Dual Polarization
the Challenge

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Two Dual Polarization Modes

Simultaneous SHV (it is not fully polarimetric)
H and V are transmitted simultaneously, both copolar components are received

Alternate AHV (it is fully polarimetric)
H and V are transmitted alternatively
Challenge: DualPol-PAR to have Same Data Quality as DualPol-WSR-88D

Polarimetric Data Quality Achieved on Conventional Radars:

- High cross-correlation coefficient $\rho_{hv}$, small bias in differential reflectivity $Z_{DR}$, and low linear depolarization ratio $L_{DR}$, characterize a well designed polarimetric radar
  - EEC recent Polarimetric Radars (Sigmet Processor, Gamic Processor): $\rho_{hv} \approx 0.996$ to 0.998
  - KOUN (WSR-88D, NSSL design) $\rho_{hv} \approx 0.998$, $L_{DR} < -33$ dB
  - $Z_{DR}$ bias should be $< 0.15$ dB
ISSUES affecting dual polarization data

- **COUPLING** between the horizontal and vertical components (inherent to Planar PAR for measurements away from the two principal planes)

- CROSS-POLAR PATTERN (present in PAR and Conventional Radar)

- MATCHING OF BEAMS at vertical and horizontal polarizations (present in PAR and Conventional Radar)
Transmitted Linearly Polarized Waves from a

- Parabolic Dish are **orthogonal** throughout the whole field of view

- Planar Phased Array are **not orthogonal** through most of the field of view
Alternate (AHV) Mode

- Tested extensively on parabolic antennas
- Planar Phased Array
  - Performs well if corrected over the field of view
  - Correction to mimic conventional radar can be done over most of the field of view
  - Correction is multiplicative and is a function of pointing direction

COUPLING, Ref: Guifu et al 2009
IEEE Tr., GRS-47
COUPLING – Planar Array

Simultaneous (SHV) Mode

• Accepted for the WSR-88D
• Planar Phased Array
  – Performs with multiplicative correction only over a limited field of view
  – Corrections* over the remaining field of view are not practical
  – Therefore alternatives are needed for most of the field of view:
    • Orthogonal coding
    • Alternate HV
    • Other?

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Field of View SHV mode

$Z_{DR} = 0 \text{ dB, } \rho_{hv} = 1, \beta = 0 \text{ deg, } \Phi_{DP} = 180 \text{ deg}$

Bias in $Z_{DR} < 0.1 \text{ dB}$
Field of View AHV mode

\[ Z_{DR} = 0 \text{ dB}, \rho_{hv} = 1, \beta = 0 \text{ deg} \]

Bias in Z_{DR} < 0.1 dB
Decoupling Doppler from Differential Phase (AHV - mode)

• Scanning strategy and transmission sequence should be designed to optimize overall performance. This is a System Design Problem.

• The following Transmitted Sequence Triplet decouples Doppler from Diff Phase.
There is no inherent coupling so CPA is equivalent to a conventional radar (Ref: Guifu 2009 – OU-NSSL Patent pending).

System Study is in Order – scanning strategy, multiple beams, frequencies, beamwidth, waveforms, ......
CPAs
Single Pol
Advantages of CPA

- No beamwidth increase if AZ scans are at constant Elevation. That is: Quality of measurements is isotropic in each conical scan.
- Effects of precipitation on the radome is expected to be smaller.
- Polarimetric issues are equivalent to the issues concerning the conventional radar.
CROSS-POLAR PATTERN

• This issue affects both the PAR and the Parabolic dish antenna

• Two types of cross polar pattern have profound effect on biases of the polarimetric variables
Two Antenna Types

1) SINGLE CROSS-POLAR MAIN LOBE:
Principal cross-polar LOBE centered on the copolar main lobe

Contours at a fixed level below main lobe peak

Copolar main lobe cross section
Cross-polar maximum lobe cross section

2) MULTIPLE CROSS-POLAR MAIN LOBES: symmetric with respect to beam axis and IN PHASE OPOSITION TO EACH OTHER:

Cross-polar maximum lobes
Copolar main lobe

CROSS-POLAR PATTERN
Comparison

• Type I (single lobe) pattern is much more detrimental than type II.

• To achieve the same reduction of bias in polarimetric variables the integrated cross-polar single lobe pattern to integrated main lobe pattern must be 10 dB lower then the value for multiple lobe (type II) pattern.
A Cylindrical PAR on every Water Tower
Envelope of $Z_{DR}$ bias < 0.15 dB in the Az – El from boresight (SHV mode)
Alternate (AHV) Mode

- The differential phase and Doppler are coupled
- Tested extensively on parabolic antennas
- Planar Phased Array
  - Performs well if corrected over the field of view
  - Correction to mimic conventional radar can be done over most of the field of view
  - Correction is multiplicative and is a function of pointing direction

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MATCHING BEAMWIDTHS

• At 20 dB below the peak the beam patterns for H and V polarizations should be within 1.85 dB of each other