AN RFMD® APPLICATION NOTE

RF2053 Phase Noise Application Note

RFMD Multi-Market Products Group

1. INTRODUCTION

The RF2053 is part of the new RF205x family of highly integrated RF synthesizers with high linearity mixers. The RF2053 has been designed so that the synthesizer can operate with an external VCO, to enable much improved phase noise performance as required for higher order modulation schemes such as 256QAM.

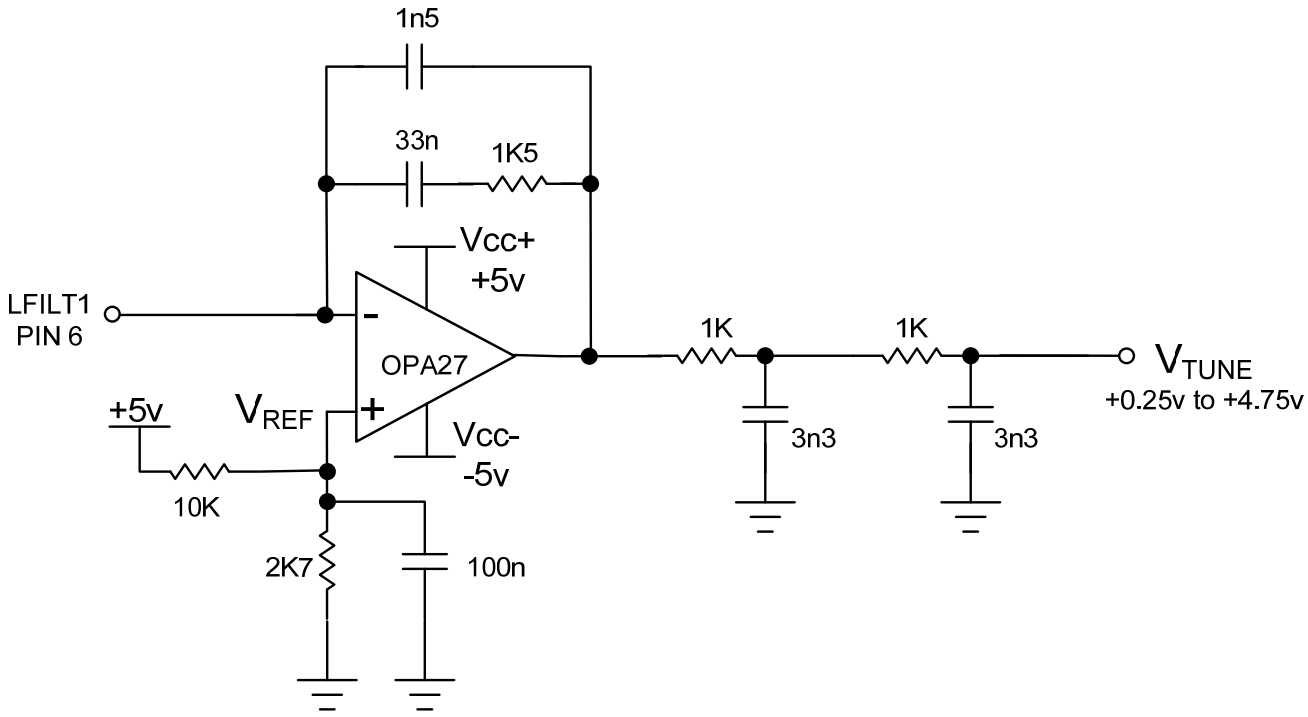
For further details please refer to the RF2053 data sheet. www.rfmd.com/rf205x

This application note presents phase noise results for the RF2053 for a narrowband / fixed LO application, and for an application requiring the VCO to tune over an octave range. The narrowband circuit uses an RFMD UMX-236-D16 VCO at 1660MHz. This VCO has very low phase noise enabling the loop bandwidth to be reduced to <10kHz. The wideband circuit uses an RFMD UMS-2150-R16 VCO covering 950MHz to 2150MHz. This could be suitable for applications such as CATV down conversion or satellite modems which require a wide LO tuning range. An external low noise op-amp is required for the active loop filter in both cases.

2. RF2053 AND UMX-236-D16 NARROWBAND VCO AT 1660MHZ

The UMX-236-D16 has very low phase noise, typically -120dBc/Hz at 10kHz offset, which allows the loop bandwidth to be reduced to <10kHz. This gives significant improvements when compared to the phase noise of the RF2052.

2.1 ACTIVE LOOP FILTER USING EXTERNAL LOW NOISE OP-AMP



Designed for:

- 5kHz loop bandwidth
- I_{CP} = 011111 (typ 120uA)
- F_{VCO} = 1660MHz
- F_{REF} = 26MHz
- K_{VCO} = 9MHz/V

2.2 RF2053 NARROWBAND PHASE NOISE RESULTS

With the default charge pump current setting of I_{CP} = 011111 then the loop bandwidth is about 5kHz as predicted. Increasing the charge pump current widens the loop bandwidth, this increases the phase noise at 10kHz offset, but the total integrated phase noise is lower. Increasing charge pump current reduces the synthesizer noise floor, which is multiplied up by $20\log_{10}N$ inside the loop bandwidth.

Note: 26MHz Crystal, Ref Divider = 1, CPL = 01

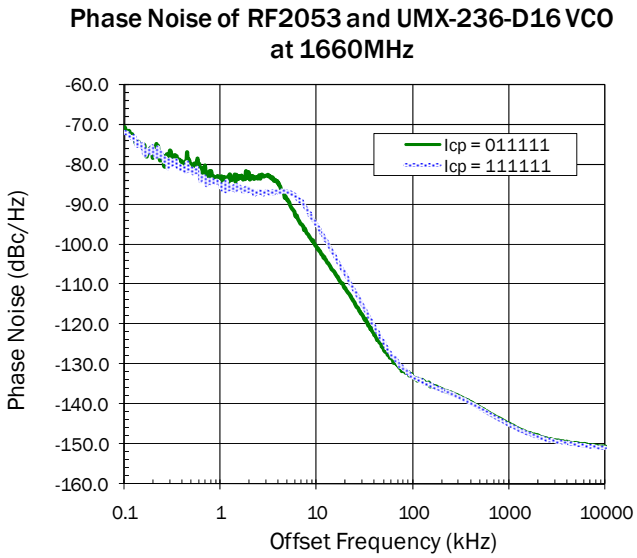


Table 1. RMS Integrated Phase Noise (100Hz to 10MHz)

Icp	RMS Int PN
011111	0.440°
111111	0.403°

2.3 COMPARING RF2052 TO RF2053 AT 1660MHZ

As can be seen below the RF2053 with UMX-236-D16 gives much lower phase noise than the RF2052. At 100kHz offset the improvement is about 40dB. Note that for small offsets the phase noise is the same, the multiplied up synthesizer noise which is dominated by the integrated charge pump's contribution.

Note: 26MHz Crystal, Ref Divider = 1, CPL = 01, I_{CP} =111111

Phase Noise of RF2052 Compared to RF2053 and UMX-236-D16 VCO at 1660MHz

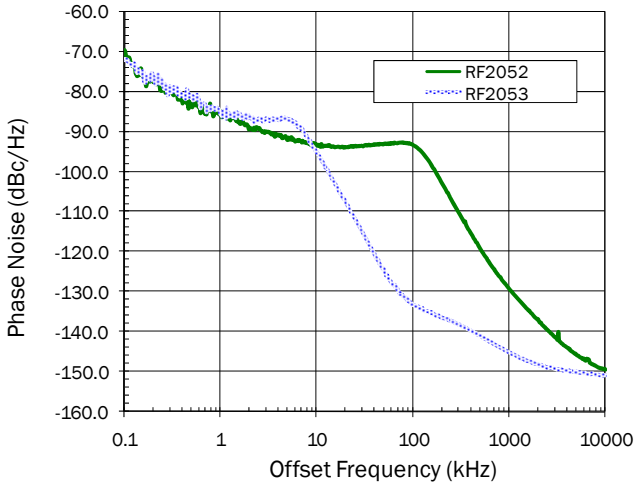


Table 2. RMS Integrated Phase Noise (100Hz to 10MHz) at 1660MHz

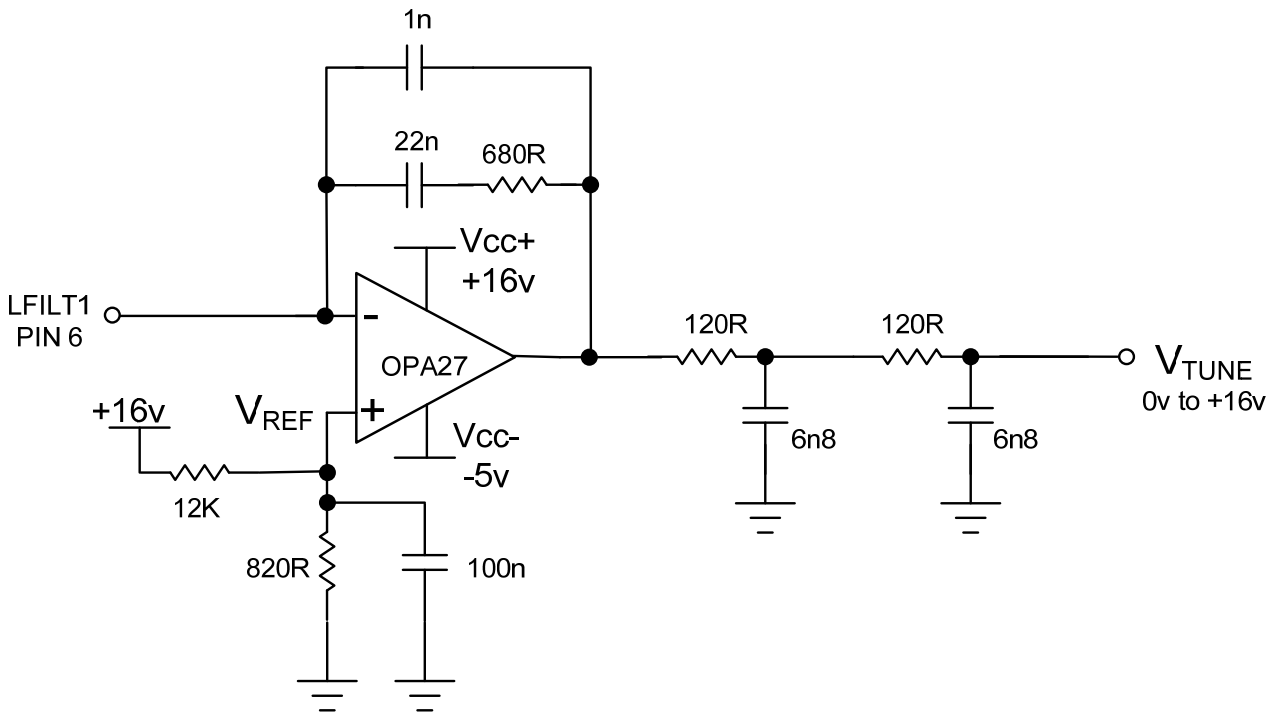
	RMS Int PN
RF2053	0.403°
RF2052	0.748°

3. RF2053 AND UMS-2150-R16 WIDEBAND VCO, 950MHZ TO 2150MHZ

The UMS-2150-R16 has over an octave tuning range. This makes designing the loop filter more challenging, the VCO tuning gain varies across the tuning range, as does the divider ratio N. The high VCO tuning gain, typically 85MHz/V means that loop filter and op-amp noise contributions become more significant.

Using the integrated LO dividers on the RF2053, divide by two and by four, the total LO frequency range possible will be from 237.5MHz to 2150MHz. The LO dividers give about 6dB ($20\log_{10}2$) and 12dB ($20\log_{10}4$) reduction in phase noise respectively on the results presented below.

3.1 ACTIVE LOOP FILTER USING EXTERNAL LOW NOISE OP-AMP



Designed for:

- 20kHz loop bandwidth
- I_{CP} = 011111 (typ 120uA)
- F_{VCO} = 1550MHz (mid-band)
- F_{REF} = 26MHz
- K_{VCO} = 85MHz/V

The loop response will change over the tuning range since the VCO tuning gain (K_{VCO}) decreases with increasing frequency, and the divider ratio (N) more than doubles. The charge pump current can be used to adjust loop response, although it is best to keep at or near maximum to get best synthesizer phase noise.

The VCO tuning voltage requires the op-amp to be supplied from +16V in order to reach the upper limit of 2150MHz. The high Kvco means that loop filter and op-amp noise become more significant, especially as the loop bandwidth is reduced. This noise contribution peaks around the loop bandwidth. The resistor values in the loop filter are scaled down to reduce their thermal noise contribution.

3.2 RF2053 WIDEBAND PHASE NOISE RESULTS

The phase noise at 100kHz offset is <-110dBc/Hz across the VCO tuning range. This is an improvement of 10 to 15dB compared with the RF2052. Note the 7dB variation in phase noise within the loop bandwidth, the multiplied up synthesizer noise, agreeing with $20\log_{10}N$. The VCO phase noise remains quite flat with frequency. The loop bandwidth is between 20kHz and 30kHz, as expected from simulations.

Note: 26MHz Crystal, Ref Divider = 1, CPL = 01

Phase Noise of RF2053 and UMS-2150-R16 VCO

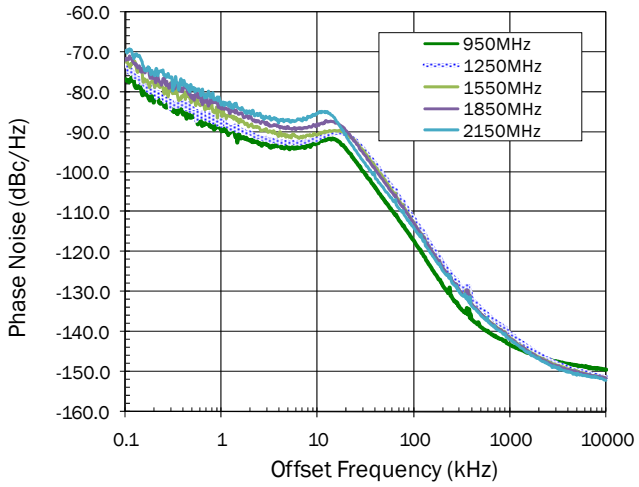


Table 3. RMS Integrated Phase Noise (100Hz to 10MHz)

Fvco (MHz)	Icp	RMS Int PN
950	101111	0.335°
1250	100000	0.450°
1550	101111	0.506°
1850	101111	0.580°
2150	101111	0.655°