Keywords: ultra-low phase noise, PLL, high frequency, RF synthesizer, microwave, MAX2880

APPLICATION NOTE 6265

MAX2880 APPLICATION NOTE: DESIGNING A 12GHZ, ULTRA-LOW PHASE NOISE (0.09 PS RMS JITTER) PHASE LOCKED LOOP

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Abstract: This application note is a detailed design guide and characterization report of a complete 12GHz, ultra-low phase noise fractional-N phase locked loop (PLL) with external VCO and active loop filter.

Introduction:

This application note details the design of a complete 12GHz, ultra-low phase noise fractional-N phase locked loop (PLL) with external VCO. It consists of a high performance fractional-N PLL (MAX2880), op-amp based active loop filter (MAX9632), and 12GHz VCO (SYNERGY DXO11751220-5).

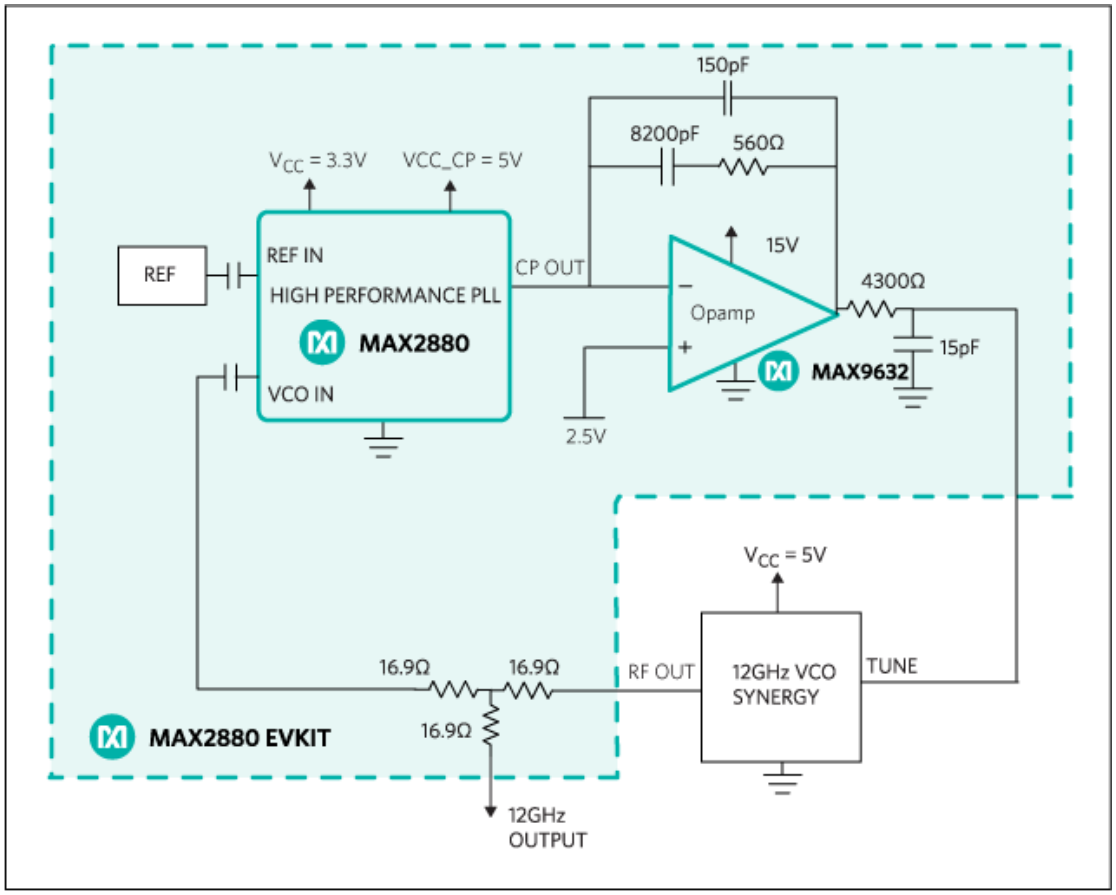

Figure 1. 12GHz ultra-low phase noise fractional-N PLL based on MAX2880.

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Key Features:

- Ultra-Low Phase Noise: 92-Femtosecond RMS Jitter (1kHz-20MHz)
- No External Frequency Divider Needed
- Active Filter with Tuning Range from 0.5V to 15V

This high performance PLL can be used to generate a mixer local oscillator (LO) frequency or an ADC/DAC clock for applications in microwave point-to-point systems, test and measurement equipment, or automotive radars.

Phase noise performance data and detailed setup guide are included in this app note.

Performance results:

PLL overall phase noise is usually dominated by the PLL's inband phase-noise floor and VCO phase noise. To build an ultra-low phase-noise PLL, the designer needs to select a low-phase noise VCO and PLL. The MAX2880 is capable of achieving an inband phase noise floor of -229dBc/Hz for integer mode and -225dBc/Hz for fractional low-noise mode.

Table 1 and **Figure 2** show the phase noise performance of the circuit at 12GHz and different modes of the MAX2880.

Table 1. 12GHZ Phase Noise Summary

Parameter	Result	Unit
Carrier Frequency	12	GHz
RMS Jitter (Integer Mode)	89	femtosecond
RMS Jitter (Fractional Low-Noise Mode)	92	femtosecond
RMS Jitter (Fractional Low-Spur Mode)	140	femtosecond
SSB Integrated Phase Noise (Integer Mode)	-46.7	dBc
SSB Integrated Phase Noise (Fractional Low Noise Mode)	-46.2	dBc
SSB Integrated Phase Noise (Fractional Low Spur Mode)	-42.7	dBc
Integration Limit	1-20,000	kHz
VCO Tuning Range	0.5-15	V

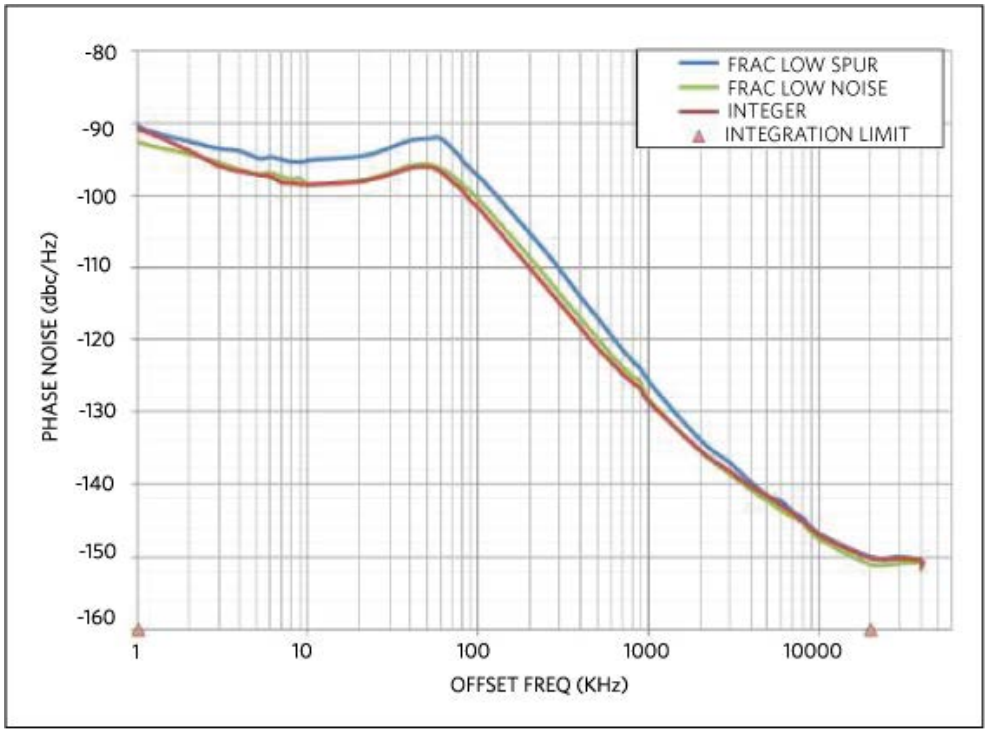

Figure 2. 12GHz phase noise plot.

Detail Setup Guide:

A MAX2880 evaluation kit (EV kit) and a 12GHz external VCO (Synergy DXO11751220-5) are required for this design.

Note: the Synergy VCO is not included in the MAX2880 EV kit, and some modifications of the EV kit are required.

1. Verify default MAX2880 functionality. Follow the MAX2880 EV kit datasheet for detailed operating procedure.
2. Modify the MAX2880 EV kit according to **Table 2** and change the jumper positions according to **Figure 3**.

Table 2. MAX2880 EV Kit Modifications

Part (unit)	Change	Default	Note
C1 (nF)	Open	10	Remove passive filter
R2A (ohm)	Open	100	Remove passive filter
C2 (nF)	Open	100	Remove passive filter
R3 (ohm)	Open	47.5	Remove passive filter
C3 (nF)	Open	1	Remove passive filter
R4 (ohm)	Open	0	Remove passive filter
R27 (ohm)	0	Open	Connect active filter
R26 (ohm)	4300	Open	Active filter
C4 (pF)	15	Open	Active filter
C101 (pF)	150	Open	Active filter
R102 (ohm)	560	Open	Active filter
C102 (pF)	8200	Open	Active filter
R9 (ohm)	Open	16.9	disconnect onboard VCO
R9 to NC1	16.9	Open	connect external VCO
JP4 2 pin jumper	Open	Connect	power down onboard VCO
JP5 3 pin jumper	connect center pin to 5P0_V_{CC}	Open	pamp input+ bias

3. Make the connections to the EV kit according to **Figure 4**. Make sure all power supply units are OFF.
4. Power up the VCO to +5V.
5. Power up the MAX2870 EV kit with +15V and +6V.
6. Program the MAX2880 registers for the desired mode:

   Integer Low-Noise mode: 003C0000,06000001,6F00CE22,00002503,00000004,00000005
   Fractional Low-Noise mode: 003C0000,06000001,0F00FFFA,00000303,00000004,00000005
   Fractional Low-Spur mode: 003C00C8,06000001,6F00CE22,00000B03,00000004,00000005

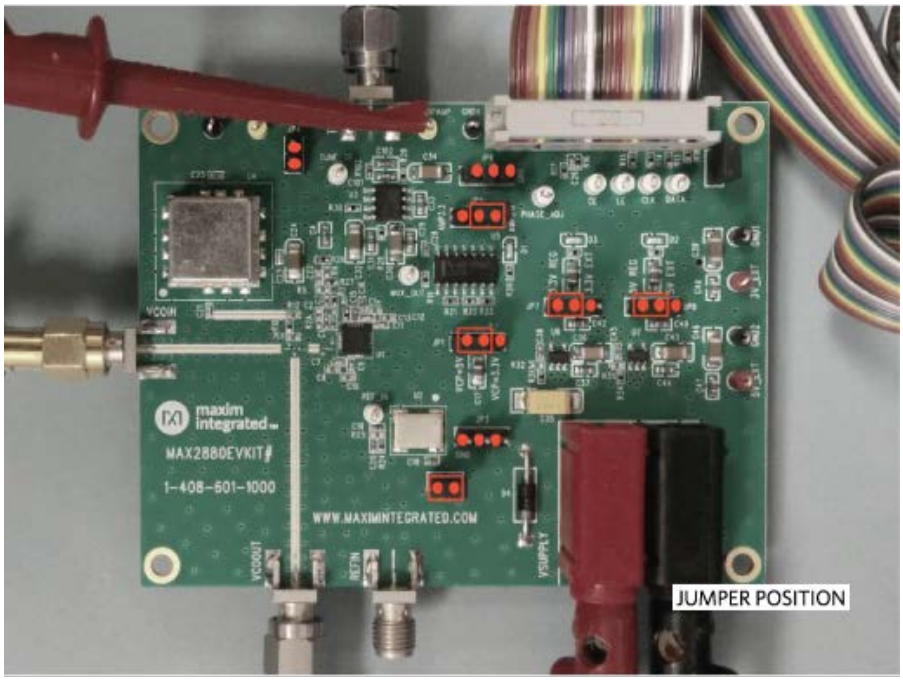

Figure 3. Jumper position.

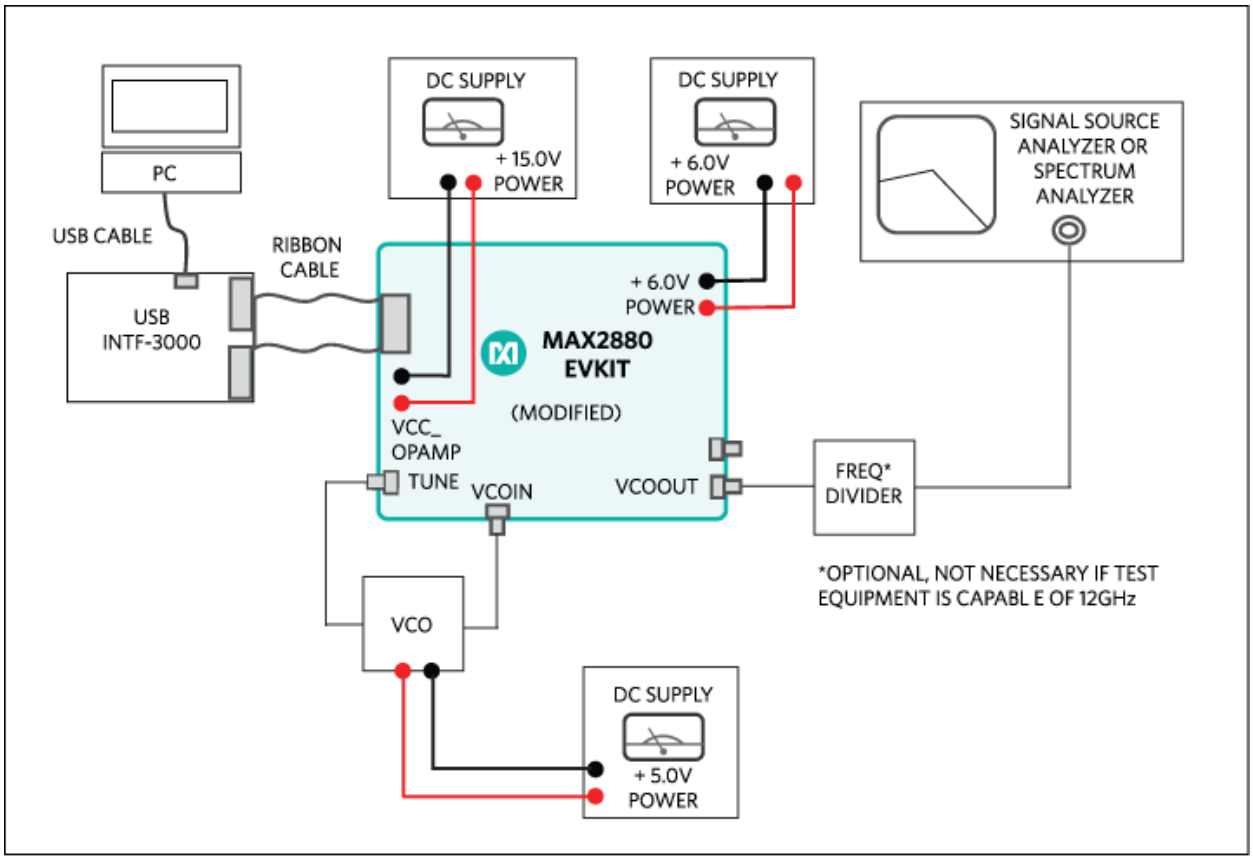

Figure 4. Detail setup diagram.

Related Parts		
MAX2880	250MHz to 12.4GHz, High-Performance, Fractional/Integer-N PLL	Free Samples
MAX9632	36V, Precision, Low-Noise, Wide-Band Amplifier	

More Information
For Technical Support: https://www.maximintegrated.com/en/support
For Samples: https://www.maximintegrated.com/en/samples
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