Interfacing a custom sensor to AmbioMote24

January 14, 2010

Table of Contents

1 INTRODUCTION

The circuitry of AmbioMote24 allows for easy interfacing of custom sensors, including voltage sources, resistive and capacitive sensors. The process of interfacing a custom sensor is performed in the following steps:

A) Connection of the custom sensor

B) Sizing and installation of a storage capacitor

C) Selection and programming of proper firmware

D) Computation of the measurement results

This application note provides instructions on interfacing resistive and capacitive sensors. The custom sensor interface board with a 3-pin terminal (SKU: SENS-0004) is required for this task. The interface board is shown in Figure 1.

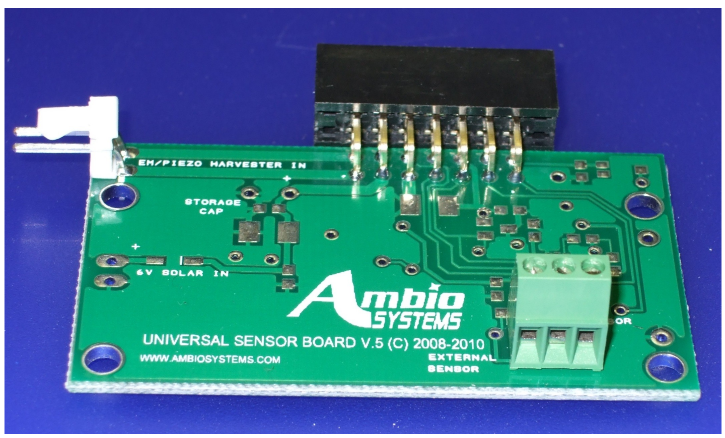

Figure 1: Custom sensor interface board.

2 SENSOR CONNECTION

A three-pin screw terminal installed on the board is used for connecting an external sensor. The three pins (left-to-right as shown on Figure 1) are:

1. **3V power.** This output pin supplies energy needed to perform a measurement. The pin is activated prior to taking a reading and deactivated immediately after taking a reading.
2. **ADC input**. This input pin connects to internal ADC of the Ambiomote24. To implement ultra-low-power consumption, the interface is not buffered, therefore caution should be exercised not to overload the input and damage the ADC. Allowed voltage range is 0-2.5V.
3. **Ground.** This output pin supplies the ground connection.

Connection of a resistive sensor

A resistive sensor connects as simple voltage divider according to the schematic shown in Figure 2. Assuming that the range of values of the resistive sensor is [Rmin, Rmax] over the measurement range, the value of the pull-up resistor should be selected as:

$$R_{PULL-UP}=0.7[R_{MAX}+R_{MIN}] \quad (1)$$

This ensures the 1.25V middle point and maximum dynamic range of signal for the ADC. Depending on a specific application requirements other values of the pull-up resistor may be used to shit the middle point or extend a part of the dynamic range.

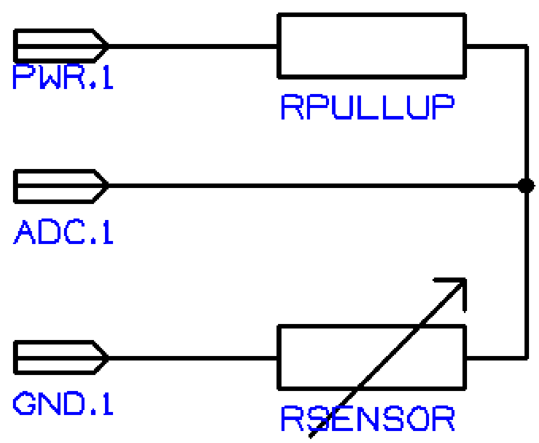

Figure 2: Interfacing a resistive sensor

Connection of a capacitive sensor

A capacitive sensor is connected using the circuit shown in Figure 3.

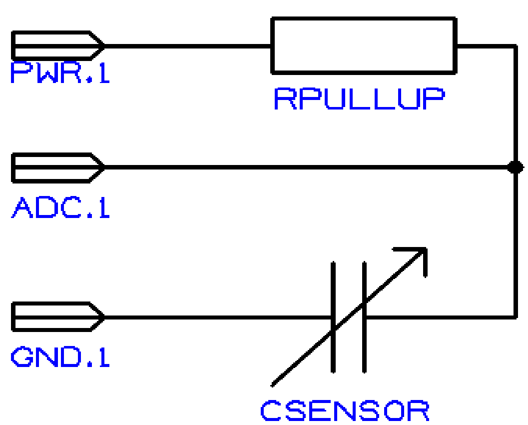

Figure 3: Interfacing a capacitive sensor

The capacitive sensor operates in the following way:

1. The capacitor is discharged to 0V by connecting the ADC input to ground for 1ms.
2. The ADC input is put into high-impedance state and capacitor is charged through the pull-up resistor for another 1ms.
3. An ADC reading is taken and transmitted.

Thus, the voltage on the on the capacitive sensor depends on the value of the capacitance and the value of the pull-up resistor.

The voltage on the capacitor at the time of measurement is defined by the following formula:

$$v(t)=3(1-e^{-0.001/RC}) \tag{2}$$

For a capacitive sensor with a range of values [Cmin, Cmax], the value of the pull-up resistor should be selected as:

$$R_{PULL-UP}=1.8553\times10^{-3}/C_{AVG} \quad \text{, where} \tag{3}$$

$$C_{AVG}=(C_{MIN}+C_{MAX})/2 \tag{4}$$

This ensures that the middle point of the sensor capacitance values will correspond to the middle point of ADC voltage (1.25V). Formula (3) is a direct derivation from formula (2) and similar calculations can be made to establish the value of the pull-up resistor if a different operational point is desired.

3 SIZING AND INSTALLATION OF STORAGE CAPACITOR

The storage built into the AmbioMote24 is sufficient to perform reading of most resistive and capacitive sensors. However, for low-impedance resistive sensors additional energy storage may be required to complete a measurement cycle and a wireless transmission. The sensor interface board has three placeholders where additional capacitors could be installed (Figure 4). We recommend using ceramic capacitors as they have the lowest leakage.

The size of the capacitor should be determined experimentally. As a rule of thumb, 1uF should be the first value to be tried, followed by progressive increase in capacitance. It should be noted that the value of the storage capacitor directly impacts the charging time. Higher capacitance will need a longer time to be charged to operational voltage, thus we recommend keeping the storage capacitor at a minimal acceptable value.

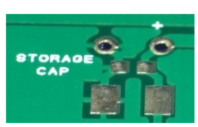

Figure 4: Storage capacitor pads on the sensor board

4 SELECTION AND PROGRAMMING OF FIRMWARE

Custom sensor interface is supported by firmware that needs to be programmed into the AmbioMote24. For programming instructions please refer to Application Note AN-07-0001-1.0 *Using AmbioMote24 configuration utility*.

Four different firmware files support custom sensor functionality:

1. A_EXTSENSOR.hex – Resistive sensor firmware for AmbioMote24-A
2. B_EXTSENSOR.hex – Resistive sensor firmware for AmbioMote24-B
3. A_CAPACITIVE.hex – Capacitive sensor firmware for AmbioMote24-A
4. B_CAPACITIVE.hex – Capacitive sensor firmware for AmbioMote24-B

5 COMPUTATION OF RESULTS

Both resistive and capacitive sensors will produce values expressed in volts (Figure 5). If the AmbioLogger software does not recognize the custom sensors correctly, please upgrade to the latest version of AmbioUtilities by downloading from www.ambiosystems.com.

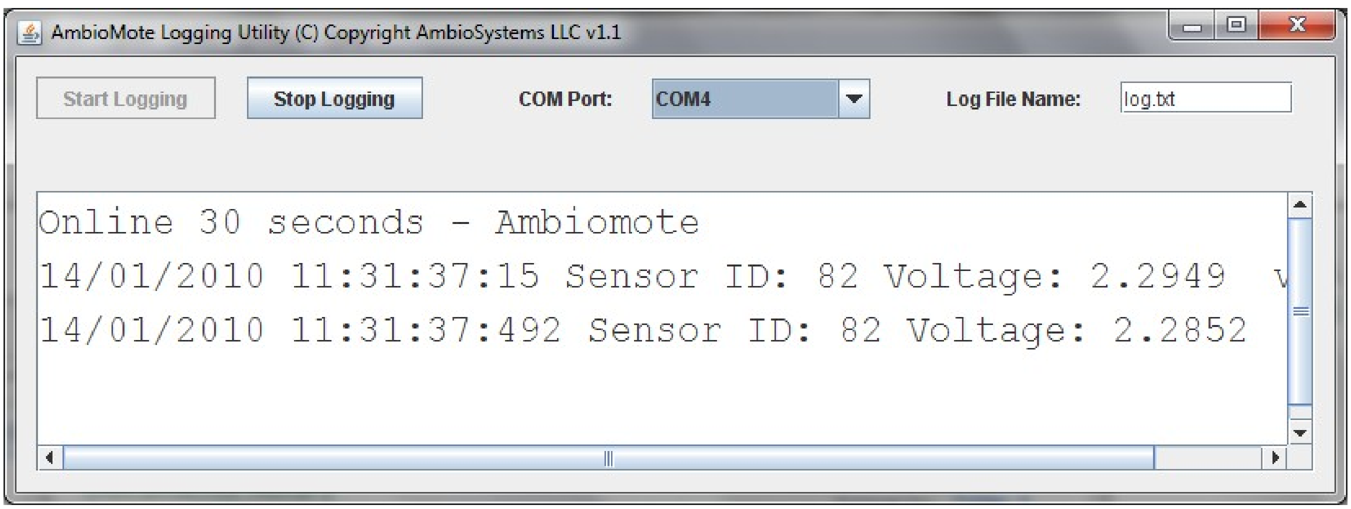

Figure 5: Log of data from a custom sensor

The values in Ohms and Farads can be computed using the following formulas where V_{ADC} is the voltage reading received from the sensor.

$$R_{SENSOR} = R_{PULL-UP} V_{ADC} / (3 - V_{ADC}) \quad (5)$$

$$C_{SENSOR} = -0.001 / (R_{PULL-UP} \ln(1 - V_{ADC}/3)) \quad (6)$$

Revision history

10-01-14

– original document

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