

## **LMK04821EVM User's Guide**

These evaluation board instructions describe how to set up and operate the LMK04821EVM evaluation module (EVM).

| <b>Topic</b>                                                     | <b>Page</b> |
|------------------------------------------------------------------|-------------|
| <b>1 Evaluation Board Kit Contents .....</b>                     | <b>2</b>    |
| <b>2 Quick Start .....</b>                                       | <b>2</b>    |
| <b>3 PLL Loop Filters and Loop Parameters.....</b>               | <b>8</b>    |
| <b>4 Default CodeLoader Modes for the LMK0482x .....</b>         | <b>9</b>    |
| <b>5 Using CodeLoader to Program the LMK04821.....</b>           | <b>10</b>   |
| <b>6 Evaluation Board Inputs and Outputs .....</b>               | <b>12</b>   |
| <b>7 Recommended Test Equipment .....</b>                        | <b>16</b>   |
| <b>8 Appendix A: CodeLoader Usage .....</b>                      | <b>17</b>   |
| <b>9 Appendix B: Typical Phase Noise Performance Plots .....</b> | <b>23</b>   |
| <b>10 Appendix C: Schematics .....</b>                           | <b>26</b>   |
| <b>11 Appendix D: Bill of Materials .....</b>                    | <b>31</b>   |

## 1 Evaluation Board Kit Contents

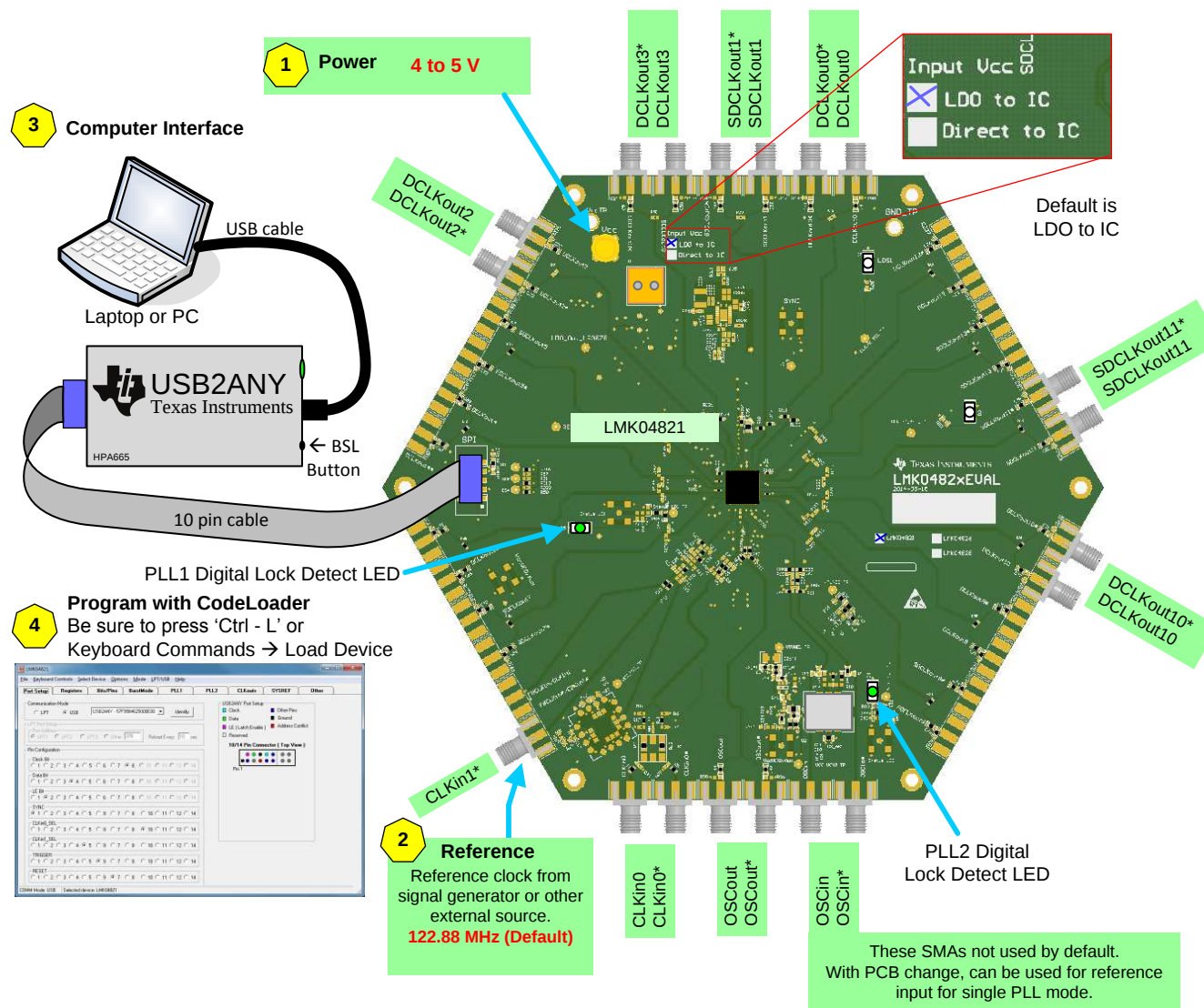
The evaluation board kit includes:

- Evaluation Board, SV600788-004
- USB2ANY interface

## 2 Quick Start

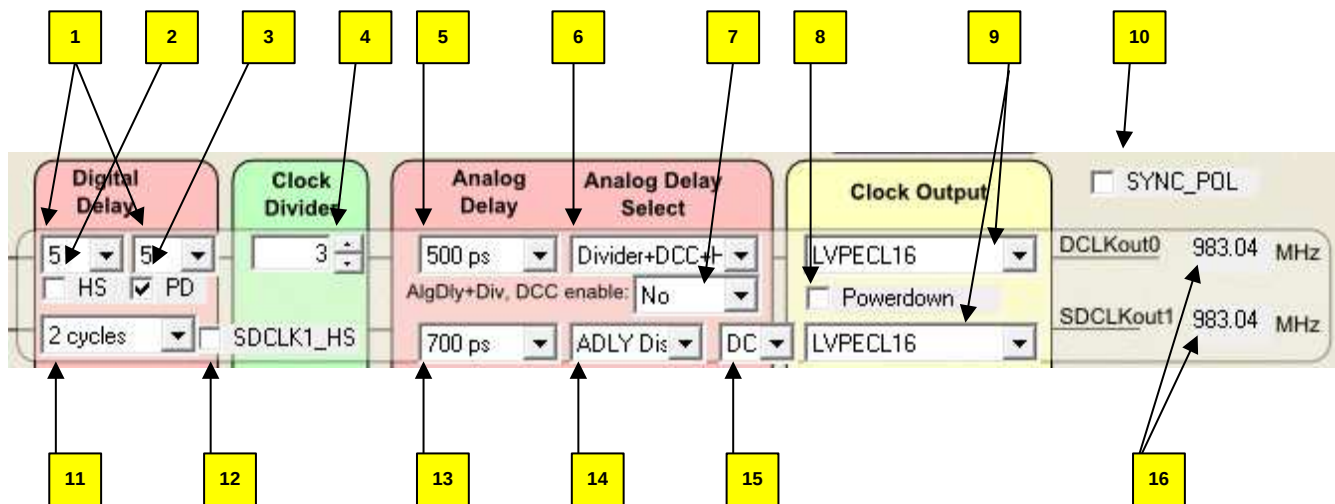
The LMK04821EVM allows full verification of the device functionality and performance specifications. To quickly set up and operate the board with basic equipment, refer to the quick start procedure below and test setup shown in [Figure 1](#).

1. Connect a voltage of **4.5** volts to the Vcc SMA connector or terminal block. Device operates at 3.3 V using onboard LP3878-ADJ LDO. VCXO operates at 3.3 V using onboard LP5900 LDO.
2. Connect a reference clock to the CLKin1 port from a signal generator or other source. Use **122.88 MHz** for default. Exact frequency and input port (CLKin0/CLKin1) depends on programming.
3. Connect the SPI header to a computer using USB2ANY.
4. Program the device with CodeLoader. CodeLoader is available for download at: <http://www.ti.com/tool/codeloader>.
  - (a) Select LMK04821 from “Select Device → Clock Conditioners” Menu.
  - (b) **Select USB mode** from the Port Setup tab. Confirm that USB device being used to communicate with EVM is chosen from list of available USB devices.
  - (c) Select a default mode from the “Mode” Menu. For the quick start use, “**CLKin1 122.88 MHz, OSCin 122.88 MHz**”
  - (d) **Ctrl-L** must be pressed at least once to load all registers. Alternatively click menu Keyboard Controls → Load Device.
5. Measurements may be made at an active CLKout port via its SMA connector.



**Figure 1. Quick Start Diagram**

## 2.1 CLKout Tab Description



**Figure 2. CLKout Tab Description Diagram**

### Device Clock Controls

1. DCLKoutX\_DDLY\_CNTL and DCLKoutX\_DDLY\_CNTH for controlling digital delay.
2. DCLKoutX\_HS, Half step bit (must have a HS mode selected by #6 or #7).
3. DCLKoutX\_DDLY\_PD, Power down digital delay for DCLKoutX.
4. DCLKoutX\_DIV, divider for the output channel.
5. DCLKoutX\_ADLY, analog delay (if enabled with #6).
6. DCLKoutX\_MUX, select source for output. Can be divider only, divider w/ DCC+HS (duty cycle correction and half step), bypass, or analog delay w/ Divider (and DCC/HS if selected by #7).
7. DCLKoutX\_ADLY\_MUX, Select DCC/HS or not when using analog delay mode.
8. CLKoutX\_Y\_PD, powerdown the entire CLKoutX\_Y block. Both outputs will be off.

### Device Clock/SYSREF Controls

9. DCLKoutX\_FMT or SDCLKoutY\_FMT, select output type for each output.
10. SYNC\_POL bit, will allow SYNC when in default configuration (SYNC\_MODE / SYSREF\_MUX setup for normal SYNC).

### SYSREF Controls

11. SDCLKoutY\_DDLY, Local SYSREF clock digital delay.
12. SDCLKoutY\_HS, SYSREF clock half step
13. SDCLKoutY\_ADLY, SYSREF analog delay (if enabled by #14)
14. SDCLKoutY\_ADLY\_EN, enable analog delay
15. SDCLKoutY\_MUX, select Device Clock or SYSREF clock for output to SDCLKoutY clock.
16. Calculated output frequency.

## 2.2 CodeLoader Tips

- On Bits/Pins tab right-clicking any register name in the Bits/Pins tab will display a Help prompt with the register address, data bit location/length, and a brief register description.
- On PLL tabs clicking Show Bits will show register info.
- On other tabs, pressing the ~ key with a control focused will show a help prompt.

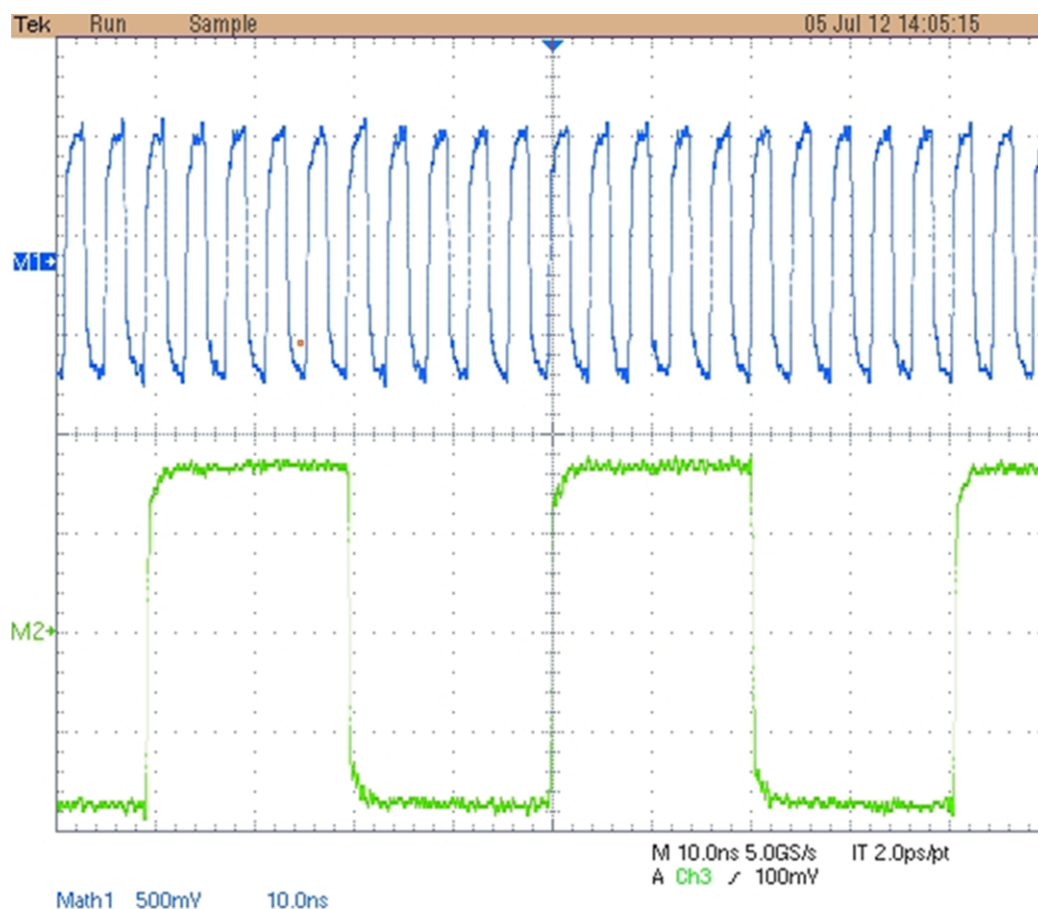
## 2.3 SYSREF Quick Start

The LMK04821 EVM allows for verification of the LMK04821's implementation of JESD204B SYSREF functionality. To quickly setup and operate the SYSREF functions refer to the following procedures.

### 2.3.1 Continuous SYSREF

1. On SYSREF Tab set SYNC\_MODE = 1 (SYNC Pin) and SYSREF\_MUX = 0 (Normal SYNC)
2. On SYSREF Tab set SDCLKoutY\_PD = 0 (where Y is the desired SDCLKout)
3. On CLKouts Tab set SDCLKoutY\_MUX = 1 (Set to "SR" for desired SDCLKout)
4. On SYSREF Tab set SYSREF\_PD and on CLKouts Tab SYSREF\_DDLY\_PD = 0
5. On CLKouts Tab set DCLKoutX\_DDLY\_PD = 0 and on SYSREF Tab set SYNC\_DISX and SYNC\_DISSYSREF = 0 (where X is the desired DCLKout)
6. Perform a SYNC event (toggle SYNC\_POL on/off/on)
7. On SYSREF Tab set SYNC\_DISX = 1 (for desired DCLKout's) and SYNC\_DISSYSREF = 1
8. On SYSREF Tab set SYSREF\_MUX = 3 (SYSREF Continuous)
9. On SYSREF Tab ensure SYSREF\_CLR = 0 (SYSREF tab, location: right side, below clock output pic)

In [Figure 3](#) and [Figure 4](#) the Blue trace is DCLKout6 at 245.76 MHz and the Green trace is SDCLKout7 (SYSREF) at 24.475 MHz. [Figure 5](#) shows the configuration of the LMK04821 outputs.



**Figure 3. Continuous SYSREF Output**

### 2.3.2 Pulsed SYSREF

1. On SYSREF tab set SDCLKoutY\_PD = 0 (where Y is the desired SDCLKout)
2. On CLKouts tab set SDCLKoutY\_MUX = 1 (Set to "SR" for desired SDCLKout)
3. On SYSREF tab set SYSREF\_PD and on CLKouts tab SYSREF\_DDLY\_PD = 0
4. On SYSREF tab set SYNC\_DISX and SYNC\_DISSYSREF = 0 (where X is the desired DCLKout)
5. Perform a SYNC event (toggle SYNC\_POL on/off/on)
6. On SYSREF tab set SYNC\_DISX = 1 (for desired DCLKout's) and SYNC\_DISSYSREF = 1
7. On SYSREF tab set SYSREF\_MUX = 2 (SYSREF Pulses)
8. On SYSREF tab set SYSREF\_PULSE\_CNT = 1, 2, 4, or 8 as desired
9. Generate a SYNC event (i.e. toggle SYNC\_POL on/off/on)
10. On SYSREF tab ensure SYSREF\_CLR = 0 (SYSREF tab, location: right side, below clock output pic)

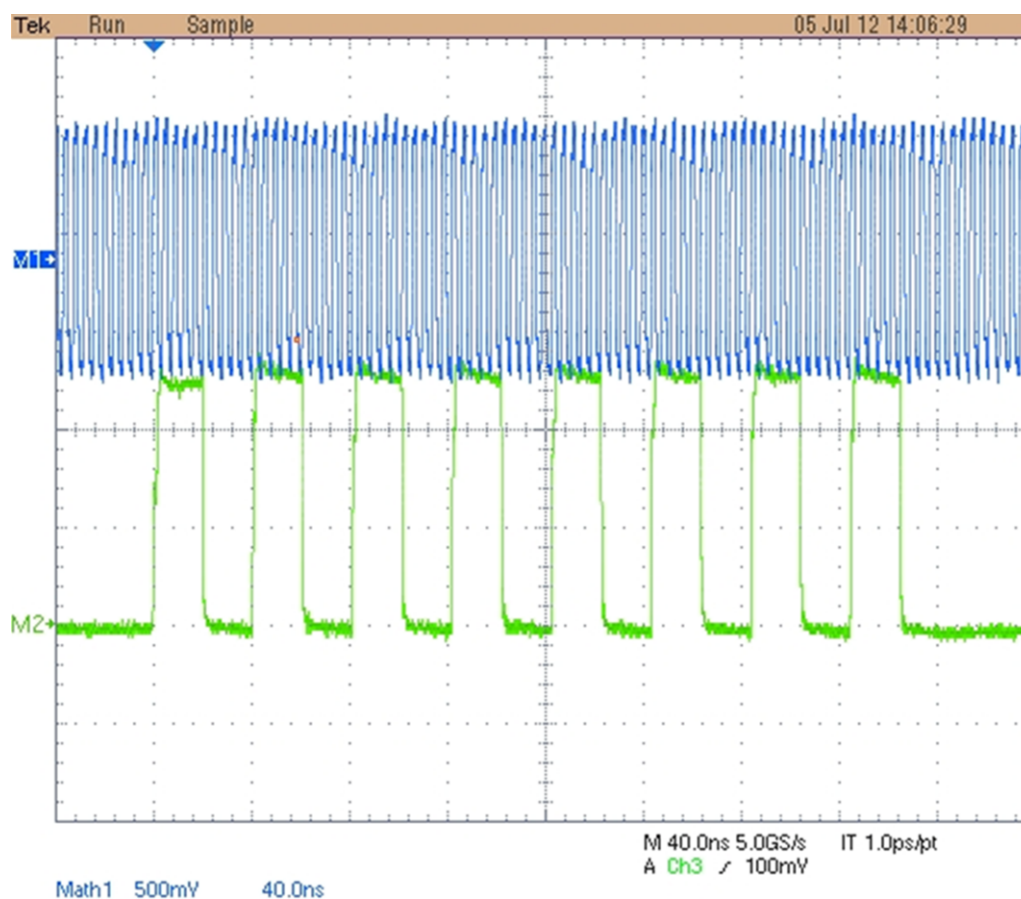


Figure 4. Pulsed SYSREF Output

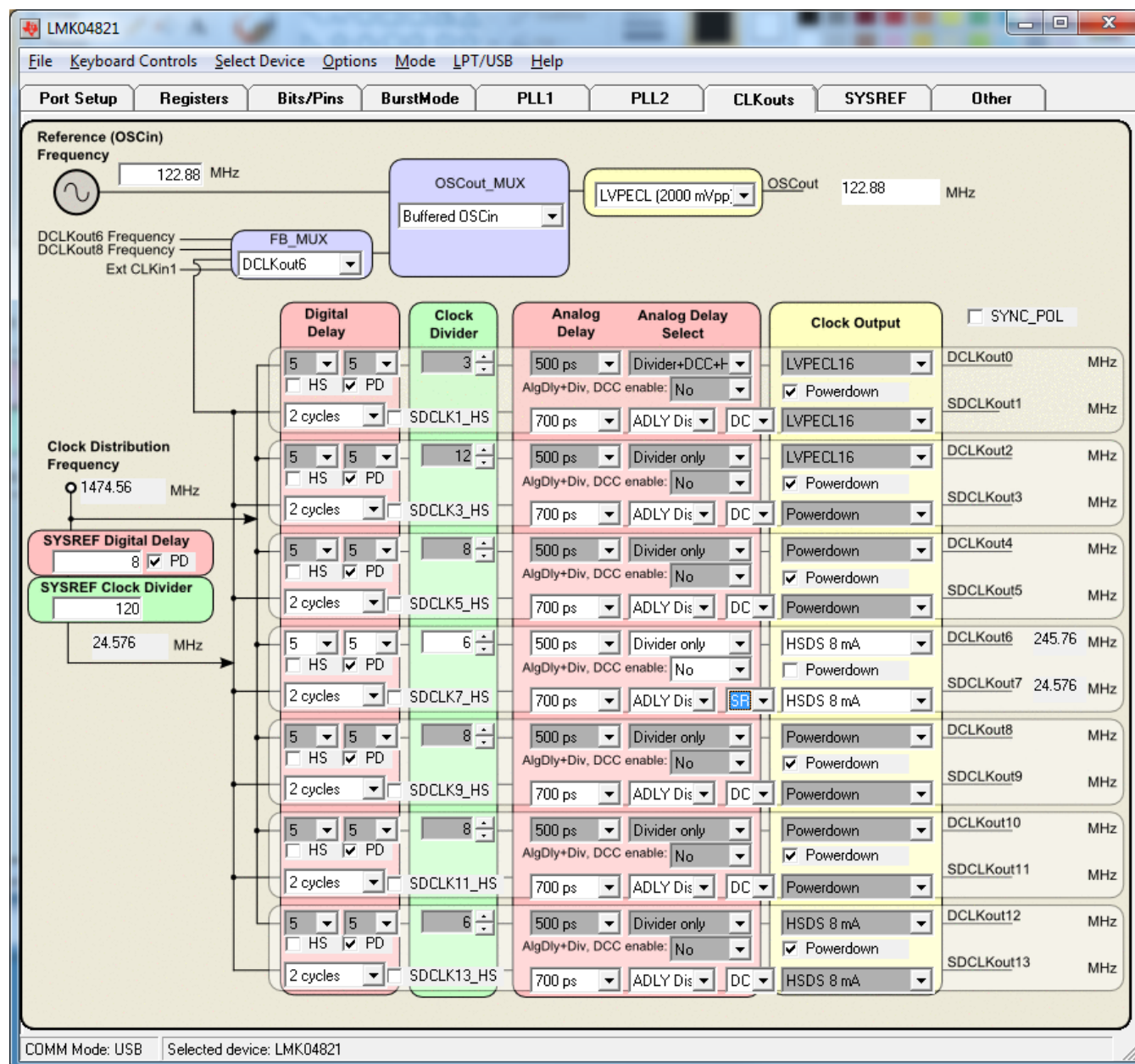


Figure 5. Clock Outputs Tab Setup for SYSREF Output on SDCLKout7

### 3 PLL Loop Filters and Loop Parameters

In jitter cleaning applications that use a cascaded or dual 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 LMK04821 evaluation board are setup using the approach above. The loop filter for PLL1 has been configured for a narrow loop bandwidth (< 100 Hz). The specific loop bandwidth values depend on the phase noise performance of the oscillator mounted on the board. The following tables (Table 1 and Integrated VCO PLL<sup>(1)</sup>) contain the parameters for PLL1 and PLL2 for each oscillator option.

TI's Clock Design Tool can be used to optimize PLL phase noise/jitter for given specifications. See: <http://www.ti.com/tool/clockdesigntool>

#### 3.1 PLL1 Loop Filter

**Table 1. PLL1 Loop Filter Parameters for Crystek 122.88 MHz VCXO**

| 122.88 MHz VCXO PLL       |                |                               |                          |
|---------------------------|----------------|-------------------------------|--------------------------|
| Phase Margin              | 50°            | Charge Pump Current, K $\phi$ | 450 $\mu$ A              |
| Loop Bandwidth            | 14 Hz          | Phase Detector Freq           | 1.024 MHz                |
|                           |                | VCO Gain                      | 2.5 kHz/V                |
| Reference Clock Frequency | 122.88 MHz     | Output Frequency              | 122.88 MHz<br>(To PLL 2) |
| Loop Filter Components    | C1_A1 = 100 nF | C2_A1 = 680 nF                | R2_A1 = 39 k $\Omega$    |

#### 3.2 PLL2 Loop Filter

**Integrated VCO PLL<sup>(1)</sup>**

|                               | LMK04821 |         | Units      |
|-------------------------------|----------|---------|------------|
|                               | VCO0     | VCO1    |            |
| C1_A2                         | 0.047    |         | nF         |
| C2_A2                         | 3.9      |         | nF         |
| C3 (internal)                 | 0.01     |         | nF         |
| C4 (internal)                 | 0.01     |         | nF         |
| R2_A2                         | 0.62     |         | k $\Omega$ |
| R3 (internal)                 | 0.2      |         | k $\Omega$ |
| R4 (internal)                 | 0.2      |         | k $\Omega$ |
| Charge Pump Current, K $\phi$ | 3.2      |         | mA         |
| Phase Detector Frequency      | 122.88   |         | MHz        |
| VCO Frequency                 | 1966.08  | 2949.12 | MHz        |
| K $v_{co}$                    | 14.5     | 16.4    | MHz/V      |
| N                             | 16       | 24      |            |
| Phase Margin                  | 72       | 70      | degrees    |
| Loop Bandwidth                | 288      | 221     | kHz        |

1. PLL Loop Bandwidth is a function of K $\phi$ , K $v_{co}$ , N, as well as loop filter components. Changing K $\phi$  and N will change the loop bandwidth

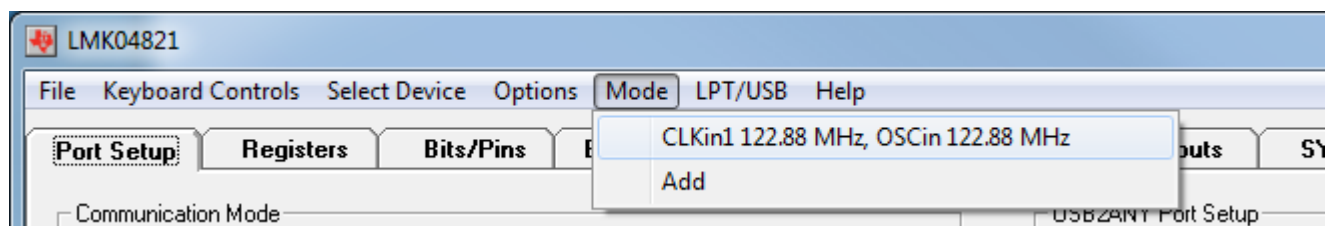
#### 4 Default CodeLoader Modes for the LMK0482x

CodeLoader saves the state of the selected LMK04821 device when exiting the software. To ensure a common starting point, the following modes listed in [Table 2](#) may be restored by clicking “Mode” and selecting the appropriate device configuration.

**NOTE:** VCO1 Divider may need to be manually set as it state is not directly saved.

**Table 2. Default CodeLoader Modes for the LMK0482x**

| Default CodeLoader Mode             | Device Mode            | CLKin Frequency | OSCin Frequency |
|-------------------------------------|------------------------|-----------------|-----------------|
| CLKin1 122.88 MHz, OSCin 122.88 MHz | Dual PLL, Internal VCO | 122.88 MHz      | 122.88 MHz      |



**Figure 6. Selecting a Default Mode for the LMK04828 Device**

## 5 Using CodeLoader to Program the LMK04821

The purpose of this section is to walk the user through using CodeLoader 4 to make some measurements with the LMK04821 device as an example. For more information on CodeLoader refer to CodeLoader 4 instructions located at <http://www.ti.com/tool/codeloader>

Before proceeding, be sure to follow the [Section 2](#) section above to ensure proper connections.

### 5.1 Start CodeLoader Application

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

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

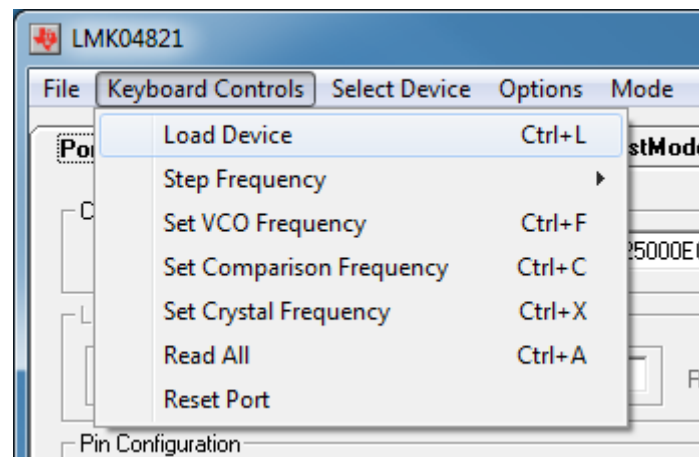
### 5.2 Select Device

Click “Select Device” → “Clock Conditioners” → “LMK04821”

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. Selecting the device does cause the device to be programmed.

### 5.3 Program/Load Device

Assuming the Port Setup settings are correct, press the “Ctrl+L” shortcut or click “Keyboard Controls” → “Load Device” from the menu to program the device to the current state of the newly loaded LMK04821 file.



**Figure 7. Loading the Device**

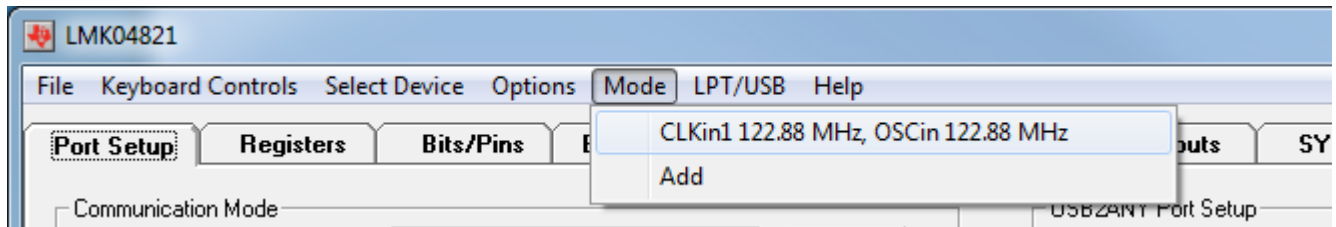
Once the device has been initially loaded, CodeLoader will automatically program changed registers so it is not necessary to re-load the device upon subsequent changes in the device configuration. It is possible to disable this functionality by ensuring there is no checkmark by the “Options” → “AutoReload with Changes.”

Because a default mode will be restored in the next step, this step isn’t completely necessary 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 CodeLoader 4 instructions located at <http://www.ti.com/tool/codeloader/> for more information on Port Setup. This contains information on troubleshooting communications.

## 5.4 Restoring a Default Mode

Click “Mode” → “CLKin1 122.88 MHz, OSCin 122.88 MHz”; then press Ctrl+L.



**Figure 8. Setting the Default Mode for LMK04828**

For the purpose 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. Again, remember to press Ctrl+L as the first step after loading a default mode.

## 5.5 Visual Confirmation of Frequency Lock

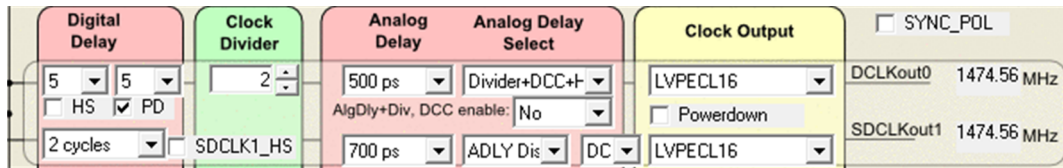
After a default mode is restored and loaded, LED D4, and D5 should illuminate when PLL1 and PLL2 are locked to the reference clock applied to CLKin1. This assumes PLL1\_LD\_MUX = PLL1\_DLD, PLL2\_LD\_MUX = PLL2\_DLD and PLLX\_LD\_TYPE = Output (Push-Pull).

## 5.6 Enable Clock Outputs

While the LMK04821 offers programmable clock output buffer formats, the evaluation board is shipped with pre-configured output terminations to match the default buffer type for each output.

To measure Phase noise at one of the clock outputs, for example DCLKout0:

1. 1. Click on the Distribution tab,
2. 2. Uncheck "Powerdown" in the Clock output box to enable the channel,
3. 3. Set the following settings as needed:
  - (a) Digital Delay value
  - (b) Clock Divider value
  - (c) Analog delay select and Analog Delay value (if not "Analog Delay and Divider" is selected in the Analog Delay Select box,



The screenshot shows the configuration interface for the LMK04821. It is divided into several sections:
 

- Digital Delay:** Includes a dropdown for '5', a dropdown for '5', checkboxes for 'HS' and 'PD' (with 'PD' checked), and a dropdown for '2 cycles'.
- Clock Divider:** Includes a dropdown for 'SDCLK1\_HS' and a numeric input field set to '2'.
- Analog Delay:** Includes a dropdown for '500 ps' and a dropdown for '700 ps'.
- Analog Delay Select:** Includes a dropdown for 'Divider+DCC+', a dropdown for 'ADLY Dis', and a dropdown for 'DC'.
- Clock Output:** Includes a dropdown for 'LVPECL16', a checkbox for 'Powerdown' (unchecked), and a dropdown for 'LVPECL16'.
- Output Summary:** Shows 'DCLKout0' at '1474.56 MHz' and 'SDCLKout1' at '1474.56 MHz'. A 'SYNC\_POL' checkbox is also present.

**Figure 9. Setting Digital Delay, Clock Divider, Analog Delay and Output Format**

4. Depending on the configured output type, the clock output SMAs can be interfaced to a test instrument with a single-ended 50-ohm input as follows.
  - (a) For LVDS:
    - (i) A balun (like ADT2-1T or high quality Prodyn BIB-100G) is recommended for differential-to-single-ended conversion.
  - (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 single-ended to the instrument.
  - (c) For HSDS:
    - (i) A balun (like ADT2-1T or high quality Prodyn BIB-100G) is recommended for differential-to-single-ended conversion.
5. The phase noise may be measured with a spectrum analyzer or signal source analyzer.

TI's Clock Design Tool can be used to calculate divider values to achieve desired clock output frequencies. See: <http://www.ti.com/tool/clockdesigntool>

## 6 Evaluation Board Inputs and Outputs

The following table (Table 3) contains descriptions of the inputs and outputs for the evaluation board. Unless otherwise noted, the connectors described can be assumed to be populated by default. Additionally, some applicable CodeLoader programming controls are noted for convenience.

**Table 3. Description of Evaluation Board Inputs and Outputs**

| Connector Name                                                                                                                                                                        | Signal Type, Input/Output | Description                                                                                                                                                                   |                                                                       |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------|
| Populated:<br>DCLKout0,<br>DCLKout0*,<br>SDCLKout1,<br>SDCLKout1*,<br>DCLKout2,<br>DCLKout2*,<br>SDCLKout3,<br>SDCLKout3*,<br>DCLKout10,<br>DCLKout10*,<br>SDCLKout11,<br>SDCLKout11* | Analog, Output            | Clock outputs with programmable output buffers.                                                                                                                               |                                                                       |
|                                                                                                                                                                                       |                           | The output terminations by default on the evaluation board are shown below:                                                                                                   |                                                                       |
|                                                                                                                                                                                       |                           | Clock Output Pair                                                                                                                                                             | Default Board Termination                                             |
|                                                                                                                                                                                       |                           | DCLKout0                                                                                                                                                                      | 240 Ω emitter resistor<br>(LVPECL16/LVPECL20/LCPECL)                  |
|                                                                                                                                                                                       |                           | SDCLKout1                                                                                                                                                                     |                                                                       |
|                                                                                                                                                                                       |                           | DCLKout2                                                                                                                                                                      |                                                                       |
|                                                                                                                                                                                       |                           | SDCLKout3                                                                                                                                                                     |                                                                       |
|                                                                                                                                                                                       |                           | DCLKout4                                                                                                                                                                      | 560 Ω across output<br>(LVDS / HSDS 6 mA / HSDS 8 mA /<br>HSDS 10 mA) |
|                                                                                                                                                                                       |                           | SDCLKout5                                                                                                                                                                     |                                                                       |
|                                                                                                                                                                                       |                           | DCLKout6                                                                                                                                                                      |                                                                       |
|                                                                                                                                                                                       |                           | SDCLKout7                                                                                                                                                                     |                                                                       |
|                                                                                                                                                                                       |                           | DCLKout8                                                                                                                                                                      |                                                                       |
|                                                                                                                                                                                       |                           | SDCLKout9                                                                                                                                                                     |                                                                       |
|                                                                                                                                                                                       |                           | DCLKout10                                                                                                                                                                     |                                                                       |
|                                                                                                                                                                                       |                           | SDCLKout11                                                                                                                                                                    |                                                                       |
|                                                                                                                                                                                       |                           | DCLKout12                                                                                                                                                                     |                                                                       |
|                                                                                                                                                                                       |                           | SDCLKout13                                                                                                                                                                    |                                                                       |
|                                                                                                                                                                                       |                           | Each CLKout pair has a programmable LVDS, LVPECL, or HSDS buffer. The output buffer type can be selected in CodeLoader in the Clock Outputs tab via the CLKoutX_TYPE control. |                                                                       |
|                                                                                                                                                                                       |                           | All clock outputs are AC-coupled to allow safe testing with RF test equipment.                                                                                                |                                                                       |
|                                                                                                                                                                                       |                           | All LVPECL clock outputs are terminated using 240 Ω emitter-resistors.                                                                                                        |                                                                       |
|                                                                                                                                                                                       |                           | All HSDS clock outputs have 560 Ω resistor across output.                                                                                                                     |                                                                       |
|                                                                                                                                                                                       |                           | If an output pair is programmed to LVCMOS, each output can be independently configured (normal, inverted, or off/tri-state).                                                  |                                                                       |
| Populated:<br>OSCout, OSCout*                                                                                                                                                         | Analog, Output            | Buffered outputs of OSCin port.                                                                                                                                               |                                                                       |
|                                                                                                                                                                                       |                           | The output terminations on the evaluation board are shown below.:                                                                                                             |                                                                       |
|                                                                                                                                                                                       |                           | OSC output pair                                                                                                                                                               | Default Board Termination                                             |
|                                                                                                                                                                                       |                           | OSCout                                                                                                                                                                        | 240 Ω emitter resistor<br>LVPECL                                      |
|                                                                                                                                                                                       |                           | OSCout has a programmable LVDS, LVPECL, or LVCMOS output buffer. The OSCout buffer type can be selected in CodeLoader on the Distribution tab via the OSCout_FMT control.     |                                                                       |
|                                                                                                                                                                                       |                           | OSCout is AC-coupled to allow safe testing with RF test equipment.                                                                                                            |                                                                       |
|                                                                                                                                                                                       |                           | The OSCout output is terminated using 240 Ω emitter-resistors.                                                                                                                |                                                                       |
|                                                                                                                                                                                       |                           | If OSCout is programmed as LVCMOS, each output can be independently configured (normal, inverted, inverted, and off/tri-state).                                               |                                                                       |
|                                                                                                                                                                                       |                           | Best performance/EMI reduction is achieved by using a complementary output mode like Norm/Inv. It is NOT recommended to use Norm/Norm or Inv/Inv mode.                        |                                                                       |



**Table 3. Description of Evaluation Board Inputs and Outputs (continued)**

| Connector Name                                 | Signal Type, Input/Output | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |               |               |              |   |   |        |   |   |        |   |   |        |   |   |          |
|------------------------------------------------|---------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|---------------|--------------|---|---|--------|---|---|--------|---|---|--------|---|---|----------|
| Populated:<br>SPI                              |                           | <p>10-pin header for SPI programming interface and programmable logic I/O pins for the LMK04821.</p> <p>The programmable logic I/O signals accessible through this header include: RESET, SYNC, Status_LD1, Status_LD2, CLKin_SEL0, and CLKin_SEL1. These logic I/O signals also have dedicated SMAs and test points.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |               |               |              |   |   |        |   |   |        |   |   |        |   |   |          |
| Test point:<br>Status_LD1_TP                   | CMOS,<br>Input/Output     | <p>Programmable status output pin. By default, set to output the digital lock detect status signal for PLL1.</p> <p>In the default CodeLoader modes, LED D5 will illuminate green when PLL1 lock is detected by the LMK04821 (output is high) and turn off when lock is lost (output is low).</p> <p>The status output signal for the Status_LD1 pin can be selected on the <b>Bits/Pins</b> tab via the PLL1_LD_MUX control.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                 |               |               |              |   |   |        |   |   |        |   |   |        |   |   |          |
| Status_LD                                      |                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |               |               |              |   |   |        |   |   |        |   |   |        |   |   |          |
| Test point:<br>Status_LD2_TP                   | CMOS,<br>Input/Output     | <p>Programmable status output pin. By default, set to output the digital lock detect status signal for PLL2.</p> <p>In the default CodeLoader modes, LED D4 will illuminate green when PLL1 lock is detected by the LMK04821 (output is high) and turn off when lock is lost (output is low).</p> <p>The status output signal for the Status_LD1 pin can be selected on the <b>Bits/Pins</b> tab via the PLL2_LD_MUX control.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                 |               |               |              |   |   |        |   |   |        |   |   |        |   |   |          |
| Status_LD2                                     |                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |               |               |              |   |   |        |   |   |        |   |   |        |   |   |          |
| Test points:<br>CLKin0_SEL_TP<br>CLKin1_SEL_TP | CMOS,<br>Input/Output     | <p>Programmable status I/O pins. By default, set as input pins for controlling input clock switching of CLKin0 and CLKin1.</p> <p>These inputs will not be functional because CLKin_SEL_MODE is set to 0 (CLKin0 Manual) by default in the <b>Bits/Pins</b> tab in CodeLoader. To enable input clock switching, CLKin_SEL_MODE must be 3 and Status_CLKinX_TYPE must be 0 to 3 (pin enabled as an input).</p> <p><b>Input Clock Switching – Pin Select Mode</b></p> <p>When CLKin_SEL_MODE is 3, the Status_CLKinX pins select which clock input is active as follows:</p> <table> <tr> <th>Status_CLKin1</th><th>Status_CLKin0</th><th>Active Clock</th></tr> <tr> <td>0</td><td>0</td><td>CLKin0</td></tr> <tr> <td>0</td><td>1</td><td>CLKin1</td></tr> <tr> <td>1</td><td>0</td><td>CLKin2</td></tr> <tr> <td>1</td><td>1</td><td>Holdover</td></tr> </table> | Status_CLKin1 | Status_CLKin0 | Active Clock | 0 | 0 | CLKin0 | 0 | 1 | CLKin1 | 1 | 0 | CLKin2 | 1 | 1 | Holdover |
| Status_CLKin1                                  | Status_CLKin0             | Active Clock                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |               |               |              |   |   |        |   |   |        |   |   |        |   |   |          |
| 0                                              | 0                         | CLKin0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |               |               |              |   |   |        |   |   |        |   |   |        |   |   |          |
| 0                                              | 1                         | CLKin1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |               |               |              |   |   |        |   |   |        |   |   |        |   |   |          |
| 1                                              | 0                         | CLKin2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |               |               |              |   |   |        |   |   |        |   |   |        |   |   |          |
| 1                                              | 1                         | Holdover                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |               |               |              |   |   |        |   |   |        |   |   |        |   |   |          |
| Test point:<br>SYNC_TP                         | CMOS,<br>Input/Output     | <p>Programmable status I/O pin. By default, set as an input pin for synchronize the clock outputs with a fixed and known phase relationship between each clock output selected for SYNC. A SYNC event also causes the digital delay values to take effect.</p> <p>SYNC/SYSREF_REQ pin forces the SYSREF_MUX into SYSREF Continuous mode (0x03) when SYSREF_REQ_EN = 1.</p> <p>SYNC/SYSREF_REQ pin can hold outputs in a low state, depending on system configuration. SYNC_POL adjusts for active low or active high control.</p> <p>A SYNC event can also be programmed by toggling the SYNC_POL_INV bit in the <b>Bits/Pins</b> tab in CodeLoader.</p>                                                                                                                                                                                                          |               |               |              |   |   |        |   |   |        |   |   |        |   |   |          |
| Not Populated:<br>SYNC                         |                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |               |               |              |   |   |        |   |   |        |   |   |        |   |   |          |
| Test point:<br>RESET_TP                        | CMOS,<br>Input/Output     | <p>Programmable status I/O pin.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |               |               |              |   |   |        |   |   |        |   |   |        |   |   |          |

## 7 Recommended Test Equipment

### **Power Supply**

The Power Supply should be a low noise power supply, particularly when the devices on the board are being directly powered (onboard LDO regulators bypassed).

### **Phase Noise / Spectrum Analyzer**

To measure phase noise and RMS jitter, an Agilent E5052 Signal Source Analyzer is recommended. An Agilent E4445A PSA Spectrum Analyzer with the Phase Noise option is also usable although the architecture of the E5052 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.

### **Oscilloscope**

To measure the output clocks for AC performance, such as rise time or fall time, propagation delay, or skew, it is suggested to use a real-time oscilloscope with at least 1 GHz analog input bandwidth (2.5+ GHz recommended) with 50 ohm inputs and 10+ Gsps sample rate. To evaluate clock synchronization or phase alignment between multiple clock outputs, it's recommended to use phase-matched, 50-ohm cables to minimize external sources of skew or other errors/distortion that may be introduced if using oscilloscope probes.

## 8 Appendix A: CodeLoader Usage

CodeLoader is used to program the evaluation board with a USB port using the included USB2ANY.

### 8.1 Port Setup Tab

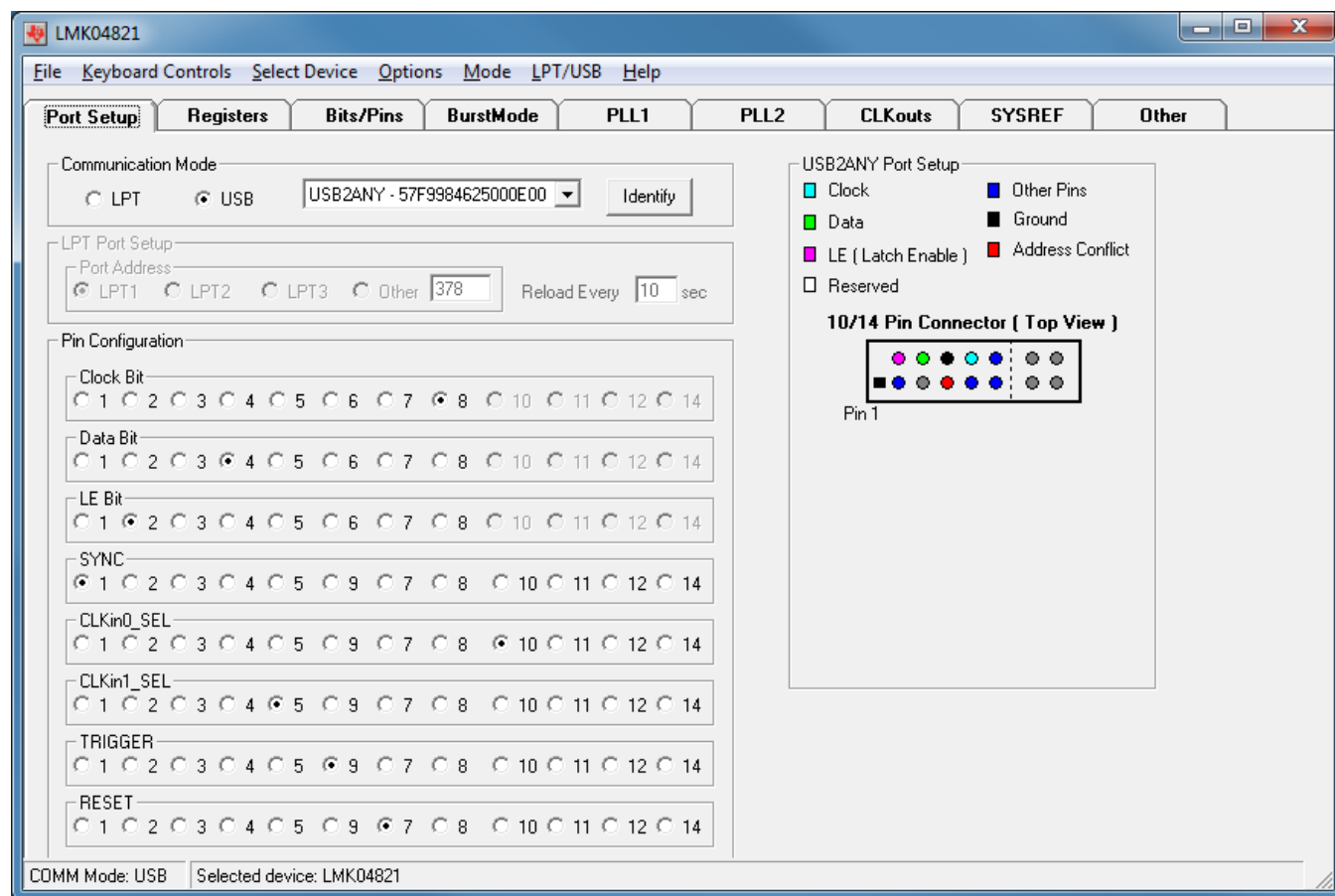


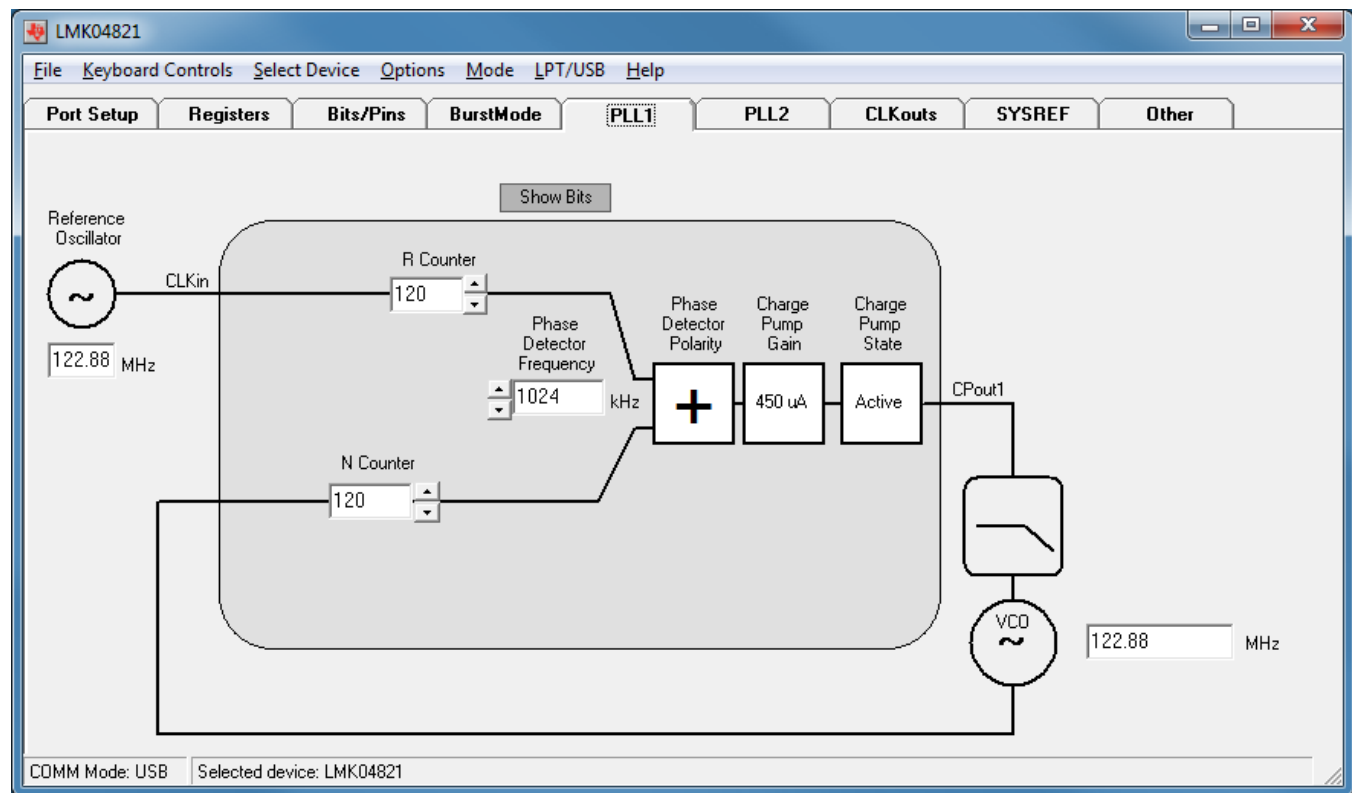
Figure 10. Port Setup Tab

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. If USB mode is selected, identify the correct target device by clicking the Identify button - the selected USB2ANY will blink the onboard LED 5 times.

The Pin Configuration field is hardware dependent and normally **does not** need to be changed by the user.

USB interface should be used for LMK04821. When using USB2ANY Clock Bit, Data Bit, and LE Bit positions have no effect.

## 8.2 PLL1 Tab



**Figure 11. PLL1 Tab**

The PLL1 tab allows the user to change the following parameters in [Table 4](#).

**Table 4. Registers Controls and Descriptions in PLL1 Tab**

| Control Name                         | Register Name | Description                                                                                                                                                                                  |
|--------------------------------------|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Reference Oscillator Frequency (MHz) | n/a           | CLKin frequency of the selected reference clock.                                                                                                                                             |
| Phase Detector Frequency (MHz)       | n/a           | PLL1 Phase Detector Frequency (PDF).<br>This value is calculated as:<br>$PLL1\ PDF = CLKin\ Frequency / (PLL1\_R)$                                                                           |
| VCO Frequency (MHz)                  | n/a           | The VCO Frequency should be the OSCin frequency, except when operating in Dual PLL with 0-delay feedback. This value is calculated as:<br>$VCO\ Freq\ (OSCin\ freq) = PLL1\ PDF * PLL1\_N$ . |
| R Counter                            | PLL1_R        | PLL1 R Counter value (1 to 16383).                                                                                                                                                           |
| N Counter                            | PLL1_N        | PLL1 N Counter value (1 to 16383).                                                                                                                                                           |
| Phase Detector Polarity              | PLL1_CP_POL   | PLL1 Phase Detector Polarity.<br>Click on the polarity sign to toggle polarity "+" or "-".                                                                                                   |
| Charge Pump Gain                     | PLL1_CP_GAIN  | PLL1 Charge Pump Gain.<br>Left-click/right-click to increase/decrease charge pump gain (50,150, 250, 1550 uA).                                                                               |
| Charge Pump State                    | PLL1_CP_TRI   | PLL1 Charge Pump State.<br>Click to toggle between Active and Tri-State.                                                                                                                     |

### 8.3 PLL2 Tab

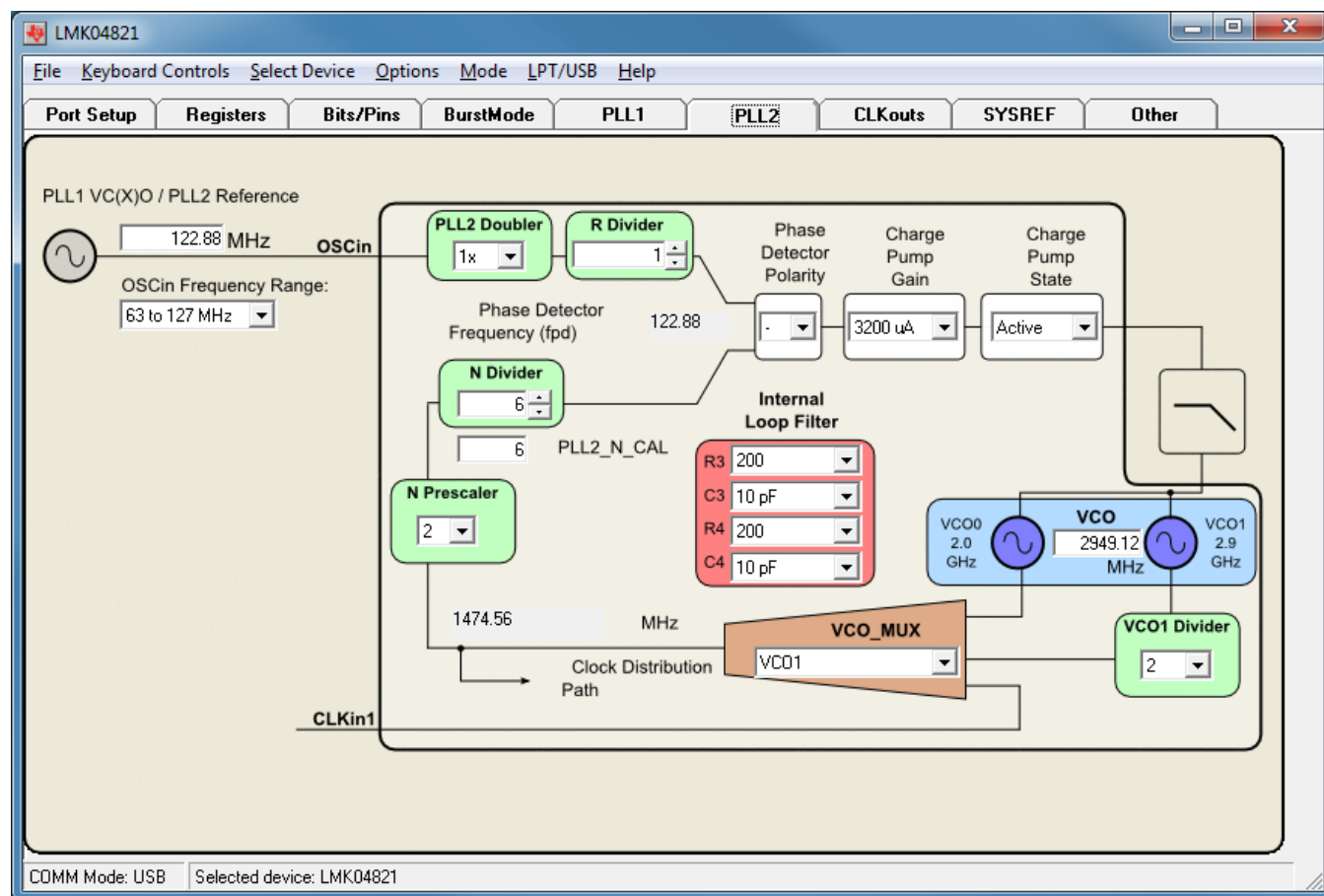


Figure 12. PLL2 Tab

Table 5. Registers Controls and Descriptions in PLL2 Tab<sup>(1)</sup>

| Control Name                         | Register Name  | Description                                                                                                                |
|--------------------------------------|----------------|----------------------------------------------------------------------------------------------------------------------------|
| Reference Oscillator Frequency (MHz) | OSCin_FREQ     | OSCin frequency from the External VCXO or Crystal.                                                                         |
| Phase Detector Frequency (MHz)       | n/a            | PLL2 Phase Detector Frequency (PDF). Calculated as:<br>$PLL2\ PDF = OSCin\ Freq * (2EN\_PLL2\_REF\_2X) / PLL2\_R$ .        |
| VCO Frequency (MHz)                  | n/a            | VCO Frequency of the LMK048xxB device. Calculated as:<br>$VCO\ Freq = PLL2\ PDF * (PLL2\_N * PLL2\_P * VCO\ div\ value)$ . |
| Doubler                              | EN_PLL2_REF_2X | PLL2 Doubler: 0 = Bypass Doubler, 1 = Enable Doubler                                                                       |
| R Counter                            | PLL2_R         | PLL2 R Counter value (1 to 4095).                                                                                          |
| N Counter                            | PLL2_N         | PLL2 N Counter value (1 to 262143).                                                                                        |
| PLL Prescaler                        | PLL2_P         | PLL2 N Prescaler value (2 to 8).                                                                                           |
| Phase Detector Polarity              | PLL2_CP_POL    | PLL2 Phase Detector Polarity. Click on the polarity sign to toggle polarity "+" or "-".                                    |
| Charge Pump Gain                     | PLL2_CP_GAIN   | PLL2 Charge Pump Gain. Left-click/right-click to increase/decrease charge pump gain (100, 400, 1600, 3200 uA).             |
| Charge Pump State                    | PLL2_CP_TRI    | PLL2 Charge Pump State. Click to toggle.                                                                                   |
| VCO Mux                              | VCO_MUX        | Allows user to select between VCO0, VCO1 with VCO1_DIV, or CLKIn1 for external VCO or clock distribution mode.             |
| VCO1 Divider                         | VCO1_DIV       | Allows user to set the divide value used by VCO1 output. This will limit maximum output frequency possible.                |

<sup>(1)</sup> Changes made on this tab will be reflected in the **Clock Outputs** tab. The VCO Frequency should conform to the specified internal VCO frequency range.

## 8.4 Distribution Tab

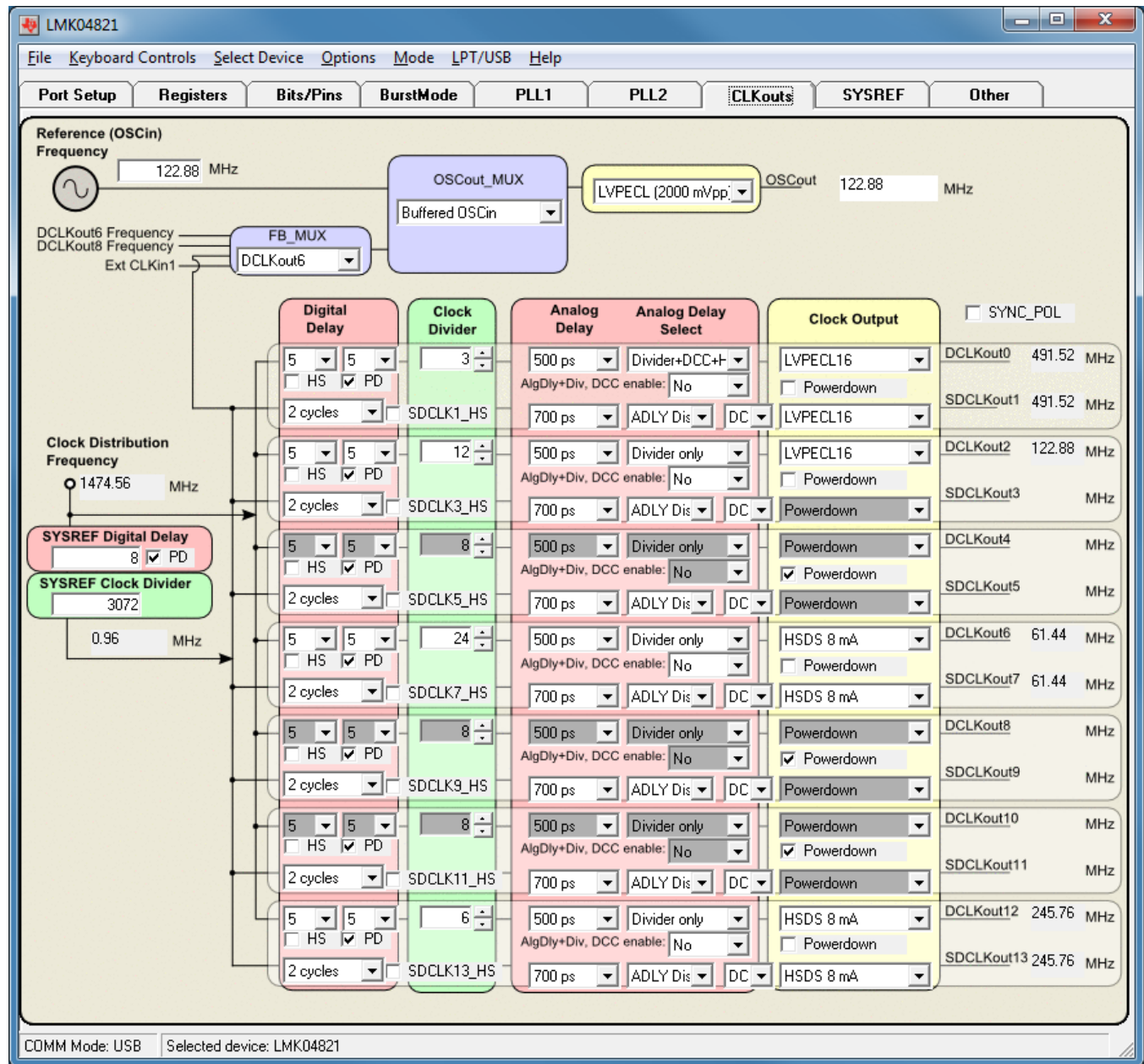


Figure 13. Distribution Tab

The **Distribution tab** allows the user to control the output channel blocks.

Note that the total PLL2 N divider value is the product of the VCO Divider value and the PLL N Prescaler and N Counter values (shown in the **PLL2** tab), and is given by:

$$\text{PLL2 N Total} = \text{PLL2 N Prescaler} * \text{PLL2 N Counter}$$

(1)

## 8.5 SYSREF Tab

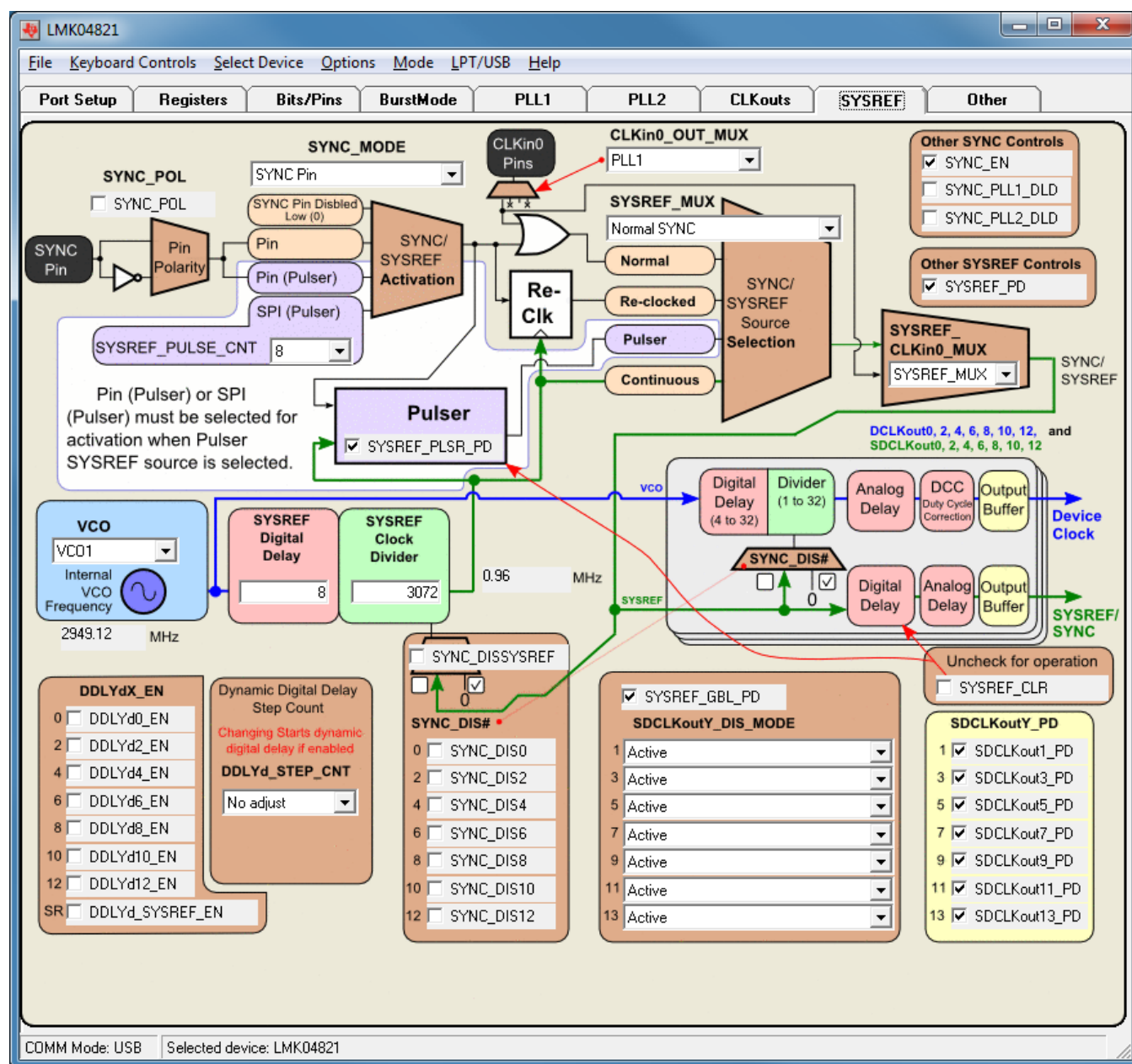


Figure 14. SYSREF Tab

The **SYSREF tab** show the controls for SYSREF functionality as well as Dynamic Digital Delay enable.

## 8.6 Bits/Pins Tab

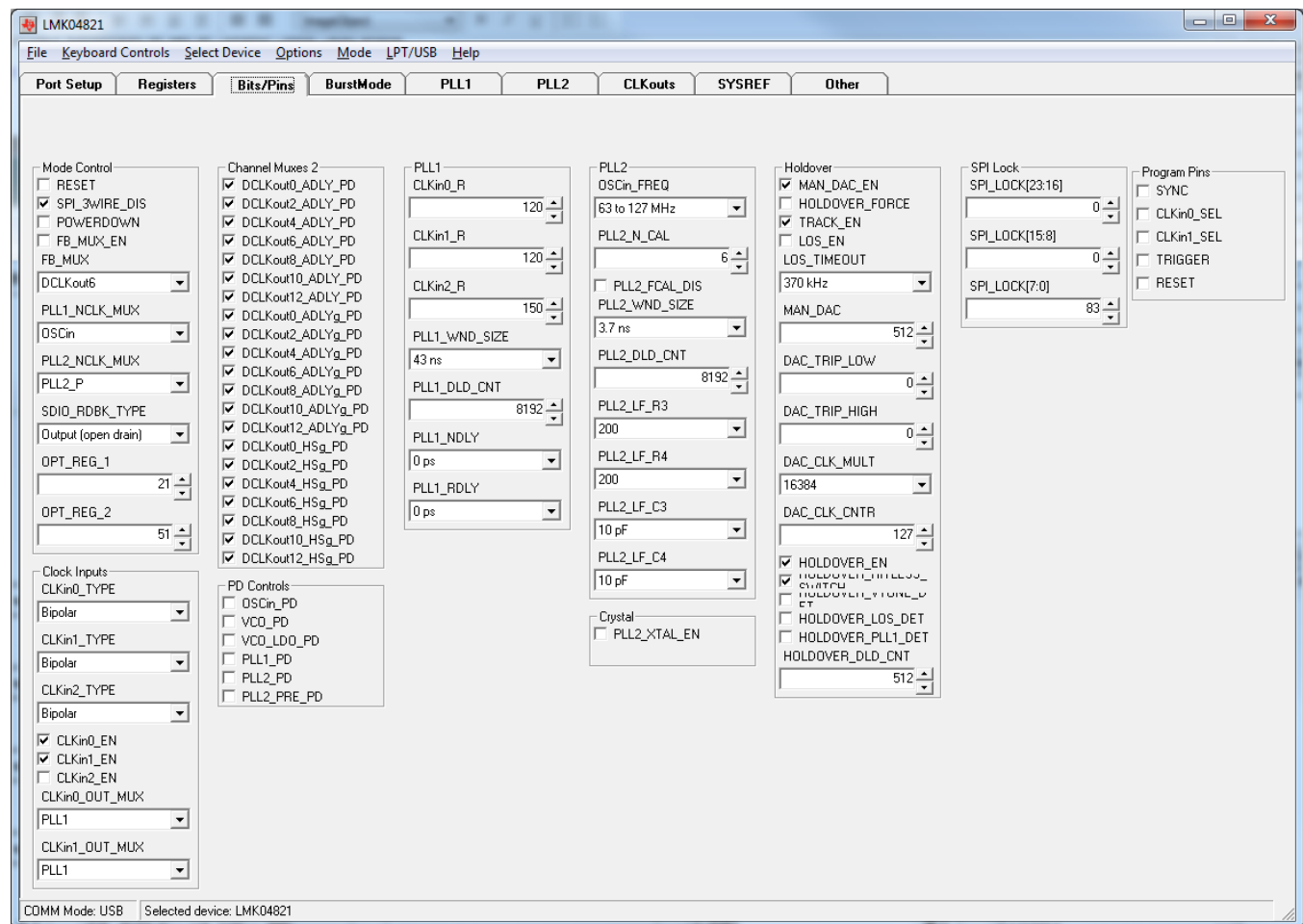


Figure 15. Bits/Pins Tab

The **Bits/Pins** tab allows the user to program bits not available on other tabs.

**NOTE:** Right-clicking any register name in the **Bits/Pins** tab will display a Help prompt with the register address, data bit location/length, and a brief register description. On PLL2, CLKouts, SYSREF, and Other tabs pressing the ` key will provide help.

## 9 Appendix B: Typical Phase Noise Performance Plots

The LMK04821's dual PLL architecture achieves ultra low jitter and phase noise by allowing the external VCXO or Crystal's phase noise to dominate the final output phase noise at low offset frequencies and the internal VCO's phase noise to dominate the final output phase noise at high offset frequencies. This results in the best overall noise and jitter performance.

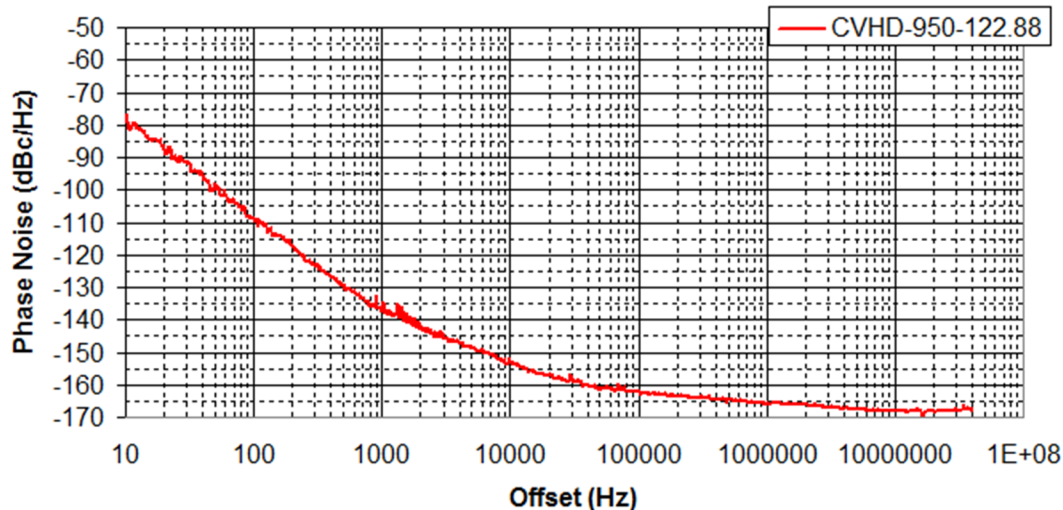
Table 6 lists the test conditions used for output clock phase noise measurements with the Crystek 122.88 MHz VCXO.

**Table 6. LMK04821 Test Conditions**

| Parameter                      | Value                                                |
|--------------------------------|------------------------------------------------------|
| PLL1 Reference clock input     | CLKin1* single-ended input, CLKin1 AC-coupled to GND |
| PLL1 Reference Clock frequency | 122.88 MHz                                           |
| PLL1 Phase detector frequency  | 1024 kHz                                             |
| PLL1 Charge Pump Gain          | 450 $\mu$ A                                          |
| VCXO frequency                 | 122.88 MHz                                           |
| PLL2 phase detector frequency  | 122.88 MHz                                           |
| PLL2 Charge Pump Gain          | 3200 $\mu$ A                                         |
| PLL2 REF2X mode                | Enabled                                              |

### 9.1 122.88 MHz VCXO Phase Noise

The phase noise of the reference is masked by the phase noise of this VCXO by using a narrow loop bandwidth for PLL1 while retaining the frequency accuracy of the reference clock input. This VCXO sets the reference noise to PLL2. Figure 16 shows the open loop typical phase noise performance of the CVHD-950-122.88 Crystek VCXO.



**Figure 16. Crystek CVHD-950-122.88 MHz VCXO Phase Noise at 122.88 MHz**

Table 7. VCXO Phase Noise and Jitter

| Offset  | VCXO Phase Noise at 122.88 MHz (dBc/Hz) | VCXO RMS Jitter to high offset of 20 MHz at 122.88 MHz (rms fs) |
|---------|-----------------------------------------|-----------------------------------------------------------------|
| 10 Hz   | -76.6                                   | 60.5                                                            |
| 100 Hz  | -108.9                                  | 36.2                                                            |
| 1 kHz   | -137.4                                  | 35                                                              |
| 10 kHz  | -153.3                                  | 34.5                                                            |
| 100 kHz | -162                                    | 32.9                                                            |
| 1 MHz   | -165.7                                  | 22.7                                                            |
| 10 MHz  | -168.1                                  | 515.4                                                           |
| 40 MHz  | -168.1                                  | 60.5                                                            |

## 9.2 Output Measurement Technique

The same technique was used to measure phase noise for all three output types available on the programmable OSCout and CLKout buffers. This was achieved by terminating one side of the LVPECL, LVDS, or LVCMOS output with a 50-ohm load, and measuring the other side single-ended using an Agilent E5052B Source Signal Analyzer.

## 9.3 Clock Outputs (DCLKout and SDCLKout)

The LMK04821 features programmable HSDS, LVDS, LVPECL buffer modes for the DCLKoutX, SDCLKout pairs. Below is a phase noise measurement of DCLKout2 (best phase noise clock output) using a balun.

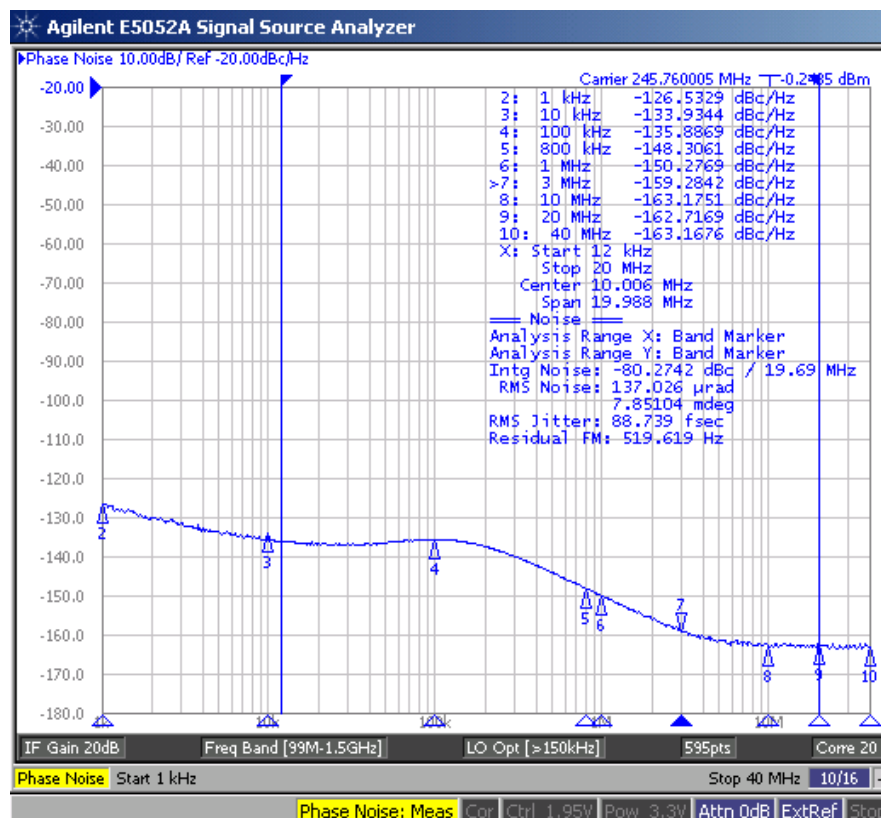


Figure 17. LMK04821 DCLKout2, VCO0, 245.76 MHz, Div8, LVPECL20 /w 240 ohm emitter resistor, DCLKoutX\_MUX=Divider, IDL=1, ODL=0, Balun = Prodyn BIB-100G

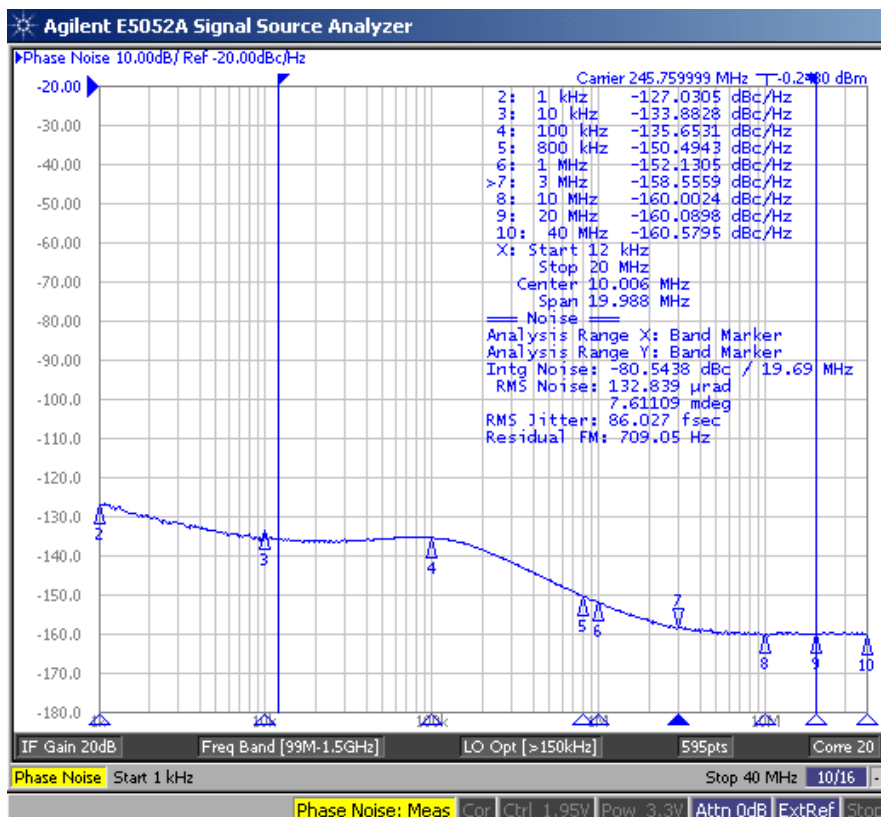
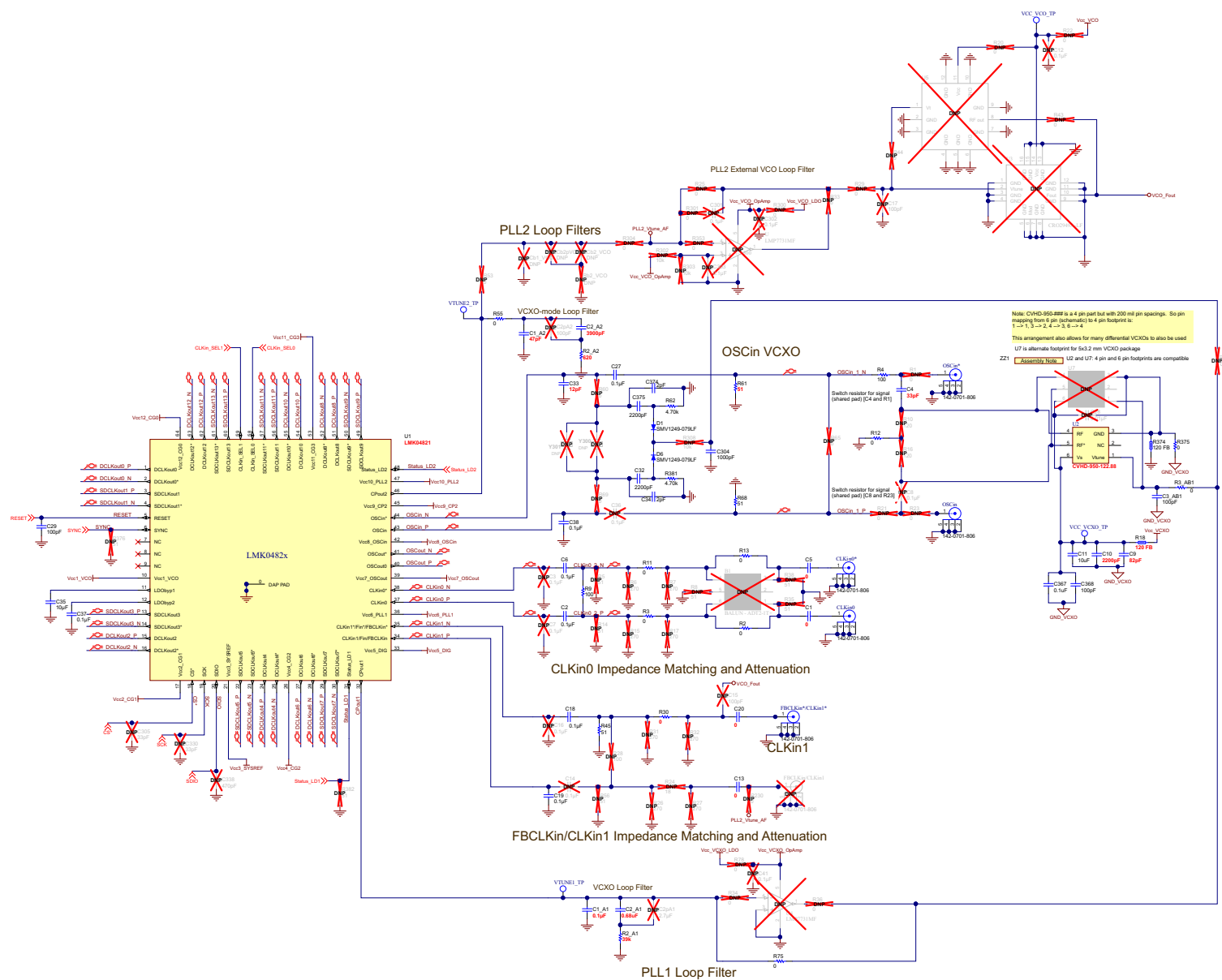


Figure 18. LMK04821 DCLKout2, VCO1, 245.76 MHz, VCO1\_DIV =  $\div 2$ , CLKout2\_DIV =  $\div 6$   
LVPECL20 /w 240 ohm emitter resistor, DCLKout2\_MUX=Divider, IDL=1, ODL=0, Balun = Prodyn BIB-100G

Figure 19. LMK04821 DCLKout2, VCO1, 245.76 MHz, Div10, LVPECL20 /w  
240 ohm emitter resistor, DCLKoutX\_MUX=Divider, IDL=1, ODL=0, Single Ended

## 10 Appendix C: Schematics



### Figure 20. Power Supply





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## SYSREF CLOCK OUTPUTS

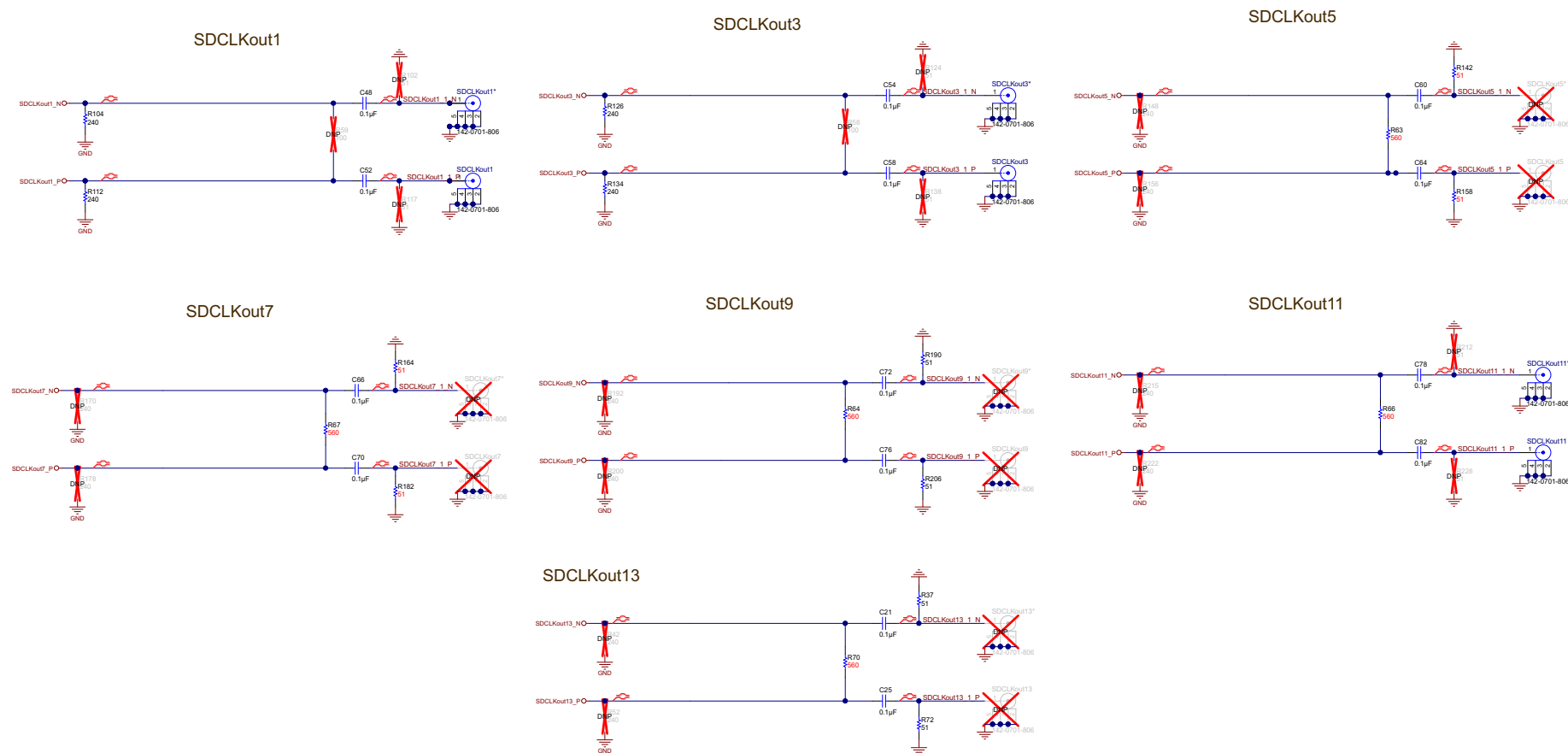


Figure 23. Clock Outputs 1 of 2

# DEVICE CLOCK OUTPUTS AND OSCout

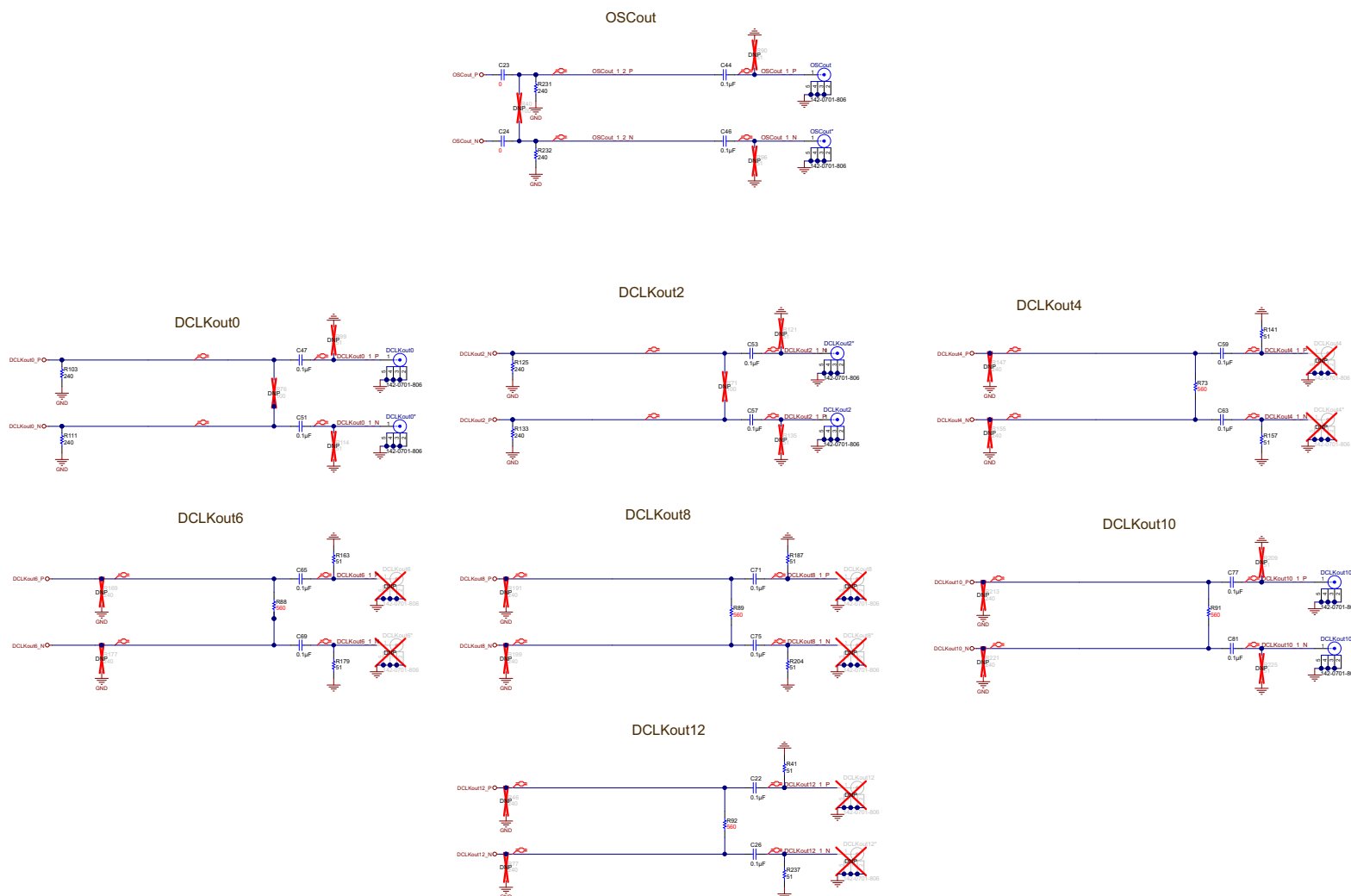


Figure 24. Clock Outputs 2 of 2

## 11 Appendix D: Bill of Materials

**Table 8. Bill of Materials**

| Item | Designator                                                                                                                                                                                                | Description                                  | Manufacturer | PartNumber         | Qty. |
|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|--------------|--------------------|------|
| 1    | PCB                                                                                                                                                                                                       | Printed Circuit Board                        | Any          | SV600788D          | 1    |
| 2    | C1, C5, C13, C20, C23, C24, R3, R3_AB1, R11, R12, R19, R30, R55, R75, R82, R84, R95, R109, R113, R310, R323, R327, R329, R331, R334, R335, R336, R337, R338, R339, R340, R346, R349, R364, R373, R375     | RES, 0 ohm, 5%, 0.1W, 0603                   | Vishay-Dale  | CRCW06030000Z0EA   | 36   |
| 3    | C1_A1, C2, C6, C18, C19, C21, C22, C25, C26, C27, C38, C37, C44, C46, C47, C48, C51, C52, C53, C54, C57, C58, C59, C60, C63, C64, C65, C66, C70, C71, C72, C75, C76, C77, C78, C81, C82, C312, C319, C346 | CAP, CERM, 0.1uF, 25V, +/-5%, X7R, 0603      | Kemet        | C0603C104J3RACTU   | 40   |
| 4    | C1_A2                                                                                                                                                                                                     | CAP, CERM, 47pF, 50V, +/-5%, C0G/NP0, 0603   | Kemet        | C0603C470J5GACTU   | 1    |
| 5    | C2_A1                                                                                                                                                                                                     | CAP, CERM, 0.68uF, 10V, +/-10%, X5R, 0603    | Kemet        | C0603C684K8PACTU   | 1    |
| 6    | C2_A2                                                                                                                                                                                                     | CAP, CERM, 3900pF, 50V, +/-10%, X7R, 0603    | MuRata       | GRM188R71H392KA01D | 1    |
| 7    | C3_AB1, C29, C368                                                                                                                                                                                         | CAP, CERM, 100pF, 50V, +/-5%, C0G/NP0, 0603  | Kemet        | C0603C101J5GACTU   | 3    |
| 8    | C4                                                                                                                                                                                                        | CAP, CERM, 33pF, 100V, +/-5%, C0G/NP0, 0603  | AVX          | 06031A330JAT2A     | 1    |
| 9    | C9                                                                                                                                                                                                        | CAP, CERM, 82pF, 50V, +/-10%, C0G/NP0, 0603  | Kemet        | C0603C820K5GACTU   | 1    |
| 10   | C10, C32, C341, C375                                                                                                                                                                                      | CAP, CERM, 2200pF, 50V, +/-10%, X7R, 0603    | Kemet        | C0603C222K5RACTU   | 4    |
| 11   | C11                                                                                                                                                                                                       | CAP, CERM, 10uF, 10V, +/-20%, X5R, 0805      | Kemet        | C0805C106M8PACTU   | 1    |
| 12   | C33                                                                                                                                                                                                       | CAP, CERM, 12pF, 50V, +/-5%, C0G/NP0, 0603   | AVX          | 06035A120JAT2A     | 1    |
| 13   | C34, C374                                                                                                                                                                                                 | CAP, CERM, 2pF, 50V, +/-12.5%, C0G/NP0, 0603 | Kemet        | C0603C209C5GACTU   | 2    |
| 14   | C35, C310, C317, C324, C352                                                                                                                                                                               | CAP, CERM, 10uF, 10V, +/-10%, X5R, 0805      | Kemet        | C0805C106K8PACTU   | 5    |
| 15   | C69, C322, C326, C367                                                                                                                                                                                     | CAP, CERM, 0.1uF, 25V, +/-10%, X7R, 0603     | Kemet        | C0603C104K3RACTU   | 4    |
| 16   | C300, C311, C314, C318, C321, C325, C337, C342, C343, C347, C364                                                                                                                                          | CAP, CERM, 1uF, 10V, +/-10%, X5R, 0603       | Kemet        | C0603C105K8PACTU   | 11   |
| 17   | C304                                                                                                                                                                                                      | CAP, CERM, 1000pF, 50V, +/-5%, C0G/NP0, 0603 | Kemet        | C0603C102J5GACTU   | 1    |
| 18   | C313                                                                                                                                                                                                      | CAP, CERM, 10uF, 6.3V, +/-20%, X5R, 0603     | Kemet        | C0603C106M9PACTU   | 1    |
| 19   | C315, C323                                                                                                                                                                                                | CAP, CERM, 0.01uF, 100V, +/-10%, X7R, 0603   | Kemet        | C0603C103K1RACTU   | 2    |
| 20   | C340                                                                                                                                                                                                      | CAP, CERM, 4.7uF, 10V, +/-10%, X5R, 0603     | Kemet        | C0603C475K8PACTU   | 1    |
| 21   | C350, C351, C359, C360                                                                                                                                                                                    | CAP, CERM, 0.47uF, 16V, +/-10%, X7R, 0603    | Kemet        | C0603C474K4RACTU   | 4    |

**Table 8. Bill of Materials (continued)**

| Item | Designator                                                                                                                                                                                                | Description                                                                                                            | Manufacturer               | PartNumber        | Qty. |
|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|----------------------------|-------------------|------|
| 22   | CLKin0, CLKin0*, DCLKout0, DCLKout0*, DCLKout2, DCLKout2*, DCLKout10, DCLKout10*, FBCLKin*/CLKin1*, OSCin, OSCin*, OSCout, OSCout*, SDCLKout1, SDCLKout1*, SDCLKout3, SDCLKout3*, SDCLKout11, SDCLKout11* | Connector, SMT, End launch SMA 50 ohm                                                                                  | Emerson Network Power      | 142-0701-806      | 19   |
| 23   | D1, D6                                                                                                                                                                                                    | DIODE VARACTOR 15V 20MA SC-79                                                                                          | Skyworks Inc               | SMV1249-079LF     | 2    |
| 24   | D2, D3                                                                                                                                                                                                    | LED 2.8X3.2MM 565NM RED CLR SMD                                                                                        | Lumex Opto/Components Inc. | SML-LX2832IC      | 2    |
| 25   | D4, D5                                                                                                                                                                                                    | LED 2.8X3.2MM 565NM GRN CLR SMD                                                                                        | Lumex Opto/Components Inc. | SML-LX2832GC      | 2    |
| 26   | J1                                                                                                                                                                                                        | CONN TERM BLK PCB 5.08MM 2POS OR                                                                                       | Weidmuller                 | 1594540000        | 1    |
| 27   | R2, R13, R332                                                                                                                                                                                             | RES, 0 ohm, 5%, 0.125W, 0805                                                                                           | Vishay-Dale                | CRCW08050000Z0EA  | 3    |
| 28   | R2_A1                                                                                                                                                                                                     | RES, 39k ohm, 5%, 0.1W, 0603                                                                                           | Vishay-Dale                | CRCW060339K0JNEA  | 1    |
| 29   | R2_A2                                                                                                                                                                                                     | RES, 620 ohm, 5%, 0.1W, 0603                                                                                           | Vishay-Dale                | CRCW0603620RJNEA  | 1    |
| 30   | R4, R9                                                                                                                                                                                                    | RES, 100 ohm, 5%, 0.1W, 0603                                                                                           | Vishay-Dale                | CRCW0603100RJNEA  | 2    |
| 31   | R18, R305, R307, R342, R343, R344, R345, R347, R354, R358, R371, R374                                                                                                                                     | FB, 120 ohm, 500 mA, 0603                                                                                              | Murata                     | BLM18AG121SN1D    | 12   |
| 32   | R37, R41, R45, R61, R68, R72, R141, R142, R157, R158, R163, R164, R179, R182, R187, R190, R204, R206, R237                                                                                                | RES, 51 ohm, 5%, 0.1W, 0603                                                                                            | Vishay-Dale                | CRCW060351R0JNEA  | 19   |
| 33   | R50, R86, R313, R316, R319, R320, R325, R384                                                                                                                                                              | RES, 27k ohm, 5%, 0.1W, 0603                                                                                           | Vishay-Dale                | CRCW060327K0JNEA  | 8    |
| 34   | R62, R381                                                                                                                                                                                                 | RES, 4.70k ohm, 1%, 0.1W, 0603                                                                                         | Yageo America              | RC0603FR-074K7L   | 2    |
| 35   | R63, R64, R66, R67, R70, R73, R88, R89, R91, R92                                                                                                                                                          | RES, 560 ohm, 5%, 0.1W, 0603                                                                                           | Vishay-Dale                | CRCW0603560RJNEA  | 10   |
| 36   | R81, R94, R312, R315, R317, R318, R321, R324                                                                                                                                                              | RES, 15k ohm, 5%, 0.1W, 0603                                                                                           | Vishay-Dale                | CRCW060315K0JNEA  | 8    |
| 37   | R83, R85                                                                                                                                                                                                  | RES, 270 ohm, 5%, 0.1W, 0603                                                                                           | Vishay-Dale                | CRCW0603270RJNEA  | 2    |
| 38   | R100, R101, R105, R106, R107                                                                                                                                                                              | RES, 0 ohm, 5%, 0.063W, 0402                                                                                           | Vishay-Dale                | CRCW04020000Z0ED  | 5    |
| 39   | R103, R104, R111, R112, R125, R126, R133, R134, R231, R232                                                                                                                                                | RES, 240 ohm, 5%, 0.1W, 0603                                                                                           | Vishay-Dale                | CRCW0603240RJNEA  | 10   |
| 40   | R333, R341                                                                                                                                                                                                | FB, 120 ohm, 500 mA, 0402                                                                                              | TDK                        | MMZ1005Y121C      | 2    |
| 41   | R350, R360, R369                                                                                                                                                                                          | RES, 51k ohm, 5%, 0.1W, 0603                                                                                           | Vishay-Dale                | CRCW060351K0JNEA  | 3    |
| 42   | R351                                                                                                                                                                                                      | RES, 2.00k ohm, 1%, 0.1W, 0603                                                                                         | Vishay-Dale                | CRCW06032K00FKEA  | 1    |
| 43   | R356                                                                                                                                                                                                      | RES, 866 ohm, 1%, 0.1W, 0603                                                                                           | Vishay-Dale                | CRCW0603866RFKEA  | 1    |
| 44   | S1, S2, S3, S4, S5, S6                                                                                                                                                                                    | 0.375" Standoff                                                                                                        | VOLTRIX                    | SPCS-6            | 6    |
| 45   | SPI                                                                                                                                                                                                       | Low Profile Vertical Header 2x5 0.100"                                                                                 | FCI                        | 52601-G10-8LF     | 1    |
| 46   | U1                                                                                                                                                                                                        | LMK04821                                                                                                               | Texas Instruments          | LMK04821          | 1    |
| 47   | U2                                                                                                                                                                                                        | 122.88 MHz VCXO                                                                                                        | Crystek                    | CVHD-950-122.88   | 1    |
| 48   | U302                                                                                                                                                                                                      | Micropower 800mA Low Noise "Ceramic Stable" Adjustable Voltage Regulator for 1V to 5V Applications, 8-pin LLP, Pb-Free | Texas Instruments          | LP3878SD-ADJ/NOPB | 1    |
| 49   | U303, U305                                                                                                                                                                                                | Ultra Low Noise, 150mA Linear Regulator for RF/Analog Circuits Requires No Bypass Capacitor, 6-pin LLP, Pb-Free        | Texas Instruments          | LP5900SD-3.3/NOPB | 2    |

**Table 8. Bill of Materials (continued)**

| Item | Designator | Description        | Manufacturer             | PartNumber   | Qty. |
|------|------------|--------------------|--------------------------|--------------|------|
| 50   | Vcc        | Connector, TH, SMA | Emerson<br>Network Power | 142-0701-201 | 1    |

## STANDARD TERMS AND CONDITIONS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, or documentation (collectively, an "EVM" or "EVMs") to the User ("User") in accordance with the terms and conditions set forth herein. Acceptance of the EVM is expressly subject to the following terms and conditions.

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- 2 *Limited Warranty and Related Remedies/Disclaimers:*

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- 2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for any defects that are caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI. Moreover, TI shall not be liable for any defects that result from User's design, specifications or instructions for such EVMs. Testing and other quality control techniques are used to the extent TI deems necessary or as mandated by government requirements. TI does not test all parameters of each EVM.
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- 3 *Regulatory Notices:*

- 3.1 *United States*

### 3.1.1 *Notice applicable to EVMs not FCC-Approved:*

This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

### 3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

## CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

## FCC Interference Statement for Class A EVM devices

*NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.*

## FCC Interference Statement for Class B EVM devices

*NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:*

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

### 3.2 Canada

#### 3.2.1 For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210

##### Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

##### Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

##### Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

##### Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

### 3.3 Japan

3.3.1 *Notice for EVMs delivered in Japan:* Please see [http://www.tij.co.jp/lstds/ti\\_ja/general/eStore/notice\\_01.page](http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_01.page) 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。  
[http://www.tij.co.jp/lstds/ti\\_ja/general/eStore/notice\\_01.page](http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_01.page)

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If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required by Radio Law of Japan to follow the instructions below with respect to EVMs:

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

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| Medical                       | <a href="http://www.ti.com/medical">www.ti.com/medical</a>                               |
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