“BrainPower”
Cranial Nerve Stimulator

Partial-Kit Assembly Instructions
“BrainPower” | Cranial Nerve Stimulator
With Some Assembly Required

Obtaining the required bits & pieces.

The package you receive from me will contain the following:

- Assembled & tested “BrainPower” CNS stimulator printed circuit board (PCB).
- “BrainPower” CNS device label (self adhesive).
- Battery compartment retaining foam (self adhesive).
- Amazingly perfect rubberized ‘D’ shaft press-on knob.
- Two PCB mounting screws.
- TENS electrode lead wire: 2.5mm mono phone to dual 2mm pins.
- An assortment of high-quality self-adhesive stimulation electrodes.

To assemble a complete working BrainPower CNS stimulator, in addition to these parts (which are more practically supplied by me for various reasons), you will also need to obtain the following parts, or their equivalent. A ready-to-order cart has been assembled at Digikey:

Bill of (Additional) Materials

http://www.digikey.com/short/353r4r

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturer</th>
<th>Manufacturer Part No.</th>
<th>Digikey Part No.</th>
<th>DigiKey Price</th>
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<tbody>
<tr>
<td>Hand-Held Grabber Belt Clip Blk</td>
<td>Bud Industries</td>
<td>HH-3595-BCB</td>
<td>377-2051-ND</td>
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<tr>
<td>Hand-Held Case 3.6x2.6x1.1</td>
<td>Hammond Mfg.</td>
<td>1593PBK</td>
<td>HM357-ND</td>
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<tr>
<td>LED Red Diffused 3mm Round</td>
<td>Broadcom Limited</td>
<td>HLMK-150</td>
<td>516-1311-ND</td>
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<td>Rotary Encoder, 18ppr &amp; detents</td>
<td>Bourns</td>
<td>PEC11R-4115F-S0018</td>
<td>PEC11R-4115F-S0018-ND</td>
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<tr>
<td>Beeper, 3-7v, 30mA, 2.3kHz</td>
<td>Soberton</td>
<td>WST-1206UX</td>
<td>433-1048-ND</td>
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<tr>
<td>Phone Connector 2.5mm Mono</td>
<td>CUI</td>
<td>MJ-2508N</td>
<td>CP-2508-ND</td>
<td>$1.50</td>
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<tr>
<td>9v Snap connector, 6” leads</td>
<td>Keystone Electronics</td>
<td>233</td>
<td>36-233-ND</td>
<td>$0.62</td>
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<tr>
<td>12 inch 22AWG stranded hookup</td>
<td>TE Connectivity</td>
<td>55A0111-22-9</td>
<td>55A0111-22-9-01-ND</td>
<td>$0.87</td>
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Total: $13.72

Notes:
The price shown for the 12-inch 22AWG stranded hookup wire is for three (3) pieces at $0.29 each.

Digikey offers a 9v non-rechargeable battery for $1.88 with Digikey part no: P687-ND.

The Digikey link above auto-populates a digikey “cart” with the required components as shown above (not including the 9v battery). Note that this includes three 12” lengths of 22 AWG hookup wire. You may remove it before completing your order if you plan to supply your own.

In addition you will, of course, require the various tools of electrical & electronic assembly, drills, screwdrivers, a soldering iron, and so on.
The photos above are largely self-explanatory. With the PCB mounted as shown, there is just enough space for the beeper. Ideally, the beeper should be placed as high up as possible to give the PCB as much clearance as possible. I mounted mine right up against the removable panel’s interior retaining ridge.

The trick, then, is to drill a horizontally centered hole at the proper height to allow the beeper’s acoustic energy to escape to the exterior. I recall that some of you wished you had not drilled a hole for the TNS’s device’s beeper, since you were using it to fall asleep and were disturbed by its end-of-session trill. And it’s true that I can easily hear the beeper inside the Omron BP meter, even though it has no hole. Be advised, though, that I also use the beeper to create a distinctive “click” to augment and acknowledge the rotary encoder’s rotation and I’m unsure whether that subtlety would be audible without a hole. If you choose not to create an acoustic port for the beeper, you’ll need to somehow affix and “aim” the beeper into the case’s interior so that it’s not completely muted against a solid wall.

In my construction shown above, a dab of epoxy adhesive was used to cement and hold the beeper directly over its exhaust port.

You can also see that the nice belt clip extends over the 9v battery compartment. Since the battery life of these devices is so long (I have never changed a single battery) the infrequent access required to the battery compartment makes this a worthwhile tradeoff.
The Hammond case has a removable end panel which should be drilled as shown in the detail above. The positioning of the \( \frac{1}{4} \)" hole for mounting the rotary actuator is somewhat critical to avoid the actuator’s intersection with internal mounting stanchions. But this placement is also ideal, since the stanchion it’s avoiding will also serve to prevent the control’s rotation.

To allow the controls to be mounted flush and clean, they are all friction-fit into their respective mounting holes. The ABS plastic used in this case, as with the previous TNS Polycase, is very soft, forgiving, and workable. This allows the controls to be mounted conveniently using the “give” of the plastic to subsequently hold them in place.

1. The rotary actuator can be hand threaded into the \( \frac{1}{4} \)" hole, which will be nicely tight, without any need for an external nut.

2. The 3mm LED will not fit through the 7/64ths” hole, but it should be press-fit from the inside rear so that it pokes through to the outside. That 7/64ths” hole should be carefully counter-sunk, without widening the front, to allow the LED’s skirt to be pushed further in.

3. The 2.5mm monophonic phone jack can also be hand threaded from the inside rear so that its neck exits flush with the front of the panel. Or, if you prefer, it can be threaded further to allow its round knurled nut to be used.

Once the controls have been mounted, they can have their wires attached, as follows:
Controls Interconnection & Wiring

- All controls are depicted from their rear as you would see them after they have been mounted and are being interconnected.
- The LED and Beeper are the only two polarity-sensitive components. Their positive connection is the longer wire, of the two.
- The 2.5mm jack connection to the electrodes is not polarity sensitive.
- The rotary controller must be wired as shown for correct knob direction.
- The **BLUE** wire above is the common ground which, as shown, ties back to the negative (black) terminal of the 9v battery.
- The removable panel’s controls should probably be interconnected first, leaving ~1 inch wires which are long enough to reach the top edge of the PCB, and a longer wire for the common ground to reach around to the PCB’s negative battery connection.
I used a different 2.5mm monophonic jack because I already had hundreds of them on hand, so the photo of the finished assembly, below, reveals different hardware. To eliminate any confusion, the diagram above shows which two of the three connections should be used (colored green) for the 2.5mm CUI phone jack purchased from Digikey. The jack’s third connection, located on the side, should remain unconnected. It’s for the “insertion switch” which we don’t use.
Putting the Pieces Together

The optimal order of assembly is probably:

1. Drill the three mounting holes for the three panel components.
2. Mount the rotary encoder, press-fit LED, and mount the 2.5mm phone jack.
3. Tie all of the controls’ grounds together.
4. Add wires to the controls with 1.25” lengths to later be connected to the PCB.
   (Note: run the encoder’s left-hand wires to the right, as shown so they do not interfere
   with the case’s upper shell screw posts.)
5. Solder the 9v battery snap wires to the PCB, with a 3” length of ground wire on the
   underside of the PCB, connected to the ground negative (black) 9v battery wire for
   connecting to the controls’ grounds.
6. Place the end panel into the slot in the back of the case.
7. Add the beeper’s negative (shorter) lead to the common ground connections.
8. Place the PCB into the back shell and secure it with the two provided silver screws.
   The battery ground wire should be protruding into the controls region.
9. Solder the battery ground wire to the controls’ common ground.
10. Solder the individual control connections, as shown, to the PCB’s connection points.

So far so good??...

Briefly touch a 9v battery’s terminals to the battery clip. You should be immediately greeted
by what will be a very familiar “trill.” ☺
Final Pre-Closure Details

The front shell of the Hammond case contains a pair of card guides on each side, shown by the yellow highlights on the left image above. When the case halves are assembled, these card guides intersect with components on the PCB – the 14-pin processor on the left and the cluster of transistors on the right. In my build, I used a chisel, running its blade down the inner face of the case to cleanly remove all four of the plastic guides. If a chisel is not handy, wire cutters can be used to “nibble” the guides down.

As shown in the above-right image, the three left-hand connections to the encoder are VERY close to the post which holds the case halves together. I was going to recommend that the encoder’s terminals be bent as close to the encoder as possible to make room… HOWEVER, the encoder CAN simply be rotated 90 degrees to make ample room for the terminals because the encoder is a non-square rectangle. I will build all future devices that way. I had it in my head that it needed to have the orientation shown above because the thinner version of the case I first used (which turned out not to be deep enough for a 9v battery!) was too shallow to allow the encoder to be oriented with its long dimension vertical rather than horizontal.

I prefer to leave the 9v battery clip wires at their full length… which is ample. This allows for easier battery detachment or change without also needing to fight (and/or pull on) wires that are inconveniently short.

Add the provided battery retaining foam to the inside of the upper case half (as shown above-left) to keep the battery from rattling around inside the battery compartment.
Closing it Up!

All that remains is putting the two halves together and adding the four screws.

When the battery retaining foam is fully expanded, it will push the bottom of the case apart if you are closing it with a battery attached.

Note that the screws are self-tapping and anchoring into soft plastic. With care, the threading you create the first time the screws are tightened will last for years. I have opened and closed my original case (using just the two middle screws for speed and ease) more than one hundred times and, while the screws now have less friction when they are inserted or removed, the mating soft plastic threading has survived perfectly.

One crucial tip for achieving long thread life: When reinserting a screw, place a tiny and gentle bit of force on the screw and rotate it in the outward (counter-clockwise) direction. At some point you will feel it “drop” into its previous threads. Only then is it safe to begin turning the screw clockwise to seat it into its self-threaded plastic post.

And, of course, the very first time you close up the case and tighten its four screws there will be no threading, so definitely provide the required pressure to create new threading as you turn the screws clockwise. Then… apply the BrainPower CNS label to the front of the case!

A quick functional test:

The final version of the CNS stimulator only runs for 60 minutes without being restarted unless it has been placed into “mega-session mode which runs for 12 hours. This meant that I didn’t need to worry about whether the user was connected, since the device would eventually stop by itself, and since it draws negligible power even when it’s running.

Consequently, although this version of the hardware has “loop monitoring” capability, future designs will not, and I have simplified the firmware by not using this capability even now. This, in turn, means that you can verify the device’s operation without needing anyone’s “head” in the loop…

Pressing the button toggles the device on and off and generates the well-known “brain zapper trill” when it’s transitioning.

While the device is running, the LED flashes every 1.255 seconds, in time with the stimulation pulse burst.

Turning the knob up and down increases the intensity though 100 levels, and you’ll enjoy the nifty “click” sound of the knob’s turning, augmented by the device’s beeper. The LED also flashes when the intensity is changed, since a stimulation burst is immediately generated to allow for adjusting the intensity level without waiting for the next regularly scheduled pulse burst. There’s much more… which will follow in the complete user’s guide. (To be written.)