Over the years, we have seen technologies come and go. While some continue to evolve and serve the industry, others simply phase out quickly. So what makes one power electronics technology great, while another vanishes rapidly? Although we may not get a complete answer to this mystery, one way to approach it is to look back at past technologies and their hierarchy and impact. Was the influence of a given technology fundamental, and will it likely be everlasting? Was it transitional, having a short or even longer impact, and then it dissolved? Or was it an empty promise with actually little to deliver?

Only methods rather than devices can qualify to be fundamental technologies. Devices are based on materials, and because there is no end to improvements, devices are transitional by their own nature. When it comes to fundamental technologies, the pulsewidth modulation (PWM) and resonant conversion methods pop up as pillars of power electronics. Although resonant conversion methods seem to be relatively new (e.g., LLC, based on the serially connected inductor-inductor-capacitor), they, in fact, predate the PWM approach. Resonant conversion and resonant switch methods were developed in connection with the silicon controlled rectifier, or thyristor technology, to enable turning off devices when switched at relatively high frequency. Largely thanks to the availability of bipolar junction transistors (BJTs) that can turn the current on and off, the PWM technology emerged and the interest in resonant converters, for at least dc–dc conversion, subsided despite their offering of soft switching. This was probably because of the relatively large size of the reactive elements that need to store much more energy, as compared to the PWM inductor, and the relatively complex control.

So, why are resonant converters popular again? The key word here is faster switches. Fast-switching MOSFETs allow higher switching frequencies, making the reactive elements smaller and thus overcoming a major drawback of the resonant conversion method. Another enabling means to the resonant conversion technology is the resonant integrated circuit (IC) controllers that have made the control simpler and relatively inexpensive. Couple them with the soft-switching capability of the resonant converters, and you have a winner! However, the faster switching devices have difficulty satisfying the appetite for faster PWM converters. Switching losses in hard-switched PWM converters are dependent on the rise and fall times of the transistors, so as one increases the frequency, there is a need for faster and faster switches—much like Zeno’s Paradox of the Tortoise and Achilles. Moreover, even if a zero-switching-time device is miraculously found, the emanating electromagnetic interference (EMI) spectrum will probably make it useless.

By nature, devices are transitional, but some made an enormous impact on power electronics. The BJT started modern power electronics, but then the MOSFET took over, making the BJT a curiosity. Will silicon carbide (SiC) take over the silicon MOSFET? I dare not predict, as prophecy, in my culture, is said to be given to the fools. However, looking at the past, one can suggest a simplistic formula to evaluate the potential $P$ for a device or method success:

$$P = \frac{\text{performance} \times \text{ease of use}}{\text{cost} \times \text{competition}},$$

which is self-explanatory. Due to the relatively high cost and a low mark on ease of use, the potential of SiC, as compared to the new MOSFET generations, not very high at this time, at least for moderate voltages and frequencies. However, things can change fast.

Like resonant conversion, another power electronics method that is now
reborn is switched capacitor conversion. Switched capacitors have been around for a long time. The seed was planted in the voltage multiplier technology, and in particular the switch-controlled version of the originally diode-based Greinacher/Cockcroft–Walton multiplier (for many years, Greinacher was overlooked as being the first inventor). Dedicated switched capacitor regulator ICs appeared on the market, but the technology was lingering on as a niche and curiosity. This is because the switched capacitor technology is efficient only for fixed voltage gains, which limits its use to low-power regulators. However, a better understanding of this technology by scholars; the introduction of soft-switched resonant converters; and the availability of low-cost ceramic capacitors that are small, inexpensive, and have a relatively low equivalent series resistance has resurrected the switched capacitor technology. Going from an unknown, a switched capacitor converter is now the favored replacement for the LLC converter in high-to midvoltage power stages of servers—as announced by Google.

The life of power electronics is full of surprises, and only the future will tell if the sudden glory of switched capacitor technology will remain.

This article would be incomplete without mentioning the disappointing power electronics technologies that burst into our lives with great expectations but did not fulfill their purpose. An example of a technology that did not fulfill its expectations is the piezoelectric transformer. The piezoelectric transformer seemed to be an excellent candidate for replacing the ruling magnetic transformer with its small size and weight, low EMI, excellent insulation, and low cost when (and if) mass produced. Many articles have been written on the device, and a number of companies began developing products. However, the promise did not materialize. Aside from some niche applications, i.e., ozone generators and sparkers, the piezoelectric transformer just cannot compete with the less glorious but trusty magnetic transformer.

An example of a magnetic transformer trumping a piezoelectric transformer is the standard wall charger. The piezoelectric transformer seemed to be perfect for this very popular application, but it failed—or at least has so far. Referring to $P = (\text{performance} \times \text{ease of use})/(\text{cost} \times \text{competitor})$, the piezoelectric transformer’s ease of use score is very low due to the finicky nature of the device, difficult-to-achieve regulation, and higher-than-expected cost. In any event, cost in $P$ is a necessary but not the dominant contributor to success.

No one can predict the future—but looking into the past is not just interesting but may teach us something about the future of power electronic technologies.

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