BROADBAND INTEGRATED UP AND DOWN CONVERTERS

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Abstract

In a 1.6 cubic inch volume, each of these units combines an up converter, down converter, LO power divider and numerous filters. Utilizing both upper and lower frequency passbands, these two units provide nearly continuous coverage of the 5.9 to 16.5 GHz range with combined down conversion and up conversion loss of 14 to 18 dB.

Summary

The design philosophy for these dual converters was to achieve wideband operation by using single ended mixing in conjunction with wideband filters, since it is far easier to make wideband filters in microstrip than wideband hybrids. Also, LO noise cancellation was not required due to the high IF (2-4 GHz), eliminating the need for a balanced mixer approach.

The dual converter is packaged, as shown in Fig. 1, in a gold-plated aluminum casting fitted with an evacuation tube for subsequent hermetic sealing. A circuit diagram showing the various components comprising the converter is shown in Fig. 2.

The center compartment houses a directional coupler which is used to split the LO power (+19 dBm) between the up and down converters, the majority of which is fed to the up converter. This coupler is of the "wiggly line" type[1] and operates with a directivity greater than 20 dB over the 8-12 GHz range. Its nominal coupling value is 10 dB $\pm$ 0.5 dB over the same frequency range. After splitting the LO signal, LO injection to the individual converters is accomplished using a resonant single ring diplexer. Over an LO bandwidth of approximately 500 MHz, these diplexers exhibit an insertion loss less than 2 dB to the LO.

The RF path to each diode contains a band pass filter which acts as a pseudo high pass filter to prevent IF from escaping out the RF port. In addition, the upconverter substrate, shown on the left of Fig. 1, contains a band rejection filter to reduce LO leakage out the RF port. This filter was computer optimized using a microwave nodal analysis and optimization routine and consists of two 100Ω stubs $\lambda_{LO}/2$ long at the LO center frequency spaced $\lambda_{LO}/4$ apart. LO-RF isolation for the upconverter is greater than 35 dB.

A GaAs Schottky barrier diode is mounted at the end of the bandpass filter and a wire is bonded from the diode to the low pass filter in the IF output line. The low pass filter for the up converter is a 5 section filter and provides 40 dB LO-IF isolation. The low pass filter for the down converter is a nine section filter, three sections of which are separated from the remaining six by a partition, which allows an LO-IF isolation in excess of 80 dB. Bias for each diode is provided by a $\lambda/4$ high impedance line connected to the low pass filter.

The GaAs diodes used are fabricated on a 1 micron thick epitaxial layer. The down converter diode has a 5 micron junction diameter while the up converter diode has a 10 micron junction diameter since it must handle input signal levels as high as +10 dBm. In each case the junction is surrounded by a contact overlay 20 microns in diameter.

Two units are used to span the 5.9 to 16.5 GHz range. The first covers the 5.9-8.3 GHz and the 11.9-14.3 GHz bands with an LO = 10.1 $\pm$ .2 GHz, while the second covers the 7.9-10.5 GHz and the 13.9-16.5 GHz with an LO = 12.2 $\pm$ .3 GHz.

Several of the more important electrical parameters for the lower band unit are illustrated in Figs. 3 and 4. Fig. 3 is a plot of combined down conversion-up conversion loss measured by connecting the two IF ports together with a short length of semi-rigid coaxial cable. This composite loss typically varies between 14 and 18 dB. Fig. 4 plots the important isolations and the VSWR's for the various bands of interest. Of particular importance is the upconverter LO-RF isolation which exceeds 35 dB, the downconverter LO-IF isolation which exceeds 80 dB, and the IF-IF isolation which exceeds 55 dB.

The upconverter must frequently operate in a high input power mode where the IF input power can be as high as +10 dBm. Under such large signal up convert conditions, all spurious signals including harmonics of the IF input signal are at least 10 dB below the desired upconverted signal.

Characteristics of the high band unit are similar with a combined down conversion-up conversion loss of typically 18 dB.

Additional measured data on both the large and small signal performance of each of these converter assemblies will be presented at the conference.

References

1. A. Podell, "A High Directivity Microstrip Coupler Technique," 1970 G-MTT International Symposium Digest, May 1970, pp. 33-36.

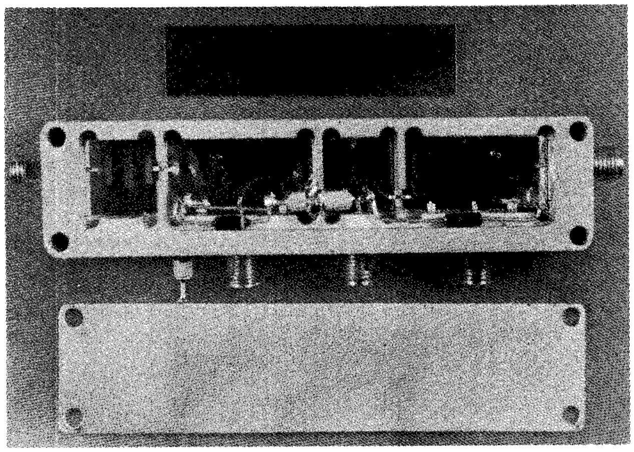

FIG. 1: Photograph of Dual Converter

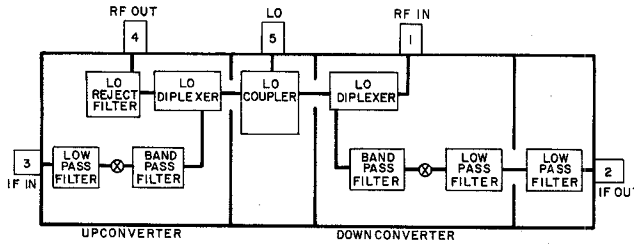

FIG. 2: Circuit Diagram of Dual Converter (Bias circuit omitted for clarity)

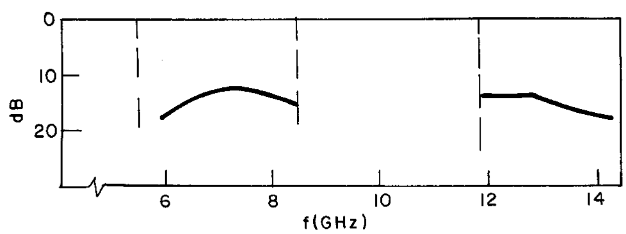

FIG. 3: Composite Conversion Loss

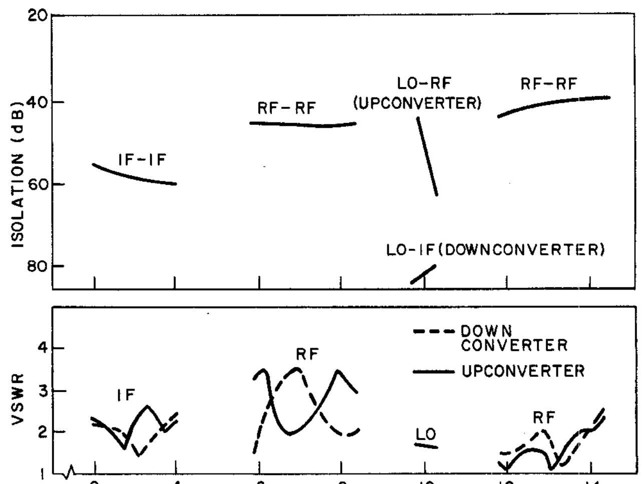

FIG. 4: Isolation and VSWR vs. Frequency