SATELLITE BROADCASTING RECEIVER - PRESENT AND FUTURE

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ABSTRACT

The present status and future trend of satellite broadcasting receiver are described in the view of low cost and low noise approach in connection with the construction and the performance. The recent results of the receiver developed by us are also shown.

INTRODUCTION

Fig.1 shows the schematic diagram of 12 GHz band FM receiver for satellite broadcasting. The main efforts to develope the receiver have been paid to make it with low cost and of high sensivity. In order to achieve our aim, the several constructions and several techniques have been developed. This paper describes not only the present status but also the future trend of the development of the receiver.

PRESENT STATUS OF DEVELOPMENT OF SATELLITE BROADCASTING RECEIVER

Approach for low noise performance

(1) Low noise direct converter The low noise direct converter without any low noise preamplifier such as GaAs FET amplifier, is achieved through an image recovery method, by using low loss circuit, low noise IF (Intermediate Frequency) amplifier and low noise local oscillator. As a low loss circuit suitable for mass-production with low cost, we have proposed and adopted a planar circuit mounted in a waveguide[1]. The most noteworthy approach to get a low noise IF amplifier, is to use a low cost UHF GaAs FET in a 1st stage of the IF amplifier. For a low noise local oscillator, it is necessary to use an oscillator which is self locked with high Q resonator such as a dielectric resonator. The utilization of a filter to remove a noise at image band is also sometimes important. By the above mentioned techniques, less than 3.6 dB of noise figure has been achieved for 500 MHz bandwidth.

(2) GaAs FET preamplifier It is tried to use a low noise 2 or 3 stages GaAs FET preamplifer before a down converter. By this method, $3.5 \sim 4.5$ dB of noise figure is achieved. This amplifer is made on a dielectric substrate together with a down converter and an image rejection filter. The preamplifer helps the improvement of the noise figure of the down converter itself. At present, the characteristics of GaAs FET such as the values of S parameter and the noise figure, however, fluctuates with $30 \sim 50\%$ dispersion in mass production, of which improvements are important together with low cost production in future. S.W.R. of GaAs FET amplifier is around $3 \sim 4$ at noise minimum design. The reduction of S.W.R. through some techniques such as utilization of a low cost isolator or adoping a balance type should be also investigated in connection with the matching to an antenna, a waveguide transition and an extra image rejection filter in the case of the requirement of more than 30 dB image rejection.

(3) Threshold extension In the case of using a small receiving antenna, signal to noise ratio of a picture (SN ratio) is mainly influenced by the threshold level of a receiver. As an usual method of a threshold extention, a narrow band tracking filter technology is used. As one of the effective methods, FM feedback of colour subcarrier was proposed by the author[2]. It is reported that it can improve the threshold level more than 4 dB[2].

Approach for low cost in mass production

(1) Consideration on low cost construction One of the important matters is to make all microwave circuits by a simple step such as a MIC technology. Concerning the MIC technology, the followings are developed.

(a) Planar circuit mounted in a waveguide To achieve a low noise direct converter, the converter is made by a metal plate with several patterns which have all functions required for a converter. The plate is inserted in the middle of a waveguide. The unloaded Q value of the circuit is $2500 \sim 3000$. The planar circuit is made by an etching or a punching machine with the accuracy of less than 20 μm which is enough for our device.

(b) MIC on a dielectric substrate This technique is widely used in making many microwave circuits. On a dielectric substrate, GaAs FET preamplifier, image rejection filter, converter and local oscillator are made by MIC technology. The noise figure of the converter is sometimes detoriated by the radiation loss and ohmic loss which increase the loss of the filter and conversion loss. The GaAs FET preamplifier serves to improve the noise figure.

(2) Consideration on the development of simple active networks and components

(a) 1st local oscillator The simple 1st local oscillator with stable fequency and low noise is important. One of the attractive methods is a direct oscillation. GaAs FET oscillator together with a dielectric resonator is developed[3], which is better than Gunn oscillator in power effeciency. The frequency deviation caused by a load impedance and temperature variation, is less than $3 \sim 4$ MHz, which should be improved by the improvement of Q values of dielectric resonator in future.

(b) Simplified 2nd IF circuits 2nd IF circuits such as AGC and Limitter are constructed by a number of transistors. It is important to make it simple. As one of approaches, the new circuit constructed by a nonlinear feedback amplifier and a locking amplifier, is reported[2]. In future, the development of low cost PLL components available to the 2nd IF circuit will be also expected.

(c) Adoption of IC components As for the base band circuits and sometimes the 2nd IF circuits, IC components are used. The cost comparison between IC and hybrid circuit, should be always necessary. It is expected that the cost of IC components will become low in future.

(d) Development of low cost passive networks There are several passive networks such as image rejection filter in 2nd converter, 2nd IF band pass filter, discriminator and so on in the receiver. To make them with low cost, the planar circuit designed by using a print substrate or a high dielectric ceramic substrate

is important. Such passive components have been developed by us. Another approach, may be to use surface wave acoustic devices, which will be attractive in future under the consideration that its cost is low.

SATELLITE RECEIVER DEVELOPED BY NHK

The technical introduction and the performances of the receiver developed by NHK are shown as an example.

Construction

(1) Out door unit This unit consists of a direct converter and 1st IF amplifier. The direct converter is made by a planar circuit mounted in a waveguide as shown in Fig.2. The power of 1st local oscillator is supplied from a step recovery diode connected to S band oscillator which consists of 1 or 2 transistors and a dielectric resonator. The frequency deviation is less than 200 KHz from -30°C through 50°C. The 1st IF amplifier consists of one GaAs FET and three bipolar transistors. It has 40 ~ 45 dB gain in the frequency range from 0.9 MHz through 1.4 GHz or 1.7 GHz.

(2) In door unit This unit consists of a 2nd converter, AGC-Limitter, a discriminator and a base band circuit. Image rejection filters in the 2nd converter are of micro-strip type made on a high dielectric ceramic substrate. 2nd local oscillator is stabilized by peaked AFC, which results in the frequency deviation less than 200 KHz from -10°C through 50°C. The construction of the AGC-Limitter circuit is shown in Fig.3, where five transistors are used. The performance is shown in Fig.4(a)(b). The 2nd IF filter is made by a print circuit. The discriminator is also made by a print circuit. The base band circuit is composed of video IC and audio IC components. The every dispersal signal is removed down to the level less than -40 dB.

Performance

(1) Noise figure The noise figures of the receivers of which band widths are 300 MHz, 500MHz and 800 MHz are less than 3.4 dB, 3.6 dB and 4 dB, respectively. The performances are shown in Fig.5(a)(b) and (c).

(2) Image rejection More than 40 dB image rejection is achieved. In the case of the requirement of a further additional rejection, 0.1 dB noise figure is increased for each additional 30 dB rejection.

(3) Total SN ratio and threshold level Unweighted SN ratio is shown in Fig.6. It shows the threshold level is -88 dBm of input level. This value was improved more than 4 dB by using the threshold extension technique described before.

(4) DG, DP of video signal DG and DP are shown for the peak to peak deviation as Table 1.

Deviation	12 MHz	19 MHz
DG	2 %	5 %
DP	2°	3°

Band width of IF filter is 27 MHz

Table 1 Performance of DG and DP

(5) Performance of sound signal It is summarized in Table 2.

Frequency performance	less than ±1 dB (50Hz ~ 13KHz)
Distortion	less than 2 % (25KHz deviation) less than 2 % (50KHz deviation)
SN ratio	more than 50dB (25KHz deviation) more than 56dB (50KHz deviation)

Table 2 Performance of sound signal

FUTURE TREND

Approach for low noise

For the purpose to achieve further low noise performance, the reduction of series resistance of a mixer diode at operational frequency is important. The values of the resistance is much larger than that of D.C. because of skin effect. The new approach for the diode will be expected. The development of low cost 1GHz ~ 2GHz band low noise transistor for 1st IF amplifier is also important.

Approach for low cost

The development of IC components for 1st and 2nd IF circuit such as amplifier, AGC, AM compression circuit and threshold extention circuit, will be desired. This becomes much more important when we consider to mount the indoor unit inside a domestic TV receiver in future. In future, surface acoustic wave devices are also attractive in this sense. The development of dielectric material with higher Q values at 12GHz band is also desirable to get more stable 1st local oscillator with low cost.

Others

When a low cost noise reducer at base band is developed and mounted in TV receiver in future, it will become a very powerful method to receive a satellite broadcasting program with small antenna. The effeciency of a receiving parabola antenna is about 50 %. The development of low cost and higher effeciency antenna is also important.

REFERENCES

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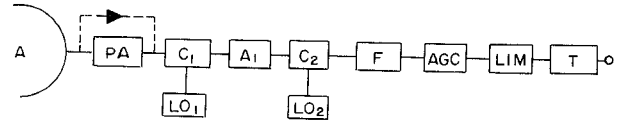


A Receiving antenna
PA Preamplifier
C1 SHF down converter
A1 IF amplifier
F1 IF BP filter
AGC Automatic gain control
LIM Limiter
T Signal processing circuit
LO1,LO2 Local oscillator SHF down converters

Fig.1 Block diagram of 12GHz band FM receiver

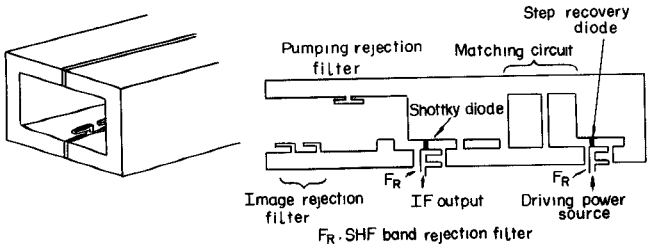
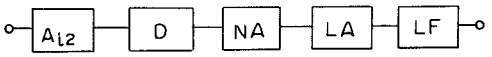


Fig. 2 Construction of planar circuit of mounted in waveguide



A_{i2} : Second IF amplifier
D : One stage diode limitter
NA : Nonlinear feed back amplifier
LA : Locking amplifier
LF : Low pass filter

Fig. 3 Block diagram of newly developed AGC and Limitter

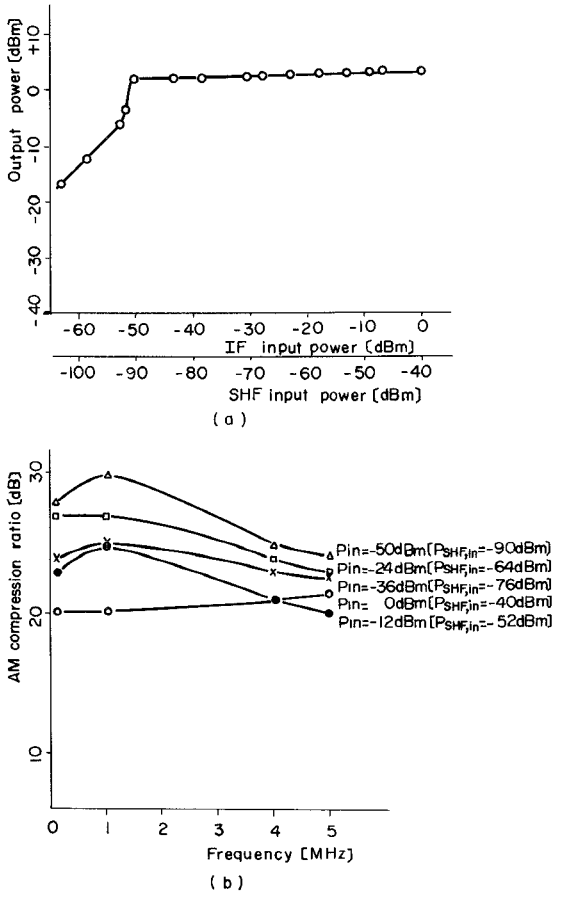


Fig. 4 Performance of newly developed AGC and Limitter

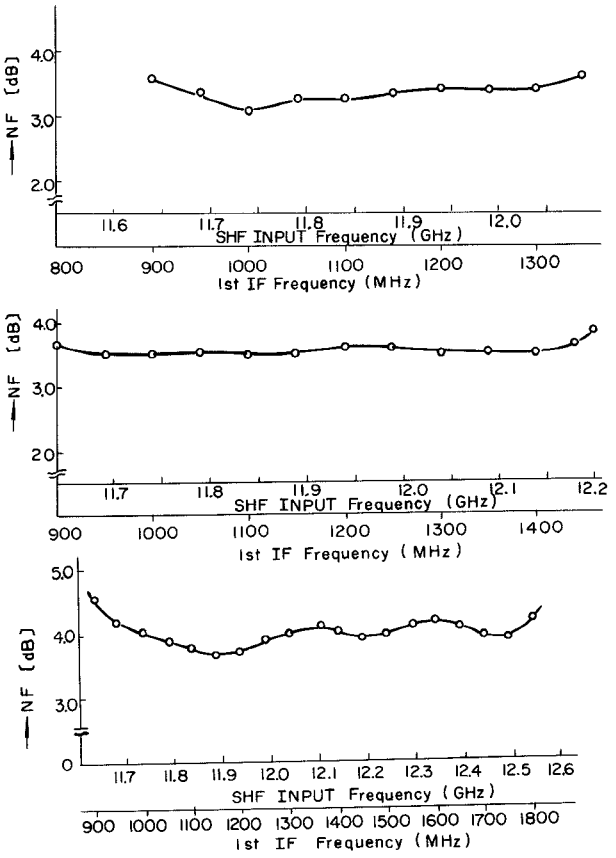


Fig. 5 Noise figure of receiver

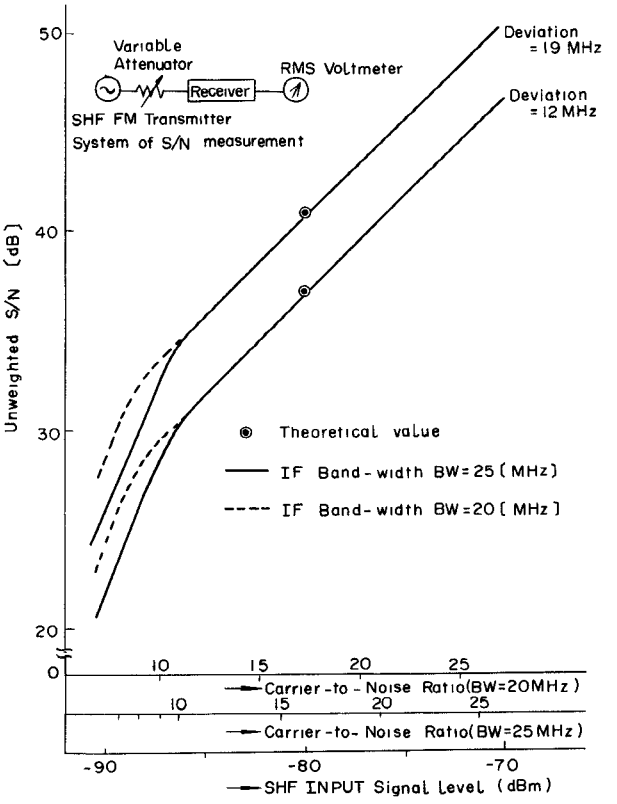


Fig. 6 Measured values of unweighted S/N