LMK01801 User's Guide

This user's guide describes how to set up and operate the LMK01801 evaluation module (EVM). The LMK01801 Evaluation Board simplifies evaluation of the LMK01801 Dual Clock Buffer Divider. Configuring and controlling the board is accomplished using Texas Instrument's TICS Pro software, which can be downloaded from TI's website: http://www.ti.com/tool/ticspro-sw. The LMK01801 can also be configured to operate in a pin control mode via headers on the PCB.

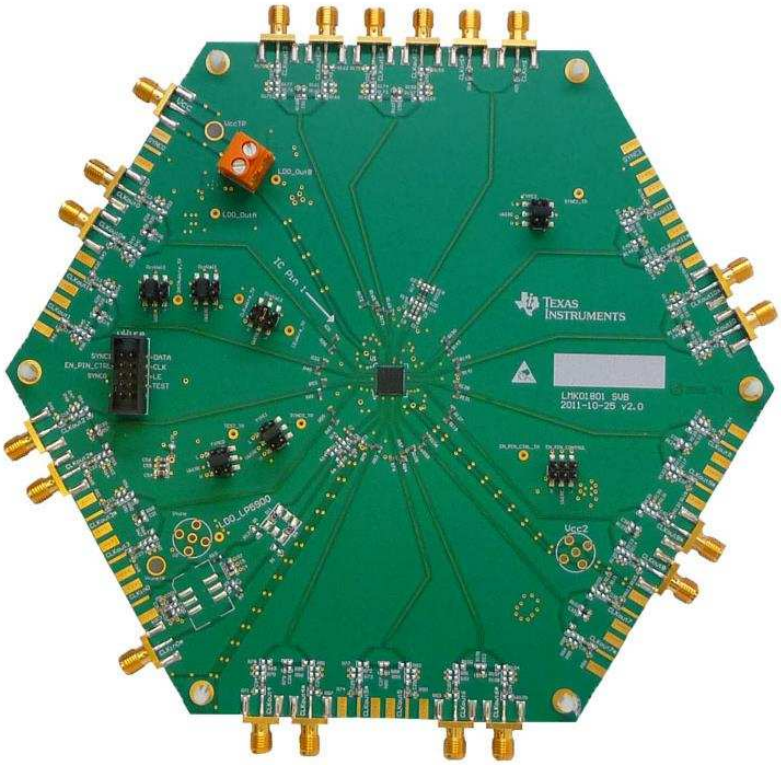

Figure 1. LMK01801 EVAL

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Trademarks

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1 Block Diagram

Figure 2 illustrates the functional architecture of the LMK01801 clock divider buffer. The LMK01801 is a very low noise solution for clocking systems that require distribution and frequency division of precision clocks. The LMK01801 features extremely low residual noise, frequency division, digital and analog delay adjustments, and fourteen (14) programmable differential outputs: LVPECL, LVDS and LVCMOS (2 outputs per differential output). The LMK01801 features two independent inputs that can be driven differentially or in single-ended mode. The first input drives output Bank A consisting of eight (8) outputs. The second input drives output Bank B consisting of six (6) outputs.

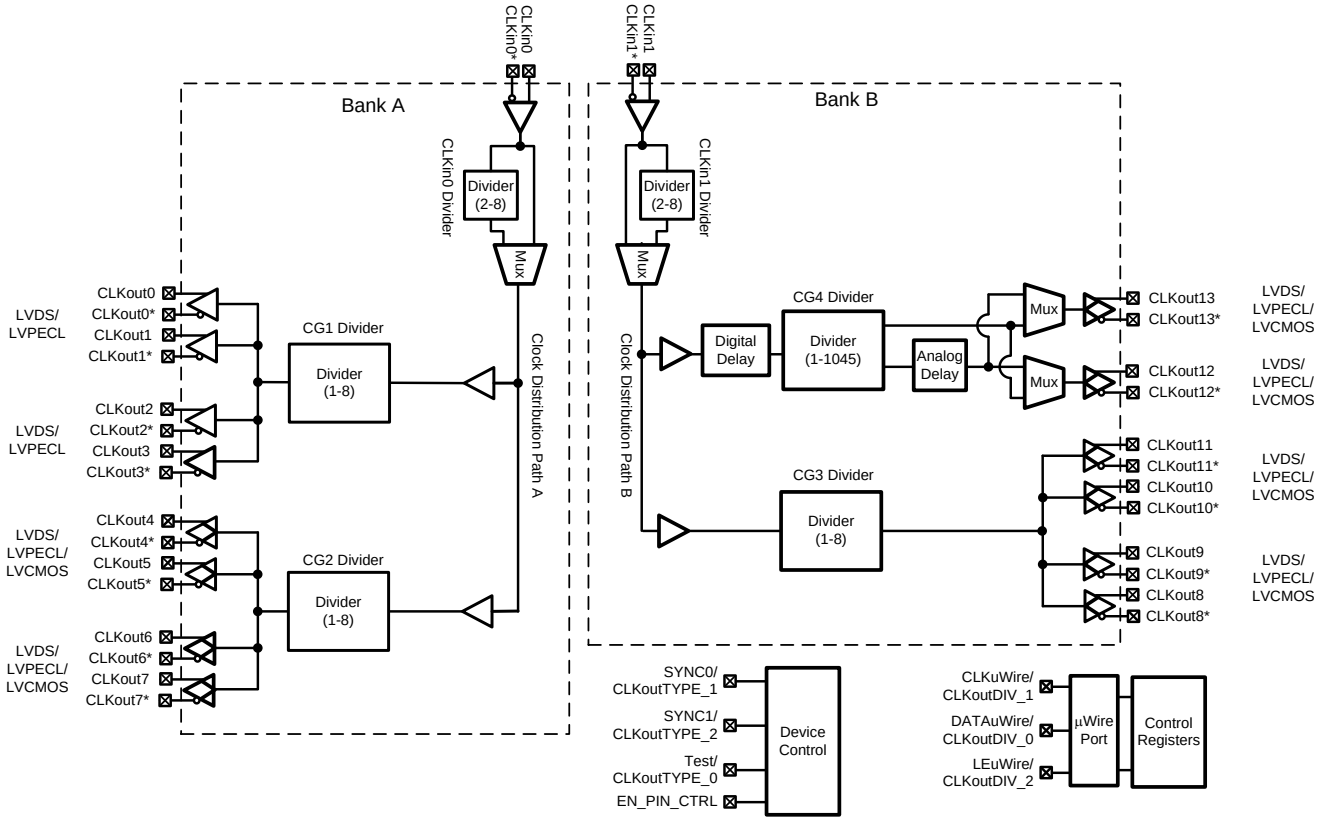


Figure 2. LMK01801 Block Diagram

2 Evaluation Board Kit Contents

The evaluation board kit contains:

- An LMK01801 Evaluation board.
- USB2ANY-UWIRE
  - Evaluation board instructions are downloadable from the product folder on Texas Instruments' website, http://www.ti.com/.

TICS Pro is the recommended program to program the evaluation board with the USB2ANY interface adapter and the USB2ANY-uWire Adapter Board.

Table 1. Clock Output Configuration

Clock	Output Type	Output Connector Installed
0	LVPECL	Yes
1	LVPECL	No
2	LVPECL	Yes
3	LVPECL	No
4	LVPECL	Yes
5	LVPECL	No
6	LVPECL	Yes
7	LVPECL	No
8	LVPECL	Yes

Table 1. Clock Output Configuration (continued)

Clock	Output Type	Output Connector Installed
9	LVPECL	Yes
10	LVPECL	Yes
11	LVPECL	Yes
12	LVPECL	Yes
13	LVPECL	Yes

3 Quick Start – SPI Mode (TICS Pro)

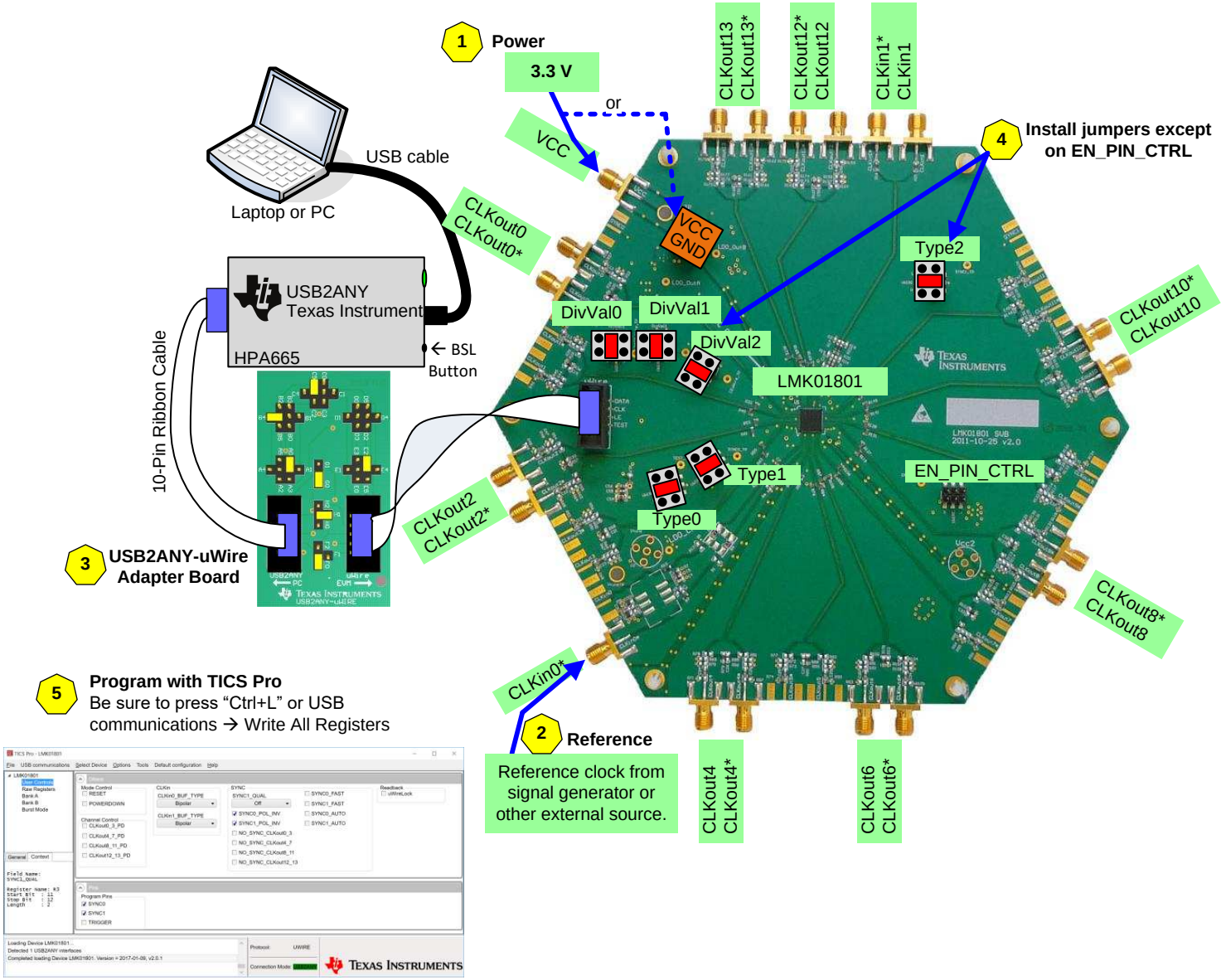


Figure 3. Quick Start - SPI Mode Diagram

3.1 Quick Start – SPI Mode (TICS Pro) Description

1. Connect a voltage of **3.3 V** to either the V_{CC} SMA connector or the alternate terminal block.
2. Connect a reference clock from a signal generator or other source. Exact frequency depends on programming.
3. Connect the PC to USB2ANY. Connect the USB2ANY-uWire Adapter Board from USB2ANY with a 10-pin ribbon cable. Install jumpers as shown in Figure 3 and connect another 10-pin ribbon cable to the uWire header on the EVM.
4. Install jumpers on TYPE0, TYPE1, TYPE2, DivVal0, DivVal1, DivVal2 in the middle uWire (pins 3,4) position but NOT on EN_PIN_CTRL.
5. Program the device with TICS Pro. TICS Pro is available for download at http://www.ti.com/tool/ticspro-sw.
    1. Select **USB2ANY mode** from the Communication Setup window. To access this, select “USB communications” → “Interface”. Confirm PC to USB communications by clicking “Identify” to see blinking green LED on USB2ANY.
    2. Select LMK04906 from the “Select Device” Menu. Click “Select Device” → “Clock Distribution with Divider” → “LMK01801”.
    3. Select a default mode from the “Default configuration” Menu. For the quick start, use “Default configuration”.
    4. **Ctrl+L** must be pressed at least once to load all registers. Alternatively click “USB communications” → “Write All Registers” or the “Write All Registers” button on the **Raw Registers** page.
6. Measurements may be made at any CLKout port via its SMA connector if enabled by programming.

NOTE: If required to assert SYNC signals through USB2ANY, remove resistors R310 and R318. Refer to Section C.2 for details. This is not required for basic functionality. These resistors terminate an external SYNC signal.

4 Quick Start – Pin Control Mode

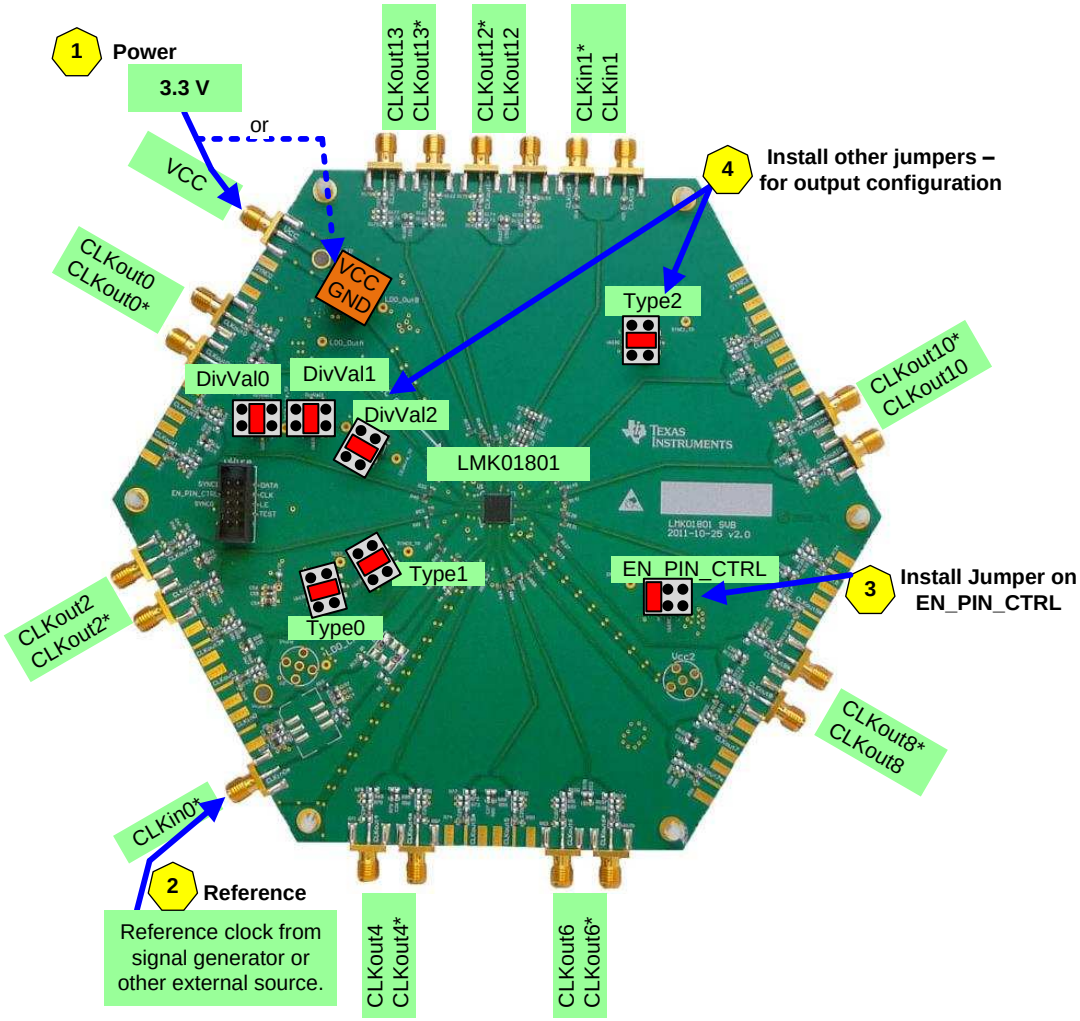


Figure 4. Quick Start - Pin Control Mode Diagram

4.1 Quick Start – Pin Control Mode Description

1. Connect a voltage of **3.3 V** to either the V_{CC} SMA connector or the alternate connector.
2. Connect a reference clock from a signal generator or other source. Exact frequency depends on programming.
3. Install a jumper on EN_PIN_CTRL header in either the High or Low position.
4. Install other jumpers on Type0, Type1, Type2, DivVal0, DivVal1, and DivVal2 headers based on the configurations shown in Table 2 and Table 3.

4.2 Pin Control Modes

For Table 2 and Table 3, LOW is defined as installing a jumper between pins 5 and 6 on the desired header. A HIGH is defined as installing a jumper between pins 1 and 2 on the desired header.

If EN_PIN_CTRL = LOW (jumper installed between header positions 5 and 6) then the following table describes possible output configurations:

Table 2. EN_PIN_CTRL = LOW Configuration

Header	Output Groups	Header = Low	Header = Middle	Header = High
Type0	CLKout0 to CLKout3	LVDS	Powerdown	LVPECL
	CLKout4 to CLKout7		LVCMOS (Norm/Inv)	
Type1	CLKout8 to CLKout11	LVDS	LVCMOS (Norm/Inv)	LVPECL
Type2	CLKout12 to CLKout13	LVDS	LVCMOS (Norm/Inv)	LVPECL
DivVal0	CLKout0 to CLKout3 Divider	÷1	÷4	÷2
DivVal1	CLKout4 to CLKout7 Divider	÷1	÷4	÷2
DivVal2	CLKout8 to CLKout11 Divider	÷1	÷4	÷2
	CLKout12 to CLKout13 Divider	÷8	÷512	÷16

If EN_PIN_CTRL = HIGH (jumper installed between header positions 1 and 2) then the following table describes possible output configurations:

Table 3. EN_PIN_CTRL = HIGH Configuration

Header	Output Groups	Header = Low	Header = Middle	Header = High
Type0	CLKout0 to CLKout3	LVDS	LVPECL	LVPECL
	CLKout4 to CLKout7		LVCMOS (Norm/Inv)	
Type1	CLKout8 to CLKout11	LVDS	LVCMOS (Norm/Inv)	LVPECL
Type2	CLKout12 to CLKout13	LVDS	LVCMOS (Norm/Inv)	LVPECL
DivVal0	CLKout0 to CLKout7 Dividers	÷1	÷4	÷2
DivVal1	CLKout8 to CLKout11 Divider	÷1	÷4	÷2
DivVal2	CLKout12 to CLKout13 Divider	÷4	÷512	÷16

5 Using TICS Pro to Program the LMK01801

The purpose of this section is to walk the user through using TICS Pro to make some measurements with the LMK01801 device. For more information on TICS Pro, refer to Appendix A. TICS Pro is available for download at http://www.ti.com/tool/ticspro-sw.

Another option is to use CodeLoader4. The tool page for CodeLoader4 is located at http://www.ti.com/tool/codeloader/.

Before proceeding, be sure to follow the Quick Start in Section 3 to ensure proper connections.

5.1 Start TICS Pro Application

Click “Start” → “Programs” → “Texas Instruments” → “TICS Pro”

The TICS Pro program is installed by default to the Texas Instruments application group.

5.2 Select Device

Click “Select Device” → “Clock Distribution with Divider” → “LMK01801”.

Once started, TICS Pro will load the last used device. To load a new device click “Select Device” from the menu bar, then select the subgroup “Clock Distribution with Divider” and finally the device to load. For this example, the LMK01801 is chosen. Selecting the device does cause the device to be programmed. However, it is advisable to press “Ctrl+L” to ensure programming.

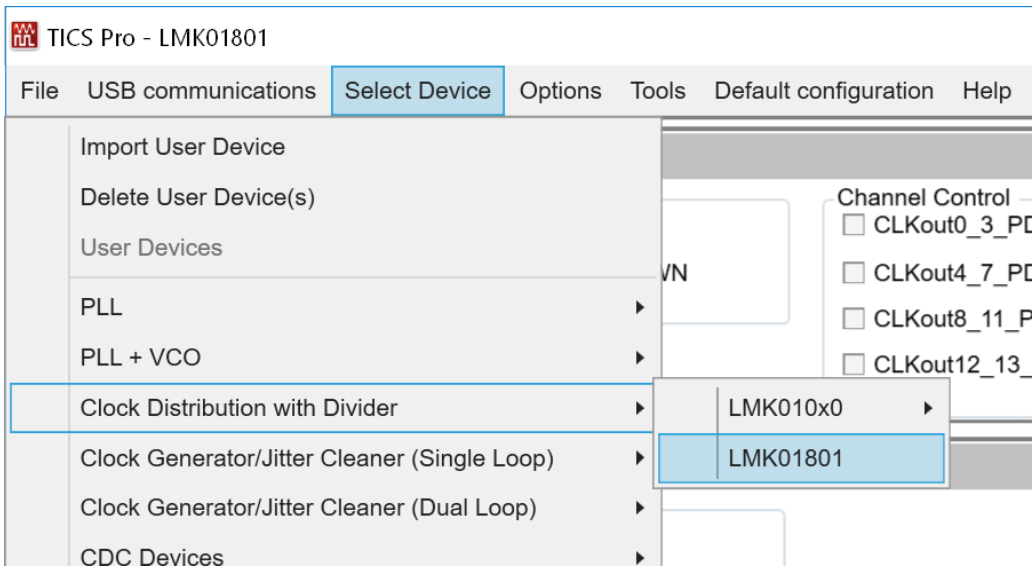


Figure 5. Selecting the LMK01801

5.3 Program/Load Device

Press “Ctrl+L”

Alternatively, click “USB communications” → “Write All Registers” from the menu to program the device to the current state of the newly loaded LMK01801 file. “Ctrl+L” is the accelerator key assigned to the “Write All Registers” option and is very convenient.

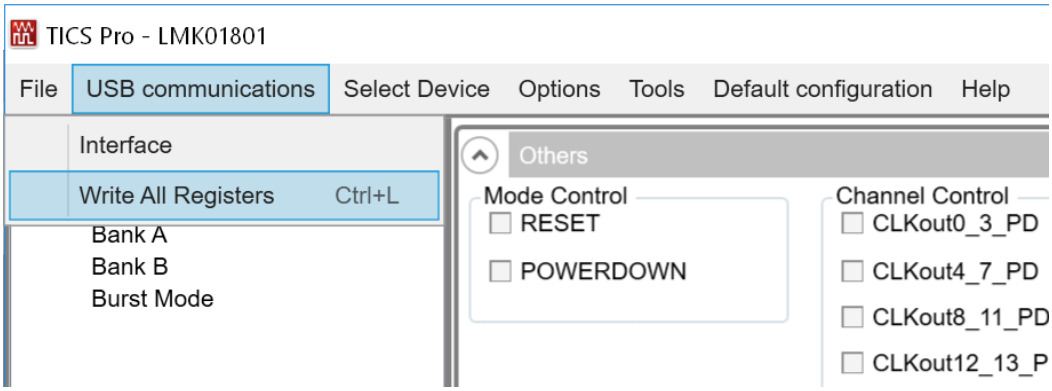


Figure 6. Loading the Device

Once the device has been initially loaded, TICS Pro will automatically program changed registers, so it is not necessary to reload 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” → “AutoUpdate”

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

5.4 Restoring a Default Mode

Click “Default configuration” → “Default Mode”; then

Press “Ctrl+L”

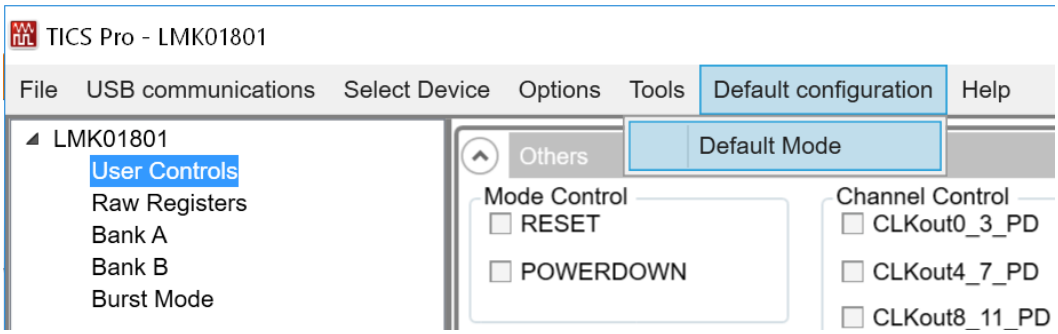


Figure 7. Setting the Default Mode

For the purposes of this walkthrough a default mode will be loaded to ensure a common starting point. This is important because TICS Pro saves the state of the selected LMK01801 device when exiting the software.

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

5.5 Enable Clock Outputs

To measure phase noise at the clock outputs:

1. Click on the **Bank A** page.
2. Enable an output.
3. Then set the:
   - CLKout Type
   - Divide value

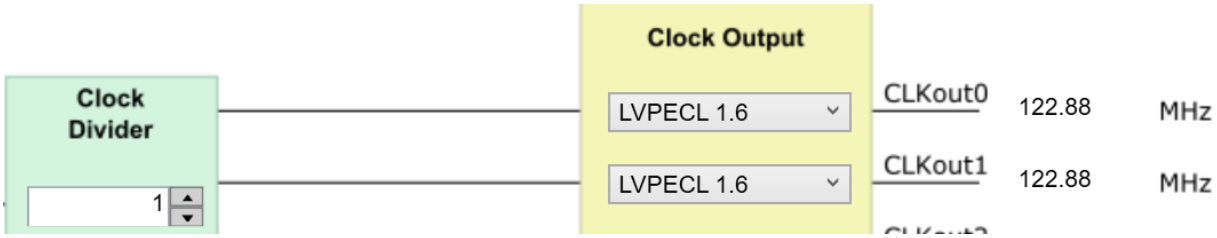


Figure 8. Setting Divider, CLKout_TYPE, Enabled for CLKoutX on "Bank A" Page

NOTE: This CLKoutX frequency value is only valid if the correct clock in value is specified. It may not necessarily represent the actual frequency unless manually entered. This is a mathematical calculation only, not a measured value.

4. Connect the clock output SMAs to a spectrum analyzer or signal source analyzer.
   - For LVDS, a balun is recommended such as the ADT2-1T (for frequency range of 0.4 MHz to 450 MHz).
   - For LVPECL
     1. A balun can be used, or
     2. One side of the LVPECL signal can be terminated with a 50-Ω load and the other side can be run to the test equipment single ended.
   - For LVCMOS
     1. One side of the LVCMOS signal can be terminated with a 50-Ω load and the other side can be run to the test equipment single ended.

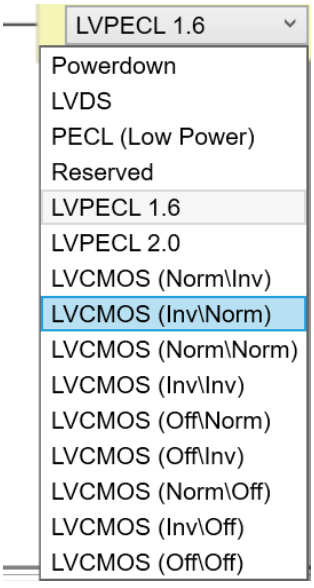


Figure 9. CLKout_TYPEs

5. The phase noise may be measured with a spectrum analyzer or signal source analyzer

See Appendix B for phase noise plots of the clock outputs

6 Evaluation Board Inputs/Outputs

Table 4 contains descriptions of the various inputs and outputs for the evaluation board.

Table 4. LMK01801 Evaluation Board I/O

Connector Name	Input/Output	Description
CLKout0 / CLKout0*, CLKout2 / CLKout2*, CLKout4 / CLKout4*, CLKout6 / CLKout6*, CLKout8 / CLKout8, CLKout9/ CLKout9*, CLKout10 / CLKout10*, CLKout11/ CLKout11*, CLKout12 / CLKout12*, CLKout13 / CLKout13*	Output	**Populated connectors.** Differential clock output pairs. All outputs are configured in LVPECL mode. On the evaluation board, all clock outputs are AC-coupled to allow safe testing with RF test equipment. All LVPECL/2VPECL clock outputs are terminated to GND with a 240-Ω resistor, one on each output pin of the pair.
V_{CC}	Input	**Populated connector.** DC power supply for the PCB. Removing R1, R2, or R3 allow for splitting the power to various devices on the board. Note: The LMK01801 Family contains internal voltage regulators for the VCO, PLL and related circuitry. The clock outputs do not have an internal regulator. A clean power supply is required for best performance.
V_{CC2}	Input	**Unpopulated connector.** Vcc input to power the output planes separately from the Aux Plane. Refer to schematics for more information.
CLKin0/CLKin0*, CLKin1/CLKin1*	Input	**Populated connectors.** The default board configuration is setup for a single-ended reference source at CLKin0* (CLKin0 pin is AC-coupled to ground). If a DC-coupled clock is used to drive either of the inputs, the high voltage level must be at least 2 volts and the low voltage no greater than 0.4 volts.
uWire	Input/Output	**Populated connector.** 10-pin header programming interface for the board. Of Most important are the CLKuWire, DATAuWire, and LEuWire programming lines from this header. Each of these signals, TEST, and SYNC0, and SYNC1 can be monitored through test points on the board.
SYNC0, SYNC1	Input	**Unpopulated connector.** Access to SYNC0 or SYNC1 of device.

7 Recommended Test Equipment

7.1 Power Supply

The Power Supply must be a low noise power supply.

7.2 Phase Noise / Spectrum Analyzer

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

TICS Pro Usage

TICS Pro is the recommended program to program the evaluation board with the USB2ANY interface adapter and the USB2ANY-uWire Adapter Board. TICS Pro can also be used to generate register maps for programming the device. This appendix outlines the basic purpose and usage of each page. TICS Pro is available for download at http://www.ti.com/tool/ticspro-sw.

A.1 TICS Pro Tips

- Mousing over different controls will display some help prompt with the register address, data bit location/length, and a brief register description in the lower left Context help pane.

A.2 Communication Setup

The USB communications window allows the USB2ANY or DemoMode to be selected. In case multiple evaluation boards are to be connected and run with multiple instances of TICS Pro, the dropdown box will allow specific USB2ANY devices to be selected. Pressing the identify button will identify which USB2ANY is currently selected. Devices used by other instances of TICS Pro won't display in this list.

A.3 User Controls

The **User Controls** page has controls not included on one of the previously discussed dedicated pages.

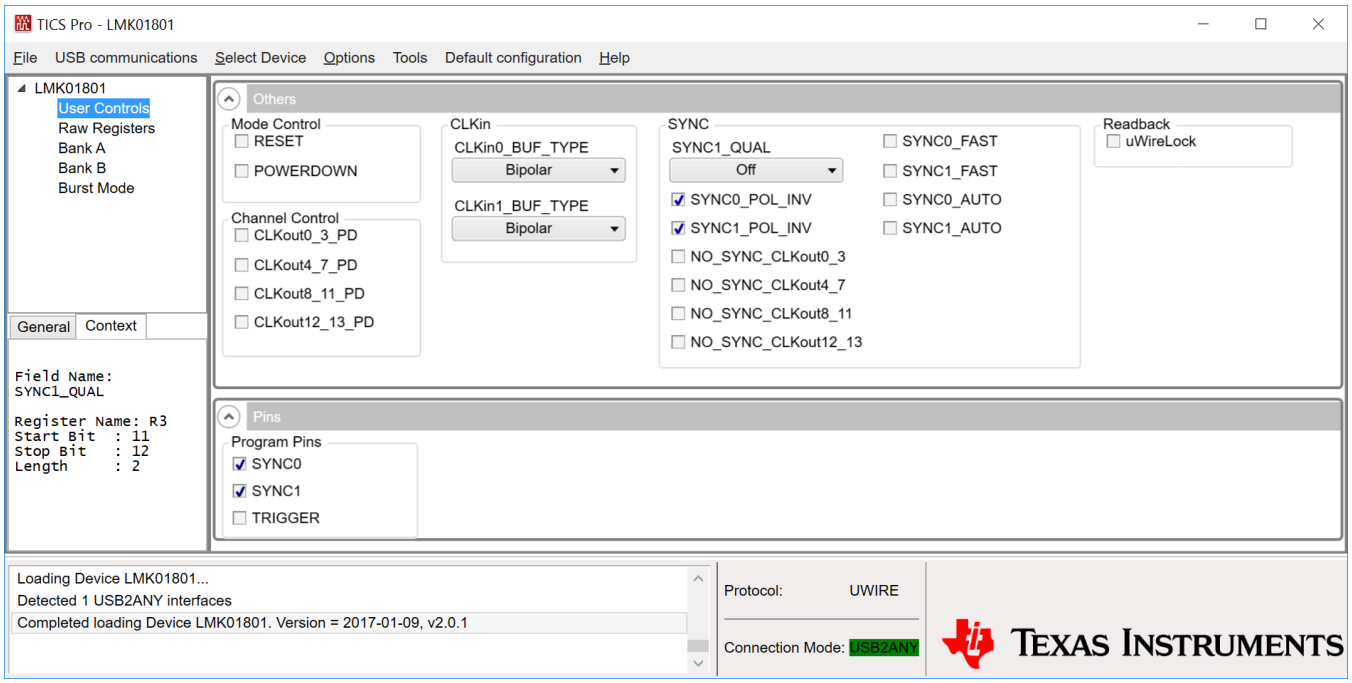


Figure 10. TICS Pro - User Controls Page

A.4 Raw Registers Page

The **Raw Register** page displays the register map including address. The address bits have the shaded background and are not editable. The unshaded bits are the data bits. This register map may be directly manipulated by clicking into the bit field, moving around with the arrow keys, and typing '1' or '0' to change a bit.

All registers may be read or written in addition to individual registers. For individual register read/write, the active register is highlighted in the list of registers and displayed in the top right. An individual register or field may be read back by entering the name into the bottom right and clicking the "Read" button.

Register maps may be exported, but also imported. The import format may simply be the address and register data in hex format as illustrated in the address/value column, one register to a line.

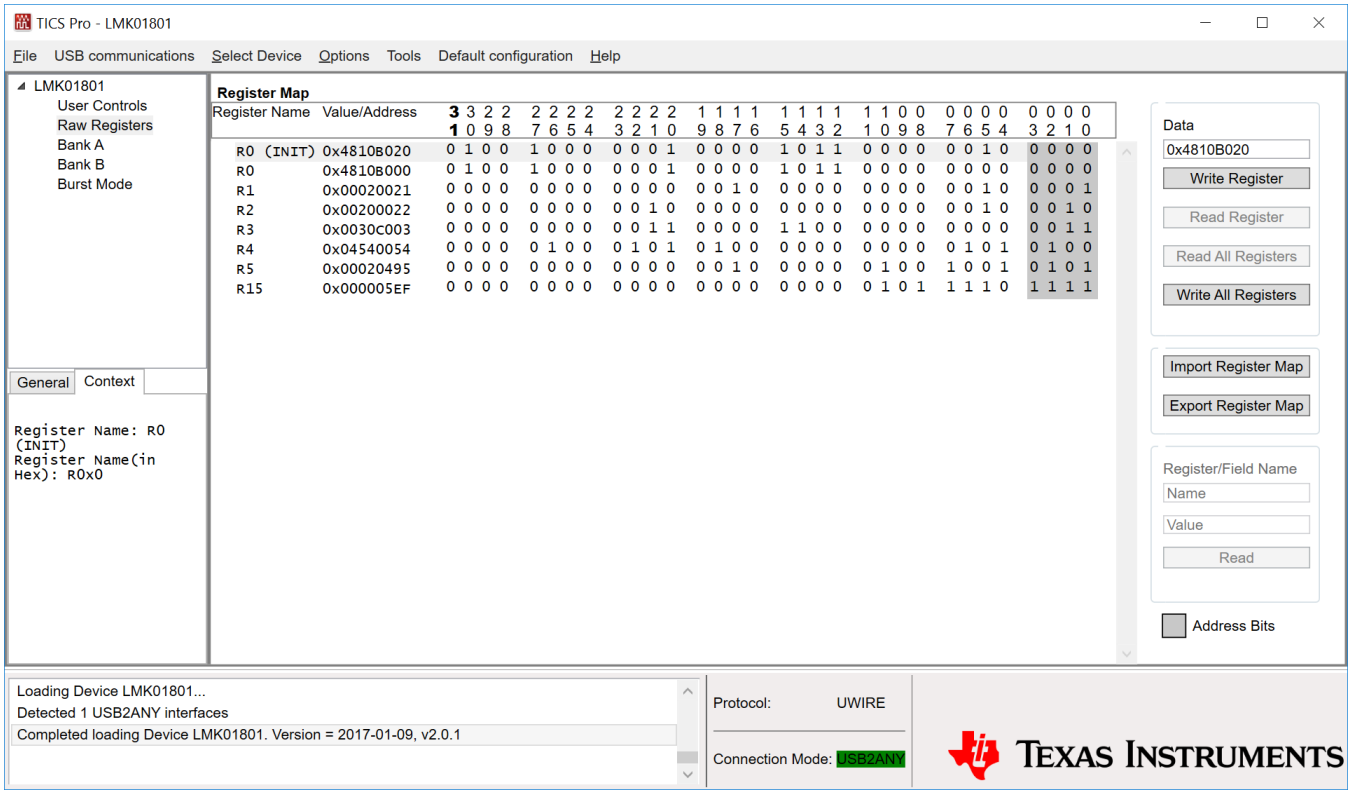


Figure 11. TICS Pro - Raw Registers Page

A.5 Bank A Page

The **Bank A** page allows control of the clock outputs format and other options relating to the clock outputs, 0 through 7.

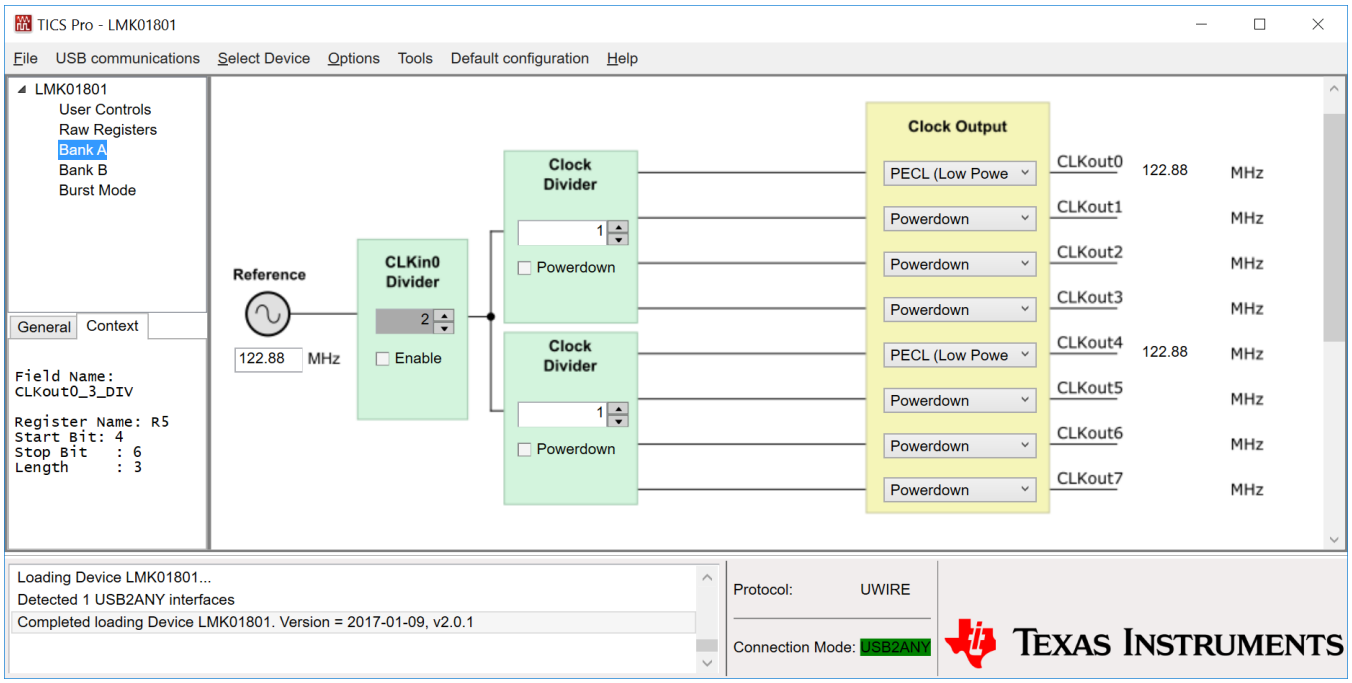


Figure 12. TICS Pro - Bank A Page

A.6 Bank B Page

The **Bank B** page allows control of the clock outputs format and other options relating to the clock outputs 8 through 13. For outputs 12 and 13, the user can enable and set the clock output delay value.

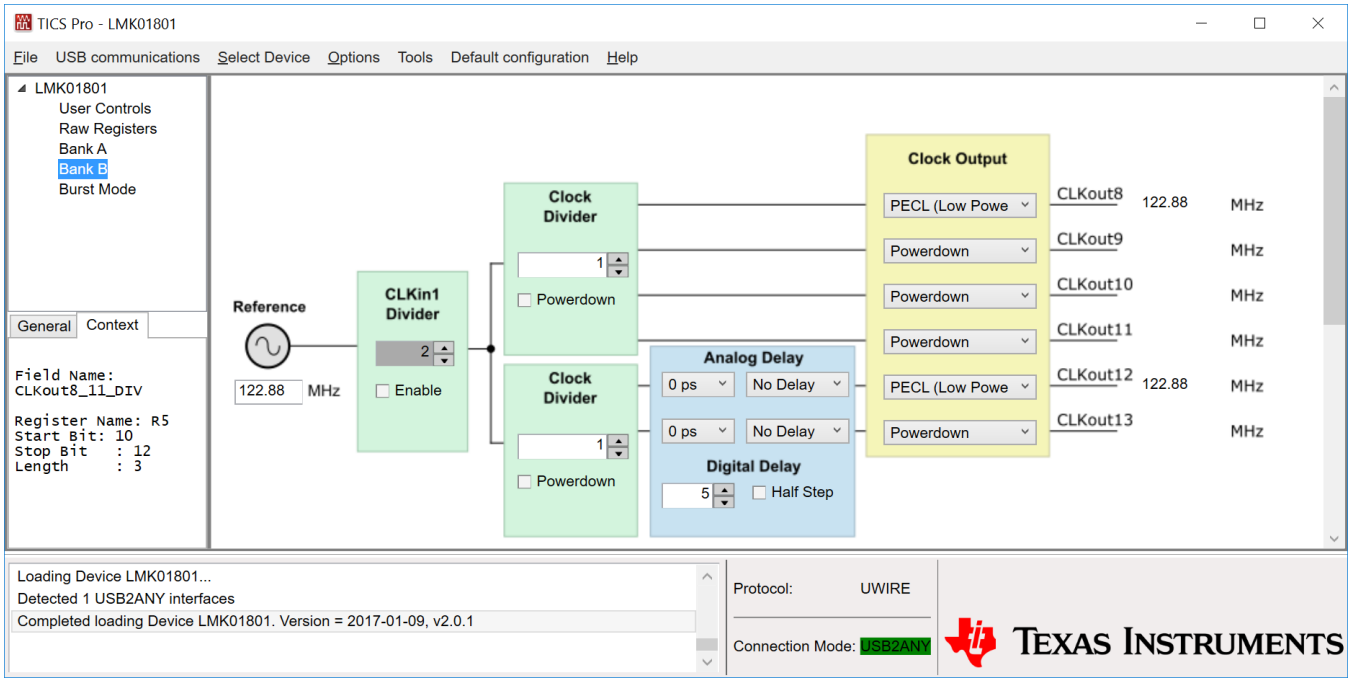


Figure 13. TICS Pro - Bank B Page

A.7 Burst Page

The **Burst** page allows the user to program sequences of register programming or pin control.

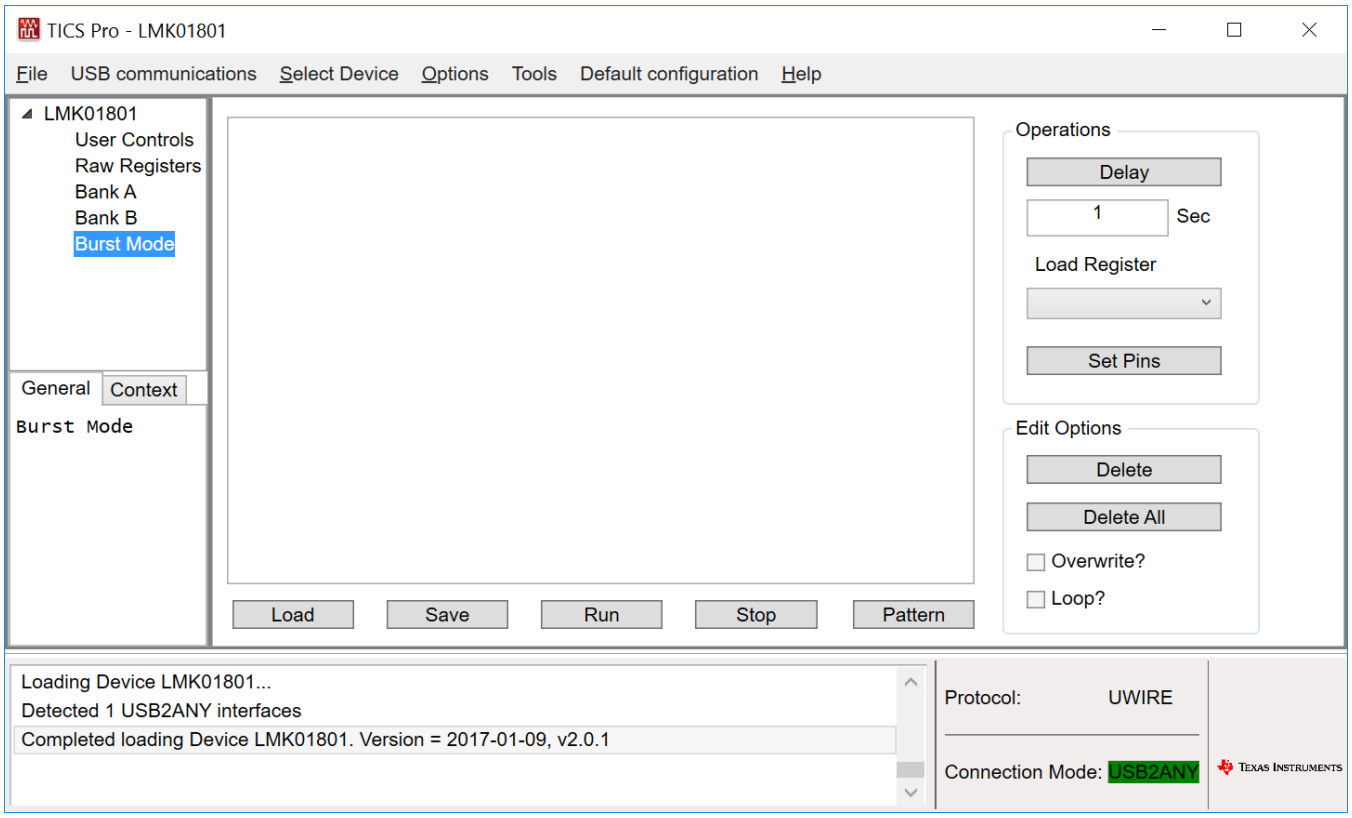


Figure 14. TICS Pro - Burst Page

Typical Phase Noise Performance Plots

B.1 Clock Outputs

The LMK01801 Family features LVDS, LVPECL, 2VPECL, and LVCMOS types of outputs. Include are the phase noise plots for the following outputs.

Table 5. Phase Noise Output Test Configuration

Device	CLKoutX	Output Divide	Output Type
LMK01801	8	1	LVPECL
	8	4	LVPECL
	8	1	2VPECL
	8	4	2VPECL
	4	1	LVDS
	4	4	LVDS
	4	1	LVCMOS(Norm/Inv)
	4	4	LVCMOS(Norm/Inv)

B.2 Clock Output Measurement Technique

The measurement technique for each output type varies.

LVPECL/2VPECL – Measured by using an Minicircuits ADT2-1T balun on the input and on the output.

LVCMOS and LVDS – Measured by using an Minicircuits ADT2-1T balun on the output and single ended input.

Table 6. LMK01801 Test Conditions

Parameter	Test Case 1	Test Case 2	Test Case 3	Test Case 4
Input Source	Wenzel XTAL	Wenzel XTAL	SMHU	Rohde & Schwarz SMHU
Input Frequency	100 MHz	100 MHz	983.04 MHz	983.04 MHz
Input Power	0 dBm	0 dBm	0 dBm	0 dBm
Output Divider	1	4	1	4
Figure	Figure 15	Figure 16	Figure 17	Figure 18

B.2.1 LMK01801 Phase Noise, CLKin = 100 MHz, Output Divider = 1

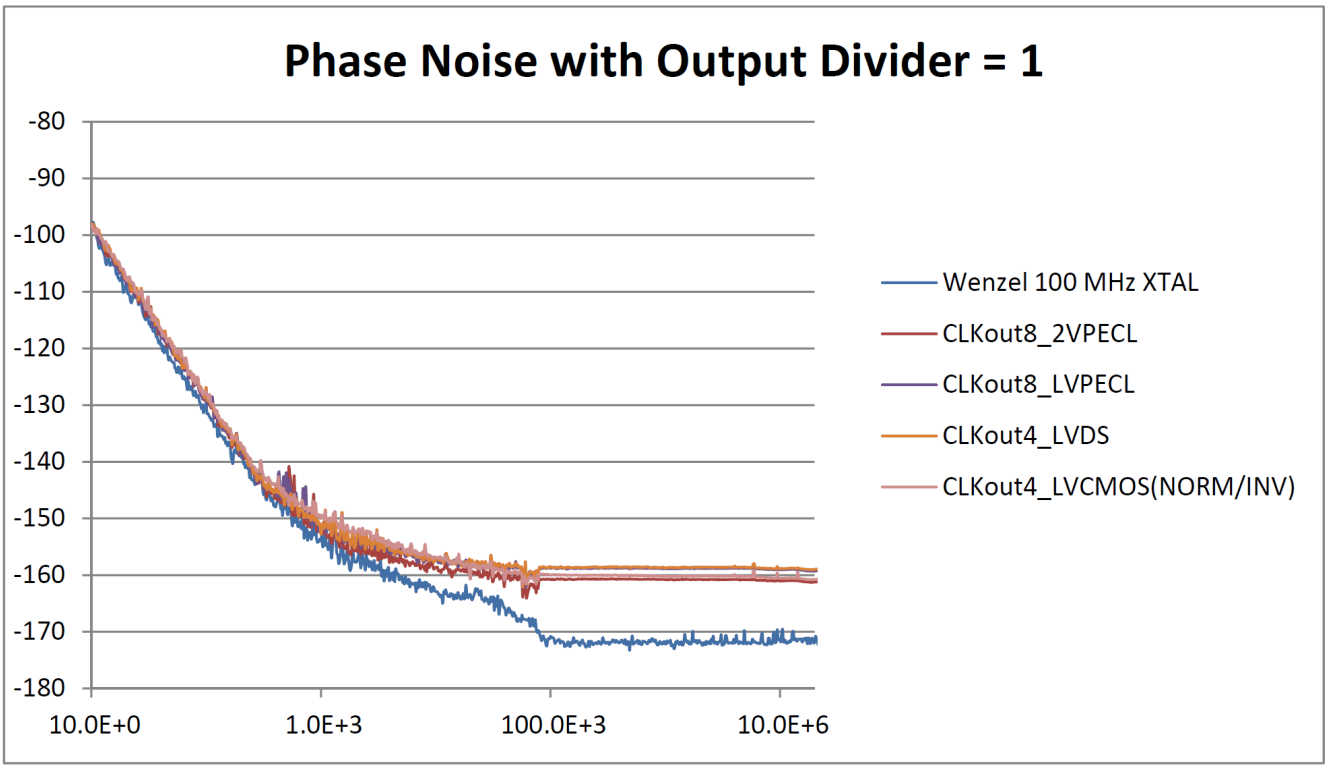


Figure 15. LMK01801 Phase Noise @ 100 MHz with Output Divider = 1

B.2.2 LMK01801 Phase Noise, CLKin = 100 MHz, Output Divider = 4

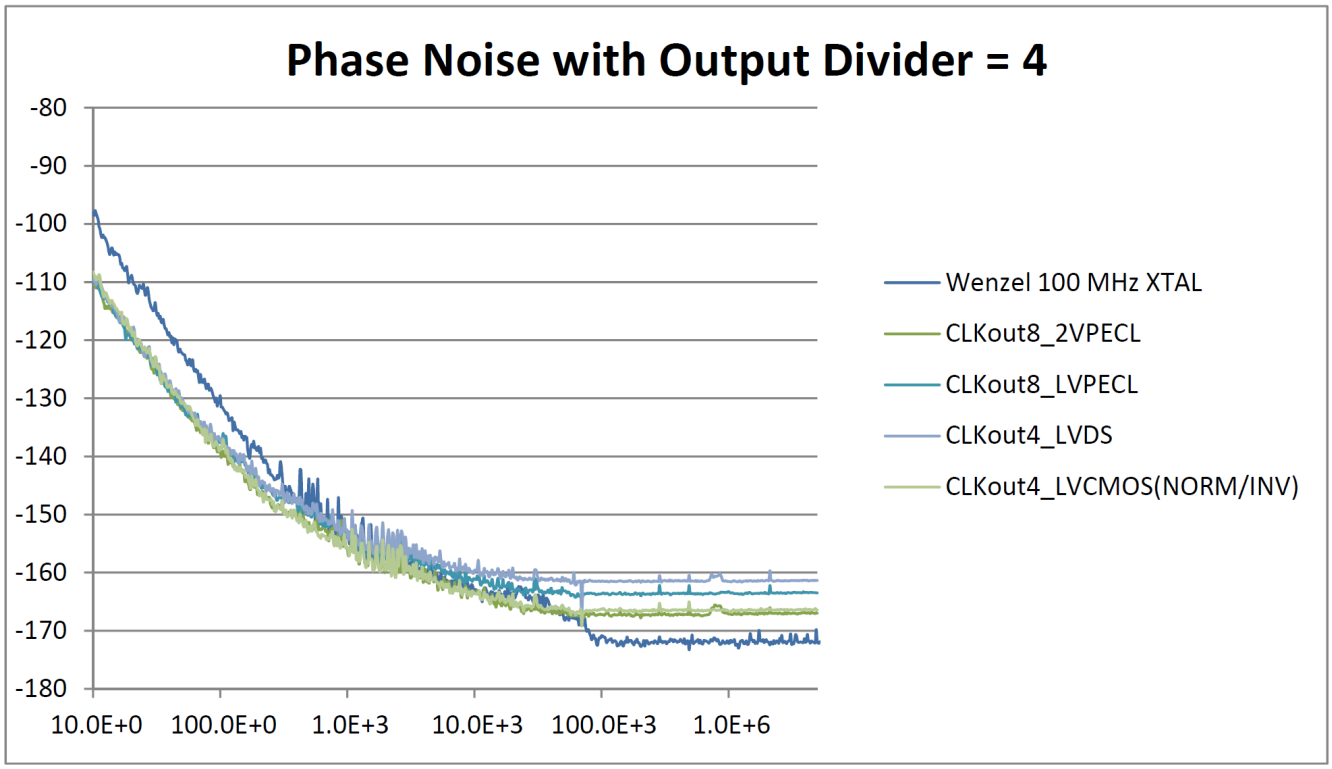


Figure 16. LMK01801 Phase Noise @ 100 MHz with Output Divider = 4

B.2.3 LMK01801 Phase Noise, CLKin = 983.04 MHz, Output Divider = 1

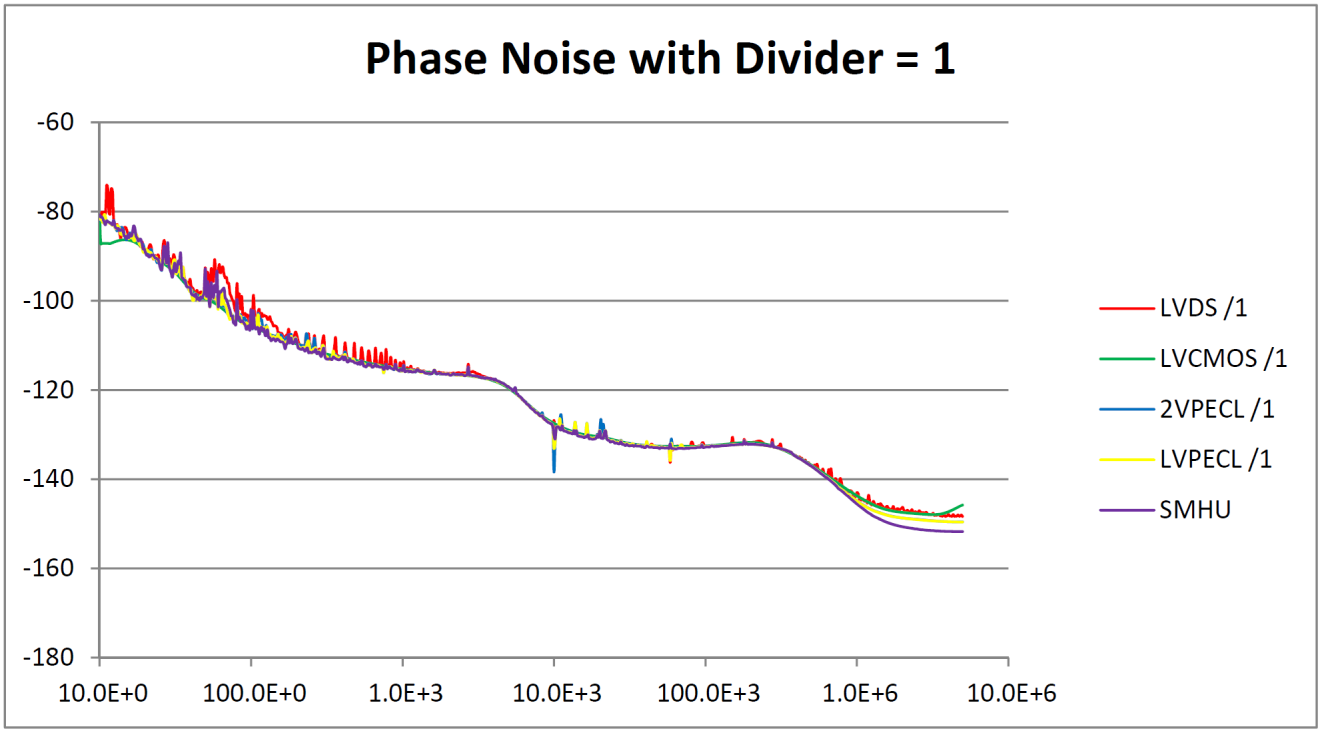


Figure 17. LMK01801 Phase Noise @ 983.04 MHz with Output Divider = 1

B.2.4 LMK01801 Phase Noise, CLKin = 983.04 MHz, Output Divider = 4

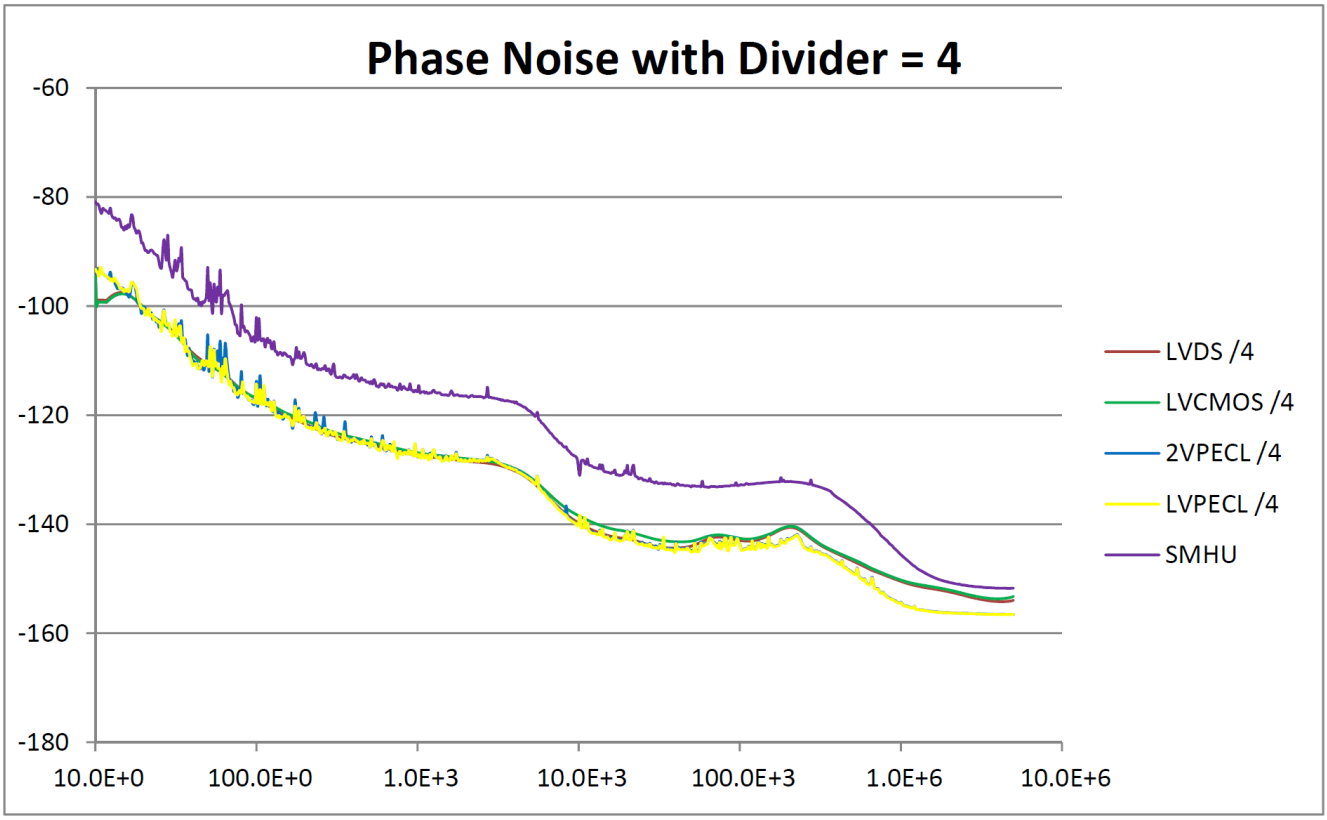


Figure 18. LMK01801 Phase Noise @ 983.04 MHz with Output Divider = 4

B.3 Phase Noise Measurement

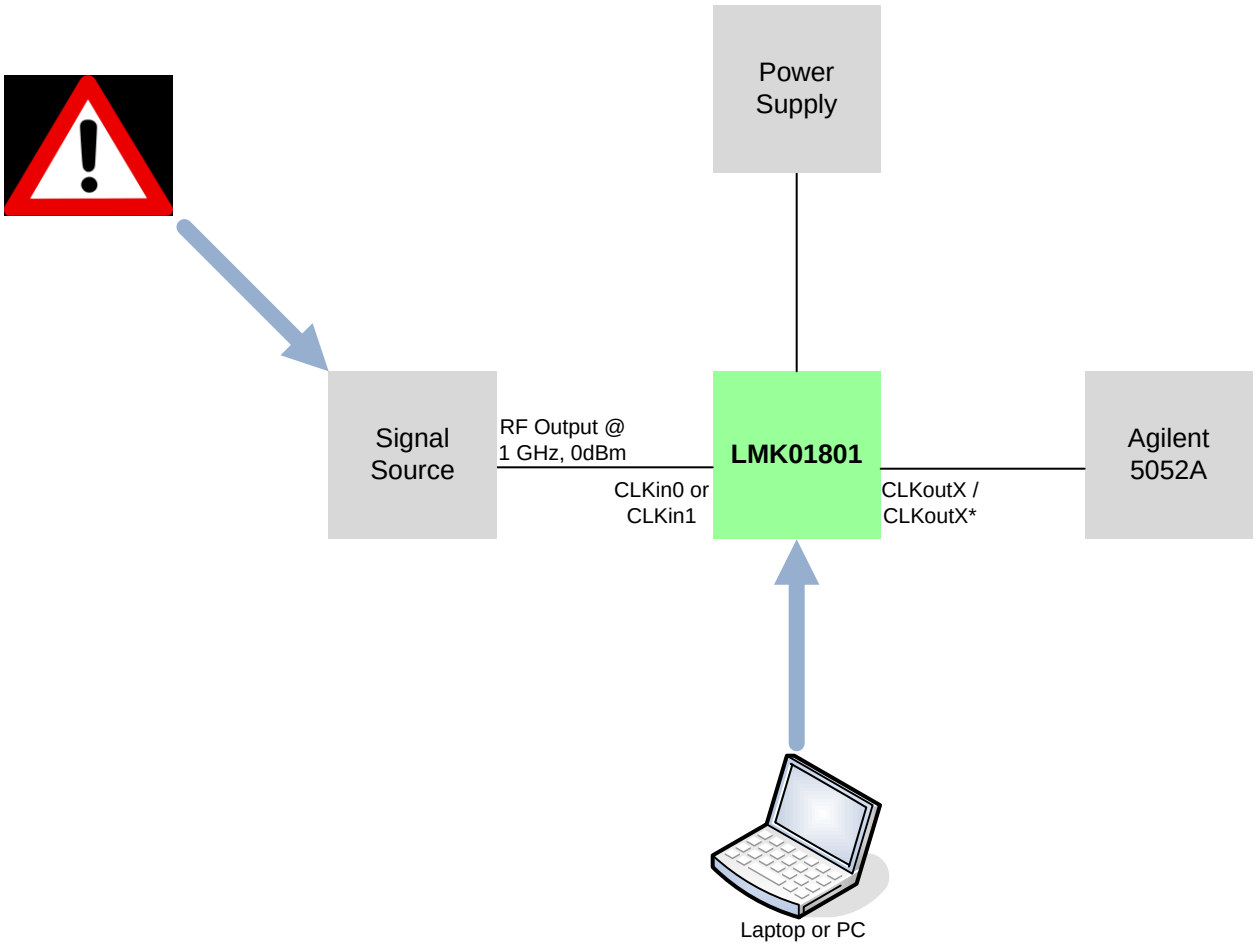


Figure 19. Phase Noise Measurement Set-Up

The phase noise of the signal source will impact the measured phase noise of the LMK01801.

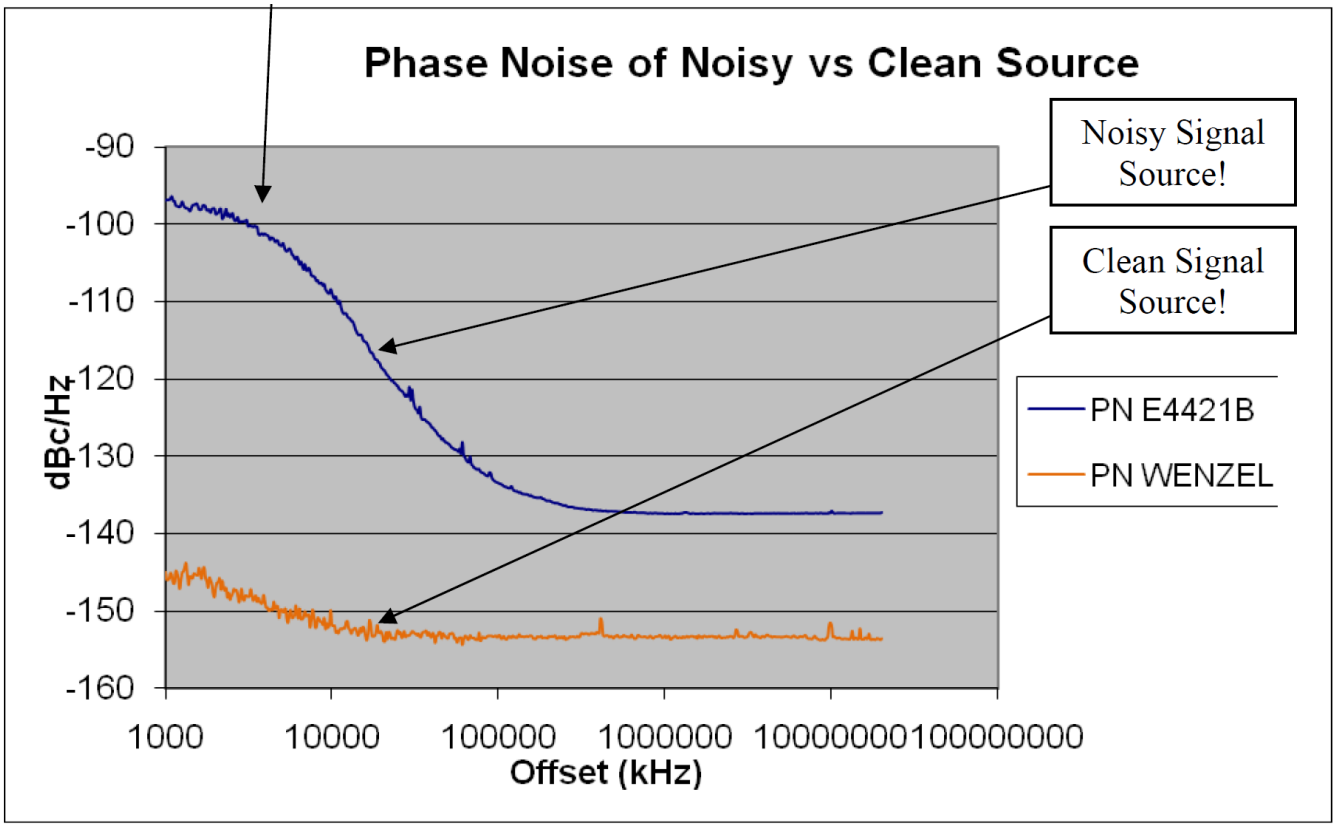


Figure 20. Noisy vs. Clean Phase Noise

B.4 LMK01801 Sample Output Waveforms

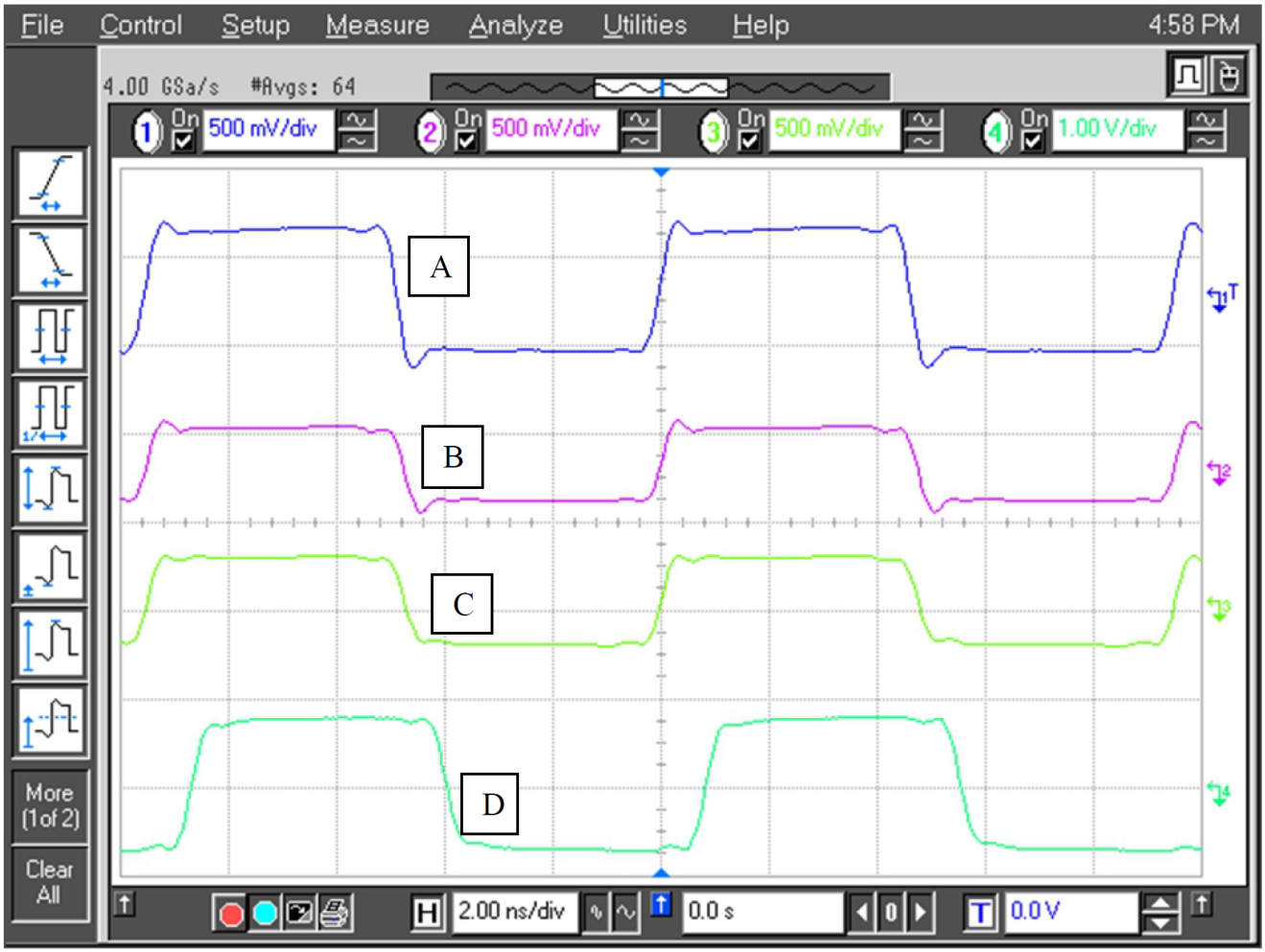


Figure 21. LMK01801 Sample Clock Output Waveforms

The output waveforms shown in Figure 21 were taken at a clock in frequency of 122.88 MHz, AC coupled. These measurements follow the VID voltage convention – See Appendix F for more information.

The output modes are as follows:

Table 7. Clock Output Modes

Trace	Clock Output	Output Type
A	CLKout0	2VPECL
B	CLKout1	PECL (Low Power)
C	CLKout4	LVDS
D	CLKout5	LVCMOS (Normal/Invert)

B.5 LMK01801 Analog Delay Sample Data

The sample analog delay data was taken at a clock in frequency of 122.88 MHz, output format of 2VPECL. Notice in Figure 22 that with analog delay enabled there is approximately 460 ps of delay. Then, in Figure 23, we added 100 ps of delay and the resulting delay is approximately 550 ps.

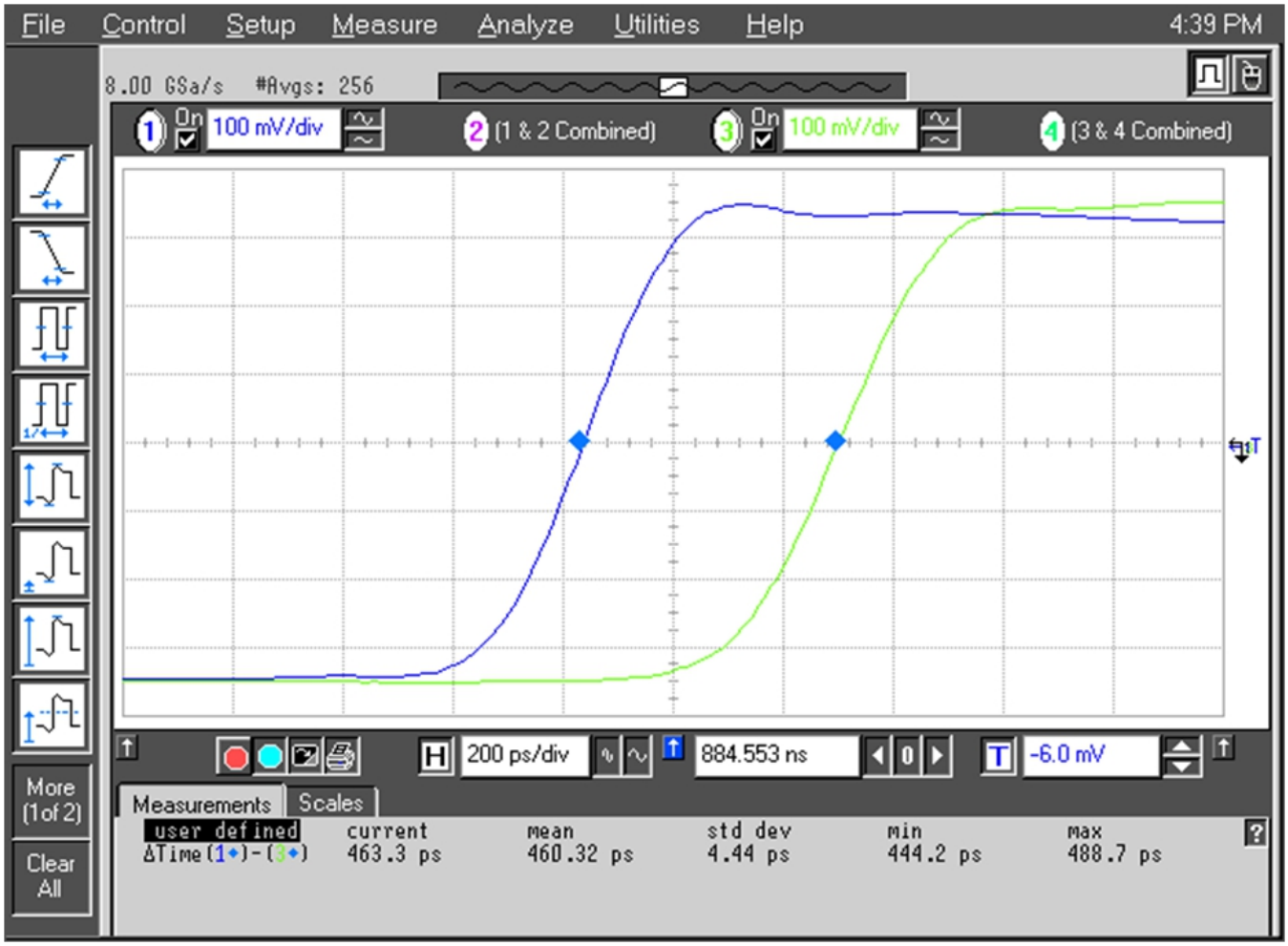


Figure 22. CLKout12 and CLKout13 No Analog Delay

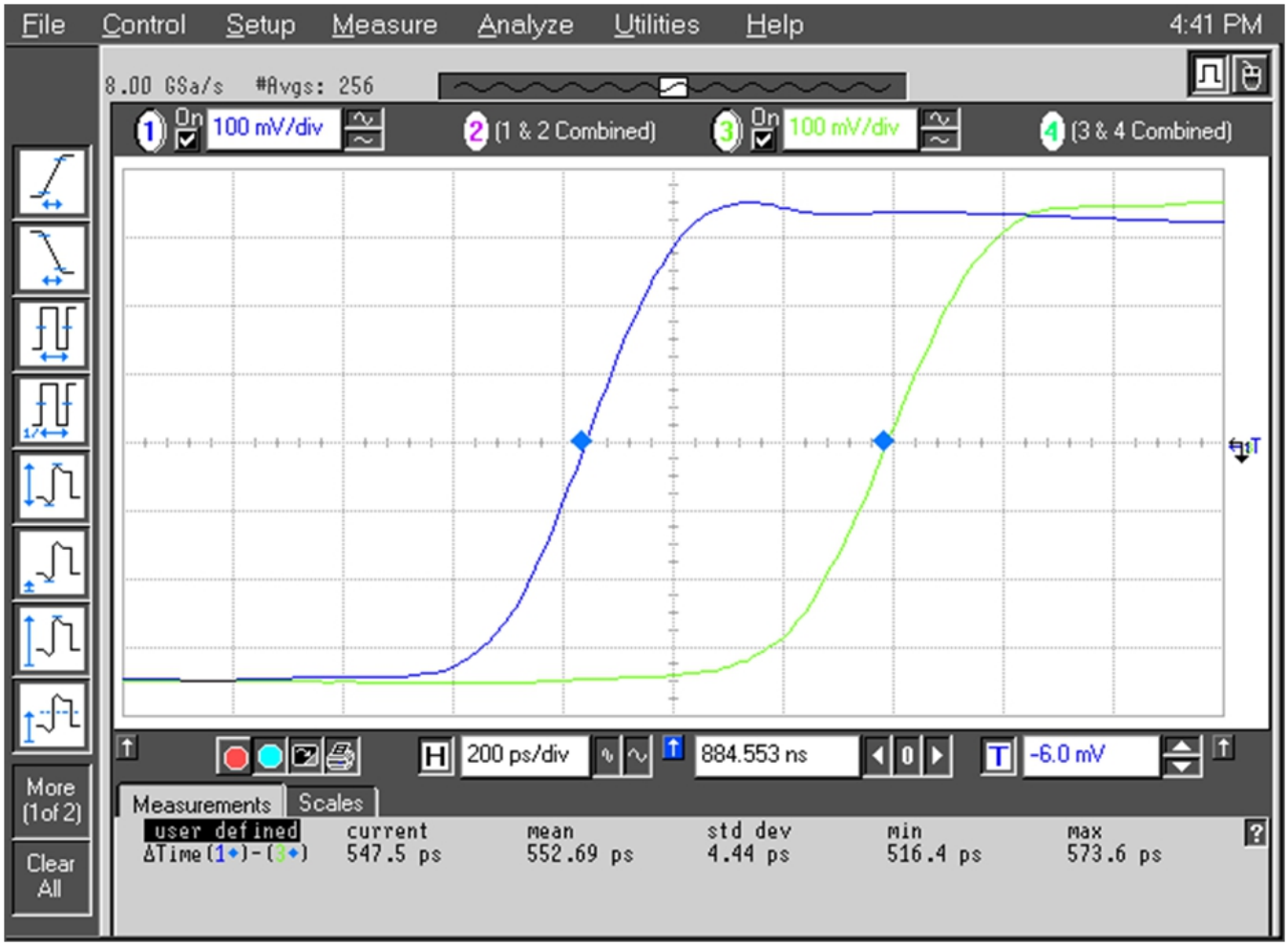
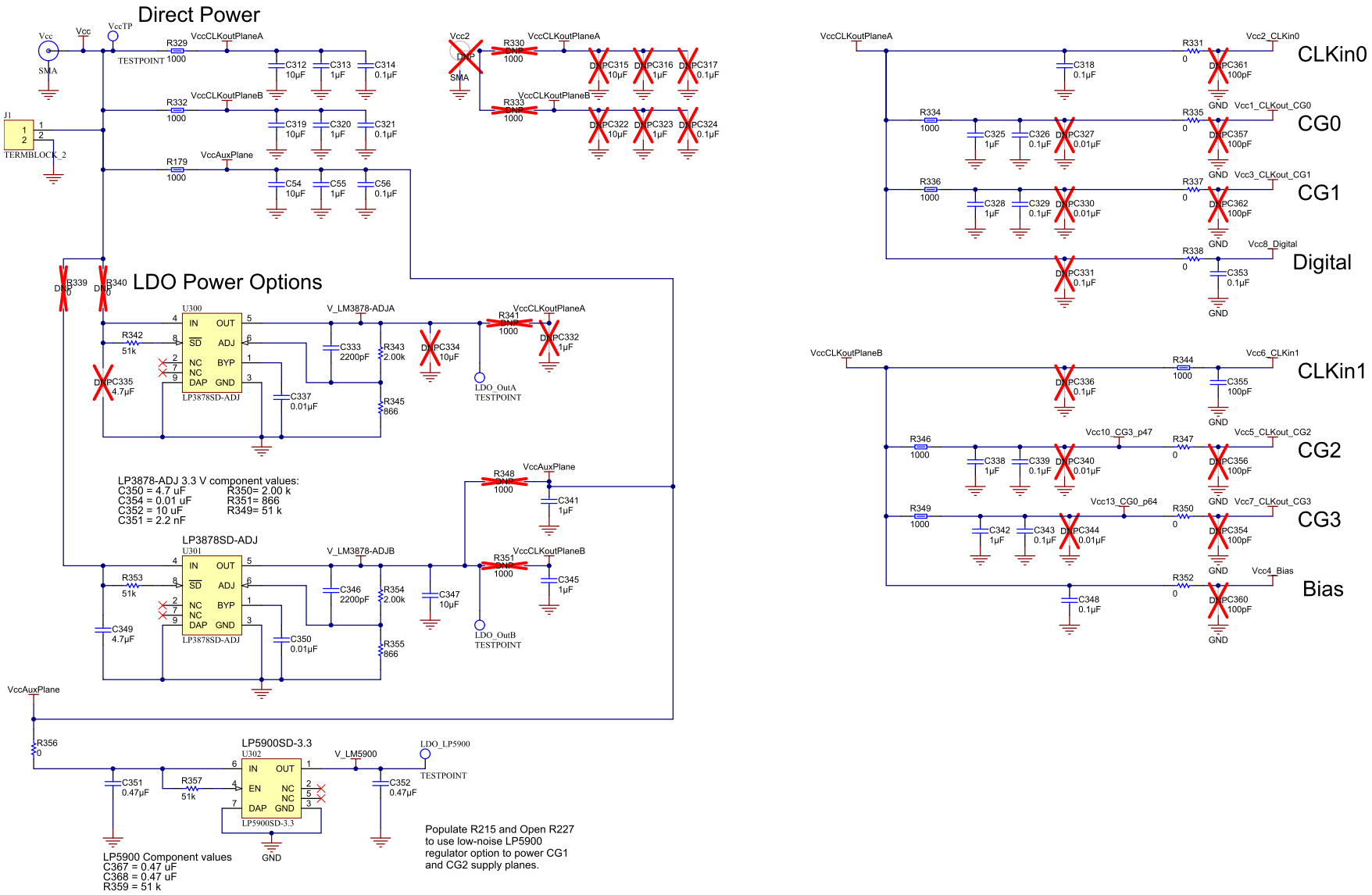


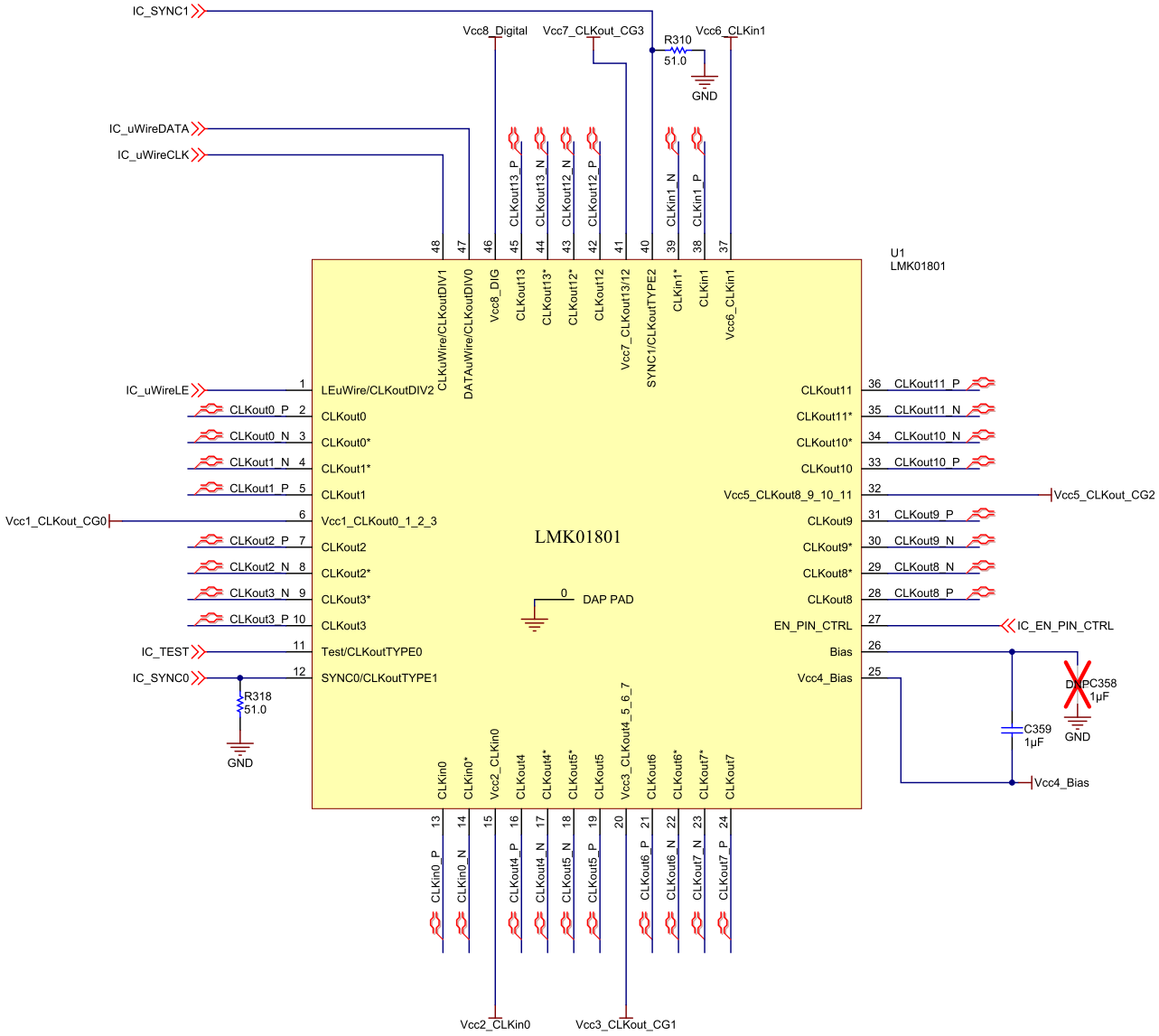
Figure 23. CLKout12 with 100 pSec of Delay Relative to CLKout13

Schematics

C.1 Power Supply



C.2 Main - LMK01801

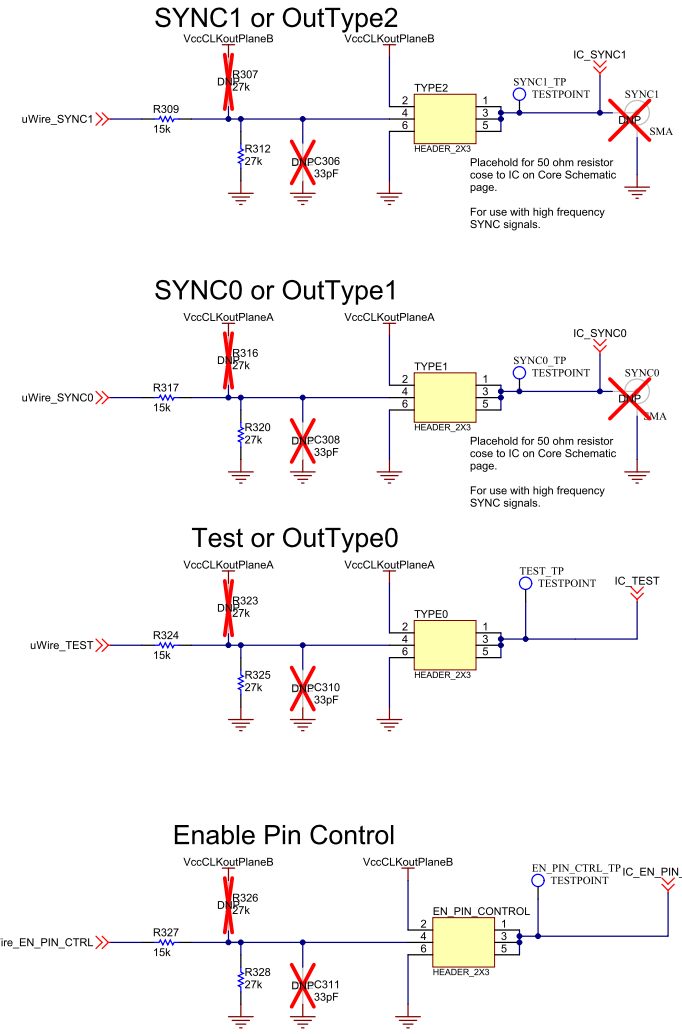


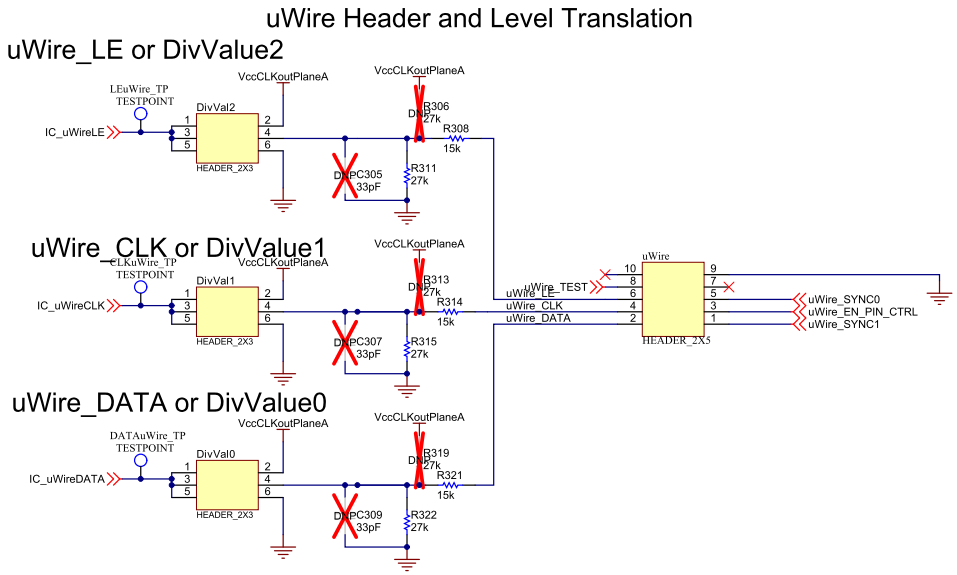
Designators greater than and equal to 200 are placed on bottom of PCB

Figure 24. NOTE: The 51 Ω resistors R310 and R318 will need to be removed for the USB2ANY to assert IC_SYNC0 and IC_SYNC1.

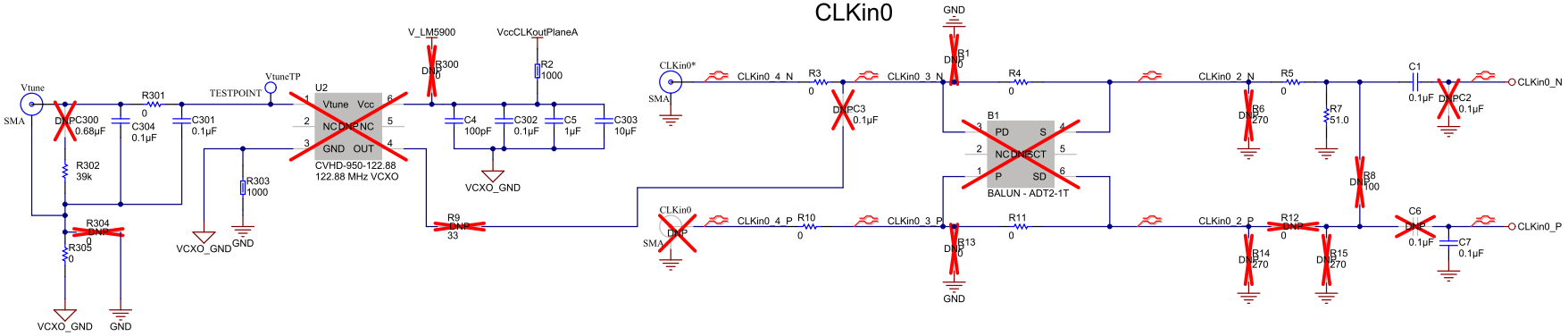
C.3 Inputs

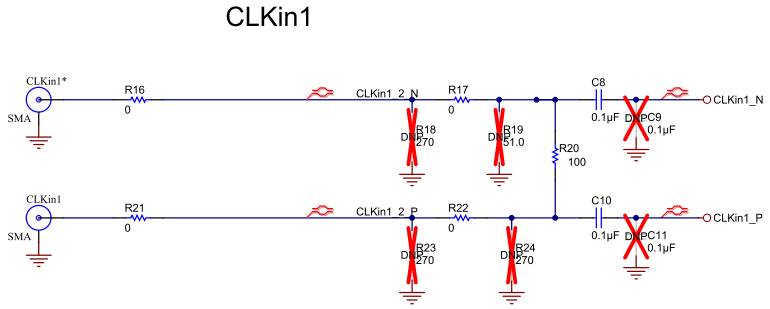
C.3.1 Inputs Page 1





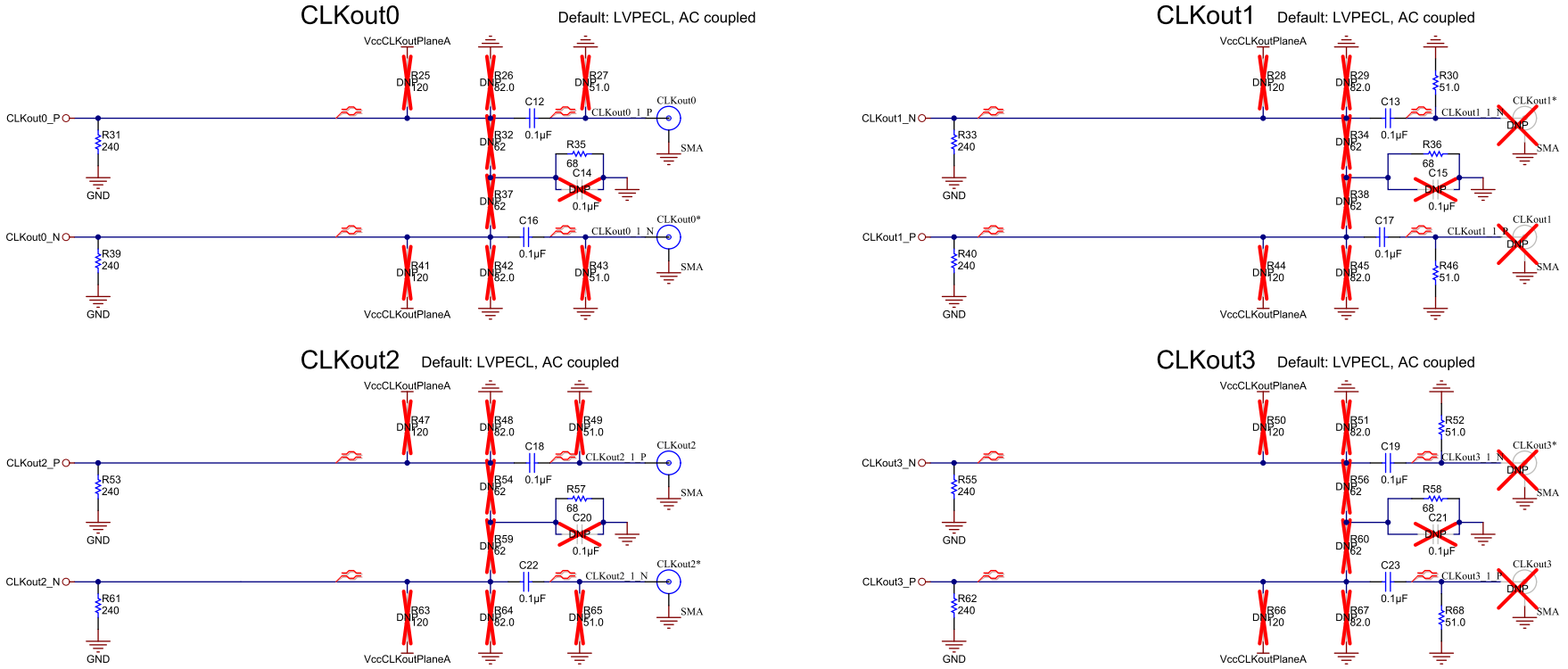
C.3.2 Inputs Page 2





C.4 Clock Outputs

C.4.1 Clock Outputs Page 1

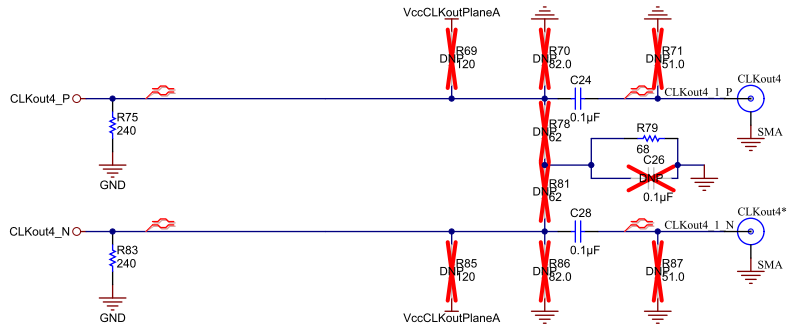


Notes:

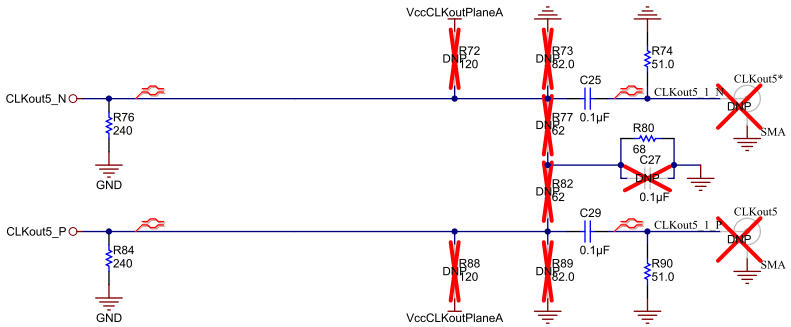
1. Designators greater than and equal to 300 are placed on bottom of PCB

C.4.2 Clock Outputs Page 2

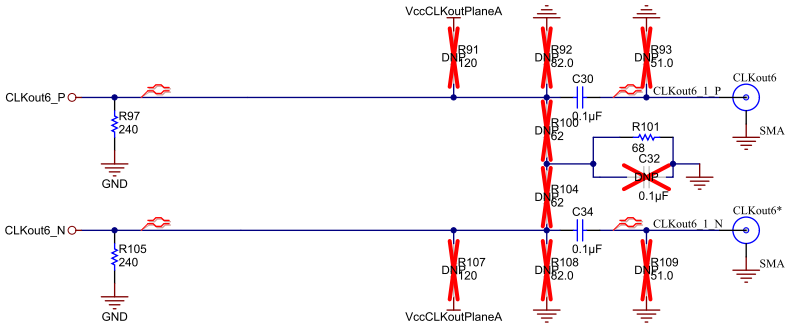
CLKout4 Default: LVPECL, AC coupled



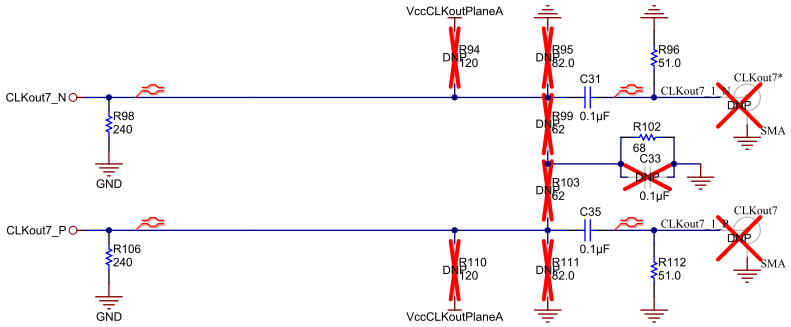
CLKout5 Default: LVPECL, AC coupled



CLKout6 Default: LVPECL, AC coupled



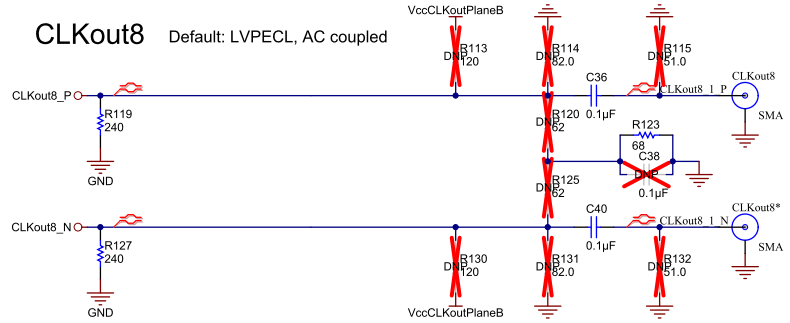
CLKout7 Default: LVPECL, AC coupled

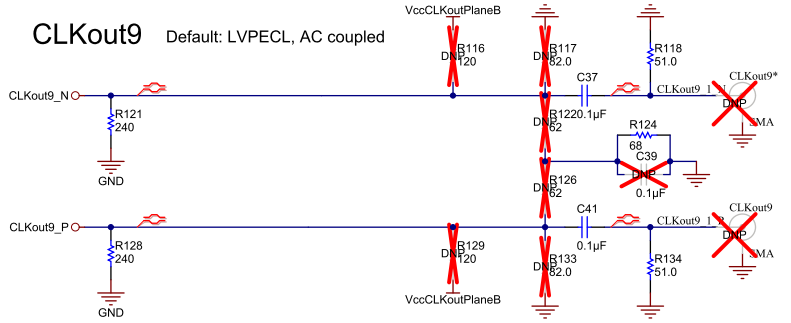


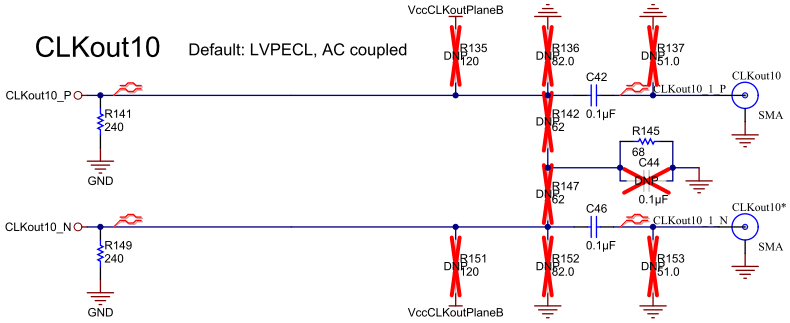
Notes:

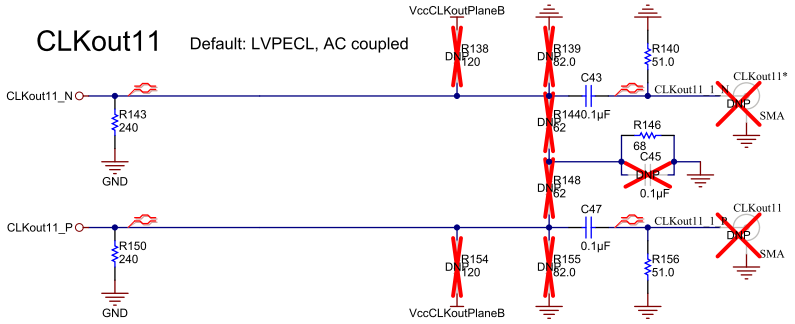
1. Designators greater than and equal to 300 are placed on bottom of PCB

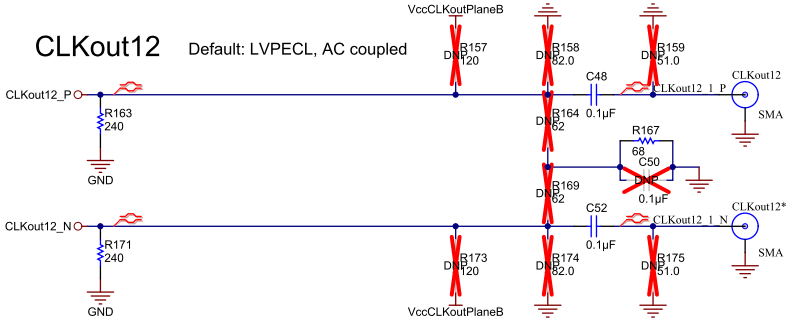
C.4.3 Clock Outputs Page 3

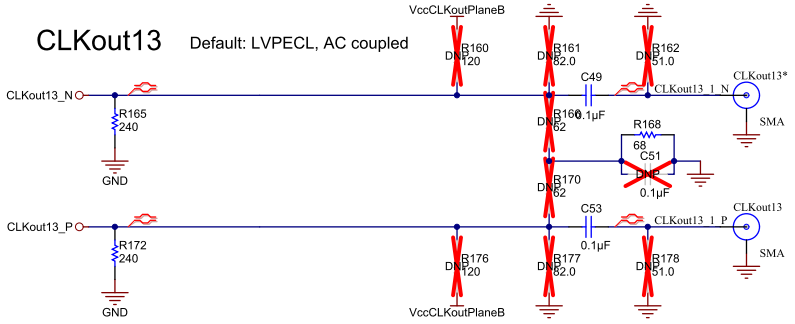












Notes:

1. Designators greater than and equal to 300 are placed on bottom of PCB

Bill of Materials

D.1 Bill of Materials

Table 8. Common Bill of Materials for Evaluation Boards

Item	Designator	Description	RoHS	Manufacturer	PartNumber	Quantity
CAPACITORS						
1	C1, C7, C8, C10, C12, C13, C16, C17, C18, C19, C22, C23, C24, C25, C28, C29, C30, C31, C35, C36, C37, C40, C41, C42, C43, C46, C47, C48, C49, C52, C53, C56, C301, C302, C304, C314, C321	CAP, CERM, 0.1 µF, 25 V, ±5%, X7R, 0603	Y	Kemet	C0603C104J3RACTU	37
2	C4	CAP, CERM, 100 pF, 50 V, ±5%, C0G/NP0, 0603	Y	Kemet	C0603C101J5GACTU	1
3	C5, C55, C313, C320, C325, C328, C338, C342, C359	CAP, CERM, 1 µF, 10 V, ±10%, X5R, 0603	Y	Kemet	C0603C105K8PACTU	9
4	C34, C326, C329, C339, C343	CAP, CERM, 0.1 µF, 25 V, ±10%, X7R, 0603	Y	Kemet	C0603C104K3RACTU	5
5	C54, C303, C312, C319	CAP, CERM, 10 µF, 10 V, ±10%, X5R, 0805	Y	Kemet	C0805C106K8PACTU	4
6	C318, C348	CAP, CERM, 0.1 µF, 16 V, ±10%, X7R, 0603	Y	TDK	C1608X7R1C104K	2
7	C341, C345	CAP, CERM, 1 µF, 16 V, ±10%, X7R, 0603	Y	TDK	C1608X7R1C105K	2
8	C333, C346	CAP, CERM, 2200 pF, 100 V, ±5%, X7R, 0603	Y	AVX	06031C222JAT2A	2
9	C347	CAP, CERM, 10 µF, 10 V, ±20%, X5R, 0805	Y	Kemet	C0805C106M8PACTU	1
10	C349	CAP, CERM, 4.7 µF, 10 V, ±10%, X5R, 0603	Y	Kemet	C0603C475K8PACTU	1
11	C337, C350	CAP, CERM, 0.01 µF, 25 V, ±5%, C0G/NP0, 0603	Y	TDK	C1608C0G1E103J	2
12	C351, C352	CAP, CERM, 0.47 µF, 25 V, ±10%, X7R, 0603	Y	MuRata	GRM188R71E474KA12D	2
CONNECTORS						
13	CLKin0*, CLKin1, CLKin1*, CLKout0, CLKout0*, CLKout2, CLKout2*, CLKout4, CLKout4*, CLKout6, CLKout6*, CLKout8, CLKout8*, CLKout10, CLKout10*, CLKout12, CLKout12*, CLKout13, CLKout13*, Vcc, Vtune	Connector, SMT, End launch SMA 50 Ohm	Y	Emerson Network Power	142-0701-851	21

Table 8. Common Bill of Materials for Evaluation Boards (continued)

Item	Designator	Description	RoHS	Manufacturer	PartNumber	Quantity
14	J1	CONN TERM BLK PCB 5.08 MM 2POS OR	Y	Weidmuller	1594540000	1
RESISTORS						
15	R2, R179, R303, R329, R332, R334, R336, R344, R346, R349	FB, 1000 Ω, 600 mA, 0603	Y	Murata	BLM18HE102SN1D	10
16	R3, R5, R10, R16, R17, R21, R22, R301, R305, R331, R335, R337, R338, R347, R350, R352, R356	RES, 0 Ω, 5%, 0.1 W, 0603	Y	Vishay-Dale	CRCW06030000Z0EA	17
17	R4, R11	RES, 0 Ω, 5%, 0.125 W, 0805	Y	Vishay-Dale	CRCW08050000Z0EA	2
18	R7, R30, R46, R52, R68, R74, R90, R96, R112, R118, R134, R140, R156, R310, R318	RES, 51.0 Ω, 1%, 0.1 W, 0603	Y	Yageo America	RC0603FR-0751RL	15
19	R20	RES, 100 Ω, 1%, 0.1 W, 0603	Y	Yageo America	RC0603FR-07100RL	1
20	R31, R33, R39, R40, R53, R55, R61, R62, R75, R76, R83, R84, R97, R98, R105, R106, R119, R121, R127, R128, R141, R143, R149, R150, R163, R165, R171, R172	RES, 240 Ω, 1%, 0.1 W, 0603	Y	Yageo America	RC0603FR-07240RL	28
21	R35, R36, R57, R58, R79, R80, R101, R102, R123, R124, R145, R146, R167, R168	RES, 68 Ω, 5%, 0.1 W, 0603	Y	Vishay-Dale	CRCW060368R0JNEA	14
22	R302	RES, 39k Ω, 5%, 0.1 W, 0603	Y	Vishay-Dale	CRCW060339K0JNEA	1
23	R311, R312, R315, R320, R322, R325, R328	RES, 27k Ω, 5%, 0.1 W, 0603	Y	Vishay-Dale	CRCW060327K0JNEA	7
24	R308, R309, R314, R317, R321, R324, R327	RES, 15k Ω, 5%, 0.1 W, 0603	Y	Vishay-Dale	CRCW060315K0JNEA	7
25	R342, R353, R357	RES, 51k Ω, 5%, 0.1 W, 0603	Y	Vishay-Dale	CRCW060351K0JNEA	3
26	R343, R354	RES, 2.00k Ω, 1%, 0.1 W, 0603	Y	Vishay-Dale	CRCW06032K00FKEA	2
27	R345, R355	RES, 866 Ω, 1%, 0.1 W, 0603	Y	Vishay-Dale	CRCW0603866RFKEA	2
INTEGRATED CIRCUITS						
28	U1	LMK01801				1
29	U300, U301	Micropower 800 mA Low Noise 'Ceramic Stable' Adjustable Voltage Regulator for 1 V to 5 V Applications	Y	Texas Instruments	LP3878SD-ADJ	2
30	U302	Ultra Low Noise, 150 mA Linear Regulator for RF/Analog Circuits Requires No Bypass Capacitor	Y	Texas Instruments	LP5900SD-3.3	1
31	uWire	Low Profile Vertical Header 2x5 0.100"	Y	FCI	52601-G10-8LF	1

Table 8. Common Bill of Materials for Evaluation Boards (continued)

Item	Designator	Description	RoHS	Manufacturer	PartNumber	Quantity
32	DivVal0, DivVal1, DivVal2, EN_PIN_CONTROL, TYPE0, TYPE1, TYPE2	Header, 2.54mm, 3x2, Gold, SMT	Y	Samtec	TSM-103-01-L-DV	7
OTHER						
33	Kitting Item	USB2ANY-UWIRE	Y	Any	SV600857-001	1
34	SH_DivVal0_3-4, SH_DivVal1_3-4, SH_DivVal2_3-4, SH_EN_PIN_CONTROL_6-FLOAT, SH_TYPE0_3-4, SH_TYPE1_3-4, SH_TYPE2_3-4	Jumper, Shunt, 100mil, Gold plated, Black	Y	3M	969102-0000-DA	7
35	S1, S2, S3, S4, S5, S6	0.875" Standoff	Y	VOLTREX	SPCS-14	6

Balun Information

E.1 Typical Balun Frequency Response

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

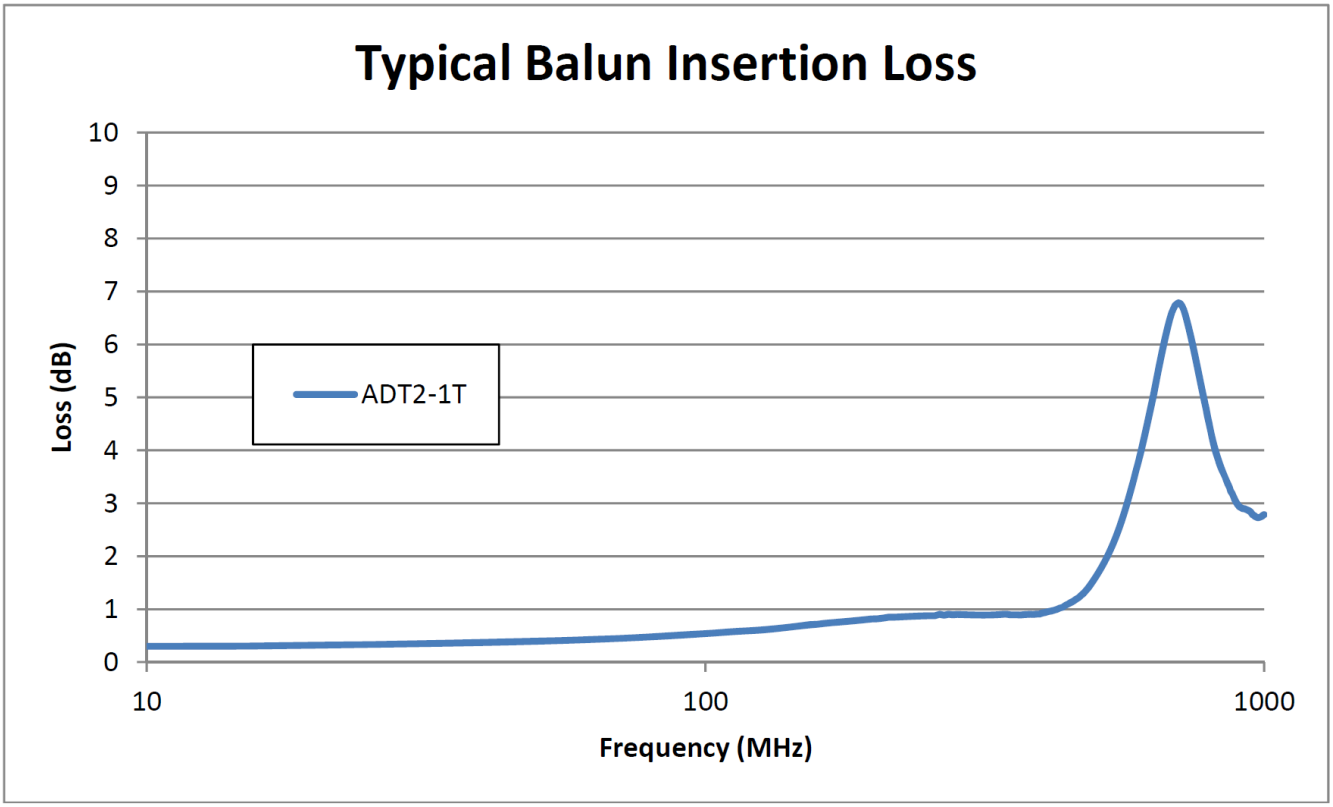


Figure 25. Typical Balun Frequency Response

Differential Voltage Measurement Terminology

F.1

The differential voltage of a differential signal can be described by two different definitions causing confusion when reading datasheets or communicating with other engineers. This section will address the measurement and description of a differential signal so that the reader will be able to understand and discern between the two different definitions when used.

The first definition used to describe a differential signal is the absolute value of the voltage potential between the inverting and non-inverting signal. The symbol for this first measurement is typically VID or VOD depending on if an input or output voltage is being described.

The second definition used to describe a differential signal is to measure the potential of the noninverting signal with respect to the inverting signal. The symbol for this second measurement is VSS and is a calculated parameter. Nowhere in the IC does this signal exist with respect to ground, it only exists in reference to its differential pair. VSS can be measured directly by oscilloscopes with floating references; otherwise this value can be calculated as twice the value of VOD as described in the first section

Figure 26 illustrates the two different definitions side-by-side for inputs and Figure 27 illustrates the two different definitions side-by-side for outputs. The VID and VOD definitions show VA and VB DC levels that the non-inverting and inverting signals toggle between with respect to ground. VSS input and output definitions show that if the inverting signal is considered the voltage potential reference, the non-inverting signal voltage potential is now increasing and decreasing above and below the non-inverting reference. Thus the peak-to-peak voltage of the differential signal can be measured.

VID and VOD are often defined in volts (V) and VSS is often defined as volts peak-to-peak (VPP).

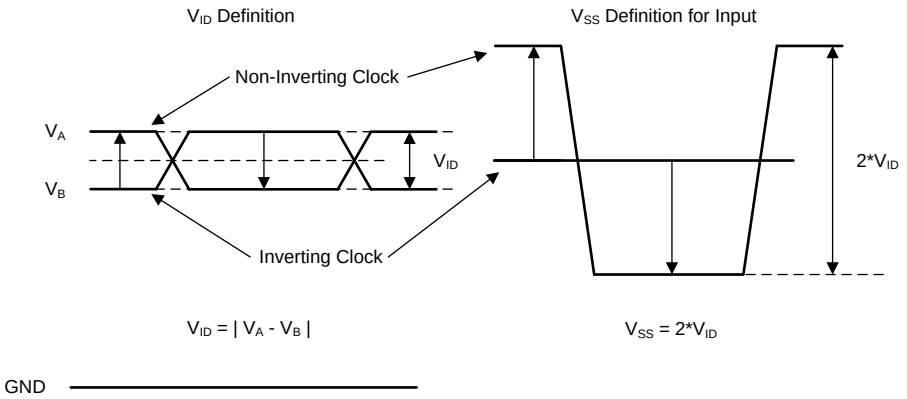


Figure 26. Two Different Definitions for Differential Input Signals

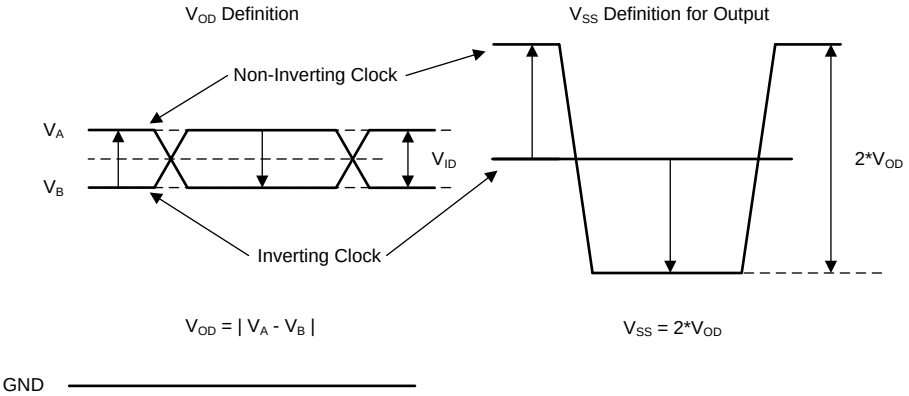


Figure 27. Two Different Definitions for Differential Output Signals

STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

   1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM (“Software”) shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software

   1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

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   2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

   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 a nonconforming EVM if (a) the nonconformity was 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, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

   2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

3 *Regulatory Notices:*

   3.1 *United States*

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

      FCC NOTICE: 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 or RSS-247*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. 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/lsds/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/lsds/ti_ja/general/eStore/notice_01.page

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

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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1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
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西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

3.4 *European Union*

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive)*:

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

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.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

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