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Two stage GaN-HEMT power amplifier for satellite communication

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Abstract: In this article a two stage GaN-HEMT power amplifier for satellite communication applications is presented. The proposed amplifier has operating frequency range of 12-18 GHz, output power of 40dBm, gain of 10dBm and, power added efficiency (PAE) of 10%.The proposed amplifier consists of gain amplifier in stage I and power amplifier in stage II which provides aforementioned characteristics. The simulation of the proposed power amplifier is carried out using ADS commercial simulation software. The proposed power amplifier is suitable for satellite communication.
Keywords: GaN-HEMT technology, power amplifier, ADS, gain, output power, input power.

I. INTRODUCTION

Wireless devices have proliferated our life by every possible means. These devices can range from as small as Bluetooth dongle to as large as satellites used for various applications. A typical wireless device can have many components ranging from simple audio converter to complex RF (Radio Frequency) devices such as LNA (low noise amplifiers) or PA (power amplifier) [1-5]. Out of all these components in a wireless application, RF power amplifiers (PA) play the most crucial role. Each wireless application can have different design specifications of PA based on frequency and type of input signal. That being said, PA may require varying output power, gain and power added efficiency based on the application specific scenario [6-10].

In this paper, we have designed the second stage of the power amplifier based on 0.25µm GaN-HEMT technology that operates at Ku band. The proposed PA consists of two identical power amplifiers that provide the output power of 40dBm. The design simulation and analysis is carried out using ADS simulation software. The proposed PA design achieves considerable gain, high output power and high PAE (Power Added Efficiency).

II. DESIGN METHOODOLOGY

A detail procedural analysis of single stage power amplifier is elaborated in our article [14]. In this article, the design of the second stage of power amplifier is investigated. The proposed PA must meet the following design specifications as presented in Table I.

TABLE I: Design specifications of Ku band PA

Parameter	Specification
Frequency	Ku band (12 to 18 GHz)
Output power	> 40dBm
Gain	> 10dBm
PAE	> 10%

In [14], we have designed a single stage PA that meets the frequency, gain and PAE characteristics. The single stage PA consists of biasing network so as to facilitate the gain of 10dBm and PAE of 10%. Class AB is selected to achieve both hihj linearity and efficiency to meet these specifications. Further, a stability network is designed to avoid any oscillations in the amplifier. The stability network is followed by matching network that provides matching of source impedance with load impedance. Proper matching of source impedance with load impedance ensures that there is maximum power transfer from source to load. The matching networks are auto tuned using the ADS auto tuning capabilities. The gain stage amplifier delivers peak gain of 10.340 dBm for input power of 24 dBm.

a) Power stage amplifier design

Power amplifier, as the name suggests, is designed to provide high power rather than high gain. Therefore same matching network that is used in the gain stage may not be used. The values of different input power levels at 15 GHz can be seen in Table II.

Table II: Input and Output impedances of power stage

Pavailable	Pout	Gain	PAE (%)	Z_{source}	Z_{load}
30 dBm	39.77 dBm	9.77 dB	42.85	0.906-j*63.382	9.639-j*52.293
31 dBm	40.62 dBm	9.62 dB	48.52	0.906-j*63.382	9.639-j*52.293
32 dBm	41.21 dBm	9.21 dB	49.79	0.906-j*63.382	9.639-j*52.293
33 dBm	41.71 dBm	8.71 dB	49.57	0.906-j*63.382	9.639-j*52.293
34 dBm	41.58 dBm	7.58 dB	49.90	0.906-j*63.382	9.639-j*52.293
35 dBm	41.24 dBm	6.24 dB	49.64	0.906-j*63.382	9.639-j*52.293
36 dBm	40.92 dBm	4.92 dB	45.22	0.906-j*63.382	9.639-j*52.293

The input matching network is designed to match the load impedance (Zload = 9.639-j*52.293) to the 50Ω transmission line impedance. With proper input and output matching networks approximately 8dB gain is expected from the power amplifier stage. However, to improve the gain and output power, two identical power amplifiers are used in balanced amplifier configuration as shown in Fig. 1.

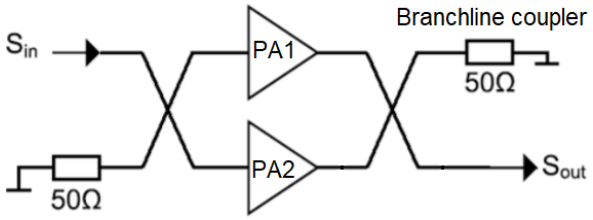

Fig. 1 Balanced amplifier configuration in PA stage-II

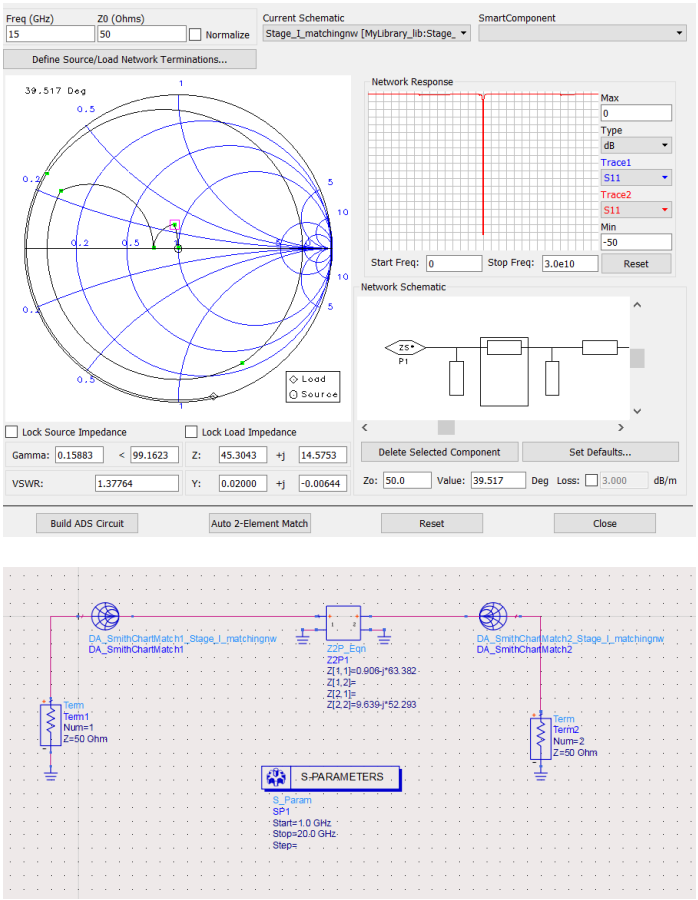

Fig. 2 Input and output matching n/w optimization using ADS

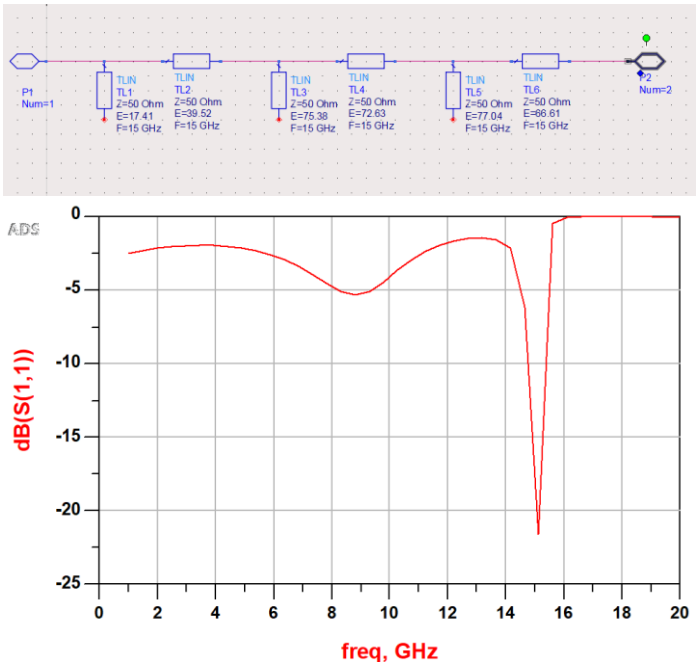

Fig. 3 Input matching network schematics and corresponding $S_{11}$for PA stage

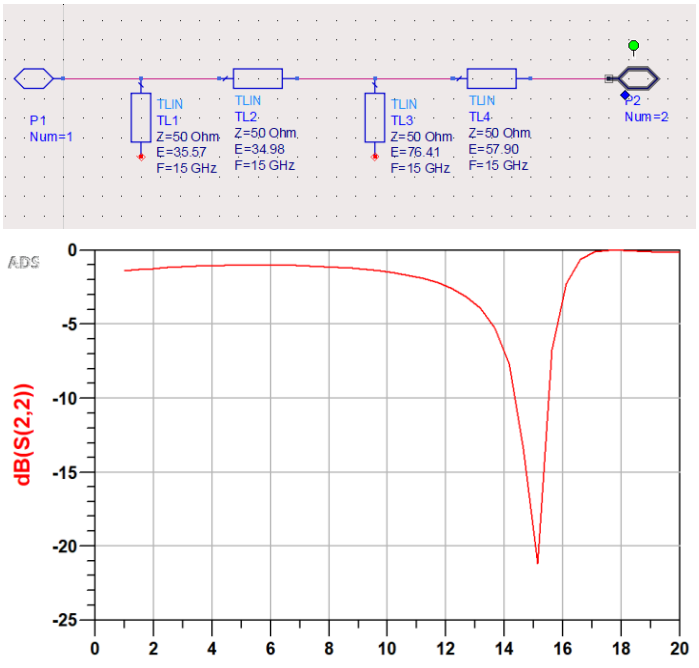

Fig. 4 Input matching network schematics and corresponding $S_{22}$for PA stage

Fig. 2 through Fig. 4 shows the development of input and output impedance matching network for PA stage. The S11 and S22 characteristics of impedance matching network shows that the PA is finely operating at 15 GHz.

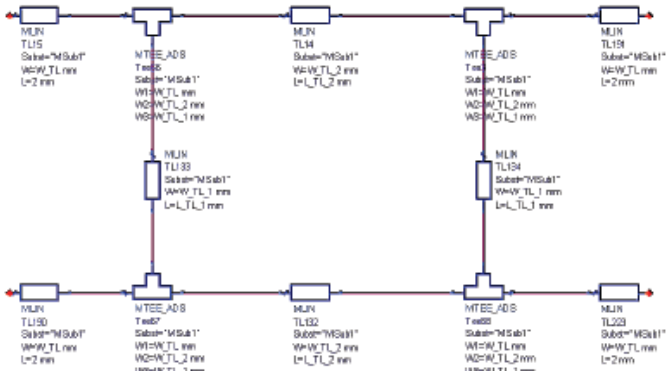

Fig. 5 -3dB branch-line coupler

b) Branch line coupler

The power stage of the power amplifier circuit is composed of two parallel identical amplifiers. This approach is used to achieve 3dB more power at the output when compared to a single power stage amplifier circuit. This topology is called balanced topology; as shown in Fig. 1. The input power to the power stage is divided by the means of a 3dB coupler, amplified and then combined again by a second coupler [6].

III. RESULTS AND DISCUSSIONS

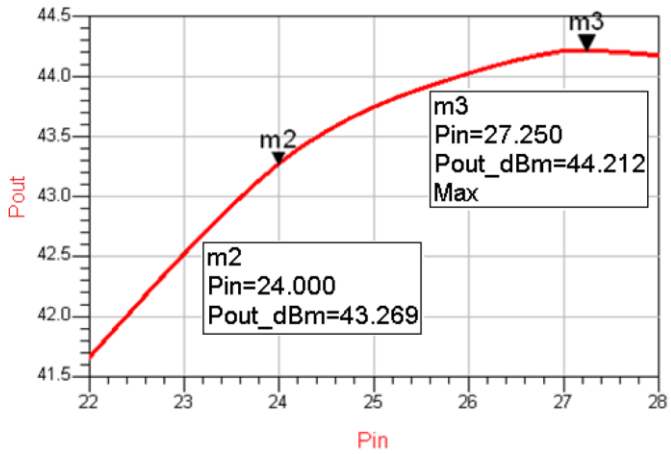

Fig.6 Input and Output power (Pout Vs Pin) characteristics of the gain stage

The input and output characteristics are shown in Fig.6. The output of the gain stage is then applied to the power amplifier. As stated earlier, the gain stage provides most of the overall gain of PA while power stage provides most of the overall power of PA. Hence, a small noticeable change in the gain can be observed after designing of the second stage (the power stage) of the PA which is reflected from Fig.7. The PAE (Power Added Efficiency) of the PA is shown in Fig.8. The proposed power amplifier at the second stage II provides output power greater than 40dBm.

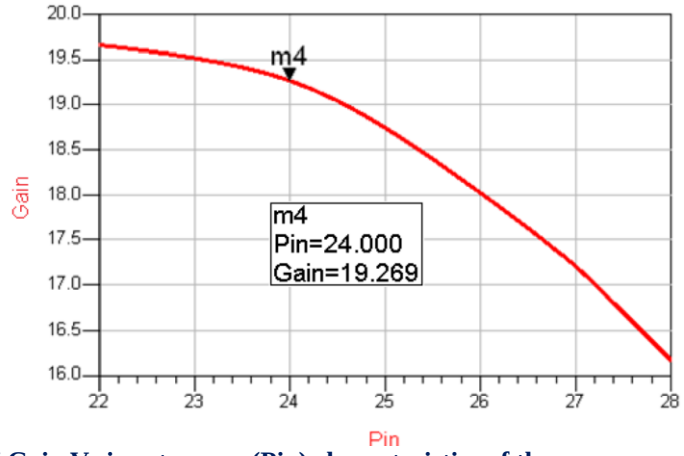

Fig. 7 Gain Vs input power (Pin) characteristics of the power amplifier

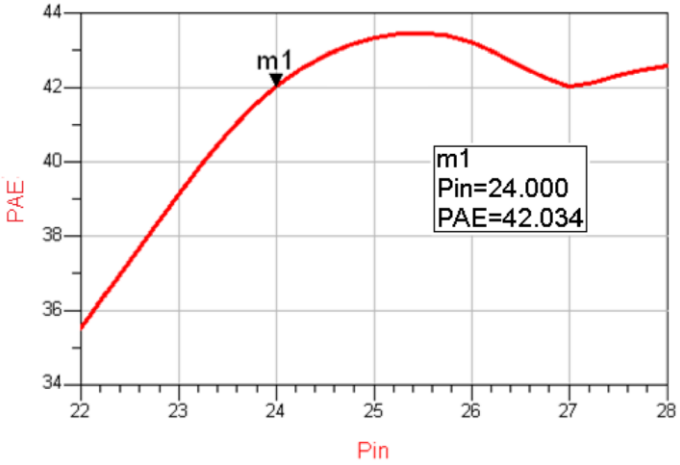

Fig. 8 PAE Vs Gain characteristics of the PA

IV. CONCLUSION AND FUTURE SCOPE

In this paper, a two stage 0.25µm GaN-HEMT technology based Ku band (12-18 GHz) amplifier is designed using ADS Keysight simulation software. The proposed two stage amplifier consists of gain stage and power stage that provides a high gain of 10.34dBm (>10 dBm as per technical specifications mentioned in Table I) while low output power of about 40dBm and PAE greater than 35% making it suitable for satellite communication.

REFERENCES

[1]. Scappaviva, F. Cignani, R. Florian, C. Vannini, G. Filicori, F. Feudale, M., "10 Watt High Efficiency GaAs MMIC Power Amplifier for Space Applications", EuMC 2008, pp. 1429 - 1432, Oct. 2008.

[2]. Alaeldine, A. Perdriau, R. Ramdani, M. Levant, J.-L. Drissi, M., "A Direct Power Injection Model for Immunity Prediction in Integrated Circuits", IEEE Transactions on Electromagnetic Compatibility, vol. 50, issue : 1, pp. 52 - 62, Feb. 2008

[3]. A. Rasmi, A. Marzuki, A.I. Abd Rahim, M.R. Yahya, A.F.A. Mat, "A 3.5 GHz Medium Power Amplifier Using 0.15 µm GaAs PHEMT for WiMAX Applications", Asia Pacific Microwave Conference, pp. 277 - 280, December 2009

[4]. http://pdfserv.maxim-ic.com/en/an/AN3175.pdf

[5]. Lai, R., Grundbacher, R., Barsky, M., Oki, A., Siddiqui, M., Pitman, B., Katz, R., Tran, P., Callejo, L., Streit, D., "Extremely High P1dB MMIC Amplifier for Ka-band Applications", GaAs IC Symposium, pp. 115 - 117, 2001.

[6]. Dong JunHong, Wang QiFeng, Xie Feng, "Design of 2.4GHz Power Amplifier used in WLAN 802.11b by pHEMT", International Conference on Future Computer and Communication, vol. 1, pp. V1.722 – V1. 724, 21-24 May 2010.

[7]. Negra, R., Vogt, R., Bachtold, W., "High Power-Density Monolithic Linear X-band Power Amplifier using A Low-Cost MESFET Technology", International Microwave and Optoelectronics Conference, vol. 2, pp. 877 - 880, 2003

[8]. De-Zhong Li, Cong Wang, Wen-Cheng Huang, R. Krishna, Sung-Jin Cho, B. Shrestha, Gear Inpyo Kyung, Nam-Young Kim, "A highpowerKa-band power amplifier design based on GaAs P-HEMT technology for VSAT ODU applications", IEEE International Microwave, Antenna, Propagation and EMC Technologies for Wireless communications, pp. 20 – 23, Oct 2009.

[9]. Qi Zhang, S.A. Brown, "A Fully Monolithic 8 Watt Ku-Band High Power Amplifier", IEEE MTT-S International Microwave Symposium, vol. 2, pp. 1161 - 1164, June 2004.

[10]. C. H. Lin, H. Z. Liu, C. K. Chu, H. K. Huang, Y. H. Wang, C. C. Liu, C. H. Chang, C. L. Wu, C. S. Chang, "A Fully Matched Ku-band 9W PHEMT MMIC High Power Amplifier", Compound Semiconductor Integrated Circuit Symposium, pp. 165 - 168, Nov 2006.

[11]. K. Fujii, H. Morkner, "Single-Supply 1W Ku-Band Power Amplifier Based on 0.25 µm E-Mode PHEMTs", IEEE MTT-S International Microwave Symposium, pp. 1855 - 1858, June 2006

[12]. Jia-You Song, Zhi-Gong Wang, Zhi-Qun Li, Yan-Jun Peng, Qin Li, "Ku-band Broadband Power Amplifier Designed in 0.2µm GaAs PHEMT Process", International conference on Microwave and Millimeter Wave Technology, pp. 1-3, Apr. 2007

[13]. Mei-Chen Chuang; Pei-Si Wu; Ming-Fong Lei; Huei Wang; Yu-Chi Wang; Chan Shin Wu, "A miniature 15-50-GHz medium power amplifier", Radio Frequency Integrated Circuits Symposium, pp. – 7, June 2006.

[14]. B. N. Ganthade, Prof. S. R. Gagare, "Design of Ku band power amplifier for satellite communication", IOSR Journal of Electronics and Communication Engineering (IOSR-JECE) e-ISSN: 2278-2834,p-ISSN: 2278-8735.Volume 14, Issue 4, Ser. II (Jul.-Aug. 2019), PP 30-36

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