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Motion and Freefall Detection Using the MMA8451, 2, 3Q

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1.0 Introduction

The MMA8451, 2, 3Q has one (1) embedded functions for both Motion and/or Freefall along with a very flexible interrupt routing scheme. Motion is often used to simply alert the main processor that the device is currently in use. This can be accomplished with the Motion function and/or with the Transient function, described in Freescale application note AN4071. The transient function has the option of disabling the high pass filter and can behave exactly like the motion detection. This gives the user two separate programmable interrupts for motion detection if desired. The motion and freefall detection is an embedded function that can save overall system power by using an interrupt scheme. This feature alerts the main processor when a motion/tilt threshold or Freefall event has occurred. The embedded motion detection allows the user to enable and disable different axes. When the event occurs the direction of the event will be given as positive or negative acceleration.

Result: This feature saves the system processor from reading out the XYZ data continually and running a software algorithm to compare data with thresholds.

1.1 Key Words

Motion, Freefall, Interrupt, Transient Detection, Acceleration, Tumble, Debounce, Embedded, Tilt, Configuration Registers, DBCNTM bit, Threshold, Sensor

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1.2 Summary

A. The advantage of having two embedded functions to detect either Motion or linear Freefall which are routed to the choice of two interrupt pins allows for many combinations of events to be detected meeting the needs of many different use cases. For example: The embedded Motion/Freefall function can be used to detect a tumble using both the linear Freefall on one channel and the Motion detection to detect the spin on another channel.

B. The status register for the Motion/Freefall function is only read when a change has occurred.

C. Less processing is required on the microcontroller or processor with the embedded function since the condition is detected internally. The XYZ registers are not polled and data is not manipulated by the processor to detect the events.

D. The threshold and debounce counter are changeable in either the active or standby mode to allow for adjustments after the part has transitioned from the wake to the sleep mode.

E. Motion detection varies from Transient detection. The Motion detection can trigger on a change in a static acceleration value such as tilt. The Transient detection can behave like the Motion detection once the HPF is bypassed.

F. The latch will hold the status register values until the status is read to clear the interrupt.

2.0 MMA8451, 2, 3Q Consumer 3-axis Accelerometer 3 by 3 by 1 mm

The MMA8451, 2, 3Q has a selectable dynamic range of ±2g, ±4g, ±8g. The device has eight different output data rates, selectable high-pass filter cutoff frequencies, and high pass filtered data. The available resolution of the data and the embedded features is dependant on the specific device.

Note: The MMA8450Q has a different memory map and has a slightly different pinout configuration.

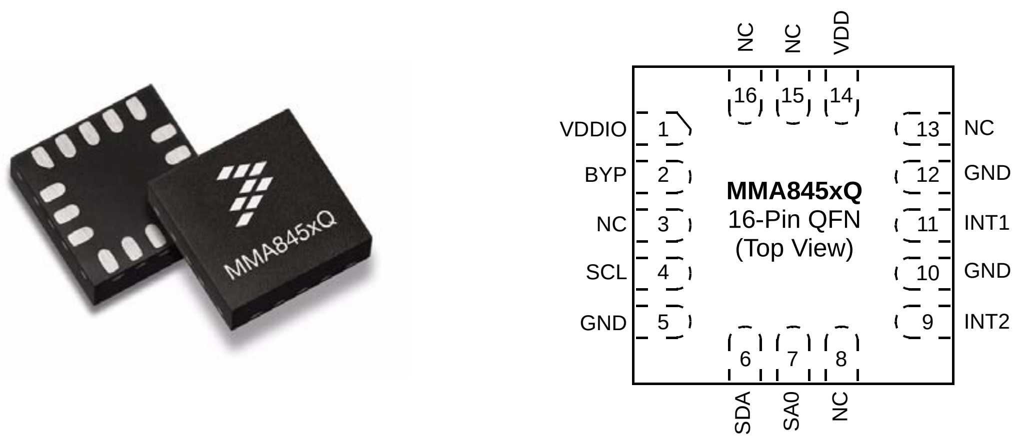

Figure 1. MMA8451, 2, 3Q Consumer 3-axis Accelerometer 3 by 3 by 1 mm

2.1 Output Data, Sample Rates and Dynamic Ranges of all Three Products

2.1.1 MMA8451Q

1. **14-bit data**
   2g (4096 counts/g = 0.25 mg/LSB) **4g** (2048 counts/g = 0.5 mg/LSB) **8g** (1024 counts/g = 1 mg/LSB)
2. **8-bit data**
   2g (64 counts/g = 15.6 mg/LSB) **4g** (32 counts/g = 31.25 mg/LSB) **8g** (16 counts/g = 62.5 mg/LSB)
3. **Embedded 32 sample FIFO (MMA8451Q)**

2.1.2 MMA8452Q

1. **12-bit data**
   2g (1024 counts/g = 1 mg/LSB) **4g** (512 counts/g = 2 mg/LSB) **8g** (256 counts/g = 3.9 mg/LSB)
2. **8-bit data**
   2g (64 counts/g = 15.6 mg/LSB) **4g** (32 counts/g = 31.25 mg/LSB) **8g** (16 counts/g = 62.5 mg/LSB)

2.1.3 MMA8453Q Note: No HPF Data

1. **10-bit data**
   2g (256 counts/g = 3.9 mg/LSB) **4g** (128 counts/g = 7.8 mg/LSB) **8g** (64 counts/g = 15.6 mg/LSB)
2. **8-bit data**
   2g (64 counts/g = 15.6 mg/LSB) **4g** (32 counts/g = 31.25 mg/LSB) **8g** (16 counts/g = 62.5 mg/LSB)

3.0 Motion and Freefall Applications Using the MMA8451, 2, 3Q Accelerometer

There are many applications that could potentially use Motion and/or Freefall. Some examples are the following:

- Simpler motion signatures for gesturing (tilt thresholds, generic motions, linear freefalls
- Human motion monitoring (specific parameters for motion and freefall)
- Tamper detection on doors (detecting a threshold is exceeded or a change in tilt)
- Shock detection or motion detection tracking assets (a threshold is exceeded)
- Risk of an object falling: hard disk drives (linear freefall and motion)
- Field meter monitoring for large motion/falls of the meters (tilt threshold change)

3.1 Freefall Detection

The Freefall function of the MMA8451, 2, 3Q detects linear freefall when X and Y and Z are ***below*** a set threshold. Typically this set threshold is below 0.35g. Although Freefall is often considered to be linear, this is often not entirely true in many fall use cases. Many falls can be tumbles which may cause the object to spin while falling.

The following are equations of motion which can be used to determine the time or distance of a fall. By integrating acceleration one can solve for velocity. Then to solve for position, a second integration is required.

$$A = \text{constant} = -9.81 m/s^2$$

(Integrate acceleration to get the velocity equation)

$$v = \int A dt = v_0 + At$$

(Integrate velocity to get position)

$$d = \int (v_0 + At) dt$$

$$d = d_0 + \boldsymbol{v_0 t} + \frac{1}{2}At^2$$

$d = \frac{1}{2}At^2$ solving for time $t = \sqrt{\frac{2d}{A}}$ (Assuming the initial conditions are equal to zero).

Table 1. Calculated Time and Distance for a Linear Freefall

Time	Distance
1 ms	4.91 µm
10 ms	0.49 mm
100 ms	4.91 cm
200 ms	19.6 cm
300 ms	44.1 cm
500 ms	1.23m
1s	4.905m

Distance	Time
1 cm	45 ms
10 cm	142 ms
20 cm	202 ms
25 cm	226 ms
30 cm	247 ms
1m	351 ms
5m	1s

Based on Table 1, one can determine the time that a fall will take based on the distance or vice-versa. When designing a freefall protection algorithm the typical height of the fall or a range of heights should be considered. Then the time the system will take to realize the device is in freefall, along with the time required to implement a protection mechanism, must be considered. For a freefall algorithm a minimum of 120 ms should be considered for the freefall condition to be met to be considered a linear freefall and not a false trigger.

3.2 Motion Detection

Motion detection can be used to alert that the device has exceeded a specific acceleration. This event could be due to a tilt or due to an acceleration that exceeds a value from a linear motion as shown Figure 2.

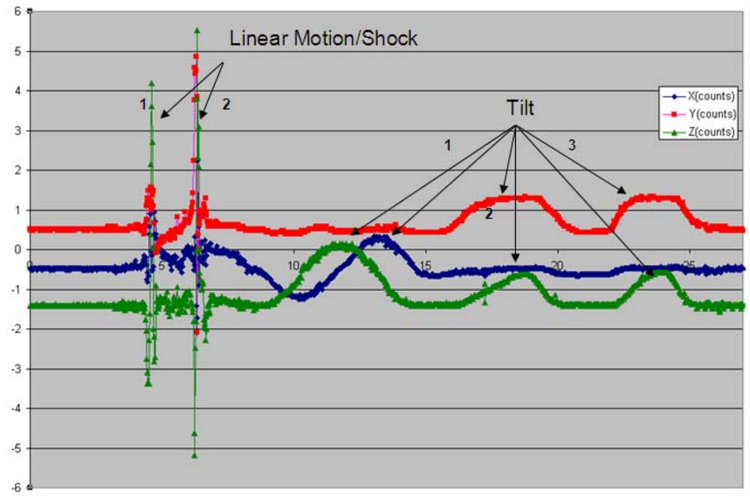

Figure 2. Motion Detection per Tilt or Linear Acceleration

The **motion function** can be used for detecting tumble. The signature of a tumble is shown in Figure 3. During the rotation of the tumble the magnitude of the three axes is much greater than 0g. In order to detect tumble, for example, the motion detection condition must be set to detect for X or Y or Z > 2g. It is also important to set the debounce counter to about 100 ms to avoid false readings. The debounce counter acts like a filter to determine whether the condition exists for 100 ms or longer.

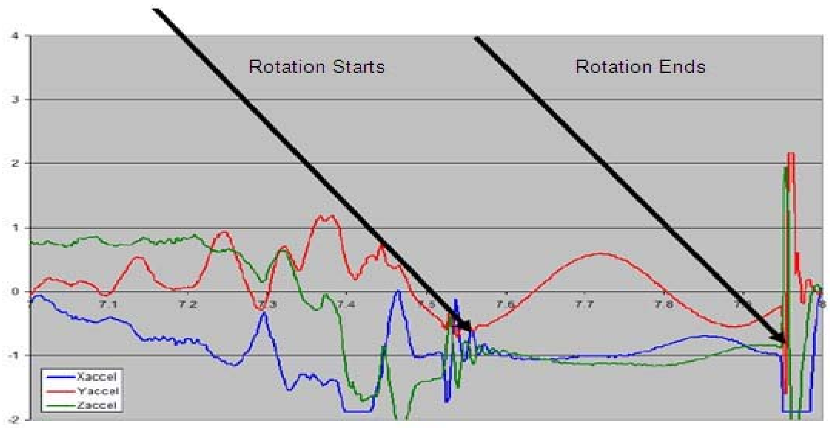

Figure 3. Rotational Freefall Signature

3.3 Signature of Linear Freefall and Rotational Fall

Figure 4, shows the signature of a Linear Freefall and a Rotational Fall. Both are falling events that require different conditions for detection. To be able to capture either a Linear Freefall or a Rotational Fall, the Motion/Freefall embedded function can be used to detect the Linear Freefall while the Transient can be used to detect the Rotational Fall (Motion). Each function can be routed to the same interrupt pin or routed to separate interrupt pins.

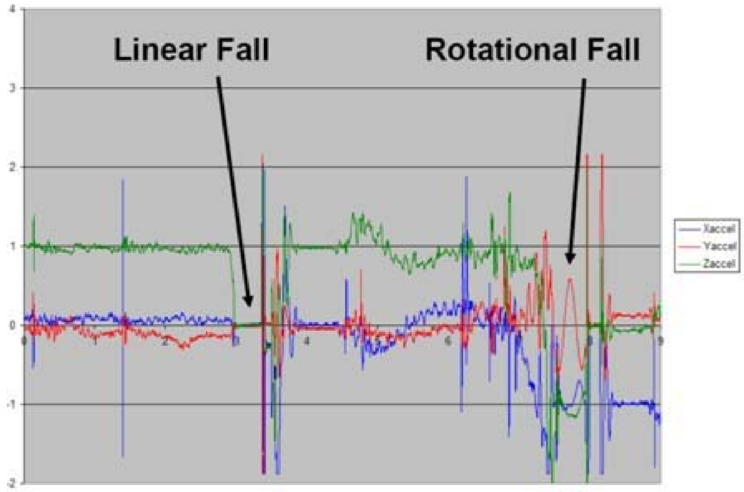

Figure 4. Fall Event Showing Linear and Rotational Fall

4.0 Register Settings for the Motion/ Freefall Function

There are four (4) registers associated with the Motion/Freefall embedded function.

1. Register 0x15 **FF/MT Config** - Motion/Freefall Configuration
2. Register 0x17 **FF_MT_THS** - Setting the Threshold
3. Register 0x18 **FF_MT_COUNT** - Setting the Debounce Counter
4. Register 0x16 **FF_MT_SRC** - Motion/Freefall Source Detection

Refer to Table 12 for the complete list of all registers that can be used with Motion/Freefall.

4.1 Register 0x15: FF/MT Config - Configuration Register

The first register is the Motion/Freefall Configuration Register shown in Table 2. This register determines which axes to enable with regards to three (3) conditions:

1. Which axes will be involved,
2. Whether the event will be a linear freefall or a motion and,
3. Whether the event detected should be latched or not into the source register.

Table 2. Register 0x15: FF/MT Config - Configuration Register (Read/Write) and Description

Reg 0x15	ELE	OAE	ZEFE	YEFE	XEFE	—	—	—
Motion	1	1	1	1	1	0	0	0
Freefall	1	0	1	1	1	0	0	0

4.1.1 Configuring the MMA845 1, 2, 3Q for Motion Detection

Motion Detection with ELE = 0, OAE = 1

In this mode, the **EA** bit indicates a motion event after the debounce counter time is reached. The ZEFE, YEFE, and XEFE control bits determine which axes are taken into consideration for motion detection. Once the **EA** bit is set, and DBCNTM = 0, the EA bit can get cleared only after the delay specified by FF_MT_COUNT. If DBCNTM = 1, the **EA** bit is cleared as soon as the motion high-g condition disappears. The event flags ZHE, ZHP, YHE, YHP, XHE, and XHP reflect the motion detection status (i.e., high-g event) without any debouncing, provided that the corresponding bits ZEFE, YEFE, and/or XEFE are set. Reading the FF_MT_SRC does not clear any flags, nor is the debounce counter reset.

Motion Detection with ELE = 1, OAE = 1

In this mode, the EA bit indicates a motion event after debouncing. The ZEFE, YEFE, and XEFE control bits determine which axes are taken into consideration for motion detection. Once the debounce counter reaches the threshold, the EA bit is set, and remains set until the FF_MT_SRC register is read. When the FF_MT_SRC register is read, all register bits are cleared and the debounce counter are cleared and a new event can only be generated after the delay specified by FF_MT_CNT. While the bit EA is zero, the event flags ZHE, ZHP, YHE, YHP, XHE, and XHP reflect the motion detection status (i.e., high-g event) without any debouncing, provided that the corresponding bits ZEFE, YEFE, and/or XEFE are set. When the EA bit is set, these bits keep their current value until the FF_MT_SRC register is read.

Table 3. Motion Example 1: X or Y > 3g

Reg 0x15	ELE	OAE	ZEFE	YEFE	XEFE	—	—	—
Motion	1	1	0	1	1	0	0	0

Example Code: IIC_RegWrite(0x15, 0xD8); //Enable Latch, Motion, X-axis, Y-axis

4.1.2 Configuring the MMA8451, 2, 3Q for Freefall Detection

Freefall Detection with ELE = 0, OAE = 0

In this mode, the **EA** bit (0x16 bit 7) indicates a freefall event after the debounce counter is complete. The ZEFE, YEFE, and XEFE control bits determine which axes are considered for the freefall detection. Once the EA bit is set, and DBCNTM = 0, the EA bit can get cleared only after the delay specified by FF_MT_COUNT. This is because the counter is in decrement mode. If DBCNTM = 1, the EA bit is cleared as soon as the freefall condition disappears, and will not be set again before the delay specified by FF_MT_COUNT has passed. Reading the FF_MT_SRC register does not clear the EA bit. The event flags (0x16) ZHE, ZHP, YHE, YHP, XHE, and XHP reflect the motion detection status (i.e. high-g event) without any debouncing, provided that the corresponding bits ZEFE, YEFE, and/or XEFE are set.

Freefall Detection with ELE = 1, OAE = 0

In this mode, the **EA** event bit indicates a freefall event after the debounce counter. Once the debounce counter reaches the time value for the set threshold, the EA bit is set, and remains set until the FF_MT_SRC register is read. When the FF_MT_SRC register is read, the EA bit and the debounce counter are cleared and a new event can only be generated after the delay specified by FF_MT_CNT. The ZEFE, YEFE, and XEFE control bits determine which axes are considered for the freefall detection. While EA = 0, the event flags ZHE, ZHP, YHE, YHP, XHE, and XHP reflect the motion detection status (i.e., high-g event) without any debouncing, provided that the corresponding bits ZEFE, YEFE, and/or XEFE are set. The event flags ZHE, ZHP, YHE, YHP, XHE, and XHP are latched when the EA event bit is set. The event flags ZHE, ZHP, YHE, YHP, XHE, and XHP will start changing only after the FF_MT_SRC register has been read.

Table 4. Freefall Example 1: X AND Y AND Z < 0.2g

Reg 0x15	ELE	OAE	ZEFE	YEFE	XEFE			
Freefall	1	0	1	1	1	0	0	0

Example Code: IIC_RegWrite(0x15, 0xB8); //Enable Latch, Freefall, X-axis, Y-axis and Z-axis

4.2 Register 0x17 FF_MT_THS Register (Read/Write) - Setting the Threshold

The threshold for the event is set in Register 0x17, shown in Table 5. The threshold register has a range of 0 to 127 counts. The minimum threshold resolution is 0.063g/LSB. The maximum value is 8g, even if the full scale value is set to 2g or 4g.

Table 5. Register 0x17 FF_MT_THS_Register (Read/Write)

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
DBCNTM	THS6	THS5	THS4	THS3	THS2	THS1	THS0

Note:

- For Motion detection the condition is > Threshold (Figure 5)
- For Freefall the condition is < Threshold (Figure 5)
- All thresholds are absolute value.

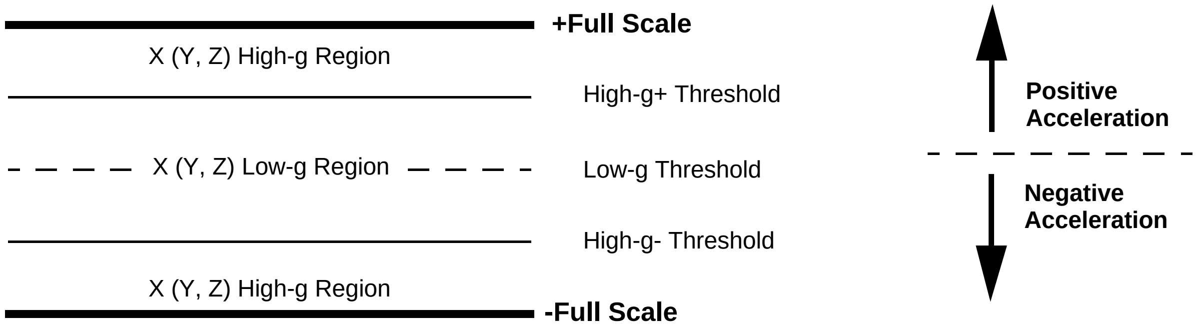

Figure 5. Freefall Condition

The **DCNTM** bit is best understood from the diagram in Figure 6. The default value is for the counter to be in the increment/decrement mode.

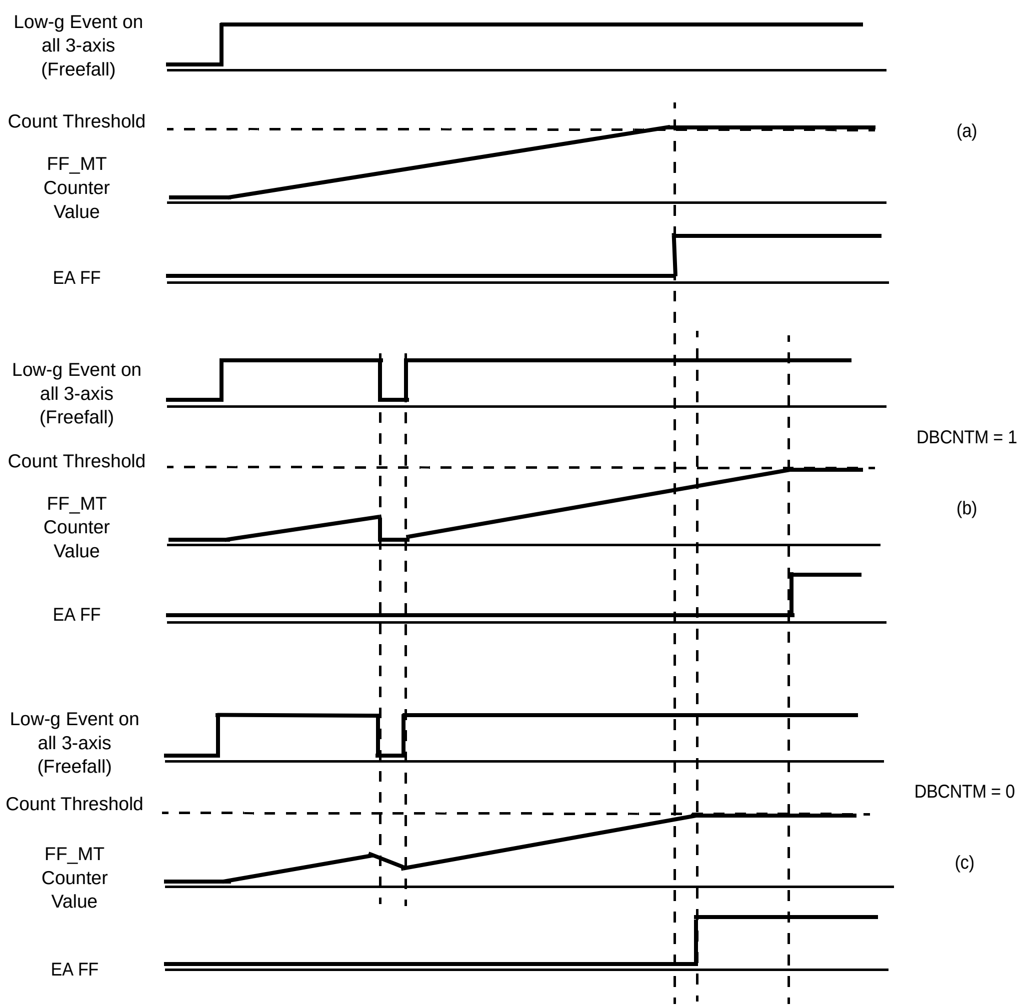

Figure 6. DBCNTM Bit Function

4.2.1 Example: Setting the Threshold for Motion Detection

Motion Example 1: X or Y > 3g

The device can be in 2g, 4g or 8g mode. The step count is 0.063 counts/g regardless of the full scale. 3g/0.063g/count = 48 counts. Note the threshold can be changed in either the Active or the Standby Mode. This may be useful for readjusting the threshold while in the active mode after an event has occurred. The **DBCNTM** bit will be kept cleared.

Example Code: IIC_RegWrite(0x17, 0x30); //Set Threshold to 48 counts

4.2.2 Example: Setting the Threshold for Freefall Detection

Freefall Example 1: X AND Y AND Z < 0.2g

In this example the device could be either 2g, 4g, or 8g mode. The step count is 0.063g/count. 0.2g/ 0.063g/count = 3 counts. For this example the **DBCNTM** bit will be kept cleared to filter out spurious noise.

Example Code: IIC_RegWrite(0x17, 0x03); //Set Threshold to 3 counts

4.3 Register 0x18 FF_MT_COUNT Register (Read/Write) - Setting the Debounce Counter

Register 0x18 shown in Table 6 is an 8-bit counter used for low pass filtering.

Table 6. Register 0x18 FF_MT_COUNT_(Read/Write)

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

The time step used for the debounce sample count depends on the ODR chosen. The relationship is shown in Table 7.

Note that there are 4 different oversampling modes in the MMA8451, 2, 3Q. There is a normal mode, a low power and low noise mode, a high resolution mode and a low power mode. The lowest power mode is the Low Power mode. The highest power mode is the high resolution mode. For more details on the different oversampling modes and their uses please refer to Freescale application note AN4075.

Table 7. FF_MT_COUNT_1 Relationship with the ODR

ODR (Hz)	Max Time Range (s)				Time Step (ms)			
	Normal	LPLN	HighRes	LP	Normal	LPLN	HighRes	LP
800	0.319	0.319	0.319	0.319	1.25	1.25	1.25	1.25
400	0.638	0.638	0.638	0.638	2.5	2.5	2.5	2.5
200	1.28	1.28	0.638	1.28	5	5	2.5	5
100	2.55	2.55	0.638	2.55	10	10	2.5	10
50	5.1	5.1	0.638	5.1	20	20	2.5	20
12.5	5.1	20.4	0.638	20.4	20	80	2.5	80
6.25	5.1	20.4	0.638	40.8	20	80	2.5	160
1.56	5.1	20.4	0.638	40.8	20	80	2.5	160

An ODR of 100 Hz in “normal mode”, with a **FF_MT_COUNT** value of 10 would result in a minimum debounce response time of 100 ms.

Note: the debounce counter can be changed in the active or the standby mode. This may be desirable when the device changes from the wake mode to the sleep mode as the ODR may change. This will change the timing of the debounce counter.

Example Code: IIC_RegWrite(0x18, 0x0A); //100 ms debounce timing

4.4 Register 0x16 FF_MT_SRC Register (Read Only) - Motion/Freefall Source Detection Register

This register keeps track of the acceleration event which is triggering (or has triggered, in case of ELE bit in FF_MT_CFG register being set to 1) the event flag. In particular EA is set to a logic 1 when the logical combination of acceleration events flags specified in FF_MT_CFG register is true. This bit is used in combination with the values in INT_EN_FF_MT and INT_CFG_FF_MT register bits to generate the freefall/motion interrupts.

An X, Y, or Z high event is true when the acceleration value of the X or Y or Z channel is higher than the preset threshold value defined in the FF_MT_THS register.

As it is possible with ELE = 1 that an X, Y, or Z high event appears or disappears during the debounce period, the bits XHE, XHP, YHE, YHP, ZHE, and ZPE represent the state when the debounce counter reaches the threshold defined by the FF_MT_COUNT register.

Conversely an X,Y, and Z low event is true when the acceleration value of the X and Y and Z channel is lower than or equal to the preset threshold value defined in the FF_MT_THS register.

Reading of this register clears FF_MT_SRC register and allows the refreshing of data in the FF_MT_SRC register if the ELE bit is set. If the ELE bit is cleared to a logic ‘0’, all bits in the FF_MT_SRC register indicate the real-time status of the event flags in the FF_MT_SRC register.

Note: The ZHP, YHP and XHP are the polarity or directional status bits. These bits update regardless of whether the event has been detected.

Table 8. Events Detected in the Motion/Freefall Source Detection Register (Read Only) and Legend

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
EA	—	ZHE	ZHP	YHE	YHP	XHE	XHP

5.0 Configuring the Motion/Freefall to an Interrupt Pin

In order to set up the system to route to a hardware interrupt pin, the System Interrupt (Bit 2 in Reg 0x2D) must be enabled. The MMA8451, 2, 3Q allows for seven (7) separate types of interrupts. One (1) of these are reserved for Motion/Freefall. For example, to configure the Motion/Freefall function, the following two steps should be followed.

Step 1: Set the Interrupt Bit 2 in Register 0x2D shown in Table 9.

Table 9. 0x2D CTRL_REG4 Register (Read/Write) – Interrupt Enable Description and Legend

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
INT_EN_ASLP	INT_EN_FIFO	INT_EN_TRANS	INT_EN_LNDPRT	INT_EN_PULSE	**INT_EN_FF_MT**	—	INT_EN_DRDY

The corresponding interrupt enable bit allows the Motion/Freefall interrupt to route its event detection flag to the interrupt controller of the system. The interrupt controller routes the enabled function to the INT1 or INT2 pin. To enable the Freefall/Motion function, set Bit 2 in Register 0x2D as follows:

Example Code: IIC_RegWrite(0x2D, 0x04);

Step 2: Route the interrupt to INT1 or to INT2. This is done in register 0x2E shown in Table 10.

Table 10. 0x2E CTRL_REG5 Register (Read/Write)

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
INT_CFG_ASLP	INT_CFG_FIFO	INT_CFG_TRANS	INT_CFG_LNDPRT	INT_CFG_PULSE	**INT_CFG_FF_MT**	—	INT_CFG_DRDY

Note: To set Motion/Freefall to INT1 set Bit 2 in register 0x2E.

Example Code: IIC_RegWrite(0x2E,0x04);

5.1 Reading the System Interrupt Status Source Register

In the interrupt source register shown in Table 11 the status of the various embedded functions can be determined. The bits that are set (logic ‘1’) indicate which function has asserted an interrupt; conversely, the bits that are cleared (logic ‘0’) indicate which function has not asserted or has de-asserted an interrupt. The bits are cleared by reading the appropriate interrupt source register.

Table 11. 0x0C INT_SOURCE: System Interrupt Status Register (Read Only)

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
SRC_ASLP	SRC_FIFO	SRC_TRANS	SRC_LNDPRT	SRC_PULSE	SRC_FF_MT	—	SRC_DRDY

6.0 Details for Configuring the MMA8451, 2, 3Q for Motion/Freefall Detection

The registers of importance for configuring the MMA8451, 2, 3Q for Motion detection or Freefall detection are listed in Table 12.

Table 12. Registers of Importance for Setting up the Motion/Freefall Detection

Reg	Name	Definition	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0C	INT_SOURCE	Interrupt Status R	SRC_ASLP	SRC_FIFO	SRC_TRANS	SRC_LNDPRT	SRC_PULSE	SRC_FF_MT	—	SRC_DRDY
15	FF_MT_CFG	FF/Motion Config R/W	ELE	OAE	ZEFE	YEFE	XEFE	—	—	—
16	FF_MT_SRC	FF/Motion Source R	EA	—	ZHE	ZHP	YHE	YHP	XHE	XHP
17	FF_MT_THS	FF/Motion Threshold R/W	DBCNTM	THS6	THS5	THS4	THS3	THS2	THS1	THS0
18	FF_MT_COUNT	FF/Motion Debounce R/W	D7	D6	D5	D4	D3	D2	D1	D0
2A	CTRL_REG1	Control Reg1 R/W	ASLP_RATE1	ASLP_RATE0	DR2	DR1	DR0	LNOISE	F_READ	ACTIVE
2D	CTRL_REG4	Control Reg4 R/W (Interrupt Enable Map)	INT_EN _ASLP	INT_EN _FIFO	INT_EN _TRANS	INT_EN_LNDPRT	INT_EN_PULSE	INT_EN_FF_MT	—	INT_EN_DRDY
2E	CTRL_REG5	Control Reg5 R/W (Interrupt Configuration)	INT_CFG_ASLP	INT_CFG_FIFO	INT_CFG_TRANS	INT_CFG_LNDPRT	INT_CFG_PULSE	INT_CFG_FF_MT	—	INT_CFG_DRDY

6.1 Example Steps for Configuring Motion Detection

X or Y > 3g using MFF Function 4g, 100 Hz ODR, Normal Mode

Step 1: Put the device into Standby Mode: Register 0x2A CTRL_REG1

IIC_RegWrite(0x2A, 0x18); //Set the device in 100 Hz ODR, Standby

Step 2: Set Configuration Register for Motion Detection by setting the “OR” condition OAE = 1, enabling X, Y, and the latch

IIC_RegWrite(0x15, 0xD8)

Step 3: Threshold Setting Value for the Motion detection of > 3g

Note: The step count is 0.063g/ count

- 3g/0.063g = 47.6; //Round up to 48

IIC_RegWrite(0x17, 0x30)

Step 4: Set the debounce counter to eliminate false readings for 100 Hz sample rate with a requirement of 100 ms timer.

Note: 100 ms/10 ms (steps) = 10 counts

IIC_RegWrite(0x18, 0x0A);

Step 5: Enable Motion/Freefall Interrupt Function in the System (CTRL_REG4)

IIC_RegWrite(0x2D, 0x04);

Step 6: Route the Motion/Freefall Interrupt Function to INT1 hardware pin (CTRL_REG5)

IIC_RegWrite(0x2E, 0x04);

Step 7: Put the device in Active Mode

CTRL_REG1_Data = IIC_RegRead(0x2A);

CTRL_REG1_Data| = 0x01;

IIC_RegWrite(CTRL_REG1_Data);

Step 8: Write Interrupt Service Routine Reading the System Interrupt Status and the Motion/Freefall Status

```
Interrupt void isr_KBI (void)
{
	//clear the interrupt flag
	CLEAR_KBI_INTERRUPT;
	//Determine source of interrupt by reading the system interrupt
	IntSourceSystem=IIC_RegRead(0x0C);
	//Set up Case statement here to service all of the possible interrupts
	if ((Int_SourceSystem &0x04)==0x04)
	{
		//Perform an Action since Motion Flag has been set
		//Read the Motion/Freefall Function to clear the interrupt
		IntSourceMFF=IIC_RegRead(0x16);
		//Can parse out data to perform a specific action based on the
		//axes that made the condition true and read the direction of the
		//motion event
	}
}
```

6.2 Example Steps for Configuring Linear Freefall Detection

X AND Y AND Z < 0.2g using MFF Function, 50 Hz ODR

Step 1: Put the device in Standby Mode: Register 0x2A CTRL_REG1

IIC_RegWrite(0x2A, 0x20); //Set the device in 50 Hz ODR, Standby

Step 2: Configuration Register set for Freefall Detection enabling "AND" condition, OAE = 0, Enabling X, Y, Z and the Latch

IIC_RegWrite(0x15, 0xB8);

Step 3: Threshold Setting Value for the resulting acceleration < 0.2g

Note: The step count is 0.063g/count

- 0.2g/0.063g = 3.17 counts //Round to 3 counts

IIC_RegWrite(0x17, 0x03);

Step 4: Set the debounce counter to eliminate false positive readings for 50Hz sample rate with a requirement of 120 ms timer, assuming Normal Mode.

Note: 120 ms/20 ms (steps) = 6 counts

IIC_RegWrite(0x18, 0x06);

Step 5: Enable Motion/Freefall Interrupt Function in the System (CTRL_REG4)

IIC_RegWrite(0x2D, 0x04);

Step 6: Route the Motion/Freefall Interrupt Function to INT2 hardware pin (CTRL_REG5)

IIC_RegWrite(0x2E, 0x00);

Step 7: Put the device in Active Mode, 50 Hz

CTRL_REG1_Data = IIC_RegRead(0x2A);

CTRL_REG1_Data| = 0x01;

IIC_RegWrite(CTRL_REG1_Data);

Step 8: Write Interrupt Service Routine Reading the System Interrupt Status and the Motion/Freefall Status

```
Interrupt void isr_KBI (void)
{
      //clear the interrupt flag
      CLEAR_KBI_INTERRUPT;
      //Determine source of the interrupt by first reading the system interrupt
      IntSourceSystem=IIC_RegRead(0x0C);
      //Set up Case statement here to service all of the possible interrupts
      if ((IntSourceSystem&0x04)==0x04)
      {
            //Perform an Action since Freefall Flag has been set
            //Read the Motion/Freefall Function to clear the interrupt
            IntSourceMFF=IIC_RegRead(0x16);
            //Can parse out data to perform a specific action based on the axes
      }
      }
```

Related Documentation

The MMA845xQ device features and operations are described in a variety of reference manuals, user guides, and application notes. To find the most-current versions of these documents:

1. Go to the Freescale homepage at:

   http://www.freescale.com/

2. In the Keyword search box at the top of the page, enter the device number MMA845xQ.
3. In the Refine Your Result pane on the left, click on the Documentation link.

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