

LMX2594 Initialization, Power Up, and VCO Calibration

Introduction

This document addresses the following questions:

- Do I need to program registers in the datasheet that show just 1's and 0's?
- Do I have to program all registers for the LMX2594 initialization sequence?
- For the initialization sequence, are there any timing requirements or wait periods required?
- When coming out of a powerdown state, do I lose my VCO calibration settings?

Do I need to program registers in the datasheet that show just 1's and 0's?

YES. The LMX2594 has many registers with undisclosed functions that control bias levels, calibration settings, and so on. Although many times, the power on reset value chosen by design is the correct value, it is also very common during our validation that we find more optimal settings. In other words, do NOT assume that the 1's and 0's in the register map are the default power on values.

Do I have to program all registers for the LMX2594 initialization sequence?

No, there are some that can be skipped and will be discussed. Table 1 gives a general guideline

Registers	Function	Comment
R107-R112	Readback	You never need to program these registers, these are for readback
R79 -R106	Ramping	If not using ramping (RAMP_EN=0), then you do not need to program these
R0 – R105	Others	These registers need to be programmed. There may be one or two that don't need programming, but for the sake of simplicity, it does not make sense to skip them.

Table 1 *Necessity of Register Programming*

Also be aware that if the intention of not programming registers is to decrease the time it takes to do the initialization sequence, then one must account for the delays that are necessary to wait for the LDOs to charge power up. This is the next question.

For the initialization sequence, are there any timing requirements or wait periods required?

Yes. Although not listed in the datasheet, there are definitely some requirements. Specifically, it is recommended to wait 10 ms before programming R0 for the last time. Violating this requirement may lead to degraded VCO phase noise, reduced VCO gain, or the device not locking at all. Note that the programming speed of the USB2ANY interface in TICSPRO is very slow, so this does not have issues with timing requirements; however, this can become much more of an issue at higher programming speeds.

The reason for this is that when R0 is programmed, it activates the VCO calibration which determines the correct values for VCO_SEL, VCO_CAPCTRL, and VCO_DACISSET. These can be read back from the device using rb_VCO_SEL, rb_VCO_CAPCTRL, and rb_VCO_DACISSET. If the VCO calibration is activated prematurely before all the LDOs on the device are to their proper bias levels, the VCO calibration can give erroneous values leading to degraded VCO performance or even unlock.

For instance, on the standard EVM, the bias levels at various pins were measured. In Table 2 the pin number, pin name, and bypass capacitor on our standard EVM is listed. Then the voltage at this pin for 3 conditions is listed. "POR" is power on reset that gives the value when power is applied to the device, but no registers are programmed, "Load No R0" gives the bias level after all registers EXCEPT register R0 is loaded. "Load R0" gives the bias level after R0 is loaded. From Table 2, Pin 3 seems to be the one that has the most change between states, and it is known that shifting this voltage can impact the VCO frequency. So it makes sense to focus on this pin.

Pin	Name	CAP	POR	Load No R0	Load R0
3	VBIASVCO	C25	1.017	1.095	1.268
27	VBIASVCO2	C19	0.652	0.657	0.653
29	VREFVCO2	C20	2.856	2.876	2.865
33	VBIASVARAC	C21	1.609	1.608	1.671
36	VREFVCO	C22	2.85	2.85	2.879
38	VREGVCO	C24	2.03	2.065	2.067

Table 2 Bias Levels of pins

Now that it is established that these bias levels change with programming, the next thing to establish is how long these bias levels take to change. Figure 1 shows that if one loads all registers except R0 "Load No R0", then it takes about 68 us after R0 is loaded for the device to reach the final bias level on pin 3. In this, the green trace is CSB and the yellow trace is the pin 3 bias level.

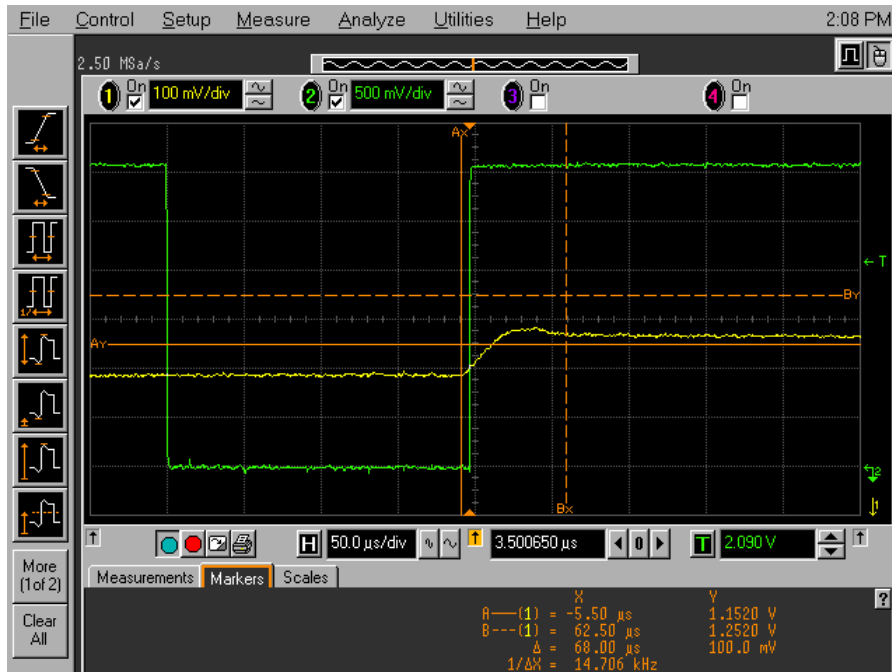


Figure 1 Pin 3 (VbiasVCO) Bias Time from “Load No R0” to “Load R0”

Ideally, it would be nice to have a word generator at full programming speed to do these measurements, but this is a fair effort to setup. Instead, a simpler experiment was done where just the R0 register was programmed, so that can eliminate the programming speed from the equation.

This was done in two ways. Figure 2 shows the result of putting the device in the reset state (this is attained by programming RESET=1 and then programming RESET=0). It seems that it takes about 2 ms.

Figure 3 shows that it takes Pin 3 on the order of 4 ms to charge up when just the R0 register is applied. This might not be the same thing as programming all the registers, but it gives a fair idea and it is more practical to measure.

Now of these, maybe figure 2 might be the most realistic wait time to wait for programming R0, but this is just one device at room temperature, so it makes sense to just make this rule 10 ms. In general, the recommended initialization sequence SHOULD be:

1. Apply power to the device
2. Program RESET=1 to reset registers
3. Program RESET=0 to remove reset
4. Program all registers in REVERSE order from highest to lowest
5. Wait 10 ms
6. Program register R0 one additional time with FCAL_EN to ensure VCO calibration runs from a steady state.

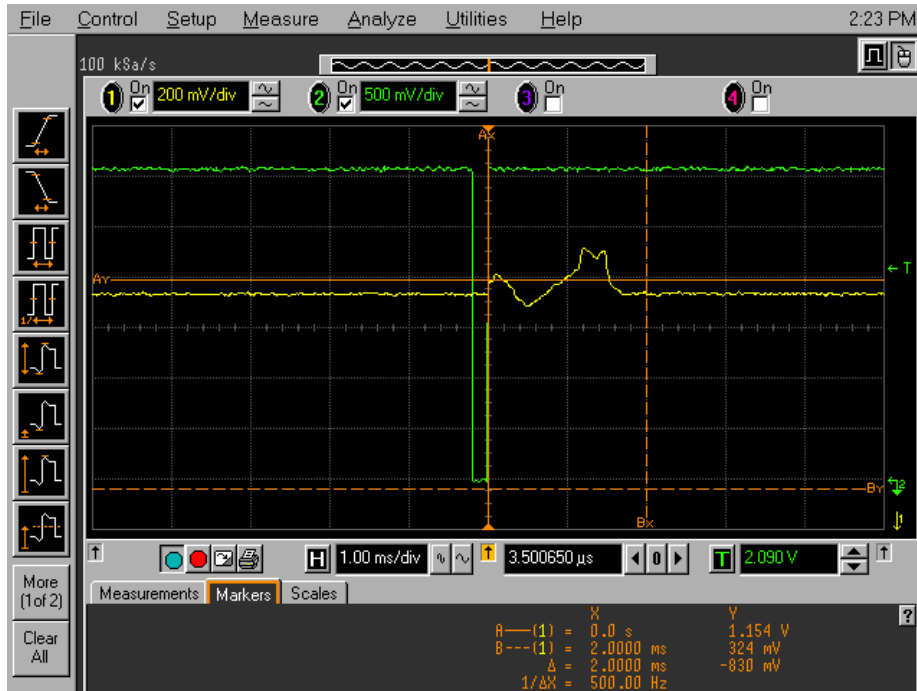


Figure 3 Pin 3 (VbiasVCO) Bias Time from POR to Programming RO

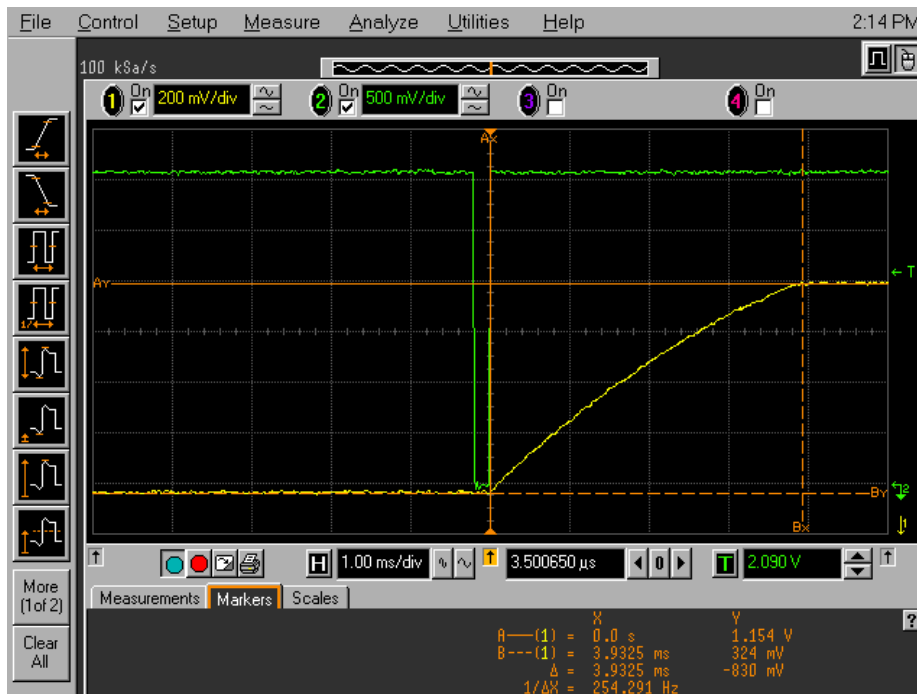


Figure 4 Pin 3 (VbiasVCO) Bias Time from POR to Programming RO

When coming out of a powerdown state, do I lose my VCO calibration settings?

No, but you need to take special precautions to ensure this. If not followed, one can come out of the powerdown state with decreased loop bandwidth, degraded VCO phase noise, or unlocked PLL. Specifically these precautions are:

- If using the CE pin for powerdown, no precautions are necessary
- If using the POWERDOWN bit, when you program POWERDOWN=0 to come out of the powerdown state, you have to ensure that FCAL_EN=0. Note that if using TICSPRO, you can disable the AutUpdate under the “Options” menu option to accomplish this.

To better understand this, the key thing to realize is that the POWERDOWN bit and the FCAL_EN bit are in the same register R0 and the action of writing register R0 with FCAL=1 activates the VCO calibration.

Address	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
R0	RAMP_EN	VCO_PHASE_SYNC_EN	1	0	0	1	OUT_MUTE	FCAL_HPFD_ADJ		FCAL_LPFD_ADJ		1	FCAL_EN	MUX_OUT_LD_SEL	RESET	POWERDOWN

So when register R0 is programmed with POWERDOWN=0 and FCAL_EN=1, the VCO calibration gets activated before the bias level on pin 3 is fully established. Figure 5 shows it takes about 2 ms.



Figure 3 Pin 3 (VbiasVCO) Bias Time from Powerdown State (from Valid Lock) to POWERDOWN=0 with

	Valid Lock State	After Powerdown	Recal
rb_VCO_SEL	7	7	7
rb_VCO_CAPCTRL	170	171	170
rb_VCO_DACISSET	286	249	283

Table 3 *Impact of POWERDOWN bit with FCAL_EN=1*

	Valid Lock State	After Powerdown
rb_VCO_SEL	7	7
rb_VCO_CAPCTRL	170	170
rb_VCO_DACISSET	286	286

Table 4 *Impact of POWERDOWN bit with FCAL_EN=0*

	Valid Lock State	After Powerdown
rb_VCO_SEL	7	7
rb_VCO_CAPCTRL	171	171
rb_VCO_DACISSET	281	281

Table 5 *Impact of CE Pin*

Table 3 shows that when the PLL was locked to VCO at 14 GHz (Default TICSPRO mode), the states were read back. Then POWERDOWN was set to 1 and the device was powered down. Then POWERDOWN was set to 0 with FCAL_EN=1 and this was recorded in the After Powerdown state. Although the correct VCO was chosen and the VCO band was very close, the amplitude setting (rb_VCO_DACISSET) was off. In fact, other times this was tried and this read back as 511, which was very far off. However, when the device was recalibrated by programming register R0 with FCAL_EN=1, then proper calibration settings were attained. So this could be a workaround, although then one needs to wait long enough for the pin 3 bias level to settle (2-10 ms).

Table 4 shows that when the same thing was done, except FCAL_EN=0 when POWERDOWN was set to 0, the calibration settings were kept and there was no issue. So this is the recommended way to come out of a powerdown state. The only thing to remember is to change FCAL_EN back to 1 when wanting to re-calibrate.

Table 5 shows that when the CE pin is toggled from Low back to high. In this case, there is no issue because the VCO calibration is NOT activated by the CE pin on the LMX2594.