Design and Devlopment of an X-Band MPM for Airborne Radar Applications

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***Abstract*— An X-band microwave power module (MPM) with peak output power of 175W (minimum) with 20% duty cycle operation is developed in a compact volume for transient operation without any additional cooling. The MPM is configured with a solid state power amplifier (SSPA), a mini-Helix-TWT, the RF chain and a compact electronic power conditioner (EPC) put together as single integral module of volume around 270mm x 250mm x 115mm and weighing less than 6.5kg. A resonant converter topology with planar magnetics is incorporated in the EPC for better thermal management and enhanced efficiency. The paper describes various technologies incorporated in the MPM to meet the stringent airborne radar requirements.**

***Keywords*— Microwave Power Module, MPM; Electronic Power Conditioner, EPC; Traveling-Wave Tube, TWT.**

I. Introduction

A Microwave Power Module (MPM) is a compact transmitter configured with solid State Power Amplifier (SSPA) as the driver amplifier followed by a power booster mini Travelling Wave Tube (TWT) for achieving better efficiency and noise performance. The MPM is packaged as two halves in order to maximize the surface area for heat spreading for transient operation. The bottom half consists of the TWT, SSPA and RF chain with necessary isolator and directional coupler for protection and power monitoring purposes, respectively. The other half is packaged with compact electronic power conditioner (EPC) with an integral microcontroller based control logic. The configuration / block diagram of MPM is shown in Fig. 1 and the engineered model of the MPM is shown in Fig. 2.

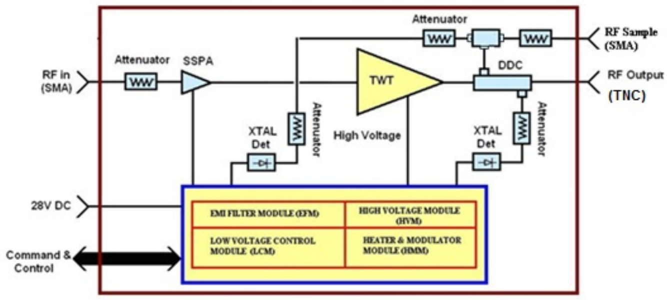

Fig. 1 X band MPM Block Diagram

Fig. 2 The engineered model of the X-Band MPM

II. The Electronic Power Conditioner (EPC)

The Electronic Power Conditioner (EPC) comprises multiple DC-DC converters configured for powering various electrodes of a TWT with built-in sequencing, fault monitoring and protection mechanisms besides a remote control interface. It is constituted with four major sections, namely, EMI Filter Module (EMIM); Low Voltage and Control Module (LCM); Heater and BFE Modulator Module (HMM); and High Voltage Converter Module (HVM). EMI Filter Module (EMIM) section comprises cascaded differential-mode and common-mode filters apart from two feed-through pi-filters to meet the EMI/EMC requirement as per Mil-Std 461E. Low Voltage and Control Module (LCM) section caters the entire internal housekeeping low voltage power supply requirements and the SSPA power requirement, and consists of microcontroller and CPLD based embedded control and monitoring electronics to implement protection, control and interface requirement for the MPM. High Voltage Converter Module (HVM) generates the high voltages for the Cathode and Collector electrodes of the TWT and is based on a full-bridge series resonant topology operating at 200 KHz to achieve better efficiency and power conversion density.

Heater and BFE Modulator Module (HMM) is multi-output half bridge converter powering the heater and BFE of the TWT. The EPC is packaged as shown Fig 3.

Fig. 3 EPC Modules Assembly

III. TRAVELLINJG WAVE TUBE AND RF CHAIN

A mini-Helix-TWT is developed to deliver an output power of 250W (min.) across the band with max duty of 21%. The tube is operated at 5.7 kV with a beam current of 260 mA. The total gain of the MPM is 54 dB and is shared between SSPA and TWT. The TWT provides gain of around 40 dB. The amount of excess gain is required to compensate the losses incurred in the input microwave chain from the input port of the MPM to the input of the TWT. The output of the TWT passes through a dual directional coupler. One coupling port samples the forward output power from the TWT and other coupling port samples the reverse power reflected from the load of the MPM. In case of load VSWR crossing the tolerable limit due to any reason, the detected signal at the output of the detector will be beyond a threshold value. This beyond-the-threshold value of reverse output power will be compared in the EPC and the high voltage to the TWT will be switched off if the reverse power goes beyond a specified value. This protection circuit saves the TWT from any irreversible damage due to load-mismatch.

IV. RESULTS AND DISCUSSION

Additive phase noise of less than 3 dB is achieved with respect to the input spectrum. The MPM weighed 6.5 kg, with a maximum power consumption of 250 W at full duty operation. The RF performance of the engineered MPM is shown in Fig. 4 and other critical parameters are given in Table I.

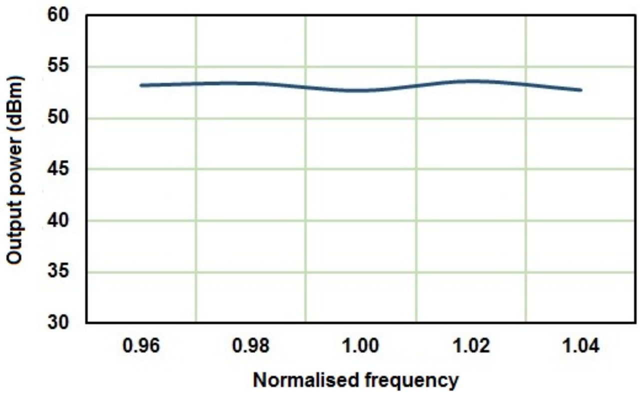

Fig. 4 RF output power

TABLE I RF PERFORMANCE OF THE X-BAND MPM

Near Carrier Phase noise @ 100 Hz offset for input purity of -78 dBc/Hz	-75 dBc/Hz
Beam off Noise Power Density	-95 dBm/MHz
Harmonics Levels	-7 dBc
RF Rise/Fall time	25 ns

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