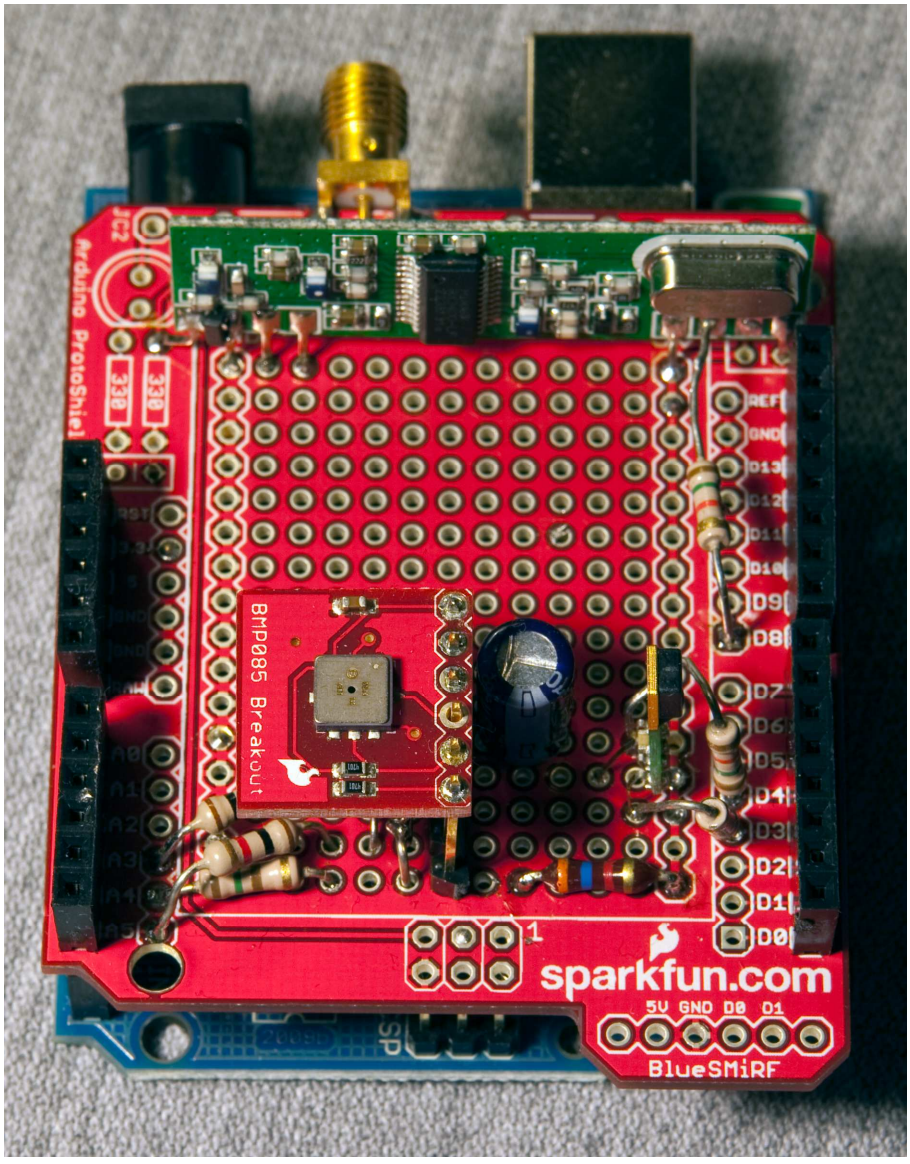
WSDL Weather Shield
for the
Arduino Duemilanove



Version 1.0
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Introduction

This design is based on using an Arduino Duemilanove board and has not been tested with other Arduino variants. It will probably also work on the Mega board. Later on, there are several tiny Arduino variants that might be really attractive.

Read the rest of this document to get a feeling for what is required to build the shield board. It is recommended that you have at least a small amount of prior experience with soldering and electronics assembly, or perhaps you know someone who does and can help you out with the project.

Do read up on the dangers of electro-static discharge (ESD) and do all your work in an ESD-safe environment. Some of the parts (e.g. the 434MHz receiver module) can easily be damaged by ESD and you'll never feel the little static zap that did it. Some components (again, like the receiver module) will not just quit working when damaged by static. Instead, their performance will degrade a little bit with every "zap". The receiver module is known to become a little less sensitive every time its' RF input pin is zapped. This shield board design adds some protection diodes to the receiver module to eliminate this problem in the completed shield board.

Tools Required

To build the shield board the following tools are needed:

- Soldering iron with a small tip. Something around 0.030 to 0.050 inch (0.7 to 1.3mm) is a good size.
- Small diameter electronic solder, somewher between 0.015 and 0.030 inch (0.4 to 0.8mm) is a good choice. It is much easier to apply the proper amount of solder with the smaller diameters. Eutectic solder is also recommended (SN63/PB37) as this mixture melts at a lower temperature and solidifies smoothly after being melted. The author has no experience with non-leaded solders and cannot make any recommendations for those wanting to be RoHS compliant.
- Tweezers, small needle-nose pliers, small wire cutters (diagonal cutting pliers).
- Maybe some 30-gauge wire-wrap wire (this example does not require any but it can be used to make some connections if desired).
- Some 20 or 22-gauge bare copper wire ("bus wire").
- An ESD-safe work area.

The Schematic

The hand-drawn schematic diagram on the next page shows how all the parts are to be connected together. The receiver module, BMP085 barometer breakout board, and SHT75 sensor are all drawn as rectangles. Pins on these items are labeled identically to what is actually printed on the physical parts.

If you are not familiar with all the symbols in the schematic perhaps an experienced friend can help out.

This remainder of this section explains the design of the shield board and can be skipped if you are only interested in building the shield and not how it works.

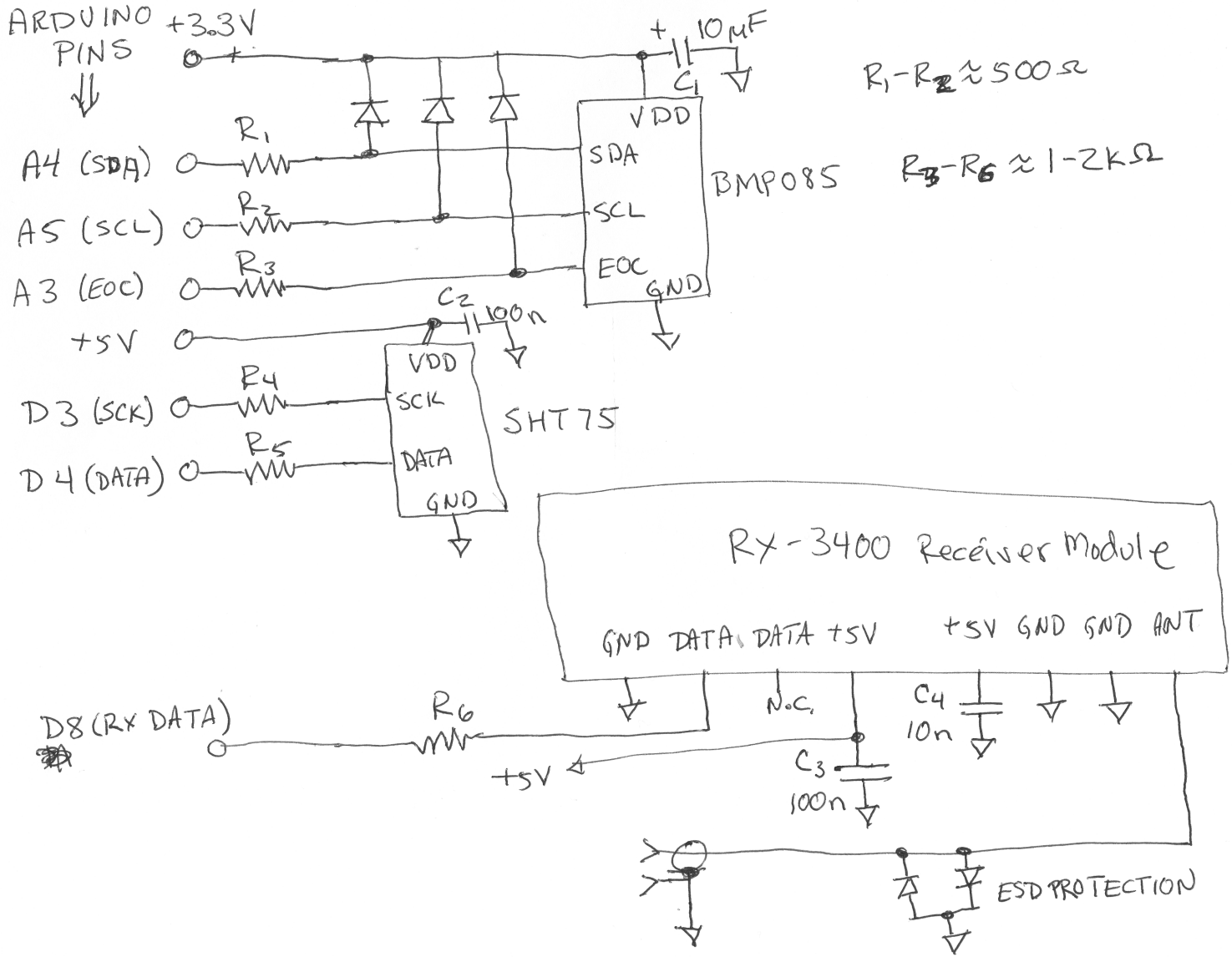
The SHT75 and receiver module can run from +5V and no logic level translation is required. The BMP085 runs on 3.3V and does require translation.

Series resistors are used on the data lines to the SHT75 and receiver module to limit current if a bus contention occurrs. The value of these is not critical – anything from 1-2k ohms should work fine. The SHT75 runs fine at 400kHz clock rate using 1.5k resistors.

Logic level translation for the BMP085 is done with series resistors and shottky diodes which clamp the BMP085 lines to the 3.3V supply voltage. The series resistors need to be smaller than the normal 1-2k. The BMP085's I2C bus is an open-collector bus with pull-up resistors to the 3.3V supply (4.7k pull-ups are included on the breakout board). Due to the size of these pull-up resistors, R1 and R2 must be smaller (around 500 ohms) so that Arduino can pull the voltage low enough to qualify as a logic "0".

Although all of the breakout boards and modules include some amount of power supply bypassing, more has been added on the shield board. Perhaps this is not completely necessary, but a little more won't hurt.

There are two +5V pins on the receiver module, which are connected together by a nice fat trace on the module's back side. Therefore, only one of the 5V pins is connected to +5V on the shield board, and the 2nd pin has some additional bypassing for good measure.


ARDUINO PINS
+3.3V
+
10μF
C1
R1-R2 ≈ 500Ω
R3-R6 ≈ 1-2kΩ
R1
A4 (SDA)
R2
A5 (SCL)
R3
A3 (EOC)
VDD
SDA
SCL
EOC
GND
BMP085
C2
100n
+5V
VDD
SCK
DATA
GND
SHT75
R4
D3 (SCK)
R5
D4 (DATA)
RX-3400 Receiver Module
GND DATA DATA +5V
+5V GND GND ANT
D8 (RX DATA)
R6
N.C.
C4
10n
C3
100n
+5V
ESD PROTECTION

General construction comments

The arduino board will come in an anti-static bag; remove it from the bag and put it somewhere safe. Now, take the receiver module out of it's tiny anti-static bag and lay it down on the bag that the Arduino was packaged in. Solder on the HSMP-3812 diode array so the antenna terminal is protected against static discharge. The center leg can be soldered to the antenna terminal pad on the PCB. The other two legs are soldered directly to the ground pad right next door. Once this is accomplished, the receiver module's RF input is protected from static discharge – but you should continue to work in a static-safe manner.

Next, unsolder the two DATA pins from the receiver module and discard them.

If you're going to use an SMA connector for the antenna, line it up as shown in the "B" photo. The spacing of the ground legs may be different than shown but scrape away enough solder mask where necessary to allow for soldering the two ground legs to the ground plane. The ground legs can be cut shorter if necessary. The important thing is to get the center pin soldered to that trace that runs over to the antenna pin on the receiver module.

Solder in the four connector headers. Then gently bend the pins on the receiver module as required to make them line up with the holes as shown in the "A" photo. All of the pins (except the antenna connection) should be very close to fitting and will only need slight tweaks to get them lined up.

It may be a bit easier to install the SHT75 before the BMP085 but either order will work. Install a 3.3V bus wire from the hole near the board header over to the pins for the breakout board first so you'll have something to solder the anodes of the schottky diodes onto.

Check all your connections component polarities visually and with an ohmmeter if available. Measure from 5V and 3.3V connections to ground to check for shorts.

Before plugging the shield board into Arduino, load the WSDL sketch into Arduino so that it will correctly configure the I/O pins next time it starts. Disconnect Arduino from power, plug in the shield, apply power and cross your fingers!

Notes on the photos

The photos don't match the schematic exactly. This is because I went through a couple of false starts before arriving at the final design. Here's what you might notice being different.

- R1 is 150 ohms in the photo. I later realized that something around 500 ohms would also work and be a bit safer if Arduino pin A4 is accidentally configured as an output and driven high.

- There is a resistor partially obscuring the view of D2. This has been cut off at one end and is not part of the circuit any more.

- There is a 3.6k resistor labeled “N.C.” that is not used for anything.

- R2 on the top side is a 1k resistor, but the total resistance needs to be closer to 500 ohms. There is another 1k resistor on the bottom sided labeled “R2” which is in parallel with the one on the top. The final design only requires a single 500 ohm resistor here, which can be on the top or bottom.

- The PIN diodes used for static protection of the receiver’s antenna terminal are not the recommended HSMP-3812 but another variant in which only one diode was usable in each package. There are therefore two SOT23 packages soldered between ANT and GND terminals – one on the front and one on the back.

- I used a 10uF aluminum electrolytic to bypass the BMP085 power supply pins, but it would be better to use a ceramic capacitor (it’s in the parts list) and solder it directly onto the pins where they connect with the breakout board.

SHT75

The pins on the sensor are only 0.050” apart and had to be bent bit to fit in the PCB holes. The two outside pins (SCK and DATA) were bent enough so there was one open PCB hole between them. The +5V pin was bent foward enough to fit into a hole in the +5V bus, while the GND pin was bent backwards to the next available hole.

Top side photo “B” shows R4 and R5 running from Arduino pins D3 and D4 over to the SCK and DATA pins on the SHT75. The resistor leads were small enough to fit in the same hole as the SHT75 leads.

Look closely at the right side of C2 on the bottom photo. It is soldered to the through-hole that contains the ground pin on the SHT75. Just below that hole, some of the red solder mask is scraped away, and solder is purposely bridged from C2’s lead to the ground plane. That’s how the ground connection for the SHT75 was made.

BMP085

Some square pin headers were used to mount the breakout board as shown, but bare bus wire would work just as well.

Arduino pins A4 and A5 are in the opposite order as the destination pins on the breakout board. Top side photo “C” shows how R1 and R2 have been crossed over each other to accomplish the swap.

The schottky clamping diodes (D1,D2,D3) can be seen there also.

In the bottom side photo, a wire is soldered from the 3.3V bus over to the VDD pin for the breakout board. The cathode wires from the clamping diodes are visible soldered to the 3.3V bus wire.

Receiver module

The top-side photo “A” shows how the receiver module fortuitously lined up with the ground bus on the left and the +5V bus on the right. There was also another ground pin on the far right that was in just the right place. There is a jumper on the bottom side which connects the two left-side ground pins together. This lucky alignment of the pins makes for a neat and simple installation.

I un-soldered the two “DATA” pins from the module before installing it, then just soldered one end of R6 directly to one of the pads where the DATA pins were (they’re both connected together so either one will work).

The antenna pin on the module had to be bent out and backwards to fit into the hole labeled for a 330 ohm resistor. Also visible is one of the PIN diodes used for ESD protection. If HSMP-3812’s are used both legs on the right side of the package should be soldered to the ground terminal. In the photo, there’s only a single usable diode in that package, so the upper-right leg is not soldered.

The bottom side photo shows the bypassing of the 5V supply with C3 and C4. The two 5V pins are connected together on the receiver module’s PCB, and only one pin is actually connected to the shield board’s 5V bus. However, both pins are bypassed to ground to help keep the supplies clean.

Just above the lower lead of C4, the jumper between the two ground pins of the receiver module can be seen.

RF connector

The photos show an SMA connector being used. These are nice because of the small size but somewhat expensive (around $4) and the cables and/or adapters to go with them are similarly priced.

A stiff vertical wire (about 7" long) can be soldered on here instead of a connector and will work fine for most folks. Other connector options are possible, but try to keep the connections to the receiver board short and tidy.

The top-side "B" photo shows how the center pin of the connector is soldered to the through-hole intended for an LED (JC3). One ground pin on the connector was soldered to a ground connection intended for the reset switch. Some solder mask was scraped to allow the other ground pin to be soldered. One ground pin can be seen extending over the top of the trace attached to the center pin – there is no connection as the red solder mask is an insulator; however it would have been better to cut the ground pin back a bit more to stay clear of the trace. Also visible is the conveniently placed trace that runs from the connector center pin over to the receiver module's antenna terminal.

The bottom side photo shows that the connector's ground pins have not been soldered there.

Parts list

Some part numbers for Mouser are included, but these are available pretty much anywhere. The boards/modules from SparkFun are also available elsewhere. This is not meant to be an endorsement for Mouser or SparkFun; please use whatever supplier you are comfortable with.

The total price is going to be somewhere around $120-130 plus shipping and taxes. Tack on another $20 or so if you want the SMA connector on the board with a cable/adapters to type-F CATV coax.

I usually order a few extra of the cheaper items (diodes, resistors, capacitors) in case I ruin one of them.

The SHT75 sensor is really an SHT15 sensor mounted on a thin PC board by Sensirion. The thin PCB is nice because it thermally isolates the sensor. This is what is used in the photos. The SHT15 breakout board from SparkFun is somewhat different and the photos will not be of much use in mounting it.

1 ea, Arduino Duemilanove board (SparkFun DEV-00666, $29.95)

1 ea, Arduino ProtoShield kit (SparkFun DEV-07914, $16.95)

1 ea, 433.92MHz receiver module (SparkFun WRL-08950 , $5.95)

1 ea, Bosch BMP085 breakout board
SparkFun SEN-09694, $19.95

1ea, Sensirion SHT75 sensor
Newark 18M2988, $35.18
SparkFun SEN-08257, $41.95

1ea, six position 0.100" single row header
from Samtec, Digikey SAM1061-06-ND, $1.48 ea
or just use some bare bus wire.

1 ea, Avago HSMP-3812 PIN diode array
Mouser 630-HSMP-3812-TR1G, $1.08 ea

3 ea, BAT48 schottky diodes
Mouser 511-BAT48, $0.38 ea

4 ea 1k ohm 1/8 watt resistors
Mouser 71-RN55D-F-1.0K, $0.11 ea

2 ea 499 ohm 1/16 or 1/8 watt resistors
Mouser 71-RN55D-F-499, $0.11 ea

1 ea 4.7 or 10uF/6.3V (or more) ceramic capacitor
4.7uF: Mouser 810-FK24X5R0J475K, $0.23 ea
10uF: Mouser 810-FK24X5R0J106M, $0.31 ea

2 ea 100nF/10V (or more) ceramic capacitors
Mouser 581-SA115C104KAR, $0.19 ea

1 ea 10nF/10V (or more) ceramic capacitors
Mouser 581-SA105E103MAR, $0.07 ea

The following set of optional parts will get you an SMA connector on the shield board plus a 2-foot cable from the board to a type-F female connection (75-ohm CATV connector). Yes, I know there's an impedance mismatch in going from 50 to 75 ohms here, but trust me – it's not going to make that much difference.

1ea, SMA edge connector, Emerson 142-0701-801 (optional)
Mouser 530-142-0701-801, $3.70 ea

1ea, 24-inch SMA male to BNC male cable, Emerson 415-0028-024 (optional)
Mouser 530-415-0028-024, $12.48 ea

1ea, BNC female to type-F female adapter (optional)
showmecables.com p/n 529, $2.95

Photos

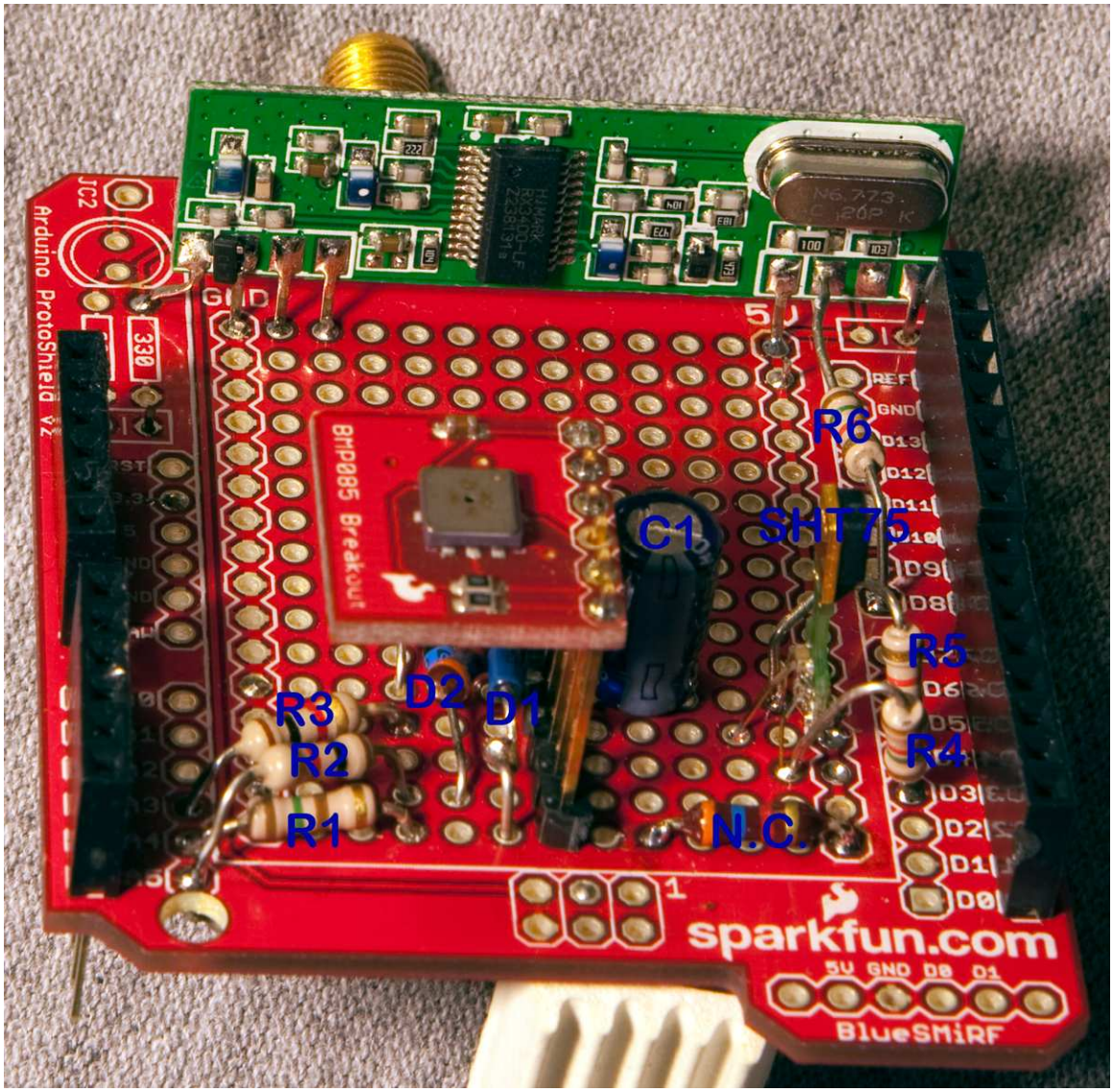


Figure 1. Top Side A

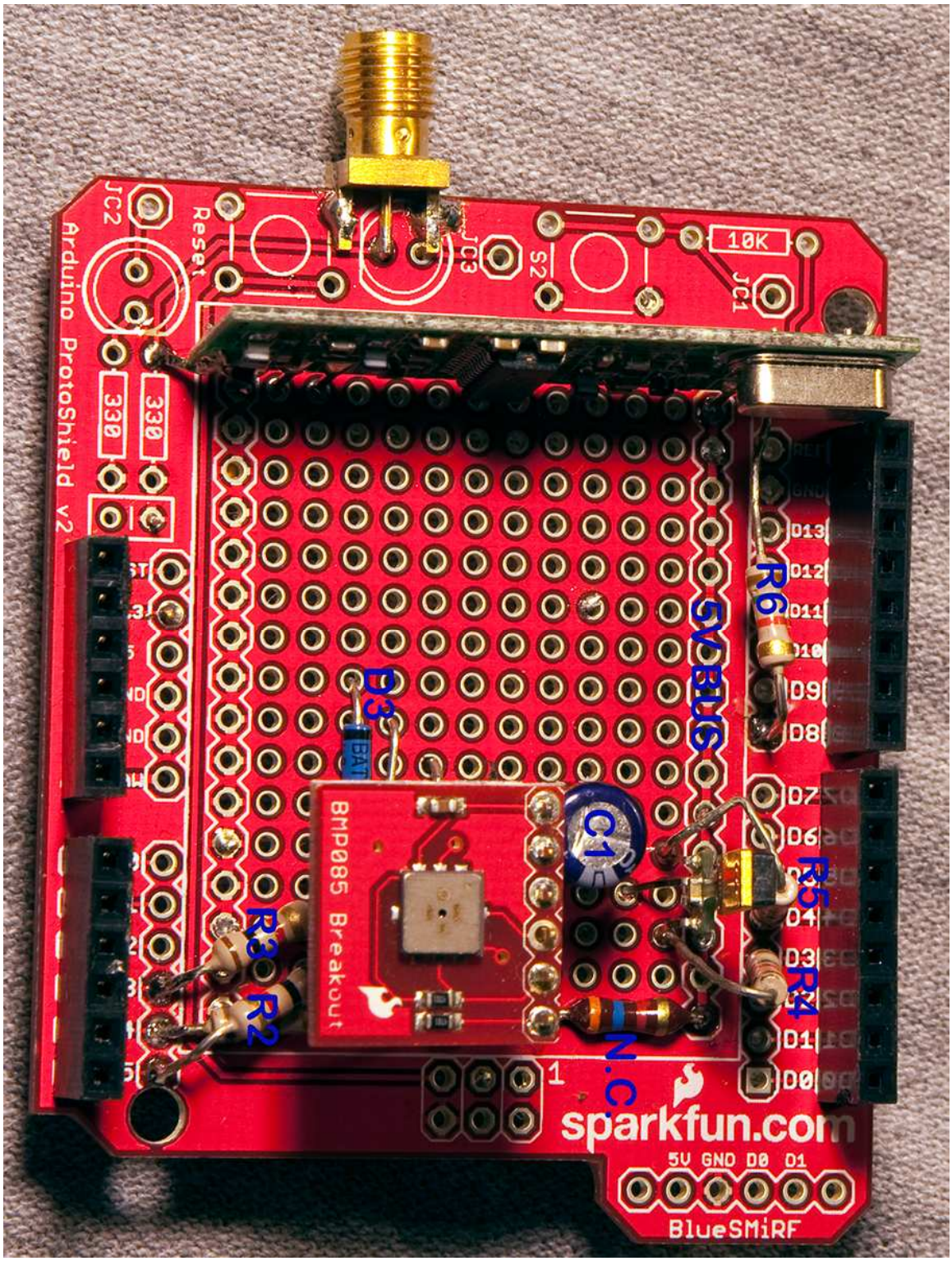


Figure 2. Top Side B

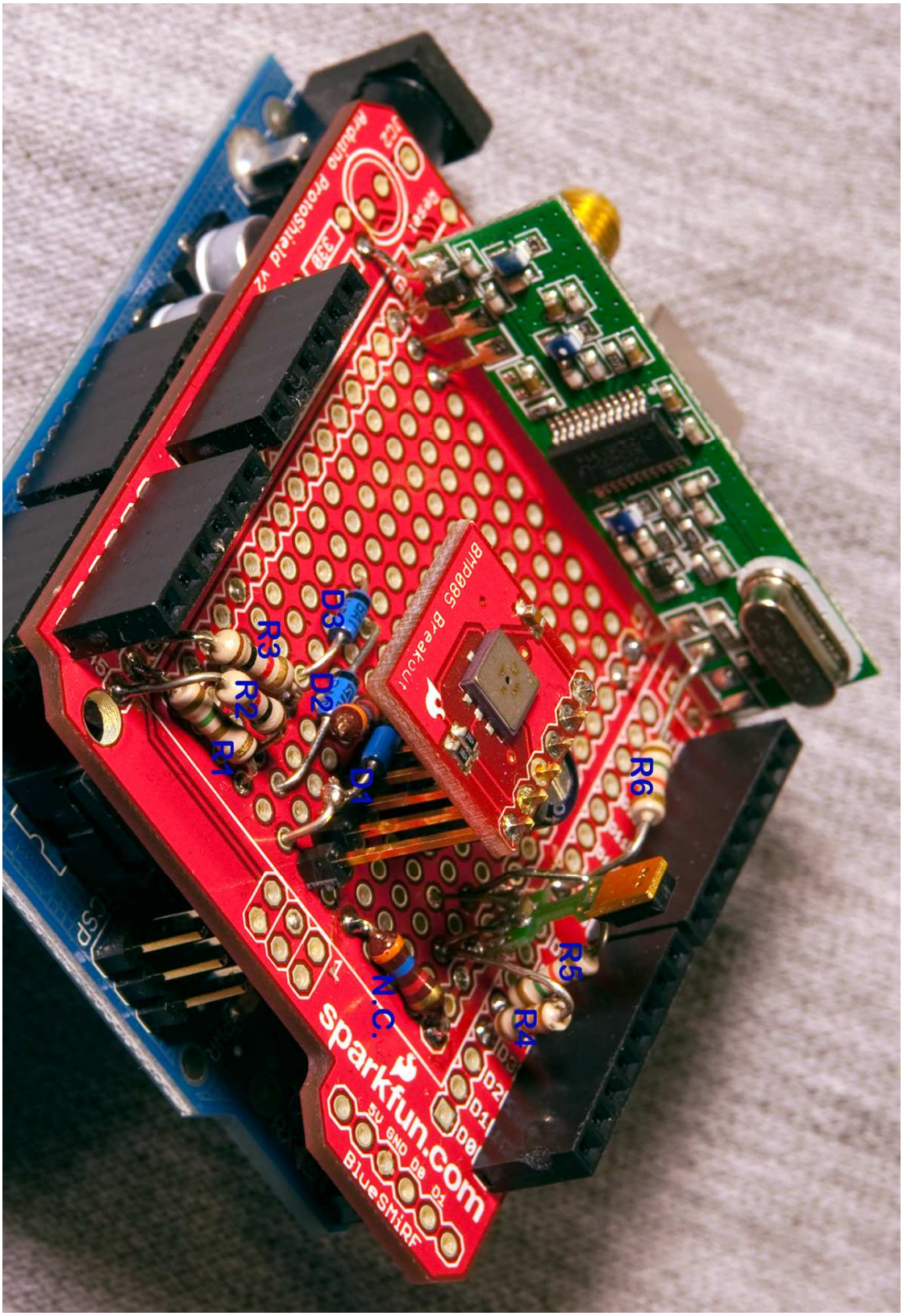


Figure 3. Top Side C

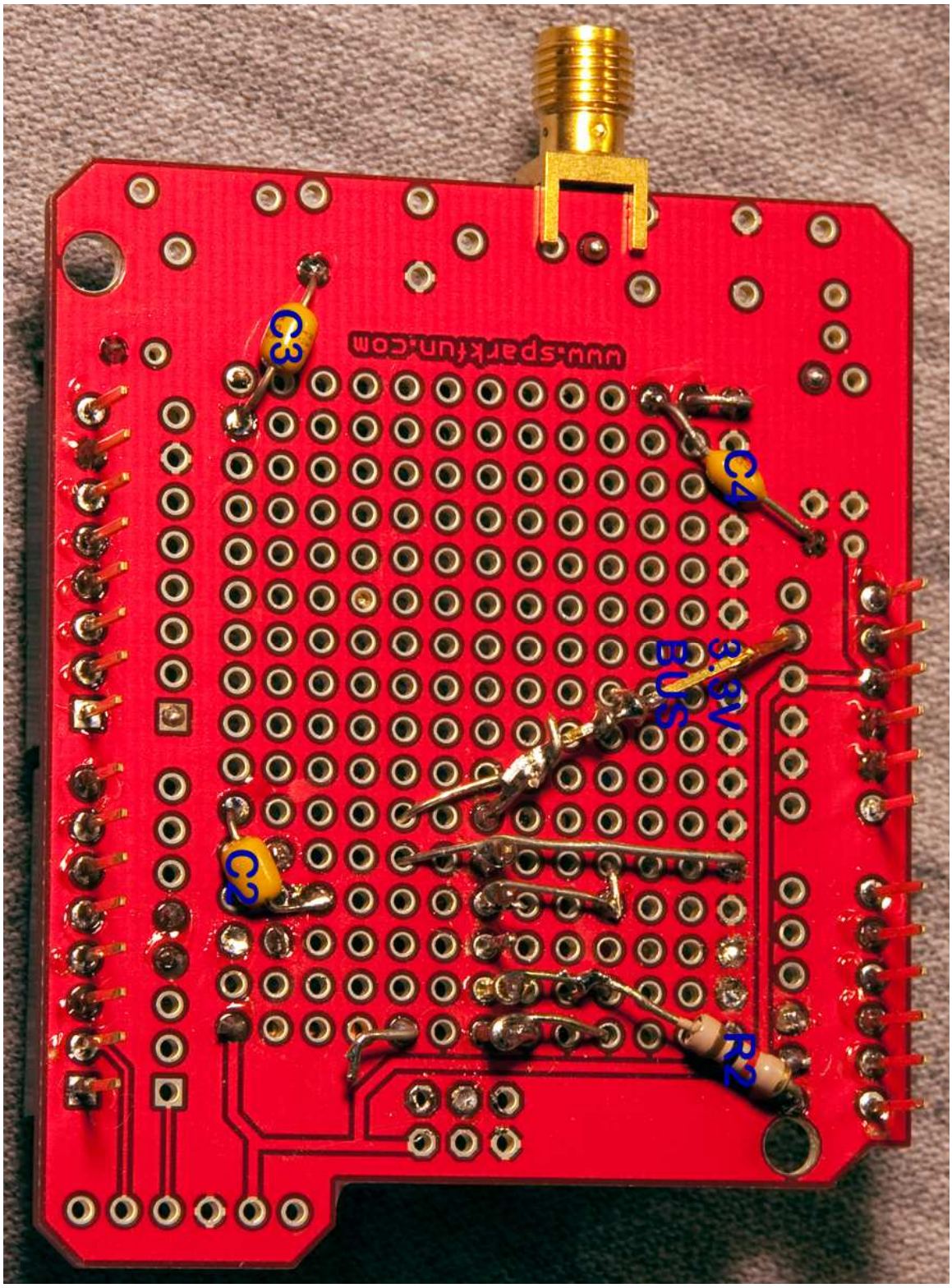


Figure 4. Bottom Side