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The Design of Automatic Gain and Phase Controlled Amplifier.

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Abstract

As the input power level applied to a RF amplifier increases, the gain and output phase of the amplifier change in a nonlinear manner. In this paper, by using AGC and I & Q demodulator, a method of controlling the gain and phase of such amplifier is presented. The proposed scheme is applicable to both single tone and multitone signals.

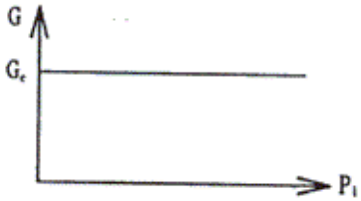
I . Introduction

(a) Gain Variation

(b) Phase Diagram

Fig.1. Characteristic's of Ordinary Amplifier

Generally, as the input power increases, the amplifier is gone into saturated region. So the gain of the amplifier decreases and the phase lag is occurred. Futhermore, when the temperature rises, the gain and the phase are distorted simultaneously. If the gain and phase of amplifier are fixed at any input power or environment, it will widely be useful for comunication circuit. When multitone signals are applied, they cannot be measured by



(a) Gain Variation

(b) Phase Diagram

Fig.2. Characteristic's of the proposed Amplifier system

II .Analysis

(1) The measurement of phase and magnitude by I & Q demodulator

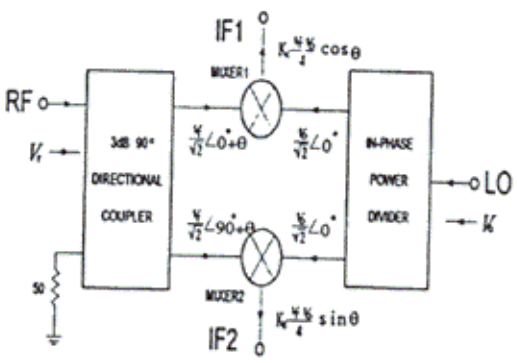


Fig.3. Block diagram of I & Q Demodulator

Fig.3 is the block diagram of I & Q Demodulator. RF and LO signal have the same frequency. One part of RF port is shifted by

the Network Analyzer. They are proved to be measured by I & Q Demodulator.

90° phase. DC signals come out of IF1, IF2 port. They are respectively expressed as $k_1 \frac{V_r V_o}{4} \cos\theta$ and $k_2 \frac{V_r V_o}{4} \sin\theta$. As

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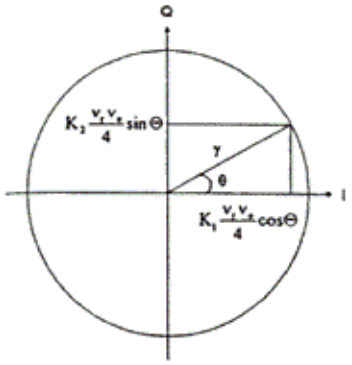

Fig.4. IF output vector of I & Q Demodulator

phase θ varies, they draw circle on X-Y plane. The circle is showed in Fig .4. S-parameter is measured by system expressed in Fig.5[1].

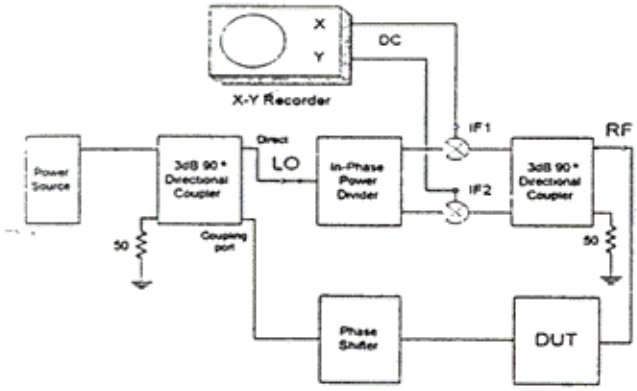

Fig.5. Block diagram of S_{21} measurement system

(2) The design of automatic gain and phase controlled amplifier

1) The design of automatic gain amplifier

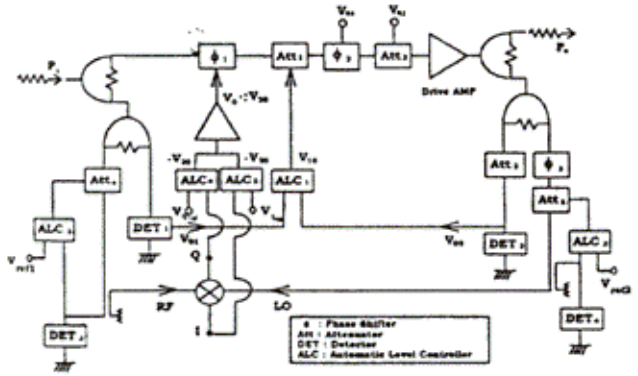

Fig.6. The Block Diagram of Gain, Phase Control AMP.

When the input power P_i is applied in Fig.6, RF signals are transformed into DC voltages at detectors DET_1, DET_2, where V_{D1} is a reference voltage. these two DC values are compared at V_{10} is varied slowly. Signal propagation velocity is vary fast. Attenuator is fixed when V_{D2} is equal to V_{D1} . Attenuator Att_3 plays a part in controlling the gain of the amplifier.

2) The design of phase controlled amplifier

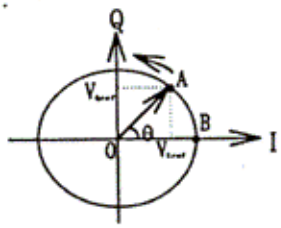

Fig 7. I.Q DC Output

Input and output signal are respectively applied into RF and LO port of I & Q Demodulator in Fig.6. The outputs of I & Q Demodulator are DC signal. These DC signals are drawn on X-Y plane at Fig.7. The phase shifter ϕ_2 is adjusted so that phase is located in point B. When phase is placed at B point, output V_0 is designed to move toward the 2 V_{20}.The phase of phase shifter ϕ_2 gets larger. It is shifting counterclockwise in Fig.7. As soon as the phase passes point A, the output V_0 is designed to be decreased by reference voltage V_{Qref} , V_{Iref} . So it is shifting clockwise. When it passes point A, the output Vo increases again. Finally, the phase is repeated at point A. Therefore the phase is fixed at point A. On the other hand, because the radius of circle has to be constant in Fig.7, the ALC_2 and ALC_3 are used to make the power level constant. The phase shifter ϕ_3 plays a role in controlling the phase of the amplifier. The phase variation of attenuator Att_4 and Att_5 must be constant during attenuation range.[2]

Ⅲ. Experimental Result.

When the input power is increased, the gain($G=P_O/P_i$) is varied at small range. In order to magnify the variation range of gain, attenuator Att_2 is used in Fig.6. The role of attenuator Att_2 is as good as that of the gain variation of amplifer. Output power Po is expressed in Fig.8 when one tone, two tones, four tones, eight tones and FM signal are applied. Then attenuation is -6dB, -1dB respectively. It is adjusted by bias voltage V_{B2}. By the way, phase shifterϕ_2 is used to magnify the variation range of phase shift. When one tone and multitones are applied into the input, phase shift is controlled. At this time phase cannot be measured by Network Analyzer. It can be measured by system expressed in Fig.5. Fig.9 proves that the phase shift value is constant when ALC is used. When ALC is not operated, the variation of V_{B1} is reflected on the circle at Fig.9.(a). Whereas, when ALC is operated, the variation of V_{B1} is fixed on the circle at Fig.9.(b)

Ⅳ. Conclusion.

ALC1. When V_{D2} is larger than V_{D1}, the attenuator Att1 is designed to be attenuated. Hear, as integrator is in ALC, output

By using the AGC, the gain of amplifier becomes to be constant. The error is below 0.1dB. Futhermore, gain can be

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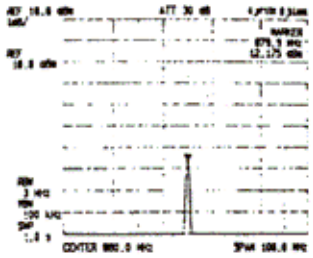
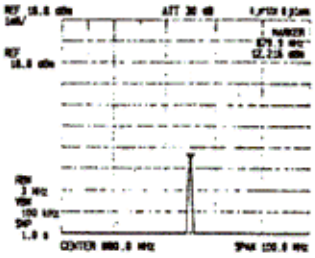
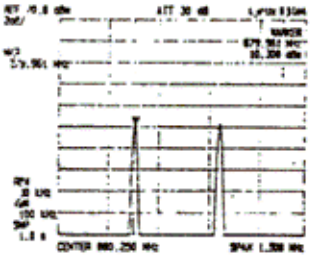


(a) Attenuation = -6dB



(b) Attenuation = -1dB

(a) 1-tone



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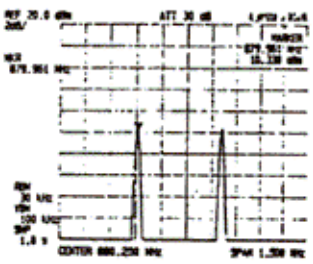
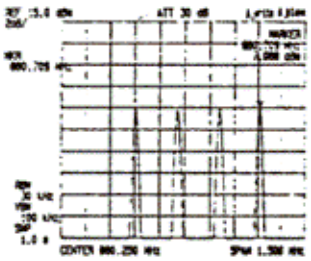
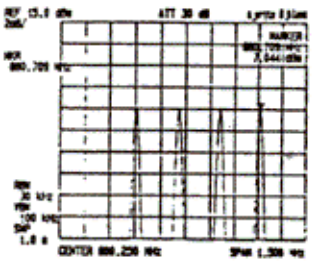


(b) Attenuation = -1dB

(2) 2-tone

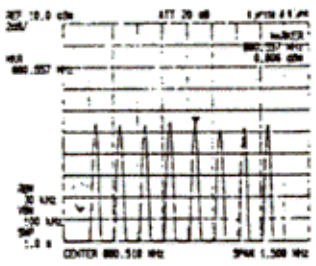


(a) Attenuation = -6dB

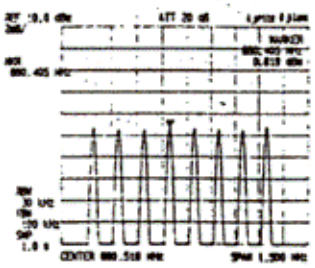


(b) Attenuation = -1dB

(3) 4-tone

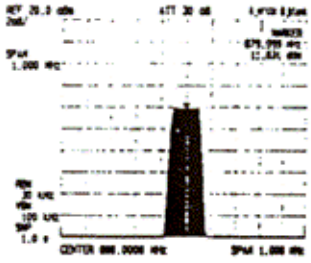


(a) Attenuation = -6dB

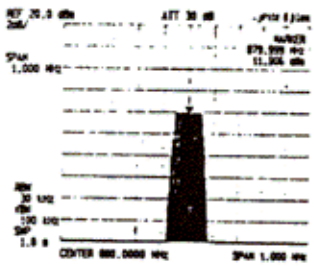


(b) Attenuation = -1dB

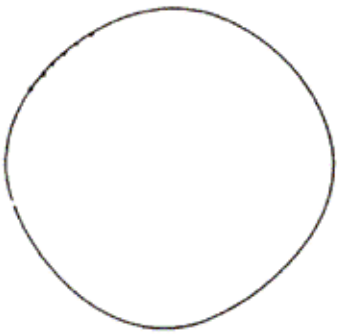
(4) 8-tone



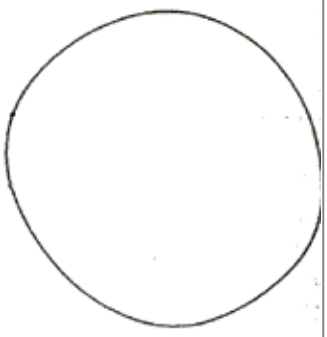
(a) Attenuation = -6dB



(b) Attenuation = -1dB



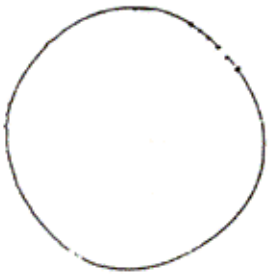
(a) When ALC is not operated



(b) when ALC is operated

V_{B1} =0,1,2,3,4,5(V) respectively clockwise

(1) 1-tone

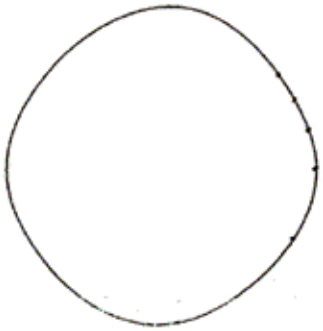


(a) When ALC is not operated

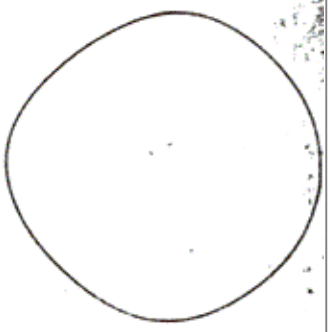
(b) when ALC is operated

V_{B1} =0,1,2,3,4,5(V) respectively clockwise

(2) 2-tone



(a) When ALC is not operated



(b) when ALC is operated

V_{B1} =0,2,4,6,8,10(V) respectively clockwise

(3) FM signal

Fig.9. Phase measurement by using I & Q demodulator

controlled by bias voltage. When I & Q demodulator and ALC are used, the phase can be fixed at constant value. The error is below 1° and phase can be controlled by bias voltage. As multitone are applied, they can be measured by system which uses the I & Q Demodulator. In this case, gain and phase can be controlled also. In conclusion, it is possible to design amplifier to be controlled with gain and phase at any input power Pi .

V. Reference

[1] I.H.Kang, C.B.Lee, I.S.Chang, S.W.Yun, O.H.Jeung, "S-parameter measurement by using quadrature mixer", Microwave Conference, The Korea Institute of Telematics and Electronics, pp.166~168 .1994

(5) FM signal

Fig.8. Output Power P_O when ALC is operated

[2] Stewart Walker, "A Low Phase Shift Attenuator". IEEE Trans, Microwave Theory Tech, vol. 42, No.2, pp. 182~185, February.1994

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