3.7 TO 4.2 GHZ PORTABLE MICROWAVE REPEATER

William W. Raukko
Hewlett-Packard Company
1501 Page Mill Road
Palo Alto, California

Abstract

This paper describes the use of microwave integrated circuit technology in the design of a frequency agile, portable microwave repeater of light weight, compact construction without sacrifice of performance.

Introduction

Standby systems which may be switched into service in the event of the failure of an operating system are common in microwave communications networks. These standby systems generally occupy a vacant channel in the RF band, and increasing traffic has encouraged reduction of the number of standby systems so that more channels may be used to carry service. Such a reduction is possible with the use of portable microwave radios that can be substituted for a system which has failed until the operation of that system is restored. The portable microwave repeater (PMR) discussed in this paper is such a radio. It is capable of being tuned to any one of 25 channels, 20 MHz wide, in the 3.7 to 4.2 GHz band and consists of the following:

1. A dual down conversion system from any channel in the 3.7 to 4.2 GHz band to 70 MHz.
2. A dual up conversion system from 70 MHz to any one of the 3.7 to 4.2 GHz channels.

Frequency modulation and demodulation occur at 70 MHz but are not a part of the PMR. The instrument can serve as a receiver down conversion system, a transmitter up conversion system, or a repeater by interconnecttion of the receiver 70 MHz output and the transmitter 70 MHz input. Because of the frequency agility requirement at 3.7 to 4.2 GHz, the components operating in this band must have minimum amplitude variation with frequency. The entire instrument must achieve flat amplitude response and minimum group delay over any 20 MHz channel.

The portability requirement makes microelectronics technology useful in this application. The small size of the circuits and the inherent short connections allow the final instrument to be portable as well as avoiding performance sacrifices. Those components which employ microelectronic (thin film) design will be emphasized in this paper.

System Description

A block diagram of the instrument appears in Figure 1, and a photograph is shown in Figure 2. The receiver 4 GHz input signal is first down converted to 1430 MHz and then down converted again to 70 MHz. The first LO is a phase locked YIG tuned oscillator; the second LO is a crystal multiplier. From the output of the 1430 MHz converter, the signal then passes to the AGC amplifier. Filtering, equalization, and additional gain are provided before the signal reaches the 70 MHz output.

The transmitter uses frequency converters which are very similar to those in the receiver. The 70 MHz input signal is applied to an AGC amplifier and then upconverted to 4 GHz in two steps. A driver amplifier and power amplifier raise this signal level to greater than 1 watt.

Microelectronic Components

The 4 GHz down converter (Figure 3) consists of an input circulator for matching, a preamplifier, a bandpass filter, a circulator for isolation, a diplexer with highpass arm terminated, a double-balanced mixer with LO circulator, a 1430 MHz preamplifier, and a π-attenuator with adjustable attenuation level and slope. The diplexer terminates high frequency mixer products which are beyond the bandwidth of the circulator.

The double balanced mixer consists of a four diode ring which is coupled to the RF and LO ports through $\lambda/4$ baluns. A $\lambda/2$ loop is center tapped to provide the 1430 MHz IF output.

The 4 GHz preamp is a two stage circuit and achieves 11 dB gain with 5.5 dB noise figure. The 1430 MHz preamp is a three stage circuit and achieves 20 dB gain and 4 dB noise figure. Typical performance for the converter assembly is as follows: 16 dB gain, 8.0 dB noise figure, ± .5 dB gain variation from 3.7 - 4.2 GHz, and ± .1 dB gain slope over any 20 MHz band.

The 4 GHz up converter is essentially identical to the down converter with amplifiers removed.

1430 MHz Converters

The 1430 MHz down converter consists of an adjustable π-attenuator, a preamplifier, and a single balanced mixer with LO amplifier. The mixer and LO amplifier are capable of operating at LO frequencies of 1360 MHz and 1500 MHz to allow reversal of modulation sense. The 1430 MHz up converter is identical to the down converter with the preamplifier reversed.

70 MHz AGC Amplifier

This component consists of four two-stage gain blocks separated by a total of three PIN diode attenuators. A photograph is shown in Figure 4. The attenuators are each capable of 20 dB AGC range. The 70 MHz signal is detected at the receiver 70 MHz output, and the three sequential AGC control signals voltages are arranged so that the PIN diode attenuator nearest the output is activated first as the receiver input signal level increases. When the AGC range of this attenuator is exhausted, the next nearest attenuator to the output is activated, and the attenuator nearest the input is used last. Effect of AGC on system thermal noise is then minimized. The AGC amplifier provides 55 dB gain and 55 dB AGC range.

4 GHz Power Amplifier and Driver

A photograph of the power amplifier appears in Figure 5. The basic building block of the power amplifier is a gain block with a single stage of gain which consists of two transistors in parallel supplying 4 dB of linear gain. The input signal to the power amplifier is split in a 90° coupler and delivered to two gain blocks. The outputs are split again, additional gain blocks are used in cascade, and the signals are recombined. The output is filtered to remove harmonics and a circulator provides output matching.

The power amplifier is preceded by a driver amplifier which combines three 4 GHz preamplifier gain blocks and four power amplifier gain blocks in cascade to achieve 46 dB linear gain.

System Performance

Receiver system noise figure is typically 8.5 dB and transmitter output power is 1.5 watts. With transmitter and receiver connected such that the receiver input level is -28 dBm, FM noise loading measurements typically yield 24 dBrnc0 in a 3 KHz slot at 7280 KHz with 1500 channel loading and Western Electric Type 457K pre-emphasis. A Western Electric Type 4A FMT-FMR is used for frequency modulation and demodulation at 70 MHz. Back-to-back measurement at 70 MHz with a Hewlett-Packard Microwave Link Analyzer yields ± .2 dB amplitude variation and 3 ns group delay variation over the significant IF band.

Reference

Bell Telephone Laboratories, Transmission Systems for Communications, Western Electric Company, Inc., Technical Publications, Winston-Salem, North Carolina, 1971.

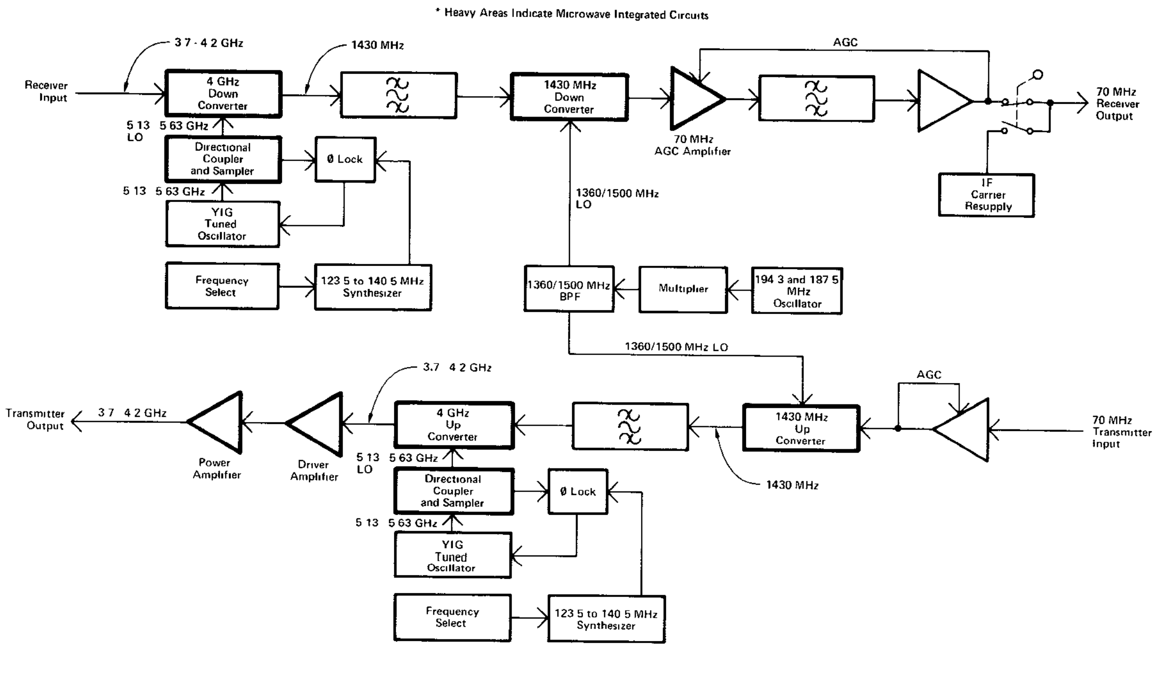

Fig. 1. Repeater block diagram

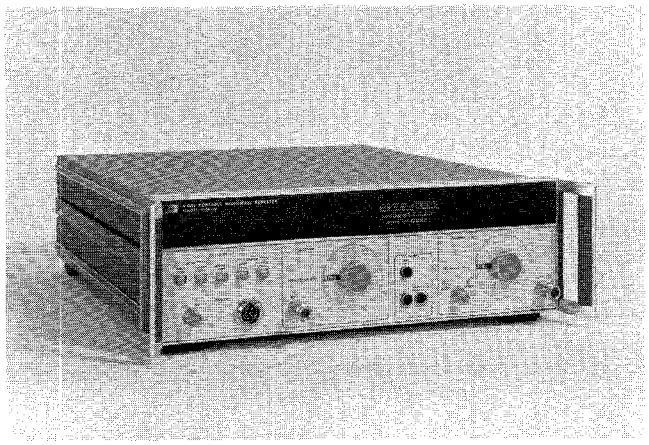

Fig. 2. 4 GHz Portable microwave repeater

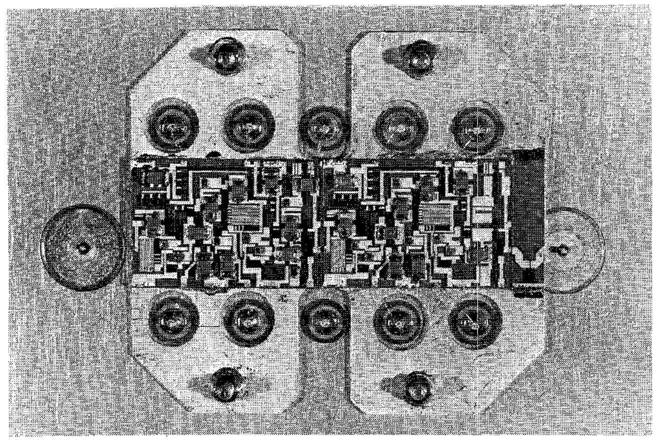

Fig. 4. Receiver 70 MHz AGC amplifier

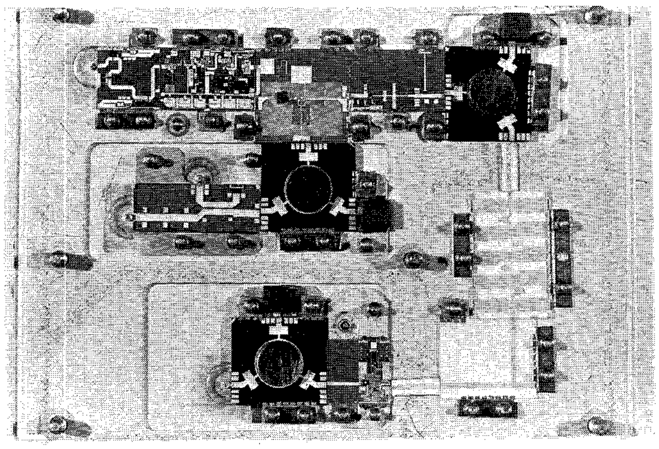

Fig. 3. 4 GHz Down converter

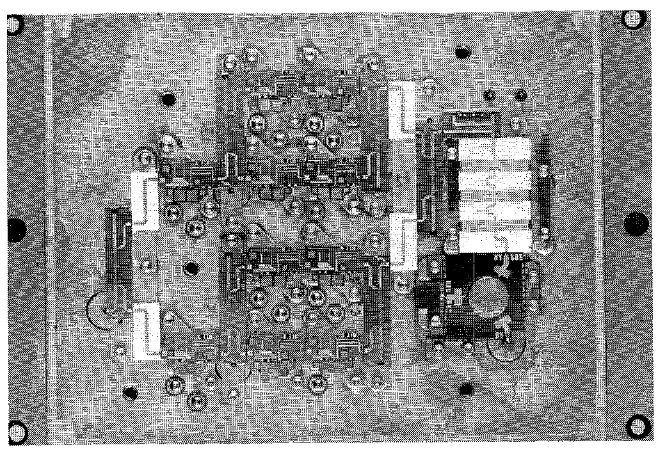

Fig. 5. 4 GHz Power amplifier