Foreign Object Debris Detection Using a 78 GHz Sensor with Cosec Antenna

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Abstract— **This paper presents the results of FOD measurements conducted using a broadband 78 GHz radar sensor. Previous studies with a short-range setup up to 30 m showed promising results. However, to meet the requirements of the intended application, the range has to be increased significantly. As for all radar systems, the range can be extended by increasing the transmitted power and/or the antenna gain. In this work two different folded reflectarray antennas with a cosec-shaped pattern have been used to improve the system performance and range. Together with a CFAR (constant false alarm rate) algorithm and a moving target indication advances could be achieved compared to the previous setup.**

I. Introduction

Since the last decade, Foreign Object Debris (FOD) detection on airport runways has been increased incessantly. Among the existing systems, we find those based on optical sensors like CDD cameras [1] or Lidar [2], and those based on mm-wave radars [3-4]. The system described in [5], which contains both radar and camera, can be located along airport travel surfaces and provides the real-time interrogation, visualization and approval of detected FODs with high speed and high resolution. Some of the above-mentioned approaches have been evaluated by the Federal Aviation Administration (FAA) in order to develop performance standards for FOD detection systems [6].

In our last work, a compact and low-cost broadband 73-80 GHz mm-wave sensor was used for FOD detection applications. High sensitivity and simultaneous objects detection capabilities were shown with a short-range setup up to 30 m [7]. But an extension of the actual detection range is required by the intended application. As the power provided by off-the-shelve MMICs is limited, the range of the system can only be affected by the antenna characteristic.

In this paper, two different folded reflect array antennas with a cosec-shaped pattern have been used to improve the system performance and range. Together with a CFAR (constant false alarm rate) algorithm and a moving target indication, advances were achieved compared to the previous setup.

Section II deals with the radar sensor, antenna, and the signal processing of the FOD detection setup. Section III treats the description and interpretation of the results issued from the tests performed on the Aix les Mille Airport in September 2009.

II. Radar Sensor, Signal Processing, and Antenna

A. Sensor Overview and Signal Processing

The same FMCW (Frequency Modulated Continuous Wave) radar sensor as in the previous work [7] was used for the FOD measurements. It comprises a PLL-stabilized synthesizer and operates at frequencies from 73 GHz to 80 GHz. A block diagram of the sensor is shown in Fig. 1.

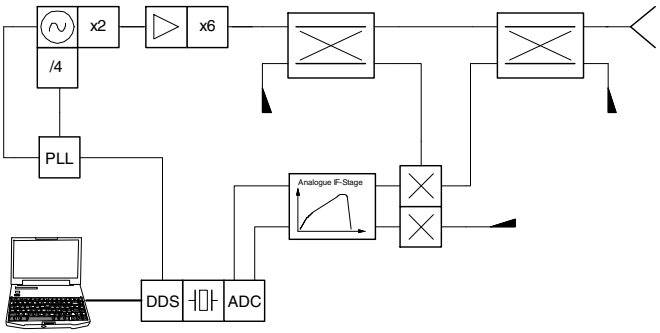

Fig. 1 Block diagram of the FMCW sensor used for foreign object detection.

As for most FMCW systems the range processing is done using a Fast Fourier Transform (FFT) of the intermediate frequency signal together with appropriate windowing. In addition, four subsequent measurements have been integrated to improve the signal to noise ratio.

A mechanical scanner was used for cross range imaging. The step size of the scanner was about 25% of the antennas' azimuthal beamwidth. This enables the application of an