Dual Bias Feed SiGe HBT Low Noise Linear Amplifier

Eiji TANIGUCHI, Kenichi MAEDA, Takayuki IKUSHIMA†, Keiichi SADAHIRO†, Kenji ITOH†, Noriharu SUEMATSU and Tadashi TAKAGI

Information Technology R&D Center, Mitsubishi Electric Corporation
5-1-1 Ofuna, Kamakura-city, Kanagawa 247-8501, Japan
Tel : +81-467-41-2544 Fax : +81-467-41-2518, e-mail : tania@isl.melco.co.jp
†Mobile Communication Business Division, Mitsubishi Electric Corporation
8-1-1 Tsukaguchi –honmachi, Amagasaki-city, Hyogo, 661-8661, Japan

***Abstract* — A 2GHz-band SiGe HBT low noise amplifier (LNA) achieving high saturation power and low distortion performance is described. It has a novel diode / resistor dual bias feed circuit for the base of the HBT to extend its P1dB. In small signal region, the conventional resistor feed circuit is a dominant base current source, but in large signal region, the diode turns on and the diode feed circuit can supply base current like a voltage source which allows higher output power and linearity. The fabricated dual feed type LNA shows the P1dB improvement of 5dB compared with the conventional resistor feed LNA.**

I. INTRODUCTION

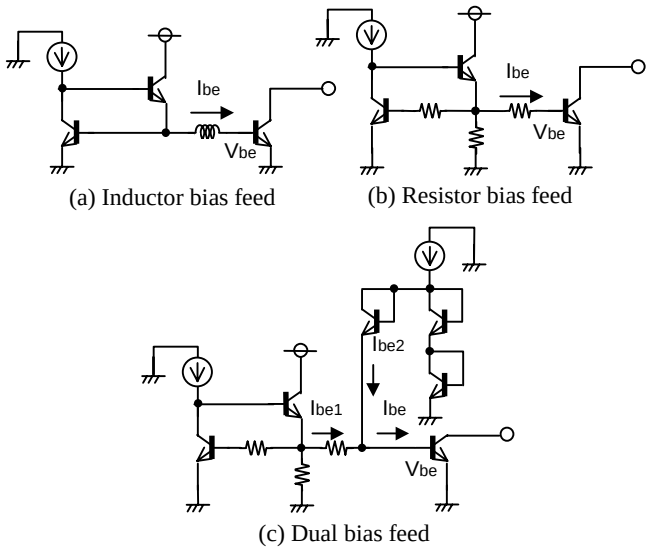
For low noise amplifiers (LNAs) used in mobile terminals, small size, low noise and low d.c. current operation are required, and high saturated RF power and linearity, i.e. P1dB and/or IP3, are also desired [1]. For the size reduction of RF section, system chips using Si technologies have been reported [2],[3]. The development of SiGe process having higher RF performance than conventional Si process has allowed us to design lower noise and lower d.c. current drive LNAs suitable for system chips [4].

In the case of BJT LNAs including SiGe HBT LNA, the design of base bias circuit is a key issue to obtain high P1dB. Since the HBT size is large enough to achieve low noise figure and the d.c. current is limited [1], the HBT is driven near pinch-off bias point, and an inductor feed has been used for the base bias circuit to obtain high P1dB and linearity [5]. From the view point of size reduction, the inductor feed bias circuit needs an area consumptive off-chip or on-chip inductor, and the use of on-chip resistor feed instead of inductor feed is preferable [1],[6].

In this paper, a novel base bias circuit for linear LNA has been proposed, which has two different bias feed circuits in parallel. One is conventional on-chip resistor feed circuit, and the other is on-chip diode feed circuit. The diode feed circuit is regarded as an open circuit in small signal region, and a voltage source in large signal region. Due to the base bias current flow from the diode feed circuit, the proposed LNA has higher P1dB than conventional resistor feed LNA.

II. BASE BIAS CIRCUIT DESIGN

In the case of SiGe HBT LNA, the base bias circuit design is one of the key issues to achieve low noise and high linearity characteristics. Figure 1 shows the variation of base bias circuits for LNA. Figure 2 and 3 show the simulated Vbe and Ibe dependences on the input power of LNA.



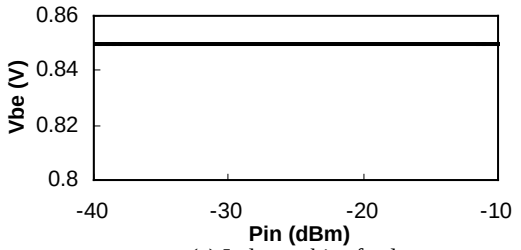
(a) Inductor bias feed (b) Resistor bias feed

(c) Dual bias feed

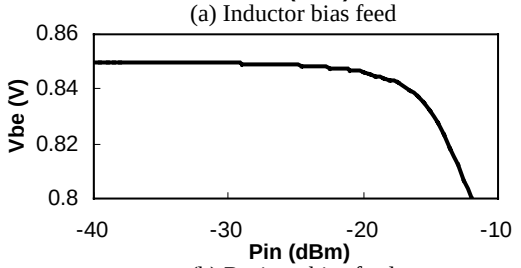
Fig. 1. Variation of base bias circuits

To achieve low noise and low d.c. power operation, the HBT is usually driven near pinch-off bias point. Therefore constant-voltage source and inductor feed circuit, shown in Fig.1(a), are preferable to obtain low noise performance, high P1dB and linearity. By using an inductor as bias feed, Vbe is constant and Ibe can be increased in large signal region to extend the output power. Inductor feed circuit provides high RF performance, but off - chip or on - chip

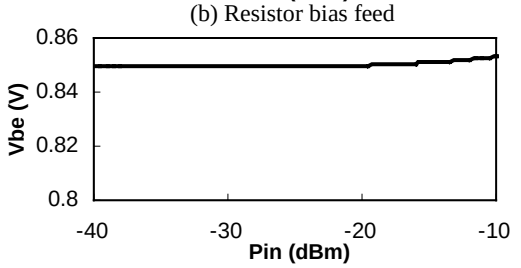
0-7803-6540-2/01/$10.00 (C) 2001 IEEE



(a) Inductor bias feed

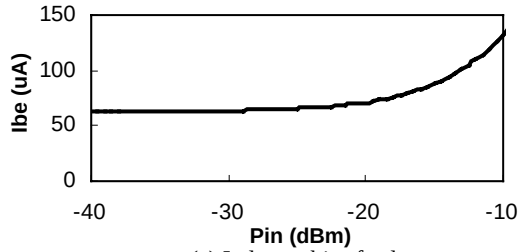


(b) Resistor bias feed

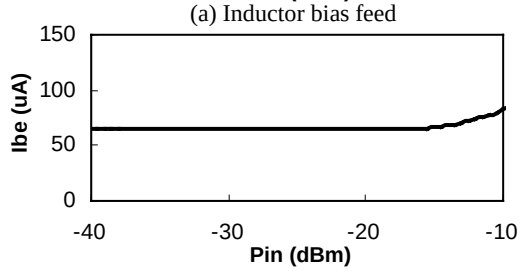


(c) Dual bias feed

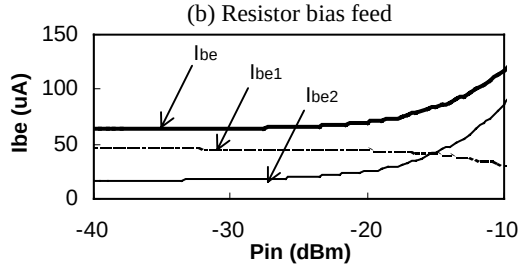
Fig. 2. Base voltage characteristics



(a) Inductor bias feed



(b) Resistor bias feed



(c) Dual bias feed

Fig. 3. Base current characteristics

inductor is area consumptive. For size reduction, resistor feed circuit, shown in Fig.1(b), has been used as conventional base bias circuit in many cases [1],[6]. To avoid the noise figure degradation due to resistor feed circuit, the value of the resistor is usually designed as several kΩ. In large signal region, since the bias point of HBT is near pinch-off, Ibe should be increased, but voltage drop due to feed resistor is occurred. Therefore, as shown in Fig.2(b) and 3(b), Vbe is dropped, and the increment of Ibe have to be limited.

Figure 1(c) shows the proposed diode / resistor dual bias feed LNA. To avoid Vbe drop in large signal region, diode feed circuit is added to the conventional resistor feed LNA. In small signal region, the diode feed circuit is regarded as an open circuit, and does not affect on noise performance. In large signal region, the diode feed circuit is regarded as a voltage source. In small signal region, the current from diode feed is relatively small and the diode feed does not affect on the noise performance of LNA. In large signal region, the diode feed provides base current like a constant-voltage source. Therefore, Vbe and Ibe characteristics, shown in Fig.2(c) and 3(c), are similar to those of inductor feed LNA.

Figure 4 shows the simulated transfer characteristics of LNAs having different base bias feed circuits. Resistor feed LNA has the lowest P1dB, and the proposed dual feed LNA has improved performance from resistor feed LNA.

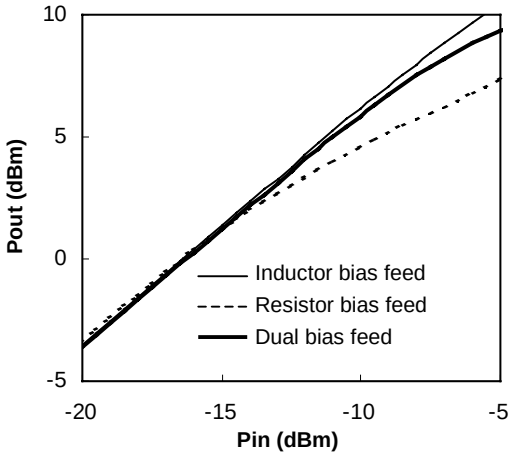
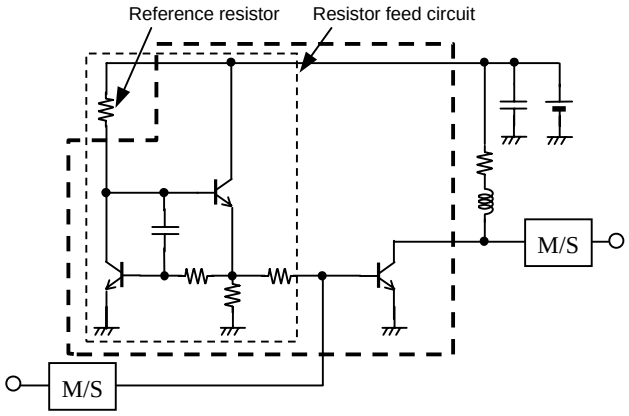


Fig. 4. Simulated transfer characteristics

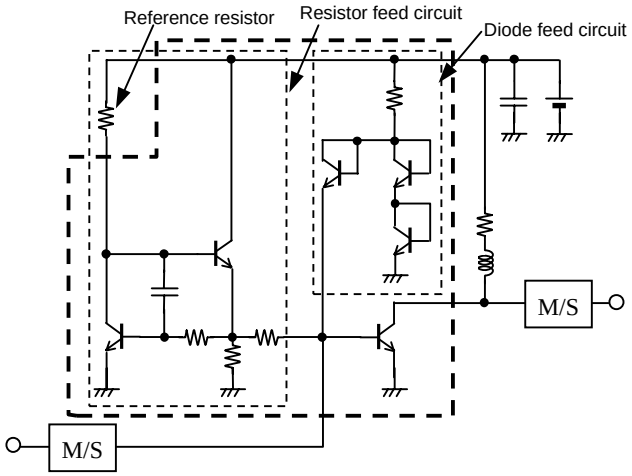
III. Implementation And Measurement

Based on the bias circuit design in Sec.II, the LNA having diode / resistor dual bias feed circuit has been designed and fabricated. For the evaluation, the LNA having conventional resistor bias feed circuit has been

fabricated. Schematic diagrams of those two LNAs are shown in Fig.5



(a) Resistor bias feed



(b) Dual bias feed

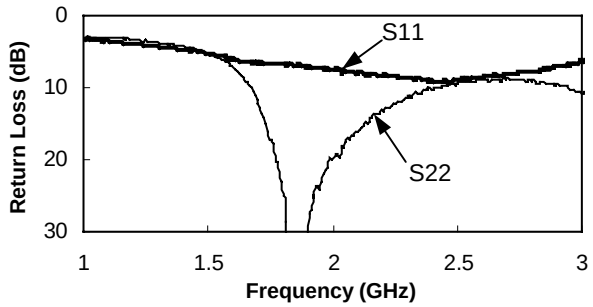
Fig. 5. Schematic diagrams of LNAs

Figure 5(a) shows the conventional resistor bias feed LNA, and Fig.5(b) shows the diode / resistor dual bias feed LNA. Both LNAs have external circuit components, i.e. matching circuits, collector bias feed circuits and reference resistors.

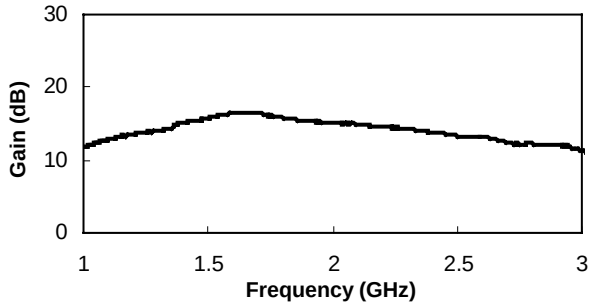
Measured small signal characteristics of dual bias feed LNA are shown in Fig.6, and the measured results including noise figure are summarized in table 1.

Figure 7 shows the measured transfer characteristics of LNAs having different base bias feed circuits. The Output P1dB of diode / resistor dual bias feed LNA is +4.5dBm and is 5.3dB higher than that of the conventional resistor feed LNA.

Figure 8 shows the measured IM3 characteristics of the LNAs. The Input IP3 of diode / resistor dual bias feed LNA is +0.2dBm and is 6.1dB higher than that of resistor bias feed LNA.



(a) Return Loss



(b) Gain

Fig. 6. Measured small signal characteristics

TABLE I
SUMMARY OF SMALL SIGNAL CHARACTERISTICS
(@2.1GHz)

	Total Current (mA)	Gain (dB)	NF (dB)
Simulated	6.1	16.5	1.5
Measured	6.2	14.8	2.0

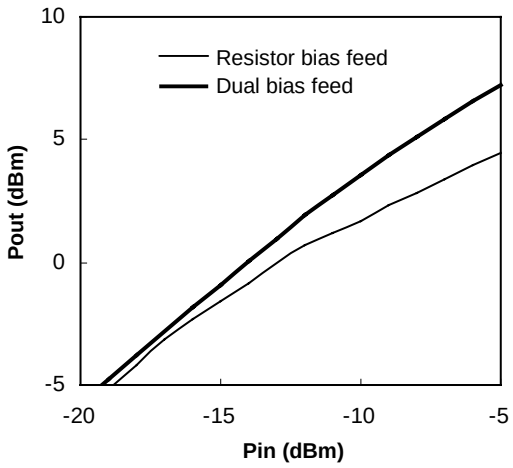
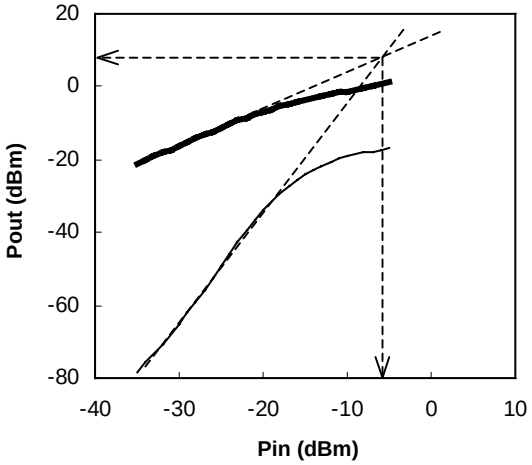
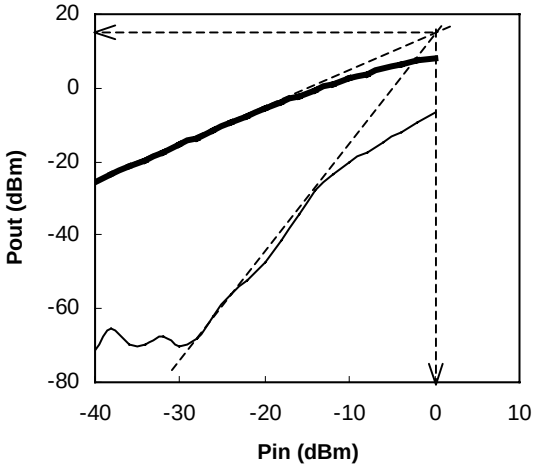


Fig. 7. Measured transfer characteristics



(a) Resistor bias feed



(b) Dual bias feed

Fig. 8. Measured IM3 characteristics

IV. Conclusion

A novel diode / resistor dual base bias feed LNA has been described. In small signal region, this dual bias feed circuit operates like a conventional resistor feed circuit, and low noise performance can be obtained. In large signal region, it operates like a constant-voltage source, and high output power and high linearity can be achieved. Since this bias feed circuit does not need any area consumptive inductors, a compact on-chip base bias circuit can be realized.

The fabricated dual bias feed SiGe HBT LNA performs high P1dB and IP3 compared with the conventional resistor feed LNA.

References

[1] N. Suematsu, M. Ono, S. Kubo, M. Uesugi, K. Hasegawa, K. Hiroshige, Y. Iyama, T. Takagi, and O. Ishida, "Intermodulation Distortion of Low Noise Silicon BJT and MOSFET Fabricated in BiCMOS Process", IEICE TRANS. ELECTRON., VOL.E82-C, NO.5 MAY 1999.

[2] D. Lovelace, S. Bader, D. Coffing, J. Durec, R. Hester, K. Huehne, E. Main, P. Ovalle, M. Randol, R. Tang, D.Welty, R. Williams and K. Wortel, "Low Cost 900MHz Single-Chip Cordless Telephone Receiver", Proc. 2000 IEEE RFIC Symp., pp.87-90, June, 2000.

[3] P. Good, J. Cheng and H. Cho, "A Highly Integrated Radio For High Performance, Low Cost 2.4GHz ISM Cordless Applications", Proc. 2000 IEEE RFIC Symp., pp.253-256, June, 2000.

[5] T. Robinson, B. Agarwal, S. Lloyd, P. Piriyapoksombut, K. Rampmeiser, M. Reddy and D. Yates, "A Highly Integrated Dual-band Tri-Mode Transceiver Chipset For CDMA TIAEIA-95 and AMPS Applications", Proc. 2000 IEEE RFIC Symp., pp.249-252, June, 2000.

[6] M. Soyuer, J. O. Plouchart, H. Ainspan and J. Burghartz, "A 5.8-GHz 1-V Low-Noise Amplifier in SiGe Bipolar Technology", Proc. 1997 IEEE RFIC Symp., pp.19-22, June, 1997.