ACHIEVING HIGHER EFFICIENCY IN VIDEO / TELEMETRY / DIGITAL TRANSMITTERS USING LATERALLY DIFFUSED METAL OXIDE SEMICONDUCTOR FIELD EFFECT TRANSISTORS (LDMOSFETs)

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ABSTRACT

A 10- or 20-Watt, L- or S-band transmitter commonly consumes the majority of the available DC power on a telemetry pack -- often more than all the remaining components combined. A new family of transistors allows a substantial increase in DC to RF efficiency without the use of complex and costly switching regulators. With ever increasing data rates requiring more RF bandwidth (and correspondingly lower receiver sensitivities), transmitters using these transistors offer twice the RF power at little or no increase in DC current. Alternately, in other situations such as observation balloons, the same RF power can be achieved with approximately 40% less current resulting in significantly longer mission life. This paper describes the method for achieving higher efficiency transmitters using new LDMOSFETs.

KEYWORDS

Laterally Diffused, LDMOSFET, Gallium Arsenide, GaAsFET, Transmitter, Efficiency

INTRODUCTION

This paper briefly summarizes an R&D effort by Emhiser Research, Inc. to determine if a new family of transistors from Motorola, termed Laterally Diffused Metal Oxide Semiconductor Field Effect Transistors (LDMOSFET), would facilitate the design of telemetry transmitters with previously unattainable efficiencies.

DISCUSSION

The majority of conventional telemetry transmitters share a block diagram as shown in Figure 1. An exciter, which generates the RF carrier and determines the modulation characteristics, drives one or more linear (class A) amplifier stages which in turn drive the power stage(s) operating in class C. The transition from class A to class C must occur at a sufficient power level to ensure that the class C stage always “turns on” at -40°C.
In Emhiser transmitters, this transition occurs at a level of 800 milliwatts.

High power LDMOSFETs, in contrast to high power bipolar transistors, are optimized for class A or AB rather than class C operation. While a class C stage is more efficient than a class A or AB stage in terms of RF Power Out/DC Power In, the situation reverses when the higher gain numbers (S21) of FETs are taken into account. This concept is discussed in a paper from the 1995 ITC Proceedings [1].

With the advent of LDMOSFETs [2], the circuits of the above referenced paper can be further simplified. As shown in Figure 2, the higher gain permits the removal of an entire gain stage and its attendant DC power losses. However, there are application limitations due to the present (May 1997) state of the art. At the present time, the only >1 GHz devices available are the Motorola MRF282 (10 Watts) and MRF284 (30 Watts). Lower and higher power as well as higher frequency devices are in development but are not yet available. Besides lack of variety, another major limitation of the present devices is frequency performance. While the overall improvement in efficiency at the lower (<2 GHz) bands is significant, this advantage vanishes at 2.2 GHz and above due to device power gains that drop to bipolar levels and the lack of benefit of class C operation.

The primary advantage of LDMOSFETs over GaAsFETs is the ability to operate at higher drain-to-source voltages thereby obviating the requirement of the switching regulators with their attendant added circuitry and added electro-magnetic interference (EMI) filtering complexity. While LDMOSFETs are intended to operate at +26 VDC, GaAsFETs typically operate in the 10 VDC range necessitating the use of switching regulators so that the efficiency gain of GaAsFETs over bipolar transistors is not overwhelmed by added regulator losses.

Assuming the utilization of a power MOSFET pass transistor, the efficiency of a linear voltage regulator approximately equals the ratio of the regulated voltage divided by the input voltage. The supply voltage to telemetry transmitters is commonly +28 ± 4 VDC. A nominal input voltage of +28 VDC and a regulated voltage of +22 VDC results in a DC/DC efficiency of approximately 78% which nearly equals that of a switching regulator operating at the same parameters thereby greatly diminishing the advantage of a switcher.

Another advantage of LDMOSFETs over both GaAsFETs and bipolars is the simplicity of the bias network. GaAsFETs require a negative gate bias (not commonly available) as well as a turn-on sequencer -- the lack of which can lead to catastrophic failure. Bipolar linear stages require a low impedance active network for optimal performance. LDMOSFETs on the other hand require only two low power resistors.

R & D RESULTS

A 5-Watt, D1 (L) band telemetry transmitter was constructed using the Motorola MRF282 LDMOSFET. As previously indicated, this transistor is a 10-Watt device at +26 VDC; however, with the linear regulator set at +22 VDC and allowing for isolator and low pass filter losses, a conservative 5-Watt transmitter results.

An RF output of 7.7 Watts was measured with a DC input current to the transmitter of 820 milliamps. The exciter section draws approximately 160 milliamps leaving 660 milliamps for the amplifier -- corresponding to a transmitter efficiency of 33.5% and an amplifier +22 VDC/RF efficiency of 53.0%. By comparison, typical values for our D1 band high efficiency series bipolar design are an output of 7.0 Watts with an input current of 1.0 Amp for a transmitter efficiency of 25.0% and an amplifier +22 VDC/RF efficiency of 37.8%. LDMOSFET efficiencies become even more significant when compared to industry standard D1 band transmitters which are worst case specified at 5 Watts at 1.5 Amps corresponding to a transmitter efficiency of less than 12%.

FUTURE RESEARCH

In the near future, a conservative 20-Watt, D1 (L) band transmitter could be constructed with a (not yet available) MRF284 final and (available) MRF280 driver. Moreover, the efficiency of this transmitter should be even higher than the above discussed 5-Watt model since the overhead current of the exciter will represent a smaller percentage of the total.

CONCLUSIONS

The advantages of LDMOSFETs are:

1. Due to the high RF gain, one or more amplifier gain stage(s) can be eliminated.

2. Due to Item 1, overall efficiency of the transmitter is greatly enhanced.

3. The linear regulator circuitry is considerably less complex than the switching regulator as required by GaAsFETs.

4. Without the switcher requirement, the EMI filtering requirement is eased.

5. The bias network is considerably simpler than that required for either GaAsFETs or bipolars.

The disadvantages are:

1. As of May 1997, no second source exists for the Motorola family of devices.

2. Only two of this family of devices are presently available.

3. Operating frequency is presently limited to less than 2 GHz.

4. The design, simulation, and tuning of these transistors are quite different from bipolar methods. Consequently, the learning curve in both the design and production phases of transmitters utilizing these devices may be substantial.

REFERENCES

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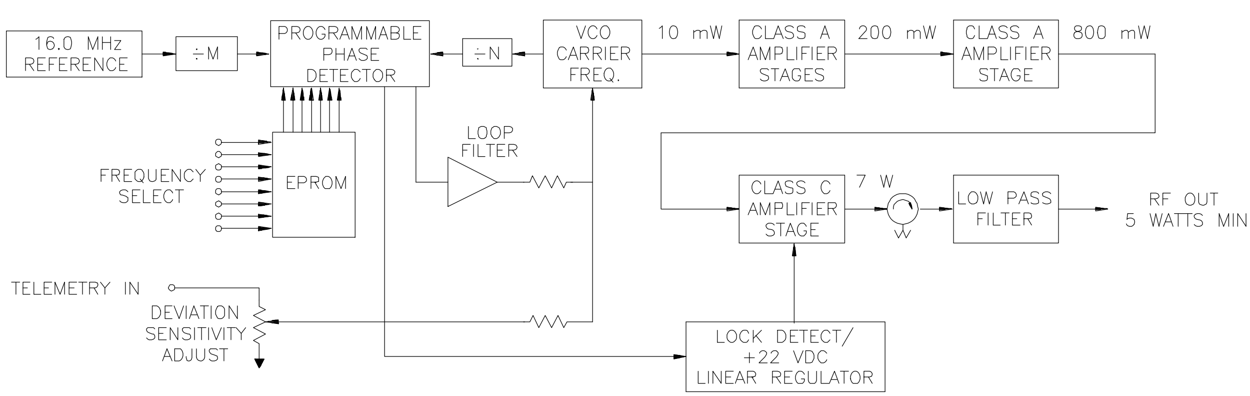

Figure 1 -- Block Diagram of Conventional 5-Watt, L-Band Transmitter

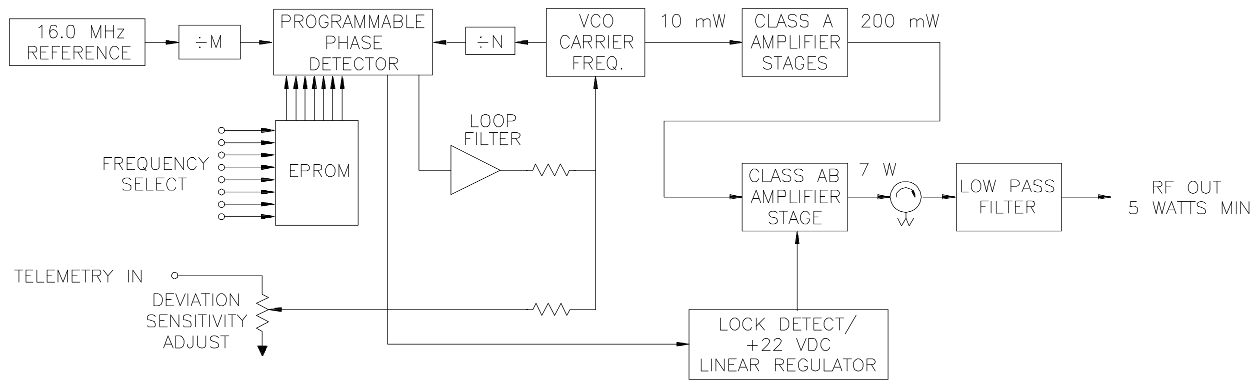

Figure 2 -- Block Diagram of 5-Watt, L-Band Transmitter Using LDMOSFET Final Stage