Power Amplifier Linearization Using Diode On Voltage

Mrunal A. K,
Makarand Shirasgaonkar MTech students
Dr R. M. Patrikar, professor,
Visvesvaraya National Institute of Technology, Nagpur INDIA.

Abstract:-
The emphasizes on higher data rates and spectral efficiency has driven the industry towards linear modulation techniques such as QPSK, 64 QAM, or multicarrier configurations. The result is a signal with a fluctuating envelope which generates intermodulation (IM) distortion from the power amplifiers. Since most of the IM power appears as interference in adjacent channels, it is important to use a highly linear power amplifier. This paper describes a new approach of using a Diode as a predistorter in view of minimizing non linear distortion introduced by the high power amplifier in microwave radio links. The approach is based on preventing the base-collector junction from becoming forward biased also preventing VDS > VGS-Vt in case of MOSFETs / pHEMTs. This approach has two advantages 1) It prevents the transistor to go into saturation 2) Reduces the effect of nonlinear terms generated by the active device.
Key words: power Amplifier, linearization, Diode ON voltage, class of operation

I. Introduction:-

The Power Amplifiers (HPA) in microwave radio systems are characterized by instantaneous non linear distortions. Consequently, they produce a widening of the power spectral density of the transmitted signal, obliging the use of strict RF filtering to avoid interferences on adjacent channels, and thus non linear intersymbol interference with memory. This last effect cannot be recovered easily by the receiver by means of fixed or adaptive equalizers. Three strategies have been proposed to limit the aforementioned negative effects. They consist of controlling either the constellation before the modulator [data predistortion], or the received signal [non linear equalization], or the modulated signal (at Intermediate Frequency IF or Radio Frequency RF)before the power amplifier analog predistortion.

Nonlinear amplifiers are characterized by measurement of their AM/AM (amplitude dependent gain) and AM/PM (amplitude dependent phase shift) characteristics. Not only are RF amplifiers nonlinear, but they also possess memory: the output signal depends on the current value of the input signal as well as previous values spanning the memory of the amplifier. Class AB power amplifiers (~25% efficient) are more power efficient than Class A amplifiers (~5% efficient) . Class AB amplifiers exhibit gain roll-off at low input powers as well as at saturation.

In this technique by DIODE connected between base-collector in the case of BJTs (HBTs) and between gate-drain in the case of enhancement mode n-channel MOSFETs (pHEMTs). Since at high frequencies, the capacitance formed by the capacitance formed by the depletion region in the pn junction becomes significant. In effect it isolates DC and RF signals. Since the diode is characterized as a capacitor at high frequencies, it acts as an RC feedback and the power amplifier is stabilized and also linearized.

In this paper AM-AM, AM-PM simulations are compared to show the effect of diode linearization.

2. Diode for Linearization:-

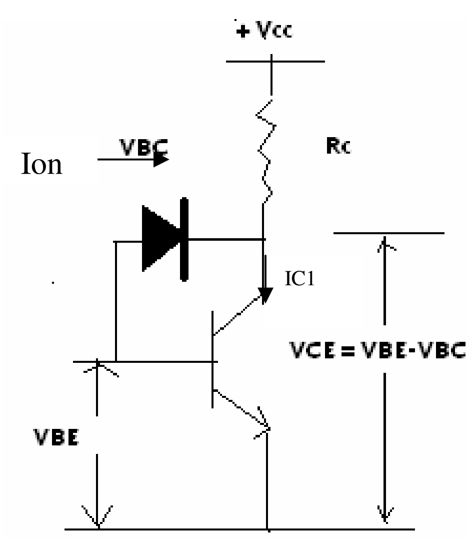


Fig1: BJT (HBT) PA linearizer

The diode is selected to have a forward voltage less than the normal base-collector voltage of the transistor in saturation in the case of BJTs (HBTs).

In the case of a Si transistor VBC > Vγ V (Built in potential) when the device is saturated. If the diode has VF < Vγ, then VBC = VF (Voltage drop across the forward biased diode), thus the transistor is prevented from becoming completely saturated.

Schottky diode is used in the case of PAs using BJTs (HBTs).

$$I_c = I_s \exp\left(\left[V_{be} - I_b R_b - I_e R_e\right] / V_t\right).$$

At the output V_0 = VCC – IcRc. Since Ic1 = Icc-Ion, and emitter is heavily doped, it reduces nonlinear terms thus improves linearity.

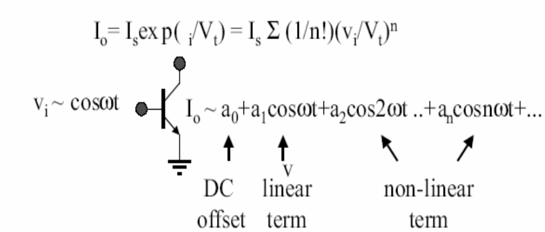
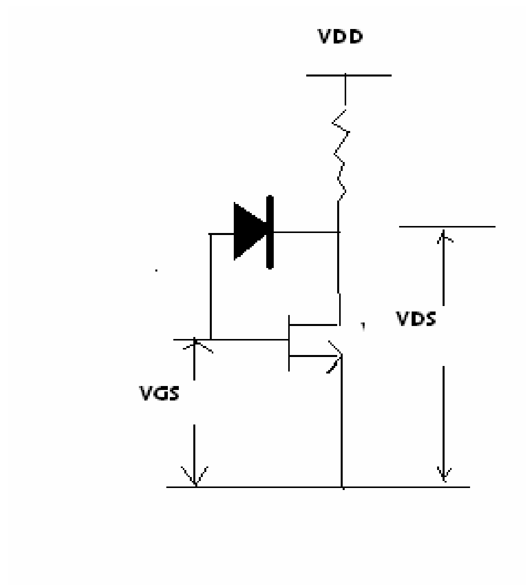


Fig2:- Output current

In the case of MOSFETs (pHEMTs) Vf of the transistor should be more than the threshold voltage Vt of the transistor.

For the signal levels when the diode turns on VDS = VGS-VF . Since VF > Vt (Threshold voltage) it ensures that VDS (VGS-VF) < VGS – Vt thus the FET operates in the ohmic region.



3.Simulation Results:-

The power amplifier system is implemented and simulated at the system-level using AGILENT'S ADS. Figure 1(a) and (b) depict the AM-AM, AM-PM conversion for the input power changing from -10dBm to 15 dBm. Figure 2(a) and (b) show the effect of linearization using the diode as explained above. Comparing figures 1 and 2 one can conclude that the 1dB compression point without linearization is at -4dBm Pin, where as it is at 10dBm after linearization.

4.References:-

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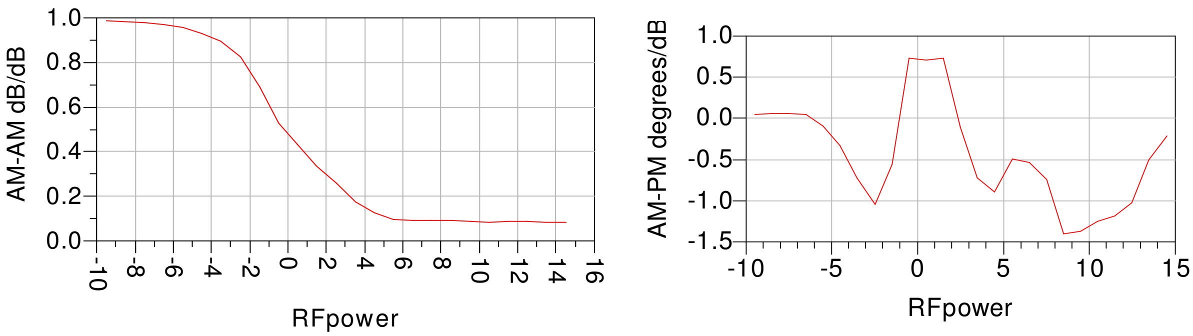
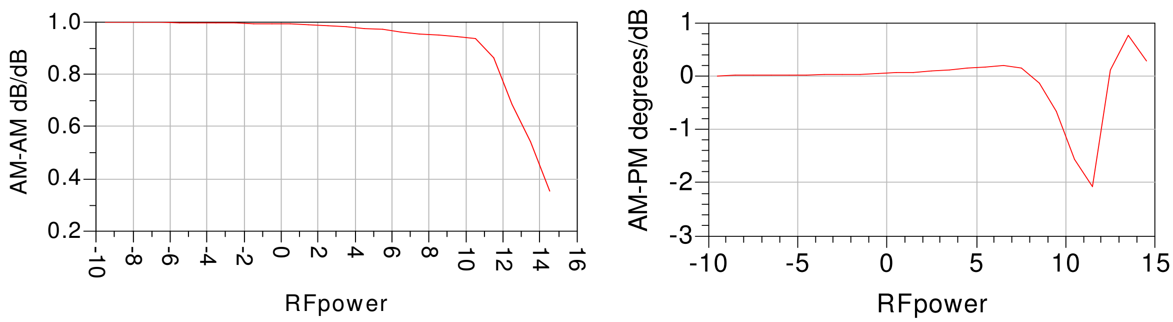


3(a) (b)

Figure 3(a): AM-AM conversion before linearization, (b):AM-PM conversion before linearization



4(a) (b)

Figure 4(a): AM-AM conversion before linearization, (b):AM-PM conversion before linearization

Author Information:

Mrunal. A.K, completed his master's in Electronics from Visvesvaraya National Institute of Technology, Nagpur, India, bachelor's from G. Pulla Reddy Engineering college, Kurnool, India. He can be contacted through email: mrunalak@gmail.com. Ph: 0091+9823149926

Makarand Shirasgaonkar, completed his master's in Electronics from Visvesvaraya National Institute of Technology, Nagpur. Email: smakarand@yahoo.co.in

Dr. R. M. Patrikar, Professor, Electronics Department, Visvesvaraya National Institute of Technology, Nagpur, INDIA. IEEE senior member, His expertise is in the field of physics, high performance computing and surface roughness.