A LOGARITHMIC DISTRIBUTED AMPLIFIER

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ABSTRACT
This paper describes a logarithmic amplifier which uses the distributed amplifier as the basic amplifying element. The successive detection technique is used and leads to a logarithmic amplifier with a 65 dB dynamic range operating over the band 2 to 6 GHz with a deviation from linearity in the middle of the band of +/- 1.0 dB over the dynamic range. Over the specified band a further deviation of +/- 1.3 dB occurs. The effect of varying temperature from 0°C to 50°C increases this figure to +/- 1.7 dB. The rise and fall times (including the associated video amplifier) are 7nS and 20nS respectively.

INTRODUCTION

The use of a cascade of linear amplifiers with a video detector at the output of each amplifier is a well known method of producing an amplifier with a logarithmic transfer function since the summation of the video detector outputs approximates to the required function. This form of amplifier is known as the successive detection logarithmic amplifier and together with other methods of obtaining a logarithmic transfer function is described in the literature (1,2).

This logarithmic amplifier uses a distributed amplifier as the basic amplifier module. It is believed that this is the first time that the distributed amplifier has been used in this way. The advantages of the distributed amplifier in this application are:

a) broadband amplification with consequent superior pulse response to that obtained by the use of conventional amplifiers.

b) a superior temperature sensitivity since the distributed amplifier has an inherently lower temperature sensitivity than the conventional amplifier

Fig.1 shows in schematic form the amplifier configuration. Six distributed amplifier-limiter modules were used.

AMPLIFIER MODULE DESIGN AND PERFORMANCE

Each module consists of two cascaded distributed amplifiers each of 7.5 dB gain followed by a Wilkinson 3 dB coupler which provides an output to the video detector and also to the next module. This arrangement is indicated in Fig.2. The overall module gain is 12 dB. An advantage of the use of the Wilkinson coupler is the 6 dB isolation provided between pairs of modules thus reducing gain variation due to the effect of input and output mismatch.

Hybrid technology is used for the module using Avantek encapsulated AT 10650 MESFETs as the active element. The video detector circuits use HP 5082-2750 Schottky diodes. The substrate selected was RT Duroid 6010.2.

Fig.3 illustrates the module equivalent circuit. Fig.4 shows the response of two modules in cascade and illustrates a gain of 24 dB with a gain fluctuation over the band 2 to 6 GHz of +/- 0.5 dB. The module return loss is better than -12 dB over the band.

The logarithmic performance of a module is shown in Fig.5 for a range of frequencies in the band 2 to 6 GHz and illustrates a log error of +/- 0.75 dB over a dynamic range of 24 dB measured at room temperature.

A major cause of deviation from linearity in successive detection amplifiers is the non-linear behavious of the video detectors with input power. This can be significantly reduced by the provision of a second detector diode, with a bias adjusted to give a composite response of improved linearity. The benefit of this technique is shown in Fig.6 which illustrates the log error with and without the second diode. The improvement approaches 10dB.

A distributed amplifier is particularly easy to compensate for gain variations due to temperature change. A simple open loop correction to the gate bias which is linearly related to the temperature is used. Measurement shows that for a module (12 dB gain) the gain fluctuation over the band is

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less than +/- 0.15 dB for a temperature change from 0°C to 50°C.

AMPLIFIER PERFORMANCE

The amplifier consists of six modules and associated video amplifier. The logarithmic linearity was measured by an A.T.E. technique which varied the input power from -60 dBm to +5 dBm (a dynamic range of 65dB) and plotted the deviation from linearity as a function of input power level. Fig.7 shows the mid-band performance at room temperature illustrating a peak to peak deviation of +/- 1.0 dB. The variation of this parameter with frequency is shown in Fig.8 over the band 2 to 6 GHz in 0.25 GHz steps and is +/- 2.25 dB at room temperature. The effect of temperature change is shown in Fig.9 for mid-band with measurements at 0°C, 25°C and 50°C and shows a temperature dependence of +/- 1.0 dB relative to 25°C. Finally both temperature and frequency were varied together over 0°C to 50°C and from 2 to 6 GHz respectively and the measured linearity deviation is shown in Fig.10. This shows that the variation of linearity due to both parameters simultaneously is within an envelope of +/- 2.5 dB.

The rise and fall times of the logarithmic amplifier were measured over the dynamic range and are shown in Figs.11 and 12. These illustrate a rise time of 7nS and a fall time of 20 nS. Fig.13 shows the response to a long pulse (200 microseconds) which is satisfactory.

Fig.14 is a photograph of the microwave part of the amplifier.

PERFORMANCE SUMMARY

The measured performance characteristics of the amplifier are summarised below:

Frequency range	2-6 GHz
Dynamic range	-60dBm to +5dBm
Log slope	15mV/dB
Linearity at 25°C at centre frequency	+/- 1.0dB
Variation of log linearity with frequency deviation from centre frequency	+/- 1.3dB
Variation of log linearity with frequency from centre frequency and temperature (0°C-50°C)	+/- 1.7dB
Input V.S.W.R	2:1
Output V.S.W.R	2:1
Rise time	7nS
Fall time	20nS
Supply voltage	+ / - 12V
Power consumption	4.8W

CONCLUSIONS

A novel logarithmic amplifier, based on the use of the distributed amplifier and using a superior video detector has been designed and tested. The rise and fall time and temperature insensitivity benefits expected from the use of the distributed amplifier as the active element have been achieved.

REFERENCES

(1) G.M.Gorman et al, "A GaAs HBT Monolithic Log IF(0.5-1.5GHz) Amplifier with 60 dB Dynamic range and 400 mW Power consumption" 1989 IEEE MTT-S Int. Microwave Symposium Digest, Vol.2, pp.537-540.

(2) R.Michels et al, "An L-band Temperature Compensated Ultra Low Power Successive Detection Logarithmic Amplifier", ibid,pp.541-544.

ACKNOWLEDGEMENT

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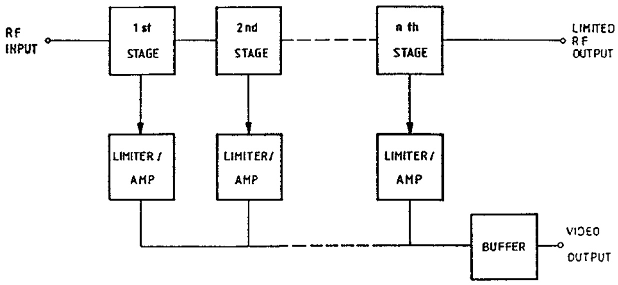


Fig.1: Schematic diagram of logarithmic amplifier and video amplifier.

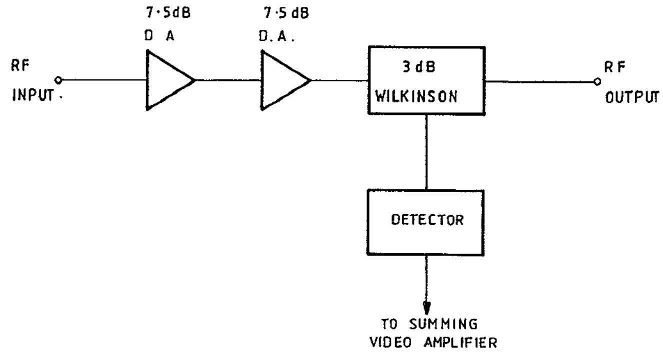


Fig.2: Module configuration

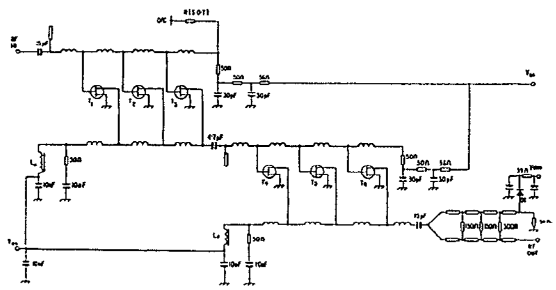


Fig.3: Module equivalent circuit

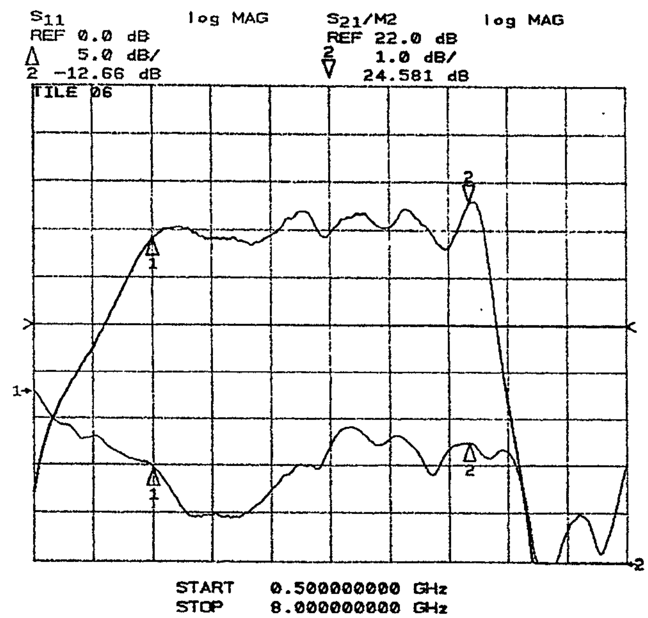


Fig.4: Gain and return loss of module.

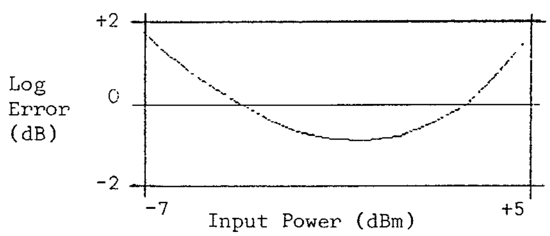
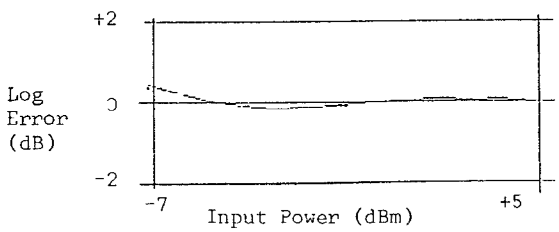


Fig.6: Log error for single diode (upper) and two diode detectors (lower)



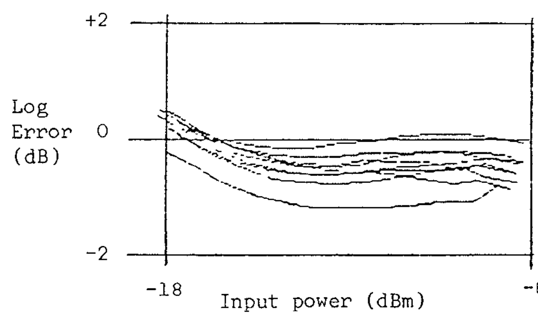


Figure5 Log error for single module over the band 2-6GHz at room temperature

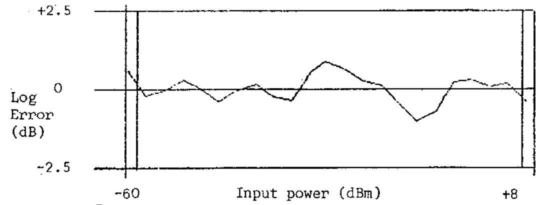


Figure 7: Log error at band centre at room temperature

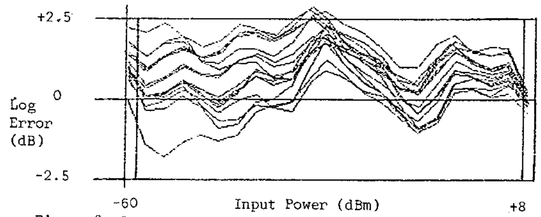


Figure 8: Log error over band 2-6 GHz at room temperature

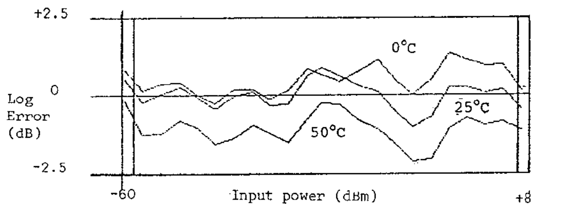
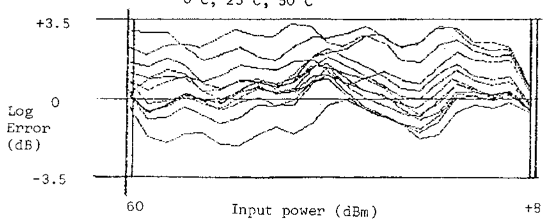


Figure 9: Log error at band centre (4GHz) at 0°C, 25°C and 50°C

Figure 10: Log error over the band 2-6 GHz and at 0°C, 25°C, 50°C



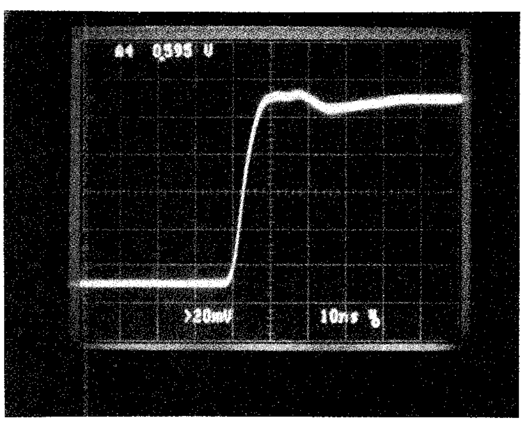


Fig.11: Rise time of log. amplifier (7nS)

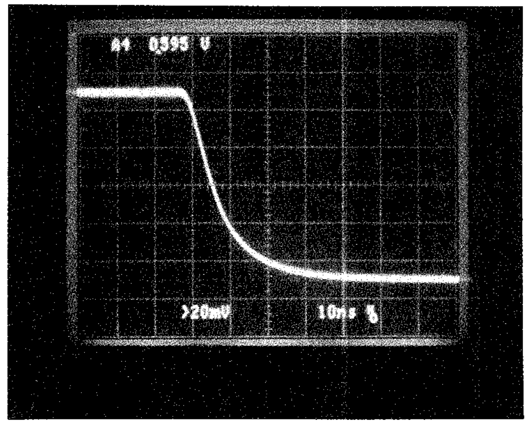


Fig.12: Fall time of log. amplifier (20nS)

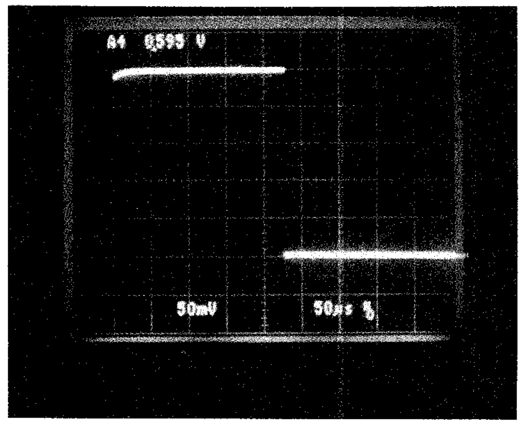


Fig.13: Response of log. amplifier to long pulse

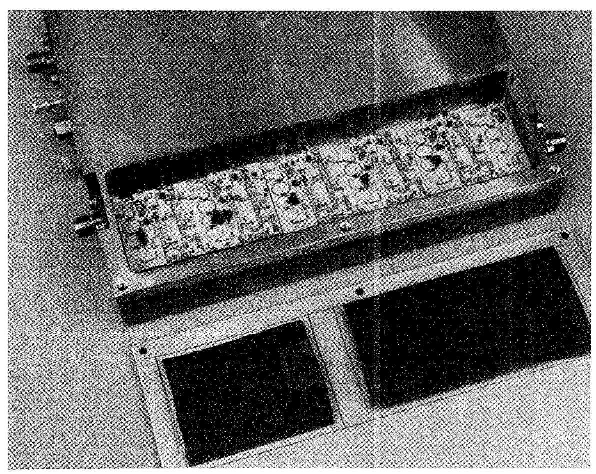


Fig.14: Photograph of log. amplifier