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Reflections On APEC 2016: GaN's Momentum, More Magnetics And An Inspiring Plenary

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At this year's APEC 2016, news about GaN power technology was probably more dominant than at any time in the past. Real product demos using GaN, new product and technology announcements, attention to GaN in the plenary, and other discussions all reinforced the impression that GaN power devices have arrived and the technology is making inroads in the marketplace. One of the tell-tale signs is a slight shift in the discussions, away from what the devices can do to what else is needed to support the design-in of GaN power transistors.

For example, at this APEC much attention was paid to magnetics and frequently the question was how to get magnetic components that will be suitable for the very high frequencies at which GaN can operate. Similarly there was more discussion about adopting power circuit topologies to suit use of GaN at higher frequencies.

Beyond highlighting GaN issues, this year's plenary talks were especially good—informative, thought provoking, funny at times, and in some instances—visionary. These talks reinforced the feeling that power electronics is currently a dynamic field with great growth potential. The various start-ups I met with also conveyed this impression.

Naturally, there were elements of the event that gave me pause such as seeing how semiconductor industry consolidation has shrunk the number of chip companies with very large exhibits. But at the same time, there always seem to be new companies in the exhibit and more on the waiting list. Also, the exhibition is probably more diverse than ever with nearly every type of power supply component (and subcomponent) represented.

The overall size of the exhibit—the number of exhibitors and the space—seems as big as ever (maybe bigger than ever). Speaking of size, the reported attendance was in the vicinity of 5000 attendees, another record. This too was one of the memorable aspects of this year's APEC. It does not seem like so many years ago that APEC could still fit in a spacious hotel. But the reality is, it outgrew such smaller venues several years ago and just kept growing. Can the day be coming when APEC requires a mega-venue like the Moscone Center?

GaN And More GaN

In previous years, the GaN start-ups showed mostly reference designs and their own demos, and occasionally a real product example from customers using their GaN devices. This year GaN device companies were showing multiple products from their customers. And these products were not just the familiar power supply types but also some cool, cutting-edge applications that are enabled by GaN's high performance.

For example, at EPC's booth there were displays of drones, remote-powered LED lights, LIDAR, envelope tracking power supplies and wireless chargers. Another company, Transphorm, had an LED studio light from Sumolight powered by their GaN devices and a 4-kW PV inverter from Yaskawa.

Perhaps, GaN Systems made the biggest splash with their display of the CE+T 2-kW inverter, which won Goggle's Little Box Challenge using GaN Systems' devices. They also had other interesting customer products on display including a 12-kW stop-start generator; a 97% efficient, ultra-compact electric vehicle charger; a multi-voltage, high-speed 1.5-kW motor controller and a high-power traction inverter using GaN power modules.

These types of demos reveal that GaN technology is being adopted, often in novel applications, and the industry is moving beyond demonstrating components to selling them. Meanwhile, the start-ups continue to make the case that they are proving GaN reliability through extensive device testing. EPC's recent announcement of their report documenting over 17 billion field device hours is an example. For another, see the discussion on Transphorm's reliability testing in "Clearing Up Confusion About GaN Power Transistors (Part 2): Proving Power GaN Reliability" in this same issue of How2Power Today.

There was also a major technology announcement on the GaN front from start-up Navitas Semiconductor, which up until APEC had been in stealth mode. In his plenary session talk, Navitas CTO & COO Dan Kinzer introduced what are described as the world's first GaN power ICs, which are fabricated in Navitas' proprietary AllGaN 650-V process. These ICs monolithically integrate a 650-V GaN FET with gate driver and logic circuitry.

According to the company, this integration will enable 10x to 100x higher switching frequencies than existing silicon circuits. Moreover, the company claims the new devices will allow designers to pursue higher frequency switching while also attaining high efficiency and low cost. For more on this news, see "GaN Power ICs Integrate Power FET With Gate Drive And Logic" in the Power Products section in this issue.

There were yet other GaN announcements that had attendees talking. Texas Instruments reported that it has "leveraged its existing manufacturing infrastructure and capabilities to qualify a 600-V GaN process." Here too the issue of reliability is a major aspect of the news with TI commenting that it "creates its GaN devices in a silicon-compatible factory and qualifies them with practices that are beyond the typical JEDEC standards to ensure reliability and robustness. With this 600-V process, TI will build out a portfolio of companion parts that will support high-voltage applications and new topologies."

There was also more GaN discussion in the plenary (in addition to Kinzer's talk.) In his plenary on "VHF Power Conversion," Anthony Sagneri of FinSIX discussed use of GaN devices in the context of developing power adapters that switch at high frequencies. This leads me to two other memorable aspects of APEC 2016—the attention given to magnetics and the very strong plenary session.

Magnetics And Topologies

Part of what made the discussions about GaN different this year was that they seemed to broaden beyond specifics of the devices as if to suggest there's already sufficient evidence that the device technology is real and commercially viable. Now the discussion seems to be shifting to what else is needed for GaN to be deployed successfully.

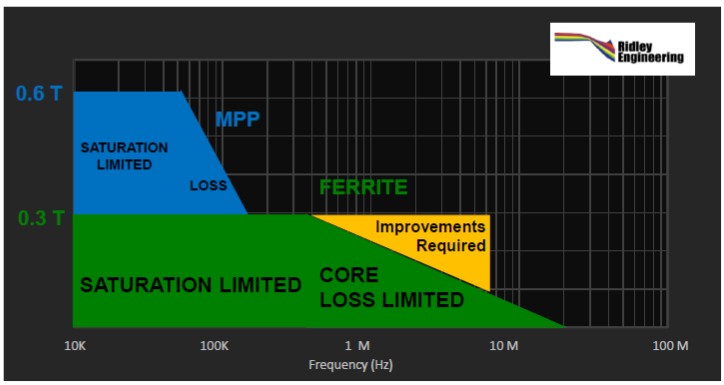
So, in the plenary talks and briefings I had with GaN vendors, the need for new, improved or optimized magnetics and power supply topologies came up. Not that this was totally new, but these issues seem to be getting more attention now. On the topology side, in his talk Kinzer noted the need to go from hard-switching to soft-switching topologies to minimize losses and achieve high efficiency at higher frequencies. In terms of magnetics, Kinzer noted the inadequacies of the existing magnetics core technology for achieving the high switching frequencies that GaN devices are capable of.

Speed Limit?

Navitas

Can Magnetics Rise to the Speed Challenge?

- Boundaries vary with material, DC/AC current mix, power, etc.
- Majority of mass production applications run 65kHz – 150kHz
- 5x frequency increase is within today's capability



Overall, magnetics received a great deal of attention at this year's APEC, starting with a special all-day workshop on Saturday (prior to the official start of the conference) hosted by PSMA and PELS. This workshop on "Power Magnetics at High Frequency – Solving the Black Magic." Focused on the "latest technology advances of magnetic materials, coil (winding) design, construction and fabrication techniques, characterization and measurement methods as well as modeling and simulation methods."

The workshop included presentations by notable speakers such as Charles Sullivan of Dartmouth, David Perreault of MIT and Ray Ridley of Ridley Engineering. It also included a structured problem session led by Dr. Khurram Afridi of University of Colorado Boulder, James Lau, CWS and Jenna Pollock that "discuss[ed] circuit design requirements through design trade-offs to final designs for different applications that require high efficiency in smaller physical volumes."

Then on Wednesday afternoon, there was an Industry session on "High Frequency Magnetics: Black Magic, Art or Science" with presentations from engineers in industry. These were in addition to the usual paper sessions on magnetics in the conference program (such as T13 "Advances in Magnetics" and T23 "Modeling of Magnetic Circuits and Systems") plus the numerous papers on magnetics scattered throughout the rest of the program.

However, the inclusion of a talk on magnetics in the plenary session, "The Future of Magnetic Design for Power Electronics" by Ridley really helped bring this topic to the fore. As he discussed the current state of magnetics and training in magnetics, Ridley made a number of memorable comments such as "Just about…everything we need to know to make magnetics better, has been discovered, analyzed, built, tested and *forgotten*." He went on to explain, "I see people solving the same problems again and again and they don't have the tools they used to have. So we need to…rediscover some of those."

He also pooh-poohed the *constantly* repeated description of magnetics (it's almost a mantra at this point), that magnetics is a black art. "There's no black magic in magnetics. It seems that way, but that's where the misinformation comes in and the confusion. There is some very complex math…[but only if] you choose that path. It doesn't have to be that complicated."

There was also a funny moment when Ridley posed the question of which of these two parties is more likely to design a better transformer? Will it be some recent engineering graduates, perhaps with advanced degrees, or Fred, who may not have a degree, but works down in the basement with a winding machine. As he came to Fred, a picture of a modest-looking fellow in a lab coat flashed on the big screen, bringing out the humor and irony in the fact that it's Fred who'll build the better transformer, because "he can actually make things."

From there the discussion got a little more serious with discussion of Maxwell's equations and what they mean, some history of magnetics developments, why few use Dowell's equations, and why we don't need to wait for new materials to create components for the new applications "if we use what we used to know."

If you missed the plenary session, you should be able to find Ridley's presentation online when the conference posts the video or slides. But my main takeaway from this plenary and other talks is that magnetics will remain a major topic of discussion at APEC in the years ahead.

A Very Strong Plenary

This year's plenary seemed much more interesting than in past years. It's hard to say exactly why that was the case. Maybe it was the discussion of high-frequency switching, which was central to several of the talks or the introduction of new technology like GaN power ICs. Certainly, it was very forward looking.

My favorite presentation was the one by Michael Harrison of EnPhase Energy, who spoke on "The Future of Power Electronic Design." Although the title is almost a generic one that might seemingly be applied to any APEC plenary talk, the content was somewhat of a revelation.

First of all, it elegantly captured certain truths about the potential of the power electronics field that are critical to understanding its relevance. Harrison described the proliferation of power electronics over the past decades by noting the rise in the amount of energy processed by power converters.

"In the 1970s, less than 1% of electrical energy flowed through electronics and that number had increased to 30% by 2005. And it's currently predicted that by 2030, 80% of the electrical energy will flow through power converters of one form or another."

Harrison went on to note that the growth in power electronics is outpacing the growth in energy consumption, predicting that "we'll get to a point sometime in the future when the total amount of energy processed through power electronics will actually exceed the global energy production."

Harrison explained this with an example of a renewable energy (PV)-powered house that illustrates how "power electronics will inevitably process the same energy several times over." Naturally this trend has profound implications. As Harrison said, "Someday in the future, we may see the energy industry as a subset of the electronics industry."

While it's not a perfect analogy, Harrison's description of the growth of power electronics, almost feels like a Moore's Law for power processing, perhaps one where we trade transistors for joules. But more importantly, his explanations offer of a simple, yet powerful means of expressing the growing importance of the whole power electronics field.

There was more to his presentation, as Harrison discussed his company's developments in PV microinverters, more on wide-bandgap technology, the "power conversion paradox" (converter physical size determines parasitics, which determine losses, which in turn determine physical size through thermal constraints) and predictions about power converter performance characteristics in 20 years.

Perhaps these latter details from Harrison's talk point me to another reason why the plenary was so interesting, the plenary speakers came mostly from within the power electronics industry and spoke from their experiences within the field even as they looked ahead to the future of the field.

There was, however, one presentation that deviated from the usual plenary themes. In his talk, David Hill of Power Clinic posed the question "Why Do Power Supplies Fail? – A Real-World Analysis." This presentation served as an interesting reality check on the challenges that power supplies face in the real world and a reminder of the importance of design for reliability—an issue (at least at the power supply level) that gets relatively little attention at power electronics conferences. Once posted, Hill's talk will provide another reference for those seeking experience-based knowledge of why power supplies fail and how to prevent those failures.

Kudos to all who contributed to selecting speakers and organizing this year's APEC plenary session.

New Startups And New Products

In addition to Navitas, I encountered a few startups at this year's conference. One was a spinout of MIT named Arctic Sand, which came out of stealth mode to disclose a "Precision Pipeline Converter" architecture and an LED driver IC (the ARC1C0608) based on that architecture.

Another was GLF Integrated Power, a Santa Clara, Calif.-based company that's developing ultra-efficient load switches. The device they discussed with me, the GLF71311, has extremely low leakage current—5 nA typical—which can be leveraged to extend battery life in wearable and IoT applications. It's not easy to make a load switch sound cool—but they did. Low-power analog circuit designers may appreciate their slogan, "Breathing life into the IOT, one nanoamp at a time."

Another start up, which I had met at the previous APEC was the Irvine, California-based Semitrex. Michael Freeman, their CEO/CTO, gave me an update on their development of the Tronium architecture Power Supply System(s) on a Chip (PSSoC), which promises a radical improvement in efficiency and standby power for ac-dc power supplies. Their chip uses a novel building block called the Muxcapacitor to perform voltage pre-regulation, stepping down the primary voltage through a series of "cascading voltage reduction capacitors."

A version of their chip for the IoT will make ac-dc and dc-dc converters highly efficient (>97%), producing 0.5 to 5 V at 10 to 500 mA, and eliminating the transformer, instead relying on capacitive isolation. According to Freeman, their chip will be in production next year. Related to this, Freeman also gave a talk in the "Very Low Power Applications" industry session titled "'A New Way to Power the World with High Efficiencies" in which he described his company's core technologies.

These startups show that wide-bandgap technology is not the only route to semiconductor and power supply innovation, that there's interest in and funding for other power technologies, and the fabless model is alive and still the most popular approach to manufacturing new chips.

There were other interesting companies, new products and technical developments in evidence at this year's APEC. I'll be reporting on more of these happenings in upcoming issues of How2Power Today.