MicroBAR Assembly Procedure

Rev. 2013-06-21

1. Materials you need:
    a. PCBs (order from Advanced Circuits)
    b. SMT solder paste stencils (order from Pololu)
    c. All components listed in bill of materials
    d. Tube of solder paste
    e. Trowel (glass slide will also work)
    f. Skillet
    g. Fine tipped tweezers
    h. Tape and scrap PCBs
    i. Power supply with a cable to plug into JST battery input connector
    j. Conductive epoxy
    k. Spray paint and primer
    l. 2-part clear epoxy (fast drying)
    m. AVR-ISP mkII in-circuit programmer
2. Printing 3D enclosure
    a. Each piece is saved as a separate STL file. Load these all simultaneously into the Zprinter software and it should automatically arrange them. You can do a "fix" on the parts if there have been changes.
    b. 3D print using default settings
    c. After 24 hours or so, remove the parts and epoxy according to directions. Let sit overnight.
3. Tapping holes in 3D enclosure
    a. In current version, I drilled pilot holes (no actual tapping) with a #43 bit in the PCB pillars and in the lid. But the material strips easily with these fine threads. In the next version, there shouldn't be any tapping (except maybe the lid). Rather, just use pockets for nuts/4-40 sleeves in the lid and base. So in all places where there should be a nut (8 in the lid and 4 in the base) that is epoxied in.
    b. Countersink the heads so the lid closes flat (may also print that directly into future designs)
    c. It's good to test fit the components. The display required some tweaking
4. Painting 3D enclosure
    a. Sand the enclosure thoroughly with 100 grit sandpaper
    b. Prime, sand, prime, sand. Be careful of rounding off edges. I applied 2-3 coats of primer, but only a little at a time. So in total I probably sprayed it 8 times with primer, and 8 times with paint, considering I also had to rotate it and get it from all sides.
    c. Spray paint with semi-gloss black. Use thin coats and even strokes. No need to paint the interior, but definitely coat it with primer.
5. Populating PCBs (see Sparkfun tutorial on using Skillet for PCB reflow)
    a. Tape several scrap PCBs to the table around the PCB to be populated so it fits snug without sliding
    b. Align and tape the stencil over the PCB. The scrap PCBs are there so the trowel doesn't bow off the edges.
    c. Squeeze out *plenty* of solder paste at one end of the board.
    d. With one firm motion, smear the solder paste over the stencil, try to keep it very uniform and get paste in all the holes. Touchup if necessary
    e. Remove the stencil with one motion.
    f. Place all the components on the top side of the board. Ensure you've got the correct polarity on things. Most solder paste bridges will fix themselves, if there's not too much solder.
    g. Plug in the skillet and turn it all the way to max. Place the board on the skillet. The warmest region is around the circular heating element.
    h. After about 3 minutes, the paste will begin to reflow. Move the board around a bit if one part isn't getting hot enough. The whole process should take <5 minutes.

i. When all the components have reflowed, turn off the skillet and carefully remove the board and set it down to cool.
j. Inspect all components for solder bridges, bad connections, etc.
k. Flip the board over and populate it with a regular tip iron
l. Populate all through-hole components by hand. If populating the cell phone module, take special care that the 60-pin socket doesn't have any solder bridges and the module is soldered down to the board securely.
m. Populate the rectangular LEDs, with special care to bend them at the correct position and solder them at the correct height.
n. Snip off the tip of the pushbutton - this will make assembly easier (only one detent is needed)
o. Note the PCB mods that I made in the "readme.txt" file and make these revisions (mostly adding jumper wires). These should be incorporated into the next version.

6. Initial testing
   a. Plug a power supply with current limiting capability to the battery in port and turn it all the way down.
   b. Slowly ramp up the voltage on the power supply and make sure there isn't a significant current draw. If there is, you've likely got a solder bridge short.
   c. Set the power supply to 4 V and probe the 5V, 3.8V, and 3.3V supplies on the board to make sure they're correct. Vary the power input and make sure they are stable
   d. Turn off the power supply and connect the top board (screw in the standoffs). Repeat this procedure.
   e. Connect a LiPo battery to the port and connect the USB port to a computer. Verify that the USB port does not overdraw current and that the battery voltage increases steadily (charging) when it is plugged in. Also verify that when you press the power switch, the computer recognizes new hardware (Atmel 8U2)
   f. Dry fit the boards to the 3D enclosure (if available) and make any adjustments to the protruding components, if necessary.
7. Install battery and cell phone antenna
   a. Cut brackets out of brass for the cell phone antenna and the LiPo battery. Attach these to the bottom PCB and mount the antenna and battery. There should be a piece of foam between the battery and the bottom of the PCB to prevent the bottom components from digging into the battery.
8. Downloading the AVR firmware (USB controller and Arduino bootloader)
   a. Make sure drivers are installed for the AVR-ISP mkII (easiest way to do this is to install AVR Studio)
   b. Connect the AVR-ISP mkII to the ICSP2 header to download the 8U2 DFU firmware.
      i. Note that this firmware is the same as that available from the Arduino website, but I modified the descriptor string.
      ii. Download with:
      avrdude -p at90usb82 -F -P usb -c avrispmkii -U flash:w:MicroBAR_dfu_and_usbserial_combined.hex -U lfuse:w:0xFF:m -U hfuse:w:0xD9:m -U efuse:w:0xF4:m -U lock:w:0x0F:m
   c. Make sure the board enumerates as "Berkeley MicroBAR 2"
      i. Point Windows to the "Windows Driver" directory and install the driver
   d. Plug in the mkII to the ICSP1 header and fire up the Arduino software. Make sure the correct board (Arduino 2560) is selected and correct COM port is selected, then go to "burn bootloader"
   e. Unplug the mkII and power cycle the board.
   f. Load the Controller.ino software onto the MicroBAR
9. Firmware testing
   a. When the MicroBAR restarts, you should hear two beeps and see the RUN/BAT lights flash. This indicates that the firmware is running.
   b. Open the arduino serial monitor and verify that you get state data from the board. Then run the Processing UI and verify that you see data from the phototransistors and that you can tell the board to run an assay.

c. Verify that all 96 phototransistors respond individually (block out all but one using black foam and observe that each one is uniquely addressed). If there is a problem, it may indicate a solder bridge on the addressing pins.

10. Assembling ITO heater
    a. Start w/ 75x50x0.5mm ITO coated glass slide from Delta Technologies (5-15 ohm/sq)
    b. Verify which side is conductive
    c. Cut ITO heater brackets
        i. Start w/ ~100um brass bar from Ace HW, 3/4" wide, K&S Engineering 614121102330
        ii. Cut to width of slide w/ tin snips (50mm)
        iii. Mark 5mm line on one side
        iv. Use tin snips to cut the pins (about 1.5mm wide)
        v. Put in vice (pins down) and cut at 5mm line using Dremel cut-off wheel
        vi. Use wire brush wheel to remove flashing and roughen back side (where epoxy will go)
        vii. Put in vice and bend legs 90 degrees
        viii. Make sure pins will insert into PCB.
    d. Glue on brackets and thermistor
        i. Lay brackes face down on kimwipe
        ii. Dry fit slide, make sure spacing is correct, double check for conductive side
        iii. Before gluing the slide, put a dot where the thermistor will go (middle of slide ~5mm in)
        iv. Mix conductive epoxy and smear on bracket evenly. Cut a small piece of the brass to apply it to the slide.
        v. Lay slide down (conductive side facing down) and push IN on brackets a bit so excess epoxy goes outside rather than smearing on the slide. Make sure it makes contact along entire length of bracket. Let it sit with a light weight on the slide for 10 minutes or so.
        vi. Mix 2-part epoxy (Loctite quickset) and then pickup a small droplet (brass piece works for this) and apply on the slide.
        vii. Use tweezers to place thermistor on slide, in the middle of the droplet
        viii. Once glue has set (20 min) transfer to oven (60C) for 1 hr. Or let sit overnight.

11. Adding LEDs/waveguides
    a. Cut/spraypaint waveguides
        i. Cut (2) 50x75x1mm glass slides and make 2 50x7mm strips to use as waveguides. Best to cut each waveguide from a separate slide.
        ii. Use flat black spraypaint, lay waveguides on napkin flat, sandwiched between other glass slides to mask off the regions we don't want to spray paint. Best to use the slides you cut from, so the edge fits perfectly.
        iii. Shake can and spray evenly, lightly so it doesn't drip on the sides
        iv. Make sure to get both ends (small ends)
        v. Once one side's dry, flip them over and do the other
        vi. Use sandpaper if necessary to remove any paint on the clear sides
    b. Glue on waveguides
        i. Once spraypaint is dry (could put in oven to accelerate this), mix more 2-part epoxy and apply small droplets at the edges of the brackets.
        ii. Set the waveguide down on top of the brass brackets. Note that the glass should extend over the ITO a bit (to avoid scattering into the ITO) and should be flush at either end of the brass brackets.
        iii. Let glue dry
    c. Glue on LEDs
        i. Use helping hands to hold ITO slide vertically. Make sure the helping hands have lots of tape around them so they don't mark the ITO. Grip it by the brackets (not the waveguide).
        ii. Pull out 3 LEDs and line them up in the same orientation (you'll want to get them quickly)
        iii. Make sure all the polarities are the same (note the position of the green line on the back)
        iv. Mix more 2-pary epoxy and dip each LED into the epoxy (just barely, don't let the epoxy cover the contacts). Place them on the edge of the glass waveguide, 3 to a side. One should be in

the center and the other two should line up so they're between columns 3 and 4 on the chip (use a scrap chip to eyeball it)...or maybe measure this precisely.

v. Once you've done 3, let the glue dry, flip over the ITO, and do the other side.
vi. Make sure the polarities of the other side line up, so a series string around all 6 will have them all in the proper polarity.

d. Wire up LEDs
    i. Use soild wire wrap wire (32 awg) and cut small pieces to connect between the LEDs. Bend the ends of the wire at 90 degrees, and solder them on one by one. The end of one side will connect with the beginning of the other.
    ii. Use small stranded wire from ribbon cable (28awg) to make a connector tying the strings together and put a JST connector on it (make sure the orientation is correct).
e. Coat all LEDs/wires with liquid electrical tape and make sure no light can escape, except through the waveguide. Hold the slide such that whichever side you're currently coating is facing down, since the liquid electrical tape tends to drip. 3-4 coats seems to do the trick. Note that this is also strain relief for the leads.
f. Let it dry
g. Connect leads to thermistor. Use smallest heatshrink to protect leads from each other, and put a JST connector on the other end.

12. Plug in the ITO, thermistor, and LEDs and test them using the software. Check to make sure the ITO is getting hot, the LEDs can vary their brightness across all the levels, and the thermistor is reading approximately the correct temperature. The ITO should have approximately 10V across it. The LEDs should not flicker.
13. Cutting foam insert and gasket
    a. The thinner foam (1/16") is for the insert underneath the ITO, and the thicker foam (1/8") is for the light gasket.
    b. These burn very easily, so cut them on the lowest power setting on the Versalaser (Paper). I used ~ 0.1mm for the 1/16" @ +10% or so, and 1mm @0% for the gasket (both on Paper).
    c. Test fit both
14. Cut green gel to fit array and sandwich this between the ITO and foam. Get the height level and as close as possible to the PTs without the slide touching, then solder down the ITO.
15. Attaching light gasket
    a. Mix up more epoxy and smear it in the trench on the base, careful to avoid getting it around the sides. Insert the gasket. Do this quickly since the epoxy sets in 5 min. DO NOT put something heavy on the foam while it's drying or it will be permanently compressed.
16. Cutting battery and antenna brackets
    a. See current design. Antenna bracket is cut from brass, 9mm wide, with a 4-40 hole at one end and a 90 degree bend at the other for the SMA connector to thread through.
    b. Battery bracket should fit between the holes under the board and be a little larger than the battery, so foam will fit snugly in there.
    c. Attach the battery. Use a 4-40 nut/bolt. Cut a square of foam to go between the battery and PCB, and a strip of foam to go along the underside of the bracket.
    d. Thread the SMA connector into the bracket.
17. Installing PCBs
    a. In this version, the clearances really aren't sufficient. The enclosure should be enlarged slightly.
    b. Use a drill bit for 75% thread engagement for 4-40 screws and drill holes in the pillars. Note that this isn't ideal, and you should instead epoxy nuts in the pillars since the 3D printed material is prone to stripping.
    c. Screw in the top board using the mid-size standoffs from Digikey). Put the board in and use a 4-40 screw to actually drive the standoff into the material (let the screw bottom out in the standoff). Then hold the standoff with pliers and back the screw out.
    d. To get the bottom board in, make sure all the LEDs are bent so they will sit just behind the enclosure and bend the board-to-board header towards the hinge side so the pins are at an angle. Then you can wiggle the bottom board in and get it to mate while the USB port protrudes through. Pushing

the switch in the ON position helps.

e. Screw in 4 more standoffs (same length). Make sure to attach the antenna bracket to one of them. This is what the base will screw in to.

18. Installing LCD module
    a. Burn LCD firmware on via USB port
    b. Modifications to Amulet LCD
        i. Remove RS-232 connector and power connector. I just used angle cutters to cut them apart and then desoldered the pieces from the board
        ii. Cut the traces which go to the MAX232 on the board (these are clearly marked)
        iii. Solder the TX/RX/+5/GND leads onto the board directly. The wire should be ~8" long
    c. New enclosure version should have pillars for mounting the LCD with embedded 4-40 nuts. So you'll just screw it in. I just cut foam (2 thick pieces) to sandwich the display in. I cut out holes in the foam for all the components on the PCB.
19. Installing GPS module
    a. Use double sided tape or hot glue to glue the module into the lid.
    b. Make a small JST connector w/ 5 wires coming off it.
    c. Attaching lid pieces and verifying that hinge works
    d. Use hot glue to attach the GPS receiver. The LCD can be floating (next version it should fit more snugly).
    e. Thread the GPS/LCD cables through the hinge and put the hinge together
    f. Screw the hinge together using wood screws (#4, 5x8")
    g. Add JST connectors to GPS cable and LCD cable.
    h. Plug GPS/LCD into PCB.
20. Attaching base
    a. Screw it in using 3/4" 4-40 screws. These should be a little more than finger tight...any more and you will strip out the pillars.