2.6 GHZ SATELLITE TV BROADCAST RECEIVER

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ABSTRACT

The microwave satellite receiver described in this paper combines state-of-art performance and excellent reliability at low cost by extensive use of microwave integrated circuit technology.

Introduction

In the years to come it is expected that microwave receivers for satellite television reception will be used by the hundreds or thousands in remote areas. These will be operated by relatively untrained people so a receiver designed for such use must not only give state-of-art performance, but it must also be reliable, simple to operate, inexpensive, and suitable for mass production. These design objectives have been met with a tuned radio frequency (TRF) receiver design using microwave integrated circuit (MIC) techniques.

Receiver Description

The receiver operates in the 2.5-2.7 GHz Satellite TV band. To achieve the desired video signal-to-noise performance (~50 dB), the transmission system uses wideband frequency modulation (20 MHz P-P). Synchronous satellites with an effective radiated power of +50 dBm, such as the ATS-F, provide sufficient signal strength to meet system objectives when a 10-foot parabolic receiving antenna is used. For multilingual voice transmission, there may be up to 4 FM audio subcarriers above the video band (4.64 - 5.36 MHz).

A block diagram of the receiver RF circuitry is shown in Figure 1. It consists of two basic units:

Antenna Unit - A feed-mounted microelectronic package that combines the two orthognal signals obtained from vertical and horizontal dipoles in the antenna. It has 55 dB of gain, a 300-MHz bandwidth, and a noise figure of better than 3.8 dB.

Indoor Unit - Contains microelectronic circuits that provide RF amplification, AGC and limiting, and an RF discriminator. In addition, it houses the channel-select filter, video amplifiers, audio subcarrier demodulators, and power supply.

RF Amplifiers

All RF amplifiers (Figure 2) are identical thin-film units. These have 4 common-emitter stages and realize a gain of greater than 30 dB and a bandwidth of 600 MHz. This same basic amplifier is used in the antenna unit pre-amplifier except that a selected low-noise transistor is used in the first stage and input matching and transistor biasing is optimized for low noise performance.

The amplifiers are fabricated with thin films of gold, tantalum, and tantalum pentoxide deposited on a sapphire substrate. Discrete transistors are bonded on the substrate. The design was optimized by use of a computer.

Filters

The antenna unit bandpass filter (Figure 3) is a thin-film, 3-pole, capacitively coupled, 1/2 λ transmission-line design with a 300-MHz bandwidth between 3 dB points. Interdigital capacitors (2 mil fingers with 2 mil gaps) are used. Insertion loss is less than 1 dB.

The channel filter is a 3 pole, interdigital design, formed from an aluminum extrusion. Temperature compensated resonators are used to assure a frequency drift of less than 2 ppm/°C. The 3 dB bandwidth is 23.5 MHz and insertion loss is less than 1.7 dB.

Limiter/AGC

In a TRF receiver such as this, the design of the limiter is particularly difficult since limiting must be performed on a 2.6 GHz signal. Meeting the design goal of greater than 30 dB of limiting for 30% AM modulation using conventional techniques (saturating amplifiers, diode limiters) is quite difficult.

Limiting is provided in this receiver by a very wideband (0-40 MHz) AGC loop. This limiting method not only provides greater than 30 dB of limiting, but it provides AGC and signal-level monitoring functions as well. In addition, since there is no signal clipping as in conventional limiters, no carrier harmonics are generated so there is no need for filtering between the limiter and discriminator.

This wideband feedback AM suppression system puts severe requirements on loop time delay. Only by using the compact, wideband RF components realizable with MIC technology is such a design practical.

Discriminator

The discriminator (Figure 4) is a MIC transmission-line design that is linear from 2500 to 2700 MHz. The advantages of this circuit are constant 50 ohm input impedance and excellent linearity. The frequency selective elements are formed by two 70 ohm transmission lines 13/8 λ long, one open-circuited, the other short-circuited.

The usual disadvantage of this type of discriminator is that it responds to harmonics generated in the detector diodes, giving rise to irregularities in the discriminator frequency/voltage curve. This problem is overcome by dissipative elements in the transmission lines placed at the proper points to absorb harmonics without affecting discriminator performance in the desired frequency range.

Conclusion

A photograph of the complete receiver system is shown in Figure 5. Typical performance obrained is:

Static FM Threshold........... <-87 dBm

Differential Gain............. < 4%

Differential Phase............ < 2°

Baseband Frequency Response, from

10 Hz to 4.2 MHz.......... ±0.5 dB

Realization of this receiver, combining low cost with state-of-art performance, opens the way for satellite TV systems with profound world-wide educational implications.

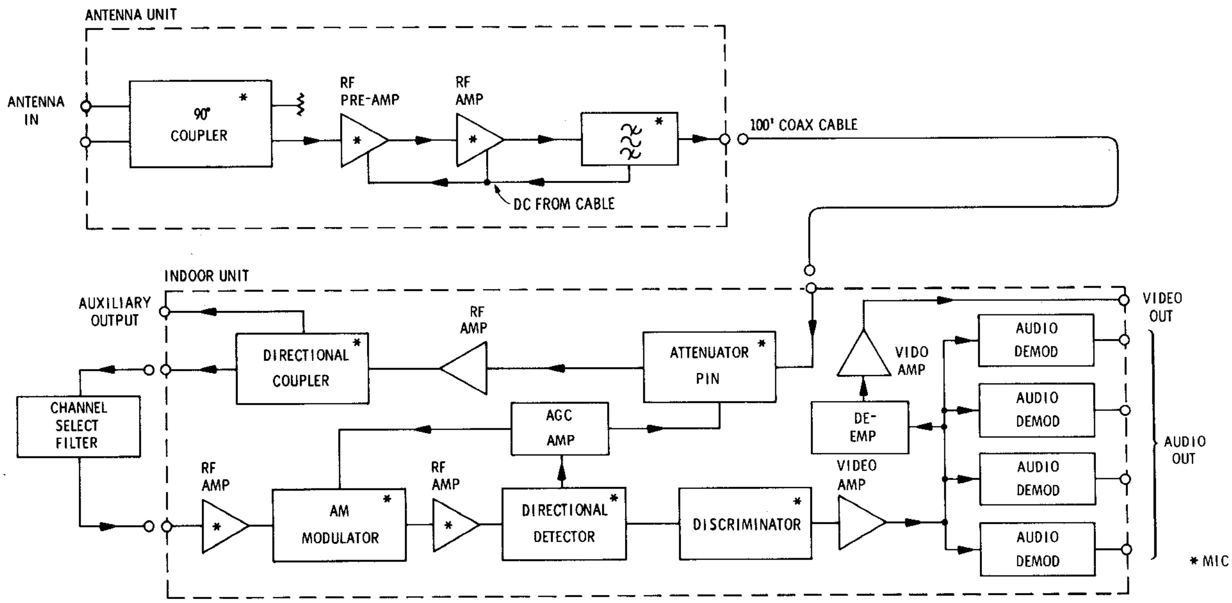

FIG.1 - RECEIVER BLOCK DIAGRAM

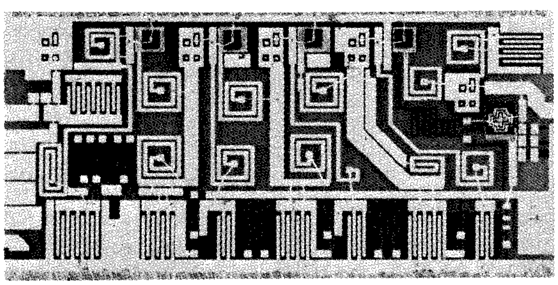

FIG. 2 - RF AMPLIFIER

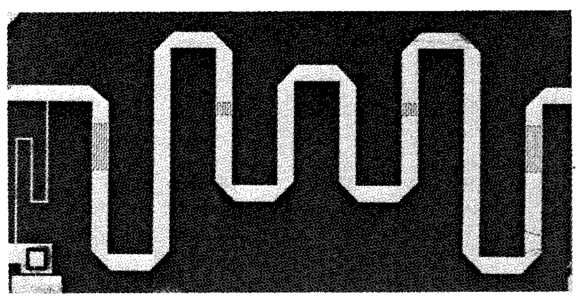

FIG. 3 - BANDPASS FILTER

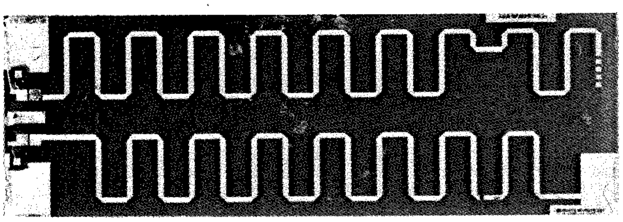

FIG. 4 - DISCRIMINATOR

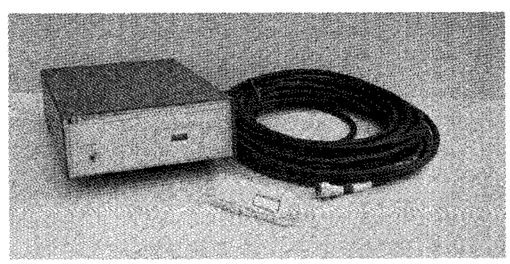

FIG. 5 - COMPLETE RECEIVER SYSTEM