A HEMT Amplifier for NRD Guide Integrated Circuits

ＮＲＤガイド集積回路に用いるＨＥＭＴ増幅器

ウィルソン アルトゥズィ　　米山 務　　黒木太司

Wilson A. Artuzi Jr.　　Tsukasa Yoneyama　　Futoshi Kuroki

東北大学　電気通信研究所

Research Institute of Electrical Communication, Tohoku University

1. Introduction

The nonradiative dielectric waveguide (NRD guide) technique [1] has been used to implement millimeter-wave components such as hybrid coupler, antenna, circulator, detector, mixer, and oscillator. These components have been properly combined to yield transmitter and receiver front-ends. In this paper, an amplifier was designed and fabricated at 35 GHz in order to further improve the performance of the NRD guide receiver. A Toshiba JS-8900-AS low noise HEMT was used.

2. Structure

The total structure is composed of two distinct dielectric strips (input and output NRD guides) and a coplanar waveguide (CPW) HEMT chip carrier, as shown in FIG. 1. The chip carrier, as in FIG. 2, is designed to provide: NRD guide - CPW transitions, matching sections, DC bias pads, stability chip resistor pads, input/output isolation chokes and HEMT chip bonding, these being vital for good amplifier performance. The basis of the matching sections and chokes resides on versatile slot line short stubs.

The metal plates of the NRD guide, in FIG. 1, have to be separated by a distance of less the half-wavelength in free space in order to avoid radiation. In the present case, this distance is 4 mm, since the center frequency is 35 GHz. The dielectric strips are fabricated in teflon with a relative permittivity of 2.04 and have cross-sectional dimensions of 3.5 mm x 4 mm. In order to avoid unwanted mode genneration, mode suppressors are used in the dielectric strip - chip carrier interfaces, as indicated in FIG. 1. The HEMT chip carrier pattern is etched on a 0.365 mm thick copper coated glass-teflon substrate whose relative permittivity is 2.6.

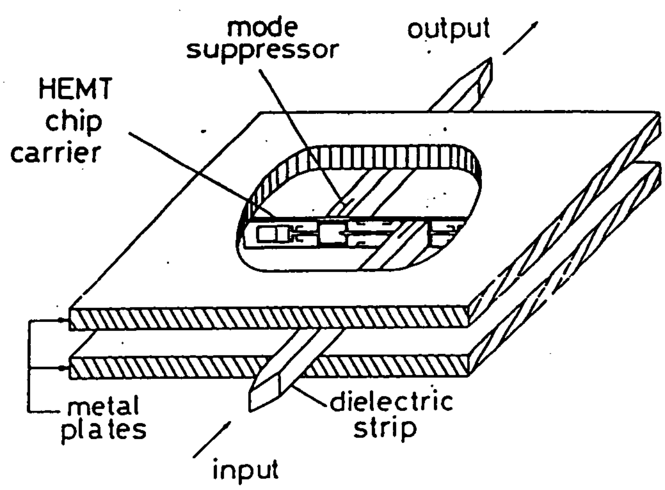


FIG. 1　View of the NRD guide HEMT amplifier

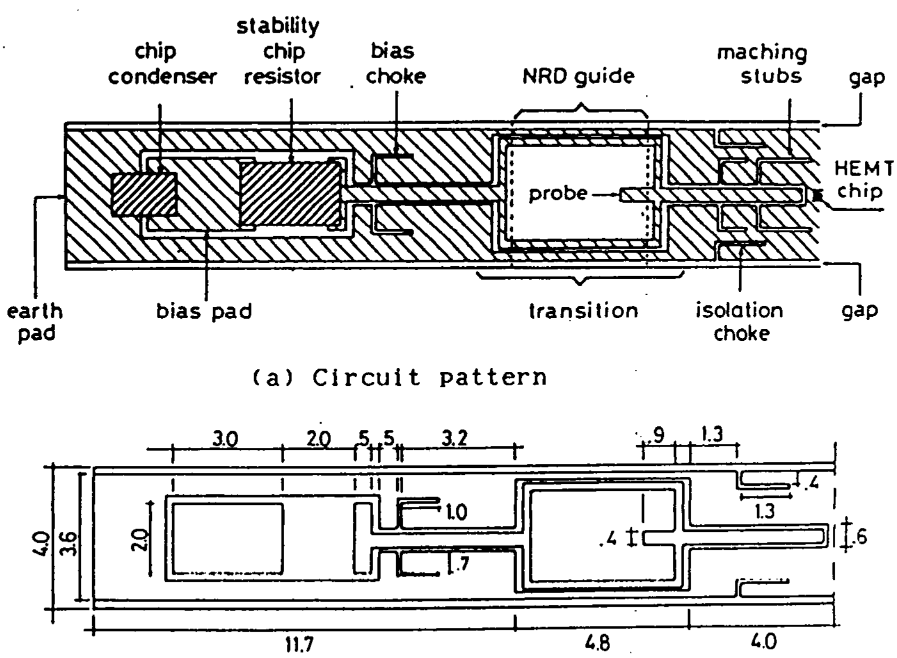
3. Choke structures

3.1. Input/output isolation

As shown in FIG. 2, there are thin gaps between the CPW earth plane and the upper and lower metal plates of the NRD guide. This gaps allow wave leakage and hence deteriorate the amplifier performance with the introduction of an unwanted feed-back path. This effect can be reduced by placing isolation chokes consisting of quarter-wavelength slot line short sutbs.

3.2. DC bias

The bias structure is a



(a) Circuit pattern

(b) Dimensions (mm)

FIG. 2　Half section of the HEMT chip carrier composition of a stability resistor and a choke centered at 35 GHz. This provides stability at the potentially unstable frequeny region from 1 to 10 GHz and avoids the power leakage to the resistor at the operating frequency. The structure is shown in the left part of FIG. 2.

4. NRD guide - CPW transition

The NRD guide - CPW transition is represented in the central part of FIG. 2. Its main part is a metal strip probe which is a portion of the center conductor of the CPW. The probe is located at the maximum field intensity region of the NRD guide in order to provide sufficient power coupling into the CPW. The connection between the main CPW and the bias conductor is made by using thin metal lines which are placed at the weak field region not so as to disturb significantly the NRD guide original field. The transition S-parameters were measured, at 35 GHz, by employing the Deschamps' method and are shown in TAB. 1.

5. Aplifier design

In order to realize a HEMT amplifier having a resonable performance, two matching sections each at the input and output ports are used. The position and length of each stub are optimized to give a gain higher than 4 dB and input and output VSWRs lower than 2 in the frequency region from 34 to 36 GHz. The S-parameters of TAB. 1 are also taken into account in the amplifier design. The equivalent circuit for these matching sections are shown in FIG. 3.

6. Amplifier performance

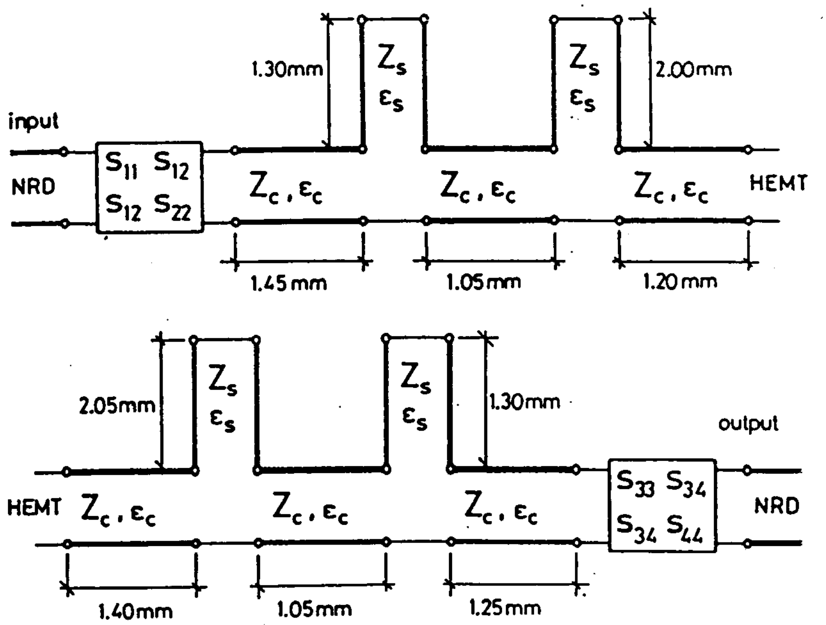
The measured performance of the amplifier exhibits a gain value higher than 4 dB, an input VSWR lower than 2.5 and an output VSWR lower than 2.7 between 33.5 and 35 GHz. Measured and calculated gain curves are compared in FIG. 4.

7. Conclusion

The fabricated amplifier exhibited a good performance. The measured bandwidth is somewhat narrower than the expected one. This difference may be caused by the mutual coupling between slot line stubs and by the frequency behavior of the bias choke. Noise characteristics have to be taken in account in a future study.

8. Reference

[1] Yoneyama, MTT-29, pp.1188-1192,1981.



Z_c = 75 ohms (CPW characteristic impedance)
ε_c = 1.72 (CPW effective permittivity)
Z_s = 75 ohms (slot line characteristic impedance)
ε_s = 1.54 (slot line effective permittivity)

FIG. 3 Equivalent circuits of the designed amplifier

parameter	magnitude	phase
S_{11}	0.398	-143°
S_{12}	0.858	45°
S_{22}	0.412	57°
S_{33}	0.215	57°
S_{34}	0.910	57°
S_{44}	0.210	-115°

TAB. 1 Measured S-parameters of the NRD guide-CPW transitons

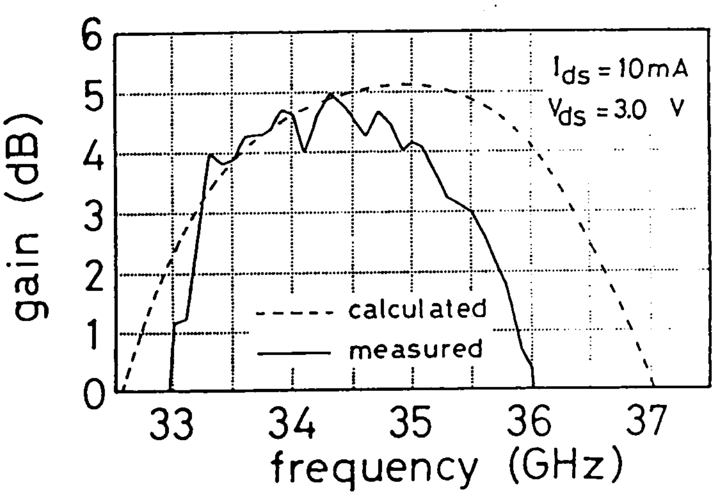


FIG. 4 Calculated and measured gain characteristics of the fabricated amplifier