LOW NOISE DOWN-CONVERTER AND HIGH EFFICIENCY UP-CONVERTER FOR 60 ~ 86 GHz TRANSMITTER-RECEIVER

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Abstract

Composition and characteristics of both low noise down-converter and high efficiency up-converter for transmitter-receiver in the frequency range of 60 ~ 86 GHz are described in this report.

Introduction

The Electrical Communication Laboratory, Nippon Telegraph & Telephone Public Corporation (NTTPC), is carrying forward a scheme of putting the guided millimeter-wave transmission system "W-40G" to practical use.

The W-40G system is capable of relaying approximately 300,000 two way telephony channels by means of both go and return 26 millimeter-wave carriers in a frequency band of 43 ~ 87 GHz.

A transmitter-receiver to be used in the W-40G system has been designed and manufactured based upon the results of overall relay experimentation performed in 1970 with the 50 GHz all solid state 4-phase PSK repeater, and with the adoption of improved performances and technology advanced thereafter.

Compositions and characteristics of both the low noise down-converter and the high efficiency up-converter that constitute an essential part of the transmitter-receiver are mainly described in this report.

Wafer Type Diode

A GaAs Schottky barrier diode, which is the so called "Wafer type diode" is employed in the up- and down-converters. The fabrication of the wafer type diode is shown in Figure 1. The chips used in the wafers for the down-converter have an array of approximately 3-micron diameter junctions, and for the up-converter an array of approximately 7-micron diameter junctions since a higher power is applied to the up-converter. These wafers contain a ridged waveguide matched to the semiconductor chips over a broadband frequency range, and a coaxial choke consisting of two re-entrant resonator cavities, which eliminates the leakage of both the RF and local signals to the IF terminal.

Down-Converter

The down-converter and the receiving IF amplifier are combined as shown in Figure 2. The amplifier is constructed with four stages of transistors 2SC-1268 (NEC) and its gain is approximately 32 dB. The center of distribution of the conversion loss of the down-converter at 86 GHz is located at a point of 5.5 dB with the local oscillator power of several mW and without DC bias.

Figure 3 shows the conversion loss vs. millimeter-wave frequency measured at 80 GHz. The down-converter is operative in a bandwidth of approximately ±10% of 80 GHz, i.e., from 72 to 88 GHz. It is clear that it would be advantageous to use a broadband down-converter in the W-40G system comprising many carriers at a millimeter-wave frequency range. The amplitude deviation vs. output frequency is within ±0.5 dB as shown in Figure 4 over the frequency range from 1.3 to 2.1 GHz.

Figure 5 shows the noise figure of the down-converter at 86 GHz. The noise figure of the down-converter is 8.6 dB, which contains the noise figure 3.1 dB of receiving IF amplifier. From the result of this measurement, the noise figure of the down-converter is essentially due to the conversion loss, and hence, the noise ratio is close to unity.

The receiving noise figure of the transmitter-receiver is 10.7 dB at 86.35 GHz, which includes the transmission loss 2.1 dB of receiving RF waveguide circuits comprizing a circulator, bandpass filter, isolator, etc.

Up-Converter

The structure of up-converter is nearly the same as that of the down-converter. It is also a single mixer employing a GaAs Schottky barrier diode of approximately 7-micron diameter junction. The amplitude characteristics vs. frequency of the up-converter is similar to that of the down-converter. The output power of the up-converter vs. IF input power is shown in Figure 6. The conversion loss when the local oscillator power is 19 dBm and the output signal power is 11.5 dBm is 7.5 dB on condition that the output signal power is 1 dB compressed against the IF input power. Consequently, the output signal power of the up-converter becomes +11.5 dBm when the local oscillator power is +19 dBm.

The local oscillator power is supplied from the negative resistance Impatt amplifier followed by the Impatt oscillator with a resonant cavity for frequency stabilization. The diode used for this oscillator is a Si Impatt diode of p^+-n-n^+ single drift region type, and it is mounted in the waveguide. The output signal power of the transmitter-receiver is +9 dBm because the output signal power of the up-converter is 11.5 dBm while the insertion loss between the up-converter output and the transmitter-receiver output is 2.5 dB. The insertion loss is caused by a circulator, bandpass filter, isolator, directional coupler, etc.

Acknowledgments

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Reference

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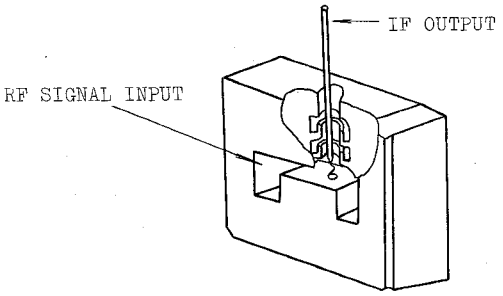

FIG. 1 A WAFER TYPE DIODE

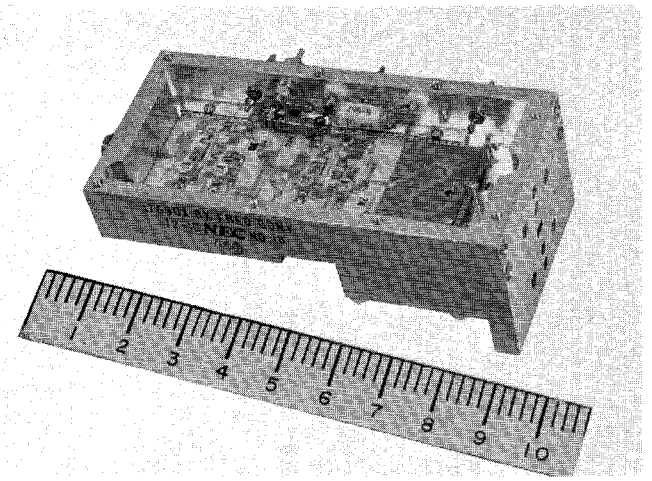

FIG. 2 THE DOWN-CONVERTER CONNECTED WITH RECEIVING IF AMPLIFIER

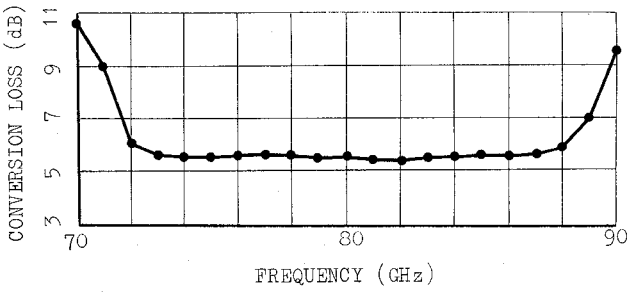

FIG. 3 CONVERSION LOSS vs. FREQUENCY OF DOWN-CONVERTER

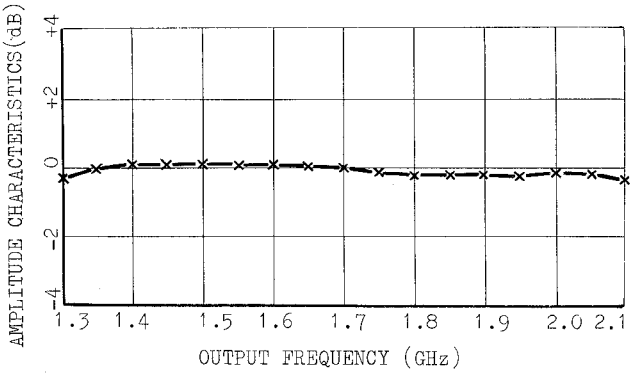

FIG. 4 AMPLITUDE CHARACTERISTICS vs. FREQUENCY OF 86/1.7GHz FREQUENCY DOWN-CONVERTER (Fo=86.35GHz)

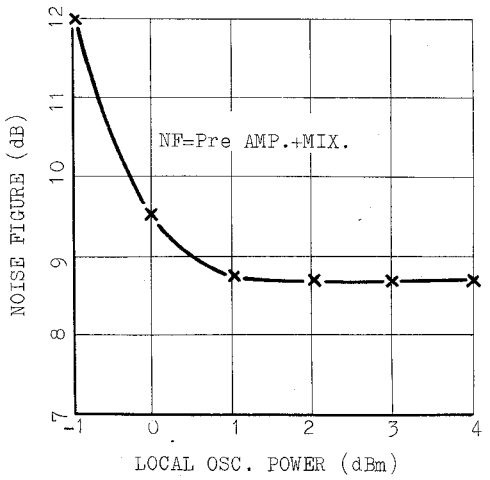

FIG. 5 NOISE FIGURE vs. LOCAL OSC. POWER OF 86/1.7GHz FREQUENCY DOWN CONVERTER (Fo=86.35GHz)

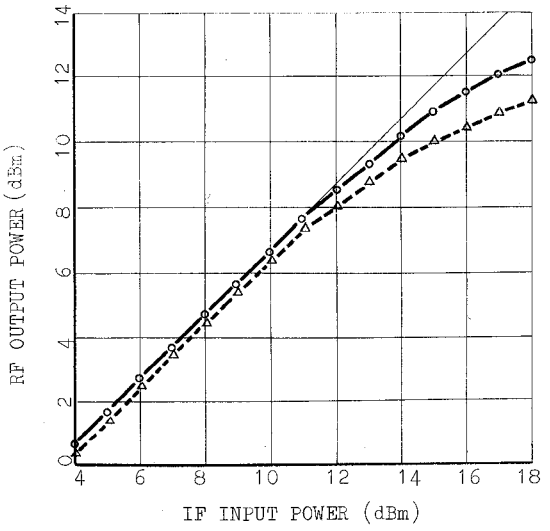

FIG. 6 OUTPUT POWER vs. IF PNPUT POWER OF A 1.7/86GHz FREQUENCY UP-CONVERTER (Fo=86.35GHz) LOCAL OSC. POWER LEVELS ARE +19dBm (o——o) AND +17dBm (△- -△)