Digital Beam Forming in Azimuth with Space Borne Reflector SAR Systems

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Abstract — Space borne Synthetic Aperture Radar (SAR) imaging enters an era where increasingly high revisit times, or large swath widths, respectively, and high spatial resolutions are requested. Those requirements impose contradicting constraints on conventional SAR systems using analog beam forming technology. The development for future radar satellites is therefore towards digital beam forming (DBF) systems where the analogous receiver hardware is replaced by digital components. Concerning the SAR antenna the innovative concept of a parabolic mesh reflector in conjunction with a digital feed array (see Figure 1 left) is becoming a promising architecture for this new SAR generation. These antennas, already a mature technique for communication satellites, have the potential to outperform planar array antennas in terms of gain at a moderate hardware effort.

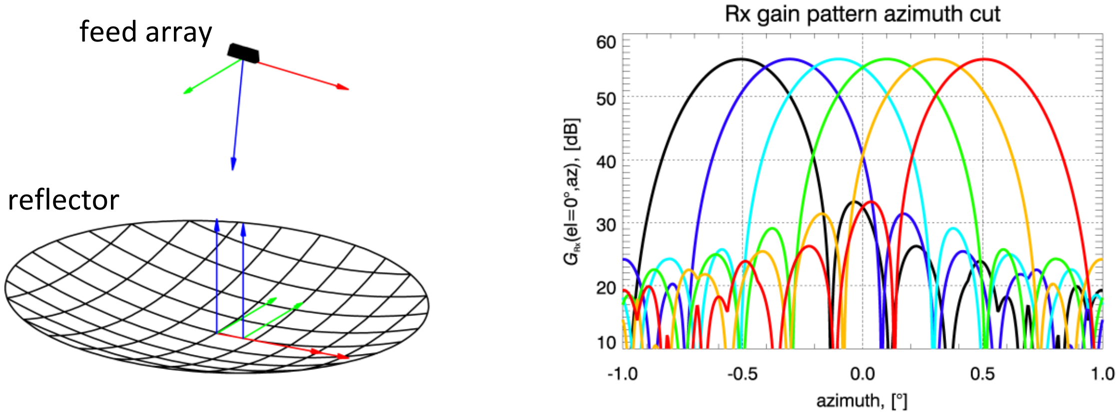

Figure 1: Parabolic reflector antenna with feed array in offset configuration (left); Azimuth gain pattern for a six channel system (right)

Conventional pulse SAR systems, specifically single channel systems, are inherently restricted with respect to their imaging capability. With those systems it is not possible to achieve a large swath width and a high azimuth resolution at the same time. A high resolution requires a broad beam, which needs a large pulse repetition frequency (PRF) in order to sample adequately. The high PRF in turn limits the swath width.

One possibility to overcome this restriction is to transmit a signal using a broad beam and collect the scattered signal with multiple receivers, represented by the azimuth channel pattern in Figure 1 on the right. Those individual signals are then processed in order to reconstruct the high resolution image.

In order to avoid too high data rates the PRF is chosen as low as possible. Consequently each individual azimuth channel is undersampled and subject to a high amount of aliasing. Therefore beam forming techniques are required which suppress these ambiguous azimuth signal energy.

This article provides an overview of the hardware aspects based on a design in X-band. Focus is put on digital beam forming algorithms adopted to the SAR case in azimuth and important performance figures are derived. Optimization potentials aiming at an improvement of the robustness of such DBF SAR systems are briefly addressed.

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