HEWLETT PACKARD

APPLICATION NOTE 997

A 2 GHz Balanced Mixer Using SOT-23 Surface Mount Schottky Diodes

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INTRODUCTION

A series of general purpose RF Schottky diodes has been introduced in the SOT-23 package. One of these diodes, the HSMS-2822, is a matched series pair, an ideal configuration for a balanced mixer. This note describes the procedure for designing the impedance matching circuit for a 2 GHz mixer using the HSMS-2822. A conversion loss of 6.6 dB was achieved.

NOVEL IMPEDANCE MATCHING TECHNIQUE

The usual procedure for impedance matching begins with a measurement of the diode impedance. A diode model is often designed so that the calculated model impedance matches the measured impedance over a range of frequencies. A matching circuit is then designed to provide the conjugate impedance to the diode. In this application a novel, more experimental technique was used. The mixer was first assembled with a commercial 3 dB, 90 degree hybrid coupler and the diode pair. No tuning was used between the diode and the hybrid. Instead, a slide screw tuner was placed after the diode. The tuner was followed by a low pass filter to terminate the circuit at 2 GHz while passing the IF output to the receiver. This technique uses only one impedance matching circuit on the IF side of the diodes rather than the conventional two matching circuits (one for each diode) on the RF input side of the diodes.

Figure 1 shows the HSMS-2822 mounted on a 0.010 inch thick Duroid circuit board. The microstrip circuit has SMA connectors for the local oscillator, RF input, and IF output.

Figure 2 shows the test set up.

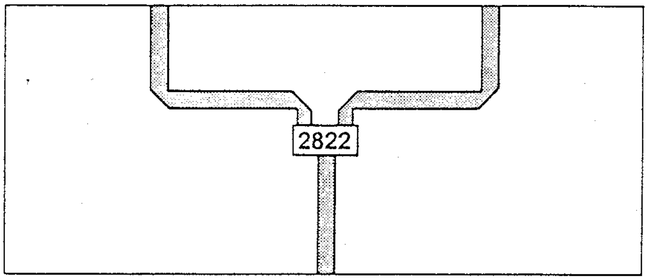

Figure 1. Test Circuit.

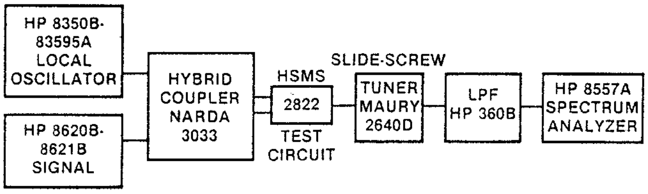

Figure 2. Test Set-up.

MATCHING CIRCUIT DESIGN

After the tuner was adjusted for best performance at 2 GHz, the impedance of the tuner and low pass filter was measured on a network analyzer at 2 GHz. The value of S11 was unity magnitude −102.3 degrees angle. This angle corresponds to the face of the SMA connector at the IF output. To convert to the edge of the circuit board, the electrical length of the connector was measured on the network analyzer to be 25.4 degrees. Subtracting 50.8 degrees (double the 25.4 degree length since S11 is a reflection measurement) gives −153.1 degrees for S11 angle at the edge of the circuit.

To move S11 to the diode a correction is needed for the 0.185 inch of 50 ohm line on Duroid between the diode and the edge of the circuit board. This corresponds to 15.5 degrees at 2 GHz so we must subtract 31.0 degrees (double 15.5 degrees) from S11 to give 175.9 degrees. This corresponds to a normalized shunt substance of nearly 30. See point A in Figure 3.

In order to keep the circuit small, the matching shunt line which duplicates the tuner impedance should be located close to the diode. However, it is also desirable to use elements that are not sensitive to frequency. If the tuning element is an open line

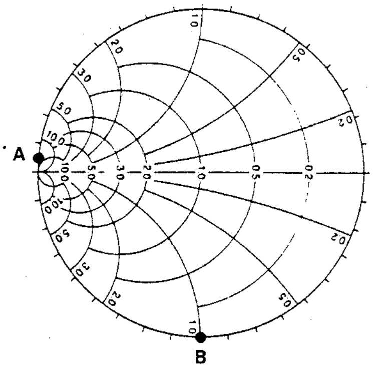

Figure 3. Shunt Tuning.

located near the diode, the line length will be close to 90 degrees. For example, a 50 ohm open line 92 degrees long provides the required susceptance. This is a very frequency sensitive tuning element. A shorter line would be less sensitive. By moving away from the diode 0.13 wavelength, the required normalized susceptance becomes +1.0 (point B in Figure 3). This is provided by an open line with 100 ohms characteristic impedance and 63.4 degrees length. The electrical length is calculated from the equation for the admittance of an open circuit transmission line:

$$0.02 = \frac{\tan\theta}{100}$$

Figure 4 shows this open line properly spaced from the diodes. The other longer open line is a quarter wave line designed to isolate the IF output circuit from the 2 GHz tuning circuit. This line is spaced a quarter wave from the tuning line and presents an open circuit at that plane. The Z of this line is not critical and was chosen to be 100 ohm for a convenient layout.

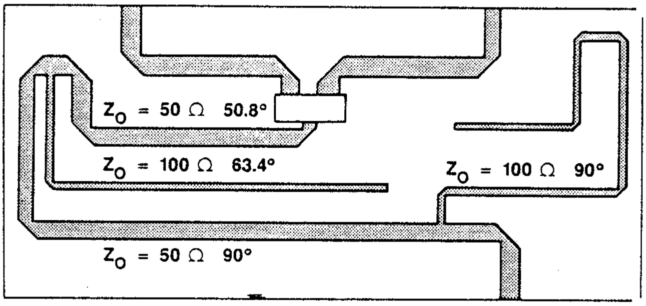

Figure 4. Tuned Mixer.

Figure 5 shows the final mixer containing a microstrip branch-line coupler.

At 2.1 GHz the conversion loss is 6.6 dB. At 8 dB conversion loss the bandwidth is 14%. The bandwidth is shown in Figure 6. The conversion loss varies with local oscillator power as shown in Figure 7.

SUMMARY

The HSMS-2822 surface mount diode pair is used in a 2 GHz balanced mixer. The conversion loss is 6.6 dB with 10 milliwatts local oscillator power. The diode impedance matching circuit is located between the diodes and the IF.

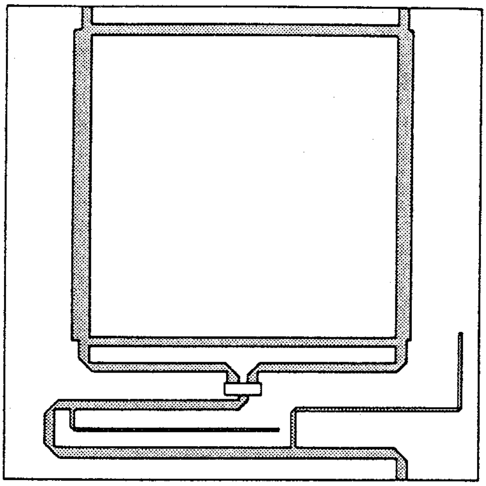

Figure 5. Complete Mixer.

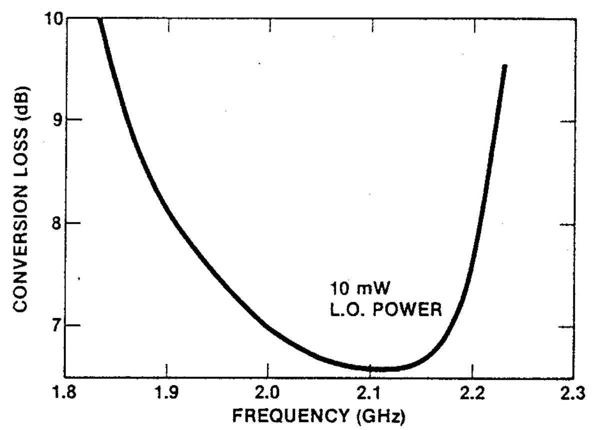

Figure 6. Conversion Loss Bandwidth.

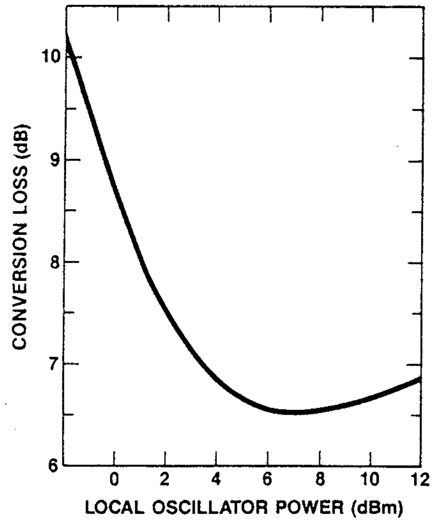

Figure 7. Effect of Local Oscillator Power on Conversion Loss.

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