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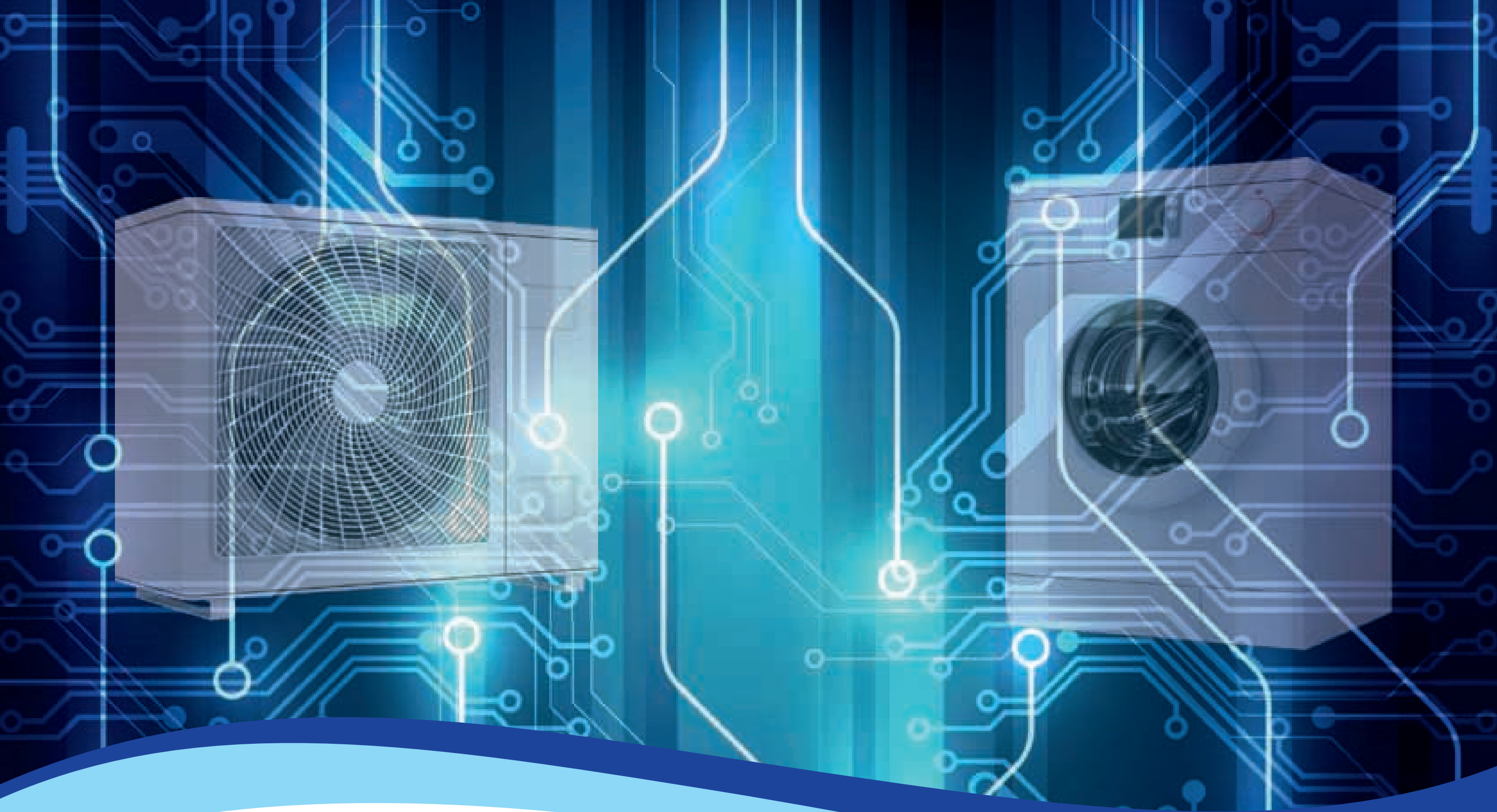
AUTOMOTIVE POWER

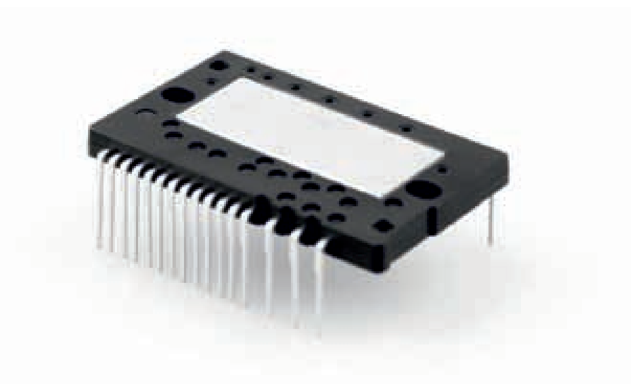
Dual Battery Require Bi-Directional DC/DC Controllers

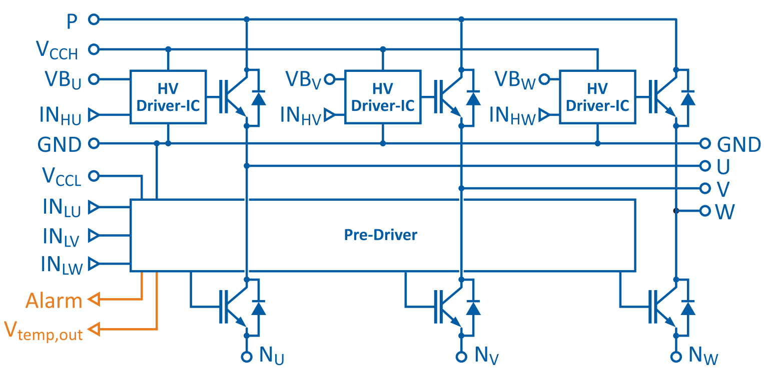
THE EUROPEAN JOURNAL FOR POWER ELECTRONICS AND TECHNOLOGY

Also inside this issue



Fuji Electric‘s X-Series - 7G IGBT





Low Power IPM for 600V/15A, 20A, 30A with High Voltage Driver-IC

Main features

- Reduced power losses
- Expanded current rating
- Increased output power
- $T_{j(op),max}$ = 175°C
- $T_{storage}$ = -40 ~ 175°C

Built-in protection functions

- Under voltage protection → self shutdown & Alarm
- Short circuit protection → self shutdown & Alarm
- Temperature monitoring → $V_{temp,out}$
- Overheating protection → self shutdown & Alarm

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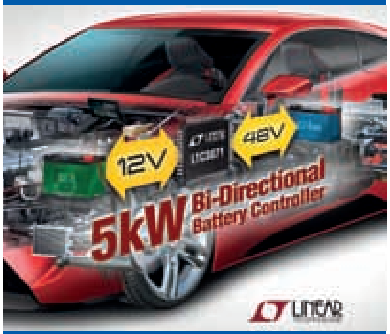
COVER STORY



Dual Battery Require Bi-Directional DC/DC Controllers

With fuel economy regulations tightening and autonomous-driving capability with connectivity proliferating, the old-fashioned 12 V automotive electrical system has reached its usable power limit. Furthermore, a vast increase in automotive electronic systems, coupled with related demands on power, has created an array of new engineering opportunities and challenges. As a result, the 12 V lead-acid battery automotive system with its 3 kW power limit has been supplemented. A newly proposed automotive standard, LV148, combines a secondary 48 V bus with the existing 12 V system. The 48 V rail includes an integrated starter generator (ISG) or belt start generator, a 48 V lithium-ion battery and a bi-directional DC/DC converter for delivery of up to 10 kW of available energy from the 48 V and 12 V batteries combined. This technology is targeted at conventional internal combustion automobiles, as well as hybrid electric and mild hybrid vehicles, as auto manufacturers strive to meet increasingly stringent carbon dioxide emissions targets.
More details on page 28.

Cover photo supplied by Linear Technology, USA

Powering the Automotive Industry

The total market for automotive power semiconductors (discretes, power modules and power ICs) will increase from $5.5 billion in 2016 to more than $8.5 billion in 2022. Revenue will grow at an annual rate of 7.5 percent from 2015 to 2022, increasing electrification in vehicles generally – and in hybrid and electric vehicles specifically – is energizing the market for power semiconductors in vehicles, market researcher IHS predicts. Anticipated growth in sales of hybrid and electric vehicles in the next few years will spur power semiconductor sales to climb by CAGR 9.6 percent from 2015 to 2022 across all vehicles, taking Powertrain's market share up to 54 percent of the total market. Discrete IGBT power transistors account for most of Powertrain power semiconductor revenue, but increased integration of discretes into modules will cause IGBT power module sales to increase at a much faster rate.

Demand for hybrid and fully electric vehicles was extremely encouraging worldwide in 2016. That applies especially to China, which is now the biggest market for electromobility. The association of Chinese vehicle manufacturers forecasts sales of around 400,000 so-called "new energy vehicles" in total in 2016, an increase of roughly 20 percent.

At Infineon the Automotive segment generated revenue of €2.651 billion in 2016, an increase of 13 percent over the previous year. Power semiconductors play a major technological role in limiting global warming to well below two degrees. Compound semiconductors, especially those made of Silicon Carbide, will enable more energy-efficient solutions in the future. This applies in particular to electromobility and the generation of renewable energies. The planned acquisition of Cree/Wolfspeed will enhance our portfolio with know-how and products in the field of compound semiconductors. Silicon Carbide has a huge potential in order to increase efficiency of the inverters used in electromobility. Here Infineon will set a focus on their 1200 V SiC Trench MOSFETs introduced at PCIM 2016 and in particular on higher battery voltages around 800 V such as proposed by Porsche with the Mission E sportscar.

But this possible business is only a small fraction of the EV market, the main music will be played in mild hybrid electric vehicles. A first step towards automotive electrification respective hybridization is been seen in the move to a 48 V board net. By 2020, automotive 48 V systems will help reduce emissions by up to 15 percent, improve fuel consumption, capture energy typically lost while braking, and provide torque in the low RPM range for start-stop mild hybrids. The 48 V power net is needed to manage the next generation of energy efficient electrical systems that require more power than available with the existing 12 V subsystem. To reduce weight, many traditionally mechanical/hydraulic systems such as power steering, roll stabilization, heating, and air conditioning will be converted to 48 V electrical drive. A new electric turbocharger will provide on-demand horsepower and torque, enabling the use of smaller more efficient combustion engines without sacrificing drive ability. A high-power starter/generator will replace the 12 V alternator, reducing noise and vibration during engine starting while allowing regenerative braking to recapture up to 4x more of the available kinetic energy. The 12 V bus and 12 V lead-acid battery will handle the lighter loads, including ignition, interior lighting, navigation and audio systems.

According to the author of our cover story, the 12 V bus will continue to power the ignition, lighting, infotainment and audio systems. The 48 V bus will supply active chassis systems, air conditioning compressors, adjustable suspensions, electric superchargers/turbos and also support regenerative braking. The decision to use an additional 48 V bus, which is expected be available across production model ranges soon, can also support starting the engine, which would make stop-start operation smoother. Moreover, the higher voltage means smaller cable cross-sections are needed which reduces cable size and weight. Today's high-end vehicles can have more than 4 kilometers of wiring. Vehicles will become more like PCs, creating the potential for a host of plug-and-play devices. On average, commuters spend nine percent of their day in an automobile. Thus, introducing multimedia and telematics into vehicles can potentially increase productivity as well as providing additional entertainment. The key components for autonomous driving include a computer, cameras, radar and LiDAR sensors, all of which require additional energy. This additional energy is required to improve vehicles' connectivity, not just to the Internet, but to other vehicles and buildings, traffic signals and other structures in the environment. Furthermore, drive train components, power steering, oil and water pumps will switch over from mechanical to electrical power.

All these applications will lead to more power electronics in the automobile – good prospects for this industry in 2017.

Enjoy reading the content of this issue!

Achim Scharf
PEE Editor

Emerging Power Delivery Standard 48 V for Data Centers

The Open Compute Project is an organization that shares designs of data center products among companies, including Facebook, Intel, Nokia, Google, Apple, Microsoft, Seagate Technology, Dell, Rackspace, Ericsson, Cisco, Juniper Networks, Goldman Sachs, Fidelity, Lenovo and Bank of America. The Open Compute Project's mission is to design and enable the delivery of the most efficient server, storage and data center hardware designs including power supply.

The OCP initiative (**www.OpenComputeProject.org**) was announced in April 2011 by Facebook to openly share designs of data center technology due to a redesign of Facebook's data center in Prineville, Oregon. One step was to improve the energy efficiency, as measured by the power usage effectiveness index. Power usage effectiveness (PUE) is a measure of how efficiently a computer data center uses energy; specifically, how much energy is used by the computing equipment (in contrast to cooling and other overhead). PUE is the ratio of total amount of energy used by a computer data center facility to the energy delivered to computing equipment, in other words it is the inverse of data center infrastructure efficiency (DCIE). An ideal PUE is 1.0. Anything that isn't considered a computing device in a data center (i.e. lighting, cooling, etc.) falls into the category of facility energy consumption.

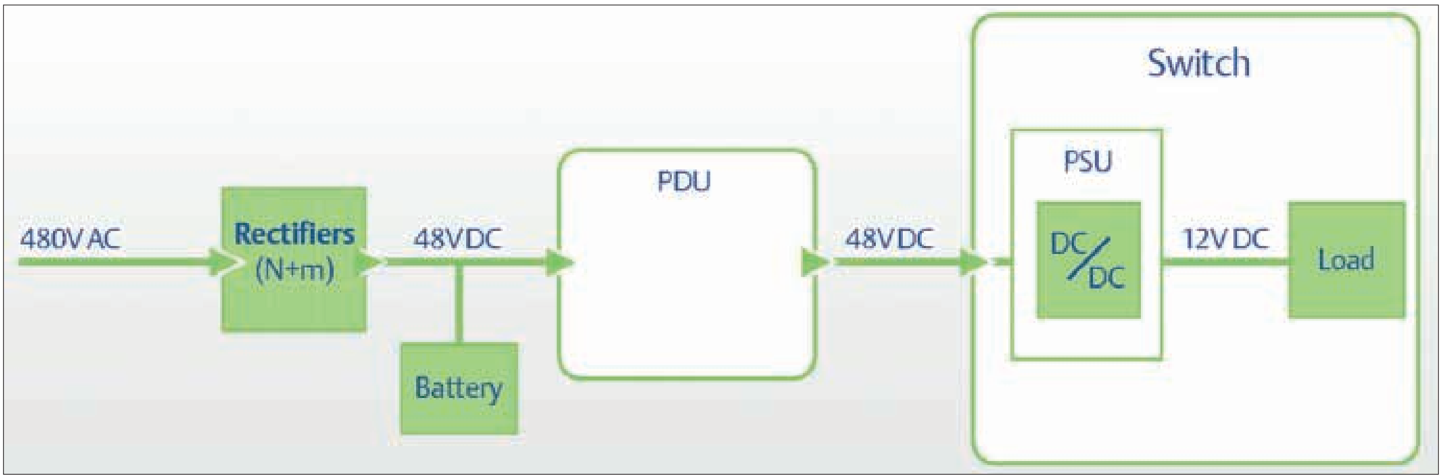
Google (**www.google.com**) joined the OCP early last year to help drive standardization in IT infrastructure. More specifically, Google is collaborating with Facebook on a new rack specification that includes 48 V power distribution and a new form factor to allow OCP racks to fit into their data centers. John Zipfel, Technical Program Manager at Google, detailed at the 2016 OCP Summit this attempt: "Energy efficiency in computing is a topic that has been near and dear to our hearts since the early days. We began advocating for efficient power supplies in 2003, and in 2006 shared details of our 12-volt architecture for racks inside our data centers – the infrastructure that supports and powers rows upon rows of our servers. In 2009, we started evaluating alternatives to our 12 V power designs that could drive better system efficiency and performance as our fleet demanded more power to support new high-performance computing products, such as high-power CPUs and GPUs. We kicked-off the development of 48 V rack power distribution in 2010, as we found it was at least 30 % more energy efficient and more cost effective in supporting these higher-performance systems. Our 48 V architecture has since evolved and includes servers with 48 V to point-of-load designs, and rack-level 48 V Li-Ion UPS systems. Google has been designing and using 48 V infrastructure at scale for several years, and we feel comfortable with the robustness of the design and its reliability. As the industry's working to solve these same problems and dealing with higher-power workloads, such as GPUs for machine learning, it makes sense to standardize this new design by working with OCP. We believe this will help everyone adopt this next generation power architecture, and realize the same power efficiency and cost benefits as Google." More can be expected at the 2017 OCP Summit in March.

Long history in telecomms

Mark Murrill and B.J. Sonnenberg, Emerson Network Power (**www.EmersonNetworkPower.com**) supported in their White Paper "Evaluating the Opportunity for DC Power in the Data Center" Google's approach.

The dramatic increase in data center energy consumption created both financial and environmental challenges. Energy costs, which once had been relatively inconsequential to overall IT management, became more significant as the rise in consumption was exacerbated by a steady– and in some years significant– increase in the cost of electricity. In addition, increased awareness of the role that power generation plays in atmospheric carbon dioxide levels prompted the US EPA to investigate large energy consumers such as data centers. In 2007 the EPA presented a report to the US Congress that included recommendations for reducing data center energy consumption. 48 V power delivery has a long history in telecommunications. It is inherently simple and reliable with few conversion stages to the point-of-load. Already in Bell's days 48 V DC was chosen as a standard for two reasons: DC power was felt to be more reliable than AC because it could be directly connected to back-up batteries, and 48 V was considered the optimal trade-off between transmission distance and human safety. Today, the authors claim that the ideal point for power conversion is as close to the point-of-load.

Global data center/cloud power market is exploding at over 10 percent annually to an estimation of 2 trillion kWh by 2020. Efficient power delivery from utility to the point of load could result in an astronomical amount of energy and expenditure savings. Today's datacenter payloads generally use traditional 12V for sub-rack power distributions, but the exponentially increased distribution losses jeopardizes efficiency and scalability as power grows rapidly. Google has deployed a compelling 48V rack ecosystem in its data centers for several years, which promised to provide better efficiency, performance and scalability for more power-hungry computing systems enabled by high-end CPUs, accelerators and ASICs. Thus the 48 V to point-of-load



48 V DC power supply as typically implemented in telecommunications central offices

conversion technology is one of the key enablers.

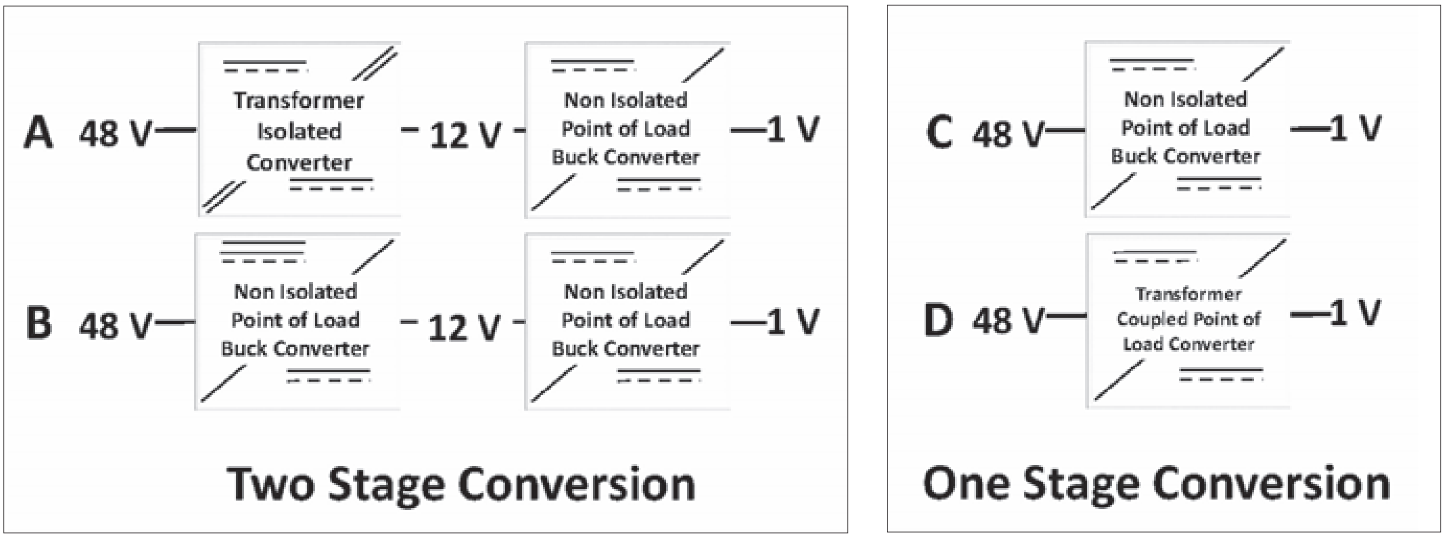
Although the benefits of a higher distribution bus voltage, particularly 48 V, which requires no special safety precautions, are well known (smaller cables and bus bars, lower distribution losses, smaller storage capacitors), conventional power conversion approaches have not been able to efficiently, or compactly, transform power from a 48 V bus into the low voltages (e.g., 3.3 V, 1.8 V and 0.8 V) and high currents (e.g. 95 A) required by contemporary CPUs or GPUs. As a result, CPU power conversion has customarily relied on 12 V distribution. A 12 V bus, however, must carry four times the current carried by a 48 V bus, and, because distribution losses are a function of the square of the current, the power lost in a 12 V bus can be as much as 16 times the loss in a 48 V bus. By providing efficiencies from a 48 V bus that are better than 12 V legacy solutions, in a fraction of the space, Thus 48 V direct-to-PoL conversion eliminating an intermediate 48 V / 12 V conversion step enable system designers to implement green distributed system solutions featuring high conversion efficiency, high power density and low distribution loss.

Direct Conversion from 48 V

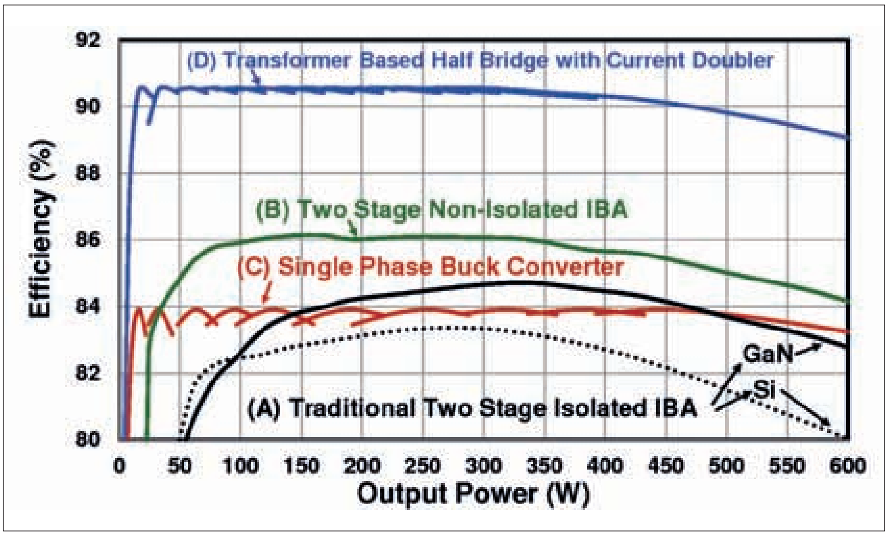
Thus direct conversion 48 V / 1 V is becoming a hot topic, i. e. at this year's APEC. Here Dr. Shuai Jiang and Xin Li, Google, Technical Lead Manager for Power Team and Sr. DC/DC Power Architect for Data Centers, Google 48V Power Architecture, will emphasize the latest achiements in the plenary speech (see our APEC preview in this issue).

At the International Electron Device Meeting (**www.IEDM.org**) in December 2016 Alex Lidow, CEO of Efficient Power Conversion (**www.EPC-Co.com**) gave a paper "System Level Impact of GaN Power Devices in Server Architectures". New power system architectures for 48 V – 1V conversion have grown in importance as power densities in server farms increase at a quickening pace due to applications such as deep learning and artificial intelligence. Four architectures were examined in this paper – each with relative strengths and weaknesses – but all of the GaN-based solutions demonstrate efficiency and power density exceeding today's silicon-based solutions. A non-isolated two-stage converter had the highest power density, lowest acquisition cost, fastest transient response, and second-best efficiency. If efficiency is paramount, a one stage transformer-based solution can achieve up to 90 % efficiency, but with a sacrifice in cost, density, and transient response. Though GaN technology, being in its infancy, it is improving at a much faster pace than their aging semiconductor ancestor and therefore forward thinking designers can create products that continuously keep up with the ever-increasing demands of the information age.

According to Ericsson (see our feature in this issue), a new generation of single-stage converters is set to emerge, to convert down from 48 V directly to logic voltages at high efficiency and within compact dimensions. The converters will be capable of supporting the low duty cycles required to convert from, say, 48 V to 1.0 V, while operating at a high switching frequency to ensure fast transient response and minimize reliance on decoupling capacitance and magnetic components. The adoption of direct conversion, implemented using the latest power technologies, is an emerging trend. The industry needs to identify the sweet spot as far as specifics such as module current ratings or power delivery are concerned. Direct conversion is expected to deliver the greatest efficiency gains in equipment at higher power levels, and can be used to dramatically reduce loads in Intermediate Bus Converters thereby allowing smaller IBCs; possibly downsizing these from quarter brick to smaller eighth brick units. This should be ideal for next-generation high-current processors. **AS**



ABOVE: Block diagrams of four different 48 V / 1 V DC/DC conversion



LEFT: Efficiency of four power system topologies for V_{IN}=48 V to V_{OUT}=1 V (the dotted line represents a Silicon-based implementation of architecture A in the figure left)

Power Semiconductors in Automotive Ramp Up $8.5 Billion by 2022

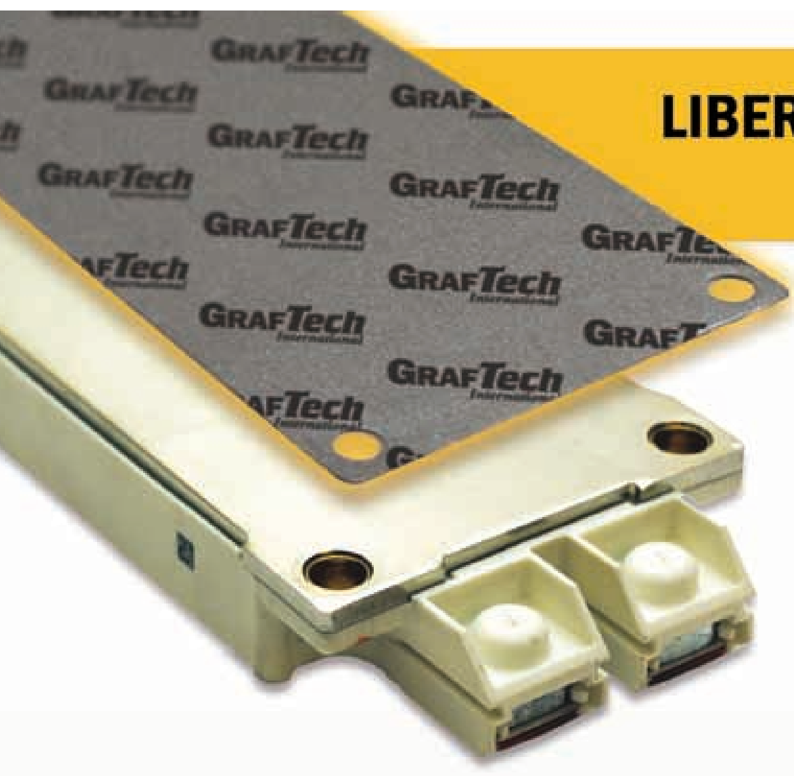
The global market for power semiconductors used in cars and light passenger vehicles will grow by more in $3 billion in the next five years, due to big jump in electrification of vehicles.

According to new analysis by IHS Markit (**www.ihsmarkit.com**). the total market for power semiconductors (discretes, power modules and power ICs) will increase from $5.5 billion in 2016 to more than $8.5 billion in 2022. Revenue will grow at an annual rate of 7.5 percent from 2015 to 2022, the report "Power Semiconductors in Automotive – 2017", predicts. "Increasing electrification in vehicles generally – and in hybrid and electric vehicles specifically – is energizing the market for power semiconductors in vehicles", said Richard Eden, senior analyst, power semiconductors for IHS Markit. "Staying connected via smartphones and tablets is the modern way of life and to this end, today's car drivers are opting for Bluetooth, cellular technologies and other telematics functions. All these features require power semiconductors to distribute and control power through vehicles." Also contributing to the rise of power semiconductors, the report notes, is the automotive industry's mission to offer self-driving, 'green' and connected cars in the next decade. "Intermediate safety milestones such as automatic emergency braking (AEB) and platooning are necessary to realize a road system that will accommodate self-driving cars. Other factors in the trend toward more power semiconductors: the need for more fuel-efficient systems, a higher proportion of electric vehicles, and more electronic content per vehicle as required for improved vehicle emission levels", Eden noted.

IHS Markit categorizes five domains on a vehicle: Body and Convenience, Chassis and Safety, Infotainment, Powertrain and Advanced Driver Assistance Systems (ADAS). Of these, Powertrain accounted for 47 percent of the total market for automotive power semiconductors in 2015, the report indicated. Anticipated growth in sales of hybrid and electric vehicles in the next few years will spur power semiconductor sales to climb by CAGR 9.6 percent from 2015 to 2022 across all vehicles, taking Powertrain's market share up to 54 percent of the total market. Discrete IGBT power transistors account for most of Powertrain power semiconductor revenue, but increased integration of discretes into modules will cause IGBT power module sales to increase at a much faster rate.

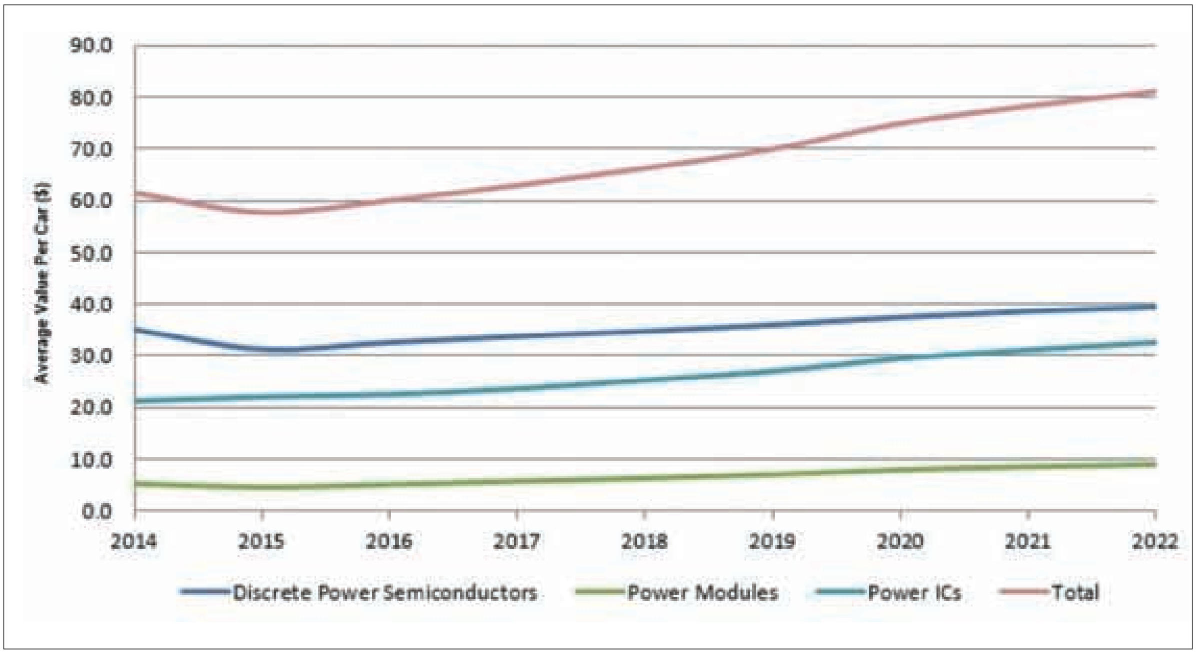
The Chassis and Safety category represents the second most-valuable automotive domain for power semiconductors, accounting for 24 percent of the total market in 2015. In contrast with Powertrain, the use of power semiconductors in Chassis and Safety will only grow with CAGR of 3.1 percent from 2015 to 2022, the report says. The biggest user of power devices in this domain are applications such as electric power steering, anti-lock braking system and electronic stability control, airbags and tire pressure monitoring, which are already relatively well-established in vehicles.

The domains of Body and Convenience and Infotainment only accounted for 14 percent and 11 percent of the total automotive power semiconductor market in 2015, respectively. Both categories are expected to grow with a CAGR of around 4 to 5 percent from 2015 to 2022, the



report predicts. At present, the smallest domain is ADAS, with only 5 percent of the total market in 2015. However, ADAS is forecast to see the fastest growth of all of the five domains, growing with a CAGR of 16 percent from 2015 to 2022. ADAS will see a rapid increase in the number of sensors, cameras and interconnectivity systems in cars, and all will need power semiconductors in their power control circuitry.

Discrete power semiconductors, the report points out, provide the highest average value per car. "This is not surprising as they have the lowest average sales price and are used in even the simplest, cheapest automotive electronic systems like engine, transmission control units, electrified oil pumps and power systems. Power ICs provide slightly less average value per car. They are more expensive and newer, so are more prevalent in high-end vehicles and more modern car designs, which contain more features, like ADAS, for example. Power modules have the smallest average value per car because their use is restricted to larger, high-end vehicles and to hybrid and electric vehicles only.



Estimated total market for discrete power semiconductors, power modules and power ICs each year divided by the total number of light vehicles produced in each year

Source: IHS Markit 2017

Silicon Carbide Spurs Electromobility

In Fiscal year 2016 Infineon's revenue rose by around 12 percent to €6.473 billion. Organic revenue growth from October 2015 to September 2016 amounted to seven percent. That's an outstanding performance, since the entire global semiconductor market experienced virtually no growth at all during the same period. Now the company is favoring Silicon Carbide technology for electromobility.

Demand for hybrid and fully electric vehicles was extremely encouraging worldwide in 2016. That applies especially to China, which is now the biggest market for electromobility. The association of Chinese vehicle manufacturers forecasts sales of around 400,000 so-called "new energy vehicles" in total in 2016, an increase of roughly 20 percent. "The rise in demand and the technical performance are also good for our business - at a leading Tier-1 supplier we secured a design-win with our IGBTs for partially and fully electric cars, with revenue potential in the three-digit million range", CEO Reinhard Ploss remarked. The Automotive segment generated revenue of €2.651 billion, an increase of 13 percent over the previous year. In the meantime, solutions for electromobility and advanced driver assistance systems (ADAS) accounted for around 50 percent of the revenue growth in the Automotive segment. The segment result rose to €396 million, a margin of 14.9 percent.

The growing spread of ADAS also led to a rise in demand for Infineon's radar chips. Two developments will ensure that sales figures continue to rise in the future: the increasing market penetration of radar-based assistance systems, and the growing number of radar sensors per vehicle. "In fiscal year 2016 we sold over 12 million of our 77-gigahertz radar chips – more than in the previous six years combined. In the current fiscal year we expect to sell between 25 and 30 million chips", Ploss stated. "Power semiconductors play a major technological role in limiting global warming to well below two degrees. Compound semiconductors, especially those made of Silicon Carbide, will enable us to develop even more energy-efficient solutions in the future. This applies in particular to electromobility and the generation of renewable energies. The planned acquisition of Cree/Wolfspeed will enhance our portfolio with know-how and products in the field of compound semiconductors. It will enable us to serve growing markets such as electromobility, renewable energies and cellular infrastructure more effectively."

With an electric drivetrain, the inverter controls the electric motor. This is a key component in the car as, similar to the Engine Management System (EMS) of combustion vehicles, it determines driving behavior. Not only does the inverter drive the electric motor, it also captures energy released through regenerative breaking and feeds this back to the battery. As a result, the range of the vehicle is directly related to the efficiency of the main inverter. According to Ploss Silicon Carbide has a huge potential in order to increase efficiency.

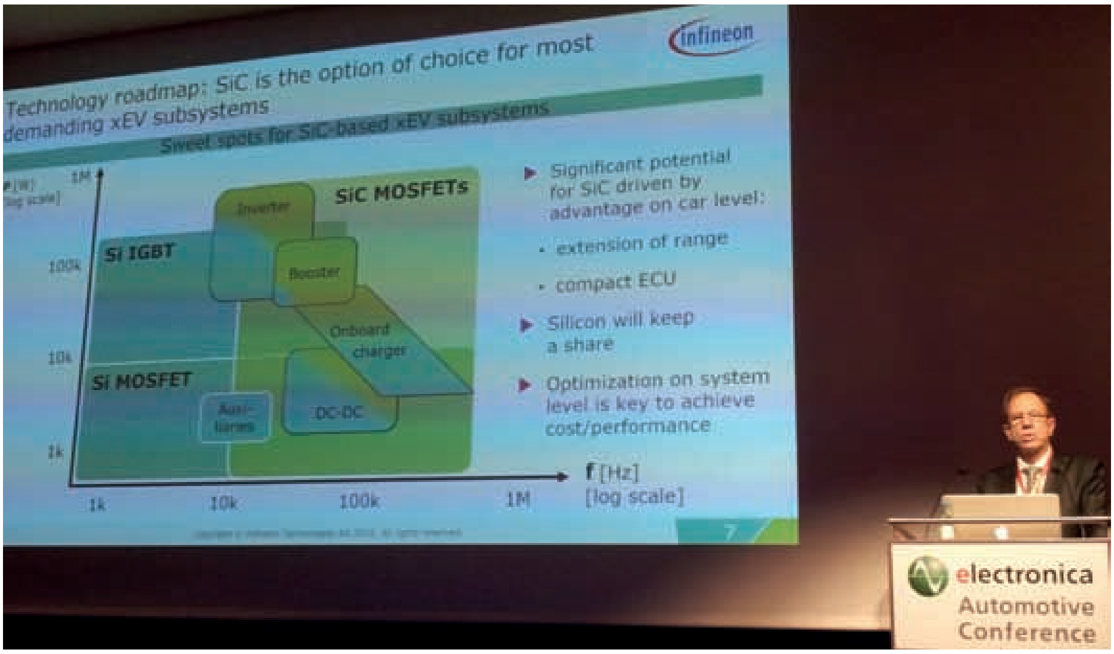
The battery in an electric vehicle is useless without a battery charger. With an on-board charger unit, the battery can be charged from a standard power outlet. Charging via the main grid calls for design flexibility given the different voltage and current levels in different countries. And charging time is an important factor for car drivers. System designers are challenged to support varied voltage and current levels while increasing power density. The key success factors of on-board charging are efficiency and high power density for a small form factor. The long-term trend is moving towards bi-directionality, where the charger also feeds power from the car to the smart grid.

Thus an appropriate charging infrastructure is critical to support the rapidly growing electric vehicles market worldwide. Infineon supports the global standardization of charging infrastructure for hybrid and electric vehicles by joining the global Charging Interface Initiative e.V. (**www.charinev.org**). CharIN's goal is to develop, establish and promote a world standard for a charging system for all kinds of battery-powered electric vehicles. Among its founding members are major automotive manufacturers.

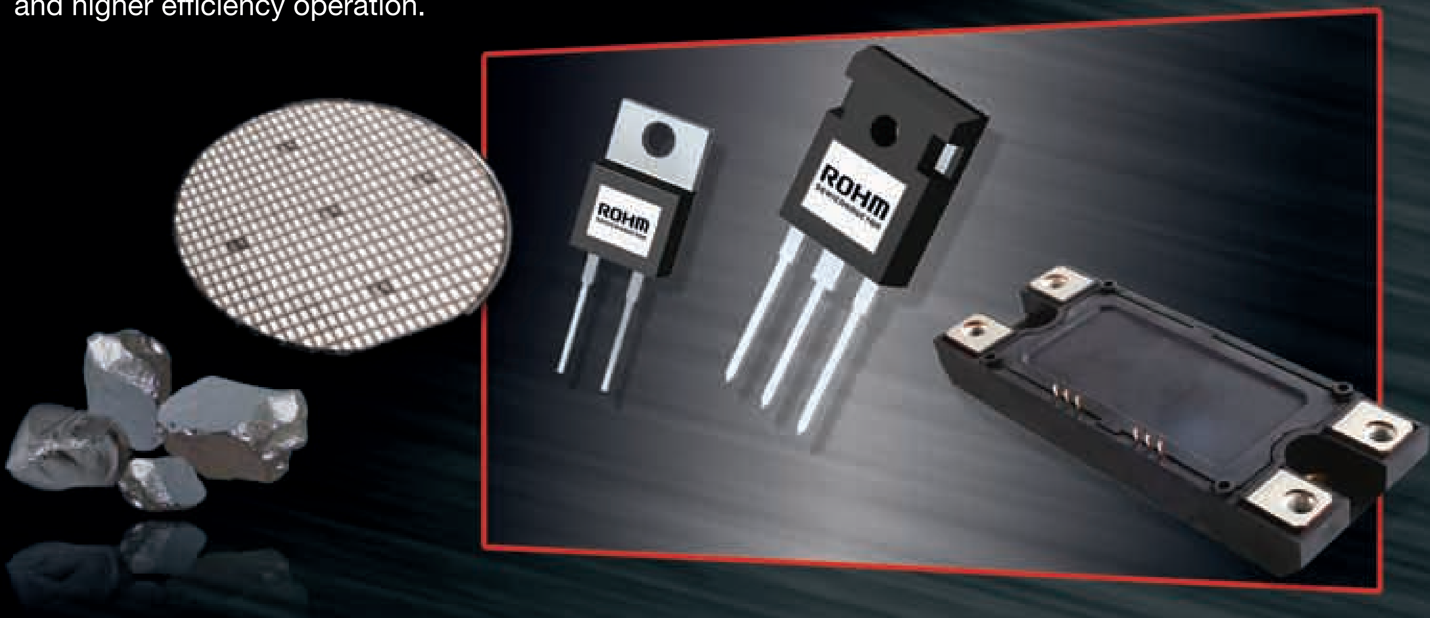
For the first quarter of the 2017 fiscal year the company reported positive results, mainly diven by the automotive sector. "We had a good start into the new fiscal year," Ploss stated. "Whereas revenue in the Power Management & Multimarket and Industrial Power Control segments decreased due to seasonal factors, revenue generated by the Automotive segment continued to rise by 2 percent to €705 million, compared with €691 million in the preceding quarter. Continued high demand for driver assistance systems and products deployed in hybrid and electric vehicles more than offset slightly lower demand in other product lines related to the seasonal development."

Based on an assumed exchange rate of $1.10 to the Euro, revenue growth for the 2017 fiscal year is forecasted of around 6 percent. According to Ploss the GaN business will ramp-up in DC/DC converters, but is still in the starting phase. Regarding technology, the focus now is on normally-off from Infineon's partner Panasonic with their X-GaN devices. Regarding Silicon Carbide, the acquisition of Wolfspeed is on track. "We expect to close this transaction in the first calendar quarter and to integrate Wolfspeed's technology and organization within one year", Ploss underlined. AS

www.infineon.com



"Silicon Carbide has a huge potential for the automotive drive train in order to increase efficiency", stated Infineon's CEO Reinhard Ploss at the electronica 2016 Automotive Conference **Photo: AS**

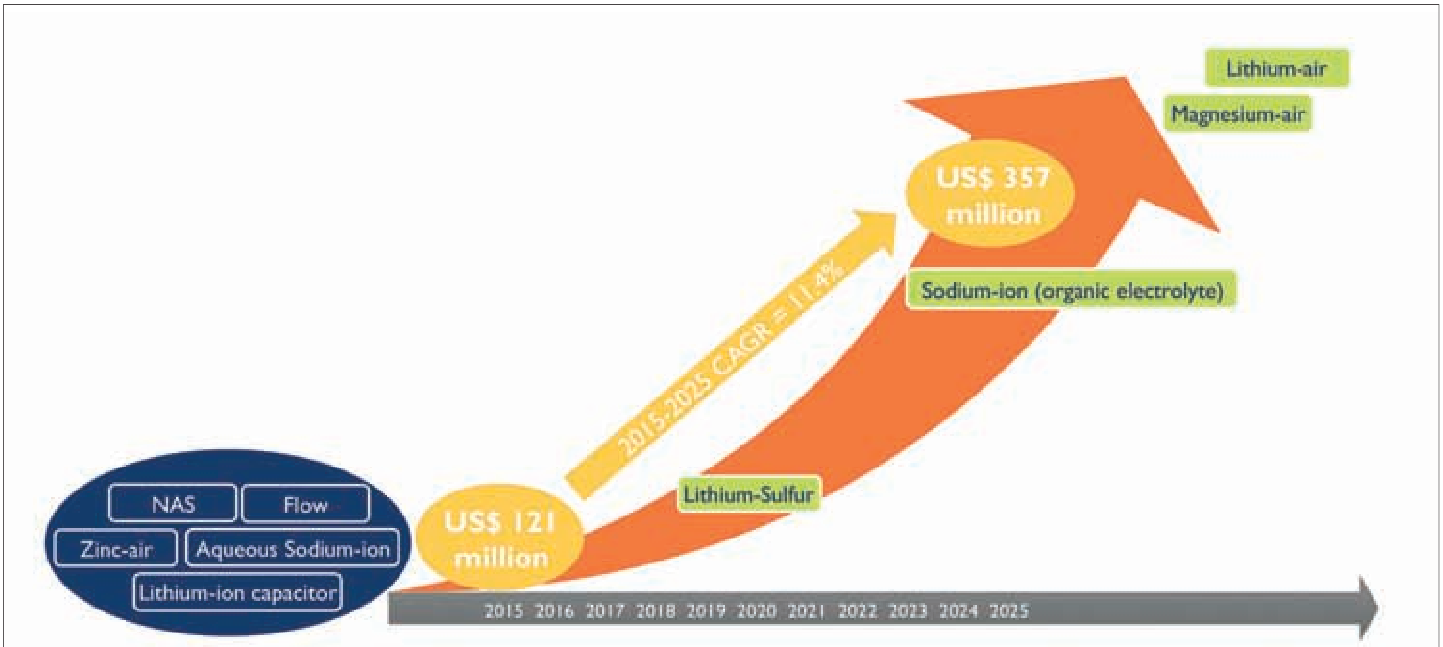


Alternative Battery Technologies to Li-Ion

Today, there is a relatively large variety of different battery technologies that can challenge Li-ion batteries such as NAS, Li-S, Na-ion, Mg-ion, Li-air, zinc-air and flow batteries, and LIC. Some of these technologies are at the R&D stage and some are already in commercial production.

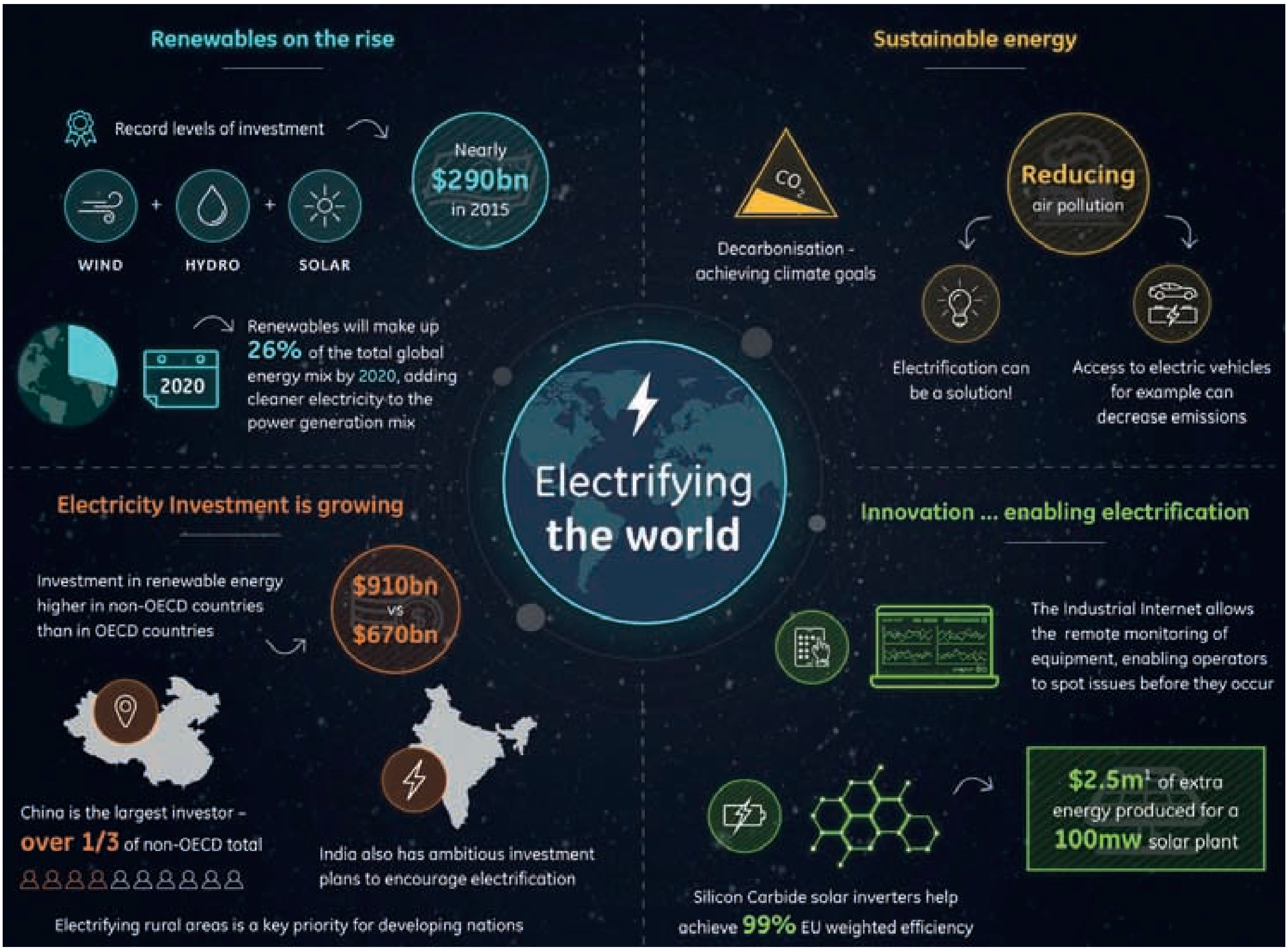
A new report entitled "Beyond Li-Ion Batteries: Present & Future Li-Ion Technology Challengers" by Yole Développement (**www.yole.fr**) estimates that the energy storage market for these technologies reached $121 million in 2015 and will grow up to $357 million by 2025, a CAGR of 11.4 percent. "The main demand for present Li-ion battery technology challengers will come via utility-size stationary battery energy storage", stated Dr Milan Rosina, Senior Analyst for Energy Conversion & Emerging Materials. "Future Li-ion challengers must overcome formidable technology challenges in order to achieve better performance and cost than Li-ion batteries. In the short-term, Li-S technology is considered the best candidate to reach sufficient technology maturity for wider commercial deployment. Li-ion battery cell supply is already well-consolidated. Three leading companies, Panasonic, LG Chem, and Samsung SDI continue to cement their position as cell suppliers by building new production facilities and developing new supply partnerships with EV/HEV manufacturers. To oppose the established Li-ion industry, challengers pursue different strategies. The safest approach involves companies focusing on one specific technology part which can be applicable in different battery chemistries, for example the improvement of lithium-metal electrode during the battery charging/discharging cycles."

Oxis Energy's initial focus is on niche markets where high energy density is a priority. The goal is to obtain the necessary income for funding further improvement of Oxis' Li-S battery technology and achieve a cycle life that is satisfactory for other applications. EnSync Energy Systems (formerly ZBB Energy) has changed from a flow battery supplier to a micro-grid solution provider. Other companies are focused on partnerships with utility companies as a means of developing demonstration projects and gaining visibility and customer confidence before developing high-volume production capacities. "Most companies developing future battery technologies are not planning to produce batteries independently. According to them, the related risk is too high. Thus they are looking for a big company interested in a partnership or a technology license. The big Li-ion players' positioning regarding Li-ion technology challengers could be affected by the arrival of new players from the EV/HEV industry. Indeed, novel battery technologies are a strong focus of automotive OEMs such as Toyota and Tier1 companies with Robert Bosch", Rosina expects.



Market for Li-Ion technology alternatives 2015 – 2015 **Source: Yole Développement 11-16**

Renewable Energies On the Rise



Strong policies—most notably from last year's Paris Climate Agreement—facilitate investment in renewable energy. This investment is crucial to achieving the goals of limiting the global increase in temperature to well below 2 degrees.

Despite the fall in oil and gas prices, renewables investment in 2015 reached nearly US$290 billion globally—almost double of what was spent a decade ago, according to Tomi Motoi, GE (www.ge.com) representative to the International Energy Agency. Furthermore, new low-carbon generation coming online in 2015 exceeds the entire growth of global power demand in that year, according to the International Energy Agency's new report, World Energy Investment 2016. This trend, driven by rapid technology progress, cost deflation and long-term price signals is expected to continue, with the renewables share of total power generation anticipated to make up 26 percent of the total global energy mix by 2020.

Electrification can be a solution for air pollution and air quality and can support the decarbonization of electricity generation, helping the world meet its energy needs with less carbon. High rates of use and overwhelming reliance on diesel fuel and heavy-duty vehicles account for a disproportionate share of emissions, according to the IEA's Energy and Air Pollution report. Access to electric vehicles can decrease emissions. In Paris, for example, between 2002 and 2012, a mobility plan which included shared bikes, electric vehicles and improved vehicle efficiency decreased 30 percent of NOx emissions and 35 percent of PM10 emissions over the period.

These trends present several challenges - and opportunities. First, the rise of variable energy renewables deployment points to a rebalancing of the energy system; as such, it requires the effective development of new technologies capable of properly managing power systems. Energy battery storage and microgrids can play a key role in balancing systems with large amounts of renewable generation and facilitating the integration of these variable energy resources. These technologies also have the potential to play a key role in countries such as Africa with limited grid access, helping to power these remote regions.

Technology can improve the reliability and efficiency of electrical equipment in power plants, two factors in determining its cost competitiveness, which encourages its use in decarbonization and facilitates its deployment. Examples are: the latest innovation in the solar industry uses Silicon Carbide power MOSFETs in solar inverters and can help achieve 99 percent EU weighted efficiency. The efficiency gain can be translated into $2.5 million of extra energy produced for a 100-megawatt solar plant over its lifetime. Additionally the Industrial Internet - which looks to link energy production assets together via a central platform such as GE's Predix - provides a number of cost-saving and efficiency benefits. For example, a connected power plant or renewables wind farm can be monitored remotely, and software analytics can lead to anomalies being spotted before they occur. This can reduce downtime and can deliver electricity where and when it's needed.

The Latest Achievements in Power Electronics On Stage

APEC (Applied Power Electronics Conference) is one of the premier global events in applied power electronics. APEC 2017 will be held at the Tampa Convention Center, Florida, from March 26-30, 2017. Over 5,000 delegates and 240 exhibiting companies are expected for this event. The conference program covers the latest advancements in power devices as well as their applications.

Professional Education Seminars offer a practical mix of theory and application for the professional working in power electronics. APEC 2017 will feature 18 professional education seminars on the Sunday and Monday ahead of the conference that cover a broad range of topics.

Over 1200 papers have been reviewed to ensure a balanced Technical Sessions line-up. The technical program includes papers of broad appeal scheduled for lecture sessions from Tuesday morning through Thursday afternoon. Papers with a more specialized focus are available for discussion with authors at the dialogue session on Thursday at 11:30 a.m. Industry Sessions continues to excel. This track runs in parallel with the traditional Technical Sessions Track. Speakers are invited to make a presentation only, without submitting a formal manuscript for the proceedings. This allows APEC to present information on current topics in power electronics from sources that would not otherwise be present at an industry conference. While many of these sessions are technical in nature, some also target business-oriented people such as purchasing agents, electronic system designers, regulatory engineers, and other people who support the power electronics industry.

Rap Sessions on March 28 will include three interesting and controversial topics.

- Power Electronic Architectures: Do we need more or have all the topologies invented?
- Do we need power to progress towards ghz switching in high-power systems and applications?
- 3D Printing and power supply on-chip (PsoC) / power supply in.package (PSiP) vs. discrete designs.

Plenary session on hot topics

One of the outstanding sessions at APEC are the traditional Plenaries on the Monday afternoon ahead of the other sessions. These will cover in form as keynotes current topics.

Dr. Ahmad Bahai, TI, Chief Technologist and Sr. VP, **Power Semiconductor Technology – Flexibility for Tomorrow's Solutions.** USB Power Delivery provides an unprecedented level of flexibility for sophisticated power control between chargers, phones, computers, monitors, accessories, and other devices. Both power and data can flow in multiple directions and options exist for complex power hand-over functions like Fast-Role-Swap. A very clear and easy to follow foundation of the essential concepts and capability is provided, stripping away the confusion around this new standard and the associated marketplace. Key capabilities, limitations, and technical challenges are discussed. How today's systems are adopting USB Power Delivery is explained and a vision of how the market will evolve is provided. A few of the more sophisticated system concepts are also discussed to provide a hint of the level of capability this new standard brings our industry. The talk closes with a view of what the future holds as USB Power Delivery evolves.

Dr. Shuai Jiang and Xin Li, Google, Technical Lead Manager for Power Team and Sr. DC/DC Power Architect for Data Centers, **Google 48V Power Architecture.** Global data center/cloud power market is exploding at over 10 percent annually to an estimation of 2 trillion kWh by 2020. Efficient power delivery from utility to the point of load could result in an astronomical amount of energy and expenditure savings. Today's datacenter payloads generally use traditional 12V for sub-rack power distributions, but the exponentially increased distribution losses jeopardizes efficiency and scalability as power grows rapidly. Google has deployed a compelling 48V rack ecosystem in its data centers for several years, which promised to provide better efficiency, performance and scalability for more power-hungry computing systems enabled by high-end CPUs, accelerators and ASICs. The 48V to point-of-load conversion technology is one of the key enablers. Beyond the fundamental goals of higher efficiency, higher density and faster response for voltage regulator designs, some other key metrics should also be considered; such as the electrical and physical interaction between the voltage regulator and the motherboard system, implication of integration and power integrity, criticalness of design scalability, cost and ease of design, are some other essential elements driving the directions of technology evolvement as well. In this presentation, we will explore together with you the 48V system architectures, 48V-to-PoL conversion technologies and challenges, and future exploration opportunities.

Hamish Laird, CTO ELMG Digital Power, Inc. **The Gap Between High Power and Low Power Converters and How it is Closing.** Large power converters have in the past had different constraints to small power converters. The first is that large converters have a lower surface area to volume ratio. The second is that capitalized cost of the lifetime power losses dominates the total cost of ownership. The third constraint is that the large converter control is necessarily constrained by the grid that it is connected to. Looking at the differences between the high power area and low power area there are now big leaps in efficiency that have brought the two together in terms of the problems that are being encountered. There are now grid or other converter interaction issues, low control margin converters and large converter behavior change with operating point at power levels as low as 500 W. In order to manage these issues, techniques from the high power converter space are now useful and necessary. The presentation will explore the gap between high power and low power and the techniques that are useful to fill the gap.

Conor Quinn, Artesyn Embedded Technologies & PSMA, PSMA Power Technology Roadmap Co-Chair, **Empowering the Electronics Industry: A Power Technology Roadmap.** Every two years, the Power Sources Manufacturers Association (PSMA) publishes its Power Technology Roadmap. This release of this cycle's roadmap coincides with APEC 2017. The presentation will focus on newer and emerging roles for power electronics circuits and technologies. The growth of the alternative energy industry, the internet as it is used today, the proliferation of mobile devices and many other technologies wouldn't be possible without continued advances in power conversion technology. This presentation will highlight the technological advances in power electronics that

empower these applications and set the stage for more advances to come.

Dr. Ljubisa Stevanovic, GE Global Research, CTO Silicon Carbide Works, **From SiC MOSFET Devices to MW-scale Power Converters.** This presentation will provide an overview of GE's vertically integrated activities from SiC devices and modules to converters for MW-scale industrial applications. GE has developed a new generation of high performance SiC MOSFETs with voltage ratings from 1.2 to 3.3 kV and current ratings up to 100A per die. Significant progress has been made towards the goal of demonstrating the MOSFET reliability comparable to mature silicon IGBTs. Extensive stress testing has also mapped out the device's safe operating area, including avalanche capability, short circuit ruggedness, body diode surge and stability, and terrestrial cosmic radiation hardness. In addition, a portfolio of low inductance half-bridge modules has been developed and optimized for fast switching SiC MOSFETs. By taking advantage of the MOSFET's body diode, the modules do not require anti-parallel diodes, saving cost and floor-space for additional MOSFETs. When compared to Silicon modules with the same mechanical footprint and voltage ratings (e.g. 1.7kV), the SiC modules deliver twice as much current (500 Arms), even when operating at three times higher switching frequency (7.5 kHz). Such performance advantage is also due in part to robust gate drivers with fast control and protection features. These efforts have culminated with the launch of the World's first MW-scale all-SiC product at the Solar Power International tradeshow in September 2016. The 2.5 MW utility scale SiC PV Inverter offers the best in class 99.0% EU weighted efficiency, delivering between 1 and 2 % more energy to customers. The single -stage inverter features a simple two-level topology switching at 8 kHz and offers higher reliability due to reduced parts count.

Vatché Vorperian, Jet Propulsion Laboratory, Principal Engineer & Fellow of the IEEE, **A Historical Perspective on the Development of the PWM Switch Model.** In this presentation, he will talk about the earliest instances in the published literature that include the works of Cuk, Landsman, Meares and Tymersky among others, of the appearance of a sub-circuit of a dc-to-dc converter as a building block of dc-to-dc converters and its connection to the conversion ratio of that converter. He will then present the subsequent emergence of the PWM switch as the smallest sub-circuit of a converter with invariant structural and electrical characteristics which bestow it with an invariant equivalent circuit model. To render the model of the PWM switch easily accessible to all those studying power electronics, from the beginning it was promoted by pointing out its similarity to the model of the transistor and its utilization in amplifier circuit analysis since both, the PWM switch and the transistor, are three-terminal non-linear devices. From a pedagogical point of view, the idea has caught on well and today the model of the PWM switch is being taught at Universities and to industry. Some examples of the application of the PWM switch model to the analysis of modern converters such the coupled SEPIC and Cuk converters will be presented.

More in our next issue. **AS**

Highly Efficient Low Power ON/OFF Switcher

Power Integration's new LinkSwitch-TN2 ICs are specifically designed to replace all linear and capacitor-fed (cap dropper) non-isolated power supplies in the under 360 mA output current range at equal system cost while offering much higher performance and energy efficiency. Applications include appliances, HVAC, industrial, home automation (IoT) and metering systems, particularly those destined for India and other geographies with challenging power grid stability.

Unlike conventional PWM (pulse width modulator) controllers, LinkSwitch-TN2 uses a simple ON/OFF control to regulate the output voltage. It consists of an oscillator, feedback (sense and logic) circuit, 5.0 V regulator, BYPASS pin under-voltage circuit, over-temperature protection, line and output over-voltage protection, frequency jittering, current limit circuit, leading edge blanking and a 725 V power MOSFET. Additional circuitry for auto-restart is incorporated. The device family supports buck, buck-boost and flyback converter topologies. It feature voltage regulation of better than -/+ 3%. This high level of accuracy allows designers to eliminate post regulators, minimizing the BOM, increasing efficiency and reducing size. The new IC requires just 20 additional components to complete a buck converter, and may be configured to use off-the-shelf inductors, further reducing cost and supply chain complexity.

High efficiency for low power applications

The new devices are very efficient in low-power applications– above 80 % in 12 V, 120 mA (1.4 W) buck designs for example. Designs typically consume less than 30 mW no-load in a buck arrangement and less than 10 mW when configured as a non-isolated flyback. This is a key tool for designers addressing Total Energy Consumption (TEC) regulations, which prescribe an energy budget limit over a range of operating modes.

TN2 ICs consume very little current in standby resulting in power supply designs that meet all no-load and standby specifications worldwide. MOSFET current limit modes can be selected through the BYPASS pin capacitor value.

This pin has multiple functions: It is the connection point for an external bypass capacitor for the internally generated 5.0 V supply. It is a mode selector for the current limit value, depending on the value of the capacitance added. Use of a 0.1 μF capacitor results in the standard current limit value. Use of a 1 μF capacitor results in the current limit being reduced, allowing design with lowest cost surface mount buck chokes. It also provides a shutdown function. When the current into the BYPASS pin exceeds IBPSD for a time equal to 2 to 3 cycles of the internal oscilator (f_{OSC}), the device enters auto-restart. This can be used to provide an output over-voltage protection function with external circuitry.

LinkSwitch-TN2 ICs are specifically designed to replace all linear and capacitor-fed (cap dropper) non-isolated power supplies

The high current limit level provides maximum continuous output current while the low level permits using very low cost and small surface mount inductors. A suite of protection features enable safe and reliable power supplies protecting the device and the system against input and output over-voltage faults, device over-temperature faults, lost regulation, and power supply output overload or short-circuit faults. The device family is available in PDIP-8C, SO-8C, and SMD-8C packages.

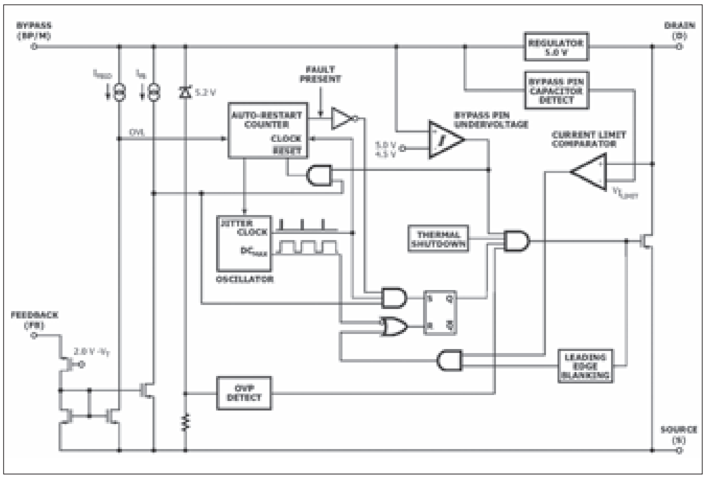
Functional description

The typical oscillator frequency is internally set to an average of 66 kHz. Two signals are generated from the oscillator: the maximum duty cycle signal ($DC_{(MAX)}$) and the clock signal that indicates the beginning of each cycle. The oscillator incorporates circuitry that introduces a small amount of frequency jitter, typically 4 kHz peak-to-peak, to minimize EMI emission. The modulation rate of the frequency jitter is set to 1 kHz to optimize EMI reduction for both average and quasi-peak emissions.

The feedback input circuit at the FEEDBACK pin consists of a low impedance source follower output set at V_{FB} (2.0 V). When the current delivered into this pin exceeds $I_{F}B$ (49 μA), a low logic level (disable) is generated at the output of the feedback circuit. This output is sampled at the beginning of each cycle on the rising edge of the clock signal. If high, the power MOSFET is turned on for that cycle (enabled), otherwise the power MOSFET remains off (disabled). The sampling is done only at the beginning of each cycle. Subsequent changes in the FEEDBACK pin voltage or current during the remainder of the cycle do not impact the MOSFET enable/disable status. If a current greater than I_{FBSD} is injected into the feedback pin while the MOSFET is enabled for at least two consecutive cycles the part will stop switching and enter auto-restart off-time. Normal switching resumes after the auto-restart off-time expires. This shutdown function allows implementing line over-voltage protection in flyback converters. The current into the FEEDBACK pin should be limited to less than 1.2 mA.

The 5.0 V regulator charges the bypass capacitor connected to the BYPASS pin to V_{BP} by drawing a current from the voltage on the DRAIN, whenever the MOSFET is off. The BYPASS pin is the internal supply voltage node for the LinkSwitch-TN2. When the MOSFET is on, the device runs off of the energy stored in the bypass capacitor. Extremely low power consumption of the internal circuitry allows the LinkSwitch-TN2 to operate continuously from the current drawn from the DRAIN pin. A bypass capacitor value of 0.1 μF is sufficient for both high frequency decoupling and energy storage.

The current limit circuit senses the current in the power MOSFET. When this current exceeds the internal threshold (I_{LIMIT}), the power MOSFET is turned off for the remainder of that cycle. The leading edge blanking circuit inhibits the current limit comparator for a short time (t_{LEB}) after the power MOSFET is turned on. This leading edge blanking time has been set so that current spikes caused by capacitance and rectifier reverse recovery time will not cause premature termination of the switching pulse. Current limit can be selected using the BYPASS pin capacitor



LinkSwitch-TN2 functional block diagram

(0.1 µF for normal current limit / 1 µF for reduced current limit). LinkSwitch-TN2 selects between normal and reduced current limit at power-up prior to switching.

The output over-voltage protection uses auto-restart that is triggered by a current $>I_{BPSD}$ into the BYPASS pin. In addition to an internal filter, the BYPASS pin capacitor forms an external filter providing noise immunity from inadvertent triggering. For the bypass capacitor to be effective as a high frequency filter, the capacitor should be located as close as possible to the SOURCE and BYPASS pins of the device.

Dual output adapter application

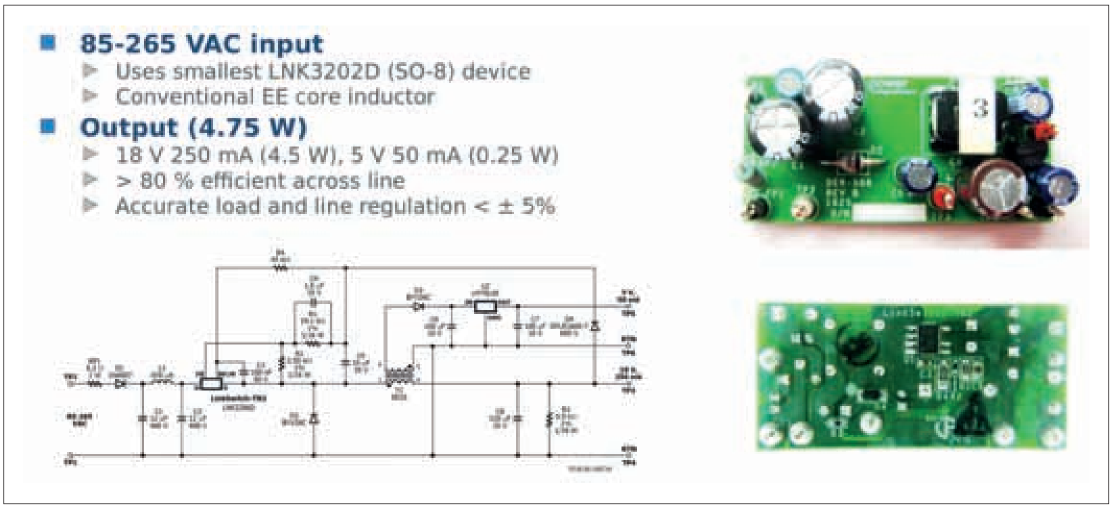
A 4.75 W dual output adapter using LNK3206D is an example for the simplicity of a power supply design.

Input rectification is provided by diode D1. The rectified input is filtered by capacitors C1 and C2. The π (pi) filter comprising of inductor L1 and capacitors C1 and C2 provides filtering for differential mode EMI. EMI is further reduced by the integrated frequency jitter feature of the devices as described above. Fusible resistor RF1 provides additional differential filtering and also protects by safely opening the circuit in case of catastrophic failure of any of the components in the circuit.

An internal current source from the DRAIN (D) pin of the LNK3206D IC U1, charges the capacitor C3 to provide control supply to the controller inside the IC. During the power MOSFET off-time, capacitor C5 is charged to the output voltage via D4. This voltage is used to provide feedback to the IC via the resistor divider formed by resistors R1 and R2. The FEEDBACK (FB) pin is sampled by the controller inside U1 during each switching cycle. If current flowing into the FB pin is below 49 µA when the sampling occurs, controller switching is enabled for that particular switching cycle and the power MOSFET turns on. This will develop a linear ramp in current through inductor T1 and C8. Once the internal current limit is reached, the power MOSFET inside IC U1 is turned OFF and will remain OFF for the remaining portion of the switching cycle and the inductor current can freewheel via diode D2. The regulation of the main output is maintained by skipping cycles (ON/OFF control).

During full load operation, only a few switching cycles will be skipped (disabled), which results in a high effective switching frequency. As the load is reduced, more switching cycles are skipped which reduces the effective switching frequency. At no-load, most switching cycles are skipped and that makes the no-load power consumption of supplies low. Switching losses are the dominant loss mechanism at light loading and effective drop in switching frequency helps to improve light load efficiency. Additionally, since the amount of energy per switching cycle is fixed by I_{LIMIT}, the skipping of switching cycles gives the supply a nearly flat efficiency characteristic over the load range.

LinkSwitch-TN2 family of devices do not require an external bias supply for operation and can be configured to be self-powered, however,



4.75 W dual output adapter design using LNK3206D

providing the operating current for the device into the BYPASS (BP) pin externally, dramatically reduces no load input power. Resistor R4 connected from output sampling capacitor C5 to the BP pin provides the required supply current for the IC U1. To achieve lowest no-load power consumption, the current fed into the BP pin should be slightly higher than 120 µA. For the best full load efficiency and thermal performance, the current fed into the BP pin should be slightly higher than 290 µA however that will marginally increase the no-load input power. Capacitor C9 ensures stable operation.

Additional auxiliary 5 V output is obtained using an additional winding on the inductor T1. This winding is rectified and filtered by diode D3 and capacitor C6. Diode D3 is a Schottky diode to reduce rectification loss.

Generally a 5 V or 3.3 V supply required for operating digital circuits in practical applications, requires regulation <5 %. A low cost linear regulator IC U2 provides a regulated 5 V output. Capacitor C7 provides filtering for IC U2.

www.power.com/linkswitch-tn2

Switcher Family Extended

Power Integrations introduced in January 2017 an extension to its LinkSwitch-TN2, the LinkSwitch-XT2 family. LinkSwitch-XT2 ICs target isolated and non-isolated flyback applications in which accurate regulation of output voltage and current are important. The new ICs can deliver up to 6.1 watts in wide-input range designs, and up to 9.2 watts for 230 VAC open-frame applications.

Designed for flyback topologies, the XT2 family delivers current and voltage regulation of better than -/+ 3% and typical efficiency above 80 % while consuming less than 10 mW in no-load conditions. High (132 kHz) operating frequency enables the use of small power transformers, while the programmable current limit function enables further transformer optimization. XT2 ICs combine also a 725 V power MOSFET with control circuitry on a single Silicon die. Integrated safety and reliability features include input over-voltage protection, hysteretic thermal shutdown for over-temperature protection, and auto-restart for output short-circuit, over-voltage and open-loop protection. The ICs come in three packages: P-package (DIP-8C), D-package (SO-8C), and G-package (SMD-8C).

www.power.com/products/linkswitch-xt2/

Multiphase PWM Controllers with AVSBus and Synthetic Current Control

Intersil recently introduced digital multiphase controllers and a companion smart power stage, including the Adaptive Voltage Scaling Bus (AVSBus). The new digital controllers provide up to seven phases assignable in any combination across two outputs, and combine with smart power stages to provide a scalable solution from 10 A to 450 A.

AVSBus™ joins the PMBus™ v1.3 specification and features a 50 MHz high-speed bus that connects directly to the processor to communicate telemetry data and deliver efficiency savings through adaptive voltage positioning. Intersil's new DC/DC controllers and ISL99227 60A smart power stage support demanding CPU core voltages, memory, and auxiliary power rails, enabling power designers to customize their solution to meet any rail requirements.

The digital multiphase family is comprised of three groups of controllers. The ISL68137 and ISL68134 controllers utilize the AVSBus to power and communicate with ARM-based processors in network routers, switches, servers, storage, and wireless telecom equipment. Two general-purpose controllers (ISL68127 and ISL68124) power network processors, FPGAs, SoCs and graphics accelerators. And eight controllers (ISL69147/44, ISL69137/34, ISL69128/27 and ISL69125/24) add a secondary high-speed interface (SVID or SVI2) to power the latest Intel and AMD processors in cloud computing applications that make up the Internet of Things (IoT) backbone.

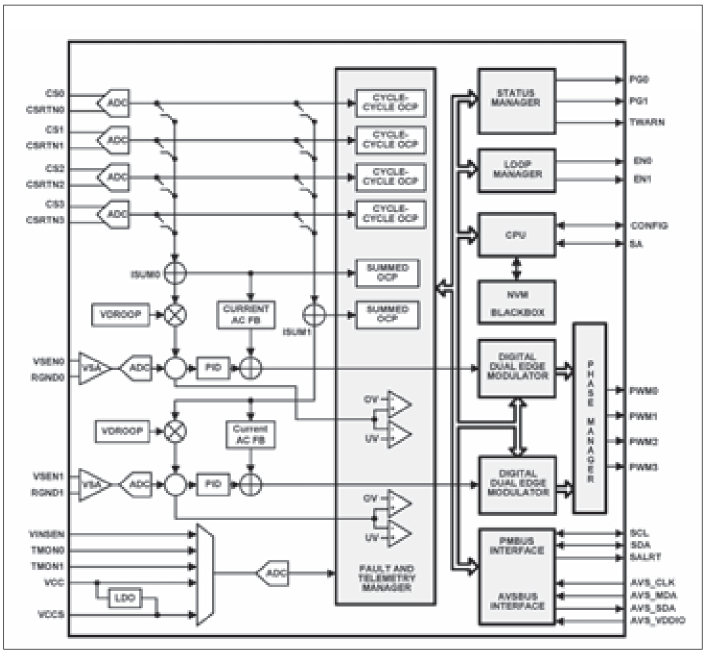
The ISL681xx and ISL691xx controllers integrate a digital engine featuring a patented synthetic current control architecture that tracks each phase current with zero latency. This allows the device to respond to any load transient with precise current and voltage positioning. Synthetic current control also makes it possible to develop high reliability systems using all-ceramic capacitors. Switching frequency is user configurable over a range of 200 kHz to 1 MHz.

PWM modulation scheme

The ISL68134 i. e. uses a proprietary linear synthetic current modulation scheme to improve transient performance. This is a constant frequency, dual edge PWM modulation scheme with both PWM leading and trailing edges being independently moved to give the best response to transient loads. Current balance is an inherent part of the regulation scheme. The modulation scheme is capable of overlapping pulses should the load profile demand such operation. In addition, the modulator is capable of adding or removing pulses from a given cycle in response to regulation demands while still managing maximum average frequency to safe levels. For DC load conditions the operating frequency is constant.

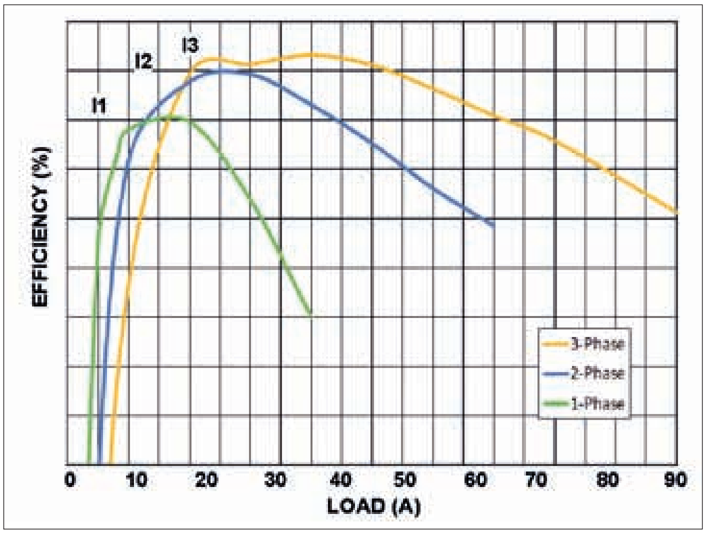
In order to produce the most optimal efficiency across a wide range of output loading, the modulator supports automatic dropping or adding of phases. Use of automatic phase dropping is optional. If automatic phase dropping is enabled, the number of active phases at any time is determined solely by load current. During operation, phases of Output 1 will drop beginning with the lowest phase number assigned. Phase dropping begins with the highest assigned phase number.

Phases are dropped one at a time with a user programmed drop delay between drop events. As an example, suppose the delay is set to 1 ms and 3 phases are active. Should the load suddenly drop to a level needing only 1 phase, the ISL68134 will begin by dropping a phase after 1 ms. An additional phase will be dropped each 1 ms thereafter until only 1 phase remains. In addition to the described load current add/drop thresholds, the fast phase add function provides a very rapid response to transient load conditions. This feature continuously monitors the system regulation error and should it exceed the user set threshold, all dropped phases will be readied for use. In



ISL68134 internal block diagram

ISL 68/69xxx multiphase contollers and ISL99227 SPS forming a complete digital power solution



Typical characteristic of efficiency vs load current vs phase count

this way, there is no delay should all phases be needed to support a load transient. The fast phase add threshold is set in the PowerNavigator GUI. Output current threshold for adding and dropping phases can also be configured.

To ensure dropped phases have sufficient boot capacitor charge to turn on the high-side MOSFET after a long period of disable, a boot refresh circuit turns on the low-side MOSFET of each dropped phase to refresh the boot capacitor. Frequency of the boot refresh is also programmable via PowerNavigator.

The ISL68134 supports up to two regulated outputs through four configurable phases. Either output is capable of controlling up to four phases in any arbitrary mix. Phase assignments are accomplished via the PowerNavigator GUI. While the device supports arbitrary phase assignment, it is good practice to assign phases to Output 1 in descending sequential numerical order starting from Phase 3. For example, a 3-phase rail could consist of Phases 3, 2 and 1. For Output 0, phases would be assigned starting from Phase 0 in ascending sequential numerical order.

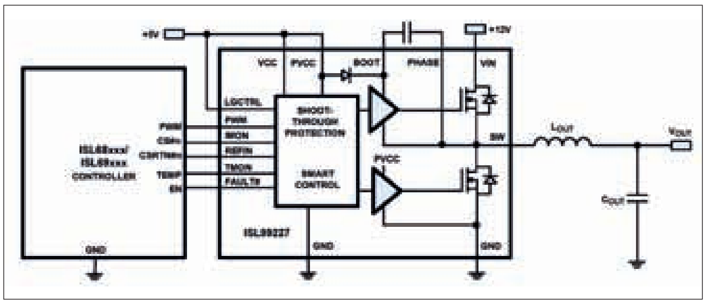
Output voltage configuration

Output voltage set points and thresholds for each output can be configured with the GUI. Parameters such as output voltage, V_{OUT} margin high/low and V_{OUT} OV/UV faults thresholds can be configured with GUI. Additionally, output voltage and margin high/low can be adjusted during regulation via PMBus command VOUT_COMMAND, VOUT_MARGIN_HIGH and VOUT_MARGIN_LOW for further tuning.

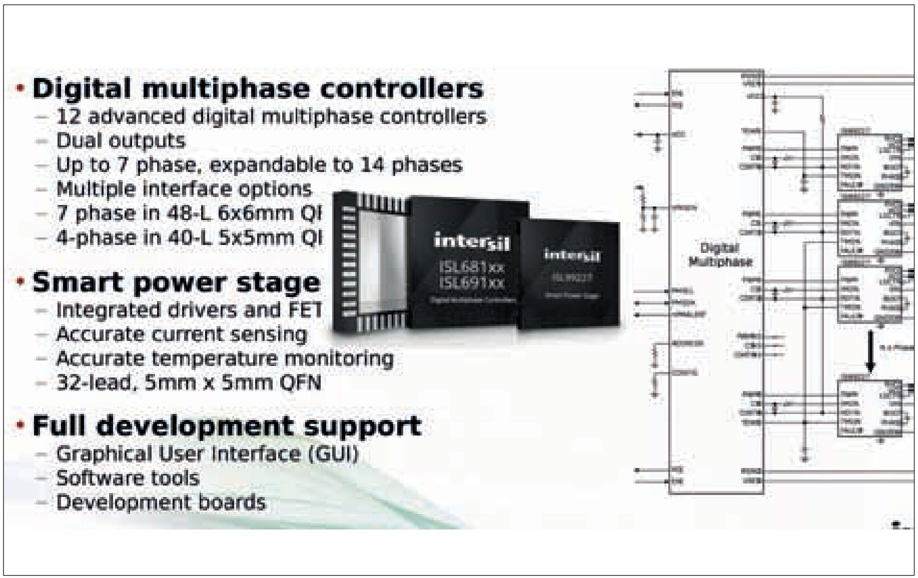
Smart power stage fault detect

The ISL99227, ISL99227B are Smart Power Stages (SPS) compatible with ISL68xxx/69xxx Digital Multiphase (DMP) controllers and phase doubler (ISL6617A), respectively.

The ISL99227, ISL99227B have integrated current and temperature



ISL99227 simplified application block diagram



A complete typical digital power solution - ISL68xxx with ISL99227 SPS

monitors that can be fed back to the controller and doubler to complete a multiphase DC/DC system. They simplify design and increase performance by eliminating the DCR sensing network and associated thermal compensation. Light-load efficiency is supported via a dedicated LFET control pin.

The ISL99227, ISL99227B feature a 3.3 V compatible, 5.0 V compatible tri-state PWM input that provide a robust solution in the event of abnormal operating conditions. The ISL99227, ISL99227B also improve system performance and reliability with integrated fault protection of UVLO, over-temperature and over-current. An open-drain fault reporting pin simplifies the handshake between SPS and controllers and can be used to disable the controller during start-up and fault conditions.

SPS will output a large signal if peak current exceeds their preprogrammed threshold. The ISL68134 is equipped to detect this fault flag and immediately shut down. This detector is enabled on the GUI OverCurrent Fault setup screen. This feature functions by detecting signals which exceed the current sense ADC full scale range. If this detector is disabled while using a SPS, the Fault# signal must be connected to the controller Enable pin of the associated rail. This will ensure that an SPS OC event will be detected and the converter will shutdown.

AVSBus functionality

The AVSBus interface provides a high speed (up to 50 MHz) serial interface to the ISL68134 allowing implementation of advanced voltage scaling functions supporting increased system efficiency and performance. Devices equipped with AVSBus master capability may use the interface to enable rapid supply voltage changes to support low power consumption modes as well as high performance modes. Due to the advanced digital regulation loop employed, the ISL68134 is well equipped to support very rapid transition rates. All commands are readable at all times, but they cannot be written to unless the device is set to AVSBus control.

www.intersil.com/en/products/power-management/zilker-labs-digital-power/digital-multiphase-controllers.html

pcim
EUROPE

International Exhibition and Conference
for Power Electronics, Intelligent Motion,
Renewable Energy and Energy Management
Nuremberg, 16 – 18 May 2017

Greatest European Power Electronics Event

PCIM Europe 2016 featured a total of 436 exhibitors, as well as 93 represented companies, more than 10,000 visitors, and 771 conference delegates. For 2017 all signs are pointing to success - exhibitor registrations increased by around ten percent and the exhibition area has remarkably grown by 12 percent. From 16 – 18 May 2017, the conference and international exhibitors will deliver customized know-how, introduce their innovations and provide insights into the latest trends and developments in power electronics.

For the first time in 2017, companies get the opportunity to present themselves and their expertise at joint stands. At the E-Mobility Area it all revolves around electric mobility. It is aimed at companies specialized in power electronics in E-Mobility such as batteries, battery management, or drive train solutions. It therefore offers the possibility to introduce products, solutions and services to an interested audience in one single spot. Thanks to the high internationality of PCIM Europe, the event is now included in the BMWi-program. This program is designed to promote the exhibition participation of young innovative German companies on a thematic pavilion. This promotion area offers companies the unique chance to present themselves to an international expert's community, as well as promising business potentials in the environment of power electronics.

The application-oriented PCIM Europe conference will take place in parallel to the exhibition. The conference program covers issues ranging from recent developments in power semiconductors, passive components, thermal management products, energy storage, and sensors to new materials and systems.

Already on the Sunday (May 14) seven seminars will be held on the subjects

- Basics of Electromagnetic Compatibility (EMC) of Power Systems
- Multi-Kilowatt Flyback Converters; Advantages and Practical Design Considerations
- What a Design Engineer Should Know About Current-Mode Control
- Modern Magnetic Technologies for High Efficiency and High Power Density

Again it's time for PCIM Europe in May 2017

- Power Electronics and Control for Battery Systems
- Power Supply Design Review: Achieving 98% Efficient Power Supplies Using GaN FETs
- Design of Magnetic Components for High Power Converters followed by seminars on the Monday (May 15) covering the following topics
- New Trends in Power Conversion for Very High Efficiency and High Power Density
- What a Design Engineer Should Know About Power Factor Correction
- Electromagnetic Design of High Frequency Converters and Drives
- High Performance Control of Power Converters
- Advanced System Design with Ultra-Fast Si/SiC/GaN Power Semiconductor Devices
- Design Considerations for High Frequency Linear Magnetics
- Reliability of Si and SiC Power Devices and Packages
- Driving Electric - Power Train, Battery, Wireless Charging and Autonomous Driving
- Design Challenges for High Frequency Magnetic Circuit Design for Power Conversion
- Reliability Engineering in Power Electronic Systems
- Energy Storage - Systems and Components

The conference starts on the Tuesday (May 16) with the Opening, Young Engineer Award and Best Paper Award Ceremony. First oral sessions will cover HV-SiC-MOSFET featuring 3.3 kV/450 A Full-SiC nHPD2 (next High Power Density Dual) with Smooth Switching by Hitachi Power Semiconductor Device, Characterization of 3.3kV and 6.5kV SiC MOSFET by ROHM Semiconductor, Dynamic Characterization of Next Generation Medium Voltage (3.3 kV, 10 kV) Silicon Carbide Power Modules by Wolfspeed, and 3.3kV All-SiC Power Module for Traction Application by Mitsubishi Electric.

In the afternoon the session SiC MOSFET covers the papers Short-Circuit Robustness of Discrete Silicon Carbide MOSFETs in Half-Bridge Configuration by Mitsubishi Electric, The new CoolSiC Trench MOSFET Technology for Low Gate Oxide Stress and High Performance by Infineon Technologies, Device Simulation Modeling of 1200 V SiC MOSFETs by Fairchild Semiconductor, and Design Rules To Adapt The Desaturation Detection For SiC MOSFET Modules by the University of Bayreuth.

Another oral session SiC-Systems on the Wednesday afternoon cover papers A Novel Gate Drive Concept to Eliminate Parasitic Turn-on of SiC MOSFET in Low Inductance Power Modules by the University of Bayreuth, Evaluation of Current Measurement Accuracy for a Power Module with Integrated Shunt Resistors by Semikron Elektronik. And on the Thursday afternoon the oral session SiC Modules Diodes will present subjects such as Design and Analysis of a Low-Inductive Power-Semiconductor Module with SiC T-MOSFET and Si IGBT in Parallel Operation by Infineon Technologies, 1.7 kV High-Current SiC Power Module Based on Multi- Level Substrate Concept and Exploiting MOSFET Body Diode during Operation by ABB Corporate Research, All SiC Module with 1st Generation Trench Gate SiC MOSFETs and New Concept Package by Fuji Electric Europe, and Robust SiC JBS Diodes for the Application in Hybrid Modules by ABB Switzerland Ltd.

Gallium Nitride device technology will be covered in one oral session called Advanced Wide Bandgap – GaN on the Thursday (May 18) morning only. Papers to be presented are Investigation of GaN-HEMTs in Reverse Conduction by Fraunhofer Institute for Applied Solid State Physics (IAF), Short-Circuit Robustness for 650 V E-Mode GaN Transistors, Current Measurement for High Speed Protection Circuit by ENS Cachan, Mechatronic Design of 2 kW SiC DC/AC Converter with 200 W/inch by Fraunhofer Institut für Integrierte Systeme und Bauelementetechnologie IISB, A Full SiC Module Operational at 200°C Junction Realized by a New Fatigue-Free Structure by National Institute of Advanced Industrial Science and Technology of Japan, and A Novel SiC Power Module with 3D Integration by ON Semiconductor.

More in our next issue. **AS**

Benefits of Direct 48 V / 1 V Conversion

In data centres and telecom offices, the most important issues affecting decisions about power supply design are usually cost, efficiency, and the available board real estate. Typical early power distribution strategies utilized multiple isolated quarter brick or eighth brick converters to convert from a bus voltage – usually 48 V – to the required IC supply voltage, at the point of load. A new generation of single-stage converters is set to emerge, to convert down from 48 V directly to logic voltages at high efficiency and within compact dimensions. **Bob Cantrell, Senior Application Engineer, Ericsson Power Modules, USA**

In a bid to save the cost and bulk of multiple isolated converters, the now-conventional distributed power architecture was proposed and became widely adopted in data centers (Figure 1) over a decade ago. This comprises an AC/DC front-end power supply, an isolated Intermediate Bus Converter (IBC) usually of an industry-standard size such as a quarter brick, and on-board non-isolated Point-of-Load (POL) converters. The POLs are positioned close to the power pins of devices such as processors, FPGAs/ASICs, memory, and other ICs, to minimize noise effects and optimize transient response.

The IBC down-converts the nominal 48 V DC from the front-end power supply to a 12 V rail that is distributed to the POL converters. The POLs then convert the 12 V input into regulated voltages as needed by on-board ICs. These typically can range to below 1 V as needed to power processor or FPGA core logic.

Efficiency is key

Today, data centres and telecom offices are under pressure to support ever-increasing numbers of subscribers and connections, and to deliver increasingly data-intensive services with minimal latency. Accordingly, the peak power consumption of large server boards has risen significantly above 1 kW and is likely to push well beyond 3 kW in the future. As power consumption continues to rise, efficiency is a growing concern for data centres seeking to control the spiralling costs of powering servers and cooling systems, and minimize the overall enterprise environmental footprint. The cost of power consumed in a large-scale data center quickly outweighs the cost of servers and networking equipment, and energy prices can be expected to continue rising.

Advantages of direct conversion

Although many of today's IBC and POL converters can achieve efficiency in the

Figure 1: **Typical data cabinet utilizing conventional point-of-load power architecture**

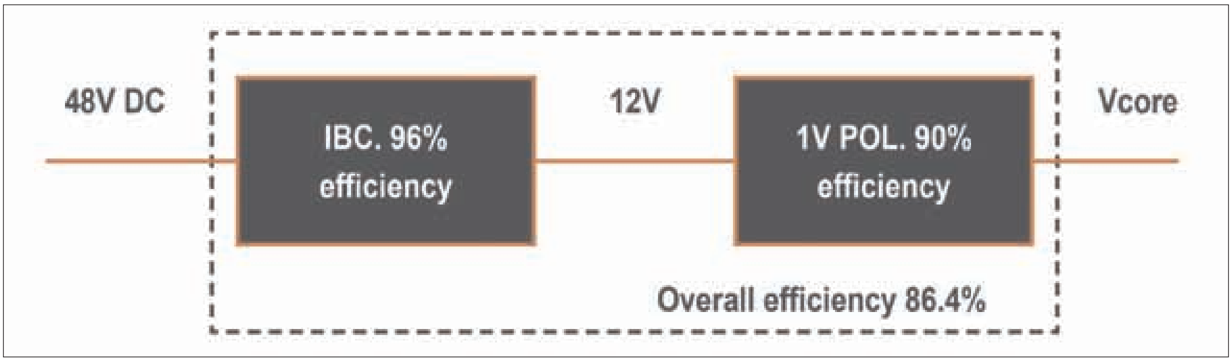


Figure 2a: Conventional two-stage 48 V-to-core voltage conversion

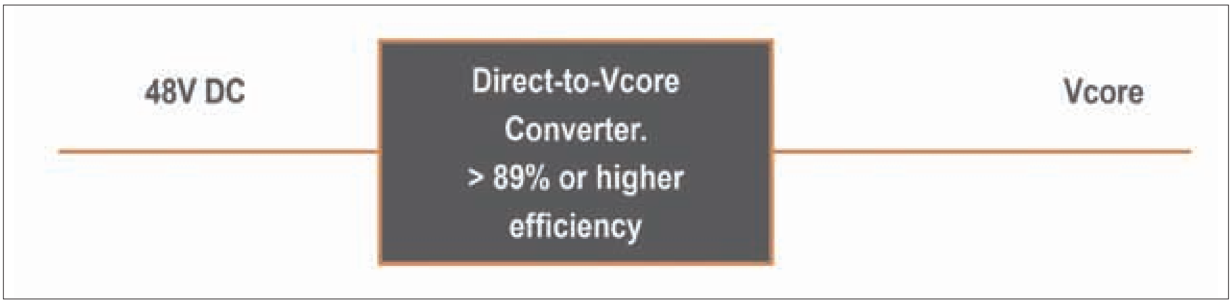


Figure 2b: Direct 48 V-to-core voltage conversion

region of 95-96 % for the IBC, and 90 % for a typical 12 V-1 V POL at a particular load, the cumulative energy loss from both stages of conversion can reduce overall efficiency to a little over 86 % (Figure 2a). If a single converter can generate the required IC supply voltage with efficiency, say 89 % for the same load used in the above example, the overall conversion efficiency can be increased by several percentage points (Figure 2b).

The I^2R distribution losses can also be reduced. By distributing 48 V DC for direct conversion at the point of load, the bus supplying the converter carries approximately 25 % of the current that would be required to deliver the same power at 12 V. Hence I^2R distribution losses from the 48 V source can be reduced by a factor of 16. Reducing I^2R distribution losses becomes increasingly important as total server power – and hence the power delivered to the POLs at 12 V or 48 V – continues to increase.

In addition, direct conversion helps to save board real-estate and to reduce the cost of materials, electronics assembly and manufacturing. Using today's technology, a direct 48 V-to-POL converter solution can be smaller in size than comparable conventional modules in quarter or eighth-brick sizes along with POL converters, and can also eliminate the need for high-current multiple and parallel IBC quarter bricks or eighth bricks. In complex or high-power systems, the need for a reduced-power Intermediate bus will still likely exist to power low-current rails, but an eighth brick IBC converter will likely be able to be used, thereby saving additional board space.

High-efficiency direct conversion

A new generation of single-stage converters is set to emerge, to convert down from 48 V directly to logic voltages at high efficiency and within compact dimensions. The converters will be capable of supporting the low duty cycles required to convert from, say, 48 V to 1.0 V, while operating at a high switching frequency to ensure fast transient response and minimize reliance on decoupling capacitance and magnetic components. The adoption of direct conversion, implemented using the latest power technologies, is an emerging trend. The industry needs to identify the sweet spot as far as specifics such as module current ratings or power delivery are concerned.

The new direct conversion solutions will enter the market alongside existing IBC and POL products that are currently used to power boards from a few hundred Watts up to 3 kW or more. Direct conversion is expected to deliver the greatest efficiency gains in equipment at higher power levels, and can be used to dramatically reduce loads in Intermediate Bus Converters thereby allowing smaller IBCs; possibly downsizing these from quarter brick to smaller eighth brick units. This should be ideal for next-generation high-current processors.

On the other hand, factors such as cost or legacy issues may determine the point at which some equipment manufacturers consider implementing direct conversion. With direct-conversion and traditional modules available side-by-side in the market, designers will also have the freedom to conceive hybrid architectures that combine Intermediate Bus and Direct Conversion topologies to deliver the best of both worlds.

Conclusion

Using a higher voltage such as 48 V to distribute power on server boards, and converting directly to the required load voltage at the point of load, offers attractive advantages including higher efficiency, lower I?R distribution losses, as well as reducing board space imposed by an intermediate converter. In practice, cost pressure, combined with engineering constraints on switching frequency, step-down ratio and transient performance, have historically driven power designers challenged to convert from a 48 V DC input to use a two-stage topology comprising an intermediate converter feeding point-of-load converters that generate the desired IC supply voltages. Now, with the growing imperative to maximize energy efficiency in every area of the server design, and drawing on the latest power technologies, direct conversion can provide not only the most efficient power-conversion architecture, but also board-space savings and potential cost advantages. The forthcoming generation of direct-conversion POL modules will establish the starting point for a major transition in the market.

Dual Battery Require Bi-Directional DC/DC Controllers

With fuel economy regulations tightening and autonomous-driving capability with connectivity proliferating, the old-fashioned 12 V automotive electrical system has reached its usable power limit. Furthermore, a vast increase in automotive electronic systems, coupled with related demands on power, has created an array of new engineering opportunities and challenges. As a result, the 12 V lead-acid battery automotive system with its 3 kW power limit has been supplemented. A newly proposed automotive standard, LV148, combines a secondary 48 V bus with the existing 12 V system. **Bruce Haug, Senior Product Marketing Engineer, Linear Technology, Milpitas, USA**

The 48 V rail includes an integrated starter generator (ISG) or belt start generator, a 48 V lithium-ion battery and a bi-directional DC/DC converter for delivery of up to 10 kW of available energy from the 48 V and 12 V batteries combined. This technology is targeted at conventional internal combustion automobiles, as well as hybrid electric and mild hybrid vehicles, as auto manufacturers strive to meet increasingly stringent carbon dioxide emissions targets.

More power required

Typically, the 12 V bus will continue to power the ignition, lighting, infotainment and audio systems. The 48 V bus will supply active chassis systems, air conditioning compressors, adjustable suspensions, electric superchargers/turbos and also support regenerative braking. The decision to use an additional 48 V bus, which is expected be available across production model ranges soon, can also support starting the engine, which would make stop-start operation smoother. Moreover, the higher voltage means smaller cable cross-sections are needed which reduces cable size and weight. Today's high-end vehicles can have more than 4 kilometers of wiring. Vehicles will become more like PCs, creating the potential for a host of plug-and-play devices. On average, commuters spend 9 % of their day in an automobile. Thus, introducing multimedia and telematics into vehicles can potentially increase productivity as well as providing additional entertainment.

The key components for autonomous driving include a computer, cameras, radar and LiDAR sensors, all of which require additional energy. This additional energy is required to improve vehicles' connectivity, not just to the Internet, but to other vehicles and buildings, traffic signals and other structures in the environment. Furthermore, drivetrain components, power steering, oil and water pumps will switch over from mechanical to electrical power.

The future for the 48 V battery system is much more near-term than the fully autonomous car, although many automotive suppliers see strong demand for the technological building blocks ultimately needed for self-driving vehicles over the next few years. According to some auto manufactures, a 48 V based electrical system results in a 10-15 % gain in fuel economy for internal combustion engine vehicles, thereby reducing CO_2 emissions. Moreover, future vehicles that use a dual 48 V/12 V system will allow engineers to integrate electrical booster technology that operates independently of the engine load, thereby helping to improve acceleration performance. Already in its advanced development phase, the compressor is placed between the induction system and intercooler and uses 48 V to spin-up the turbos.

Nevertheless, the implementation of an additional 48 V supply network into vehicles translates into major design challenges for suppliers across the value chain. In particular, providers of semiconductors and Electronic Control Units (ECUs) will be affected – they will need to adjust their operational range to the higher voltage and in part re-design their products. Correspondingly, the manufactures of DC/DC converters will need to develop and introduce specialized ICs to enable this high power transfer.

It is clear that there is a need for a bi-directional step-down and step-up DC/DC converter that goes between the 12 V and 48 V batteries. This DC/DC converter can be used to charge either battery and allows both batteries to supply current to the same load if required. Most of the early 48 V/12 V dual battery DC/DC converter designs use different power components to step-up and step-down the voltage. However, the recently released LTC3871 bi-directional DC/DC controller from Linear Technology uses the same external power components for the step-up conversion as it does for stepping down the voltage.

A single bi-directional IC solution

The LTC3871 is a 100V/30V bi-directional two phase synchronous buck or boost controller which provides bi-directional DC/DC control and battery charging between the 12 V and 48 V board nets. It operates in buck mode from the 48 V bus to the 12 V bus or in boost mode from 12 V to 48 V. Either mode is configured on demand via an applied control signal. Up to 12 phases can be paralleled and clocked out-of-phase to minimize input and output filtering requirements for high current applications (up to 250 A). Its current-mode architecture provides current matching between phases when paralleled. Up to 5 kW can be supplied in buck mode or in boost mode with a 12-phase design.

When starting the car, or when additional power is required, the device allows both batteries to supply energy simultaneously by converting energy from one board net to the other. Up to 97 % efficiency can be achieved and the on-chip current programming loop regulates the maximum current that can be delivered to the load in either direction. Four control loops, two for current and two for voltage, enable control of voltage and current on either the 48 V or 12 V board nets.

The LTC3871 operates at a user selectable fixed frequency between 60 kHz and 475 kHz, and can be synchronized to an external clock over the same range. The user can select from continuous operation or pulse skipping during light loads. Additional features include overload and short-circuit protection, independent loop

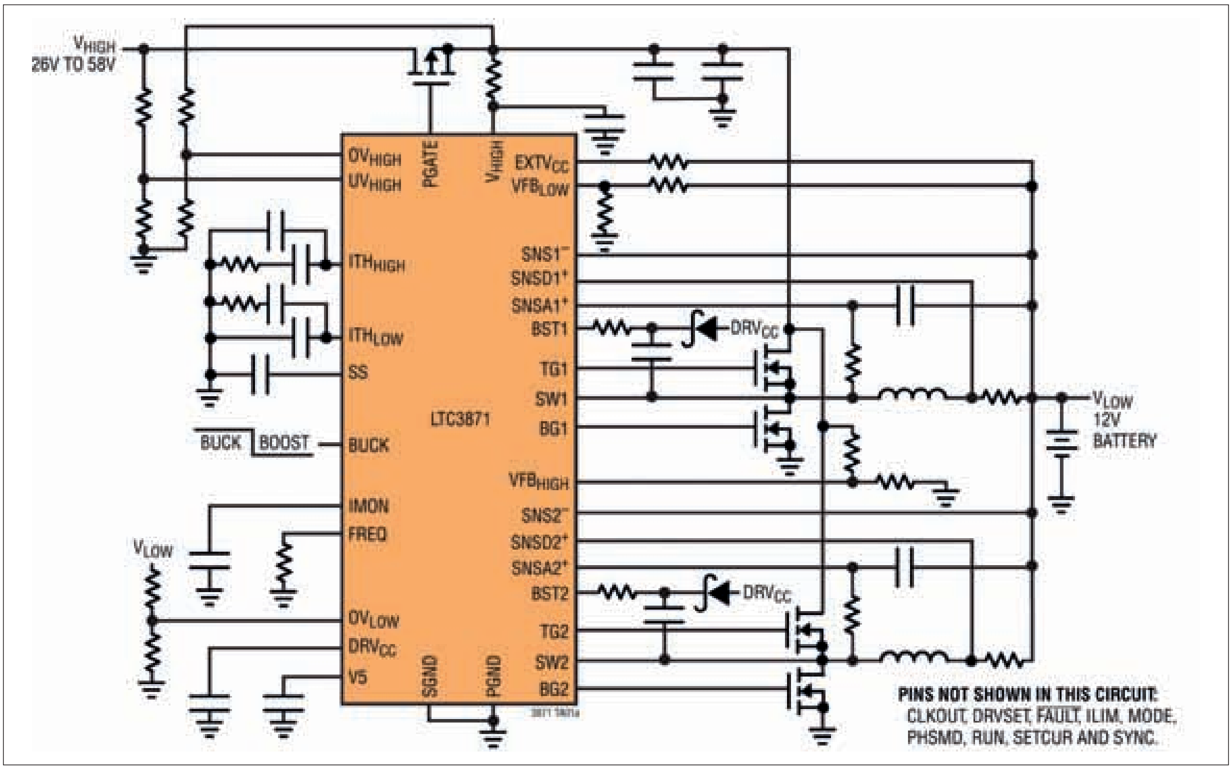


Figure 1: **LTC3871 bi-directional schematic 12 V output from a 26 V to 58 V input delivering 30 A of current**

compensation for buck and boost modes, EXTVcc for increased efficiency, ±1% output voltage regulation accuracy over temperature, along with under-voltage and over-voltage lockout. The LTC3871 has been qualified to meet AEC-Q100 specifications and was designed for diagnostic coverage in ISO26262 systems.

The LTC3871 is available in a thermally enhanced 48-lead LQFP package. Three temperature grades are available, with operation from –40°C to 125°C for the extended and industrial grades and a high temp automotive range of –40°C to 150°C. Figure 1 shows its typical applications schematic. The P-Channel MOSFET shown at the top of the schematic is for over-current and short-circuit protection.

Integrated starter-generator operation modes

The electronically controlled ISG replaces both the conventional starter and alternator with a single electric device for the following reasons: 1 - eliminate the starter which is only a passive component during engine operation; 2 - replaces the present belt and pulley coupling between the alternator and the crankshaft; 3 - provide fast control of the generator voltage during load dumps; and 4 - eliminate the slip rings and the brushes in some present wound rotor alternators.

The ISG has three important features which are the start-stop function, electricity generation and power assistance. The ISG allows the internal combustion engine to turn off its motor to save fuel at stops and instantly re-starts upon pressing of the gas pedal. Normally referred to as a start-stop system, an ISG makes for a smoother transition when starting the engine. Like a conventional alternator, the ISG produces electric power when the vehicle is running. In addition, the ISG can help to decelerate

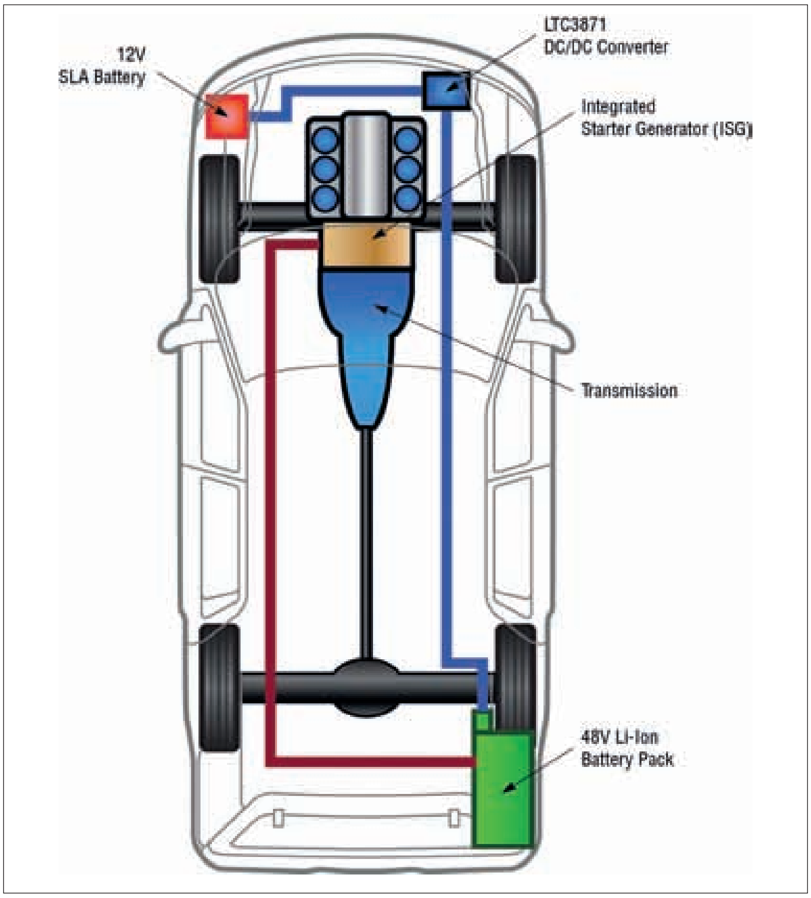


Figure 2: **Block diagram of the ISG, LTC3871 along with the 12 V and 48 V batteries are incorporated**

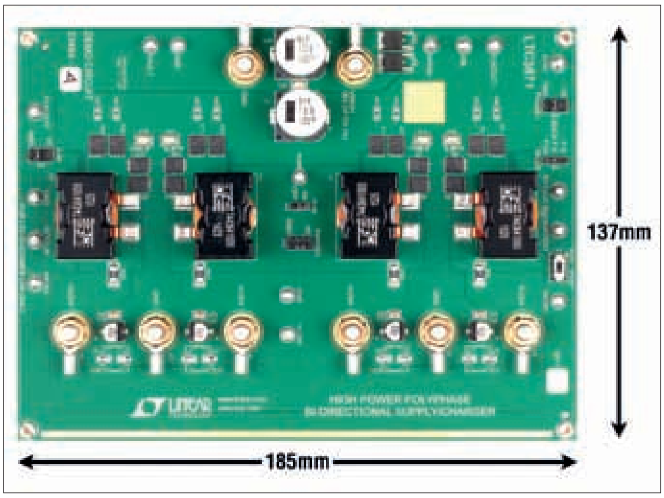


Figure 3: LTC3871 four-phase demo board

the vehicle by generating electric power (regenerative braking). The electric power generated during regenerative braking charges the 48 V battery, which in turn reduces fuel consumption and its resultant emissions. Figure 2 shows a block diagram how the ISG, LTC3871 along with the 12 volt and 48 volt batteries are incorporated into an internal combustion engine vehicle.

The LTC3871 can be dynamically and seamlessly switched from buck mode to boost mode and vice versa via a simple control signal. There are two separate error amplifiers for V_{HIGH} or V_{LOW} regulation. Having two error amplifiers allows fine tuning of the loop compensation for the buck and boost modes independently to optimize transient response. When the buck mode is selected, the corresponding error amplifier is enabled, and I_{THLOW} voltage controls the peak inductor current. The other error amplifier being disabled. In boost mode, ITHHIGH is enabled while ITHLOW is disabled. During a buck to boost or a boost to buck transition, the internal soft-start is reset. Resetting soft-start and parking the ITH pin at the zero current level ensures a smooth transition to the newly selected mode.

Multiple LTC3871s can be daisy chained to run out of phase to provide more output current without increasing input and output voltage ripple. The SYNC pin allows to synchronize to the CLKOUT signal of another LTC3871. The CLKOUT signal can be connected to the SYNC pin of the following device stage to line up both the frequency as well as the phase of the entire system. A total of 12 phases can be daisy chained to run simultaneously out-of-phase with respect to each other.

The demonstration circuit DC2348A shown in Figure 3 can be configured with two or four phases utilizing one or two LTC3871 devices. The four phase version operating in buck mode has an input voltage range of 30 V to 75 V and produces a 12 V output at up to 60 A. When operating in boost mode, the input voltage is from 10 V to 13 V and produces a 48 V at up to 10 A.

The LTC3871 efficiency curves in Figure 4 are representative of a four-phase demo board design using two LTC3871 devices. The buck mode curve steps the 48 V down to 12 V at up to 60 A, while the boost curve steps up the 12 V to 48 V at up to 10 A. Both operate with 97 % peak efficiencies.

In buck mode, the LTC3871 includes current fold-back protection to limit power dissipation in an over current condition or when the V_{LOW} is shorted to ground. If the V_{LOW} falls below 85 % of its nominal output level, then the maximum sense voltage is progressively lowered from its maximum programmed value to one-third of the maximum value. Foldback current limiting is enabled during soft-start. Under short-circuit conditions with very low duty cycles, the LTC3871 will begin cycle skipping in order to limit the short-circuit current.

In a typical boost controller, the synchronous diode or the body diode of the synchronous MOSFET conducts current from the input to the output. As a result, an output (V_{HIGH}) short will drag the input (V_{LOW}) down without a blocking diode or MOSFET to block the current. The LTC3871 uses an external low $R_{DS(ON)}$ P-channel MOSFET for input short-circuit protection when V_{HIGH} is shorted to ground. In normal operation, the P-channel MOSFET is always on, with its gate-source voltage clamped to 15 V maximum. When the UVHIGH pin voltage goes below its 1.2 V threshold, the FAULT pin goes low 125 µs later. At this point, the PGATE pin turns off the external P-channel MOSFET.

Conclusion

The LTC3871 brings a new level of performance, control and simplification to 48 V/12 V dual battery DC/DC automotive systems by allowing the same external power components to be used for step-down and step-up purposes. It operates on demand in buck mode from the 48 V bus to the 12 V bus or in boost mode from 12 V to 48 V. Up to 12 phases can be paralleled for high power applications and when starting the car or when additional power is required, the LTC3871 allows both batteries to supply energy simultaneously to the same load. The additional 48 V battery running a portion of a vehicle's electrical system will play a central role in increasing available energy, while reducing wiring harness weight and losses. This additional energy capacity paves the way for new technologies, enabling cars to be safer and more efficient, all while lowering its CO_2 emissions.

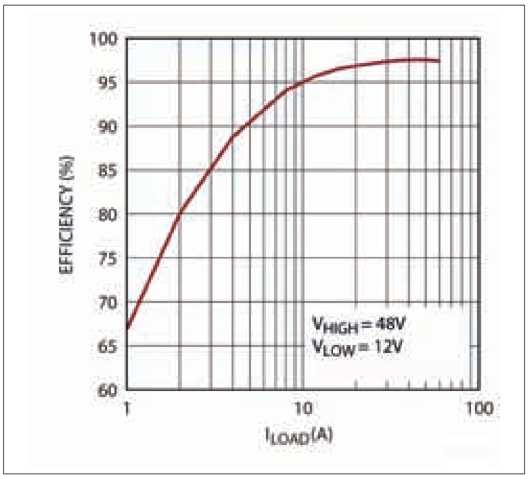
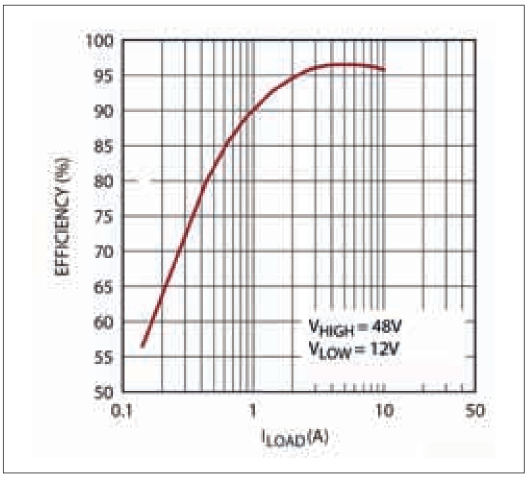
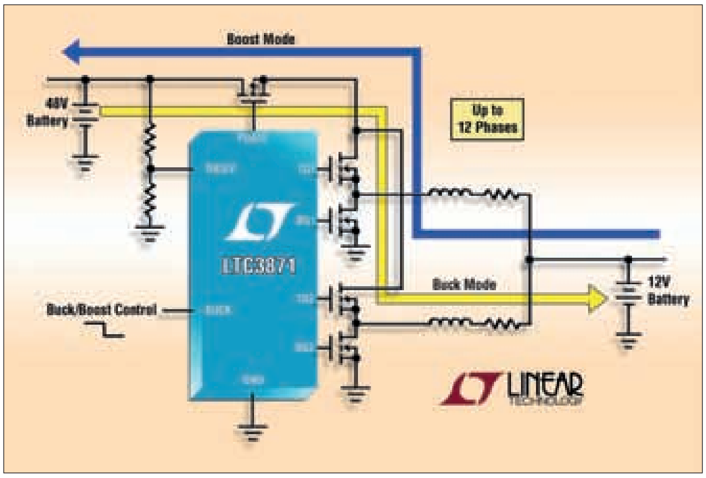


Figure 4: Buck (left) and boost (right) efficiency curves with a four-phase design





48 V/12 V Automotive Bidirectional Synchronous DC/DC Controller

Linear Technology offers now the LTC3871, a 100 V/30 V bidirectional two phase synchronous buck or boost controller, ideal for 48 V/12 V automotive dual battery systems. Current 12 V automotive systems are reaching their 3 kW power limit due to the increasing demand for more electrical devices. A newly proposed standard, LV148, combines a secondary 48 V bus with the existing 12 V system. The 48 V rail includes a belt starter generator (BSG) or an integrated starter generator (ISG), a 48 V lithium-ion battery and a bidirectional DC/DC converter for delivery of up to 10 kW of available energy from the 48 V and 12 V batteries combined. This technology is targeted for conventional internal combustion automobiles, as well as hybrid electric and mild hybrid vehicles. The LTC3871 operates in buck mode from the 48 V bus to the 12 V bus or in boost mode from 12 V to 48 V. Either mode is configured on demand with an applied control signal. Up to 12 phases can be paralleled and clocked out-of-phase to minimize input and output filtering requirements for high current applications (up to 250 A). Its current mode architecture provides current matching between phases when paralleled. Up to 3 kW can be supplied in buck mode or in boost mode with a 12-phase design.

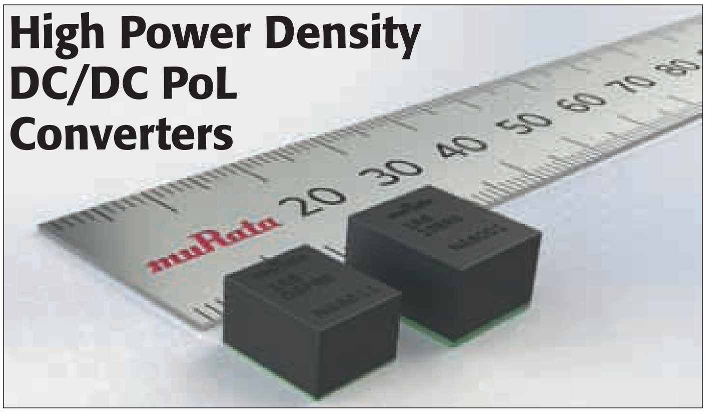
www.linear.com

650 V SuperFET III MOSFET Family

Fairchild Semiconductor, now part of ON Semiconductor, introduced its SuperFET® III family of 650V N-channel MOSFETs, that meet the higher power density, system efficiency and reliability requirements of telecom, server, electric vehicle (EV) charger and solar products. According to Fairchild SuperFET III technology has the lowest on-resistance in any easy drive version of a Super Junction MOSFET, delivering best-in-class efficiency. It achieves this thanks to advanced charge balancing technology which also enables 44 percent lower on-resistance than its SuperFET II predecessors, in the same package size. A key factor in the SuperFET III's ruggedness and reliability is its best-in-class body diode. The lower peak drain-source voltage during turn off improves system reliability in low temperature operation because the breakdown voltage naturally drops by 5 % at -25°C junction temperature than room temperature and the peak drain-source voltage becomes higher at low temperature.

www.fairchildsemi.com/superfet

High Power Density DC/DC PoL Converters



Murata announced the MYMGK series of miniature non-isolated "Mono Block" type surface mount point-of-load (PoL) DC/DC converters. These converters are available in two models at 6 A and 20 A. Each version is available with two output voltage range options. Typical applications for these converters include powering FPGAs and CPUs. Across the range control signals include remote on/off and a power good indication. Safety and protection features include under input voltage lock out (UVLO), output short circuit and output over-current. The use of increasingly compute intensive devices such as programmable logic, FPGAs and CPU is demanding high reliable power supplies that have can quickly respond to load variations, good transient response, a low core voltage high current supply. Mono Block type MYMGK series delivers fast transient response with a minimum of external output capacitors, this contributes to significantly shrinking the customer's board size. These efficient converters, typically between 87.8 % to 95 % model and load dependent, meet the industrial and telecom requirements for size, efficiency and power density, especially in high temperature operating case.

www.murata.com

160 A MOSFET for Automotive Applications

Toshiba Electronics Europe has expanded its family of automotive power MOSFETs with the TK1R5R04PB - the first device in its new low-resistance D2PAK+ package. While the D2PAK+ has the same footprint as a conventional D2PAK (or TO-263) package, it offers reduced package resistance. This is thanks to a source pin that is much wider near to the mould surface than that of a conventional D2PAK. The TK1R5R04PB is rated for 40 V / 160 A and has a maximum on resistance of 1.5 mΩ. Minimum and maximum voltage threshold ratings are 2 V and 3 V respectively. Target applications for the new device include automotive pumps, fans, DC/DC converters and load switches. The TK1R5R04PB will conform with AEC-Q101 automotive level qualification requirements.

www.toshiba.semicon-storage.com

Charge Controller for Next Generation Power Banks

ON Semiconductor has introduced a highly integrated single chip for the development of next generation Li-Ion powered products. The LC709501F total Li-Ion battery solution offers broad power and voltage/current output range of 5 V, 9 V and 12 V operation, with a maximum charge/discharge capability of up to 30 W through simple FET selection. The LC709501F determines what type of device is connected and automatically selects the fastest available method for charging. Advanced users can even reprogram the LC709501F to support custom charge/discharge profiles, as well as USB Type-C and PD "Policy Engine" functions. This IC includes integrated fuel gauge function, configurable I/O, LED drivers, I?C interface, and pre-drivers for external power MOSFETs. A design reference kit is available to realize fast time to market. The LC709501F supports various output power levels up to 30 W, by changing external MOSFETs. In addition, there is an integrated USB 2.0 Full Speed host controller. The internal USB host controller supports connectivity with iOS and Android apps that enable the device to communicate with the connected smartphone and subsequently make use of its display to show information concerning the battery health and the charging process (charging time, battery life, number of charging cycles completed). The device works with the proprietary charging protocols (such as Fast Charge and Qualcomm Quick Charge™) now being utilized by smartphone manufacturers to accelerate the charging period.

www.onsemi.com

Extended Power Range in a MiniSKiiP Module

Vincotech announced a new MiniSKiiP® product line featuring sixpack topology and able to handle up to 200 A, available with the new Mitsubishi gen 7 IGBT chips. These 1200 V MiniSKiiP® PACK 2 & 3 modules reduce static losses by 20 %. Designed for industrial and embedded drive applications, they provide superior EMI behavior and cut overall system costs. With the benefit of this extended power range of up to 200 A in the MiniSKiiP® PACK 3 module, it is far more easy for engineers to design flexible, scalable inverters.

www.vincotech.com/PACK-M7

New series of Welding Diodes

Proton-Electrotex, the Russian manufacturer of power semiconductors and power stacks, recently released new series of welding diodes – one in ceramic housing and two housingless diodes. All welding diodes can be used in industrial welding equipment and perfectly suit welding robots. The company offers diodes with enhanced average forward current ratings comparing to available on the market alternatives. On top of that, all diodes completely correspond to industrial standards and requirements including low on-state and switching losses, low thermal resistance, and high load cycle capability. Application note, data sheets, and additional information can be found on the company website.

This March Proton-Electrotex will participate in APEC 2017 conference, which will take place in Tampa, FL, USA. Everyone interested can appoint a meeting with company representatives to have all their questions about welding diodes as well as IGBTs, power thyristors and diodes to be answered. An appointment can be made through a form available at company website.

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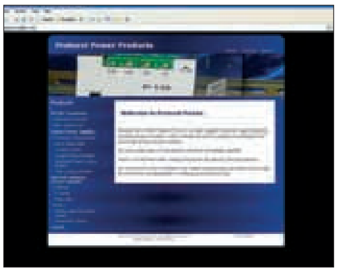

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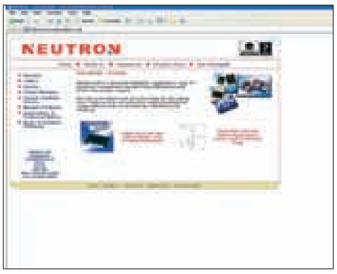
Diodes



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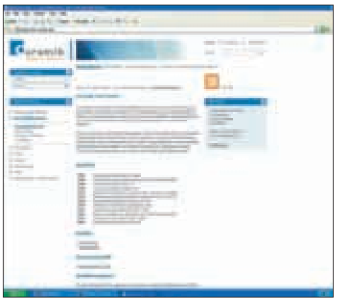

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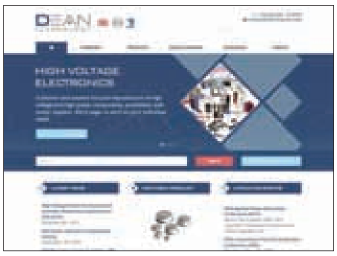

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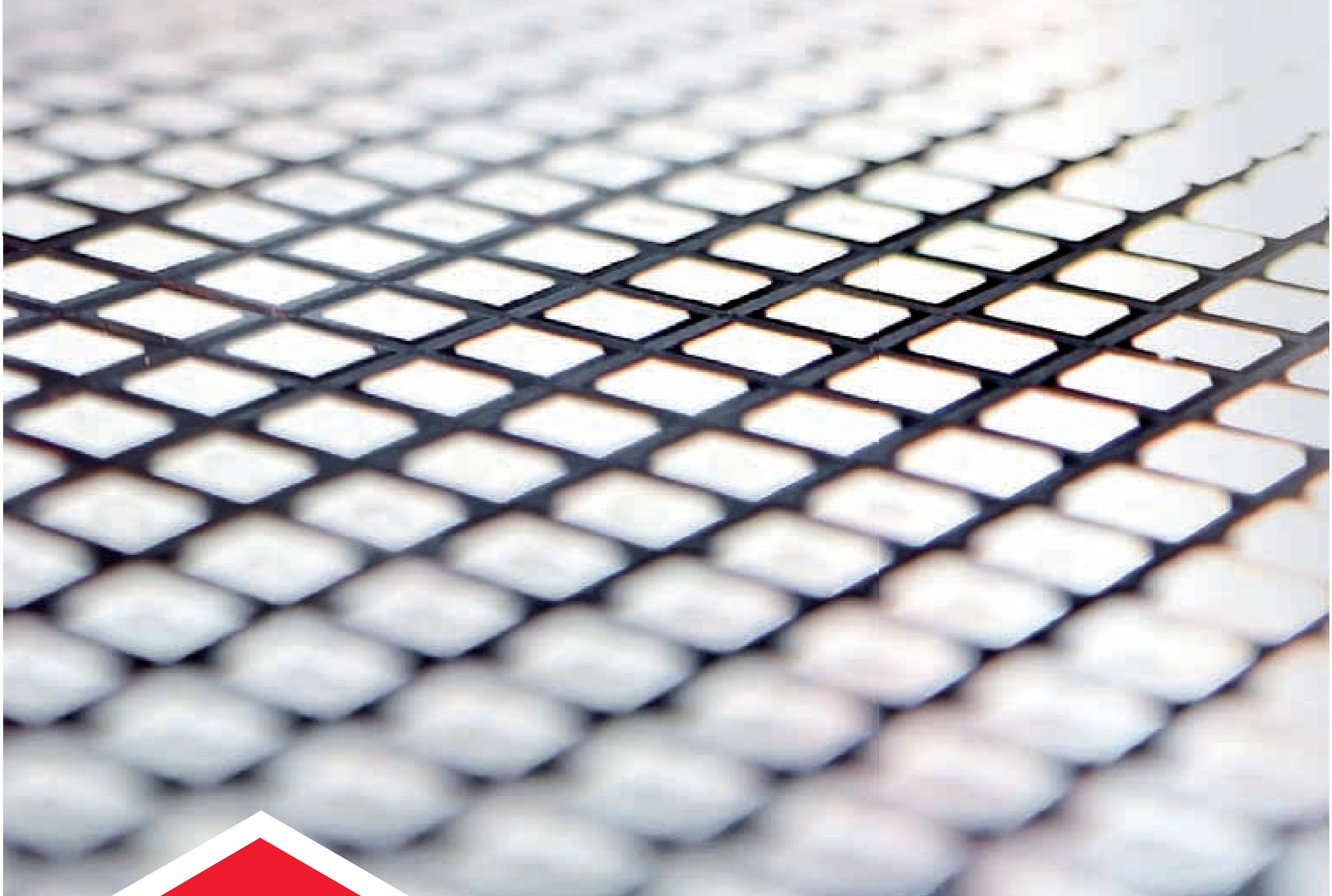

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