DRV8662 Piezo Haptics Driver Evaluation Module

This DRV8662EVM user guide provides instructions for using the DRV8662EVM evaluation module (EVM). The DRV8662EVM features the fully-differential, high-voltage DRV8662 driver that provides fast response times and complete control for piezo loads. The DRV8662EVM can be used in-system or as a stand-alone module for complete evaluation of the DRV8662 driver.

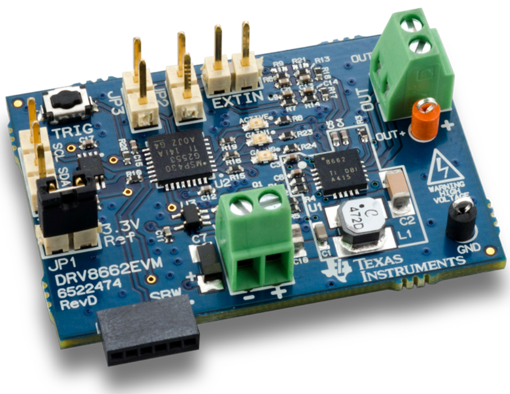

Figure 1. DRV8662EVM

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1 Introduction

The DRV8662EVM is a fully-differential, high-voltage piezo actuator driver that provides quick response times for single layer and multi-layer piezo actuators. The DRV8662 drives piezo loads up to 200 V differentially using an adjustable 100-V integrated boost converter. The evaluation module contains the DRV8662RGP piezo haptics driver, an MSP430 microcontroller, and passive components for complete evaluation. This document contains the EVM schematic, printed circuit board (PCB) images, and a complete bill of materials (BOM) as well as instructions for operating the EVM.

1.1 DRV8662RGP EVM Operating Specifications

Table 1 lists the EVM operating parameters at room temperature. See the DRV8662 product data sheet for a comprehensive list of operating parameters and descriptions.

Table 1. EVM Operating Specifications

Parameter	Specification
Supply voltage range, V_{BAT}	3 V to 5.5 V
Power-supply current rating required	1 A
Input voltage, V_I	0 V to 3.3 V
Maximum output voltage, V_{OUT}	200 V

WARNING

Care should be taken while handling and evaluating this module because of high voltages (up to 200 V).

2 Quick Start for Stand-Alone Operation

This section helps you get started quickly by describing the default setup of the DRV8662EVM. The EVM, by default, generates sample haptic waveforms using an onboard MSP430. During operation, the MSP430 outputs a PWM waveform on the PWM+ and PWM– traces that are connected to the DRV8662 low-pass input filter. The low-pass filtered signals are then input to the DRV8662. The DRV8662 output appears on the output terminal block (OUT) which can be connected directly to a high-voltage piezo load. The pushbutton (TRIG) triggers various software events on the MSP430. When pressed, the button alternates between the four DRV8662 gain settings, four sample haptic waveforms, and analog input modes. The list of output waveforms can be found in Table 2.

To set up the EVM using the default configuration, follow the instructions presented below.

2.1 Powering the Board

1. Set the voltage of an external power supply to 3.6 V to 5.5 V.
2. With the power supply off, attach the ground connection of the power supply to the negative terminal of the VBAT terminal block (VBAT–) and connect the positive supply to the positive terminal of the VBAT terminal block (VBAT+).
3. Ensure the terminals are connected correctly, then enable the supply.
4. If the power is connected correctly the ACTIVE LED will blink.

2.2 Connecting a Load

1. With the power supply off, connect the negative terminal of the load to OUT– and connect the positive terminal of the load to OUT+.
2. Ensure the terminals are connected correctly, then enable the supply.

WARNING

Before connecting the load, ensure that the piezo actuator (or other load) is rated for 200 $V_{peak\text{-}to\text{-}peak}$. If not, see the section *Programming the Boost Voltage* to adjust the DRV8662 maximum output voltage.

2.3 Output Waveforms

The MSP430 has eight different output modes that can be accessed using the pushbutton (TRIG). The pushbutton will advance to the next mode and continue to cycle through each mode in a loop. Powering off the EVM resets the board to Mode 1. A description of each mode is shown in Table 2. Use the three onboard LEDs [GAIN1, GAIN0, and ACTIVE (EN)] to determine the current output mode.

Table 2. Default EVM Modes

Mode	Description	Gain (dB)	V_{OUT}	GAIN1	GAIN0	EN
1	Sample Waveforms	28	50	0	0	0 / 1 [(1)]
2	External Analog/PWM Input					1
3	Sample Waveforms	34	100	0	1	0 / 1 [(1)]
4	External Analog/PWM Input					1
5	Sample Waveforms	38	150	1	0	0 / 1 [(1)]
6	External Analog/PWM Input					1
7	Sample Waveforms	40	200	1	1	0 / 1 [(1)]
8	External Analog/PWM Input					1

(1) Enable is high only during waveform output.

NOTE: To optimize the DRV8662 and reduce power losses, use the mode with an output voltage (V_{OUT}) closest to the actuator voltage requirements. For best performance, adjust the feedback resistors so that the boost voltage is 5 V greater than the peak voltage requirement of the actuator. See Table 4 for examples.

3 General Operation

This section guides you though the advanced configurations options of the DRV8662EVM including the input, output, power supply, internal boost converter, and MSP430 firmware. Use the following sections to configure the board for your specific application.

3.1 Power

The VBAT rail powers the DRV8662 directly and should be set between 3 V and 5.5 V. The MSP430 (U2) and level-shifter (U4) are powered by an onboard LDO (U3) with an output voltage of 3.3 V.

To power the board:

1. Set an external power supply between 3.5 V and 5.5 V.
2. Connect the negative terminal of the power supply to VBAT– and the positive terminal of the power supply to VBAT+.

3. Verify the terminals are connected correctly, then enable the supply.

To disable the MSP430 (U2) and level-shifter (U4) remove resistor R22 to disconnect the 3.3 V LDO (U3).

NOTE: The DRV8662 is capable of operating down to 3 V. To use the DRV8662EVM at a voltage lower than 3.3 V, follow the instructions for using an external analog input source and control.

3.2 Boost Converter

The DRV8662 has a 100-V internal boost converter to drive up to 200 V differentially across the output. Before connecting the load, ensure the piezo actuator (or other load) is rated for 200 $V_{peak\text{-}to\text{-}peak}$. If the load is rated for a lower voltage, see Section 3.2.1 for information about adjusting the maximum output voltage.

3.2.1 Programming the Boost Voltage

The boost output voltage (VBST) is programmed via two external resistors R1 and R2, as shown in Figure 2. In addition, the DRV8662EVM includes two additional resistors, R4 and R5, which allow the MSP430 to digitally adjust VBST based on the gain settings. Refer to Table 3 for VBST at each gain setting and the equivalent low-side resistance.

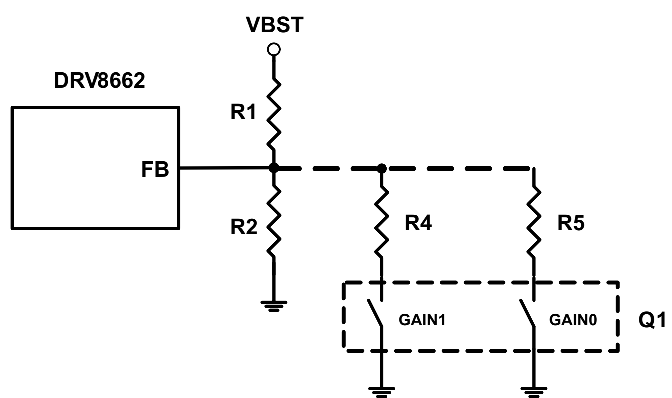


Figure 2. Boost Voltage Programming Resistors

NOTE: R4 and R5 should be removed if adjusting VBST using resistors R1 and R2.

Table 3 lists typical boost voltage values for resistors R4 and R5.

Table 3. Boost Voltage with R4 and R5

GAIN1	GAIN0	V_{FB} Low-Side Resistance	VBST
0	0	35.7k	30
0	1	19.1k	54
1	0	12.8k	80
1	1	9.8k	105

With only resistors R1 and R2 present, the boost output voltage is given by Equation 1.

$$V_{BOOST} = V_{FB}\left(1 + \frac{R_1}{R_2}\right) \quad (1)$$

where V_{FB} = 1.32 V.

The maximum boost output voltage is 105 V. VBST should be programmed to a value 5 V greater than the largest peak voltage expected in the system to allow adequate amplifier headroom. Because the programming range for the boost voltage extends to 105 V, the current through the resistor divider can become significant. The sum of the feedback resistors R1 and R2 should be greater than 500 kΩ.

NOTE: When the feedback resistor values are greater than 1 MΩ, PCB contamination may cause boost voltage inaccuracies. Be sure to keep the board clean from excess solder and flux when modifying the board.

Table 4 lists typical resistor values for common boost voltage levels.

Table 4. Boost Voltage and Gain Settings

R1	R2	GAIN1	GAIN0	VBST	V_O (peak-to-peak)
402k	18.2k	0	0	30	50
392k	9.76k	0	1	55	100
768k	13k	1	0	80	150
768k	9.76k	1	1	105	200

3.2.2 Programming the Boost Current Limit

The peak inductor current is set by resistor R3 (R_{EXT}). The current limit is not a safety mechanism, but the highest value current the inductor will see each cycle. The inductor must be capable of handling this programmed limit during normal operation. The relationship of R_{EXT} to I_{LIM} is approximated by Equation 2:

$$R_{EXT} = \left(K \frac{V_{REF}}{I_{LIM}} \right) - R_{INT} \tag{2}$$

where I_{LIM} is the current limit set by R_{EXT}, K = 10500, V_{REF} = 1.35 V and R_{INT} = 60 Ω.

3.2.3 Boost Inductor Selection

Inductor selection plays a critical role in the performance of the DRV8662. The range of recommended inductor values is 3.3 µH to 22 µH. When a larger inductance is chosen, the DRV8662 boost converter will automatically run at a lower switching frequency and incur less switching losses; however, the larger inductors may also have a higher equivalent series resistance (ESR), which will increase the parasitic inductor losses. Smaller inductances generally have higher saturation currents; therefore, they are better suited for maximizing the output current of the boost converter. Table 5 lists several sample inductors that provide adequate performance.

Table 5. Inductor Selection

Manufacturer	Part Number	DCR (Ω)	Inductance (µH)	I_{SAT} (A)	R_{EXT} (Ω)	I_{LIM} (A)
Coilcraft	LPS4018-332MLB	0.080	3.3	1.9	7.32k	1.9
Coilcraft	LPS4018-472MLB	0.125	4.7	1.8	7.5k	1.8
TDK	VLS3012T-3R3M1R3	0.100	3.3	1.5	9.31k	1.5

3.2.4 Boost Capacitor Selection

The boost output voltage may be programmed as high as 105 V. A capacitor must have a voltage rating equivalent to the boost output voltage or higher. A 250-V rated 100-nF capacitor of X5R or X7R type is recommended for a boost converter voltage of 105 V. The selected capacitor should have a minimum derated capacitance of 50 nF.

3.3 Input Modes

The DRV8662 requires either a low-pass filtered PWM waveform or an analog signal to drive piezo loads. By default, the DRV8662EVM uses the MSP430 PWM input mode with a low-pass filter. This section describes each input mode in detail and the modifications necessary for operation of each. See the *Filtering and Adapting PWM Waveforms* section for more details on adapting the PWM waveform using a low-pass filter.

The DRV8662EVM supports four input modes for driving the DRV8662:

- **MSP430 PWM input**: In this mode, the onboard MSP430 (U2) generates a PWM waveform that is sent through the low-pass input filter to the DRV8662.
- **External PWM input**: An external source supplies a PWM waveform to the EXTIN header which is sent through the low-pass input filter to the DRV8662.
- **External analog input**: An external source supplies an analog waveform (sine wave) to the EXTIN header. The low-pass input filter may be removed.
- **I²C input**: An external source supplies an I²C™ stream that is decoded by the MSP430 to produce a PWM output waveform. The PWM waveform is then sent through the low-pass input filter to the DRV8662. This option requires special firmware for decoding the I²C stream.

NOTE: By default, the EVM is configured to use the PWM waveform generated by the MSP430. Follow the instructions given in Section 3.3.2 if you plan to use an external input source or change the PWM frequency.

3.3.1 MSP430 PWM Input Mode

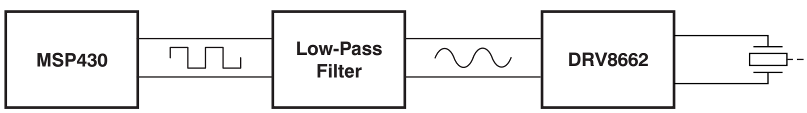


Figure 3. MSP430 PWM Input Mode

When using the DRV8662EVM in MSP430 PWM input mode, the onboard MSP430 generates a differential PWM signal that is sent through a low-pass filter to the DRV8662. The DRV8662EVM is setup to use this mode by default. Follow the quick-start instructions (refer to Section 2) for using the DRV8662EVM in this configuration.

If specific waveforms are needed other than those already on the MSP430, the firmware can be updated. To update the firmware, download Code Composer Studio (or a third-party MSP430 IDE) and connect the DRV8662EVM SpyBiWire to the computer. The TI website offers an MSP430 USB-to-JTAG hardware interface (MSP-FET430UIF) for updating and debugging MSP430 code. The DRV8662EVM kit includes a JTAG-to-SpyBiWire adapter for connecting the JTAG interface to the DRV8662EVM SpyBiWire connector. Sample code is also available on the DRV8662 product webpage.

3.3.2 External PWM Input Mode

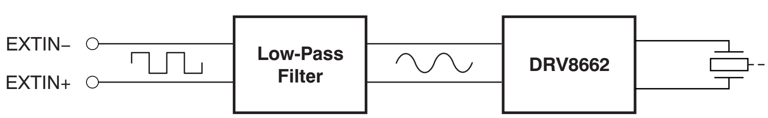


Figure 4. External PWM Input Mode

The PWM input mode can be used with an external processor or PWM source. The PWM signal is a carrier wave (duty-cycle modulated) at a frequency much higher than the analog signal it represents. This approach is a common and easy way to create haptic waveforms. Using this mode requires an input filter that transforms the PWM carrier waveform into an analog signal. This transformation is achieved by low-pass filtering the PWM carrier waveform which is at a frequency typically 20 kHz or greater.

To use an external PWM source to drive the DRV8662, follow these instructions to modify the board.

1. Disconnect the MSP430 output pins from the DRV8662 input pins by removing jumpers JP2 and JP3.
2. Depending on the input source, follow the instructions in the *Filtering and Adapting PWM Waveforms* section to adjust the input filter.
3. Connect DRV8662 control signals:
   (a) **Use the onboard MSP430 to control the EN, GAIN0, and GAIN1 pins.** Using the onboard push button (TRIG), select an external analog/PWM input mode and appropriate gain setting from Table 2. The MSP430 must be set to an even number output mode with a constant voltage on the DRV8662 EN, GAIN0, and GAIN1 pins; otherwise, the output will pulse during operation. The ACTIVE LED will glow solid if a constant voltage waveform is selected.
   (b) **Use an external controller.** Remove resistors R15, R16, and R19 to disconnect the MSP430 from the EN, GAIN0, and GAIN1 pins. Then solder three control wires to the resistor pads.
4. Connect the positive terminal of the input signal source to EXTIN+ and the negative terminal to EXTIN–.
5. Enable the power supply.

3.3.3 External Analog Input Mode

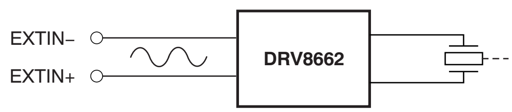


Figure 5. External Analog Input Mode

To use an external analog source (sine wave) to drive the DRV8662, follow these instructions to modify the board.

1. Disconnect the MSP430 output pins from the DRV8662 input pins by removing jumpers JP2 and JP3.
2. Modify the input filter according to the *Filtering and Adapting PWM Waveforms* section. The default PWM filter is no longer necessary.
3. Connect the DRV8662 control signals:
   (a) **Use the onboard MSP430 to control the EN, GAIN0, and GAIN1 pins.** Using the onboard push button (TRIG), select an external analog/PWM input mode and appropriate gain setting from Table 2. The MSP430 must be set to an even number output mode with a constant voltage on the DRV8662 EN, GAIN0,and GAIN1 pins; otherwise, the output will pulse during operation. The ACTIVE LED will glow solid if a constant voltage waveform is selected.
   (b) **Use an external controller.** Remove resistors R15, R16, and R19 to disconnect the MSP430 from the EN, GAIN0, and GAIN1 pins. Then solder three control wires to the resistor pads.
4. Connect the positive terminal of the input signal source to EXTIN+ and the negative terminal to EXTIN–.
5. Enable the power supply.

3.3.4 I²C Input Mode

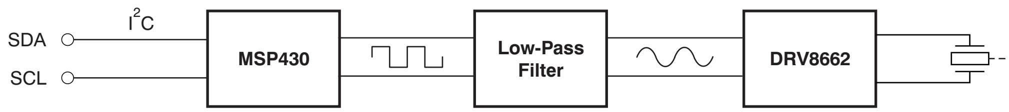


Figure 6. I²C Input Mode

This mode uses a serial bus protocol (I²C) to transfer waveform data points digitally from an external I²C source to the MSP430. Using the I²C terminal block, the MSP430 receives the I²C values and decodes them to produce a PWM waveform.

1. Update the firmware on the MSP430 for I²C input mode. To update the firmware, download Code Composer Studio (or a third-party MSP430 IDE) and connect the DRV8662EVM SpyBiWire to the computer. The TI website offers an MSP430 USB-to-JTAG hardware interface (MSP-FET430UIF) for updating and debugging MSP430 code, and the DRV8662EVM kit includes a JTAG-to-SpyBiWire adapter for connecting the JTAG interface to the DRV8662EVM SpyBiWire connector.
2. Connect the SDA, SCL, and GND signals to the I²C header.
3. Enable the power supply.

3.3.5 Single-Ended and Differential Inputs

The input signal can either be a single-ended or differential source. Follow the instructions below for each input source.

- **Single-ended input:** Connect the input source to the positive terminal of EXTIN (+) and ground of the source to the negative terminal of EXTIN (–).
- **Differential input:** The input should be applied differentially across the EXTIN header.

If using a PWM waveform, it is recommended to use a PWM signal greater than 20 kHz and vary the duty cycle to produce a sine wave.

3.4 Programming the MSP430

The MSP430 can be reprogrammed to create unique functionality and custom haptic effects. To update the firmware, the following tools and software are required:

1. An integrated development environment (IDE) for the MSP430, such as Code Composer Studio (CCS) (free) or the IAR Embedded Workbench Kickstart Edition.
2. The MSP-FET430UIF USB Debugging Hardware Interface.
3. The MSP-JTAG2SBW JTAG to Spy-Bi-Wire adapter (included in the DRV8662EVM kit).

To reprogram the MSP430, follow this procedure:

1. Connect the DRV8662EVM to a computer using the MSP-FET430UIF and the JTAG to Spy-Bi-Wire adapter. The Spy-Bi-Wire adapter should be attached to the small 6-pin header (SBW) on the DRV8662EVM.
2. Start the MSP430 IDE.
3. Ensure that the IDE is configured for the MSP430G2553.

Table 6 lists the MSP430G2553 pinout on the DRV8662EVM.

Table 6. DRV8662EVM MSP430 Pinout

Pin No.	Label	Description
1	P1.1	GAIN0
2	P1.2	GAIN1
3	P1.3	EN / ACTIVE
12	P3.2	PWM+
13	P3.3	PWM–
17	P2.5	TRIG (Pushbutton)
21	P1.6/SCL	I^2C Clock
22	P1.7/SDA	I^2C Data
23	SBWTDIO	Spy-Bi-Wire Data
24	SBWTCK	Spy-Bi-Wire Clock
25	P2.7	GAIN1 FET Control
26	P2.6	GAIN0 FET Control
27	AVSS	Analog Ground
28	DVSS	Digital Ground
29	AVCC	Analog Supply
30	DVCC	Digital Supply

3.5 Filtering and Adapting PWM Waveforms

The DRV8662EVM has the capability to support many different input filter configurations. Depending on the input mode, input frequency and input voltage the filter can be adapted to attenuate any undesired out-of-band content. This section describes the input filter requirements and the various respective configurations.

3.5.1 PWM Input

When using a PWM input, a low-pass filter is required. The primary parameters for determining the input filter are the PWM input frequency and sample rate. Because haptic waveforms are typically less than 500 Hz, the input filter must attenuate frequencies above 500 Hz. For samples rates above 20 kHz, a simple first-order RC filter is recommended; however, for sample rates much lower (such as 8 kHz), a first-order filter may not sufficiently attenuate the high-frequency content. Thus, for lower sampling rates, a second-order RC filter may be required. The following sections describe example filter configurations for both first-order and second-order filters. The DRV8662EVM default configuration uses a second-order, differential filter, but it can be replaced by a first-order, single-ended or differential filter.

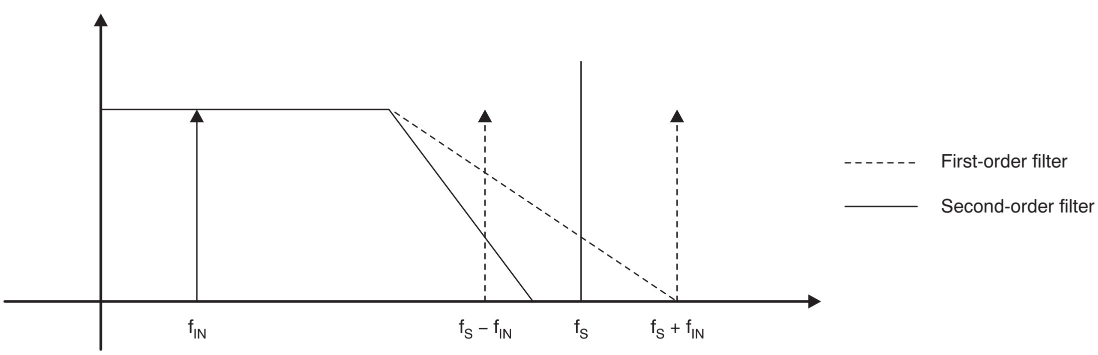


Figure 7. Filter Response

3.5.1.1 Filter Selection Criteria

Apply these criteria to select an input filter.

1. First-order RC filters, both single-ended and differential, are recommended for 20 kHz and higher data sample rates. The first-order filters have adequate settling time and the fewest components.
2. Second-order filters are recommended for noiseless operation when using a lower data sample rate where a sharper cutoff is necessary.
3. The attenuation at the PWM carrier frequency should be at least –40 dB for haptic applications.

3.5.1.2 First-Order Filter

For sample rates 20 kHz and greater, a first-order filter is recommended. The first-order filter is used in both single-ended or differential configurations. Figure 8 shows a differential, first-order filter. The PWM input filter is optimized for a 3.3-V differential PWM input signal (–11-dB attenuation); remove R17 and R18 when applying a 1.8-V input signal.

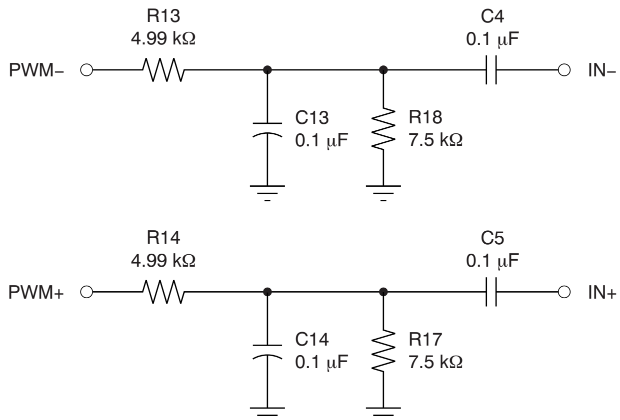


Figure 8. First-Order Input Filter

The first-order filter in Figure 8 contains one pole with a slope of –20 dB. Figure 9 shows the frequency response of the first-order filter.

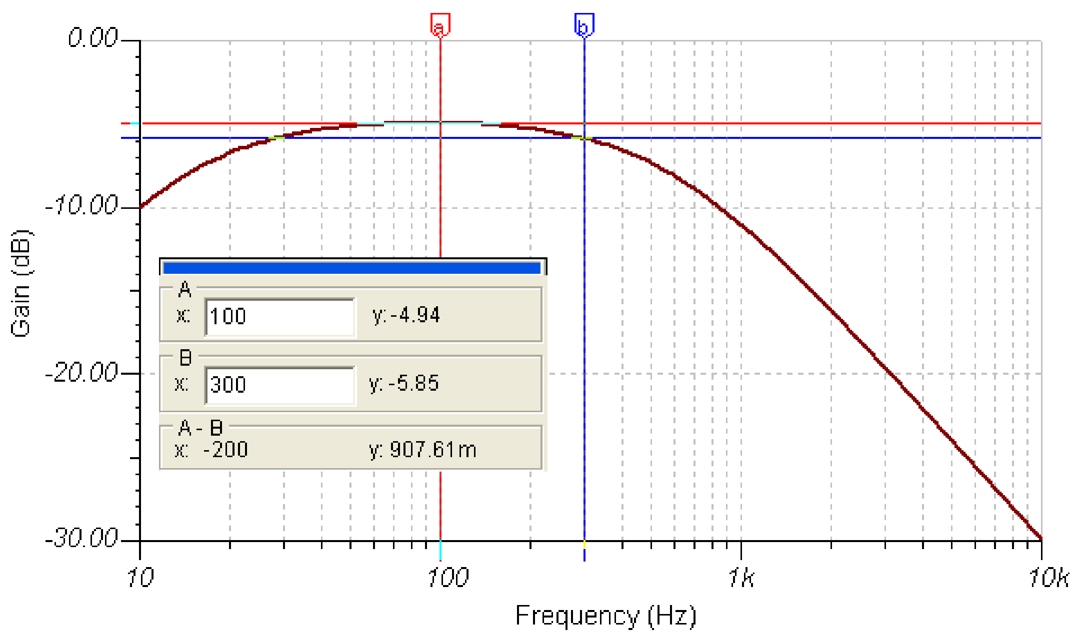


Figure 9. First-Order Frequency Response

3.5.1.3 Second-Order Filter, Differential

For data sample rates less than 20 kHz, a second-order filter is recommended. A differential input signal is recommended for use with a second-order filter because of the longer settling time; however, if a single-ended signal is used, see the *Second-Order Filter, Single-Ended* section. Figure 10 shows the differential, second-order filter that is the default filter configuration for the EVM. The PWM input filter is optimized for a 3.3-V differential PWM input signal (–1- dB attenuation); remove R17 and R18 when applying a 1.8-V input signal.

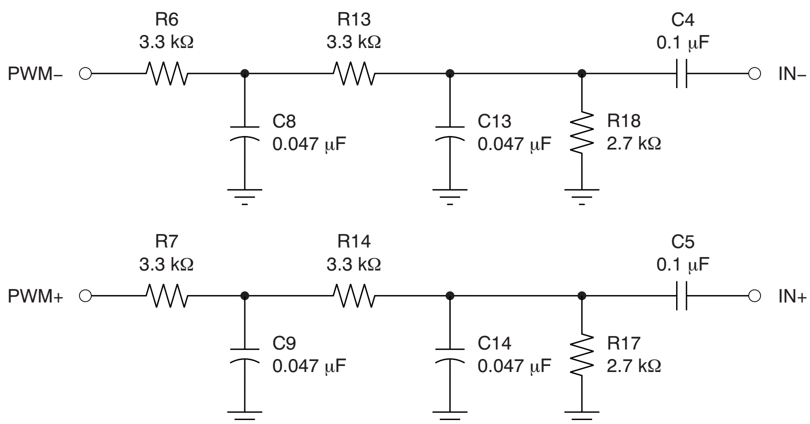


Figure 10. Second-Order Input Filter

The second-order filter in Figure 10 contains two poles resulting in a slope of –40 dB. Figure 11 shows the frequency response of the second-order filter.

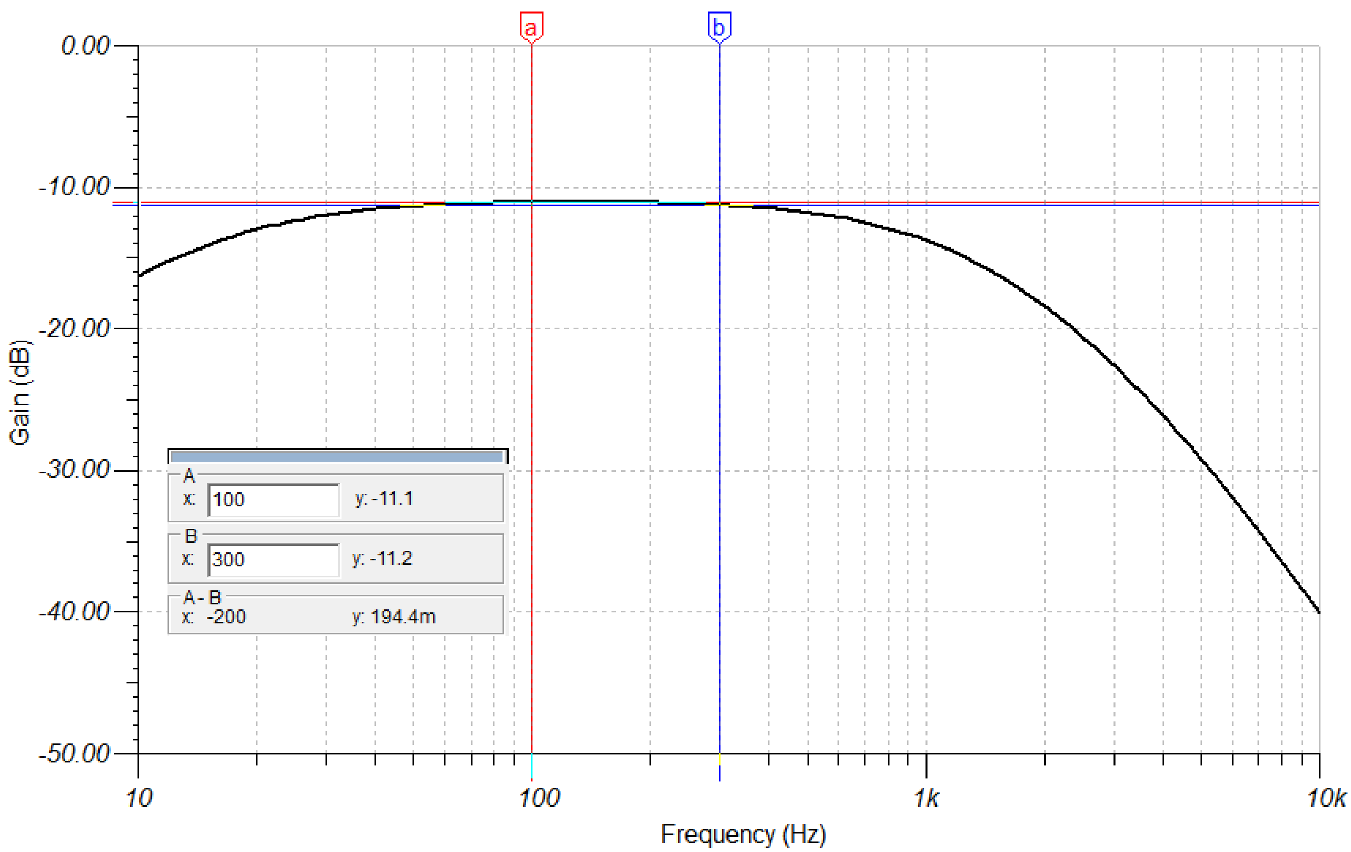


Figure 11. Second-Order Filter Frequency Response

3.5.1.4 Second-Order Filter, Single-Ended

Second-order filters take longer to settle than first-order filters. With differential inputs, the inverting and noninverting inputs settle at the same time. With a single-ended input, they do not. This characteristic is seen in the waveforms (refer to Figure 12 and Figure 13).

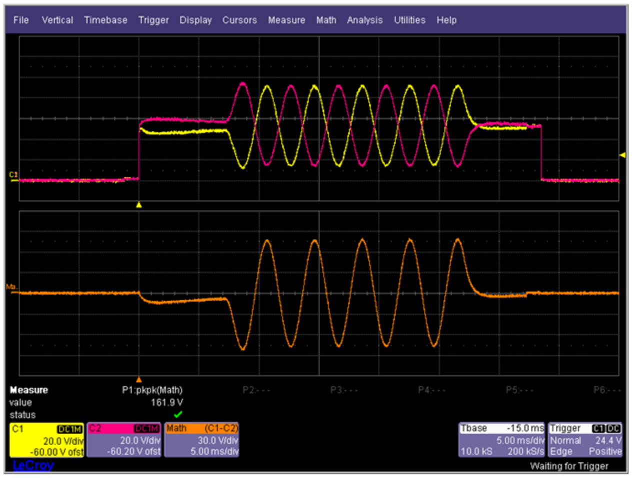


Figure 12. Second-Order, Single-Ended Filter

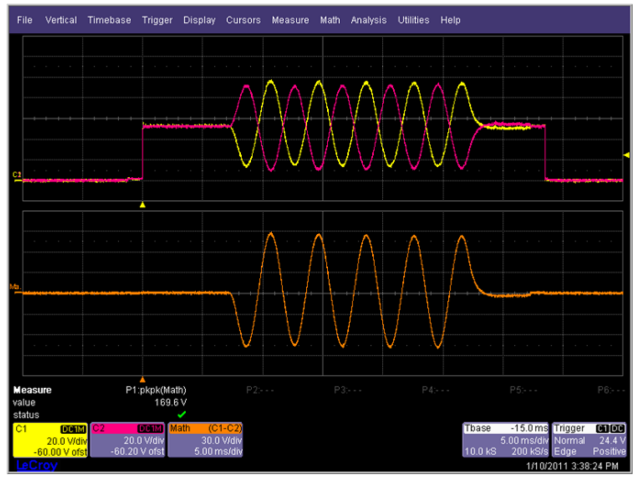


Figure 13. Second-Order, Differential Filter

To avoid this issue, a *dummy filter* may be connected to the unused input; the filter input should then be tied to the DRV8662 enable (EN) signal through a resistor divider, as seen in Figure 14. When the DRV8662 is enabled, the enable (EN) signal charges this dummy filter.

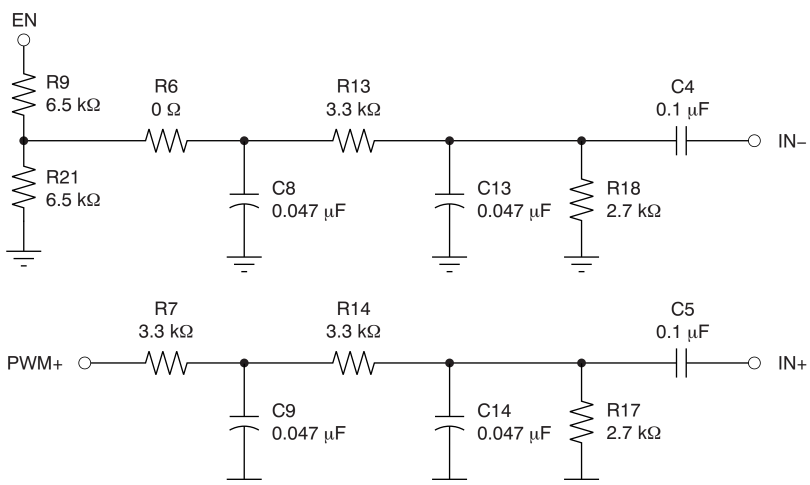


Figure 14. Single-Ended Input with Dummy Filter

The dummy filter shown in Figure 14 has the same settling time as the active filter; therefore, the offset is cancelled and the issue is avoided.

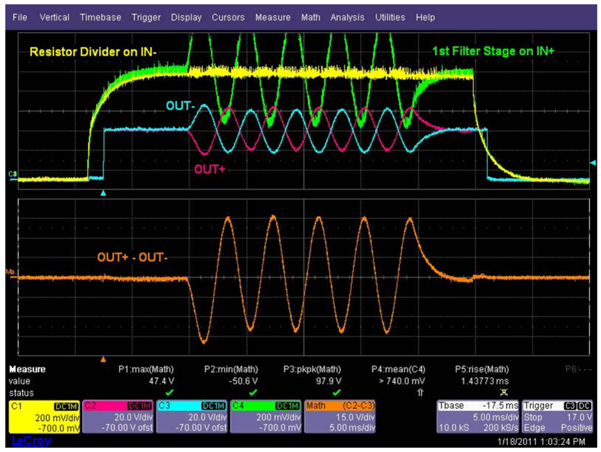


Figure 15. Dummy Filter Waveform

3.5.2 Remove Filter for Analog Input

If the input signal is an analog waveform, as opposed to a PWM, then an input filter may not be necessary. Before removing the filter, ensure that a simple RC filter is not needed to remove any artifacts from the digital-to-analog converter (DAC) output or other input source. Follow these instructions to remove the input filter completely.

1. Replace resistors R6, R7, R13, and R14 with 0-Ω resistors.
2. Remove resistors R17 and R18.
3. Remove capacitors C8, C9, C13, and C14. Do not remove ac coupling capacitors C4 and C5.

3.6 Output

The DRV8662 is capable of driving high-voltage piezo loads. When connecting a load, ensure that the voltage rating of the piezo load is equal to or greater than the maximum output voltage set by the feedback resistors.

3.6.1 Piezo Actuator Selection

There are several key specifications to consider when choosing a piezo actuator for haptics, including size, blocking force, and displacement. However, the key electrical specifications are voltage rating and capacitance. At the maximum frequency of 500 Hz, the DRV8662 is optimized to drive up to 50 nF at 200 V_{PP}, which is the highest voltage swing capability. It is also capable of driving larger capacitances if the programmed boost voltage is lower or if the user limits the input to lower frequencies. (such as 300 Hz).

Table 7 gives a list of recommended piezo actuators.

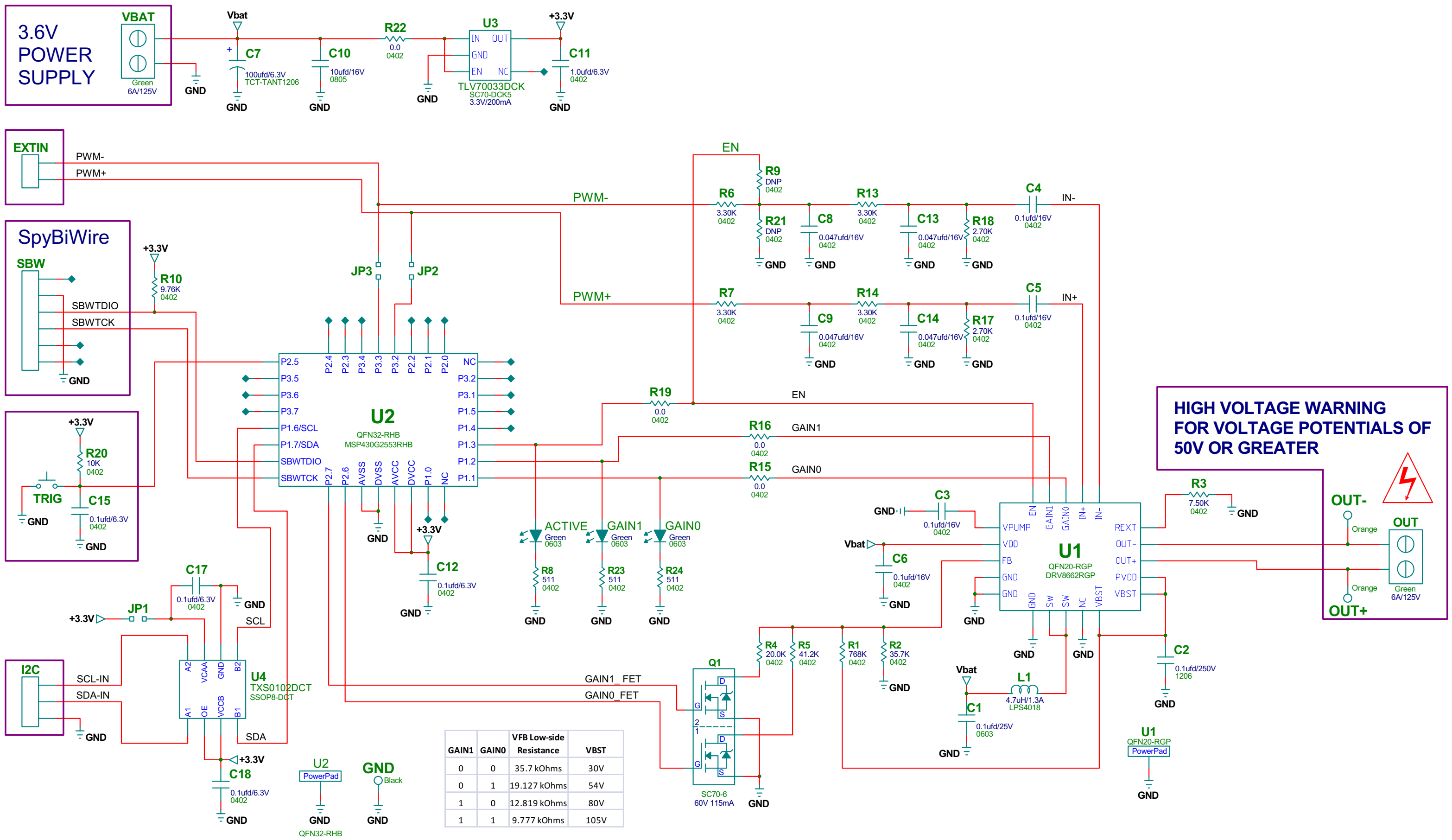
Table 7. Piezo Actuator Selection

Manufacturer	Part Number	Capacitance (nF)	Voltage Rating (V_{PP})	Dimensions (mm)
AAC	MLB3503-G	50	200	35 x 3 x 0.96
AAC	MLB3503B-G	180	100	35 x 3 x 1
AAC	MLB3503C-G	670	48	35 x 3 x 1

4 Reference

This section includes the DRV8662EVM schematic, PCB layout, and bill of materials.

4.1 Schematic



GAIN1	GAIN0	VFB Low-side Resistance	VBST
0	0	35.7 kOhms	30V
0	1	19.127 kOhms	54V
1	0	12.819 kOhms	80V
1	1	9.777 kOhms	105V

4.2 PCB Layout

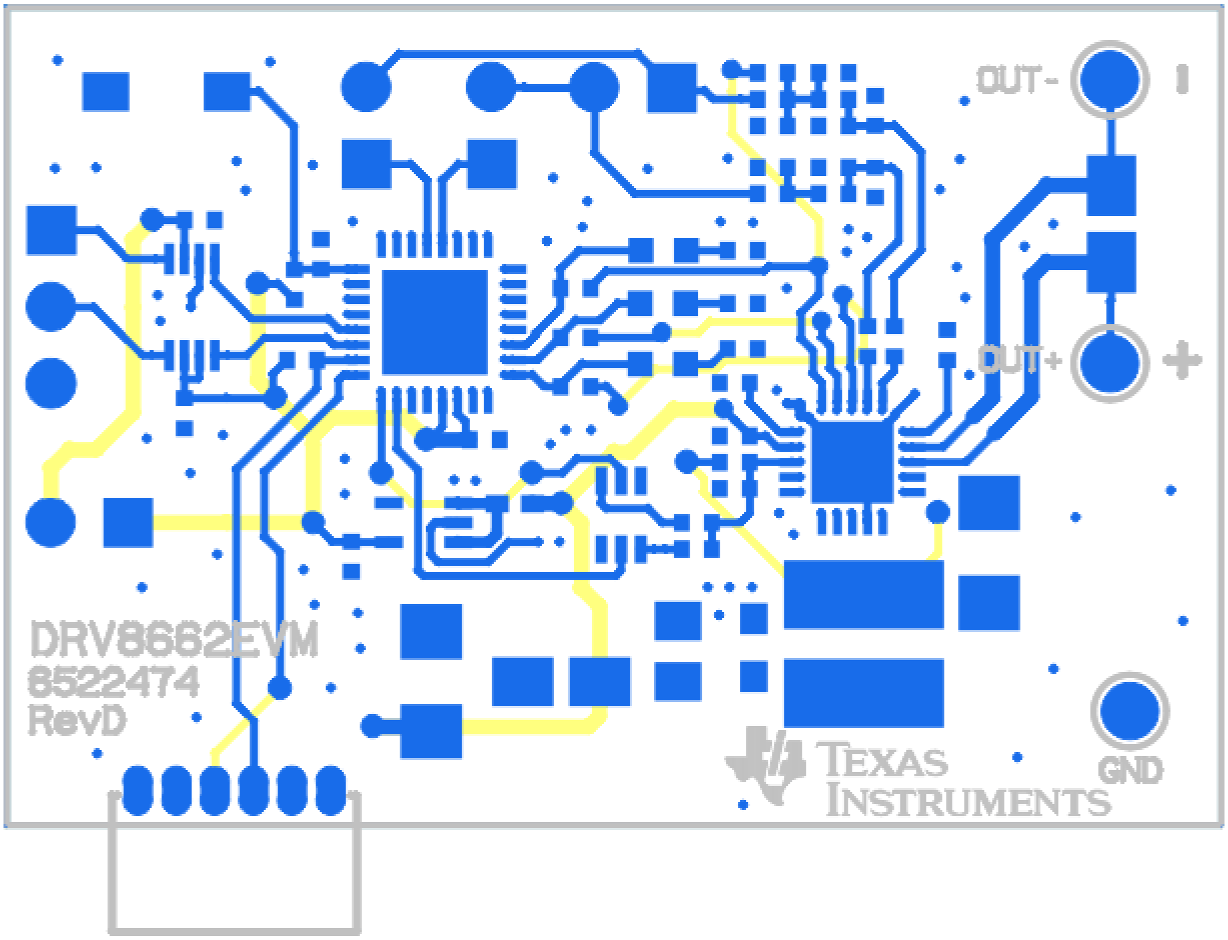


Figure 16. EVM Top X-Ray

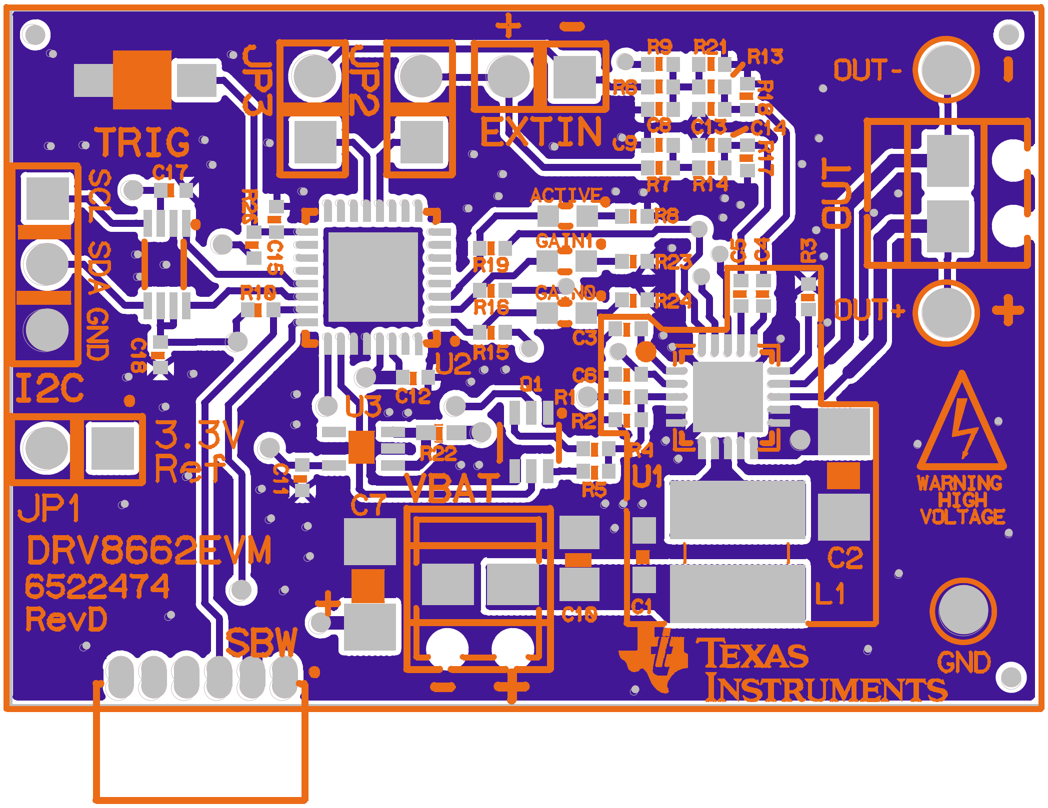


Figure 17. EVM Top Layer

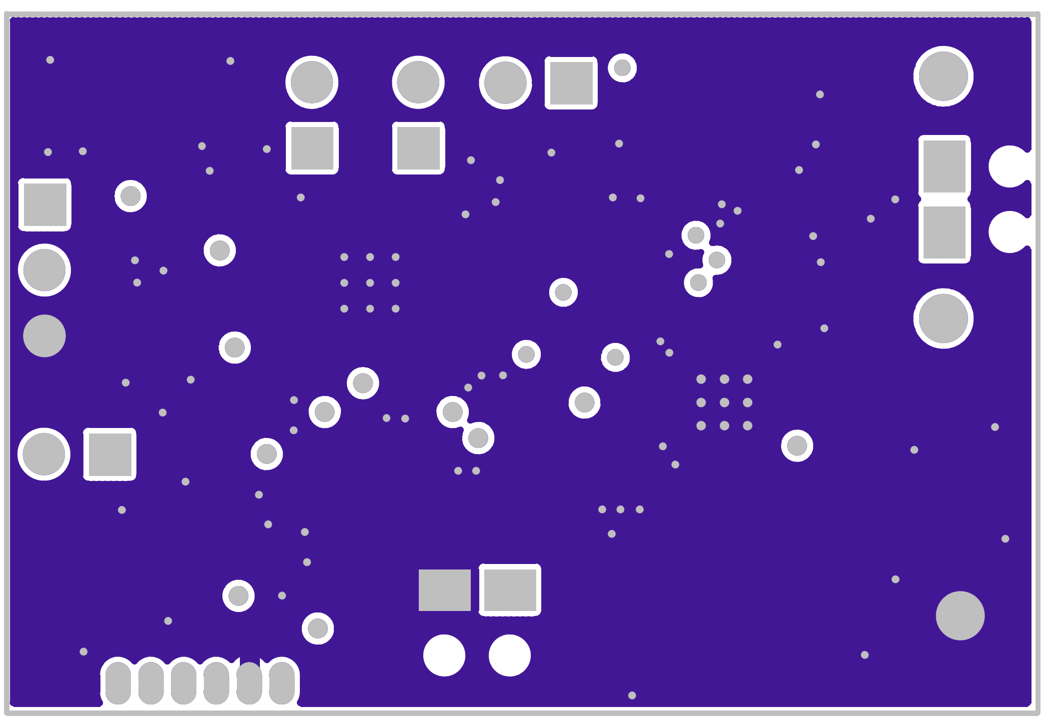


Figure 18. EVM Layer 2

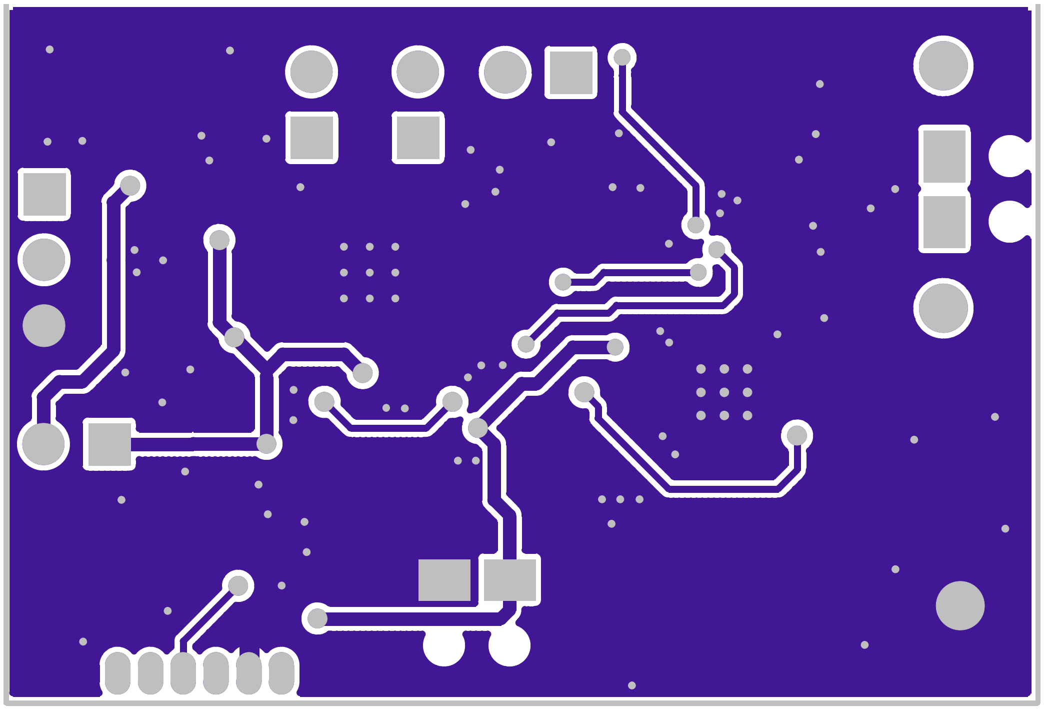


Figure 19. EVM Layer 3

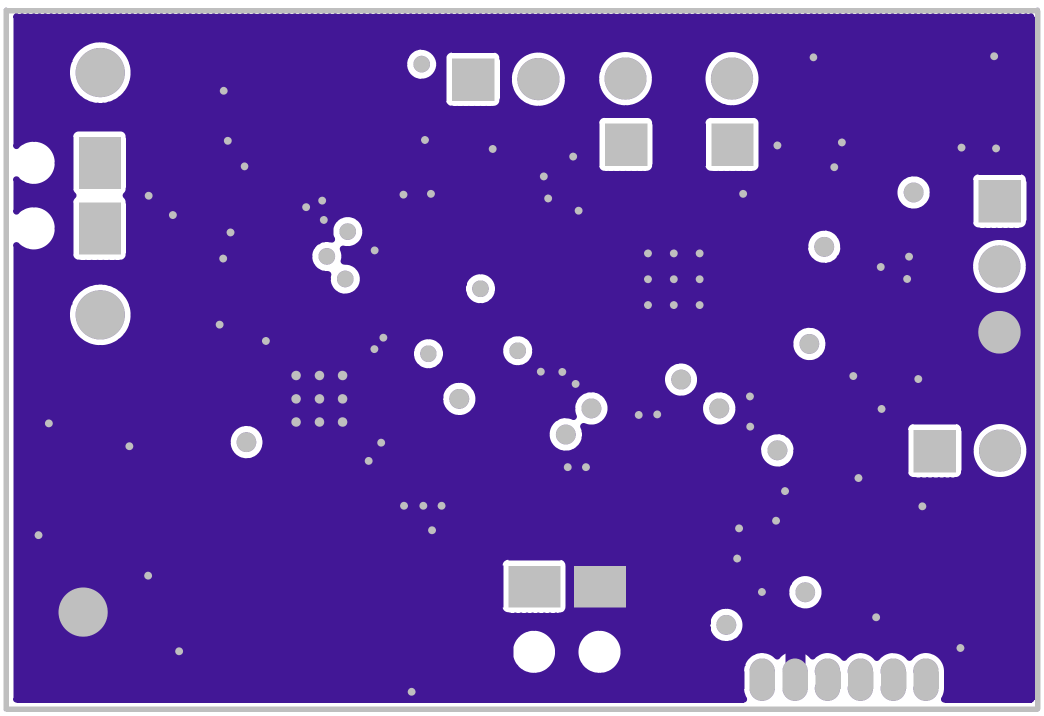


Figure 20. EVM Bottom Layer

4.3 Bill Of Materials

SEMICONDUCTORS				
ITEM	**MANU PART NUM**	**REF DESIGNATORS**	**DESCRIPTION**	**MANUFACTURER**
1	2N7002DW	Q1	N CHANNEL FET ENHANCEMENT MODE 60V 115mA SC70-6 ROHS	FAIRCHILD
2	DRV8662RGP	U1	PIEZO HAPTIC DRIVER W/INTEGRATED DC-DC CONV QFN20-RGP ROHS	TEXAS INSTRUMENTS
3	TLV70033DCKT	U3	LDO VOLTAGE REGULATOR 3.3V 200mA LOW-IQ SC70-DCK5 ROHS	TEXAS INSTRUMENTS
4	TXS0102DCTR	U4	2-BIT BIDIR LEVEL TRANSLATOR SSOP8-DCT ROHS	TEXAS INSTRUMENTS
5	MSP430G2553RHB	U2	MIXED SIGNAL MICRO 16KB FLASH 512B RAM QFN32-RHB ROHS	TEXAS INSTRUMENTS
6	LTST-C190KGKT	GAIN0, GAIN1, ACTIVE	LED, GREEN, 2.0V SMD0805603 ROHS	LITE-ON INC.
CAPACITORS				
7	C1005X5R0J104K	C12, C15, C17, C18	CAP SMD0402 CERM 0.1UFD 6.3V 10% X5R ROHS	TDK CORP
8	GRM155R71C104KA88D	C3, C4, C5, C6	CAP SMD0402 CERM 0.1UFD 16V X7R 10% ROHS	MURATA
9	06033D104KAT2A	C1	CAP SMD0603 CERM 0.1UFD 25V 10% X5R ROHS	AVX
10	0805YD106KAT2A	C10	CAP SMD0805 CERM 10UFD 16V X5R 10% ROHS	AVX
11	C3216X7R2E104K	C2	CAP SMD1206 CERM 0.1UFD 250V 10% X7R ROHS	TDK
12	GRM155R60J105KE19D	C11	CAP SMD0402 CERM 1.0UFD 6.3V X5R 10% ROHS	MURATA
13	EMK105B7473KV-F	C8, C9, C13, C14	CAP SMD0402 CERM 0.047UFD 16V 10% X7R ROHS	TAIYO YUDEN
14	TCTAL0J107M8R	C7	CAP TANT1206 100UFD 6.3V 20% TCT SERIES ROHS	ROHM
RESISTORS				
15	ERJ-2RKF9761X	R10	RESISTOR SMD0402 THICK FILM 9.76K OHMS 1/10W 1% ROHS	PANASONIC
16	RC0402FR-07768KL	R1	RESISTOR SMD0402 THICK FILM 768K OHM 1% 1/16W ROHS	YAGEO
17	CRCW040235K7FKED	R2	RESISTOR SMD0402 35.7K OHMS 1% 1/16W ROHS	VISHAY/DALE
18	RC0402FR-077K5L	R3	RESISTOR SMD0402 THICK FILM 7.50K OHM 1% 1/16W ROHS	YAGEO
19	RMCF0402ZT0R00	R15, R16, R19, R22	ZERO OHM JUMPER SMT 0402 0 OHM 1/16W,5% ROHS	STACKPOLE ELECTRONICS
20	CRCW040210K0JNED	R20	RESISTOR SMD0402 10K OHMS 5% THICK FILM 1/16W ROHS	VISHAY
21	RC0402FR-072K7L	R17, R18	RESISTOR SMD0402 THICK FILM 2.70K OHMS 1% 1/16W ROHS	YAGEO
22	RC0402FR-07511RL	R8, R23, R24	RESISTOR SMD0402 THICK FILM 511 OHMS 1% 1/16W ROHS	YAGEO
23	RC0402FR-073K3L	R6, R7, R13, R14	RESISTOR SMD0402 THICK FILM 3.30K OHM 1% 1/16W ROHS	YAGEO

SEMICONDUCTORS				
ITEM	**MANU PART NUM**	**REF DESIGNATORS**	**DESCRIPTION**	**MANUFACTURER**
24	CRCW040220K0FKED	R4	RESISTOR SMT 0402 1% 1/16W 20.0K ROHS	VISHAY
25	RMCF0402FT41K2	R5	RESISTOR SMD0402 41.2K OHMS 1% 1/16W ROHS	STACKPOLE ELECTRONICS
INDUCTORS				
26	LPS4018-472MLB	L1	SHIELDED POWER INDUCTOR 4.7uH,ROHS	COIL CRAFT
HEADERS, JACKS, AND SHUNTS				
27	LPPB061NGCN-RC	SBW	HEADER THRU FEMALE 1X6-RA 50LS GOLD ROHS	SULLINS
28	PBC02SAAN	JP1, JP2, JP3, EXTIN	HEADER THRU MALE 2 PIN 100LS GOLD ROHS	SULLINS
29	PBC03SAAN	I2C	HEADER THRU MALE 3 PIN 100LS GOLD ROHS	SULLINS
30	1725656	OUT, VBAT	TERMINAL BLOCK MPT COMBICON 2PIN 6A/125V GREEN 100LS ROHS	PHOENIX CONTACT
–	SPN02SYBN-RC	Place on JP1, JP2, JP3	CONN SHUNT 2MM OPEN TOP 2PS GOLD	SULLINS
TEST POINTS AND SWITCHES				
31	5001	GND	PC TESTPOINT, BLACK, ROHS	KEYSTONE ELECTRONICS
32	5003	OUT+, OUT–	PC TESTPOINT, ORANGE, ROHS	KEYSTONE ELECTRONICS
33	TL1015AF160QG	TRIG	SWITCH, MOM, 160G SMT 4X3MM ROHS	E-SWITCH
34	R0402_DNP	R9, R21	R0402_DNP	VISHAY
–	SJ61A1	NA	RUBBER BUMPONS CYLINDRICAL 312x200 BLACK	3M

5 Related Documentation From Texas Instruments

All documents are available for download from the TI website at www.ti.com.

- DRV8662 Product data sheet. Literature number SLOS737.
- Using the USCI I^2C Master. Application report. Literature number SLAA382.
- Using the USCI I^2C Slave. Application report. Literature number SLAA383.

Revision History

Changes from Original (August, 2011) to A Revision **Page**

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

EVALUATION BOARD/KIT/MODULE (EVM) ADDITIONAL TERMS

Texas Instruments (TI) provides the enclosed Evaluation Board/Kit/Module (EVM) under the following conditions:

The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the user indemnifies TI from all claims arising from the handling or use of the goods.

Should this evaluation board/kit not meet the specifications indicated in the User's Guide, the board/kit may be returned within 30 days from the date of delivery for a full refund. THE FOREGOING LIMITED WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. EXCEPT TO THE EXTENT OF THE INDEMNITY SET FORTH ABOVE, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

Please read the User's Guide and, specifically, the Warnings and Restrictions notice in the User's Guide prior to handling the product. This notice contains important safety information about temperatures and voltages. For additional information on TI's environmental and/or safety programs, please visit www.ti.com/esh or contact TI.

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REGULATORY COMPLIANCE INFORMATION

As noted in the EVM User's Guide and/or EVM itself, this EVM and/or accompanying hardware may or may not be subject to the Federal Communications Commission (FCC) and Industry Canada (IC) rules.

For EVMs **not** subject to the above rules, this evaluation board/kit/module is intended for use for ENGINEERING DEVELOPMENT, DEMONSTRATION OR EVALUATION PURPOSES ONLY and is not considered by TI to be a finished end product fit for general consumer use. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC or ICES-003 rules, which are designed to provide reasonable protection against radio frequency interference. Operation of the equipment may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

General Statement for EVMs including a radio

User Power/Frequency Use Obligations: This radio is intended for development/professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability of this EVM and its development application(s) must comply with local laws governing radio spectrum allocation and power limits for this evaluation module. It is the user's sole responsibility to only operate this radio in legally acceptable frequency space and within legally mandated power limitations. Any exceptions to this are strictly prohibited and unauthorized by Texas Instruments unless user has obtained appropriate experimental/development licenses from local regulatory authorities, which is responsibility of user including its acceptable authorization.

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

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

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.

For EVMs annotated as IC – INDUSTRY CANADA Compliant

This Class A or B digital apparatus complies with Canadian ICES-003.

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

Concerning EVMs including radio transmitters

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

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.

Cet appareil numérique de la classe A ou B est conforme à la norme NMB-003 du Canada.

Les changements ou les modifications pas expressément approuvés par la partie responsable de la conformité ont pu vider l'autorité de l'utilisateur pour actionner l'équipement.

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.

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.

【Important Notice for Users of this Product in Japan】

This development kit is NOT certified as Confirming to Technical Regulations of Radio Law of Japan

If you use this product in Japan, you are required by Radio Law of Japan to follow the instructions below with respect to this product:

1. Use this product 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 this product only after you obtained the license of Test Radio Station as provided in Radio Law of Japan with respect to this product, or
3. Use of this product only after you obtained the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to this product. Also, please do not transfer this product, unless you give the same notice above to the transferee. Please note that if you could not follow the instructions above, you will be subject to penalties of Radio Law of Japan.

Texas Instruments Japan Limited
(address) 24-1, Nishi-Shinjuku 6 chome, Shinjuku-ku, Tokyo, Japan

http://www.tij.co.jp

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http://www.tij.co.jp

EVALUATION BOARD/KIT/MODULE (EVM) WARNINGS, RESTRICTIONS AND DISCLAIMERS

For Feasibility Evaluation Only, in Laboratory/Development Environments. Unless otherwise indicated, this EVM is not a finished electrical equipment and not intended for consumer use. It is intended solely for use for preliminary feasibility evaluation in laboratory/development environments by technically qualified electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems and subsystems. It should not be used as all or part of a finished end product.

Your Sole Responsibility and Risk. You acknowledge, represent and agree that:

1. You have unique knowledge concerning Federal, State and local regulatory requirements (including but not limited to Food and Drug Administration regulations, if applicable) which relate to your products and which relate to your use (and/or that of your employees, affiliates, contractors or designees) of the EVM for evaluation, testing and other purposes.
2. You have full and exclusive responsibility to assure the safety and compliance of your products with all such laws and other applicable regulatory requirements, and also to assure the safety of any activities to be conducted by you and/or your employees, affiliates, contractors or designees, using the EVM. Further, you are responsible to assure 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.
3. You will employ reasonable safeguards to ensure that your use of the EVM will not result in any property damage, injury or death, even if the EVM should fail to perform as described or expected.
4. You will take care of proper disposal and recycling of the EVM's electronic components and packing materials.

Certain Instructions. It is important to operate this EVM within TI's recommended specifications and environmental considerations per the user guidelines. Exceeding the specified EVM ratings (including but not limited to input and output voltage, current, power, and environmental ranges) may cause property damage, personal injury or death. If there are questions concerning these ratings please 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 result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM User's 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, some circuit components may have case temperatures greater than 60°C as long as the input and output are maintained at a normal ambient operating temperature. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during normal operation, please be aware that these devices may be very warm to the touch. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use these EVMs.

Agreement to Defend, Indemnify and Hold Harmless. You agree to 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 use of the EVM that is not in accordance with the terms of the agreement. This obligation shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if the EVM fails to perform as described or expected.

Safety-Critical or Life-Critical Applications. If you intend to evaluate the components for possible use in safety critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, such as devices which are classified as FDA Class III or similar classification, then you must specifically notify TI of such intent and enter into a separate Assurance and Indemnity Agreement.

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