Understanding Specifications.

The specifications for multi range instruments have to often cover a large number of ranges, operating conditions, environmental factors and the instruments performance over time (ageing). Manufacturers use different terminology to describe the same thing which can make the initial look at specifications confusing.

This document is aimed at helping the reader understand specifications

The Components of Accuracy

Firstly when using any instrument or making any measurement there are always two main components which make up the accuracy :

- **Imported uncertainty**
  The accuracy of the calibration performed when the instrument was certified
- **Change (or drift) in the instrument since it was calibrated**.

It is important to know and understand these two terms and the difference they make, both in terms of accuracy and also economically. It would be possible, for example, to achieve the same accuracy by using a very stable standard and having it calibrated very infrequently or by using a less stable standard and calibrating it more frequently. The users requirements will determine which is the correct solution, even the availability of local calibration services should be considered, a less accurate calibration performed locally may only slightly change the overall uncertainties.

Total Uncertainty Vs Relative to calibration

Transmille publish both the *'1 year total uncertainty specification (95%)'* which includes the calibration based on calibration performed by Transmille's own UKAS laboratory and also the *'Relative to Calibration standards*' (the performance of the instrument only) specification - this is for users who wish to select their own calibration source.

To get the total uncertainty when using the *'Relative to Calibration Standards'* specifications the <u>uncertainty of the laboratory which performed the calibration</u> must also be taken into account. A spread sheet of uncertainty calculations is available from Transmille for this.

The reason Transmille (and other manufacturers) separate the instruments performance from the calibration / traceability source is to allow the user the freedom to choose the most suitable calibration laboratory / traceability for themselves. This is only possibly when the performance of the instrument by itself is known. Obviously a laboratory with low uncertainties will be able to calibrate the instrument more accurately than a laboratory with larger uncertainties but in practice there are many factors which will decide the choice of calibration laboratory such as location, cost etc which may be more important than best accuracy.

Calibration Interval

Specifications apply for a given period of time since the instrument was last adjusted to nominal. This is because almost all electronic instruments and standards are effected by ageing and change with time, put simply the longer the period the greater the change, or drift, from the calibrated value. Transmille gives specifications for calibration periods up to 2 years and when calculating error (unless correcting for drift/ageing) the time since last calibrated must be known so as to use the correct specifications.

Calculating Errors from Specifications

Specifications which cover a range of outputs, e.g. 0 to 20 volts are often written using several terms which need to be combined to produce the actual error at any specific output. The most common terms (and those used by Transmille) are :

- **Percentage (or ppm) of the output set**
- **Percentage (or ppm) of the Full Scale of the Range selected**
- **Zero term**

Note : For a DMM the 'of full scale or range' may be given as a number of digits or counts

Error = ppm of setting + ppm of range + zero

ppm : Parts per million - for larger values % is used, note 100ppm = 0.01%

'of setting' : The output value.

'of range' : The maximum value available on a range.

Zero : Expressed as absolute units (uV,nA etc) or a number of digits.

Adding these terms together arithmetically (100% confidence level) gives the total error due to the instrument at that setting.

Calculation Examples for 2006A calibrator.

Example 1
Error at 100mV (Published 1 year spec = 8ppm Range + 2ppm Setting + 2uV)

8ppm of 100mV = 0.8uV
2ppm of Rng (200mV) = 0.4uV
zero allowance = 2.0uV
Total Error
of calibrator = 3.2uV

This must be combined with the calibration laboratory's uncertainties (which will be on the calibration certificate) to obtain the total error. Transmille's UKAS Laboratory uncertainties from 0 to 1.1Volts are 2.2ppm + 0.3uV.

Example 2
Error at 100V (Published 1 year spec = 6ppm Range + 2ppm Setting + 2uV)

6ppm of 100V = 0.6mV
2ppm of Rng (200mV) = 0.4mV
zero allowance = 0.002mV
Zero term is insignificant
at this level
Total Error
of calibrator = 1.2mV

This must be combined with the calibration laboratory's uncertainties which will be on the calibration certificate to obtain the total error (Transmille's UKAS Laboratory uncertainties from 1.1 to 1000Volts are 3.3ppm)

It is also important when verifying the calibrators performance to take into account the accuracy/uncertainty of the measuring system used and other possible sources of error such as lead, earthing, loading and thermal errors etc and how the measuring system itself was zeroed. The calibration temperature, warm up time etc. should also be considered.

IMPORTANT NOTE

To obtain the accuracy of your calibrator, the *specifications of the calibrator* and the *uncertainties of the laboratory which calibrated the calibrator* must be combined as per the *UKAS M3003* document. A spreadsheet is available from Transmille to allow this to be calculated automatically if the calibrator has been calibrated at the Transmille UKAS laboratory.

Additional Documents

- 2006A / 2041A / 2050 Extended Specifications
- 2000 Brochure
- Expanding Workload Coverage With Calibration Adapters For The 2000 Series Calibrators

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