THE DATASHEET OF

MMA9555LR1

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MMA9555L Intelligent Motion-Sensing Pedometer

The MMA9555L intelligent motion-sensing pedometer is an extension of the MMA955xL intelligent sensor platform. This device incorporates a 3-axis MEMS accelerometer, signal conditioning, data conversion, and a 32-bit microcontroller. This intelligent motion-sensing sensor provides sophisticated pedometer functionality, activity level and six directional orientation monitoring.

The integrated functionality of sensor initialization, calibration, data compensation, and computation functions off-loads CPU bandwidth from the system application processor. Therefore, total system power consumption is significantly reduced, because the application processor stays powered down until absolutely needed. In addition, the device can be configured for an autosleep/autowake capability.

MMA9555L is available in a plastic LGA package; the device is guaranteed to operate over the extended temperature range of –40 °C to +85 °C.

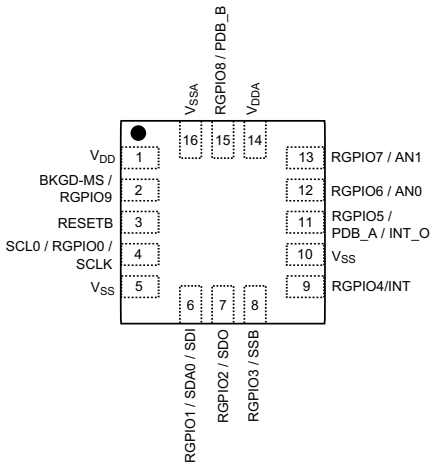
Features

- High resolution 3-axis accelerometer with 16-bit ADC (0.061 mg/LSB @ 2 *g*)
- Selectable *g* range (±2/4/8 *g*) and output data rates (488 Hz–3.8 Hz)
- One slave SPI or I^2C interface operating at up to 2 Mbps for communication with the host processor
- 1.8 V supply voltage low power consumption
  - 2 µA typical current at stop mode
  - 117 µA for pedometer running at active and 92 µA at suspend
  - 87 µA when six-direction detection mode
- Complete built-in firmware for smart sensing intelligence
  - Real time and preemptive application task scheduling
  - Command interpreter support command/response and streaming mode
  - Low-power pedometer with rich output information
    - Step counting
    - Speed, distance, calorie count estimation
    - Activity level (rest, walking, jogging, running)
  - Six-direction detection output
  - Extensive set of power-management features and low-power mode
  - GPIO2–GPIO8 can be used for expanded configurable GPIO functions
- Minimal external component requirements

MMA9555L

16-pin LGA
3 mm x 3 mm x 1 mm
Case 2094-01

Top view



Pin Connections

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Typical Applications

This low-power, intelligent sensor is optimized for use in portable and mobile consumer products such as:

- Pedometers, wearable devices, smart watches, wristband
- Sleep monitoring
- Smart earphone
- Health monitoring

Ordering information

Part number	Firmware	Temperature range	Package description	Shipping
MMA9555LR1	Pedometer + Six Directions of Orientation + GPIO Input/Output	–40 °C to +85 °C	LGA-16	Tape and reel

Related Documentation

The MMA9555L device features and operations are described in reference manuals, release notes, and application notes. To find the most-current versions of these documents:

1. Go to the NXP homepage at: nxp.com.
2. In the Keyword search box at the top of the page, enter the device number MMA9555L.

In the Refine Your Results pane on the left, click on the Documentation link.

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1 Intelligent Sensing Platform Offering

NXP has a broad offering of MMA955xL devices.

The MMA9550L, MMA9551L, MMA9553L, and MMA9555L devices can function immediately as shipped. They have an internal command interpreter and applications scheduler. These devices can interact directly with the users' host system.

The MMA9550L, MMA9551L, MMA9553L and MMA9559L devices are programmable with additional user application software. These devices have a variety of user flash and RAM memory space available. The MMA9555L is provided with complete factory build application specific software, no additional user software programming in the device is needed.

NOTE

The information and specifications provided in this data sheet are specific to the MMA9555L. Information for the other devices can be found in the MMA955xL collateral and datasheet.

Table 1. NXP Intelligent Sensing Product Comparison

Feature - Device	MMA9550L	MMA9551L	MMA9553L	MMA9555L	MMA9559L
Key elements	Motion sensing	Gesture sensing	Pedometer	Pedometer + six-direction orientation + GPIO Input/Output	High flexibility
ADC resolution (bits)	10,12,14,16 bits	10,12,14,16 bits	10,12,14,16 bits	10,12,14,16 bits	10,12,14,16 bits
g measurement ranges	2 *g*, 4 *g*, 8 *g*	2 *g*, 4 *g*, 8 *g*	2 *g*, 4 *g*, 8 *g*	2 *g*, 4 *g*, 8 *g*	2 *g*, 4 *g*, 8 *g*
Real-time and preemptive scheduling	Yes	Yes	Yes	Yes	No
Event management	No	No	No	No	Yes
Slave Port Command Interpreter					
• Normal mode	Yes	Yes	Yes	Yes	No
• Legacy mode	Yes	Yes	Yes	Yes	No
• Streaming mode	Yes	Yes	Yes	Yes	No
Front-end processing					
• 100 Hz BW anti-aliasing	Yes	Yes	Yes	Yes	No
• 50 Hz BW anti-aliasing	Yes	Yes	Yes	Yes	No
• *g*-mode-dependent resolution	Yes	Yes	Yes	Yes	Yes
• Absolute value	Yes	Yes	Yes	Yes	No
• Low-pass filter	Yes	Yes	Yes	Yes	No
• High-pass filter	Yes	Yes	Yes	Yes	No
• Data-ready interrupt	Yes	Yes	Yes	Yes	Yes
Gesture applications					
• High *g*/Low *g*	No	Yes	No	No	No
• Tilt	No	Yes	No	No	No

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Table 1. NXP Intelligent Sensing Product Comparison (Continued)

Feature - Device	MMA9550L	MMA9551L	MMA9553L	MMA9555L	MMA9559L
• Portrait/Landscape	No	Yes	No	No	No
• Programmable orientation	No	Yes	No	No	No
• Tap/Double-tap	No	Yes	No	No	No
• Freefall	No	Yes	No	No	No
• Motion	No	Yes	No	No	No
Data-storage modules					
• Data FIFO	Yes	Yes	Yes	Yes	No
• Event queue	Yes	Yes	Yes	Yes	No
• Inter-process FIFO	No	No	No	No	Yes
Power-control module					
• Run and Stop on idle	Yes	Yes	Yes	Yes	Yes
• Run and No stop	Yes	Yes	Yes	Yes	Yes
• Stop NC	Yes	Yes	Yes	Yes	Yes
• Auto-Wake / Auto-Sleep / Doze	Yes	Yes	Yes	Yes	No
Data-management daemons	Yes	Yes	Yes	Yes	Yes
Pedometer applications					
• Step count	No	No	Yes	Yes	No
• Distance	No	No	Yes	Yes	No
• Adaptive distance	No	No	Yes	Yes	No
• Activity monitor	No	No	Yes	Yes	No
Six Directional Orientation	No	No	No	Yes	No
GPIO management	No	No	No	Yes	No

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2 General Description

2.1 Functional Overview

The MMA9555L is an intelligent motion sensing pedometer, it consists of a 3-axis, MEMS accelerometer and a mixed-signal ASIC with an integrated, 32-bit CPU. The mixed-signal ASIC can be utilized to measure and condition the outputs of the MEMS accelerometer, internal temperature sensor, or a differential analog signal from an external device.

The calibrated, measured sensor outputs can be read via the slave I^2C or SPI port and utilized internally within the MMA9555L to provide advanced intelligent motion detection outputs like pedometer step count, activity level and six directional orientation detections which can be accessed via the slave I^2C or SPI port.

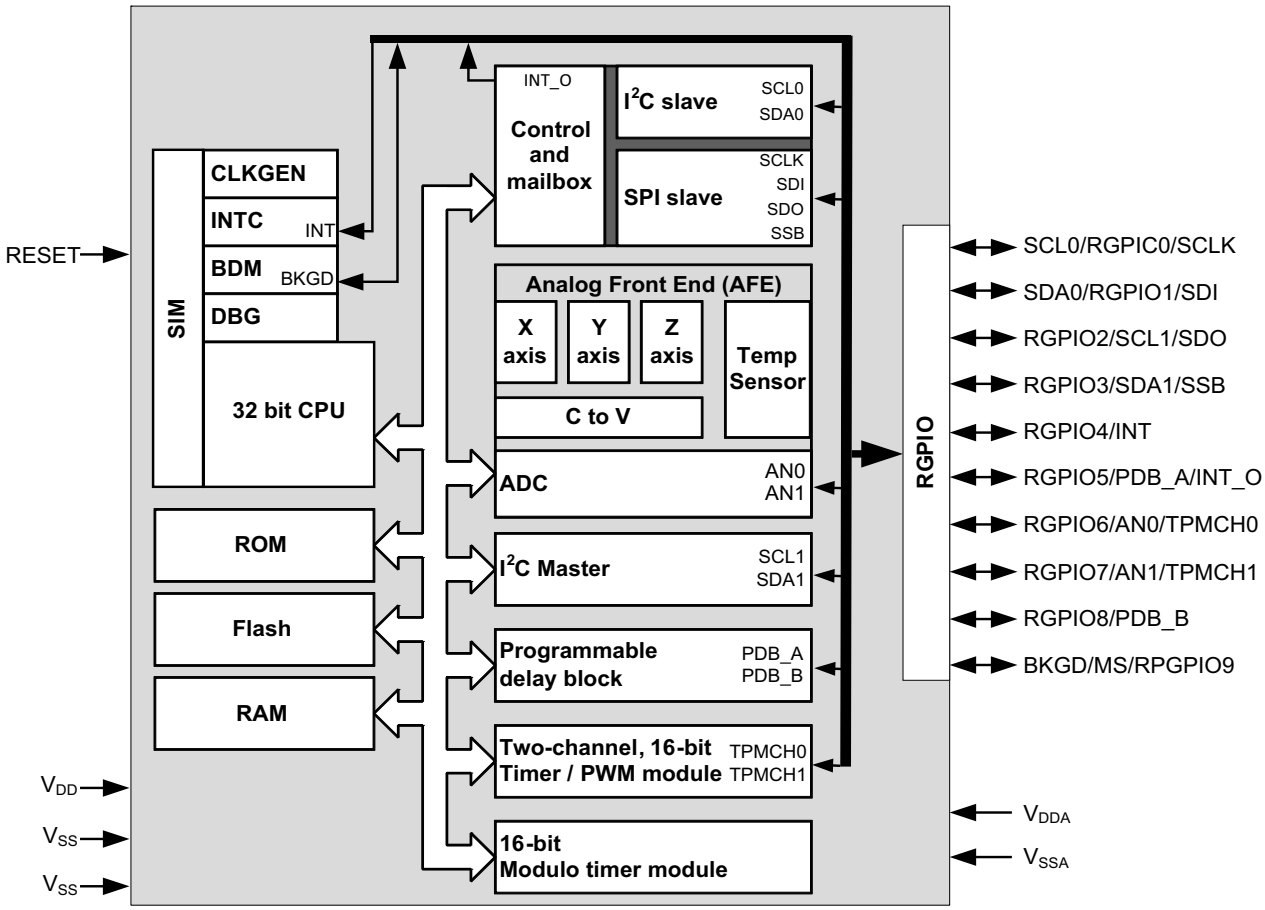

Figure 1. MMA9555L block diagram

A block-level view is shown in Figure 1 with building blocks of devices and built-in applications summarized at a high level. The analog/mixed-mode subsystem associated with a digital engine is composed of:

- The analog subsystem is composed of:
  - A 3-axis transducer that is an entirely passive block including the MEMS structures.
  - An Analog Front End (AFE) with the following:
    - A capacitance-to-voltage converter
    - An analog-to-digital converter
    - A temperature sensor
- The digital subsystem is composed of:
  - A 32-bit CPU
  - Memory: RAM, ROM, and flash
  - Rapid GPIO (RGPIO) port-control logic

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- I^2C or SPI slave interface
- System Integration Module (SIM)
- Clock-Generation Module

The slave interfaces (either SPI or I^2C) operate independently of the CPU subsystem. They can be accessed at any time, including while the device is in low-power, deep-sleep mode.

2.2 Pinout

The package pinout definition for this device is designed as a superset of functions on NXP's other MMA955xL offerings. All pins on the device are utilized and many are multiplexed.

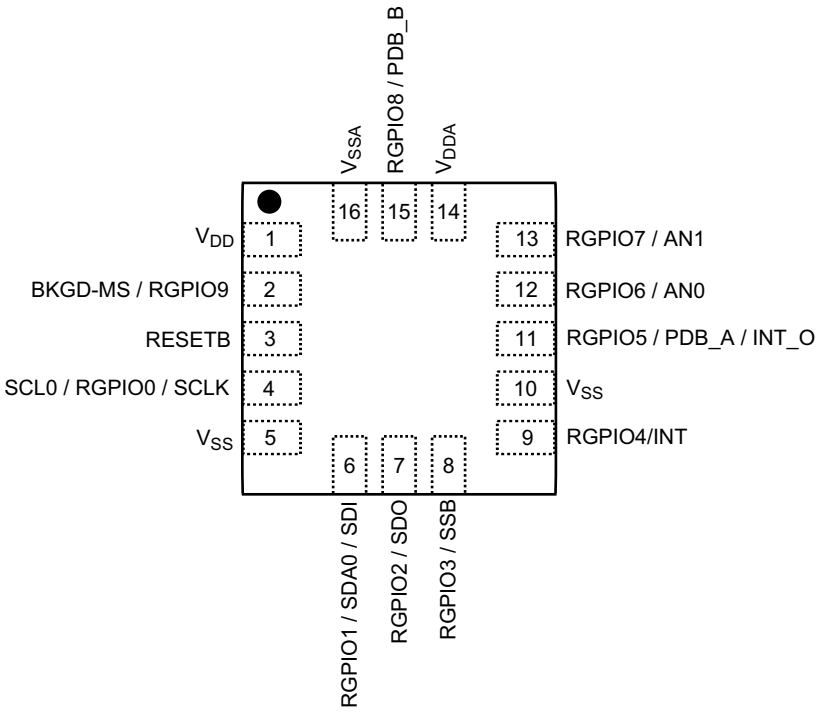

Figure 2. Device pinout (top view)

2.2.1 Pin Functions

The following table summarizes functional options for each pin on this device.

Table 2. Pin functions

Pin #	Pin Name	Description
1	V_{DD}	Digital power supply
2	BKGD / MS / RGPIO9	Background-debug / Mode select / RGPIO9
3	RESETB	Active-low reset. RESETB is an open-drain, bidirectional pin. By default, the output function is not on. Must be pulled to V_{DD} via resistor at startup. After startup, Reset may be asserted low to reset the device.
4	SCL0 / RGPIO0 / SCLK	Serial clock for slave I^2C / RGPIO0 / Serial clock for slave SPI
5	V_{SS}	Digital ground
6	SDA0 / RGPIO1 / SDI	Serial data for slave I^2C / RGPIO1 / SPI serial data input
7	RGPIO2 / SDO	RGPIO2 / SPI serial data output
8	RGPIO3 / SBB	RGPIO3 / SPI slave select. RGPIO3 / SSB = Low at startup selects SPI. High at startup selects I^2C.

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Table 2. Pin functions (Continued)

Pin #	Pin Name	Description
9	RGPIO4/INT	RGPIO4 / Interrupt input
10	RESERVED	Must be connected to V_{SS} ground externally
11	RGPIO5 / INT_O	RGPIO5 or INT_O slave-port interrupt output. INT_O can only output interrupts from the COCO bit. **For setting sensor data output interrupts, use RGPIO6–RGPIO9.**
12	RGPIO6 / AN0	RGPIO6 / ADC Input 0
13	RGPIO7 / AN1	RGPIO7 / ADC Input 1
14	V_{DDA}	Analog power
15	RGPIO8	RGPIO8
16	V_{SSA}	Analog ground

2.3 Pin Function Descriptions

This section provides a brief description of the various pin functions available on the MMA9555L pedometer sensor. Ten of the device pins are multiplexed with Rapid GPIO (RGPIO) functions.

V_{DD} and V_{SS}: Digital power and ground. V_{DD} is nominally 1.8 V.

V_{DDA} and V_{SSA}: Analog power and ground. V_{DDA} is nominally 1.8 V. To optimize performance, the V_{DDA} line can be filtered to remove any digital noise that might be present on the 1.8 V supply. (See Figure 3 and Figure 4.)

RESETB: The RESETB pin is an open-drain, bidirectional pin with an internal, weak, pullup resistor. At start-up, it is configured as an input pin, but also can be programmed to become bidirectional. By default, the output function is not on. Using this feature, the MMA9555L device can reset external devices for any purpose other than power-on reset. Reset must be pulled high at power up to boot to Application code space. If low, it will boot to ROM code. After startup, Reset may be asserted to reset the device. The total external capacitance to ground has to be limited when using RESETB-pin, output-drive capability. For more details, see the “System Integration Module” chapter of the MMA955xL *Intelligent, Motion-Sensing Platform Hardware Reference Manual* (MMA955xLHWRM), listed in “Related Documentation” on page 2.

Slave I^2C port: SDA0 and SCL0: These are the slave-I^2C data and clock signals, respectively. The MMA9555L device can be controlled via the serial port or via the slave SPI interface.

Analog-to-Digital Conversion: AN0, AN1: The on-chip ADC can be used to perform a differential, analog-to-digital conversion based on the voltage present across pins AN0(–) and AN1(+). Conversions for these pins are at the same Output Data Rate (ODR) as the MEMS transducer signals. Input levels are limited to 1.8 V differential.

Rapid General Purpose I/O: RGPIO[9:0]: The Intelligent Pedometer has a feature called Rapid GPIO (RGPIO). This is a 16-bit, input/output port with single-cycle write, set, clear, and toggle functions available to the CPU. The MMA9555L device brings out the lower 10 bits of that port as pins of the device. At reset, all of the RGPIO pins are configured as input pins, although pin muxing does reassign some pins to non-RGPIO function blocks. Pullups are disabled.

RGPIO[9:6] can be set as interrupt pins for most interrupt sources. INT_O can only output interrupts from the COCO bit. For setting sensor data output interrupts, use RGPIO6–RGPIO9.

RGPIO3 / SBB = Low at startup selects SPI. High at startup selects I^2C.

RGPIO[5] or INT_O can only output interrupts from the COCO bit. For setting sensor data output interrupts, use RGPIO6–RGPIO9.

RGPIO[9] is connected to BKGD/MS.

RGPIO[1:0] SDA0 and SCL0 are connected at reset.

Interrupts: INT: This input pin can be used to wake the CPU from a deep-sleep mode. It can be programmed to trigger on either rising or falling edge, or high or low level. This pin operates as a Level-7 (high-priority) interrupt.

Debug/Mode Control: BKGD/MS: At start-up, this pin operates as mode select. If this pin is pulled high during start up, the CPU will boot normally and run code. If this pin is pulled low during start-up, the CPU will boot into active Background-Debug Mode (BDM). In BDM, this pin operates as a bidirectional, single-wire, background-debug port. It can be used by development tools for downloading code into on-chip RAM and flash and to debug that code. There is an internal pullup resistor on this pin, therefore, It may be left floating.

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Slave SPI Interface: SCLK, SDI, SDO and SBB: These pins control the slave SPI clock, data in, data out, and slave-select signals, respectively. The MMA9555L platform can be controlled via this serial port or via the slave-I^2C interface. SBB has a special function at startup that selects the Slave interface mode. Low at startup selects SPI and high selects I^2C.

INT_O: The slave-port output interrupt pin can be used to flag the host when a response to a command is available to read on the slave port. INT_O can only output interrupts from the COCO bit. For sensor data output interrupts, use RGPI06–RGPIO9.

2.4 System Connections

2.4.1 Power Sequencing

An internal circuit powered by V_{DDA} provides the device with a power-on-reset signal. In order for this signal to be properly recognized, it is important that V_{DD} is powered up before or simultaneously with V_{DDA}. The voltage potential between V_{DD} and V_{DDA} must not be allowed to exceed the value specified in Table 6 on page 14.

2.4.2 Layout Recommendations

- Provide a low-impedance path from the board power supply to each power pin (V_{DD} and V_{DDA}) on the device and from the board ground to each ground pin (V_{SS} and V_{SSA}).
- Place 0.01 to 0.1 µF capacitors as close as possible to the package supply pins to meet the minimum bypass requirement. The recommended bypass configuration is to place one bypass capacitor on each of the V_{DD}/V_{SS} pairs. V_{DDA}/V_{SSA} ceramic and tantalum capacitors tend to provide better tolerances.
- Capacitor leads and associated printed-circuit traces that connect to the chip V_{DD} and V_{SS} (GND) pins must be as short as possible.
- Bypass the power and ground with a capacitor of approximately 1 µF and a number of 0.1-µF ceramic capacitors.
- Minimize PCB trace lengths for high-frequency signals. This is especially critical in systems with higher capacitive loads that could create higher transient currents in the V_{DD} and V_{SS} circuits.
- Take special care to minimize noise levels on the V_{DDA} and V_{SSA} pins.
- Use separate power planes for V_{DD} and V_{DDA} and separate ground planes for V_{SS} and V_{SSA}. Connect the separate analog and digital power and ground planes as close as possible to power supply outputs. If both analog circuit and digital circuits are powered by the same power supply, it is advisable to connect a small inductor or ferrite bead in series with both the V_{DDA} and V_{SSA} traces.
- Physically separate the analog components from noisy digital components by ground planes. Do not place an analog trace in parallel with digital traces. It is also desirable to place an analog ground trace around an analog signal trace to isolate it from digital traces.
- Provide an interface to the BKGD/MS pin if in-circuit debug capability is desired.
- Ensure that resistors R_{P1} and R_{P2}, in the following figure, match the requirements stated in the I^2C standard. For the shown configuration, the value of 4.7 kΩ would be appropriate.

2.4.3 MMA9555L Pedometer Sensor as an Intelligent Slave

I^2C pullup resistors, and a few bypass capacitors are all that are required to attach this device to a host platform. The basic configurations are shown in the following two figures. In addition, the RGPIO pins can be programmed to generate interrupts to a host platform in response to the occurrence of real-time application events. In this case, the pins should be routed to the external interrupt pins of the CPU.

NOTE

Immediately after a device reset, the state of pin number 8 (RGPIO3 / SDA1 / SSB functions) is used to select the slave port interface mode. This implies important rules in the way the host controller or, more generally, the complete system should be handling this pin.

First of all, whenever a reset occurs on the MMA9555L, the RGPIO3 pin level shall be consistent with the interface mode of operation. This is particularly important if this pin is driven from external devices. If the RGPIO3 level does not match the current mode of operation, an alternate mode is selected and communication with the host is lost.

If I^2C mode is used, a good practice is to tie RGPIO3 to a pull-up resistor so that it defaults to high level. When using I^2C mode for the slave interface, the RGPIO3 pin plays two roles: RGPIO3 and mode selection. When the MMA9555L is powered on and the mode selection is I^2C, the RGPIO3 pin is released as a GPIO pin. The default setting of RGPIO3 is as an output pin and

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output low. In order to reduce the leakage current on the pull-up resistor, a large resistor value can be used or RGPIO3 can be set as an input pin.

When using SPI mode for the slave interface, the situation is more complex as the same pin plays two roles: SSB and mode selection. Moreover, after a SPI read or write operation, the SSB line returns to high level. Consequently, if the host is sending a command to the MMA9555L that induces a subsequent reset, immediately after the write transaction, the host shall force the SSB line to low level so that SPI mode is still selected after reset. The duration for the SSB line to be kept low typically depends on the latency between the write transaction and the execution of the reset command. Such latency can be significant for the MMA9555L pedometer firmware as the Command Interpreter and Scheduler Application are running at 30 Hz which gives a 33 ms typical latency.

The rule obviously applies also when a hardware reset is issued by the host through MMA9555L pin number 3 (RESETB active low). Again the host has to drive the SSB line low prior to release of the hardware reset line to high level, which triggers immediate MMA9555L reset and boot sequence. Keeping the SSB line low for a 1 ms duration (after RESETB is released) is enough for the MMA9555L slave device to re-boot into SPI mode.

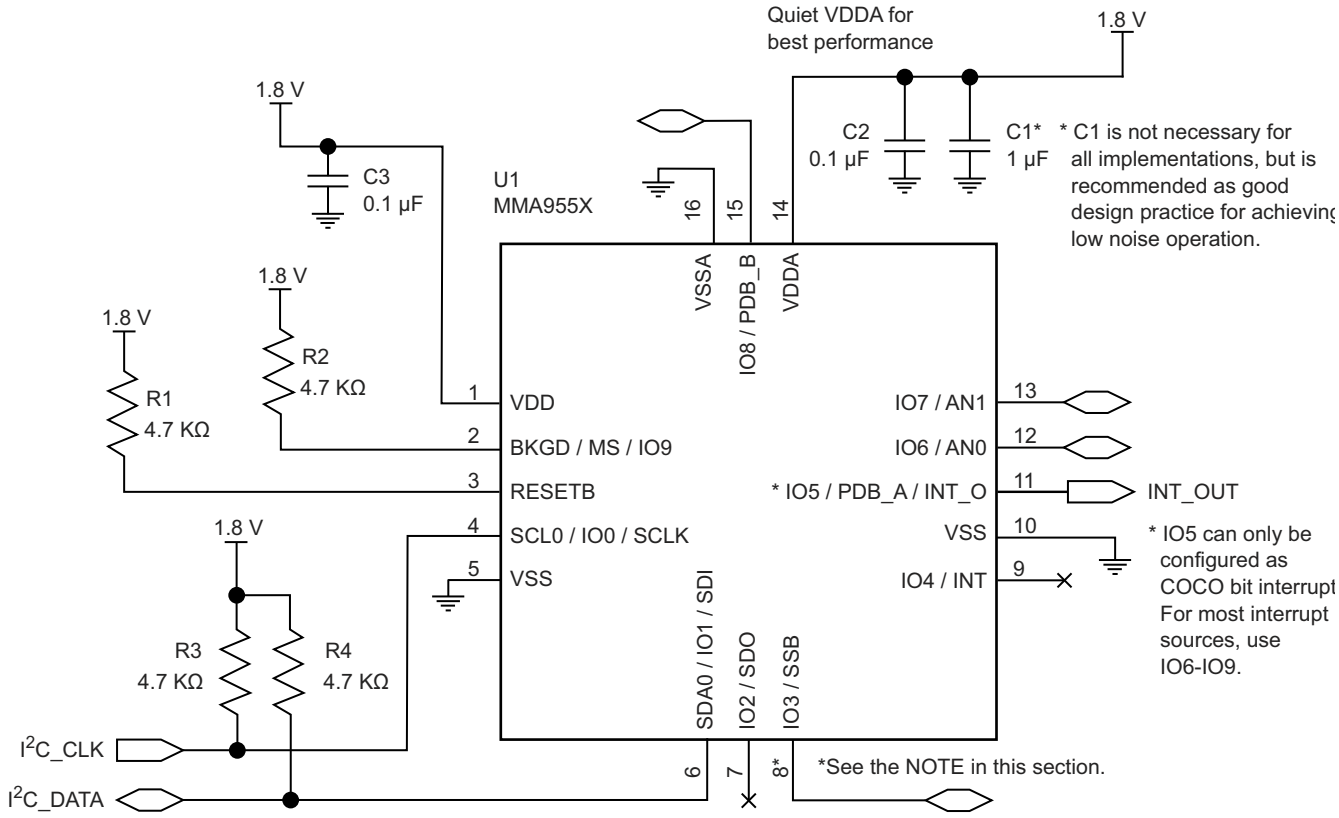

Figure 3. MMA9555L Pedometer Sensor as an I^2C slave

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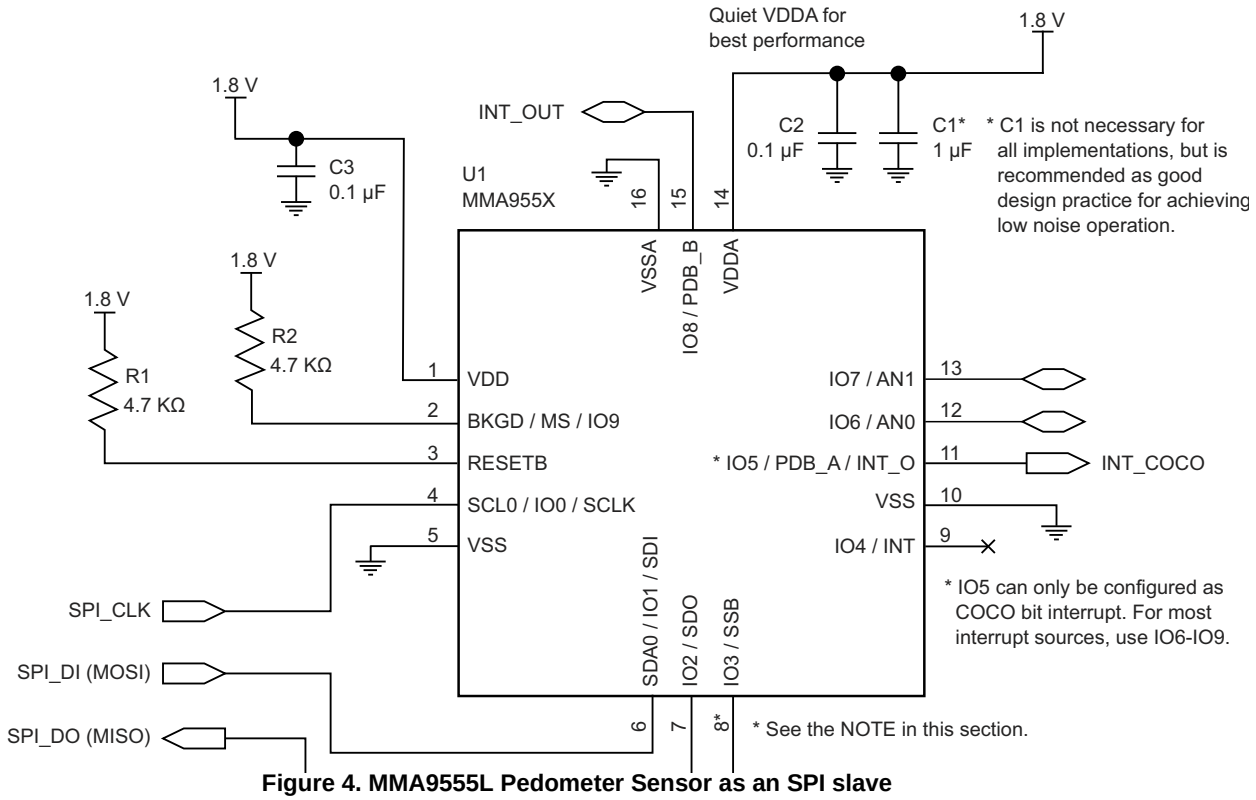

Figure 4. MMA9555L Pedometer Sensor as an SPI slave

2.4.4 Sensing Direction and Output Response

Figure 5 shows the device's default sensing direction when measuring gravity in a static manner from the six standard orientation modes: portrait up/down, landscape left/right and back/front.

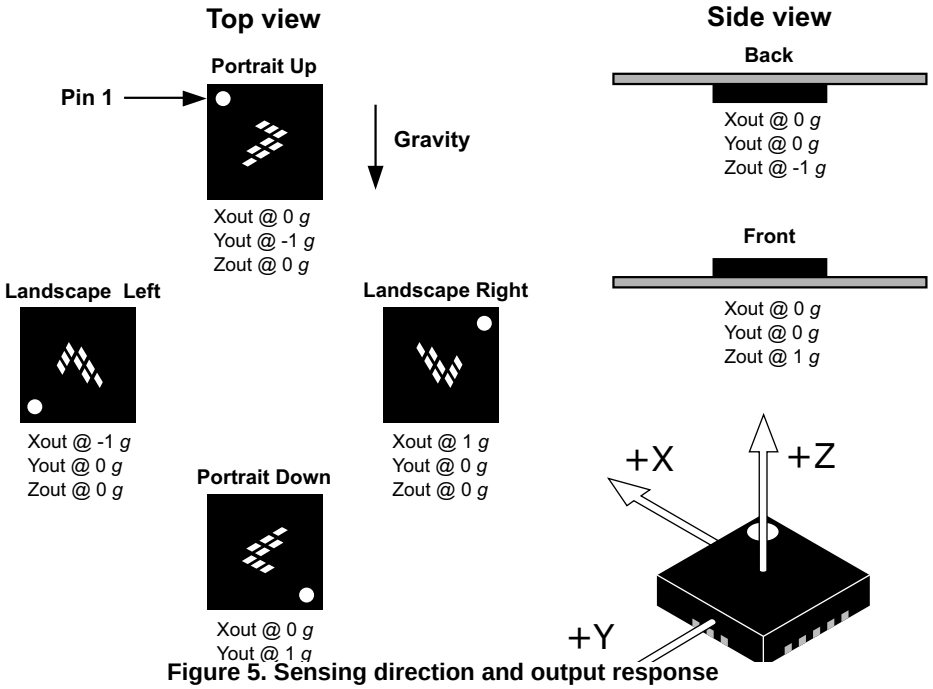

Figure 5. Sensing direction and output response

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3 Mechanical and Electrical Specifications

This section contains electrical specification tables and reference timing diagrams for the MMA9555L device, including detailed information on power considerations, DC/AC electrical characteristics, and AC timing specifications.

3.1 Definitions

Cross-axis sensitivity	The proportionality constant that relates a variation of accelerometer output to cross acceleration. This sensitivity varies with the direction of cross acceleration and is primarily due to misalignment.
Full range	The algebraic difference between the upper and lower values of the input range. Refer to the input/output characteristics.
Hardware compensated	Sensor modules on this device include hardware-correction factors for gain and offset errors that are calibrated during factory test using a least-squares fit of the raw sensor data.
Linearity error	The deviation of the sensor output from a least-squares linear fit of the input/output data.
Nonlinearity	The systematic deviation from the straight line that defines the nominal input/output relationship.
Pin group	The clustering of device pins into a number of logical pin groupings to simplify and standardize electrical data sheet parameters. Pin groups are defined in Section 3.2, “Pin Groups”.
Software compensated	NXP’s advanced nonlinear calibration functions that—with the first-order hardware gain and offset calibration features—improve sensor performance.
Warm-up time	The time from the initial application of power for a sensor to reach its specified performance under the documented operating conditions.

3.2 Pin Groups

The following pin groups are used throughout the remainder of this section.

Group 1 RESETB

Group 2 RESERVED

Group 3 RGPIO[9:0]

3.3 Absolute Maximum Ratings

Absolute maximum ratings are the limits the device can be exposed to without permanently damaging it. Absolute maximum ratings are stress ratings only; functional operation at these ratings is not guaranteed. Exposure to absolute maximum ratings conditions for extended periods may affect reliability.

This device contains circuitry to protect against damage due to high static voltage or electrical fields. It is advised, however, that normal precautions be taken to avoid application of any voltages higher than maximum-rated voltages to this high-impedance circuit. Reliability of operation is enhanced if unused inputs are tied to an appropriate logic voltage level (for instance, either V_{SS} or V_{DD}).

Table 3. Absolute maximum ratings

Rating	Symbol	Minimum	Maximum	Unit
Digital supply voltage	V_{DD}	–0.3	2.0	V
Analog supply voltage	V_{DDA}	–0.3	2.0	V
Voltage difference, V_{DD} to V_{DDA}	$V_{DD} – V_{DDA}$	–0.1	0.1	V
Voltage difference, V_{SS} to V_{SSA}	$V_{SS} – V_{SSA}$	–0.1	0.1	V
Input voltage	V_{In}	–0.3	V_{DD} + 0.3	V
Input/Output pin-clamp current	I_C	–20	20	mA
Output voltage range (Open-Drain Mode)	V_{OUTOD}	–0.3	V_{DD} + 0.3	V
Storage temperature	T_{stg}	–40	125	°C
Mechanical shock	SH	—	5k	g

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3.4 Operating Conditions

Table 4. Nominal operating conditions

Rating	Symbol	Min	Typ	Max	Unit
Digital supply voltage	V_{DD}	1.71	1.8	1.89	V
Analog supply voltage	V_{DDA}	1.71	1.8	1.89	V
Voltage difference, V_{DD} to V_{DDA}	$V_{DD} – V_{DDA}$	–0.1	—	0.1	V
Voltage difference, V_{SS} to V_{SSA}	$V_{SS} – V_{SSA}$	–0.1	—	0.1	V
Input voltage high	V_{IH}	0.7 * V_{DD}	—	V_{DD}+0.1	V
Input voltage low	V_{IL}	V_{SS} – 0.3	—	0.3*V_{DD}	V
Operating temperature	T_A	–40	25	85	°C

3.5 Electrostatic Discharge (ESD) and Latch-up Protection Characteristics

Table 5. ESD and latch-up protection characteristics

Rating	Symbol	Value	Unit
Human Body Model (HBM)	V_{HBM}	±2000	V
Machine Model (MM)	V_{MM}	±200	V
Charge Device Model (CDM)	V_{CDM}	±500	V
Latch-up current at 85 °C	I_{LAT}	±100	mA

3.6 General DC Characteristics

Table 6. DC characteristics[1]

Characteristic	Symbol	Condition(s)[2]	Min	Typ	Max	Unit
Output voltage high • Low-drive strength • High-drive strength	V_{OH}	Pin Groups 1 and 3 I_{LOAD} = –2 mA I_{LOAD} = –3 mA	V_{DD} – 0.5	—	—	V
Output voltage low • Low-drive strength • High-drive strength	V_{OL}	Pin Groups 1 and 3 I_{LOAD} = 2 mA I_{LOAD} = 3 mA	—	—	0.5	V
Output-low current Max total I_{OL} for all ports	I_{OLT}	—	—	—	24	mA
Output-high current Max total I_{OH} for all ports	I_{OHT}	—	—	—	24	mA
Input-leakage current	$\|I_{IN}\|$	Pin Group 2 V_{in} = V_{DD} or V_{SS}	—	0.1	1	µA
Hi-Z (off-state) leakage current	$\|I_{OZ}\|$	Pin Group 3 input resistors disabled V_{in} = V_{DD} or V_{SS}	—	0.1	1	µA
Pullup resistor	R_{PU}	when enabled	17.5	—	52.5	kΩ
Power-on-reset voltage	V_{POR}	—	—	1.50	—	V
Power-on-reset hysteresis	$V_{POR–hys}$	—	—	100	—	mV
Input-pin capacitance	C_{IN}	—	—	7	—	pF
Output-pin capacitance	C_{OUT}	—	—	7	—	pF

1. All conditions at nominal supply: V_{DD} = V_{DDA} = 1.8 V.
2. Pin groups are defined in "Pin Groups" on page 13.

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3.7 Supply Current Characteristics

Table 7. Supply current characteristics[1]

Characteristic	Symbol	Condition(s)	Min	Typ	Max	Unit
Supply current in $STOP_{NC}$ mode	$I_{DD–SNC}$	Internal clocks disabled	—	2	—	µA
Supply current in $STOP_{SC}$ mode	$I_{DD–SSC}$	Internal clock in slow-speed mode	—	15	—	µA
Supply current in RUN mode[2]	$I_{DD–R}$	Internal clock in fast mode	—	3.1	—	mA

1. All conditions at nominal supply: $V_{DD} = V_{DDA} = 1.8$ V.
2. Total current with the analog section active, 16 bits ADC resolution selected, MAC unit used and all peripheral clocks enabled.

3.8 Accelerometer Transducer Mechanical Characteristics

Table 8. Accelerometer characteristics

Characteristic	Symbol	Condition(s)	Min	Typ	Max	Unit
Full range	A_{FR}	2 *g*	±1.8	±2	±2.2	g
		4 *g*	±3.6	±4	±4.4	
		8 *g*	±7.2	±8	±8.8	
Sensitivity/resolution	A_{SENS}	2 *g*	—	0.061	—	mg/LSB
		4 *g*	—	0.122	—	
		8 *g*	—	0.244	—	
Zero-*g* level offset accuracy (Pre-board mount)	OFF_{PBM}	2 *g*	–100	—	+100	mg
		4 *g*				
		8 *g*				
Nonlinearity Best fit straight line	A_{NL}	2 *g*	—	±0.25	—	% A_{FR}
		4 *g*	—	±0.5	—	
		8 *g*	—	±1	—	
Sensitivity change vs.temperature	TC_{SA}	2 *g*	—	±0.17	—	%/°C
Zero-*g* level change vs. temperature[1]	TC_{Off}	—	—	±1.9	—	mg/°C
Zero-*g* Level offset accuracy (Post-board mount)	OFF_{BM}	2 *g*	–100	—	+100	mg
		4 *g*				
		8 *g*				
Output data bandwidth	BW	—	—	ODR/2	—	Hz
Output noise	Noise	2 *g*, ODR = 488 Hz	—	100	—	µg/sqrt(Hz)
		8 *g*, ODR = 488 Hz	—	120	—	µg/sqrt(Hz)
Cross-axis sensitivity	—	—	–5	—	5	%

1. Relative to 25 °C.

3.9 ADC Characteristics

Table 9. ADC characteristics[1]

Characteristic	Symbol	Condition(s)	Min	Typ	Max	Unit
Input voltage	V_{AI}	Voltage at AN0 or AN1	0.2	—	1.1	V
Differential input voltage	V_{ADI}	AN1 – AN0	–0.9	—	0.9	V
Full-scale range	V_{FS}	—	—	1.8	—	V
Programmable resolution	R_{ES}	—	10	14	16	Bits

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Table 9. ADC characteristics[1] (Continued)

Characteristic	Symbol	Condition(s)	Min	Typ	Max	Unit
Conversion time @ 14-bits resolution (Three-sample frame)	t_c	—	—	207	—	µs
Integral nonlinearity	INL	Full scale	—	±15	—	LSB
Differential nonlinearity	DNL	—	—	±2	—	LSB
Input leakage	I_{IA}	—	—	—	±2	µA

1. All conditions at nominal supply: $V_{DD} = V_{DDA} = 1.8$ V and $R_{ES} = 14$, unless otherwise noted.

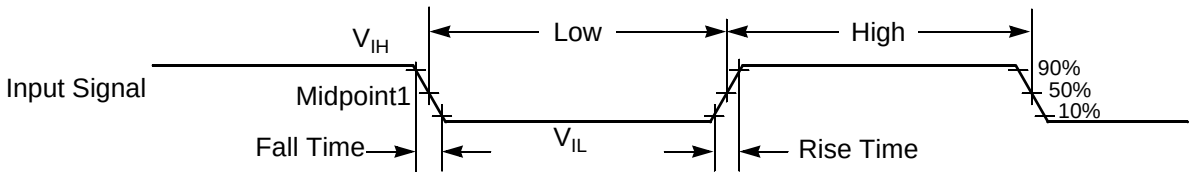
3.10 ADC Sample Rates

The MMA9555L internal ADC supports the following sample output rates, while the pedometer application uses 30.52 fps as default:

- 488.28 frames per second (fps)
- 244.14 fps
- 122.07 fps
- 61.04 fps
- 30.52 fps
- 15.26 fps
- 7.63 fps
- 3.81 fps

3.11 AC Electrical Characteristics

Tests are conducted using the input levels specified in Table 4 on page 14. Unless otherwise specified, propagation delays are measured from the 50-percent to 50-percent point. Rise and fall times are measured between the 10-percent and 90-percent points, as shown in the following figure.



Note: The midpoint is $V_{IL} + (V_{IH} – V_{IL})/2$.

Figure 6. Input signal measurement references

The subsequent figure shows the definitions of the following signal states:

- Active state, when a bus or signal is driven and enters a low-impedance state
- Three-stated, when a bus or signal is placed in a high-impedance state
- Data Valid state, when a signal level has reached V_{OL} or V_{OH}
- Data Invalid state, when a signal level is in transition between V_{OL} and V_{OH}

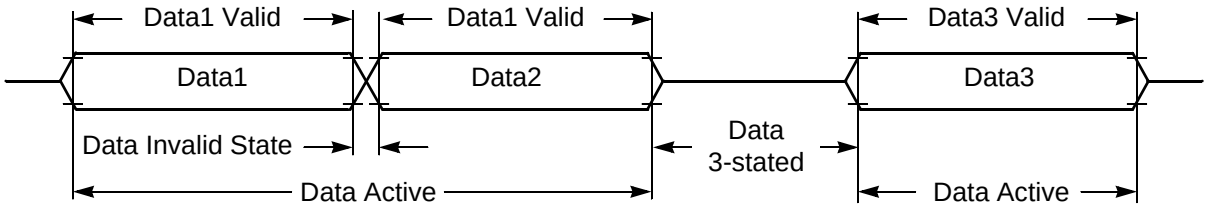


Figure 7. Signal states

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3.12 General Timing Control

Table 10. General timing characteristics[1]

Characteristic	Symbol	Condition(s)	Min	Typ	Max	Unit
V_{DD} rise time	T_{rvdd}	10% to 90%	—	—	1	ms
POR release delay[2]	T_{POR}	Power-up	0.35		1.5	ms
Warm-up time	T_{WU}	From $STOP_{NC}$	—	7	—	sample periods
Frequency of operation	F_{OPH}	Full Speed Clock	—	8	—	MHz
	F_{OPL}	Slow Clock	—	62.5	—	KHz
System clock period	t_{CYCH}	Full Speed Clock	—	125	—	ns
	t_{CYCL}	Slow Clock	—	16	—	µs
Full/Slow clock ratio	—	—	—	128	—	
Oscillator frequency absolute accuracy @ 25 °C	—	Full Speed Clock	–5	—	+5	%
Oscillator frequency variation over temperature (–40 °C to 85 °C vs. ambient)	—	Slow Clock	–6	—	+6	%
Minimum RESET assertion duration	t_{RA}	—	4T[3]	—	—	—

1. All conditions at nominal supply: $V_{DD} = V_{DDA} = 1.8$ V
2. This is the time measured from $V_{DD} = V_{POR}$ until the internal reset signal is released.
3. In the formulas, T = 1 system clock cycle. In full speed mode, T is nominally 125 ns. In slow speed mode, T is nominally 16 µs.

3.13 I2C Timing

This device includes a slave I^2C module that can be used to control the sensor and can be active 100 percent of the time.

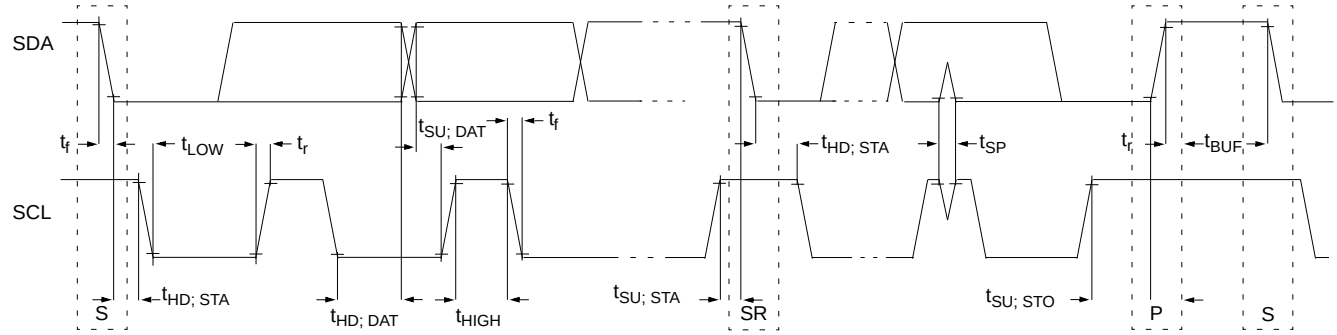

Figure 8. I^2C standard and fast-mode timing

3.13.1 Slave I2C

Table 11. I^2C Speed Ranges

Mode	Max Baud Rate (f_{SCL})	Min Bit Time	Min SCL Low (t_{LOW})	Min SCL High (t_{HIGH})	Min Data setup Time ($t_{SU;\ DAT}$)	Min/Max Data Hold Time ($t_{HD;\ DAT}$)
Standard	100 kHz	10 µs	4.7 µs	4 µs	250 ns	0 µs/3.45 µs[1]
Fast	400 kHz	2.5 µs	1.3 µs	0.6 µs	100 ns	0 µs/0.9 µs[1]
Fast +	1 MHz	1 µs	500 ns	260 ns	50 ns	0 µs/0.45 µs[1]
High-speed supported	2.0 MHz	0.5 µs	200 ns	200 ns	10 ns[2]	0 ns/70 ns (100 pf)[1]

1. The maximum $t_{HD;\ DAT}$ must be at least a transmission time less than $t_{VD;DAT}$ or $t_{VD;ACK}$. For details, see the I2C standard.
2. Timing met with IFE = 0, DS = 1, and SE = 1. Refer to the chapter titled *Port Controls* in the *MMA955xL Intelligent, Motion-Sensing Platform Hardware Reference Manual* (MMA955xLHWRM), listed in "Related Documentation" on page 2.

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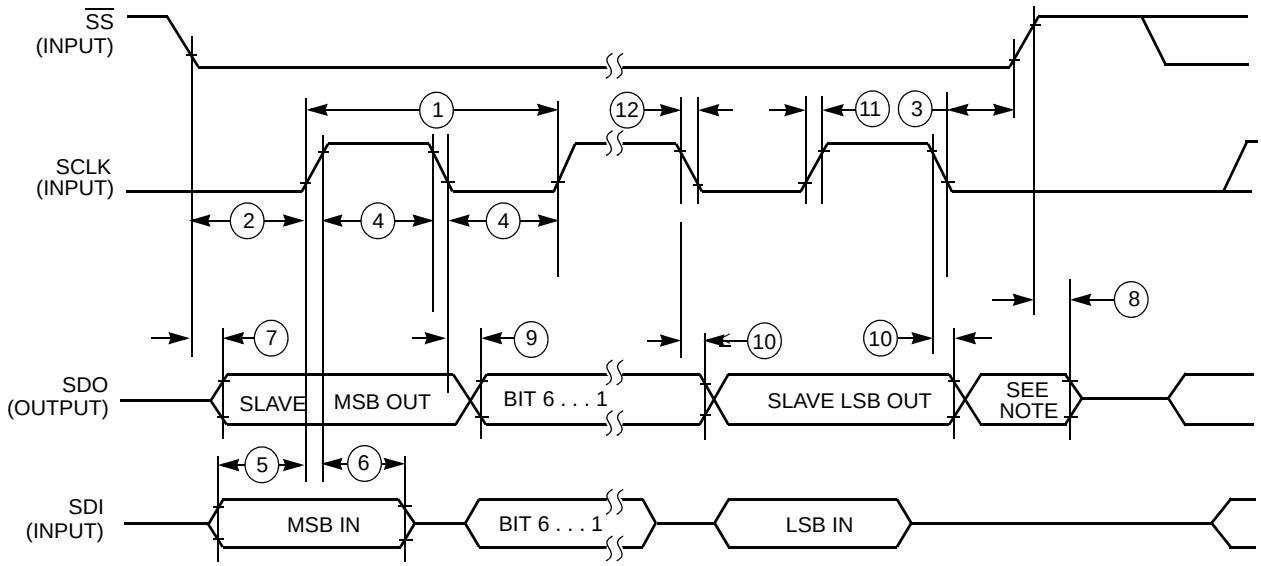
3.14 Slave SPI Timing

Table 12. Slave SPI timing

Time Period (1)	Function	Symbol	Min	Max	Unit
—	Operating frequency	f_{op}	0	$F_{OPH}/4$	Hz
1	SCLK period	t_{SCLK}	4	—	t_{CYCH}
2	Enable lead time	t_{Lead}	0.5	—	t_{CYCH}
3	Enable lag time	t_{Lag}	0.5	—	t_{CYCH}
4	Clock (SCLK) high or low time	t_{WSCLK}	200	—	ns
5	Data-setup time (inputs)	t_{SU}	15	—	ns
6	Data-hold time (inputs)	t_{HI}	25	—	ns
7	Access time	t_a	—	25	ns
8	SDO-disable time	t_{dis}	—	25	ns
9	Data valid (after SCLK edge)	t_v	—	25	ns
10	Data-hold time (outputs)	t_{HO}	0	—	ns
11	Rise time Input Output	 t_{RI} t_{RO}	 — —	 25 25	 ns ns
12	Fall time Input Output	 t_{FI} t_{FO}	 — —	 25 25	 ns ns

1. Time period from Figure 9.



NOTE:
1. Not defined but normally MSB of character just received.

Figure 9. SPI slave timing

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4 Communication Interface

4.1 Overview of Communication Interface

All access to the MMA9555L is made via the slave, serial Communication Interface that is part of the hardware and firmware infrastructure of the platform. The communication occurs in Command/Response (Normal) or Quick Read (Legacy) mode.

Commands are sent from the host and through the slave communications port (either SPI or I^2C). The Communication Interface interprets the command and sends the data to the correct application. The application executes the command and returns with data, if requested with the command response. It also responds with error codes when appropriate.

The Communications Interface works with the Mailbox application to implement the command and response. The mailboxes' functionality is configured with two applications: the MBOX Configuration application (APP_ID = 0x18) and the MBOX application (APP_ID = 0x04).

4.2 Mailbox Interface

Commands are received through a set of 32 mailboxes that are 32 registers arranged consecutively to provide addressable memory regions. Each mailbox can hold one byte of data.

After a command has completed, the Communication Interface writes the results to the mailboxes and the results (response out) are retrieved by the host via the SPI or the I^2C slave interface.

The following figure shows the structure of the data packet when writing one byte into a specific mailbox.

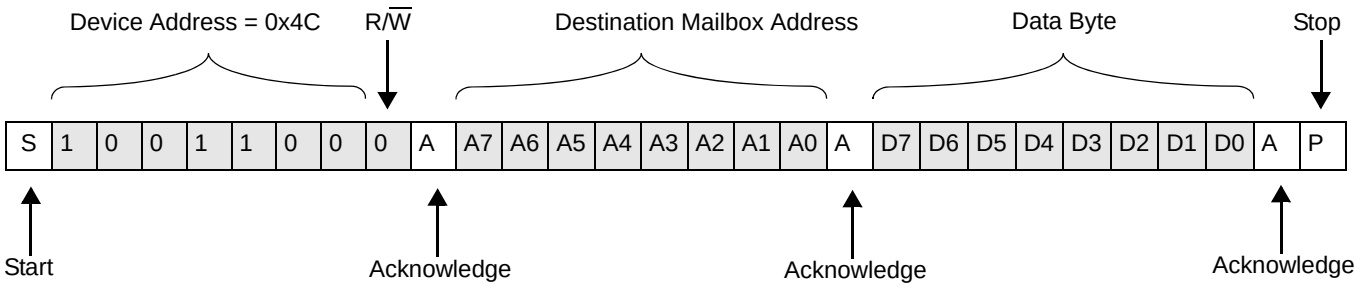

Figure 10. I^2C interface writing one byte of information to a mailbox

If the transaction contains more than one data byte, the internal-destination mailbox address is automatically incremented so that the incoming byte is placed in the next mailbox. For mailbox addresses greater than 31 bytes or for transactions where the mailbox address auto-increments past mailbox 31, the destination address wraps back to the start of the mailbox addresses.

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4.2.1 Mailbox Timing

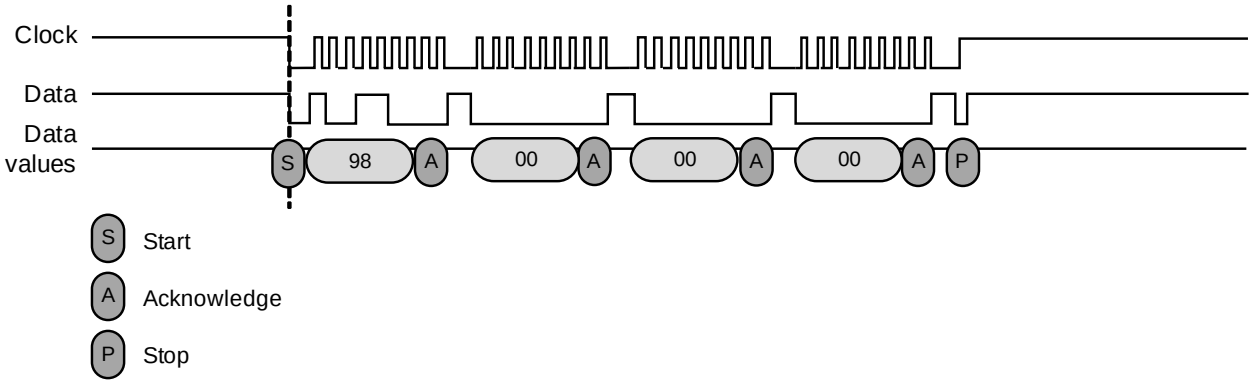
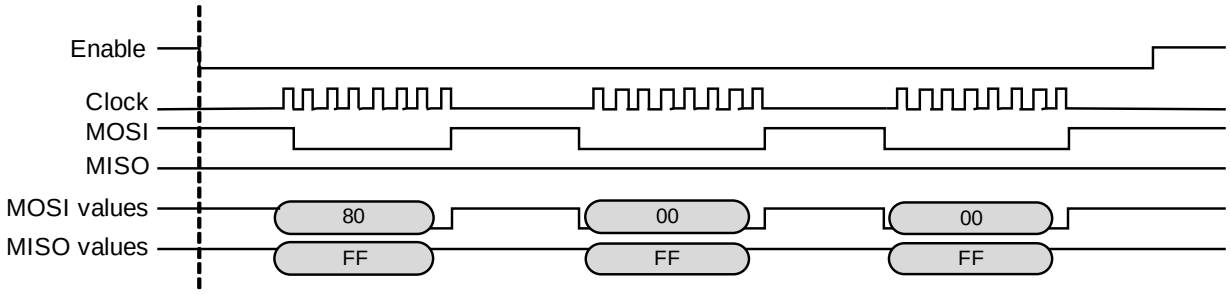


Figure 11. I²C timing diagram



MISO: SPI Master In, Slave Out
MOSI: SPI Master Out, Slave In
SPI: Serial, Peripheral Interface

Figure 12. SPI timing diagram

4.3 Mailbox Usage

Commands to the MMA9555L consist of a write followed by one or more reads. It may take some time to complete the command and a flag can be checked to determine if the command has completed. That flag is the Command Complete (COCO) bit, the seventh bit of the read data in the second mailbox. (See Table 16 on page 23.)

On a read operation, the COCO bit indicates if the command has been processed. The host processor can determine the status of the command's processing by repeatedly reading or polling the second mailbox until the COCO bit is set. Alternatively, the

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MMA9555L can be configured to assert an interrupt signal at the completion of a command. If configured, the INT_O interrupt will be set immediately after the COCO bit has been set.

For more information, see “Configuring mailbox operational mode” on page 96.

4.3.1 Mailbox Command Format for a Write

Commands written to the MMA9555L are sent in the format shown in the following table. Mailboxes are filled with data, depending on the target application. All commands start with the APP_ID, the command, the destination offset, and the number of data bytes to write.

All commands must be written in a single, I^2C/SPI transaction starting at Mailbox 0, but the response can be read from any subset of the mailbox registers.

For a write-request command, the first four mailboxes must be written with enough bytes to hold the requested number of bytes. The format of the data bytes is specific to the targeted application. (Applications are described in Table 15.)

Table 13. Mailbox commands formats

Offset	7	6	5	4	3	2	1	0
0x00	Application ID (APP_ID)							
0x01	0	Command			Byte offset (upper 4 bits)			
0x02	Byte offset (lower 8 bits)							
0x03	Requested number of bytes to read/write							
0x04	Write data 0							
0x05	Write data 1							
0x06	Write data 2							
….	Write data n							

The following table gives the details of the different parts of the data packet for a Write command.

Table 14. Mailbox command format details

Block	Description
Application ID	Application targeted for the issued command, see Table 15.
Command	Command to be performed: • 0: Read application fixed bytes (version information) • 1: Read application configuration bytes • 2: Write application configuration bytes • 3: Read application status or output
Byte offset	Sets the offset of the first byte to be accessed, counting from the start of the register space. This enables a subset of the registers to be accessed by setting the start location to something other than zero.
Requested number of bytes	Number of bytes requested to be read or written.
Write data	The data being written.

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4.3.2 Application IDs, names, and descriptions

The following table gives the names and IDs of the NXP applications associated with MMA9555L.

Table 15. Application descriptions

Application ID	Application Name	Description
0x00	Version	Returns a 12-byte pack with the device identifier number and the version numbers of the ROM, firmware, and hardware. (For more details, see Chapter 5, “Version Application”.)
0x01	Scheduler	Configures the system, applications, and the MMA9555L infrastructure to run at specific sample rates. Additionally, the identifier reads the number of times each task has been executed.
0x02	Reserved	
0x03	GPIO-AppMap	Configures the GPIO application to map a specific application output bit to specific GPIO pins. (For more details, see Chapter 7, “GPIO-AppMap Application”) The GPIO pins are limited to GPIO6 through 9.
0x04	Mailbox	Configures an internal mailbox table to map which output bytes from specific application identifiers will be accessible in the Normal mode and the Legacy mode’s Quick-Read registers mailboxes. The application identifier can perform a table reset to reinstall the default values when the MMA9555L resets.
0x05	Reserved	
0x06	Analog Front End	Configures different parameters of the AFE and reads XYZ data from the accelerometer. For further details, see Chapter 9, “Analog Front End Application”.
0x0C–0x0D	Reserved	
0x0F	Data FIFO	Configures parameters of the Data-FIFO application and reads the output bytes from its output structure and the contents of the FIFO buffer.
0x10	Event queue	Configures parameters of the Event-queue application and reads the output bytes from its output structure and the contents of the Event-queue buffer.
0x11	Status register	Provides access to the MMA9555L system-status information.
0x12	Wake/Sleep	Configures the power-control modes of the accelerometer. The application has three modes of operation: Run, Doze, and Sleep.
0x13–0x14	Reserved	
0x15	Pedometer	Application that can detect the step count.
0x16	Reserved	
0x17	Reset/suspend/clear	Controls the Reset/Suspend/Clear functions of the MMA9555L.
0x18	Mailbox mode config	Configures different operation modes of the mailbox and provides the status value of the mailbox when Stream mode is running.
0x19	GPIO Input/Output	Controls GPIO2–GPIO8 as input or output pins.
0x1B–0x1F	Reserved	
0x20–0xFF	Reserved	Indicates an invalid application index.

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4.3.3 Mailbox command format for a read

Though all commands must be written in a single I^2C/SPI transaction starting at Mailbox 0, the response can be read from any subset of the mailbox registers. When the MMA9555L is configured to stream data (as in FIFO mode), the read commands must be constructed as multiples of 32 bytes in order to trigger the internal transfer of the next set of data to the mailboxes.

A read-request command requires a write to the first four mailboxes.

The format of the information returned from the MMA9555L is shown in Table 16. Similar to the command format, the response format follows the specific application's format.

Mailboxes are filled with data depending on the target application.

All responses start with the responding APP_ID, the COCO the ERROR STATUS, the actual data count, and the requested data count.

The format of the remaining data bytes is specific to the responding application.

Table 16. Mailbox response formats

Mailbox	7	6	5	4	3	2	1	0
0x00	Application ID (APP_ID)							
0x01	COCO	Error code						
0x02	Actual number of bytes read/written							
0x03	Requested number of bytes to read/write							
0x04	Read data 0							
0x05	Read data 1							
0x06	Read data 2							
….	Read data n							

Table 17 describes the details of the different parts and fields of a response message.

Table 17. Mailbox response format details

Block	Description
Application ID (APP_ID)	The ID of the application that is responding. (See Table 16 on page 23.)
COCO	Command complete. This bit must be set to 0b when a command is written and is set to 1b by the MMA9555L platform, when the command has been processed. The other registers do not contain valid results until this bit is set.
Error code	The seven bytes that store the error code of the command. A zero indicates there was no error. (For more information, see Table 18.)
Actual number of bytes	Actual number of bytes read or written. This block reports back the actual number of bytes that were read or written. It is normally the same as the requested number of bytes, but it will be reduced if the requested number of bytes plus the Byte Offset exceeds the number of bytes in the requested block's data structure.
Requested number of bytes	Number of bytes requested to be read or written.
Read data	The data that was read.

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Table 18 describes the status or error-code results returned in Mailbox 0x01.

Table 18. Error-Status codes returned in Mailbox 0x01

Error Code	Name	Description
0x00	MCI _ERROR_NONE	Command completed with no errors.
0x04	MCI _ERROR_PARAM	Incorrect input parameter. Error may be due to an incorrect application ID, an incomplete command, or an incorrect offset.
0x19	MCI _INVALID_COUNT	Returned when the command COUNT is greater than the output structure size.
0x1C	MCI_ERROR_COMMAND	Returned any time that the command interpreter does not recognize a command code.
0x21	MCI_ERROR_INVALID_LENGTH	Returned when the host sends a number of bytes with a wrong payload. MMA9555L checks any mismatches between the amount of bytes received and the actual payload sent by the host.
0x22	MCI_ERROR_FIFO_BUSY	FIFO is busy performing a push operation and it is not possible to execute any other function.
0x23	MCI_ERROR_FIFO_ALLOCATED	Returned when the host tries to reconfigure the FIFO module. The FIFO application configuration can only be written once. In order to reconfigure the FIFO, the whole device must be reset. This is because the FIFO application requests RAM and RAM can only be allocated once.
0x24	MCI_ERROR_FIFO_OVERSIZE	Returned when the host wants to set a FIFO buffer size out of the memory boundaries within the MMA9555L device.

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5 Version Application

The MMA9555L device's system-version information is stored in a 12-byte packet and contains system-identity information including device-hardware ID; the versions of the ROM bootloader, primary firmware, and hardware; and the system-build information.

Table 19 describes the system-version packet and its corresponding mailbox alignment.

Application ID	0x00
Default speed	Always available.
Configuration registers	None.
Status registers	None.

Table 19. Version command description bytes

Mailbox number	Description	Byte
4	Device identifier	31:24
5	Device identifier	24:16
6	Device identifier	15:8
7	Device identifier	7:0
8	ROM major version number	7:0
9	ROM minor version number	7:0
10	Firmware major version number	7:0
11	Firmware minor version number	7:0
12	Hardware major version number	7:0
13	Hardware minor version number	7:0
14	Build major version number	7:0
15	Build minor version number	7:0

Table 20 describes the Build Major and Build Minor version-number fields.

Table 20. Version application, Build major and minor bytes

Byte	Address	Description	Bit fields
3	0x1FD	Build major version number	• 7–3 Build's day of the month Range, 1 to 31 • 2–0 Year of build, from 2010 Range, 0 to 7.
4	0x1FC	Build minor version number	• 7 — Release – 1 Engineering version – 0 Production release • 6–4 Build number • 3–0 Month of build Range, 1 to 12

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5.1 Reading the version information

To read the MMA9555L's version information, send the following command packets to the mailboxes:

1. MB0: Set APP_ID to 0x00.
2. MB1: Command to 0x00.
   Reads version information.
3. MB2: Set offset to zero 0x00.
   Starts reading at offset 0.
4. MB3: Set count field to 0x0C.
   Reads12 bytes of data.

Bytes to Send: 0x00, 0x00, 0x00, 0x0C.

The expected response to these commands is given in the following example.

NOTE

The current Firmware Build information reflects the framework build and not the pedometer or directional features of the MMA9555L.

Example 1.

```
00 80 0C 0C 2F 33 48 B8 01 01 02 02 01 06 03 41

MB0: APP_ID = 0x00
MB1: STATUS = 0x80 Command Complete, no errors
MB2: RequestedData count= 0xC
MB3: Actual Data Count= 0xC
MB4-7: Device ID = 0x2F3348B8
MB8-9: ROM Version = 01.01
MB10-11: Firmware Version = 02.02
MB12-13: Hardware Version = 01.06
MB14-15: Firmware Build = 03.41 (Production #3, 4 Mar 2011)
```


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6 Scheduler Application

A simple task scheduler manages execution of the applications of the MMA9555L. Based on a run-to-completion scheme, the scheduler features very low cycle and memory overhead.

The scheduler is tightly coupled with the Analog Front End's sampling rate and is triggered at the start of every sample interval. The system is designed such that all applications must complete their processing within the sample interval. The scheduler is used in the defined applications.

A priority scheme allows short-duration, high-priority tasks, such as data sampling and filtering, to preempt long-duration, low-priority tasks.

The scheduler scans serially through the list of applications, looking for applications that have the same priority as the scheduler's current priority. When there is a priority match, an activity level is checked to determine if the application should be run in the current scheduler's interval.

Application ID	0x01
Default speed	(Runs all the time.)
Configuration registers	Start on page 29.
Status registers	Start on page 36.

An application’s activity mask can be set to High, Low, Both, or None. This feature allows an application to run during high activity, low activity, both, or not at all. The Sleep/Wake application defines the thresholds of activity between Sleep and Wake, or High and Low activity.

Priorities from 16 to 23 are linked directly to the frame execution rate, see Table 21. The lower-priority levels provide a range of values for managing applications in the user system.

The scheduler automatically executes all the applications with a priority corresponding to the scheduler's current running priority level.

Once the scheduler has identified an application to run, it does a context switch to that application. When the application completes, context is returned to the scheduler and it looks for more applications with the same priority.

For additional information, contact NXP Sensors Applications Engineering.

6.1 Scheduler application elements

Each MMA9555L application is assigned an application code, a priority and an activity level. The priority and activity level parameters determine when the scheduler runs the application.

6.1.1 Priority levels

A priority scheme allows short-duration, high-priority applications—such as data sampling and filtering—to preempt long-duration, low-priority applications.

The scheduler supports 24 unique priorities, from 0x00 to 0x17 (0 to 23, in decimal). The larger the number, the higher the priority—higher-numbered applications run before lower-numbered applications. Multiple applications can be assigned the same priority level.

The priority level for each application is encoded by the lower six bits in the scheduler_parameters registers. See “Scheduler parameters register” on page 33.

Priorities from 0 to 15 (0x00 to 0x0F) can trigger an application when an interrupt occurs. Priorities 16 to 23 (0x10 to 0x17) are linked to the Analog Front End (AFE) execution rate. All applications with a priority of 16 to 23 are automatically software-triggered by the Scheduler.

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Table 21. Priorities descriptions

Priority Level	Description
0x17	Applications with this priority run at 488 Hz
0x16	Applications with this priority run at 244 Hz
0x15	Applications with this priority run at 122 Hz
0x14	Applications with this priority run at 61 Hz
0x13	Applications with this priority run at 30 Hz
0x12	Applications with this priority run at 15 Hz
0x11	Applications with this priority run at 7 Hz
0x10	Applications with this priority run at 3 Hz
0x0F	Highest user assignable priority level (lower than 3 Hz)
0x0E	User-assignable priority levels
0x0D	
0x0C	
0x0B	
0x0A	
0x09	
0x08	
0x07	
0x06	
0x05	
0x04	
0x03	
0x02	
0x01	
0x00	Lowest user assignable priority level

6.1.2 Activity levels

The MMA9555L uses an activity level attribute to indicate how physically active the device is. The measured physical acceleration and motion actions of the device are classified into two ranges: high activity and low activity.

The activity level is used with the priority level to determine which applications run first. Applications can be set to run during these conditions:

- Always run
- Run during high activity
- Run during low activity
- Never run

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The activity level for each application is encoded in the upper two bits of the scheduler_parameters registers. See “Scheduler parameters register” on page 33.

The Sleep/Wake application alone determines the activity level, therefore high/low activity is entirely a function of the sleep/wake threshold parameters. When in run mode, the scheduler only executes applications with the high activity parameter bit set. Similarly, when in doze mode, the scheduler only executes applications with the low activity parameter bit set. Since these bits are separate, an application has the option to set both to run regardless of the activity level.

The low activity level parameter is like a filter that skips applications normally run after each AFE sample interval. The idea is that when the sensor is not moving, such as sitting on your desk, you can save power by not running applications, for example portrait landscape.

6.2 Interrupts

Interrupts immediately divert execution from any application or the idle state into dedicated interrupt handlers. The scheduler is not invoked, so the interrupt returns without redirection.

All interrupt handlers disable interrupts, so application ready, communication, and pin interrupts divert execution only from applications or the idle state.

Interrupts are never nested.

The MMA9555L supports the interrupts listed in the Table 22. Each supported interrupt can be associated with zero or more priorities. When the interrupt occurs, the scheduler triggers all the applications associated with the priorities configured for that interrupt.

The priorities for each interrupt are configured in the scheduler configuration parameter structure.

Table 22. Supported interrupts [1]

Name	Description
SFD	Start of Digital Frame interrupt. This interrupt occurs when the start of frame signal is asserted.
COCO	Conversion-complete interrupt. This interrupt occurs when the AFE cycle has completed and all ADC conversions are complete and ready to be used.
IRQ	IRQ pin interrupt. This interrupt occurs when the selected input pin detects the configured condition (rising edge/high level or falling edge/low level).

1. For more information, see the *MMA955xL Intelligent, Motion-Sensing Platform Hardware Reference Manual* (MMA955xLHWRM), listed in “Related Documentation” on page 2.

Interrupts are assigned to an application in the Interrupt Assignment registers. See “Interrupt assignment registers” on page 32.

6.3 Scheduler configuration registers

The scheduler has the following three groups of configuration registers:

- request_to_start register
- interrupt assignment registers
- scheduler parameters registers

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Scheduler configuration registers

The configuration and status registers are listed in the following table.

Table 23. Scheduler configuration and status registers

Register type	Address	Width (bits)	Register Name
Configuration	0x00–0x03	32	Request_to_start
	0x04–0x07	32	SFD Interrupt_AppIDs
	0x08–0x0B	32	AFE COCO Interrupt_AppIDs
	0x0C–0x0F	32	IRQ Interrupt_AppIDs
	0x10–0x13	32	Reserved
	0x14–0x17	32	Reserved
	0x18–0x1B	32	Reserved
	0x1C–0x1F	32	Reserved
	0x20–0x23	32	Reserved
	0x24–0x27	32	Reserved
	0x28–0x2B	32	Reserved
	0x2C	8	sched_parms_APP_ID_0x00
	0x2D–0x4A	8 each	sched_parms_APP_ID_0x01 through 0x1E[(1)]
	0x4B	8	sched_parms_APP_ID_0x1F
Status	Address	Width (bits)	Register Name
	0x00–0x03	32	Timeout Status

1. Shaded rows indicate the compressed registers.

The request_to_start register is a way to run the applications under scheduler control. The interrupt assignment registers connect applications to interrupt events. The scheduler parameter registers assign activity levels and priorities to the applications.

In the event that an application does not complete before it is triggered again, the first instance of the application runs to completion before the second instance starts. If a third trigger occurs before the first instance of the application completes, the application misses an instance and is marked in the timeout register.

By checking the timeout_status register, the user can determine which priority application was missed. The corresponding bit of the timeout is set in the timeout_status register.

6.3.1 request_to_start register

An application can be scheduled to run by setting the bit corresponding to the application's APP_ID in the request_to_start register. The scheduler manages starting applications, depending on priority and activity.

When an application finishes and returns, the scheduler clears the corresponding bit in the request_to_start register.

The request_to_start register enables a user to trigger one or more applications via the slave-port command. When modifying this register, the user must logically OR the current value with the new value (with a read/modify/write access) to prevent the erasure of the task waiting to be started.

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Table 24. request_to_start register

Offset	0x00(MSB)								0x01							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	request_to_start [31:24]								request_to_start [23:16]							
Reset	0x00								0x00							
Offset	0x02								0x03(LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	request_to_start [15:8]								request_to_start [7:0]							
Reset	0x00								0x00							

Table 25. request_to_start description

Field	Description
31:0 request_to_start	Indicates which APP_IDs are marked for starting at the beginning of the next scheduler interval. Each bit corresponds to an APP_ID. It is important that the user do a read/modify/write type of access to ensure that the contents of the resister are logically ORed with the new value to avoid erasing the request_to_start bit of the other APP_IDs that are waiting to start. Setting the bit will mark the APP_ID for starting in the next scheduler loop. Units: None. Range of valid values: 0 to 0xFFFFFFF.

The host controller may issue a command through the slave communications port to trigger the running of an application. To do this, the host controller does a read/modify/write to the request_to_start configuration register and sets the appropriate bit associated with the application that the host wants to start.

Regardless of which mechanism triggers the Scheduler application to start—a hardware interrupt, a slave port command, or an internal trap interrupt—it always executes the highest-priority applications first. As a result, a slave-port command could trigger a low-priority application, but some time may occur before that application actually executes.

6.3.2 request_to_start register configuration example

To configure the request_to_start register, send this command, read the register and modify it, and write it back.

Example 2.

1. MB0: Set the Scheduler application identifier (0x01).
2. MB1: Set the Command: Read Config application identifier (0x10).
3. MB2: Set the Offset to Zero field (0x00) to point to the request_to_start configuration register.
4. MB3: Set the Count field (0x04) to request four bytes.

Bytes to send: 0x01, 0x10, 0x00, 0x04.

5. Read back the mailboxes.
   The current value of the request_to_start register is stored in MB4–MB7.
6. Modify the value as needed:
7. MB0: Set the Scheduler application identifier (0x01).
8. MB1: Set the Command: Write Config application identifier (0x20).
9. MB2: Set the Offset to Zero field (0x00) to point to the request_to_start configuration register.
10. MB3: Set the Count field (0x04) to writing four bytes.
11. MB4: Set the DATA value to 0xAA.
12. MB4: Set the DATA value to 0xBB.
13. MB4: Set the DATA value to 0xCC.
14. MB4: Set the DATA value to 0xDD.

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Bytes to send: 0x01, 0x20, 0x00, 0x04, 0xAA, 0xBB, 0xCC, 0xDD.

6.3.3 Interrupt assignment registers

There are 10 possible interrupts in the MMA955xL platform, among these interrupts three are accessible in MMA9555L from the host system. Each interrupt is assigned to an application through the user_interrupt parameter registers. When an interrupt happens, the scheduler handler logically ORs the contents of the user_interrupt register with the request_to_start parameter register.

The scheduler runs the appropriate application the next time the application's priority is runable.

The scheduler uses the interrupt vector to determine which application-ready interrupt occurred and sets a bit in the request_to_start register. In the bit vector, each bit corresponds to a task and the bit position indicates the priority of the application.

The appropriate interrupt is acknowledged to the hardware, usually by clearing a flag bit in the peripheral's memory-mapped status register. In the special case that an AFE, results-ready interrupt occurred, supervisor-only AFE registers are copied into user-mode shadow registers.

Table 26. user_interrupt registers

Offset	0x04(MSB)								0x05							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	SFD Interrupt_AppIDs [31:24]								SFD Interrupt_AppIDs [23:16]							
Reset	0x00								0x00							
Offset	0x06								0x07(LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	SFD Interrupt_AppIDs [15:8]								SFD Interrupt_AppIDs [7:0]							
Reset	0x00								0x00							

Offset	0x08(MSB)								0x09							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	AFE_COCO Interrupt_AppIDs [31:24								AFE_COCO Interrupt_AppIDs [23:16]							
Reset	0x00								0x00							
Offset	0x0A								0x0B(LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	AFE_COCO Interrupt_AppIDs [15:8]								AFE_COCO Interrupt_AppIDs [7:0]							
Reset	0x00								0x00							

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Table 26. user_interrupt registers (Continued)

Offset	0x0C(MSB)								0x0D							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	IRQ Interrupt_AppIDs [31:24]								IRQ Interrupt_AppIDs [23:16]							
Reset	0x00								0x00							
Offset	0x0E								0x0F(LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	IRQ Interrupt_AppIDs [15:8]								IRQ Interrupt_AppIDs [7:0]							
Reset	0x00								0x00							

Table 27. user_interrupt bit descriptions

Field	Description
31:0 Interrupt_AppIDs	Bit vector indicating the tasks that start after the interrupt. Each bit corresponds to a task and the bit position indicates the task's priority. This 32-bit parameter should match the priority of the task that is executing when the interrupt occurs. Units: None. Range of valid values: 0 to 0xFFFFFF.

6.3.3.1 Interrupt_App_IDs register configuration example

In this example, the user has an external interrupt source that wants to run application APP_ID = 0x19. This requires setting the 0x19 bit position in the IRQ_interrupt_APP_IDs register at offset 0x0C–0x0F.

Example 3.

1. MB0: Set the Scheduler application identifier (0x01).
2. MB1: Set the "Command: Write Config" application identifier (0x20).
3. MB2: Set the Offset to Zero field (0x0C) to point to the IRQ_interrupt_APP_IDs register.
4. MB3: Set the Count field (0x04) to write four bytes.
5. MB4: Set the DATA value to 0x20.
   This bit is the 0x19th bit in this 32 bit register.
6. MB4: Set the DATA value to 0x00.
7. MB4: Set the DATA value to 0x00.
8. MB4: Set the DATA value to 0x00.

Command to send for write: 0x01, 0x20, 0x0C, 0x04, 0x20, 0x00, 0x00, 0x00.

6.3.4 Scheduler parameters register

The sched_parms registers structure is shown in Table 28. For more information on the (Activity) and (Priority) bits, see Table 29 on page 34.

Table 28. sched_parms register structure

Bit	7	6	5	4	3	2	1	0
Field	(Activity)		(Priority)					

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Table 29. sched_parms_APP_ID bit descriptions

Field	Description
7:6 (Activity)	Scheduler parameters for each task, this value allows accelerometer activity (motion) to determine whether a task should run. High and low activity thresholds are defined with the Sleep/Wake application. (See Chapter 13, “Sleep/Wake Application”.) Units: None. Range of valid values: • 0x03: ALWAYS // execute application during high and low activity • 0x02: ACTIVE // execute application only during high activity • 0x01: INACTIVE // execute application only during low activity • 0x00: NEVER // never execute application
5:0 (Priority)	Scheduler parameters for each task, this value determine the priority of the application. Units: None. Range of valid values: • 0x17: TASK488HZ // task running at 488 Hz • 0x16:TASK244HZ // task running at 244 Hz • 0x15: TASK122HZ // task running at 122 Hz • 0x14: TASK61HZ // task running at 61 Hz • 0x13: TASK30HZ // task running at 30 Hz • 0x12: TASK15HZ // task running at 15 Hz • 0x11: TASK7HZ // task running at 7 Hz • 0x10: TASK3HZ // task running at 3 Hz • 0x0F: PRIORITY15 • 0x0E: PRIORITY14 • 0x0D: PRIORITY13 • 0x0C: PRIORITY12 • 0x0B: PRIORITY11 • 0x0A: PRIORITY10 • 9: PRIORITY9 • 8: PRIORITY8 • 7: PRIORITY7 • 6: PRIORITY6 • 5: PRIORITY5 • 4: PRIORITY4 • 3: PRIORITY3 • 2: PRIORITY2 • 1: PRIORITY1 • 0: PRIORITY0

The variable data for the sched_parms registers include the register name, offset, and reset. Each of the possible application IDs (0x00–0x1F) is associated with a scheduler parameter register. The following table shows the APP_IDs and their associated register offsets and reset values.

Table 30. sched_parms registers’ differentiating values

Register			Resets	
Offset	**Name**	**Application**	**Bits 7:6**	**Bits 5:0**
0x2C	sched_parms_APP_ID_0x00	Version	0x00	0x00
0x2D	sched_parms_APP_ID_0x01	Scheduler	0x00	0x17
0x2E	sched_parms_APP_ID_0x02	Communications	0x03	0xD7

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Table 30. sched_parms registers' differentiating values (Continued)

Register			Resets	
Offset	**Name**	**Application**	**Bits 7:6**	**Bits 5:0**
0x2F	sched_parms_APP_ID_0x03	GPIO-AppMap	0x03	0xD7
0x30	sched_parms_APP_ID_0x04	Mailbox	0x03	0x17
0x31	sched_parms_APP_ID_0x05	Reserved	—	—
0x32	sched_parms_APP_ID_0x06	AFE	0x03	0xD7
0x33	sched_parms_APP_ID_0x07	Reserved	0x00	0x00
0x34	sched_parms_APP_ID_0x08	Reserved	0x00	0x00
0x35	sched_parms_APP_ID_0x09	Reserved	0x00	0x00
0x36	sched_parms_APP_ID_0x0A	Reserved	0x00	0x00
0x37	sched_parms_APP_ID_0x0B	Reserved	0x00	0x00
0x38	sched_parms_APP_ID_0x0C	Reserved	0x00	0x00
0x39	sched_parms_APP_ID_0x0D	Reserved	0x00	0x00
0x3A	sched_parms_APP_ID_0x0E	Reserved	0x00	0x00
0x3B	sched_parms_APP_ID_0x0F	Data FIFO	0x03	0xD7
0x3C	sched_parms_APP_ID_0x10	Event Queue	0x03	0xD7
0x3D	sched_parms_APP_ID_0x11	Status Register	0x03	0xD7
0x3E	sched_parms_APP_ID_0x12	Wake/Sleep	0x03	0xD7
0x3F	sched_parms_APP_ID_0x13	Reserved	0x00	0x00
0x40	sched_parms_APP_ID_0x14	Reserved	0x00	0x00
0x41	sched_parms_APP_ID_0x15	Reserved	0x00	0x00
0x42	sched_parms_APP_ID_0x16	Reserved	0x00	0x00
0x43	sched_parms_APP_ID_0x17	Reset/Suspend/Clear	0x03	0xD7
0x44	sched_parms_APP_ID_0x18	Mailbox Configuration	0x00	0x00
0x45	sched_parms_APP_ID_0x19	GPIO Input/Output	0x00	0x00
0x46	sched_parms_APP_ID_0x1A	6 Directions Detection	0x00	0x00
0x47	sched_parms_APP_ID_0x1B	Reserved	0x00	0x00
0x48	sched_parms_APP_ID_0x1C	Reserved	0x00	0x00
0x49	sched_parms_APP_ID_0x1D	Reserved	0x00	0x00
0x4A	sched_parms_APP_ID_0x1E	Reserved	0x00	0x00
0x4B	sched_parms_APP_ID_0x1F	Reserved	0x00	0x00

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6.4 Scheduler status registers

The scheduler applications contain a set of output or status registers. Status registers can be read by a host processor, through the I^2C/SPI slave-port read-data commands, or by internal applications, through direct reads.

The scheduler status is a 32-bit register that gives the priority levels for applications that have timed out. Applications time out when their priority level is the one that is currently running and they have been marked with request_to_start. Such an application has not finished running before it needs to start again.

6.4.1 Timeouts

A timeout condition indicates that the scheduler has been compromised by an application.

Table 31. Scheduler status register

Offset	0x00(MSB)								0x01							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	timeout_status[31:24]								timeout_status[23:16]							
Reset	0x00								0x00							
Offset	0x02								0x03(LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	timeout_status[16:8]								timeout_status[7:0]							
Reset	0x00								0x00							

Table 32. sched_parms_APP_ID bit descriptions

Field	Description
31:0 timeout_status	Indicates the priority level of the task that has timed out, one or more times. The register sets the corresponding priority-level bit when a task is timed out (currently running and being marked request_to_start). This bit must be monitored to verify that no user task is compromising the scheduler execution. Units: None. Range of valid values: 0 to 0xFFFFFFFF.

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7 GPIO-AppMap Application

7.1 Overview of GPIO-AppMap application

Application ID	0x03
Default speed	30 Hz.
Configuration registers	Start on page 37.
Status registers	None.

The GPIO-AppMap application assigns a bit from an application's status register to a specific GPIO pin. The configuration registers contain the application ID and the bit number of the output byte for each GPIO pin.

The GPIO-AppMap application connects the MMA955xL platform's GPIO pins to status bits in an application's status registers. The GPIO-AppMap application can control four physical GPIO pins. Each of the four GPIO pins (GPIO6, 7, 8, and 9) has an associated APP_ID register and an SR_bit register.

The GPIO-AppMap application also has a general polarity register where the GPIO pins can be set to be active high or active low. The default or start-up condition of the GPIO pins are unassigned.

The GPIO pins that can be mapped are described in Table 33.

Table 33. GPIO pin names, numbers and functions

Name	Pin number
GPIO6	12
GPIO7	13
GPIO8	15
GPIO9	2

7.2 GPIO configuration registers

The GPIO-AppMap application's configurations registers consist of 10 eight-bit registers. This includes two registers for each of the four GPIO pins and two registers for setting the polarity of the GPIO pin. Each GPIO pin is assigned to an APP_ID and as an output bit from the assigned application.

The following table gives the bit descriptions for the GPIO-AppMap application's registers. The application's registers are shown in Table 35 through Table 43.

The bit descriptions are given in Table 45 on page 40.

7.2.1 GPIO register tables

Table 34. APP_ID GPIO6 register

Offset	0x00							
Bit	7	6	5	4	3	2	1	0
Field	APP_ID GPIO6							
Reset	0xFF							

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Table 35. SR_bitnum GPIO6 register

Offset	0x01							
Bit	7	6	5	4	3	2	1	0
Field	SR_bitnum GPIO6							
Reset	0x00							

Table 36. APP_ID GPIO7 register

Offset	0x02							
Bit	7	6	5	4	3	2	1	0
Field	APP_ID GPIO7							
Reset	0xFF							

Table 37. SR_bitnum GPIO7 register

Offset	0x03							
Bit	7	6	5	4	3	2	1	0
Field	SR_bitnum GPIO7							
Reset	0x00							

Table 38. APP_ID GPIO8 register

Offset	0x04							
Bit	7	6	5	4	3	2	1	0
Field	APP_ID GPIO8							
Reset	0xFF							

Table 39. SR_bitnum GPIO8 register

Offset	0x05							
Bit	7	6	5	4	3	2	1	0
Field	SR_bitnum GPIO8							
Reset	0x00							

Table 40. APP_ID GPIO9 register

Offset	0x06							
Bit	7	6	5	4	3	2	1	0
Field	APP_ID GPIO9							
Reset	0xFF							

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Table 41. SR_bitnum GPIO9 register

Offset	0x07							
Bit	7	6	5	4	3	2	1	0
Field	SR_bitnum GPIO9							
Reset	0x00							

Table 42. GPIO_pol MSB register

Offset	0x08(MSB)							
Bit	7	6	5	4	3	2	1	0
Field	Reserved						GPIO9	GPIO8
Reset	0x00						0	0

Table 43. GPIO_pol LSB register

Offset	0x09(LSB)							
Bit	7	6	5	4	3	2	1	0
Field	GPIO7	GPIO6	Reserved					
Reset	0	0	0x00					

7.2.2 GPIO polarity configuration

Table 44. GPIO output, depending on polarity configuration and bit value

Input Bits		Output Bit
GPIO_POLARITY	**SR_bit x**	**VAL GPIO x**
0	0	0
0	1	1
1	0	1
1	1	0

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7.2.3 GPIO application bit descriptions

Table 45. GPIO application bit descriptions

Field	Description
7:0 APP_ID GPIOx	The application identifier (APP_ID) of the application assigned to the GPIO pin. A value of 0xFF indicates there is no application assigned. After a reset, no application output bits are mapped to a GPIO. Units: None. Range of valid values: [0:31] and 0xFF.
7:0 SR_bitnum GPIOx	The bit number of the application status registers being assigned to the GPIO pin. The bit number depends of the amount of output bytes and the position of the bit in the register. Units: None. Range of valid values: [0:255]
GPIO_pol*x*	Defines the output polarity of the GPIO pin designated by the *n* variable in the field name. This register uses negative logic 0 to configure active high and 1 for active low. Table 34 on page 37 indicates which pin of the register corresponds to each GPIO. Units: None. Range of valid values: 0: Output is active high (output bit = high → high on GPIO pin). 1: Output is active low (output bit = high → low on GPIO pin).
Reserved	Indicates that the bit is reserved.

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8 Mailbox Application

8.1 Overview of Mailbox application

Application ID	0x04
Default speed	30 Hz.
Configuration registers	Start on page 41.
Status registers	None.

The Mailbox (MBOX) application gathers output data from other applications and puts that data into the mailbox registers. This enables users to customize and group up to 28 applications' specific data bytes for quick reads.

Normally, the host may need to read the status and output data from many applications. This requires multiple, serial-slave-port transactions. Using the mailbox application enables the host to read all necessary data in one serial, I^2C or SPI transaction.

The MBOX application provides a shortcut for the user to read different pieces of data from different applications by combining the data for reading in one I^2C or SPI read transaction.

The MBOX application is different than the hardware mailboxes used by the Communication Interface application. The MBOX application combines selected data bytes from specific applications and loads them into the Communications Interface mailboxes.

In order to properly configure the system Communications Interface, the MBOX Configuration and Mailbox applications also must be properly configured. The MBOX Configuration application controls how the mailboxes behave and the Mailbox application controls what is placed in the mailboxes.

8.2 Mailbox configuration registers

The Mailbox application's registers are described in the following table. The registers' bit descriptions are given in "MBOX bit descriptions" on page 45.

Each response mailbox (MB4 to MB31) has two associated configuration registers: APP_ID register and Byte_ID register. When the Mailbox application runs, it copies the data at the Byte_ID from the specified APP_ID and puts that value in the associated mailbox.

Users can configure mailboxes 4 through 31. Mailboxes 20 through 31 have a special function in Legacy mode. They are updated automatically in the Legacy/Quick-Read mode.

Table 46. MBOX registers

Offset	0x00								0x01							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	APP_ID MBOX_4								Byte_ID MBOX_4							
Reset	0x00								0x00							
Offset	0x02								0x03							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	APP_ID MBOX_5								Byte_ID MBOX_5							
Reset	0x00								0x00							
Offset	0x04								0x05							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	APP_ID MBOX_6								Byte_ID MBOX_6							
Reset	0x00								0x00							

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Table 46. MBOX registers (Continued)

Offset	0x06								0x07							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	APP_ID MBOX_7								Byte_ID MBOX_7							
Reset	0x00								0x00							
Offset	0x08								0x09							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	APP_ID MBOX_8								Byte_ID MBOX_8							
Reset	0x00								0x00							
Offset	0x0A								0x0B							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	APP_ID MBOX_9								Byte_ID MBOX_9							
Reset	0x00								0x00							
Offset	0x0C								0x0D							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	APP_ID MBOX_10								Byte_ID MBOX_10							
Reset	0x00								0x00							
Offset	0x0E								0x0F							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	APP_ID MBOX_11								Byte_ID MBOX_11							
Reset	0x00								0x00							
Offset	0x10								0x11							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	APP_ID MBOX_12								Byte_ID MBOX_12							
Reset	0x00								0x00							
Offset	0x12								0x13							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	APP_ID MBOX_13								Byte_ID MBOX_13							
Reset	0x00								0x00							
Offset	0x14								0x15							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	APP_ID MBOX_14								Byte_ID MBOX_14							
Reset	0x00								0x00							

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Table 46. MBOX registers (Continued)

Offset	0x16								0x17							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	APP_ID MBOX_15								Byte_ID MBOX_15							
Reset	0x00								0x00							
Offset	0x18								0x19							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	APP_ID MBOX_16								Byte_ID MBOX_16							
Reset	0x00								0x00							
Offset	0x1A								0x1B							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	APP_ID MBOX_17								Byte_ID MBOX_17							
Reset	0x00								0x00							
Offset	0x1C								0x1D							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	APP_ID MBOX_18								Byte_ID MBOX_18							
Reset	0x00								0x00							
Offset	0x1E								0x1F							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	APP_ID MBOX_19								Byte_ID MBOX_19							
Reset	0x00								0x00							
Offset	0x20								0x21							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	APP_ID MBOX_20								Byte_ID MBOX_20							
Reset	0x11 (Defaults to Status Register application)								0x00 (Status application - MSB)							
Offset	0x22								0x23							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	APP_ID MBOX_21								Byte_ID MBOX_21							
Reset	0x11 (Defaults to Status Register application)								0x01 (Status application - LSB)							
Offset	0x24								0x25							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	APP_ID MBOX_22								Byte_ID MBOX_22							
Reset	0x10 (Defaults to Event Queue application)								0x03 (Event Queue Status)							

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Table 46. MBOX registers (Continued)

Offset	0x26								0x27							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	APP_ID MBOX_23								Byte_ID MBOX_23							
Reset	0x0F (Defaults to Data FIFO application)								0x03 (FIFO status)							
Offset	0x28								0x29							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	APP_ID MBOX_24								Byte_ID MBOX_24							
Reset	0x06 (Defaults to Analog Front End application)								0x28 (Analog Front End Frame Counter - MSB)							
Offset	0x2A								0x2B							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	APP_ID MBOX_25								Byte_ID MBOX_25							
Reset	0x06 (Defaults to Analog Front End application)								0x29 (Analog Front End Frame Counter - LSB)							
Offset	0x2C								0x2D							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	APP_ID MBOX_26								Byte_ID MBOX_26							
Reset	0x06 (Defaults to Analog Front End application)								0x00 Analog Front End Stage 0 - X MSB							
Offset	0x2E								0x2F							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	APP_ID MBOX_27								Byte_ID MBOX_27							
Reset	0x06 (Defaults to Analog Front End application)								0x01 (Analog Front End Stage 0 - X LSB)							
Offset	0x30								0x31							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	APP_ID MBOX_28								Byte_ID MBOX_28							
Reset	0x06 (Defaults to Analog Front End application)								0x02 (Analog Front End Stage 0 - Y MSB)							
Offset	0x32								0x33							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	APP_ID MBOX_29								Byte_ID MBOX_29							
Reset	0x04 (Analog Front End Stage 0 - Z MSB)								0x03 (Analog Front End Stage 0 - Y LSB)							
Offset	0x34								0x35							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	APP_ID MBOX_30								Byte_ID MBOX_30							
Reset	0x06 (Defaults to Analog Front End application)								0x04 (Analog Front End Stage 0 - Z MSB)							

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Table 46. MBOX registers (Continued)

Offset	0x36								0x37							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	APP_ID MBOX_31								Byte_ID MBOX_31							
Reset	0x06 (Defaults to Analog Front End application)								0x05 (Analog Front End Stage 0 - Z LSB)							

8.2.1 MBOX bit descriptions

Table 47. MBOX bit descriptions

Field	Description
7:0 APP_ID MBOX_*x*	Specifies the application to provide the output byte, using the application identifier. Units: None. Range of valid values: 1 to 31. Values outside this range or values for a nonexistent application may cause unexpected system behavior.
7:0 Byte_ID MBOX_*x*	Indicates the byte number of the application's status or output registers that are being sent to this mailbox. The most-significant byte for a specific application's output is identified as Byte 0 and the least-significant byte is Byte *x*. Units: Nondimensional. Range of valid values: 0 to 255.

8.2.2 Configuring XYZ data

The MBOX application aggregates application data and presents it in the mailboxes.

The AFE application (APP_ID 0x06) provides the XYZ accelerometer data with output registers 0 through 5 containing the FRONTEND_Stage_0 XYZ data. The following example shows what a host would send to the MMA9555L device to create the configuration to set up quick-read mailboxes 4–9 to contain the following, FRONTEND_Stage_0_XYZ data:

- Data X to mailboxes 4 and 5
- Data Y to mailboxes 6 and 7
- Data Z to mailboxes 8 and 9

Example 4.

```
MBOX0 = 0x04     /* Host communicating to MBOX Application */
MBOX1 = 0x20     /* CONFIG_W command */
MBOX2 = 0x00     /* Starting at Offset 0 which is the config for MB4 */
MBOX3 = 0x0C     /* Number of bytes to write 12 bytes */
MBOX4 = 0x06     /* APP_ID_MBOX4 0x06 - AFE APP_ID = 0x06 */
MBOX5 = 0x00     /* Byte_ID_MBOX4 Data - X MSB */
MBOX6 = 0x06     /* APP_ID_MBOX5 */
MBOX7 = 0x01     /* Byte_ID_MBOX5 Data - X LSB */
MBOX8 = 0x06     /* APP_ID_MBOX6 */
MBOX9 = 0x02     /* Byte_ID_MBOX6 Data - Y MSB */
MBOX10 = 0x06    /* APP_ID_MBOX7 */
MBOX11 = 0x03    /* Byte_ID_MBOX7 Data - Y LSB */
MBOX12 = 0x06    /* APP_ID_MBOX8 */
MBOX13 = 0x04    /* Byte_ID_MBOX8 Data - Z MSB */
MBOX14 = 0x06    /* APP_ID_MBOX9 */
MBOX15 = 0x05    /* Byte_ID_MBOX9 Data Z - LSB */
```


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8.3 Mailbox status registers

There are no status registers for this application.

8.4 Reading aggregated data (Legacy mode—Quick read)

Once the MBOX application is configured and the device is set to Legacy communication mode, the aggregated data can be read.

Assuming that the MBOX application was set up as shown in Section 8.2.2, “Configuring XYZ data”, the X, Y, and Z acceleration data output will be available in mailboxes 4 through 9, through the normal command/response Communications Interface.

If the host needs to just read the data without the finer control of the command/response model, the MMA9555L can be put into Legacy mode. This assigns the desired data to registers in the Quick-Read section of the Mailbox registers (MB20–MB31).

In Legacy mode, the lower mailbox registers continue to operate in the command/response mode and the upper registers operate in the Quick-Read mode. The data in the Quick-Read registers is automatically updated, so a read-request command is not required before reading the data form the upper mailboxes.

The following examples show how to wake up the device, configure it for quick-reading the low-passed-filtered XYZ data, enable the Legacy mode, and read the data.

The MMA9555L platform comes out of reset in the Low-Power or Sleep mode. In order to start the AFE application and start collecting samples, the MMA9555L must be brought out of Sleep mode and into Run mode

This example shows how to disable Sleep mode and enable Wake mode.

Example 5.

```
MBOX0 = 0x12 /* Host communicating to Sleep/Wake Application */
MBOX1 = 0x20 /* CONFIG_Write command */
MBOX2 = 0x06 /* Starting at Offset 0x6 */
MBOX3 = 0x01 /* Number of bytes to write 1 byte */
MBOX4 = 0x00 /* Write 0x00 which wakes up the device */
```

Bytes to Send: 0x12, 0x20, 0x06, 0x01, 0x00

The AFE application (APP_ID 0x06) provides the XYZ accelerometer data with output registers 0 through 5 containing the FRONTEND_Stage_0 XYZ data. By default, the Quick-Read registers (MB26–MB31) are assigned 0x00 Analog Front End Stage 0 - X MSB.

The AFE application, however, provides XYZ, low-pass-filtered data in registers 0x18 through 0x1D (FRONTEND_488_100_LPF). To quickly read this data, the Quick-Read mailbox registers would have to be configured so that they are populated with the low-passed-filtered, XYZ data.

The following example shows how a host would direct the MMA9555L device to set up quick-read mailboxes to contain the following, FRONTEND_488_100_LPG XYZ data:

- Data X to mailboxes 26 and 27
- Data Y to mailboxes 28 and 29
- Data Z to mailboxes 30 and 31

Example 6.

```
MBOX0 = 0x04 /* Host communicating to MBOX Application */
MBOX1 = 0x20 /* CONFIG_W command */
MBOX2 = 0x2C /* Starting at Offset 0x2C, the configuration starting point for MB26 */
MBOX3 = 0x0C /* Number of bytes to write 12 bytes */
MBOX4 = 0x06 /* APP_ID_MBOX26 = 0x06 - AFE APP_ID = 0x06 */
MBOX5 = 0x18 /* Byte_ID_MBOX26 = 0x18 - LPF Data starts at register 0x18 - X MSB */
MBOX6 = 0x06 /* APP_ID_MBOX27 */
MBOX7 = 0x19 /* Byte_ID_MBOX27 Data - X LSB */
MBOX8 = 0x06 /* APP_ID_MBOX28 */
MBOX9 = 0x1A /* Byte_ID_MBOX28 Data - Y MSB */
MBOX10 = 0x06 /* APP_ID_MBOX29 */
```


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```
MBOX11 = 0x1B /* Byte_ID_MBOX29 Data - Y LSB */
MBOX12 = 0x06 /* APP_ID_MBOX30 */
MBOX13 = 0x1C /* Byte_ID_MBOX30 Data - Z MSB */
MBOX14 = 0x06 /* APP_ID_MBOX31 */
MBOX15 = 0x1D /* Byte_ID_MBOX31 Data Z - LSB */
```

Bytes to send: 0x04, 0x20, 0x2C, 0x0C, 0x06, 0x18, 0x06, 0x19, 0x06, 0x1A, 0x06, 0x1B, 0x06, 0x1C, 0x06, 0x1D.

The host then must configure the Mailbox application to operate in Legacy mode, as shown in the following example.

Example 7.

1. MB0 = 0x18.
   Sets the “APP_ID: Mailbox Mode Config” application identifier (0x18).
2. MB1 = 0x20.
   Sets the “Command: Write Config” (0x20).
3. MB2 = 0x00.
   Sets the Offset to Zero field (0x00) to point to the configuration register.
4. MB3 = 0x01.
   Sets the Count field to 0x01 because only one data byte needs to be sent.
5. MB4 = 0x10.
   Sets the DATA value to 0x10, which sets the LEGACY field to 1b or Legacy mode.

Bytes to send: 0x18, 0x20, 0x00, 0x01, 0x10.

The MMA9555L platform now is set to Legacy mode and the Quick-Read registers are being constantly updated with the low-pass-filtered, AFE data.

All that remains is the issuing of a command to read the six bytes starting at MB26, which contains the XYZ data in constant-read mode.

In the following example, “0x__ ” represents the data that is sent back to the host.

Example 8.

```
MBOX0 = 0x04 /* Host communicating to MBOX Application */
MBOX1 = 0x30 /* Read Output Data command */
MBOX2 = 0x1A /* Starting at Offset 0x1A, the hexadecimal offset for mailbox 26 */
MBOX3 = 0x06 /* Number of bytes to read 6 bytes two bytes each for X, Y, andZ*/
MBOX4 = 0x__ /* MSB  - X */
MBOX5 = 0x__ /* LSB - X */
MBOX6 = 0x__ /* MSB - Y */
MBOX7 = 0x__ /* LSB - Y */
MBOX8 = 0x__ /* MSB - Z */
MBOX9 = 0x__ /* LSB - Z*/
```

Bytes to send: 0x04, 0x30, 0x1A, 0x06, 0x__ , 0x__ , 0x__ , 0x__ , 0x__ , 0x__ .

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9 Analog Front End Application

9.1 Overview of Analog Front End application

Application ID	0x06
Default speed	30 Hz.
Configuration registers	Start on page 52.
Status registers	Start on page 56.

The Analog Front End application (AFE) samples raw accelerometer data from the analog-to-digital converter (ADC) at the execution rate of the application, applies factory and user trim-correction terms, and filters data to several configurable bandwidths.

For the proper operation of the Pedometer, it is recommended that any change to any of the configuration registers of the AFE Application be avoided unless the outcome is well understood.

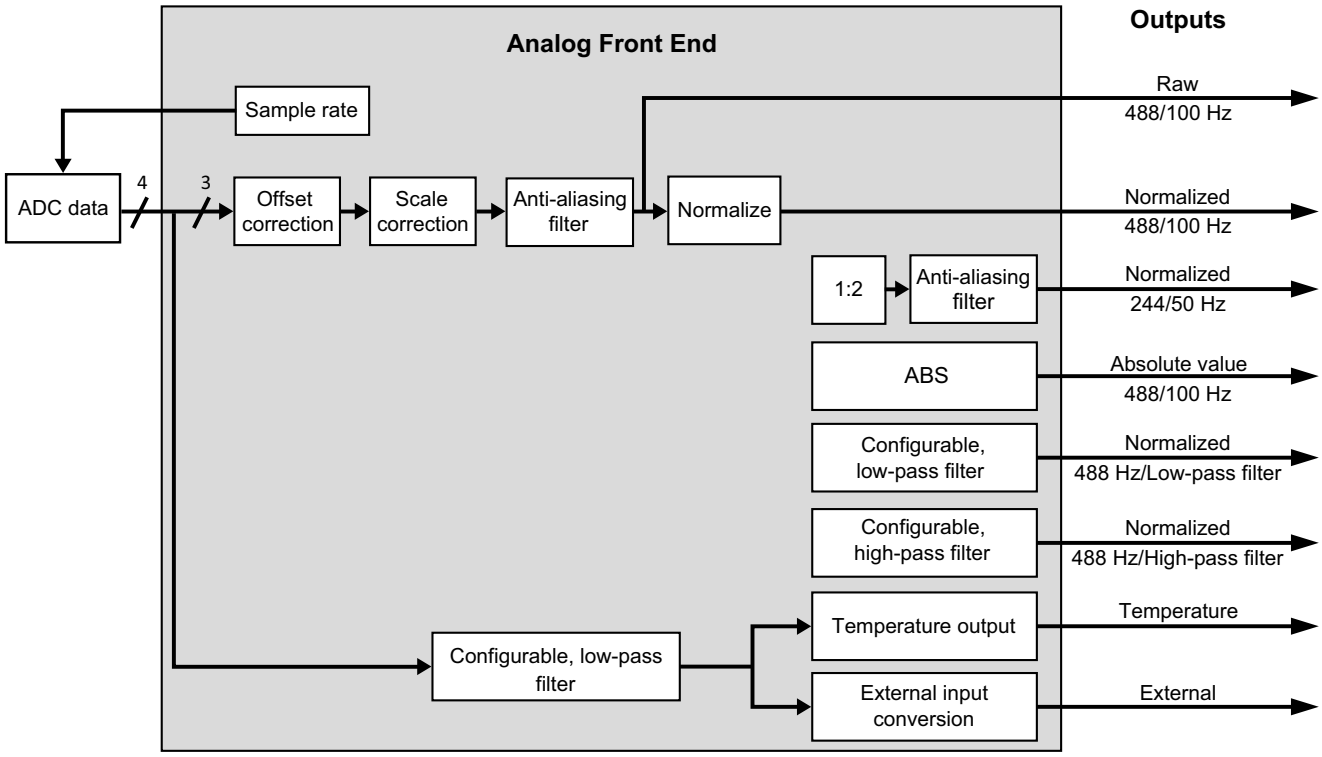

Figure 13. Front-end signal processing

9.1.1 Sample rate

The rate at which the ADC samples the accelerometer data is defined by the sfd_rate register, which is offset 0x0C in the configuration registers of this application. The sample rate can be changed from 488 Hz to 3.81 Hz by setting the appropriate value in the sfd_rate register. For more details, see Table 59 and Table 60 on page 55.

NOTE

Although the sample rate can be changed in the hardware, it is recommended that the 30 Hz sample rate not be changed, because the Pedometer application requires 30 Hz and the MMA9555L runs at 30 Hz after MMA9555L startup.

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9.1.2 Offset and scale correction

The AFE's offset and scale correction stages of the signal chain applies trim offset and scaling correction factors which were measured at factory calibration and stored inside each device. Since user offsets are defined at 8-*g* resolution, those offsets are shifted according to the *g* mode.

User offsets are used to calibrate and compensate for the physical mounting of the part inside the final product. After board mount and assembly, the final test process may include a test to fine tune and compensate the accelerometer orientation.

9.1.3 Anti-aliasing filter

After trim correction, the front end uses a sixth-order Chebyshev filter, running up to 488 Hz, to limit the signal bandwidth to 100 Hz.

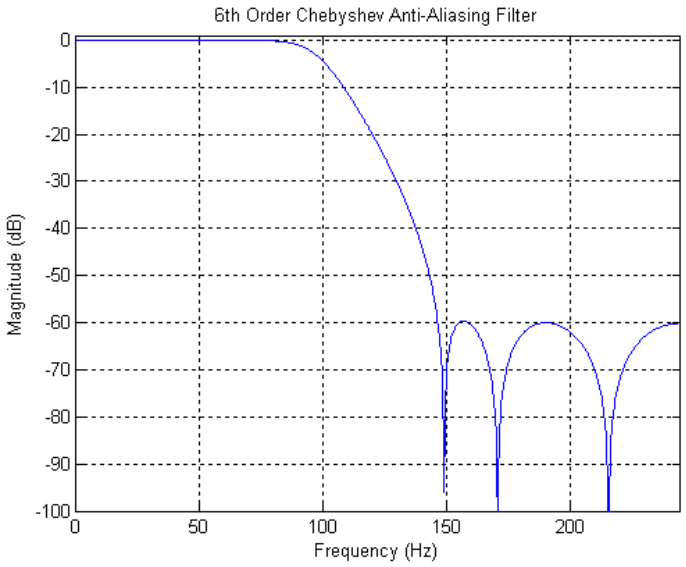

Figure 14. Frequency response of Analog Front End anti-aliasing filter

The bandwidth of the anti-aliasing filter depends on the sample rate at which the front end application is running. The following table shows the variation of the filter bandwidth according to the sample rate.

Table 48. Anti-aliasing filter bandwidth for different sample rates

Sample rate	Stage-0 anti-aliasing Filter	Stage-1 anti-aliasing Filter
	Bandwidth (Hz)	Bandwidth (Hz)
488.28	100	50
244.17	50	25
122.07	25	12.5
61.04	12.5	6.25
31.52	6.25	3.125
15.26	3.125	1.562
7.63	1.562	0.781
3.81	0.781	0.390

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9.1.4 Raw data

The output of the sensor is a 16-bit, signed value. The sensor always uses all the bits for high accuracy. Depending on the range setting (2-, 4-, or 8-*g* mode), the output value per *g* changes.

The following table shows the full scale value at the different *g* ranges, as well as the value of a measured 1-*g* acceleration at the different *g* ranges.

Table 49.Raw accelerometer output, according to g mode

Range	Full scale	One-*g* acceleration
± 2 *g*	± 32 K	16 K
± 4 *g*	± 32 K	8 K
± 8 *g*	± 32 K	4 K

9.1.5 Normalization

The filtered data is shifted according to the g mode to normalize the resolution to the 8-*g* range. The normalized data allows for common handling of the data in the other applications. Data is normalized so that 1-*g* force acceleration shows output of 0x1000 counts or 4096 decimal counts.

9.1.6 Down-sampling and stage-1, anti-aliasing filter

The output of the normalizer is down-sampled by two to generate data sampled at half of the original sample rate. At 488 Hz, the previous, sixth-order Chebyshev filter is applied to down-sampled (244 Hz) data, to create a 50-Hz bandwidth data stream.

Table 60 on page 55 provides more details about the varying of the bandwidth, depending of the sample rate of the front-end application.

9.1.7 Absolute value

The absolute value of the sensor output is computed.

9.1.8 Configurable, low-pass and high-pass filters

First-order, low-pass and high-pass filters—with separate configurable cutoff frequencies at –3 dB—are provided.

$$H_{LPF}(z) = \frac{2^{-K}}{1 + (2^{-K} - 1)z^{-1}} \quad \textit{Eqn. 1}$$

$$H_{HPF}(z) = \frac{1 - z^{-1}}{1 + (2^{-K} - 1)z^{-1}} \quad \textit{Eqn. 2}$$

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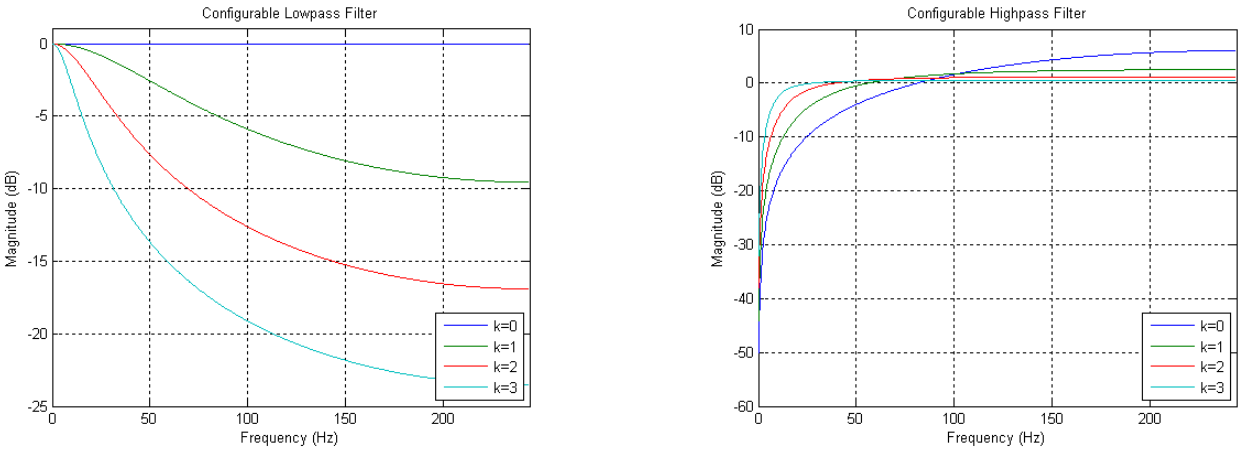

Figure 15. Frequency response of configurable, high- and low-pass filters

The two following tables contain the cutoff frequency of the filters, varying with the value of K and the sample rate at which the front-end application is executed.

Table 50. Cut-off frequency as a function of K and the sample rate for low-pass filter

K	LPF cut-off frequency (Hz)							
	Sample rate = 488.28	Sample rate = 244.14	Sample rate = 122.07	Sample rate = 61.04	Sample rate = 30.52	Sample rate = 15.26	Sample rate = 7.63	Sample rate = 3.81
1	56.13	28.07	14.03	7.02	3.51	1.75	0.88	0.4385
2	22.50	11.25	5.62	2.81	1.40	0.70	0.3516	0.1758
3	10.39	5.19	2.60	1.30	0.65	0.32	0.1623	0.0811
4	5.014	2.51	1.25	0.63	0.31	0.16	0.0783	0.0392
5	2.47	1.23	0.62	0.31	0.15	0.08	0.0385	0.0193
6	1.22	0.6116	0.31	0.15	0.08	0.04	0.0191	0.0096
7	0.61	0.30	0.15	0.08	0.04	0.02	0.0095	0.0048
8	0.30	0.15	0.08	0.04	0.02	0.01	0.0048	0.0024
9	0.15	0.076	0.04	0.02	0.01	0.0047	0.0024	0.0012
10	0.0759	0.038	0.019	0.0095	0.0047	0.0024	0.0012	0.0006
11	0.0379	0.019	0.0095	0.0047	0.0024	0.0012	0.0006	0.0003
12	0.019	0.0095	0.0048	0.0024	0.0012	0.0006	0.0003	0.0001
13	0.0095	0.0048	0.0024	0.0012	0.0006	0.0003	0.0001	0.00007
14	0.0047	0.0024	0.0012	0.0006	0.0003	0.0001	0.0007	0.00004
15	0.0024	0.0012	0.0006	0.0003	0.0002	0.00008	0.00004	0.00002

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Table 51. Cut-off frequency as a function of K and the sample rate for high-pass filter

K	HPF cut-off frequency (Hz)							
	Sample rate = 488.28	Sample rate = 244.14	Sample rate = 122.07	Sample rate = 61.04	Sample rate = 30.52	Sample rate = 15.26	Sample rate = 7.63	Sample rate = 3.81
1	31.932	15.966	7.9831	3.9915	1.9958	0.9979	0.4989	0.2495
2	17.405	8.7023	4.3511	2.1756	1.0878	0.5439	0.2719	0.136
3	9.1573	4.5787	2.2893	1.1447	0.5723	0.2862	0.1431	0.0715
4	4.7092	2.3546	1.1773	0.5887	0.2943	0.1472	0.0736	0.0368
5	2.3912	1.1956	0.5978	0.2989	0.1495	0.0747	0.0374	0.0187
6	1.2054	0.6027	0.3014	0.1507	0.0753	0.0377	0.0188	0.0094
7	0.6051	0.3026	0.1513	0.0756	0.0378	0.0189	0.0095	0.0047
8	0.3026	0.1513	0.0757	0.0378	0.0189	0.0095	0.0047	0.0024
9	0.1513	0.0757	0.0378	0.0189	0.0095	0.0047	0.0024	0.0012
10	0.0756	0.0378	0.0189	0.0095	0.0047	0.0024	0.0012	0.0006
11	0.039	0.0195	0.0098	0.0049	0.0024	0.0012	0.0006	0.0003
12	0.0195	0.0098	0.0049	0.0024	0.0012	0.0006	0.0003	0.0002
13	0.0098	0.0049	0.0025	0.0012	0.0006	0.0003	0.0002	8E–05
14	0.0049	0.0025	0.0012	0.0006	0.0003	0.0002	8E–05	4E–05
15	0.0024	0.0012	0.0006	0.0003	0.0002	8E–05	4E–05	2E–05

9.2 AFE configuration registers

9.2.1 afe_csr

Table 52. afe_csr registers

Offset	0x00(MSB)								0x01(LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	FS		Ext ADC	Temp	CM		Reserved		Reserved							
Reset	0x00		0	0	0x00		0x00		0x00							

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Table 53. afe_csr bit descriptions

Field	Description
7:6 FS	Full-scale selection. AFE_CSR[FS] and AFE_BIAS[SC_AAF_EN] are combined to control AFE gain and trim mode. Units: None. Range of values: Full-scale data range / XYZ acceleration scaling (mg/LSB) 00: ±8 g 0.244 01: ±2 g 0.061 10: ±4 g 0.122 11: ±8 g 0.244
5 Ext ADC	Specifies whether an external input will or will not be measured during the next analog acquisition phase. **Note:** The ExtADC and Temp bits must not be set at the same time. Units: None. • 0: No external input is measured during the next analog acquisition phase. • 1: Enables the four AFE channels to measure the external analog input during the next analog acquisition phase.
4 Temp	Specifies whether the temperature sensor output will or will not be measured during the next analog acquisition phase. **Note:** The ExtADC and Temp bits must not be set at the same time. Units: None. Temperature will change slowly so it can be measured with a very low sample rate (1 Hz or less) by occasionally replacing an external ADC measurement with the Temperature ADC measurement. Range of valid values: For valid values for FS and CM parameters, see the *Intelligent, Motion-Sensing Platform Hardware Reference Manual* (MMA955xLHWRM), listed in "Related Documentation" on page 2 Accelerometer Reference Manual (MMA955xLRM). • 0: No temperature sensor output will be measured during the next analog acquisition phase. • 1: The temperature sensor output will be measured during the next analog acquisition phase.
3:2 CM	Conversion Mode. Controls the ADC resolution/accuracy versus power and conversion time trade-offs. Units: None • 00: Conversion complete in 32 cycles • 01: Conversion complete in 16 cycle • 10: Conversion complete in eight cycles • 11: Conversion complete in four cycles
Reserved	Bit field reserved.

9.2.2 user_offset [XYZ]

Often, during the mounting process, the accelerometer sensor is not mounted perfectly flat to the board and might also be rotated slightly. This register enables a user to make an after-manufacturing calibration correction.

Table 54. user_offset [XYZ] registers

Offset	0x02(MSB)								0x03(LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	user_offset[X]								user_offset[X][							
Reset	0xFF								0xFF							
Offset	0x04(MSB)								0x05(LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	user_offset[Y]								user_offset[Y]							

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Table 54. user_offset [XYZ] registers (Continued)

Reset	0xFF								0xFF							
Offset	0x06(MSB)								0x07(LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	user_offset[Z]								user_offset[Z]							
Reset	0xFF								0xFF							

Table 55. user_offset [XYZ] bit descriptions

Field	Description
7:0 user_offset[XYZ]	Sets user offsets in the X, Y, and Z axes for the accelerometer, depending on the position on the device in the user board. These values are considered as post-mount offsets. Units: 0.244 mg/LSB. Range of valid values: –32,768 to 32,767. Reset value: 0xFF which is interpreted as –1.

9.2.3 config_k

This register's bits are shown in the following table.

Table 56. config_k registers

Offset	0x08								0x09							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	config_k[HIGHPASS]								config_k[LOWPASS]							
Reset	0x00								0x00							
Offset	0x0A								0x0B							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	config_k[TEMP_LPF]								config_k[EIC_LPF]							
Reset	0x00								0x00							

Table 57. config_k bit descriptions

Field	Description
7:0 config_k[HIGHPASS]	High-pass filter configurable cutoff. Units: None. Range of valid values: 0 to 15.
7:0 config_k[LOWPASS]	Low-pass filter configurable cutoff. Units: None. Range of valid values: 0 to 15.

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Table 57. config_k bit descriptions

Field	Description
7:0 config_k[TEMP_LPF]	Low-pass filter, configurable cutoff for temperature sensor output. Units: None. Range of valid values: 0 to 15.
7:0 config_k[EIC_LPF]	Low-pass filter, configurable cutoff for external input conversion output. Units: None. Range of valid values: 0 to 15.

9.2.4 sfd_rate

This register's bits are shown in the following table. The system defaults to 30 Hz; therefore, this document assumes that 30 Hz is the rate being run. If the user slows down the rate by changing the sfd_rate register, all references to the system frame rate scale accordingly.

Table 58. sfd_rate register

Offset	0x0C							
Bit	7	6	5	4	3	2	1	0
Field	sfd_rate							
Reset	0	0	0	0	0	1	1	1

Table 59. sfd_rate bit description

Field	Description
7:0 sfd_rate	Defines the system frame interval, the time period for each sample or the system sample rate in Hz. Units: None. Range of valid values: 7 to 14. Table 60 shows the relation between the register value and the interval between each frame.

Table 60. Frame interval, according to the sfd_rate value

sfd_rate value	Time frame (s)	Max frames per second
7	2.05E–3	488.28
8	4.10E–3	244.17
9	8.19E–3	122.07
10	1.64E–2	61.04
11	3.28E–2	30.52
12	6.55E–2	15.26
13	1.31E–1	7.63
14	2.62E–1	3.81

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9.3 AFE status registers

9.3.1 output[FRONTEND_Stage_0][XYZ]

These registers' bits are shown in the following table.

Table 61. output[FRONTEND_Stage_0][XYZ] registers

Offset	0x00(MSB)								0x01(LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	output[FRONTEND_Stage_0][X]								output[FRONTEND_Stage_0][X]							
Reset	0x00								0x00							
Offset	0x02(MSB)								0x03(LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	output[FRONTEND_Stage_0][Y]								output[FRONTEND_Stage_0][Y]							
Reset	0x00								0x00							
Offset	0x04(MSB)								0x05(LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	output[FRONTEND_Stage_0][Z]								output[FRONTEND_Stage_0][Z]							
Reset	0x00								0x00							

Table 62. output[FRONTEND_Stage_0][XYZ] bit description

Field	Description
7:0 output[FRONTEND_Stage_0][XYZ]	Normalized accelerometer data sampled at the default rate with complete bandwidth. Units: 0.244 m*g*/LSB. Range of valid values: –32,768 to 32,767.

9.3.2 output[FRONTEND_Stage_1][XYZ]

These registers' bits are shown in the following table.

Table 63. output[FRONTEND_Stage_1][XYZ] registers

Offset	0x06(MSB)								0x07(LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	output[FRONTEND_Stage_1][X]								output[FRONTEND_Stage_1][X]							
Reset	0x00								0x00							
Offset	0x08(MSB)								0x09(LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	output[FRONTEND_Stage_1][Y]								output[FRONTEND_Stage_1][Y]							
Reset	0x00								0x00							

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Table 63. output[FRONTEND_Stage_1][XYZ] registers (Continued)

Offset	0x0A(MSB)								0x0B(LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	output[FRONTEND_Stage_1][Z]								output[FRONTEND_Stage_1][Z]							
Reset	0x00								0x00							

Table 64. output[FRONTEND_Stage_1][XYZ] bit description

Field	Description
7:0 output[FRONTEND_Stage_1][XYZ]	Normalized accelerometer data sampled at the default rate of half bandwidth. Units: 0.244 m*g*/LSB. Range of valid values: –32,768 to 32,767.

9.3.3 output[FRONTEND_Stage_0_ABS][XYZ]

These registers' bits are shown in the following table.

Table 65. output[FRONTEND_Stage_0_ABS][XYZ] registers

Offset	0x0C(MSB)								0x0D(LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	output[FRONTEND_Stage_0_ABS][X]								output[FRONTEND_Stage_0_ABS][X]							
Reset	0x00								0x00							
Offset	0x0E(MSB)								0x0F(LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	output[FRONTEND_Stage_0_ABS][Y]								output[FRONTEND_Stage_0_ABS][Y]							
Reset	0x00								0x00							
Offset	0x10(MSB)								0x11(LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	output[FRONTEND_Stage_0_ABS][Z]								output[FRONTEND_Stage_0_ABS][Z]							
Reset	0x00								0x00							

Table 66. output[FRONTEND_Stage_0_ABS][XYZ] bit description

Field	Description
7:0 output[FRONTEND_Stage_0_ABS][XYZ]	Absolute value normalized accelerometer data sampled at the default rate of complete bandwidth. Units: 0.244 m*g*/LSB. Range of valid values: 0 to 32,767.

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9.3.4 output[FRONTEND_Stage_0_GM][XYZ]

These registers' bits are shown in the following table.

Table 67. output[FRONTEND_Stage_0_GM][XYZ] registers

Offset	0x12(MSB)								0x13(LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	output[FRONTEND_Stage_0_GM][X]								output[FRONTEND_Stage_0_GM][X]							
Reset	0x00								0x00							
Offset	0x14(MSB)								0x15(LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	output[FRONTEND_Stage_0_GM][Y]								output[FRONTEND_Stage_0_GM][Y]							
Reset	0x00								0x00							
Offset	0x16(MSB)								0x17(LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	output[FRONTEND_Stage_0_GM][Z]								output[FRONTEND_Stage_0_GM][Z]							
Reset	0x00								0x00							

Table 68. output[FRONTEND_Stage_0_GM][XYZ] bit description

Field	Description
7:0 output[FRONTEND_Stage_0_GM][XYZ]	Raw accelerometer data sampled at the default rate with complete bandwidth. The resolution depends on the *g*-mode setting configured by afe_csr[fs]. Units: • ±2 *g* mode: 0.061 mg/LSB • ±4 *g* mode: –0.122 mg/LSB • ±8 *g* mode: 0.244 mg/LSB Range of valid values: • ±2 *g* mode: 0.061 mg/LSB = –32768 to 32767 • ±4 *g* mode: 0.122 mg/LSB = –8192 to 8192 • ±8 *g* mode: 0.244 mg/LSB = –4096 to 4096

9.3.5 output[FRONTEND_Stage_0_LPF][XYZ]

These registers' bits are shown in the following table.

Table 69. output[FRONTEND_Stage_0_LPF][XYZ] registers

Offset	0x18(MSB)								0x19(LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	output[FRONTEND_Stage_0_LPF][X]								output[FRONTEND_Stage_0_LPF][X]							
Reset	0x00								0x00							
Offset	0x1A(MSB)								0x1B(LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	output[FRONTEND_Stage_0_LPF][Y]								output[FRONTEND_Stage_0_LPF][Y]							
Reset	0x00								0x00							

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Table 69. output[FRONTEND_Stage_0_LPF][XYZ] registers (Continued)

Offset	0x1C(MSB)								0x1D(LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	output[FRONTEND_Stage_0_LPF][Z]								output[FRONTEND_Stage_0_LPF][Z]							
Reset	0x00								0x00							

Table 70. output[FRONTEND_Stage_0_LPF][XYZ] bit description

Field	Description
7:0 output[FRONTEND_Stage_0_LPF][XYZ]	Normalized accelerometer data sampled at the default rate, with configurable, low-pass filter cutoff. Units: 0.244 m*g*/LSB. Range of valid values: –32,768 to 32,767.

9.3.6 output[FRONTEND_Stage_0_HPF][XYZ]

These registers' bits are shown in the following table.

Table 71. output[FRONTEND_Stage_0_HPF][XYZ] registers

Offset	0x1E(MSB)								0x1F(LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	output[FRONTEND_Stage_0_HPF][X]								output[FRONTEND_Stage_0_HPF][X]							
Reset	0x00								0x00							
Offset	0x20(MSB)								0x21LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	output[FRONTEND_Stage_0_HPF][Y]								output[FRONTEND_Stage_0_HPF][Y]							
Reset	0x00								0x00							
Offset	0x22(MSB)								0x23(LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	output[FRONTEND_Stage_0_HPF][Z]								output[FRONTEND_Stage_0_HPF][Z]							
Reset	0x00								0x00							

Table 72. output[FRONTEND_Stage_0_HPF][XYZ] bit description

Field	Description
7:0 output[FRONTEND_Stage_0_HPF][XYZ]	Normalized accelerometer data sampled at the default rate, with configurable, high-pass filter cutoff. Units: 0.244 m*g*/LSB. Range of valid values: –32,768 to 32,767.

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9.3.7 output_temp

This register's bits are shown in the following table.

Table 73. output_temp registers

Offset	0x24(MSB)								0x25(LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	output_temp								output_temp							
Reset	0x00								0x00							

Table 74. output_temp bit description

Field	Description
7:0 output_temp	Temperature sensor output measurement. Units: ADC counts. output_temp(in count) = –51.4T + 1146, where T is temperature in °C Note that this is only a typical characteristic example. User shall perform minimal calibration to adjust at least the offset. Range of valid values: –32,768 to 32,767.

9.3.8 output_EIC

This register's bits are shown in the following table.

Table 75. output_EIC registers

Offset	0x26(MSB)								0x27(LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	output_EIC								output_EIC							
Reset	0x00								0x00							

Table 76. output_EIC bit description

Field	Description
7:0 output_EIC	Output of the external, analog-input conversion value. Units: ADC counts. output_EIC(in count) = 29570 (AN0–AN1) – 122, where AN0–AN1 is in V. Note that this equation is only a typical example, with ADC conversion in 16-bit mode. Range of valid values: –32,768 to 32,767.

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9.3.9 frame_counter

This register's bits are shown in the following table.

Table 77. frame_counter registers

Offset	0x28(MSB)								0x29(LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	frame_counter								frame_counter							
Reset	0x00								0x00							

Table 78. output_EIC bit description

Field	Description
7:0 frame_counter	Provides the number of frames processed at the configured sample rate. It is not a real-time representation because the time that the device remains in the stop mode is not taken into account. The frame counter will restart at zero when it reaches 65,535. Units: Nondimensional. Range of valid values: 0 to 65,535.

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10 Data FIFO Application

10.1 Overview of Data FIFO application

Application ID	0x0F
Default speed	30 Hz.
Configuration registers	Start on page 67.
Status registers	Start on page 69.

The Data FIFO (First In First Out) application is a buffer intended to store the output data from an application. Every scheduler interval, the Data FIFO application gathers the output data from an application and stores it until the host processor reads the data.

The FIFO application uses the mailboxes differently than other applications—operating in the streaming mode. In streaming mode, the host continues reading data until a maximum of up to 255 bytes is read per host request. The host must read all the data that it requested.

The FIFO can be connected to one application and can collect packets of data in different sizes (one, two, four, or six bytes).

The Data FIFO has two different modes of operation: Stop on Overflow and Free Run.

The application's status register displays current status values such as overflow condition, watermark reached, and buffer empty. These conditions have a flag that is asserted individually each time one of these conditions occurs.

The user can configure the FIFO buffer size by writing to the fifo_size word within the configuration registers. The buffer size can be configured only once and is limited by the amount of RAM available. The amount of available RAM can be impacted by the Event Queue Application which also can be configured to use large amounts of RAM.

NOTE

Before configuring the Data FIFO application, it is recommended that the Data FIFO Application be suspended. After the parameter is configured, remove the application from suspend. A suspend is done with the Reset/Suspend/Clear Application (APP_ID 0x17).

10.2 Modes of operation

This section examines the modes of operation of the FIFO buffer.

10.2.1 Stop-on-overflow

The FIFO stores data from an application, every single frame (a scheduler interval), as long as the FIFO is enabled. In this mode, the FIFO stores data until an overflow condition is reached. At an overflow condition, the overflow flag is set.

The host asynchronously reads payload packets from the Data FIFO application. Reading payload packets frees up slots for new entries into the FIFO. If the host reads data faster than the applications put data into the FIFO, the overflow condition will never happen.

The overflow condition occurs when the available buffer memory is full and there is no space available for another packet.

10.2.2 Free-run

The FIFO behaves as a circular buffer that stores data from the configured channel, every single frame, as long as the FIFO is enabled. In this mode, the FIFO never stops storing data, even though the overflow condition is reached and the overflow flag is set.

When the FIFO becomes full, the oldest data in the buffer will be overwritten first.

10.3 Reading process

To read the data FIFO, the host sends a read-data command to the MMA9555L device that calls the Data FIFO application, stores the requested data within the FIFO into a buffer, and returns the number of bytes read. The data FIFO does not tag each entry with a timestamp, only storing a timestamp for the last entry.

When the reading process is performed, the Data FIFO application calculates the timestamp for the first group of requested data and appends the timestamp to the data. If the host requests *N* bytes and that is bigger than the entry size, the pop routine will

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append the timestamp only for the first entry that fits in the *N* bytes requested. The host must calculate the timestamps for the extra entries requested within the *N* bytes.

The host can request to read up to 255 bytes at a time. Assuming the AFE is providing data, this is exactly 36 packets of AFE data.

Each host, FIFO-read transaction includes a status byte and a timestamp word. These three bytes are prefixed to the payload data.

Payload data is prefixed with the APP_ID of the application that has provided the data. In the AFE case, the APP_ID is 0x06.

(255 – 3 (status and timestamp)) / 7 (APP_ID + 6 byte XYZ data) = 36

Reading the FIFO example

The device powers up in Sleep mode, but it may become necessary to wake the MMA9555L device.

Waking the device uses the following mailboxes:

MB0: 0x12, App_ID = 0x12; Power Controller modes

MB1: 0x20, Command 0x20 = Write configuration; Offset = 0

MB2: 0x06, Offset = 0x06

MB3: 0x01, Count of data to write

MB4: 0x00, Actual Data Value; Clears sleep bit

Bytes to Send: 0x12, 0x20, 0x06, 0x01, 0x00.

Example 9.

To configure for FIFO operation, write the following transaction to the Data-FIFO application:

1. MB0: Set APP_ID to (0x0F).
   Selects the Data-FIFO application.
2. MB1: Command to (0x20).
   Command is a Write Configuration space.
3. MB2: Set offset to zero (0x00).
   Start writing configuration values at register 0.
4. MB3: Set count field to (0x0A).
   Sends nine bytes.
5. MB4: Send Data (0x0C).
   Sends six bytes, free-run mode.
6. MB5: Send Data (0x00).
7. MB6: Send Data (0x00).
8. MB7: Send Data (0x00).
9. MB8: Send Data (0x00).
10. MB6: Send Data (0x3C).
    Reserves 60 bytes—10 packets of six bytes each.
11. MB7: Send Data (0x06).
    Associates APP ID = AFE – .
12. MB5: Send Data (0x00).
13. MB6: Send Data (0x00).
14. MB7: Send Data (0x00).

Bytes to Send: 0x0F, 0x20, 0x00, 0x0A, 0x0C, 0x00, 0x00, 0x00, 0x00, 0x3C, 0x06, 0x00, 0x00, 0x00.

The configuration registers can only be written once. To reconfigure the FIFO, the device first must be reset.

Read the FIFO applications status register to get the data.

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Send the following command to set up for reading the status register.

Example 10.

1. MB0: Set APP_ID to (0x0F).
   Selects the Data-FIFO application.
2. MB1: Command to (0x30).
   Sends a Read Status space command.
3. MB2: Set offset to zero (0x03).
   Starts reading the configuration values from register 0x03.
4. MB3: Set count field to (0x0A).
   Reads 10 bytes (three status bytes, one APP_ID, and six bytes of data).

Bytes to Send: 0x0F, 0x30, 0x03, 0x0A.

This results in the following response.

0F 80 0A 0A 05 83 13 06 00 81 FF EA 11 0C

The last six bytes are the AFE data: X, Y, and Z.

This response was with the device flat, in the Face-Up orientation. The X and Y data are close to 0x0000, or 0 *g,* and the Z data is close to 0x1000, or 1 *g*.

MB0: APP_ID = 0x0F; FIFO application

MB1: STATUS = 0x80; Command Complete, no errors

MB2: RequestedData count = 0x0A; 10 bytes of data

MB3: Actual Data Count = 0x0A; 10 bytes of data

MB4: 0x05 = FIFO Status; Watermark and Overflow flag is set

MB5–MB6: = 0x8313; Timestamp

MB7: APP ID of the application providing the actual data = 0x06; AFE application

MB8–MB9: AFE X data; 0x0081

MB10–MB11: AFE Y data; 0xFFEA

MB12–MB13: AFE Z Data; 0x110C

The read size for one (1+6 byte) payload is 10 bytes. The size for two payloads is 17 bytes, 3 = 24 bytes.

Reading three payloads

Send the following command to set up for reading the status register.

Example 11.

1. MB0: Set APP_ID to (0x0F).
   Selects the Low-g application.
2. MB1: Command to (0x30)
   Sends a Write Configuration space command.
3. MB2: Set offset to zero (0x03).
   Starts writing configuration values at register 0.
4. MB3: Set count field to (0x18)
   Reads 24 bytes (3 status byes + 3x(APP_ID+6 data)).

Bytes to Send: 0x0F, 0x30, 0x03, 0x18.

The response is below:

0F 80 18 18 05 33 53 06 00 93 00 7F 11 06 06 00 A2 00 7D 11 08 06 00 9C 00 79 11 07

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The last six bytes are the AFE data, X, Y, and Z.

This response was with the device flat, in the Face-Up orientation. The X and Y data are close to 0x0000—or 0-g—and the Z data is close to 0x1000—or 1-g.

MB0: APP_ID = 0x0F; FIFO application

MB1: STATUS = 0x80; Command Complete, no errors

MB2: Requested data count = 0x18; 24 bytes of data

MB3: Actual Data Count = 0x18; 24 bytes of data

MB4: 0x05 = FIFO Status; Watermark and Overflow flag is set

MB5-6: = 0x3353; Timestamp

MB7: APP ID of the application providing the actual data = 0x06; The AFE application

MB8-9: AFE X data; 0x0093

MB10-11: AFE Y data; 0x007F

MB12-13: AFE Z Data; 0x1106

MB14: APP ID of the application providing the actual data = 0x06; the AFE application

MB15-16: AFE X data; 0x00A1

MB17-18: AFE Y data; 0x007D

MB19-20: AFE Z Data; 0x1108

MB21: APP ID of the application providing the actual data = 0x06; the AFE application

MB22-23: AFE X data; 0x009C

MB24-25: AFE Y data; 0x0079

MB26-27: AFE Z Data; 0x1107

To read data stored by the data FIFO application, the host must send a Read Data command along with a specific offset value.

This process has three conditions:

- The offset must be fixed to three
- The number of bytes to read must be larger than one and a multiple of the entry size
- The host must add three bytes to de-count the total bytes to read

Failure to adhere to the three conditions above could cause the data FIFO to enter into an error state and be unable to pop coherent data. To recover the data FIFO, reset the flag in the Reset_control byte (APP_ID 0x17).

When the command is sent, the first four bytes that the MMA9555L device returns correspond to the response of the command. The next byte gives the status of the data FIFO application module and the following two bytes represent the timestamp; thus the three-byte offset.

These bytes are part of those requested by the host, so it is very important that the user add three bytes to the number of bytes to read. The data stored in the data FIFO comes after these seven bytes.

If the module is storing data at the exact moment that a read is issued by the host, the MMA9555L device will return an error condition (A2). When this occurs, the host must retry reading the data. If any other error is returned, the host must take the proper action.

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10.4 Data FIFO block diagram

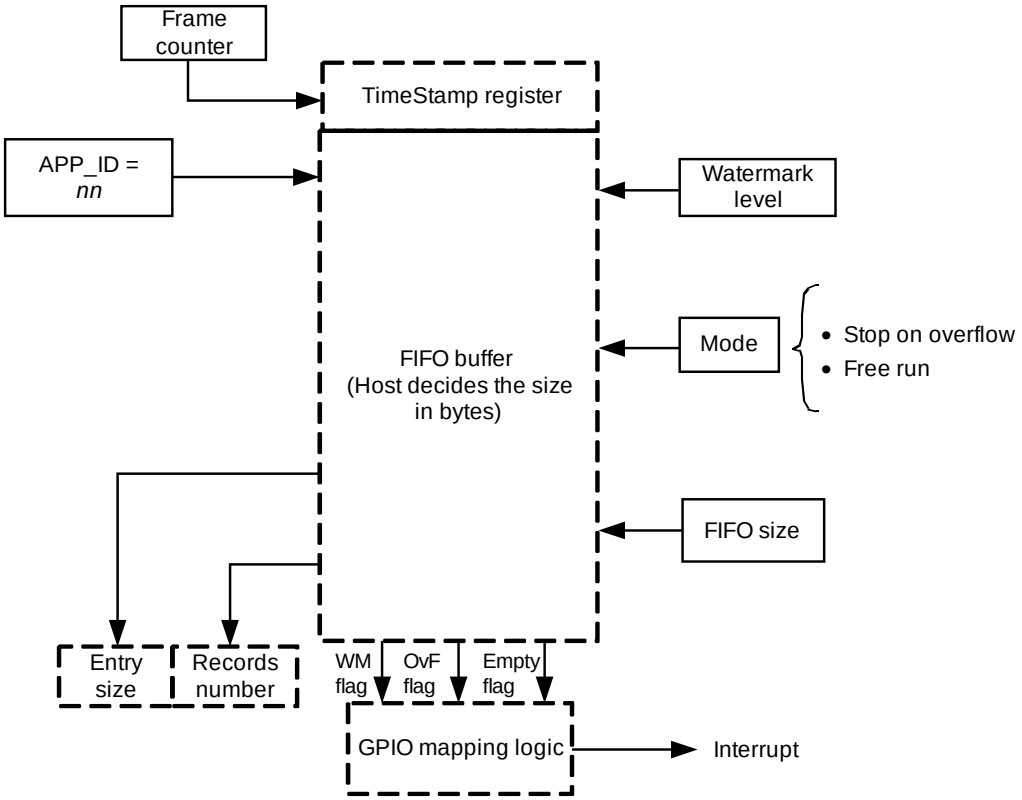

Figure 16. Data FIFO model

Figure 16 shows the block-level model of the data FIFO. The application is driven by the watermark and mode inputs that configure the functionality.

The watermark level helps the host prevent data loss by raising a warning just before the overflow condition occurs. When the number of bytes in the buffer approaches its capacity, the data FIFO asserts the watermark flag in the status register. The watermark level is user-configurable. If the level of 0 is configured, the watermark is disabled.

The channel has its own data format code (DFC) bit field that configures the payload to be stored (one, two, four, or six bytes). A NULL or zero value in the APP_ID Channel register means the channel is disabled. Any valid APP_ID value means the channel is enabled.

The data FIFO has a status register in its output structure that contains status flags such as watermark, overflow, and buffer empty. These flags can be mapped to the GPIO pins to generate an interrupt to the host.

The output also has an Entry Size register that shows the size, in bytes, of each entry that the data FIFO calculated, according to its payload configuration. A Records Number register records the number of entries stored in the data FIFO. Both registers help the host to calculate how many bytes to request, so that it can dump the entire FIFO buffer. A simple multiplication of those two registers' value gives the total number of bytes stored in the FIFO.

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10.4.1 Entries format

Channel enabled

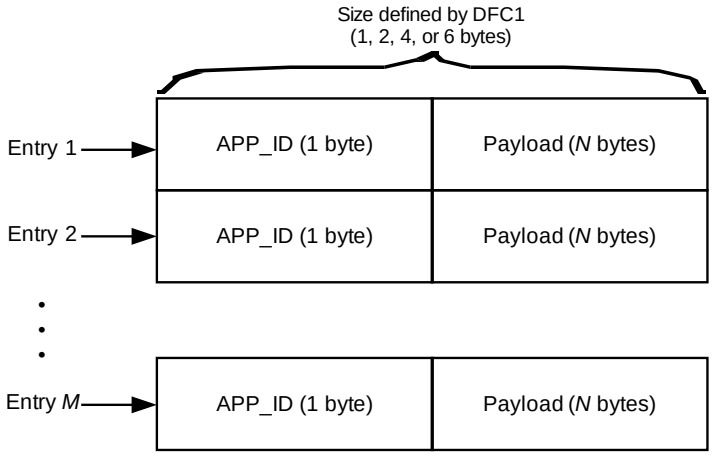

Figure 17. FIFO-entry formats, when channel enabled

10.5 Data FIFO configuration registers

This section contains the FIFO configuration registers. These registers can only be written once. To reconfigure the FIFO, the device must be reset. This is because the FIFO application requests RAM and RAM can only be allocated once.

10.5.1 FIFO configuration byte

Table 79. FIFO Config Byte register

Offset	0x00							
Bit	7	6	5	4	3	2	1	0
Field	Reserved				DFC1		Mode	
Reset	0x00				0x00		0x00	

Table 80. FIFO Config Byte bit descriptions

Field	Description
Reserved	Bit field reserved.
3:2 DFC1 (Data Format Code)	Configures the payload size of the channel. Units: None. Range of valid values: 0 to 3. • 00: One byte. • 01: Two bytes. • 10: Four bytes • 11: Six bytes.
1:0 Mode	Configures the FIFO mode. Units: None. Range of valid values: • 00: Free Run. • 01: Stop On Overflow.

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10.5.2 FIFO size word

Table 81. FIFO-size word registers

Offset	0x04(MSB)								0x05(LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	FIFO Size Word 1								FIFO Size Word 2							
Reset	0x00								0x00							

Table 82. FIFO-size word bit description

Field	Description
7:0 FIFO Size Word	Reserves the maximum size (in bytes) that the FIFO can use. This is limited by the available RAM. Units: Bytes. Range of valid values: 0 to available RAM. 0x1C8 (decimal, 456) is the maximum amount of RAM that can be requested from the MMA9555L device. The RAM is shared by multiple applications, so be careful not to set the FIFO to use more memory than is physically available. That will cause unknown and undesirable results.

10.5.3 FIFO APP_ID

Table 83. FIFO Channel APP_ID register

Offset	0x06							
Bit	7	6	5	4	3	2	1	0
Field	FIFO Ch APP_ID							
Reset	0x00							

Table 84. FIFO Channel APP_ID bit description

Field	Description
7:0 FIFO Ch APP_ID	The APP_ID of the application that supplied data to be buffered by the FIFO. Range of valid values: 0 to 0xFF.

10.5.4 Watermark

Table 85. Watermark registers

Offset	0x08(MSB)								0x09(LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	Watermark								Watermark							
Reset	0x00								0x00							

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Table 86. Watermark bit description

Field	Description
7:0 Watermark	Sets the count, in bytes, for the FIFO to set or clear the watermark flag. Units: Bytes. Range of valid values: 0–available RAM.

10.6 Data FIFO status registers

10.6.1 Records number

Table 87. Records-number register

Offset	0x00(MSB)								0x01(LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	Records Number								Records Number							
Reset	0x00								0x00							

Table 88. Records-number bit description

Field	Description
7:0 Records Number	This word stores the current number of records in the FIFO buffer. A record is the payload packet of data comprised of an APP_ID and the actual data—which could be one, two, four, or six bytes long. A record can be two, three, four, or seven bytes long. Units: Number of entries in the Data FIFO (entry size in bytes = Ch APP_ID+ DFC1). Range of valid values: 0 to available oxFFFF.

10.6.2 Entry size

Table 89. Entry-size register

Offset	0x02							
Bit	7	6	5	4	3	2	1	0
Field	Entry Size							
Reset	0x00							

Table 90. FIFO config-byte/bit description

Field	Description
7:0 Entry Size	This byte shows the size in bytes of each entry that the data FIFO has stored, that calculation based on its configuration. Units: Bytes. Range of valid values: 0 to 6.

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10.6.3 FIFO_Status

Table 91. FIFO_Status register

Offset	0x03							
Bit	7	6	5	4	3	2	1	0
Field	on_going_push	on_going_pop	Reserved			ovf_flag	empty_ flag	wmrk_ flag
Reset	0x00	0x00	0x00			0	0	0

Table 92. FIFO_Status bit descriptions

Field	Description
7 fifo_on_going_push	Indicates that a push operation is being executed—the is FIFO receiving data from the application. Units: Nondimensional. Range of valid values: 0 to 1. • 0: A push is not being executed. • 1: A push is being executed.
6 fifo_on_going_pop	Indicates that a pop operation is being executed. The FIFO is sending out data and it is being read. Units: Nondimensional. Range of valid values: 0 to 1. • 0: A pop operation is not being executed. • 1: A pop operation is being executed.
5:3 Reserved	Bit field reserved.
2 fifo_ovf_flag	Indicates that FIFO buffer has reached the maximum number of entries allowed. This meaning can vary depending of the mode of operation. Units: Nondimensional. Range of valid values: • 0: Not overflow condition. • 1: Overflow condition.
1 fifo_empty_flag	Indicates whether the FIFO buffer is empty. Units: Nondimensional. Range of valid values: • 0: FIFO buffer is not empty. • 1: FIFO buffer is empty.
0 fifo_wmrk_flag	Indicates when the entries in the FIFO buffer have reached the watermark count. Units: Nondimensional.. Range of valid values: • 0: Watermark not reached. • 1: Watermark reached.

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11 Event Queue Application

11.1 Overview of Event Queue application

Application ID	0x10
Default speed	30 Hz.
Configuration registers	Start on page 74.
Status registers	Start on page 76.

This application manages a queue of asynchronous events. The size of the queue is flexible and can be configured by writing to the queue_size word within the configuration registers of the Event Queue Application.

The size of the Event Queue is limited by the available RAM. The amount of RAM may be reduced by the Data FIFO Application which also can be configured to use the RAM.

Some applications inside the MMA9555L platform have an eight-bit event-mask register within configuration-registers structure that selects the specific event to be stored into the Event Queue. The user can set an application's event-mask bit to enable or prevent that application's events from being added to the Event Queue.

When the selected event happens, Event Queue Application calls a routine with the following prototype to push the application's event into the Event Queue:

```
void eventQueue_push(void *data, uint8_t size)
```

With these variables:

- Data: Pointer to the first element of the data to be stored into the queue. The data must have the order: APP_ID + Payload bytes.
- Size: Amount of data (in bytes) to be stored into the queue.

Each entry into the Event Queue is of fixed size and has the following format:

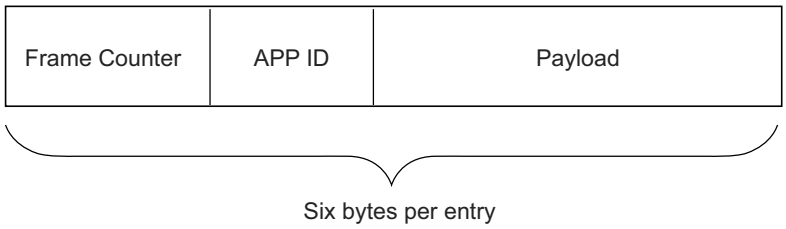

Figure 18. Entry format for the Event Queue

If an application's payload is less than three bytes, the Event Queue will store the data and complete the entry padding with zeros. If the application has a payload more than three bytes, the Event Queue will calculate the number of entries that this payload needs to be successfully stored, split in the format shown in Figure 18.

If an application tries to push data into the Event Queue and there is not enough space to store it, the Event Queue will ignore the attempt. This will be transparent for the application since there is no communication between the application and the Event Queue.

11.1.1 Modes of operation

The Event Queue works only in one mode. It stores data and stops when the end of the queue is reached and asserts an overflow flag. The queue is not circular.

The application has a configurable watermark that asserts a flag when entries have reached the configured point.

11.1.2 Reading process

To read the Event Queue, the host sends a read-status command to the MMA9555L device, calling the Event Queue application that stores the data within the queue into a buffer and returns the number of bytes read. If the number of requested bytes is not a multiple of the entry size, the pop routine ignores the extra bytes and tells the host how many effective bytes were popped.

To read data stored by the Event Queue application, the host must send a Read Data command along with a specific offset value. The following examples show the command for reading the data stored by the Event Queue Application.

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Reading Event Queue example

The following example shows how to configure the Event Queue application.

Example 12.

1. MB0: Set APP_ID to (0x10).
   Selects the Data-FIFO application.
2. MB1: Command to (0x20).
   Sends a Write Configuration space command.
3. MB2: Set offset to zero (0x00).
   Starts writing configuration values at register 0.
4. MB3: Set count field to (0x06).
   Sends nine bytes.
5. MB4: Send Data (0x00).
   Sets Queue size.
6. MB5: Send Data (0x50).
7. MB6: Send Data (0x00).
   Watermark
8. MB7: Send Data (0x05).
9. MB8: Send Data (0x00).
   Timeout.
10. MB6: Send Data (0x00).

Bytes to Send: 0x10, 0x20, 0x00, 0x06, 0x00, 0x50, 0x00, 0x05, 0x00, 0x00.

The configuration registers can only be written once. If the Event Queue must be reconfigured, the device must be reset and the configuration rewritten.

Some data now must be sent to the event queue. In this example, the Low-*g* application is configured to send an event.

Example 13.

1. MB0: Set APP_ID to (0x09).
   Specifies the Low-*g* application.
2. MB1: Command to (0x20).
   Sends a Write Configuration space command.
3. MB2: Set offset to zero (0x09).
4. Start writing configuration values at Register 9.
5. MB3: Set count field to (0x01).
   Sends nine bytes.
6. MB4: Send Data (0x08) – Event Mask Register.
   Enables Low-*g* events.

Bytes to Send: 0x09, 0x20, 0x09, 0x01, 0x08.

In this example, all other Low-*g* configuration register values are at the reset default values.

The device powers up in Sleep mode, but it may become necessary to wake the part. That process is done in the following example.

Example 14.

1. MB0: Set App_ID to (0x12).
   Selects the Power Controller modes.
2. MB1: Command to (0x20).
   Sends a write configuration, with offset = 0.
3. MB2: Set offset to (0x06).
4. MB3: Set count field to (0x01).

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5. MB4: Send the data value (0x00).

Bytes to Send: 0x12, 0x20, 0x06, 0x01, 0x00.

The device is enabled and configured to have an event Queue and send Low-*g* events to the Event Queue.

To cause a Low-*g* event that can be measured on the X, Y, and Z axes, toss the board into the air. Read the Event Queue applications status register to get the data.

To set up for reading the status register, send the command in the following example.

Example 15.

---

1. MB0: Set APP_ID to (0x10).
   Selects the Event Queue application.
2. MB1: Command to (0x30).
   Sends a Read Status space command.
3. MB2: Set offset to zero (0x03).
   Start reading status values at register 0.
4. MB3: Set count field to (0x20).
   Reads 10 bytes (3 status + APP_ID+6 data)

Bytes to Send: 0x10, 0x30, 0x03, 0x20.

The following response is returned:

10 80 13 20 09 95 AC 09 0F 00 00 95 BE 09 0F 00 00 95 D0 09 0F 00 00

MB0: APP_ID = 0x10; Event Queue application

MB1: STATUS = 0x80; Command Complete, no errors

MB3: Actual Data Count = 0x13; 10 bytes of data

MB2: Requested Data count = 0x20; 10 bytes of data

MB4: 0x09 = Event Queue Status; Watermark and Overflow flags are set

MB5–MB6: = 0x95AC; Timestamp

MB7: APP ID of the application providing the actual data = 0x09; the AFE application

MB8–MB10: 0x0F0000 = 0x0F is the status register from the Low-*g* applications; 0x0F indicates a Low-*g* event on all axes.

MB5–MB6: = 0x95BE; Timestamp

MB7: APP ID of the application providing the actual data = 0x09; the AFE application

MB8–MB10: 0x0F0000

MB5–MB6: = 0x95D0; Timestamp

MB7: APP ID of the application providing the actual data = 0x09; the AFE applications

MB8–MB10: 0x0F0000

The offset is fixed to three bytes.

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When the command is sent, the first four bytes that the MMA9555L device returns correspond to the response of the command.

The fifth byte is the status from the Event Queue application. This byte is part of the bytes requested by the host, therefore it is very important that the user adds one byte to the number of bytes to be read.

Due to the application's read functionality, if the application is storing data at the exact moment a read is issued by the host, the MMA9555L device will return an error condition. When this occurs, the host must retry reading the data. If any other error is returned, the host must take the proper action.

11.1.3 Event Queue block diagram

The following figure shows the Event Queue Data Flow Model that receives the Application ID and the *N* size of the payload from a specific application. The Event Queue logic appends the frame counter with this data and pushes the entry (six bytes in size) into the queue. If the queue is full, the logic will ignore the push request.

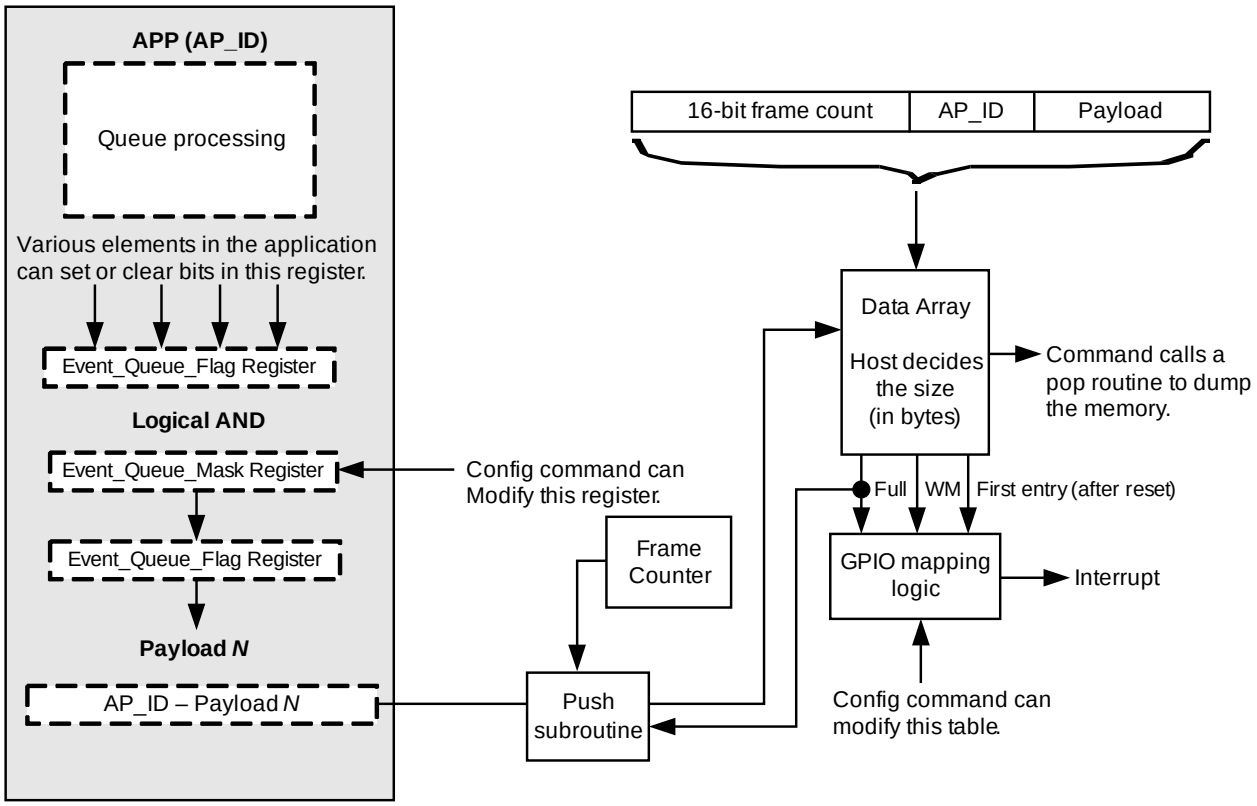

Figure 19. Event Queue data flow

11.2 Event Queue configuration registers

The Event Queue application's configuration can only be written once. In order to reconfigure the Event Queue, the whole device must be reset. This is because the Event Queue application requests RAM and RAM can only be allocated once.

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11.2.1 queue_size

Table 93. queue_size registers

Offset	0x00(MSB)								0x01(LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	queue_size															
Reset																

Table 94. queue_size bit description

Field	Description
7:0 queue_size	Defines the size in bytes that the Event Queue will reserve, in order to store the data sent by any application. Units: Bytes Range of valid values: 0–available RAM. 0x1C8 (decimal 456) is the maximum amount of RAM that can be requested from the MMA9555L device. The RAM is shared by multiple applications, so be careful not to set the FIFO to use more memory than is physically available. That will cause unknown and undesirable results.

11.2.2 queue_wmrk

Table 95. queue_wmrk registers

Offset	0x02(MSB)								0x03(LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	queue_wmrk															
Reset																

Table 96. queue_wmrk bit description

Field	Description
7:0 queue_wmrk	Sets the count, in bytes, for the Event Queue to set or clear the watermark flag. Units: Bytes. Range of valid values: 0 to available bytes in the buffer.

11.2.3 queue_timeout

Table 97. queue_timeout registers

Offset	0x04(MSB)								0x05(LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	queue_timeout															
Reset																

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Table 98. queue_timeout bit description

Field	Description
7:0 queue_timeout	Sets the count, in cycles, for the Event Queue to set or clear the time-out flag. Units: Time; [queue_timeout] * [1/SR_{queue}]). Range of valid values: 0 to 65,535. SR_queue is the sample rate of the Event Queue application, which defaults to 30 Hz.

11.3 Event Queue status registers

11.3.1 records_number

Table 99. records_number registers

Offset	0x00(MSB)								0x01(LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	records_number															
Reset																

Table 100. records_number bit description

Field	Description
7:0 records_number	Shows the current number of entries or records stored in the queue. Units: Entries (Entry = six bytes). Range of valid values: 0 to 65,535. Typically, this number should not be more than the available RAM divided by the payload size.

11.3.2 entry_size

Table 101. entry_size registers

Offset	0x02							
Bit	7	6	5	4	3	2	1	0
Set-bit values	0	0	0	0	0	1	1	0
Field	entry_size							
Reset	0	0	0	0	0	1	1	0

Table 102. entry_size bit description

Field	Description
7:0 entry_size	Shows the size in bytes of each entry or record in the queue. This value is six bytes fixed and is not user-configurable. Units: Bytes. Range of valid values: Fixed to six.

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11.3.3 queue_status

Table 103. queue_status registers

Offset	0x03							
Bit	7	6	5	4	3	2	1	0
Field	on_going_push	on_going_pop	Reserved		to_flag	ovf_flag	empty_flag	wmrk_flag
Reset								

Table 104. queue_status bit descriptions

Field	Description
7 on_going_push	Indicates that a push operation is being executed. Units: Nondimensional. Range of valid values: 0 to 1.
6 on_going_pop	Indicates that a pop operation is being executed. Units: Nondimensional.. Range of valid values: 0 to 1.
5:4 Reserved	Bit field reserved.
3 to_flag	Indicates when the Event Queue has not been read for the time configured by the queue_TimeOut parameter once the overflow marker has been reached. Units: Nondimensional. Range of valid values: 0 to 1.
2 ovf_flag	Indicates when the Event Queue is full and no more entries can be stored. Units: Nondimensional. Range of valid values: 0 to 1.
1 empty_flag	Indicates when the Event Queue is empty, no records or entries having been stored. Units: Nondimensional. Range of valid values: 0 to 1.
0 wmrk_flag	Indicates when the number of bytes within the Event Queue has reached the watermark. Units: Nondimensional. Range of valid values: 0 to 1.

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12 Status Register Application

12.1 Overview of Status Register application

Application ID	0x11
Default speed	30 Hz.
Configuration registers	Start on page 78.
Status registers	Start on page 82.

The Status Register Application provides a simple way for users to combine specific status information bits from multiple applications and read that combined information from one place.

The Status Register Application configures the output of its status register by mapping a specific status register bit to a specific output bit of a specific application. This enables the Status Register Application to provide a combined status from the selected bits of user-specified applications.

There are eight, user-configurable bits in the Status Register. Each bit mirrors an output bit in the related application.

12.2 Status Register configuration registers

The following tables show the configuration registers for the Status Register Application. The bit descriptions are given in Table 122 on page 82.

12.2.1 APP_ID SR_00

Table 105. APP_ID SR_00 register

Offset	0x00							
Bit	7	6	5	4	3	2	1	0
Field	APP_ID SR_00							
Reset	0x07							

12.2.2 Output_Bit_ID SR_00

Table 106. Output_Bit_ID SR_00 register

Offset	0x01							
Bit	7	6	5	4	3	2	1	0
Field	Output_Bit_ID SR_00							
Reset	0x00							

12.2.3 APP_ID SR_01

Table 107. APP_ID SR_01 register

Offset	0x02							
Bit	7	6	5	4	3	2	1	0
Field	APP_ID SR_01							
Reset	0x07							

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12.2.4 Output_Bit_ID SR_01

Table 108. Output_Bit_ID SR_01 register

Offset	0x03							
Bit	7	6	5	4	3	2	1	0
Field	Output_Bit_ID SR_01							
Reset	0x01							

12.2.5 APP_ID SR_02

Table 109. APP_ID SR_02 register

Offset	0x04							
Bit	7	6	5	4	3	2	1	0
Field	APP_ID SR_02							
Reset	0x07							

12.2.6 Output_Bit_ID SR_02

Table 110. Output_Bit_ID SR_02 register

Offset	0x05							
Bit	7	6	5	4	3	2	1	0
Field	Output_Bit_ID SR_02							
Reset	0x02							

12.2.7 APP_ID SR_03

Table 111. APP_ID SR_03 register

Offset	0x06							
Bit	7	6	5	4	3	2	1	0
Field	APP_ID SR_03							
Reset	0x07							

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12.2.8 Output_Bit_ID SR_03

Table 112. Output_Bit_ID SR_03 register

Offset	0x07							
Bit	7	6	5	4	3	2	1	0
Field	Output_Bit_ID SR_03							
Reset	0x03							

12.2.9 APP_ID SR_04

Table 113. APP_ID SR_04 register

Offset	0x08							
Bit	7	6	5	4	3	2	1	0
Field	APP_ID SR_04							
Reset	0x07							

12.2.10 Output_Bit_ID SR_04

Table 114. Output_Bit_ID SR_04 register

Offset	0x09							
Bit	7	6	5	4	3	2	1	0
Field	Output_Bit_ID SR_04							
Reset	0x04							

12.2.11 APP_ID SR_05

Table 115. APP_ID SR_05 register

Offset	0x0A							
Bit	7	6	5	4	3	2	1	0
Field	APP_ID SR_05							
Reset	0x00							

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12.2.12 Output_Bit_ID SR_05

Table 116. Output_Bit_ID SR_05 register

Offset	0x0B							
Bit	7	6	5	4	3	2	1	0
Field	Output_Bit_ID SR_05							
Reset	0x00							

12.2.13 APP_ID SR_06

Table 117. APP_ID SR_06 register

Offset	0x0C							
Bit	7	6	5	4	3	2	1	0
Field	APP_ID SR_06							
Reset	0x07							

12.2.14 Output_Bit_ID SR_06

Table 118. Output_Bit_ID SR_06 register

Offset	0x0D							
Bit	7	6	5	4	3	2	1	0
Field	Output_Bit_ID SR_06							
Reset	0x06							

12.2.15 APP_ID SR_07

Table 119. APP_ID SR_07 register

Offset	0x0E							
Bit	7	6	5	4	3	2	1	0
Field	APP_ID SR_07							
Reset	0x00							

Table 120. APP_ID SR_07 register description

Field	Description
7:0 APP_ID (APP_ID SR_n)	The application identifier. Zero value and 0xFF are reserved. Units: None. Range of valid values: [0 to 31] and 0xFF, realistically up to 0x1F, refer to the App-ID table

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12.2.16 Output_Bit_ID SR_07

Table 121. Output_Bit_ID SR_07 register

Offset	0x0F							
Bit	7	6	5	4	3	2	1	0
Field	Output_Bit_ID SR_07							
Reset	0x00							

Table 122. Output_Bit_ID SR_07 register description

Field	Description
7:0 Bit_ID (Output_Bit_ID SR_n)	The bit number to be mapped on the Status Register bit *n*. Units: None. Range of valid values: [0 to 255], refer to the register memory map of each application

12.3 Status Register default configuration

After reset, the status register configuration registers contain the Data Ready and Command Complete bits.

NOTE

The upper two bits in the upper byte are fixed, but the lower eight bits in the lower byte can be remapped by the user to any application and bits.

Table 123. Status Register MSB

Offset	0x00							
Bit	15	14	13	12	11	10	9	8
Field	Command Complete	Data Ready	N/A	N/A	N/A	N/A	N/A	N/A
Reset								

Table 124. Status Register LSB

Offset	0x01							
Bit	7	6	5	4	3	2	1	0
Field	Unassigned	Reserved	Unassigned	Reserved				
Reset								

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13 Sleep/Wake Application

13.1 Overview of Sleep/Wake application

Application ID	0x12
Default speed	30 Hz.
Configuration registers	Start on page 84.
Status registers	Start on page 87.

This application configures and controls the power-control modes of the accelerometer provides configuration flexibility for minimizing power consumption.

The application has three modes of operation: Run, Doze, and Sleep. The Sleep/Wake module puts the accelerometer into Doze mode automatically when no movement is detected. When a change in orientation or movement above the threshold is detected for the specified time period, the application returns to the Run mode.

To save a significant amount of power, only run the calculation-intensive applications when the accelerometer is in motion.

Using the activity level settings, some tasks may easily be bypassed when the accelerometer is sleeping. For example, it may not be necessary to run the Pedometer application while the device is sitting undisturbed flat on a desktop.

13.1.1 Run mode

In Run mode, all applications are scheduled to run at their maximum established frame rate. An application enters Run mode if the following conditions are met:

- The GPIO interrupt is asserted (RGPIO4/INT)
- A write command is issued from the host to the MMA9555L
- Movement above the threshold is detected and the previous state was Doze mode

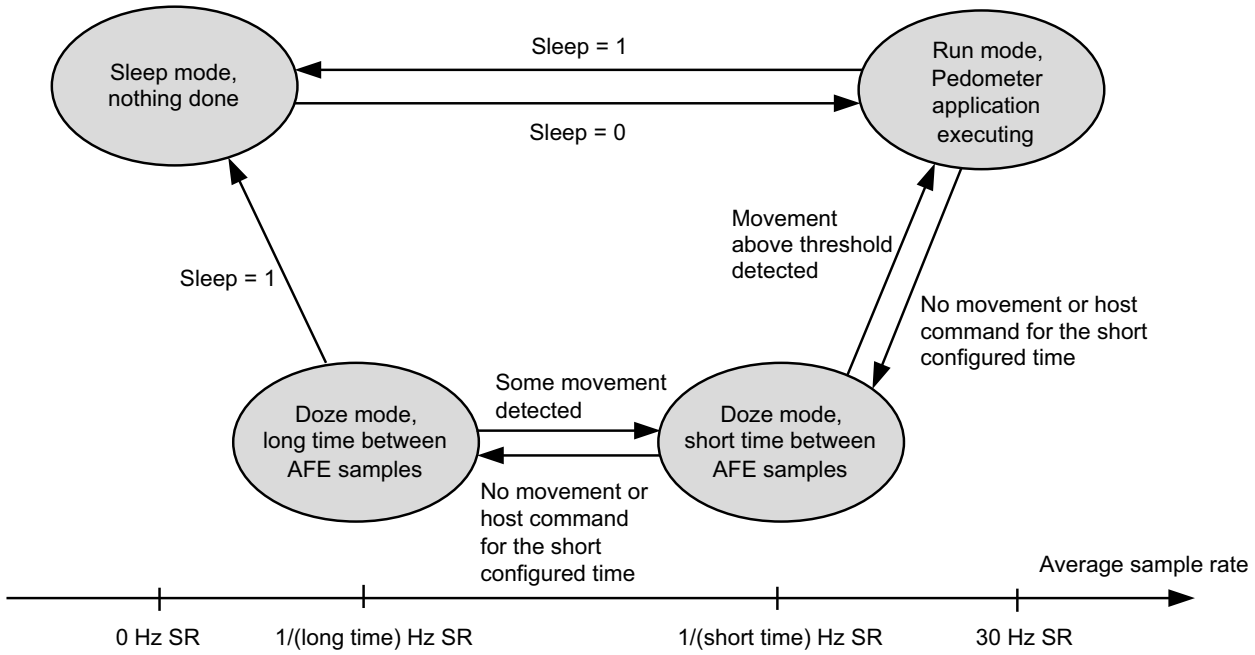

Figure 20. MMA9555L's power modes state diagram

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13.1.2 Doze mode

In Doze mode, the application only executes four AFE samples at a sample rate defined by the user. The user can configure two sample rate values: long time and short time. These parameters are configured in the **long_time_off** and **short_time_off** registers, respectively.

The short-time sample rate is used when the sensor detects some movement, but not enough to change to Run mode.

The long-time sample rate is used when the Sleep/Wake module detects no movement in the accelerometer.

The application enters Doze mode when the Sleep/Wake module detects no movement in the accelerometer for a specified period of time. The amount of time is configured in the **doze_thresh** register.

13.1.3 Sleep mode

In Sleep mode, the MMA9555L device does nothing and remains in the lowest power mode. The device can enter this mode only when the user sets the SNCEN bit from the **cfg** configuration register or when the application starts. Since the SNCEN bit is set by default, the application starts in Sleep mode.

To exit the Sleep mode, the user must clear the SNCEN bit from the **cfg** configuration register. This is done by issuing the corresponding write configuration command through the slave communications interface.

13.2 Sleep/Wake configuration registers

The following sections give the configuration registers for the Sleep/Wake application.

13.2.1 sensitivity_thresh

Table 125. sensitivity_thresh registers

Offset	0x00(MSB)								0x01(LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	sensitivity_thresh								sensitivity_thresh							
Reset	0x00								1	0	1	0	0	0	0	0

Table 126. sensitivity_thresh bit description

Field	Description
7:0 sensitivity_thresh	Configures the movement threshold of the application to change from Doze to Run mode. Units: None. Range of valid values: 120 to 300.

13.2.2 doze_time_thresh

Table 127. doze_time_thresh registers

Offset	0x02 (MSB)								0x03 (LSB)							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Field	doze_thresh								doze_thresh							
Reset	0	0	0	0	1	1	1	1	1	0	1	0	0	0	0	0

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Table 128. doze_time_thresh bit description

Field	Description
7:0 doze_thresh	Configures the time that the device must be still before entering Doze mode. For example, if the system sample rate if 488 Hz, then to set a time of 1 second, write 488 (0x1EB) to this register. Units: Algorithm cycles (Time = [Algorithm cycles] * [1/$SR_{PWRCTRL}$]). Range of valid values: 1 to 65,535

13.2.3 long_time_off

Table 129. long_time_off registers

Offset	0x04							
Bit	7	6	5	4	3	2	1	0
Field	Reserved				long_time_off [3:0]			
Reset	0x00				0	1	1	1

Table 130. long_time_off bit description

Field	Description
7:4 Reserved	Bit field reserved.
3:0 long_time_off	Configures the long-time interval between AFE samples when the application is in Doze mode. Units: Time. Range of valid values: from 0 to 10. Long-time values Time (seconds) • 0..... 4.1 ms • 1..... 8.19 ms • 2..... 16.4 ms • 3..... 32 ms • 4..... 65.5 ms • 5..... 131 ms • 6..... 162 ms • 7..... 524 ms • 8..... 1.05 s • 9..... 2.1 s • 10..... 4.19 s

13.2.4 short_time_off

Table 131. short_time_off register

Offset	0x05							
Bit	7	6	5	4	3	2	1	0
Field	Reserved				short_time_off [3:0]			
Reset	0x00				0	1	1	0

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Table 132. short_time_off bit description

Field	Description
7:4 Reserved	Bit field reserved.
3:0 short_time_off	Configures the short-time interval between AFE samples when the application is in Doze mode. Units: Time. Range of valid values: 0 to 10. Long-time values Time (seconds) • 0..... 4.1 ms • 1..... 8.19 ms • 2..... 16.4 ms • 3..... 32 ms • 4..... 65.5 ms • 5..... 131 ms • 6..... 162 ms • 7..... 524 ms • 8..... 1.05 s • 9..... 2.1 s • 10..... 4.19 s

13.2.5 cfg

Table 133. cfg register

Offset	0x06							
Bit	7	6	5	4	3	2	1	0
Field	Reserved			Stop_DIS	IRQ_EN	SCHEN	FLEEN	SNCEN
Reset	0x00			0	0	0	0	1

Table 134. cfg bit descriptions

Field	Description
7:5 Reserved	Bit field reserved.
4 Stop_DIS	Disables or enables the low-power mode. If this bit is set, the device doesn't execute the STOP assembler instruction even if the SNCEN, FLEEN, or SCHEN bits are set as 1b. • 0: Enables STOP mode. • 1: Disables STOP mode.
3 IRQ_EN	Enables or disables the IRQ interruption in the GPIO4. • 0: Disables IRQ interruption. • 1: Enables IRQ interruption.
2 SCHEN	Enables or disables the Doze mode. • 0: Disables the Doze mode. • 1: Enables the Doze mode.

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Table 134. cfg bit descriptions (Continued)

Field	Description
1 FLEEN	Controls the use of long and short time between AFE samples when in Doze mode. If this bit is cleared, the application does not use the long- and short-time values to determine the time between AFE samples. Instead, the time is fixed as 2.05 ms. • 0: Time between AFE samples fixed at 2.05 ms. • 1: Long- and short-time values determine the time between AFE samples.
0 SNCEN	Enables or disables the Sleep mode. **Note:** When this bit is set, the device will enter Sleep mode. The device can only exit this mode is by clearing this bit via a configuration-write command. • 0: Disables the Sleep mode. • 1: Enables the Sleep mode.

13.3 Sleep/Wake status registers

13.3.1 scheduler_mode

Table 135. scheduler_mode register

Offset	0x00							
Bit	7	6	5	4	3	2	1	0
Field	—	—	—	—	—	—	scheduler_mode	
Reset	0	0	0	0	0	0	0	0

Table 136. scheduler_mode bit description

Field	Description
1:0 scheduler_mode	Shows the scheduler mode when the SCHED and FLEEN bits are set in the **cfg** register. If those bits are not set, the value of this register may not reflect the actual scheduler mode. Units: None. Range of valid values: 0 to 0x02. • 00: Doze mode. Frame rate determined by the **long_time_off** configuration register. • 01: Doze mode. Frame rate determined by the **short_time_off** configuration register. • 10: Run mode.

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14 Reset/Suspend/Clear Control Application

14.1 Overview of Reset/Suspend/Clear Control application

Application ID	0x17
Default speed	30 Hz.
Configuration registers	Start on page 89.
Status registers	None.

This application provides a way to reset, suspend, and clear the outputs of the applications in the MMA9555L. The reset and clear functions are implemented in each application as callback functions. The suspend function is handled in the Scheduler Application.

One of the requirements of an application on the MMA9555L device is that it has a reset and clear function that can be called by the scheduler or another application. This chapter describes how an application's reset and clear callback functions can be called or triggered.

There are three groups of configuration registers for the Reset/Suspend/Clear Control application.

14.1.1 Reset

The reset bit, when set, schedules a reset for an application. At the next system cycle, the reset process is handled. The reset bit is automatically cleared by the Scheduler Application.

When the reset bit for an application is set, the following actions occur:

- The application's reset callback function is executed. The reset function is part of an application and it typically resets the application's outputs and internal variables.
- The reset bit is cleared.
- The scheduled application is executed.

14.1.2 Suspend

The suspend bit, when set, prevents an application from executing while the suspend bit is set. Setting or clearing the suspend flag is managed by the host through a command.

To preserve data coherency in an application, the suspend flag must be set before attempting to modify an application's configuration. The bit then must be cleared after the configuration has been changed.

14.1.3 Clear

The clear bit clears an application's outputs. The clear flag is automatically cleared by the scheduler.

When an application's clear bit is set, it causes the following actions:

- The application's clear callback is executed. This typically resets the application's outputs.
- The clear flag is cleared.
- The application is executed.

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14.2 Configuration registers for Reset/Suspend/Clear Control applications

14.2.1 Reset configuration register

Table 137. Reset registers

Offset	(MSB) 0x00 = reset_bits[31:24]							
Bit	31	30	29	28	27	26	25	24
Field	Reserved					Six-Direction	GPIO Input/ Output	Reserved
Reset	1	1	1	1	1	1	1	1
Offset	0x01 = reset_bits[23:16]							
Bit	23	22	21	20	19	18	17	16
Field	Rst/Susp/ Clr	Reserved	Pedometer	Reserved	Reserved	Auto-Wake/ Sleep	Status	Event FIFO
Reset	0	1	1	1	1	1	1	1
Offset	0x02 = reset_bits[15:8]							
Bit	15	14	13	12	11	10	9	8
Field	Data FIFO	Reserved						
Reset	1	1	1	1	1	1	1	1
Offset	(LSB) 0x03 = reset_bits[7:0]							
Bit	7	6	5	4	3	2	1	0
Field	Reserved	AFE	Reserved	MBOX	GPIO_AP PMAP	CI	Scheduler	General Rst
Reset	1	1	1	1	1	1	1	1

Table 138. Reset bit descriptions

Field	Description
31:27 Reserved	Not used.
26 Six Direction	• 0: Normal operation. • 1: Initiates the reset sequence of the Six Direction application.
25 GPIO Input/Output	• 0: Normal Operation. • 1: Initiates the reset sequence of the GPIO Input/Output application.
24 Reserved	Not used.
23 Reset/Suspend/Clear	• 0: Normal operation. • 1: Initiates the reset sequence of the Reset/Suspend/Clear application.
22 Reserved	Not used.

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Table 138. Reset bit descriptions (Continued)

Field	Description
21 Pedometer	• 0: Normal operation. • 1: Initiates the reset sequence of the Pedometer application.
20:19 Reserved	Not used.
18 Auto-Wake/Sleep	• 0: Normal operation. • 1: Initiates the reset sequence of the Auto-Wake/Sleep application.
17 Reserved	Not used.
16 Event-FIFO	• 0: Normal operation. • 1: Initiates the reset sequence of the Event-Queue application.
15 Data FIFO	• 0: Normal operation. • 1: Initiates the reset sequence of the Data FIFO application.
14:8 Reserved	Reserved
7 Reserved	Reserved
6 AFE	• 0: Normal operation. • 1: Initiate the reset sequence of the front-end application.
5 Reserved	Reserved
4 Mailbox	• 0: Normal operation. • 1: Initiates the reset sequence of the mailbox application.
3 GPIO_AppMap	• 0: Normal operation. • 1: Initiates the reset sequence of the GPIO AppMap application.
2 Command Interpreter	• 0: Normal operation. • 1: Initiates the reset sequence of the command-interpreter application.
1 Scheduler	• 0: Normal operation. • 1: Initiates the reset sequence of the scheduler-application.
0 General Reset	• 0: Normal operation. • 1: Initiates a system-wide reset sequence of all MMA9555Lapplications.

14.2.2 Suspend configuration register

Table 139. Suspend registers

Offset	(MSB) 0x04 = reset_bits[31:24]							
Bit	31	30	29	28	27	26	25	24
Field	Reserved					Six Direction	GPIO Input/ Output	Reserved
Reset	1	1	1	1	1	1	1	1

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Table 139. Suspend registers (Continued)

Offset	0x05 = reset_bits[23:16]							
Bit	23	22	21	20	19	18	17	16
Field	Rst/Susp/Clr	Reserved	Pedometer	Reserved		Auto-Wake/ Sleep	Status	Event FIFO
Reset	0	1	1	1	1	1	1	1
Offset	0x06 = reset_bits[15:8]							
Bit	15	14	13	12	11	10	9	8
Field	Data FIFO	Frame Counter	Reserved					
Reset	1	1	1	1	1	1	1	1
Offset	(LSB) 0x07 = reset_bits[7:0]							
Bit	7	6	5	4	3	2	1	0
Field	Reserved	AFE	Reserved	MBOX	GPIO	CI	Scheduler	General Susp
Reset	1	1	1	1	1	1	1	1

Table 140. Suspend bit descriptions

Field	Description
31:27 Reserved	Not used.
26 Six Direction	• 0: Normal Operation • 1: Suspend the Six Direction application.
25 GPIO Input/Output	• 0: Normal Operation • 1: Suspend the GPIO Input/output application.
24 Reserved	Not used.
23 Reset/Suspend/Clear	• 0: Normal operation. • 1: Initiates the suspend sequence of the Reset/Suspend/Clear application.
22 Reserved	Not used.
21 Pedometer	• 0: Normal operation. • 1: Suspend the Pedometer application.
20:19 Reserved	Not used.
18 Auto-Wake/Sleep	• 0: Normal Operation • 1: Initiates the suspend sequence of the Auto-Wake/Sleep application.
17 Reserved	Not used.
16 Event-FIFO	• 0: Normal Operation • 1: Initiates the suspend sequence of the Event-Queue application.

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Table 140. Suspend bit descriptions (Continued)

Field	Description
15 Data FIFO	• 0: Normal operation. • 1: Initiates the suspend sequence of the Data FIFO application.
14:8 Reserved	• Reserved
6 AFE	• 0: Normal Operation • 1: Initiate the suspend sequence of the front-end application.
5 Reserved	Reserved.
4 Mailbox	• 0: Normal Operation • 1: Initiates the suspend sequence of the mailbox application.
3 GPIO AppMap	• 0: Normal Operation • 1: Initiates the suspend sequence of the GPIO AppMap application.
2 Command Interpreter	• 0: Normal Operation • 1: Initiates the suspend sequence of the command-interpreter application.
1 Scheduler	• 0: Normal Operation • 1: Initiates the suspend sequence of the scheduler-application.
0 General Suspend	• 0: Normal Operation • 1: Initiates a system-wide suspend sequence of all MMA9555Lapplications.

14.2.3 Clear configuration register

Table 141. Clear registers

Offset	(MSB) 0x08 = reset_bits[31:24]							
Bit	31	30	29	28	27	26	25	24
Field	Reserved					Six Direction	GPIO Input/ Output	Reserved
Reset	1	1	1	1	1	1	1	1
Offset	0x09 = reset_bits[23:16]							
Bit	23	22	21	20	19	18	17	16
Field	Rst/Susp/Clr	Reserved	Pedometer	Reserved		Auto-Wake/ Sleep	Status	Event FIFO
Reset	0	1	1	1	1	1	1	1
Offset	0x10 = reset_bits[15:8]							
Bit	15	14	13	12	11	10	9	8
Field	Data FIFO	Frame Counter	Reserved					
Reset	1	1	1	1	1	1	1	1

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Table 141. Clear registers (Continued)

Offset	(LSB) 0x11 = reset_bits[7:0]							
Bit	7	6	5	4	3	2	1	0
Field	Reserved	AFE	Reserved	MBOX	GPIO	CI	Scheduler	General Clear
Reset	1	1	1	1	1	1	1	1

Table 142. Clear bit descriptions

Field	Description
31:27 Reserved	Not used.
26 Six Direction	• 0: Normal Operation • 1: Clear the Six Direction application
25 GPIO Input/Output	• 0: Normal Operation • 1: Clear the GPIO Input/output application
24 Reserved	Not used.
23 Reset/Suspend/Clear	• 0: Normal operation. • 1: Clear the Reset/Suspend/Clear application.
22 Reserved	Not used.
21 Pedometer	• 0: Normal operation. • 1: Clear sequence of the Pedometer application.
20:19 Reserved	Not used.
18 Auto-Wake/Sleep	• 0: Normal Operation • 1: Clear the Auto-Wake/Sleep application.
17 Reserved	Not used.
16 Event-FIFO	• 0: Normal Operation • 1: Clear the Event-Queue application.
15 Data FIFO	• 0: Normal operation. • 1: Clear the Data FIFO application.
14:8 Reserved	Reserved.
7 AFE	Reserved.
6 AFE	• 0: Normal Operation • 1: Clear the front-end application.
5 Reserved	Reserved.
4 Mailbox	• 0: Normal Operation • 1: Clear the mailbox application.

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Table 142. Clear bit descriptions (Continued)

Field	Description
3 GPIO AppMap	• 0: Normal Operation • 1: Clear the GPIO AppMap application.
2 Command Interpreter	• 0: Normal Operation • 1: Clear the command-interpreter application.
1 Scheduler	• 0: Normal Operation • 1: Clear the scheduler-application.
0 General Clear	• 0: Normal Operation • 1: Clear all MMA9555L applications.

Once an application has set a flag, it can be reset by one of the following mechanisms:

- Execute a power-on reset.
- Wake the device after a low-power mode.
- Direct the host to write to general, reset/suspend/clear configuration bit.
- Direct the host to write to an application reset/suspend/clear configuration bit.

14.3 Reset/Suspend/Clear status registers

There are no status registers.

14.4 Reboot to ROM CI from flash code

In order to reboot to ROM Command Interpreter, it is necessary to execute the reset callback function of the reset/suspend/clear application by setting the respective reset flag. The complete command for this operation is:

Example 16.

```
MBOX0 = 0x17 /*Application ID*/
MBOX1 = 0x20 /*CONFIG_W command*/
MBOX2 = 0x01 /*Offset*/
MBOX3 = 0x01 /*Number of bytes to write*/
MBOX4 = 0x80 /*Data*/
```

14.5 Reboot to flash code from ROM CI

The operation to reboot into flash code when the ROM Command Interpreter is running can be performed by sending a CI_RESET command, the mailbox settings for this command is:

Example 17.

```
MBOX0 = 0x29 /*ROM Command for boot to flash*/
MBOX1 = 0x00 /*Reserved*/
MBOX2 = 0xFF /*CI_PWR*/
MBOX3 = 0xFF /*CI_PWR*/
MBOX4 = 0xFF /*CI_PWR*/
MBOX5 = 0xFF /*CI_PWR*/
```

For details about the ROM CI commands, see the *MMA955xL Intelligent, Motion-Sensing Platform Hardware Reference Manual* (MMA955xLHWRM), listed in “Related Documentation” on page 2.

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15 MBOX Configuration Application

15.1 Overview of MBOX Configuration application

Application ID	0x18
Default speed	Always available.
Configuration registers	See page 97.
Status registers	None.

The MBOX Configuration application works with the Mailbox application (Chapter 8, “Mailbox Application”) and the Communications application (Chapter 4, “Communication Interface”) to provide data back to the host in a way that the host can best use the data.

The MBOX Configuration application configures how the mailboxes behave. The Mailbox application configures what data is stored in the mailboxes.

By default, the MMA9555L operates in the Command/Response mode, where a host must issue a write command followed by one or more reads to get data. The MMA9555L can also be put into a Legacy mode, where the host just issues a read command to get data.

The mailboxes can be accessed in either of two modes: Normal or Legacy. The mailboxes’ default mode is Normal, but the mode can be changed through this the mailbox configuration application (APP_ID = 0x18).

The following figure shows the differences between the Normal and Legacy modes.

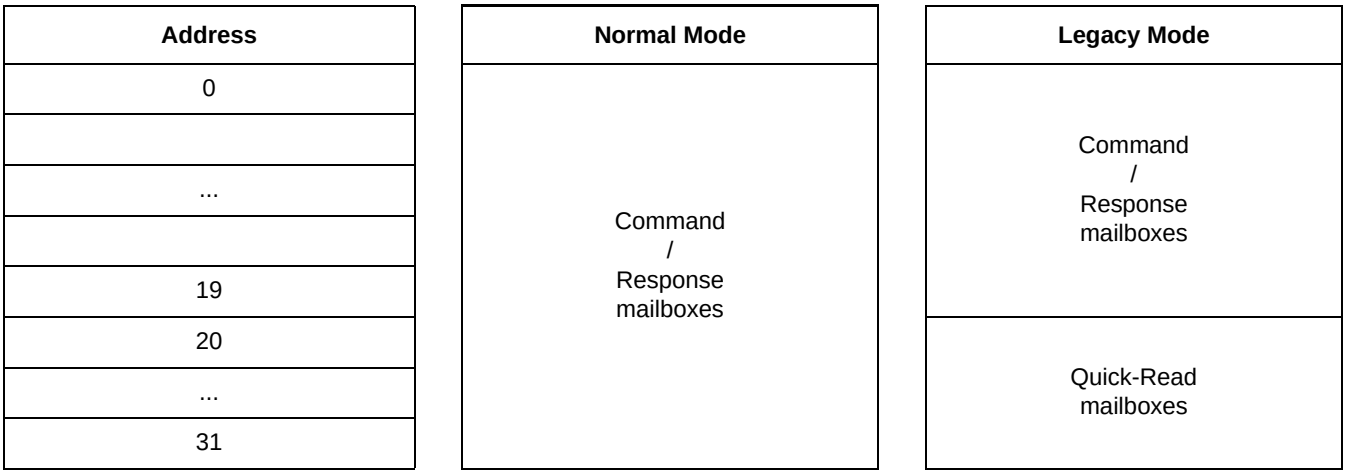

Figure 21. Difference between Normal and Legacy modes

15.2 Normal mode

In Normal mode, only the command/response communications model is supported. In order to read valid data from the MMA9555L, the host must send a command through the mailboxes and wait for the command to be processed. Then, the host must read back the mailboxes that now have the data. The host can wait for the command to be processed by polling the Command Complete (COCO) bit or the host can wait for the INT_O interrupt.

The Normal mode fully supports streaming-read transactions when the response to a command may be more than 32 bytes long.

The following procedure gives the sequence for setting up the interrupt pin to go active after a COCO:

Example 18.

1. MB0: Set the “APP_ID: Communication application” (0x18) application identifier.
2. MB1: Set the “Command: Write Config” (0x20) application identifier.
3. MB2: Set the Offset to Zero field (0x00) to point to the configuration register.
4. MB3: Set the Count field to (0x01).
   This is done because only one data byte needs to be sent.
5. MB4: Set the DATA (0x80) bit 7.
   This enables the interrupt pin.

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Bytes to Send: 0x18, 0x20, 0x00, 0x01, 0x80.

15.3 Legacy mode

In Legacy mode, the lower-address mailboxes operate as described in the Normal mode—in the command/response communications model. MB20 through MB31, however, are used as Quick-Read registers. These registers are automatically updated at the end of each sample frame with the latest results from the chosen applications.

The Mailbox application determines what data will appear in the mailboxes.

The quick-read output data is selected with the configuration of the Mailbox application. (For more detail, see “Mailbox Application” on page 41.)

Quick-Read registers enable the host to quickly and directly read a limited set of data directly from the MMA9555L without first having to issue a command and wait for the completion of the command processing. This makes support easier for legacy systems that expect to read sensor data. (In Legacy mode, MB20 to MB31 are reserved for mapping the Quick-Read registers.)

By default, the Quick-Read registers (MB20–MB31) contain the following data:

MB20–MB21 = Status 0,1

MB22 = Event Queue status

MB23 = FIFO status

MB24–MB25 = AFE Frame Counter

MB26–MB27 = AFE, Stage 0; X-axis data

MB28–MB29 = AFE, Stage 0; Y-axis data

MB30–MB31 = AFE, Stage 0; Z-axis data

This data—in the Quick-Read registers in Legacy mode—can be changed with the Mailbox application.

15.4 Configuring mailbox operational mode

The operational mode of the slave communications interface mailbox is configured via the Mailbox Configuration application. This application allows the host system to configure the slave communications interface functions including the mailbox transaction interrupt pin mode, mailbox Normal/Legacy modes, and transaction-streaming modes.

The following example shows how to configure the mailbox operating mode from Normal to Legacy

Example 19.

1. MB0: Set the “APP_ID: Mailbox Mode Config” application identifier (0x18).
2. MB1: Set the “Command: Write Config” application identifier (0x20).
3. MB2: Set the Offset to Zero field (0x00) to point to the configuration register.
4. MB3: Set the Count field to 0x01 because only one data byte needs to be sent.
5. MB4: Set the DATA value to 0x10.
   This sets the Legacy field to 1b which selects the Legacy mode.

Bytes to send: 0x18, 0x20, 0x00, 0x01, 0x10.

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15.5 MBOX Configuration memory map and register

15.5.1 MBOX Configuration memory map

Table 143. memory map

Offset address	Register	Access	Reset	Details
0x00	MBOX Configuration register	Read/Write	0x00	Section 15.5.2

15.5.2 MBOX Configuration register

Table 144. MBOX Configuration register

Offset	0x00							
Bit	7	6	5	4	3	2	1	0
Field	INT_O_EN	INT_O_POL	INT_O_ FRAME_EN	LEGACY	UPDMODES		—	—
Reset	0	0	0	0	00		0	0

Table 145. Communications configuration register field descriptions

Field	Description
7 INT_O_EN	Enables or disables the assertion of the INT_O signal every time a mailbox command is been processed. Range of valid values: 0 Disables the assertion of the INT_O signal. 1 Enables the assertion of the INT_O signal.
6 INT_O_POL	Configures the polarity of the INT_O signal when it is asserted. Range of valid values: 0 Active high. 1 Active low.
5 INT_O_FRAME_EN	If enabled, generates the INT_O interrupt on completion of the AFE sample—once each frame. If not enabled, the INT_O signal is generated on a command-complete basis. This bit was added to support synchronization between the host and the MMA9555L device. Data will be ready on a frame basis. Range of valid values: 0: Interrupt not generated. 1: Interrupt generated on completion of AFE sample.

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Table 145. Communications configuration register field descriptions (Continued)

Field	Description
4 LEGACY	Selects between Normal and Legacy mode. Range of valid values: 0: Normal mode. 1: Legacy mode.
3 UPDMODES	When in Legacy mode, configures how and when the Quick-Read registers are updated. This field is valid only if the Mailbox is operating in Legacy mode. See Bit 4. Range of valid values: 00 Mode 0: Updates the Quick–Read registers (QR) whether the slave port is active or inactive. 01 Mode 1: Updates the QR registers only if the slave port is inactive. If the slave port is active, the update takes no action and waits until the slave port is inactive. 10 Mode 2: Updates the QR registers if the slave port is inactive. If the slave port is active (I^2C transactions are running), this mode will enable a receive interrupt in the slave port to be triggered immediately after the transaction ends. After this, the QR register is immediately updated and the receive interrupt disabled.
1:0 Reserved	Reserved.

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16 Pedometer Application

16.1 Background and overview

Application ID	0x15
Default speed	30 Hz.
Configuration registers	Start on page 104.
Status registers	Start on page 108.

The MMA9555L's major application is the pedometer.The pedometer has calculations for step-counting, speed, distance, activity-monitoring, and calorie-counting, as well as autonomous sleep functionality to minimize current consumption.

The following figure illustrates the hardware and software components and interactions in the MMA9555L.

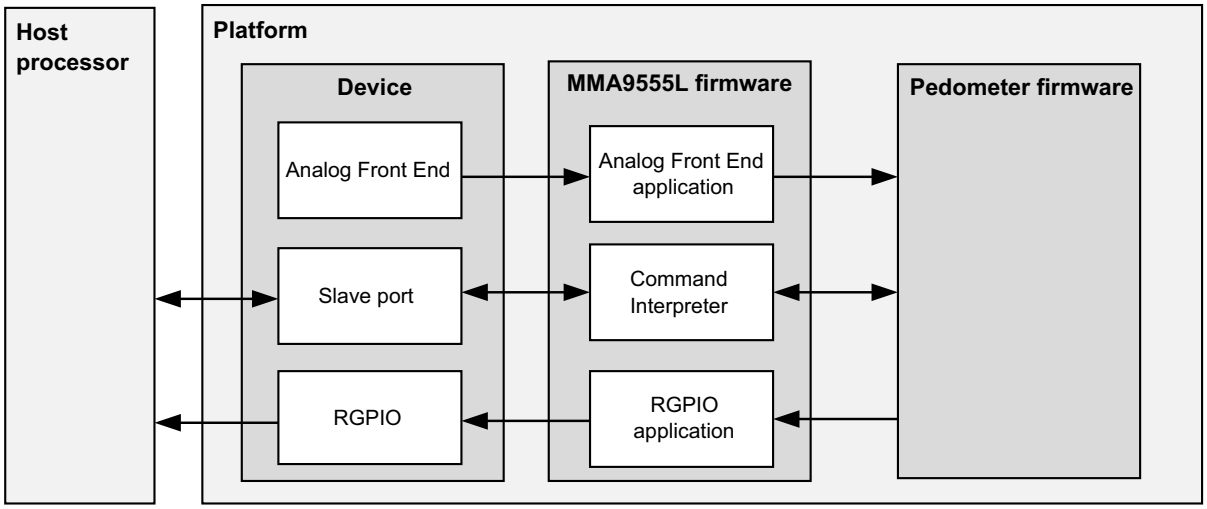

Figure 22. Pedometer Data Flow Diagram

16.2 Functional description

16.2.1 Step detection

Step detection is based solely on detecting step impact, without taking into consideration the consumer's height, weight, or gender.

The algorithm operates by keeping track of momentary acceleration, defined as:

$$A = \sqrt{X^2 + Y^2 + Z^2}$$

where X, Y, and Z represent a single accelerometer reading, normalized by dividing by 1 *g*.

The values of A are accumulated over a fixed period of time (0.19 seconds). At every reading, the average A for that period is calculated and saved. The algorithm detects steps by analyzing the spread of the accumulated average A values. The spread is the difference between minimum and maximum of the calculated values.

For a step to be reported, the spread in the buffer of average values of A has to exceed a fixed threshold (0.13 *g*) and stay above that threshold for at least the fixed value of 0.07 seconds. If the spread falls below the threshold sooner than 0.07 seconds, the motion is ignored.

The STEPCNT variable contains the number of steps detected since the last reset. That count is updated every time a step is detected.

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16.2.2 Distance estimation

The distance estimation begins with the Base Stride Length (BSL), the estimated stride length for this consumer. The BSL is calculated as follows:

$$BSL = Height\ (centimeters) \times GenderFactor \times 1.1$$

where Height is the consumer's height and GenderFactor is 0.415 for males or 0.413 for females. For more information about Height, see "Height/Weight register" on page 106. For more information on GenderFactor, see "Filter register" on page 106.

If no consumer information is provided, BSL is set to 0, and the resulting distance values are 0. If there is a need to update the BSL without consumer information, the configuration structure can be used to set a fixed stride length.

The estimated stride length is calculated by adjusting the BSL for step rate (steps/second). Stride length for a particular step is calculated as follows:

$$Stride = BSL \times StepRateFactor$$

The StepRateFactor values are shown in the following table:

Table 146. StepRateFactor calculation

Step rate, S (steps/sec)	StepRateFactor
$S < 1.6$ (very slow)	0.88
$1.6 \leq S < 1.8$ (slow)	0.95
$1.8 \leq S < 2.35$ (normal)	1.00
$2.35 \leq S < 2.8$ (fast)	1.30
$S \geq 2.8$ (very fast)	2.30

The overall distance is calculated as the sum of estimated stride lengths for all steps detected since the last reset.

The DISTANCE variable contains the value of overall distance and is updated every time a step is detected.

16.2.3 Speed calculation

Speed is calculated over a sliding time window as:

$$Speed = \frac{Distance\ (meters)}{Time}$$

where Distance is the total distance covered by all steps detected within the time window. Time is the length of the window and can be configured by the SPDPRD variable.

For more information, see:

- Speed: "Speed register" on page 110
- Distance: "Distance register" on page 110
- Time: "Filter register" on page 106
- SPDPRD variable: "Speed Period/Step Threshold register" on page 107

The SPEED variable contains the current speed value and is updated every time a step is detected or once per second if there are no steps. If there are no steps, the speed may not necessarily fall to zero even if the activity level, which is described in the following section, falls to Rest. The activity level is reset to Rest if there are no steps for a certain amount of time. The speed calculation does not include a similar reset when there are no steps. Therefore, it may conflict with the activity level. In this scenario, the user should disregard the speed if the activity level is Rest.

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16.2.4 Activity-level calculation

The activity-level calculation is based on the speed value. The activity-level value is assigned according to the following table.

Table 147. Activity-level calculation

Latest speed, S (Km/h)	Activity level
$S \geq 10.5$	Running
$6.5 \leq S < 10.5$	Jogging
$1.0 \leq S < 6.5$	Walking
$S < 1.0$	Rest

The ACTIVITY variable contains the current activity level and is updated every time a step is detected or once per second if there are no steps. Additionally, if no steps are detected for the previous 2.5 seconds, the activity level is reset to Rest.

16.2.5 Calorie-expenditure calculation

The estimated amount of calories burned by a single step is calculated as:

$$\text{Calories} = \frac{\text{MetabolicFactor} \times 0.00029}{\text{StepRate}} \times \text{Weight}$$

where StepRate is calculated as described in “Distance estimation” on page 100, Weight is the consumer’s weight in kilograms, and MetabolicFactor is calculated according to the following table:

Table 148. MetabolicFactor calculation

Step Rate, S (steps/sec)	MetabolicFactor
$S < 1.6$ (very slow)	2.0
$1.6 \leq S < 1.8$ (slow)	2.5
$1.8 \leq S < 2.35$ (normal)	3.8
$2.35 \leq S < 2.8$ (fast)	8.0
$S \geq 2.8$ (very fast)	12.5

For more information, see:

- StepRate: “Filter register” on page 106
- Weight: “Height/Weight register” on page 106

The CALS variable contains the total amount of calories burned since the last reset. The value is updated every time a step is detected.

16.2.6 Debounce count

The debounce_count() function implements a debounce counter as defined in application note *Motion and Free fall Detection Using the MMA8450Q* (AN3917), listed in “Related Documentation” on page 2.

If the input condition is satisfied, the count is incremented by one up to the threshold. Otherwise, the count is decremented or cleared depending on the debounce counter mode.

The debounce counter’s behavior is shown in Figure 23.

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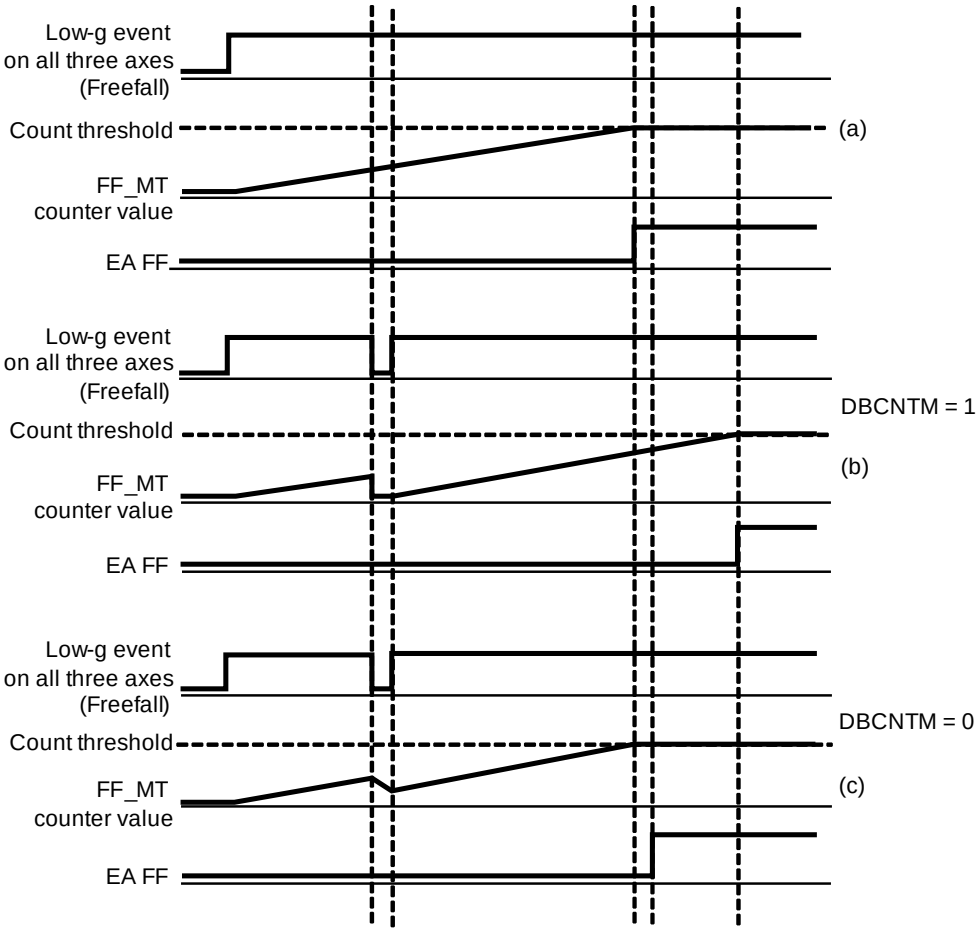

Figure 23. Debounce counter behavior

16.2.7 Autonomous suspend

The pedometer uses the acceleration vector magnitude squared, ($X^2 + Y^2 + Z^2$), to determine if the device is stationary. It is designed to suspend the pedometer conservatively and wake the pedometer aggressively to avoid missing any steps.

The autonomous-suspend function compares the acceleration vector magnitude to the configurable minimum and maximum thresholds (SLEEPMIN and SLEEPMAX) and passes the boolean result to a debounce counter. If the thresholds are satisfied for at least SLEEPTHD samples, the pedometer autonomously suspends. The thresholds are satisfied if the output of the debounce counter is asserted.

If the thresholds are not satisfied for at least SLEEPTHD samples, the pedometer executes normally.

The parameters SLEEPMIN, SLEEPMAX, SLEEPTHD, and SLP_DBCNTM configure the behavior. The SLEEPMAX parameter's reset value disables the autonomous suspend function by default.

For more information, see:

- SLEEPMIN: "Sleep Minimum register" on page 104
- SLEEPMAX: "Sleep Maximum register" on page 104
- SLEEPTHD: "Sleep Count Threshold register" on page 105
- SLP_DBCNTM: "Configuration/Step Length register" on page 105

If custom sleep functionality is desired, a user may disable the pedometer's autonomous-suspend functionality and instead use the MMA9555L's Reset/Suspend/Clear application to enable or disable the pedometer. For an example, see "Enable/disable the Pedometer application" on page 124.

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16.3 Memory-maps and register descriptions

The Pedometer Application running in the MMA9553L device has eight configuration registers and six status or data registers. The configuration registers allow the user to customize and control the behavior of the pedometer application. The status registers report back the measured and calculated data.

All status registers are shown as 16-bits wide. They are byte-accessible, but should be read 16 bits (two bytes) or more at a time with a single command, if the user wishes to read them atomically.

Similarly, configuration registers are shown as 16-bits wide but are also byte-accessible. Most fields defined within the configuration registers are 8-bits or less and are byte-aligned, so they can be written one byte at a time if desired. All bytes should be written using a single command if the user wishes to modify them atomically.

16.3.1 Pedometer memory maps

Table 149. Configuration registers

Offset address	Register	Access	Reset	Details
0x0	Sleep Minimum register	R/W	0x0000	“Sleep Minimum register” on page 104
0x2	Sleep Maximum register	R/W	0x0000	“Sleep Maximum register” on page 104
0x4	Sleep Count Threshold register	R/W	0x0001	“Sleep Count Threshold register” on page 105
0x6	Config/Step Length register	R/W	0x0000	“Configuration/Step Length register” on page 105
0x8	Height/Weight register	R/W	0xAF50	“Height/Weight register” on page 106
0xA	Filter register	R/W	0x0403	“Filter register” on page 106
0xC	Speed Period register	R/W	0x0582	“Speed Period/Step Threshold register” on page 107
0xE	Activity Count Threshold register	R/W	0x0000	“Activity Count Threshold register” on page 107
0x10	Step Coalesce register	R/W	0x01	“Step Coalesce register” on page 107

Table 150. Status registers

Offset address	Register	Access	Reset	Details
0x0	Status register	R	0x0002	“Status register” on page 108
0x2	Step count register	R	0x0000	“Step Count register” on page 109
0x4	Distance register	R	0x0000	“Distance register” on page 110
0x6	Speed register	R	0x0000	“Speed register” on page 110
0x8	Calories register	R	0x0000	“Calories register” on page 110
0xA	Sleep Count register	R	0x0000	“Sleep Count register” on page 111

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16.3.2 Pedometer configuration-register descriptions

16.3.2.1 Sleep Minimum register

Table 151. Sleep Minimum register

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Read	SLEEPMIN															
Write																
Reset	0x0000															

Table 152. Sleep Minimum register field descriptions

Field	Description
15:0 SLEEPMIN	Minimum acceleration vector magnitude for autonomous suspend. The acceleration vector magnitude must be greater than SLEEPMIN and less than SLEEPMAX to satisfy the autonomous suspend condition[(1)]. At rest, the acceleration vector magnitude measures approximately 1 *g*. Therefore, SLEEPMIN and SLEEPMAX are expected to be set to values near 1 *g* (4096 at 0.244 m*g*/LSB resolution). Valid range: 0x0000:0xFFFF (uint16). Units: 0.244 mg/LSB

1. This condition must be satisfied for SLEEPTHD samples for the pedometer to autonomously suspend. See Table 156 on page 105.

16.3.2.2 Sleep Maximum register

Table 153. Sleep Maximum register

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Read	SLEEPMAX															
Write																
Reset	0x0000															

Table 154. Sleep Maximum register field descriptions

Field	Description
15:0 SLEEPMAX	Maximum acceleration vector magnitude for autonomous suspend. The acceleration vector magnitude must be greater than SLEEPMIN and less than SLEEPMAX to satisfy the autonomous suspend condition[(1)]. At rest, the acceleration vector magnitude measures approximately 1 *g*. Therefore, SLEEPMIN and SLEEPMAX are expected to be set to values near 1 *g* (4096 at 0.244 mg/LSB resolution). Set to SLEEPMAX 0 to disable autonomous suspend. Valid range: 0x0000:0xFFFF (uint16). Units: 0.244 m*g*/LSB

1. This condition must be satisfied for SLEEPTHD samples for the pedometer to autonomously suspend. See Table 156 on page 105.

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16.3.2.3 Sleep Count Threshold register

Table 155. Sleep Count Threshold register

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Read Write	SLEEPTHD															
Reset	0x0001															

Table 156. Sleep Count Threshold register field descriptions

Field	Description
15:0 SLEEPTHD	Autonomous suspend debounce count threshold. The autonomous suspend condition(1) must be satisfied for SLEEPTHD samples for the pedometer to autonomously suspend. Valid range: 0x0000:0xFFFF (uint16).

1. The acceleration vector magnitude must be greater than SLEEPMIN and less than SLEEPMAX to satisfy this condition. For more information on SLEEPMIN and SLEEPMAX, see "Sleep Minimum register" and "Sleep Maximum register".

16.3.2.4 Configuration/Step Length register

Table 157. Configuration/Step Length register

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Read	CONFIG	ACT_DBCNTM	SLP_DBCNTM	—					STEPLEN							
Write																
Reset	0	0	0	00000					0x00							

= Unimplemented or reserved

Table 158. Configuration/Step Length register field descriptions

Field	Description
15 CONFIG	(Re)initializes the pedometer with current configuration values. Modifications to other pedometer configuration registers will not take effect until this bit is set. It is automatically cleared after the (re)initialization completes. 0: Do not (re)initialize the pedometer 1: (Re)initialize the pedometer with current configuration values
14 ACT_DBCNTM	Activity debounce counter mode. 0: Decrement the count when the activity level changes 1: Clear the count when the activity level changes
13 SLP_DBCNTM	Autonomous suspend debounce counter mode. 0: Decrement the count when the device is in motion 1: Clear the count when the device is in motion
12:8 —	Reserved. Set to 0.
7:0 STEPLEN	Step length in centimeters. Set to 0 to automatically estimate the consumer's step length based on gender and height. Valid range: 0x00:0xFF (uint8)

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16.3.2.5 Height/Weight register

Table 159. Height/Weight register

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Read	HEIGHT								WEIGHT							
Write																
Reset	0xAF								0x50							

Table 160. Height/Weight register field descriptions

Field	Description
15:8 HEIGHT	Height in centimeters. Used to estimate step length, if STEPLEN = 0. Valid range: 0x00:0xFF (uint8) Default = 0xAF (175 centimeters).
7:0 WEIGHT	Weight in kilograms. Used to estimate step length, if STEPLEN = 0. Valid range: 0x00:0xFF (uint8) Default = 0x50 (80 kilograms).

16.3.2.6 Filter register

Table 161. Filter register

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Read	FILTSTEP								MALE	FILTTIME						
Write																
Reset	0x04								0	0x03						

Table 162. Filter register field descriptions

Field	Description
15:8 FILTSTEP	Number of steps that must occur within FILTTIME for the pedometer to decide the consumer is making steps. Set to 0 to disable step filtering. If the value specified is greater than 6, then 6 will be used. Valid range: 0x00:0x06 (uint8). Default = 0x04.
7 MALE	Gender 0: Female 1: Male
6:0 FILTTIME	Number of seconds in which filter steps must occur. Set to 0 to disable step filtering. Valid range: 0x00:0x7F (uint8) Default = 0x03.

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16.3.2.7 Speed Period/Step Threshold register

Table 163. Speed Period register

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Read	SPDPRD								STEPTHRESHOLD							
Write																
Reset	0x05								0x82							

Table 164. Speed Period/Step Threshold register field descriptions

Field	Description
15:8 SPDPRD	Number of seconds in which to compute speed. If set to a value greater than 5, then 5 will be used. Valid range: 0x02:0x05. **Warning:** Do not set SPDPRD to 0 or 1 as this may cause undesirable behavior.
7:0 STEPTHRESHOLD	Magnitude acceleration threshold to detect a step. Large values make the pedometer less sensitive; small values make the pedometer more sensitive and may lead to false positives. Units: 1 mg/LSB Valid range: 0x00:0xFF (uint8) Default: 0x82 (0.13 *g*)

16.3.2.8 Activity Count Threshold register

Table 165. Activity Count Threshold register

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Read	ACTTHD															
Write																
Reset	0x0000															

Table 166. Activity Count Threshold register field descriptions

Field	Description
15:0 ACTTHD	Activity debounce count threshold. The internal activity level must be stable for ACTTHD samples before ACTIVITY is updated. Valid range: 0x0000:0xFFFF (uint16) 0: The activity debouncer is effectively bypassed.[(1)] 1: The current internal activity level must equal the previous internal activity level in order to update ACTIVITY.

1. For more information on the activity debouncer, see Table 158 on page 105.

16.3.2.9 Step Coalesce register

Table 167. Step Coalesce register

Bit	7	6	5	4	3	2	1	0
Read	STEPCOALESCE							
Write								
Reset	0X01							

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Table 168. Activity Count Threshold register field descriptions

Field	Description
7:0 STEPCOALESCE	Number of steps to coalesce before asserting STEPCHG. 0: Disables STEPCHG. 1: Asserts STEPCHG after every step. The default. Valid range: 0x00:0xFF (uint8).

16.3.3 Pedometer status-register descriptions

Table 169. Status register

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Read	MRGFL	SUSPCHG	STEPCHG	ACTCHG	SUSP	ACTIVITY			VERSION							
Write																
Reset	0	0	0	0	0	000			0x02							

= Unimplemented or reserved

16.3.3.1 Status register

Table 170. Status register field descriptions

Field	Description
15 MRGFL	Merged status change flags. This bit is the logical OR of the SUSPCHG, STEPCHG, and ACTCHG flags. It can be routed to a pin to enable a single, merged-output interrupt using the MMA955xL GPIO application(1). The host can trigger an interrupt on rising edges to receive notification when at least one of the status change flags is asserted. The host is responsible for resolving the source if desired. That can be done by comparing the STEPCNT to a previous value to determine that a STEPCNT change caused the MRGFL assertion. 0: None of the status change flags are asserted 1: At least one of the status change flags (SUSPCHG, STEPCHG, ACTCHG) is asserted
14 SUSPCHG	Indicates a change in the SUSP bit. This bit is transient and only asserts during frames in which the SUSP bit changes from the previous frame. A frame is one 30-Hz period. This bit can be routed to a pin to enable output interrupts using the MMA9555L GPIO AppMap application(1). The host can trigger an interrupt on rising edges to receive notification when the pedometer suspends or resumes. 0: No change in the SUSP bit since the last pedometer call. 1: The SUSP bit changed since the last pedometer call.
13 STEPCHG	Indicates a change in STEPCNT by STEPCOALSCE steps. This bit is transient and only asserts during frames in which STEPCNT changed from the previous frame. A frame is one 30-Hz period. This bit can be routed to a pin to enable output interrupts using the MMA9555L GPIO AppMap application(1). The host can trigger an interrupt on rising edges to receive notification after every step. 0: The step count has not been incremented by STEPCOALESCE steps since the last STEPCHG assertion or the pedometer was last initialized. 1: The step count has been incremented by STEPCOALESCE steps since the last STEPCHG assertion or the pedometer was last initialized.

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Table 170. Status register field descriptions

Field	Description
12 ACTCHG	Indicates a change in activity level. This bit is transient and only asserts during frames in which ACTIVITY changed from the previous frame. A frame is one 30-Hz period. This bit can be routed to a pin to enable output interrupts using the MMA9555L GPIO AppMap application[(1)]. The host can trigger an interrupt on rising edges to receive notification when the activity level is changed. 0: No change in activity level since last pedometer call 1: New activity level since last pedometer call
11 SUSP	Indicates whether the pedometer is active or has been autonomously suspended. This bit can be routed to a pin to enable output interrupts using the MMA9555L GPIO AppMap application[(1)]. The host can trigger an interrupt on rising edges to receive notification when the pedometer is autonomously suspended and trigger an interrupt on falling edges to receive notification when the pedometer resumes. 0: Pedometer is active 1: Pedometer is suspended
10:8 ACTIVITY	Activity level: 000: Unknown 001: Rest 010: Walking 011: Jogging 100: Running 101–111: Reserved
7:0 VERSION	Version number of the pedometer application, incremented by one for each new release. 0: R1.32 1: R1.33 2: R1.34

1. For more information on the GPIO AppMap application, see Chapter 7, “GPIO-AppMap Application”.

16.3.3.2 Step Count register

Table 171. Step Count register

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Read	STEPCNT															
Write																
Reset	0x0000															

= Unimplemented or reserved

Table 172. Step Count register field descriptions

Field	Description
15:0 STEPCNT	The total step count since the pedometer was last reset. Valid range: 0x0000:0xFFFF (uint16)

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16.3.3.3 Distance register

Table 173. Distance register

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Read	DIST															
Write																
Reset	0x0000															

= Unimplemented or reserved

Table 174. Distance register field descriptions

Field	Description
15:0 DIST	The total distance in meters since the pedometer was last reset. Valid range: 0x0000:0xFFFF (uint16).

16.3.3.4 Speed register

If there are no steps, the speed may not necessarily fall to zero even if the activity level falls to rest. See 16.2.3, “Speed calculation” on page 100 for more information.

Table 175. Speed register

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Read	SPEED															
Write																
Reset	0x0000															

= Unimplemented or reserved

Table 176. Speed register field descriptions

Field	Description
15:0 SPEED	Average speed in meters per hour over SPDPRD[(1)]. Valid range: 0x0000:0xFFFF (uint16)

1. For information on SPDPRD, see Table 164 on page 107.

16.3.3.5 Calories register

Table 177. Calories register

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Read	CALS															
Write																
Reset	0x0000															

= Unimplemented or reserved

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Table 178. Calories register field descriptions

Field	Description
15:0 CALS	Total calorie count since the pedometer was last reset. Valid range: 0x0000:0xFFFF (uint16)

16.3.3.6 Sleep Count register

Table 179. Sleep Count register

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Read	SLEEPCNT															
Write																
Reset	0x0000															

= Unimplemented or reserved

Table 180. Sleep Count register field descriptions

Field	Description
15:0 SLEEPCNT	Current value of the autonomous suspend debounce counter. Valid range: 0x0000:0xFFFF (uint16)

16.4 Pedometer application examples

16.4.1 Pedometer application configuration example

To write all the pedometer configuration registers, the following command packet shall be sent from the host to the device mailboxes. The most significant byte of a register (MSB) is written in the lowest-numbered mailbox.

NOTE

The question marks represent placeholders for the application specific values. Please replace the question marks with values for the application.

MB0 = 0x15: Set the Pedometer Application Identifier (0x15)

MB1 = 0x20: Set the Command: Write Config command, with zero offset (0x20)

MB2 = 0x00: Set the Offset to point to the first configuration register

MB3 = 0x11: Set the Count field to declare writing 17 bytes

MB4–MB5 = 0x????: Value for Sleep Min Register

MB6–MB7 = 0x????: Value for Sleep Max Register

MB8–MB9 = 0x????: Value for Sleep Count Threshold

MB10–MB11 = 0x????: Value for Config / Step Length Register

MB12–MB13 = 0x????: Value for Height / Weight

MB14–MB15 = 0x????: Set the Filter Register

MB16–17 = 0x????: Set the Speed Period / Step Threshold Register

MB18–19 = 0x????: Set the Activity Count

MB20 = 0x??: Set the Step Coalesce

Bytes to send: 0x15, 0x20, 0x00, 0x11, 0x??, 0x??, 0x??, 0x??, 0x??, 0x??, 0x??, 0x??, 0x??, 0x??, 0x??, 0x??, 0x??, 0x??, 0x??, 0x??, 0x??

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Pedometer application examples

To read all the pedometer configuration registers, send the following command packet from the host to the device mailboxes. This can be used as a device identification command, allowing a host to differentiate the MMA9555L from the MMA955xL.

MB0: 0x15 = pedometer application ID

MB1: 0x10 = opcode to read configuration

MB2: 0x00 = offset into pedometer configuration register map

MB3: 0x11 = number of bytes to read

The MMA9555L response will be:

MB0: 0x15 = pedometer application ID

MB1: 0x80 = COCO=1, error code=0

MB2: 0x11 = actual number of bytes read

MB3: 0x11 = requested number of bytes to read

MB4: sleep minimum MSB

MB5: sleep minimum LSB

MB6: sleep maximum MSB

MB7: sleep maximum LSB

MB8: sleep count threshold MSB

MB9: sleep count threshold LSB

MB10: config

MB11: step length MB12: height

MB13: weight

MB14: filter step

MB15: male, filter time

MB16: speed period

MB17: step threshold

MB18: activity count threshold MSB

MB19: activity count threshold LSB

MB20: step coalesce

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16.4.2 Pedometer application read example

To read all the pedometer status registers, send the following command packet from the host to the device mailboxes:

MB0 = 0x15: Set the Pedometer Application Identifier (0x15)

MB1 = 0x30: Set the Command: Read Status command, with zero offset (0x30)

MB2 = 0x00: Set the Offset (0x00) to point to the first status register

MB3 = 0x0C: Set the Count field to (12) to declare reading 12 bytes

Read back the mailboxes, when the COCO (Command Complete) bit is set the status data will be in the mailbox registers.

Bytes to send: 0x15, 0x30, 0x00, 0x0C

The response to this command will be:

MB0: 0x15 = pedometer application ID

MB1: 0x80 = COCO=1, error code=0

MB2: 0x0C = actual number of bytes read

MB3: 0x0C = requested number of bytes to read

MB4: pedometer status register MSB

MB5: pedometer status register LSB

MB6: step count MSB

MB7: step count LSB

MB8: distance MSB

MB9: distance LSB

MB10: speed MSB

MB11: speed LSB

MB12: calories MSB

MB13: calories LSB

MB14: sleep count MSB

MB15: sleep count LSB

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17 GPIO Input/Output Application

17.1 Overview of GPIO Input/Output application

Application ID	0x19
Default speed	30 Hz.
Configuration registers	Start on page 115.
Status registers	Start on page 116.

The GPIO input/output application provides a function that can control seven physical GPIO pins of MMA9555L. It can set the direction GPIOs as input or output, control the pin level when the pin is set as an output pin and read the pin level through its status register. It also has a mask register, called the *Enable Configuration Register*, to avoid conflict with the GPIO AppMap application APP-ID 0x03.

The GPIO pins that are available to this application are described in Table 181.

Table 181. GPIO pin names, numbers and functions

Name	Pin number
GPIO2	7
GPIO3	8
GPIO4	9
GPIO5	11
GPIO6	12
GPIO7	13
GPIO8	15
GPIO9	2

17.2 Memory maps and register descriptions

The GPIO Input/Output Application has three configuration registers and one status register. The configuration registers allow the user to customize and control the behavior of the GPIO Input/Output application. The status registers report back the level of the GPIO2–GPIO9. The status register is 8 bits wide.

Similarly, configuration registers are 8 bits wide. They can be written one byte at a time if desired. All bytes should be written using a single command if the user wishes to modify them atomically.

17.2.1 GPIO Input/Output memory maps

Table 182. Configuration Registers

Offset address	Register	Access	Reset	Details
0x00	GPIO input/output direction register	R/W	0x0F	"GPIO input/output direction register" on page 115
0x01	GPIO input/output enable register	R/W	0x0F	"GPIO input/output enable register" on page 115
0x02	GPIO input/output data register	R/W	0x05	"GPIO input/output data register" on page 116

Table 183. Status register

Offset address	Register	Access	Reset	Details
0x00	GPIO input/output Status register	R	0x05	"GPIO Input/Output Status register" on page 116

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17.3 GPIO Input/Output configuration register descriptions

17.3.1 GPIO input/output direction register

Table 184. GPIO input/output direction register

Bit	7	6	5	4	3	2	1	0
Read		DIR8	DIR7	DIR6	DIR5	DIR4	DIR3	DIR2
Write								
Reset	0x0F							

= Unimplemented or reserved

Table 185. GPIO input/output direction register field description

Field	Description
6:0 DIR8–DIR2	GPIO data direction. The value of this register is shifted and then copied to the hardware register RGPIO_DIR. 0: Configured as an input 1: Configured as an output

17.3.2 GPIO input/output enable register

Table 186. GPIO input/output enable register

Bit	7	6	5	4	3	2	1	0
Read		EN8	EN7	EN6	EN5	EN4	EN3	EN2
Write								
Reset	0x0F							

= Unimplemented or reserved

Table 187. GPIO input/output enable register description

Field	Description
6:0 EN8–EN2	GPIO enable. The value of this register is shifted and then copied to the hardware register RGPIO_EN. 0: Disable the pin in this application 1: Enable the pin in this application

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17.3.3 GPIO input/output data register

Table 188. GPIO input/output data register

Bit	7	6	5	4	3	2	1	0
Read		DATA8	DATA7	DATA6	DATA5	DATA4	DATA3	DATA2
Write								
Reset	0x05							

= Unimplemented or reserved

Table 189. GPIO input/output data register description

Field	Description
6:0 EN8–EN2	GPIO data output. The value of this register is shifted and then copied to the hardware register RGPIO_DATA. 0: Output low on the pin 1: Output high on the pin

17.4 GPIO Input/Output Status register descriptions

17.4.1 GPIO Input/Output Status register

Table 190. GPIO input/output status register

Bit	7	6	5	4	3	2	1	0
Read	DATA9	DATA8	DATA7	DATA6	DATA5	DATA4	DATA3	DATA2
Write								
Reset	0x05							

= Unimplemented or reserved

Table 191. GPIO input/output status register description

Field	Description
7:0 DATA9–DATA2	GPIO data output. The value of this register is read from hardware register RGPIO_DATA. 0: A properly enabled RGPIO output pin is driven with a logic 0, or a properly enabled RGPIO input pin was read as a logic 0 1: A properly enabled RGPIO output pin is driven with a logic 1, or a properly enabled RGPIO input pin was read as a logic 1

NOTE

Though GPIO9 cannot be set in the configuration registers, the pin level can be detected in the status register when GPIO9 is set as interrupt pin in APP-ID 0x03.

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17.5 GPIO Input/Output application examples

17.5.1 GPIO Input/Output application configuration example

To write all the GPIO Input/Output configuration registers, the following command packet should be sent from the host to the device mailboxes. The most significant byte of a register (MSB) is written in the lowest-numbered mailbox.

NOTE

The question marks represent placeholders for the application specific values. Please replace the question marks with the values for the application.

MB0 : 0x19= Set the GPIO Input/Output Application Identifier (0x19)

MB1 : 0x20= Set the Command: Write Config command, with zero offset (0x20)

MB2 : 0x00= Set the Offset to point to the first configuration register

MB3 : 0x03= Set the Count field to declare writing 3 bytes

MB4 : 0x??= Value for GPIO input/output direction register

MB5 : 0x??= Value for GPIO input/output enable register

MB6 : 0x??= Value for GPIO input/output data register

Bytes to send: 0x19, 0x20, 0x00, 0x03, 0x??, 0x??, 0x??

To read all the GPIO Input/Output configuration registers, the following command packet should be sent from the host to the device mailboxes.

MB0: 0x19= GPIO Input/Output application ID

MB1: 0x10= opcode to read configuration

MB2: 0x00= offset into GPIO Input/Output configuration register map

MB3: 0x03= number of bytes to read

The MMA9555L response will be:

MB0: 0x19 = GPIO Input/Output application ID

MB1: 0x80 = COCO=1, error code=0

MB2: 0x03 = actual number of bytes read

MB3: 0x03 = requested number of bytes to read

MB4: Value of GPIO input/output direction register

MB5: Value of GPIO input/output enable register

MB6: Value of GPIO input/output data register

17.5.2 GPIO Input/Output application read example

To read the GPIO Input/Output status register, the following command packet is sent from the host to the device mailboxes:

MB0 : 0x19 = Set the GPIO Input/Output Application Identifier (0x19)

MB1 : 0x30 = Set the Command: Read Status command, with zero offset (0x30)

MB2 : 0x00 = Set the Offset (0x00) to point to the first status register

MB3 : 0x01= Set the Count field to (1) to declare reading 1 byte

Bytes to send: 0x19, 0x30, 0x00, 0x01

To read the mailboxes, when the COCO (Command Complete) bit is set, the status data are in the mailbox registers.

The response to this command is:

MB0: 0x19 = GPIO Input/Output application ID

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MB1: 0x80 = COCO=1, error code=0

MB2: 0x01 = actual number of bytes read

MB3: 0x01 = requested number of bytes to read

MB4: GPIO input/output Status register

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18 Six-Direction Application

18.1 Overview of the Six-Direction application

Application ID	0x1A
Default speed	30 Hz.
Configuration registers	Start on page 120.
Status registers	Start on page 121.

The Six-Direction application detects six major directional orientations of the device in three-dimensional space. It determines the primary axis that the device is oriented: +X, –X, +Y, –Y, +Z or –Z, with reference opposite to the direction of gravity. It uses the coordinate system as defined in Figure 5 on page 12.

When the absolute *g* value of the current direction is less than half *g*, the application detects which axis has the largest absolute *g* value. If this axis is kept as the largest and the debounce count meets the count threshold, it updates the status of the direction. When the absolute *g* value of the current direction is larger than half *g*, it keeps current direction.

18.2 Memory maps and register descriptions

The Six-Direction Application running in the MMA9555L device has two configuration registers and two status registers. The configuration registers allow the user to customize and control the behavior of the Six-Direction application. The status registers report current direction status, status change flag and debounce count status.

The status registers are 8 bits wide. They are byte-accessible, but should be read two bytes at a time with a single command, if the user wishes to read them atomically.

Similarly, configuration registers are 8 bits wide. They can be written one byte at a time if desired. All bytes should be written using a single command if the user wishes to modify them atomically.

18.2.1 Six Direction register memory maps

Table 192. Configuration registers

Offset address	Register	Access	Reset	Details
0x00	SixDir Count Threshold register	R/W	0x1E	"SixDir Count Threshold register" on page 120
0x01	SixDir Debounce mode register	R/W	0x01	"SixDir Debounce mode register" on page 120

Table 193. Status register

Offset address	Register	Access	Reset	Details
0x00	SixDir Current Status register	R/W	0x06	"SixDir Current Status register" on page 121
0x01	SixDir Debounce count register	R/W	0x00	"SixDir Debounce count register" on page 121

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18.3 Six Direction configuration register descriptions

18.3.1 SixDir Count Threshold register

Table 194. SixDir Count Threshold register

Bit	7	6	5	4	3	2	1	0
Read Write	SDTHD							
Reset	0x30							

= Unimplemented or reserved

Table 195. SixDir Count Threshold register description

Field	Description
7:0 SDTHD	SixDir debounce count threshold. The status of the direction is not changed until the debounce count meets this threshold. Valid range: 0x00:0xFF (uint8).

18.3.2 SixDir Debounce mode register

Table 196. SixDir Debounce mode register

Bit	7	6	5	4	3	2	1	0
Read Write								SDM
Reset	0x01							

= Unimplemented or reserved

Table 197. SixDir Debounce mode register description

Field	Description
0 SDM	SixDir debounce counter mode. 0: Decrement the count when the device changes direction 1: Clear the count when the device changes direction

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18.4 Six Direction Status register descriptions

18.4.1 SixDir Current Status register

Table 198. SixDir Current Status register

Bit	7	6	5	4	3	2	1	0
Read Write	SC_FLG					AXIS_POS	AXIS	
Reset	0x06							

= Unimplemented or reserved

Table 199. SixDir Current Status register description

Field	Description
7 SC_FLG	Direction Status change flag. 0: Direction has not changed 1: Direction changed. The bit is cleared when the register is read.
2 AXIS_POS	Sign of the direction of the axis detected 0 : Negative Direction 1: Positive direction
1:0 AXIS	Direction is on which axis. 00: X axis 01: Y axis 10: Z axis

18.4.2 SixDir Debounce count register

Table 200. SixDir Debounce count register

Bit	7	6	5	4	3	2	1	0
Read Write	SDCNT							
Reset	0x00							

= Unimplemented or reserved

Table 201. SixDir Debounce count register description

Field	Description
7:0 SDCNT	The total debounce count since the direction status was last reset. Valid range: 0x00:0xFF (uint8)

18.4.3 Six Direction application configuration example

To write all the Six-Direction configuration registers, the host should send the following command packet to the mailboxes. The most significant byte of a register (MSB) is written in the lower numbered mailbox.

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NOTE

The question marks represent placeholders for the application-specific values. Please replace the question marks with the desired values for the application.

MB0 : 0x1A= Set the Six-Direction Application Identifier (0x1A)

MB1 : 0x20= Set the Command: Write Config command, with zero offset (0x20)

MB2 : 0x00= Set the Offset to point to the first configuration register

MB3 : 0x02= Set the Count field to declare writing 2 bytes

MB4 : 0x??= Value for SixDir Count Threshold register

MB5 : 0x??= Value for SixDir Debounce mode register

Bytes to send: 0x1A, 0x20, 0x00, 0x02, 0x??, 0x??

To read all the Six-Direction configuration registers, the following command packet is sent from the host to the device mailboxes.

MB0: 0x1A= Six-Direction application ID

MB1: 0x10= opcode to read configuration

MB2: 0x00= offset into Six-Direction configuration register map

MB3: 0x02= number of bytes to read

The MMA9555L response will be:

MB0: 0x1A = Six-Direction application ID

MB1: 0x80 = COCO=1, error code=0

MB2: 0x02 = actual number of bytes read

MB3: 0x02 = requested number of bytes to read

MB4: Value of SixDir Count Threshold register

MB5: Value of SixDir Debounce mode register

18.4.4 Six Direction application read example

To read the Six-Direction status register, the following command packet is sent from the host to the device mailboxes:

MB0 : 0x1A = Set the Six-Direction Application Identifier (0x1A)

MB1 : 0x30 = Set the Command: Read Status command, with zero offset (0x30)

MB2 : 0x00 = Set the Offset (0x00) to point to the first status register

MB3 : 0x02= Set the Count field to (2) to declare reading 2 bytes

Bytes to send: 0x1A, 0x30, 0x00, 0x02

To read the mailboxes, when the COCO (Command Complete) bit is set, the status data is in the mailbox registers.

The response to this command is:

MB0: 0x1A= Six-Direction application ID

MB1: 0x80 = COCO=1, error code=0

MB2: 0x02 = actual number of bytes read

MB3: 0x02 = requested number of bytes to read

MB4: Value of SixDir Current Status register

MB5: Value of SixDir Debounce count register

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19 Sample operations

This section provides sample slave-port commands to read and modify application variables.

19.1 Read pedometer status variables

This command reads all 12 bytes of the status variables from the Pedometer application (APP_ID=0x15), starting at byte offset 0.

```
15 30 00 0C
```

19.2 Read pedometer configuration variables

This command reads all 16 bytes of the configuration variables from the Pedometer application (APP_ID=0x15), starting at byte offset 0.

```
15 10 00 10
```

19.3 Write pedometer configuration variables

This command writes all 16 bytes of the configuration variables to the Pedometer application (APP_ID=0x15), starting at byte offset 0.

```
15 20 00 10 00 11 22 33 44 55 66 77 88 99 AA BB CC DD EE FF
```

19.4 Read GPIO Input/output status variables

This command reads the status variable from the GPIO input/output application (APP_ID=0x19), starting at byte offset 0.

```
19 30 00 01
```

19.5 Read GPIO Input/output configuration variables

This command reads all 3 bytes of the configuration variables from the GPIO input/output application (APP_ID=0x19), starting at byte offset 0.

```
19 10 00 03
```

19.6 Write GPIO Input/output configuration variables

This command writes all 3 bytes of the configuration variables to the GPIO input/output application (APP_ID=0x19), starting at byte offset 0.

```
19 20 00 03 xx xx xx
```

19.7 Read Six direction status variables

This command reads the two status variables from the Six Direction application (APP_ID=0x1A), starting at byte offset 0.

```
1A 30 00 02
```

19.8 Read Six direction configuration variables

This command reads all 2 bytes of the configuration variables from the Six Direction application (APP_ID=0x1A), starting at byte offset 0.

```
1A 10 00 02
```


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19.9 Write Six direction configuration variables

This command writes all 3 bytes of the configuration variables to the Six Direction application (APP_ID=0x19), starting at byte offset 0.

```
1A 20 00 02 xx xx
```

19.10 Reset pedometer configuration variables to their defaults

This command writes one byte of configuration variable to the Reset/Suspend/Clear application (APP_ID=0x17) starting at byte offset 1.

This causes the scheduler to invoke the pedometer's reset function, pedometer_reset().

```
17 20 01 01 20
```

19.11 Enable/disable the Pedometer application

This command writes one byte of configuration variable to the Reset/Suspend/Clear application (APP_ID=0x17) starting at byte offset 5.

This causes the scheduler to suspend the Pedometer application, even if the device is not stationary.

```
17 20 05 01 20 (disable)
17 20 05 01 00 (enable)
```

19.12 Configure the AFE range

This command writes one byte of the configuration variable to the AFE application (APP_ID=0x06), starting at byte offset 0. Since the pedometer uses a normalized acceleration output provided by the AFE application, the g mode only affects the saturation level and noise.

Regardless of what *g* mode the AFE is configured to, for or by other applications, the resolution seen by the Pedometer application is always 8 *g*.

```
06 20 00 01 40 (2 g mode)
06 20 00 01 80 (4 g mode)
06 20 00 10 00 (8 g mode)
```

For more information on configuring the AFE range, see the "AFE configuration registers" section.

19.13 Configure output interrupt: Activity change on GPIO6

This command writes two bytes of the configuration variable to the GPIO application (APP_ID=0x03), starting at byte offset 0.

This causes the GPIO application to copy the pedometer's ACTCHG status bit to GPIO6 after every new accelerometer sample. The host processor can trigger an interrupt on rising edges of this pin to receive notification when the activity level changes.

```
03 20 00 02 15 04
19 20 01 01 (AB & 6F)
```

19.14 Configure output interrupt: Step change on GPIO7

This command writes two bytes of the configuration variable to the GPIO application (APP_ID=0x03), starting at byte offset 2.

This causes the GPIO application to copy the pedometer's STEPCHG status bit to GPIO7 after every new accelerometer sample. The host processor can trigger an interrupt on rising edges of this pin to receive notification when the step count changes.

```
03 20 02 02 15 05
19 20 01 01 (AB & 5F)
```


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19.15 Configure output interrupt: Suspend change on GPIO8

This command writes two bytes of the configuration variable to the GPIO application (APP_ID=0x03) starting at byte offset 4.

This causes the GPIO application to copy the pedometer's SUSPCHG status bit to GPIO8 after every new accelerometer sample. The host processor can trigger an interrupt on rising edges of this pin to receive notification when the pedometer autonomously suspends or resumes.

```
03 20 04 02 15 06
19 20 01 01 (AB & 3F)
```

19.16 Configure output interrupt: Merged flags on GPIO6

This command writes two bytes of the configuration variable to the GPIO application (APP_ID=0x03) starting at byte offset 0.

This causes the GPIO application to copy the pedometer's MRGFL status bit to GPIO6 after every new accelerometer sample. The host processor can trigger an interrupt on rising edges of this pin to receive notification the activity-level, step-count, or suspend-state changes.

```
03 20 00 02 15 07
19 20 01 01 (AB & 6F)
```

19.17 Configure output interrupt: Every 10 steps on GPIO7

The first command writes one byte of configuration variable to the Pedometer application (APP_ID = 0x15), starting at byte offset 13. This causes the pedometer to coalesce steps and assert STEPCHG once every 10 steps.

The second command writes two bytes of configuration variables to the GPIO application (APP_ID = 0x03), starting at byte offset 2. This causes the GPIO application to copy the pedometer's STEPCHG status bit to GPIO7 after every new accelerometer sample.

```
15 20 0D 01 0A
03 20 02 02 15 05
19 20 01 01 (AB & 5F)
```

19.18 Configure output interrupt: Device direction change on GPIO6

This command writes two bytes of the configuration variable to the GPIO application (APP_ID=0x03), starting at byte offset 0.

This causes the GPIO application to copy the Six-Direction's SC_FLG status bit to GPIO6 after every new accelerometer sample. The host processor can trigger an interrupt on rising edges of this pin to receive notification when the activity level changes.

```
03 20 00 02 1A 07
19 20 01 01 (AB & 6F)
```

19.19 Wake up from Deep Sleep (Stop No Clock mode)

By default, the MMA955xL initializes all applications after a hardware reset and then falls into Deep Sleep mode where all system clocks are stopped. A slave-port command can be used to wake up the clocks, enable the accelerometer, and execute the pedometer.

This command writes one byte of configuration variable to the sleep/wake application (APP_ID=0x12) starting at byte offset 6.

```
12 20 06 01 00
```


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20 Package Information

The MMA9555L uses a 16-lead LGA package, case number 2094. Use the following link for the latest diagram of the package: www.nxp.com/files/shared/doc/package_info/98ASA00287D.pdf

20.1 Footprint and pattern information

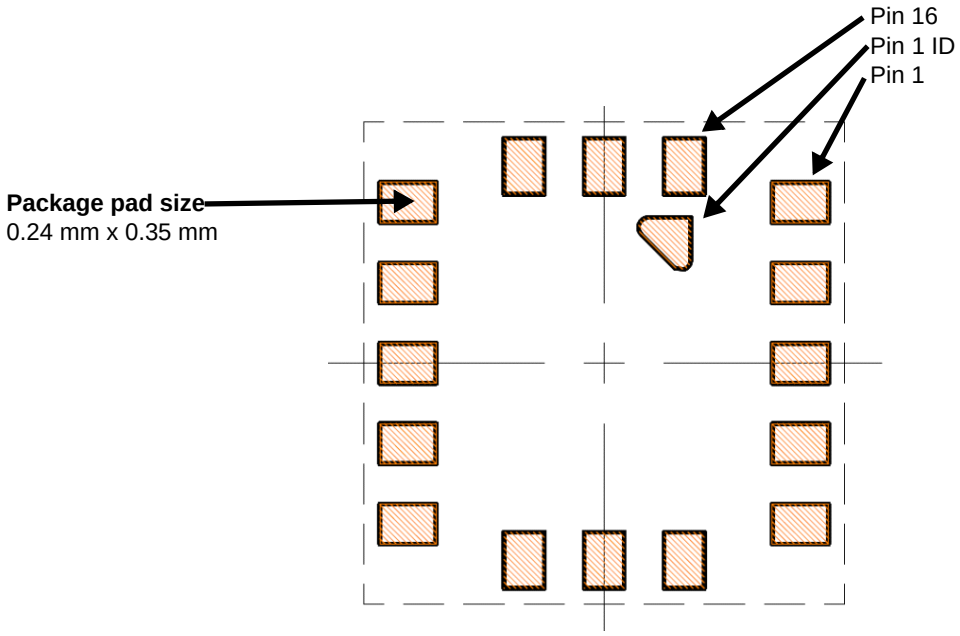

Figure 24. Package bottom view

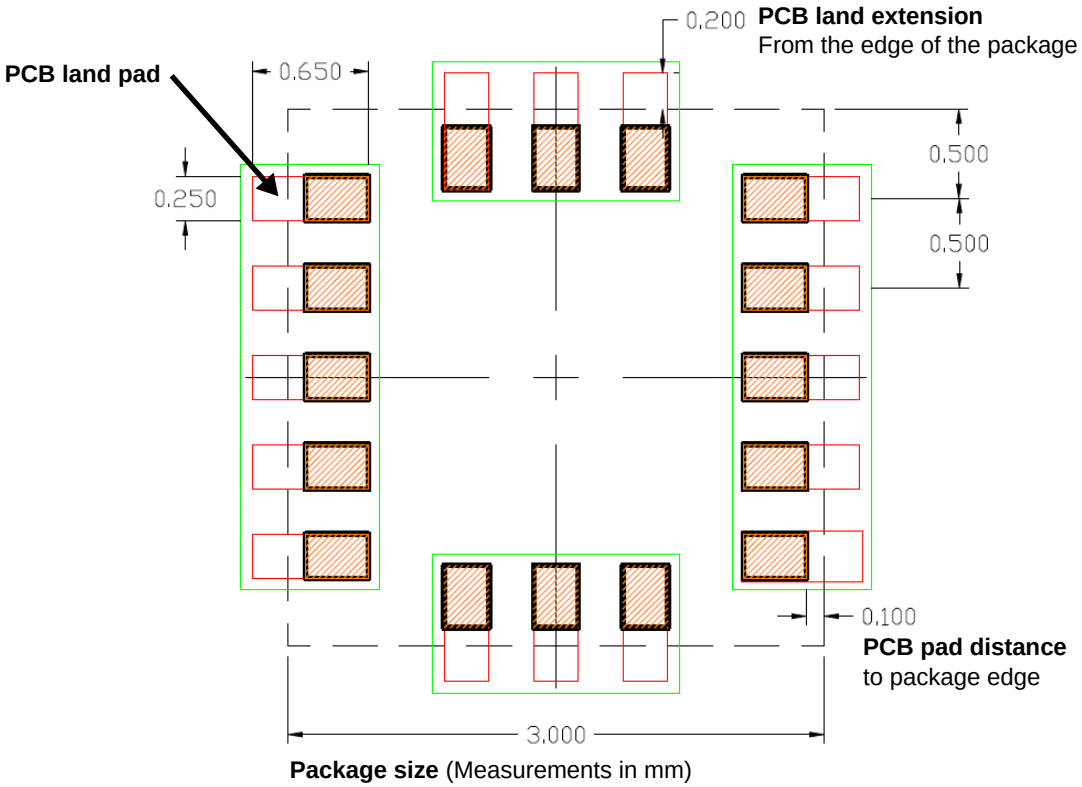

Figure 25. Package overlaid on PCB footprint diagram (top view)

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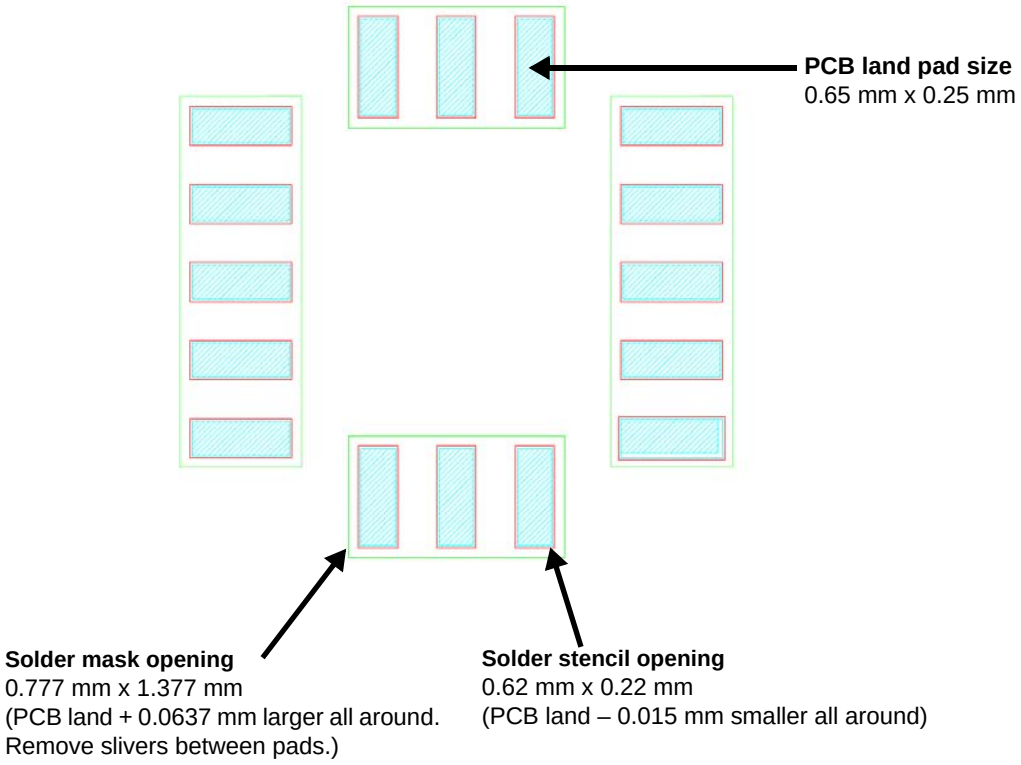
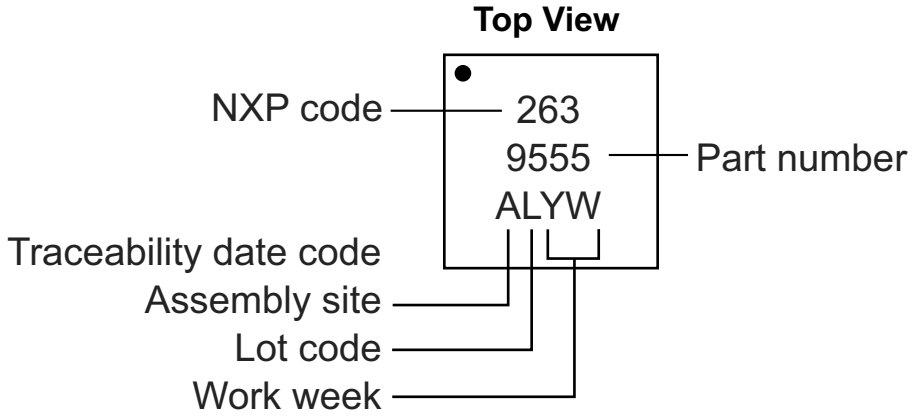


Figure 26. Recommended PCB footprint

20.2 Marking



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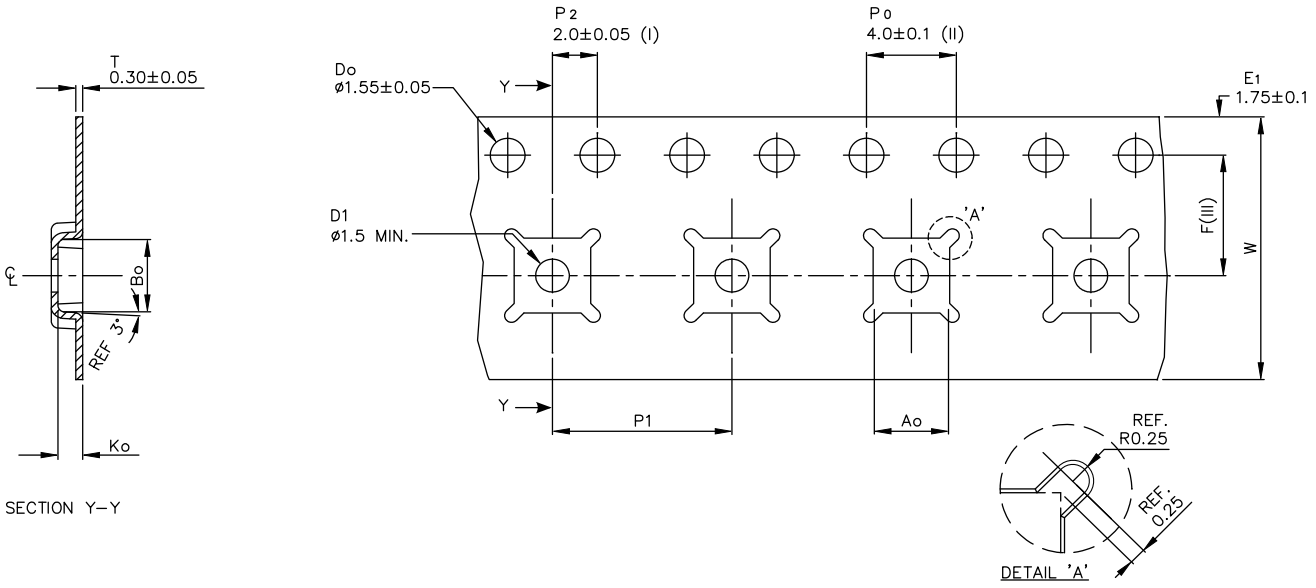
20.3 Tape and reel information



Ao	3.30 +/− 0.1
Bo	3.30 +/− 0.1
Ko	1.10 +/− 0.1
F	5.50 +/− 0.05
P_1	8.00 +/− 0.1
W	12.00 +/− 0.3

(I) Measured from centerline of sprocket hole to centerline of pocket.
(II) Cumulative tolerance of 10 sprocket holes is ± 0.20 .
(III) Measured from centerline of sprocket hole to centerline of pocket.
(IV) Other material available.
(V) Typical SR value Max 10^9 OHM/SQ
ALL DIMENSIONS IN MILLIMETERS UNLESS OTHERWISE STATED.

Figure 27. Tape dimensions

The devices are oriented on the tape as shown in Figure 28. The dot marked on each device indicates pin 1.

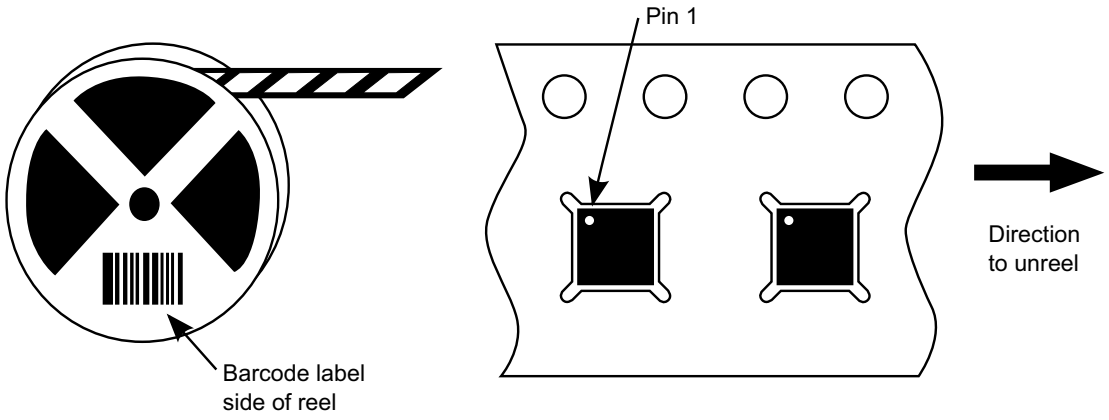


Figure 28. Tape and reel orientation

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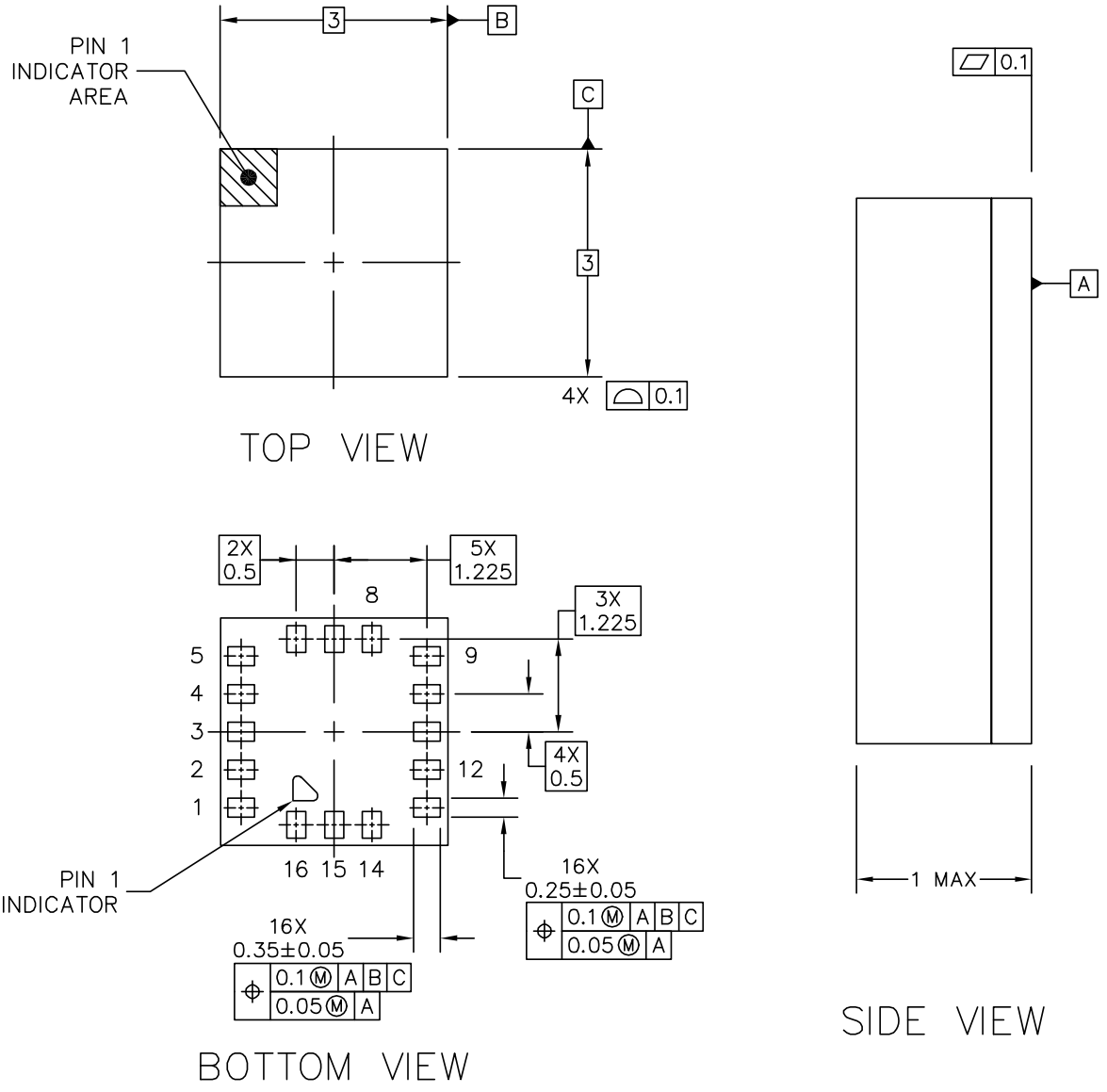
20.4 Package Description

Use the following link for the latest diagram of the package:
www.nxp.com/files/shared/doc/package_info/98ASA00287D.pdf



NOTES:

1. ALL DIMENSIONS IN MILLIMETERS.
2. DIMENSIONING AND TOLERANCING PER ASME Y14.5M–1994
3. DIMENSIONS ARE SYMETRIC ABOUT THE CENTEP

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TITLE: LGA 16 I/O, 3 X 3 X 0.5 PITCH, SENSOR, 1 MM PKG	DOCUMENT NO: 98ASA00287D	REV: O	
	CASE NUMBER: 2094–01	21 OCT 2010	
	STANDARD: NON–JEDEC		

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Revision History

Revision number	Revision date	Description of changes
1.0	10/2014	Initial release of document.
2.0	3/2015	Features, 117 µA for pedometer... was 190 µA for pedometer Figure 2, Device pinout Changed pin 6 from RGPIO/SDA0/SDI to RGPIO1/SDA0/SDI Changed pin 8 from RGPIO3/SBB to RGPIO3/SSB Figures 3 and 4 Changed pin 7 from IO2/SCL1/SDO to IO2/SDO Changed pin 8 from IO3/SDA1/SSB to IO3/SSB Added Sections 4–10. Section 16.3.2.7, added Step Threshold Table 167, Version Reset changed from 0x01 to 0x02 Table 168, 7:0, VERSION, added 2: R1.34 Section 16.4.1, To write all the pedometer configuration registers,... MB3 = 0x11: Set the Count field to declare writing 17 bytes was MB3 = 0x10: Set the Count field to declare writing 16 bytes MB16-17 = 0x????: Set the Speed Period / Step Threshold Register was MB16–MB17 = 0x????: Set the Speed Period Added MB20 = 0x??: Set the Step Coalesce Bytes to send: 0x15, 0x20, 0x00, 0x11, 0x??, 0x??, 0x??, 0x??, 0x??, 0x??, 0x??, 0x??, 0x??, 0x??, 0x??, 0x??, 0x??, 0x??, 0x??, 0x??, 0x??, 0x?? was Bytes to send: 0x15, 0x20, 0x00, 0x10, 0x??, 0x??, 0x??, 0x??, 0x??, 0x??, 0x??, 0x??, 0x??, 0x??, 0x??, 0x??, 0x??, 0x??, 0x??, 0x?? Section 16.4.1, To read all the pedometer configuration registers,... MB3: 0x11=number of bytes to read was MB3: 0x10=number of bytes to read MB2: 0x11 = actual number of bytes read was MB2: 0x10 = actual number of bytes read MB3: 0x11 = requested number of bytes to read was MB3: 0x10 = requested number of bytes to read MB15: male, filter time was MB15: male, filter time MB16: step period Added MB16: speed period MB17: step threshold was MB17: step coalesce Added MB20: step coalesce Deleted Added Section 19.3.2.9, Step Coalesce register Section 19.6, Write GPIO Input/output configuration variables was Write pedometer configuration variables Section 19.13, 19 20 01 01 (AB & 6F) was 19 20 01 01 Section 19.14, added 19 20 01 01 (AB & 5F) Section 19.15, 19 20 01 01 (AB & 3F) was 19 20 01 01 Section 19.16, 19 20 01 01 (AB & 6F) was 19 20 01 01 Section 19.17, 19 20 01 01 (AB & 5F) was 19 20 01 01 Section 19.18, 19 20 01 01 (AB & 6F) was 19 20 01 01
2.1	5/2015	Section 2.4.3, Note, deleted “Note that such a connection exists when the Master I2C interface is used (SDA1 function for pin 8).” Figure 3, changed resistor from R2 to R4 Table 150, Status register, changed Reset from 0x0001 to 0x0002

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Revision number	Revision date	Description of changes
2.2	6/2015	• Table 146 StepRateFactor value changed to 1.30 • Section 16.2.5, “Calorie-expenditure calculation,” on page 101 corrected Calorie-expenditure equation to match the calculation.
2.3	8/2016	• Section 16.3.1, “Pedometer memory maps,” on page 103, changed Step Coalesce register offset address from 0xF to 0x10

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