LMK61E2EVM, LMK61E0MEVM

User's Guide

Literature Number: SNAU188B
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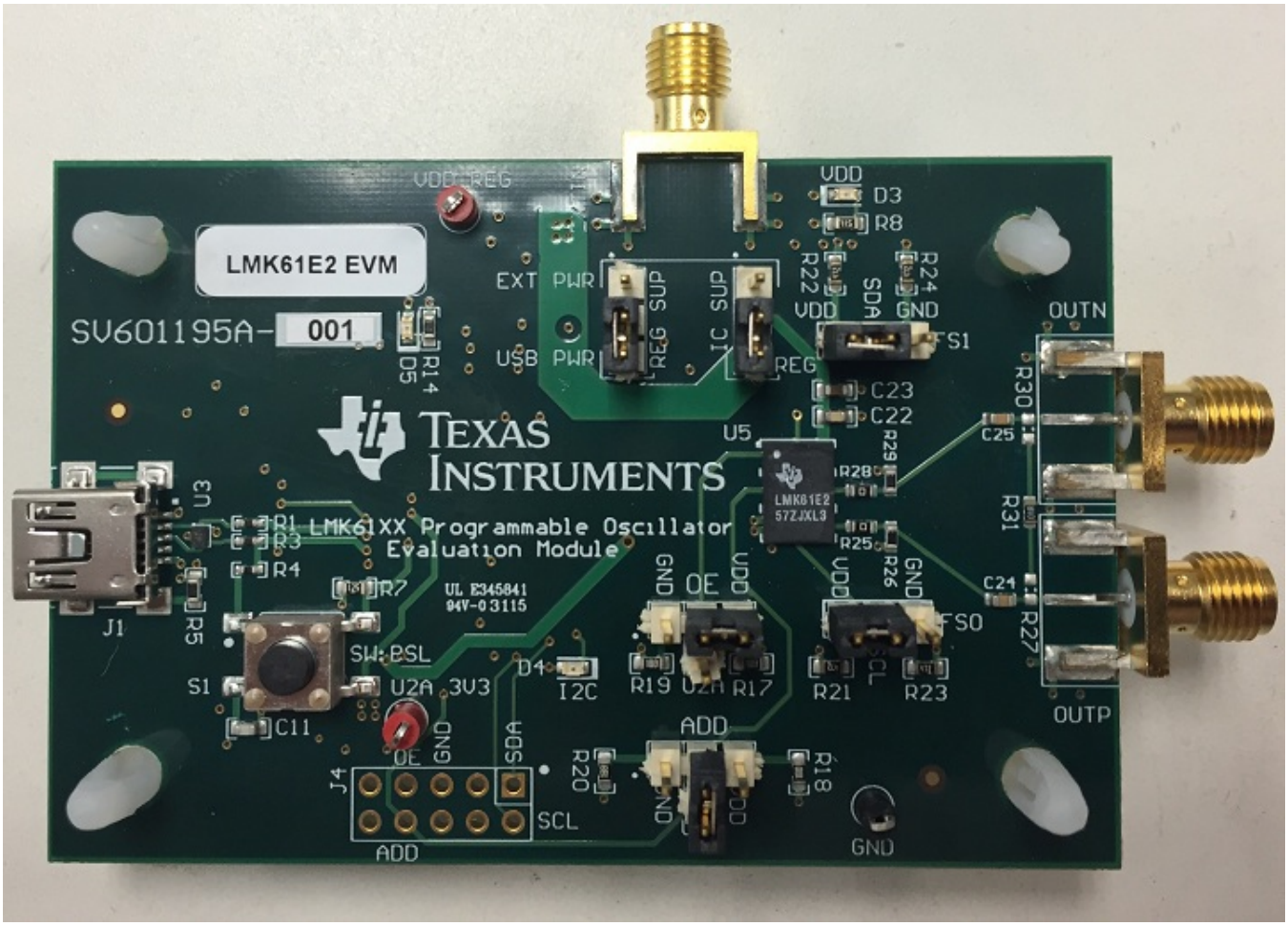


Figure 1. LMK61E2EVM Photo

Table 1. Ordering Information

EVM ID	DEVICE ID	DEVICE PACKAGE
LMK61E2EVM	LMK61E2-SIA	5 mm × 7 mm 8-pin QFM (SIA)
LMK61E0MEVM	LMK61E0M-SIA	5 mm × 7 mm 8-pin QFM (SIA)

1 Overview

The LMK61E2EVM and LMK61E0MEVM evaluation modules provide a complete evaluation platform to evaluate the clock performance and flexibility of the Texas Instruments LMK61XX Ultra-Low Jitter Crystal Oscillator family, with integrated tunable 50-MHz crystal, low noise PLL, universal output, and integrated EEPROM.

The EVM can be used as a flexible clock source for compliance testing, performance evaluation, and initial system prototyping. The onboard edge-launch SMA ports provide access to the LMK61XX's configurable clock output for interfacing to test equipment and reference boards using commercially available coaxial cables, adapters, or baluns (not included). This connectivity enables integrated system level testing between TI's LMK61XX and third-party FPGA/ASIC/SoC reference boards. A software graphical user interface (GUI) platform can be installed on a Host PC to access the LMK61XX's device registers and EEPROM through the onboard USB-to-I^2C interface.

2 Features

- Integrated low-noise, 50-MHz tunable crystal
  - Fine frequency margining in ppm steps through the I^2C
- Coarse frequency margining in percentage steps through the I^2C
- Configurable output format
  - LMK61E2EVM supports LVPECL, LVDS, or HCSL
  - LMK61E0MEVM supports dual LVCMOS
- Programmable Output Enable polarity
- EEPROM allows for custom configuration for power-up defaults
- Footprint compatible with industry standard 5 mm × 7 mm XO package
  - 2 additional pins allow for optional I^2C programing
- GUI platform for full access to device registers and EEPROM
- Onboard USB-to-I^2C programming interface
- External power supply inputs or powered over USB
- LEDs indicators: Device Power and USB / I^2C activity

3 Configuring the EVM

The LMK61XX is a highly-configurable crystal oscillator with simple power supply requirements and flexible clock output formats. To support a wide range of evaluation use cases, the EVM was designed for maximum flexibility so various configurations or options that are not required in all typical system applications have been included.

This section describes the jumpers and connectors on the EVM, as well as how to connect, set up, and use the EVM. When operating the EVM, the power supply and clock outputs can be connected to the SMA ports shown in Figure 2. Additionally, the USB port can be used to power the entire EVM without the need for external power supplies. These SMA ports are labeled in the top silkscreen layer.

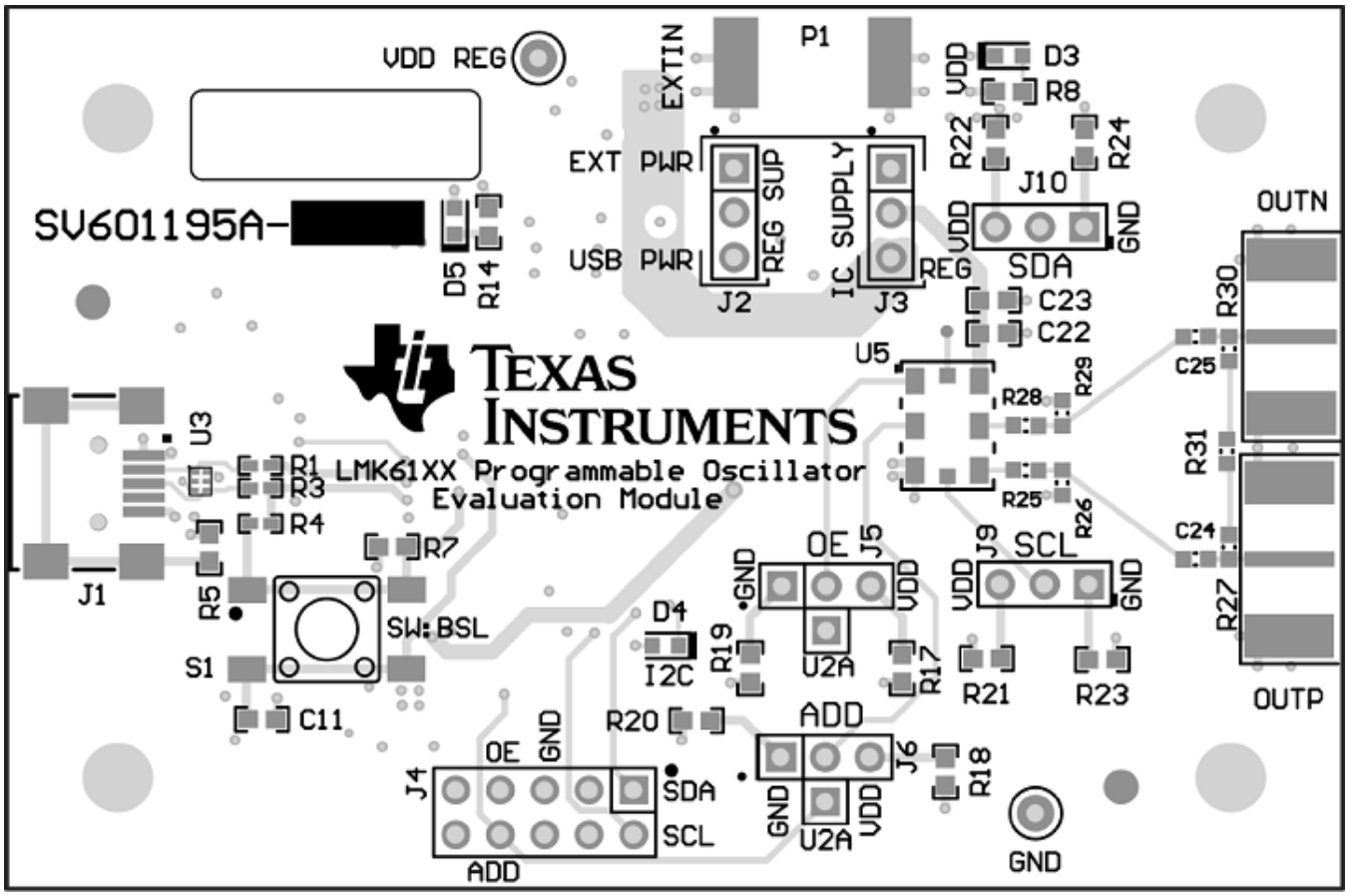


Figure 2. EVM Board Layout

4 Configuring the Power Supply

The LMK61XX features a single VDD supply pin that operates from 3.3 V (+5%). This supply can be powered directly from an external supply or through an on-board LDO regulator. Although the LMK61XX has integrated LDO regulators for excellent power-supply-ripple-rejection (PSRR), the EVM's onboard regulator (U2) can allow a higher supply voltage (like 5 V) to power the EVM. The direct external supply or onboard regulator can be independently routed for the VDD supply pin by configuring the power terminals and jumpers shown in Figure 3. J1 (USB mini connector) is the default power supply for the EVM, featuring a low noise regulator for voltage step-down. Power SMA Port EXTIN (P1) provides an alternative connector style to apply power using coax cables. Using EXTIN while connected to USB power is not required but can be useful when testing with externally regulated supplies.

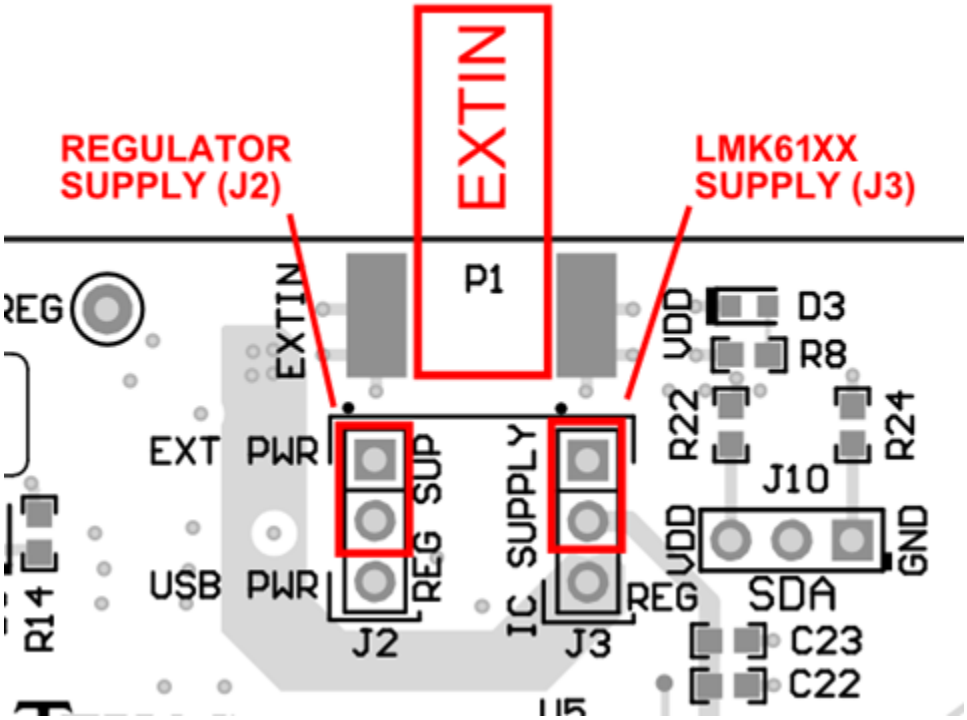


Figure 3. Power Terminals and Jumpers

Table 2 summarizes the EVM power configurations to connect and route power to the onboard LDOs and LMK61XX. Refer to the EVM schematic for more details.

Table 2. Power Configurations

MODE	EXTIN VOLTAGE	J2 SETTING (1)	J3 SETTING (1)
USB Powered (2)		USB PWR	
External Power + LDO	4.3 V to 5.5 V	EXT PWR	REG
External Power	3.3 V	Remove Jumper	EXT PWR

(1) Markings left of J2 indicate the orientation of jumper settings EXT PWR (pins 1 and 2 of jumper) and USB PWR / REG (pins 2 and 3 of jumper)
(2) USB cable must be connected to J1 for operation

5 Configuring the Control Pins

The LMK61XX has several control pins dedicated for control of I^2C communications, device I^2C address, and output enable control. These control pins can be configured through the jumpers shown in .

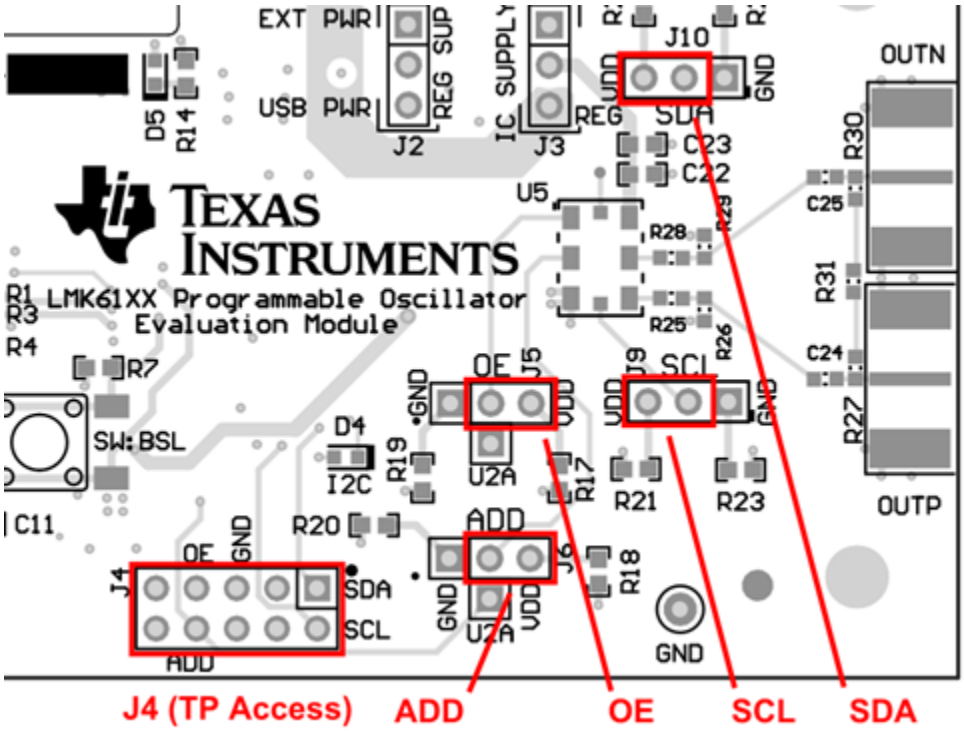


Figure 4. Control Pin Interfaces (Default Jumper Settings Shown)

Jumpers J9 and J10 can be used to configure the corresponding control pin to either high or low state by strapping the center pin to *VDD* position (tie pins 1-2) or *GND* position (tie pins 2-3), respectively. Connections from the *VDD* position to the device supply or from the *GND* position to the ground plane are connected by 4.7-kΩ resistors.

Jumpers J5 and J6 can be configured in a static configuration through a high or low state by strapping the center pin to *VDD* position or to the *GND* position. Similarly, these connections are made through a 4.7-kΩ resistor to the respective supply and ground planes. The third position, U2A, allows for control of the respective control pins over software through the onboard microcontroller. Biasing is established externally and is default set to a high state.

The LMK61XX control pins serve several functions unique to device pins. For a description of each pin's functionality and the device configuration based on their power-up state, refer to Table 3.

Table 3. Control Pin Interfaces

COMPONENT	NAME (TYPE)	DESCRIPTION	
J5	OE (passive or software control)	Output Enable Pin Output Enable Pin	
		OE state controls the differential output operation in LMK61E2EVM and OUTP operation in LMK61E0MEVM. Polarity can be adjusted in the LMK61XX's register settings. OUTN in LMK61E0MEVM is controlled by register R24[4] and is disabled by default.	
		OE STATE	**OPERATING MODE (BASED ON DEFAULT)**
		GND	Differential Output Disabled in LMK61E2EVM, OUTP DIsabled in LMK61E0MEVM
		VDD (JP Default)	Differential Output Enabled in LMK61E2EVM, OUTP Enabled in LMK61E0MEVM
J6	ADD (passive or software control)	I^2C Slave Address LSB Select pin	
		ADD is sampled on POR to configure the lower 2 bits of the 7-bit slave address. The upper 5 bits of the slave address are initialized from EEPROM (SLAVEADR[7:3] = 10110b). By configuring ADD, the composite slave address can be selected as follows:	
		ADD STATE	**7-BIT SLAVE ADDRESS (EXCLUDES W/R BIT)**
		GND	1011000b / 0x58
		High Z (no connect)	1011001b / 0x59
		VDD (JP Default)	1011010b / 0x5A
J9 J10	SCL SDA (I^2C inputs)	I^2C Serial Interface Pins	
		An I^2C master device can interface with the LMK61XX over the I^2C clock line (SCL) and data line (SDA). The open-drain topology of the SCL and SDA pins require an external pullup resistor. J9 and J10 should always be set in the VDD position to ensure proper I^2C communication. The SCL and SDA lines are connected with the onboard microcontroller, which is controlled by the GUI.	
J1	USB (not shown in Figure 4)	USB port (Mini-B type) USB port (Mini-B type)	
		Using the GUI platform, USB controller (U4) provides the USB-to-I^2C interface to manage the LMK61XX device registers and EEPROM. When USB communication is established with a Host PC running the GUI, LED D5 should be lit solid green.	
		The USB port powers LDO regulator U1 to supply 3.3-V power for the MCU and its peripheral circuitry.	
J4 (not populated)	U2A	Optional Test Point Access to I^2C and Control pins	
		Pin 1: SDA	Pin 2: SCL
		Pin 4: N/C	Pin 3: N/C
		Pin 5: GND	Pin 6: N/C
		Pin 7: OE	Pin 8: ADD
		Pin 9: N/C	Pin 10: N/C

6 Configuring the Clock Output

The LMK61E2's differential output is routed through 50-Ω, single-ended traces to SMA ports (OUTN and OUTP) through AC-coupling capacitors. The LMK61E0M's dual LVCMOS outputs are DC coupled and routed directly to the SMA ports through the 50-Ω traces. The output also has a series resistor (0 Ω populated by default, R25 ad R28) and emitter resistors (150 Ω populated by default for LVPECL, R26 and R29). Common output format terminations are shown in Table 3. The output termination schematic is shown in Figure 5.

Table 4. Output Termination Schemes

OUTPUT FORMAT	COUPLING	COMPONENT	VALUE
LVPECL	AC (LMK61E2EVM default configuration)	R25, R28	0 Ω
		R26, R29	150 Ω
		C24, C25	0.01 uF
		R27, R30, R31	DNP
	DC[1]	R25, R28, C24, C25	0 Ω
		R26, R27, R29, R30, R31	DNP
LVDS[2]	AC	R25, R27, R28, R30	0 Ω
		R31	100 Ω
		C24, C25	0.01 uF
		R26, R29	DNP
	DC	R25, R27, R28, R30, C24, C25	0 Ω
		R31	100 Ω
HCSL	AC	R25, R28	0 Ω (22 Ω optional)
		R26, R29	50 Ω
		C24, C25	0 Ω
		R27, R30, R31	DNP
	DC	R25, R28	0 Ω (22 Ω optional)
		R26, R29	50 Ω
		C24, C25	0.01 uF
		R27, R30, R31	DNP
LVCMOS	AC	R25, R28	0 Ω
		C24, C25	0.01 uF
		R26, R27, R29, R30, R31	DNP
	DC (LMK61E0MEVM default configuration)	R25, R28, C24, C25	0 Ω
		R26, R27, R29, R30, R31	DNP

(1) 50 Ω to Vcc-2 V termination is required on receiver.
(2) 100-Ω differential termination (R31) is provided on the LMK61E2EVM. Removing the differential termination on the EVM is possible if the differential termination is available on the receiver.

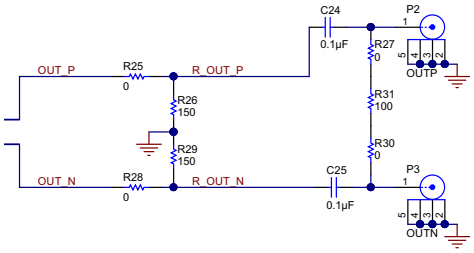


Figure 5. EVM Termination Schematic

7 Using the USB Interface Connection

The onboard MSP430F5529 USB microcontroller (U4) provides an I^2C host interface to the LMK61XX slave device. The device registers can be controlled through USB using the GUI platform running on a Host PC.

8 EVM Quick Start Guide

The following guide allows the user to quickly configure the LMK61XX to evaluate performance and device flexibility

- 1. Set the Control Pin jumpers to the default configuration as noted in Table 1 and Table 3.
- 2. Confirm the EVM Default power configuration is set per Table 2 to power the LMK61XX in USB POWER mode using the onboard LDO regulators and power supplied over USB.
- 3. Observe any active output clock on OUTN and OUTP SMA ports.
  - 3.1. Default LMK61E2EVM configuration is AC-coupled LVPECL as noted in Table 4.
  - 3.1. Default LMK61E0MEVM configuration is DC-coupled LVCMOS as noted in Table 4. By default OUTP is enabled and OUTN is disabled.
  - 3.2. Use 50-Ω coax cables to connect the test equipment to the output SMA ports. If making a single-ended measurement, terminate the unused SMA port with a 50-Ω load.
  - 3.3. Power LEDs, D3, and D5 should be illuminated when the EVM is connected to power
  - 3.4. I^2C activity can be seen on LED D4 (active with activity).
- 4. Refer to Table 5 for recommended device configurations configurable through the GUI.

Table 5. Recommended Device Configurations(1)

PARAMETER		156.25 MHz(2)	100 MHz	161.1328125 MHz
PLL	Reference Doubler	Enabled		
	N Divider	50	48	51
	Fractional Numerator			22500
	Fractional Denominator			40000
	VCO frequency	5000 MHz	4800 MHz	5162.25 MHz
	Output Divider	32	16	32
Loop Filter	Charge Pump Gain	6.4 mA		2.8 mA
	Loop Filter Order	2nd Order		3rd Order
	C1	5 pF		105 pF
	C2	10 nF		
	C3	0 pF		35 pF
	R2	800 Ω		1.1 kΩ
	R3	18 Ω		1.3 kΩ
	Modulator Order	Integer Mode		1st Order
	Dithering	Disable		Weak
	Charge Pump Bleed	None		8.5 kΩ 1 ns

(1) Termination schemes should match device settings. See Table 4.
(2) LMK61E2EVM Device default

9 Recommended Test Instruments

For making accurate measurements on ultra-low noise/jitter, high-speed clock signals, the following instruments are recommended:

- Source Signal Analyzer: Keysight/Agilent E5052 for phase noise and jitter measurements
- Oscilloscope: Agilent DSA90000A series (or equivalent) for AC measurements and time-domain jitter analysis with jitter software package
- Balun: M/A-COM H-183-4 (30-3000 MHz) 180° coupler, or equivalent

10 Example Performance Measurements

RMS Jitter and phase noise measurements were taken on the differential output clock was measured using a balun to a Keysight/Agilent E5052B. Some phase noise plots are provided below.

Table 6. Typical Output RMS Jitter Summary

OUTPUT FREQUENCY	OUTPUT FORMAT(1)	RMS JITTER (fs),12k-20M BAND, SPURS OFF	REFERENCE PLOT
156.25 MHz	LVPECL	90	Figure 6
	LVDS	100	Figure 7
	HCSL	100	
161.1328125 MHz	LVPECL	150	
	LVDS	150	
	HCSL	150	Figure 8

(1) All measurements are AC coupled with recommended board terminations as in Table 4.

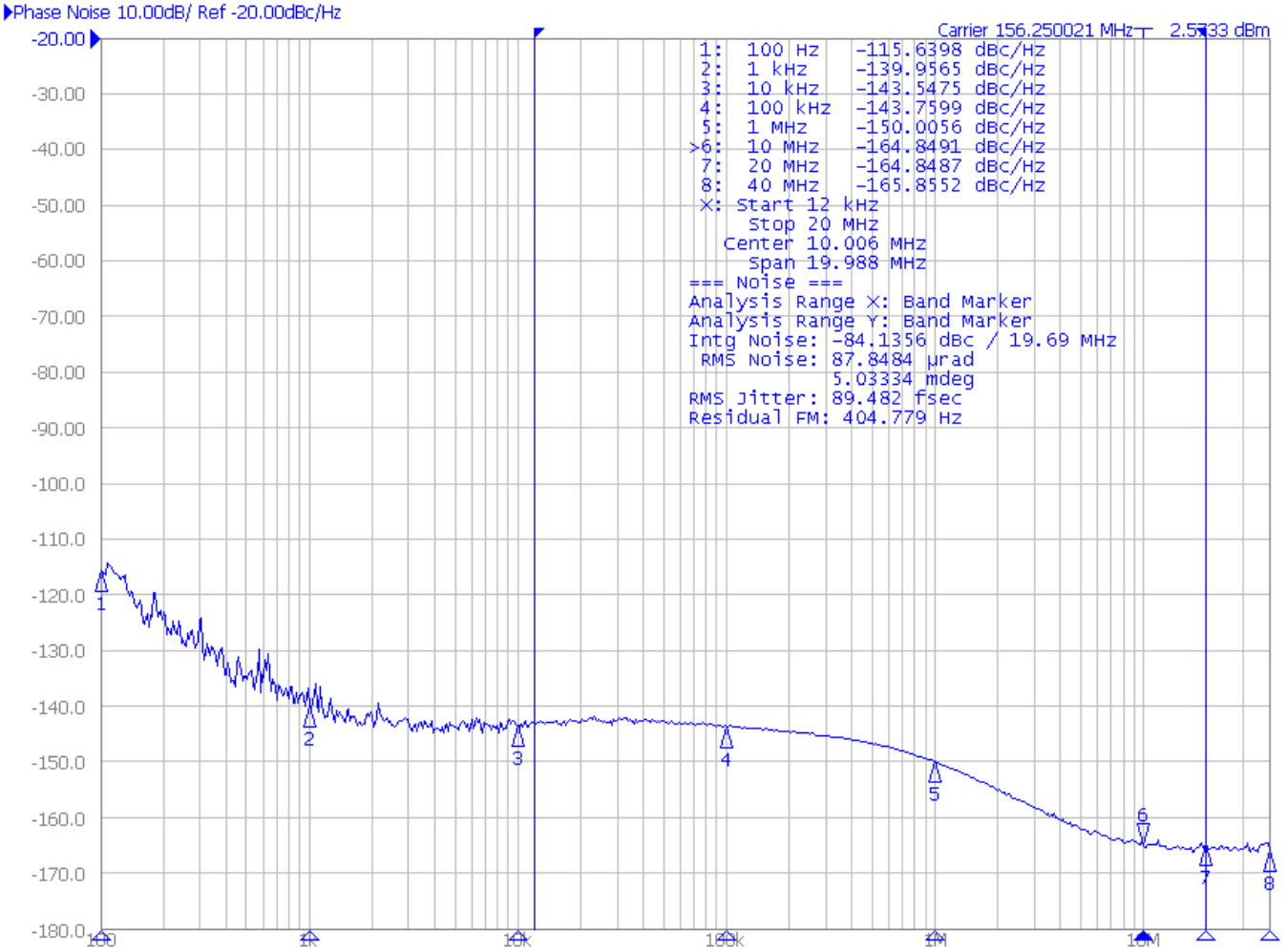


Figure 6. 156.25-MHz LVPECL Differential Phase Noise

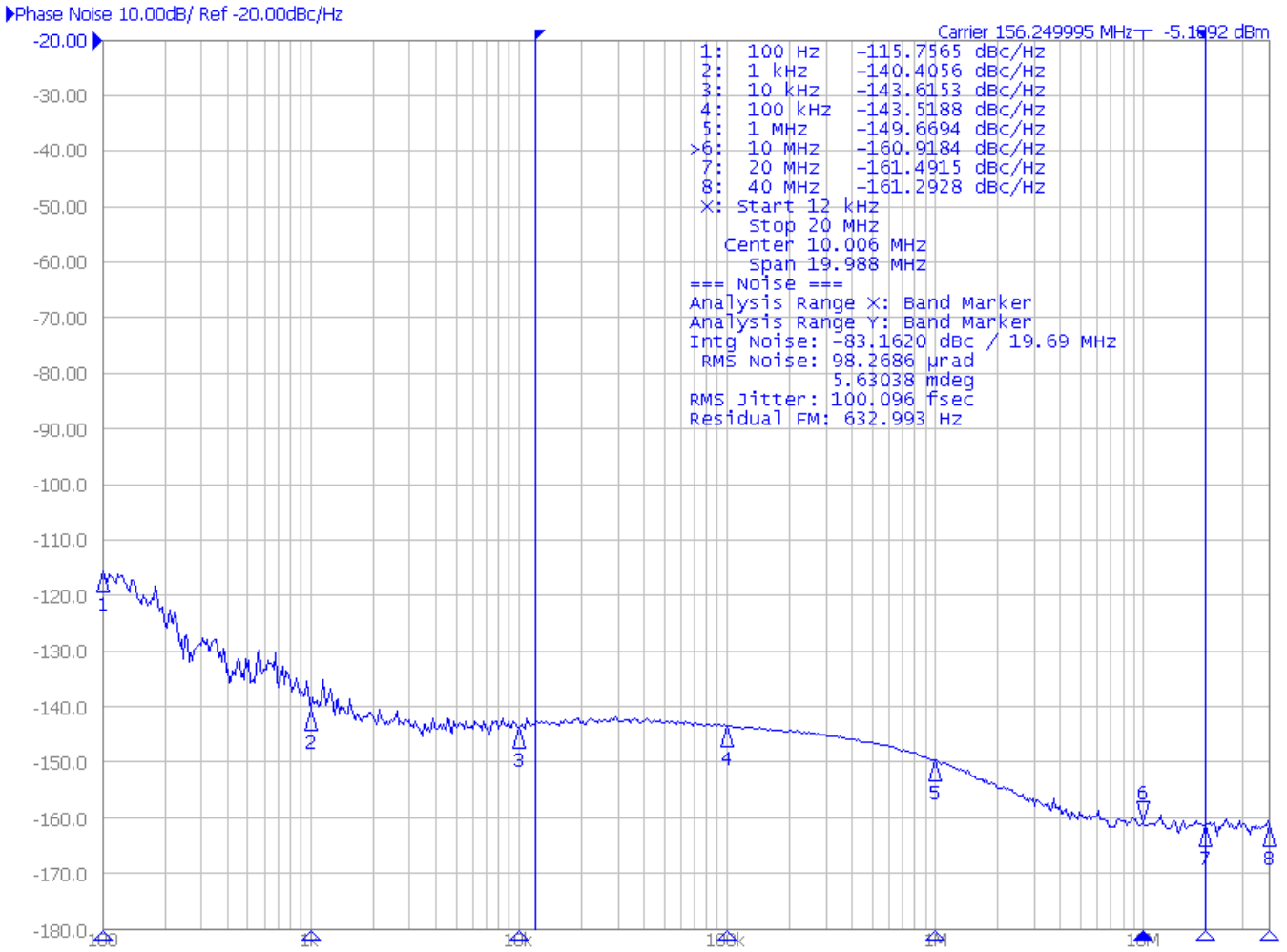


Figure 7. 156.25-MHz LVDS Differential Phase Noise

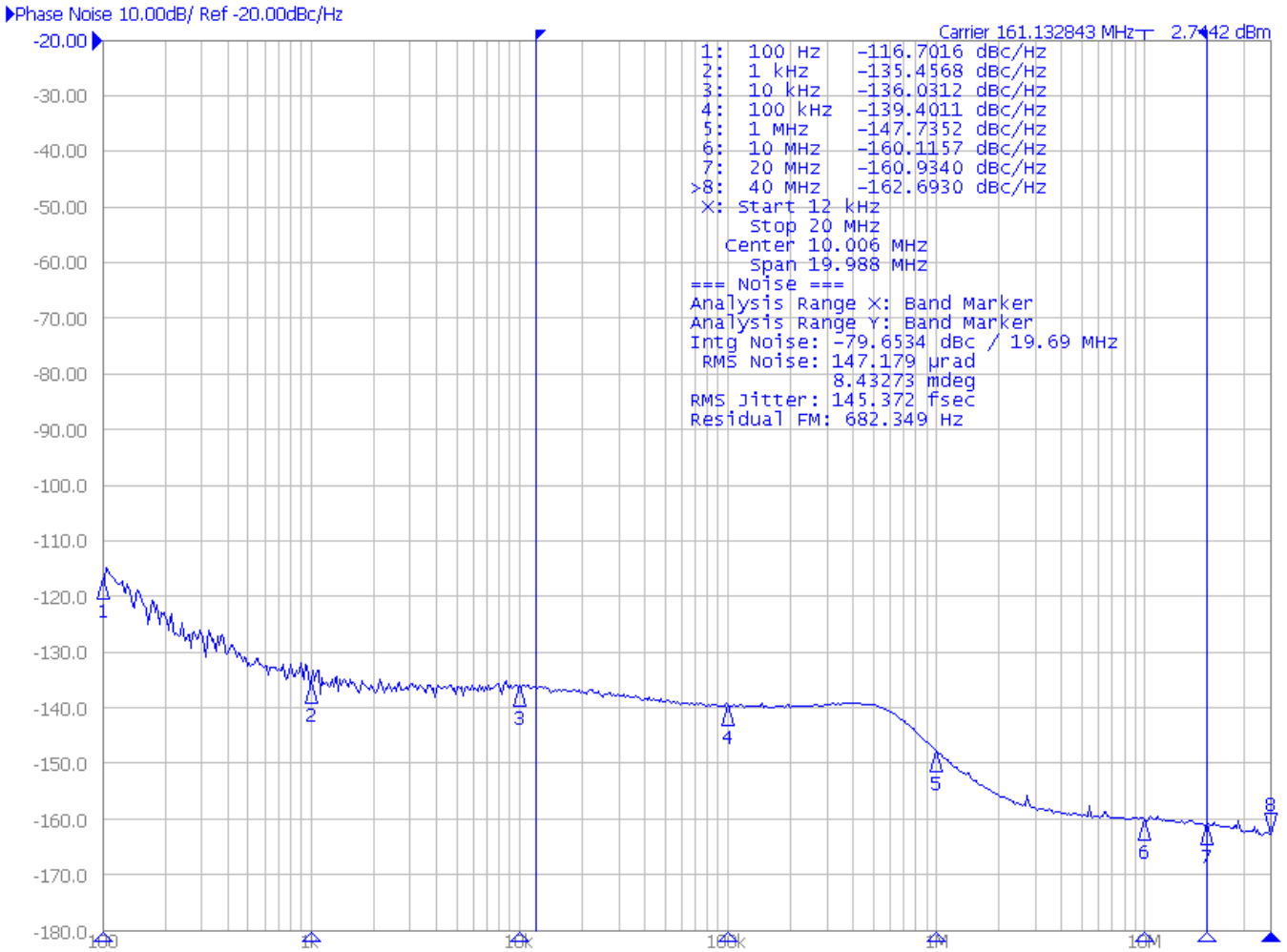


Figure 8. 161.1328125-MHz HCSL Differential Phase Noise

11 EVM Layout

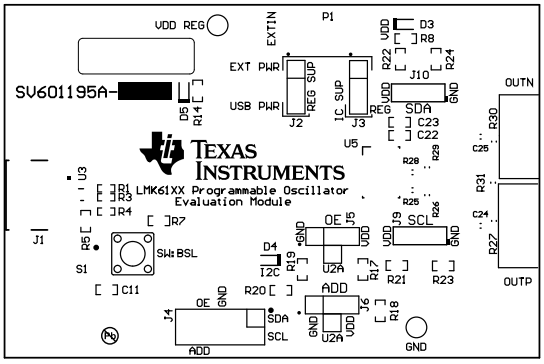


Figure 9. Top Overlay

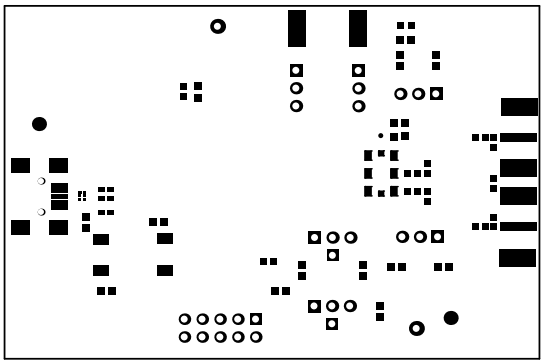


Figure 10. Top Solder Mask

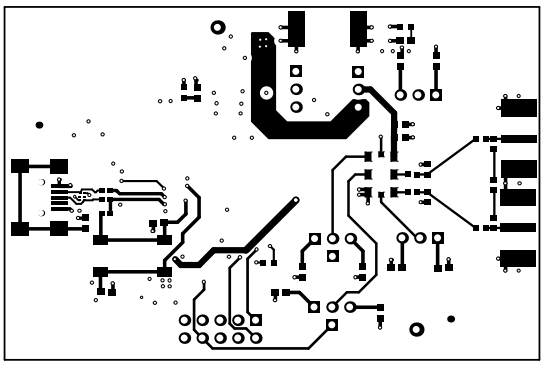


Figure 11. Layer 1 (Top Side)

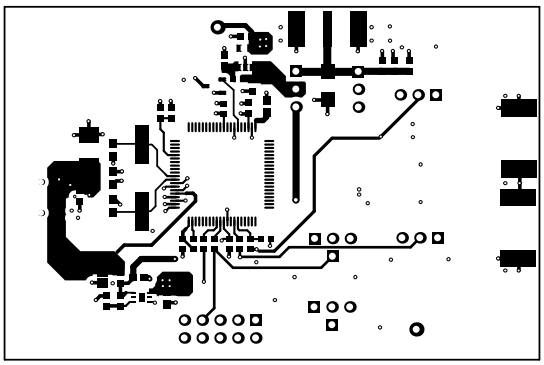


Figure 12. Layer 4 (Bottom Side, View From Bottom)

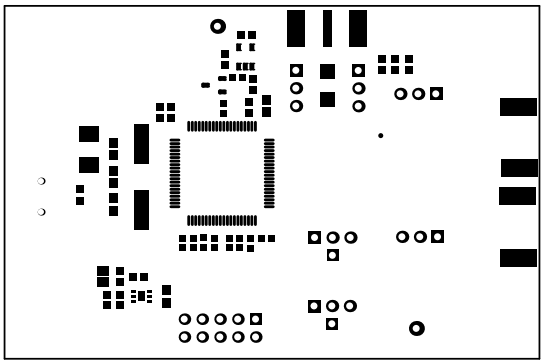


Figure 13. Bottom Solder Mask

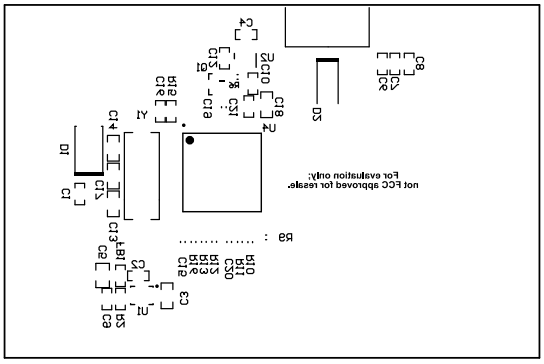
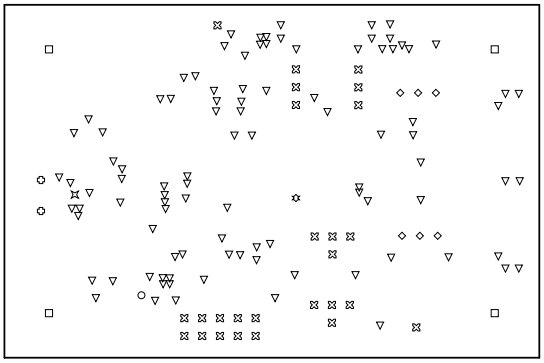


Figure 14. Bottom Overlay



Symbol	Hit Count	Tool Size	Plated	Hole Type
○	1	7.874mil (0.2mm)	PTH	Round
⌑	1	9mil (0.229mm)	PTH	Round
▽	98	13mil (0.33mm)	PTH	Round
☼	1	22mil (0.559mm)	PTH	Round
⌬	2	35.433mil (0.9mm)	NPTH	Round
◇	6	39.37mil (1mm)	PTH	Round
⊠	26	40mil (1.016mm)	PTH	Round
□	4	157mil (3.988mm)	NPTH	Round
	139 Total			

Figure 15. Drill Drawing

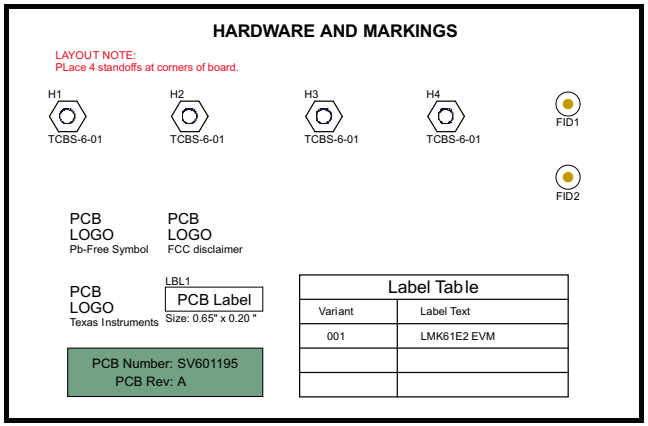
12 EVM Schematic

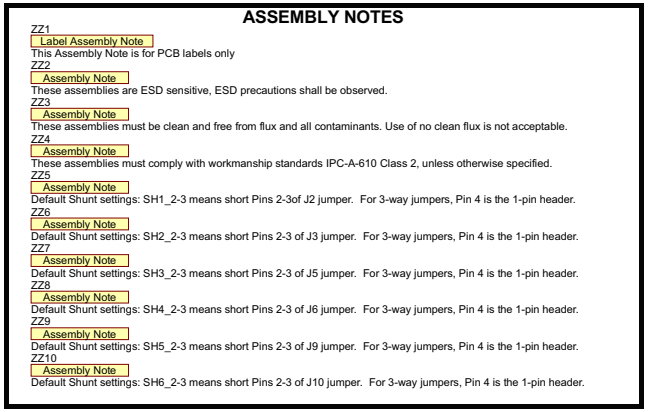
LMK61XX Evaluation Module (EVM)

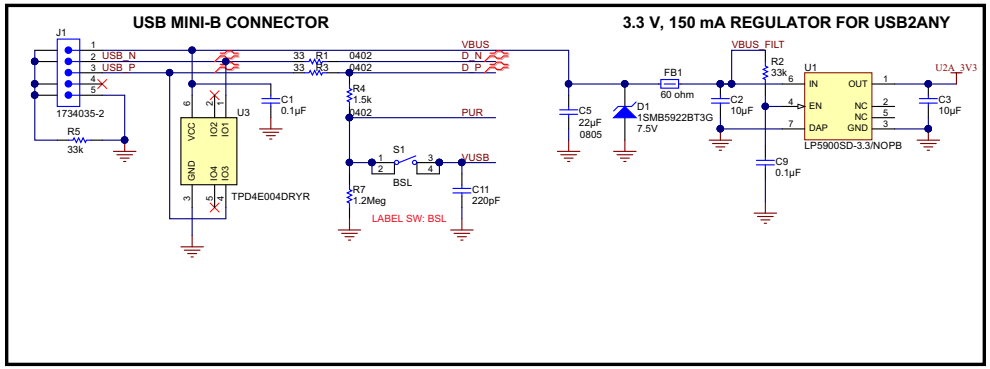
DIMENSIONS:
-- Rectangular shape with height minimized (SMA spacing + board stand offs)
-- Final PCB thickness 62 mil +/- 10% ****

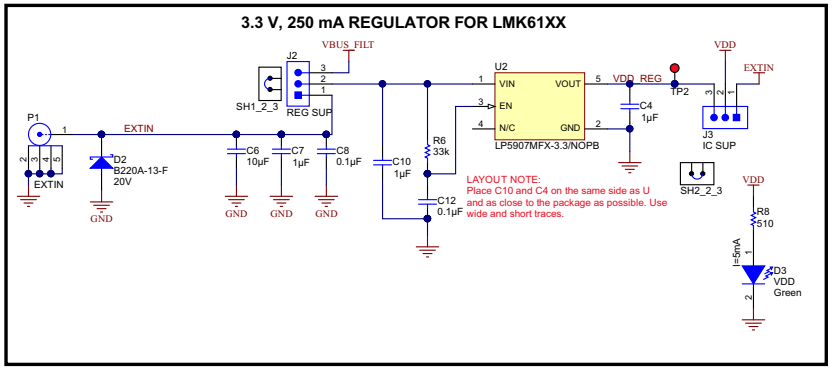
STACKUP:
-- Layer 1: Device layer, Power/GPIO Jumper/Switches, RF microstrip from DUT to SMA, USB connector, Silkscreens + Labeling
===== FR4: 8 mil
-- Layer 2: Ground Plane
===== FR4: 38 mil
-- Layer 3: Split Power planes for USB circuitry and DUT circuitry
===== FR4: 8
-- Layer 4: USB circuitry

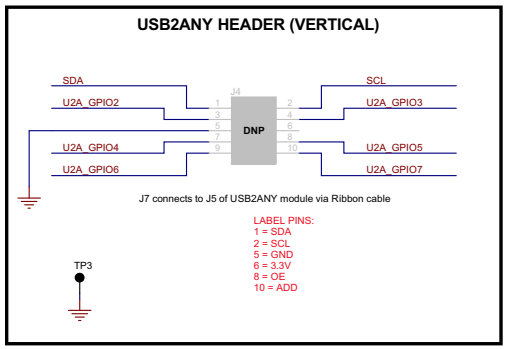
Controlled Impedance Traces
-- TOP: 13 mil traces to be 50 ohm Zo +/- 5% reference to L2

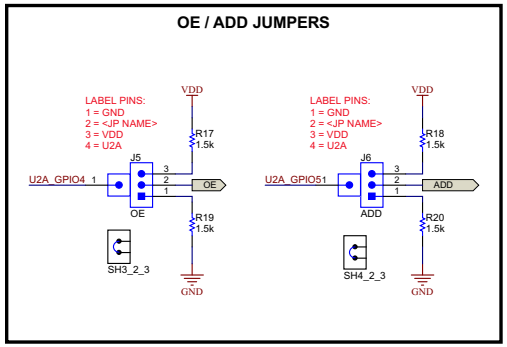


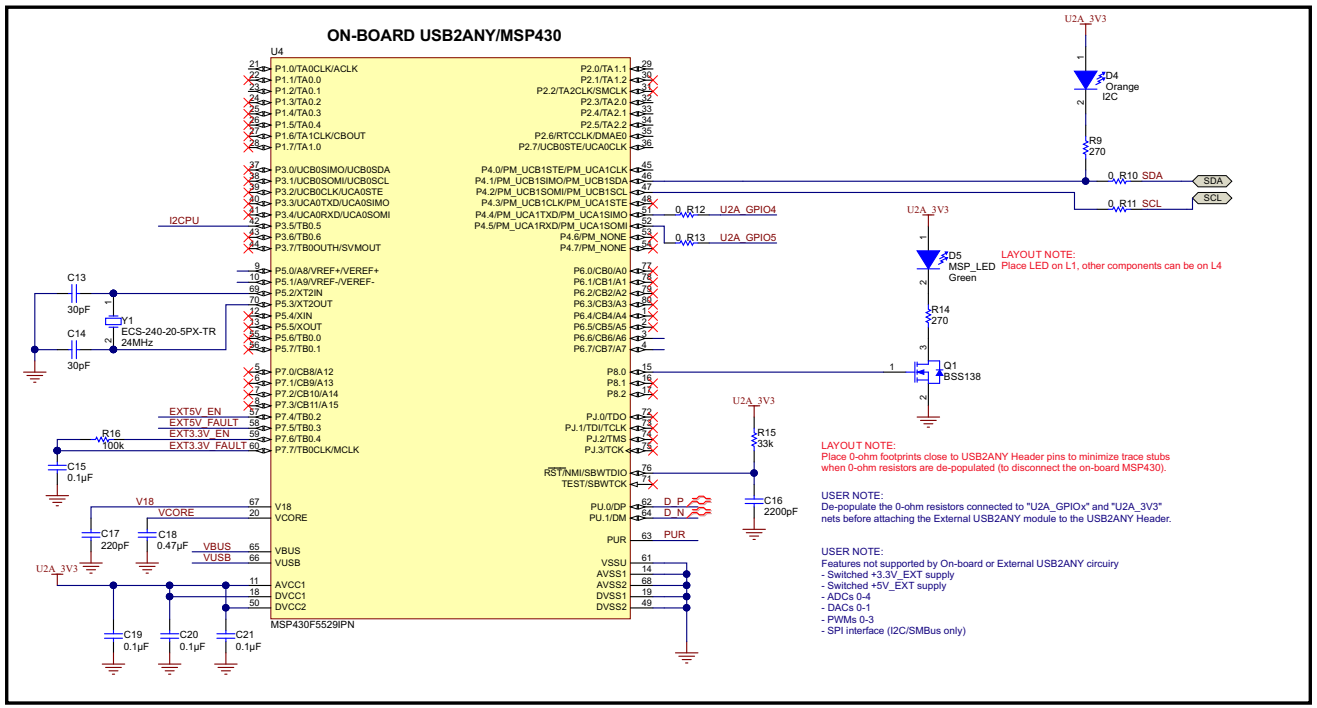


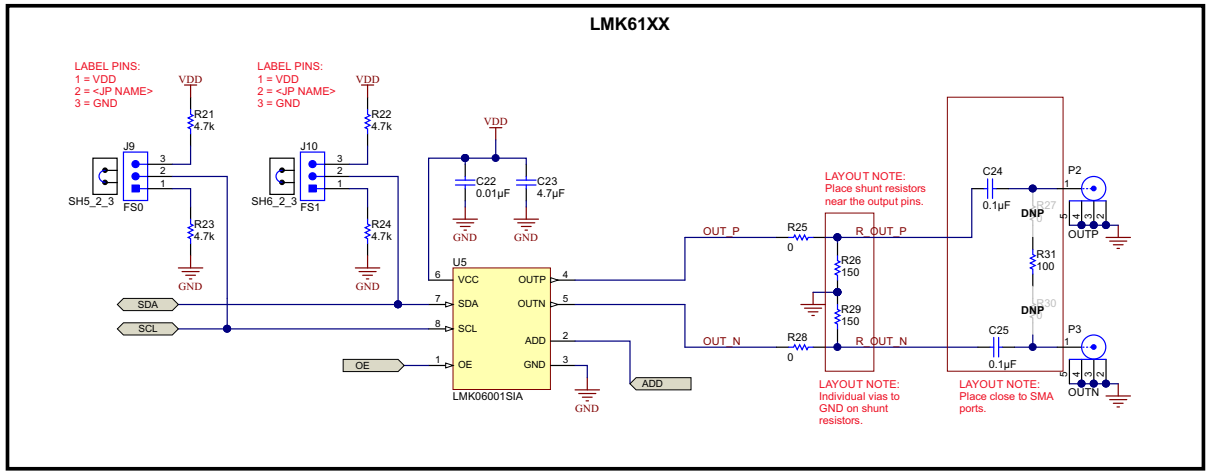












13 LMK61E2EVM Bill of Materials

DESIGNATOR	DESCRIPTION	MFR	PART NUMBER	QTY
C1, C8, C9, C12, C15, C19, C20, C21, C24, C25	CAP, CERM, 0.1 µF, 16 V, ±5%, X7R, 0603	Kemet	C0603C104J4RACTU	10
C2, C3, C6	CAP, CERM, 10 µF, 10 V, ±20%, X5R, 0603	TDK	C1608X5R1A106M	3
C4, C7, C10	CAP, CERM, 1 µF, 10 V, ±10%, X5R, 0603	Kemet	C0603C105K8PACTU	3
C5	CAP, CERM, 22 µF, 10 V, ±20%, X5R, 0805	Taiyo Yuden	LMK212BJ226MG-T	1
C11, C17	CAP, CERM, 220 pF, 50 V, ±1%, C0G/NP0, 0603	AVX	06035A221FAT2A	2
C13, C14	CAP, CERM, 30 pF, 50 V, ±5%, C0G/NP0, 0603	AVX	06035A300JAT2A	2
C16	CAP, CERM, 2200 pF, 50 V, ±10%, X7R, 0603	Kemet	C0603C222K5RACTU	1
C18	CAP, CERM, 0.47 µF, 10 V, ±10%, X7R, 0603	MuRata	GRM188R71A474KA61D	1
C22	CAP, CERM, 0.01 µF, 100 V, ±5%, X7R, 0603	AVX	06031C103JAT2A	1
C23	CAP, CERM, 4.7 µF, 10 V, ±10%, X5R, 0603	Kemet	C0603C475K8PACTU	1
D1	Diode, Zener, 7.5 V, 550 mW, SMB	ON Semiconductor	1SMB5922BT3G	1
D2	Diode, Schottky, 20 V, 2 A, SMA	Diodes Inc.	B220A-13-F	1
D3, D5	LED, Green, SMD	Lite-On	LTST-C190GKT	2
D4	LED, Orange, SMD	Lite-On	LTST-C190KFKT	1
FB1	Ferrite Bead, 60 Ω at 100 MHz, 3.5 A, 0603	TDK	MPZ1608S600A	1
H1, H2, H3, H4	HEX STANDOFF SPACER, 9.53 mm	Richco Plastics	TCBS-6-01	4
J1	Connector, Receptacle, Mini-USB Type B, R/A, Top Mount SMT	TE Connectivity	1734035-2	1
J2, J3, J5, J6	Header, 100 mil, 3x1, Gold, TH	Samtec	TSW-103-07-G-S	4
J7, J8	Header, 100 mil, 1pos, Gold, TH	Samtec	TSW-101-07-G-S	2
J9, J10	Header, 100 mil, 3x1, Tin, TH	TE Connectivity	5-146278-3	2
P1, P2, P3	Connector, End launch SMA, 50 Ω, SMT	Emerson Network Power	142-0701-851	3
PCB1	Printed-Circuit Board	Any	SV601195	1
Q1	MOSFET, N-CH, 50 V, 0.22 A, SOT-23	Fairchild Semiconductor	BSS138	1
R1, R3	RES, 33 Ω, 5%, 0.063 W, 0402	Vishay-Dale	CRCW040233R0JNED	2
R2, R5, R6, R15	RES, 33 kΩ, 5%, 0.1 W, 0603	Vishay-Dale	CRCW060333K0JNEA	4
R4	RES, 1.5 kΩ, 5%, 0.063 W, 0402	Vishay-Dale	CRCW04021K50JNED	1
R7	RES, 1.2 MΩ, 5%, 0.1W, 0603	Vishay-Dale	CRCW06031M20JNEA	1
R8	RES, 510, 5%, 0.1 W, 0603	Vishay-Dale	CRCW0603510RJNEA	1
R9, R14	RES, 270 Ω, 5%, 0.1 W, 0603	Vishay-Dale	CRCW0603270RJNEA	2
R10, R11, R12, R13, R25, R28	RES, 0 ohm, 5%, 0.1 W, 0603	Vishay-Dale	CRCW06030000Z0EA	6
R16	RES, 100 kΩ, 5%, 0.1 W, 0603	Vishay-Dale	CRCW0603100KJNEA	1
R17, R18, R19, R20	RES, 1.5 kΩ, 5%, 0.1 W, 0603	Vishay-Dale	CRCW06031K50JNEA	4
R21, R22, R23, R24	RES, 4.7 k, 5%, 0.1 W, 0603	Vishay-Dale	CRCW06034K70JNEA	4
R26, R29	RES, 150, 5%, 0.1 W, 0603	Vishay-Dale	CRCW0603150RJNEA	2
R31	RES, 100, 1%, 0.1 W, 0603	Vishay-Dale	CRCW0603100RFKEA	1
S1	Switch, Tactile, SPST-NO, 0.05 A, 12 V, SMT	TE Connectivity	4-1437565-1	1

DESIGNATOR	DESCRIPTION	MFR	PART NUMBER	QTY
SH1_2_3, SH2_2_3, SH3_2_3, SH4_2_3, SH5_2_3, SH6_2_3	Shunt, 100 mil, Gold plated, Black	3M	969102-0000-DA	6
TP2	Test Point, Miniature, Red, TH	Keystone	5000	1
TP3	Test Point, Miniature, Black, TH	Keystone	5001	1
U1	Ultra-Low Noise, 150-mA Linear Regulator for RF/Analog Circuits Requires No Bypass Capacitor, 6-pin LLP, Pb-Free	Texas Instruments	LP5900SD-3.3/NOPB	1
U2	ULTRA-LOW NOISE, 250-mA LINEAR REGULATOR FOR RF AND ANALOG CIRCUITS REQUIRES NO BYPASS CAPACITOR, DBV0005A	Texas Instruments	LP5907MFX-3.3/NOPB	1
U3	ESD-Protection Array for High-Speed Data Interfaces, 4 Channels, –40 to +85 °C, 6-pin SON (DRY), Green (RoHS & no Sb/Br)	Texas Instruments	TPD4E004DRYR	1
U4	Mixed Signal MicroController, PN0080A	Texas Instruments	MSP430F5529IPN	1
U5	LMK61E2SIA, SIA0008B	Texas Instruments	LMK61E2-SIA	1
Y1	Crystal, 24.000 MHz, 20 pF, SMD	ECS Inc.	ECS-240-20-5PX-TR	1

14 LMK61E0MEVM Bill of Materials

DESIGNATOR	DESCRIPTION	MFR	PART NUMBER	QTY
C1, C8, C9, C12, C15, C19, C20, C21	CAP, CERM, 0.1 µF, 16 V, ±5%, X7R, 0603	Kemet	C0603C104J4RACTU	8
C2, C3, C6	CAP, CERM, 10 µF, 10 V, ±20%, X5R, 0603	TDK	C1608X5R1A106M	3
C4, C7, C10	CAP, CERM, 1 µF, 10 V, +/-10%, X5R, 0603	Kemet	C0603C105K8PACTU	3
C5	CAP, CERM, 22 µF, 10 V, +/-20%, X5R, 0805	Taiyo Yuden	LMK212BJ226MG-T	1
C11, C17	CAP, CERM, 220 pF, 50 V, +/-1%, C0G/NP0, 0603	AVX	06035A221FAT2A	2
C13, C14	CAP, CERM, 30 pF, 50 V, +/- 5%, C0G/NP0, 0603	AVX	06035A300JAT2A	2
C16	CAP, CERM, 2200 pF, 50 V, +/-10%, X7R, 0603	Kemet	C0603C222K5RACTU	1
C18	CAP, CERM, 0.47 µF, 10 V, +/-10%, X7R, 0603	MuRata	GRM188R71A474KA61D	1
C22	CAP, CERM, 0.01 µF, 100 V, +/-5%, X7R, 0603	AVX	06031C103JAT2A	1
C23	CAP, CERM, 4.7 µF, 10 V, +/- 10%, X5R, 0603	Kemet	C0603C475K8PACTU	1
D1	Diode, Zener, 7.5 V, 550 mW, SMB	ON Semiconductor	1SMB5922BT3G	1
D2	Diode, Schottky, 20 V, 2 A, SMA	Diodes Inc.	B220A-13-F	1
D3, D5	LED, Green, SMD	Lite-On	LTST-C190GKT	2
D4	LED, Orange, SMD	Lite-On	LTST-C190KFKT	1
FB1	Ferrite Bead, 60 Ω at 100 MHz, 3.5 A, 0603	TDK	MPZ1608S600A	1
H1, H2, H3, H4	HEX STANDOFF SPACER, 9.53 mm	Richco Plastics	TCBS-6-01	4
J1	Connector, Receptacle, Mini-USB Type B, R/A, Top Mount SMT	TE Connectivity	1734035-2	1
J2, J3, J5, J6	Header, 100 mil, 3x1, Gold, TH	Samtec	TSW-103-07-G-S	4

DESIGNATOR	DESCRIPTION	MFR	PART NUMBER	QTY
J7, J8	Header, 100 mil, 1 pos, Gold, TH	Samtec	TSW-101-07-G-S	2
J9, J10	Header, 100 mil, 3x1, Tin, TH	TE Connectivity	5-146278-3	2
P1, P2, P3	Connector, End launch SMA, 50 Ω, SMT	Emerson Network Power	142-0701-851	3
PCB1	Printed-Circuit Board	Any	SV601195	1
Q1	MOSFET, N-CH, 50 V, 0.22 A, SOT-23	Fairchild Semiconductor	BSS138	1
R1, R3	RES, 33 Ω, 5%, 0.063 W, 0402	Vishay-Dale	CRCW040233R0JNED	2
R2, R5, R6, R15	RES, 33 kΩ, 5%, 0.1 W, 0603	Vishay-Dale	CRCW060333K0JNEA	4
R4	RES, 1.5 kΩ, 5%, 0.063 W, 0402	Vishay-Dale	CRCW04021K50JNED	1
R7	RES, 1.2 MΩ, 5%, 0.1 W, 0603	Vishay-Dale	CRCW06031M20JNEA	1
R8	RES, 510, 5%, 0.1 W, 0603	Vishay-Dale	CRCW0603510RJNEA	1
R9, R14	RES, 270 Ω, 5%, 0.1 W, 0603	Vishay-Dale	CRCW0603270RJNEA	2
R10, R11, R12, R13, R25, R28, C24, C25	RES, 0 Ω, 5%, 0.1 W, 0603	Vishay-Dale	CRCW06030000Z0EA	8
R16	RES, 100 kΩ, 5%, 0.1 W, 0603	Vishay-Dale	CRCW0603100KJNEA	1
R17, R18, R19, R20	RES, 1.5 kΩ, 5%, 0.1 W, 0603	Vishay-Dale	CRCW06031K50JNEA	4
R21, R22, R23, R24	RES, 4.7 k, 5%, 0.1 W, 0603	Vishay-Dale	CRCW06034K70JNEA	4
R31	RES, 100, 1%, 0.1 W, 0603	Vishay-Dale	CRCW0603100RFKEA	1
S1	Switch, Tactile, SPST-NO, 0.05 A, 12 V, SMT	TE Connectivity	4-1437565-1	1
SH1_2_3, SH2_2_3, SH3_2_3, SH4_2_3, SH5_2_3, SH6_2_3	Shunt, 100 mil, Gold plated, Black	3M	969102-0000-DA	6
TP2	Test Point, Miniature, Red, TH	Keystone	5000	1
TP3	Test Point, Miniature, Black, TH	Keystone	5001	1
U1	Ultra-Low Noise, 150-mA Linear Regulator for RF/Analog Circuits Requires No Bypass Capacitor, 6-pin LLP, Pb-Free	Texas Instruments	LP5900SD-3.3/NOPB	1
U2	ULTRA-LOW NOISE, 250-mA LINEAR REGULATOR FOR RF AND ANALOG CIRCUITS REQUIRES NO BYPASS CAPACITOR, DBV0005A	Texas Instruments	LP5907MFX-3.3/NOPB	1
U3	ESD-Protection Array for High-Speed Data Interfaces, 4 Channels, –40 to +85°C, 6-pin SON (DRY), Green (RoHS and no Sb/Br)	Texas Instruments	TPD4E004DRYR	1
U4	Mixed Signal MicroController, PN0080A	Texas Instruments	MSP430F5529IPN	1
U5	LMK61E0MSIA, SIA0008B	Texas Instruments	LMK61E0M-SIA	1
Y1	Crystal, 24.000 MHz, 20 pF, SMD	ECS Inc.	ECS-240-20-5PX-TR	1

Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from A Revision (January 2017) to B Revision	Page
• Changed J6 VDD (JP Default) From: 1011011b / 0x5B To: 1011010b / 0x5A in Table 3	9

Revision History

Changes from Original (October 2015) to A Revision	Page
• Added LMK61E0MEVM	4

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.

2 *Limited Warranty and Related Remedies/Disclaimers*:

   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.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。 技術適合証明を受けていないもののご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

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。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。 日本テキサス・インスツルメンツ株式会社

東京都新宿区西新宿６丁目２４番１号

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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.

6. *Disclaimers:*

   6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

   6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

   8.1 *General Limitations*. IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMS , REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

   8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

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