A Novel Series Diode Linearizer for Mobile Radio Power Amplifiers

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Abstract

A novel series diode linearizer has been developed for mobile radio power amplifiers. It is composed of a series diode with a parallel capacitor, which provides positive amplitude and negative phase deviations with the increase of input power ,and can compensate AM-AM and AM-PM distortions of power amplifiers. Applying this linearizer to 1.9 GHz MMIC power amplifier for the Japanese Personal Handy-phone System(PHS), an improvement of adjacent channel leakage power(ACP) up to 5 dB has been achieved for the π/4-shifted QPSK modulated signal.

Introduction

There are increasing demands for highly efficient and linear microwave power amplifiers as a key component in mobile and satellite communication systems [1,2]. The power amplifier should be operated near saturation region to achieve high efficiency. At the near saturation region, amplitude and phase distortions of the amplifier remarkably increase with the increase of input power and cause a significant adjacent channel interference. To achieve high efficiency and low distortion simultaneously, several types of linearizers have been reported [3,4,5]. They have an advantage of providing large compensation for distortions. However these linearizers have drawbacks of large size, highly complex system and high d.c. power consumption. As a linearizer to address these drawbacks, we have presented an amplitude and phase linearizing technique by utilizing an FET with a large source inductance [6]. However it has a difficulty to apply to the amplifier whose input power is less than about 20 dBm.

To overcome this problem, we introduce a novel linearizer composed of a series diode with a parallel capacitor. This linearizer utilizes a nonlinearity of a series resistance of the diode. Applying this linearizer to the 1.9GHz MMIC power amplifier for the Japanese Personal Handy-phone System(PHS), an improvement of adjacent channel leakage power(ACP) up to 5dB has been achieved for the π/4-shifted QPSK modulated signal.

Compensation technique using a series diode

A circuit of the series diode linearizer is shown in Fig.1. It is comprised of a series Schottky diode with a parallel capacitor, two bias chokes for d.c. feed and two capacitors for d.c. block. We utilize a nonlinearity of the resistance R of the series diode to achieve positive amplitude and negative phase deviations for input power under low forward bias conditions.

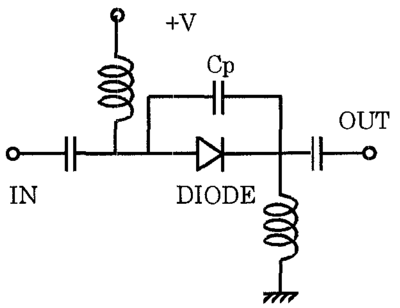

Fig.1 Circuit of a series diode linearizer

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Figure 2 shows a simplified equivalent circuit of this linearizer. S21 of the circuit is given by

$$S_{21} = \frac{2ZoY}{1+2ZoY} \quad (1)$$

$$Y = \frac{1}{R} + j\omega C \quad (2)$$

,where R is the resistance of the series diode and C is the sum of the parallel capacitance Cp and the junction capacitance Cj of the diode,and Zo is a characteristic impedance. With the increase of an incident RF signal power, the average current increases. An increase of d.c. current can be verified with calculating Fourier transform of the wave. It implies that the forward diode current increases and that the equivalent resistance R decreases.

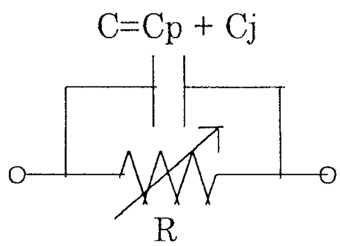

Fig.2 Equivalent circuit of the series diode with a parallel capacitor

Amplitude and phase deviations of S21 are calculated by using equations (1) and (2). The calculated results at 1.9GHz are shown in Fig.3 where the equivalent resistance R is varied from 1 to 1000 Ω. It is assumed that the capacitance C is constant value of 1pF. It is noted in Fig.3 that amplitude and phase of S21 monotonously change in the range from 10 to 100 Ω. It is expected that these curves can compensate AM-AM and AM-PM distortions of power amplifiers which provide negative amplitude and positive phase deviations with the increase of input power.

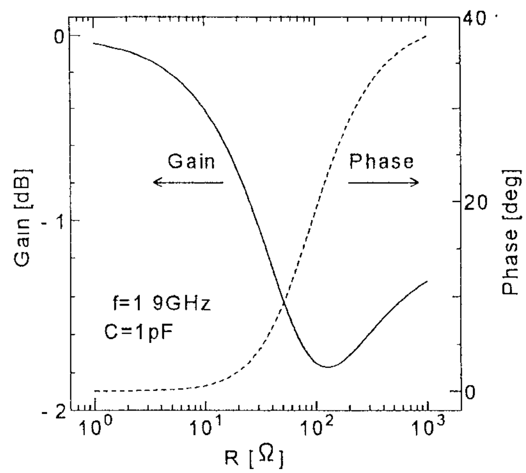

Fig.3 Calculated gain and phase deviations of S21

To verify this, we designed and fabricated the linearizer. Figure 4 shows the measured amplitude and phase deviations of the linearizer for input power at 1.9GHz as a parameter of the forward diode current. Here we use the junction capacitor Cj of a series diode as the parallel capacitance without external capacitor Cp in Fig. 2. The input and output impedance are 50 Ω. It is clear in Fig.4 that positive amplitude and negative phase deviations have been achieved under low forward bias conditions that the diode current ranges from 0.1 to 0.8mA of the diode current. By adjusting a forward current of the diode, amplitude and phase deviations of power amplifiers can be compensated.

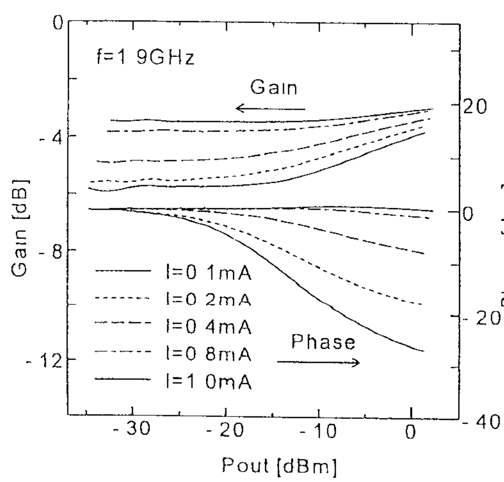

Fig.4 Measured gain and phase deviations of S21

Linearized power amplifier performance

A block diagram of the power amplifier coupled with the linearizer is shown in Fig.5. It is comprised of the 1.9 GHz MMIC power amplifier, the series diode linearizer, isolators and an attenuator for adjusting input power level. The MMIC power amplifier gives a linear gain of 35 dB, a saturation power of 22.5 dBm, a P_1dB of 12 dBm, and a maximum phase deviation of 10 degrees at 1.9 GHz. Figure 6 shows the measured gain compression and phase deviation of the linearizer.

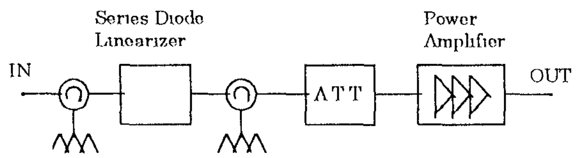

Fig.5 Block diagram of the linearized amplifier

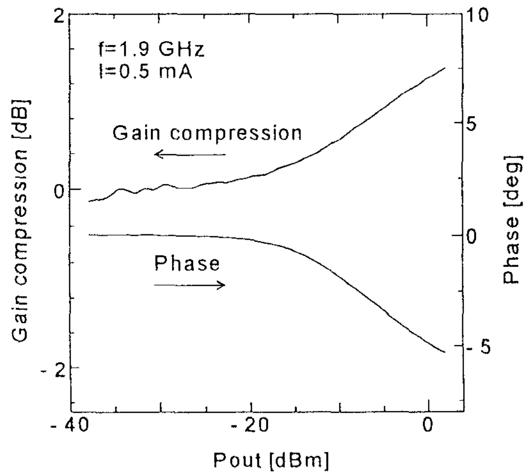

Fig.6 Measured gain compression and phase deviations of the series diode linearizer

Figure 7 shows the measured gain compression and phase deviation of the 1.9 GHz power amplifier with and without the series diode linearizer. A gain compression and a phase deviation have been improved by 1.2 dB and 5.7 degrees, respectively, at an output power of 21.3 dBm.

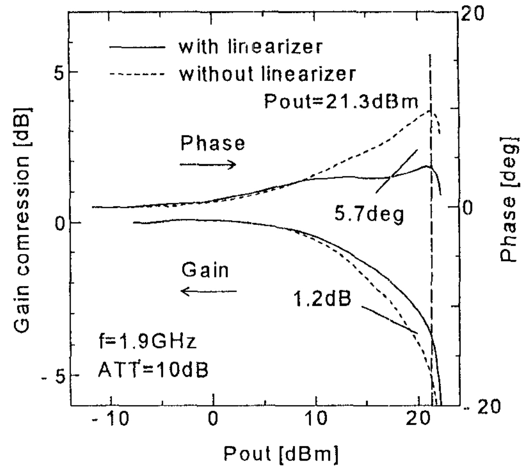

Fig.7 Measured gain compression and phase of the power amplifier with and without the series diode linearizer

In order to demonstrate the capability of the linearizer for digital modulated signals, an adjacent channel leakage power(ACP) was measured for the 384kbps π/4-shifted QPSK modulated signal utilized in the PHS in Japan. Figure 8 shows the measured ACP at 600kHz offset with a bandwidth of 192 kHz. An improvement of about 5dB has been achieved

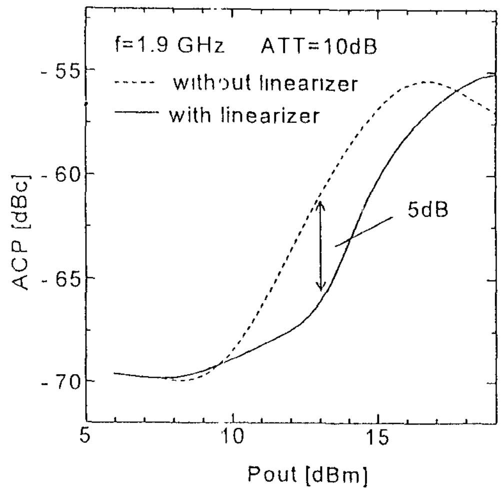

Fig.8 Measured ACP of the power amplifier with and without the series diode linearizer

Conclusion

A novel series diode linearizer has been developed for mobile radio power amplifiers. It is composed of a series diode with a parallel capacitor, which provides positive amplitude and negative phase deviations with the increase of input power. Applying this linearizer to the 1.9 GHz MMIC power amplifier used for the Japanese Personal Handy-phone System(PHS), an improvement of adjacent channel leakage power(ACP) up to 5 dB has been achieved for the π/4-shifted QPSK modulated signal.

References

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