Traceable Power standards above 110 GHz – An Investigation at the National Physical Laboratory

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Since the late 1960s NPL has been involved with realising the primary Guided Wave parameters:

**Impedance** – from dimensional metrology

**Power** - thermal / DC metrology

**Noise** - thermal metrology

**Attenuation** – DC and Low frequency metrology
Currently the power coverage extends from the kHz region to 110 GHz in coaxial and rectangular waveguide transmission lines.

To meet new requirements, we want to extend upwards in frequency.
What do we have now?

- We have both coaxial and waveguide capability
  - ‘Classic’ - thermal / DC metrology primary standards
  - Photo Acoustic power meter
  - Waveguide Multistate Reflectometers and coaxial power splitter transfer instruments
Micro - calorimeter
Waterbath
Multistate reflectometer – transfer instrument
Photo acoustic power meter
Extending beyond 110 GHz

• Can’t we just make smaller versions of what we already have?

• No - commercial thermistor sensors are not available

• Low source power and high line losses means we need more sensitivity

• So we will try and make a thermistor based sensor ourselves
• Why a thermistor sensor?

• A DC substitution device – hence suitable for calorimetry

• Inherently linear power response – a useful characteristic for instrumentation

• Should be easy to model
Initial Plans - sensor

- Investigate building our own thermistor sensor
- Based on a ‘dead’ WG27 Hughes device
- Evaluate its performance with our current equipment
- Scale to WG29 – build and test
Dismantled WG27 sensor
Dismantled WG27 sensor
Sensor considerations

- **Dimensions**
  
  - WG27 2.4 x 1.3 mm
  
  - WG 29 1.7 x 0.82 mm
  
  - Thermistor bead in our ‘dead’ sensor is approx 0.14 mm diameter
  
  - We have found a source of thermistors approx 0.25 mm diameter
    - A little too large?
Some thermistor beads
Sensor considerations

• Good match – to optimally couple available power
  – Possible we compromise on bandwidth

• Select thermistor bead for sensitivity (low thermal mass, R-T performance)

• Improved electronics - low noise self balancing bridge

• Lower the thermal mass by removing excess metal – suitable for a microcalorimeter

• Temperature stability – a thermal enclosure or a compensation thermistor
We have recently built a WG 27 dual load microcalorimeter for a client.

- It has potential to develop into a higher frequency instrument.
- 30% faster thermal response than our corresponding single load calorimeter.
- Potential to make the thermopile more sensitive.
- Short thermally isolating input lines (lower loss for same isolation).

NPL logo
Dual load microcalorimeter
And transfer instruments

• A Multistate Reflectometer
• Has the ability to compare sensor efficiencies
• And measure single port reflection coefficient
• Can be physically small – good for line loss
Multistate Reflectometer mono-block dual coupler
• This is intended to be the start of a larger coordinated programme for 2009 - 2012

• We are always looking for partners!

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