T/R Module Performance Monitoring of the TerraSAR-X Active Phased Array Antenna

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Abstract

The German remote sensing satellite TerraSAR-X, launched in 2007, hosts a flexible X-Band synthetic aperture radar (SAR) operating in Stripmap, Spotlight, ScanSAR, and additional experimental modes. For these various antenna beams, its active phased array antenna electronically steers and shapes the patterns in azimuth and elevation direction. The array consists of 384 radiating sub-arrays for horizontal and vertical polarisation each. Each individual array element is controlled by a transmit/receive (T/R) module to adjust phase and gain in a very short time.

The TerraSAR-X antenna with a large number of T/R modules and radiators is designed to be insensitive to contingencies like those of individually failed or drifting modules. However, it is necessary to detect such failures and characterise the T/R modules for consequences on the performance. Precise modelling of the antenna is only possible, if the actual characteristics of each individual T/R module are known.

Individual measurements on T/R modules would only be possible if all modules except the one being characterized are switched off. This procedure is implemented as module stepping mode in the ASAR instrument of ENVISAT with each module measured separately. Consequently, the characterisation does not represent the actual status of the operating modules due to the different power supply loading in this mode.

Performance monitoring of T/R modules under most realistic conditions require the same power loads like in the nominal mode with all T/R modules operating. Thus, TerraSAR-X has been equipped with an additional calibration mode based on the so-called "PN Gating method". The PN Gating mode allows operating all individual T/R modules under most realistic conditions with the advantage that all modules can be characterised simultaneously. For the first time ever, the technique, implementation, and reliability are confirmed by in-orbit measurements of a SAR satellite system.

This paper demonstrates the excellent accuracy of this novel characterisation technique down to accuracies of better than 0.1dB. During on-ground characterisation of the TerraSAR-X instrument this technique has established as a crucial diagnostic tool for functional checks. After launch, this innovative method is applied for in-flight performance monitoring of the TerraSAR-X antenna front-end. The technique described above is also applicable for characterisation and calibration of other advanced sensor systems coping with active phased arrays.