How to use BMA253 flat interrupt in low power mode

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1   Introduction

BMA253 has built-in flat interrupt feature. By default the flat interrupt is with respect Z axis. This means that at the beginning Z axis is pointing to sky +1g or pointing down -1g, while X and Y axes are flat at 0g. Flat interrupt is to recognize if X-Y plane is tilted beyond the threshold Theta angle. It doesn't require high sampling rate for the accelerometer data.

There is a flat interrupt zone defined by the angle Theta as shown below. Whenever Z axis is exiting the flat interrupt zone as shown in blue color arrow longer than the duration of flat hold time, a flat interrupt will be generated. Likewise, whenever Z axis is entering the zone as shown in red color arrow longer than the duration of the flat hold time, a flat interrupt will also be generated.
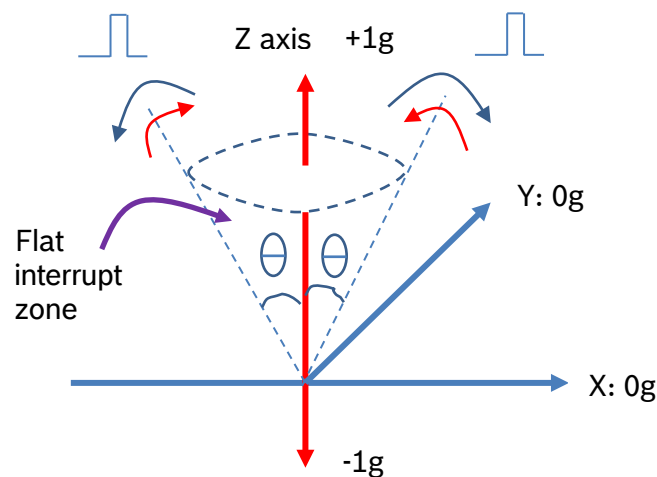
When Z axis is moving within the zone or out of the zone, there will be no more flat interrupts generated. Due to vibration or swing motions, Z axis acceleration data may change a lot which means that Z axis can exit the zone or enter the zone easily. But if the duration of the flat hold time is set to 0ms, then there may be some false interrupts. If it is set to 512ms, then flat interrupt is very robust.

BMA253 register 0x2D bit-7 is 0 by default. If this bit is set to 1, then the X axis and Z axis will be swapped for the flat interrupt engine. However, BMA253 data registers will remain the same for X/Y/Z data as before. Then flat interrupt will be with respect to X axis.

Section 2 will present sample code about how to initialize BMA253 flat interrupt in low power mode. Section 3 will show how to test the flat interrupt. Section 4 shows the swap feature of X axis and Z axis for flat interrupt engine.

2   BMA253 sample code

The following pseudo code shows how to configure BMA253 to monitor flat interrupt in low power mode.

Theta angle can be calculated as shown below which is also shown in the datasheet. It can be fine-tuned to meet the application requirement.

$$\theta = a\tan\left(\frac{1}{8}\sqrt{flat\_theta}\right) = a\tan\left(\frac{1}{8}\sqrt{decimal\_value\_of\_register0x2E}\right)$$

For example, if register 0x2E has the value of 0x3F, then,

$$\theta = a\tan\left(\frac{1}{8}\sqrt{63}\right) = a\tan(0.9921) = 44.77\deg$$

For example, if register 0x2E has the value of 0x10, then,

$$\theta = a\tan\left(\frac{1}{8}\sqrt{16}\right) = a\tan(0.5) = 26.57\deg$$

```
void BMA253_flat_int_init(void)
{
        // basic settings
        Write value of 0x03 to register 0x0F;     // default value for +/-2g FS range
        Write value of 0x0F to register 0x10;     // set BW to 1KHz or 2KHz ODR
        Write value of 0x56 to register 0x11;     // set low power mode with 25ms sleep time
                                                   Current consumption = 6.5uA

        // flat interrupt settings
        Write value of 0x80 to register 0x19;     // route flat interrupt to INT1 pin
        Write value of 0x10 to register 0x2E;     // set Theta angle to 26.57 degrees
        Write value of 0x00 to register 0x2F;     // 0ms flat hold time and no hysteresis

        Write value of 0x05 to register 0x20;     // default value for active-high and push-pull
        Write value of 0x01 to register 0x21;     // temporarily latch interrupt signal for 250ms

        // enable flat interrupt
        Write value of 0x80 to register 0x16;     // enable flat interrupt
}
```
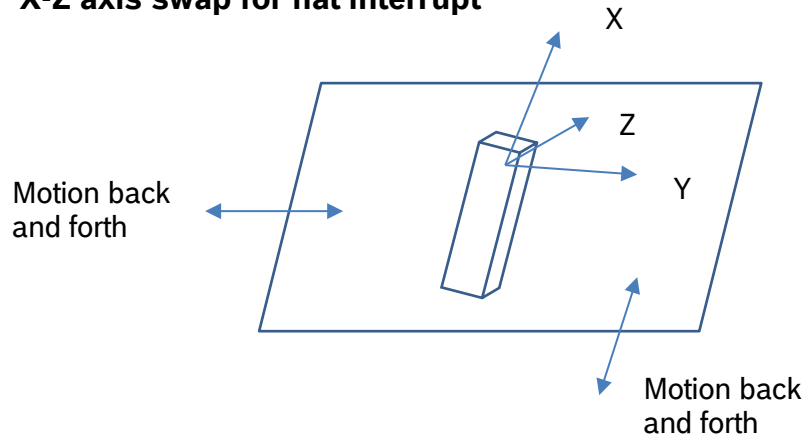
BMA253 current consumption is 130uA in normal mode and 2.1uA in suspend mode. From the logic analyzer screenshot below, BMA253 will stay in normal mode for 0ms and then stay in suspend mode for 25ms. So the average current will become about 6.5uA with about 40Hz sampling rate.

3   X-Z axis swap for flat interrupt

If the device is sitting on a surface with Z and Y axes flat, while X axis is pointing to sky or down, you can set BMA253 register 0x2D bit-7 to "1". Then for flat interrupt engine, X axis will become Z' and Z axis becomes X'. Therefore, the flat interrupt zone still works the same way.

At this situation, BMA253 data registers for X/Y/Z axes don't swap. They are still the same as before.

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5   Document history and modification

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