A 25 WATT, 5 GHz GaAs FET AMPLIFIER FOR MLS

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A 25-Watt, 29-dB gain, 5-GHz FET amplifier for the transmitter in the Microwave Landing System has been developed using practical GaAs FETs assembled in ceramic packages with internal matching networks. This four-stage amplifier provides 30-Watt power output with 18.5% power efficiency at 17 dBm power input level.

Introduction

With the recent significant progress of power GaAs FETs, it has become possible to replace TWTAs by solid-state FET amplifiers in some microwave communication systems. To push the replacement still further, practical higher power devices under reliable operating conditions are required.

This paper presents a 25-Watt 5-GHz solid-state amplifier using practical power GaAs FETs assembled in ceramic packages with internal matching networks. The power FET amplifier was developed for the transmitter in the Microwave Landing System for the TWTA replacement. This four-stage amplifier provides 25-Watt power output with 29 dB gain and 18% power efficiency over the 4.9 to 5.2 GHz range. At 17 dBm power input level, 30-Watt power output was obtained. The amplifier exhibited excellent linearity, compared to TWTAs.

Internal Matching for Power GaAs FETs

The power GaAs FETs used in the amplifier are NE868496 in the first stage, V248A in the second stage, two V248Bs in the third stage and four V248Bs in the last stage. The newly developed V248 series power GaAsFETs[1] are assembled in 98 ceramic packages with internal matching networks. The V248A power FET has 15.2mm total gate width with one-chip structure. The V248B has two-chip structure with 30.4mm total gate width. The FET has gate-source cross-over structure and side metallization for source grounding. The single-chip FET measures 2.2x0.7mm.

The equivalent circuit for the internal matching network is shown in Fig.1[2][3]. The input internal matching network has a lumped-element two-section low pass form. The output matching network has a one-section semi-distributed form. The matching networks were designed with a CAD optimization based on small-signal S-parameters. The output networks were experimentally optimized using the equivalent load-pull measurements for trial devices with the matching networks.[2][3][4] A photograph of the internally matched V248B assembled in a 98 hermetically sealed ceramic package is shown in Fig.2. The input network consists of lumped-element capacitors and inductors. The low-loss capacitors were formed with a single 0.1mm thick ceramic plate, whose relative dielectric constant is 39. All inductors were realized by gold bonding wires 30 μm in diameter. The output network consists of bonding wires and microstrip stubs formed on a 1mm-thick alumina substrate.

The input-output response and output power response versus frequency for the V248B power FET are shown in Fig.3. The V248B FET has 8 Watt power output at 1 dB gain compression with 7 dB small-signal gain, over the 4.9 to 5.2 GHz range, without any external matching. The internally matched power GaAsFET V248A has 4.4 Watt power output at 1 dB gain compression with 8 dB small-signal gain.

Amplifier Description

A block diagram of the 25-Watt amplifier is shown in Fig.4. The first stage has an external matching circuit. The V248A and V248B stages have no external matching circuits, except phase adjusting stubs for power combining. This four-stage amplifier has a four-way power combining output stage consisting of four internally matched power FETs (V248B). Power dividing and combining are made with 3 dB branch-type couplers. Output stage power combining efficiency is more than 90%. Microwave microstrip circuits, including the 3 dB couplers and the first-stage matching circuit, were fabricated on 0.6mm thick teflon-glass fiber substrates (εr= 2.6). The amplifier requires 9V for drain bias power supply and -5V for gate bias power supply. The gate bias voltage for each FET is adjusted individually, considering power efficiency and nonlinearity.

Figure 5 is a photograph of the 25 Watt four-stage amplifier with the housing cover removed. Amplifier size, including the heat radiating fin, is 24x23x8.5cm.

Performance

Power output versus power input and frequency response for the four-stage amplifier are shown in Fig.6. The amplifier provides more than 25 Watt power output over the frequency range from 4.98 to 5.1 GHz and more than 20 Watt power output over the frequency range from 4.9 to 5.2 GHz, for 15 dBm input power level. It also covers the 4.9 to 5.2 GHz range with more than 25 Watt power output, and has 30 Watt power output with 18.5% power-added efficiency at 5.05 GHz, for 17 dBm input power level.

The AM/AM and AM/PM transfer characteristics are shown in Fig.7. The AM/PM conversion of the FET amplifier is approximately 1°/dB over the input dynamic range of 5 dBm to 18 dBm. These demonstrate superior linearity of the FET amplifier, compared to 6°/dB of a TWTA. The amplifier was evaluated over a wide ambient temperature range from -20°C to 50°C. Figure 8 shows the output power versus frequency at four temperatures, -20°, 0°, 26° and 50°C. The variation in output power over the temperature range was 2 dB at 15 dBm input power level, and the device channel temperature was estimated to be lower than 125°C at 50°C ambient temperature under the forced air cooling condition.

Conclusion

A 25-Watt 5-GHz GaAs FET amplifier for the transmitter in the Microwave Landing System has been developed. The four-stage amplifier, using pracitcal GaAs FETs assembled in a package with internal matching networks, provides 25-Watt power output at 1 dB gain compression with 29 dB gain over the MLS-band. At 17 dBm power input level, 30-Watt power output was obtained with 18.5% power efficiency. The amplifier exhibited excellent linearity, compared to TWTAs.

Acknowledgements

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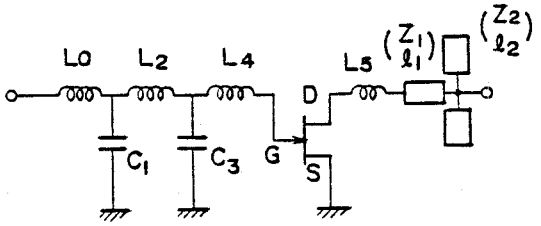

Fig.1 Equivalent circuit for internally matched GaAs FET.

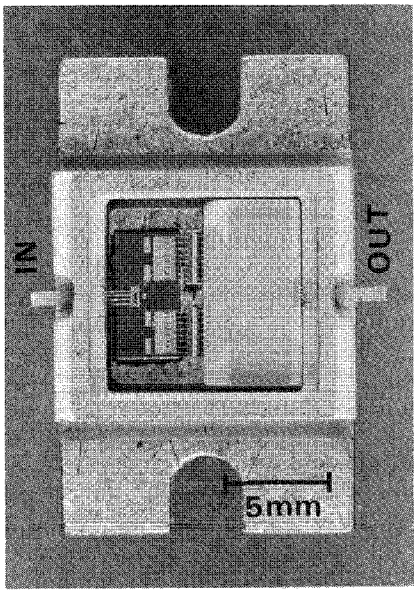

Fig.2 Photograph of internally matched FET V248B assembled in ceramic package.

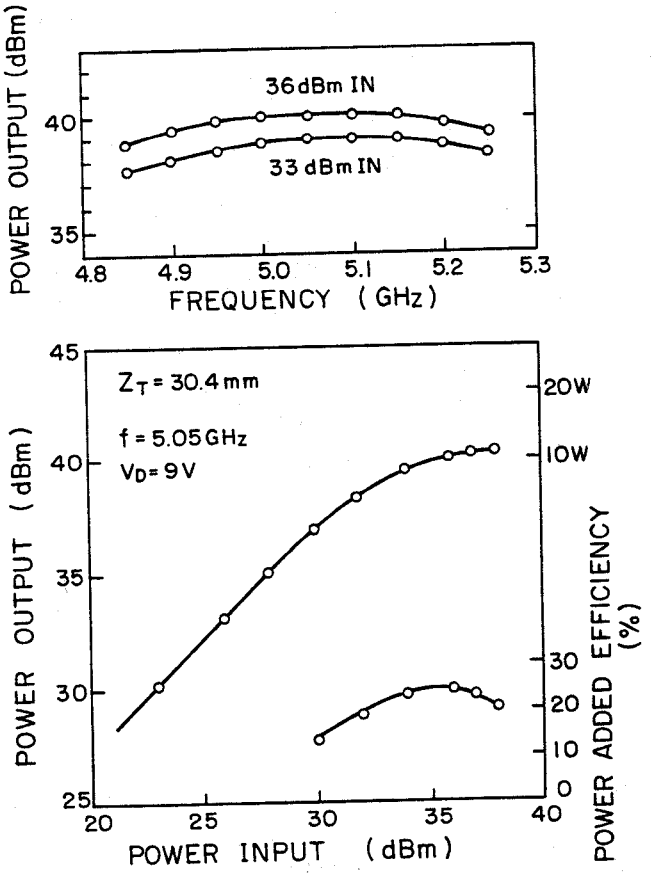

Fig.3 Internally matched power GaAs FET V248B performance.

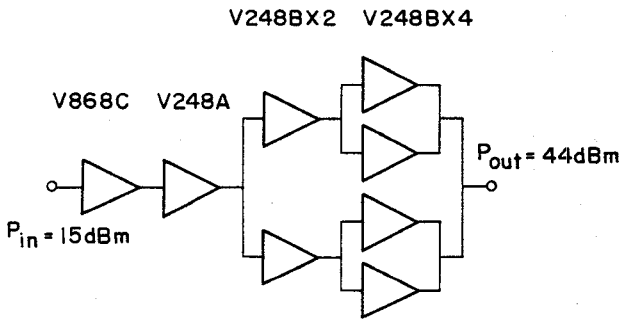

Fig.4 Block diagram of 25 Watt FET amplifier.

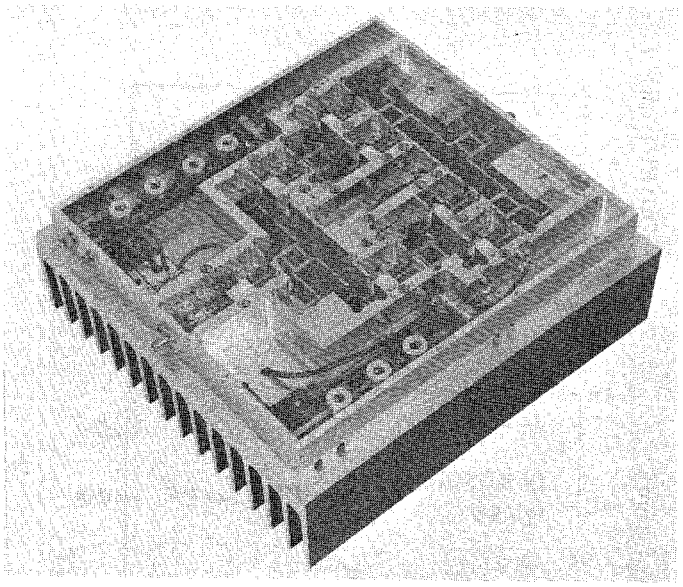

Fig.5 Internal view of 25 Watt FET amplifier.

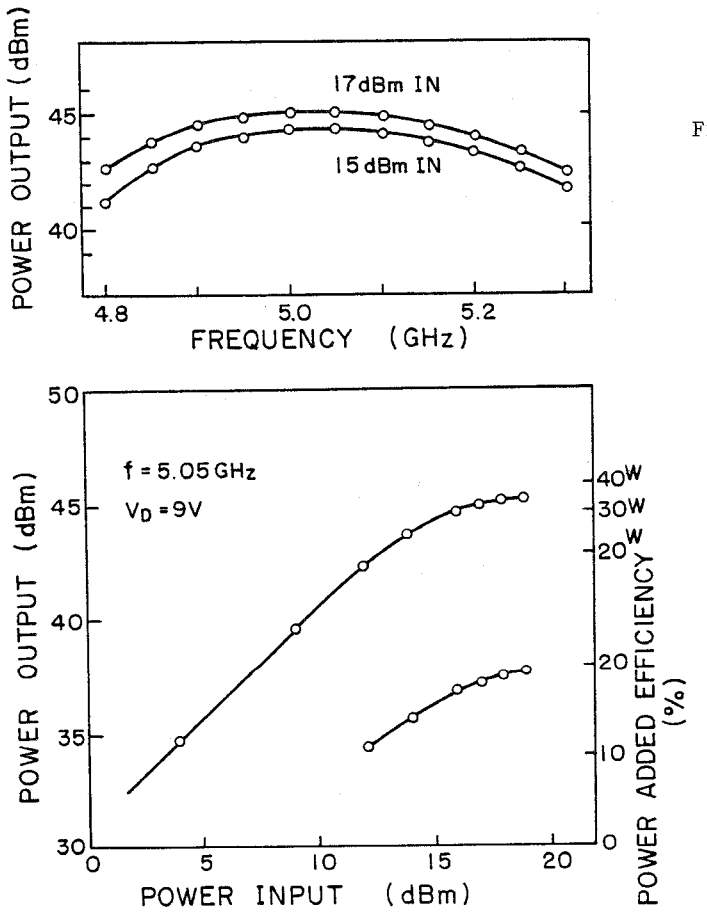

Fig.6 Four-stage GaAs FET amplifier performance.

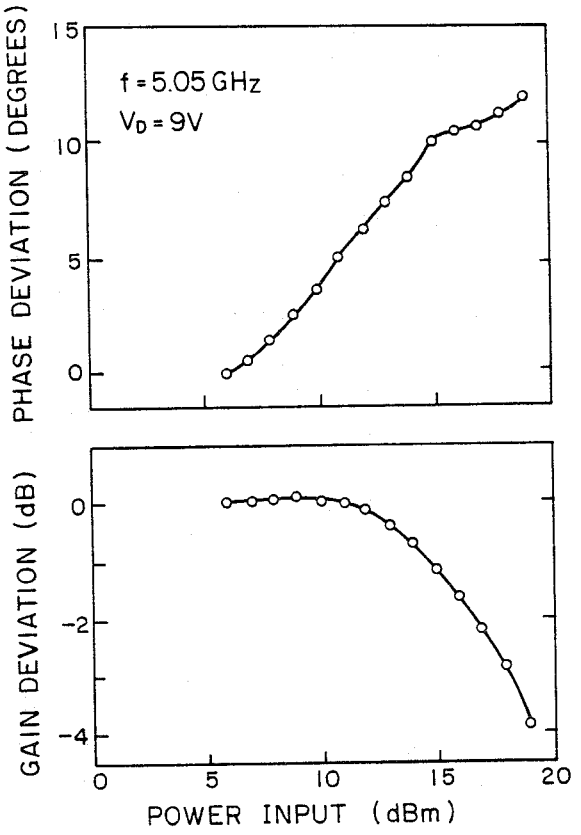

Fig.7 Transfer characteristics of four-stage FET amplifier.

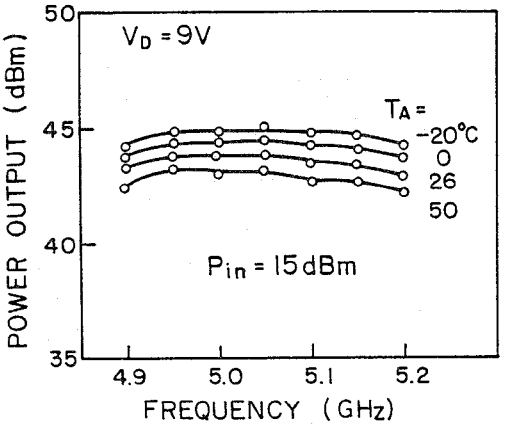

Fig.8 Output power versus frequency of FET amplifier at four temperatures, -20°, 0°, 26° and 50° C.