NEXRAD TAC Meeting 1 Nov 2006

The Uncertainty of RF Power Measurements for ZDR Calibration

Engineering Calibration (EC) Sub-Task

Objectives of EC Subtask

- Develop practical ZDR uncertainty budget for the test radar instrument (S-Pol) wherein component uncertainties are frequently ~ 0.1 dB.

- Apply findings to dual-polarization WSR-88D, where desired Uc < 0.1 dB.

Method

- Modify NCAR's S-Pol to accommodate a high-stability measurement/calibration sub-system, including waveguide re-plumbing and design/assembly of automated test equipment (ATE).
- Execute tests or experiments designed to differentiate the component uncertainties.
- Test procedures, environments, and applications of field calibration activity.

Characterize RF Power Measurements

- Separate, quantify, and correlate instrument uncertainty components (errors).
- Systematic (bias, often Type B)
  - from calibration procedures
  - from influence factors & drift
  - from secondary effects, such as mismatch
  - from component replacement.
- Random (noise, often Type A).

Guidelines

- Evaluation will be based on designed calibration experiments to determine the relative importance of 10% (< 0.5 dB) effects.
- Manual calibration experiments.
- Automated calibration experiments.

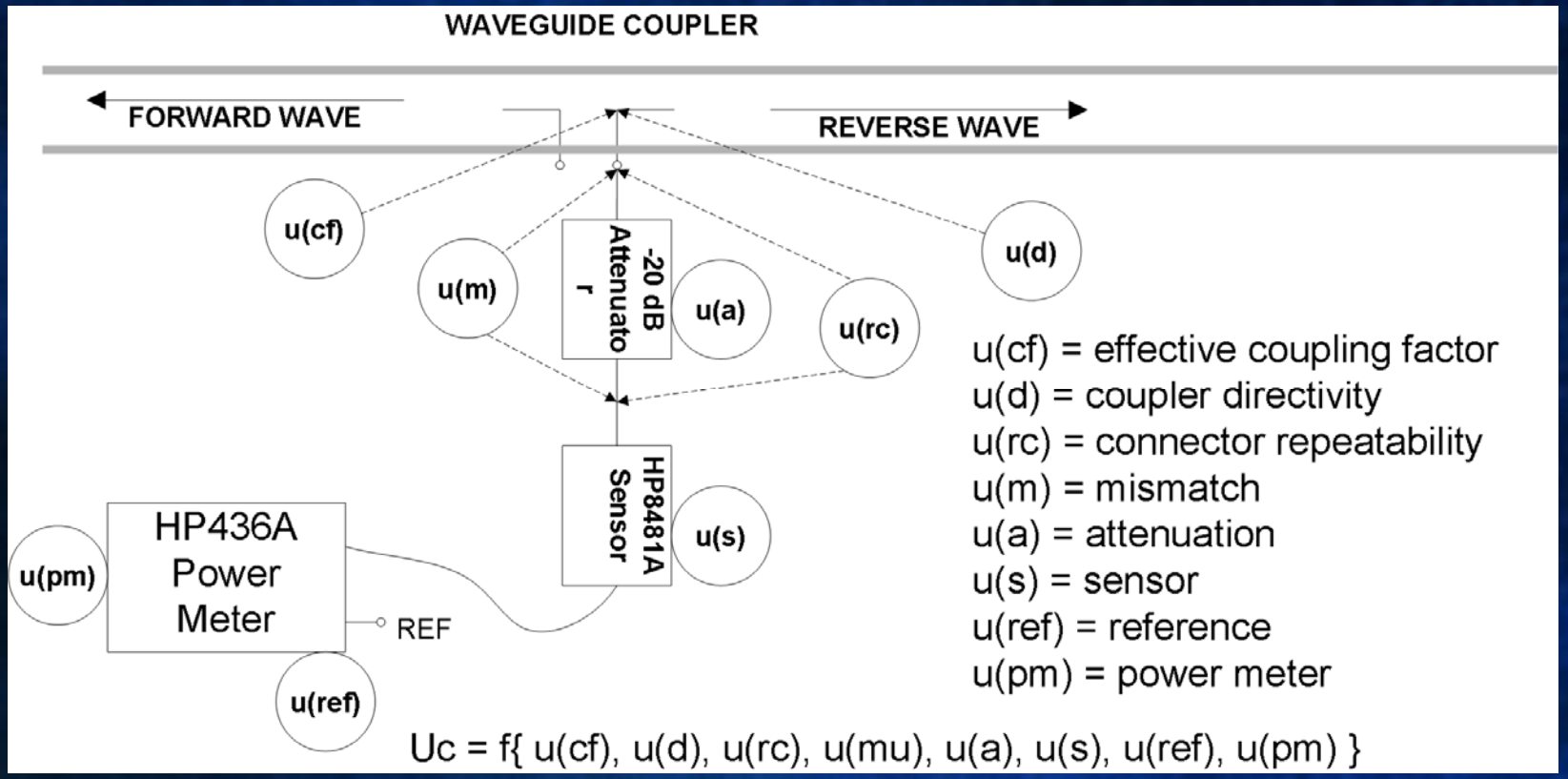
Influences

- Thermal stress
- Mechanical stress
- Chemical stress
- Moisture
- Source stability
- Modulation
- RF Interference
- Procedural (operator, computation, ..)

Environmentally-driven Uncertainties Affect:

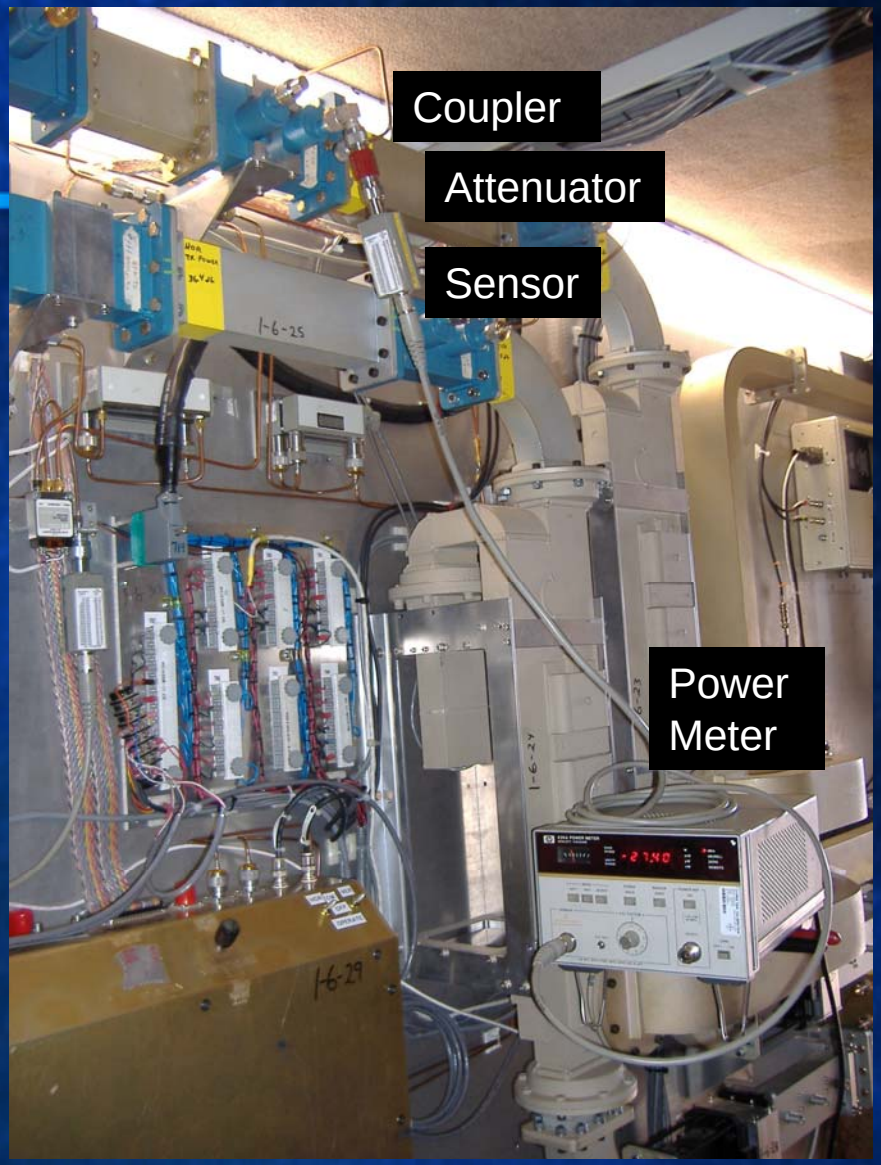
- Power Sensors.
- Attenuators.
- Cables & Power Splitters.
- Connectors.
- Waveguide Couplers.
- Mismatch Coefficients.
- Solar Flux.
- Amplifiers.
- CW Generators.
- Noise Generators.

RF Power Measurement Uncertainty



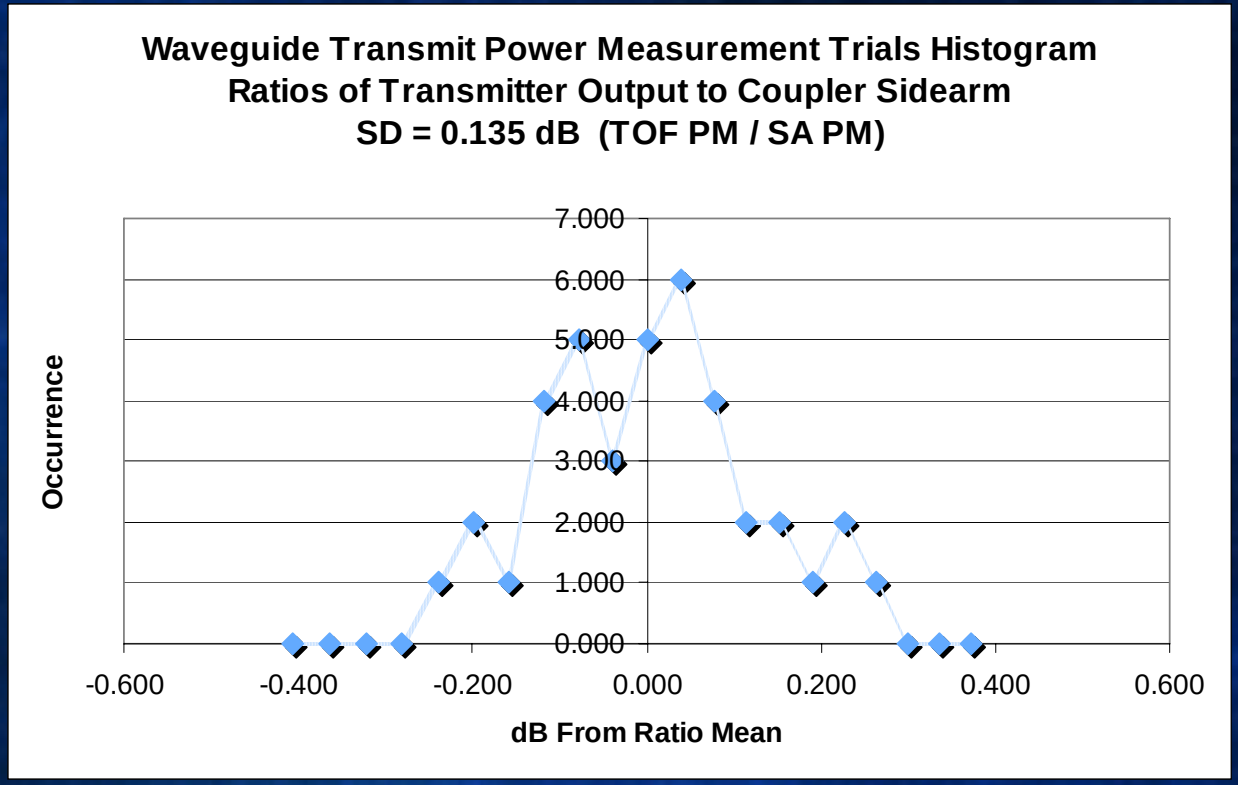
S-Pol

Measuring Waveguide Transmit Power



S-Pol

Distribution Of Differential Waveguide Power Measurements



S-Pol

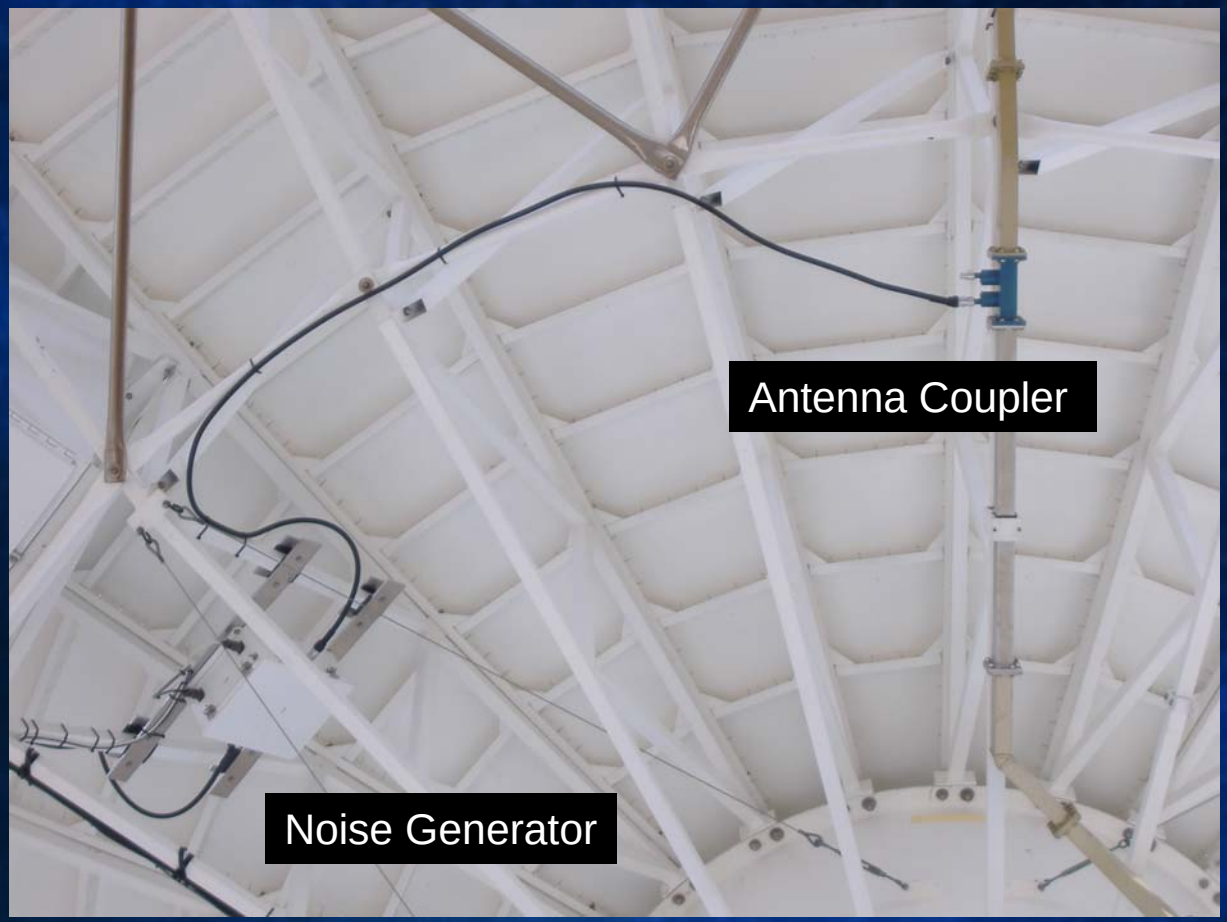
Practical S-Pol ZDR Instrument Bias Uncertainty Budget

Engineering Calibration (EC), S-Pol, Instrument Bias for ZDR
(based on RVP8 and waveguide RF power measurements)

October 26, 2006	H dB	V dB	"Meas" H/V dB	"Select" H/V dB
PtH, PtV Transmit Power Ratio				
PTX dBm Mon Point	0.565	-0.581		
Tx Cal Factor dB	56.26	57.26		
Pt AVG Est at ref dBm	56.83	56.68	0.15	
Pick Pt ratio dB				0.15
Estimate uc dB Type A				0.07
Estimate uc dB Type B				0.11
GaH, GaV, Antenna System Gain Ratio				
Gs dB REFRACTT cals	45.23	44.81	0.41	
Gs config.rdr dB	45.63	45.40	0.23	
Gs dB Long Term	45.10	44.97	0.13	
Gsh/Gsv Solar Dixon			*0.19*	
Gsh/Gsv Solar Manual Fit			*0.35*	
Pick Gs ratio dB				0.19
Estimate uc dB Type A				0.03
Estimate uc dB Type B				0.11
GHc, GVc Receiver Gain Ratio				
Gr_RVP8 dB	37.52	37.19		
Balance Attn	0.00	0.00		
Gr_RVP8 Est from ref	37.52	37.19	0.33	
Pick Gr ratio dB				0.33
Estimate uc dB Type A				0.04
Estimate uc dB Type B				0.11
ThetaH, ThetaV Beamwidth Ratio				
Theta (config.rdr) deg	0.89	0.89		
Theta (solars) deg	0.92	0.88		
Pick Theta ratio dB	0.90	0.89		
Theta Est at ref dB	-0.92	-1.01	0.10	
Pick Theta ratio dB				0.10
Estimate uc dB Type A				0.03
Estimate uc dB Type B				0.08
S-Pol ZDR Instrument Bias dB				**1.05**
Uc (2-sigma) ZDR Instrument Bias dB				**0.37**

S-Pol Automated Test Equipment

S-Pol Automated Test Equipment



Subtask Deliverables

- Uncertainty of engineering calibration (EC) estimates of radar measurement bias.
- Recommendations for installation of dual polarization capability.
- Recommendations for optimized calibration interval & procedures.
- Recommendations for training.

Future Instrument-related Issues

- Quantify selected WSR-88D components in field with ATE, such as LNAs, couplers, power sensors, test cables.
- Develop enhanced SunCheck for dual-polarization WSR-88D / RVP8 with additional functionality for differential antenna parameters.
- Develop calibration-tracking software.

Consultants

- NIST Statistical Engineering Division
- NIST RF, Microwave and Millimeter Wave Measurements Group
- Agilent
- Micronetics
- NCAR Design and Fabrication Services

Measurement References

- American National Standard for Expressing Uncertainty--U.S. Guide to the Expression of Uncertainty in Measurement, ANSI/NCSL Z540-2-1997

- Taylor, B.N. and C.E. Kuyatt (2004, 1994) Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results, NIST Technical Note 1297, Gaithersburg, MD.