A Low Cost, Surface Mount X-Band Mixer

Application Note AN 1052

Introduction

Historically, low cost has not been a factor in microwave receivers. Production volume has been low so the savings associated with high volume production have not been investigated.

Recent development of commercial microwave communication systems has stimulated development of low cost techniques for these frequencies. Surface mount components for balanced mixers and multipliers are appropriate for these systems.

Balanced Mixer

A balanced mixer requires a well matched pair of diodes with capacitance less than a quarter picofarad. The Avago Technologies HSMS-8202 is a low cost SOT-23 package containing two matched Schottky mixer diodes with each diode capacitance less than 0.26 pF. Although many designers consider the SOT-23 package unsuitable for X-band, the parasitics are easily tuned out. Figure 1 is a sketch of the mixer circuit on 10-mil Duroid. The branch line coupler distributes the local oscillator and signal to the diodes. The diode impedance is matched to the 50 Ω coupler by a shunt open line spaced from the diode by a 70 Ω line. This line impedance was chosen for the 18-mil line width to match the SOT-23 tabs.

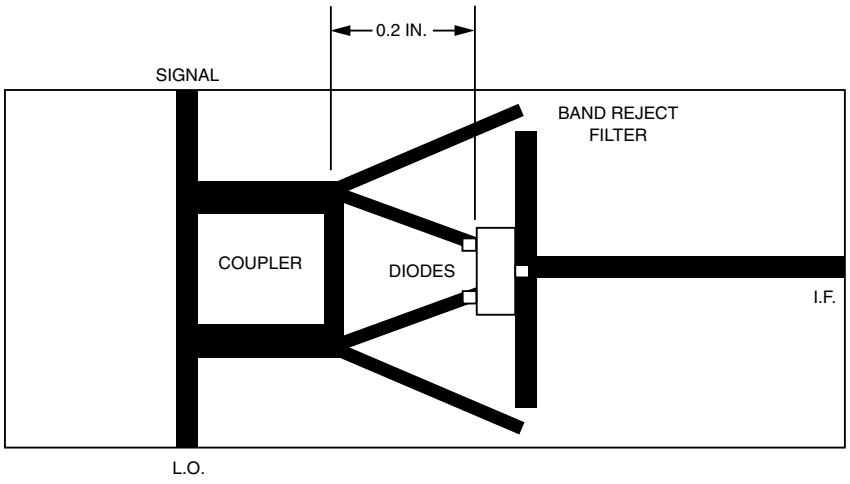

Figure 1. Mixer circuit

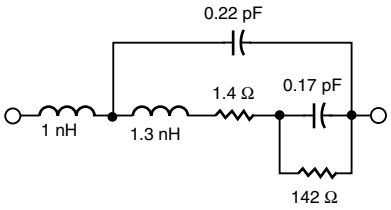

Figure 2. Diode equivalent circuit

The diode equivalent circuit is shown in Figure 2. At 12 GHz S11 is 0.486, 41.8° for 2.5 mA rectified current. This corresponds to 0.57-j0.45 admittance normalized to 70 Ω. Figure 3 shows how a 0.273 wavelength series line transforms this admittance (A) to the 1.4 (50 Ω) conductance circle (B). The susceptance is 0.96. The 70 Ω shunt open line provides the 0.96 negative susceptance needed to complete the match (C). The electrical length is:

$$\tan(-0.96) = 136.2°$$

The mixer was measured with local oscillator frequency 10.75 GHz and signal swept from 11.70 GHz to 12.35 GHz. The conversion loss (Figure 4) is about 8.5 dB up to 12.1 GHz and increases about 2 dB at the highest frequency. Before installing the diodes the circuit was measured for loss between the LO and signal ports. Figure 5 shows the loss exceeding 1.2 dB at 12.1 GHz and reaching 2 dB at 12.35 GHz. The high frequency performance can be improved by modifying the coupler design.

Figure 6 shows the effect of local oscillator power on conversion loss. The range of loss is less than 0.5 dB from 6 to 11.5 dBm.

This circuit on 10-mil Duroid measures 0.5 inch by 1.2 inches. Similar performance was obtained with a circuit on a low cost soft substrate, Avago Technologies HT-2. This material has superior thermal and mechanical properties compared to conventional FR-4. Dielectric constant is better controlled and somewhat lower in value. Cost of this mixer would be less than a dollar.

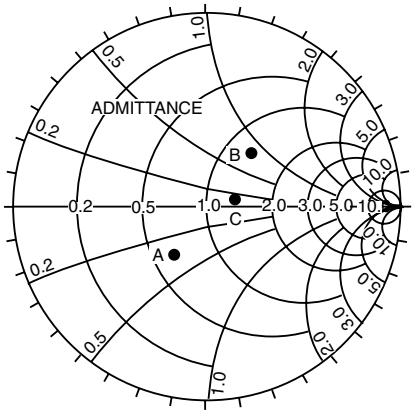

Figure 3. Diode matching

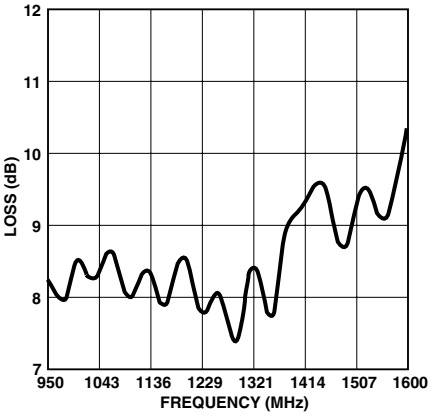

Figure 4. Conversion loss

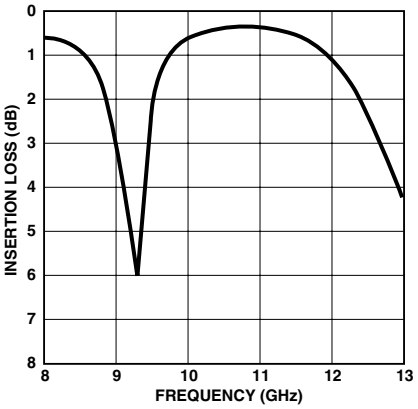

Figure 5. LO to Signal loss without diodes

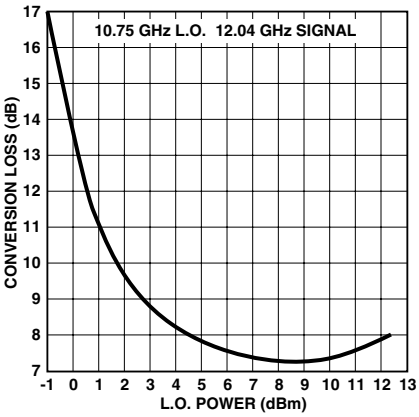

Figure 6. Effects of LO power level

For product information and a complete list of distributors, please go to our web site: **www.avagotech.com**

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