AUTOMATION OF THE CALCULATION OF UNCERTAINTIES USING PROCAL

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Introduction to Calculation of Uncertainties Using ProCal

ProCal provides several different methods to present uncertainties, including automatic calculation for uncertainties to M3003/GUM for each individual measurement made in a procedure.

Automatic calculation will only operate when there are no uncertainty statements selected in a procedure and the uncertainties box in the test data for that test is empty.

To perform this calculation ProCal uses;

1. An uncertainty template, which details the contributions affecting the uncertainty of that type of measurement.

2. The Imported and stability data for the reference standards used for that measurement.

3. Data taken at the time of measurement; noise/flicker & resolution

The calculation runs at the time of measurement, combing several contributions to give a k=2, 95% expanded uncertainty which is calculated in the units of the measurement and stored along with the result in the ProCal results database.

For ProCal to perform this calculation correctly the uncertainty template must contain all the contributions affecting the measurement, the imported uncertainty and stability data, and the procedure detailing the reference standards used, the uncertainty template and the resolution must all be correct.

Using ProEdit

Create the measurement tests, which form a procedure. The test data used for uncertainty calculation in each test is the

1. Test value
2. Reference standard used
3. Uncertainty template to use
4. For multi-range instruments the uncertainty line to use
5. Resolution of measurement

From this information ProCal can calculate the values for the 'greyed' out line in the uncertainty template.

For Meter, Measurement and 3200 functions using Transmille instruments ProCal will automatically select the correct default uncertainty templates for the measurement type and also the correct reference standard and range line in the uncertainty table.

Note 1: ProCal defaults to use the multi-product calibrator selected in 1st line in Proset, The DMM as selected in the 2nd line and the electrical test equipment calibrator in the 4th line. Further information on the configuration of ProSet can be found in the ProCal Manual.

Note 2: Default uncertainty tables for Transmille instruments are installed as are default uncertainty templates. These templates should however be carefully checked to meet the requirements of the laboratory. When you receive new calibration data for your standards you must update the uncertainty tables in ProSet for the new information to be reflected in ProCal.

Below is a table containing the ProCal test type and the default uncertainty file in ProSet used:

ProCal Test Type	Default Uncertainty File Used
Meter	
DCV	DCV Source
DCI	DCI Source
ACV	ACV Source
ACI	ACI Source
Resistance 2W	OHMS2 Source
Resistance 4W	OHMS4 Source
Capacitance	CAP Source
Inductance	IND Source
Frequency	FREQ Source
Temperature	TEMP Source
PRT	PT100 Source
RPM	RPM Source
Measurement	
DCV	DCV Measure
DCI	DCI Measure
ACV	ACV Measure
ACI	ACI Measure
Resistance 2W	OHMS2 Measure

Resistance 4W	OHMS4 Measure
Capacitance	CAP Measure
Inductance	IND Measure
Frequency	FREQ Measure
Temperature	TEMP Measure
Continuity / Insulation Testers	
Continuity Resistance	Continuity Resistance
Insulation Resistance	Insulation Resistance
Insulation Test Voltage	Insulation Test Voltage
Voltage Measurement	ACV Output
Continuity Current	Continuity Current
PAT	
Earth Bond Resistance	Earth Bond Resistance
Earth Bond Current	Earth Bond Current
Insulation Testing	
Load Testing	Load Testing
Leakage Current	Leakage Current
Flash C1 Voltage (No Load)	Flash Voltage
Flash C1 Voltage (1mA)	Flash Voltage
Flash C1 Current	Flash Current
Flash C2 Voltage (No Load)	Flash Voltage
Flash C2 Voltage (1mA)	Flash Voltage
Flash C2 Current	Flash Current
RCD	
RCD Current	RCD Current
RCD Time	RCD Time
Mains Voltage Measurement	ACV Output
Loop	
Loop Resistance	Loop Resistance
Mains Voltage Measurement	ACV Output

Table 1 - ProCal Test Types

Using ProSet

Adding reference standards

1: Enter the imported uncertainty and stability (drift between calibrations) of the reference standards. Note some reference standards will only have one value for imported & stability, for example a standard resistor, while others like a DMM will have several ranges to enter. The uncertainty table in ProSet allows for '%' & 'floor' data to be entered.

2: Create & edit the uncertainty templates used for different types of measurements. Each type of measurement will need its own template detailing the contributions, which affect that measurement type. For example the contributions for a Frequency measurement are different from a voltage measurement. Templates can contain fixed value contributions, or value dependant contributions. The first 4 contributions are always present and will be calculated by ProCal when the measurement (test) is made by ProCal. These are;

1. Reference Imported Uncertainty (Normal Probability)
2. Reference stability (Rectangular Probability)
3. Resolution (Rectangular Probability)
4. Noise/digit flicker (Rectangular Probability)

ProCal will calculate the value of these terms at the time of measurement in the units of the measurement. For example if the measurement in Volts the uncertainty calculation will be in Volts.

Creating Uncertainty Templates

Note: New uncertainty files can easily be created. Extreme care should be used to remove or delete an unwanted file. To avoid accidental deletion of uncertainty templates no facility is available in ProCal/ProSet.

To delete an unwanted file use Windows explorer.

Using the menus in ProSet, go to: - *File:- Edit Uncertainty templates:--*

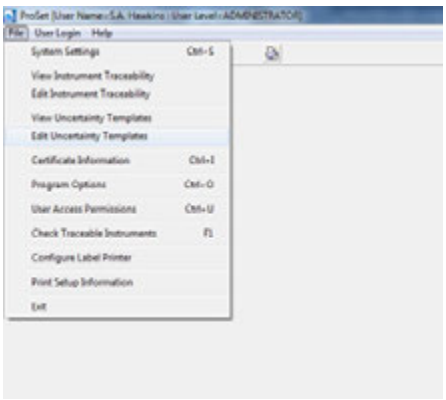

Figure 1 - ProSet File Menu

When the uncertainty templates view screen is displayed, select the template to edit from the scroll box on the left or select 'add new template'

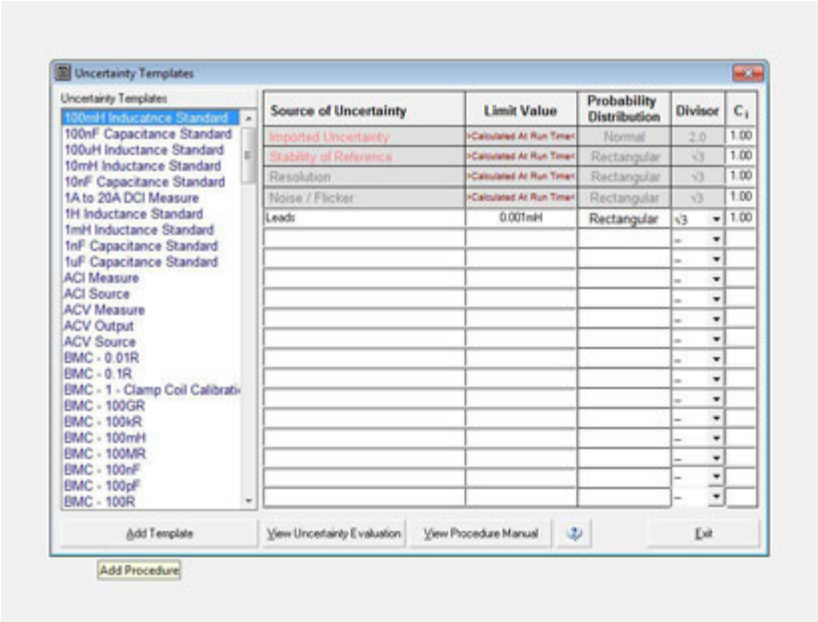

Figure 2 - ProSet Uncertainty Templates

The first 4 lines will already be greyed out; ProCal automatically fills these lines during uncertainty calculations during the actual calibration.

To add a contribution fill in the box's provided for;

- Source of uncertainty (Text description)
- Limit Value (including units)
- Divisor (setting this also sets the probability distribution
- Ci - Sensitivity Coefficient.

This will add a 'fixed value' contribution.

Contributions from a second reference standard

To add a contribution from a second reference standard, for example measuring current using a current shunt, where the voltage drop is measured by the system DMM.

In this example two reference standards are being used, the DMM and a current shunt.
In the uncertainty calculation both the imported uncertainty and stability data for both references must be included in the uncertainty template.

The current shunt must be added to the Traceable reference standards list in ProSet, and the imported uncertainty & stability (drift between calibrations) data must be entered. The line number of the shunt in the list will be used to identify this reference in the uncertainty template.

The imported & stability for the system DMM measuring the voltage will automatically be in the uncertainty template, greyed out, values will be calculated by Procal at run time. The imported and stability contributions for the shunt must be added to the template.

The shunt imported and stability can be entered in the limit value column as

Imported uncertainty: EI 'line number of the reference'
Stability ES 'line number of the reference'

For example if the shunt was at line number 23 in the ProSet list of traceable instruments,

EI23 - For the imported uncertainty for the standard in line 23 in ProSet

ES23 - For the stability for the standard in line 23 in Proset.

See example below:

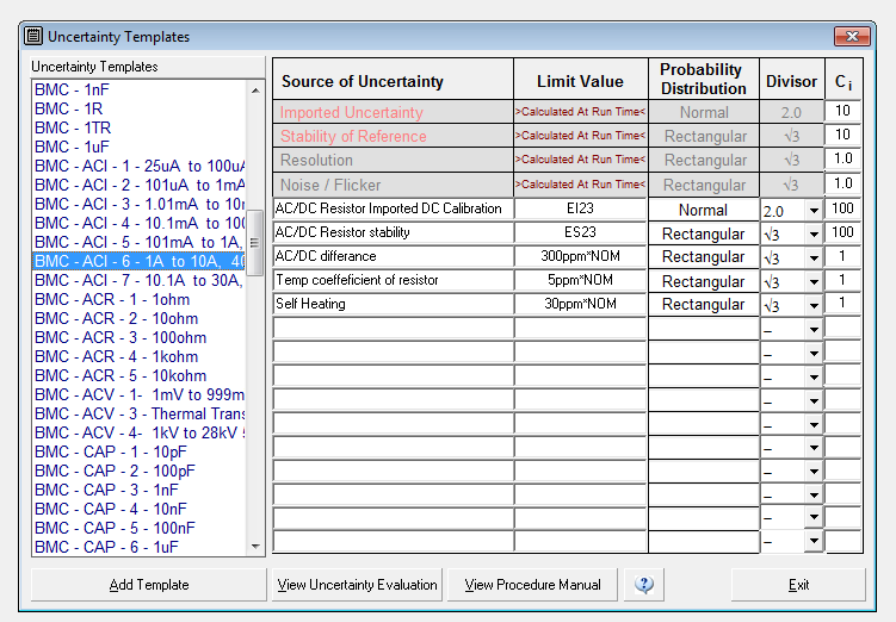

Figure 3 - ProSet Uncertainty Template

Contribution dependant on the nominal test value.

Some contributions will depend on the test value. These can be entered in the limit value column, for example 30ppm*NOM.

Create/Edit/View Uncertainty Contribution Word Document

At some future time it may be necessary to explain or justify in more detail where and why the contributions have been added to this measurement type. The button on this screen creates/opens a word document linked to this template, which can be used to record the data and details behind each contribution

Linking to a Procedure Manual

To link a procedure manual to ProCal, create a word document/pdf file named “Procedure Manual” to “C:/ProCal/Calibration Methods”

You can obtain an example Procedure Manual by contacting Transmille.

Using ProCal to create a BMC (Best Measurement Capability) Schedule:

A ProCal procedure can be written for the purpose only of using ProCal to calculate uncertainties. This procedure will never actually be used to calibrate a real instrument, or produce a calibration certificate.

Instead of a calibration certificate, a crystal report written to produce an uncertainty schedule can be selected in the procedure.

This procedure can then be run in ProCal, with the nominal value for each test point being entered. The 'uncertainty calculation' can be printed for each value. This is a very fast and easy way to produce an uncertainty budget. Different 'BMC' procedures can be written for example for a 3010 multiproduct calibrator, and for the 3200 electrical test calibrator. These BMC procedures along with the procedure manual are available from Transmille.

Software Validation:

Most accreditation authorities accept that the computer and propriety software are usually sound on the maths. The problems usually are with installation and default data. For example if the time/date on the PC is incorrect the date will almost certainly be incorrect on the calibration.

With ProCal there is a great deal of data, mostly to do with the reference standards which must not only be entered correctly, but also kept up to date.

The BMC procedure makes it very easy to compare a previously run BMC with a new run. Any errors in data will show as a different uncertainty. As a refinement it is a good idea to set the accuracy limits in the BMC procedure to the calculated uncertainties, and then if anything changes ProCal will display a failed test.

Printing Uncertainties on certificates generated by crystal reports:

Using crystal reports, any format of certificate can be generated.

The uncertainties stored in the database can be printed along side the measurement result.

Explanation of terms used

Imported Uncertainty:

This is the uncertainty of calibration from the laboratory that calibrated the reference standard used in the calibration. It can be found on the certificate issued for that standard. Note the imported uncertainty can change from year to year even from the same laboratory.

Reference Standard:

The instrument used by the laboratory to perform the calibration on the DUT, also providing the through which traceability to the nation standards is shown. Note in many measurements there may be several reference standards used. For example measuring current using a shunt resistor, where both the resistor and the voltage measuring device are reference standards.

Reference Stability:

Stability is the change in a references value with time, some times referred to as drift between calibrations. This in some cases can be predicted from history and corrected for. It is often normal to use the manufacturers 1 year specification for this figure.

Calibration Referenced to calibration standards:

Used in manufacture's specification to specify the performance of the instrument alone, and therefore not including any errors or uncertainty from the adjustment/calibration of the instrument by a laboratory.

Digits, Counts or LSD: Least significant digit:

Used mainly in specification of digital multimeters to specify the error in reading; usually added to a % of reading. For example a DMM display may show 1.000Volt. The specification could be 0.1% + 2 digits. This means 0.1% of the value on the display + 3mV, being 3 digits in the last digit.