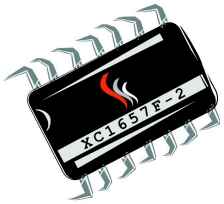


Wireless Tilt Sensing

WiTilt v2.5
2.4GHz Wireless 3-axis Tilt Sensor
3/2/2006

1 Overview

The original WiTilt v1 started out as a controller for a toy robot. But it soon grew into a precision remote sensing device, giving 2 axes of acceleration measurement over a wireless link. However, growing customer need and popular demand spurred us on to develop the next generation of WiTilts, the V2 series. And now the WiTilt v2.5.

The WiTilt v2.5 employs a Freescale MMA7260Q *triple-axis* accelerometer and a class 1 Bluetooth link for more robust communications ove a more universal platform. Features on the WiTilt v2.5 include:

- Selectable channels for sampling (X, Y or Z axes)
- Greater range achieved with external antenna
- Status LED's to indicate Bluetooth activity
- Adjustable sensor range and calibration (1.5g, 2g, 4g, 6g)
- Output in calculated gravity or raw ADC values in ASCII format
- Output in binary format
- Adjustable report threshold
- Adjustable output frequency

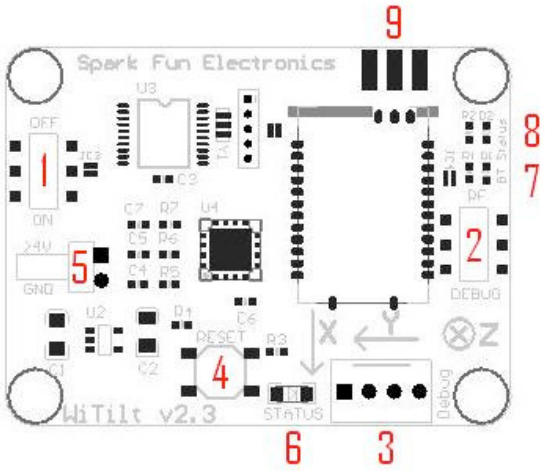
  135Hz max in gravity mode

  220Hz max in raw ADC mode

  610Hz max in binary mode

2 Hardware Layout

There are only a few things that the reader should be familiar with before using the WiTilt v2.5 (indicated by the red numbers):



1) Power Switch
2) Debug/RF Switch, switches the PIC16LF88

UART between the Blue Tooth module and the debug header

3) Debug header. **Note:** The reader must take care to switch the Debug/RF switch before connecting to the debug header to avoid a UART conflict
4) uC reset button (does not reset the Blue Tooth module)
5) Power connector (4 to 6V)
6) Status LED
7) Bluetooth connection indicator LED
8) Bluetooth 1Hz pulse, mode indicator LED
9) Reverse-polarized SMA antenna connector (optional, v2.5 is also available with the standard chip antenna if space is a concern)

3 Connecting to the WiTilt v2.5

The Witilt v2.5 uses a greater degree of flow control for a more uniform data throughput with the Bluetooth interface. It is now necessary to select from within the configuration menu whether you will be using the Bluetooth link or the optional hardline connection (the default setting is with Bluetooth active). Please see section 4.8 for details on this setting.

3.1 Bluetooth

Ensure that the Debug/RF switch is set to "RF" and turn the unit on. From your base Bluetooth device, connect to the WiTilt v2.5 in serial mode and open a terminal program to which ever port your Bluetooth device is set to. Set the connection speed at 57600bps (necessary for the higher speed reporting rates). Upon making the connection you should see the configuration menu come up.

3.2 Debug Header

The user has the option of connecting directly to the UART on the PIC16LF88. This is a TTL signal, not RS232 so level conversion is necessary. First from the configuration menu, select option 8 to toggle the Bluetooth active/inactive. Once it shows "inactive", ensure that the Debug/RF switch is set to debug (you may also disconnect the Bluetooth link at this point) and connect your hardline to the debug header at TTL levels. Start your terminal program with port settings of 57600/8/n/1. Once the terminal is open, hit the reset button on the WiTilt v2.5 and you should see the configuration menu come up. The unit will now ignore flow control signals from the Bluetooth module.

To re-enable the Bluetooth link, go to the configuration menu, select option 8, disconnect your hardline, set the "debug/RF" switch to "RF", establish a Bluetooth link and open a com port to the device. Hit the reset button or the spacebar and you should see the configuration menu come up.

4 Configuration Menus

4.1 Top Menu and Start/Stop

The top-level menu for the WiTilt v2.5 can be seen below:

```
WiTilt V2.5, Firmware V4.1 - Configuration Menu:
========================
 [1] Start Tri-Ax detection (hit spacebar to stop)
 [2] Set Active Channels (XYZ Active)
 [3] Calibrate
 [4] Sensor Range (+/-1.5g)
 [5] Display Mode (Gravity)
 [6] Set Threshold (Currently +/-0.0g)
 [7] Set Output Frequency (100Hz)
 [8] Set Bluetooth (Currently Active)
```

To start the WiTilt v2.5, just press '1' and values will start pouring out. To stop, press spacebar.

4.2 Active Channel Select

Selection #2 is for setting the active channels that the unit will report. If the channel isn't selected as active, it will generate no report. Pressing '2' will enter the active channel select mode.

You will be prompted for each channel (X, Y and Z) to be set. Press 'y' or 'n' to make your selection.

4.3 Calibrate

Press '3' from the top menu to enter calibration mode. You will be prompted to manipulate the WiTilt v2.5 into various positions that maximize and minimize the readings and to press <enter> upon achieving those values.

Note: calibration should be performed every time the sensor range is changed. Calculated values that the WiTilt uses depend on the calibration being correct.

4.4 Sensor Range

Press '4' from the top menu to enter the sensor range setting mode. You will be prompted to set the range of the MMA7260Q to +/-1.5g (press '1'), +/-2g (press '2'), +/-4g (press '3'), or +/-6g (press '4'). You can also hit 'x' to exit without changing anything.

Note: calibration should be performed every time the sensor range is changed. Calculated values that the WiTilt uses depend on the calibration being correct.

4.5 Display Mode

Press '5' to set the display mode. You will be prompted to select either calculated gravity values (press '1'), raw ADC values (press '2') or binary output format (press '3'). You can also press 'x' to exit without changing anything.

Note: each display mode has a different maximum output frequency. After changing display modes, you should enter the output frequency mode. If the current value is too high for the given display mode, the unit will default to the maximum allowed value.

4.5.1 Raw and Gravity output formats

Raw ADC and calculated gravity values are output in ASCII form for ease of reading. For example, here's what you can expect to see in Raw mode with all channels active and threshold set to zero:

```
X=580   Y=485   Z=754
X=570   Y=480   Z=746
X=572   Y=488   Z=747
X=573   Y=488   Z=753
X=575   Y=486   Z=752
X=572   Y=476   Z=749
```

The display for calculated gravity values will be almost identical, except that quiescent values will be something in the range of +/-1g rather than the ADC values in the example.

Inactive channels will simply be omitted from the display, as will any reading that's below a preset threshold value.

4.5.2 Binary Output Format

The WiTilt v2.5 has a 'Binary Mode' feature. In Binary mode, it will act very differently. Once attached to a computer, the WiTilt v2.5 in Binary mode will broadcast the 'Ready' string (**#R$**) and wait for one of three commands from the host:

1) **Ready:** Sending a capitol 'R' character (**0x52**) at any time will cause the WiTilt v2.5 to respond with the 'Ready' string: **#R$** once it has completed all current measurements.
2) **Abort:** Sending an 'A' character (**0x41**) will cause the WiTilt v2.5 to stop any data output and respond with the 'Ready' string: **#R$.** From here, you can also hit spacebar to get back into the configuration menu.
3) **Start:** Sending an 'S' character (**0x53**) will cause the WiTilt v2.5 to respond with the 'Ready' string (**#R$**) and then begin to transmit the following data string:

Binary Output Format	
Byte	**Description**
0	**Start Character - always #**
1	**Data Output Designator - always @**
2	**Sample Number High Byte**
3	**Sample Number Low Byte**
4	**X Axis High Byte**
5	**X Axis Low Byte**
6	**Y Axis High Byte**
7	**Y Axis Low Byte**
8	**Z Axis High Byte**
9	**Z Axis Low Byte**
10	**End Character - always $**

The reader should bear in mind that the length of the data frame can vary depending on the number of active channels. For example, if the X channel is inactive, all following data shift up in the data frame by two bytes.

The threshold setting is also different in binary mode in that a report will still be generated even if it's below the threshold setting, but it will read '1025'. This is to ensure that the data frame is always a known length.

The *Sample Number* increases with every output and will roll-over at 65535. The *X, Y, and Z Axis* are in 16 bit binary form. They are numbers directly returned from the ADC conversion.

4.6 Threshold

A threshold setting has been added in the WiTilt v2.5. For example, by setting the threshold to 0.5g, only accelerations greater than 0.5g will be displayed. This is useful if your system is only looking for a certain shock threshold. By returning the threshold to 0.0g, all acceleration values will be reported.

Press '6' from the top menu to get into the threshold setting mode. You will then be prompted to press 'i' to increase or 'd' to decrease the threshold setting in +/-0.1g increments. **Note:** make sure you're working with a fresh calibration before setting this to a non-zero value.

4.7 Output Frequency

Press'7' from the top menu to enter the output frequency select mode. You will then be prompted to press 'i' to increase or 'd' to decrease the output frequency in 5Hz steps.

Each display mode has a maximum output frequency setting: 135Hz for gravity mode, 220Hz for Raw ADC mode and 610Hz for binary mode. You will not be able to exceed the maximum allowed value for the given display mode from the output frequency menu, but it is possible to get an incorrect setting if you don't set the output frequency after changing the display mode.

4.8 Set Bluetooth

Press '8' to select between using the Bluetooth link as flow control or no flow control. This option is used for an optional hardline connection to the WiTilt v2.5.

Selecting option 8 toggles the Bluetooth active state (default is active). For details on connecting a hardline to the debug header, please see section 3.2

4.9 Steps for Reliable Operation

A great deal of versatility has been built into the WiTilt v2.5. And as such, it may be possible to get it into a questionable state (though we've taken great pains to see that it won't). To keep everything running as smoothly as possible, please follow this sequence of steps:

1) Set the sensor range
2) Calibrate the device

3) Set the threshold (if any)
4) Set the display mode
5) Set the output frequency
6) Set active channels (anytime, really)
7) Go!

5 Sampling Rate and Aliasing

The Freescale MMA7260Q has a BW of 350Hz on its X and Y axes and a BW of 150HZ on its Z axis. These are set by internal switched capacitor filters on the device.

The WiTilt v2.5 allows the use to se the output frequency of a full frame of data, where one frame is one measurement from each axis. Therefore the output frequency is equivalent to the sampling rate for any given axis. This will be true in all cases, even where channels are inactive or threshold settings prevent a report.

Because of the BW restrictions of the MMA7260Q, some aliasing may be seen at output frequencies lower than about 225Hz. Best results can be realized while operating in binary output format at high frequency.