Comparing Measurements of Millimetre-wave Power in W-band Rectangular Waveguide

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Summary—The UK’s National Physical Laboratory (NPL) is responsible for developing and maintaining the UK’s most accurate standards of measurement. For high frequency power measurement, NPL provides the UK’s contribution to the Calibration and Measurement Capabilities (CMCs) listed in the International Bureau of Weights and Measures (BIPM) key comparison database (KCDB) [1]. This demonstrates the international equivalence of these measurements via the International Committee of Weights and Measures (CIPM) Mutual Recognition Arrangement (MRA) [2]. At present, the KCDB only shows power measurements up to 110 GHz. No traceability in the UK exists for power measurements above this frequency.

However, a European project, entitled “TEMMT” [3], is establishing a programme of work to extend this traceability to higher millimeter-wave frequencies, and above. This programme of work is based around using a commercially available power meter [4], as shown in Fig 1. However, in order to demonstrate the suitability of this power meter as a standard at frequencies above 110 GHz, a comparison is first needed with the existing primary power measurement standards that are used at frequencies below 110 GHz. The UK’s primary standards for power measurement at millimetre-wave frequencies [5] are used for this purpose – specifically, a microcalorimeter operating at W-band (75 GHz to 110 GHz), as shown in Fig 2. This calorimeter is used to provide traceability to the international system of units (SI) for power measurements in rectangular waveguide. This calorimeter has previously been verified using free space measurement techniques [6].

This paper describes the comparison, between the commercial power meter and the NPL microcalorimeter using a direct comparison transfer method and presents some initial results obtained using these measurement systems. Fig. 3 shows results for the expected indicated power for a fixed incident power, for this commercial power meter and a conventional thermistor. This is expected to be different for each based on their respective reflection coefficients and efficiencies. In use a correction would then be applied to correct for these. The degree of equivalence between the two sets of measurements can then be investigated and used as a means of demonstrating the overall performance of the commercial power measurement system (with respect to the UK primary national standard microcalorimeter system).

Once the commercial power measurement system has been verified at W-band, its performance will be further evaluated in other waveguide bands used for higher millimetre-wave frequencies, and above, where currently no other reference standards for power measurements exist. This will then provide the first reference for power measurement traceability in the UK, at these millimetre- and submillimetre-wave frequencies.

REFERENCES

Fig. 1. Photograph showing the commercial power meter used for power measurement at millimetre-wave frequencies and above.

Fig. 2. Photograph showing NPL’s W-band microcalorimeter setup in a Waterbath, used as the UK’s primary reference standard.

Fig. 3. Plots of expected uncorrected indicated power for a nominal 5mW incident power for the commercial power meter (blue) and a traditional thermistor style sensor (orange).