Ultra Small Sized Low Noise Block Downconverter Module

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ABSTRACT

A compact low noise block (LNB) downconverter module for use in direct broadcast satellite (DBS) utilizing only GaAs MMICs has been successfully demonstrated. Four kinds of MMICs designed with 0.5μm-gate pulse-doped MESFETs were assembled in a miniaturized flat package (24.5×17.8×6.0mm^3). 52dB conversion gain and 2.1dB noise figure were obtained using no discrete HEMTs in the preceding stage and no stub-tuning.

INTRODUCTION

New generation of microwave communication has arrived, utilizing satellite systems. Applications of microwave communication systems have been expanding not only for business but for personal use. DBS reception is the most popular system, which has spread to over four million households in Japan and will increase to more than thirty million worldwide in the next five years. It is required to reduce the size and the fabrication cost, moreover it is necessary to realize fashionable design for consumer applications. For business use, a DBS reception system for auto mobiles is being developed with planar antennas. Size and weight have become important considerations as well as low noise performance.

Recent developments [1][2][3] indicate the suitability and inevitable use of MMIC technology for these demands. The purpose of this work is to achieve an extremely small, cost-acceptable and mass-producible LNB downconverter module for DBS reception. This paper describes a very compact LNB module made using GaAs MMICs designed with pulse-doped MESFETs and a miniaturized flat package.

LNB DOWNCONVERTER MODULE

Fig.1 shows the functional block diagram of the LNB, which is performed in the out-door unit. An input RF signal 11.7-12GHz is converted to an intermediate frequency (IF) 1.022-1.322GHz mixed with local oscillation signal 10.678GHz. Four parts of this LNB were ali designed to MMIC chips [4] except a dielectric resonator in the local oscillator (DRO).

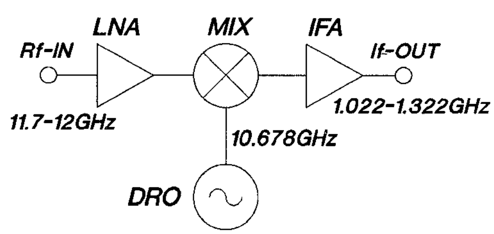

Fig.1 Functional diagram of MMIC LNB

A further complete LNB module including voltage regulators and a primary radiator is proposed as shown in Fig.2. and Fig.3. Fig.4 shows their configurations. MMIC chips are mounted in the specially developed package (24.5×17.8×6.0mm^3). The structure of this package is very simple. As a result, it is suitable for cost-acceptable mass-production. It has a 400μm thick mono-layered alumina ceramic base, a brazed shield, and a lead frame. The input and output signals are propagated through a lead frame and a via hole of the ceramic

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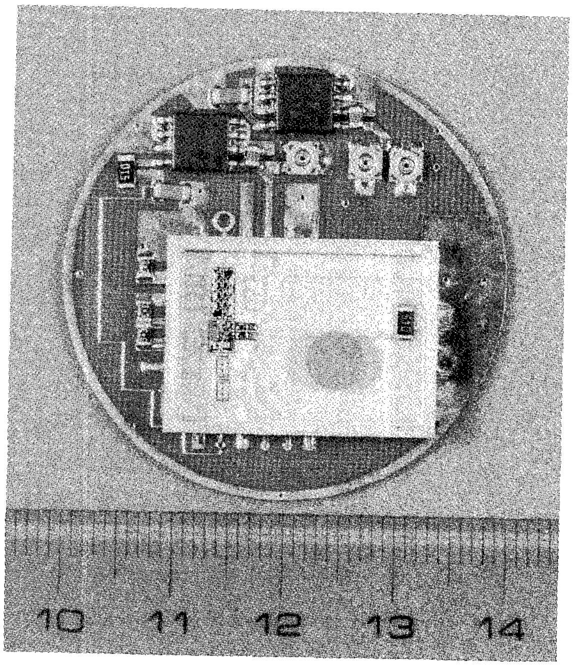

Fig.2 Photograph of LNB module

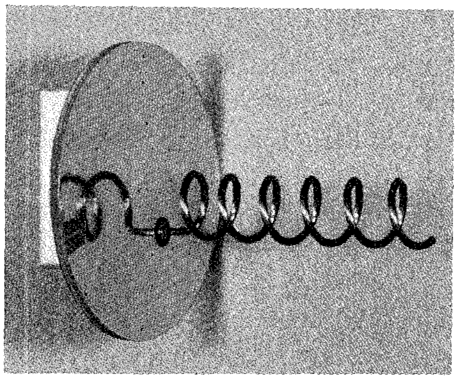

Fig.3 Photograph of LNB with helical antenna

base. It has excellent input VSWR matching less than 1.2. The thickness of the ceramic base was determined to accommodate both reduction of the electrical loss at the via hole, which was evaluated as less than 0.3dB, and the mechanical reliability of the package. Besides, the package was designed to avoid cavity resonance in the applicable frequency band (11.7 to 12GHz) and to get the desired resonance (10.678GHz) as a grounded shield at the dielectric resonator coupling to the microstrip line on the ceramic base.

The packaged LNB module is soldered to a glass / epoxy substrate, whose diameter is 40.2mm. A helical

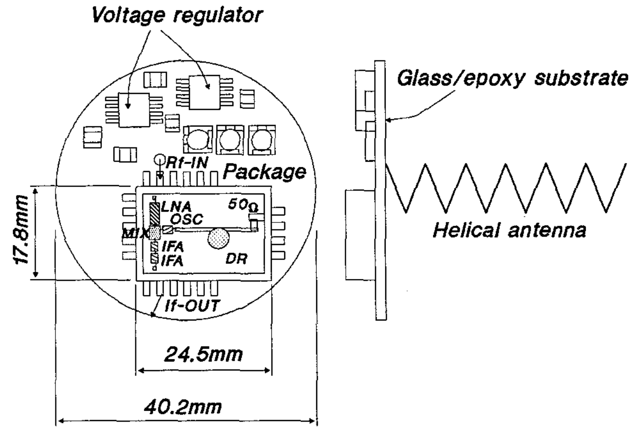

Fig.4 Schematic view of LNB module

antenna, designed to resonate to the input RF signal from a parabolic reflector as a primary radiator, is attached to the opposite side of the substrate functioning as the capacitance substrate for the VSWR match of the helical antenna. The RF signal is propagated from the helical antenna to the LNB package via a through-hole of the substrate. This LNB module can operate with a +15V single power supply from an indoor unit through an IF transmission line.

DEVICE TECHNOLOGY

In this LNB, four kinds of MMIC chips are utilized. The active devices are all 0.5μm-gate (280μm width) pulse-doped GaAs MESFETs [5]. As shown in Fig.5, the device has a high Si-doped, very narrow GaAs active layer ($4\times10^{18}/cm^3$,100A) on an undoped p- GaAs buffer layer (1μm), and an undoped n- GaAs cap (300A) grown by OMVPE. A conventional photo-lithography process with SAINT-like technology was used for T-shaped dummy gate self-alignment. Minimum noise figure and associated gain are 1.23dB

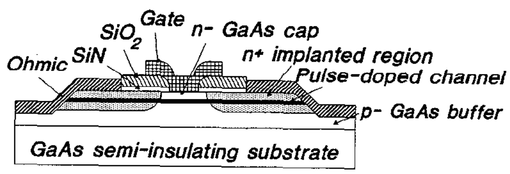

Fig.5 Cross-section of pulse-doped MESFET

and 9.0dB at 12GHz, respectively. The excellent low noise characteristics are comparable to HEMT devices and the fabrication process simpler than theirs.

Fig.6 shows the schematic cross-section of the MMICs.

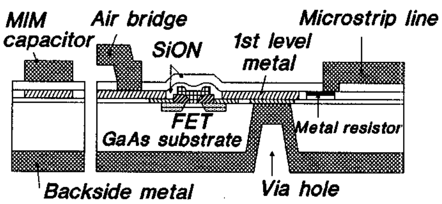

Fig.6 Cross-section of MMIC

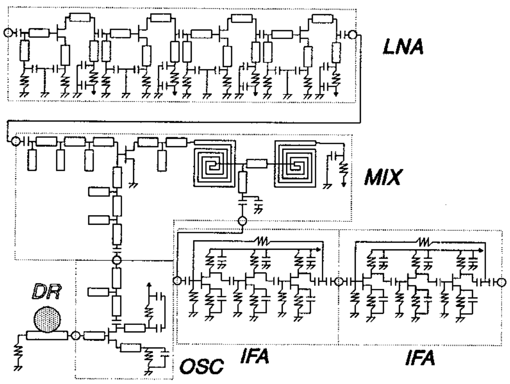

Fig.7 Circuit description of MMIC LNB

MMIC PERFORMANCE

Fig.7 illustrates the circuit description of this LNB module corresponding to Fig.1.

The LNA chip (Fig.8, 4.5×2.2mm^2)[6] has the performances of 1.6dB noise figure, 24dB gain, 1.3:1 input VSWR, and 1.6:1 output VSWR at 12GHz. The MIX chip (Fig.9, 2.9×2.4mm^2) has 2dB conversion gain and 20dB image rejection due to the filter in the input circuit. DRO is composed of an oscillator MMIC chip OSC (Fig.10, 1.9×1.6mm^2) and an additional dielectric resonator which is coupled to the microstrip line constituted in the package for the connection to the gate. It achieves an 9dBm output power at 10.678GHz and -80dBc phase noise at 10kHz offset. IFA (Fig.11, 1.9×1.2mm^2) is a three-stage resistive feedback amplifier, which has 20dB gain and less than 1.7:1 VSWR match at 1.3GHz.

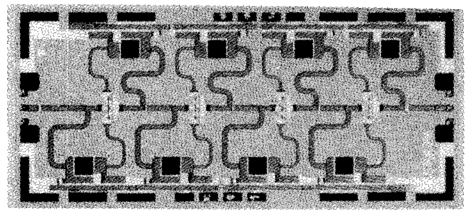

Fig.8 Photomicrograph of LNA

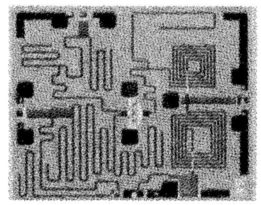

Fig.9 Photomicrograph of MIX

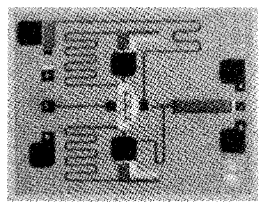

Fig.10 Photomicrograph of OSC

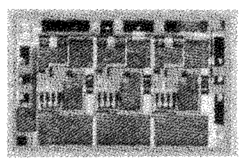

Fig.11 Photomicrograph of IFA

MEASURED RESULTS

Fig.12 illustrates the input/output power response of the LNB. The conversion gain was 52dB, and the saturation output power was 7dBm, for a 12GHz input signal. The input frequency dependence of the response is shown in Fig.13. 16dB image rejection for the applicable frequency band were measured. The overall noise figure at 12GHz input was 2.1dB, which was corresponding to the quality of the received picture.

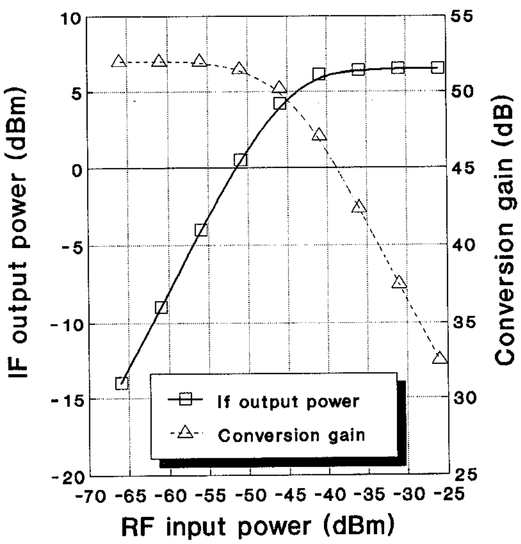

Fig.12 Input/output response of LNB

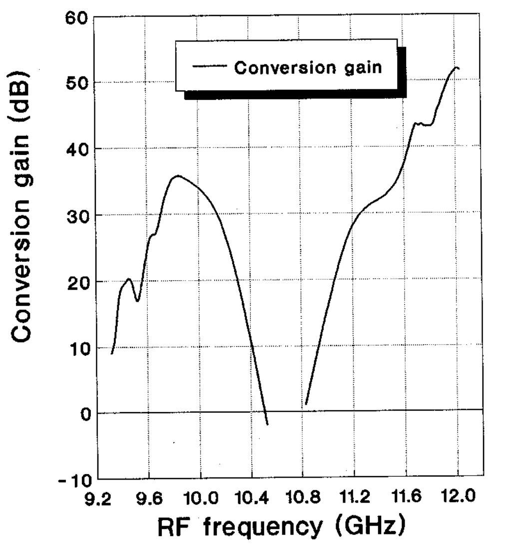

Fig.13 RF frequency dependence of LNB response

CONCLUSION

An "extremely miniaturized" LNB is required for use in not only households but also mobiles with planar antennas. The most remarkable result of this work is that only six parts, replacing more than fifty parts in a typical LNB, can achieve the complete LNB function, making the best use of MMIC technology. A reduction in the number of parts results in the assembly cost reduction and reliability improvement. This MMIC packaging technology is quite suitable for consumer applications.

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