LMX2594 Calibration Free Ramping

Dean Banerjee, 2018-7-23

Note: This document is just a casual opinion and does NOT imply any sort of guarantee!

Introduction

The LMX2594 allows the user to do ramps and chirps while using the integrated VCO. Ideally, one would like to have these ramps and chirps without any disturbances for the VCO calibration. Who wouldn't want this? However, if the VCO frequency change is too large, then the VCO will automatically calibrate. For these instances, the LMX2594 allows the user to make it so that the calibration takes place at uniform time intervals and takes the same amount of time.

This drives the fundamental question: How much can the LMX2594 frequency change before calibration is necessary?

Typical Calibration Free Range

Define the calibration free range as the maximum amount that the VCO frequency can change before calibration is absolutely necessary. It turns out that this largely impacted by temperature and VCO frequency, and somewhat by process.

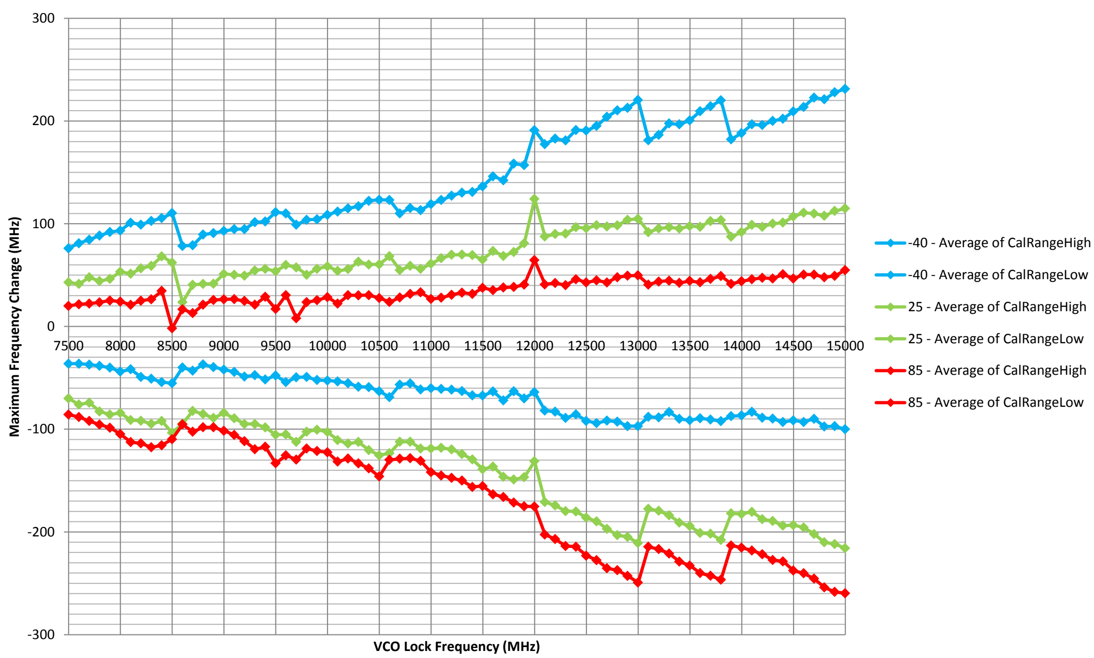

Figure 1 *Calibration Free Range*

Figure 1 gives good insight into the answer. To produce this, the VCO was locked to the VCO Lock frequency. Then the frequency was changed and the VCO was pushed as far as it could. For instance at 25 C and 10 GHz, the figure shows that the VCO frequency could be increased by 70 MHz to 10070 MHz or decreased by 100 MHz down to 9900 MHz without the need for calibration. Note that no claims are made about the phase noise or performance at these extremes as they are likely not great due to the VCO tuning voltage being close to the rail. Also, remember that this is just one device. Also note that this was taken with an automated test program and data points were not double checked. In other words, don't get distracted by the measurement error at 85C for 8500 MHz; it's amost surely a measurement error.

Dispelling Some Confusion

Compare figure 1 to figure 2, which is a plot taken from our datasheet. Here we see 120 MHz ramping change at 12 GHz. Figure 1 shows this is possible, but not over temperature. Also, 12 GHz seems like a favorable frequency to choose. So in other words do NOT assume this 120 MHz frequency change to be production worthy, because it is not.

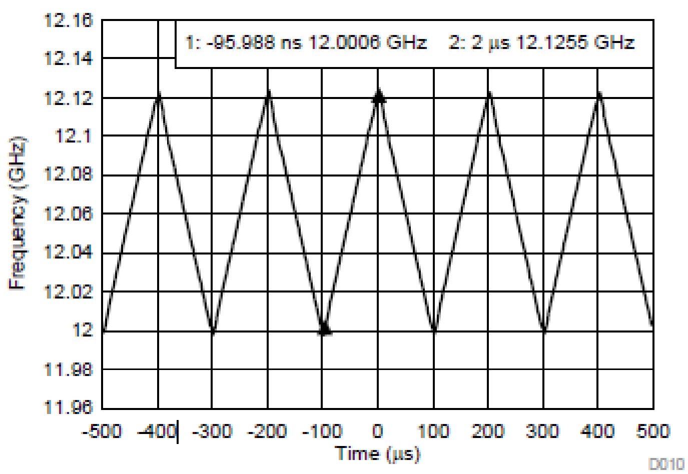

Figure 2 Plot from Datasheet (Do NOT design to this)

Another point to also be aware of is that the VCO has 7 different cores, but do not be confused into thinking that there are only 7 different frequency bands. This is because each core has 256 different bands. So there are 7 x 256 = 1792 different frequency bands.

Choosing a Calibration Threshold

Figure 1 is really the key plot and what is really useful is how to choose a calibration threshold based on VCO frequency. As this is just one device, this shows the worst over the three temperatures.

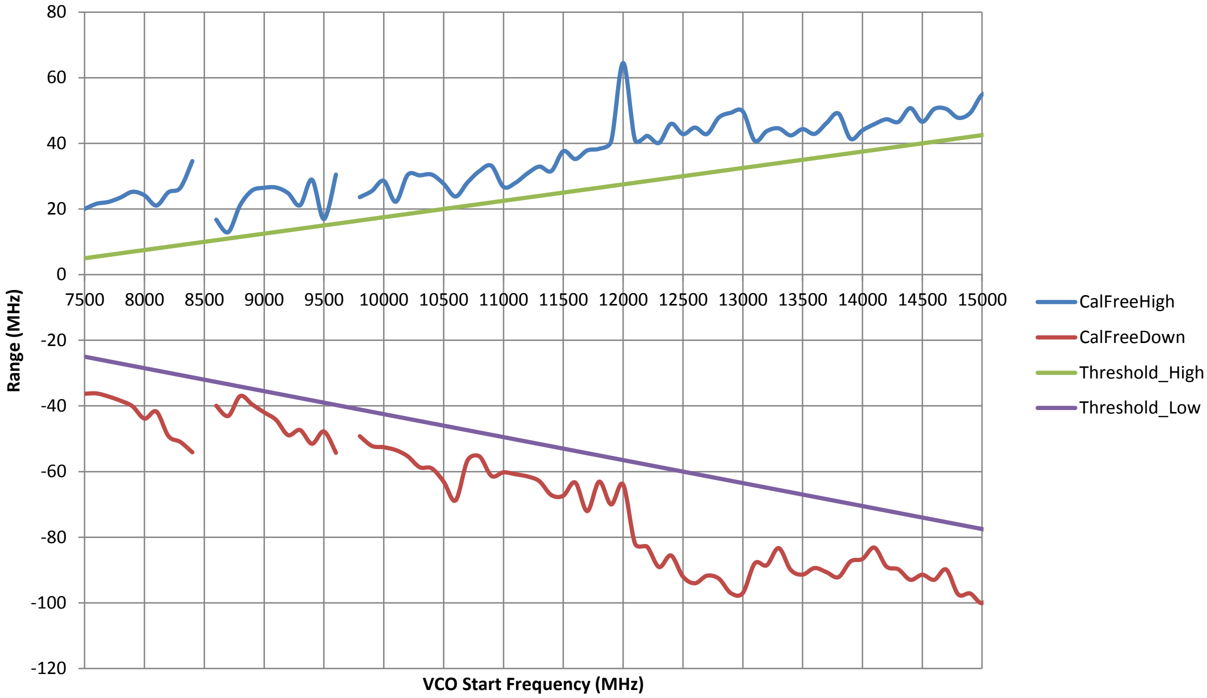

Figure 3 Suggesting Thresholds

Note that Fvco=8500 MHz and Fvco = 9700 MHz were removed as they were likely bad data points. The equations for the lines are:

$$Threshold_{High} = 0.005 \cdot f_{VCO} - 32.5$$

$$Threshold_{Low} = -0.007 \cdot f_{VCO} + 27.5$$

So based on the VCO frequency, these might be more realistic expectations to set, although no guarantees. At 10 GHz, this translates to 17.5 MHz upward and 42.5 MHz downwards. Fir

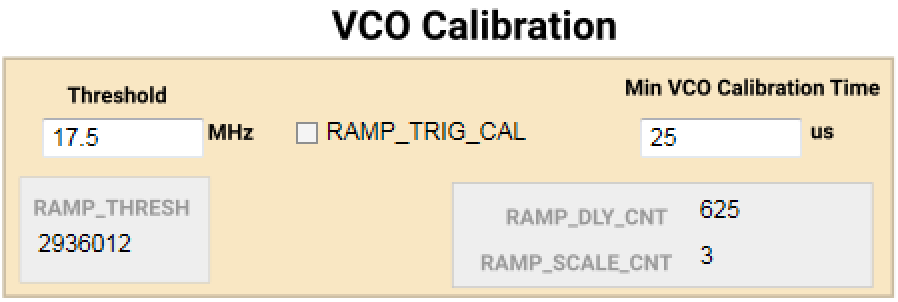

Figure 4 TICSPro settings

Improving the Calibration Threshold

For the calibration free range, one observation is that the upward threshold is much less than the downward threshold. For instance, at 10 GHz, maybe you can go up 17.5 MHz upward, but 27.5 MHz downward. However, by skewing the VCO, maybe the range can be increased. For example, suppose you wanted to ramp from 10000 to 10040 MHz, could it be done over temperature? Here is one potential approach.

1. Lock and Calibrate device at 10025 MHz with FCAL_EN=1
2. Set FCAL_EN=0
3. Lock the PLL without calibrating the VCO to 10000 MHz
4. Check the lock detect to ensure PLL is locked
5. Start automatic ramping by programming R0 with FCAL_EN=0 and RAMP_EN=1

Now if there is knowledge of the temperature, other schemes could be used to increase the range. For instance, looking at figure 2 at 10 GHz, the downward threshold is 27.5 MHz, but if we look at figure 1, we see this is really because this is for cold temperature. Typically at room, the device can tolerate a downward threshold of 100 MHz, so at room, you could do step 1 in the procedure above and lock closer to 10100 MHz and get much more ramping range.

Conclusion

The LMX2594 offers the ability to ramp the VCO frequency with integrated VCO. The major consideration of this is the VCO calibration. For small frequency ramps, it can be done without the VCO calibrating, but larger ones require VCO calibration. If one programs a threshold that is larger than the VCO can do, the VCO will automatically calibrate anyways and ignore this threshold. Also, if one programs a calibration time that is shorter than is required, the VCO will take the required time. By setting the threshold less than what the device really needs and the calibration time more than what the device really needs, the calibration steps can be made uniform and at predictable times.

If the VCO calibration is an issue with ramping, then one other approach is to use a device that uses an external VCO that supports ramping, such as the LMX2491/92.