

POWER SUPPLIES – MAKE VS BUY

Kevin Parmenter

Director of Applications Engineering

ON Semiconductor

As a co-op student at a medical instrument company in 1980, I received my first exposure to the world of power electronics. The task I was given (as the new guy of course) was to make 30 power supplies in a large clinical chemistry analyzer work properly.

The company had designed and built everything. The instrument sold for \$350,000 to labs and hospitals. Uptime was critical as these facilities run 24x7.

First on the checklist was to see what sort of test equipment we had for the task.

Gain-phase analyzer to measure bode plots – No.

Electronic load – No.

Leakage safety analyzer – No.

Temperature test chamber - No.

Oscilloscopes and voltmeters - Yes.

An electronic load was acquired and the task of testing these power supplies began.

The first unit was a 30-amp 5-volt unit which powered a computer system (also designed and built in-house).

At 15 amps it was hot.

At 20 amps on the electronic load it was smoking.

Using the schematic, I managed to get it working at full load reliably and made it stable.

The drawback was that the parts alone - including sheet metal and magnetics we had custom fabricated - cost about \$1500.

My next official act was an update meeting with the VP of Engineering. I mentioned that the cost of the supply - in fact, all the supplies - would be high compared to the market. A 30-amp 5-volt commercial power supply out of the catalog was about \$350 and came with a 5-year warranty. I further explained that if we incorporated the standard supply into our system - which had a 1-year warranty to our customers – and the supply failed, we simply received a replacement unit from the supplier. If it failed within the next 4 years we received a no charge replacement for which we charged the customer.

I told him I was not trying to escape the task but it made no sense for us to then take \$1500 in parts, add labor by assembling it all, and warranty it ourselves from day one. The VP of Engineering was an extremely bright ex NASA program manager, one of 12 on the Apollo program. He immediately told me to buy what I could and design only what we could not buy. He said that NASA got us to the moon by designing only what they could not buy. That gifted leader also got us to stop trying to design our own computers and buy those too. We outsourced all but one power supply, which was very unique and specialized, and our power supply problems disappeared.

Although this was many years ago, the situation exists today. My career has taken me into applications sales and marketing and over the years I have observed many companies attempt to design their own power systems and power supplies. Some have been successful but many have incurred large expenses and wasted precious time to market because they simply do not know how to design power supply systems which are stable, reliable, and manufacturable in high volume and operate over long periods of time. WHY?

I receive calls every week at ON Semiconductor, from engineers whose bosses want them to “get that 40 dollar part out of our networking system to cut the cost”. After all, it’s just a power supply and any fresh out engineer can do that. Right, Mr. Manager?

Often times organizations with core products that are not power supplies and power electronics systems do not have the proper background, people, test equipment. Additionally they are often unaware of all the associated issues. We see them dive headlong into an area they are ill prepared to navigate. The mistake is assuming that power supplies are simple components and can be designed by anyone.

Why are companies outsourcing manufacturing to EMSI providers?
Simply because it costs less and they can do a better job than in house assembly and amortize the costs across multiple customers gaining economies of scale.

The same is true of power supplies.

Let’s take a look at some of the pitfalls of designing power systems:

Do you have the proper test equipment? Frequency response analyzers, electronic loads, electrical safety testers and other specialized equipment are needed and many companies simply don’t have these items on hand.

Do you have the people needed to design power supplies with proper skill sets in magnetics, PCB layout for power systems and high frequency power and the grounding and shielding techniques needed? The autorouter will need to be turned off and manual layout skills will be needed, safety spacing techniques in layout to meet leakage guidelines will need to be considered. Do you have the staff available?

Do you have thermal simulation software such as flowtherm and magnetics simulation software such as magsoft or other specialized CAD tools?

Safety – do you have the expertise and equipment to perform electrical safety testing on the designs to worldwide safety specifications and regulations? Do you know how to design magnetics for clearances required by safety agencies and approvals? The expenses of obtaining safety agency approvals are great and take time. If your product will ship

internationally it will require large input ranges of voltage 90-240 50-60 HZ and will require a long list of agency approvals for world wide acceptance, are you prepared for this expense and delays? Do you have safety experts on staff who knows the regulatory requirements?

EMI-RFI – switching supplies can generate lots of noise and lots more if they are not properly designed. Shipping world wide requires meeting these approvals. The testing is expensive and requires even more specialized test equipment and people who know how to do the testing in an anechoic chamber or a test range. The FCC dictates even domestic EMI-RFI and they have no sense of humor or sympathy for your poor switching power supply design.

Is power your company's core competence? Can you add real value by undertaking a power supply design or should those precious engineering resources be applied to other areas your end customers care about more? Customers assume your power supplies will work. They may place more value on other aspects and attributes of your product, which if you apply those precious few engineering resources to, will enable you to add more value to your end customer and sell more of your product or extract a premium and add more value.

PFC – Power factor correction is required in many countries with equipment over certain power levels. Will your in house design have the necessary PFC installed to meet the requirements of other countries world wide?

Ambient temperatures: Do you have temperature test equipment to evaluate designs over min and max temp humidity extremes and high and low input voltages and min – max output loads? What about shock and vibration? Even during transport and shipping this can be quite severe.

Will the design have protection for inrush current as well as transient protection? Most commercial supplies do. What is the MTBF of your in house design? Many manufactured supplies have predicted reliability as well as established reliability as they have been shipping off the shelf models to other customers in high volumes for extended periods of time.

Efficiency and thermal management, Will your in house supply design be as efficient as an off the shelf model and will the thermal characteristics be well understood and predicted? Do you have a thermal imaging camera for testing in the lab looking for hot spots?

Will an in house design be well behaved under fault conditions including short circuits, brownouts and over voltages? Will it survive and recover?

What is the transient recovery time and stability over time and temperature? Is the temperature coefficient for both current limit and voltage stability well understood?

Established reliability: Many customers are buying commercial power supplies for many applications, with established reliability. In other words they may have more demanding customers than you. This will mean that the quality – reliability and cost have been beat out of the process with a bigger stick than just your organization does by itself. Are you willing to warranty and guarantee your design over time and field conditions? Repairs, returns and field service are expensive.

Amortization of development costs over volume: Assuming you can meet all the technical merits as well as a commercially available supply, will you be making enough of these to pay off and make sense in the long run?

When does it make sense to build your own?

- a. If you can't buy something that meets your needs. .
- b. If you have considered all the above issues and feel you have what it takes.
- c. If buying a supply is really too much cost for the application and you are going to build enough of something to make a difference.
- d. If the requirement for designing your own supply can be handled with off the shelf semiconductors that are well supported by applications engineering staff and software design tools.

If you are going to design your own supply it is strongly recommended you involve semiconductor suppliers up front in the process in the definition process. I can't tell you how many times someone has chosen the wrong part, topology or circuit only to have 3000 units in stock with failures mounting. When they call, we often have a reliable and elegant solution as a reference design which could have been implemented months earlier when it was thousands or millions of dollars less expensive – the customer simply did not contact us at that time and designed in a vacuum.

I have seen companies attempt to design their own DC-DC converters only to have reliability problems in production or in the field. Any cost savings by making vs. buying power supplies is quickly consumed under those circumstances. In one particular instance, a customer copied a design (which turned out to not be very good) from a piece of equipment they took apart. They duplicated the power supply circuit because they needed similar input voltage and output voltage and current. The customer had field failures simply because the design was poor. We later recommended circuit modifications (which they argued about all along the way). This eventually eliminated the problem. If they had consulted someone in the upfront design or had simply purchased an off the shelf DC-DC converter no problems would have occurred. This company had no power supply expertise in house other than the digital guys who copied the circuit from another piece of gear. In addition to failures they had audible noise and EMI-RFI problems in the original design and untold other problems.

While it is not impossible, especially with today's design tools and software to create a reliable power supply the odds are often not in the favor of the casual designer. Sometimes companies will go out for quotes on a power supply and then assume internal resources which are "free" or external consultants can do it at less cost. The hidden costs

of such an effort are often very expensive indeed during the mop up phase at the end with time and money over runs. Ask yourself what it would cost for your company to design a "silver box" 300 watt PC power supply in house. Would you undertake such an effort?

I recently bought several electronic loads from a company which also designs and builds power supplies interestingly enough the power supplies used in the loads were purchased outside. Of course they had the internal talent to design them but they purchased externally, why? It cost them less to buy off the shelf than to do an in house design effort.

For many applications, especially off line and isolated telecom supplies or other sophisticated power electronics, the majority of designs are best left to those who do it full time for a living, those who only focus on power supplies as their product. In this manner your organization can focus on your end product. For power supply manufactures for your applications take a look at the companies listed and those who actively are participating in PSMA the power sources manufacturers association. See them listed at: <http://www.pdma.com> ON Semiconductor <http://www.onsemi.com> also offers many reference designs and consultative – collaborative designs for the correct applications. Once we understand your business needs, technology, volumes, service levels (price, delivery response time) and expectations we can make recommendations for build vs. buy decisions for specific applications where it makes sense for many applications off the shelf supplies best fit the bill.