800 MHZ-BAND LOW NOISE LOW DISTORTION SI-MMIC FRONT-END USING BJT/MOSFET LNA AND MOSFET MIXER

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ABSTRACT

Both low noise and low distortion characteristics are strongly desired for cellular terminal receiver application. In the case of Si-MMIC, BJT has superior feature in it's low noise performance and MOSFET has it in low distortion performance. By using BJT amplifier as the 1st. stage of LNA and MOSFET as the 2nd. stage of LNA and a down mixer, both low noise and low distortion performance is achieved. The fabricated Si-MMIC front-end, which contains two-stage LNA and down mixer and LO amplifier, performs 3.7 dB NF, 16.7 dB conversion gain and -15.5 dBm IIP_3 with 3V / 13.7 mA d.c. power and -10 dBm LO power.

I. INTRODUCTION

In recent years, Si-MMIC's have been focused on as the next generation MMIC's for cellular terminal applications [1]-[3]. Because Si-MMIC has the feasibility to reduce the terminal size by realizing system on-chip, and the ability to reduce the production cost of the terminals [1]. From the view point of noise versus d.c. power consumption, the performance of Si-MMIC based on bipolar junction transistor (BJT) is approaching to that of GaAs-MMIC on the market, but the improvement of distortion performance is still necessary to achieve the requirements for cellular terminal application such as digital cellular [1].

In this paper, combined BJT/MOSFET configuration Si-MMIC front-end is proposed. By using BJT having low noise characteristic as the 1st. stage of LNA and MOSFET having low distortion characteristic as the 2nd. stage of LNA and the down mixer, both low noise and low distortion performance is achieved. By adopting BiCMOS process, both type transistor can be monolithically integrated on a single chip. Fabricated Si-MMIC front-end has applicable performance to achieve the requirement of digital cellular terminals.

II. CONFIGURATION

BJT has relatively low noise and high gain in low d.c. power supply condition. Therefore, it doesn't have fair distortion characteristics. On the other hand, MOSFET has extremely low distortion performance [4]-[5], whereas it has relatively poor performance in it's gain and NF.

Since BiCMOS process is able to fabricate BJT and MOSFET on the same chip at once, it is possible to realize combined BJT/MOSFET MMIC's [2]. By using BJT as the 1st. stage of LNA and MOSFET's as the 2nd. stage of LNA and the down mixer, lower NF and lower distortion performance can be obtained.

Figure 1 shows the block diagram of Si-MMIC front-end. This MMIC contains two-stage BJT/MOSFET LNA and MOSFET down mixer with BJT local (LO) amplifier. External band pass filter (BPF) is required to achieve the regulation of spurious response and image response.

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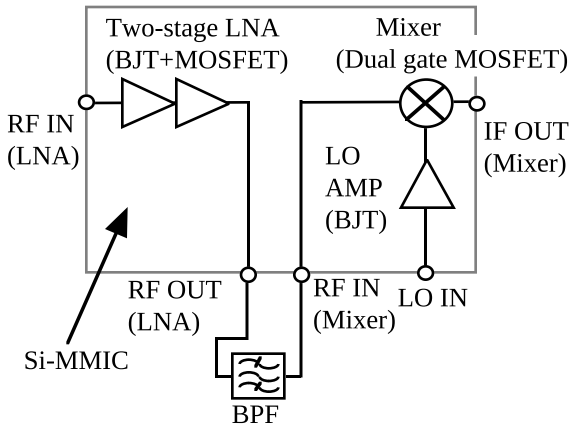

Fig.1 Block diagram of Si-MMIC front-end.

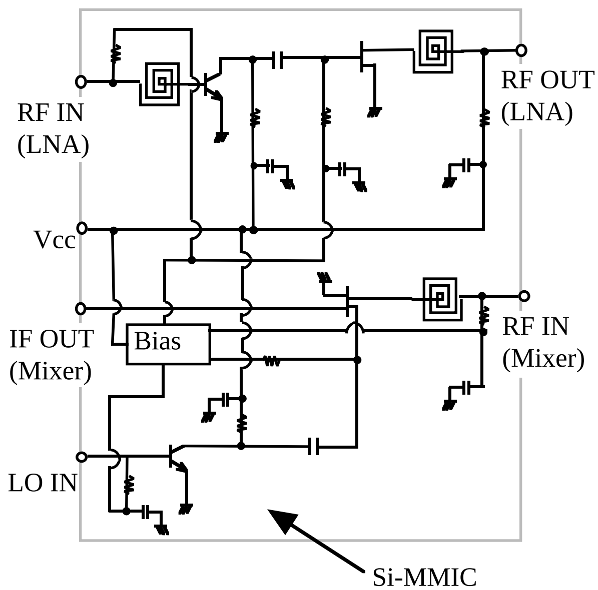

Fig.2 Schematic diagram of Si-MMIC front-end.

In general case, SAW filter is used as the BPF. Fig. 2 shows the schematic diagram of Si-MMIC front-end. All RF in / out ports are reactive matched on chip by using coplanar type spiral inductors [2] and LO port is resistive matched. Since the IF out port of mixer is open drain configuration, external IF matching circuit and drain bias circuit are required. In this MMIC, enhance mode N type MOSFET's are used, so that all transistor can be operated at positive polarity d.c. power supply. Since bias voltage generation circuit for gate of MOSFET and base of BJT is integrated on the same chip, single 3V operation is available. Fig.3 shows the microphotograph of fabricated Si-MMIC front-end. Since the LNA and the mixer are shielded by grounded metal, more than 30 dB isolation can be obtained.

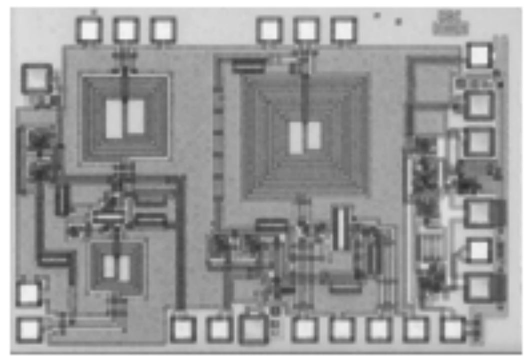

Fig.3 Microphotograph of Si-MMIC front-end.
Chip size: 1.6mm x 2.4mm

III. MEASURED RESULTS

Figure 4 shows the measured frequency dependence of gain and NF of two-stage LNA. NFmin of BJT is 1.7 dB and that of NMOSFET is 4.0 dB at 1.2 V / 2 mA operation. Gain of 19.3 dB and NF of 2.5 dB are obtained at 800 MHz-band with 3V / 7.2 mA d.c. power supply. Fig.5 shows the input / output return loss of LNA. The input port is NF matched and the output port is gain matched to 50 ohm by using on-chip spiral inductors. Fig.6 shows the measured two-tone transfer characteristic of LNA. IIP3 is -14.6 dBm, and this performance is mainly due to the BJT 1st. stage amplifier.

Figure 7 shows the measured LO power dependence of conversion gain and NF (SSB) of the MOSFET mixer with BJT LO amplifier. Conversion gain of -1.1 dB and NF of 15.4 dB are achieved with -10 dBm LO power and 3V / 6.5 mA (0.6 mA for mixer and 5.9 mA for LO amplifier) d.c. power supply. Fig.8 shows the measured two-tone transfer characteristic of the mixer. IIP3 of 2.3 dBm can be obtained, and this performance is competitive level with conventional GaAs MESFET mixer for mobile handset terminal application [6].

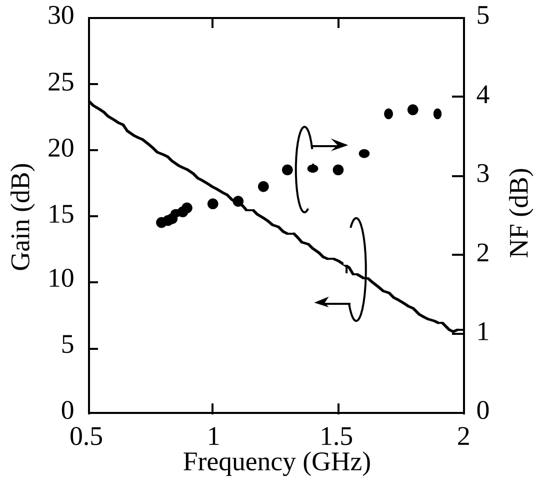

Fig.4 Gain and NF performance of two-stage LNA.
(Vcc=3V, Id.c.=7.2mA)

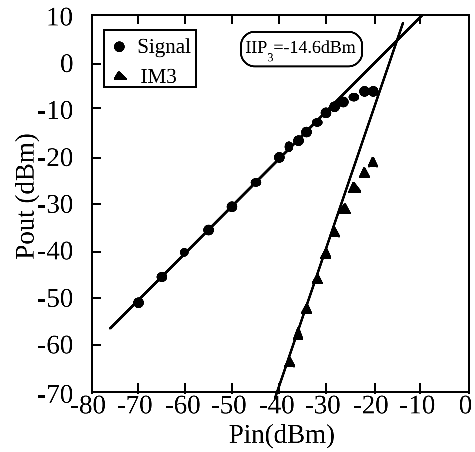

Fig.6 Two-tone transfer characteristic of two-stage LNA. (Vcc=3V, Id.c.=7.2mA)

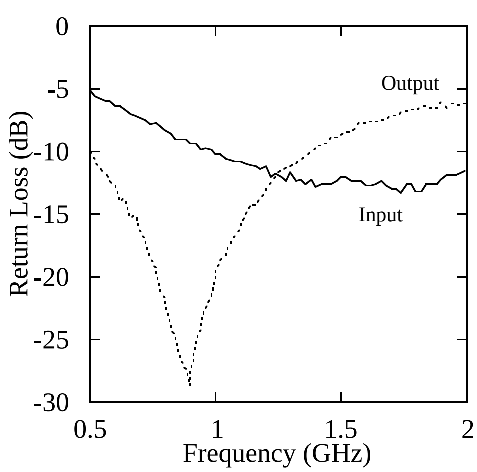

Fig.5 Input / output return loss of two-stage LNA.
(Vcc=3V, Id.c.=7.2mA)

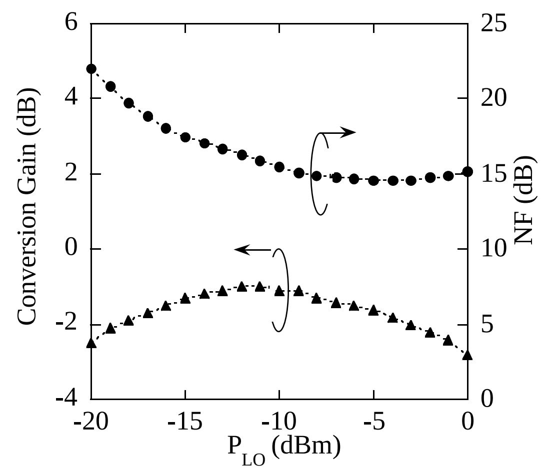

Fig.7 Conversion gain and NF performance of mixer with LO amplifier. (Vcc=3V, Id.c.=0.6mA for mixer and 5.9mA for LO amplifier)

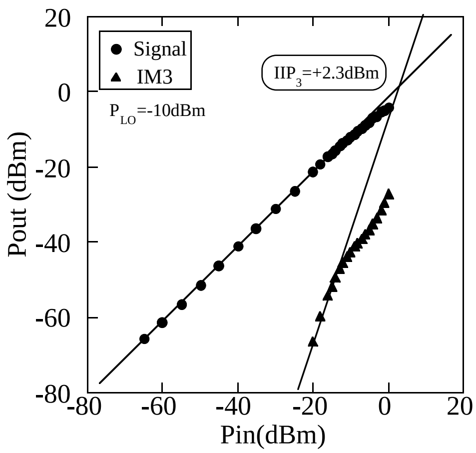

Fig.8 Two-tone transfer characteristic of mixer with LO amplifier. (Vcc=3V, Id.c.=0.6mA for mixer and 5.9mA for LO amplifier, PLO= -10 dBm)

Table 1 shows the performance of receiver using fabricated Si-MMIC front-end. The insertion loss of the BPF, located between LNA and mixer, is 1.5 dB. As the receiver, conversion gain of 16.7 dB, NF of 3.7 dB and IIP_3 of - 15.5 dBm are obtained with LO power of -10 dBm and 3 V / 13.7 mA d.c. power supply. This performance satisfies the requirements for digital cellular terminal application.

Table 1 Performance of the receiver using fabricated Si-MMIC fornt-end.

	LNA	BPF	MIX	Total
Gain (dB)	19.3	-1.5	-1.1	16.7
NF (dB)	2.45	-	15.4	3.7
IIP_3 (dBm)	-14.6	-	2.3	-15.5
Idc (mA)	7.2	-	6.5	13.7

V. CONCLUSION

Low noise, low distortion Si-MMIC front-end is developed. By integrating BJT as the 1st. stage of LNA, low noise characteristics can be achieved, and by adapting MOSFET's as the final stage of LNA and the down mixer, low distortion characteristics can be also obtained. The measured performance of fabricated Si-MMIC front-end demonstrates sufficient performance for digital cellular terminal application.

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