<photo of assembled Smart Battery Meter>

Smart Battery Meter

Assembly Instructions

Written by Dale Wheat – 26 April 2009

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Thank you!

I certainly appreciate your interest in the Smart Battery Meter project. Thank you for reading these assembly instructions. You are obviously a cut above the rest. Your attention to detail and sense of quality has been duly noted.

The Smart Battery Meter was designed to be easy to assemble. The assembly of the Smart Battery Meter should take between twenty minutes to an hour, depending on your familiarity with the included components. Please take your time and enjoy the build process. You will be rewarded with a quality measurement device that should serve you well for many years.

Please let me know if you have any questions or comments about either the Smart Battery Meter project or these instructions. I hope you enjoy working with the Smart Battery Meter project as much as I have.

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26 April 2009
http://dalewheat.com/slameter

Step 1: Parts check

Please verify that you have all of the parts required to assemble the Smart Battery Meter.

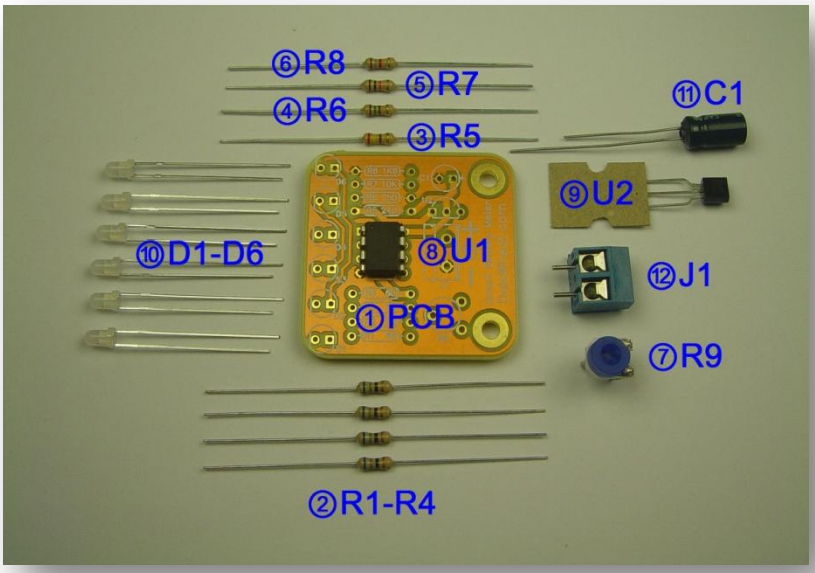


Photo 1. The contents of the Smart Battery Meter kit.

Item #	Quantity	Reference designator	Description
①	1	none	Printed circuit board (PCB)
②	4	R1, R2, R3, R4	Resistor, 68Ω , 1/4W
③	1	R5	Resistor, 240Ω, 1/4W
④	1	R6	Resistor, 750Ω, 1/4W
⑤	1	R7	Resistor, 10KΩ, 1/4W
⑥	1	R8	Resistor, 1.8KΩ, 1/4W
⑦	1	R9	Potentiometer, 6mm, 500Ω
⑧	1	U1	Atmel AVR ATtiny13 microcontroller chip
⑨	1	U2	LM317 or LM217 voltage regulator
⑩	6	D1-D6	3mm LED, red+green bipolar, 2 pin
⑪	1	C1	Capacitor, electrolytic, 10uF
⑫	1	J1	Terminal block, 2 position

Table 1. List of Smart Battery Meter kit contents.

Step 2: Tool check

The construction of the Smart Battery Meter consists of two stages. In the first stage you install the individual components on the printed circuit board (PCB). Once assembled, the unit is tested and calibrated in the second stage.

Step 2a: Assembly

To assemble the Smart Battery meter, you will need the following tools, as well as the skill to use them:

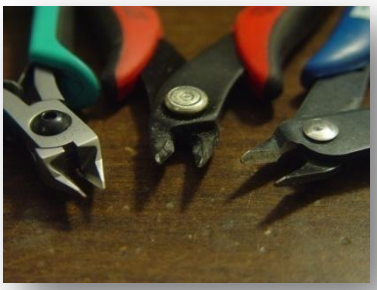
Soldering iron and solder

Use a small soldering iron in the 15-30 watt range. You're looking for something with a "pencil grip". Anything with a "pistol grip" is most likely too large. A higher-powered iron with a temperature controlled output will also work well.

Use a small gauge wire solder that contains flux. Almost anything will do. You can use lead-free solder if you like but there may be long-term reliability problems with lead-free solder.

Side cutters

You could *almost* use scissors to trim the leads during the assembly of the 12 Volt Dimmer kit, but you will find that the right tool for the job is a pair of "side cutters" or "flush cutters". They allow you to get the cutting parts right up against edge of the solder joint and cut the majority of the excess lead off cleanly and safely. You really should wear safety glasses when soldering and especially when cutting leads. They have a bad habit of jumping up and flying this way and that.



Step 2b: Calibration

To test and calibrate the Smart Battery Meter, you will need the following test equipment, as well as a knowledge of their use:

Adjustable voltage reference

The Smart Battery Meter is calibrated by applying a fixed 7.500 volt supply to the unit and adjusting the calibration adjustment (R9) until the proper calibration pattern appears on the LED display. The precision of your voltage reference will determine the effective accuracy of the Smart Battery Meter.

Voltage meter

If your adjustable voltage reference has its own accurate voltmeter, you can use that to set the output to the correct level. If not, you will need a separate voltage meter to verify the reference voltage.

A three and a half (3.5) digit digital voltage meter should be sufficient.

Step 3: Install the resistors

There are eight (8) fixed resistors, R1-R8, and one variable resistor, R9, in the Smart Battery Meter circuit. We will begin by installing the fixed resistors. The variable resistor, a potentiometer, will be installed in Step 6.

Step 3a: Identify the resistors by value

Identify the resistors by reading their color-coded bands. The values are interpreted by the first three colored bands. Each color represents a different number.

The first two bands indicate the two most significant digits of the value. The third band indicates the multiplier, or the number of zeros following the first two digits. The fourth band, which is gold in all cases, indicates the value tolerance is five percent (5%).

Reference designator	Photo	Value	1st band	2nd band	3rd band
R1 R2 R3 R4		68Ω	Blue	Gray	Black
R5		240Ω	Red	Yellow	Brown
R6		750Ω	Violet	Green	Brown
R7		10KΩ	Brown	Black	Orange
R8		1.8KΩ	Brown	Gray	Red

Table 2. Identify the resistor values by their color codes.

Step 3b: Form the leads of the resistors

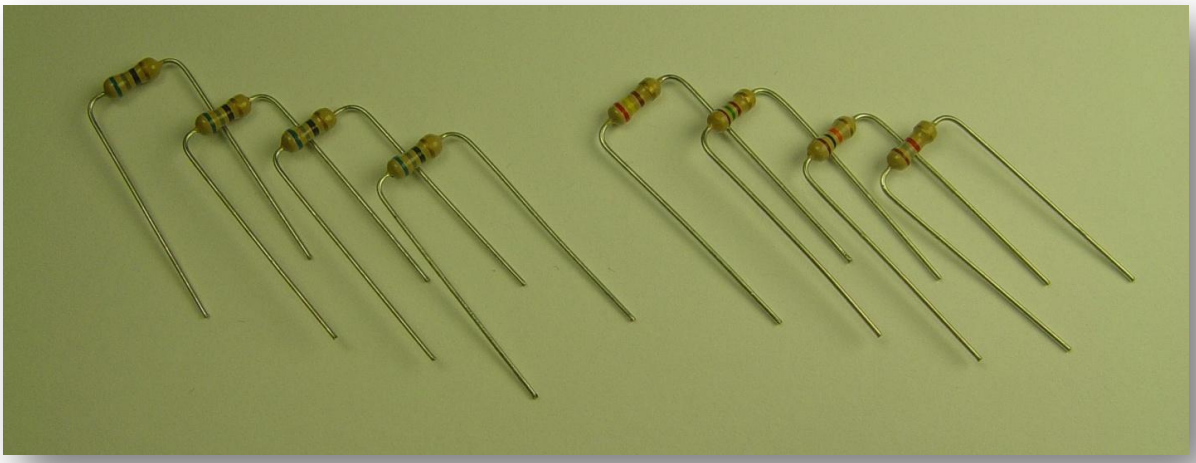


Photo 2. Form the leads of the resistors before inserting them into the PCB.

Bend the leads of each resistor so that they both point the same direction.

Step 3c: Insert the resistors into the PCB in the correct locations

After identifying and forming the leads of each resistor, find the marked location on the PCB and insert the resistor leads through the holes. Resistors are not polarized and can be inserted in either direction.

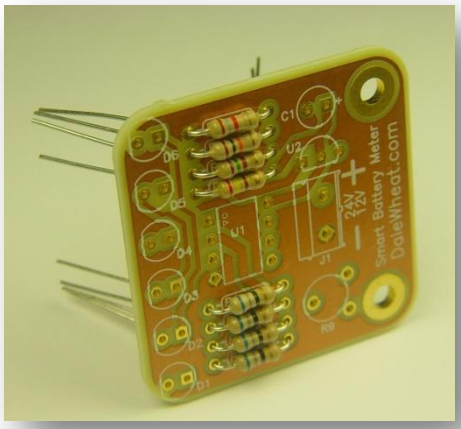


Photo 3. Here's how the resistors are supposed to be inserted in the PCB.

When the leads are pushed all the way through the PCB and the resistor body is laying flat against the PCB, bend the protruding resistor leads outward to prevent the resistors from falling back out of the PCB when it is turned upside down.

Note: You can insert, solder and trim the resistors one at a time or all at once. It is easier to install them one at a time and quicker to install them all at once. My preference is to install R1 through R4 together and then install R5 through R8 last.

Step 4d: Solder and trim the resistors leads

Flip the PCB over and solder the leads to the PCB. After the solder joints have cooled, clip the excess leads off near the PCB, taking care not to cut into the actual solder joints.

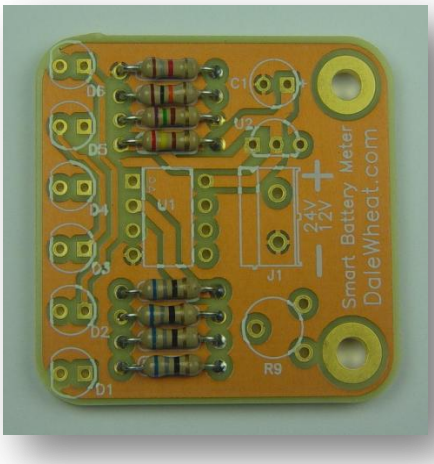


Photo 4. All of the fixed-value resistors have been installed.

Step 4: Install the microcontroller chip

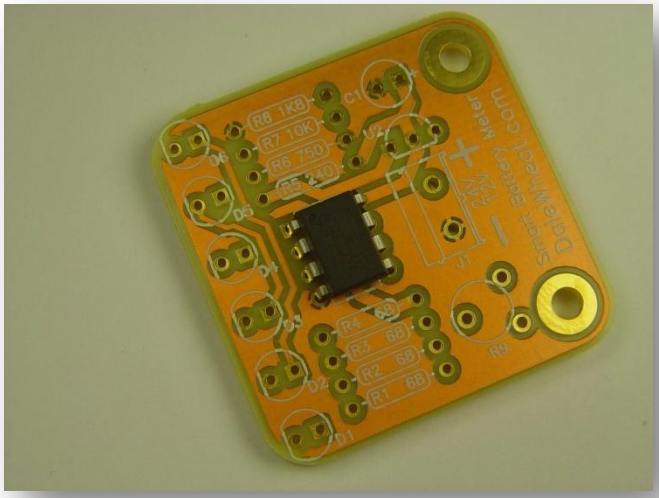


Photo 5. The microcontroller chip is normally shipped pre-installed in the correct orientation.

The microcontroller ship will normally be pre-inserted into the PCB. This insures that the chip is installed with the correct orientation as well as protecting the pins of the chip from damage during shipment. If the chip is already inserted correctly, you may skip the next section on orientation.

Step 4a: Chip orientation and insertion

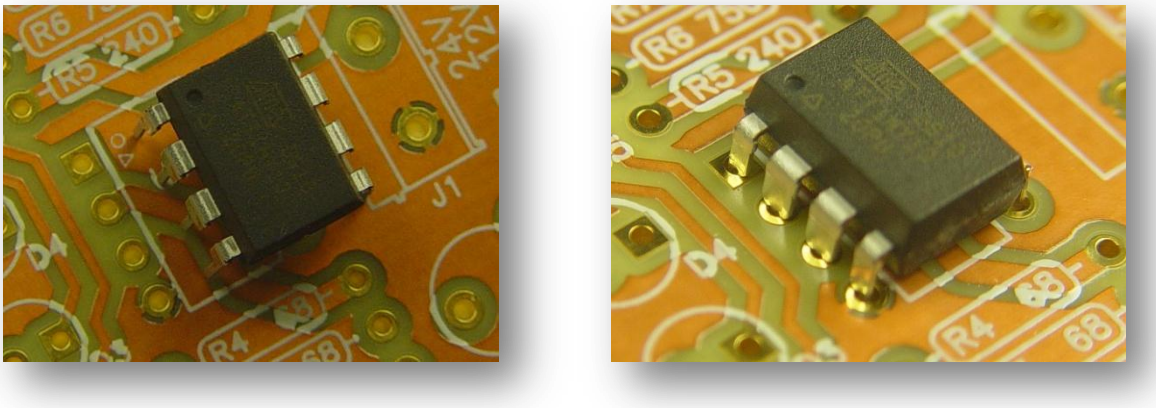


Photo 6. Pin 1 is identified by a molded dimple in the IC package, an etched triangle and a square pad on the PCB.

If the chip is not already inserted into the PCB, look at the PCB and located the part outline for the microcontroller chip, U1. In one corner it has a small circle and triangle to indicate the position of pin 1 of the chip. In addition, the hole for pin 1 has a square pad while the remaining pads are round.

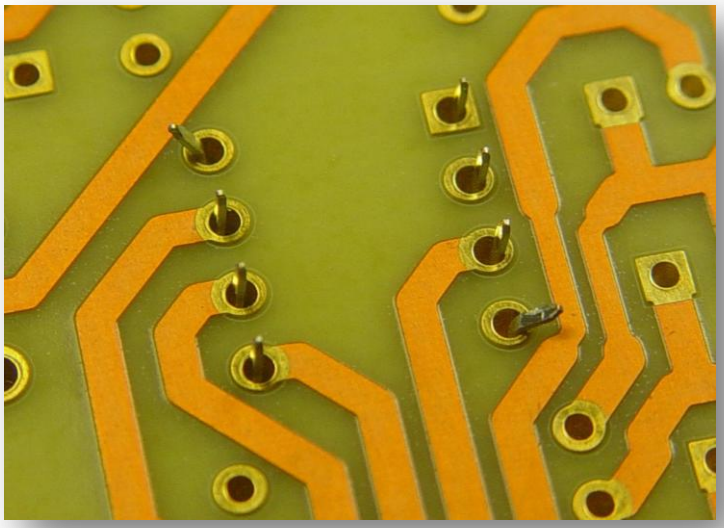


Photo 7. Bend opposite corner pins to hold the chip in the PCB.

The microcontroller chip itself has a triangle printed or etched on the package adjacent to pin 1. There is also a small dot molded into the package. Make sure these symbols align with the markings on the PCB part outline when inserting the chip.

Align all eight (8) pins of the microcontroller package with the holes in the PCB. Make sure all pins emerge from the other side of the PCB. Bend a pair of opposite corner pins outward to secure the chip to the PCB while inverted.

Step 4b: Solder the chip to the PCB

Note which corner pins have been bent outwards and then solder the other two corner pins first. Flip the PCB back over and take a look at the chip. Make sure that the body of the chip is still laying flush against PCB.

Now flip the PCB back over and solder the remaining pins to the PCB. After the solder joints have cooled, clip the excess leads, taking care not to cut into the actual solder joint itself.

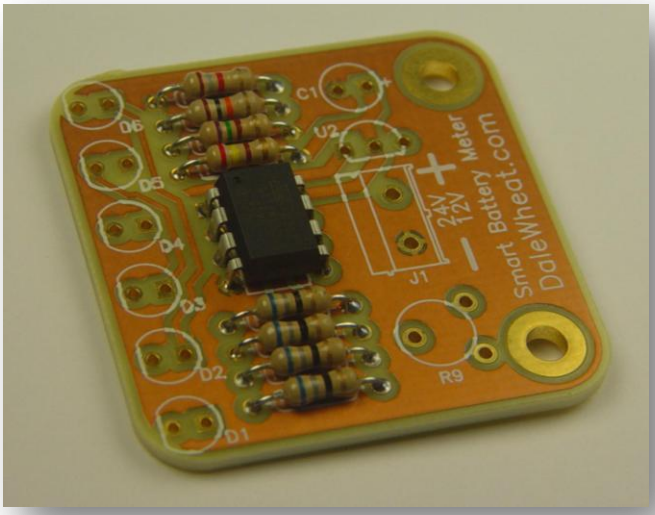


Photo 8. The computer chip is installed correctly.

Step 5: Install the LEDs

Find the six (6) LEDs. Take a look at the leads sticking out of the plastic body. One of the leads is longer than the other one. The longer lead is the *anode* and is the positive connection to the red LED, as well as being the negative connection, or *cathode*, of the green LED. Remember that there are two distinct LEDs in each of these packages: both a red and a green LED. You must install them in the correct orientation or the colors will not make sense.

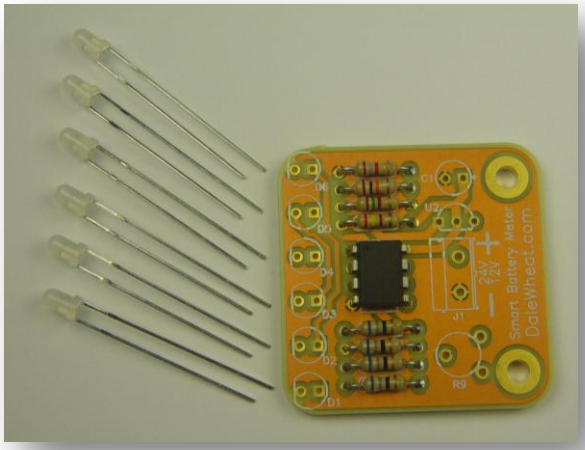


Photo 9. The longer lead goes into the hole with the square pad.

Insert each of the LEDs into the PCB in the locations labeled D1 through D6. Each LED has two mounting holes. The anode, or longer lead, goes into the hole with the square pad. The other lead goes in the other hole, i.e., the one with the round pad.

It can be a little tricky trying to install all of the LEDs at once. If you have super-awesome soldering and assembly skills, go ahead and try it. If not, then I suggest installing one LED at a time.

For each LED, first solder one lead to the PCB and then flip the PCB over to see if it is aligned correctly. Adjust the LED appropriately and then solder the other lead.

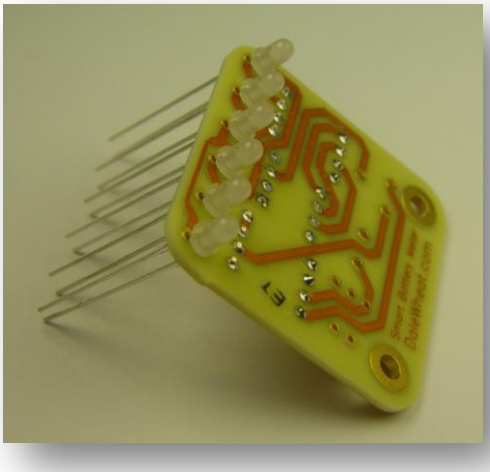


Photo 10. LEDs inserted from the back side.

The LEDs are typically installed on the back side of the PCB so that they are the only components protruding on that side, leaving all the other components hidden on the other side. You can mount the LEDs any way you like, including on the same side as the rest of the components, if you wish. It is entirely up to you.

The advantage of installing the LEDs on the reverse side is that it makes it easier to install the assembled Smart Battery Meter in an enclosure, mounted flush against a panel. Your choice will depend on your application.

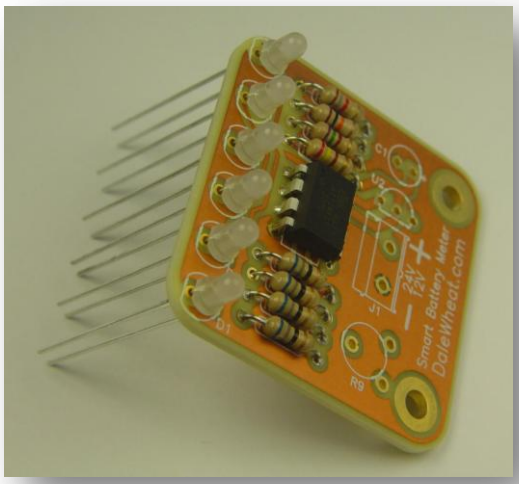


Photo 11. LEDs inserted from the front.

Step 6: Install the calibration potentiometer

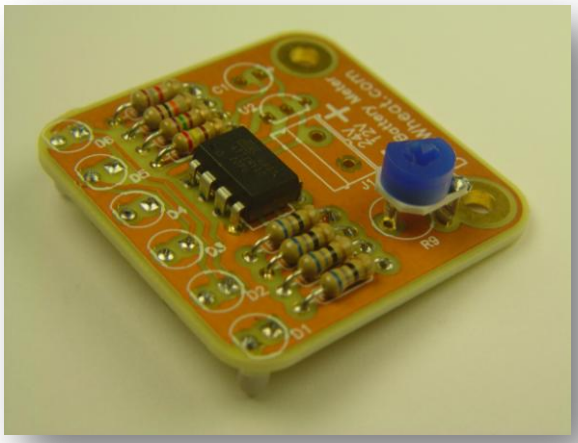


Photo 13. Trimmer potentiometer inserted.

Find R9, the trimmer potentiometer. Insert it into the PCB using the outline printed on the PCB as a guide. The legs of the trimmer potentiometer are made so that the body of the potentiometer stays a short distance above the top of the PCB.

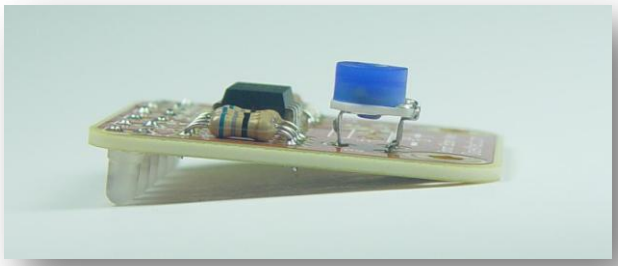


Photo 12. The trim pot stands above the PCB.

Solder the leads of the potentiometer to the PCB. After the solder joints cool off, trim the excess leads from the back of the PCB. Don't cut into the actual solder joint.

Step 7: Install the terminal block

Find the terminal block, J1. Insert it into the PCB with the connection openings facing outward. Solder the leads to the PCB. Trimming the excess leads is optional as the lead diameter is much larger than the other components and may damage your trimmers. I usually don't.

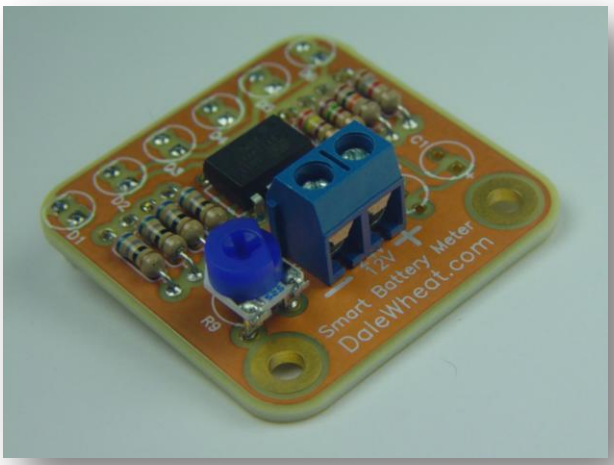


Photo 14. Terminal block J1 inserted into the PCB.

Step 8: Install the capacitor

Find C1, the electrolytic capacitor. This part is polarized and must be installed in the correct orientation for proper operation. There are two clues built into the capacitor itself to divulge the polarity. The plastic sleeve of the capacitor is marked with a stripe down one side that corresponds to the negative lead. The positive lead is generally somewhat longer that the negative lead.

If the capacitor is supplied on tape, cut the leads from the tape with your cutters. Don't try to unpeel the tape as this will leave adhesive on the leads that can then contaminate the solder joint.

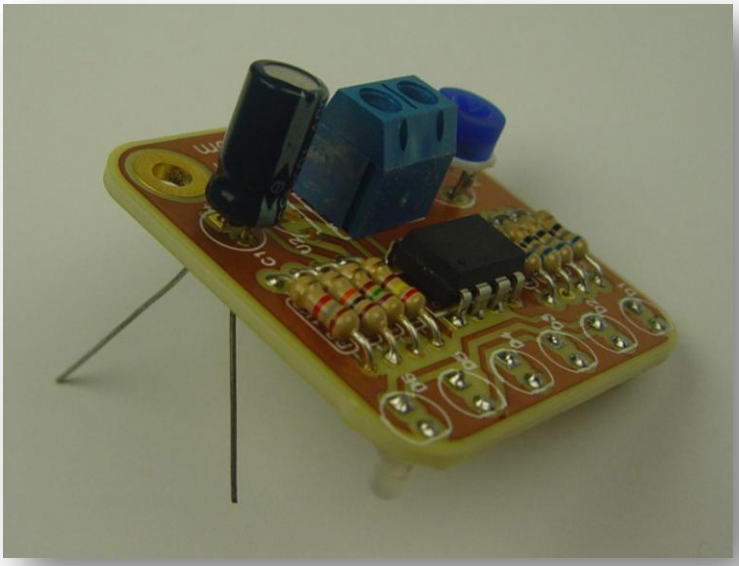


Photo 15. Insert capacitor into PCB. Please observe the polarity. The stripe on the capacitor is the negative lead.

The PCB is marked with two clues to the polarity as well. A small plus sign ("+") is printed beside the positive connection, which also has a square pad.

After verifying that the capacitor is inserted into the PCB in the correct orientation with respect to polarity, solder the leads to the PCB. After the solder joints have had time to cool down, clip the excess leads from the back of the PCB, being careful not to cut into the solder joint itself.

Step 9: Install the voltage regulator

Step 10: Calibration procedure

Step 11: Testing

Step 12: Installation