I-7 RESEARCH ON MILLIMETER WAVE COMMUNICATION IN JAPAN

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The present status of the research on millimeter wave communication in Japan is reviewed. This paper begins with a description of a millimeter-wave PCM transmitter assembly composed of an 12 GHz band diode switch and a quadrupler. This assembly was developed for the purpose of building an experimental PCM repeater for a long distance circular-electric-waveguide communication system. A repeater circuitry associated with this assembly is described.

Germanium silber-bonded diode GSB3 generates above 0 dBm of millimeter continuous wave in the avalanche bias region. New components for repeater including this diode which would offer advantages in simplifying repeater, are also discussed.

Pulsed Modulated Millimeter Wave Generation by Germanium Silber-Bonded Diode Multiplier

One of the main problems of the repeater is how to produce a millimeter wave transmitting pulse. The regenerated video pulses are converted into millimeter wave pulses through a microwave diodeswitch and frequency quadrupler. In this system 12 GHz pulses are generated by applying 12 GHz continuous power to a diode switch controlled by binary pulse train. For this microwave diode switch, a silber-bonded germanium diode type GSB1 is quite suitable because of low-loss and high speed. The insertion loss of the diode switch is varied from 0.7 dB to 12 dB for the bias voltage variation from -5 volts to 0 volts in the case of an 18.5 dBm input. Therefore, by varying the bias voltage of the diode by a binary train, a microwave pulse with a peak output power of 17.8 dBm and an on-off ratio of more than 10 dB can be generated. The measured rise and fall times are less than 1 ns.

For the quadrupler, a silber-bonded germanium diode type GSB3 is used. Examples of the measured microwave and quardrupler outputs versus bias voltage of diode switch are shown in Fig. 1. The peak output power and on-off ratio of the millimeter wave pulse are 4 dBm and 42 dB, respectively.(1) In a dozen of GSB3, 10 of them produced 47 GHz power more than 3 dBm, when 11.75 GHz input power is 20 dBm.

Millimeter-Wave PCM Repeater

Silicon epitaxial point contact diode mounted in prong type cartridge have been developed which down convert from 50 GHz region with losses around 8 dB. The bandwidths of 5 GHz in millimeter wave region and 600 MHz in 4 GHz IF region are obtained at a cross waveguide type converter circuit using the diode mounted in the prong type cartridge.(2)

Esaki diode amplifiers at 4 GHz have been reported. Typical results exhibit 17 dB midband gain, 1050 MHz bandwidth and 5.5 dB noise figure.(3) Transistor amplifier has been reported which exhibits 4 dB gain and 550 MHz bandwidth centered at 3.6 GHz.(4) These two kinds of amplifiers can provide required characteristics for the IF amplifier of 200 Megabaud millimeter-wave repeater at 4 GHz.

IF output is applied to an envelop detector, tunnel diode pair decision circuit and timing circuit assembly. -7 dBm IF output power is detected and provides current to the decision circuit more than 10 times the sum of uncertain current of the decision circuit and threshold level variation due to the temperature variation from 5°C to 40°C at 200 Megabaud.(5) Fig. 2 shows 4 GHz IF signal modulated by a non-return-to-zero pattern and regenerated pulses at 200 Megabaud.

A millimeter continuous wave oscillation can be obtained by GSB3 diode inserted in a 50 GHz-band waveguide and a reverse bias condition where a reverse current of more than 10 mA.(6) Typical measured values of oscillating power are 1.3 milliwatts at 52.7 GHz and 2.2 milliwatts at 40 GHz. Pulse response of the avalanche oscillation has been investigated and it has been found that the start of the oscillation delays by around 10 ns, but the amplitude variation follows without delay at up to 500 MHz if the oscillation does not stop.(7)

Four class hierarchical branching filter system is tentatively planned for repeater station. Two circular TE_{01} mode waveguide coupled wave type hybrids and two cutoff filters are used to assemble branching filter which can be used to split 20 GHz bandwidth into two with a loss around 0.8 dB. Fig. 3 shows the measured insertion loss of the hybrid used as a zero dB coupler.(8)

The wave reflected from cutoff tapered waveguide have an inverse delay characteristics of those in a waveguide transmission line. A 4 GHz pulse was produced and distorted by pseudo waveguide line whose delay characteristics are the same as 15 kilometers long and 51 millimeters diameter circular waveguide at 50 GHz. A tapered rectangular waveguide type equalizer could equalize the distorted pulse to the extent of -30 dB timecrosstalk.(9) Fig. 4 shows original (top), distorted (middle) and equalized (bottom) 10101 pattern at 200 Megabaud.

References

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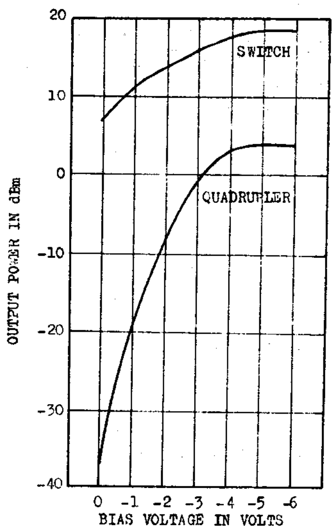

FIG. 1 - Output power of the diode switch and the quadrupler versus bias voltage of the diode switch

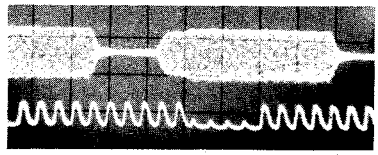

FIG. 2 - 4 GHz signal modulated by an NRZ pattern and regenerated waveform at 200 Megabaud

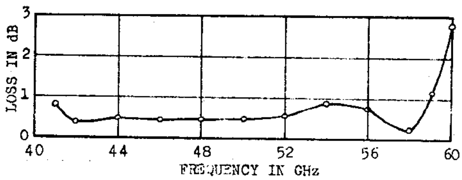

FIG. 3 - Insertion loss of the circular TE_{01} mode zero-decibel coupler

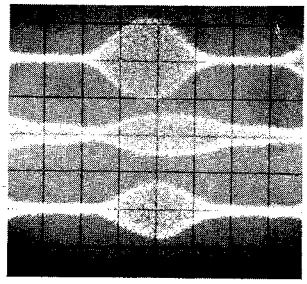

FIG. 4 - Waveform equalization by taper type delay equalizer