

Four-Wire Testing

Purpose

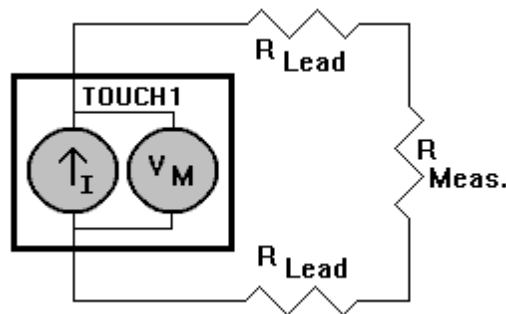
- Extend resistance testing to 0.001Ω resolution.
- Remove unwanted lead resistance from testing.

Uses of Four-Wire Testing

- Meet test specifications below 0.1 ohm.
- Eliminate fixture resistance.
- Verify different gauges of wire in a cable assembly.
- Make sure a shield is connected to the correct point.

How Four-Wire Testing Differs from Two-Wire Testing

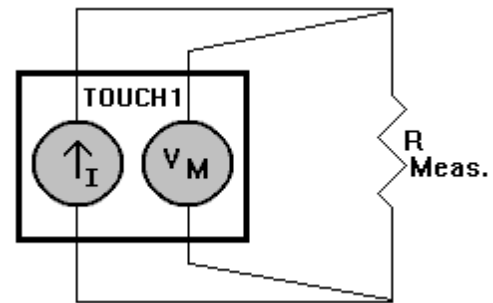
Two-Wire Test



Measures resistance at the Touch1:

- Adds lead resistance (R_{Lead}) to the measurement (R_{Meas}) of the device-under-test (DUT).
- Uses two wires per measurement.
- Tests all wires to the same *LV Connection Resistance* setting and can test wires to different thresholds using *Wire Components* (optional).
- Measurement resolution (V_m):
 $.1\ \Omega$ for $R = 0.1$ to 99.9Ω

Four-Wire Test



Measures resistance away from the Touch1 by using separate leads:

- Only measures resistance (R_{Meas}) at the device-under-test (DUT).
- Uses four wires per measurement.
- Tests wires to different resistance values using *4-Wire Components*.
- Measurement resolution (V_m):
 $.001\Omega$ for $R = 0.001$ to $0.999\ \Omega$
 $.01\Omega$ for $R = 1.00$ to 9.99Ω
 $.1\Omega$ for $R = 10.0$ to 99.9Ω

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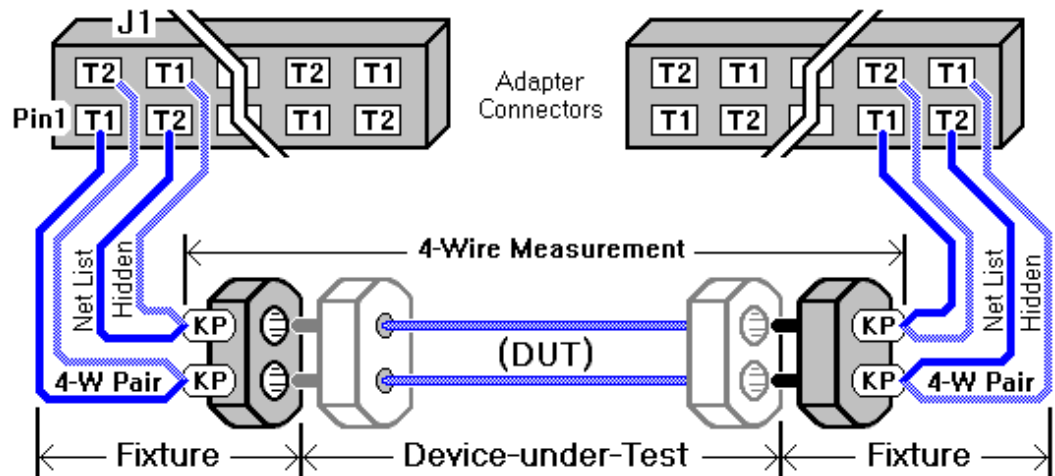
TASK 1: Building 4-Wire Test Fixtures

Using four wires in two pairs per measurement, 4-wire fixtures connect each pair's T1 and T2 points at the Touch1 to a kelvin point (KP) as close as possible to the device-under-test.

Note. You can mix 2-Wire Testing with 4-Wire Testing in any combination.

Important! Before you begin building 4-wire fixtures, it is necessary to identify which pins of an adapter are T1 and T2 points so every 4-wire pair has one of each. See page 3.

Example of a Fixture and Device-Under-Test



Terms Used in the Example

Fixture

User-supplied cable or harness assembly consisting of:

- Adapter connector(s) attached at the Touch1.
- Paired wires connecting adapter connectors to...
- Mating connectors to attach the device-under-test.

Device-under-Test (DUT)

Part or all of a cable/harness intended for 4-Wire Testing.

4-Wire Pair (also called "Kelvin Pair")

Two wires going from two connections (T1 & T2) at the Touch1 to a junction (KP) at the point of measurement.

Net List [point]

Name of the wire in a 4-wire pair that corresponds to the test point of the device-under-test as listed in the Net List.

Hidden [point]

Name of the other wire of a 4-wire pair that is necessary for 4-wire testing. It lists only in the 4-Wire Pairs List.

KP [Kelvin Point]

Physical junction of the two wires in a 4-wire pair and one of the end points of a 4-wire measurement.

4-Wire Measurement

The part measured for resistance by the 4-Wire Test.

T1 & T2

Two types of test points required by each 4-wire pair.

Adapter Connector(s)

Connector(s) in the fixture that plug into Cirris Adapter(s).

J1, Pin 1

Adapter and test point location (in the wirelist as J1-001).

Building 4-Wire Test Fixtures Is a Four-Part Process

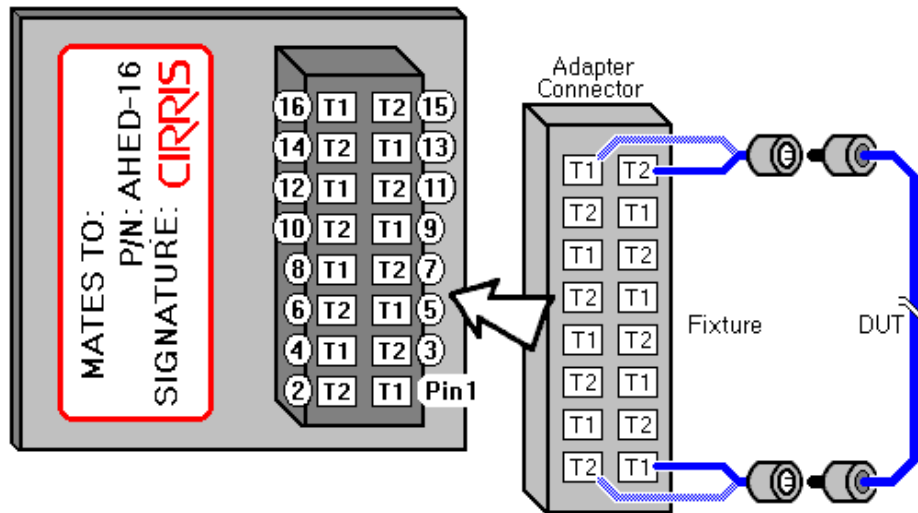
- Select the appropriate Cirris Adapters to install in the Touch1.
- Find T1 and T2 pins on Cirris Adapters installed in the Touch1.
- Choose a connection pattern for wiring 4-wire pairs to T1 and T2 adapter pins.
- Join 4-wire pairs to kelvin points as close as possible to the device-under-test.

Task 1, Part A: Selecting Adapters to Install in the Touch1

You can use any Cirris Adapter in any combination to connect a fixture to the Touch1.

Recommended: AHED-10 to AHED-64 adapters. Why? AHED adapters map T1 and T2 points in a uniform alternating pattern: pin 1=T1, pin 2=T2, pin 3=T2, pin 4=T1, etc.

Example of an AHED Adapter Showing T1 and T2 Locations



Task 1, Part B: Finding T1 and T2 Points Automatically

The Touch 1 can locate Type 1 and Type 2 pins automatically (especially useful if the pattern is irregular). You can then print all T1 and T2 points for reference in two separate lists.

Why find T1 and T2 pins? The location of T1 and T2 adapter pins is determined by the Touch1's internal wiring and 4-wire pairs must be wired to one of each.

To set up the Touch1 to locate T1 and T2 points

1. Install the adapters you intend to use.
2. Learn any kind of wirelist (in **Test Setup**, press **Learn Sample**).

To create the list of T2 points

1. In **Test Setup**, press **View & Change Wirelist**.
2. In **View/Change Wirelist**, press **More, 4-Wire**, and then **Change 4-Wire**.
3. In **Four-Wire Pairs**, press **Add**.
4. In **Four-Wire Pair**, press **Net List Point**.
5. In **Add/Change 4-Wire Point**, select **J1-001**, and then press **OK**.
6. In **Four-Wire Pair**, press **Hidden Point**.
7. In **Add/Change 4-Wire Point**, the test points listed will be T2 points. Press **Print** to record T2 points, and then press **Cancel** twice to get back to the Four-Wire Pairs window.

To create the list of T1 points

1. Repeat steps 3 to 7 of the above procedure, except in step 5, select a test point from the T2 printout you just made. This time, in step 7 the list will be T1 points.
2. Compare the lists—no points should be in both lists.

To find T1 and T2 points on adapters using the probe and the lists

1. In **View/Change Wirelist**, press **CON**, and then **Change CON**.
2. In **Change Connections** press **Add**.
3. While in **Add/Change Net**, probe adapter pins and match them to each list.

Task 1, Part C: Selecting a Fixture Wiring Pattern

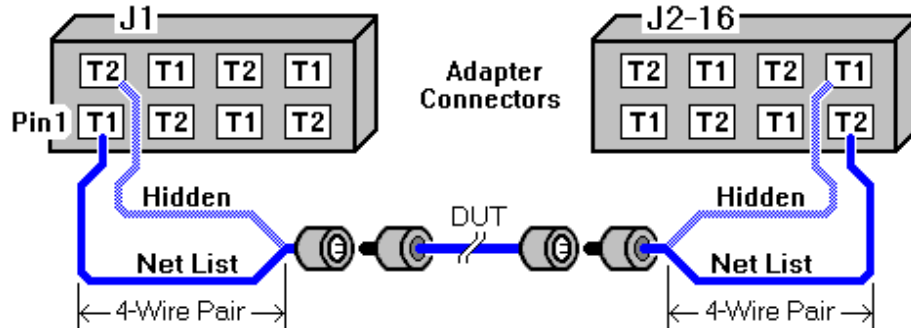
Important! The design of the hardware determines which pins are Type 1 or Type 2 and every 4-wire pair must be wired to one of each. To find them, see page 3.

How wiring patterns determine documentation

For each 4-wire pair, one wire goes to the Net List; the other “hides” in the 4-Wire Pairs List. The Net List wire can be either T1 or T2 as long as the Hidden point is the other wire. When learning (*Method #1*, page 6), the first-scanned point of each 4-wire pair goes to the Net List. Scanning starts at J1-001 using the counting pattern of AHED adapters (page 3).

Two Patterns for Matching Type 1 and Type 2 Points to 4-Wire Pairs

- *Alternate - Net List and Hidden Points Alternate in the Same Adapter*



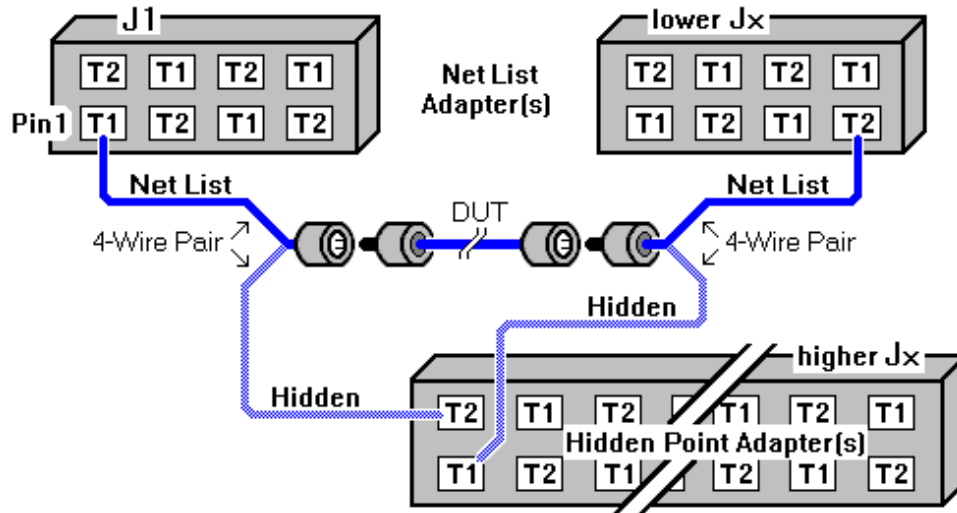
Advantage:

- Ease of use (ribbon cable) - solder adjacent wires to join 4-Wire Pairs.

Disadvantage:

- Wirelist documentation - connector adapter pin numbers won't match the pin numbers of the Device-under-Test. See *Re-labeling Test Points*, page 10.

- *Separate - Net List and Hidden Points in Separate Adapter Connectors*



Advantages:

- If the fixture uses the same adapter connector(s) as the device-under-test, the Net List will document correctly without using Custom Test Point Labels.
- The original 2-wire Net List is preserved when converting to 4-wire.

Note: Learning (*Method #1*, page 6) scans correctly if Hidden point adapter(s) are in a higher-counting “J” position than Net List adapter(s).

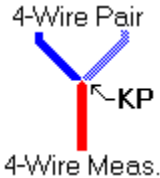
Task 1, Part D: Placing Kelvin Points

Connecting 4-Wire Pairs at the Device-Under-Test (DUT)

The two wires in each 4-wire pair must physically join to one test point of the device-under-test in a manner that creates a kelvin point (KP).

Definition - Kelvin Points (KP)

- A kelvin point is a place that makes a “Y” junction by joining three parts:
- One of the end points of the 4-wire measurement.
 - First wire of a 4-wire pair.
 - Second wire of a 4-wire pair.



Note: The “Y” junction can be a solder joint or it can be where a paired wire on one side of the measurement is closest to a paired wire on the other side (see below—DUT #3).

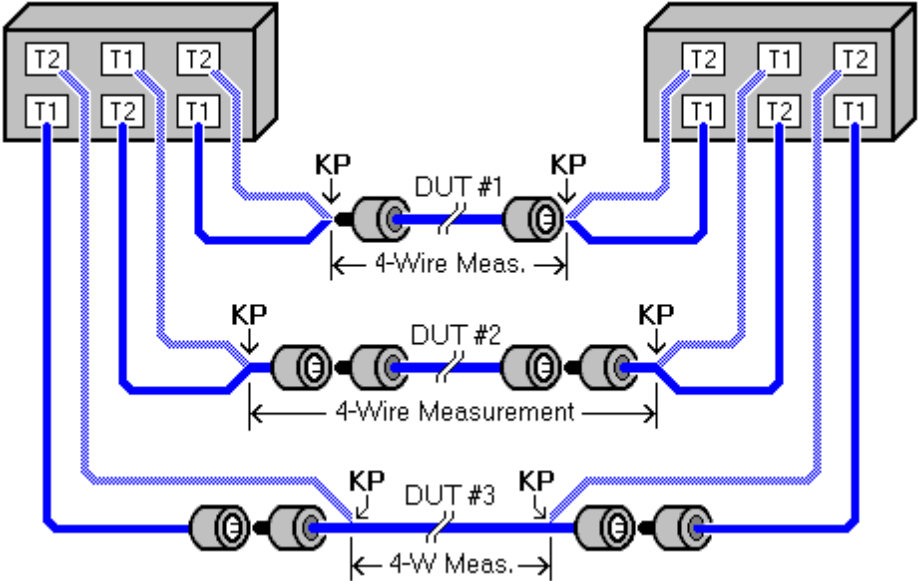
Requirements - Kelvin Points (KP)

Each 4-wire measurement requires two kelvin points—one at each end.

IMPORTANT! Place the kelvin points as close to the device-under-test as possible. WHY?

The 4-Wire Test measures from kelvin point to kelvin point, so any contact and lead resistance between the kelvin points is added to the resistance measurement of the device-under-test (DUT).

How Kelvin Point (KP) Placement Affects the 4-Wire Measurement



- DUT #1:** The measurement is only of the device-under-test. This is the ideal, but in real-world situations it may be nearly impossible.
- DUT #2:** The measurement includes part of the fixture. **Warning!** If a lot of the fixture is between a kelvin point and the device-under-test, the 4-Wire Test will be considerably compromised.
- DUT #3:** The measurement tests only part of the device-under-test. For example, by using probe pins, you can eliminate the resistance of a connector from the measurement.

TASK 2: Creating 4-Wire Pair Lists and Net Lists in the Wirelist

Four-wire wirelists require a list of all 4-wire pairs and a list of the wire connections of the device-under-test. Without 4-wire pairs, you cannot add 4-Wire Components.

Parts of the wirelist created in Task 2

- 4-Wire Pairs List* List of fixture wires in groups of two test points each—the Net List point and the Hidden point of each 4-wire pair (example on page 9).
- Net List* Wire connections of the device-under-test, grouped by numbered nets—each net lists only the test points connected to each other.

Two Ways to Create a 4-Wire Pairs List and a Net List

- Method #1:* Learn the fixture and sample to automatically detect 4-wire pairs.
- Method #2:* Convert an existing 2-wire wirelist by hand-entering 4-wire pairs.

Method #1: Learning a Fixture & Cable to Create a 4-Wire Pairs List

Method #1 automatically detects 4-wire pairs in the fixture, then learns the interconnections of the device-under-test to create the Net List.

Note: During fixture learning, the first-scanned point of each 4-wire pair goes to the Net List. Scanning is in the same counting order as an AHED adapter (page 3).

METHOD #1 IS A THREE-PART PROCESS

- A. Enable fixture learning.
- B. Learn the fixture separately to automatically detect 4-wire pairs, and then...
- C. Learn a sample of the device-under-test while attached to the fixture.

To enable fixture learning

1. In the **Main Menu**, press **Test Setup**.
2. In **Test Setup**, press **Learn Sample**.
3. In **Learn Setup**, press **Change**.
4. In **View/Change Learn Settings**, press **More, 4-Wire**, then **Change 4-Wire**.
5. In **Change Learn Four-Wire**, put a **check** in the box, then press **OK**.
6. In **View/Change Learn Settings**, set other parameters, if necessary. (See page 13 for information on *Connection Resistance*). Then press **OK**.
7. In **Learn Setup**, press **Learn**. (**FOUR-WIRE FIXTURE LEARN** opens)

To learn only the fixture

1. Attach only the fixture.
2. In **Four-Wire Fixture Learn**, press **OK**.
3. If there were errors on learning the fixture, skip to *Troubleshooting*, page 7.
or
If the fixture learned correctly, continue...

To learn the sample cable or harness

1. Attach the sample cable assembly to the fixture just learned.
2. In **Start Learn**, press **OK**. (OK is disabled until the sample is attached)
3. In **Learn Complete**, press **OK**.
4. In **Four-Wire Setup Warning**, to add 4-Wire Components:
 - press **Ignore** to: identify measurement locations (*From & To*, page 11), or custom-label test points (page 10).**or**
 - press **Add 4-Wire Comp** if you know the *From & To* points (page 12).

WARNING! It is absolutely necessary to add 4-Wire Components (see page 11).

Troubleshooting: Method #1 – Learning Fixtures

- **ERROR MESSAGE**

**Invalid 4-Wire Kelvin Pair:
More than two points connected
J1-001 J1-002 J3-063 J3-064**

Possible Causes

- The sample cable was not removed before learning the fixture.
- 4-wire pair(s) are shorted to other pairs or have more than two wires.

Solutions

1. Do one of the following:
 - Remove the sample from the fixture.
 - or
 - **Print** the error for reference, then remove and re-wire the fixture.
2. In **Four-Wire Fixture Error(s)**, press **Cancel**.
3. In **Learn Setup**, press **Learn** to start over, or **Cancel** to quit the learn.

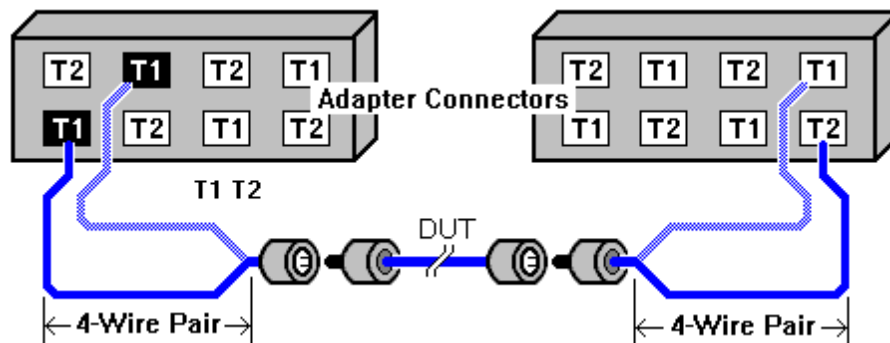
- **ERROR MESSAGE**

**Invalid 4-Wire Kelvin Pair:
Both points J1-001 and J1-004
are Type 1 [or 2] points.**

Cause of the Error

- Four-wire pair(s) lack one Type 1 and one Type 2 point each.

Example of the Wiring Error:



The 4-wire pair on the left duplicates T1; the pair on the right is correct.

Solution

1. In **Four-Wire Fixture Error(s)**, **Print** the error for reference. Then press **Cancel**.
2. Remove the fixture.
3. Re-wire the fixture at the adapter connector so each 4-wire pair has one T1 and one T2 point. (See pages 3-4 for a map of T1 & T2 points).
4. In **Learn Setup**, press **Learn** to start over, or **Cancel** to quit the learn.

Method #2: Editing a Wirelist to Create a 4-Wire Pairs List

Method #2 is for editing a 4-wire wirelist or converting an existing 2-wire wirelist into a 4-wire wirelist by manually selecting the 4-Wire Pairs List and Net List.

METHOD #2 IS A THREE STEP PROCESS

- A. Load a 2-wire wirelist so it is the active test setup.
- B. Identify 4-wire pairs and the test points in the Net List (Connections).
- C. Select each pair's Net List & Hidden points to create the 4-Wire Pairs List.

To load a 2-wire wirelist so it is the active test setup

1. In the **Main Menu**, press **Test Setup**.
2. In **Test Setup**, press **Retrieve Wirelist**.
3. In **Retrieve Wirelist**, select the desired wirelist, then press **Retrieve**.
4. In **Test Setup**, press **View & Change Wirelist**.
5. *Optional:* If you are converting a 2-wire wirelist to 4-wire by adding the fixture's Hidden wires to a new adapter (see *Separate Pattern*, page 4), it will be necessary to add the Hidden Wire adapter to the wirelist now.
 - a. In **View/Change Wirelist**, press **ADP**, then **Change**.
 - b. In **Change Adapters**, press **Add**.
 - c. In **Add Adapter Position**, select (highlight) the position where the Hidden Point adapter is located (J2, J3, etc.). Then press **Add**.
 - d. In **Add Adapter**, select (highlight) the new adapter, then press **Add**.
 - e. In **Change Adapters**, press **OK**.
6. *Optional:* To help identify test points, see *Re-labeling Test Points*, page 10.

To identify the four wires of matching 4-wire pairs from a printout

You can assign either wire in a 4-wire pair to the Net List, and consequently, the other wire to the Hidden point. It largely depends on how the fixture is built.

1. In **View/Change Wirelist**, press the **Print** button.
2. Locate the Net List (**Connections**) in *Touch1 Cable Documentation*.
 - a. Mark from each net the two Net List points of each 4-wire measurement. (applies only to connections below *Connection Resistance*—page 13)
 - b. Add to each net the two matching Hidden points from the fixture build list.

Example of the original test points of two nets (uses graphic, page 10)

Connections :

1	J1-001	J3-063
2	J1-003	J3-061
	↑	↑
	<i>Net List</i>	<i>Net List</i>

Example of All Four Wires of Two 4-Wire Measurements:

Connections :

1	J1-001	J1-002	J3-063	J3-064
2	J1-003	J1-004	J3-061	J3-062
	↑	↑	↑	↑
	<i>Net List</i>	<i>Hidden</i>	<i>Net List</i>	<i>Hidden</i>
	<i>4W Pair</i>		<i>4W Pair</i>	

Note: If the fixture and sample are learned together in 2-Wire mode (*No 4-Wire Fixture Learn* in "Learn Setup"—opposite of *Method #1*), all four wires of the fixture will be in the Net List similar to the second example. If this is the case, a window will open for Hidden Point removal from the Net List.

Method #2: Editing a Wirelist to Create a 4-Wire Pairs List, *cont.*

To select the Net List test point

1. In **View/Change Wirelist**, press **More**, **4-Wire**, then **Change**.
2. In **Four-Wire Pairs**, press **Add**.
3. In **Four-Wire Pair**, press **Net List Point**.
4. In **Add/Change Four-Wire Point**, select (highlight) a Net List point using:
 - Up/down arrows
 - Scroll bar (gray between arrows)
 - Hand-held probe.
5. Then press **OK**.

To select the Hidden point

1. In **Four-Wire Pair**, press **Hidden Point**.
2. In **Add/Change Four-Wire Point**, select the Hidden test point of the *same* 4-wire pair for which you just selected the Net List point.

Note: Not all test points are available for the Hidden point...WHY?

Each 4-wire pair requires one T1 and one T2 point (pages 3-4).

Selecting the Net List point has used one of the types, so only the unused points of the other type are available for the Hidden point.

Also: Adapters must be in the wirelist before test points will display (page 8).

3. Press **OK** to return to the *Four-Wire Pair* window.
4. In **Four-Wire Pair**, both points must be selected. If so, press **OK**.

To complete the 4-Wire Pairs List

1. In **Four-Wire Pairs**, do one of the following:
 - press **Add** to add more 4-wire pairs—each measurement requires two!
 - or**
 - press **Print** to verify the list is complete.

Example: Four-Wire Kelvin Pairs Listing

J3-063	J3-064	}	<i>one 4-wire measurement</i>
J1-001	J1-002		
↑	↑		
<i>Net List</i>	<i>Hidden</i>		

2. Press **OK** for one of three possible outcomes:
 - If **Four-Wire Setup Warning** opens—to add 4-Wire Components:
 - Press **Ignore** to identify measurement locations (*From & To*, page 11).
 - or**
 - Press **Add 4-Wire Comp** if you know the *From & To* points (page 12).
 - or**
 - If **Four-Wire Pair Warning** opens:
 - Press **Add a Pair** to complete 4-Wire Pair selection.
 - or**
 - If **Remove Points From Net List** opens, continue on...

To remove Hidden points from the Net List, if necessary

1. In **Remove Points From Net List**, press **Delete Points**.
2. Then press **OK**.
3. In **Four-Wire Setup Warning**—to add 4-Wire Components:
 - press **Ignore** to: identify measurement locations (*From & To*, page 11),
or custom-label test points (page 10).
 - or**
 - press **Add 4-Wire Comp** if you know the *From & To* points (page 12).

WARNING! It is absolutely necessary to add 4-Wire Components. (see page 11)

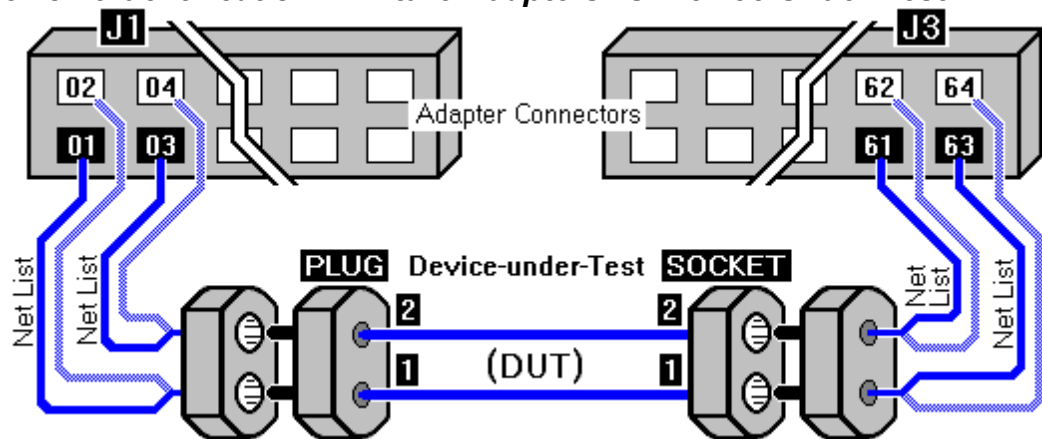
TASK 3: (Optional) Re-Labeling Test Points

By default, the Touch1 labels test points in a Net List (**Connections**) according to the fixture adapter connector(s). It uses the location of the adapters (J1, J2, etc.) and the adapter's connector pin names (001, 002, etc.). Custom labeling allows you to re-label the Net List and Components List to match the device-under-test.

Benefits of Custom Labels

- Wirelist documentation and error reporting will match the connector and pin names of connectors on the device-under-test (DUT).
- When creating 4-Wire Components, it will be easier to identify the *From* and *To* points required to identify the location of the 4-wire measurement.
- When creating the 4-Wire Pairs List using *Method #2* (page 8) it will be easier to identify the Net List and Hidden points of each 4-wire pair.

Test Point Identification – Fixture Adapters vs. Device-Under-Test



FIXTURE	DUT		DUT	FIXTURE
J1-001	= Plug, pin 1	<= connected =>	Socket, pin 1	= J3-063
J1-003	= Plug, pin 2	<= connected =>	Socket, pin 2	= J3-061

Net List using Default Test Points:
(documents Fixture Adapter connectors)

Connections:
 1 J1-001 J3-063
 2 J1-003 J3-061

Same Net List using Custom Labels:
(documents the Device-under-Test)

Connections:
 1 PLUG_PIN-1 SOCKET_PIN-1
 2 PLUG_PIN-2 SOCKET_PIN-2

To re-label default test points to match the device-under-test (DUT)

1. In **View/Change Wirelist**, press the **Print** button.
2. Locate the Net List (**Connections**) in *Touch1 Cable Documentation*.
3. From the Net List, match the fixture (default) test points to the DUT.
4. In **View/Change Wirelist**, press **More-Label**, then **Change**.
5. In **Change Labels**, select (highlight) a Net List test point using:
 - Up/down arrows • Scroll bar (gray between arrows) • Hand-held probe.
 Then press **Change Label**.
6. Enter a label from the touch screen or a user-supplied computer keyboard.

Format: 30 characters, maximum.

First character: A to Z and underscore.

All others: A to Z, 0 to 9, dash, #, underscore.

Note: Lower case is available by using a computer keyboard.
7. Return to either *Method #2* (page 8), or to *4-Wire Components* (page 11).

TASK 4: Creating 4-Wire Components

Purpose of 4-Wire Components

- Defines the resistance parameter of *each* 4-wire measurement.
- Identifies the location of *each* measurement (*From* & *To* test points).

Specifications: Two Kinds of 4-Wire Components

4-W WIRE: Sets the maximum allowable resistance a wire segment can have between two Kelvin Points (KP).

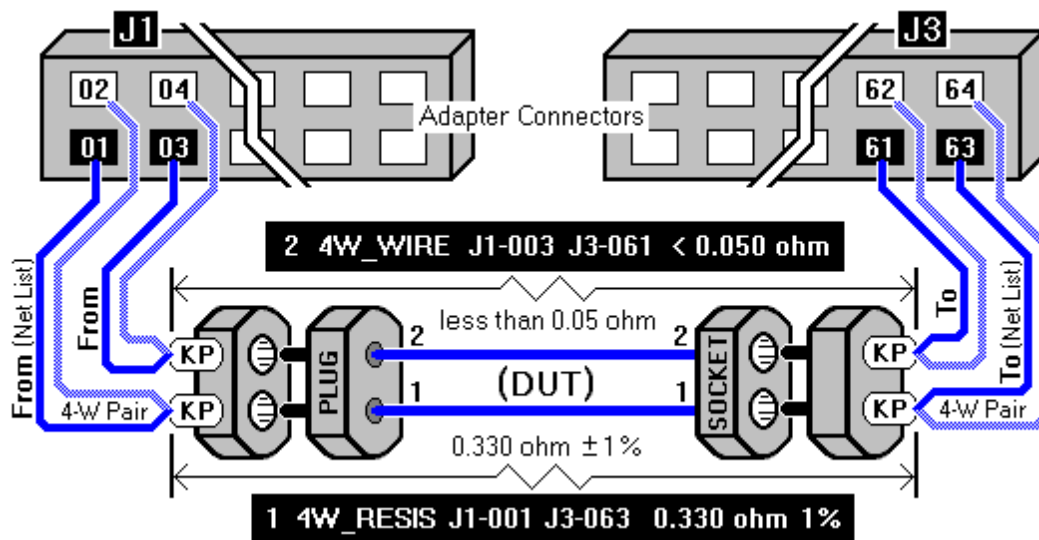
RANGE: 0.001Ω to 1.0MΩ ±4% ±0.001Ω

TOLERANCE: Threshold—good if less than.

4-W RESISTOR: Sets the resistance value and tolerance for resistors or wire segments between two Kelvin Points (KP).

RANGE: 0.001Ω to 1.0MΩ ±4% ±0.001Ω

TOLERANCE: 1-99%



- Important!**
- A 4-Wire Component is required for *each* 4-wire measurement.
 - Resistance is measured from kelvin point to kelvin point (KP).

Identifying *From* and *To* Points—the Location of the Measurement

The window used to select *From* & *To* points does not match the points for you. However, by referring to a Net List, you can easily find the *From* & *To* test points for each 4-Wire Component because the two points are always in the same net.

Note: Using the Net List for reference applies only to connections with resistance below *Connection Resistance* at the time of creating the wirelist. (page 13)

To print out a net list to identify the location of each measurement

1. In **View/Change Wirelist**, press the **Print** button.
2. Locate the Net List (**Connections**) in *Touch1 Cable Documentation*.
3. Mark test points from one net (example: J1-001 J1-063) for *From* & *To*.

“From” & “To” using defaults: *“From” & “To” using Custom Labels:*

Connections:

1 J1-001 J3-063

2 J1-003 J3-061

Connections:

1 PLUG_PIN-1 SOCKET_PIN-1

2 PLUG_PIN-2 SOCKET_PIN-2

(See also: Custom-labeling, page 10)

Creating 4-Wire Components, *cont.*

To open the **Change Components** window

- If you pressed **Add 4-Wire Comp** in **4-Wire Setup Warning**, at the end of Method #1 (page 6) or Method #2 (page 9), either see page 11 for theory, or stay here in **Change Components**.
- or -
- In **View/Change Wirelist**, press **More-Comp**, then **Change**.

To select the kind of 4-Wire Component

1. In **Change Components**, press **Add**.
2. In **Add Components**, select one of the following:
 - **Four-Wire Wire** - test wires to a threshold (good if less than).
 - **Four-Wire Resistor** - test wires or resistors to a value & tolerance.**Note:** These buttons disable if there is no 4-Wire Pairs List (pages 6 & 8)

To enter the location—*From & To*—of the 4-wire measurement

1. In **Add/Change 4-Wire Wire [or] Resistor**, press the **From** box.
2. In **Add/Change Component**, select (highlight) a test point using:
 - Up/down arrows
 - Scroll bar (gray between arrows)
 - Hand-held probe.Then press **OK**.
3. Press the **To** box and repeat Step #2.
Note: Only test points in the 4-Wire Pairs List display. (see pages 6 & 8).

To enter a 4-Wire Component value (and tolerance)

1. In **Add/Change 4-Wire Wire [or] Resistor**, press **Component Value**.
2. In **Enter 4-Wire...Value**, enter the **Component Value** using:
 - Touch screen
 - User-supplied computer keyboard. Then press **OK**.
3. If for a 4-Wire Resistor, also press **Tolerance Level**, then **OK** when done.
4. Press **OK** to return to the Change Components window.
Note: Delete Resistor Components if 4-W Resistors are replacing them.

To verify the 4-Wire Components before completing setup

1. In **Change Components**, do one of the following:
 - Press **Add** to create more 4-Wire Components.
 - or -
 - Press **OK** to save your work. **Warning!** pressing Cancel is like “undo.”
2. In **View/Change Wirelist**, **Print** the wirelist:

Example of completed 4-Wire Components (using graphic on page 11)

Four-Wire Kelvin Pairs :		Components :				
J3-061	J3-062	1	4W_RESIS	J1-001	J3-063	0.33 ohm 1%
J1-003	J1-004	2	4W_WIRE	J1-003	J3-061	< 0.05 ohm
J3-063	J3-064			↑	↑	
J1-001	J1-002			From	To	
↑						
From & To						

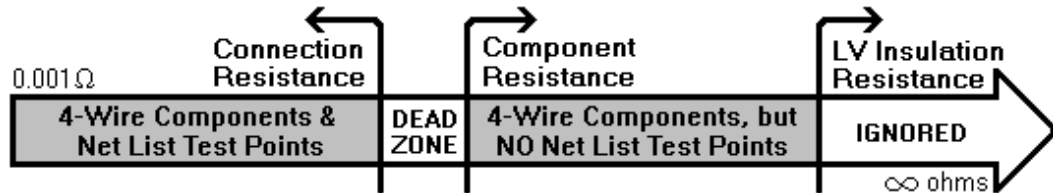
3. Verify the test points in the left column of **Four-Wire Kelvin Pairs** are used as intended for the *From & To* points in the **Components** list.
 - If not, press **More-Comp**, then **Change** to complete 4-W Components.
 - or
 - If 4-Wire Components are complete, continue to page 13.

TASK 5: Verifying Setup and Troubleshooting, if necessary

An otherwise good 4-Wire Test setup can cause LV Continuity Errors if:

- *Connection Resistance* is set too low or *Component Resistance* is set too high.
- Net List test points are missing for components set below *Connection Resistance* or are unnecessarily present for components set above *Component Resistance*.

Relationship of LV Continuity Settings to 4-Wire Component Values



Connection Resistance should be at least 20% higher than the resistance value of any 4-Wire Components used in this region.

From & To test points of 4-Wire Components in this region should also be in the Net List.

Component Resistance should be at least 20% lower than the resistance value of any 4-Wire Components used in this region.

From & To test points of 4-Wire Components in this region should NOT be in the Net List.

To adjust Continuity (Low Voltage) settings, if necessary

1. Open the **Change Low Voltage** window one of two ways:
 - Fixture/sample learning (page 6): In **View/Change Learn Settings**,
 - Editing an existing wirelist (pages 8,14): In **View/Change Wirelist**, press **LV**, then **Change**.
2. In **Change Low Voltage**, press either or both:
 - **Connection Resistance** - to set at least 20% higher than any 4-Wire Components intended below this setting.
 - **Component Resistance** - to set at least 20% lower than any 4-Wire Components intended above this setting.
3. Press **OK** when done.

To edit the Net List, if necessary

1. In **View/Change Wirelist**, press **Con**, then **Change**.
2. In **Change Connections**, press either or both:
 - **Add** - to add test points identical to the *From & To* points of 4-Wire Components set lower than *Connection Resistance*.
 - **Delete** - to remove test points identical to the *From & To* points of 4-Wire Components set higher than *Component Resistance*.
3. Press **OK** when done.

To save the wirelist to disk

1. In **View/Change Wirelist**, press **OK**. (pressing Cancel is like "Undo")
2. In **Test Setup**, press **Save Wirelist**.

To test a sample cable to verify the setup

1. Install a cable you have reason to believe is good.
2. In the **Main Menu**, press **Test Cable** or in **Test Setup**, press **Test**.
3. If the cable tested correctly—test setup is complete.
or
If there were errors during the test—continue to *Troubleshooting*, page 14.

Troubleshooting: Continuity Test Errors

- **Error Message**

High Resistance Errors:

NET 1: Measured 2.9 ohm

Detected at J1-001 and J1-063

Possible Causes

- Setup Error:
 - ✓ *Connection Resistance* is set lower than the detected resistance of a good connection. (See graph on page 13).
- Defective Cable:
 - ✓ Detected resistance is higher than *Connection Resistance*.

Solutions

- Raise *Connection Resistance* so it is 20% higher than the 4-Wire Component value describing the connection causing the error. (See *To Adjust Continuity*, page 13)
- Repair or test another cable.

- **Error Message**

Invalid 4-Wire Kelvin Pair – see page 7.

- **Error Message**

NET 1:

OPEN J1-001 and J1-063

Possible Causes

- Setup Errors:
 - ✓ *Component Resistance* is set lower than the detected resistance of a good connection intended to be in the Net List.
 - ✓ Unnecessary test points are in the Net List corresponding to 4-Wire Components set higher than *Component Resistance*.
- Defective Cable:
 - ✓ Intended connection is missing.

Solutions

- Raise both *Connection Resistance* & *Component Resistance* for wires to be tested by 4-Wire Components set below *Connection Resistance*. (See *To Adjust Continuity*, page 13)
- Delete from the Net List corresponding test points of 4-Wire Components set above *Component Resistance*. (See *To Edit the Net List*, page 13)
- Repair or test another cable.

- **Error Message**

NET 1:

SHORT J1-001 and J1-063

Possible Causes

- Setup Errors:
 - ✓ Test points are missing from the Net List for 4-Wire Components set below *Connection Resistance*.
 - ✓ *Component Resistance* is set too high for a 4-Wire Component set above *Connection Resistance*.
- Defective Cable:
 - ✓ Unintended connection.
 - ✓ Resistor - detected resistance is less than *Component Resistance*.

Solutions

- Add to the Net List corresponding test points of 4-Wire Components set below *Connection Resistance*. (See *To Edit the Net List*, page 13)
- Lower *Component Resistance*—to 20% less than the Component Value. (See *To Adjust Continuity*, page 13)
- Repair or test another cable.

Troubleshooting: 4-Wire Test Errors

- **Error Message**

**4-Wire Kelvin Pair Error
J1-002 and J3-064
not connected**

Possible Causes

- Hidden Point wires are not connected at the Touch1.
- Defective fixture—opens.
- Incorrect 4-Wire Pairs List.

Solutions

- Re-connect or repair the fixture. (See *Building...Fixtures*, pages 2-4)
- Test with the correct 4-wire fixture.
- Edit Hidden points (See page 9)

- **Error Message**

**Bad 4-W Resistor between:
J1-001 and J3-063
[also: Resistor Missing]
Expected value 1.00 ohm 1%
Measured value: 1.30 ohm**

Possible Causes

- Setup Errors:
 - ✓ Incorrect or unrealistic settings: Component Value or Tolerance.
 - ✓ Incorrect “From” & “To” points. (reports “Resistor Missing”)
- Fixture not built correctly.
- Defective Cable:
 - ✓ Missing wire or resistor.
 - ✓ Detected resistance out of range (Value or Tolerance or both).

Solutions

- Edit the 4-Wire Resistor reporting the error. (See *Creating 4-Wire Components*, pages 11-12)
- Reduce unwanted lead resistance. (See *Placing Kelvin Points*, page 5)
- Repair or test another cable.

- **Error Message**

**Bad 4-W Wire between:
J1-003 and J3-061
[also: Wire Missing]
Expected value < 0.05 ohm
Measured value: 1.22 ohm**

Possible Causes

- Setup Errors:
 - ✓ Incorrect or unrealistic setting: Component Value.
 - ✓ Incorrect “From” & “To” points. (reports “Wire Missing”)
- Fixture not built correctly.
- Defective Cable:
 - ✓ Missing wire.
 - ✓ Detected resistance over threshold (Component Value).

Solutions

- Edit the 4-Wire Wire reporting the error. (See *Creating 4-Wire Components*, pages 11-12)
- Reduce unwanted lead resistance. (See *Placing Kelvin Points*, page 5)
- Repair or test another cable.