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DIGITAL MULTIMETER APPLICATIONS (3)

RATIOMETRIC MEASUREMENT

Datron Selfcal (1281 and 1271), Autocal (1061A and 1062) and 1362 VXI card Digital Multimeters (DMM's), have the most comprehensive ratiometric facility available in a DMM. The models listed can provide for DC/DC, AC/DC (transfer), DC/AC and Ω/Ω ratio measurement, with a full function choice of reference input in the range 0 - 250V rms, compared to most competitive products which can only provide a DCV reference over a limited range.

The question is frequently asked what is the Ratio Accuracy? The data sheet and User's Handbook state:

+/- (net ChA accuracy + net ChB accuracy)

This is very much a "worst case" statement, presuming as it does that the two individual measurements will each use up the full specification. In practice an empirical calculation, based on a number of reasonable assumptions, can be made to determine the "real" uncertainty. This real uncertainty will be dependent on the relationship of the signals being compared, and on the result required.

1. Where the result required is a relative rather than an absolute measurement, then a short term (24 hour) specification can be applied, subject to a number of other considerations:

2. If the two signals being compared share the same function, then the following assumptions could also apply:

3. Where the voltages to be compared are within the same range, then the same reading error will apply to both measurements, and "relatively," the ppm/reading can be ignored, and only the linearity error (ppm/full scale) need be applied.

4. Further, if the signals are of near equal amplitude (+/- 10%) the linearity (ppm/full scale) can also be ignored.

5. Equally in an AC/AC ratio, if the frequencies are the same, then the flatness errors can be ignored.

6. Indeed, where the signals and conditions are identical, then the only contribution to uncertainty would be the DMM's short term noise.

If however the user wishes to compare ratio measurements over a period of time, then even where the five conditions above (2,3,4,5 & 6) are met, and the temperature and humidity are the same, at least one ppm/reading for the appropriate timescale must be applied.

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TYPICAL EXAMPLE

An example calculation would be an AC/DC transfer measurement in order to set the accuracy of an AC calibrator, using the ratio and DC coupled AC facilities of a Datron Selfcal 1281 Digital Multimeter.

a) Absolute traceability for voltage level or amplitude would be established through the calibration of the DC Calibrator.

b) The signals will be of equal amplitude.

c) The measurement requirement from the 1281 is a short term relative one.

Where (a) to (c) above apply, then the 1281 uncertainties that need to be taken into account are as follows:

(i) Both signals will share the same function, therefore the basic ppm/R will not apply, but the AC/DC difference error will, ie the additional DC coupled uncertainty of +/-(50 ppm/R + 20 ppm/FS + 20μV).

(ii) In that the signals are of the same amplitude, the Full Scale (linearity) errors can be ignored.

(iii) The uncertainties due to frequency response (flatness errors) need to be taken into account. These can be calculated from the difference between the "Wideband" and "Spot" frequency specifications: +/- (20 ppm/R + 5 ppm/FS) in the frequency range 2 KHz to 10 KHz, on the 1 to 100V ranges (Enhanced 1 year .specification).

Accepting the above assumptions, the total AC/DC transfer error, using a Datron 1281 in the Ratio mode with a function selection of DC coupled AC, will be:

+/- (70 ppm/R + 25 ppm/FS + 20 μV) = +/- 122 ppm at a 10 Volt level

Of course where the 1281 was characterized at the frequencies of interest to the user, the transfer accuracy would be improved to:

+/- (50 ppm/R + 20 ppm/FS + 20μV) = +/- 92 ppm at a 10 Volt level & at a spot frequency

SUMMARY

In summary therefore, the "real" ratio uncertainty depends on the relationship of the two signals being compared, on the repeatability of the conditions, and on the time-scale over which the comparisons are to be made.

Calculated empirically,the uncertainty will fall between a worst case +/-(net ChA accuracy + net ChB accuracy), and a best equal to the short term noise of the DMM.

Again please do note that the Datron DMM range offer the best Ratio facility available in a contemporary DMM.