



PROCAL


UNCERTAINTIES
CALCUATION
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.

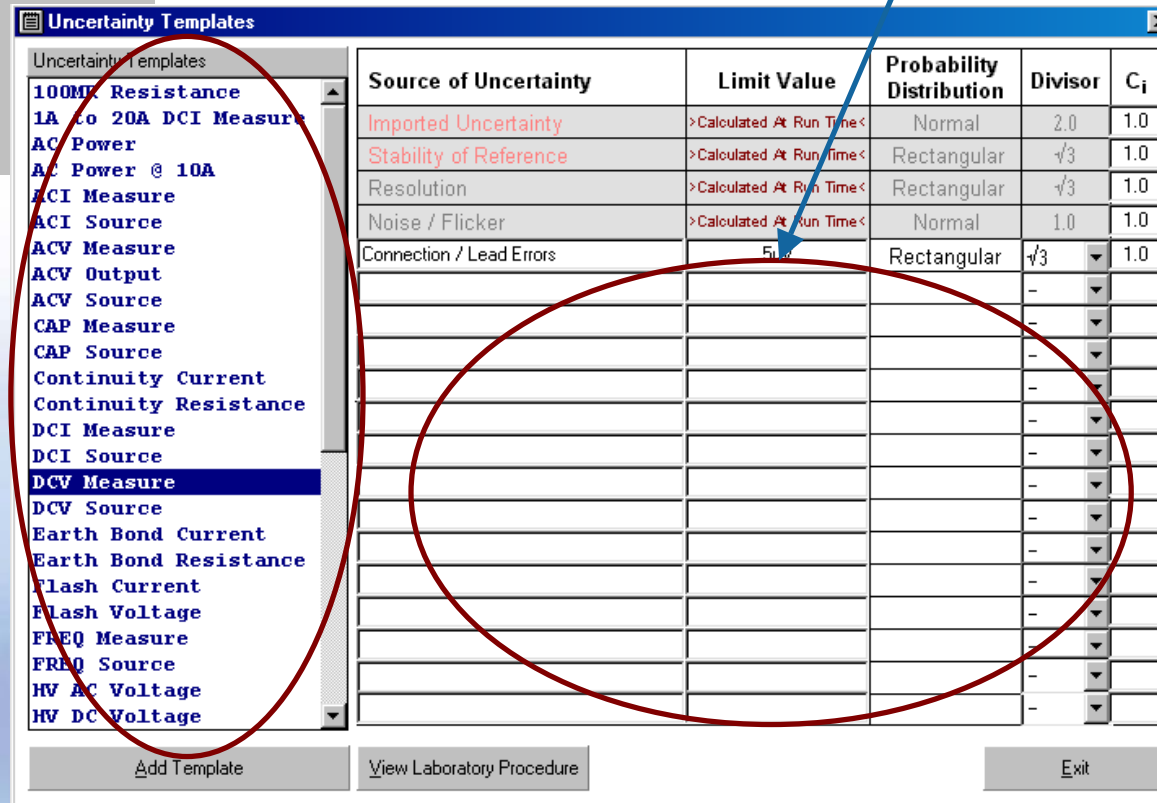
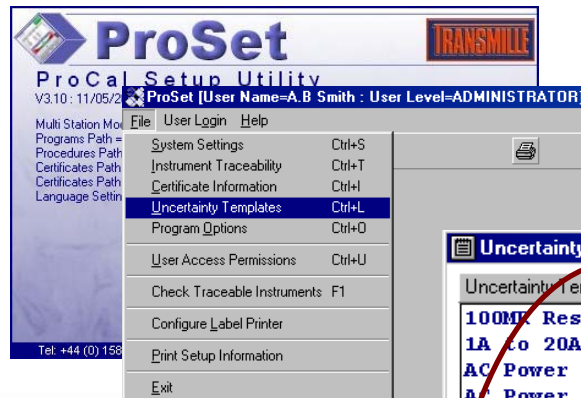
Source of Uncertainty	Limit Value	Probability Distribution	Divisor	C _i
Imported Uncertainty	>Calculated At Run Time<	Normal	2.0	1.0
Stability of Reference	>Calculated At Run Time<	Rectangular	√3	1.0
Resolution	>Calculated At Run Time<	Rectangular	√3	1.0
Noise / Flicker	>Calculated At Run Time<	Normal	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



Uncertainty Templates

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	5%	Rectangular	$\sqrt{3}$	1.0

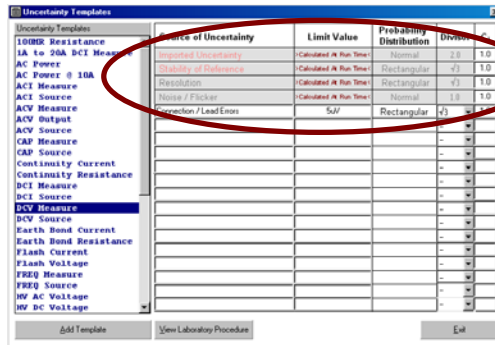
Add Template View Laboratory Procedure Exit

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 _i
Imported Uncertainty	>Calculated At Run Time<	Normal	2.0	1
Stability of Reference	>Calculated At Run Time<	Rectangular	√3	1
Resolution	>Calculated At Run Time<	Rectangular	√3	1
Noise / Flicker	>Calculated At Run Time<	Normal	1.0	1
Connection / Lead Errors	0.5uV	Rectangular	√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, √2, √3)
- **C_i** : 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 _i
Imported Uncertainty	>Calculated At Run Time<	Normal	2.0	
Stability of Reference	>Calculated At Run Time<	Rectangular	$\sqrt{3}$	

ProSet
ProCal Setup Utility
V3.10

No.	Model Number & Description	Serial Number	GPIO/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

Information For 2041A Precision Multi-Product Calibrator [LOCAL]
 Instrument Model Number & Description: 2041A Precision Multi-Product Calibrator
 Serial Number: 123456A1
 Certificate Number: U00123
 Calibration Date: 01/01/2005
 Calibration Interval: 52 Weeks
 COM Port (COM1 to COM8) or GPIB Address (0 to 30): COM1
 Measured Value (Including Units) [Optional]:
 Uncertainty Template (Optional):

Instruments : [1] = Multifunction Calibrator [2] = Multimeter [3] = Oscilloscope Calibrator [7 to 10] = Reserved
 [4] = Electrical Test Calibrator [5] = Bridge (C / L) [6] = Pressure Source [11+] = User

	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	0.011	180uA	0.04	400uA
ACV : 20mV 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

- 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 _i
Resolution	>Calculated At Run Time<	Rectangular	$\sqrt{3}$	

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)

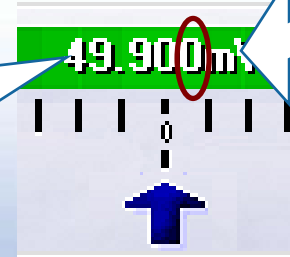
TEST PASSED

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 > 49.900 < Manu

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

Test Value 49.900mV Noise / Flicker 1uV Uncertainty 4.9uV 0% of Spec.



→ 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 _i
Noise / Flicker	>Calculated At Run Time<	Normal	1.0	

ProCal Instrument Calibration System
V3.12.8
Fully Rec
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 : The complete calculation (cont'd)

- IMPORTED UNCERTANTY
- STABILITY OF REFERENCE

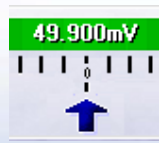


Range	Imported Uncertainty	Stability of Reference
DCV : 0mV to 322mV	0.00026 ± 0.5uV	0.0003 ± 3.6uV
DCV : 202mV to 2.02V	0.00033	0.0003
DCV : 2.02V to 20.2V	0.00033	0.0003
DCV : 20.2V to 202V	0.00033	0.0003
DCV : 202V to 2022V	0.00033	0.0003
DCE : 0mA to 202uA	0.00018 ± 18nA	0.01 ± 15nA
DCE : 202uA to 2.02mA	0.00018 ± 18nA	0.00018
DCE : 2.02mA to 20.2mA	0.00033	0.005
DCE : 20.2mA to 202mA	0.011 ± 11uA	0.01
DCE : 202mA to 2.02A	0.011 ± 11uA	0.01
DCE : 2.02A to 20.2A	0.011 ± 11uA	0.04
DCE : 20.2A to 202A	0.015 ± 15uA	0.5

Currently Selected: DCV : 0mV to 202mV
Imported Uncertainty: 0.00026 % of Reading, 0.5uV Zero
Stability of Reference: 0.0003 % of Reading, 3.6uV Zero



→ RESOLUTION



→ NOISE / FLICKER



Noise / Flicker: 1uV
Dropdown menu options: 0uV, 1uV, 2uV, 3uV, 4uV, 5uV

Source of Uncertainty	Limit Value	Probability Distribution	Divisor	C _i	±U _i
Imported Uncertainty	516.6nV	Normal	2.0	1.0	258.3nV
Stability of Reference	3.7uV	Rectangular	√3	1.0	2.2uV
Resolution	1.0uV	Rectangular	√3	1.0	0.6uV
Noise / Flicker	1uV	Normal	1.0	1.0	1.0uV
Connection / Lead Errors	0.5uV	Rectangular	√3	1.0	288.7nV
Combined Standard Uncertainty		Normal			2.5uV
Expanded Uncertainty		Normal (k=2)			5uV

2041A Precision Multi-Product Calibrator
Line 1 [DCV : 0mV to 202mV] - Calibration = 0.00026% ± 0.5uV ; Stability = 0.0003% ± 3.6uV



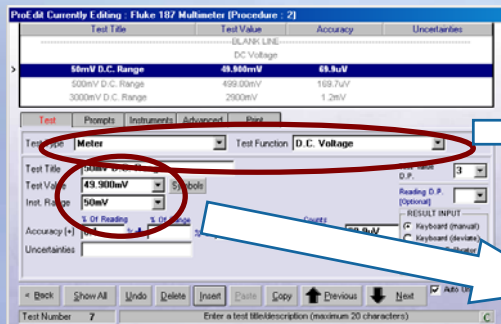
→ The uncertainty template screen displays the reference instrument description and uncertainty line used at the bottom of the screen.

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 : 20.2uA 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 : 20mV to 202mV (10Hz to 30Hz)	0.025	20uV	0.2	180uV




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

The screenshots illustrate the following steps:

- Reference Instrument selection:** Selecting the specific instrument model in the 'Uncert' dropdown menu.
- Uncertainty table selection:** Choosing an appropriate uncertainty template from the 'Uncertainty Templates' window.
- Reference table line selection:** Selecting the specific measurement range and uncertainty value from the 'Uncertainties For 2041A Precision Multi-Product Calibrator' table.

→Reference Instrument selection

→Uncertainty table selection

→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.