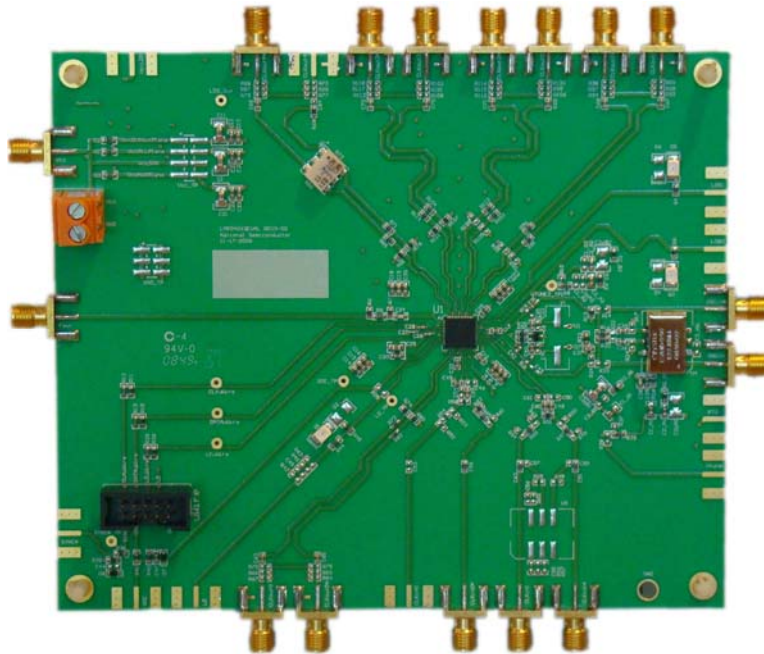




*National
Semiconductor*

**LMK04000 Family
Precision Clock Conditioner with Dual PLLs and Integrated VCO
Evaluation Board Operating Instructions for rev3 PCBs**



**LMK04000BEVAL
LMK04000BEVAL-XO
LMK04031BEVAL
LMK04031BEVAL-XO
LMK04002BEVAL
LMK04033BEVAL**

National Semiconductor Corporation
Interface Division
Precision Timing Devices



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General Description

The LMK040xx Evaluation Board simplifies evaluation of the LMK040xxB Precision Clock Conditioner with Dual PLLs and Integrated VCO. Configuring and controlling the board is accomplished using National Semiconductor’s *CodeLoader* software, which can be downloaded from: <http://www.national.com/timing/software/>.

The *CodeLoader* software will run on a Windows 2000 or Windows XP PC. The *CodeLoader* software is used to program the internal registers of the LMK040xxB device through a MICROWIRE™ interface.

Evaluation Board Kit Contents

The evaluation board kit contains...

- An LMK040xx Evaluation board (one from Table 1).
- LMK04000 Family quick start guide.
 - Evaluation board instructions are downloadable from the product folder on National’s website, www.national.com/.
- CodeLoader uWire cable (LPT --> uWire).

Available Evaluation Boards

National Semiconductor has released a series of evaluation boards which allow the customer to evaluate the different output types and VCO frequency ranges made available by the LMK04000 Family.

Note: It is possible to mount a VCXO on a –XO board or a Crystal on a non –XO board. See Appendix G: VCXO/Crystal changes for more details.

Table 1. Available Evaluation boards and configuration

| Evaluation Board NSID | VCXO | Crystal (XTAL) |
|-----------------------|--------------------|----------------------------|
| LMK04000BEVAL | 122.88 MHz Crystek | - |
| LMK04000BEVAL-XO | - | Vectron 12.288 MHz crystal |
| LMK04031BEVAL | 122.88 MHz Crystek | - |
| LMK04031BEVAL-XO | - | Vectron 12.288 MHz crystal |
| LMK04002BEVAL | 122.88 MHz Crystek | - |
| LMK04033BEVAL | 122.88 MHz Crystek | - |

Available LMK04000 Family NSIDs

Please refer to the datasheet for the most up to date list of available devices in the LMK04000 Family.

Table 2. LMK040xxB Clock Output Configuration

| Part Number | CLKout0 | CLKout1 | CLKout2 | CLKout3 | CLKout4 | VCO Frequency |
|--------------|-------------------|-------------------|-------------------|-------------------|-------------------|---------------------|
| LMK04000BISQ | LVPECL/ 2VPECL | LVC MOS (x2) | LVC MOS (x2) | LVPECL/ 2VPECL | LVPECL/ 2VPECL | 1185 to 1296 MHz |
| LMK04001BISQ | LVPECL/ 2VPECL | LVC MOS (x2) | LVC MOS (x2) | LVPECL/ 2VPECL | LVPECL/ 2VPECL | 1430 to 1570 MHz |
| LMK04002BISQ | LVPECL/ 2VPECL | LVC MOS (x2) | LVC MOS (x2) | LVPECL/ 2VPECL | LVPECL/ 2VPECL | 1566 to 1724 MHz |
| LMK04010BISQ | LVPECL/ 2VPECL | LVPECL/ 2VPECL | LVPECL/ 2VPECL | LVPECL/ 2VPECL | LVPECL/ 2VPECL | 1185 to 1296 MHz |
| LMK04011BISQ | LVPECL/ 2VPECL | LVPECL/ 2VPECL | LVPECL/ 2VPECL | LVPECL/ 2VPECL | LVPECL/ 2VPECL | 1430 to 1570 MHz |
| LMK04031BISQ | LVDS | LVPECL/ 2VPECL | LVC MOS (x2) | LVPECL/ 2VPECL | LVDS | 1430 to 1570 MHz |
| LMK04033BISQ | LVDS | LVPECL/ 2VPECL | LVC MOS (x2) | LVPECL/ 2VPECL | LVDS | 1840 to 2160 MHz |

Note: LVPECL/2VPECL is software programmable.

Quick Start

Full evaluation board instructions with data are downloadable from the product folder of the device at National Semiconductor's website, www.national.com/.

1. Connect a voltage of 3.3 volts to either the Vcc SMA connector or the alternate connector.
2. Connect a reference clock from a signal generator or other source. Exact frequency depends on programming. Default modes use a 122.88 MHz reference.
3. Connect the uWire header to a computer parallel port with the CodeLoader cable. A USB communication option is available, search at www.national.com/ for: USB2UWIRE-IFACE.
4. Program the device with CodeLoader. Ctrl-L must be pressed at least once to load all registers once after CodeLoader is started or after restoring a Mode. CodeLoader is available for download at www.national.com/timing/software/.
5. Measurements may be made at any clock output or Fout if enabled by programming.

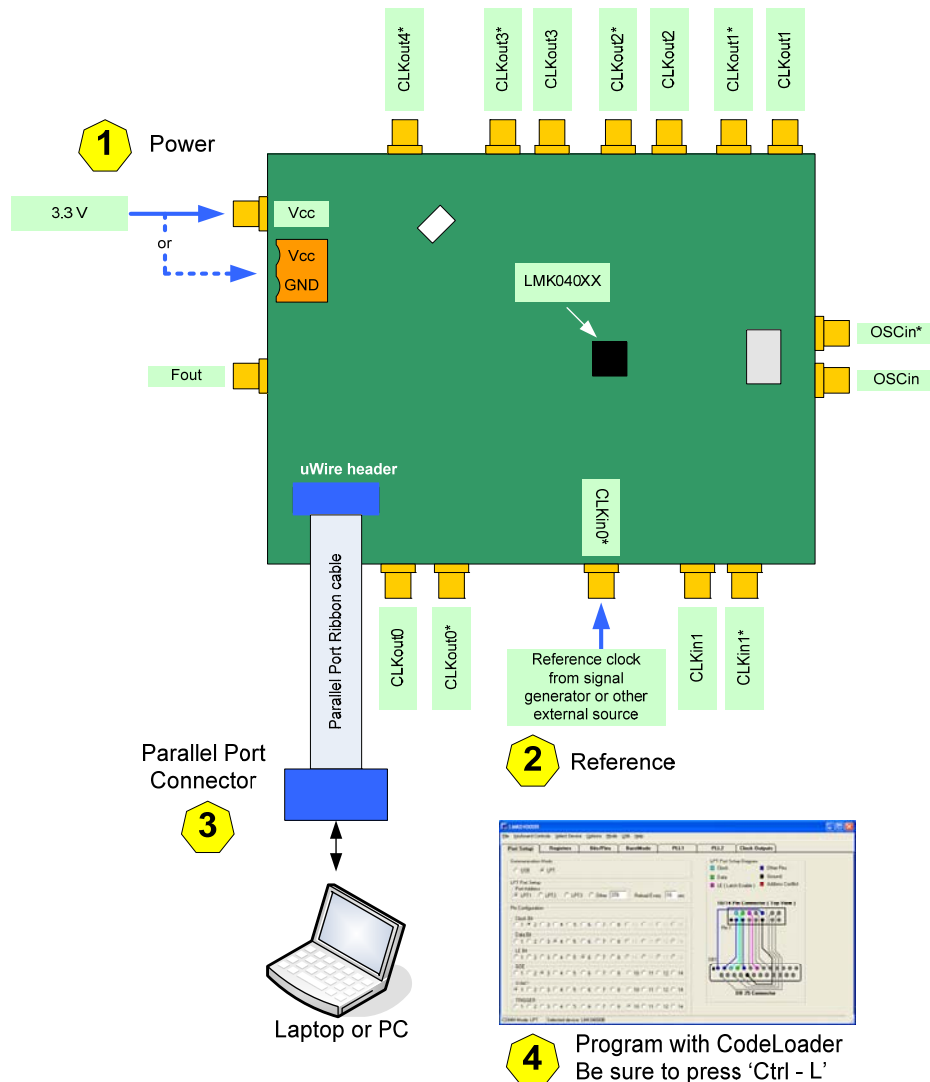


Figure 1 - Quick Start Diagram

Default CodeLoader modes for evaluation boards

CodeLoader saves the state of the device when exiting the software. To ensure a common starting point, the following modes listed in Table 3 may be restored by clicking “Mode” → <Default Mode for evaluation board>.

After restoring a mode, be sure to press Ctrl-L to program the device. The default modes also disable all outputs, so be sure to enable an output to make measurements.

Table 3 - Default Evaluation Board Modes

| Evaluation Board NSID | Default Mode |
|------------------------------|---|
| LMK04000BEVAL | 122.88 MHz VCXO Default |
| LMK04000BEVAL-XO | 12.288 MHz Crystal Default, or 12.288 MHz Crystal with Doubler Default |
| LMK04031BEVAL | 122.88 MHz VCXO Default |
| LMK04031BEVAL-XO | 12.288 MHz Crystal Default, or 12.288 MHz Crystal with Doubler Default |
| LMK04002BEVAL | 122.88 MHz VCXO Default |
| LMK04033BEVAL | 122.88 MHz VCXO Default |

The next section outlines step-by-step procedures for using an LMK04031B evaluation board. The process is the same for other evaluation boards except the part number is different.

Using CodeLoader to Program the LMK040xxB

The purpose of this section is to walk the user through using CodeLoader to make some measurements with the LMK040xxB device. For more information on CodeLoader refer to Appendix A: CodeLoader Usage or the CodeLoader 4 instructions located at <http://www.national.com/timing/software/>.

Before proceeding, be sure to follow the Quick Start section above to ensure proper connections.

1. Start CodeLoader 4 Application

Click “Start” → “Programs” → “CodeLoader 4” → “CodeLoader 4”

The CodeLoader 4 program is installed by default to the CodeLoader 4 application group.

2. Select Device

Click “Select Device” → “Clock Conditioners” → “LMK04031B”

Once started CodeLoader 4 will load the last used device. To load a new device click “Select Device” from the menu bar, then select the subgroup and finally device to load. For this example, the LMK04031B is chosen. Selecting the device does cause the device to be programmed.

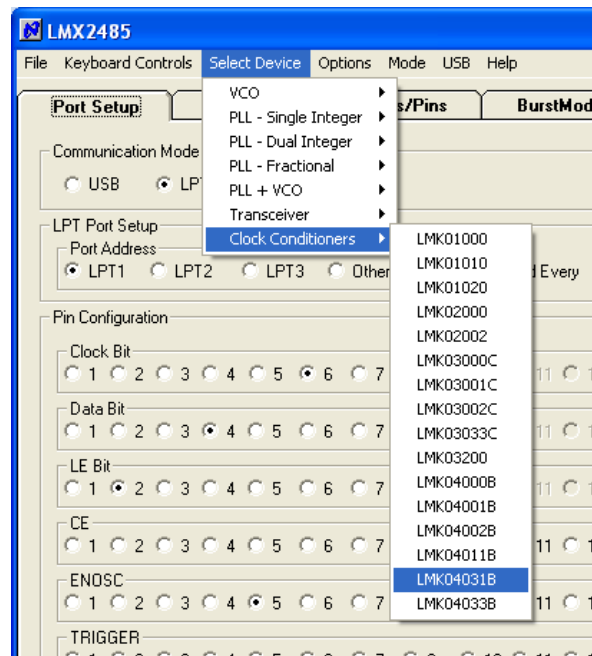


Figure 2 – Selecting the LMK04031B

3. Program/Load Device

Press “Ctrl – L”

Assuming the Port Settings are correct, it is now possible to click “Keyboard Controls” → “Load Device” from the menu to program the device to the current state of the newly loaded LMK04031B file. Ctrl-L is the accelerator assigned to the Load Device option and is very convenient.

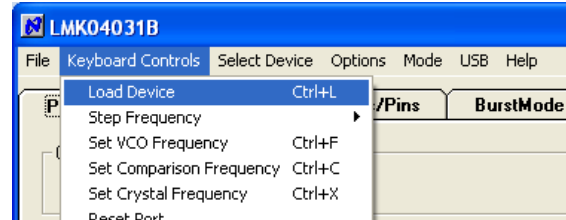


Figure 3 - Loading the Device

Once the device has been loaded, by default CodeLoader will automatically program changed registers, so it is not necessary to load the device again completely. It is possible to disable this functionality by ensuring there is no checkmark by the “Mode” → “AutoReload with Changes.”

Since a default mode will be restored in the next step, this step isn’t really needed but included to emphasize the importance of pressing “Ctrl-L” to load the device at least once after starting CodeLoader, restoring a mode, or restoring a saved setup using the File menu.

See Appendix A: CodeLoader Usage or the CodeLoader 4 instructions located at <http://www.national.com/timing/software/> for more information on port setup. Appendix J: Troubleshooting Information contains information on troubleshooting communications.

4. Restoring a Default Mode

Click “Mode” → “122.88 MHz VCXO Default”; then Press “Ctrl – L”

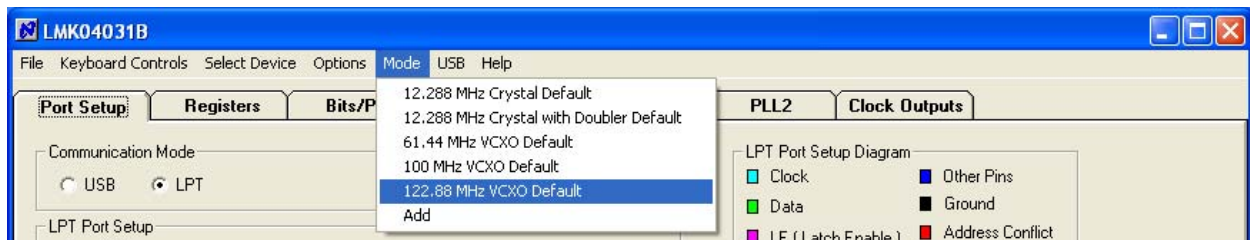


Figure 4 – Setting the 122.88 MHz VCXO Default mode

For the purposes of this walkthrough a default mode will be loaded to ensure a common starting point. This is important because when CodeLoader is closed, it remembers the last settings used for a particular device. By loading the default mode a common starting point is ensured.

Loading a mode does not automatically program the device so it is necessary to press “Ctrl – L” again to program the device.

5. Visual Confirmation of Frequency Lock

After a device is selected and a default mode restored and loaded, the visual display on the board should indicate a clock present at CLKIn0 (LED D3 off) and that the PLL is locked (LED D1 on). D1 will be on because the mode default sets PLL_MUX = PLL1/2 DLD Active High.

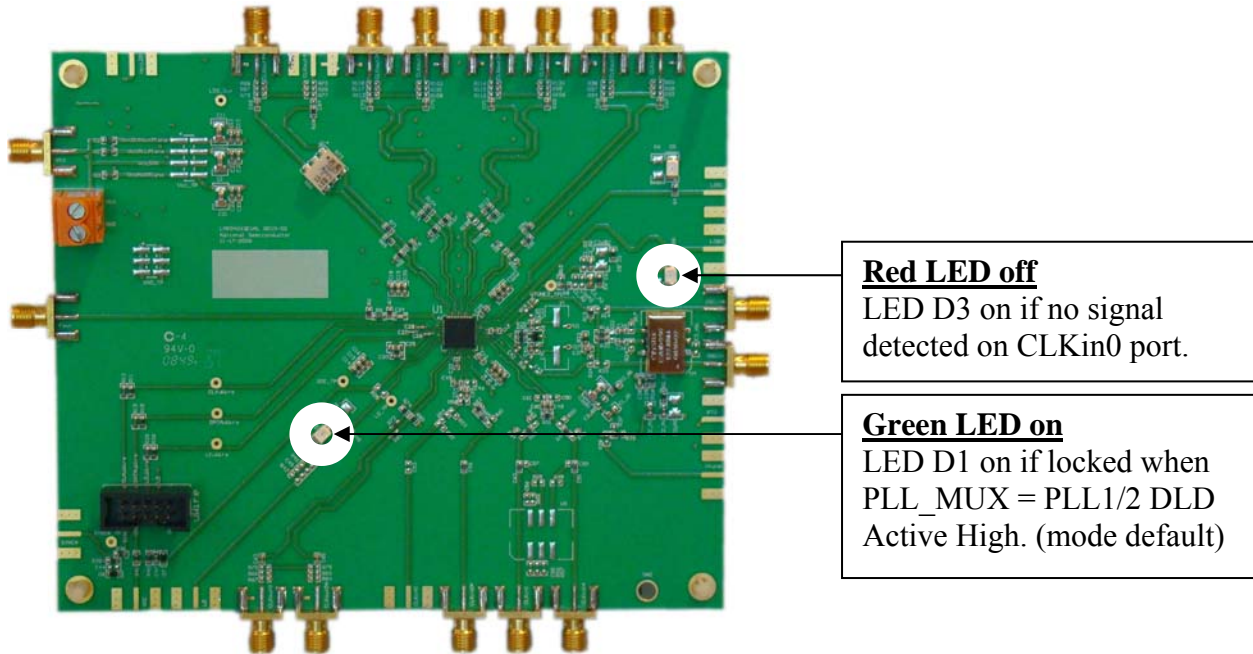


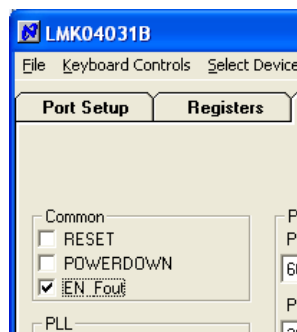
Figure 5 – Visual indicators of proper operation of evaluation board

6. Enable Fout

To measure the phase noise of the VCO,

1. Go to the Bits/Pins tab and enable the “EN_Fout” bit.
2. Connect the Fout SMA on the left hand side of the board to a spectrum analyzer or signal source analyzer.

See Appendix B: Typical Phase Noise Performance Plots for phase noise plots of the VCO.



7. Enable Clock Outputs

To measure phase noise at the clock outputs,

1. Click on the “Clock Outputs” tab,
2. Enable an output,
3. Then set the
 - a. CLKout MUX mode,
 - b. divide value, and
 - c. delay value.

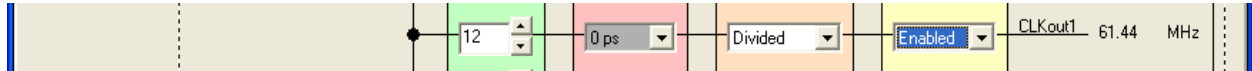


Figure 6 - Setting Divide, Delay, CLKout_MUX, Enabled for CLKout1 on "Clock Outputs" tab.

4. Connect the clock output SMAs to a spectrum analyzer or signal source analyzer.
 - a. For LVDS, a balun is recommended such as the ADT2-1T.
 - b. For LVPECL,
 - i. A balun can be used, or
 - ii. One side of the LVPECL signal can be terminated with a 50 ohm load and the other side can be run to the test equipment single ended.
 - c. For LVCMOS,
 - i. Only one side of the LVCMOS signal can be turned on by setting the CLKout_#a / CLKout_#b states in the CLKout CMOS Options on the Bits/Pins tab.
 - ii. One side of the LVCMOS signal can be terminated with a 50 ohm load and the other side can be run to the test equipment single ended.
 - iii. A balun may be used. Ensure CLKout_#a and CLKout_#b states are complementary, for example: Non-inverted and Inverted.
5. The phase noise may be measured with a spectrum analyzer or signal source analyzer.

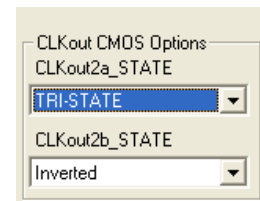


Figure 7 - Setting LVCMOS modes.

See Appendix B: Typical Phase Noise Performance Plots for phase noise plots of the clock outputs.

National’s Clock Design Tool can be used to calculate divider values to achieve desired clock output frequencies. See: <http://www.national.com/timing/software/>.

PLL Loop Filters and Loop Parameters

In jitter cleaning applications that use a cascaded PLL architecture, the first PLL’s purpose is to substitute the phase noise of a low noise oscillator (VCXO or crystal resonator) for the phase noise of a “dirty” reference clock. The first PLL is typically configured with a narrow loop bandwidth in order to minimize the impact of the reference clock phase noise. The reference clock consequently serves only as a frequency reference rather than a phase reference.

The loop filters on the LMK040xx evaluation board are setup using the approach above. The loop filter for PLL1 has been configured for a narrow loop bandwidth (< 100 Hz), while the loop filter of PLL2 has been configured for a wide loop bandwidth (> 100 kHz). The specific loop bandwidth values depend on the phase noise performance of the oscillator mounted on the board. The following tables contain the parameters for PLL1 and PLL2 for each oscillator option.

National’s Clock Design Tool can be used to optimize PLL phase noise/jitter for given specifications. See: <http://www.national.com/timing/software/>.

PLL 1 Loop Filter

Table 4. PLL1 Loop Filter Parameters for Crystek 122.88 MHz VCXO and 12.288 MHz Vectron Crystal

| 122.88 MHz VCXO option | | | |
|---------------------------------|-------------|------------------------|-----------------------|
| Phase Margin | 50° | K ϕ (Charge Pump) | 100 uA |
| Loop Bandwidth | 12 Hz | Phase Detector Freq | 1.024 MHz |
| | | VCO Gain | 2.5 kHz/Volt |
| Reference Clock Frequency | 122.88 MHz | Output Frequency | 122.88 MHz (To PLL 2) |
| Loop Filter Components | C1 = 100 nF | C2 = 680 nF | R2 = 39 k Ω |
| 12.288 MHz Crystal (-XO) option | | | |
| Phase Margin | 60° | K ϕ (Charge Pump) | 100 uA |
| Loop Bandwidth | 8 Hz | Phase Detector Freq | 1.024 MHz |
| | | VCO Gain | 1.5 kHz/Volt |
| Reference Clock Frequency | 122.88 MHz | Output Frequency | 12.288 MHz (To PLL 2) |
| Loop Filter Components | C1 = 330 nF | C2 = 10 uF | R2 = 3.9 k Ω |

Note: PLL Loop Bandwidth is a function of K ϕ , K ν_{co} , N as well as loop components. Changing K ϕ and N will change the loop bandwidth.



PLL2 Loop Filter

| 122.88 MHz VCXO (Reference Input) | | | | | |
|-----------------------------------|-----------|-----------|-----------|-----------|------------|
| | LMK040x0B | LMK040x1B | LMK040x2B | LMK040x3B | Units |
| C1 | Open | | | | |
| C2 | 12 | | | | nF |
| C3 | 0 | | | | nF |
| C4 | 0.01 | | | | nF |
| R2 | 1.8 | | | | k Ω |
| R3 | 0.6 | | | | k Ω |
| R4 | 0.2 | | | | k Ω |
| Charge Pump Current, $K\phi$ | 3.2 | | | | mA |
| Phase Detector Frequency | 61.44 | | | | MHz |
| Frequency | 1228.8 | 1474.56 | 1720.32 | 1966.08 | MHz |
| K_{vco} | 8 | 9 | 13 | 19 | MHz/V |
| N | 20 | 24 | 28 | 32 | |
| Phase Margin | 85.5 | 85.5 | 85.0 | 84.0 | degrees |
| Loop Bandwidth | 366 | 343 | 424 | 542 | kHz |

| 12.288 MHz Crystal (-XO) option (Reference Input) | | | | | |
|---|-----------|-----------|-----------|-----------|------------|
| | LMK040x0B | LMK040x1B | LMK040x2B | LMK040x3B | Units |
| C1 | Open | | | | |
| C2 | 6.8 | | | | nF |
| C3 | 0 | | | | nF |
| C4 | 0.01 | | | | nF |
| R2 | 2.7 | | | | k Ω |
| R3 | 0.6 | | | | k Ω |
| R4 | 0.2 | | | | k Ω |
| Charge Pump Current, $K\phi$ | 3.2 | | | | mA |
| Phase Detector Frequency | 12.288 | | | | MHz |
| Frequency | 1228.8 | 1474.56 | 1720.32 | 1966.08 | MHz |
| K_{vco} | 8 | 9 | 13 | 19 | MHz/V |
| N | 100 | 120 | 140 | 160 | |
| Phase Margin | 62 | 63 | 60 | 56 | degrees |
| Loop Bandwidth | 98 | 93 | 112 | 136 | kHz |

Note: PLL Loop Bandwidth is a function of $K\phi$, K_{vco} , N as well as loop components. Changing $K\phi$ and N will change the loop bandwidth.

Evaluation Board Inputs/Outputs

The following table contains descriptions of the various inputs and outputs for the evaluation board.

Table 5. LMK040xx Evaluation Board I/O

| Connector Name | Input/Output | Description |
|---|--------------|--|
| CLKout0 / CLKout0* CLKout1 / CLKout1* CLKout2 / CLKout2* CLKout3 / CLKout3* CLKout4 / CLKout4* | Output | <p>Populated connectors.</p> <p>Differential clock output pairs. See Table 2 for format of the output depending on part number. If an LVCMOS output, each output can be independently configured (non-inverted, inverted, tri-state, and LOW).</p> <p>On the evaluation board, all clock outputs are AC-coupled to allow safe testing with RF test equipment.</p> <ul style="list-style-type: none"> All LVPECL/2VPECL clock outputs are terminated to GND with a 120 ohm resistor, one on each output pin of the pair. <p>CLKout4 is configured with an on board balun. Part number is Mini-circuits' ADT2-1T. According to the ADT2-1T datasheet the 3 dB frequency range is 0.4 to 450 MHz. See Appendix F: Balun Information for more detail.</p> |
| Fout | Output | <p>Populated connector.</p> <p>When enabled, buffered VCO output. AC-coupled. The default configuration on the board contains a 3-dB attenuator on the Fout signal.</p> |
| Vcc | Input | <p>Populated connector.</p> <p>DC power supply for the PCB. Removing R1, R2, or R3 allow for splitting the power to various devices on the board. For example, the VCXO is powered from the VccAUXPlane connected via R3.</p> <p>Note: The LMK04000 Family contains internal voltage regulators for the VCO, PLL and related circuitry. The clock outputs do not have an internal regulator. A clean power supply is required for best performance.</p> |
| VccLDO | Input | <p>Unpopulated connector.</p> <p>Vcc input for LDOs on bottom of PCB. Refer to schematics for more information.</p> |



| Connector Name | Input/Output | Description | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---------------------------------------|--------------|---|---------------------------------------|-------|--|--|--|-------|------|-----|-----|-------|--------------|---------|------|-----|-----|--------------|-----|------|-----|-----|--------------|---------|-----|-----|-----|--------------|-----|-----|-----|-----|
| CLKin0/CLKin0*, CLKin1/CLKin1* | Input | <p>Populated connectors.</p> <p>Reference clock inputs for PLL1. The default board configuration is setup for a single-ended reference source at CLKin0* (CLKin0 pin is AC-coupled to ground). The mode of the clock input buffer is programmable in CodeLoader on the Bits/Pins tab, and may be either bipolar junction mode or MOS mode.</p> <p>The input level for the various modes is as in the datasheet:</p> <table border="1"> <thead> <tr> <th colspan="5">AC Coupled Input Clock Voltage Levels</th> </tr> <tr> <th>Input</th> <th>Mode</th> <th>Min</th> <th>Max</th> <th>Units</th> </tr> </thead> <tbody> <tr> <td>Differential</td> <td>Bipolar</td> <td>0.25</td> <td>2.0</td> <td>Vpp</td> </tr> <tr> <td>Differential</td> <td>MOS</td> <td>0.25</td> <td>2.0</td> <td>Vpp</td> </tr> <tr> <td>Single Ended</td> <td>Bipolar</td> <td>0.5</td> <td>3.1</td> <td>Vpp</td> </tr> <tr> <td>Single Ended</td> <td>MOS</td> <td>0.5</td> <td>3.1</td> <td>Vpp</td> </tr> </tbody> </table> <p>If a DC-coupled clock is used to drive either of the inputs, the high voltage level must be at least 2 volts and the low voltage no greater than 0.4 volts.</p> <p>By default CLKin0 is the active input in either of the auto-switching modes (<i>CLKin0 non-revertive</i>, <i>CLKin0 revertive</i>). When loss of CLKin0 is detected, the device automatically switches to CLKin1 if an active reference clock is attached. See datasheet for further explanation.</p> | AC Coupled Input Clock Voltage Levels | | | | | Input | Mode | Min | Max | Units | Differential | Bipolar | 0.25 | 2.0 | Vpp | Differential | MOS | 0.25 | 2.0 | Vpp | Single Ended | Bipolar | 0.5 | 3.1 | Vpp | Single Ended | MOS | 0.5 | 3.1 | Vpp |
| AC Coupled Input Clock Voltage Levels | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Input | Mode | Min | Max | Units | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Differential | Bipolar | 0.25 | 2.0 | Vpp | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Differential | MOS | 0.25 | 2.0 | Vpp | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Single Ended | Bipolar | 0.5 | 3.1 | Vpp | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Single Ended | MOS | 0.5 | 3.1 | Vpp | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| LOS0, LOS1 | Output | <p>Unpopulated connectors.</p> <p>Loss-of-Signal indicator (when LOS_TYPE = Active CMOS, default) for CLKin0/0* and CLKin1/1*. The LEDs D5 and D3 are light red when no signal is detected according to the datasheet specification for LOS pins. Bits/Pins, LOS_TYPE = Active CMOS for default operation.</p> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| OSCin/OSCin* | Input | <p>Populated connectors.</p> <p>By altering the PCB an external VCXO may be attached to the OSCin/OSCin* SMA connectors. Either a differential or single-ended device may be used. If a single-end device is used, OSCin* should be tied to GND through a capacitor that matches the AC-coupling capacitor value used for the OSCin pin. See datasheet for OSCin port signal specifications.</p> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |



| Connector Name | Input/Output | Description |
|----------------|--------------|---|
| Vtune1 | Output | <p>Unpopulated connector.</p> <p>Tuning voltage output from the loop filter for PLL1. If an external VCXO is used, this tuning voltage should be connected to the voltage control pin of the external VCXO.</p> <p>Note: Resistor R38 must be populated with a zero ohm resistor to control an off-board VCXO.</p> |
| uWire | Input/Output | <p>Populated connector.</p> <p>10-pin header programming interface for the board. Of most important are the CLKuWire, DATAuWire, and LEuWire programming lines from this header. Each of these signals, GEO, and SYNC* can be monitored through test points on the board.</p> |
| LD | Output | <p>Unpopulated connector.</p> <p>The LD pin is attached to a multiplexer inside the device and may be programmed with a variety of internal signals for monitoring internal device functions and troubleshooting. See datasheet for further explanation.</p> <p>The <i>lock detect</i> signal is accessible through this pin.</p> |
| LD_TP | Output | <p>Test point attached to the LD pin of the device. See LD above for more information.</p> |
| GOE | Input | <p>Unpopulated connector.</p> <p>Access to GOE of device.</p> |
| SYNC* | Input | <p>Unpopulated connector.</p> <p>Access to SYNC* of device.</p> |
| PTO | Output | <p>Unpopulated connector.</p> <p>Vcc SMA located close to OSCin SMAs for powering external oscillator boards.</p> |



Recommended Test Equipment

Power Supply

The Power Supply should be a low noise power supply.

Phase Noise / Spectrum Analyzer

For measuring phase noise an Agilent E5052A Signal Source Analyzer is recommended. An Agilent E4445A PSA Spectrum Analyzer with the Phase Noise option is also usable although the architecture of the E5052A is superior for phase noise measurements. At frequencies less than 100 MHz the local oscillator noise of the E4445A is too high and measurements will reflect the E4445A's internal local oscillator performance, not the device under test.

Appendix A: CodeLoader Usage

Code Loader is used to program the evaluation board with either an LPT port using the included CodeLoader cable or with a USB port using the optional USB <--> uWire cable available from <http://store.national.com/>. The part number is USB2UWIRE-IFACE.

Port Setup Tab

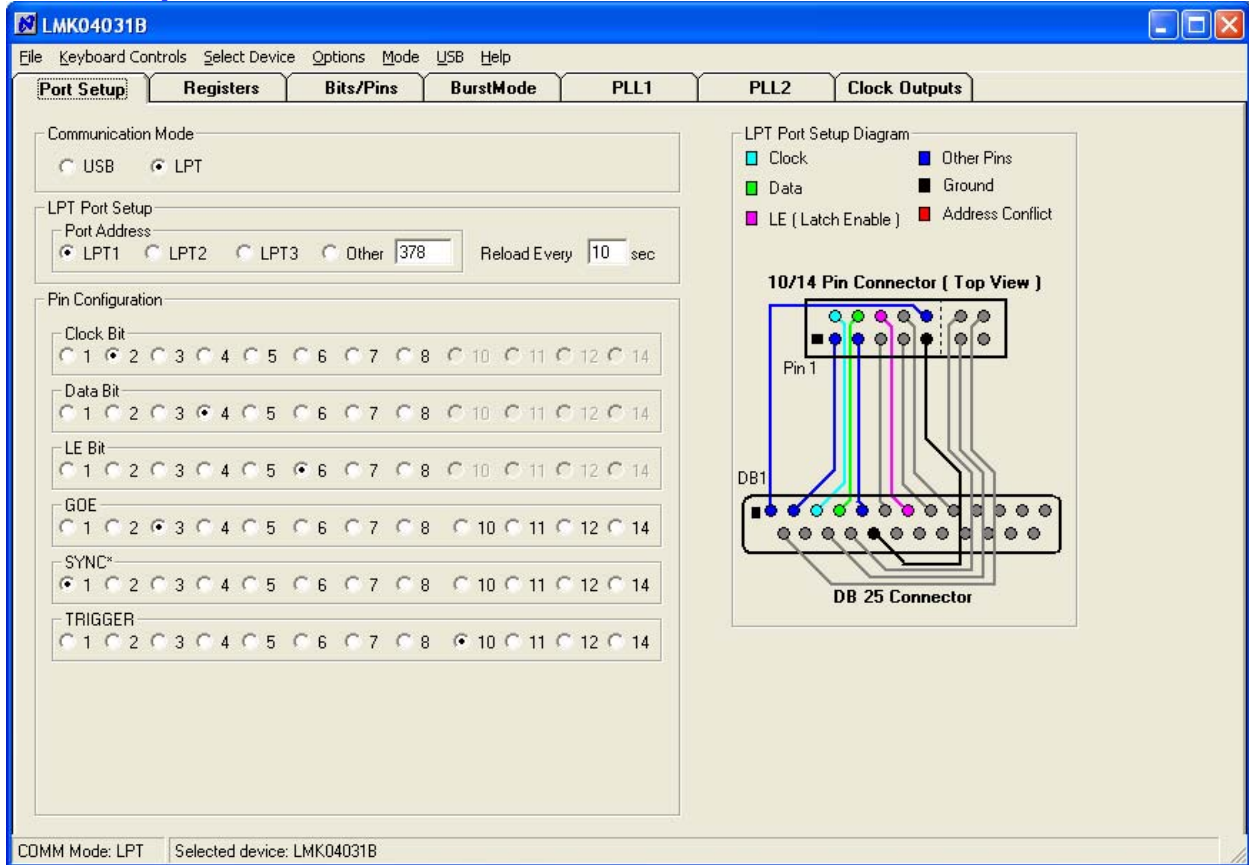


Figure 8 - Port Setup tab

On the Port Setup tab, the user may select the type of communication port (USB or Parallel) that will be used to program the device on the evaluation board. If parallel port is selected, the user should ensure that the correct port address is entered.

The Pin Configuration field is hardware dependent and normally SHOULD NOT be changed by the user. Figure 8 shows the default settings.

Clock Outputs Tab

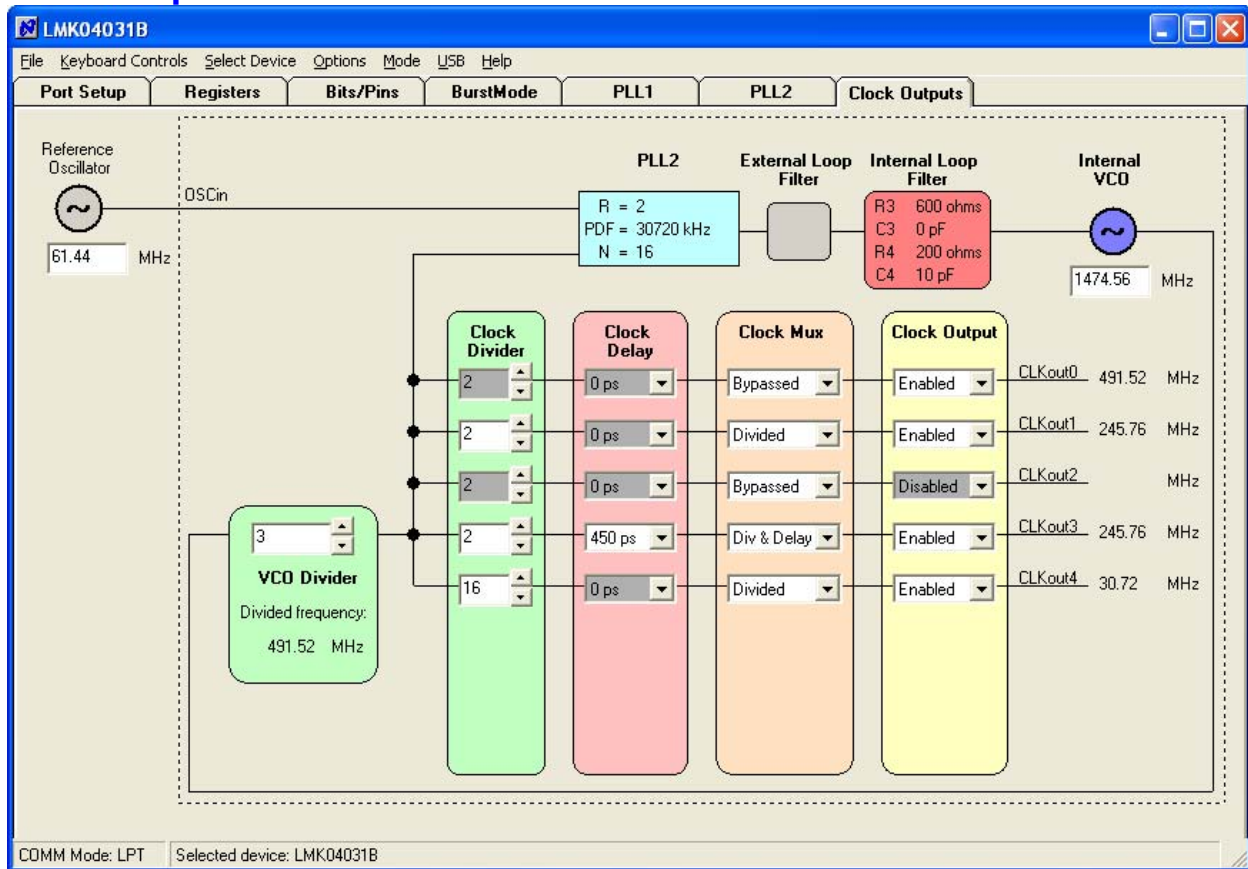


Figure 9 - Clock Outputs tab

The clock outputs tab allows the user to Enable/Disable individual clock outputs, select the clock mode (Bypass/Divided/Delayed/Divided & Delayed), set the clock output delay value (if delay is enabled), and the clock output divider value (2, 4, 6, ..., 510).

This tab also allows the user to select the VCO Divider value (2, 3, ..., 8). Note that the total PLL2 N divider value is composed of both the VCO Divider value and the N value shown in the blue box in the image, and is given by: $N_TOTAL = VCO\ Divider * N$.

Clicking on the blue box that contains R, PDF and N values takes the user to the PLL2 tab where these values may be changed.

Clicking on the components in the box containing the Internal Loop Filter values allows the user to change these component values.

The Reference Oscillator value field may be changed in either the Clock Outputs tab or the PLL2 tab. Note this value should match the value of the on-board VCXO or Crystal. **When using the EN_PLL2_REF2X = 1**, then Reference Oscillator field should be twice the VCXO or Crystal frequency.

PLL1 Tab

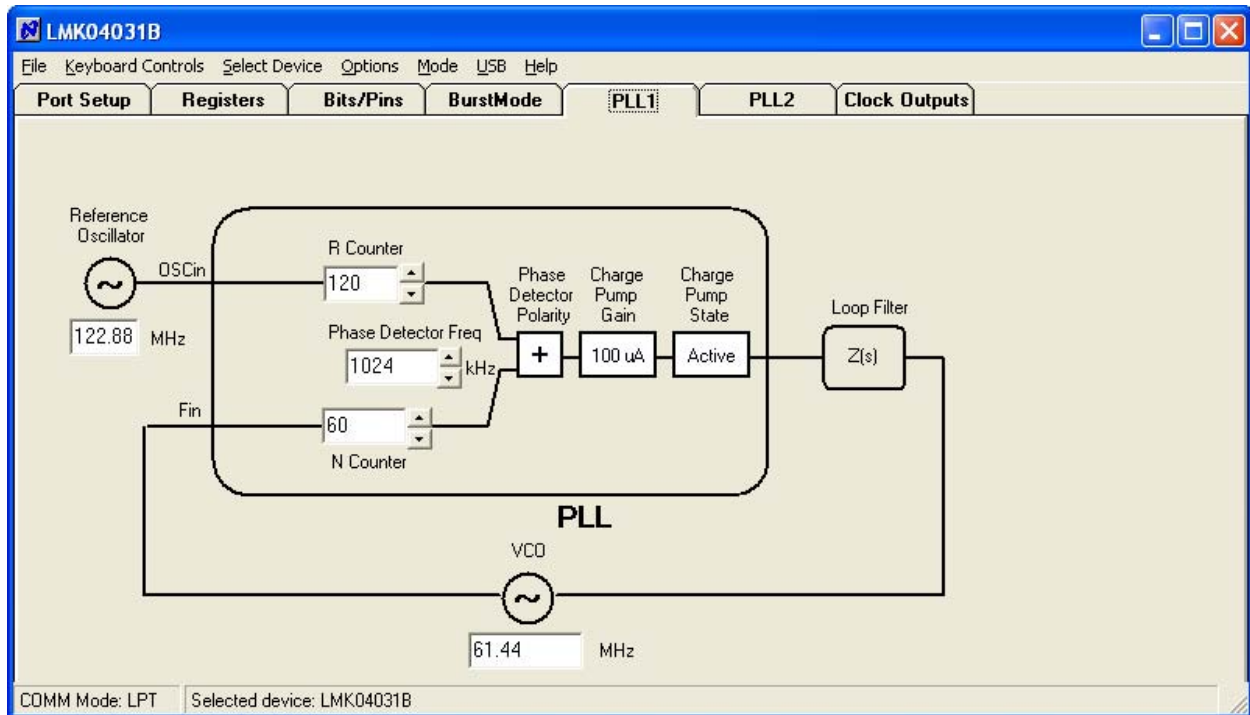


Figure 10 - PLL1 tab.

The PLL1 tab allows the user to change:

- External VCXO (or Crystal oscillator) frequency. *Note: This value must be entered in both the PLL1 and PLL2 tabs.*
- PLL1 Phase detector frequency
- PLL1 R-counter value
- PLL1 N-counter value
- CLKin (Reference) oscillator frequency
- PLL1 Phase Detector polarity (for external VCXO tuning slope, click on the polarity value)
- PLL1 Charge pump gain (left click and right click on the charge pump current value)
- PLL1 Charge pump state (click on the charge pump state value)

Note that the value entered in the **VCO** frequency field on the PLL1 tab must match the **Reference Oscillator** frequency entered on the PLL2 tab and the OSCin_FREQ on the Bits/Pins tab. Updating the PLL2 tab Reference Oscillator frequency will automatically update the value of OSCin_FREQ on the Bits/Pins tab. The only time that the Reference Oscillator frequency of PLL2 tab will be different from the VCO frequency of PLL1 is when the EN_PLL2_REF2X mode is enabled.

PLL2 Tab

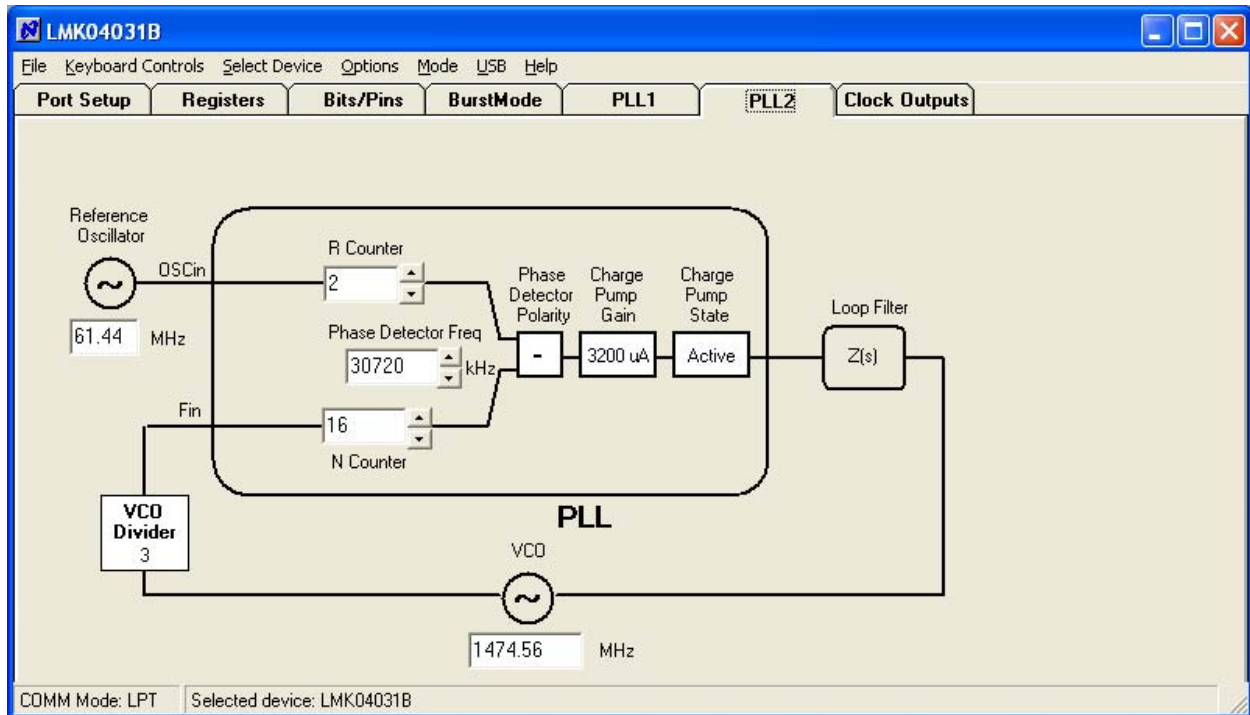


Figure 11 - PLL2 tab.

The PLL2 tab allows the user to change:

- VCO frequency
- PLL2 Phase detector frequency
- PLL2 R-counter value
- PLL2 N-counter value
- The frequency of the external VCXO (or XTAL oscillator). **Note: This value must be entered in both the PLL1 and PLL2 tabs.**
- PLL2 Charge pump gain
- PLL2 Charge pump state

Any changes made on this tab are reflected in the Clock Outputs tab. Note that the PLL2 Phase Detector polarity is fixed and cannot be changed by the user. Also note that the VCO frequency should conform to the specified frequency range for the device.

Note that the value entered in the **VCO** frequency field on the PLL1 tab must match the **Reference Oscillator** frequency entered on the PLL2 tab and the OSCin_FREQ on the Bits/Pins tab. Updating the PLL2 tab Reference Oscillator frequency will automatically update the value of OSCin_FREQ on the Bits/Pins tab. The only time that the Reference Oscillator frequency of PLL2 tab will be different from the VCO frequency of PLL1 is when the EN_PLL2_REF2X mode is enabled.

Bits/Pins Tab

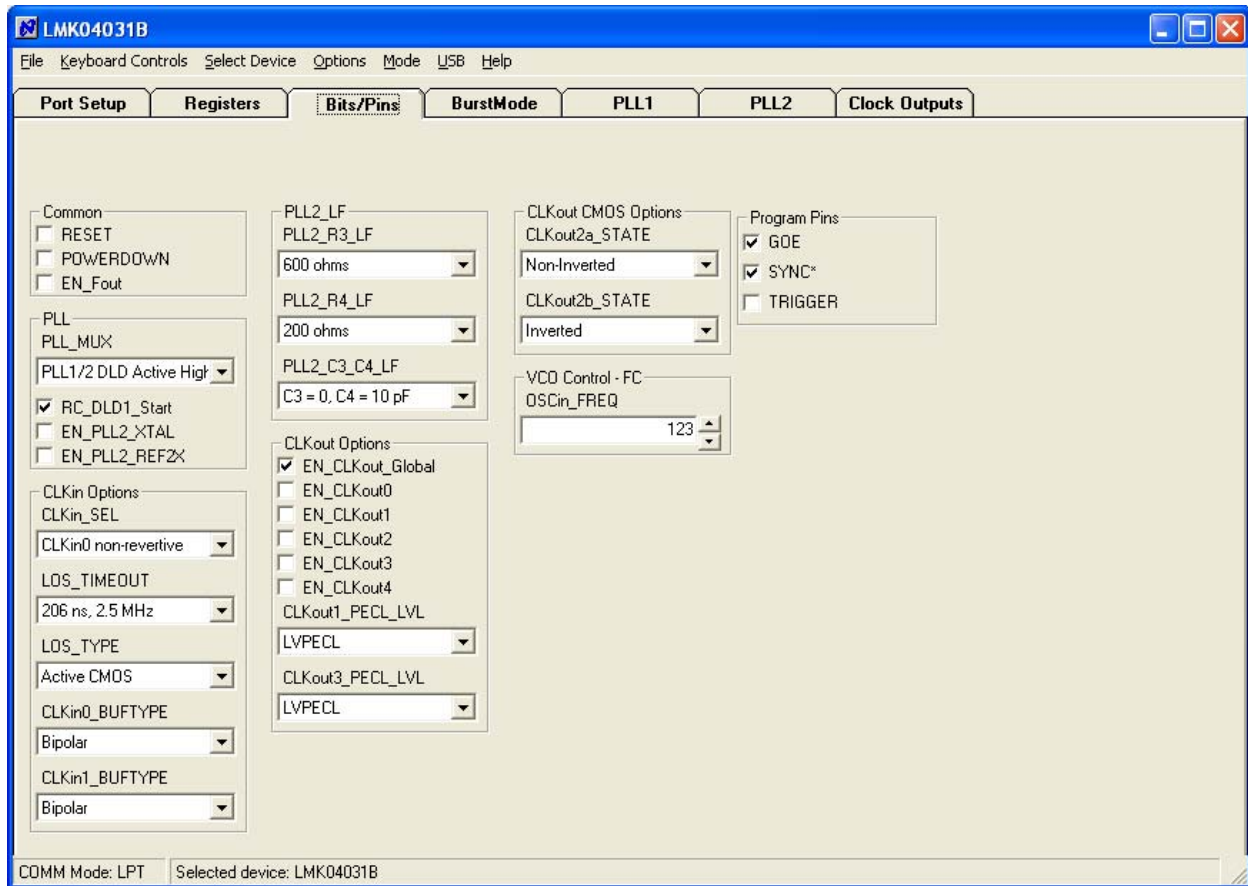


Figure 12 - Bits/Pins tab.

The Bits/Pins tab allows the user to program bits directly. Many of which are not available on other tabs. Refer to the datasheet for more detailed information. The bits available are:

- Common Box
 - RESET - Set the reset bit. This will reset the device. In a normal application it is not necessary to program this bit clear since it is auto-clearing. However in the CodeLoader software, RESET must be clicked again (cleared) to not cause a reset every time R7 is programmed.
 - POWERDOWN - Place the device in powerdown mode.
 - EN_Fout – Enable the Fout port.
- PLL Box
 - PLL_MUX – Set the function of the LD pin.
 - RC_DLD1_Start – Prevent PLL2 from locking until digital lock detect from PLL1 is achieved.
 - EN_PLL2_XTAL – Enables Crystal mode for PLL2. For use with Crystals as opposed to a VCXO.
 - EN_PLL2_REF2X – Doubles the reference frequency of PLL2. Note with this is enabled, the PLL_R value is invalid. Program the Reference Oscillator on PLL2 Tab to be twice the VCO frequency on PLL1 tab. This adjustment must be done manually.



- CLKin Options Box
 - CLKin_SEL – Sets manual or automatic switching modes for selecting a reference oscillator for PLL1.
 - LOS_TIMEOUT – The timeout value before a loss of signal on a clock input is registered on the LOS pins.
 - LOS_TYPE – Set the type of output for the LOS pins.
 - CLKin0_BUFTYPE & CLKin1_BUFTYPE – Select the input buffer used for the respective clock input.
- PLL2_LF Box
 - Set the integrated loop filter values for PLL2 including,
 - PLL2_R3_LF – R3 value
 - PLL2_R4_LF – R4 value
 - PLL2_C3_C4_LF – C3 and C4 value at the same time
 - It is also possible to set these values by clicking on the loop filter values on the Clock Outputs tab.
- CLKout Options Box
 - EN_CLKout_Global – A global enable for clocks, **if unchecked no outputs will be observed!**
 - EN_CLKout0 through EN_CLKout4 – Individual clock output enables. These can also be set on the Clock Outputs tab.
 - The number of options vary depending on the option of the LMK device selected.
 - CLKout#_PECL_LVL – Set the level of an LVPECL output to LVPECL or 2VPECL. The 2VPECL a higher output level than LVPECL.
- CLKout CMOS Options Box
 - The presence of this box and the number of options on this tab depends upon the option of the LMK device.
 - CLKout##_STATE – Set the state of the individual LVCMOS output.
- VCO Control – FC Box
 - OSCin_FREQ – Must be set to the reference frequency of PLL2 in MHz, which should normally be the VCO frequency of PLL1. **NOTE: It is important to enter the correct frequency value in this field, as it is used by the internal state machine of the LMK040xxB to execute its calibration routine for the internal VCO.** An incorrect value may result in an unlocked condition for the synthesizer.
 - Entering a reference oscillator frequency on PLL2 tab will automatically update this register with the frequency to the nearest MHz.
- Program Pins Box
 - GOE – Set high or low voltage on GOE pin. Checked is high voltage.
 - If GOE is low, then no clock outputs will be observed!
 - SYNC* – Set high or low voltage on SYNC* pin. Checked is high voltage.
 - If SYNC* is low, then no clock outputs will be observed on divided clock outputs!
 - TRIGGER – Set high or low voltage on pin 10 of uWire header.

Registers Tab

MSB --> 3 3 2 2 2 2 2 2 2 2 2 2 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0

1 0 9 8 7 6 5 4 3 2 1 0 9 8 7 6 5 4 3 2 1 0 9 8 7 6 5 4 3 2 1 0

| Register | Bit Field | Load | Hex Value |
|-----------|---|------|-----------------------|
| R7 (INIT) | 0 1 0 1 1 1 | Load | R7 (INIT) 0x0000 0017 |
| R0 | 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 | Load | R0 0x0100 0100 |
| R1 | 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 | Load | R1 0x0108 0101 |
| R2 | 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 | Load | R2 0x0108 0102 |
| R3 | 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 1 | Load | R3 0x0108 0103 |
| R4 | 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 | Load | R4 0x0100 0104 |
| R7 | 0 1 1 1 | Load | R7 0x0000 0007 |
| R10 | 0 0 1 0 0 0 0 1 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 | Load | R10 0x2150 000A |
| R11 | 0 0 0 0 0 0 0 0 0 1 1 0 0 1 0 1 0 0 0 0 0 0 0 0 1 1 1 1 1 0 1 0 1 1 | Load | R11 0x0065 01EB |
| R12 | 1 1 1 0 0 0 0 0 0 1 1 1 1 0 0 0 0 0 0 0 0 0 1 1 1 1 0 0 0 1 1 0 0 | Load | R12 0xE078 078C |
| R13 | 0 0 0 0 1 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 | Load | R13 0x0A04 000D |
| R14 | 0 0 0 0 1 1 1 1 0 1 1 1 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 0 | Load | R14 0x0F77 003E |
| R15 | 0 0 0 1 1 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0 1 1 1 | Load | R15 0x1C80 012F |

COMM Mode: LPT Selected device: LMK04031B

The registers tab shows the value of each register. This is convenient for programming the device to the desired settings, then recording the hex values for programming in your own application.

By clicking in the “bit field” it is possible to manually change the value of registers by typing ‘1’ and ‘0.’

Appendix B: Typical Phase Noise Performance Plots

PLL1

The LMK040xxB's two stage jitter cleaning process involves masking the reference noise with a VCXO or Crystal. Therefore the phase noise performance of the VCXO or Crystal of PLL1 is a very important contributor to the final phase noise of the system.

Crystek 122.88 MHz VCXO

The phase noise of the reference is masked by the phase noise of this VCXO by using a narrow loop bandwidth. This VCXO sets the reference noise to PLL2. Figure 13 shows the open loop typical phase noise performance of the CVHD-950-122.88 Crystek VCXO.

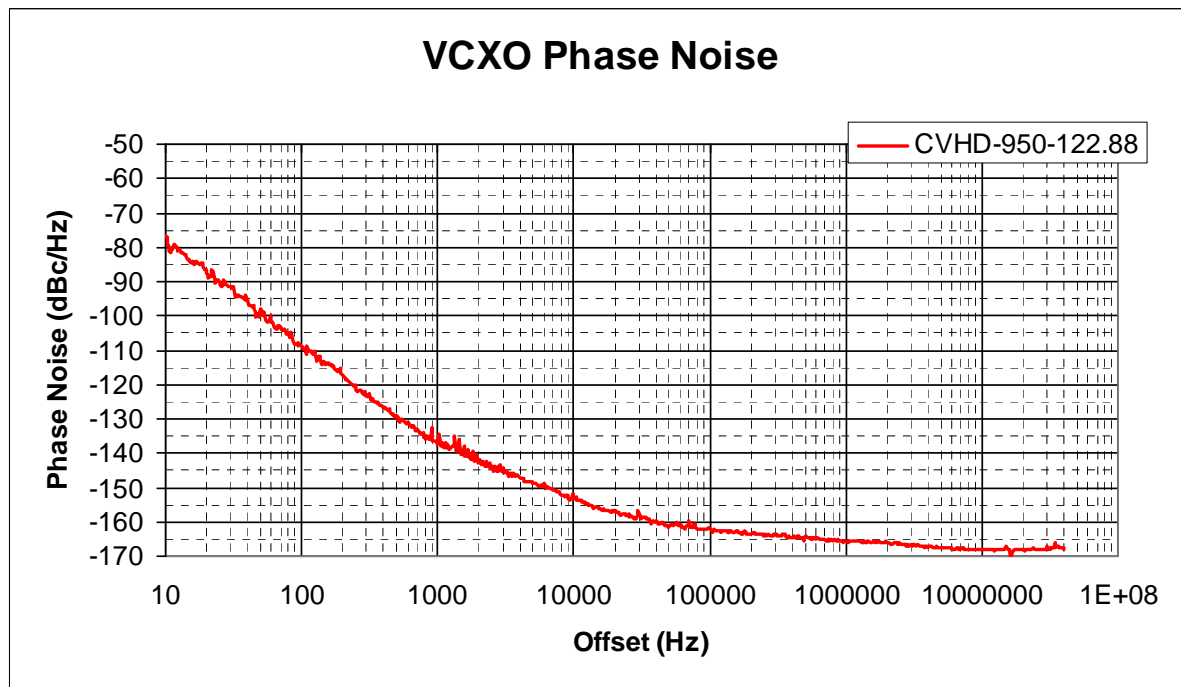


Figure 13 - CVHD-950-122.88 MHz VCXO Phase Noise at 122.88 MHz

Table 6 - VCXO Phase Noise at 122.88 MHz (dBc/Hz)

| Offset | Phase Noise |
|---------|-------------|
| 10 Hz | -76.6 |
| 100 Hz | -108.9 |
| 1 kHz | -137.4 |
| 10 kHz | -153.3 |
| 100 kHz | -162.0 |
| 1 MHz | -165.7 |
| 10 MHz | -168.1 |
| 40 MHz | -168.1 |

Table 7 - VCXO RMS Jitter to high offset of 20 MHz at 122.88 MHz (rms fs)

| Low Offset | Jitter |
|------------|--------|
| 10 Hz | 515.4 |
| 100 Hz | 60.5 |
| 1 kHz | 36.2 |
| 10 kHz | 35.0 |
| 100 kHz | 34.5 |
| 1 MHz | 32.9 |
| 10 MHz | 22.7 |

Vectron 12.288 MHz Crystal

The phase noise of the reference is masked by the phase noise of the crystal by using a narrow loop bandwidth. The crystal sets the reference noise to PLL2. Figure 14 shows the typical open loop phase noise performance of the VXB1-1127-12M288 Vectron Crystal.

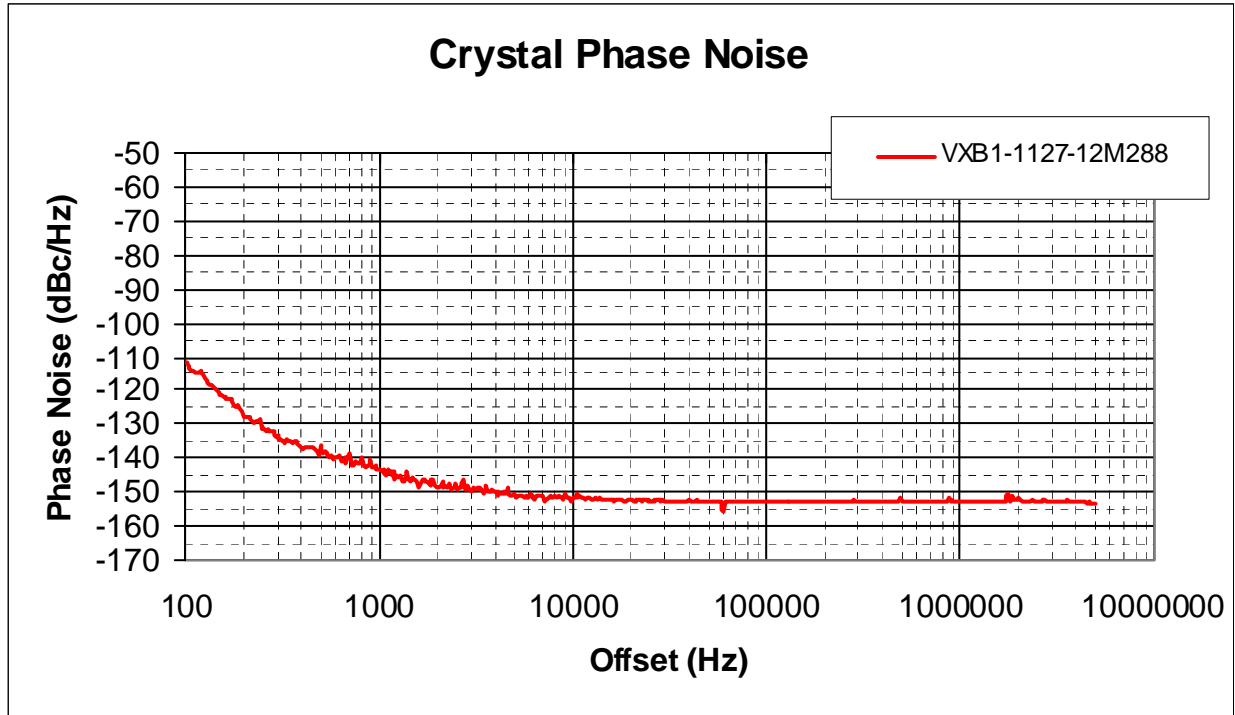


Figure 14 - Vectron VXB1-1127-12M288 Crystal Phase Noise at 12.288 MHz

Table 8 - VCXO Phase Noise at 12.288 MHz (dBc/Hz)

| Offset | Phase Noise |
|---------|-------------|
| 100 Hz | -111.6 |
| 1 kHz | -143.3 |
| 10 kHz | -151.6 |
| 100 kHz | -152.7 |
| 1 MHz | -152.8 |
| 5 MHz | -153.3 |

Table 9 - VCXO RMS Jitter to high offset of 20 MHz at 12.288 MHz (rms fs)

| Low Offset | Jitter |
|------------|--------|
| 100 Hz | 964.1 |
| 1 kHz | 934.5 |
| 10 kHz | 932.7 |
| 100 kHz | 924.0 |
| 1 MHz | 834.5 |

PLL2

The closed loop performance of the system as measured at the VCO output Fout. Fout phase noise performance of the various LMK options is plotted in Figure 15. Table 10 and Table 11 summarize the phase noise and jitter of Fout.

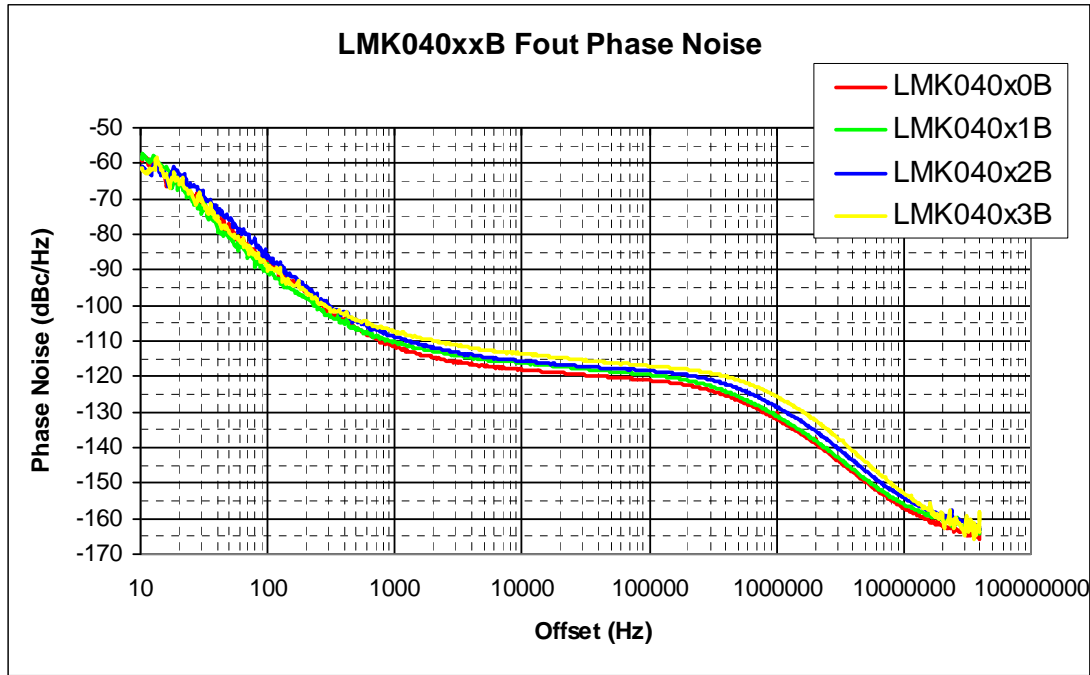


Figure 15 - LMK040xxB PLL2 Phase Noise (Fout)

Table 10 - LMK040x0B Phase Noise (dBc/Hz)

| Offset | LMK040x0B | LMK040x1B | LMK040x2B | LMK040x3B |
|---------|-----------|-----------|-----------|-----------|
| 10 Hz | -58.7 | -58.3 | -61.3 | -61.1 |
| 100 Hz | -88.0 | -88.3 | -85.7 | -90.4 |
| 1 kHz | -111.6 | -110.2 | -108.9 | -107.5 |
| 10 kHz | -118.2 | -116.3 | -115.7 | -113.5 |
| 100 kHz | -121.1 | -119.5 | -118.4 | -117.0 |
| 1 MHz | -132.0 | -131.1 | -128.6 | -125.6 |
| 10 MHz | -157.1 | -155.8 | -154.0 | -152.7 |
| 40 MHz | -165.9 | -164.2 | -162.3 | -160.8 |

Table 11 - LMK040x0B RMS Jitter; Integrated to from low limit to 20 MHz (rms fs)

| Low Offset | LMK040x0B | LMK040x1B | LMK040x2B | LMK040x3B |
|------------|-----------|-----------|-----------|-----------|
| 10 Hz | 580.0 | 506.6 | 443.4 | 356.0 |
| 100 Hz | 127.2 | 117.5 | 124.5 | 132.8 |
| 1 kHz | 114.8 | 111.3 | 114.9 | 128.1 |
| 10 kHz | 111.7 | 108.0 | 112.0 | 125.0 |
| 100 kHz | 97.3 | 92.7 | 99.2 | 112.2 |
| 1 MHz | 39.7 | 36.2 | 41.6 | 50.9 |
| 10 MHz | 6.0 | 5.9 | 6.0 | 5.5 |

Clock Outputs

The LMK04000 Family features LVDS, LVPECL, 2VPECL, and LVCMOS types of outputs. Included below are various phase noise measurements for each output.

| Device | LVDS | LVPECL/2VPECL | LVCMOS | VCO Frequency |
|--------------------------|------|---------------|--------|------------------|
| LMK040x0B (LMK04000B) | | X | X | 1185 to 1296 MHz |
| LMK040x1B (LMK04031B) | X | X | X | 1430 to 1570 MHz |
| LMK040x2B (LMK04002B) | | X | X | 1566 to 1724 MHz |
| LMK040x3B (LMK04033B) | X | X | X | 1840 to 2160 MHz |

Note: The device in parenthesis is the device used for the measurement in these evaluation board instructions.

Clock Output Measurement Technique

The measurement technique for each output type varies.

LVDS – measured with an ADT2-1T balun to test equipment.

LVPECL/2VPECL – Measured by terminating complementary output with 50 ohm load, then taking output to test equipment.

LVCMOS – Measured by enabling only one side of the LVCMOS output and taking the operating output to test equipment.

The following table lists the test conditions used for the phase noise measurements for the VCXO option:

Table 12 . LMK040xxB test conditions

| Parameter | Value |
|--------------------------------|--|
| PLL1 Reference clock input | CLKin0* single-ended input, CLKin0 AC-coupled to GND |
| PLL1 Reference Clock frequency | 122.88 MHz |
| PLL1 Phase detector frequency | 1024 kHz |
| PLL1 Charge Pump Gain | 100 uA |
| VCXO frequency | 122.88 MHz |
| PLL2 phase detector frequency | 61.44 MHz |
| PLL2 Charge Pump Gain | 3200 uA |
| PLL2 REF2X mode | Disabled |

LMK040x0B Phase Noise

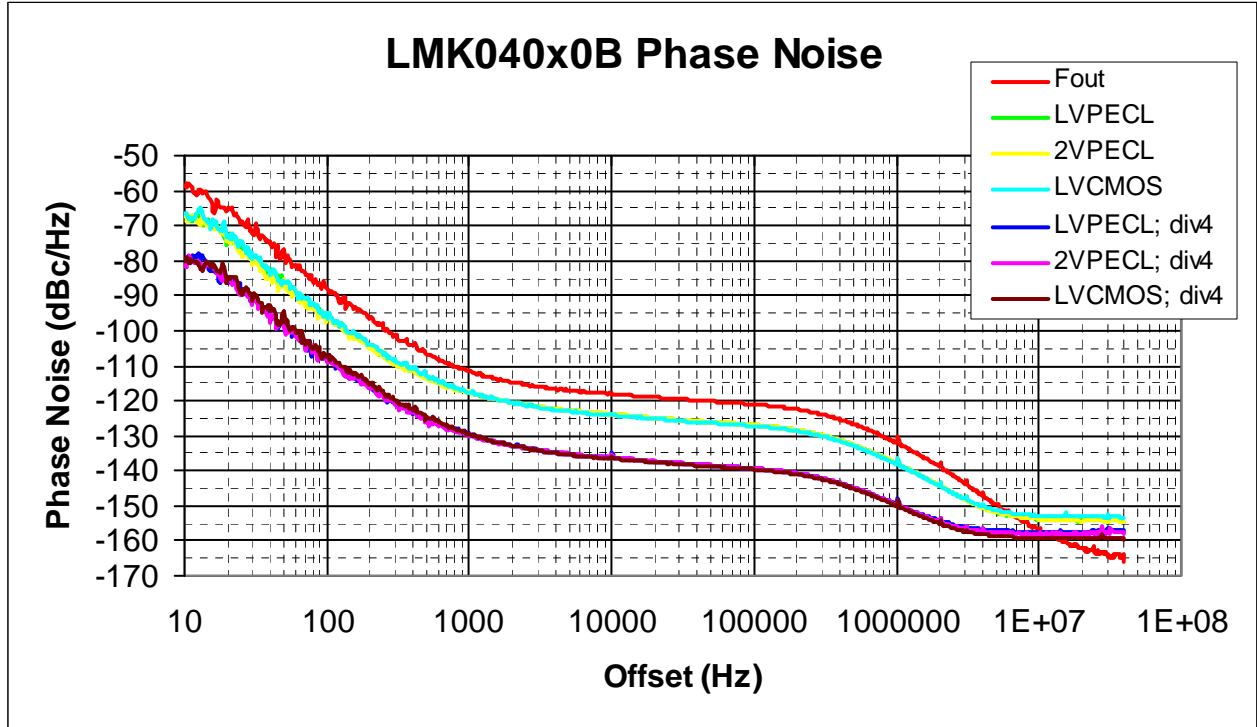


Figure 16 - LMK040x0B Phase Noise

The Fout frequency is 1228.8 MHz. The clock out frequency is 614.4 MHz, and the clock out div 4 frequency is 153.6 MHz.

Table 13 - LMK040x0B Phase Noise (dBc/Hz)

| Offset | Fout | LVPECL | 2VPECL | LVCMOS | LVPECL div4 | 2VPECL div4 | LVCMOS div4 |
|---------|--------|--------|--------|--------|-------------|-------------|-------------|
| 10 Hz | -58.7 | -67.1 | -67.1 | -66.3 | -79.8 | -81.5 | -79.7 |
| 100 Hz | -88.0 | -95.8 | -96.8 | -94.8 | -107.5 | -109.1 | -106.6 |
| 1 kHz | -111.6 | -117.6 | -117.7 | -117.9 | -129.5 | -130.2 | -129.4 |
| 10 kHz | -118.2 | -123.8 | -123.8 | -124.2 | -134.8 | -135.2 | -136.0 |
| 100 kHz | -121.1 | -127.0 | -127.0 | -127.3 | -139.4 | -139.3 | -139.6 |
| 1 MHz | -132.0 | -137.9 | -137.8 | -138.1 | -149.5 | -149.6 | -150.0 |
| 10 MHz | -157.1 | -153.8 | -153.8 | -152.8 | -157.4 | -158.1 | -159.2 |
| 40 MHz | -165.9 | -154.8 | -154.8 | -153.6 | -157.3 | -158.0 | -159.7 |

Table 14 - LMK040x0B RMS Jitter; Integrated to from low limit to 20 MHz (rms fs)

| Low Limit | Fout | LVPECL | 2VPECL | LVCMOS | LVPECL div4 | 2VPECL div4 | LVCMOS div4 |
|-----------|-------|--------|--------|--------|-------------|-------------|-------------|
| 10 Hz | 580.0 | 474.7 | 449.2 | 522.4 | 493.9 | 466.5 | 493.5 |
| 100 Hz | 127.2 | 128.3 | 127.9 | 127.1 | 148.9 | 145.6 | 139.4 |
| 1 kHz | 114.8 | 119.9 | 120.4 | 117.9 | 141.8 | 138.7 | 129.9 |
| 10 kHz | 111.7 | 116.8 | 117.3 | 114.9 | 139.3 | 136.2 | 127.3 |
| 100 kHz | 97.3 | 102.9 | 103.3 | 101.6 | 128.8 | 125.3 | 116.3 |
| 1 MHz | 39.7 | 50.5 | 50.6 | 52.4 | 94.3 | 89.5 | 79.5 |

LMK040x1B Phase Noise

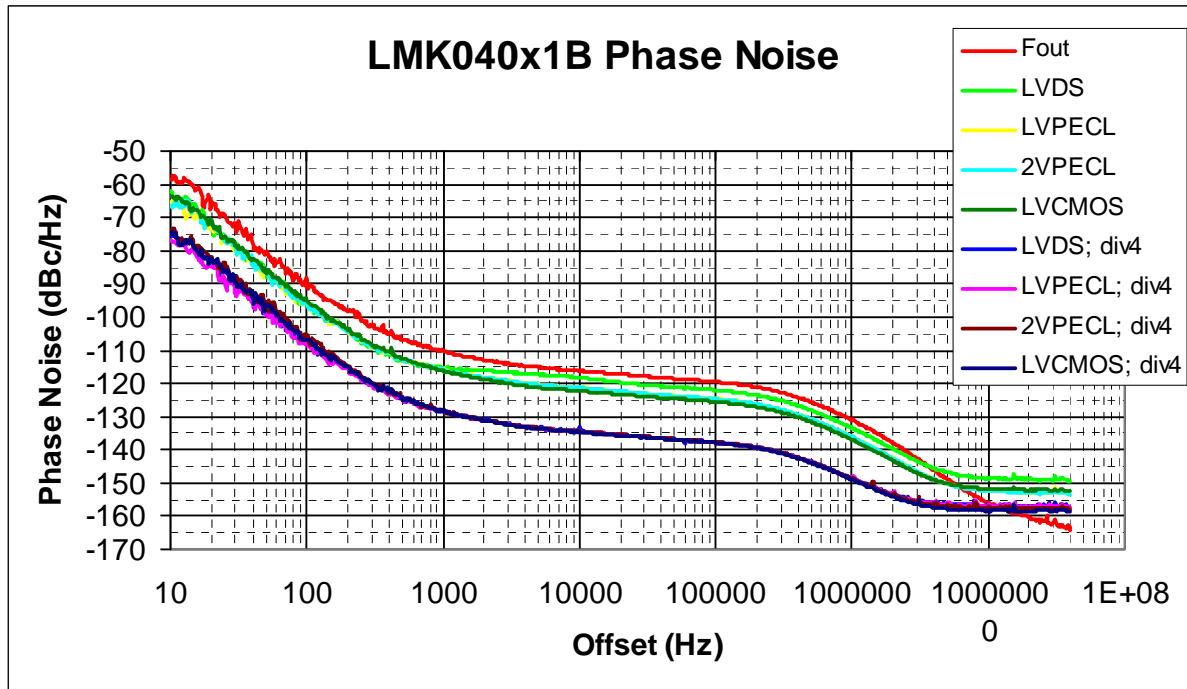


Figure 17 - LMK040x1B Phase Noise

The Fout frequency is 1474.56 MHz. The clock out frequency is 737.28 MHz, and the clock out div 4 frequency is 184.32 MHz. Note that the LVDS performance at 737.28 MHz is degraded because it is outside of the balun’s operational bandwidth.

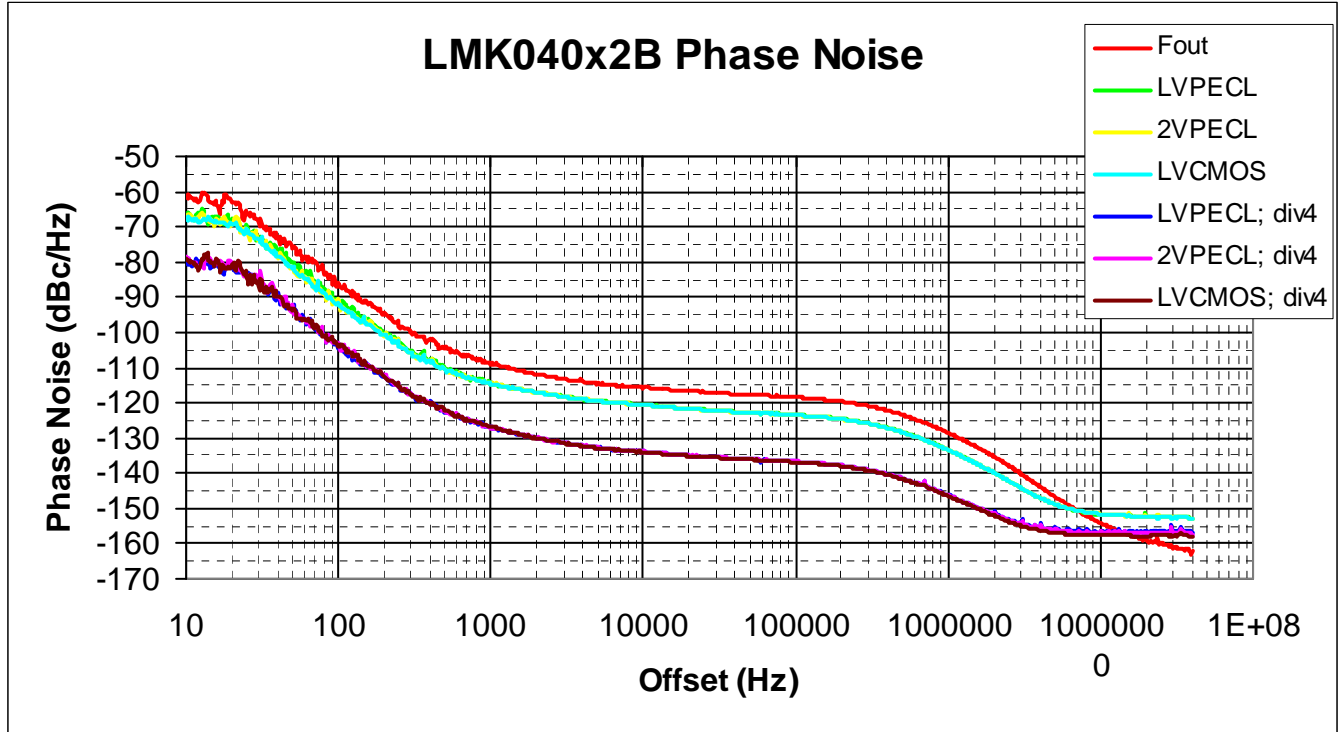
Table 15 - LMK040x1B Phase Noise (dBc/Hz)

| Offset | Fout | LVDS | LVPECL | 2VPECL | LVCMOS | LVDS div4 | LVPECL div4 | 2VPECL div4 | LVCMOS div4 |
|---------|--------|--------|--------|--------|--------|-----------|-------------|-------------|-------------|
| 10 Hz | -58.3 | -62.0 | -65.4 | -66.4 | -63.4 | -74.8 | -76.7 | -73.8 | -74.6 |
| 100 Hz | -88.3 | -96.4 | -95.9 | -96.0 | -94.8 | -106.7 | -107.7 | -105.3 | -106.7 |
| 1 kHz | -110.2 | -115.3 | -115.7 | -115.8 | -116.2 | -128.3 | -128.3 | -128.1 | -128.3 |
| 10 kHz | -116.3 | -118.1 | -121.2 | -121.3 | -122.0 | -132.8 | -134.0 | -134.3 | -134.7 |
| 100 kHz | -119.5 | -122.0 | -124.7 | -124.7 | -125.5 | -137.7 | -137.7 | -137.8 | -137.9 |
| 1 MHz | -131.1 | -133.5 | -136.2 | -136.2 | -137.0 | -148.5 | -148.7 | -148.7 | -148.9 |
| 10 MHz | -155.8 | -148.2 | -152.3 | -152.3 | -151.7 | -156.9 | -157.1 | -157.5 | -158.3 |
| 40 MHz | -164.2 | -149.5 | -153.5 | -153.6 | -152.5 | -157.5 | -157.3 | -158.0 | -158.8 |

Table 16 - LMK040x1B RMS Jitter; Integrated to from low limit to 20 MHz (rms fs)

| Low Limit | Fout | LVDS | LVPECL | 2VPECL | LVCMOS | LVDS div4 | LVPECL div4 | 2VPECL div4 | LVCMOS div4 |
|-----------|-------|-------|--------|--------|--------|-----------|-------------|-------------|-------------|
| 10 Hz | 506.6 | 538.4 | 425.5 | 458.5 | 501.9 | 532.2 | 445.6 | 591.0 | 544.1 |
| 100 Hz | 117.5 | 178.3 | 132.4 | 131.8 | 123.1 | 141.0 | 138.6 | 139.1 | 132.5 |
| 1 kHz | 111.3 | 174.2 | 127.0 | 126.4 | 116.2 | 135.1 | 133.3 | 131.4 | 125.5 |
| 10 kHz | 108.0 | 169.5 | 123.4 | 122.8 | 113.0 | 132.4 | 130.7 | 128.7 | 122.8 |
| 100 kHz | 92.7 | 147.7 | 107.2 | 106.7 | 98.7 | 120.7 | 119.0 | 116.8 | 110.8 |
| 1 MHz | 36.2 | 72.9 | 50.4 | 50.1 | 49.1 | 85.2 | 83.4 | 80.3 | 73.4 |

LMK040x2B Phase Noise



The Fout frequency is 1720.32 MHz. The clock out frequency is 860.16 MHz, and the clock out div 4 frequency is 215.04 MHz.

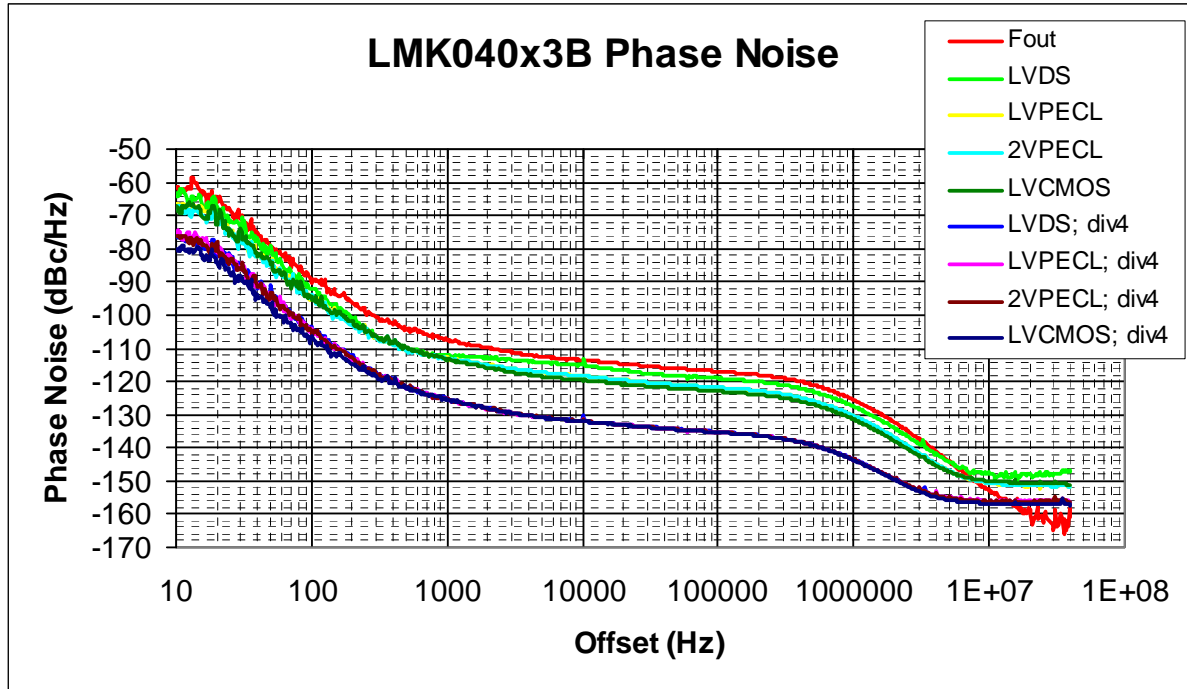
Table 17 - LMK040x2B Phase Noise (dBc/Hz)

| Offset | Fout | LVPECL | 2VPECL | LVCMOS | LVPECL div4 | 2VPECL div4 | LVCMOS div4 |
|---------|--------|--------|--------|--------|-------------|-------------|-------------|
| 10 Hz | -61.3 | -66.6 | -67.3 | -67.7 | -80.1 | -78.7 | -78.9 |
| 100 Hz | -85.7 | -91.5 | -90.4 | -91.9 | -103.3 | -103.2 | -103.8 |
| 1 kHz | -108.9 | -114.3 | -114.2 | -114.6 | -126.7 | -127.2 | -126.5 |
| 10 kHz | -115.7 | -120.7 | -120.7 | -120.6 | -133.5 | -133.7 | -134.1 |
| 100 kHz | -118.4 | -123.5 | -123.5 | -123.5 | -136.7 | -136.7 | -136.8 |
| 1 MHz | -128.6 | -133.4 | -133.4 | -133.4 | -146.2 | -146.3 | -146.5 |
| 10 MHz | -154.0 | -151.5 | -151.5 | -151.6 | -156.7 | -157.0 | -157.7 |
| 40 MHz | -162.3 | -153.0 | -153.2 | -153.2 | -157.0 | -157.3 | -158.2 |

Table 18 - LMK040x2B RMS Jitter; Integrated to from low limit to 20 MHz (rms fs)

| Low Limit | Fout | LVPECL | 2VPECL | LVCMOS | LVPECL div4 | 2VPECL div4 | LVCMOS div4 |
|-----------|-------|--------|--------|--------|-------------|-------------|-------------|
| 10 Hz | 443.4 | 498.1 | 477.3 | 450.5 | 439.3 | 473.4 | 458.5 |
| 100 Hz | 124.5 | 143.1 | 140.8 | 140.4 | 141.0 | 140.7 | 136.6 |
| 1 kHz | 114.9 | 132.7 | 132.1 | 132.0 | 132.3 | 131.1 | 126.6 |
| 10 kHz | 112.0 | 129.6 | 129.0 | 129.0 | 130.0 | 128.7 | 124.2 |
| 100 kHz | 99.2 | 115.7 | 115.2 | 115.2 | 119.7 | 118.3 | 113.7 |
| 1 MHz | 41.6 | 54.9 | 54.8 | 54.7 | 79.2 | 77.1 | 71.8 |

LMK040x3B Phase Noise



The Fout frequency is 1966.08 MHz. The clock out frequency is 983.04 MHz, and the clock out div 4 frequency is 245.76 MHz. Note that the LVDS performance at 737.28 MHz is degraded because it is outside of the balun’s operational bandwidth.

Table 19 - LMK040x3B Phase Noise (dBc/Hz)

| Offset | Fout | LVDS | LVPECL | 2VPECL | LVCMOS | LVDS div4 | LVPECL div4 | 2VPECL div4 | LVCMOS div4 |
|---------|--------|--------|--------|--------|--------|-----------|-------------|-------------|-------------|
| 10 Hz | -61.1 | -63.9 | -66.2 | -67.6 | -67.0 | -76.1 | -75.2 | -75.9 | -80.1 |
| 100 Hz | -90.4 | -92.1 | -94.6 | -93.9 | -94.3 | -103.5 | -103.7 | -104.4 | -106.3 |
| 1 kHz | -107.5 | -112.2 | -112.8 | -112.8 | -113.6 | -125.5 | -125.8 | -125.5 | -125.4 |
| 10 kHz | -113.5 | -115.1 | -118.1 | -118.2 | -119.7 | -130.3 | -131.4 | -131.5 | -132.0 |
| 100 kHz | -117.0 | -119.1 | -121.8 | -121.9 | -123.0 | -135.2 | -135.3 | -135.3 | -135.3 |
| 1 MHz | -125.6 | -127.6 | -130.4 | -130.4 | -131.5 | -143.5 | -143.6 | -143.6 | -143.7 |
| 10 MHz | -152.7 | -148.0 | -150.6 | -150.6 | -150.0 | -156.3 | -156.1 | -156.3 | -156.8 |
| 40 MHz | -160.8 | -147.2 | -151.9 | -151.9 | -151.2 | -156.8 | -156.4 | -156.6 | -157.3 |

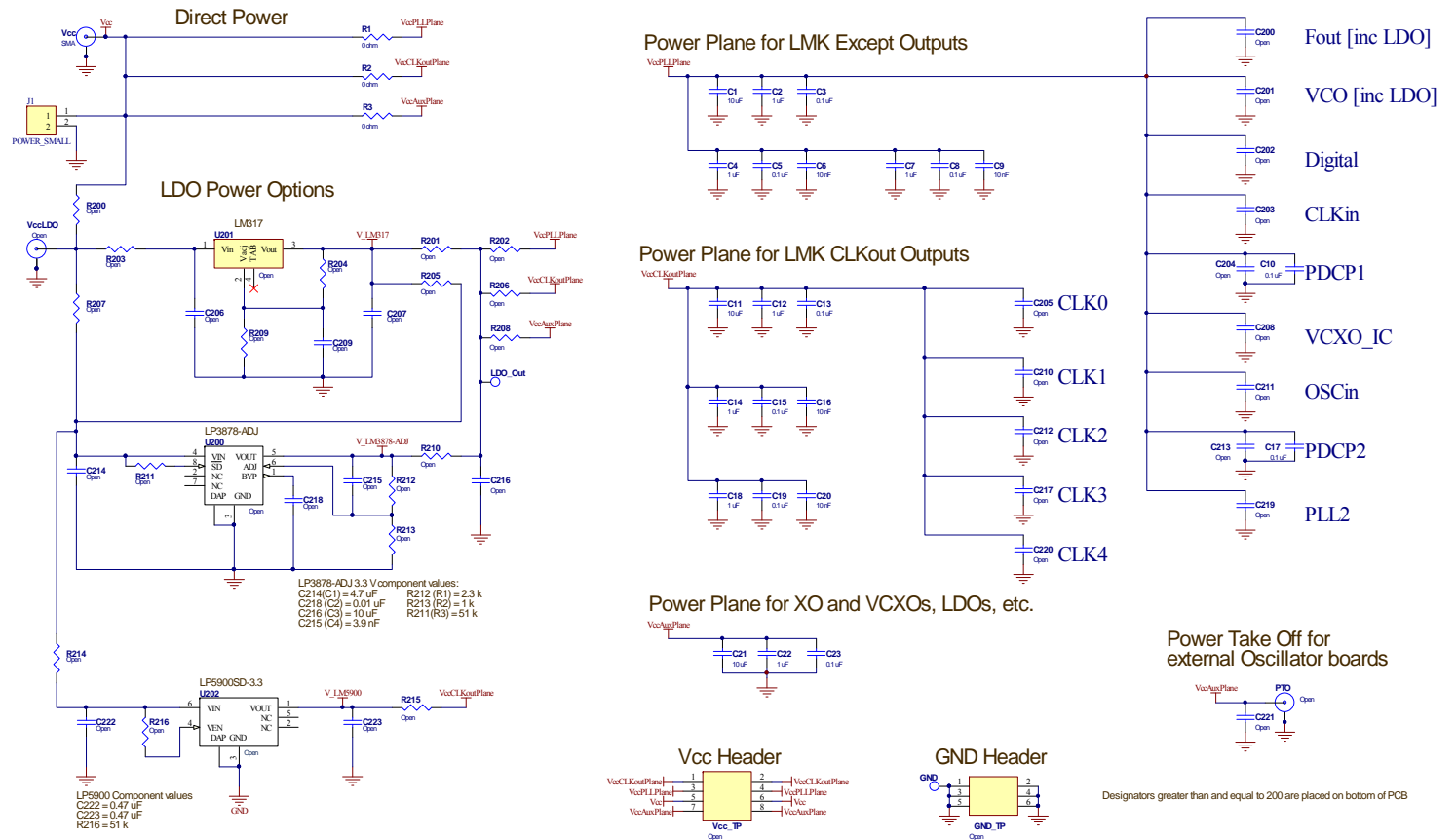
Table 20 - LMK040x3B RMS Jitter; Integrated to from low limit to 20 MHz (rms fs)

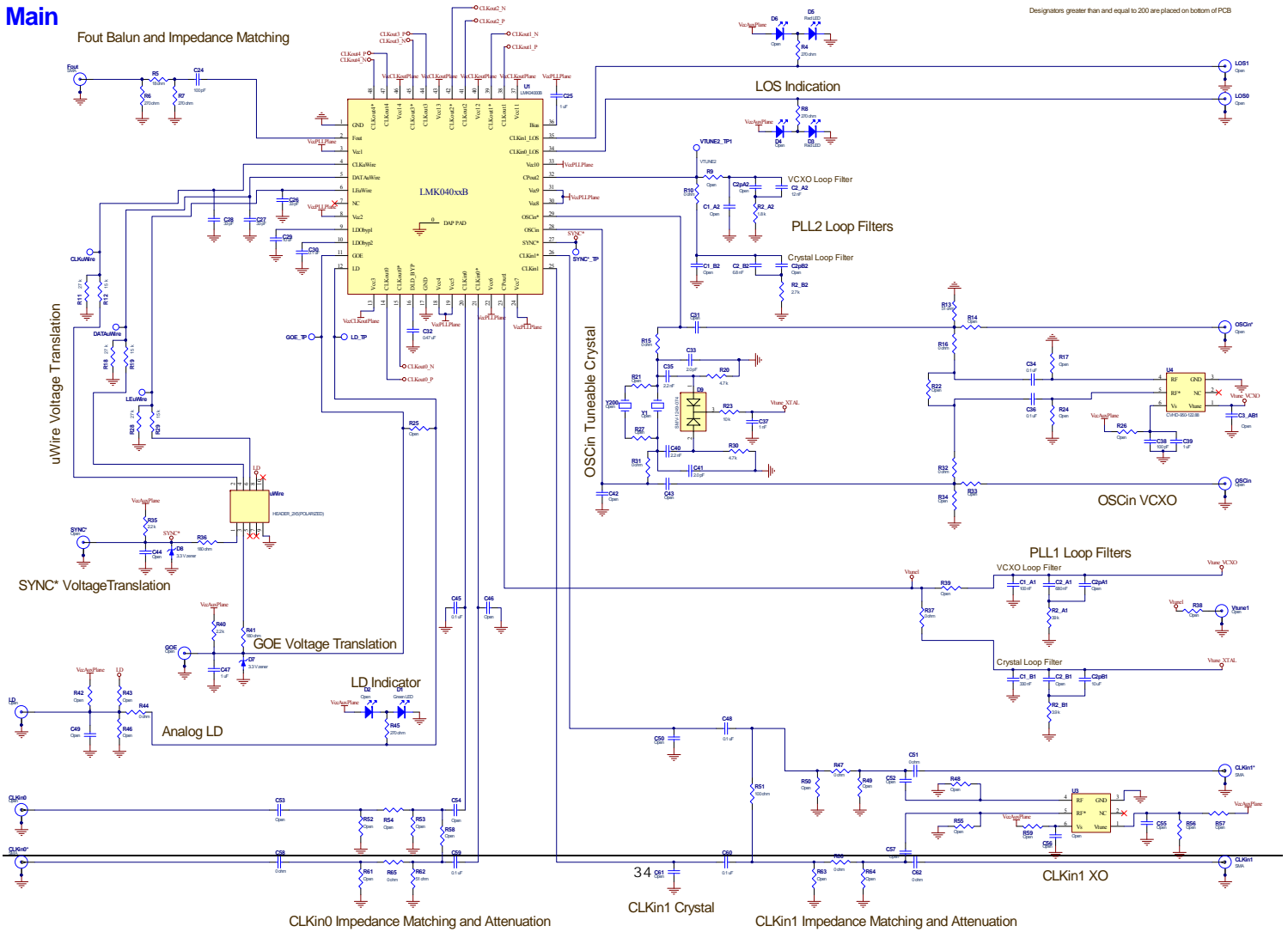
| Low Limit | Fout | LVDS | LVPECL | 2VPECL | LVCMOS | LVDS div4 | LVPECL div4 | 2VPECL div4 | LVCMOS div4 |
|-----------|-------|-------|--------|--------|--------|-----------|-------------|-------------|-------------|
| 10 Hz | 356.0 | 384.3 | 560.5 | 457.3 | 482.9 | 324.3 | 337.9 | 389.6 | 453.4 |
| 100 Hz | 132.8 | 134.1 | 102.4 | 101.2 | 95.2 | 105.9 | 104.1 | 103.2 | 101.1 |
| 1 kHz | 128.1 | 131.3 | 95.6 | 95.0 | 87.4 | 101.8 | 100.2 | 98.3 | 94.3 |
| 10 kHz | 125.0 | 127.8 | 92.9 | 92.4 | 85.0 | 99.9 | 98.2 | 96.3 | 92.3 |
| 100 kHz | 112.2 | 111.4 | 80.7 | 80.2 | 74.2 | 91.1 | 89.4 | 87.3 | 83.2 |
| 1 MHz | 50.9 | 55.2 | 37.9 | 37.6 | 36.9 | 64.4 | 62.5 | 59.5 | 55.0 |

LMK0400BEVAL schematic.
Refer to BOM for differences.

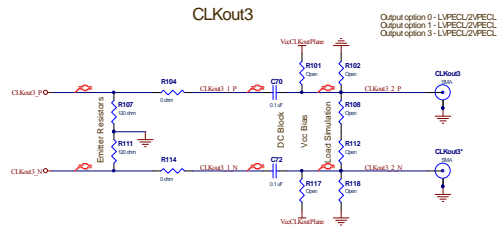
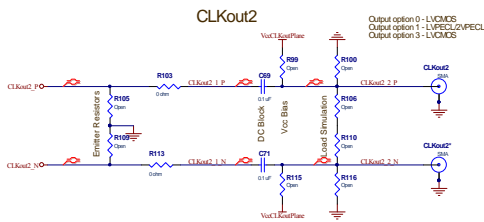
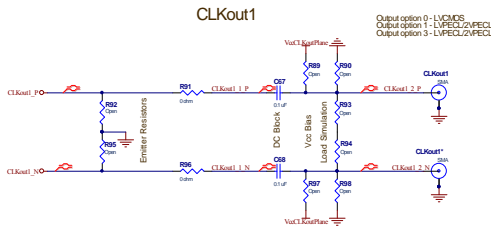
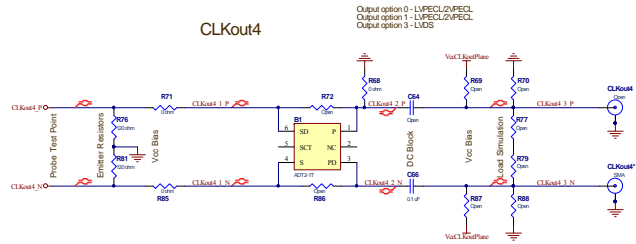
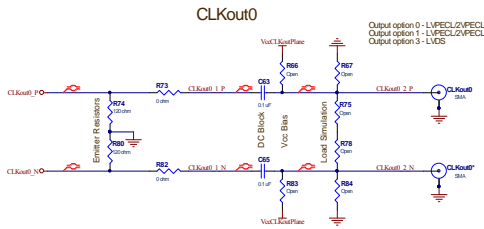
Appendix C: Schematics

Power





Clock Outputs



Notes:

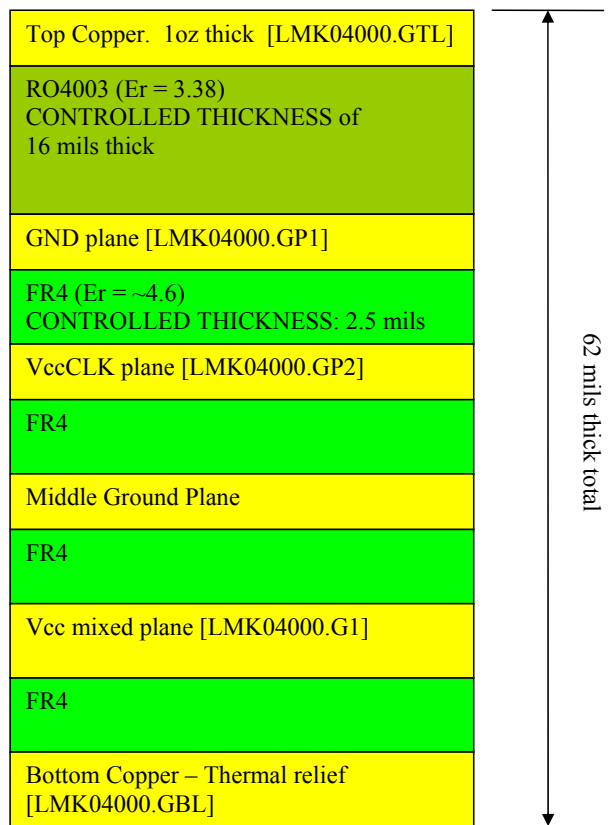
1. A15ub will be placed near all CLKout SMA connectors to test the effects of capacitive loading.
2. CLKout0 and CLKout4 are both the same type and never CMOS.
3. CLKout1, CLKout2 and CLKout3 can be made LVPECL or CMOS via metal mask.

Appendix D: Board Layers Stackup

Layers of the 6 layer evaluation board include:
Blue is dielectrics

- Top layer for high priority high frequency signals
 - 1 oz CU
- RO4003 Dielectric, 16 mils
- Ground plane
- FR4, 2.5 mils thick.
- Power plane #1 – VccCLK
- FR4, xx mils
- middle ground plane
- FR4, xx mils
- VccPLL, VccAux
- FR4, xx mils
- Bottom layer copper clad for thermal relief

Top to bottom layer order:
 LMK04000.GTL (1) top copper
 LMK04000.GP1 (2) gnd
 LMK04000.GP2 (3) vcc
 LMK04000.GP3 (4) gnd
 LMK04000.G1 (5) vcc
 LMK04000.GBL (6) bottom copper



Appendix E: Bill of Materials

Common Bill of Materials for Evaluation Boards (page 1/3)

| Part | Manufacturer | Part Number | Qty | Identifier |
|-------------------|--------------|------------------|-----|--|
| Capacitors | | | | |
| 33 pF | Kemet | C0402C330J5GAC | 3 | C26, C27, C28 |
| 100 pF | Kemet | C0603C101J5GAC | 2 | C24, C38 |
| 1 nF | Kemet | C0603C102J5GAC | 1 | C37 |
| 2.2 nF | Kemet | C0603C222K5RAC | 2 | C35, C40 |
| 6.8 nF | Kemet | C0603C682K1RACTU | 1 | C2_B2 |
| 10 nF | Kemet | C0603C103K1RACTU | 4 | C6, C9, C16, C20 |
| 12 nF | Kemet | C0603C123K1RACTU | 1 | C2_A2 |
| 0.1 uF | Kemet | C0603C104J3RAC | 25 | C3, C5, C8, C10, C13, C15, C17, C19, C23, C30, C34, C36, C45, C48, C59, C60, C63, C65, C66, C67, C68, C69, C70, C71, C72 |
| 100 nF | Kemet | C0603C104J3RAC | 1 | C1_A1 |
| 330 nF | Kemet | C0603C334K4RACTU | 1 | C1_B1 |
| 0.47 uF | Kemet | C0603C474K8PACTU | 1 | C32 |
| 680 nF | Kemet | C0603C684K8PAC | 1 | C2_A1 |
| 1 uF | Kemet | C0603C105K8VAC | 10 | C2, C4, C7, C12, C14, C18, C22, C25, C39, C47 |
| 10 uF | Kemet | C0805C106K9PAC | 5 | C1, C2pB1, C11, C21, C29 |

Common Bill of Materials for Evaluation Boards (continued, 2/3)

| Resistors | | | | |
|-----------------------|------------------------|------------------|----|--|
| 0 ohm | Vishay/Dale | CRCW06030000Z0EA | 23 | C51, C58, C62, R1, R2, R3, R16, R26, R32, R44, R47, R60, R65, R71, R73, R82, R85, R91, R96, R103, R104, R113, R114 |
| 18 ohm | Vishay/Dale | CRCW060318R0JNEA | 1 | R5 |
| 51 ohm | Vishay/Dale | CRCW060351R0JNEA | 2 | R62, R68 |
| 100 ohm | Vishay/Dale | CRCW0603100RJNEA | 2 | R22, R51 |
| 120 ohm | Vishay/Dale | CRCW0603120RJNEA | 2 | R107, R111 |
| 180 ohm | Vishay/Dale | CRCW0603180RJNEA | 2 | R36, R41 |
| 270 ohm | Vishay/Dale | CRCW0603270RJNEA | 5 | R4, R6, R7, R8, R45 |
| 1.8 k | Vishay/Dale | CRCW06031K80JNEA | 1 | R2_A2 |
| 2.2 k | Vishay/Dale | CRCW06032K20JNEA | 2 | R35, R40 |
| 2.7 k | Vishay/Dale | CRCW06032K70JNEA | 1 | R2_B2 |
| 3.9 k | Vishay/Dale | CRCW06033K90JNEA | 1 | R2_B1 |
| 4.7 k | Vishay/Dale | CRCW06034K70JNEA | 2 | R20, R30 |
| 10 k | Vishay/Dale | CRCW060310K0JNEA | 1 | R23 |
| 15 k | Vishay/Dale | CRCW060315K0JNEA | 3 | R12, R19, R29 |
| 27 k | Vishay/Dale | CRCW060327K0JNEA | 3 | R11, R18, R28 |
| 39 k | Vishay/Dale | CRCW060339K0JNEA | 1 | R2_A1 |
| Other | | | | |
| SMA | Johnson Components | 142-0701-851 | 16 | Vcc, Fout, CLKout0, CLKout0*, CLKin0*, CLKin1, CLKin1*, OSCin, OSCin*, CLKout1, CLKout1*, CLKout2, CLKout2*, CLKout3, CLKout3*, CLKout4* |
| Red LED | Lumex | SML-LX2832IC-TR | 2 | D3, D5 |
| Green LED | Lumex | SML-LX2832GC-TR | 1 | D1 |
| TERMBLOCK_2 | Weidmuller | 1594540000 | 1 | J1 |
| ADT2-1T | Minicircuits | ADT2-1T | 1 | B1 |
| HEADER_2X5(POLARIZED) | FCI Electronics | 52601-S10-8 | 1 | uWire |
| 3.3 V zener | Comchip | CZRUS2C3V3 | 2 | D7, D8 |
| SMV-1249-074 | Skyworks | SMV-1249-074 | 1 | D9 |
| PCB | Printed Circuits Corp. | LMK040xx-rev3 | 1 | The PCB Board |
| 0.875" Standoffs | SPC Technology | SPCS-14 | 4 | Standoffs in the four corners (insert from bottom) |

Common Bill of Materials for Evaluation Boards (continued, 3/3)

| Open | | | | |
|------|--|--|----|--|
| Open | | | 78 | R13, R14, R17, R21, R24, R25, R27, R33, R34, R38, R42, R43, R46, R48, R49, R50, R52, R53, R54, R55, R56, R57, R58, R59, R61, R63, R64, R66, R67, R69, R70, R72, R75, R77, R78, R79, R83, R84, R86, R87, R88, R89, R90, R93, R94, R97, R98, R99, R100, R101, R102, R105, R106, R108, R109, R110, R112, R115, R116, R117, R118, R200, R201, R202, R203, R204, R205, R206, R207, R208, R209, R210, R211, R212, R213, R214, R215, R216 |
| Open | | | 46 | C1_A2, C1_B2, C2pB2, C2pA2, C2pA1, C2_B1, C3_AB1, C33, C41, C42, C44, C46, C49, C50, C52, C53, C54, C55, C56, C57, C61, C64, C200, C201, C202, C203, C204, C205, C206, C207, C208, C209, C210, C211, C212, C213, C214, C215, C216, C217, C218, C219, C220, C221, C222, C223 |
| Open | | | 4 | U3, U200, U201, U202 |
| Open | | | 9 | CLKin0, CLKout4, GOE, LD, LOS0, LOS1, PTO, VccLDO, Vtune1 |
| Open | | | 1 | Y200 |
| Open | | | 1 | Vcc_TP |
| Open | | | 1 | GND_TP |
| Open | | | 3 | D2, D4, D6 |
| Open | | | 1 | SYNC* |

Bill of Material Custom to LMK04000BEVAL

| Part | Manufacturer | Part Number | Qty | Identifier |
|-------------------|------------------------|------------------|-----|------------------------------|
| Capacitors | | | | |
| 0.1 uF | Kemet | C0603C104J3RAC | 2 | C31, C43 |
| Resistors | | | | |
| 0 ohm | Vishay/Dale | CRCW06030000Z0EA | 2 | R9, R39 |
| 120 ohm | Vishay/Dale | CRCW0603120RJNEA | 4 | R74, R76, R80, R81 |
| Other | | | | |
| LMK04000B | National Semiconductor | LMK04000B | 1 | U1 |
| CVHD-950-122.88 | Crystek | CVHD-950-122.88 | 1 | U4 |
| Open | | | | |
| Open | | | 6 | R10, R15, R31, R37, R92, R95 |
| Open | | | 1 | Y1 |

Bill of Material Custom to LMK04000BEVAL-XO

| Part | Manufacturer | Part Number | Qty | Identifier |
|-------------------|------------------------|------------------|-----|--------------------|
| Capacitors | | | | |
| Resistors | | | | |
| 0 ohm | Vishay/Dale | CRCW06030000Z0EA | 4 | R10, R15, R31, R37 |
| 120 ohm | Vishay/Dale | CRCW0603120RJNEA | 4 | R74, R76, R80, R81 |
| Other | | | | |
| LMK04000B | National Semiconductor | LMK04000B | 1 | U1 |
| 12.288 MHz XTAL | Vectron | VXB1-1127-12M288 | 1 | Y1 |
| Open | | | | |
| Open | | | 2 | C31, C43 |
| Open | | | 4 | R9, R39, R92, R95 |
| Open | | | 1 | U4 |

Bill of Material Custom to LMK04031BEVAL

| Part | Manufacturer | Part Number | Qty | Identifier |
|-------------------|------------------------|------------------|-----|--|
| Capacitors | | | | |
| 0.1 uF | Kemet | C0603C104J3RAC | 2 | C31, C43 |
| Resistors | | | | |
| 0 ohm | Vishay/Dale | CRCW06030000Z0EA | 2 | R9, R39 |
| 120 ohm | Vishay/Dale | CRCW0603120RJNEA | 2 | R92, R95 |
| Other | | | | |
| LMK04031B | National Semiconductor | LMK04031B | 1 | U1 |
| CVHD-950-122.88 | Crystek | CVHD-950-122.88 | 1 | U4 |
| Open | | | | |
| Open | | | 8 | R10, R15, R31, R37, R74, R76, R80, R81 |
| Open | | | 1 | Y1 |

Bill of Material Custom to LMK04031BEVAL-XO

| Part | Manufacturer | Part Number | Qty | Identifier |
|-------------------|------------------------|------------------|-----|-----------------------------|
| Capacitors | | | | |
| Resistors | | | | |
| 0 ohm | Vishay/Dale | CRCW06030000Z0EA | 4 | R10, R15, R31, R37 |
| 120 ohm | Vishay/Dale | CRCW0603120RJNEA | 2 | R92, R95 |
| Other | | | | |
| LMK04031B | National Semiconductor | LMK04031B | 1 | U1 |
| 12.288 MHz XTAL | Vectron | VXB1-1127-12M288 | 1 | Y1 |
| Open | | | | |
| Open | | | 2 | C31, C43 |
| Open | | | 6 | R9, R39, R74, R76, R80, R81 |
| Open | | | 1 | U4 |

Bill of Material Custom to LMK04002BEVAL

| Part | Manufacturer | Part Number | Qty | Identifier |
|-------------------|------------------------|------------------|-----|------------------------------|
| Capacitors | | | | |
| 0.1 uF | Kemet | C0603C104J3RAC | 2 | C31, C43 |
| Resistors | | | | |
| 0 ohm | Vishay/Dale | CRCW06030000Z0EA | 2 | R9, R39 |
| 120 ohm | Vishay/Dale | CRCW0603120RJNEA | 4 | R74, R76, R80, R81 |
| Other | | | | |
| LMK04002B | National Semiconductor | LMK04002B | 1 | U1 |
| CVHD-950-122.88 | Crystek | CVHD-950-122.88 | 1 | U4 |
| Open | | | | |
| Open | | | 6 | R10, R15, R31, R37, R92, R95 |
| Open | | | 1 | Y1 |

Bill of Material Custom to LMK04033BEVAL

| Part | Manufacturer | Part Number | Qty | Identifier |
|-------------------|------------------------|------------------|-----|--|
| Capacitors | | | | |
| 0.1 uF | Kemet | C0603C104J3RAC | 2 | C31, C43 |
| Resistors | | | | |
| 0 ohm | Vishay/Dale | CRCW06030000Z0EA | 2 | R9, R39 |
| 120 ohm | Vishay/Dale | CRCW0603120RJNEA | 2 | R92, R95 |
| Other | | | | |
| LMK04033B | National Semiconductor | LMK04033B | 1 | U1 |
| CVHD-950-122.88 | Crystek | CVHD-950-122.88 | 1 | U4 |
| Open | | | | |
| Open | | | 8 | R10, R15, R31, R37, R74, R76, R80, R81 |
| Open | | | 1 | Y1 |

Appendix F: Balun Information

Typical Balun Frequency Response

The following figure illustrates the typical frequency response of the Mini-circuit's ADT2-1T balun.

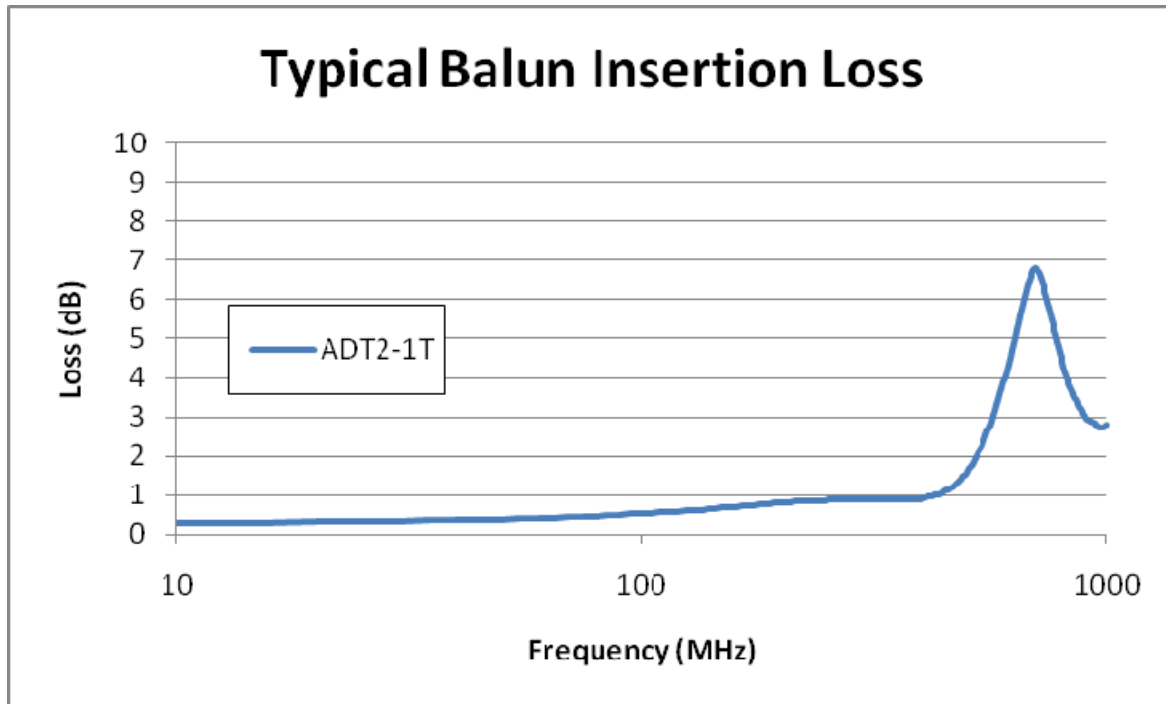


Figure 18 - Typical Balun Frequency Response

Appendix G: VCXO/Crystal changes

This appendix contains instructions for changing the active on-board oscillator for PLL1.

Changing from Crystal Resonator to VCXO

If the board has been setup to use the crystal-based oscillator with PLL1, the crystal may be disabled and the VCXO enabled as described on the following pages:

Summary

1. Connect power to VCXO
2. Disconnect Crystal RF path and connect VCXO RF path
3. Connect charge pump output from PLL1 to VCXO Loop Filter (A1) and VCXO.
4. Connect charge pump output from PLL2 to VCXO Loop filter (A2).

Procedures

1. Connect power to VCXO
 - a. Install a 0 ohm resistor in R26 (near the VCXO)

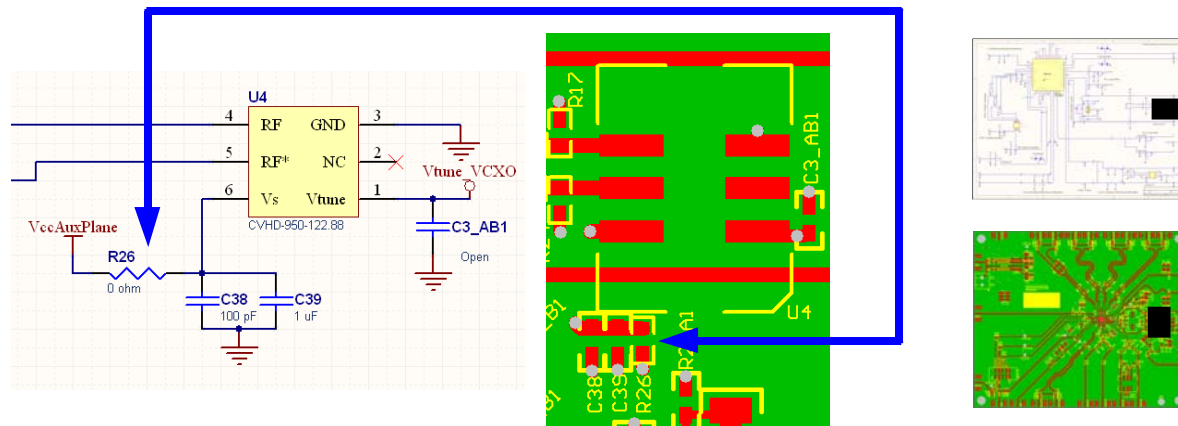


Figure 19

2. Disconnect Crystal RF path and connect VCXO RF path
 - a. Remove resistors R15 and R31.
 - b. Install 0.1 uF capacitors in C31 and C43.

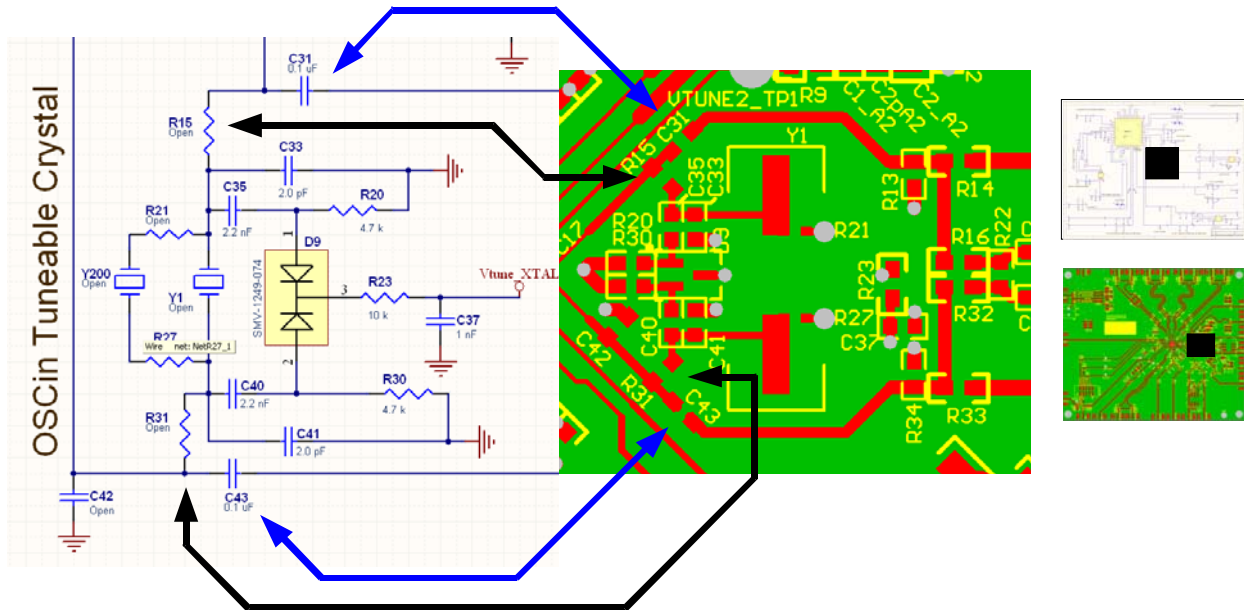


Figure 20

3. Connect charge pump output from PLL1 to VCXO Loop Filter (A1) and VCXO.
 - a. Remove R37 and install a 0 ohm resistor in R39. This resistor can be “switched” between the two footprints.

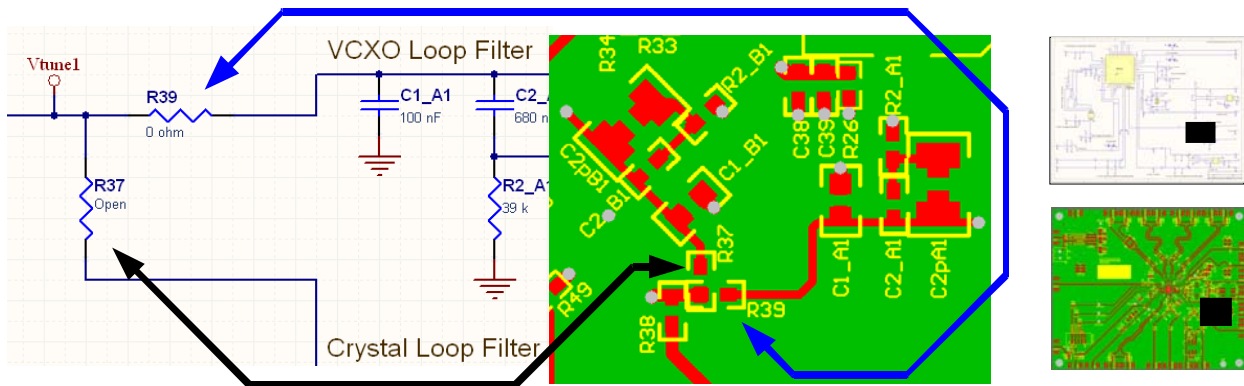


Figure 21

4. Connect charge pump output from PLL2 to VCXO Loop filter (A2).
 - a. Remove R10 and install a 0 ohm resistor in R9. This resistor can be “switched” between the two footprints.

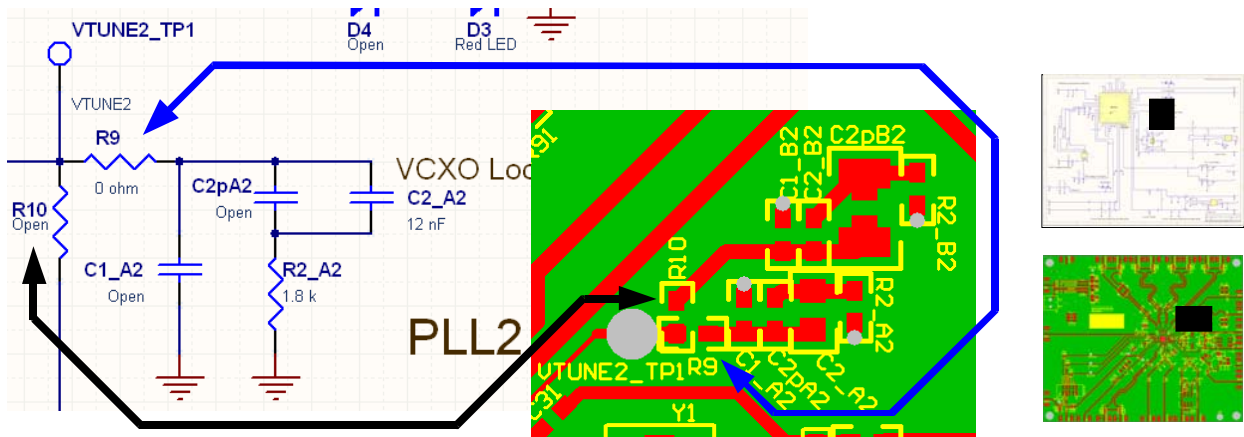


Figure 22

Changing from VCXO to Crystal Resonator

If the board has been setup to use the VCXO for PLL1, the VCXO may be disabled and the crystal enabled as described on the following pages:

Summary

1. Remove power from VCXO
2. Disconnect VCXO RF path and connect Crystal RF path
3. Connect charge pump output from PLL1 to Crystal Loop Filter (B1) and Crystal
4. Connect charge pump output from PLL2 to Crystal Loop filter (B2)

Procedures

1. Remove power from VCXO
 - a. Remove 0 ohm resistor in R26 (near the VCXO)

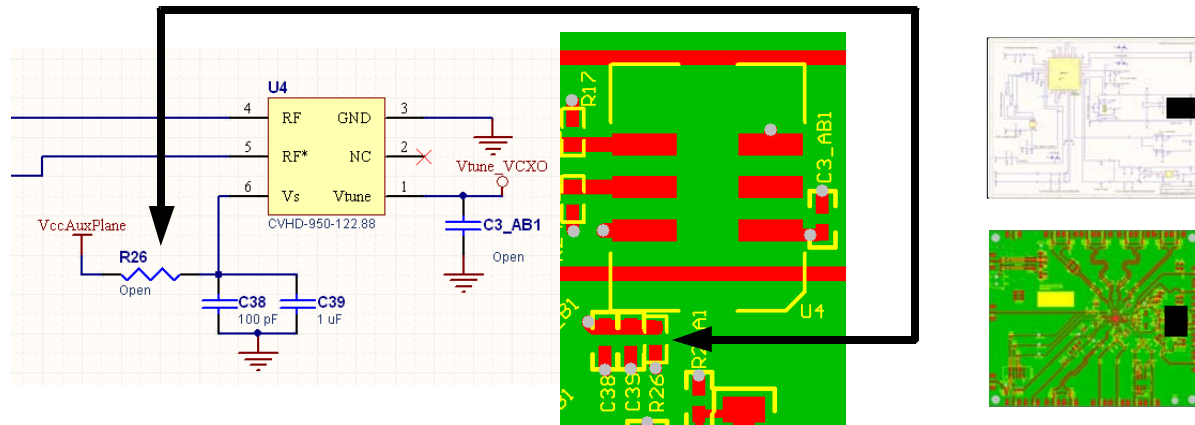


Figure 23

2. Disconnect VCXO RF path and connect Crystal RF path
 - a. Install 0 ohm resistors R15 and R31.
 - b. Remove 0.1 uF capacitors in C31 and C43.

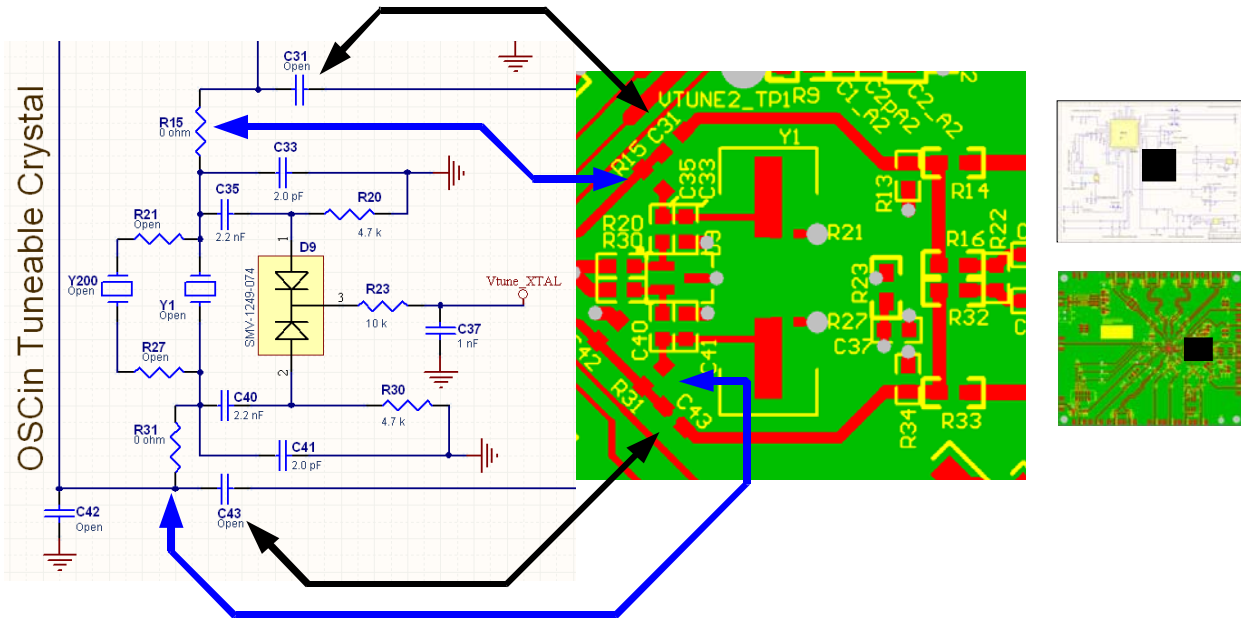


Figure 24

3. Connect charge pump output from PLL1 to Crystal Loop Filter (B1) and Crystal
 - a. Remove R39 and install a 0 ohm resistor in R37. This resistor can be “switched” between the two footprints.

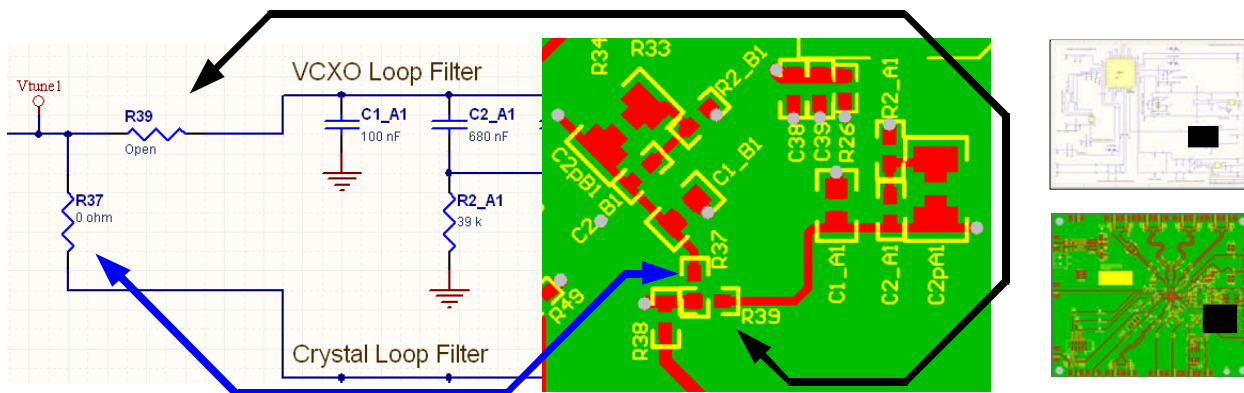


Figure 25

4. Connect charge pump output from PLL2 to Crystal Loop filter (B2)
 - a. Remove R9 and install a 0 ohm resistor in R10. This resistor can be “switched” between the two footprints.

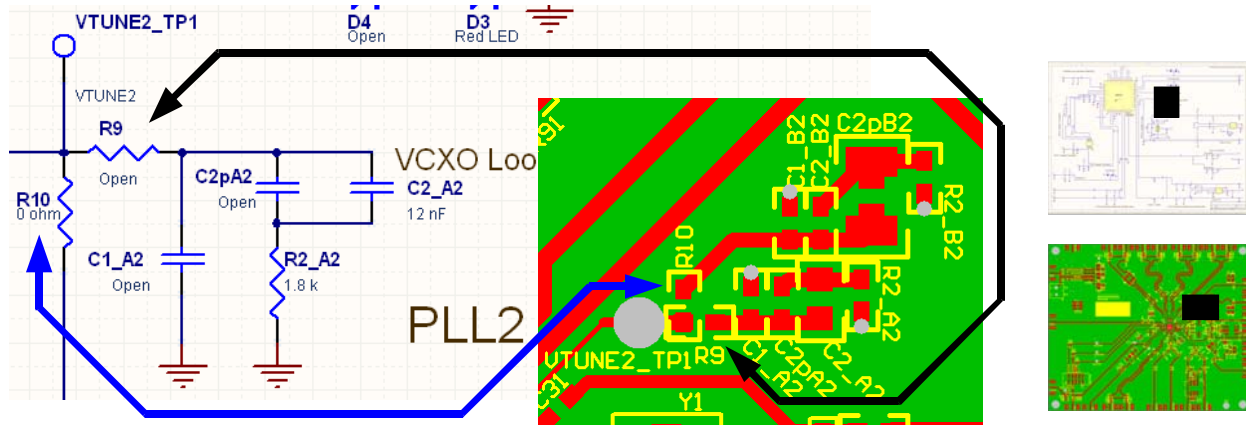


Figure 26

Appendix H: LMK04000

The block diagram in Figure 27 illustrates the functional architecture of the LMK040xxB clock conditioner. It features a cascaded, dual PLL arrangement, available internal loop filter components for PLL2, internal VCO with PLL2 for frequency synthesis, and clock distribution section with individual clock output dividers and delay adjustment blocks. The dual reference clock input to PLL1 provides fail-safe redundancy for phase locked loop operation. The cascaded PLL architecture allows PLL1 to be used as a jitter cleaner for an incoming reference clock that contains excessive phase noise. This requires the user to select an external oscillator (VCXO or crystal) that provides the desired phase noise performance at the clock output. This external oscillator becomes the reference clock for PLL2 and along with the phase noise characteristics of PLL2 and the internal VCO, determines the final phase noise performance at FOUT and the output of the clock distribution section.

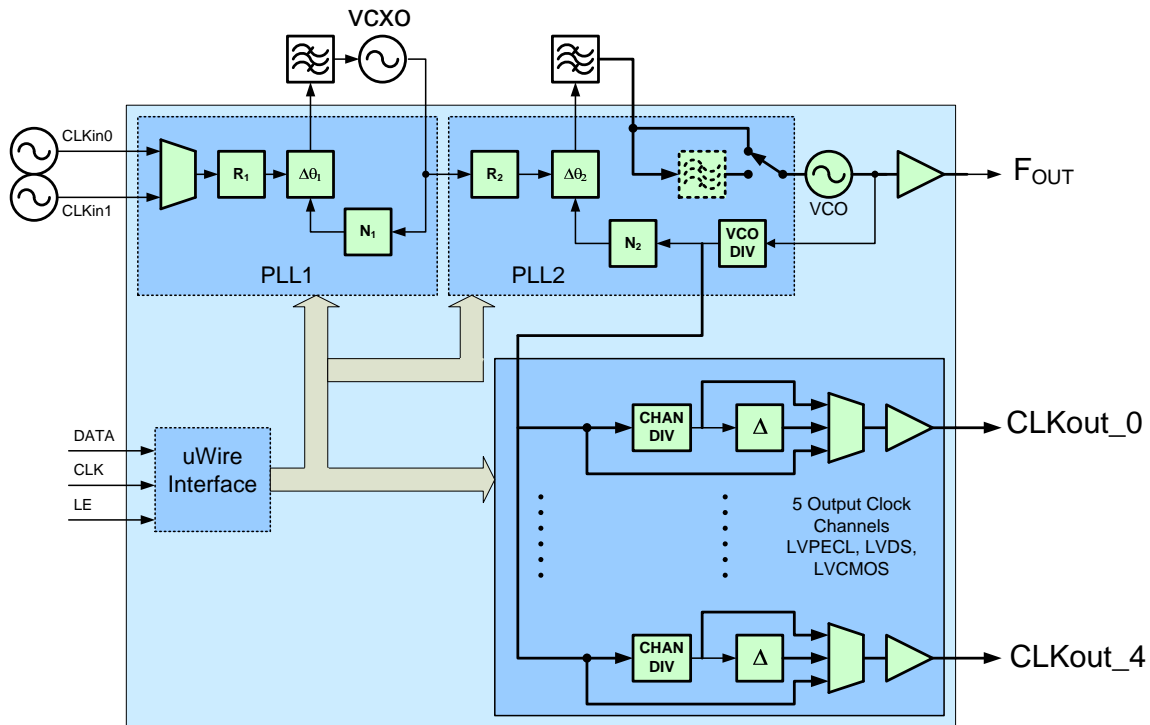


Figure 27 - Functional Block Diagram of the LMK040xxB Dual PLL Precision Clock Conditioner with External VCXO module.

PLL1 has been designed to work with either an off-the-shelf VCXO package or with a user-designed discrete implementation that employs a crystal resonator and associated tuning components. The Figure 28 shows an example of a discretely implemented VCXO using a crystal resonator.

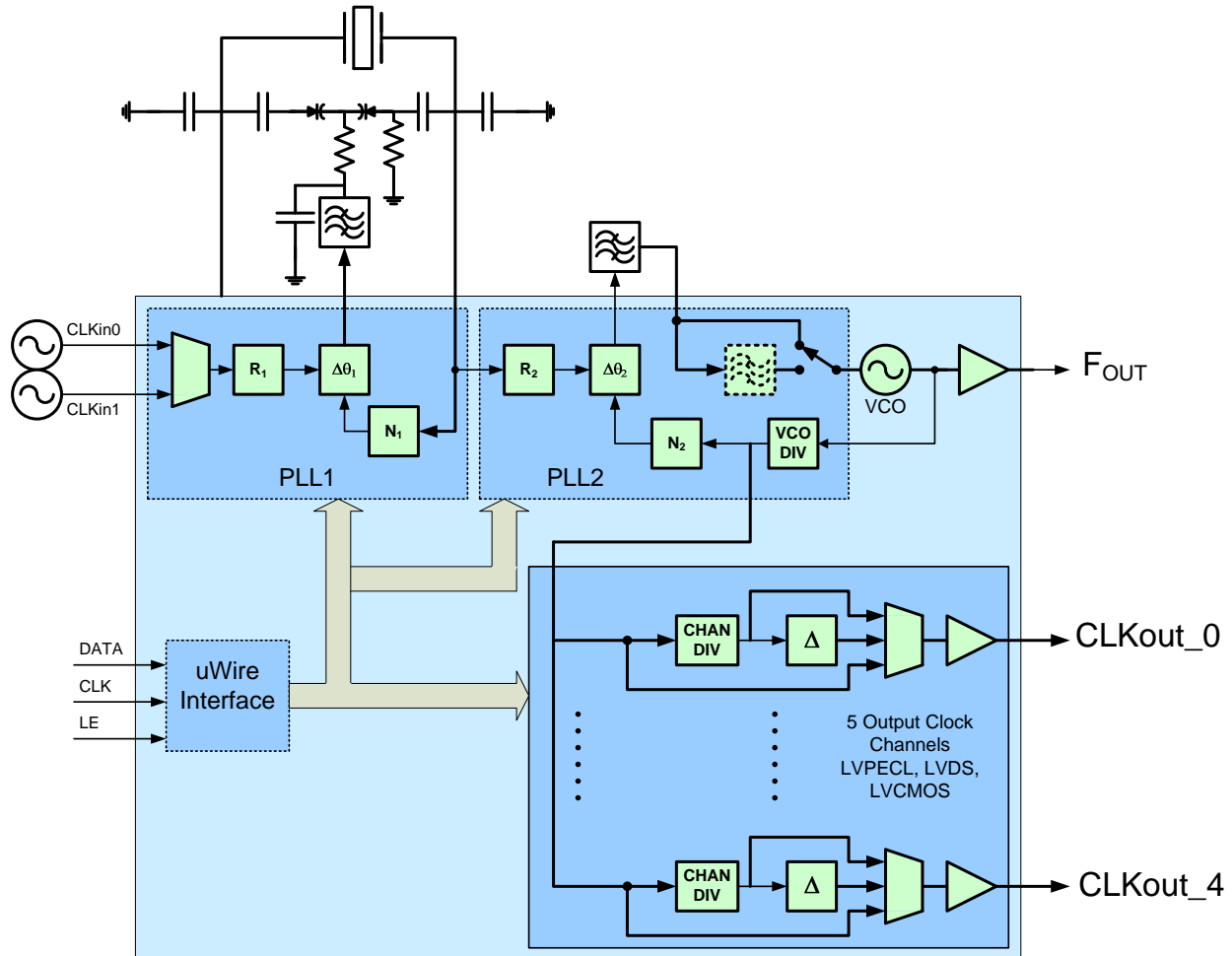


Figure 28 - LMK040xxB with the XTAL Resonator option and Tuning Circuit

LMK04000 Family evaluation boards are configured with either a VCXO or Crystal (-XO) on board. It is possible to place a VCXO on a Crystal board or a Crystal on a VCXO board by removing and replacing certain components on the board. Instructions for modifying the board are presented in Appendix G: VCXO/Crystal changes.

Figure 29 below shows the crystal oscillator circuit diagram.

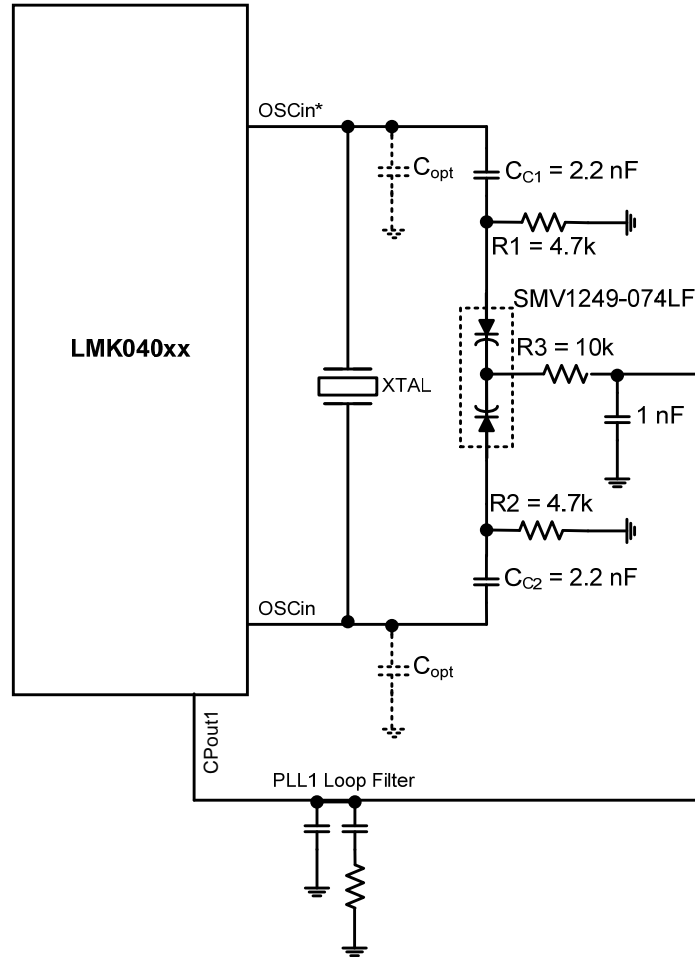


Figure 29 - Crystal Oscillator Circuit diagram

Appendix I: Properly Configuring LPT Port

When trying to solve any communications issue, it is convenient to program the POWERDOWN bit to confirm high/low current draw of the evaluation board or the PLL_MUX between “Logic Low” and “Logic High” LD output to confirm successful communications.

LPT Driver Loading

The parallel port must be configured for proper operation. To confirm that the LPT port driver is successfully loading click “LPT/USB” → “Check LPT Port.” If the driver properly loads then the following message is displayed:

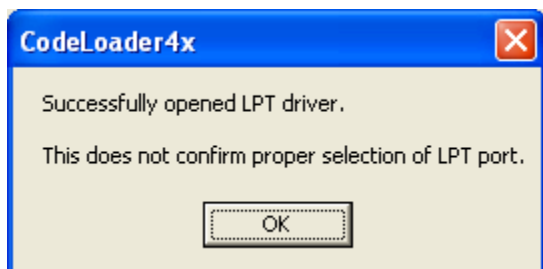


Figure 30 - Successfully Opened LPT Driver

Successful loading of LPT driver does not mean LPT communications in CodeLoader are setup properly. The proper LPT port must be selected and the LPT port must not be in an improper mode.

The PC must be rebooted after install for LPT support to work properly.

Correct LPT Port/Address

To determine the correct LPT port in Windows, open the device manager (On Windows XP, Start → Settings → Control Panel → System → Hardware Tab → Device Manager) and check the LPT port under the Ports (COM & LPT) node of the tree. It can be helpful to confirm that the LPT port is mapped to the expected port address, for instance to confirm that LPT1 is really mapped to address 0x378. This can be checked by viewing the properties of the LPT1 port and viewing resources tab to verify that the I/O Range starts at 0x378. CodeLoader expects the a traditional port mapping:

| Port | Address |
|------|---------|
| LPT1 | 0x378 |
| LPT2 | 0x278 |
| LPT3 | 0x3BC |

If a non-standard address is used, use the “Other” port address in CodeLoader and type in the port address in hexadecimal. It is possible to change the port address in the computer’s BIOS settings. The port address is set in CodeLoader at the Port Setup tab as shown in Figure 31.

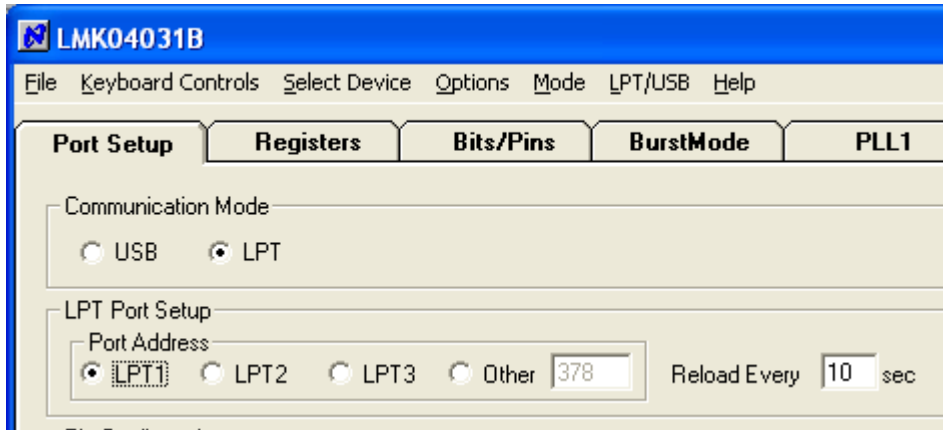


Figure 31 - Selecting the LPT Port

Correct LPT Mode

If communications are not working, then it is possible the LPT port mode is set improperly. It is recommended to use the simple, Output-only mode of the LPT port. This can be set in the BIOS of the computer. Common terms for this desired parallel port mode are “Normal,” “Output,” or “AT.” It is possible to enter BIOS setup during the initial boot up sequence of the computer.



Appendix J: Troubleshooting Information

If the evaluation board is not behaving as expected, the most likely issues are...

- 1) Board communication issue
- 2) Incorrect Programming of the device
- 3) Setup Error

Refer to this checklist for a practical guide on identifying/exposing possible issues.

1) Confirm Communications

Refer to Appendix I: Properly Configuring LPT Port to trouble shoot this item.

Remember to load device with Ctrl-L!

2) Confirm PLL1 operation/locking

- 1) Program PLL_MUX = "PLL 1 R Divider /2"
- 2) Confirm that LD pin output is half the expected phase detector frequency of PLL1.
 - i. If not, examine CLKin_SEL programming.
 - ii. If not, examine CLKin0_BUFTYPE / CLKin1_BUFTYPE.
 - iii. If not, examine PLL1 register R programming.
 - iv. If not, examine physical CLKin input.
- 3) Program PLL_MUX = "PLL 1 N Divider /2"
- 4) Confirm that LD pin output is half the expected phase detector frequency of PLL1.
 - i. If not, examine PLL1 register N programming.
 - ii. If not, examine physical OSCin input.

Naturally, the output frequency of the above two items, PLL 1 R Divider/2 and PLL 1 N Divider /2, on LD pin should be the same frequency.

- 5) Program PLL_MUX = "PLL1 DLD Active High"
- 6) Confirm the LD pin output is high.
 - i. If high, then PLL1 is locked, continue to PLL2 operation/locking.

(continued on next page)



- 7) If LD pin output is low, but the frequencies are the same, it is possible that excessive leakage on Vtune pin is causing the digital lock detect to not activate. By default PLL2 waits for the digital lock detect to go high before allowing PLL2 and the integrated VCO to lock. Different VCXO models have different input leakage specifications. High leakage, low PLL1 phase detector frequencies, and low PLL1 charge pump current settings can cause the PLL1 charge pump to operate longer than the digital lock detect timeout which allows the device to lock, but prevents the digital lock detect from activating.
 - i. Redesign PLL1 loop filter with higher phase detector frequency
 - ii. Redesign PLL1 loop filter with higher charge pump current
 - iii. Isolate VCXO tuning input from PLL1 charge pump with an op amp.
 - iv. Program RC_DLD1_Start = 0, this will allow PLL2 to starting lock even if the digital lock detect on PLL1 is not high.

3) Confirm PLL2 operation/locking

- 1) Program PLL_MUX = "PLL 2 R Divider /2"
- 2) Confirm that LD pin output is half the expected phase detector frequency of PLL2.
 - i. If not, examine PLL2 register R programming.
 - ii. If not, examine physical OSCin input.
- 3) Program PLL_MUX = "PLL 2 N Divider /2"
- 4) Confirm that LD pin output is half the expected phase detector frequency of PLL2.
 - i. If not, confirm OSCin_FREQ is programmed to OSCin frequency.
 - ii. If not, examine PLL2 register N programming.

Naturally, the output frequency of the above two items should be the same frequency.

- 5) Program PLL_MUX = "PLL2 DLD Active High"
- 6) Confirm the LD pin output is high.
- 7) Program PLL_MUX = "PLL1/2 DLD Active High"
- 8) Confirm the LD pin output is high.