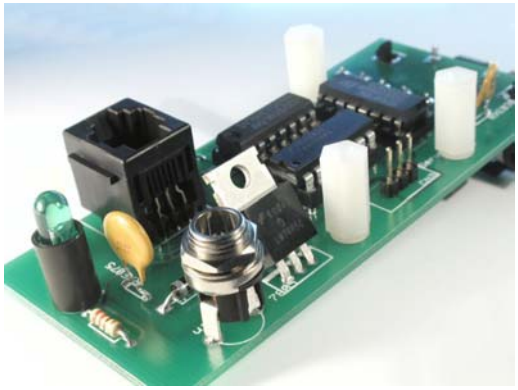
Assembling the Pointer / Power Pulley



The Pointer / Power Pulley allows a calculator to precisely control rotational motion by specifying the angular displacement and the angular velocity.

The Pointer / Power Pulley also provides a controllable 12-Volt output to operate low-current devices (such as the small laser pointer shown). In addition, there is an output for a hobby servo motor. **Note: the 12-Volt output and the servo output use the same signal lines and should <u>not</u> be connected simultaneously**.

The system can be operated with the CBL2, the original CBL (using an adapter), or the LabPro. Since the LabPro has 2 digital ports, it can operate 2 Pointer / Power Pulleys.

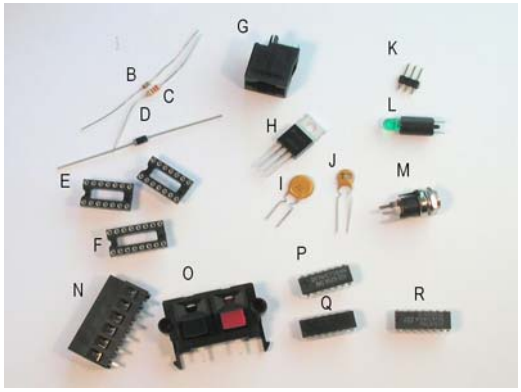
Step 1 -- Orientation to the Printed Circuit Board

Look at the printed circuit board (PCB) and be sure you understand how it should be oriented. Most of the components will be placed on top of the board while it is oriented as shown above. This is the side of the board which will face the outside of the box. The last two components you will solder--the connectors to the stepper motor and the side power connectors--will be fastened on the opposite side.

Step 2 -- Identify the Components

The parts to be attached to the PCB are shown at left. Identify each one, and lay them out where you can keep track of them. The letters indicate the recommended order of assembly.

Order	Component	#
A	Circuit Board	1
B	Resistor, 10 kohm, 1/8 W, 5%, Carbon Film	1
C	Resistor, 220 ohm, 1/4 W, 5%, Carbon Film	1
D	Diode, 1N4001	1
E	Socket, DIP 14 pin	2
F	Socket, DIP 16 pin	1
G	Modular Jack, 6P6C, top entry with stops	1
H	Voltage Regulator, 7805	1
I	Fuse, Resettable, 0.75A	1
J	Fuse, Resettable, 0.30A	1
K	Header, 3 Pos	1
L	LED assembly, green, 0.5"	1
M	Power Jack, DC, straight, 2.1mm	1
N	Terminal Block, 6 position	1
O	Speaker Jack	1
P	IC, 74HC08, Quad "AND" gate	1
Q	IC, 74HC04, Hex Inverter	1
R	IC, ULN2003A, Darlington Array	1
S	Standoff, Shoulder Washer and Screw	4
T	Plastic washer for power jack	1



Step 3 -- Add the First Resistor

- Be sure that you and all the people near you are wearing eye protection.
- Be very alert to the fact that the soldering iron is hot.

Insert the 10-kohm resistor from the top of the PCB as shown. So others can easily interpret the color code, it should be oriented so the colors read from left to right. The resistor has colored bands of brown, black, and orange (for 10×10^3) and a gold band to indicate 5% tolerance. Brown should be at the left.

Turn the board over and solder the 2 leads. When finished, you should see a small "candy kiss"-shaped mound of solder that clings to both the solder pad on the PCB and to the resistor's wire lead. You should also be able to see that the solder has passed through the hole in the PCB board.

Step 4 -- Another Resistor and a Diode

Solder the 220-W resistor into place in the same way as the first one. This resistor is larger in size, since it must be able to handle a bit more heating--up to 0.25 watts. It should be oriented with the red band at the top. The color code of red, red, black (for 22×10^1) shows it is a 220 ohm resistor. This resistor controls the amount of current that flows to the "power on" LED.

Also solder the diode to the board. It MUST be oriented with the silver band to the left, since diodes only conduct electricity in one direction. The job of this diode is to protect the circuit if the power is ever connected in the wrong direction. The circuit is designed for "center-positive" power transformers, but some transformers are wired in the opposite way. If you are absolutely sure that no one will ever connect the wrong transformer to your pointer, you might want to replace the diode with a jumper wire.

Step 5 -- Put in the Sockets

Carefully align the 3 sockets as shown on the board. The notches on the two 14-pin sockets should go to the left, and the notch on the 16-pin socket should go up. (They will work if you put them in backwards, but the notches are supposed to show you and anyone working with your circuit how the integrated circuits must be oriented.)

Solder all of the pins on the sockets, being careful to avoid solder bridges (where solder provides a path from one pin to the next) and cold solder joints (where the solder fails to stick to either the pin or the pad).

Be sure to give your soldering a visual inspection before you go on. Use desoldering braid or another desoldering tool to remove any solder bridges and use more solder to redo any cold joints.

Step 6 -- Add the Phone Jack and the Voltage Regulator

Very carefully insert the 6 terminal wires of the phone jack into the board, and then snap the plastic holders into place. The terminals are smaller and closer together than the ones you've soldered up until this point, so they require less heat and more care. Be especially careful to avoid "solder bridges."

Insert the voltage regulator. It must be oriented with the printing toward the front and the metal heat sink toward the back. The voltage regulator sometimes gets warmer than other components, and it is designed to stand up away from the board itself. Its leads are larger than those on the phone jack, and will require more heat and solder. The center lead in particular is attached to ground and to the heat sink, and may be somewhat difficult to heat sufficiently. Once you have soldered the voltage regulator into place, trim off the excess leads. Bend the voltage regulator backwards to about a 45° angle, so it will not touch either the other components or the pointer box.

The job of the voltage regulator is to reduce the 12 volts (or a bit more) that the motor needs to the 5-volt level needed by the integrated circuits. The extra energy "wasted" as it drops the voltage is what produces some extra heating. Even with this waste, it's still a lot cheaper and easier to use a single power supply than to attach a separate 5-volt source. It's probably better for the environment this way as well--but you may want to do the calculation. How much energy would the circuit have to "waste" in order justify buying a second power supply?

Step 7 -- Connect the 2 Fuses

The circuit is equipped with 2 resetable fuses. The larger one is designed to protect the circuit, the power supply, and everything else from a short circuit within the board. If too much current flows through the fuse, it overheats and temporarily shuts down, stopping the flow or current. Once the fuse has cooled, it resumes normal operation. If the short circuit is still present, the fuse will shut down again. If you ever see the "power on" LED cycling on and off, that almost certainly means you have a short circuit that needs to be fixed.

The smaller resetable fuse is designed to protect against short circuits outside the pointer, at the programmable 12-volt output. Neither fuse can provide 100% protection, so you still need to do everything possible to avoid short circuits.

Place the 2 fuses as shown and solder them into place. As long as you get the right fuse in the right location, the orientation doesn't matter.

Step 8 -- Insert the Servo Motor Header

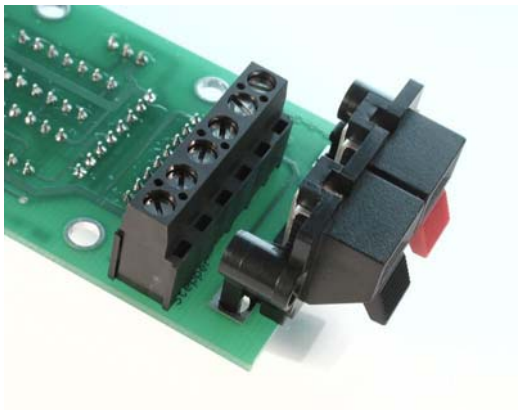
The three-pin header provides a place to attach an optional servo motor. Insert it with the longer pins upwards, and then solder it into place. You may want to use masking tape to be sure the header stays straight while you solder it.

Step 9 -- LED Assembly and Power Jack

Insert the LED assembly as shown above. It only fits with one orientation. Since the LED must match a hole in the pointer box, you should be careful to push it flush against the board and to align it perpendicular to the PC board. Solder the two leads and trim them if necessary.

Insert the power jack, again being careful to insert the small portion of the pins fully and to align the jack perpendicular to the PC board. Solder the jack's three leads.

Step 10 -- Terminals for the Stepper Motor



Turn the board over. The last 2 soldered components must be attached on the opposite side. Be very careful to align the 6-position terminal block as shown. In order to attach the wires from the stepper motor, the terminal block must be place as shown on the opposite side of the board and the wire opening must be pointed towards the center of the board.

When you are sure you have the orientation correct, solder the six pins. You will now be soldering on the side where the other components are located.

Step 11 -- External Power Output

Carefully align the speaker jack as shown above on the same side of the board as the terminal block. Also note that the colored jacks face the outside of the board, where they will match a set of holes in the box.

Insert the leads of the speaker jack into the board and snap the plastic supports into the appropriate holes of the PC board. Solder the 2 leads and trim them if necessary.

Step 12 -- Insert the Integrated Circuits

Insert the 3 integrated circuits as shown. Location and orientation are important, and it's also very important that you not bend any of the pins as you put them in. Be sure the notch on each IC matches the notch on its socket. Also be sure you get all of the pins started before you "seat" each IC by pushing it firmly into the socket.

The top left IC is a 7408 AND gate, which combines multiple signals from the CBL to turn on the correct lines to the stepper motor.

The lower left IC is a 7404 INVERTER, needed to convert some signals from high to low before they go to the AND gate.

The right, vertical IC is the ULN2003A, the workhorse of the circuit. It takes the weak information from the rest of the system and uses it to control the much stronger currents that must flow to the motor.

Step 13 – Testing the Board

- Apply 14 to 15 V DC at the power input terminals. The LED should light and the current input should be about 60 mA. Turn off the power.
- Load the appropriate POINTER program group into your calculator. Connect your calculator to the interface (CBL, CBL2 or LabPro) and connect the interface to your board. Run the program DCUINIT to verify that the calculator and LabPro are connected properly. If the batteries in the LabPro have not been changed recently, consider replacing them or using the DC adapter.
- Attach a servo motor to the servo connect, with the black ground wire to the right. Turn the power back on to the board and use the POIPUT (*Pointer Put*) program to verify that the servo responds. Before running each program, you must store an angle in degrees (between -80 and +80) as the variable "A" (for example, 45→A) and then run the program. After the motor moves to position A, it should remain in or close to the same position, until you change the value for "A" and run the program again.
- Use the POISWF (*Pointer Switch For*) program and a buzzer, laser pointer or another 12-V device to verify that the programmable switch is functioning properly. Before running the program, you must store a time (in seconds) to the variable "T" (for example, 3→T). The programmable switch will then provide about 12 V for the time specified. Turn off the power and disconnect the device motor after the test.
- Attach the 6 wires of a stepper motor. The two bicolored wires must be attached to the top terminals, both marked "+." (It doesn't matter which one goes in which of the two "+" terminals.") Below the positive terminals, the wires should be connected in the sequence red, blue, black and white. Store a value such as 40 to the variable A, then run POIPIV (*Pointer Pivot*). A positive value for A should make the pointer pivot counterclockwise. Store a negative value for A (such as -20) and run POIPIV again. The motor should reverse direction. Turn off the power when finished.

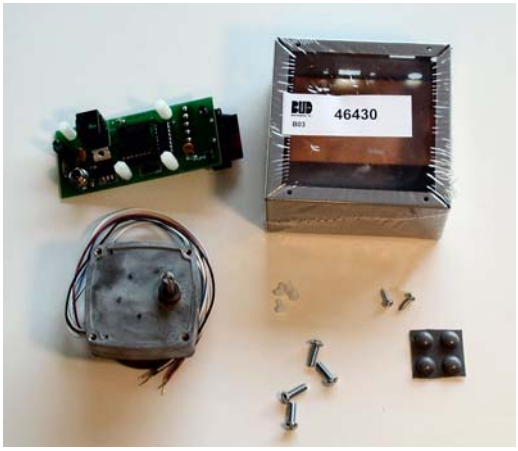
Step 14 – Standoffs

Four nylon standoffs must be attached to the PC board, to hold it in place against the front of the Pointer box.

To be sure the standoffs are centered correctly and that they have the correct height, begin by placing a "shoulder washer" into each mounting hole from the top side. You can then insert a screw from the bottom side and fasten the standoff into place.

The standoffs should be snug, but don't over tighten the screws or you may strip the threads.

Step 15 – Material for the Final Assembly



To finish assembling the Pointer / Power Pulley you need:

- The assembled circuit board
- Stepper motor
- Box (sides, top, bottom, 8 screws)
- #4-40 x 1/4" nylon machine screws (4)
- #8-32 x 1/2" machine screws (4)
- #4 x 3/8" sheet metal screws (2)
- Rubber feet (4)
- Plastic washer for power jack (1)

Step 16 – Into the Box

Remove the nut and washer from the power jack and bend the voltage regulator and fuse so they will not touch either the box or the PC board or any other components. Put the plastic washer onto the power jack, so it will be inside the box.

DO NOT FORCE THE BOARD INTO THE BOX.

Carefully insert the board into the box. Be sure you have it oriented correctly so the power jack, phone jack and other features of the board match the holes in the box.

It is important to guide the external power terminals gently into place by pulling upwards as shown in the picture.

When the board is correctly alligned, replace the washer and nut on the power jack and use the 4 nylon screws to fasten the board in place. Do not over tighten the screws.

Step 17 – Attach the Motor and Top

Use the 4 #8-32 machine screws to fasten the motor loosely to the top plate of the box.. It doesn't matter which side of the top plate you use, unless one side is cosmetically better than the other.

Use 4 of the sheet metal screws supplied with the box to attach the top plate to the sides of the box. The motor must be aligned so that it does not touch the PC board. Keep the wires arranged so they are not pinched between the top plate and the sides.

After you have fastened the top plate securely in place, tighten the machine screws holding the motor.

Step 18 – Attach the Bottom Plate

Note that the motor shaft is not quite in the center of the box. The bottom plate should be aligned so its primary hole is directly beneath the motor shaft.

Also, before you finish closing the box, make a note of the model number for your motor. It is likely to be 4004-010, but it may be something different.

Lay the bottom plate over the top, to be sure you know how it should be oriented. Then use the remaining 4 sheet metal screws to fasten it into place on the bottom.

Attach the 4 rubber feet near the corners of the bottom plate.

Step 19 – One More Step

Use 2 #4 x 3/8" sheet metal screws to secure the external power terminal. You may want to go back and retest your Pointer / Power Pulley as described in Step 13.

See the document, *Simple Programming for the Pointer*, for information about how to operate the pointer with a TI graphing calculator.