

# Accurately Measure Low Valued Capacitors

Measuring components in-circuit can often present challenges. Understanding the factors that affect a measurement and the available system tools will provide the optimum result.

Each test system will include some capacitance based on the specific measurement electronics, cables and wiring. Some of the capacitance is due to the test system cables and wiring and some capacitance is due to an interchangeable test fixture. This system capacitance is in addition to the capacitance from the PCB and the components on the board.

The system includes tools to remove (subtract) the measured system capacitance. To do this, setup the system with the test fixture and measure the system capacitance. This value will be saved in the test program step as an offset of the measurement and subtracted from the UUT (unit under test) component measurement. The result is that only the component capacitance is tested to the test limits.

The following is a typical example where C1 initially measures 155pF since this measurement includes the system capacitance. Capacitor C1 has a value of 50pF. This value is too small to verify without compensating for the system capacitance.

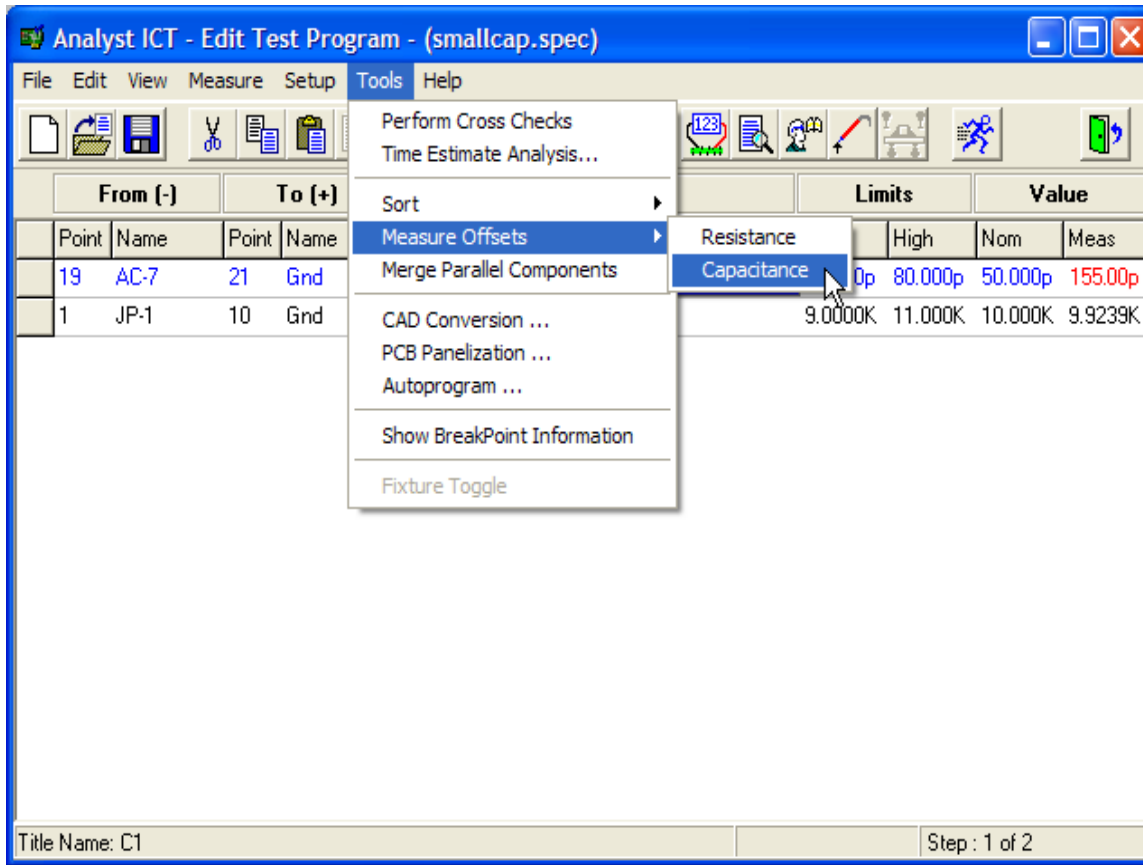
| From (-) |      | To (+) |      | Test |       |       | Limits |         | Value   |         |         |
|----------|------|--------|------|------|-------|-------|--------|---------|---------|---------|---------|
| Point    | Name | Point  | Name | Type | Range | Delay | Title  | Low     | High    | Nom     | Meas    |
| 19       | AC-7 | 21     | Gnd  | Cap  | 1048  |       | C1     | 20.000p | 80.000p | 50.000p | 155.00p |
| 1        | JP-1 | 10     | Gnd  | Res  | 264   |       | R1     | 9.0000K | 11.000K | 10.000K | 9.9239K |

Title Name: C1

Step : 1 of 2

An automated tool can be used to remove the system capacitance.

In the editor, select the menu item *Tools > Measure Offsets > Capacitance*:



A message to select some selected steps or all steps will pop-up, press OK:

The screenshot shows the 'Analyst ICT - Edit Test Program - (smallcap.spec)' window. It features a menu bar (File, Edit, View, Measure, Setup, Tools, Help) and a toolbar with various icons. Below the toolbar is a table with columns: From (-), To (+), Test, Limits, and Value. The table contains two rows of test data. A dialog box titled 'Measure CAP Offset on' is overlaid on the table, with two radio button options: 'Selected Step' (which is selected) and 'All Steps'. At the bottom of the dialog are 'OK' and 'Cancel' buttons. The status bar at the bottom of the window shows 'Title Name: C1' and 'Step: 1 of 2'.

| From (-) |      | To (+) |      | Test |       |       | Limits |         | Value   |         |         |
|----------|------|--------|------|------|-------|-------|--------|---------|---------|---------|---------|
| Point    | Name | Point  | Name | Type | Range | Delay | Title  | Low     | High    | Nom     | Meas    |
| 19       | AC-7 | 21     | Gnd  | Cap  | 1048  |       | C1     | 20.000p | 80.000p | 50.000p | 155.00p |
| 1        | JP-1 | 10     | Gnd  | Res  | 264   |       | R1     | 9.0000K | 11.000K | 10.000K | 9.9239K |

Measure CAP Offset on

- Selected Step
- All Steps

OK Cancel

Title Name: C1 Step: 1 of 2

A message to remove the UUT from the fixture will pop-up. Remove the UUT to allow the system to measure just the system capacitance and press OK:

The screenshot shows the Analyst ICT software interface. The main window is titled "Analyst ICT - Edit Test Program - (smallcap.spec)". It features a menu bar (File, Edit, View, Measure, Setup, Tools, Help) and a toolbar with various icons. Below the toolbar is a table with columns for "From (-)", "To (+)", "Test", "Limits", and "Value". The table contains two rows of test data. A confirmation dialog box titled "Confirm" is overlaid on the main window, displaying a question mark icon and the text "Remove UUT from fixture". An "OK" button is visible in the dialog, with a mouse cursor hovering over it.

| From (-) |      | To (+) |      | Test |       |       | Limits |         | Value   |         |         |
|----------|------|--------|------|------|-------|-------|--------|---------|---------|---------|---------|
| Point    | Name | Point  | Name | Type | Range | Delay | Title  | Low     | High    | Nom     | Meas    |
| 19       | AC-7 | 21     | Gnd  | Cap  | 1048  |       | C1     | 20.000p | 80.000p | 50.000p | 155.00p |
| 1        | JP-1 | 10     | Gnd  | Res  | 264   |       | R1     | 9.0000K | 11.000K | 10.000K | 9.9239K |

Confirm

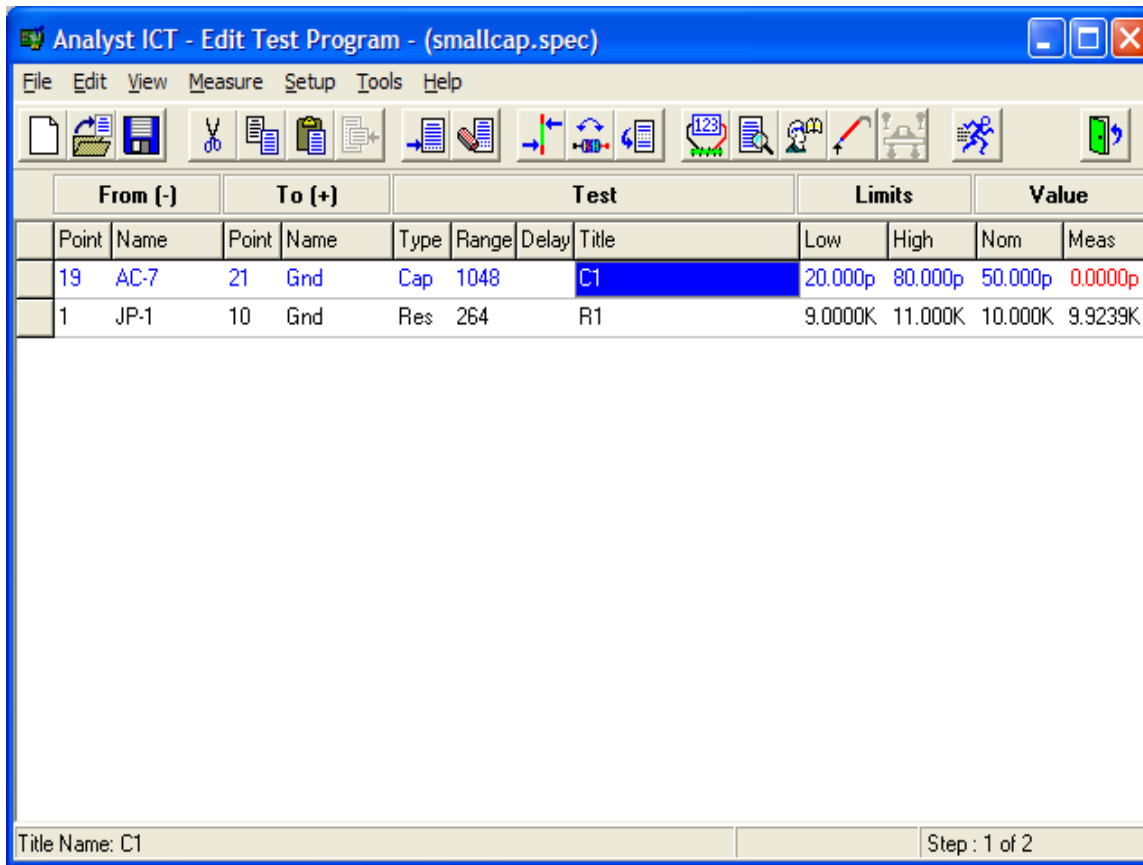
Remove UUT from fixture

OK

Title Name: C1

Step: 1 of 2

The system will measure the system capacitance and subtract that value from the measurement:



| From (-) |      | To (+) |      | Test |       |       | Limits |         | Value   |         |         |
|----------|------|--------|------|------|-------|-------|--------|---------|---------|---------|---------|
| Point    | Name | Point  | Name | Type | Range | Delay | Title  | Low     | High    | Nom     | Meas    |
| 19       | AC-7 | 21     | Gnd  | Cap  | 1048  |       | C1     | 20.000p | 80.000p | 50.000p | 0.0000p |
| 1        | JP-1 | 10     | Gnd  | Res  | 264   |       | R1     | 9.0000K | 11.000K | 10.000K | 9.9239K |

Title Name: C1 Step: 1 of 2

Without the UUT on the fixture, the displayed measurement should be very close to 0pF.

Now load the UUT on the test fixture and press the toolbar **Measurement** icon or the **F3** function key to measure C1 accurately, without the system capacitance contribution.

| From (-) |      | To (+) |      | Test |       |       |       | Limits  |         | Value   |         |
|----------|------|--------|------|------|-------|-------|-------|---------|---------|---------|---------|
| Point    | Name | Point  | Name | Type | Range | Delay | Title | Low     | High    | Nom     | Meas    |
| 19       | AC-7 | 21     | Gnd  | Cap  | 1048  |       | C1    | 20.000p | 80.000p | 50.000p | 49.000p |
| 1        | JP-1 | 10     | Gnd  | Res  | 264   |       | R1    | 9.0000K | 11.000K | 10.000K | 9.9239K |

Title Name: C1 Step : 1 of 2

The Measurement Analysis window provides a manual, step-by-step method to remove (subtract) the system capacitance. To do this, setup the system with the test fixture and measure the system capacitance. This value will be saved in the test program step as an offset of the measurement and subtracted from the UUT (unit under test) component measurement.

Without compensation for the system capacitance, the C1 measurement fails. Click on the **Measurement Analysis** icon or press the **F6** function key:

The screenshot shows the 'Analyst ICT - Edit Test Program - (smallcap.spec)' window. The interface includes a menu bar (File, Edit, View, Measure, Setup, Tools, Help) and a toolbar with various icons. A table displays test results, with the first row highlighted in blue. The table has columns for 'From (-)', 'To (+)', 'Test', 'Limits', and 'Value'. The 'Test' column is further divided into 'Point', 'Name', 'Type', 'Range', 'Delay', and 'Title'. The 'Limits' column is divided into 'Low', 'High', 'Nom', and 'Meas'. The first row shows a failed measurement for C1, with a measured value of 155.00p, which is outside the specified limits of 20.000p to 80.000p.

| From (-) |      | To (+) |      | Test |       |       | Limits |         | Value   |         |         |
|----------|------|--------|------|------|-------|-------|--------|---------|---------|---------|---------|
| Point    | Name | Point  | Name | Type | Range | Delay | Title  | Low     | High    | Nom     | Meas    |
| 19       | AC-7 | 21     | Gnd  | Cap  | 1048  |       | C1     | 20.000p | 80.000p | 50.000p | 155.00p |
| 1        | JP-1 | 10     | Gnd  | Res  | 264   |       | R1     | 9.0000K | 11.000K | 10.000K | 9.9239K |

Title Name: C1 Step : 1 of 2

The **Measurement Analysis** window shows the C1 measurement under several stimulus applications with up to 2V in Voltage mode or Constant Current mode. Since C1 is a small valued capacitor, the 100 KHz stimulus is appropriate, click on the box as shown:

**Analyst ICT - Measurement Analysis**

Measure Setting Help

| From (-) |      | To (+) |      | Test                  |       |       | Limits  |         | Value   |         |
|----------|------|--------|------|-----------------------|-------|-------|---------|---------|---------|---------|
| Point    | Name | Point  | Name | Type                  | Range | Title | Low     | High    | Nom     | Meas    |
| 19       | AC-7 | 21     | Gnd  | Cap                   | 1048  | C1    | 20.000p | 80.000p | 50.000p | 174.00p |
| 0        |      | 0      |      | <b>External Sense</b> |       |       |         |         |         |         |

Range : Auto Range

|        | Measured in Voltage Mode |         |         |         | Measured in DC constant-current Mode |         |
|--------|--------------------------|---------|---------|---------|--------------------------------------|---------|
| Output | 100 KHz                  | 10 KHz  | 1 KHz   | 100 Hz  | 10 mA                                | 1 mA    |
| 2 V    | 158.00p                  | 163.00p | 177.00p | 240.00p | ↓ Range                              | ↓ Range |
| .2 V   | 155.00p                  | 162.00p | 174.00p | 233.00p | ↓ Range                              | ↓ Range |
| .02 V  | 117.00p                  | 143.00p | 257.00p | 1668.0p |                                      |         |

**Press the Insert key to insert a Guard Point**

Guards / Nominal Fit

Delay : 0 mSec

Click the **Nominal Fit** tab at the bottom of the window to display the various functions:

**Analyst ICT - Measurement Analysis**

Measure Setting Help

| From (-) |      | To (+) |      | Test                  |       |       | Limits  |         | Value   |         |  |
|----------|------|--------|------|-----------------------|-------|-------|---------|---------|---------|---------|--|
| Point    | Name | Point  | Name | Type                  | Range | Title | Low     | High    | Nom     | Meas    |  |
| 19       | AC-7 | 21     | Gnd  | Cap                   | 1048  | C1    | 20.000p | 80.000p | 50.000p | 174.00p |  |
| 0        |      | 0      |      | <b>External Sense</b> |       |       |         |         |         |         |  |

**Range : Auto Range**

| Output | Measured in Voltage Mode |         |         |         | Measured in DC constant-current Mode |         |
|--------|--------------------------|---------|---------|---------|--------------------------------------|---------|
|        | 100 KHz                  | 10 KHz  | 1 KHz   | 100 Hz  | 10 mA                                | 1 mA    |
| 2 V    | 158.00p                  | 163.00p | 177.00p | 240.00p | ↓ Range                              | ↓ Range |
| .2 V   | 155.00p                  | 162.00p | 174.00p | 233.00p | ↓ Range                              | ↓ Range |
| .02 V  | 117.00p                  | 143.00p | 257.00p | 1668.0p |                                      |         |

**[Alt] Functions for making measured value fit nominal value**

|                     |                |                    |                       |
|---------------------|----------------|--------------------|-----------------------|
| [Alt+F2] Enter Zero | <b>0.000 F</b> | [Alt+F5] Fit Zero  | [Alt+F7] Reset Values |
| [Alt+F3] Enter Gain | <b>x1.000</b>  | [Alt+F11] Fit Gain | [Alt+F8] Measure Zero |
|                     |                |                    | [Alt+F9] No Offset    |
|                     |                |                    | [Alt+F10] Norm Model  |

Guards **Nominal Fit**

Delay : 0 mSec

Remove the UUT and click on the **Group Measurement** toolbar icon or press the **Shift+F3** function key:

The screenshot shows the 'Analyst ICT - Measurement Analysis' software window. The main table displays measurement data for a capacitor (C1) between points 19 (AC-7) and 21 (Gnd). The measured value is 124.00pF, which is within the nominal range of 50.000pF to 124.00pF. Below the table, there are controls for 'Measured in Voltage Mode' and 'Measured in DC constant-current Mode'. The 'Measured in Voltage Mode' section shows a table of measured values for different output frequencies and voltages. The measured value for 2 V at 100 KHz is 110.00pF, which is highlighted in red. Below this, there are buttons for '[Alt+F2] Enter Zero', '[Alt+F3] Enter Gain', '[Alt+F5] Fit Zero', and '[Alt+F11] Fit Gain'. The current settings are 0.000 F and x1.000. On the right, there are buttons for '[Alt+F7] Reset Values', '[Alt+F8] Measure Zero', '[Alt+F9] No Offset', and '[Alt+F10] Norm Model'. At the bottom right, there is a 'Delay : 0 mSec' control.

| Point | Name | Point | Name | Type                  | Range | Title | Low     | High    | Nom     | Meas    |
|-------|------|-------|------|-----------------------|-------|-------|---------|---------|---------|---------|
| 19    | AC-7 | 21    | Gnd  | Cap                   | 1048  | C1    | 20.000p | 80.000p | 50.000p | 124.00p |
| 0     |      | 0     |      | <b>External Sense</b> |       |       |         |         |         |         |

| Measured in Voltage Mode |         |         |         | Measured in DC constant-current Mode |         |         |
|--------------------------|---------|---------|---------|--------------------------------------|---------|---------|
| Output                   | 100 KHz | 10 KHz  | 1 KHz   | 100 Hz                               | 10 mA   | 1 mA    |
| 2 V                      | 110.00p | 112.00p | 120.00p | 148.00p                              | ↓ Range | ↓ Range |
| .2 V                     | 108.00p | 112.00p | 135.00p | 308.00p                              | ↓ Range | ↓ Range |
| .02 V                    | 75.000p | 107.00p | 108.00p | ↓ Range                              |         |         |

**[Alt] Functions for making measured value fit nominal value**

|                     |                |                    |                       |
|---------------------|----------------|--------------------|-----------------------|
| [Alt+F2] Enter Zero | <b>0.000 F</b> | [Alt+F5] Fit Zero  | [Alt+F7] Reset Values |
| [Alt+F3] Enter Gain | <b>x1.000</b>  | [Alt+F11] Fit Gain | [Alt+F8] Measure Zero |
|                     |                |                    | [Alt+F9] No Offset    |
|                     |                |                    | [Alt+F10] Norm Model  |

Delay : 0 mSec

The measurements shown are for the system capacitance including the fixture capacitance, about 110pF.

Now press the **Measure Zero** button to measure the system capacitance and store this value as the “Zero”. The Zero value is subtracted from the measurement for C1 and displayed as the Measured value. A small \* is displayed after **Nominal Fit** on the tab to indicate some type of special function has been selected, such as a Zero value. The system capacitance in this example is 109.91pF:

The screenshot shows the Analyst ICT - Measurement Analysis software interface. At the top, there is a menu bar with 'Measure', 'Setting', and 'Help'. Below the menu bar is a toolbar with various icons. The main area contains a table with columns for 'From (-)', 'To (+)', 'Test', 'Limits', and 'Value'. The table has two rows: one for a test point (19 AC-7 to 21 Gnd) and one for 'External Sense' (0 to 0). Below the table, there are two tabs: 'Measured in Voltage Mode' and 'Measured in DC constant-current Mode'. The 'Measured in Voltage Mode' tab is active, showing a table with columns for 'Output', '100 KHz', '10 KHz', '1 KHz', '100 Hz', '10 mA', and '1 mA'. The '2 V' row shows a measured value of 0.0000pF. Below the table, there is a section titled '[Alt] Functions for making measured value fit nominal value' with several buttons: '[Alt+F2] Enter Zero', '[Alt+F3] Enter Gain', '[Alt+F5] Fit Zero', '[Alt+F11] Fit Gain', '[Alt+F7] Reset Values', '[Alt+F8] Measure Zero', '[Alt+F9] No Offset', and '[Alt+F10] Norm Model'. A mouse cursor is pointing at the '[Alt+F8] Measure Zero' button. At the bottom, there is a 'Delay : 0 mSec' field and a 'Nominal Fit \*' tab.

| Point | Name | Point | Name | Type                  | Range | Title | Low     | High    | Nom     | Meas    |  |
|-------|------|-------|------|-----------------------|-------|-------|---------|---------|---------|---------|--|
| 19    | AC-7 | 21    | Gnd  | Cap                   | 1048  | C1    | 20.000p | 80.000p | 50.000p | 0.0000p |  |
| 0     |      | 0     |      | <b>External Sense</b> |       |       |         |         |         |         |  |

| Output | 100 KHz | 10 KHz  | 1 KHz   | 100 Hz  | 10 mA   | 1 mA    |
|--------|---------|---------|---------|---------|---------|---------|
| 2 V    | 0.0000p | 112.00p | 120.00p | 148.00p | ↓ Range | ↓ Range |
| .2 V   | 108.00p | 112.00p | 135.00p | 308.00p | ↓ Range | ↓ Range |
| .02 V  | 75.000p | 107.00p | 108.00p | ↓ Range |         |         |

**[Alt] Functions for making measured value fit nominal value**

[Alt+F2] Enter Zero    **109.91pF**    [Alt+F5] Fit Zero

[Alt+F3] Enter Gain    **x1.000**    [Alt+F11] Fit Gain

[Alt+F7] Reset Values

[Alt+F8] Measure Zero

[Alt+F9] No Offset

[Alt+F10] Norm Model

Delay : 0 mSec

Guards    Nominal Fit \*

Now load the board on the fixture, engage the fixture, and click on the Group Measurement toolbar icon or press the Shift+F3 function key. The measurement table is updated with the “compensated” measurement of C1:

| From (-) |      | To (+) |      | Test                  |       |       | Limits  |         | Value   |         |
|----------|------|--------|------|-----------------------|-------|-------|---------|---------|---------|---------|
| Point    | Name | Point  | Name | Type                  | Range | Title | Low     | High    | Nom     | Meas    |
| 19       | AC-7 | 21     | Gnd  | Cap                   | 1048  | C1    | 20.000p | 80.000p | 50.000p | 49.000p |
| 0        |      | 0      |      | <b>External Sense</b> |       |       |         |         |         |         |

Range : Auto Range

| Measured in Voltage Mode |         |         |         | Measured in DC constant-current Mode |         |         |
|--------------------------|---------|---------|---------|--------------------------------------|---------|---------|
| Output                   | 100 KHz | 10 KHz  | 1 KHz   | 100 Hz                               | 10 mA   | 1 mA    |
| 2 V                      | 49.000p | 53.000p | 66.000p | 116.00p                              | ↓ Range | ↓ Range |
| .2 V                     | 45.000p | 54.000p | 68.000p | ↓ Range                              | ↓ Range | ↓ Range |
| .02 V                    | 7.0000p | 58.000p | 81.000p | 501.00p                              |         |         |

**[Alt] Functions for making measured value fit nominal value**

[Alt+F2] Enter Zero    **109.91pF**

[Alt+F3] Enter Gain    **x1.000**

[Alt+F5] Fit Zero

[Alt+F11] Fit Gain

[Alt+F7] Reset Values

[Alt+F8] Measure Zero

[Alt+F9] No Offset

[Alt+F10] Norm Model

Delay : 0 mSec

Use the green door toolbar icon or press the Esc key to save this setup. The Zero is saved as part of this test step in the test program.

### Automated Tool or Manual Method

The automated tool and the manual method both will accomplish the same result, the system capacitance is removed from the measurement and the low-valued capacitor can be tested to the component test limits.