

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.

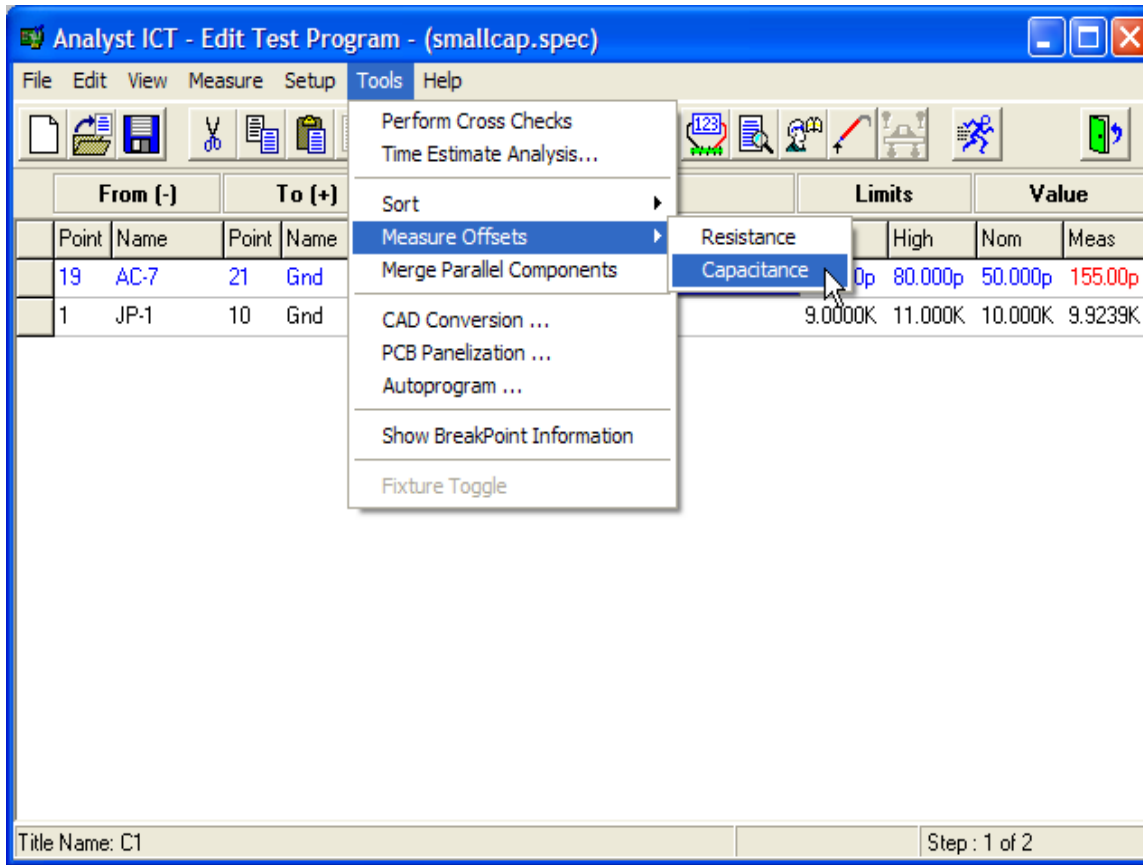
The following is a typical example where C1 initially measures 155pF since this measurement includes the system capacitance. Capacitor C1 has a value of 50pF. This value is too small to verify without compensating for the system capacitance.

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

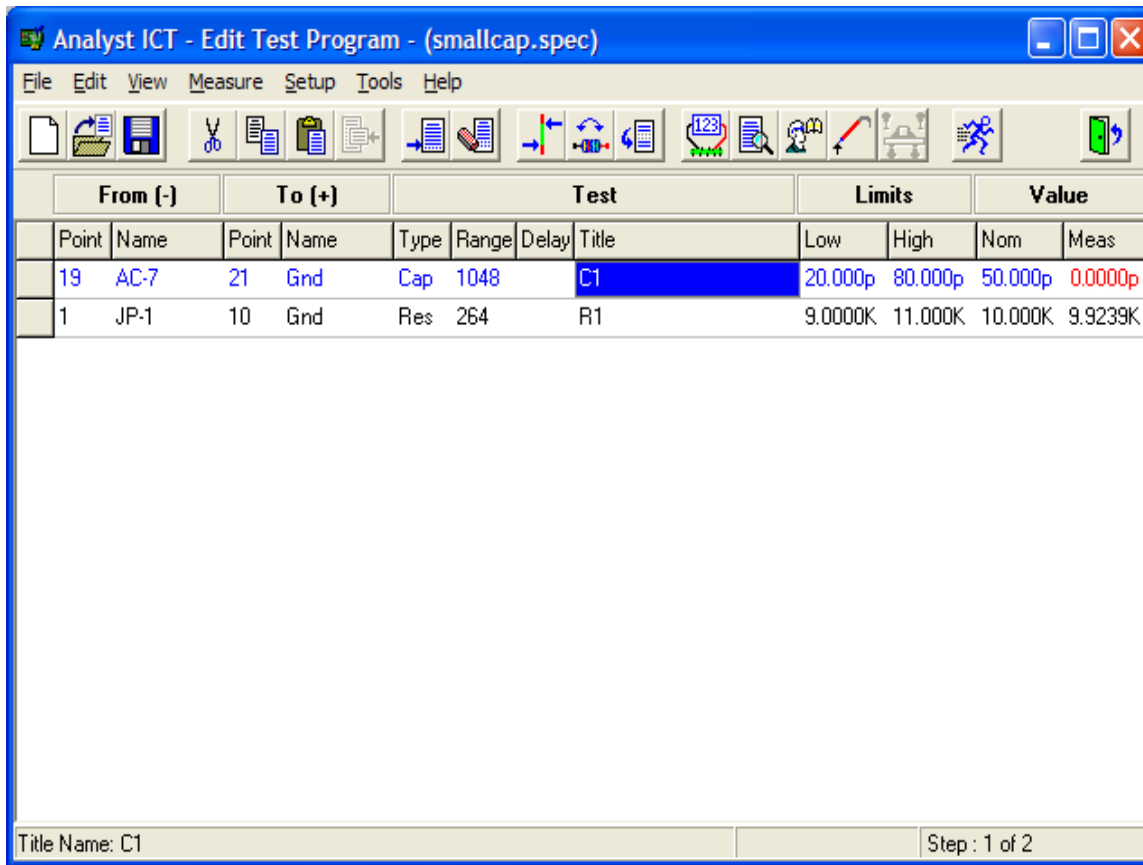
Remove UUT from fixture

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.

The screenshot shows the Analyst ICT software interface. The title bar reads "Analyst ICT - Edit Test Program - (smallcap.spec)". The menu bar includes "File", "Edit", "View", "Measure", "Setup", "Tools", and "Help". The toolbar contains various icons, with the "Measurement" icon (a green square with a white circle and a red 'X') highlighted by a mouse cursor. Below the toolbar is a table with columns for "From (-)", "To (+)", "Test", "Limits", and "Value". The table contains two rows of test data. The first row is for capacitor C1, and the second row is for resistor R1. The status bar at the bottom 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	49.000p
1	JP-1	10	Gnd	Res	264		R1	9.0000K	11.000K	10.000K	9.9239K

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 capacitor C1.

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

At the bottom of the window, the status bar shows 'Title Name: C1' and '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		External Sense						
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		External Sense							

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	0.000 F	[Alt+F5] Fit Zero	[Alt+F7] Reset Values
[Alt+F3] Enter Gain	x1.000	[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' table shows results for 2V, .2V, and .02V outputs. The 2V output shows a measured value of 110.00pF, which is highlighted in red, indicating it is outside the nominal range. The 'Measured in DC constant-current Mode' table shows results for 10 mA and 1 mA currents. The 10 mA current shows a measured value of 75.000pF, which is also highlighted in red. At the bottom, there are buttons for various functions like 'Enter Zero', 'Fit Zero', 'Reset Values', 'Measure Zero', 'No Offset', and 'Norm Model'. A 'Delay' field is set to 0 mSec.

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		External Sense						
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	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	0.000 F	[Alt+F5] Fit Zero	[Alt+F7] Reset Values
[Alt+F3] Enter Gain	x1.000	[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 shows a test point for C1 with a measured value of 0.0000p. Below the table, there is a section for 'External Sense' and a 'Range : Auto Range' indicator. A table of measured values is shown for different output frequencies and current levels. At the bottom, there is a control panel with buttons for '[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'. The measured value is displayed as 109.91pF and x1.000. A 'Delay : 0 mSec' field is also present.

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		External Sense						
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	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		External Sense						
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+F5] Fit Zero	[Alt+F7] Reset Values
[Alt+F3] Enter Gain	x1.000	[Alt+F11] Fit Gain	[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.