A High Resolution 2D Omnidirectional Synthetic Aperture Radar Scanner at K Band

Faiza Ali, Alexander Urban, Martin Vossiek

Institute of Electrical Information Technology,
Clausthal University of Technology
D-38678 Clausthal-Zellerfeld, Germany
{ali,urban,vossiek}@iei.tu-clausthal.de

Abstract— **In this paper a K-band 360° 2D imaging radar utilizing a synthetic aperture scanning principle is introduced. A small omnidirectional antenna is mounted on a rotating platform to create a circular synthetic aperture. Based on a broadband holographic reconstruction principle a high resolution 360° 2D image is calculated after each turn of the platform. The size of the synthetic aperture and thus the lateral resolution of the imaging system are determined by the diameter of the resulting circular antenna trajectory. In contrast to common radar scanner-concepts that utilize highly directional and thus bulky antennas, the proposed scanner concept has the advantage that it uses a small and lightweight omnidirectional antenna. This results in a much more compact radar system with notably relaxed requirements for the scanning mechanics. In addition it will be shown that the use of an omnidirectional antenna allows for very simple options to transfer energy to the radar on the rotation platform. The performance of the proposed SAR radar scanning method is illustrated with a 24 GHz FMCW radar sensor system.**

Keywords-FMCW radar; synthetic aperture; omni directional antenna, scanning.

I. INTRODUCTION

Radar scanning has been used for imaging and detection of objects for nearly a century [1]. Radar scanners are mainly used for aviation, navigation, space and military applications [2]. However, nowadays radar imaging also becomes more and more relevant for commercial applications in the area of robotics, automation, security and vehicular systems [3, 4]. In most cases, scanning radar utilizes a direct imaging method where the object scene is sampled line by line or sector by sector with a moved directional antenna or an array of antennas. The image is then created by combining consecutive radar brightness scans next to each other line by line. The lateral resolution of such a direct imaging method is dependent on the antenna beam angle. We can write:

$$\delta_{lat} \sim z_0 \cdot \lambda / D \ , \qquad (1)$$

where z_0 is the distance from the radar to the object scene, λ is the radar signal wavelength and D is the aperture size (i.e. approx. the antenna or array size). Hence, for a good lateral resolution large antennas must be used which results in a mechanically burdensome and bulky system.

It is well known, that images with a high lateral resolution can also be obtained using a synthetic aperture radar approach. In this case small omnidirectional antennas are used to acquire a hologram from which the final image is calculated in an additional reconstruction process. The lateral resolution of a SAR system follows (1) as well, but here D denotes the size of a synthetic aperture that is created by the antenna movement. It was shown e.g. by Klausing [5] that it is possible to create a high resolution 360° 2D image with a synthetic aperture radar with rotating antennas (ROSAR). Here it was suggested to mount omnidirectional antennas at the tips of the rotor blades of a helicopter to create a large circular synthetic aperture.

In the past, especially the commercial application of SAR principles was hindered by the huge computational load required for the reconstruction algorithms. However, as the capability of modern embedded systems increases steadily the SAR concept becomes more and more attractive and practical.

In this paper a high resolution synthetic aperture 360° 2-D imaging radar scanner is presented. The system is based on a FMCW radar unit and a small omnidirectional antenna that is mounted on a compact rotating platform.

II. SAR SCANNER CONCEPT

A. *System setup and signal specification*

The measuring concept and schematic system setup of the proposed SAR scanner is depicted in Fig. 1.

A rotating radar platform with a radius r_{sc} is located at the center of a coordinate system (x=0, y=0). The radar sensor comprises an omnidirectional transmit and receive antenna that is located at the edge of the circular platform at position

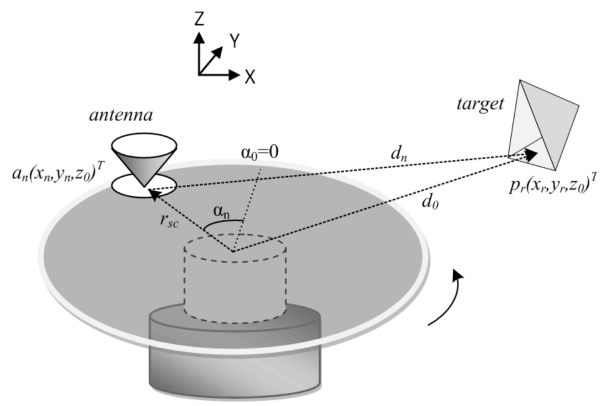

Fig. 1 Radar scanner and the measurement setup.