13-3

TWTA LINEARIZER USING DUAL-GATE MESFET

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ABSTRACT

This paper presents a new predistortion technique using GaAs dual-gate MESFETs to linearize the microwave power amplifiers. The results of a linearized 16-watt traveling wave tube amplifier at 12 GHz are presented. The linearizer affects a 12 dB reduction in this third-order intermodulation products at 2.5 dB input power back off.

I. INTRODUCTION

Microwave power amplifiers used in ground station transmitters and communication satellites should be highly efficient and provide linear amplification. The performance of these amplifiers is limited by nonlinearities. In order to reduce amplitude and phase distortions of the signals generated in the microwave power amplifiers and obtain higher C/I (carrier to third-order intermoduation distortions products) ratios, amplifiers are operated well below saturation with consequent loss of efficiency.

Predistortion is one of the best of the many methods of non-linear compensation (1-5). In this technique, the inverse amplitude and phase non-linearities are added to the TWTA input signal to cancel the TWTA output non-linearities. Most of the predistortion circuits have used either diodes or the MESFETs as the non-linear elements along with associated complex circuits, such as phase shifters, attenuators, etc. (1-5).

In this paper, we present a new technique of predistorting the input signal to the TWTA, using dual-gate FETs. The circuit is quite simple and employs fewer components than in other techniques. Test results for a linearized 12 GHz 16-watt TWTA are presented. The third order IMD signals are reduced by 12 dB at saturation and 7 dB at -2.5 dB input power backoff. We believe that this is the first linearizer circuit developed at 12 GHz.

II. PRINCIPLE OF OPERATION

There are two sources of non-linearities in the TWTA: (a) amplitude non-linearity and (b) phase non-linearity. The intermodulation distortion generated by phase non-linearity is orthogonal to that generated by amplitude non-linearity. Therefore, a linearizer should be capable of generating both inverse amplitude and phase nonlinearities to achieve a substantial reduction in the IMD products.

Fig. 1 is a schematic diagram of the linearizer. The input to the linearizer is divided into two equal quadrature components in a 90° hybrid power splitter. The two quadrature components pass through non-linear dual-gate FETs, and are recombined in an in-phase combiner. The output of the in-phase combiner is first amplified in a linear amplifier, which is used to compensate for the loss in the linearizer and then fed into the TWTA. The amplitude and phase of the non-linearity introduced by the two dual-gate FETs can be varied by adjusting the dc biases on the second gates of the dual-gate FET. The dc bias on the second gate of the FET controls the drain current and therefore the gain of the dual-gate FET. The dual-gate FET behave as a non-linear device and with different second-gate biases the non-linearity characteristics of the two dual-gate FETs can be controlled. In order to compensate for the non-linear effects of the TWT, the linearizer produces a phase advance increasing, and an attenuation decreasing, with the increasing input power level. It is illustrated by vector diagram representation in Fig. 2. The two vectors A and B increase in their amplitude independently with increase in the input power at the linearizer, thus producing inverse phase and amplitude non-linearities at the output of the linearizer.

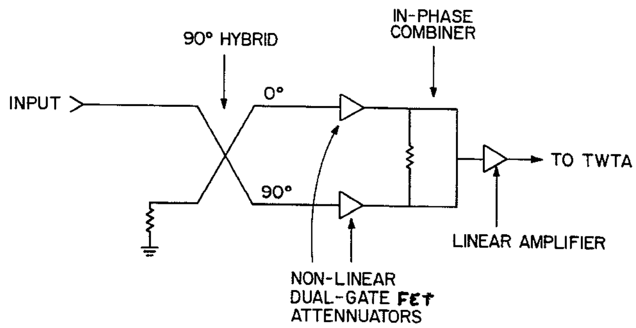

Fig. 1 Schematic diagram of the dual-gate FET linearizer.

III. EXPERIMENTAL RESULTS

Fig. 3 shows the variation output power backoff with input power backoff from saturation with and without linearizer. The phase transfer characteristics are presented in Fig. 4 as a function of input power backoff. The composite phase shift using linearizer varies only 5° over a 15 dB dynamic

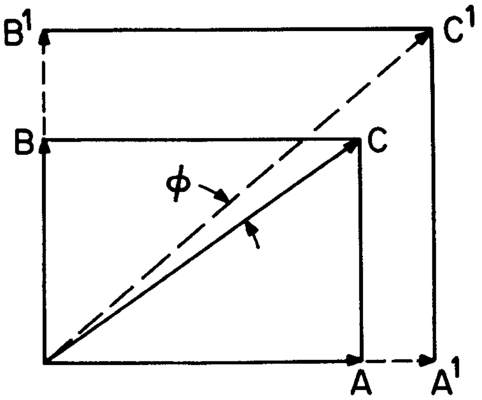

Fig. 2 Linearizer vector diagram.

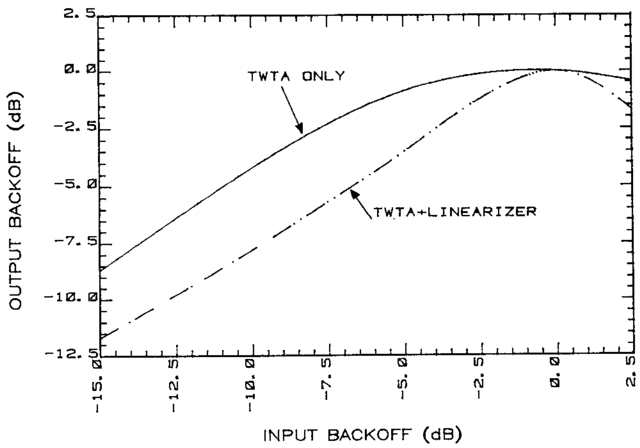

Fig. 3 Output power back-off as a function of input power back-off for single carrier.

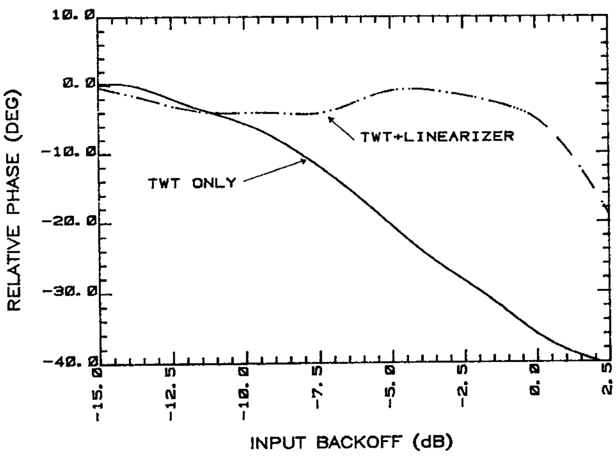

Fig. 4 Output phase of the TWTA with and without linearizer as a function of input power back-off.

range of -15 dB to 0 dB input backoff. The phase variation without the linearizer is 36° over the same dynamic range. The carrier to third-order intermodulation products are presented in Fig. 5 as a function input drive. The reduction in C/3rd IM is 7 dB at saturation and 12 dB at 2.5 dB input power back-off.

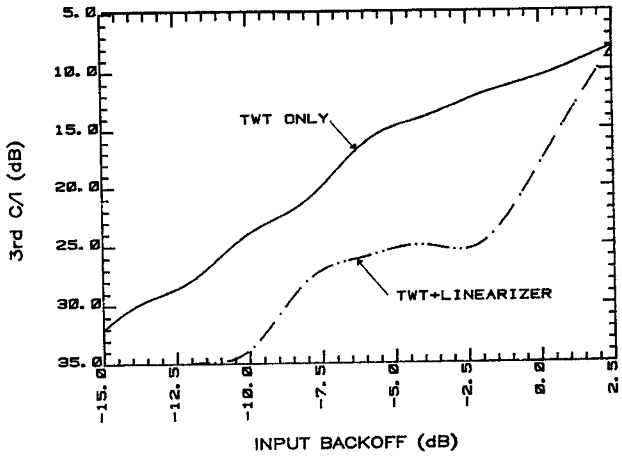

Fig. 5 Carrier to third-order intermodulation distortion ratio (C/3IMD) with and without linearizer as a function of input power back-off.

IV. CONCLUSIONS

A new pre-distortion technique is presented for linearizing microwave power amplifiers. In this technique, dual-gate FETs are used as non-linear devices to generate the amplitude and phase non-linearities. The results for a 12 GHz linearized 16-watt, TWTA are presented. A 12 dB reduction in the third order intermodulation products was obtained at 2.5 dB input power back-off. The overall phase variation of the output signal of the TWTA over a drive range of -15 dB input back-off to saturation is reduced from 36° without linearizer to 5° with linearizer.

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