AN INTERNAL CALIBRATION SCHEME FOR POLARIMETRIC SYNTHETIC APERTURE RADAR SYSTEM

Shuo Wang [1], Weidong Yu [2], Haiming Qi [2]

1. Graduate University of Chinese Academy of Sciences,
2. Institute of Electronics, Chinese Academy of Sciences,
Tel: +86 010 5888 7157, E-mail: kukata@163.com

ABSTRACT

Introduction. Extensive investigations have been devoted to the external calibration of polarimetric SAR, which is carried out utilizing on-ground targets. External calibration can provide radiometric, polarimetric and geometric calibration of SAR. But its effectiveness is limited by calibrator deployment or targets location. Internal calibration, on the contrary, can be carried out without these restrictions. It tracks the instantaneous performance of the radar system by transmitting calibration pulses and collecting them through a dedicated network of signal paths inside the system (internal calibration loops). It makes comparable the images of different areas obtained at different time and is a means of relative calibration.

System structure. An internal calibration scheme for our polarimetric SAR system (shown in Fig. 1) is proposed. The system transmits H-pol or V-pol signals alternately and receives both polarizations at the same time. The two polarization channels are implemented within each transmit/receive module (TRM), as shown in Fig. 2. The two channels share a common calibration port (port C). And, calibration ports of all the TRM's are connected to a power combiner, to minimize the number of cables used.

Individual TRM calibration. One of the main tasks of internal calibration is to obtain the in-orbit status of each TRM [1]. Dual-channel TRM gain and phase calibration is carried out using Orthogonal Phase Coding (OPC), in which signal of individual TRM is phase-coded according to a set of orthogonal codes in order to be separated from the composite calibration signal of all TRMs [2] [3]. The OPC method uses one bit of a digital phase-shifter for encoding, without the need for additional encoding hardware. Performance of the method is examined in different signal-to-noise conditions.

TRM failure detection. There are cases when one or several TRMs failed to function, once mounted on the platform and subjected to the harsh environment of space. Calibration results are given both in cases of TRM amplifier or phase-shifter failure. The normal TRMs' gain and phase values are close to their true values, while those mal-functioning ones shows an evident noise-like behavior, which could be used to pick them out (Fig. 3). The simple way to detect TRM mal-function is verified through simulation, and it is also in accordance with TerraSAR-X in-orbit calibration outcome [4]. We have also discovered an inherent flaw when using Hadamard matrices for encoding, i.e., the calibration result of the TRM coded by the first row of Hadamard matrix is always erroneous in case of a phase shifter failure of another TRM. Zero-padding is used to eliminate such error.

Crosstalk analysis. In view of the structure of TRM, it is worthwhile to examine the impact of imperfect isolation on the calibration result between the two polarization channels. A crosstalk model (Fig. 4) is developed to investigate it and a way to reduce this error is also given, using pre-launch tested parameters.

System gain. At last, system path gain variation is measured utilizing the internal calibration loop. The system gain (including magnitude and phase) calibration scheme involves three steps, namely, transmit path calibration, receive path calibration and reference calibration.

Conclusion. Simulation results show the OPC method has an accuracy of 0.2 dB for gain and better than 2° for phase, with signal-to-noise ratio of 10 dB and perfect isolation between the two polarization channels. The error due to imperfect isolation is usually small and can be ignored. The simple way to detect TRM malfunction is verified through simulation, and it is also in accordance with TerraSAR-X in-orbit calibration outcome. The proposed OPC method is shown to be an effective way of internally calibrating TRMs of phased array antenna.

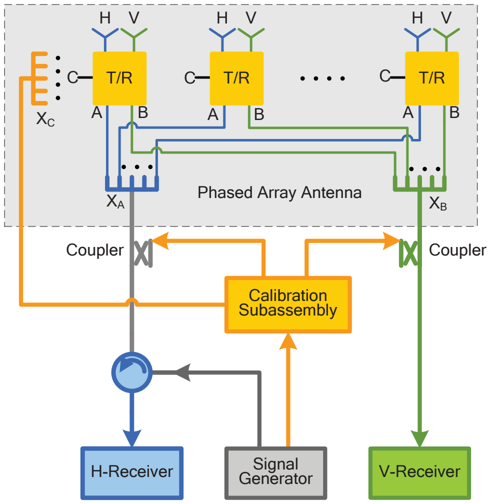

Fig. 1. Block diagram of the system internal calibration loop.

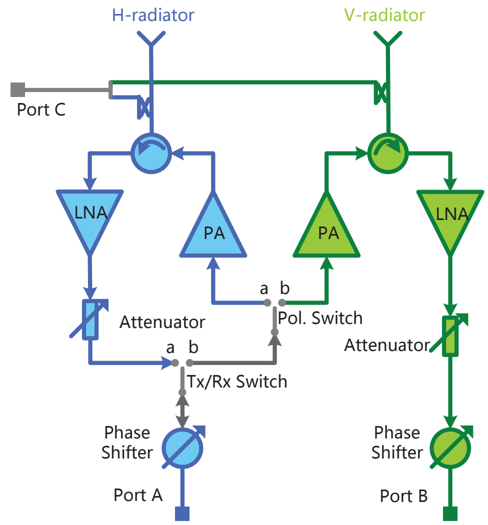

Fig. 2. Block diagram of a dual-channel TRM.

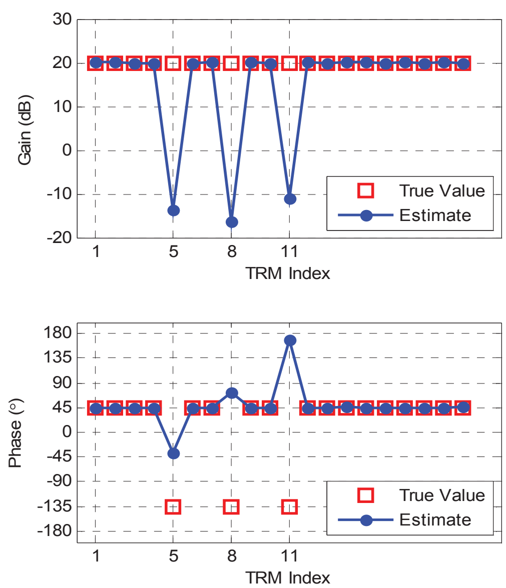

Fig. 3. H-channel transmit characteristics calibration result using the proposed OPC method for 20 TRMs with failed phase shifters. SNR=8 dB. The TRMs with failed phase shifters show a noise-like characteristics.

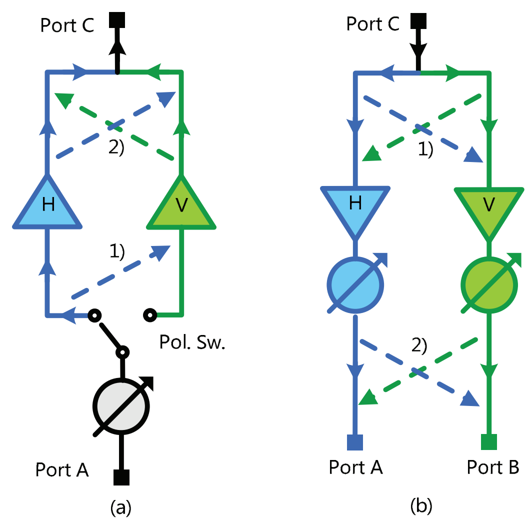

Fig. 4. Crosstalk model for only H-polarization transmit channel (a) and the two receive channels (b) of a TRM. The dashed lines with arrow point out signal leakage direction between H- and V-channel.

11. REFERENCES

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