Assembling the microAlt 4600/9200

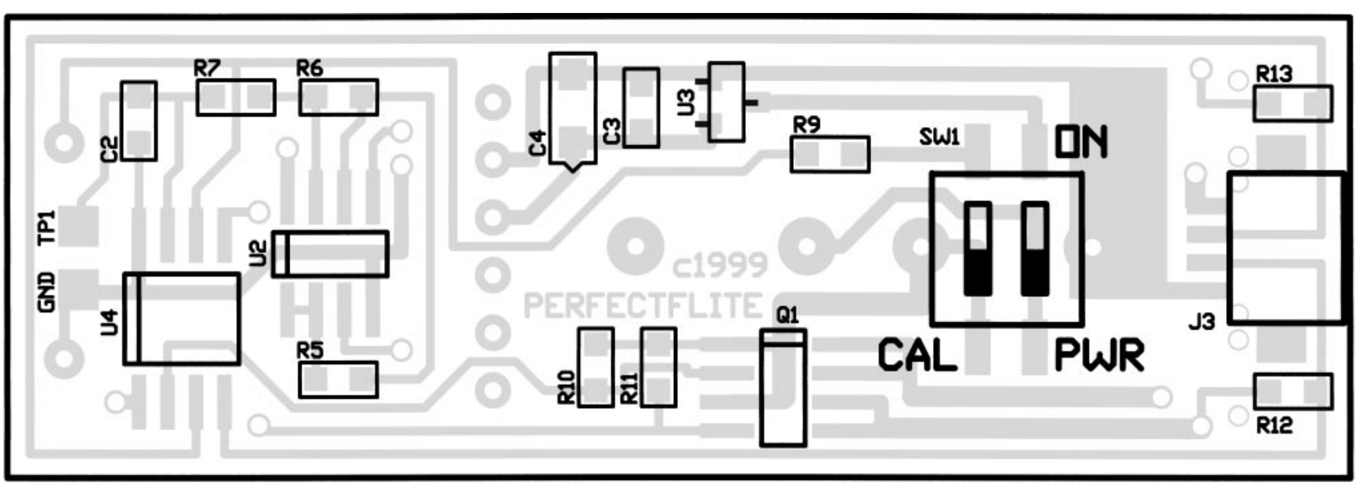
Preliminary Inspection
Before beginning construction of your microAlt altimeter, inspect the blank PCB carefully for defects. Look for broken traces or adjacent traces that are "bridged" by excess material. While the likelihood of receiving a damaged board is almost nil, it is much easier to rectify these problems before any parts are installed.

Read through the enclosed surface mount soldering primer. Look over the components but do NOT remove them from the identifier card at this time. If you are unsure of your ability to assemble the kit, seek experienced help or return the kit to PerfectFlite for assembly.

The markings on the individual components are very small and hard to read without magnification. For this reason, we recommend that the parts be left attached to the identification card until they are needed for assembly. Only remove one part type at a time to prevent mixing component values (e.g. install all 12.7KΩ resistors, then all 90.9KΩ resistors, etc). Immediately before installation, inspect a representative sample of each value to confirm that the proper part is being installed. It is much easier to resolve problems before assembly than it is to remove parts that were installed in the wrong positions.

Read through the "Surface Mount Soldering Procedure" document that came with your kit for tips on assembling surface mount components. You may want to try the simpler microTimer kit before attempting the more complex altimeter project.

Bottom Side Assembly
We will start with the bottom side of the board. It will be easiest to work on the board if it is held stationary during assembly. Sticking the board to a ~3" square block of wood (bottom side up) with a small strip of double sided foam tape will allow the board to be rotated for convenient access to both horizontally and vertically oriented components



❏ Install resistor R5 (12.7K, marked "1272").

❏ Install resistor R7 (12.7K, marked "1272").

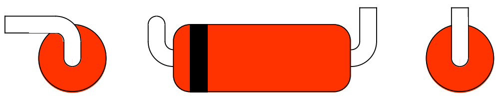
❏ Install resistor R9 (12.7K, marked "1272").

- ❏ Install resistor R10 (12.7K, marked "1272").
- ❏ Install resistor R11 (12.7K, marked "1272").
- ❏ Install resistor R12 (90.9K, marked "9092").
- ❏ Install resistor R13 (90.9K, marked "9092").
- ❏ Install resistor R6: for microAlt 4600, 90.9K, marked "9092".
  for microAlt 9200, 42.2K, marked "4222".
- ❏ Install capacitor C2 (.047µF, brown chip with silver ends).
- ❏ Install capacitor C3 (.047µF, brown chip with silver ends).
- ❏ Install capacitor C4 (6.8µF, marked "JW6"). Note polarity — the white band must face toward the center of the board. The outline on the PCB indicates this with a pointed end.
- ❏ Install voltage regulator U3 (marked 5AO_). Note orientation — the side with a single lead faces toward the end of the board with the ejection connectors. Do not overheat this device.
- ❏ Install MOSFET Q1 (marked F7313). Note orientation — the end with the round dimple (signifying pin 1) faces toward the center of the board. Tack down one pin, check alignment and centering of remaining pins and adjust as necessary, then solder down the remaining pins. Inspect carefully for bridges between adjacent pins and correct if necessary.

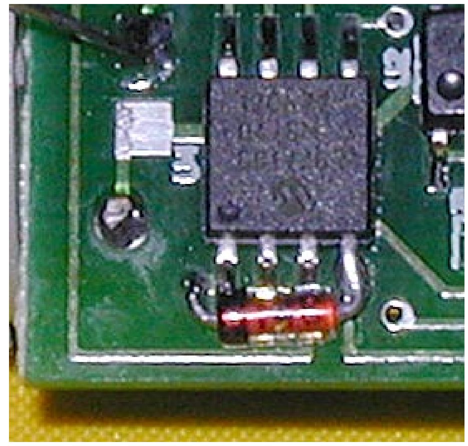
Important!
Refer to the calibration section at the end of these instructions. If you will be performing calibration procedure #2 or #3, do not install U2 at this time.

- ❏ If you will be performing calibration procedure #1, install IC U2 (marked LMV358M). Note orientation — the end with the round dimple (signifying pin 1) faces toward the beeper end of the board. Tack down one pin, check alignment and centering of remaining pins and adjust as necessary, then solder down the remaining pins. Inspect carefully for bridges between adjacent pins and correct if necessary.
- ❏ Install IC U4 (marked 12C672). Note orientation — the end with the round dimple (signifying pin 1) faces toward the beeper end of the board. Tack down one pin, check alignment and centering of remaining pins and adjust as necessary, then solder down the remaining pins. Inspect carefully for bridges between adjacent pins and correct if necessary.
- ❏ Install J3 (four pin connector for ejection power and data I/O). Apply small amounts of solder to both of the mounting pads (but *not* the four pads for the pins), then apply flux to all six pads. Quickly (you don't want to melt the plastic body of the connector) apply a small amount of solder to the metal mounting ears on the connector. Position the connector on the board, aligning the two plastic pins with the holes in the board. Press down gently on the connector while you heat the solder on the board — when it melts it will melt the solder on the connector and you will feel the connector dropping down into place against the board. Repeat this procedure for the other end, working quickly to prevent melting the connector body. After you are satisfied with the placement of the connector (it should be flush against the board, with all four of the pins centered on their pads) you can add a small amount of additional solder to each of the mounting lugs for additional strength. Then solder the four pins to their pads, being careful to not create bridges between adjacent pins.

❑ Install diode D1 as shown in the following illustrations. Bend and trim the leads as shown, insert the cathode (banded end) through the hole adjacent to pin 1 of U4, and solder this end. The anode is soldered directly to pin 4 of U4.



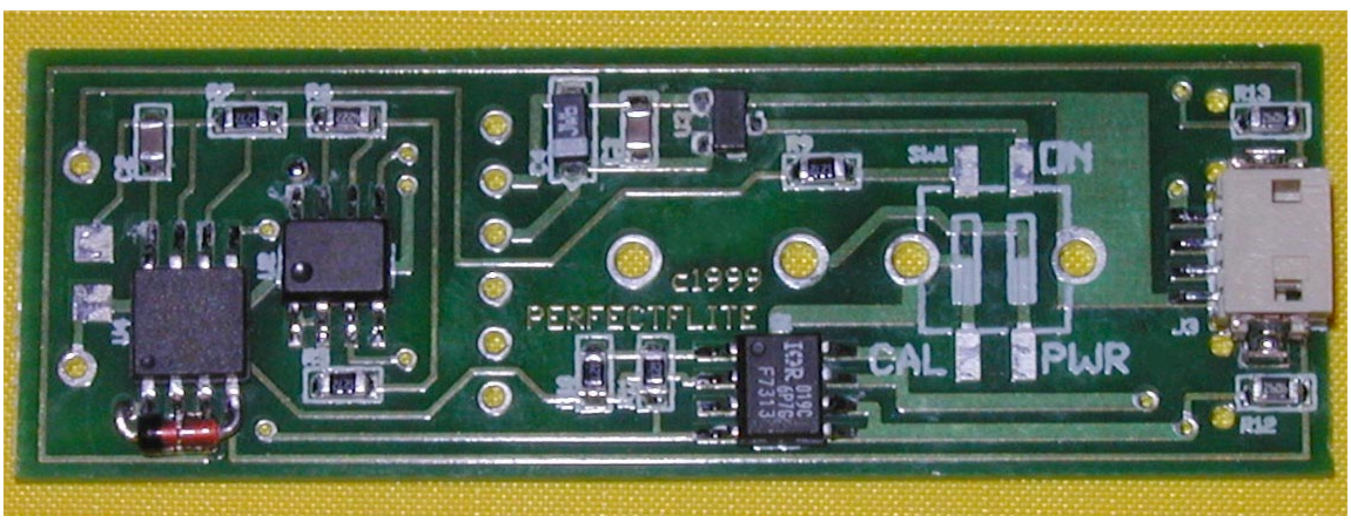
Lead forming detail for diode D1



Placement of diode D1

Do not install SW1 (two position DIP switch) at this time.

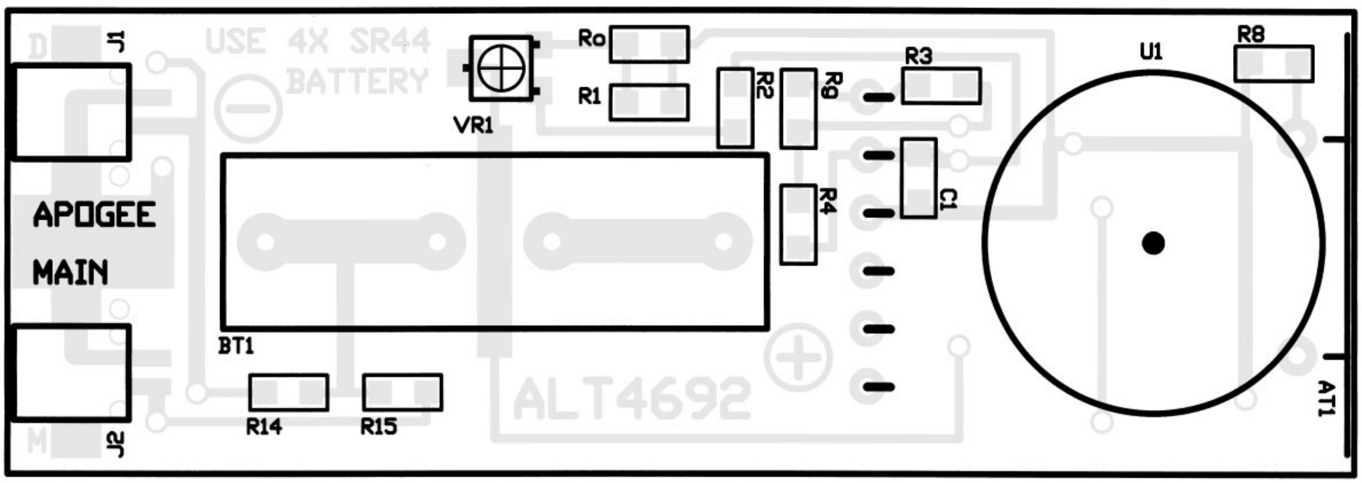
Go back and inspect your work carefully before proceeding. Check for solder bridges, poor solder connections, and mis-placed parts. Correct any problems before proceeding.



Board with bottom side components installed

Top Side Assembly

Flip the board over, remove all traces of tape if you used tape to hold it in place, and resecure the board with the top side facing up. Continue with component installation.



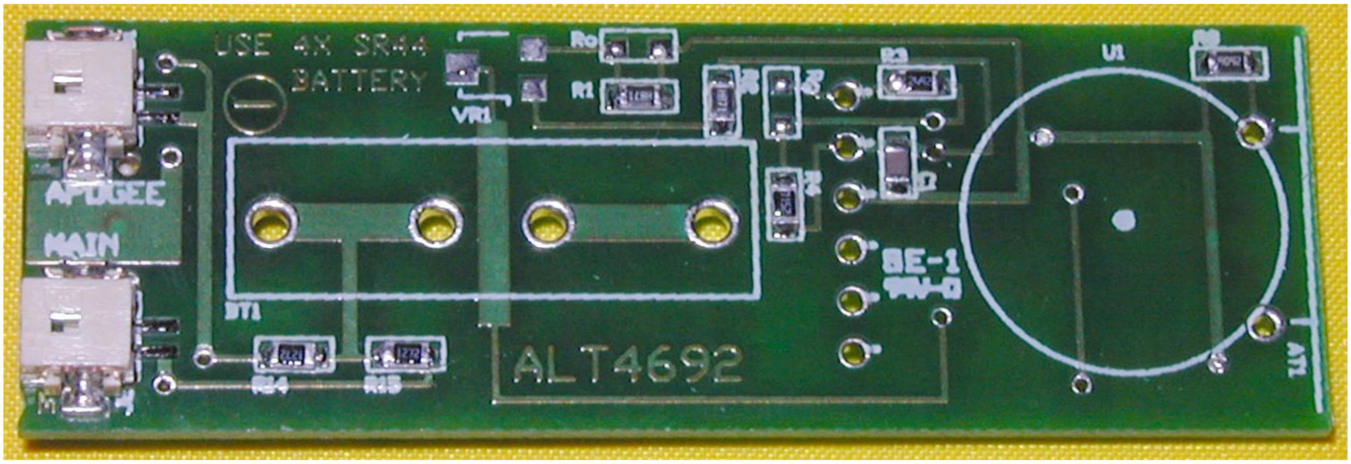
- ❏ Install resistor R1: for microAlt 4600, 6.98K, marked "6981".
for microAlt 9200, 8.87K, marked "8871".
- ❏ Install resistor R2 (8.87K, marked "8871").
- ❏ Install resistor R3 (24.9K, marked "2492").
- ❏ Install resistor R4 (71.5K, marked "7152").
- ❏ Install resistor R8 (90.9K, marked "9092").
- ❏ Install resistor R14 (12.7K, marked "1272").
- ❏ Install resistor R15 (12.7K, marked "1272").

Rg and Ro will be added later as part of the calibration procedure.

- ❏ Install capacitor C1 (.047µF, brown chip with silver ends).
- ❏ Install J1 (two pin connector for apogee ejection). Follow the same procedure used earlier to install J3.
- ❏ Install J2 (two pin connector for main ejection). Follow the same procedure used earlier to install J3.

Do not install trim pot VR1, battery clips BT1, pressure transducer U1, or audio transducer AT1 at this time.

Go back and inspect your work carefully before proceeding. Check for solder bridges, poor solder connections, and mis-placed parts. Correct any problems before proceeding.



Board with top side components installed

Cleanup

At this point the board is covered with flux residue from the soldering process. While flux is beneficial during the soldering process, it can absorb moisture or attract other contaminants, leading to erratic operation due to stray current paths. Flux removal is easily accomplished with isopropyl alcohol. We have intentionally left off the components that could be damaged by immersion in solvent, so the whole board can be placed in a small container of alcohol to soften the flux. After letting the board sit for a few minutes, use a small brush or cotton ball to dislodge the flux. Remove the board, rinse off the flux residue, and allow to dry. You may need to repeat the procedure with a fresh batch of alcohol if the board still shows signs of residue after drying.

Final Assembly

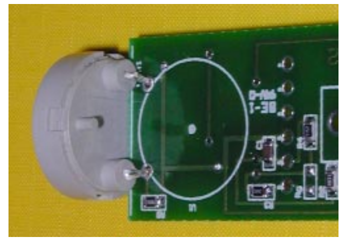
- ❏ Install trim pot VR1 (1K, small black cube with silver adjustment slot). Apply a small amount of solder to the pad on the board nearest J1, and a *small* amount of flux to all three pads. Observe the terminal layout on the *bottom* of VR1 — two terminals on one side, and one terminal in the center of the other side. Position VR1 over its pads, press down gently, and apply heat to the solder on the board. You should be able to feel the trimpot dropping down into place when the solder melts. Work quickly — do not overheat this part. Apply heat and a small amount of solder to the other two pads, checking to make sure that the solder adheres to both the pads and the component terminals. Again, do not overheat this part. When you are satisfied with all three solder joints, use a cotton swab and a *small* amount of alcohol to remove flux residue from around VR1. *Do not get alcohol or flux inside VR1.*

- ❏ Install battery clips at BT1. Insert the pin on the open end of a clip into one of the two middle holes, then push the other pin down toward the board. The clip should snap into place. Repeat with the other clip. Verify proper positioning before soldering these clips, then solder in place. Do not use excessive amounts of solder or you will have trouble positioning the switch assembly. Use a cotton swab and alcohol to remove flux residue.

- ❏ Two types of audio transducer are supplied — you can choose to use whichever suits your needs better. The model with wire leads can be mounted remotely, or glued to the top of U4. The model with short leads is intended to be secured to the end of the board. If you are using the unit with wire leads, solder the black lead into the hole closest R8, and the red lead into the other hole.

If you are using the unit that mounts to the end of the board, you will need to form the leads for a proper fit. Carefully bend the leads over 90° and snip off one of the plastic protrusions as shown in the photo below. You may need to compress the leads slightly to get a proper fit in the holes on the board. Test the fit, and when proper fit is achieved (the transducer should be flush and square against the end of the board) solder both leads. Trim any excess lead material. Do not glue the transducer in place yet - this will be done at a later time. Use a cotton swab and alcohol to remove flux residue.

AT1 lead bending detail

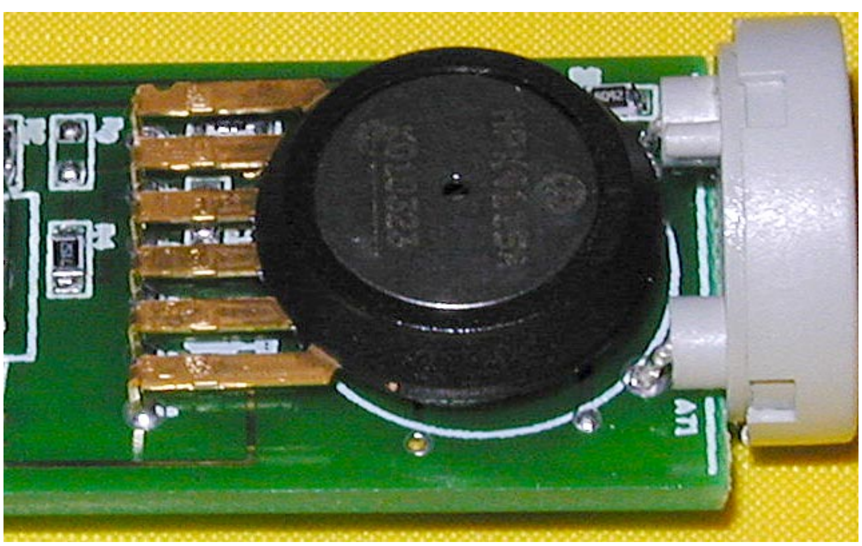


Mounting detail for AT1

❏ Install switch assembly SW1. Position the switch between the pins of the battery clip, with the "1" designator near the CAL label and the "2" designator near the PWR label. Center the pins on the pads, tack solder one pin, and check alignment of the remaining pins. Re-melt the tacked joint and reposition as necessary. When the switch is in the proper position, solder the remaining pins, resolder the tacked pin, and remove flux residue with a cotton swab and alcohol. Remove the tape seal from the switch.

Important!
Refer to the calibration section at the end of these instructions. If you will be performing calibration procedure #2 or #3, do not install U1 at this time.

❏ If you will be performing calibration procedure #1, install pressure transducer U1 (marked MPX4115A). Note orientation — the metal face with markings goes up, away from the board. Form the leads by bending a 90° angle at the point where they transition from wide to narrow, making sure that you bend in the proper direction. The leads cannot be bent more than once, so make sure you get it right the first time. Solder the leads and remove flux residue with a cotton swab and alcohol.



Preliminary Test
Inspect the entire altimeter at this time for solder bridges, poor joints, or mis-placed components. If you have a multimeter, turn the altimeter power switch ON and confirm that the battery clip terminals are not shorted (this would indicate a solder bridge around U3 or SW1). Turn the power switch OFF, and the CAL switch ON. Install a battery, observing proper polarity. Turn the power switch ON - the audio transducer should start beeping. If it does, verify that the +5V is in spec (4.9 to 5.1V across C4) and proceed to the calibration section. If the altimeter remains silent, turn the power switch OFF at once and recheck your work.

Calibration Procedure
Calibration can be difficult with limited equipment. Ideally you would place the altimeter in a controlled barometric chamber with wires from the calibration pads (connected to the altimeter's A/D input) leading to an accurate voltmeter. You would then take one voltage reading at atmospheric pressure, and another at a vacuum level near the end of the range for the model under test (~-16 KPa for 4600, ~-30 KPa for 9200). This would allow you to calculate the actual slope of the transfer function $m=\Delta V/\Delta P$. Measuring Vcc of the altimeter under test (also Vref for the A/D) would allow you to calculate the desired slope, where $m=Vcc*0.05690$ for the 4600 or $m=Vcc*0.03015$ for the 9200. The gain trim resistor, Rg, would be derived from the ratio of the desired and actual slopes and a fixed resistor of the appropriate size installed. The microcontroller on the altimeter board would then receive accurate pressure information, converting it to altitude data in software via a non-linear function.

You may not have access to this equipment, so there are several options avaialble:

1. *Forgo calibration altogether.* The pressure transducer that we employ has a typical slope calibration accuracy of about 0.2% from the manufacturer. Other errors from the various resistors' tolerances and reference voltage tolerance may add another percent or two (typical, not worst-case). If you choose this route, simply install a 120KΩ resistor for Rg.

2. *Forgo the calibration of the pressure transducer and just calibrate the signal conditioning circuitry.* You will need an accurate (4 1/2 digit, good quality) digital multimeter for this procedure, and can achieve calibration accuracy of better than 0.5%. You will also need a 10K potentiometer to supply an adjustable calibration voltage to the circuitry. Pressure transducer U1 and integrated circuit U2 *must **not** be installed yet* for this procedure.

   Make sure trim pot VR1 is centered - it is by default if you have not adjusted it.

   With U1 and U2 out of circuit, measure the values of R3 and R4 as accurately as your meter will allow. Make sure your body resistance is not in parallel with the meter leads as that will affect the reading. After the values are recorded, install U2 (*but **not** U1*) and clean any flux residue from the board.

   Temporarily solder the 10K potentiometer into the holes for the pressure transducer (U1). One end of the pot goes to pin 2 (GND), the other end of the pot goes to pin 3 (Vcc), and the wiper goes to pin 1 (Vout). You can now simulate the pressure transducer by "dialing in" a voltage on the pot.

   Set the pot so that you get a voltage of approximately 4.05 volts on pin 1 of U1 (the wiper of the pot). The exact value of this voltage is not important, but it should be stable and drift-free (don't bump the pot while you are taking measurements!). Record the voltage that you have set as accurately as possible, labelling it V1. Then move the voltmeter to the upper calibration pad (connected to C2 - the other pad is ground so you won't get any reading if you're on the wrong one!) and take another reading. Record this reading as V2.

Now reset the pot so that you get a voltage of about 3.4 volts (microAlt 4600) or 2.75 volts (microAlt 9200) on pin 1 of U1. Record this value as V3. Finally, move the voltmeter to the upper calibration pad and take the last reading. Record this as V4.

If V2 is greater than 4.75 volts or V4 is less than 0.25 volts, the trim pot (VR1) was probably not in its center position, creating invalid data due to amplifier saturation. If this is the case, recenter the pot and repeat the above procedures to get a new set of V1, V2, V3, V4.

You have just applied a signal that varied from V1 to V3, and measured output voltages of V2 and V4 respectively. The gain of the amplifier and associated scaling resistors is then (V2-V4)/(V1-V3). Calculate this value and write it down as the uncorrected gain.

Now measure Vcc (also Vref for the A/D) across the ends of the pot (pins 2&3 of U1). Record this value.

The A/D converter uses 230 of its 256 steps to measure a pressure range of 15.791 KPa (microAlt 4600) or 29.799 KPa (microAlt 9200). The pressure change for each step is then equal to the range divided by 230, or ~0.06866 KPa for the 4600 and ~0.1296 KPa for the 9200. The input voltage for each step is equal to the reference voltage (Vcc) divided by 256. Therefore the desired slope at the A/D input (Volts/KPa pressure) is m=(Vcc/256)/0.06866 for the 4600 and m=(Vcc/256)/0.1296 for the 9200. Calculate the desired slope now and record it.

The pressure transducer produces a voltage that changes by (Vcc/5.0)*0 .045 volt per KPa of pressure variation. We have already determined the actual uncorrected stage gain, so we can now calculate the voltage that will appear at the A/D before calibration. This is simply the product of these two numbers. Multiply the uncorrected gain that you derived earlier by (Vcc/5) * 0.045 and record the result as the actual slope at the A/D input. It should be close to the desired slope at the A/D that you calculated in the previous step.

The actual slope should be less than the desired slope. We are now going to add a resistor in parallel with one of the resistors in the signal conditioning circuitry to increase the gain of the amplifier and bring the actual slope up to the desired slope. We could do this by trial and error: adding a random value resistor and repeating the above steps until the slopes matched. But there is a better way.

Divide the desired slope by the actual slope ($m_{desired}/m_{actual}$) and record the result as SF. Refer back to the values that you recorded earlier for R3 and R4. The value for gain trim resistor Rg can then be calculated by the formula:

Rg=(((R4/(SF*(R4/(R4+R3))))-R4)*R3)/(R3-((R4/(SF*(R4/(R4+R3))))-R4))

Select a resistor as close as possible to this value (100K to 150K supplied in 10K steps) and install at Rg. Remove the 10K pot that you added as a variable voltage source, install the pressure transducer (forming the leads as described earlier), and clean any flux residue from the board. Be careful to keep solvent out of the pressure transducer sensing hole.

3. *Full calibration of the pressure transducer and signal conditioning circuitry.* You will need an accurate (4 1/2 digit, good quality) digital multimeter and a vacuum chamber with precision vacuum gauge for this procedure, and can achieve calibration accuracy of better than 0.25%. Pressure transducer U1 and integrated circuit U2 *must* ***not*** *be installed yet* for this procedure.

   With U1 and U2 out of circuit, measure the values of R3 and R4 as accurately as your meter will allow. Make sure your body resistance is not in parallel with the meter leads as that will affect the reading. After the values are recorded install U2. Bend the leads of pressure transducer U1 as described earlier and install it as well. Clean any flux residue from the board, being careful to keep solvent out of the pressure transducer sensing hole.

   Apply power to the altimeter and adjust trim pot VR1 to get a voltage of approximately 4.75V at the upper calibration pad (connected to C2).

   Place the altimeter in your vacuum chamber, routing wires from the calibration pads near AT1 to your digital multimeter. Record the exact voltage reading on the DMM at atmospheric pressure as V1. Seal your chamber and pump it down to a vacuum of approximately -14KPa (microAlt 4600) or -28KPa (microAlt 9200). Allow the chamber to stabilize, then record the exact vacuum level (P1) and voltage reading (V2). If VR1 was set properly earlier, V1 should be in the ~4.75 volt range, and V2 should be between 0.4 and 1.0 volt.

   The voltage at the calibration pads (A/D input) varies by (has a slope of) (V1-V2)/ΔP volts per KPa. Record this number as “actual slope”.

   Now bleed down the chamber, remove the altimeter, and measure Vcc (Vref for the A/D) across pins 2&3 of U1. Record this value.

   The A/D converter uses 230 of its 256 steps to measure a pressure range of 15.791 KPa (microAlt 4600) or 29.799 KPa (microAlt 9200). The pressure change for each step is then equal to the range divided by 230, or ~0.06866 KPa for the 4600 and ~0.1296 KPa for the 9200. The input voltage for each step is equal to the reference voltage (Vcc) divided by 256. Therefore the desired slope at the A/D input (Volts/KPa pressure) is m=(Vcc/256)/0.06866 for the 4600 and m=(Vcc/256)/0.1296 for the 9200. Calculate the desired slope now and record it.

   The actual slope should be less than the desired slope. We are now going to add a resistor in parallel with one of the resistors in the signal conditioning circuitry to increase the gain of the amplifier and bring the actual slope up to the desired slope. We could do this by trial and error: adding a random value resistor and repeating the above steps until the slopes matched. But there is a better way.

   Divide the desired slope by the actual slope ($m_{desired}/m_{actual}$) and record the result as SF. Refer back to the values that you recorded earlier for R3 and R4. The value for gain trim resistor Rg can then be calculated by the formula:

   $$Rg=(((R4/(SF*(R4/(R4+R3))))-R4)*R3)/(R3-((R4/(SF*(R4/(R4+R3))))-R4))$$

   Select a resistor as close as possible to this value (100K to 150K supplied in 10K steps) and install at Rg.

There are other procedures that you can use to calibrate your altimeter. You can use method #1 or #2 to get an appr oximate calibration, and then improve on it. One method involves using a tall mountain of known height (preferrably at least 3000 feet base to peak) as a reference. With the CAL switch ON, adjust trim pot VR1 at the base of the mountian so the beeper is indicating the proper altitude at that point. Drive to the top of the mountain and listen for another reading. If the altitude reported at the peak is greater than it should be, install a larger resistor for Rg. If the reported altitude is low, install a smaller resistor for Rg.

Another option is to launch the altimeter in a rocket alongside another altimeter of known accuracy, again comparing readings and adjusting Rg as necessary. For best results, try to do this test when the atmospheric pressure at sea level is as close as possible to 29.92″ Hg (call your local airport to get this information). Bear in mind that other altimeters which use 8 bit A/D converters but have higher 25,000 - 35,000 foot maximum ranges will usually have about +/- 100 feet of resolution uncertainty (in addition to their calibration errors). Calibrating a potentially much more accurate device like the microAlt against such an inaccurate device would be a waste of time.

You have now calibrated the gain of the altimeter to the best of your abilities. Remember that there are other variables involved: pressure transducer nonlinearity, A/D errors and quantization, temperature related drift, potentially incorrect setting of the ambient barometric pressure compensation trimpot (VR1), etc. This is why we specify an overall accuracy of +/- 1% typical, even though the assembled and tested altimeters are calibrated to within 0.25% at PerfectFlite.

Offset Trim

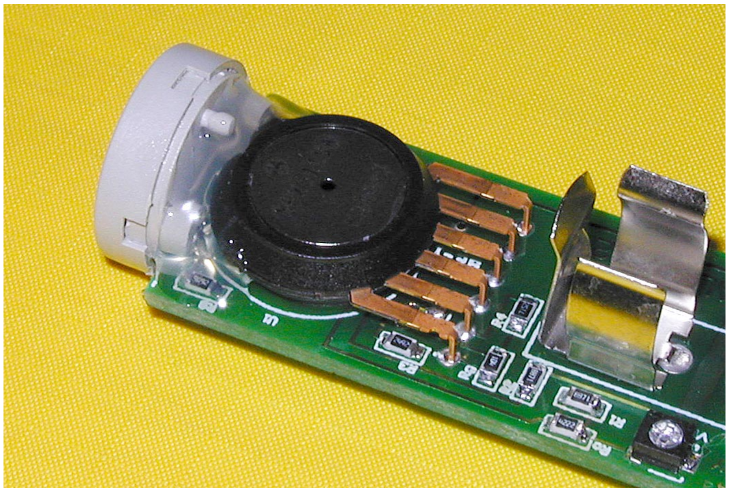
The last step in the calibration procedure is to trim the offset potentiometer VR1 so the pot gives a compensation range of +/- 1″Hg centered around 29.92″Hg (normal barometric pressure at sea level). Make sure VR1 is centered, and call your local airport for the current sea level barometric pressure. It will be easiest to make this adjustment if the pressure is 29.92″Hg or lower.

Turn ON the CAL switch, turn on the altimeter, and listen to the reported altitude. If the pressure is exactly 29.92, you will be installing a resistor at Ro to make the reported altitude as close as possible to the real elevation of your test site. If the presure is lower than 29.92, install a resistor such that the altitude is reported 100′ high for each 0.1″Hg that the barometric pressure is below 29.92. Conversely, if the pressure is higher than 29.92, you want the reported altitude to be 100′ lower than it really is for each 0.1″Hg greater than 29.92. The beeper will not report negative values, so if you are at a low elevation you may not be able to perform this test on a day with high barometric pressure. If you are at 100′ above sea level, the sea-level barometric pressure must be less than 30.02″Hg, if you are at 200′ above sea level, the sea-level barometric pressure must be less than 30.12″Hg, etc.

Start with the 47K resistor, pressing it firmly in place with a non-conductive object like a toothpick. If the reported altitude is too low, swap in the next lower value and try again. Continue until the reported altitude is as close as possible to your actual elevation, adjusted as described above for current barometric conditions (example: your elevation is 440′ above sea level. The barometric pressure is 29.72″Hg. You want a reported altitude of 440′+200′ or 640′). The trim pot has a significant range, so it is not necessary to get this adjustment exact. When you have found the best resistor to use, solder it in place and clean any flux residue from the board.

The Last Step

Now we can secure the audio transducer AT1 and the pressure transducer U1 to the board. Start on the bottom of the board and run a bead of hot-melt glue or epoxy along the board edge, creating a fillet against the audio transducer. When the glue has hardened, repeat the procedure on the top of the board, capturing the end of the pressure transducer as well (see photo below). Do not get any glue in the sensing hole in the middle of the pressure transducer cover disk.



AT1/U1 glue detail

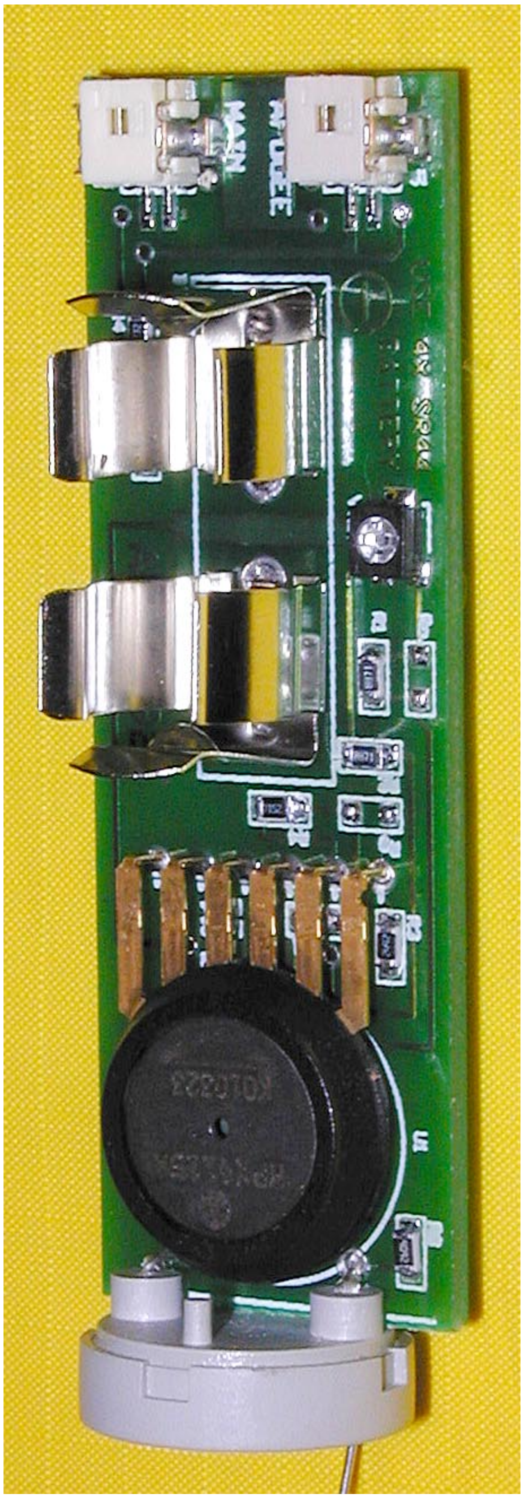
Checkout

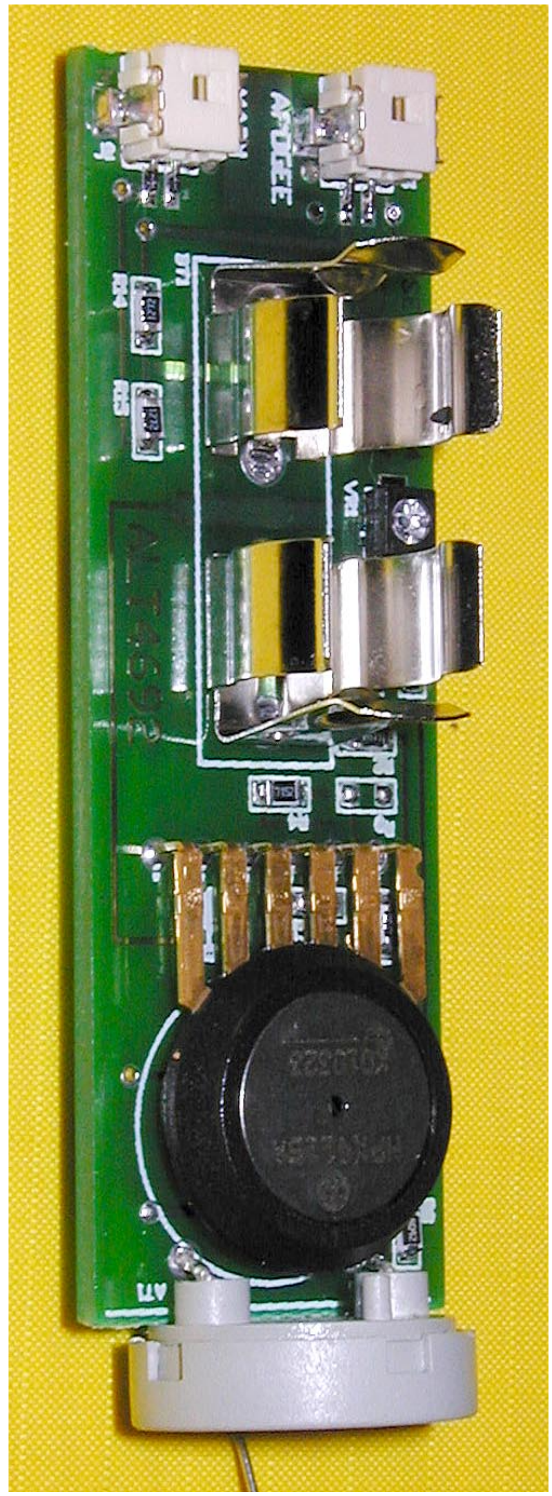
Turn the altimeter's power switch OFF. Turn the CAL switch ON, and then turn on the altimeter. Adjust trim pot VR1 so that the reported altitude is greater than zero. Turn the altimeter's power and CAL switches OFF. Connect suitable dummy loads (12V, 20W to 50W halogen lamps work well) to the apogee and main ejection charge connectors. Connect a 12V battery to the ejection power connector, observing proper polarity. Both lights should be off. If either lamp turns on, even briefly, you have a problem - disconnect power and loads and look for shorts near Q1. If both lamps are off, turn on the altimeter. Again, the lamps should not light. You will hear a long power-up beep, followed by a sequence of three short beeps indicating continuity on both charge connectors. If you just get one continuous warning tone, you did not set the ground level adjustment to a value greater than zero - go back and recheck that if needed. If you have the proper sequence of three beeps, try removing the main charge/dummy load and confirm that the beeping sequence changes to a single beep (continuity on apogee only). Remove the apogee charge/dummy load and the altimeter should be silent. Reconnect the main charge and confirm that you get a sequence of two beeps. Reconnect the apogee charge and wait until the three beep sequence stops (approximately 30 seconds from power-on). The altimeter will report ground level once, then go silent as it awaits "launch". Hold one end of a piece of plastic tubing gently over the hole in the pressure transducer, and suck on the other end of the tube. This lower pressure will simulate an abrupt increase in altitude, which the altimeter will recognize as launch. When the pressure ceases to decrease, the altimeter will sense apogee and the lamp connected to the apogee charge connector will come on for two seconds. When your vacuum decreases to the pressure differential corresponding to the main deployment level (300′ or 440′), the lamp connected to the main charge connector will come on for two seconds. After approximately 19 seconds from launch detect (a full 19.2 seconds of data are collected) the altimeter will start a beeping sequence reporting the maximum "altitude" attained.

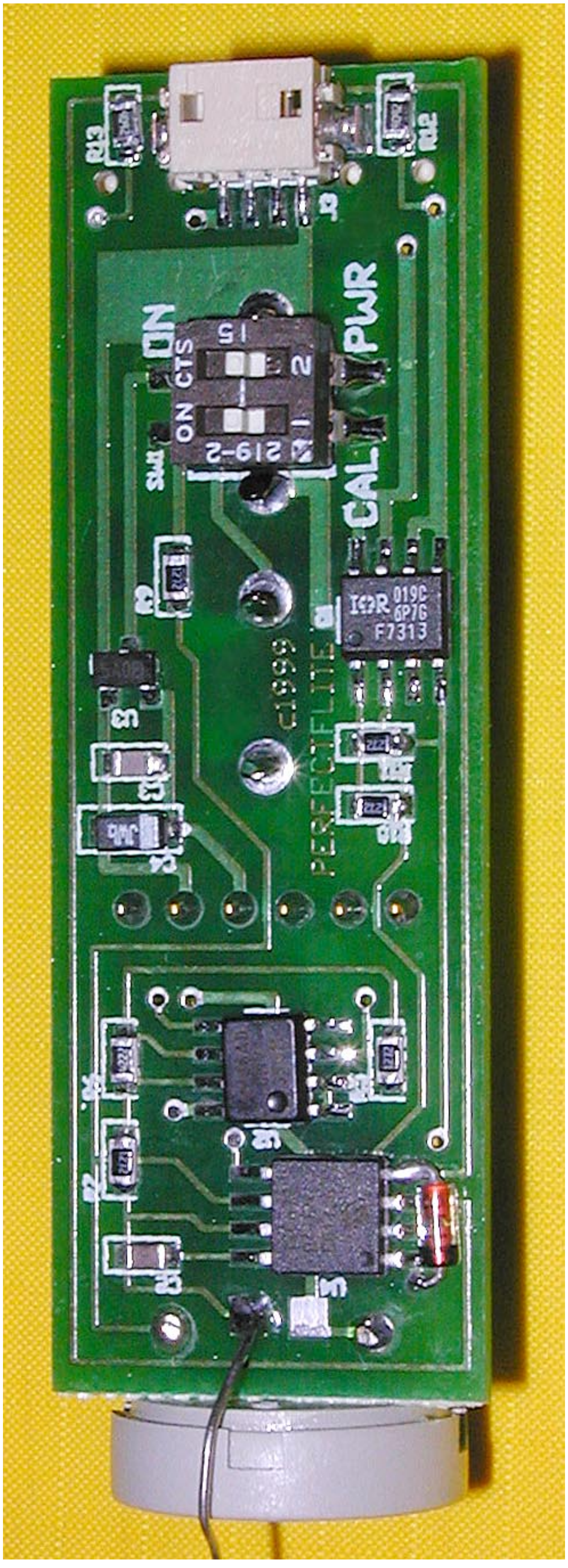
Congratulations! If you made it this far, you now have a working altimeter that you can be proud of. Refer to the separate user's manual for additional application information. Try launching your microAlt in small rockets using "record-only" mode until you are comfortable with the operation of the unit, and then move on to recovery device deployment. Have fun, and always remember to exercise caution whenever using live ejection charges.

Reference Photos

The following photos are included to help resolve any questions about component placement, etc. This unit was hand-assembled using the procedures described in this document. Calibration wire still attached and visible near AT1. Calibration resistors not yet installed. AT1 and U1 not yet glued.






PWR
CAL
ON
CTS
219-2
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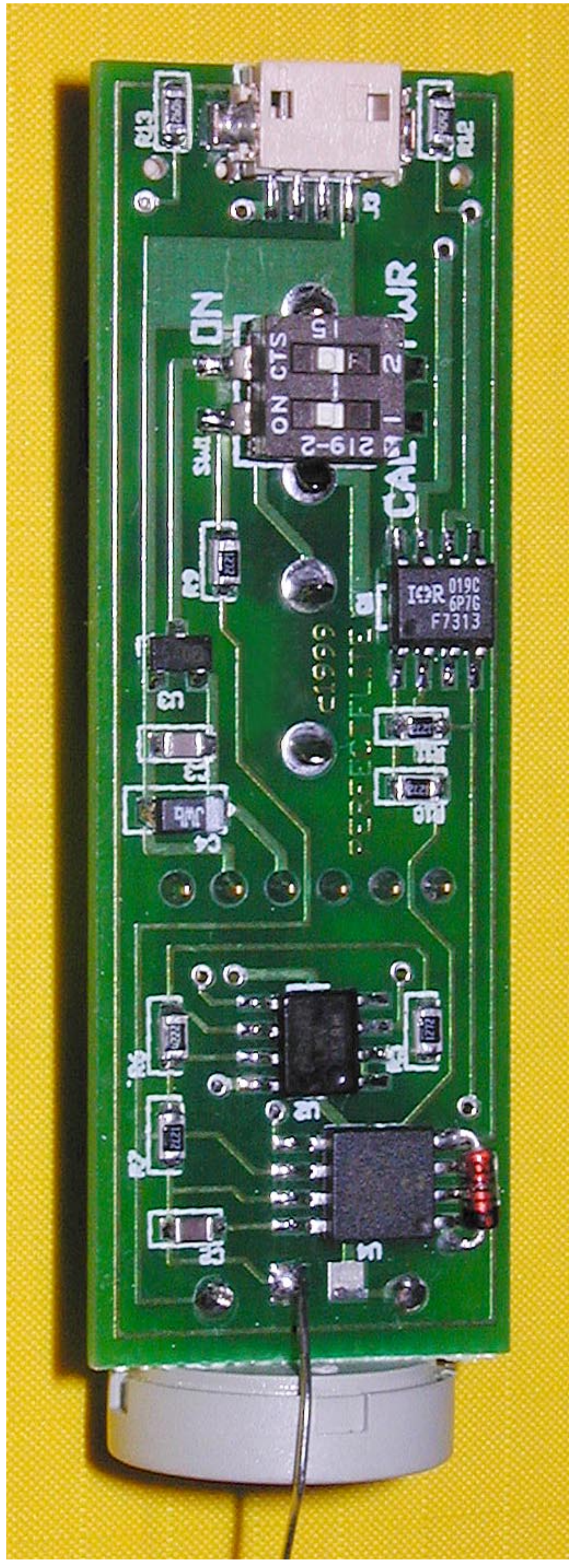
PERFECTFLITE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