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IMAP X-Band 10W GaN SSPA Design and Test Results

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The Interstellar Mapping and Acceleration Probe (IMAP) mission is set to launch in 2024. The mission's science objective aims to improve the understanding of the composition and properties of the local interstellar medium by advancing the understanding of boundary region in which the solar wind and interstellar medium interact, identifying the processes related to the Sun's magnetic field and interstellar medium interaction, and identifying and understanding particle injection and acceleration processes near the Sun, in the heliosphere, and the heliosheath [1]. In addition to a suite of instruments for data collection, the spacecraft will rely on a 10W GaN Solid State Power Amplifier (SSPA) for the RF telecommunications X-band downlink. The SSPA was chosen due to the low Size, Weight, and Power (SWaP) compared to a Travelling Wave Tube Amplifier (TWTA).

The 10W GaN SSPA consists of an RF Amplifier box and a Power Converter Unit (PCU), each with their standalone housing, connected via an inter-box harness. The RF Amplifier box was designed, assembled, and tested at the Johns Hopkins University Applied Physics Laboratory (JHU/APL), building upon past design's as discussed in [2]. The RF Amplifier box consists of three hybrid amplifiers, an isolator, and DC bias circuitry. The hybrid amplifiers consist of two unique designs, two 3W hybrids and one 12W hybrid, each utilizing a purchased GaN transistor die and tuned to cover the Deep Space Network (DSN) near-earth downlink frequency band, 8450-8500 MHz.

A test fixture was designed to test the hybrid amplifiers individually. This was necessary for tuning prior to hermetically sealing the hybrid packages, as well as to gather large signal measurement data over temperature to influence the temperature compensation scheme. The temperature compensation is achieved via a thermistor in the gate bias circuit similar to that discussed in [3]. Once the hybrid amplifier testing was finished, the RF amplifier box was assembled and large signal measurements were made over temperature using a laboratory power supply. These measurements included power sweeps up to 4dB compression, 2^{nd} and 3^{rd} harmonic measurements at maximum RF input power, and DC power consumption. Finally, the full SSPA was subjected to environmental testing, which includes thermal vacuum testing from -25C to +55C and a powered 3-axis vibration test. The results from all testing above will be discussed.

References

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