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GATE-DRIVER ICS

Versatile Gate Driver IC Featuring Unique Isolation Technique

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Also inside this issue

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DfA media

COVER STORY

Versatile Gate Driver IC Featuring Unique Isolation Technique

The newest member of the SCALE-iDriver™ IC family, SID1102K is a single-channel, isolated, IGBT and MOSFET gate driver in a wide-body eSOP package. Featuring a peak drive current of up to 5 A, the new part is able to drive 300 A switches without boosters; external boosters can be used to cost-effectively scale gate current up to 60 A peak. Reinforced galvanic isolation up to 1200 V is provided by Power Integrations' innovative, solid insulator FluxLink™ technology which eliminates the need for optocouplers. The FluxLink technology is a high speed bi-directional communications link that sits across the isolation gap. It is a solution for the secondary side isolation and coupling replacing an optocoupler which degrades over time, but more importantly also to save cost. The idea is using the "parasitic" inductance of the bond wires (which can be manufactured repeatable) and leadframe as a coreless pulse transformer. More details on page 30.

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The Race Is On

APEC 2018 from March 3 – 8 in San Antonio/Texas is the first Power Electronics Conference & Exhibition in 2018 with a global footprint due to its international reputation leading to 5,000+ conference attendees and 240 exhibiting companies in 2017. One of APEC's specialities are the keynotes within the plenary session covering the history of power, the current needs in energy efficiency and future possibilities. 'Does Power Efficiency Improve with Consolidation in the Semiconductor Industry?' asks Hans Stork, Senior Vice President and Chief Technology Officer, ON Semiconductor, in his keynote. Recently, the semiconductor industry has been rapidly consolidating for financial, operational, pricing and market-share reasons. Having fewer and larger businesses may actually accelerate the broad acceptance and commercialization of innovative technologies like wide bandgap power devices. Although many concepts for smaller and more efficient power management have been demonstrated by research and startup companies, the realization of full-scale adoption, ranging from household adaptors to automobiles and to data center management, requires significant resources to meet demands for global supply and quality. Large enterprises have the manufacturing and supply chain infrastructure, as well as the depth in R&D knowledge. His talk will provide an overview of the progress, in cost and performance, of both Silicon and wide bandgap materials, devices, circuits and applications, highlighting both technical and commercial challenges. Muhammad Nawaz, Principal Scientist, ABB Corporate Research, talks about 'Moving from Si to SiC from the End User's Perspective'. Ever increasing demand of energy supply as a result of continuous population growth, human mobility leading to more urbanization and widening industrialization scope with lower environmental impact is the basic challenge that power electronics community is facing nowadays for sustainable societal growth. While electricity consumption is continuously growing at a fast rate over the coming decade, combating the energy demand and climatic problem therefore requires a more complex interdisciplinary approach involving new technological solutions such as sustain able energy sources and more efficient energy usage. With these considerations in mind, an enabling technology that provides an efficient energy conversion and distribution, reliable control and conditioning of electric energy from the source to the load end will be the main objective of futuristic research and development. High power Semiconductor devices such as MOSFETs, IGBTs and IGCTs provide basic building blocks for variety of high power conversion applications. As witnessed by recent device technological trend, wide bandgap electronic devices using Silicon Carbide material system promise potential replacement to leading horse Silicon based devices.

These keynotes underline the ongoing popularity of wide bandgap power devices, though they have today a low market share of 0.1 % of the total semiconductor market. But this share is expected to increase by a factor of 10 up to 1 % by the year 2025, according to statistics of German Electrotechnical Association (ZVEI) and market researcher IHS. The World Semiconductor Trade Statistics (WSTS) estimate the total semiconductor market in 2017 to around $400 billion with an increase of 5 % up to $420 billion in 2018!

The main portion of this grow comes from the automotive industry. Since more than three years the automotive semiconductor market outperforms the increase in automobile production by around 10 percentage points in 2017, illustrating the increasing content of (power) semiconductors in automobiles. For new applications such as (H)EV and ADAS an annual growth rate of 20 % is expected in the coming years.

Autonomy and electrification are demanding significant changes to electrical and electronic architectures within vehicles. This is due in part to the introduction of high voltages, increased safety considerations and significant weight reductions needed to maximise vehicle range from electrification, and 'fail operational' designs, hugely increased data network loading and virtual validation requirements from autonomy. At a recent count there are approximately 300 companies developing electric cars and light trucks, with approximately 100 companies having announced autonomous drive programs. The race to self-driving cars is on. In KPMG's survey of automotive executives in 2017, electric drive technologies have jumped from number 10 to number 1 in the list of concerns for executives in just three years. Electric vehicle related technologies occupy three of the top four slots.

Formula E is a typical example for the progress in performance due to the application of wide bandgap power semiconductors. Formula E features cars powered solely by electric power and represents a vision for the future of the motor sports industry, serving as a framework for research and development around zero-emission motoring. ROHM in example provides its full SiC power modules to the VENTURI Formula E team. This power module will support further improvements in the car's performance under racing conditions. The inverter for season four features embedded full SiC Power modules, making it 43 % smaller and 6 kg lighter than the inverter for season two. Compared to conventional IGBT modules with similar current ratings, this module reduces switching losses by 75 % (at a chip temperature of 150°C). This contributes to the energy efficiency for the whole application. Also, the high frequency drive facilitates the use of smaller peripheral components. This, as well as the effect of reductions in switching losses contributes to a more compact cooling system.

This example illustrates the important contribution of power semiconductors in automotive applications, though this example is a little bit outstanding. But by gaining experience new technologies will penetrate the mid-class cars sooner or later, as (H)EVs become more popular.

Enjoy reading this issue!

Achim Scharf
PEE Editor

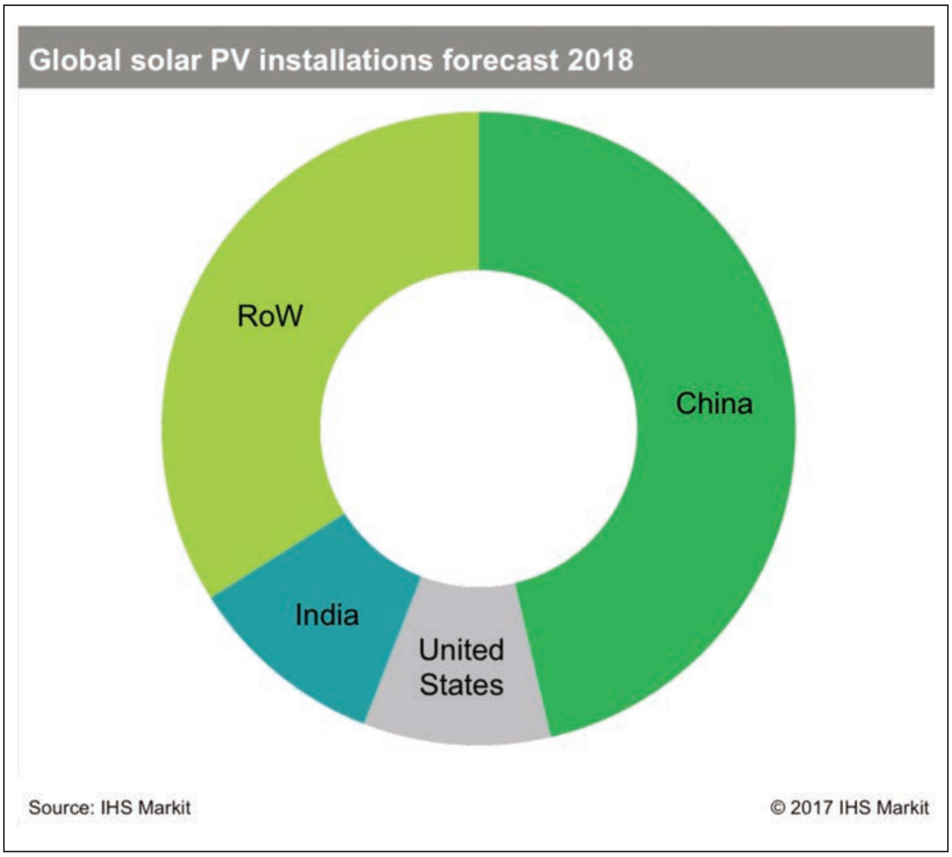
Global Photovoltaic Installations to Exceed 100 Gigawatts in 2018

Largely driven by an improvement in the outlook in China, global photovoltaic (PV) demand is forecast to reach 108 GW in 2018. According to IHS Markit strong demand from the Chinese market is expected to continue on the back of strong policy support, a successful transition to a more diverse market and strong momentum in the distributed-PV (DPV) sector.

"Exceeding 108 gigawatts of PV installations is close to the top-end of what can be achieved, based on the global polysilicon manufacturing capacity," said Edurne Zoco, research and analysis director for IHS Markit. "Supply will therefore be tight throughout the first half of the year at least, resulting in stable to higher prices across the supply chain. Short supply and higher-than-anticipated module prices in the first half of 2018 will impede many markets outside China, due to worsening project economics. Projects in some regions might be delayed or even canceled, because market prices are higher than were estimated during the planning phase."

In a marked change from the past, Chinese PV module suppliers are now prioritizing their domestic market. At one time China represented one of the lowest-priced PV markets, but after prices increased in 2017, China became an attractive market for local manufacturers. As a result, supply to other regions is restricted when demand in China is strong. In addition to the expected shortfall in PV modules, following are the two most important factors influencing the PV outlook outside of China next year: The United States, which is still forecast to be the second-largest PV market in 2018, is facing significant policy uncertainty. President Trump's final ruling on Suniva's 201 petition case could significantly affect global PV economics in this market. Planned corporate tax reforms could also significantly weaken investor interest in the sector. The relationship between supply and demand has already become distorted, due to the stockpiling of modules ahead of the 201 decision. Secondly, India, the third-largest market in 2018, is mulling the introduction of anti-dumping duties for modules manufactured in China in the second half of 2018. The country has also announced tenders for projects with local content. Such measures may limit the amount of modules available to supply India's PV demand over the next few years, unless local manufacturers ramp up production quickly.

www.ihsmarkit.com



Can Power Electronics Support Market Growth?

Recent market research by Grand View Research has projected that the global power electronics market will be valued around $39 billion by 2025. To ensure electrical products and infrastructure are capable of supporting this 40 % growth, power quality expert REO UK is calling on laboratories and testing facilities to invest in stable DC power supplies for electrical testing.

Electrical testing is a critical part of the design and development of power electronics and electrical components. Testing involves running accurately monitored voltages through a component or product to ensure it is capable of withstanding and performing under specified currents. This ensures smooth performance and correct specification details once the tested equipment is on the market. REO UK has worked extensively with test facilities and laboratories in the past and has identified a recurring problem of poor power quality affecting test accuracy. The company has previously launched ranges of electrical power supplies to provide stepless voltage adjustment to overcome this issue. "Electrical testing requires absolute accuracy to ensure that products are reliable, safe and able to perform," expressed Steve Hughes, managing director of REO UK. "If the market for power electronics is to reach its projected 40 percent growth in the coming decade, testing must be accurately controlled and reliable to ensure a consistently high standard of products. Unfortunately, we often see that test facilities lack this control, either due to inaccurate electrical equipment or electromagnetic interference (EMI) making the current unreliable."

Now, the company has stepped up its focus on test facilities with its new REOLAB 1000E electronic DC power supply for test equipment. The product is designed for use in testing the operating current of semiconductor diodes and rectifiers, as well as the maximum DC reverse voltage of a system up to 1200 V. "Our new REOLAB 1000E helps to tackle the lack of electrical control with its stepless voltage adjustments and current tolerance of 1 percent, this tolerance level means that the supplied power is highly accurate and controllable," continued Steve. "In addition to this, the REOLAB range has a design that complies with electromagnetic compatibility (EMC) standards to prevent creating power quality problems. This ensures test and laboratory facilities can test properly and effectively with minimal concerns over unstable loads."

www.reo.co.uk

Electronics Powers Automobiles

The amount of electrical and electronic content in new vehicles continues to explode as consumers demand greater personalization of products along with regular updates and new technologies such as autonomous and electric drive become established. And here SiC and GaN will play a major role, expects Walden C. Rhines, CEO of Mentor, now a Siemens Business. The semiconductor market of $375 billion in 2017 will still grow due to further specialization by the vendors, not by consolidation.

Autonomy and electrification are demanding significant changes to electrical and electronic architectures within vehicles. This is due in part to the introduction of high voltages, increased safety considerations and significant weight reductions needed to maximise vehicle range from electrification, and 'fail operational' designs, hugely increased data network loading and virtual validation requirements from autonomy. At a recent count there are approximately 300 companies developing electric cars and light trucks, with approximately 100 companies having announced autonomous drive programs. The race to self-driving cars is on. Leading automakers have responded with plans to launch autonomous cars including GM (targeting 2018), Hyundai, Renault-Nissan, Toyota, through to Honda (aiming for 2025).

Similarly electric vehicles dominate the thinking of automotive leaders. In KPMG's survey of automotive executives in 2017, electric drive technologies have jumped from number 10 to number 1 in the list of concerns for executives in just three years. Electric vehicle related technologies occupy three of the top four slots displacing usual business concerns like emerging market growth or big data.

"Specialization in semiconductors is a prerequisite to be successful in the market, particularly in automotive", states Mentor's CEO Walden C. Rhines

The challenge with 'mass-customisation' is to enable customers to choose the specific combination of vehicle options they want at unit costs in-keeping with the reality of mass production. This means that the vehicle electrical and electronic architectures have to be optimized at a vehicle platform level, early in the design process. In a typical vehicle there are hundreds of possible options which combine so that manufacturers have to manage billions of potential electrical configurations to satisfy that demand. The two main approaches to solving this challenge are exemplified by the Porsche Cayenne options booklet, which runs to 160 pages, compared to a similar Lexus vehicle option booklet, containing only 14 pages. German automakers lead the way in adopting the modular design & manufacturing approach, where individual harnesses are built to cover multiple option choices. The other widely utilized alternative is to adopt the 'packaged' or composite approach, where the available options are grouped together, so the total number of possible options to be supported is reduced.

Mentor's 'Capital' product portfolio, which supports the electrical systems and network domains, is an example of how we can transform design capabilities across organizations. Using a model based design paradigm, Capital can define system architectures and then, using in-built metrics and design rule checks, compare and contrast multiple potential architectures to ensure the platform design meets the original intent. The tools can then automatically integrate the electrical systems to be incorporated into a vehicle into the mechanical structure of that vehicle. Systems devices are automatically placed, interconnected and the entire wiring system automatically generated using rules and constraints embedded by the OEM into the software. The result is design tasks that took months can now be achieved in hours or days and critically, the designs can be verified as they are created. Data can be reused across vehicle programs and in the downstream processes of manufacturing and service.

www.mentor.com

Thermal Management is Key Not Only for Smartphones

Many thermal management technologies have been developed and tested to support new requirements and follow industries evolution. Therefore the market for thermal management solutions is today clearly in expansion. Amongst the numerous industries, the growing smartphone market, expected to reach almost 2.1 billion smartphones annually by 2022, represents a great opportunity. Indeed thermal management solutions enable better performance and longer lifetime as well as comfort and safety for the end-users. The thermal management components for smartphone applications is showing more than 26 % CAGR between 2016 and 2022. The components involved include packaging, PCB, heat pipe/vapor chamber, thermal sheet, or smartphone back cover.

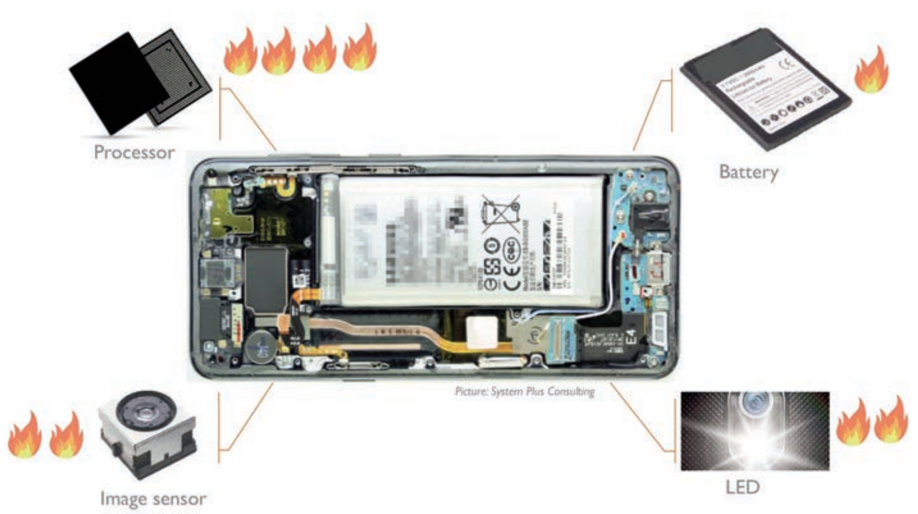
Many companies are today deeply involved in the development of innovative thermal management solutions and would like to ensure their business expansion in this field. Beyond the interest for smartphones, thermal management solutions could also be applied in other electronic devices: power electronics and automotive components are part of them. That is why lot of companies are keeping a close eye on this topic and lot of questions are pending. How can smartphones deal with growing heat management challenges? What are the current solutions? Who are involved in this industry? Yole and System Plus Consulting analysts offer you today a snapshot of this promising industry. "The importance of thermal management in smartphones is due to the growing number of smartphone functionalities and raised customer requirements for processing speed, leading to increased heat dissipation," explains Dr Milan Rosina, Senior Analyst for Energy Conversion and Emerging Materials at Yole. "Additional components needed to ensure new smartphone functions desired by customers, including wireless charging, high-resolution cameras, 3D gaming, security, authentication, and high-speed streaming, also result in denser component integration, making thermal management even more difficult", he adds.

Actually, smartphones contain several components that generate heat, and components whose performance and lifetime is negatively impacted by heat. Excessive heating of some components, such as lithium ion batteries, has to be carefully handled for safety reasons. The processor is the most important and hottest component in a smartphone. To improve low power and high efficiency processors, companies including Apple and Samsung decreased their technology node up to 10 nm, this approach allowed an I/O increase, more than 1,500 solders balls for the latest generation as well as a decrease the processor die size. Amongst the other heat-generating components are image sensors, light sources and batteries. Suitable thermal management solutions are now sought to avoid hot spots in smartphone and keep the component temperature at acceptable levels. The enclosure temperature, or skin temperature, must be also kept relatively low.

So what are today's solutions? Smartphones pose a significant challenge to the implementation of traditional cooling schemes, such as heat sinks and fans, due to form factor limitations and the specific way the device is used by customers. According to Yole's analysts, there are different approaches for thermal management, based both on hardware and software solutions. Software thermal management (STM) has several advantages. It enables additional design flexibility and an optimal reaction to a given thermal event

Main heat sources in a smartphone

(Source: Market Opportunities for Thermal Management Components in Smartphones, Yole Développement, November 2017)



and can be improved by a software update in existing products. Contrary to hardware solutions, such as heat pipes, STM does not take additional space in smartphone. The optimal way to deal with heat would be to reduce heat generation, by using higher performance chips. Significant improvements have been made in chip manufacturing, with the 10 nm node introduced in 2016, and chip architectures, including multiple core architectures, with "high-power" and "low-power" cores, associated with appropriate software control. However, in the future, processor improvements might be not fast enough to follow rapidly elevating customer requirements for smartphone functionality and performance. So other thermal management solutions will increasingly be needed. Similar trends were observed in the past, when thermal transfer sheet performance was not sufficient to dissipate heat from poorly thermally designed processors, leading to heat pipes being introduced into the first smartphones from NEC and Sony. Today, the Samsung Galaxy S8, LG G5, Google Pixel 2 XL are just a few examples of smartphones relying on heat pipes to improve their thermal management. Alternatively, vapor chambers might perform better than heat pipes in the near future. Ultrathin vapor chambers are already under development by several players, such as Furukawa Electric, TaiSol, AVC and Delta, but still face difficult technology challenges.

www.yole.fr

Accelerating Formula E

The 2018 season marks the fourth edition of Formula E racing and the fourth-straight year that Mouser Electronics will be a team sponsor along with valued supplier Molex. Formula E features cars powered solely by electric power and represents a vision for the future of the motor sports industry, serving as a framework for research and development around zero-emission motoring. Mouser and Molex will sponsor Dragon Racing team throughout the season in collaboration with TTI, Inc. Racing is all about speed and endurance, and racing sponsorships are an innovative way for Mouser to communicate its performance-driven business model and promote the newest technologies from its manufacturer partners. "All of us at TTI are proud to once again partner with Mouser to support this exciting team and the sustainable automotive technologies of the future," said Mike Morton, President, TTI Global Sales and Marketing. "This is very much a pioneering venture," said Fred Bell, Vice President of Global Distribution for Molex. "We welcome the opportunity to once again collaborate with Mouser and TTI as a sponsor of the Dragon team, supporting such an important, innovative technology." "Formula E cars are employing the very latest sustainable and high-performance components to gain the competitive edge. By teaming up with TTI and Molex to sponsor Dragon Racing, Mouser shows its commitment to keeping engineers up to date with these innovative technologies," added Todd McAtee, Vice President, Americas Business Development for Mouser Electronics.

ROHM provides its full SiC power modules to the VENTURI Formula E team in the FIA Formula E 2018. This module will support further improvements in the car's performance under racing conditions. The inverter for season four features embedded full SiC Power modules, making it 43 % smaller and 6 kg lighter than the inverter for season two. "The Formula E is the only motorsports event for testing the latest technology in next-generation electric vehicles. We are extremely happy about our technical partnership with ROHM in the area of power management, which is the foremost key to the Formula E race. For season 4, by adopting a full SiC power module, we were able to bring to reality a lightweight inverter that requires only a minimum amount of space. By using the latest technology, I expect that we will be able to dramatically reduce our lap times, and I hope that we can continue to move forward with revolutions in technology through our partnership with ROHM," commented Franck Baldet, CTO VENTURI Formula E Team. The SiC power

module used in the inverter achieves a large power throughput. This is due to the development of a new package with an improved internal module structure, as well as optimized thermal management. Compared to conventional IGBT modules with similar current ratings, this module reduces switching losses by 75 % (at a chip temperature of 150°C). This contributes to the energy efficiency for the whole application. Also, the high frequency drive facilitates the use of smaller peripheral components. This, as well as the effect of reductions in switching losses contributes to a more compact cooling system. "ROHM has been providing products for many years for today's constantly evolving automobiles, this is currently a field in which we would like to give our special attention; and semiconductor devices are certain to play a crucial role in recent hybrid and electric automobiles. The SiC power device that we are providing for the Formula E racing car is one example. We provided SiC-SBDs in season 3 last year (2016–2017), but this year we provide full SiC power modules that combine SiC SBD and SiC MOSFET. These modules will contribute to improve vehicle performance", said Kazuhide Ino, Group General Manager of Power Device Production Headquarters, ROHM Co., Ltd.

The Audi Sport ABT Schaeffler racing team starts the fourth season of the FIA Formula E Championship with the technology partnerWürth Elektronik eiSos Group. The manufacturer of electronic and electromechanical components is not only an avid supporter of the successful racing stable spearheaded by FIA Formula E world champion Lucas di Grassi, but is also supplier of the products and solutions that will race around with the electric-powered racing cars. "The Audi e-tron FE04 now boasts a completely overhauled drive train" said Alexander Gerfer, CTO Würth Elektronik eiSos Group. "Its core element is a highly efficiency gearbox with only one gear." "We are committed to advancing eMobility. Our technology partnership with the Audi Sport ABT Schaeffler Team provides this involvement with a special kick. Many employees keenly follow the races and keep their fingers crossed for our drivers. Lucas di Grassi and Daniel Abt have been a strong duo in Formula E from the very start, achieving 24 podium finishes in the 33 races staged so far with six victories and four pole positions. We look forward to a particularly exciting season", says Oliver Konz, CEO Würth Elektronik eiSos Group. Würth Elektronik eiSos managed to put innovative solutions onto the race track in the past. REDCUBE terminals have been installed on the inverter boards since the second season. During the third season, the company optimized the backup battery for the cockpit, together with ABT. The associated battery charger was also jointly developed. Further projects are already in progress.

The series travels to Mexico City, March 3; São Paulo, March 17; Rome, April 14; Paris, April 28; Berlin, May 19; Zurich, June 10; and New York City, July 14 and 15, Montreal, July 28 and 29.

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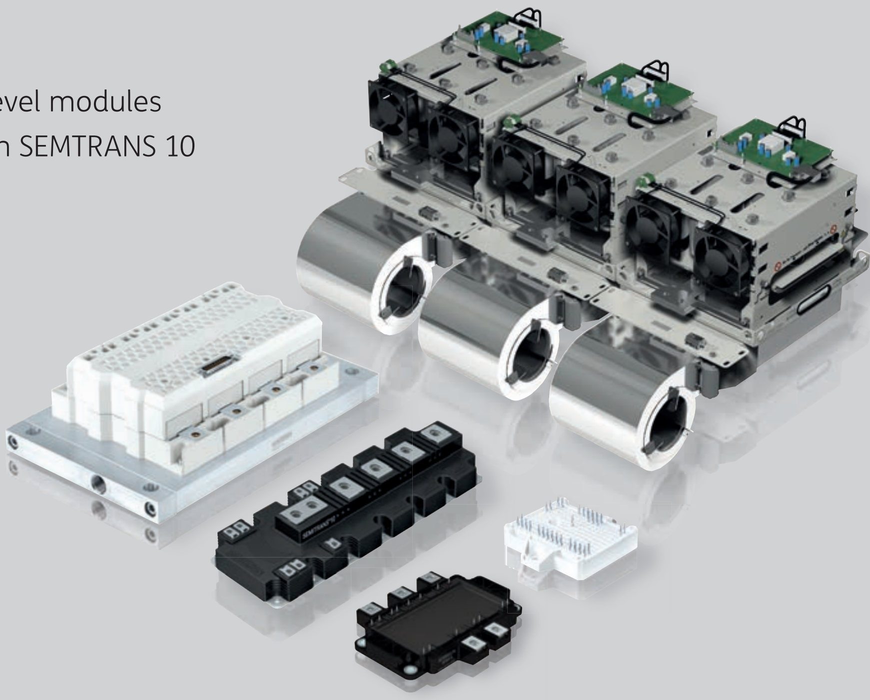

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Novel Solid Sodium Battery To Store Extra Energy

Batteries are everywhere. And to meet future expectations, these batteries are increasingly lighter, more powerful and designed to last longer. Currently the core technology for these applications is lithium ion batteries. But the technology is expensive and contains a flammable liquid, which may represent a safety hazard, when the battery is abused.

To satisfy the growing demand from emerging markets (electric cars, for example, and renewable energy storage), researchers from Empa, the Swiss Federal Laboratories for Materials Science and Technology, and the University of Geneva (UNIGE) have devised a new battery prototype known as «all-solid-state», this battery has the potential to store more energy while maintaining high safety and reliability levels. Furthermore, the battery is based on sodium, a cheap alternative to lithium.

For a battery to work, it must have the following three key components: an anode (the negative pole), a cathode (the positive pole) and an electrolyte. Most of the batteries used in our electronic equipment today are based on lithium ions. When the battery charges, the lithium ions leave the cathode and move to the anode. To prevent lithium dendrites forming – a kind of microscopic stalagmite that can induce short circuits in the battery that may cause fire – the anode in commercial batteries consists of graphite rather than metallic lithium, even though this ultra-light metal would increase the amount of energy that can be stored.

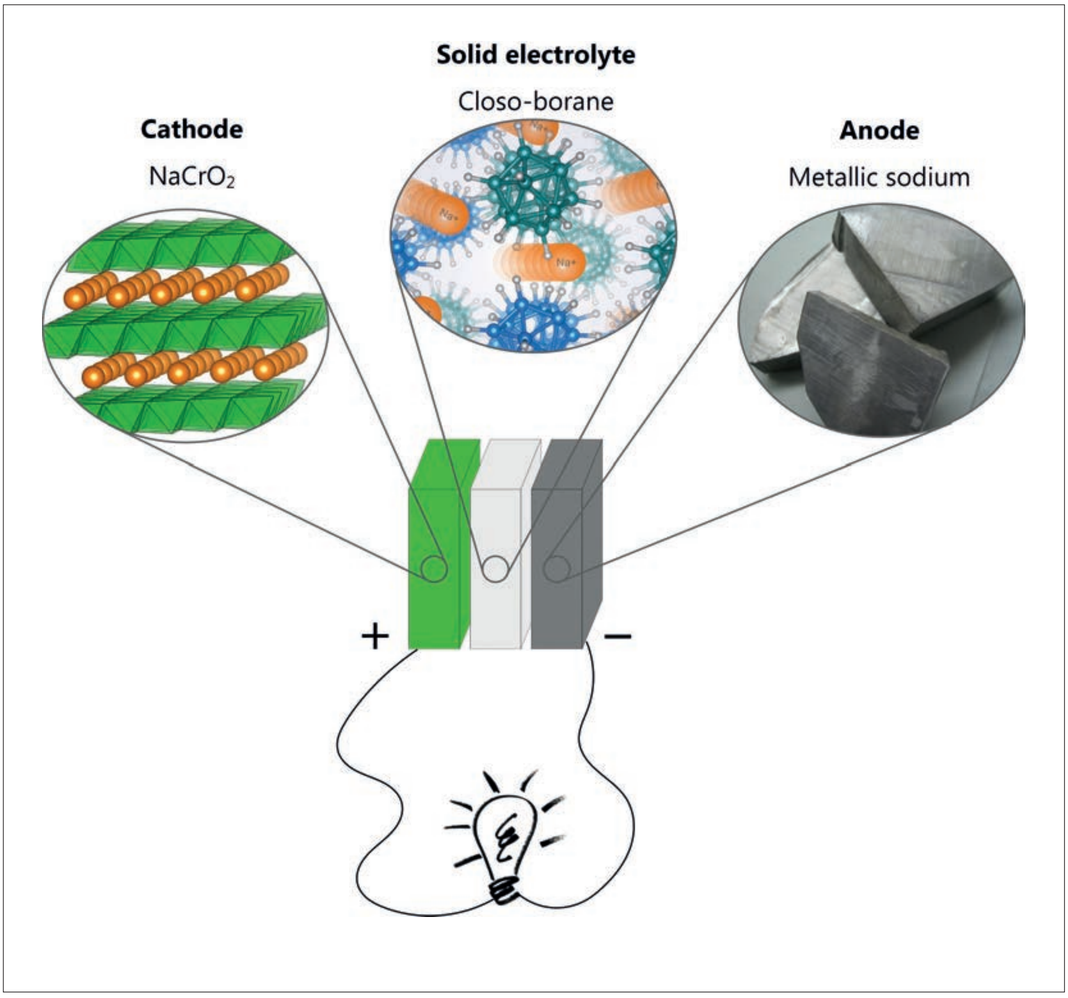
A non-flammable solid sodium battery

The Empa and UNIGE researchers focused on the advantages of a «solid» battery to cope with the heightened demand from emerging markets and to make batteries with even better performance: faster charging together with increased storage capacity and improved safety. Their battery uses a solid instead of a liquid electrolyte that enables the use of a metal anode by blocking the formation of dendrites, making it possible to store more energy while guaranteeing safety. "But we still had to find a suitable solid ionic conductor that, as well as being non-toxic, was chemically and thermally stable, and that would allow the sodium to move easily between the anode and the cathode," explains Hans Hagemann, professor in the Physical Chemistry Department in UNIGE's Faculty of Sciences. The researchers discovered that a boron-based substance, a closo-borane, enabled the sodium ions to circulate freely. Furthermore, since the closo-borane is an inorganic conductor, it removes the risk of the battery catching fire while recharging. It is a material, in other words, with numerous promising properties.

"The difficulty was establishing close contact between the battery's three layers: the anode, consisting of solid metallic sodium; the cathode, a mixed sodium chromium oxide; and the electrolyte, the closo-borane," states Léo Duchêne, a researcher at Empa's Materials for Energy Conversion lab. The researchers dissolved part of the battery electrolyte in a solvent before adding the sodium chromium oxide powder. Once the solvent had evaporated, they stacked the cathode powder composite with the electrolyte and anode, compressing the various layers to form the battery. The team then tested the battery. "The electrochemical stability of the electrolyte we are using here can withstand three volts, whereas many solid electrolytes previously studied are damaged at the same voltage," said Arndt Remhof, a researcher at Empa and leader of the project, which is supported by the Swiss National Science Foundation (SNSF) and the Swiss Competence Centre for Energy Research on Heat and Electricity Storage (SCCER-HaE). The scientists also tested the battery over 250 charge and discharge cycles, after which 85 % of the energy capacity was still functional. "But it needs 1,200 cycles before the battery can be put on the market", the researchers expect. "In addition, we still have to test the battery at room temperature so we can confirm whether or not dendrites form, while increasing the voltage even more. Our experiments are still ongoing."

https://www.empa.ch/web/s604/solid-state-battery

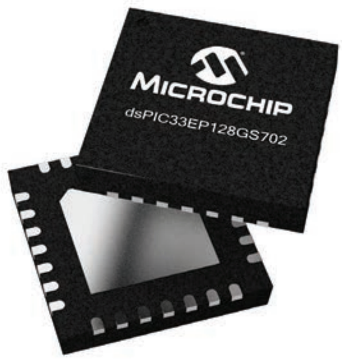
BELOW: Composition of the solid sodium battery



Digital Power Designs Made Easier

Products, Tools, Software and Reference Designs

Microchip's digital power design suite includes the Digital Compensation Design Tool (DCDT), MPLAB® Code Configurator (MCC), Microchip compensator libraries and design examples.



These four components of the digital power design suite provide the tools and required guidance for developing complete digital power designs. Once the initial simulation model of your design is ready, the DCDT can be used to analyze the design and the feedback transfer function, and to generate compensator coefficients. Device initialization code can be generated with the help of MCC; and the final firmware can be created with some help from the code examples and the code generated from MCC and the DCDT.

Key Features

- Digital Compensation Design Tool to analyze your design
- Libraries and design examples to jump start your development
- Feature-rich dsPIC33EP "GS" family of DSCs

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Power For The World

APEC 2017 marked a milestone in power electronics with record 5,000+ conference attendees and 240 exhibiting companies. The focus were not so much on new power devices, but more on new circuit topologies and applications. APEC 2018 from March 3 – 8 in San Antonio/Texas will follow this path with even higher figures.

The Professional Education Seminars on the Sunday (March 4) and Monday address the need for in-depth discussion of important and complex power electronics topics. Seminars are 3.5 hours in length, including breaks, and can range from broad to narrow in scope. They can vary from introductory to advanced in technical level, and complement the technical papers, special presentations and comprehensive exposition.

The technical program includes papers of broad appeal scheduled for oral presentation 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. The various technical venues cover all areas of technical interest for the practicing power electronics professional.

The Industry Sessions track continues to expand. 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 APEC 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.

Plenary sessions

One of APEC's specialities are the keynotes within the plenary session on the Monday afternoon (March 5), giving an overview of the latest developments and an outlook on future applications.

The Plenary Session will take place Monday afternoon and covers the history of power, the current needs in energy efficiency and the future possibilities. The plenary is made up of several presentations from respected industry leaders. Each presentation is 30 minutes in length and allows for interactive Q&A at the end of each presentation. Confirmed speakers and topics are as follows:

Adam L. Hamilton, President and Chief Executive Officer, Southwest Research Institute, will give a speech entitled **'A Fundamental Ingredient of Advanced Science and Applied Technology'.** Imagine a sophisticated and expensive scientific instrument package that must function flawlessly and never be serviced during its one way mission. Years of research, development, and planning depend on embedded power components to conduct the furthest exploration in the history of humankind. The New Horizons spacecraft left Earth in 2006, sped perilously close to Pluto in 2015, and promises another scientific bounty in 2019 with the flyby of 2014 MU69, an object outside of our solar system. Next, imagine the interconnected infrastructure of a smart transportation system dependent on a trickle of power to predict and prevent catastrophic accidents. Humankind's insatiable scientific and engineering curiosity, and its continuing advancement, will always require power.

Dr. Johann W. Kolar, Independent International Consultant, University of Technology Vienna, will talk about the **'Vienna Rectifier and Beyond'.** Twenty years ago at the Plenary Session of APEC 1998 in Anaheim, CA, a single stage isolated three-phase PWM rectifier system was introduced.

Since then the Vienna Rectifier has been proven to fit well for today's applications. With newer and wider range of power semiconductor devices and updated system requirements, topological variations in today's uses and what's in store in research for the future trends will be discussed.

Dr. Muhammad Nawaz, Principal Scientist, ABB Corporate Research, talks about **'Moving from Si to SiC from the End User's Perspective'.** Ever increasing demand of energy supply as a result of continuous population growth, human mobility leading to more urbanization and widening industrialization scope with lower environmental impact is the basic challenge that power electronics community is facing nowadays for sustainable societal growth. While electricity consumption is continuously growing at a fast rate over the coming decade, combating the energy demand and climatic problem therefore requires a more complex interdisciplinary approach involving new technological solutions such as sustain able energy sources and more efficient energy usage. With these considerations in mind, an enabling technology that provides an efficient energy conversion and distribution, reliable control and conditioning of electric energy from the source to the load end will be the main objective of futuristic research and development. High power Semiconductor devices such as MOSFETs, IGBTs and IGCTs provide basic building blocks for variety of high power conversion applications. As witnessed by recent device technological trend, wide bandgap electronic devices using Silicon Carbide material system promise potential replacement to leading horse Silicon based devices.

Zoya Popovic, Distinguished Professor and Lockheed Martin Endowed Chair, Electrical, Computer and Energy Engineering, University of Colorado, Boulder, will cover in his presentation **'WPT - from μW/cm² Harvesting to kW Capacitive Vehicle Powering'.** This talk will overview

Tuesday Mar 6th, 2018 08:30-12:00	T01 Three-Phase AC-DC Converters (9 papers) Chr: Haoyu Wang, Ruoyu Hou Track: 1	T02 Hybrid DC-DC Converters (9 papers) Chr: Cahit Gezgin, Pradeep Shenoy Track: 2	T03 Powe Interf Topo Chr: Track
Wednesday Mar 7th, 2018 08:30-10:10	T09 Resonant Converters (5 papers) Chr: Jason Neely, Veda Galigekere Track: 2	T10 Power Electronics for Utility Interface - Power Quality & Harmonics (5 papers) Chr: Davide Giacomini, Alireza Bakhshai Track: 3	T11 Cont II (5 Chr: Onar Track
Wednesday Mar 7th, 2018 14:00-17:30	T17 Single-Phase AC-DC Converters (9 papers) Chr: Gerry Moschopoulos, Leila Parsa Track: 1	T18 Soft Switching Converters (9 papers) Chr: Luke Jenkins, Aleksandar Prodic Track: 2	T19 Cont I (8 p Chr: Bazz Track
Thursday Mar 8th, 2018 08:30-11:20	T25 DC-DC Converter Applications (7 papers) Chr: Olivier Trescases, David Reusch Track: 2	T26 Switched And Synchronous Reluctance Motor Drives (7 papers) Chr: Prerit Pramod, Rakib Islam Track: 4	T27 Powe Prog Chr: Track
Thursday Mar 8th, 2018 14:00-17:30	T33 High Conversion Ratio Converters (9 papers) Chr: Xin Zhang, Robert Pilawa Track: 2	T34 Power Electronics for Utility Interface - Control (9 papers) Chr: Yongheng Yang, Majid Pahlevani Track: 3	T35 Multi Conv Chr: Track

wireless power transfer for power levels from µW to kW. The ultra-low power density application is in far-field harvesting at GHz frequencies for unattended wireless sensors. In this case, efficiency and power management are challenging, as well as miniaturization and energy storage. Several examples will be shown, including harvesting sidelobes from a 4.3GHz altimeter radar antenna on a Boeing 737 aircraft for powering health-monitoring aircraft sensors. At the high power levels, near-field capacitive power transfer is chosen in the 6 MHz range for powering stationary vehicles and vehicles in motion. In this case, over 85 % efficiency is achieved for 1 kW of capacitive power transfer while meeting safety standards in the vicinity of the vehicle through a near-field phased array approach. Other approaches, such as power beaming and multi-mode shielded wireless powering will also be discussed.

'3D Power Packaging made Real with Embedded Component and Substrate Technologies', this is the title of the talk, given by P. Markondeya Raj, Associate Research Director, Georgia Tech – PRC. Future electronic systems require new strategies for power module integration, much beyond discrete and two-dimensional packaging that has been prevalent for decades. Packaging will add dramatic value in supplying power to high-performance devices and systems by addressing the barriers to better and cheaper components and their heterogeneous integration as 3D power packages. Power Sources Manufacturers Association (PSMA) is releasing its extensive industry report this year, compiling these latest industry advances with improved passive component designs, nano-structured materials and innovative process integration that benefits from such materials.

'Does Power Efficiency Improve with Consolidation in the Semiconductor Industry?' asks Hans Stork, Senior Vice President and Chief Technology Officer, ON Semiconductor. Recently, the semiconductor industry has been rapidly consolidating for financial, operational, pricing and market-share reasons. Having fewer and larger businesses may actually accelerate the broad acceptance and commercialization of innovative technologies like wide bandgap power devices. Although many concepts for smaller and more efficient power management have been demonstrated by research and startup companies, the realization of full-scale adoption, ranging from household adaptors to automobiles and to data center management, requires significant resources to meet demands for global supply and quality. Large enterprises have the manufacturing and supply chain infrastructure, as well as the depth in R&D knowledge. This talk will provide an overview of the progress, in cost and performance, of both Silicon and wide bandgap materials, devices, circuits and applications, highlighting both technical and commercial challenges.

Rap Sessions

Dialogue-oriented Rap sessions allow for interaction amongst attendees and presenters. Three topics are available for also an Exhibits Only Registration on the Tuesday (March 6) afternoon. Rap Session 1 is entitled **'Biggest Impact on Power Conversion - Devices or Magnetics?'** moderated by Kevin Parmenter, VP of Applications Engineering, Excelsys. Session Speakers are Ray Ridley, Ridley Engineering (magnetics); Jim Marinos, Executive VP at Payton America (patents on Magnetics); Dan Kinzer, COO&CTO, Co-Founder, Navitas; Manfred Schlenk, Infineon; Ira Patel, Magnapower Electronics; and Dan Jitaru, President, RomPower. Rap Session 2 covers **'Gate Drive Isolation Technologies: Optical, Magnetic, or Capacitive Coupling?'**, moderated by Aung Tu, Director of Application and Marketing for Industrial Gate Drivers, Infineon. Speakers are Baoxing Chen, (inventor of micro-transformers), Analog Devices; Laszlo Balogh, ON Semiconductor; Tom Bonifield, TI Fellow (authority on HV isolation processes, materials, & structures), Texas Instruments; Wolfgang Frank, Senior Member of Technical Staff, Infineon; and Keith Coffey, Silicon Labs. Rap Session 3 discusses the popular subject **'GaN vs. SiC vs Si for Next Generation Power Devices',** moderated by Indumini Ranmuthu, Manager, Advanced Development Group in Power Management, Distinguished Member Technical Staff, Texas Instruments. Session Speakers are John Palmour, CTO Wolfspeed; Paul Brohlin, Technical Manager of GaN Development, Texas Instruments; Gerald DeBoy , New technology development lead, Infineon; Chingchi Chen, Ford Research Labs; and Alex Huang, Professor, University of Texas at Austin.

BELOW: APEC 2018 lecture session schedule

er Electronics for Utility face - Structures & ologies (9 papers) Tiefu Zhao, Praveen Jain k: 3	T04 Faults in Electric Machines And Drives (8 papers) Chr: Joshua Hawke, Siavash Pakdelian Track: 4	T05 Power Devices Modeling (9 papers) Chr: Jin Wang , Sara Ahmed Track: 7	T06 Control of DC-DC Converters (9 papers) Chr: Jaber Abu Qahouq, Martin Ordonez Track: 8	T07 Inverters for PV Systems (9 papers) Chr: Afridi Khurram, Hadi Marlek Track: 10	T08 SMP Audio and Battery (9 papers) Chr: Johan Strydom, Ed Massey Track: 12
rol of Inverters and Drives papers) Bulent Sarlioglu, Omer r k: 4	T12 Magnetics (5 papers) Chr: Matt Wilkowski, Jason Pries Track: 5	T13 EMI Detection and Mitigation Methods (5 papers) Chr: Lei Wang, Jim Marinos Track: 6	T14 Battery Systems (5 papers) Chr: Robert Balog, Reza Sharifi Track: 10	T15 Charging and Energy Storage Topics (5 papers) Chr: Omer Onar, Yingying Kuai Track: 11	T16 New Technology (4 papers) Chr: Indumini Ranmuthu, Jeff Nilles Track: 12
rol of Inverters and Drives apers) Thomas Gietzold, Ali zi k: 4	T20 GaN Device Opportunities and Challenges (9 papers) Chr: Tim McDonald, Xin Zhang Track: 5	T21 Power Converter Modeling & Control (9 papers) Chr: Sara Ahmed, Liming Liu Track: 7	T22 Control Strategies for Inverters & Motor Drives (9 papers) Chr: Jaber Abu Qahouq, Xiong Li Track: 8	T23 Wireless Power Transfer Applications (9 papers) Chr: Afridi Khurram, Michael de Rooij Track: 9	T24 Photovoltaic & Grid Tie Systems (9 papers) Chr: Martin Ordonez, Veda Galigekere Track: 10
er Module Integration & nostics (7 papers) Liming Liu, Zach Pan k: 6	T28 Power Quality Oriented Control (7 papers) Chr: Martin Ordonez, Manish Bhardwaj Track: 8	T29 Wireless Power Transfer for EV Applications (7 papers) Chr: Raghav Khanna, Sheldon Williamson Track: 9	T30 Renewable Energy Topics (7 papers) Chr: Katherine Kim, Haoyu Wang Track: 10	T31 Conversion Systems for Electric Vehicles (7 papers) Chr: Serkan Dusmez, Yongheng Yang Track: 11	T32 Grid Applications (7 papers) Chr: Mike Seeman, Zhong Nie Track: 12
-level Inverters and verters (8 papers) Scott Ramsay, Jeff Czapor k: 4	T36 Opportunities and Challenges of SiC & Si Devices (9 papers) Chr: Douglas Hopkins, Jean-Luc Schanen Track: 5	T37 Magnetics Modeling Design & Applications (9 papers) Chr: Rolando Burgos, Sandeep Bala Track: 7	T38 Control Application (9 papers) Chr: Seungdeog Choi, Shamim Choudhury Track: 8	T39 Renewable Energy Converter Topologies (9 papers) Chr: Jin Wang , Akshay Rathore Track: 10	T40 Industrial Applications (9 papers) Chr: Jim Moss, Lanhua Zhang Track: 12

Towards Integrated Systems

In the next decades, power electronic system development will be driven by energy saving systems, intelligent energy management, power quality, system miniaturization and high reliability. Monolithic and hybrid system integration will include advanced device concepts including wide bandgap devices, new packaging technologies and the overall integration of actuators/drives (mechatronic integration).

CIPS (Conference on Integrated Power Systems) from March 20 – 22 in Stuttgart/Germany is focused on the following main aspects:

- assembly and interconnect technology for power electronic devices and converters
- integration of hybrid systems and mechatronic systems with high power density
- systems' and components' operational behavior and reliability.

Basic technologies for integrated power electronic systems as well as upcoming new important applications will be presented in interdisciplinary invited papers.

Prior to the conference (March 19) a GaN Workshop, organized by VDE/ETG, will highlight the latest developments in technology, topology and applications particularly in the high-frequency domain.

www.cips-conference.de

13:00 Begrüßung
Klaus F. Hoffmann, HSU Hamburg
Sibylle Dieckerhoff, TU Berlin

13:15 - 14:45
GaN Bauelemente und Technologie

- 600V GaN Leistungstransistoren – Technologie, Fertigung und Anwendung
  O. Häberlen, Infineon Technologies, Villach
- GaN Power Switching Devices: Competing Technologies and Future Trends
  H.-J. Würfl, Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik, Berlin
- Potential and Challenges of Monolithic Multi-Functional Integration of 600V Class GaN HEMT-Based Power Circuits
  I. Kallfass, Universität Stuttgart

14:45 Kaffeepause

15:00 - 16:30
Schaltungstechnik und Ansteuerung

- Bipolare DC-Netz-Kopplung mit GaN-Halbleitern
  S. Klötzer, Helmut-Schmidt-Universität, Hamburg
- Anwendung bidirektionaler GaN Transistoren in der Leistungselektronik
  C. Kuring, TU Berlin
- Entwicklung und EMV-Analyse eines modularen GaN-DC/DC-Wandlers
  L. Middelstädt, OvGU Magdeburg

16:30 Kaffeepause

17:00 - 18:30
Systemaspekte und Applikationen

- Resonant High-Frequency DC/DC-Converter with GaN-Transistors for Aviation Applications
  C. Schöner, Fraunhofer ISE
- Betriebsmodi und Schaltverluste einer GaN-PFC-Stufe
  Nikolas Bauer, BMW Group, München
- GaN-Stromrichter für die Elektromobilität
  C. Henkenius, Firma Delta Energy Systems GmbH, Soest

18:30 - 19:00 Abschlussdiskussion

Tuesday, March 20

10:00-10:10	*Introduction*	
10:10-11:50	*Clean switching, electromagnetic compatibility (EMC)*	
11:50-13:20	*Lunch break*	
13:20-15:00	*EMC, Components to be integrated*	
15:00-15:30	*Tea break*	
15:30-17:00	*Reliability (1)*	
17:00-17:20	*Break*	
17:20-18:30	*Reliability (2)*	
19:00-22:00	*Get Together + Poster Session*	

Wednesday, March 21

08:30-10:10	S2.1: *General aspects of packaging (1/2)*	S4: *Mechatronic systems and their applications*
10:10-10:40	*Tea break*	
10:40-12:20	S2.2: *General aspects of packaging (2/2)*	S5.1: *Condition Monitoring (Reliability (1/2)*
12:20-13:50	*Lunch break*	
13:50-15:30	S1.1: *Components to be integrated (1/2)*	S5.2: *Degradation of Interconnects (Reliability (2/2)*
15:30-16:00	*Tea break*	
16:00-17:00	S.1.2: *Components to be integrated (2/2)*	S6.1: *EMI (Clean switching, electromagnetic compatibility (1/2)*
16:20-17:20	S3.1: *Power packages and modules (1/2)*	
17:20-17:40	*Break*	
17:40-19:00	S3.2: *Power packages and modules (2/2)*	S6.2: *Clean switching, electromagnetic compatibility (2/2)*
19:30-22:00	*Dinner*	

Thursday, March 22

08:30-10:10	*Mechatronic systems and their applications*	
10:10-10:40	*Tea break*	
10:40-12:10	*Packaging (1)*	
12:10-13:40	*Lunch break*	
13:40-14:20	*Packaging (2)*	
14:20-14:30	*Closing remarks*	
14:30-14:45	*Ceremony: CIPS Young Engineer Award , CIPS Best Poster Award*	
14:45-15:15	*Ceremony: Semikron Innovation and Young Engineer Award*	

Simplifying Power Supply Design with a 15 A/42 V Power Module

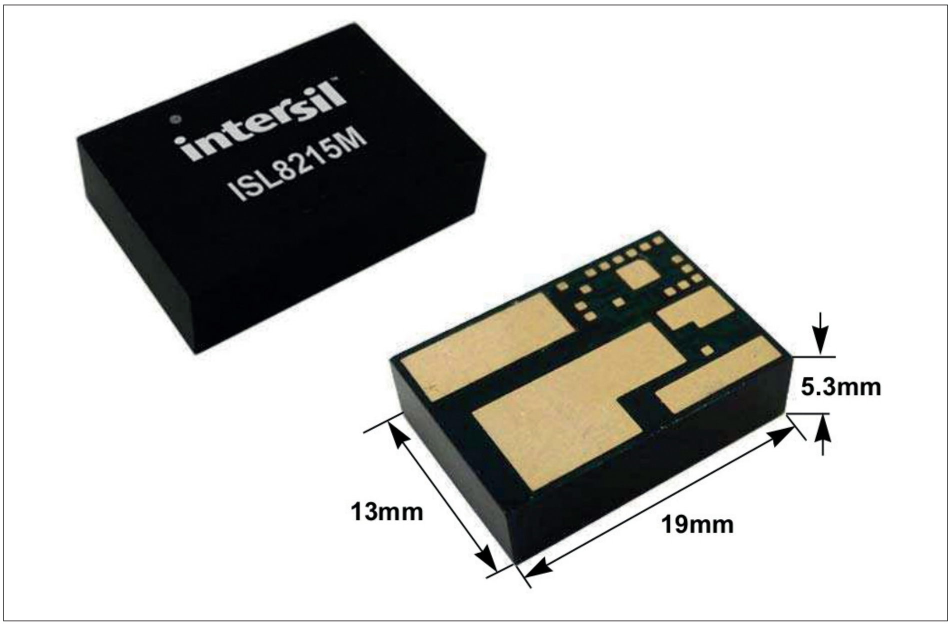
The DC/DC buck converter is one of the most popular and widely used power supply topologies, finding applications in industrial, servers, telecom, and automotive sectors. The non-isolated buck converter also sees increasing use as a point-of-load (POL) solution to deliver power from a DC bus to individual POLs. It steps down the DC bus voltage to lower regulated output voltages. An ideal POL solution should be capable of supporting a wide range of input voltages while providing a stable operation at small duty cycles. For applications constrained by board space, a compact, higher power density design is required, and to minimize power losses and provide cost savings, high conversion efficiency is needed. This article explores the simplicity of using a so-called power module for POL designs, and describes how it can reduce the burden on power supply designers, leading to shorter design cycles and faster time to market. A look inside a new 15A, 42V power module shows that it offers a highly integrated, characterized solution that provides superior efficiency, power density and reliability.

Discrete POL solutions involve careful selection of components, including inductor, MOSFETs and capacitors, and that requires an experienced power supply designer. In addition, the placement of the components on the PCB is crucial since they have a direct correlation with efficiency, noise and thermal performance. Compensation elements must be carefully selected to keep the converter stable across all operating conditions. This is a cumbersome task, especially if the system has multiple POL power rails. All of these factors can lead to longer design cycles and increased cost of ownership.

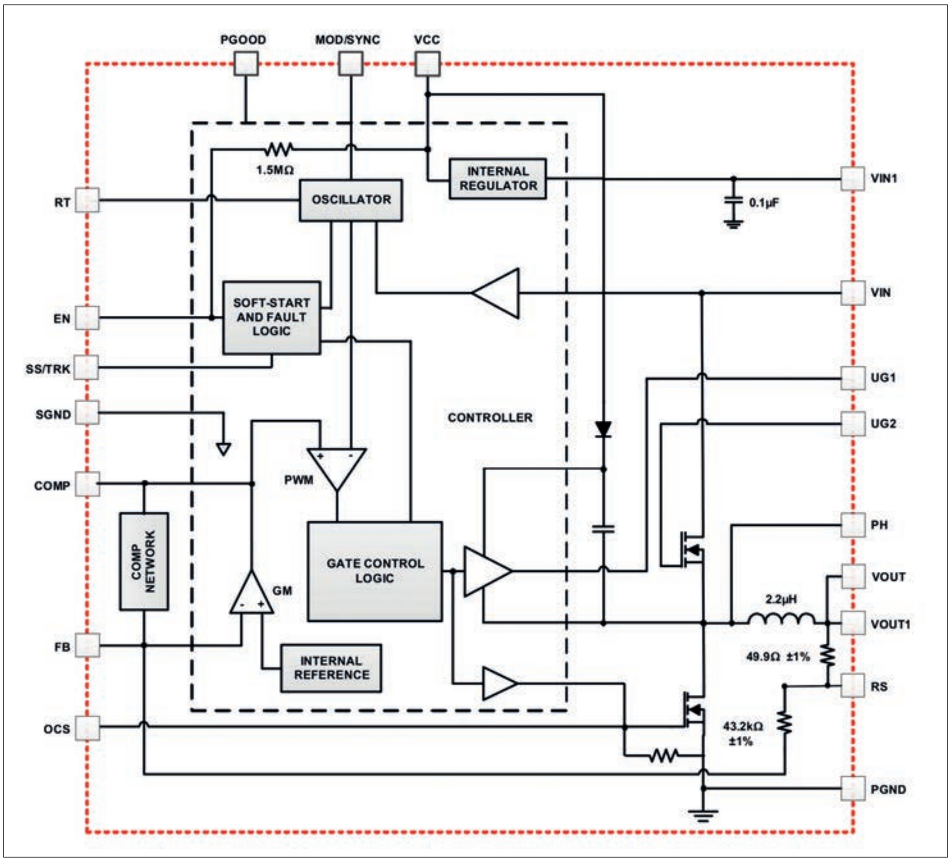
A simpler approach

Power modules provide an alternative to the lengthy and arduous process of discrete power supply design by integrating all of the key components inside the package. A power module is a complete power supply in a condensed package that requires only a few external components to function.

The 12V DC bus is a popular power rail found in data centers, automotive and battery backup systems. Most POL solutions can easily achieve a step-down ratio from 12V to 0.9V/1V while delivering good transient performance



ISL8215M power module layout



ISL8215M power module block diagram

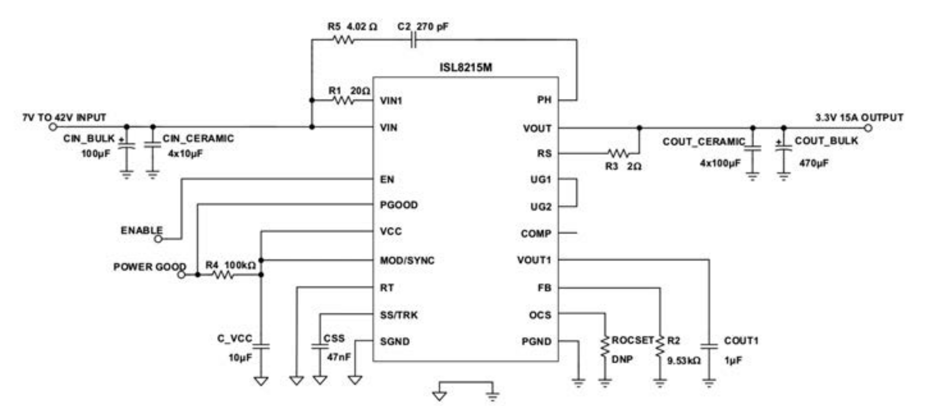


Figure 4. V_{OUT} = 3.3V, f_{SW} = 300kHz, Light-Load Mode, t_{SS} = 15ms

Typical ISL8215M application with 3.3 V output

and efficiency. However, as the trend moves towards higher input voltages, the performance and efficiency tend to suffer.

Industrial applications typically use a 24V~36V DC bus, which is stepped down to a lower voltage level to feed key downstream components such as microprocessors, FPGAs, DSPs, memory, and more. This big conversion ratio leads to narrow pulses that can be a challenge to control. Moreover, if the input DC voltage is not properly regulated, there might be voltage spikes present on the bus; this may necessitate the need for an even wider input voltage range for the power module. Because of their inherent compact and dense nature, thermal dissipation can pose a serious challenge.

Thermal performance becomes even more important when considering operations over a wide range of temperature. High efficiencies can lead to lower power dissipation, which can aid thermal performance greatly. Use of heat sinks and system airflow may also be required to realize better performance efficiency.

Increasing power density in a module usually leads to a trade-off between package size and the output current supported. Higher output voltages supported by the power module also increases the power processed through the converter, which poses a thermal challenge. Again, good efficiency is the key in pushing the module to higher power densities while keeping the size of the package small.

180 W in small package

The ISL8215M is a first of its class single-phase power module supporting a wide input/output voltage range, while delivering up to 180 W output power from a small 13 mm x 19 mm thermally enhanced High Density Array (HDA) package. The input voltage can vary from 7 to 42 V and the output voltage is adjustable from 0.6 to 12 V, while allowing a programmable switching frequency from 300 kHz to 2 MHz.

The ISL8215M power module is a single-channel, synchronous step-down, non-isolated complete power supply, integrating the controller, power inductor, and MOSFETs, The ISL8215M requires only a few external components to operate and is optimized for space constrained applications.

Based on a valley current mode PWM control scheme, the module provides fast transient response and high loop stability. It offers an adjustable output voltage range of 0.6 V to 12 V with better than 1.5 % accuracy over line, load, and temperature. A 40 ns typical minimum on time and an adjustable operating frequency allow it to support low duty cycle, single-step down conversions to point-of-load voltages and its operating frequency can also be synchronized with an external clock signal.

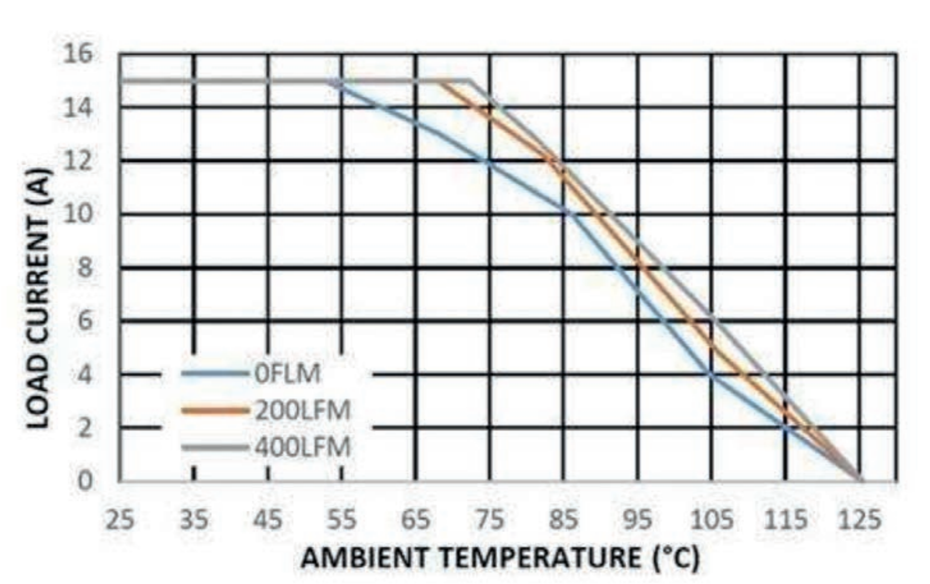
The ISL8215M implements a selectable Pulse Skipping Mode (PSM) with Diode Emulation Mode (DEM) to improve light-load efficiency for battery related applications. A programmable soft-start reduces the inrush current from the input supply while a dedicated enable pin and power-good flag allow for easy system power rails sequencing with voltage tracking capability. Excellent efficiency and low thermal resistance permit full power operation without heatsinks. Input under-voltage lockout (UVLO), over-temperature, programmable over-current, output over-voltage, and output prebias start-up protections ensure safe operations under abnormal operating conditions.

As can be seen in the application schematic, the ISL8215M requires only a few external resistors and capacitors to form a complete power supply solution. Internal compensation networks are implemented to stabilize the converter and achieve an optimal transient response across the full range of input and output operating conditions.

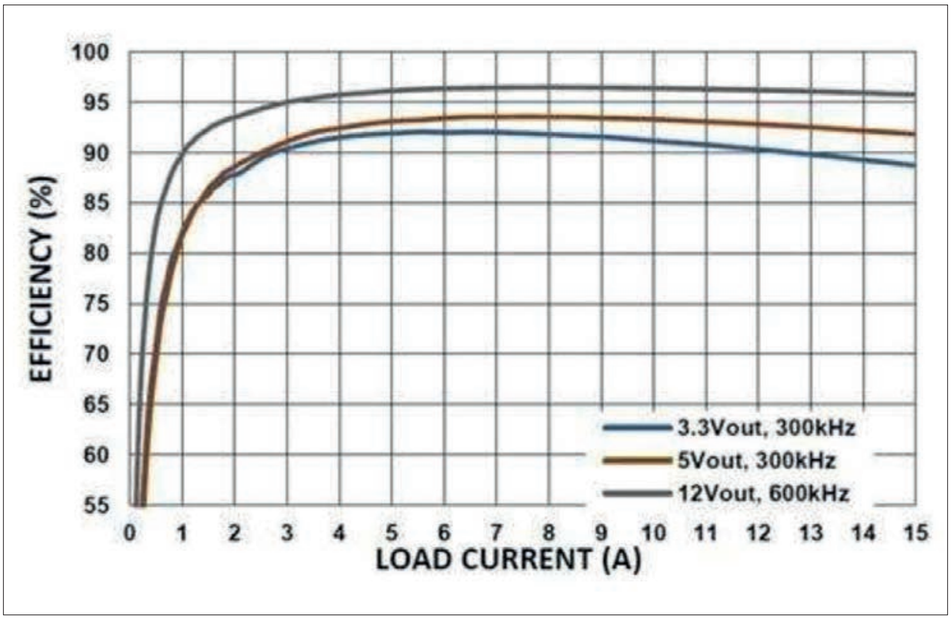
The device is able to operate from a 42 V input rail, providing the designer with extra input voltage safety margin. This makes it ideal for industrial applications. It is able to achieve a high conversion ratio (42 V input to 1.2/3.3 V output) by employing valley current mode control with an input voltage feed-forward ramp. This eliminates the need for blanking time (as is the case with peak current mode), making it possible to control very narrow on-time pulses and provide high transient performance.

A high conversion ratio also eliminates the need for multistage conversion since 42 V can be directly stepped down to 1.2V, without the need of an intermediate 12/5 V bus. It should also be noted that this intermediate bus voltage can also be generated by the ISL8215M, making it a versatile solution.

The small footprint is possible due to advanced packaging technology that utilizes a copper lead frame on which the MOSFETs and inductor are directly mounted. This



Derating curve (PWM/CCM mode, Vin = 24 V, Vout = 3.3 V, fsw = 300 kHz)



Efficiency curves for PWM/CCM mode (Vin = 24 V)

allows for a direct heat transfer to the PCB, making thermal management more efficient and allowing the power module to run cooler and more efficiently without the need for heatsinks or system airflow. Mounted on a standard evaluation board can the module can safely deliver up to 10A of continuous current at 85°C ambient temperature—with no airflow on a 24V to 3.3V conversion.

The ISL8215M can support current up to 15 A, while the output voltage can be set as high as 12 V. This high power density is possible due to the high efficiency of the module, which reduces power loss and makes thermal management easier. With a peak efficiency greater than 96 % and over 80 % efficiency for most of its output current range and conversions, it is possible for the power module to achieve a compact form factor.In conclusion, the ISL8215M is a highly characterized power module, which requires a minimal number of external components for developing a complete power supply solution. Its advanced packaging technology provides good thermal performance over a wide range of operating temperatures. And, its high power density in a small footprint is made possible due to the high efficiency of the module, which reduces power dissipation and increases the current rating of the device. A wide output voltage range from 0.6 V to 12 V enables the module to be an efficient POL solution, while also allowing for an intermediate 12 V/5 V bus voltage generation.

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ISO 26262/ASIL-D Power Management IC for Automotive Control Units

Allegro MicroSystems Europe has announced a power management IC that integrates a buck or buck/boost pre-regulator, four LDOs, and four floating gate drivers. The pre-regulator uses a buck or buck/boost topology to efficiently convert automotive battery voltages into a tightly regulated intermediate voltage complete with control, diagnostics, and protections. The ARG82800 device is targeted at automotive end applications such as electronic power steering (EPS), transmission control units (TCU), and advanced braking systems (ABS). The ARG82800 is supplied in a low-profile (1.2 mm maximum height) 38-lead eTSSOP package (suffix "LV") with exposed power pad for enhanced thermal performance.

The output of the pre-regulator supplies a 3.3 V or 5.0 V selectable 350 mA linear regulator, a 5 V / 100 mA linear regulator, and two 120 mA protected linear regulators which track VUC output. Designed to supply power for microprocessors, sensors, and CAN transceivers, the ARG82800 is ideal for under-hood applications.

Diagnostic outputs from the device include a power-on reset output (NPOR) and a fault flag output (FFn) to alert the microprocessor that a fault has occurred. The microprocessor can read fault status through SPI. Dual bandgaps (one for regulation and one for fault checking), BIST, and a myriad of internal diagnostics enhance Functional Safety (FuSa) coverage for critical automotive applications.

ARG82800 power management IC that integrates a buck or buck/boost pre-regulator, four LDOs, and four floating gate drivers

Serial peripheral interface

The IC provides the user with a three-wire synchronous serial interface that is compatible with SPI. A fourth wire can be used to provide diagnostic feedback and readback of the register content.

The serial interface timing requirements are specified in the Electrical Characteristics table and illustrated in the Serial Interface Timing diagram. Data is received on the SDI terminal and clocked through a shift register on the rising edge of the clock signal input on the SCK terminal. STRn is normally held high, and is only brought low to initiate a serial transfer. No data is clocked through the shift register when STRn is high, allowing multiple SDI slave units to use common SDI, SCK, and SDO connections. Each slave then requires an independent STRn connection.

Pre-regulator

The pre-regulator incorporates an internal high-side buck switch and a boost switch gate driver. An external freewheeling diode and LC filter are required to complete the buck converter. By adding a MOSFET and boost diode, the pre-regulator can now maintain all outputs with input voltages down to 3.8 V. The pre-regulator provides many protection and diagnostic functions such as pulse-by-pulse and hiccup mode current limit; under-voltage detection and reporting; shorted switch node to ground; open freewheeling diode protection; and high-voltage rating for load dump.

Bias supply

The bias supply (V_{CC}) is generated by an internal linear regulator. This supply is the first rail to start up. Most of the internal control circuitry is powered by this supply. The bias supply includes some unique features to ensure safe operation of the ARG82800, including input voltage under-voltage lockout; output under-voltage detection and reporting; over-current and short-circuit limit; and dual input, V_{IN} and V_{REG}, for low battery voltage operation.

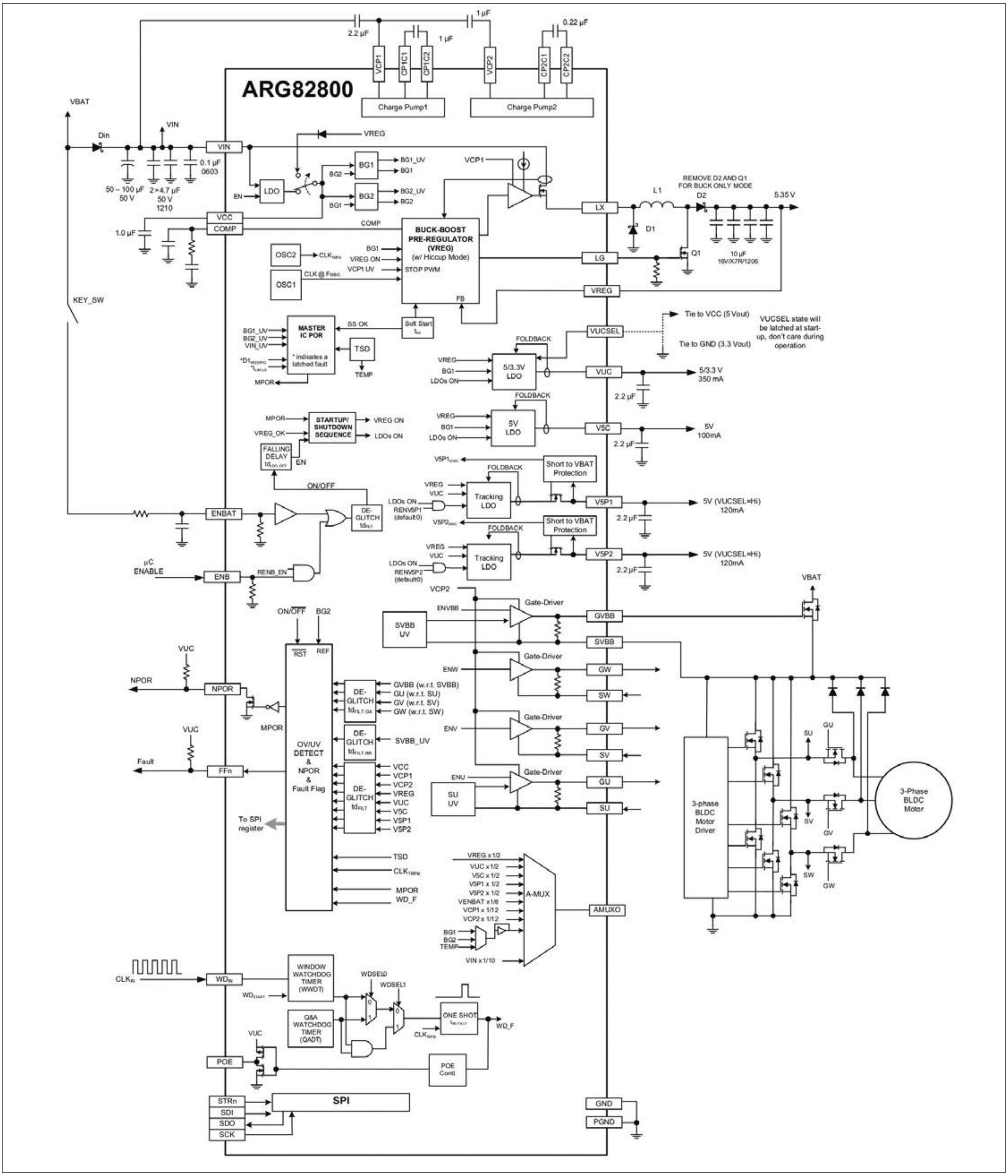
Charge pump

Charge pump circuits provide the voltage necessary to drive high-side N-channel MOSFETs in the pre-regulator, linear regulators, and floating gate drivers. Four external capacitors are required for charge pump operation. During the first cycle of the charge pump action, the flying capacitor between pins CP1C1 and CP1C2 is charged either from V_{IN} or V_{REG}, whichever is highest. During the second cycle, the voltage on the flying capacitor charges the VCP1 capacitor and the flying capacitor, between pins CP2C1 and CP2C2. During the next cycle, the voltage on the flying capacitor charges the VCP2 capacitor. The charge pump incorporates under- and over-voltage detection and reporting as well as over-current safe mode protection.

Bandgap

Dual bandgaps are implemented within the ARG82800. One bandgap is dedicated to the voltage regulation loops within each of the regulators, V_{CC}, V_{CPx}, V_{REG}, and the four post-regulators. The second is dedicated to the monitoring function of all the regulators under- and over-voltage. This improves safety coverage and fault reporting.

Should the regulation bandgap fail, then the outputs will be out of specification and the monitoring bandgap will report the fault. If the monitoring bandgap fails, the outputs will remain in regulation, but the monitoring circuits will report the outputs as out of specification and trip the fault flag.



ARG82800 functional block diagram

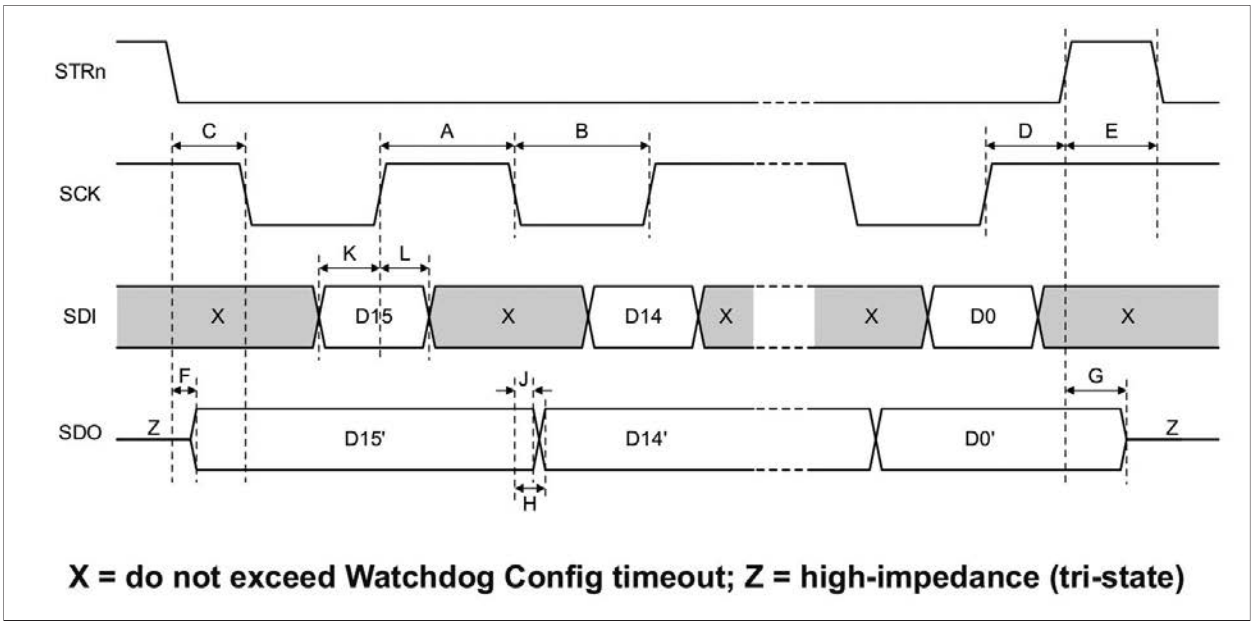
The bandgap circuits include two other bandgaps that are used to monitor the under-voltage state of the main bandgaps.

Two Enable pins are available on the ARG82800. A high signal on either of these pins enables the regulated outputs. One Enable (ENB) is logic-level compatible. The second enable (ENBAT), is battery-level rated and can be connected to the ignition switch.

Linear regulators

The ARG82800 has four linear regulators: one 5 V regulator, one 5 V or 3.3 V selectable regulator, and two protected regulators which track V_{UC} (5 V or 3.3 V).

All linear regulators provide the protection features current limit with foldback as well as under- and over-voltage detection and reporting.



SPI timing diagram

The protected regulators (V5P1 and V5P2) include protection against connection to the battery voltage. This makes these outputs suitable for powering remote sensors or circuitry where short to battery is possible. The pre-regulator powers these linear regulators which reduces power dissipation and temperature.

Self-tests

The IC includes self-test which is performed during the startup sequence. This self-test verifies the operation of the under-voltage and over-voltage detection circuits for the main outputs. In the event the self-test fails, the ARG82800 will report the failure through SPI.

The under-voltage (UV) detectors are verified during startup. A voltage that is higher than the under-voltage threshold is applied to each UV comparator; this should cause the relative under-voltage fault bit in the diagnostic registers to change state. If the diagnostic UV register bits change state, the corresponding verify register bits will latch high. When the test of all UV detectors is complete, the verify register bits will remain high if the test passed. If any UV bits in the verify registers, after test, are not set high, then the verification has failed. UV detectors include V_{REG}, V_{UC}, V5C, V5P1, and V5P2.

The over-temperature shutdown (TSD) detector is verified on startup. A voltage is applied to the comparator that is lower than the over-temperature threshold and should cause the general fault flag to be active and an over-temperature fault bit, TSD, to be latched in the Verify Result register 0. When the test is complete, the general fault flag will be cleared and the over-temperature fault will remain in the Verify Result register 0 until reset. If the TSD bit is not set, then the verification has failed.

The ARG82800 also incorporates continuous self-testing of the power-on enable (POE) output. It compares the status of the POE pin with the internal demanded status. If they differ for any reason, an FFn is set and the POE_OK in SPI diagnostic register goes low.

Watchdog

The ARG82800 has two watchdog functions: window watchdog timer and Q&A watchdog timer. When the regulators (VUC and V5C) have been above their under-voltage thresholds for watchdog activation delay (td(WD)), WD is activated, WD state will be in the configuration state (“Config”), and the user can set the configuration within 220 ms.

The window watchdog circuit monitors an external clock applied to the WDIN pin. This clock should be generated by the microcontroller or DSP. The time between rising edges of the clock must fall within a SPI-programmed “window” or a watchdog fault will be generated. A watchdog fault will set NPOR and POE “low”. After startup, if no clock edges are detected at WDIN for watchdog activation delay td(WD) + max timeout (written in 0x09), the IC will generate watchdog fault and reset its counters. This process will repeat until the system recovers and clock edges are applied to WDIN.

The Q&A watchdog circuit monitors an answer code from the microcontroller.

Floating MOSFET gate drivers

The ARG82800 has four independent floating gate drive outputs to drive external, low on-resistance, power N-channel MOSFETs connected as a 3-phase solid state relay in phase-isolation applications and an input battery line isolator. The independent floating gate drivers have the capability of controlling N-channel MOSFETs through SPI. These MOSFETs can be configured as phase or battery isolation devices in high current motor applications. An integrated charge pump allows the driver outputs to maintain the power MOSFETs in the on state over the full supply range with high phase-voltage slew rates. Enable inputs to the ARG82800 include a logic level (ENB) and a high voltage key-switch enable (ENBAT). It also provides flexibility with a disable function of the individual outputs through SPI.

A charge pump regulator provides the above-battery supply voltage necessary to maintain the power MOSFETs in the on state continuously when the phase voltage is equal to the battery voltage. An internal resistor, R_{GPD}, between the Gx and Sx pins plus an integrated hold-off circuit, will ensure that the gate-source voltage of the MOSFET is held close to 0 V even with the power disconnected. This can remove the need for additional gate-source resistors on the isolation MOSFETs. In any case, if gate-source resistors are mandatory for the application, then the pump regulator can provide sufficient current to maintain the MOSFET in the on-state with a gate-source resistor as low as 100 kΩ.

The four gate drives can be controlled independently through the serial interface by setting the appropriate bit in the control register. The floating gate-drive outputs for external N-channel MOSFETs are provided on pins GVBB, GU, GV, and GW. Gx=1 (or “high”) means that the upper half of the driver is turned on and current will be sourced to the gate of the MOSFET in the phase isolation circuit, turning it on. Gx=0 (or “low”) means that the lower half of the driver is turned on and will sink current from the external MOSFET’s gate to the respective Sx terminal, turning it off.

The reference points for the floating drives are the load phase connections, SVBB, SU, SV, and SW. The discharge current from the floating MOSFET gate capacitance flows through these connections.

In some applications, it may be necessary to provide a current recirculation path when the motor load is isolated. This will be necessary in situations where the motor driver does not reduce the load current to zero before the isolation MOSFETs are turned off. The recirculation path can be provided by connecting a suitably rated power diode to the “motor” side of the isolation MOSFETs and GND (see the Functional Block Diagram for more details).

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Driving SiC MOSFETs Efficiently

AgileSwitch, a US-based start-up, is addressing the increasing demand of renewable, high-efficiency energy applications with IGBT and SiC MOSFET gate drivers. The IGBT market is rapidly growing and creating a requirement for more efficient and reliable IGBT gate drivers.

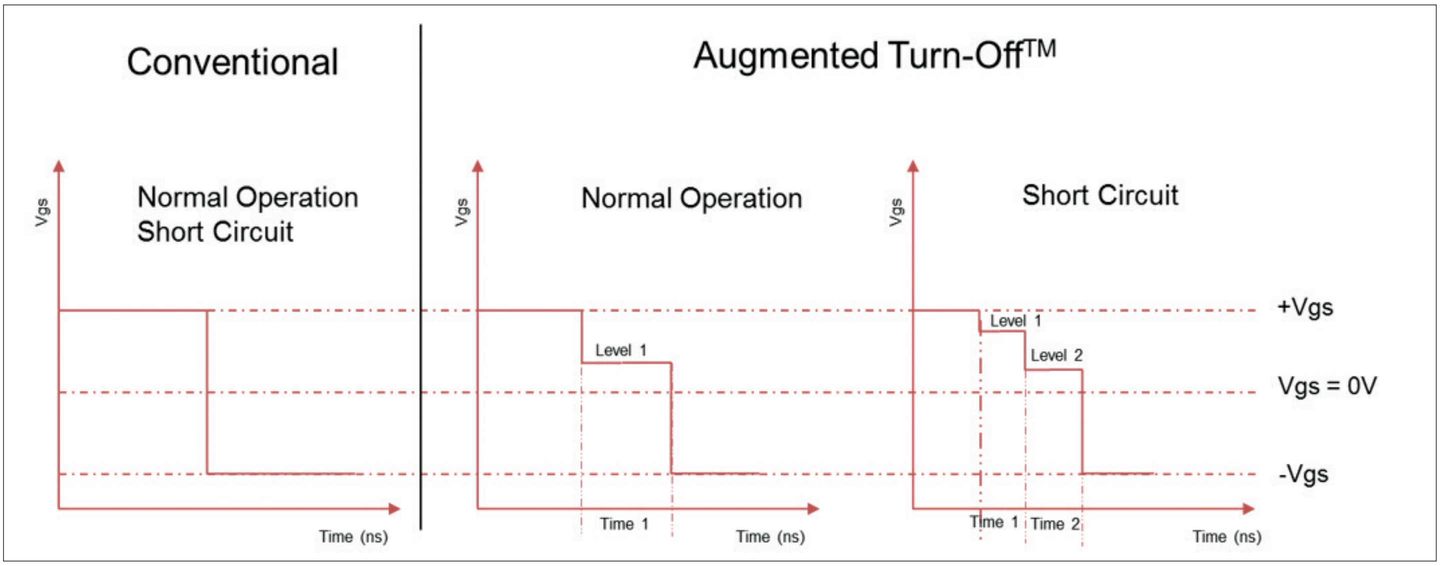
By leveraging high speed FET driver technology and magnetics expertise, AgileSwitch IGBT drivers can capture up to 8 distinct fault conditions. The programmable CPLD chip on the driver also provides customers with the ability to characterize the switch to fit into any application. Additionally, the drivers have higher wattage and current outputs than existing drivers.

SiC MOSFET gate drive boards

AgileSwitch has developed a patent-pending line of programmable Gate Drive Boards (GDBs) that address these problems, controlling the turn-off di/dt by varying the gate voltage level and dwell time to one or more intermediate levels during turn-off. This process is typically referred to as Augmented Turn-Off or ATOff. In addition, AgileSwitch software configurable GDBs report out 7 unique fault conditions along with temperature and DC Link Voltage. The combination of these effects will help drive growth in adoption of SiC devices.

Switching an SiC MOSFET Power Module creates two significant problems that need to be addressed to optimize the performance of the device: turn-off spikes and ringing. These two parasitic problems need to be controlled while maintaining efficient switching.

Protecting the power semiconductor is a continuous process and AgileSwitch Gate Drivers have a unique capability in this regard. The driver boards are able to reduce the stress on the Power Semiconductor while reducing switching losses, through the use of Augmented Turn-Off.



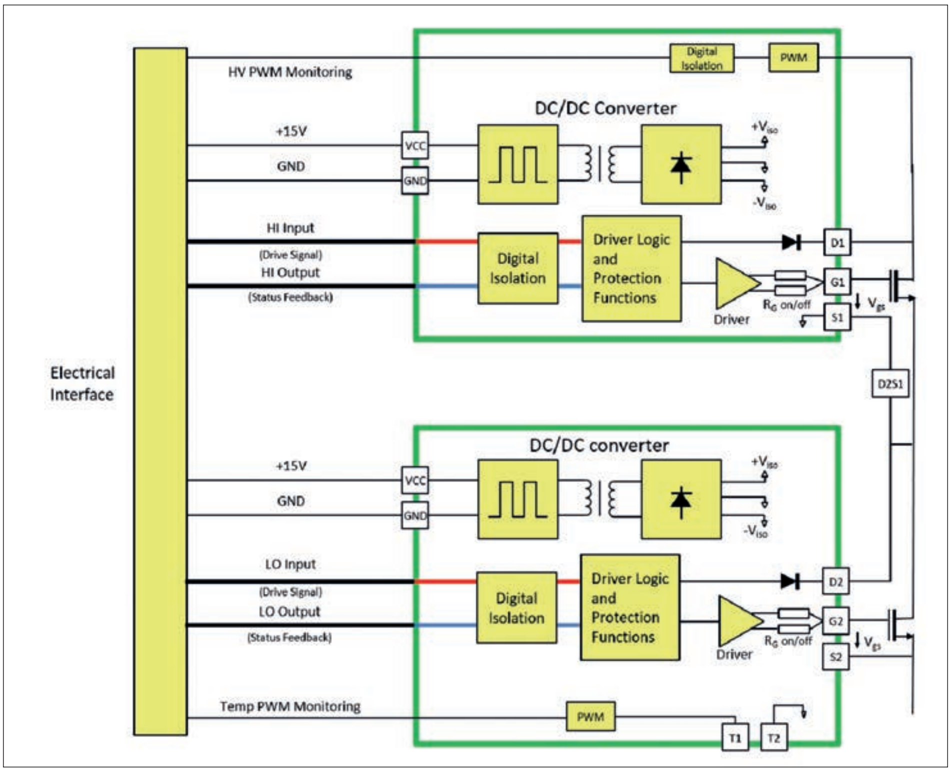
ABOVE: Augmented Turn-Off reduces the stress on the Power Semiconductor by reducing switching losses

Under normal operating conditions, the gate voltage in a turn-off cycle steps through an intermediate level before reaching the off voltage level. Under short circuit conditions, the gate voltage steps through multiple intermediate levels before reaching the off voltage level.

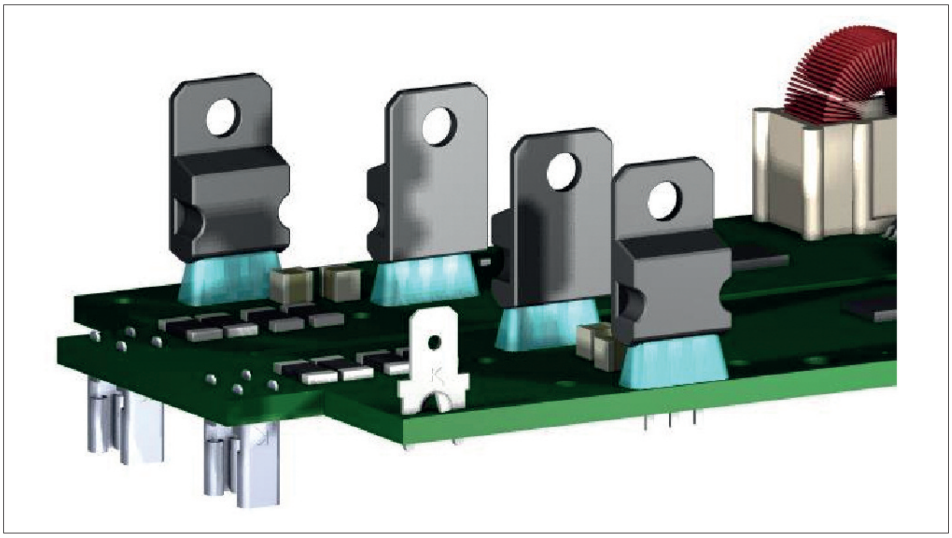
Drivers for SiC MOSFET modules in 62 mm packages

The 62EM1-62mm Electrical driver provides monitoring and fault reporting information to enable better control and analysis of an SiC MOSFET-based power systems. The 62EM1 provides up to 20 A of peak current at an operating frequency up to 125 kHz. The driver includes isolated HI and LO Side DC/DC converters and provides seven fault conditions that are reported as a combination of the three fault lines via the 20 pin control header. All drivers use automotive temperature grade components and allow for modifying settings of gate resistors.

SiC Gate Drivers for Traction and Heavy-Duty



LEFT: Basic schematic of the 62EM1 gate driver



ABOVE: Gel shown in blue, conformal coating on rest of PCB not shown

Vehicle (HDV) applications can be exposed to extreme environments. To date, AgileSwitch Gate Drivers have undergone mean-time between failure (MTBF) testing. Future testing will include highly accelerated life testing (HAST) along with additional environmental tests. MTBF testing was performed per MIL-STD-883 Method 1005.9 to achieve a 20-year product lifetime at an ambient of 85°C. HAST testing to be performed, per JESD22-A118B, with conformal coated boards at the conditions 105°C, 85% RH, 96 hours, +15V supply. Storage, transportation, and operational testing to be performed in accordance with IEC 60721-2-9:2014. All testing is performed at certified third-party testing facilities.

Conformal coating

Electronics used in traction inverters are exposed to a variety of severe environmental conditions caused by dirt, corrosion, moisture, and hazardous chemicals. Additionally, based on these higher pollution environments, SiC MOSFET Gate Drivers for modules rated above 3000 V often require a combination of larger creepage-clearance distances and barrier protection to meet UL requirements.

Conformal coating adds a thin lacquer to all surfaces of the PCB that include exposed metal contacts. This lightweight finish can protect the gate driver from moisture, chemicals, and corrosion. In systems requiring enclosures, conformal coating can reduce the need for an expensive, complex design.

For these applications, AgileSwitch recommends HumiSeal UV40 UV curable coating for a good balance of protection and cost. This material has excellent dielectric withstand voltage properties, humidity resistance, and chemical resistance. The company also has customer experience with Humiseal 1A33 polyurethane and IB33 acrylic materials. The 62EM1 Gate Driver requires additional consideration due to the exposed leads on the TO-220 packages. These components are critical to the final output stage of the gate drive circuitry. Traditional conformal coating material is not sufficient. Typically, a gel is used to encapsulate these pins, as shown. AgileSwitch typically specifies Dymax 9001E-v3.7 Gel.

In the Conformal Coating Process the PCBs are washed and dried in a batch cleaner to remove any residue that may get trapped underneath the coating. Trapped residue can degrade the coating over time and may lead to failure. Next, the coating and gel is dispensed by a programmable Selective Coating/ Dispensing System. Each board is transported under a digitally-controlled nozzle where the conformal coating is dispensed precisely to specifications including coating thickness and keep-out areas. The final step is curing the coating by UV light, or other methods, depending on the material.

The final coating is precise, repeatable, and minimizes material waste. This process does not require manual masking or additional handling of the PCBs.

AgileSwitch does not recommend manual spray or dip coating of the PCB. The uniformity, thickness, and coverage of the components will vary from board to board which can produce conductive paths and/or voids that can lead to failure.

The 62EM1 Gate Driver can be mounted in two orientations to meet the packaging design requirements of traction inverters.

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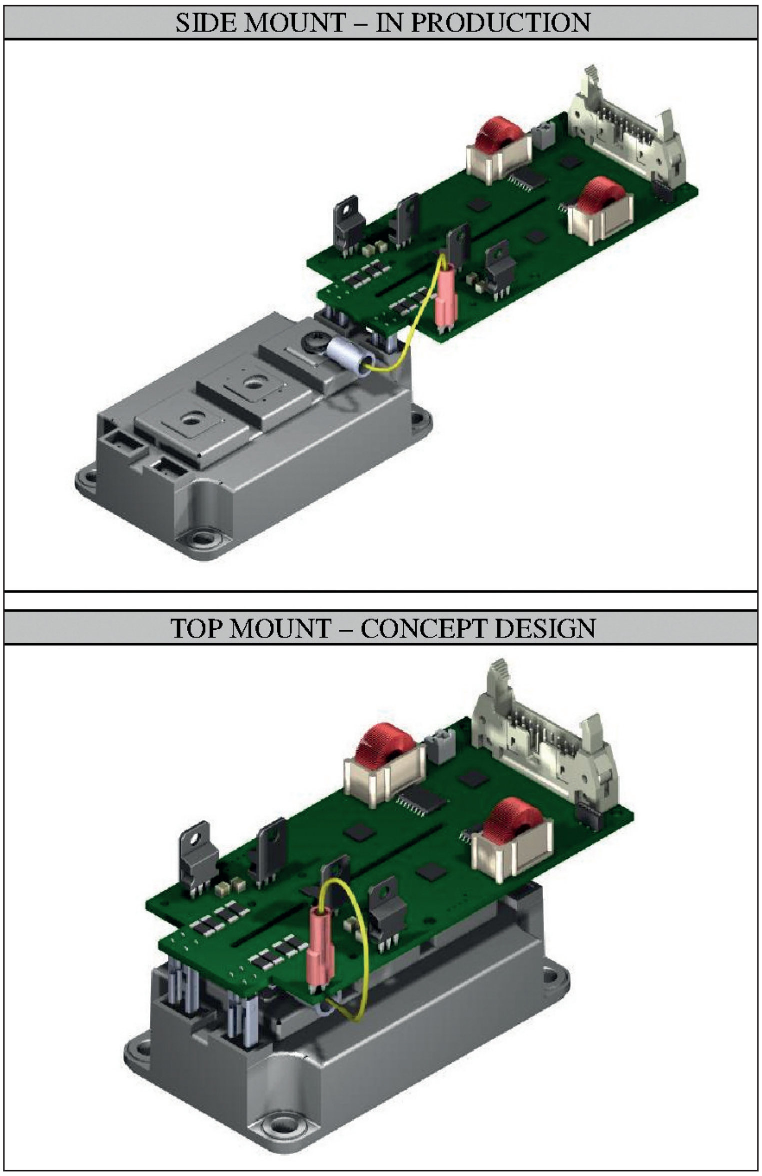


LEFT: The 62EM1 Gate Driver can be mounted in two orientations

Simplifying Lithium Ion Battery Testing and Formation

Analog Devices recently introduced a precision integrated analog front end, controller, and pulse-width modulator (PWM) for battery testing and formation capable of increasing system accuracy and efficiency in lithium-ion battery formation and grading. Compared to conventional technology, the new AD8452 provides 50 % more channels in the same amount of space, adding capacity and increasing battery production throughput.

The AD8452 is intended for use as the core controller for commercial battery test and formation systems. Its miniaturization and high level of analog precision meet the challenge of mass production of high energy density storage Lithium Ion (Li-Ion) packs for transportation and energy storage in homes.

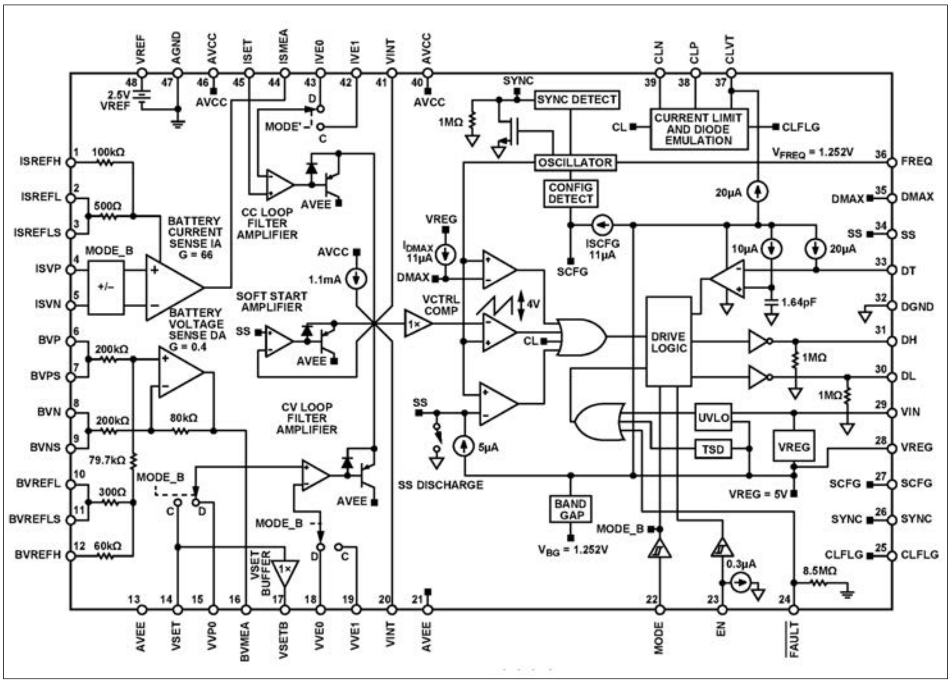
Li-Ion batteries require an elaborate and time consuming post-production process known as forming. Battery formation consists of a series of charge/discharge cycles that require precise current and voltage control and monitoring. The AD8452 provides not only the stringent current and voltage accuracy requirements, but also a highly accurate PWM, with logic level DH and DL outputs ready for a half-H bridge configured switch mode power output converter in a compact 7 mm ? 7 mm package.

The device combines a precision analog front-end controller and SMPS, PWM driver into a single silicon platform for high volume battery testing and formation manufacturing. A precision instrumentation amplifier (in-amp) measures the battery charge/discharge current to better than ±0.1 % accuracy, while an equally accurate difference amplifier measures the battery voltage. Internal laser trimmed resistor networks establish the in-amp and difference amplifier gains (66 V/V and 0.4 V/V, respectively), and stabilize the AD8452 performance across the rated operating temperature range.

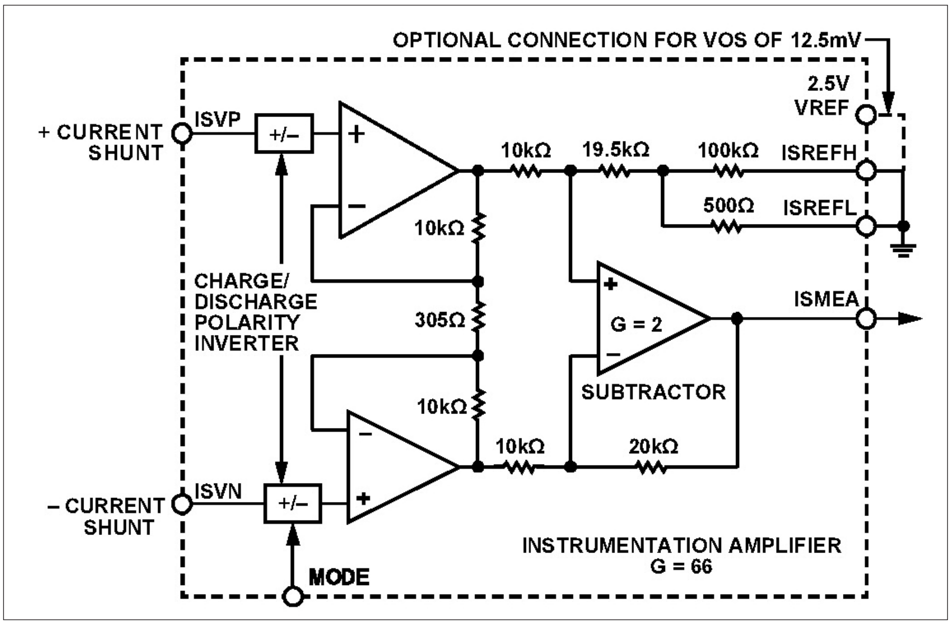
Transparent charge cycles

The analog front end of the AD8452 includes a precision current sense in-amp with gain of 66? ±0.1% and a precision voltage sense difference amplifier with a gain of 0.4 × ±0.1% for battery voltage. It provides constant CC/CV charging technologies, with transparent internal switching between the two. Typical systems induce predetermined levels of current into or out of the battery until the voltage reaches a target value. At this point, a set constant voltage is applied across the battery terminals, reducing the charge current until reaching zero.

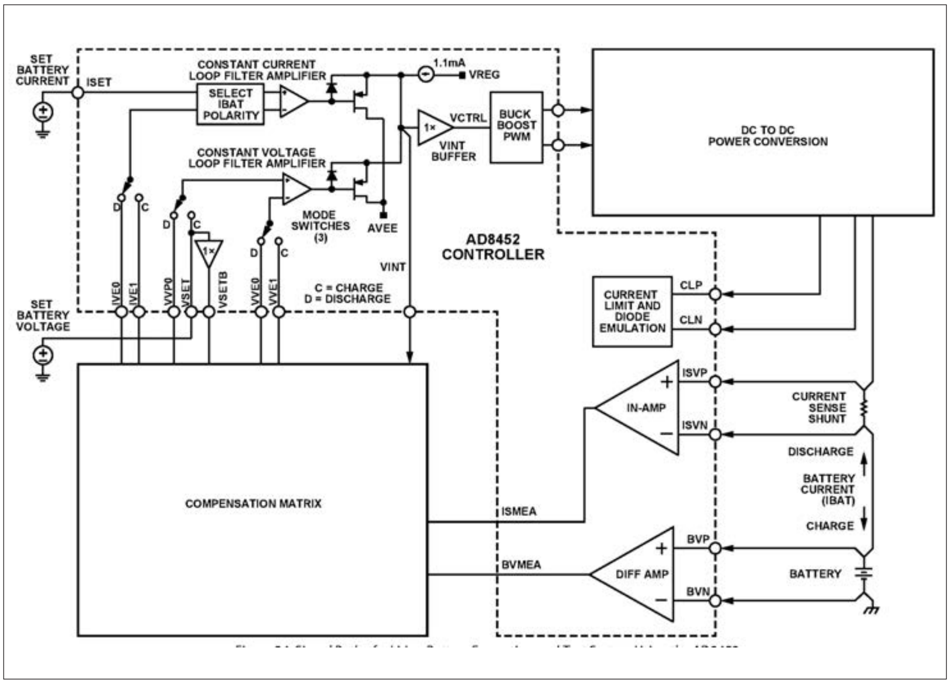
Desired battery cycling current and voltage levels are established by applying precise control voltages to the ISET and VSET inputs. Actual charge and discharge current levels are sensed (usually by a high power, highly



AD8452 block diagram illustrating the distinct sections including the in-amp and difference amplifier measurement blocks, loop filter amplifiers, and PWM



The in-amp is used to monitor battery current when connected to a low ohmic value shunt



Signal path of a Li-Ion battery formation and test system using the AD8452

accurate shunt resistor) whose value is carefully selected according to system parameters. Switching between constant current (CC) and constant voltage (CV) loop integration is instantaneous, automatic, and completely transparent to the observer. A logic high at the MODE input selects the charge or discharge mode (high for charge, low for discharge).

The device features a complete PWM including on-board user adjustable features such as clock frequency, duty cycle, clock phasing, current limiting, soft start timing, and multichannel synchronization. The block diagram illustrates the distinct sections of the AD8452, including the in-amp and difference amplifier measurement blocks, loop filter amplifiers, and PWM. The AD8452 is usable over a wide range of current and voltage applications simply by judicious selection of a current sense shunt, selected according to system requirements.

The in-amp is used to monitor battery current when connected to a low ohmic value shunt. Its architecture is the classic 3-op-amp topology, and is configured for a fixed gain of 66 V/V. Combined with precision laser trimming, the highest achievable CMRR and error free (gain error better than 0.1 %) high-side battery current sensing is provided.

During the charge cycle, the power converter drives current into the battery, generating a positive voltage across the current sense shunt. During the discharge cycle, however, the power converter drains current from the battery, generating a negative voltage across the shunt resistor. In other words, the battery current reverses polarity when the battery discharges.

When in the constant current discharge mode control loop, this reversal of the in-amp output voltage drives the integrator to the negative rail unless the polarity of the target current is reversed.

To solve this problem, the in-amp includes a double pole, double throw switch preceding its inputs that implements an input polarity inversion, thus correcting the sign of the output voltage. This multiplexer is controlled via the MODE pin. When the MODE pin is logic high (charge mode), the in-amp gain is non-inverting, and when the MODE pin is logic low (discharge mode), the in-amp gain is inverting.

The polarity control of the current sense voltage to the input of the in-amp enables the integrator output voltage (VINT) to always swing positive, regardless of the polarity of the battery current.

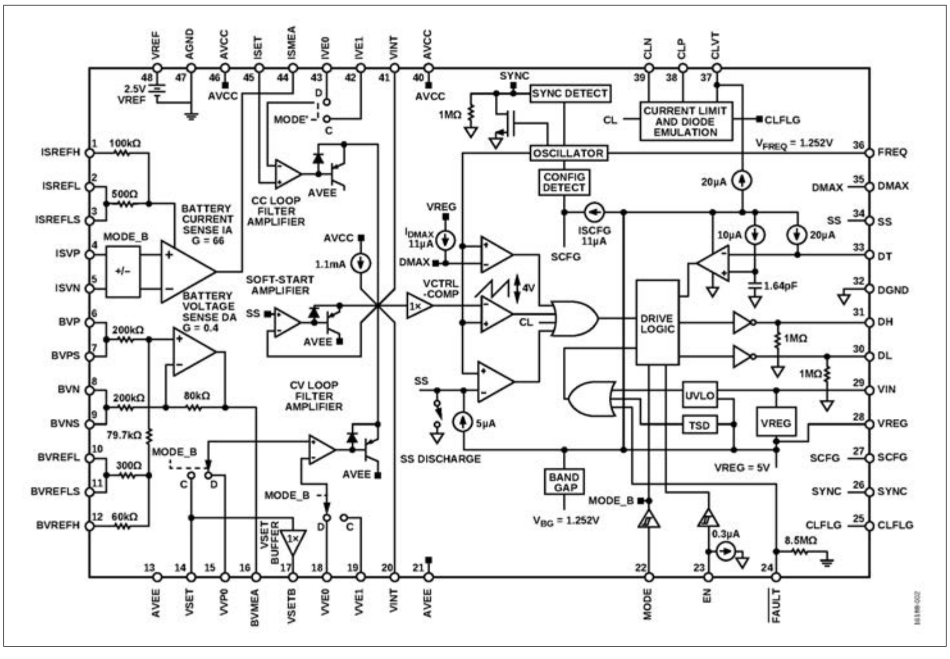
Evaluation board

The AD8452-EVALZ is designed for investigation of the AD8452 analog and PWM features and performance without the added complications of a driver and/or switch mode power supply (SMPS) design. For convenience, a precision 5 V reference IC and four trim pots are built in to the evaluation board, for driving the battery current and voltage ISET and VSET inputs. All device pins are accessible with test loops or probe landings. Also the AD8452-EVALZ has the flexibility to interface and drive a typical half bridge inductor input SMPS with output levels in the 1 A to 15 A range. SMPS and associated components are specified and sourced by the user.

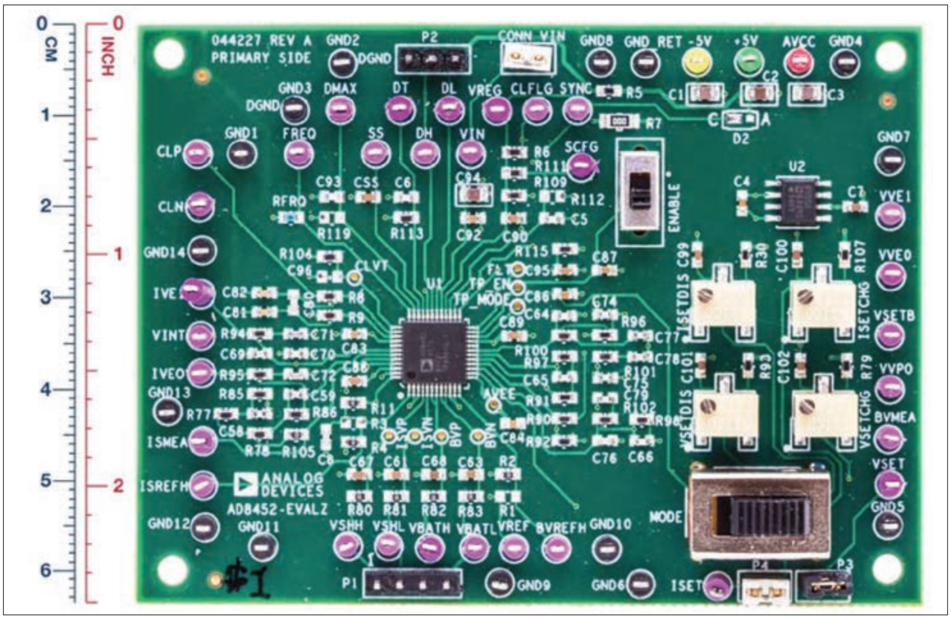
The system level block diagram comprises three functional system level block diagrams, an AD8452-EVALZ block diagram, including its user adjustable current and voltage control compensation matrix, and a simple precision reference (an ADR4550) for driving current and voltage inputs throughout the PWM conversion process to the outputs DH and DL.

The balance of the large signal system is user supplied and consists of the MOSFET driver and user supplied SMPS, an L-C output filter with a current limiting resistor (RCL), and a current sense shunt.

The EVALZ can be connected as the analog and PWM small signal digital controller of a complete battery formation system, allowing users to explore the AD8452 functions in detail, with an emulated system input/output (I/O) provided. The board can also be operated as a channel controller for a power



Evaluation board block diagram showing the AD8452 and external circuitry boundaries



Evaluation board hardware

channel custom designed to the unique needs.

Summary

The AD8452 uses switching technology that recycles the energy from the battery while discharging and delivers 10 times more accuracy than conventional switching solutions. The higher accuracy allows for more uniform cells within battery packs and contributes to longer living batteries in applications such as electric vehicles. It also enhances the safety of manufacturing processes by providing better detection and monitoring to help prevent over and undercharging which can lead to battery failures. The AD8452 delivers bill of material (BoM) cost savings of up to 50 % for charging/discharging boards and potential system cost savings of approximately 20 %. System simulating demonstration boards will be available and can enable lower R&D engineering cost and shorter time to market for test equipment manufacturers

The AD8452 simplifies designs by providing excellent performance, functionality, and overall reliability in a space saving 48-lead, 7 mm × 7 mm × 1.4 mm LQFP package rated for operation at temperatures from –40°C to +85°C.

www.analog.com/AD8452

Versatile Gate Driver IC Featuring Unique Isolation Technique

The newest member of the SCALE-iDriver™ IC family, SID1102K is a single-channel, isolated, IGBT and MOSFET gate driver in a wide-body eSOP package. Featuring a peak drive current of up to 5 A, the new part is able to drive 300 A switches without boosters; external boosters can be used to cost-effectively scale gate current up to 60 A peak. Reinforced galvanic isolation is provided by Power Integrations' innovative, solid insulator FluxLink™ technology which eliminates the need for optocouplers. "This new gate-driver IC reduces time-to-market for designers by providing an easy-to-implement, scalable solution which includes critical safety and protection features in a single, compact, robust package", comments **Michael Hornkamp, Senior Director of Marketing for Gate-Driver Products at Power Integrations in Ense, Germany.**

The single channel SCALE-iDriver SID1102K drives IGBTs and MOSFETs or other semiconductor power switches with a blocking voltage of up to 1200 V and provides reinforced isolation between micro-controller and the power semiconductor switch. Command signals are transferred from the primary (IN) to secondary-side via FluxLink isolation technology. The G pin supplies a positive gate voltage and charges the semiconductor gate during the turn-on process. During the turn-off process the G pin supplies the negative voltage and discharges the gate. Additionally, dedicated AUXGL and AUXGH output pins are available to drive external n-channel MOSFETs as booster stage that can be configured to provide increased peak output gate drive current. Therefore additionally AUXGL and AUXGH output pins can drive external n-channel MOSFETs as a booster stage. Controller (PWM) signals are compatible with 5 V CMOS logic, which may also be adjusted to 15 V levels by using external resistor divider.

FluxLink technology

The FluxLink technology is a high speed bi-directional communications link that sits across the isolation gap. It is a solution for the secondary side isolation and coupling replacing an optocoupler which degrades over time, but more importantly also to save cost. The idea is using the "parasitic" inductance of the bond wires (which can

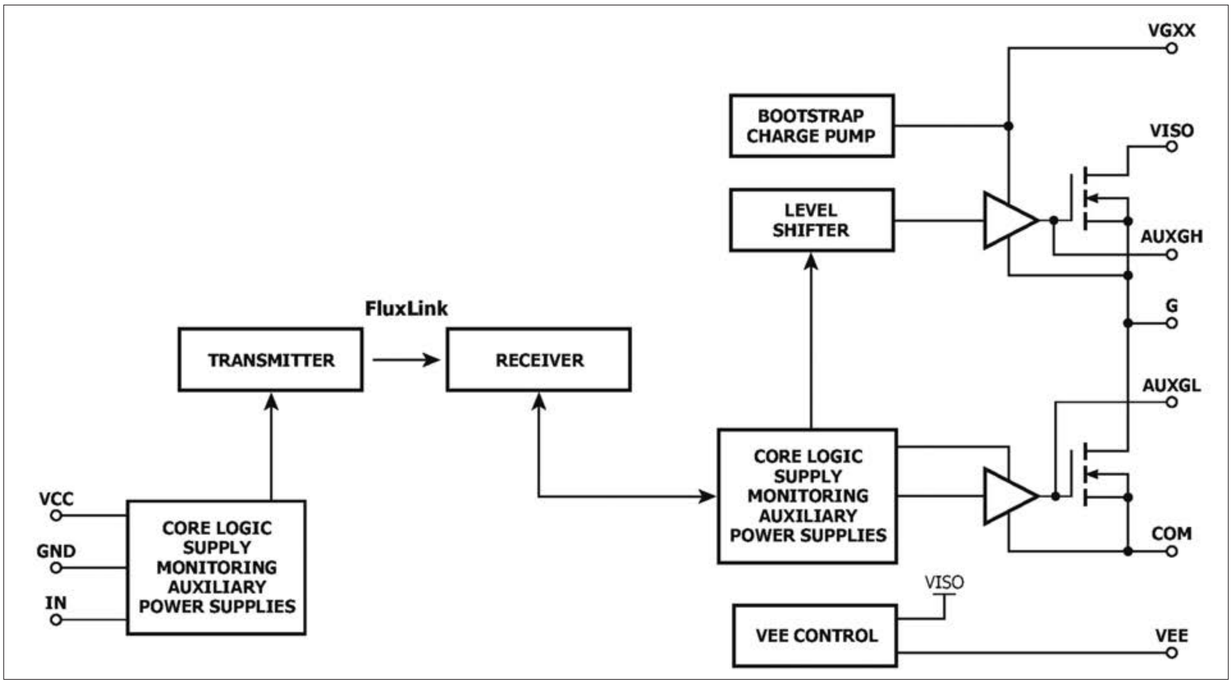


Figure 1: SID1102K functional block diagram

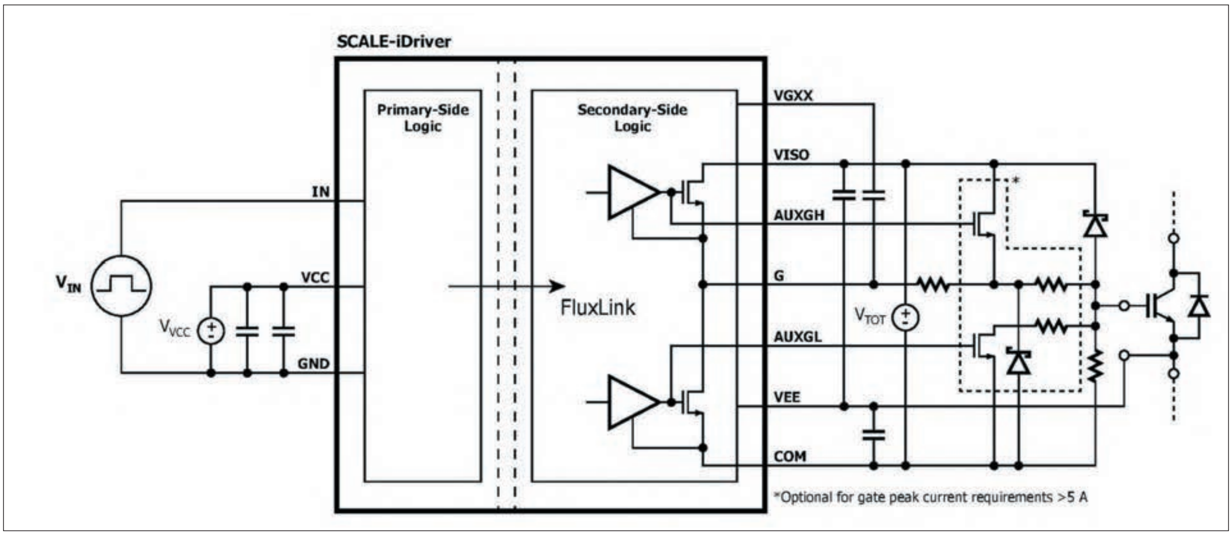


Figure 2: Typical application schematic highlighting FluxLink and with external N-channel MOSFET booster stage

be manufactured repeatable) and leadframe as a coreless pulse transformer, in particular optimizing its physical layout.

Using a robust signalling protocol, it provides very high EMI and magnetic field immunity and exceeds the standards IEC61800-4-8 and IEC61800-4-9 in all three axes. It features a very low propagation delay and a very low jitter of only +/-5ns. This link not only isolates the low voltage input control side of the device but also communicates back any fault conditions measured on the high voltage side of the device back across the barrier to a microcontroller responsible for control and monitoring the device operation.

Driver details

The SID1102K requires two power supplies. One for the primary-side (V_{VCC}), which powers the primary-side logic and communication with the secondary (insulated) side. The other supply voltage (V_{TOT}) is required for the secondary-side. V_{TOT} is applied between VISO pin and COM pin. V_{TOT} should be insulated from the primary-side and should provide at least the same insulation capabilities as the SCALE-iDriver. V_{TOT} should have a low capacitive coupling to the primary or any other secondary-side. The positive gate-emitter source voltage is provided by V_{VISO}, which is internally generated and stabilized to 15 V (typically) with respect to VEE. The negative gate-emitter source voltage is provided by VEE with respect to COM. Due to the limited current sourcing/sinking capabilities of the VEE pin, any additional load needs to be applied between the VISO and COM pins. No additional load between VISO and VEE pins or between VEE and COM pins is allowed.

The input (IN) logic is designed to work directly with micro-controllers using 5 V CMOS logic.

If the physical distance between the controller and the iDriver is large or if a different logic level is required, the resistive divider in Figure 3 is recommended. This solution adjusts the logic level as necessary and will also improve the driver's noise immunity.

Gate driver commands are transferred from the IN pin to the G pin with a propagation delay tP(LH) and tP(HL).

The gate of the power semiconductor switch should be connected to the iDriver output via pin G, using a suitable gate resistor RG as shown in Figure 4.

Note that most power semiconductor data sheets specify an internal gate resistor R_{GINT}, which is already integrated into power semiconductor switches. In addition to RG_{INT}, external resistor device R_G is specified to set-up the gate current level to the application requirements. Careful consideration should be given to the power dissipation and peak current associated with the external gate resistor.

The G pin output current source ($I_{G(H)}$, $I_{G(L)}$) is capable of sinking and sourcing

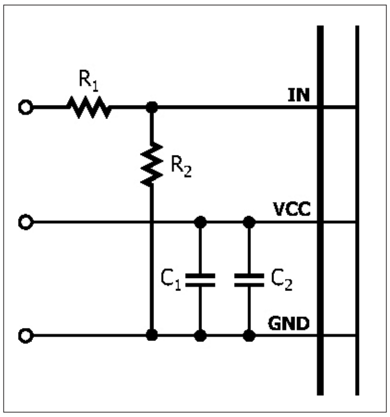


Figure 3: Recommended circuitry for increased IN logic levels (for R1 = 3.3 kΩ and R2 = 1 kΩ the IN Logic Level is 15 V)

(typically) 5 A at 25°C. The internal resistances are described as R_{GHI} and R_{GLI} respectively. If the gate resistor attempts to draw a higher peak current, the peak current will be internally limited to a safe value.

It is recommended during power-up and power-down that the IN pin stays at logic low. Any supply voltage related to VCC, VISO, VEE and VGXX pins should be stabilized using ceramic capacitors. After supply voltages reach their nominal values, the driver will begin to function after a time delay tSTART.

If command signals applied to the IN pin are shorter than the minimum specified by $t_{GE(MIN)}$, then SID1102K output signals at G, AUXGH, and AUXGL pins will extend to value $t_{GE(MIN)}$. The duration of pulses longer than $t_{GE(MIN)}$ will not be changed.

Application example and components selection without booster

Figure 4 show the schematic and typical components used for a SID1102K design without a booster stage, in which the primary-side supply voltage (V_{VCC}) will be connected between VCC and GND pins and supported through supply bypass ceramic capacitors C1 (4.7 ?F typically) and C2 (470 nF typically). If the command signal voltage level is higher than the rated IN pin voltage, a resistive voltage divider should be used (Figure 3).

Additional capacitor CF can be used to provide input signal filtering as shown in Figure 4. The filter time τ can be calculated according to equation (1):

$$\tau = \frac{R_1 \times R_2}{R_1 + R_2} \times C_F$$

The secondary-side isolated power supply

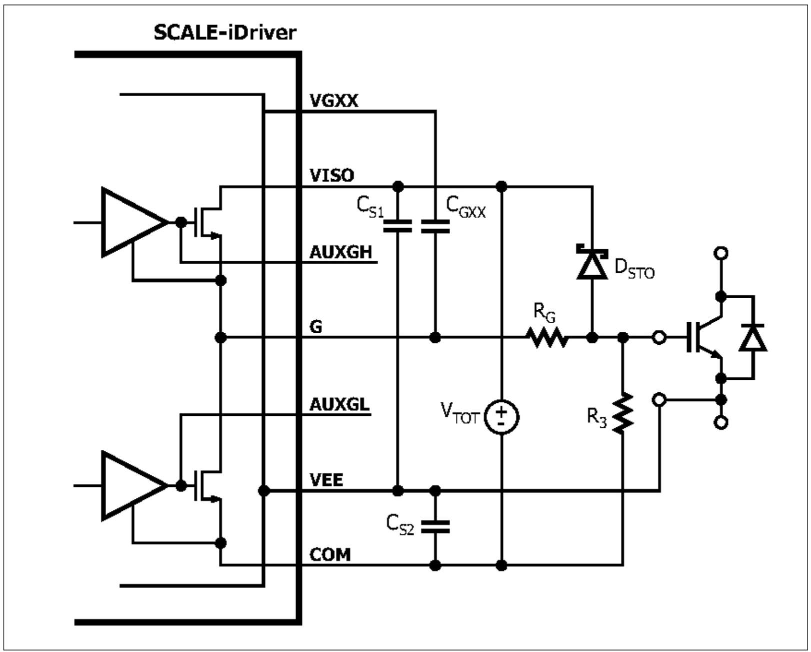


Figure 4: SID1102K without external booster stage incorporating gate resistor RG

(V_{TOT}) is connected between VISO and COM. The positive voltage rail (V_{VISO}) is supported through ceramic capacitor C_{S1}. The negative voltage rail (VVEE) is similarly supported through capacitor C_{S2}. Typically, C_{S1} and C_{S2} should be at least 3 µF multiplied by the total gate charge of the power semiconductor switch (Q_{GATE}) divided by 1 µC. A 10 nF capacitor C_{GXX} is connected between the G and VGXX pins.

To ensure gate voltage stabilization and collector current limitation during short-circuit the gate is connected to V_{VISO} through Schottky diode D_{STO}.

To avoid parasitic power-switch-conduction during system power-on the gate is connected to COM through 22 kΩ resistor R 3, as shown in Figure 4.

Gate resistors are located physically close to the power semiconductor switch. As these components can get hot, it is recommended that they are placed away from the SCALE-iDriver.

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www.accelrf.com
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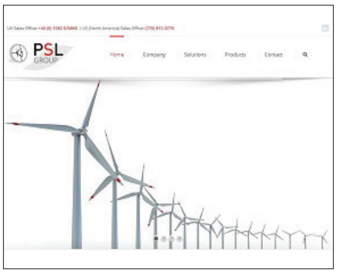

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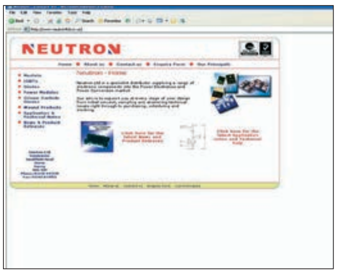

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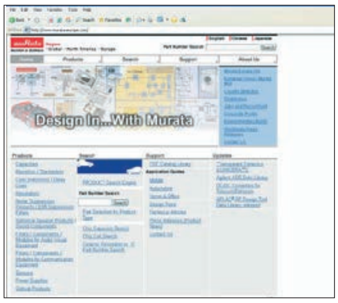

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