



Science Education and Technology Division

Professional Group S4 (Fundamental aspects of measurement)
Evening Lecture:

**"Improvements to
traceability for impedance
measurements at RF in the
UK"**

by Mr N M Ridler and Mr J C Medley (NPL)

IEE, Savoy Place, London on Thursday, 13 June 1996 at 5.30 pm, tea at 5 pm

Admission is free and non-members are welcome
For further information, please phone 0171 240 1871 x2205/2206

Improvements to traceability for impedance measurements at RF in the UK

Nick M Ridler* and John C Medley (National Physical Laboratory)

Traceability to national measurement standards for electrical impedance at radio frequencies has historically been an area where the customer has been less than well-served. Before 1991, traceability was only available at three frequencies, 15 MHz, 100 MHz and 200 MHz, and was extremely time consuming in its implementation.

The work presented here represents a sustained and successful effort to improve dramatically the traceability for this type of measurement. These improvements can be summarised as follows:

- (i) A broadband capability - Traceability is now available at any frequency between 100 kHz and 8.5 GHz;
- (ii) Improved measurement quality - Measurement uncertainties, in terms of complex reflection coefficient magnitude (linear quantities), of 0.0008 up to 300 MHz and 0.004 at higher frequencies, are typical;
- (iii) Cost reduction - The use of automated computer-controlled equipment has cut measurement time considerably, thus reducing the cost per calibration point;
- (iv) Technological developments - The hardware and software that has been developed can be transferred readily to other measurement laboratories without degradation of performance.

This work has relied on a number of significant developments:

1 *Primary impedance standard*

A new primary standard for impedance measurement, the calculable offset open-circuit, has been introduced. This device is suitable for use as a standard over the entire frequency range of the coaxial line. Offset open-circuits were initially developed in the 14 mm 50 ohm coaxial line size used by top echelon measurement laboratories. More recent work has transferred this technology to the 7 mm 50 ohm line size used extensively by commercial measurement laboratories.

2 *National standard impedance measuring instruments*

Two new national standard measuring instruments for impedance measurements have been developed, one operating at VHF and the other at UHF. Both instruments are based on the six-port technique, since this technique is well-suited for the design principles of primary measuring instruments.

3 *Generalised uncertainty evaluation technique*

An uncertainty evaluation technique for generalised impedance measuring instruments has been introduced to verify the accuracy of the measurements. The technique has been used to assess the accuracy of the primary measurement systems mentioned above, as well as the commercially available vector network analysers which are now used for cost-effective customer measurements.

* Mr Ridler is employed by Assessment Services Ltd and works under contract to NPL.

4 *Low frequency measurement capability*

A new measurement capability for lower RF (below 50 MHz) has been established. A near-matched load, characterised using an equivalent circuit derived from measurements at higher frequencies, is used as one of the standards. The new capability was verified initially in the 14 mm line size by comparison with the earlier, manual, bridge techniques. More recent work has transferred the capability to the more popular 7 mm line size.

5 *Transfer of technology*

The information necessary to implement these techniques has been disseminated to top UK and European laboratories via two short courses, the supply of the open-circuit standards from NPL, and software which performs the uncertainty assessment.

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CONTINUING PROFESSIONAL DEVELOPMENT

This Lecture qualifies as a CPD activity, and its unit value is $\frac{3}{4}T$.