Data Center Frontier Special Report

Optimizing Data Center Power Efficiency

How forefront GaN technologies show significant benefits for data center refreshes

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Summary

The data center is a fundamental component of today's businesses, without question. As such, the data center's performance and reliability are top concerns for corporations and small companies alike. The growth of data generation and use puts mounting pressure on facility managers to intelligently adapt, as they strategize on how to increase efficiency while controlling operational budgets.

Power efficiency in terms of power supplies and power systems within other equipment is an area sometimes deprioritized during refresh cycles. The reasons for this may range from minimal or retracted regulatory requirements to more pressing issues with other complex data center systems and controls. For the most part, the common belief is that the status quo is good enough today as power conversion technology is what it is — reaching efficiencies of 90 percent or higher.

Times are changing, though.

For the first time in decades, emerging semiconductor technologies are proving to be more efficient than silicon while reducing overall power system costs (an appealing selling point for power system manufacturers).

Power currently accounts for approximately 10 percent of data center operating expenditure (OPEX) — a number expected to rise to 15 percent within five years. Related, Gartner estimates that ongoing power costs are rising at least 10 percent per year due to cost per kilowatt-hour (kwh) increases and underlying demand, especially for high-power density servers. And, all of this demand increase is often expected to be accommodated in same-size or smaller facilities.

Data center managers can keep up with this demand by taking advantage of every opportunity available to them to get more out of their systems, end-to-end — more performance, more power, more efficiency.

As the age of electronics progressed, silicon became the power semiconductor material of choice given its superior electrical properties and far less expensive production cost compared with the vacuum tube. However, as per Moore's law, the semiconductor industry is reaching the point where silicon power can no longer deliver better performance. In short, we're capping out on silicon-driven power efficiency.

Good news exists for data center managers, though. For the first time in decades, emerging semiconductor technologies are proving to be more efficient than silicon while reducing overall power system costs (an appealing selling point for power system manufacturers). This means that better data center solutions are materializing — solutions that address mission-critical power density and efficiency challenges while maintaining attractive data center power economics.

Welcome to the age of Gallium Nitride (GaN), the GaN transistor and next-generation power efficiency.

Contents

As we enter this new phase, data center and IT leaders have an opportunity to employ cutting-edge technologies that can impact efficiency and improve overall performance in their facilities. Again, with refresh cycles occurring roughly every 36 months, now is the time to evolve your thinking during the systems and solutions evaluation stage. So, as you consider upgrades within your data center, ask yourself the following:

1. Do currently deployed solutions still provide the best possible benefits?
2. How does currently deployed technology impact power requirements and supply?
3. What next-generation solutions exist that can improve power efficiency?
4. Have my suppliers explained the limitations of current power solutions and assessed whether new solutions, like those built using GaN, can make a difference?

Here is where this guide picks up the conversation. In it, we will examine the state of the data center industry as far as power is concerned, growth around the data center model, and where new technologies like GaN make direct power efficiency impacts. Importantly, we'll define GaN and discuss how its inherent benefits disrupt the conventional power conversion market as demonstrated by real-world case studies.

Introduction

> The rising need for complex data management, security and other software solutions is a continual and heavy demand on data center resources.

As data becomes the lifeblood of any organization, the data center becomes the heart. Managers demand new technologies to help their organizations respond to changing business conditions with agility and flexibility. This is where the refresh cycle comes into play.

The refresh cycle has historically been managed with a systematic approach that in recent years has arguably prioritized power system performance as a secondary concern. Perhaps this is because minimal innovation has occurred in this area and current solutions perform well enough.

> A recent NRDC report indicates that data center electricity consumption is projected to increase to roughly 140 billion kwh annually by 2020 — the equivalent annual output of 50 power plants — costing American businesses $13 billion annually in electricity bills.

However, the rising need for complex data management, security and other software solutions is a continual and heavy demand on data center resources. The correlation between all of these computing solutions and power consumption is a given. So, during the refresh process, a necessary part of the review must revolve around efficiency. This metric can help lower power usage effectiveness (PUE), increase density and even support new kinds of business use cases. As this report will discuss, a key question to ask is, "Are GaN solutions right for me and are we ready to deploy this kind of architecture?"

Data center administrators are being tasked with delivering much more while still retaining optimal efficiency levels. Remember, data center power consumption is growing. In fact, IDC reports that energy consumption per server is growing by 9 percent per year globally as growth in performance pushes demand for energy. As more organizations place their environments into the data center, energy efficiency and data center management have become extremely important for multiple reasons. Not only are data center administrators working hard to cut costs, they're also working overtime to minimize management overhead and improve infrastructure efficiency.

Consider this: A recent NRDC report indicates that data center electricity consumption is projected to increase to roughly 140 billion kwh annually by 2020 — the equivalent annual output of 50 power plants — costing American businesses $13 billion annually in electricity bills.

Similarly, the same report indicates that U.S. data centers use more than 90 billion kilowatt-hours of electricity a year, requiring roughly 34 giant (500-megawatt) coal-powered plants. Global data centers used roughly 416 terawatts (4.16 x 1014 watts —or about 3% of the total electricity) last year, nearly 40% more than the entire United Kingdom. And this consumption will double every four years.

The latest AFCOM State of the Data Center report lends deeper insight into future usage. The majority of respondents indicate rack power density is increasing. The estimated mean target for rack power density is 7.3 kW. The report also indicates very little growth around actual data center capacity requirements. This means that data center leaders are actively looking at new solutions that can offer greater amounts of efficiency while taking up less space.

So, how do you keep up with the pace of demand? How do you ensure that your data center can support business requirements, power efficiency and density? **You deploy next-generation tools, which elevate your efficiency levels as well as data center control capabilities.**

The power electronics industry is no longer status quo. Semiconductor pioneers have taken this mature, conservative market and reignited innovation.

Being cognizant of such breakthroughs can have considerable impact on your bottom line over time. Perhaps more importantly, as power levels increase, power supplies within infrastructure components, like servers and other IT computing products, that are built using GaN can give you the power density required to maximize your rack space and, ultimately, your overall data center performance.

This is the age of GaN.

In this paper, we will review the major changes that have happened within the data center, particularly as they concern power and density.

This paper will address:

1. The state of data center power and what to expect moving forward
2. GaN's fundamental attributes and benefits
3. Maturity and reliability of GaN products
4. GaN's potential operating expenditure impact
5. Demonstrated GaN benefits in real-world use cases
6. How to leverage GaN in data centers today

SECTION 1: The State of the Data Center

Nearly every data center project — whether related to facility space, equipment implementations, software rollouts, infrastructure upgrades or other areas of responsibility — today revolves around the demand for more utilization through improved efficiencies (meaning do more while remaining economical). To achieve this, cross-function data center managers are adopting smaller facility footprints, new architecture and infrastructure design concepts, and more power-efficient solutions.

However, while power efficiency is routinely considered as it interplays with all data center elements, power costs alone only account for approximately 10 percent of a facility's OPEX today. What's more, data center managers are taxed not only with identifying smarter technologies and physical spaces, but with implementing complex controls and training staff to manage them, which means power ranks lower on the list of priorities, perhaps fairly so until now: That OPEX percentage is expected to rise to 15 percent within five years with no clear or guaranteed limit, considering the influencing factors mapped out next.

Cross-function data center managers are adopting smaller facility footprints, new architecture and infrastructure design concepts, and more power-efficient solutions.

STATISTICALLY SPEAKING

Inarguably, data centers are the hub of most organizations small to large. And, changing business conditions continue to put more and more demand on the data center rack by rack. For context, 70 percent of respondents covered in AFCOM's *State of the Data Center Report 2018* indicate that rack power density increased over the past three years, with 21 percent noting it increased significantly. Related, the estimated mean target for rack power density across all centers is 7.3 kW.

In addition, the data center landscape is changing due to the newly trending edge computing designs. Edge computing directly impacts the way smaller data center locations are deployed, from rack density to power consumption. In fact, edge data centers are designed to be more dense, capable of supporting various types of workloads. Remember, the entire purpose behind edge is to place data centers close to where data is being created and consumed. This means that, although there will be a greater number of data centers deployed, they must be smaller and hyper-efficient to address the fact that they may be erected in locations that cannot accommodate resource requirements for large-scale data centers. So, for evolving designs like edge, data center managers will benefit from advanced power solutions delivering higher performance, higher power efficiency and greater power density.

Edge computing: A high-level definition

Edge computing allows an organization to process data and services as close to the end user as possible.

When researching dedicated edge facility demands, the stats indicate clear growth in the edge data center industry as well as requirements around power efficiency:

- Thirty percent of AFCOM report respondents have already deployed between six and 10 edge locations; 57 percent stated that they'll have 21 to 40 potential edge locations within 36 months.
- The average power **density for edge deployments** is currently 6kW to 10kW per rack, as indicated by about 34 percent of respondents.

> U.S. data centers use more than 90 billion kilowatt-hours of electricity a year, requiring roughly 34 giant (500-megawatt) coal-powered plants.

Meanwhile, the same report also reveals that data center capacity requirements as a whole show little growth. (As mentioned earlier, the idea is to "do more while remaining economical.")

This all suggests that data center managers overseeing architecture, infrastructure and IT are actively looking for solutions that offer more performance and better efficiency while taking up less space. This is with good reason given that power consumption increases as rack density increases.

Data center power use is escalating. IDC research shows that energy consumption per server increases 9 percent per year globally as performance growth pushes demand. Related, NRDC reports that global data centers used roughly 416 terawatts (4.16 x 1014 watts—or about 3% of the total electricity) last year, nearly 40% more than the entire United Kingdom. And this consumption will double every four years.

NRDC also reports that U.S. data centers use more than 90 billion kilowatt-hours of electricity a year, requiring roughly 34 giant (500-megawatt) coal-powered plants.

DatacenterDynamics also notes that data centers currently consume about 31 GW of energy. The average total power to rack is about 4.05 kW today, with 58 percent of racks consuming up to 5 kW per rack; 28 percent consuming between 5 and 10 kW per rack; and, the remainder consuming more than 10 kW per rack.

Furthermore, Gartner estimates that ongoing power costs are rising at least 10 percent per year due to increasing cost per kWh and underlying demand, especially for high-power density servers. Note that total power costs currently account for approximately 10 percent of data center OPEX, a number expected to rise to 15 percent within five years.

In short, power density demands are ramping as power consumption and cost are mounting, with no foreseeable end. This means identifying more power efficient solutions at every turn is critical to ensure that power's ranking remains lower on the OPEX list.

RECOGNIZING OPPORTUNITY

For the better part of a century, power electronics relied on silicon semiconductors to convert energy to power. Generation after generation brought about better technology efficiencies and performance, which, in turn, yielded innovation around high-voltage power supplies and power systems within equipment that positively aided data centers.

Trench silicon metal oxide semiconductor field effect transistors (MOSFETs) proved optimal for low to intermediate voltage applications. Superjuncton MOSFETs served as the silicon solution for higher voltage applications, given their ability to switch faster with less resistance (mΩ-cm2). In 2012, this technology ultimately enabled development of the first 80 Plus Titanium server power supply — a power supply running at a remarkable 96 percent efficiency.

However, that's essentially where the power electronics industry has remained to date — and where it could, in theory, stay as silicon is reaching its limits per Moore's law. The technology has been optimized to its maximum potential in many cases. To get more performance or efficiency out of silicon MOSFET power systems would mean incurring unreasonable costs that could not be recovered in end product sales.

Moore's law: High-level definitions

Moore's law observes that the number of transistors in integrated circuits (ICs) doubles every two years, logically driving down consumer device cost as demand rises. Related is Moore's second law, which observes that as consumer costs go down, development and production costs inversely rise. Often associated with Moore's law is the additional concept that IC performance doubles every 18 months. Collectively, these laws indicate that, eventually, there will be an end point at which transistors will reach their limits of performance to cost viability. The currently accepted end date is the year 2025.

> Use of rack mount power supplies and other equipment built using high-voltage GaN can produce the power density required to maximize rack space and, ultimately, a data center's overall performance.

Luckily for data center managers, the power electronics industry is no longer accepting the status quo. Semiconductor pioneers have taken this mature, conservative market and reignited innovation with high-voltage GaN, a disruptive technology that, when compared to silicon:

- Increases power density by as much as 40 percent
- Increases power efficiency of the PSU rectifier stage to more than 99 percent
- Switches two to three times faster
- Reduces heat dissipation
- Reduces overall power system cost

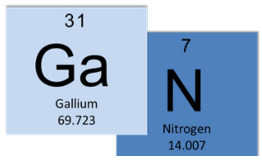
GaN is the new high-efficiency power semiconductor material that operates cooler, smaller and faster.

Being cognizant of this breakthrough can have notable impact on a data center's bottom line over time, which will be demonstrated in the next section. Perhaps more importantly, use of rack mount power supplies and other equipment built using high-voltage GaN can produce the power density required to maximize rack space and, ultimately, a data center's overall performance.

GaN use can mean higher performance, higher power output in the same space. Alternatively, GaN use can mean the same performance and the same power output in a smaller space. Increase the number of racks, decrease the number of racks… for data center managers coping with the intense demands noted earlier, flexibility can breed opportunity. Lastly, innovative GaN-based solutions are already in the market, demonstrating their benefits in real-world applications.

It's time to confidently let go of legacy technology and embrace powerful next-generation solutions.

SECTION 2: Leaving Legacy Behind – Understanding GaN



Gallium nitride (GaN) is a wide bandgap semiconductor material that has been in use since the 1990s. GaN initially found its way into light emitting diodes (LED) as well as optoelectronics. GaN's very high breakdown voltages, high electron mobility, and saturation velocity has also made it an ideal candidate for high-power applications

In 2010, the first low-voltage GaN transistors hit the market. In 2012, the first high-voltage GaN FETs targeting 650 Volt (V) applications became available, which is where GaN gets interesting. At this power level, GaN's inherent attributes enable it to displace silicon in numerous AC to DC applications designed for server, automotive, broad industrial, computing, renewable energy and telecom. Adoption is gaining momentum in these markets as confidence in the technology's reliability and performance rise.

Manufacturers of power supplies, servers and other power-driven equipment typically vet power converter technologies based on four key pillars. Viewing GaN in this light provides a fundamental understanding of the value proposition that GaN-based solutions can bring to data center applications.

Pillar One: Quality and reliability

Heavily-stressed power systems like those used in data center equipment and infrastructure must operate reliably. Power conversion technologies, therefore, must first and foremost exhibit high quality and high reliability. Will transistors fail under high-stress conditions? What is a transistor's average life span? Will transistor performance degrade over time and, if so, how much? To determine answers to these and other questions, semiconductor leaders put devices through industry-standard qualification tests and, in the case of high-voltage GaN pioneer Transphorm, extended rigorous tests to assure product reliability.

JEDEC (general market) and AEC-Q101 (automotive market) are trusted industry qualifications testing a transistor's infant mortality rate (device interactions between package mold compound materials, lead frames, die attachments).

Lifetime reliability tests determine the GaN solution's intrinsic capabilities within extreme temperature and voltage environments. They involve accelerating normal life cycle factors to identify failure rates over time (e.g., FIT, MTBF and PPM rates).

Temperature cycles, power cycles, high-temperature gate bias, high-temperature direct current, high-voltage overstress, and high-temperature reverse bias (including destructive physical analysis), unbiased accelerated stress testing, wire bond integrity, and much more are all analyzed. Note: GaN exhibits different failure modes than silicon. And, as many of these tests were designed for silicon, select tests such as High-Temperature Direct Current, High-Temperature Over Stress, and Low/High-Temperature Reverse Bias are necessary to accurately determine GaN-specific lifetime reliability.

Certain GaN power transistors have successfully gone through all of the above discretionary tests, satisfying basic requirements for use in real-world applications, including earning JEDEC and AEC-Q101 qualifications. These transistors are designed and manufactured by Transphorm. The company's quality and reliability data are publicly available as they build confidence in GaN as well as inspire application engineers to push the envelope with respect to system features and designs.

GaN fact:

Transphorm manufactures the market's first JEDEC and AEC-Q101 qualified high-voltage GaN platform.

Pillar Two: Performance

Performance can be viewed in three segments: efficiency, density and system cost.

GaN transistors convert energy to usable power at traditional frequencies, as they internally switch two to three times faster than silicon transistors. High switching speeds result in lower crossover losses; simply put, less energy is lost/wasted during conversion. Collectively, these advantages then result in higher power efficiency, increased power density with the same thermal footprint, and the ability to reduce size, creating a lighter weight, smaller overall system that can lead to still more benefits.

Related, GaN can be used in various power system topologies. However, GaN uniquely enables power system engineers to use a hard-switching topology with a specific power factor correction technique (bridgeless totem-pole) that is, in most cases, impractical with silicon. This system configuration maximizes the GaN's total potential (efficiency, power density and size) while lowering system component count, and, thereby the overall system cost.

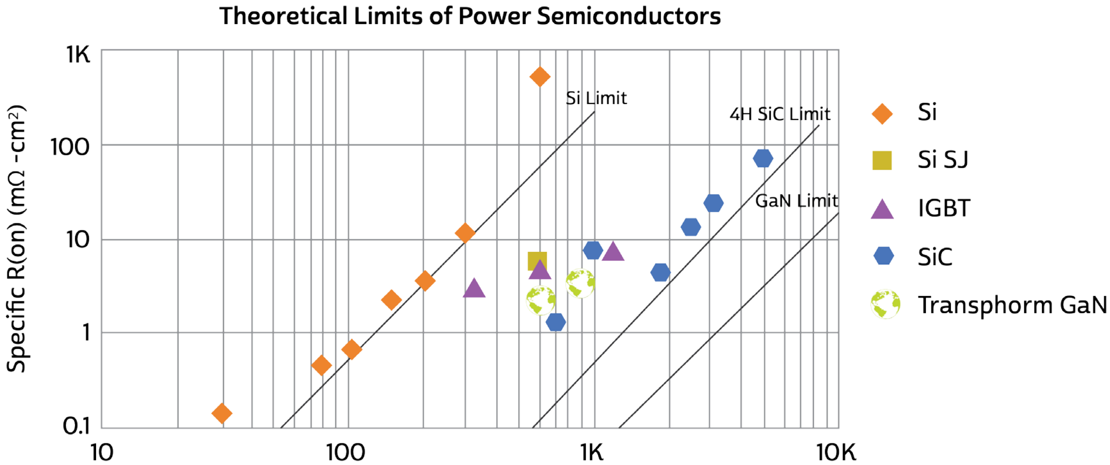


Figure 1: Theoretical limits of power semiconductor materials (GaN, silicon, and silicon carbide) show that GaN reaches notably lower specific ON resistance values versus silicon.

Outside of the hard-switched bridgeless totem-pole PFC, GaN can also be used in soft-switching topologies. In these applications, GaN again offers lower crossover losses and reduced output capacitance, therefore having the ability to operate efficiently at lower load currents and be driven at higher frequencies than silicon to achieve performance increases.

This is all a cursory explanation as to how GaN-based power systems can dramatically increase power density over silicon-based power systems, generating more power output in the same-sized system or the same power output in a smaller-sized system. These are key capabilities desired, for example, by power supplies seeking greater than 80 PLUS Titanium efficiency levels.

On the topic of performance, specific on-resistance is a standard used to show MOSFET technology evolution. As seen in Figure 1, silicon MOSFETs have hit their theoretical limits. Related, though silicon carbide (SiC) — another high-voltage alternative material — is coming closer to its limits, GaN still has a way to go.

Pillar Three: Production

Though introduced in recent years, high-voltage GaN is in production and accessible. In fact, 6-inch wafers are produced in a number of fabs with manufacturing lines dedicated to GaN's unique requirements.

What's more, reputable power supply and industrial equipment manufacturers are in production — Bel Power, CORSAIR, Seasonic, Yaskawa — selling groundbreaking GaN-based products that literally demonstrate GaN's ability to increase efficiency and power density. For example, Seasonic's new high-efficiency 1.6 kW platform uses leading GaN technology. This platform yields a 99 percent PFC efficiency and will be deployed in Seasonic battery chargers as well as catalog Seasonic PC, server and gaming power supplies. Additional use cases will be outlined in a later section.

Pillar Four: Cost and technology evolution

Leaders in the power space have been researching and developing high-voltage GaN for a decade or more. In fact, the GaN technology specifically referenced as examples in this paper is third-generation. High-voltage GaN suppliers have published real-world use cases based on customer products available in the market. (Consider this: When going through a data center refresh cycle, you don't have to work with "up-and-coming" solutions that may or may not stand the test of time.)

The generational improvements have not only increased performance, quality and reliability highlighted above, they have also enabled transistor price reductions year over year. This is an important outcome as it demonstrates that high-voltage GaN innovation and volume increases will drive down cost. This bodes well for the technology's overall ROI factor and market longevity.

SECTION 3: Decrease OPEX Using GaN

Understanding why power system manufacturers view GaN as an attractive technology only sets the stage for understanding GaN's literal potential impact in a data center environment.

The following hypothetical scenarios are calculated using methods outlined in the white paper: *A Simple Model for Determining True Total Cost of Ownership for Data Centers*. Notably, they only demonstrate effect on a simple data center profile, understanding that there are far more complex facility designs and power architectures.

The example data center consumes about 4.4 MW of power.

Silicon-based data center profile

- PSU power efficiency: 94 percent 80 Plus Platinum
- Current deployment: 9,167 servers x 500 W
  - Rack power = 16 kW
  - Number of racks = 160
- Floor space: 40,000 ft2
- Server capital cost savings: baseline
- Server direct cost savings (electricity): baseline

Keeping the data center at the same power consumption level of 4.4 MW, introducing high-efficiency GaN power supplies has the following impact:

GaN-based data center profile

- PSU power efficiency: 96 percent 80 Plus Titanium
- Current deployment: 8,800 servers x 500 W
  - Rack power = 16 kW
  - Number of racks = 153
- Floor space: 38,250 ft2
- Server capital cost savings: $73,400
- Server direct cost savings (electricity): $79,200/year

The change in power semiconductor choice equates to:

- A 2 percent increase in power efficiency
- A direct savings on electricity of $9 per server, per year
- A capital cost savings of $200 per server
- Reduced build-out costs for a fully commissioned facility of $1M

With higher efficiency power solutions, marked savings in OPEX and capital expenses can be realized.

SECTION 4: High Voltage GaN Use Cases

High-voltage GaN power applications are in production and performing as intended, legitimizing the previously outlined value propositions. Use cases follow that demonstrate benefits in power supplies for high-end consumer computing and enterprise server and network applications, setting a true baseline for what can be realized within data center equipment. Interestingly, the consumer computing supply originally targeted PC gamers, though quickly found a home with cryptocurrency mining enthusiasts and artificial intelligence applications due to its unprecedented performance.

CUSTOMER: CORSAIR

Customer Product: AX1600i Power Supply Unit

Target Market: Consumer Computing/PC Gaming

Market Impact: First Known GaN-based PC Computing Power Supply

GaN Supplier: Transphorm

Full Press Announcement: Transphorm GaN Moves into PC Gaming Market with CORSAIR

Overview: CORSAIR supplies the PC gaming community with high-performance peripheral and computing products for custom PCs. In January 2018, the company launched its first high-voltage GaN power supply unit (PSU) — the AX1600i — establishing a new class of AC to DC high-end computing PSUs.

Dubbed the "Emperor of Efficiency" by AnandTech, the new PSU achieves greater than 99 percent efficiency in the rectifier stage and earns a rating of better than 80 PLUS Titanium when operating at a low-line 115 V.

When compared to its award-winning predecessor (the AX1500i), the AX1600i offers the following GaN-driven benefits:

- 2 percent AC to DC efficiency increase, yielding >99 percent
- 100 W power increase from 1.5 kW to 1.6 kW
- 6.3 percent reduced system cost from 0.30 $/W to 0.28 $/W
- 12.5 percent smaller enclosure (by 25 mm)
- Same thermal performance (50°C continuous output at full load)
- Same PSU retail price for higher performance
- A 10-year warranty

NOTE: Previous CORSAIR power supplies used silicon superjunction MOSFETs in an interleaved PFC. The AX1600i uses high-voltage GaN in an interleaved bridgeless totem-pole PFC.

"Our objective was to take an already award-winning PSU and make it better," explained Jon Gerow, PSU R&D manager, CORSAIR. "We aimed to maximize output from any PC running on a 115V mains. To do this was, we had to adopt innovative methods and materials. GaN ultimately gave us the boost in performance, efficiency and size we wanted along with the high quality and reliability we needed to confidently release the AX1600i to our customers."

Market Response:

"The Corsair AX1600i is the best PSU that money can buy today, period." – Tom's Hardware

"Corsair managed to again shake up the PSU market with another masterpiece. It is the Ferrari among PSUs, combining high performance in all sections with incredibly high efficiency throughout."
- Tech Powerup

"The outworldish efficiency of the Corsair AX1600i allows it to deliver similarly astonishing thermal performance as well." – AnandTech

CUSTOMER: BEL POWER SOLUTIONS

Customer Product: TET3000 Power Supply Unit

Target Application(s): Enterprise Reliability Server, Router, Network Switching Subsystems

Market Impact: First Known GaN-based Enterprise-level AC-DC Power Supply

GaN Supplier: Transphorm

Full Press Announcement: Bel Power Solutions Introduces First-Ever AC-DC Power Supply Using Transphorm GaN FETs

Overview: Bel Power Solutions provides intelligent, efficient and reliable AC to DC and DC to DC power conversion devices. Applications range from board-mount power to system-level architectures for servers, storage, networking, industrial and transportation. In May 2017, Bel Power released the first GaN-based AC to DC front-end PSU, the TET3000. The product is certified for 80 PLUS efficiency and earned a CE Mark per the European Commission's Low Voltage Directive, having achieved a greater than 96 percent efficiency with a volume power density of 31.7W/in^3.

The TET3000 is 2.72 x 1.59 x 21.85 inches, small enough to meet 1U end-system design requirements. And, when compared to a standard, silicon-based interleaved boost converter, the new PSU delivers the following GaN-driven benefits:

- Higher power density: 50 percent improved inductor utilization and lower component count deliver the same power in a smaller footprint.
- Higher efficiency: Faster switching speeds lower crossover losses by 20 percent to 30 percent.

"Bel Power's legacy of leading the global power management industry is built on responsible innovation that empowers our customers," said Alain Chapuis, CTO, Bel Power Solutions. "The TET3000 is a result of that commitment. After considerable R&D weighing various semiconductor materials and power system designs, GaN proved the most reliable, highest performing solution possible today. In turn, our customers gain access to a next-generation power supply that stands to outperform incumbent solutions while delivering a greater ROI."

SECTION 5: Leveraging GaN – How to Get Started

Foresight is invaluable to any forward-thinking strategic business leader, whether they operate in the data center industry or elsewhere. Pre-empting the capping out of silicon-driven power is an opportunity for data center leaders to design future-proofed facilities that maximize performance and output at every level. Consider that power supply efficiency — particularly when gained through the use of GaN — affects more than just the power supplies themselves. It also affects cooling and space efficiency as power density increases and cooling loads decrease.

Proving the technology's viability, high-voltage GaN applications demonstrate the potential positive impact from OPEX to power output. The market will see more product manufacturers releasing servers, power supplies and other end equipment that leverage this semiconductor technology's benefits. Related, as explained earlier, these manufacturers often source Transphorm, as it is currently the only high-voltage GaN manufacturer offering qualified, high-reliability third-generation transistors. Trusted Transphorm transistors deliver:

- **Bi-directional switch.** Ability to use Bridgeless Totem-pole topology efficiently
- **Faster devices.** Lower cross over switching losses
- **Lower capacitance.** Reduced losses when charging and discharging devices
- **Less drive charge needed.** Reduced gate drive requirements, which improves the circuit's efficiency and ease of driveability

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In short, the new power semiconductor technology can translate to better data center performance and efficiency, as it reliably handles growing workloads.

The takeaway for data center and IT decision makers is simply this: During your next refresh cycle, consider a "bottoms up" approach. Explore whether supplies and other IT equipment you are vetting deploy GaN. Research what's available to you. Ask the right questions of your suppliers.

While this is a niche area within the data center's overall infrastructure and IT plan, making small changes at this level may impact decisions you make at more prominent levels. If you have more efficient main power sources, cooler supplies, smaller supplies, what changes can you make elsewhere to produce a higher performing, more competitive data center overall?

As you embark on your next refresh cycle, evaluate GaN as a technology that can make a real difference. Educate yourself, and start the conversation with your suppliers and colleagues.