Help me build an electronic load & bench supply

Michael Dunn - January 23, 2018

EDN Labs (well...the part of it in my basement) has always been a bit short on power sources (and even shorter on electronic loads). A 5A buck-boost module recently caught my eye, and I’ve decided to build a bench supply using two of them. And, why not throw in an electronic load too?

![Figure 1 The 5A 0-32 V buck-boost module](image)

First, the easy choice: How to power the buck-boost converters. They need at least 18V in order to supply full current output at 32 V. Note that I can’t use a common supply for the modules, as input & output are not isolated (though not common ground either). I’ll do a review and analysis of them in a future blog. Here are the power options that come to mind, based partly on what’s already at hand:

- Linear supply, using some beefy (300 VA?) toroids in my parts box
- Switching supply, 2×24V at ≥ 8A (name brand, but cheap, like Meanwell)

I’d hoped to use an old PC supply, but they can’t reach both the needed voltage & current.
Electronic load

Here are the lab’s current electronic loads:

I could mount these in the supply chassis along with a fan. But it might be nice to have a true electronic load – something with a bit more functionality. Something that doesn’t require a screwdriver to adjust. Something like:

150W Constant Current Adjustable Load
200V/20A

These appear to be the same board, just different heat sinks and power ratings.
Admittedly, there are some negative reviews. The modules might do the trick, but would probably disappoint sooner or later.

Could this be the opportunity to actually design my own gear? Our own gear?! I think so. Because I really need another project on the to-do list. Well, this one should be pretty simple. Gotta start somewhere.

[n.b., What I really want to design is my own high performance oscilloscope, but given the years that would take, I don’t expect it’ll ever happen. Today, a load. Someday, signal generators. That might have to be enough.]

The EDN Community-Designed Electronic Load (EDN CDEL)

What are the minimum design elements required for a useful load?

- MOSFETs, one or more, big & honkin’
- Current measurement
- Voltage measurement
- Microcontroller (sure, the design could be all-analog, all the time, but hey, it’s 2018)
- UI elements
- Floating power supply

I propose a base spec of 100 V, 20 A, and 200 W, though the design should be flexible enough to alter those parameters with minimal rework (okay, I just assembled a MOSFET shortlist, and I think I’ll actually use a 200 V, 130 A, 500 W part; even a MOSFET of this stature is in single digits onesie cost).

The finished design will be open-source, and I’ll lay out a PCB for it. I will host the project on EasyEDA.
Figure 4  I knew these rack cases would get used someday.

User Interface

I could design the whole unit, but...time...and then it wouldn't be a community project, would it? Also, I’d love help with the UI end of things especially. Many of you are more experienced, and will be better able to specify an optimal combination of cheapness, ease of development, and general niceness.


My preference: A Cortex-M3 or -M4 board with a small colour touchscreen. I know that’s processor overkill, but they’re so cheap, who cares. Besides, I bet the peripherals will be better (ADC & DAC are important). That processor choice is contingent on easy development. If the rich Arduino library ecosystem makes it ten times easier to develop the UI compared to the ARM world, that’s a major consideration, though ARM boards have been integrated into the Arduino ecosystem too... Help!

Did I mention...? I don't much care for C. If we can instead develop in Python, Free Pascal + Lazarus, BASIC even...! That would make me happy. In fact, at the top of my review pile is the 2018 ARM-based reincarnation (concluded Kickstarter) of the classic BASIC Stamp, but creating a UI with any of these would realistically depend on library support I guess. Not that I’m averse to creating our own fonts if that’s all we need :-) But...it’s not a big project, so using the default C will likely be the simplest route.
Figure 5  Potential controllers: Arduino clone ($10), ST Cortex-M4 ($30), ARM Stamp ($25, no LCD), Teensy ($35)

(approx. USD prices w/touch LCD)

Load core

Putting aside the UI+µC for the moment, here’s a rough sketch of what I think is needed for the actual core circuitry:
Figure 6 Block diagram (PadCAD)

It’s pretty self-explanatory, but here are some issues to ponder:

A wide dynamic range, say, 1 mA to 100 A, would be difficult to achieve, needing precision current sensing, high-res ADC, etc. The easiest solution might be to parallel two or three FET “assemblies”, each with its own $R_{\text{sense}}$ (as drawn on the block diagram). The controller would drive only one at a time, depending on the desired current.

Fan control could be implemented. Open-loop would be fine, as the controller always knows how much power is being dissipated.

If you want to get involved with the EDN CDEL or just monitor its progress, be sure to follow the comments here by logging in, then clicking the folder icon in the toolbar underneath the article’s title. I’ve also set up a discussion list on Groups.io, where more in-depth chats can take place without completely cluttering the EDN comments, and files and images can be posted. There’s even a wiki feature. That’s the same service the TekScopes list migrated to (from Yahoogroups), because, well, Yahoo. We’ve been pretty happy with the results. Join up there too. I haven’t set up the EasyEDA project yet, but will as soon as enough has been decided to make a first cut at a schematic.

MOSFET shortlist download

Wait! Don’t download that shortlist.
As you'll see in my comment below, the fact that the vast majority of power MOSFETs these days are optimized for switching (not linear mode) had been relegated to a very dark corner of my mind. Download this [new shortlist](#), where I've done my best to focus on FETs better suited to linear operation.

Funny thing is, when power MOSFETs were young, one of their touted features was immunity to thermal runaway compared to BJTs (specifically when shared, I believe). Now though, switching-optimized parts can exhibit *internal* thermal runaway when used in linear mode, where a cell or small area of the die becomes hotter than its surrounding area, which causes higher spot current, which makes it hotter, which... You see the problem.

The new shortlist includes some *Ixys* parts specifically designed for linear use. But I went through all 44 datasheets, checking linear suitability. As you can see in my added column, most are not even specified for linear DC operation! For ones that are, I calculated their maximum power dissipation at 100 V. The special *Ixys* parts range from 735-960 W. Not too shabby. Other suitable parts, from *Ixys* and *Toshiba*, range from 100-800 W. Quite respectable too. Choose whichever meets your needs and budget. They all cost more than I originally anticipated, but not much more in the grand scheme of things.

In addition to my added column, I’ve coloured the other key specs: Cost, Voltage, Current, Power, Resistance. Most of those are obvious, but keep in mind that resistance will limit low-voltage, high-current use. It’s not unusual for a high-end processor to require on the order of 100 A at 1 V. To test a power supply for this application, the maximum tolerable resistance is 10 mΩ. That means a FET of about 5 mΩ, because resistance increases with temperature. Only one FET in the list meets that spec! Short of increasing design complexity by using multiple FETs, you’ll have to pick and choose your tradeoffs carefully.

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