

Historical Progress in Accredited DC/LF Electrical Measurement Capabilities – 1966-2007.

By

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Since the establishment of formal Measurement Accreditation in 1966 there has been a continual demand from UKAS accredited laboratories to improve their capabilities, especially in the DC/LF field of measurement. Whilst DC/LF laboratories have necessarily enhanced their overall measurement performance over the years in response to advancements in both technology and system management, the continual process of increasing scope and reducing uncertainties of measurement has been most notable for DC/LF Voltage and Current parameters of measurement.

The advancement of technology in the sixties, seventies, eighties and nineties and the Development of Electrical Instrumentation based on the advancement in technology have made this progress possible.

The most significant advances in Electrical Instrumentation have been with both passive devices and active devices. In the passive field, especially with resistance standards, it has been the construction of the standard and its environmental enclosure that has changed most. However, for active devices new standards have been produced for nearly all the electrical parameters of measurement and some of these are listed below: -

Zener reference standards, Long-scale digital multi-meters, Multi-function calibrators, Multi-function transfer standards, AC voltage standards, Bridges, Comparators, Phase meters, Power meters, Frequency standards and computerised support systems for more effective and efficient management of the measurement process.

These devices are a major improvement over their predecessors and provide a far more detailed coverage of each measurement parameter. They are also more stable, more robust, more transportable, and generally more user friendly, all of which contribute to faster service.

In the early sixties most electrical calibration reference standards used in calibration laboratories comprised of Thermocouples, Thermal Standards, Electrostatic Voltmeters, Electrostatic Powermeters, DC and AC Potentiometers, Standard Cells and Voltage and Current Ratio Devices. Best Measurement Capabilities (BMC) at that time would have been perhaps ± 50 ppm for DC Voltage and ± 100 ppm for AC Voltage. The stability and distortion of supplies was a major problem and calibration took much longer than today.

It was not until the late sixties and early seventies that Digital Voltmeters, AC/DC Transfer Devices, and Calibrators started to appear. Digital Voltmeters gave the extra resolution; Calibrators gave the much needed improved stability and low distortion. While the AC/DC Transfer devices such as the Fluke 540B made it possible for assessors to recommend a BMC of ± 50 ppm for Voltage AC/DC Transfer Measurement at one major laboratory. However, it should be noted that this was only made possible by a special calibration of the device by NPL. For other voltage and current ranges BMC started to improve and by the late seventies and early eighties accredited DC Voltage claims were generally within ± 10 ppm, with $\pm 2 \mu\text{V}$ for Standard Cells.

There were a number of accredited laboratories in the mid-eighties seeking the prestigious accreditation of $\pm 1 \mu\text{V}$ for Standard Cells. To help resolve this issue UKAS formed a measurement committee to discuss the accreditation of standard cells and the problem of producing an uncertainty budget to support the claim of $\pm 1 \mu\text{V}$. The use of measurement

audits had shown that accredited laboratories could achieve a measurement capability of $\pm 1 \mu\text{V}$, although initially it was difficult to produce an uncertainty budget to support it. Eventually this was achieved and two laboratories were granted this level of accreditation.

In more recent times the Zener Reference Standard, with its improved stability and reliability, has replaced the Standard Cell as the main Laboratory DC Voltage Standard for fixed values of voltage at 1.0 V, 1.018 V and 10.0 V. In addition the Zener Reference Standard furthered the measurement evolution making it possible to grant an accredited DC Voltage uncertainty of measurement of $\pm 0.1 \mu\text{V}$ at the 1 V and 1.018 V output levels, with a better uncertainty of measurement also available at the 10 V output level. In the mid-nineties the INTA Laboratory in Madrid was part of NAMAS/UKAS accreditation system and received an accreditation for 10 V DC of $\pm 0.05 \mu\text{V}$, and this was based on their Josephson-Junction System.

From about the mid-1960 and for the next 15 years the most suitable instrument for AC voltage was an AC-DC thermal transfer reference standard. From the 1980s onwards, the market demands of the defence industry led to the development of improved AC voltage measurement standards. This technology has been developed to the extent that these instruments can now provide a high resolution AC voltage reading without the need for repetitive AC/DC transfer. Moreover, the measurement can be made over a very wide dynamic range from a few milli-volts up to a kilovolt at frequencies up to 30 MHz. The main advantage however, is that there is now a standard which can measure AC voltage directly to a very high accuracy and accreditation has been granted within $\pm 20\text{ppm}$.

Other exciting areas for development have been made in phase measurement accreditation $\pm 0.01^\circ\text{C}$, high resistance measurement $\pm 1\%$ at 1 Tera-ohm and frequency measurement ± 5 parts in 10^{12} at 10 MHz. Before accreditation could be granted in these areas UKAS assessors required laboratories to undertake considerable time consuming technical investigations to prove their claims.

3. Conclusions

This paper has discussed some of the improvements in Best Measurement Capabilities made in the DC and LF Electrical calibration field by accredited laboratories since the inception of the BCS/NAMAS/ UKAS accreditation system in 1966. At times it has been a very challenging task for accredited laboratories and UKAS, but the improvements made have always been worth while. It has meant that UKAS laboratories can provide accredited measurements to satisfy most of their customer's specification requirements.

Note: This paper has been written based on the achievements and progress of those UKAS accredited laboratories outside of the National Physical Laboratory NPL Teddington. However, it is instructive to study the UKAS accreditation schedule for NPL, which is surely the best list of formally accredited measurement capabilities in the world.

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