WiEye®

Sensor board for wireless surveillance and security applications

Plug-in sensor board for IEEE 802.15.4/Zigbee compliant TelosB wireless motes

Four Sensor channels including Long-Range Passive Infrared (PIR), Visual Light, Low Pass Filtered Acoustic Envelope and Unprocessed Acoustic Channels

Product Description

EasySen WiEye is a low-power, multi-channel sensor board designed for use with IEEE 802.15.4/Zigbee compliant TelosB[1] wireless sensor network platforms in security and surveillance applications. WiEye features passive infrared (PIR), visual light, low pass filtered acoustic envelope and unprocessed acoustic channels. It can be directly connected to the expansion connectors of the TelosB platforms using an IDC header.

WiEye has a smaller form-factor than TelosB platforms and enables a wide variety of multi-modal sensor applications for security, surveillance and monitoring using wireless sensor networks. It is particularly suited to support perimeter security applications and can detect movement of individuals from a distance of 30 feet and the movement of vehicles from distances up to 150 feet.

Key Features

- Long-range passive infrared (PIR) sensor well suited for detecting human presence or vehicles (90-100° wide detection cone, **20-30 feet detection range for human presence, 50-150 feet detection range for vehicles depending on the size of vehicle**)
- Visual light and acoustic sensors complementing the PIR sensor for improved detection
- Adjustable time constant in PIR sensor output for customized applications
- Rectified acoustic envelope output with adjustable time constant and adjustable low-pass filter for customized applications
- Additional acoustic channel allowing high frequency sampling of voice and other noise signals
- Can be directly plugged into the external connector of IEEE 802.15.4/Zigbee compliant TelosB motes
- Smaller form factor than TelosB motes
- TinyOS and Java code support available for sampling sensor channels, display readings on a PC
- Power saving mode

[1] CrossBow Inc, TelosB (TPR2400CA) Product Datasheet, http://www.xbow.com/Products/Product_pdf_files/Wireless_pdf/TelosB_Datasheet.pdf

Table of Contents

Table of Contents....................2

1. Board Description....................3

2. Sensor Description....................3
   2.1. Passive Infrared (PIR) Sensor....................3
   2.2. Visual Light Sensor....................5
   2.3. Unprocessed Acoustic Sensor Output (Acoustic Channel I)....................5
   2.4. Low Pass Filtered Acoustic Envelope (Acoustic Channel II)....................5

3. Connection to TelosB....................8
   3.1. Instruction for Soldering Connector to TelosB....................8

4. TinyOS and Java code for reading sensors....................10

5. Power....................11

6. General Information....................11
   6.1. Document History....................11
   6.2. Disclaimer....................11
   6.3. Contact Information....................11

1. Board Description

EasySen WiEye is a low power, flexible sensor board with high sensitivity and long sensing range sensor modalities (passive infrared (PIR), visual light, acoustic and low pass filtered acoustic signal envelope) that is specifically designed to be plugged into TelosB wireless motes for use in sensor networks, data fusion, rapid application prototyping and particularly security, surveillance and monitoring applications. A front layout of WiEye is shown in Figure 1.

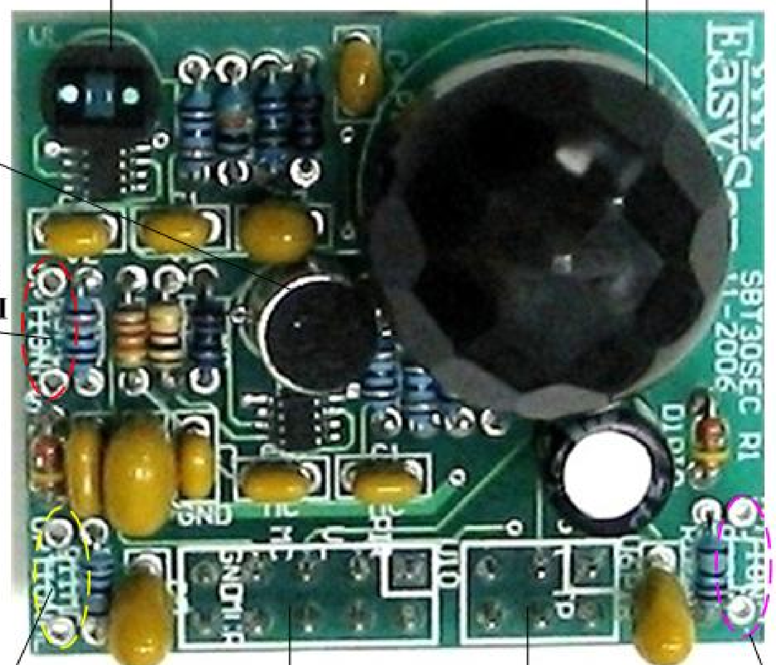

Figure 1. Top view of WiEye

2. Sensor Description

2.1. Passive Infrared (PIR) Sensor

This channel uses the digital passive infrared sensor (AMN44121, http://pewa.panasonic.com/). It has the ability to detect movements at distances up to 20-150 feet, depending on the IR signature of the moving object. The sensor output jumps approximately from 0 to 4000 when a object is detected and then decays exponentially at an adjustable rate. The default rate is given by a time constant of approximately 3 seconds. This time constant can be increased by soldering a capacitor on the optional pin slots R_{opt} (see Figure 1) and decreased by soldering a resistor on the same slot. The resulting circuit is shown in Figure 2 and the signal output after detection of an event is exponentially decaying with a known, adjustable rate as shown in Figure 3. This allows the user to sample the sensor at a very low rate if so desired. The signal level allows to calculate how far back in time the event actually occurred.

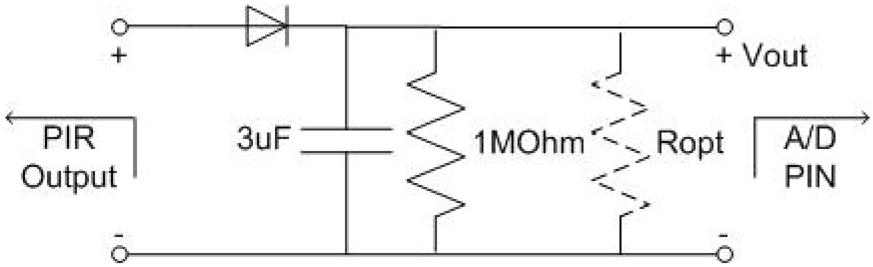

Figure 2. Circuitry of PIR channel

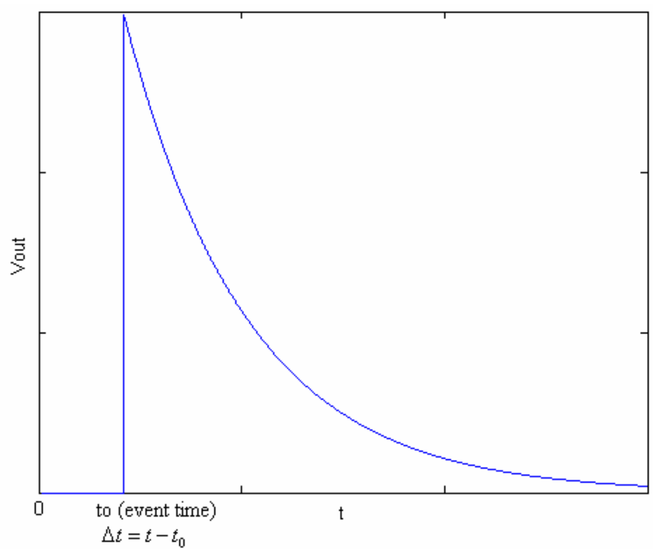

Figure 3. PIR channel output signal after an event is detected

The relevant equations are:

Time constant:
$\tau = (1M\Omega \| R_{opt}) \cdot 3\mu F$ (if R_{opt} is an optional resistor to reduce the default time constant);
or
$\tau = 1M\Omega \cdot (R_{opt} + 3\mu F)$ (if R_{opt} is substituted by an optional capacitor to increase the default time constant).

The resulting event time can then be expressed as $t - \Delta t$ where t is current time and
$\Delta t = \ln(4000 / MSS) \cdot R \cdot C$
where MSS is the measured signal strength on the PIR channel and R and C are the resulting resistor and capacitor used in the RC circuit.

2.2. Visual Light Sensor

The visual light sensor (VTB9412B, http://optoelectronics.perkinelmer.com/) is a small area planar silicon photodiode in a recessed ceramic package. The package incorporates an infrared rejection filter. The sensor has very high shunt resistance and good blue response. It has a wide viewing angle, high sensitivity, and an excellent linearity. The spectral response of the visual light sensor is depicted in Figure 4.

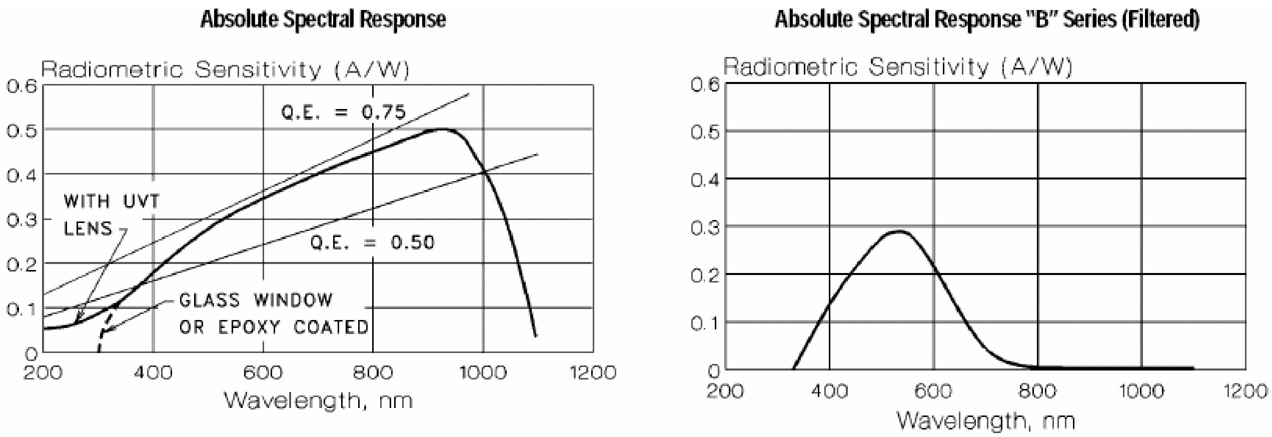

Figure 4. Spectral Response of the Visual Light Sensor

2.3. Unprocessed Acoustic Sensor Output (Acoustic Channel I)

The acoustic sensor (EM6050P-423, http://www.digikey.com/) is a high sensitivity omni directional condenser microphone. It consists of a high voltage internal electret membrane, a metal electrode and a field effect transistor (FET). Its adoption of a high quality FET ensures its reliability and durability.

2.4. Low Pass Filtered Acoustic Envelope (Acoustic Channel II)

This channel provides an acoustic signal envelope that is generated from the low pass filtered audio signal of the unprocessed acoustic signal (acoustic channel I). It allows the user to sample at a lower speed to detect the "activity" on the acoustic channel. The time constant is preset to 3 seconds, so that acoustic activity can be checked with very low sampling rates (in the order of hundreds of ms or even seconds). The cutoff frequency of the low pass filter can easily be increased from the nominal 50Hz by adding the resistor Rp1 as shown on Figure 1. The circuitry is illustrated in Figure 5 below. Since the filter is a simple first order RC filter, adding a resistor of 20K would move the 3db frequency to 100Hz. (Rp1 is in parallel with the 20K resistor R1 and the capacitor of the RC filter is 0.16uF). One may also change the RC time constant envelop detector by either adding a resistor in the position of Rp2 (see Figure 1) or adding a capacitor in this position. If a resistor is added, it reduces the time constant since it is in parallel with R2=$1M\Omega$. If a capacitor is added, it increases the time constant since it is in parallel with the capacitor C2=3uF. The frequency response of the RC low pass filter and the typical acoustic envelope signal are shown in Figure 6 and 7.

In summary, the equations for the LP cutoff frequency and the time constant τ of the acoustic envelope detector are:

$$f_c = \frac{1}{2\pi \cdot (20K\Omega \| R_{p1}) \cdot 0.16\mu F}$$

$$\tau = \begin{cases} (1M\Omega \| R_{p2}) \cdot 3\mu F & if \quad R_{p2} \quad is \quad a \quad resistor \\ 1M\Omega \cdot (R_{p2} + 3\mu F) & if \quad R_{p2} \quad is \quad replaced \quad by \quad a \quad capacitor \end{cases}$$

It should be noted that the output signal of acoustic signal 2 (acoustic envelop) will stay between approximate ADC sample values 1600 (no signal) to 3500 (strong signal in the passband).

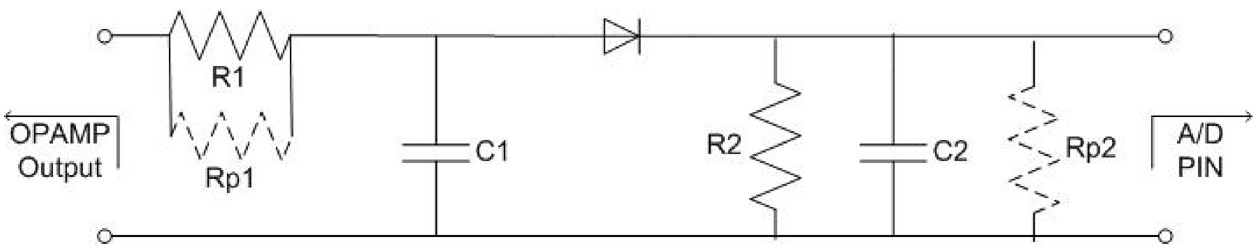

Figure 5. Circuitry for Acoustic Channel I

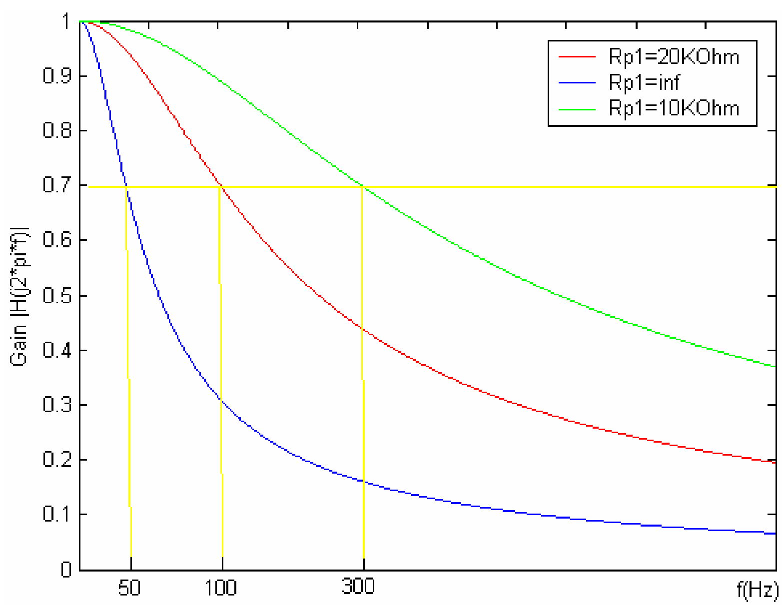

Figure 6. Frequency Response of the RC low pass for acoustic channel I

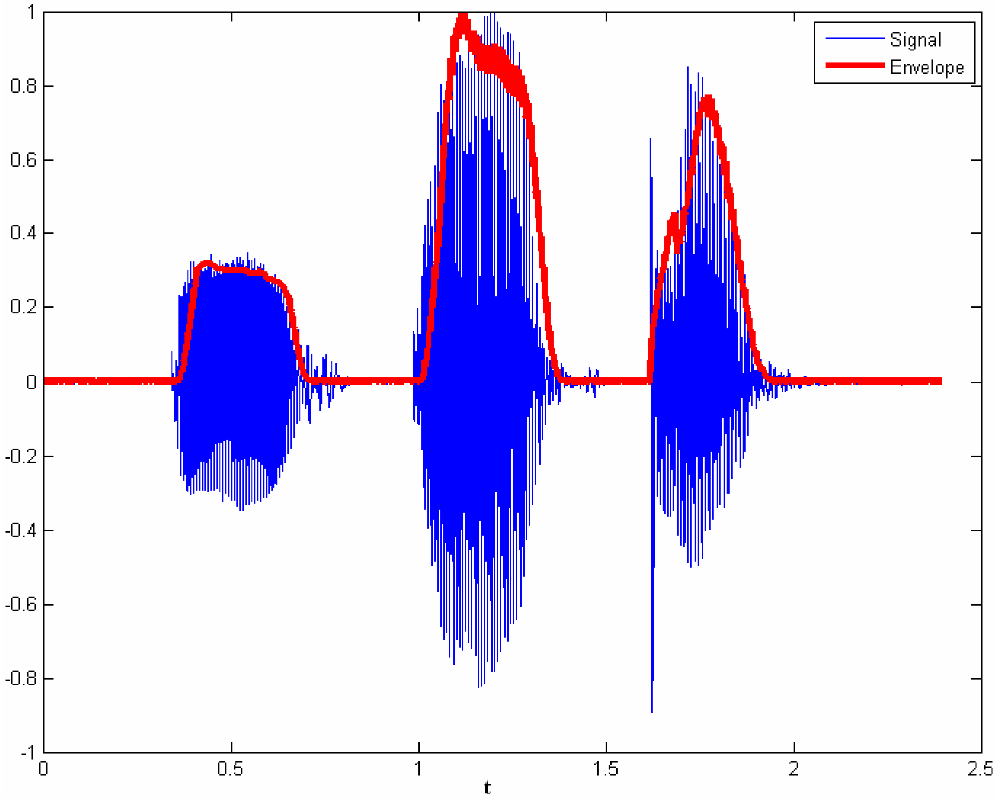

Figure 7. Typical output of acoustic envelope channel (Acoustic I)

3. Connection to TelosB

WiEye provides two interfacing male connectors to Telos motes, a 6-pin IDC header at position U6 and a 10-pin IDC header at U10. After soldering the female parts on expansion connectors of the Telos motes, WiEye can be directly plugged into these motes (please see below for soldering instructions). The functionality layouts of these two IDC connectors are shown in Figure 8 and 9.

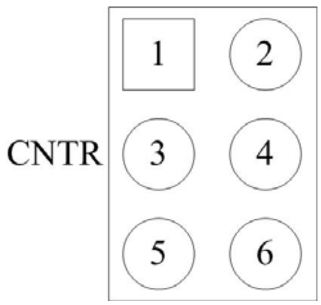

Figure 8. Functionality of the 6-pin IDC connector (U6) (top view)

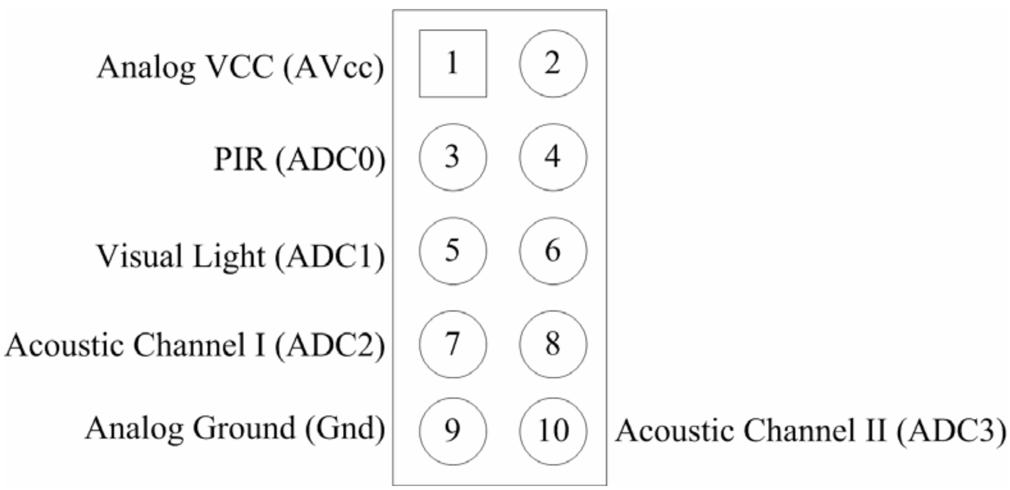

Figure 9. Functionality of the 10-pin IDC connector (U10) (top view)

Note: The ADC channel labels correspond to the expansion connector layout of the TelosB mote. The power of WiEye is supplied by the connected radio mote (through pin 1 and 9 of U10). The sensor board can be switched to the low power "sleep mode" using the CNTR (Pin 3) of U6 connector.

3.1. Instruction for Soldering Connector to TelosB

In order to connect a WiEye to a TelosB mote, a 10-pin female connector (S4305-ND, www.digikey.com) and a 6-pin female connector (S4303-ND, www.digikey.com) need to be soldered to the 10-pin (U2) and 6-pin (U28) expansion connectors on the TelosB mote (**These connectors are included in your WiEye purchase).** After soldering these two connectors, the WiEye can be directly plugged into these connectors and interfaced with the TelosB mote, as shown in Figure 10.

Figure 10. WiEye plugged into a TelosB mote (top view)

4. TinyOS and Java code for reading sensors

Sample TinyOS and Java code available for reading sensors in the companion SBT80 multi-sensor board (http://www.easysen.com/support/SBT80v2/samplecode_SBT80v2) will work for the WiEye board with no changes. In this case, users must ignore the last 4 data bytes of each packet displayed on the PC.

For an explanation of this code, users are referred to the programming instructions on the SBT80 datasheet (http://www.easysen.com/support/SBT80v2/DatasheetSBT80v2.pdf).

If a customized program and a shorter packet format are preferred, one can be easily adopt and modify the above code as explained below. Minor changes may be required as explained in the following.

(a) WiEye has 4 sensor channels as compared to 8 channels in SBT80. To accommodate for these, users can simply omit the sampling of the unused channels and only sample ADC channels 0,1,2,3. For this, use the following mappings to map the corresponding ADC ports to the sensor components in the configuration file MobileNode.nc :

```
MobileNodeM.PIR      -> ADCC.ADC[TOS_ADC_EXTERNAL_ADC0_PORT];
MobileNodeM.VL       -> ADCC.ADC[TOS_ADC_EXTERNAL_ADC1_PORT];
MobileNodeM.MC       -> ADCC.ADC[TOS_ADC_EXTERNAL_ADC2_PORT];     //Acoustic I envelope
MobileNodeM.MCR      -> ADCC.ADC[TOS_ADC_EXTERNAL_ADC3_PORT];     //Acoustic II raw
```

and use these components to sample the corresponding sensors in the module file MobileNodeM.nc

(b) Code related to switching pin of SBT80 is not required for WiEye. Hence, users may **remove** the following code line from the configuration file MobileNode.nc

```
MobileNodeM.SBswitch  -> MSP430GeneralIOC.Port26;
```

and the related code from the module file MobileNodeM.nc

(c) Users may use the same data packet format as specified in the header file SBT80Msg.h and the java code used to display data on PC ListenSBT80v2.java, with dummy data for the additional fields. Otherwise, it is straightforward to modify the code in SBT80Msg.h and ListenSBT80v2.java to have a shorter packet format and a display format.

5. Power

WiEye is powered by the attached TelosB mote through the 10-pin interfacing connector. The mote itself is powered by two AA batteries or a host computer is it is attached to its USB. The operating voltage for WiEye falls between 2.4V and 3.6V. At no point should the input voltage exceed 3.6V—doing so may damage certain components. A power control pin is provided on the 6-pin connector (see Figure 4), which switches WiEye to the normal "work" mode if input is low, and to the "sleep" mode if input is high.

6. General Information

6.1. Document History

Revision	Date	Notes
1.0	02/22/2007	Initial Release
1.1	03/12/2007	Correction on detection range

6.2. Disclaimer

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6.3. Contact Information

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