USB Weather Board V3

2013.07.05

Overview

Got weather? The USB Weather Board V3 can handle it. This board was designed to perform atmospheric measurements using a suite of onboard and external sensors, and consolidate that data into a serial data stream suitable for a datalogger or computer.

This versatile board features the following built-in sensors:

- Humidity (SHT15, COM-08227)
- Pressure (BMP085, COM-09603)
- Temperature (available from both humidity and pressure sensors)
- Light (TEMT6000, COM-08348)

You can optionally connect the board to SparkFun's Weather Meters (SEN-08942, not included), to add the following sensors:

- Wind speed
- Wind direction
- Rainfall

The board can send all this information to a host computer or datalogger via:

- Mini-USB cable (not included)
- Logic-level serial
- BlueSMiRF Bluetooth modem (not included)
- XBee radio module (not included)

The board can be powered via:

- Mini-USB cable (not included)
- An external DC power source from 3.7V to 12V (a JST connector is provided for a 3.7V Lithium-Polymer battery, not included).
- A regulated external 3.3V supply.

To top it all off, the board is Arduino compatible (3.3V, 8MHz, w/ ATmega 328) for easy reprogramming and customization.

Specifications

Power

- Voltage: 3.7V to 12V unregulated supply, such as 5V via mini-USB cable (not included) or 3.7V LiPo battery (not included).
- Current: 15mA average (no wireless), 60mA average with wireless module (1mW Xbee or class 1 Bluetooth).

  The internal 3.3V regulator can supply 500mA peak to an XBee or additional hardware. The XBee socket is powered by the board's 3.3V regulator, while the BlueSMiRF socket is powered by USB 5V or raw external voltage.

Data

- 9600 baud 8N1 async serial (default).
- Numerous data output options available from configuration menu.

Sensors

- SHT15 humidity/temp sensor (COM-08227)
- BMP085 pressure/temp sensor (COM-09603)
- TEMT6000 ambient light sensor (COM-08348)
- Unpopulated headers provided for Weather Meters (SEN-08942, not included), which add sensors for wind direction, wind speed, and rainfall.

Wireless (optional)

The board can optionally accommodate either an XBee or BlueSMiRF radio module for wireless operation. Radio module and socket not included.
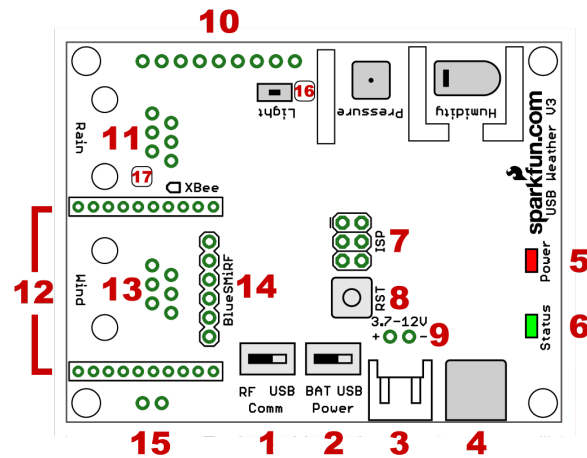
Dimensions

- Overall: 2.6" x 2" (1/16" board thickness)
- Bolt pattern: 2.4" x 1.8" (4-40)
- A socketed XBee module (optional) will extend 0.4" above the board
- A socketed BlueSMiRF module (optional) will extend 0.6" above the board
- RJ11 connectors for the Weather Meters (optional) extend 0.6" *below* the board

1

USB Weather Board V3
2013.07.05

Board layout (component side)

1. Comm switch (USB or RF)
2. Power switch (USB or battery/external)
3. JST battery connector (3.7V to 12V)
4. Mini-USB connector
5. Power LED (red)
6. Status LED (green)
7. ISP programming header (JP3)
8. Reset button
9. External power header (JP2, 3.7V to 12V)
10. Expansion header (JP7, see schematic)
11. Rain gauge RJ11 header
12. XBee header
13. Wind speed / direction RJ11 header
14. BlueSMiRF header
15. Regulated 3.3V in / out header (JP8)
16. SJ1, solder jumper for external light sensor
17. SJ2, solder jumper for BlueSMiRF reset
    (see "Hacking Tips" below)

TIP: Whenever you solder on the Weather Board, take care when cleaning up afterward. The pressure and humidity sensors are sensitive to contaminants, so don't get them wet or dirty if possible. See the sensor datasheets for more information.

Power connection

The board can be powered via USB cable, or a 3.7V LiPoly battery, or an external DC power source from 3.7V to 12V, or an external regulated 3.3V source.

The power switch lets you choose between USB and battery/external power. To turn the board on, move

the power switch towards the power source you're using, USB or BAT (BAT includes external power). The red power LED will illuminate and the green status LED will blink three times. To turn off the board, move the power switch to the other position.

Power via USB

To power the board from USB, connect it to a computer using a standard mini-B USB cable (such as SparkFun part number CAB-00598), and move the power switch to the USB position. The first time the board is plugged into a computer, FTDI drivers will be automatically loaded to activate the serial port (see "Data via USB" below).

Power via battery or external supply

To power the board from a 3.7V Lithium Polymer battery (not included, see sparkfun.com for options), connect the battery to the white JST connector. To turn on the board, move the power switch to BAT. Note that there is no onboard charging for a LiPo battery, you will need to charge it separately.

To power the board from an external 3.7V to 12V source, you can connect a JST pigtail (SparkFun part number PRT-08670) to the JST connector, or solder wires directly to the 2-pin header behind the JST connector. Connect positive to the red wire on the pigtail, or the header labeled "+". Connect ground to the black wire on the pigtail, or the header labeled "-". *Note that the board is not reverse-polarity protected, so double check your polarity before providing power*.

You can also use an external, regulated 3.3V supply to run the board, by connecting it to header JP8. Note that the power switch will not operate in this case, and that an attached BlueSMiRF will not function (the BlueSMiRF requires 3.7V or above through the unregulated power input).

Data connection

There are several ways to get weather data out of the board. Note that you will only be able to use one data connection at a time. The Comm switch controls where the board will receive data from (USB or RF).

Data via USB

To power and communicate with the board via USB, connect it to a computer using a standard mini-B USB

cable (SparkFun part number CAB-00598). Move the Power switch and Comm switch to USB.

Once the switches are correctly set and the board is plugged into a computer, the correct drivers should be loaded automatically. If there is a problem, you can manually download and install the drivers from http://www.ftdichip.com/Drivers/VCP.htm. Once the drivers are working, a virtual COM port will be created in your computer that links to the Weather Board's FTDI chip. The COM port number should be listed in your computer's Device Manager and the Arduino IDE or terminal software you use to communicate with the board (see "Using the board" below).

Data via logic-level (3.3V) serial

To connect the board to a 3.3V microcontroller serial port (UART), you will need to solder wires to the BlueSMiRF connector. You'll need 3 wires; TXO (data transmitted out of the board), RXI (data received into the board), and GND. Move the Comm switch to RF.

Note that these are 3.3V logic-level signals, and should not be connected to a true RS-232 (+/-10V) port without translating hardware (not included). However, you *may* connect these signals to a 5V system as the BlueSMiRF header contains clipping circuitry to lower incoming voltages to 3.3V (the outgoing voltage will still be 3.3V, which most 5V systems can successfully read).

Data via wireless module

The Weather Board has provisions to transmit data via wireless radio module. Connections are provided for either a BlueSMiRF Bluetooth modem, or XBee. Note that no radio systems are included with the weather board, and as the connectors overlap, you can only install one type of radio (Bluetooth or XBee) at a time.

Connecting a Bluetooth modem

You can use a SparkFun BlueSMiRF modem (part no. WRL-00582 and others) to allow the board to transmit data wirelessly. You will also need a Bluetooth receiver, such as those built into many laptops, to receive the data.

The header on the Weather Board is configured for the BlueSMiRF pinout, and will accommodate any of the BlueSMiRF products sold by SparkFun. (You may be able to adapt other radio systems to the Weather

Board, but it will require manually wiring the header to your radio inputs and outputs.)

You could solder a BlueSMiRF module directly to the Weather Board using M-M headers (SparkFun part no. PRT-00116), but we recommend using male *and* female headers (PRT-00115) to allow the BlueSMiRF to be removed if necessary. Ensure that you plug the BlueSMiRF module into the Weather Board in the correct orientation (the BlueSMiRF should "point" back towards the USB socket):
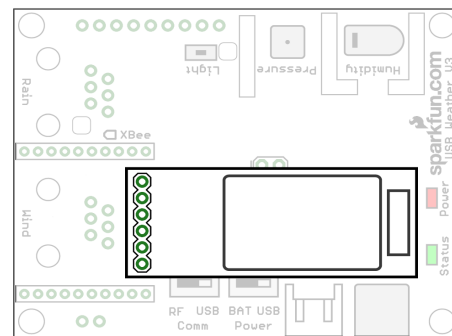
To configure your BlueSMiRF module, set up your computer to find nearby Bluetooth devices, and power up the Weather Board + BlueSMiRF. Your computer should see the BlueSMiRF module listed as "FireFly" followed by four hexadecimal digits. Connect to the module, entering the PIN code "1234" when asked. A new virtual COM port will be created, and the solid green LED on the BlueSMiRF will light up. Connect to the new COM port using your terminal program of choice (Coolterm, etc.) at 115200 baud, 8 bits, 1 stop bit, no parity.

At this point, you'll want to configure the BlueSMiRF module to work with the Weather Board. The first step is to configure the BlueSMiRF module's serial port for 9600 baud (the Weather Board's default baud rate). *Within the first 60 seconds after the BlueSMiRF has been powered on*, connect to it with your terminal program, and type "$$$". The BlueSMiRF will respond with "CMD". Type the following commands, pressing enter after each one:

+
SU,96
ST,255
---   *(three minus signs)*

The "+" turns on local echo so you can see what you're typing. The "SU,96" sets the BlueSMiRF's baud rate to 9600 baud. (Note that you should *not* change your terminal program settings to 9600 baud; leave them at 115200. This 9600 baud rate is only between the BlueSMiRF and the Weather Board.) The "ST,255" turns off the 60-second remote configuration timer, which will allow you to remotely configure the BlueSMiRF at any time. Finally the "---" (three minus signs) exits command mode and returns you to the serial connection. You will need to power-cycle the Weather Board / BlueSMiRF to cause these commands to take effect; once you do and reconnect to the module, you should see weather data being transmitted to your computer. See the BlueSMiRF documentation for more information.

Connecting an XBee radio

You can use an optional XBee module to wirelessly connect to the Weather Board. A wide variety of XBee modules are available, select one for your desired frequency and range. You will need two matching XBee modules, one for the Weather Board, and one for the receiving side. (If the receiving end is a PC, you may want to use an adapter such as SparkFun part no. WRL-08687 to connect the XBee module to your computer's USB port.) You will also need two 2mm 10-pin XBee sockets (part no. PRT-08272) to connect an XBee module to the Weather Board.

Solder the XBee sockets to the Weather Board. Note that these sockets attach to the top of the board, in the long white rectangles. **TIP**: *The XBee sockets tend to wick solder up into them (which ruins them), so use the smallest amount of solder possible.*
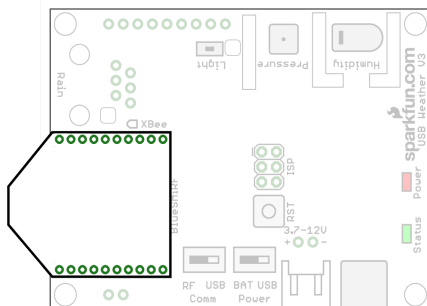
Your XBee modules may need to be configured to connect to each other. Series 1 modules do not need any configuration, they'll talk to each other at 9600

baud out of the box. Series 2 and above modules may need to be configured. See the XBee tutorials at www.sparkfun.com/tutorials for instructions on how to accomplish this. Be sure to set the baud rate of both XBee modules to 9600 to match the Weather Board's default baud rate (or the rate you've set using the Weather Board's configuration menu, see below).

Once the sockets are soldered to the board and your XBee modules are properly configured, plug your XBee into the Weather Board, ensure that the "Comm" switch is set to "RF", and power up. If everything is working, the XBees should link up and weather data should appear at the computer.

Connecting to the Weather Meters

You can optionally connect the Weather Board to SparkFun's Weather Meters (SEN-08942), giving you three additional outdoor sensors: wind speed, wind direction, and rainfall. To do this, you will need to solder two RJ11 telephone-style connectors (PRT-00132, not included) to the Weather Board.

TIP: If you're ever going to connect the Weather Board to an XBee module, it's easiest to solder the XBee sockets to the board *before* you attach the RJ11 connectors.

IMPORTANT: The RJ11 connectors attach to the *bottom* of the board (the side without components), inside the white rectangular outlines. Fit each connector to the bottom of the board, ensuring that all six pins go into their respective holes. Once the pins are all in the holes, press the posts on the connector into the holes on the Weather Board until the connector snaps into place. Once the connector is snapped onto the board, carefully solder the six pins. Be especially careful when soldering near the surface-mount components on the top side of the board.

The Weather Meters come with preattached 10' cables that click into the connectors you just added to the Weather Board. Connect the wind direction/speed cable to the Weather Board connector labeled "Wind", and the rain gauge cable to the connector labeled "Rain". If you need to locate the Weather Meters further away from the Weather Board, you can use RJ11 extension cables, which are commonly used for wired telephones and available wherever telephone accessories are sold. Be sure you get four-conductor telephone cables, not two-conductor handset cables.

USB_Weather_Board_V3_datasheet_130705.odt

TIP: After you've installed the extension cables, use silicone sealant on the outdoor connections to prevent water from getting into them.

Using the board

Here's where the fun begins! Note that this section refers to the default firmware, which is the code we load onto the board during manufacture. However, you can always change the firmware to do what *you* want it to do; see "Programming" below.

The Weather Board's firmware periodically reads all the onboard (and external) sensors, translates the raw data into standard units, and transmits the data out the serial port. To see the data that the board is transmitting, use a terminal program such as Coolterm or the Arduino Serial Monitor. Configure the terminal program to talk to the COM port you set up during the above steps (USB, XBee, or Bluetooth), and set it to 9600 baud, 8 bits, 1 stop bit, no parity. Once everything is powered up, you should see live data.

Data Formats

The default firmware has several data formats built into it, and additional formats are easy to add using the Arduino development environment (see "Programming" below).

The default data format is human-readable, ANSI-formatted data, with "pass/fail" information we use for testing. If you use an ANSI-aware terminal program, it will neatly display the data and units:

```
SHT15 temperature:              77.4 deg F
SHT15 humidity:                 29%
SHT15 dewpoint:                 43.1 deg F
BMP085 pressure:                30.065 in Hg
BMP085 temperature:             78.9 deg F
TEMT6000 light:                 2.2%
Weather meters wind speed:      6.0 MPH
Weather meters wind direction:  90 degrees
Weather meters rainfall:        0.40 inches
External power:                 3.84 Volts
```

Several other formats are available from the configuration menu, see below.

Note that there are two temperature readings, one from the pressure sensor, and one from the humidity sensor. You will probably see slightly different readings between them; this is due to local heating and calibration differences between the sensors.

By default, the board will sample and send one data string every two seconds. This can be changed in the configuration menu.

Configuration menu

If you would like to bring up the configuration menu, send a CTRL-Z character (as of firmware version 1.3 you can also send a normal 'Z' or 'z') using the terminal software you're using to view the data. The Weather Board will stop sending data and print out a menu of options with the current settings in parenthesis.

TIP: The Arduino serial monitor window cannot send control characters. For firmware version 1.3 and later, you can type a 'Z' (no CTRL) into the box at the top of the serial monitor window and click the "send" button or press return. You should also set the serial monitor's baud rate to 9600 (if using the default rate), and set "line ending" to "carriage return". (For earlier versions of the firmware, we recommend using a different terminal program such as Coolterm.)

TIP: Ensure the Comm switch on the Weather Board is set to the connection you're using (USB or RF), or the Weather Board won't be able to see data sent *to* the board (like 'Z').

The menu (and default options) are:

```
1. Data format (ANSI)
2. General units (English)
3. Sample rate (2)
4. Pressure units (inches Hg)
5. Pressure type (relative)
6. Station altitude (1596 meters)
7. Baud rate (9600 baud)
8. Zero rain counter
9. Weather Meters attached (yes)
R. Reset to factory defaults
X. Exit (don't save changes to EEPROM)
S. Save (save changes to EEPROM)
```

You can exit the menu with 'X' or 'S'. When you choose 'S', changes to these settings are stored in EEPROM (non-volatile memory) so that the Weather Board will remember the settings the next time it is powered up.

USB_Weather_Board_V3_datasheet_130705.odt

Here are the menu options in detail:

Data format:

CSV
A machine-friendly data format good for computers and dataloggers, consisting of a NMEA-like sentence of comma-separated values:

```
$,80.7,25,43.2,29.986,3.5,10.8,270,0.45,3.90,*
```

$	Header
80.7	Temp. from humidity sensor, degrees F
25	Humidity, percent
43.2	Dewpoint, degrees F
29.986	Barometric pressure, inches of mercury
3.5	Relative light level, percent
10.8	Wind speed, miles per hour
270	Wind direction, degrees
0.45	Cumulative rainfall, inches
3.90	Battery level, volts
*	Trailing character (no checksum)

This data format, known as comma-separated values or CSV, is easily captured and imported into spreadsheet software such as Excel or Open Office. It's also straightforward to write decoding software in the language of your choice that separates out the data between the commas for processing or display.

ANSI (default)
A human-friendly format which uses ANSI characters to place formatted data at fixed points on an ANSI-compatible terminal screen, with basic pass / fail functionality tests.

TIP: To test each board, we've programmed in a pass / fail range for each sensor that is appropriate for our factory floor in Boulder Colorado. FAIL will be printed if the sensor is outside that range. This does not necessarily mean there's a problem with your board! Contact techsupport@sparkfun.com if you have questions.

LCD
A format which will directly drive a SparkFun serial-enabled 16x2 LCD display such as SparkFun LCD-09066.

TIP: The sample rate setting (below) controls the rate at which the LCD display will change screens.

TIP: Disconnect the display from the Weather Board while you're uploading new code or it may become corrupted by binary data. (You can recover it by resending the proper setup commands, see the LCD datasheet for info.)

General units:

English (default)
Wind speed in miles per hour, rain in inches, temperature in degrees Fahrenheit.

SI
International System, aka the metric system. Wind speed in meters per second, rain in mm, temperature in degrees Celsius.

Sample rate:

Enter the desired sampling rate in integer (whole) seconds, as in "sample once every x seconds." The default rate is 2 seconds, as the board requires about 1 second to sample all the sensors. "0" will cause the board to sample as fast as possible (about once per second), but this will not output data on an accurate timebase.

TIP: The green status LED is on while the board is sampling sensors, and off while it's waiting. This should give you an idea of how long things take.

TIP: Rates greater than 5 seconds will provide more accurate readings as the lower duty cycle will result in less self-heating in the sensors.

Pressure units:

mbar
Millibars (one mbar = 100 pascals = 1hPa)

inches Hg (default)
Inches of Mercury (as used in weather reports)

PSI
Pounds per square inch

Pressure type:

Absolute
The true pressure that the sensor sees (will vary with altitude as well as weather effects).

USB_Weather_Board_V3_datasheet_130705.odt

Relative (default)

Pressure adjusted for the altitude at which the measurement is taken. *Note that for accurate readings, you will need to enter your altitude.*

Whether you choose absolute or relative depends on your use for the board. The pressure that is provided in weather reports is always adjusted to be **relative** to sea level, to remove the effects of altitude at each station location. If you're comparing data with other weather stations, you will likely want to calculate relative pressure. However, if you're using the pressure sensor to directly measure altitude (such as on a balloon), or the board is not going to stay in a fixed location, you may want absolute pressure.

TIP: If you are measuring relative pressure, you will need to enter the altitude of the station location in the next menu item. Otherwise the readings will be incorrect.

Station altitude:

As stated above, in order to calculate pressure readings with altitude effects removed, the Weather Board needs to know its current altitude. The default, 1596 meters, is the altitude of SparkFun's secret labs in Boulder Colorado. If you are using absolute pressure, this number is ignored.

TIP: You can find your station's exact altitude using Google Earth.

Zero rain counter:

The Weather Board counts pulses from the Weather Meters' bucket-tilt rain gauge. This number will increase as long as the Weather Board is powered up. The default firmware uses an "unsigned long int" for this counter, which can keep track of up to 584 *miles*, or 940 *kilometers* of rainfall (that's a lot of rain!) before it rolls over. You can zero it by power-cycling or resetting the board, or by selecting this menu item.

Why keep track of so much rain? If we used an normal unsigned int, we could only keep track of 565 inches of rain, which is a bit more than the yearly rainfall at the wettest place on earth. Since we don't know what you'll be using the board for (and it only cost us two extra bytes of RAM), we

sprung for the deluxe package.

Baud rate:

The Weather Board has a default baud rate (the speed at which serial bits are sent) of 9600 baud. If you would like it to run at a different speed, specify it here. Note that you will need to manually reboot the board in order for the new baud rate to take effect. Also note that you will need to manually change the settings of all your radio systems and software (such as terminal programs) to match the new baud rate.

Weather Meters attached:

If "no", the data output formats will not include the nonexistent sensors from the Weather Meters (wind speed, wind direction, and rainfall).

Reprogramming

The USB Weather Board is preloaded with the Arduino bootloader. This means you can easily reprogram the board via USB using the Arduino IDE available from www.arduino.cc.

The latest code is available from the product page at www.sparkfun.com/products/10586. It's heavily commented and a good starting point for modifications.

TIP: *The code requires several nonstandard "libraries" to function. These are included in the software archive, but must be copied to the correct place on your computer to function correctly. Be sure to follow all of the installation instructions in the file named README or there will be errors when you try to compile the code.*

Before compiling and uploading code to the board, you will need to select the correct processor: Go to the Arduino IDE's Tools / Board menu, and choose "Arduino Pro or Pro Mini (3.3V, 8MHz) w/ ATmega 328". You will also need to select the correct COM port, which you've already been using to view the sensor data.

If you want to skip the bootloader and get down to the bare metal, you can also use an Atmel-compatible ISP programmer to program the board through the 6-pin ISP header JP3. This header is not populated.

USB_Weather_Board_V3_datasheet_130705.odt

Hacking tips

A word about calibration

Apart from what the sensors get at their factories, we don't do any calibration of individual Weather Boards other than having determined some constants by driving around with the Weather Meters sticking out of Robert's very fast car. As with all uncalibrated sensors, they will show some amount of error from "true" readings. Measurement error analysis (known as metrology) is a complex field, but don't let that stop you from implementing your own calibration if you need highly-accurate results. This is left as an exercise for the reader.

External light sensor

Bummed that the onboard light sensor won't do much if you put your Weather Board in an enclosure? You can easily connect an external TEMT6000 light sensor (BOB-08688) to the board by connecting it to the LIGHT and GND pins on expansion connector JP7, then desoldering solder jumper SJ1. This will disable the onboard sensor and use the same input for an external sensor.

Add more sensors (or outputs)

The I2C bus (SCL and SDA signals), along with regulated 3.3V are brought out to the JP7 expansion connector. You can use these lines to add additional I2C sensors if desired. And don't forget that the ISP header provides a few more processor pins that may be useful for additional inputs or outputs.

Two more wires to the Weather Meters

The rain gauge in the Weather Meters uses a two-conductor telephone cable. It's possible to replace this cable with a standard four-conductor telephone cable (like that used by the wind sensors), giving you two extra conductors up to the Weather Meters.

The unused connections are brought out to the expansion header labeled as "2" and "5" (the numbers of the pins on the RJ11 connector). What would this be good for? A heater to melt snowfall in the rain sensor? LED anticollision lights? It's up to you.

Wireless bootloading

You can experiment with wireless bootloading using an Xbee-connected system. IO3 on the XBee header is connected to the ATmega 328's reset circuitry. By using a modified XBee on the PC side, you can send a reset signal to the remote XBee, activating the bootloader. See http://www.sparkfun.com/tutorials/122 for details (and Google for other advice).

Note that wireless bootloading is currently not 100% reliable, and is only available through the XBee, not the BlueSMiRF. (The passthrough DTR signal necessary for Arduino programming is unfortunately not available on the BlueSMiRF hardware. However, if it ever becomes available, solder jumper SJ2 can be used to activate it.)

Questions?

We're happy to help with any issues you have, and love to hear about your projects! Contact us at techsupport@sparkfun.com, or seek other users advice at http://forum.sparkfun.com.

Have fun!

-Your friends at SparkFun.

Errata

For firmware prior to version 1.3, the board may not reliably reboot due to an I2C lockup issue. When the board resets successfully, the green status LED will blink three times. Version 1.3 fixes this issue and several other bugs. We recommend running the latest firmware, which is available from the product page at www.sparkfun.com/products/10586.

We've noticed that the Weather Meters wind direction sensor doesn't always resolve all 16 possible wind directions, although it does appear to work fine for the 8 major ones. This problem appears to be internal to the Weather Meters, not the USB Weather Board.

FINAL TIP: If you're having problems, check the Weather Board product page at www.sparkfun.com/products/10586 for tips from other users, and updated firmware to fix bugs and add functionality.

USB_Weather_Board_V3_datasheet_130705.odt

Optional hardware

Mini-USB cable

   1 x USB Mini-B cable, 6' (CAB-00598)

Weather Meters

   1 x Weather Meters (SEN-08942)
   2 x RJ11 6-pin connectors (PRT-00132)
   2 x RJ11 M-F 4-pin extension cable (if necessary,
   available wherever wired telephone accessories
   are sold)

XBee and connectors

   2 x XBee (various, see www.sparkfun.com)
   2 x 2mm 10-pin XBee connectors (PRT-08272)
   If connecting to a PC, an XBee interface such as
   (WRL-09819) is also required

BlueSMiRF and connectors

   1 x BlueSMiRF (various, see www.sparkfun.com)
   1 x Breakaway male 0.1" headers (PRT-00116)
   1 x Breakaway female 0.1" headers (PRT=00115)
   Bluetooth receiver also required

Battery

   1 x 3.7V LiPoly battery with JST connector
   (various, see www.sparkfun.com)
   Battery charger also required

External power connector

   1 x JST jumper wire (PRT-08670)
   Or solder directly to 0.1" header JP2

External light sensor

   1 x TEMT6000 breakout board (BOB-08688)

Standoffs

   4 x 3/4" Nylon 4-40 standoff (PRT-10315)
   1 x 1/4" Phillips 4-40 screw 10-pack (PRT-10453)

USB_Weather_Board_V3_datasheet_130705.odt