A MINIATURE 17/12 GHz MMIC RECEIVER FOR SATELLITE COMMUNICATION

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ABSTRACT

We have developed a novel high gain, low noise, miniature 17/12 GHz receiver with MMIC insertion for satellite communication. This receiver has a nominal conversion gain of 60+/-0.25 dB with gain adjustment range of 60 dB and noise figure of 1.6 dB. The third order intermodulation is 32 dBc @ -50 dBm input drive level, from 17.3 to 17.8 GHz at room temperature. It has a size of 5.7x1.8x0.3", a mass of 90 gm and a DC power consumption of 2.8 Watt.

INTRODUCTION

Implementation of MMICs into future communication satellites has the potential for providing significant reductions in cost, size and mass while offering good uniformity and reproducibility, and higher reliability than the discrete circuits being used today [1-2]. However MMIC insertion has high initial development costs, longer design cycles and almost no adjustability after manufacturing.

The current use of MMICs in space applications has been mainly in the area of large volume active phased array antennas. However, in any functions where mass, volume and power consumption are critical in future satellite design, MMICs can provide a means to improve payload properties.

At Space Systems/Loral we have developed a novel high gain, low noise, miniature 17/12 GHz receiver with MMIC insertion for satellite communication application. Reductions in size, weight, power consumption and cost of this receiver by more than 50% compared to conventional designs have been successfully demonstrated. Beyond high performance this receiver development was intended to accomplish high reliability, low cost and capable of quick delivery through the use of modular construction.

This receiver has a nominal conversion gain of 60+/-0.25 dB, digital gain adjustment range of 60 dB in 256 steps of 0.25 dB, noise figure of 1.6 dB, third order intermodulation of 32 dBc @ -50 dBm input drive level, from 17.3 to 17.8 GHz at room temperature. It has a size of 5.7x1.8x0.3", a mass of 90 gm and a DC power consumption of 2.8 Watt.

17/12 GHz RECEIVER DEVELOPMENT

In order to achieve the challenging requirements of this receiver development, the following strategies have been used:

First, a high quality, high yield, low cost laser sealed hermetic package approach was selected. A variable two dimensional model aluminum housing design was used with laser sealed RF and DC/command connectors. The top aluminum lid of the package is also laser sealed. This package approach has passed the stringent leak test with 100 % yield.

Secondly, a fully modular approach was used for lowest cost and shortest delivery time. Standard housings and modules were designed for different types of payload components while standard carriers and substrates were used for mounting the MIC and MMIC circuits. This standardization simplifies the inventory tracking and reduces the part counts and cost.

Thirdly, MMIC amplifiers and MMIC mixer were inserted in this receiver for the advantages of small size, less active/passive part counts and low assembly labor cost.

Figure 1 shows the block diagram of the 17/12 GHz receiver. The photograph of the 17/12 GHz receiver is shown in Figure 2. Both MIC and MMIC circuits were mounted on kovar carriers for ease of insertion. This receiver consists of a MIC 17 GHz LNA using low noise PHEMT, a 17/12 GHz MMIC mixer using FET diode, a 12 GHz MMIC IF amplifier and a 5.1 GHz LO buffer MMIC amplifier using MESFET, a 12 GHz PIN diode MIC attenuator, a 12 GHz MIC output amplifier using power PHEMT and a 12 GHz coupler/detector to monitor the output power. Three passive filters on alumina substrate were also utilized at the RF, LO and IF ports of the MMIC mixer.

A thick film control circuit which consists of the temperature compensation circuit, the linearizer circuit for the PIN attenuator and the voltage regulators was used, as shown in the bottom part of Figure 2. This control circuit provides the amplifiers with proper bias voltages, compensates the gain variation over temperatures and sets the gain of the receiver according to the command. The gain adjustment range of this receiver is 60 dB in 256 steps of 0.25 dB.

MEASURED RESULTS

Table 1 summarizes the measured performance of this 17/12 GHz receiver. This receiver has a measured maximum gain of 85 dB, a nominal gain of 60+/-0.25 dB, a gain variation of +/- 0.5 dB over the temperature range of -10 to +60 C, from 17.3 to 17.8 GHz, as shown in Figure 3. The receiver gain can be varied over 60 dB range in 0.25 dB step size with +/- 0.05 dB accuracy over 70 C temperature range, by external digital command.

A noise figure of 1.6 dB from 17.3 to 17.8 GHz at 25 C was measured for this receiver, as shown in Figure 4. The noise figure decreases to 1.4 dB at -10 C and increases to 1.8 dB at 60 C.

The third order intermodulation was measured to be -32 dBc with -50 dBm input power per carrier at 17.5 GHz and at room temperature, as shown in Figure 5. Figure 6 shows that the measured spurious levels with -70 dBm RF input power at 17.55 GHz and -5 dBm LO input power at 5.1 GHz. The dominating 2LO spurious level @ 10.2 GHz is ~ 31 dBc below the IF signal level. Other spurious such as 6LO-RF @ 13.04 GHz iss ~ 58 dBc below the IF level.

CONCLUSION

In conclusion, we have developed a low cost, low power consumption, miniature 17/12 GHz receiver with MMIC insertion for satellite communication applications. This receiver has excellent measured performance over the temperature range of -10 to +60 C, from 17.3 to 17.8 GHz. A receiver stack which integrates the 17/12 receiver with a miniature 5.1 GHz LO and a DC-DC converter is currently in testing.

Efforts to use these advances in developing the next generation of payload components such as channel amplifiers and upconverters with further reductions in size, weight, power consumption, cost and delivery time while maintaining the high performance and high reliability qualities are continuing.

ACKNOWLEDGMENT

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Table 1. Measured Performance of 17/12 GHz Receiver

Frequency Range	17.3-17.8 GHz
Maximum Gain	85 dB
Nominal Gain	60 dB
Gain Flatness	0.5 dB p-p
Gain variation over -10 C to +65 C	+/- 0.5 dB
Gain Adjustment	60 dB
Noise Figure	1.6 dB
C/3IM @ -50 dBm/input tone	32 dBc
IF Output & Spurious Level @ RF:-70 dBm @ 17.55 GHz, LO: -5 dBm @ 5.1 GHz	IF: 12.4 GHz, 14.6 dBm 2LO: 10.2 GHz, -16.5 dBm (31 dBc) 6LO-RF: 13.04 GHz, -43.5 dBm (58 dBc)

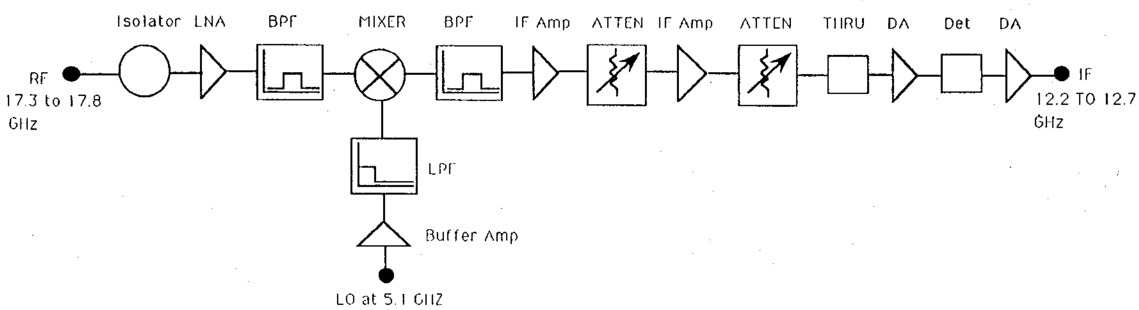

Figure 1. Block Diagram of 17/12 GHz Miniature Receiver.

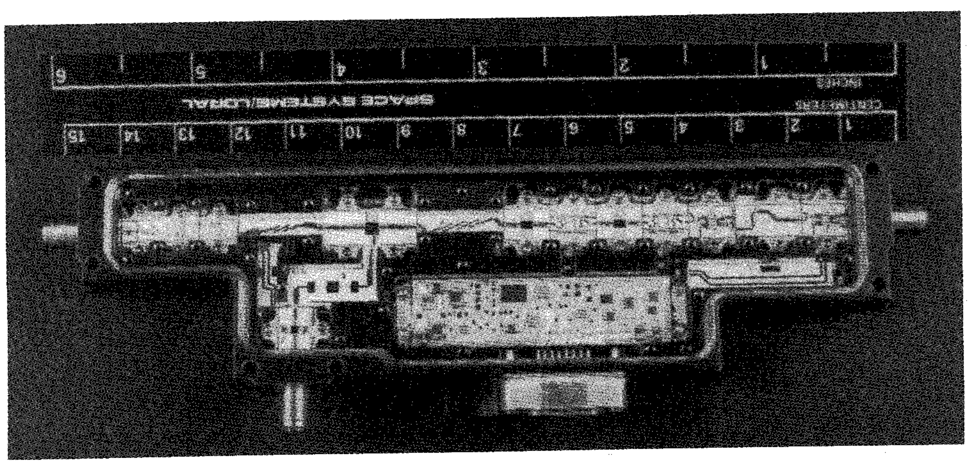

Figure 2. Photograph of 17/12 GHz Miniature Receiver.

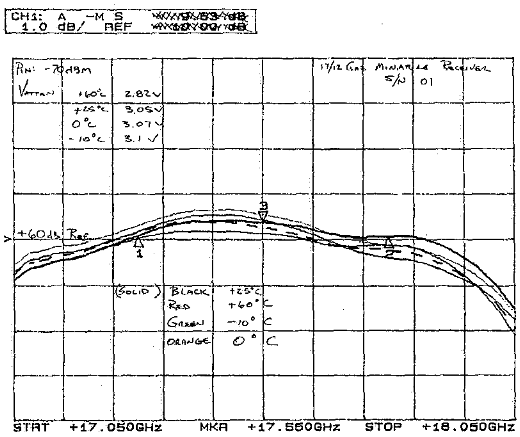

Figure 3. Measured Gain Performance Over -10 to +60 C for 17/12 GHz Miniature Receiver.

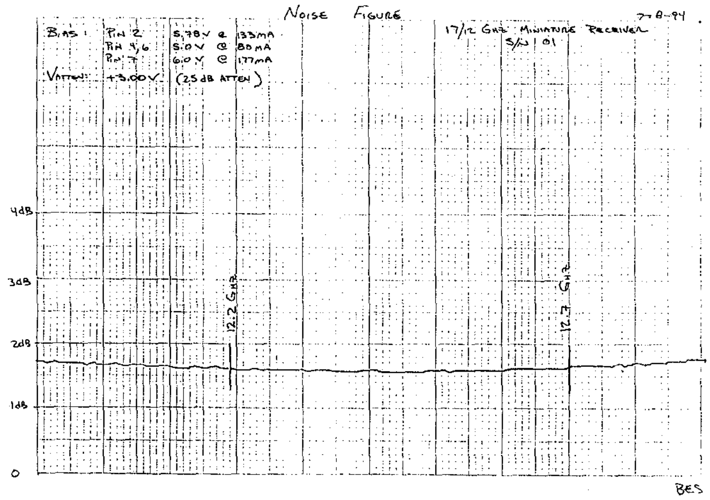

Figure 4. Measured Noise Figure Performance at 25 deg C for 17/12 GHz Miniature Receiver.

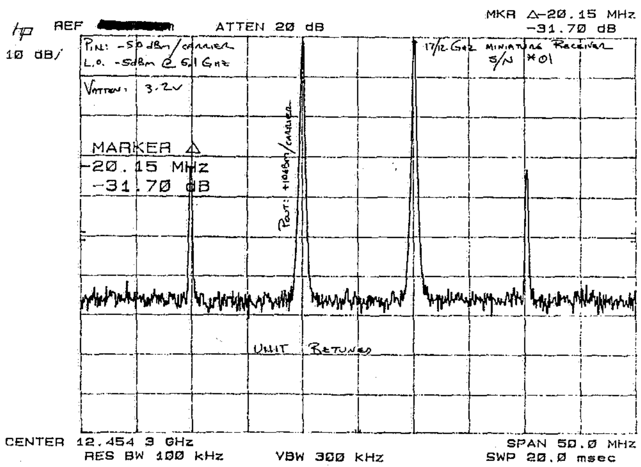

Figure 5. Measured Third Order Intermodulation Performance at 25 deg C for 17/12 GHz Miniature Receiver.

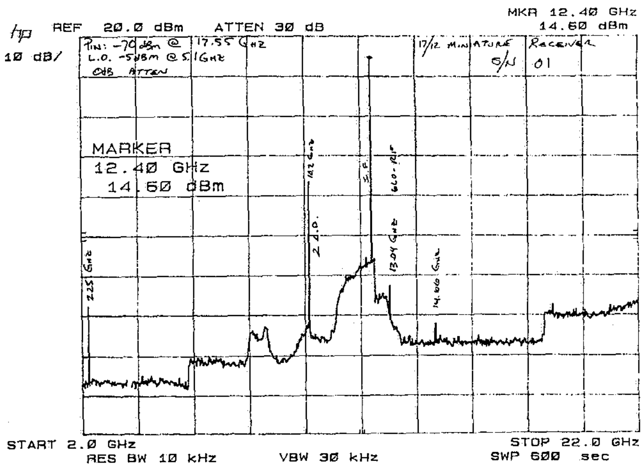

Figure 6. Measured Frequency Spectrum Performance for 17/12 GHz Miniature Receiver.