A Comparison of Power Measurements from 100 GHz to 600 GHz

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Introduction

The accurate measurement of absolute power at millimeter and submillimeter wavelengths is difficult, and different power meters can give substantially different results, thus complicating comparisons between measurements by different groups. This paper will present a comparison of measurements done using a variety of commonly used power meters over a frequency range from 100 GHz to 500 GHz.

Measurement

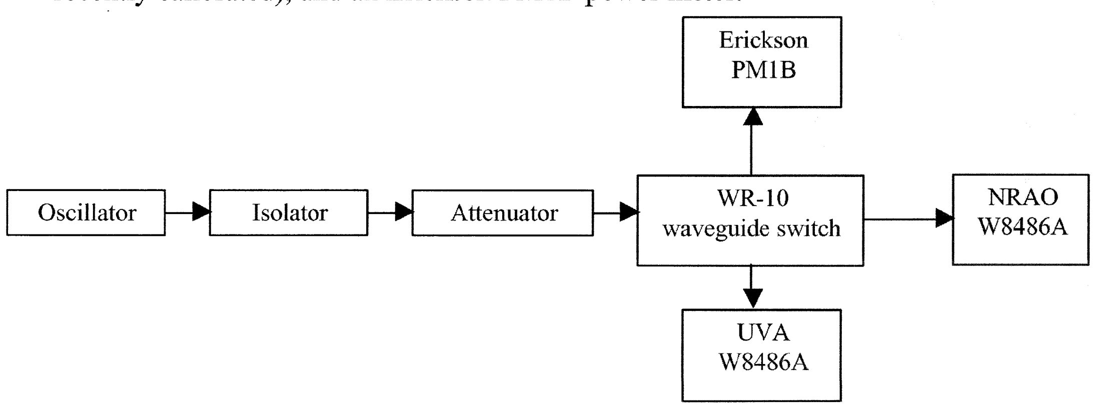
In the WR-10 frequency range we compare power measurements using two HP-437B power meters with W8486A diode power sensors [1], [2], and an Erickson PM1B calorimeter power meter [3]. Each of these meters is used to measure the power output from a Gunn oscillator.

In the WR-8 frequency band we compare an Erickson PM1B power meter with two Anritsu ML83A power meters with WR-8 thermistor power sensors. The power source is a WR-8 Gunn oscillator.

In the WR-3 frequency range, we compare the measurement results of the Anritsu ML83A power meter with both WR-3 and WR-8 power sensors and the Erickson PM1B power meter. The power source is a WR-10 to WR-3 frequency tripler. Finally, some power measurement results above the WR-3 frequency band are presented.

1.WR-10 measurement

In WR-10 frequency band, a Carlstrom Gunn oscillator is measured using a variety of power meters: an HP W8486A power sensor (which is borrowed from NRAO and is calibrated and traceable to NIST), an HP W8486A power sensor (which has not been recently calibrated), and an Erickson PM1B power meter.



The following graph shows the measurement results. Figure 1 shows the power measured using the various meters and the calibration factors for the Erickson PM1B power meter and the UVA HP W8486A sensor.

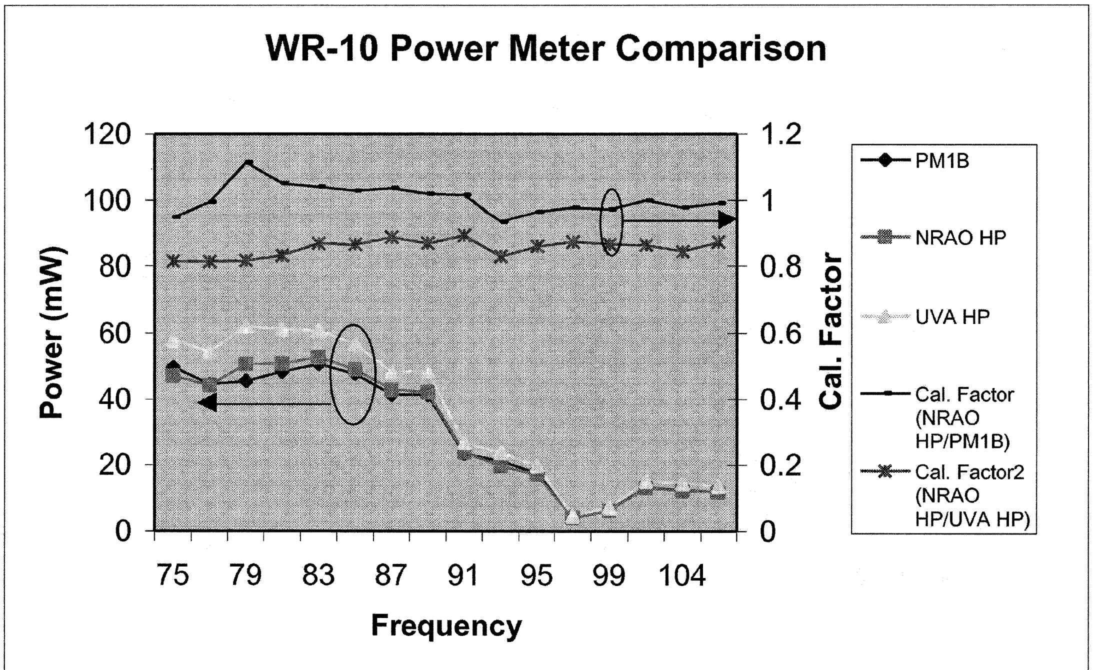


Figure 1

From Figure 1, we can observe that the reading of Erickson PM1B is quite consistent with that of NRAO HP power meter, with is calibrated and traceable to NIST. The reading of UVA HP power meter has a similar shape to that of NRAO HP power meter, but shifts to a higher level. We believe the reason is that this meter has not been recently calibrated.

We also checked the power meters' performance at lower power levels. The HP power meters can automatically select scale range. The Erickson PM1B needs to be set manually. The results are plotted in Figure 2. From Figure 2, we can observe similar behavior as we saw at higher power level. This means all power meters perform consistently on different power levels.

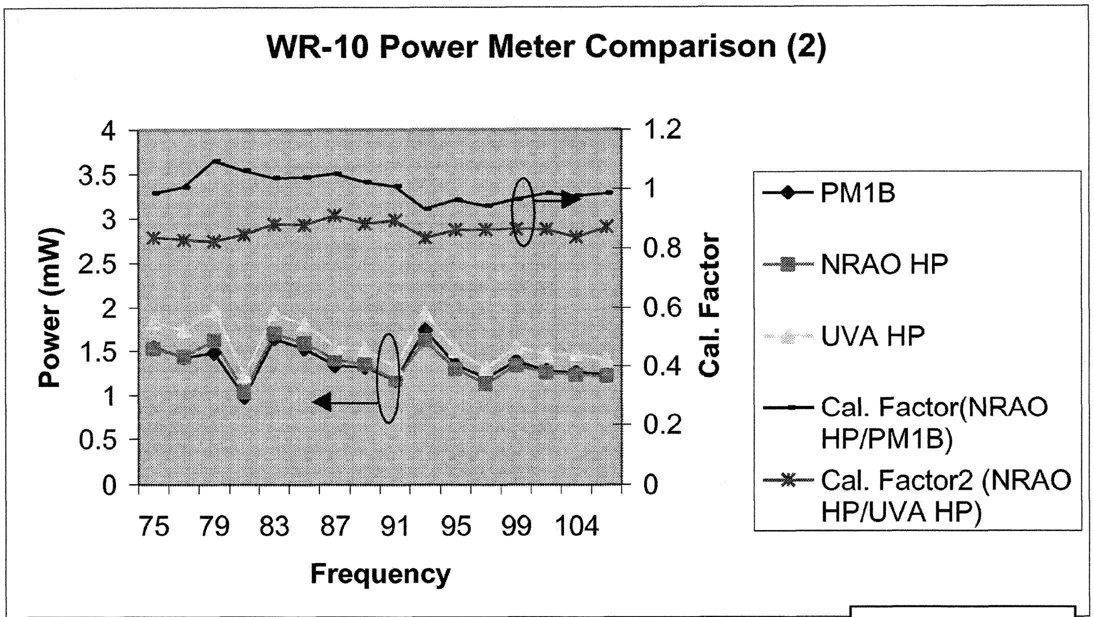
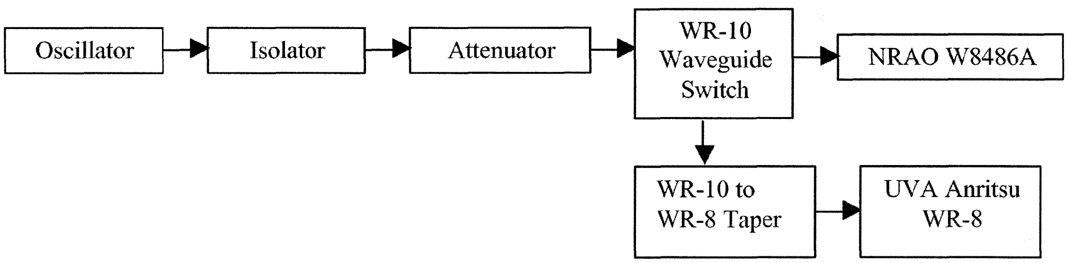


Figure 2

2. WR-8 measurement

In the overlap frequency band of WR-8 and WR-10, we compare the NRAO HP W8486A power sensor with Anritsu WR-8 power sensor.



Measurement Setup for 90-110 GHz

The measurement result is plotted in Figure 3. We can observe that the reading of the Anritsu WR-8 is lower than the HP meter, but the scale factor is constant and remains between 1.25 and 1.35.

In the higher end of WR-8 frequency band we test the UVA Anritsu WR-8 power meter, the NRAO Anritsu WR-8 power meter, and an Erickson PM1B power meter. The results at lower power level are showed in Figure 4 and at higher power level in Figure 5.

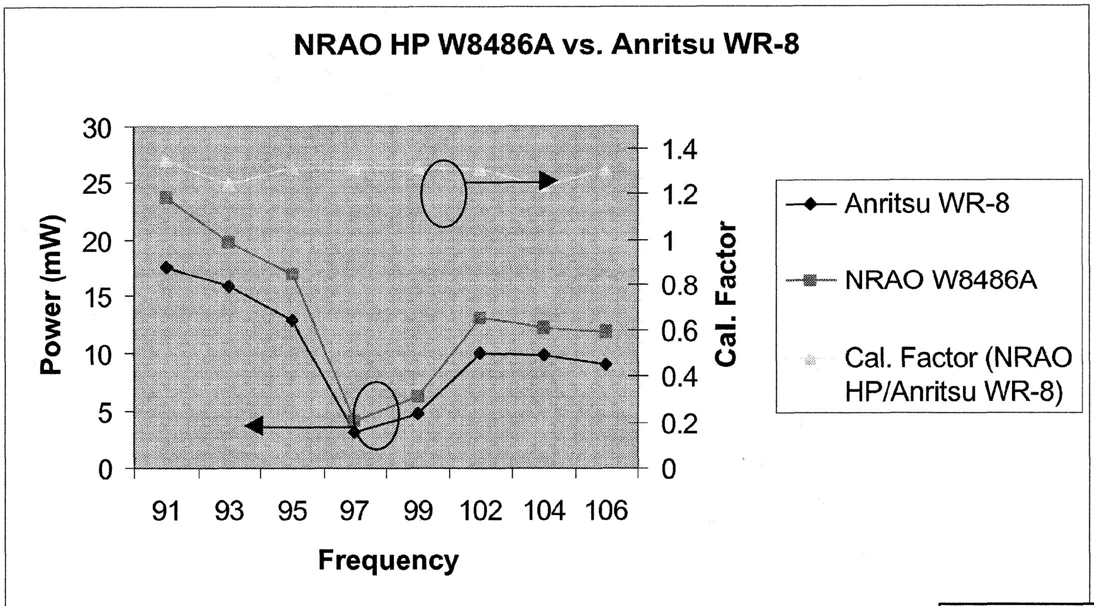


Figure 3

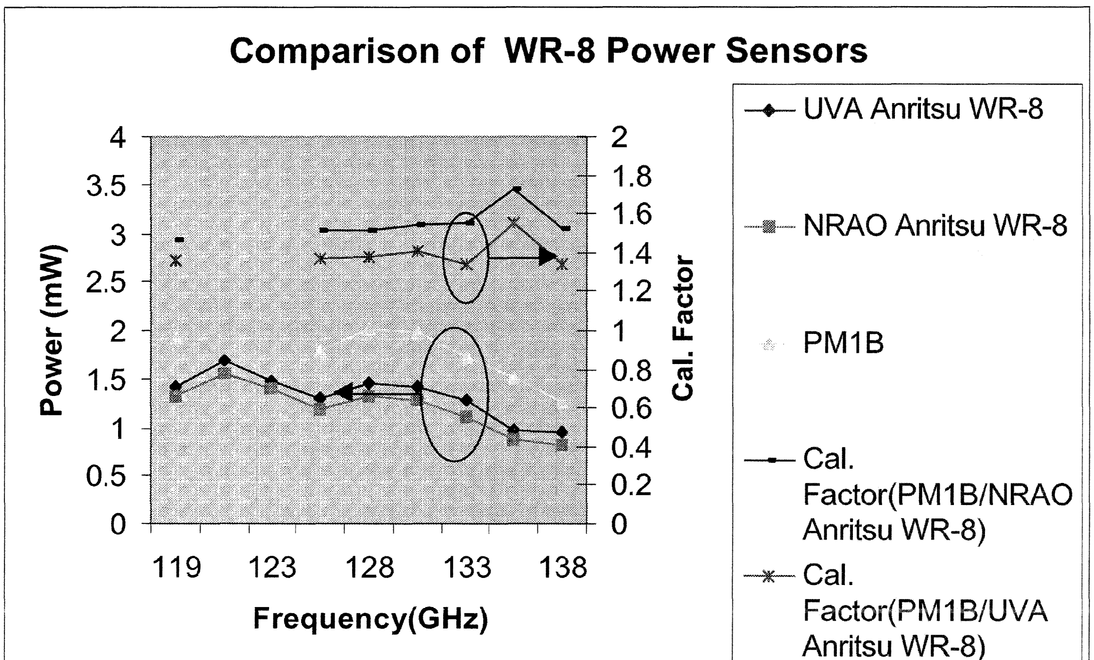


Figure 4

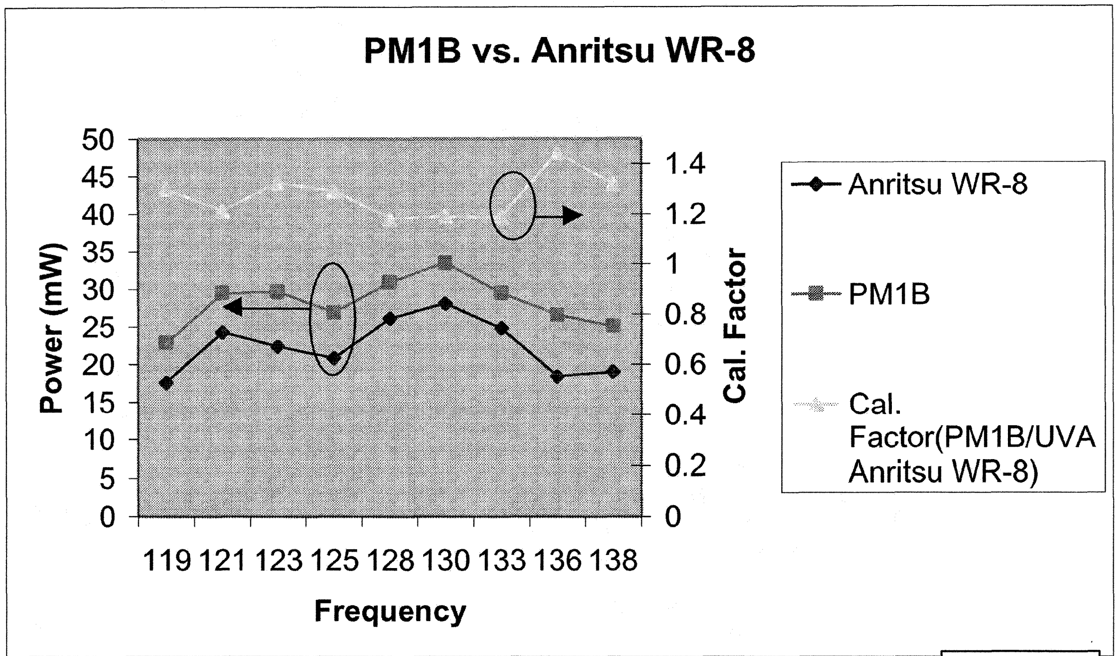
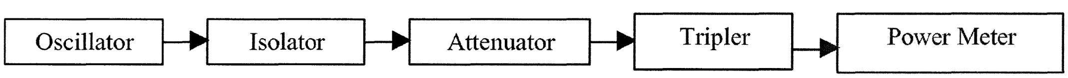


Figure 5

In the measurement shown in Figure 4 we use the Erickson PM1B with its scale range set to 2+ mW to measure the Gunn power. At 120GHz and 122GHz the reading is out of range, so those two points are omitted. The readings of the two Anritsu WR-8 power meters are very consistent to each other, but are lower than the reading from the Erickson PM1B.

3. WR-3 Measurement

In WR-3 frequency range, we compare 2 power measurement methods. They are an Anritsu WR-3 power meter and an Erickson PM1B power meter. We use a WR-3 to WR-10 tripler as the power source. When we use the PM1B power meter, we insert a WR-3 to WR-10 taper between the tripler and the power meter.



Measurement Setup for the WR-3 frequency range

The measurement results are shown in Figure 6.

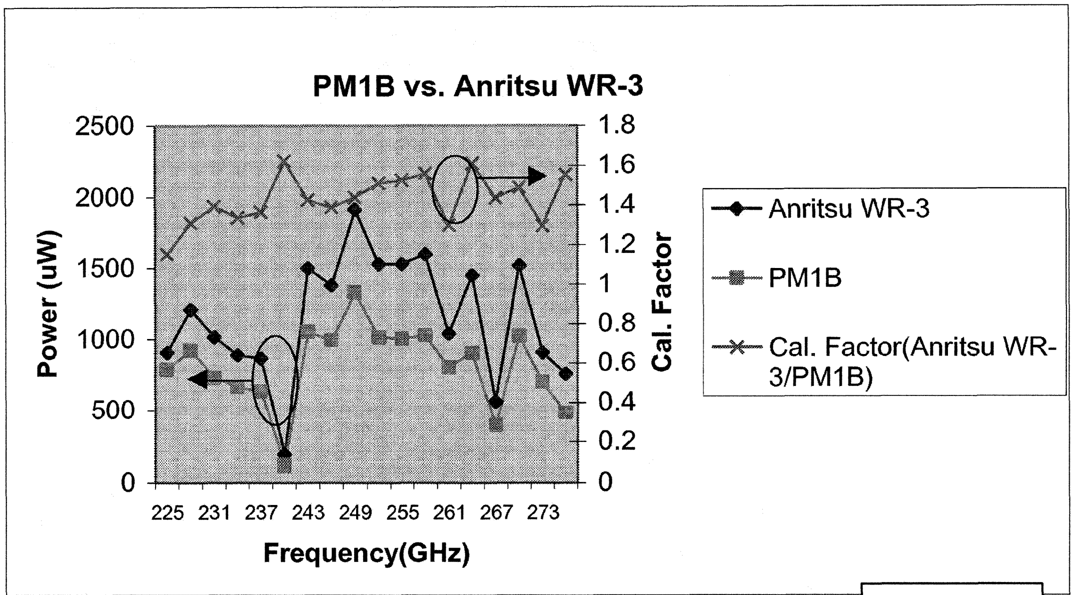


Figure 6

As shown in Figure 6, the Anritsu and Erickson meters track very well over this frequency range.

We also compare the Anritsu WR-3 power meter, an Erickson PM1 (borrowed from NRAO), and an Anritsu WR-8 power meter in the WR-3 frequency band.

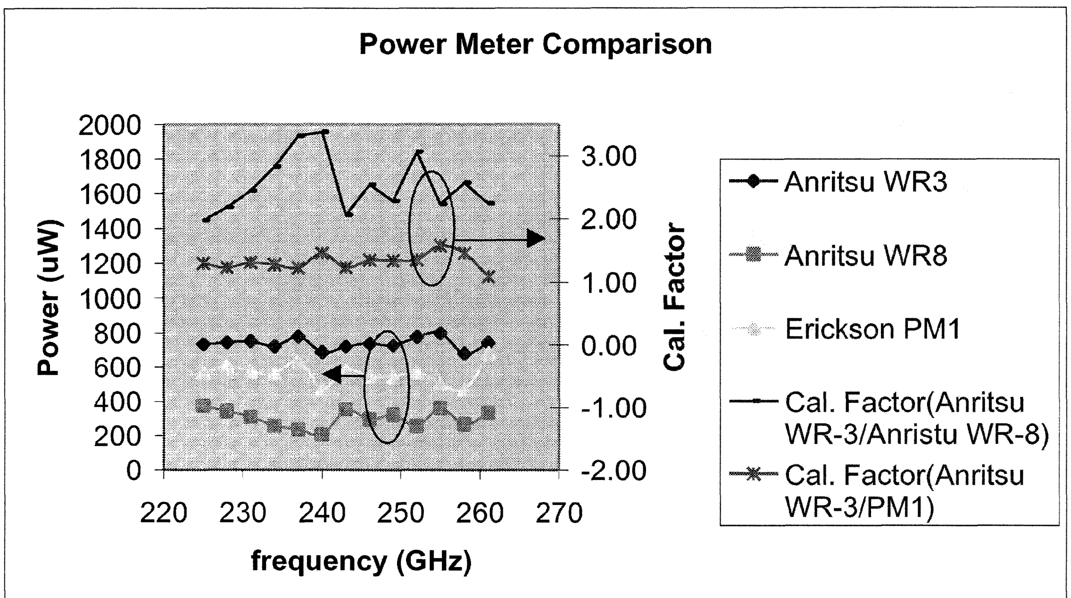


Figure 7

From figure 7, we can observe the Erickson PM1 power meter has almost same performance as Erickson PM1B, with a scale factor about 1.4 compared to the Anritsu WR-3 power meter. However, the scale factor for the Anritsu WR-8 power meter referenced to the Anritsu WR-3 power meter varies over a much larger range, from 2 to3.5. Also, this correction factor was found to vary significantly from measurement to measurement. This shows the problem associated with using a meter above band.

4. Power measurement above the WR-3 frequency band.
We also measured power in the 400 to 500 GHz range. The power source is a quintupler pumped by a Gunn oscillator.

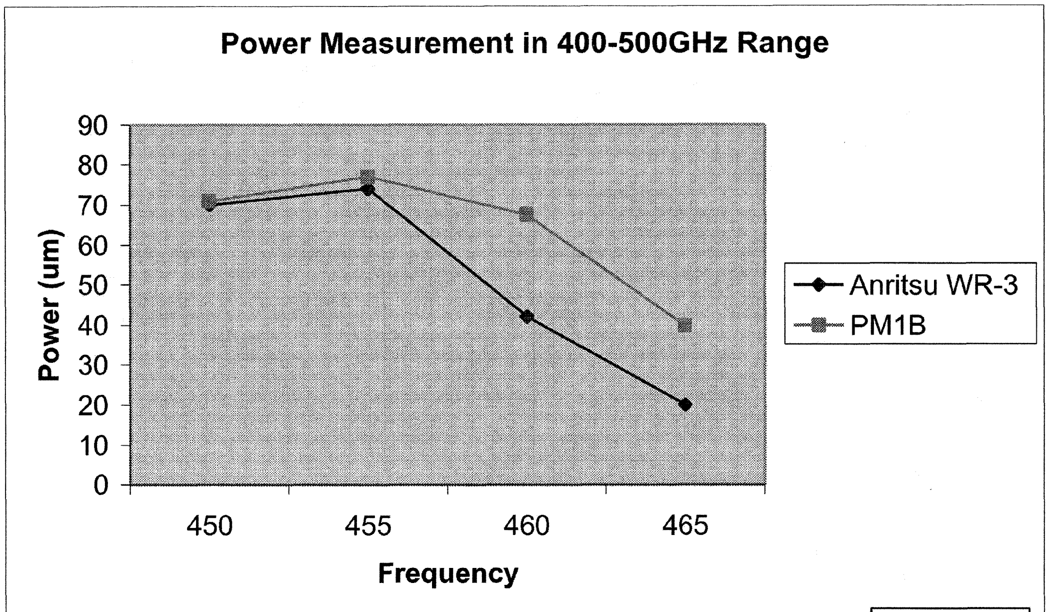


Figure 8

As found when using the WR-8 Anritsu power meter above band, the WR-3 Anritsu power meter shows significant deviation from the Erickson PM1B power meter above band.

Conclusion

In the WR-10 frequency range, the calibrated HP W8486A power sensor is the best choice because it is traceable to NIST and has a faster measurement speed compared with the Erickson PM1B power meter. The measurement result from the Erickson PM1B is very close to that of the W8486A.

In the WR-8 frequency range NIST has not set any power calibration standard yet. From the comparisons in the overlap frequency range of WR-8 and WR-10, we believe the Erickson PM1B power meter will be quite accurate over the WR-8 frequency range.

The use of the Anritsu power meter heads above their specified band was found to be prone to significant error and repeatability problems.

Up to the WR-3 frequency range, the measurement results of the Anritsu WR-3 power meter, the Erickson PM1, and the Erickson PM1B have very similar shape and with a scale factor about 1.4. Since Anritsu Corp. no long produces the WR-3 power sensor we have decided to use the Erickson power meter series PM1B as our power standard.

Reference

[1] EPM Series Power Meters E-Series and 8480 Series Power Sensors Technical Specifications, *Agilent Technologies*
[2] Choosing the Right Power Meter and Sensor Product Note, *Agilent Technologies*
[3] Operation Manual of Erickson PM1B Power Meter, *Erickson Instruments LLC*

Acknowledgement

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