

**TRANSMILLE**

**SOLUTIONS IN CALIBRATION**



# PROCAL

## UNCERTAINTIES CALCULATION OVERVIEW

# UNCERTAINTIES : Overview

→The uncertainties function takes information from several sources to combine in a statistical calculation.

→Each parameter, eg. DC Voltage Source, has a template set up which contains all the information required to calculate the uncertainty for a specific test.

Source of Uncertainty	Limit Value	Probability Distribution	Divisor	C <sub>i</sub>
Imported Uncertainty	>Calculated At Run Time<	Normal	2.0	1.0
Stability of Reference	>Calculated At Run Time<	Rectangular	√3	1.0
Resolution	>Calculated At Run Time<	Rectangular	√3	1.0
Noise / Flicker	>Calculated At Run Time<	Normal	1.0	1.0
Connection / Lead Errors	5uV	Rectangular	√3	1.0
			-	▼
			-	▼
			-	▼
			-	▼
			-	▼
			-	▼
			-	▼
			-	▼
			-	▼
			-	▼
			-	▼
			-	▼

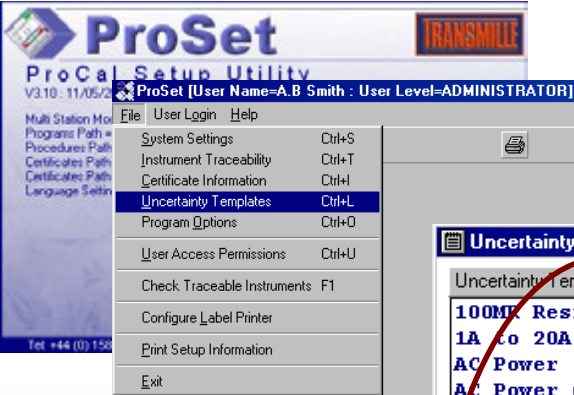
- Imported Uncertainty
- Stability of Reference
- Resolution
- Noise / Flicker
- Up to 15 additional sources of uncertainty



A set of common uncertainty templates are installed with ProCal (AC/DC Voltage, Current Resistance etc.)

# UNCERTAINTIES : Uncertainty Templates

Up to 15 user defined sources of uncertainty can be added



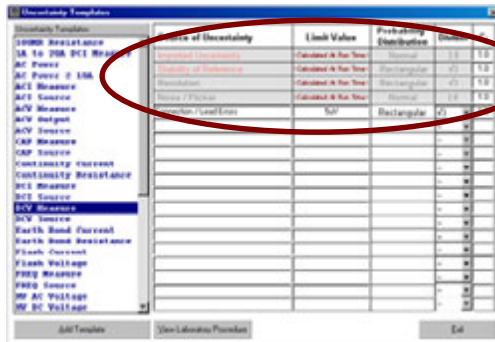
The 'Uncertainty Templates' dialog box is shown. It features a list of templates on the left and a table of sources on the right. The list on the left includes items like '100MΩ Resistance', '1A to 20A DCI Measure', 'AC Power', 'AC Power @ 10A', 'ACI Measure', 'ACI Source', 'ACV Measure', 'ACV Output', 'ACV Source', 'CAP Measure', 'CAP Source', 'Continuity Current', 'Continuity Resistance', 'DCI Measure', 'DCI Source', 'DCV Measure' (highlighted), 'DCV Source', 'Earth Bond Current', 'Earth Bond Resistance', 'Flash Current', 'Flash Voltage', 'FREQ Measure', 'FREQ Source', 'HV AC Voltage', and 'HV DC Voltage'. The table on the right has columns for 'Source of Uncertainty', 'Limit Value', 'Probability Distribution', 'Divisor', and  $C_i$ . The first row shows 'Imported Uncertainty' with a limit value of '> Calculated At Run Time <', Normal distribution, divisor of 2.0, and  $C_i$  of 1.0. Other rows include 'Stability of Reference', 'Resolution', 'Noise / Flicker', and 'Connection / Lead Errors'.

Source of Uncertainty	Limit Value	Probability Distribution	Divisor	$C_i$
Imported Uncertainty	> Calculated At Run Time <	Normal	2.0	1.0
Stability of Reference	> Calculated At Run Time <	Rectangular	$\sqrt{3}$	1.0
Resolution	> Calculated At Run Time <	Rectangular	$\sqrt{3}$	1.0
Noise / Flicker	> Calculated At Run Time <	Normal	1.0	1.0
Connection / Lead Errors	5mV	Rectangular	$\sqrt{3}$	1.0

List of available uncertainty templates →  
Click here to add a new template →

→ Each parameter has its own template which includes the four main sources of uncertainty. Up to 15 user defined sources of uncertainty can also be added.

# UNCERTAINTIES : Uncertainty Templates (Cont'd)



Source of Uncertainty	Limit Value	Probability Distribution	Divisor	C <sub>i</sub>
Imported Uncertainty	>Calculated At Run Time<	Normal	2.0	1
Stability of Reference	>Calculated At Run Time<	Rectangular	$\sqrt{3}$	1
Resolution	>Calculated At Run Time<	Rectangular	$\sqrt{3}$	1
Noise / Flicker	>Calculated At Run Time<	Normal	1.0	1
Connection / Lead Errors	0.5uV	Rectangular	$\sqrt{3}$	1.0

Each line of the uncertainty template is comprised of the following :

- Source of Uncertainty : A description of the uncertainty
- Limit value : The contribution of the uncertainty source
- Probability Distribution : A description of the distribution, as determined by the divisor
- Divisor : Divisor term (1.0, 2.0,  $\sqrt{2}$ ,  $\sqrt{3}$ )
- C<sub>i</sub> : Multiplier  
used to scale different measurement functions uncertainty eg. measuring current using a shunt with a reading returned in volts)

# UNCERTAINTIES : Reference Instrument Data

Source of Uncertainty	Limit Value	Probability Distribution	Divisor	C <sub>i</sub>
Imported Uncertainty	>Calculated At Run Time<	Normal	2.0	
Stability of Reference	>Calculated At Run Time<	Rectangular	√3	

No.	Model Number & Description	Serial Number	GPIB/RS232	Location
1	2041A Precision Multi-Product Calibrator	123456A1	COM1	L
2	3458A Multimeter	1234A1	10	L
3	2000 Oscilloscope Calibration Module			L
4	2100 Electrical Test Calibrator (HI)	1234A1	COM2	L
5	** NONE **			L
6	** NONE **			L
7	** NONE **			L

	Imported Uncertainty		Stability of Reference	
	% Reading	Zero	% Reading	Zero
DCV : 0mV to 202mV	0.00026	0.5uV	0.0003	3.6uV
DCV : 202mV to 2.02V	0.00033		0.0003	9uV
DCV : 2.02V to 20.2V	0.00033		0.00025	63uV
DCV : 20.2V to 202V	0.00033		0.0003	603uV
DCV : 202V to 1020V	0.00033		0.0003	6mV
DCI : 0uA to 202uA	0.00018	10nA	0.01	16uA
DCI : 202uA to 2.02mA	0.00018	50nA	0.008	44nA
DCI : 2.02mA to 20.2mA	0.00033	0.6uA	0.005	404nA
DCI : 20.2mA to 202mA	0.011	1uA	0.008	4uA
DCI : 202mA to 2.02A	0.011	180uA	0.015	40uA
DCI : 2.02A to 20.2A	0.11	180uA	0.04	400uA
ACV : 20mV to 202mV (10Hz to 30Hz)	0.025	20uV	0.2	180uV

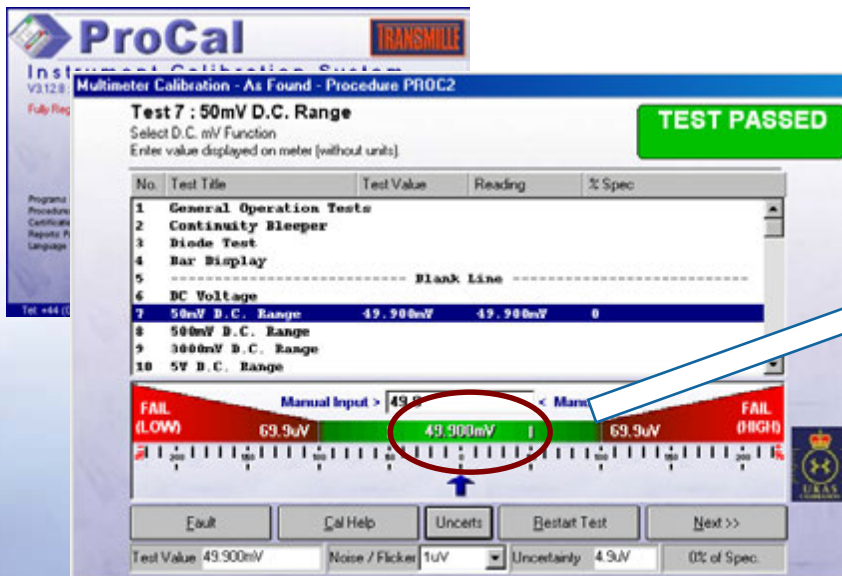
→ The reference uncertainty is calculated from the reference database (set using ProSet) - this data includes :

→ IMPORTED uncertainty (from the laboratory which calibrated to instrument)

→ STABILITY of reference (accuracy of instrument from manufacturer specification)

# UNCERTAINTIES : Resolution

Source of Uncertainty	Limit Value	Probability Distribution	Divisor	C <sub>i</sub>
Resolution	>Calculated At Run Time<	Rectangular	$\sqrt{3}$	



→ The resolution of the instrument is determined when the test is run in ProCal.

→ This is based on the number of decimal places, and is calculated as 1 count.



# UNCERTAINTIES : Noise / Flicker

Source of Uncertainty	Limit Value	Probability Distribution	Divisor	C <sub>i</sub>
Noise / Flicker	>Calculated At Run Time<	Normal	1.0	

ProCal  
Instrument Calibration System  
V3.12.8  
Multimeter Calibration - As Found - Procedure PROC2

Test 7 : 50mV D.C. Range  
Select D.C. mV Function  
Enter value displayed on meter (without units)

**TEST PASSED**

No.	Test Title	Test Value	Reading	% Spec
1	General Operation Tests			
2	Continuity Bleeper			
3	Diode Test			
4	Bar Display			
5	----- Blank Line -----			
6	DC Voltage			
7	50mV D.C. Range	49.900mV	49.900mV	0
8	500mV D.C. Range			
9	3000mV D.C. Range			
10	5V D.C. Range			

Manual Input > 49.9 < Manual Input

FAIL (LOW) 69.9uV | 49.900mV | 69.9uV FAIL (HIGH)

Test Value 49.900mV Noise / Flicker 1uV Uncerts 0% of Spec.

Noise / Flicker 1uV

- 0uV
- 1uV
- 2uV
- 3uV
- 4uV
- 5uV

- The noise / flicker is any observed change in the reading
- This is selected from the drop down list provided on screen







# UNCERTAINTIES : Reference Range Lookup

→ If the reference has multiple functions / ranges, ProCal is required to determine which function / range to use.

→ The complete range of Transmille calibrators has a built in lookup table which enables ProCal to automatically find the correct line to use – for all other references the procedure will require the exact uncertainty line to be selected using ProEdit.

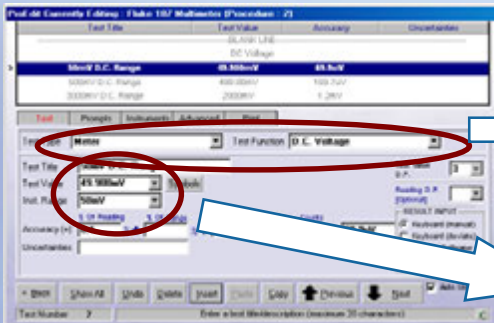
Range	Imported Uncertainty		Stability of Reference	
	% Reading	Zero	% Reading	Zero
DCV : 0mV to 202mV	0.00026	0.5uV	0.0003	3.6uV
DCV : 202mV to 2.02V	0.00033		0.0003	9uV
DCV : 2.02V to 20.2V	0.00033		0.00025	63uV
DCV : 20.2V to 202V	0.00033		0.0003	603uV
DCV : 202V to 2020V	0.00033		0.0003	6mV
DCI : 0uA to 202uA	0.00018	10nA	0.01	16uA
DCI : 202uA to 2.02mA	0.00018	50nA	0.008	44nA
DCI : 2.02mA to 20.2mA	0.00033	0.6uA	0.005	404nA
DCI : 20.2mA to 202mA	0.011	1uA	0.008	4uA
DCI : 202mA to 2.02A	0.011	180uA	0.015	40uA
DCI : 2.02A to 20.2A	0.011	180uA	0.04	400uA
ACV : 0mV to 202mV (10Hz to 30Hz)	0.025	20uV	0.2	180uV

Currently Selected : DCV : 0mV to 202mV

Imported Uncertainty % of Reading **0.00026** % Zero **0.5uV**

Stability of Reference % of Reading **0.0003** % Zero **3.6uV**

Add Range Edit Range Exit




Test Type **Meter** Test Function **D.C. Voltage**

Test Title **50mV D.C. Range**

Test Value **49.900mV** Symbols

Inst. Range **50mV**

 ProCal can also look up the uncertainty template required, based on the test type and function

→ ProCal looks up based on Test Type, Function & Test Value to determine the correct reference instrument line to select.

# UNCERTAINTIES : Reference Range Lookup (cont'd)

→ For other multi-range references, the specific reference line needs to be selected in ProEdit

This screenshot shows the ProEdit interface. On the left, a tree view shows the instrument selection path: '2041A Precision Multi-Product Calibrator' is highlighted with a red oval. An arrow points from this selection to the main configuration window. In the main window, the 'Inst' dropdown is set to 'A Precision Multi-Product Calibrator'. Below it, a list of uncertainty templates is shown, with '@01 R1/O100' and '@04 F20/R2' selected. To the right, the 'Uncert. Line' dropdown is set to '[B] / [RS]', and a list of measurement ranges is visible, including 'DCV : 0mV to 202mV'.

This screenshot shows the 'Instrument Traceability' table and its configuration window. The table lists several instruments, with the first row selected: '2041A Precision Multi-Product Calibrator' with serial number '123456A1' and GPIB/RS232 address 'COM1'. Below the table, the configuration window for this instrument is shown, with fields for 'Instrument Model Number & Description', 'Serial Number', 'Certificate Number', 'Calibration Date', 'Calibration Interval', and 'COM Port (COM1 to COM8) or GPIB Address (0 to 30)'. The 'COM1' port is selected.

→Reference Instrument selection

This screenshot shows the 'Uncertainty Templates' table. The table has columns for 'Source of Uncertainty', 'Limit', 'Probability Distribution', 'Display', and 'C<sub>i</sub>'. The 'DCV Source' row is highlighted, indicating it is the selected template for the current measurement.

→Uncertainty table selection

This screenshot shows the 'Uncertainties For 2041A Precision Multi-Product Calibrator' table. The table has columns for 'Imported Uncertainty', 'Stability of Reference', '% Reading', and 'Zero'. The first row is selected: 'DCV : 0mV to 202mV' with an imported uncertainty of 0.00026 and a stability of reference of 0.0003. Below the table, the 'Currently Selected' row shows 'DCV : 0mV to 202mV' with the same values.

→Reference table line selection

→These selections tell ProCal which reference table, reference table line and uncertainty template to use when calculating the uncertainty for this test.