Pre flight Evaluation of SAR Using Payload Preparation Unit

Ramakrishnan S, Anju Rao M, Thiruchelvi M, Peter Joseph Basil Morris,
Haroon Ahammed and Ramkumar A
Electronics & Radar Development Establishment, DRDO
anju.rao@lrde.drdo.in

Abstract:

Synthetic Aperture Radar Payload Preparation Unit (SPPU) is designed and developed to test the RF hardware as well as the processor functionality of the medium range Ku Band SAR system developed for the Unmanned Aerial Vehicle (UAV) for ground imaging and ground moving target detection. This unit is developed to test SAR on ground end-to-end before actual flight sorties. The SPPU hardware is catered to test the SAR system. This unit can generate analog SAR signal for the given digital SAR returns data generated offline and evaluate all the SAR processing algorithms capability in real time to clear the actual system on ground before flight evaluation and testing. The unit is also used to test and validate changes in the processing algorithms, by feeding the actual data collected on board the aerial platform and verifying the SAR system.

Key Words: Stripmap, UAV, SAR

I. INTRODUCTION

Synthetic Aperture Radar (SAR) is day/night airborne radar capable of generating ground-map images. SAR uses the motion of the vehicle to generate high resolution images. SAR consists of various sub-systems (LRUs) such as Digital Unit (DU), Exciter-Receiver Unit (ERU), Ground Exploitation Station (GES), Antenna assembly and Transmitter unit. The DU and ERU have complex functionality and the testing of these hardware units on ground for SAR functionality is not possible through standard equipment. Hence, custom-built equipment is required for testing SAR which is the SAR Payload Preparation Unit (SPPU). SPPU has the capability to up-convert the required digital SAR signal returns, simulated at baseband in Matlab, including the platform motion of the aircraft, to L Band signal at the system PRF rate and this SAR signal, after intermediate down-conversion, is in-turn fed to the processor for digital down conversion and SAR processing. The SPPU generates the SAR returns to check the system performance in real time scenario. SPPU is used in the lab for testing and clearing of both hardware and software prior to flight testing of the radar. This paper elaborates on the design and architecture of SPPU, followed by integration and testing of SPPU with SAR system.

II. SPPU FEATURES

The functional modules of SPPU are the following:

- Digital Board
- Analog board
- Clock synthesizer
- Power Modules

The digital board consists of high speed mezzanine connector with LVDS link to analog board through which the radar IQ data is transferred to high speed DACs at 1.2Gsps. Data from host machine is downloaded through USB/Ethernet/PCIe. DDR2 RAM is provided to store the raw I/Q data. Data from RAM is read out and sent to high speed DAC on real-time trigger using FPGA control. The Analog board consists of 2 channel high speed DACs with in-built in NCO and programmable phase and gain for individual channels. DAC outputs are connected to IQ modulators. The Clock synthesizer is a module for converting the input clock to required clocks, required for the operation of DAC and Digital board within the SPPU. All clocks in SPPU were derived from the 120MHz Sinusoidal Clock supplied to the unit. A power module within the SPPU enables all boards within SPPU to be operational from a single 230V AC 50Hz power supply. The physical configuration of SPPU is shown in Figure 1.

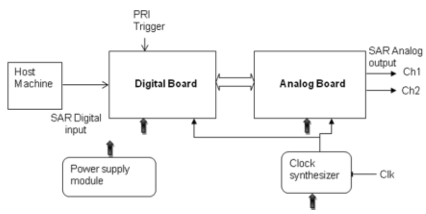

Figure. 1 Physical configuration of SPPU

IV. SPPU SOFTWARE GUI FEATURES

The software GUI allows user to enter system parameters such as pulse-width, bandwidth, PRF, interpolation factor etc. SPPU comprises of both the pulse compression as well as the De-ramp channels. Channels can be selected based on the mode in which the SAR system is configured. Provision is made in SPPU to store the IF data alone in the third channel where data is in the two’s complement format. A GUI snapshot of the configurable parameters is shown in Figure 2.0.

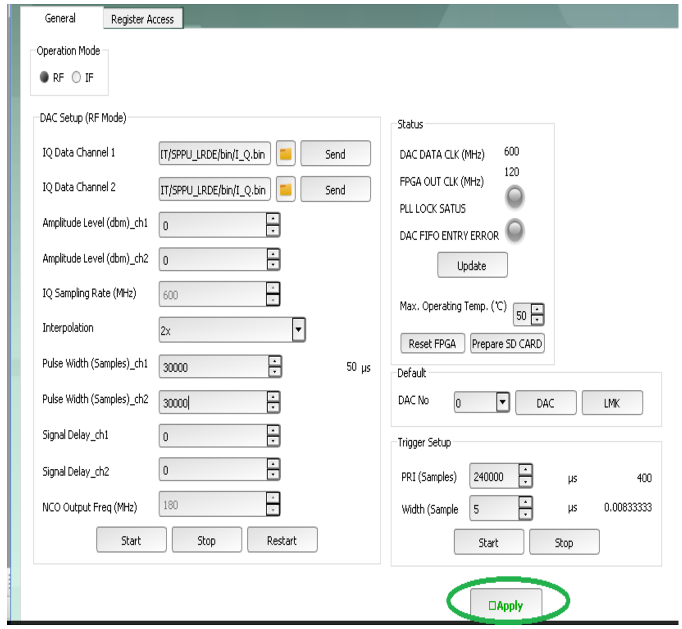

Figure 2 GUI Snapshot of SPPU configuration

V. TESTING METHODOLOGY OF SPPU

MATLAB has been used for the generation of SAR complex phase histories for the various scenarios of operation. The complex IQ data is stacked on to SPPU RAM module. The RAM module supports data storage of up to 4GB which helps in generating phase histories for distributed targets that form the SAR scene. The stored data is then passed on to the DAC module using the FPGA based on the external trigger supplied to the SPPU which converts the digital complex samples into analog waveforms. The process simulates every pulse return corresponding to the individual position of the platform in the SAR geometry. The analog pulse returns at 180MHz is then fed into the processing unit (Digital Unit) for digital down conversion and SAR image processing. The setup for the generation and processing of complex SAR returns is shown in Fig 3.0.

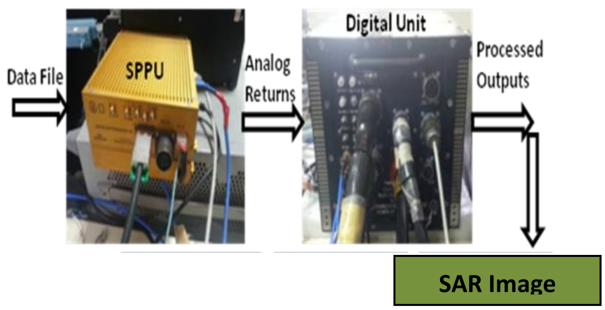

Figure 3. Test set up for SPPU

VI. TEST RESULTS

SPPU has been tested for its specifications. Digital I/Q data (LFM waveform for Stripmap-I mode of 50 microseconds pulse width and 40 MHz bandwidth) from PC is input to Channel 1 and the output waveform after up-conversion to L-Band frequency is checked for amplitude levels/ripple, bandwidth and pulse-width. Figures 4 and 5 shows a snapshot of the Stripmap-Mode-I waveform after up-converting to L Band.

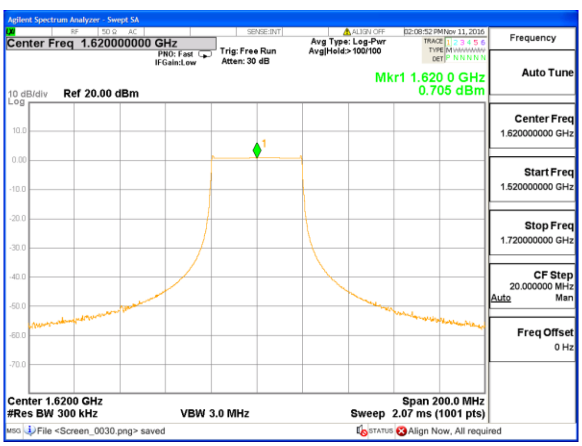

Figure 4. Output waveform after up-conversion to L-Band showing 40MHz bandwidth and 0 dBm power

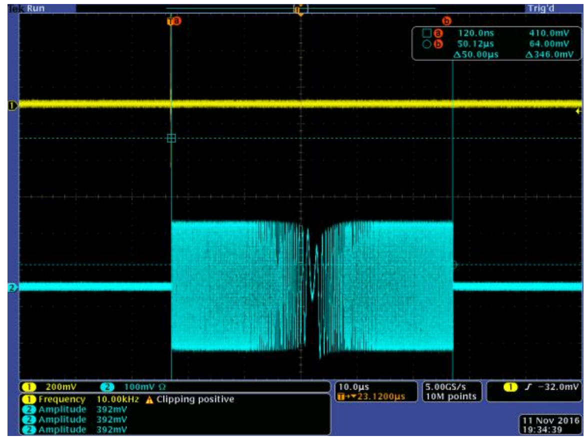

Figure 5. Output waveform after up-conversion to L-Band with 50 microsecond pulse-width

In the testing of imaging mode, SAR returns with multiple point targets distributed over the full range and azimuth swath is simulated in Matlab and fed into the input of SPPU channel 1. This is shown in Figure 6 a.

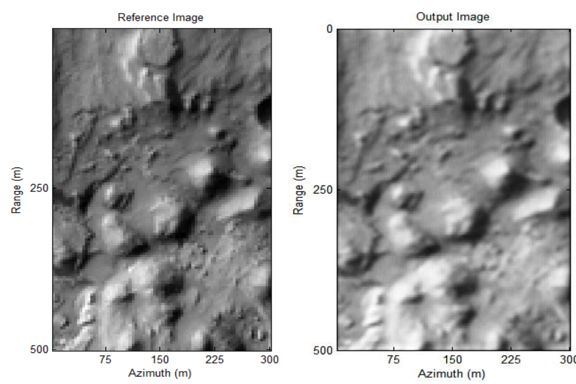

Figure 6. a) Input Image Data to SPPU; b) Output Image from SPPU displayed on HMI

This data after RF conversion (both up and down), digitization and image processing is magnituded and displayed at the HMI and is shown in Figure 6 b. The output of SPPU, displayed on HMI, is then compared visually with the input optical image for its correctness. It is further captured in the PC and evaluated for SAR image Quality Metrics.

VII. CONCLUSION

This paper presented the development and testing of an SAR payload preparation unit for testing of SAR system on ground. The paper has focused on the architecture of SPPU and the testing methodology that was employed to clear the SAR system on ground, both RF and digital, prior to aircraft sorties.

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BIO DATA OF AUTHOR(S)

Ramakrishnan S is Scientist F in LRDE, DRDO Bangalore. He is heading the design and development activities for Synthetic Aperture Radar and its variants. His main area of interests includes Active Array radars, Radar target Simulator and SAR.

Anju Rao M is Scientist 'E' in LRDE, DRDO Bangalore. She has been working in the field of Radar Signal Processing for Airborne Radar Systems. Her areas of interest include statistical signal processing and SAR signal processing.

Thiruchelvi M is Scientist 'E' in LRDE, DRDO Bangalore. She has been working in the field of Radar Signal Processing for Airborne Radar Systems.

Peter Joseph Basil Morris is Scientist 'D' in LRDE, DRDO Bangalore. He has been working in the field of Radar Signal Processing for Airborne Radar Systems.

Haroon Ahammed is Scientist 'D' in LRDE, DRDO Bangalore. He is working in the areas of waveform generation, FPGA design and SAR simulator. He is also involved in the system integration and testing of SAR on aerial platform.

Ramkumar A is Sc 'C' in LRDE, DRDO, Bangalore. He is working in the areas of embedded systems as well as SAR simulator. He is also involved in the system integration and testing of SAR on aerial platform.