

# Wulfden Freeduino Kit

an Arduino clone

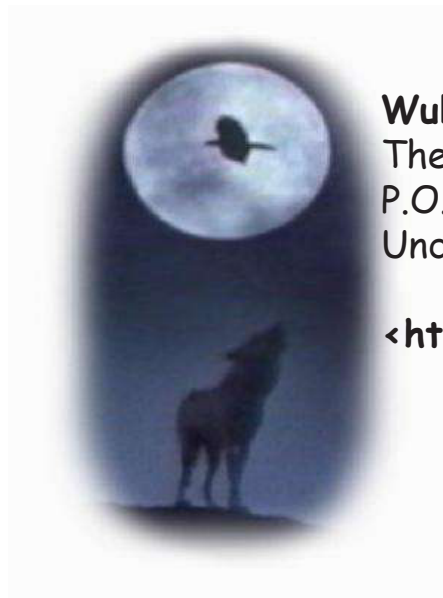


**Revised - 12/09/2007**

Totally Open Arduino-Compatible  
Hardware Development

**Prepared for**

**Advanced Micro Circuits Corp**



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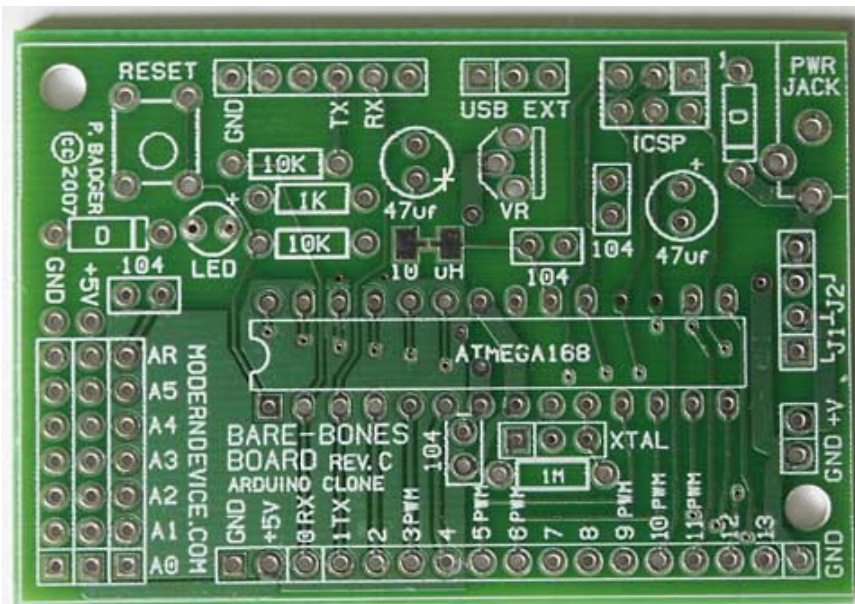
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# 1

## Freeduino Kit BoM

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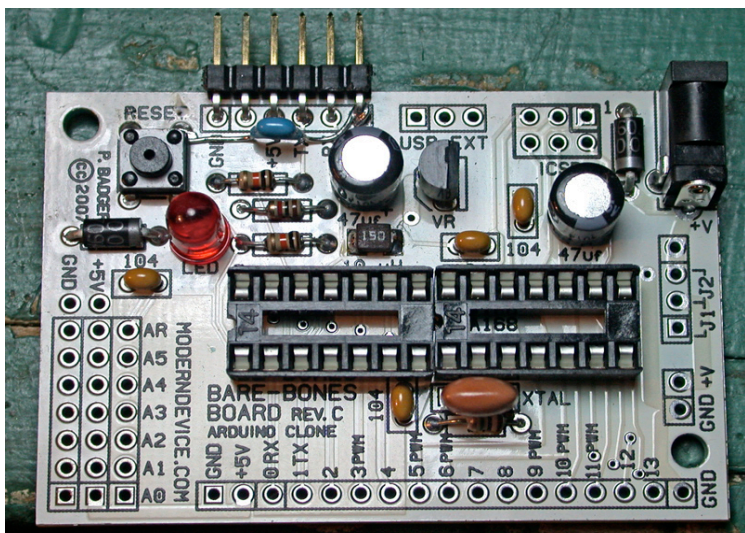
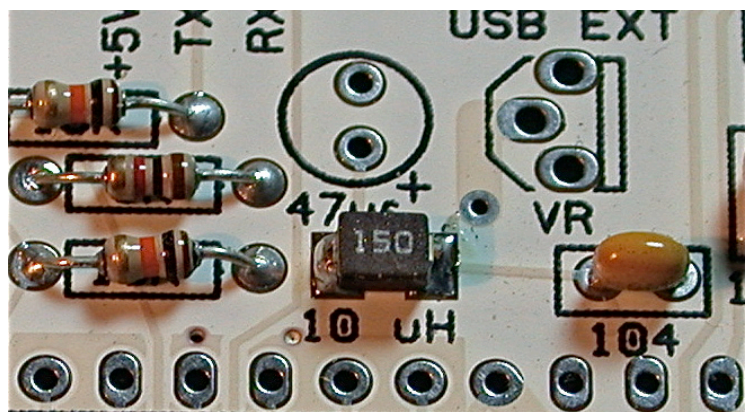
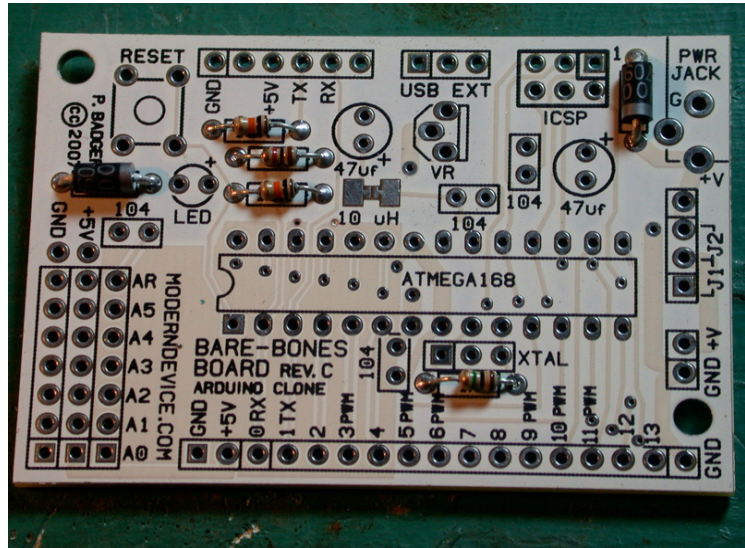
1.	1	Atmega 168-20PU	Mouser 556-ATMEGA168-20PU
2.	4	0.1 uF monolithic capacitors (short leads, yellow "104")	Mouser 80-C315C104M5U
3.	1	0.1 uF monolithic capacitor (long leads, blue "104")	DigiKey 490-3873-ND
4.	1	carbon film resistor 1 Kohm 1/8 w	Mouser 299-1K-RC
5.	2	carbon film resistor 10 Kohm 1/8 w	Mouser 299-10K-RC
6.	1	carbon film resistor 1 Megohm 1/8 w	Mouser 299-1M-RC
7.	2	2 x14 pin 3M DIP sockets	Mouser 517-4814-3004-CP
8.	1	standard 5mm red LED	
9.	1	n.o. pushbutton switch	
10.	2	4.7-47 uF electrolytic capacitors	Mouser 140-HTRL25V22-RC
11.	1	L4931CZ50 5v 200 ma voltage regulator	Mouser 511-L4931CZ50-AP
12.	2	1N4001 diodes	Mouser 625-1N4001-E3
13.	1	1.3 mmm coaxial power jack	DigiKey CP-2519-ND
14.	1	16 MHz ceramic resonator	Mouser 520-ZTT1600MX
15.	2	red jumpers	Mouser 517-951-00
16.	1	15 uH surface mount inductor ("150")	DigiKey PCD1099CT-ND
17.	34 pins	.100"pin headers, single row, snap-off	Mouser 517-6111TG
18.	20 pins	.100" pin headers double row - 2x7 and 2x3	Mouser 517-6121TG
19.	6 pins	.100" pin headers, single row, right angle	Mouser 517-5111TG



***For ease of viewing this is picture of the final prototype board. The production board is identical except that it is white solder mask with black silk-screening***

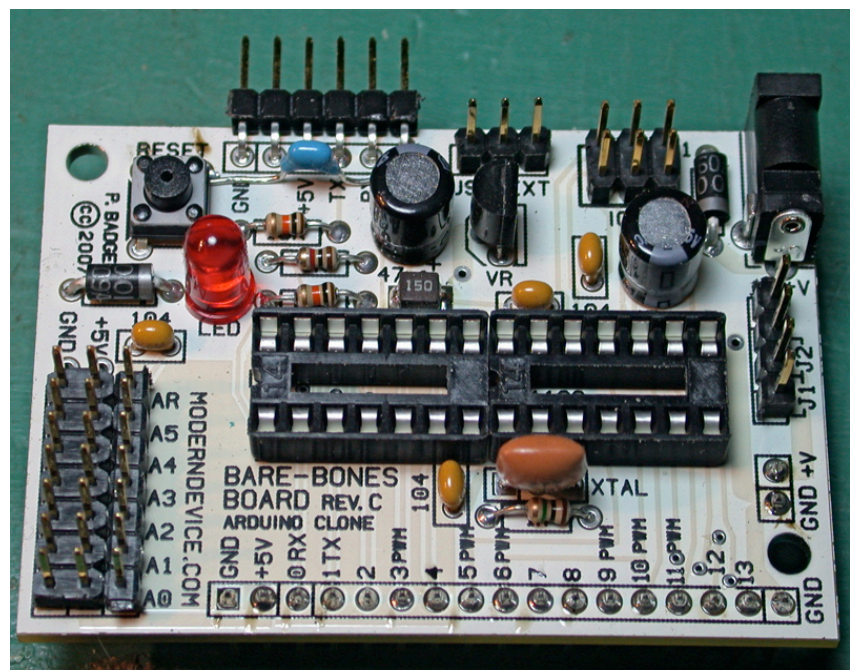
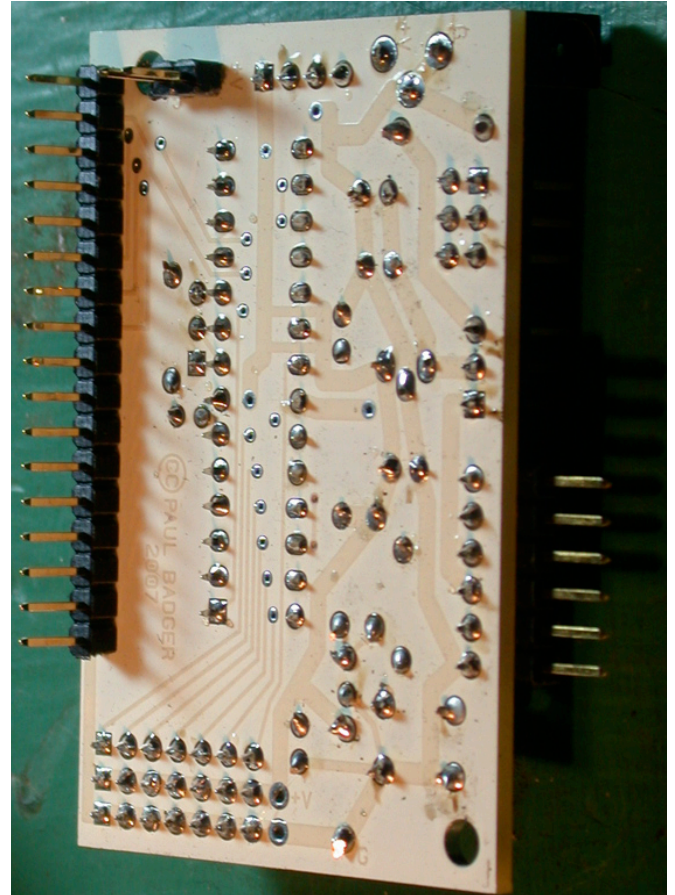
# 1 Freeduino Kit Assembly

1. Assembly is straight forward. Suggested that you start with the four resistors and two diodes. Observe the silk-screen for the diode band placement. Bend the leads and insert the parts in the proper places. Solder and clip leads off close.
2. The value of the surface mount inductor is 15  $\mu\text{H}$  not 10  $\mu\text{H}$  as the board is marked. You start by putting a small bead of solder on the left hand solder pad, then place the part down on the board and slide it right until it slightly rides up on the bead of solder. Holding it in place with a toothpick, apply heat from the soldering iron to the exposed solder. The part should sink down flush, remove heat and let cool. Now solder the left side.
3. If you are going to do the modification for auto-reset for the optional FTDI USB cable it should be done here, jump to the end of this section for instructions.
4. The resistors and inductor in place, insert and solder the four yellow 0.1  $\mu\text{F}$  caps ("104"), then the two 14 pin DIP sockets (notch to the left).
5. If you did not do the modification in #3 above, now is the time to insert the reset switch and solder. You may



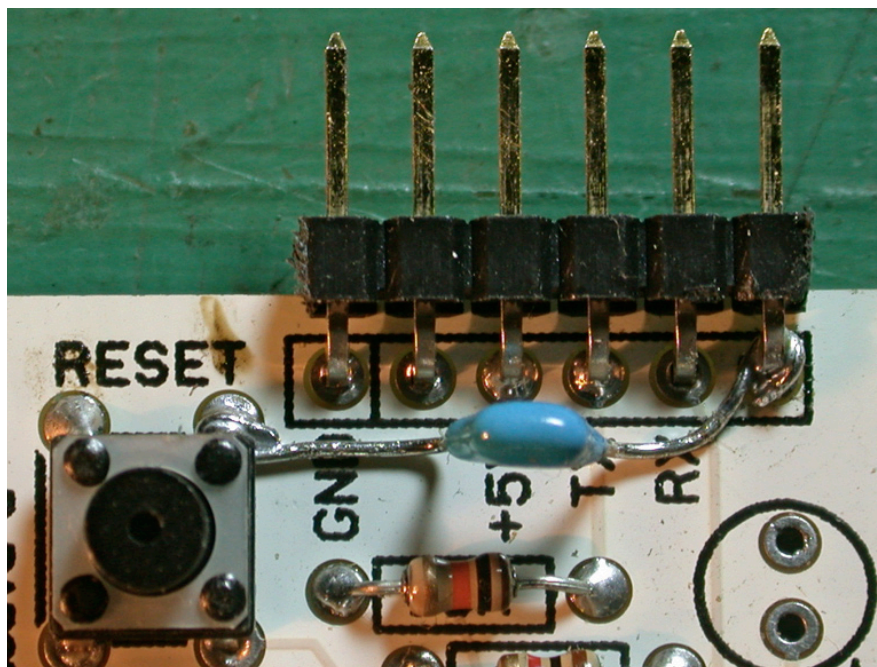
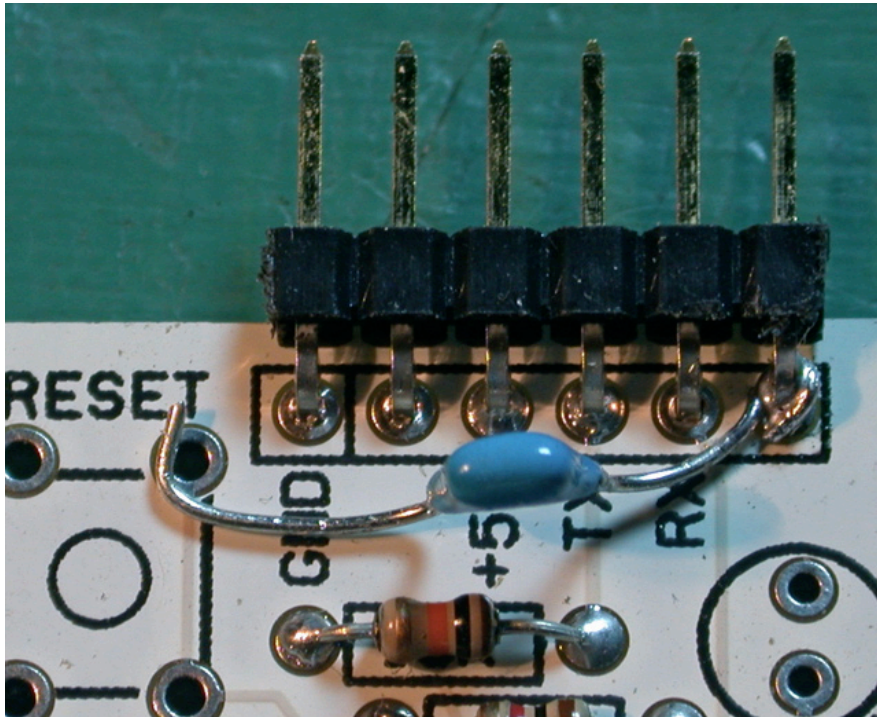
at this time insert and solder the 6 pin right angle connector that is used for the FTDI USB cable, or you may leave it out.

6. The onboard power supply is limited to about 200 ma. You may chose to leave it out. To install, you insert the two 47 uF electrolytic capacitors observing polarity markings, then the voltage regulator and the 1.3mm coaxial power receptacle.
7. We now insert and solder the various pin headers. The BBB was designed with flexible configuration in mind. I will describe the *standard* configuration, which is oriented to breadboard operation with the digital I/O pins pointing down to plug into the breadboard and two pins picking up the power rails of the breadboard. See pictures. **HINT - with all pin headers, solder ONE pin only to hold it in place, then lift and look and check that it is aligned correctly! Then go back and solder.**
8. Insert, solder, and trim leads for the 16 MHz resonator in spot marked "XTAL". Then, insert solder and trim the leads for the LED. Be sure to place the short lead is the negative side
9. The 1x7 and 2x7 pin headers fill the 3x7 hole matrix. Inserted from component side and soldered on the solder side.
10. The 1x3, 1x4, 2x3 pin headers are also inserted from the component side and soldered on the solder side.
11. Take the 1x18 and trim one pin off to make it 1x17 and insert it from the bottom (solder) side and solder from the top (component) side. Insert the 1x2 from the bottom and solder on the top. See picture at top of this page

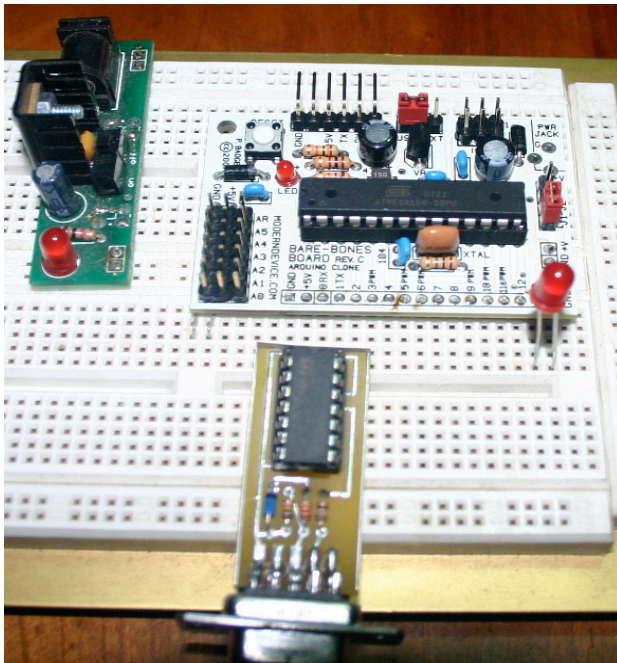
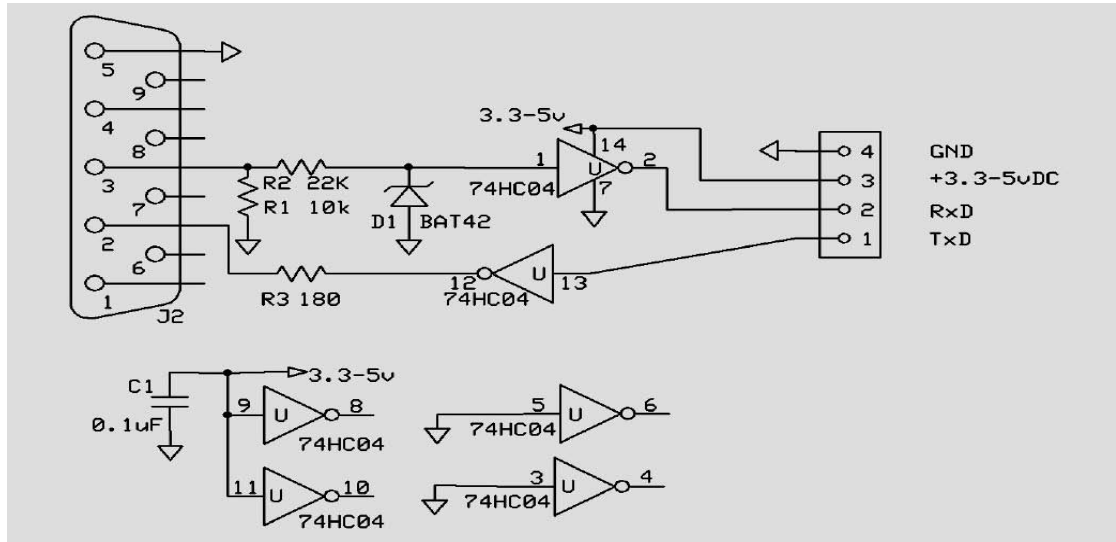


# 1 Freeduino Kit Optional FTDI Cable Auto-Reset Modification

1. Insert and solder 6 pin right angle header.
2. Trim lead of blue long leaded 0.1 uF ("104") capacitor, bending the ends to fit as shown.
3. Use needle nose pliers to snug wire around pin 6 of the pin header, solder.
4. Insert reset switch. Leaving the leg with wire from the cap, solder the other three legs.
5. Use Needle-nosed pliers to snug the wire around the fourth leg, Carefully solder (don't melt the body of the switch!)
6. Use needle-nosed pliers to square away the capacitor lead from pin 6 to make sure it is well away from pin 5.
7. Solder fourth pin on the bottom making sure to use enough heat to re-flow the joint on top and bottom, but not so much to melt the switch body.
8. Return to step #4 of main assembly

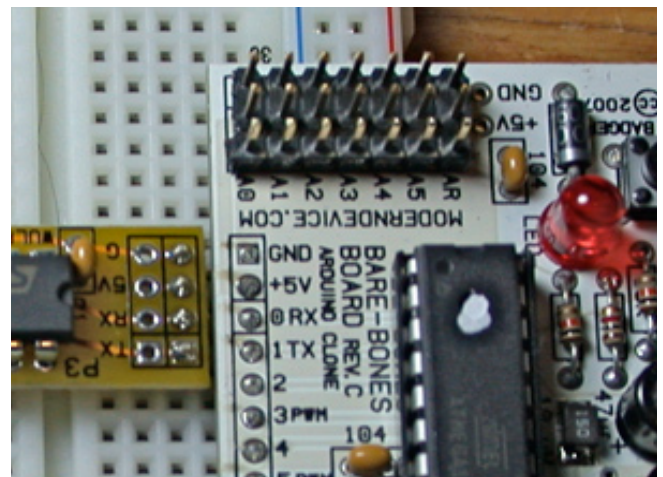


# 2 P3 - Wulfden/Modern Device Serial Programming Adapter



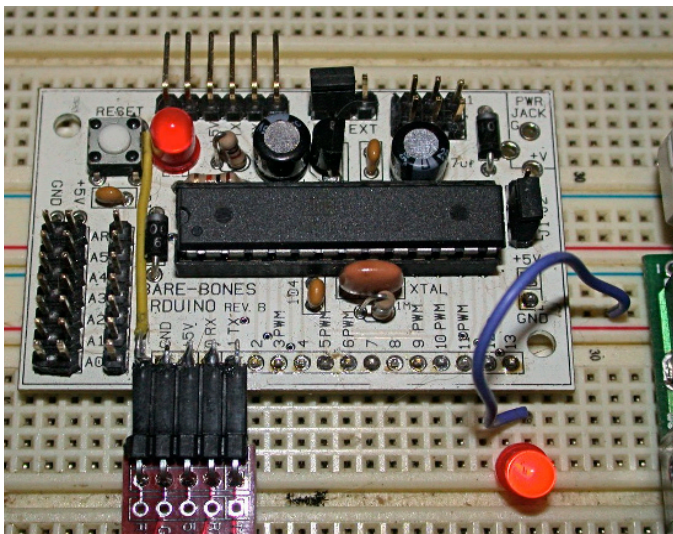
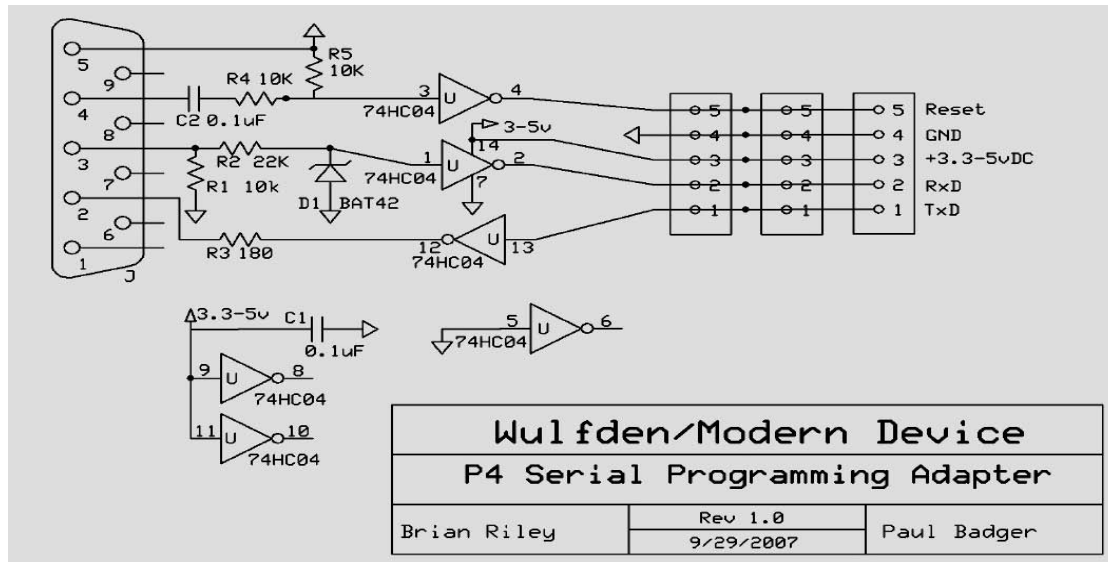
1. This picture represents the most basic F-Kit setup. An external power supply that, in this case plugs into the breadboard power rails, the BBB Rev C, Arduino CPU board, and the P3 Wulfden/Modern Device serial program adapter

2. For basic programming and hardware serial access to the Arduino board/chip, the P3 simply plugs into the breadboard with its pins for GND, +5V, Rx, and Tx of the P3 aligned with the same pins on the Freduino Kit's BBB, as shown in the closeup below.



## 2

## P4 - Wulfden/Modern Device Serial Programming Adapter



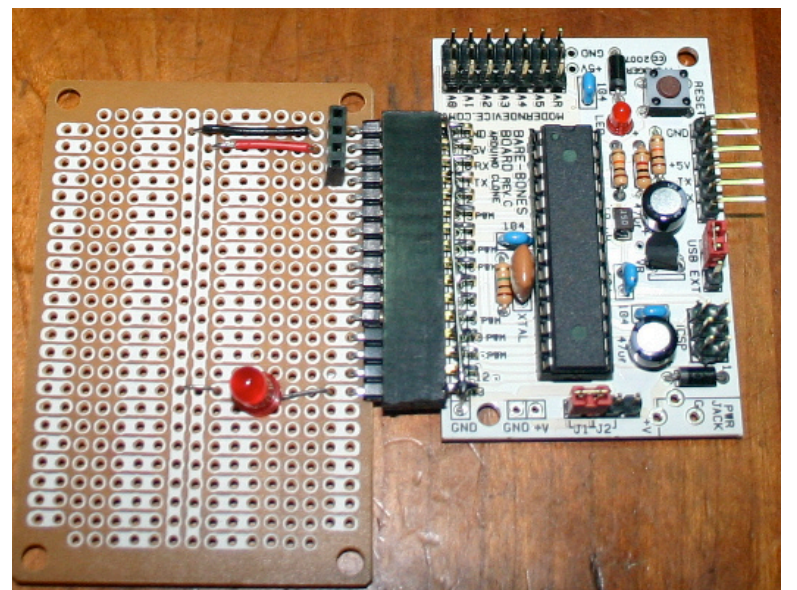
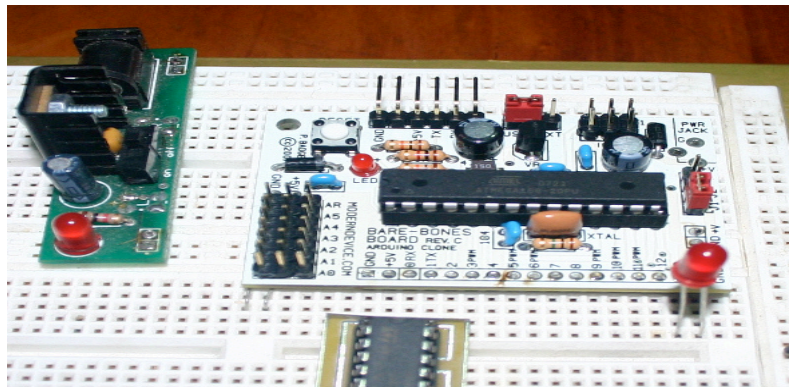
1. This picture represents a modified Rev B BBB with the reset line brought forward and attached to a 5 pin straight socket header. The right four pins of the socket header are soldered to the tops of GND, +5, Rx, Tx. The leftmost, 5th, pin is soldered to a wire that goes back and picks off the reset line from the reset switch. On a Rev C, if this mod is done at build time it would be easiest to tap the wire to the end of the 10 K pullup resistor for the reset line near pin 28 of the CPU.
2. For basic programming and hardware serial access to the Arduino board/chip, the P4 simply plugs into the breadboard with its pins aligned from left to right with Reset, GND, +5V, Rx, and Tx of the F-Kit board. If the Arduino-0009 IDE is used, the IDE will cause the F-Kit to auto-magically reset when uploading a sketch



# 3 Bare Bones Board - Notes and Alternate Ideas

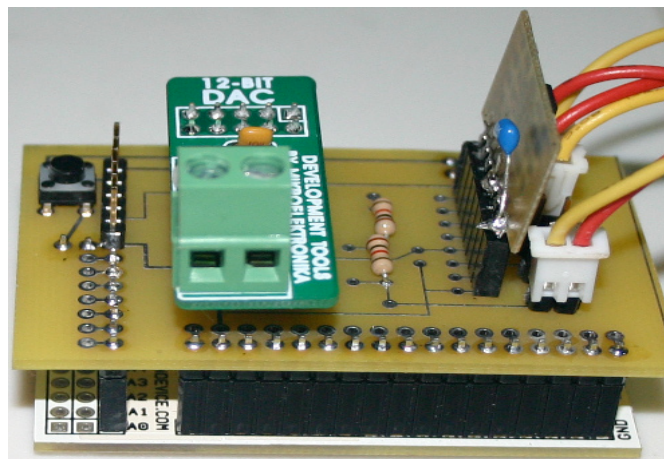
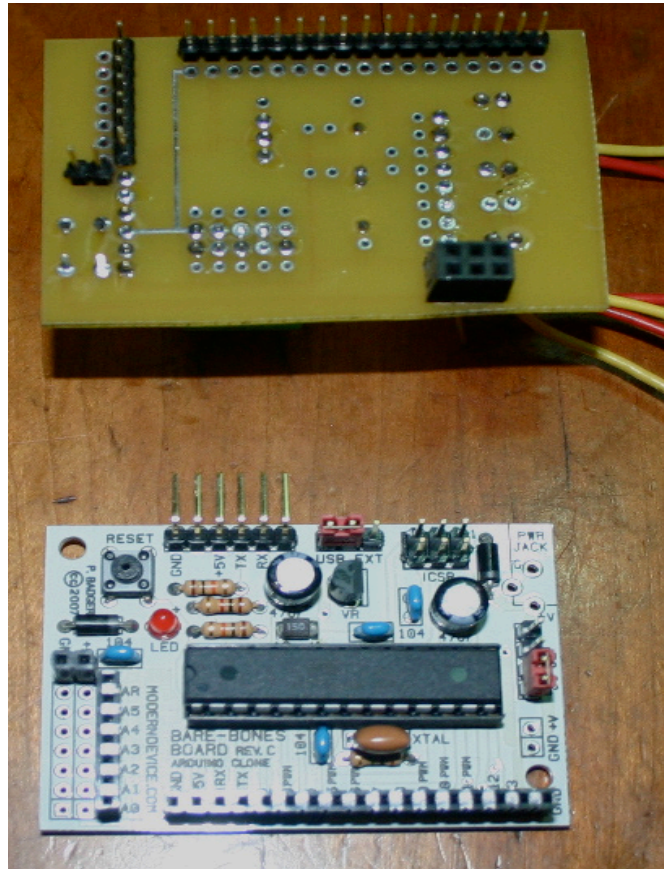
1. The primary reference for building the board is the Modern Devices documentation. In general, where instructions in Section 3 of this document disagree with the Modern Device document, use the section 3 information/instructions.
2. Digital Pin 13 (bottom row second from right) has a 'special' status. If you place an LED with its anode top to Pin 13 and its cathode to ground., when the bootloader initializes it will blink four times rapidly. Further Arduino prepared chips supplied by Wulfden come with the sketch BlinkLED burnt in, so after the initial bootloader blink and bootloader timeout, an LED so attached to Pin 13 will slowly blink on/off.

3. The picture to the left represents the standard bread board configuration, as described earlier. It uses exactly the parts contained in the kit; a 2x7 pin header is inserted into the component side and soldered from the solder side to the pair of GND and +5 volt buses associated with the analog inputs. Likewise a 1x7 pin header is inserted and soldered into A0 to A5 and Aref. Then a 1x17 pin header is inserted into the solder side and soldered to the component side to cover Digital pins 0-13, plus 2 GNDs and +5v. and a single 1x2 pin header is also inserted from the solder side and soldered from the component side. This goes into two holes adjacent to the right hand ground of the 17 pin row. The two pins are for GND and +5 and are aligned to pick power from the breadboard power rails. The 17 pins plug into the breadboard in such away that they leave three holes exposed for connections.

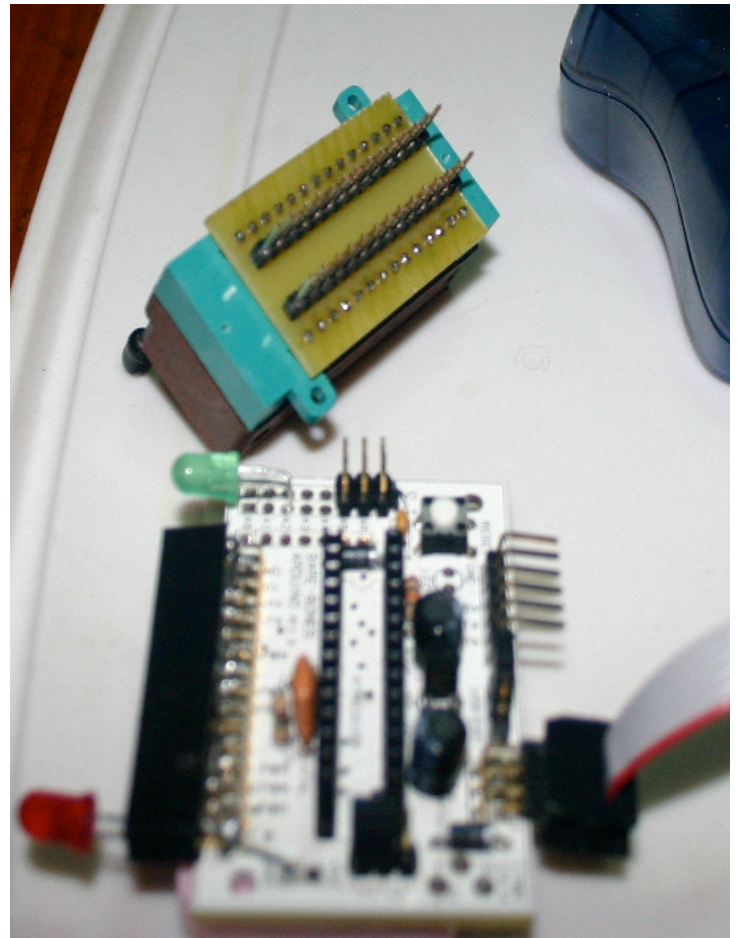
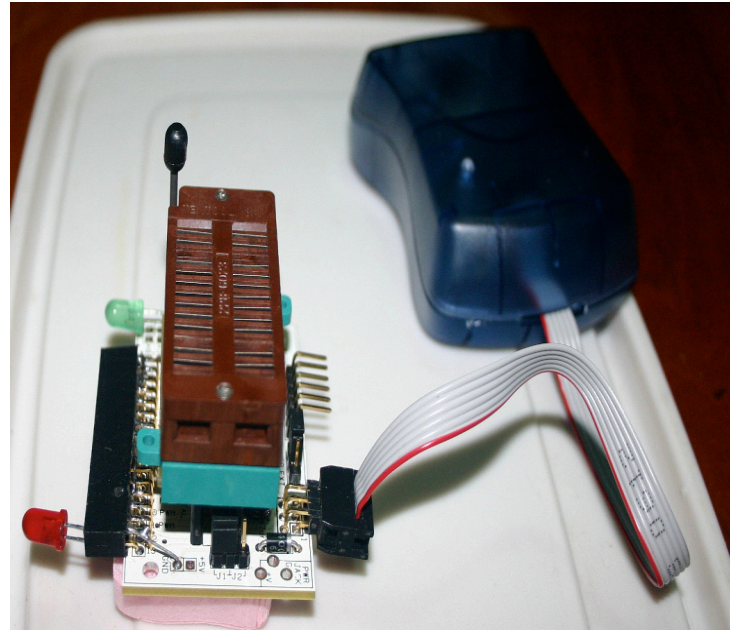


4. Another way to construct the BBB would be to proceed as above, except for the last two headers. Instead of a 1x17 pin header uses a 1x17 right angle socket header, and leave the two pin header off altogether. The proto board, the ubiquitous Radio Shack 276-150 has a 17 pin right angle header to mate to the BBB, Power can be supplied via the power supply on the BBB or a source mounted on the proto board or from an FTDI USB cable. The 4 pin socket header on the proto board is for the P3 serial programming adapter.

5. In a different manner the board to the left was constructed with a single 2 pin socket header in the GND and +5 in the middle of the left edge of the board. Then a single 1x7 pin socket header in A0-A5 and Aref, and a 1x17 pin socket header along the front. All three were inserted on the component side and soldered on the solder side. I fabricated a prototype pcbard with matching pin headers as shown in the upper half of the photo. the 2x3 socket header mates to the In System Programming (ISP, sometimes called ICSP) connector. This is used for nothing but picking up the CPU RESET line. the daughter board (called a "shield" in Arduino) is the inverted and placed upon the CPU board as shown in the next photograph.



6. Yet another form this flexible board can take. I call this the Bare Bones Bootloader Burner Board. Instead of a conventional 28 pin socket for the ATmega168, two 1x14 pin socket headers are substituted. then an adapter board was made to adapt the wide spaced (0.6") fat pins of a 3M/Textool ZIF (zero insertion force) socket to the narrow spacing (0.3") of the CPU socket. The following changes to the normal assembly were also made; (1) the 2x3 ISP pin header was made a right angle so the connector from the AVRISP MKII wouldn't conflict with the ZIF socket. (2) the red power LED is covered by the ZIF socket so I added a Green LED that has its own internal series limiting resistor. It is soldered into one of the GND/+5v pairs over by the analog inputs. (3) I added a 2x17 pin right angle socket header for the digital pins. Since there is only one row of holes. I clipped the top pins off so they just barely rest on the solder mask when the other row of pins are inserted to the right depth. I soldered the front row of pins in place then ran a bare wire across the top and soldered it to each pin and grounded the wire. This way each digital pin has a ground right above it. (4) I put a red LED, also one with an internal series limiting resistor into Digital 13. When the AVRISP unit burns the flash memory it blinks this LED - it makes a good progress indicator.



# 4

## Modern Devices Rev C BBb Manual

# Bare Bones Board Arduino Assembly Instructions, Rev. C

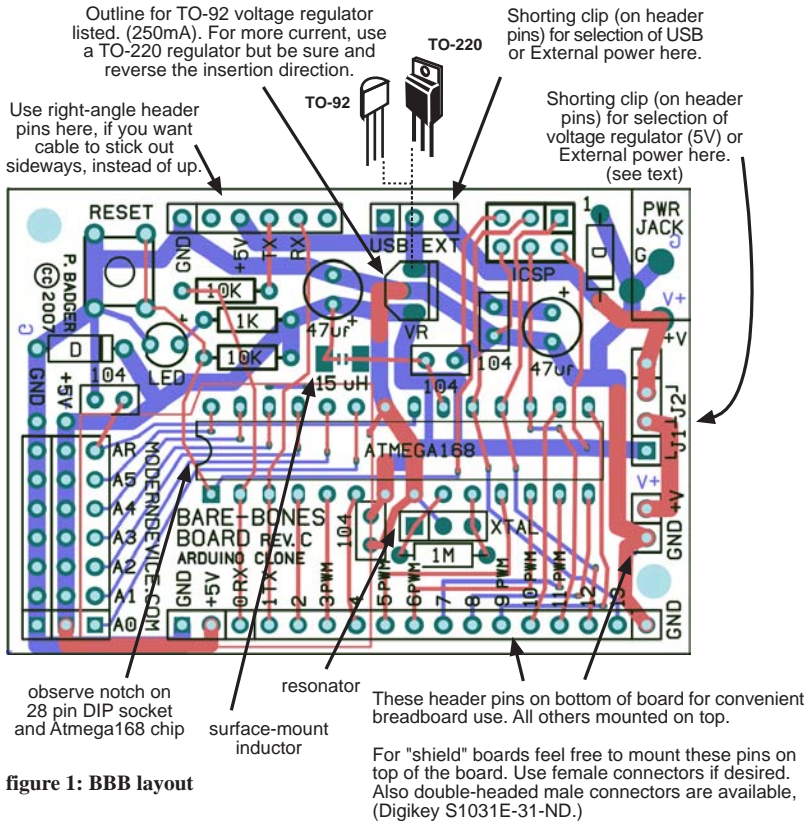


figure 1: BBB layout

The Bare-Bones Board has been engineered to be a low-cost easy-to-construct Arduino, specially aimed at students and prototypers. The board plugs into a breadboard, and has several convenient features that make it easy to use for both beginning and advanced prototyping.

Despite its title, the Bare-Bones Board includes all of the functionality of the most robust Arduino boards, and even some recommended analog noise-reducing components not found on any of the Arduino reference designs.

The boards and kits, which have been engineered to be as flexible as possible for widely varied types of prototype designs, can be built in an hour by a beginner at soldering, or in a half-hour by someone who has built a few of them before.

Only a low-wattage soldering iron (15 - 25 Watts), and solder is required.

## Assembly Instructions

Start assembling the board with the smallest, lowest profile components first. That way taller components will not get in the way when trying to install smaller components. Also when parts are inserted, and the board is flipped over to solder, components will tend to stay in the board better, if similar, low-profile components are inserted first.

For beginners that have never done electrical soldering before see the Soldering section before starting. There are a few tips for multiple-unit "power builders" too.

## Parts List

### Inductor

- 1 15 uH surface-mount inductor

### Axial 1/4W Resistors

- 2 10k (brown - black - orange)
- 1 1M (brown - black - green)
- 1 1k (brown - black - red)

### Capacitors

- 4 .1uFd (104) ceramic, 25 V
- 2 4.7-47 uFd tantalum or electrolytic capacitors (polarized), 25V

### Semiconductors

- 2 400x 1amp power diodes
- 1 L4931CZ50LDO 5V, low-dropout voltage regulator, TO-92 package
- optional** - LM2937 500 mA LDO regulator TO-220 package
- 1 3mm (T1) LED any color
- 1 Atmega168 28 pin DIP package preprogrammed with bootloader
- 1 16 MHz ceramic resonator with built-in capacitors, three-terminal SIP package

### Hardware

- 50 snap-off male header pins .100" centers, or .100" female headers as desired.
- 6 right-angle male-header pins .100" centers
- 1 momentary switch
- 1 28 pin (narrow .3") IC socket OR
- 2, 14 pin DIP sockets
- 2 .100" header 2 position shorting clip (shunt)
- 1 1.3mm power jack, Digikey CP-2519-ND

FTDI TTL-232R programming cable FTDIchip.com

5 Volt - 1A power adapter (optional)

All Electronics CAT# PS-504

- The first component to deal with is the smallest, the 15 uH surface-mount inductor, marked "150". This inductor provides a small amount of analog (A/D) noise reduction, it is recommended in the Atmega168 datasheet, but is not included in other Arduino implementations. If you do not wish to deal with the small surface mount component you may just solder up (short circuit) the surface mount pads where it was to be mounted.

If you do decide to mount the surface-mount inductor follow the instructions on page 4.

- Solder in the resistors, diodes, small ceramic capacitors, LED, reset switch, and voltage regulator next.
- The resistors and smaller capacitors have no polarity and may be inserted in either direction.
- Make certain that polarized components, such as diodes, LED, voltage regulator, and larger electrolytic caps are inserted in the correct direction. Note that the long lead on the LED is positive.
- Mount the two 47 uF electrolytic capacitors, carefully observing the polarities and orientation of each. The long leads on the capacitors are positive.
- Insert the IC socket (not the chip) into the board, taking care to align the notch with the notch on the board silkscreen.

*For larger and multi-pin components, such as the chip socket and header pins, there is a little trick that may be helpful to get them mounted neatly.*

*Solder in one pin only, or in the case of the socket, two diagonal corner pins. Then flip the board over to inspect it. If the component is not mounted tightly down on the board, simply put a little pressure on the component with your index finger while reheating the soldered pad(s) with the soldering iron, this will get the part mounted down flush before you solder in the other pins.*

- Solder in the power jack.
- Solder in the header pins. The board is made to be easy to customize for particular applications. The following instructions are for the most standard orientation for header pins, but feel free to mount (or omit them) as you wish. In some installations it may be more robust and reliable to solder wires directly to the board.
- The seventeen digital output header pins gets inserted into the bottom of the board and soldered on the top, as do the two pins, at front right, that are designed to power the breadboard. Mount these pins last after the others are mounted on top.
- All other header pins get inserted into the top of the board and soldered on the bottom. Using right-angle header pins for the USB-to-Serial cable connector makes the cable convenient to connect.
- Finally, mount the resonator (marked XTAL on board). It can be inserted either way but it's a good idea to insert it with the label showing.
- Hobbyists and prototypers often omit this step, but it's a good idea to clean the solder flux off your board with a toothbrush and isopropyl (not denatured) alcohol. Scrub and rinse with clean alcohol until the board looks flux-free. Dry it off a little with a paper towel or rag and have a good inspection of your solder joints, to make sure pins are not bridged (shorted) with solder, and that all the solder joints look shiny, smooth, and cover the pads completely. Questionable solder joints may be fixed simply by reheating with the soldering iron.
- Add the shorting clip to the power selection header in the desired position, and the J1/J2 shunt (see below).

### Testing your BB Arduino

- Put the USB / EXT shorting clip on the power selector pins. Power up the board, either with the programming cable or an external supply and make sure that the pilot light goes on. If not, disconnect the power right away, and consult the troubleshooting section. Do a check with a multimeter for 5 volts at the power pins to the left end of the digital breadboard pins.
- If all seems well, disconnect the power, and insert your Atmega 168 chip into the socket, taking care to align the notch on the chip with the notch on the socket and on the board silkscreen. Chips come from the factory with the legs splayed, and the chip will be much less fuss to insert if you

perform the following operation. Hold the chip exactly perpendicular to a table and press down until the all the legs have a 90 degree angle to the chip top. Flip, repeat, and you're ready to put the chip into the socket.

- Next hook up a LED and a 1K series resistor on pin 13. Boot up the Arduino application and try downloading the blinking light program. Push the reset button on the board and click the download icon at about the same time.
- If your board doesn't seem to work, see the troubleshooting guide on page 6.

### Powering the BBB Arduino.

There are two options for powering the Arduino Board. The USB cable can supply 5 volts to the board. How much current the FTDI 232R cable can provide is an open question. The USB standard calls for available current to be controlled by software and the cable's manufacturer quotes 50 mA as the amount of available current. (This limit is from the expected behavior of the USB interface and not any electrical limit from the cable.)

In practice, a Mac and a PC I tested were both able to provide 500 mA, which is as high as I went in my testing. Since I can't get access to any of the software interaction, it is impossible for me to know if the cable's software "asks" for higher current limits or the USB ports just generously provides more without being asked. I would guess the latter.

USB is a convenient option for powering your board because it eliminates other wires and batteries and it should be viable for many projects that only involve interfacing sensors, lighting LED's, or communicating with a laptop/desktop computer.

For circuit experiments and construction you are probably better off using a 5 - 9 volt power adapter. This will take the strain off your laptop battery and protect more expensive systems in the case of short circuits and the like. For powering small DC motors or solenoids especially, you will be much better off using an external power supply.

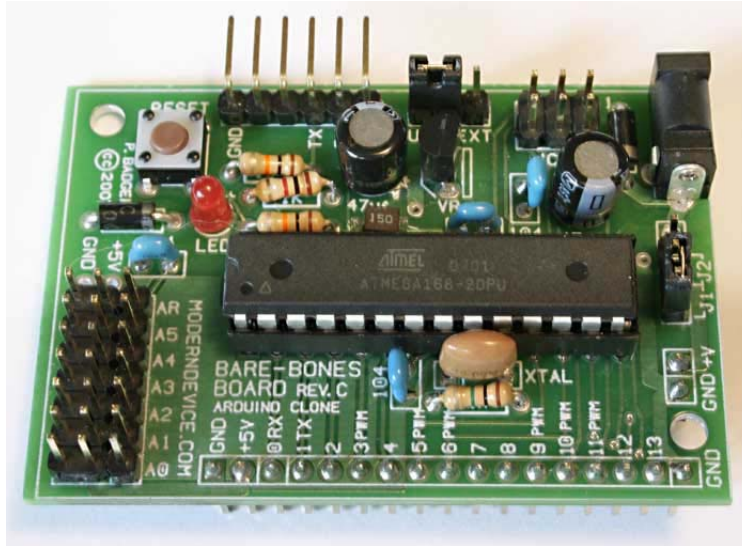
The board contains a 5 volt low-dropout regulator. In the case of an accidental short circuit, the voltage regulator on the board will limit the current draw to about 300 mA. This should protect the power supply although the regulator will get very hot. The tipoff to a short circuit will be the LED pilot light going off, and of course, a hot regulator, if you put your finger on it.

### J1 / J2 Shunt or jumper

J1 or J2 is an option that sets how the BB Arduino is connected to the two breadboard bus power pins on the right side of the board.

Use J1 in these cases:

J1 jumper is used to power for the breadboard power-rail bus comes through the Arduino LDO voltage regulator. Use this if you want to power your breadboard from your Arduino adapter, and the adapter is between 5-9 volts. Most users will probably want this option, unless you have DC motors running on the breadboard.



**Bare-Bones Arduino module with header pins set up for breadboard use. There are several options for the header pins depending on the project requirements.**

Use J2 in these cases:

J2 is used to connect power to (or from) the breadboard power-rail bus, directly from the Arduino power jack. In most cases you probably don't want a higher voltage than 5 volts on the breadboard power rail so use this option only with a regulated 5 V adapter such as the All Electronics unit in the parts list.

J2 can also be used if you have a powered breadboard, with regulated 5 volts available, and you want to run your BB Arduino from the breadboard rails. It is also possible to use J1 when powering the BBB off 5V breadboard rails - in that case, the regulator would not be in the circuit.

If your BB Arduino is tethered to a laptop or desktop computer as an IO device you may just want to run off USB. In this case the low-dropout regulator is redundant and you could just solder a jumper from one outside pin to the other.

If you are powering the board from a 5 volt, regulated adapter, such as the All Electronics model listed on the parts list, you could also leave out the regulator and one of the electrolytic capacitors that are associated with the regulator.

The pilot light and its associated resistor is a useful feedback signal, but if you are building a battery powered device which requires minimal power draw, for example, leave out the LED and add an LED (with series resistor) connected to an Arduino digital pin and blink the LED every 3 or four seconds, to save power.



**jumpered  
voltage regulator**

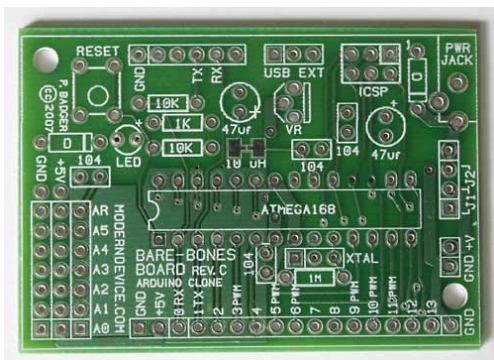
### Options, Parts You Perhaps Don't Need

The Bare-Bones Arduino was engineered to be a small, versatile prototyping board, so depending on your circumstances, there may be several parts you can do without.

Any of the header pins can be left out, or soldered on the top or bottom of the board, or can be replaced by female headers, (for mating with shield boards, for example). One flexible option might be to use longer, male, header pins that protrude both above, and below, the board. This would make it possible to use your BB Arduino with either a breadboard, or a shield board. See Digikey part # S1031E-36-ND for example.

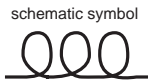
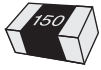
You could even leave out the 16 Mhz resonator, and program the Atmega168 chip to run on the internal RC oscillator, at 8 Mhz. This would require reprogramming the Atmega168 fuses. This is not rocket science, but not for those impatient with trial & error, in my experience, see <http://www.arduino.cc/playground/Learning/Atmega83-3V>.

Please let us know if there are features you think would be handy or should be built into the next version. Corrections and suggestions for this documentation are also highly valued and appreciated. Most will be implemented immediately.

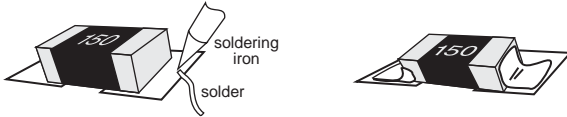


**A BBB pcb board shown actual size, for comparison purposes. The production run boards however, are white, not green.**

## Inductor



Inductors (coils) act to oppose a change in current. In the BBB circuit the inductor's role is to reduce fast-changing power-supply noise. The 15 mh (millihenry) inductor is the only surface-mount component on the board. Here's how to mount it.



Place the inductor on the pad, hold it down by laying an Exacto knife or needlenose pliers on top of it, and heat the pad, (do not touch the inductor with the soldering iron). Solder will rapidly flow onto the pad and inductor, lift the soldering iron immediately. This will hold the inductor down, touch the other pad for a second with some solder and your soldering iron, and you're almost done. Just reheat the first side quickly to insure a good solder joint.

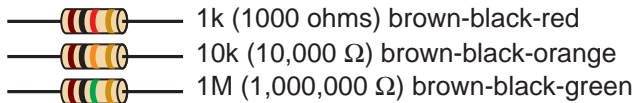
Don't worry if the inductor is not on perfectly straight, the electricity can't tell the difference. Don't overheat it either, it's small and will solder quickly. If it's really crooked, you can position it by quickly and alternately heating opposite ends and pushing gently with the soldering



solder pool to short pads if not using inductor

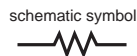
If you don't want to fuss with the tiny inductor, just leave it out and solder up the pads as shown above. No other Arduino boards include it although the Atmega 168 datasheet recommends it, and the reduction in analog noise that it provides is fairly minor.

## Resistors

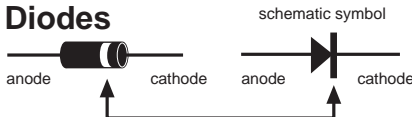


tolerance band: gold = 5%

resistors are not polarized, meaning it doesn't matter which end goes where



## Diodes



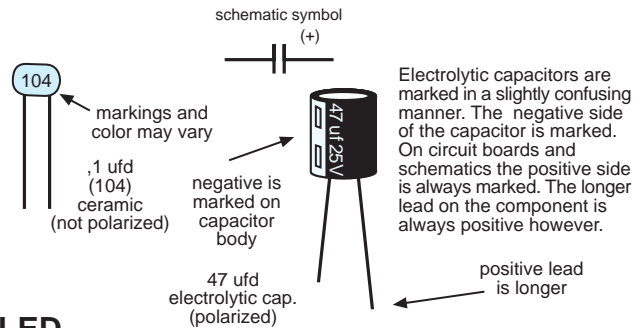
Diodes act as electrical "one-way" valves. Electricity flows in the direction of the arrow, but not the other way. They are polarized. Stripe is negative (cathode end). Think of the stripe on the diode as the stripe in the schematic. Get the stripe oriented the correct way on the board, or the project is almost guaranteed not to work.



Prepare all the resistors and diodes for inserting into pcb by bending their leads at right angles, adjacent to the component body.

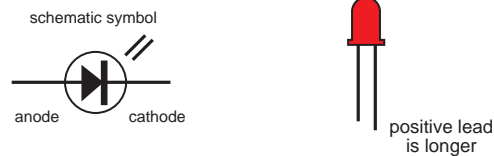
## Capacitors

Capacitors are components that store electrical energy (charge). There are several different technologies that are used to construct capacitors. The BBB contains ceramic capacitors, that are not polarized, and electrolytic capacitors, that are polarized, and must be inserted with the correct orientation.



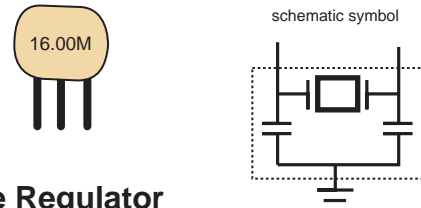
## LED

LED's are diodes which emit light. They are polarized like diodes so insert them in the correct direction.



## Resonator

The 16 Mhz ceramic resonator acts as a calibrated oscillator for the BBB. As you can see from the schematic, it contains a crystal element and two small capacitors. It's symmetrical, so you can't put it in backwards, but it is a good idea to put it in so that you can read the label.

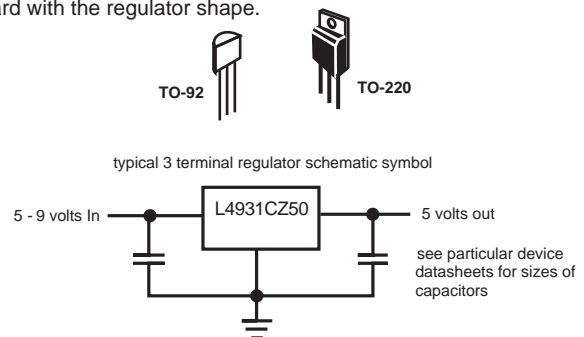


## Voltage Regulator

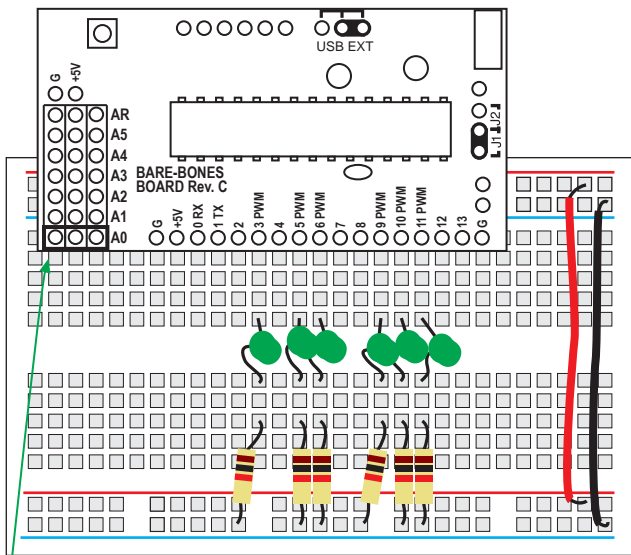
The voltage regulator is an integrated circuit which will limit higher input voltages to 5 volts. It will also limit the current flow in case of short circuits. The electronics industry calls the physical form an IC is packaged in a "package" or "case", the actual IC is always a small chip embedded somewhere in the plastic. The voltage regulator provided may vary by number but is in a TO-92 case.

If you need to have more regulated power, to power a lot of high powered LED's on a breadboard, for example, then, your board will accommodate a TO-220 package regulator, such as the LM2937 listed in the parts list, or the popular 7805. Just remember to insert it backwards as shown in figure 1.

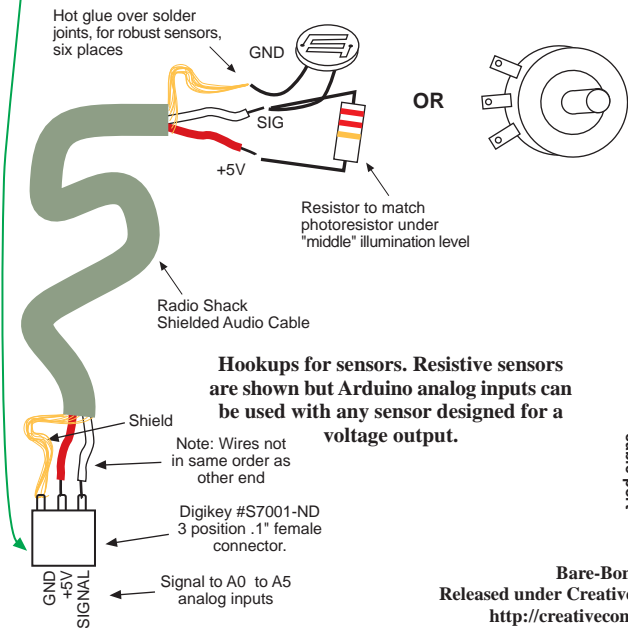
Make sure you get the TO-92 regulator inserted in the correct orientation. It is **not** symmetrical so match the part outline on the board with the regulator shape.



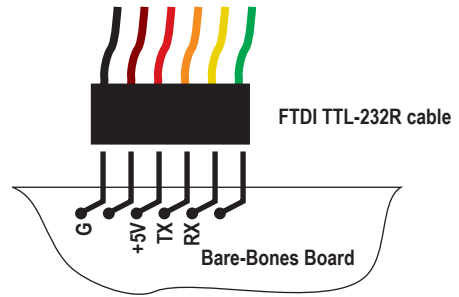




An Arduino Board set up on a solderless breadboard with six LED's ready for dimming with the PWM outputs.

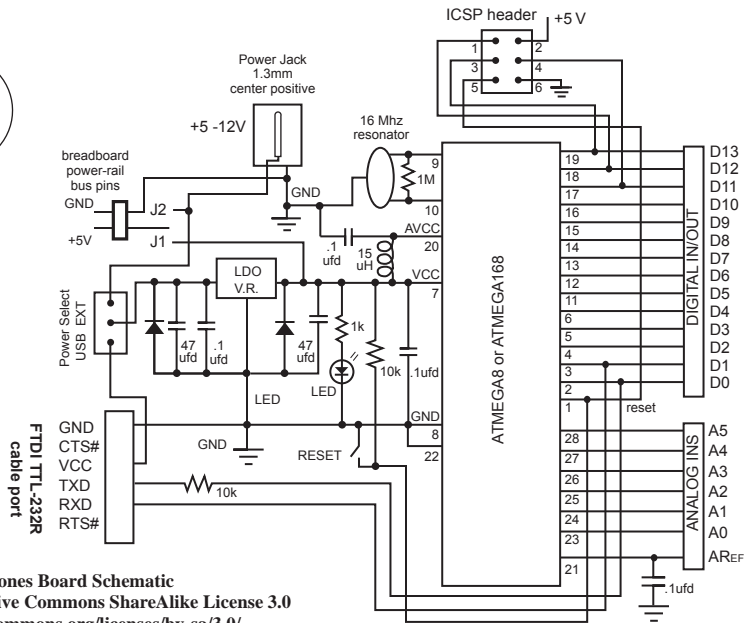


Hookups for sensors. Resistive sensors are shown but Arduino analog inputs can be used with any sensor designed for a voltage output.



Programming cable connections between a BBB and a FTDI TTL-232R USB to TTL serial cable.

Please note that the TX and RX labels refer to the cable's labeling, not the chip's. The TX label at the programming connector is electrically connected to the Arduino's RX pin (0) and the cable's RX pin is connected to the Arduino's TX pin.



Bare-Bones Board Schematic  
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Bare-Bones Board Arduino Schematic

Arduino Pins  
digital pins

- digital pin 0 (RX)
- digital pin 1 (TX)
- digital pin 2 (INT0)
- d.p. 3 (INT1, PWM)
- digital pin 4
- digital pin 5 (PWM)
- digital pin 6 (PWM)
- digital pin 7
- digital pin 8

(PCINT14/RESET) PC6	1	Atmega 168
(PCINT16/RXD) PD0	2	
(PCINT17/TXD) PD1	3	
(PCINT18/INT0) PD2	4	
(PCINT19/OC2B/INT1) PD3	5	
(PCINT20/XCK/T0) PD4	6	
VCC	7	
GND	8	
(PCINT6/XTAL1/TOSC1)	9	
(PCINT7/XTAL2/TOSC2) PB7	10	
(PCINT21/OC0B/T1) PD5	11	
(PCINT22/OC0A/AIN0) PD6	12	
(PCINT23/AIN1) PD7	13	
(PCINT0/CLKO/ICP1) PB0	14	

Arduino Pins  
analog inputs

- analog input 5
- analog input 4
- analog input 3
- analog input 2
- analog input 1
- analog input 0
- digital pin 13 (LED)
- digital pin 12
- digital pin 11 (PWM)
- digital pin 10 (PWM)
- digital pin 9 (PWM)

C5 (ADC5/SCL/PCINT13)	28
PC4 (ADC4/SDA/PCINT12)	27
PC3 (ADC3/PCINT11)	26
PC2 (ADC2/PCINT10)	25
PC1 (ADC1/PCINT9)	24
PC0 (ADC0/PCINT8)	23
GND	22
AREF	21
PB6 AVCC	20
PB5 (SCK/PCINT5)	19
PB4 (MISO/PCINT4)	18
PB3 (MOSI/OC2A/PCINT3)	17
PB2 (SS/OC1B/PCINT2)	16
PB1 (OC1A/PCINT1)	15

Pin mapping of the Atmega168 chip to the Arduino Board

## Troubleshooting

### Symptom: No pilot light.

#### Causes:

LED in backwards  
 electrolytic capacitor in backwards  
 voltage regulator in backwards  
 no power select shunt (shorting clip)  
 no power at external jack - check power adapter & polarity  
 bad solder connection - check power at power jack &  
 power-select pins  
 diode in backwards (disconnect power supply right away)  
 power supply connections reversed - check external supply  
 with a multimeter

**Procedure:** check for 5 volts at power buses: at USB port, at power jack, near analog pins, at pins 7&8 of the Atmega168

If 5V is found at power bus pins, LED is in backwards or poor solder joint. If low or incorrect voltage, check diodes, voltage regulator, solder joints, power supply

### Symptom: Pilot light on but program won't download to board

#### Hardware Causes:

Atmega168 in backwards or not seated properly (check for pins that have "escaped the socket")  
 Atmega168 not programmed with bootloader  
 bad cable  
 drivers not installed on PC - Check Arduino->Tools->Serial Port  
 solder joint at cable connector or pins 2& 3 (check for shorts or bad (solder joints) on all pins, reheat all solder joints  
 wrong resonator value  
 wrong resistor across resonator (1M)

**Procedure:** if you have an oscilloscope, check for signals across resonator pins and on RX line during download.

#### Software/PC side causes:

check for FTDI drivers installed (if using USB cable)  
 check for proper chip (Atmega168) selected in  
 Arduino->Tools->Microcontroller->Atmega168  
 click RESET switch simultaneously with download attempt.

#### General "Cure-Alls":

check orientation on all polarized parts, V.R., caps, diodes, V.R., socket and chip.  
 check values of resistors  
 Reheat all solder pads on bottom of board, look for bridges (shorts) on chip pins  
 clean PCB with toothbrush and isopropyl alcohol

Arduino is an open-source hardware and software initiative closely related to the Wiring and Processing open-source initiatives.

Arduino Home - <http://arduino.cc>

Wiring Home - <http://wiring.org.co/>

Processing Home - <http://processing.org/>

The Bare-Bones Board is an open-source hardware project of Paul Badger and Modern Device Company  
[moderndevice.com](http://moderndevice.com)

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## Electrical Soldering for Beginners

Use a high-quality soldering iron with the sharpest point you can find. It should be rated between 15 and 25 watts.

Keep the soldering iron tinned (coated with solder) at all times. The tip should look silvery and shiny. It is important to do this as soon as a new soldering iron gets hot.

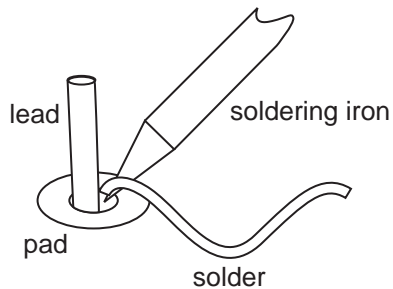
Wipe your soldering iron tip off on a wet sponge, or a copper "scrubie", to keep it clean and shiny. Do this whenever the tip stops looking shiny or has too much solder buildup on it.

Use either leaded or "no-lead" solder but be aware no-lead solder is a little harder to use for beginners, and makes solder joints that are slightly less shiny than leaded solder.

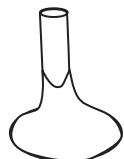
Work in a room with some ventilation. There is a tiny bit of lead in solder fumes but the flux fumes are more of a health-hazard than the lead. Jameco sells a nice soldering iron / carbon filter combination for under \$100.

Heat the pad for about a second, then apply solder to the heated pad or leads, not the soldering iron. After the solder melts and "grabs" the pad, continue heating for another second.

If you haven't gotten the solder to grab after about 4 seconds let the joint cool down before trying again. Too much heat can ruin electronic components, but most beginners err on the side of too little heat ("cold" solder joints). If the solder joint looks lumpy, or if the solder doesn't completely cover the pad, the solder joint needs more heat. Just reheat it again until you see the flux around it "simmer" a bit, and the solder grabs the pad and smoothes out.



cold solder joint  
(not enough heat)



good solder joint

- smooth meniscus
- shiny
- covers pad

It is a good idea to clean the solder flux off your board with a toothbrush and isopropyl (not denatured) alcohol, when you are done with your board. Most fluxes when left on the board for extended periods of time, will corrode pcb pads and traces. Additionally, fluxes are not perfect insulators, so can affect the electrical operation of your circuit.

Splash a little alcohol on the board and scrub with a toothbrush. Rinse with clean alcohol and repeat until the board looks flux-free. Dry it off a little with a paper towel or rag and have a good inspection of your solder joints, to make sure pins are not bridged (shorted) with solder, and that all the solder joints look shiny, smooth, and cover the pads completely. Questionable solder joints may be fixed simply by reheating with the soldering iron.

## Power Soldering for Multiple-Kit Builders: or How to put together 10 BBB kits on Saturday and still have time to meet your friends.

Additional items required: Piece of foam rubber - antistatic pink foam is ideal, small alligator clips.

We insert parts in groups and don't bend any leads to hold parts in. Once the board is flipped for soldering, the foam holds the components against the board. We put the boards together in 4 steps.

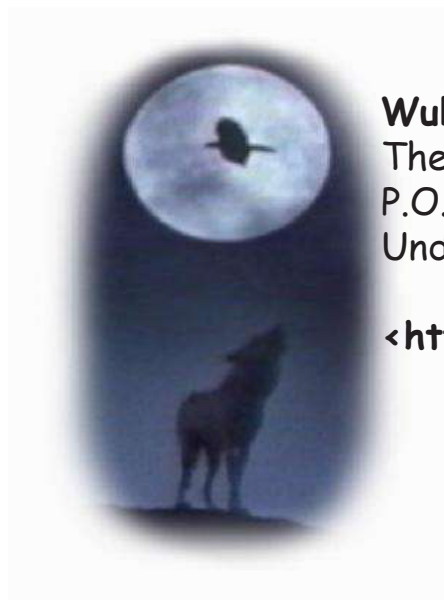
Step 1: mount the inductor, covered on page 4. You can get it straight by quickly and alternately heating either end and gently moving it.

Step 2: Insert the resistors, diodes, reset switch, LED and small (104) caps. Don't bend the leads. Cover the parts with the foam and flip the whole board, then solder it. If you are worried that a part may not be seated down against the board apply some pressure to the board while heating one pin.

Step 3: Cut the leads from the last step. Insert *all* the remaining parts *except* the 17 pin header and 2 pin header. If you have alligator clips, clip the programming header and the power jack to the board with them, you could also try this on the other headers if you have a lot of clips handy - the small ones are better.

Put the foam on top of the board and flip the whole mess so foam is now on bottom and board is upside down. Tack down one pin only on headers and socket. Solder in all pins on electrolytic caps, resonator and parts held in with clips. (You could also inspect them first for correct fit) Flip the board to inspect "fit" on headers and socket and adjust by heating with pressure from index finger. A thimble might be useful if you haven't burned out all the nerves in your index finger soldering, as we have. Flip and finish soldering.

Step 2: Insert the 17 pin and 2 pin header on bottom. Tack, inspect, straighten if necessary and solder.



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