86 GHz High Power IMPATT Negative Resistance Amplifier

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ABSTRACT

Describes the development of a millimeter-wave two-stage IMPATT negative resistance amplifier, using a Si DDR IMPATT diode sealed in a ceramic package to obtain a gain of 10 dB and an output power of 18 dBm in the 86 GHz frequency range.

Introduction

A Si DDR IMPATT diode is suitable to obtain a high power in millimeter-wave frequency range. A high power reflection type negative resistance amplifier using this diode has been developed. The guided millimeter-wave transmission system in Japan, W-40G system, uses the frequency range 43.80 - 86.35 GHz, and the repeater system transmits a 806 Mb/s 4-phase PSK format.(1) The center frequency of the amplifier is 86.35 GHz and the amplifier has been successfully tested with a 806 Mb/s 4-phase PSK input. Experimental results of one-stage and two-stage IMPATT amplifiers are described below.

Configuration and Performance of the One-stage Amplifier

A block diagram of the one-stage reflection type negative resistance amplifier and a cutway view of the diode mount are shown in Fig. 1. A Si DDR IMPATT diode, with a diamond heat sink, is hermetically sealed in a ceramic package to guarantee high reliability.(2) The diode breakdown voltage (VB) is 16.0V and the total capacitance at zero voltage (includes package capacitance of 0.1 PF) is 0.57 PF.

The input (P in) - output (P out) characteristics and the frequency response of the one-stage amplifier are shown in Fig. 2. With an input level of +15 dBm, an output of +19 dBm can be obtained. The gain compression at this level is 0.6 dB and the junction temperature rise is 174°C. To amplify a 806 Mb/s PSK signal, the bandwidth of the amplifier must be wider than 0.8 GHz. The bandwidth of the one-stage amplifier is more than 3 GHz as shown in Fig. 2. No possible adverse effects of the ceramic package on the frequency response (previously a main concern in millimeter-wave band development) has been observed. Insertion loss of the circulator used in this amplifier, is 0.5 dB/pass.

The input-output characteristics as a function of the distance between the diode and the waveguide short appear in Fig. 3. The small-signal gain can be changed continuously up to about 9 dB. If two amplifier units with these characteristics are combined in cascade, an overall gain of 10 dB can be obtained with an input level of +8 dBm.

Performance of Two-stage Amplifier

A block diagram of a two-stage amplifier and its characteristics are shown in Fig. 4. With an input level of +8 dBm, an output level of +18 dBm can be obtained. The gain compression at this level is 2 dB. The amplitude deviation within the band (0.8 GHz for 806 Mb/s 4-phase PSK signal) is less than 1 dB at the individual level. The diode breakdown voltages and the total capacitances at zero voltage are 16.8V, 0.55 PF for the first stage and 16.0V, 0.57 PF for the second stage respectively. The junction temperature rise of the IMPATT diode is less than 180°C for each stage.

Error Rate Measurement

To study the effects of gain compression on the transmitted waveform distortion, a two-stage amplifier was connected to a 806 Mb/s 4-phase PSK repeater and the error rate was measured. Coherent detection was employed at the repeater and the measurements were made using an error rate measuring equipment.(3)

The measured error rates with gain compression levels of 2.3 dB and 1.6 dB and without the amplifier appear in Fig. 5. With these gain compression levels, the error rate degradation is slight.

AM-PM Conversion

The measured results of the AM-PM conversion factor are shown in Fig. 6. This factor was obtained by measuring the variation of the output phase against the static change at each input level. The AM-PM conversion factor at a high input level is 6 degrees/dB. The phase-shift at an input level of 10 dBm is approximately 50 degrees compared to the phase shift at an input level of -10 dBm.

Pulse Transient Response

The output pulse transient response in which the input phase abruptly changes from 0 to π radian with gain compression level of 1.4 dB and without gain compression and without the amplifier appears in Fig. 7. The risetime of the input step pulse is 0.7 ns. The output waveform distortion is minimal with the above gain compression levels. Judging from the results of the measurements shown in Figs 5 to 7, it is apparent that the AM-PM conversion factor at such level does not affect the error rate characteristics much.

Conclusion

The reflection type negative resistance amplifier using a Si DDR IMPATT diode hermetically sealed in a ceramic package is a two-stage amplifier operating at 86.35 GHz to produce an output power of 18 dBm, with a gain of 10 dB and gain compression of 2 dB. The amplifier has good wide band performance characteristics and the results of the error rate measurements have also been very satisfactory. This amplifier will be effective in extending the distance between millimeter-wave transmission repeaters.

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References

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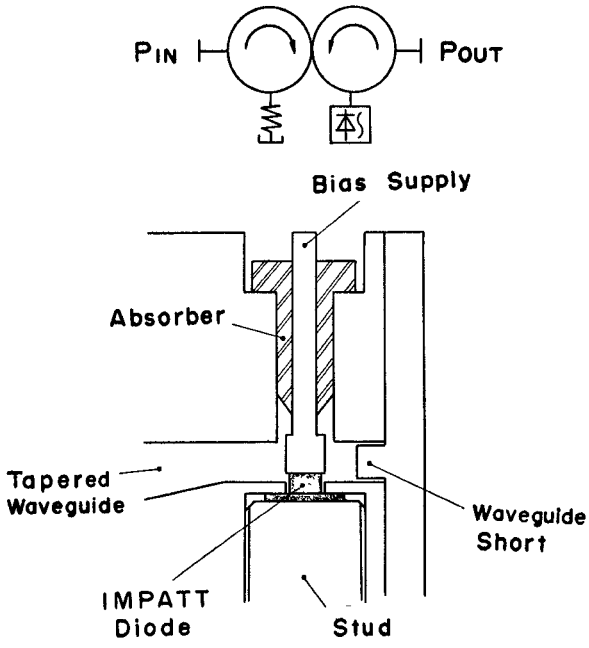

FIG. 1 BLOCK DIAGRAM OF A REFLECTION TYPE AMPLIFIER AND CUTWAY VIEW OF THE DIODE MOUNT

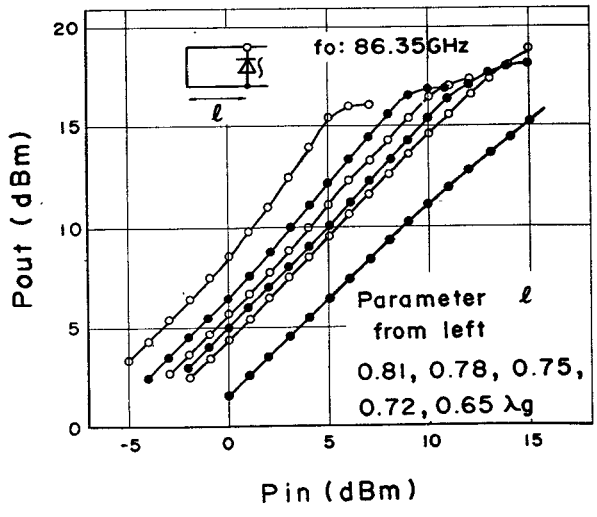

FIG. 3 INPUT-OUTPUT CHARACTERISTICS AS A FUNCTION OF A DISTANCE BETWEEN THE DIODE AND THE WAVEGUIDE SHORT

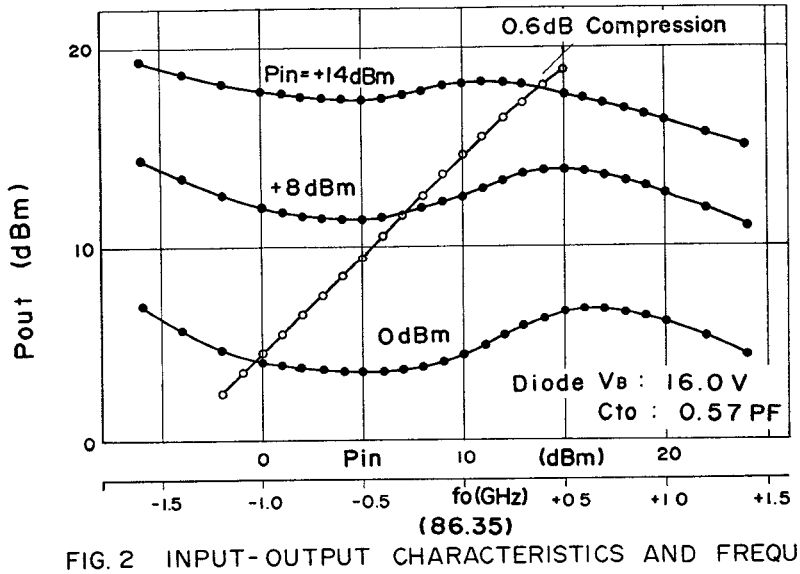

FIG. 2 INPUT-OUTPUT CHARACTERISTICS AND FREQUENCY RESPONSE OF THE ONE-STAGE AMPLIFIER

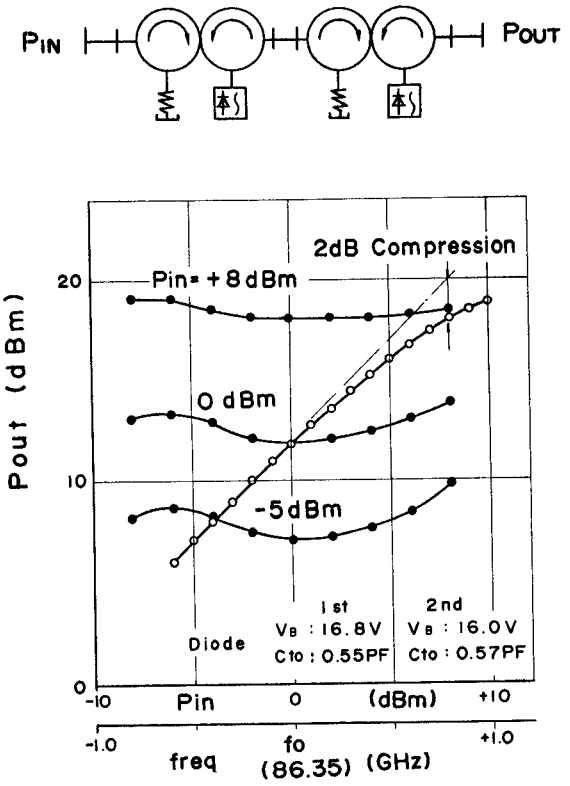

FIG. 4 BLOCK DIAGRAM OF A 2-STAGE AMPLIFIER AND ITS CHARACTERISTICS

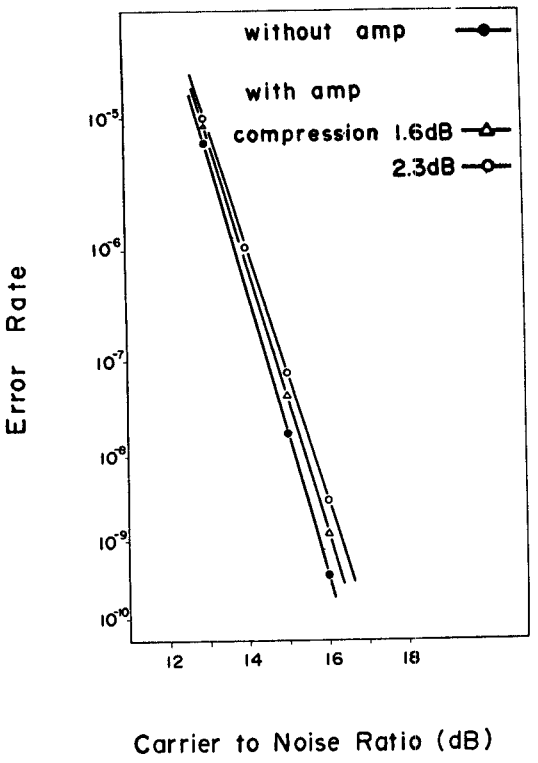

FIG. 5 RESULTS OF ERROR RATE MEASUREMENT FOR THE 2-STAGE AMPLIFIER

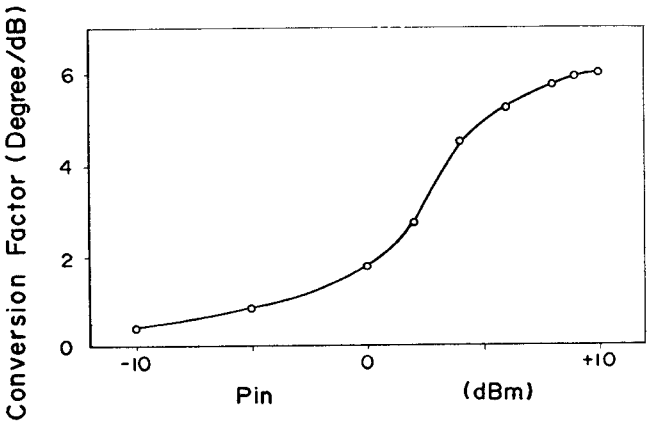

FIG. 6 AM-PM CONVERSION FACTOR

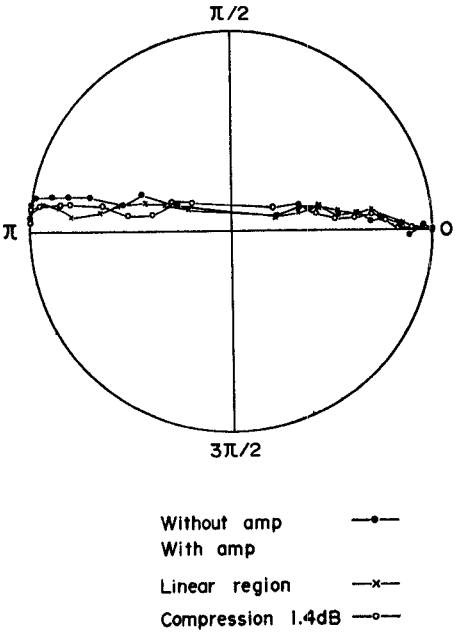

Fig7 PULSE TRANSIENT RESPONSE (INPUT IS 0-π PHASE STEP)