FTM

FUTURE ELECTRONICS

FUTURE TECHNOLOGY MAGAZINE

19-iv **AMERICAS**

LATEST

Discover the new entry-level S5 MCUs from Renesas

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DESIGN

Best practices for designing induction motors and PMSMs

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TECH VIEW

Why it pays to choose your AC-DC converter topology carefully

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MOTOR CONTROL

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Entry-level MCU offers high security capability for use in IoT end points

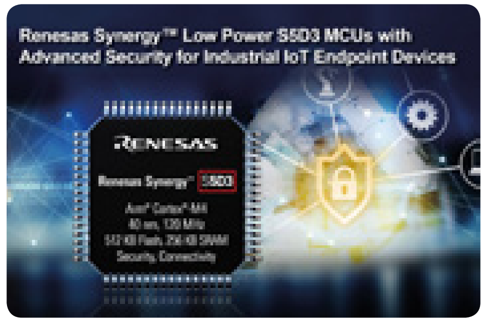
RENESAS
BIG IDEAS FOR EVERY SPACE

Renesas Electronics has extended its Synergy™ S5 MCU series with the introduction of the entry-level S5D3 MCU group. The four new S5D3 MCUs join the mid-range S5D5 and high-end S5D9 MCU groups in the S5 series.

Based on a 120MHz Arm® Cortex®-M4 core, the S5D3 MCUs provide features, including advanced security capabilities, which simplify the design of cost-sensitive, low-power IoT end points.

In addition, the Renesas Synergy Software Package (SSP) supports the S5D3 MCUs through the provision of drivers, application frameworks and a real-time operating system. Embedded system designers can use either the Renesas e² studio or the IAR Embedded Workbench® integrated development environment to build and customize their designs.

Based on a 40nm fabrication process, the S5D3 MCUs integrate a secure cryptographic engine, the SCE7, with key protection which safeguards boot code and IoT end point device communication with a root of trust. This capability eliminates the need for external security functions. The SCE7 features encryption hardware accelerators for RSA, DSA, AES, ECC and SHA cryptography, alongside a true random number generator, to enable secure system connections to the cloud.



The S5D3 MCUs feature 512kbytes of Flash memory and a large 256kbyte SRAM. This 2:1 ratio of embedded Flash to SRAM supports intensive utilization of communication stacks for robust IoT connectivity. The 8kbytes of data Flash enable more read/write cycles than competing MCUs.

ENERGY · INDUSTRIAL · LIGHTING · MEDICAL · TRANSPORT · SECURITY · CONSUMER · TELECOMS

APPLICATIONS

- Industrial equipment
- Building automation
- Office equipment
- Smart metering
- Home appliances

FEATURES

- Operating current:
  - 100μA/MHz in active mode
  - 1.3μA in stand-by mode
  - 900nA in battery power-saving mode
- Two 12-bit ADCs
- Two-channel 12-bit DAC
- High-speed six-channel comparator
- Temperature sensor
- Six-channel programmable gain amplifier
- USB, CAN, I²C, SPI, SDHI and SSI interfaces

FTM DEVELOPMENT BOARD
Orderable Part Number: YSTBS5D3E10
Available at FutureElectronics.com

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Integrated power modules provide point-of-load power at high efficiency

RENESAS
BIG IDEAS FOR EVERY SPACE

The ISL8212M and ISL8210M from Renesas are analog power modules which provide a single-channel, synchronous step-down, non-isolated power supply circuit to a point-of-load such as an FPGA or DSP.

The ISL8282M and ISL8280M modules have the same electrical characteristics, but provide a PMBus channel interface rather than supporting analog control. Integrated LDOs provide the module's bias voltage, allowing for single-supply operation.

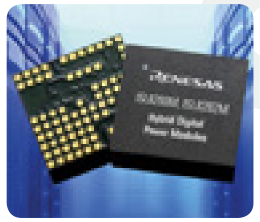
All four modules accept a wide 4.5V to 16.5V input-voltage range, and provide an output ranging between 0.5V and 5V. The ISL8212M and ISL8282M are capable of delivering up to 15A of continuous current, and the ISL8210M and ISL8280M have a 10A maximum current rating.

The ISL82xxM products benefit from proprietary Renesas R4™ technology. The R4 control scheme offers extremely fast transient performance, accurately regulated frequency control, and comprehensive internal compensation. Variable-frequency and duty-cycle control during load transients provide for the fastest possible response.

An efficiency-enhancing Pulse Frequency Modulation (PFM) mode greatly improves light-load efficiency, while peak efficiency at full load is as high as 95%.

The module integrates all power and most passive components in its thermally-enhanced 12mm x 11mm x 5mm HDA package, and requires only a few external components. The addition of optional external resistors provides for flexible configuration options for parameters such as frequency and output voltage. The modules' excellent efficiency and low thermal resistance allow for full-power operation without a heat-sink.

The ISL82xxM modules also feature remote voltage sensing and completely eliminate any potential difference between remote and local grounds, improving regulation and protection accuracy.



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APPLICATIONS

- Telecoms, storage and network equipment
- Industrial equipment
- Automatic test equipment
- Graphics cards
- Power supply for an ASIC, FPGA, DSP or memory IC

FEATURES

- ±1.5% load and line regulation with remote sense
- 256 output-voltage levels set via configuration pin
- Seven switching frequency options from 300kHz to 1MHz
- Start-up into pre-charged load
- Power-good monitor for soft-start and fault detection

FTM DEVELOPMENT BOARD
Orderable Part Number: ISL8212MEVAL1Z
Available at FutureElectronics.com

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COMPONENT FOCUS

New true bi-directional synchronous buck-boost controllers for industrial battery-powered applications

RENESAS
BIG IDEAS FOR EVERY SPACE

Renesas Electronics has announced an innovative new family of bi-directional four-switch synchronous buck-boost controllers.

The ISL81601 and ISL81401 are the industry's only true bi-directional controllers that sense peak current at both ends and provide cycle-by-cycle current limiting in both directions while in buck or boost mode. They generate Point-of-Load (PoL) power supplies at a peak efficiency of up to 99%.

The ISL81601 has a wide input-voltage range of 4.5V to 60V and produces a 0.8V to 60V output. This is compatible with most industrial batteries, which typically operate at 12V, 24V, 36V or 48V. Also available is the ISL81401, which has a 4.5V to 40V input range and 0.8V to 40V output range, and a unidirectional counterpart, the ISL81401A.

The ISL81601 and ISL81401's bi-directional peak current-sensing capability eliminates the complex external circuitry required for charging and discharging a battery that supplies power to loads. Their proprietary algorithm provides smooth transitions between buck, boost and buck-boost modes, while reducing low-frequency ripple at the output. This produces minimal disturbance during line or load transients. The algorithm also maintains a predictable ripple voltage under all conditions.

Designers can easily expand system power by paralleling an unlimited number of controllers. The ISL81601 and ISL81401 operate two switches at a time to minimize power loss and achieve higher efficiency.

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APPLICATIONS

- Battery back-up power supplies
- USB Type-C™ power supplies and chargers
- Battery-powered industrial applications
- Aftermarket automotive equipment
- Redundant power supplies
- Robots and drones
- Medical equipment
- Security and surveillance equipment

FEATURES

- Programmable frequency range: 100kHz to 600kHz
- MOSFET drivers with adaptive shoot-through protection
- Light-load efficiency mode
- 2.7μA shut-down current
- Frequency dithering for lower EMI in ISL81601 and ISL81401
- Over-voltage, under-voltage, over-current, over-temperature and short-circuit protection

FTM DEVELOPMENT BOARD
The ISL81601EVAL1Z evaluation board features the ISL81601, a 60V synchronous buck-boost controller.
Orderable Part Number: ISL81601EVAL1Z
Available at FutureElectronics.com

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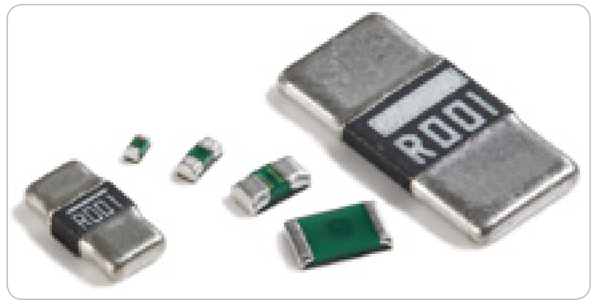
Precise chip resistors offer stable current-sensing performance

YAGEO

Yageo's PA series of metal current-sense chip resistors offer very stable performance over a broad operating-temperature range from -55°C to 170°C. They are suitable for all types of current sensing, voltage division and pulse applications.

AEC-Q200 qualified for use in automotive equipment, the PA series resistors feature a robust all-welded construction which offers superior resistance to atmospheric sulfur. The devices' excellent temperature coefficient of resistance, as low as ±50ppm/°C, makes it suitable for use in applications exposed to wide temperature variations.



Yageo's PA series: Suitable for use in wide temperature variation applications

The PA series resistors are available in case sizes from 0201 to 2512, and in resistance values from 0.5mΩ to 100mΩ. Designers can specify the resistance value with a tolerance of ±0.5%, ±1% or ±5%.

Jumper chip resistors are also available in the PA series.

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APPLICATIONS

- Consumer goods
- Computers
- Telecoms and datacoms equipment
- Industrial equipment
- Power supplies
- Automotive systems

FEATURES

- Power ratings: 0.05W to 3W
- Excellent current sensing performance
- Low power dissipation
- ≤0.3μV/°C thermal EMF

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Poke-in wire connectors make wall-mounting easy

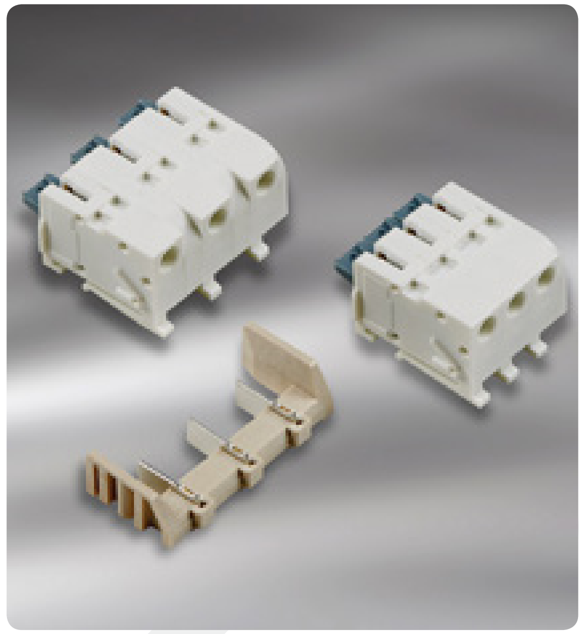
TE Connectivity's (TE) BUCHANAN WireMate two-piece poke-in series of connectors provides designers with a three-directional solution for wall-mounting a device. Terminations are easy to make, and present no difficulties even to the novice installer.

Wires are routed through an opening in the wall to TE's BUCHANAN WireMate connector mounted on a wall plate. Once stripped of insulation, wires may be easily poked into the terminal block device, providing a reliable termination without the need for tooling. Wire extracting is also easy by means of a simple lever. The system provides a flat connector surface reserved for wire marking. Color options are available.

The mating header is surface-mounted to the PCB in the device to be mounted on the wall.

The two-piece combination allows for wall mounting of a device in three different directions: into the wall, along the wall, or in a twisting or rotating motion.

Separate headers and connectors are available with 2, 3, 4, 5, 6, 7 or 8 positions. The connector/header combinations are supplied in 5mm and 8mm versions.



TE's BUCHANAN WireMate: Flat connector surface reserved for wire marking

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APPLICATIONS

- Thermostats
- Smoke detectors
- Control panels
- Environmental monitors

FEATURES

- Current ratings:
  5A for 18 AWG wire
  3A for 20 to 24 AWG wire
- 250V AC voltage rating
- 2mm panel thickness
- 10mm height from wall plate to PCB
- UL recognized

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Ethernet jacks with integrated magnetics save board space

Ethernet jacks from TE Connectivity (TE) with integrated magnetics and Power over Ethernet (PoE) capability offer a highly integrated connectivity solution for industrial Ethernet applications.

TE Ethernet jacks support power delivery via Power-over-Ethernet

The use of a three-wire choke improves EMI performance and allows for remote powering of peripherals over the Ethernet cable. The new jacks comply with the IEEE 802.3at PoE+ standard, under which up to 25.5W of power may be supplied per port.

The integrated magnetics eliminate the need for external magnetic components, saving board space and reducing system component count.

The TE Ethernet jacks operate over an industrial temperature range of -40°C to 85°C and can be used in reflow soldering production processes at 260°C for easy and cost-effective manufacturing.

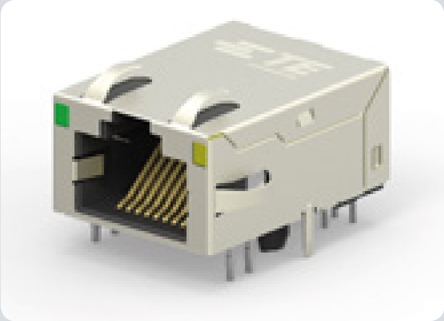
ENERGY INDUSTRIAL LIGHTING MEDICAL TRANSPORT SECURITY CONSUMER TELECOMS

APPLICATIONS

- Industrial communications equipment
- Industrial machinery
- Production equipment
- Automated test equipment

FEATURES

- High resistance to corrosion
- Minimum 750 mating cycles
- 2,250V DC dielectric withstanding voltage



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INTERCONNECT • PASSIVE • ELECTROMECHANICAL COMPONENT FOCUS

New heavy-duty connector products extend design flexibility and add CAN bus support

The Heavy Duty Sealed Connector Series (HDSCS) of connector products from TE Connectivity (TE) meets the rigorous demands of the commercial vehicle industry and of off-road applications which require the highest standards of performance. They can also be used whenever environmentally sealed circuit protection is needed in applications subject to high levels of vibration.

Made from a rugged UL 94-V0-rated thermoplastic material, HDSCS connectors have an integrated secondary lock with a termination feature which can be used for inline or flange-mounted applications in a wire-to-wire or wire-to-device configuration.

Rated to IP67, and to IP6K9K when used with a backshell, HDSCS connectors are available in five housing sizes with four keying options. They are offered in arrangements ranging from two to 18 positions. TE also supplies products in the HDSCS series which support the CAN bus architecture.

The HDSCS connectors are available in four connector colors and with mechanical polarized keyings to reduce the risk of mating and identification errors.

TE's HDSCS: Housings available in five sizes

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APPLICATIONS

- On-highway and off-road trucks
- Commercial passenger buses and school buses
- Construction equipment
- Agricultural equipment
- Special vehicles

FEATURES

- Voltage ratings up to 60V DC
- Familiar AMP MCP contact system
- Accessories:
  - Backshells
  - Protection caps
  - Cavity plugs
  - Fixing slides

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Shorting caps provide long-lasting method for closing or opening circuits in outdoor lighting fixtures

TE Connectivity's (TE) LUMAWISE Endurance N Shorting Caps provide a safe, convenient and economical method to close or open the primary circuit path across a NEMA-compliant receptacle on an outdoor light.

The ANSI-compliant LUMAWISE Endurance N caps have an IP66 rating for use in harsh outdoor environments.

TE's LUMAWISE shorting caps: High resistance to impacts

Description	Part Number
LUMAWISE Endurance N Shorting Cap assembly	2328118-1
LUMAWISE Endurance N Shorting Cap assembly with surge protection	2328118-2
LUMAWISE Endurance N Shorting Cap assembly, open cap	2328118-3

They are used to disconnect service (Open Cap) or to provide continuous power from the pole to the luminaire (Shorting Cap). A shorting cap with an integrated Metal Oxide Varistor (MOV) provides surge protection for LED luminaires that are required to be on continuously.

The LUMAWISE Endurance N Shorting Caps provide an alternative to light-sensing control units. Their distinctive cap shape provides an obvious visual distinction from standard photo-controls.

The IK08 construction provides high resistance to impacts.

ENERGY INDUSTRIAL LIGHTING MEDICAL TRANSPORT SECURITY CONSUMER TELECOMS

APPLICATIONS

- Highway lighting
- Streetlights
- Area lighting

FEATURES

- 15A maximum current
- Voltage-rating range: 0V to 480V AC
- Ultraviolet-stabilized material
- UL recognized
- C-UL listed

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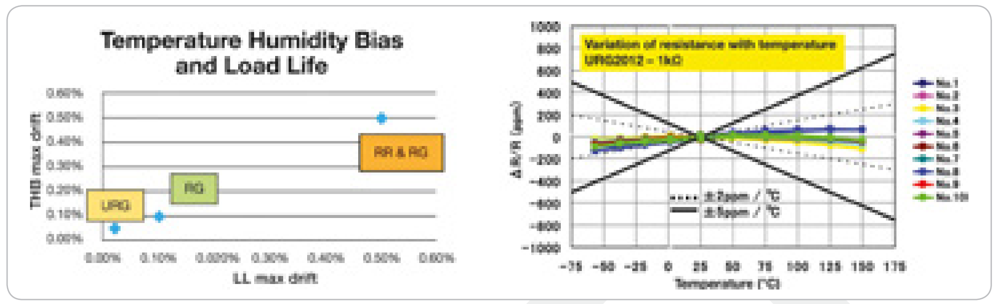
Thin-film precision resistor series sets new standard for reliability

Susumu's new URG series of thin-film chip resistors offers an improvement in reliability as well as in the linearity of its Temperature Coefficient of Resistance (TCR) compared to the high standard set by the existing RG series.

The URG series offers better absolute tolerance of resistance, at ±0.01%, than any other thin-film chip resistor on the market. It also offers the lowest TCR of ±2ppm/°C. It offers all the advantages of the thin-film type of resistor, such as low noise of -25dB to -35dB, and support for high frequencies up to 1GHz. In addition, the linearity of the URG series' TCR makes it easy to develop an appropriate compensation algorithm.

For applications that require extreme precision and reliability, Susumu now offers a wide choice of resistor families, providing in addition to the URG series:

- The RG-PV series offering tolerance of ±0.02% and TCR of ±5ppm/°C
- The RG-LL series with tolerance of ±0.01% and TCR of ±2ppm/°C



URG series: Extremely stable resistance over a wide temperature range

APPLICATIONS
- Precision industrial instruments
- Test and measurement instruments
- Automotive electronics
- Laboratory-grade scales

FEATURES
- ±0.02% maximum drift for load life (2,000 hours at 70°C)
- ±0.05% humidity bias drift
- ±0.02% temperature cycle drift
- ±0.02% high-temperature exposure drift
- Stable when exposed to atmospheric sulfur
- EIA standard package sizes: 0603, 0805 and 1206

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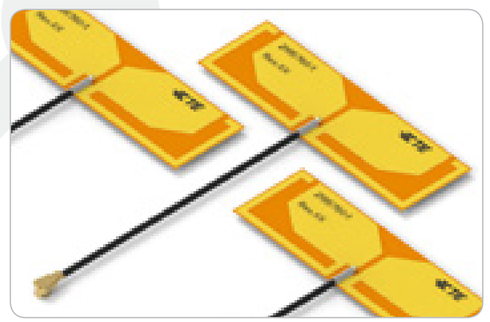
Standard GNSS antennas enable designers to reduce system size and cost

TE Connectivity's (TE) new standard portfolio of Global Navigation Satellite System (GNSS) antennas satisfies the most important requirements for the performance of a positioning antenna: efficiency and bandwidth.

They are suitable for use in a wide range of use cases, from generic consumer navigation to high-precision positioning.

Many TE antennas support more than one frequency band or wireless technology, enabling the system designer to reduce total volume by integrating multiple antenna functions into a single device. The resulting reduction in component count also helps to reduce bill-of-materials and assembly costs, and cuts the operating expense and effort associated with inventory management.

Part Number	Supported Technologies	Description
2118900-1	GNSS, GPS and Glonass	Surface-mount chip antenna
2195760-1	Dual-band Wi-Fi and GNSS	Single-feed antenna
2195761-1	GNSS	25mm x 25mm surface-mount patch antenna
2195762-1	GNSS	35mm x 35mm surface-mount patch antenna
2195763-1	GNSS	35mm x 35mm surface-mount patch antenna with cable feed
2195764-1	GPS and Glonass	Surface-mount chip antenna
2195765-1	GPS and 2.4GHz radio	Surface-mount chip antenna
2195766-1	GNSS L1, GPS L2	Surface-mount PCB module
2195767-1	GNSS L1, GPS L2	Surface-mount PCB module
2195768-1	GNSS global active	Includes u.fl connector



GNSS antennas: Multi-band operation

APPLICATIONS
- Tracking devices
- Navigation devices
- Security applications
- Remote controls
- Autonomous driving
- Infotainment
- Unmanned vehicles
- Smart home equipment
- Wireless handheld devices

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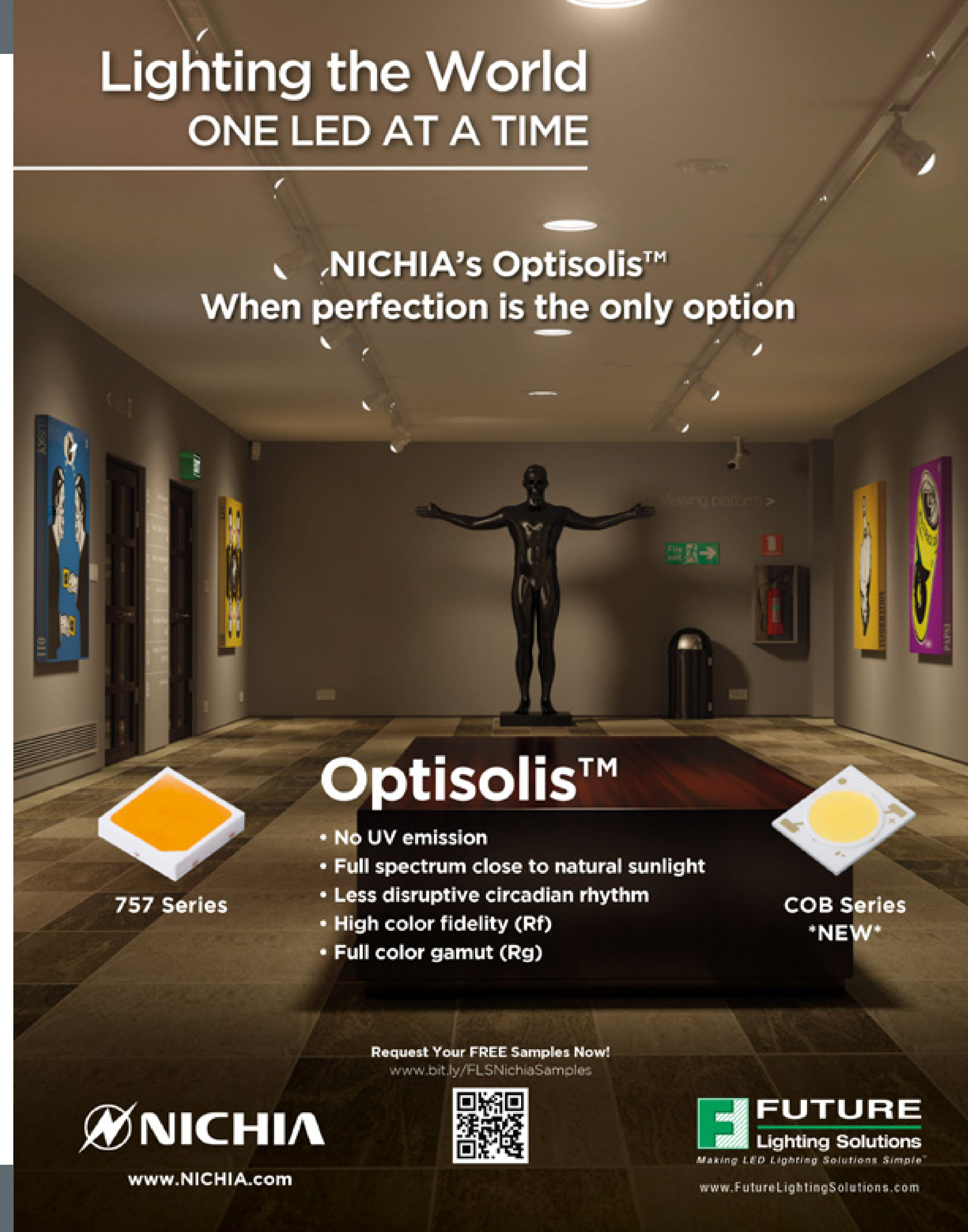

 DESIGN NOTE

A comparison of control techniques for three-phase induction motors

By Gianluigi Forte and Andrea Spampinato, STMicroelectronics

The three-phase induction motor is one of the most reliable types of electric machine. Induction motors are known to work for many years with very little maintenance effort. They also offer great operational flexibility.

Today, induction motors are the industrial sector's most widely used electric machine, and so are responsible for a very high proportion of the industrial sector's total electricity consumption. This means that improvements to the energy efficiency of induction motor systems resulting from a reduction in energy losses will have enormous benefits, both in cutting operating expenses and in supporting compliance with efficiency regulations.

This has led to a growth in the adoption of variable-speed drive technology in preference to fixed-speed drives. STMicroelectronics provides a complete solution for controlling a variable-speed induction motor using either scalar or vector controls. This Design Note describes how an efficient variable-speed drive design may be developed quickly on the basis of a combination of ST boards which implement control and power functions.

ST boards for induction motor control

The proposed solution can be evaluated by assembling a system composed of the following:

- A NUCLEO-F303RE control board based on the STM32F303RE, a 32-bit microcontroller which includes an Arm® Cortex®-M4F processor core.
- An STEVAL-IPM10B power board based on an STGIB10CH60TS-L second-generation SLLIMM™ Intelligent Power Module (IPM). It is an easy-to-use demonstration board for driving electric motors up to 1.2kW supplied by a 125V to 400V DC bus voltage. The board is provided with bootstrap and snubber capacitors, short-circuit protection, a fault event signal, and temperature monitoring.
- A motor control connector expansion board, the X-NUCLEO-IHM09M1.

With the architecture shown in Figure 1, it is possible to assemble a full inverter system which is simple, cheap and flexible, and fits the requirements of the chosen application in terms of computational and electrical power, using the appropriate STM32 microcontroller and IPM.

In addition, the NUCLEO board supports the STM32CubeMX system, which provides a full array of expansion elements for functions such as sensors and communication channels. It also provides a graphical configuration tool and project generator, and enables the user to set up peripherals in just a few steps.

Induction motors: control techniques

An induction motor can provide torque only if the frequency of the three-phase stator voltages and currents, ωe, is higher than the electrical shaft rotation frequency, ωre. This difference is called the slip frequency, $\omega slip$, and the value of its normalization with respect to ωe is the slip.

The motor itself can increase or decrease the torque in response to changes in the mechanical load, respectively decreasing or increasing the shaft speed in a slip range of around 20%. Using an inverter, it is possible to change the frequency of ωe, greatly reducing the start-up current.

It is possible to change the rotor speed by varying the synchronous frequency, ωe. If the voltage amplitude remained the same, the electromagnetic flux would change and saturation problems could occur. But by maintaining a constant ratio between the stator voltage amplitude and ωe, the electromagnetic flux remains constant, a technique known as V/f control.

Assuming the load is constant, this method allows the rotor speed to change at a constant slip, minimizing power losses. Since this is an open-loop control technique, for a fixed value of ωe an increase or a decrease in the mechanical load will cause a variation of the rotor speed.

By implementing a closed-loop version of this technique, the developer can add the ability to control the motor's speed, while retaining the combination of low cost and low dynamic performance offered by the open-loop version. A speed sensor must be used to vary the slip frequency according to the actual rotor speed and to the mechanical load.

The only MCU peripherals required for these techniques are a timer for generating the six PWM signals, and a DAC for debugging. The closed-loop technique also requires a timer for decoding the speed/position sensor output.

An alternative to either of the above techniques, Field-Oriented Control (FOC) is an advanced control method which achieves high efficiency and excellent dynamic control by using a simple estimation of the rotor flux position. The indirect FOC method estimates the motor flux by using rotor speed information from a speed sensor, and the electrical rotor time constant, τr. It requires a speed sensor even if speed control is not needed.

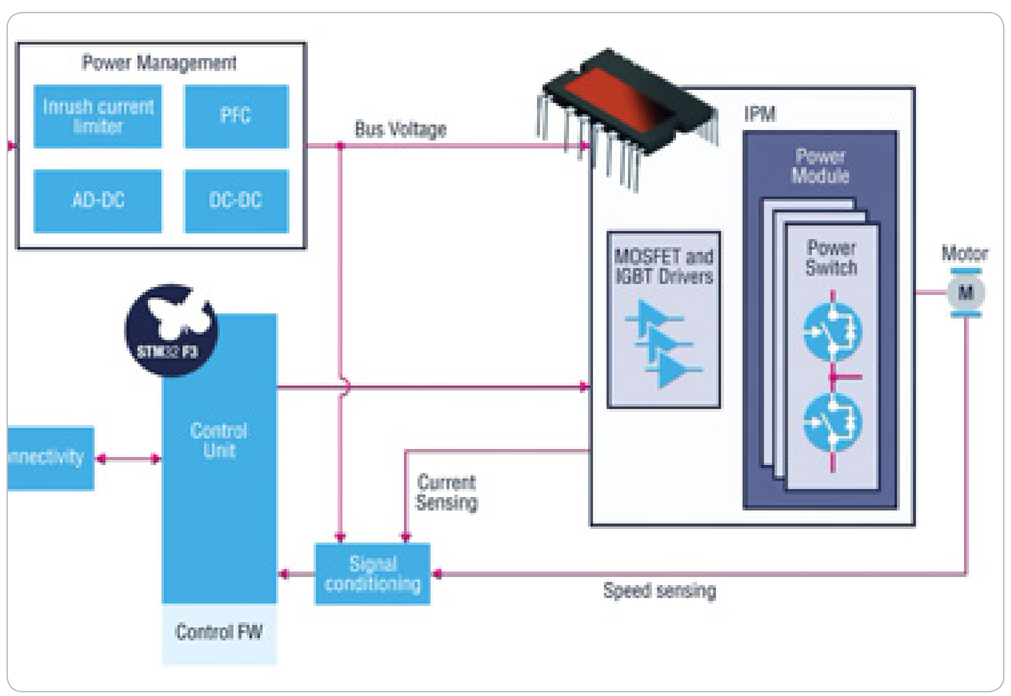

Fig. 1: Block diagram of induction motor system based on ST power and control boards

In an induction motor, both the magnetization field and the stator field are provided by the stator windings, so it is more difficult to control them independently than it is in a DC motor. FOC enables such control, but requires continuous information about the rotor flux position.

In fact, FOC is based on the co-ordinate transformation theory, which transforms vectors from a 120°-abc (uvw) reference frame to a 90°-qd; the angle of the rotor flux is used in these transformations. But unlike a permanent magnet synchronous motor, in an induction motor the rotor flux angle does not coincide with the shaft electrical angle because of the slip frequency. This means that when FOC is implemented in an induction motor, regardless of the speed control loop, the rotor flux angle must be known.

In practice, to save cost the rotor flux angle is normally estimated rather than measured. Once the angle is known, the currents in the stator, Iqd, will control respectively the electromagnetic torque and the magnetizing flux.

To perform this type of FOC, the STM32 MCU only requires two or three ADCs for measuring the motor phase currents, one ADC for measuring the DC bus voltage, one PWM timer to generate the gate commands, and if needed, a timer for decoding the shaft speed sensor output.

The indirect FOC technique estimates the rotor flux angle by using the rotor speed information from a speed sensor. The technique is 'indirect' since the flux vector is not directly estimated but only its momentary position. The speed sensor enables the indirect FOC technique to work at zero speed.

Sensor-less FOC offers benefits in terms of both reliability and cost saving. There are several techniques for estimating rotor flux and shaft speed: the ST solution is a Model Reference Adaptive System (MRAS) observer which can work from low to very high speed, but not when the motor is stationary.

Demonstrated performance of the ST system

The performance of an induction motor running ST's control algorithms on an STM32F303 MCU board was tested on a three-phase induction motor with the following specifications:

- $1.9A_{rms}$ nominal current
- $380V_{rms}$ nominal voltage
- 50Hz frequency
- 750W nominal power
- 2,650rpm maximum speed

Figure 2 shows the speed step response from standstill to 2,500rpm when the closed-loop V/f control technique is in action. Although no mechanical load is applied to the shaft, the graph shows that, as expected, the response time is longer than when using the FOC technique.

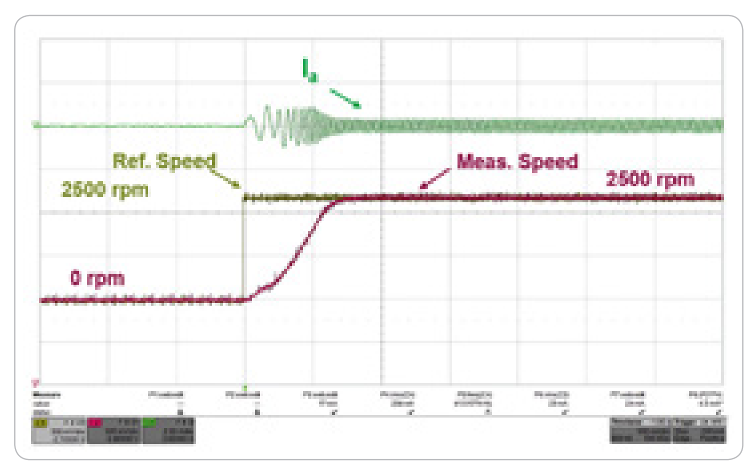

Fig. 2: Speed step response under no load from 0rpm to 2,500rpm using closed-loop V/f control

Nevertheless, this closed-loop control technique is suitable for any application that requires a cheap and simple implementation and that can tolerate relatively low dynamic performance.

If cost is the main factor, indirect FOC should be chosen instead of closed-loop V/f control. The indirect FOC technique is little more complex than closed-loop V/f control: both require a speed sensor, and the algorithm is ready to use once the STM32 peripherals are configured to match the topology of the hardware sensing network. What is more, the dynamic performance and efficiency of the indirect FOC technique are clearly better than that of a scalar method such as the closed-loop control scheme, as shown in Figure 3.

What is true for the indirect FOC method is even more true for sensor-less FOC, as shown in Figure 4. The main limitation of this method is that it does not operate when the motor is stationary.

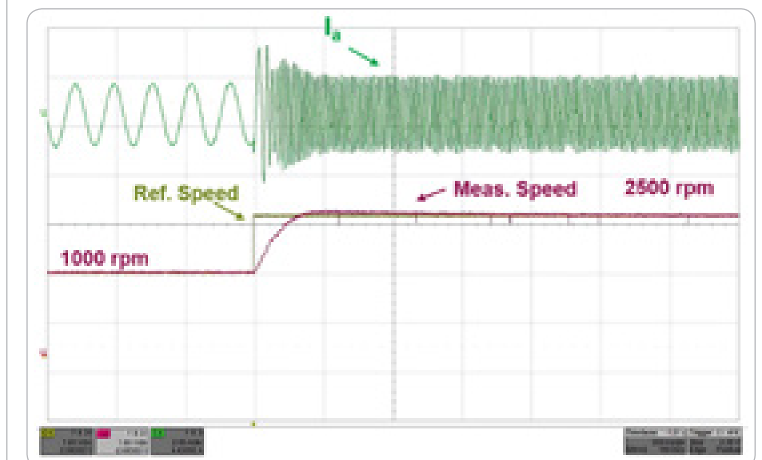

Fig. 3: Speed step response under a 1Nm load from 1,000rpm to 2,500rpm using indirect FOC control

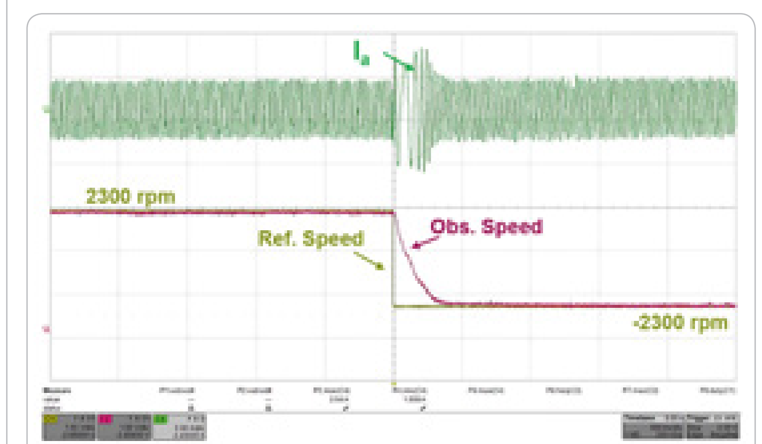

Fig. 4: Response time when reversing under sensor-less FOC control from 2,300rpm to -2,300rpm

FTM DEVELOPMENT BOARD

Orderable Part Numbers: NUCLEO-F303RE, STEVAL-IPM10B and X-NUCLEO-IHM09M1

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DESIGN NOTE

Innovations in MOSFET technology bring new value to low-voltage motor-drive applications

nexperia

Some high-power motor-control systems include multiple MOSFETs connected in parallel. Such circuits often call for MOSFETs that have a matched gate-source threshold voltage. Even when a MOSFET's production facility is very tightly controlled, however, there is inevitably a spread of threshold voltage values across each wafer: any attempt to provide parts with matched threshold voltage values might require special screening and sorting procedures. This in turn will tend to reduce production yield, thus increasing the unit cost of the product.

To address this problem, Nexperia has developed MOSFETs that provide an improved current-sharing capability. When used in parallel configuration, these devices remove the need for matched threshold voltage values.

These are evidence that the parts which support improved current sharing offer important benefits when used in hot-swap linear mode and in motor drives. In fact, even more potential for optimization has been discovered, and new products in the pipeline will implement these additional improvements to bring yet more benefit to these applications.

Encouraging findings have emerged from testing in a parallel motor-drive application: the test compared standard MOSFET designs with the new optimized parts, as shown in Figure 1. The test used three parts each from the 90th percentile, and one from the 10th percentile. The optimized parts achieved close to ideal current-sharing performance, and much better thermal performance than the standard parts, as shown in Figures 2, 3, 4 and 5.

The optimizations for improved current sharing complement the superjunction trench technology used in the latest generation of power MOSFETs, which gives outstanding linear-mode performance. This leads to the next innovation in this industry segment.

The 100V, 120A-rated PSMN3R7-100BSE MOSFET from Nexperia is an ideal choice in high-current, battery-powered applications in which the battery voltage must be isolated under certain fault conditions. In this case, the battery-protection MOSFET must sometimes operate in linear mode until the battery voltage is isolated.

Nexperia has developed parts in several package styles which give far superior linear-mode performance, as much as six times better than leading competitors' products. They also provide high current capability up to 380A. Parts are available to provide the increased spacing required by the UL2595 standard.

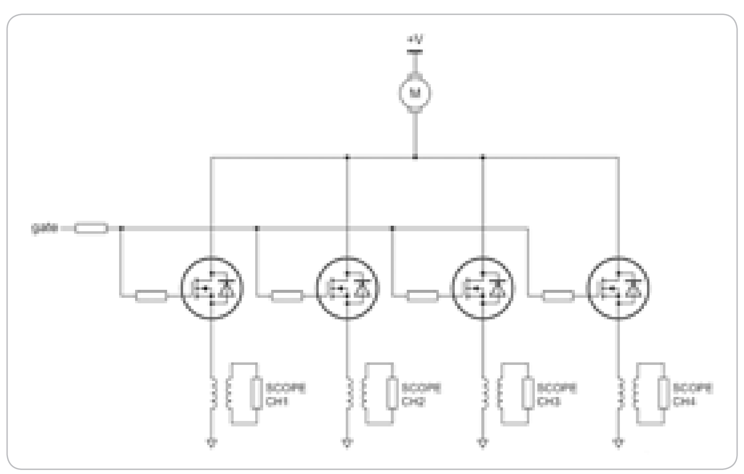

Fig. 1: Parallel motor drive test circuit

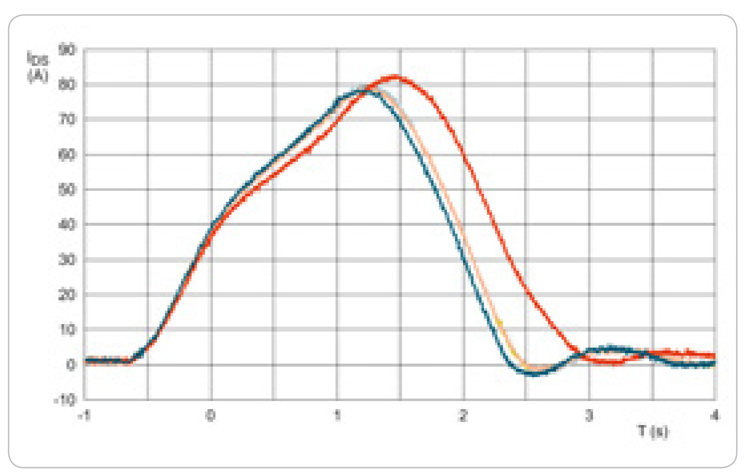

Fig. 2: Control (standard parts): Up to 30A current difference during switching

The Nexperia 100V-rated MOSFETs are notable for their low reverse-recovery charge, and provide excellent EMC performance. Other parts under development include 40V, 425A-rated half-bridge and dual MOSFETs supplied in an LFPAK88 package. These parts will be available in several voltage ratings.

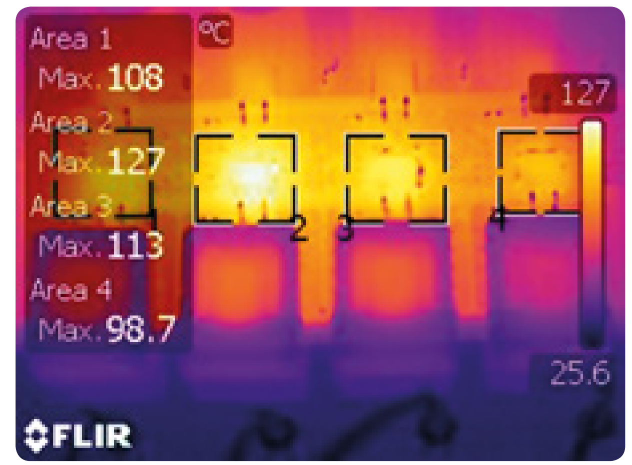

Fig. 3: Control (standard parts): Up to 28.7°C difference, and peak of 127°C during switching

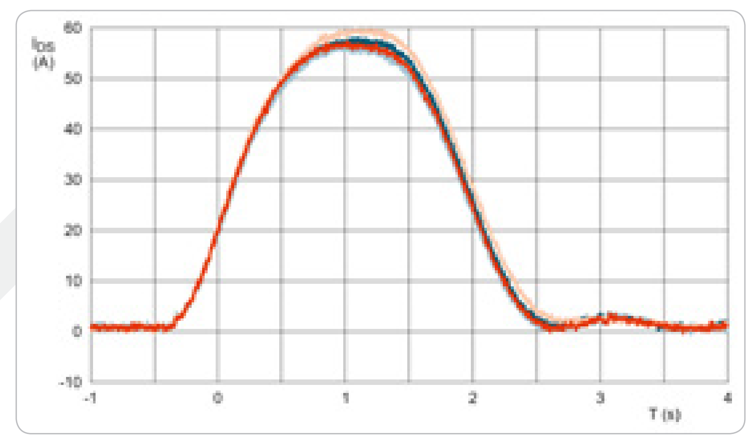

Fig. 4: Optimised parts: Up to 4A current difference during switching

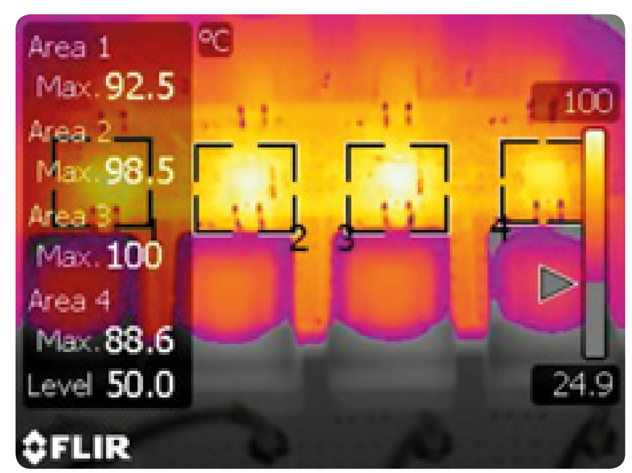

Fig. 5: Optimised parts: 11.4°C difference, and peak of 100°C during switching

LFPAK56-packaged parts	Part Number	On-resistance at a Gate-source Voltage of 10V	Maximum Drain Current
30V	PSMNR58-30YLH	0.60mΩ	380A
	PSMNR70-30YLH	0.70mΩ	300A
	PSMN0R9-30YLD	0.87mΩ	300A
	PSMN1R0-30YLD	1.0mΩ	300A
	PSMN1R2-30YLD	1.2mΩ	100A
	PSMN1R4-30YLD	1.4mΩ	100A
	PSMN2R4-30YLD	2.4mΩ	100A
40V	PSMN1R0-40YLD	1.1mΩ	280A
	PSMN1R4-40YLD	1.4mΩ	240A
60V	PSMN4R0-60YS	4.0mΩ	100A
	PSMN5R5-60YS	5.5mΩ	100A
	PSMN4R1-60YL	4.1mΩ	100A
100V	PSMN5R6-100YSF	5.6mΩ	120A
	PSMN6R9-100YSF	7.0mΩ	90A
	PSMN8R7-100YSF	9.0mΩ	90A
LFPAK56-UL2595-packaged parts	**Part Number**	**On-resistance at a Gate-source Voltage of 10V**	**Maximum Drain Current**
30V	PSMN0R9-30ULD	0.97mΩ	300A
40V	PSMN1R0-40YLD	1.1mΩ	280A
LFPAK33-packaged parts	**Part Number**	**On-resistance at a Gate-source Voltage of 10V**	**Maximum Drain Current**
30V	PSMN1R6-30MLH	1.90mΩ	160A
Wide SOA (Linear Mode) part	**Part Number**	**On-resistance at a Gate-source Voltage of 10V**	**Maximum Drain Current**
100V	PSMN3R7-100BSE	3.95mΩ	120A

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DESIGN NOTE

How to implement field-oriented control for PMSMs with a dynamic speed observer

By Jia Li, Engineer, Monolithic Power Systems

Permanent Magnet Synchronous Motors (PMSMs) are widely used in electric vehicles, robots, home appliances and other products. For good dynamic response and motor performance, engineers normally use a form of vector control method to drive a PMSM.

Vector control requires a means to measure the speed and position of the rotor. Optical quadratic sensors or Hall effect magnetic position sensors are the most common types of sensor used for this function, but they are expensive components.

A promising alternative technique for driving a PMSM is to use a combination of a low-cost magnetic angular sensor and a dynamic observer to estimate the rotor speed. The motor control module from Monolithic Power Systems (MPS) implements this technique. It includes a motor-control ASIC, a magnetic angular sensor, and a three-phase MOSFET power stage and pre-drivers, all mounted on a single PCB to fit NEMA 23- and NEMA 17-format motors.

The motor-control ASIC provides excellent computation ability for applications such as electric motor drives. It works with the MA702, a 12-bit magnetic angular sensor which detects the absolute position of the rotor. The MA702 is cheaper than an optical quadratic or Hall effect sensor.

The motor's speed can be calculated from continual rotor position measurements by a dynamic state observer. The ASIC uses the dynamic observer to filter out position measurement noise and to estimate the rotor speed, enabling the system to implement vector-based Field-Oriented Control (FOC) effectively.

The operation of FOC

Three-phase PMSM machine operation is expressed here as:

$$v_{as} = r_s i_{as} + \rho\lambda_{as}$$
$$v_{bs} = r_s i_{bs} + \rho\lambda_{bs}$$
$$v_{cs} = r_s i_{cs} + \rho\lambda_{cs}$$
$$T_e = \frac{P}{2}\lambda'_m\left[\cos(\theta_e)\, i_{as} + \cos\left(\theta_e - \frac{2}{3}\pi\right) i_{bs} + \cos\left(\theta_e + \frac{2}{3}\pi\right) i_{cs}\right]$$

Where:

v, i, and λ are the voltage, current, and flux respectively.

The subscripts a, b, and c represent the variables in phases a, b, and c. Subscript s is the stator variable, ρ represents the derivative of the certain value, and P is the number of poles in the motor.

The electromagnetic torque, T_e, is produced by the three-phase current and the rotor flux. λ'_m is the rotor flux sensed on the stator side of the motor. The angle θ_e is the electrical angle between the rotor flux and the stator's a phase.

To perform FOC, a dynamic model under q-d is required to decouple the air gap-flux and electromagnetic torque. Following the Clarke-Park transformation, the PMSM model in equation set 1 under the synchronous rotating q-d frame is calculated with the equation:

$$v_{qs} = r_s + \omega_r\lambda_{ds} + \rho\lambda_{qs}$$
$$v_{ds} = r_s - \omega_r\lambda_{qs} + \rho\lambda_{ds}$$
$$\lambda_{qs} = L_s i_{qs} + L_m i_{qr}$$
$$\lambda_{ds} = L_s i_{ds} + L_m i_{dr}$$

Where:

the subscripts q-d are the q-d axis variables.

L_s is the self-inductance and L_m is the mutual inductance of the machine.

To further simplify control, the rotor flux should be aligned on the d-axis while there is zero rotor flux on the q-axis.
The flux is calculated with the equation:

$$\lambda_{qs} = L_s i_{qs}$$
$$\lambda_{ds} = L_s i_{ds} + \lambda'_m$$

The electromagnetic torque is estimated with the equation:

$$T_e = \frac{3}{2}\frac{P}{2}\left(\lambda'_m i_{qs} + (L_d - L_q) i_{ds} i_{qs}\right)$$

Following the transformation steps performed in the four equation sets, the magnetic flux can be directly controlled by the d-axis current. With a constant i_{ds}, the torque, T_e, can be controlled directly by manipulating the q-axis current. If $i_{ds} = 0$, then the electromagnetic torque is directly proportional to i_{qs}.

Figure 1 shows the PMSM FOC technique in schematic form.

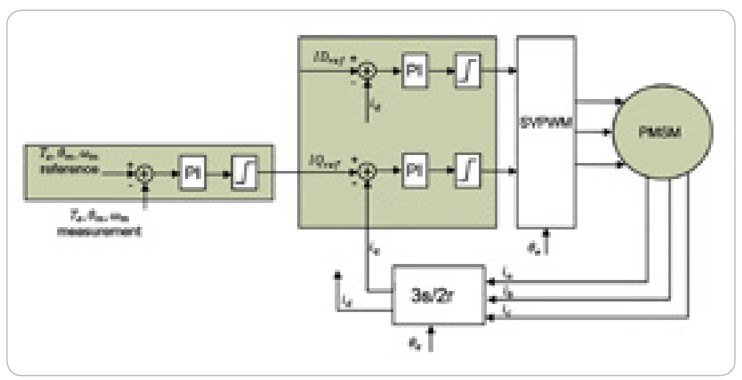

Fig. 1: PMSM FOC schematic

The outer loop reference makes a comparison with the measured variables, and feeds the error to a controller, a PI controller is the most common type, to generate the command torque current, IQ_{ref}. The d-axis current reference, ID_{ref}, is set according to the magnetic flux requirement. The output of the current regulators/controllers, VD_{ref}, VQ_{ref}, VD_{ref} and VQ_{ref}, are the input for the space vector PWM. The PWM block generates the gate signals for the inverter to drive the motor.

Driving the motor with no speed sensor

The MA702 detects the position of a permanent magnet, θ_e. The speed of the rotor can be calculated as $\omega_e = \rho\theta_e$. A digital sensor, the MA702 inevitably introduces noise into the position measurement: this calls for the addition of a digital filter/estimator.

The system estimator can be based on the mechanical PMSM model using the equation:

$$\rho\omega_m = -\frac{B}{J}\omega_m - \frac{T_l}{J} + \frac{T_e}{J}$$
$$\rho\theta_m = \omega_m$$

Where:

T_e is the electromagnetic torque and T_l is the load torque. ω_m and θ_m are the mechanical rotor speed and position, compared to the electrical rotor speed and position ω_e and θ_e. ρ is the pole number of the PMSM.

The parameters J and B represent the PMSM inertia and the combined viscous friction of rotor and load respectively.

The MA702 feeds the absolute rotor position to the motor-control ASIC, making the mechanical model system matrix A a simple 3x3 matrix with only two non-zero elements. A simpler system matrix helps to decrease the computation burden on the microcontroller, making the algorithm easier to implement and faster to execute.

The state variables x, C, and R^n, are the states of a system process that can be expressed in discrete time with the equation:

$$x_k = Ax_{k-1} + Bu_{k-1} + w_{k-1}$$
$$y_k = Hx_k + v_k$$
$$p(w) \sim N(0, Q)$$
$$p(v) \sim N(0, R)$$

Where:

u is the input variable and y is the output measurement.

w and v are the process and measurement noise with noise co-variance of Q and R respectively.

Following classic control theory, a state estimator with estimator gain k can be calculated with the equation:

$$\hat{x}_{k|k} = \hat{x}_{k|k-1} + K(y_k - H\hat{x}_{k|k-1})$$

The notation a_{nlm} represents the estimation of a at step n up to the observation of step m and $m \leq n$. The carat^ denotes that the variable is estimated.

Unlike the classic state observer using a constant gain k, a dynamic observer recursively updates its estimator gain k with each iteration.

Compared to the FOC schematic shown in Figure 1, the dynamic speed observer schematic uses machine measurements as the system input, as shown in Figure 2. The dynamic observer outputs the filtered/estimated rotor speed.

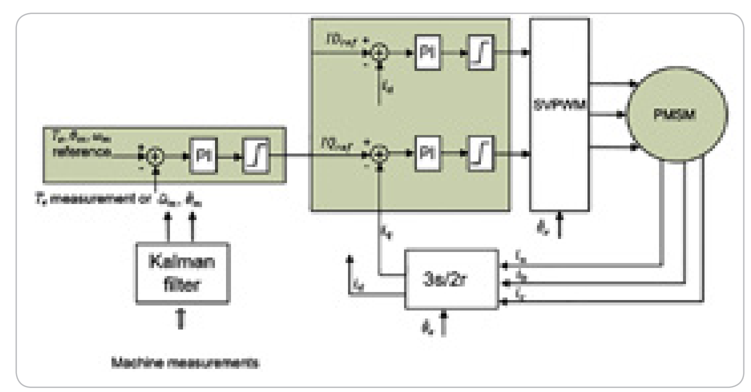

Fig. 2: Dynamic observer-based FOC

Measured performance on reference motor design

To validate its algorithm, MPS measured its performance on an example motor system. The MPS Motor Control Module, designed for 57mm NEMA 23 motors, can be directly mounted on the motor, as shown below in Figure 3.

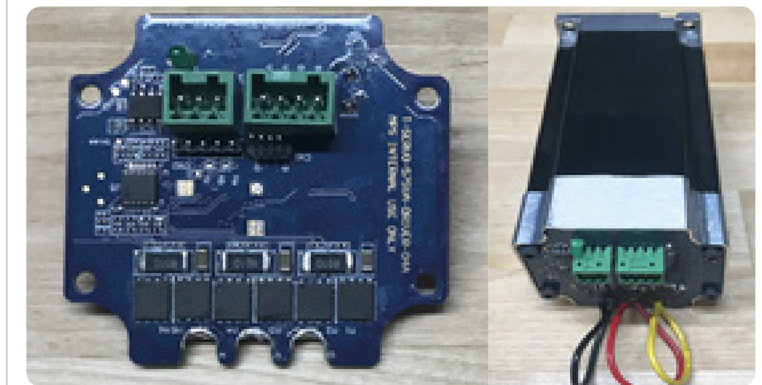

Fig. 3: The MPS Motor Control Module (left) and MPS Smart Motor (right)

Because the MA702 angular sensor feeds absolute rotor position measurements to the motor-control ASIC, the implementation of the dynamic observer's recursive iteration is easier, and places a low computation burden on it. Since the measurement is only of one variable, the observer's gain calculation is a simple division. The entire dynamic observer calculation takes less than 20µs for each iteration.

Figure 4 shows a wide range of reference speeds, from 1,000rpm to -500rpm, fed to the motor-control system's simulator in step changes. The dynamic observer-estimated speed can still track the motor speed accurately in real time at each different speed step. The algorithm can also give a stand-still reference.

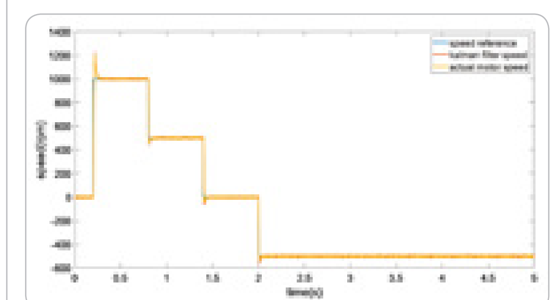

Fig. 4: Step-speed response in real time

Conclusion

This article presents a promising solution for PMSM FOC based on a combination of a low-cost magnetic angular sensor and a dynamic observer to estimate the rotor speed accurately. The algorithm is implemented in a motor-control ASIC from MPS.

The MA702 angle sensor provides a high-resolution, on-board angle measurement, so the algorithm avoids the need to perform a complex inverse calculation. This eases code development and reduces the time that the ASIC spends on calculations.

Real-time validation test results show the proposed solution has good dynamic performance and is able to control the PMSM at different reference speeds.

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200V high-/low-side gate drivers produce high performance from standard low-profile SO-8 package

DIODES INCORPORATED

The new DGD2003S8, DGD2005S8 and DGD2012S8 are 200V gate-driver ICs for driving two external N-channel MOSFETs in a half-bridge configuration.

Part Number	Source Current (A)	Sink Current (A)
DGD2003S8	0.29	0.60
DGD2005S8	0.29	0.60
DGD2012S8	1.9	2.3

Featuring both high- and low-side output-drive capability, and compatible with simple logic-level inputs of >2.5V, these Diodes gate drivers provide an easy interface between a microcontroller and the power MOSFET switches in a motor or inverter.

Supporting half-bridge circuits operating at up to 200V via a floating high side, the DGD20xxS8 gate drivers are suitable for a wide range of motor-drive applications in battery-operated equipment.

The DGD2003S8, DGD2005S8, and DGD2012S8 gate drivers are supplied in a standard low-profile SO-8 package. They feature junction-isolated level-shift technology to create a floating channel high-side driver for use in a bootstrap topology.

DGD20xxS8: Ideal for battery-powered devices

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APPLICATIONS
- Power tools
- Garden tools
- Home appliances
- Robotics
- Drones
- Small electric vehicles
- Consumer devices
- Industrial equipment

FEATURES
- Dead time and matched delays to eliminate shoot-through
- Schmitt-triggered inputs
- Resistant to negative transient voltages
- Under-voltage lock-out for high-side and low-side drivers

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Integrated commutation encoder provides accurate angle measurements for BLDC motors

CUI INC

CUI Inc.'s AMT31 series is a rugged, high-accuracy commutation encoder which generates standard U/V/W communication signals for commutating Brushless DC (BLDC) motors.

Thanks to its innovative capacitive platform, the series is not susceptible to contaminants such as dirt, dust, and oil which typically plague encoders in industrial environments. The AMT31's design also simplifies the assembly process, enabling the normally time-consuming tasks of mounting and alignment to be accomplished in seconds due to its One Touch Zero™ feature.

This position-measurement encoder also offers high accuracy of ±0.2° and operates up to a maximum rotation speed of 8,000rpm. It provides position measurement outputs at a resolution of up to 4,096 points per revolution.

AMT31: Maximum rotation speed of 8,000rpm

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APPLICATIONS
- Industrial equipment
- Automation systems
- Robotics
- Renewable energy equipment

FEATURES
- Modular locking hub design for simple assembly
- Up to nine sleeve options ranging in size from 2mm to 8mm
- Programmable incremental output
- Compatible with AMT Viewpoint™ GUI
- 16mA current with unloaded output
- Input-voltage range: 4.5V to 5.5V
- Operating temperature range: -40°C to 125°C

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Over 30 standard Triad current sense transformer models support low (50Hz to 400Hz) and high frequencies (20kHz to 200kHz), with many UL-approved and all RoHS compliant. They are ideal for a wide range of both common everyday and high-reliability applications that include:
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- **Remote power monitoring**
- **Industrial control equipment**
- **Inverters and UPS**

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KEY SPECIFICATIONS
- Monitors current 0.1A to 30A (depending on model)
- Frequency: 50Hz to 400Hz
- Turns: 16.67 to 500
- Integral primary
- Potted version for 4000V isolation
- UL recognized

CST 1000 Series Low Frequency

KEY SPECIFICATIONS
- Monitors current: 5A to 30A (depending on model)
- Frequency: 50Hz to 400Hz
- Turns: 1000
- Tombstone design for flexibility

CST206/306 High Frequency

KEY SPECIFICATIONS
- Monitors current: 25A to 110A
- Frequency: 20KHz to 200kHz
- Turns: 50 to 300
- UL rated 130°C materials
- Available with center tap option
- Ideal for wide range of switching power supply applications

CSE5 Series SMD High Frequency

KEY SPECIFICATIONS
- Monitors current to 10A
- Frequency: 250kHz and greater
- Turns: 20 to 125
- Secondary impedance 80µH to 3000µH
- Maximum secondary DCR: 55mΩ to 8500mΩ

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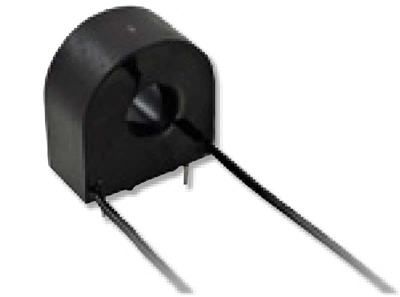
We've designed custom current sense transformers for power supplies, instrumentation, aerospace systems, medical devices, motor speed controls and many more unique applications. The creative minds at Triad will find a powerful custom solution that meets your design requirements, as well as helping you to improve performance, increase reliability, extend life and manage costs.

California Design Center

Our innovative California design center speeds your custom transformer, inductor or power supply from design to prototype to testing to production within weeks.



Expert Engineering Staff

With decades of expertise, our design engineers work directly with you. They know the complexities of combining cores, laminations and bobbins into custom transformers and magnetic components. Let our engineers suggest changes in design or materials to optimize your custom magnetic component.

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Our system of in-process inspection, pre-ship audits and failure analysis has allowed many of our customers to eliminate their incoming inspection process while our continuous improvement protocol provides the highest levels of product quality and reliability.

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MOTOR CONTROL

New discrete 1,200V SiC MOSFETs combine low losses and high reliability

Infineon

Infineon Technologies has announced that it has begun volume production of discrete 1,200V CoolSiC™ MOSFET devices in a TO247 package, with on-resistance ratings ranging from 30mΩ to 350mΩ.

The new devices will help satisfy fast-growing demand for energy-efficient Silicon Carbide (SiC) MOSFETs in power-conversion applications. They provide new system-design flexibility in power factor correction circuits, bi-directional topologies, and any hard- or soft-switching DC-DC converters or DC-AC inverters.

The new discrete devices benefit from Infineon's advanced trench SiC MOSFET semiconductor fabrication process, which produces devices notable for their low losses and high reliability. In addition, the CoolSiC MOSFETs feature gate-source operating voltages suitable for discrete packaged devices. Their low dynamic losses result in high efficiency with a simple unipolar gate-drive scheme.

Another unique advantage of the Infineon CoolSiC trench MOSFET technology is a high threshold voltage of >4V combined with low Miller capacitance. This means that CoolSiC MOSFETs offer much higher immunity to unwanted parasitic turn-on effects than other SiC MOSFETs on the market. Turn-on gate-source voltage is +18V with a 5V margin to a maximum rated voltage of +23V.

The new 1,200V CoolSiC MOSFETs in a TO247 package are available to order now in production volumes.

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APPLICATIONS
- Solar inverters
- Battery charging infrastructure
- Energy storage solutions
- Uninterruptible power supplies
- Motor drives
- Data center and telecoms power supplies

FEATURES
- Low device capacitance
- Temperature-independent switching losses
- Integral diode with low reverse-recovery charge
- Threshold-free on-state characteristics

FTM DEVELOPMENT BOARD

This evaluation board demonstrates the functionality and key features of the Infineon EiceDRIVER™ and CoolSiC™ MOSFET. It contains two gate drivers to drive two SiC MOSFET switches in a half-bridge configuration.

An additional gate driver is used to transfer over-current information through the isolation barrier between the high-voltage power side to the low-voltage input side.

A DC-DC converter provides galvanically-isolated supply voltages for each driver stage.

Orderable Part Number: EVAL-1EDC20H12AH-SIC

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Gate-driver ICs optimized for fast-switching 1,200V CoolSiC MOSFETs

Infineon

Infineon provides a range of EiceDRIVER™ driver IC products suitable for use with its CoolSiC™ MOSFETs, which are capable of switching at extremely high frequency.

Together, CoolSiC MOSFETs and EiceDRIVER gate-driver ICs take full advantage of the superior characteristics of Silicon Carbide (SiC) technology: improved efficiency, space and weight savings, part count reduction and enhanced system reliability. This gives designers great scope to lower system cost, reduce operating expenses and total cost of ownership, and devise new solutions for an energy-smart world.

Infineon has now gone into volume production with its portfolio of 1,200V CoolSiC MOSFETs (see above). This portfolio includes:
- **IMW120R045M1** CoolSiC 1,200V, 45mΩ SiC MOSFET in a TO247-3 package
- **IMZ120R045M1** CoolSiC 1,200V, 45mΩ SiC MOSFET in a TO247-4 package

Infineon's recommended EiceDRIVER parts for these SiC MOSFETs are:
- 1EDI60H12AH
- 1EDI30I12MF
- 1ED020I12-F2
- 1EDS20I12SV
- 1EDI20I12SV
- 1EDC20H12AH

Integrated power modules offer more efficient alternative to legacy products from International Rectifier and Mitsubishi

ON Semiconductor®

ON Semiconductor's comprehensive range of integrated power modules for motor driving includes pin-compatible replacements for International Rectifier and Mitsubishi parts. Power modules from ON Semiconductor are available to drive brushless DC motors with power ratings up to several kilowatts.

iRAM replacement modules

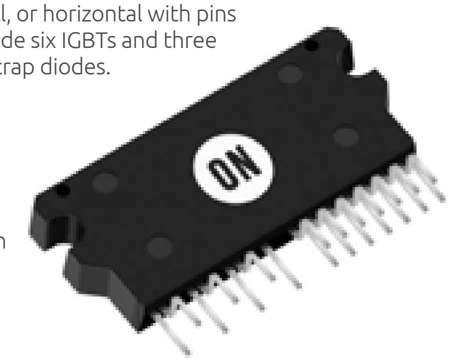
ON Semiconductor has introduced a new power module in a low-profile SIP-K package which shares the same footprint, pin-out and mounting-screw locations as legacy International Rectifier iRAM series power modules.

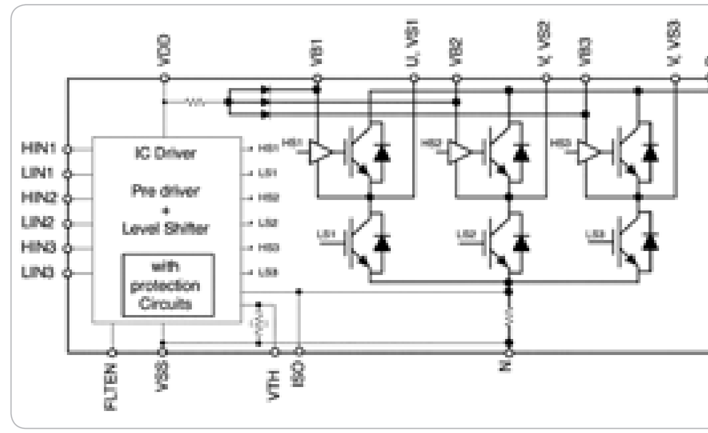
The NFAP1060L3TT can be used as a like-for-like replacement for the iRAM136-1060A module, which has a power rating of 10A and 600V. Depending on the application requirements, it might also be suitable as a replacement for the 5A/600V IRAM136-0760A.

The new SIP-K package, based on the SIP-05 module style, integrates Field Stop 3 short-circuit rated IGBT technology and a new high-voltage driver IC. These improvements decrease the losses inside the module, and increase efficiency. In addition, the dies inside the module are smaller.

ON Semiconductor also supplies a wider range of iRAM-replacement single-in-line modules for use in brushless DC motors. There are two mounting options: vertical, or horizontal with pins bent at 90°. The modules include six IGBTs and three half-bridge drivers with bootstrap diodes.

FEATURES
- Under-voltage protection
- Over-current protection
- Cross-conduction protection
- Under-voltage lock-out
- Thermal sensor
- Fault output





Block diagram of an ON Semiconductor intelligent power module

iRAM CROSS-REFERENCE TABLE

ON Semiconductor Part Number	Package	iRAM Equivalent	Power Rating
STK534U363C-E*	SIP-05	IRAM136-0760A	5A/600V
STK534U363C-E	SIP-05	IRAM136-1060A	10A/600V
STK554U362C-E	SIP-1A	IRAM136-1061A	10A/600V
STK554U362A-E	SIP-1A	IRAM136-1061A-2	10A/600V
STK554U392C-E	SIP-1A	IRAM136-1561A	15A/600V
STK554U392A-E	SIP-1A	IRAM136-1561A-2	15A/600V
STK554U362C-E	SIP-1A	IRAM256-1067A	10A/600V
STK554U362A-E	SIP-1A	IRAM256-1067A-2	10A/600V
STK554U392C-E	SIP-1A	IRAM256-1567A	15A/600V
STK554U392A-E	SIP-1A	IRAM256-1567A-2	15A/600V
STK544UC63K-E	SIP-1	IRAMS10UP60A	10A/600v
STK541UC62K-E	SIP-1	IRAMS10UP60B	10A/600V
STK541UC62A-E	SIP-1	IRAMS10UP60B-2	10A/600V
STK544UC63K-E*	SIP-2	IRAMX16UP60A	16A/600V
STK541UC62K-E*	SIP-2	IRAMX16UP60B	16A/600V
STK541UC62A-E*	SIP-2	IRAMX16UP60B-2	16A/600V

* Current rating is not identical - check application requirements.

Replacement modules for Mitsubishi parts

ON Semiconductor offers two new ranges of power modules for motor drivers which are pin-compatible with legacy Mitsubishi parts.

MITSUBISHI CROSS-REFERENCE TABLE

ON Semiconductor Part Number	Package	Mitsubishi Equivalent	Power Rating
NFAM3065L4B	SPM®31	PS21767/PSS30S71F6	30A/650V
NFAM5065L4B	SPM®31	PSS50S71F6	50A/650V
NFAL5065L4B	SPM®49	PS21A79	50A/650V
NFAL7565L4B	SPM®49	PS21A7A	75A/650V

The ON Semiconductor SPM®49 series has the same footprint as the Mitsubishi Large DIP modules. The SPM®31 series is compatible with the Mitsubishi Mini DIP series.

The new ON Semiconductor modules offer superior thermal performance and higher power ratings than the equivalent Mitsubishi modules. This is because they have a Direct Bonded Copper (DBC) substrate which improves heat conduction from the module. Modules with a DBC and the same heat-sink as earlier devices run cooler and can carry a higher motor current in the same package.

ON Semiconductor modules in the SPM31 package can handle motor current up to 50A in 650V IGBTs, and up to 20A in 1,200V IGBTs.

Modules in the SPM49 package support up to 75A with 650V IGBTs and up to 50A with 1,200V IGBTs.

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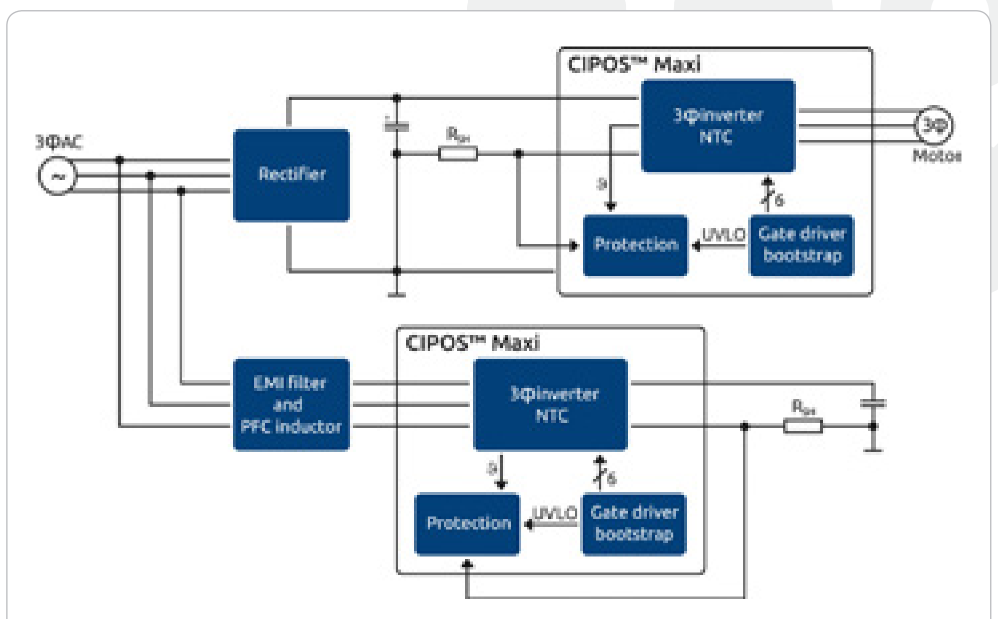
1,200V power modules offer best power density in their class

Infineon

Infineon's high-performance CIPOS™ Maxi Intelligent Power Modules (IPMs) provide a highly integrated inverter power stage for electric motors, helping system designers to achieve high reliability while optimizing PCB size and system costs.

The CIPOS Maxi products may be used to control three-phase AC motors and permanent magnet motors with a variable-speed drive. They support motor power loads up to 1.8kW in systems rated for up to 1,200V. The small size of the CIPOS Maxi IPMs – they are housed in a thermally-efficient DIP package measuring 36mm x 23mm – means that users benefit from the highest power density as well as the best performance in the 1,200V IPM class.

The devices are also the first 1,200V IPMs to include an optimized six-channel Silicon-On-Insulator (SOI) gate driver to provide built-in dead-time, which prevents the risk of damage from high transient voltages.



CIPOS Maxi: Typical application circuit for a three-phase motor's power stage

Part Number	Voltage	Nominal Current at 25°C	Nominal Current at 80°C	Maximum Power	Maximum Junction Temperature
IM818-SCC	1,200V	8A	5A	1.2kW	150°C
IM818-MCC	1,200V	16A	10A	1.8kW	150°C

ENERGY INDUSTRIAL LIGHTING MEDICAL TRANSPORT SECURITY CONSUMER TELECOMS

APPLICATIONS

- Pumps
- Blowers
- Fan motors
- Active power factor correction for HVAC systems
- Low-power general-purpose drives
- Servo drives

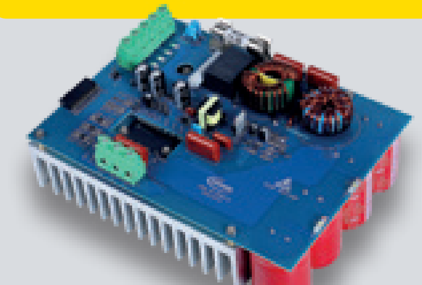
FEATURES

- Direct Bonded Copper (DBC) substrate offers excellent thermal conductivity
- Six 1,200V TRENCHSTOP™ IGBTs
- Allows negative supply voltage up to -11V for signal transmission at 15V
- Integrated bootstrap functionality
- Over-current shutdown
- Under-voltage lock-out on all channels
- All six switches turn off when a protection function is activated
- Cross-conduction prevention
- Low-side emitter pins accessible for phase-current monitoring
- Enable input
- UL-certified thermistor

FTM DEVELOPMENT BOARD

Orderable Part Numbers:
EVALM1IM818ATOBO1 and EVALM1101TTOBO1

Available at FutureElectronics.com



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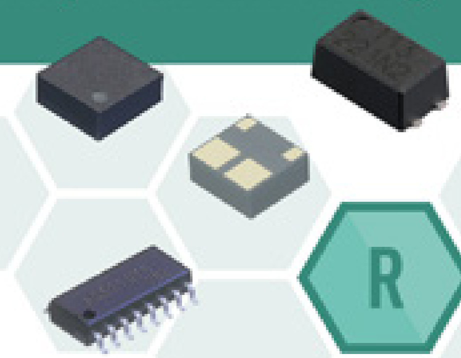
PhotoMOS®

Optically Isolated Solid State Relays



Long life and low power

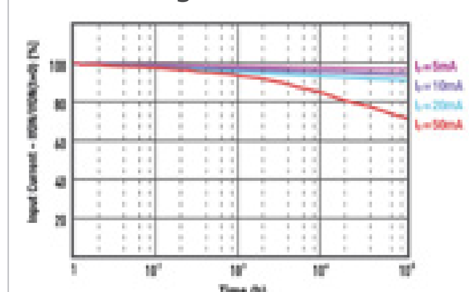
Panasonic
INDUSTRY

Panasonic's patented PhotoMOS® optically isolated MOSFET relays have an LED at the input which transmits light when activated to a series of photocells that, in turn, charge a pair of MOSFETs on the output side.

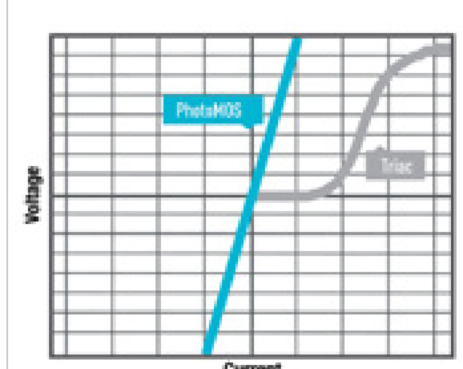
The PhotoMOS technology produces solid-state relays which offer superior operating characteristics:

- Low power consumption
- No contact wear
- No arcing
- No bounce
- No noise

Long Product Life



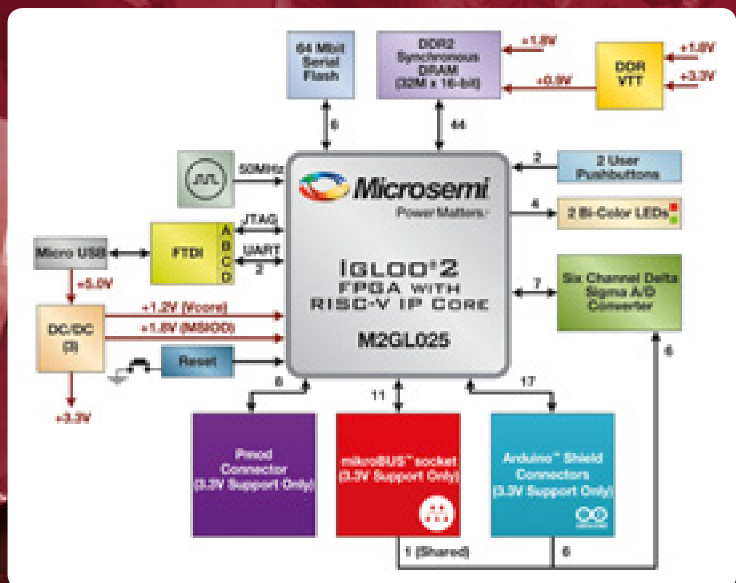
High Linearity



Panasonic general-purpose PhotoMOS relay range

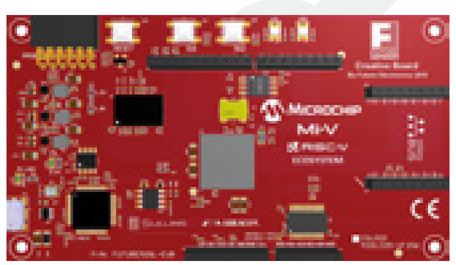
Part Number	Package	Form Factor	Load Voltage (V)	Load Current (mA)	On Res. (Ron) Typ./Max. (Ohm)	Turn On Typ./Max. (mS)	Turn Off Typ./Max. (mS)
Standard							
AQY282SX	SOP 4	1A	60	500	0.85/2.5	0.9/3	0.5/2
AQY280SX	SOP 4	1A	350	120	20/25	0.3/3	0.5/2
AQY284SX	SOP 4	1A	400	100	28/35	0.3/3	0.5/2
AQW282SX	SOP 8	2A	60	350	0.85/2.5	0.9/3	0.5/2
AQW280SX	SOP 8	2A	350	100	20/25	0.3/3	0.5/2
AQW284SX	SOP 8	2A	400	80	28/35	0.3/3	0.5/2
AQY282EH	DIP 4	1A	60	500	0.85/2.5	1.8/5	0.5/2
AQY280EH	DIP 4	1A	350	130	20/25	1.5/5	0.5/2
AQY284EH	DIP 4	1A	400	120	28/35	1.5/5	0.5/2
AQW282EH	DIP 8	2A	60	400	0.85/2.5	1.8/5	0.5/2
AQW280EH	DIP 8	2A	350	120	20/25	1.5/5	0.5/2
AQW284EH	DIP 8	2A	400	100	28/35	1.5/5	0.5/2
High Performance							
AQY212S	SOP 4	1A	60	500	0.83/2.5	0.65/2	0.008/0.2
AQY210S	SOP 4	1A	350	120	17/25	0.23/0.5	0.04/0.2
AQY214S	SOP 4	1A	400	100	25/35	0.21/0.5	0.04/0.2
AQW212S	SOP 8	2A	60	400	0.83/2.5	0.65/2	0.008/0.2
AQW210S	SOP 8	2A	350	100	16/35	0.23/0.5	0.04/0.2
AQW214S	SOP 8	2A	400	80	30/50	0.21/0.5	0.04/0.2
AQY211EH	DIP 4	1A	30	1000	0.25/0.5	1.5/5	0.1/1
AQY212EH	DIP 4	1A	60	550	0.85/2.5	1.0/4.0	0.05/1
AQY210EH	DIP 4	1A	350	130	18/25	0.5/2	0.08/1
AQY214EH	DIP 4	1A	400	120	26/35	0.5/2	0.08/1
AQY216EH	SIP-1A	1A	600	50	52/120	0.5/2	0.04/1
AQW212EH	DIP 8	2A	60	500	0.83/2.5	1.0/4.0	0.08/1
AQW210EH	DIP 8	2A	350	120	18/25	0.5/2	0.08/1
AQW214EH	DIP 8	2A	400	100	26/35	0.5/2	0.08/1
AQW216EH	DIP 8	2A	600	40	52/120	0.5/2	0.04/1

Creative development board now supports FreeRTOS running on its FPGA's RISC-V soft core



Microsemi
Power Matters.™

Future Electronics has announced that its Creative Board now offers developers the freedom to implement designs running the FreeRTOS kernel on the RISC-V CPU soft core embedded in the board's FPGA.



The Creative Board is an integrated development platform for users of IGLOO®2 FPGAs or SmartFusion®2 SoC FPGAs from Microsemi, a Microchip company. The IGLOO2 and SmartFusion2 FPGAs are suitable for a wide array of functions, including PCIe Gen2 control planes, image processing, motor control, I/O expansion and bridging. They also address design requirements for advanced security, high reliability and low power consumption.

Future Electronics designed the Creative Board to provide customers with a ready-made operating environment for proofs-of-concept and prototypes based on the low-cost IGLOO2 or SmartFusion2 FPGAs. As well as the FPGA, it features power, memory, connectivity, signal-processing and user-interface components.

Microsemi has implemented RISC-V, an open Instruction Set Architecture (ISA), as a soft CPU core in the IGLOO2 and SmartFusion2 FPGAs. Now Amazon has announced that RISC-V support is available in its FreeRTOS kernel. This enables embedded developers to create IoT applications on the officially supported FreeRTOS kernel for microcontrollers that use the free, open and extensible RISC-V ISA. It gives them the flexibility to create applications that are portable across any device and architecture that supports the FreeRTOS kernel.

RISC-V support in the FreeRTOS kernel is available for any RISC-V microcontroller that uses the base ISA, including Antmicro's Renode emulator for the Creative Board.

Developers can also run the ThreadX or µC/OS operating systems on the Creative Board's RISC-V core.

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APPLICATIONS
- Industrial equipment
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- Communications equipment
- Medical equipment

FEATURES
- Microsemi LX7167 DC-DC converter
- 32Mbits x 16-bit DDR2 SDRAM
- 64Mbit serial Flash
- 16-/24-bit delta-sigma ADCs
- FTDI USB-JTAG adaptor
- Arduino™-compatible expansion headers
- MikroBUS™-compatible expansion headers
- PMOD™-compatible expansion connector
-

FTM DEVELOPMENT BOARD
Orderable Part Number: Creative Board
Available at FutureElectronics.com

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Renesas portfolio
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- Automotive Power Management
- Automotive Battery Management
- Automotive Video and Display
- Embedded System Platforms
- Analog ICs
- Power Management ICs
- Space and Harsh Environment ICs

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- Interface and Connectivity
- Power Management
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TECHNICAL VIEW

Choose your AC-DC converter topology in haste, regret it at your leisure: why detailed evaluation of topologies pays off

By Riccardo Collura
Northern Europe Power Specialist Field Application Engineer
Future Electronics

When power-system designers start a new design for an AC-DC power converter, they are faced straight away with the important choice of topology. Broadly seven different topologies at least are supported by suppliers of power controller ICs. Each has a different set of advantages and drawbacks. So what is the best way to choose the topology for any given application?

> **Read this to find out about:**
> - Common causes of failure in new power-converter design projects
> - The relative advantages and drawbacks of various AC-DC power-converter topologies
> - The benefits of using wide-bandgap semiconductor components in AC-DC converters
> - The availability of power controllers which integrate primary- and secondary-side control

This article provides guidelines to help narrow down the range of topologies selected for detailed evaluation. Using guidelines such as these, designers will find that they can streamline their research and more effectively make a sound choice of topology at the outset of a new project.

As any experienced power designer will acknowledge, however, history is littered with examples of failed or delayed projects, the downfall of which may be attributed directly to decisions made at the start of the project. Before introducing the best practice guidance on topology evaluation, it is worth understanding first the factors that undermine AC-DC converter designs at their earliest stage.

Fig. 1: The GaNdalf AC-DC power supply reference design board from Future Electronics

The causes of misjudgement about topology

In this author's experience, the most common causes of design failure in AC-DC converter projects have their roots in either technical misjudgement or human behaviour.

On the technical side, inexperienced designers are prone to using a crude rule-of-thumb based on the maximum power loading that the converter is required to support. Power rating is of course an important parameter, but it is by no means the only one which is affected by the choice of topology.

System size and weight, system cost, power efficiency, thermal efficiency, complexity and EMI are all factors that the designer can optimize for with the right topology. It should also be recognised that these factors are inter-dependent. For instance, a complex Zero-Voltage Switching (ZVS) topology will produce far less severe EMI effects than a simpler hard-switched scheme. The choices made at the outset of a design should not only reflect the technical specifications of the product design, but also the capabilities of the development team and the design time available to it.

A development team which has deep expertise in EMI mitigation and EMC compliance, for instance, might be happy to employ a hard-switched topology in place of the complex ZVS alternative.

The other factor which in practice undermines good topology selection is human nature. It is common, and all too understandable, to rush the initial topology choice in order to more quickly progress to hardware development. This is often because a manager can see, and potentially be impressed by, a working prototype: it is a visible sign of progress with the project. The truth is, as well, that designing circuits and building boards is more fun and interesting than doing paper research into topologies.

Another human failing common among engineers bedevils power-system design projects: a preference for solitary technical problem-solving over collaborative activities and teamwork. A choice of topology normally calls for careful weighting of the various trade-offs at the system level. For instance, a decision which reduces Bill-of-Materials (BoM) cost but increases a converter's size and weight might affect logistics arrangements and raise shipping costs for the end product as a whole. These factors go far beyond the management authority of the engineering department. A holistic view of all costs across the entire product life cycle could help the design engineer to make better and more informed component choices.

Overall, experience suggests that failure to take into account the wider commercial environment can lead to project delays or even cancellation.

Avoiding early mistakes in power design projects

The question that arises from the above discussion is, how best to avoid this kind of mistake?

The obvious answer is of course to do the reverse of the flawed approaches:

- Collaborate extensively with colleagues across departments to gain relevant input on all the factors affected by the choice of topology
- Perform in-depth research into all applicable topologies, weighing up all the factors which are affected by the choice.

This second recommendation can appear challenging because there are so many choices of topology to evaluate. In fact, it is not as daunting as it might seem at first sight, because for any given power rating it is normally possible to narrow the choice down to two or three suitable topologies.

Table 1 is intended to facilitate this first-level evaluation: it provides a score for each topology on each engineering factor that should be considered, where the best topology has a score of five stars (*****) and the worst a score of one (*). The scores provide a rough indication, and experienced power-system designers might dispute one score or another. Overall, however, the table provides a useful guide to orientate the evaluation process and to inform the designer's discussion of trade-offs with colleagues.

Impact of new technology options

Beyond the choice of topology, there is one other important element of a designer's research before embarking on hardware implementation: the discovery of new components or technologies that have altered the landscape since earlier design projects were implemented.

Today, for instance, many AC-DC converter designers should be considering the use of new wide-bandgap Silicon Carbide (SiC) or Gallium Nitride (GaN) power components, which support much faster switching than silicon equivalents and can operate at higher temperatures.

Power Level	Topology	Efficiency	Complexity	EMI	Size/ Power Density	Cost	Power Factor
<100W	Flyback	**	*****	**	*****	*****	No PFC <75W, CrCM >75W
100W to 150W	Flyback	**	*****	**	*****	*****	CrCM
	Forward	***	****	***	***	***	CrCM
150W to 200W	Forward	**	****	***	***	***	CrCM
	LLC Resonant	****	*	*****	****	*	CrCM
200W to 250W	Forward	**	****	**	**	****	CrCM/CCM
	Two-Switch Forward	***	***	***	***	***	CrCM/CCM
	LLC Resonant	****	*	*****	****	*	CrCM/CCM
250W to 300W	Forward	**	****	**	**	****	CrCM/CCM
	Two-Switch Forward	***	***	***	***	***	CrCM/CCM
	LLC Resonant	****	*	*****	****	**	CrCM/CCM
	Half Bridge	****	**	***	**	**	CrCM/CCM
300W to 400W	Two-Switch Forward	**	***	**	***	****	CCM
	LLC Resonant	*****	*	*****	*****	**	CCM
	Half Bridge	****	**	***	***	**	CCM
400W to 500W	LLC Resonant	*****	**	*****	*****	**	CCM
	Half Bridge	****	***	***	***	***	CCM
500W to 600W	Half Bridge	***	***	***	***	***	CCM/ Interleaved
	Full Bridge	*****	**	***	**	**	CCM/ Interleaved
600W to 800W	Full Bridge	****	**	***	***	**	Interleaved
	Phase Shift ZVT	*****	*	****	****	*	Interleaved
>800W	Phase Shift ZVT	*****	*	****	****	*	Three-Phase Interleaved

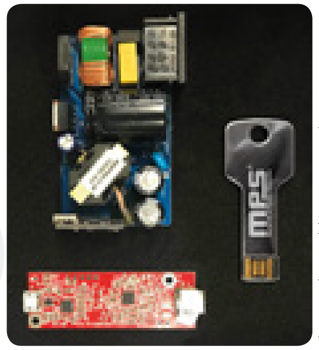
Table 1: rankings of various AC-DC power converter topologies. In the power factor correction column, CrCM = Critical Conduction Mode, and CCM = Continuous Conduction Mode

If the design priority is to achieve small size and weight and high power density, these characteristics become especially attractive. SiC MOSFETs, available today in production volumes from suppliers such as STMicroelectronics, ROHM Semiconductor and Microchip, enable the use of smaller capacitors and inductors, reducing the size of the complete converter assembly. The higher maximum operating temperature of SiC devices can also sometimes allow the designer to eliminate a fan or heat-sink that would have been required in a design using silicon MOSFETs, even in a densely populated enclosure with limited circulation of cooling air flows.

X-Gan High Electron Mobility Transistors (HEMTs) from Panasonic provide similar advantages in the GaNdalf reference design board from Future Electronics, as shown in Figure 1. This design demonstrates the bridgeless totem pole topology in the Power Factor Correction (PFC) stage of a <1kW AC-DC power supply. The use of GaN transistors helps the circuit to achieve high efficiency of better than 99.0% in the PFC stage.

The other important new product concept to affect AC-DC converter design today is the integration of the primary and secondary controller in a single IC for converters supplying less than 80W. This approach is enabled by an innovative power controller IC from Monolithic Power Systems. The MPX2001 provides a fully integrated solution for flyback converter designs.

It is a flyback controller with integrated primary and secondary control, and a synchronous rectification driver with capacitive isolation. Using the MPX2001, system complexity can be reduced since no feedback circuit is needed. This also has the effect of reducing total BoM cost. At the same time, a synchronous rectifier can be matched perfectly with the driving signal of the primary-side MOSFET. With this feature, the rectifier can operate safely in continuous conduction mode, which helps increase overall efficiency and provides the design with more flexibility.



(Image credit: Monolithic Power Systems)

Fig. 2: The MPX2001 evaluation kit, a small design intended as a demonstation of a power adaptor or charger for a computer or smartphone.

The high efficiency of MPX2001-based AC-DC converters is demonstrated by the EVKT-MPX2001-45-PD evaluation kit from Monolithic Power Systems, as shown in Figure 2. This is a design for a 45W USB Power Delivery power adapter intended to transfer power via a USB Type-C connector. It far exceeds the efficiency requirements of the US Department of Energy's Level VI and the European CoC Tier 2 standards. No-load power consumption is <0.075W.

Combining improved component technologies such as these, alongside comprehensive consideration of the contrasting advantages and drawbacks of each converter topology, and an understanding of the requirements of other departments beyond the engineering lab, power-system designers can give their projects the best chance of reaching a successful conclusion – as well as of meeting or exceeding the end product's design specifications.

FTM DEVELOPMENT BOARD
Orderable Part Numbers:
EVKT-MPX2001-45-PD and GaNdalf
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