

USER MANUAL



XTRINSIC-SENSORS-EVK

Evaluation Kit for Freescale Xtrinsic Sensors

Exclusively from

element14

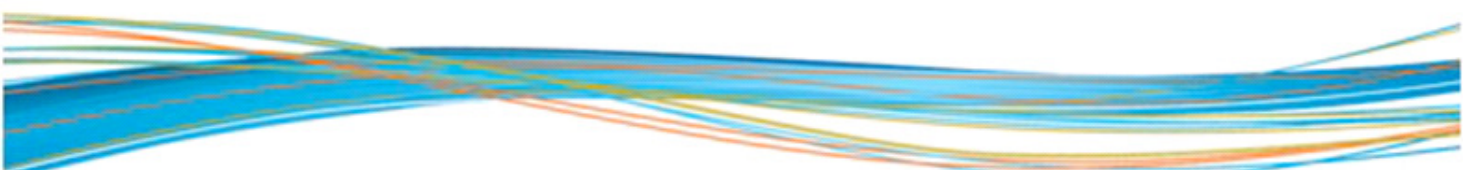


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Kit Overview

The Xtrinsic sensor evaluation kit comes with a sensor board together with the Freescale FRDM-KL25Z platform. The software drivers and code enable engineers to easily evaluate and demonstrate the performance of the sensors in a variety of applications including:

- eCompass
- Mobile Phones/Tablet Computers
- Remote Control/Wireless Mouse
- Game Consoles
- Navigation Devices
- Medical Devices

Kit Contents:

- Xtrinsic Sensors Board
- FRDM-KL25Z board
- Quick Start Guide

Xtrinsic Sensor Board

The sensor board comes equipped with three of Freescale's new-generation XTRINSIC MEMS sensors. The MPL3115 is designed for accurate measurement of altitude and pressure, the MAG3110 for detection of magnetic fields, and the MMA8491 for measurement of physical positions.

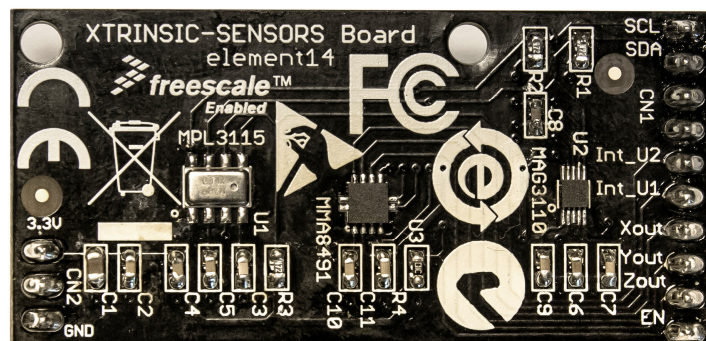


Figure 1 Sensor Board

MPL3115

The MPL3115 is a high-precision sensor used to provide accurate pressure and altitude data. It features an adjustable sampling rate, ultra-low power consumption and intelligent functions, suitable for applications such as mobile, medical and security devices. MPL3115 is able to provide digitized output, two separated wake-up interrupts, minimum/maximum threshold mechanism, and autonomous data acquisition. The self data processing ability of the MPL3115 reduces the need for communication with MCUs, which reduces overall system power consumption.

MAG3110

The MAG3110 is a small, low-power, digital 3-axis magnetometer featuring a wide measurement range. It can measure magnetic fields (the overlapped fields consisting of the geomagnetic field and the fields created by components on PCB) on each of the 3 axes in the position where it is placed. The MAG3110 features an I2C serial interface, and is capable of measuring magnetic fields of up to 10 Gauss with an output data rate up to 80Hz. The output data rate can vary depending on the sampling intervals and may be adjusted from 12ms to several seconds.

MMA8491Q

The MMA8491Q is a low voltage, 3-axis low-g accelerometer housed in a 3 mm by 3 mm QFN package. The device can accommodate two accelerometer configurations, acting as either an easy to implement 45° Tilt Sensor or a digital (I2C) output accelerometer. In the 45° Tilt Sensor mode, it offers extremely easy board implementation by using a single line of output per axis. In the digital output mode, 14-bit $\pm 8g$ raw data can be read from the device with high 1 mg/LSB sensitivity. The extreme low power capabilities of the MMA8491Q reduce the low data rate current consumption to less than 400 nA per Hz.

Pin Definition of Connectors

This section will briefly introduce the connectors used on sensor board and the pins of these connectors in terms of definition, function and application.

Board Top View

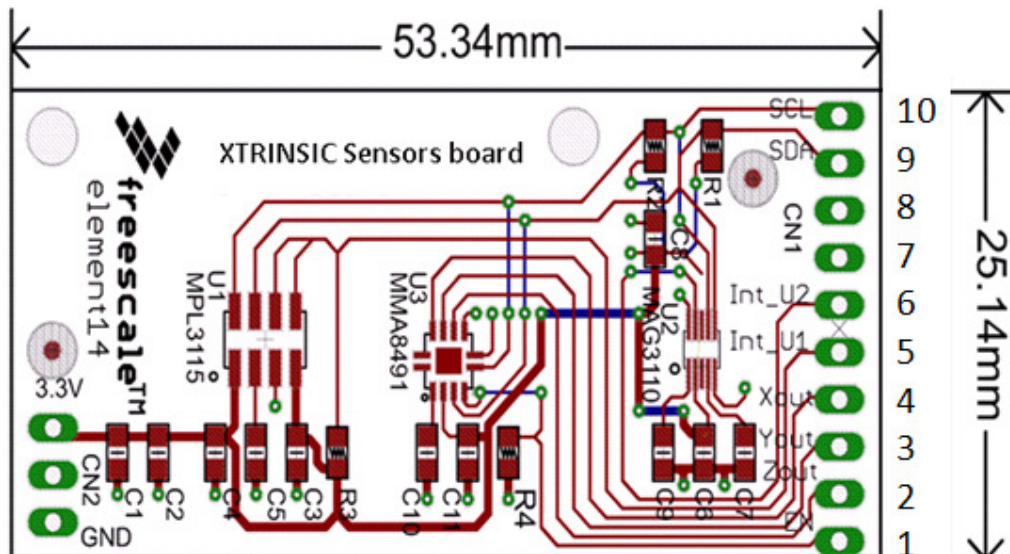


Figure 2 Sensor Board Top View

Pin Definition

CN1 – Data interface

Pin No.	Pin Name	Description
1	EN	MMA8491 Enable Pin
2	Zout	MMA8491 Push-Pull Z-Axis Tilt Detection Output
3	Yout	MMA8491 Push-Pull Y-Axis Tilt Detection Output
4	Xout	MMA8491 Push-Pull X-Axis Tilt Detection Output
5	Int_U1	MPL3115 Interrupt
6	Int_U2	MAG3110 Interrupt
7	GND	Ground
8	NC	No Connection
9	SDA	I2C Slave Data Line
10	SCL	I2C Slave Clock Line

Table 1 CN1 Data Interface Connector

CN2: Power Supply Connector

Pin No.	Pin Name	Description
1	VDD	+3.3V DC Power Supply
2	NC	No Connection
3	GND	Ground

Table 2 CN2 Power Supply Connector

Freescale Freedom FRDM-KL25Z

The FRDM-KL25Z features a KL25Z128VLK - a KL2 family device boasting a max operating frequency of 48MHz, 128KB of flash, a full-speed USB controller, and loads of analog and digital peripherals. The FRDM-KL25Z has an easy access to MCU I/O via Arduino™ R3 compatible I/O connectors.

The board also features a programmable OpenSDA debug interface with multiple applications available including:

- Mass storage device flash programming interface
- P&E Debug interface provides run-control debugging and compatibility with IDE tools
- CMSIS-DAP interface: new ARM standard for embedded debug interface

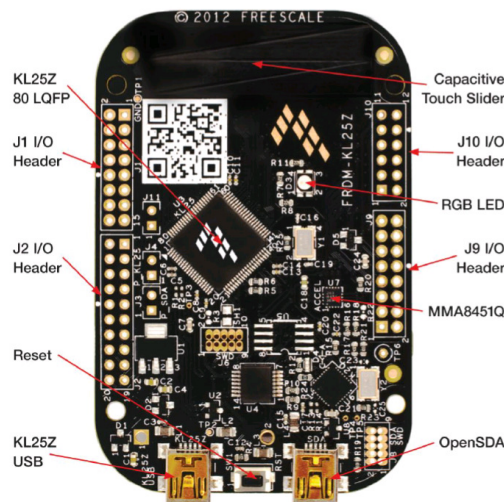


Figure 2 FRDM-KL25Z board

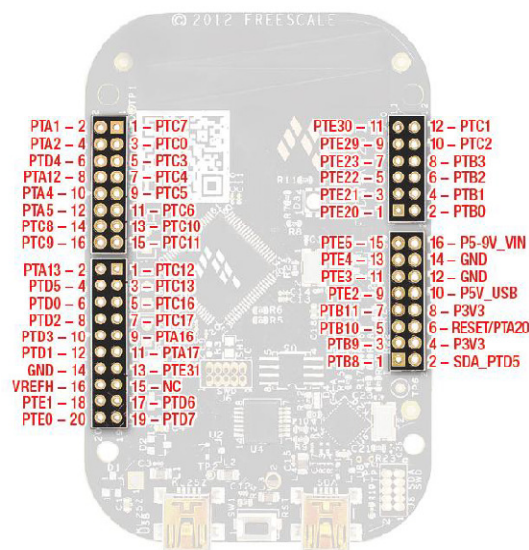


Figure 3: Pinouts of I/O headers on FRDM-KL25Z

XTRINSIC-Sensor board and FRDM-KL25Z

Pin mapping

Sensor Board	FRDM KL25Z	Sensor Board	FRDM KL25Z
CN1	J2	CN2	J9
EN 1	2	GND 3	12 – GND
Z _{OUT} 2	4	NC 2	10 – P5V_USB
Y _{OUT} 3	6	VDD 1	8 – P3V3
X _{OUT} 4	8		
INT_U1 5	10		
INT_U2 6	12		
GND 7	14		
NC 8	16		
SDA 9	18		
SCL 10	20		
	PTA13		
	PTD5		
	PTD0		
	PTD2		
	PTD3		
	PTD1		
	GND		
	VREFH		
	PTE1		
	PTE0		

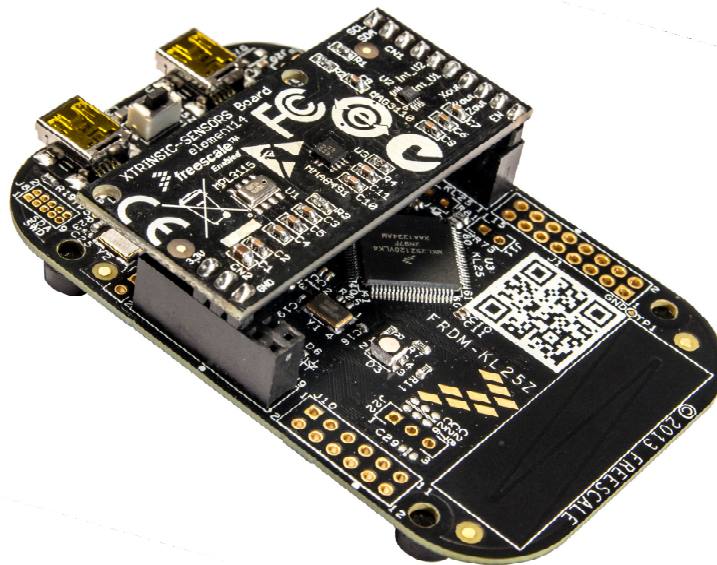


Figure 4 XSTRINSIC-SENSORS-EVK

Drivers for Sensor Board

Driver for MPL3115A2

Driver Interfaces

The MPL3115A2 features three kinds of modes, 8 different sample rates, 16 different acquisition time steps (1 second to 9 hours), and compensated direct reading of pressure (20 bit in Pascal) or altitude (20 bit in meters). The driver provides the following interfaces for implementing these features.

Table 3 MPL3115A2 Interface list

1	Modes of Operation	void MPL3115A2_Active (void)
2		Uin8_t MPL3115A2_Standby (void)
3		Uin8_t MPL3115A2_Init_Alt (void)
4		Uin8_t MPL3115A2_Init_Bar (void)
5	Over sample	void MPL3115A2_SetOSR (uin8_t)
6		void MPL3115A2_SetStepTime (uin8_t)
7	Read raw data	uint32_t MPL3115A2_Read_Alt (void)
8		uint32_t MPL3115A2_Read_Bar (void)
9		uint32_t MPL3115A2_Read_Temp (void)

Operation Modes

MPL3115A2 has three operation modes: Standby, Active Altitude, and Active Barometer. These modes can be implemented using the following interfaces.

Table 4 MPL3115A2_Active

Name	MPL3115A2_Active
Prototype	void MPL3115A2_Active (void)
Param	Void
Return Value	Void
Description	Put MPL3115A2 into Active Mode

Table 5 MPL3115A2_Standby

Name	MPL3115A2_Standby
Prototype	Uin8_t MPL3115A2_Standby (void)
Param	Void
Return Value	The value of CTRL_REG1 before modification
Description	Put MPL3115A2 into Standby Mode

Table 6 MPL3115A2_Init_Alt

Name	MPL3115A2_Init_Alt
Prototype	Uin8_t MPL3115A2_Init_Alt (void)
Param	Void
Return Value	0 – fail, 1 – success
Description	Initialize MPL3115A2 for Alt mode

Table 7 MPL3115A2_Init_Bar

Name	MPL3115A2_Init_Bar
Prototype	uint8_t MPL3115A2_Init_Bar (void)
Param	Void
Return Value	0 – fail, 1 – success
Description	Initialize MPL3115A2 for Bar mode

Over Sampling

Output Sample Rate can be set as shown in Table 8 System Output Data Rate Selection. Table 10 and 11 contain the functions used for configuring over-sampling parameters.

Table 8 System Output Data Rate Selection

OSR	Oversample Ratio	Minimum Time Between Data Samples
0	1	2.5 ms
1	2	5 ms
2	4	10 ms
3	8	20 ms
4	16	40 ms
5	32	80 ms
6	64	160 ms
7	128	320 ms

Table 9 MPL3115A2_SetOSR

Name	MPL3115A2_SetOSR
Prototype	void MPL3115A2_SetOSR (uint8_t osr)
Param	OSR Ratio
Return Value	Void
Description	Change the OSR Ratio

Table 10 MPL3115A2_SetStepTime

Name	MPL3115A2_SetStepTime
Prototype	void MPL3115A2_SetStepTime (uint8_t step)
Param	Sample Step = 2^{step} ;
Return Value	Void
Description	Change sample step

Data Acquisition

Pressure (20 bit in Pascals), Altitude (20 bit in meters), and Temperature (12 bit in degrees Celsius) can be read by functions contained in the following tables, and be calculated using the formulas in section 0

Table 11 MPL3115A2_Read_Alt

Name	MPL3115A2_Read_Alt
Prototype	uint32_t MPL3115A2_Read_Alt (void)
Param	Void
Return Value	The raw data for Altitude:
Description	Read Altitude data from MPL3115A2

Table 12 MPL3115A2_Read_Bar

Name	MPL3115A2_Read_Bar
Prototype	uint32_t MPL3115A2_Read_Bar (void)
Param	Void
Return Value	The raw data for Barometer
Description	Read Barometer data from MPL3115A2

Table 13 MPL3115A2_Read_Temp

Name	MPL3115A2_Read_Temp
Prototype	uint32_t MPL3115A2_Read_Temp (void)
Param	Void
Return Value	The raw data for temperature
Description	Read Temperature data from MPL3115A2

Raw Data Structure and Calculations

Alt Raw Data

Table 14 Alt raw data structure

31								24	23									16	15										8	7									0
Invalid									ALT_MSB									ALT_CSB									ALT_LSB												

Integer part: $ALT_MSB \times 2^8 + ALT_CSB$

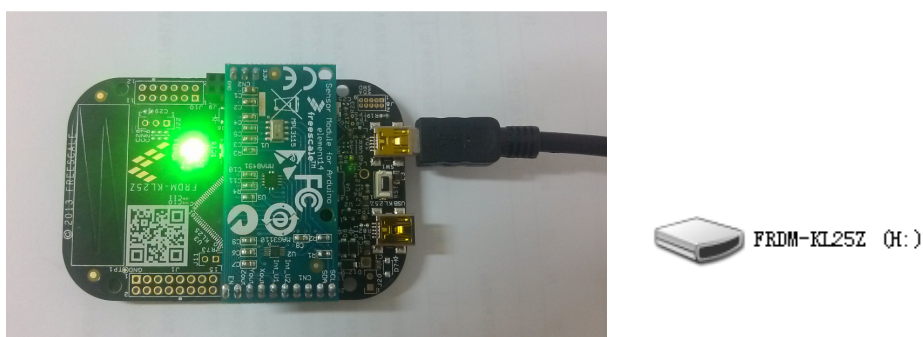
Decimal part: $(ALT_LSB / 2^4) \times 0.0625$

Demonstration

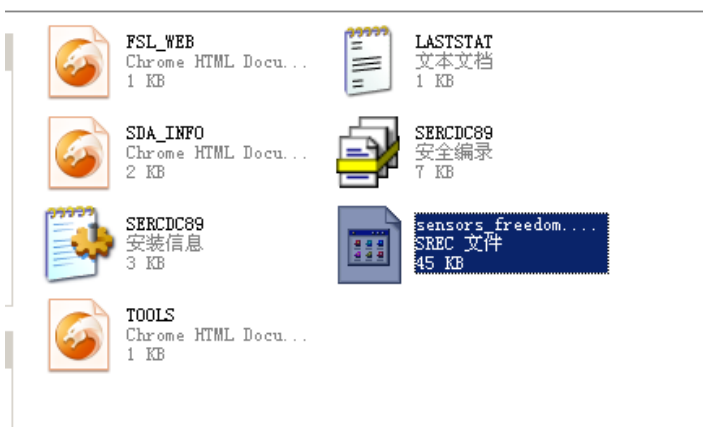
After the driver code is loaded onto the Freedom KL25Z, the sensor features can be demonstrated with a command line interface of HyperTerminal, or another UART tools.

Setup and Configuration

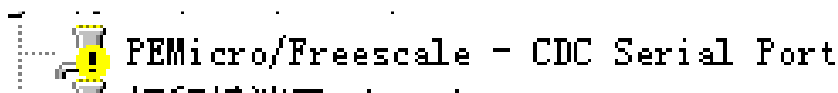
1. Plug in a USB cable from a USB host to the OpenSDA mini-B USB connector of the FRDM-KL25Z. The FRDM-KL25Z will be powered by this USB connection. FRDM-KL25Z comes with the mass-storage device (MSD) Flash Programmer OpenSDA Application preinstalled. It will appear as a removable storage drive with a volume label of FRDM-KL25Z. (Note: For more details on setup of the FRDM-KL25Z please refer to <http://www.element14.com/community/docs/DOC-49219>)

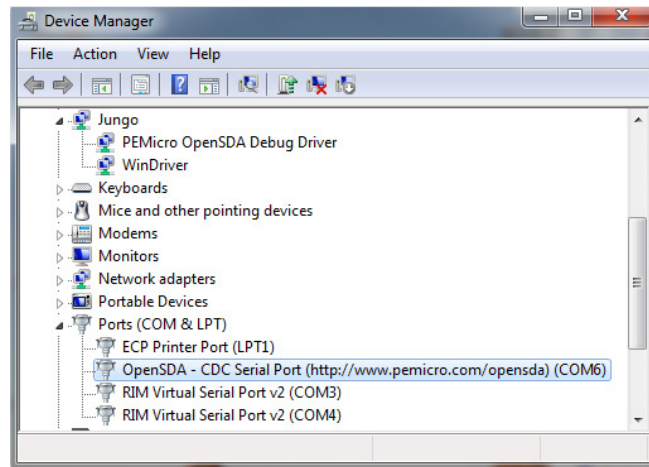


2. Open the FRDM-KL25Z drive, and drop the image “sensors_freedom.srec” into it, as seen below.



3. The MSD Flash Programmer also includes a USB virtual serial port which requires an .INF file for proper installation in Windows. The necessary .INF file is available as part of the P&E OpenSDA USB Drivers and on the FRDM-KL25Z removable drive.

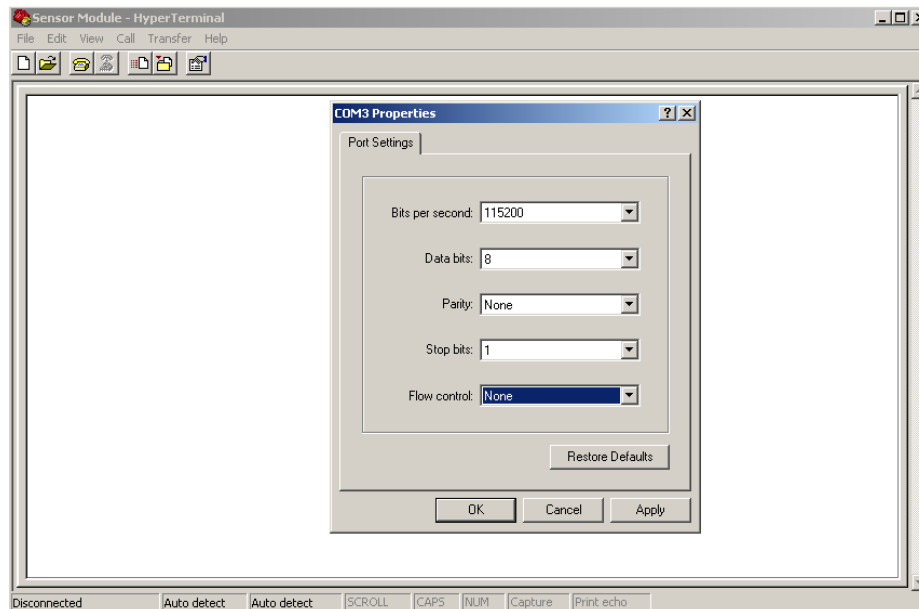




The serial port will be configured after the driver installation – eg. COM6 in the example.

4. Launch the terminal program (eg. Tera Term) with the properties as follows:

Baud rate	115200
Data bits	8-bit
Stop bits	1-bit
Parity	None
Flow control	None



5. Reset the board by pressing the reset button (SW1), and you can see the information displayed below

```

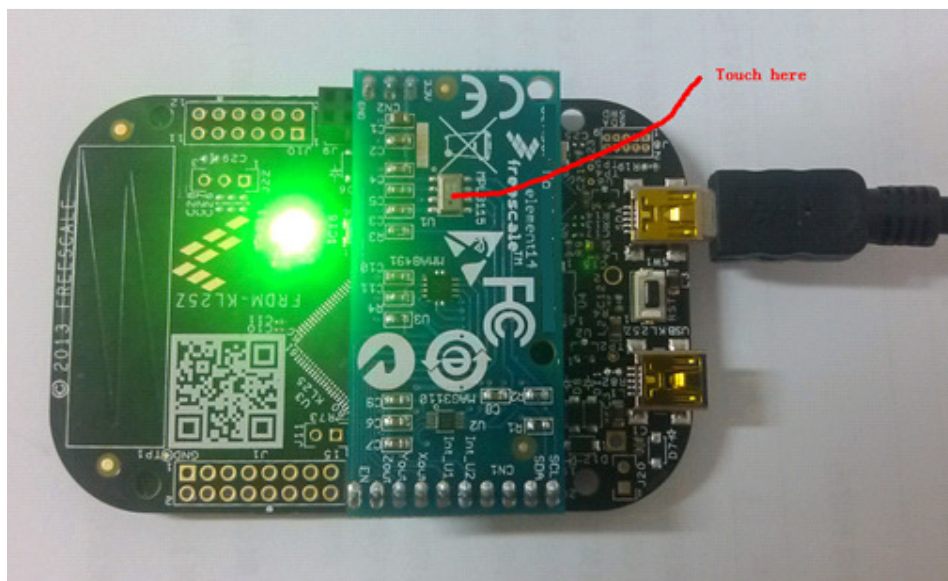
sensor - 超级终端
文件(F) 编辑(E) 查看(V) 呼叫(C) 传送(T) 帮助(H)

External Pin Reset
K2580pin      Low Power Line with Cortex M0+
SRAM Size: 16 KB |
Silicon rev 15
Flash parameter version 0.0.8.0
Flash version ID 6.0.1.0
Flash size: 128 KB program flash, 4 KB protection region
Running the blinky project.

** Element14 & Freescale **
** MPL3115A2&MAG3110 Demo **
Initializing to:
OSR = 128 Time Step = 2^00 Mode = Altimeter

Sx          : Stream Polling 0=MPL3115A2, 1=MAG3110, 2=MMA8491Q
MPL3115A2> _
    
```

6. Type 'S0' into the terminal through the PC keyboard, to try out the MPL3115A2 sensor. The terminal will begin to display temperature readings. Touch the sensor with your finger and notice that the temperature readings will start to rise. At the same time, the RGB LED will begin blinking red.

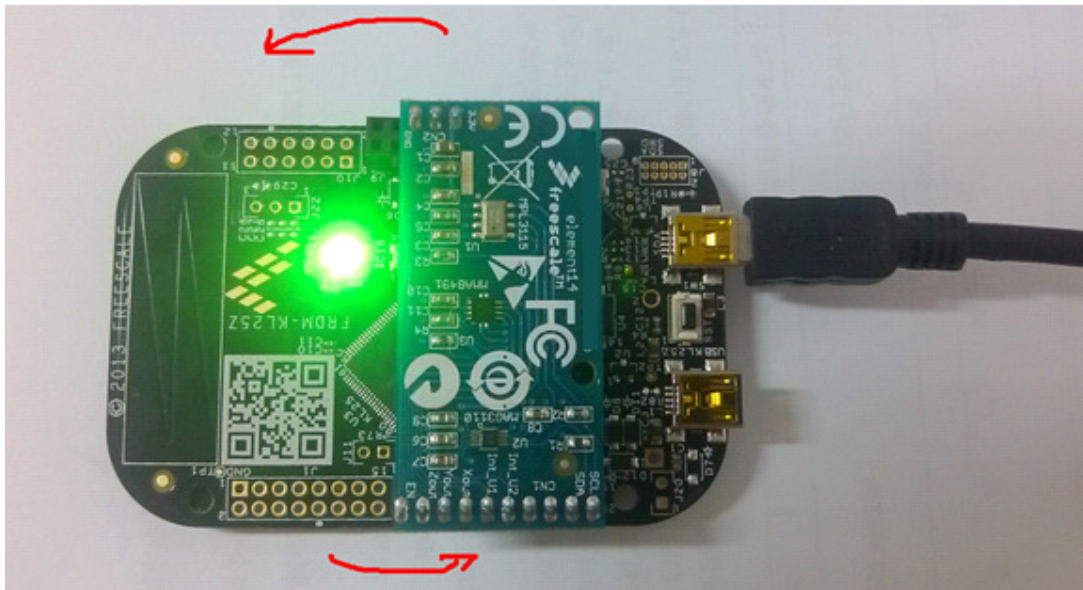


```
Sx      : Stream Polling 0=MPL3115A2, 1=MAG3110, 2=MMA8491Q
MPL3115A2> S0
MPL3115: Alt. + 51.5625 Temp+ 24.0625
MPL3115: Alt. + 51.6875 Temp+ 24.0625
MPL3115: Alt. + 51.8750 Temp+ 24.0625
MPL3115: Alt. + 51.8750 Temp+ 24.0625
MPL3115: Alt. + 51.3750 Temp+ 24.0625
MPL3115: Alt. + 51.3750 Temp+ 24.0625
MPL3115: Alt. + 51.5000 Temp+ 24.0625
MPL3115: Alt. + 48.8750 Temp+ 24.8125
MPL3115: Alt. + 9.4375 Temp+ 25.3125
MPL3115: Alt. - 22.0625 Temp+ 25.6250
MPL3115: Alt. - 40.2500 Temp+ 25.8125
MPL3115: Alt. - 62.0625 Temp+ 26.0000
MPL3115: Alt. - 52.6875 Temp+ 26.0625
MPL3115: Alt. - 63.5625 Temp+ 26.1250
MPL3115: Alt. - 64.4375 Temp+ 26.2500
MPL3115: Alt. - 78.3750 Temp+ 26.3125
MPL3115: Alt. - 75.0625 Temp+ 26.3750
MPL3115: Alt. - 84.6250 Temp+ 26.5000_
```

The temperature will rise when sensor is touched

Figure 5: MPL3115 demo

- Press the "Enter" key on the keyboard to quit the demo and go back to the menu. Type 'S1' to try out the MAG3110 sensor. Shake the board around, and you can see the 3-D magnetic field measurement change. At the same time, the RGB LED will begin blinking green.



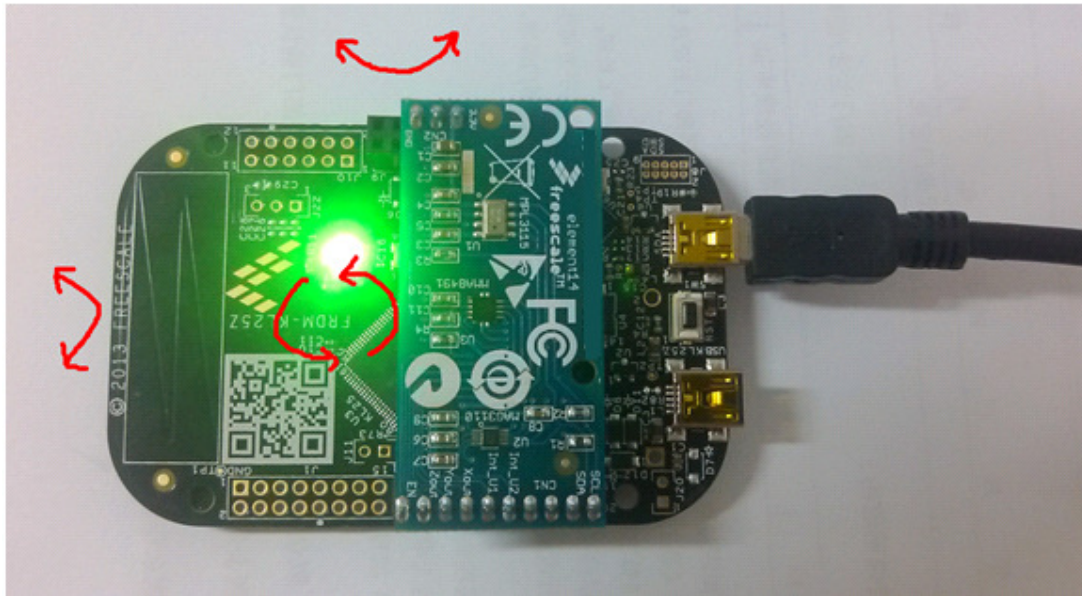
MAG3110:	X.-	8uT	Y.+	11uT	Z.-	30uT
MAG3110:	X.-	9uT	Y.+	10uT	Z.-	31uT
MAG3110:	X.-	11uT	Y.+	8uT	Z.-	32uT
MAG3110:	X.-	11uT	Y.+	5uT	Z.-	33uT
MAG3110:	X.-	9uT	Y.+	0uT	Z.-	32uT
MAG3110:	X.-	5uT	Y.-	1uT	Z.-	33uT
MAG3110:	X.-	3uT	Y.-	2uT	Z.-	32uT
MAG3110:	X.-	1uT	Y.-	1uT	Z.-	31uT
MAG3110:	X.+	0uT	Y.+	0uT	Z.-	30uT
MAG3110:	X.+	1uT	Y.+	2uT	Z.-	27uT
MAG3110:	X.+	1uT	Y.+	1uT	Z.-	31uT
MAG3110:	X.+	0uT	Y.+	0uT	Z.-	28uT
MAG3110:	X.-	3uT	Y.+	0uT	Z.-	30uT
MAG3110:	X.-	7uT	Y.+	1uT	Z.-	31uT
MAG3110:	X.-	10uT	Y.+	5uT	Z.-	30uT
MAG3110:	X.-	10uT	Y.+	10uT	Z.-	29uT
MAG3110:	X.-	7uT	Y.+	12uT	Z.-	29uT
MAG3110:	X.-	4uT	Y.+	12uT	Z.-	30uT
MAG3110:	X.-	2uT	Y.+	12uT	Z.-	28uT
MAG3110:	X.-	1uT	Y.+	12uT	Z.-	30uT
MAG3110:	X.-	2uT	Y.+	12uT	Z.-	27uT
MAG3110:	X.-	2uT	Y.+	13uT	Z.-	30uT
MAG3110:	X.-	2uT	Y.+	13uT	Z.-	29uT
MAG3110:	X.-	2uT	Y.+	13uT	Z.-	30uT

Figure 6 MAG3110 Demo

- Press the "Enter" key on the keyboard to return the menu, and type 'S2' to try out the MMA8491Q sensor

```
Sx      : Stream Polling 0=MPL3115A2, 1=MAG3110, 2=MMA8491Q
MPL3115A2> S2
```

Turn the board from side to side and from front to back to see the corresponding x, y, and z coordinates change as the board is tilted. At the same time, the RGB LED will begin blinking blue.



MMA8491Q:	X. - 129mg	Y. - 652mg	Z. + 618mg
MMA8491Q:	X. - 220mg	Y. - 909mg	Z. + 479mg
MMA8491Q:	X. - 38mg	Y. -1136mg	Z. + 458mg
MMA8491Q:	X. + 33mg	Y. - 696mg	Z. + 593mg
MMA8491Q:	X. + 36mg	Y. - 306mg	Z. +1001mg
MMA8491Q:	X. + 73mg	Y. + 297mg	Z. + 930mg
MMA8491Q:	X. + 101mg	Y. + 881mg	Z. + 486mg
MMA8491Q:	X. + 14mg	Y. +1320mg	Z. + 121mg
MMA8491Q:	X. + 120mg	Y. +1203mg	Z. + 67mg
MMA8491Q:	X. + 99mg	Y. + 491mg	Z. + 506mg
MMA8491Q:	X. - 78mg	Y. - 17mg	Z. +1171mg
MMA8491Q:	X. - 50mg	Y. - 1mg	Z. + 909mg
MMA8491Q:	X. - 131mg	Y. - 89mg	Z. + 976mg
MMA8491Q:	X. - 184mg	Y. - 29mg	Z. +1175mg
MMA8491Q:	X. - 87mg	Y. + 70mg	Z. + 904mg
MMA8491Q:	X. - 95mg	Y. - 74mg	Z. +1026mg
MMA8491Q:	X. - 72mg	Y. + 33mg	Z. +1057mg
MMA8491Q:	X. - 84mg	Y. + 0mg	Z. +1036mg
MMA8491Q:	X. - 88mg	Y. + 33mg	Z. +1002mg
MMA8491Q:	X. - 76mg	Y. + 24mg	Z. +1015mg
MMA8491Q:	X. - 71mg	Y. + 49mg	Z. +1017mg
MMA8491Q:	X. - 88mg	Y. + 50mg	Z. + 986mg
MMA8491Q:	X. - 118mg	Y. + 30mg	Z. +1023mg
MMA8491Q:	X. - 153mg	Y. + 64mg	Z. + 987mg

已连接 0:14:44 自动检测 115200 8-N-1 SCROLL CAPS NUM 捕 打印

Figure 7 MMA8491Q Demo

Hardware

This document includes the hardware design files for the XTRINSIC Sensors board. For the FRDM-KL25Z board, please refer to <http://www.element14.com/community/docs/DOC-46626>

Schematic

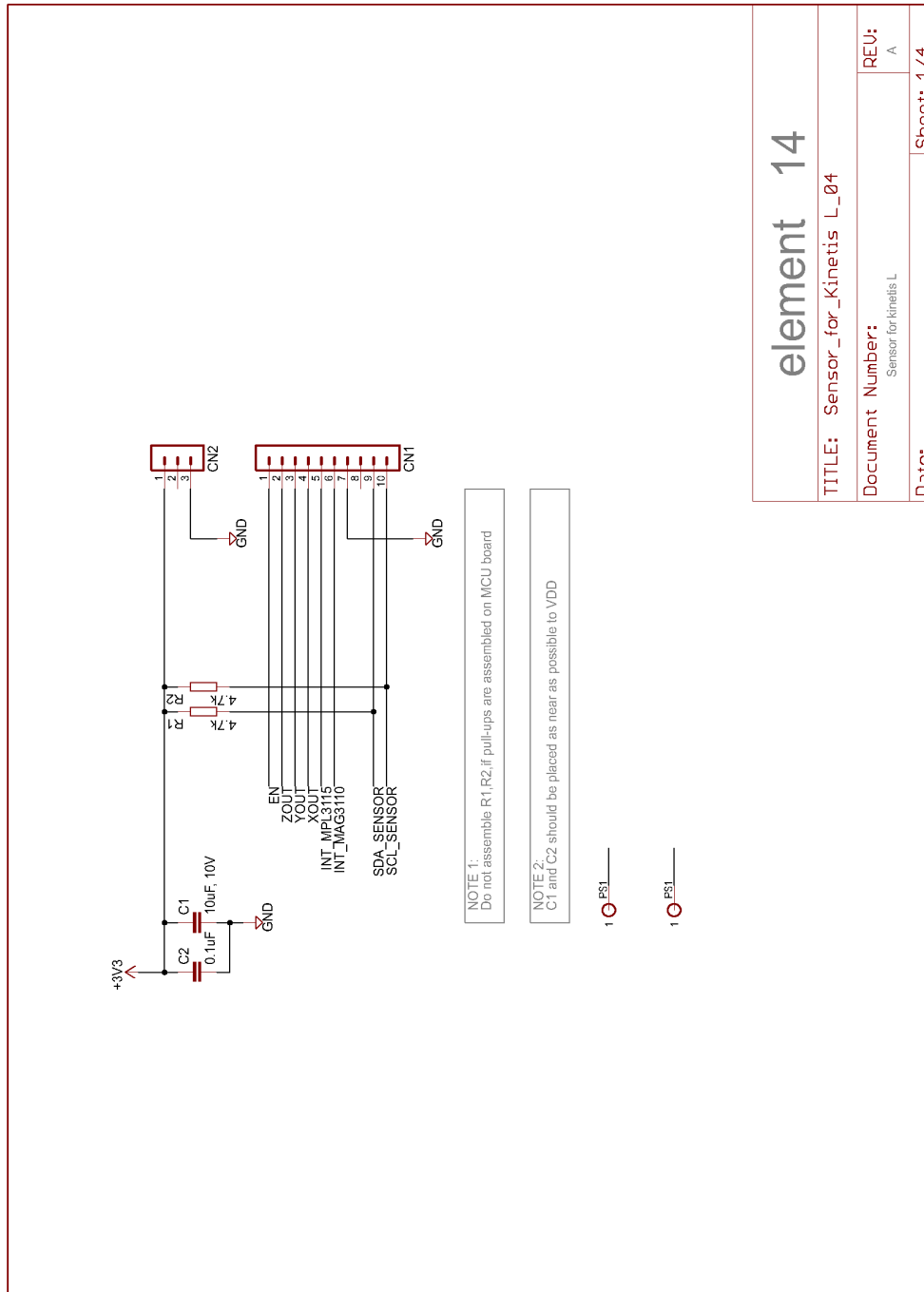
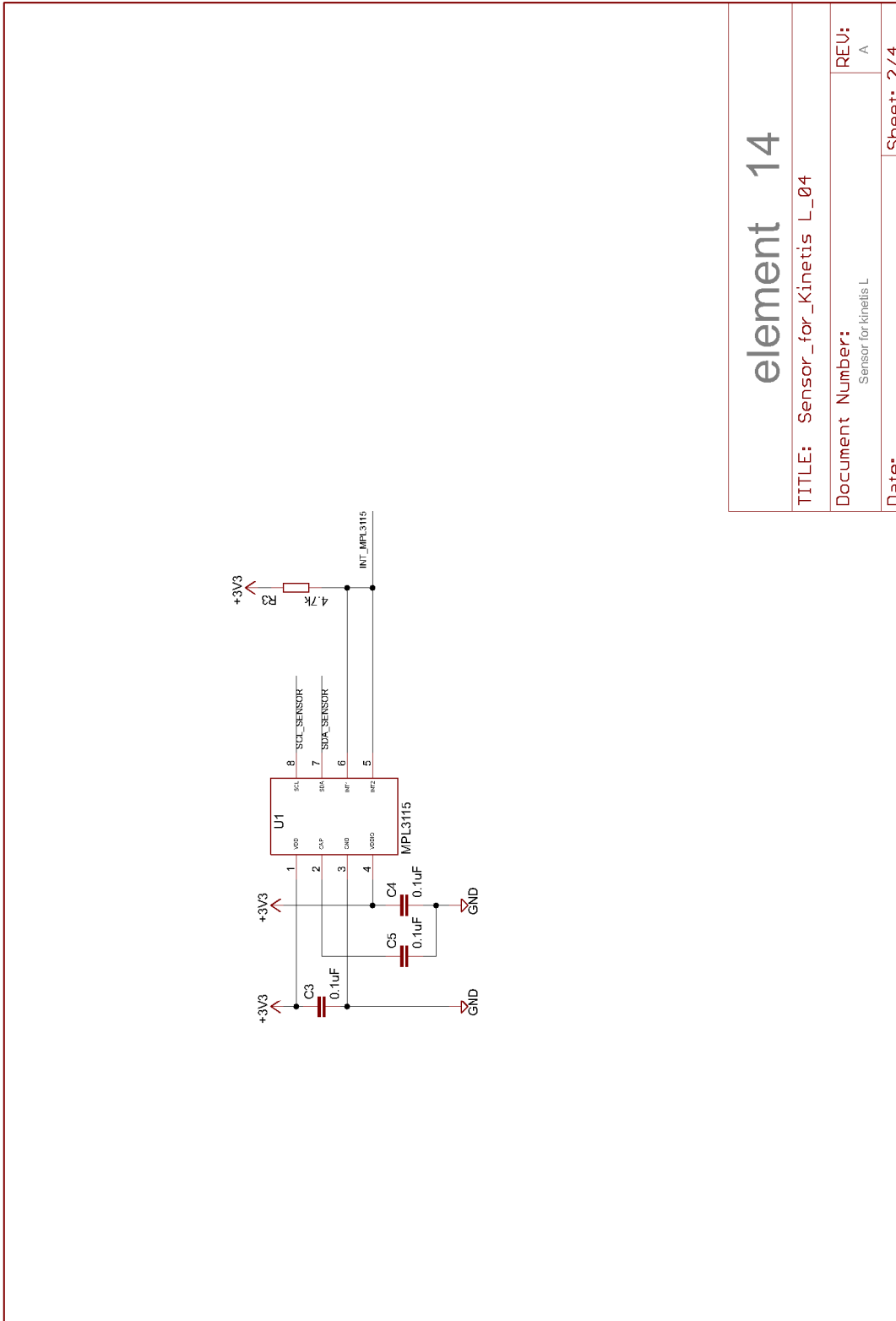


Figure 8 Sensor Board Schematic - 1



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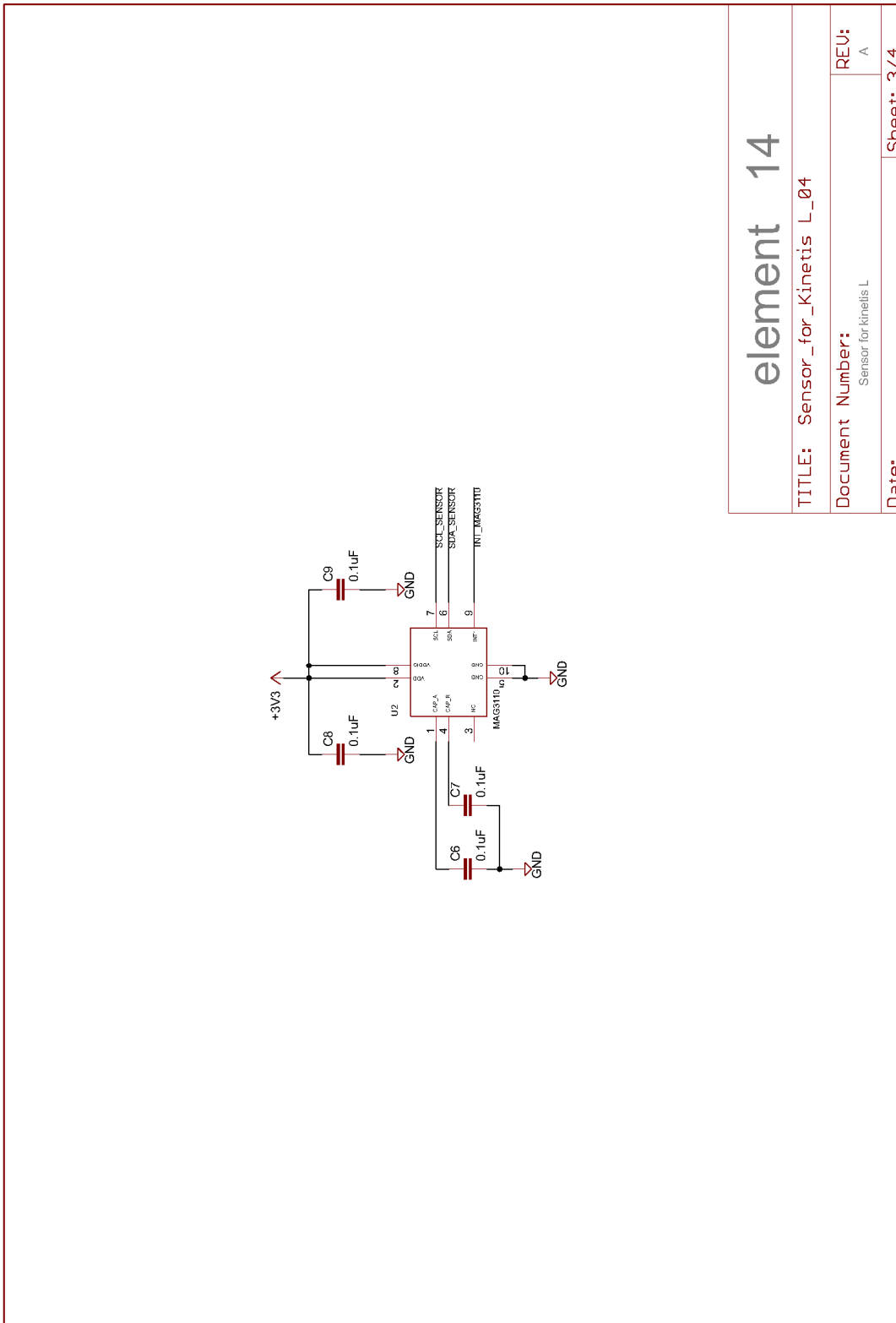
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Document Number:
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Date:
 Sheet: 2/4

Figure 9 Sensor Board Schematic - 2



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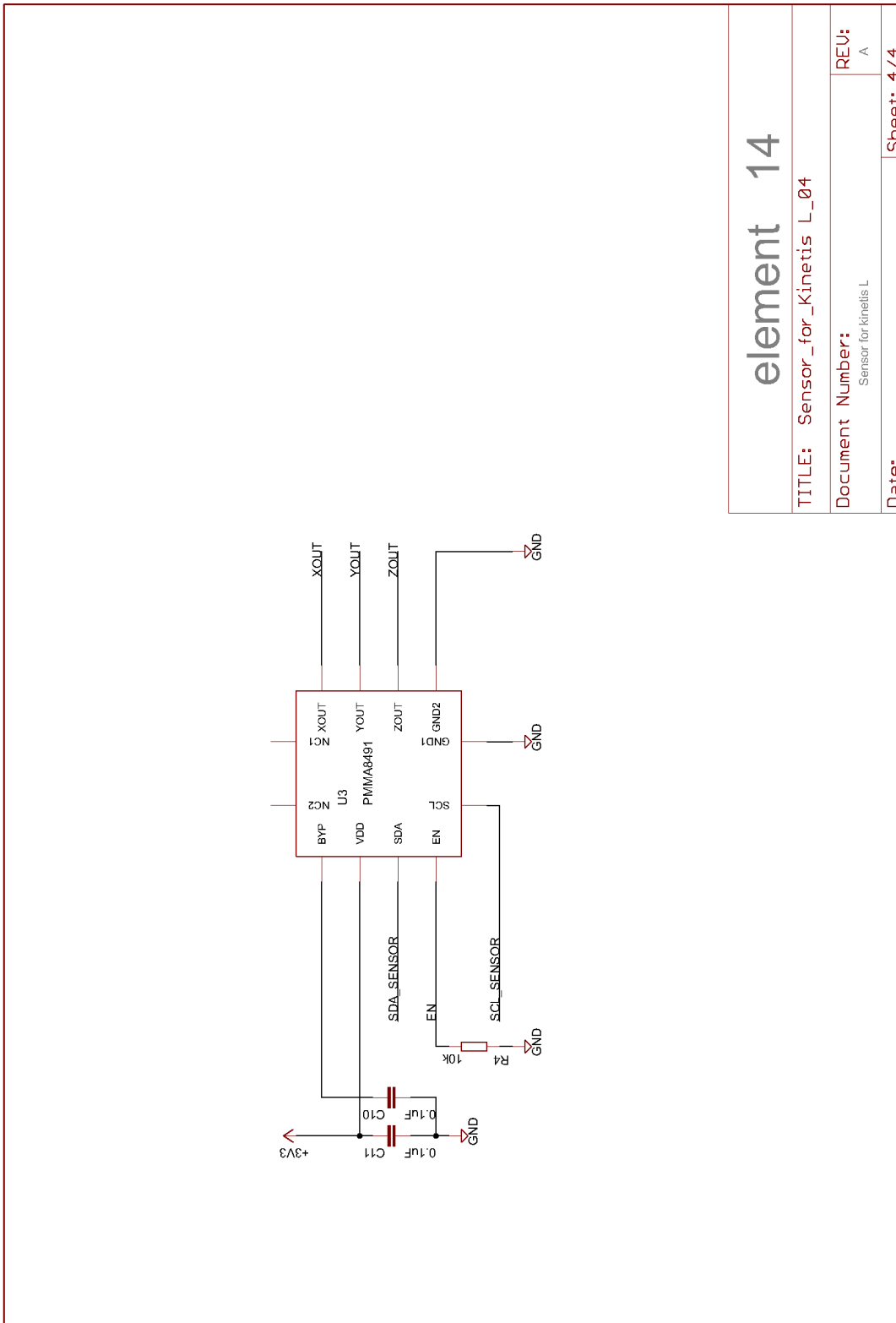
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 Sensor for kineticis L

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 A

Date:

Sheet: 3/4

Figure 10 Sensor Board Schematic - 3



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TITLE: Sensor_for_Kinetis_L_04

Document Number: Sensor for Kinetis L
 REV: A

Date: Sheet: 4/4

Figure 11 Sensor Board Schematic - 4

PCB Layout

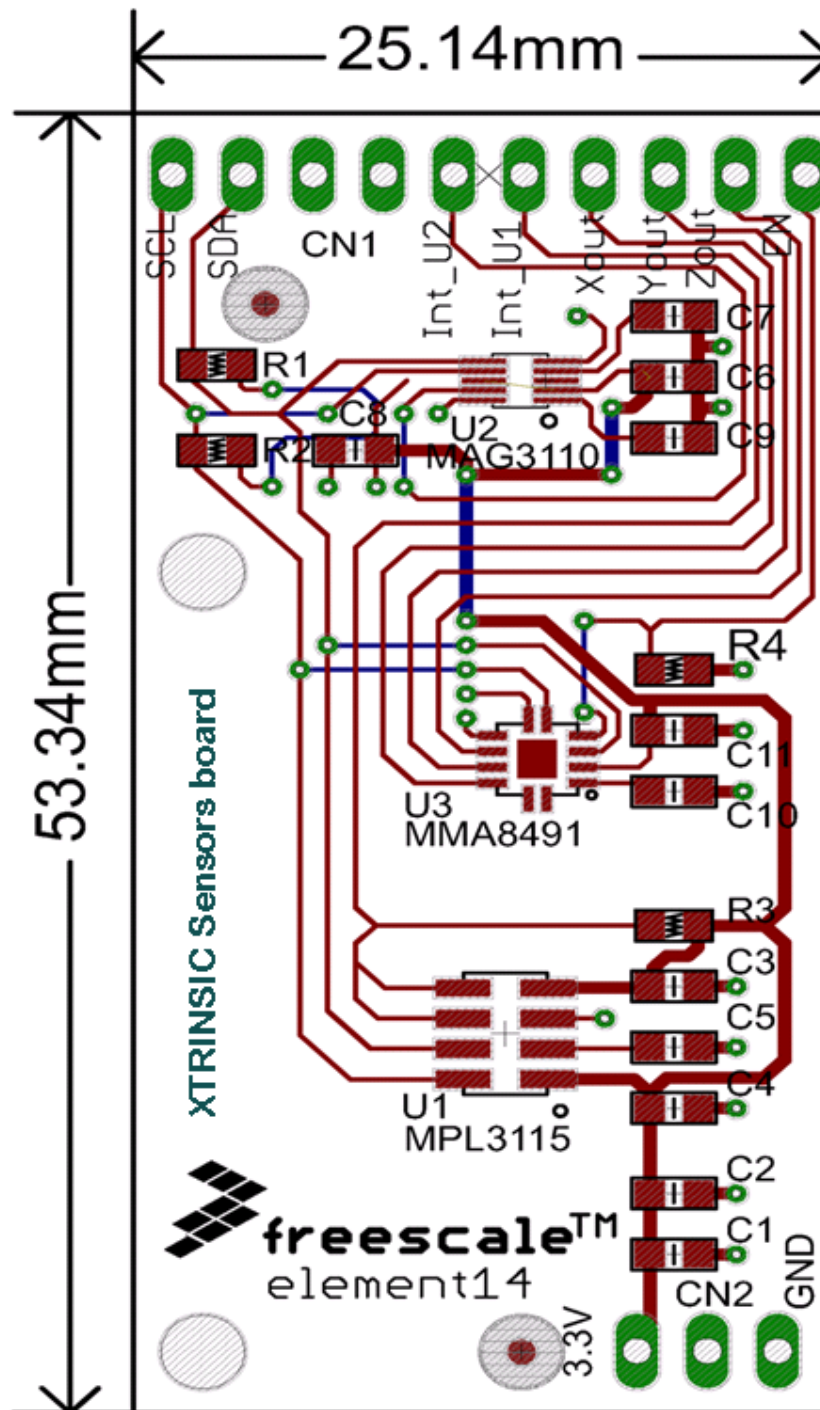


Figure 12 Sensor Board PCB TOP View

Bill of Materials

Reference	Description	Manufacturer	Part No.	Farnell	Newark	Priority
U1	PRESSURE SENSOR, 20-110KPA					
		FREESCALE	MPL3115A2	2009084	61T7697	Preferred
U2	MAGNETOMETER, 3AXIS, I2C, 80HZ					
		FREESCALE	MAG3110FCR1	2080492	83T2982	Preferred
U3	ACCELEROMETER - SENSOR, QFN-16					
		FREESCALE	MMA8491Q	2291592	47W865	Preferred
C1	MLCC, 0603, 6.3V, 10UF					
		KEMET	C0603C106M9PACTU	1288201	86K0597	Preferred
		TAIYO YUDEN	JMK107BJ106MA-T	1463375	30K5476	Alternate
		AVX	QM036D106MAT	1867960	20T0206	Alternate
C2~ C11	MLCC, 0603, 16V, 0.1UF					
		AVX	CM105X7R104K16AT	1216538	01M7218	Preferred
		KEMET	C0603C104J4RACTU	1650834	64K2836	Alternate
		MULTICOMP	B0603R104KCT	9406140	37K9922	Alternate
R1, R2, R3	RESISTOR, 0603, 4.7K, 1%					
		MULTICOMP	MCHP03W8F4701T5E	1576293	01N6891	Preferred
		VISHAY	CRCW06034K70FKEA	1469807	52K8494	Alternate
		YAGEO	RC0603FR-074K7L	1117265	98K7410	Alternate
R4	RESISTOR, 0603, 10K, 1%					
		MULTICOMP	MCHP03W8F1002T5E	1576297	01N6844	Preferred
		VISHAY	CRCW060310K0FKEA	1469748	52K8063	Alternate
		YAGEO	RC0603FR-0710KL	1117235	68R0049	Alternate
CN1	HEADER, 2.54MM, VERTICAL THT, 10WAY					
		MOLEX	90120-0770	9733353	25M5816	Preferred
		SAMTEC	HTS-110-G-A	1929555	83T9016	Alternate
CN2	HEADER, 2.54MM, VERTICAL THT, 3WAY					
		TE	825433-3	3417657	99K0795	Preferred
		SAMTEC	HTS-103-G-A	1926586	83T8997	Alternate

Table 26 Sensor Board BOM list

ESD PRECAUTIONS AND PROPER HANDLING PROCEDURES

This section includes the precautions for mechanical handling and static precautions to be taken to avoid ESD damage:

- Avoid carpets in cool, dry areas. Leave development kits in their anti-static packaging until ready to be installed.
- Dissipate static electricity before handling any system components (development kits) by touching a grounded metal object, such as the system unit unpainted metal chassis.
- If possible, use antistatic devices, such as wrist straps and floor mats.
- Always hold a evaluation board by its edges. Avoid touching the contacts and components on the board.
- Take care when connecting or disconnecting cables. A damaged cable can cause a short in the electrical circuit.
- Prevent damage to the connectors by aligning connector pins before you connect the cable. Misaligned connector pins can cause damage to system components at power-on.
- When disconnecting a cable, always pull on the cable connector or strain-relief loop, not on the cable itself.