A Si WIDE-BAND MMIC AMPLIFIER FAMILY FOR L-S BAND CONSUMER PRODUCT APPLICATIONS

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ABSTRACT

By using a novel Si bipolar process technology, medium power, low noise and low power consumption amplifiers have been successfully realized. For the low power consumption amplifier, as little as 4mA of total supply current is required with 3.4V supply voltage, 2.3GHz 3dB-bandwidth, and 10.8dB gain at 1GHz.

INTRODUCTION

In order to meet with expanding application needs for consumer products such as DBS(Direct Broadcasting Satellite System), GPS(Global Positioning System), cellular radio, etc., a Si wide-band MMIC amplifier family has been developed. This paper presents three types of amplifiers: a medium power amplifier with 9.0dBm output power at 2GHz, a low noise amplifier with 2.3dB NF at 1GHz, and a low power consumption amplifier which consumes only 13.6mW. All of these circuits employ a novel Si bipolar process technology.

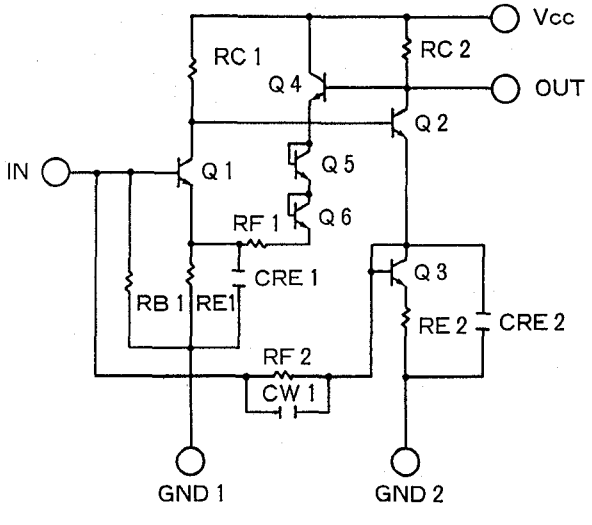

Fig. 1 Schematic circuit diagram for the low power consumption amplifier IC.

CIRCUIT DESIGN

The circuit schematic for the low power consumption amplifier is shown in Fig. 1. The circuit consists of two amplifier stages. Multiple feedback loop technology is used to achieve broad-band gain together with good noise figure and good terminal impedance matching.

Similar multiple feedback loop circuit design was employed for the medium power and low noise amplifiers. These two amplifiers feature Darlington output stages to achieve high output power. Circuit parameter optimization was performed by using SPICE simulation.

CHIP FABRICATION

The circuits were fabricated by the Direct Nitride Passivated Base Surface process. This process features direct passivation of the base surface with Si_xN_y, the most effective way for realizing high reliability, especially for moisture proof performance in molded plastic packages. The emitter width is 0.6 μm. A typical transistor f_T of 20GHz is achieved using this process.

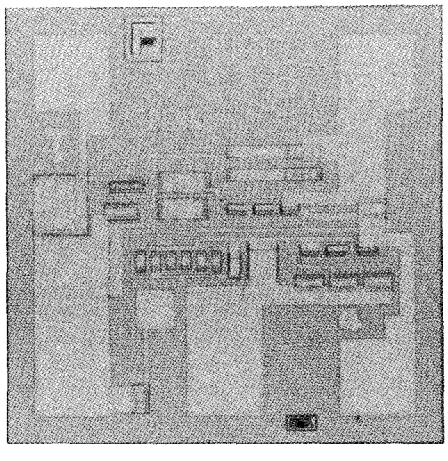

Fig. 2 Microphotograph for the low power consumption amplifier IC (Chip size: 0.65mm×0.65mm).

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A chip micropotograph is shown in Fig. 2. In order to minimize parasitic elements, a 2 μ/2 μm line/space rule was employed for plated gold interconnections. The chip size is very small; 0.65mm×0.65mm. The ground pads for the first and second stage amplifiers are separated. This results in excellent isolation between the two stages and excellent frequency response in spite of the small chip size. Furthermore separating the ground pads has the effect of reducing bonding wire inductance.

RESULTS

The RF characteristics for the low power consumption amplifier are shown in Figs. 3 and 4. The device exhibited good RF performance for relatively low power operation. Power consumption was 13.6mW (Icc=4mA at Vcc 3.4V). The gain is essentially flat at 10dB up to 1.8GHz. The 3dB bandwidth is 2.3GHz(Fig. 3). Saturated output power is -12dBm at 2GHz(Fig. 4).

The RF characteristics for the Si-wideband MMIC amplifier family are summarized in Table 1. Exceptionally good efficiency was obtained from the medium power amplifier, which provides 9dBm of saturated output power at 2GHz for only 30mA of supply current(Vcc=5V). The low noise amplifier is biased at 5V and 8.6mA exhibits 2.3dB NF at 1GHz with 36dB gain.

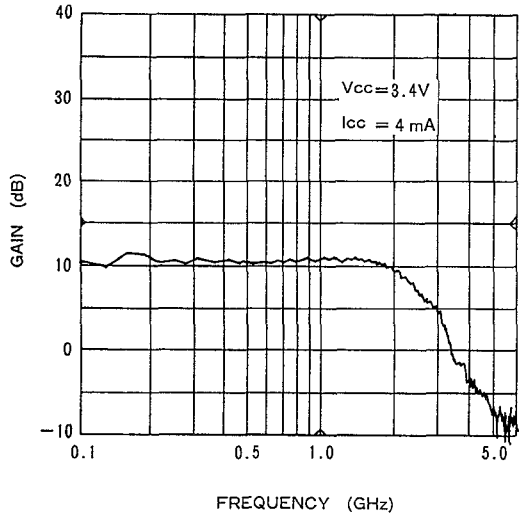

Fig. 3 Gain vs. frequency for the low power consumption amplifier IC (Vcc=3.4V, Icc=4mA).

CONCLUSION

A Si wide-band MMIC amplifier family has been developed using the direct nitride passivated base surface process. The achieved results clearly suggest the merit for a Si MMIC approach to commercial microwave markets.

ACKNOWLEDGMENT

The authors would like to express their thanks to S. Ikeda and H. Aoyama for their continuous support and encouragement. They also wish to acknowledge A. Mineo, T. Furutsuka and S. Watanabe for their useful advice and H. Kawamata for her documentation support throughout this work.

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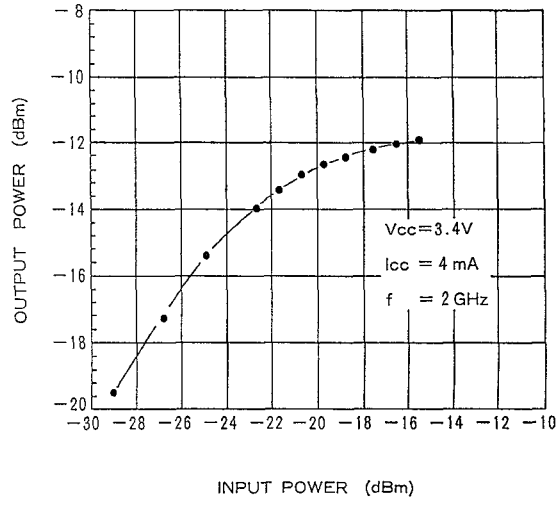

Fig. 4 Input power vs. output power for the low power consumption amplifier IC (Vcc=3.4V, Icc=4mA, f=2GHz).

type	RF Characteristic				Condition		
	f3dB (GHz)	Po(sat) (dB)	NF (dB)	$\|S21\|^2$ (dB)	Vcc (V)	Icc (mA)	f (GHz)
medium power amp.	1.90	9	5.3	23 *1	5	30	2
low noise amp.	0.84	—	2.3	36 *2	5	8.6	1
low power consumption amp.	2.30	-12	6.0	10.8*1	3.4	4	2

*1 f=1GHz *2 f=0.5GHz

Table 1 RF characteristics for Si wideband MMIC amplifier family