A 4GHz LOW NOISE GaAsFET AMPLIFIER

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ABSTRACT

A 4GHz low noise GaAsFET amplifier has been designed and fabricated. Time-delay protection circuit and input circuit without separation DC element has been used. The performance of two stages 4,0-4,5 GHz amplifier is N_F 2 db, G_a 24 db.

Introduction

In order to further developing the research achievement of low noise GaAsFET in Hebei Semiconductor Research Institute and well matching the requests of consumers, a 4GHz low noise GaAsFET amplifier has been designed and fabricated.

Device Characterization

The transistor selected for the 4GHz GaAsFET amplifier was home made planar type GaAsFET (type CX 51). It is a 1 μ gate-length device in a hermetic ceramic package. Its typical low frequency and microwave parameters of the CX 51-GaAsFET are listed in Tab.1. Optimum source impedance for low noise performance and S-parameters of the CX 51-GaAsFET are shown in Fig.1.

D.C.Bias Circuit

The D.C.bias circuits with separated elements has been reported[1] The circuit is described in Fig.2(a) and (b). In this paper one stage time-delay protection circuit is added in order to further improving the protection properties of the D.C. bias circuit (see Fig.2(c) and (d)).Thus, the out-voltage applies to the operating GaAsFET only after passing through the charged delay time, which is determined by R_1C_1, so the demage of external pulse and static charge on GaAsFET can be decreased to the minimum. At present, the time-delay is approximately 1 second. The excellent protection property of the circuit is proved by long-time testing and its adoption for several kinds of amplifiers. To coordirate the input circuit without separation DC elements described later, the gate end of the DC bias circuit must be grounded in such manner that the bias circuit is additionally used(see Fig.2 (e)).

In order to obtain the good microwave property, it is important to select the DC operating point of GaAsFET according to the optimum noise measure. If the DC operating point is selected only according to the optimum noise figure, the property of the device, however, connot be well displayed. Table II gives an exemple of this kind of result of measurement. Although the optimum noise figure operating point of CX 51-type GaAsFET is at 0,1 I_{dss}, when the drain current is selected at about 0,2 I_{dss}, the results are not only good for decreasing the noise figure of amplifier, but also more advantagous for displaying the gain property. So it is sure that two stage amplifier is available for realizing the requirement of gain higher than 20 db.

Microwave Circuit

Because of the narrow bandwidth of the amplifier, quarter-wave length impedance transformer has been used within the input and output circuit. Input circuit is matched for optimum noise figure and output circuit---for maximum gain.

The source electrode of GaAsFET can't be directly grounded, since the previous biased circuit of the single power supply is applied. In our experiment a structure of so

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called "piece-capacitor grounded" was used, i.e. the source electrodes of the GaAsFET are bounded on the single layer piece-capacitor, then it is grounded. The capacitance is 200pf.

Two different models of input circuits habe been tested : first, quarter-wavelength coupled line in input circuit for separation DC current, and the second, no separation DC elements in input circuit. 50 Ohm microstripline is directly connected with the externalcircuit. The results in several runs of experiments showed that the total noise figure in the second form could reduced by 0,2-0,4 db. Moreover, this form is advantagous not only for decreasing the noise figure, but also for direct cascade after the fixing of the single stage. Due to the direct connection of the input circuits with the external circuit, no DC voltage should be added. In this way, only the biased circuit with grounded gate is used. It is neccessary to use the biased circuit shown in Fig.2(e).

The amplifier consists of two stages, each stage is made on the alumina ceramic wafer with its area of 30 x 45 mm^2. Ceramic wafers are assembled on the right side of gold-electroplated Al box, while the biased circuits---on the back side. Microstrip isolators are used for both input and output circuit (insert loss 0,5 db). The N-type coaxial connector is connected with the external circuit. The photographs of right and back sides of the sample are shown in Fig.3.

To ensure the reliability of the amplifier, the fixing of gold slice of fine adjusting of microstripline circuit is achieved by thermal pulse welding method. It is hard in various surrounding condition.

Results

A small amount of 4GHz GaAsFET amplifier were fabricated using the above mentioned design principle. Main parametric characteristics are shown in Table III. Noise figure of the best sample including microstrip isolator is 2,0 db. Gain and noise figure curves of 6# amplifier are shown in Fig.4, the power dispersion of the amplifier is about 12V,28mA.

The reliability tests were carried out for the amplifiers by sampling according to the following rules, i.e. all elements of an amplifier are converted into the number of standard elements in terms of the known reliability data, e.g. a transistor is converted into a standard element, while 5 resistors or 5 capacitors are converted into a standard element etc. Then the sampling element numbers are determined by the total standard elements number of this lot of amplifiers and thus the number of sampled amplifiers can be determined.For sampling amplifiers the following tests have to undertake : enviromental test (consisting of vibration,shock,centrifugal, variable frequency vibration,temperature cycling, low and high temperature tests),high temperature storage test (+85°C) and operating lifetime test (at 12V bias). All the test results are satisfied with the rule of reliability of our Institute.

Acknowledgement

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References

(1) S.Aihara et al : "Low Noise GaAsFET Amplifier", NEC Research and Development No.48, pp.67 Jan.1978

(2) R.H.Knerr and C.B.Swan : "A Low-noise GaAs FET Amplifier for 4 GHz Radio" B.S.T.J. vol.57, No.3,pp.479, March 1978

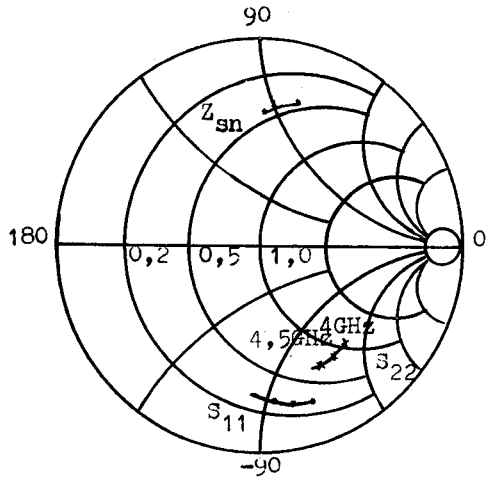


Figure 1. Z_{SN}, S_{11} and S_{22} of CX51-GaAsFET

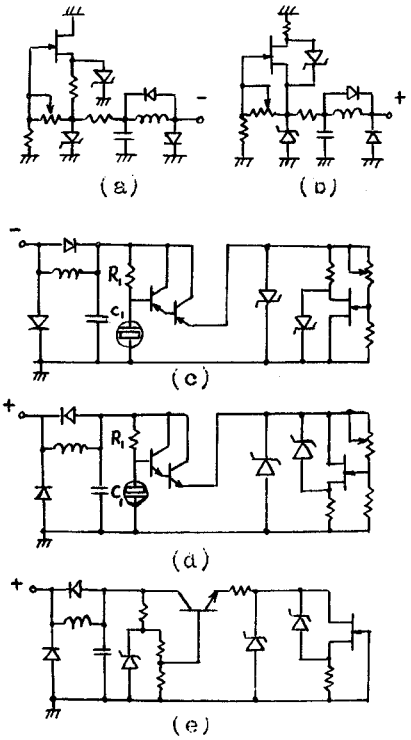


Fig.2. D.C. bias circuit of the 4 GHz GaAsFET amplifier

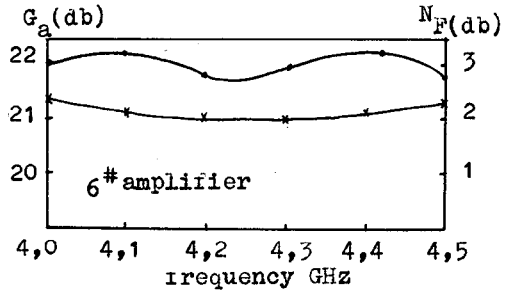


Fig.4. Gain and noise figure vs frequency of 4GHz GaAsFET amplifier

Table I. Parameters of CX51-GaAsFET

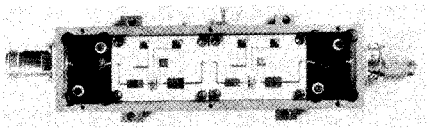
Parameter	Typical value
I_{Oss}	50 mA
g_{mo}	20 mU
$-V_p$	2-3 v
G_a (12GHz)	6 db
N_F (12 GHz)	4,5 db

Table II. Performance of different I_{ds}

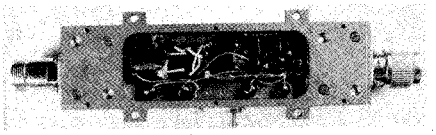
I_{DS}	Single stage Gain (db)	Total N_F (including mixer) (db)
$0,12I_{DSS}$	9	3,3
$0,2\ I_{DSS}$	11	3,0
$0,22I_{DSS}$	11,5	3,0

Table III. Specification of 4 GHz GaAsFET Amplifier

Parameter	Specification
Power Gain G_a	≥20 db
Gain Variation	±0,5 db
Noise figure N_F	2,5 db
input VSWR	≤1,5
output VSWR	≤1,5
output power P_{-1}	≥ 3 dbm
dimension mm^3	138x38x28



(a) top view



(b) back view

Fig. 3. Photograph of 4 GHz GaAsFET amplifier