AN3838
Rev 2, 9/2009

# How to use the MMA7660FC with a Microcontroller to do Software Enhancements to Change Orientation Detection Trip Points

**by: Fengchao Zhang**

## ACRONYMS

PMP: Portable Media Player
PDA: Personal Digital Assistant
P/L: Portrait to Landscape
L/P: Landscape to Portrait
INT: Interrupt
TILT: MMA7660FC Internal register 0x03: Tilt Status
SR: MMA7660FC Internal register 0x08: Sample rate register, Auto-Wake and Active Mode Portrait/Landscape Samples per Seconds Register
INTSU: MMA7660FC Internal register 0x06: Interrupt Setup Register
XOUT/YOUT/ZOUT: MMA7660FC Internal registers 0x00/0x01/0x02: 6 bits output value X/Y/Z
GINT: MMA7660FC automatic interrupt feature after every measurement
ODR: Output Data Rate

## ABSTRACT

The MMA7660FC has the built-in capability to do orientation detection. This feature gives the customer the ability to do applications such as portrait/landscape in mobile phones/PMP/PDAs. The MMA7660FC provides 6 different positions: left, right, up, down, back, and front. The tilt orientation of the device is in 3 dimensions and is identified in its last know static position. The trip points for up/down/left/right occur at approximately 45 degrees from horizontal. The back/front interrupts occur at approximately 15 degrees from horizontal. This allows a product to set its display orientation appropriately to either portrait or landscape mode or to turn off the display when the device is placed upside down.

This application note explains how to use software enhancements using a microcontroller to configure the MMA7660FC to do orientation detection, beyond what the sensor could provide given its internal functionality.

**Table 1. Orientation Detection Logic of when Interrupt will Occur**

| Orientation | Xg | Yg | Zg |
|---|---|---|---|
| Up | \|Z\| < 0.8g and \|X\| > \|Y\| and X < 0 | | |
| Down | \|Z\| < 0.8g and \|X\| > \|Y\| and X > 0 | | |
| Right | | \|Z\| < 0.8g and \|Y\| > \|X\| and Y < 0 | |
| Left | | \|Z\| < 0.8g and \|Y\| > \|X\| and Y > 0 | |
| Back | | | Z < -0.25g |
| Front | | | Z > 0.25g |

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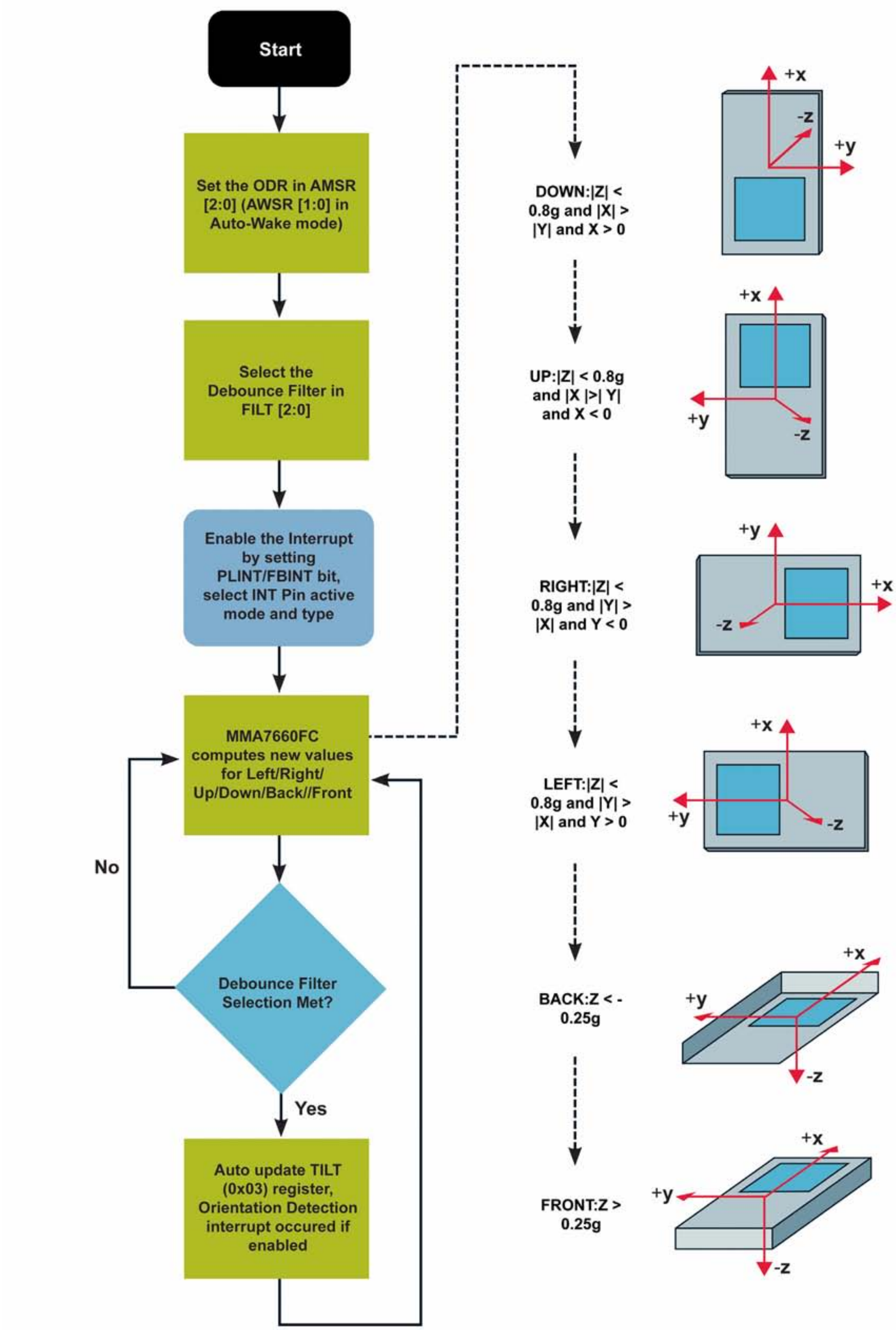


**Figure 1. Flow Chart of Orientation Detection**

Using the built-in orientation detection with the interrupt capability will save significant system resources and power consumption, when compared to the polling method. The polling method requires the main processor to start a timer to read the accelerometer output (XYZ), and then use a software algorithm to judge the sensor orientation. By using this method, the system will constantly have to read and calculate the new orientation position. But with the MMA7660FC, the user can configure the part for orientation detection by selecting the sample rate based on power consumption targets, the TILT debounce count, auto wake/sleep feature and choose the interrupts enabled. Then once an INT signal is received, the application must read the TILT register to update the new orientation position. The internal logic, defines the P/L trip point at approximately 45 degree, this trip point can not be changed. Therefore, it is recommended to use an enhanced software solution with the built-in capability of the MMA7660FC to change the trip point while still using significantly less resources and power consumption.

There are 2 cases when defining application specific trip points:

1. One or two different P/L and L/P trip points, not using MMA7660FC built-in Orientation Detection Interrupt, but GINT capability. The GINT interrupt sets off an automatic interrupt after every measurement when g-cell readings are updated XOUT, YOUT and ZOUT. Examples: the P/L and L/P trip points are 20 degrees instead of built-in 45 degrees; or P/L trip point is 30 degrees while L/P is 70 degrees. In this case, GINT feature plus software enhancement is recommended.
2. Using the built-in orientation detection interrupts in combination with an application specific trip point. Example: L/P trip point is built-in 45 degrees, while the P/L is 20 degrees, a software solution is required, which will use the built-in interrupt capability for 45 degrees and GINT interrupt mechanism for 20 degrees.

## SAMPLE RATE

The sampling rate can be selected based on the targeted power consumption per the application specification or the desired response rate of the orientation detection. The following are the sample rates available in the MMA7660FC sensor with the corresponding approximate power consumption rates.

**NOTE:** These power consumption rates were tested in the factory and could vary given PCB board design.

**Table 2. Sample Rate vs. Current Consumption**

| Sampling Rate | Current Consumption |
|---|---|
| Stand By | 2.33 μA |
| 1 SPS | 46.9 μA |
| 2 SPS | 49.3 μA |
| 4 SPS | 54 μA |
| 8 SPS | 65.8 μA |
| 16 SPS | 89.2 μA |
| 32 SPS | 133 μA |
| 64 SPS | 221 μA |
| 120 SPS | 294 μA |

## REGISTER DEFINTIONS:

### $08: Auto-Wake and Active Mode Portrait/Landscape Output Data Rates Register (Read/Write)
### SR — Sample Rate Register

| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|---|---|---|---|---|---|---|---|
| X | X | X | X | X | AMSR[2] | AMSR[1] | AMSR[0] |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| AMSR[2:0] | NAME | DESCRIPTION |
|---|---|---|
| 000 | AMPD | 120 Samples/Second Active and Auto-Sleep Mode<br>**For portrait/landscape detection:** The device takes and averages 32 g-cell measurements every 8.36ms in Active Mode and Auto-Sleep. The update rate is 120 samples per second. These measurements update the XOUT (0x00), YOUT (0x01), and ZOUT (0x02) registers also. |
| 001 | AM64 | 64 Samples/Second Active and Auto-Sleep Mode<br>**For portrait/landscape detection**: The device takes and averages 32 g-cell measurements every 15.625ms in Active Mode and Auto-Sleep. The update rate is 64 samples per second. These measurements update the XOUT (0x00), YOUT (0x01), and ZOUT (0x02) registers also. |
| 010 | AM32 | 32 Samples/Second Active and Auto-Sleep Mode<br>**For portrait/landscape detection:** The device takes and averages 32 g-cell measurements every 31.25ms in Active Mode and Auto-Sleep. The update rate is 32 samples per second. These measurements update XOUT (0x00), YOUT (0x01), and ZOUT (0x02) registers also. |
| 011 | AM16 | 16 Samples/Second Active and Auto-Sleep Mode<br>**For portrait/landscape detection:** The device takes and averages 32 g-cell measurements every 62.5ms in Active Mode and Auto-Sleep. The update rate is 16 samples per second. These measurements update the XOUT (0x00), YOUT (0x01), and ZOUT (0x02) registers also. |
| 100 | AM8 | 8 Samples/Second Active and Auto-Sleep Mode<br>**For portrait/landscape detection:** The device takes and averages 32 g-cell measurements every 125ms in Active Mode and Auto-Sleep. The update rate is 8 samples per second. These measurements update the XOUT (0x00), YOUT (0x01), and ZOUT (0x02) registers also. |
| 101 | AM4 | 4 Samples/Second Active and Auto-Sleep Mode<br>**For portrait/landscape detection:** The device takes and averages 32 g-cell measurements every 250ms in Active Mode and Auto-Sleep. The update rate is 4 samples per second. These measurements update the XOUT (0x00), YOUT (0x01), and ZOUT (0x02) registers also. |
| 110 | AM2 | 2 Samples/Second Active and Auto-Sleep Mode<br>**For portrait/landscape detection:** The device takes and averages 32 g-cell measurements every 500ms in Active Mode and Auto-Sleep. The update rate is 2 samples per second. These measurements update the XOUT (0x00), YOUT (0x01), and ZOUT (0x02) registers also. |
| 111 | AM1 | 1 Sample/Second Active and Auto-Sleep Mode<br>**For portrait/landscape detection:** The device takes and averages 32 g-cell measurements every 1000ms in Active Mode and Auto-Sleep. The update rate is 1 sample per second. These measurements update the XOUT (0x00), YOUT (0x01), and ZOUT (0x02) registers also. |

**$06: Interrupt Setup Register**
**INTSU**

| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|---|---|---|---|---|---|---|---|
| X | X | X | GINT | X | X | PLINT | X |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**GINT**
0:There is not an automatic interrupt after every measurement
1:There is an automatic interrupt after every measurement, when g-cell readings are updated in XOUT, YOUT, ZOUT registers, regardless of whether the readings have changed or not. This interrupt does not affect the Auto-Sleep or Auto-Wake functions

**PLINT**
0:Up/Down/Right/Left position change does not cause an interrupt
1:Up/Down/Right/Left position change causes an interrupt

## GINT VS. POLLING

Once the GINT interrupt occurs, the microcontroller will read the XOUT, YOUT and ZOUT, and then use the algorithm to detect the orientation. This method is better than pure polling method because the microcontroller does not need to start an external timer for reading the sensor output (XYZ). This method can be used in combination with the Auto Wake-Sleep feature. When no activity on the sensor is detected the sampling rate will change to a lower rate (as specified by the AWSR) as a result less power consumption will be used.

**NOTE:** For Auto Wake-Sleep functionality refer to the MMA7660FC Data Sheet.

## ONE OR TWO DIFFERENT P/L AND L/P TRIP POINTS DESIRED

In this condition, if the user wants the P/L and L/P trip points to be a value other than 45 degrees, the GINT feature can be used. If the GINT bit in INTSU register is set to 1, an automatic interrupt will occur after every measurement based on the sampling rate in AMSR [3:0]. The INT will occur when the g-cell readings are updated in XOUT, YOUT, ZOUT registers, regardless of whether the readings have changed.

**Example 1**: The trip point of P/L and L/P is 55 degrees, debounce count = 4.


**Figure 2. Orientation Detection Trip Point**

**PSEUDOCODE**

1. Configure the ODR = 32 Samples Per Second. GINT Enabled.
2. If GINT occurs
   a. Read XOUT, YOUT and ZOUT value
   **NOTE:** Calculate the arctan of the angle.
   b. Calculate arctan = arctan (|YOUT|/|XOUT|)
   c. If the Z angle of the device is between ±33 degrees
   **NOTE:** Z lockout value = 0.84g, |ZOUT| < 0.84g.
      i. If arctan > 55 degrees
         1.Orientation = Portrait
      iii. Else if arctan < 55 degrees
         1.Orientation = Landscape
3. If Orientation = Portrait
   a. If XOUT < 0
      i. Orientation = Up
         1. increase the up debounce count if prior position is UP, else reset debounce count
   b. If XOUT > 0
      i. Orientation = Down
         1. increase the down debounce count if prior position is Down, else reset debounce count
4. If Orientation = Landscape
   a. If YOUT < 0
      i. Orientation = Right
         1.increase the up debounce count if prior position is Right, else reset debounce count
   b. If YOUT > 0
      i. Orientation = Left
         1. increase the down debounce count if prior position is Left, else reset debounce count
5. If debounce count = 4
   a. Update Application View to Orientation.

**Advantages of using arc tangent and not sine function to calculate the angle:**

1. The arctangent function eliminates sensitivity error when dividing X and Y.
2. The device will not rotate in the vertical plane, therefore the real X/Y value should be (XOUT/YOUT)/(cosineZ = |OUT/Sensitivity|). By using the arctangent function, we don't need to care about the Z -axis.

**NOTE:** For further advantages on using arctangent functions please refer to AN3461

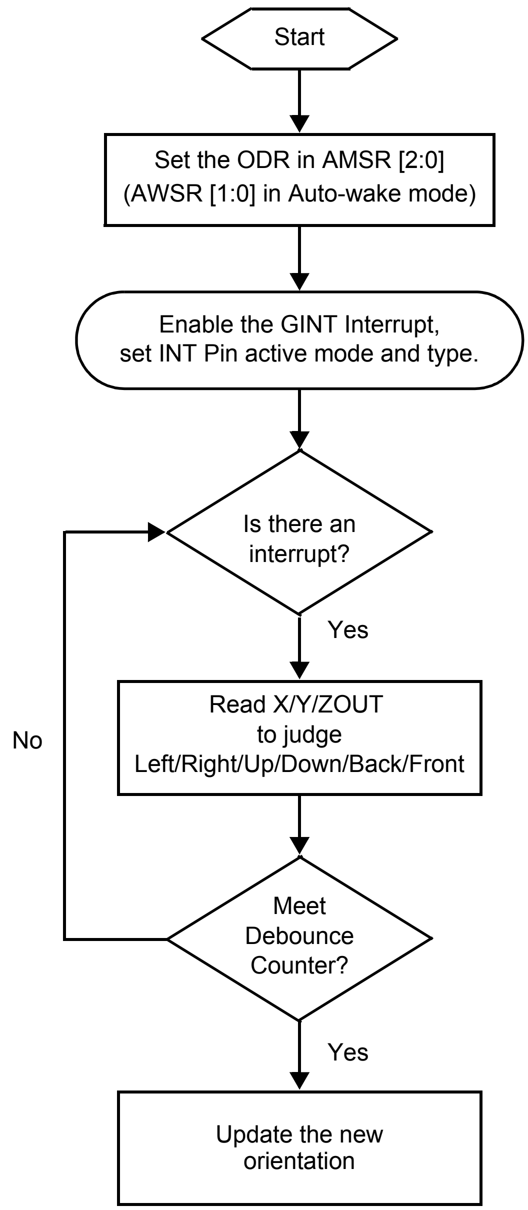


**Figure 3. Flow Chart of Orientation Detection with User Defined Trip Points**

**Example 2:** The trip point of P/L is 30 degree and L/P is 55 degree, debounce count = 4.

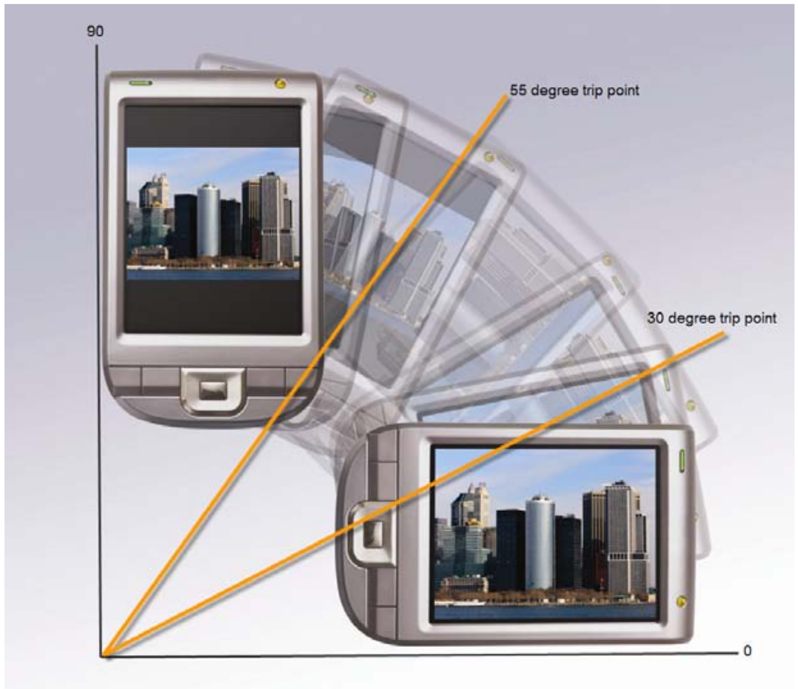


**Figure 4. 2 Orientation Detection Trip Point**

**PSEUDOCODE**

1. Configure the ODR = 32 Samples Per Second. GINT Enabled.
2. If GINT occurs
   a. Read XOUT, YOUT and ZOUT value
   **NOTE:** Calculate the arctan of the angle.
   b. Calculate arctan = arctan (|YOUT|/|XOUT|)
   c. If the Z angle of the device is between ± 33 degrees
   **NOTE:** Z lockout value = 0.84g, |ZOUT| < 0.84g.
      i. If arctan > 55 degrees
         1.Orientation = Portrait
      ii. Else if arctan < 30 degrees
         1.Orientation = Landscape
3. If Orientation = Portrait
   a. If XOUT < 0
      i. Orientation = Up
         1.increase the up debounce count if prior position is Up, else reset debounce count
   b. If XOUT > 0
      i. Orientation = Down
         1.increase the down debounce count if prior position is Down, else reset debounce count
4. If Orientation = Landscape
   a. If YOUT < 0
      i. Orientation = Right
         1.increase the up debounce count if prior position is Right, else reset debounce count
   b. If YOUT > 0
      i. Orientation = Left
         1. increase the down debounce count if prior position is Left, else reset debounce count
5. If debounce count = 4
   a. Update Application View to Orientation

**USING THE BUILT-IN ORIENTATION DETECTION THRESHOLD IN COMBINATION WITH AN APPLICATION SPECIFIC TRIP POINT**

In this case only one trip point is the built-in 45 degree trip point and the other is a value other than 45 degrees. In this condition, we can use hybrid solution to reduce more system resources and power consumption.

**Example 3**: The P/L trip point is 30 degrees with debounce count = 4, and the L/P is 45 degrees with debounce count = 2.

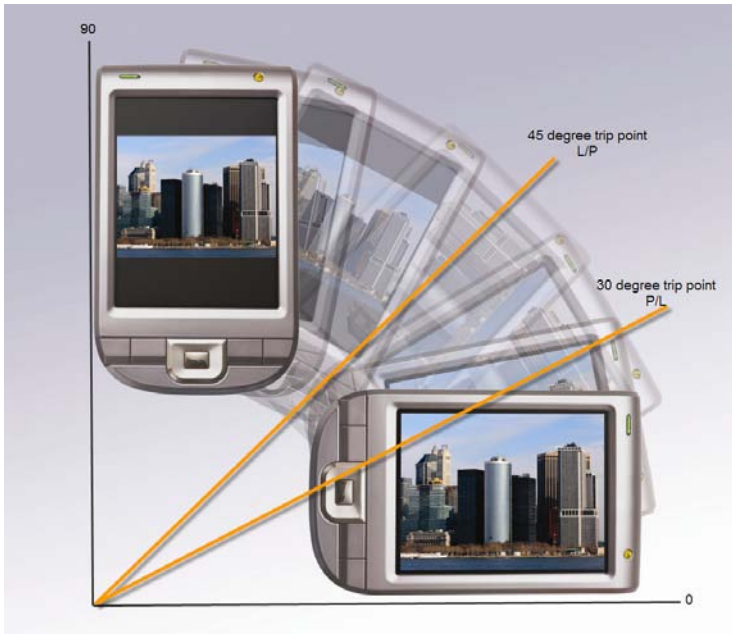


**Figure 5. Built-in Detection Trip Point for L/P and 30 Degree for P/L**

**PSEUDOCODE**

1. Configure the PLINT feature, the ODR = 8 Samples Per Second. TILT debounce filter = 8.
2. If INT occurs
   a. Read TILT value
   b. If PoLa = 5
      i. Update Orientation = Down (Portrait Upside Down)
   c. If PoLa = 6
      i. Update Orientation = Up (Portrait)
   d. If PoLa = 1 or PoLa = 2 (Landscape)
      i. Enable GINT< set ODR = 32 Samples Per Second
      ii. If GINT occurs
         1.Read XOUT, YOUT and ZOUT value
         **NOTE:** Calculate the arctan of the angle.
         2.Calculate arctan = arctan (|YOUT|/|XOUT|)
         3.If the Z angle of the device is between ± 33 degrees
         **NOTE:** Z lockout value = 0.84g, |ZOUT| < 0.84g
         1.Else if arctan < 30 degrees
           a. Orientation = Landscape
              i. If YOUT < 0
                 1. Orientation = Right
                 2. Increase the up debounce count if prior position is Right, else reset debounce count
              ii. YOUT > 0
                 1. Orientation = Left
                 2. Increase the down debounce count if prior position is Left, else reset debounce count
           b. If debounce count = 4
              i. Update Application View to Landscape Orientation
              ii. Enable Tilt Interrupt in Step1.

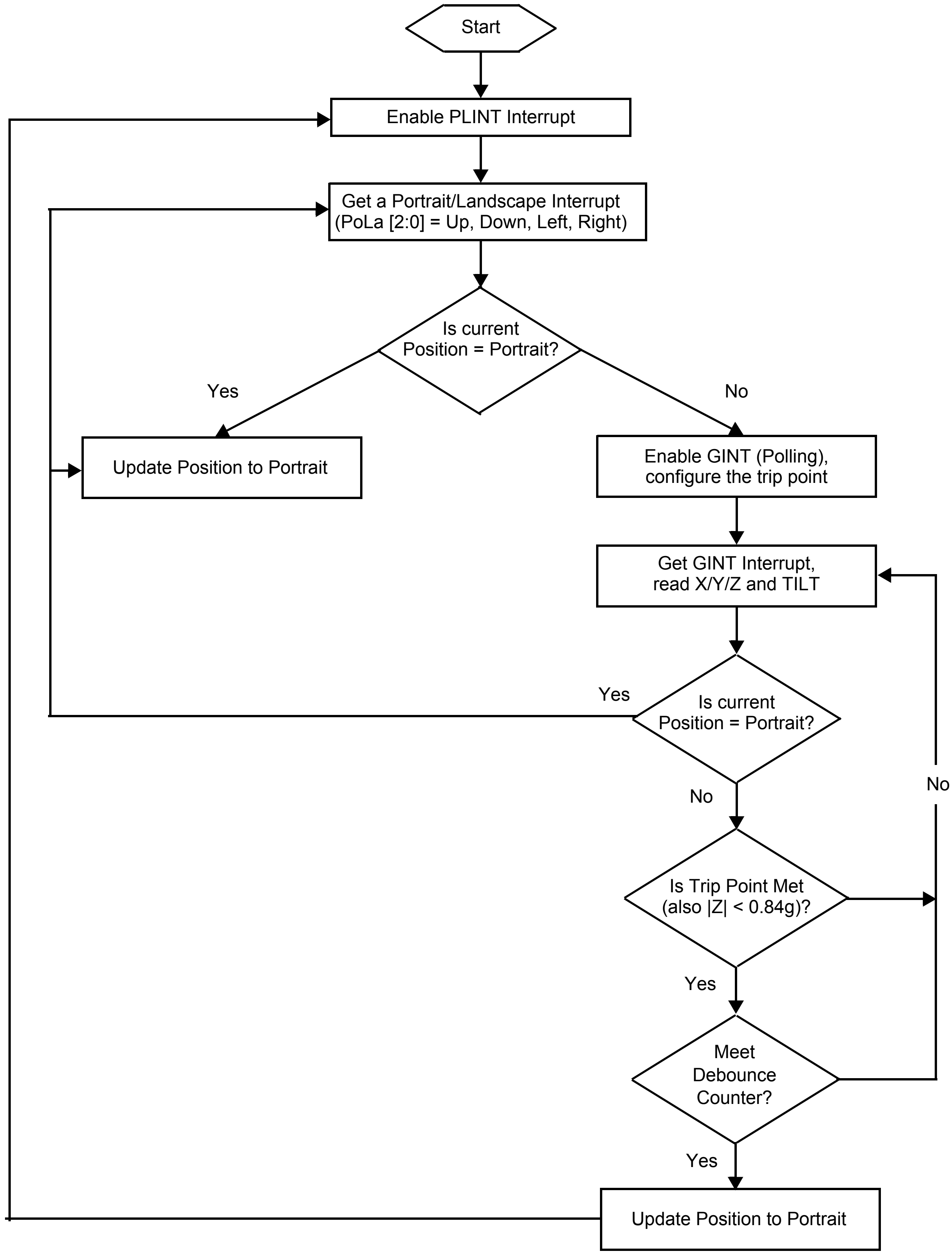


**Figure 6. Flow Chart of Orientation Detection with Built-in Trip Point and User Defined Trip Point**

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Headquarters
ARCO Tower 15F
1-8-1, Shimo-Meguro, Meguro-ku,
Tokyo 153-0064
Japan
0120 191014 or +81 3 5437 9125
support.japan@freescale.com

**Asia/Pacific:**
Freescale Semiconductor China Ltd.
Exchange Building 23F
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AN3838
Rev. 2
9/2009