Paper

The 100 W class A power amplifier for L-band T/R module

Wojciech Wojtasiak, Daniel Gryglewski, and Edward Sędek

Abstract — In the paper a balanced high power amplifier with class A silicon bipolar transistors for L-band T/R module is described. The amplifier was designed for maximum power and minimum transmitance distortions. The obtained parameters of the amplifier are as follow: output power at 1 dB compression $P_{1\ dB} > 49$ dBm, linear gain $|S_{21}| > 10$ dB, and transmitance deviations during the RF pulse: phase $\Delta \arg(S_{21}) < 0.9^\circ$ and $\Delta P_{out} < 0.2$ dB.

Keywords — modeling, MESFETs, finite difference time domain method, power transistors, microwave transistors.

1. Introduction

For the last few years fast development of microwave power amplifier has been achieved. These devices are widely applied in radiocommunication and radiolocation systems [1]. The power amplifiers for T/R modules of active phased array radar should be characterized by small transmitance distortions. The recommended phase changes of transmitance during power pulse are less than $\Delta arg(S_{21}) < 1^\circ$, between pulses $\Delta arg(S_{21}) < 0.1^\circ$ at the power changes less than $\Delta P_{out} < 0.2$ dB [1].

The paper describes 100 W balanced power amplifier with two bipolar transistors designed at the Institute of Radioelectronics of the Warsaw University of Technology. The presented project is a continuation of a research work [2]. The significant improvement has been achieved.

2. The design method

The design procedure of power amplifiers has been exactly explained in the grant KBN report [3]. The described amplifier was designed with two silicon, bipolar transistors LFE15600X made by Philips. It's parameters are shown in the Table 1. These transistors are intended for use in common emitter, class AB amplifiers in CW conditions for professional applications. The amplifier described in the paper was worked in keyed class A mode.

The selected transistors, due to input and output inner matching sections, essentially are intended for amplifiers with a relative bandwidth less than 5% at $1.5 - 1.7$ GHz range. The outside input and output matching sections were designed in such way to change the frequency range into desired range of $1.28 - 1.42$ GHz. The developed algorithm with aid of universal microwave circuits simulator as well as an original, self-made computer program was used for calculation [3]. As a substrate RT/Duroid 6010 (Rogers Corp.), $\varepsilon_r = 10.8$, $h = 0.635$ mm was used. The layout of the amplifier is shown in Fig. 1.

Table 1
Parameters of the class AB power amplifier

Mode of operation	f [GHz]	U_{CE} [V]	I_{CQ} [A]	P_{out} [W]	G_{po} [dB]	η_c [%]
Class AB (CW)	1.5	24	0.2	55	8	50

3. Measurement results

The amplifier worked in keyed class A mode. This kind of work permit to increase the supply conditions of transistors. Quiescent bias point was: $I_C = 6$ A and $U_{CE} = 24$ V at open state of the transistors. The open time was 50 μs, duty factor 0.3% and the width of power pulse was 24 μs. The linear gain and output power at 1 dB gain compression point versus frequency is shown in Fig. 2. The characteristic of output power versus input power are presented in Fig. 3.

The measurements of transmitance distortions during RF pulse were made. The self-invented measurement system was applied [3]. The measured transmitance phase changes were less than $\Delta arg(S_{21}) < 0.9^\circ$. The "stability" of the output power was better than $\Delta P_{out} < 0.2$ dB during the RF pulse.

4. Conclusions

The measured amplifier parameters prove accuracy of used design procedure. The output power at 1 dB compression point exceeds 49 dBm, gain is better than 10 dB in band $1.28 - 1.42$ GHz. The amplifier's transmitance deviations during the RF-pulse are less than: 0.9° for phase and 0.2 dB for amplitude.

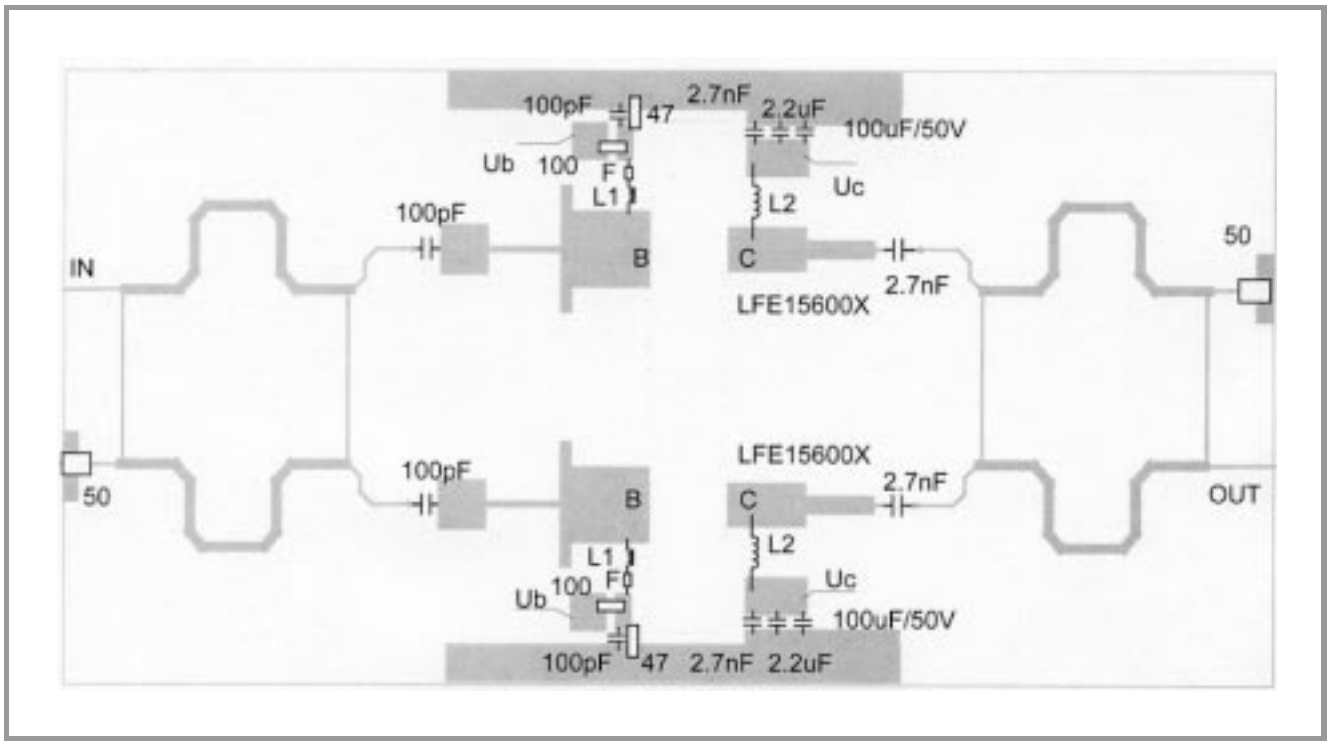

Fig. 1. The layout of the 100 W amplifier. Explanations: F – ferrite bead, L1 – 4 turns 0.5 mm copper wire, L2 – 3 turns 0.5 mm copper wire.

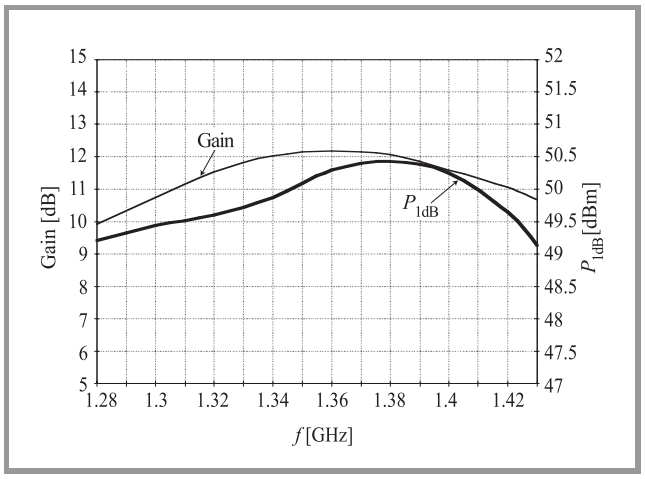

Fig. 2. The amplifier gain and output power at 1 dB gain compression point.

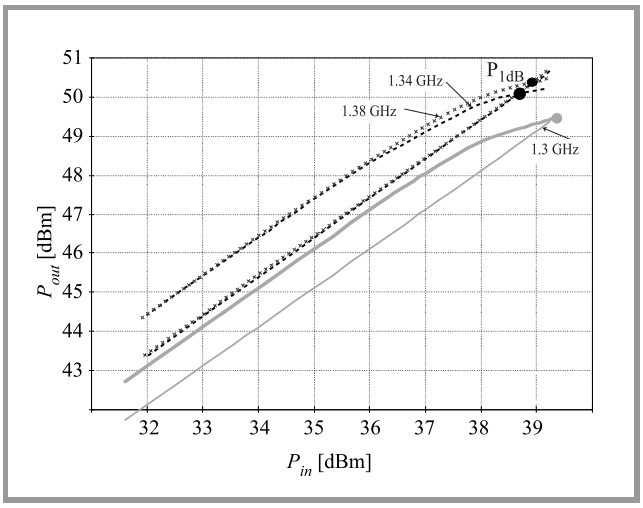

Fig. 3. The amplifier output power versus input power.

The amplifier worked in keyed class A mode. This kind of work permit to increase the supply conditions. The supply conditions were safe. It is possible to increase the $P_{1\,dB}$ above 50 dBm by changing supply: U_{CE} up to 28 V and I_C up to 8 A. The obtained results show that the amplifier can be applied in T/R module for active phased array radar.

References

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Wojciech Wojtasiak received the M.Eng.Sc. degree and the Ph.D. degree in electronic engineering from the Warsaw University of Technology, Warsaw, Poland in 1984 and 1998, respectively. In 1984 he become a Lecture and

in 1998 an Assistant Professor at WUT. His primary research interests were characterization and application of nonuniform transmission lines. Now, his research interest concerns with design of high power microwave amplifiers. Since 1998 he has been a member of MTT.
e-mail: wwojtas@ire.pw.edu.pl
Institute of Radioelectronics
Warsaw University of Technology
Nowowiejska st 15/19
00-665 Warsaw, Poland

Daniel Gryglewski received the M.Eng.Sc. degree and the Ph.D. degree in electronic engineering from the Warsaw University of Technology, Warsaw, Poland in 1996 and 2001, respectively. In 2001 he become an Assistant Professor at WUT. His primary research interest was frequency synthesis. Now, his research interest concerns with design of high power microwave amplifiers.
e-mail: dgrygle@ire.pw.edu.pl
Institute of Radioelectronics
Warsaw University of Technology
Nowowiejska st 15/19
00-665 Warsaw, Poland

Edward Sędek received the M.Eng.Sc. degree and the Ph.D. degree in electronic engineering from the Warsaw University of Technology, Warsaw, Poland in 1968 and 1980, respectively. In 1968 he joined the Telecommunications Research Institute, Warsaw, and become an Assistant Professor in 1980. His primary research interests are microwave ferrite devices, CAD method of waveguide, strip-line, microstrip circulators and isolators and ferrite phase shifters. His other research interests include planar antenna techniques and optoelectronics method for scanning radar beam. In recognition of his contributions in the area of design, modeling and testing of microwave ferrite devices he received the Doctor of Engineering Degree (higher doctorate) from Warsaw University of Technology in 1990. In March 1991 he was appointed scientific director for Telecommunications Research Institute where he holds Professor of electronic engineering post. In the years 1994–1998 Dr Sędek was Chapter Chairman of Poland Section of MTT.
e-mail: sedek@pit.edu.pl
Telecommunications Research Institute
Poligonowa st 30
04-051 Warsaw, Poland