INTEGRATED MMIC AND MIC COMPONENTS FOR MULTICHANNEL Ka-BAND RECEIVERS*

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ABSTRACT

Integrated circuit (IC) modules have been developed for a multichannel Ka-band receiver. The modules include a MMIC-compatible mixer/IF amplifier and a MIC LO-distribution network. Four mixer/IF modules have been integrated with the LO network and other components to form a multichannel receiver prototype. This work is an important step toward the realization of a new generation of compact low-cost receivers for airborne and ground-based applications.

SUMMARY

MMIC-compatible and MIC modules have been developed for a new generation of Ka-band (26 to 40 GHz) multichannel low-cost receivers. The modules developed were: (1) an integrated quasimonolithic dc-biased low-loss mixer with a two-stage 2 to 6 GHz FET amplifier and (2) a MIC LO-distribution network. Four mixer/IF modules have been integrated with the LO network and other components to form a multichannel receiver prototype.

Figure 1 shows the mixer, which was designed and tested prior to integration with the IF amplifier. To minimize the development turnaround time, quasimonolithic construction was utilized, wherein beam-lead diodes are bonded to a GaAs chip containing monolithic lumped and distributed elements. For low-noise wide-band operation, the mixer incorporates low-parasitic GaAs in-house devices [1]. As in a related design [2], the IF output circuit is an RF/LO band-reject filter. (Relative to the conventional low-pass approach, the band-reject filter avoids the re-entry problems associated with multioctave microwave/mm-wave applications.)

Mixer measurements, conducted with only 2 mW of LO drive, showed that the conversion loss was low (6.9 ± 1.0 dB) across a 9-GHz range in Ka-band. Figure 2 shows that a wide range of LO drive levels can be used, with suitable dc bias. With this low-drive capability, a single LO can provide the power for all the mixers in a multichannel receiver, thereby minimizing the cost and size of the system.

While the mixer development was in progress, a quasimonolithic FET IF amplifier was designed and tested. The single-stage prototype has a noise figure of 3.2 ± 0.1 dB and a gain of 8.9 ± 0.3 dB across the design band of 2 to 6 GHz. The design, which utilizes an MGFC 1402 device, can be tailored to multistage amplifiers by optimizing the bias conditions to favor either noise figure or output power.

After the above development was completed, the mixer chip and a two-stage IF amplifier were integrated in a single housing (Figure 3). A split-block multichamber approach was utilized to assure single-mode resonance-free operation. The RF input is a probe transition [3] to standard WR-28 waveguide, whereas the LO and RF ports are coax (Type K) connectors.

Figure 4 is a plot of the noise figure of the mixer/IF module, across the 4-GHz design band, with mixer bias as a parameter. As shown, the noise figure is typically 9.5 dB, which is more than adequate for multichannel receiver applications. (A lower noise figure could be obtained with an input RF amplifier, but only at the expense of dynamic range and production cost.) Additional measurements of the module show a typical RF/IF gain of 10 dB and a 1-dB compression point of 0 dBm, referenced at the input.

The other module, developed expressly for the receiver program, is the LO-distribution network, which is shown in Figure 5. To further reduce the development time, alumina-substrate MIC construction was utilized for this network. (Since the dielectric constant of alumina is not far from that of GaAs, the network can be easily scaled for future all-MMIC applications.) The MIC module integrates a four-way power divider, a low-loss dc block, and a 7-dB input pad. (The pad assures good LO stability, without the cost and size limitations associated with a ferrite isolator.)

Tests show that the LO-network has a coupling of 15 ± 2 dB, as measured from the input port to each of the four outputs. This result is in reasonable agreement with the expected coupling of 14 dB. Since the network is designed to interface with a high-power (+21 dBm) Gunn oscillator, adequate drive (4 to 8 dBm) will be available in each of the four receiver channels. The measured SWR of the LO network is 1.8, or better, at each of the input/output ports.

After constructing four mixer/IF modules and integrating them with the LO-distribution and other components, a multichannel receiver was assembled and tested. Figure 6 shows the front-end receiver components, mounted on a plate measuring 8 in. by 8 in. In addition to the previously described components, the front end includes preselectors, horn antennas (three azimuth and one zenith-directed), and a lumped-element Gunn LO [4].

Measurements of the receiver confirm that the system objectives have been achieved. In particular, the system tests show high sensitivity, wide dynamic range, and the ability to accurately measure the relative amplitude among channels. By using MMIC-compatible front-end components in key locations, the feasibility of low-cost production has been demonstrated. With future work, it should be possible to achieve a higher level of MMIC integration, thereby paving the way for a new generation of compact receivers for airborne and ground-based applications.

ACKNOWLEDGMENTS

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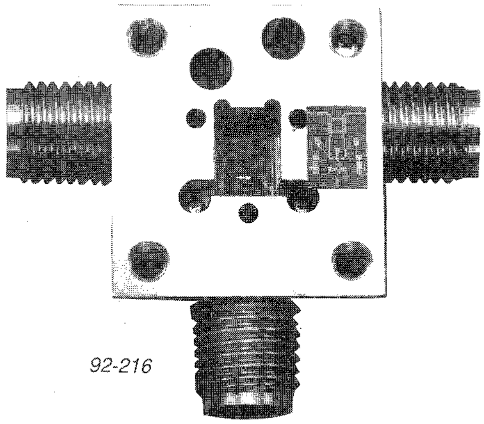

Figure 1. Quasimonolithic Ka-Band Mixer in Test Housing with Duplicate GaAs Chip

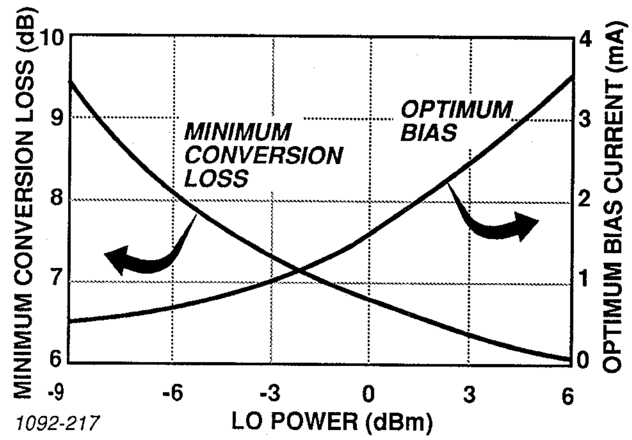

Figure 2. Minimum Conversion Loss and Optimum Bias vs. LO Power Level

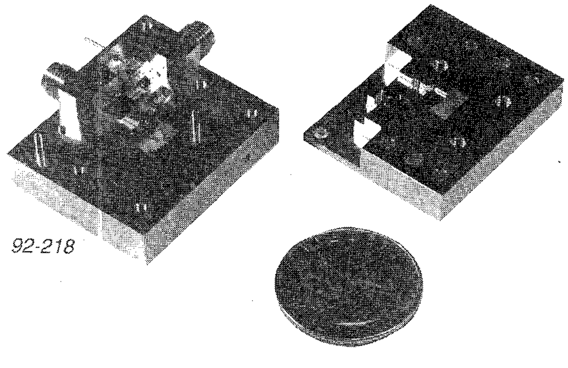

Figure 3. Integrated Mixer/IF Amplifier Module

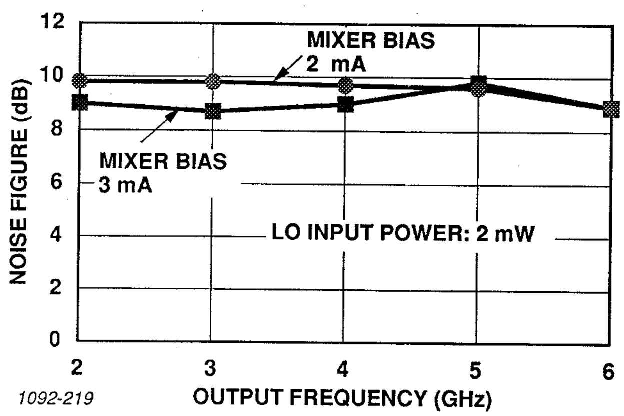

Figure 4. Measured Noise Figure of MMIC Module

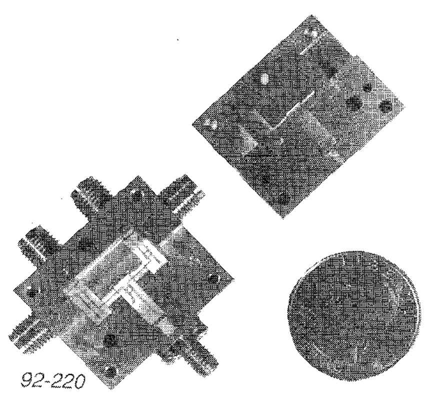

Figure 5. Ka-Band MIC LO Distribution Network

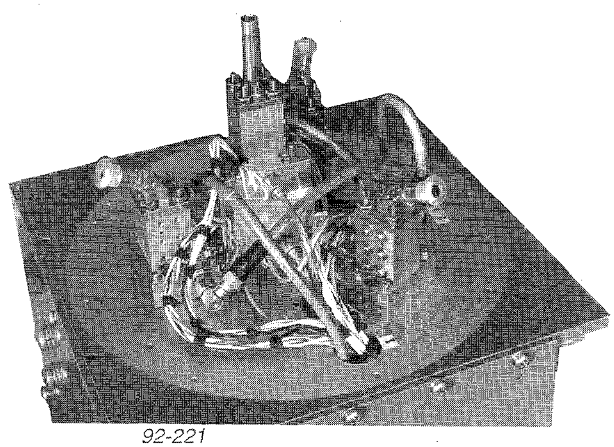

Figure 6. MMIC and MIC Modules Integrated into the Receiver System