These accuracy values apply when you measure embedded resistors. When you set thresholds, we have added an offset to ensure that most of the inaccuracies occur on the inside of the threshold. That is, if you set the maximum conductor resistance threshold to 5 ohms, the software will internally set the threshold slightly lower than that to guarantee that nothing greater than 5 ohms will be allowed.

Remember that when you test for resistance values less than 100 ohms or greater than one Megohm, the measurement accuracy decreases to ±20%, and at ranges below 1 ohm may have an even higher variation. In the interest of scanning speed, the method of testing at these extreme ranges was intended primarily for thresholding and not for precision measurements.

Measurement Time

Generally, CableEye needs about one second to complete a measurement with 152 active test points. If you need only 128 test points (no expander cable attached to the CB boards) or 64 test points (only the Bank 1 in use), the scanning time will be faster. Under the following circumstances, however, the scanning time may increase to more than one second:

1 – If you connect one or more expansion modules, the test time can increase significantly. For 256 test points, the measurement time will typically be two seconds. For 1024 test points (the maximum permissible), the measurement time will be about 30 seconds.

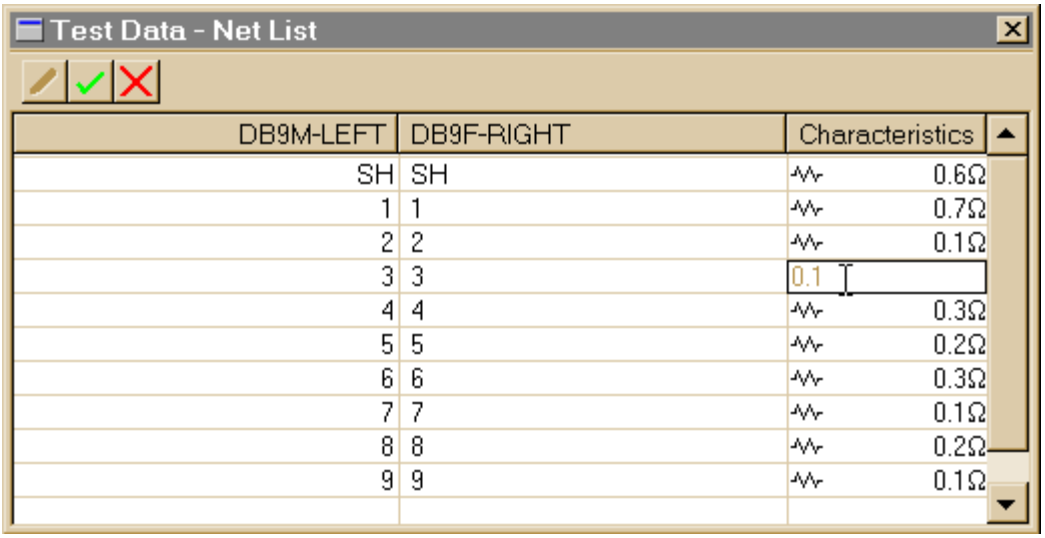
2 – If your cable contains embedded resistors, the measurement time will increase slightly in proportion to the number of resistors present.

3 – If the cable has many threshold violations, the software will test each individually for a resistance value. Doing so will take time and may result in a long list of resistors in the net list. For example, if all conductors in a 64-conductor flat cable had threshold violations, the resistance of each conductor would be separately measured, requiring about 6 seconds to complete rather than the usual one second when no threshold violations occur.

Editing the Netlist

Wiring Data is normally acquired by measuring a cable or by loading a previously measured cable from the database. You may also enter wiring data from the keyboard, or edit existing wiring data, by manually typing pin-to-pin connections and resistance values. You may add connections, delete connections, define resistance values, insert diodes, and change the connector styles. Refer to page 4-37 in the CableEye User's Guide for general information on Netlist Editing. The latest version of the CableEye Software designed for use with Model M3 allows you to enter or edit *resistance values* that appear in a netlist; this is not something described in the original CableEye User's

Guide. Do do so, simply double-click in the *Characteristics* column to open an edit box, and type in the desired values (see below). You may use "k" for kilohm and "M" for megohm if desired You do not need to type the "ohms" symbol. Examples of allowable entries: 0.4, 2300, 2.3k, 2.3 k, 5000000, 5 m, 5M.



Multinode Groups

In addition to the simple case of a series resistor embedded in a cable, you may find other situations in which one or more resistors and wires are connected in a network. We refer to such networks as *multinode groups*. CableEye can make resistance measurements on most configurations, while in some complex situations, the interconnections between components may be determined, but without resistance measurements. Figure 13-7 shows examples of networks for which the embedded resistors can be accurately measured. In this figure, the first circuit shows a simple series resistor. The others are multinode groups, include at least one resistor, and involve three or more test points.

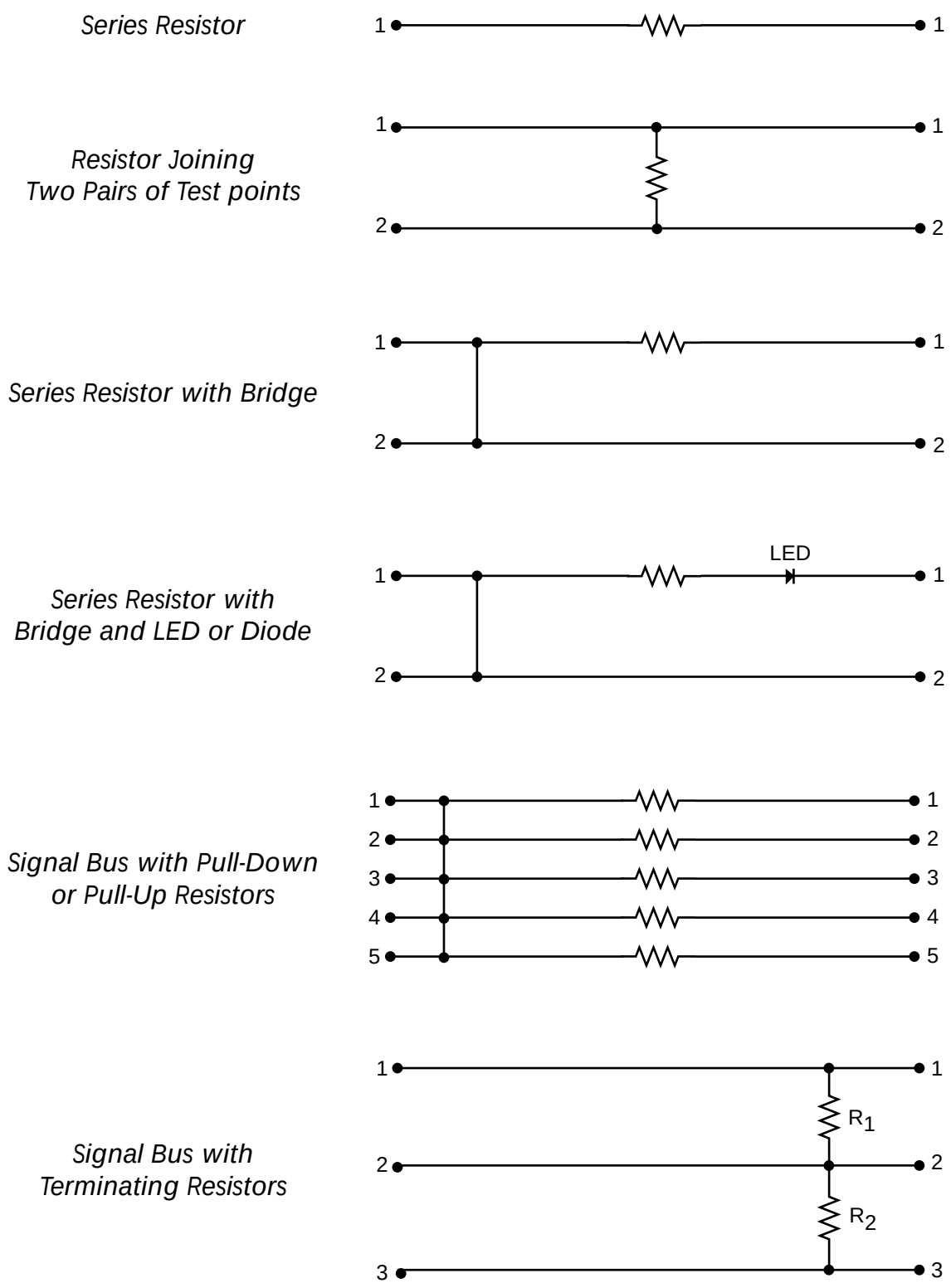


Figure 13-7 *Simple resistor networks in which the resistance can be accurately measured.*

When CableEye detects a multinode group, the wire list shown on the screen may appear different from the physical layout of your circuit. This occurs because several different circuit topologies could give rise to *electrically equivalent* networks. In the absence of Match Data, measurements of multinode groups containing resistors may show resistors in incorrect locations, and their values may be inaccurate. The next section describes how to define the Match Data in advance of testing a cable to ensure that CableEye understands exactly how you have connected multinode groups and where the resistors are located. Once the Match Data reflects the actual resistor positions in the network, consistent and accurate measurements of their values will be produced.

In cases where it is not possible to show an exact representation of the network in the wire list or on the screen, CableEye uses the following methods for reporting the network:

1 – The wire list generally shows a network in what we refer to as "Normal" form, even for simple displayable networks. In Normal form, the connections involved in the network are sorted numerically according to the left-sided pins, and then reduced to the simplest possible arrangement of connections. While the Normal form may not necessarily reflect the physical connections of the network, *it is electrically identical* when resistors are not involved and ensures that a complex wirelist can be easily compared to other wirelists without generating false comparison errors. Refer to Figures 13-8 and 13-9 to see how geometrically different but electrically identical wire networks are expressed in Normal Form.

Note that when resistors are involved in a multi-node network and Match Data is not present to specify the network topology, the Normal form may show resistors in incorrect locations and with incorrect values when you execute *Test Cable*. This results simply because the Normal form of the network topology may be one of many equivalent forms that correspond to the measurements Test Cable produced.

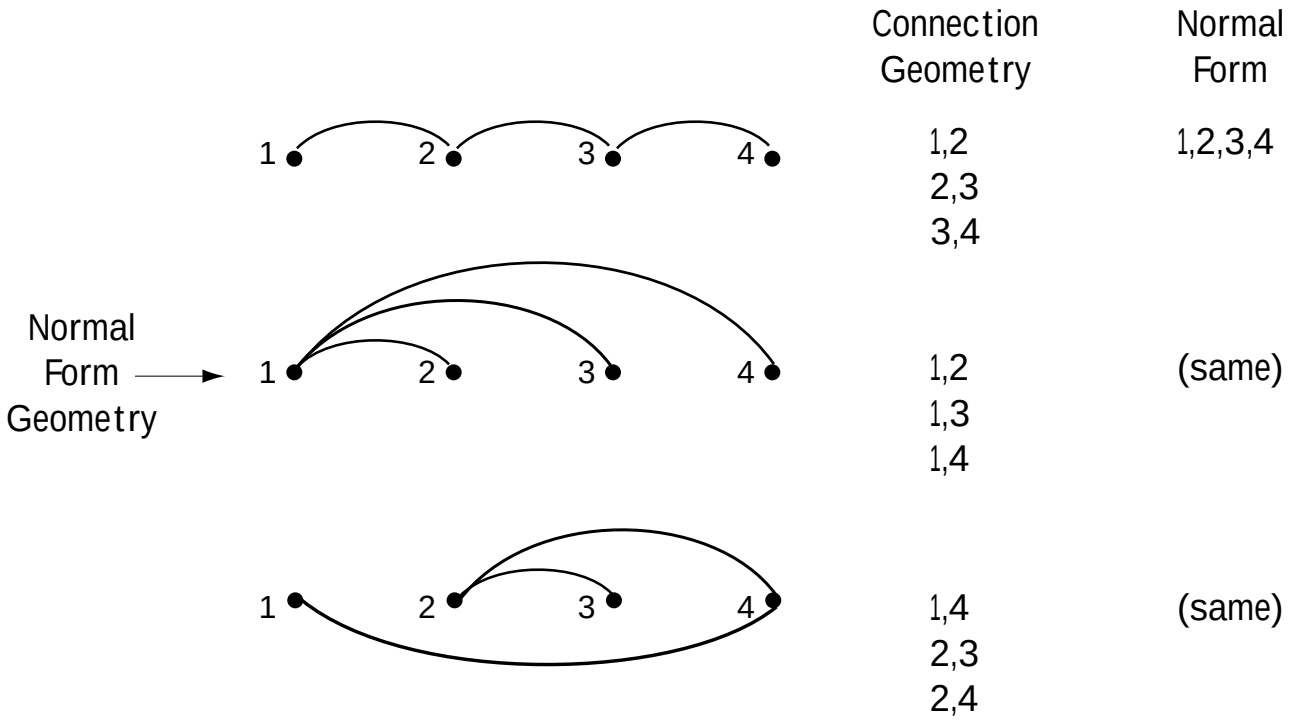


Figure 13-8 *Three electrically identical wiring networks that have identical normal form but different layouts.*

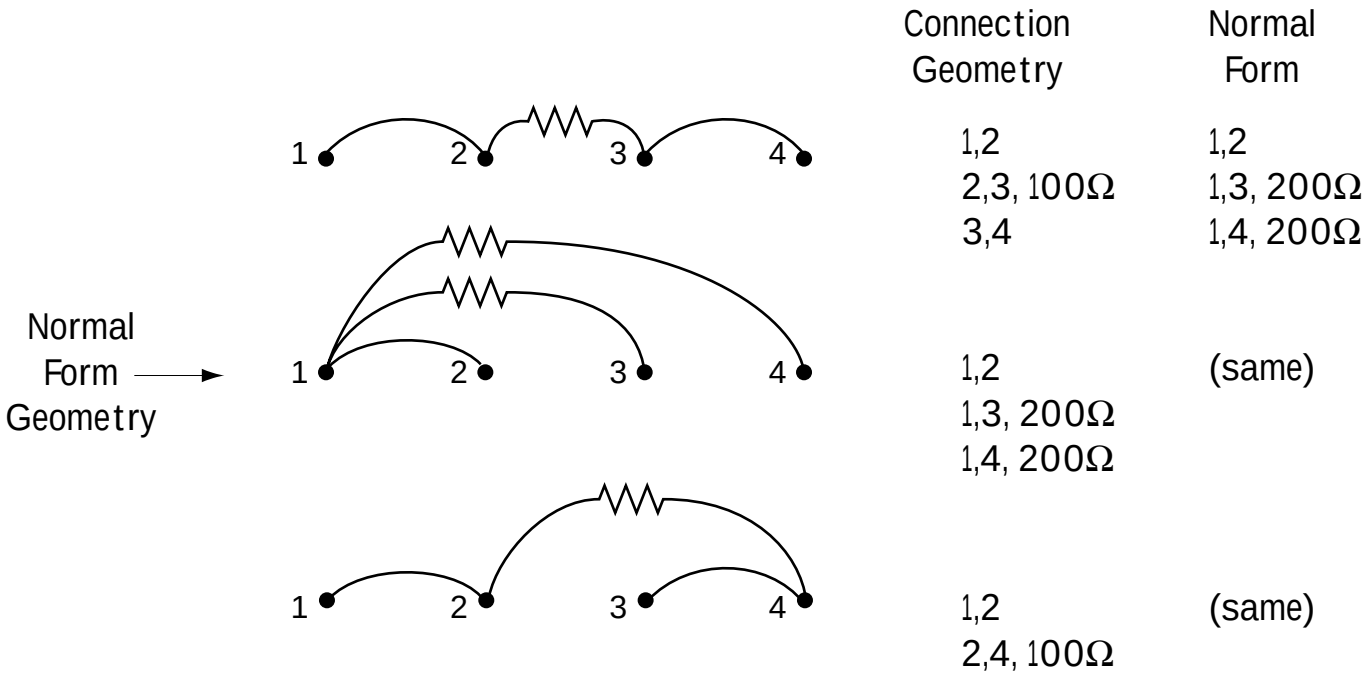


Figure 13-9 *These three electrically identical networks all contain a 100 ohm resistor in slightly different positions. Note that two 200Ω resistors in parallel are equivalent to 100Ω as seen from the lowest numbered test point.*

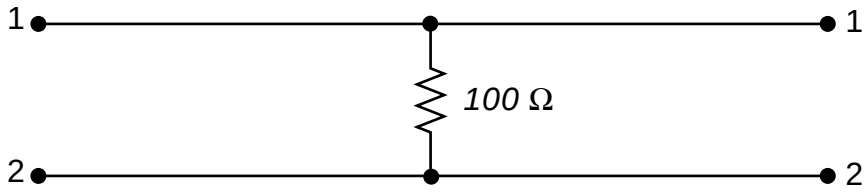
2 – When CableEye finds a multinode group in a cable, the wiring schematic displayed for that group shows *dashed lines connecting the involved test points* without actually drawing the circuit. To provide details of any connection denoted by a dashed line, simply *highlight* the dashed line using the Up- or Down-Arrow keys and a pop-up window will appear showing the details of the network.

3 – If the network includes diodes or a combination of resistors an diodes, the wiring schematic also shows dashed lines connecting the involved test points without showing the component details.

Future plans for the CableEye software will allow the wiring schematic to grow horizontally as well as vertically. At that time, we will have the screen space to insert component icons, pin numbers, and resistance values all at the same time. For the moment, we hope that the pop-up window will be serviceable.

The following examples illustrate how CableEye displays various multinode groups containing resistors:

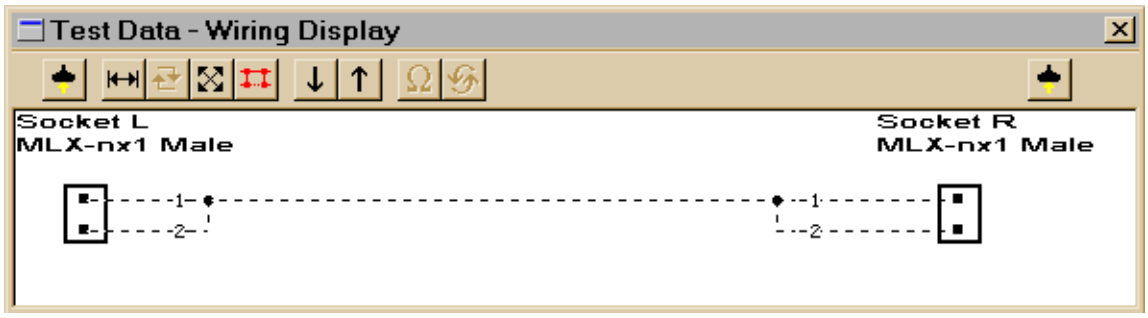
Example 1: This simple network shows a resistor connecting two parallel conductors. It is a multinode group because more than two test points are interconnected. In the



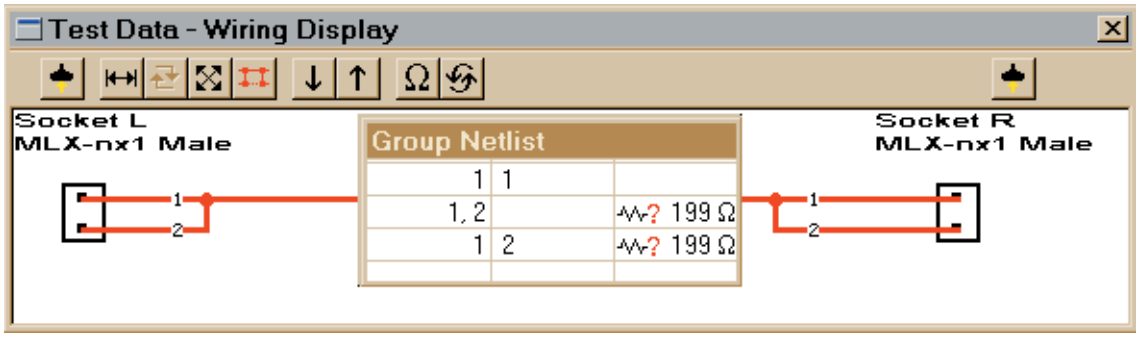
netlist, we distinguish the left- and right-sided test points with the prefix "L" for Left and "R" for right:

L-1 to R-1
L-1 to L-2, 100 Ω
L-2 to R-2

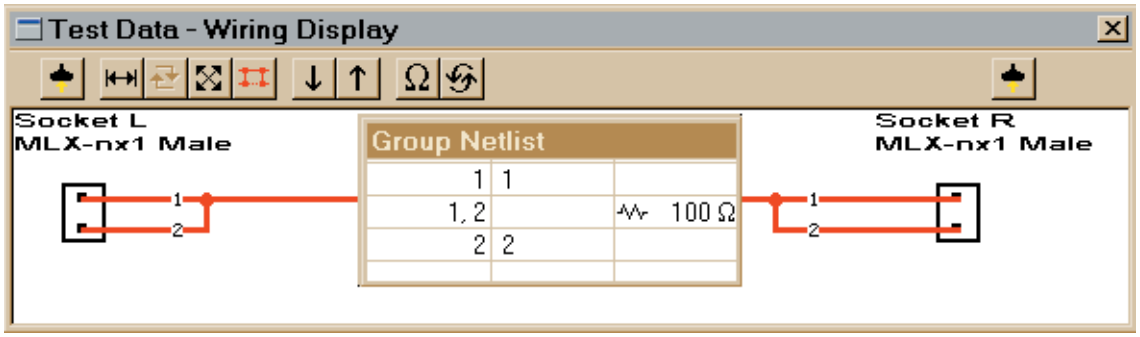
CableEye produces this wiring schematic for the multinode group (the connectors are arbitrary). Dashed lines show which test points are interconnected without drawing the components.



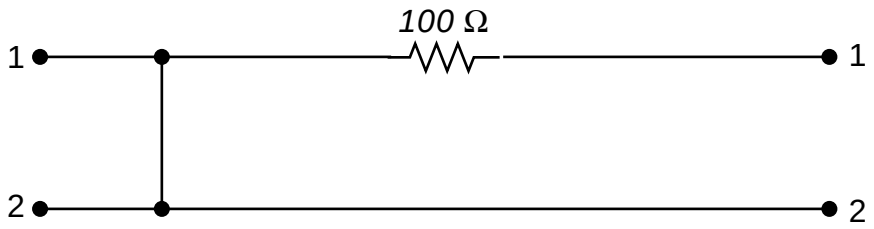
When you highlight the dashed line, a "Group Netlist" window appears showing the connections in Normal Form. Because Match Data was not present to define the topology when Test Cable was executed, the Group Netlist shows the Normal Form netlist. As you can see, this does not reflect the actual circuit topology. Two parallel resistors



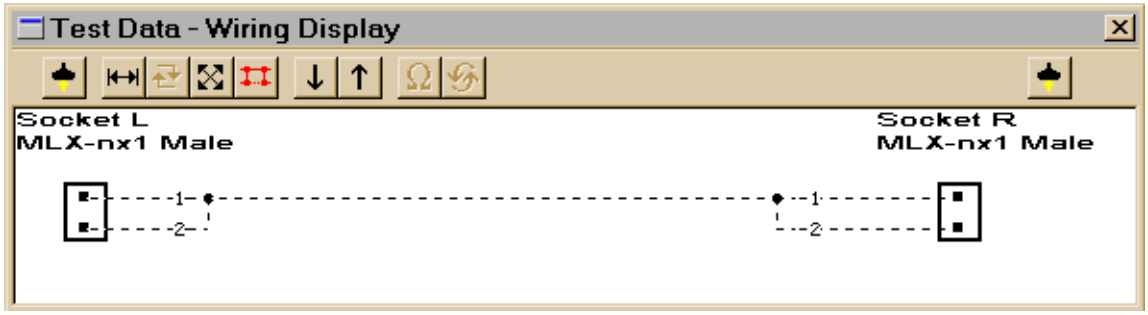
appear of about twice the value of the actual single resistor; when these two resistors are electrically combined into one, a single resistor of the correct value would be shown. The red question mark next to the resistor symbol indicates that Match Data for this group was not found. With proper Match Data entered, the correct Group Netlist would be shown, as below.



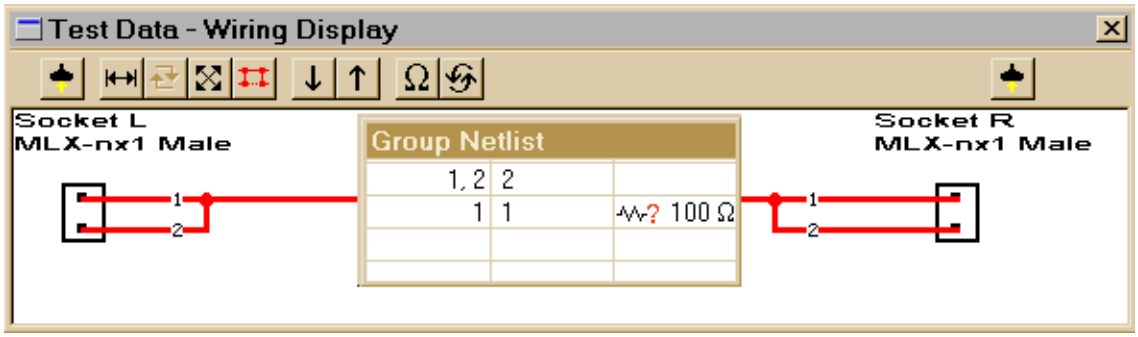
Example 2: This network shows a connection between a conductor with an embedded resistor and a conductor without any resistors.



Because the same test points are connected in this example as were connected in the last example, the dashed line drawing will be the same.



In this case, when the dashed line network is highlighted, a different Group Netlist provides details of the connections. The red question mark in the netlist shows that Match Data is not present. However, because the Normal Form happens to be the correct



topology, the netlist is correct as it stands. Were proper Match Data loaded, you would see the same netlist but the red question mark would disappear.

IMPORTANT: Figure 13-10 shows examples of networks that *cannot* be accurately measured. These circuits contain loops, as shown. The software would require knowledge of at least one of the resistor values in advance in order that the other values be computable based on the measurements. If you measure an arrangement like this, resistor values will be shown and successive measurements will be consistent, but the network topology and values will be incorrect. If you attempt to enter a Match Data netlist that contains loops, the software will detect this and produce a warning message "The netlist you have specified contains circular connections . . ."

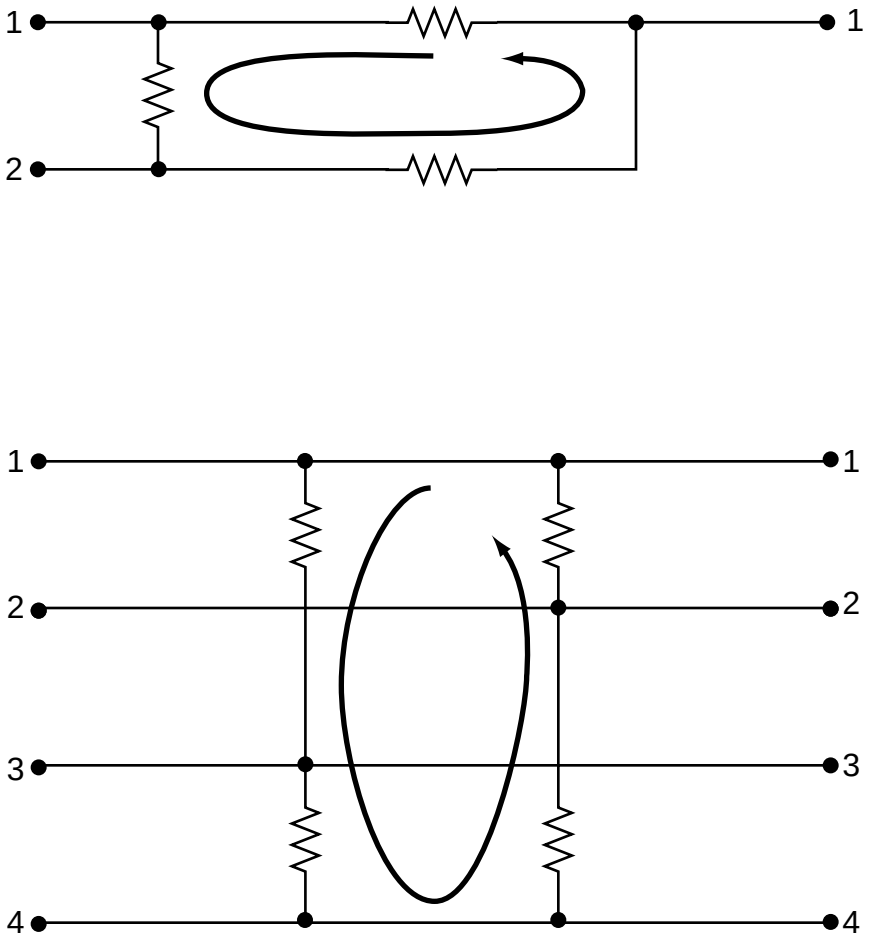
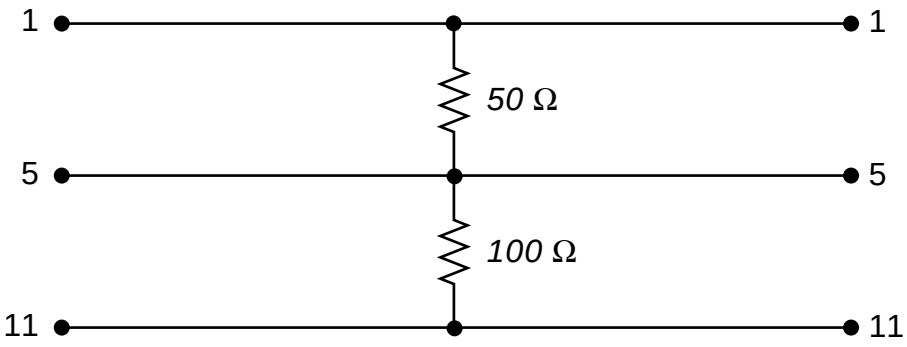


Figure 13-10 *These networks of multiple resistors cannot contain circular connections (loops). As a result, accurate resistance measurements are not possible.*

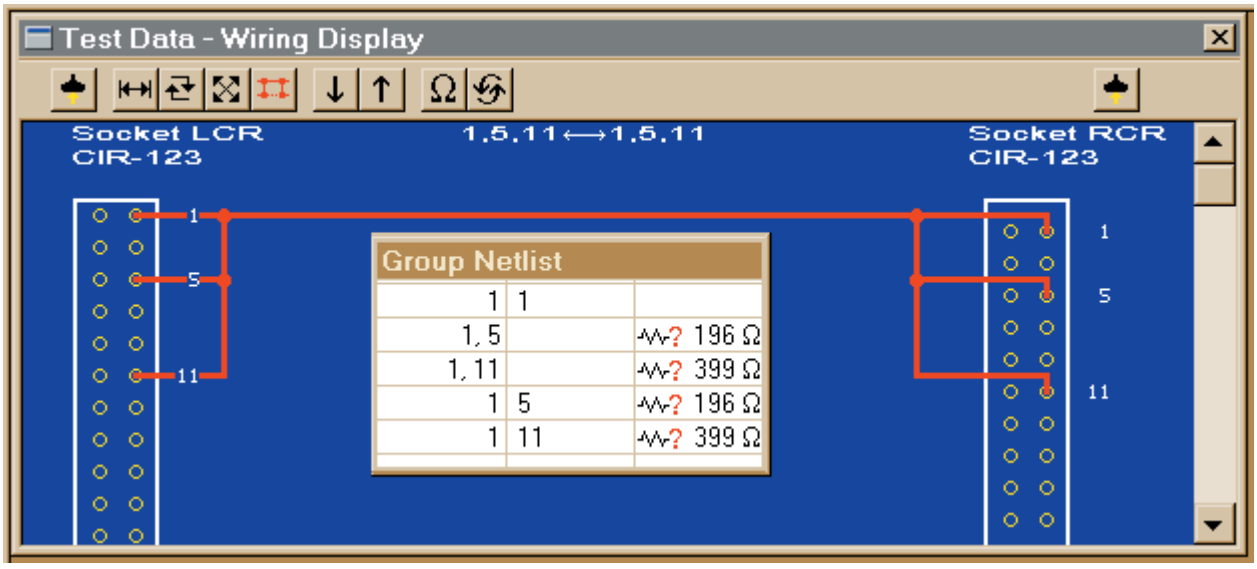
Entering Multinode Connections

To ensure that resistors in multinode groups are placed correctly and measured accurately when you execute *Test Cable*, you must predefine the connections in Match Data. This simple process will take only take a few moments, and once done, may be stored in the database for future reference. The example below outlines the process.

Example 3: This drawing shows a multinode network involving six test points and five branches.

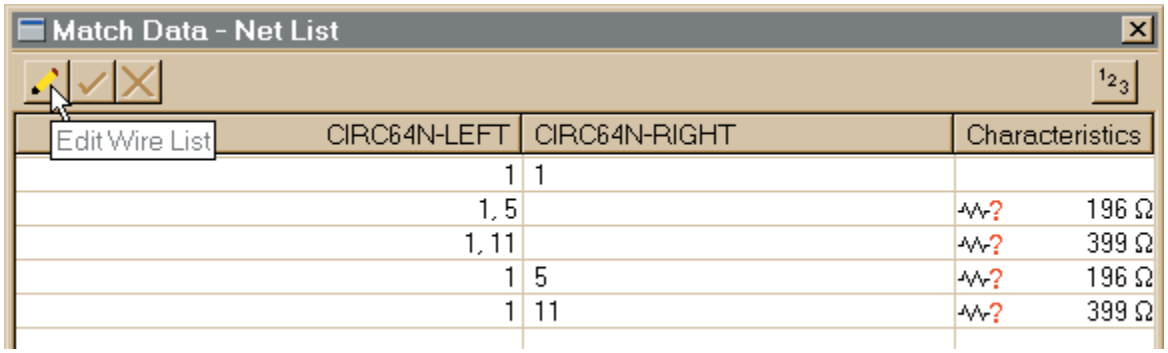


Using *Test Cable* to directly measure this network without Match Data present produces the following Normal Form wiring schematic and netlist:

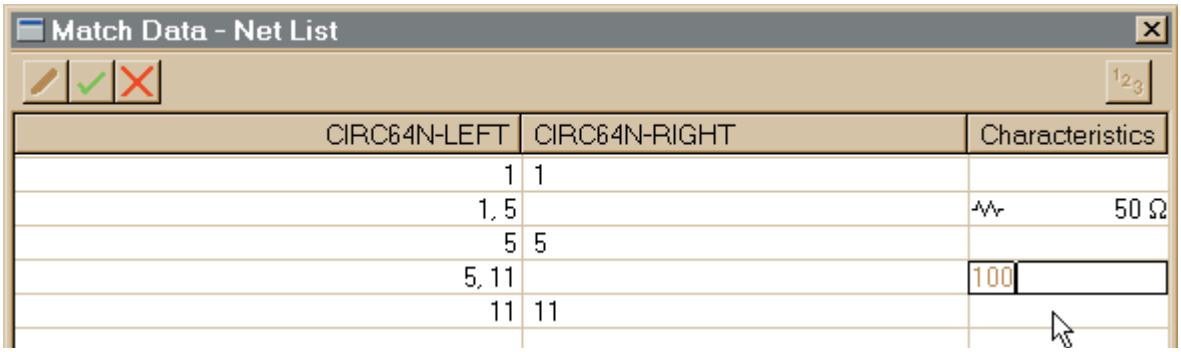


Clearly, the position of the resistors and their values in the Normal form netlist do not accurately reflect the actual layout of the network. To correct this, first use *Learn Cable* to

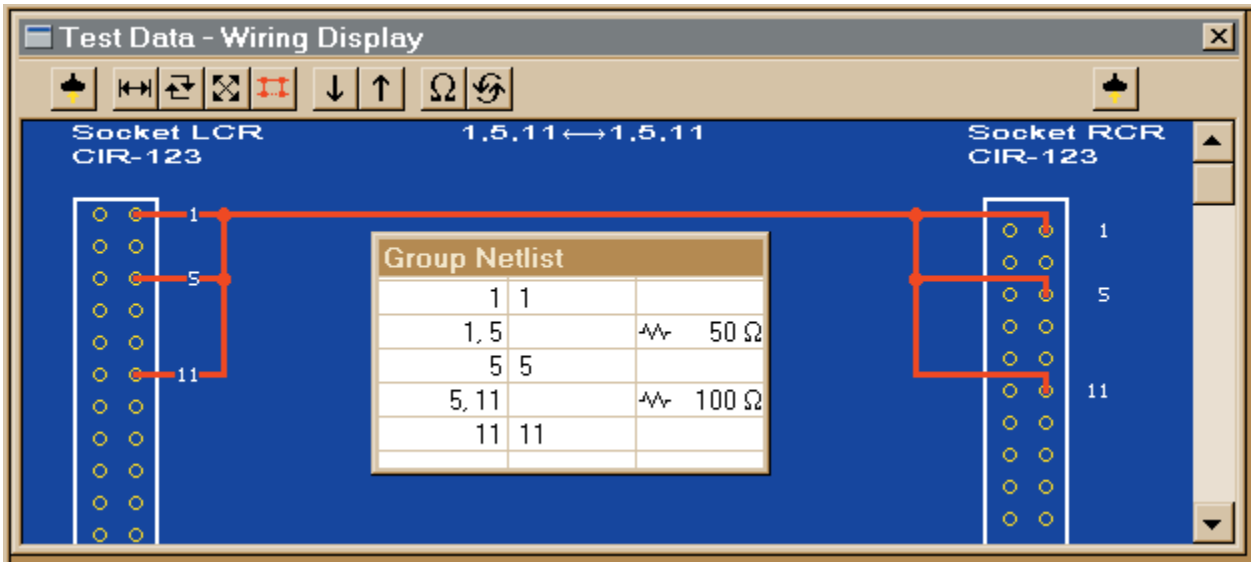
read the Normal Form measurements directly into Match Data. Then, click the yellow "pencil" button to begin editing.



Enter the actual network connections and resistance values, eliminating any spurious resistors shown in the original netlist. Press the green checkmark button when finished. Then, save the edited netlist in the database.



Finally, with the correct Match Data loaded, execute *Test Cable* again to produce the proper netlist with accurate resistance values.



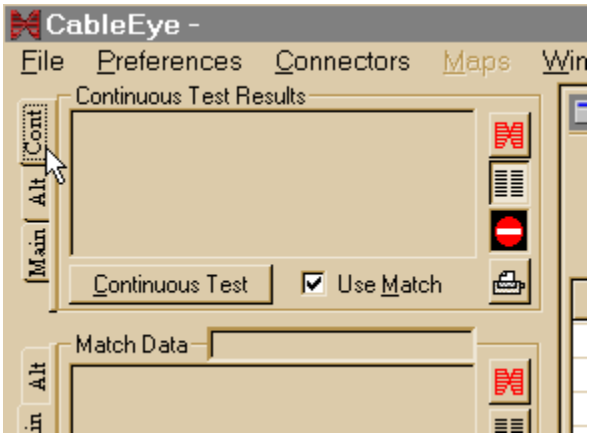
Causes of Inconsistent Resistance Readings

You may encounter situations where the resistance reading of a connection varies slightly from one measurement to the next, particularly when the resistance is below 100 ohms or above 100k ohms. This results from increased amplification needed at the extreme ends of the test range which adds noise to the measurement. By averaging several readings, you will obtain a more accurate result.

Note that faulty connections caused by cold solder joints, bad crimps, or broken wires may exhibit *nonlinear resistance characteristics*. Because such connections do not behave like carbon resistors, extremely minor changes in position, vibration, voltage, or temperature changes may cause highly variable readings. Use CableEye's *Continuous Test* function, describe below, to flex wires while you continuously send test signals through the cable. Variations in resistance that exceed the low threshold will flag an error.

Detecting Intermittent Connections

Bad crimps, broken wires, and cold solder joints, among other things, may cause intermittent connections. CableEye tests for this with the "Continuous Test" function. Test signals are passed through the cable continuously while you flex the cable and connectors. Changes in continuity cause a warning tone to sound and a wiring diagram to appear with intermittent connections highlighted. Click the "Cont" tab to reveal the Continuous Test controls. Check "Use Match" if you want to compare measurements to Match Data. If unchecked, the first measurement will serve as Match Data against which subsequent measurements are compared.



In the interests of scanning speed, CableEye uses only your current *Low Threshold* setting as the decision point when performing continuous test; high threshold tests are not performed. However, if you wish also to check against a high threshold, go to the Resistance Preferences panel after you finish the low threshold test, change the Low Threshold to whatever *high* threshold you wish to use, and repeat the test. When finished, *don't forget to go back to the Resistance Preferences and set your Low Threshold back to its normal range!*

View Continuous Test errors on a window to the right of the controls. The error list is *cumulative,* so that once an intermittent error is detected, it remains on the list even if the error condition (open, short, or threshold violation) returns to normal. Note that *CableEye does not detect resistance errors using Continuous Test*; we look only for intermittent connections.

13.4 Self-Test and Calibration

13.4.1 – Testing the Internal Electronics

Although CableEye is extremely reliable, component failure may occur in the electronics if a high level of static electricity discharges into one or more test points, or if a live (externally powered) cable is attached to the fixture. If you suspect an internal failure, the CableEye software includes a *Self-Test* function capable of detecting most electronic problems. Refer to page 3-28 in the CableEye User's Guide for details. *Self-Test* operates the same way in M3 as it does in M2, and the description in the User's Guide applies.

13.4.2 – Precautions Against Static Discharge

IMPORTANT: CableEye Model M3 is tolerant of occasional low levels of static discharge into the test points without causing permanent damage. Repeated low-level discharges or a high level discharge, however, can cause component failure. We suggest the following precautions in preventing damage by static electricity:

1 – Use the supplied green grounding wire to ground the CableEye test fixture to the chassis of your computer. The computer itself should be connected to the power mains with a three-prong cord whose third prong properly connects to an earth ground.

2 – Provide a static-dissipative surface for the test technician to stand on when testing cables, especially if the technician works on a rug-covered floor.

3 – In very high static areas, provide the test technician with a certified static-dissipative wrist strap.

4 – When testing cables longer than 6 feet (2 meters), and especially for cables longer than 20 feet (7 meters), *be sure the cable itself is discharged before connecting it to CableEye!* Do so by briefly attaching to the test cable a mating connector in *which all pins are bussed together and connected by a single wire to ground.* Once discharged, you may remove the grounded connector and test the cable.

Note that although the technician, workstation, and tester may be grounded, if the technician picks up a cable whose conductors themselves hold static charge, it is possible that nothing capable of discharging cable's wires will touch the connector pins before the cable is attached to the test fixture, resulting in discharge of the static held in the cable's wires directly into CableEye's electronics. Cables of 50 feet (17 meters) or longer can hold a great deal of static energy and can destroy components if not discharged in advance.

13.4.3 – Testing the Connectors on your CB Boards

The *Self-Test* function cannot detect mechanical failure of the CB board connectors. To confirm that your CB board connectors a mechanically sound, you should keep readily available a set of cables that are known to be good (“golden” cables). Use these golden cables *only* for fixture certification to ensure that they do not wear out. Periodically, check the connector boards to confirm that all pins and shells are intact.

For each test of a golden cable, print the test results as confirmation that this test procedure was performed. The date will automatically be included on the printout, and you may add custom notes or label text before printing.

13.4.4 – Calibration

Certain components within CableEye Model M3 are analog components whose characteristics change slightly over time. This aging is a natural phenomenon common to all electronic components and may cause resistance measurements to gradually deviate from normal. To ensure that resistance measurements remain accurate, we suggest yearly calibration. One month before your equipment reaches its recalibration anniversary, CAMI Research will automatically send a letter to the person whose name is on record

as the contact individual at your company advising this fact and the cost and procedure for recalibration. You will need to send the test fixture and power module to CAMI Research or to an authorized international distributor for recalibration. The equipment will be returned with a floppy disk containing the calibration data file. You would then replace your existing calibration file with the new one. Recalibration can usually be done the day we receive your equipment, so you would be deprived of its use only for the round-trip transportation time which will of course depend on the shipping method you choose.

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