

HIGH ISOLATION MIC Ka BAND UPCONVERTER  
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**Abstract**

A mixer is a critical element in almost every microwave communication system. The two most important parameters of an up-converter mixer are the LO to RF isolation and its P<sub>1</sub>dB.

In many cases the LO frequency is too close to or even overlapping the RF frequency. In that case the rejection of the LO signal by a filter is difficult or sometimes even impossible. The LO signal could possibly saturate the following power amplifiers and /or be too high at the antenna port. A high LO to RF isolation mixer can solve this problem. An up-converter with a high dynamic range or high 1dB compression point can simplify the amplifier chain by reducing the number of stages.

There are a few techniques one can use to design an up-converter with high LO to RF isolation. The solutions can be system solutions such as the multi-order cancellation technology [2] [1], or a feed-forward up-converter solution. High LO/RF isolation can also be realized by designing a special mixer such as balanced, double balanced mixers or fin- line mixers [1], [4]. Most of the solutions however are not fully compatible with the microstrip technology, are complicated to implement and add high cost to the total solution. A sub-harmonic mixer is another option to achieve high isolation, but it has about 10 dB lower P<sub>1</sub>dB when compared with the fundamental mixer.

In order to develop a manufacturable product and to achieve enough margin over the temperature range, we considered developing a “power combined” up-converter mixer [1] for 40 GHz range, which is simple, inexpensive, and provides both high LO to RF isolation and high P<sub>1</sub>dB.

In the paper we present a Ka band up-converter mixer with LO to RF isolation of better than 50dB and 1dB compression of 3dBm at the RF port over a bandwidth of 2 GHz. The up-converter was implemented using thin film alumina technology.

**Block Diagram**

The block diagram of the up-converter is shown in fig. 1. The up-converter mixer is a kind of high level mixer consisting of two hybrid “power combined” mixers implemented with thin film alumina technology. It consists of two identical ring balanced mixers. The LO signal comes with 90° phase difference to the mixers and the IF signal is supplied with a 180° phase

difference. The RF signals from the two balanced mixers are added at the output port [4], while the LO signal is reduced by the two  $90^\circ$  branch line splitters. The more identical the two mixers are, and the closer to  $90^\circ$  phase difference the branch lines are, the more the LO cancellation will be improved. Inaccuracy of the IF  $180^\circ$  splitter has no real influence on the LO to RF isolation, but it does on the conversion loss. Using this method, the LO to RF isolation is improved by more than 20dB compared to using only a single balance mixer. The solution presented here can obtain more than 40dB of isolation using conventional balance mixers.

Utilizing balance mixers with LO to RF isolation of 30 dB, as described in the following section, and properly channelizing the circuit achieved more than 50 dB of LO to RF isolation in a bandwidth of 2GHz at the Ka band.

#### **The Balanced Mixer**

The up-converter consists of two identical microstrip balanced mixers. The balance mixer, which has a rat race configuration, was designed with HP MDS and fabricated on 5 mils ceramic substrate as shown in fig. 2. The beam lead schottky diodes are connected in between ports 1 and 3 of the rat race circuit. A radial stub creates an RF short in between the two diodes, and DC and IF returns are implemented with via holes at the other ports of the diodes. The LO signal is divided and arrived with opposite phase to the diodes and then alternately operates the two diodes. The IF signals from the two diodes are combined in phase in the junction between the two diodes. A balance mixer using this configuration can achieve a bandwidth of about 5 percent.

The schottky diodes are matched to reduce the reflection signals and to improve the isolation between the LO to RF and to optimize the conversion loss.

The balance mixer performances are shown in fig.3. A LO to RF isolation of more than 28dB was obtained in the frequency range of 38 to 40 GHz. The conversion loss is about 5dB, and the 1dB compression at the RF port is more than 0 dBm.

#### **$90^\circ/180^\circ$ Splitters**

A branch line is simple  $90^\circ$  power divider with a bandwidth of more than 5 percent. Two sections of branch line for each of the hybrid dividers gives wider bandwidth. The branch lines were implemented by microstrip design and fabricated on 5 mils ceramic substrate. The overall mixer performance at Ka band depends on the alumina substrate thickness due to the dispersion phenomena and deteriorates dramatically using thicker substrates.

Both the loss of less than  $-0.5\text{dB}$  and the  $90^\circ$  phase difference are obtained in bandwidth of  $2\text{GHz}$ . In order to ascertain the splitters' contributions to the LO to RF isolation, we combined and tested the two branch lines back to back. The isolation of better than  $22\text{ dB}$  was measured.

In order to get an up-converter mixer with a wide band of IF frequency, a  $180^\circ$  splitter was designed as appears in fig. 4. The balloon was implemented using  $50\Omega$  TWISTITE wires MWS #T-2361121-12 rolled on PHENOLYC core. The phase difference of  $180^\circ$  achieved between  $2$  to  $3\text{ GHz}$ .

### Experimental Results and Conclusion

A novel Ka band up-converter with high LO to RF isolation has been presented in the paper. The up-converter consists of two identical balance mixers that are connected in the configuration shown in fig. 1.

Using that method a LO to RF isolation of better than  $50\text{dB}$  was obtained in a bandwidth of  $1\text{GHz}$  at frequency of  $40\text{GHz}$ . As was expected, the output  $1\text{dB}$  compression point of the up-converter was about three dB more than that of only one balanced mixer.  $3\text{dBm}$  of  $1\text{dB}$  compression was achieved at the RF. The experimental results and the theoretical simulation results appear in fig. 5.

### Reference

- [1] Stephen A. Maas "Microwave Mixers" Artech House. Inc.
- [2] Frank X. L. and Greg C. "Multi-Order Cancellation Technology" Microwave Journal October 1997 PP. 84-91.
- [3] J. Helszajn "Passive and Active Microwave Circuits" Chapter 13, John Wiley & Sons
- [4] James B. Tsui "Microwave Receiver and Related Components" Chapter 14. Peninsula Publishing

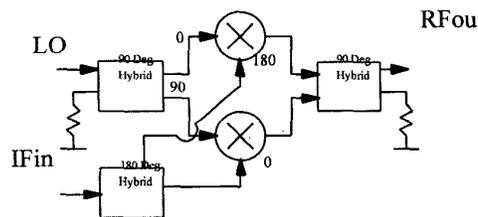


Fig. 1 The block diagram of the up-converter.

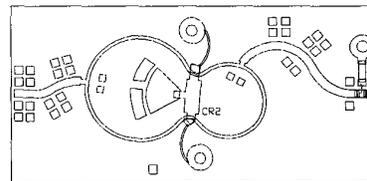


Fig. 2 The ratrace balanced mixer configuration

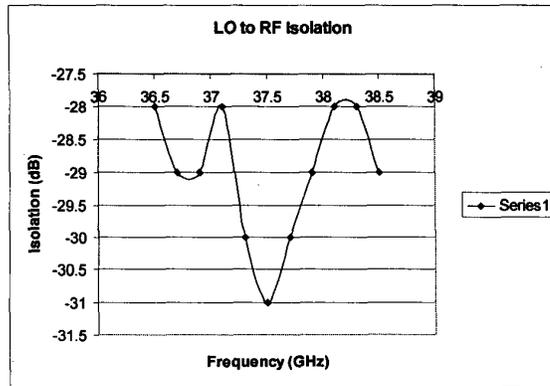


Fig. 3 The balanced-mixer LO to RF isolation.

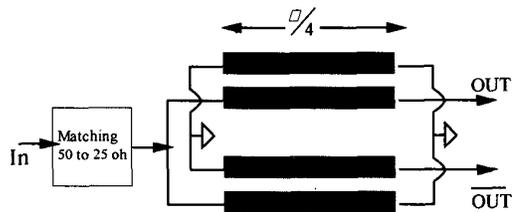


Fig. 4 180° splitter for the IF.

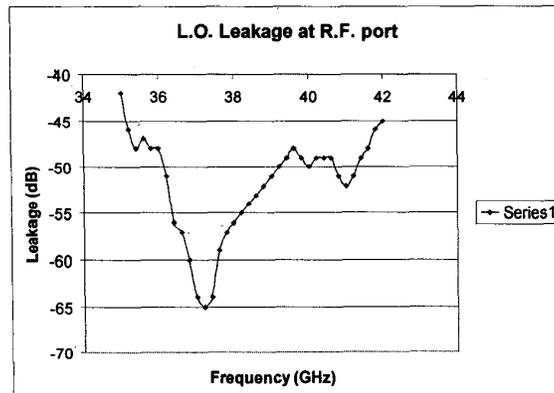


Fig. 5 The up-converter LO to RF isolation results.