RBX: THE NEW X-BAND RADAR FROM INTA

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1. INTRODUCTION

The Spanish National Institute of Aerospace Technology (INTA) developed, in 2004, its first airborne Synthetic Aperture Radar (SAR) system. This system, named RIX, provides its users access to raw and ancillary data to generate two-dimensional SAR images, however, it is limited to a 75MHz bandwidth and a single polarization. Since its first flight in 2004 this system has been improved, to correct shortcomings in the design and include new capabilities. In parallel to the maintenance on RIX, and using the experience obtained, the design of a new system was started. The new prototype, named RBX, should provide the necessary capacity for new development and research in SAR technology. This system was designed to provide more flexibility, allowing easy modification in order to adapt to new requirements or provide new functionality. This paper describes the main characteristics of the RBX prototype.

2. GENERAL OVERVIEW

The primary goal for the new system specification was to design a prototype with a performance on par with that of current systems[1][2], however, combined with a high degree of flexibility, permitting easy modification of the system for research purposes. Additional requirements were that the data quality of the system would be excellent. Planned capabilities for the system include interferometry and polarimetry allowing research on detection and classification. Also planned is the ability to process images in real time, to enable an on-line check that the system is working correctly, but also for a future use in Unmanned Autonomous Vehicles (UAV) with a ground station for processing and data dissemination.
To do this, the system is divided in modular units with controlled interfaces. In this way, each unit can be updated or replaced with minimal need for modification in the other units.
To comply with the requirements, the system was designed with a bandwidth of 600MHz and 4 antennas (2 in H and 2 in V polarization), a real-time on-board processor and a great flexibility for system configuration, allowing nearly all the possibilities in the antenna selection, as well as adaptation of the parameters for the data acquisition (delays, window length, and so on). Additionally, in order to assure optimal the data quality, a special effort is invested in calibration techniques, including, acquisition of a replica of the transmitted signal, temperature measurement of critical components, etc.

3. MAIN FEATURES

This section describes the main features for the system in development. The key feature for obtaining the necessary flexibility is the use of programmable logic for both instrument control and for signal generation, data acquisition and data processing. This allows modification of the system behavior using FPGA reconfiguration, obviating the need for hardware changes.

3.1. Signal generation

The signal bandwidth is limited to 600MHz in the RF module, although the baseband module is designed to support the generation of a signal in quadrature at a sampling frequency of 1,2GHz, allowing a final bandwidth of 1GHz. The waveform data are stored in memory during system configuration and read for every pulse during system operation. With this methodology any waveform can be transmitted (including pseudo-random codes) as long as it does not exceed the generation bandwidth. This also enables compensation of the signal in order to correct for errors in the generation chain.
The system is capable of storing 8 different waveforms, and it is possible to select from these waveforms for each pulse. Another feature is that the system can measure the transmitted power and correct it to maintain the output power constant.

3.2. Signal acquisition

A main characteristic of the acquisition chain is a variable attenuator to adjust the signal input level as desired. Currently, the attenuation is fixed during a data take , but an option to implement an Automatic Gain Control (AGC) (selectable by user) is foreseen.
As in the generation chain, the baseband module supports the acquisition of a signal in quadrature at 1,2GHz. Subsequently, it is possible to filter the data, with a variable length filter, for sub-sampling and storage in the onboard storage unit.

3.3. Real time processor

The system has an onboard real time (RT) processor implementing the chirp scaling algorithm[3], which includes a first order motion compensation and an expected resolution of approximately 5 meters. This processor is implemented in COTS boards with PPC processors connected using high speed buses to share the data.
Before the data are passed to the RT processor, the system uses a dedicated FPGA to do data preprocessing, such as data filtering, reducing the computational load of RT processor.

3.4. Synchronization and timing

The system has a 10MHz master clock with high stability, from which all other frequencies, among which the 1.2GHz clock, are derived. Generation and acquisition clocks are synchronized, and compensation is provided to keep delays in the generation and acquisition chains, introduced by the use of PLL´s internal to the converters and timing unit, constant during the system use.
The system supports a large flexibility in the generation of triggers for various components, because it can generate, for each trigger, any delay/length value pair, with values until 400µs in steps of 6,6ns. Also, the system generates a synchronization signal to a GPS/IMU unit at the maximum frequency supported by the GPS unit, to enable determination of the sensor position for each pulse.

3.5. Calibration

As described in section 2, the data quality is an important requirement for the system. For this reason, several calibration loops are implemented, at different stages in the analog chain, in order to measure any errors in different sections of the transmission/reception chain. These loops cover the path from baseband to RF, including the power amplifier.
An important feature is the possibility to acquire the generated pulse at the same time it is transmitted, using a coupler and a switch. In this way, an exact replica of the transmitted signal is obtained, which can be used in the processing step to adjust the matched filter. This replica acquisition can be made for each pulse (for every N´th pulse, as commanded) without affecting the bandwidth available for sending data to the storage unit.
Also, the system stores the temperature of temperature sensitive components. Thus, during the processing steps, it is possible to correct errors due to temperature variations using calibration characteristics obtained beforehand.

4. CONCLUSIONS

The Spanish National Institute of Aerospace Technology is finishing the construction of a new SAR system with high performances, which can support the developments that in SAR processing are carried out in his facilities. The design for this system is presented. It appears feasible to create a system with a high degree of flexibility - thus facilitating the research on SAR radar technology - that at the same time can provide state-of-the-art performance. The design also incorporates facilities for system calibration, providing both a better signal quality and data integrity.

5. REFERENCES

[1] Horn, Ralf; Nottensteiner, Anton; Scheiber, Rolf, "F-SAR – DLR's advanced airborne SAR system onboard DO228", Proceedings EUSAR 2008
[2] Dreuillet, Ph. Cantalloube, H. et al, "The ONERA RAMSES SAR: latest significant results and future developments", IEEE Conf. on Radar 2006.
[3] Moreira, A. Yonghong Huang, "Airborne SAR processing of highly squinted data using a chirpscaling approach with integrated motion compensation", Tans. on Geoscience and Remote Sensing, Vol 32, pp 1029-1040