Microwave amplifier with power range of 5 - 18 GHz with output power of more than 10 W.

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Abstract: The report describes the design and characteristics of an ultra-wideband solid-state microwave power amplifier based on modern monolithic integrated circuits, providing output power of more than 12 - 16 W and efficiency of 14 to 20% in the operating frequency range from 5 to 18 GHz.

Keywords: ultrahigh frequencies, metal ceramic casing, power amplifier, gallium nitride, monolithic integrated circuit.

1. Introduction

Due to growing needs to reduce weight and size characteristics, reduce power consumption of broadband radio transmitting devices, the developers of microwave modules tend to use modern integrated components based on gallium nitride technology in the output stages of power amplifiers [1]. This solution greatly simplifies the amplifier design in comparison with solutions based on discrete GaAs transistors [2] while improving the basic parameters of the amplifier.

2. Amplifier design

The block diagram of the developed power amplifier is shown in Fig. 1.

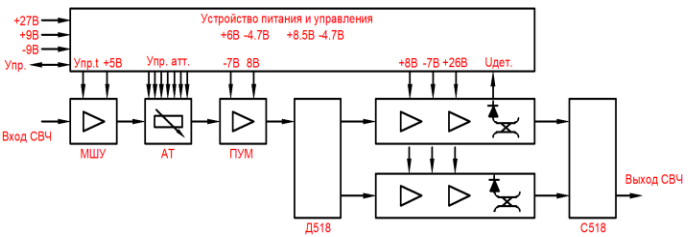

Fig. 1. The block diagram of amplifier

The diagram includes:

- input low-noise amplifier stage (LAS);
- digital five-digit attenuator (AT);
- the input LAS gain level control circuit for smooth compensation of the temperature drift of gain coefficient in the temperature range of minus 60 to +75 ºC;
- preliminary power amplifier, corrector of the frequency response and phase response of the amplifier path (PPA);
- divider and combiner (D518 and C518);
- two integrated amplifier modules made in a ceramic-metal casing containing the input balanced monolithic GaAs amplifier cascade of own design, GaN monolithic amplifier with distributed amplification with output power of 7-10 W, available on the market, and directional output power detector;
- power stabilizers, high-speed power modulator; buffer TTL logic elements of digital attenuator control, thermal compensation attenuator control circuit, temperature sensor, protection device (Power and control device).

The photograph of internal structure of developed amplifier is shown in Fig. 2. The amplifier housing is sealed, the elements of the power supply and control are located on the underside of the housing. The overall dimensions of the amplifier are 64.2 x 117 x 20 mm3, the weight is 300 g.

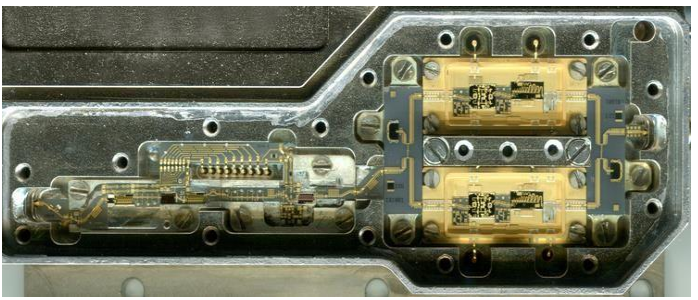

Fig. 2. Amplifier design

Figure 3 shows The photograph of the integrated amplifier module, made in an sealed metal ceramic microcasing developed in cooperation with Kyocera [3]. The overall dimensions of the case are 10.8 x 26 x 2.6 mm3, the weight is less than 5 g.

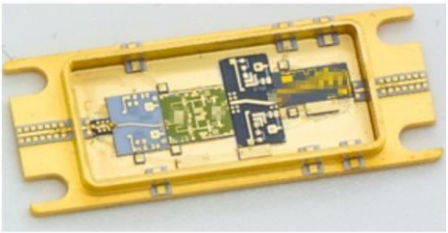

Fig. 3. The integrated amplifier module design

In the 5–18 GHz operating frequency band the module provides output power of more than 7 W with efficiency of 18–20%, low-signal gain of 18–20 dB, and VSWR of the input and output of no greater than 2.5. The module may be used independently, for example, in multi-channel amplification paths.

To summarize capacities of two integrated modules, a quadrature combiner with three communication areas was developed (general view shown in Fig. 2). The firm connection is provided by the central section in the Lange bridge form with clearance between conductors of 13 μm, and weak connection is provided by wide supply lines. This design allows effectively using its length and increasing broadband due to use of areas with different connection coefficients. The estimated parameters of combiner are shown in Fig. 4.

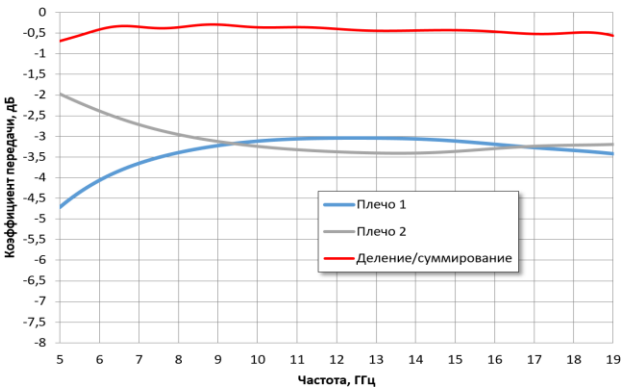

Fig. 4. The estimated parameters of the quadrature combiner used in developed amplifier

3. Principal characteristics of the amplifier

Fig. 5-7 provide standard characteristics of three models of developed power amplifier. In the temperature range of minus 60ºC to +75 ºC, the amplifier provides output power of greater than 10 W, with input power of 2 mW (gain compression of about 7 dB), the transmission coefficient in the low-signal mode of 44 to 47 dB. The efficiency of the amplifier is from 14 to 18% in the entire temperature range. The frequency response unevenness (Fig. 5) is about 3 dB, the VSWR of the input and output of the amplifier is equal or less than 2.5.

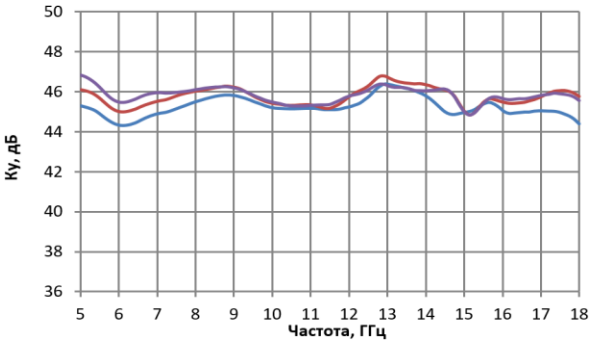

Fig. 5. Small signal gain

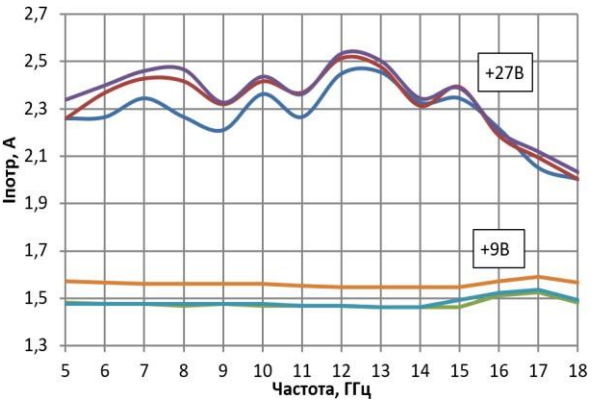

Fig. 6. Consumption currents in power circuits in saturation mode

With decreasing casing temperature, the output power grows, reaching 12-16 W under normal conditions with effective cooling of the amplifier casing (Fig. 7).

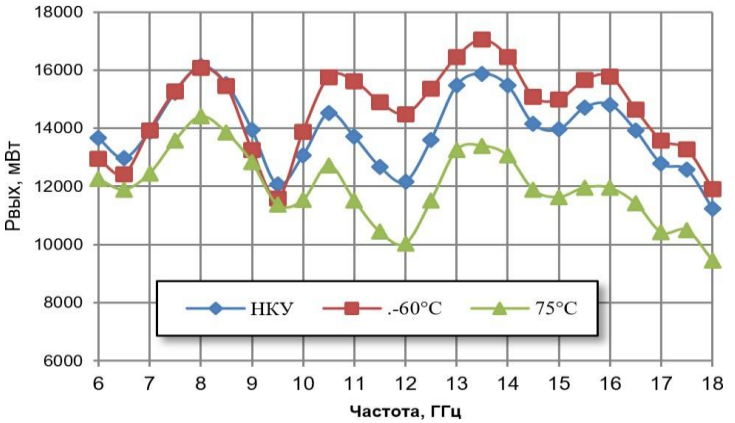

Fig. 7. Standard nominal output power (at Pin = 2 mW)

4. Conclusion

The results of development of an amplifier with output power of at least 10 W, operating in the frequency range of 5 to 18 GHz, which may be used as a terminal power amplifier in transmitters operating in continuous wave mode, are laid out in the present article. In terms of specific parameters (weight per unit of output power, hardware efficiency [1], cost of one watt of output power) the amplifier shows a 30-45% better performance than previously developed GaAs amplifier of similar frequency band [2].

Reference list

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