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Time-Efficient Computation of EOS-04 Cross-Polarization Imbalance

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Abstract

Measurement of Cross-Polarization Imbalance (CPI) of the phased array antenna is a critical step during SAR payload characterization. In this paper, we demonstrate a time-efficient measurement scheme of H-V CPI for EOS-04 antenna via single 2-D raster-scan near-field measurements. The set-up utilizes full-polarization mode of EOS-04 payload and a dual polarized probe for this purpose.

1. Introduction

The electromagnetic field radiated by an antenna is typically classified into three regions based on their locations from antenna aperture: 1) Reactive Near-Field: 0 to 3λ, 2) Radiating Near-Field: 3λ to $\frac{2D^2}{\lambda}$, 3) Far-Field: $>\frac{2D^2}{\lambda}$ (D: Maximum Antenna Dimension and λ: RF wavelength.) [1], [2], [3]. Near-field measurements are used to generate far-field patterns of the large sized phased array antennas [4]. Far-field pattern generation is a topic of interest in several works reported in the literature [5],[6],[7]. Cross-polarization imbalance, which refers to the amount of power coupled between two orthogonally polarized ports, is a key parameter to assess the dual-polarization antenna as cross-polarization closely affects the antenna application [8]. Dual-polarized antennas with better cross-polarization isolation are desirable for more convenient polarimetric data calibration [9].

EOS-04, a space borne C-Band Synthetic Aperture Radar (SAR), has recently been launched by ISRO to provide continuity of the services by its predecessor RISAT-1. It is configured with an active phased array antenna of dimension 6m (azimuth) x 2m (elevation/range) having dual polarized transmit-receive modules.

Measurement of H-V Cross-Polarization Imbalance (CPI) of the phased array antenna is important during SAR payload characterization as the source of crosstalk is mostly from the cross-polarization level of the SAR antenna [10]. For computing H-V CPI of the given antenna, one requires 4 types of far-field patterns, namely, H-Co, H-Cross, V-Co , V-Cross. The individual near-field 2-D raster scan measurement for each of these cases is a time-consuming process, thereby requiring considerably high payload checkout-time. For EOS-04 H-V CPI measurement, we expedite this process by utilizing its full-polarization mode and a dual polarized probe, thereby requiring only a single near-field 2-D raster scan.

The paper is organized as follows: Section 2 presents details of our measurement set-up that requires single 2-D scan for simultaneous estimation of H-V CPIs. In Section 3, we discuss the obtained results for EOS-04 in 3 modes, namely, Medium Resolution ScanSAR (MRS), Fine Resolution Stripmap-2 (FRS-2), and Fine Resolution Stripmap-1 (FRS-1). Finally, Section 4 provides the concluding remarks.

2. Measurement Set-up for Time-Efficient CPI Estimation

As seen from the figure 1, the 2-D near-field data acquisition consists of 1) Active phased array radiating antenna and 2) Receiver Probe Antenna (open-ended waveguide-type) mounted on a movable scanner which can be positioned anywhere in front of radiating antenna in 2-D plane. The movable scanner moves the probe antenna over a raster scan path that captures all significant microwave emissions from radiating active phased array antenna. The path of motion is constrained to a 2-D plane, which lies at a distance of close to 10λ (50cm) from antenna plane.

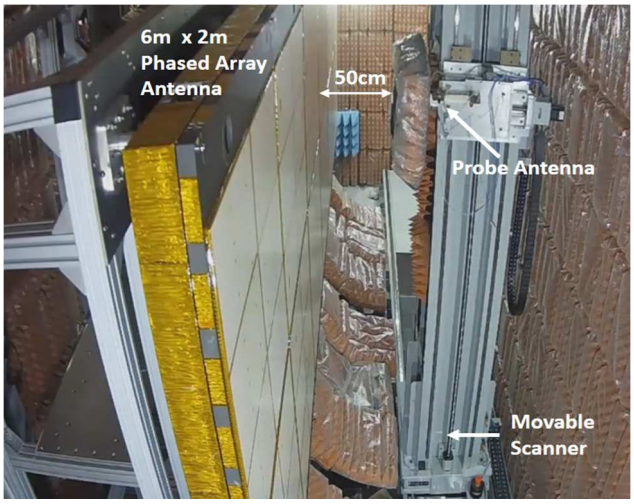

Figure 1: Measurement Inside Near Field Chamber

Before actual measurement, roll-pitch-yaw (R-P-Y) of antenna plane are carefully aligned with scanner

plane. The accuracy parameters of R-P-Y alignment are given the Table-1.

Table 1: Antenna Alignment w.r.t. Scanner Plane

	Roll (R)	Pitch (P)	Yaw (Y)
Desired	0/360deg.	0/360deg.	0/360deg.
Measured	0.073deg.	0.132deg.	0.095deg.

Figure 2 shows the block diagram of measurement set-up for time-efficient CPI estimation. In full-polarization mode of operation, the EOS-04 SAR antenna radiates microwave signal in both H and V polarizations alternately. This microwave signal is received by the dual polarized probe. For transmitted H and V polarized signals, co and cross-pol signals are received as shown in figure 3.

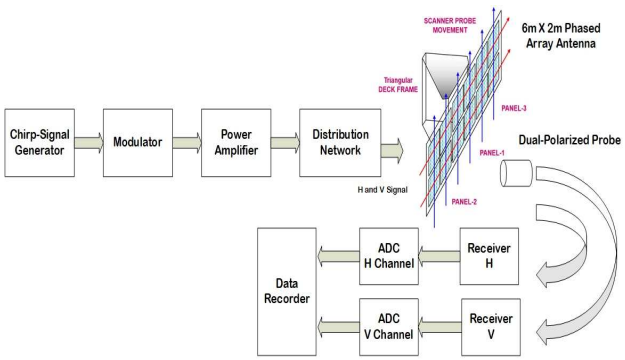

Figure 2: Block Diagram of Measurement Set-up

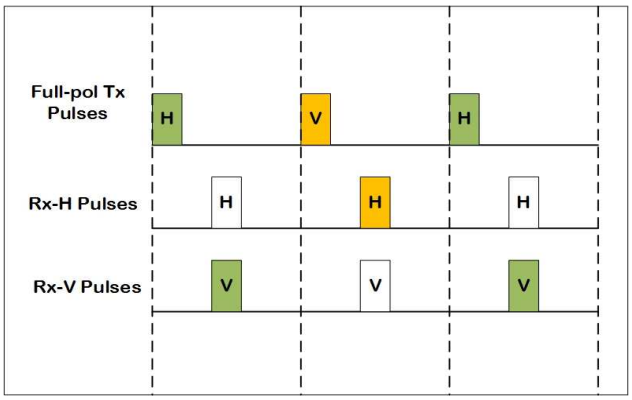

Figure 3: Timing Diagram for Tx and Rx Pulses

For H polarization transmission case, one receives near-field data for H-Co and H-Cross for given position of the probe. Similarly, in the next pulse repetition cycle, i.e. V polarization transmission case, one gets near-field data for V-Co and V-Cross. For each position of the scan, captured chirp signal is time-correlated with a constant reference signal. Subsequently, the peak Amplitude and corresponding phase of the time-correlated signal is calculated. This information is further back-projected towards the surface of Phased array antenna to generate Hologram and corresponding Far field antenna patterns as described in [4].

In this way, we get the far-field 3-D patterns for H-co, H-cross, V-pol, and V-cross in a single 2-D scan, from which, the H-V CPIs are obtained by subtracting the Co-Pol peak from Cross-Pol peak in each case. This process reduces the CPI computation time considerably (to 25%), as it does not require individual scans for H-co, H-cross, V-pol, and V-cross far-field patterns.

3. CPI Computation for EOS-04 Antenna

Using the full-polarization mode of EOS-04 (i.e. HH (H-Co), HV (H-Cross), VH (V-Cross), VV (V-Co)), the near-field data is received in H and V polarization for alternately sent H and V transmit pulses. Correspondingly, the far-field antenna patterns are generated in each case. This is done for three bandwidth modes, namely MRS (18.75MHz), FRS-2 (37.5 MHz), and FRS-1 (75 MHz).

Figure 4 and figure 5 show the amplitude and phase holograms for H polarization in MRS mode.

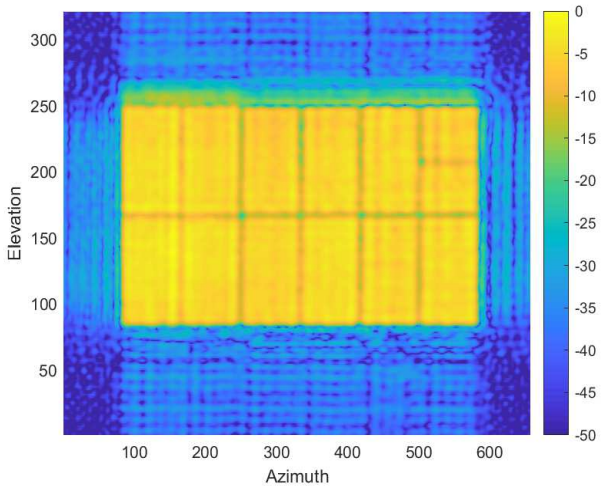

Figure 4: MRS: Amplitude Hologram for H

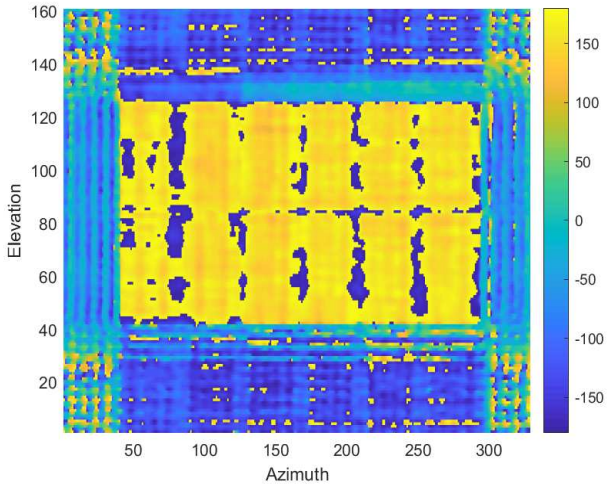

Figure 5: MRS: Phase Hologram for H

The holograms for V polarization in MRS mode are shown in figure 6 and figure 7.

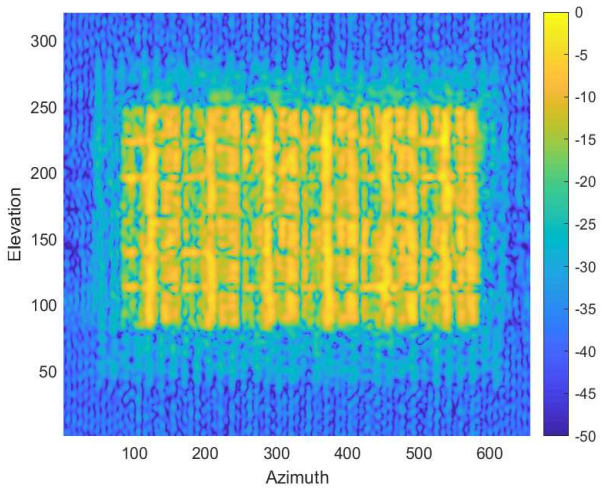

Figure 6: MRS: Amplitude Hologram for V

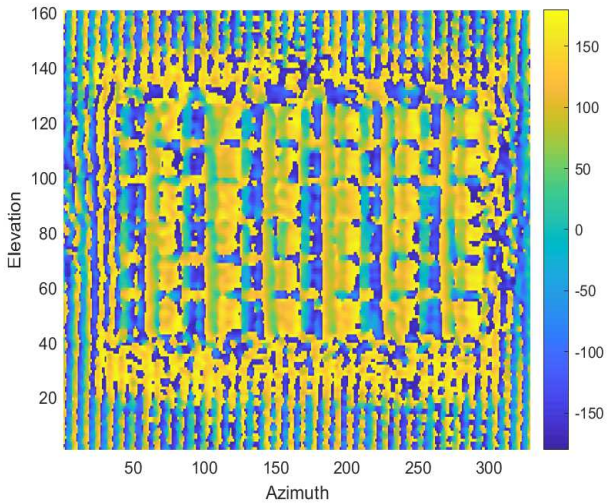

Figure 7: MRS: Phase Hologram for V

Figure 8 shows the generated co and cross-pol far-field patterns for transmit H case in elevation direction for MRS. Figure 9 presents the corresponding patterns in transmit V case.

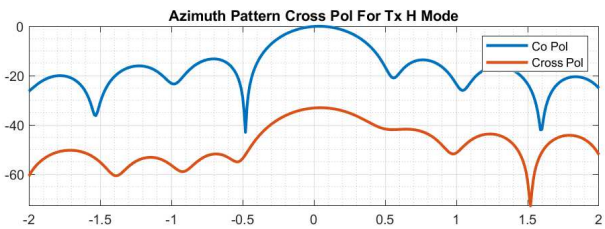

Figure 8: MRS: Co and Cross Pol Patterns For Tx H

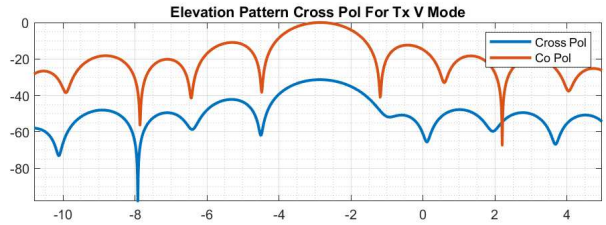

Figure 9: MRS: Co and Cross Pol Patterns For Tx V

The similar patterns corresponding to FRS-2 and FRS-1 are shown in figures 10-11 and figures 12-13, respectively. The computed CPIs have been presented in Table-2.

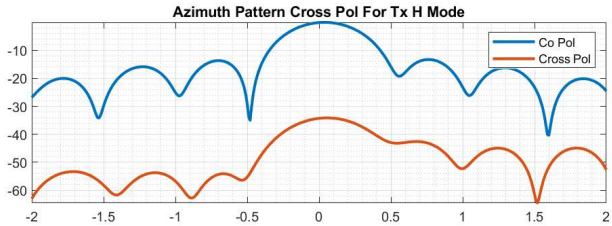

Figure 10: FRS 2: Co and Cross Pol Patterns For Tx H

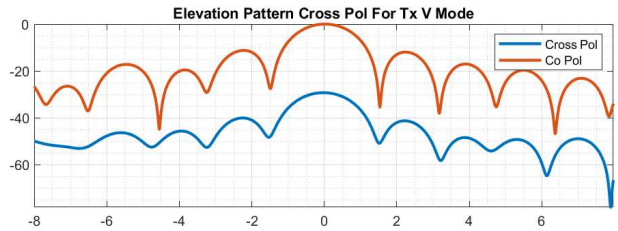

Figure 11: FRS 2: Co and Cross Pol Patterns For Tx V

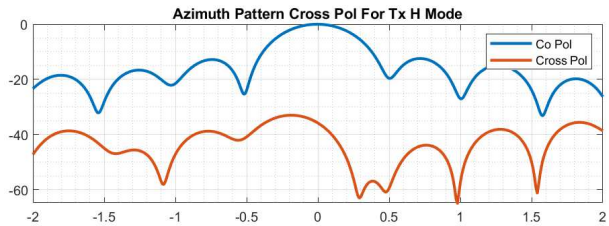

Figure 12: FRS 1: Co and Cross Pol Patterns For Tx H

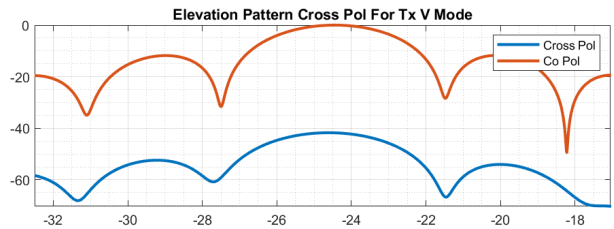

Figure 13: FRS 1: Co and Cross Pol Patterns For Tx V

Table 2: CPIs for MRS, FRS2, and FRS1

Tx	Rx	MRS	FRS2	FRS1
H	V	33.1dB	34.1dB	35.8dB
V	H	31.4dB	29.3dB	41.8dB

4. Conclusion

In this paper, we presented a time-efficient scheme for computation of H-V CPIs of EOS-04 antenna with a single 2-D scan near-field measurement using dual-polarized probe. For this purpose, we utilized the full-polarization mode of EOS-04, which transmits H and V polarized signal in alternating pulses. The CPIs were measured for three bandwidth cases, namely, MRS, FRS2, and FRS1.

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