AN INTEGRATED LOW-NOISE BLOCK DOWNCONVERTER

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ABSTRACT

In this paper, a small-sized low-noise integrated block downconverter (LNB) used for Ku-band direct reception from broadcasting satellites (DBS) is proposed. The operating frequency of the LNB is from 11.7 to 12.2GHz. The outlook dimension is 41 X 41 X 110mm³. Measured results show that the average gain of the LNB is 57dB, and noise figures are less than 1.7dB. It has been found that clear TV pictures have been received using the LNB for the experiment of receiving the "BS-2b" (Japanese broadcasting satellite) at Harbin region, Heilongjiang Province, P. R. China.

KEY WORDS

Downconverter, Low-noise Amplifier

1. INTRODUCTION

Within the next decade, 120 new satellites are to be launched in the world, more than half of them will be in Asia, so it is quite important to accelerate the research on DBS receiving systems.

China is a developing country. It began to use satellites to deliver TV programs in 1985. At present, the State is planing to launch large-capacity broadcasting satellite and will start Ku-band DBS services. This stimulates intensively the research on receiving techniques.

Prior to utilizing Ku-band to transmitte satellite TV broadcasting programs was recommended by the world Administrative Radio Conference (WARC) in 1977. Because the frequency of Ku-band is 3 times higher than that of a C-band, and the Equivalent Isotropically Radiated Power (EIRP) of a Ku-band satellite transponder is 20dB higher than that of a C-band, this will permit the uses of even smaller size and lower cost Television Receive-Only (TVRO) earth stations for individual subscribers. It is possible for individual homes to receive the direct broadcasting TV programs from the satellite, Thus, the diameters of receiving antennas may be expected to be below 1.2-meter diameter, whereas, for the central areas of the territory, the diameters of the antennas will be as small as 0.5 meter. As a result, ordinary homes can afford
those. In practice, only adopting the Ku-band, can the direct broadcasting from a satellite be popularized to million of homes. In particular, territory in our country (China) is quite large, moreover, 70 percent of the country's territory is mountainous areas, it is necessary to use Ku-band satellite to deliver TV programs to subscribers in the remote rural, mountainous areas and countrysides.

The LNB is the receiving front-end of a TVRO earth station and is one of the key components among whole reception system, so, not only higher gains are needed, but also lower noise figures. In order to study the system of the Ku-band small-sized satellite reception, the integrated LNB for Ku-band was developed in our laboratory. This paper describes the circuit structure, composition, performance and experimental results of the LNBs developed.

2. CIRCUIT STRUCTURE

Usually, small-sized front-feed antennas (for example: the diameter from 0.5 to 1.2 meters) are always adopted for the Ku-band TVRO earth stations, so the small-sized LNBs are expected so as to further reduce the shelter to the receiving signals coming from the satellite. To do so, we developed a small-sized Ku-band LNB which integrated assembly was employed. The LNB consists of two pieces of double-foil printed-circuit blocks that the material of the substrates is PTET with a thickness of 0.5mm and a relative permittivity of 2.8. One is a high-frequency circuit block, with the dimension of 25 X 78mm$^2$ which installed low-noise amplifier circuit, mixer circuit and local oscillator circuit; the other is an intermediate-frequency (IF) amplifier circuit block with the dimension of 25X 66mm$^2$ which installed IF amplifier circuit and power supply conversion circuit. The two printed-circuit blocks were fixed in upper and lower layers and installed inside water-resistant rectangular waveguide with the type of WRT-120. The input connector of the LNB is a waveguide flange with the type of WBM-B-120, and the output high-frequency coaxial connector with the type of C15. The outline dimensions of the LNB is 41 X 41 110mm$^3$.

3. CIRCUIT COMPOSITION

The specifications required for the LNB are as follows:

(1) Frequency range: 11.7~12.2GHz
(2) Output IF: 950~1450MHz
(3) Working bandwidth: 50OMHz
(4) Total gain: 52±4dB
(5) Noise figure: <2.0dB
(6) Image rejection ≤30dB
(7) Local oscillator frequency: 10.75GHz
(8) Local oscillator frequency stability: <700MHz (-40°C~+60°C)

On the basis of above technical specifications, the LNB was designed in the following methods:
Circuits of the LNB can be divided into four main parts. The low-noise amplifiers consist of
three-stage amplifiers, which use microwave transistors with the type of 2SK877, NE71084 and MGF 1302 (all are made in Japan). The first-stage amplifier is designed according to the minimun noise figure theory. The second-stage and the third-stage amplifiers are designed according to maximum power gain theory. The total voltage gain of the three-stage amplifier is designed for 18dB. In the mixer circuit, a MGD1302-type transistor was used as a frequency-mixing device.

The high-frequency input signals is fed into the gate of the transistor. The local-oscillator input signal is fed into the drain through a band-pass filter. IF output signals from the drain is fed it into first-gate of IF amplifier by a low-pass filter. A MGF1302-type transistor is used as the local-oscillation device. Frequency stability of the local oscillator is made by a small-sized dielectric resonator which produces a frequency of 10.73GH. The relative dielectric constant of the resonator is 40, and the quality factor Q is 9000. Because both the dielectric constant and the quality factor are large enough, the electromagnetic energy is concentrated on the inside dielectric material. The resonator and microstrip lines composite the local oscillation circuit. The IF amplifier circuit consists of three-stage amplifiers. All the transistors are home-made (CX661-type dual-grate FETs). The IF amplifier is a wide-band amplifier and total gains of the three-stage amplifier is 35dB. Bias voltages of positive and negative power supply needed for a drain and a gate are fed by a coaxial cable which connected into a in-door unit. The power supply conversion circuit can convert the D. C. 15V into positive and negative bias voltage needed for them respectively.

4. EXPERIMENTAL RESULT

Performance of The LNBs were measured by Beijing Institute of Radio Measurement. Measured results of two samples of LNBs are shown in Fig. 1. From those curves, it has been shown that the gains within the working frequency band are 52 to 63dB and the minimum noise figure is 1.1dB. So, measured results show that performances of the LNBs are content with the demand for design. Fig 2 gives the sketch map of HF printed circuit board.

At present, the broadcasting satellite with Ku-band transponders hasn't yet been lunched in our country (China), in order to experiment on the LNBs,a TVRO earth station with a 4.2-meter diameter front-feed parabolic antenna was set up.

We installed the LNB on the TVRO earth station and try to receive TV programs that leaked from the "BS-2b" (Japanese broadcasting satellite) at Harbin region of Heilongjiang Province in China. It has been proved that received quanlity is over 4-levels, especially it has still a good receiving picture quanlity under enviromental conditions of extremely cold winter and hot summer seasons.

This work merely is a starting of the research on Ku-band LNBs. There are a lot of work to do in improvement of the performance of LNBs.
5. CONCLUSION

The small-sized integrated Ku-band LNB was developed using home-made devices except the microwave transistors. Therefore, the performance of the LNB has reached a satisfied technological level compared with the similar LNB products from abroad during the end of 80's. The results of research on LNB in our country will produce a basis on future development of the DBS receiving technique.

Fig. 1  The measured results of (a) gain and (b) noise figure of two LNB samples (the bold curve represents No. 1 LNB, the dot curve No. 2 LNB sample)

Fig. 2  The sketch map of the HF printed circuit board