Keywords: lo, phase noise, vco, if, bandwidth, reference, pll

APPLICATION NOTE 1744

VCO Phase Noise Optimization for the MAX2309

Jan 09, 2003

Abstract: LO phase noise on the MAX2309 is improved at 100MHz. PLL bandwidth, reference noise, and VCO components are changed to allow ~-90dBc/Hz phase noise at a 10kHz offset. The on-chip VCO is set to operate at 200MHz, with a comparison frequency of 1MHz. Three sets of PLL components are installed and the performance is documented on spectral and phase noise plots for each rendition.

Additional Information:

- Wireless Product Line Page
- Quick View Data Sheet for the MAX2309
- Applications Technical Support

Click here for an overview of the wireless components used in a typical radio transceiver.

This application note describes a method to achieve local oscillator (LO) phase noise performance of nearly -90dBc/Hz (at 10kHz offset) using the MAX2309 I/Q demodulator. A complete 100MHz intermediate frequency (IF) design solution is offered including voltage controlled oscillator (VCO), loop filter components, and performance plots.

Objective

Optimize the MAX2309 evaluation kit for LO phase noise as measured at the LO buffer output.

Procedure

A standard MAX2309 evaluation kit was obtained and the VCO tank components were re-configured, allowing for oscillation at 200MHz (twice the IF Frequency) with K_{VCO} = 6.6MHz/V. Please see the MAX2309 evaluation kit schematic for reference designator locations. The component values are shown in **Table 1**.

Table 1. VCO Component Changes

Reference Designator	New Value (200MHz)	Part Number	Manufacturer
L5	82nH	0805CS-820XKBC	Coilcraft
C61	3.9pF	COG capacitor	Murata
C4, C6	27pF	COG capacitor	Murata
D3, D5	Varactor	SMV1763-079	Alpha-Industries

Loop Filter Design 1

The loop filter component values are shown in **Table 2**. This loop is designed for a unity gain frequency of 11.6kHz with

50° phase margin, and a 425µA charge pump current.

Table 2. Loop Filter #1

Reference Designator	Filter Value
C30	560pF
R23	5.1kΩ
C29	5.6nF
R10	0Ω
C31	Open

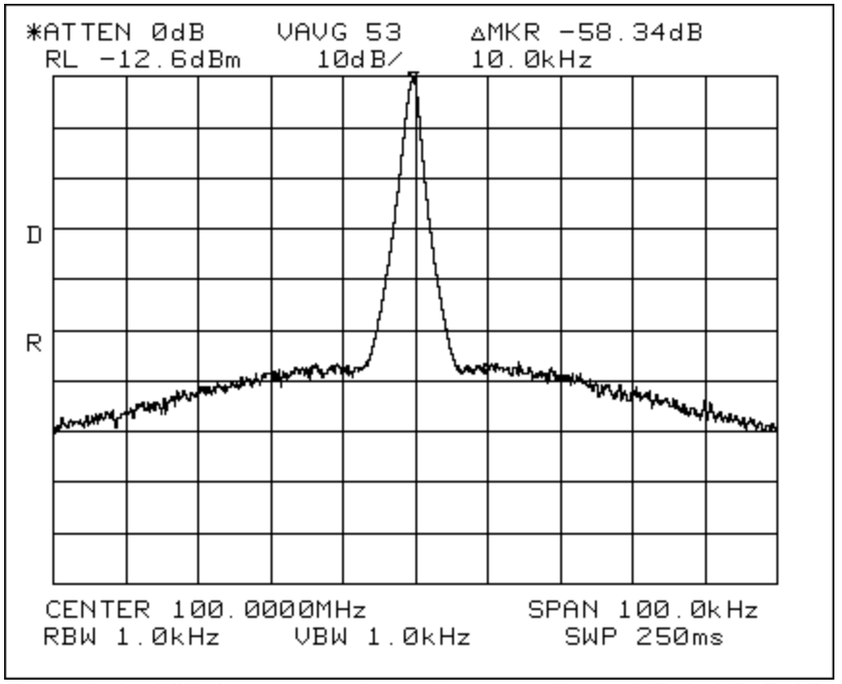

Figure 1. 100MHz LO signal at LO buffer output I_{CP} = 425µA, HP8561E.

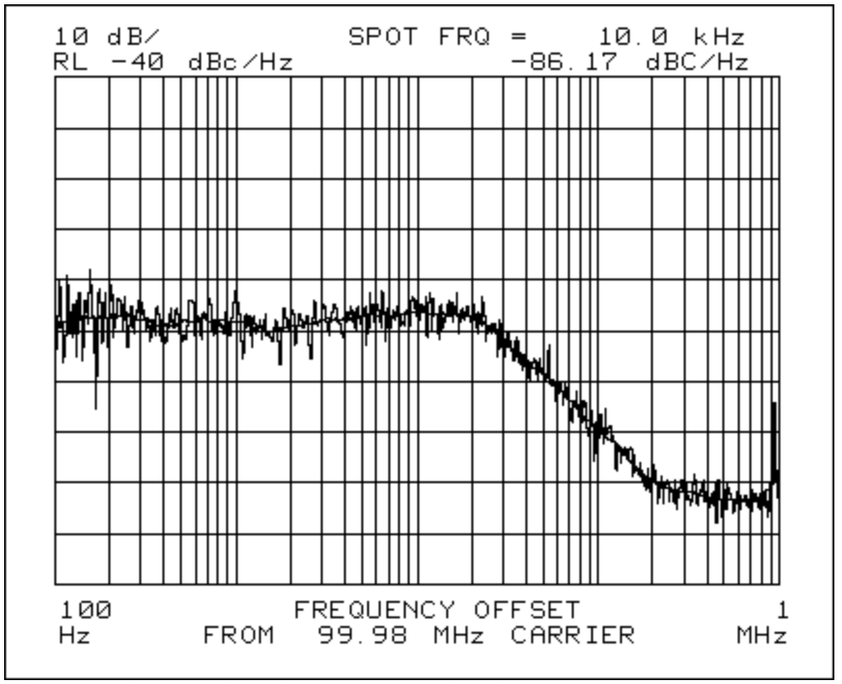

Figure 2. Phase noise of 100MHz LO signal, HP8561E.

Important Note: Originally phase noise was measured at approximately -80dBc/Hz, however it was determined that the 13MHz reference source possessed less than acceptable noise output itself. The source was changed to a KSS VC-TCXO-208C-13.0 and phase noise improved by approximately 6dB.

Table 3. Key Test Parameters

Parameter	Value	Units
V_{CC}	3.0	V
FIF	100	MHz
F_{REF}	13	MHz
F_{OSC}	200	MHz
F_{COMP}	1	MHz
K_{VCO}	6.6	MHz/V
Target Phase Noise at 10kHz	-90	dBc/Hz
T_A	+25	°C

Loop Filter Design 2

After measuring phase noise with the modified VCO and loop filter, a second loop filter was evaluated. This filter was designed for a narrower loop bandwidth with a 9kHz unity gain frequency, 53° phase margin, and 425µA charge pump current. The values are shown in **Table 4**.

Table 4. Loop Filter #2

Reference Designator	Filter Value
C30	1nF
R23	3.9kΩ

C29	10nF
R10	0Ω
C31	Open

The phase noise was measured and the results are shown in **Figure 3** and **Figure 4**.

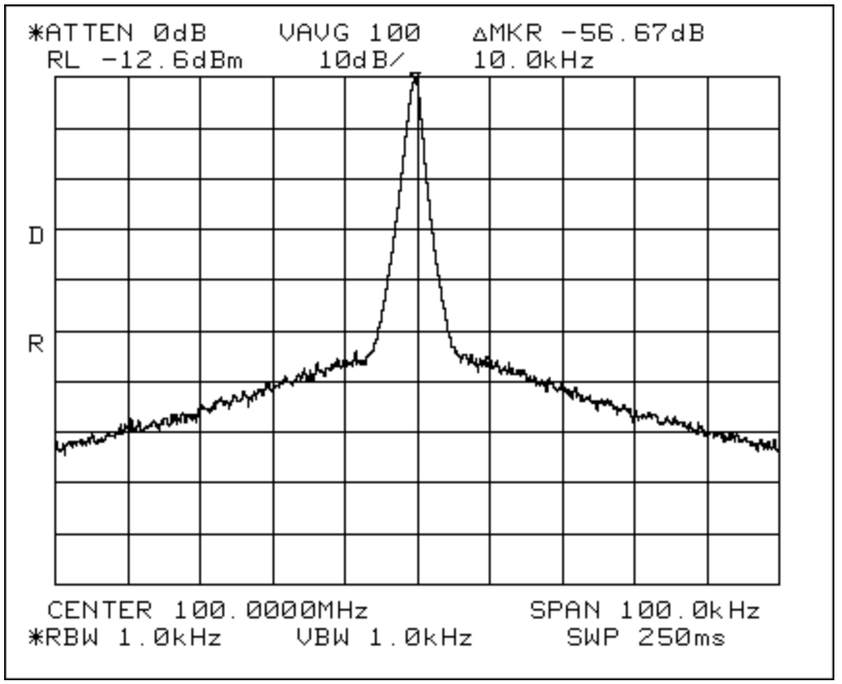

Figure 3. 100MHz LO signal at LO buffer output I_{CP} = 425µA, HP8561E.

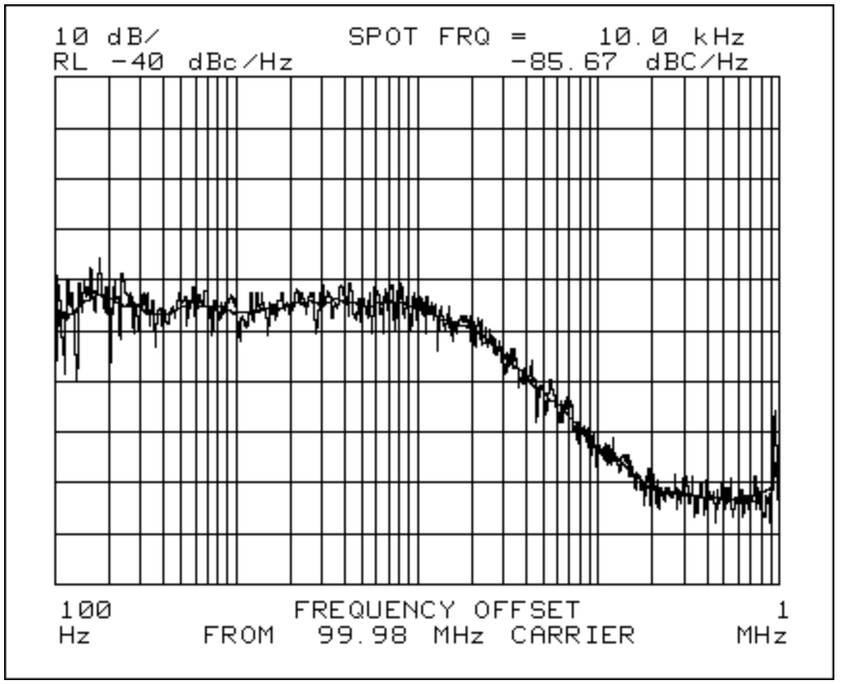

Figure 4. Phase noise of 100MHz LO signal, HP8561E.

Finally, a 210µA charge pump current was selected to further reduce the loop bandwidth. This resulted in much improved phase noise at 10kHz offset at the expense of tuning speed. This loop has a unity gain frequency of 5kHz and still has very good phase margin of 44°. The final results are shown in **Figure 5** and **Figure 6**.

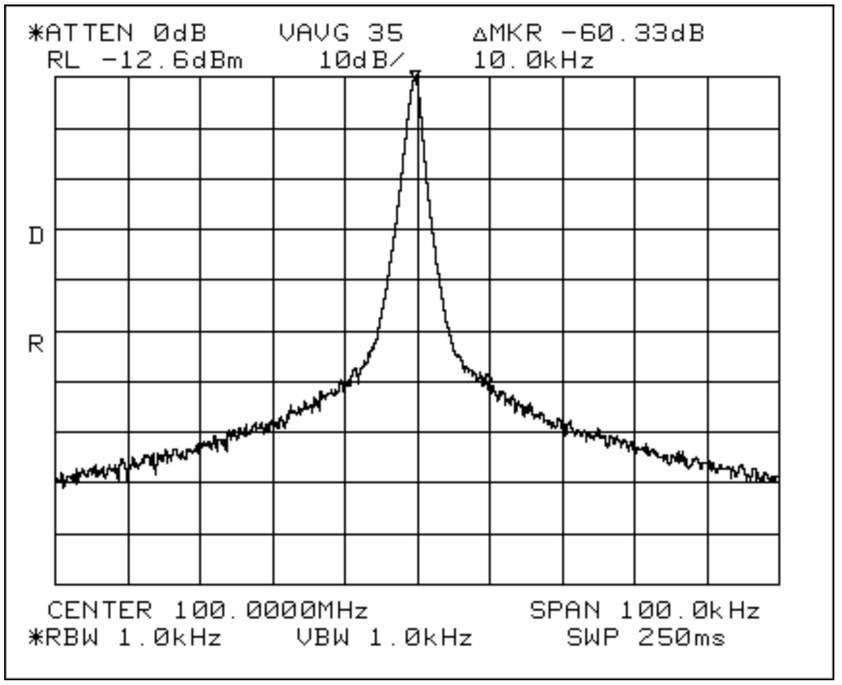

Figure 5. 100MHz LO signal at LO buffer output I_{CP} = 210µA, HP8561E.

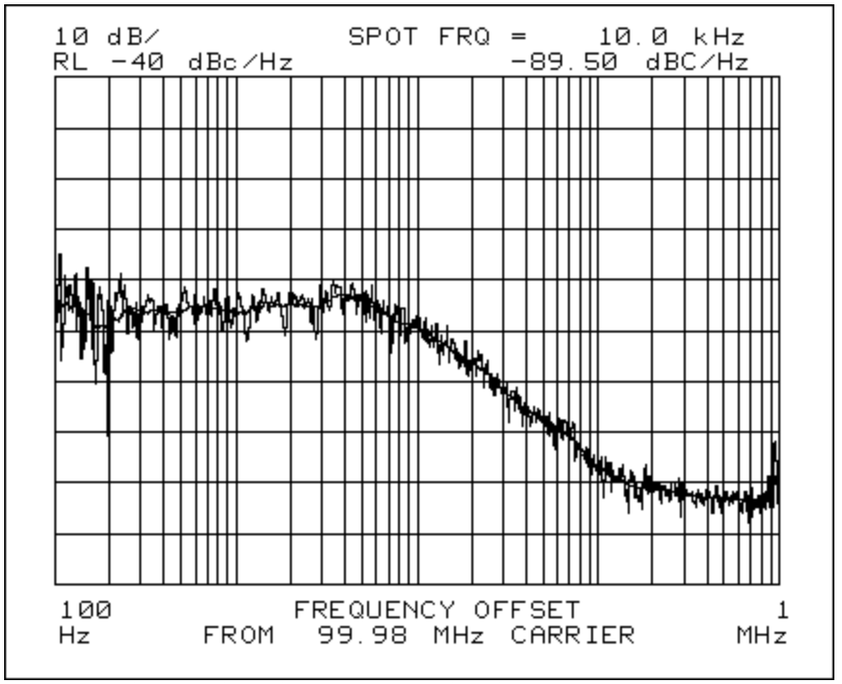

Figure 6. Phase noise of 100MHz LO signal, HP8561E.

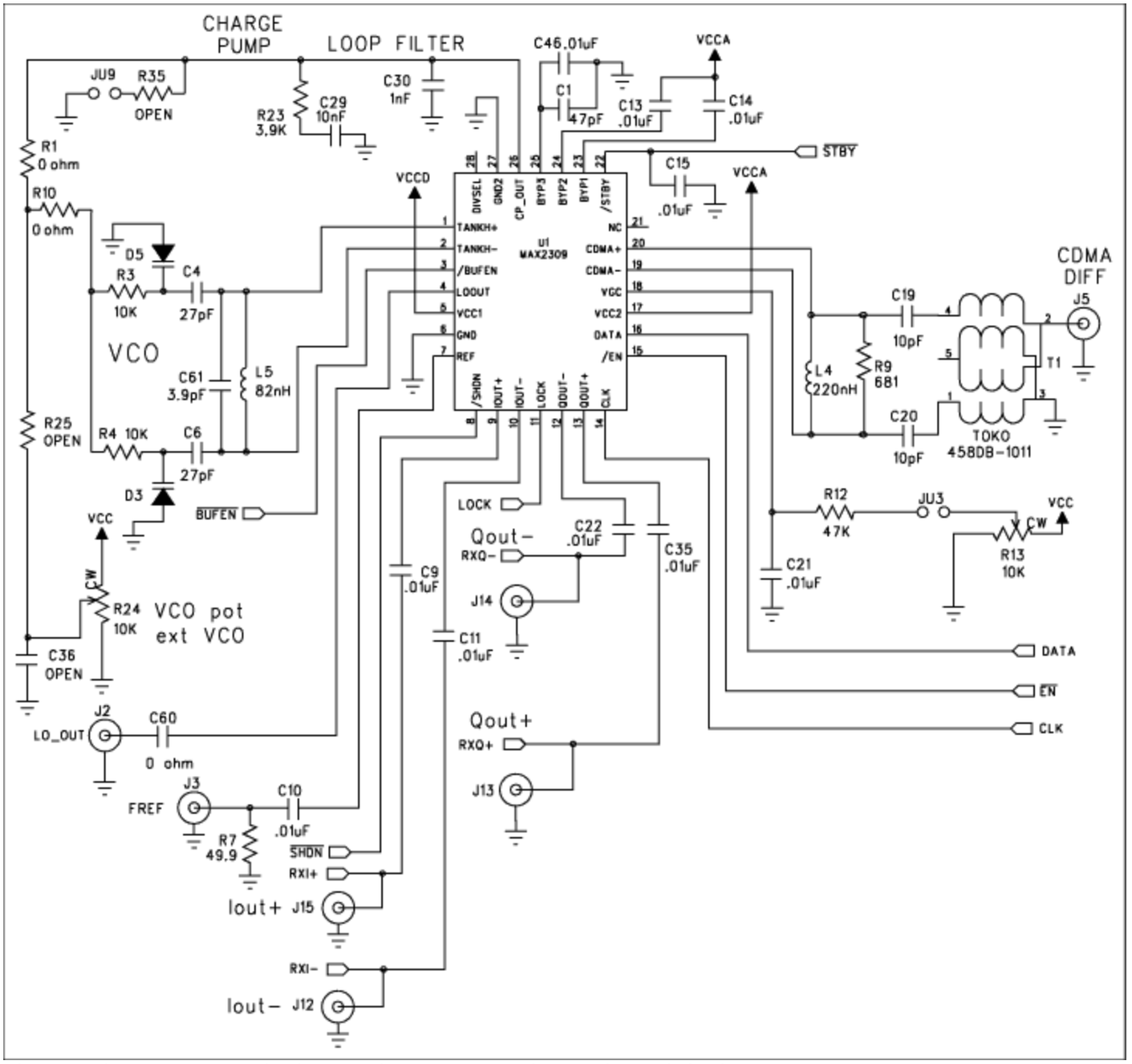

Figure 7. The MAX2309 Evaluation Board, 100MHz LO, Phase-noise optimized.

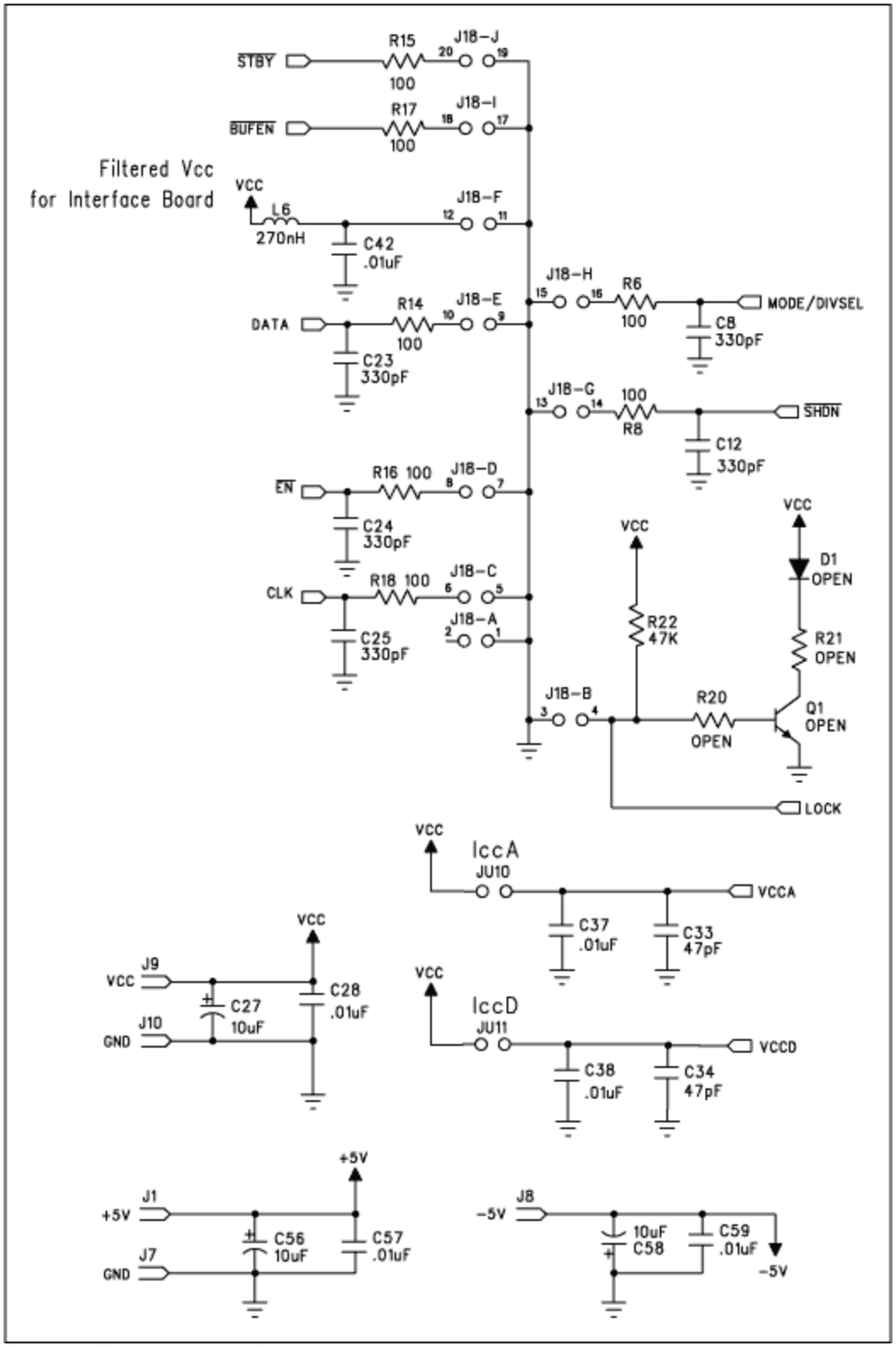

Figure 8. The MAX2309 Evaluation board.

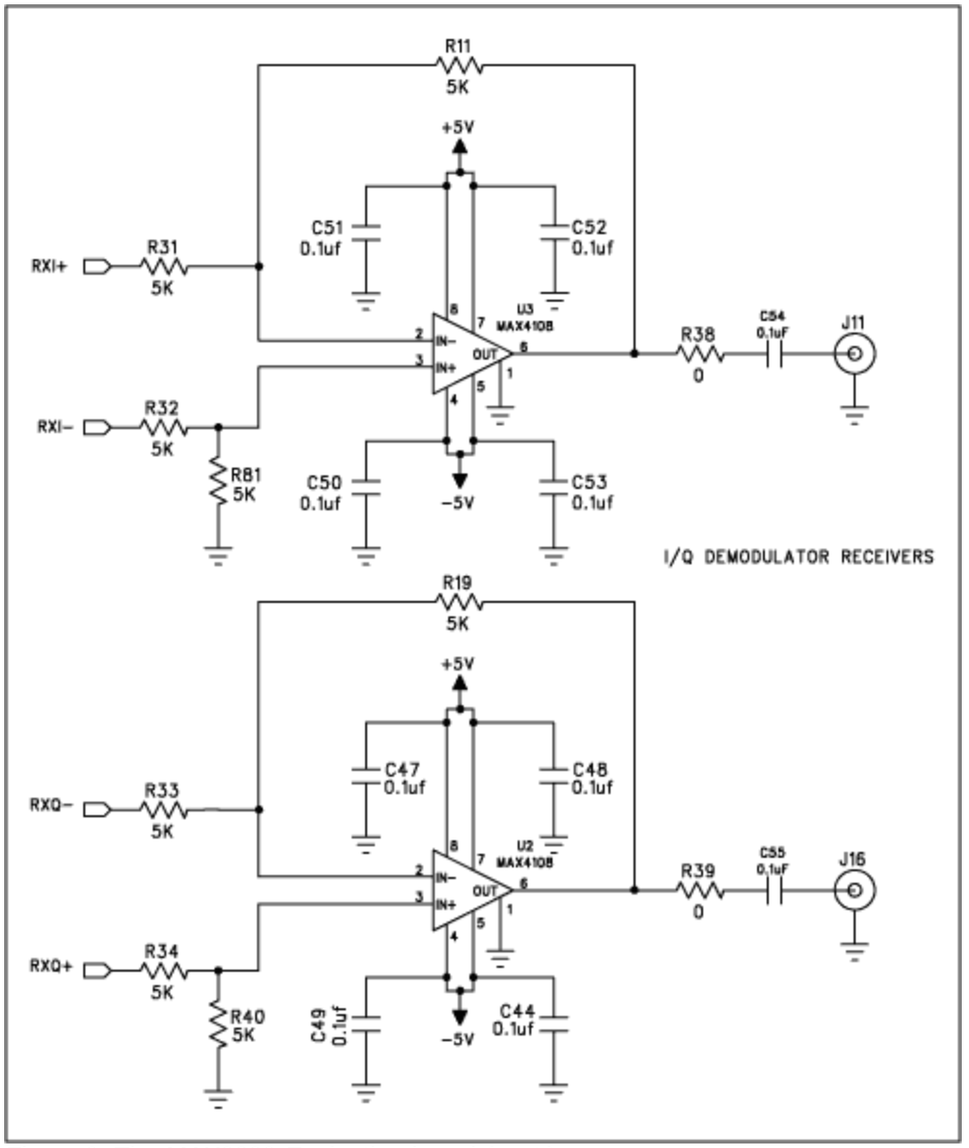

Figure 9. The MAX2309 Evaluation board (cont.).

Conclusion

The MAX2309 is capable of achieving approximately -90dBc/Hz phase noise at 10kHz offset. While quite dependent on the reference oscillator spectral purity, loop filter design, and charge pump current, the end result is ultimately achievable once optimized.

Related Parts		
MAX2309	CDMA IF VGAs and I/Q Demodulators with VCO and Synthesizer	Free Samples

More Information
