行政院國家科學委員會專題研究計畫　成果報告

高線性度功率放大器(3/3)

計畫類別：個別型計畫
計畫編號：NSC91-2219-E-009-051-
執行期間：91 年 08 月 01 日至 92 年 07 月 31 日
執行單位：國立交通大學電信工程學系

計畫主持人：孟慶宗

計畫參與人員：王維

報告類型：完整報告

處理方式：本計畫可公開查詢

中　華　民　國 92 年 10 月 27 日

行政院國家科學委員會專題研究計劃期末報告

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高線性度功率放大器(3/3)

High Linearity Power Amplifier (3/3)

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計劃類別: ■個別型計劃□ 整合型計劃

計劃編號: NSC 91-2219-E-009-051

執行期間:91 年 8 月 1 日 92 年 7 月 31 日

計劃主持人: 孟慶宗

本成果包含以下應繳交文件:

□ 赴國外出差或研習心得報告一份

□赴大陸地區出差或研習心得報告一份

□出席國際學術會議心得報告及發表論文各一份

□ 國際合作研究計劃國外研究報告一份

執行單位: 國立交通大學電信系

中華民國:92 年 10 月 20 日

行政院國家科學委員會專題研究計畫成果報告

高線性度功率放大器(3/3)

High Linearity Power Amplifier (3/3)

計畫編號: NSC91-2219-E-009-051
執行期限:91 年 8 月 1 日至 92 年 7 月 31 日
主持人:孟慶宗　國立交通大學電信系

中文摘要：

功率放大器在無線通信系統中扮演了一個非常重要的角色，它位於發射機的最後一級，為無線前端電路提供足夠的增益及輸出功率。而在無線通訊系統當中，功率放大器的前後會置入一濾波器，其作用是控制了通訊系統中的頻率響應，以抑制雜訊訊號。我們此次功率放大器是採用 GaAs MESFET 的製程技術，設計一個中心頻率為 2.3GHz、頻寬為 200MHz 的高線性度功率放大器。此電路可提供 33.4 dbm 的輸出功率、15 dB 的線性增益及 42 %的功率增加效率。

Abstract

A one stage hybrid power amplifier integrated with gap-coupled filters is demonstrated in this work. The gap-coupled filter amplifier module realized here can provide 15 dB power gain, 33.5 dBm output power and 42 % power added efficiency at 2.3 GHz. The topology demonstrated is suitable in monolithic IC technology especially in the millimeter-wave frequency because the gap-coupled filter can be easily compacted into small size.

Introduction

The demand for high level integration in MMICs has increased and become more important. The off-chip band-select filters are often too bulky to fit in the IC technology for cost reduction. Typical microwave and millimeter-wave transceivers still consist of MMIC chips and off-chip filters to achieve maximum performance. In this work, a GaAs MESFET power amplifier with gap-coupled filters has been developed. The gap-coupled filters serve impedance transformation and also provide DC blocking. Chip capacitors are inserted into the gaps to optimize the design.

The resulting filter amplifier provides 15 dB gain and 33.5 dBm output power at 2.3 GHz. The power added efficiency (PAE) at maximum output power is 42%. The gap-coupled filter can be easily compacted into a serpentine shape and thus the filter amplifier topology demonstrated here is very suitable for millimeter-wave monolithic IC.

Circuit Design

Figure 1 illustrates the one stage GaAs MESFET power amplifier. A load pull measurement is used to obtain the optimum load impedance and the packaged device S parameters are also measured for the power amplifier design. A gap-coupled filter topology is simple and is used here for both input and output impedance matching. The gap-coupled microstrip lines filters have been well established for 50 Ω to 50 Ω microwave band-pass filter design. Here we utilize the gap-couple microstrip lines for impedance transformation by extending the filter design theory to unequal source and load impedances. In other words, the gap-coupled microstrip lines not only have the band-pass characteristics but also provide the input and output impedance matching of power amplifier. The band-pass nature of gap-coupled matching network also helps the stability of power amplifier because a device is prone to low frequency oscillation and the gain mismatch at low frequency increases the stability. There are two design parameters in gap-coupled 50 Ω microstrip lines; the length of the microstrip lines and the capacitors inserted in the gaps. Then we utilize microwave filter design theory to design two-gap band-pass filter at both input and output. A conventional power amplifier design methodology is used here; the input impedance is optimized for power gain and the output impedance is optimized to obtain maximum output power. Quarter-wavelength rf chokes are used at gate and drain to provide dc bias. The stability factor K is large than 1 and B factor is large than zero to avoid oscillation in the filter amplifier design.

Measurement results

A standard microwave ceramic package is used to package the GaAs power MESFET. The device has 6 mm gate width and 0.7 μm gate length. The FET has via holes for grounding and the backside of the die attaches to the bottom of the package by Au-Sn solder. A brass heat sink is used to dissipate heat and the case of device package contacts directly to the heat sink for better thermal resistance and electrical grounding. The gate lead and drain lead of the packaged device are connected to the input and output gap-coupled microstrip lines by soldering, respectively. The microstrip lines are fabricated on FR4 PC board. The FR4 material has high dielectric loss in the rf frequency and might influence the performance of the circuit. Figure 2 and figure 3 are the S-parameter measurement results, the input return loss S_{11} is –13 dB and the small signal gain S_{21} is 15 dB at the frequency of 2.3 GHz. The output power, power gain and power added efficiency measurement results are shown in figure 5. The maximum saturation output power is 33.5 dBm, the max gain is 15 dB and PAE is 42% at maximum output power. Two tone intermodulation measurements results are shown in figure 6 and the OIP_3 is 40 dBm. The power module is also tested by WLAN 802.11b emission mask specification and the ACPR is -30 dBc at output power of 26 dBm.

Conclusion

We have demonstrated a band-pass filter amplifier operating in the center frequency 2.3 GHz with 200 MHz bandwidth. The gap-coupled filter amplifier provides 15 dB gain and 33.5 dBm output power. The power added efficiency (PAE) at maximum output power is 42 %. The structure of gap filter is very simple and could be miniature by a serpentine shape. Thus, the topology demonstrated is suitable for monolithic integration especially in the millimeter-wave frequency range.

Reference:

[1] J. Walker, “High power GaAs FET amplifier”, Artech House.

[2] David M. Pozar “Microwave Engineering”, Wiley

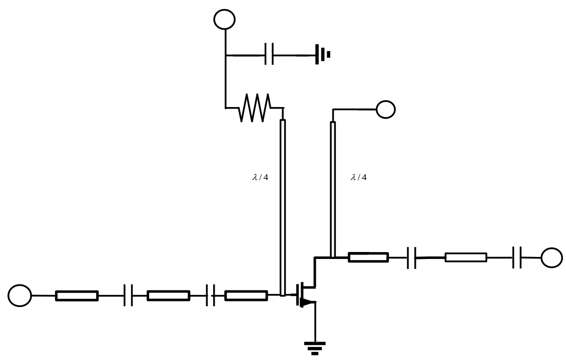

Figure 1. Schematic of the gap-coupled filter amplifier.

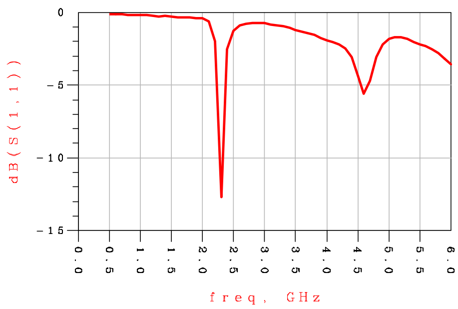

Figure 2. Measured S_{11} of the gap-coupled filter amplifier

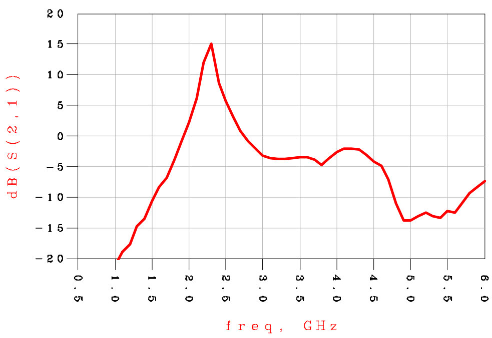

Figure 3. Measured S_{21} of the gap-coupled filter amplifier.

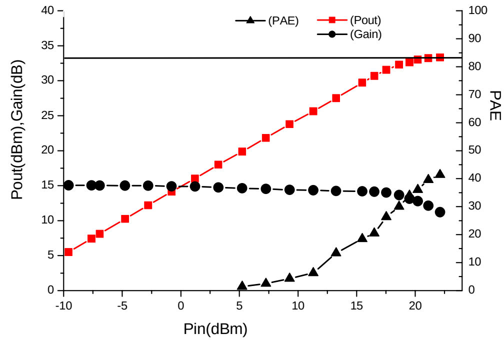

Figure 4. Output power, gain and power added efficiency of the gap-coupled power amplifier.

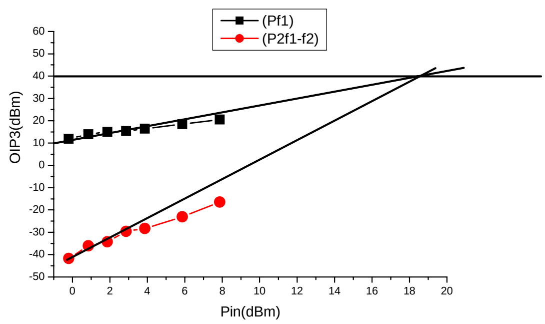

Figure 5. Two tone intermodulation measurement results of the gap-coupled power amplifier.

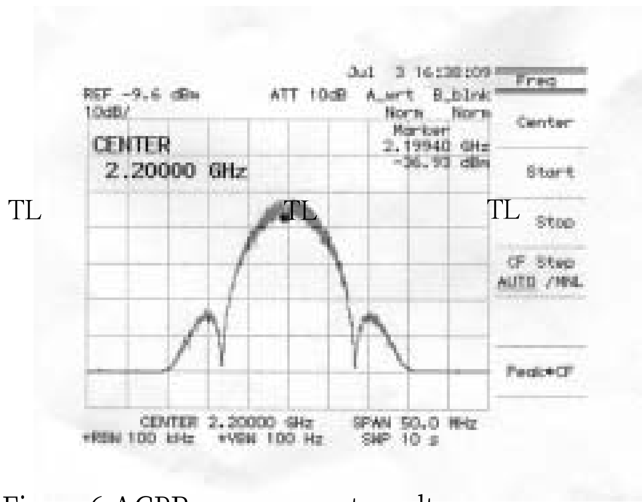

Figure 6 ACPR measurement result