FTM

FUTURE TECHNOLOGY MAGAZINE

FUTURE ELECTRONICS

19-iv EMEA

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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

FREE DEVELOPMENT BOARD

The ISL8212MEVAL1Z is a 3" x 3" six-layer FR4 board with 2oz copper on all layers. By default, the board is set to a 1V output voltage with a 400kHz switching frequency.

Orderable Part Number: ISL8212MEVAL1Z

Apply at: www.my-boardclub.com

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32-bit MCU provides compact and efficient platform for consumer devices and home appliances

The STM32G071 microcontroller from STMicroelectronics offers high analog performance and low-power operation for use in consumer and industrial devices and home appliances.

It is part of ST's new STM32G0 series of 32-bit MCUs, aimed at entry-level applications which require high energy efficiency, functionality and value in a small footprint. The STM32G0 MCUs feature flexible packaging and memory options to enable designers to do more in less space, and to reduce costs. A new power-distribution architecture reduces external power and ground connections to just a single pair of pins, allowing more of the package pins - a precious resource in many embedded projects - to be allotted to user connectivity.

The STM32G071 MCU is based on a high-performance Arm® Cortex®-M0+ core operating at a frequency of up to 64MHz. It incorporates a memory protection unit, up to 128kbytes of Flash program memory and 36kbytes of SRAM, a DMA unit and an extensive range of system functions, enhanced I/Os and peripherals.

The part's strong analog capabilities include one 2.5Msamples/s 12-bit ADC with up to 19 channels, one 12-bit DAC with two channels, two fast comparators, an internal voltage reference buffer, and a low-power real-time clock.

Optimized dynamic power control combined with a comprehensive set of power-saving modes, low-power timers and a low-power UART allow the designer to implement successful low-power applications.

The MCU's I²S and HDMI CEC interfaces support the requirements of consumer device designs. It also provides a fully integrated USB Type-C™ Power Delivery controller.

NUCLEO-G071RB board: Arduino and ST morpho headers

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APPLICATIONS

- IoT devices
- Home entertainment products
- Home appliances
- Industrial equipment

FEATURES

- Cyclic redundancy check calculation unit
- Up to 60 fast I/Os
- Two I²C interfaces
- Four USART interfaces
- Two serial peripheral interfaces
- Operating-temperature range: -40°C to 125°C
- Supply-voltage range: 1.7V to 3.6V

FREE DEVELOPMENT BOARD

The 64-pin NUCLEO-G071RB board features an STM32G071RB MCU and provides connectivity support for the addition of Arduino® and ST morpho boards.

Orderable Part Number: NUCLEO-G071RB

Apply at: www.my-boardclub.com

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Power capacitor with ESTAspring features lever-operated spring terminal connection

VISHAY

Vishay Intertechnology has introduced a new series of Low-Voltage AC (LVAC) power capacitors which feature ESTAspring, the industry's first lever-operated spring terminal connection.

Thanks to the ESTAspring, the new ESTA PhMKP series of power capacitors can be used to increase the reliability of connections in applications that are subject to high levels of vibration, such as wind turbines.

While most tubular power capacitors feature an IP20 terminal block which has a screw connection, the ESTAspring connection of the PhMKP series contains no screw fastenings, reducing assembly time by 60%.

Since the PhMKP capacitors eliminate the need to tighten screws, they provide a completely maintenance-free connection. On assembly, a simple visual check that the lever is closed verifies that the device is successfully connected.

PhMKP capacitors: Maintenance-free connection

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APPLICATIONS

- Wind power plants
- Solar panels and inverters
- Thermal power stations

FEATURES

- Corrosion-proof
- Stainless steel spring
- Voltage options from 230V to 1,000V
- Output from 2kVA to 37.1kVA
- Maximum terminal current of 90A
- Available in oil-filled and dry gas-filled versions
- UL and cUL recognised

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Anti-vandal, sealed push-button switch features damage-proof body

C&K

C&K supplies the ATP16 series of anti-vandal sealed push-button switches, which offer high strength in a lightweight housing.

The sealed switches are suitable for operation in harsh conditions, and can withstand attempts to inflict malicious damage. They feature a scratch-resistant actuator with housings made from robust stainless steel or aluminium alloy, so they are particularly effective for use in remote and unsupervised locations in which resistance to damage from vandalism is important.

ATP16 switches: choice of button symbols and colours

The switches feature a current rating of 2A and a voltage rating of 36V DC. They are supplied in a single-pole, single-throw configuration with a momentary or lock switch function. The threaded panel-mount housing fits in a 16mm-diameter cut-out.

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APPLICATIONS

- Alarm, safety and security systems
- Access controls
- Door intercoms
- Service station equipment
- Automatic food and drink vending machines
- Transportation controls

FEATURES

- Snap action provides positive feedback
- IP67 seal rating
- LED indicator illumination in various colours
- Choice of button symbols

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New low-cost package option for 48V-to-point-of-load buck regulators

VICOR

The PI358x series is the latest addition to the Vicor 48V ZVS Buck Regulator portfolio, offering a new low-cost grid-array QFN package option to the existing LGA and BGA System-in-Package (SiP) products.

The PI358x modules' Zero-Voltage Switching (ZVS) topology enables direct and highly efficient conversion from a 48V power bus to point-of-load voltages as low as 2.2V without sacrificing performance. By implementing step-down regulation from a 48V source, engineers can deploy more efficient power-distribution architectures, reduce conduction losses, and eliminate costly and inefficient intermediate conversion stages.

The PI358x devices achieve very accurate line and load regulation of 0.10%. They are highly integrated regulator modules and the few external components required include an inductor and ceramic input and output capacitors. To set the output voltage, the user configures an external resistor divider network using guidelines supplied by Vicor.

Multiple PI358x-00 units may be connected in parallel to increase the output capability of a single output rail. Modules do not have to be interleaved or synchronized to share current.

PI358x: Accurate voltage regulation

Part Number	Package	Input-voltage Range	Nominal Output Voltage (range)	Current
PI3583-00-QFYZ	7mm x 8mm GQFN	30V to 60V	3.3V (2.2V to 4.0V)	10A
PI3585-00-QFYZ	7mm x 8mm GQFN	30V to 60V	5.0V (3.8V to 6.5V)	10A
PI3586-00-QFYZ	7mm x 8mm GQFN	30V to 60V	12V (6.5V to 14V)	9A

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APPLICATIONS
- Telecoms equipment
- Network infrastructure
- Data centres
- Industrial equipment
- Lighting

FEATURES
- Power-up into pre-biased load <6V
- Fast and slow current limits
- Differential amplifier for remote output sensing
- User-adjustable soft-start and tracking

FREE DEVELOPMENT BOARD
Orderable Part Number: PI3583-00-EVAL1
Apply at: www.my-boardclub.com

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IR transmissive sensors provide accurate and robust position encoder outputs

VISHAY

The TCUT and TCPT series of compact transmissive sensors from Vishay Intertechnology can be used to accurately detect the position of an object such as an optical codewheel moving between the arms of the device.

The sensors consist of infrared (IR) emitters and photo-transistor detectors located face-to-face in a surface-mount package. The TCxT series includes devices with specifications optimized for various application conditions.

The surface-mount TCUT1630X01 and TCUT1800X01 each measures 5.5mm x 5.9mm x 7mm, and provide a gap of 3mm between the emitter and detector. With a tall dome and an additional channel for a vertical push function or indexing tab, the TCUT1630X01 is ideal for turn and push encoding. It features one IR emitter and three detectors.

The quad-channel TCUT1800X01 includes two IR emitters and four detectors, and can detect up to 16 positions, a capability suitable for absolute and incremental encoding applications.

The TCxT1300X01 sensors are single or dual-channel sensors with a 5.5mm x 4.0mm footprint. The TCxT1350X01 is a high-temperature version rated for operation at up to 125°C.

The TCxT1600X01 is a compact high-dome transmissive sensor which has a footprint of 5.5mm x 4.0mm, and is just 7.7mm high.


Vishay transmissive sensors: Air gap of 3mm

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APPLICATIONS
- Automotive:
  - Encoders in high-temperature environments close to motors
  - Interior knobs
  - Ignition locks
  - Adaptive headlights
  - Electric power steering
- Industrial:
  - Gas and water meters
  - Vending machines
  - Credit card readers
  - Door and panel opening detection

FEATURES
- 950nm emitter wavelength
- AEC-Q101 qualified

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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 microcontroller 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.

S5D3 Part	Package
R7FS5D37A2A01CLJ	100-pin LGA
R7FS5D37A3A01CFP	100-pin LQFP
R7FS5D37A3A01CFM	64-pin LQFP
R7FS5D37A3A01CNB	64-pin QFN

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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

FREE DEVELOPMENT BOARD
The TB-S5D3 Target Board Kit allows customers to start system development using an on-chip debugger, a header giving access to all the MCU's pins, a USB port, LEDs and capacitive touch-sensing buttons.
Orderable Part Number: YSTBS5D3E10
Apply at: www.my-boardclub.com

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Low-power DC-DC converter modules provide precise voltage outputs

RECOM

RECOM has launched the R0.5ZX and R1ZX series of modules which include an internal linear regulator to give a precise, load-independent and low-noise output. This means that they provide an ideal power supply for sensitive devices such as sensors and test and measurement instruments.

The new modules are based on the R1SX series of low-profile, surface-mount regulators and, like them, provide up to 2kV of isolation.

The output from the R0.5ZX and R1ZX products is notable for its low output ripple and noise, but this can be reduced even further to $2mV_{p-p}$ with the addition of a simple external filter circuit. The output is also continuously protected against short circuits.

In the event of a continuous overload or over-temperature condition, the output will shut down, thus protecting the converter and the application from over-current damage. The output will automatically restart once the fault condition has been lifted.

RECOM R1ZX: Low output ripple and noise

Part Number	Nominal Input Voltage (V DC)	Output Voltage (V DC)	Output Current (mA)	Typical Efficiency (%)	Maximum Capacitive Load (µF)
R0.5ZX-0505/P	5	5	100	71	470
R1ZX-0505/P	5	5	200	68	1,000

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

APPLICATIONS
- Industrial controls
- Bus isolators
- Test and measurement equipment

FEATURES
- 1W power output
- Industry-standard pin-out
- Operating-temperature range: -40°C to 100°C
- IEC/EN/UL62368-1 certified

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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

FREE DEVELOPMENT BOARD

The ISL81601EVAL1Z evaluation board features the ISL81601, a 60V synchronous buck-boost controller.

Orderable Part Number: ISL81601EVAL1Z

Apply at: www.my-boardclub.com

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40V and 60V MOSFETs offer large reductions in on-resistance and board footprint

VISHAY

Vishay Intertechnology has introduced new 40V and 60V power MOSFETs based on its latest fourth-generation TrenchFET® technology which offer the lowest on-resistance in their class.

Use of the new 40V SiSS12DN or 60V SiSS22DN MOSFETs enables power-system designers to increase system efficiency by reducing conduction losses. The devices also feature a new space-saving package design which dramatically reduces the board footprint compared to the previous generation of MOSFETs.

The SiSS22DN has a maximum on-resistance of 4mΩ at a gate-source voltage of 10V. For the SiSS12DN, this on-resistance value is even lower at just 1.9mΩ. Typical gate charge of 28.7nC for the SiSS12DN, and just 22.5nC for the SiSS22DN, give outstanding figures of merit for the product of on-resistance and gate charge. This means that developers can use the new fourth-generation TrenchFET MOSFETs to realise highly efficient power-conversion system designs.

The small package size and high efficiency of the SiSS12DN and SiSS22DN also enable users to increase power density without breaching thermal limits. The devices have a board footprint of just 10.89mm². This compares to the 31.67mm² footprint of the equivalent parts, the SiR640ADP and the SiR670DP, from the previous generation of TrenchFET MOSFETs.

The new SiSSx2DN MOSFETs are expected to be used in synchronous rectification circuits, as primary-side switches and in DC-DC converters.

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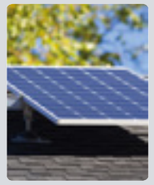
APPLICATIONS



- Solar micro inverter
- Motor-drive switch
- Battery and load switch
- Industrial equipment

FEATURES

- 90A maximum continuous drain current
- 3.6V maximum gate-source threshold voltage
- 100nA maximum gate-source leakage current

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Optically-coupled gate driver IC provides safety and noise isolation

VISHAY

Vishay has released a new isolated IGBT/MOSFET driver which produces a high peak drive current of 2.5A with a high-efficiency, low power-drop MOSFET output stage, sufficient to directly drive high-power IGBTs with a rating up to 1,200V and 100A.

The VOD3120 combines a control stage optically coupled to a rail-to-rail MOSFET power-output circuit. This means it can provide safety and noise isolation for digitally-controlled power electronics systems such as AC inverters and motor drives.

The VOD3120 is rated for a maximum repetitive peak voltage of 891V. Intended for use in applications such as solar inverters, which often have digital controls close to noise-generating power devices, the VOD3120 benefits from a high common-mode voltage rejection rating of 35kV/µs to protect control circuitry from electrical noise.

The VOD3120 provides under-voltage lock-out protection with hysteresis. It operates from a supply-voltage range of 15V to 30V.

VOD3120: Capable of driving up to 1,200V IGBTs

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APPLICATIONS

- Solar inverters
- Motor drives
- Uninterruptible power supplies
- Induction hobs

FEATURES

- Compatible with industrial three-phase line voltages
- Highly efficient output drive dissipation
- Can be triggered by embedded digital controllers
- 0.5µs maximum propagation delay time
- Low-power CMOS output stage
- 5mA threshold current

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Miniature board-mount connectors supplied in DIP and surface-mount styles

HIROSE ELECTRIC EUROPE B.V.

Hirose has introduced the DF13 series of miniature wire-to-board and board-to-wire connectors, which have compact dimensions for use in densely populated board designs.

This miniature connector has a 1.25mm contact pitch. It is supplied in many versions to give the designer flexibility to configure the board layout to make the best use of limited space.

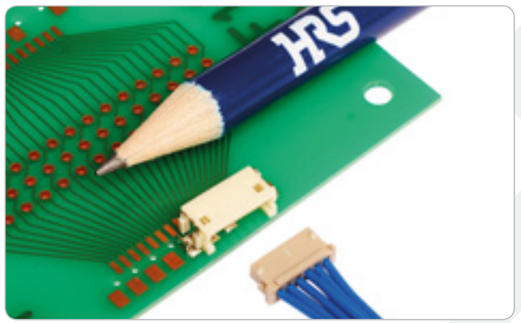
The DF13 series includes DIP solder, surface-mount, vertical and right-angle header variants.

Vertical versions are available in two mounting heights: a DIP version with a 5.3mm mounting height, and a surface-mount version with a 5.8mm mounting height.

Right-angle versions of the DF13 are available in DIP and surface-mount styles with a 3.6mm mounting height. Double-row board-mount receptacles are available in addition to crimp sockets in single or double rows.

The connector in a single-row configuration has 2 to 15 contacts, and in double-row configuration offers 10 to 40 contacts.

The DF13 series is part of the SignalBee™ product family. SignalBee consists of compact and high-performance wire-to-board and wire-to-wire connectors which are suitable for industrial applications.



Hirose DF13: Surface-mount connector is just 5.8mm high

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APPLICATIONS

- Industrial equipment
- LED lighting
- Measurement equipment
- Security devices

FEATURES

- Contact positions:
  - Single row: 2 to 15
  - Double row: 10, 20, 30, 40
- 1A current rating
- 150V AC voltage rating
- Up to 50 mating cycles
- Cable size: 26 to 32 AWG

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Ethernet jacks with integrated magnetics save board space

TE connectivity

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.

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.

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

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

TE connectivity

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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Peak current and temperature-resistant 32V chip fuse maintains stable operating characteristics

SCHURTER ELECTRONIC COMPONENTS

Schurter's UAI 1206 is a pulse- and temperature-resistant surface-mount chip fuse with time-lag characteristics for applications in which high durability and reliability are required.

Conventional fuses are subject to a memory effect: exposure to pulse-shaped current peaks and high temperature fluctuations changes their properties, weakening them and shortening their operating lifespan.

The Schurter UAI 1206 fuse is immune to these pulse and temperature effects. It benefits from a special construction, called trace-in-air technology, which increases exponentially the UAI fuse's ability to resist current pulses smaller than the melting integral. This means that the UAI 1206 requires almost no derating. The ingenious design of the fuse body also greatly dampens the effect of temperature fluctuations.

The UAI 1206 is hermetically sealed against potting compound for use in intrinsically safe applications.

It is suitable for any application exposed to high levels of pulse currents, high thermal fluctuations, or high mechanical loads. It is offered in two versions with rated currents of 5.3A and 7.5A.

UAI 1206: Hermetically sealed against potting compound

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APPLICATIONS

- Automotive systems
- LCD backlights
- Inverters

FEATURES

- AEC-Q200 qualified
- 32V DC rated voltage
- 100A breaking capacity
- Withstands 1,500g shock
- Ambient-temperature range: -40°C to 140°C

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Wire-to-wire and wire-to-board connectors offer wide choice of mounting and contact options

The VAL-U-LOK connector system from TE Connectivity (TE) offers wire-to-wire and wire-to-board connections which have contacts on a 4.2mm centreline and provide current ratings up to 9A maximum per line.

TE's VAL-U-LOK connectors carry up to 9A current per line

The plug and receptacle housings of the VAL-U-LOK connectors support wire-to-wire and wire-to-panel configurations. Their header assemblies offer wire-to-board connections in vertical and right-angle configurations.

VAL-U-LOK connector systems are available with between two and 24 positions in dual-row configurations, and three, four or five positions in single-row configurations.

Vertical headers are available with or without polarization pegs, and with or without drain holes. They offer a blind mate version. The right-angle headers are available with or without screw-mount flanges. Crimp, snap-in pin and socket contacts are used to terminate 26-16 AWG wire with an insulation diameter up to 3.1mm.

ENERGY INDUSTRIAL LIGHTING MEDICAL TRANSPORT SECURITY CONSUMER TELECOMS

APPLICATIONS

- Household appliances
- Desktop computers
- Indoor and outdoor lighting
- Security systems
- Industrial controls
- HVAC system controls
- Storage and networking

FEATURES

- 600V AC rating
- 105°C maximum operating temperature
- Contacts are available in strip form or loose piece
- Mate-first/break-last feature on three-position single-row receptacle housings
- Housings offered in glow wire-compatible material
- UL and CSA recognized

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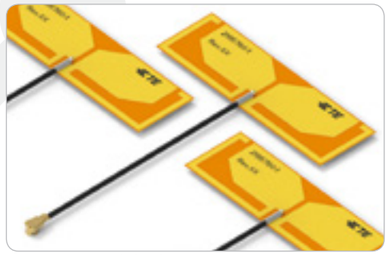
Standard GNSS antennas enable designers to reduce system size and cost

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

ENERGY INDUSTRIAL LIGHTING MEDICAL TRANSPORT SECURITY CONSUMER TELECOMS

APPLICATIONS

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

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Current Sense Transformers

TRIAD MAGNETICS

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:

- **Overcurrent protection**
- **Remote power monitoring**
- **Industrial control equipment**
- **Inverters and UPS**

CSE180L Series Low Frequency

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

Custom Design Sensors

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.

Quality and Reliability

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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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, ωslip, 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, tr. It requires a speed sensor even if speed control is not needed.

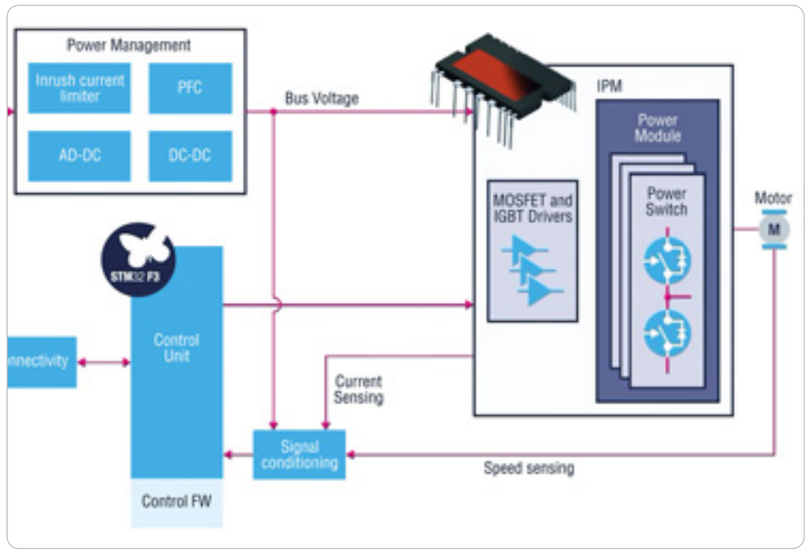


Fig. 1: Block diagram of induction motor system based on ST power and control boards

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.

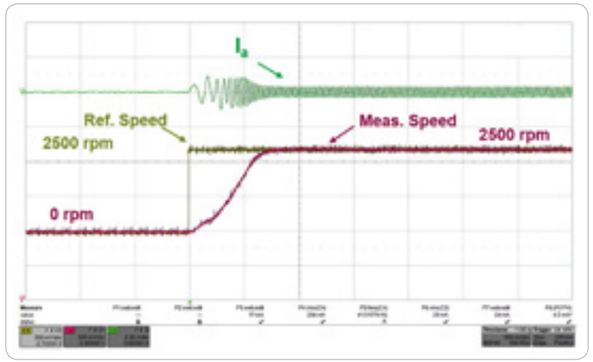


Fig. 2: Speed step response under no load from 0rpm to 2,500rpm using closed-loop V/f control

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.

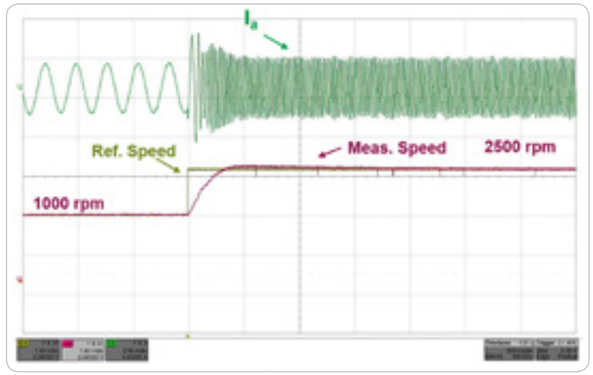


Fig. 3: Speed step response under a 1Nm load from 1,000rpm to 2,500rpm using indirect FOC control

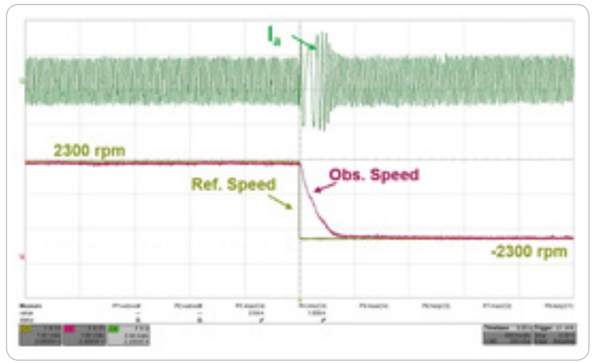


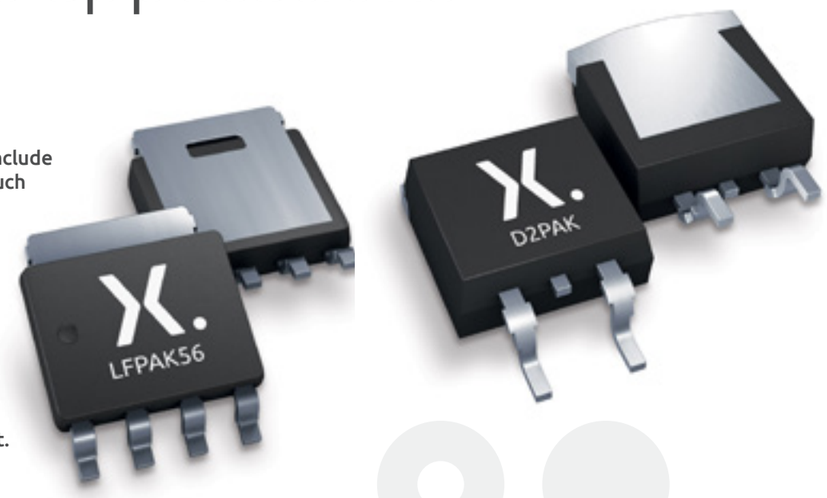
Fig. 4: Response time when reversing under sensor-less FOC control from 2,300rpm to -2,300rpm

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.

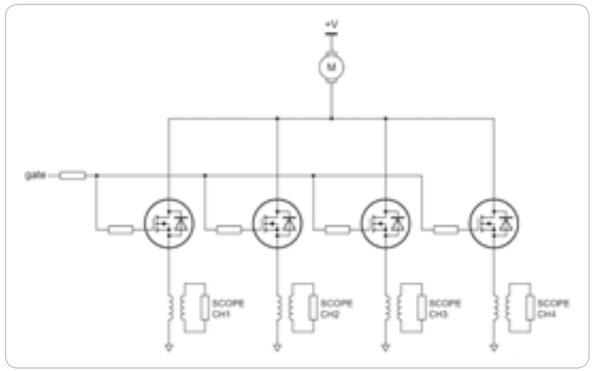


Fig. 1: Parallel motor drive test circuit

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.

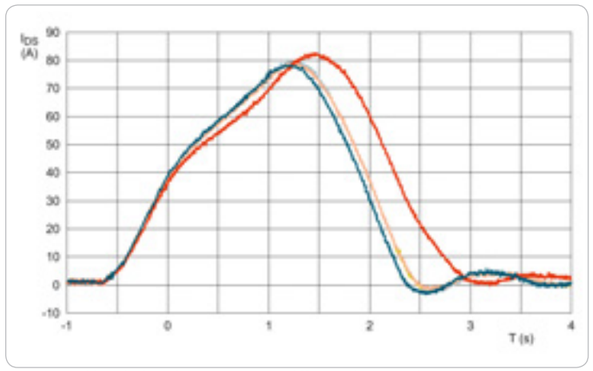


Fig. 2: Control (standard parts): Up to 30A current difference during switching

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.

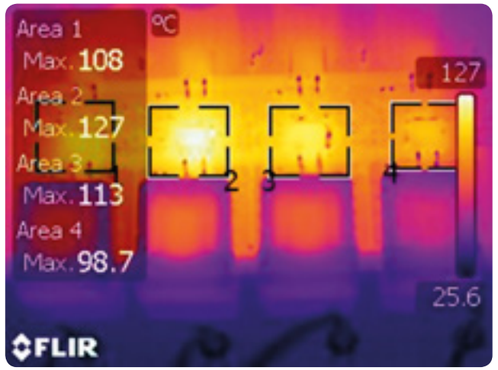


Fig. 3: Control (standard parts): Up to 28.7°C difference, and peak of 127°C during switching

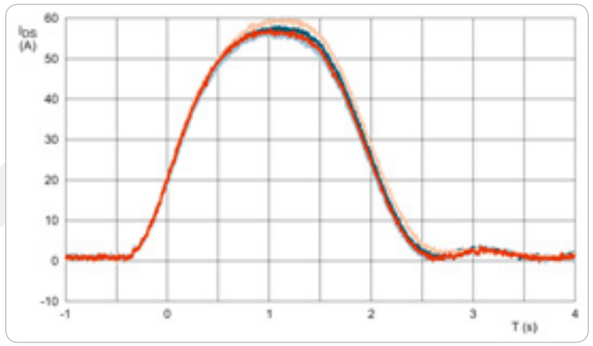


Fig. 4: Optimised parts: Up to 4A current difference during switching

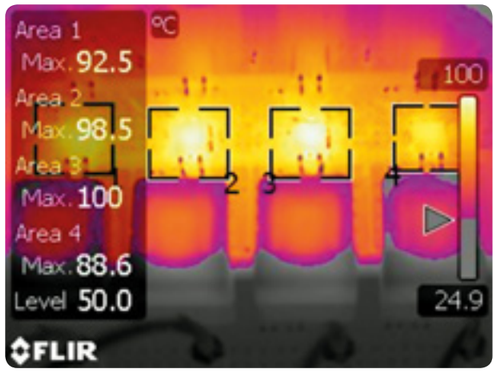


Fig. 5: Optimised parts: 11.4°C difference, and peak of 100°C during switching

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:

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

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:

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

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.

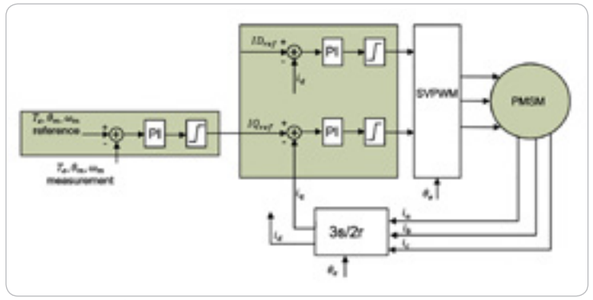


Fig. 1: PMSM FOC schematic

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 $a_{n|m}$ represents the estimation of a at step n up to the observation of step m and $m \le n$. 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.

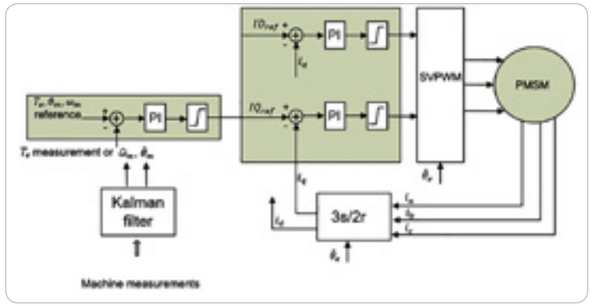


Fig. 2: Dynamic observer-based FOC

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.

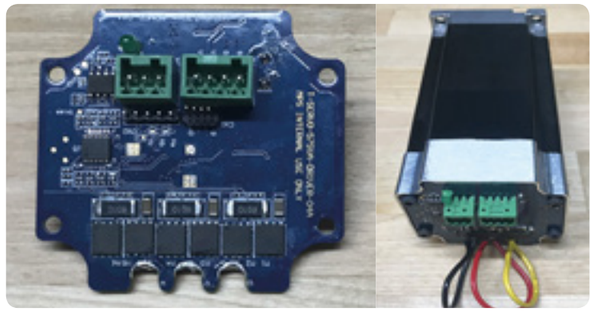


Fig. 3: The MPS Motor Control Module (left) and MPS Smart Motor (right)

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.

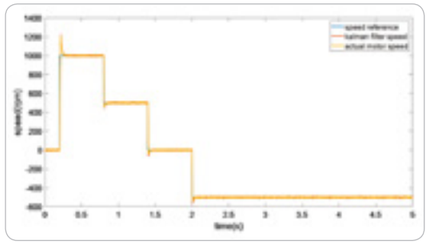


Fig. 4: Step-speed response in real time

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.

New PMSM control software in ready-to-run reference design for i.MX RT processors

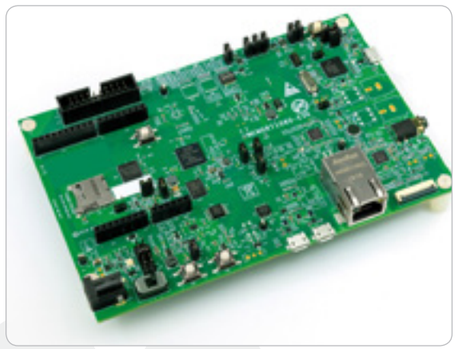
NXP Semiconductors has released a new version 1.2.0 of its three-phase Permanent Magnet Synchronous Motor (PMSM) control software for the i.MX RT series of crossover processors.

Combined with an evaluation kit for an i.MX RT processor such as the MIMXRT1050-EVK and a FRDM-MC-LVPMSM low-voltage evaluation board in a shield form factor, the software provides a reference design for three-phase PMSM designs operating as either sensor-less systems or with a position sensor. The reference design uses a closed-loop field-oriented vector control algorithm.

The i.MX RT series crossover processors on which the reference design runs combine the high performance and high level of integration of an applications processor with the ease of use and real-time functionality of a microcontroller.

The i.MX RT1050 and RT1060 devices run on an Arm® Cortex®-M7 core at an operating frequency of 600MHz, the i.MX RT1020 at 500MHz.

The i.MX RT1050 processor is equipped with 512kbytes of on-chip RAM memory. Four Flex Pulse-Width Modulator (eFlexPWM) modules and two 12-bit, 16-channel ADCs make this device a good choice for high-end multi-motor control applications.



i.MX RT1050 evaluation kit: Processor platform for PMSM reference design

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APPLICATIONS

- 3D printers
- Drones

FEATURES

- Application code detailed in NXP's AN12214
- Control theory described in DRM148
- User guide provides full guidance on board configuration and setting up the motor demonstration

FREE DEVELOPMENT BOARD

The i.MX RT1050 evaluation kit is a four-layer through-hole USB-powered PCB.

Orderable Part Numbers:
MIMXRT1050-EVK and FRDM-MCLVPMSM

Apply at: www.my-boardclub.com

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REFERENCE NUMBER 19-iv 23

Three-axis accelerometer and temperature sensor includes internal motion-detection engine

The LIS2DTW12 from STMicroelectronics is an ultra low-power temperature sensor with an embedded high-performance, three-axis linear accelerometer which may be used to detect temperature, motion and acceleration.

The LIS2DTW12's accelerometer has user-selectable full scales of ±2g, ±4g, ±8g or ±16g, and is capable of measuring acceleration at output data rates from 1.6Hz to 1.6kHz. Its temperature measurements are accurate to ±0.8°C at output data rates ranging from 50Hz to 1.6Hz, and in 8- to 12-bit resolution.

This integrated sensor has a 32-level First-In, First-Out (FIFO) buffer allowing the user to store data in order to limit the requirement for intervention by a host processor. An embedded self-test capability enables the user to check the functioning of the sensor in the final application.

It also has a dedicated internal engine which can perform motion- and acceleration-detection functions including free-fall, wake-up, single- or double-tap recognition, activity/inactivity detection, portrait/landscape detection and 6D/4D orientation.

The LIS2DTW12 is available in a small thin plastic LGA package measuring 2mm x 2mm x 0.7mm. It is guaranteed to operate over an extended temperature range from -40°C to 85°C.

LIS2DTW12: Built-in free-fall, tap, orientation and other detection functions

ENERGY INDUSTRIAL LIGHTING MEDICAL TRANSPORT SECURITY CONSUMER TELECOMS

APPLICATIONS

- Fragile shipment tracking
- Hearing aids
- Portable healthcare devices
- Wireless sensor nodes
- Metering equipment

FEATURES

- Supply-voltage range: 1.62V to 3.6V
- 50nA current in power-down mode
- <1µA current in active low-power mode
- 1.3mg$_{rms}$ noise in low-power mode
- 16-bit accelerometer data output
- 12-bit temperature sensor output
- Survives 10,000g shock

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REFERENCE NUMBER 19-iv 24

Automotive motor control toolkit includes comprehensive software library for field oriented control

The SPC5-MCTK-01 Automotive Motor Controller Toolkit from STMicroelectronics combines control and power components with ST's SPC5-MCTK-LIB Field Oriented Control (FOC) software library and system monitoring tools.

The toolkit incorporates the SPC560P-DISP MCU platform for the SPC560P automotive microcontroller with an EVAL-L9907 evaluation board for the L9907 motor driver and an inverter. It also includes a 24V, 64W motor to provide users with a complete evaluation system which is quick to set up.

Software is an important component of the platform: the software library is designed for flexibility and ease of integration into the SPC5 platform, which supports both the SPC560P and the SPC56EL MCUs.

The software package includes:

- The motor control library, which can drive single- or dual-FOC three-phase permanent magnet motors. It supports power stages with a single- or two-shunt topology while managing Hall, encoder and resolver types of position sensor. It also supports sensorless configurations.
- A plug-in configurator integrated into the SPC5Studio Open Development Environment, which helps the user to find the best setting for control efficiency and performance.
- SPC5 Motor Control Live Monitor to check and control the motor, and to change control algorithm parameters such as amplification gain and reference speed on the fly. Demonstration application examples are available for the SPC560P, L9907, STGAP1AS and L99ASC03G.

ENERGY INDUSTRIAL LIGHTING MEDICAL TRANSPORT SECURITY CONSUMER TELECOMS

APPLICATIONS

- Automotive motor systems

FEATURES

- L9907:
  - Three low-side and three high-side drivers
  - PWM operation up to 20kHz
  - Gate driver current adjustable in four steps
  - 600mA maximum gate-controlled current
  - Source connection to each MOSFET
- SPC560P:
  - Based on Power Architecture technology
  - Advanced timer with programmable cross-triggering unit
  - Single e200z0 core
  - Up to 1Mbyte of Flash memory
  - Up to 80kbytes of RAM

FREE DEVELOPMENT BOARD

Orderable Part Number: SPC560P-DISP

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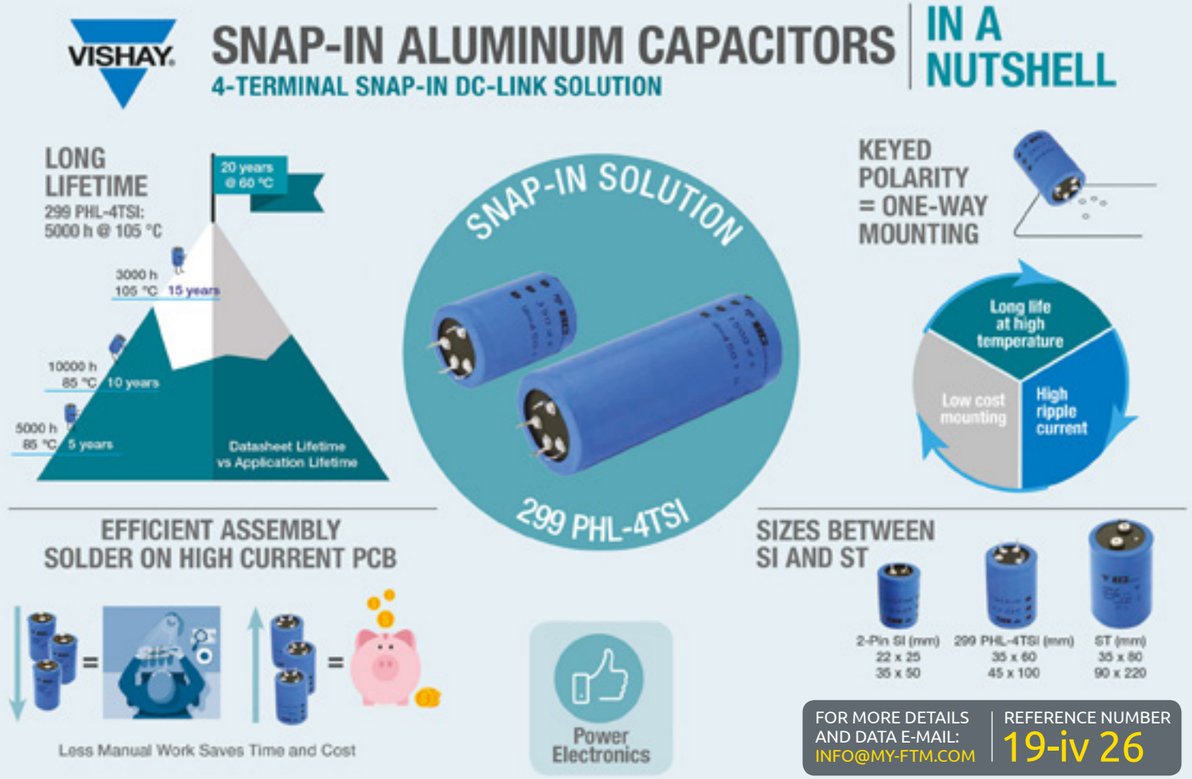
REFERENCE NUMBER 19-iv 25



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REFERENCE NUMBER 19-iv 26

Complete motor controller/driver in a single compact package

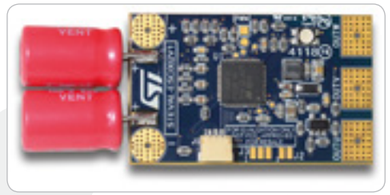
The STSPIN32F0B from STMicroelectronics is a System-in-Package (SiP) which provides an integrated solution incorporating a microcontroller and power stage suitable for driving three-phase brushless motors. It is supplied in a compact 7mm x 7mm x 1mm quad flat package.

Its triple half-bridge gate driver can drive power MOSFETs with a current capability of up to 600mA sink and source. The SiP prevents the high- and low-side switches of the same half-bridge from being simultaneously driven high thanks to its integrated interlocking function.

An internal DC-DC buck converter provides the 3.3V supply for both the MCU and external components. An internal linear regulator supplies the gate drivers. An integrated operational amplifier is available for conditioning signals such as a shunt resistor's current measurements.

The integrated STM32F031C6 MCU can implement field oriented control, six-step sensorless and other advanced motor-driving algorithms. It is based on an Arm® Cortex®-M0 core operating at up to 48MHz.

The STSPIN32F0B device also features over-temperature and under-voltage lock-out protection functions, and can be put in stand-by mode to reduce power consumption. The device offers 20 general-purpose I/Os, one 12-bit ADC with up to nine channels performing conversions in single-shot or scan modes, and five general-purpose timers.



STEVAL-ESC002V1: Electronic speed controller reference design

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APPLICATIONS

- Power tools
- Fans and pumps
- Industrial automation
- Battery-powered home appliances

FEATURES

- Comparator for over-current protection with programmable threshold
- I²C, USART and serial peripheral interfaces
- Operating-voltage range: 6.7V to 45V
- Operating-temperature range: -40°C to 125°C

FREE DEVELOPMENT BOARD

The STEVAL-ESC002V1 board is a compact, ready-to-use reference design for an electronic speed controller based on the STSPIN32F0A brushless motor controller. The board can easily fit in a small drone, and is also suitable for any three-phase brushless DC motor application requiring a small form factor, low cost and high-speed rotation.

Orderable Part Number: STEVAL-ESC002V1

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Integrated commutation encoder provides accurate angle measurements for BLDC motors

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

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

DGD20xxS8: Ideal for battery-powered devices

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.

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

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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High-voltage power driver system-in-package for industrial motor applications

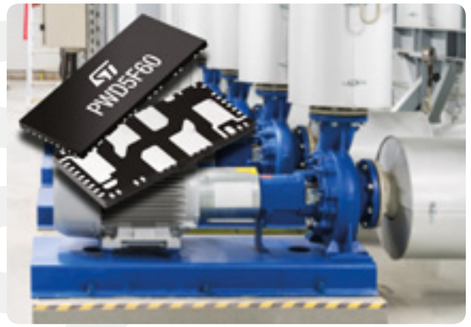
STMicroelectronics' PWD5F60 high-density power driver is an integrated System-in-Package (SiP) which is suitable for high-voltage brushed DC and single-phase brushless motors.

It integrates a 600V/3.5A single-phase MOSFET bridge with gate drivers, bootstrap diodes, protection features and two comparators in a package with a 15mm x 7mm footprint. The user has the option to configure the MOSFETs as a single full bridge or two half-bridges.

The PWD5F60's thermally efficient package occupies 60% less board space than an equivalent circuit made up of discrete components. The use of a SiP in place of discrete components gives higher reliability and simplifies both the circuit design and the assembly process.

Featuring on-resistance of 1.38Ω, the PWD5F60's integrated N-channel MOSFETs operate at high efficiency when handling medium-power loads. The gate drivers provide for reliable switching and low EMI. The integrated bootstrap diodes enable high-voltage start-up with no need for external diodes and passive components to supply the high-side inputs.

Two uncommitted comparators allow an easy implementation of peak-current control or over-current and over-temperature protection features. By implementing peak-current control together with Hall-effect position sensors, designers can make the PWD5F60 a stand-alone controller with no need for an MCU.



PWD5F60: 60% board space saving

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APPLICATIONS

- Industrial pumps, fans and blowers
- Domestic appliances
- Factory-automation systems
- Power supplies

FEATURES

- Adjustable dead-time
- Operating-voltage range: 10V to 20V
- Inputs compatible with 3.3V to 15V control signals
- Cross-conduction prevention
- Under-voltage lock-out

FREE DEVELOPMENT BOARD

The EVALPWD5F60 demonstrates how to use the PWD5F60 to drive a single-phase load in full-bridge topology. This allows control of both the direction and the value of the current flowing into the load.

Orderable Part Number: EVALPWD5F60

Apply at: www.my-boardclub.com

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New aluminium-polymer solid capacitors for high-temperature applications

Panasonic
INDUSTRY

Panasonic Industry Europe has extended its capacitor product line with the OS-CON aluminium-polymer solid capacitors, which maintain very stable Equivalent Series Resistance (ESR) across their entire rated temperature range.

OS-CON capacitors: Low and stable ESR

Available in both surface-mount and through-hole mounting versions, the OS-CON product line includes the SVP, SVPC, SVPF, SVPE, SEP, SEPC and SEPF series of solid-electrolyte aluminium capacitors. Formed from a combination of aluminium and a highly conductive polymer material, OS-CON capacitors offer low and stable ESR and excellent noise reduction.

In addition, the capacitors feature a high ripple current with a tiered ripple-current rating, so in applications which briefly reach an operating temperature of 125°C, the devices change to the lower ripple-current rating, while offering the higher rating at lower temperatures.

Voltage Range	2V to 100V DC
Capacitance Range	3.3µF to 2,700µF
Ripple Current	Up to 7.2A_{rms}

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APPLICATIONS

- Industrial equipment
- Harsh or hazardous environments

FEATURES

- 5,000 hours lifetime at 105°C
- 125°C maximum operating temperature
- Withstands 95% humidity at 95°C for 1,000 hours

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H-bridge driver ICs for automotive motors offer wide range of protection functions

The VNHD7008 and VNHD7012 ICs from STMicroelectronics are H-bridge drivers for driving automotive DC motors.

The devices include a dual high-side driver and the drivers and protection functions for two external power MOSFETs in low-side configuration.

These products benefit from ST's VIPower™ M0-7 technology, which allows a true power MOSFET to be integrated in the same die with intelligent signal and protection circuitry.

The VNHD7008 and VNHD7012 provide input signals for a direct interface with a microcontroller, allowing the user to configure the motor direction and the brake conditions. Two selection pins are available to address to the MCU the data acquired by the drivers' MultiSense function. The MultiSense pin provides the ability to monitor the motor current, provides a voltage proportional to the battery value, and tracks the temperature of the chip.

A PWM interface operating at up to 20kHz allows the user to control the speed of the motor in all possible conditions.

VNHD70xx: Provides direct interface to a microcontroller

Part Number	Package	On-resistance per Channel	Current Limit	Monitoring Capabilities
VNHD7008AY	PowerSSO-36	8mΩ	51A	Motor current, chip temperature, battery voltage
VNHD7012AY	PowerSSO-36	12mΩ	38A	Motor current, chip temperature, battery voltage

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APPLICATIONS

- Automotive motor systems

FEATURES

- AEC-Q100 qualified
- Half-bridge operation
- Load-current limitation
- Cross-current protection
- Over-temperature shut-down
- Self-limiting of fast thermal transients
- Over-voltage clamp and under-voltage shutdown

FREE DEVELOPMENT BOARD

The EV-VNHD7012AY board enables the user to directly connect the load, the power supply and a microcontroller without any additional design effort.

Orderable Part Number: EV-VNHD7012AY

Apply at: www.my-boardclub.com

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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.

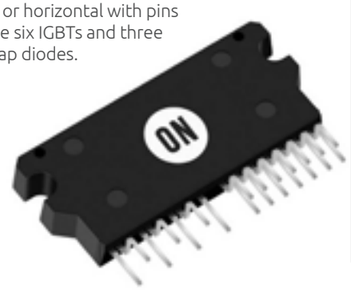
iRAM replacement modules

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.

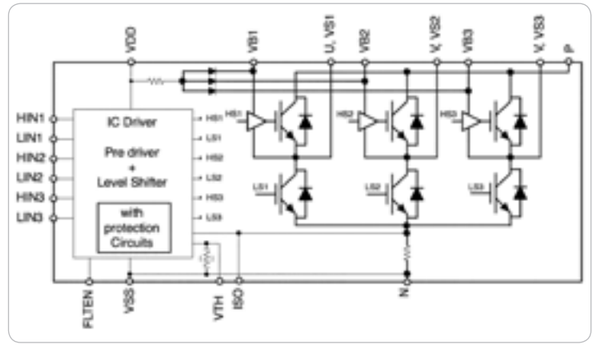
The new SIP-K package, based on the SIP-05 module style, integrates Field Stop 3 short-circuit rated IGBT technology and a new high-voltage driver IC. These improvements decrease the losses inside the module, and increase efficiency. In addition, the dies inside the module are smaller.

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.

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.

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

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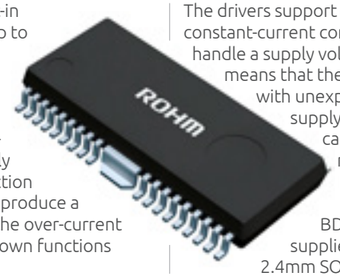
50V motor driver ICs offer high reliability and multiple protection functions

ROHM Semiconductor has extended its family of H-bridge motor driver ICs with the release of the BD63130AFM and BD63150AFM, which are for use with brushed DC motors.

The new drivers include built-in protection circuits which help to improve the reliability of the application. These functions include thermal shut-down, over-current protection, under-voltage lock-out, over-voltage lock-out, ghost supply prevention and cross-conduction prevention. The devices also produce a fault detection signal when the over-current protection or thermal shut-down functions operate.



The drivers support direct PWM or PWM constant-current control methods. They can handle a supply voltage of up to 50V, which means that they are robust enough to deal with unexpected spikes in the power-supply bus. Built-in transient noise cancellation eliminates the need for external noise filtering.

The BD63130AFM and BD63150AFM devices are supplied in an 18.5mm x 9.9mm x 2.4mm SOP package.

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APPLICATIONS
- Copiers
- Multi-function printers
- Laser and inkjet printers
- General industrial applications

FEATURES
- Supply-voltage range: 8.0V to 46.2V
- Rated output current
  - 3.0A for BD63130AFM
  - 5.0A for BD63150AFM
- Output on-resistance
  - 0.55Ω for BD63130AFM
  - 0.30Ω for BD63150AFM
- Operating-temperature range: -25°C to 85°C

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Power modules offer superior performance in industrial power applications up to 30kW

STMicroelectronics' ACEPACK™ 1 (Adaptable Compact Easier PACKage) and ACEPACK 2 power modules provide a highly integrated power-conversion capability for applications with high power loads between 3kW and 30kW.

Thanks to their high configuration flexibility, these robust power modules can implement various topologies in IGBT, MOSFET and silicon carbide (SiC) power-switching applications, providing both a compact and cost-effective design.

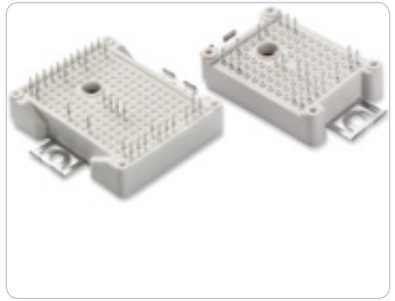
Features include optional solder-free press-fit connections, which provide for a simpler assembly process than conventional soldered pins, and metal screw clamps which enable fast and reliable mounting.

The ACEPACK modules include the latest ST power technologies, including third-generation Trench Field Stop IGBTs. These highly reliable products offer the best compromise between conduction and switching losses, maximizing the efficiency of any converter system operating at frequencies up to 20kHz in hard-switching topologies.

Two configurations are available:
- Sixpack modules contain six IGBTs with freewheel diodes configured as a three-phase inverter
- CIB modules have a Converter-Inverter-Brake topology, and integrate a three-phase rectifier, a three-phase inverter, and a braking chopper for handling energy returned from the load.

Both types also contain an NTC thermistor for temperature sensing and control.

Part Number	Topology	Maximum Breakdown Voltage (V)	Maximum Current at 100°C Case Temperature
A1C15S12M3-F	CIB	1,200	15A
A1P25S12M3	Sixpack	1,200	25A
A1P25S12M3-F	Sixpack	1,200	25A
A1C15S12M3	CIB	1,200	15A
A1P35S12M3	Sixpack	1,200	35A
A1P35S12M3-F	Sixpack	1,200	35A
A1P50S65M2	Sixpack	650	50A
A1P50S65M2-F	Sixpack	650	50A
A2C25S12M3	CIB	1,200	25A
A2C25S12M3-F	CIB	1,200	25A
A2C35S12M3	CIB	1,200	35A
A2C35S12M3-F	CIB	1,200	35A
A2C50S65M2	CIB	650	50A
A2C50S65M2-F	CIB	650	50A
A2P75S12M3	Sixpack	1,200	75A
A2P75S12M3-F	Sixpack	1,200	75A



ACEPACK modules include ST's Trench Field Stop IGBTs

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APPLICATIONS
- Industrial motor drives
- Three-phase inverters for motor drivers up to 30kW
- Uninterruptible power supplies
- Hybrid electric and electric vehicles

FEATURES
- 2.5kV AC isolation voltage
- Soft and fast recovery diode
- Low stray inductance
- 175°C maximum junction temperature

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Galvanic isolated gate driver protects SiC or silicon power transistors

Offering a maximum 26V gate-drive output voltage, STMicroelectronics' STGAP2S is a single-channel galvanic isolated gate driver which can control Silicon Carbide (SiC) or silicon MOSFETs and IGBTs in a range of switching topologies.

The device is available in two versions. The STGAP2SCM has a dedicated Active Miller Clamp pin which provides a convenient way to prevent unwanted transistor turn-on in half-bridge configurations. Connecting the MOSFET gate to this pin clamps the voltage to isolated ground at turn off until the next genuine turn-on signal.

The STGAP2SM offers separate turn-on and turn-off outputs to help optimise switching transitions using two external gate resistors.

Both STGAP2S gate drivers have 4A rail-to-rail outputs for crisp, efficient switching, even with high-power inverters. Input-to-output propagation delay is within 80ns for precise PWM control at the high switching frequencies at which SiC devices can operate. High dV/dt common-mode transient immunity prevents energy-sapping spurious switching.

With 1,700V galvanic isolation built-in, these devices can simplify the bill-of-materials in designs for high-voltage equipment. Extensive integrated protection features include under-voltage lock-out to protect the power switch if the supply voltage falls too low. Hardware interlocking prevents high-side/low-side cross-conduction in half-bridge circuits.

ST also supplies the STGAP2D, a dual-channel gate driver for use in half-bridge circuits.

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- Motor drivers
- 600V/1,200V inverters
- Battery chargers
- Induction heating
- Welding
- Uninterruptible power supplies
- Power-supply units
- DC-DC converters
- Power factor correction

FEATURES
- ±100V/ns dV/dt transient immunity
- 3.3V/5V TTL/CMOS inputs with hysteresis
- Temperature shut-down protection
- Stand-by function

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New design blueprint for Space Vector Modulation motor-control runs on low-cost 8-bit MCU

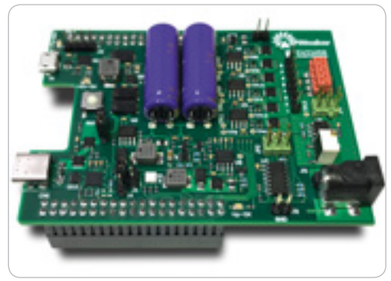
Future Electronics has introduced SPINnaker, a motor-control and driver reference design board which is hardware- and software-compatible with the STMicroelectronics Nucleo-8S208RB, a development kit for the STM8S series of low-cost 8-bit microcontrollers.

The SPINnaker daughterboard is the ideal rapid prototyping platform for motor control applications based on the use of an 8-bit MCU. It is supplied with example application code and an intuitive PC Graphical User Interface (GUI) to support the development of new motor control projects.

The SPINnaker reference design implements the Space Vector Modulation (SVM) method of motor control, a technique which is normally used in systems based on more expensive 16- or 32-bit MCUs. SVM offers various advantages over another commonly used technique for motor control, block commutation, such as low acoustic noise and the elimination of torque ripple. But an SVM system normally has a higher bill-of-materials cost than a circuit implementing block commutation.

The SVM motor-control software developed by Future Electronics, however, is able to run on the low-cost STM8S MCU or the automotive-qualified STM8AF, and only occupies a small Flash memory footprint of less than 8kbytes and requires less than 1.5kbytes of RAM. It includes a unique algorithm for speed control and flux reduction, and controls motor position at a resolution of up to 384 steps per revolution.

The SPINnaker design also follows a cost-saving approach to the design of the three-phase power stage, which is composed of six 60V STL20N6F7 MOSFETs from STMicroelectronics.



SPINnaker board: Control software runs on STM8S MCU

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APPLICATIONS
- Automotive systems
- Industrial equipment
- Consumer devices
- Home automation

FEATURES
- Panasonic supercapacitor for back-up power supply
- Panasonic POSCAP polymer capacitors
- 150°C maximum operating temperature
- Supplied with hardware and software design files

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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

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

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?

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.

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