Reduction of Cross-polarization on a Single Offset Parabolic Reflector using Digital Beam Forming Techniques and Combination of Elements

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Abstract

The antenna configuration studied is part of Tandem-L project, a proposal for interferometric radar mission to monitor the Earth. It consists of a large deployable reflector antenna in offset configuration with a digitized feed. The high crosspolar level due to the reflector geometry must be compensated to fulfil the requirements of fully polarimetric applications. Synthetic Aperture (SAR) calibration methods known until now are not able to reduce the crosspolar component of the radiation pattern of single offset reflector antennas. A reduction of the antenna crosspolar level must be performed in the antenna design stage. This paper shows the characterization and combination of two different techniques to reduce the crosspolar level of a large deployable single offset parabolic reflector.

1 Introduction

Most of recent SAR systems have polarimetric capabilities to measure the amplitude and phase of the full scattering matrix. Tandem-L is a proposal for interferometric radar mission to monitor the Earth [1]. The mission is based on co-flying two fully-polarimetric L-band reflector-based SAR satellites in a close formation. The system provides high versatility since combine the high gain provided by a large parabolic reflector with a digitized feed system. Digital Beam Forming techniques allow the instrumentation to operate in multiple modes for different applications [2].With this system it will be possible to image a swath width of 350 km with a 15m diameter parabolic reflector. In transmit, all the elements in the feed system are activated generating a wide beam that illuminates the complete swath. In receive, a narrow high gain beam is generated that follows the pulse echo traversing the ground. This paper investigates the combination of two possible techniques two reduce or even cancel the crosspolarization of the antenna system: first, combination of couple of azimuth elements in the feed system are considered to cancel the crosspolar component of the antenna produced by the offset configuration, second, digital beam forming techniques combining a set of elements in elevation are studied to reduce the crospolar level while keeping the copolar component performance.

2 Antenna geometry and simulated results

The antenna system consists of a single offset parabolic reflector of 15m diameter in both elevation and azimuth planes, with a focal length of 13.5 m and an offset clearance of 9 m. The feed system consists of 6 patch elements in azimuth and 32 in elevation. Every patch element is fed through transmit/receive modules. The elements are separated 0.6 λ in azimuth and 0.6816 λ in elevation. When the antenna is working in transmit all the patch elements are activated, the center part of the parabolic reflector is illuminated providing a wide, low gain beam covering the complete swath. On receive the energy returned from a narrow portion of the ground, it illuminates the entire reflector and is focused on individual elements or groups elements of the feed aperture. Two patches are combined in azimuth to form one digital channel. The number of azimuth channels which need to be active depend on the different operation modes provided. In this paper, the antenna performance is analyzed in receive. The antenna position on the satellite is assumed with the Y axis perpendicular to the Equator and pointing the the North, so that V-polarized field is parallel to Y.

3 Reduction of the cross-polarization

3.1 Combination of couple of elements in the feed system

The slot aperture coupled patches of the feed system have been designed and analysed with MoM assuming local periodicity. The sandwich stack-up has been designed at 1.2575 GHz, the thickness and electrical properties of each layer are provided in Figure 1. In the metallization layer, the patches are distributed in a rectangular lattice of 0.6816λ × 0.6 λ. The feed array is arranged in a grid of 6 × 32 elements in azimuth and elevation planes respectively. The radiation patterns obtained for both polarizations are shown in Figure 2.

The crosspolar cancellation implemented in the feed array is based on a beam forming network connected to the feed array that combines couple of azimuth patches, the crosspolar component of one of the patched for certain polarization will be used to cancel the crosspolar component of the second patch of the couple for the other polarization. This approach has been

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previously presented in **Error! Reference source not found.**. Figure 3 shows the radiation patterns of a couple of designed elements when applying the mutual cancellation. The reduction of the crosspolar component of the pattern is not significant due to the asymmetry in the performance of the radiation pattern of each element for the orthogonal polarization. Further studies are being performed to combine couple of elements keeping the symmetry of the copolar and crosspolar components of the radiation pattern for the two elements.

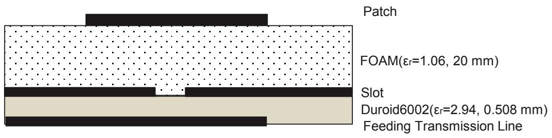

Figure 1: Sandwich configuration

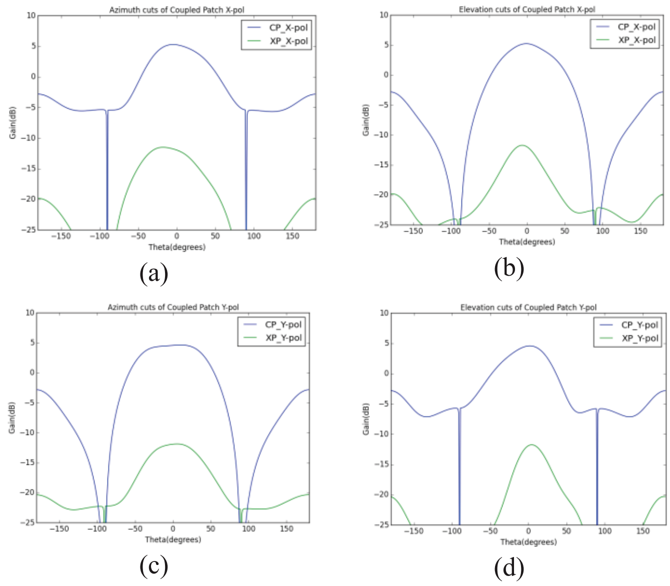

Figure 2 (a) Azimuth and (b) elevation cuts of the patch radiation pattern for X-pol (c) Azimuth and (d) elevation cuts of the patch radiation pattern for Y- pol

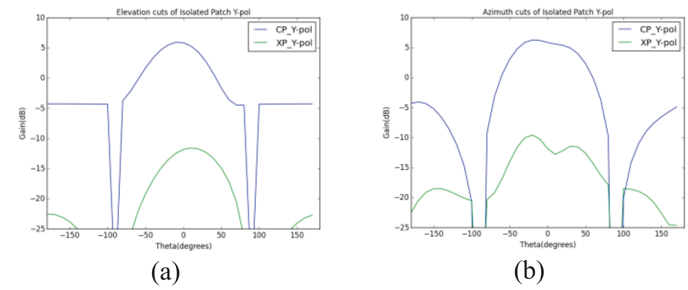

Figure 3: (a) Azimuth and (b) elevation cuts of the radiation pattern of a couple of elements applying the reduction of the crosspolar for Y-pol.

3.2 Digital beam forming techniques

Digital beam forming techniques are more and more considered for future earth observation missions. The motivation is the versatility they present to fulfill the stringent required performance level for the current SAR systems. The requirements consist of providing simultaneously high resolution within a wide swath. This versatility is considered in this paper to reduce also the crosspolar component produced by the antenna offset configuration. The minimum variance distortionless response (MVDR) beamforming is computed combining 3 elevation couple of elements of the feed system as it is shown in Figure 4. Figure 5 shows the 2D radiation pattern of the antenna analysed considering this MVDR for 3 couple of elements and Figure 6 shows the two main cuts of the radiation pattern for both polarizations. A modification on the MVDR technique is applied to reduce the crosspolar component of the radiation pattern computed for one polarization using the crosspolar component generated in the orthogonal polarization. Figure 7 shows the main cuts of the radiation pattern when applying the modified technique for the X polarization. At the moment a drastic reduction of the crosspolarization has not been achieved and further studies implementing a pattern synthesis for both copolar and crosspolar components of the radiation pattern combining different set of elements is being performed.

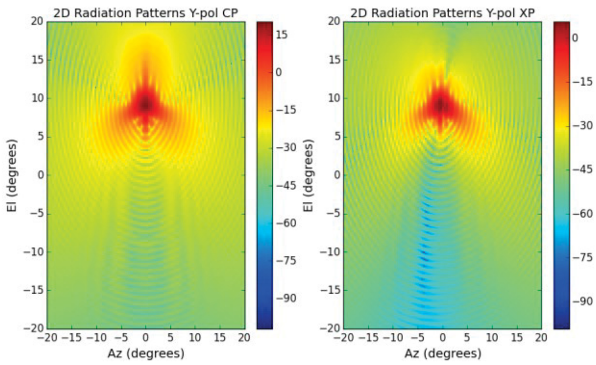

Figure 5: (a) Copolar and (b) crosspolar components of the 2D radiation pattern using MVDR for 3 couples of elements.

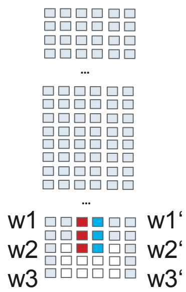

Figure 4: Activated elements of the feed system with different weights.

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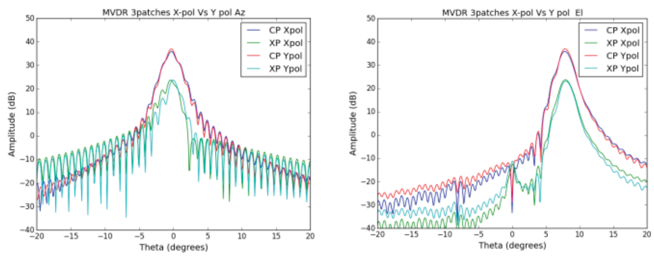
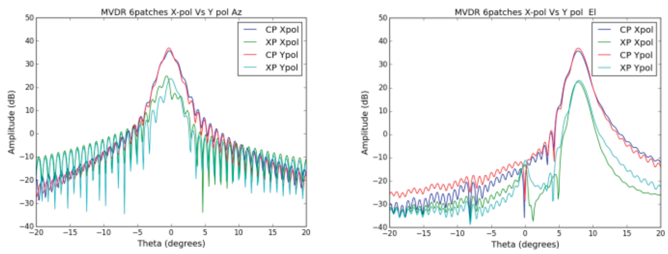


(a) (b)

Figure 6: (a) Azimuth and (b) elevation cuts of the radiation pattern of the antenna using MVDR for 3 couples of elements for both polarizations.



(a) (b)

Figure 7: (a)Azimuth and (b) elevation cuts of the radiation pattern of the antenna using a modification of MVDR for 3 couples of elements for both polarizations.

4. Conclusions

A 15 m single offset parabolic reflector antenna for Tandem-L mission has been designed and analyzed. The simulated radiation patterns of couple of feed patches and the complete antenna patterns are provided. Different techniques to reduce the cross-polar level have been considered. Combining both cancellations of the crosspolar component, first combining couple of elements in the feed system and second using DBF techniques, the crosspolar contribution due to the antenna geometry and the feed elements should be reduced. Further improvements and studies are required to achieve 30 dB cross-polar discrimination in the antenna pattern for all receive beams as required for the SAR mission.

References

[1] A. Moreira, I. Hajnsek, G. Krieger, K. Papathanassiou, M. Eineder, F. De Zan, M. Younis and M. Werner, "Tandem-L: Monitoring the Earth's dynamics with insar and pol-insar", International Workshop on Applications of Polarimetry and Polarimetric Interferometry (Pol-InSAR), Frascati, Italy, January 2009.

[2] G. Krieger, N. Gebert, M. Younis and A. Moreira, "Advanced synthetic aperture radar based on digital beamforming and waveform diversity", IEEE Radar Conference, Rom, Italy, May 2008.

[3] M. Naranjo, A. Montesano, F. Monjas, M. Gomez, R. Manrique, F. Heliere, K. Van't Klooster, "Biomass P-band SAR reflector antenna-feed S7S breadboarding", EUSAR 2014, Berlin, Germany, June 2014

