AVALANCHE DIODE SOURCE WITH INTEGRATED AFC CIRCUIT AND FREQUENCY CONVERTER FOR DIGITAL COMMUNICATION SYSTEMS

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Abstract

An integrated 11 GHz source is developed for a digital communication system with emphases on suppression of interference by spurious signals. Performance characteristics of the integrated source/converter module are measured in a Q-PSK modulated system carrying up to 40 M-bits of data.

Summary

RF sub-systems (including signal sources, frequency converters, etc.) used in microwave communication systems must meet rigid specifications on frequency stability and spurious signal levels. In most systems, the frequency stability is attained by locking the signal source to a reference oscillator. Frequency control circuits used for this purpose generally contain one or more frequency multipliers and a mixer circuit. Nonlinear elements in the multiplier and the mixer are potential sources of spurious signals. When one attempts to integrate these circuits into one MIC module, one finds that the isolation between various parts of the MIC is inadequate to suppress leakage of spurious signals generated by the nonlinear elements. Because of this need to increase isolation and for diagnosis of problems encountered in system tests, it is desirable (and often necessary) to limit the scale of integration of these MIC circuits to a moderate level.

This paper describes a partially integrated RF sub-system designed for use in both transmitters and receivers of a digital Q-PSK modulated radio operating in the 10.7 - 11.7 GHz band. FIG. 1 is the block diagram of the subsystem whose unique features are:

(1) An avalanche diode oscillator.

(2) Ferrite substrate microstrip construction.

(3) A low level multiplier in the AFC circuit.

The local oscillator is a tunable avalanche diode oscillator constructed in a high Q cavity resonator. The high Q cavity is necessary to reduce FM noise and frequency drift. It has a mechanical tuning range of 1 GHz covering the entire band (10.7 to 11.7 GHz) with a power output of +16 dBm ± 1 dB. Since it is intended for use in heterodyne systems, no attempt was made to make it frequency modulable, but a tuning varactor is included in the cavity design for AFC purposes. The minimum range of varactor tuning required is twice the range of frequency drift anticipated under all operating conditions. Typically, with an external Q of about 500, the frequency drift over the temperature range of $-30^{o}C$ to $+60^{o}C$ is less than 10 MHz. The minimum electrical tuning range at any point within the mechanical tuning range of the oscillator, therefore, is 20 MHz. In digital radio systems, the FM noise of the source need not be as low as in FM systems. With diffused-junction GaAs IMPATT diodes in high Q cavities, RMS deviations of less than 20 Hz/kHz are attainable routinely. FIG. 2 shows the FM noise characteristics of sources used in this system plotted in dBmO (0 dBmO = 200 kHz RMS/4kHz).

The oscillator output is fed into the MIC module which contains a power splitter, a frequency converter (up-converter for the transmitter and down-converter for the receiver), and an AFC mixer. This integrated circuit module is constructed in ferrite-substrate microstrip to allow liberal use of isolating junctions as shown in FIG. 3. In addition to these RF isolators, several IF traps are designed into the substrate to prevent system degradation by interference. Beam-lead Schottky-barrier diodes are used in both the down-converter and the AFC mixer. The up-converter is designed to allow maximum use of available LO power. Using PIN diodes with a very short minority-carrier life time, the converter output can be made to increase linearly with the LO drive. The conversion loss from LO to RF output is less than 10 dB.

The reference signal for the AFC circuit is derived from a low frequency stabilized source. The level of the reference signal available at 400 MHz is +6 dBm, and after two stages of multiplication to the 28th harmonic, the reference signal level at the AFC mixer is typically -25 dBm. This low-level of RF drive to the multiplier limits spurious signal generation by the diodes. FIG. 4 shows the two-stage frequency multiplier (X7 and X4) with the inter-stage isolator integrated into one module.

The ultimate system performance of the integrated RF sub-system is measured with the transmitter and the receiver sub-assemblies connected back to back with an appropriate attenuation to simulate the path loss. FIG. 5 shows the bit-error-rate measured as a function of the receiver input level with a 40 M-bit Q-PSK modulation on the carrier. This data is compared to the theoretical limit and to a similar result obtained with discrete RF components, and to an IF-to-IF transmission data.

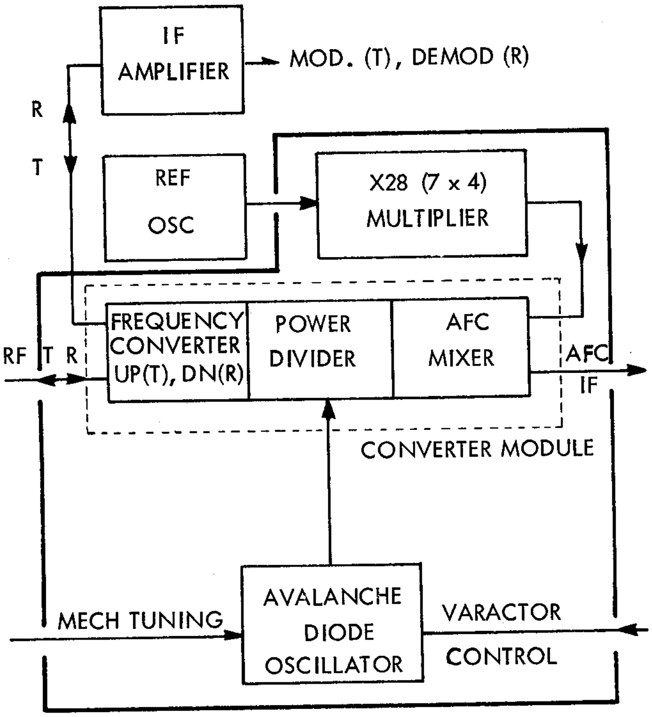

FIG. 1 BLOCK DIAGRAM OF THE RF SOURCE/CONVERTER ASSEMBLY

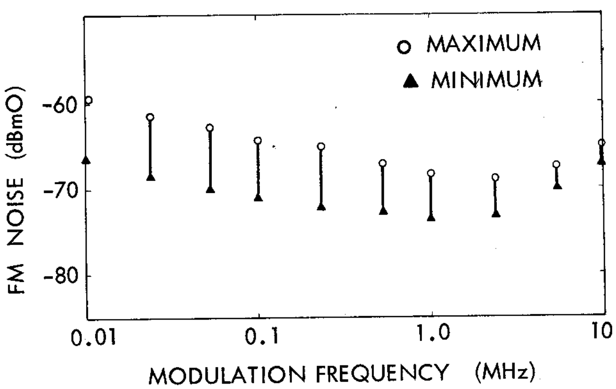

FIG. 2 FM NOISE CHARACTERISTICS OF AVALANCHE-DIODE OSCILLATOR

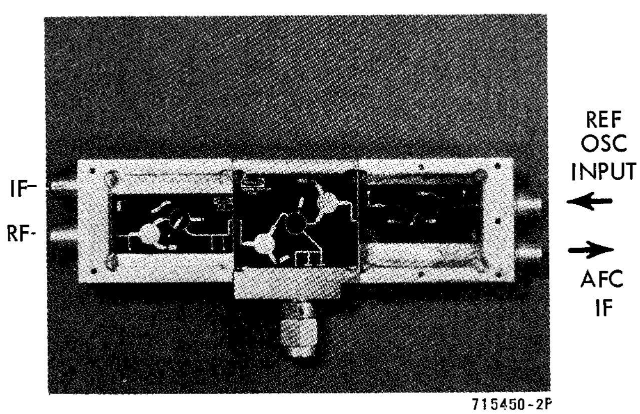

FIG. 3 FREQUENCY CONVERTER AND AFC MIXER WITH INTEGRATED ISOLATORS

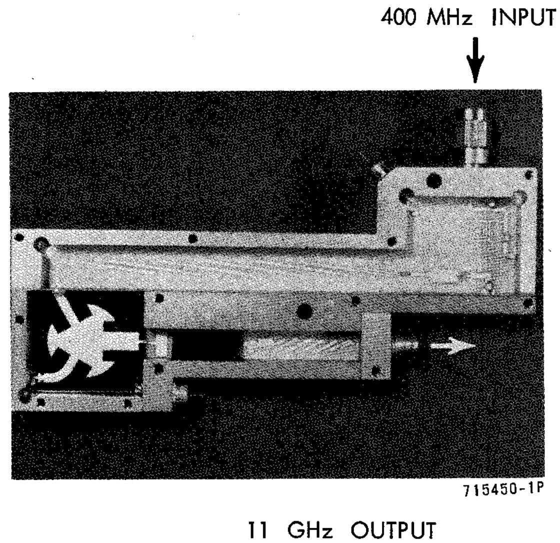

FIG. 4 TWO-STAGE (X7 and X4) MULTIPLIER

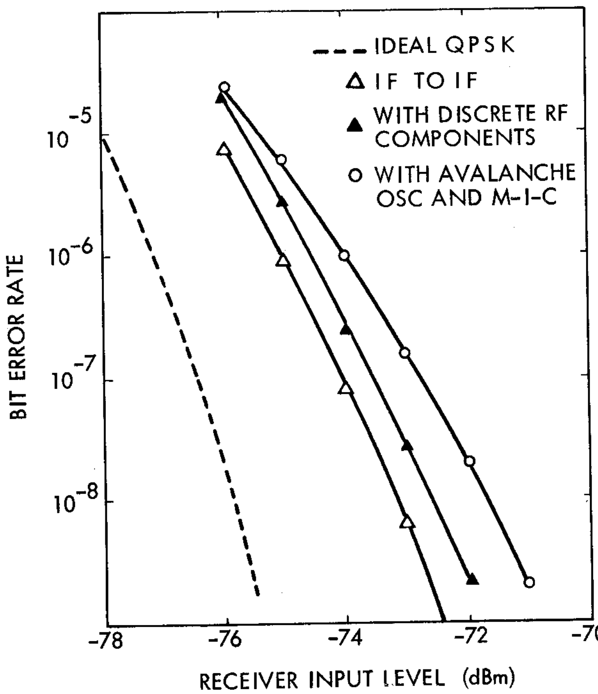

FIG. 5 BIT ERROR RATE VS. RECEIVER INPUT LEVEL

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