# 1 kW S-band GaN HEMT Pulsed Power Amplifier Module for High Power Electromagnetic System

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## Abstract

This paper presents the implementation of a 1 kW S-band GaN HEMT pulsed power amplifier module. The measured results show efficiency higher than 37% and output power more than 60.22 dBm in S-band at a pulse width of 100 us with a duty of 1%.

**Keywords :** GaN HEMT High Power Amplifier

## 1. Introduction

As the state-of-the-art in solid state device technology advances, vacuum tube microwave device used in high power electromagnetic system as well as military radar system can be replaced with solid state power amplifier (SSPA). Especially, wide bandgap semiconductor materials like a gallium nitride high electron mobility transistor (GaN HEMT) have potential to operate at power densities several times higher than that of conventional silicon laterally diffused metal-oxide semiconductor (Si-LDMOS), gallium arsenide (GaAs), and silicon carbide (SiC) devices. Power density is a very important factor for high power devices because a higher power density enables a smaller die size and more easily realized input and output matching network [1].

GaN HEMTs have other advantages including high breakdown voltage, high saturated electron velocity, good thermal conductivity, low parasitic capacitance, low turn-on resistance, and high cut off frequency. Consequently, the superior properties of the GaN HEMTs are well suited to provide high power and high efficiency SSPAs in many RF and microwave systems, such as high power electromagnetic system, military radar, and high-data-rate satellite communication systems [2]-[5].

## 2. Design and Implementation

Figure 1 shows the block diagram of the 1kW S-band pulsed power amplifier module. It consists of a drive amplifier module, 4 pallet power amplifier modules, a digital control module, and a RF power combiner. A RF switch is used to operate pulse mode in a drive amplifier module. Digital phase shifter and variable attenuator are used to balance the phase and amplitude of the 4 pallet power amplifier module output signals. A photograph of the fabricated 300 W pallet power amplifier module is shown in Fig. 2. As shown in Fig. 2(a), the substrate used in the fabricated module is a Teflon substrate with a dielectric constant of 2.6 and a thickness of 0.504mm. The pallet power amplifier module includes three stages of amplification. In order to have high efficiency of the pallet power amplifier module, all amplifiers are designed to the switching-mode amplifier. Figure 2(b) shows a voltage regulator integrated circuit of the pallet power amplifier module. Figure 3 presents the measured output power and efficiency as a function of frequency at a drain bias voltage of 46 V. We have carried out the pulsed tests for a duty cycle of 1% and 0.1%, respectively, with a fixed pulse width of 100 us. The measured results show efficiency higher than 40 % and output power more than 54.32 dBm in S-band. A photograph of the implemented 1kW S-

band pulsed power amplifier module is shown in Fig. 4. Figure 5 presents the measured output power and efficiency as a function of frequency for a duty cycle of 1% and 0.1%. The measured results show a greater result than the efficiency of 37 %, and an output power of 60.22 dBm in S-band at a pulse width of 100 us with a duty of 1%.

## 3. Conclusion

In this paper, we have implemented a 1kW S-band pulsed power amplifier module with the packaged GaN HEMT device for high power electromagnetic system. Based on the switching-mode topology, we have designed and fabricated a high efficiency 300 W pallet power amplifier module. Output powers from 4 pallet power amplifier modules have equal magnitude and phase to meet the power output of 1 kW. The measured output power is more than 60.22 dBm and the measured efficiency is higher than 37% in S-band at a pulse width of 100 us with a duty of 1%.

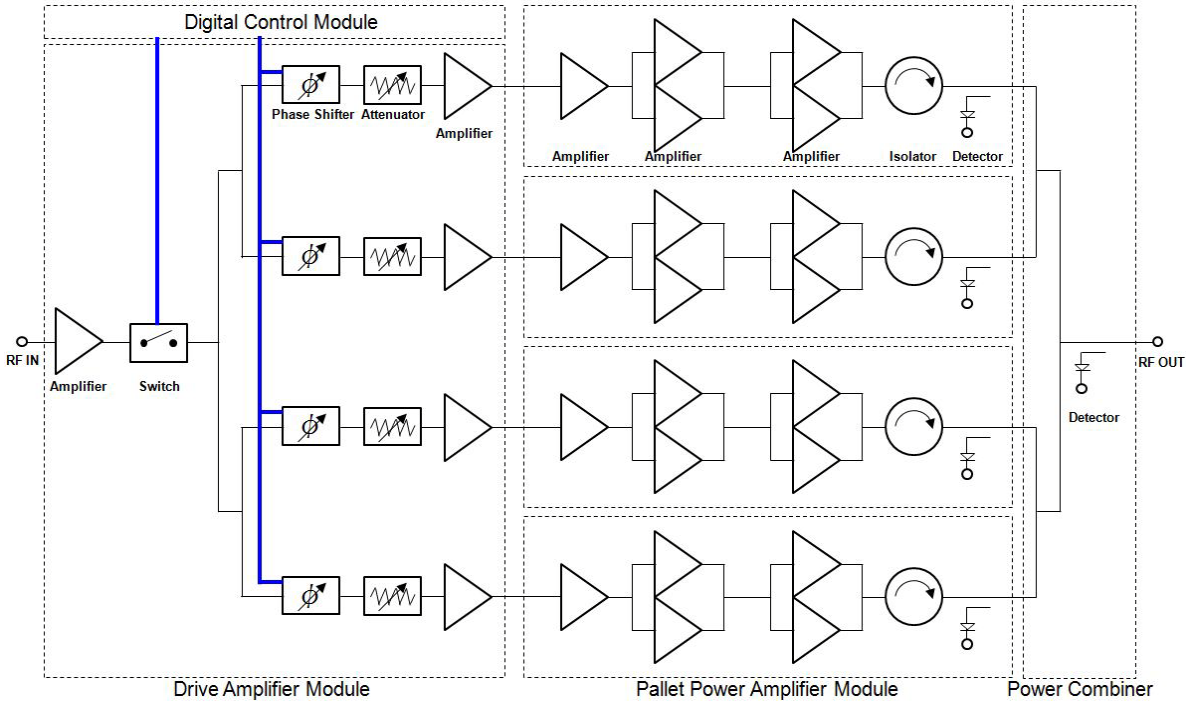
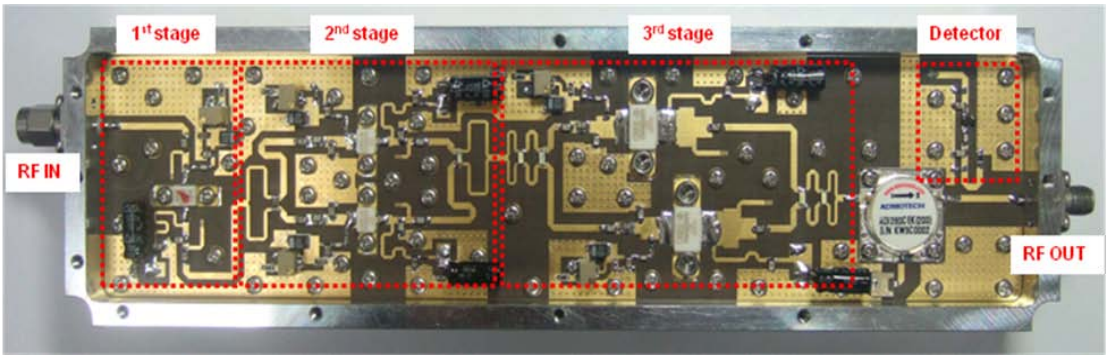
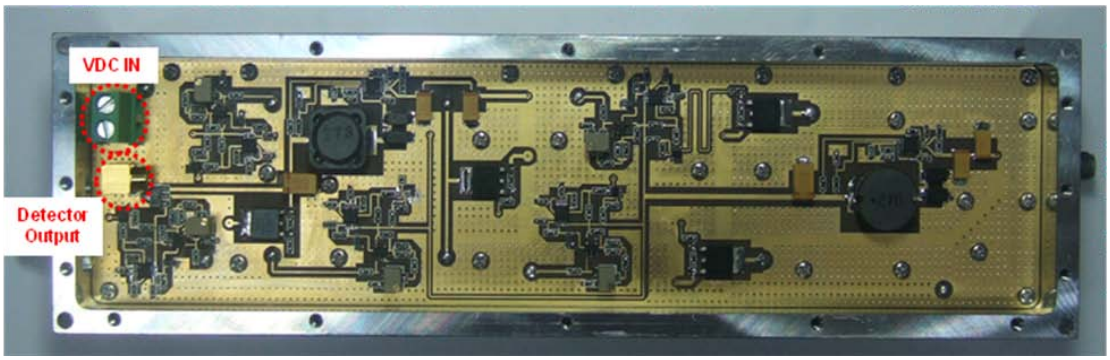



Figure 1: Block diagram of a 1kW S-band pulsed power amplifier module.

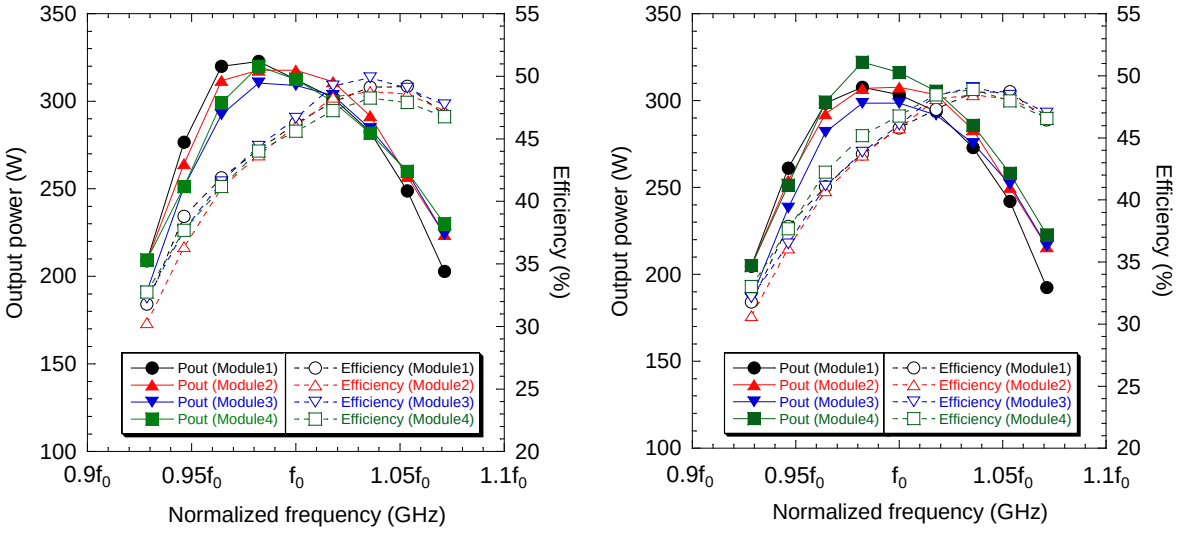



(a)




(b)

Figure 2: Photograph of a 300 W pallet power amplifier module; (a) top view, (b) bottom view.




(a) (b)

Figure 3: Measured output power and efficiency versus frequency; (a) duty: 1%, (b) duty: 0.1%.

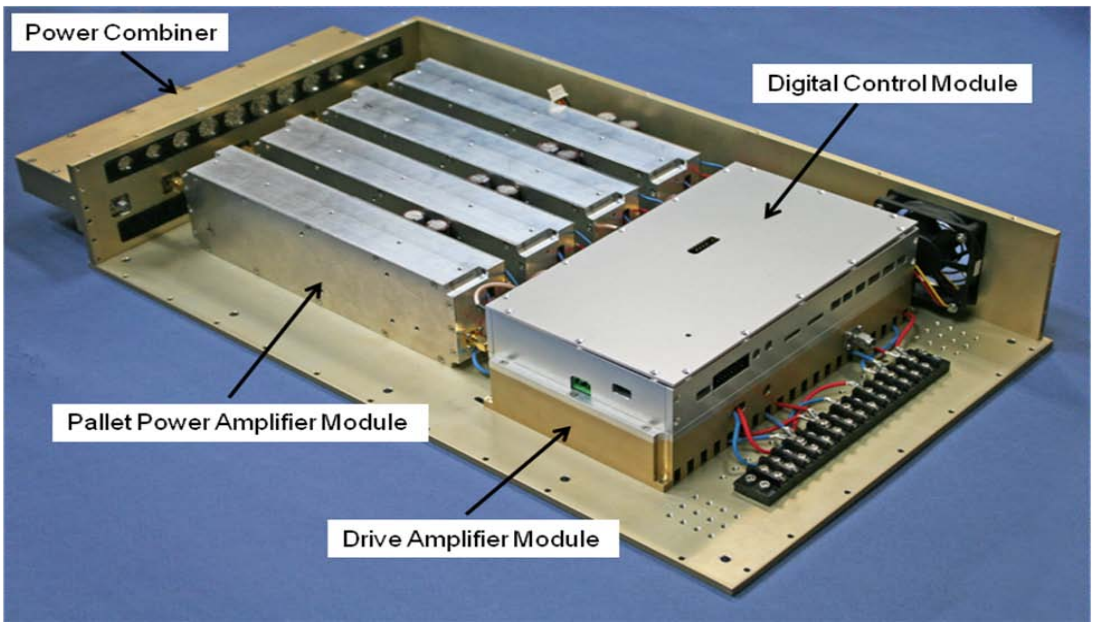



Figure 4: Photograph of a 1kW S-band pulsed power amplifier module.

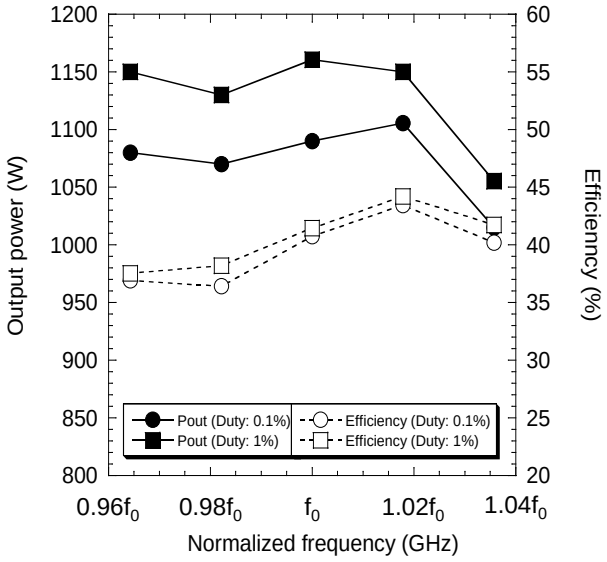



Figure 5: Measured output power and efficiency versus frequency.

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