QUASAR SBK ACCURATE INTERNAL CALIBRATION

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1.INTRODUCTION

QUASAR (Quicklook Unmanned Aerial SAR) project has started as part of INTASAR program activities, in order to involve INTA Radar Laboratory developments for UAVs and lightweight platforms[1][2]. At its complete development stage, QUASAR system will be an interferometric and fully polarimetric Ku-band sub-metric SAR with ground segment station for mission planning, image formation and data exploitation [3]. The first prototype of QUASAR flight segment: SBK (Ku-band sensor), to be available in 2011, will be based on previous developments from RBX [4], focusing the works in units miniaturization, new RF stages and Antenna unit development, and pod integration and operation [3].

As an operative system, SBK shall allow a precise calibration of the obtained data in order to achieve high product quality. SAR calibration can be divided into internal and external calibration stages [5]. Internal calibration purpose is to perform system variation tracking during Data Take by including hardware facilities in order to compensate the instrument instabilities. External calibration purpose is to estimate the whole system effect (including parts not covered by internal calibration) by using external reference targets of known RCS[6].

This paper summarizes the QUASAR SBK first prototype internal calibration, by presenting system internal calibration architecture, in flight calibration method and predicted calibration accuracy results. The external calibration of the system is out of the scope of this paper

2. QUASAR INTERNAL CALIBRATION ARCHITECTURE

Main objective of QUASAR internal calibration is to provide a simpler but operation flexible as time as accurate calibration method, reducing the on ground measurement previous flight campaigns and making easy after flight data processing steps. QUASAR internal calibration will be based on SBK internal calibration architecture and on ground characterization tasks during system development.

A. SBK Internal calibration architecture

To allow in-flight calibration of QUASAR system, an internal calibration facility will be included inside the radar payload. Figure 1 shows the QUASAR Ku-Band payload functional diagram. The system will be divided into three main units (fully developed by INTA). The SAR Operator Equipment (EAV) to control and monitor the system on board. The ANK (Ku-band ANtenna) unit: a double polarization planar antenna mounted on a gyrostabilized structure. The UER (RADAR Electronics Unit): based on the RBX UER [4] is the core of the system, containing all the electronics to provide the generation, control, formatting, and RF modulation/demodulation capabilities to the sensor. Three additional COTS unit are also included: a GPS/INS unit (UPA), a Storage Device Unit (UAD) and a Microwave Power Module (MPM).

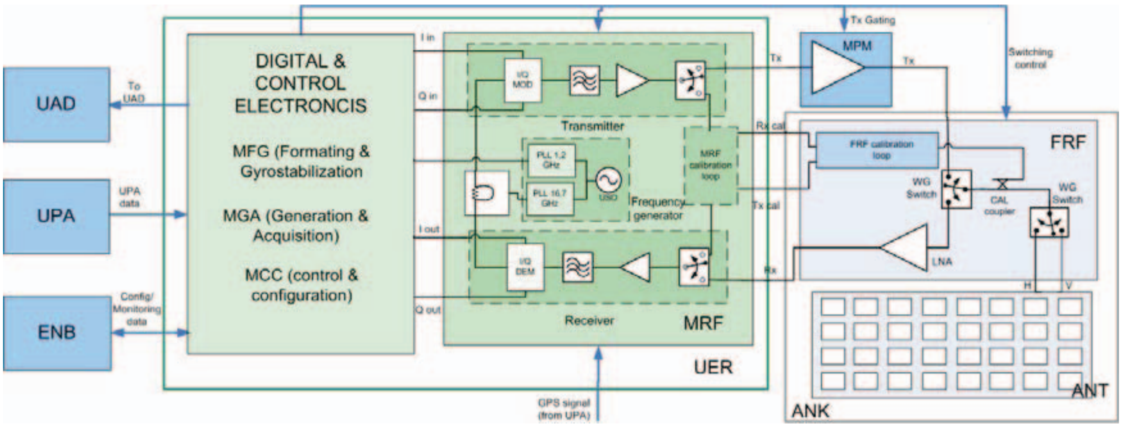

Figure1. SBK functional block diagram with detailed view of RF stages

From the radar signal path point of view, SBK RF stage starts inside UER where a RF Module (MRF) has to provide the up-converted chirp to MPM and down-convert the antenna received echo. MRF and MPM are followed by the RF Front-end Module (FRF) that performs Transmission/Reception switching and Polarization selection and the Antenna module (ANT) both inside the Ku band Antenna unit (ANK).

QUASAR internal calibration facility is based on the MRF cross-strapping internal loop and the FRF calibration loop, that would allow the system response estimation and tracking during its operation. As can be seen on Fig. 1 by means of the MRF module switches and the FRF calibration loop, three calibration paths can be selected: Transmission calibration, Reception calibration and MRF Internal calibration.

The selected architecture has the next advantages:

- A unique loop between FRF and MRF is shared for both transmission and reception calibration, reducing added components to system, thus reducing complexity and on ground characterization.
- The only component added in the critical part of design, that is, after MPM and before Rx LNA; is a waveguide coupler that presents low insertion losses. Noise figure and Transmitted peak power are not hardly penalized.
- To select the different signal routing, switches in MRF have been selected instead of couplers in order to isolate in a higher degree parasitic coupling of different calibration signals during each calibration type.

B. On ground characterization

Internal calibration facility response shall be measured and its variations have to be characterized in order to assure an accurate calibration method. In the case of QUASAR SBK the next parts shall be measured on ground:

- FRF calibration loop will be characterized over full bandwidth and full operation temperature range as its variations can affect the calibration results.
- A portion of MRF that is not directly covered when performing a MRF Internal calibration shall be measured in case of precise system response estimation is required.

To assure thermal behaviour compensation, both MRF and FRF internal calibration loop will be monitored in temperature during system operation, in order to apply the proper correction to calibration results.

3. IN- FLIGHT CALIBRATION METHOD

QUASAR calibration method will follow a concurrent calibration philosophy, where the calibration is performed while the data acquisition of radar echoes, by the use of three calibration pulses: Transmitter calibration Pulse, Receiver calibration Pulse, and MRF calibration pulse, of same characteristics as those used in radar operation.

QUASAR internal calibration data will be used in two different ways:

- To track the system amplitude and phase variations to compensate for possible instrument components instabilities during a data take in order to achieve a high radiometric stability of QUASAR products.
- To estimate system response by means of chirp replica derivation to be used during product generation if desired in order to reduce IRF degradation due to system.

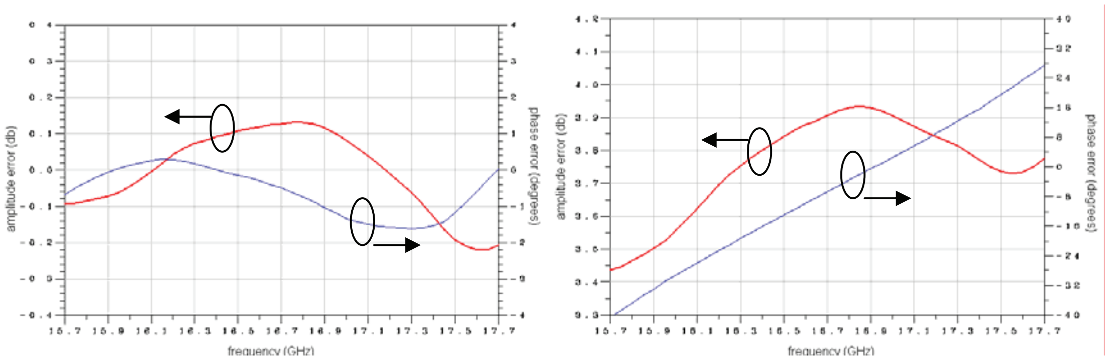

Figure 3. Amplitude and phase estimation error vs. transmitted frequency: (left) corrected response with on-ground characterization data, (right) non-corrected

By different combinations of the three pulses, variations in TX path, in RX path or in the whole system can be measured. Furthermore, by addition of MRF cross-strapping path and FRF Calibration loop on ground characterization data, whole system frequency response can be measured, by means of replica reconstruction.

Figure 3 shows the accuracy of estimated system response. Amplitude error of less than 0.3dB and phase error of less than 1.5º can be achieved.

CONCLUSIONS

In the present work QUASAR Ku-band radar payload (SBK) in flight calibration concept is presented. By means of a simple but operation flexible internal calibration facility scheme, an accurate on ground characterization plan, and a flexible in flight calibration method, not only different system parts variations but also whole system variations during operation can be tracked. In addition, the presented calibration concept can be used to retrieve system frequency response by means of replica reconstruction. QUASAR calibration method can achieve an error of less than 0.3dB/1.5º in system response estimation.

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