PRODUCT AND TECHNOLOGY NEWS FROM FUTURE ELECTRONICS

FTM

FEBRUARY 2018
AMERICAS' EDITION

APPLICATION SPOTLIGHT:

Embedded Processing & Software

Renesas

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FUTURE ELECTRONICS

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Future Electronics' New Product Introduction (NPI) program is an important part of our commitment to servicing all of our customers' needs from prototype to production.

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Follow us on:

INTRODUCING THE NEW RX65N

SPECIFICALLY TAILORED FOR TODAY'S EMBEDDED PROCESSING CHALLENGES

Renesas' new RX65N MCU, the latest addition to the RX600 Series, is architected to address the fast-changing requirements of today's embedded processing applications. Offering a rich feature set, advanced security capabilities, and the superior 120 MHz Renesas RX v2 CPU core, the RX65N provides dual-bank flash memory with best-in-class speed, the fastest interrupt response time, and built-in hardware DSP, all in a cost-efficient, low-power 40-nm process.

Powerful single-chip solution

– No need for external memory

Performance without Sacrifice

- Dual-bank flash memory running at 50 MHz – over 60% faster interrupt response time vs. competitive MCUs
- Superior RXv2 CPU core with FPU
- Optimized DSP performance with 32-bit barrel shifter

On-Chip Security for Today's IoT

- Cost-effective Trusted-Secure IP (TSIP™) with embedded root key and Crypto engine
- Ideal for root-of-trust secure systems requirements

Advanced RX65N capabilities fit the requirements of today's embedded applications.

Efficient HMI Support

- Embedded TFT Display controller and 2D accelerator
- 384 KB RAM dedicated to LCD function
- Drives WQVGA resolution with double buffering, without the need for external memory

The powerful RX65N 32-bit MCU with Ethernet, TFT controller, security, and dual-bank flash with on-the-fly firmware updates is ideal for industrial and building automation requirements. The combination of a low-power 40-nm process with high-performance CPU is perfect for metering applications. The on-chip 2 MB of flash memory, built-in motor control timers, and DSP capabilities are optimal for advanced medical applications. And the built-in DSP and Ethernet features are ideally suited for digital audio.

Get a Renesas RX65N Kit (#YRTK50565N2S00000BE)

To learn more, please visit:

www.FutureElectronics.com/Renesas

RENESAS SYNERGY™ EMBEDDED PROCESSING PLATFORM

ALL-INCLUSIVE SOFTWARE PLATFORM SOLUTION ACCELERATES DESIGN INNOVATION

RENESAS synergy™
Accelerate. Innovate. Differentiate.

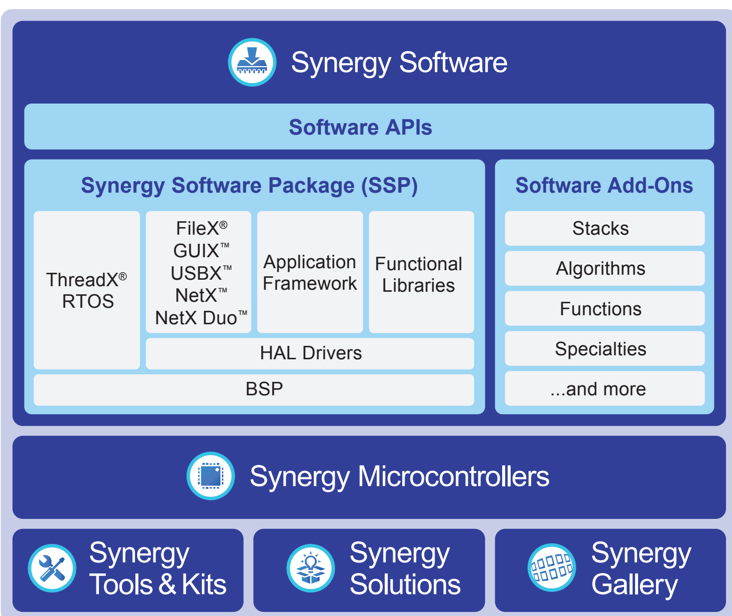
With ever-shrinking time to market, developers are facing increased pressure to get more products with more features to market, but on the same or truncated timetables as in years past. This leaves little to no time to properly research the latest microprocessors, tools, and software packages to create differentiated products. Inevitably, as products are rushed to consumers' hands, software quality also suffers with escaping bugs and missing product features, leading to returns, monetary losses, and an erosion of market potential.

The innovative Renesas Synergy™ Platform aims to help reduce these pitfalls in product development by giving control back to the developer and allowing them to focus on what matters most: creating innovative and differentiated applications on time with high quality. The platform consists of a qualified and tested RTOS and middleware package with an extensible and easy-to-use framework for leveraging third-party software, stacks, IP, or solutions. All of this runs on Arm® Cortex®-M microcontrollers (MCU) with a wide selection of peripherals to meet the exact needs of developers.

Challenges for the New Market

Barriers to Entry | Total Cost of Ownership | Time to Market

Unprecedented software quality. Fully warrantied by Renesas.



The Synergy Software Package (SSP) is the core of the Synergy platform and provides an extensible framework with a ThreadX® -based RTOS and accompanying middleware and drivers, fully warrantied and supported by Renesas. Software quality is a big aspect of the SSP, and the software quality assurance (SQA) process is based on ISO/IEC/IEEE 12207 standards. Renesas warrants SSP operation against the publicly available SSP software datasheet, a first for the microcontroller industry. Renesas stands behind not only its hardware, but the software as well, meaning developers can innovate at the application layer instead of reinventing low-level device drivers and libraries.

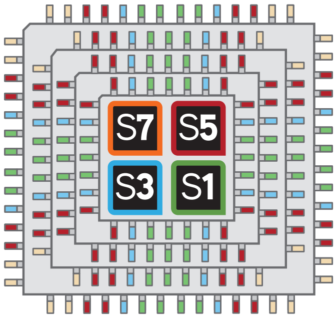
Third parties can extend the feature set of Synergy by providing their own software and hardware packages that stitch seamlessly into the Synergy framework. Verified software add-ons are tested by Renesas to ensure compatibility with each SSP release, and partner projects allow third parties to highlight the capabilities of the Synergy platform with their innovative extensions. These add-ons are showcased in the Synergy Gallery, allowing for easy download and inclusion in a developer's project.

Scalable hardware and software.

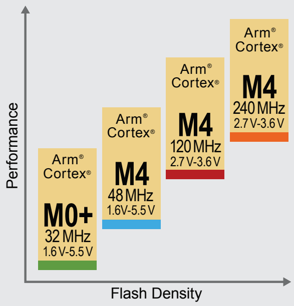
Scalability is at the core DNA of the Synergy platform. The four families of Synergy Arm MCUs are pinned out with similar feature sets in the same locations for each family. Additionally, similar peripherals in each family have the same register addresses and functionality, allowing the use of the same APIs. This allows the developer to scale their design with little to no change in software and hardware.

The Arm MCUs in the Synergy family have well over 60 variants and counting, with variable peripherals, feature sets, and package types. This wide variety allows a developer to easily scale up or down based on their project requirement. Developers can now invest in a platform and reuse a significant portion of their hardware and software development cycles across multiple product variants.

Package Footprint



Technology



- 40-nm and 130-nm processes
- Operating temperature range: -40°C to 105°C
- Flash: 64 KB - 4 MB
- SRAM: 16 KB - 640 KB
- Pin count: 36 - 224
- GPIO pins: Up to 172

Synergy Microcontrollers

Tools should not be the last thing you think about.

The RTOS, middleware, and tools are an often-overlooked part of the embedded software development process. However, these are some of the most critical pieces of the software puzzle as they form the basis for everything that will be developed on top of it.

With Synergy, everything needed for development is included with the platform. This includes the RTOS from ThreadX® and the accompanying middleware. Synergy works with the Eclipse-based Renesas e² studio or with Embedded Workbench® from IAR Systems. As an added benefit, both the Arm GCC and IAR compilers can be used under-the-hood of e² studio. Using IAR under e² studio gives the developer the best of both worlds: the highly efficient IAR compiler inside an Eclipse-based development environment. Synergy provides all of this, with no additional licenses or seat costs.

IAR SYSTEMS

RENESAS synergy™
Accelerate. Innovate. Differentiate.

Get a Renesas Synergy™ Target Board
(YSTBS3A6E10)
To learn more, please visit:
www.FutureElectronics.com/Renesas

XMOS® xCORE VocalFusion™ SPEAKER: Featuring Infineon's XENSIV™ MEMS Microphones with a 69dB Signal-to-Noise Ratio

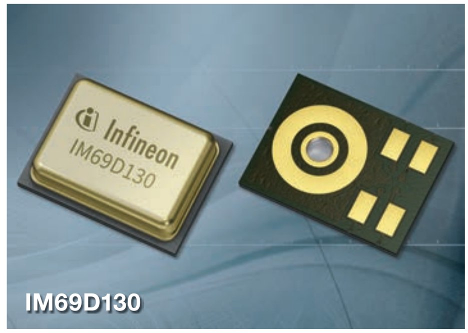
Infineon Technologies is entering the packaged silicon microphone market. With this it is addressing the needs for high performance, low noise MEMS microphones. The analog and digital microphones are based on Infineon's dual backplate MEMS technology and distinguish themselves with a 70dB signal-to-noise ratio (SNR). This is combined with an exceptionally low distortion level of 10% at a 135dB sound pressure level (SPL). In a 4 x 3 x 1.2mm XENSIV MEMS package, the microphones are very well suited for high-quality acoustic recordings and far field voice capturing applications.

Current MEMS microphone technology uses a sound wave actuated membrane and a static backplate. Infineon's dual backplate XENSIV MEMS technology uses a membrane embedded within two backplates thus generating a truly differential signal. This allows improved high frequency immunity for better audio signal processing and increases the acoustic overload point of 10% Total Harmonic Distortion (THD) to 135dB SPL.

The SNR of 70dB is an improvement of 6dB compared to a conventional MEMS microphone. This improvement is equivalent to doubling the distance from which a user can give a voice command that is captured by the microphone. Additionally, the analog and digital microphones have excellent microphone-to-microphone matching (±1dB sensitivity matching and ±2° phase matching) which is ideal for implementing in arrays. For this reason the XENSIV MEMS microphones are a perfect fit for ultra-precise beam forming and noise cancelling.

FEATURES

- SNR:69dB
- AOP: 13dBSPL
- <±1dB sensitivity matching at 1kHz
- <±2° phase matching at 1kHz
- Interface: digital (PDM)



- Infineon dual backplate XENSIV MEMS technology
- Package: 4 x 3 x 1.2mm³

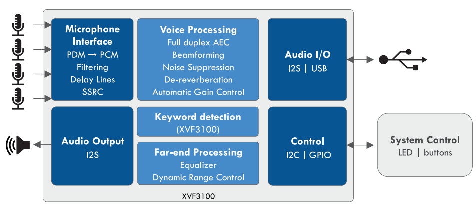
APPLICATIONS

- Voice user interface (VUI) devices
  - Smart speakers
  - Laptops
  - TVs and set top boxes
  - Smart home appliances
- Active noise cancellation (ANC) headphones and earphones
- Conference systems
- Cameras

XMOS is a leading supplier of far-field voice and audio solutions to the consumer electronics market. The company develops embedded interfaces that enable people to listen to the highest quality audio, and control electronic devices using their voice.

VocalFusion evaluation kits are designed to enable developers and OEMs to voice-enable edge-of-room consumer electronics products, and make the integration of the XMOS voice processing device simple in mass production.

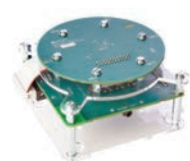
The xCORE VocalFusion™ Speaker kit provides high performance far-field voice processing solutions for voice-activated speaker applications. VocalFusion Speaker delivers direct interfacing to four PDM (Pulse Density Modulation) microphones in either linear or circular arrays, with a choice of USB or I²S interfaces to connect to application or host processors (-AVS kit is I²S/I²C only).



XMOS technology ensures voice sources are isolated from unwanted noise with the integration of advanced DSP techniques including beamforming, acoustic echo cancellation, de-reverberation and noise suppression. Optional keyword trigger detection is delivered on the device by Sensory TrulyHandsfree™, or the system processor such as the Raspberry Pi in the Amazon Alexa Voice Service (AVS) qualified kit.

VocalFusion Speaker Evaluation Kits

XK-VF3100-L33



XK-VF3100-C43

XK-VF3000-L33-AVS

FEATURES

- xCORE VocalFusion Speaker Evaluation Kits
  - High performance microphone array for voice interfaces
- Integrated microphone and voice DSP including full duplex AEC, noise suppression, de-reverberation, AGC
- Microphone interface
  - Direct interfacing to 4 PDM microphones (Infineon IM69D130)
  - Support for linear or circular arrays
- Audio output
  - I²S output to DAC, 16kHz PCM, and 48kHz PCM on the -AVS kit
- Host processor interface options
  - High speed USB2.0 compliant device
  - Optional I²S interface, with I²C for control
- Sensory TrulyHandsfree™ technology license included with XVF3100
  - Custom triggers and multi-language support available from Sensory

For more information on the XMOS Amazon AVS qualified kit, the only solution qualified for far-field linear applications, visit www.xmos.com/avs

To buy products or download data, go to **www.FutureElectronics.com/FTM**

PSoC® CREATOR™ 4.2

PSoC Creator is Cypress' intuitive Integrated Design Environment (IDE) that enables concurrent hardware and firmware editing, compiling and debugging of PSoC MCUs. Applications are created using schematic capture and over 150 pre-verified, production-ready peripheral components.

New in PSoC Creator 4.2

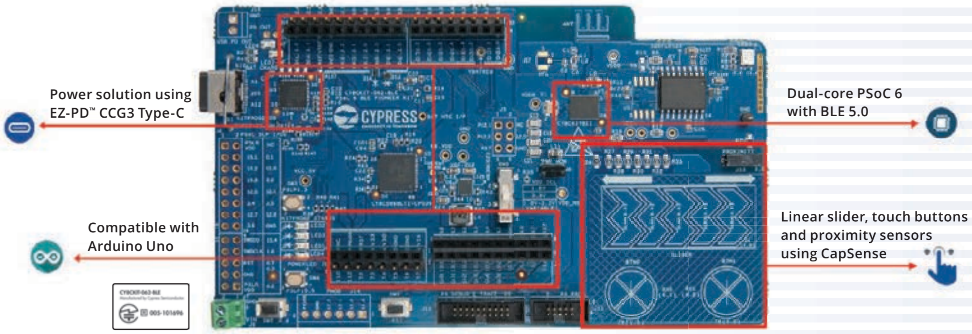
PSoC 6 Support

PSoC Creator 4.2 provides support for Cypress' newest IoT game-changer: The PSoC® 6 MCU. The PSoC 6 family is a series of dual-core MCUs, both of which have separate source code available in Creator. Building projects is fully automated for both cores so the result of a build is always a complete application in a single file for ease-of-use.

Peripheral Driver Library (PDL)

The Peripheral Driver Library (PDL) provides firmware to manage all the digital and analog peripherals included with PSoC Creator 4.2 such as CapSense®, USB, Bluetooth Low Energy (BLE), and more. PDL is a suite of highly-efficient, MISRA-compliant drivers for PSoC peripherals with a comprehensive, searchable documentation package that is HTML-based for easy viewing in any browser.

More info on PSoC Creator 4.2 is available in the Cypress Developer Community



Get started with PSoC Creator 4.2 and PSoC 6 MCUs with the **PSoC 6 BLE Pioneer Kit (CY8CKIT-062-BLE):**

Available now at Future!

For more information or to buy products, go to www.FutureElectronics.com/FTM

CYPRESS®
EMBEDDED IN TOMORROW™

APPLICATION SPOTLIGHT

Epson S1C31W74 32-bit MCU with ARM® Cortex® M0+ Core and Built-in LCD Driver

NEW PRODUCT INTRODUCTION

EPSON
EXCEED YOUR VISION

Epson's low-power MCU family with rich peripherals offers ideal solutions for display in consumer and industrial applications

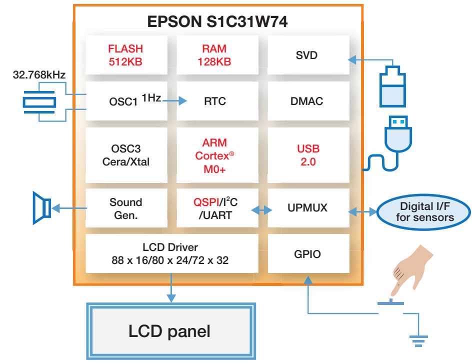
The S1C31W74 MCU is a 32-bit MCU with embedded ARM® Cortex® M0+ core and features low-power operation. S1C31W74 also features a rich set of peripherals, serial interfaces and embedded LCD drivers that makes it an ideal choice for implementing display solutions in battery-operated and power sensitive applications such as wearables, fitness gadgets, home/building and industrial automation applications.

The S1C31W74 features 512KB of embedded Flash memory, 128KB of SRAM, and supports a maximum clock speed operation of 22MHz. The MCU supports multiple clocking modes including RTC for performance and wide functionality. The S1C31W74 features 24-bit resistance-to-frequency converter (RFC) as well as serial interfaces including Quad-SPI (QSPI), USB 2.0 controller, 2-channels of UART 2 channels of I²C, SPI. The embedded LCD Driver supports 80 SEG x 24 COM and 72 SEG x 32 COM LCD output along with 16-levels of LCD contrast to interface with a suitable external LCD display. In addition, the MCU also features DMA controllers, ample number of GPIOs, watchdog timers and 16-bit PWM timers and sound generator to support other auxiliary system functions.

The operating voltage for S1C31W74 is 1.8V to 3.6V and with an operating temperature range of -40°C to +85°C. S1C31W74 is in production now with samples and evaluation kit available from major distributors.

FEATURES

- Embedded 32-bit ARM® Cortex® M0+
- Embedded 512KB Flash and 128KB RAM
- Max clock speed 22MHz
- Built-in LCD driver for 80 x 24, 72 x 32
- 24-bit resistance/frequency converter
- USB 2.0 device controller
- 32-level supply voltage detector
- Quad-SPI 1ch, SPI 1ch, I²C 2ch, UART 2ch
- 72 GPIOs
- Sound generator
- Memory display controller (software)



APPLICATIONS

Ideal for display solutions in:

- Wearables and fitness equipment
- Home appliances
- Factory automation
- Industrial equipment
- Consumer medical devices

To buy products or download data, go to **www.FutureElectronics.com/FTM**

MINMAX® POWER For A Better Future

A High Power Density & Performance DC-DC Converter for Space-Critical Applications

10-25W • MJ Group • 1" x 1" Package

- Higher Full Range Efficiency
- Excellent Energy Savings
- Lower Ripple & Noise
- Protection Functions on Abnormal Operation

c UL us UL 62368-1 UL 60950-1 | CB Scheme | CE | 3 YEAR WARRANTY | RoHS Compliant

General Industrial Power Solutions	Ultra-high Isolation Power Solutions	Railway Certified Power Solutions	Medical Safety Power Solutions
1-60W DC-DC Converter	1-60W DC-DC Converter	3-75W DC-DC Converter	1-20W DC-DC Converter
2-60W AC-DC Power Supply			24-60W AC-DC Power Supply

For more information or to buy products, go to www.FutureElectronics.com/FTM

DJ-H Series Latching Relays for Building Automation

NEW PRODUCT INTRODUCTION

Panasonic

Panasonic 1 Form A 50A Latching Relays for Building Automation – IoT Switching Actuators, Suitable For Lighting And Motor Loads

Panasonic, a worldwide leader in relay products, introduces the new DJ-H Series relays product line. The new DJ-H Series relays are single-coil or double-coil latching relays containing a UL rating for electronic ballast load of 20A at 277VAC/347VAC. This is the main switching requirement for lighting controls set by industry standard NEMA 410. DJ-H Series relays are also rated for 50A at 277VAC (or 30A at 480VAC) nominal resistive switching capacity. DJ-H Series relays are capable of withstanding ballast loads up to 347VAC required for the Canadian lighting market and have a TV-20 inrush rating. A manual switch lever is also available. The nominal operating power for the single-coil latching is 1,000mW and double-coil latching is 2,000mW contributing to higher energy savings. DJ-H Series relays are ideal for applications such as lighting control, shutters, and blind controls.

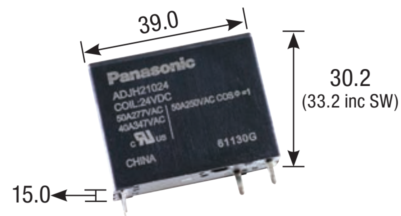
With the new DJ-H Series, Panasonic launches a latching relay to meet the requirements of the IoT and building automation market for switching actuators. The DJ-H Series power relay is equipped with a manual lever acting as a test button to allow electric installation service personnel to check circuits. It handles inrush currents created by capacitive load types like fluorescent lamps. Due to its cleverly designed internal structure and the excellent contact material, the relay switches 50A at 277VAC (resistive load) and is certified for fluorescent lamp loads acc. to IEC 60669-1 at 200µF/20A and 250VAC.

FEATURES/BENEFITS

- High capacity power relay with manual switch
- 20A at 27/347VAC electronic ballast rating (for Canadian market)
- Conforms to NEMA 410 standard for 347VAC
- 9.5mm clearance and 12.7mm creepage
- Maximum switching voltage of 480VAC
- 5,540W Tungsten load (TV-20 rating)
- 4,000V isolation between contact and coil
- Low coil power consumption
  - 100mW (single-coil latching)
  - 200mW (double-coil latching)
- Maximum ambient operation temperature at +85°C
- Flux resistant construction
- Various DC coil options: 5V, 12V and 24V
- 12kV surge breakdown voltage
- High inrush capability
  - 20A at 250VAC capacitive load (200µF)
- Supports manual operation
  - Manual switch type available
- IEC 60669-1 compliant
- UL/C-UL approved
- RoHS/REACH compliant

INDUSTRIES AND APPLICATIONS

- Lighting
- Building automation
- Industrial
- Lighting controls
- Shutter and sunblind control
- Power distribution unit (PDU)
- Industrial controls



Types	Ratings	Temperature	Cycles
Resistive	50A at 277 VAC	85°C	10k
	40A at 347 VAC	40°C	20k
	30A at 480 VAC	40°C	20k
Tungsten	5540W at 277VAC	40°C	25k
Standard ballast	20A at 120/277VAC	85°C	30k
	15A at 347VAC	85°C	30k
Electronic ballast	20A at 277VAC	85°C	6k
	20A at 347VAC		
TV	TV-20	Room	15k

ORDERING INFORMATION

ADJH 2 ☐ ☐ ☐

Contact arrangement
2: 1 Form A

Operation Function
1: Single-coil latching
2: Single-coil latching (reverse polarity)
3: Double-coil latching
4: Double-coil latching (reverse polarity)

Type classification
0: Standard type (without manual switch)
2: Manual switch type

Related voltage
05: 5V, 12: 12V, 24: 24V

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DC Fans with omniCOOL™ System

CUI INC

The CFM-V line of DC axial fans boasts superior performance and reliability compared to conventional sleeve bearing fans, thanks to its innovative omniCOOL system. This advanced bearing design bridges the cost-performance gap between traditional sleeve and ball bearing fan technologies. Incorporating a magnetic structure that enables rotor-balancing to minimize tilt, wobble, and friction, the omniCOOL system allows for fan operation at any angle. It also reduces the need for lubricant, further decreasing fan noise and friction. In addition, the bearing system extends operational life by utilizing a specially hardened material that provides additional heat resistance and offers protection against any abrasion that may occur.

Available with rated voltages of 5, 12, 24, and 48 Vdc, all axial fans come as standard with auto restart protection and feature options for tachometer signal and rotation detector depending on the model. Static pressure values range from 0.04 up to 0.41 inch H2O with low rated currents from 26 to 958 mA.

All models in the CFM-V series also carry UL/cUL 507 and TUV EN 60950-1 safety approvals while complying with EN 61000-6-1:2007 limits for EMI/EMC.

FEATURES

- omniCOOL system
- 40 ~ 120mm frame sizes
- Airflow, 5.4 ~ 138 CFM
- Speeds, 1700 ~ 8500 RPM
- Noise, 10.7 ~ 48dB

APPLICATIONS

- Telecommunications equipment
- Medical devices
- Industrial applications

To buy products or download data, go to **www.FutureElectronics.com/FTM**

100G QSFP28 and CFP2/CFP4 Optical Transceivers

LUMENTUM

100G Transceivers for Data Center, Enterprise, and Telecom Network Applications

Lumentum offers the industry's most comprehensive 100G short-reach, intermediate-reach, and long-reach transceivers for data center, enterprise, and telecom network applications. Our 100G portfolio includes QSFP28 transceivers supporting CWDM4, LR4, SR4, and CFP2/CFP4 LR4 transceivers. Compliant with a variety of industry standards and multisource agreements, our family of 100G transceivers has all the bases covered for your 100G network speed upgrades.

In addition to a wide selection of 100G transceivers, Lumentum also offers 10G tunable SFP+ optical transceivers.

To buy products or download data, go to **www.FutureElectronics.com/FTM**

FEATURES

CWDM4

- Optical line rate of 103.125Gbps (4 x 25.78125Gbps)
- Requires host system to enable RS-FEC RS (528,514) in accordance with IEEE802.3 clause 91
- Supports up to 5dB channel insertion loss including up to 2km of single mode fiber
- Operating case temperature range of 0°C to +70°C
- Power dissipation <3.5W

LR4

- Supports 100GBASE-LR4 for line rate of 103.125Gbps and OTU4 for line rate of 111.81Gbps
- Integrated LAN WDM TOSA/ROSA for up to 10km reach over SMF-28
- Operating case temperature range of 0°C to +70°C
- Low power dissipation <3.5W or <4W

SR4

- 100G Ethernet aggregate optical line rate of 103.125Gbps (4 x 25.78125Gbps I/O)
- 4Tx + 4Rx parallel channels for transmission on 8 parallel MMF fibers with up to 100m reach
- Operating case temperature range of 0°C to +70°C
- Power dissipation <2.5W (SFF Power Class 3)

CFP2/CFP4

- Compliant with 100GBase-LR4 and OTU4
- Supports 103.125 to 111.81Gbps line rates
- Operating case temperature range of -5°C to +70°C
- Low power dissipation <9W (CFP2), <6W (CFP4)

APPLICATIONS

- Local area network (LAN)
- Wide area network (WAN)
- Ethernet switches and router applications

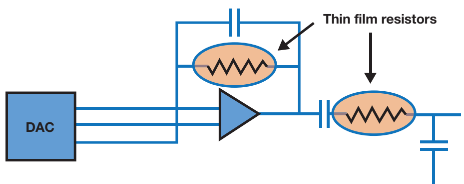
New Precision Audio Resistor, the RS Series

SUSUMU
Thin Film Specialist and Innovator

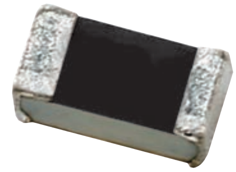
Susumu, an innovative precision thin film chip resistor manufacturer, introduces the RS series, a new chip resistor series specially created for audio applications.

Thin film resistors have been known to have better frequency characteristics, less noise, and less signal distortion than other types of resistors. It seems clear that for audio applications, the natural choice should be a thin film resistor. However until now, the usage of thin film resistors has been limited to high end audio despite the fact that the most popular audio devices on the market today are smart phones and automotive audio systems. Susumu contends that the sound quality of these popular audio systems can be improved significantly by utilizing thin film resistors, such as Susumu's RG series. However, Susumu wanted to make the RG series even better for all audio systems. After numerous prototypes, simulations, and evaluations by sound professionals, Susumu discovered that design methods of resistive patterns and terminal materials had the most impact on sound quality. The RS series was born as a series of thin film resistors targeted specifically for high quality Hi Fi audio applications.

The RS series is a perfect solution for any sound circuits including digital analog converter circuits. If you are interested in improving the sound quality of your audio devices, from high end to personal mobile devices, Susumu's RS series is the answer to your needs.



Typical digital analog converter circuit



PERFORMANCE CHARACTERISTICS

- Current noise: -40dB or less (typical)
- Frequency performance: up to GHz level (depending on resistance value)
- Tolerance: ±0.1%, ±0.5%
- TCR: ±25ppm
- Resistance range: 47-100KΩ
- Power ratings: 1/16W (1005 size), 1/8W (2012 size).
- Gold terminal available upon request

To buy products or download data, go to **www.FutureElectronics.com/FTM**

Non-Rechargeable Cylindrical Batteries: Lithium Batteries - Designed for High Capacity and High Temperature

Panasonic

Panasonic cylindrical lithium batteries are known for their high voltage, energy density.

Panasonic cylindrical-type lithium batteries come in both BR and CR Series. BR Series are used extensively as power supplies for a variety of meter type systems that require long life and also as memory backup power supplies. The CR Series is used widely as power supplies of high current devices such as cameras and lights.

FEATURES

- High energy density
- Long shelf life
- Stable operation
- High rate discharge
- Strong leakage resistance
- Excellent durability

APPLICATIONS

- Cameras
- Memory backup
- Utility meters
- Emergency signal light
- Electric locks
- Electronic measurement equipment

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omniCOOL™ System Improves Longevity and Performance in DC Fans

CUI INC

Fans are all around us and form an integral part of our mechanized, electronics centered lifestyles. From consumer appliances to large industrial machinery, devices we use every day rely on fans to expel hot air and keep them cool enough to operate reliably.

At the very heart of the fan – both literally and figuratively – is the bearing that enables the rotor to turn. A typical fan will need to make a significant number of rotations during its lifetime, so a lot gets asked of the bearing. It is therefore crucial that it is up to the task.

Types of Fan Motor Bearings

Fan motor bearings typically come in two forms: sleeve bearings or ball bearings. Both are widely used and well-understood, but both have their drawbacks.

Sleeve Bearings: The Pros and Cons

The simpler of the two traditional designs is the sleeve bearing (figure 1), so called because the central shaft rotates inside a cylindrical sleeve-like structure. Oil gets added to lubricate the bearing and enables the shaft to turn. The bearing sleeve holds the rotor in the correct position relative to the motor stator, and ensures there is a sufficient gap between the two.

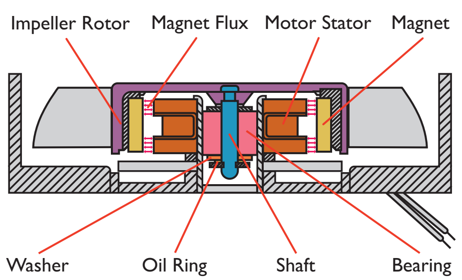


Fig 1: Cross section of a sleeve bearing

Sleeve bearings are highly impact-resistant and are significantly less expensive than ball bearings, but they also have their drawbacks.

Firstly, the gap between the shaft and the inside of the bearing bore needs to be as small as possible to minimize rotor wobble and tilt as it turns. However, this increases the contact area between the shaft and the sleeve, creating friction that limits how quickly and easily the fan can be started. It also signifies that more energy is required to start the fan and keep it turning.

Secondly, in a straightforward sleeve bearing, there are no additional methods of holding the rotor in position. This means the rotor weight is borne entirely by the shaft sitting in the sleeve. As the shaft rotates, it gradually wears away the inside of the bearing bore. Over time, this will distort the cross section of the sleeve. In fans that always operate in the same orientation, this results in an oval-shaped bearing sleeve that can make the bearing noisier, while affecting the rotation of the fan, causing it to wobble. Ultimately, this wear process shortens the life of the bearing and/or the whole fan unit.

This issue of bearing wear becomes a particular problem for fans required to operate in multiple orientations and angles, such as those used in portable equipment. As gravity will not always be pulling the rotor's mass in the same direction, the inside of the bearing will get worn in different directions and become uneven. This can exacerbate the noise and wobble challenges highlighted above.

Thirdly, sleeve bearings traditionally include an oil ring and Mylar washer at either end of the bore. These retain the aforementioned lubricant that is required to keep the shaft turning smoothly and quietly. However, the very presence of the oil ring and washer adds friction and hinders the escape of the gases generated by rotational friction. If these gases cannot escape, they solidify into nitride particles, which gradually clog up the bearing, impeding the shaft's rotation and shortening the life of the bearing.

Ball Bearings: The Pros and Cons

The other common type of bearing found in fan motors is the ball bearing (figure 2), made up of a ring of little steel balls surrounding the shaft. There are typically two such bearings in a fan motor, one in front of the other. Compared to a sleeve bearing, ball bearings reduce the amount of friction that must be overcome to start and operate the fan motor.

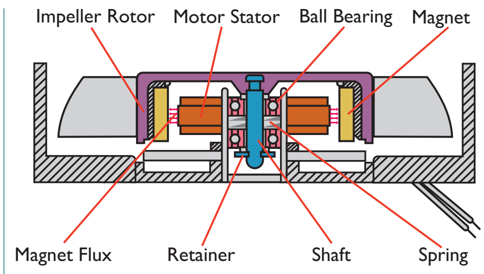


Fig. 2: Cross section of a ball bearing

Ball bearing systems also help to address the problem of uneven wear and rotor tilt/ wobble in sleeve bearings. This is because the two bearing rings are typically separated by springs that press them apart. The weight of the rotor rests on the inner bearing, closest to the rotor itself, while the springs help to mitigate any tilt to the fan blades that the weight of the rotor may cause. Having these springs all the way around the shaft means fans with this type of bearing can be used at any angle, making them suitable for portable devices. Less wear equates to a significantly higher MTBF on average compared to a sleeve bearing.

That said, ball bearings are not perfect. They are less robust than sleeve bearings, so they need to be treated with care and protected from impacts. They are also noisier, more complex, and costlier than their sleeve-based counterparts.

How the omniCOOL System Improves Fan Design

There is a third option, a fan design that incorporates magnetic rotor-balancing (we will refer to it from here on as the 'magnetic structure') and an enhanced sleeve bearing. This combination is called the omniCOOL system (figure 3).

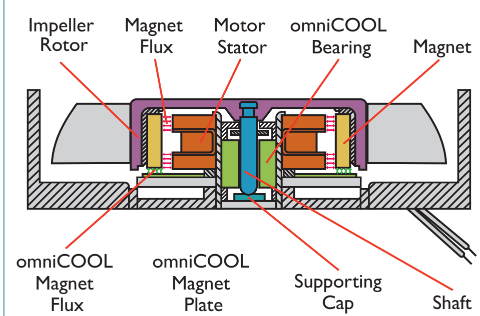
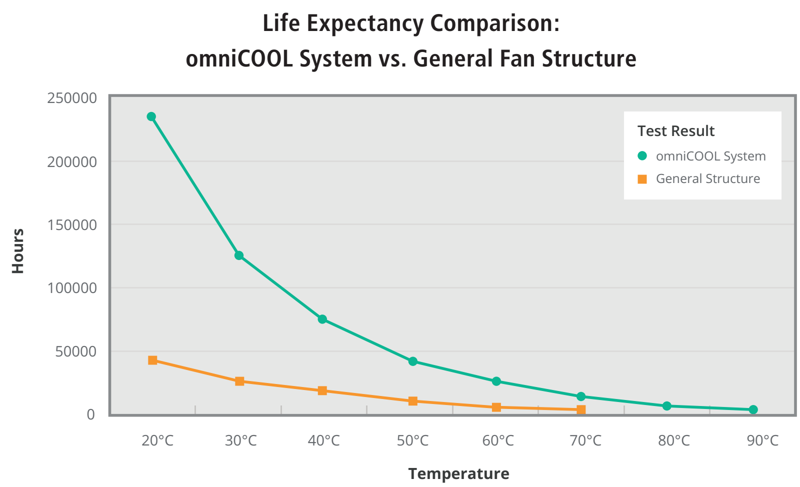


Fig. 3: Cross section of a fan motor with the omniCOOL system

In the omniCOOL system, the magnetic structure effectively makes the rotor work like a spinning top – but one that never falls over and can operate at any angle. The magnetic structure sits in front of the rotor and, because its flux is parallel to the direction of the rotor shaft, uniformly attracts the entire rotor, at whatever angle the fan unit is being held.



Useful Life	Temperature	20°C	30°C	40°C	50°C	60°C	70°C	80°C	90°C
omniCOOL	Test Result (hours)	231509	120459	65349	36820	21473	12923	8004	5090
General Structure		41842	24643	15013	9431	6092	4037	-	-

Fig. 4: Life expectancy of the omniCOOL system versus fans with a traditional sleeve bearing

The shaft tip is held in place by a supporting cap at the very front of the bearing bore. This forms the point around which the rotor can rotate, like the point on a spinning top. Thanks to the magnetic structure, the shaft and bearing sleeve no longer bear the weight of the rotor, which is instead suspended in the air. Additionally, the magnetic field works to lower the center of gravity by pulling the shaft downward, which minimizes the tilt and wobble issues that exist with traditional sleeve bearings, thereby enabling a fan with the omniCOOL system to be used at any angle. It also dramatically reduces the friction between the shaft and the inside of the bearing.

This type of magnetic structure can be applied to a traditional sleeve or ball bearing, but on its own it would not address all of the challenges we have looked at. And this is where the omniCOOL system's enhanced bearing design comes in.

Coupled with the magnetic structure, the omniCOOL system also incorporates an enhanced bearing design to further improve performance. While the magnetic structure greatly reduces contact between the shaft and the inside of the bearing, the bearing in the omniCOOL system is specially hardened to provide additional resistance to any abrasion that does occur. The omniCOOL system's bearing lining is highly heat resistant, capable of operating at up to +90°C. Therefore, this bearing design has a much longer operating life than a traditional sleeve bearing.

Secondly, because the magnetic structure prevents the shaft from physically rubbing against the inside of the bearing, the need for lubricant is reduced. The omniCOOL system takes advantage of this by removing the oil rings and Mylar washers that would be required in traditional sleeve bearings. This has several advantages. It removes a big source of friction, which reduces noise and makes it easier to physically start the motor.

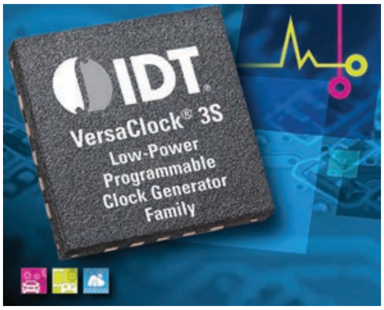
It also creates a clear space at either end of the shaft, enabling the gas generated by the rotational friction to escape, rather than solidifying and clogging the bearing. The eradication of the oil rings, Mylar washers, and other small components required in sleeve or ball bearings, means the omniCOOL system requires fewer parts, is easier to manufacture, and its quality is easier to assure compared to more complex designs.

omniCOOL System Solves Long-Standing Challenges of Fan Motor Design

CUI's omniCOOL system's blend of technologies results in a fan motor that addresses the long-standing challenges of traditional ball and sleeve bearings. Integrating a magnetic structure with an enhanced bearing delivers a quiet, robust, longer-life fan that can be used in any orientation, and is more affordable than a ball bearing design. As a result, CUI's fans with

the omniCOOL system neatly bridge the gap in the market between ball bearings and sleeve bearings, giving designers a genuinely new and different option when it comes to cooling their products.

Analog Signal Chain

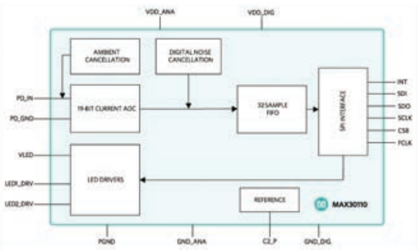


5L35023: VersaClock® 3S Programmable Clock Generator

The 5L35023 is a VersaClock programmable clock generator and is designed for low power and high performance PCI Express applications. The device is a three PLL architecture design, and each PLL is individually programmable, allowing for up to five unique frequency outputs. The 5L35023 has built-in unique features such as Proactive Power Saving (PPS), Performance-Power Balancing (PPB), Overshot Reduction Technology (ORT) and extreme low power DCO. An internal OTP memory allows the user to store the configuration in the device without programming after power up, then program the 5L35023 again through the I^2C interface.

FEATURES

- PCIe Gen1/2/3 compliant
- 1MHz to 125MHz output frequency
- 1.5ps rms jitter integer range: 12kHz - 20MHz
- 2 DIFF outputs with configurable LPHSCL, LVCMOS output pairs
- 3 LVCMOS out
- <65µA ultra-power-down
- Spread spectrum clock support to lower system EMI
- <2µA RTC clock in suspend mode operation
- Configurable OE pin function
- Maximum of 8 LVCMOS outputs

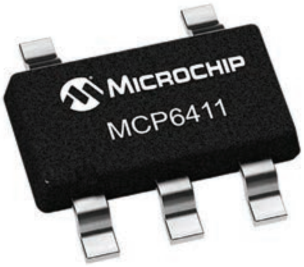


MAX30110/2: Optimized Pulse-Oximeter and Heart Rate AFE for Wearable Health

The MAX30110/2 is a family of complete optical pulse oximetry and heart rate detection integrated analog front-end. The devices integrated a high-resolution, optical readout signal-processing channel with built-in ambient light cancellation, as well as high-current LED driver DACs, to form a complete optical readout signal chain. With external LED(s) and photo diode(s), the MAX30110/2 offers the lowest power, highest performance heart rate detection solution for wrist applications. The MAX30110/2 operates on a 1.8V main supply voltage, with a separate 3.1V to 5.25V LED driver power supply.

FEATURES

- Reflective or transmissive heart rate, heart rate variability, or SpO2 monitoring
- 50mA, 100mA, 150mA, 200mA selectable LED current ranges
- 19-bit optical ADC path
- Less than 25µA power consumption at 25sps
- 20sps to 3.2ksps multiple sample rate options
- Two 8-bit LED current DACs
- Low noise current sources
- Built-in front and back end ambient light cancellation
- 32 sample FIFO to support batch processing
- I^2C (MAX30112) and SPI (MAX30110) interface



MCP6411: 1MHz Operational Amplifier with EMI Filtering

The MCP6411 is a single general purpose op amp offering integrated EMI protection and rail-to-rail input/output over the 1.7 to 5.5V operating range. This amplifier has a typical Gain Bandwidth Product (GBWP) of 1 MHz with typical quiescent current of 50 uA. The MCP6411 has enhanced EMI protection to minimize any electromagnetic interference from external sources. This feature makes it well suited for EMI sensitive applications such as power lines, radio stations and mobile communications.

FEATURES

- 50µA quiescent current
- 90dB EMIRR at 1.8GHz
- 1MHz GBWP
- 0.5V/µs slew rate
- No phase reversal
- ±1.0mV maximum input offset voltage
- 1.7V to 5.5V supply voltage range
- Rail-to-rail input/output
- Unity gain stable
- SC70-5, SOT-23-5 packages

Drivers

AL16937: Buck Dimmable LED Driver

The AL16937 is a high performance, high power factor, high efficiency, and high current precision buck dimmable LED driver for triac dimmable LED lamp applications. The wide switching frequency operates at boundary conduction mode (BCM) to ease EMI/EMC design and testing, and to meet the latest regulatory standards. The AL16937 LED driver integrates 400V/3A MOSFET and has the built-in thermal fold-back protection trigger point to automatically reduce output current.

FEATURES

- ± 3% current sense tolerance
- 210µA operation current
- Wide range of dimmer compatibility
- NEMA SSL6 dimming curve compliant
- Leading-edge blanking
- 100µA startup current
- Single winding inductor
- Integration of 400V/3A MOSFET
- Internal under-voltage lockout
- SO-7 package

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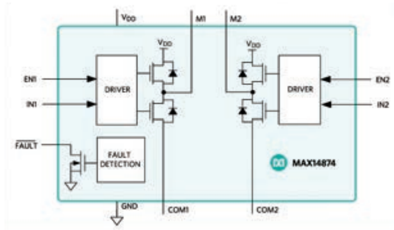
Drivers



MAX14874: 4.5V to 36V Dual Relay/ Valve/Motor Driver

The MAX14874 dual push-pull driver provides a small and simple solution for driving and controlling relays and valves with voltages between 4.5V and 36V. It is also designed to drive brushed DC motors. Separate COM pins allow monitoring of individual driver load currents. Peak currents up to 2.5A ensure for PWM controlled large motor torque. Low driver on-resistance reduces power dissipation. The MAX14874 features a charge-pump-less design for reduced external components and supply current.

FEATURES

- Up to 2.5A peak motor current
- Flexible 4.5V to 36V supply voltage
- Independent driver control for each driver
- Diagnostic active-low FAULT output
- Charge-pump-less architecture
- 480mΩ bridge on-resistance
- Individual current sensing
- Thermal shutdown under-voltage lockout
- -40°C to +85°C temperature range
- 3 x 3mm TDFN-EP package

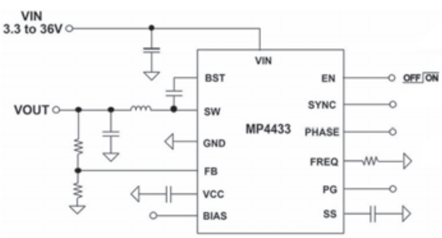
Power Regulation, Conversion and Management

ISL32740E/41E: High-Speed RS-485 Transceivers with Highest Reinforced Isolation

The ISL3274xE is a family of high-speed, isolated RS-485 differential bus transceivers that provide 40Mbps bidirectional data communication for Industrial Internet of Things (IIoT) networks. The ISL32741E offers 1,000VRMS working voltage and 6kV of reinforced isolation, more than 2x higher than competitive solutions. The higher working voltage and reinforced isolation is required for today's most rigorous medical and high-speed motor control applications. The ISL32740E with 2.5kV of isolation and 600VRMS working voltage comes in the industry's smallest package, enabling high channel density for programmable logic controllers (PLCs) in factory automation applications.

FEATURES

- 40Mbps data rate
- 5ns pulse skew and 20ns propagation delay
- 50kV/µs (typ), 30kV/µs (min) common-mode transient immunity
- 15kV ESD bus-pin protection
- PROFIBUS compliant
- 3V to 5V power supplies
- Single unit load allows up to 160 devices on the bus
- 44,000 years barrier lifetime
- Thermal shutdown protection
- 1k MSRP: $3.79 to $4.49 US



MP4433: 36V, 3A Synchronous Step-Down Converter

The MP4433 is a frequency-programmable (350kHz to 2.5MHz), synchronous, step-down switching regulator with integrate high-side and low-side power MOSFETs. It provides up to 3A of highly efficient output current with current mode control for fast loop response. The wide 3.3V to 36V input range accommodates a variety of step-down applications in automotive input environments and is ideal for battery-powered applications due to its extremely low quiescent current.

FEATURES

- 3.3V to 36V operating input range
- 1µA shutdown mode current
- 350kHz to 2.5MHz programmable switching frequency
- Synchronize to external clock, selectable in-phase or 180° out-of-phase
- Programmable soft start time
- Low dropout mode
- 3A continuous output current
- 10µA sleep mode quiescent current
- 3.3V, 3.8V, 5V fixed output options
- Power good indicator
- Selectable forced CCM or AAM
- 3 x 4mm QFN-16 package

PI3526-00-LGIZ: Cool-Power ZVS Buck Regulator

The PI3526-00-LGIZ is the latest addition to the Cool-Power ZVS Buck Regulator Portfolio with a 48V (30 - 60 V_{IN}) input. The PI352x is a higher current offering to the existing PI354x portfolio, enabling scalable power options for 48V Direct to Point-of-Load (PoL) applications. The PI3526-00-LGIZ is a 12V output regulator, supplying up to 18A, packaged in a 10 x 14mm LGA SiP package. Offering all the same industry leading features of Vicor's existing 48V Cool-Power ZVS buck regulators, the PI352x portfolio extends performance by delivering twice the power of the PI354x regulators using only a 40% larger package.

FEATURES

- 30V to 60V input voltage range
- Parallel capable with single wire current sharing
- Output over-voltage protection (OVP)
- Fast and slow current limits
- User adjustable soft start and tracking
- Constant voltage operation
- Input over/under-voltage lockout (OVLO/UVLO)
- Over-temperature protection (OTP)
- Differential amplifier for output remote sensing
- -40°C to +120°C operating range

Flyback Transformer Design: Practical Guidance on Minimizing Losses

By: David Woodcock, BSc, MEng, MBA, System Design Center Manager, Future Electronics

There are many possible topologies for a Switch-Mode Power Supply (SMPS), but the most popular for circuits supplying a load less than 150W is the flyback converter. Some estimates go so far as to suggest that up to 75% of offline power supplies use the flyback topology.

Many power-system designers are therefore faced with the challenge of developing a flyback converter circuit. To achieve the best performance, satisfy electrical specifications and stay within cost and space limits, the designer will need to implement some form of customization in the design; and the most important custom element of a flyback converter is the transformer.

In the design engineering community, transformer design and prototyping is generally regarded as a black art. To the uninitiated, the wide range of parameters affecting transformer performance – from selection of core material and size to the arrangement of the windings around the core – can appear confusing. In fact, the process of transformer design can be worked through in an orderly way by applying a small number of important equations, combined with a certain degree of trial and error – perhaps better described as 'experienced guesswork'.

The team of designers at the Future Electronics EMEA System Design Center (SDC, in Egham, UK) has gained much practical experience from its work on the development of custom power supplies for OEM customers. The purpose of this article is to share some of this experience and reveal effective ways to optimize transformer design in flyback converter circuits.

Flyback Topology: Theory of Operation

The flyback converter is an isolated form of buck-boost converter (see Figure 1). It consists of:

- A primary side switch, typically a MOSFET
- Two inductors in the form of a primary and a secondary winding around a magnetic core (see Figure 2). The windings are turned around a plastic bobbin which provides mechanical support and a set of pins for the wire connections and through-hole mounting on a PCB. In its operation, the arrangement of the two inductors is more correctly called a 'magnetically coupled inductor'. But because of the two separate windings, it is commonly referred to by designers as a 'flyback transformer'. Strictly this is a misnomer, but for convenience this article will refer to it this way.
- A secondary side switch, typically a diode
- An output capacitor

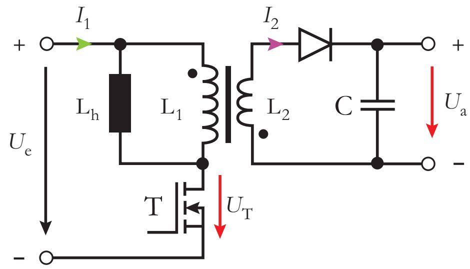


Fig. 1: a typical flyback converter circuit. (Image credit: Walter Dvorak, Wdwd on Wikimedia Commons, under Creative Commons license)

Feedback for control purposes across the isolation barrier is generally implemented with an optocoupler and compensation circuitry.

When the primary switch is turned on, current is drawn through the primary winding, generating a magnetic field which is readily transferred through the low-reluctance core to a small air gap in the center of the core, where stored magnetic energy accumulates. When the primary-side switch is turned off, the stored magnetic energy induces current to flow through the secondary winding and the output diode to the load.

The various advantages of this converter topology explain its widespread adoption:

- Isolation is readily achieved via the flyback transformer and optocoupler feedback compensation.
- Component count and cost are low.
- The turns ratio of the flyback transformer allows for a high ratio between input and output voltages, such as a 3.3V output directly from an AC mains voltage input.
- A single power stage can provide multiple output-voltage rails, of both positive and negative polarity.
- The flyback topology supports both step-up and step-down operation (it is a buck-boost topology).

But there are drawbacks to the flyback converter. The most important are:

- Voltage stress on the MOSFET and output diode are high, and widely variable from design to design.
- Relatively high noise, due to high peak currents and high voltage peaks at both switch elements during switch transitions. The flyback transformer may also contribute noise via coupling across and radiation from the windings.

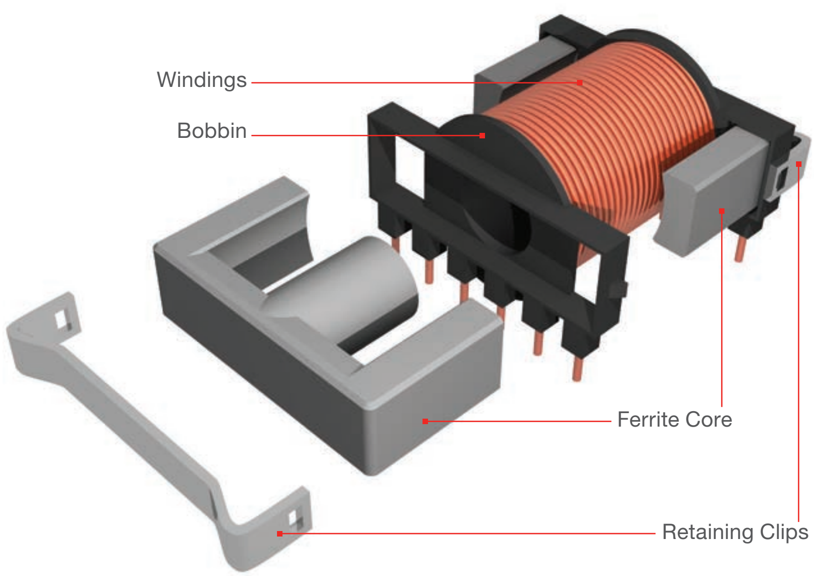


Fig. 2: diagram showing an exploded view of an inductor made from a winding on two E-shaped cores. The transformer's air gap is formed between the opposing faces of the center arms of the core. (Image credit: Cyril Buttay under Creative Commons license)

How Converter Specification Affects Transformer Design

Optimization of the flyback transformer is determined by the key parameters specified by the designer, which are:

- Output power
- Switching frequency
- Peak and average current values in the primary and secondary windings (taking account of the worst case of maximum load at minimum input voltage)
- Primary inductance
- Maximum flux density
- Turns ratio

Before the designer can begin the process of designing the flyback transformer, however, the conduction mode of operation needs to be chosen: Continuous Conduction Mode (CCM), Discontinuous Conduction Mode (DCM) or Critical Conduction Mode (CRM). The process of transformer design is the same for all three conduction modes, but in any power converter the operation is different, and fundamentally so in the case of the flyback converter, because the transfer function of the converter is different in each case, affecting feedback compensation.

There is substantial literature available to guide the designer's choice, so this article does not deal with conduction modes in detail. Practical experience at the Future Electronics SDC suggests that the choice is most often determined by:

- Size and cost pressures, in which case DCM has the advantage because of its lower inductance requirement.
- Requirement for low conduction losses and high efficiency at higher output power levels, in which case CCM is preferred because peak and Root Mean Square (RMS) output current are lower for any given output-power value.

A further decision to be taken early in the development process is the choice of core material. The main parameters affecting the choice of core material are maximum flux density, reluctance and cost. For flyback transformers the magnetic material most commonly used is ferrite. This is a cheap material which suffers from low losses at switching frequencies up to around 500kHz. Ferrite cores become saturated at a relatively low flux density, typically around 0.4T. This means that, in designs using a conventional ferrite core, flux density should be kept to a value no higher than 0.3T at the peak primary-side current to avoid saturation.

The Causes of Losses, and How to Manage Them

It is a rare power converter design project in which the engineer's attention is not firmly focused on power efficiency, and the minimization of power losses. In general, loss reduction helps to reduce thermal stress and the need for cooling devices, improves system reliability, and enables the creation of a smaller, lighter and cheaper end product.

In a flyback converter, there are many sources of loss, including MOSFET and diode conduction and switching losses, output capacitor ripple-current loss, snubber losses, and input and output filter losses. But in most cases by far, the greatest proportion of total losses is attributable to the flyback transformer. Therefore, there is considerable benefit to be gained from efforts to reduce transformer losses.

It is helpful to start with an understanding of the various sources of loss within a flyback transformer. These are:

- Copper losses due to the DC and AC resistance of the copper wire used for the primary and secondary windings.
- Proximity losses due to the effect of closely-coupled currents within a strong magnetic field, concentrating current flow in a portion of the copper wire's cross-section.
- Leakage inductance – magnetic field leakage results in electrical power loss. This must also be taken into account in the circuit design, since the level of leakage inductance directly affects so-called 'snubber losses'. A basic requirement for avoiding magnetic field leakage is to locate the air gap inside the winding.
- Loss in the magnetic core material due to the switching action and the inherently hysteretic behavior of core materials.

Copper Losses

The amount of loss in a winding's copper wire is influenced by:

- The current waveform, and the relative sizes of the DC and the AC components
- The overall DC and AC resistance of the windings
- Switching frequency
- Proximity loss

In particular, a high switching frequency and a relatively high AC component in the current waveform will increase resistance due to the so-called 'skin effect'. The skin effect causes high-frequency AC components to be conducted toward the outer surface of the wire, effectively reducing the cross-sectional area of the conductor, and therefore increasing its resistance.
Future Electronics' practical evaluation of real-world transformer designs operating at switching frequencies below 100kHz has shown that the skin effect – and copper losses – can be minimized by using single-strand copper wire with a diameter of ≤0.5mm.

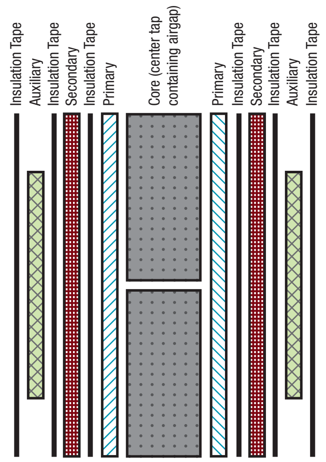
Proximity loss also adds to the losses in copper wiring: in essence, a conductor which carries a high-frequency current induces copper loss in an adjacent conductor by a phenomenon known as the proximity effect. This effect causes copper losses to compound with each additional layer in a multiple-layer winding.

To minimize the effect of proximity losses, therefore, the designer must keep the number of winding layers to a minimum: ideally no more than two or three for the primary and secondary windings, particularly when the current waveforms have a high proportion of AC components (which is the case in DCM operation).

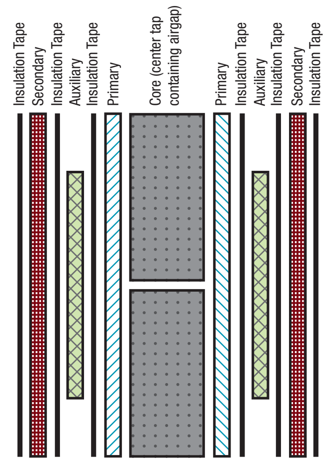
Leakage inductance is a function of the number of turns squared (N^2) and the winding geometry. To minimize leakage inductance for a given core and bobbin, the designer should choose a core that provides an appropriate cross-sectional area, thus minimizing the number of turns required to reach the target inductance.

FlybackTransformer Design: Practical Guidance on Minimizing Losses (cont'd)

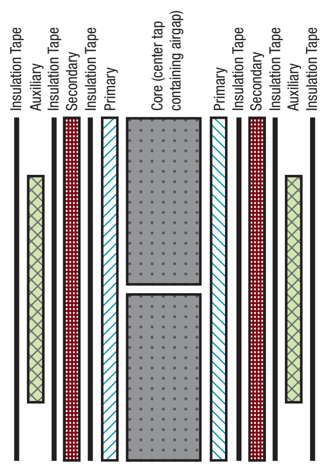
Another important step is to provide the best possible coupling between the primary and secondary windings. The best results are achieved when the winding widths of the primary and secondary layers are matched, and kept on adjacent layers, or when the secondary layer is sandwiched between two primary windings (see Figure 3).



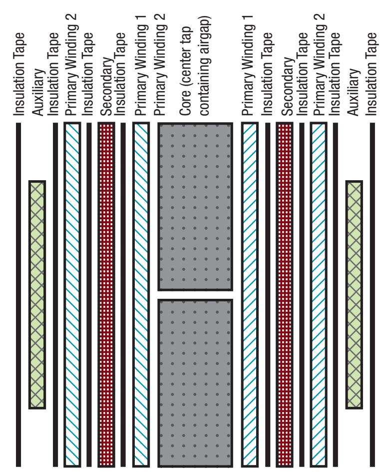
Example 1: Single winding layers (one primary and one secondary) = LOW Leakeage Inductance



Example 2: Single winding layers (one primary and one secondary), with auxiliary in between) = HIGH Leakeage Inductance



Example 3: Single winding layers (one primary and one secondary) with mismatched winding widths) = HIGH Leakeage Inductance



Example 4: Sandwiched secondary layers (two primary windigns and one secondary) = LOW Leakeage Inductance

Fig. 3: examples of various winding configurations that produce low or high leakage inductance

Core Losses

Energy is required to effect a change in the magnetization of the core. Not all of this energy is recoverable in electrical form; a fraction is lost as heat. This power loss can be observed electrically as the hysteresis of the B-H loop.

The losses are generally proportional with the change in flux density (ΔB) and the square of the switching frequency (F_{sw}^2).

For magnetic components in general, there is a trade-off between saturation flux density and core loss. The use of materials with a high operating flux density offers benefits in the form of reduced size, weight and cost. For example, silicon steel cores typically have saturation flux densities of 1.5-2T. Unfortunately, such core materials also suffer from high core loss.

In contrast, ferrite cores are ceramic materials which have low saturation flux densities in the range 0.25-0.5T. But because their electrical resistivity is high, their core losses are low. Ferrite core materials commonly used in flyback transformers include 3C90 from Ferroxcube and the Magnetics® 'R' material (see Figure 4).

Curves showing core losses at various switching frequencies (typically plotted as core loss in kW/m³ over ΔB, measured in Teslas) are provided in material datasheets, and can be used to estimate the core loss in any given application.

All of the considerations of loss above also have an effect on the calculation of core size.

Fig. 4: a 70 x 54mm Magnetics ferrite 'E' core

Readily available technical papers explain various methods for determining core size. In Future Electronics' experience, it is often better to start with a slightly larger core size than strictly necessary, if space and cost constraints allow, since this will reduce the number of turns, core losses and leakage inductance.

In addition, it is best to choose a bobbin for the core of choice which provides the best winding length-to-height ratio: this will minimize the number of winding layers required.

The Next Step: Hands-On Prototyping

This article has outlined the important theoretical factors and design decisions that have to be taken into account in developing a design for a flyback transformer on paper. It also provides some guidance drawn from Future Electronics' practical experience of transformer design, affecting factors such as core sizing and winding arrangement.

With this information, the designer is ready to embark on the practical process of building a transformer prototype in the laboratory .

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Silicon Carbide: Time for the Adventurous Designer to Take Advantage of the Latest Standard Products

By: Erich Niklas, Power Specialist FAE, Future Electronics

The performance advantages of Silicon Carbide (SiC), a wide bandgap material, are well known to designers of high-voltage power systems. The drawbacks of the products and the supply chain that supported them, however, have in the past appeared sufficiently serious to dissuade some designers from taking the risk of using SiC components in switching power converters.

A distributor such as Future Electronics is in a unique position to see the rapid evolutions as they happen in a growing market, such as that for SiC MOSFETs. And it is clear now that the drawbacks of standard SiC products that might have discouraged some designers in the past have for all intents and purposes been eliminated.

It is true that the successful use of a SiC MOSFET in power circuits which historically would have used a silicon MOSFET or IGBT calls for a rethinking of the approach to the design, as this article will explain. But the availability, reliability and affordability of SiC MOSFETs have all improved dramatically compared even to two or three years ago. Adventurous designers who are prepared to think differently about high-voltage system components can now gain a substantial advantage over systems that fail to move on from the familiar silicon MOSFET or IGBT.

SiC: Time to Break Out of Its Niche?

To date, usage of SiC MOSFETs has generally been confined to end product types in which an unusually high value is placed on efficiency, power density and light weight, or high-temperature operation. For these reasons, SiC MOSFETs are widely used in:

- Inverters in renewable energy generation systems
- Deep-hole drilling equipment
- Aircraft
- Induction heating systems

The distinctive requirements of these applications reflect the particular strengths of SiC power semiconductors (see Figure 1):

- Extremely low switching and conduction losses – a SiC MOSFET's zero reverse-recovery charge helps markedly improve conversion efficiency. SiC MOSFETs also have lower on-resistance than silicon equivalents, and on-resistance is more stable over temperature.
- High switching frequency – the ability to operate at maximum frequencies as much as ten times higher than that of an IGBT with the same voltage rating means that a SiC MOSFET requires much less inductance and capacitance, helping the designer to reduce system size and weight.
- High thermal conductivity, which allows the use of a smaller heat sink, again helping to reduce size and weight.
- High-temperature operation – this gives the designer greater headroom in the design of the thermal management system, and can again enable the use of a smaller heat sink.

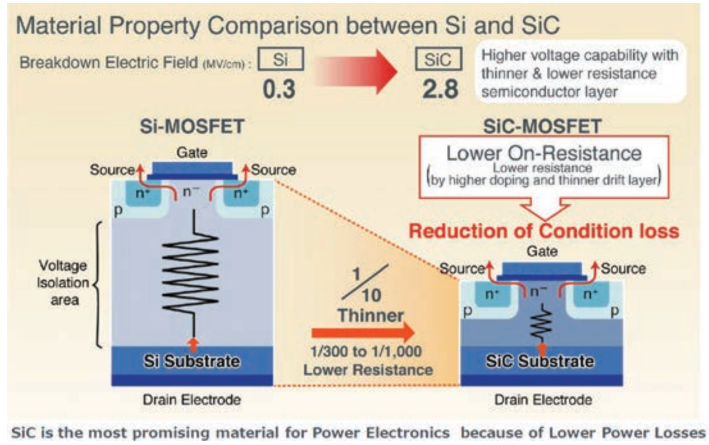

Fig. 1: comparison of the construction of a silicon (left) and a SiC (right) MOSFET

Despite the substantial physical superiority of the SiC material over silicon, however, SiC's share of the market for power transistors remains small, and this is probably due to designers' fears over the three factors of availability, reliability and affordability. These fears in the past had a reasonable foundation; SiC MOSFETs did indeed suffer from these drawbacks until relatively recently. On all three counts, however, the situation today is very much improved or indeed eliminated altogether.

Broader Supply Base

Before 2010, there was only one high-volume source of SiC wafers: Cree. Naturally, this meant that the supply chain for packaged SiC MOSFETs was tight and volatile. Today, the situation is very different; several semiconductor manufacturers now perform in-house SiC wafer fabrication, including, in Europe, ROHM Semiconductor and STMicroelectronics, as well as ON Semiconductor and Littelfuse.

At the same time, supply volatility has been greatly reduced. In the past, one market sector – inverters for solar power-generation equipment – sucked up almost all of the available supply, leaving a tiny surplus for the wider market. This meant that it was very hard to predict in any given month whether any product would actually be available to buy.

With more suppliers in the SiC market, there has been a huge increase in the rate of production of SiC wafers, and so the inverter market consumes a smaller proportion of total production. There is now a reliable unallocated supply at any time of available-to-buy standard SiC MOSFETs from distributors such as Future Electronics that are committed to the technology.

Improved Reliability

Another concern that has discouraged designers from the use of SiC MOSFETs has resulted from reports of poor reliability compared to equivalent silicon devices. In the early years of SiC production, this was justified. Over the past five years, however, SiC device manufacturers have spent heavily to implement sophisticated and effective testing and validation processes which enable them to identify potentially weak devices and to prevent them from entering the supply chain.

In fact, SiC device manufacturers now make detailed quality test reports freely available on the web. These provide users with assurance that the quality and reliability of SiC MOSFETs are now equal to that of any equivalent silicon device.

Unit Cost vs System Cost

The third concern that designers have had, affordability, has to some extent declined in importance as the supply chain has broadened. Market forces have worked their usual magic, and a better balance between supply and demand has helped to put downward pressure on the unit cost of SiC MOSFETs.

More significantly, SiC device manufacturers are starting to migrate production to larger wafer sizes. Today, 70% of the world's SiC devices are fabricated in small 4″ wafers. Some manufacturers, such as ROHM Semiconductor and STMicroelectronics, have already begun SiC production on 6″ wafers; this gives a huge reduction in production costs, and this will feed through into lower prices for packaged devices.

The fall in SiC device costs relative to silicon device costs is set to continue as well, since manufacturers' road maps forecast production on 8″ wafers in 3-5 years, promising another big fall in production costs.

Nevertheless, SiC is a more expensive material than silicon, and the unit cost of SiC MOSFETs is noticeably higher than that of silicon MOSFETs or IGBTs, and will likely remain so. But when total system cost, rather than MOSFET unit cost, is compared, the SiC alternative can be preferable in high-voltage power-system designs – provided the user is prepared to rethink the circuit design to make the most of the attributes of SiC devices.

This can mean for instance:

- Reducing the size, weight and cost of the heat sink, and allowing a SiC MOSFET to run hotter than the equivalent Si MOSFET or IGBT. ST's SiC MOSFETs such as the 1,200V SCT50N120 are rated for a maximum junction temperature of +200°C, compared to +150°C for a typical silicon MOSFET and +175°C for an IGBT.
- Increasing the switching frequency and reducing the size of the inductor and capacitors in the power-converter circuit.
- Including transportation costs in the system cost budget. A system based on SiC technology should be both lighter and smaller than the silicon-based alternative, and this can result in a substantial reduction in shipping charges.

Care Required in Board Layout

As part of the process of rethinking the power system, the designer must also consider the special factors that affect the way a SiC-based circuit is laid out on the board.

In particular, high di/dt and dv/dt ratios during switching operations call for careful design of all switching loops and nodes. It is important to keep a close eye on parasitic inductance and capacitance in the design to keep current/voltage spikes at a minimum and to reduce the risk of exceeding EMI emissions limits.

A successful SiC layout requires smaller and more carefully designed switching paths than is the case with designs using silicon devices. There are however tools available to guide the designer through the process of optimising the layout; the Dynamic Characterization Platform, a tool developed jointly by Littelfuse and Monolith Semiconductor, is a good example.

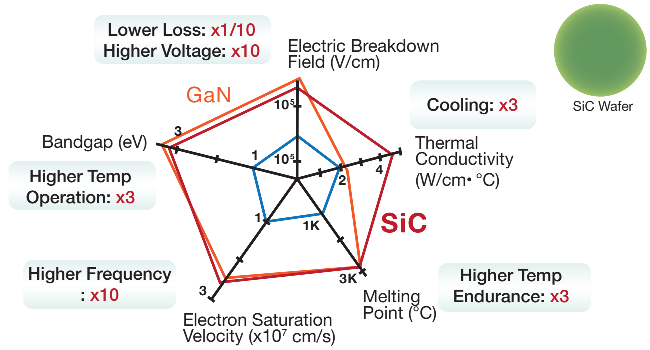

Fig. 2: Comparison of attributes of SiC, silicon and gallium nitride (GaN) semiconductor materials

Figure 2 illustrates in a diagram the size of the advantage that SiC devices (and gallium nitride, another wide bandgap material) have over silicon equivalents. When implemented successfully, these devices can produce dramatic results. Examples of successful designs implemented by customers include:

5kW LLC DC-DC converter:

75% smaller than the equivalent siliconbased design, with 85% weight saving. 60% more efficient.

60kW inverter:

Total power dissipation reduced by 75%; lower component count.

Silicon Carbide: Time for the Adventurous Designer to Take Advantage of the Latest Standard Products (cont'd)

6-20kW EV battery charger:
Up to 50% higher power output with the same physical dimensions as the equivalent silicon-based design.

Magnetic bearing amplifier:
80% reduction in filter inductor size and weight, 25% output power increase.

New Opportunity to Improve System Cost and Performance

The description above shows that SiC devices are now ready for use in any high-voltage power-switching application. SiC offers lower on-resistance for higher efficiency, and higher switching frequency for smaller passive components and reduced size and system cost. Lower power losses at high temperature and support for a higher maximum junction temperature help to reduce the cooling requirement and enable the use of a much smaller heat sink.

In addition, SiC MOSFETs are easier to drive, resulting in a lower component count and giving reduced bill-of-materials cost and improved reliability.

As Tables 1 and 2 show, there is a large and healthy supplier base today for SiC diodes, MOSFETs and modules. The problems of availability, reliability and affordability have been eliminated by the SiC device manufacturers' investments in production, design and testing.

For high-voltage system designers, the time has come for experimentation with the latest standard SiC devices in new designs.

Supplier	Diode			MOSFET				Module	
	600V/650V	1200V	1700V	650V	700V	1200V	1700V	hybrid	full SiC
ROHM	x	x	x	x	x		x		
STMicroelectronics	x	x		x		x	x		
Microsemi	x	x	x		x	x	x		x
ON Semiconductor	x	x	•	•	•	•	•		•
Littelfuse	x	x	•			x			•
Panasonic									•
Remark	x = Production								
	o = Design								

Table 1: SiC packaged device manufacturers' current and planned product portfolios

Schottky diodes								
Voltage (V)	Current (A)	Current (A)	Current (A)	Current (A)	Current (A)	Current (A)	Current (A)	Current (A)
600/650	2/4	6	8	10	12/15	20	30	40/50
1200	2	5/6		10	15/16	20	30	40/50
1700				10			30	50

MOSFETs								
Voltage (V)	$R_{DS(ON)}$ (mΩ)	$R_{DS(ON)}$ (mΩ)	$R_{DS(ON)}$ (mΩ)	$R_{DS(ON)}$ (mΩ)	$R_{DS(ON)}$ (mΩ)	$R_{DS(ON)}$ (mΩ)	$R_{DS(ON)}$ (mΩ)	$R_{DS(ON)}$) (mΩ)
650	10	20/25		60	80	120		
650	17	20		55				
700/750		20	35		75	125		
1200		20/22	30	40	80	160	280	450
1200			30	52/65	80/85	169		500
1700							750	1000/1150

Table 2: typical specifications for SiC power ICs available as packaged parts from STMicroelectronics, ON Semiconductor, Littelfuse, ROHM Semiconductor and Microsemi


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- Power Factor Correctors (PFC)
- Electric/Hybrid Vehicle Chargers
- Uninterruptible Power Supplies (UPS)
- Telecom Power Supplies
- Server Power Supplies

NEW PRODUCT INTRODUCTION

Devices*	Description	Voltage (V)	Current (A)
FFSPxx65	SiC Diode	650	6, 8, 10, 12, 16, 20, 30
FFSPxx120	SiC Diode	1200	5, 8, 10, 15, 20
FFSHxx120	SiC Diode	1200	10, 15, 20, 30, 40
FFSDxx120	SiC Diode	1200	8, 10

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For more information or to buy products, go to www.FutureElectronics.com/FTM

*The SiC diode family comes in a range of packages: TO-247-3L, TO-247-2L, TO-220-2L, D2PAK, and Die. The xx notation in the part number indicates current level.