Development of an X-band 600-W Pulsed Mini-TWT

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Abstract: *This paper describes the development of an X-band pulsed miniature traveling-wave tube (mini-TWT) at the Aerospace Information Research Institute, Chinese Academy of Sciences (AIRCAS). This mini-TWT can produce more than 600-W peak output power and 47.5% minimum overall efficiency over the frequency range of 9 to 10 GHz. It achieves a compact size less than 180mm (L) × 30mm (W) × 20mm (H) and weighs less than 0.3kg.*

Keywords: mini-TWT; X-band; high efficiency; high power

Introduction

Microwave Power Module (MPM) is a hybrid combination of solid-state and vacuum tube electronics, which encloses a solid-state driver amplifier, traveling-wave tube and electronic power conditioning modules into a single unit. Based on miniaturization and lightweight, MPM has higher efficiency and linearity than both ordinary TWT amplifiers and solid-state power amplifiers. With the growing demand for the microwave power amplifier, high efficiency, high power, miniaturization and lightweight are the future development direction of the microwave power module [1, 2]. Therefore, the development of mini-TWT is the key criterion for achieving high-performance MPM.

Design

In general, it is difficult to reach high overall efficiency in mini-TWTs with 600-W peak power and beyond owing to many technological challenges. These challenges include the high perveance electron beam, thermal design, and high-voltage breakdown issues. Besides, grid modulation enables high-speed pulse operation, but its existence on the electron beam trajectory affects beam focusing and results in the low total efficiency of TWTs.

The X-band mini-TWT adopted an electron gun with the non-intercepting double gridded structure and an M-type dispenser cathode. To obtain flat dispersion relations and high impedance, the helix slow-wave structure of this mini-TWT used three T-shaped BN support rods. The mini-TWT used an asymmetric three-stage depressed collector to achieve high collector efficiency and low back-streaming current.

TWT Performance

By leveraging an existing TWT product line, the AIRCAS has successfully developed an X-band helix mini-TWT. The X-band mini-TWT has provided saturated peak output power more than 600-W across 9 to 10 GHz. Table I describes the basic operating parameters and performance of the helix mini-TWT. The X-band TWT nominally operates at a 7.8-kV cathode voltage and achieves a compact size of 177.0 mm (length) × 27.0 mm (width) × 19.5 mm (height) with a lightweight of 0.27 kg.

Table 1. Operating parameters and performance

Frequency range	9 GHz to 10 GHz
Saturated peak output power	608 W min
Overall efficiency	47.5% min
Duty cycle	30%
Weight	0.27 kg
Dimensions	(177.0 x 27.0 x 19.5) mm^3

Output window physical model VSWR versus frequency tested by vector network as shown in Fig. 1, cold test results of the output window show that the VSWR is less than 1.20 in the operating frequency.

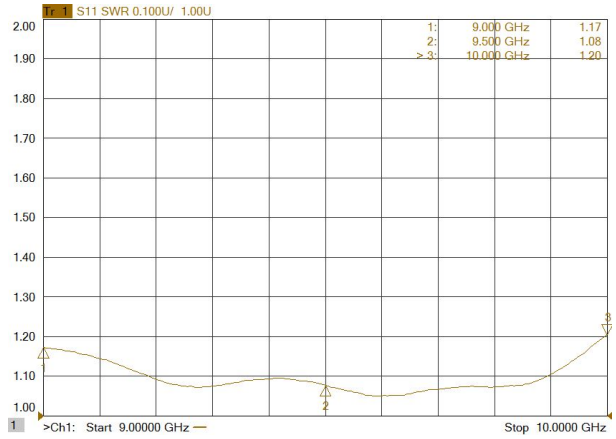

Figure 1. Output window physical model VSWR versus frequency tested by a vector network.

The saturated performance of the mini-TWT, measured at 30% duty, over 608-W minimum peak saturated output power with overall efficiency ranging from 47.5% to 50.5% across the 1 GHz full bandwidth as shown in Fig. 2.

Conclusion

In this paper, we have presented an X-band helix mini-TWT at the AIRCAS. The X-band mini-TWT can generate great than 608-W peak output power with 47.5% minimum overall efficiency over 9-10 GHz. The X-band mini-TWT also has achieved a small size of 177.0 mm (L) × 27.0 mm (W) × 19.5 mm (H) and a lightweight of 0.27 kg. We will continue to improve the performance of the mini-TWT in the future.

References

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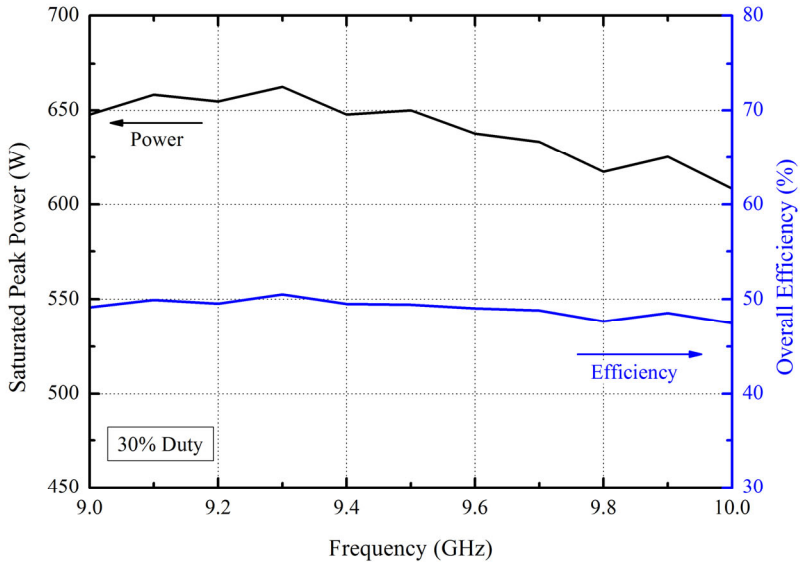

Figure 2. Measured saturated peak output power and overall efficiency at 30% duty.