ISSN: 1863-5598

ZKZ 64717
12-15

Bodo´s Power Systems®

Electronics in Motion and Conversion

December 2015

POWER ANALYSIS AT YOUR FINGERTIPS

Touch screen control and remote front panel operation

ZES ZIMMER

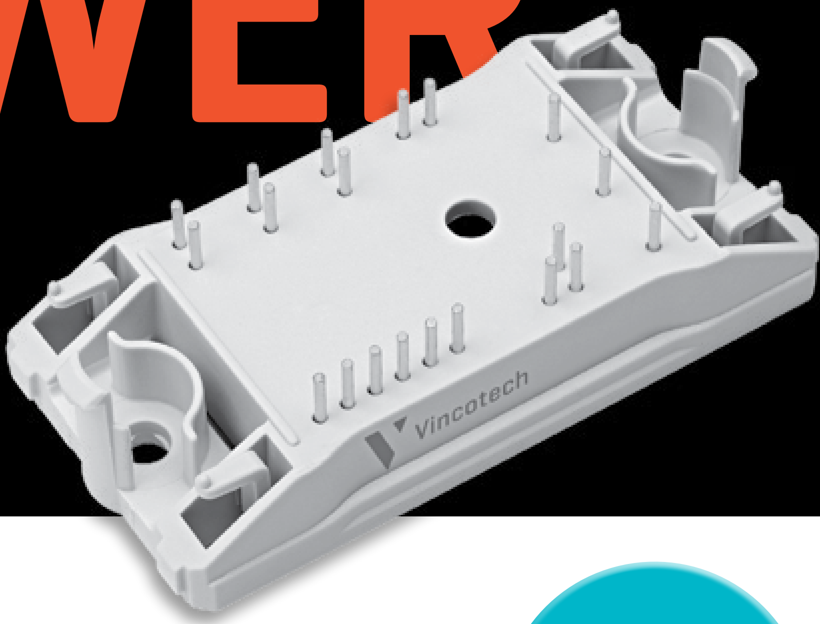
Read online and search for key subjects from all articles in Bodo's Power Systems by going to Powerguru: www.powerguru.org

powerguru.org

The Gallery

Vincotech

MAX POWER



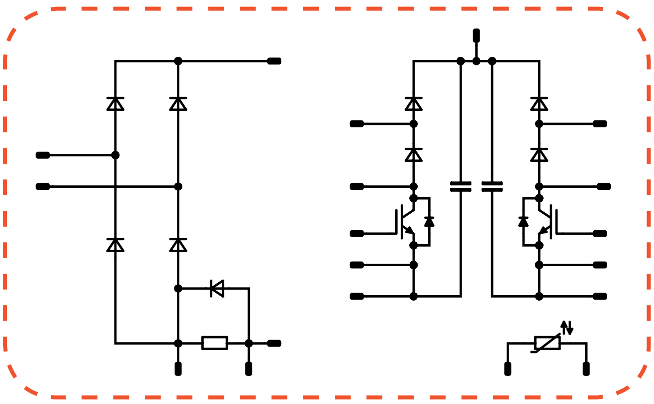
*flow*PFC 0 CD: 650 V / 1 – 6 kW

Maximize your application's power by upping efficiency and minimizing net reactive current loading.

SAMPLE
www.vincotech.com/PFC-sample

Main benefits

/ Draws max power from the grid
/ Optimizes energy quality and consumption
/ Increases your SMPS' efficiency
/ Enables fast switching up to 75 kHz
/ Comes in compact, low inductive 12 or 17 mm *flow* 0 housings
/ Designed for welding, SMPS and embedded drive applications



www.vincotech.com/*flow*PFC_0_CD

EMPOWERING **YOUR IDEAS**

Bodo´s Power Systems®

A Media
Katzbek 17a
D-24235 Laboe, Germany
Phone: +49 4343 42 17 90
Fax: +49 4343 42 17 89
editor@bodospower.com
www.bodospower.com

Publishing Editor
Bodo Arlt, Dipl.-Ing.
editor@bodospower.com

Senior Editor
Donald E. Burke, BSEE, Dr. Sc(hc)
don@bodospower.com

UK Support
June Hulme
Phone: +44(0) 1270 872315
junehulme@geminimarketing.co.uk

Creative Direction & Production
Repro Studio Peschke
Repro.Peschke@t-online.de

Free Subscription to qualified readers
Bodo´s Power Systems
is available for the following
subscription charges:
Annual charge (12 issues)
is 150 € world wide
Single issue is 18 €
subscription@bodospower.com

circulation ASC audit since 09/2006 print run 24 000

Printing by:
Druckhaus Main-Echo GmbH & Co KG
63741 Aschaffenburg, Germany

Events

Embedded World 2016,
Nuremberg, Germany, February 23-25
http://www.embedded-world.de

EMC 2016,
Düsseldorf, Germany, February 23-25
http://www.mesago.de/en/EMV/home.htm

APEC 2016, Long Beach, CA,
March 16-20 http://www.apec-conf.org/

New Energy Husum 2016,
Husum Germany, March 17-20
http://www.new-energy.de/new_energy/de/

battery university 2016,
Aschaffenburg, Germany,
http://www.batteryuniversity.eu

ExpoElectronica 2016, Moscow Russia,
http://expoelectronica.primexpo.ru/en/

Santa is coming for Peace!

Soon it will be Christmas Eve. It portrays the love and peace that should be everywhere. At the moment we are facing terrorism that impacts all our lives. Respect and tolerance for others is what counts in a community that shares lives in peace together. We cannot allow terrorism to rule. We must be on the watch to keep our societies free from threats, and the intolerance that leads to conflicts; first local, then war-like.

It is a tragedy to see refugees fleeing their homes and making the dangerous journey to Europe to save their lives. The discussions about how many of them Europe can support is a political discussion held by different peoples, but sometimes exaggerated to frighten a given population. The humanitarian side must be first - to help and save their lives. We have to be very clear in separating terrorism from the plight of simple families fleeing for their safety. The terrorism attack in Paris in November was very serious. We must fight this kind of terrorism while we support the refugees.

Keep in mind how many foreign players are in the soccer teams in Europe. Unfortunately, fans going to soccer games and being proud to win with these foreign players are sometimes the same people that do not like to have them as refugees. Our governments must get better organized throughout Europe to speak with one caring voice when it comes to help. Accepting refugees as residents must be a process that does not take years.

Integrating people into the workplace helps them to achieve independence from government financial support and restores their dignity and self-esteem. This has great challenges for all of us - but the refuges have skills and their contribution can develop our future. Especially the children that have faced war must get an education; in this way to see a future for themselves without conflict. Santa should show up for all children, regardless of age - as we are always children to our parents.

Power electronics plays an important role in developing a more efficient future. In November, productronica in Munich showcased the manufacturing side, while sps/ipc/drives in Nuremberg pointed out the solutions in industry.

The year 2016 will start soon and the first important show and conference of the year will be APEC in Long Beach California, in March. And in May we all will be back in Nuremberg for the PCIM Europe conference. And in 2016 we have electronica again.

We have delivered twelve issues this year. All technical articles are archived on my website and are also retrievable at PowerGuru. Bodo's Power Systems reaches readers across the globe. If you speak the language, or just want to have a look, don't miss our Chinese version: www.bodoschina.com

My Green Power Tip for December:
Use your winter sleigh. You just need some snow. If you are lucky, living in Scandinavia, you may have your own reindeer to pull the sleigh - like Santa. Otherwise, you yourself get to pull your kids: a low friction, renewable energy ride !

Merry Christmas


LEM
LEM
LEM

Internet-of-Things (IoT) Interface Software for Electrical Equipment Products

Alizem – a Canadian firm specialized in embedded software for power electronics applications - has recently announced the release of its new software interface for Internet-of-Things (IoT) applications based Initial State's platform, a recognized leader and innovator in IoT technology. This interface is meant to help electrical equipment manufacturers to design better products faster by enabling them to easily and quickly pipe out critical data from the operation and health state of their product without having to invest in complex and expensive data monitoring equipment.

Benefits of this software are applicable during and after product development phase: (1) early bug detection by visualizing all your measurements and system states and quickly isolate bugs, (2) easily share data between development teams working at different locations, (3) remotely monitor critical performance data such as power consumption, load motion profiles, current shape and temperature, (4) generate new revenues by bundling your electrical equipment products with SaaS based monitoring services and provide peace-of-mind to your customers by having them access to all their equipment operation data.

This IoT software is offered in standalone (great for existing products) and integrated (great for new products) versions.

www.alizem.com/iot

IPEMC 2016-ECCE Asia Call for Papers

The 2016 8th International Power Electronics and Motion Control Conference - ECCE Asia (IPEMC 2016-ECCE Asia) will be held during May 22 - May 25, 2016 in Hefei, Eastern China. The Organizing Committee cordially invites you to submit digests, organized session proposals, and tutorial proposals on broad topics relevant to power electronics, electric drives, sustainable energy and emerging applications. The details can be found on:

www.IPEMC2016.org

ON Semiconductor to Acquire Fairchild Semiconductor

ON Semiconductor Corporation and Fairchild Semiconductor International Inc. announced that they have entered into a definitive agreement for ON Semiconductor to acquire Fairchild for $20.00 per share in an all cash transaction valued at approximately $2.4 billion. The acquisition creates a leader in the power semiconductor market with combined revenue of approximately $5 billion, diversified across multiple markets with a strategic focus on automotive, industrial and smartphone end markets.

Following consummation, the transaction is expected to be immediately accretive to ON Semiconductor's non-GAAP earnings per share and free cash flow, excluding any non-recurring acquisition related charges, the fair value step-up inventory amortization, and amortization of acquired intangibles. ON Semiconductor anticipates achieving annual cost savings of $150 million within 18 months after closing the transaction.

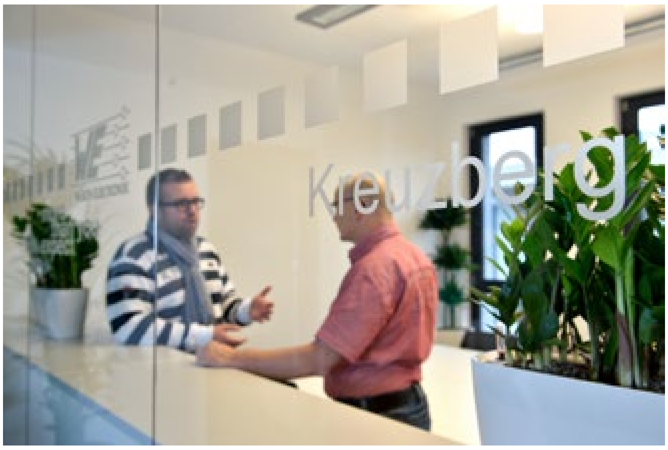
The transaction is not subject to a financing condition. ON Semiconductor intends to fund the transaction with cash from the combined companies balance sheet and $2.4 billion of new debt. The debt financing commitment also includes provisions for a $300 million revolving credit facility which will be undrawn at close. ON Semiconductor remains committed to its share repurchase program, and the agreed upon financing provides flexibility to continue share repurchases going forward.

www.onsemi.com

www.fairchildsemi.com

Vibrant Research Environment

Würth Elektronik eiSos GmbH & Co. KG opened its Competence Center Berlin on 23 October 2015, marking a further milestone of the company's expansion strategy. The Competence Center Berlin will primarily be a hub for hard- and software engineers designing and programming applications for new components, and supporting customers with product integration or application developments. Students



will also be given opportunities to contribute their innovative ideas to the organization.

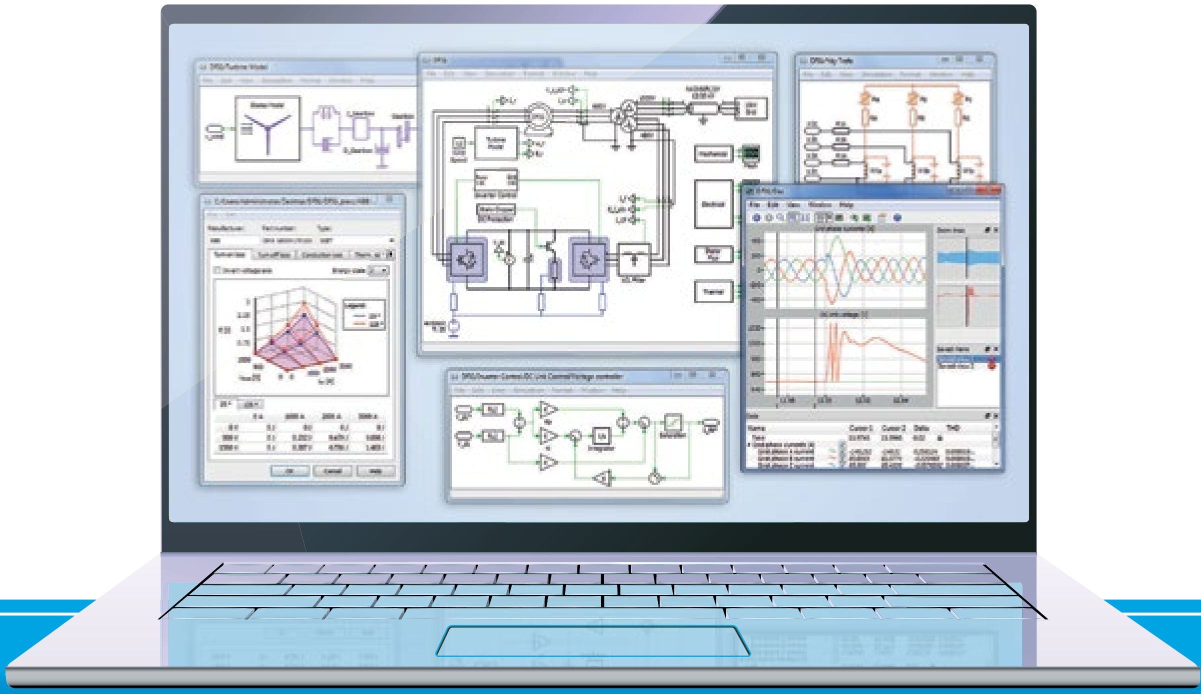
The 640 m² site in Adlershof Technology Park was chosen with foresight as the location of the new Würth Elektronik eiSos office. Berlin's governing mayor Michael Müller embraced the company's decision to settle in the capital: "A warm welcome to Würth Elektronik eiSos and all its staff. The investment of such an innovative player in Berlin proves that our city has successfully established itself as an attractive high-tech location. Adlershof offers Würth Elektronik eiSos numerous partner companies, skilled professionals, and potential from our universities. The Würth Elektronik eiSos subsidiary here is an example of our successful economic development policy and confirms that we are doing a good job". Adlershof Technology Park is already home to ten independent research institutes, six Humboldt University institutes, and almost 1000 companies. The impressive number of electrical engineering firms and high-tech start ups, on the one hand, and academic institutes, on the other, was a key factor for the electronics and electromechanical components manufacturer. Berlin-Adlershof is already a dynamic technology hub with a huge potential of skilled professionals to support the further development of the subsidiary.

www.we-online.com

plexim
electrical engineering software

plecs

THE SIMULATION SOFTWARE PREFERRED BY POWER ELECTRONICS ENGINEERS



MODELING DOMAINS

- Electrical
- Control
- Thermal
- Magnetic
- Mechanical

KEY FEATURES

- Fast simulation of complex systems
- Code generation
- Frequency analysis
- Available as standalone program or Simulink blockset

Get a free test license
www.plexim.com/trial

carabinbackhaus.com

On the Shape of Near 100% Renewable Energy Grid

The Technical Committee of the World Wind Energy Association has published its latest report Wind Energy 2050: On the Shape of Near 100% Renewable Energy Grid. With wind energy increasingly getting established as a mainstream option for electricity generation in many countries, its integration with the conventional grid has emerged as a technological challenge. The report looks at the year 2050, when near 100% renewable energy grids will be established.

The key recommendations are:

There is a need for flexibility in the power system, which implies a lesser capacity based on nuclear and coal and a larger capacity based on hydro or fast response units.

Even in the absence of wind, a power system has to deal with many dynamic parameters such as availability of plants and variability in load demand. Wind generation only adds to the dynamics in the system.

A larger number of transmission links needs to be set up from a high wind resource area to the adjoining areas

DC and HVDC technologies need to be deployed, with converters and power electronics that address issues of harmonics and stability

There is a need for utility scale storage systems to balance fluctuations

There is a need for forecasting power output from wind farms over both, long term (1 week) and very short term (1 hr)

Wind turbines need to be modified to enable better control and grid friendly operation such as LVRT, HVRT, curtailed operation or power factor adjustments. Technologies are also required to interface with storage systems with wind turbines or independent of wind turbines

In large scale wind generation, variabilities are evened out and pose less of a problem at system operation level. However, local variabilities may cause surge or dip voltage and frequency.

Smart grid options need to be explored for better communication in different parts of grid and better control

Proliferation of battery storage systems in vehicles, power back ups in domestic, industrial and commercial establishments can be leveraged to achieve high penetration of wind energy and other renewable

Hydro capacity with the ability to ramp up and ramp down in a matter of minutes is a good combination with wind energy. Pumped hydro capacity in the system has the same effect.

The full version of the report Wind Energy 2050: On the Shape of Near 100% Renewable Energy Grid can be downloaded from the WWEA website:
http://www.wwindea.org/wind-energy-2050-on-the-shape-of-near-100-renewable-energy-grid/

www.wwindea.org

Contest to Create Wirelessly Powered Devices

Integrated Device Technology, Inc and Digi-Key Electronics announced a new contest that seeks the most innovative use of IDT's

wireless power technology. The contest asks electronics experts and tinkerers alike to proffer creative ways to incorporate wireless charging capabilities into products by using IDT's 5W kits. Sponsored by Digi-Key Electronics, a leading global distributor of electronic components, the theme of the contest is, "Power Without Borders."

Judges will be looking for designs that demonstrate the advantages wireless charging systems offer, such as convenience, the ability to develop a waterproof charging system, or the elimination of failure-prone charging contacts. The winner of the global competition will receive a Samsung Galaxy Note 5 or Galaxy S6 edge+, plus a Gear S2 Smart Watch; second and third place winners also will receive Samsung products featuring wireless charging enabled by IDT chips. The contest will be hosted by the world's largest hardware creation community, hackster.io. Contest details can be found, and submissions entered, at www.hackster.io/IDTWirelessPower. The deadline for submitting designs is Dec. 31, and the winners will be announced Feb. 15, 2016.

www.idt.com

EtherCAT Slave Controller for SmartFusion2 FPGAs

Microsemi Corporation and TRINAMIC Motion Control announced the availability of a plugfest-tested EtherCAT®intellectual property (IP) and chip solution from TRINAMIC for Microsemi's SmartFusion™2 system-on-chip (SoC) field programmable gate arrays (FPGAs). In addition to accelerated time to market and lower total cost of ownership, the new solution offers scalability, low power, security, and TRINAMIC's customization and integration services for Microsemi's FPGAs.

The new solution, leveraging TRINAMIC's well-established track record of delivering embedded motor drives with high-level bus interfaces for the industrial motion control market, provides IP, software and design services to target an EtherCAT solution for Microsemi's SmartFusion2 SoC FPGAs. Industry experts estimate that more than one third of automation equipment is being used or migrated from fieldbus to Ethernet-based solutions. As a result, sales of TRINAMIC's solution are expected to increase Microsemi's revenue opportunities for SmartFusion2 and continue the company's commitment to the growing industrial Ethernet market.

TRINAMIC's EtherCAT solution is suitable for a variety of applications in the industrial and communications markets, including factory automation applications like programmable logic controller (PLC), motor drive/motion drive control, safety input/output (IO) modules, and other applications where EtherCAT communications are required.

www.trinamic.com

Innovation Everywhere

Digital Position Sensor ICs

Hall-effect digital position sensor ICs detect movement and position via changes in magnetic flux density. Allegro is the market leader in magnetic sensor ICs* with one of the industry's broadest portfolios of switch, latch, and speed & direction ICs. They are contactless, require few external components, and are AEC-Q100 qualified.

We continue to add new and exciting products:

- **Vertical Hall** sensing enables new, smaller, lower-cost system form-factors and revolutionizes motors/encoders, delivering quadrature signals independent of magnet pitch.
- Allegro-developed **packaging** integrates the typical discrete components for **improved EMC** performance and **PCB-less** sensor implementations.
- Patented **self-test** features for safety-critical systems required to meet **ISO 26262 (ASIL)** guidelines.

A2-SIL™

* per IHS Magnetic Sensors Market Tracker, 2H 2014

Representatives

ALLREM
94616 Rungis Cedex, FRANCE
Tel: +33 (0) 1 56 70 03 80
E-mail: info@allrem.com

Allegro MicroSystems Germany GmbH
Adlerweg 1, D-79856 Hinterzarten, GERMANY
Tel: +49-(0)7652-9106-0
Fax: +49-(0)7652-767
E-mail: info.germany@allegromicro.com

Consystem S.r.l.
I-20144 Milano, ITALY
Tel: +39 02 4241471
Website: www.consystem.it
E-mail: support@consystem.it

Allegro™ MicroSystems Europe Ltd

Visit our website to review product datasheets

www.allegromicro.com/camp1252

Expanding the LinPak to 3300V

Following the announcement of the innovative 1700V 2x1000A open standard LinPak phase-leg module, ABB expands the lineup with a 3300V 2x450A version of the LinPak.

Thus for the first time a very low-inductive phase-leg/dual-IGBT module for the 3300V voltage class becomes available. Thanks to the identical outline, designers can keep the same electromechanical inverter concepts as with the 1700V LinPak modules. The 3300V LinPak allows, for the first time, customers to build low-inductive high-voltage converters with various power levels with just one IGBT article thanks to the easy paralleling capability of the LinPak. The 3300V 2x450A LinPak offers a fast and low switching loss SPT+ chip set that ideally fits to the LinPak module.

The LinPak is the first 3300V module with an integrated temperature sensor and offers unrivaled reliability thanks to well matched materials such as AlN insulation and AlSiC base-plate, as well as advanced wire-bonding techniques and particle free ultrasonic welded main connections.

The 3300V LinPak is an enabler for more reliable, efficient and compact inverter designs in traction applications such as regional trains and metros but as well locomotives and high-speed trains. It also serves markets such as OHV (off-highway-vehicle) and industrial converters for drives and wind-power.

Prototype sampling of the low-inductive 3300V LinPak IGBT modules will start in 1Q16.

www.abb.com/semiconductors

EPIC on the Council of Management of ISA

"I am looking forward to Mr. Lee to make contribution to the ISA Council of Management as well as bring value to the ISA." says Ms. Ling Wu, President of ISA and (International SSL Alliance) and Secretary General of CSA (China Solid State Lighting Alliance). Carlos Lee brings valuable experience from his personal semiconductor industry background, and feedback from the activities he organizes at EPIC for instance on lighting for automotive, lighting for horticulture, and many other application areas. "I am honoured to join ISA and contribute to accelerate and foster the development of the global SSL industry and its applications. With EPIC on board, we also further strengthen additional global connections for our members in Europe." says Carlos Lee, Director General at EPIC, the European Photonics Industry Consortium representing 240 leading companies.

ISA, based in Beijing, is a not-for-profit international alliance of regional alliances and associations, renowned universities and institutions and leading companies in the SSL field. ISA is unique because its scope covers the complete spectrum of SSL technologies and applications.

Technologies include materials and equipment, LED-based light sources, modules, lamps, luminaires, electronics for lighting, systems, lighting design and architecture, testing and qualification, recycling, SSL related regulations, etc. Applications include all segments of general lighting, backlighting, transport and mobility, horticulture, healthcare, safety, communications, and other societal needs.

www.isa-world.org

A New Diamond in the Making

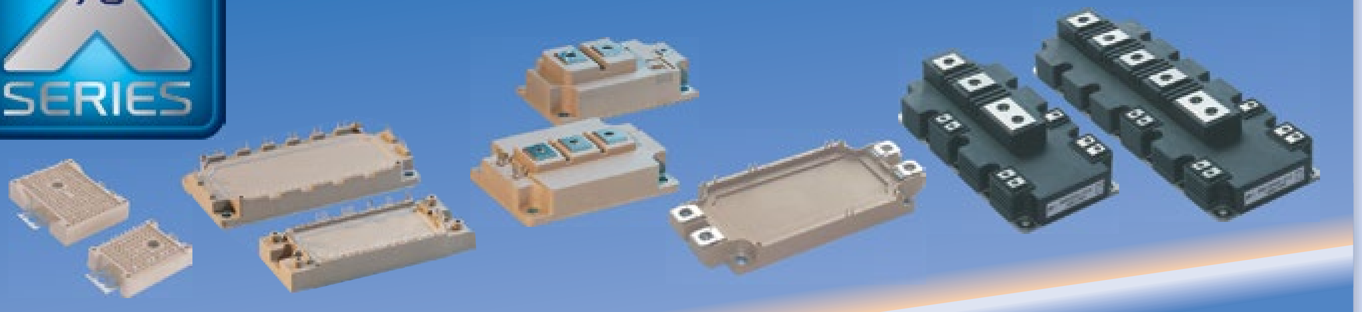
Diamond Electronics announced the launch of their new Power Component Sales Division focusing on provision of exemplary power components (including power semiconductors, Silicon Carbide devices and custom wound components) to the UK power market. Newly appointed Business Development Manager, Craig Ardrey commented "We have brought together a group suppliers who have been successful in the global market place but have had little or no exposure to the UK. All of our principles offer innovative technologies, designed-in quality and strong commercial options to UK design engineers. With the help of Diamond Power our customers can leverage the high quality, leading tech from suppliers that are winning more and more market share from the established European/US suppliers in the Asian high volume market place."

The initial offering will include HV MOSFETs, Super Junction MOSFETs, SiC SJT and diodes, IGBTs, Thyristors, rectifier and fast diodes all in discrete, module or capsules packages with the initial line card featuring such suppliers as TECH SEM, MAGNACHIP, GENESIC SEMICONDUCTOR, POWERSEM and EGSTON for magnetics.

Diamond Power's team includes Product specialists and technical sales personnel with over 40 years' experience of Power components and their applications.

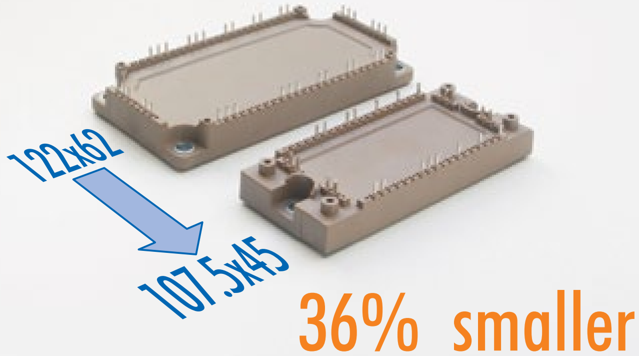
www.diamondpowercomponents.co.uk

The new X-series with 7th generation IGBT and innovative package technologies

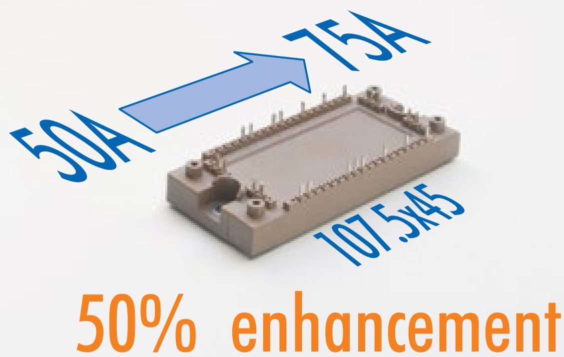


Downsizing package / Upgrading current rating

Downsizing package
Example 75A PIM-IGBT



Upgrading current rating
Example 50A PIM-IGBT



Main Features and Improvements

- Reduced power dissipation
- Reduced thermal impedance
- More output power
- 175°C operating temperature at high reliability level

Voltage and current range

650V	1 200V	1 700V
10A - 600A	10A - 1 800A	75A - 1 800A

Samples on request, please contact us

Fuji Electric Europe GmbH
Goethering 58
63067 Offenbach am Main
Germany

Fon +49(0)69-66 90 29 0
Fax +49(0)69-66 90 29 56

www.fujielectric-europe.com
info.semi@fujielectric-europe.com

Win a PICDEM Lab II Development Platform!

Win the PICDEM™ Lab II Microchip Development Board (DM163046) from Bodo's Power! The board is a development and teaching platform for use with 8-bit PIC® microcontrollers (MCUs). At its center, a large prototyping breadboard enables users to easily experiment with different values and configurations of analog components for system optimization. Several external connectors allow for user-customizable expansion, while our library of labs and application notes enrich the development experience. The PICDEM Lab II Development Board is also fully compatible with our latest software development environment.

Features:

Supports all 8-bit PIC MCUs from 6 to 40 pins

- Programming headers and power connections for all MCU sockets
- Three individual power supplies
- 5V, 3.3V, variable (1.5-4.5V)
- Large breadboard area for external analog and sensor connections
- External connections for industry-standard communications and expansion interfaces
- Lab hardware and documentation for four labs included in the box
- RS232 and Bluetooth® Low Energy interfaces

The original PICDEM Lab Development Board has remained one of the most popular development tools for PIC MCUs since its introduction. Microchip has taken this concept and expanded it for 21st century embedded development. The PICDEM Lab II Development Board supports any 8-bit PIC microcontroller (6-, 8-, 14-, 18-, 20-, 28- and 40-pin footprints), and provides an expansive array of connections for programming, I/O, analog and communications interfaces. The PICDEM Lab II Development Board will be a valuable resource to engineers across a broad spectrum of specialties, from analog designers looking to explore the power and flexibility of MCU-based systems to engineering professors seeking a flexible and relevant teaching tool that they can add to their curricula.

For your chance to win a Microchip PICDEM Lab II Development Board, visit the web-site and enter your details in the online entry form:

http://www.microchip-comps.com/picdemlab2-bodo

Silicon Valley - the Shimmering Glow is Crumbling

By Henning Wriedt, corresponding editor Bodo´s Power Systems

The worldwide fame of this huge innovation machine still attracts countless engineers from all parts of the world. Most of those young programmers and freshly minted electronic engineers are dreaming of the Mega-Hit, despite the fact, that the costs of living in the Bay Area are extremely high. And countless working hours seem to be the rule.

In order to spend as much as possible hours at their desks, those who are chasing the big success, are now trying to skip the usual times for breakfast, lunch and dinner. Instead they are mixing their own power drinks. Very popular is a mix out of water, macadamia nut oil and a powder called Schmoylent.

That freed extra time can easily be invested in any current development project. And - if that is still not enough, a sleeping bag is the right 'tool' for a power nap under the desk. For very ambitious system designers this sleeping bag is almost a trade mark of its own.

But hold for a minute. While young people dream of a fast career in the Silicon Valley, many insider recommend, that the ambitious engineers should test the waters in Seoul or Singapore before settling down in the Bay Area, since the technology in these places seems to be far ahead of what you can experience in California.

By-the-way: If you are employed by one of the many start-ups in San Francisco and you are looking for a decent apartment in the well-known SOMA district, don't be surprised to find a rental fee of $750 for one bed in a room with 3 beds.

Are Start-ups the real Job Creators?

Almost every politician evokes on his constituents again and again, that only the start-ups are bringing back those lost jobs with new working places and good wages. Just look into the Silicon Valley with its start-ups like Google and Facebook. Those are the engines of the much needed economic expansion - isn't that so?

Well, that might be not the case - at least when you talk with Professor George Foster of the Stanford Graduate School of Business. He recently finished his multi-country-study about start-ups and found out, that most of the start-ups don't even take off. And even when the few lucky ones are 'air born', several setbacks often enough reduce the payroll and revenues and keeps all on a horrendous roller coaster.

For five years Foster and his team collected data from more than 150000 start-ups worldwide. They discovered, that in fact a few companies make money and reputation - but these successes are more than counterbalanced by the losses in other companies. Foster recommends, that the politicians should put their eyes on 'Net-Job-Creation' - this would indeed cause a deep disillusion.

A Technology Boom only for the wealthy Few?

This question causes a high blood pressure in those people, who believe in technology. They throw tons of paper at you, which describe the blessings of the silicon technology. Costs for those gadgets are falling every day, just look at the computers and cell phones.

Recently, the editors of the New York Times looked into this theme and reported, among other facts, about the start-up Shuddle, which takes care of children, while the parents are working full-time. Shuddle transports the students to school and to all the other activities

Right now, the Shuddle customers pay about $12 to $15 per trip. That is much more than public transportation might cost. But most of the time, that service is not available. In order to keep this complex transportation service running, Shuddle customers must carry a cell phone.

No doubt, this kind of service, made possible due to the latest technology, is a big relief for the parents. But when you do the math, then this service is not within reach for the average family. The Shuddly management plans for the future a fee of $5 per trip - it has to be seen, if the average family can buy into this.

Is it possible, that the blessings of an innovative technology doesn't reach the Have Nots?

Electronics Industry: Business as usual

If you noticed the beginning of the electronics industry in the seventies and eighties, you may recall, that several start-ups during their first years booked huge revenues with innovative ideas and products. But today, this spirit of optimism and achievement seems to be gone. Every year the US-business magazine 'Fortune' publishes a list of 100 companies, which show high growth numbers. This year, only six electronic companies made it onto this list: Alliance Fiber Optic Products, Methode Electronics, Universal Display, Skyworks Solutions, and Super Micro Computer. That speaks for itself.

Company related Notes from the Silicon Valley

Mouser Electronics combines fast Distribution with efficient Marketing

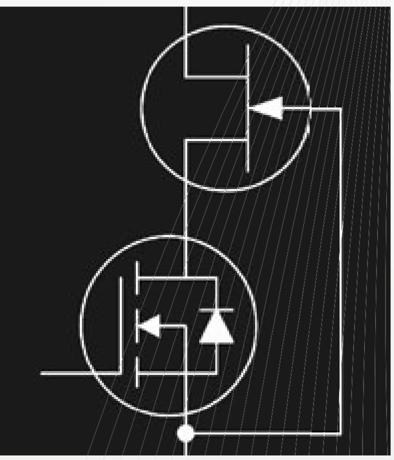
When I asked Mark Burr-Lonnon, Mouser's Senior Vice President of Europe-Middle East-Africa (EMEA) and Asia-Pacific (APAC) business, what separates his company from his competition, he points out, that Mouser not only distributes more than 10 Million electronic products worldwide and operates its Websites in no less than 17 languages, but puts lots of efforts in their NPI program (New Product Introduction), which ensures, that the information about a flow of new products reaches the electronic engineers in a very short time frame after the manufacturers released those products.

Since those websites have to handle around 15 Million searches per day, one can imagine, that Mouser.com is a very good source of technical information.

Picture 1: Mark Burr-Lonnon, Senior Vice President of EMEA and APAC business, Mouser Electronics

Silicon Carbide:
our sole focus, your superior solution.

USCi
United Silicon Carbide, inc.



Our name says it all. At United Silicon Carbide, Inc, we are solely devoted to bringing you the best and most efficient Silicon Carbide (SiC) power devices available in the marketplace. These devices deliver the performance of silicon carbide with the ease of use of low voltage silicon.

United Silicon Carbide's cascode products co-package xJ series high-performance SiC JFETs with a cascode optimized MOSFET to produce the only standard gate drive SiC device in the market today. These normally off devices exhibit ultra-low on resistance and gate charge, but also the best reverse recovery characteristics of any device of a similar current rating. These devices are excellent for switching inductive loads in bridge configurations with boot strap or floating high side drive.

By leveraging the SiC JFETs proven superior performance with low voltage silicon, these innovative devices enable industry leading efficiency in applications such as EV Charging, PV inverters, Power Factor Correction and Motor Drives. Cascode products are available through our World Wide Sales Partners, or can be purchased directly from the USCi website.

USCi has a new office in Europe (Contact: crocneanu@unitedsic.com, +49(0)151-210-634-11

Mouser Electronics seems to be on the right track, with revenue growth in all global markets. Burr-Lonnon's revenue forecast for 2015 is the 1 Billion Dollar target. The projected current revenue stream splits in around 55% from the USA, 20% from Asia and around 26% from Europe. Especially the European market shows for Mouser a significant growth throughout the years.

According to Burr-Lonnon, Mouser is among the fastest to stock more New Product Introductions (NPIs) than any other distributor. In the last 12 months alone, his company launched over 2,200 NPIs for its 500 manufacturer partners.

Picture 2: Mouser Warehouse in Mansfield, Texas

But there are more activities. Experiencing several years of record business, the global distributor is preparing for continued growth with a major addition to its 49200 m2 headquarters in Mansfield, Texas, just south of Dallas. The first phase, due for completion by early 2016, will add around 25000 m2 to the distributor's global distribution facilities.

Picture 3: Inside the Warehouse, Mouser Electronics

Recently the company opened a new customer service center in Tokyo. The new office provides customer service and local technical support as Mouser establishes a deeper collaboration with its local manufacturer partners. The new office makes a total of 21 locations worldwide and eight offices in the Asian-Pacific region for the component distributor that caters to electronic design engineers and procurement professionals.

Online, Mouser.com features several resources where engineers can quickly research new products and ideas, including the "Newest Products site", which provides detailed technical information that can be viewed by category, manufacturer or week. Mouser also provides its customers with the latest life cycle status on components. By clearly identifying end-of-life (EOL), obsolete and not-recommended-for-new-design (NRND) components, Mouser helps its customers select the right product for their designs.

The "Services and Tools" site makes it simple for design engineers and buyers to search for products, personalize their orders, and access their previous purchases, helping to speed time-to-market. With real-time availability, each resource on the site gives unique capabilities to help customers in their design and creation processes. Mouser also offers MultiSIM BLUE, a supercharged circuit simulation, layout, and bill of materials (BOM) tool powered by National Instruments.

Power is a real Growth Segment

The explosion of M2M communications is fostering a need for more compact, low power (and low cost) power supplies, so Barry McConnell, Senior Vice President of Products. In the coming years, tens of billions of devices will join the Internet of Things (IoT), and many are likely to be compact, requiring equally compact, simple and dependable low-power solutions.

Low-power wireless technologies will be needed to provide energy-efficient means for new M2M devices to exchange information. Additionally, the market for AC-DC and DC-DC power supplies will grow to over $25 billion by 2018, driven by LED lighting systems and media tablets, according to a study by IHS.

Power is one of our leading growth segments at Mouser. With new power products being introduced every day, the company gives the engineer a quick way to access the latest products from the industry's top power manufacturers.

At www.mouser.com/new, engineers can see the latest products based on launch date, category or by manufacturer, and within a click, they can see product features, applications, data sheets, and more. NPI (New Product Introductions) is a major differentiator for Mouser, and engineers rely on Mouser to stock the broadest selection of the newest power products.

Along with NPIs, Mouser has a growing number of Applications and Technologies sites, which give engineers online access to specific applications, providing a head start in their overall design process. Each site offers block diagram navigation for many different designs that leads the engineer to the latest power products for specific projects.

The sites include power supply, M2M, industrial and computing, to name a few. Included are application notes, technical articles, videos, featured products and other solution-based content to help deliver a time-to-market advantage.

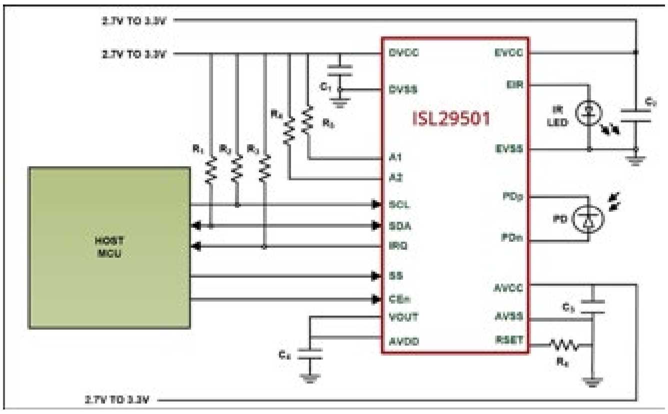
http://www.mouser.com

Time-of-Flight IC for Object Detection and Distance Measurement

Intersil introduced a Time-of-Flight (ToF) signal processing IC that, according to Andrew Cowell, Senior Vice President, Mobile Power Products, provides a complete object detection and distance measurement solution when combined with an external emitter (LED or laser) and a photodiode.

The ISL29501 ToF device offers a high functionality, including ultra-small size, low-power consumption and superior performance ideal for connected devices that make up the Internet of Things (IoT), as well as consumer mobile devices and the emerging commercial drone market.

Picture 4: Andrew Cowell, SVP, Mobile Power Products, Intersil



Picture 5: Sample Application of the Time-of-Flight IC

The ISL29501 overcomes the shortcomings of traditional amplitude-based proximity sensors and other ToF solutions that perform poorly in lighting conditions above 2,000 Lux, or cannot provide distance information unless the object is perpendicular to the sensor.

Alternative solutions are too expensive, bulky or power hungry for use in small form factor, battery-powered applications. The ISL29501 sensor provides a small solution footprint and precision long-range accuracy up to 2 m in both dark and bright ambient light conditions. Unlike competitive solutions, the new IC allows customers to select the emitter and photodiode of their choice and configure a low power ToF sensing system customized for their application.

To make system design easy for customers, the company offers a reference design featuring the ISL29501, emitter and photodiode, along with graphical user interface (GUI) software and user's guide.

The ISL29501 saves power and extends battery life through several innovations. The on-chip emitter DAC with programmable current up to 255 mA allows designers to select the desired current level for driving the external infrared (IR) LED or laser.

This feature enables optimization of distance measurement, object detection and power budget. The device's single shot mode saves power by allowing designers to define the sampling period for initial object detection and approximate distance, while continuous mode more accurately measures distance. The ISL29501 also performs system calibration to accommodate performance variations of the external components across temperature and ambient light conditions.

Intersil's Power Management

Today's systems require a much higher level of efficiency in a smaller footprint, which requires more integration, expertise in circuit design, package and process technology. Intersil addresses this need by leveraging patented technology to provide innovative power management solutions.

For example, the ISL8117 synchronous step-down PWM controller is the first to enable the direct step-down conversion from 48 V to a 1 V point-of-load.

This technical achievement reduces system complexity and cost. In high voltage applications where a lower output voltage is required, designers have traditionally relied on two stage DC/DC solutions that increase solution footprint and complexity to get from high to low voltage.

The ISL8117 uses a patented approach to accomplish this without any external components for compensation, significantly simplifying design, improving system power efficiency and enabling 98% conversion efficiency, which translates to better system power performance.

Intersil has a growing family of products targeting the industrial and infrastructure markets, where the increasing number of voltage rails to support processors, memory, FPGAs, and ASICs is making designs more complex. This requires more DC/DC converters to manage the power load. This complexity has resulted in a revival of the power module to save design time. Highly integrated power modules that leverage sophisticated ICs and packaging to deliver efficient and turn-key power solutions are giving system designers access to the very best power technology without requiring them to become experts.

For example, the ISL827xM module family offers the industry's first 80 A fully encapsulated digital DC/DC PMBus power module. The ISL8273M is a complete step-down power supply that delivers up to 80 A of output current from industry standard 12 V or 5 V input power rails, and four modules can be combined to support 320 A rails. These modules are easily configured through simple pin-strap options or by using PMBus commands with the PowerNavigator™ software. PowerNavigator makes it easy for system designers to develop their power supplies without having to write a single line of code.

www.intersil.com/power

Network-on-Chip Connections for SoC Designs

Arteris provides Network-on-Chip (NoC) interconnect semiconductor intellectual property (IP) to System on Chip (SoC) makers so they can reduce cycle time, increase margins, and easily add functionality.

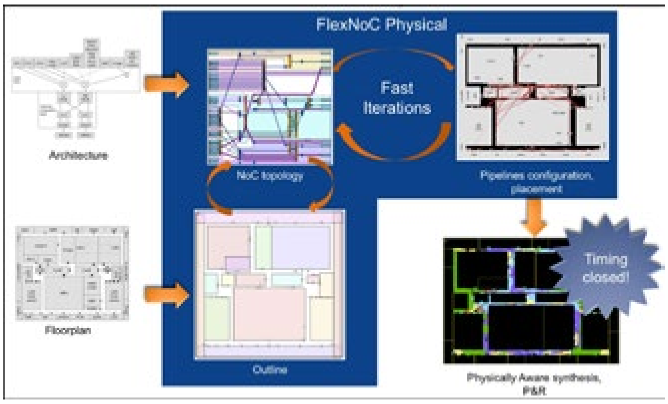
Arteris invented the industry's first commercial NoC SoC interconnect IP solutions, which are flexible and efficient, allowing designers to optimize for throughput, power, latency and floorplan.

According to Kurt Shuler, VP of Marketing, the FlexNoC offers system designers significant savings of iterations with automatic pipeline insertion and saves 10 to 15% of interconnect area compared to having to overdesign with an excessive number of pipelines. Designers shouldn't forget, that they save also two to four critical latency cycles by matching timing goals to implementation of each NoC IP version compared to an overdesign.

Picture 6: Kurt Shuler, VP of Marketing, Arteris

A final advantage point is a better starting point for layout processes to cut place and route cycles and improve productivity.

The NoC architecture borrows concepts from the computer networking arena and adapts them to system-on-chip design constraints. The network on chip solution optimizes performance, silicon area, and power, and reflects an in-depth understanding and integration of the constraints imposed by SoC implementations and semiconductor processes.



Picture 7: Block Diagram of FlexNoC

FlexNoC Physical IP includes all the features of the industry-standard FlexNoC interconnect IP. In addition, it uses information from the SoC interconnect architecture, SoC floorplan, and semiconductor process technology to both accelerate timing closure and improve QoR by using less slack to meet timing, further reducing SoC silicon area and improving performance.

FlexNoC Physical offers features to separate the interconnect IP at the physical level the same way that it allows such isolation at the architectural level. Users can now generate interconnect floorplan outlines and treat the interconnect as a separate IP to be independently placed and routed by itself. Such a separation simplifies the job of the layout team.

http://www.arteris.com

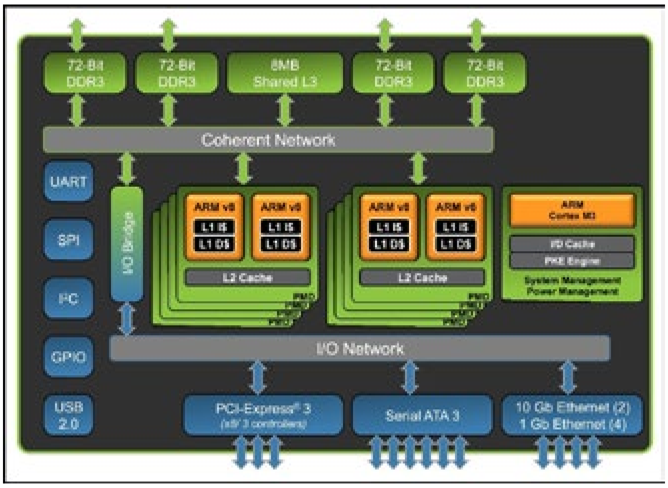
64-bit ARM Solutions of high Performance Server
John Williams, VP of Marketing at Applied Micro Circuits in Sunnyvale, California is convinced, that the server market is evolving rapidly, driven by cloud computing, open-source software and big data, but unfortunately dominated by a single x86 vendor. Applied Micro delivers ARM-based silicon solutions that dramatically lower total cost of ownership.

AppliedMicro acquired the first architectural license for the ARM® v8 64-bit architecture in 2010. The company helped to complete the ARMv8 64-bit spec and wrote more than 20,000 instruction set verification tests. These tests will be used to certify and test ARMv8 64-bit cores from all manufacturers.
ARM vendors are expanding into the Server CPU market, which currently splits into three regions: North America (40%), China (25%) and Western Europe (15%).

ARM 64-bit Server-on-a-Chip
The X-Gene™ Server-on-a-Chip™ product is the world's first and currently only ARM® 64-bit Server-on-a-Chip solution, featuring enterprise class high performance Cloud Processor® cores coupled with switch fabric and high-speed networking capabilities.

Combined, they deliver substantially lower power consumption and substantial total cost of ownership (TCO) savings. X-Gene represents a new, grounds-up Cloud Server® solution tailored for the rapid growth of structured and unstructured compute requirements in next generation data centers.

The X-Gene 1 processor consists of 8 custom ARMv8 64-bit Cores (up to 2,4 GHz), 8 MB shared L3 cache, integrated memory controllers, integrated networking, storage, 6 lanes of Serial-ATA 3, integrated I/O interfaces, and 45 watt TDP.



Picture 8: Block Diagram of the X-Gene 2 Processor

The X-Gene 2 processor, a scale-out optimized server-on-a-chip, is faster than model 1, but offers RDMA over Ethernet support, a full I/O virtualization (SMMU) and only 35 watt TDP. That means a 50% higher Performance/Watt.

HeliX for a higher Performance Level
Representing the high end of all ARM processors, HeliX™ delivers CPU performance that provides the next level of performance in power-constrained embedded applications. It is a fully integrated SoC, eliminating the need for other discrete chips including standard interfaces for storage, networking, and expansion.
Two or four ARM V8 compliant 64b cores are operating at up to 2.4 GHz. Each core contains a FPU/Single Instruction Multiple Data (SIMD) Unit, a shared 256 KB L2 cache per each pair of cores, ECC protection covering all cache data, shared 2 MB L3 cache, and Hardware Cache Coherency.

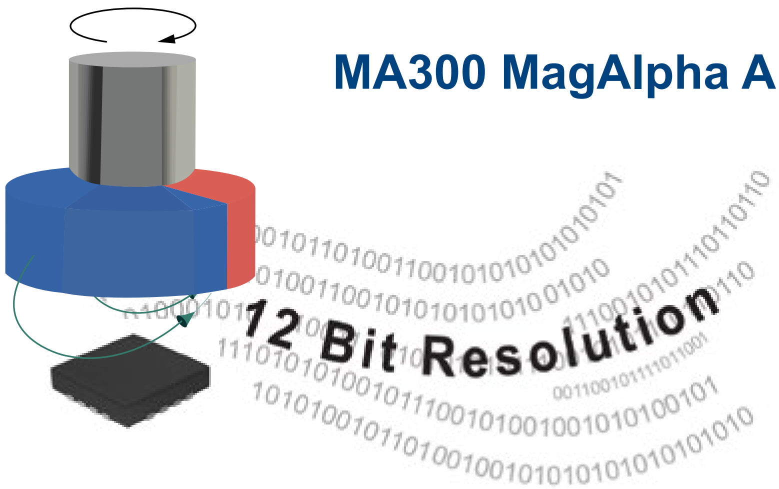
Connectivity Solutions
APM supplies also a range of physical layer, framer and mapper solutions including high-speed mixed signal PHY silicon solutions for networking and routing applications.
The X-Weave Datacenter Connectivity Solutions support 100 / 400 / 1000 Gbps of connectivity with multi-protocol features and high density. The solutions target needs of high bandwidth applications in public and private cloud and enterprise data centers. Customers can expect latest PAM4 and DSP solutions for next-generation cloud/data center connectivity.
With PAM4, customers can maximize the fiber utilization in Metro Access Networks, driven by the market transition to 100GE/400GE. PAM4, which requires a combination of DSP, Analog and system expertise, is the most economic solution for 100G/400G up to 80 km (single laser per 100G).

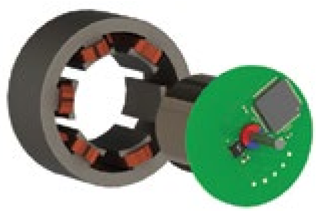
www.apm.com

Simple, Easy Solutions

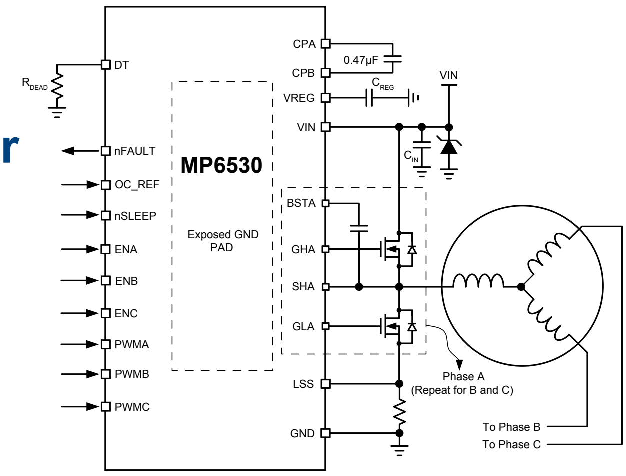
New Angles Drive the Future

MA300 MagAlpha Angle Sensor





MP6500 Brushless Motor Driver



MagAlpha MA300 Features

- UVW Signals for Block Commutation
- 12-Bit Resolution Absolute Angle Encoder
- 500kHz Refresh Rate
- Ultra-Low Latency: 3μs
- Serial Interface for Data Readout and Settings
- 10-Bit Incremental Output (A, B, Z)
- Built-In Linearization for Side-Shaft Mounting
- 7.5mA Supply Current

MP6530 Features

- Wide 5V to 60V Input Voltage Range
- Bootstrap Gate Driver with Trickle-Charge Circuit Supports 100% Duty Cycle Operation
- Low-Power Sleep Mode for Battery-Powered Applications
- Programmable Over-Current Protection of External MOSFETs
- Adjustable Dead-Time Control to Prevent Shoot-Through
- Thermal Shutdown and UVLO Protection
- Fault Indication Output
- Thermally Enhanced Surface-Mount Package

www.monolithicpower.com

Follow us on:

Innovations in the IOT 2.0 Era

Broadcom has one of the industry's broadest portfolio of state-of-the-art products for seamless and secure transmissions of voice, video, data and multimedia. The company holds more than 10,950 U.S. and 3,925 foreign patents.

Based on this kind of treasure, Michael Hurlston, VP Worldwide Sales, likes to point out, that the Iot market is still in its infancy, but his company sees in this market a huge opportunity, and is focused on the IoT development community as well as the market for home automation.

Picture 9: Michael Hurlston, VP World-wide Sales, Broadcom

In order to reach the mass market, his company wants to expand demand generation, the distributor customer reach, and expand its WICED program via major e-tailers. Additional help comes from the IoT partner ecosystem, consisting of module makers, VARs, technology partners and ODMs.

Broadcom wants to stimulate the IoT market with modules and platforms, SDKs and Apps, Tools and reference designs. Right now there are three interesting development kits:

* WICED™ Smart is a very-low-power family of pin-compatible modules that, when paired with the included software development kit, reduce the effort required to add Bluetooth Smart wireless connectivity and cable replacement capabilities to a range of embedded applications.

* The WICED™ Wi-Fi Development Kit features the Broadcom BCM43362 wireless LAN MAC/Baseband/Radio together with a 32-bit embedded processor, a unique self-hosted Wi-Fi networking library and a software application stack that allows manufacturers to easily integrate Wi-Fi connectivity into any microcontroller-based consumer product.

* The WICED Sense™ Bluetooth Smart Sensor Tag/Experience Kit is an affordable entry point to the ever-expanding Internet of Things (IoT) ecosystem and a platform for engineers, tinkerers, DiY-ers and entrepreneurs. It delivers complex technology in an easy-to-use and easy-to-understand development kit.

Picture 10: Bluetooth Smart Sensor Tag/Experience Kit

The kit consists of a WICED™-branded Bluetooth Low Energy board housed in a sturdy plastic case. Inside is the BCM20737S Bluetooth Smart, SIP Module, five microelectromechanical sensors (MEMS) and the WICED™ Smart software stack that's Bluetooth 4.1 compatible.

The simplified set-up process - it takes less than five minutes - allows users to quickly establish a link from the tag to their mobile device so they can almost instantly start gathering data from the sensors. This data includes direction, temperature, humidity and more. The BCM20737 Bluetooth Smart SoC inside the tag ensures privacy with advanced security and encryption features and also includes software to support iBeacon technology.

www.broadcom.com

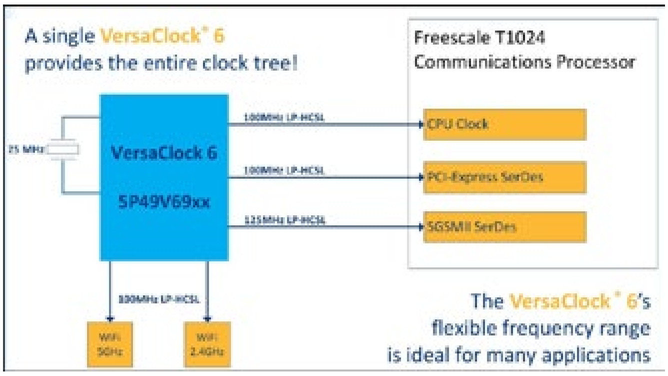
IDT concentrates on specific Markets

IDT develops a broad range of low-power, high-performance mixed-signal semiconductor solutions that optimize customers' applications in key markets. In addition to its timing products, the company offers semiconductors targeting communications infrastructure - both wired and wireless - high-performance computing and power management.

Picture 11: Graham Robertson, Vice President, IDT

These products are used for next-generation development in areas such as 4G infrastructure, network communications, cloud datacenters and power management for computing and mobile devices.

Graham Robertson, Vice President, explains, that his company concentrates on four industrial areas: High performance Interconnect, Power, RF, and Timing, because the high-performance Memory SAM still expands, mobile video is driving infrastructure upgrades, and mobile data is driving the need for wireless charging.



Picture 12: VersaClock 6 programmable Clock Generator

The VersaClock® 6 programmable clock generator family delivers flexible, low-power timing for demanding high-performance applications. With RMS phase jitter of less than 500 fs, the new products offer an exceptional combination of jitter performance, flexibility, and low operating power.

With RMS phase jitter less than 500 fs over the full 12 kHz to 20 MHz integration range, the new devices meet the stringent jitter and phase noise requirements of applications and standards such as10G Ethernet, enterprise storage SAS and SATA, PCI Express Gen 1/2/3, XAUI, SRIO, stringent PHY reference clocks and the newest generations of high-end FPGAs - all while operating at about half the core power of competing devices.

The devices' core current consumption of 30 mA eases system thermal constraints and reduces operating power expenses. The programmable clock generator offers universal output pairs that are independently configurable as LVDS, LVPECL, HCSL, or dual LVCMOS and can generate any output frequency from 1 MHz to 350 MHz on each output pair independently.

Picture 13: Turnkey wireless Power Kits

One of the recent product introductions are jitter attenuator and frequency synthesizer devices that deliver ultra-high performance, meeting the phase noise requirements of the most stringent applications, including JESD204B-compliant RF timing. The 8V19N407 and 8V19N408 support up to 3 GHz output frequencies, as well as 82 fs of RMS phase noise, addressing the requirements of multi-carrier GSM radio transceivers as well as 40 and 100 Gb Ethernet PHYs and other high-performance applications.

Wireless Power for the Mass Market

Recently, the company introduced turnkey wireless power kits that make integrating wireless charging easy, affordable and practical for a broad range of consumer electronics. The new Qi-compliant transmitter and receiver reference kits deliver plug-and-play ease of integration, enabling engineers to incorporate wireless charging capabilities into their designs in a matter of hours.

The 5-Watt, 5-Volt solution is suitable for a wide range of applications, including PC peripherals, furniture, medical devices, and other portable devices still hindered by traditional contact-based charging bases or cables.

The two reference kits offer 2-layer board layout files, providing maximum flexibility for most applications. The boards are Qi-compliant for use as-is. The kits can be used for immediate prototyping. An associated layout module enables direct instantiation on to a system board, while an optimized and fully tested BOM takes the guess-work out of component selection. Foreign object detection (FOD) tuning is supported via selectable pre-programmed curve settings and extensive collateral documenting FOD tuning for these devices.

http://www.idt.com

My Continuing Enthusiasm About 2D Material

By Ronald Ackermann, corresponding editor Bodo´s Power Systems

Besides being curious and inquisitive journalists must also be enthusiastic about revolutionary new technologies. Thus, about ten years ago, I was excited enough to write my first article about the promising new material "graphene" and about the hype and upheaval it would most probably trigger. But, as mostly, realization took (and takes) longer than expected.

In this case, the innovation in a way moves in horizontal direction: Materials R&D for demanding future electronics with the ability to eventually, at least partly, replace silicon point towards two-dimensional (2D) materials like graphene. In 2010, the Noble Prize made graphene famous overnight, and this gave it an additional push.

In the early days graphene produced by exfoliation was one of the most expensive materials on earth (about $100,000,000/cm²). Meanwhile the synthesis of large-scale graphene films using chemical vapor deposition (CVD) opened the door to research on practical applications. In 2013, the European Union made a €1 billion grant to be used for research into potential graphene applications, and in the same year the Graphene Flagship consortium was formed.

Basically, graphene, made from carbon, is said to be the world's strongest, thinnest and most conductive material. Graphene's remarkable properties enable exciting new applications in electronics, solar panels, batteries, medicine, aerospace, 3D printing and more. There are already numerous publications, and IDTechEx – besides publishing extensive market surveys – organizes international tradeshows and conferences "Graphene & 2D Materials" in the USA and in Europe. However, though Europeans won the Noble Prize for their work on graphene, they are not necessarily winning on the commercial front: the Chinese might overtake them. Many indicators support this claim; e.g. Chinese entities are taking the patent landscape by storm and have now put a seemingly unbridgeable distance between themselves and the rest of the world. They feature heavily in the list of top ten patent holders, while there is a notable absence of Western companies and institutions.

The electronic and thermal properties of graphene are tantalizing to technologists who see it as the potential basis for new kinds of electronics chips that are faster, use less power, and can flex and bend. But as it is not semi-conducting, graphene on its own lacks the characteristics necessary for transistors that are energy-efficient enough to be practical. It does not have a band gap, the electronic property that is necessary for switching transistors between two discrete states — as we all know, the development here went successfully in the direction of wide bandgap semiconductors like SiC or GaN.

Graphene´s two-dimensional – a single-atom thick – crystals combine high electrical conductivity with physical flexibility and a huge surface to weight ratio which make them highly suitable for storing electric charge in batteries and supercapacitors, and as catalysts in solar and fuel-cell electrodes. Researchers are convinced that innovative technologies will emerge from our ability to understand and control the electrochemical properties of graphene, and to fully integrate graphene with the materials used today in energy applications. Organic solar cells with better efficiency are one goal. As for batteries, commercial graphene-coated copper foils are a smart way of manufacturing novel flexible battery systems which meet mobile application requirements.

The interest in 2D materials for energy applications derives not only from their properties, but also from the possibility of cost-effectively producing and processing them in large quantities. Printable inks, for example, are the gateway to the realisation of new-generation electrodes in energy storage and conversion devices. The challenge ahead is to demonstrate a disruptive technology in which 2D materials not only replace traditional electrodes, but, more importantly, enable whole new device concepts. Swedish researchers have found a graphene-based film with four times the thermal conductivity of copper which holds a great deal of promise for the field of electronics, especially in cooling.

But 2D is not restricted to graphene. A purely theoretical mathematical study has inspired an experiment that could have serious real-world applications: a crystalline material called titanium trisulfide could perform almost as well as graphene in many areas, while lacking one key weakness. The electronic "bandgap" of titanium trisulfide is about that of silicon, potentially making it a better candidate than graphene to allow truly next-generation electronics. The computer model predicted the crystals were incredibly conductive, and had one wonderful electronic property that graphene does not: just as in silicon, the electrons orbiting within titanium-trisulfide can be easily pushed up into the conduction band, and just as easily brought back down out of it. This means that it can be turned on and off, and in theory work as the basis for a next-generation processor.

Similar layers can also be made from phosphorus. Chemists of the Munich Technical University (TUM) developed a semiconductor material (black arsenic-phosphorus, b-AsP) with highly tunable chemical compositions and electronic and optical properties. In an international cooperation with US colleagues they have built the first FETs.

I hope, this will foster a successful (non-Chinese) 2D R&D to keep my continuing enthusiasm alive!

Biricha Lecture Notes on Analog and Digital Power Supply Design

Part 2.D Why A PID Controller Is Not Suitable for Stabilizing Many Power Supply Topologies

Whether or not a Proportional + Integral + Derivative (PID) controller is suitable for stabilising power supplies has become an emotive debate rather than a scientific discussion. The debate has been compounded by the arrival of many digital power solutions, which seem to come as standard with a PID controller programmed in their software.

By Dr Ali Shirsavar, Biricha Digital Power Ltd

People like PID controllers for their simplicity and are reluctant to change what they know and love for something else that performs better, but needs a more delayed understanding of control theory. In this article we would like to present our reasons as to why, here at Biricha we try to avoid using PID controllers for the majority of the power supplies that we design. This is merely our opinion and is not intended to re-start a debate, and as such, we ask you to decide for yourselves as to whether or not PID is suitable for your application.

Introduction

PID controllers are extremely easy to design and implement. With less than 10 minutes on any search engine you will find many analog and digital realizations; there are even automatic tuning algorithms. Whilst this controller and its close relative (PI) are excellent for stabilizing motor control systems or temperature controllers and the like, it is our opinion that they are unsuitable for compensating most switch mode power supplies. Furthermore, although one may be able to get away with using a PID controller in a current mode converter or a PSU with lots of ceramic caps on the output there are better alternatives. If you do intend to use a PID controller, we highly recommend reading the excellent analysis by Christophe Basso which was presented at APEC in 2011 and is available for free on Mr Basso's website [1].

The main attraction of PID is that one does not need to know much about control theory, frequency response analysis, pole-zero placement, phase margin, gain margin, stability criteria, etc etc. Instead, you heuristically (i.e. scientific word for semi-educated trial and error) change the compensator's 3 gain terms to achieve the desired response. Though this method is extremely effective in millions of applications, we feel that it is not suitable for power supply design. Most experts agree that switching power supplies should be designed in frequency domain, and yet PID is a tool whose main advantage is that you don't design in frequency domain! This is a contradiction and, therefore, you can see from the onset that PID is not suitable for what we are trying to do, even though it is ideal for many other applications.

PID Compensator Explained

The transfer function of the PID is shown in the following equation:

$$H(s) = Kp + \frac{Ki}{s} + Kd\,s$$

Where, Kp is the proportional gain, Ki is the integral gain, Kd is the differential gain and s is the Laplace operator.

The design procedure is usually based around simply changing these gains until our control system's transient response becomes satisfactory after a unit step. Please note that we are now working in time domain and not frequency domain. However, almost everyone agrees that we should design our power supplies in frequency domain to ascertain a measure of our relative stability. So, how does changing these gains heuristically impact our poles and zeros in frequency domain? How do we assess that we do not violate the stability criteria? Let us find out!

If we take common denominators on the previous equation, we will have:

$$H(s) = \frac{Kd\,s^2 + Kp\,s + Ki}{s}$$

You can immediately see that the numerator is a simple quadratic equation i.e. we have 2 zeros and in the denominator we have only 1 pole, which is at the origin. Please note that for a realizable system we need another pole, but this will have to be placed so high in frequency that it does not impact the transfer function at the frequencies of interest (or it would not be a pure PID)

To find the zeros, we need to solve the quadratic using:

$$Postion\ of\ Zeros = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

In our case a = Kd, b = Kp and c = Ki; substituting these in the above equation we have:

$$H(s) = \frac{\left(s + \frac{-Kp + \sqrt{K_p^2 - 4Kd\,Ki}}{2\,Ki}\right)\left(s - \frac{-Kp - \sqrt{K_p^2 - 4Kd\,Ki}}{2\,Ki}\right)}{s}$$

Looking at the equation above you will see that the positions of both zeros and the pole at origin are inter-dependant on all three gains. This means that if you change any of the gains you will mess up the position of everything in frequency domain!

If you wish to place your pole and zeros intelligently, then you will have to derive the modulus and the phase of the transfer function, then solve several equations simultaneously and place the 2 zeros and the only pole in such a way so as to meet the stability criteria (please see our previous articles about loop stability).

Hang on, I hear you say; wasn't the whole point of PID that we did not have to do this sort of analysis? The answer is yes, but we have to do this to show why it will not work very well! If you are already convinced, then please stop reading the rest of this article and pick up one of the many fantastic books in this field, written by experts and design a proper Type III compensator. There are several excellent book on the market (e.g. Basso, Erickson & Maksimovic), but for an eloquently written section on loop stability, and simple explanation of control loops, I really like Mr Maniktala's Red A to Z book [2].

So Why Will Our PID Not Work Very Well?

Voltage Mode PSU performance with a Type III compensator
From figure 1 you can see an optimally compensated voltage mode power supply with a Type III compensator using our WDS software [3]. You can see that we have got good cross-over, phase margin and gain margin. We have also marked danger zones you should try and avoid crossing at.

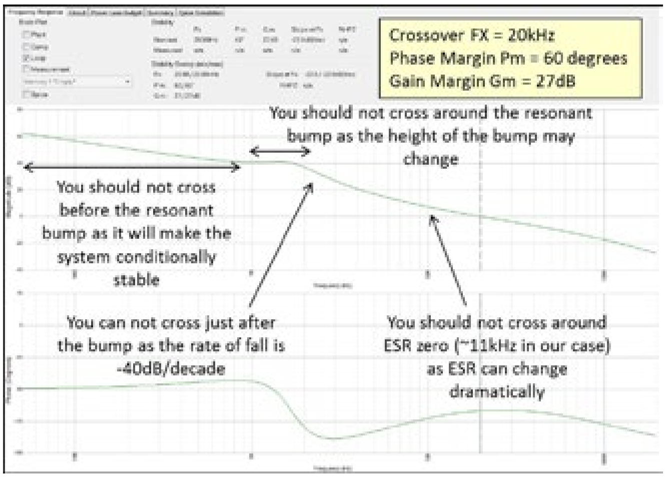


Figure 1: Optimally compensated voltage mode power supply with a Type III compensator using our WDS software

For this power supply, we have kept the default values so that you can use our evaluation version to reproduce these experiments exactly. Please just download a free copy from our website (www.biricha.com/wds) and you can repeat these experiments yourselves.

WDS also allows you to run a spice simulation using LTSpice and figure 2 is the result of a 50% step load. You can see that our Type III compensator is performing very well.

Voltage Mode PSU performance with a PID compensator
Now let us see if we can design a PID compensator in WDS with a similar performance. In order to do this, all you have to do is to select a Type III and then manually set the two poles (not the pole at the origin) to 10MHz so that they do not impact the control loop. You now have a PID controller.

With a PID, we only have 2 zeros and one pole at origin. In order to meet the stability criteria, we must place our zeros at around the resonance frequency, otherwise we will cross with a sharp slope. We can then use the pole at origin to get a high gain at low frequencies and good cross over. (Please see our previous articles on this subject).

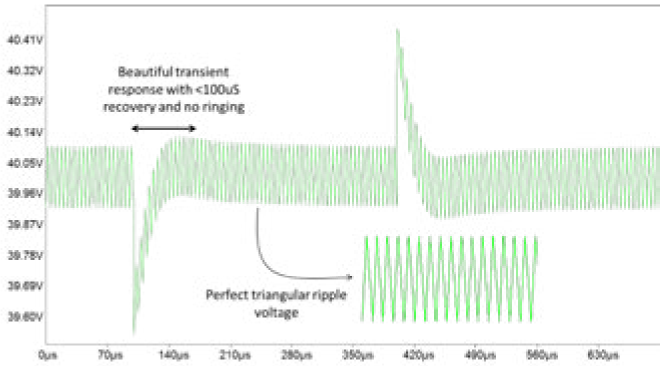


Figure 2: Type III compensator is performing very well

So if we cancel the 2 plant poles with our 2 PID zeros and then place our PID's pole at the origin, the gain of our open loop frequency response will be rolling off at a rate of 20 dB/decade.

We will then hit our capacitor's ESR zero. If our gain is going down at 20dB/decade and then hits a zero, then the gain plot will go flat with a gradient of 0dB/decade. There are only 2 alternatives: either it will go flat before we cross over, i.e. we don't cross at all, or it will go flat after we cross over i.e. we may end up with very little gain margin.

The best way to get a good feel of this is to simulate. You can simply download the evaluation version of WDS and keep all the default values. In the "Controller Design" tab under "Controller Poles and Zeros" select "Manual Placement" then set the two zeros at the resonant frequency (~1.7kHz), set "First Pole" and "Second Pole" to 10MHz to minimize their impact and then experiment with the "Pole at the Origin", you will see how hard it is to cross at a reasonable position without violating the stability criteria. You can then run an LT Spice simulation from within WDS from the Spice Simulation Tab.

Let us first see what happens if the loop does not cross:
Figure 3 shows the loop response with our PID's pole and zeros placed in such a way that the loop goes flat before we cross the 0dB axis. Please note that Bode's stability terms such as gain margin and phase margin are only defined at crossover frequency. If we do not cross, then we have absolutely no idea of whether this power supply is stable or not. We can either resort to looking at the Nyquist plot (even more analysis) or make sure that we do cross.

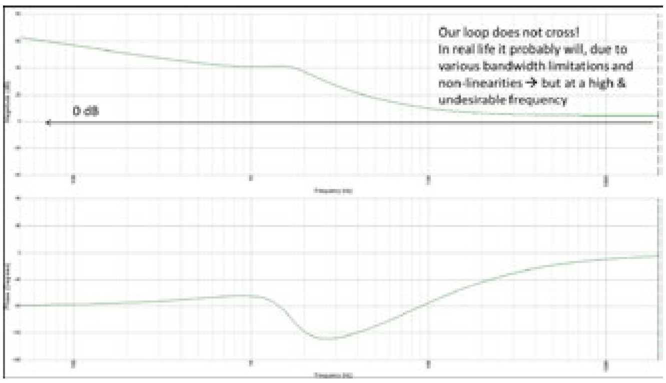


Figure 3: Spice simulation of the PSU's output ripple voltage

Now let us look at Spice simulation of figure 3 PSU's output ripple voltage:

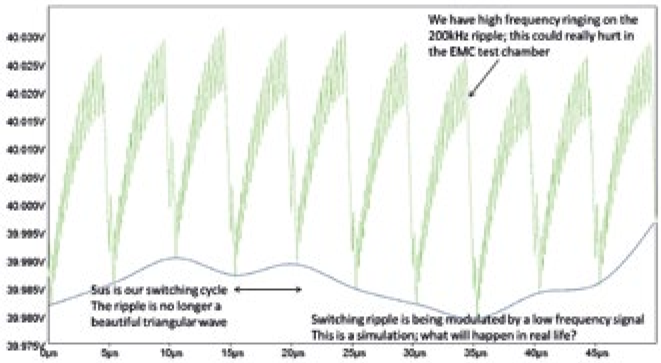


Figure 4: How are we going to make this power supply stable

The figure 4 does not even take into consideration that we don't have Kp, Ki and Kd's relationships with the positions of our pole and zeros and that they are inter-dependant! How are we going to make this power supply stable "heuristically" by playing with these values?

The short answer is that we can't without a great deal of mathematical analysis in frequency domain! Fortunately WDS will do this for you, but we have lost the main advantage of PID's which was its ease of design in time domain.

Now what if we do cross? Can we get a better performance? The answer is no. In the following figure we changed the position of the pole at the origin in WDS to make sure that the loop does cross at 20kHz just like our Type III. But please have a look to figure 5 at our gain; from our crossover up to half the switching frequency (Fs) we are only 2dBs below the 0dB point! This may work in this simulation, but in real life the loop may cross the 0dB point many times! This is very dangerous; it is certainly not a product you can ship! Again, we recommend having a play with WDS yourself to see if you can get a good response.

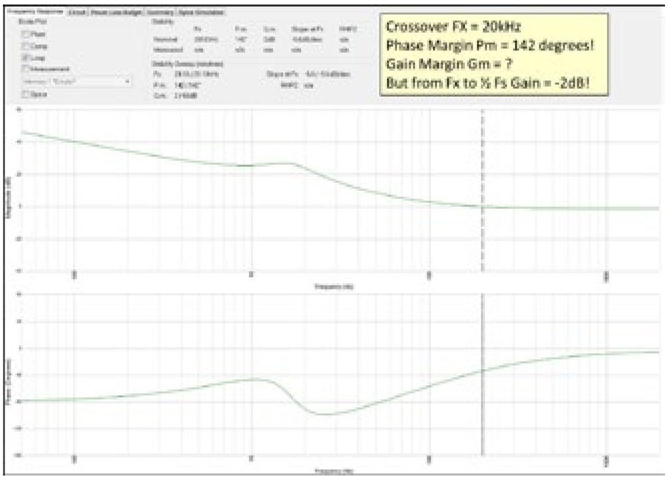


Figure 5: We are only 2dBs below the 0dB point

Current Mode PSU with PID Controllers

It is certainly possible to stabilize a current mode PSU with a PID controller. After all, at low frequencies our plant's transfer function "looks" like a first order system and we usually use a Type II compensator which ONLY has one zero, one pole at origin and extra pole.

So our PID only has one pole less than a Type II. The Type II's extra pole is usually used to cancel the capacitor's ESR zero; so with this pole missing again our loop will go flat at some point. However, if we derived the mathematical relationships between Kp, Ki, Kd and our pole and zeros then by clever pole zero placement, we could possibly get a relatively stable power supply. The question is, if we need to do all these derivations, why not just use a Type II?

PID and Digital Controllers

The use of PID has been suggested by almost all digital power supply IC vendors. The irony of course is that digital power supplies are by far more susceptible to instability when used with a PID than analog ones [4].

The reason is that the phase in a digital power supply deteriorates much faster than an analog equivalent. This extra phase erosion is due to the sampling and reconstruction on our discrete time system. The net result is that our phase usually crosses the -180 degree point and therefore we must have at least 10 dB of gain margin. However, with the loop flattening, the gain margin will be poor.

In figure 6 we have used WDS to design a digital power supply with similar specification to the analog ones (please note that the change in the specification was necessary to make sure that the spice completed the simulation in a reasonable time).

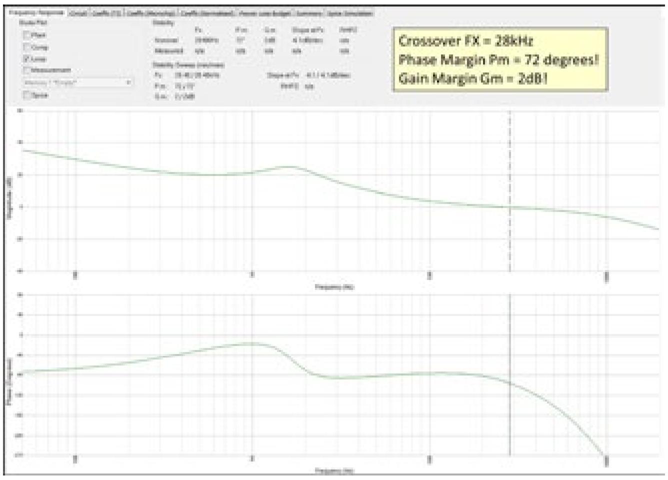


Figure 6: We have used WDS to design a digital power supply with similar specification

You can easily see how much faster the phase is rolling off compared to an analog supply. Furthermore, as it crosses the -180 degree point our gain margin is very poor indeed. The spice simulation of the step response for this power supply is shown in figure 7.

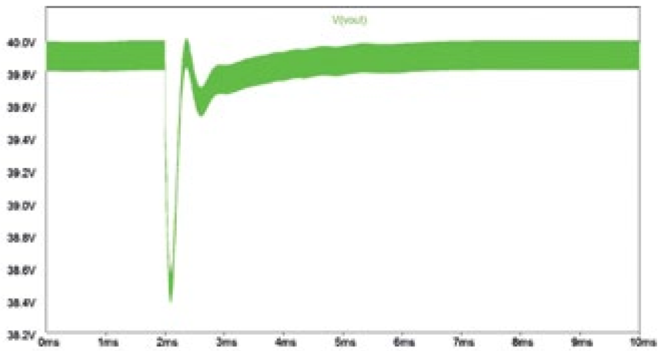


Figure 7: The spice simulation of the step response

Note that even though we have 70 degrees of phase margin, due to the low gain margin, we still have large undershoot and ringing. We must stress at this juncture that, this is only a simulation and a digital power supply in real life, with this specification, will almost certainly be completely unstable for many different reasons.

Concluding Remarks

In this article, we discussed why we feel that a PID controller is not best suited for stabilising most switch mode power supplies. We supported our hypothesis with transfer function analysis, and various simulations in both frequency and time domain. We believe that switch mode power supplies are best designed in frequency domain and presented the main downfall of PID as the need to heuristically adjust the gain terms in time domain.

PID controllers are excellent for thousands of applications; millions are in use right now, but in our opinion there are superior alternatives to PID for compensating switch mode power supplies.

Things to Try

1 - Download a copy of Biricha WDS PSU Design software from www.biricha.com

2 - Attend one of our Analog or Digital Power Supply Design workshops

Bibliography

[1] "The Dark Side of Loop Control Theory" by C. Basso, APEC 21011 http://cbasso.pagesperso-orange.fr/Downloads/PPTs/Chris%20Basso%20APEC%20seminar%202012.pdf
[2] "Switching Power Supplies A - Z, Second Edition 2nd Edition" by Sanjay Maniktala ISBN-13: 978-0123865335
[3] Biricha Digital's "Analog PSU Design Workshop" Handbook
[4] Biricha Digital's "Digital PSU Design Workshop" Handbook

For the PDF version and related videos please visit:

www.biricha.com/bodo2D

Re-thinking Power Analysis

The quest for increased power efficiency permeates every level in the electronics industry, from individual semiconductor components over circuits and modules to entire devices and even complex systems. From a power analysis point of view, every part of this spectrum has different requirements and poses different challenges. To keep up with those diverging demands has been increasingly difficult for conventional architectures – reason enough for ZES ZIMMER Electronic Systems GmbH to come up with a radically changed power analysis platform to address the needs of the future.

By Bernd Neuner, ZES ZIMMER Electronic Systems GmbH

ZES ZIMMER has been designing and manufacturing precision power analyzers for more than three decades. Since we have always been exclusively dedicated to power analysis, we have accumulated a considerable amount of experience and have been exposed to lots of meaningful customer feedback across all industries and geographies. Our design philosophy is centered on how an instrument interacts with its environment. We believe that in order to increase an instrument's value to our customers, we must strive to improve those interactions on all levels. All interaction occurs via interfaces, which can be categorized into three distinct types:

- the physical interface to the device under test
- the user interface
- the interface to other devices like PCs, peripherals etc.

Over the years, those interfaces have gradually been enhanced and modified in most power analyzers in the market due to innovations in the devices under test and general IT infrastructure changes. But sometimes gradual change is not good enough any longer, a step change is required. One needs to go back and take a fresh direction. We will subsequently describe major innovations we feel have become necessary in order to successfully cope with the power analysis demands of tomorrow. To illustrate the extent of those changes, we will pick one example for each type of interface.

The physical interface to the device under test (DUT)

The defining parameter of any power analyzer is active power of the measured signal. In addition, harmonics, or more generally speaking, information about power distribution in the frequency domain, are crucial when it comes to optimizing efficiency and avoiding damage to components. Unfortunately, power values and frequency domain information cannot always be obtained under the same circumstances, sometimes you have to decide which one you are interested in, modify the measurement setup accordingly, carry out the measurement, and repeat it with modified settings in order to obtain the rest of the required values.

Where does the problem come from? Harmonics, filtered values etc. are constrained by the Nyquist-Shannon theorem, whereas the power value is not necessarily. In practice, this means you can still correctly derive the power values for signals with their bandwidth exceeding half the sampling frequency, while this is impossible for harmonics etc. In order to look at the frequency distribution, you need to sample fast enough in order to reconstruct the original signal from the sample values. To merely measure power, this is not mandatory. A loss of information is unproblematic, as the exact signal shape does not matter: an infinite number of different signals can end up having the same power. What is important is to obtain a statistically significant number of random power samples to calculate the right average. However, when looking at the frequency domain (or calculating harmonics, applying digital filtering etc.), one has to be careful to obey the Nyquist-Shannon criterion. Thus any signal content above half the sampling frequency has to be removed to avoid erroneously undersampling it and mixing it up with the rest of the signal. This order cannot be reversed, it is impossible to sample first and filter later, since the sample values of an undersampled high-frequency signal are indistinguishable from those of a "genuine" lower-frequency signal. The result of this erroneous undersampling is aliasing, which puts the results of the measurement in danger. Generally, there is no fool-proof way to predict its influence on overall accuracy, so it is best to make sure to eliminate it entirely.

One way to avoid the above dilemma is to carry out two separate measurements – which creates a fresh quandary: for most devices under test, it is close to impossible to reach exactly the same point of operation for two independent measurements. Theoretically, the only safe way out would be two parallel measurements on the same DUT at the same time. What sounds like an instrument manufacturer's dream is unattractive in practice due to the doubled cost for measurement instruments. In reality, you do not necessarily have to duplicate the entire instrument: it is sufficient to sample/filter twice in parallel. This underlying idea eventually lead to the birth of ZES ZIMMER's DualPath architecture depicted in figure 1. The incoming signal is split up and gets sampled concurrently by two independent A/D converters – the users get both results they are interested in, taken exactly at the same time under the same operational circumstances.

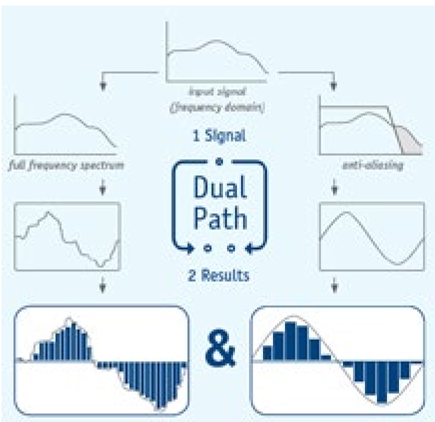


Figure 1: Two A/D converters/ channel for faster & better results

As long as the measurement bandwidth required by the application does not approach half of the instrument's sampling frequency, there is no problem at all, since there is no frequency content in danger of getting undersampled. However, this does not reflect the current state-of-affairs for most power analysis applications. Such diverse products as LED circuits, switch-mode power supplies, variable frequency drives (VFDs) and welding equipment share pulse-width modulation (PWM) as a common feature. While PWM has many advantages in terms of efficiency and flexibility, it also comes with harmonics and other by-products that completely redefine the conditions for power analysis. The measurement bandwidth no longer depends on the frequency of the application itself alone, it also has to accommodate the switching frequency of the PWM, which often extends from 2000 Hz to 100 kHz and beyond. This signifies in turn that the frequencies certainly reach into the MHz range. How important their contribution is cannot be generally determined, it is a question of the requirements of the application at hand. If there is no need for high

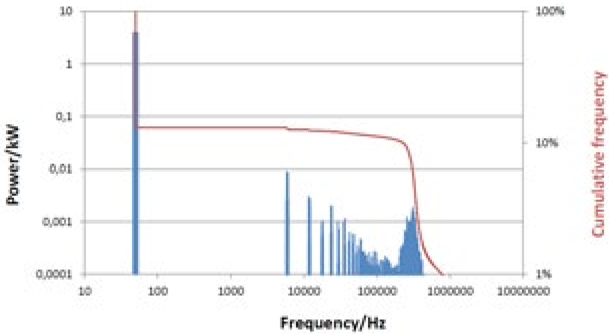


Figure 2: VFD power spectrum

accuracy, the high-frequency portions might be omitted. Typically, the higher you go in frequency, the lower the remaining share of the power spectrum. Figure 2 shows an example of the output power distribution of a frequency converter in an electric drive application. (Please note that both the x- (frequency) and the y-axis (power) are scaled logarithmically.)

There are three distinct areas that are somewhat typical for this kind of application: the tall bar to the left represents the fundamental frequency of the motor, which is where most of the power is intended to end up, since only this portion can potentially contribute to torque. The successively shorter bars in the center represent the switching frequency of the converter and its harmonics. While this frequency is in the lower kHz-range in the above example, it can easily be located at 20 kHz and beyond, with the 40th harmonic already close to the MHz range. The blue "triangle" on the right is made up of line reflections and other by-products. Due to the logarithmic scaling it appears more substantial than it actually is, but it contributes still about 10% to total power. The depicted distribution illustrates that insufficient measuring bandwidth will truncate the power spectrum and omit portions of the true power output. There is no point in measuring the lower-frequency content with 0.1% accuracy while completely cutting of 10% at the upper end. Thus, ample analog bandwidth is crucial for precise measurements in high-frequency applications.

Still, expanding the bandwidth at the expense of accuracy does not yield any benefits either. With an increased shift to variable-frequency drives for motor control, the use of modified oscilloscopes has become more popular for power measurements, since they typically offer superior analog bandwidth when compared to "native" power analyzers. However, a closer look reveals this increased bandwidth does not result in more precise power measurements. What is gained by adding the spectrum e.g. between 10-20 MHz (often at unspecified accuracy) is more than lost by deteriorating basic measuring accuracy from typical values for a high-end power analyzer (0.03% or better) to those of an oscilloscope (typically around 0.1%). Since the vast majority of the measured power is to the left of the graph, a measurement error about 3x worse at the fundamental frequency of the motor makes a much bigger difference than the entire contribution from 10 MHz on. The conclusion is obvious: both accuracy and bandwidth need to be taken to the maximum, one cannot replace the other.

The user interface

The above example hopefully already serves to hint at the many degrees of freedom and associated choices when measuring power in real-life scenarios. Yet, it only captures one aspect of a single application on one device under test. It does not take a lot of imagination to picture the numerous ramifications opened by the diverse range of devices found in the market. Unless one wanted to develop application-specific power analyzers, every power analyzer needs to offer all the possibilities required in all applications across industries. The individual user, however, typically only accesses and uses a tiny fraction of these features. As long as they are easy to access, there is no issue. Once they become hard to find because they are buried under a multitude of options, usability severely suffers.

In our experience,the time engineers spend with desktop power analyzers varies considerably. (Integrated test systems are a different story.) Some use it daily, some after longer periods of R&D work to qualify theimpact of some design or design change. Once they need to measure, there is little time to re-familiarize themselves with its functions.In an ideal world, the user would set up the test, connect the instrument, power it up, configure it, start measuring, save the data and call it a day. In reality, people soon get stuck during configuration already. Of course, there is the user manual, and hopefully also the instrument manufacturer's competent customer support team. Still, more often than not, the entire procedure is quite time consuming and nerve-wrecking.

Since users have little time to adapt to the instrument, the logical consequence is that the instrument needs to adapt to the user. In other words, the user needs to be able to shape the instrument in a way so it becomes the perfect tool for the job at hand. Easy to understand, easy to use. This means first and foremost eliminating features and functions that are not relevant to the task at hand and thus become mere distractions. It also means creating a meaningful context for the measurement task by adding useful information, and it means the ability to structure the results obtained during the course of measurement in a way so that excessive jumps between different menu items and screens can be minimized or eliminated altogether. Figures 3-6 show some exemplary implementations of this principle.

Figure 3: Conventional "spreadsheet" view

It is not sufficient to simply reduce or reformat the amount of displayed data, the combination of data from different domains on one page is crucial to switch from an analyzer-centric to an application-centric view. In the context of a given application it might be useful to collocate RMS values, external inputs, like torque and speed, harmonics and even derived variables calculated from the electric measurements. A widespread example of the latter are properties like field strength, flux density and losses of magnetic cores. Displaying them next to the electric parameters concentrates all desired results in a single spot, allowing to easily check the plausibility of the obtained values. There is no need to navigate through different menus and submenus any longer for collecting various bits of information to manually aggregate them later on. Nothing needs to be remembered regarding the structure of the instruments menu tree: the user simply

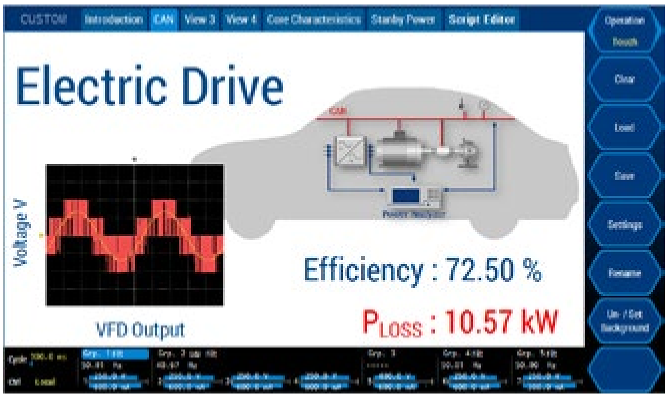


Figure 4: Individualized application-specific GUI layout

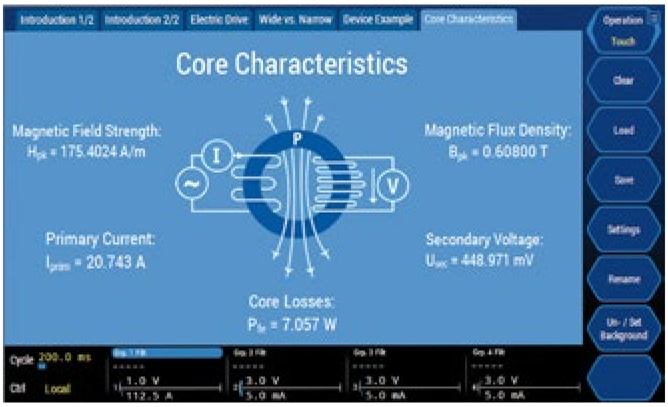


Figure 5: From power analyzer to magnetic core analyzer

Figure 6: Combining graphs and tables

connects the device under test, loads the individualized GUI accompanied by the right settings and starts testing. There is no "programming" necessary, apart from simple drag-and-drop operation when defining the ideal GUI setup to be re-used later for subsequent tests.

The interface to the periphery
Improving usability of an instrument does not stop at the built-in screen: sometimes operation from the front panel is not advisable, since the unit under test is situated in an environment hazardous to human health or otherwise unsuitable. This is typical when machine-to-machine communication comes into play: data needs to be transferred from the analyzer to a control computer or a peripheral device for visualization, storage etc. Of course there are other scenarios when instruments need to be remote-controlled – first and foremost in the context of automated test systems, where the analyzer plugs into a larger umbrella structure. Those shall not concern us here, for the moment we would like to focus on how a single user can carry out all those actions he normally initiates from the front panel at a distance.

As with all other described functions, remote operation of the power analyzer should be easy to set up and use. Remote-control software tools have long been established for those scenarios and are readily available for most power analyzers on the market. If the proper infrastructure – mainly PC/notebook and software – is in place, controlling the instrument should not be an issue. Sometimes not all front panel features can be made available, sometimes the feature-set remotely available is even more powerful. Often, however, users do not have access to a separate PC, and accessing the existing LAN with power analyzer and control computer might need to undergo approval by the IT department, which tends to complicate and slow down the process. Thus, many customers jokingly confessed they wished they could just remove the front panel, take it to their desk, and operate the unit from there. With conventional power analyzer architectures this would probably have remained a joke forever. The only part of the front panel that could effectively be redirected was its graphical output, e.g. via VGA or DVI interface. Although this turned out useful for sharing the screen content, it was merely a one-way street: while it was possible to look at a remote screen to see what was going on, there was no way to influence what was happening – not without an additional computer.

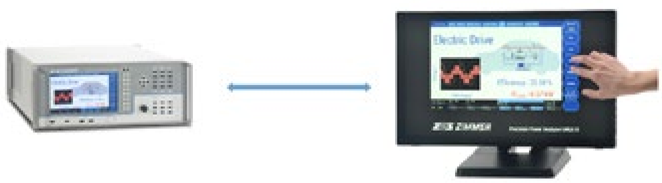


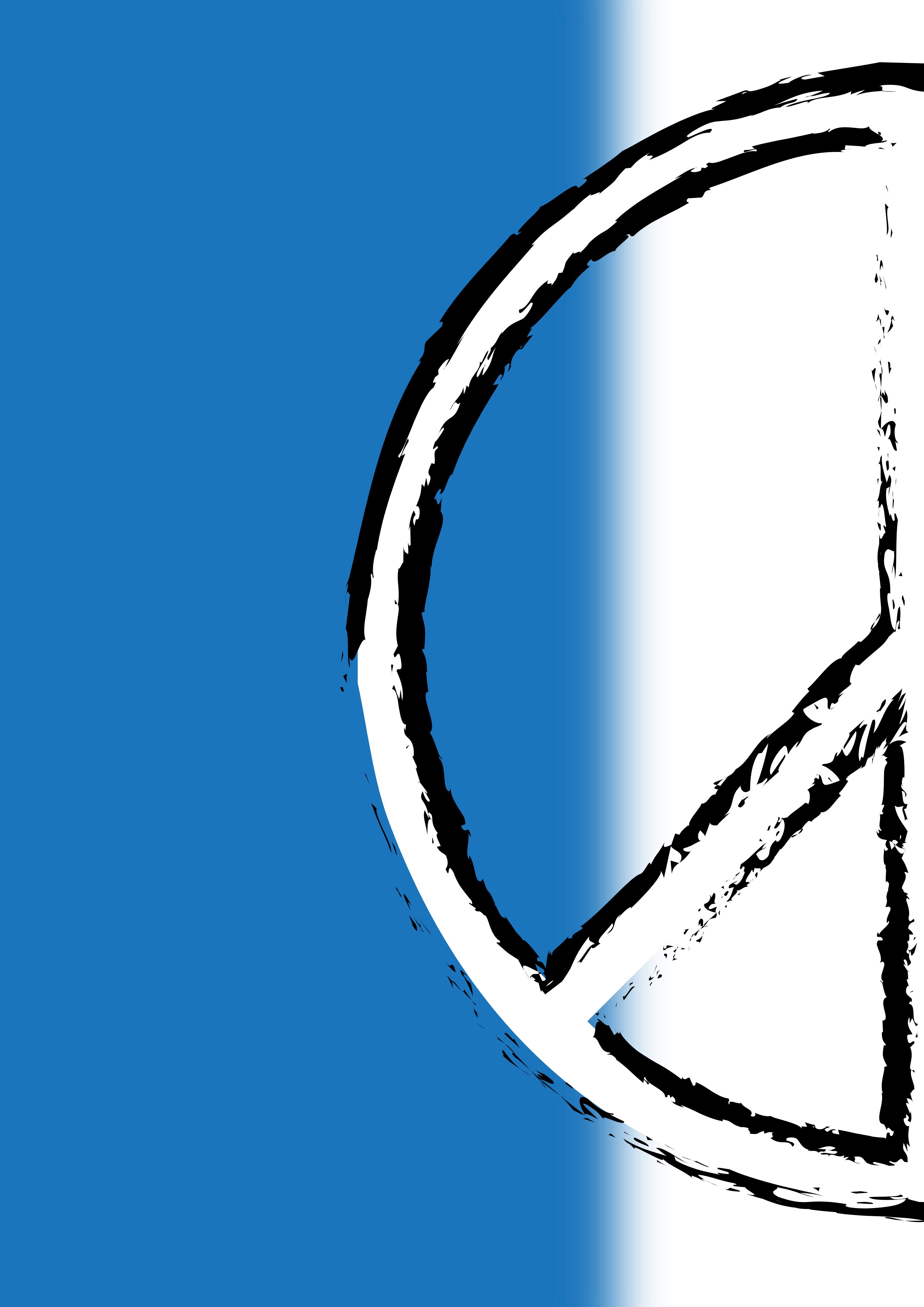
Figure 7: "Remote front panel" operation

The only way to achieve true "remote front panel" operation without at least an additional keypad was to make screen interaction bidirectional: the screen had to serve both as output and input device. Looking at all available options, ZES ZIMMER decided for a touch screen interface. Not only did it turn out to be enormously advantageous when it came to simplifying the use of the power analyzer, it also solved the remote operation problem in a very elegant way: all you need to do is plug a touchscreen into the LMG600, and you can control the instrument the same way you would from the built-in front panel.

Conclusion
The increasing sophistication of applications in combination with a general trend away from specialization among test engineers have reshaped the requirements for power analysis. ZES ZIMMER has successfully addressed these emerging challenges with a series of innovations aimed at improving the analyzer's interactions with its environment. Combining the customizability and flexibility typical for generic data acquisition systems with an off-the-shelf power analyzer's ease of use of is a huge step towards quick, low-cost and low-effort test automation for engineers.

References
- Neuner, B., DualPath explained: Why one A/D converter per channel is not (always) sufficient, ZES ZIMMER, 2015
- Jaeckle, T., How to avoid typical pitfalls when measuring Variable Frequency Drives, ZES ZIMMER, 2014
- Jaeckle, T., Power measurement and its theoretical background, ZES ZIMMER, 2009

www.zes.com



Advantages of the 1200 V SiC Schottky Diode with MPS Design

Single- and three-phase inverters in solar, UPS or energy storage applications today demand for high efficiency, compact designs and extended reliability. Inverter implementation in these applications is limited by silicon devices' high dynamic losses when operated at 1200 V. Alternative designs using 600 V/650 V devices can partially improve efficiency. However, they come at the expense of more complex topologies with special control schemes and high component count.

By Omar Harmon, Thomas Basler and Fanny Björk, Infineon Technologies AG

A Silicon Carbide (SiC) Schottky diode has no real reverse recovery charge. Thus a hybrid set of 1200 V SiC diode and 1200 V Silicon (Si) IGBT enables simpler 2-level topologies by reducing the diode turn-off loss as well as dramatically lowering the turn-on loss of the Si IGBT. In this setup the static losses of the SiC diode often limit the optimization potential of Si IGBT/SiC diode solutions. To overcome this limitation, the new generation 5 diode from Infineon comes with a reduction of forward voltage and its temperature dependency to reduce static losses. This article describes how consistent innovations in device design and assembly techniques improve diode performance, reliability and cost position resulting in easier system implementation for efficient, reliable and robust inverter designs.

Zero reverse recovery charge – the signature of SiC Schottky diodes

Silicon pin diodes are bipolar devices depending on the injection of minority charge carrier which are characterized by a large reverse recovery charge. During conduction state of the diode, charge carriers are injected into the device and need to be removed from the device before a voltage can be blocked or, in other words, a space-charge region can be built-up. A higher charge carrier concentration will result in a high reverse recovery charge. Moreover, reverse recovery charge is dependent on forward current and device junction temperature. The advantage of using SiC Schottky diodes being a majority carrier device is that they virtually show zero reverse recovery charge. Looking at the switching waveforms in Figure 1, the reverse recovery current peak is very small compared to a fast Si pin diode. Only the displacement current from the junction capacitance is visible. This leads to significantly lower turn-off losses. Moreover, since the dynamic characteristic of a Schottky diode is capacitive in nature, the reverse recovery characteristic of a SiC Schottky diode is independent from forward current, di/dt and device junction temperature.

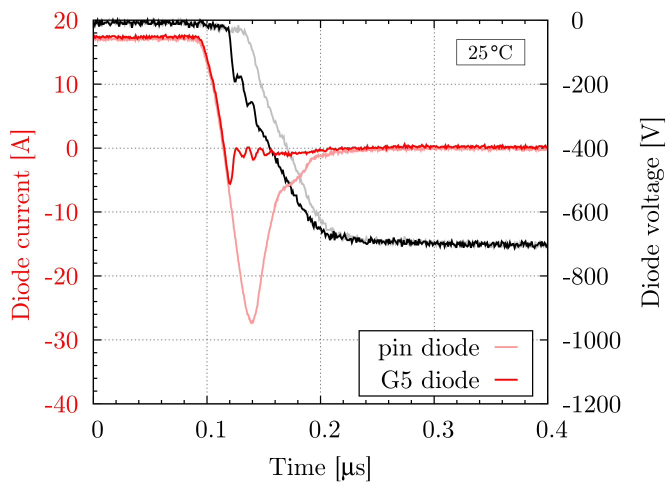


Figure 1: Reverse recovery behavior of a fast state of the art 1200 V Si-pin diode and SiC Schottky diode generation 5 (G5). V_{DC}=700 V, switch: 1200 V IGBT, di/dt=1300 A/µs, losses: 50 µWs for G5, 190 µWs for Si-pin diode. Reverse voltage applied to the diode is represented in black curves.

Static loss reduction and improved thermal performance

The new 1200 V SiC Schottky diodes implement a merged pn-Schottky (MPS) structure, representing the same technology base as the latest 650 V diode generation. To better understand this MPS design, the anode side of a SiC Schottky diode is shown in Figure 2. The blocking capability of a SiC diode during reverse voltage application is provided by a drift layer. This layer is also a major contributor to the overall resistance of the device. In this regard, it is best to lower the drift resistance to lower the forward voltage when the diode is conducting. A higher drift layer doping (n) lowers the resistance but at the expense of higher device leakage current.

Introducing p+ islands in this structure additionally shields the electric field from the Schottky contact thus reducing the leakage currents. Hence, using MPS structure enables lower overall resistance by increasing drift layer doping without significantly increasing the leakage current.

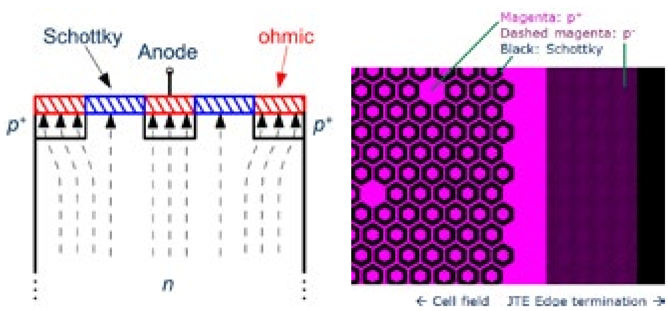


Figure 2: 1200 V thinQ!™ SiC Schottky diode generation 5 design. MPS (merged-pin-Schottky) structure combines the shielding of the electric field from the Schottky barrier and an increased surge current capability by hole injection. Dashed lines (left) show current density at higher currents. Cell design (right) of an optimized cell structure with hexagonal p+ islands.

Capacitors for Power Electronics

IGBT Snubbers
RF Mica Capacitors
DC Link Capacitors
- **High Current, High Voltage Film**
- **High Capacitance Aluminum Electrolytic**

AC Output Harmonic Filter Capacitors

CDE ENERGIZING IDEAS
CORNELL DUBILIER

www.cde.com

The new diode with MPS design enables a 50 percent reduction of drift resistance compared to the previous Schottky design. In Figure 3 the corresponding forward voltage contributions at 600 A/cm2 are compared. Current densities of a final product are usually lower and mainly depend on the achievable thermal resistance Rth of the packaging vehicle. The reduction in drift resistance results in a mild increase in forward voltage with temperature. The forward voltage of generation 5 diodes only increases by 35 percent when the temperature is raised from 25 °C to 150 °C, significantly lower than the 60 percent increase in previous generation using Schottky design.

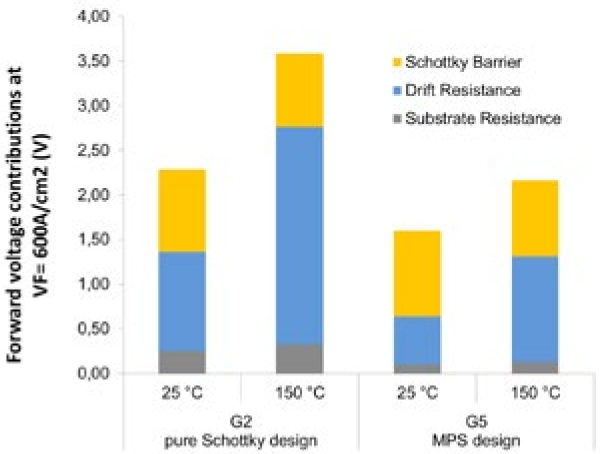


Figure 3: Comparisons of resistive contributions to forward voltage of a Schottky diode design and MPS design at junction temperatures 25 °C and 150 °C.

Massively increased surge current handling

Another positive side effect of the MPS design is the increased surge current capability. At higher currents the build-in voltage of the p+ islands in n-junction is overcome and holes are injected into the drift layer. The diode becomes bipolar in terms of forward characteristics, as shown in Figure 4. Due to this design, Infineon's generation 5 1200 V SiC Schottky diode is able to withstand surge current levels more than 15 times the nominal current for a typical 10 ms sine half-wave.

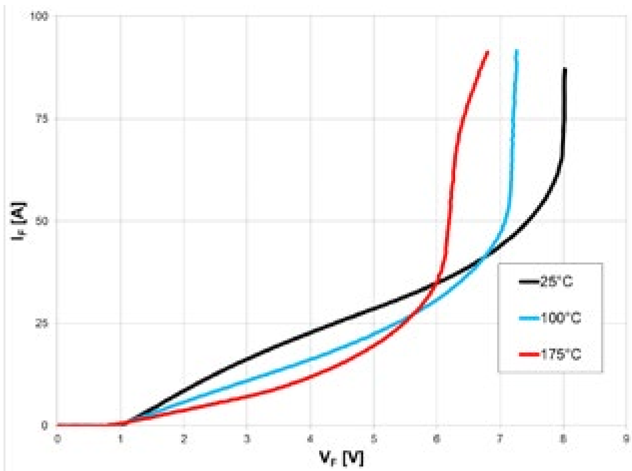


Figure 4: I-V curve of a 5 A rated generation 5 1200 V SiC Schottky diode (TO-220) at high currents.

Thin wafer technology for lower forward voltage and improved thermal performance

To provide mechanical stability to the semiconductor device, a substrate is used which is depicted in Figure 5 as a schematic cross section of a SiC Schottky diode. The substrate resistivity labeled as R_{bulk} is also a contributor to the diode's total differential resistance. The thickness of this substrate has a direct impact on the forward voltage when the diode is conducting. It is therefore best to reduce this thickness to lower the forward voltage while considering mechanical stability.

The well-established thin wafer technology allows for the reduction of the substrate thickness to around one third compared to the original layout. With this thickness, the reduced total differential resistance leads to a 150 mV to 200 mV reduction of typical forward voltage for the identical chip sizes.

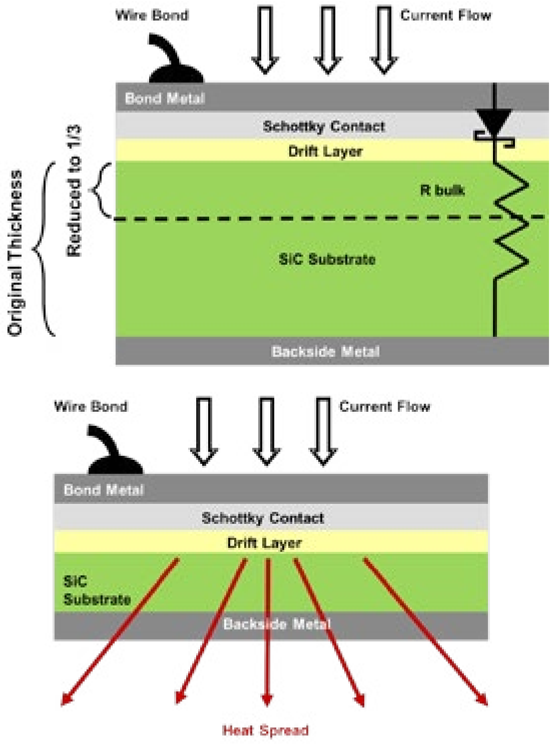


Figure 5: Schematic representation of a SiC Schottky diode indicating thick and thin wafers and showing the thermal path for the heat generated in the junction of the diode. Merged pn junction is not represented for simplicity.

Besides the reduction of the forward voltage, the reduced chip thickness also leads to an improved thermal resistance which, in return, is beneficial for the power dissipation of the device. Obviously, a thinner substrate layer offers a shorter thermal path for the heat generated inside the Schottky junction and drift layer of the diode. The heat spread from the junction is enhanced, thus reducing the thermal resistance between junction and the package lead-frame or case. This holds true especially if sophisticated low R_{th} die attach techniques like diffusion soldering are used. In addition, the thin substrate enhances the propagation of the thermal flux not just only vertically but also laterally as shown in Figure 5b. The reduction in thermal resistance thus corresponds to an equivalent increase of power dissipation for the same case temperature. However, it has to be kept in mind that by wafer thinning the "junction-near" thermal capacitance (C_{th}) is reduced. Regarding short-time events like surge current there is a trade-off between the reduction of forward voltage drop and the reduction of C_{th}.

Experimental results in a boost topology

The performance of SiC and Si diodes was evaluated in a boost circuit. The test setup has an input voltage of 400 V_{DC} and an output of 800 V_{DC} capable of delivering 3000 W output power. IKW25N120H3, a 25 A 1200 V IGBT from Infineon is used as a boost switch switching at 20 kHz. A commercially available 18 A ultrafast Si diode commonly integrated for this output power range was used. The boost inductor has an inductance value of 2.5 mH. Figure 6 plots the efficiency curves and boost diode case temperature as a function of the output power for a 10 A SiC and 18 A Si diodes used as boost diode. The tests were performed at an ambient temperature of 25 °C.

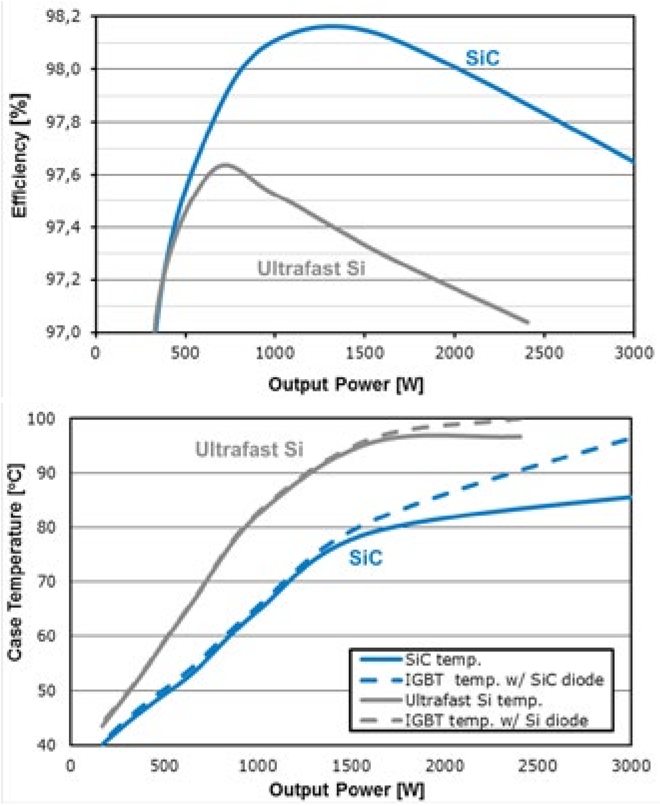


Figure 6: Efficiency results (top) of boost circuit and boost diode case temperature (bottom) of the 10 A SiC and 18 A Si diode over a maximum output power of 3000 W.

At 2400 W output power, the boost efficiency using SiC is 97.9 percent compared to Si diodes' 97.0 percent. The measured case temperature at this output power for the Si diode is 96.7 °C while the SiC diode reaches 84 °C. Due to reduced reverse recovery charge of SiC, the boost output power can reach 3000 W at a case temperature of 85 °C.

To compare the efficiency improvement of the SiC diode technology generations, the same test setup mentioned above is used, except for the boost switch. In this test a SiC JFET is used as the boost switch, which enables a maximum output power of 6 kW. Figure 7 plots the efficiency curves and boost diode case temperature as a function of the output power percentage.

At 100 percent output power, boost efficiency using generation 5 is 97.1 percent while generation 2 achieves 96.2 percent. Moreover, at this output power the measured case temperature for generation 5 is 93.6 °C while generation 2 is 115.1 °C. This reduction of device temperature at 100 percent output power is the result of the diodes' loss reduction which amounts to 30 percent.

Conclusion

Compared to a pure Si based solution design engineers gain a higher flexibility in system optimization for UPS, solar inverters, energy storage and other industrial applications when using hybrid Si IGBT/SiC diode sets. The replacement of a Si by a SiC diode increases the system reliability because of lower device temperatures. Additionally, a higher output power in the same form factor can be achieved. By minor additional system changes, power density can be increased when using smaller heatsinks and EMI filters. The new generation 5 1200 V SiC Schottky diode from Infineon supports this higher flexibility with a low-loss turn-off, a dramatic improvement in static losses especially at elevated temperature and a massively increased surge current capability.

References

[1] Björk, F., Harmon, O., Draghici, M., Gerlach, R., Basler, T., Rupp, R. (2015). "1200 V thinQ!™ SiC Schottky Diode Generation 5: what are the three keys for simple, compact and high efficiency inverter designs?" PCIM Europe 2015.

[2] Fichtner, S., Lutz, J., Basler, T., Rupp, R., Gerlach R. (2014). "Electro – Thermal Simulations and Experimental Results on the Surge Current Capability of 1200 V SiC MPS Diodes" proceedings of CIPS, 2014.

[3] Rupp, R., Gerlach R., Kirchner U., Schlögl A., Ronny Kern R., "Performance of a 650V SiC diode with reduced chip thickness", ICSCRM2011, proceedings of.

[4] Scarpa, V., Kirchner, U., Gerlach, R., Kern, R. (2012). "New SiC Thin-Wafer Technology Paving the Way of Schottky Diodes with Improved Performance and Reliability," PCIM Europe 2012.

www.infineon.com/power

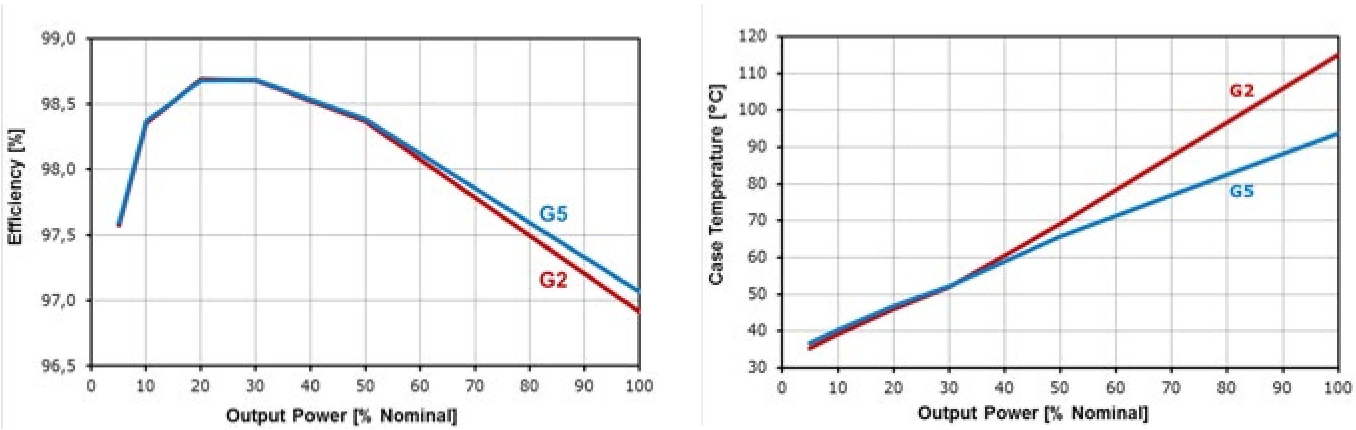


Figure 7: Efficiency (left) and SiC diode case temperature (right) results of a boost circuit with 800V output voltage, with Infineon's generation 5 and generation 2 10A SiC Schottky diodes in TO-247.

Incorporating Magnetic Saturation of a PMSM for Drive Systems Modeling in PLECS

Saturable machine models are needed by drives engineers to develop, tune, and evaluate the performance of advanced control algorithms. PLECS is a simulation tool that allows for very efficient and robust modeling of drive systems and their associated controls. In this study, modeling of PMSM saturation for simulation of drive systems is discussed.

By Munadir Ahmed, Plexim Inc.

Introduction

Electric machines play an integral part of systems in a variety of industries. In applications such as electric vehicles [1] and starter-generators [2], machines are driven into saturation to meet high torque demands while optimizing for cost and weight. Therefore, the electric machine parameters can vary substantially during normal operation. When developing controls, machine parameters are often used to tune the controller gains. As a machine is driven into saturation, the controller gains may need to be modified online to correctly compensate for the change in machine parameters. If not correctly compensated, the controller may become unstable [3]. Further, control strategies such as Maximum Torque per Ampere are impossible to implement without considering saturation effects in the control algorithm [4].

In the design phase, engineers develop, tune, and benchmark the performance of different strategies for machine controls in a simulation environment like PLECS. When developing advanced control algorithms, it is important to use machine models that accurately reflect machine saturation while maintaining fast and robust simulation.

Modeling saturation effects of a PMSM

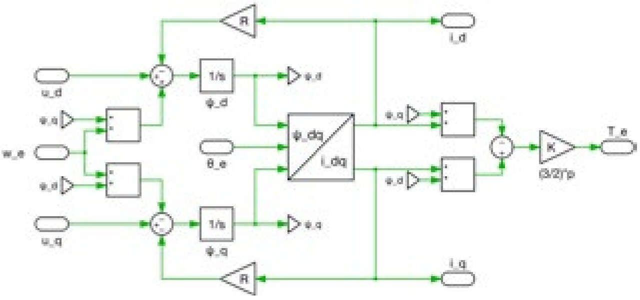


Figure 1: Implementation for the flux-based PMSM model [5]

Machines are often modeled in the synchronous reference frame (dq-model) for simulation of drive systems. This dq-model is a flux-based implementation where input voltages are converted from the abc-frame (u_{abc}) to the dq-frame (u_{dq}), and the flux linkages in the dq-frame (ψ_{dq}) are calculated. ψ_{dq} are then used to derive the dq-currents (i_{dq}). The flux-based implementation for a PMSM machine is shown in Fig. 1. In a linear model, the currents are determined by simply dividing the flux linkage by an equivalent inductance (L_{dq}). The linear model is limited, as it doesn't consider the change in L_{dq} as the machine is driven into saturation. Thus the effects of saturation are not reflected in the simulation.

Saturation using Analytical Fit

One method to incorporate saturation into the dq-model is to use analytical functions to model the saturation effects. High-order polynomial functions can potentially be used to estimate flux linkage as a function of current. The coefficients of these polynomials are determined through curve fitting data gathered from measurements, FEA simulation, or technical papers and do not represent any physical meaning. Additionally, there is a limited range where these polynomials provide a correct estimate of the flux linkage.

Magnetic materials exhibit an approximate linear relationship between flux linkage and current in both unsaturated and highly saturated regions. It is only the slopes and intercepts that differ. Fig. 2 shows flux linkage as a function of magnetizing current. It can be seen that initially there is a linear increase, followed by a period where the slope decreases. Finally the relationship becomes linear again. An arctangent function provides a good method to model the saturation effect [6]. One advantage of using arctangents as opposed to polynomials is the larger range of definition. Additionally, the function is completely characterized by four parameters that relate to the unsaturated and saturated magnetizing inductances, location of the transition and a factor determining the transition tightness.

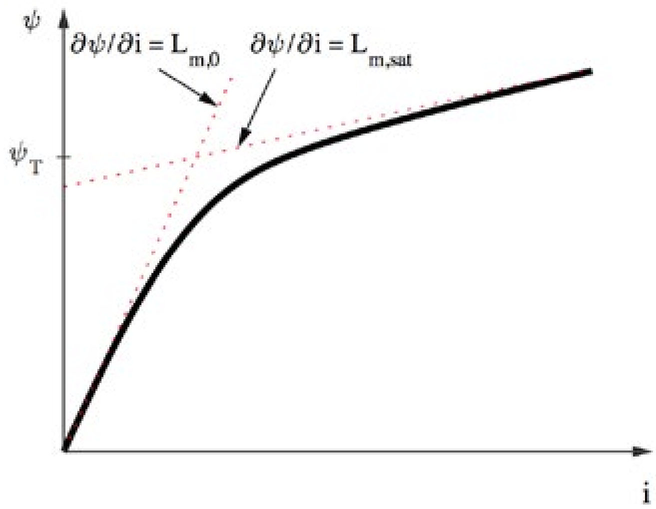


Figure 2: Flux vs Current for a saturable machine based on an arctangent function

The arctangent-based, analytical model allows users to incorporate saturation effects into their simulation in a very easy and efficient manner. However, the model only considers saturation of ψ_{dq} occurring due to an increase in i_{dq}, respectively. The inability to take cross-saturation effects into account is a major drawback of the analytical model. Fig. 3 shows the analytical model's limitation for a machine with heavy cross-saturation effects. The machine data was generated using Infolytica's MotorSolve tool.

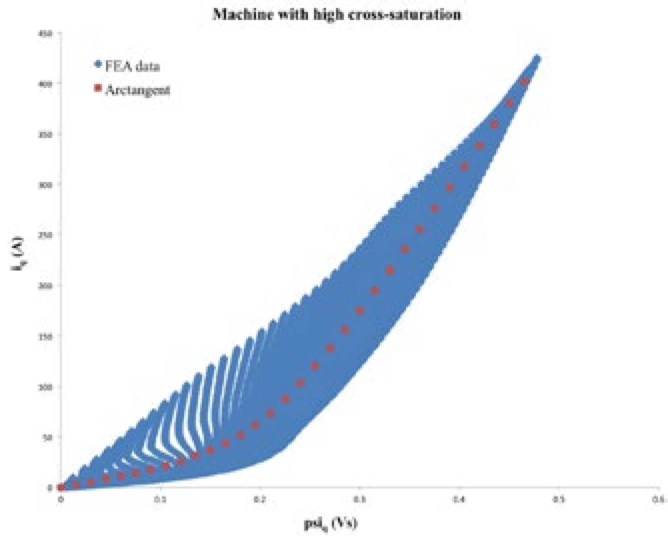


Figure 3: iq as a function of ψq for a machine with heavy cross-saturation

One solution is to use functions that describe 2D surfaces. However, this may require the use of optimization tools to estimate the parameters [7]. An alternative approach for machines experiencing high cross-saturation effects is to use two-dimensional (2D) look-up tables.

Saturation using 2D Look-Up Tables

Measurements made on dynamometers or data obtained from FEA tools can provide ψ_{dq} as a function of i_{dq}. This information can be incorporated into the flux-based PMSM model using 2D look-up tables. The look-up tables take ψ_{dq} as inputs and output i_{dq}, allowing

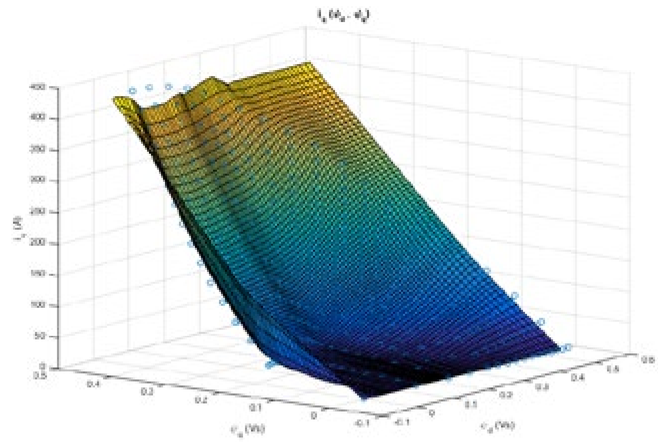


Figure 4: Look-up table generated for machine with high cross-saturation effects (surface: look-up table, dots: FEA data)>

cross-saturation effects to be incorporated into the model. The raw measurement or simulated data must first be processed to produce a constant grid of ψ_{dq}, and i_{dq} is determined over this grid using interpolation and extrapolation. It is also important that the look-up table output be a smooth data surface to ensure simulation stability.

Fig. 4 shows i_q as a function of ψ_{dq} for the same machine as in Fig. 3. The generated data was processed through Matlab scripts, developed at Plexim, to generate 2D look-up tables for i_{dq} as a function of ψ_{dq}. This data is then tied into a PLECS PMSM machine model via 2D look-up table components. This allows data generated from an FEA tool or from hardware measurements to be tied into a PLECS simulation.

Simulation results

The Infolytica interior PMSM tutorial model represents a machine with heavy cross-saturation. Fig. 3 shows an attempt to capture the magnetic saturation effects of this machine using an arctangent function and thus highlights the limitation of the analytical model when heavy cross-saturation is present. Fig. 4 shows the same machine where the magnetic saturation effects were captured using a 2D look-up table.

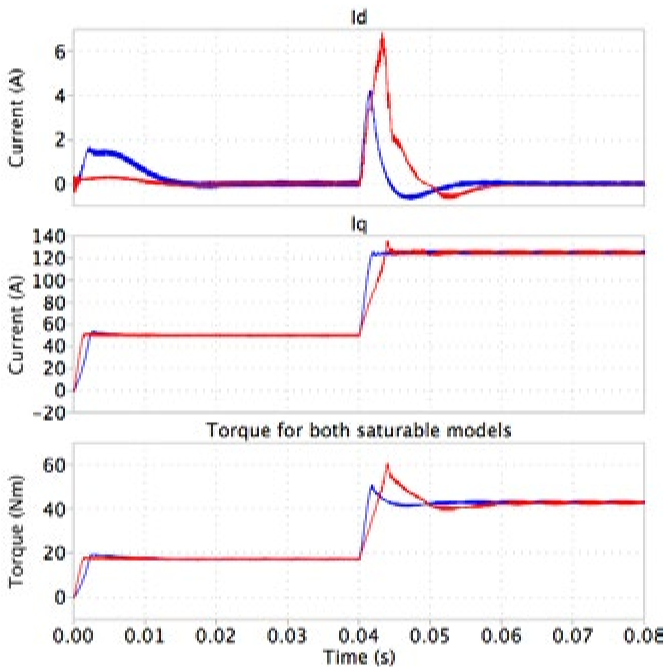


Figure 5: Transient response of i_d, i_q, and torque for a machine with heavy cross-saturation modeled with analytical functions (blue) and look-up tables (red)

PLECS models for the saturable PMSM based on both look-up tables and analytical models were developed. Both machine models were run at constant speed by setting the inertia of the machines to zero and connecting the rotors to a constant speed source. Identical synchronous frame regulators were developed to maintain i_{dq} at the desired levels. During simulation, the i_d set point is set to zero while the i_q set point is stepped from 50A to 125A. The dc-link voltage is sufficient to avoid operating the machine under flux weakening operation. Fig. 5 shows the operation of the two machines under identical conditions and the effects of heavy saturation on the transient response. It can be seen that under the same control strategy, the model incorporating cross-saturation has a more accurate transient response than the model using an analytical function.

Conclusion

When a machine is driven into saturation its parameters change. These changing machine parameters may be incorporated into the controller design to ensure system stability and optimal performance. In the design phase, simulation tools like PLECS are used to validate advanced control algorithms. To evaluate the performance of control algorithms incorporating changing machine parameters, it is necessary to have a model that accurately represents the machine saturation. In this study, flux-based PMSM models incorporating saturation using analytical functions and look-up tables are discussed. Further, simulation results of a machine with heavy cross-saturation modeled based on an analytical function and look-up tables are shown. The PLECS models for the PMSM with heavy cross-saturation are available for download on the Plexim website. Additionally, a model of a PMSM with low cross-saturation is provided.

Plexim would like to thank Infolytica for providing access to MotorSolve for this study.

www.plexim.com

www.infolytica.com/en/products/motorsolve

Reference

[1] Sullivan, C.R.; Sanders, S.R., "Models for induction machines with magnetic saturation of the main flux path," in IEEE Transactions on Industry Applications, vol.31, no.4, pp.907-917, Jul/Aug 1995
[2] Chedot, L.; Friedrich, G., "A cross saturation model for interior permanent magnet synchronous machine. Application to a starter-generator," in Conference Record of the 2004 IEEE Industry Applications Conference. 39th IAS Annual Meeting, vol.1, pp.70, 3-7 Oct 2004
[3] Morimoto, S.; Ueno, T.; Sanada, M.; Yamagiwa, A.; Takeda, Y.; Hirasa, T., "Effects and compensation of magnetic saturation in permanent magnet synchronous motor drives," in Industry Applications Society Annual Meeting, vol.1, pp.59-64, 2-8 Oct 1993
[4] Li, Z.; Li, H., "MTPA control of PMSM system considering saturation and cross-coupling," in 15th International Conference on Electrical Machines and Systems (ICEMS), 2012, pp.1-5, 21-24 Oct 2012
[5] Uebener, S.; Bocker, J., "Application of an Electric Machine Emulator for Drive Inverter Tests within the Development of Electric Drives", in European Electric Vehicle Congress, Nov 2012
[6] Corzine, K.A.; Kuhn, B.T.; Sudhoff, S.D.; Hegner, H.J., "An improved method for incorporating magnetic saturation in the q-d synchronous machine model," in IEEE Transactions on Energy Conversion, vol.13, no.3, pp.270-275, Sept 1998
[7] Stumberger, B.; Stumberger, G.; Dolinar, D.; Hamler, A.; Trlep, M., "Evaluation of saturation and cross-magnetization effects in interior permanent-magnet synchronous motor," in IEEE Transactions on Industry Applications, vol.39, no.5, pp.1264-1271, Sept/Oct 2003

Calibration: Meeting the Challenges of High-Frequency Power Measurement

The need for high accuracy power measurement

As more and more innovation focuses on energy efficiency and the use of renewable energy resources, engineers are increasingly demanding accuracy and precision from their power measurements.

By Clive Davis and Erik Kroon, Yokogawa Europe

At the same time, new standards such as IEC62301 Ed2.0 and EN50564:2011, covering standby power consumption, and the SPEC guidelines, covering power consumption in data centres, demand more precise and accurate testing to ensure compliance.

To meet these challenges, R&D teams are coming to terms with the need for new levels of precision in power measurement, but these levels of precision can only be achieved if the measuring instruments are properly calibrated with reference to national and international standards.

Regular calibration by a laboratory, which can provide very low measurement uncertainties at the specific measurement points applicable to individual users, should enable instrument makers and their customers to have confidence in their test results.

However, with power measurements in particular, the situation is not so clear cut – to the extent that the accuracy figures quoted in manufacturers' specifications – and indeed some of the parameters listed in calibration certificates issued by well-established test houses – can be meaningless when taken out of context.

The need for high frequency power measurement
One key area which is often neglected in traditional specifications is that of power measurements at high frequencies. Traditionally, AC power meters are calibrated at frequencies of 50 to 60 Hz. Nowadays, however, there is a demand for power measurement at high frequencies on devices such as switch-mode power supplies, electronic lighting ballasts, soft starters in motor controls and frequency converters in traction applications.

Calibration of high-frequency power has lagged behind the development of power meters to address these applications, and few national laboratories can provide traceability up to 100 kHz: the frequency at which instruments have to be calibrated to provide accurate results in these application sectors.

There are a number of other parameters involved in power measurements that determine the performance of an instrument in a particular application. It is no longer sufficient merely to list voltage and current specifications: today's power environment needs to address variables such as phase shift, power factor and the effects of distorted waveforms.

It is also important to calibrate the instrument under the right conditions. Many test houses still use pure sine waves at only 50 Hz to calibrate power meters, which renders the results virtually useless for users carrying out tests under "real world" conditions.

It is therefore important for users of power measuring instruments to look at the actual "calibrated" performance of different manufacturers' products rather than just comparing specifications. This is the key thinking behind Yokogawa's policy of having its own European Standards Laboratory with minimal uncertainties and capabilities which are almost second to none: as confirmed by the fact that it has become the world's first non-governmental facility to receive full ISO17025 accreditation for power measurements at up to 100 kHz.

What is calibration?
"Calibration" can be defined as the comparison of an instrument's performance with a standard of known accuracy.

No measurement is ever correct. There is always an unknown, finite, non-zero difference between a measured value and the corresponding "true" value. In other words, a user can never be 100% sure that an instrument is operating within its specified tolerance limits.

However, there are steps that can be taken to minimise the possibility of a measurement falling outside specified tolerance or uncertainty bands. Regular traceable calibration is a method for gaining quantifiable confidence in a measurement system by comparing the instrument's performance to a standard of known accuracy.

However, all laboratory standards and even national standards have uncertainties of measurement; hence it is difficult to be 100% confident that an instrument is operating within its stated tolerance limits.

It is important to understand the difference between "calibration" and "adjustment". Calibration is the comparison of a measuring instrument (an unknown) against an equal or better standard. A standard in a measurement is therefore the reference.

Instruments are adjusted initially at the factory to indicate a value that is as close as possible to the reference value. The uncertainties of the reference standard used in the adjustment process will also dictate the confidence that the indicated value is "correct".

As the instrument ages, the indicated value may drift due to environmental factors (temperature, humidity, oxidation, loading etc.) which will also be dependent on the quality of its design and manufacture. To ensure that the instrument continues to operate within the manufacturer's tolerances, the instrument should be compared to the reference value on a regular basis (usually annually). If necessary, the instrument can then be re-adjusted.

If there is no appreciable change in the calibrated results, this means that the instrument's design is inherently highly stable. In this case, there is no need to adjust it, and the user can also rely on the fact that the unit will exhibit the same stability on a day-by-day basis.

It goes without saying that all instruments should be calibrated on a regular basis. Not calibrating carries a number of costs and risks:

- In production/acceptance testing, users may encounter false passes or (equally undesirable) false failures.
- In an engineering laboratory, inaccurate measurements can distort the findings.
- Contractual requirements may inadvertently fail to be met
- Quality issues may result in customer dissatisfaction or even product recalls and rework.
- Regular calibration by a laboratory, which can provide very low measurement uncertainties at the specific measurement points applicable to individual users, should enable instrument makers and their customers to have confidence in their test results.

Yokogawa's calibration capabilities
As indicated above, Yokogawa's European Calibration Laboratory has become the world's first non-governmental facility to receive full ISO17025 Accreditation for power measurements at up to 100 kHz. This is in addition to its established capability for providing high-accuracy calibration at 50 Hz, especially at very low power factors (down to 0.0001) and at high currents.

At the heart of the laboratory is a special calibration system with the capability to calibrate power up to 100 kHz. Housed in a climate-controlled environment (23.0 ± 1.0)°C, the system is able to calibrate voltage, current, DC power, AC power, frequency and motor functions, all under fully automatic control.

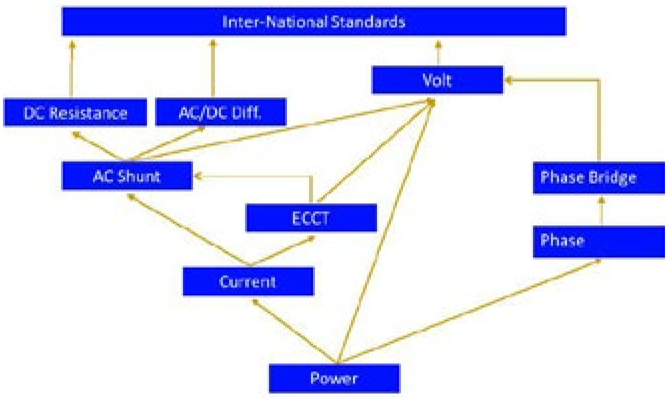


Figure 1: Traceability overview

The system consists of two parts, a signal generator section and a reference measuring unit. Those two parts are separated by a metal shield in order to prevent the heat generated by the signal sources from affecting the reference meters. Different sources are used to generate the calibration signal because a single source is not sufficient to generate all the signals required. Instead, multiplexers are used to select the sources needed for any particular measurement. Similarly, different reference power meters are selected via a multiplexer. This allows the selection of the best reference power meters for high-current, low-current or low-voltage calibrations. The reference power meters are from Yokogawa and are special models modified with aged components and firmware to enhance the resolution. They have an excellent stability and performance.

The power meter under calibration is connected via a multiplexer on the calibration system. Each element of the power meter under calibration is calibrated separately. A power meter with mixed inputs is easily calibrated. Extra instruments are added to the calibration system to calibrate any additional options of the power meter such as the motor function and analogue output.

The system is designed to minimise effects such as capacitive leakage and crosstalk, with special attention given to the wiring harness and multiplexers. For voltage, twisted and screened coaxial cables are used, while current uses coaxial cabling. The multiplexers use special relays to avoid leakage and crosstalk. The influence of the wiring harness is now kept to a minimum. With a worst-case measurements using 100 V at 100 kHz, the crosstalk suppression to the current channels is better than -93 dB. For mixed-input units, every element is calibrated separately to minimise the effects of loading.

The in-house developed software makes this system very flexible. A calibration is normally based on the Yokogawa Quality Inspection Standards (QIS). If the QIS is passed, it is demonstrated that the measured values are within specifications. However, on request of the customer, it is possible to calibrate additional points within our capability. The system is able to communicate with the power meter under calibration by GPIB, RS232, USB or Ethernet.

When the calibration is finished, the results are used to generate the calibration certificate.

A typical calibration of a power meter takes a few hours, depending on the number of elements. For each element, tests are made at about 45 voltage calibration points, 65 current calibration points and 78 power calibration points. Using all those points the voltage gain, voltage linearity, voltage flatness, current gain, current linearity, current flatness, power gain, power linearity, power flatness, power factor and frequency are calibrated at DC and from 10 Hz to 100 kHz. This includes also the external current sensor if applicable. A total of about 180 calibrations are done for each element. The system is also able to calibrate the motor function by using analogue or pulse shape signals. A 30-channel multiplexer measurement system is installed to measure the analogue output of the power meter.

The calibration of the system itself is also carried out in the European standards laboratory, and includes the effect of the multiplexers and wiring harness to remove the unknown uncertainty.

Traceability
Traceability for power is based on values for voltage, current and phase (Figure 1). Using these units, it is possible to calculate power by the equation: $P = U \cdot I \cdot \cos(\varphi)$

which is valid only for sine waves, so that special attention has to be taken into account for the harmonic distortions of the generated signals.

The measurement of voltage is straightforward using a digital multimeter. However, using a digital multimeter to measure the current is limited due to the frequency capability and uncertainty, and therefore two different options are used. If the current frequency is 50 to 60 Hz, an electronic compensated current transformer (ECCT) is used to measure the current, but if the frequency is higher current shunts have to be used for the other frequencies. Yokogawa has built its own current shunts to measure from 1 mA up to 10 A at up to 100 kHz with a maximum AC/DC difference of 3 parts in a million at 100 kHz. Measuring the voltage over the shunt allows the current to be calculated.

To obtain the phase, a phase measurement device based on a high-speed, high-resolution digitiser is used. The digitiser is equipped with differential inputs to avoid ground loops. The biggest uncertainty here is the phase angle deviation of the current shunts, which is corrected by calibrating the shunt at different frequencies. The phase measurements device is calibrated via a phase standard, which in turn is calibrated using self-calibrating phase bridges.

This setup enables power to be made traceable at up to 100 kHz.

To confirm the calibration setup, a Yokogawa WT3000 power analyser was calibrated by Yokogawa, and then sent to the national Standards Laboratory of Sweden (SP). At SP they also calibrated the Yokogawa WT3000 at the same points which verified the results (Figure 2).

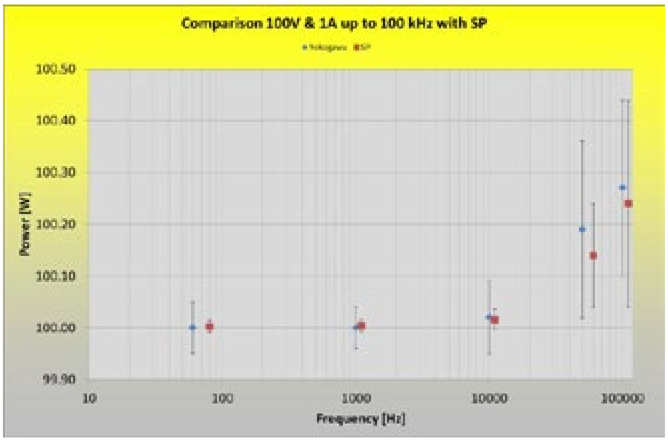
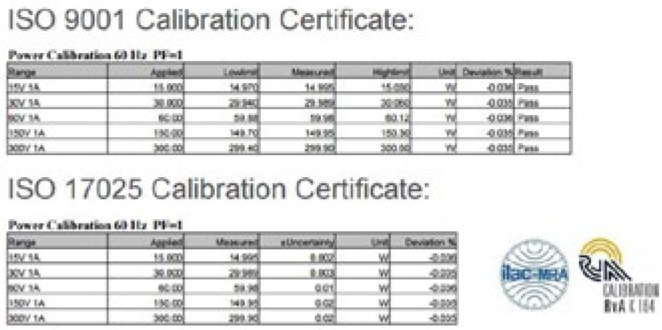


Figure 2: Power Comparison with SP

The importance of accreditation

The familiar ISO 9001 standard aims at confirming the traceability of a measurement but does not define how the measurement is carried out. Laboratories that are accredited to ISO 17025 (General requirements for the competence of testing and calibration laboratories), however, have demonstrated that they are technically competent and able to produce precise and accurate calibration measurements. Figure 3 shows an ISO 17025 certificate complete with measurement uncertainties, which confirms that the power meter is truly much more accurate than its specification. There is no guarantee that the measurements on an ISO9001 certificate are correct.

Yokogawa's European Calibration Laboratory is the only industrial (i.e. non-government or national) organisation to offer traceability up to 100 kHz, and thus is the only power meter manufacturer which can directly prove the performance of its own instruments. Only a Yokogawa Calibration Certificate gives the user trust in their instrument's measurements.



ISO 9001 Calibration Certificate:

Power Calibration 60 Hz PF=1

Range	Applied	Lowlimit	Measured	Highlimit	Unit	Deviation %	Result
15V 1A	15.000	14.970	14.995	15.030	W	-0.036	Pass
30V 1A	30.000	29.940	29.989	30.060	W	-0.035	Pass
60V 1A	60.00	59.88	59.98	60.12	W	-0.036	Pass
150V 1A	150.00	149.70	149.95	150.30	W	-0.035	Pass
300V 1A	300.00	299.40	299.90	300.60	W	-0.035	Pass

ISO 17025 Calibration Certificate:

Power Calibration 60 Hz PF=1

Range	Applied	Measured	±Uncertainty	Unit	Deviation %
15V 1A	15.000	14.995	0.002	W	-0.036
30V 1A	30.000	29.989	0.003	W	-0.035
60V 1A	60.00	59.98	0.01	W	-0.036
150V 1A	150.00	149.95	0.02	W	-0.035
300V 1A	300.00	299.90	0.02	W	-0.035

Figure 3: Differences between the ISO9001 and ISO17025 Certificates

ISO17025 accreditation also reflects the attention paid to the design of the input circuits of Yokogawa's precision power analysers, with an emphasis on wideband, high-linearity characteristics that make them the world's most accurate instruments in their class (Figure 4).

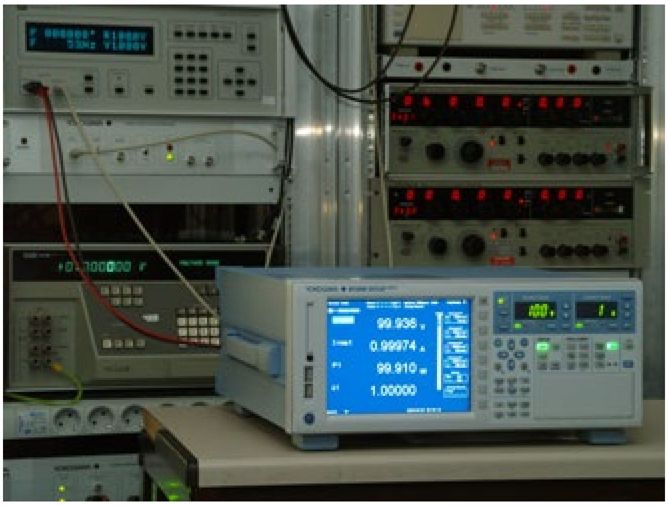


Figure 4: Yokogawa WT3000 Power Analyser

tmi.yokogawa.com

Non-IGBT Power Modules: Acoustic Inspection

Power modules and power devices - including IGBTs, GTOs, thyristors, discrete devices, MOSFETs, etc. - all require for their successful long-term operation the dissipation of high levels of heat. The desired longevity can be achieved by assuring before mounting that the module or device does not harbor a delamination, void or other heat-blocking defect that can lead, quickly or gradually, to the destruction of the die by overheating.

By Tom Adams, consultant, Sonoscan, Inc.

The standard means for locating and imaging an internal delamination or other heat-blocking defect is an acoustic micro imaging (AMI) tool. The other methods for finding such typically very thin defects are either destructive (sectioning, grinding) or less effective (X-ray). Acoustic imaging of IGBT modules has been discussed in previous issues of Bodo's Power Systems (most recently in December 2014). Here we discuss other devices and modules.

GTOs and Similar Devices

Heat-blocking voids/gaps are the defects most commonly seen in power devices such as GTOs and thyristors. The second biggest concern is typically solder thickness uniformity. Non-uniformity of the solder thickness can still affect the thermal transfer rate, even if the solder bond is good. There are a few other less frequent defects, the most common of which is probably non-bonding or delamination from the die of a tab-type lead from the die. But the number of types of potential defects and anomalies in power modules is quite small compared, say, to a discrete plastic-encapsulated microcircuit (PEMs) device format, where die face delaminations, lead finger delaminations, popcorn cracks and other defects may occur.

GTOs, thyristors and IGBT modules are all similar in their structure. The die is bonded via a multi-layer structure to a metal heatsink that is designed to dissipate sufficient heat to keep all regions of the die, in all operating conditions, below the temperature at which damage will occur. The power module has at least three leads per die, and sometimes more than three to accommodate higher current levels. Compared to the gold wires of plastic-encapsulated microcircuits (PEMs), the leads of these power modules are large and robust. A single die is soldered to one electrode of the multilayer structure, dissipating heat to the metal heatsink. The die of the module is typically encapsulated in silicone to prevent direct moisture contact on the topside. The metal heatsink on the bottom side is either mounted or exposed for heat dissipation. In many modules of these types, the metal base is extended horizontally with holes to permit bolting of the module to a cooling source or to an even bigger heatsink.

An AMI tool uses a scanning transducer that moves, in the case of the Sonoscan C-SAM® systems, horizontally at speeds that can exceed 1 meter per second. The transducer is coupled to the surface of the sample being inspected by a column of water that travels with the transducer. The sample may be a single device or module, or a JEDEC-style tray of devices or modules. Some power modules may be sensitive to contamination from water. They are scanned from the bottom side (the transducer is beneath the module) with WaterPlume™ techniques in order to ensure a dry module. WaterPlume can be used for all modules, but typically not for discrete devices that are sealed, and not at all for PEMs type devices.

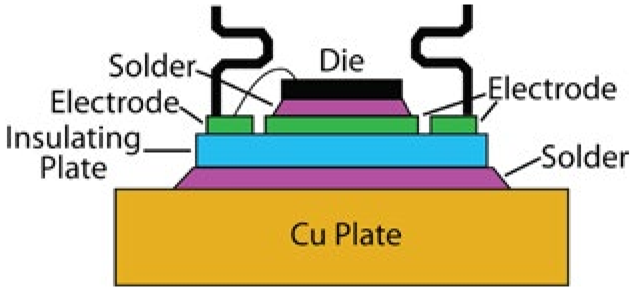


Figure 1: Diagrammatic side view of a GTO, Thyristor or IGBT module

A side view (Figure 1) of a GTO, Thyristor or IGBT module before encasement and encapsulating will show, starting at the top, the die, solder, electrode, insulator (typically ceramic raft), solder and finally the metal heatsink. Typically each of these materials is supposed to be homogeneous when assembled. If the die is sensitive to water, the device is scanned through the heatsink from the bottom side. The transducer scans the surface of the heatsink and sends a pulse of ultrasound into the surface several thousand times a second. The echoes from material interfaces inside the sample arrive back at the transducer and are recorded before the next pulse is launched. The round-trip time for a pulse to be launched and the echoes to be received is typically several microseconds.

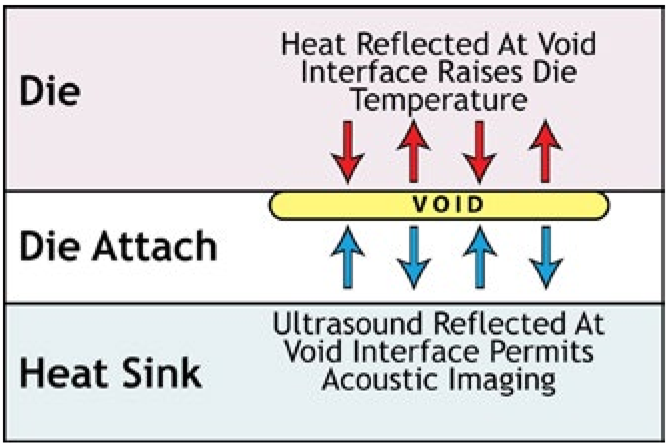


Figure 2: Any gap-type anomaly reflects heat (top), but also reflects the ultrasound that images the anomaly (bottom).

Ultrasound pulsed into the sample travels through homogeneous materials without sending back echoes. Echoes are created only by the interface between two materials. If two solid materials are well bonded, their interface will return to the transducer an echo whose amplitude depends on the density and velocity of each of the two materials. Typically the interface between two well bonded solids will return between 20% and 80% of the pulsed ultrasound. A portion of the ultrasound will cross the interface and travel deeper, where it will in turn be reflected by the next well bonded interface between two solids.

Note the phrase "well bonded." If there is a gap (delamination, void, non-bond) between two solid materials, then what the ultrasound encounters is the interface between a solid and the air or another gas in the gap - even if the gap is as thin as 100Å (Figure 2). The densities and acoustic velocities of these two materials are so different that virtually 100% of the ultrasound from this type of interface is reflected as an echo. None of the ultrasound crosses the gap. Gaps also reflect and block heat being dissipated by the die; voids, non-bonds and delaminations are therefore undesirable. The echo signal from any gap has the highest possible amplitude and will accordingly be bright white in a grayscale acoustic micro image, although the color is often modified to red or another color for publication. Well bonded interfaces will be some shade of gray.

Power Discrete Devices

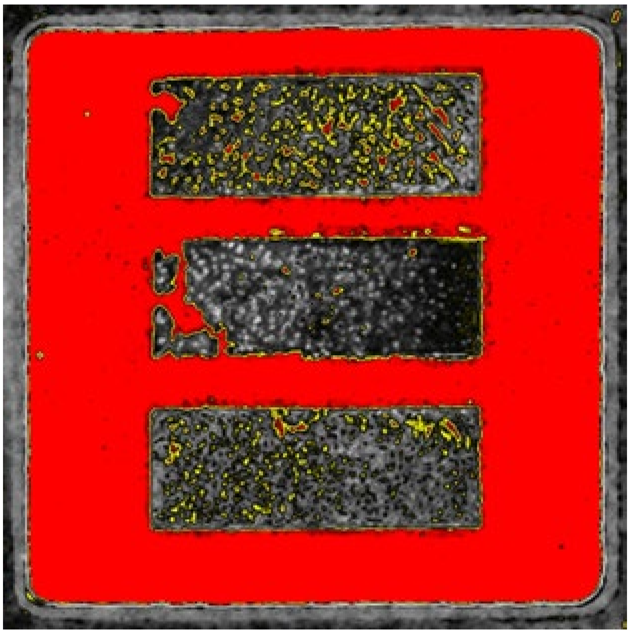


Figure 3: The three die in this power discrete device have voids in the die attach.

Figure 3 is the acoustic micro image, through the heatsink, of a power discrete device. The image was gated on the die attach layer through the insulating plate substrate. Red/yellow areas within each of the three rectangular die attaches are voids or other gaps between the die and the substrate. There are a few large heat-blocking voids, but there are large numbers of much smaller voids (collectively termed porosity), some of which are so small that rather than red they appear yellow or another color based on their relative size and depth in the solder. Even if these die attaches could accomplish the required heat dissipation in their present condition, the likelihood that some of the voids may expand as a result of thermal cycling during service renders this device risky at best.

The area around the die is also red, like the voids, and for the same reason: it is air, present here because this is a hermetically sealed device. The ultrasound "sees" the other side of the substrate, where nothing is attached.

PEM Type Power Devices

MOSFETs and other smaller power or voltage regulator devices are more similar in their structure to plastic-encapsulated microcircuits (PEMs). They tend to be found in applications having lower power loads than their module cousins, and utilize higher switching frequencies. But like the higher-power modules, they need to dissipate heat.

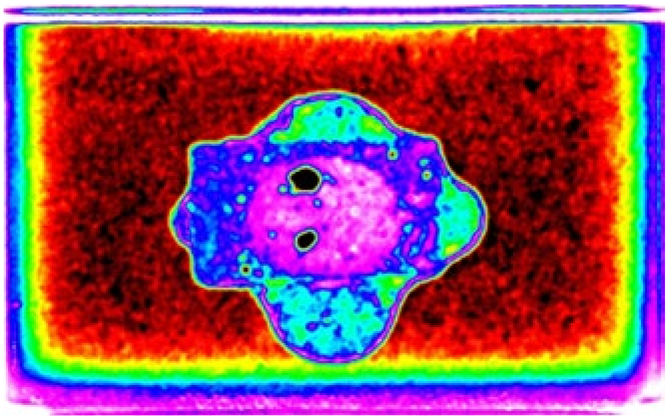


Figure 4: Black features in the die attach of this TO220 device are voids.

Figure 4 is the acoustic image of a TO220 package device. Ultrasound was pulsed into the backside of the device - i.e., through the heatsink. Return echoes were collected only from a depth that included the die attach material and the bottom side of the die. The resulting "thin slice" image was made by rejecting echoes from all other depths.

The faintly outlined rectangular blue/magenta horizontal feature at the center is the bottom side of the die. During placement of the die, the attach material extended beyond the outline in all four directions. At the center of the die outline can be seen the pink original oval shape of the die attach material before the die was placed.

The only anomalies are the two black features within the die attach material. These are voids (air bubbles) in the die attach. Except in an application where maximum heat dissipation from the die is very critical, voids of this relative size probably would not by themselves cause rejection. But these are flattened air bubbles and are likely to expand as a result of thermal excursions during service. They are very efficient reflectors of heat as well as of ultrasound, and may cause the die to overheat and fail. Such failure is more likely if a void happens to lie just below a hot spot within the die.

The various types of power modules described here differ in structure and capacity, but all are susceptible to failure originating in gap-type defects. AMI inspection nondestructively finds and images the defects to avoid performance interruption in use.

www.sonoscan.com

Everything for Capacitive Power Supplies from a Single Source

Designs based on capacitive topologies are particularly suitable for power supplies in the milliwatt range. They are simple, compact and economical. In addition to the capacitors – and therefore the key components – TDK offers almost all the other passive components for these designs.

By Christoph Jehle, Epcos Munich

Development engineers are faced with the task of supplying a growing number of devices and system units that only have low voltages and currents in the milliampere range. Typical examples are displays for measurement data or timers, microcontroller-based measuring systems and simple open- and closed-loop controls. Similar challenges are presented when devices have to be connected to wireless networks – for example, in the case of smart meters whose readings are taken wirelessly, or network-operated devices for the Internet of Things.

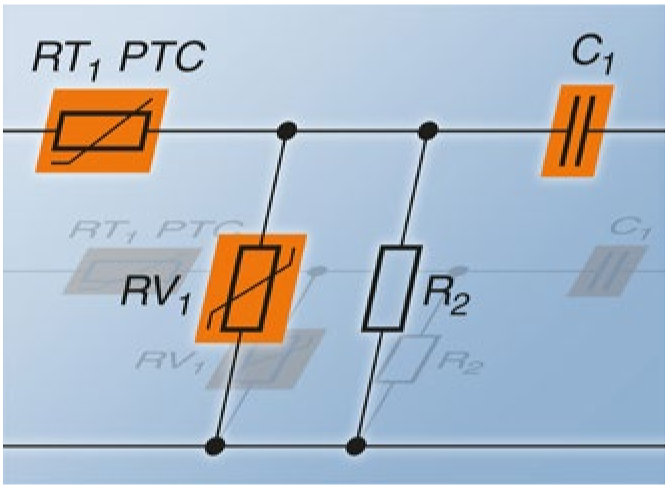


Figure 0: Capacitive power supplies

Conventional power supply designs have a number of disadvantages in the very low power range. Solutions with transformers or switched circuits require a lot of space and are expensive. In addition, the copper and iron losses are disproportionately high in relation to the low output. Although the simplest solution – the line-side connection of an ohmic resistor – is inexpensive, it does generate high losses and thus opposes the high efficiency rates required.

Exploiting the reactance of capacitors to practical effect

One possibility for supplying small loads from the AC power supply that is not only elegant, but also simple and cost-effective, is to connect the capacitor and load in series. This makes use of the otherwise unwanted effect of phase shift: The voltage arrives at a capacitor with a 90-degree phase shift from the current; the capacitor acts as a reactive power, at which practically no actual losses occur. A capacitor used as a series resistor is therefore the ideal solution. Figure 1 shows the circuit diagram as well as the associated vector diagram of the voltages. In contrast to conventional designs, the capacitive power supplies are short-circuit-proof at the output.

As the capacitor is directly connected to the power supply, very high demands are made on its reliability. It is therefore recommended that only X2 capacitors compliant with UL and ENEC are used for capacitive power supplies.

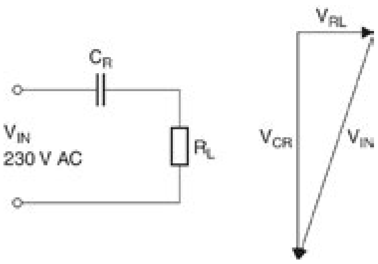


Figure 1: Circuit diagram of a capacitive power supply. The vector diagram makes it clear: The majority of the input voltage drops out at the reactance of the capacitor with virtually no power dissipation being created in the capacitor.

For this purpose, TDK offers a wide range of EPCOS X2 capacitors such as the new B3292*H/J* series. To permit reliable operation with stable capacitance values, even under extreme climatic conditions such as high temperatures in combination with high humidity, the X2 Heavy-Duty Series (B32932* through B32936*) was developed. These components show a capacitance drift of no more than 10 percent in a 1000-hour test at 85°C and 85 percent relative humidity. There is one more advantage of these capacitors: they are self-healing. This means that smaller disruptive discharges result in a locally limited vaporization of the metallization without creating a short circuit and therefore retaining the function of the capacitor.

Calculation of a capacitive power supply

In practice, the power supplies most in demand are those that provide a DC voltage at the output. The simplest solution is in single pulse rectification as shown in Figure 2; for the calculation example, an output voltage of around 9 V DC is generated at a maximum load current of 15 mA.

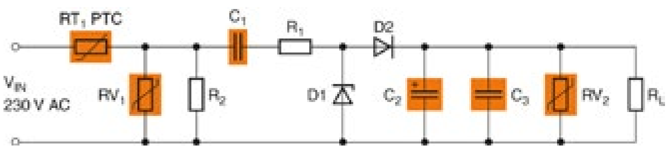


Figure 2: Simple capacitive power supply

For the function of a Zener diode: During the positive half-wave, D1 operates as a voltage-limiting component. In order to achieve the required output voltage of 9 V, the Zener's voltage would have to be 9.7 V, because about 0.7 V drops off at D2. However, as no Zener diodes with this value are available, a diode with a value of 10 V and a maximum power dissipation of 1.3 W is chosen. If the power supply switches on at the line voltage peak, an inadmissibly high current would flow through D1, resulting in its destruction. To limit the current therefore, R1 is connected on the line side. As a rule, Zener diodes with a power dissipation of 1.3 W can manage momentary currents of about 1 A. This enables the value of R1 to be calculated as follows:

$$R_1 = \frac{230\ \mathrm{V} \times \sqrt{2}}{1\ \mathrm{A}} = 325.27\ \Omega$$

The nearest standard value is 330 Ω. In operation, R1 is continuously subjected to the entire load current. To calculate this, the ratio of ACRMS to the DC average value must be taken into consideration. As this involves single pulse rectification, the form factor is 2.22. With the required 15 mA output current this produces a current through R1 of 33.3 mA and consequently a power dissipation of:

$$P = (33.3\ \mathrm{mA})^2 \times 330\ \Omega = 0.366\ \mathrm{W}$$

A resistor is chosen with a load capacity of 0.5 W. The voltage drop through this resistor is almost 11 V.

From the data determined thus far, it is now possible to calculate the necessary reactance of capacitor C1. In order to guarantee a reliable supply of the load even when there is an undervoltage, the calculation should be performed with a voltage drop of at least 10 percent; in addition, the voltage drop via R1 and D1 must to be taken into consideration. This produces the reactance as follows:

$$XC_1 = \frac{230\ \mathrm{V} - 23\ \mathrm{V} - 11\ \mathrm{V} - 10\ \mathrm{V}}{33.3\ \mathrm{mA}} = 5585.6\ \Omega$$

From this it is possible to calculate the necessary capacitance at the normal line frequency of 50 Hz:

$$C_1 = \frac{1}{2\pi \times 50\ \mathrm{Hz} \times 5585.6\ \Omega} = 0.57\ \mu\mathrm{F}$$

Consequently, the next standard value is a capacitance of 0.68 µF. Depending on the climatic conditions this means, for example, that the EPCOS X2 capacitor type B32933A3684K* from the heavy-duty series is suitable. This has a lead spacing of 22.5 mm and is designed for a voltage of 305 V ACRMS at a maximum permissible operating temperature of 105°C. Alternatively, one can use the B32923H3684K* type, which is even designed for up to 110°C, likewise with a lead spacing of 22.5 mm. Both types exhibit a capacitance tolerance of ±10%.

Figure 3: EPCOS capacitors for capacitive power supplies
*Two typical EPCOS X2 capacitors that are suitable for capacitive power supplies: on the left a type from the heavy-duty series, and on the right a type from the B3292*H/J series.*

The economical standard type 1N4001 (50 V, 1 A), designed for peak currents of up to 35 A, is sufficient for the diode D2 which ensures the single pulse reactance. This diode is offered by a number of semiconductor suppliers.

Secure supply through efficient smoothing

C2 is is responsible for smoothing the output voltage. As this is a one-pulse reactance, the entire output current of C2 must be made available during the negative half-wavelength. The necessary capacitance of this depends on the permissible ripple of the output voltage. For the circuit in the example, a maximum value of 1 V is required. At the maximum load current consumption of 15 mA at 9 V, a load resistance of 600 Ω is produced. With a line frequency of 50 Hz (10 ms per half-wavelength) the minimum capacitance of C2 can thus be determined:

$$C_2 = \frac{-10\text{ ms}}{600\ \Omega \times \ln\left(\frac{8\text{ V}}{9\text{ V}}\right)} = 140\ \mu\text{F}$$

A single-ended aluminum electrolyte capacitor is selected with a capacitance of 150 µF and a permissible voltage of 25 V DC. In order to achieve the longest possible life, this capacitor should be designed for a temperature of at least 105°C.

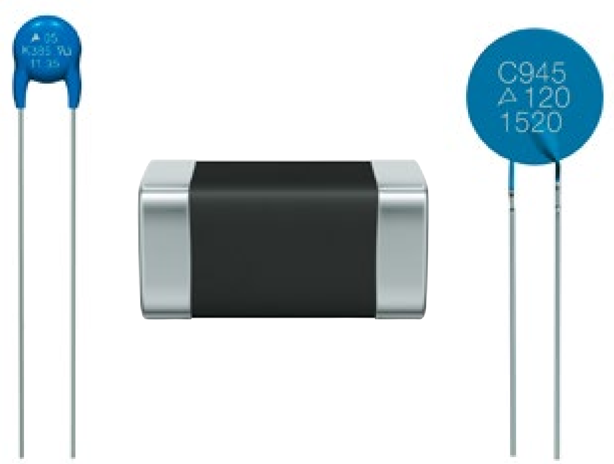


Figure 4: EPCOS protective component for power supplies
From left to right: Disk varistor for overvoltage protection at the power input and CeraDiode® for protecting the output, PTC for overcurrent protection at the power input.

Optionally, a ceramic capacitor (C3) can additionally be connected in parallel with C2. This is used for noise suppression and for blocking voltage peaks. For example, a TDK MLCC with a capacitance of 0.1 µF can be considered for this purpose. The type C1608X7R1E104K080AA was selected with a nominal voltage of 25 V DC with size 1608 (IEC) and X7R temperature characteristic (-55 to +125ºC, ±15%).

Circuit protection is essential

In a worst-case scenario it may happen that, when switching off without load, C1 remains charged with the peak voltage of 325 V. It is then the task of R2 to discharge the capacitor as quickly as possible. When setting the resistance value, a compromise must be made between power dissipation and discharge time constant. In this case the value of 470 kΩ was selected. A power dissipation of approx. 0.1 W occurs here and the discharge time to a maximum permissible touch voltage of 50 V takes around 0.5 s. If the power supply is continuously connected to the grid, however, there is no need for this resistor.

The overvoltage protection at the line input (RV1) is also important, of course. For this purpose, TDK offers various series of EPCOS varistors. The types from the EPCOS standard series are suitable for the stated circuit, as these cover a wide range of voltages from 11 VRMS to 1100 VRMS. These protection components are available with disk diameters of between 5 mm and 20 mm, corresponding to the required surge current capability and energy absorption. In this case, for example, the compact type B72205S0231K101 with a disk diameter of 5 mm is suitable, which features a surge current capability of 400 A at a pulse of 8/20 µs.

In addition, the output of the circuit can also be protected against overvoltage (RV2), for example, using the EPCOS SMT CeraDiode® B72590D0150A060, which has a DC voltage of 15 V.

Finally, an EPCOS PTC B59873C0120A570 (RT1), which is designed for a maximum load current of 90 mA at 25°C, ensures the current limitation at the power input. If a fault should occur in the circuit that results in an increased current flow, the PTC heats up, causing its resistance to rise sharply and thus limit the current to non-critical values.

Thanks to the comprehensive range of TDK components, capacitive power supplies with other voltage and current values can be realized.

Bill of material

ID	Type / Value	Ordering code	Manufacturer
R1	330 Ω, 0.5 W		various
R2	470 kΩ		various
RT2	PTC, 90 mA	B59873C0120A570	EPCOS
RV1	Varistor, 230 V	B72205S0231K101	EPCOS
RV2	Varistor, 14 V	B72590D0150A060	EPCOS
C1	0.68 µF	B32933A3684K* or B32923H3684K*	EPCOS
C2	150 µF, 25 V		various
C3	0.1 µF, 25 V	C1608X7R1E104K080AA	TDK
D1	ZD10, 1.3 W		various
D2	1N4001		various

www.epcos.com/emi_capacitors

www.epcos.com/alu_single

www.epcos.com/ptc

www.epcos.com/varistors_leaded

www.epcos.com/ceradiode

Transform an LED Driver from Buck to Boost for Enhanced Flexibility, Reduced BOM

With a few extra components and some rearrangement of the topology, a buck-mode DC-DC converter IC can be made into a boost-mode device, to drive LED strings with voltages higher than the supply voltage.

By Fons Janssen, Principal Member Technical Staff, and Field Application Engineer, Maxim Integrated

The hysteretic-buck LED-driver is a popular, easily implemented current source for situations where the voltage across the LED string is lower than the input voltage. By rearranging the external components, it is practical to switch this topology from buck mode to boost mode, to support LED strings where the sum of the diode drops is greater than the input voltage.

While there are many boost regulators available, this topology allows a single buck regulator IC to provide both buck and boost functions, and so may simplify the bill of materials (BOM) and reduce overall cost. Although using the buck device for boost operation may result in increased variation in the LED current beyond what is acceptable, an additional control loop can be added to further regulate the current, if needed.

This transformation example uses the MAX16822/32 hysteretic buck converters from Maxim Integrated, which are 2-MHz high-brightness LED-driver ICs with integrated MOSFET and high-side current sense, Figure 1. (The MAX16822 and MAX16832 differ only in current rating: 500mA versus 1A, respectively.)

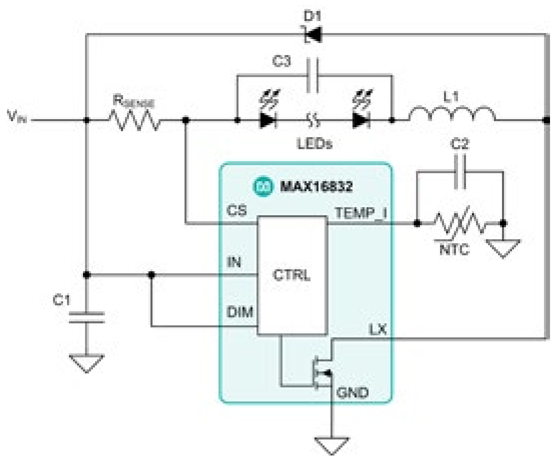


Figure 1: Typical application circuit of the MAX16832 as a buck-converter LED driver

This circuit regulates the voltage on sense resistor Rsense so that a constant current flows through the LEDs that are in series with that resistor. The MOSFET within the MAX16832 is turned on for currents below the set point and turned off for currents above it. When the MOSFET is on, the current ramps up and flows from input voltage Vin to GND via the sense resistor, the LEDs, the inductor, and the MOSFET; when the MOSFET is off, the current ramps down and flows back to Vin via the sense resistor, the LEDs, the inductor, and diode D1.

Adding the hysteresis results in a self-oscillating system which generates a sawtooth-shaped LED current, Figure 2. The amplitude of the sawtooth is determined by the amount of hysteresis. Capacitor C3 acts as a filter, so that the LEDs will mainly see a DC current. This topology is a known as a high-side buck topology.

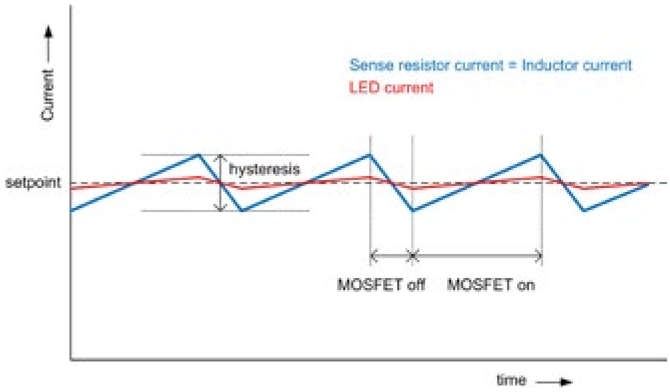


Figure 2: The current waveform of the hysteretic buck LED driver has a sawtooth LED current due to self-induced oscillation.

Going from buck to boost

A buck topology can only be used if the voltage across the LEDs is less than the input voltage. When voltage across the LEDs is greater than the input voltage, a boost topology is needed. Since the boost topology also has the switching MOSFET on the low-side, it is straightforward to change the high-side buck topology into a boost topology by rearranging the external components, Figure 3. In this boost topology, the current is regulated in the same way as in the high-side buck topology.

The difference is that the LEDs are no longer in series with the sense resistor and inductor. The result is that the input current is regulated rather than the LED current. Figure 4 shows the waveforms for the input and output currents; the LED current is a filtered version of the output current via C3.

The result of this arrangement is that the LED current will depend not only on the regulated input current (IIN), but also on input voltage (VIN), output voltage (VLED), and the efficiency (η) of the converter:

$$I_{LED} = \frac{\eta V_{IN} I_{IN}}{V_{LED}}$$

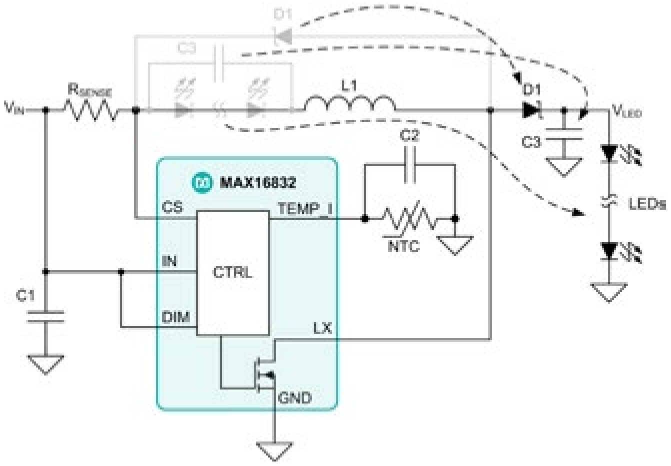


Figure 3: Change topology from high-side buck to boost just requires some rearrangement of the external components.

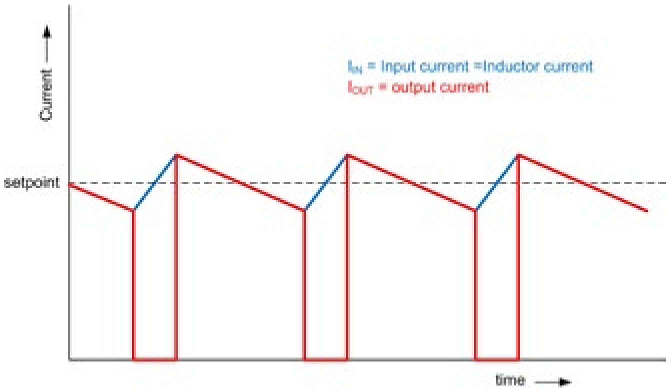


Figure 4: When configured as a hysteretic boost LED driver, the input current is regulated rather than the LED current, as shown by the waveforms for the input and output currents.

If the resulting variation in the LED current is greater than acceptable, an extra circuit based on the MAX8515 (a wide-Input, 0.6V shunt regulator for isolated DC-to-DC converters) can be added to regulate the LED current, Figure 5.

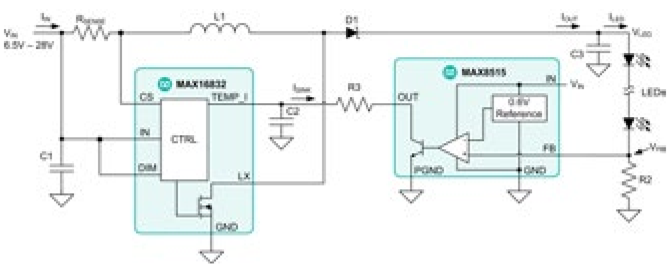


Figure 5: An additional circuit based on the MAX8515 shunt regulator can be used to improve LED current regulation, if needed.

The MAX8515 acts as an error amplifier and compares feedback voltage VFB to an internal reference voltage of 0.6V. VFB is directly proportional to the LED current, with VFB = R2 × ILED. Since the output of the amplifier can sink current from the TEMP_I pin but cannot source current, a small constant current is sourced by the TEMP_I pin itself.

The difference between both currents is integrated by capacitor C2. If the MAX8515 sinks more current than the TEMP_I pin sources, the voltage decreases; the reverse is true as well. The set point for the input current IIN is proportional to this voltage, Figure 6. Therefore, if VFB is smaller than the 0.6V reference, no current will be sunk and the voltage on TEMP_I increases. This, in turn, will increase the input power, and therefore the LED current and VFB. If VFB is greater than the reference, the voltage on TEMP_I will be pulled lower in order to reduce the LED current.

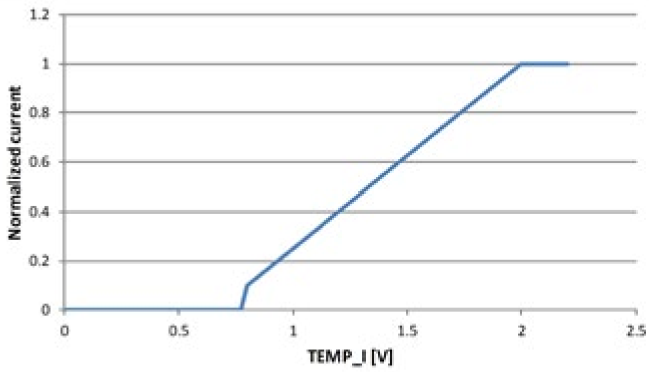


Figure 6: The MAX8515 manages the sinking and sourcing, as seen in the relation between voltage on TEMP_I and input-current set point.

LED current-control loop minimizes variations

These parameters apply to the control loop used to regulate the LED current, Figure 7:

The 0.6V reference voltage of the MAX8515 is the input for the control loop;

V_{FB} is the output and is directly proportional to the LED current, with $I_{LED} = V_{FB}/R2$;

G1 is the gain of the MAX8515 and resistor R2 (note that the gain of MAX8515 is actually negative due to the inverting action of the NPN transistor; this is compensated by swapping the plus and minus signs on the adder);

Capacitor C2 is the integrator while G2 is the gain between the TEMP_I voltage and the feedback voltage.

This control loop will regulate VFB to 0.6V:

$$I_{LED} = \frac{0.6V}{R2}$$

To correctly configure the boost circuit, sense resistor RSENSE should be chosen so that the maximum input current is slightly higher than needed. The extra control loop will then reduce the input current to get the correct LED-current value. The value of this resistor can be calculated as follows:

$$R_{sense} < \frac{\eta V_{IN} 200mV}{I_{LED} V_{LED}}$$

The additional sense resistor R2 can be calculated by:

$$R_2 = \frac{0.6V}{I_{LED}}$$

Overvoltage protection also needed

A LED normally fails as a short circuit, thus lowering the output voltage. If the output voltage remains higher than the input voltage, the circuit will continue to function correctly. However, if the LED fails by becoming a high impedance (open circuit) rather than a short circuit, the output current will charge the output capacitor C3 to a value beyond the operating range of the IC, and cause it to fail.

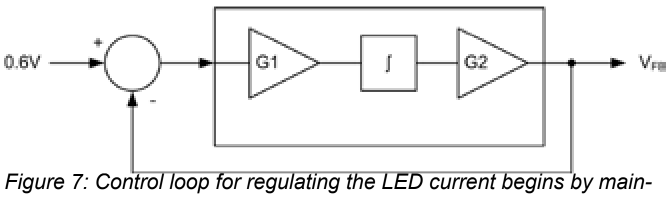


Figure 7: Control loop for regulating the LED current begins by maintaining the feedback voltage VFB at 0.6V.

To protect the circuit from such a condition, a few extra components can be added, Figure 8, to the basic circuit. If the gate voltage of Q2 reaches its turn-on threshold, Q2 will pull down the DIM pin on the converter. This will automatically stop the converter from switching and the output voltage will slowly drop until Q2 is turned off. The cycle will repeat so that the output voltage will vary around the overvoltage threshold, which is chosen to be within the operating range of the converter.

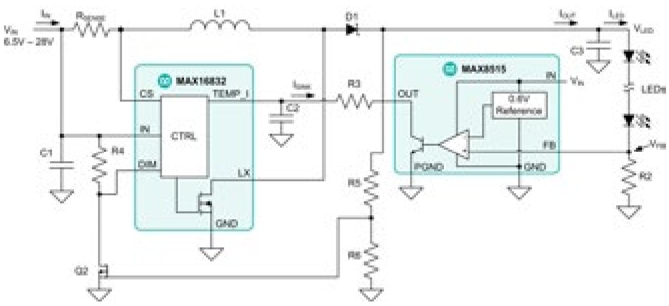


Figure 8: Over-voltage protection is needed when an LED fails open circuit, thus allowing C3 to become charged beyond the maximum rating of the IC.

Reference	Without LED current regulation	With LED current regulation
L1	100µH	100µH
R_{SENSE}	470mΩ	300mΩ
R2	N.A.	3Ω
R3	N.A.	27kΩ
C1, C2	1µF	1µF
C3	10µF	10µF

Table 1: key component values

Measurements confirm, extend analysis

To verify the buck/boost analysis and assess overall performance, two circuits were built and tested, one with the extra LED current regulation and one without it. The circuits were designed to drive eight LEDs (≈24V) at 200 mA from a 12-V input. The efficiency was estimated to be around 95%.

With the output at 4.8W (24V × 200mA), input power was 4.8 W/0.95 ≈ 5.05 W. Using a 12-V power supply, the input current should be regulated to 5.05W/12V ≈ 421 mA, which results in a 470-mΩ value for the sense resistor (200mV/421mA).

For the circuit with regulation of the LED current, R2 needs to be 3Ω (600mV/200mA). To extend the input voltage down to 8V, the sense resistor should meet the following condition:

$$R_{sense} < \frac{0.95 \times 8V \times 200mV}{200mA \times 24V} = 317m\Omega$$

so a value of 300mΩ was chosen.

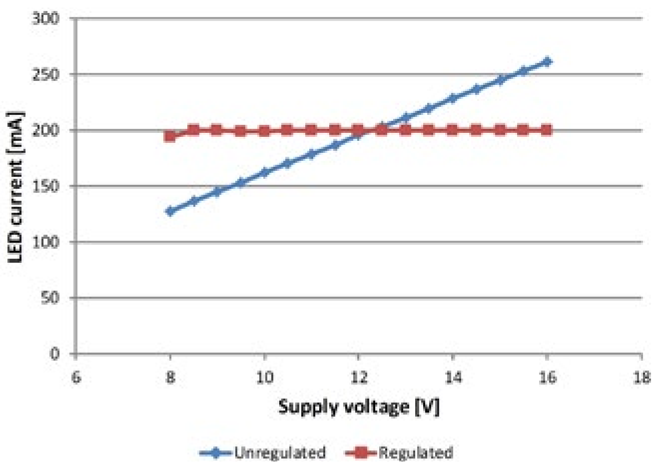


Figure 9: LED current versus input voltage with (red) and without (blue) additional regulation shows the output current's sensitivity to the value the input voltage.

To demonstrate the added value of the LED current regulation, the LED current was recorded for an input voltage range of 8V up to 16V for both circuits, Figure 9. It is clear is that for the circuit without LED current regulation, the LED current is only at its 200-mA target value when the input voltage is at its nominal value of 12V. For other values, it scales linearly with the input voltage. If the input voltage is regulated, the variation on VIN may be very small and result in an acceptable LED current variation.

In comparison, the circuit with LED current regulation does not show this effect but has a constant value over the entire input voltage range. The extra control loop clearly shows its value by regulating the LED current to the target value for the entire input-voltage range; it is slightly lower only with 8-V input. Most likely, the efficiency was slightly lower than the estimated 95% due to losses in R2. A quick measurement showed that the input current was at the maximum for VIN = 8V. A simple fix would be to lower RSENSE to 270mΩ.

Another nice feature of the hysteretic-buck LED driver is that the control loop is inherently stable, since there is no feedback. Adding the additional control loop introduces feedback, which could introduce instabilities. A Bode plot of the stability of the control loop revealed that the circuit has a phase margin of about 47°, which is sufficient to guarantee stable operation, Figure 10.

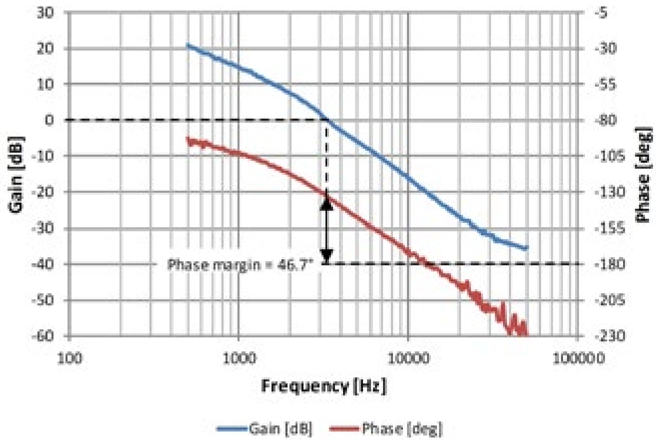


Figure 10: The Bode plot of the LED driver circuit with the current regulation confirms the circuit has sufficient phase margin to guarantee stable operation.

References

- MAX16832 data sheet: http://datasheets.maximintegrated.com/en/ds/MAX16832-MAX16832C.pdf
- MAX8515 data sheet: http://datasheets.maximintegrated.com/en/ds/MAX8515-MAX8515A.pdf

About the author

Fons Janssen is a Principal Member of Technical Staff for Maxim Integrated. Prior to joining the company in 2003, he worked at ThreeFive Photonics developing integrated optical circuits, and before that at Lucent Technologies, where he worked on optical-access networks. He graduated from Eindhoven University of Technology (The Netherlands) with an Electrical Engineering degree. Postgraduate studies at this university led to a Master's degree in Technological Design.

www.maximintegrated.com

European 'PowerBase' to Explore the Next-Generation Power Devices

Partners within the European 'PowerBase' project are developing the next-generation of energy-saving chips (or power devices) based on materials such as gallium nitride (GaN). Under the coordination of Infineon, they will prepare these semiconductors for mass industrial use in smartphones, laptops, servers and many other applications. Among the 39 project partners is imec. Its main role: looking beyond the traditional substrate technologies in order to improve the crystal quality of the GaN layer.

GaN: efficient power conversion

Power semiconductors play a key role in the power conversion in electronic devices such as smartphones, computers, servers and lighting systems, and photovoltaics. Built into the device's charger or power supply, they convert the mains voltage from the wall socket according to the needs of the device. A major requirement is keeping the amount of energy lost during conversion (usually in the form of waste heat) to an absolute minimum. Traditionally, Si is used as the base materials for power devices. But with its higher breakdown strengths, faster switching speeds and lower on-resistance, power devices based on the wide-bandgap semiconductor material GaN can convert power far more efficiently than Si-based chips. In AlGaN/GaN HEMTs for example, a very low on-resistance and high switching speed is obtained due to the two-dimensional electron gas (2DEG) which is formed spontaneously at the AlGaN/GaN interlayer.

Figure1: Imec´s GaN power devices on 200mm Si wafer

In the future, a new generation of GaN-based power semiconductors is expected to reduce the amount of energy lost in power supplies even further. They will also enable miniaturization in many applications where size matters. For example, chargers and power supplies will become significantly smaller and lighter. An important step on the way to a laptop power supply with the size of a matchbox or conveniently integrated into a power plug.

The PowerBase project

39 partners from nine European countries have joined the PowerBase project to develop these next-generation energy-saving chips. The PowerBase research focus includes intensive material and reliability research to improve the quality and lengthen the service life of GaN-based semiconductors. Plans also foresee the establishment of pilot lines for 200mm wafers to manufacture GaN-based power components in a high-volume industrial production environment. The project involves the entire value chain, covering expertise in raw materials research, process innovation, assembly innovation, pilot lines up to various application domains.

ECSEL Joint Undertaking PowerBase

Figure 2: The PowerBase project

Keeping Europe at the forefront

The overall research activities in the project are coordinated on a European-wide basis in order to make the new semiconductors ready for mass industrial use at globally competitive cost levels. Infineon Austria leads the PowerBase project, which kicked off in May 2015. It is a private-public partnership in which investments from industry, funding from individual countries and the support of the ECSEL (Electronic Components and Systems for European Leadership) Joint Undertaking are being applied. The 87 million euro project volume and the participation of so many partners give an idea of the great importance the EU is attaching to the project. PowerBase, set to run until 2018, will strengthen and expand Europe's status as a center of expertise for the development and production of innovative power electronics.

Imec looks beyond traditional substrate technologies

While SiC substrates are often preferred for easier thermal management, Si substrates have become very attractive for GaN growth because of their larger wafer diameter (200mm and higher) and lower costs perspectives. The growth of GaN on Si is however very challenging and is seen as a possible stumbling block for further improving on the current generation of GaN-based power devices. The lattice mismatch between Si and GaN and the thermal expansion mismatch during growth or cool down can lead to film cracking or wafer bowing, and can generate a high density of defects. The wafer bow also increases with increasing wafer sizes which makes up-scaling difficult.

Within the PowerBase project, imec will therefore look into new substrate approaches that provide a better (Al)GaN crystal quality and lower wafer bow. Novel substrates (such as AlN and Mo substrates) as well as alternative growth techniques will be explored. The target diameter for the advanced substrates is 200mm, and their compatibility with the pilot line activities within the PowerBase project will be assessed.

EpiGaN partners to push the boundaries of commercial state-of-the-art products

It is essential that the performance of these new developments can be benchmarked against state-of-the-art existing GaN-on-Si substrates that are produced on an industrial scale. For this task, imec's spin-off EpiGaN comes into the picture. As a partner in the PowerBase project, EpiGaN – a supplier of GaN-on-Si wafers – will continuously push the boundaries of its state-of-the-art GaN-on-Si epitaxial technology for power switching. They will act as a benchmark for the novel substrates developed by imec. As a result of the project, EpiGaN will also have established the technology to supply low-cost 600V GaN-on-Si on 200mm substrates to Europe and to the world.

Novel isolation technologies

Imec will also look into alternative techniques for the electrical isolation in GaN-on-Si power devices. Today, isolation in GaN-on-Si devices comprises of lateral and vertical isolation. While lateral isolation is provided by an isolation implant, vertical isolation is realized by the high-resistive buffer. In addition, one of the terminals, typically the source, is connected to the substrate to make sure it is not floating. This configuration however brings along limitations for some convertor topologies that consist of high-side switches (with the source at a high potential) and low-side switches (with the source at a low potential). With traditional means, those two switches cannot be co-integrated as the substrate can only be referenced to a single potential at a time. Therefore, imec will look into alternative isolation modules that allow increasing the level of integration.

This project has received funding from the Electronic Component Systems for European Leadership Joint Undertaking under grant agreement No 662133. This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme and Austria, Belgium, Germany, Italy, Slovakia, Spain, United Kingdom and the Netherlands.

www.imec.be

DC/DC Converters for Railway Applications

PEAK electronics has expanded its proven DC/DC converter family in DIP24 package with the PMRW series (P34TG), which features a 5:1 ultra-wide input. The new modules, which will be presented in Hall 3A, Booth 3A-620 at the SPS IPC Drives exhibition in Nuremberg,

Germany from November 24 to 26, 2015, are available with two input ranges from 13 VDC to 70 VDC and from 42 VDC to 176 VDC, and were specially designed for use in railway applications.

The DC/DC converters of the PMRW series deliver regulated output voltages of 3.3, 5, 12 and 15 VDC, and are available both as single and dual output. The power is 8 watt and the high efficiency ranges up to 86 %, depending on the module. The input/output isolation is 3000 VDC (3 kV DC). A continuous short circuit protection with automatic recovery is included. Furthermore, the devices provide overvoltage and overcurrent protection.

All DC/DC modules come in a 1.25 inch (31.8 mm) x 0.8 inch (20.3 mm) compact DIP24 metal case including remote on/off control pin. The operating temperature range is from -40°C to +85°C.

www.peak-electronics.de

Ultra-High-Efficiency 76V DC/DC Buck Converter

ROHM is announcing the availability of a 12 to 76V input, 3A variable output voltage, DC/DC Buck converter with integrated 76V MOSFET optimized for high power (high voltage x large current) applications such as motors, factory automation equipment, communications infrastructure, and industrial machinery.

The BD9G341AEFJ utilizes ROHM's high voltage 0.6um BiCDMOS process to achieve an industry-leading maximum breakdown voltage of 80V (the highest in ROHM's non-isolated DC/DC converter lineup) and a continuous operating input range of 12 to 76V, while market-proven advancedanalog design technology results in the highest conversion efficiency in its class. In addition, multiple protection circuits minimize heat generation, even during output pin shorts (contact), preventing possible damage and increasing reliability vs. conventional products. And the compact 8pin package requires fewer parts and reduces mounting area, contributing to easier PCB placement and end-product miniaturization.

www.rohm.com/eu

Dual-Channel USB-Port Power Controller Maximizes System Reliability

Microchip announces the expansion of its programmable USB-port power controller portfolio with the dual-channel UCS2112. This USB-port power controller supports two ports, with eight programmable continuous current limits, ranging from 0.53 to 3.0 Amps for each port, to enable faster charging times at higher currents. Features for

protecting and increasing overall system uptime also include integrated current monitoring, precision current limiting, charge rationing and dynamic thermal management. The UCS2112 helps designers to address a wide array of host devices, such as the laptops, tablets, monitors, docking stations and printers found in automotive, computing, education and aviation applications, as well as multi-port charging accessories and storage. This device has the flexibility to work individually, or in conjunction with USB hubs, to create a complete charging and/or USB-communication system.

For a better end-user experience, the UCS2112's dynamic thermal-management feature throttles back the current limit as it approaches the thermal limit, preventing shutdown and allowing for charging where other devices have stopped completely. The UCS2112's integrated current monitor eliminates the need for an external sense resistor and enables an "attach detect" signal that does not rely on the main power to be active for hosts that are off or sleeping. Current monitoring and rationing also help to manage multiple charging devices and can balance a dynamic load current for systems with smaller power supplies.

www.microchip.com/UCS2112-102615a

High Efficiency, Highly Integrated 8A and 3A Synchronous Buck Regulators

Intersil Corporation announced five highly integrated synchronous buck regulators that step-down 5V rails to point-of-load (POL) inputs as low as 0.6V for FPGAs, DSPs and microprocessors. The feature-rich ISL8018 delivers up to 8A of continuous output current from a 2.7V to 5.5V input supply, while offering up to 97% efficiency and higher integration than competitive devices. The 2 x 2mm ISL8003x family of devices delivers up to 3A of continuous output current from a 2.7V to 5.5V input supply and offers up to 95% peak efficiency for delivering general POL conversions in telecom, cloud computing, industrial, instrumentation and medical equipment.

The ISL8018 provides an innovative SYNCIN and SYNCOUT feature that connects and synchronizes multiple regulators at the same switching frequency in a master/slave configuration using a phase shifting time delay. This prevents ON time overlapping and reduces RMS current, ripple and input capacitance requirements to improve EMI and efficiency. With the ISL8018's VSET feature, the voltage output margining can be set at +/- 10% to compensate for output voltage IR drop. The ISET feature provides programmable output current limits to support 8A, 5A and 3A applications. This allows customers to leverage one design with smaller inductors for reduced costs and board area. In addition, the ISL8018's programmable switching frequency from 500 kHz up to 4MHz enables the use of smaller passive components for faster transient response and further board space savings.

The ISL80030, ISL80030A, ISL80031, and ISL80031A are pin-compatible and integrate very low RDS(ON) high-side PMOS and low-side NMOS MOSFETs, which reduces external component count and power losses. With lower die temperatures, these buck regulators allow the system to operate without cooling fans or heatsinks and still deliver a continuous 3A to the load, significantly increasing reliability. They also offer internal compensation, which eliminates additional

external components to reduce design complexity. The complete converter occupies less than 64mm2 of board space. And the ISL80031 and ISL80031A offer a light load mode to improve efficiency over all load currents when the system switches to a low power state.

www.intersil.com

Low Leakage Power Supplies Resuscitating Medical Technology

Powerbox introduces products in the medical Medline family. The OFM30 30W extra low leakage power supplies are best in class EMC for medical systems in CF class, and its leading OFM225 225W series suitable for BF class expands with additional voltages.

Designed to meet and exceed new safety standards for medical systems and equipment; and based upon an innovative building practice, reducing leakage current below 10 µA and EMC, the new Powerbox OFM30 series delivers 30W in continuous operation (peak up to 45W) features Class II double isolation and is UL/IEC60601-1 medically approved.

It is like the Holy Grail, trying to achieve low leakage current with low EMC, based on a very innovative design. The OFM30 combines both of them, reaching a leakage current below 10 µA and an EMC Class B average margin of 6dB.

Combining low power loss switching topology and selected components, the OFM30 series has an efficiency up to 88% whilst, fulfilling the Green Mode requirements of IEC60950-1, CEC Level V, EISA and ErP, at zero load. The OFM30 power consumption is below 0.3W thus assuring the family of its green credentials.

The OFM30 output power is rated at 30W continuously, at 50ºC and free convection cooling; though it can respond to peak demands for extra power (e.g. pump systems), allowing up to 45W during 10 seconds, with repetition every 100 seconds. In case of over temperature, the OFM30 integrates a unique protection system operating with linearity, reducing the output power down to 50%, securing the payload to proceed to all appropriated processes to avoid treatment disruption.

www.prbx.com

Small, Fast and Affordable: *flow*PHASE 0 Featuring NTC

Vincotech announced the release of its flowPHASE 0 family featuring NTC, a high-voltage half-bridge topology aimed to upgrade applications and drive down costs. This module is designed for charger, SMPS, solar, or ESS applications rated from 5 to 20 kW.

The speedy flowPHASE 0 modules featuring NTCs not only deliver high power density; they also facilitate and enhance the engineering effort. Low- and high-speed versions are available to satisfy the requirements of different applications.

High-speed versions can serve to attain switching frequencies up to 50 kHz. The latest IGBT chip technologies from various silicon manufacturers, alongside full current fast and efficient diodes, are on board to keep conduction and switching losses low. These modules ship with an integrated thermistor for temperature monitoring and cost-effective Al2O3 ceramic or AlN DCB substrates for high thermal performance.

The flowPACK 0 family comes in compact flow 0 housings 12 or 17 mm in height. Press-fit pins and phase-change material are available on request. These modules will be manufactured in series in early 2016.

www.vincotech.com

Precision DC calibrator offers ease of testing at high currents and voltages

The Yokogawa 2560A precision DC calibrator offers a simple, stand-alone solution for the testing and calibrating DC measuring instruments such as analogue meters, clamp meters, thermometers, temperature transmitters and data loggers.

The 2560A generates signals over a wide output range to enable the testing of products over their full operating ranges. In particular, it can generate DC voltages up to 1224 V and DC currents up to 36.72 A. By connecting two instruments in parallel, a maximum current of 73.44 A can be generated. These values are produced with high accuracy, high stability, and high resolution over the full voltage and current range.

Intuitive operation is provided by rotary dials and switches for each digit and function, along with traditional 7-segment LEDs to provide clear visibility. In addition, a range of computer interfaces enable the 2560A to be integrated into an automatic test system.

With the flick of a switch, the output can be swept within the source range with sweep times of 8, 16, 32 or 64 seconds. Linearity tests can be simply performed by dividing the output into steps, with a setting of four, for example, generating steps of 25, 50, 75 and 100% of the set output value.

When the deviation dials are adjusted to check the full-scale value on the meter, the deviation from the main output setting is displayed as a percentage of full scale. The output value calculated from the main, divider and deviation settings is displayed, so that the user can directly read the output value. The EMF equivalent to the thermocouple temperature and resistance equivalent to RTD temperature can also be displayed.

tmi.yokogawa.com

www.yokogawa.com

Isolated Converters Delivering Surface-Mount Space Savings

Dengrove Electronic Components has extended its range of RECOM R1Z surface-mount 1W DC-DC converters for isolating or converting DC power rails, giving more choices for engineers who need a regulated voltage within tight space constraints.

The 10-pin surface-mount R1Z modules occupy no more board space than standard unregulated converters, but ensure 1% load regulation to meet the demands of applications such as instrumentation, industrial controls and bus isolation. RECOM has recently completed the R1Z range, which now comprises 200 part numbers, and Dengrove is bringing all variants to the UK leveraging its close links with the Austria-based manufacturer.

The R1Z series offers versatile configurations, including 1kV or 2kV isolation, optional continuous short-circuit protection, and a choice of 3.3V, 5V, 9V, 12V or 15V output voltage. Customers can combine any output voltage with 3.3V, 5V, 12V, 15V or 24V input. All models integrate an EN 55022 class-A EMI filter, and are specified over the industrial temperature range -40°C to +85°C. The converters carry EN 60950-1 (safety) and EN 60601-1 (medical) certifications, and are backed up by a 3-year manufacturer's warranty.

www.dengrove.com

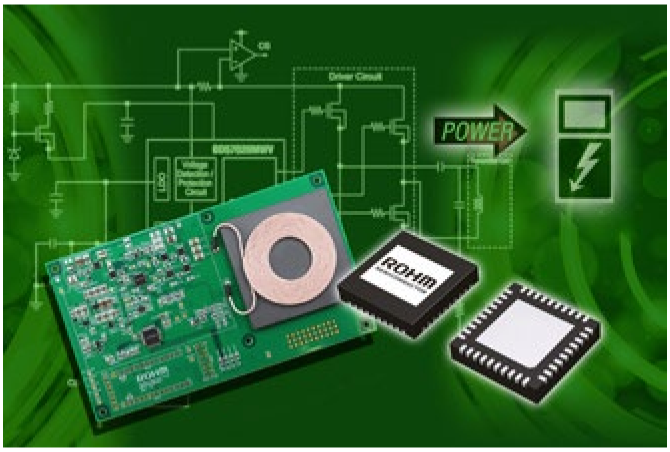
First Qi-Certified Medium Power Transmitter Reference Design

ROHM has received certification from WPC (Wireless Power Consortium) for its reference design using the BD57020MWV wireless power transmitter IC. This is the first device in the world certified to be compliant with the new Qi medium power specification.

WPC's Qi standard for medium power has attracted attention as a next-generation standard for inductive power transmission that will enable wireless charging of tablet PCs while allowing smartphones and other mobile devices to be charged up to 3x faster than the existing low power standard (5W). In addition, a Foreign Object Detection (FOD) function is included to provide greater safety by detecting foreign metallic objects before power transfer to protect against possible damage due to overheating.

In addition to pioneering the development of a wireless power transmitter IC (BD57020MWV) compliant with the Qi medium power specification, ROHM has developed a reference design that is expected to not only facilitate the introduction of wireless charging in new applications requiring higher power, but also accelerate adoption in applications that can benefit from wireless charging.

Going forward, ROHM will continue to provide safe, easy-to-use, end-to-end wireless power solutions, and is currently scheduled to receive Qi certification under the medium power standard for a reference design using the BD57015GWL wireless power receiver IC.



Wireless power technology is garnering increased interest in the mobile device market due to the capability of charging a variety of devices using a single charging pad while also contributing to improved device safety and reliability by enabling device connectors to be made more water-resistant and dust-proof.

www.rohm.com/eu

World's Smallest 75W Power Supply Series

Just after the successful launch of the world's smallest 120W-Power Supply last month, EOS Power announced the release of the (M) WLP75 series, yet another "smallest of its class"- power supply. The new (M)WLP75 Series is packed in a 2 x 3 x 1 inch (2,5 cm) profile, which makes the (M)WLP75 series the smallest convection cooled 75 Watt AC/DC-Converter on the market.

The (M)WLP75 Open Frame Series is the fourth and smallest addition to the EOS low profile high efficiency (M)WLP-series of products - following upon the successful releases of the 350W, 225W and 120W power supply ranges. The (M)WLP75 series is available in medical and industrial versions and again is packed with market leading specification.

www.eospower.com

Expanded Portfolio with Lowest On-Resistance Battery Protection Device

Alpha and Omega Semiconductor Limited announced the release of AOC3864, a common-drain 20V dual n-channel MOSFET with an ultra-low on-resistance of 5.7mOhms at 4.5V. This new device offers the best approach in designing battery protection circuit modules, while providing a strong and reliable solution. It's designed with a standardized pin-out layout of CSP products with the added superior mechanical robustness of AOS's patented AlphaDFN™ packaging technology. This new device joins the AlphaDFN family in targeting applications such as the latest smart phones, tables, media players, and wearable devices.

The growing demand on more data processing capabilities and longer operating time of current smart phones is driving the lithium battery toward another stage of higher capacity. At the same time, innovation in battery cell and charging technology is allowing higher charging current to power-up batteries much faster. As an essential device for battery safety design, MOSFETs with ultra-low on-resistance and small form factors are in high demand by smart phone designers.

Using AOS's latest silicon technology, the AOC3864 is able to achieve a 5.7mOhm at 4.5V maximum source-to-source resistance within an ultra-thin 2.7mm x 1.8mm x 0.19mm package. All while providing a robust structure to solve die chipping, cracking and placement issues associated with standard CSP products.

www.aosmd.com

Ultra-Compact 1,000W Power Supply

Excelsys Technologies, XSolo family of 1U high, ultra-compact single output modular power supplies offer designers of critical systems an off the shelf high reliability power solution. The most common way of increasing system reliability is to deploy a redundant power solution. This is much more cost effective that the alternative, which is to over-engineer the power supply using high grade components which are rated for a higher degree of thermal and electrical stress. All Excelsys XSolo power supplies are designed to operate in N + 1 redundant mode with no additional components and have I2C digital control for communicating to operators and system hosts. Redundant power systems are found in emergency, medical, security and communications systems, server rooms and data-centres.

To implement a redundant power system, a power supply is specified that can support the load by itself and second, identical power supply, is connected in parallel providing a system that is more reliable than its component parts. This is because the application will continue to function even in the event of one power supply becoming non-operational. This power supply configuration is commonly referred to as an N + 1 redundant system and may be extended to N + X depending on how critical the application is.

www.excelsys.com

Ultra-Thin Profile 60W Desktop AC-DC Adapter

Enargy Power announces the release of the new BM60 series of ultra-thin profile BladeAdapter™ for powering medical devices. Measuring just 127x65x22mm (5.0x2.56x0.87in), the enclosure is 34% thinner and has 28% less volume than typical 60W medical adapters available in the market today.

Compliant with the new 4th Edition of IEC60601-1-2:2014, which becomes effective in February of 2016, the BM60 series meets the more severe EMC immunity requirements for Professional, Home Healthcare and Emergency Medical environments. Additionally, the products satisfy the new US Department of Energy LEVEL VI energy efficiency requirements with less than 200mW no load power consumption and average efficiencies from 89-92% on 12V output models and above.

The BM60 series operates over a universal input voltage range of 90-264Vac with DC outputs available from 5 to 53.5Vdc. In fact, the BM60 series with 11 standard output voltages represents the broadest portfolio available, including 5, 9, 12, 15, 18, 19, 24, 28, 36, 48 and 53.5V options. The adapters are specified for operation up to 60°C with derating.

A peak power rating of 90W for up to 1sec makes them particularly well suited for driving motors and pumps with highly capacitive and inductive loads, such as CPAP & BPAP breathing devices. Protection features includes OVP, OCP, OTP and short-circuit protection. All models have 4000V reinforced isolation and are IP22 waterproof rated.

For more information: Contact Jingyi Yu (+1)800-988-2850; email: Jingyi.Yu@EnargyPower.com

www.EnargyPower.com

Advertising Index

Infineon’s building block µHVIC™ family

Now including new single channel low side drivers and single channel high side drivers

Addressing your need for high efficiency, fast design cycle times, stringent space constraints and high cost pressure, Infineon offers the µHVIC™ family - a collection of simple, high-voltage and low-voltage ICs for common circuit elements in power electronics.

Latest µHVIC™ product offerings:

› **IR44252L, IR44272L, IR44273L** – Tiny 5-Lead SOT23 single channel low side drivers with high drive capability up to 1.5A
› **IRS25752L, IRS20752L, IRS10752L** – Tiny 6-Lead SOT23 600V, 200V and 100V single channel high side drivers

www.infineon.com/microHVIC