General Build Instructions

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This document outlines common build strategies I use when buying parts, assembling circuits and drilling boxes. It's structured in the same way as you would go through the process of building a DIY pedal. I hope this will help you with your build, having a fun time and minimizing the need for trouble shooting. A careful and diligent approach should usually lead to a pedal that works as expected on the first try.

Expect to occasionally encounter an error in your build. This could be a wrong component value, a flipped IC, cold solder joint and what not. As you become a more experienced builder, the build process will speed up and the quality of your builds will improve.

Of course you can always contact me at Nucleon if you have questions or doubts. However I highly recommend joining an online DIY community. For instance check out:

- The (Dutch) Newtone Online forum
- Madbeanpedals forum
- DIYStompboxes forum

A lot of people can simultaneously have a look at your work and help you out with your questions. It's also a great place to show of your crazy cool pedal builds.There's lots of great help, advice and examples to be found in these places. Personally I frequent the Madbean community the most. It's very mild mannered, not too big but very high in quality. Besides pedal building, there's lots of other interesting topics the members share with each other.

Buying parts

A general shopping guide.

Online Vendors

In Europe I highly recommend these companies as a reliable source of components:

- Newtone Online (NL)
- Banzai Music (Ge)
- UK-electronic (Ge)
- Thonk (UK)

For US-based builders, consider:

- SmallBear Elec
- Mammoth
- LoveMySwitches

For small scale DIY purposes, the sources above are the best option. These companies specifically cater to the DIY pedal community with their inventory and presentation.

If you are planning to build a lot of effects and really want to stock up consider a company like Mouser for bulk orders.

You can also try eBay and Asian companies like Tayda. As is to be expected, component quality may vary with these outlets. Some stuff is good (enough) and great deals can be had, but be aware of counterfeit transistors or resistors with very flimsy leads.

Resistors

Nucleon boards are designed for 0.6W metal film resistors that can be installed flat to the board.

Capacitor Types

I roughly follow these guidelines for capacitor size when designing the:

- smaller than 1nF: Multi Layer Ceramic (MLCC) for filtering
- smaller than 1nF: WIMA box caps in audio path (slowly phasing this out in favor of MLCC)
- 1nF - 10nF: 'greenies' or MKP box caps. Wima is one of the best brands out there
- 10n - 1u: Panasonic ECQ-V (or similar film caps) in audio path. Out of production but still available online. MKP or MKT box caps will also work. Again, Wima comes highly recommended.
- 100n - 1u: MLCC for power filtering, audio path if box caps are too bulky for the board.
- 1u - 470u: Electrolytics, usually power filtering. Use a quality brand, like Nichicon or Panasonic if possible. If you want to go the extra mile, go with low ESR, although that's probably overkill for guitar pedal purposes. Electrolytics can be very bulky, both in radius as in height. Try to gauge if your pedal will close after assembly (not all enclosures are created equal!).

This is mostly due to what's available in my personal stash. You can deviate from this. MLCC do a better job than film caps for filtering power lines. In tight spaces I've started using 1u MLCC caps in the signal path as well. I've not noticed any adverse effects on the sound.

Potentiometers

The pots used in Nucleon projects are either 9mm or 16mm board mounted pots from the Alpha brand. You can use other brands but alignment might be off. On new projects I prefer using 9mm pots because the board sits closer to the enclosure surface (less likely to have problems with tall electrolytics, more room for the power jack). They also allow for a tighter board layout.

With both 9 and 16mm pots there's a small metal tab protruding from the pot to help center the pot:

- 9mm has one on the lower side, south of the shaft, small nib a fraction of a mm high
- 16 mm has a clearly visible tab on the side, to the left of the shaft, 1.5 mm or so tall

If you want to go the extra mile, make a groove or drill a hole in the enclosure for these tabs to sit in. However the easiest thing to do is to just snap (16mm) or cut (9mm) the tab off so the pots can sit flush with the enclosure surface and you have some wiggle room in case your drilling is not 100% centered.

Enclosures

Most part vendors offer enclosures as well. The most common boxes are die cast aluminum made by the Hammond company. There's other companies with measurements similar to the Hammonds. Most DIY pedal projects out there use one of these four types:

- 1590A (the mini sized pedals)
- 1590B (comparable to the compact MXR pedals)
- 125B (similar footprint as Boss pedals)
- 1590BB (comparable to larger MXR pedals)

There's other (smaller or bigger) boxes out there. See the project documentation for what is recommended.

Places like Newtone and Banzai offer bare aluminum enclosures or powder coated ones in (very) basic colors. If you want fancy colors (like, say, Cinnamon Sparkle Translucent) check out PedalPartsPlus. It'll cost you though, especially if you're outside the US (don't forget about additional customs fees and taxes).

As stated before, not all enclosures are created equal. For instance, there's different manufacturers offering something that resembles the standard Hammond 1590B sized injection molded aluminium box. But only Hammond makes a box to exactly those specs. Other brands (4 Site, Eddy Stone and others) may be slightly less tall, have more rounded or sharper corners or a different angle for the sides (boxes are made with a mold so the sides have to be angled to reliably release them from it after pouring). Of course, there's also different types of enclosures to consider. The main alternative to injection molded enclosures is enclosures bent from sheet metal. These have the advantage that they are easier to work on when you have to wire up the box and such. The EHX Big Muff Pi comes to mind as a good example.

Soldering

The following section assumes you're assembling a through hole style pcb (no SMD).

Populating a PCB

General wisdom is to work from low profile to high profile components. In practice that means you first populate a PCB with resistors and diodes (assuming they lay flat on the board, not standing up). Then you move on to capacitors, ICs and transistors. Then solder any required wires to the board. If the potentiometers are board mounted, fit them potentiometers to the board and test fit them with your enclosure before soldering. A 9mm pot is kept in place mechanically by the tabs on the side. A 16mm pot can be tagged in place by soldering one of the legs, then test fit it to the enclosure and solder the remaining legs. Lastly reflow the first joint to relieve any mechanical stress from the fitting.

I usually fit all the resistors and then all capacitors to the board before I touch a soldering iron. Push a components trough the pads and on the back bend the leads flat with the PCB and cut of the excess lead. Put a little thought in the direction you bend the leads. Usually, I bend them outward. Sometimes though component pads might be close together and to prevent the risk of a solder bridge I bend the lead the other way. This method gives you a good mechanical contact before soldering and holds the components in place.

Types of solder

Coming soon (flux core, diameter, lead and lead free)

Don't mix lead and lead free. If you use both, use different tips (or better yet, two different soldering stations).

Soldering components

Once you've fitted all resistors and capacitors clamp the PCB in a holder or vice (buy one or build one, there's instructions online) and fire up the soldering iron. Apply some fresh solder to the tip and wipe it clean. This removes crud and corrosion, prolonging the live of your soldering tip. Heat one side of the pad-component joint with the soldering iron and flow in solder from the other side. With a bit of practice, you can really work very fast here. Clean the tip or the iron regularly (that's what the wetted sponge is for).

With both the solders recommend above you're looking for a nice clean, shiny solder joint. No blobs, not barely filling the pad, but just right. Pictures coming soon, but really, a good joint looks...good.

Using Sockets (soldering)

When soldering ICs, silicon transistors or germanium transistors, you can use a socket. Heat is applied to the socket when soldering. The component is added afterwards so you can't damage it by overheating

Personally, I usually use sockets on all dual opamps in a build. I tend to solder transistors directly to the board. This requires a good soldering technique. I've never destroyed a transistor with heat from soldering, but it's been known to happen. Basically, you need to work fast to get a joint done. There's a few tricks that can help:

- Clean the tip of your iron before soldering the semiconductor.

- Give the component time to cool off between joint. If you've got 4 transistors (say) to solder, do the left pin of each of them, hopping from transistor to transistor. While you're soldering transistors 2, 3 and 4, transistor 1 can cool off a bit.

- Don't clip the leads before soldering, clip them afterwards. The legs can act as a heat sink, taking away heat from the fragile semiconductor structures in the chip

- With opamps, you can also hop to the opposite site of the chip after each joint, again to spread the heat more evenly.

- Germanium transistors very sensitive to heat and also costly components. That means that all tips above especially apply to these.I leave the leads on germanium transistors extra long, the transistors legs sticks out an inch or more above the PCB and after soldering I bend if horizontally to loom over the other components. You can cover the leads with some left over sleeve material from wires to isolate the legs from each other. It looks nice too.

Using Sockets (swapping components)

The other of using a socket is that you can swap components. Silicon transistors, FETS (esp. In buffers) and dual opamps (more on these below) can in many cases be substituted, at least temporarily, when testing a circuit

Most dual opamps, usually in the DIP format (dual inline package), share the same pinout as (say) the TL072 opamp (check the datasheet for a particular chip to be sure). Using a socktel enables you to swap ICs in your builds. Maybe you've got your build almost running but haven't got a particular IC at hand? Subsitute a different one for the time being. It may even suit your tastes better. Below are some general thoughts on this.

In low gain overdrives I quite like the 1458 and 4559 ICs. Compared to a TL072 these chips have a higher noise level but in a low gain effect they are very pleasing. If quieter operation is required, try the TL072 first, and maybe a 5532. If youré dealing with EQ sections (where noise and sound quality are really important) it might be worth investing in some Burr Brown OPA type ICs, like the OPA2134 or OPA2277. These are pricey buggers (10 to 20x the price of most other opamps), so a socket can help you determine if you really need it in a particular build.

There's more to opamps than just their noise figures. Some things to look out for:

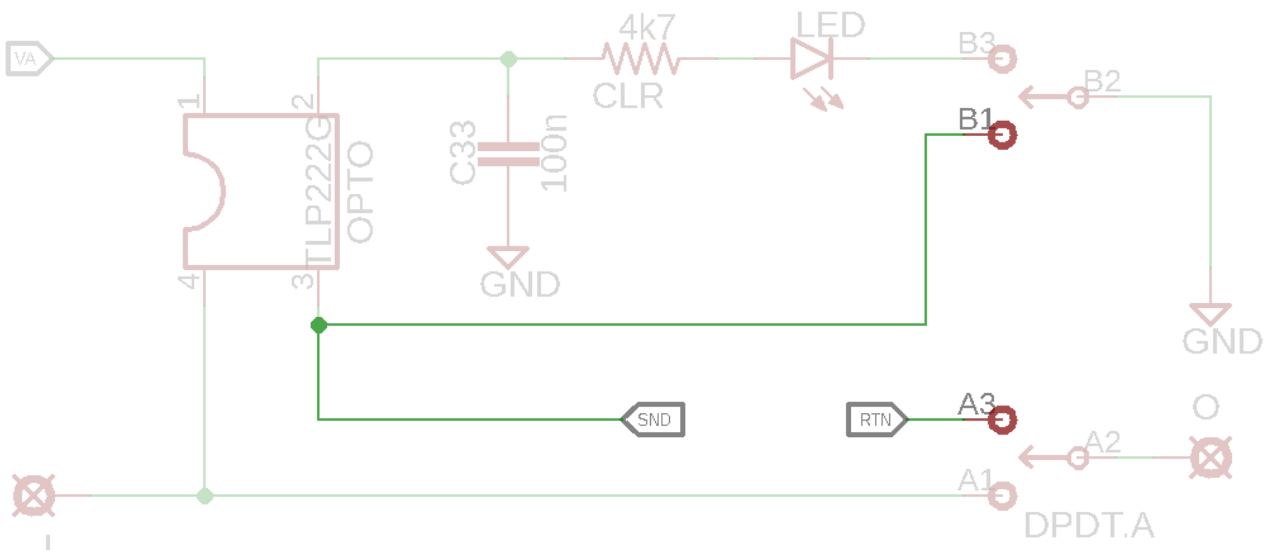
- Is the opamp BJT (Bipolar Junction Transistor) or FET (Field Effect Transistor)?
- What's the noise rating? (measured in nV/√Hz)
- Slew rate (sort of the 'speed' of the opamp, also a factor in how gracefully the opamps reacts to and restores from clipping)
- Operating voltages (is it suitable for your project's power requirements?)

There is a drawback of using sockets: components are only fitted mechanically and can fall out over time (you shake them loose each time you step on that foot switch). I've not encountered this with ICs (as they are clamped at 8 or more points) but it has happened with transistors. One way to solve this problem is to fill the socket with some solder once you've tested several and settled on the particular transistor you want to use in your build.

Testing (Rock before you box)

Once you've populated the PCB with all components, including the pots, it's time for wiring. If you're very confident you could commit the circuit directly to its final destination: a purdy aluminum box. But it's a real pain to troubleshoot from once the effect has been boxed. So in general the advice is to 'rock before box'.

On effects that don't have on board optical bypass (the TLP222 thingy) you can use the I(nput) and O(utput) pads directly. Most Nucleon boards do have optical bypass and then we need a little trick to circumvent this. See diagram below, showing the bypass circuit.



B1 (pin 4 of they bypass/DPDT strip on the PCB) will be our input and A3 (pin 3 on the PCB) will be the output. Solder a wire to both pins, make sure it's long enough to reach the DPDT later when boxing it up. Strip the free ends. Also wire the G and 9V pads. It's good practice to make these black and red respectively.

Minimum additional tools for testing

- DC power jack
- Two ¼" mono jacks
- Plenty of leads with alligator clips on the end (5 or 6 should do)

My best advice is to actually build yourself a testbox with a bypass switch, status LED, jacks and alligator leads. You could use the Nucleon Photon board for this. It will save a lot of hassle in the future and if there is a mistake and the effect goes into oscillatory madness you just hit that bypass switch and all is quiet (the effect itself will still be going bonkers, just not audibly). Also, I like to use the following color coding scheme (you can of course choose your own):

- Red = positive power (+9v)
- Black = ground
- Yellow = audio input
- Green = audio output

Other stuff highly recommended for testing:

- Battery powered practice amp (don't use your 120W amp pointed at your neighbours. A fault in the PCB could damage your hearing.
- Power supply (I love using a Pedaltrain Volto for this, but others will do just fine)
- Compact looper pedal with some single note lines and chord strums loaded. This frees up your hands to poke around the board with a multimeter etc. I test all my builds looping the riffs from She Sells Sanctuary by The Cult. Just saying…

So now it goes like this:

- Guitar lead (from looper) to a jack
- Tip connection of the jack to board input (pin 4 in our example) with alligator clip
- Alligator clip from board output (pin 3 in our example) to tip connection of 2nd jack
- Guitar lead from jack to (practice) amp
- Commect sleeve connections of both jacks with each other (otherwise, very loud hum will be your surprise)

That's the audio path setup. Now for power:

- Connect (black) wire with (black) alligator clip to the negative (ground) tab of the power jack
- Connect (red) wire with (red) alligator clip to the positive tab of a DC power jack
- Be very carefull that the black and red connections don't touch. Best thing to do if a quick loop of scotch tape around the red alligator clip for insulation.

Have some audio run through your effect. If all is well, test it on a mains powered amp to see if it's still silent. If all is well, box her up and rock out.

Enclosure drilling

Cover a 1590B in painters tape. Print the template from the build document at 100% scale and stick the template on top of the tape with some glue or tape. Double check alignment with the PCB.