4W GaAs MMIC Power Amplifier for PCS and W-CDMA Base Station

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***Abstract* – A three stage amplifier has been developed for PCS, EDGE and W-CDMA applications. Using the MESFET GaAs process of the Fujitsu foundry, we achieved a typical 30dB gain and 4 Watts output power. The input matches for a 50ohm system and the output used a pre-match circuit in order to increase its low impedance. This amplifier has a frequency range of 1.7Ghz to 2.3 Ghz.**

I. INTRODUCTION

The demand for Power Amplifiers for base station EDGE or W-CDMA is increasing. High power devices of 60-80 Watts or even higher are in demand to satisfy the difficult requirement of the new third generation (3G) Base Station. High efficiency, good Adjacent Channel Power Ratio, good Intermodulation product are the new key words of this field. Also a need of a driver stage for this high power devices is required. This driver may be composed of a two or three stage amplifier in order to get the power and gain required to drive this High PA. The idea of having an MMIC is to reduce the space and volume of the inside Base Station. From the point of view of the Base Station design it is also easier to introduce an MMIC in order to integrate directly the three stage amplifier. Using this MMIC may mean that only external matching has to be adjusted which simplifies the design and gives a shorter design time cycle of the Base Station system. This MMIC has to be designed in order to respect the condition of the 3G system. Therefore the device has to be tested for its Power, its Third Intercept Intermodulation Point, its Adjacent Channel Power Ratio. The design of this MMIC seems to be a long process but it is one of the steps towards a new and more convenient part for this new generation technology.

II. TECHNOLOGY

The Metal-Semiconductor FET process used for the MMIC is a well-established process of Fujitsu. Due to this stable GaAs MESFET process, high production of the MMIC can be easily provided for a large volume needed for the 3G application. We had to optimize some parameters such as the thickness of the substrate, the unit gate width, the total gate width, the gate to gate pitch in order to get good performances with a compromise between the Output Power, the Gain and the thermal resistance of the circuit [1]. The package used for the circuit is a ceramic package of internal size 4.5 x 4.5mm, leaving us only with little space for the overall circuit, but it gives us a very compact design.

III. DESIGN

We designed a 4-Watt 3- stage amplifier MMIC using the GaAs MESFET technology. The bandwidth frequency is 1.7 to 2.3Ghz. This frequency is mainly targeting the new mobile frequency band. The input matching circuit was matched for a 50 ohms impedance system. The output matching was realized out of the MMIC chip due to the compact size of the MMIC and also due to the current limitation which occur at the last stage of the chip. Therefore a Pre- matching element has been inserted inside the VF package at the output of the MMIC in order to lower the output impedance of the circuit. The inter-matching circuits have been designed in order to get the bandwidth frequency required. Also the design has been conceived in the view to get a good linearity, as it should be used for multicarrier systems. The 16mm total gate width of the last stage amplifier has been matched using parallel techniques similar to the ref. [2]. With this technique the last stage amplifier, which has a large total gate width, is been considered as parallel amplifiers added together.

IV. TEST RESULTS

Layout and Matching circuits:

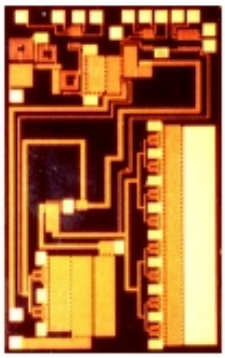

Figure1: MMIC Chip

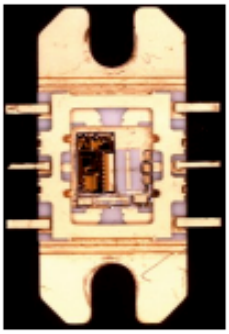

Figure2: VF Package with chip and pre-matching

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In figure 1 and 2 we can see the size which have been achieved. The overall chip size is 2.16 x 3.46mm. The Ceramic package gives us a compact device of 8.33x 17.78mm. Inside the package a pre-matching circuit composed of bondwire and Alumina substrate gives us higher impedance. The fact to use an MMIC gives us a very small device for a 30dB gain and 4 Watts output power amplifier.

Output power results:

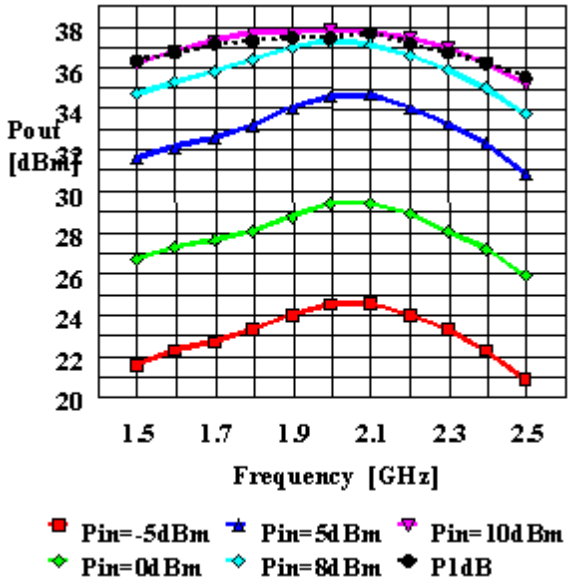

Figure 3: Output power vs. Frequency

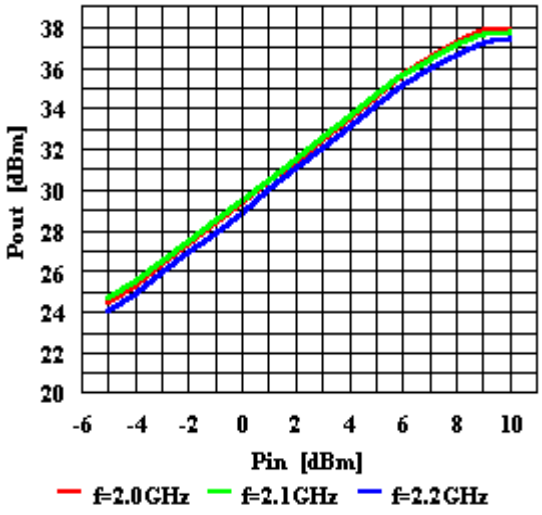

Figure 4: Output power vs. Input Power

The three stage amplifier has been tested inside a test fixture tune for the 3G W-CDMA frequency range 1.9 to 2.2Ghz. A 37dBm of P1dB has been achieved at Vds=10V, Vgs= -5V
In figure 4 we see a good linearity, which is an important point when using a multicarrier system like the EDGE or W-CDMA.

Intermodulation and Adjacent Channel Power performance:

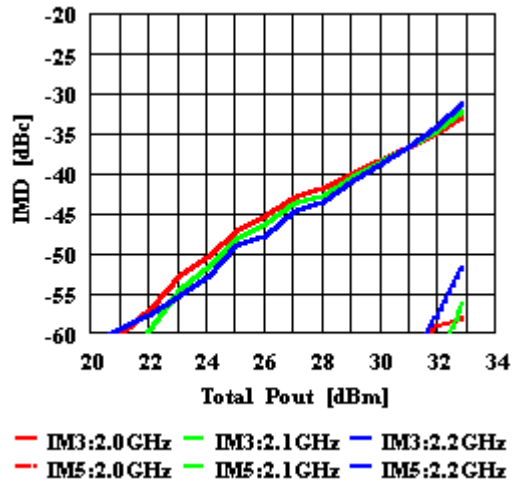

Figure 5: Intermodulation performance.

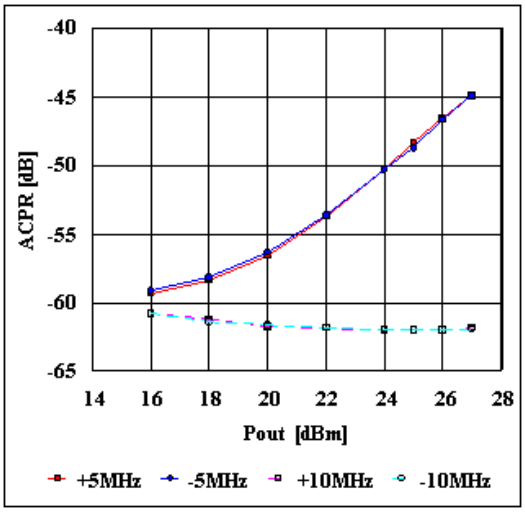

Figure 6: Adjacent Channel Power Ratio.

In Figure 6 the data have been measured for fo=2.14GHz , VDD=10V [PEP=17.8dBm] this using a Signal Source W-CDMA of 15ch . Additional important points for the 3G systems are the IM3 and the ACPR. Also it must be remembered that the device is usually back-off at 5 to 10dB depending on the application giving us an ACPR of –47dBc and an IMD of <46dBc for 2 to 2.2Ghz at Pout(average)=26dBm.

V. CONCLUSION

We have presented a compact 4 watt Power Amplifier with a good linearity and ACPR and a gain of approximately 30dB, which will give to the designer of the Base Station a good and compact driver stage, or a good PA for macro cell Base Station.

VI. ACKNOWLEDGEMENT

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VII. REFERENCES

[1] Chapter 2 by Y. Aoki and Y.Hirano “High Power GaAs FET Amplifiers” John L.B. Walker.

[2] Short course on High Efficiency Power Amplifier- Gallium Arsenide Applications Symposium- Munich Oct 1999.