A HYBRID INTEGRATED L-BAND ALC AMPLIFIER

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Abstract

An ALC amplifier consisting of an rf amplifier, a detector, a variolosser, and an operational amplifier is described. The complete amplifier is realized on an alumina substrate using tantalum RC thin-film technology with appliqued beam-lead devices.

Introduction

In this paper a hybrid integrated L-Band amplifier with automatic level control (ALC) is described. This amplifier has been designed to furnish part of the gain required at the IF frequency in the repeater of a millimeter-wave transmission system. For this application the output power level of the amplifier must be maintained at -13 ± .5 dBm for an input power level variation from -25 to -17 dBm over the frequency range from 1.2 to 1.6 GHz in a 50-ohm system.

A schematic diagram of the ALC amplifier is given in Figure 1. As shown, the circuit consists of four major parts: the rf amplifier, the variolosser,[1] the detector, and the operational amplifier.[1] The detector monitors the output power and provides a signal for the operational amplifier which drives the variolosser, thereby controlling the power level at the input of the rf amplifier.

The physical configuration consists of beam-lead devices appliqued to a tantalum thin-film circuit which includes both capacitors and resistors on a 1-inch by 1.6-inch glazed high-alumina substrate. The transmission medium is suspended-substrate stripline.

Detector

Two slightly forward-biased GaAs Schottky Barrier diodes are used in the detector circuit. One of these diodes monitors the rf signal at the output of the rf amplifier while the other, located nearby, provides a reference voltage that compensates for temperature variations.

Variolosser

The variolosser is a bridged-T configuration with forward-biased GaAs Schottky Barrier diodes used as the variable resistive elements. This configuration has the advantage of using only two variable resistive elements while providing matched input and output. When the input power to the circuit is high, the variolosser is set into its high-loss condition with diodes D_1 and D_2 in their high and low resistance regions respectively. This condition reverses when a low power level is present at the input of the circuit. Thus the power level at the input of the rf amplifier remains essentially constant for variations in the power level at the input of the overall circuit.

As shown in Figure 1, bias resistors are in series with the variolosser diodes which are driven from the differential output of the operational amplifier. The diodes in the detector circuit provide the differential input for the operational amplifier. A resistive network is used to set the biases of these diodes for proper circuit operation.

RF Amplifier

The rf amplifier consists of two ac-coupled, common-emitter stages designed to give a total of 17.5 dB gain over the 400-MHz band with minimum return losses of 10 dB in a 50-ohm system. A circuit schematic is shown in Figure 2. The transistors used in this circuit are beam-lead silicon units with an f_T of 4 GHz. The common-emitter configuration was chosen since it provides greater stability and facilitates broadband matching.

The rf circuit of the amplifier was obtained by initially designing a lossless interstage circuit which provides most of the equalization required to compensate for the 6-dB/octave gain rolloff per transistor. Simple matching circuits were then added at input and output to obtain the required 10-dB minimum return loss over the band. An additional circuit was connected in shunt at the output to reduce the gain at frequencies below the band. The rf circuit was designed with the aid of a computer by programming the equivalent circuit of the transistor and a model of the passive circuit using a frequency-domain network analysis program.

It should be noted that the circuit shown in Figure 2 depicts only the actual components fabricated or appliqued on the circuit board. The final circuit response is significantly affected by the presence of various parasitic elements, notably grounding path inductances, which were included in a more accurate simulation of the circuit. Also the length and configuration of some of the inductors call for a distributed representation to obtain close agreement between design and measured performance.

Physical Realization

A photograph of the complete circuit is shown in Figure 3. The resistors, bypass capacitors, and large blocking capacitors are all realized using tantalum technology. These components utilize the same tantalum nitride film in order to reduce the number of processing steps. This common value of resistivity results in resistors which are physically somewhat large and necessitated the use of a back-to-back, interdigitated configuration for the capacitors in order to minimize the loss. The inductors were approximated with short straight sections, longer meandered lengths, and square spirals of narrow lines. The small capacitors required for impedance matching and tuning are SiO_2 beam-lead units which are appliqued to the substrate. Springs provide an rf ground connection to the package.

Performance

The performance of the entire circuit is shown in Figures 4 and 5. The output power level is plotted as a function of input power level at midband and at the edges of the 400-MHz band in Figure 4. As shown, the output power level shows no significant change with a variation in input power from -27 to -17 dBm.

The output power level, as a function of frequency, for input power levels of -25, -21, and -17 dBm is shown in Figure 5. As indicated, the power level characteristic remains the same for the three input power levels and is constant across the frequency band to within ± 0.25 dBm. The return losses which, of course, are functions of the power level are a minimum of 10 dB across the 400-MHz band.

Acknowledgements

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Reference

1. W. G. Garrett and T. G. Maxfield, "A Monolithic Differential-Output Operational Amplifier," 1972 IEEE ISSCC Dig. Tech. Papers, Philadelphia, Pa., February 1972, pp. 174-175.

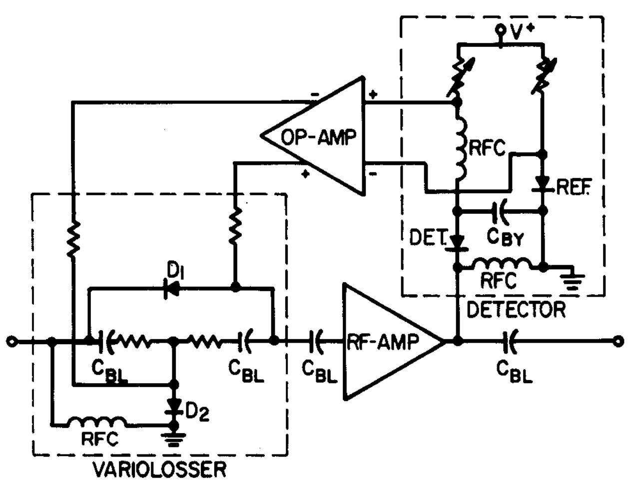

FIG. 1 ALC AMPLIFIER SCHEMATIC

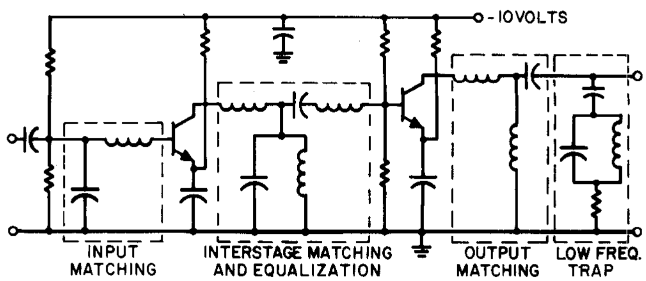

FIG. 2 CIRCUIT DIAGRAM OF RF AMPLIFIER

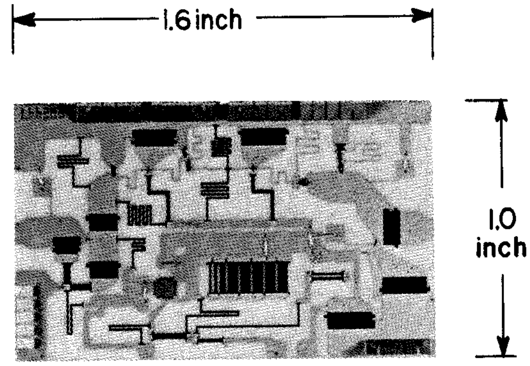

FIG. 3 ALC AMPLIFIER CIRCUIT CARD

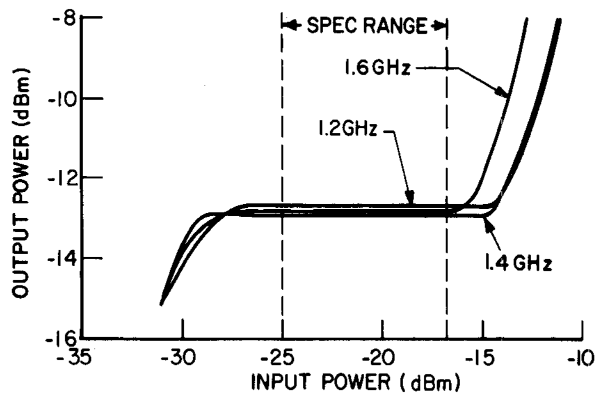

FIG. 4 LEVELING CHARACTERISTICS

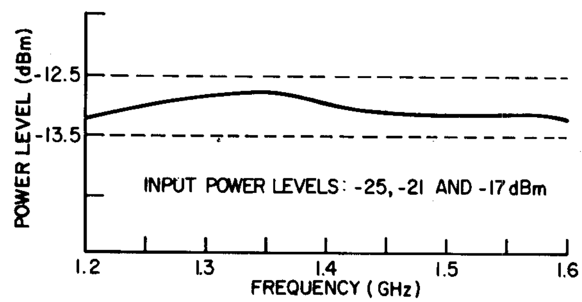

FIG. 5 FREQUENCY RESPONSE