

## **EVM430-FR6989 Evaluation Kit**

The EVM430-FR6989 Evaluation Kit is designed to demonstrate and provide a development platform for the new Extended Scan Interface (ESI or E-ScanIF) on the MSP430FR6989. The main board of the evaluation kit provides basic user interface such as LCD, LEDs, and buttons for user interaction. The functionality of the ESI is customizable by designing a daughter board. An LC sensor board is included in the evaluation kit for demonstrating the rotation detection using LC sensors. The main board also provides RF module connectors to extend the function of the board for wireless connectivity.

**Contents**

1	Overview .....	3
2	Main Board .....	7
3	LC Sensor Board .....	12
4	Motor Board .....	13
5	Loading Example Code to the EVM .....	15
6	References .....	16
7	Appendix.....	16

**List of Figures**

1	EVM430-FR6989 .....	3
2	Main Board .....	4
3	LC Sensor Board .....	5
4	Motor Board .....	6
5	Main Board Layout.....	7
6	Motor Board Layout .....	13
7	Control Rotating Direction in Manual Mode.....	14
8	EVM Fixture Dimensions .....	16

**List of Tables**

1	Jumper Setting for Powering From EZ-FET for Energy Tracing.....	8
2	Jumper Setting for Powering From USB Power Circuit.....	8
3	EZ-FET Jumper Connection for Programming Target MCU .....	9
4	LCD Voltage Generator Configuration.....	10
5	RF Connector Pin Configuration .....	11
6	PORT_9/ESI Pin Configuration.....	12
7	GPIO Configuration .....	12
8	Components Used for Different LC Sensor Configuration .....	12
9	LC Sensor Component Example .....	13
10	Motor Board Power Source Jumper Setting .....	13
11	Motor Board External Power Pin Setting.....	13
12	I <sup>2</sup> C Connections Between the Main Board and the Motor Board .....	14
13	Motor Board I <sup>2</sup> C Write Command .....	14
14	Write Command .....	15
15	Motor Board I <sup>2</sup> C Read Command .....	15
16	Connection for Downloading Firmware to the Motor Board .....	15

## 1 Overview

The EVM430-FR6989 Evaluation Kit consists of three boards:

- Main board
- Motor board with a PCB wheel attached
- LC sensor board

Developers can design their own sensor boards to support different kinds of sensors that make use of the ESI module such as optical sensors, GMR sensors, and Hall Effect sensors.

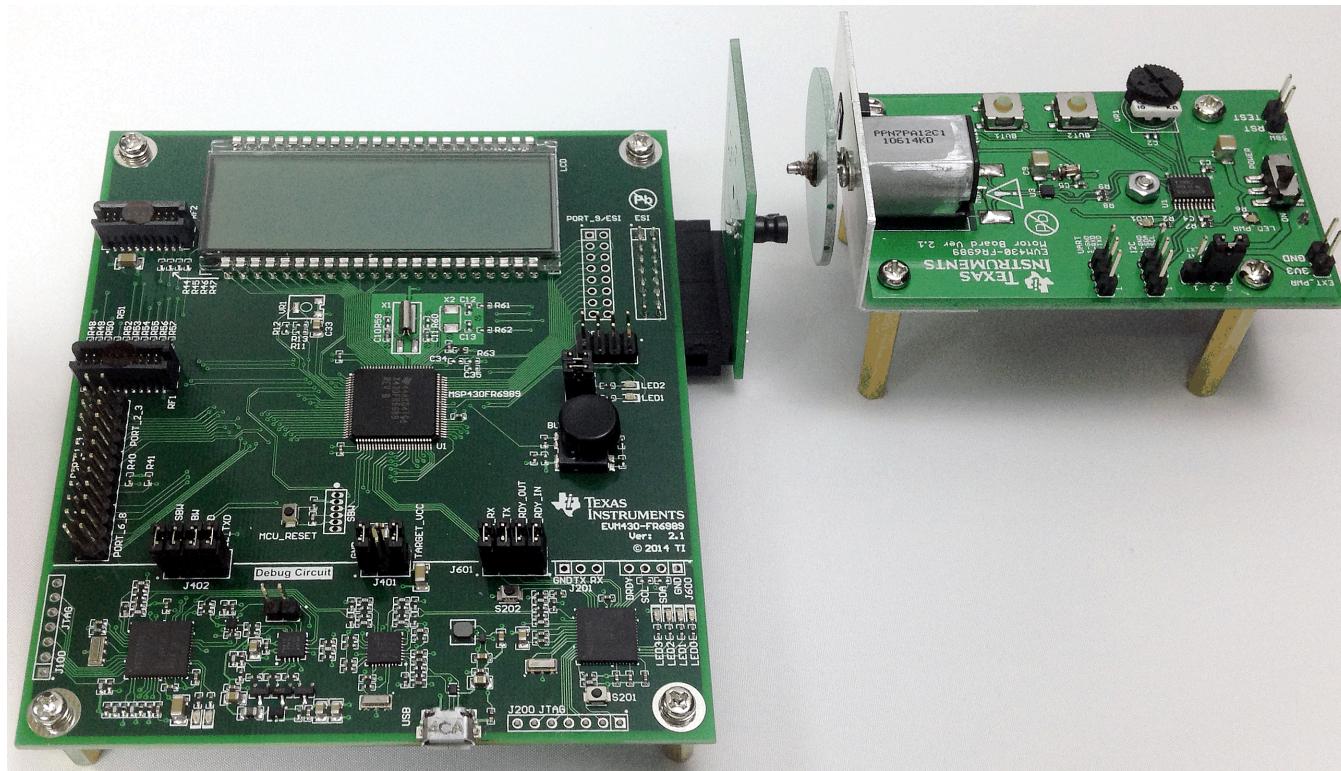
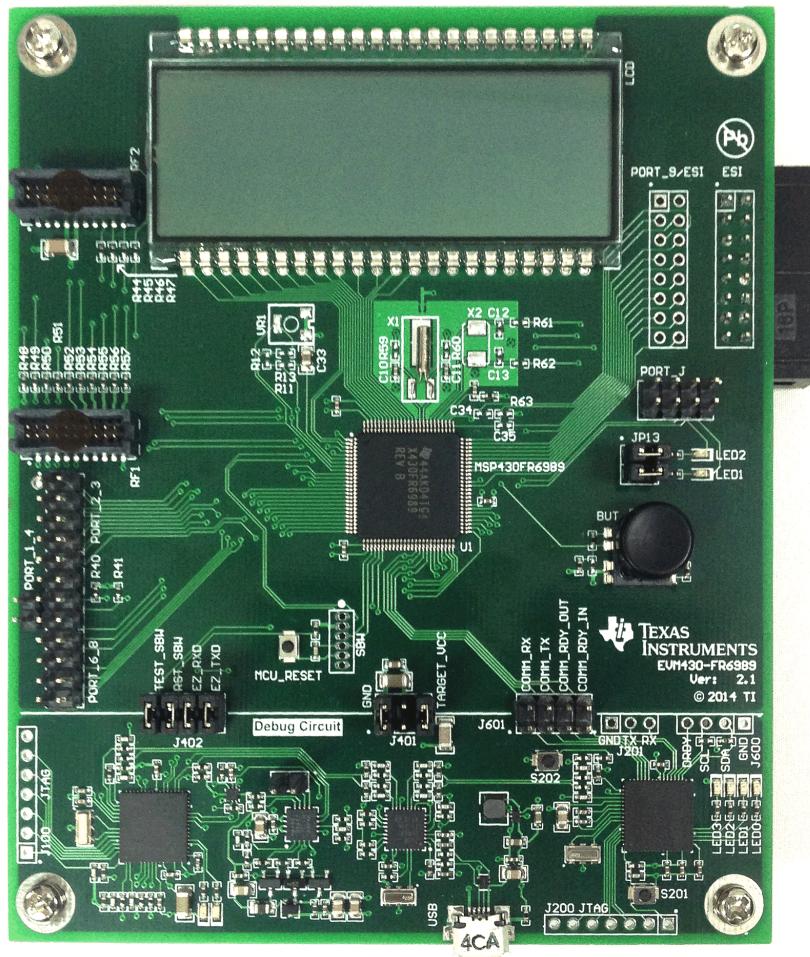


Figure 1. EVM430-FR6989

## 1.1 Main Board

- Powered by MSP430FR6989 mixed-signal microcontroller
- Provides basic UI such as LCD, LEDs, and buttons
- ESI port for external sensor board
- RF connector for wireless modules such as CC112xEM
- GPIO pins routed on the board for debugging or user development
- On board EZ-FET
  - For programming and debugging for the MSP430FR6989
  - Support energy tracing
  - UART communication between MSP430FR6989 and PC through USB cable
- USB communication bridge for PC GUI.



**Figure 2. Main Board**

## 1.2 LC Sensor Board

- For rotation detection using LC sensors
- Different LC sensor configurations are supported:
  - Two sensors (90-degree separation, default)
  - Two sensors (45-degree separation)
  - Three sensors
  - Four sensors



Figure 3. LC Sensor Board

### 1.3 Motor Board

- MSP430G2553 is used for motor control.
- A dc motor is driven by motor driver DRV8837.
- The attached PCB wheel on the motor is used for rotation detection.
- Adjustable motor speed by turning the onboard variable resistor
- Adjustable motor speed by sending commands through the I<sup>2</sup>C port
- Supports bidirectional rotation
- Customizable firmware of the MSP430G2553 through SBW connector

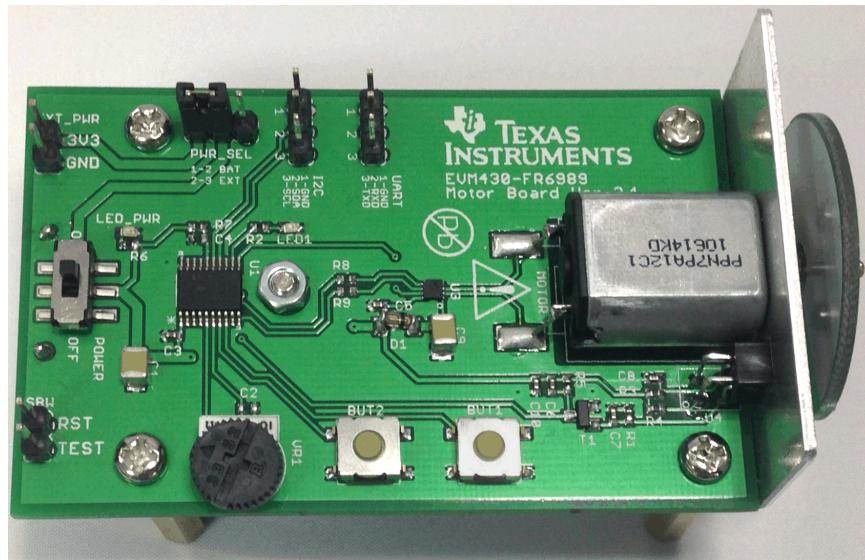


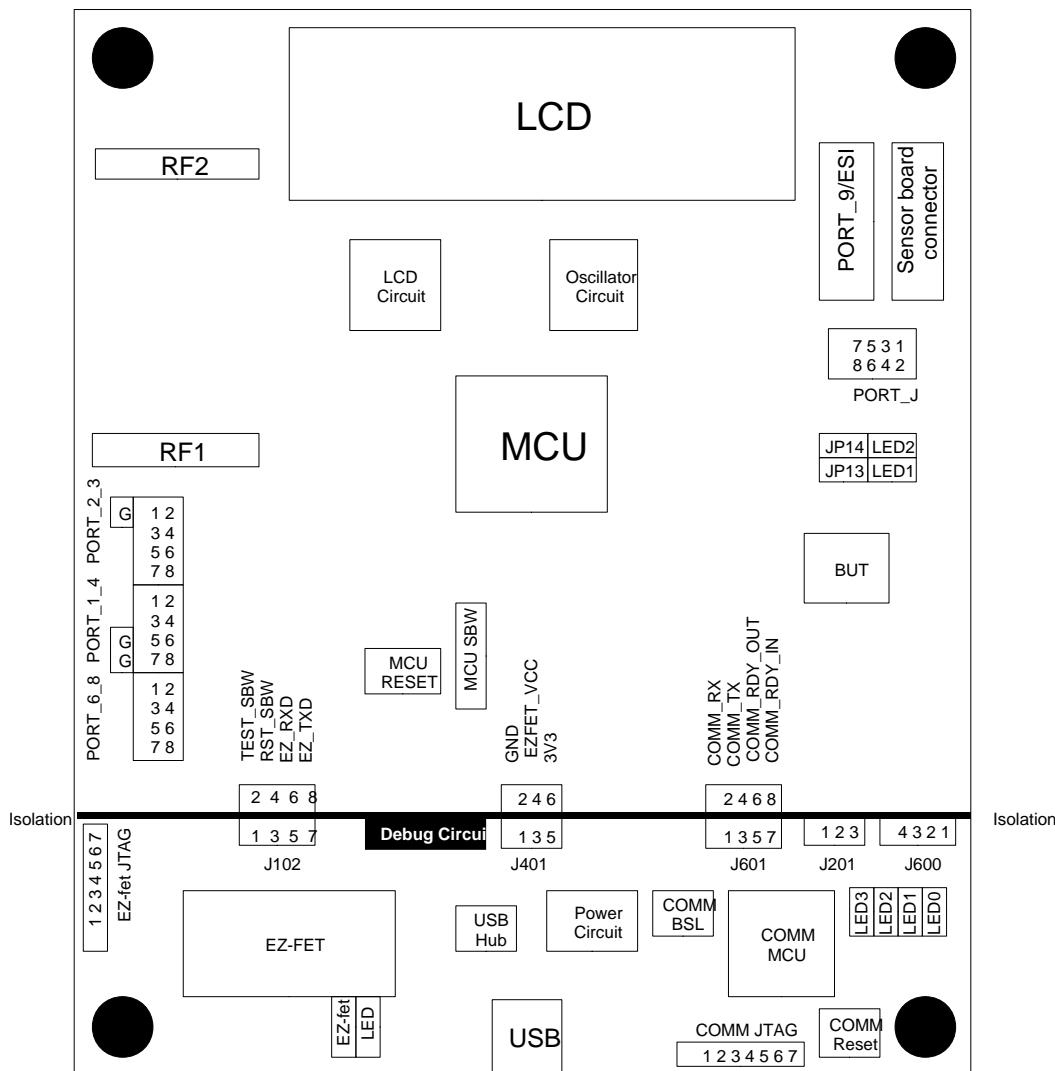
Figure 4. Motor Board



**WARNING:** Moving parts. Do not touch the spinning disk or motor during operation.

## 2 Main Board

The main board is separated into two parts by a black line shown in [Figure 5](#). The upper part is the target area of the evaluation board for development. The lower part of the board is the debug circuit for programming and debugging for the target MCU, and for connecting the PC GUI to the target MCU.



**Figure 5. Main Board Layout**

## 2.1 Powering the Board

The upper part and the lower part of the main board are electrically isolated. They are connected using jumpers. To power the upper part using USB power, connect 1-2 (GND to TARGET\_GND) and 3-4 (EZFET\_VCC to TARGET\_VCC) of the J401, and use a standard USB cable (Standard A to Micro B cable) to connect between the main board and the USB power supply.

**Table 1. Jumper Setting for Powering From EZ-FET for Energy Tracing**

			TARGET_GND	TARGET_VCC			
			2	4	6	Target area	
			1	3	5	Debug circuit	
	J401	GND	EZFET_VCC		3V3		

The TARGET\_VCC is sourced from the EZ-FET circuit for energy tracing. To bypass the EZ-FET and power from the USB power circuit directly, connect 1-2 (GND to TARGET\_GND) and 5-6 (3V3 to TARGET\_VCC) of the J401.

**Table 2. Jumper Setting for Powering From USB Power Circuit**

			TARGET_GND	TARGET_VCC			
			2	4	6	Target area	
			1	3	5	Debug circuit	
	J401	GND	EZFET_VCC		3V3		

The target area of the board can also be powered by external power by connecting pin 2 (TARGET\_GND) and pin 4 or 6 (TARGET\_VCC) of the J401.



**CAUTION:** Only use certified USB cable and USB power supply to power the main board through USB cable.



**CAUTION:** If the board is powered externally, use bench power supply. BE AWARE THAT THE BOARD IS NOT EQUIPPED WITH A POWER PROTECTION CIRCUIT.

## **2.2 Debug Circuit**

The debug circuit consists of different parts for programming and debugging for the target MCU.

### **2.2.1 USB**

The USB connector connects to a PC using USB cable. The USB supplies power to the debug circuit by using a voltage regulator converting 5-V USB power to 3.3 V. The 3.3-V power can also supply current for the development part of the board by applying jumpers on J401.

The USB connection of the EZ-FET and the communication bridge is connected through an USB hub.

### **2.2.2 EZ-FET**

The EZ-FET is an on-board emulator for the target MCU. It allows direct interfacing to PC for easy programming and debugging. It also provides a USB-to-UART bridge for serial connection to the target MCU.

The EZ-FET programs the target MCU through the Spy-Bi-Wire interface. To program the target MCU, connect pin 1-2 (TEST\_SBW) and pin 3-4 (RST\_SBW) of J102, and pin 1-2 (GND) and pin 3-4 (3V3) of J401.

To enable USB-to-UART serial connection, also connect pin 5-6 (EZ\_RXD) and pin 7-8 (EZ\_TXD) of the J402. The EZ\_RXD and EZ\_TXD connect to P4.3/UCA0RXD and P4.2/UCA0TXD of the MSP430FR6989 respectively.

**Table 3. EZ-FET Jumper Connection for Programming Target MCU**

	TEST_SBW	RST_SBW	P4.3/UCA0RXD	P4.2/UCA0TXD	
J402	2	4	6	8	Target area
	1	3	5	7	Debug Circuit
	TEST_SBW	RST_SBW	EZ_RXD	EZ_TXD	

The on-board EZ-FET supports Energy Trace™ Technology. This energy-based code analysis tool measures and displays the application's energy profile and helps to optimize it for ultra-low-power consumption.

For more information about MSP430™ EnergyTrace Technology, visit <http://www.ti.com/tool/energytrace>.

### **2.2.3 Communication Bridge**

The communication bridge is a USB-HID device for controlling and monitoring the target MCU using the FlowESI GUI. The target MCU communicates with the communicate bridge by UART channel. To connect the target MCU and the communication bridge, connect pin 1-2, 3-4, 5-6, and 7-8 of J601.

The COMM MCU can be reset by pressing button S201.

The FlowESI GUI is a utility to develop configuration code for the ESI module. It enables communication between PC and microcontroller through this communication bridge.

For more information about FlowESI, visit <http://www.ti.com/tool/flowesi-gui>.

## 2.3 Target Circuit

This section describes the parts in the target circuit that is used for application development on MSP430FR6989.

### 2.3.1 LED

LED1 and LED2 are connected to PJ.2 and PJ.3 of the MSP430FR6989 respectively. Turn on the LED by output low to the corresponding pin.

Those two pins can be released as GPIOs by removing the jumpers on JP13 and JP14

### 2.3.2 LCD

A LCD screen is connected to the MSP430FR6989 for displaying information. The LCD is a 160-segment display using 40 segment pins and 4 MUX pins. On this EVM board, the LCD uses S0 to S21 and S26 to S43 of the MSP430FR6989. By default, the board uses a capacitor charge pump to provide the LCD voltage. For lower power consumption, it is also possible to use an external resistor ladder by replacing the charge pump capacitor.

**Table 4. LCD Voltage Generator Configuration**

Charge Pump (Default)		External Resistor Ladder	
VR1, R11, R12, R13	Not used	R11, R12, R13	330K
C33	4.7 µF, 10 V		For contrast adjustment (for example, 200K)
			Not used

### 2.3.3 Oscillator Circuit

The MSP430FR6989 consists of an internal DCO and a low-frequency oscillator to provide clock for the MCU. The clock can also be provided by low-frequency clock or high-frequency clock externally. X1 is for a low-frequency oscillator, typically a 32.768-kHz crystal. X2 is for a high-frequency oscillator with a maximum frequency of 16 MHz. C10 and C11 are the load capacitors for X1, and C12 and C13 are the load capacitors for X2. The capacitor value depends on the characteristic of the crystals.

The oscillator pins of the MSP430FR6989 are Port J (PJ.4 and PJ.5 for LFXTL, PJ.6 and PJ.7 for HFXTL) and disconnected to the GPIO pool by default. If oscillators are not used, those four pins can be released for general use by shorting R59 and R60 (LFXTL) or R61 and R62 (HFXTL).

### 2.3.4 4-Way With Select Navigation Switch

The board provides a 4-way with select navigation switch. The switch is connected to the ADC input pin (P1.2/A2) of the MSP430FR6989. The switch is connected using a resistor ladder. The internal ADC and VREF are used to determine in which direction the button is pressed. To save power, the ADC is not always on. When it is idle, the pin is set as GPIO and waits for falling edge interrupt. The resistor values of the resistor ladder are calculated such that each direction of the switch triggers the falling edge interrupt of the pin. Then the pin is set as ADC and measures the voltage to determine which direction is pressed. The voltage reference for the ADC is set at 1.2 V by VREF.

### 2.3.5 RF Connector

The board provides an RF connector for wireless communication. The connector is compatible with TI's wireless EM modules. Refer to specific EM modules for device-specific information. The SPI of the EM module utilizes UCA1 of the MSP430FR6989 while the UART and the alternate SPI utilizes UCA0.

**Table 5** shows the pin mapping. Note that not all of the GPIOs are connected. All of the GPIO pins and communication ports of the RF connectors are connected to the MSP430FR6989 using resistors, and they can be released for general use by removing the corresponding resistors.

**Table 5. RF Connector Pin Configuration**

EM Pin	EM Signal Name	Description	MSP430FR6989	Associated Resistor
RF1-1	GND	Ground	TARGET_GND	
RF1-2	NC	Not connected		
RF1-3	P1_4 / RF_SPI1_CS_N	GPIO / Alt. SPI	P2.3/UCA0STE	R48
RF1-4	P1_1	GPIO	NC	
RF1-5	P8_2	GPIO	P8.4	R49
RF1-6	P1_5	GPIO	NC	
RF1-7	RF_UART_TXD / RF_SPI1_MISO	UART / Alt. SPI	P2.1/UCA0SOMI/UCA0RXD	R50
RF1-8	(breakout)	GPIO	NC	
RF1-9	RF_UART_RXD / RF_SPI1莫斯	UART / Alt. SPI	P2.0/UCA0SIMO/UCA0TXD	R51
RF1-10	P1_7	GPIO	P1.0	R52
RF1-11	P8_3	GPIO	NC	
RF1-12	P1_3	GPIO	P1.1	R53
RF1-13	(breakout)	GPIO	NC	
RF1-14	RF_SPI0_CS_N	SPI Chip Select	P3.7/UCA1STE	R54
RF1-15	P8_4	GPIO	NC	
RF1-16	RF_SPI0_SCLK	SPI Clock	P3.6/UCA1CLK	R55
RF1-17	P8_5	GPIO	NC	
RF1-18	RF_SPI0莫斯	SPI MOSI	P3.4/UCA1SIMO/UCA1TXD	R56
RF1-19	GND	Ground	TARGET_GND	
RF1-20	RF_SPI0_MISO	SPI MISO	P3.5/UCA1SOMI/UCA1RXD	R57
RF2-1	NC	Not connected	NC	
RF2-2	GND	Ground	TARGET_GND	
RF2-3	NC	Not connected	NC	
RF2-4	NC	Not connected	NC	
RF2-5	NC	Not connected	NC	
RF2-6	(breakout)	GPIO	NC	
RF2-7	RF_PWR	EM Power	TARGET_3V3	
RF2-8	(breakout)	GPIO	NC	
RF2-9	RF_PWR	EM Power	TARGET_3V3	
RF2-10	(breakout)	GPIO	NC	
RF2-11	(breakout)	GPIO	NC	
RF2-12	(breakout)	GPIO	NC	
RF2-13	(breakout)	GPIO	NC	
RF2-14	(breakout)	GPIO	NC	
RF2-15	RF_RESET_N	EM board reset	P8.7	R44
RF2-16	NC	Not connected	NC	
RF2-17	P8_1	GPIO	P8.6	R45
RF2-18	P1_2/RF_SPI1_SCLK	GPIO / Alt. SPI	P2.2/UCA0CLK	R47
RF2-19	P1_0	GPIO	P8.5	R46
RF2-20	GND	Ground	TARGET_GND	

### 2.3.6 ESI Port

The ESI port is designed for different sensor boards that utilizes ESI module for automatic detection. The original design of the sensor boards is for rotation detection. Detailed information of the sensor board can be found in [Section 3](#).

If the sensor boards are not used, the Port 9 and P1.3 can be used as normal GPIOs. The pin configuration of ESI port is shown in [Table 6](#).

**Table 6. PORT\_9/ESI Pin Configuration**

Function	Pin Number		Function
TARGET_GND	1	2	TARGET_3V3
ESIVSS	3	4	ESIVCC
ESICOM	5	6	ESICI
P9.7/ESICI3/A15/C15	7	8	P9.6/ESICI2/A14/C14
P9.5/ESICI1/A13/C13	9	10	P9.4/ESICI0/A12/C12
P9.3/ESICH3/ESITEST3/A11/C11	11	12	P9.2/ESICH2/ESITEST2/A10/C10
P9.1/ESICH1/ESITEST1/A9/C9	13	14	P9.0/ESICH0/ESITEST0/A8/C8
TARGET_GND	15	16	P1.3/ESITEST4/TA1.2/A3/C3

### 2.3.7 GPIO Ports

Some of the GPIO pins are routed to the edge of the board as shown in [Table 7](#).

**Table 7. GPIO Configuration**

Pin	PORT_1_4		Pin
P1.0	G <sup>(1)</sup>	1	2
TARGET_GND		3	4
P1.6	G <sup>(1)</sup>	5	6
P4.2	G <sup>(1)</sup>	7	8
			P4.3

Pin	PORT_6_8		Pin
P6.0	1	2	P6.1
P6.2	3	4	TARGET_GND
P8.4	5	6	P8.5
P8.6	7	8	P8.7

Pin	PORT_2_3		Pin
P2.0	G <sup>(1)</sup>	1	2
P2.2		3	4
P3.4		5	6
P3.6		7	8
			P3.7

Pin	PORT_J		Pin
PJ.0	1	2	PJ.1
PJ.2	3	4	PJ.3
PJ.4	5	6	PJ.5
PJ.6	7	8	PJ.7

<sup>(1)</sup> Pin G = TARGET\_GND

## 3 LC Sensor Board

This LC sensor board is designed for rotation detection using LC sensors.

There are several configuration can be used: two sensors, three sensors, or four sensors. The default option is two LC sensors in 90° separation. Each sensor consists of one inductor and one capacitor. [Table 8](#) shows the default components.

**Table 8. Components Used for Different LC Sensor Configuration**

	Component Used
Two Channels (90°) (Default)	L1, L2, C1, C2
Two Channels (45°)	L1, L5, C1, C2
Three Channels	L2, L6, L7, C1, C2, C3

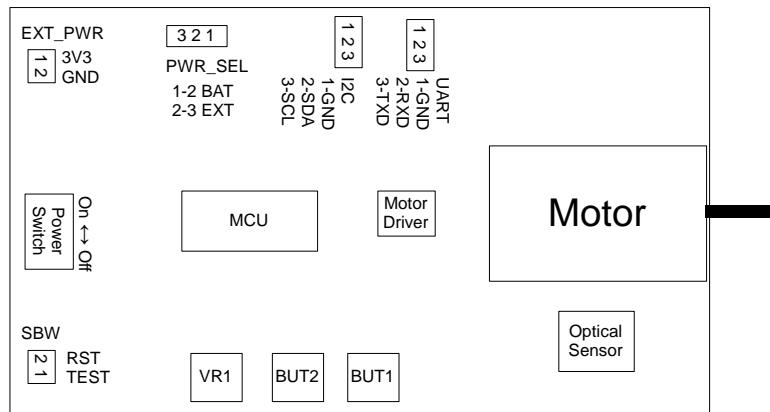
The following is the example value for the LC sensor. The oscillating frequency of this sensor is approximately  $\frac{1}{2\pi\sqrt{LC}}$ . (2π√LC).

**Table 9. LC Sensor Component Example**

LC Sensor	
Capacitor	Generic C0G/NP0 220-pF ceramic capacitor
Inductor	470 $\mu$ H Radial type (Murata 11R474C, DigiKey: 811-2034-ND)

## 4 Motor Board

The motor board is MCU controlled with speed adjustment and bidirectional rotation. With attaching the rotating disc, this motor board can simulate the rotation of a propeller inside flow meters.


**Figure 6. Motor Board Layout**

There are two power sources available, the battery power and the external power. To use battery power, insert two 1.5-V AAA alkaline batteries. Connect pin 1-2 of PWR\_SEL. To use external power, connect pin 2-3 of JP2. Connect a 3.3-V power to pin 1 and GND to pin 2 of EXT\_PWR.

**Table 10. Motor Board Power Source Jumper Setting**

Power Source	PWR_SEL
Battery Powered	1-2
External Power	2-3

**Table 11. Motor Board External Power Pin Setting**

EXT_PWR	
Pin 1	3.3 V
Pin 2	GND



**WARNING:** To minimize the risk of personal injury or property damage, never use rechargeable batteries to power the boards. Only use 1.5-V AAA alkaline batteries.



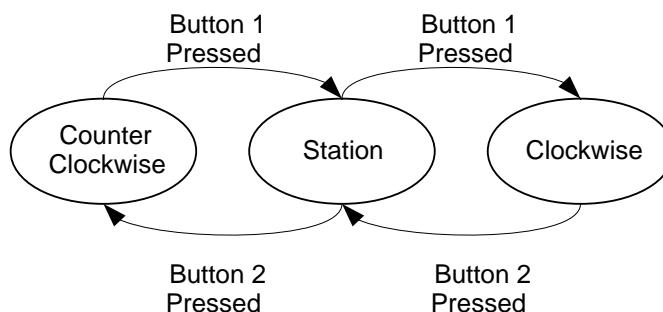
**CAUTION:** If the board is powered externally, use bench power supply. BE AWARE THAT THE BOARD IS NOT EQUIPPED WITH A POWER PROTECTION CIRCUIT.

**NOTE:** Only one power source should be active at any time. Do not leave the EVM powered when unattended.

The board consists of a MCU MSP430G2553. It controls the rotation of the motor by sending PWM signals to the motor driver IC DRV8837. The PWM signals are generated by two timer outputs which also controls the rotating direction by outputting either one timer output. A rotating disc PCB is attached on the motor. The rotating speed of the disc is detected by the optical sensor circuit and is maintained by adjusting the PWM output.

The firmware consists of two modes: manual mode and auto mode.

In manual mode, two buttons are used to control the motor from rotating in clockwise/counter-clockwise direction or to keep station. The variable resistor VR1 controls the rotating speed of the motor. Turn VR1 clockwise to increase the rotating speed or turn it counter clockwise to decrease the rotating speed.



**Figure 7. Control Rotating Direction in Manual Mode**

In auto mode, the motor board receives commands from I<sup>2</sup>C port. The protocol consists of one write command and one read command. A counter records the number of cycle of rotating disc been rotated. It accumulates when the optical sensor detects a complete rotating cycle of the disc, regardless to its rotating direction.

The connection between the main board and the motor board is shown in [Table 12](#).

**Table 12. I<sup>2</sup>C Connections Between the Main Board and the Motor Board**

Main Board (PORT_1_4)		Motor Board (I <sup>2</sup> C)
Pin G	↔ GND ↔	I <sup>2</sup> C Pin 1
(P1.6) Pin 5	↔ SDA ↔	I <sup>2</sup> C Pin 2
(P1.7) Pin 6	↔ SCL ↔	I <sup>2</sup> C Pin 3

The motor board is set as slave device with address 0x02.

- Write command: Controls the rotation of the motor and clears the rotation counter.

**Table 13. Motor Board I<sup>2</sup>C Write Command**

1 Bit	7 Bit	1 Bit	1 Bit	8 Bit	1 Bit
Start	Address: 0x02	0: Write	ACK	Write Data (see <a href="#">Table 14</a> )	Stop

**Table 14. Write Command**

Write Data							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved (00b)	Action 00b = Stop (also stops counter) 01b = Clockwise 10b = Counter Clockwise 11b = Clear counter			If Action = 01b or 10b, 0000b-1111b = Motor Speed 0000b = min speed (Stop, counter still updating) 1111b = max speed No effect for Action = 00b or 11b			

- Read command: Returns 2-byte counter value to the Master.

**Table 15. Motor Board I<sup>2</sup>C Read Command**

1 Bit	7 Bit	1 Bit	1 Bit	8 Bit	1 Bit	8 Bit	1 Bit
Start	Address: 0x02	1: Read	ACK	Counter Value (Lower byte)	ACK	Counter Value (Higher byte)	Stop

Two modes are switched automatically. If a button is pressed, the motor board switches to manual mode. If the motor board receives a command from the I<sup>2</sup>C port, it switches to auto mode.

The firmware of the motor board can be customized. The firmware can be downloaded and debugged by using the EZ-FET of the main board. The connection of the motor board and the main board is shown as below. Be reminded that the C4 of the motor board may require to be removed for proper communication of the spy-bi-wire connection.

**Table 16. Connection for Downloading Firmware to the Motor Board**

Main Board		Motor Board
TEST_SBW (J102 Pin 1)	↔	(SBW Pin 1) TEST
RST_SBW (J102 Pin 3)	↔	(SBW Pin 2) RST
GND (J401 Pin 1)	↔	(EXT_PWR Pin 2) GND

## 5 Loading Example Code to the EVM

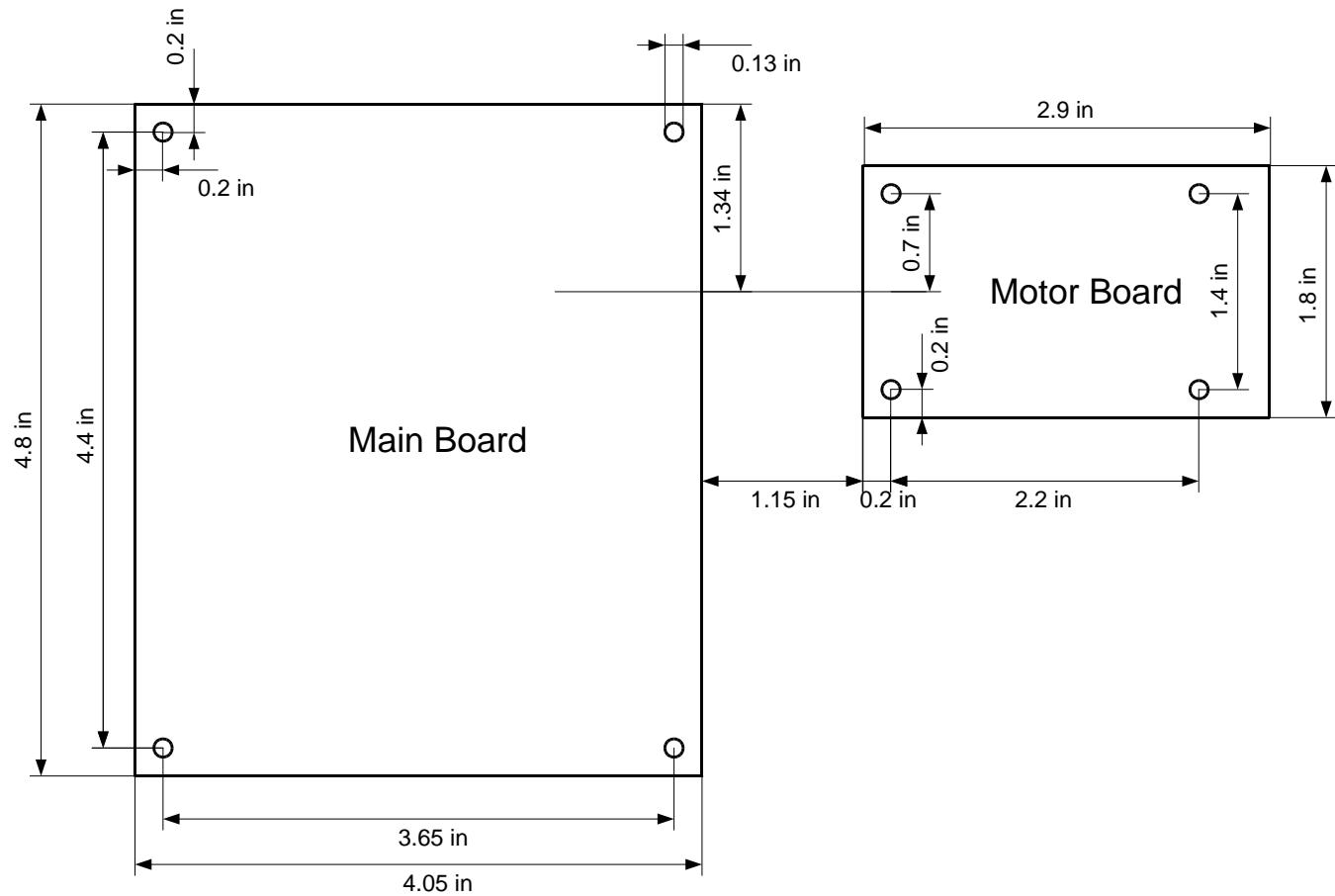
1. (Motor board) Insert batteries for the motor board.
2. (Motor board) Connect pin 1-2 of PWR\_SEL using jumpers.
3. (Optional) Place the Main board and the Motor board on the fixture. (See Appendix)
4. (Main board) Attach the sensor board to the "ESI" of the main board.
5. (Main board) Connect pin 1-2 (TEST\_SBW) and pin 3-4 (RST\_SBW) of J102 using jumpers.
6. (Main board) Connect pin 1-2 (GND) and pin 3-4 (3V3) of J401 using jumpers.
7. (Main board) Connect the main board and the PC using an USB cable.
8. Switch on the motor board.
9. Launch Code Composer Studio™ IDE v6.0 on the computer.
10. Import example code project to the CCS workspace
11. Run Debug mode.
12. Place the motor board. Keep the position of the PCB wheel and the LC sensors approximately 5 mm apart.
13. Click 'Run' to start the firmware on the main board.

## 6 References

1. MSP430FR698x(1), MSP430FR598x(1) Mixed-Signal Microcontrollers (<http://www.ti.com/product/msp430fr6989>)
2. *MSP430FR58xx, MSP430FR59xx, MSP430FR68xx, and MSP430FR69xx Family User's Guide (SLAU367)*
3. MSP430G2x53, MSP430G2x13 Mixed-Signal Microcontrollers (<http://www.ti.com/product/msp430g2553>)
4. *MSP430x2xx Family User's Guide (SLAU144)*
5. DRV883x Low-Voltage H-Bridge Driver (<http://www.ti.com/product/drv8837>)
6. MSP430 EnergyTrace Technology (<http://www.ti.com/tool/energytrace>)
7. FlowESI GUI for flow meter configuration using the Extended Scan Interface (ESI) (<http://www.ti.com/tool/flowesi-gui>)

## 7 Appendix

Users can make a board with drill holes and screw the boards on this fixture for easier hardware setup. The dimension of the boards and the position of the drill holes are shown in **Figure 8**.



**Figure 8. EVM Fixture Dimensions**

## STANDARD TERMS AND CONDITIONS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, or documentation (collectively, an "EVM" or "EVMs") to the User ("User") in accordance with the terms and conditions set forth herein. Acceptance of the EVM is expressly subject to the following terms and conditions.
  - 1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM ("Software") shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms and conditions that accompany such Software.
  - 1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.
- 2 *Limited Warranty and Related Remedies/Disclaimers:*
  - 2.1 These terms and conditions 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 any defects that are 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. Moreover, TI shall not be liable for any defects that result from User's design, specifications or instructions for such EVMs. Testing and other quality control techniques are used to the extent TI deems necessary or as mandated by government requirements. TI does not test all parameters of each EVM.
  - 2.3 If any EVM fails to conform to the warranty set forth above, TI's sole liability shall be at its option to repair or replace such EVM, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

- 3 *Regulatory Notices:*

- 3.1 *United States*

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

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

###### **Concerning EVMs Including Radio Transmitters:**

This device complies with Industry Canada license-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.

###### **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/lsts/ti\\_ja/general/eStore/notice\\_01.page](http://www.tij.co.jp/lsts/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/lsts/ti\\_ja/general/eStore/notice\\_01.page](http://www.tij.co.jp/lsts/ti_ja/general/eStore/notice_01.page)

##### 3.3.2 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.

#### 【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】

本開発キットは技術基準適合証明を受けておりません。

本製品のご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

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

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

上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。

日本テキサス・インスツルメンツ株式会社

東京都新宿区西新宿 6 丁目 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/lsts/ti\\_ja/general/eStore/notice\\_02.page](http://www.tij.co.jp/lsts/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/lsts/ti\\_ja/general/eStore/notice\\_02.page](http://www.tij.co.jp/lsts/ti_ja/general/eStore/notice_02.page)

#### 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 WRITTEN DESIGN MATERIALS PROVIDED WITH THE EVM (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 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 AND CONDITIONS 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 MADE, CONCEIVED OR ACQUIRED PRIOR TO OR AFTER DELIVERY OF THE EVM.
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 AND CONDITIONS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.
8. *Limitations on Damages and Liability:*
  - 8.1 *General Limitations.* IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS AND CONDITIONS OR THE USE OF THE EVMS PROVIDED HEREUNDER, 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 ONE YEAR AFTER THE RELATED CAUSE OF ACTION HAS OCCURRED.
  - 8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY WARRANTY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS AND CONDITIONS, OR ANY USE OF ANY TI EVM PROVIDED HEREUNDER, EXCEED THE TOTAL AMOUNT PAID TO TI FOR THE PARTICULAR UNITS SOLD UNDER THESE TERMS AND CONDITIONS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM AGAINST THE PARTICULAR UNITS SOLD TO USER UNDER THESE TERMS AND CONDITIONS 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.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2015, Texas Instruments Incorporated

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers' products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers' products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

<b>Products</b>	<b>Applications</b>		
Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>	Automotive and Transportation	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
Amplifiers	<a href="http://amplifier.ti.com">amplifier.ti.com</a>	Communications and Telecom	<a href="http://www.ti.com/communications">www.ti.com/communications</a>
Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>	Computers and Peripherals	<a href="http://www.ti.com/computers">www.ti.com/computers</a>
DLP® Products	<a href="http://www.dlp.com">www.dlp.com</a>	Consumer Electronics	<a href="http://www.ti.com/consumer-apps">www.ti.com/consumer-apps</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>	Energy and Lighting	<a href="http://www.ti.com/energy">www.ti.com/energy</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>	Industrial	<a href="http://www.ti.com/industrial">www.ti.com/industrial</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>	Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>	Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>	Space, Avionics and Defense	<a href="http://www.ti.com/space-avionics-defense">www.ti.com/space-avionics-defense</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>	Video and Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>	<b>TI E2E Community</b>	
OMAP Applications Processors	<a href="http://www.ti.com/omap">www.ti.com/omap</a>	<a href="http://e2e.ti.com">e2e.ti.com</a>	
Wireless Connectivity	<a href="http://www.ti.com/wirelessconnectivity">www.ti.com/wirelessconnectivity</a>		