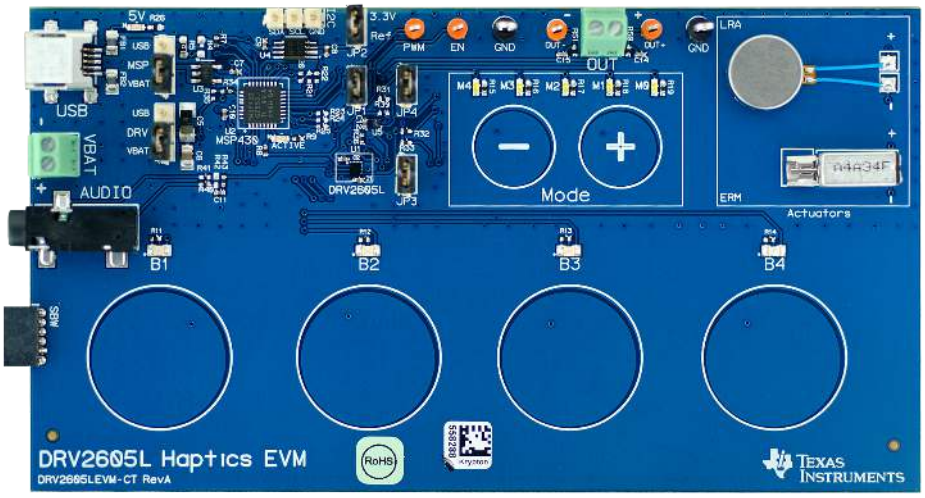
DRV2605L ERM and LRA Haptic Driver Evaluation Kit

The DRV2605L is a haptic driver designed for linear resonant actuators (LRA) and eccentric rotating mass (ERM) motors. It provides many features, which help eliminate the design complexities of haptic motor control including:

- Reduced solution size
- High-efficiency output drive
- Closed-loop motor control
- Quick device startup
- Embedded waveform library
- Auto-resonance frequency tracking

The DRV2605LEVM-CT evaluation module (EVM) is a complete demo and evaluation platform for the DRV2605L. The kit includes a microcontroller, linear actuator, eccentric rotating mass motor, sample waveforms, and capacitive touch buttons, which can completely demonstrate and evaluate the DRV2605L.

This user's guide contains instructions to setup and operate the DRV2605LEVM-CT in demonstration and evaluation mode.



Evaluation Kit Contents:

- DRV2605LEVM-CT demo and evaluation board
- Mini-USB cable
- Demonstration mode firmware

Needed for programming and advanced configuration:

- Code Composer Studio™ (CCS) or IAR Embedded Workbench IDE for MSP430
- MSP430 LaunchPad (MSP-EXP430G2), or MSP430-FET430UIF hardware programming tool
- DRV2605LEVM-CT firmware available on www.ti.com

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1 Getting Started

The DRV2605L can be used as a demonstration or evaluation tool. When the DRV2605LEVM-CT is powered on for the first time, a demo application automatically starts. To power the board, connect the DRV2605LEVM-CT to an available USB port on your computer using the included mini-USB cable. The demo begins with a board power-up sequence, and then enters the demo effects mode. The four larger buttons (B1 to B4) can be used to sample haptic effects using both the ERM and LRA motor in the top right corner. The two smaller mode buttons ("–" and "+") are used to change between the different banks of effects. See the DRV2605L Demonstration Program section for a more detailed description of the demo application.

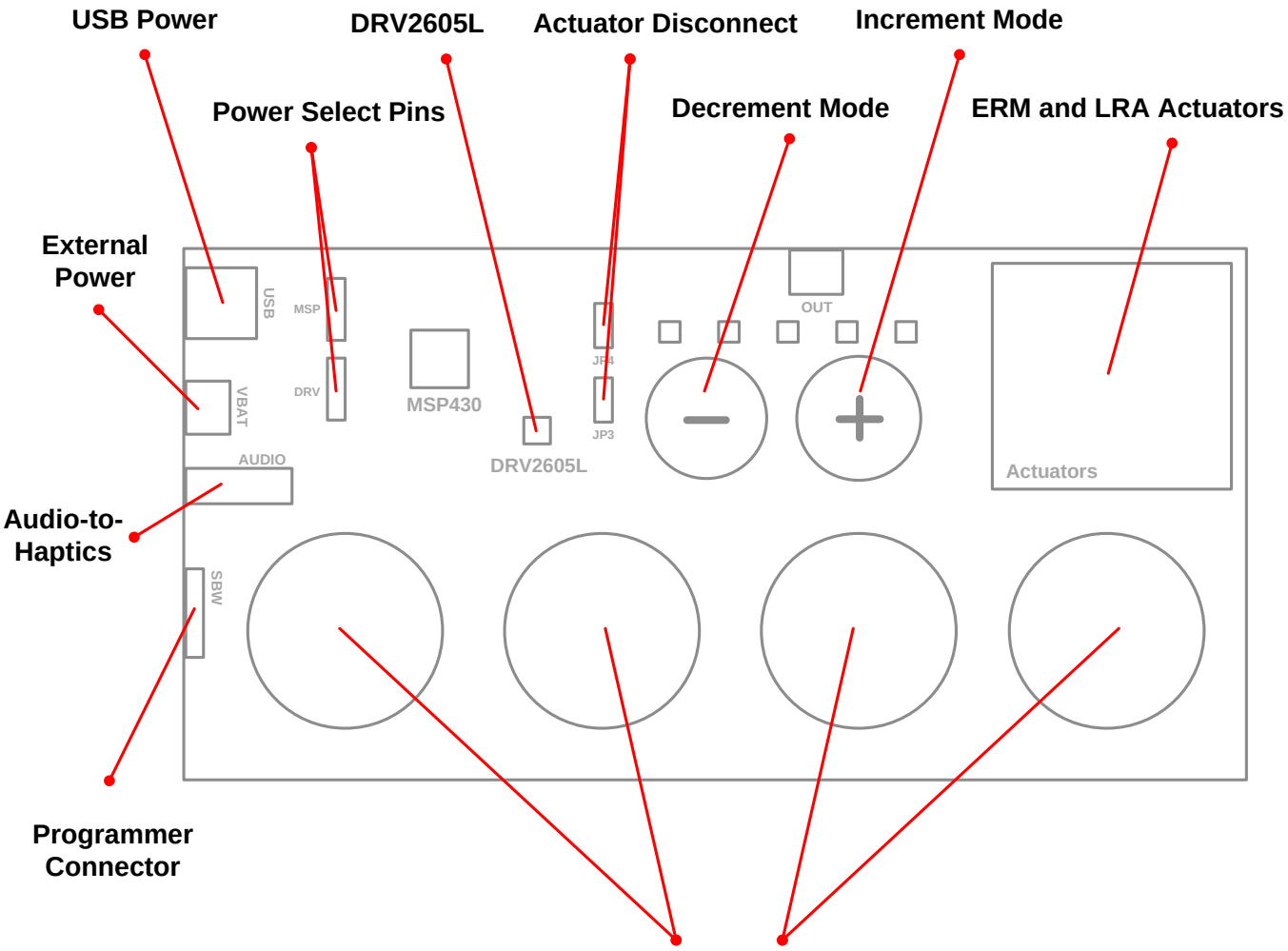

Figure 1. Board Diagram

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1.1 Evaluation Module Operating Parameters

The following table lists the operating conditions for the DRV2605L on the evaluation module.

Parameter	Specification
Supply voltage range	2.5 to 5.5 V
Power-supply current rating	400 mA

1.2 Quick Start Board Setup

The DRV2605LEVM-CT firmware contains haptic waveforms which showcase the features and benefits of the DRV2605L. Follow the instructions below to begin the demo.

1. Out of the box, the jumpers are set to begin demo mode using USB power. The default jumper settings can be found in Table 1.

Table 1. Jumper Descriptions

Jumper	Default Position	Description
JP1	Shorted	Connect MSP430 GPIO or PWM output to DRV2605L IN/TRIG
JP2	Shorted	3.3-V reference for I^2C
JP3, JP4	Shorted	Connect on-board actuators to DRV2605L
MSP	USB to MSP	Select USB (5 V) or VBAT power for the MSP430
DRV	USB to DRV	Select USB (5 V) or VBAT power for the DRV2605L

2. Connect the included mini-USB cable to the USB connector on the DRV2605LEVM-CT board.
3. Connect the other end of the USB cable to an available USB port on a computer, USB charger, or USB battery pack.
4. If the board is powered correctly, the four colored LEDs turn on, four mode LEDs flash, and the LRA and ERM perform auto-calibration, indicating the board has been successfully initialized.

2 DRV2605L Demonstration Program

The DRV2605LEVM-CT contains a microcontroller and embedded software to control the DRV2605L. There are three sets of modes accessible by pressing and holding the "+" button. Follow the instructions in the following sections to access the effects in each set.

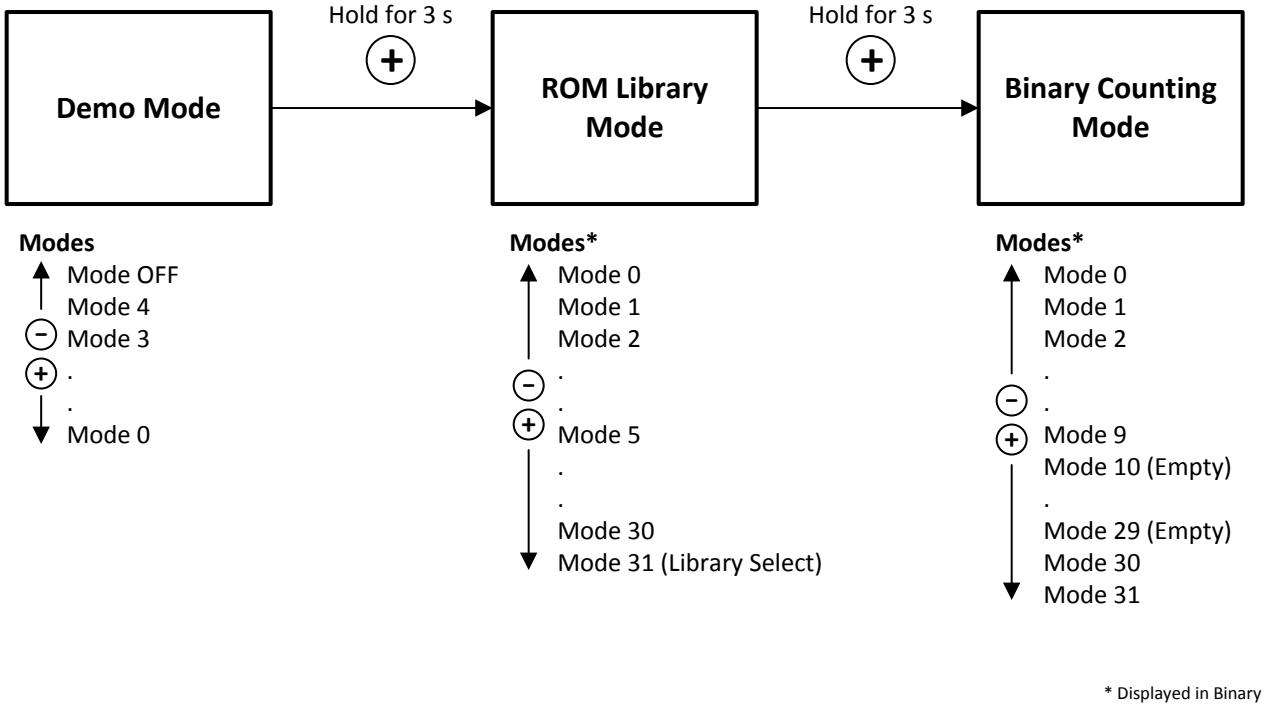

Figure 2. DRV2605LEVM-CT Mode Sets

2.1 Demo Mode

Table 2 lists the effects preloaded on the DRV2605LEVM-CT. The modes are selected using the "+" and "–" mode buttons in the center of the board. The current mode can be identified by the white LEDs directly above the mode buttons. Buttons B1 to B4 trigger the effects listed in the description column and change based on the selected mode.

Table 2. Mode and Effects Table

Mode	Button	Description	Actuator	Waveform Location	Interface
Mode Off LEDs Off	B1	Click + Ramp Down	ERM	ROM	Internal trigger (I^2C)
	B2	Ramp Up + Pulsing			
	B3	Click + Ramp Down	LRA		
	B4	Ramp Up + Pulsing			
Mode 4 LED M4 On	B1	SharpClick_100	ERM	ROM	Internal trigger
	B2	StrongClick_60 + Release			External edge trigger
	B3	SoftBump_100			Internal trigger
	B4	DoubleClick_100			External level trigger
Mode 3 LED M3 On	B1	SharpTick2_80	LRA	ROM	Internal trigger
	B2	StrongClick_100 + Release			External edge trigger
	B3	SoftBump_100			Internal trigger
	B4	DoubleClick_100			External level trigger
Mode 2 LED M2 On	B1	LRA auto-resonance on	LRA	µController	RTP
	B2	LRA auto-resonance off			PWM
	B3	ERM buzz alert (closed loop)	ERM		RTP
	B4	ERM buzz alert (open loop)		ROM	Internal trigger
Mode 1 LED M1 On	B1	Matching Game: The board gives several waveforms to match. Must match from a given waveform list each time before going to the next given waveform.	ERM and LRA	ROM	Internal trigger (I^2C)
	B2				
	B3				
	B4				
Mode 0 LED M0 On	B1	Audio-to-haptics enable	ERM	External analog source	Audio-to-haptics
	B2	Audio-to-haptics enable	LRA		
	B3	Exit A2H, click, return to A2H	ERM and LRA	ROM	Internal trigger (I^2C)
	B4	Exit A2H, buzz, return to A2H			

2.2 Description of the Demo Modes

The following sections describe each demo mode in more detail.

2.2.1 Mode Off – Haptics Effect Sequences

Mode Off contains a set of haptic sequences that combine a series of haptic effects. The two following effects show combinations of clicks, ramps, and pulses.

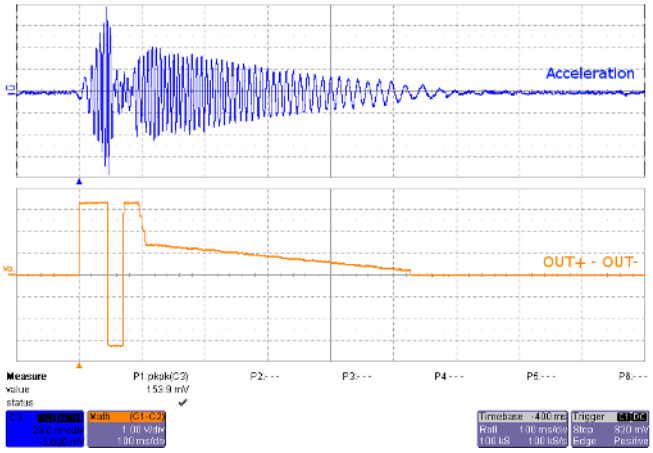

Figure 3. ERM Click and Ramp-Down Waveform (Button 1)

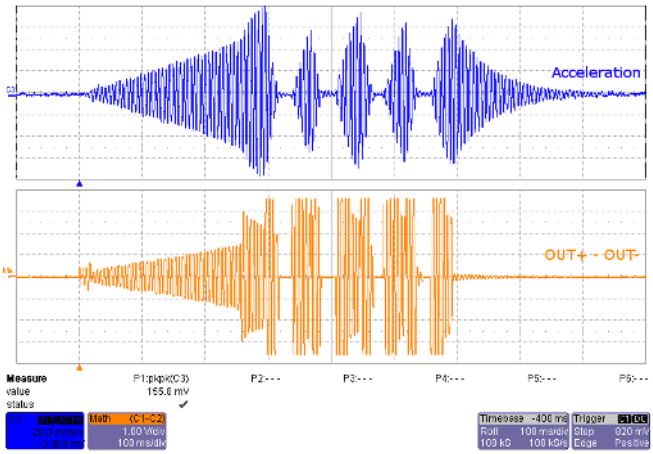

Figure 4. LRA Ramp-Up and Pulsing Waveform (Button 4)

2.2.2 Mode 4 – ERM Clicks

Mode 4 shows two different ERM click styles. Button 1 shoes a single sharp click. Button 2 shows a click and release effect. The click and release effect provides a haptic waveform on both the button press and the button release.

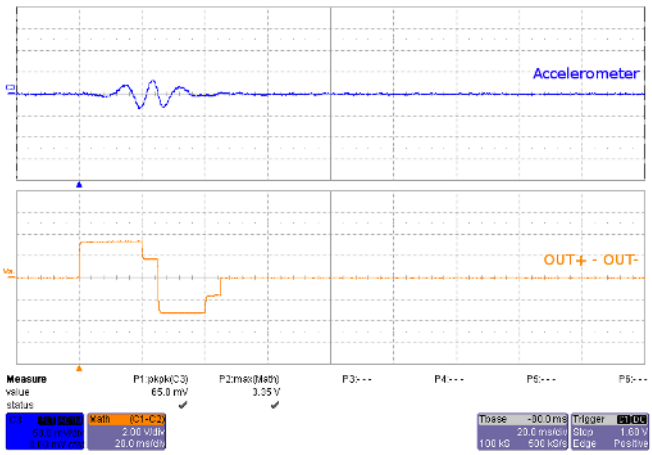

Figure 5. ERM SharpClick_100 (Button 1)

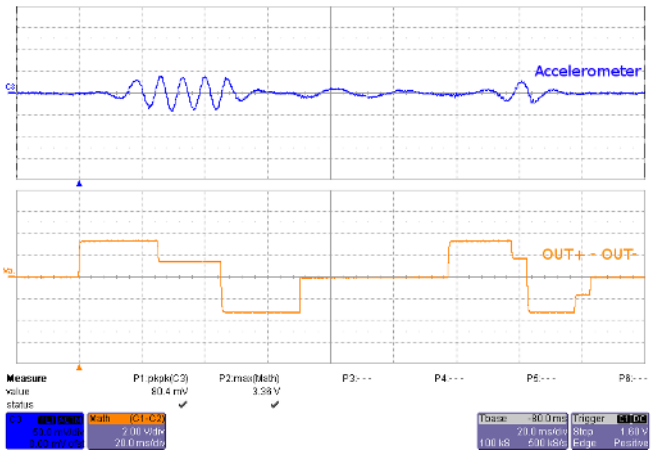

Figure 6. ERM StrongClick_60 and Release SharpClick_100 (Button 2)

2.2.3 Mode 3 – LRA Clicks

Mode 3 shows two different LRA click styles. Button 1 shoes a single sharp click and Button 2 shows a click and release effect. The click and release effect provides a haptic waveform on both the button press and the button release.

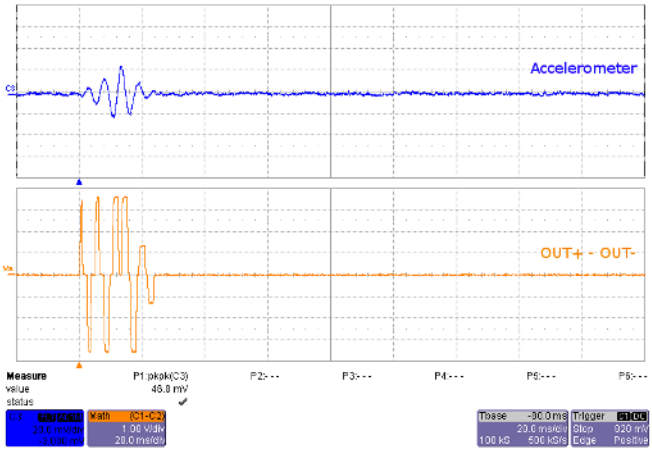

Figure 7. LRA SharpTick2_80 (Button 1)

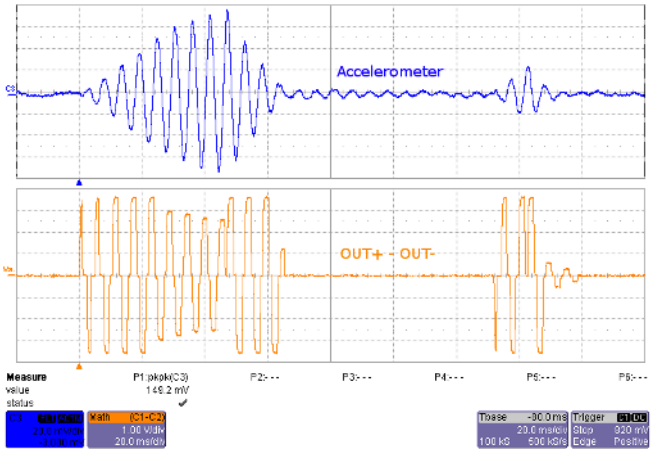

Figure 8. LRA StrongClick 100 and Release SharpTick2 80 (Button 2)

2.2.4 Mode 2 – Alerts

Mode 2 showcases the advantages of the smart loop architecture, which includes auto-resonance tracking, automatic overdrive, and automatic braking.

Figure 9 and Figure 10 show the difference in acceleration when using LRA auto-resonance on and LRA auto-resonance off. Notice that the acceleration is higher when driven at the resonant frequency. Also, notice the start and stop time of the acceleration are much quicker when using the overdrive and braking feature of the DRV2605L.

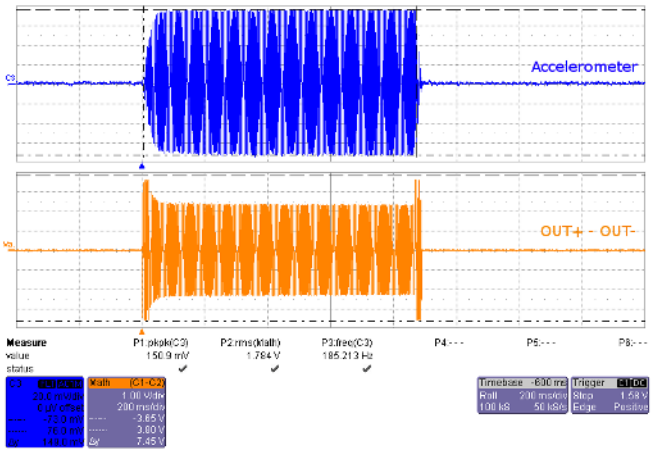

Figure 9. LRA Auto-Resonance On (Button 1)

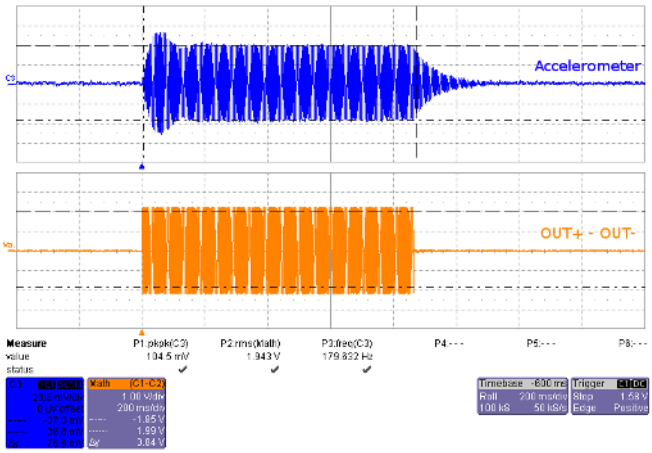

Figure 10. LRA Auto-Resonance Off (Button 2)

The reason for higher acceleration can be seen in Figure 11. The LRA has a very-narrow operating frequency range due to the properties of a spring-mass system. Furthermore, the resonance frequency drifts over various conditions such as temperature and drive voltage (the effects shown in Figure 11). With the smart loop auto-resonance feature, the DRV2605L dynamically tracks the exact resonant frequency to maximize the vibration force.

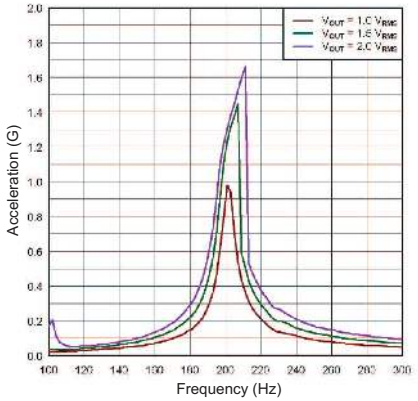

Figure 11. LRA Acceleration versus Frequency over Output Voltage

Figure 12 and Figure 13 show the difference between an ERM with automatic closed-loop overdrive and braking, and the open-loop library waveform with a predefined overdrive period. The closed-loop version starts and stops the actuator perfectly and does not drive too long or too short. Automatic overdrive and braking simplify the design of haptic effects by eliminating the tuning time for actuator startup and stop.

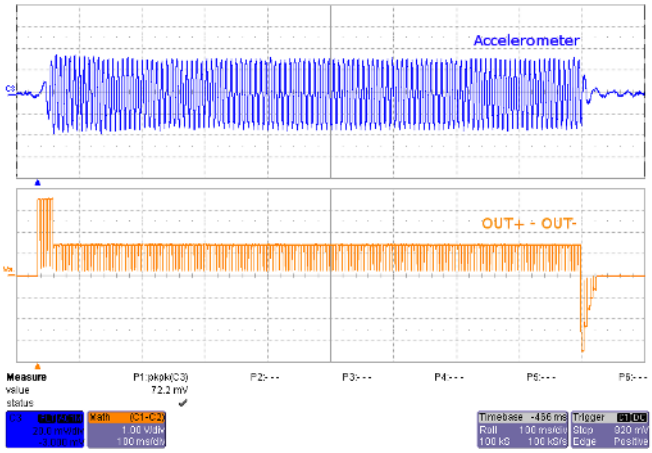

Figure 12. ERM Closed Loop (Button 3)

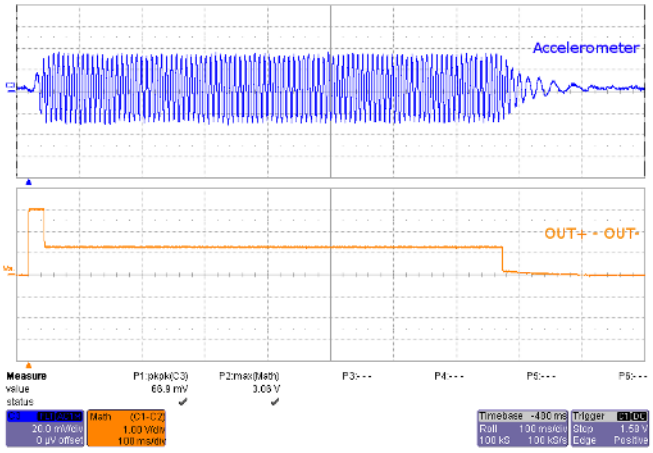

Figure 13. ERM Open Loop (Button 4)

2.2.5 Mode 1 – Waveform Matching Game

Mode 1 is a game that incorporates the various LRA effects. This can be used to demonstrate haptics in a real application.

To begin playing Matching:

1. Press any of the large effect buttons.
2. The game then counts down.
3. Once the countdown completes, a waveform will play from the LRA and the user must match that given waveform from the given options list before going to the next waveform match.
   - B1 - Play/repeat selected waveform from the options list
   - B2 - Cycle through the waveforms in the options list to choose from
   - B3 - Selects the guessed waveform (B1) as answer
   - B4 - Play/repeat the given waveform
4. After each successfully successful match, the board will buzz from the LRA and count down to the next given waveform. If the user selects incorrectly, then the ERM will buzz and the game is over. If the user matches all of the given waveforms, the LEDs will scroll and flash twice.

2.2.6 Mode 0 – Audio-to-Haptics

Audio-to-haptics is a unique feature that converts an audio signal to haptics. Take audio from music, games, or movies and automatically create haptic effects.

Buttons B1 to B4 perform the following actions:

- Button 1 – Audio-to-haptics using ERM
- Button 2 – Audio-to-haptics using LRA
- Button 3 – Switch to internal trigger and play library click effect
- Button 4 – Switch to internal trigger and play library buzz effect

To use this mode:

1. Connect an audio source to the audio jack on the left side of the board. The tip of the audio connector is applied to the input of the DRV2605L.
2. Press button 1 which enables audio-to-haptics using the on-board ERM
3. Decrease the volume of the audio source, if the ERM is constantly vibrating, or increase the volume, if the ERM is not vibrating at all.
4. Feel the haptic vibrations as the audio plays.
5. Press button 2 which enables audio-to-haptics using the on-board LRA.
6. Decrease the volume of the audio source if the LRA is constantly vibrating or increase the volume if the LRA is not vibrating at all.
7. Feel the haptic vibrations as the audio plays.
8. Press button 3 or 4 to trigger a click or buzz during audio-to-haptics playback.

Figure 14 and Figure 15 show the conversion process from audio to hatpics for both ERM and LRA.

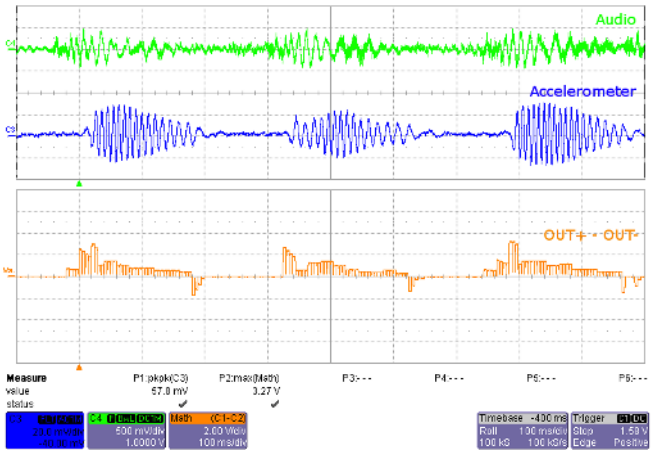

Figure 14. ERM Audio-to-Haptics Conversion (Button 1)

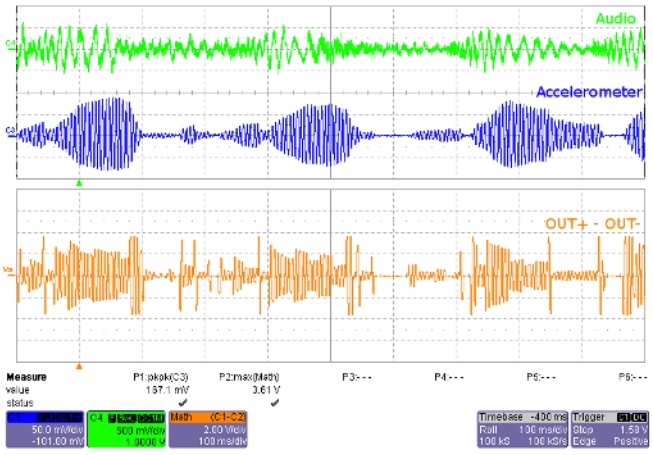

Figure 15. LRA Audio-to-Haptics Conversion (Button 2)

2.3 ROM Library Mode

ROM library effects can be accessed by holding the "+" button until the mode LEDs flash and colored LEDs flash once.

Once in "Library Mode," the DRV2605L embedded ROM effects can be accessed in sequential order. For example, with all mode LEDs off, B1 is waveform 1, B2 is waveform 2, and so on. Then when mode LED M0 is on, B1 is waveform 5, B2 is waveform 6, and so on.

The equations for calculating the mode and button of an effect are:

Mode = RoundDown([Effect No.] / 4)

Button = ([Effect No.] - 1) % 4 + 1

% - is the modulo operator

To change between the 5 ERM libraries and the Johnson Electric (JE) ROM Library:

1. Select mode 31 (11111'b) using the "+" or "–" buttons.
   - B1 – Press repeatedly to access ROM libraries 1 through 5 and the JE ROM library. The current library flashes on the mode LEDs
   - B2 – Press to select the LRA ROM library
2. Then use the ROM effects as described previously

Each ERM library was designed for specific actuator behavior. Table 3 describes the actuator properties that are best suited for each library. Note that the rated and overdrive voltages can be changed using the rated and overdrive clamp registers in the DRV2605L. The most important parameters to characterize with your actuator are the rise and brake times.

Table 3. DRV2605L Library Table

Number	Library	Actuator Properties			
		Rated Voltage (V)	Overdrive Voltage (V)	Rise Time (ms)	Brake Time (ms)
1	Library A	1.3	3	40 – 60	20 – 40
2	Library B	3	3	40 – 60	5 – 15
3	Library C	3	3	60 – 80	10 – 20
4	Library D	3	3	100 – 140	15 – 25
5	Library E	3	3	>140	>30
7	Library F	4.5	5	35 – 45	10 – 20

2.4 ROM Library Effects List

Below is a description of the 123 waveforms embedded in the DRV2605L.

Effect ID#	Waveform Name	Effect ID#	Waveform Name	Effect ID#	Waveform Name
1	Strong click – 100%	42	Long double sharp click medium 2 – 80%	83	Transition ramp up long smooth 2 – 0 to 100%
2	Strong click – 60%	43	Long double sharp click medium 3 – 60%	84	Transition ramp up medium smooth 1 – 0 to 100%
3	Strong click – 30%	44	Long double sharp tick 1 – 100%	85	Transition ramp up medium smooth 2 – 0 to 100%
4	Sharp click – 100%	45	Long double sharp tick 2 – 80%	86	Transition ramp up short smooth 1 – 0 to 100%
5	Sharp click – 60%	46	Long double sharp tick 3 – 60%	87	Transition ramp up short smooth 2 – 0 to 100%
6	Sharp click – 30%	47	Buzz 1 – 100%	88	Transition ramp up long sharp 1 – 0 to 100%
7	Soft bump – 100%	48	Buzz 2 – 80%	89	Transition ramp up long sharp 2 – 0 to 100%
8	Soft bump – 60%	49	Buzz 3 – 60%	90	Transition ramp up medium sharp 1 – 0 to 100%
9	Soft bump – 30%	50	Buzz 4 – 40%	91	Transition ramp up medium sharp 2 – 0 to 100%
10	Double click – 100%	51	Buzz 5 – 20%	92	Transition ramp up short sharp 1 – 0 to 100%
11	Double click – 60%	52	Pulsing strong 1 – 100%	93	Transition ramp up short sharp 2 – 0 to 100%
12	Triple click – 100%	53	Pulsing strong 2 – 60%	94	Transition ramp down long smooth 1 – 50 to 0%
13	Soft fuzz – 60%	54	Pulsing medium 1 – 100%	95	Transition ramp down long smooth 2 – 50 to 0%
14	Strong buzz – 100%	55	Pulsing medium 2 – 60%	96	Transition ramp down medium smooth 1 – 50 to 0%
15	750-ms alert 100%	56	Pulsing sharp 1 – 100%	97	Transition ramp down medium smooth 2 – 50 to 0%
16	1000-ms alert 100%	57	Pulsing sharp 2 – 60%	98	Transition ramp down short smooth 1 – 50 to 0%
17	Strong click 1 – 100%	58	Transition click 1 – 100%	99	Transition ramp down short smooth 2 – 50 to 0%
18	Strong click 2 – 80%	59	Transition click 2 – 80%	100	Transition ramp down long sharp 1 – 50 to 0%
19	Strong click 3 – 60%	60	Transition click 3 – 60%	101	Transition ramp down long sharp 2 – 50 to 0%
20	Strong click 4 – 30%	61	Transition click 4 – 40%	102	Transition ramp down medium sharp 1 – 50 to 0%
21	Medium click 1 – 100%	62	Transition click 5 – 20%	103	Transition ramp down medium sharp 2 – 50 to 0%
22	Medium click 2 – 80%	63	Transition click 6 – 10%	104	Transition ramp down short sharp 1 – 50 to 0%
23	Medium click 3 – 60%	64	Transition hum 1 – 100%	105	Transition ramp down short sharp 2 – 50 to 0%
24	Sharp tick 1 – 100%	65	Transition hum 2 – 80%	106	Transition ramp up long smooth 1 – 0 to 50%
25	Sharp tick 2 – 80%	66	Transition hum 3 – 60%	107	Transition ramp up long smooth 2 – 0 to 50%
26	Sharp tick 3 – 60%	67	Transition hum 4 – 40%	108	Transition ramp up medium smooth 1 – 0 to 50%
27	Short double click strong 1 – 100%	68	Transition hum 5 – 20%	109	Transition ramp up medium smooth 2 – 0 to 50%
28	Short double click strong 2 – 80%	69	Transition hum 6 – 10%	110	Transition ramp up short smooth 1 – 0 to 50%
29	Short double click strong 3 – 60%	70	Transition ramp down long smooth 1 – 100 to 0%	111	Transition ramp up short smooth 2 – 0 to 50%
30	Short double click strong 4 – 30%	71	Transition ramp down long smooth 2 – 100 to 0%	112	Transition ramp up long sharp 1 – 0 to 50%
31	Short double click medium 1 – 100%	72	Transition ramp down medium smooth 1 – 100 to 0%	113	Transition ramp up long sharp 2 – 0 to 50%
32	Short double click medium 2 – 80%	73	Transition ramp down medium smooth 2 – 100 to 0%	114	Transition ramp up medium sharp 1 – 0 to 50%
33	Short double click medium 3 – 60%	74	Transition ramp down short smooth 1 – 100 to 0%	115	Transition ramp up medium sharp 2 – 0 to 50%
34	Short double sharp tick 1 – 100%	75	Transition ramp down short smooth 2 – 100 to 0%	116	Transition ramp up short sharp 1 – 0 to 50%
35	Short double sharp tick 2 – 80%	76	Transition ramp down long sharp 1 – 100 to 0%	117	Transition ramp up short sharp 2 – 0 to 50%
36	Short double sharp tick 3 – 60%	77	Transition ramp down long sharp 2 – 100 to 0%	118	Long buzz for programmatic stopping – 100%
37	Long double sharp click strong 1 – 100%	78	Transition ramp down medium sharp 1 – 100 to 0%	119	Smooth hum 1 (No kick or brake pulse) – 50%
38	Long double sharp click strong 2 – 80%	79	Transition ramp down medium sharp 2 – 100 to 0%	120	Smooth hum 2 (No kick or brake pulse) – 40%
39	Long double sharp click strong 3 – 60%	80	Transition ramp down short sharp 1 – 100 to 0%	121	Smooth hum 3 (No kick or brake pulse) – 30%
40	Long double sharp click strong 4 – 30%	81	Transition ramp down short sharp 2 – 100 to 0%	122	Smooth hum 4 (No kick or brake pulse) – 20%
41	Long double sharp click medium 1 – 100%	82	Transition ramp up long smooth 1 – 0 to 100%	123	Smooth hum 5 (No kick or brake pulse) – 10%

3 Additional Hardware Modes

Additional modes are available on the DRV2605LEVM-CT that provide increased board control and functionality. The additional modes are not available in “demo” mode, but can be accessed by switching to “binary counting mode”. In “binary counting mode,” the mode LEDs count in binary (32 modes) rather than in “demo” mode format (only six modes including off).

3.1 Enter Binary Counting Mode

To enter “binary counting mode” and access the additional modes:

1. Press and hold the increment mode button (“+”) for approximately 3 seconds until the mode LEDs flash and the colored LEDs flash once.
2. Press and hold the increment mode button ("+") one more time until the mode LEDs flash and the colored LEDs flash twice.
3. Select from the “binary counting modes” using the “+” and “–" buttons.

3.2 Exit Binary Counting Mode

To exit “binary counting mode” and return to “demo” mode:

1. Press and hold the decrement mode button (“–") for approximately 3 seconds.
2. Release the button when the actuator buzzes and mode LEDs flash.
3. Select from the “demo” modes using the “+” and "–" buttons.

3.3 Binary Counting Modes

Table 4 lists the modes available in “binary counting mode”.

Table 4. Binary Counting Modes

Mode	Button	Description	Notes
Mode 0 External I²C mode LEDs: 00000	B1	Set ERM output	Use this mode to control the DRV2605L using an external I²C Master. Press B1 or B2 to choose between the ERM or LRA. Press B3 to choose the trigger type. (1 - Internal, 2 - External edge, 3 - External level). Press B4 to trigger the waveform sequencer.
	B2	Set LRA output	
	B3	Choose trigger	
	B4	Trigger button	
Mode 1 Auto-calibration and diagnostics LEDs: 00001	B1	ERM auto-calibration	Run the auto-calibration. The new auto-calibration results are used for all board effects, 1 flash = successful, 3 flashes = error.
	B2	LRA auto-calibration	
	B3	ERM diagnostics	Run diagnostics, 1 flash = successful, 3 flashes = error. The status register bits [3:0] are displayed on the mode LEDs [3:0] when complete.
	B4	LRA diagnostics	
Mode 2 External PWM LEDs: 00010	B1	Disable PWM mode	External PWM - disconnect MSP430 PWM using JP1. Connect external PWM signal to the "PWM" test point at the top of the board. Select actuator using buttons B2 and B3.
	B2	Set ERM output	
	B3	Set LRA output	
	B4	–	
Mode 3 External PWM and enable LEDs: 00011	B1	Return to typical mode	External PWM and enable - disconnect MSP430 PWM using JP1. Connect external PWM signal to the "PWM" test point at the top of the board. Connect an external enable signal to the "EN" test point. Select actuator using buttons B2 and B3. Press B1 before switching modes.
	B2	Set ERM output	
	B3	Set LRA output	
	B4	–	
Mode 4 Analog Input LEDs: 00100	B1	AC coupling - ERM	Analog input - apply an external analog signal for AC coupling on the "audio" jack. Apply a DC coupled signal to the "PWM" test point.
	B2	DC coupling - ERM	
	B3	AC coupling - LRA	
	B4	DC coupling - LRA	
Mode 5 Auto-resonance OFF frequency adjust LEDs:00101	B1	Alert (auto-resonance on)	Vary the auto-resonance off (open-loop) output frequency and see the change in vibration force over frequency. Hold B3 or B4 for quick frequency adjustment. Compare B2 (auto-resonance off) with B1 (auto-resonance on).
	B2	Alert (auto-resonance off)	
	B3	Decrease output frequency	
	B4	Increase output frequency	
Mode 6 Life test (RTP) 2s ON, 1s OFF LEDs: 00110	B1	Begin life test	Life test using RTP (2 seconds on, 1 second off) - life test repeats infinite times and board must be powered down to stop. Increment or decrement amplitude using B3 and B4. Test new amplitude using B2. Choose actuator using buttons B1 and B2 in mode 0 or mode 1.
	B2	Test buzz	
	B3	Decrease output voltage (–1)	
	B4	Increase output voltage (+1)	
Mode 7 Life test (RTP) Infinite buzz LEDs: 00111	B1	Begin life test	Life test using RTP (infinite buzz) - board must be powered down to stop buzz. Increment or decrement amplitude using B3 and B4. Test new amplitude using B2 before beginning life test. Choose actuator using buttons B1 and B2 in mode 0 and mode 1.
	B2	Test buzz	
	B3	Decrease output voltage (–1)	
	B4	Increase output voltage (+1)	
Mode 8 Life test (PWM) 2s ON, 1s OFF LEDs: 01000	B1	Begin life test	Life test using PWM (2 seconds on, 1 second off) - life test repeats infinite times and board must be powered down to stop. Increment or decrement amplitude using B3 and B4. Test new amplitude using B2. Choose actuator using buttons B1 and B2 in mode 0 or mode 1.
	B2	Test buzz	
	B3	Decrease output voltage (–1)	
	B4	Increase output voltage (+1)	
Mode 9 Recorder LEDs: 01001	B1	Start or stop recording	Recorder - use this mode to create a single amplitude pattern. Start by pressing the record button (B1), then use B2 to create the pattern by tapping the button. When finished, press the play back button (B3).
	B2	Create effect	
	B3	Start or stop play back	
	B4	–	
Mode 11 Frequency Sweep LEDs: 01011	B1	BuzzAlert @ Frequency	Frequency Sweep (ROM Mode) - Increment or decrement the frequency using B3 and B4. B1 - Start/stop buzz alert at chosen frequency. B2 - Start/Stop buzz alert using auto-resonance. Frequency range: (50 Hz – 300 Hz)
	B2	BuzzAlert @ Resonance	
	B3	Decrease Frequency (–1)	
	B4	Increase Frequency (+1)	
Mode 12 2nd Cycle Test LEDs: 01100	B1	Never transition to open loop	2nd Cycle Test - for this mode, connect a resistor of 20 Ω (min of 8 Ω, max of 25 Ω) to simulate the resistance of a frozen actuator. B1 plays a buzz alert with OL drive disabled. B2 plays a buzz alert with the automatic transition to open loop drive enabled (when back-EMF not detected). Demonstrates DRV2605L improved algorithm to sync.
	B2	Auto-transition to OL drive	
	B3		
	B4		

Table 4. Binary Counting Modes (continued)

Mode	Button	Description	Notes
Mode 13 ROM Playback Interval LEDs: 01101	B1	5 ms playback interval enabled	Playback interval - demonstrates the 1 ms or 5 ms playback interval. Affects buzz waveform by multiplying the time data either by 1 ms or 5 ms. B1 - 5 ms mode enabled, B2 - 1 ms mode enabled, B3 - selects between ERM or LRA.
	B2	1 ms playback interval enabled	
	B3	Selects ERM or LRA	
	B4		
Mode 30 Actuator break-in LEDs: 11110	B1	Begin actuator break-in	Actuator break-in - used to break in new actuators
	B2		
	B3		
	B4		
Mode 31 About the board LEDs: 11111	B1	Device ID	About the board - the value appears on the mode LEDs in binary. DRV2605L Device ID = 00011
	B2	Silicon revision	
	B3	Code revision	
	B4		

4 Hardware Configuration

The DRV2605LEVM-CT is flexible and can be used to completely evaluate the DRV2605L. The following sections list the various hardware configurations.

4.1 Input and Output Overview

The DRV2605LEVM-CT allows complete evaluation of the DRV2605L though test points, jacks, and connectors. Table 5 gives a brief description of the hardware.

Table 5. Hardware Overview

Signal	Description	I/O
PWM	External input to DRV2605L IN/TRIG pin	Input / Observe
EN	External DRV2605L enable control	Input / Observe
OUT+ / OUT–	Filtered output test points for observation, connect to oscilloscope, or measurement equipment	Output
OUT	Unfiltered output terminal block, connect to actuator	Output
USB	USB power (5 V)	Input
VBAT	External supply power (2.5 to 5.5 V)	Input
SBW	MSP430 programming header	Input / Output
I^2C	DRV2605L and MSP430 I^2C bus	Input / Output
Audio	The audio jack is connected to the IN/TRIG pin of the DRV2605L. When the DRV2605L is in audio-to-haptics mode, audio from this jack is converted to haptics	Input

Hardware configuration details can be found in the following sections.

4.2 Power Supply Selection

The DRV2605LEVM-CT can be powered by USB or an external power supply (VBAT). Jumpers “DRV” and “MSP” are used to select USB or VBAT for the DRV2605L and MSP430G2553, respectively. See the following table for possible configurations.

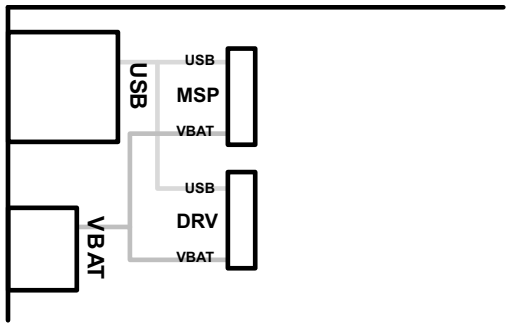

Figure 16. Power Jumper Selection

Supply Configuration	DRV	MSP	DRV2605L Supply Voltage[1]
USB – both	USB	USB	5 V
DRV2605L external supply, MSP430 USB	VBAT	USB	VBAT
External Supply – both	VBAT	VBAT	VBAT
USB with 3.3-V LDO[2] – Both	USB	USB	3.3 V (R4 = Short, R5 = Open)

(1) The DRV2605L supply must be on before operating the MSP430.
(2) If a 3.3-V DRV2605L supply voltage is preferred while using the USB as the power source, remove R5 and add a 0-Ω resistor across R4.

4.3 Using an External Actuator

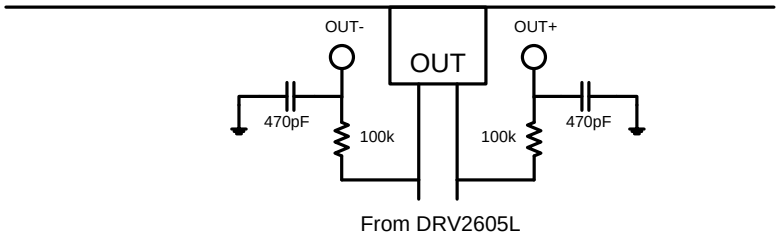

Figure 17. Terminal Block and Test Points

The DRV2605LEVM-CT can be used with an external actuator. Follow the instructions below to attach an actuator to the "OUT" terminal block.

1. Remove jumpers JP3 and JP4, which disconnects the on-board actuators from the DRV2605L.
2. Attach the positive and negative leads of the actuator to the green “OUT” terminal block keeping in mind polarity.
3. Screw down the terminal block to secure the actuator leads.

NOTE: It is important to use the green terminal block when connecting an external actuator. The "OUT+" and "OUT–" test points have low-pass filters and should only be used for oscilloscope and bench measurements.

4.4 PWM Input

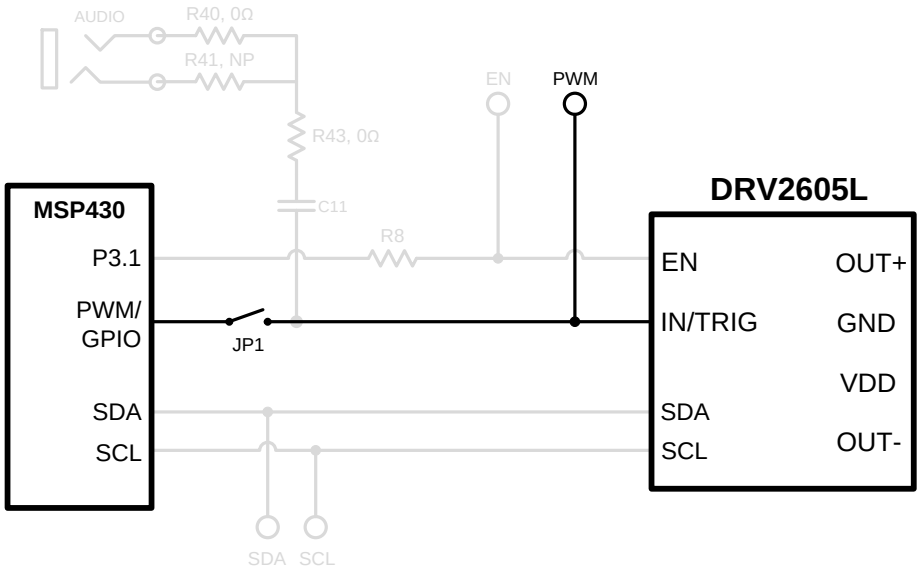

Figure 18. External PWM Input

JP1	PWM Source
Shorted	MSP430
Open	External PWM using PWM test point

To control the DRV2605L using PWM follow the instructions below.

1. Enter Additional Hardware Modes.
2. Select Mode 2 (00010'b) using the increment mode button ("+").
   - B1 - Disable amplifier
   - B2 - ERM mode
   - B3 - LRA mode
   - B4 - No function
3. Choose either the on-board ERM or LRA using button B1 or B2.
4. Apply the PWM signal to the PWM test point at the top of the board.

4.5 External Trigger Control

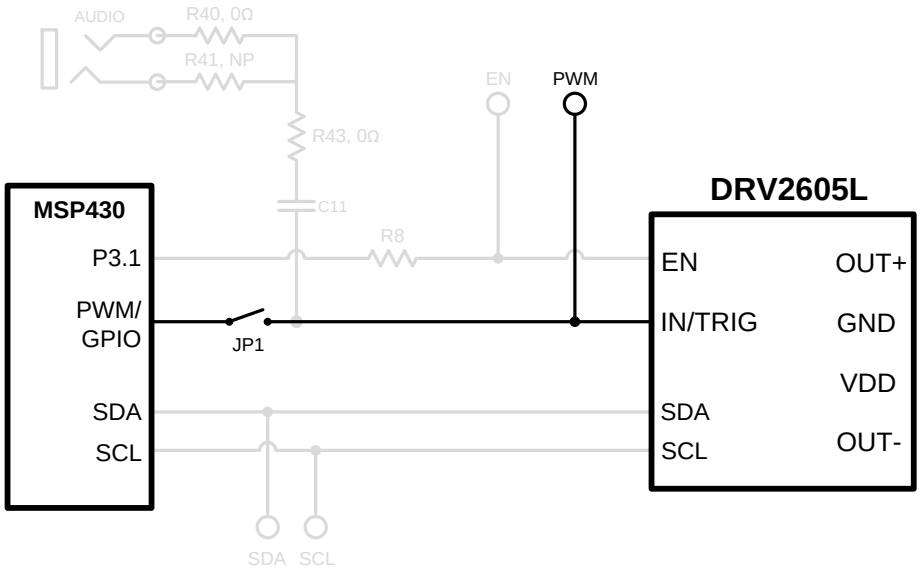

Figure 19. External Trigger Control

JP1	PWM Source
Shorted	MSP430
Open	External GPIO using PWM test point

The DRV2605L internal waveform sequencer can be triggered by controlling the IN/TRIG pin. There are two external trigger options: edge trigger and level trigger. See the datasheet for more information on these input trigger modes.

In mode 0 in the Additional Hardware Modes section, the DRV2605L can be set in external trigger mode, and then triggered by using the trigger button control on button B4, or alternatively by applying an external trigger signal to the PWM test point.

4.5.1 MSP430 Trigger Control

1. Enter Additional Hardware Modes.
2. Select Mode 0 (00000'b) using the increment mode button ("+").
   - B1 - Select the on-board ERM
   - B2 - Select the on-board LRA
   - B3 - Trigger select (1 = Internal trigger, 2 = External edge, 3 = External level)
   - B4 - Trigger the waveform sequence using the MSP430
3. Fill the waveform sequencer with waveforms using the external I^2C port.
4. Choose either the on-board ERM or LRA using buttons B1 or B2.
5. Select either external edge (2) or external level (3) trigger using button B3. The trigger type appears in binary on the mode LEDs.
6. Apply the trigger signal to the IN/TRIG pin by pressing button B4.

4.5.2 External Source Trigger Control

1. Remove jumper JP1.
2. Enter Additional Hardware Modes.
3. Select mode 0 (00000'b) using the increment mode button ("+").
   - B1 - Select the on-board ERM

- B2 - Select the on-board LRA
- B3 - Trigger Select (1 = Internal trigger, 2 = External edge, and 3 = External level)
- B4 - Trigger the waveform sequence using the MSP430

4. Fill the waveform sequencer with waveforms using the external I²C port.
5. Choose either the on-board ERM or LRA using buttons B1 or B2.
6. Select either external edge (2) or external level (3) trigger using button B3. The trigger type appears in binary on the mode LEDs.
7. Apply the external logic signal to the PWM test point to trigger the waveform.

4.6 External I²C Input

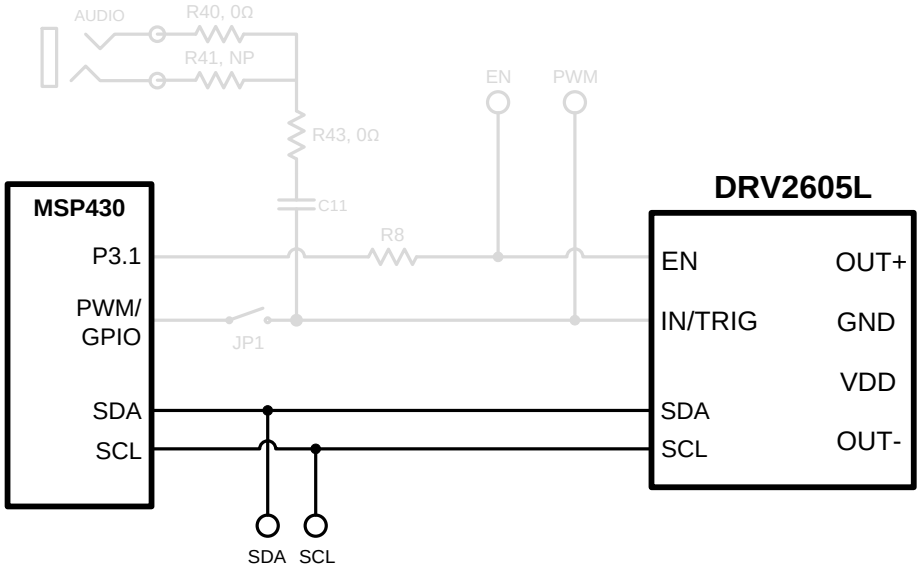

Figure 20. External I²C Input

The DRV2605L can be controlled by an external I²C source. Attach the external controller to the I²C header at the top of the board; be sure to connect SDA, SCL, and GND from the external source.

I²C communication is possible only when the EN pin is set high. To enable the DRV2605L and allow external I²C control, follow these instructions:

1. Enter Additional Hardware Modes.
2. Select mode 0 (00000'b) using the increment mode button ("+").
   - B1 - Select the on-board ERM
   - B2 - Select the on-board LRA
   - B3 - Trigger Select (1 = Internal trigger, 2 = External edge, 3 = External level)
   - B4 - Trigger the waveform sequence using the MSP430
3. Choose either the on-board ERM or LRA using buttons B1 or B2. Either button sets the EN pin high and turns on the "Active" LED.
4. Begin controlling the DRV2605L using the external I²C source.

4.7 Audio-to-Haptics Input

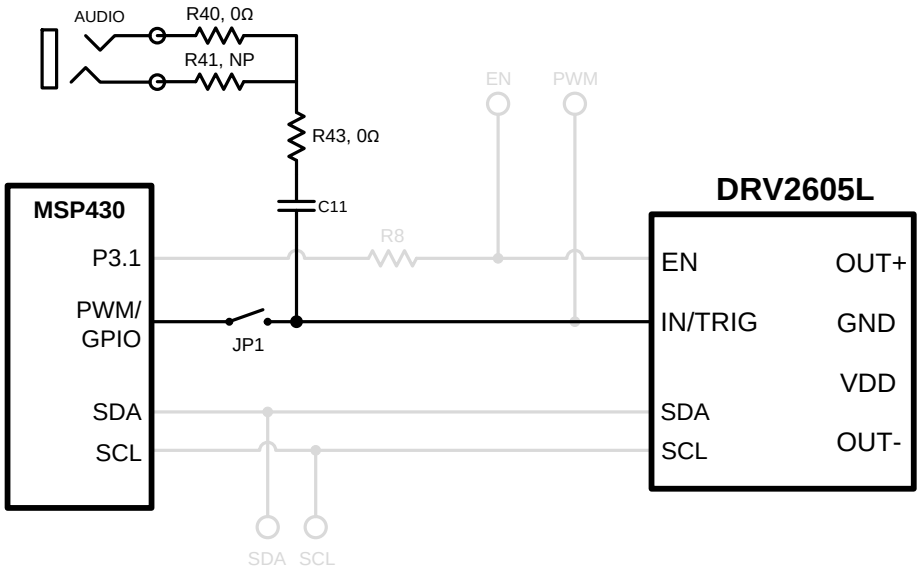

Figure 21. Audio-to-Haptics Input

The DRV2605L audio-to-haptics feature converts an audio signal to a corresponding haptics waveform. This can be used to simulate bass in music, or use the audio track of a game to produce haptic effects.

To use audio-to-haptics:

1. Apply an analog line-out audio signal (not PWM) to the AUDIO jack on the left side of the board. The tip of the inserted male audio plug is applied to the IN/TRIG pin of the DRV2605L. See Figure 21.

NOTE: To get the best performance using a headphone out, the user may need to adjust the volume, so that the input signal is near, but does not exceed 1.8 V_{peak}.

2. In demo mode, select mode 0 (00001'b) using the increment mode button ("+").
3. In mode 0, press either button B1 or B2 to enable the DRV2605L audio-to-haptics. Buttons B3 and B4 switch to internal trigger mode, play a ROM library effect, and then switch back to audio-to-haptics mode.
   - B1 – Audio-to-haptics using ERM
   - B2 – Audio-to-haptics using LRA
   - B3 – Switch to internal trigger and play library click effect
   - B4 – Switch to internal trigger and play library buzz effect
4. Play music and feel the vibrations of the actuator.

NOTE: Some audio signals are too large or too small and the volume must be adjusted. Adjust appropriately so that the maximum input voltage is 1.8 V and the bass of the input signal can be felt on the actuator. The audio input minimum and maximum thresholds can be adjusted using I^2C. See the datasheet for more details.

5 Measurement and Analysis

The DRV2605L uses PWM modulation to create the output signal for both ERM and LRA actuators. To measure and observe the DRV2605L output waveform, connect an oscilloscope or other measurement equipment to the filtered output test points, “OUT+” and “OUT–".

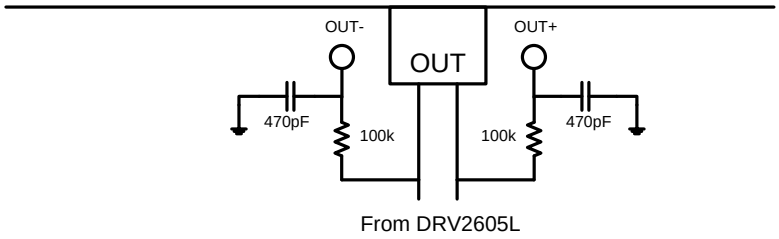

Figure 22. Terminal Block and Test Points

The DRV2605L drives LRA and ERM actuators using a 20-kHz PWM modulated waveform, but only the frequencies around the LRA resonant frequency, or the ERM DC drive voltage, are relevant to the haptic actuator vibration. The higher frequency switching content does not contribute to the vibration strength of the actuator and can make it difficult to interpret the modulated output waveform on an oscilloscope. The oscilloscope image Figure 23 shows the DRV2605L unfiltered waveform and Figure 24 shows a filtered version used for observation and measurement.

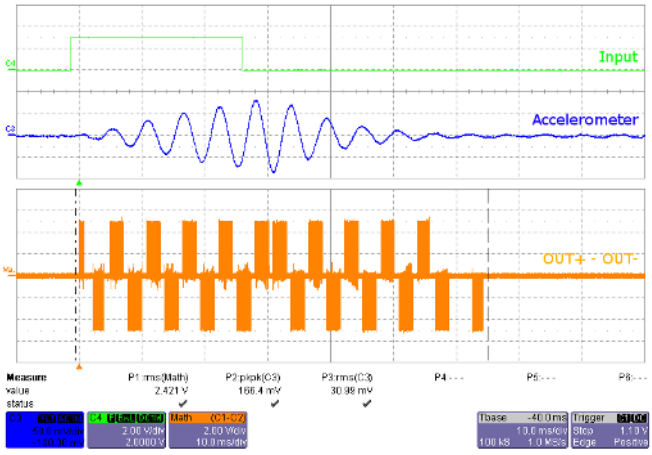

Figure 23. DRV2605L Unfiltered Waveform

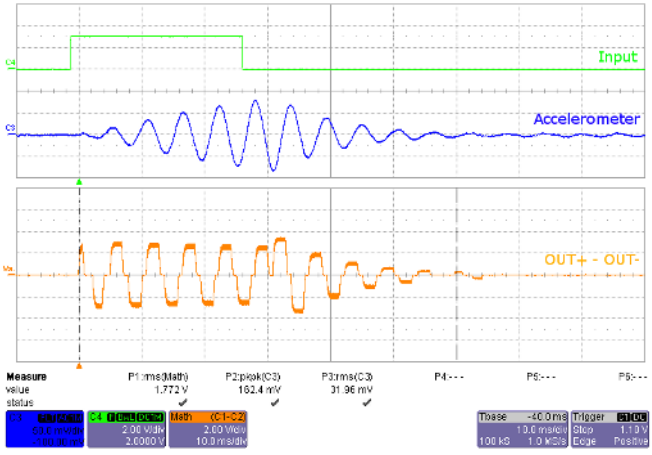

Figure 24. DRV2605L Filtered Waveform

If the DRV2605LEVM-CT filter is not used, TI recommends using a first-order, low-pass filter with a cutoff between 1 and 3.5 kHz. Figure 25 shows a recommended output filter for use while measuring and characterizing the DRV2605L in the lab.

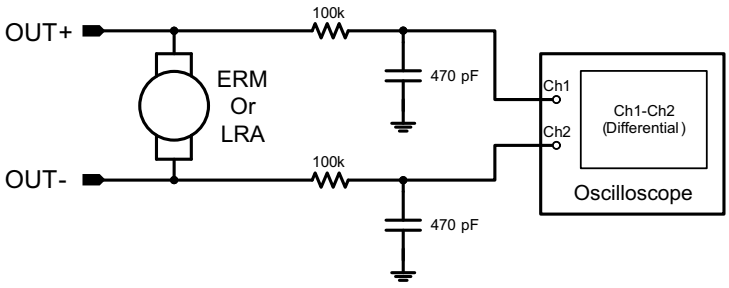

Figure 25. Measuring the DRV2605L Output Signal With an Analog Low-Pass Filter

6 MSP430 Firmware

The MSP430 firmware on the DRV2605LEVM-CT can be modified or reprogrammed to create new haptic effects or behaviors. Find the latest firmware source code and binaries on www.ti.com. Follow these instructions to modify or reprogram the DRV2605LEVM-CT:

1. Purchase one of the following MSP430G2553 compatible programmers:
   - MSP430 LaunchPad (MSP-EXP430G2) – requires the additional purchase of a header for J4 (recommended)
     - Digi-Key: ED8650-ND
     - Mouser: 575-500201
   - MSP430-FET430UIF – requires a JTAG to Spy-Bi-Wire adapter (MSP-JTAGSBW if available)
2. Download and install Code Compose Studio (CCS), or IAR Embedded Workbench IDE.
3. Download the DRV2605LEVM-CT source code and binaries from www.ti.com.
4. Connect the programmer to an available USB port.
5. Connect the programmer to the “SBW” header on the DRV2605LEVM-CT.
6. In CCS,
   (a) Open the project file by selecting Project → Import Existing CCS Project.
   (b) Select Browse and navigate to the DRV2605LEVM-CT project folder, then press OK.
   (c) Select the checkbox next to the DRV2605LEVM-CT project in the “Discovered projects” window, and then press Finish.
   (d) Before compiling, navigate to Project → Properties → Build → MSP430 Compiler → Advanced Options → Language Options, and make sure the checkbox for “Enable support for GCC extensions (--gcc)” is checked.
7. In IAR,
   (a) Create a new MSP430 project in IAR
   (b) Select the MSP430G2553 device
   (c) Copy the files in the project folder downloaded from www.ti.com to the new project directory

Figure 26 shows the connection between the MSP430 LaunchPad (MSP-EXP430G2) and the DRV2605LEVM-CT.

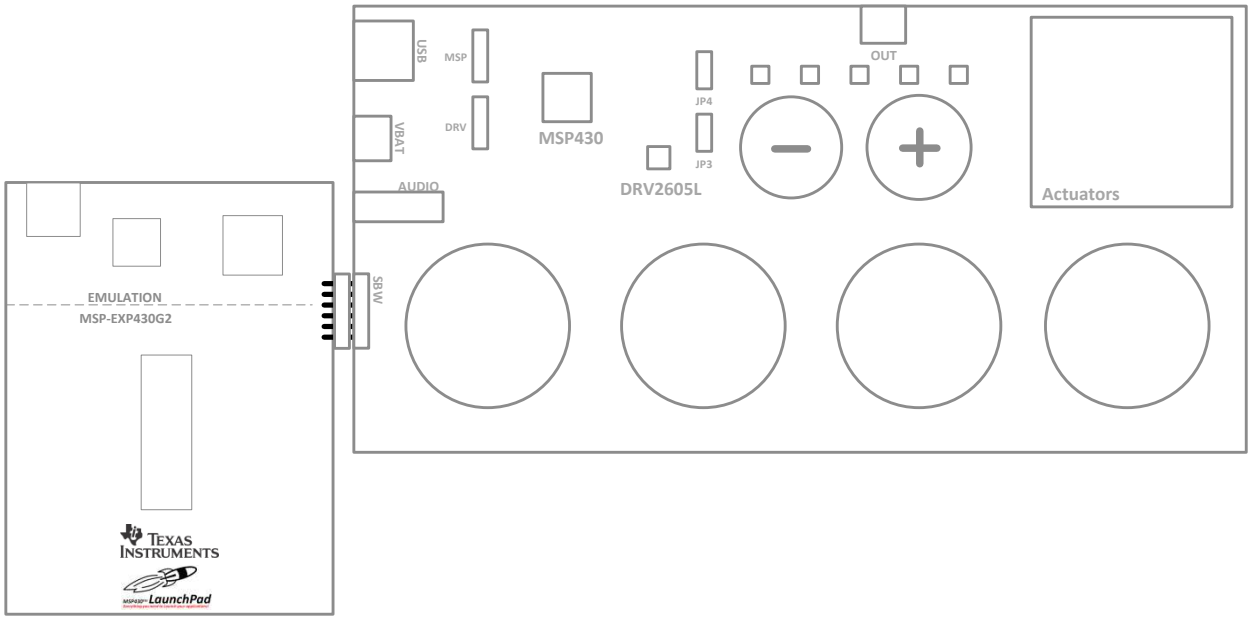

Figure 26. LaunchPad Programmer Connection

6.1 MSP430 Pinout

The DRV2605LEVM-CT contains a MSP430G2553 low-cost microcontroller, which controls the board and contains sample haptic effects. The pinout for the microcontroller can be found in Table 6.

Table 6. MSP430 Pinout

NO.	NAME	DESCRIPTION
1	P1.1	Green LED
2	P1.2	Yellow LED
3	P1.3	Blue LED
4	P1.4	VREF+
5	P1.5	Audio-to-haptics
6	P3.1	Enable
7	P3.0	Actuator mode selection
8	NC	
9	P2.0	Button 1
10	P2.1	Button 2
11	P2.2	Button 3
12	P3.2	PWM
13	P3.3	WLED 0
14	P3.4	WLED 1
15	P2.3	Button 4
16	P2.4	"+" button
17	P2.5	"–" button
18	P3.5	WLED 2
19	P3.6	WLED 3
20	P3.7	WLED 4
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	
26	P2.6	LRA/ERM load switch
27	AVSS	Analog ground
28	DVSS	Digital ground
29	AVCC	Analog supply
30	DVCC	Digital supply
31	P1.0	Red LED
32	NC	

7 Schematic

Figure 27 illustrates the EVM schematic.

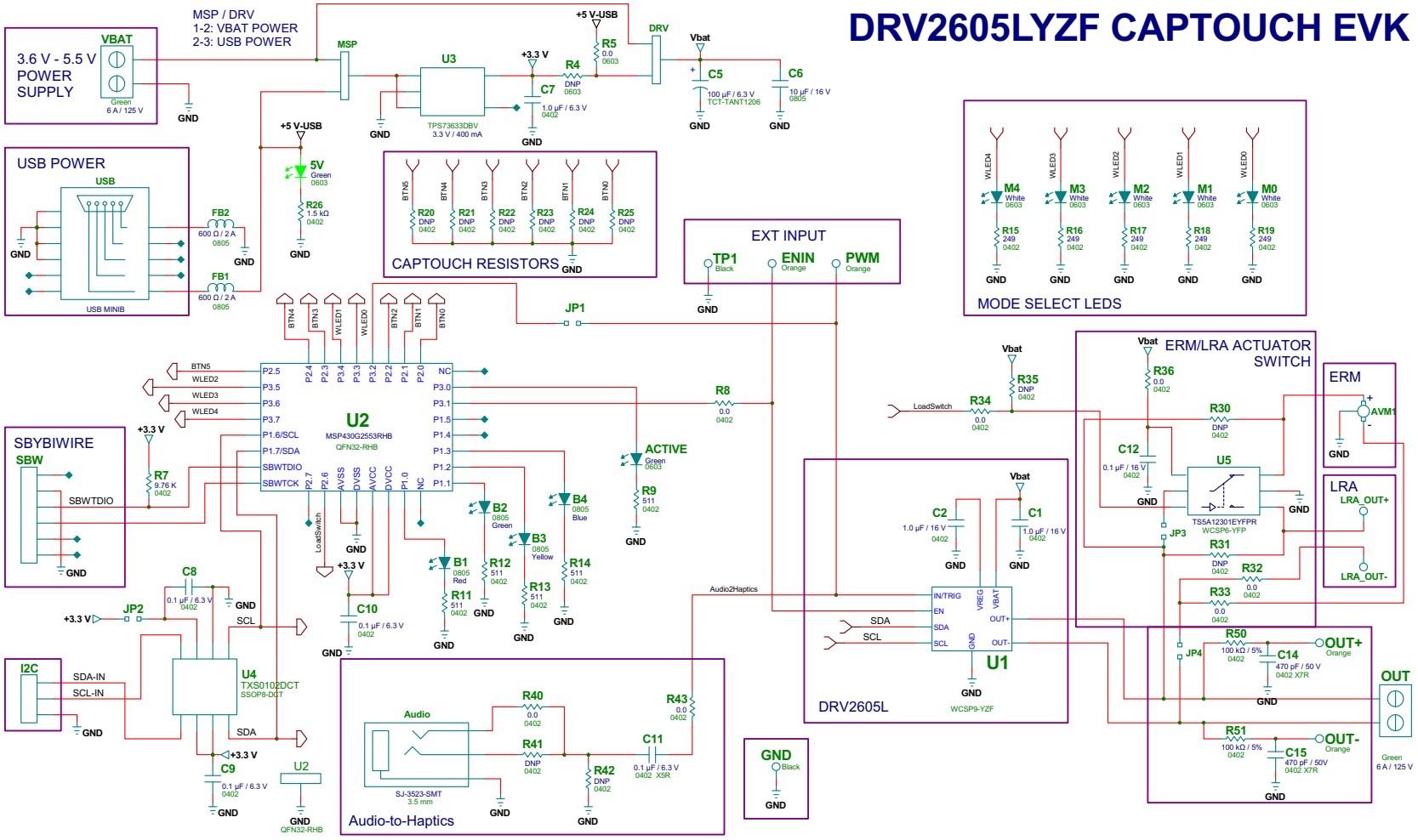

Figure 27. DRV2605LEVM-CT Schematic

8 Layout

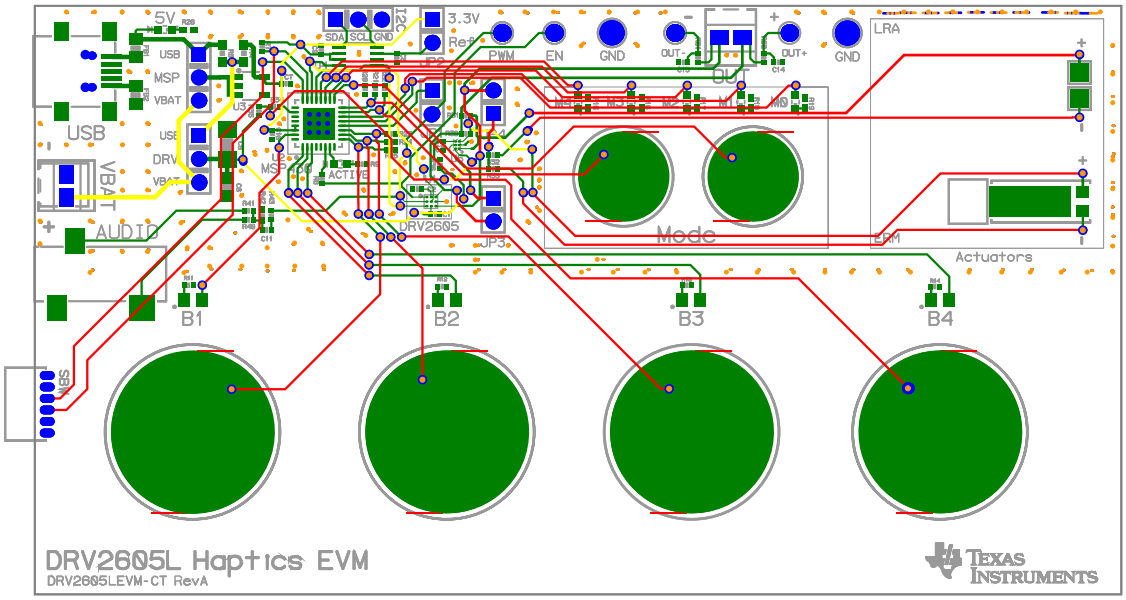

Figure 28. X-Ray Top View

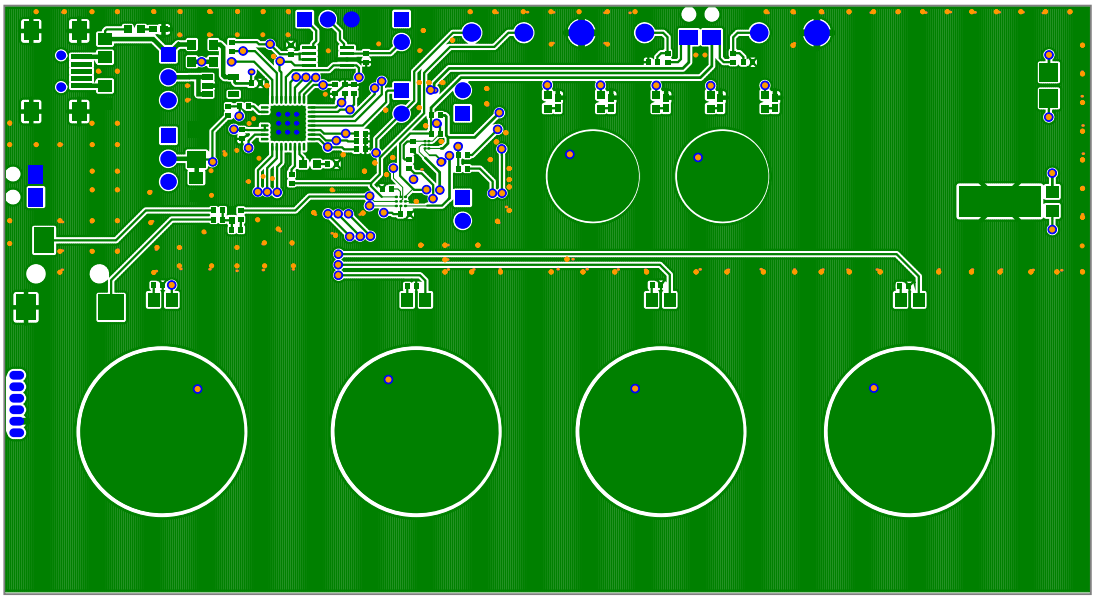

Figure 29. Top Copper

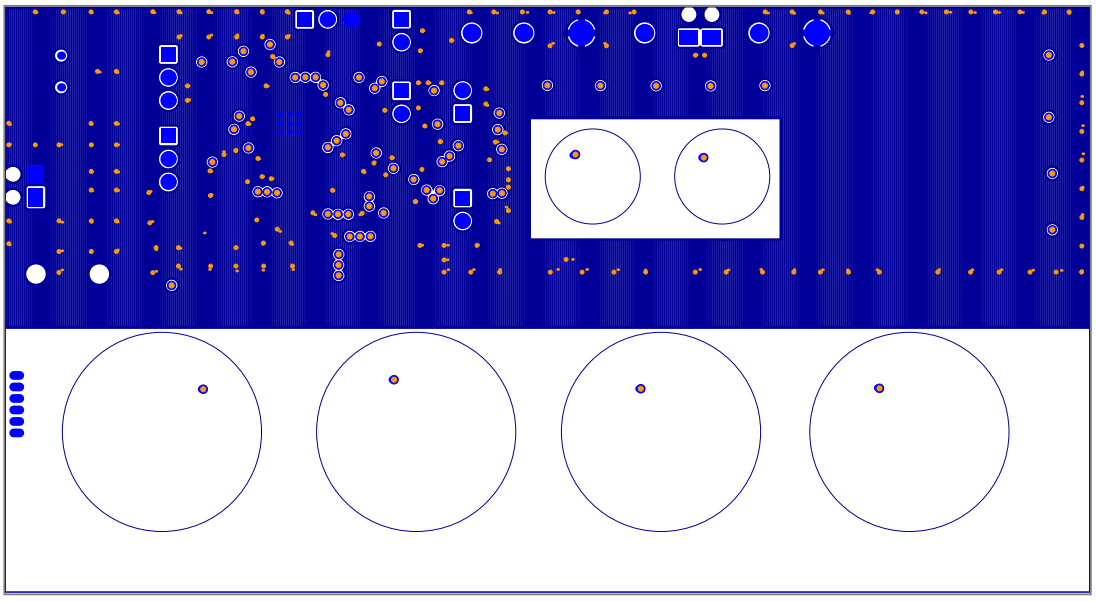

Figure 30. Layer 2 Copper

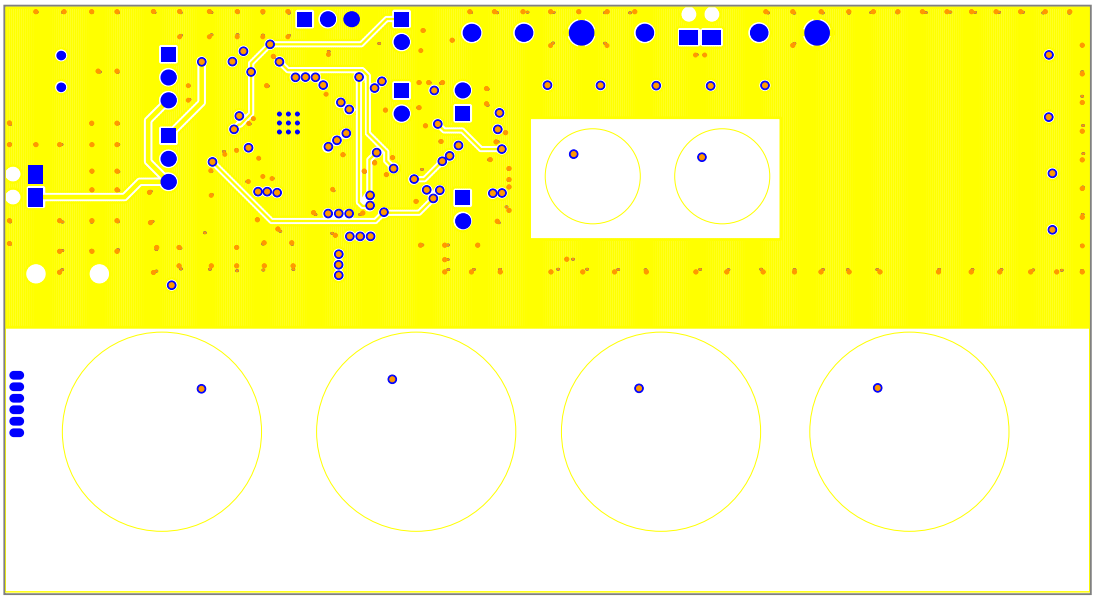

Figure 31. Layer 3 Copper

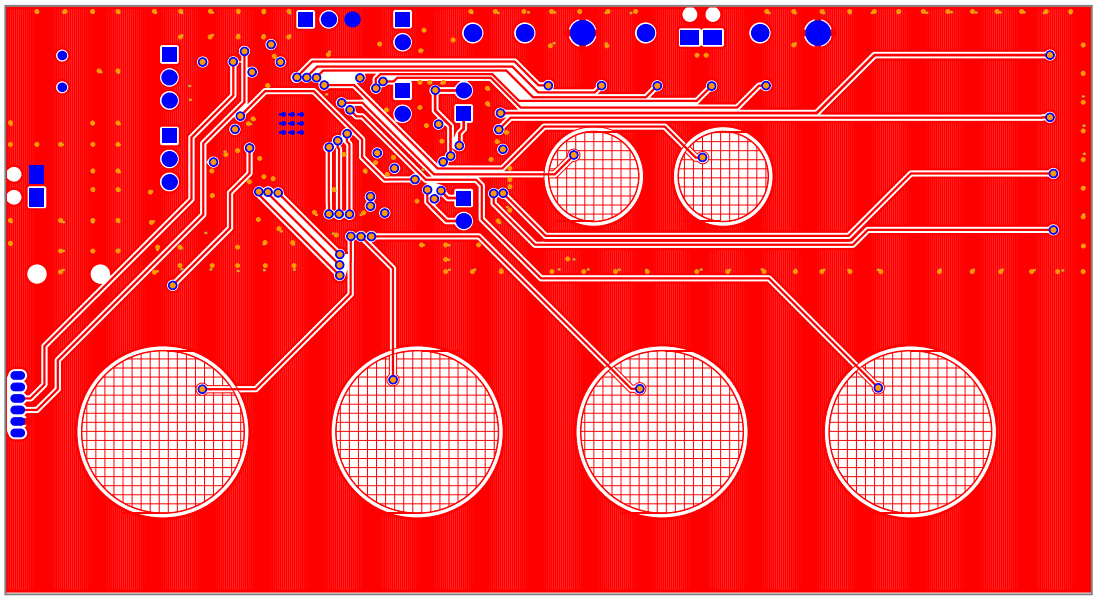

Figure 32. Bottom Copper

9 Bill of Materials

Table 7 lists the bill of materials.

Table 7. Bill of Materials

Item	MFR Part Number	QTY	Ref Designators	Vendor Part Number	Description	MFR
Semiconductors						
1	DRV2605LYZF	1	U1	DRV2605LYZF	HAPTIC DRIVER AUTO DETECT FOR LRA AND ERM WCSP9-YZF ROHS	TEXAS INSTRUMENTS
2	TXS0102DCTR	1	U4	296-21978-1	2-BIT BIDIR LEVEL TRANSLATOR SSOP8-DCT ROHS	TEXAS INSTRUMENTS
3	MSP430G2553IRHB32T	1	U2	595-P430G2553IRHB32T	MIXED SIGNAL MICRO 16KB FLASH 512B RAM QFN32-RHB ROHS	TEXAS INSTRUMENTS
4	TPS73633MDBVREP	1	U3	296-21283-1	VOLT REG 3.3V 400MA LDO CAP FREE NMOS SOT23-DBV5 ROHS	TEXAS INSTRUMENTS
5	TS5A12301EYFPR	1	U5	296-23757-1-ND	IEC LEVEL 4 ESD-PROTECTED 0.75-OHM ANALOG SWITCH WCSP6-YFP ROHS	TEXAS INSTRUMENTS
6	LTST-C190KGKT	2	5V, ACTIVE	160-1435-1-ND	LED,GREEN,2.0V,SMD0603,ROHS	LITE-ON INC.
7	LNJ037X8ARA	5	M0, M1, M2, M3, M4	LNJ037X8ARACT-ND	LED, WHITE 2.9V SMD0805 ROHS	PANASONIC
8	SML-LXT0805SRW-TR	1	B1	67-1555-1	LED, RED 2.0V SMD0805 ROHS	LUMEX OPTO
9	SML-LXT0805GW-TR	1	B2	67-1553-1	LED, GREEN 2.0V SMD0805 ROHS	LUMEX OPTO
10	SML-LXT0805YW-TR	1	B3	67-1554-1	LED, YELLOW 2.0V SMD0805 ROHS	LUMEX OPTO
11	LTST-C171TBKT	1	B4	160-1645-1-ND	LED, BLUE 3.3V SMD0805 ROHS	LITE-ON INC.
Capacitors						
12	GRM155R71C104KA88D	1	C12	490-3261-1-ND	CAP SMD0402 CERM 0.1UFD 16V X7R 10% ROHS	MURATA
13	C1005X5R1C105K050BC	2	C1, C2	445-4978-1-ND	CAP SMD0402 CERM 1.0UFD 16V 10% X5R ROHS	TDK CORP
14	C1005X5R0J104K	3	C8, C9, C10	445-1266-1	CAP SMD0402 CERM 0.1UFD 6.3V 10% X5R ROHS	TDK CORP
15	0805YD106KAT2A	1	C6	478-5165-1	CAP SMD0805 CERM 10UFD 16V X5R 10% ROHS	AVX
16	GRM155R60J105KE19D	1	C7	490-1320-1	CAP SMD0402 CERM 1.0UFD 6.3V X5R 10% ROHS	MURATA
17	C1005X5R0J104K	1	C11	445-1266-1	CAP SMD0402 CERM 0.1UFD 6.3V 10% X5R ROHS	TDK CORP
18	C0402C471K5RACTU	2	C14, C15	399-1025-1	CAP SMD0402 CERM 470PFD 50V 10% X7R ROHS	KEMET
19	TCTAL0J107M8R	1	C5	511-1498-1-ND	CAP TANT1206 100UFD 6.3V 20% TCT SERIES ROHS	ROHM
Resistors						
20	ERJ-2RKF9761X	1	R7	P9.76KLCT-ND	RESISTOR SMD0402 THICK FILM 9.76K OHMS 1/10W 1% ROHS	PANASONIC
21	RMCF0402ZT0R00	5	R8, R32, R33, R34, R36	RMCF0402ZT0R00CT	ZERO OHM JUMPER SMT 0402 0 OHM 1/16W,5% ROHS	STACKPOLE ELECTRONICS
22	RC0402FR-07511RL	5	R9, R11, R12, R13, R14	311-511LRCT-ND	RESISTOR SMD0402 THICK FILM 511 OHMS 1% 1/16W ROHS	YAGEO
23	ERJ-2GEJ152	1	R26		RESISTOR,SMT,0402,THICK FILM,5%,1/16W,1.5K	Panasonic
24	RMCF0603ZT0R00	1	R5	RMCF0603ZT0R00CT-ND	RESISTOR SMD0603 ZERO OHMS 1/10W ROHS	STACKPOLE ELECTRONICS
25	ERJ-2RKF2490X	5	R15, R16, R17, R18, R19	P249LTR-ND	RESISTOR,SMT,0402,249 OHM,1%,1/16W	Panasonic
26	CRCW04020000Z0ED	2	R40, R43	541-0.0JCT	ZERO OHM JUMPER SMT 0402 0 OHM 1/16W,5% ROHS	VISHAY
27	ERJ-2GEJ104	2	R50, R51	P100KJCT	RESISTOR SMD0402 THICK FILM 100K OHMS 1/16W 5% ROHS	PANASONIC

Table 7. Bill of Materials (continued)

Item	MFR Part Number	QTY	Ref Designators	Vendor Part Number	Description	MFR
Ferrite Beads						
28	MPZ2012S601A	2	FB1, FB2	445-2206-1	FERRITE BEAD SMD0805 600 Ohms 2A ROHS	TDK
Headers, Jacks, and Shunts						
29	LPPB061NGCN-RC	1	SBW	S9010E-06	HEADER THRU FEMALE 1X6-RA 50LS GOLD ROHS	SULLINS
30	PBC03SAAN	3	DRV, I2C, MSP	S1011E-03-ND	HEADER THRU MALE 3 PIN 100LS GOLD ROHS	SULLINS
31	PBC02SAAN	1	JP2	S1011E-02	HEADER THRU MALE 2 PIN 100LS GOLD ROHS	SULLINS
32	PBC02SAAN	3	JP1, JP3, JP4		HEADER THRU MALE 2 PIN 100LS GOLD ROHS	SULLINS
33	UX60-MB-5ST	1	USB	H2959CT	JACK USB MINIB SMT-RA 5PIN ROHS	HIROSE
34	SJ-3523-SMT	1	Audio	CP-3523SJCT-ND	JACK AUDIO-STEREO MINI(3.5MM ,3-COND SMT-RA ROHS	CUI STACK
35	SPC02SYAN	6	MSP (2-3), DRV (2-3), JP1, JP2, JP3, JP4	S9001-ND	SHUNT BLACK AU FLASH 0.100LS CLOSED TOP ROHS	SULLINS
36	1725656	2	OUT, VBAT	277-1273	TERMINAL BLOCK MPT COMBICON 2PIN 6A/125V GREEN 100LS ROHS	PHOENIX CONTACT
Test Points and Switches						
37	5011	2	GND, TP1 (Solder so that color ring is secured)	5011K	PC TESTPOINT BLACK 063 HOLE ROHS	KEYSTONE ELECTRONICS
38	5003	4	PWM, ENIN, OUT+, OUT– (Solder so that color ring is secured)	5003K	PC TESTPOINT, ORANGE, ROHS	KEYSTONE ELECTRONICS
39	NRS-2574	1	AVM1	NRS-2574	ACUTATOR VIBRATION MOTOR 1,3V 9000 RPM ROHS	SANYO
40	SEMCO1030	1	-	-	ACTUATOR - LINEAR VIBRATOR, 2VRMS	SAMSUNG
40 (1)	ELV1036	-	-	-	Alternate ACTUATOR – LINEAR VIBRATOR, 2VRMS	AAC
42	3-5-468MP	1	-	3M9724-ND	TAPE TRANSFER ADHESIVE 3" X 5YD	3M
43	2-5-4466W	1	-	3M9962-ND	TAPE POLY FOAM 2" x 5YD	3M
Components Not Assembled						
44	TestPoint_SMD-Square_2.0mm	2	LRA_OUT+,LRA_OUT–		TESTPOINT SMD SQUARE 2.0mm	
45	R0402_DNP	9	R20, R21, R22, R23, R24, R25, R30, R31, R35		R0402_DNP	
46	R0603_DNP	1	R4	RMCF0603ZT0R00CT-ND	R0603_DNP	STACKPOLE ELECTRONICS
47	R0402_DNP	1	R41	P4.99KLCT-ND	R0402_DNP	PANASONIC
48	R0402_DNP	1	R42	541-0.0JCT	R0402_DNP	VISHAY

(1) This is an alternate actuator used on the EVM.

Revision History

Changes from Original (May 2014) to A Revision	Page
• Changed C1 designator value to 1.0 µF in the schematic.	26
• Changed C1 from item 12 to item 13 in BOM.	30

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U.S. Federal Communications Commission Compliance

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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 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 its 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.

Industry Canada Compliance (English)

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.

Canada Industry Canada Compliance (French)

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.

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Important Notice for Users of EVMs Considered "Radio Frequency Products" in Japan

EVMs entering Japan are NOT certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If user uses EVMs in Japan, user is required by Radio Law of Japan to follow the instructions below with respect to EVMs:

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

http://www.tij.co.jp

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