MORE THAN 4 PERCENT EFFICIENCY SOLID-STATE TRANSMITTER FOR 4 GHz RADIO RELAY

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Abstract

This paper describes a 4 GHz transmitter developed by using a low-level varactor up converter and a high-gain transistor injection locked amplifier. This transmitter, permitting to obtain an RF output of 220 mW at an efficiency of more than 4% for a DC input of 5 W, is usable as a transmitter or exciter for radio relay of a maximum of 1380 channels.

Introduction

The major feature of this 4 GHz transmitter is the development in efficiency by the use of a high-gain transistor injection locked amplifier whereby the power consumption is much reduced as compared with that of the conventional transmitters and the use of battery cells or thermo-electric generator is allowed. The external view (photograph) of this transmitter and the block diagram thereof are shown in Fig. 1.

Circuit Description

This transmitter is composed of a local oscillator, an up converter and a transistor injection locked amplifier, as shown in the block diagram of Fig. 1. The local oscillator is a transistor oscillator using a 2 GHz band re-entrant coaxial cavity made of super-invar and a 4 GHz band local power is simultaneously obtained by doubling the fundamental frequency with the same transistor.

The varactor up converter is composed of a microstrip line and a varactor diode and the mechanical construction and equivalent circuit of the varactor up converter are shown in Fig. 2.

The varactor diode has a case of ribon type and is mounted on a microstrip line made of a dielectric of teflon fiberglass. This up converter is tunable over a 4 GHz frequency band and the local power to RF signal power conversion efficiency of the up converter is less than 8 dB.

The injection locked amplifier is composed of a 4 GHz transistor oscillator and a 4-port circulator and permits to efficiently obtain a high gain over a sufficiently wide frequency bandwidth.

Performance

The output power of the local oscillator is +19.5 dBm.

The output power and gain characteristics of the injection locked amplifier are shown in Fig. 3. The output power characteristic of the figure is obtained by varying the input RF frequency with the RF input power being +9 dBm constant. The locking range at the standard gain of 14 dB is approximately 2.2% band.

The output power and AM-PM conversion of up converter for 70 MHz IF input power are shown in Fig. 4. The output power of injection locked amplifier v.s 70 MHz IF input power is also shown in Fig. 4. The output power of the transmitter at the standard IF input level of +2 dBm is +23.5 dBm (approximately 220 mW).

The AM-PM conversion shows the phase shift caused when varying the IF input level with the phase being 0^{o} at the standard IF input level of +2 dBm. The AM-PM conversion of this transmitter is extremely small. The differential characteristic and amplitude response of this transmitter are shown in Fig. 5. The 200 kHz delay of this transmitter is within 3ns/$\pm$10 MHz. The differential gain and amplitude response of this transmitter respectively 0.1%/$\pm$10 MHz and within 0.3 dB/$\pm$10 MHz.

The baseband frequency response of this transmitter is shown in Fig. 6. The solid line in the figure shows the frequency response of this transmitter at the standard IF input level of 2 dBm and the dotted lines show the frequency responses at lower IF input levels. When the IF input level is +2 dBm, the deviation of the amplitude characteristic is within 0.05 dB through 10 kHz to 10 MHz.

When the IF input level is lowered, the frequency response in the high frequency range lowers since the gain of the injection locked amplifier is raised and the

locking range is narrowed.

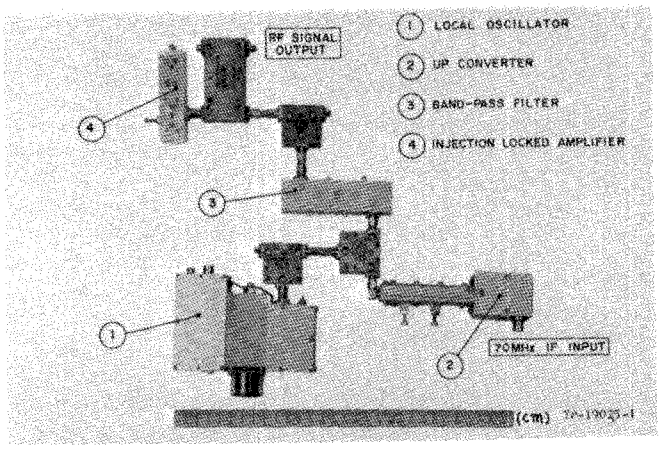
When this transmitter is used in combination with a receiver, the S/N+D and thermal noise in the noise loading test of 1380 channels are more than 75 dB and more than 78 dB, respectively.

Conclusion

So far, amplifiers using Gunn, Impatt, or Tunnel diodes have had to be used as injection locked amplifiers or negative resistance amplifiers and transistors have generally been used as conventional amplifiers. However, when an injection locking method is used in place of a conventional one to compose a high frequency transistor amplifier, this transistor injection locked amplifier provides much high gain at high working frequencies as compared with the conventional amplifiers. Therefore, through selection of a proper oscillator mount and a proper level diagram, a transmitter having a small power consumption and such a transmission characteristic as permits transmission of 1380 channels can be composed by using such a transistor injection locked amplifier, a high-efficiency local oscillator and an up converter in combination.

Acknowledgement

They would like to express our sincerest thanks to Dr. Y.Kaito for giving chance and valuable suggestions of this work, and Mr. I.Haga for his design of a transistor injection locked amplifier and a local oscillator.



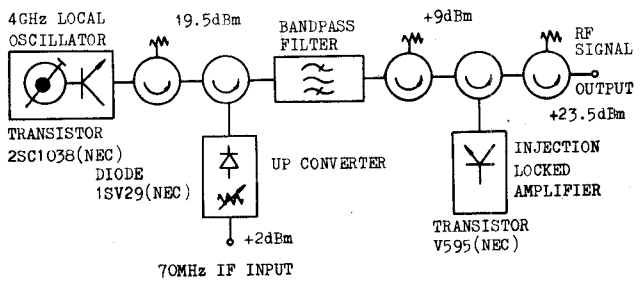


FIG. 1 Photograph and block diagram of transmitter.

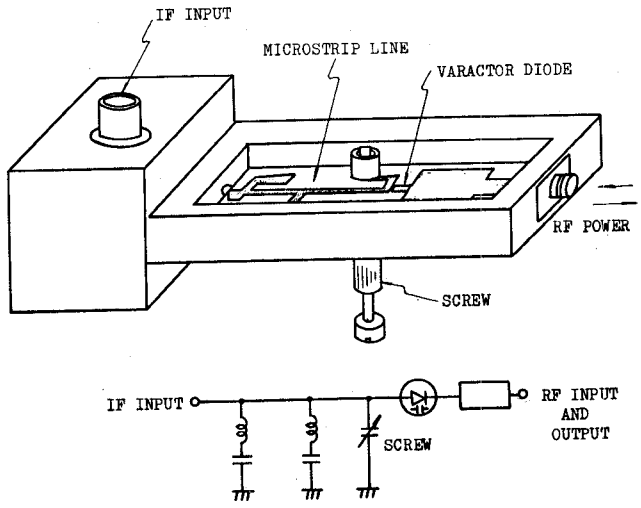


FIG. 2 Mechanical construction and equivalent circuit of UP converter.

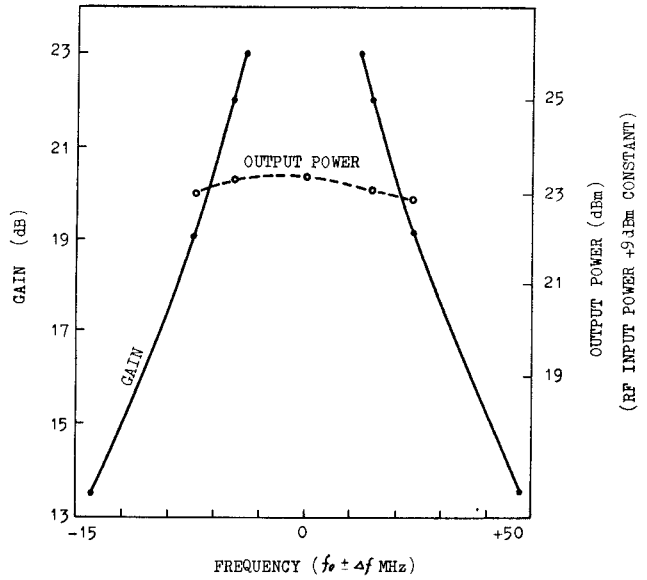


FIG. 3 Output power and gain characteristics of injection locked amplifier.

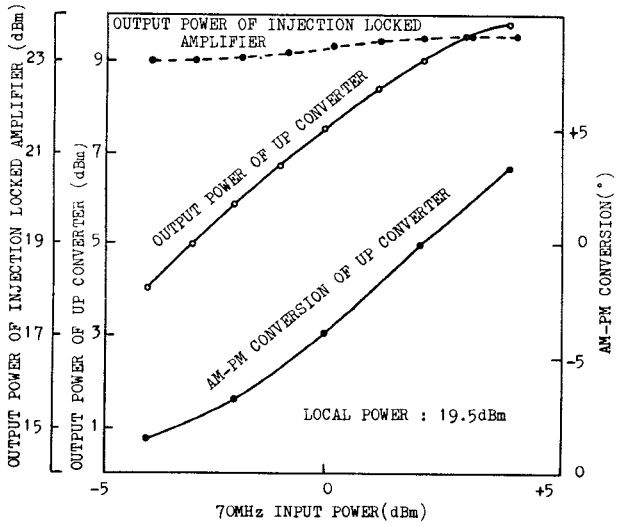


FIG. 4 Output power and AM-PM conversion of up converter vs. 70 MHz IF input power and output power of injection locked amplifier vs. 70 MHz IF input power.

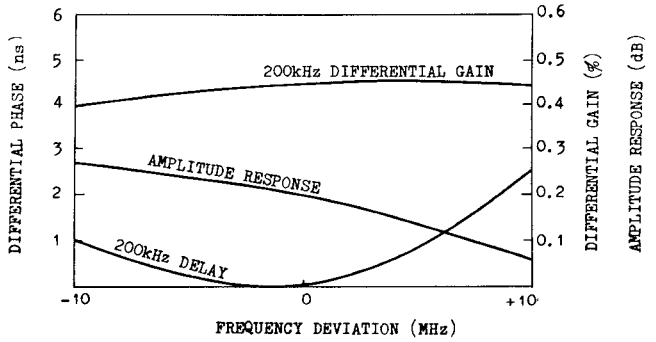


FIG. 5 Amplitude response and differential characteristics of transmitter.

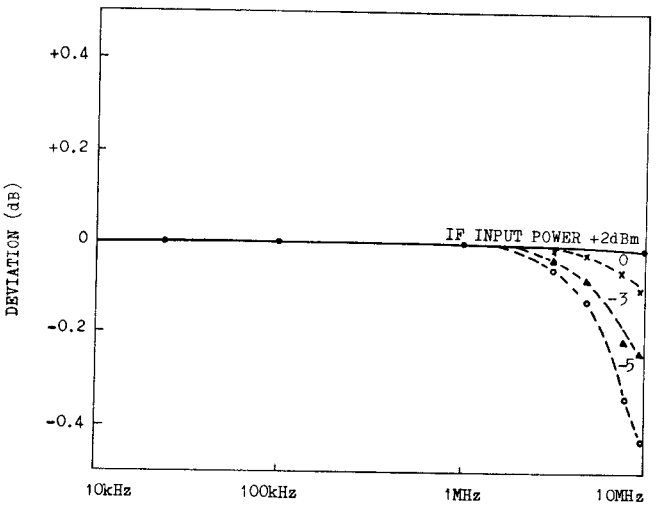


FIG. 6 Baseband frequency response of transmitter.