Application Note 1744: Sep 25, 2002

VCO Phase Noise Optimization for the MAX2309

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

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

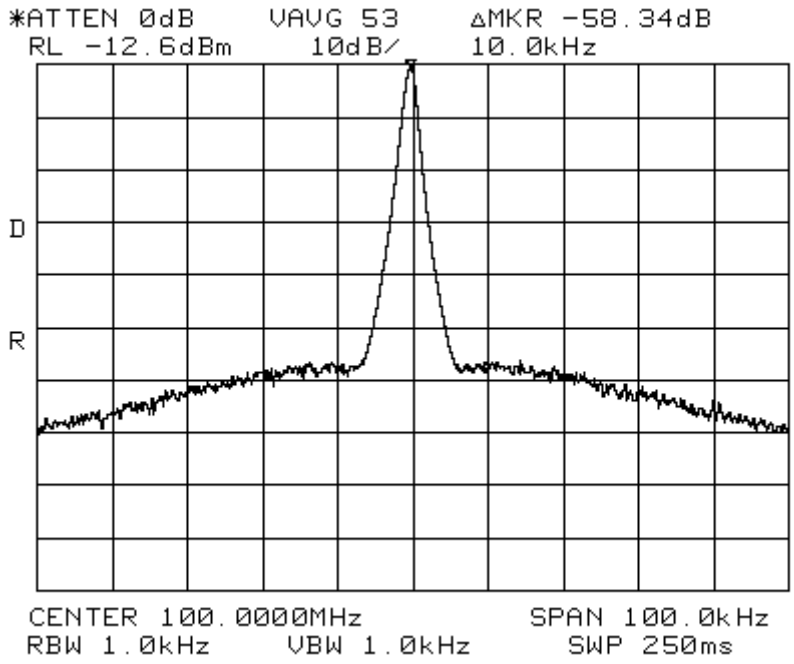


Figure 1. 100MHz LO signal at LO buffer output Icp = 425mA, HP8561E

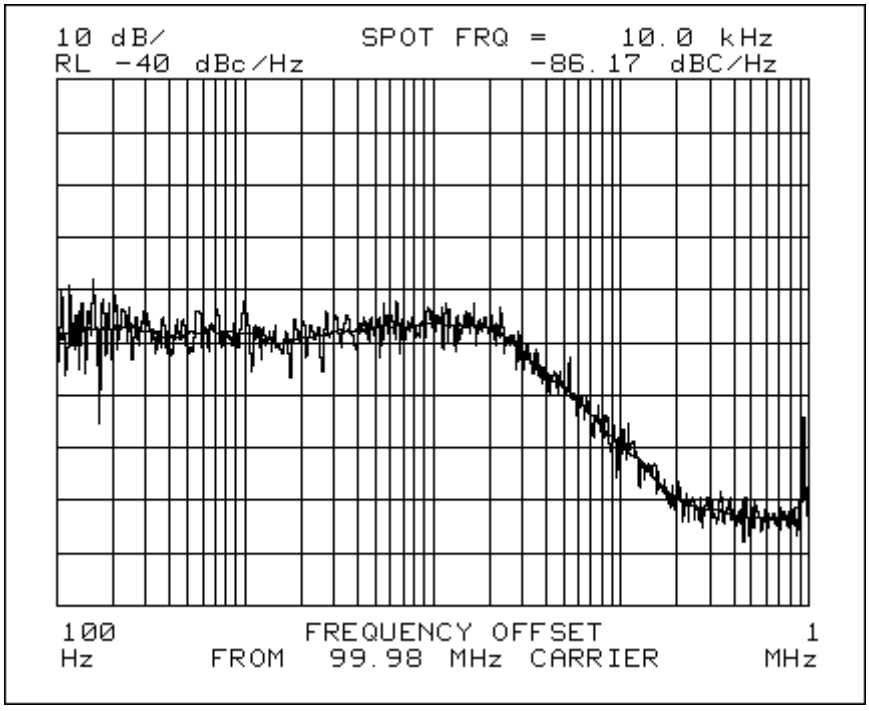


Figure 2. Phase noise of 100MHz LO signal, HP8561E

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
Vcc	3.0	V
FIF	100	MHz
Fref	13	MHz
Fosc	200	MHz
Fcomp	1	MHz
Kvco	6.6	MHz/V
Target Phase Noise @ 10kHz	-90	dBc/Hz
Ta	+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.

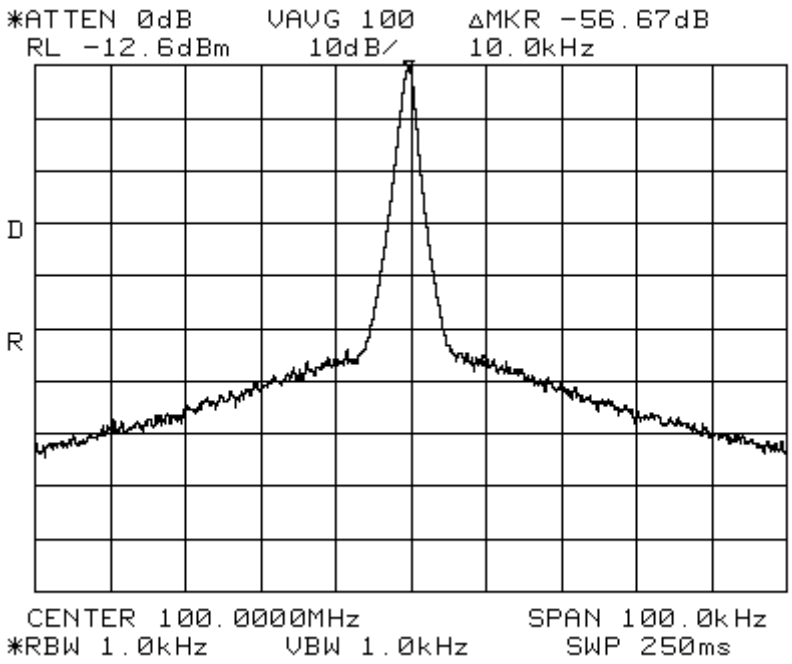


Figure 3. 100MHz LO signal at LO buffer output Icp = 425mA, HP8561E

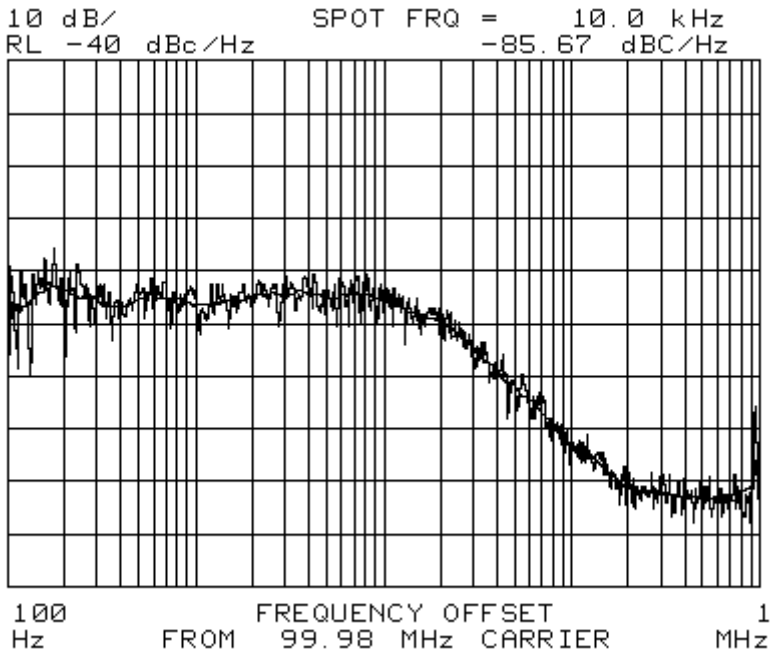


Figure 4. Phase noise of 100MHz LO signal, HP8561E

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.

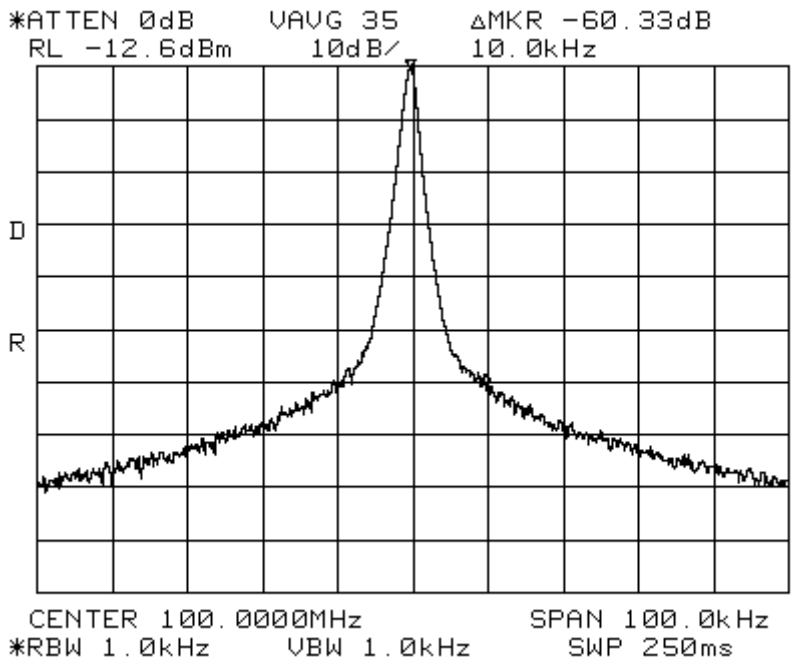


Figure 5. 100MHz LO signal at LO buffer output ICP = 210uA, HP8561E

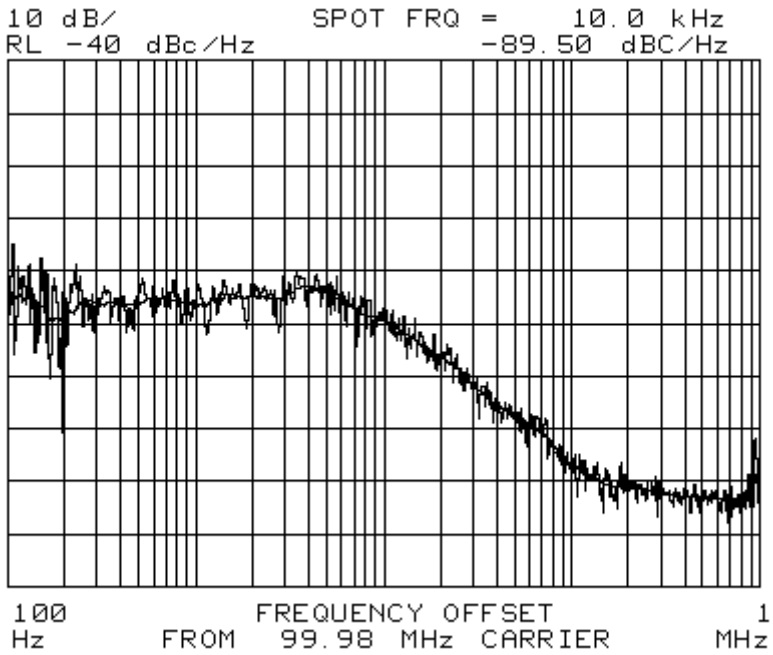
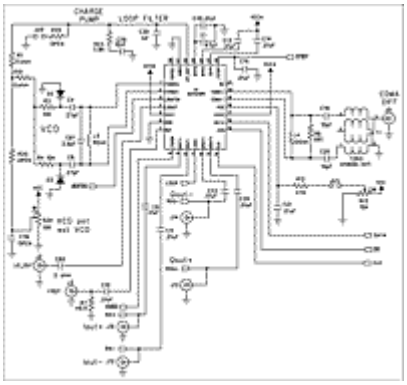


Figure 6. Phase noise of 100MHz LO signal, HP8561E



For Larger Image

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

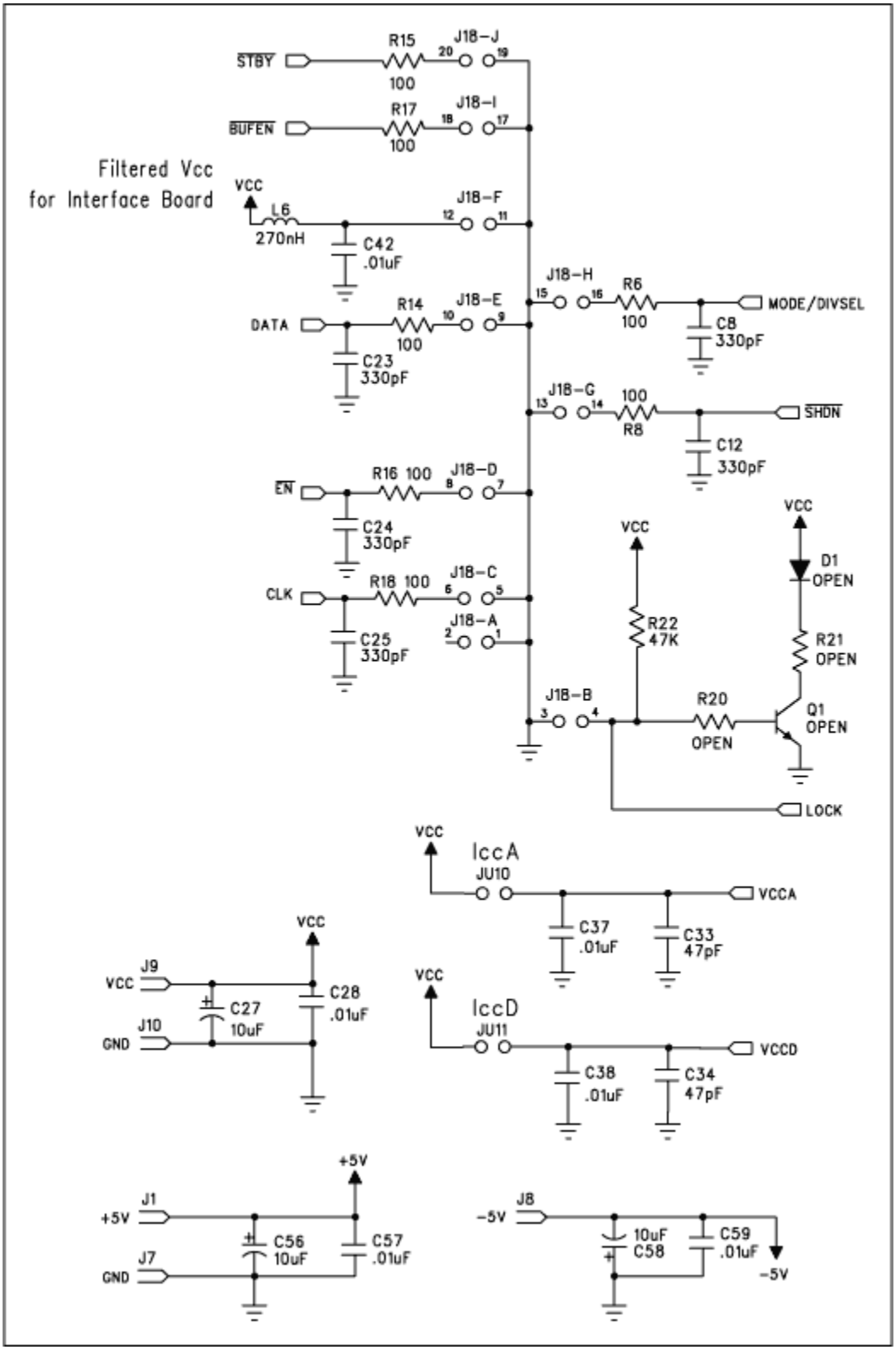


Figure 8. The MAX2309 Evaluation board

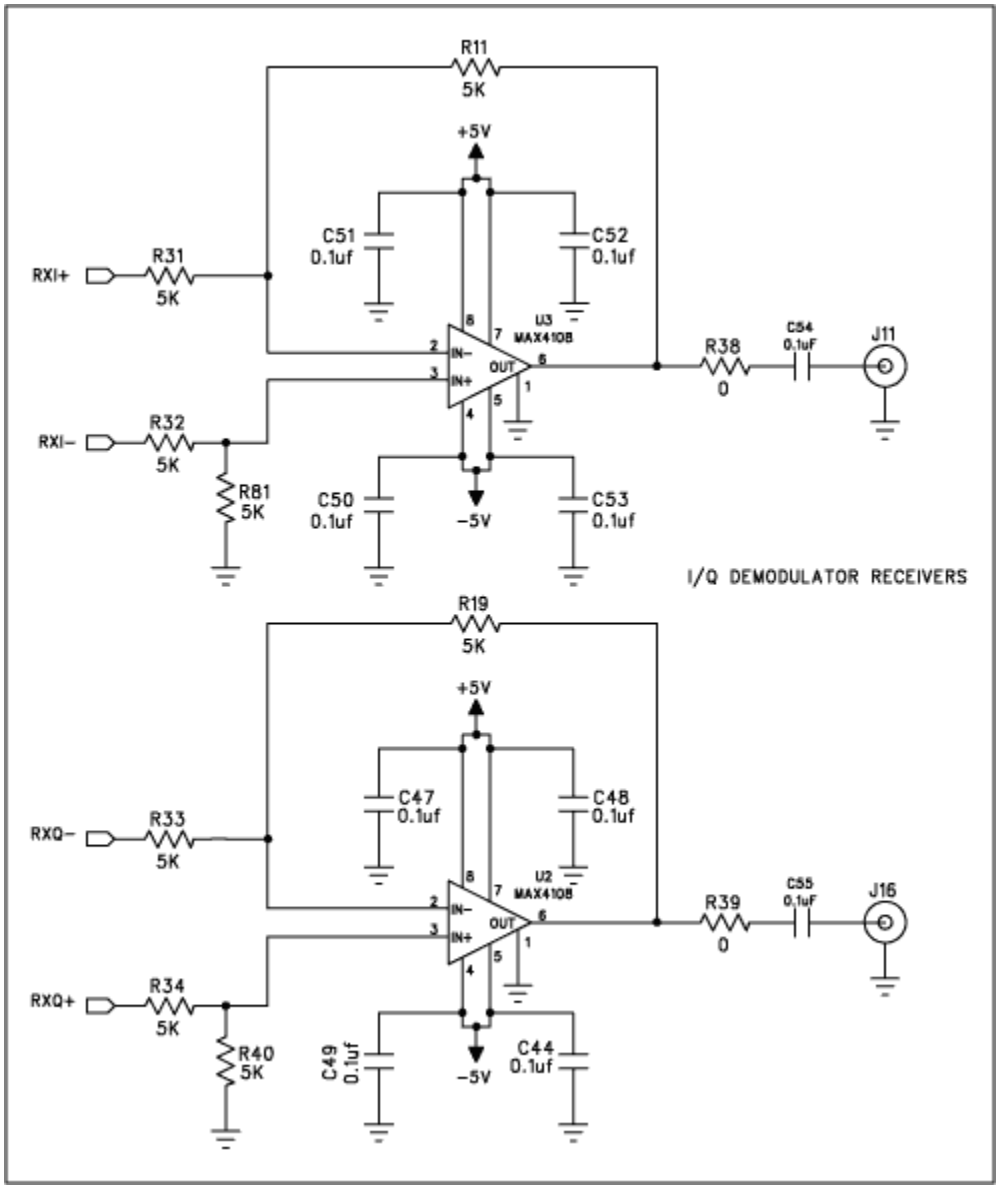


Figure 9. The MAX2309 Evaluation board (cont.)

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.

MORE INFORMATION

MAX2309: QuickView -- Full (PDF) Data Sheet (304k) -- Free Sample

MAX2312: QuickView -- Full (PDF) Data Sheet (344k) -- Free Sample