

DRV2625 Haptics BoosterPack™ Plug-In Module

The DRV2625 Haptics BoosterPack™ kit (BOOSTXL-DRV2625) is an easy-to-use plug-in module compatible with the MSP-EXP430FR6989 LaunchPad™ development kit. SimpleLink™ microcontroller (MCU) LaunchPad development kit developers can use this BoosterPack plug-in module to start creating haptics applications using an LRA load.

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1 Introduction

The DRV2625 is a haptics 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 actuator control, quick device startup, waveform storage, and auto-resonance frequency tracking. For more information, please visit <http://www.ti.com/product/DRV2625>.

The BOOSTXL-DRV2625 BoosterPack is an evaluation platform that allows the user to assess the haptic driver with different actuators using TI's LaunchPad environment. The BoosterPack features an actuator output terminal and 4 capacitive touch buttons. Using the default program, each capacitive button has specific functions as described in [Section 4](#).

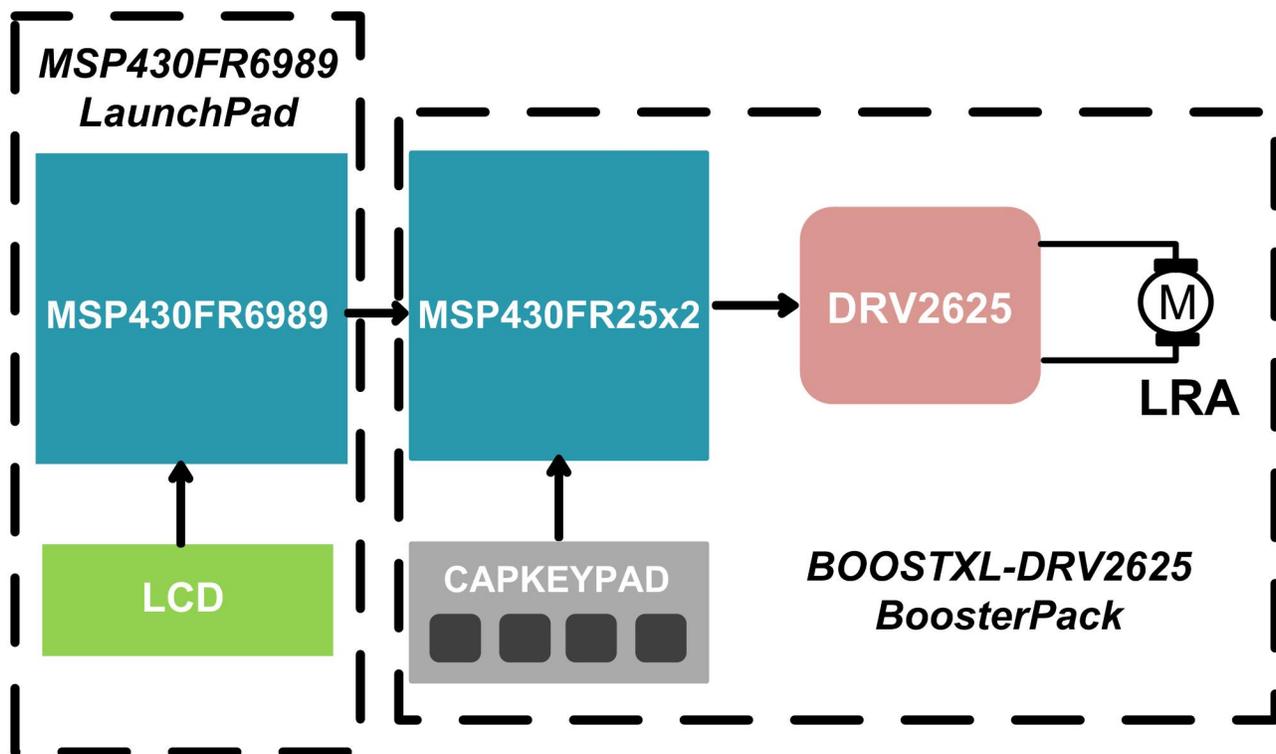


Figure 1. DRV2625 BoosterPack Block Diagram

This document contains instructions to setup and operate the DRV2625 BoosterPack with the MSP-EXP430FR6989 LaunchPad.

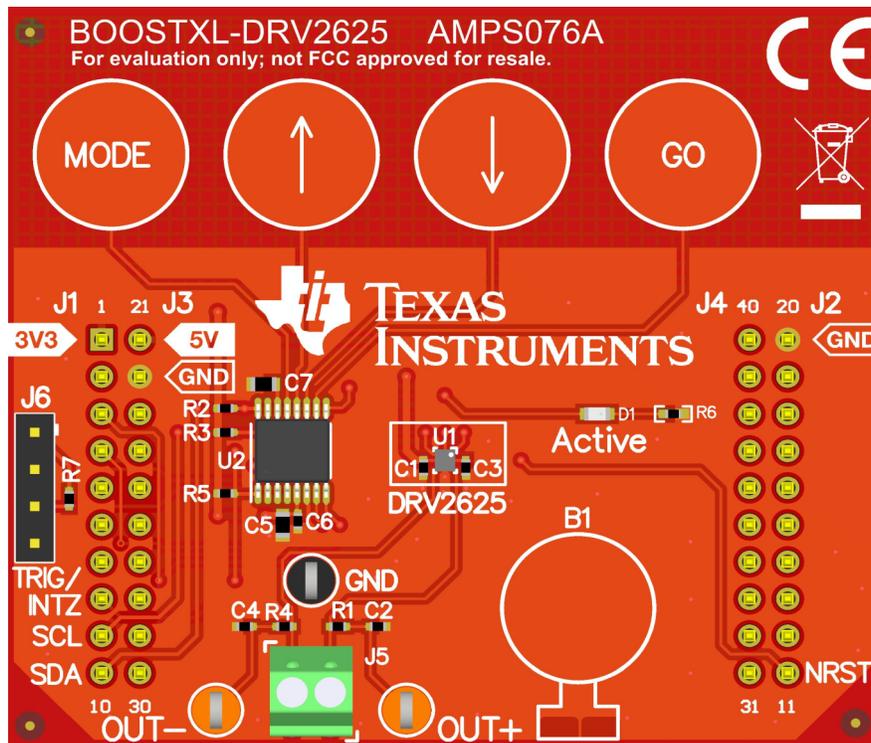


Figure 2. DRV2625 BoosterPack (3D Top View)

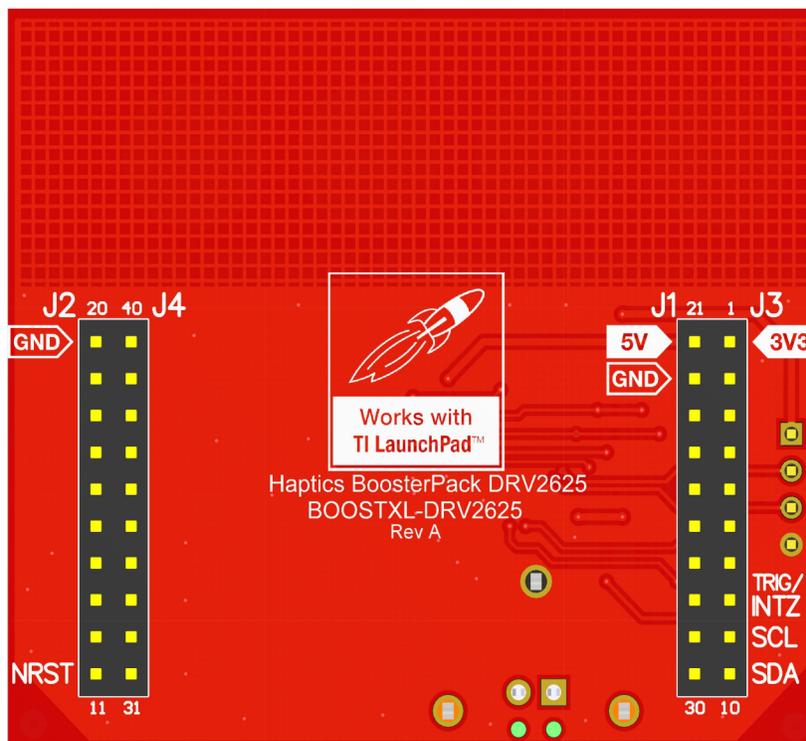


Figure 3. DRV2625 BoosterPack (3D Bottom View)

1.1 Evaluation Kit Contents

- BOOSTXL-DRV2625 board with integrated demonstration firmware

1.2 Additional Tools (not included)

- MSP-EXP430FR6989 LaunchPad Development Kit. Easy-to-use evaluation module (EVM) for the MSP40FR6989. It contains everything needed to start developing on the ultra-low-power MSP430FRx FRAM microcontroller platform, including on-board emulation for programming, debugging and energy measurements.

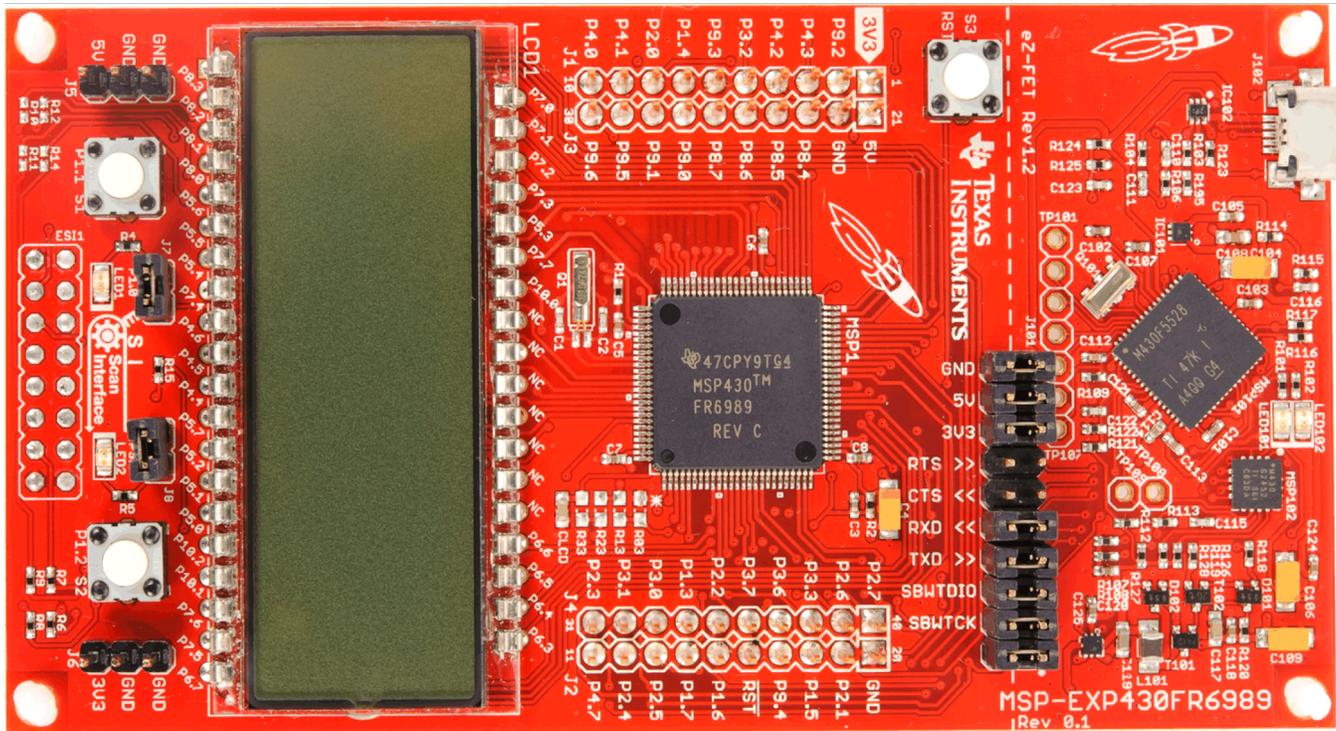


Figure 4. MSP-EXP430FR6989 LaunchPad

- MSP430 CapTIvate MCU Programmer. Comprehensive, easy-to-use platform, it features EnergyTrace™ technology to measure energy consumption with the Code Composer Studio™ IDE. It can be used to program your own firmware code in the BOOSTXL-DRV2625 board.

1.3 Required for Programming

- Code Composer Studio™ (CCS) for MSP430FR. See <http://www.ti.com/tool/ccstudio> to download Code Composer Studio™
- MSP-EXP430FR6989-DisplayDriver-Demo (Code Composer Studio Project). It will be used to configure the MSP-EXP430FR6989 LaunchPad. See the DRV2625 Haptics BoosterPack Product Folder page for details.
- BOOSTXL-DRV2625-Demo (Code Composer Studio Project). Default demo firmware of the DRV2625 Haptics BoosterPack. See the DRV2625 Haptics BoosterPack Product Folder page for details.

1.4 Additional Resources

- For more information about BoosterPacks, please visit <http://www.ti.com/tools-software/launchpads/boosterpacks/build.html>

2 Getting Started

2.1 Quick Start Steps

1. Program the LaunchPad board as described in [Section 2.4.1](#).
2. If the BoosterPack firmware needs to be modified, program it as described in [Section 2.4.2](#).
3. Connect the BoosterPack to the LaunchPad as described in [Section 3](#).
4. Connect the LaunchPad to the PC with the help of a micro-USB to USB cable.
5. The BoosterPack is ready to use. For details about the BoosterPack Modes, see [Section 5](#).

2.2 DRV2625 BoosterPack Overview

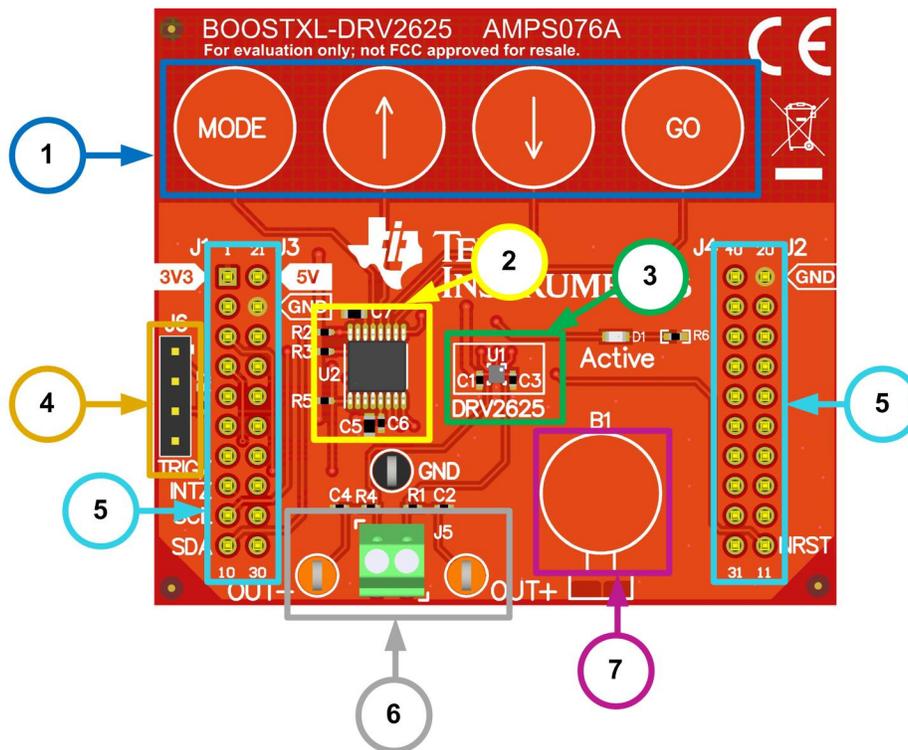


Figure 5. BoosterPack Overview

All the sections of the DRV2625 BoosterPack are separated in 7 sections in the picture above. All the functions are described in [Table 1](#) below:

Table 1. Function Descriptions

Marker	Section Name	Function Description
1	Capacitive touch buttons	The DRV2625 BoosterPack features 4 capacitive touch buttons which are used to enable or disable the features of the DRV2625 device. The buttons functions are described in Section 4 .
2	MSP430FR2512	Microcontroller used as interface between the touch buttons and the DRV2625.
3	DRV2625	Haptics driver that controls the LRA load.
4	Programming pins	In case the demo firmware needs to be modified. The DRV2625 BoosterPack features 4 programming pins that can be used with the MSP430 CapTivate MCU Programmer (not included).

Table 1. Function Descriptions (continued)

Marker	Section Name	Function Description
5	Board pins	The 40 pins included in this board are used to connect the MSP-EXP430FR6989 LaunchPad with the DRV2625 BoosterPack. These pins include the functions of power on/off the DRV2625, place it in shutdown mode (NRST pin) and provide an interrupt signal (TRIG/INTZ) from it. The pins map is described in Section 2.3 .
6	Actuator terminal and test points	The LRA load must be connected to the terminal J5 for a proper usage. Since the OUT- and OUT+ test points include a low pass filter, they can be used for measuring purposes.
7	LRA space	The LRA load can be glued to this space for its evaluation.

2.3 Pinout

Only 10 pins are connected from the MSP-EXP430FR6989 LaunchPad to the BoosterPack. Pins 1, 3, 4, 8, 9, 10, 11, 20, 21 and 22, which are highlighted in green in table 2, allow the communication between the two boards.

Pins 1 (3.3V), 20 (GND), 21 (5V) and 22 (GND) are used to power on the BoosterPack. The 3.3V from pin 1 are connected to the MSP430FR2512 power supply pin (DVCC). The 5V from pin 21 are connected to the power supply pin of the DRV2625.

Pins 3 (UART_RX) and 4 (UART_TX) are connected to allow the serial communication from the MSP-EXP430FR6989 to the MSP430FR2512.

Pin 8 (TRIG/INTZ) can be used either as interrupt signal which comes from the DRV2625. This pin alerts the host processor (MSP-EXP430FR6989 in this case) of a critical condition such an over-current or over-temperature event.

Pins 9 and 10 (SCL and SDA respectively) are the I2C communication pins. These pins allow the connection between the LaunchPad and the BoosterPack. The MSP-EXP430FR6989 would work as the master device, and the MSP430FR2512 and the DRV2625 as the slave devices.

Finally, the pin 11 (NRST) is the DRV2625 reset pin. This pin is connected directly to the BoosterPack and LaunchPad microcontrollers so the user can reset the registers with either the BoosterPack or the LaunchPad.

The rest of pins that are not highlighted in green can be connected to another board if required. The MSP-EXP430FR6989 LaunchPad can be programmed to configure these pins according to the users' needs.

Table 2. Jx Pins Functions

J1 Pins	Function	J2 Pins	Function	J3 Pins	Function	J4 Pins	Function
1	3.3V	11	NRST	21	5V	31	GPIO
2	Analog in	12	SPI CS / GPIO	22	GND	32	GPIO
3	UART_RX	13	SPI CS / GPIO	23	Analog In	33	GPIO
4	UART_TX	14	SPI MISO	24	Analog In	34	GPIO
5	GPIO	15	SPI MOSI	25	Analog In	35	Timer/GPIO
6	Analog In	16	RST	26	Analog in	36	Timer/GPIO
7	SPI_CLK	17	GPIO	27	Analog In/I2S WS	37	PWM/GPIO
8	TRIG/INTZ	18	GPIO	28	Analog In/I2S SCLK	38	PWM/GPIO
9	SCL	19	PWM/GPIO	29	Analog In/I2S Dout	39	PWM/GPIO
10	SDA	20	GND	30	Analog In/I2S Din	40	PWM/GPIO

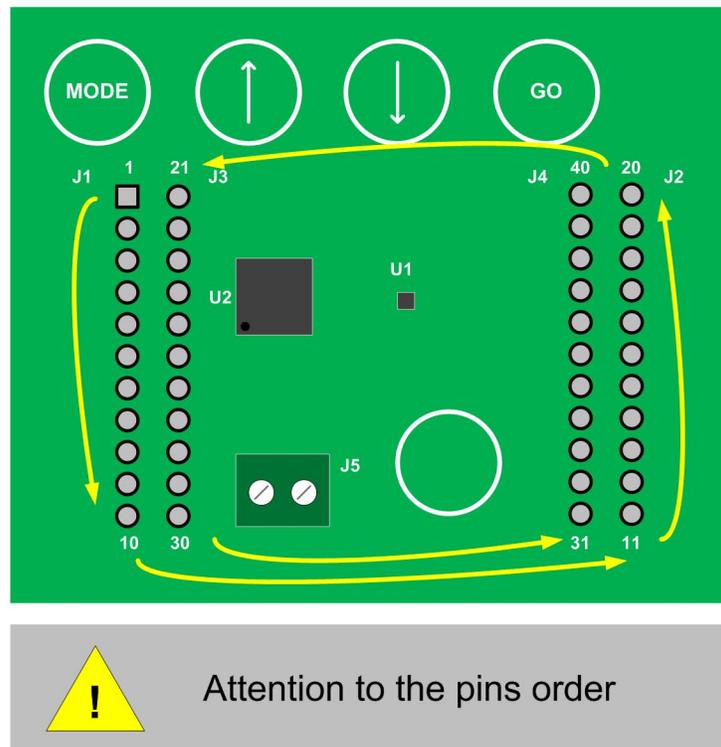


Figure 6. Pins Map

2.4 Programming

2.4.1 MSP-EXP430FR6989 LaunchPad

The MSP-EXP430FR6989 is a rapid prototypic simplified by the 40-pin BoosterPack™ Plug-in Module headers, which support a wide range of available BoosterPacks. Each BoosterPack requires of a proper Firmware code to work.

When it is used with the DRV2625 Haptics BoosterPack, it is necessary to configure the MSP-EXP430FR6989 using the MSP-EXP430FR6989-DisplayDriver-Demo (Code Composer Studio Project) with the help of Code Composer Studio.

See DRV2625 Haptics BoosterPack Product Folder page to download the Demo Code.

See [MSP430FR6989 LaunchPad™ Development Kit \(MSP EXP430FR6989\) User's Guide](#) for details about how to use and configure the LaunchPad and Code Composer Studio.

When the LaunchPad is correctly configured and connected to the PC through the micro-USB cable, the message “DRV26X” should be displayed in the LCD.

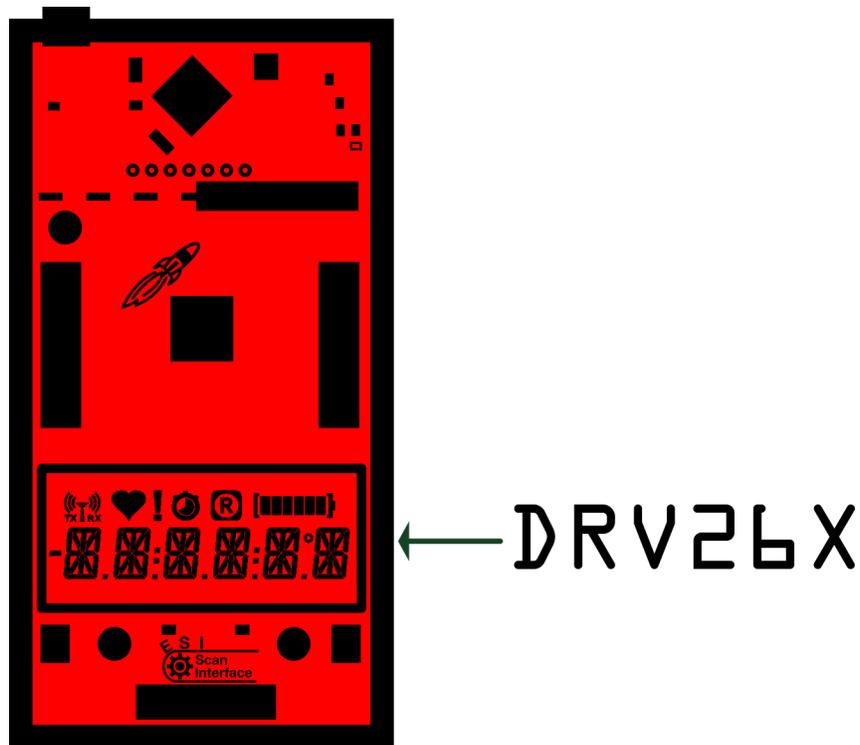


Figure 7. LCD DRV26X Text

2.4.2 BOOSTXL-DRV2625 BoosterPack (Advanced).

The BoosterPack has a preconfigured and ready-to-use demo firmware. However, for cases where it is required a different firmware for evaluation purposes or the demo firmware needs to be programmed again, it is possible to configure it with the help of the MSP430 CapTIvate MCU Programmer and Code Composer Studio.

See [MSP430 CapTIvate MCU Programmer Product Folder](#) for details about this tool.

For more details about the demo firmware programming, see Appendix A [Section 9](#).

3 Assembling System

The DRV2625 Haptics BoosterPack is designed to work with the MSP-EXP430FR6989 LaunchPad. Before powering up, begin by assembling the two board system by aligning the 40 connectors on the bottom of the DRV2625 Haptic BoosterPack to the 40 pins on top of the LaunchPad. Make sure you plug in the J1 column connectors on the back of the DRV2625 Haptic BoosterPack to the J1 column pins on the front of the MSP-EXP430FR6989 LaunchPad. This will align all pins. After aligning, plug the boards into one another. Refer to [Figure 8](#) below for more details.

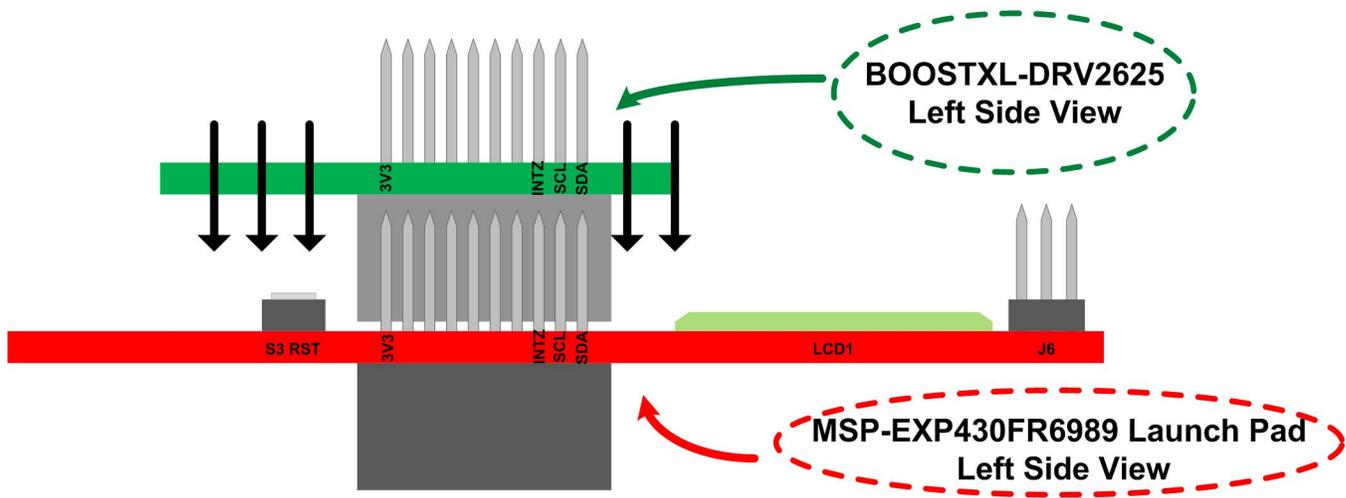


Figure 8. Assembling Boards

The LRA load to be tested can be glued to the LRA space section. Then, the PCB will work as the LRA mass. Once the LRA is fixed in the LRA space section, it must be connected to the actuator terminal. The BoosterPack is now ready to be powered on.

4 Capacitive Touch Buttons

Once the boards are aligned and plugged, and the LRA load is connected, the MSP-EXP430FR6989 LaunchPad can be connected to the PC through a micro-USB cable. The LaunchPad will be powered on and enabled immediately. Consequently, the BoosterPack will be energized and initialized with the default configuration.

The MSP430FR2512 microcontroller on the BoosterPack can be used now to interpret the touch buttons being pressed.

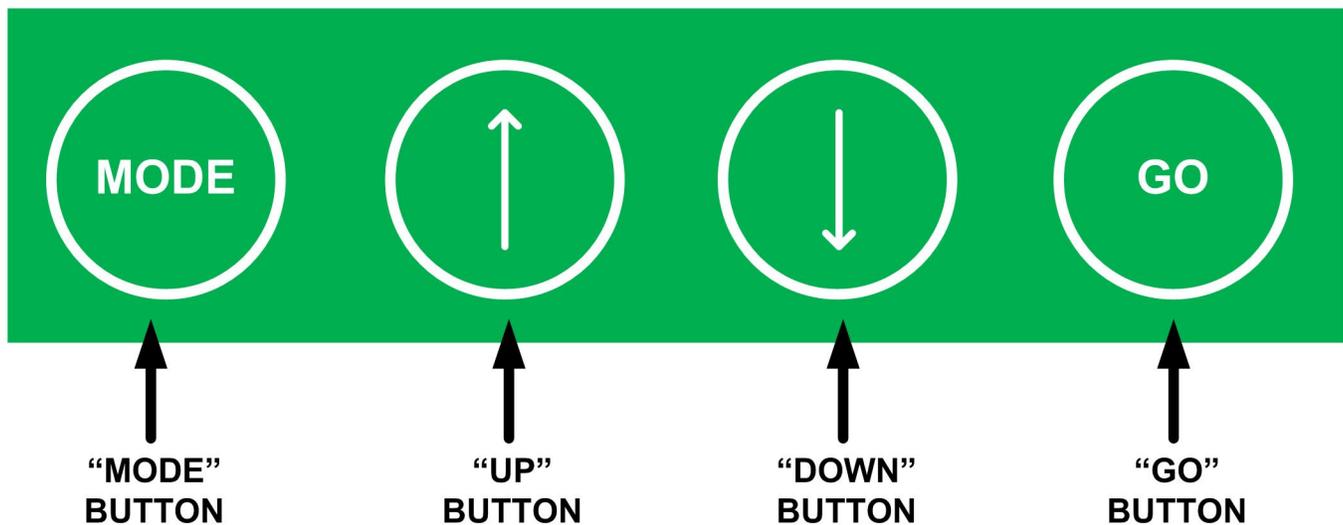


Figure 9. Capacitive Touch Buttons

The touch buttons functions are described below:

- **MODE Button.** This capacitive touch button is used to change from one mode to another. The BoosterPack features three modes: Demo, Auto-Calibration and Off modes. Once the BoosterPack is powered up, it enters in Demo mode. These modes are described in [Section 5](#).
- **UP and DOWN Buttons.** In Demo Mode, there are many sub-options that the user can select with the help of the UP and DOWN arrows buttons. These sub-options are effects that the DRV2625 can create on the LRA load.
 - Short Double Sharp Tick
 - Strong Buzz
 - Sharp Tick
 - Strong Click
 - Transition Click

These effects that the Demo Mode supports are described with its respective waveform in [Section 7](#).

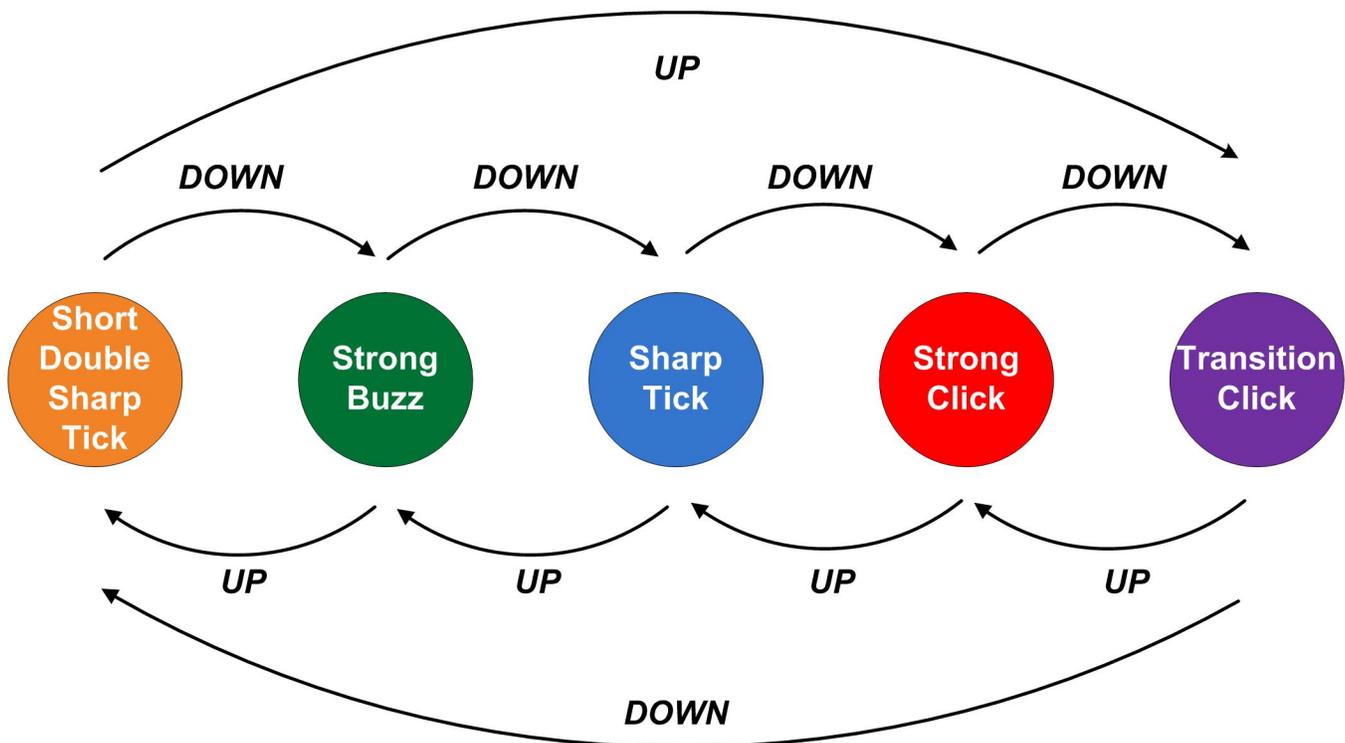


Figure 10. Effects Transitions

The last effect used before the BOOSTXL-DRV2625 board is powered down will be selected once the board is powered on. The user can select any of these sub-options with the help of the UP/DOWN buttons. If the DOWN button is pressed while the Sharp Tick is selected, the selected effect will be now the Strong Click. If the DOWN buttons is pressed again, the Transition Click effect will be selected.

UP and DOWN buttons do not have any effect in Auto-Calibration nor Off modes.

- GO Button. Once the Demo mode and its respective effect is selected or once the Auto-Calibration Mode is selected, the GO button can be pressed to start the selected effect or the Auto-Calibration routine. This button does not have any effect in the Off mode.

The BoosterPack also includes a LED (D1) marked as Active in the PCB board that blinks when a touch button is pressed. This LED indicates that the MSP430FR2512 detected a press event in the capacitive buttons.

5 BoosterPack Modes Description

5.1 Demo Mode

This is the main mode in the BoosterPack and it is selected as default mode once the device is powered on. The purpose of this mode is to test many of the most common waveforms that the DRV2625 effects library contains: Short Double Sharp Tick, Strong Buzz, Sharp Tick, Strong Click and Transition Click. This mode allows using any of these effects and evaluating its behavior in the LRA load. The LCD in the LaunchPad board will show the following words according to the selected effect.

- Short Double Sharp Tick → “DBLTCK”
- Strong Buzz → “BUZZ”
- Sharp Tick → “TICK”
- Strong Click → “CLICK”
- Transition Click → “TRNCLK”

The user can select the effects with the help of the UP and DOWN buttons. Once one of these buttons is pressed, the MSP430FR2512 configures the DRV2625 to prepare the selected effect. When the user presses the GO button, the MSP430FR2512 writes '1' to the GO bit of the DRV2625 (Register Address 0x0C; Bit 0). This particular bit fires the selected waveform.

For more details about the DRV2625 Registers Map, please consult the [DRV2625 data sheet](#).

5.2 Auto-Calibration Mode

It is always recommended to use the auto-calibration mode when the DRV2625 is powered on. This mode allows the DRV2625 determining the best parameters to handle the connected LRA load.

In order to access to this mode, the user must press once the MODE button after the device is powered on. The word "AUTCAL" will be shown in the LCD of the LaunchPad when the auto-calibration mode is selected.

The GO button will start the auto-calibration mode. If the LRA is connected and fixed in the PCB correctly, it will be activated few seconds. During this time, the DRV2625 will configure the appropriate LRA frequency and the rest of the parameters to control the LRA load.

During this mode, the UP and DOWN buttons do not have any effect.

5.3 Off Mode

This mode places the DRV2625 in standby state. Any attempt to enable the device with the UP, DOWN, and GO buttons does not have any effect in the DRV2625. The LCD in the LaunchPad board will show the word "OFF" when this mode is selected.

The device will be enabled again until the MODE button is pressed again. If the MODE button is pressed once, the Demo mode will be selected. If it is pressed one more time, the device is configured in Auto-Calibration mode.

6 Additional BoosterPacks

The TI LaunchPad system allows you to purchase multiple BoosterPacks to add additional features to your system such as Wi-Fi and Bluetooth capability. For more information on BoosterPacks, please visit <http://www.ti.com/byob>.

The DRV2625 Haptic BoosterPack is designed to be compatible with the CC3120 BoosterPack which allows the system to have Sub- 1GHZ, Bluetooth®, and Wi-Fi® capability. For more information on how to interface using the CC3120 BoosterPack, please visit <http://www.ti.com/tool/cc3120boost>.

For more information about BoosterPacks, please visit <http://www.ti.com/tools-software/launchpads/boosterpacks/build.html>.

7 Waveforms

Short Double Sharp Tick



Figure 11. Short Double Sharp Tick Waveform

Strong Buzz

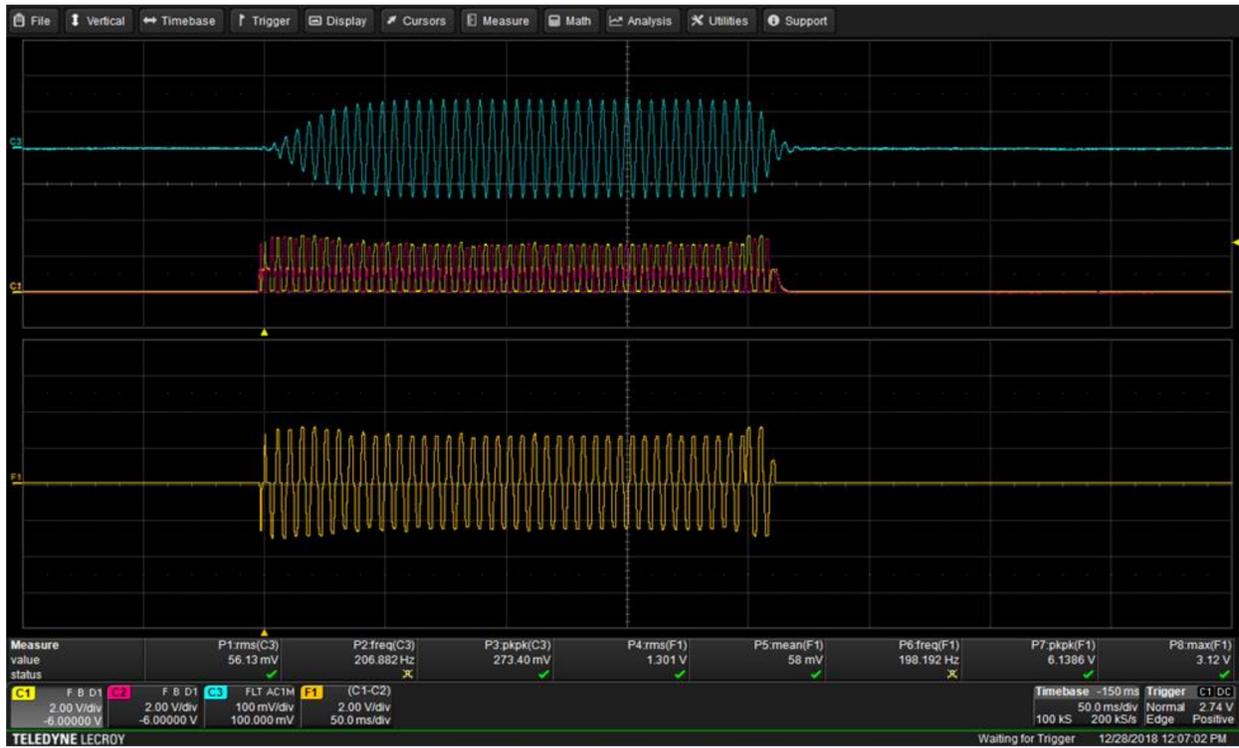


Figure 12. Strong Buzz Waveform

Sharp Tick



Figure 13. Sharp Tick Waveform

Strong Click



Figure 14. Strong Click Waveform

Transition Click

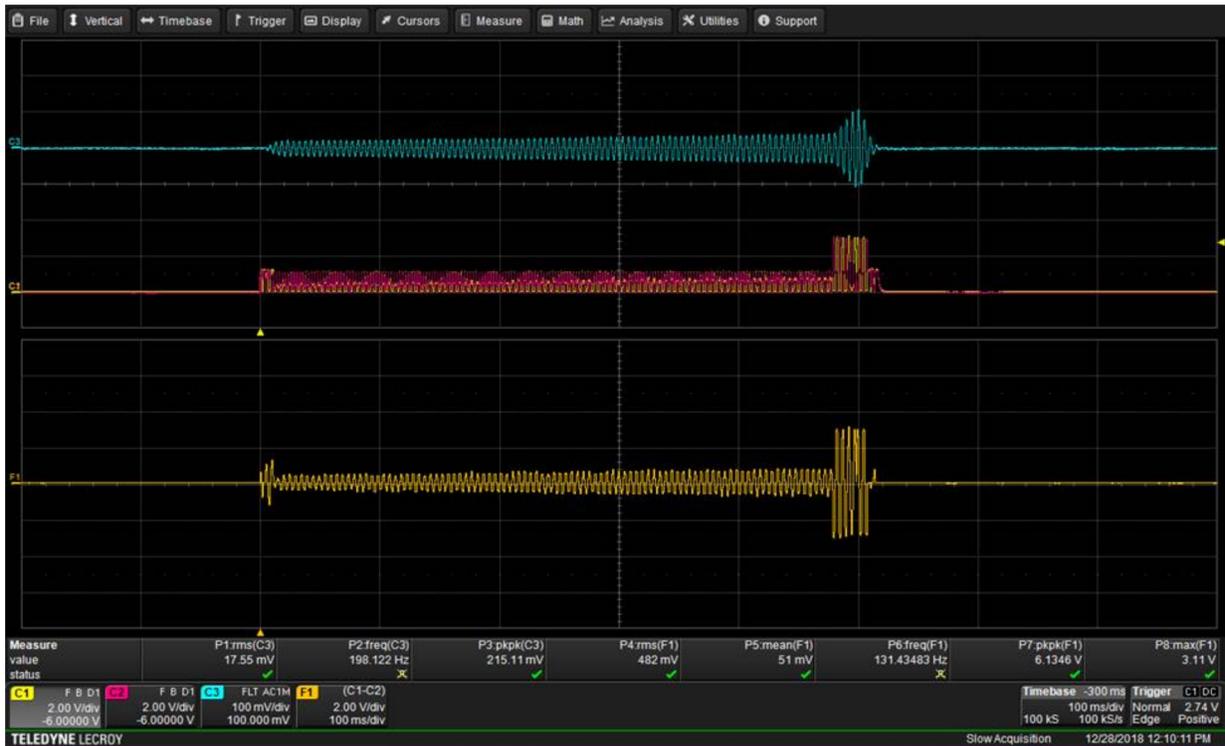


Figure 15. Transition Click

8 Schematic, Board Layers, and Bill of Materials

8.1 Schematic

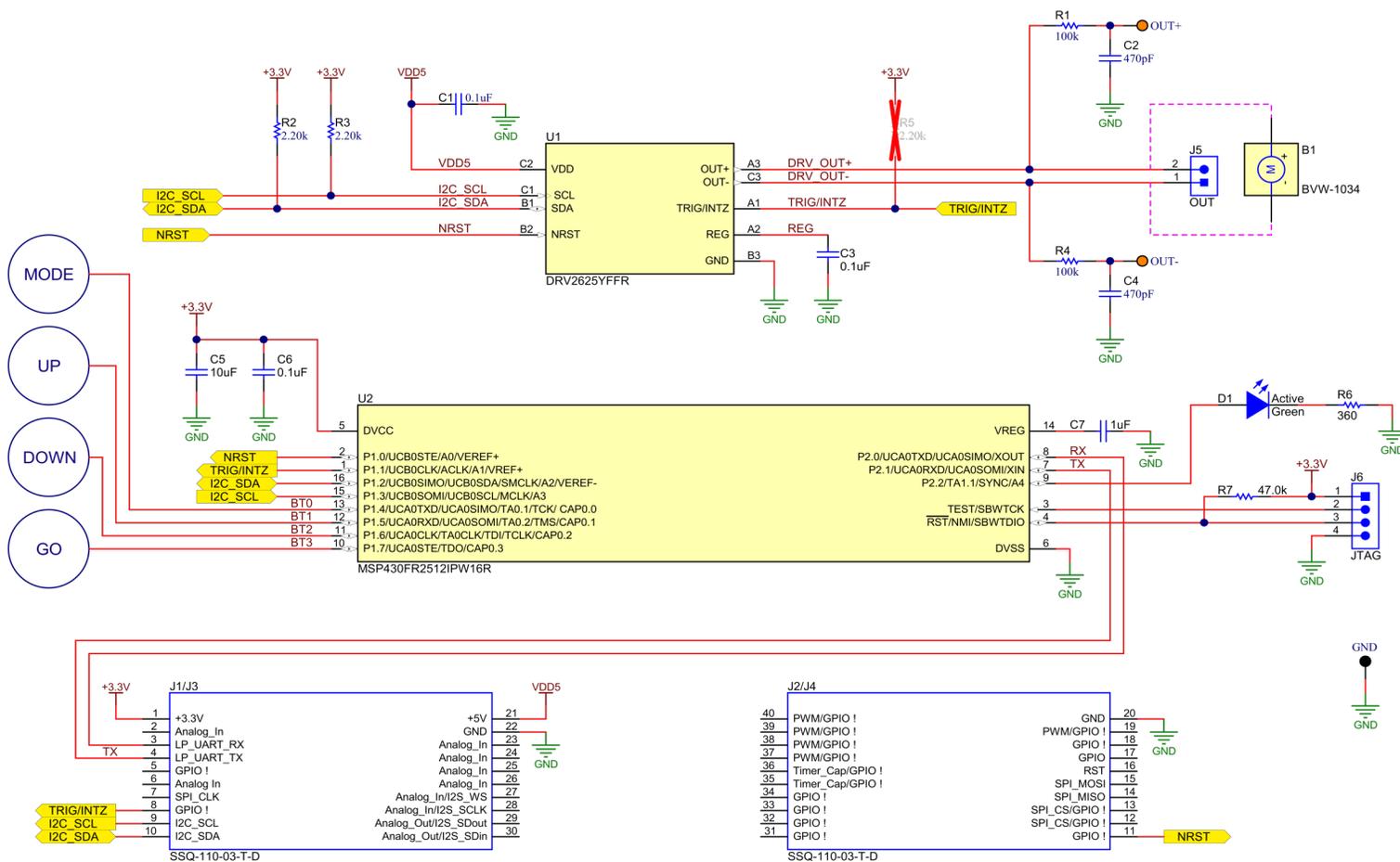


Figure 16. DRV2625 BoosterPack Schematic

8.2 PCB Layers

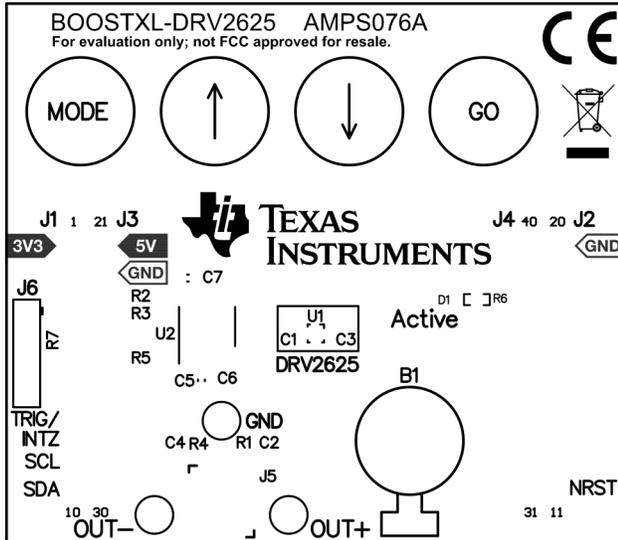


Figure 17. Top Overlay

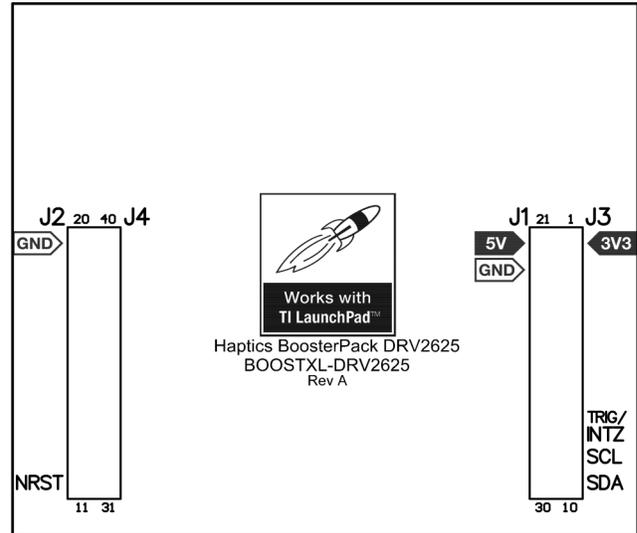


Figure 18. Bottom Overlay

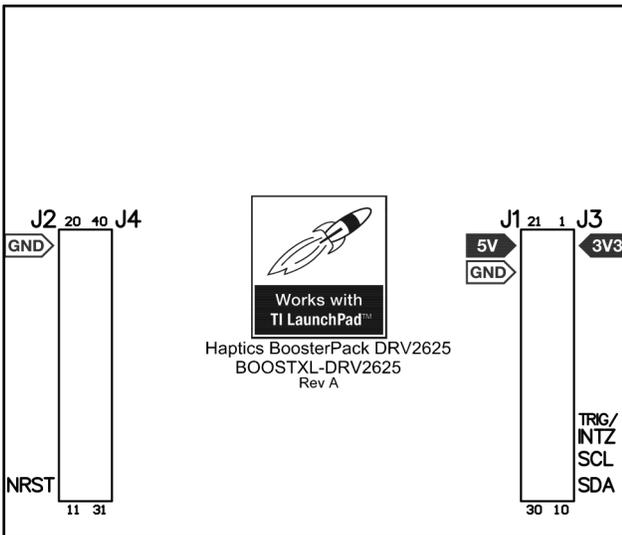


Figure 19. Top Layer

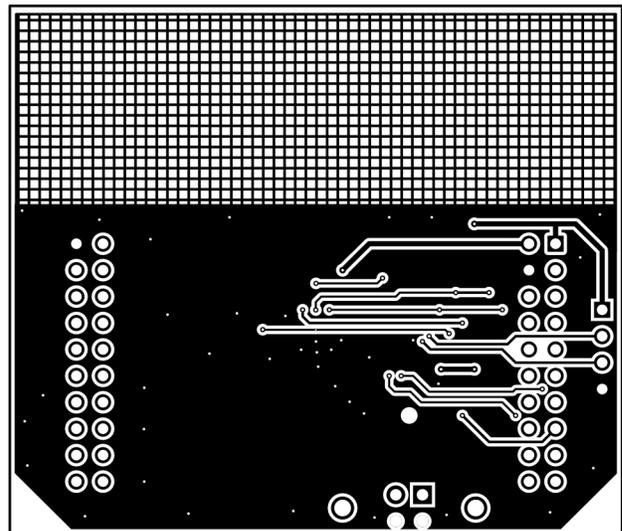


Figure 20. Bottom Layer

8.3 Bill of Materials

Table 3. Bill of Materials

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer
!PCB	1		Printed Circuit Board		AMPS057	Any
B1	1		Vibrator, 205 Hz. SMT	Dia 10mm	BVW-1034	Bluecom Co. Ltd
C1, C3, C6	3	0.1µF	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 0402	0402	C1005X7R1H104K050BB	TDK
C2, C4	2	470pF	CAP, CERM, 470 pF, 25 V, +/- 5%, COG/NP0, 0402	0402	GRM1555C1E471JA01D	MuRata

Table 3. Bill of Materials (continued)

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer
C5	1	10µF	CAP, CERM, 10 uF, 6.3 V, +/- 20%, X5R, 0603	0603	GRM188R60J106ME47D	MuRata
C7	1	1µF	CAP, CERM, 1 uF, 10 V, +/- 10%, X5R, 0603	0603	GRM188R61A105KA61D	MuRata
D1	1	Green	LED, Green, SMD	1.6x0.8mm	LTST-C193KGKT-5A	Lite-On
GND	1		Test Point, Compact, Black, TH	Black Compact Testpoint	5006	Keystone
J1/J3, J2/J4	2		Receptacle, 2.54mm, 10x2, Tin, TH	10x2 Receptacle	SSQ-110-03-T-D	Samtec
J5	1		Terminal Block, 100mil, 2x1, 6A, 63V, TH	6.2x8.5x5.54 mm	1725656	Phoenix Contact
OUT+, OUT-	2		Test Point, Compact, Orange, TH	Orange Compact Testpoint	5008	Keystone
R1, R4	2	100k	RES, 100 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW0402100KFKED	Vishay-Dale
R2, R3	2	2.20k	RES, 2.20 k, 0.1%, 0.0625 W, AEC-Q200 Grade 0, 0402	0402	ERA2AEB222X	Panasonic
R6	1	360	RES, 360, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	0402	ERJ-2GEJ361X	Panasonic
R7	1	47.0k	RES, 47.0 k, 1%, 0.0625 W, 0402	0402	RC0402FR-0747KL	Yageo America
U1	1		Advanced ERM & LRA Haptics Driver with Smart Loop and Embedded Effects Library, YFF0009AHAN (DSBGA-9)	YFF0009AHAN	DRV2625YFFR	Texas Instruments
U2	1		Capacitive Touch Sensing Mixed-Signal Microcontroller, PW0016A (TSSOP-16)	PW0016A	MSP430FR2512IPW16R	Texas Instruments
FID1, FID2, FID3	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A
J6	0		Header, 2.54 mm, 4x1, Gold, TH	Header, 2.54 mm, 4x1, TH	PBC04SAAN	Sullins Connector Solutions
R5	0	2.20k	RES, 2.20 k, 0.1%, 0.0625 W, AEC-Q200 Grade 0, 0402	0402	ERA2AEB222X	Panasonic

9 BoosterPack Demo Firmware Programming

Taking as example the Demo Firmware configuration, the following procedure is used to program the DRV2625 BoosterPack with the CapTlvate Programming Tool.

1. Connect the CapTlvate MCU Programmer to the BOOSTXL-DRV2625 board.

Pins 9, 10, 18 and 19 from the J301 component of the CapTlvate MCU Programmer are required to configure the BoosterPack. These pins must be connected to the 4 pins of the J6 component of the BoosterPack. Use [Table 4](#) as a reference:

Table 4. CapTlvate Programmer and BoosterPack Pins Connection

CapTlvate MCU Programmer (J301)	BOOSTXL-DRV2625 (J6)
SBWTCK_TST (pin 10)	SBWTCK (pin 2)
SBWTDIO_RST (pin 9)	SBWTDIO (pin 3)
3.3V (pin 18)	3.3V (pin 1)
GND (pin 19)	GND (pin 4)

For more details about the BOOSTXL-DRV2625 pins, see [Section 8.1](#) of this user's guide.

For details about the CapTlvate MCU Programmer, see [Hardware Section of the CapTlvate-PGMR Guide](#).

2. Connect the CapTlvate MCU Programmer to the PC.

Use a micro-USB cable to connect the programmer to the PC. The required drivers must be installed once the device is powered up.

3. Download the Demo Firmware and Open it with Code Composer Studio (CCS).

In the BOOSTXL-DRV2625 Haptics LaunchPad product folder, download the Code Composer Studio project called "BOOSTXL-DRV2625-Demo". This project contains the demo firmware that can be opened in CCS.

Open this folder with the help of Code Composer Studio (a new work workspace should be created). Build the project and load the code. If it is the first time that the programmer is used, additional time could be required to configure or update the CapTIvate MCU Programmer Firmware.

Once CCS finishes loading the code, the BOOSTXL-DRV2625 will be ready to be used with the MSP-EXP430FR6989 LaunchPad.

STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an "EVM" or "EVMs") to the User ("User") in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.
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 - 2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.
 - 2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.
 - 2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

WARNING

Evaluation Kits are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.

User shall operate the Evaluation Kit within TI's recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI's recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI's instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGRADATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3 Regulatory Notices:

3.1 United States

3.1.1 Notice applicable to EVMs not FCC-Approved:

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

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

CAUTION

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

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

FCC Interference Statement for Class A EVM devices

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

FCC Interference Statement for Class B EVM devices

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

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

3.2 Canada

3.2.1 For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

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

Concerning EVMs Including Detachable Antennas:

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

Concernant les EVMs avec antennes détachables

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

3.3 Japan

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

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

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

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

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

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2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

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東京都新宿区西新宿 6 丁目 2 4 番 1 号
西新宿三井ビル

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

3.4 European Union

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

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

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- 4 *EVM Use Restrictions and Warnings:*
 - 4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.
 - 4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.
 - 4.3 *Safety-Related Warnings and Restrictions:*
 - 4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.
 - 4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.
 - 4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.
 5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.
 6. *Disclaimers:*
 - 6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.
 - 6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.
 7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.
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8. *Limitations on Damages and Liability:*

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

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

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

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

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