Miniaturized LTCC based C-Band transmit receive integrated module for EOS-04 SAR payload

Ravi Khatri*, Yudhbir, Kare Mounika, Jolly Dhar and Ch. V. N. Rao

Space Applications Centre, Indian Space Research Organisation, Ahmedabad 380 015, India

This article presents the design, development and realization of miniaturized C-Band transmit receive integrated module (TRiM) for Earth observation satellite-04 (EOS-04) synthetic aperture radar (SAR) payload. State-of-the-art low temperature co-fired ceramic (LTCC) technology is used for localized hermetic sealing of bare microwave monolithic integrated circuits (MMICs). A miniaturization of ~35% is achieved in this TRiM as compared to Radar Imaging Satellite-1 TR module, enabling >100 kg reduction in the overall EOS-04 SAR payload mass. The design of LTCC module is done using Ferro A6M-E and DuPont 951 based LTCC processes. Two such dual polarized LTCC TR modules along with *in situ* TR controller are housed inside a single TRiM housing. More than 13,000 MMICs are fabricated indigenously and utilized for the development of the TRiMs. About 350 such TRiMs have been mass produced through extensive participation of various Indian industries leading to the development and space qualification of several state-of-the-art processes. Measured transmit output power of >40 dBm, transmit gain >51 dB, receive gain >36 dB, noise figure <4.25 dB, phase error <4.5°, amplitude error <0.4 dB have been achieved for a 250 MHz wide bandwidth over 350 mass produced TRiMs.

Keywords: EOS-04, LTCC, MMIC, TRiM, TR modules.

Introduction

TRANSMIT receive (TR) [illegible] multiple imaging modes of EOS-04 are taken care by a 6 m × 2 m active phased array antenna with scanning capability in the elevation direction. The total active antenna is configured in 3 panels of 2 m × 2 m each, in deployable configuration. Each panel comprises of 4 tiles of 1 m × 1 m size, each consisting of 24 dual polarized transmit receive integrated modules (TRiMs). The total active phased array antenna comprises 288 dual polarized TRiMs. Apart from generating required transmit power of 10 W and low noise reception, the TR module provides precise control of phase of transmit signal and amplitude, and the phase of receive signal.

Since the TRiMs were required in bulk quantity, the major goals while realization of EOS-04 TRiMs were miniaturization, and production through Indian industry. To achieve these goals, state-of-the-art low temperature co-fired ceramic (LTCC) technology[6] was used for the design of TR module along with extensive usage of indigenously developed gallium arsenide (GaAs) based microwave monolithic integrated circuits (MMICs), which builds upon the heritage of RISAT-1. As compared to RISAT-1, where each MMIC was packaged in separate metal ceramic packages, in EOS-04 TRiMs, 10 MMICs are packaged in a single LTCC module. The LTCC module is designed using 10 layers of Ferro-A6ME green tape as well as DuPont 951 green tape. Along with the miniaturization achieved through localized sealing using LTCC technology, the front-end elements of the TR modules, viz. high power amplifier in transmit chain and low noise amplifier (LNA)