Article

It’s a mad, mad, mad, mad 48V world

VICOR

It seems that many of our electronic systems (communications, computing, automotive, industrial, etc.) are transitioning from 12V to 48V. How are you going to power yours? (Don't worry, that's a trick question because I'm about to expound, explicate, and elucidate like an Olympic champion.)

> "Today more and more power electronic systems are transitioning from 12V to 48V to garner competitive advantage. Vicor is supporting this movement by introducing a new family of 48V to 12V DC-DC converters. These new products help to easily transition to 48V architectures while reducing power losses and delivering better overall performance."

For some reason, I currently find the phrase "It's a Mad, Mad, Mad, Mad 48V World" bouncing around my bonce. Since we're already on the subject, the 1963 movie, It's a Mad, Mad, Mad, Mad World, was an epic comedy featuring Spencer Tracy, accompanied by an all-star cast composed largely of comedians. I grew up thinking this was a black-and-white film, but that's because we had only a black-and-white television set at our house throughout the 1960s. It wasn't until years later that I discovered it was filmed in Technicolor. Rumor has it that Eddie Murphy is planning a remake of this movie, showcasing the top comedians of the past 30 years. Now, that's one movie I would love to see, so I hope this project comes to fruition, but (I know you're surprised) we digress…

The reason my head is currently filled with 48V factoids is that I was just chatting with Maury Wood, who is Vice President of Strategic Marketing at Vicor Corporation. Based in Andover, Massachusetts, Vicor is a purveyor of high-performance power conversion solutions. Vicor's offerings include a wide range of AC-DC and DC-DC converters, power modules, and custom power systems that are utilized across various industries, including computing, industrial automation, robotics, transportation, aerospace, and defense.

While 12V is most commonly associated with automotive systems, it's actually used widely across various industries and applications thanks to its balance of safety, efficiency, and compatibility. These include home and consumer electronics, renewable energy systems, recreational and specialty vehicles, medical devices, laboratory equipment, industrial and office equipment, and photography and broadcasting applications. In many ways, 12V is kind of like the Swiss Army knife of voltages—it's low enough to be safe to handle, and high enough to power useful stuff.

As an aside, and jumping a little ahead, did you ever wonder why so many systems are powered by multiples of 6V, like 12V, 24V, and 48V? Well, 6V lead-acid batteries were standard in the early half of the 20th Century (3 cells x ~2V per cell). When more "oomph" was required to power things like starters, lighting, windshield wipers, heaters, and radios, doubling to 12V (6 cells) was simple and used the same chemistry. (Volkswagen Beetles kept using 6V batteries until around 1966, which was rather late compared to other vehicles.)

Similarly, when commercial vehicles (e.g., trucks, buses, construction equipment) needed more clout, 12V systems simply couldn't handle their loads efficiently, so the transition to 24V (12 lead-acid cells) was an obvious move. Meanwhile, in the case of industrial settings (think PLC systems, sensors, actuators), the move to 24V was driven by factors like improved noise immunity and lower current for the same power, resulting in smaller wires, less heat, and more efficient power delivery.

As a reminder, direct current (DC) electrical power (P), which is measured in watts (W), is calculated as the product of voltage and current; that is, $P = V \times I$. This means that if we double the voltage, we can deliver the same power using half the current, and a lower current means that thinner (cheaper and lighter) wires can be used, and less heat is generated due to lower I^2R losses.

A similar argument applies to the transition from 12V to 48V, except that now we're talking about quadrupling the voltage, which means we can deliver the same power using a quarter of the current.

As I said earlier, we've jumped ahead a little because the move to 48V wasn't initially driven by automotive applications (no pun intended). Way back in the mists of time, circa the early 1900s, in the early days of analog telephony, $48V_{DC}$ became the standard voltage for central office (CO) telephone systems. This standard stuck around for landline infrastructure and evolved with the industry, all the way into modern telecom and data networks.

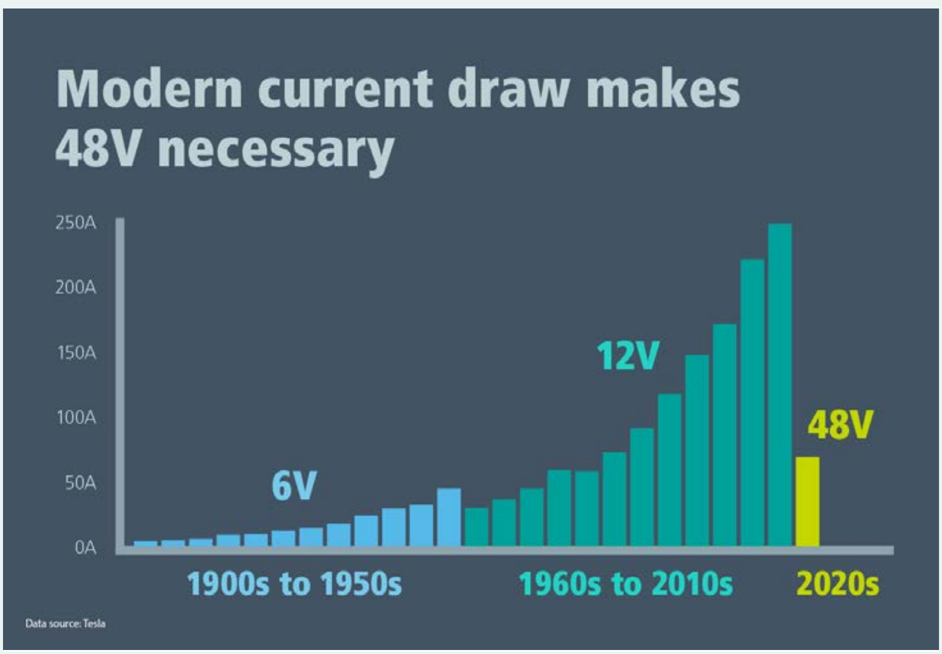

Figure 1: The current draw in today's automobiles necessitates 48V. (Data Source: Tesla)

Communication systems were followed by computing. The push for 48V power distribution in data centers by Google and the Open Compute Project (OCP) began gaining significant attention circa 2016.

The Tesla Cybertruck is widely reported to be the first production vehicle to use an all-native 48V electrical architecture across its systems, replacing the traditional 12V setup entirely. Maury tells me that many other automotive companies are starting to jump on the 48V bandwagon (and that's not something I expected to hear myself saying when I woke up this morning).

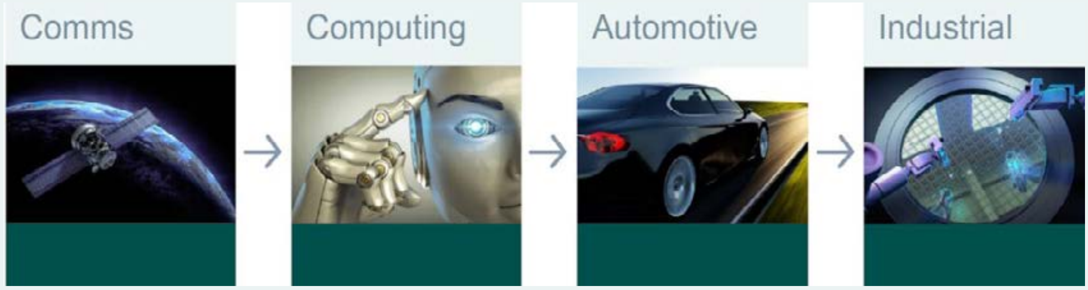

Figure 2: The world is transitioning to 48V.

Last, but certainly not least, there's a growing trend toward using 48V systems in industrial applications, although this is more of an evolution than a revolution. The use of 48V is gaining ground in sectors where higher efficiency, power density, and compactness are priorities. To pick robotics as just one example, these little rascals benefit from 48V because (a) DC motors, servo drives, and control systems get more efficient, and (b) power supplies and converters are more compact.

All of this is music to Maury's ears because Vicor has been evangelizing 48V for the past twenty years. Maury says that Vicor is "by far and away" the leader in 48V space. A high-level view of Vicor's 48V portfolio is depicted below.

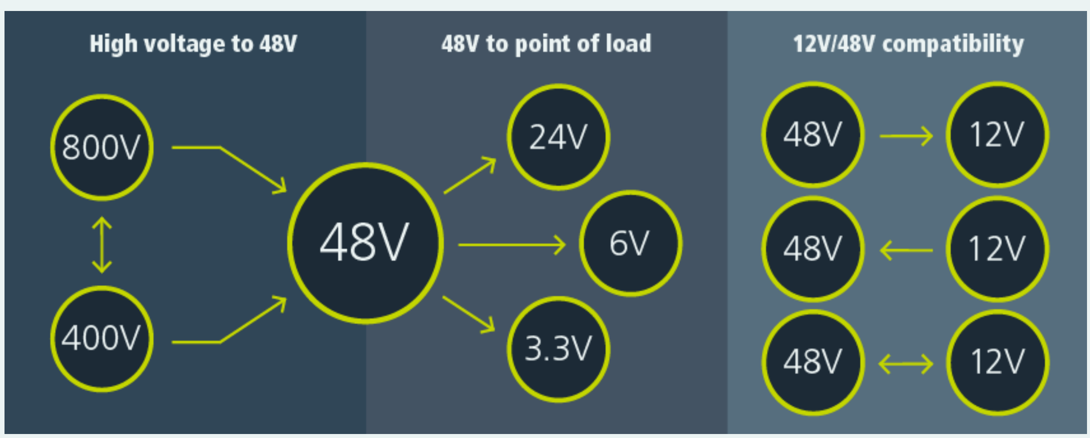

Figure 3: The Vicor 48V portfolio.

This portfolio can be visualized as being partitioned into three areas. The first (left in the image above) is from high voltage (400V and 800V) to 48V. This is of particular interest in the electric vehicle (EV) automotive arena, where 400V batteries are transitioning to 800V.

The second area (middle in the image above) is from 48V down to a point of load (POL). Only three examples (24V, 6V, and 3.3V) are shown in the image above, but we could add others, like 12V and sub-1V, if we wished.

The third area, and the focus of this column (right in the image above), is something we can think of as 12V/48V compatibility. There are vast numbers of 12V subsystems in the world with years (perhaps decades) of life expectancy remaining. When higher-level systems transition to 48V, users need some way to bridge the 48V to 12V divide (upper right in the image above).

Looking at this another way, there's a mind-boggling amount of existing equipment being powered by 12V. However, when users purchase new "bits and pieces," they may decide to go for the latest and greatest 48V offerings, in which case they need some way to bridge the 12V to 48V gulf (middle-right in the image above). The third case (lower right in the image above) is for bidirectional converters that can instantaneously switch from one direction (48V to 12V) to the other (12V to 48V) for tasks like regenerative braking.

The point I'm trying to make here is that Vicor is a "one-stop shop" for all of these converters, but that's not what I wanted to talk to you about (sorry).

The reason Maury wanted to chat with me, and the reason I want to chat with you, is that—as illustrated below—Vicor recently introduced a pair of 48V to 12V non-isolated regulated DC-DC converters to their portfolio. These new offerings will make even grizzled and grumpy elder engineers squeal with excitement. Say hello to the DCM3717 (lower right) and the DCM3735 (upper left)

Figure 4: The latest additions to Vicor's 48V to 12V portfolio.

Interestingly, these part numbers reflect the sizes of the modules. The DCM3717 is 37mm x 17mm (well 36.77 x 17.3mm, but who's counting?), while DCM3735 is 37mm x 35mm (36.7mm x 35.4mm). Both modules are only 5.2mm thick.

The DCM3717 comes in two flavors: 750W and 1kW. By comparison, the DCM3735 offers 2kW. In both cases, 2, 3, or 4 of these modules can be ganged together to supply more power, so 4x DCM3735 modules can provide 8kW, for example.

Both modules have ~96.5% efficiency, an extended operating temperature range of –40°C to +125°C, and can accept an input voltage of 40V to 60V (48V nominal). Wait! What? How can this be? Well, if the input is less than the nominal 48V, then an internal boost converter raises it to 48V, after which a buck converter drops it to the required 12V output.

These modules are instantly recognizable (I know I'll recognize them if I see them in the future), both for their small size, regular flat shape, and gold color. Initially, I thought that the gold color was just that (i.e., a color), but I was wrong; it's actually an incredibly thin layer of gold over a layer of copper. The result is both electrically and thermally conductive; the gold doesn't oxidize, and it's great for soldering; also, it creates a Faraday shield around the module, thereby reducing EMI/RFI.

PMBus® is supported for telemetry of things like over-voltage, over-current, and over-temperature, and they can be surface-mounted, thereby providing an ideal two-sided thermal interface for heat sinks and cold plates.

Applications for these little scamps are wide-ranging, from automated test equipment (ATE) to zonal architectures, from data centers to edge computing, and from 5G connectivity to 12V battery replacement. When people hear the term "zonal architecture," they tend to think in terms of modern automobiles, but, in the context of this column, this applies to any 12V zone in any kind of equipment. As Maury says, "Due to the fact that there's so much legacy equipment, peripheral subsystems, and whatnot, we will continue to see twelve volts being used, probably for the rest of our lives."

Figure 5: Vertically integrated manufacturing provides a reliable source of supply.

Returning to the DCM3717 and DCM3735 modules, I could waffle on about these bodacious beauties for yonks and yonks (which is a lot of yonks). Suffice it to say that they are less than half the size of the nearest competing products, they offer 10% higher output power, and 7x higher power density in terms of W/mm^3.

And one final point that's well worth mentioning in these uncertain times of tortuous tariffs and supply-chain disruptions is that, in 2015, the guys and gals at Vicor opened the world's first ChiP (Converter housed in Package) fabrication facility just down the road from their corporate headquarters in Andover, Massachusetts.

Maury says that having its own factory gives Vicor a greater level of control and oversight on product quality and lead time, that their patented fabrication processes enable continued innovation, and that they use sustainable manufacturing practices to protect and preserve the environment.

All I can say is that if I were still giving Cool Beans Awards, then Vicor's latest and greatest DCM3717 and DCM3735 48V to 12V converters would be flaunting one as we speak.

What say you? Are you currently experiencing a 12V to 48V evolution or revolution yourself, do you expect to do so in the not-so-distant future, or do you know anyone with whom you should share this column?

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