Freescale Semiconductor
User's Guide

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MMA845xQ Sensor Toolbox User's Guide

1 Introduction

The Freescale MMA845xQ sensor toolbox accelerometer kit provides hardware and software for development and demonstration of the MMA845xQ family of accelerometers.

The kit includes the following:

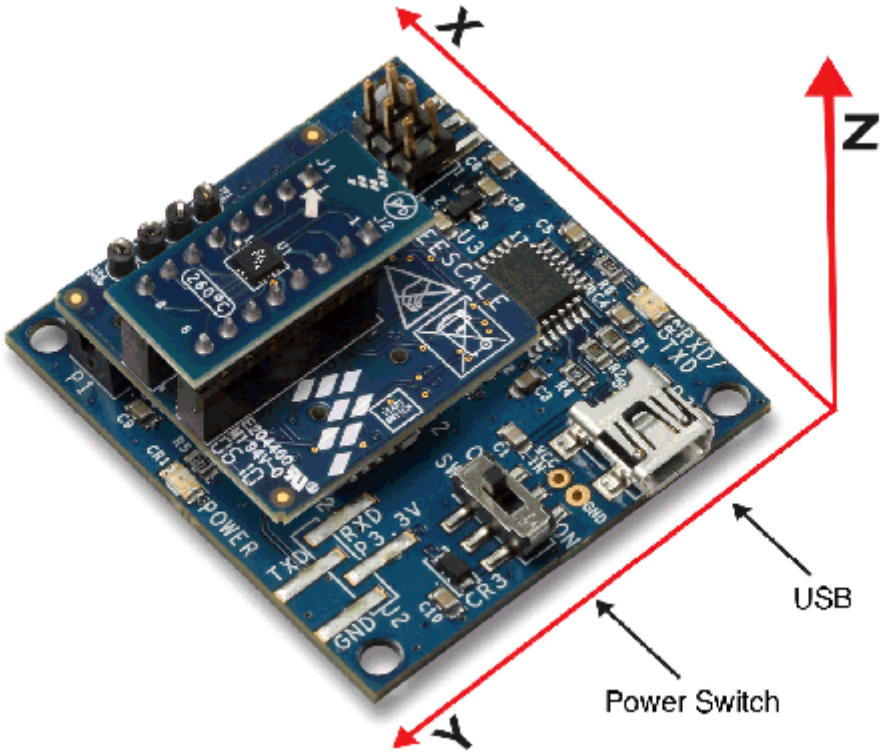
- MMA845xQ evaluation board
- MMA8451Q accelerometer daughter board
- MMA8452Q accelerometer daughter board
- MMA8453Q accelerometer daughter board

The kit requires the LFSTBUSB USB-interface board to attach the kit to a personal computer. If you already have the RD3924MM450Q Sensor Toolbox, for the MMA8450Q accelerometer, the USB board is in that kit.

The MMA845xQ kit's part number is LFSTBEB845x and the USB-interface board's part number is LFSTBUSB. Both items can be purchased on the Freescale website.

When assembled, the device detection axes are as shown in the following illustration.

Contents



2 Getting Started

To begin using the kit, connect it to your PC and install the sensor toolbox software.

2.1 Connecting the Kit

Select one of the three daughter boards and attach it to the evaluation board, as directed in the *MMA845xQ Quick Start Guide* included with the boards.

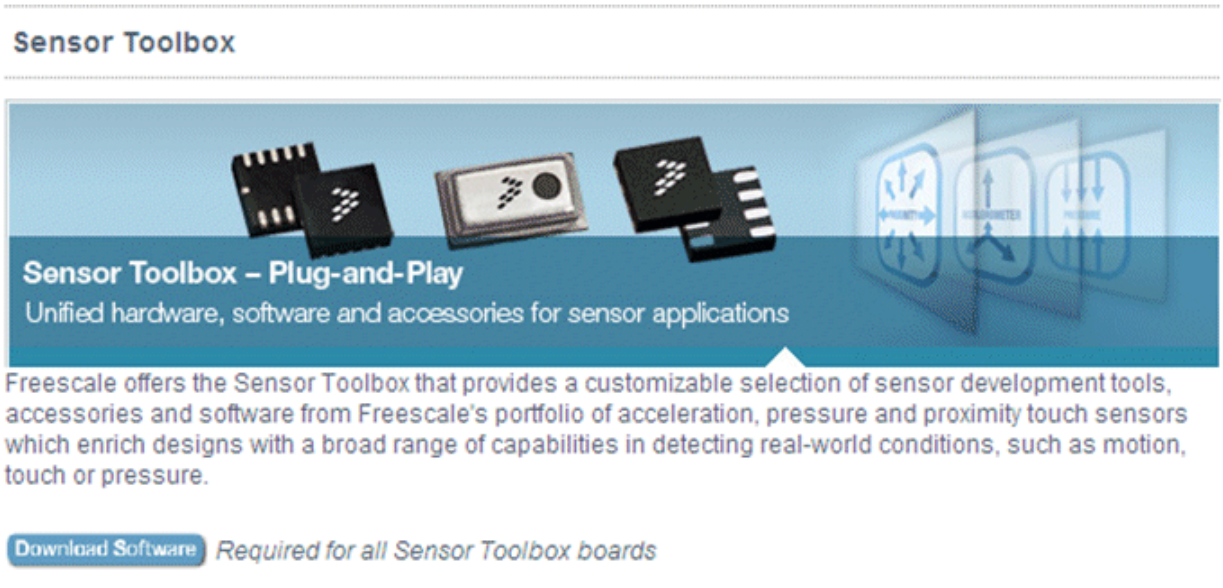
Connect the LFSTBUSB USB-interface board to a spare USB port on a Windows-based PC using the USB cable that comes with the USB board. If the board's red power LED does not illuminate, check the board's power switch, near its USB connector.

2.2 Installing the Sensor Toolbox Software

Perform the following procedure to install the software.

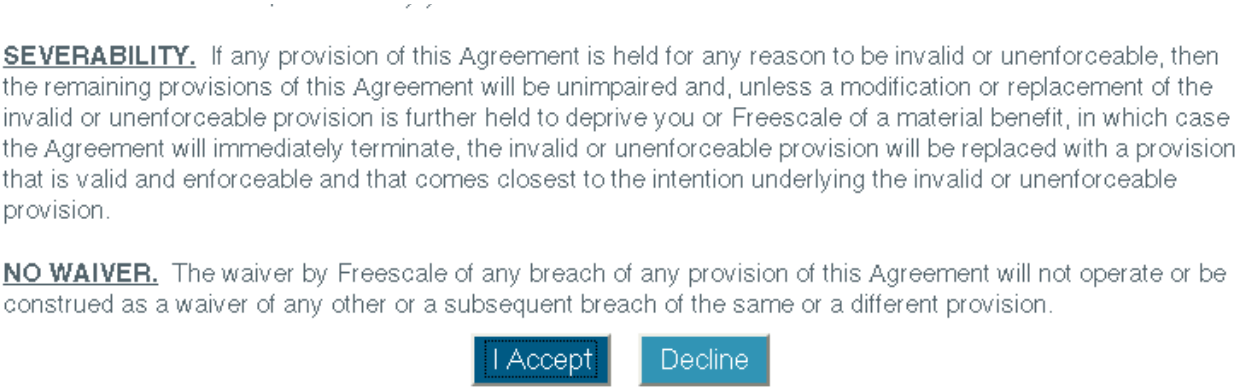
Near the end of this process, you will be asked if you want to install a serial-to-USB driver included with the sensor toolbox. If you have been previously used Freescale's sensor toolbox software, these drivers already are installed on your PC.

1. To download the sensor toolbox software, click the following link:
   http://www.freescale.com/sensortoolbox.
   The webpage, shown below, appears.



2. Click the Download Software button.

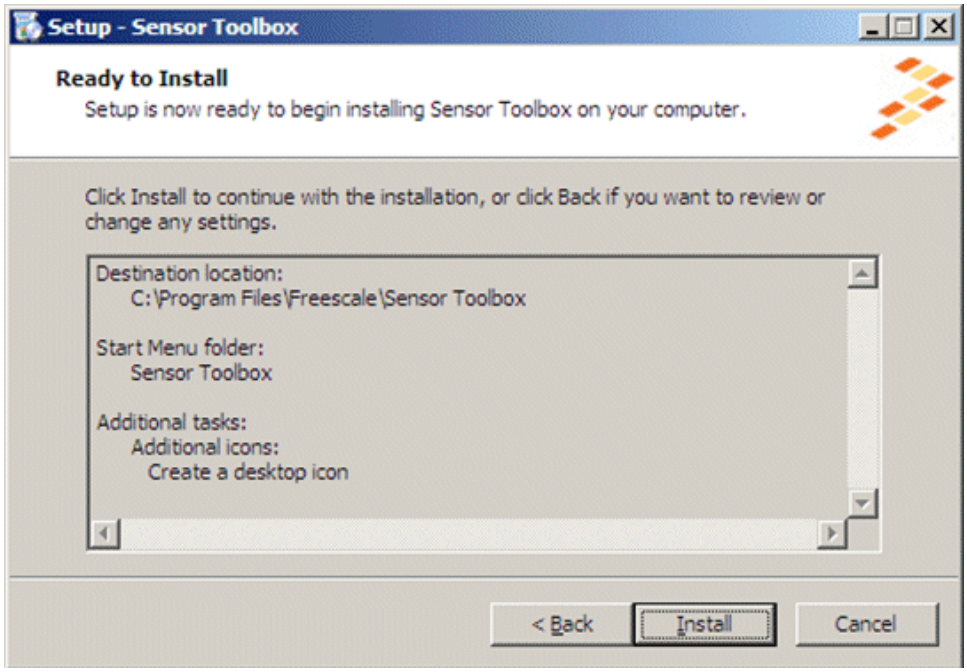
   The Sensor Toolbox Installer license agreement page appears.
3. Scroll down to the bottom of the page, shown below, and click the I Accept button.



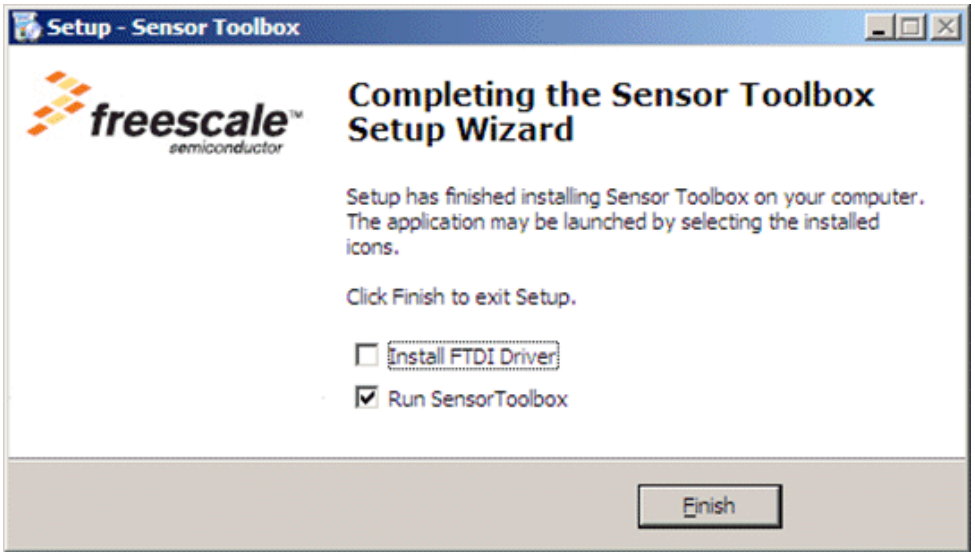
4. Save the software's installation executable file (SensorToolboxInstaller.exe) to your PC.
5. If you have not already connected the toolkit to your PC, perform the procedure in Section 2.1, "Connecting the Kit".
6. Locate the installation file on your PC and double-click on it.
7. Proceed through the setup wizard's series of dialog boxes.

   During the process, you will be asked if you want a Sensor Toolbox icon added to your Start menu and desktop.

8. When the Ready to Install dialog box, shown below, appears, review the installation configuration and click the Install button.



A progress bar displays the status of the software installation and the final dialog box, shown below, appears.



9. Do any of the following and click the Finish button:
   — To install the Future Technology Devices International (FTDI) serial-to-USB communications driver, enable the Install FTDI Driver checkbox
   — To launch the toolbox software upon completion of the setup, leave the Run Sensor Toolbox checkbox enabled

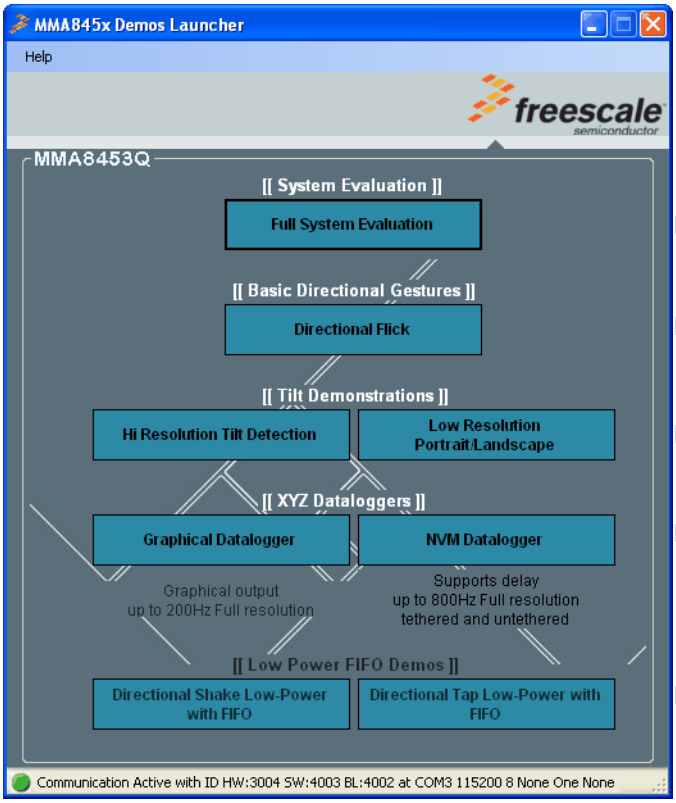
   If you chose to install the FTDI driver, a command-line window briefly appears.

The application is now ready for use.

2.3 Opening the Sensor Toolbox Software

To launch the toolbox software, either double-click on the application's desktop icon or choose Start > Programs > Sensor Toolbox > Sensor Toolbox. This displays the sensor toolbox's hardware-detection dialog box, shown below.

If the LFSTBUSB USB-interface board is connected properly, then the software will detect which of the MMA845xQ daughter boards is attached to the evaluation board, and display the device-specific menus. Upon device connection, the software displays the demo launcher menu, shown in the next illustration.



Note: The low power FIFO demonstrations are available only for the MMA8451Q device.

- To launch a demo, click on its box.
- To navigate to a different demo, close the browser window for the current demo and click on a different demo box in the launcher menu, which remains in the background as long as the application is running.

3 Understanding the Accelerometer Demonstrations

The sensor toolbox has several demonstrations for the MMA845xQ accelerometers, each showcasing the built-in intelligence of the individual devices. The demos include tilt detection, orientation detection, directional tap, and directional shake. There also is a full-system evaluation mode that allows you to evaluate the sensor at the register level.

3.1 Directional Flick Application

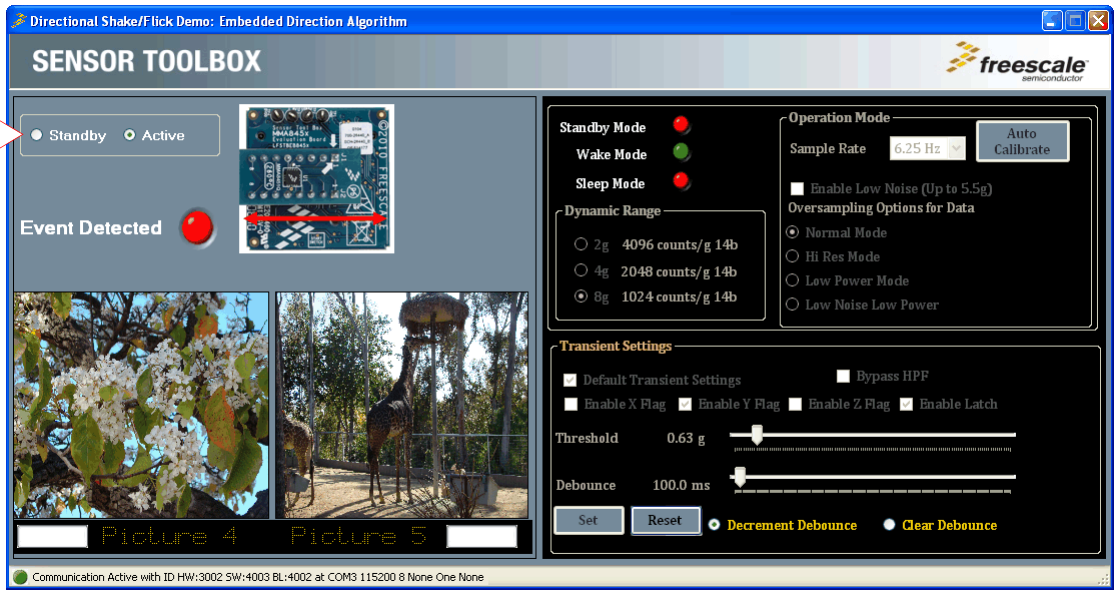
This demo enables you to evaluate the built-in algorithm for detecting flicks (transient events) with all three accelerometers. You can evaluate Freescale's default configuration and modify those settings to tailor a demonstration to your target application.

Launching the demo displays the Active screen.

3.1.1 Active Screen

The Active screen contains a Direction Event Detected indicator with a direction text display, a picture showing how to hold the device, and some pictures that can be manipulated by flicking the device. The flick must be done in the direction indicated by the red arrow.

Note: Before changing any of the Active screen's settings, select the Standby option button.



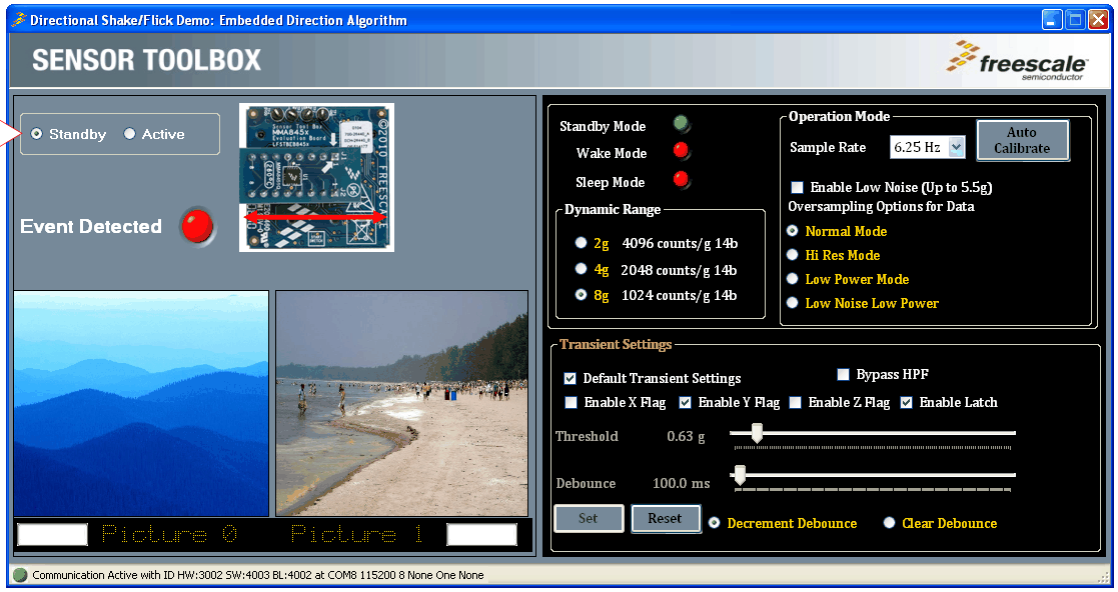
3.1.2 Standby Screen

Use the Standby screen to:

- Change the sample rate of the device
- Enable the low-noise mode
- Change the over-sampling setting
- Calibrate the device

- Set the dynamic range
- Change the device state and the parameters for detecting transient events

Note: To modify the default configuration, first enable the Standby option button on the right side of the screen.



The screen contains the following menu frames:

- Operation Mode
- Dynamic Range
- Standby Active
- Transient Settings

Each menu frame's fields and options are described in the following table.

Table 1. Directional Flick – Active/Standby screens

Screen frame	Field or option	Description	
Operation Mode	Sample Rate	Enables you to change the rate at which the device acquires data.	
	Enable Low Noise	Enables the device's Low Noise Mode for more accurate readings. **Note:** In this mode, any g-force greater than ±4g will not be read.	
	Over-Sampling Options for Data	Normal Mode	Normal operation.
		Hi Res Mode	The device gives more accurate readings, but draws more current.
		Low Power Mode	The device draws less current than Normal mode, but at the expense of accuracy.
		Low Noise Low Power	The device draws more current Normal mode, but less than Low Power mode and reduces noise.
	Auto Calibrate	Directs the device to calculate the offsets for each axis (account for any error in measurements). For maximum resolution, the calibration is done with a dynamic range of 8g and a sample rate of 1.563 Hz. **Note:** Before enabling this mode, place the device on a flat and stationary surface.	
Dynamic Range	• 2g • 4g • 8g	Sets the range over which the accelerometer is acquiring data.	

Table 1. Directional Flick – Active/Standby screens (Continued)

Screen frame	Field or option	Description
Standby Active	Standby option button	Deactivates the device. **Note:** Before any settings can be changed, the Standby option must be enabled.
	Active[1] option button	Activates the device. **Note:** Settings cannot be changed in the Active state. **Note:** After changing the configuration settings, enable the Active option.
	• Standby Mode • Wake Mode • Sleep Mode	Indicates the device's status.
Transient Settings	Default Transient Settings	Sets the parameters for detecting flicks to their working values, as defined at the factory.
	Bypass HPF (High-Pass Filter)	Directs the application to use the raw accelerometer data before it has been passed through the HPF. **Note:** The Bypass HPF setting should normally be disabled.
	• Enable X Flag • Enable Y Flag • Enable Z Flag	Allows flicks along these axes to trigger the "Event Detected" Indicator on the Demo Screen. **Note:** Only the Y axis will move the pictures and correctly trigger the direction indicator. If enabled, the X and Z axes will only trigger the Event Detected indicator on the Demo screen.
	Enable Latch	Causes any triggered event to remain until the status buffer is read. If this checkbox is not enabled, the interrupt will only last as long as the event and the status buffer will represent the most-recent event. This setting should be enabled for the flick detection to work properly. If it is disabled, the events that are moving the pictures will constantly occur as you move the device and the pictures will simply flick from end to end.
Transient Settings (continued)	Threshold slider	Sets the threshold for flick events to be detected. Flicks at a smaller g-force than this value are filtered out. To move the slider, the Reset button must be clicked. After the selection is made, click the Set button to change the setting.
	Debounce slider	This slider sets the amount of time that the configured conditions must be in place to trigger the main flick event. Any event whose duration does not exceed this time will not trigger an interrupt. To move the slider, the Reset button must be clicked. After the selection is made, click the Set button to change the setting.
	Decrement Debounce option button	Selecting this option causes the Debounce timer to be decremented each time an event fails to reach the debounce time.
	Clear Debounce option button	Selecting this option will cause the timer set by the Debounce slider to reset each time an event fails to reach the debounce time.
	Set button	Saves the new configuration settings after the repositioning of the Threshold and Debounce sliders.
	Reset button	Enables you to move the Threshold and Debounce sliders.

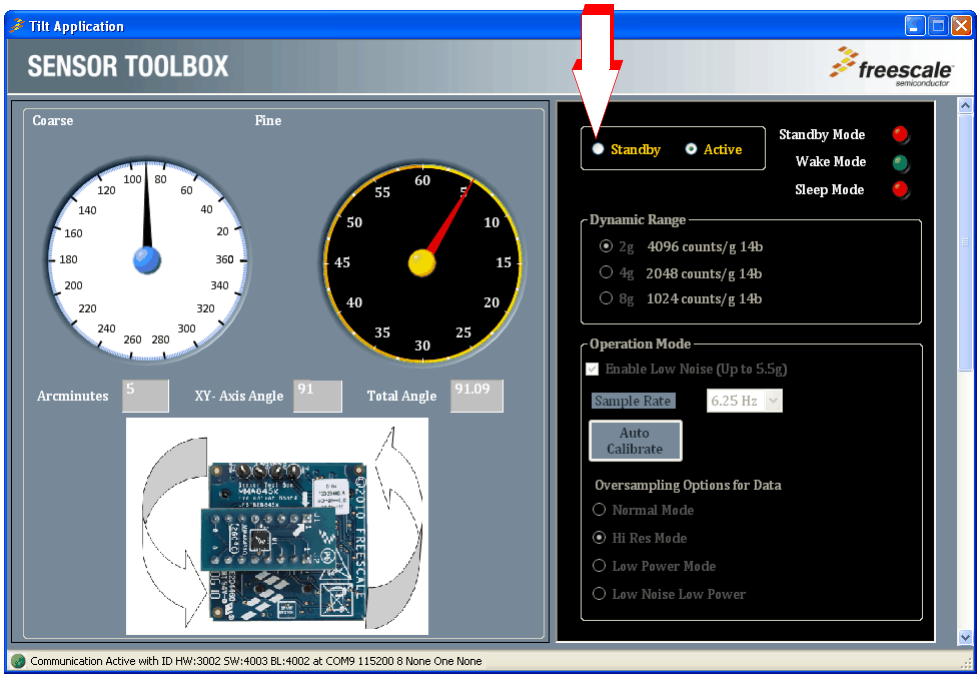
[1] After Changing the configuration settings, you must enable the Active option button.

3.2 Tilt Detection Application

3.2.1 Active Screen

The Active screen enables you to evaluate the built-in algorithm for detecting the device's tilt, in conjunction with the device's resolution mode (coarse or fine). You can evaluate the default configuration and modify the settings to tailor the demonstration to your target application.

Note: Before changing any of the Active screen's settings, select the Standby option button.



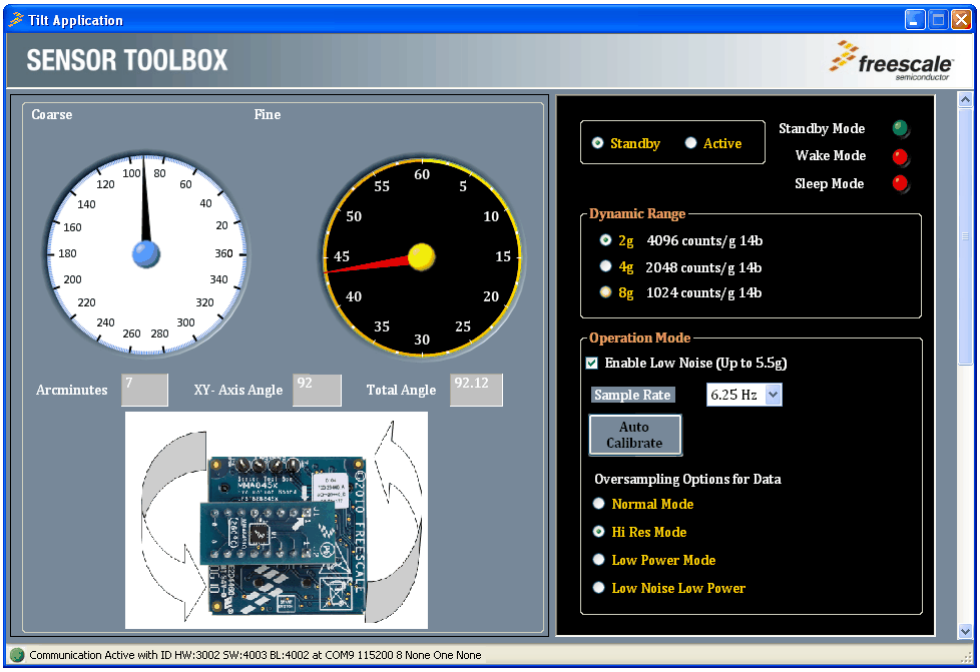
The Active screen's display shows the accelerometer output and a picture describing how the device should be oriented.

Note: In order for the tilt to be registered, the device must be held up so that it is facing you (or held on a desk on its edge).

3.2.2 Standby Screen

Use the Standby screen to:

- Change the sample rate of the device
- Change the over-sampling setting
- Enable Low-Noise mode
- Set the dynamic range
- Change the device state



The Standby screen contains the following menu frames:

- Operation Mode
- Dynamic Range
- Standby Active

Each menu frame's fields and options are described in the following table.

Table 2. Tilt Detection – Active/Standby screens

Screen frame	Field or option	Description
(Resolution)	Coarse	Indicates the angle the device is being held at, along the X and Y axes (degrees).
	Fine	Shows the Arcminutes value of the angle (where an Arcminute is equal to1/60 of a degree).

Table 2. Tilt Detection – Active/Standby screens (Continued)

Screen frame	Field or option	Description	
Operation Mode	Sample Rate	Enables you to change the rate at which the device acquires data. **Note:** The tilt demo will not function at the 1.563 Hz Sample Rate.	
	Enable Low Noise	Enables the device's Low Noise Mode for more accurate readings. **Note:** In Enable Low Noise mode, any g-force greater than ±4g will not be read.	
	Over-Sampling Options for Data	Normal Mode	Normal operation.
		Hi Res Mode	The device gives more accurate readings, but draws more current.
		Low Power Mode	The device draws less current than Normal mode does, but at the expense of accuracy.
		Low Noise Low Power	The device draws more current than Normal mode does, but less current than Low Power mode does, and reduces noise.
	Auto Calibrate	Directs the device to calculate the offsets for each axis (accounting for any error in measurements). For maximum resolution, the calibration is done with a dynamic range of 8g and a sample rate of 1.563 Hz. **Note:** Before enabling Auto Calibrate mode, place the device on a flat and stationary surface. **Note:** Before returning to active mode, it is necessary to set the Sample Rate back to a usable value, because running Auto Calibrate sets the device to the 1.563 Hz Sample Rate (a frequency at which the tilt application cannot function).	
Dynamic Range	• 2g • 4g • 8g	Sets the range over which the accelerometer is acquiring data.	
Standby Active	Standby option button	Deactivates the device. **Note:** Before any settings can be changed, the Standby option must be enabled.	
	Active[1] option button	Activates the device. Settings cannot be changed in the Active state. **Note:** After changing the configuration settings, enable the Active option.	
	• Standby Mode • Wake Mode • Sleep Mode	Indicates the device's status.	
Start button	(This button currently is not functional.)		

1 After changing the configuration settings, you must enable the Active option button.

3.3 Orientation Application

The Orientation application demo enables you to evaluate the built in Portrait/Landscape algorithm for detecting orientation. Using this application, you can evaluate Freescale's default configuration, as well as change the settings to tailor the demonstration to your target application

3.3.1 Active Screen

You can evaluate the default configuration and modify the settings, to tailor the demonstration for your target application.

Note: Before changing any of the Active screen's settings, select the Standby option button.

The Active screen contains a Portrait/Landscape gauge, which is a simulated mobile phone that displays the orientation indicated by the device, and a Back/Front gauge.

3.3.2 Standby Screen

Use the Standby screen to:

- Change the sample rate of the device
- Change the over-sampling setting
- Enable low noise mode
- Set the dynamic range
- Set the device's state
- Change the parameters for detecting orientation changes

The configure screen contains the following menu frames:

- Operation Mode
- Dynamic Range
- Standby Active
- Orientation Detection

Note: Before changing the Orientation Detection values, select the Enable P/L button.

Each menu frame's fields and options are described in the following table.

Table 3. Orientation – Active/Standby screens

Screen frame	Field or option	Description
	Portrait/Landscape	Shows the angle of the X and Y axes of the device. If the device is tilted and passed the Z-lockout angle, then changes in the X and Y axes are ignored and the gauge displays "Lock Out." To resume orientation detection, rotate the device away from the Z-lockout angle. For more information about the Z-lockout angle, see Section 3.3.2, "Standby Screen".
	(Simulated mobile phone)	Orients the phone at the angle indicated by the data from the accelerometer.
	Back/Front	Displays the Front/Back angle of the device.

Table 3. Orientation – Active/Standby screens (Continued)

Screen frame	Field or option	Description	
Operation Mode	Sample Rate	Enables you to change the rate at which the device acquires data.	
	Enable Low Noise	Enables the device's Low Noise Mode for more accurate readings. **Note:** In Enable Low Noise mode, any g-force greater than ±4g will not be read.	
	Over-Sampling Options for Data	Normal Mode	Normal operation.
		Hi Res Mode	The device gives more accurate readings, but draws more current.
		Low Power Mode	The device draws less current than Normal mode does, but at the expense of accuracy.
		Low Noise Low Power	The device draws more current than Normal mode does, but less current than Low Power mode does, and reduces noise.
	Auto Calibrate	Directs the device to calculate the offsets for each axis (account for any error in measurements). For maximum resolution, the calibration is done with a dynamic range of 8g and a sample rate of 1.563 Hz. **Note:** Before enabling this mode, place the device on a flat and stationary surface.	
Dynamic Range	• 2g • 4g • 8g	Sets the range over which the accelerometer is acquiring data.	
Standby Active	Standby option button	Deactivates the device. **Note:** Before any settings can be changed, the Standby option must be enabled .	
	Active[1] option button	Activates the device. **Note:** Settings cannot be changed in the Active state. **Note:** After changing the configuration settings, enable the Active option.	
	• Standby Mode • Wake Mode • Sleep Mode	Indicates the device's status.	

Table 3. Orientation – Active/Standby screens (Continued)

Screen frame	Field or option	Description
Orientation Detection	Enable P/L	Enables the frame's settings to be modified. Clearing the checkbox will not, however, prevent the demo from functioning.
	Set Default Settings	Resets the frame's settings to the default values defined at the factory.
	Portrait-To-Landscape Trip Angle	Shows the current value.
	Landscape-To-Portrait Trip Angle	Shows the current value.
	Z-Lock Angle	Changes the Z-axis angle at which the device will ignore changes in orientation. (For more information, see "Orientation Application.")
	B/F Trip Angle	(Back/Front Trip Angle) Changes the range of z-axis angles within which the device considers itself facing front and back.
	P-L Trip Angle	(Portrait-to-Landscape Trip Angle) Changes the *midpoint* of the angle at which the device will change from portrait to landscape orientation, or vice versa. • For changing to right, the angle is measured down from the positive X axis. • For changing to the left, landscape orientation, the angle is measured up from the X-axis.
	Hysteresis Angle	Changes the *distance from the midpoint* of the angle at which the device will change from portrait to landscape orientation, or vice versa. The actual trip angle for changing orientation is the P-L angle ± this angle.
	Debounce slider	Changes the time that the device waits after a physical orientation change is detected, before triggering an orientation-change interrupt. To move the Debounce slider, the Reset button must be clicked. After the Debounce selection is made, click the Set button to change the setting.
	Decrement Debounce	Causes the Debounce timer to decrement each time that an event fails to reach the debounce time.
	Clear Debounce	Causes the timer set by the Debounce slider to reset each time that an event fails to reach the debounce time.
	Set button	Saves the new configuration settings after the repositioning of the Threshold and Debounce sliders.
	Reset button	Enables you to move the Threshold and Debounce sliders.

[1] After changing the configuration settings, you must enable the Active option button.

3.4 Graphical Datalogger Application

This application generates a data log from the accelerometer and enables you to export it to a text file. This enables you to evaluate the device's default settings and any of your modifications, and to tailor the datalogger to your data-collection needs.

3.4.1 Main Screen

The Main screen selects the data to be logged, and includes a drop-down menu for saving that data to a file.

Two other screens can be displayed from the Main screen: the Configuration and Registers screens.

- To access the Registers screen, click the Registers button.
- To access the Configuration screen, point the mouse at the bottom of the screen.

The elements of the main screen are described in the following table.

Table 4. Graphical Datalogger – Main screen

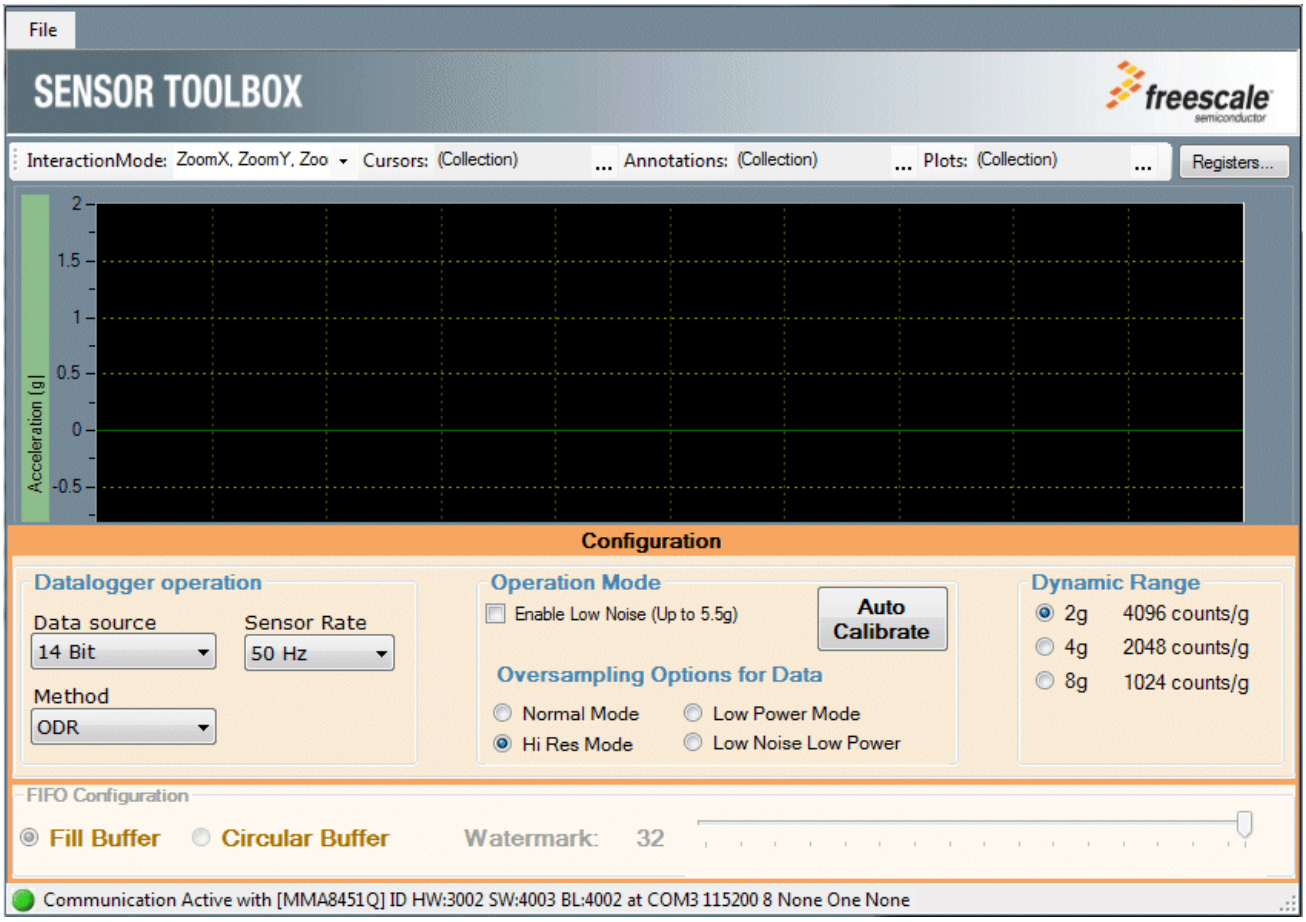
Element	Description	
File drop-down menu	Selecting File > Save saves the graph's currently displayed data to a file at your specified location.	The data is saved as a Comma-Separated Values (*.csv) file, which can be viewed with any text-based or spreadsheet application.
Registers	Opens the Registers section.	
Acceleration graph	Displays the data acquired by the accelerometer.	The data is acceleration (g value or counts) vs. time (seconds).
Start a New Datalog button	Starts logging the data acquired by the accelerometer and displays it in the graph.	
• X-Axis • Y-Axis • Z-Axis Checkboxes	• Enabling a checkbox begins displaying accelerometer data for the specified axis. • Clearing the checkbox stops displaying the data.	The legend items above each checkbox indicate the line colors for the respective axes.

Table 4. Graphical Datalogger – Main screen (Continued)

Element	Description	
Show G Values	Pushing this toggle up graphs the accelerometer's Y-axis g-force readings.	
Show Count Values	Pushing this toggle down graphs the accelerometer's Y-axis count readings.	
Number of points	The number of points in the current graph.	
Ctrl+N to start a new datalog	Keyboard shortcut to start a new datalog.	
Configuration status bar	Configuration Active with	
	[MMA8451Q] ID	The device ID
	HW:3002	The device's hardware revision number
	SW:4003	The device's software revision number
	BL:4002	
	at COM3	The communications port that the device is using
	115200	The baud rate at which the device is communicating with the computer (PC)
	8 None One None	8 data bits, no parity, 1 stop bit, no error checking

3.4.2 Configuration Screen

The Configuration screen gives you access to advanced options.



The Configuration screen contains the following menu frames:

- Datalogger Operation
- Operation Mode
- Dynamic Range
- FIFO Configuration

Each menu frame's fields and options are described in the following table.

Table 5. Graphical Datalogger – Configuration screen

Screen frame	Field or option	Description	
Datalogger Operation	Data Source	Selects the number of bits to be read from the device. A higher number of bits produces more-precise values, but it requires more time and power. • Selecting the 8-bit option causes the program to read only the 8 bits stored in the X, Y, and ZMSB registers. • Selecting 14 bit for the MMA8451Q reads the 8 MSB bits and the 6 bits stored in the X, Y, and ZLSB registers. • Selecting 12 bit for the MMA8452Q reads the 8 MSB bits and the 4 bits stored in the X, Y, and ZLSB registers. • Selecting 10 bit for the MMA8453Q reads the 8 MSB bits and the 2 bits stored in the X, Y, and ZLSB registers.	
	Method	This drop-down list enables you to select how the data is read from the device. • Selecting ODR will cause the data to be read directly from the device's output registers. • Selecting FIFO will cause the data to be collected from the FIFO on the device. To use the functions in the FIFO Configuration frame, the FIFO option must be selected.	
	Sensor Rate	This drop-down list enables you to select the rate that the accelerometer collects data at. **Note:** While sensor rate options above 200 Hz are included in the list (because the device is capable of operating at these rates), 200 Hz is the highest sensor rate at which the Datalogger can function— therefore these sensor rates will not be selectable in this application.	
Operation Mode	Enable Low Noise	Enables the device's Low Noise Mode for more accurate readings. **Note:** In Enable Low Noise mode, any g-force greater than ±4g will not be read.	
	Auto Calibrate	Directs the device to calculate the offsets for each axis (accounting for any error in measurements). For maximum resolution, the calibration is done with a dynamic range of 8g and a sample rate of 1.563 Hz. **Note:** Before enabling Auto Calibrate mode, place the device on a flat and stationary surface.	
	Over-Sampling Options for Data	Normal Mode	Normal operation.
		Hi Res Mode	The device gives more accurate readings, but draws more current.
		Low Power Mode	The device draws less current than Normal mode does, but at the expense of accuracy.
		Low Noise Low Power	The device draws more current than Normal mode does, but lesscurrent than Low Power mode does, and reduces noise.
Dynamic Range	• 2g • 4g • 8g	Sets the range over which the accelerometer acquires data.	
FIFO Configuration[1]	Fill Buffer option button	Fills the FIFO with data and then dumps that data to the Acceleration graph each time that the FIFO is full.	
	Circular Buffer option button	Fills the FIFO with data and then begins feeding it out from the front of the line. This will cause a 32-point lag between when the data is acquired and when it is displayed on the graph.	

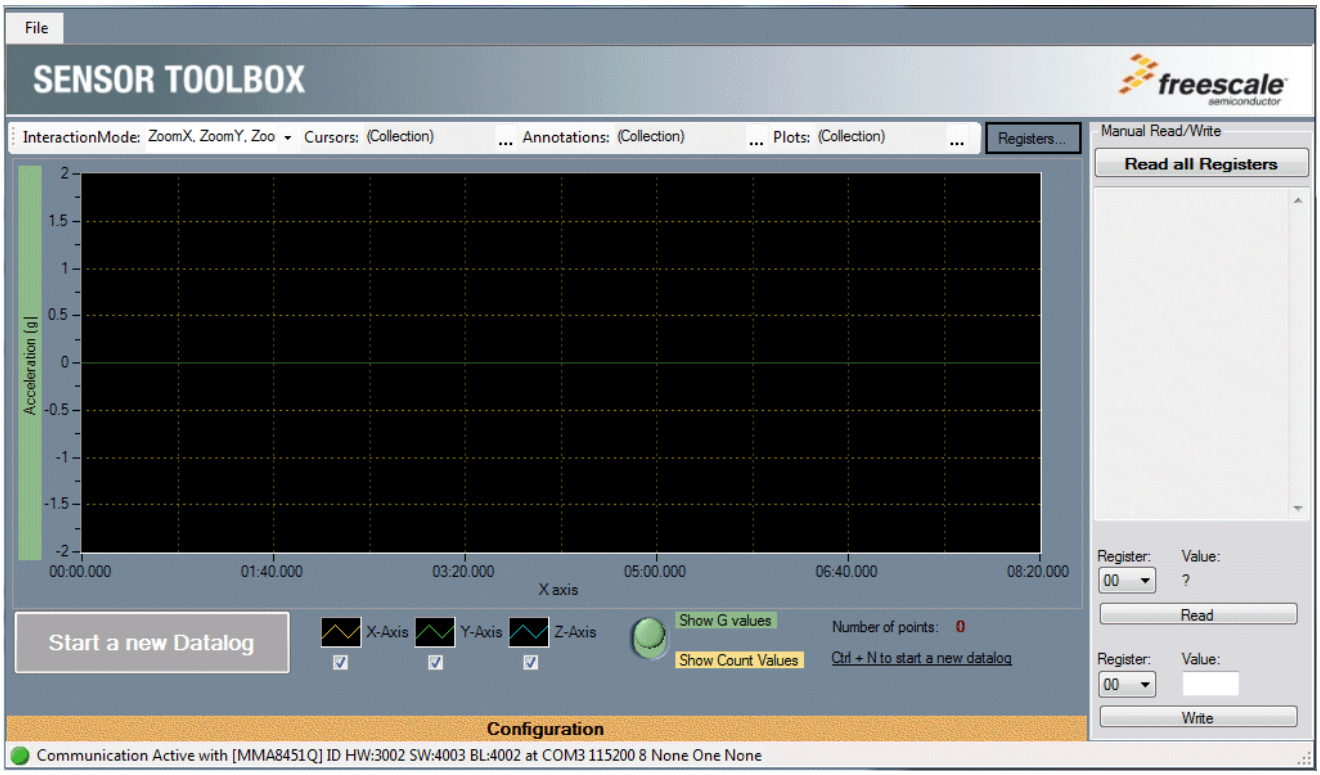
Table 5. Graphical Datalogger – Configuration screen (Continued)

Screen frame	Field or option	Description
	Watermark slider	Determines when the Watermark Flag will activate.

1 To use the functions in this frame, the Method drop-down field must be set to FIFO.

3.4.3 Registers Screen (Advanced Users Only)

The Registers screen enables you to read from or write to any of the device's registers. For information about the functions and values of each register, see the *Intelligent Motion Sensing Platform Data Sheet* (MMA845xL).



3.5 NVM Datalogger Application

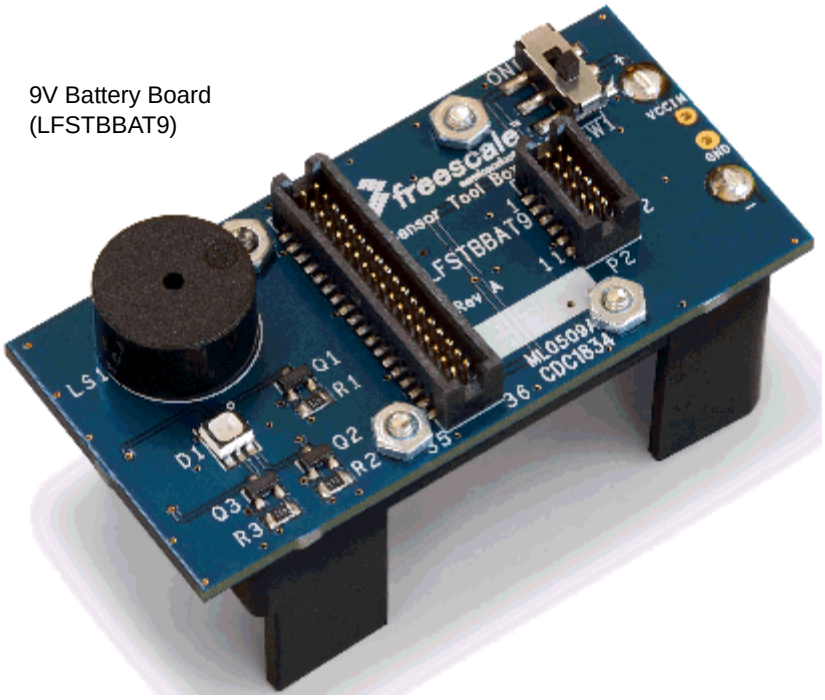
The Non-Volatile Memory (NVM) datalogger application enables you to make a log of data collected from the accelerometer (using the device's non-volatile memory), and export it (the data) to a text file. This enables you to evaluate the device's default settings and any of your modifications, for tailoring the datalogger for your data-collection needs.

NOTE

- The datalog is not erased when the device is powered off and on.
- When the NVM datalogger is started, a new piece of firmware is loaded onto the device to enable its use (you may see a Loader screen). When a new application is next opened, the firmware will be returned to normal (you will see the same screen again).

The application can collect the data, using either the device tethered to the computer with the USB cable or using a 9V battery board (LFSTBBAT9). The battery board can be purchased on the Sensor Toolbox website.

9V Battery Board
(LFSTBBAT9)



3.5.1 Main Screen

The Main screen enables you to start a new datalog, erase an existing datalog, or configure the datalog options. The Main screen's elements are described in the following table.

To display the Configuration screen, move the mouse over that menu's heading, at the bottom of the main screen.

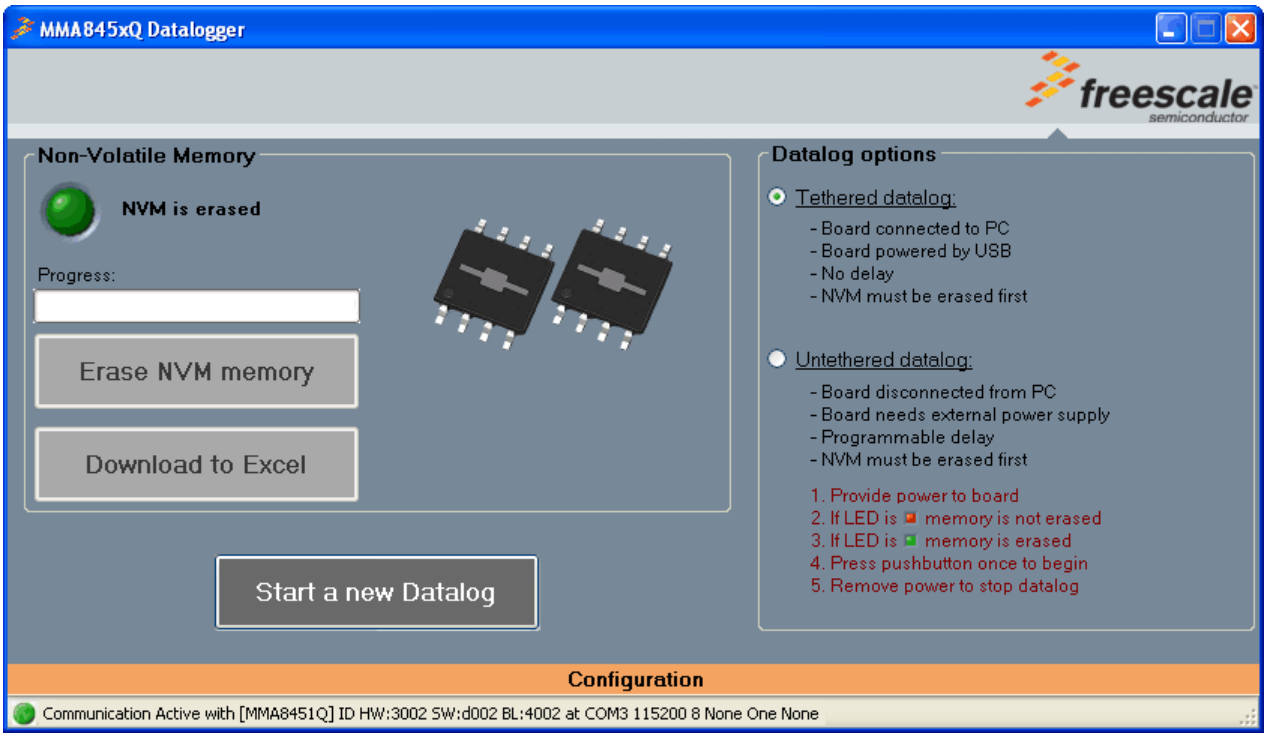


Table 6. NVW Datalogger – Main screen

Screen frame	Element	Description
Non-Volatile Memory	NVM is Erased status indicator	• If green, the text “NVM is erased” is displayed, indicating that the device is ready to start a new datalog. • If red, the text “NVM is not erased” is displayed, indicating that the device has stored a new datalog to memory. Pressing the “Erase NVM memory” button deletes all data currently stored in NVM, and returns the indicator to the green state.
	Progress indicator	Shows the progress of the “Erase NVM memory” or “Download to Excel” operation.
	Erase NVM memory button	Erases the non-volatile memory on the device. **Note:** Before a new datalog is started, the “Erase NVM memory” button must be clicked .
	Download to Excel button	Exports the data stored in the device’s NVM to a comma-separated-values (.csv) file (which can be opened with any spreadsheet or text application).
Datalog Options	Tethered Datalog	Collects data with the NVM while the device is still connected to the computer. The device will begin taking data as soon as the “Start a New Datalog” button is clicked.
	Untethered Datalog	Enables an external source to power the device while data is being collected in the NVM. (See Section 3.5.1.1, “Process for Untethered Dialog”, just after this table.)

Table 6. NVW Datalogger – Main screen (Continued)

Screen frame	Element	Description
Start a New Datalog	Starts a new datalog. Before using the “Start a New Datalog” function, the Erase NVM memory button must be clicked.	

3.5.1.1 Process for Untethered Dialog

1. If the NVM Status Indicator is not green, then click the Erase NVM Memory button.
2. Click the Start New Datalog button.
3. Disconnect the device from the computer and attach it to the external power source.
4. If you have configured a delay, then start the timer (by pressing the small button on the right side of the device).

   For information about setting a delay, see Delay Options in Table 7, “NVW Datalogger – Configuration screen,” on page 25.
5. To download the data, reconnect the device to the computer and re-open the NVM Datalogger demo.

3.6 Configuration Screen

The Configuration screen is displayed by moving the mouse pointer over the Configuration heading at the bottom of the main screen. The screen’s elements are described in the following table.

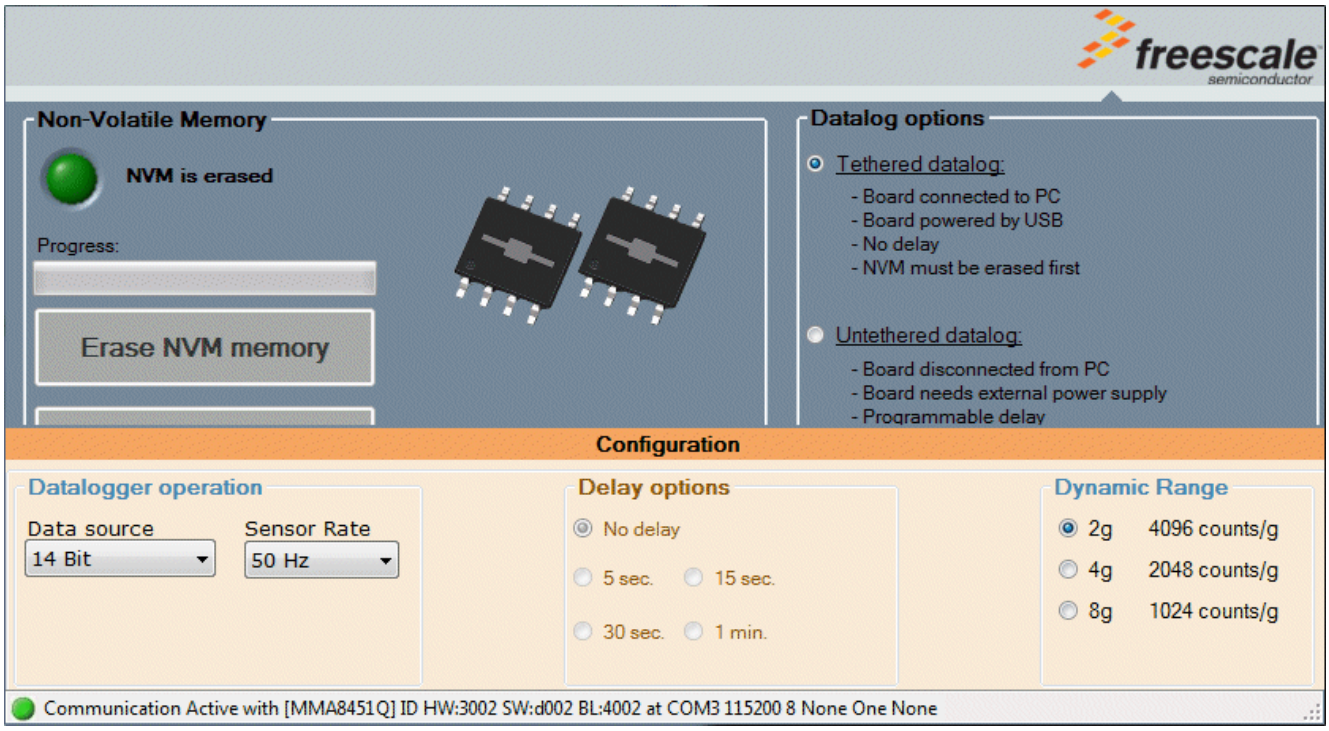


Table 7. NVW Datalogger – Configuration screen

Screen frame	Element	Description
Datalogger Operation	Data Source	Selects the number of bits to be read from the device. A higher number of bits produces more-precise values, but requires more time and power. • Selecting the 8-bit option causes the program to read only the 8 bits stored in the X, Y, and ZMSB registers. • Selecting 14 bit for the MMA8451Q reads the 8 MSB bits and the 6 bits stored in the X, Y, and ZLSB registers. • Selecting 12 bit for the MMA8452Q reads the 8 MSB bits and the 4 bits stored in the X, Y, and ZLSB registers. • Selecting 10 bit for the MMA8453Q reads the 8 MSB bits and the 2 bits stored in the X, Y, and ZLSB registers.
	Sensor Rate	This drop-down list enables you to select the rate that the accelerometer collects data at.
Delay Options	No Delay	Disables the delay function.
	• 5 sec • 15 sec • 30 sec • 1 min	Sets how long that the device waits, after its start button is pressed, before data is passed to the NVM.
Dynamic Range	• 2g • 4g • 8g	Sets the range over which the accelerometer acquires data.

3.7 Directional Tap with FIFO Application

The Directional Tap Application demo evaluates the built-in algorithm for detecting pulses in conjunction with the FIFO. You can evaluate Freescale's default configuration and modify those settings to tailor a demonstration for your target application.

This demo includes MCU-status and estimated-current displays, which enable you to demonstrate the device's power-saving sleep mode feature.

NOTE

The Directional Tap Application demo is available only for the MMA8451Q device.

3.7.1 Active Screen

The Active screen contains a set of indicators that change to green when a tap is detected. It also has a graph displaying the data stored in the FIFO, displays that show the MCU status, an estimate of used current, and the direction of the last tap. The screen's elements are described in the following table.

Note: Before changing any of the Active screen's settings, select the Standby option button.

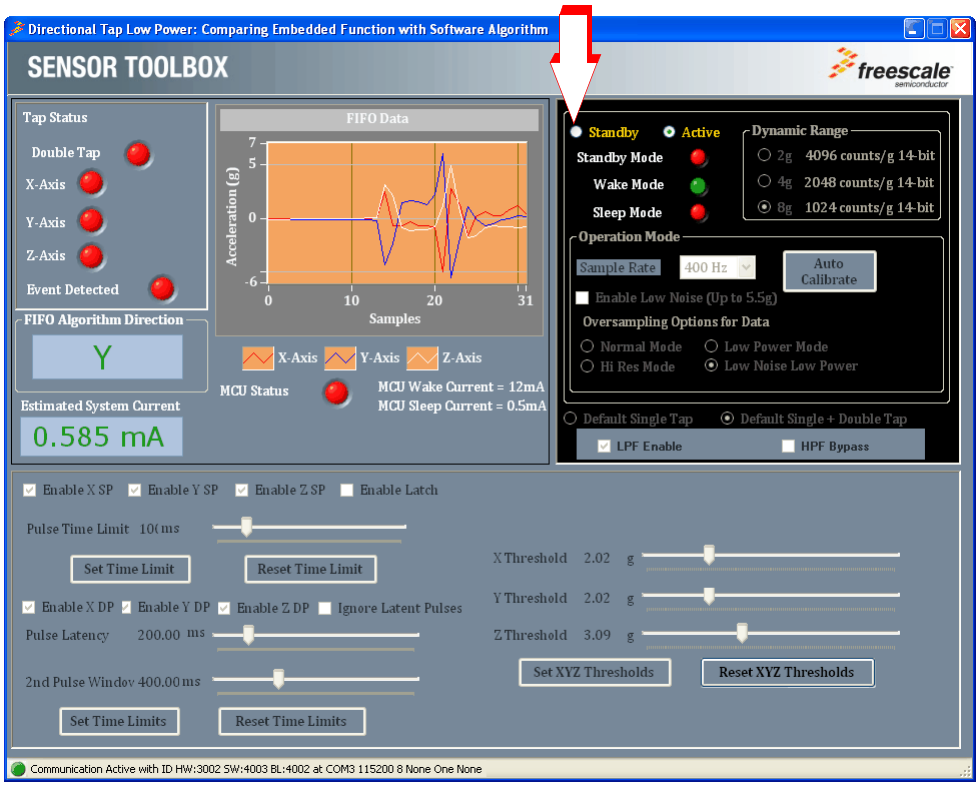


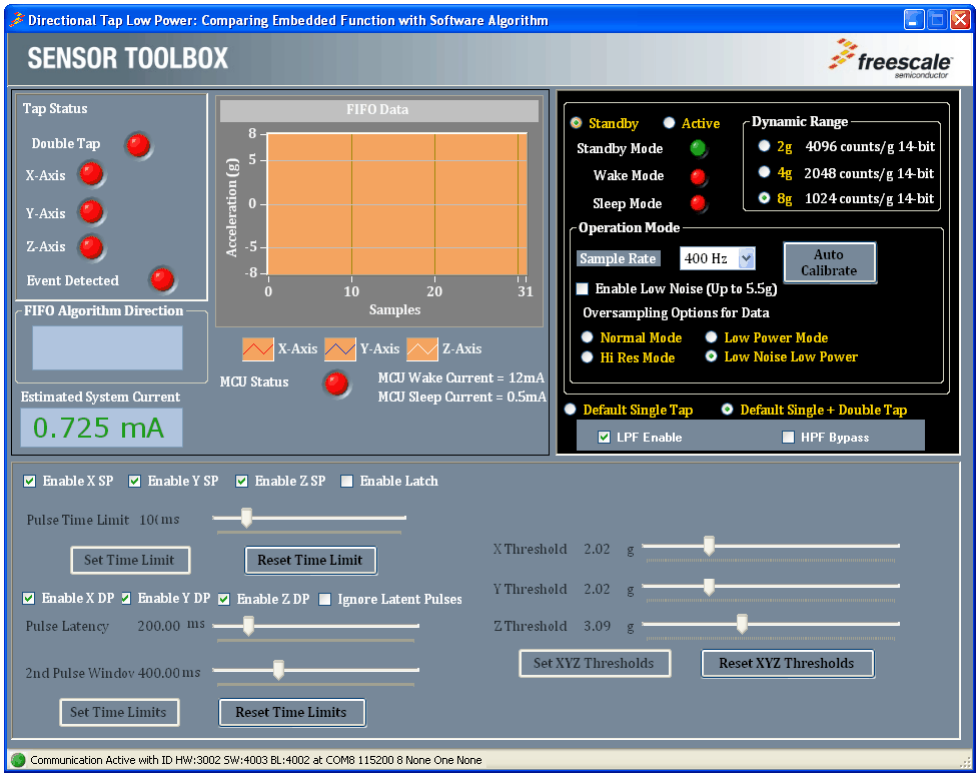
Table 8. Directional Tap – Active/Standby screens

Screen frame	Element	Description
Tap Status	Double Tap	Green indicates that a double tap has been detected.
	• X-Axis • Y-Axis • Z-Axis	Green indicates the axis or axes along which the tap is occurring.
	Event Detected	Green indicates that a tap has been detected along any axis.
FIFO Algorithm Direction	Direction	Indicates the direction of the last tap the device detected. For example, “z-negative” indicates a tap on the top of the device.
FIFO Data	Acceleration Graph	Shows the data collected and stored in the FIFO from the last tap.
	• X-Axis • Y-Axis • Z-Axis	Indicate the color of the graph lines for the respective axes.
MCU Status	Green indicates that the MCU has gone from Sleep to Wake mode.	
Estimated System Current	Displays the amount of current that the device is probably drawing from the power source.	

3.7.2 Standby Screen

Use the Standby screen to:

- Change the sample rate, over-sampling setting, and orientation-detection parameters
- Enable the low-noise mode
- Set the dynamic range
- Choose the state of the device



The Standby screen contains the following menu frames:

- Operation Mode
- Dynamic Range
- Standby Active
- (Tap Settings)

Each menu frame's fields and options are described in the following table.

Table 9. Directional Tap – Active/Standby screens

Screen frame	Field or option	Description	
Operation Mode	Sample Rate	Enables you to change the rate at which the device acquires data.	
	Enable Low Noise	Enables the device's Low Noise Mode for more accurate readings. **Note:** In Enable Low Noise mode, any g-force greater than ±4g will not be read.	
	Over-Sampling Options for Data	Normal Mode	Normal operation.
		Hi Res Mode	The device gives more accurate readings, but draws more current.
		Low Power Mode	The device draws less current than Normal mode does, but at the expense of accuracy.
		Low Noise Low Power	The device draws more current than Normal mode does, but less current than Low Power mode does, and reduces noise.
	Auto Calibrate	Directs the device to calculate the offsets for each axis (accounting for any error in measurements). For maximum resolution, the calibration is done with a dynamic range of 8g and a sample rate of 1.563 Hz. **Note:** Before enabling Auto Calibrate mode, place the device on a flat and stationary surface.	
Dynamic Range	• 2g • 4g • 8g	Sets the range over which the accelerometer acquires data.	

Table 9. Directional Tap – Active/Standby screens (Continued)

Screen frame	Field or option	Description
Standby Active	Standby option button	Deactivates the device. **Note:** Before any settings can be changed, the Standby option must be enabled.
	Active option button	Activates the device. **Note:** Settings cannot be changed in the Active state. **Note:** After changing the configuration settings, enable the Active option.
	• Standby Mode • Wake Mode • Sleep Mode	Indicates the device's status.
(Tap Settings)	• Enable X SP • Enable Y SP • Enable Z SP	(Enable Single Pulse) Allows flicks along these axes to trigger the "Event Detected" Indicator on the Demo Screen.
	Enable Latch	Causes any triggered event to remain until the status buffer is read. If this checkbox is not enabled, then the interrupt will only last as long as the event, and the status buffer will represent the most-recent event. • The Enable Latch setting should be enabled for the tap detection to work properly. • If Enable Latch is disabled, then tap events will trigger multiple interrupts, instead of triggering a single interrupt.
	Pulse Time Limit	Sets the maximum time that a pulse can last before it (the pulse) is ignored as a non-tap event. • Before using the Pulse Time Limit slider, you must click the Reset Time Limits button. • After using the Pulse Time Limit slider, click the Set Time Limits button to change the setting.
	Default Single Tap	Sets the parameters for detecting single taps to the factory-defined values. To configure this frame's other values, the Default Single Tap option button must be cleared.
	Default Single + Double Tap	Sets the threshold for detecting single and double taps to the factory-defined values. To configure this frame's other values, the Default Single + Double Tap option button must be cleared.

Table 9. Directional Tap – Active/Standby screens (Continued)

Screen frame	Field or option	Description
(Tap Settings, continued)	LPF Enable	(Low-Pass Filter) Sends accelerometer data through a low-pass filter before it is processed by the tap application. This filter treats higher frequency signals as noise, filtering out very fast shocks (to prevent them from being detected as taps).
	HPF Bypass	(High-Pass Filter) Sends the raw accelerometer data to the tap application, bypassing the high-pass filter. • The HPF Bypass option button normally should be cleared. • Enabling the HPF Bypass can cause non-tap events (such as tilting the device) to be registered as taps.
	Set Time Limit[1]	After changing the value of the Pulse Time Limit slider, you must click the Set Time Limit button.
	Reset Time Limit[1]	• Before using the slider in the Pulse Time Limit field, you must click the Reset Time Limit button. • After using the slider in the Pulse Time Limit field, click the Set Time Limits button.
	• X Threshold • Y Threshold • Z Threshold	Sets the G threshold for a tap to be detected along the designated axis. Pulses with a G value less than the setting will be ignored. • Before using the sliders, you must click the Reset XYZ Thresholds button. • After using the sliders, click the Set XYZ Thresholds button.
	Set XYZ Thresholds button[2]	After changing the value of any of the axis threshold slider settings, click the Set XYZ Thresholds button.
	Reset XYZ Thresholds button[2]	Before changing the settings of any of the axis threshold sliders, you must click the Reset XYZ Thresholds button first.
	• Enable X DP • Enable Y DP • Enable Z DP	(Enable Double Pulses) Enables detection of double pulses along the specified axis or axes. For example, if you only want to see double taps on the right side of the device, then clear the Z and Y DP checkboxes.
	Ignore Latent Pulses	Causes the device to ignore the Pulse Latency timer (set by the Pulse Latency Slider) and to detect taps directly after other taps.
	Pulse Latency	Sets the amount of time that the device waits after a tap, before registering the next tap. Subsequent taps that occur within this period are ignored.
	Second Pulse Latency	Sets the amount of time that the device will wait to reset, after receiving an initial pulse. A pulse detected after the set time will be considered a new first pulse.

1 Before resetting the value of the Pulse Time Limit slider, you must click the Reset Time Limit button. After setting the value, you must then click the Set Time Limit.

2 Before resetting the value of the X, Y, or Z threshold sliders, you must click the Reset XYZ Thresholds button. After setting the value, you must then click the Set XYZ Thresholds button.

3.8 Directional Shake with FIFO Application

The Directional Shake Application demo evaluates the built-in algorithm for detecting transient events in conjunction with the FIFO. You can evaluate Freescale's default configuration and modify those settings, to tailor a demonstration for your target application.

This demo includes MCU-status and estimated-current displays, which enable you to demonstrate the device's power-saving sleep mode feature.

NOTE

The Directional Shake Application demo is available only for the MMA8451Q device.

3.8.1 Active Screen

The Active screen contains a set of indicators that change to green when a transient event (shake) is detected. A graph displays the data stored in the FIFO with MCU-status and shake-direction indicators, and also provides an estimated-current field.

Note: Before changing any of the Active screen's settings, select the Standby option button.

Table 10. Directional Shake – Active/Standby screens

	Element	Description
Transient Status	• X Negative • Y Negative • Z Negative	Indicators change from red to green when a shake event is detected along the indicated axis.
	Event Detected	Indicator changes from red to green when a shake event is detected along any axis.
Software Direction	Direction	Displays the direction of the last shake that the device detected. For example, the display “z-negative” indicates the device was shaken downward.
FIFO Data	Acceleration	Shows the data collected and stored in the FIFO from the last shake.
	• X-Axis • Y-Axis • Z-Axis	These graph-legend entries give the line color of the graph lines for the respective axes.
MCU Status	Indicator changes from red to green when the MCU is active (not in Sleep mode).	
Estimated System Current	Displays the amount of current the devices is probably drawing from the power source.	

3.8.2 Standby Screen

Use the Standby screen to:

- Change the sample rate of the device
- Enable low-noise mode
- Change the over-sampling options
- Calibrate the device
- Set the dynamic range
- Change the device mode
- Change the parameters for detecting the transient events

The Standby screen contains the following menu frames:

- Operation Mode
- Dynamic Range
- Standby Active
- Transient Settings

Each menu frame's fields and options are described in the following table.

Table 11. Directional Shake – Active/Standby screens

Screen frame	Field or option	Description	
Operation Mode	Sample Rate	Enables you to change the rate at which the device acquires data.	
	Enable Low Noise	Enables the device's Low Noise Mode for more accurate readings. **Note:** In Enable Low Noise mode, any g-force greater than ±4g will not be read.	
	Over-Sampling Options for Data	Normal Mode	Normal operation.
		Hi Res Mode	The device gives more accurate readings, but draws more current.
		Low Power Mode	The device draws less current than Normal mode does, but at the expense of accuracy.
		Low Noise Low Power	The device draws more current than Normal mode does, but less current than Low Power mode does, and reduces noise.
	Auto Calibrate	Directs the device to calculate the offsets for each axis (accounting for any error in measurements). For maximum resolution, the calibration is done with a dynamic range of 8g and a sample rate of 1.563 Hz. **Note:** Before enabling Auto Calibrate mode, place the device on a flat and stationary surface.	
Dynamic Range	• 2g • 4g • 8g	Sets the range over which the accelerometer acquires data.	

Table 11. Directional Shake – Active/Standby screens (Continued)

Screen frame	Field or option	Description
Standby Active	Standby option button	Deactivates the device. **Note:** Before any settings can be changed, the Standby option must be enabled.
	Active[1] option button	Activates the device. **Note:** Settings cannot be changed in the Active state. **Note:** After changing the configuration settings, enable the Active option.
	• Standby Mode • Wake Mode • Sleep Mode	Indicates the device's status.
Transient Settings	Default Transient Settings	Returns the demo parameters for detecting shakes to the default settings (configured at the factory).
	Bypass HPF	(High-Pass Filter) Sends the raw accelerometer data to the shake application, bypassing the high-pass filter. • Normally, the Bypass HPF option button should be cleared. • Enabling the Bypass HPF can cause non-shake events (such as tilting the device) to be registered as shakes.
	Threshold slider	Sets the threshold for flick events to be detected. Flicks at a smaller g-force than this value are filtered out. • Before using the Threshold slider, you must first click the Reset button. • After using the Threshold slider, click the Set button to change the setting.
	Debounce slider	Sets the amount of time that the configured conditions must be in place to trigger the main flick event. Any event whose duration does not exceed this time will not trigger an interrupt. • Before using the Debounce slider,you must first click the Reset button. • After using the Debounce slider, click the Set button to change the setting.
	• Enable X SP • Enable Y SP • Enable Z SP	(Enable Single Pulse) Allows flicks along these axes to trigger the "Event Detected" Indicator on the Demo Screen. **Note:** Only the Y axis will move the pictures and correctly trigger the direction indicator. If enabled, the X and Z axes will trigger only the Event Detected indicator on the Demo screen.
	Enable Latch	Causes any triggered event to remain until the status buffer is read. If the Enable Latch checkbox is not enabled, then: • the interrupt will only last as long as the event • the status buffer will represent the most-recent event
	Set[2]	After changing the values of the Threshold and Debounce sliders, you must click the Set button to implement the settings.
	Reset[3]	Before changing the settings of the Threshold and Debounce sliders, first you must click the Reset button.
	Decrement Debounce	Selecting the Decrement 'debounce option causes the Debounce timer to be decremented, for each time that an event fails to reach the debounce time.
	Clear Debounce	Selecting Clear Debounce option will cause the timer set by the Debounce slider to reset, for each time that an event fails to reach the debounce time.

1 After changing the configuration settings, you must enable the Active option button.

2 After the settings of the Threshold and Debounce sliders have been changed, you must click the Set button to implement the new values.

3 Before changing the settings of the Threshold and Debounce sliders, first you must click the Reset button.

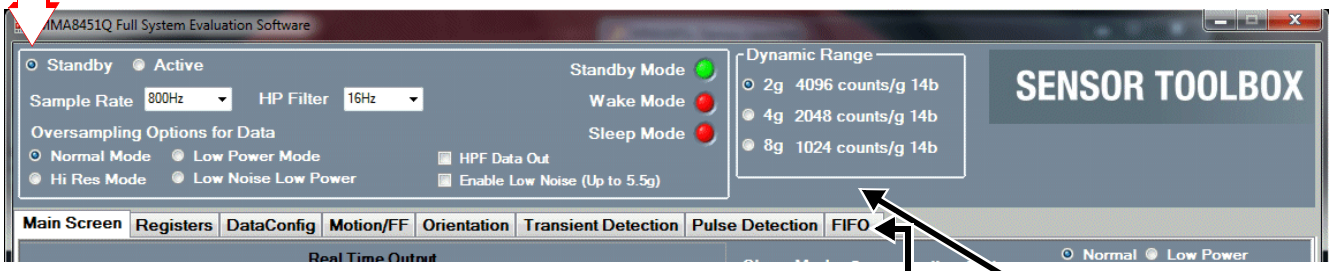
3.9 Full-System Evaluation

The Full-System Evaluation application enables you to access all of the features of the device from a single screen. You can evaluate Freescale's default configuration for all device features, and modify feature settings to tailor a demonstration for your target application.

3.9.1 Operation-Mode Frame

An operation-mode frame appears at the top of each screen, with tabs below that frame, enabling you to quickly navigate among the different demos.

Note: Before changing any of the Operation-Mode Frame settings, select the Standby option button.



The Operation-Mode frame contains the following frame groups:

- Main
- Dynamic Range

Each menu frame's fields and options are described in the following table.

Table 12. Full-System Evaluation – Operation-Mode screen

Screen frame	Field or option	Description	
Main	Standby[1] Option Button	Deactivates the device. **Note:** Before any settings are changed, the Standby option must be enabled . **Note:** Standby mode is not the same as Sleep mode.	
	Active[2] Option Button	Activates the device, enabling data to be collected. • Settings cannot be changed in the Active state. • After changing the configuration settings, enable the Active option.	
	Sample Rate	Enables you to change the rate at which the device acquires data.	
	HP Filter	Sets the cut-off frequency for the high-pass filter that data is processed with, before it (the data) is displayed on a demo screen. The HP filter is enabled by the HPF Data Out checkbox.	
	• Standby Mode • Wake Mode • Sleep Mode	Indicates the device's status.	
	Over-Sampling Options for Data	Normal Mode	Normal operation.
		Hi Res Mode	The device gives more accurate readings, but draws more current.
		Low Power Mode	The device draws less current than Normal mode does, but at the expense of accuracy.
		Low Noise Low Power	The device draws more current than Normal mode does, but less current than Low Power mode does, and reduces noise.
	HPF Data Out	(High-Pass Filter) Causes data to be processed by the device's high-pass filter, before that data is used by the application for the graphical or other display.	
	Enable Low Noise	Enables the device's Low Noise Mode for more accurate readings. **Note:** In Enable Low Noise mode, any g-force greater than ±4g will not be read.	
Dynamic Range	• 2g • 4g • 8g	Sets the range over which the accelerometer acquires data.	

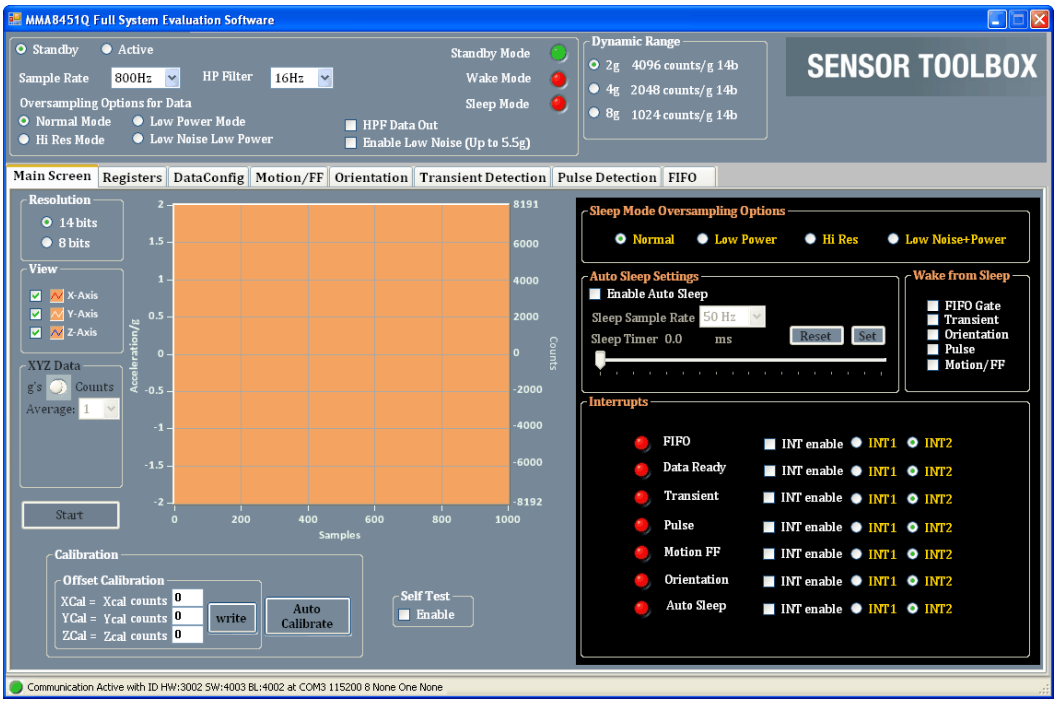
1 Before any settings can be changed, the Standby option button must be enabled.

2 After changing the configuration settings, you must enable the Active option button.

3.9.2 Main Screen

The Main screen contains the following frame groups:

- Real-Time Output
- Sleep Mode Over-Sampling Options
- System Interrupt Settings



Each menu frame's fields and options are described in the following table.

Table 13. Full-System Evaluation – Main screen

Screen Frame	Element or screen group	Element or description	Description
Real-Time Output[1]	Acceleration Graph	Shows the data collected and stored in the FIFO from the last shake. The acceleration in Gs is plotted against the number of samples.	
	• XYZ 14-Bit (for MMA8451Q) • XYZ 12-Bit (for MMA8452Q) • XYZ 10-Bit (for MMA8453Q) • XYZ 8-Bit	Selects the number of bits to be read from the device. A higher number of bits produces more precise values, but requires more time and power.	• Selecting 14 bit for the MMA8451Q reads the 8 MSB bits and the 6 bits stored in the X, Y, and ZLSB registers. • Selecting 12 bit for the MMA8452Q reads the 8 MSB bits and the 4 bits stored in the X, Y, and ZLSB registers. • Selecting 10 bit for the MMA8453Q reads the 8 MSB bits and the 2 bits stored in the X, Y, and ZLSB registers. • Selecting the 8-bit option causes the program to read only the 8 bits stored in the X, Y, and ZMSB registers.
	• X-Axis • Y-Axis • Z-Axis	Directs the device to display the current g-force, and count measurements for the selected axis or axes.	

Table 13. Full-System Evaluation – Main screen (Continued)

Screen Frame	Element or screen group	Element or description	Description
Real-Time Output (continued)	View button	To display any data in this screen frame's fields, the View button must be clicked.	
	Disable button	To stop displaying current readings in this screen frame's fields, click the Disable button.	
	Self Test	Enable Button	Initiates a test where the device applies a small electrostatic force to the sensor, to simulate a small acceleration. If you leave this box checked during tests, then all measurements will be offset by this simulated acceleration.
	• X-Axis • Y-Axis • Z-Axis	These graph-legend entries give the line colors for the respective axes.	
	Offset Calibration	• XCal Counts • YCal Counts • ZCal Counts	Specifies the values to be added to the device's output measurements, to correct for any data inaccuracies. The calibration values will need to be calculated differently, varying with the Dynamic Range setting. If the device is reading 21 counts in the X-axis when sitting flat on a table (should be 0 counts), then the following correct values are required for the indicated Dynamic Range setting: • **2g** – Divide the count by 4 before storing it in the register. It is not possible to store fractional values, so in this case $2^1/_4 = 5.25$, and you must round down and put -5 in the XCal field. • **4g** – you must divide the number by 2, before storing it in the register. In the above situation, you would place ($2^1/_2 = 10.5$) either -10 or -11 in the XCal field. • **8g** – No correction is required.
		Write	Writes the values in the XCal, YCal, and ZCal text boxes into the calibration register.
	Auto Calibrate	Makes the device calculate the necessary values for the X, Y, and ZCal fields. The calibration is done with an 8g Dynamic Range and a Sample Rate of 1.563 Hz. Before clicking the Auto Calibrate button: • Place the device on a flat, stationary surface. • Enable the Standby button (in the Operation Mode screen).	

Table 13. Full-System Evaluation – Main screen (Continued)

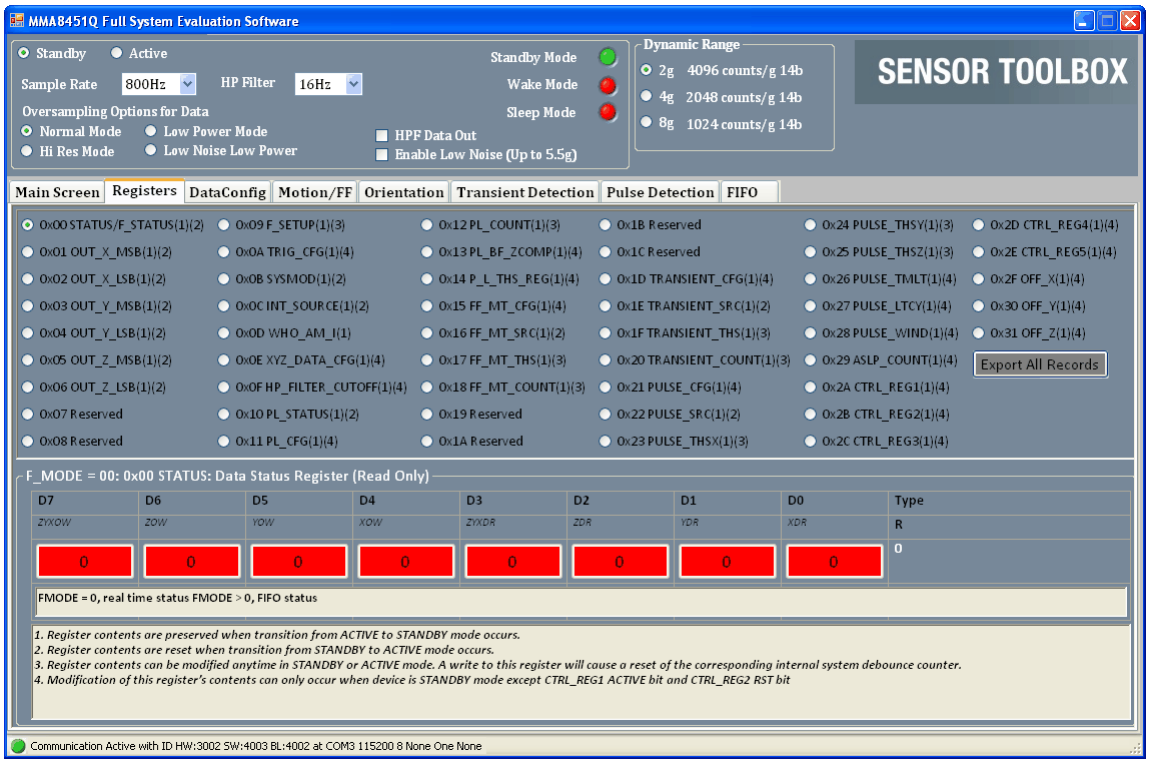
Screen Frame	Element or screen group	Element or description	Description
Sleep Mode Over-Sampling Options	• Normal Mode • Hi Res Mode • Low Power Mode • Low Noise Low Power	Selects the over-sampling options to be used when the device is in Sleep Mode: • Normal — Implements normal operation. • Hi Res — Collects more accurate readings, but draws more current. • Low Power — Draws less current than Normal mode does, but at the expense of accuracy. • Low Noise Low Power — Draws more current than Normal mode does, but less current than Low Power mode does, and reduces noise.	
	Auto Sleep Settings[2]	Enable Auto Sleep	Enables the Auto-Sleep function of the device, which puts the device in Sleep mode when no actions are taken for the duration of the sleep timer.
		Sleep Sample Rate	Sets the sample rate for the device when it is in Sleep mode. Lower sample rates will use less power while the device is sleeping.
		Sleep Timer Slider	Determines how long a period of inactivity must pass before the device enters Sleep mode.
		Reset	Before changing any setting in the Auto Sleep Settings screen group, the Reset button must be clicked.
		Set	After changing any settings in the Auto Sleep Settings screen group, the Set button must be clicked.
	Wake from Sleep	• FIFO Gate • Transient • Orientation • Pulse • Motion/FF	Specifies what type of event wakes the device from Sleep Mode. For example, if the Pulse box is checked, then tapping the device will wake it from sleep. **Note:** An application cannot wake the device from sleep (even if selected in this box) unless: • the application is configured in its own screen (in the case of a Pulse, the Pulse Detection screen), • and the application's interrupt is enabled in the Interrupts section of the Main Screen.
System Interrupt Settings	• FIFO • Data Ready • Transient • Pulse • Motion FF • Orientation • Auto Sleep	• INT Enable — Specifies what event triggers an interrupt. • INT1 and INT2 — Specifies which interrupt pin is triggered.	

1 To display data in the Real-Time Output frame, the View button must be clicked. To stop displaying the current readings, click the Disable button.

2 To change any setting in the Auto Sleep Settings screen group, first the Reset button must be clicked. After the settings are changed, the Set button must be clicked.

3.9.3 Registers Screen (Advanced Users Only)

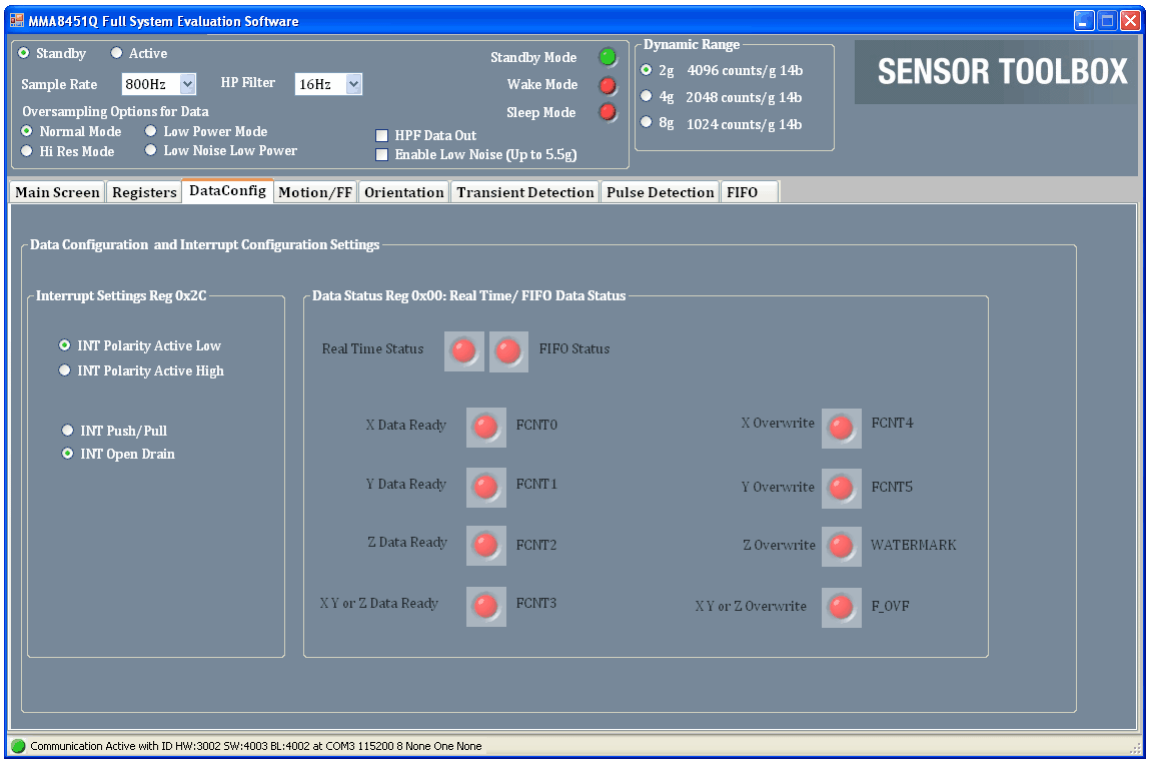
The Registers screen enables you to read from or write to any of the device's registers. For information about the functions and values of each register, see the *Intelligent Motion Sensing Platform Data Sheet* (MMA845xL).



3.9.4 DataConfig Screen

The Data Configuration and Interrupt Configuration Settings (DataConfig) screen enables you to:

- Toggle the Data Ready indicators for each axis
- Enable the FIFO
- Set the operation mode for the interrupt pins



Each menu frame's fields and options are described in the following table.

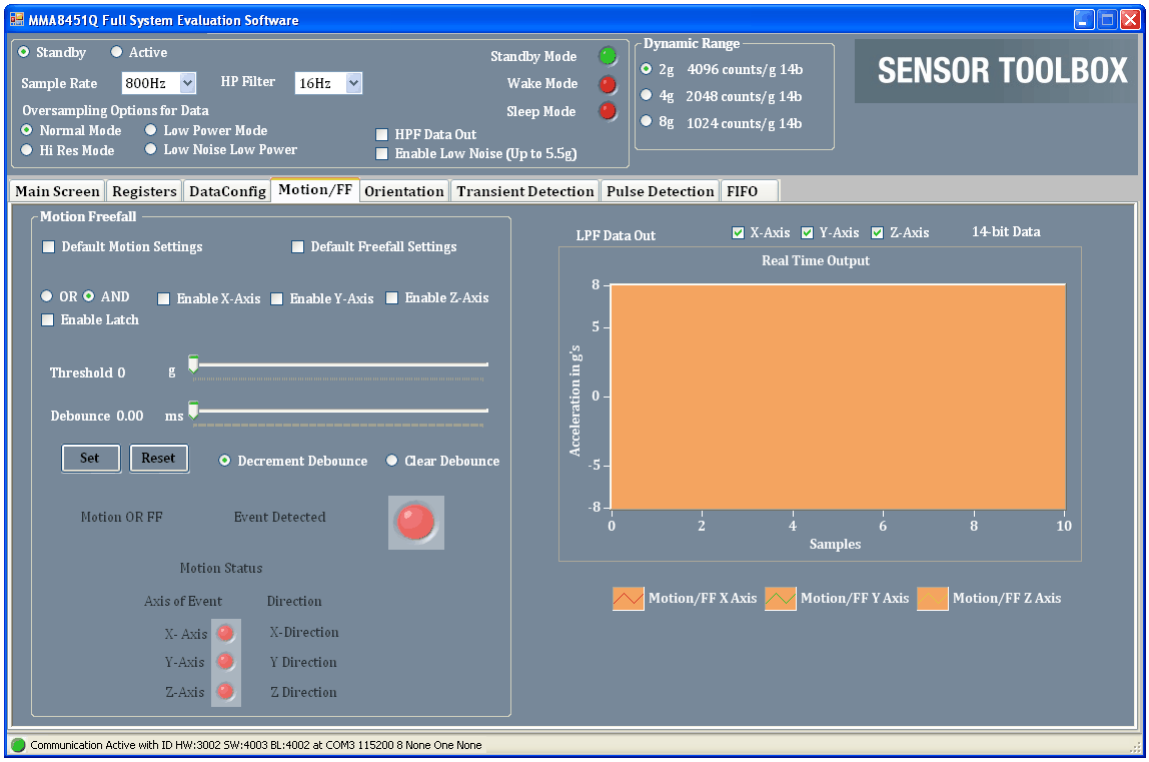
Table 14. Full-System Evaluation – DataConfig screen

Screen frame	Element	Description
Interrupt Settings (Reg 0x2C)	• INT Polarity Active Low • INT Polarity Active High	• Active Low — Causes the interrupt pins to sit at a logical high level (1), and to go to logical low (0) when they are triggered. • Active High — Causes the interrupt pins to sit at a logical low level (0), and to go to logical high (1) when they are triggered.
	• INT Push/Pull • INT Open Drain	• Push/Pull — Activates two transistors on the interrupt pins that push up or pull down the output to the desired level. *This is the default setting.* • Open Drain— When selected, the interrupt pins will be open drain, which allows multiple interrupt signals to be connected to the same interrupt line.

Table 14. Full-System Evaluation – DataConfig screen (Continued)

Screen frame	Element	Description
Data Status Reg 0x00: Real Time/FIFO Data Status	• Real-Time Status • FIFO Status	• Real-Time Status — Indicator goes from red to green when the demo data is being read directly from the device (rather than being read from the FIFO). • FIFO Status — Indicator goes from red to green when the data is being read from the FIFO (rather than being read directly from the device)
	• X Data Ready (FCNT0) • Y Data Ready (FCNT1) • Z Data Ready (FCNT2)	These indicators shift from red to green when a new measurement is waiting to be read in the output register for the respective axis or axes.
	X, Y, or Z Data Ready (FCNT3)	Shifts from red to green if *any axis* has a new reading waiting to be read. If there is no data, then the indicator remains red.
	• X Overwrite (FCNT4) • Overwrite (FCNT5) • Overwrite (Watermark)	These indicators shift from red to green if a new measurement has replaced a measurement (that previously triggered the Data Ready indicator) before that earlier measurement was read.
	X, Y, or Z Overwrite (F_OVF)	Shifts from red to green if *any axis* had an old measurement that was replaced by a new measurement before the earlier measurement was read.

3.9.5 Motion/Freefall (M/FF) Screen



The Motion/Freefall screen's elements are described in the following table.

Table 15. Full-System Evaluation – Motion/FF Screen

Screen frame	Element or frame group	Element	Description
Motion Freefall	Default Motion Settings[1]	Sets the parameters for detecting general motion to the values set at the factory. Before changing any other settings in this frame, the Default Motion Settings checkbox must be cleared.	
	Default Freefall Settings[1]	Sets the parameters for detecting freefall to the values set at the factory. To change any other settings in this frame, the Default Freefall Settings checkbox must be cleared.	
	• OR • AND	• OR — Directs any options selected by the checkboxes to the button's right, to be run through a logical OR. • AND — Directs any options selected by the checkboxes to the button's right, to be run through a logical AND. This will trigger an event only if all of the checked events occur. **Note:** In order to select OR or AND, both the Default Motion Settings and Default Freefall Settings checkboxes must be cleared.	
	• Enable X-Axis • Enable Y-Axis • Enable Z-Axis	Directs the device to monitor for an event along the specified axis or axes, at a g force with an absolute value higher than that specified by the Threshold slider. Any event meeting this criteria is run through the configured OR or AND setting, to determine if the event is displayed.	
	Enable Latch	Causes any interrupt triggered by an event to remain until the status buffer is read. If the Enable Latch checkbox is not enabled, then the interrupt will last only as long as the event does, and the status buffer represents the most-recent event.	

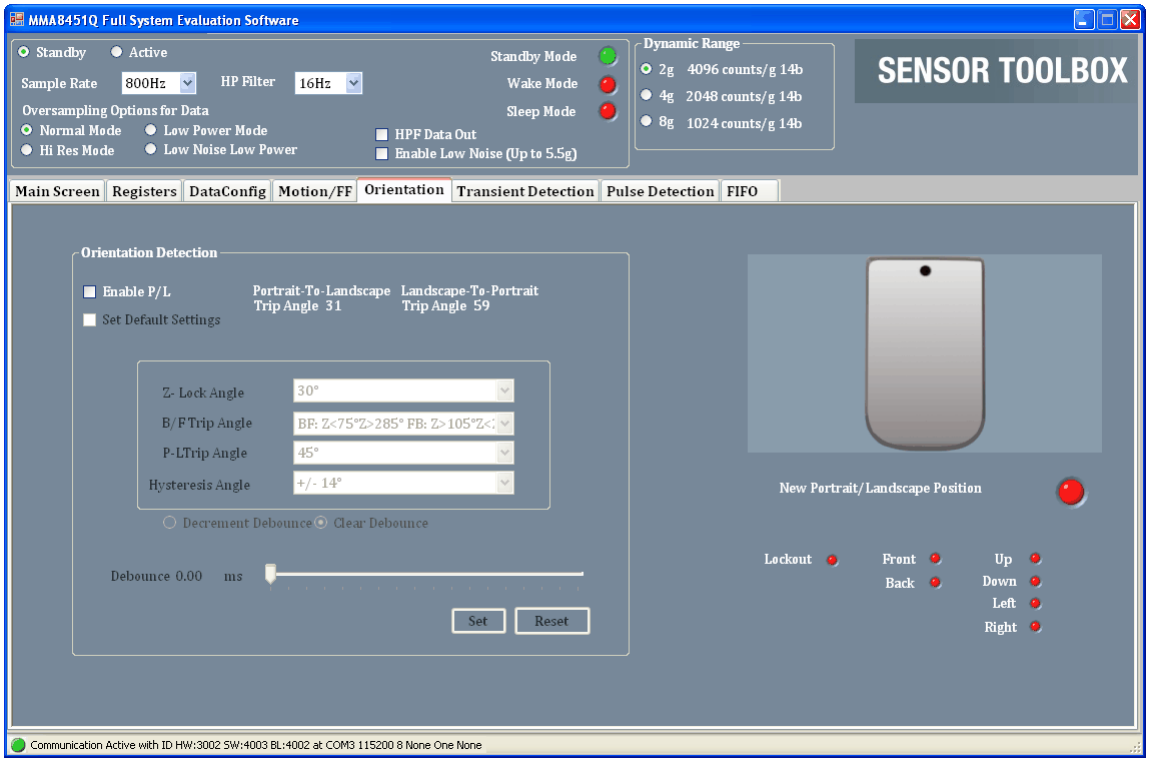
Table 15. Full-System Evaluation – Motion/FF Screen (Continued)

Screen frame	Element or frame group	Element	Description
Motion Freefall (continued)	Threshold Slider	Sets the threshold for events to be detected. Events at a smaller g-force than this value are filtered out. • Before using the Threshold slider, the Reset button must be clicked. • After using the Threshold slider, click the Set button to change the setting.	
	Debounce Slider	Sets the amount of time that the configured conditions must be in place to trigger an interrupt. Any event whose duration does not exceed this time will not trigger an interrupt. • Before using the Debounce slider, the Reset button must be clicked. • After using the Debounce slider, click the Set button to change the setting.	
	Set[2] Button	After the resetting either Threshold or Debounce slider, the Set button must be clicked.	
	Reset[2] Button	Before configuring the Threshold or Debounce sliders in the Motion Freefall frame, the Reset button must be clicked.	
	Decrement Debounce	Causes the Debounce timer to be decremented, for each time that an event fails to reach the debounce time.	
	Clear Debounce	Causes the timer set by the Debounce slider to reset, for each time that an event fails to reach the debounce time.	
	Motion or FF Event Detected	This indicator switches from red to green if an event is triggered.	
	Motion Status	Axis of Event	The indicator(s) switch from red to green when an event is triggered along the specified axis or axes: • X-Axis • Y-Axis • Z-Axis
		Direction	Displays the direction(s) of the event: • X-Direction • Y-Direction • Z-Direction For example, the display “z-negative” indicates the device was shaken downward.
LPF Data Out –OR– HPF Data Out	This frame’s label displays Low-Pass Filter Data Out or High-Pass Filter Data Out depending on whether the HP Filter option button has been enabled on the Full-System Evaluation demo’s Operation Mode screen.		
	Real-Time Output	• X-Axis • Y-Axis • Z-Axis	Each checkbox enables the collection of data along the selected axis or axes.
		(Graph)	Displays the data acquired by the accelerometer. Acceleration in Gs is plotted against the number of samples.
		• X-Axis • Y-Axis • Z-Axis	These graph-legend entries give the line color of the graph lines for the respective axes.

1 To configure a value in the Motion Freefall frame, both the Default Motion Settings and Default Freefall Settings checkboxes must first be cleared.

2 To configure the sliders in the Motion Freefall frame, first the Reset button must be clicked. After setting your slider(s), the Set button must be clicked.

3.9.6 Orientation Screen



The Orientation screen's elements are described in the following table.

Table 16. Full-System Evaluation – Orientation screen

Screen Frame	Element	Description
Orientation Detection[1]	Enable P/L	Enables configuration of the other parameters in the frame. (Clearing this checkbox will not, however, prevent the demo from functioning.)
	Portrait-to-Landscape Trip Angle	Shows the current value.
	Landscape-to-Portrait Trip Angle	Shows the current value.
	Set Default Settings	Restores all portrait-to-landscape orientation settings to the default values configured at the factory.
	Z-Lock Angle	Sets the Z-axis angle at which the device will ignore changes in orientation, because that value is considered to be the flat orientation. **Note:** Before configuring the Z-Lock Angle parameter, the Enable P/L checkbox must be enabled.
	B/F Trip Angle	(Back/Front Trip Angle) Sets the range of z-axis angles that the device considers as facing front and back. **Note:** Before configuring the B/F Trip Angle parameter, the Enable P/L checkbox must be enabled.
	P-L Trip Angle	(Portrait to Landscape) Sets the *midpoint* of the angle at which the device changes from portrait to landscape orientation. The P-L Trip Angle is measured down from the x axis (for changing to the right landscape orientation), and up from the x axis (for changing to left landscape orientation). **Note:** Before configuring the P-L Trip Angle parameter, the Enable P/L checkbox must be enabled.

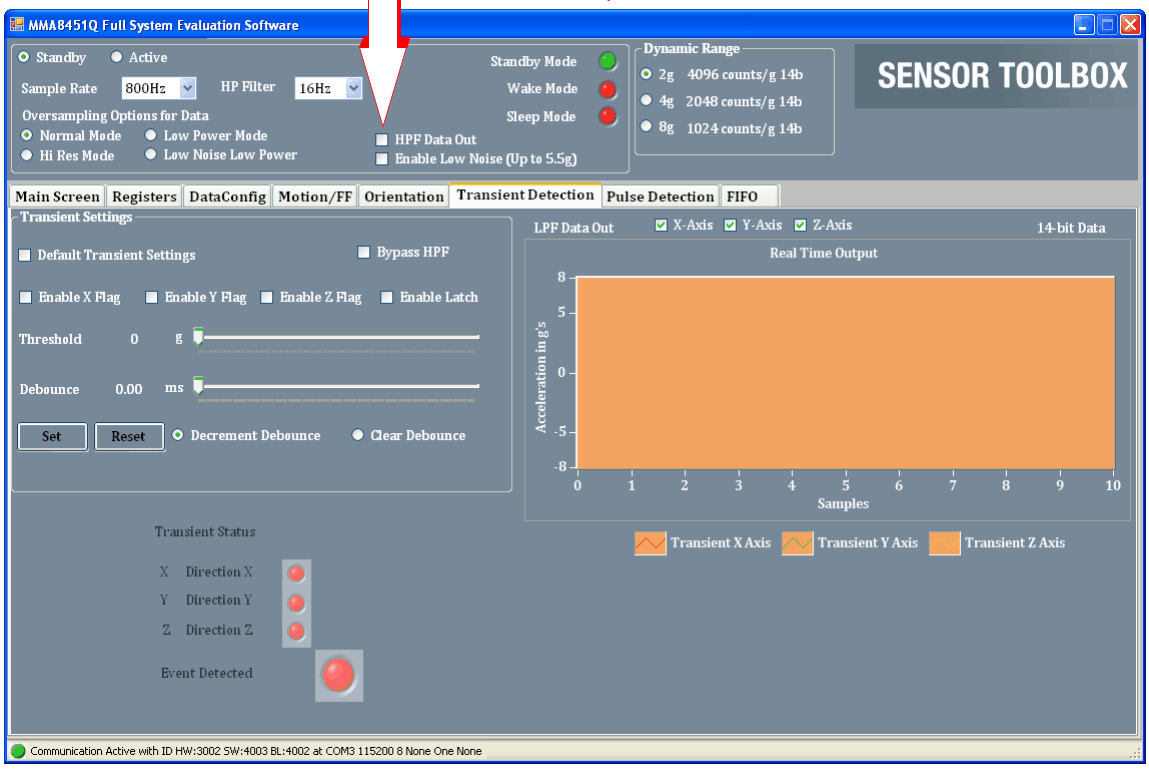
Table 16. Full-System Evaluation – Orientation screen (Continued)

Screen Frame	Element	Description
Orientation Detection[1] (continued)	Hysteresis Angle	Sets the *distance from the midpoint* of the angle at which the device changes from portrait to landscape orientation. The actual trip angle for changing orientation is the P-L Angle ± this angle. **Note:** Before configuring the Hysteresis parameter, the Enable P/L checkbox must be enabled.
	Decrement Debounce	Causes the Debounce timer to be decremented, for each time that an event fails to reach the debounce time. **Note:** Before configuring the Decrement Debounce parameter, the Enable P/L checkbox must be enabled.
	Clear Debounce	Causes the timer set by the Debounce slider to reset, for each time that an event fails to reach the debounce time. **Note:** Before configuring the Clear Debounce parameter, the Enable P/L checkbox must be enabled.
	Debounce slider	Sets the amount of time that the configured conditions must be in place, in order to trigger an interrupt. Any event whose duration does not exceed this time will not trigger an interrupt. • Before moving the Debounce slider, the Enable P/L checkbox must be enabled and the Reset button must be clicked. • After moving the Debounce slider, click the Set button to change the setting.
	Set	After the resetting the Debounce slider, the Set button must be clicked.
	Reset	Before configuring the Debounce slider in the Motion Freefall frame, the Reset button must be clicked.
(Orientation change)	New Portrait/Landscape Position	Indicator switches from red to green when there is an orientation change.
	Lockout	Indicator switches from red to green, to display which parameter (of the configured orientation parameters) has been tripped.
	• Front • Back	
	• Up • Down • Left • Right	

[1] To change settings in the Orientation Detection frame, first the Enable P/L checkbox must be enabled.

3.9.7 Transient (Shake) Detection Screen

Note: For best results in detecting transient events, the HPF Data Out box in the Operation-Mode Frame should be checked.



The elements of this shake-detection screen are described in the following table.

Table 17. Full-System Evaluation – Transient Detection screen

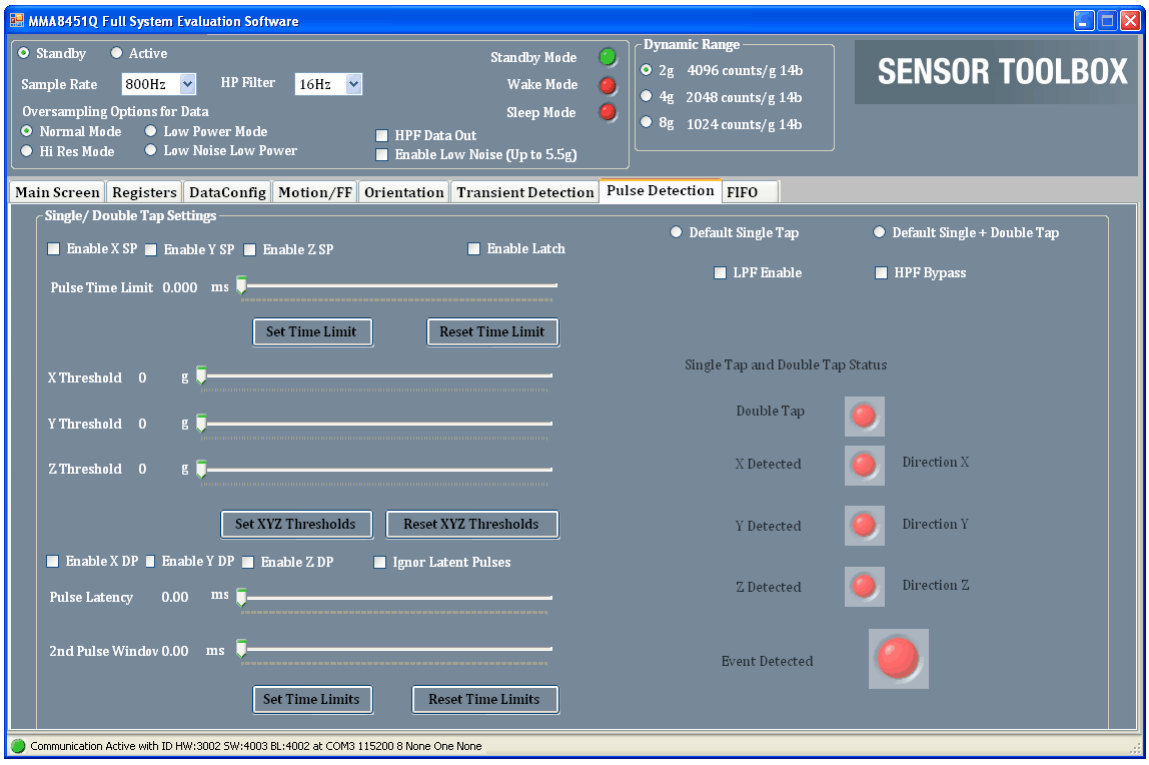
Screen frame	Element	Description
Transient Settings[1]	Default Transient Settings	Restores all transient-detection settings to the default values configured at the factory. **Note:** In order to change any of the settings in this screen frame, the Default Transient Settings checkbox must be cleared.
	Bypass HPF	(Bypass High-Pass Filter) Directs the application to use the raw accelerometer data before it (the raw data) has been passed through the HPF. The Bypass HPF setting should normally be disabled.
	• Enable X Flag • Enable Y Flag • Enable Z Flag	Allows shakes along these axes to trigger the “Event Detected” Indicator on the Demo Screen. **Note:** Only the Y axis will move the pictures and correctly trigger the direction indicator. If enabled, the X and Z axes will only trigger the Event Detected indicator on the Demo screen.
	Enable Latch	Causes any triggered event to remain until the status buffer is read. If the Enable Latch checkbox is not enabled, then the interrupt will only last as long as the event, and the status buffer will represent the most-recent event.
	Threshold slider	Sets the threshold for the minimum g force at which a shake event is detected. Shakes at a smaller g-force than this value are filtered out. • To move the Threshold slider, the Reset button must be clicked. • After moving the Threshold slider, click the Set button to change the setting.
Orientation Detection	Debounce slider	Sets the minimum time that a shake must last, in order to trigger the main transient event.
	Set	After the resetting the Debounce slider, the Set button must be clicked
	Reset	Before configuring the Debounce slider in the Motion Freefall frame, the Reset button must be clicked.
	Decrement Debounce	Causes the Debounce timer to be decremented, for each time that an event fails to reach the debounce time. **Note:** Before configuring the the Decrement Debounce parameter, the Enable P/L checkbox must be enabled.
	Clear Debounce	Causes the timer set by the Debounce slider to reset, for each time that an event fails to reach the debounce time. **Note:** Before configuring the Clear Debounce parameter, the Enable P/L checkbox must be enabled.
	Note: Before changing settings in the Orientation Detection frame, the Enable P/L checkbox must be enabled.	

Table 17. Full-System Evaluation – Transient Detection screen (Continued)

Screen frame	Element	Description
LPF Data Out or HPF Data Out	This frame's label displays Low-Pass Filter Data Out or High-Pass Filter Data Out, depending on whether the HP Filter option button has been enabled on the Full-System Evaluation demo's Operation Mode screen.	
	• X-Axis • Y-Axis • Z-Axis	Each checkbox enables the collection of data along the selected axis or axes.
	(Graph)	Displays the data acquired by the accelerometer.
	• X-Axis • Y-Axis • Z-Axis	These graph-legend entries give the line color for the respective axes.
Transient Status	• X Direction X • Y Direction Y • Z Direction Z	The indicator(s) switch from red to green when an event is triggered along the specified axis or axes.
	Event Detected	This indicator switches from red to green if an event is triggered.

1

3.9.8 Pulse Detection Screen



The elements of the Pulse Detection (*tap detection*) screen are described in the following table.

Table 18. Full-System Evaluation – Pulse Detection screen

Screen frame	Field or option	Description
Single/ Double Tap Settings	Default Single Tap	Sets the parameters for detecting single taps to the factory-defined values. **Note:** To configure this frame's other values, the Default Single Tap option button must be cleared.
	Default Single + Double Tap	Sets the threshold for detecting single and double taps to the factory-defined values. **Note:** To configure this frame's other values, the Default Single + Double Tap option button must be cleared.
	• Enable X SP • Enable Y SP • Enable Z SP	(Enable Single Pulse) Allows taps along these axes to trigger the "Event Detected" Indicator on the Tap Status frame. For example, to see only taps on the top of the device, clear the X and Y SP boxes.
	Enable Latch	Causes any triggered event to remain until the status buffer is read. If the Enable Latch checkbox is not enabled, then the interrupt will only last as long as the event, and the status buffer will represent the most-recent event.
	LPF Enable	(Low-Pass Filter) Sends accelerometer data through a low-pass filter before it (the data) is processed by the tap application. The low-pass filter treats higher frequency signals as noise, filtering out very fast shocks, to prevent them (the fast shocks) from being detected as taps.

Table 18. Full-System Evaluation – Pulse Detection screen (Continued)

Screen frame	Field or option	Description
Single/ Double Tap Settings (continued)	HPF Bypass	(High-Pass Filter) Sends the raw accelerometer data to the tap application, bypassing the high-pass filter. • The HPF Bypass option button normally should be cleared. • Disabling the high pass filter can cause non-tap events (such as tilting the device) to be registered as taps.
	Pulse Time Limit slider	Sets the maximum time that a tap can last before it is ignored (i.e., it is not considered a tap). • Before using the Pulse Time Limit slider, you must click the Reset Time Limit button. • After using the Pulse Time Limit slider, click the Set Time Limit button to change the setting.
	Set Time Limit[1]	After changing the value of the Pulse Time Limit slider, the Set Time Limit button must be clicked.
	Reset Time Limit[1]	• Before using the Pulse Time Limit slider, the Reset Time Limit button must be clicked. • After using the Pulse Time Limit slider, the Set Time Limit button must be clicked.
	• X Threshold • Y Threshold • Z Threshold sliders	Sets the g threshold for a tap to be detected along the designated axis. Pulses with a G value less than the setting will be ignored. • Before using the axis threshold sliders, you must click the Reset XYZ Thresholds button. • After using the axis threshold sliders, the Set XYZ Thresholds button must be clicked.
	Set XYZ Thresholds button[2]	After changing the value of any of the axis threshold slider settings, the Set XYZ Thresholds button must be clicked.
	Reset XYZ Thresholds button[2]	Before changing the settings of any of the axis threshold sliders, the Reset XYZ Thresholds button must be clicked.
	• Enable X DP • Enable Y DP • Enable Z DP	(Enable Double Pulses) Enables detection of double pulses along the specified axis or axes. For example, if you only want to see double taps on the right side of the device, then the Z and Y DP checkboxes should be cleared.
	Ignore Latent Pulses	Causes the device to ignore the Pulse Latency timer (set by the Pulse Latency Slider) and detect taps directly after other taps.
	Pulse Latency slider	Sets the amount of time that the device waits after a tap, before registering the next tap. Subsequent taps that occur within this period are ignored. • Before using the Pulse Latency slider, you must click the Reset Time Limits button. • After using the Pulse Latency slider, click the Set Time Limits button to change the setting.
	Second Pulse Latency slider	Sets the amount of time that the device will wait to reset, after receiving an initial pulse. A pulse detected after the set time will be considered a new first pulse. • Before using the Second Pulse Latency slider, you must click the Reset Time Limits button. • After using the Second Pulse Latency slider, click the Set Time Limits button to change the setting

Table 18. Full-System Evaluation – Pulse Detection screen (Continued)

Screen frame	Field or option	Description
Single/ Double Tap Settings (continued)	Set Time Limits	After changing the value of the Pulse Latency or Second Pulse Window slider, the Set Time Limits button must be clicked.
	Reset Time Limits	• Before changing the Pulse Latency or Second Pulse Window slider, the Reset Time Limit button must be clicked. • After changing the Pulse Latency or Second Pulse Window slider, the Set Time Limits button must be clicked.
Single Tap and Double Tap Status	Double Tap	Turns green to indicate that a double tap has been detected.
	• X Detected - Direction X • Y Detected - Direction Y Z Detected - Direction Z	The indicator(s) switch from red to green when an event is triggered along the specified axis or axes.
	Event Detected	This indicator switches from red to green if an event is triggered.

1 Before resetting the value of the Pulse Time Limit slider, you must click the Reset Time Limit button. After setting the value, you must then click the Set Time Limit.

2 Before resetting the value of the X, Y, or Z threshold sliders, you must click the Reset XYZ Thresholds button. After setting the value, you must then click the Set XYZ Thresholds button.

3.9.9 FIFO Screen

Note: The FIFO screen is available only for the MMA8451Q device.

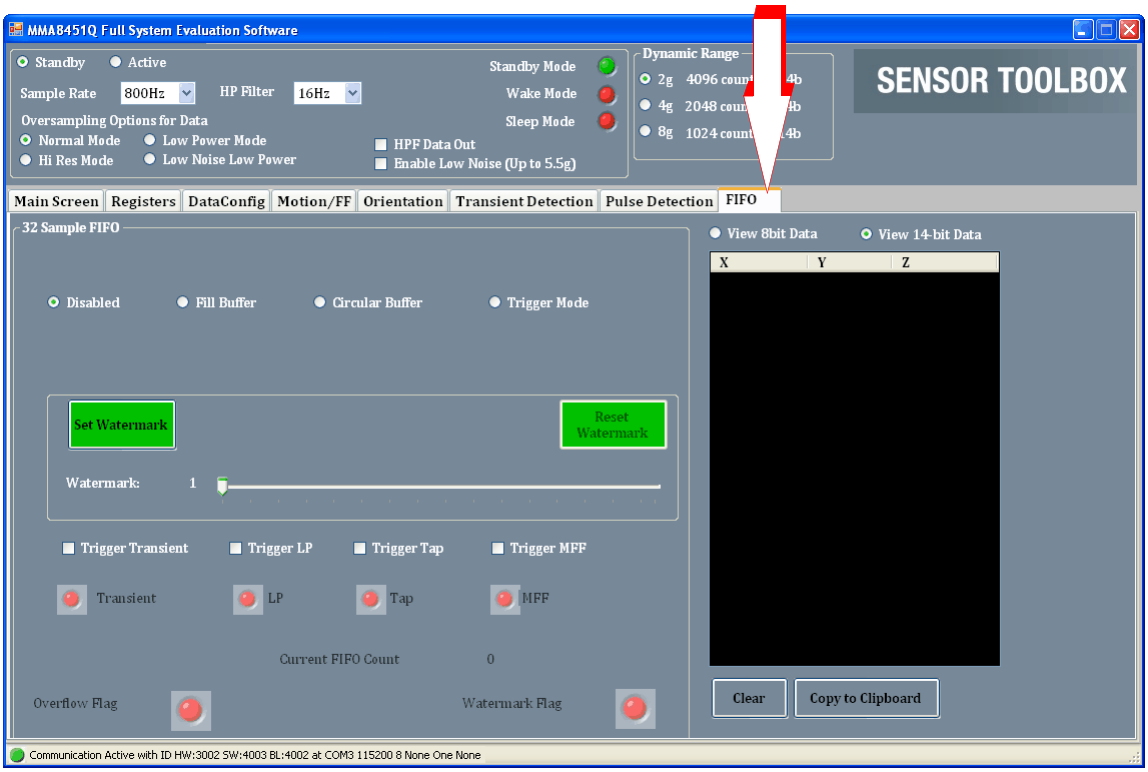


Table 19. Full-System Evaluation – FIFO screen

Screen frame	Field or option	Description
(Option buttons)	Disabled option button	Disables use of the FIFO.
	Fill Buffer option button	Fills the FIFO with data, dumps that data to the text field on the right, and begins filling the FIFO again.
	Circular Buffer option button	Fills the FIFO with data until it is full, and then begins overwriting the oldest data, each time that new data is received.
	Trigger Mode option button	Collects data in the Circular mode up to the watermark. When the trigger event occurs, the device fills the rest of the FIFO with data, and then stops taking data.
(Watermark)	Set Watermark	After changing the value of the Watermark slider, the Set Watermark button must be clicked.
	Reset Watermark	Before changing the value of the Watermark slider, the Reset Watermark button must be clicked.
	Watermark	Determines the FIFO count after which the Watermark Flag activates. • Before changing the Watermark slider's value, the Reset Watermark button must be clicked. • After the Watermark value has been changed, the Set Watermark button must be clicked.
(Trigger options)	• Trigger Transient • Tripper LP • Trigger Tap • Trigger MFF	When the Trigger Mode option button is enabled, these option buttons determine what event(s) trigger the FIFO to fill up and then stop taking data. The options include: • Transient (shake) • LP (landscape/portrait) • Tap • MFF (Motion/Freefall)
(Indicators)	• Transient • LP • Tap • MFF	The indicators switch from red to green to indicate the following events have occurred: • Transient (shake) • LP (landscape/portrait) • Tap • MFF (Motion/Freefall)
	Current FIFO Count	Displays the number of samples currently stored in the FIFO.
	Overflow Flag	Switching from red to green indicates that the FIFO has begun overwriting data in the Circular Buffer mode.
	Watermark Flag	Switching from red to green indicates that a watermark event has occurred.

Table 19. Full-System Evaluation – FIFO screen (Continued)

Screen frame	Field or option	Description
(Data)	• View 8-Bit Data • View 14-Bit Data	Specifies the number of bits to be read from the FIFO and displayed in the text field. A higher bit count produces more-precise values, but requires more time and power. • 8-Bit — Dumps only the 8 bits stored in the X, Y, and ZMSB registers • 14-Bit (MMA8451Q) — Dumps the 8 MSB bits and the 6 bits stored in the X, Y, and ZLSB registers. • 12-Bit (MMA8452Q) — Dumps the 8 MSB bits and the 4 bits stored in the X, Y, and ZLSB registers. • 10-Bit (MMA8451Q) — Dumps the 8 MSB bits and the 2 bits stored in the X, Y, and ZLSB registers.
	(Text field)	Displays data dumped from the FIFO.

4 Running the Accelerometer Demonstrations

This section gives examples of how the demonstrations can be used. For details about each demonstration, see Section 3, “Understanding the Accelerometer Demonstrations”.

4.1 Directional Flick Application

1. Connect any of the accelerometers to the evaluation board and launch the sensor toolbox software.
2. From the Demo Launch menu, select the Directional Flick Low-Power with FIFO demonstration button.
3. Hold the device as indicated in the screen’s picture.
4. Flick the device to the right.

   The pictures to the right should scroll in the direction of flick.

Also see “Directional Flick Application” on page 7.

4.2 Orientation (Portrait/Landscape) Application

1. Launch the sensor toolbox software with any of the accelerometers connected to the evaluation board.
2. Select the Orientation Detection demonstration from the main launcher menu.
3. Hold the device flat with the USB connection on the *right*.
4. Rotate the device clockwise, so that the USB connector is pointing down.
   - The Portrait/Landscape gauge on the left should read “Right.”
   - The phone displayed in the middle should be facing you while laying on its side with the buttons on the left.
   - The Front/Back gauge should read “Front.”

The device can be placed in any orientation to demonstrate its ability to detect changes. You can also position the device to exceed the configured ZY angle so that changes are prevented, with the simulated phone not changing orientation when the device is placed on a table.

Also see “Orientation Application” on page 13.

4.3 Graphical Datalogger Application

1. Launch the sensor toolbox software with any of the accelerometers connected to the evaluation board.
2. Select the Graphical Datalogger application from the main launcher menu.
3. Click the Start a New Datalog button.
4. Move the device to observe how the data is graphed on the screen.

Also see “Graphical Datalogger Application” on page 17.

4.4 Non-Volatile Memory Datalogger Application

1. Launch the sensor toolbox software with any of the accelerometers connected to the evaluation board.
2. Select the NVM Datalogger application from the main launcher menu.
3. Click the Erase NVM Memory button.
4. Click the Start a New Datalog button.
5. Move the device around.

   Sharper movements are easier to see when the output is exported to a spreadsheet application.
6. When you have collected sufficient data, click the Stop Current Datalog button.
7. Click the Download to Excel button.

   The data in the non-volatile memory is exported as a comma-separated values (.csv) file. The file can be opened with a spreadsheet or text application.

Also see "NVM Datalogger Application" on page 22.

4.5 Directional Tap with FIFO Application

1. Launch the sensor toolbox software with the MMA8451Q accelerometer connected to the evaluation board.
2. Select the Directional Tap Low-Power with FIFO demonstration from the main launcher menu.
3. Hold the device flat with the USB connection on the left.
4. Tap the top of the device.

   The z-axis indicator should switch to green and the Directional Tap window should display Z-Negative.
5. To demonstrate the device's ability to detect taps, tap other sides of the device (or hold the device at an angle while tapping).

Also see "Directional Tap with FIFO Application" on page 26.

4.6 Directional Shake with FIFO Application

1. Launch the sensor toolbox software with the MMA8451Q accelerometer connected to the evaluation board.
2. Select the Directional Shake Low-Power with FIFO demonstration from the main launcher menu.
3. Hold the device flat with the USB connection on the left.
4. Shake the device away from your body.

   The Y-axis indicator should switch to green and the Direction window should display Y Positive.
5. To demonstrate the device's ability to detect shakes, shake the device along any of its axes.

Also see "Directional Shake with FIFO Application" on page 31.

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