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Federal Institute of Metrology METAS

Power Sensor Calibration Using a VNA

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Outline

RF Power at METAS

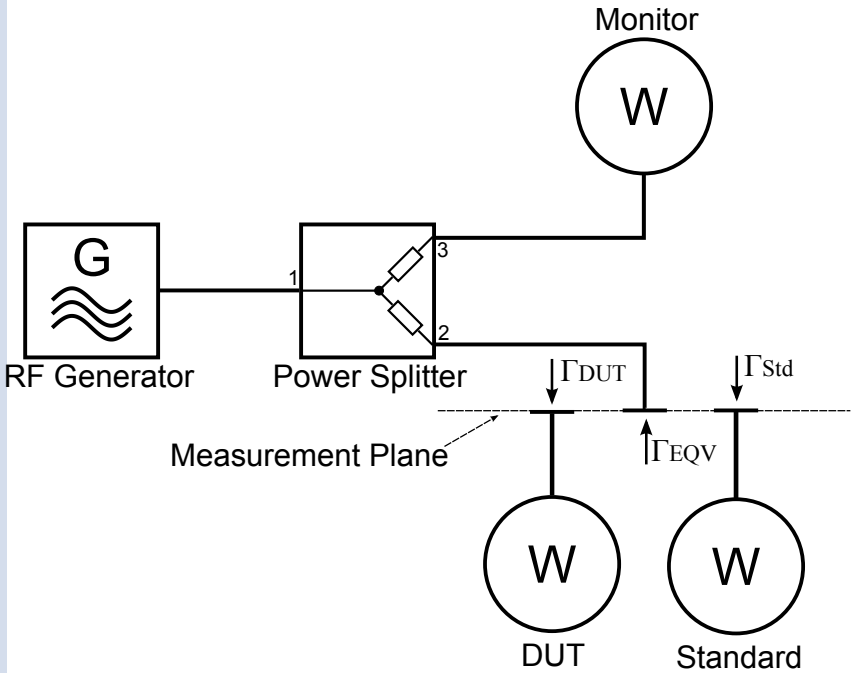
Direct Comparison - Classic

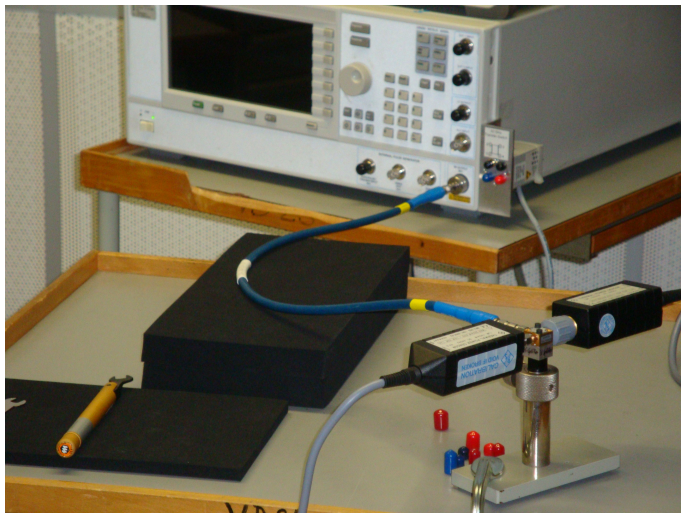
Direct Comparison - VNA

RF Power at METAS

- Frequency range: DC to 67 GHz (110 GHz)
- Power range: 1 μW to 10 mW
- Connector families: BNC, Type-N, 3.5 mm, 2.92 mm, 2.4 mm, 1.85 mm, (1.00 mm)
- Calibration objects: Power Sensors, Voltage Sensors, Spectrum Analyzers, Oscilloscopes, Generators
- Traceable to primary standards at PTB, NPL and NIST
- Low addidional uncertainties thanks to well characterized components (s-parameters) and direct comparison system.

Direct Comparison - Classic

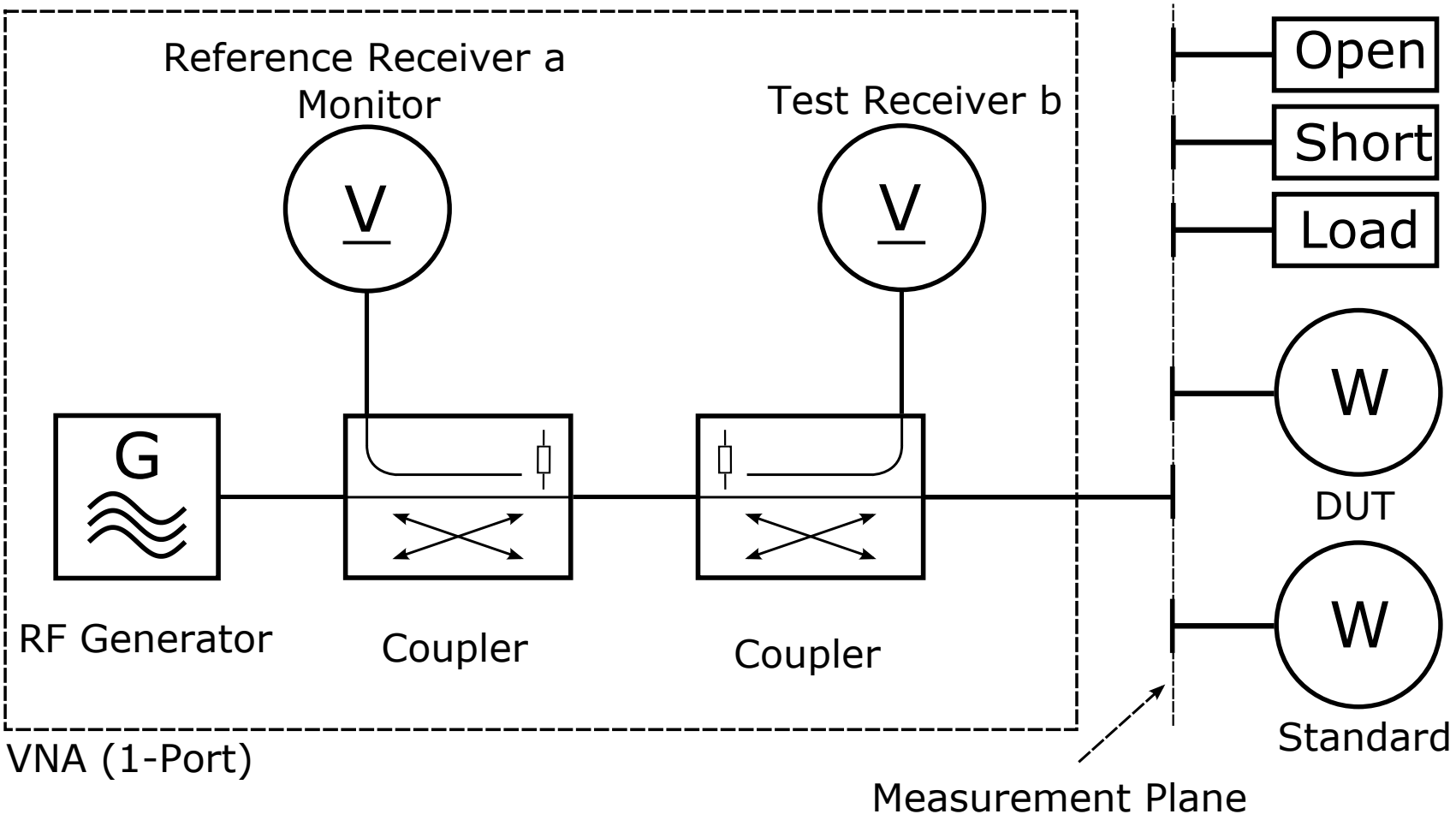




$$CF_{DUT} = CF_{Std} \cdot \frac{P_{DUT}}{P_{MON_{DUT}}} \cdot \frac{P_{MON_{Std}}}{P_{Std}} \cdot \frac{|1 - \Gamma_{DUT} \cdot \Gamma_{EQV}|^2}{|1 - \Gamma_{Std} \cdot \Gamma_{EQV}|^2} \quad (1)$$

$$\Gamma_{EQV_{Port_2}} = S_{22} - S_{S21} \cdot \frac{S_{32}}{S_{31}} \quad (2)$$

Direct Comparison - VNA



Calculation of the Calibration Factor

$$P_{Incident_{Std}} = \frac{P_{Indicated_{Std}}}{CF_{Std}} \quad (3)$$

$$P_{Z0_{VNA_{Std}}} = P_{Incident_{Std}} \cdot |1 - \Gamma_{Std} \cdot \Gamma_{EQV}|^2 \quad (4)$$

$$CF_{VNA} = \frac{P_{Indicated_{VNA_{Std}}}}{P_{Z0_{VNA_{Std}}}} \quad (5)$$

$$P_{Z0_{VNA_{DUT}}} = \frac{P_{Indicated_{VNA_{DUT}}}}{CF_{VNA}} \quad (6)$$

$$P_{Incident_{DUT}} = \frac{P_{Z0_{VNA_{DUT}}}}{|1 - \Gamma_{DUT} \cdot \Gamma_{EQV}|^2} \quad (7)$$

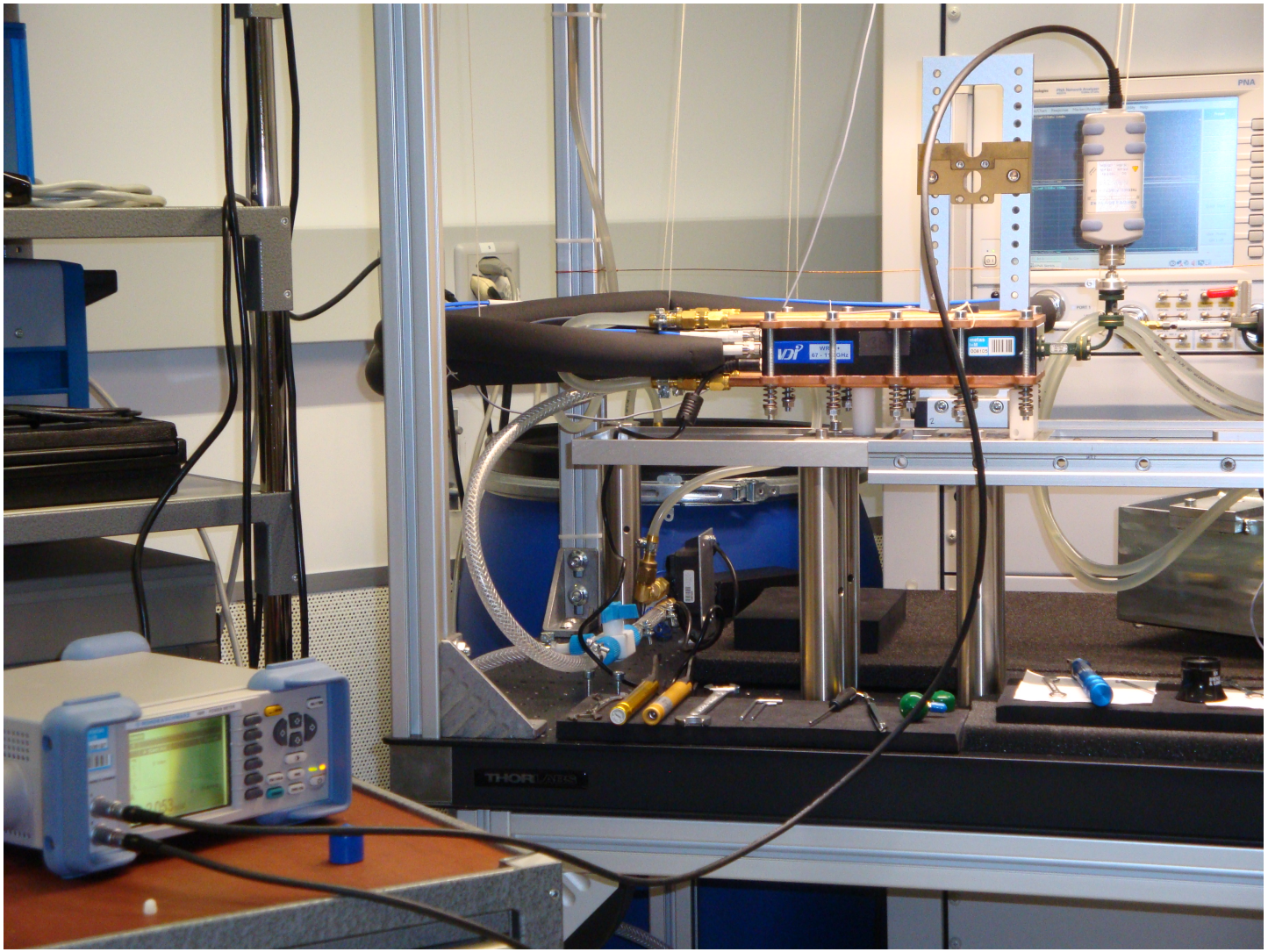
$$CF_{DUT} = \frac{P_{Indicated_{DUT}}}{P_{Incident_{DUT}}} \quad (8)$$

- Γ_{EQV} is the source match of the VNA and is a result of the one-port VNA calibration
- $P_{Indicated_{VNA}} = |V_{Indicated_{VNA}}|^2$ is the unscaled indicated power level at the reference receiver
- Same equation for Classic and VNA

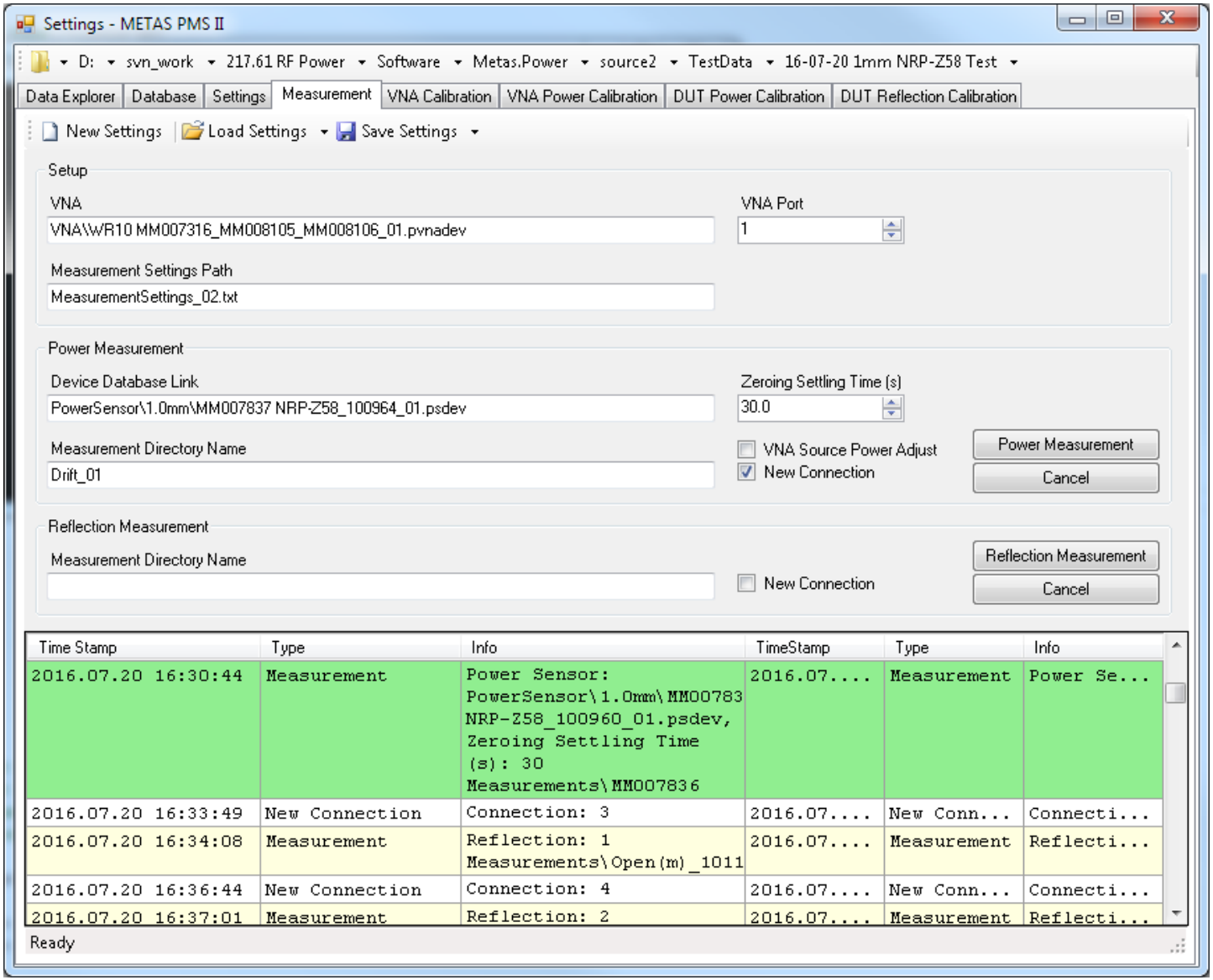
Pros and Cons

- + VNA replaces generator, splitter and monitor sensor (less equipment).
- + Reflexion and calibration factor is measured at the same time (more efficient).
- + No need to characterize a splitter/coupler - source match is given through one-port calibration.
- - VNA can only be used as short-time transfer-standard (additional verification necessary).
- - limited power level range
- - VNA source is less clean (harmonics, spurs).

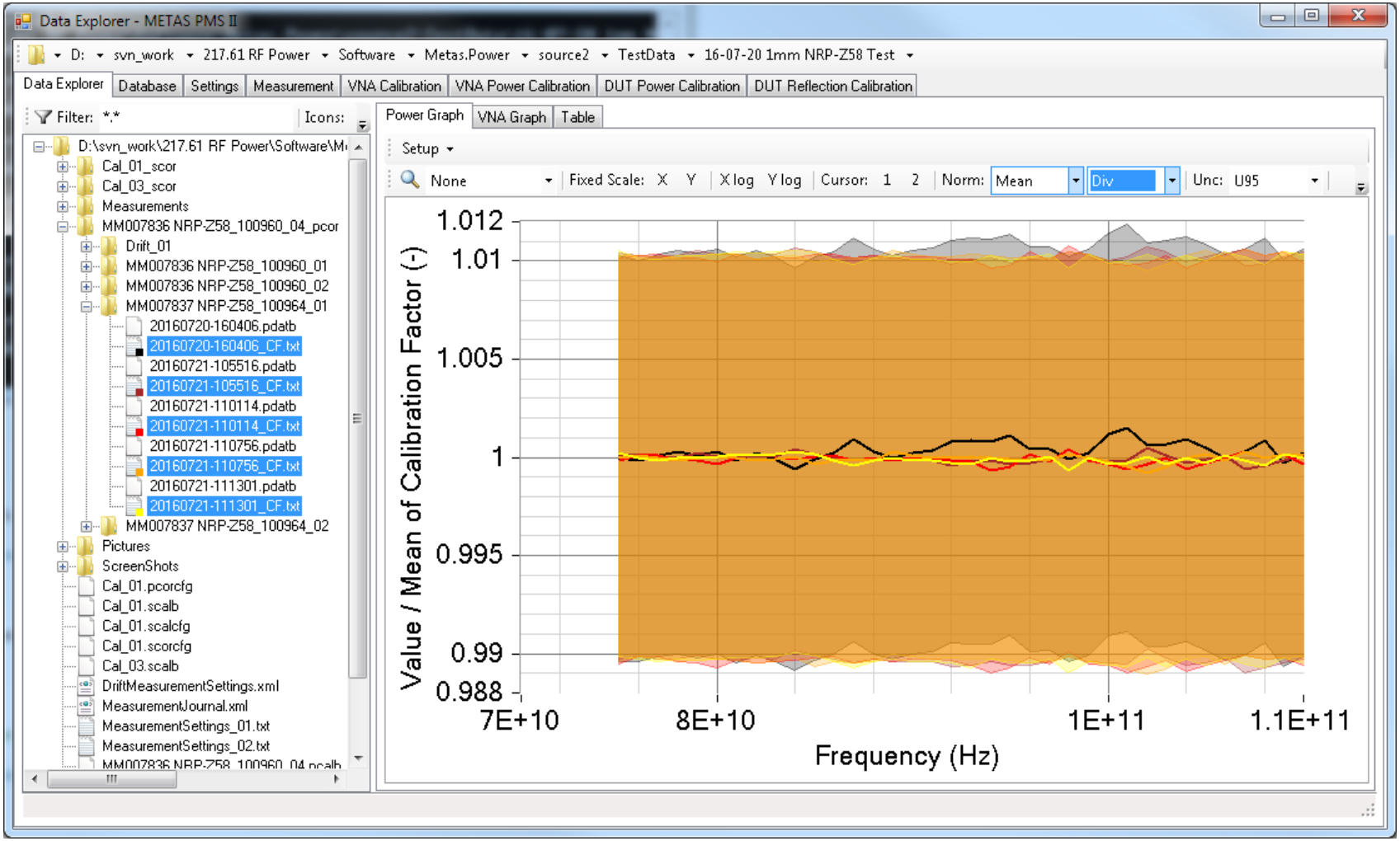
1-mm Power Sensor Calibration Using a VNA



METAS Power Measurement Software



METAS Power Measurement Software



METAS PMS II uses METAS UncLib and is compatible to METAS VNA Tools II.