FET vs. Diode-ring Demodulator Performance Comparison
LIGO-T0900485-v3
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7 October, 2009

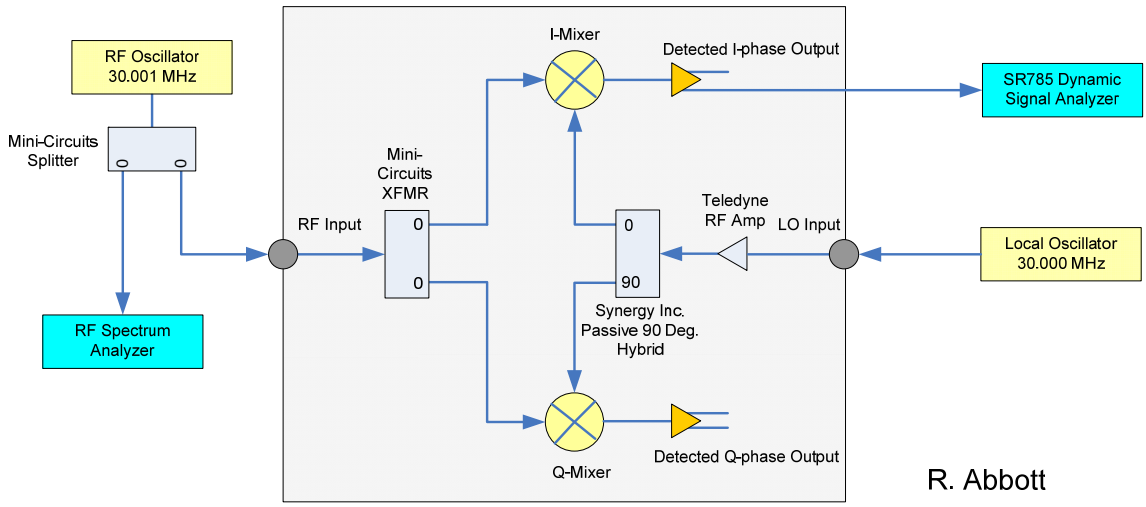
1. Overview

A side by side test has been performed to compare the noise performance of a diode-ring based I&Q demodulator cell against a FET based solution of similar architecture. In each case, the input referred noise is calculated based on the measured down-conversion gain, and the measured output noise spectral density.

2. Test Setup

As shown in figure 1, two signals are heterodyned together in the device under test. The resultant beat note is measured on an audio analyzer. The incident RF is measured by an RF signal analyzer.

Figure 1
Noise Test Setup for FET Mixer vs. Diode Ring Mixer



3. Results

As shown in table 1, relative to the theoretical thermal noise floor (-174dBm/Hz), the FET demodulator has an input referred noise floor 4.32dB higher than the diode ring. Care was taken to keep the test setup identical in order to preserve the validity of the results.

Table 1

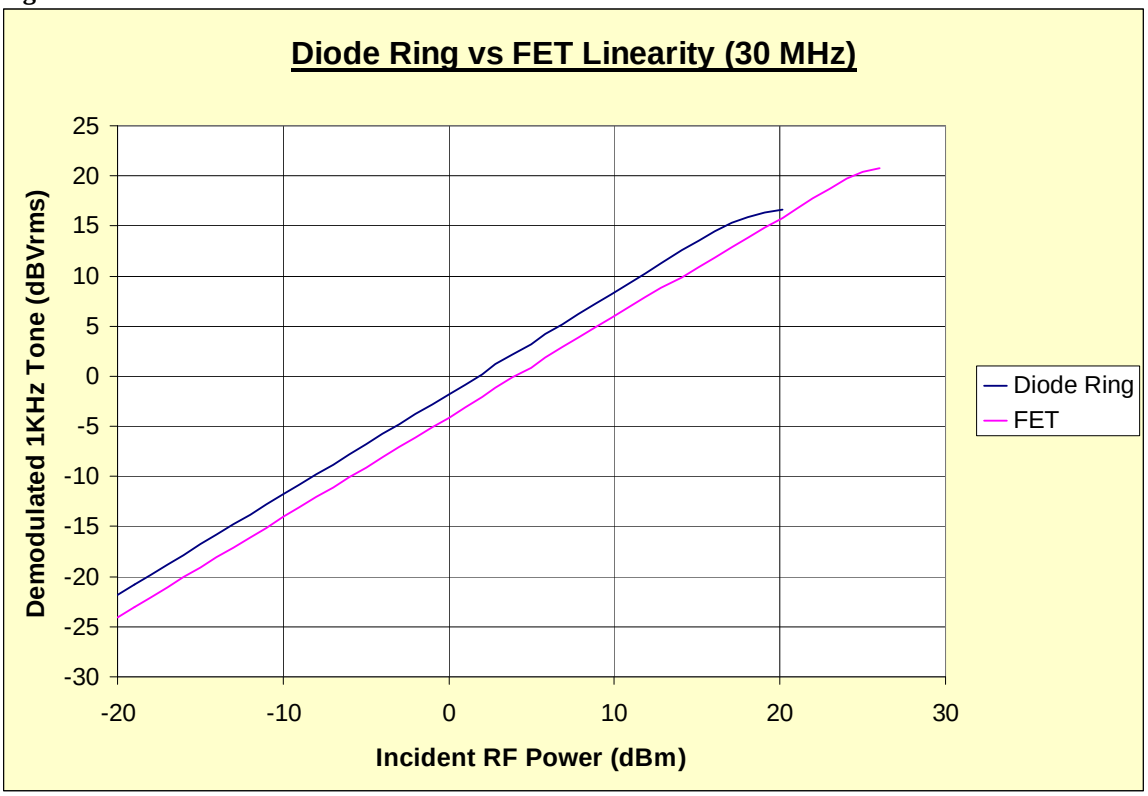
Device Under Test (DUT)	**FET Ring**	**Diode Ring**
RF Test Frequency	30.001MHz	30.001MHz
LO Test Frequency	30.000MHz	30.000MHz
Incident RF Level	-19.33dBm	-19.33dBm
LO Level at Hybrid Input	20dBm (1)	20dBm
Detected 1kHz Beat-note on SR785	-23.129dBVrms	-20.84dBVrms
dB Gain Audio-out/RF-in (*calculated*)	9.18dB	11.47dB
SR785 Noise Floor (50 ohms termination)	-165dBVrms/rtHz	-165dBVrms/rtHz
Measured DUT Output Noise, RF-input Terminated in 50 ohms (@1kHz on SR785)	-152dBVrms/rtHz	-154dBVrms/rtHz
Voltage Noise Referred to RF-input (*calculated*)	-161.18dBVrms/rtHz	-165.5dBVrms/rtHz
RF Noise PSD Referred to RF-input (50 ohms, *calculated*)	**-148dBm/Hz**	**-152dBm/Hz**
dB Above 50 ohm Thermal Noise Floor (-174dBm/Hz, *calculated*)	25.83dB	21.51dB

(1) 20dBm at the hybrid input of the FET mixer results in 3.8vp-p at each LO pin of the FET quad pack. This means there is 7.6vp-p differential across the LO+ and LO- pins of the FET quad. The FET quad was transformer coupled with a center tapped secondary, 4:1 transformer. Each half of the center tapped secondary was terminated with a 100 ohm resistor.

4. Linearity Comparison

Although considerable time and effort went into an attempt to measure the two-tone, third order, intermodulation distortion of the two candidate demodulators, no reliable results have been obtained. Figure 2 shows the results of beating a 30.001 MHz LO with a 30 MHz RF signal, and plotting the demodulated 1 kHz beat-note as a function of incident RF power. There's nothing surprising here, the diode ring shows signs of compression before the FET quad. The barely observable compression of the FET quad is due to the post demodulation operational amplifier hitting the rails.

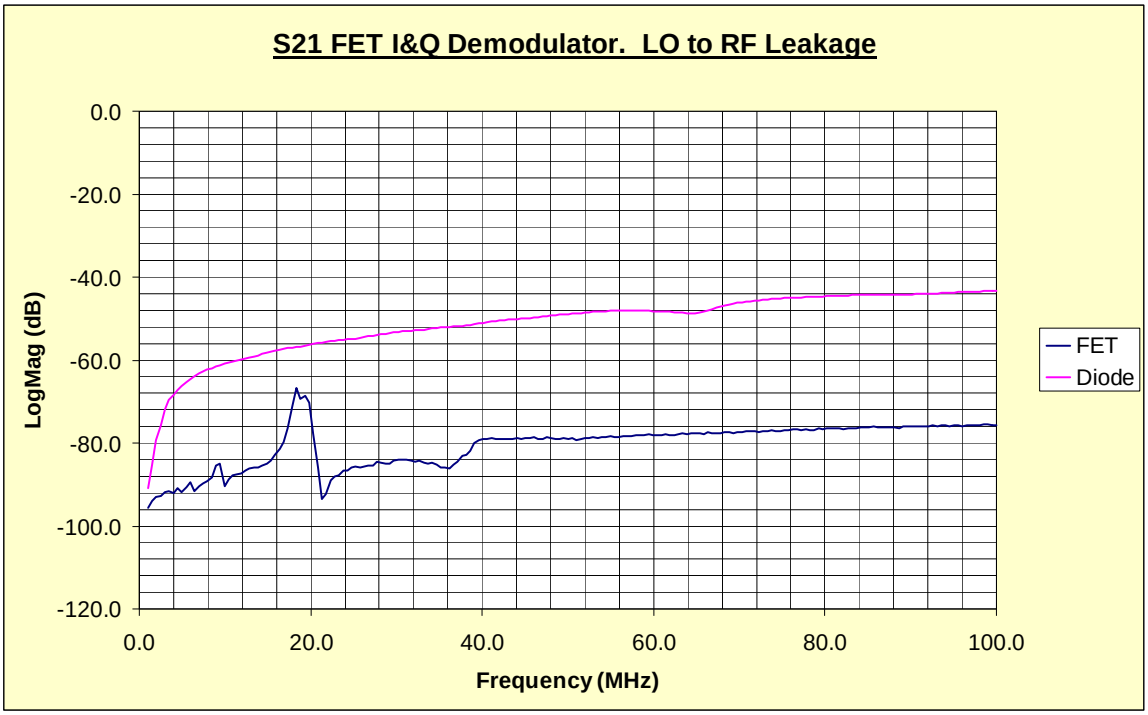
Figure 2



5. Local Oscillator to RF Port Leakage

Some reverse leakage of the energy present at the LO port of a mixer will always bleed through to the RF port. This is due to parasitic effects associated with the imperfect balance of real-world components. Figure 3 shows the FET ring mixer to be approximately 30dB better than the diode-ring mixer as measured over a range of frequencies from 1 to 100 MHz.

Figure 3



6. Mixer Conversion Loss

Underway