FTM

FUTURE TECHNOLOGY MAGAZINE

FUTURE ELECTRONICS

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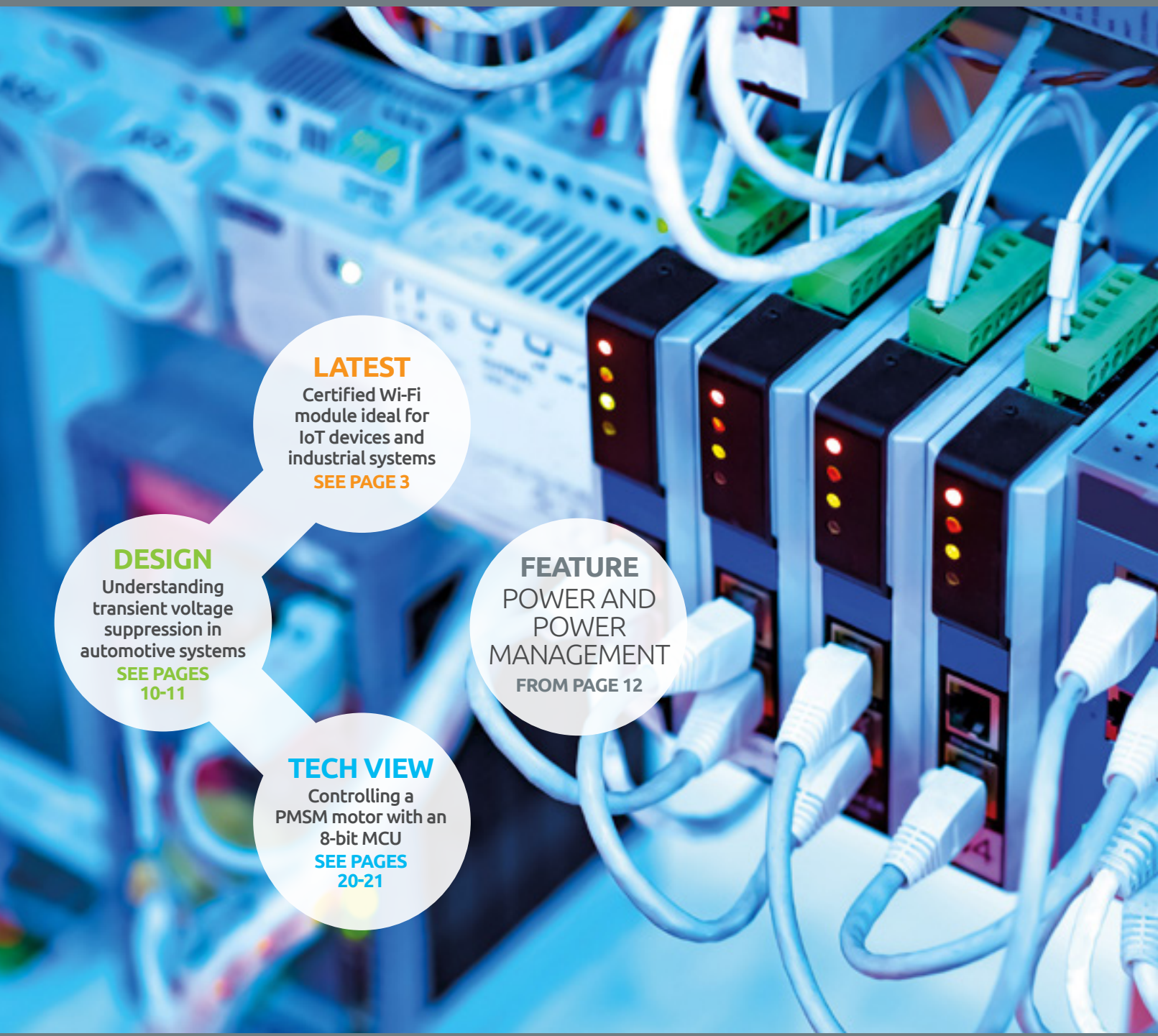

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POWER AND POWER MANAGEMENT

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TECH VIEW

Controlling a PMSM motor with an 8-bit MCU

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Family of automotive TVS diodes now available in SMA, SMB and SMC packages

Diodes Incorporated has introduced 84 new automotive-qualified Transient Voltage Suppression (TVS) diodes packaged in a choice of SMA, SMB or SMC packages.

These devices are intended for use in a wide range of automotive applications, in which they protect sensitive circuits such as Electronic Control Units (ECUs) from powerline transients generated by inductive switching at the alternator or at an electric motor.

The reverse stand-off voltage values available in the new TVS products range from 14V to 36V. They are supplied as both unidirectional and bidirectional devices. Power dissipation ratings, tested for 10/1,000µs pulses, are 400W for the SMA package, 600W for the SMB and 3,000W for the SMC.

All parts conform to the specifications of the ISO 7637-2 automotive standard for load dumps, pulses 1, 2a, 2b and 3. The diodes are also compatible with the ISO 10605 ESD standard.

Automotive diodes: Supplied in unidirectional and bidirectional versions

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APPLICATIONS

- Automotive systems:
  - ADAS
  - Infotainment systems
  - Navigation systems
  - Heating, ventilation and air conditioning
  - Body control modules

FEATURES

- AEC-Q101 qualified
- PPAP support
- High forward surge current capability
- Excellent clamping capability

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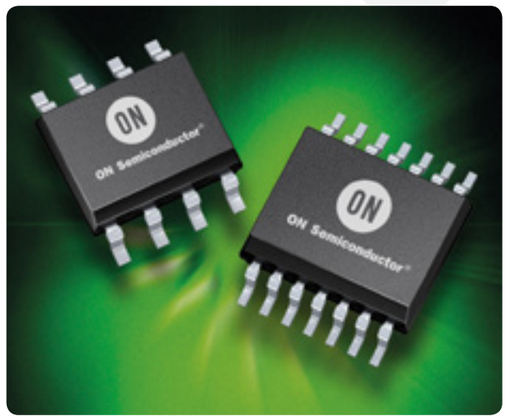
Precision op amps feature low noise and low drift

ON Semiconductor's NCS2191x family of high-precision operational amplifiers combine a low maximum input-offset voltage of just 25µV with low-noise operation to provide for accurate signal-conditioning in demanding sensing applications.



NCS2191x: Rail-to-rail output

The NCS2191x devices' noise performance is specified as 22nV/√Hz, ensuring minimal distortion of the input signal. The clean operation of the op amps is also very stable: maximum input-offset drift is just 0.085µV/°C.

The op amps' rail-to-rail output swings to within 10mV of the rails. Gain-bandwidth product is 2MHz.

The NCS2191x family is available in three versions and in various package styles: the single-channel NCS21911, the dual-channel NCS21912 and the quad-channel NCS21914. The NCV2191x parts are automotive-qualified versions of these op amps.

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APPLICATIONS

- Temperature monitoring
- Transducer systems
- Electronic scales
- Medical instrumentation
- Current sensing
- Automotive systems

FEATURES

- Supply-voltage range: 4V to 36V
- 570µA maximum quiescent current
- 3pF input capacitance
- 1.6V/µs slew rate
- 3kV ESD rating on the human body model
- Operating-temperature range: –40°C to 125°C

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New serial narrow-beam surface-mount LEDs

The new Lumex® SML-LXIL0603 products are serial narrow-beam surface-mount LEDs in a choice of colors.

The SML-LXIL0603 serial LEDs, available in red, yellow, green and blue versions, have a narrow viewing angle of 75˚. Since the light output from an LED chip is directional, higher light output may be achieved by concentrating the light in a tight beam. This means that the narrower the viewing angle, the higher the brightness value, in the case of the SML-LXIL0603, up to 2,135mcd.

Part Number	Emitted Color	Chip Material	Peak Wavelength	Forward Voltage	Forward Current	Light Intensity
SML-LXIL0603SIC-TR	Red	-	630nm	2.1V	25mA	1600mcd
SML-LXIL0603SYC-TR	Yellow	-	585nm	2.1V	25mA	1350mcd
SML-LXIL0603UPGCTR	Green	InGaN	520nm	3.0V	25mA	2135mcd
SML-LXIL0603USBCTR	Blue	InGaN	470nm	3.0V	25mA	500mcd

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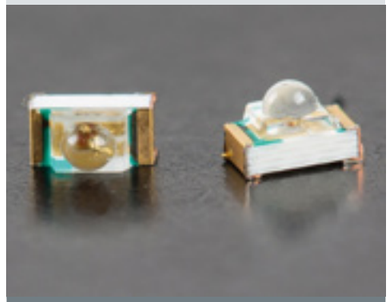
FEATURES

- Water-clear lens
- Junction-temperature range: -40°C to 85°C



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Certified Wi-Fi module ideal for IoT devices and industrial systems

WIZnet's WizFi360 is a complete Wi-Fi® networking module with a built-in microcontroller core, for use in IoT devices and industrial applications.

The WizFi360 includes a 2.4GHz transceiver and supports the IEEE 802.11b/g/n versions of the Wi-Fi networking standard. Its maximum UART baud rate is 2Mbits/s. It is supplied with FCC, CE, KC and J-MIC certificates.

The Wi-Fi module supports the TCP, UDP, MQTT and DHCP communications protocols using AT commands. Featuring an Arm® Cortex®-M3 core, it works as a serial interface-to-Wi-Fi bridge.

The WizFi360 is available in two versions:

- WizFi360-PA has an on-board PCB antenna. It measures 24mm x 16mm x 3mm.
- WizFi360-CON has an IPEX connector for an external antenna. Its dimensions are 17mm x 16mm x 3mm.

The WizFi360's hardware and software can be customized to meet user-specific requirements. Custom variants available to order include the WizFi360io-H, an XBee header-compatible module, and the WizFi360io-C, which features a 5V UART interface.

WizFi360 is also certified for the Microsoft Azure cloud computing platform, enhancing interoperability and allowing for faster time to production.


WizFi360-EVB: Compatible with the Arduino board standard

FTM DEVELOPMENT BOARDS

WizFi360-EVB-Mini is a compact evaluation board which can be easily integrated and programmed to reduce development time and cost.

Orderable Part Number: WizFi360-EVB-Mini

The WizFi360-EVB-Shield is an industrial-grade development board for testing and verification of the WizFi360 Wi-Fi module, and can be used as an Arduino shield.

Orderable Part Number: WizFi360-EVB-Shield

Available at FutureElectronics.com

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APPLICATIONS

- IoT devices
- Air/water purifiers
- Smart devices
- Industrial systems

FEATURES

- Firmware may be upgraded over-the-air or via UART interface
- Station, SoftAP and SoftAP+Station operating modes
- Supports AirKiss with app
- WPA-PSK or WPA2-PSK encryption
- Operating-temperature range: -40°C to 85°C

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3.5" VGA display combines sunlight readability with low power consumption

DLC Displays has extended its family of industrial transflective LCDs with the new 3.5" DLC0350SZG. Like the other displays in the family, it offers a long backlight lifetime, high brightness and low heat emission. The displays are available with capacitive touch-sensing capability.

The DLC0350SZG is particularly well suited to use in handheld devices, as it is easily readable both indoors and outdoors, even in direct sunlight. Transflective LCDs perform particularly well in applications which operate in a wide variety of lighting conditions, from complete darkness to full sunlight. In dim lighting, transflective LCDs offer visual performance similar to transmissive LCDs, while in bright lighting they match reflective LCD screens.

In a transflective display, ambient light passes through the LCD and hits the semi-reflective layer. Most of the light is then reflected back through the LCD. When combined with the optional touchscreen capability, a DLC Displays DLC0350SZG provides a superior human-machine interface.

DLC Displays' DLC0350SZG: Ideal for handheld and portable devices

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APPLICATIONS

- Medical diagnostic equipment
- Portable video equipment
- Portable media players
- Industrial equipment
- Consumer devices
- Security systems
- Access control panels

FEATURES

- 50,000h minimum backlight lifetime
- 100mW power consumption without backlight
- Operating-current range: 30 to 40mA
- 7% reflection ratio without backlight
- 480px x 640px resolution
- LED backlighting system
- Operating-temperature range: -20°C to 70°C

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Popular connector line extended to provide new 13A current rating

TE Connectivity (TE) has introduced an extension to its VAL-U-LOK connector product line, adding new parts which offer a higher 13A maximum current capability on a 4.2mm centerline spacing. Earlier VAL-U-LOK connectors have a 9A rating.

These VAL-U-LOK connectors are also available in a new vertical header style which provides from two to 24 positions, and in a choice of UL 94 V-0 or Glow Wire test/UL94 V-2 or V-0 material.

The new high-current vertical headers are available with or without polarization pegs, and with or without drain holes. The new headers mate with existing UL 94 V-0 flammability and Glow Wire test housings populated with new high-conductivity socket terminals offered in 16 AWG and 18 to 22 AWG sizes. In addition, the new products use the same application tooling as the legacy 9A-rated contacts, allowing for backward compatibility.

The high-current pin and socket contacts are also designed for use in housings suitable for wire-to-wire applications.


VAL-U-LOK: 4.3mm centerline spacing

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APPLICATIONS

- Household appliances
- Industrial machinery
- Automotive systems
- Medical devices
- Vending machines
- Gaming equipment
- HVAC equipment
- Indoor and outdoor lighting
- Security systems
- Storage and networking systems

FEATURES

- Vertical and right-angle pin headers available
- Contacts available in strip form or loose pieces
- UL recognized
- CSA certified

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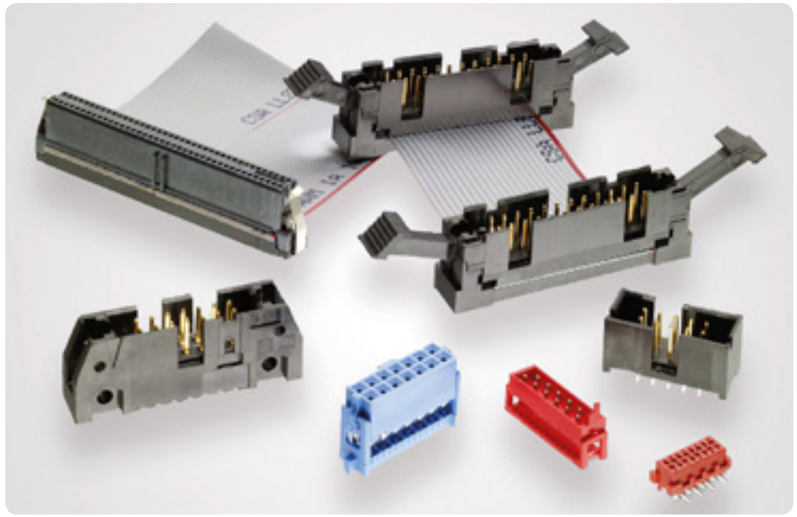
Ribbon cable connectors enable board-to-board connections

AMP-LATCH connectors from TE Connectivity (TE) are ribbon cable-to-board devices used to make a connection between ribbon cable and PCB circuits. Embedded in electronics equipment, the AMP-LATCH connectors may be used to connect one board to another, or one subsystem to another.

The most commonly used AMP-LATCH products terminate to a 0.050" (1.27mm) ribbon cable pitch. TE also supplies AMP-LATCH connectors which terminate to 0.025" (0.64mm) and 0.39" (1.0mm) ribbon cable.


AMP-LATCH connectors: No need to strip or prepare wire on the assembly line

ENERGY INDUSTRIAL LIGHTING MEDICAL TRANSPORT SECURITY CONSUMER TELECOMS

APPLICATIONS

- Computers
- Business equipment
- Medical equipment

FEATURES

- Mass termination capabilities
- No need to strip or prepare wire
- Labor savings
- 1A current rating
- Operating-temperature range: -65°C to 105°C
- UL 94V-0 flammability rating
- Contact materials: phosphor bronze or brass

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Connector provides ready-made interface for sensors in lighting systems

TE Connectivity's LUMAWISE Endurance S Connector System is an ecosystem of products designed for sensor- and other control-system applications. Now, the Endurance S ecosystem has been expanded to enable additional use cases.

The sensor-ready components offer all the original Endurance S benefits, and now also feature extended electrical ratings, plus alternate key combinations for protected mating.

The compact design of the LUMAWISE connectors is UV-resistant and attractive. It may be mounted facing upwards, downwards or sideways. The keyed mating combinations are flexible, and enable lighting-system designers to create differentiated product designs.

The sealing cap or base and receptacle may be securely mated with a low-torque action. An optional vent gives the user the ability to minimize condensation.


LUMAWISE Endurance S: UV-resistant for use in applications exposed to sunlight

ENERGY INDUSTRIAL LIGHTING MEDICAL TRANSPORT SECURITY CONSUMER TELECOMS

APPLICATIONS

- Street lighting
- Area lighting
- Sensor-ready control applications
- Outdoor luminaires
  - Wall packs
  - Parking lots
  - Walkways
- Photo-controls
- Central management systems
- City management systems

FEATURES

- Contact rating: 1.5A, 30V
- 10kV dielectric withstand voltage to mounting surface
- Four-pole contacts

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USB connectors support data-transfer rates up to 480Mbits/s

TE Connectivity (TE), a standing member of the USB Implementers Forum (USB-IF) industry consortium, offers a wide range of connectors which conform to the specifications of USB standards.

TE's products accommodate the two differentially-driven data wires which provide bidirectional, simultaneous signals in USB 2.0 connections operating at data-transfer rates up to 480Mbits/s. The connectors are also compatible with USB 1 interfaces operating at rates of 1.5Mbits/s or 12Mbits/s.

TE provides USB connectors in the various USB form factors: standard A and B, mini B, and micro A/B and micro B sizes.

TE's standard USB connectors are also available in locking versions, and its standard and micro USB connectors are available in latching versions.

TE USB connectors: Locking and latching versions available

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APPLICATIONS

- Desktop and laptop computers
- Keyboards/mice/joysticks
- Printers/scanners
- Game ports
- Digital audio
- Modems
- Portable storage devices.
- Mobile phones
- GPS devices
- MP3 players

FEATURES

- Cable-mount overmold plug kits for all USB sizes and types
- Consolidates serial parallel, keyboard, mouse and game ports
- Compatible with asynchronous and isochronous data-transfer methods
- Polarized for proper orientation
- Plug-and-play capability
- Hot pluggable
- Supports battery charging

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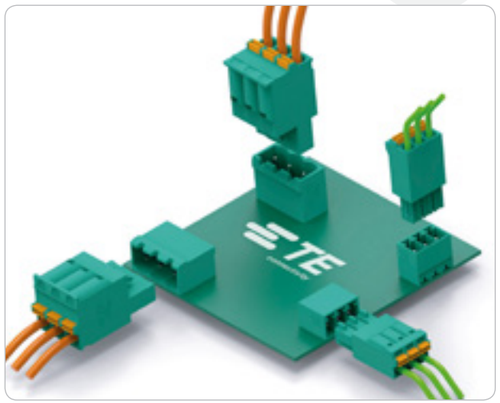
Push-in clamp connectors give 80% reduction in installation time

TE Connectivity (TE) is expanding its Buchanan portfolio with new push-in clamp termination PCB connectors which enable tool-less insertion of ferruled and unferruled wires. This reduces the labor time in installation by as much as 80% compared to the installation of traditional screw-clamp terminations.



TE push-in PCB connectors: 3.5mm or 5.0mm pitch

The design of the PCB connectors in a 3.5mm or 5.0mm pitch consists of two-piece plug connectors with straight and right-angled shrouded headers. The wide range of options for pitch and number of positions gives considerable design flexibility.

TE's Buchanan clamp connectors are intended for use in high-density signal and power applications. The maintenance-free push-in clamp technology gives higher reliability and longer uptime in manufacturing process equipment and control devices.

Products with Buchanan push-in clamp technology are also suitable for use in harsh environments.

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

APPLICATIONS

- Servo/inverter drives
- Industrial controls
- Programmable logic controllers
- Safety controls and modules
- Power-supply units
- Heating, ventilation and air-conditioning units

FEATURES

- 2 to 16 poles
- Solid or stranded wire
- Operating-temperature range: -40°C to 105°C
- >2,000MΩ insulation resistance
- UL recognized

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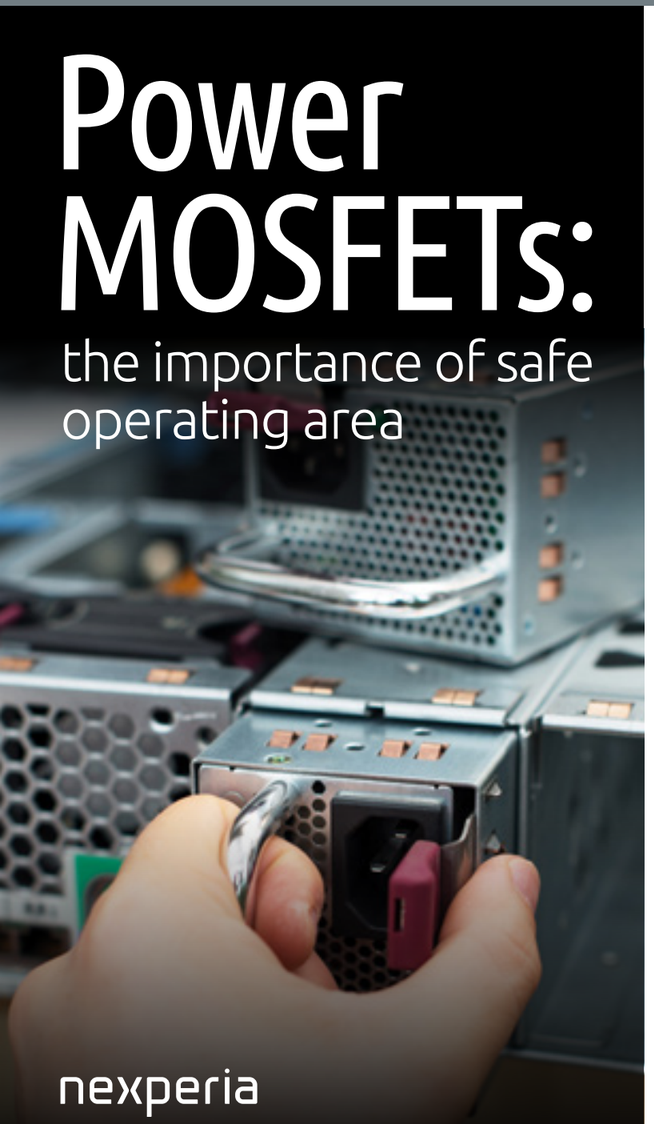
Power MOSFETs:

the importance of safe operating area



nexperia

When MOSFETs are being evaluated for a high-power design, engineers often make their choice based on the parameter of on-resistance. Lower on-resistance means that the MOSFET will have a lower power loss, which in turn means it will generate less heat and provide for safer operation.

However, a MOSFET's ability to handle a large current is not determined by its on-resistance alone, but also by its Safe Operating Area (SOA) rating. SOA, a characteristic specified in most MOSFET datasheets, is the amount of power which the device can handle for a period of time before failing. A strong SOA capability can make a power design more robust and reliable; conversely, a weak SOA rating indicates that a MOSFET is prone to failure under some expected fault conditions.

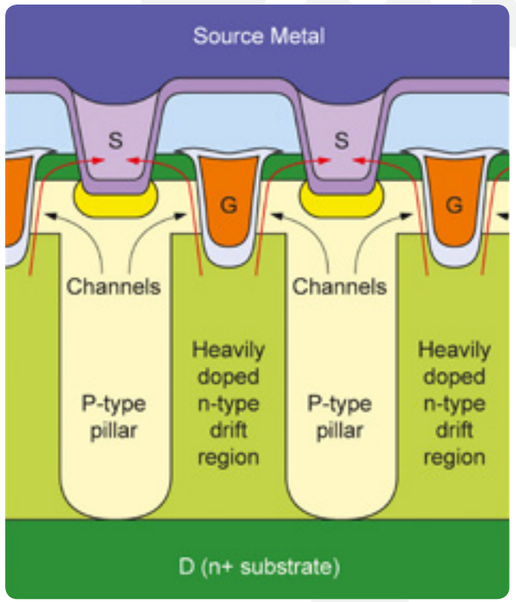


Fig. 1: Trench structure of a superjunction MOSFET

Some applications rely on a good SOA rating. For example, hot-swap power supplies will hold the MOSFET in linear mode at start-up to limit the in-rush current. Here, the MOSFET must handle a large amount of power for a short period of time to protect the load circuit: this calls for strong SOA performance.

Circuits which can encounter faults, such as power ORing or e-fuses, might be exposed to large fault currents for short periods of time: here too, the SOA rating is important. A MOSFET might fail if it cannot handle the power in the time needed to switch it off. In other words, during the fault and switch-off time, a MOSFET with a smaller SOA can fail, as it is incapable of handling the energy driven through it.

What determines a MOSFET's on-resistance and SOA?

Most modern power MOSFET manufacturers use a variant of the trench design shown in Figure 1. To turn the device on, the gate has a voltage applied to it: this creates current carriers in the channel which connects the Drain and Source of the device. Each gate trench has two channels carrying current, one on each side of the trench. Applying a larger gate voltage creates more charge carriers in the channels, which in turn reduces on-resistance.

Another way to reduce on-resistance is to put more trenches in parallel. The effect is the same as when resistors are inserted in parallel in a circuit: adding trenches in parallel decreases on-resistance. To reduce on-resistance even more, trenches can be placed closer together to allow for more paralleling.

The trench itself acts as a heat-sink, allowing heat to pass through to the device's package. Narrowing the trenches impairs thermal performance, and this reduces the SOA. This creates an inverse correlation between these two aspects of MOSFET performance: improving on-resistance tends to impair SOA.

What happens if SOA capability is exceeded?

A MOSFET's SOA dictates the amount of power the device can tolerate over a period of time before failure. There are two failure modes: it can fail either because the entire MOSFET overheats, or because a part, or so-called 'hot spot', overheats.

As the temperature of the device rises, the value of its threshold voltage falls, which dictates when the device turns on and off. This has the effect of lowering the device's on-resistance. This effect is usually negated by a general increase in the MOSFET's on-resistance as temperature increases.

When a hot spot is created, however, the device turns on more in that region, allowing for more current to flow through it. This in turn heats the area up further, reducing the threshold voltage and increasing current until the device fails. This effect is called thermal run-away: the device will fail under this condition.

When the MOSFET manufacturer puts channels closer together to reduce on-resistance, it increases the risk of hot spots, since the narrower structure reduces the current-carrying capability and thermal performance of each trench. Overheating and thermal run-away are the signs of failure caused when a MOSFET operates outside its SOA.

During excessive heating or thermal run-away, the device may also suffer from a short-circuit failure. The device will then act as a three-terminal short-circuit, with the Gate, Source and Drain pins shorted together, until the large current causes it to burn.

Avoiding the SOA/on-resistance trade-off

Nexperia has created superjunction MOSFET technology which avoids the trade-off between on-resistance and SOA to which competing MOSFETs are susceptible. The Nexperia superjunction structure extends SOA performance by adding extra p-doped trenches between the gate trenches, to provide more charge carriers in the channel. This reduces on-resistance without affecting the SOA.

Another method used is 'Super SOA', which extends SOA performance. This allows Nexperia MOSFETs to offer competitive on-resistance while providing up to ten times higher SOA performance than competitors' parts.

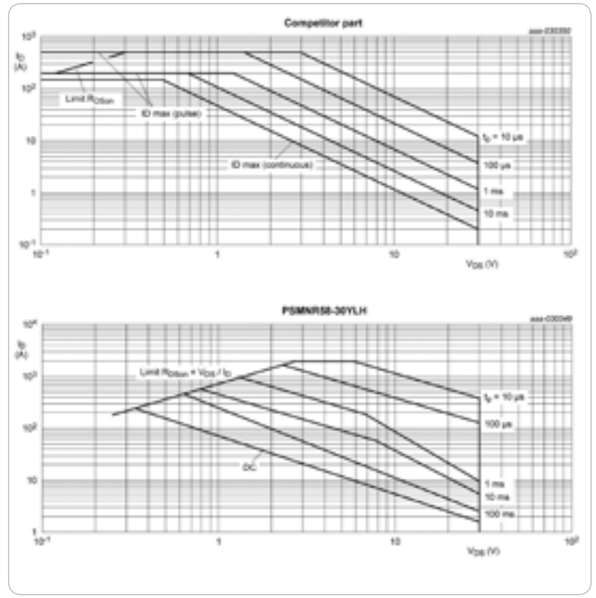


Fig. 2: SOA comparision of similar $R_{DS(ON)}$ devices

Understanding SOA graphs

Figure 2 shows a comparison between a 0.67mΩ Nexperia MOSFET and a competing device with slightly lower on-resistance of 0.60mΩ. On the drain current, I_D, axis, the difference between the two devices is of an order of magnitude. Each curve on the graph shows the time for which the device can safely handle a specific voltage at a specific current before failing.

For example, for a duration of 10ms when the voltage over the device is limited to 12V, the Nexperia device can handle a current of 30A; the competing device can only handle 2A.

This indicates the strength of Nexperia's SOA performance. A wide range of applications might benefit from this characteristic. A good SOA capability gives the MOSFET a greater chance of surviving faults and unexpected transients which might damage or break another device.

Nexperia's range of NextPower Live MOSFETs, which have superior SOA capability, are listed in the table to the left.

LFPAK56 Packaged Parts	Part Number	On-resistance at a Gate-source Voltage of 10V (mΩ)	Maximum Drain Current (A)
25V	PSMNR51-25YLH	0.47	380
	PSMNR60-25YLH	0.59	300
	PSMN0R7-25YLD	0.57	300
	PSMN0R9-25YLD	0.72	300
	PSMN1R0-25YLD	0.89	100
30V	PSMNR58-30YLH	0.54	380
	PSMNR70-30YLH	0.66	300
	PSMN0R9-30YLD	0.65	300
	PSMN1R0-30YLD	0.79	300
D²PAK Packaged Parts	**Part Number**	**On-resistance at a Gate-source Voltage of 10V (mΩ)**	**Maximum Drain Current (A)**
100V	PSMN3R7-100BSE	3.36	120
	PSMN4R8-100BSE	4.1	120
	PSMN7R6-100BSE	6.5	75

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DESIGN NOTE FUTURE ELECTRONICS

Understanding transient voltage suppression in automotive systems

By Isaac Sibson
Automotive Applications Engineer,
Diodes Incorporated

In automotive applications, it is essential to protect sensitive semiconductor components against power surges, transients and ESD events. A single transient voltage spike could easily damage a component or disrupt its operation, while even moderate electrical noise energy can interrupt digital communications.

Transients can occur as momentary or continuous surges wherever high voltages are present, and can propagate through PCB tracks and cables. Momentary surges can easily reach a voltage of 3kV, and can often occur when inductive loads are switched, for example when a motor stops. As most modern ICs operate from low DC voltages, transients are a common threat both to these components and to the digital signals that they handle.

To stop these transients, a common solution is the Transient Voltage Suppressor (TVS). This article explains the characteristics of TVS devices, and discusses the way they may be used in automotive applications.

TVS explained

The TVS is a solid-state device which provides a low-impedance path to earth for a transient voltage surge, but a high-impedance path at all other times. This allows supply voltages and signals to operate as intended, with no current routed via the TVS, but almost instantly clamps any high voltages safely, protecting sensitive components and routing the excess surge to earth.

A TVS is effectively a PN junction diode designed to enter avalanche mode, in which it can pass very high currents, when the potential on its cathode exceeds a preset level. This level will depend on the application, but the important characteristic is that the junction should break down quickly - in less than 1ns - so that the transient surge is handled rapidly enough to avoid damage. The TVS would normally be placed either in parallel with the load across the 0V and supply rail, between ground and a single-ended signal, or across a differential pair of signals.

A TVS resembles a Zener diode, but is designed to operate slightly differently. Instead of handling a steady voltage for a sustained period of time, a TVS is designed to break down quickly and absorb a high amount of energy for a short time.

TVS in automotive applications

In most cars, the main voltage rail is at 12V DC, supplied by the rectified and regulated output of an alternator, as well as from the battery. The alternator is inductive, and therefore a potential source of transient voltages.

In addition, car manufacturers are adding more automatic features to their products. This means that new car designs include more electrical motors, for powering functions such as mirrors, windows and seats. The electrification of the drivetrain also means that mechanical systems such as water and oil pumps are driven by electric motors. These motors impose an inductive load on the system. They are therefore potential sources of transient voltages when loads are connected and disconnected.

Industry standards apply to the implementation of surge protection in the automotive environment, including ISO 7637-2 and ISO 16750. Figure 1 shows the shape of the test pulses on the 12V power rail specified by these two standards. Separately, national standards are also applied in some countries.

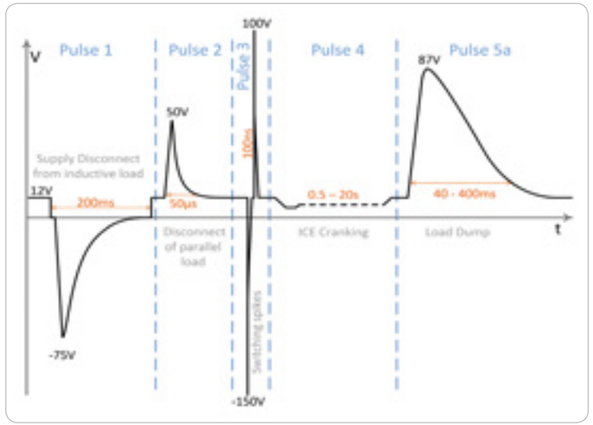

Fig. 1: TVS test pulses used in the automotive industry

The circuit protection system must be able to handle each of the pulses shown in Figure 1. This may call for several TVS devices to be distributed around the circuit. For example, there is likely to be a large main load-dump TVS located close to the alternator, as shown in Figure 2. The remaining energy would need to be dissipated by supplementary TVS protection devices at each module, and a system-level approach should be used to define the requirements for this.

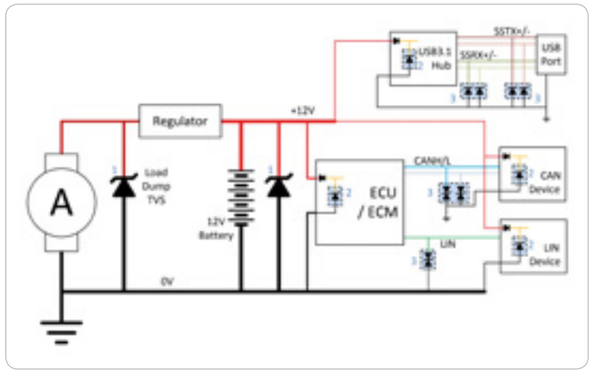

Fig. 2: A typical automotive application using large devices around alternator and regulator; TVS and reverse-polarity protection around modules; and protection around data buses

In harsh environments there will be a markedly larger area under the curve of the pulse, corresponding to more energy to be dissipated, compared to other use cases.

This holds true for automotive applications. In fact, large vehicles such as trucks and vans might operate from a 24V supply rail, which means that the protection must be able to deal with much larger amounts of energy.

Protecting safety-critical signals with TVS devices

As modern vehicles include more and more data communications, the use of automotive-qualified TVS devices for CAN, FlexRay™ and LIN networks is becoming more common.

These networks are used to carry safety-critical communications between automotive modules. Their signals might be interrupted by noise at a lower energy than transient surges. The signals and modules must therefore be protected while avoiding any impact on signal bandwidth. As CAN and FlexRay are differential buses, they require a dual bidirectional TVS to protect both lines.

The simplest type of TVS is unidirectional, and is used when the area of the circuit to be protected is always positive, for example 0V to 5V. The unidirectional TVS is still able to protect against both positive and negative transients.

In contrast, a bidirectional TVS provides protection from transients across a split-rail system or differential signaling scheme, to protect against transients that are both positive and negative with respect to the signal. These devices can be either symmetrical, when the breakdown voltage is the same in both directions, or asymmetrical, when the reverse breakdown voltage is higher in one direction than in the other. A LIN bus, for example, would employ an asymmetrical bidirectional TVS because the signal line can easily fluctuate between -15V and 24V due to ground variance.

A vehicle might also include high-speed data buses such as USB and HDMI, which require low-capacitance TVS protection to preserve data integrity.

The electrical characteristics of a TVS device

A TVS is specified based on the nominal working voltage. To protect a microcontroller operating at 3.3V, for example, a TVS of 3.3V could be used.

The actual parameter specified in this case is the reverse working voltage, V_{RWM}, defined as the voltage at which the device is guaranteed not to pass more than a minimal specified leakage current, I_R. This means that the reverse working voltage is the voltage at which the TVS has a negligible influence on the rest of the circuit.

The related breakdown voltage parameter, V_{BR}, is the point at which the device will conduct at least a specified minimum current IT. Figure 3 shows that this is measured at the value of IT at which the TVS starts to conduct strongly.

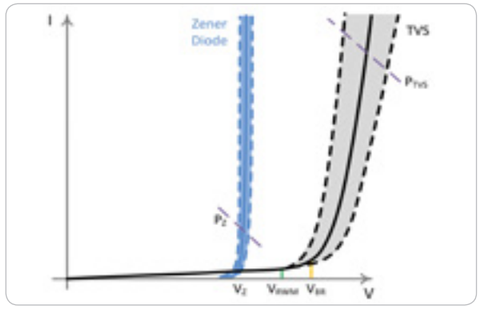

Fig. 3: A TVS operates over a shorter period than a Zener diode

As shown by the dotted lines in Figure 3, the breakdown voltage can vary over a wide range, so it is important to consider this variation with respect to the circuit being protected. The device's peak pulse power limit, P_{PK}, can be found on the transfer characteristic of a TVS, as shown in Figure 4. The point at which the transfer curve intersects with the peak pulse power curve denotes the maximum clamping voltage, V_C, and the maximum peak current, I_{PP}, for the device.

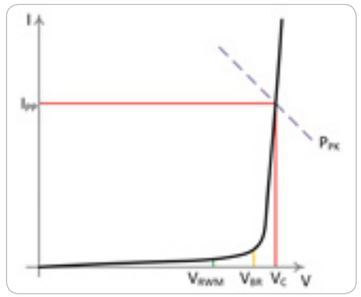

Fig. 4: The transfer characteristics of a typical TVS diode

The length of the pulse determines the amount of energy that can be absorbed. Standard duration and magnitude pulses are defined in international standards. These include IEC 61000, which covers fast surges such as those caused by by electro-static discharges and lightning strikes, and defines two relevant points on the power curve: 8µs (t1) and 20µs (t2) which are commonly referred to as 8/20. Another relevant standard is IEC 6164, which deals with slower surges with higher energy levels, such as those that would occur from inductive loads. The time intervals for this standard are 10/1000, which equals 10µs (t1) and 1,000µs (t2). These figures are used to define TVS performance, as shown in Figure 5. Note that t2 is total elapsed time from 0.

Conclusion

Transient voltages are an ever-present threat to sensitive ICs, and in automotive applications they are unavoidable. The TVS is the right component, in many cases, to provide protection against surges, spikes and transients.

Diodes Incorporated offers a wide range of TVS protection products, enabling every part of a vehicle's electronic systems to be protected from hazardous transients, and providing for higher reliability and safety.

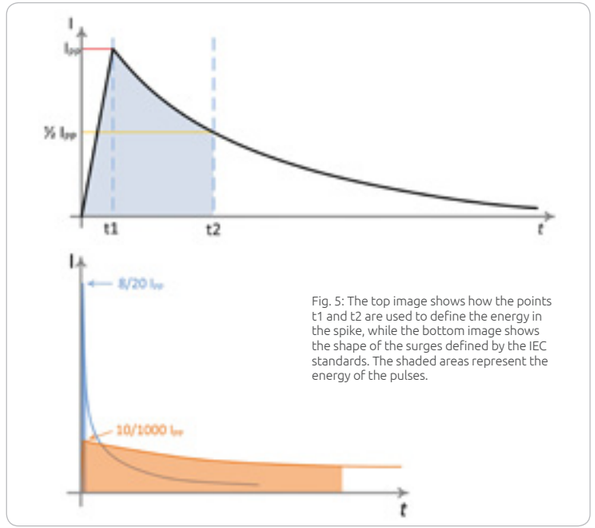

Fig. 5: The top image shows how the points t1 and t2 are used to define the energy in the spike, while the bottom image shows the shape of the surges defined by the IEC standards. The shaded areas represent the energy of the pulses.

GaN power transistors offer higher efficiency and power density in switch-mode power supplies

Infineon Technologies has extended its CoolGaN™ series of ultra-high efficiency Gallium Nitride (GaN) power transistors with the introduction of two new devices.

The IGLD60R190D1 is a 600V CoolGaN industrial-grade High Electron Mobility Transistor (HEMT) for low- and mid-power applications. Like every CoolGaN switch, it conforms to JEDEC standards.

Infineon has also launched the IGT40R070D1 E8220, a 400V CoolGaN HEMT tailored for premium hi-fi audio systems.

Infineon: innovating in GaN technology

Fabricated in Infineon's newly developed GaN-on-silicon process, the CoolGaN family substantially increases power-conversion efficiency, improves power density and reduces the environmental impact of power management by comparison with today's alternative solutions.

The benefits of the CoolGaN technology result from the transistor's ability to operate at high switching frequencies while keeping losses to a very low level. Zero reverse-recovery charge enables the implementation of topologies that have never before been used in power supplies, such as the full-bridge totem pole topology for power factor correction.

Infineon's reliable GaN HEMTs are backed by a matched EiceDRIVER™ series of GaN gate drivers.

New 600V GaN HEMT for industrial and consumer applications

The IGLD60R190D1, which features on-resistance of 190mΩ, is intended for use in consumer and industrial applications. It is available at an attractive cost which lowers the barrier to entry into this new field of technology.

Easy to design-in to power circuits, the new 600V CoolGaN HEMT is supplied in a standard DFN 8mm x 8mm outline, making it the smallest GaN device in Infineon's portfolio.

New 400V GaN HEMT for audio applications

By replacing bulky linear or tube amplifiers with the IGT40R070D1 E8220 CoolGaN 400V switch as a Class D amplifier output stage, audio-system designers can produce an excellent listening experience while saving space and reducing power consumption.

The new device, which features a zero reverse-recovery charge in the body diode and very small, linear input and output capacitances, enables hi-fi systems to produce a more natural and wider sound stage.

Part Number	Package	Maximum Drain-source Voltage	Maximum On-resistance	Gate Charge	Maximum Continuous Drain Current
IGOT60R070D1	PG-DSO-20	600V	70mΩ	5.8nC	31A
IGLD60R070D1	PG-LSON-8	600V	70mΩ	5.8nC	15A
IGO60R070D1	PG-DSO-20	600V	70mΩ	5.8nC	31A
IGT60R070D1	PG-HSOF-8	600V	70mΩ	5.8nC	31A
IGT40R070D1 E8220	PG-HSOF-8	400V	70mΩ	4.5nC	31A
IGLD60R190D1	PG-LSON-8	600V	190mΩ	3.2nC	10A
IGT60R190D1S	PG-HSOF-8	600V	190mΩ	3.2nC	12.5A

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APPLICATIONS

- Low-power switch-mode power supplies
- Telecoms rectifiers
- Servers
- Adapters and chargers
- Wireless charging
- Hi-fi and audio equipment

FEATURES

- Thermally-efficient surface-mount packages
- Low capacitance
- High quality and reliability
- Devices can be paralleled

FTM DEVELOPMENT BOARD

This CoolGaN evaluation board features a half-bridge made up of 70mΩ GaN power transistors, and a pair of EiceDRIVER™ GaN gate drivers, along with input logic which controls the adjustable dead-time. Using an external inductor, the board can be configured for buck or boost-mode, double-pulse testing or continuous PWM operation, and for hard or soft switching at power levels as high as several kilowatts, and at frequencies higher than 1MHz.

Orderable Part Number: EVAL_1EDF_G1_HB_GAN

Available at FutureElectronics.com

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1,200V SiC MOSFET features very low switching and conduction losses

The NTHL080N120SC1 from ON Semiconductor is a 1,200V N-channel MOSFET fabricated in the wide bandgap Silicon Carbide (SiC) material to give superior switching performance and higher reliability than equivalent silicon devices.

1,200V NTHL080N120SC1: Maximum on-resistance is just 110mΩ

SiC transistors are notable for their very low reverse-recovery charge and on-resistance, characteristics which minimize both switching and conduction losses and produce very high conversion efficiency.

In the NTHL080N120SC1, maximum on-resistance is rated at 110mΩ at a gate-source voltage of 20V and a drain current of 20A. Low total gate charge of 56nC also contributes to the device's high efficiency.

The NTHL080N120SC1 can support high-frequency switching circuits: it features short rise and fall times of 6ns and 8ns, and short turn-on and turn-off delays of 6ns and 28ns.

This SiC MOSFET is ideal for use in power factor correction circuits, boost inverters and charger circuits. Easy to drive, its gate-source threshold voltage is just 2.5V.

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APPLICATIONS

- Solar inverters
- Networking equipment power supplies
- Server power supplies
- Industrial motor drives
- Uninterruptible power supplies

FEATURES

- 44A maximum drain current
- Operating junction-temperature range: -55°C to 175°C
- 80pF output capacitance
- 100% UIL tested
- Three-lead through-hole TO247 package

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High-frequency AC-DC power controller implements efficient active clamp flyback topology

ON Semiconductor's NCP1568 is a highly integrated AC-DC power controller which implements an active clamp flyback topology to produce high conversion efficiency.

The NCP1568 uses a proprietary variable-frequency algorithm to enable it to perform Zero-Voltage Switching (ZVS) of a converter's MOSFETs across all line and load conditions. Because of the ZVS capability, the NCP1568 can operate at high switching frequencies up to 1MHz.

NCP1568: High switching frequency for compact power-system designs

This enables the use of small magnetic components for high power density, while also achieving high efficiency.

The NCP1568's high level of integration means that a complete AC-DC converter circuit can be implemented with a small number of external components. The controller includes a high-voltage start-up circuit, a low-side driver and a 5V logic-level driver for the active clamp transistor. It is compatible with both silicon superjunction MOSFETs and Gallium Nitride (GaN) FETs.

FTM DEVELOPMENT BOARD

The NCP1568PDUHD90WGEVB evaluation board is a design for an efficient, high-density 90W USB Type-C®, USB Power Delivery 3.0 and Quick Charge 4 power adapter design featuring the NCP1568, the NCP1622 PFC controller, the NCP51530 half-bridge driver and the NCP4306 synchronous rectifier driver.

Orderable Part Number: NCP1568PDUHD90WGEVB

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APPLICATIONS

- AC-DC power converters
- Battery pack chargers
- High-density USB Power Delivery adapters
- Notebook computer adapters
- Industrial power supplies
- Telecoms power supplies
- Lighting

FEATURES

- No audible noise
- Frequency foldback with 31kHz minimum frequency
- Frequency jittering
- Programmable optional transition to discontinuous mode
- Quiet-Skip technology
- Short-circuit protection

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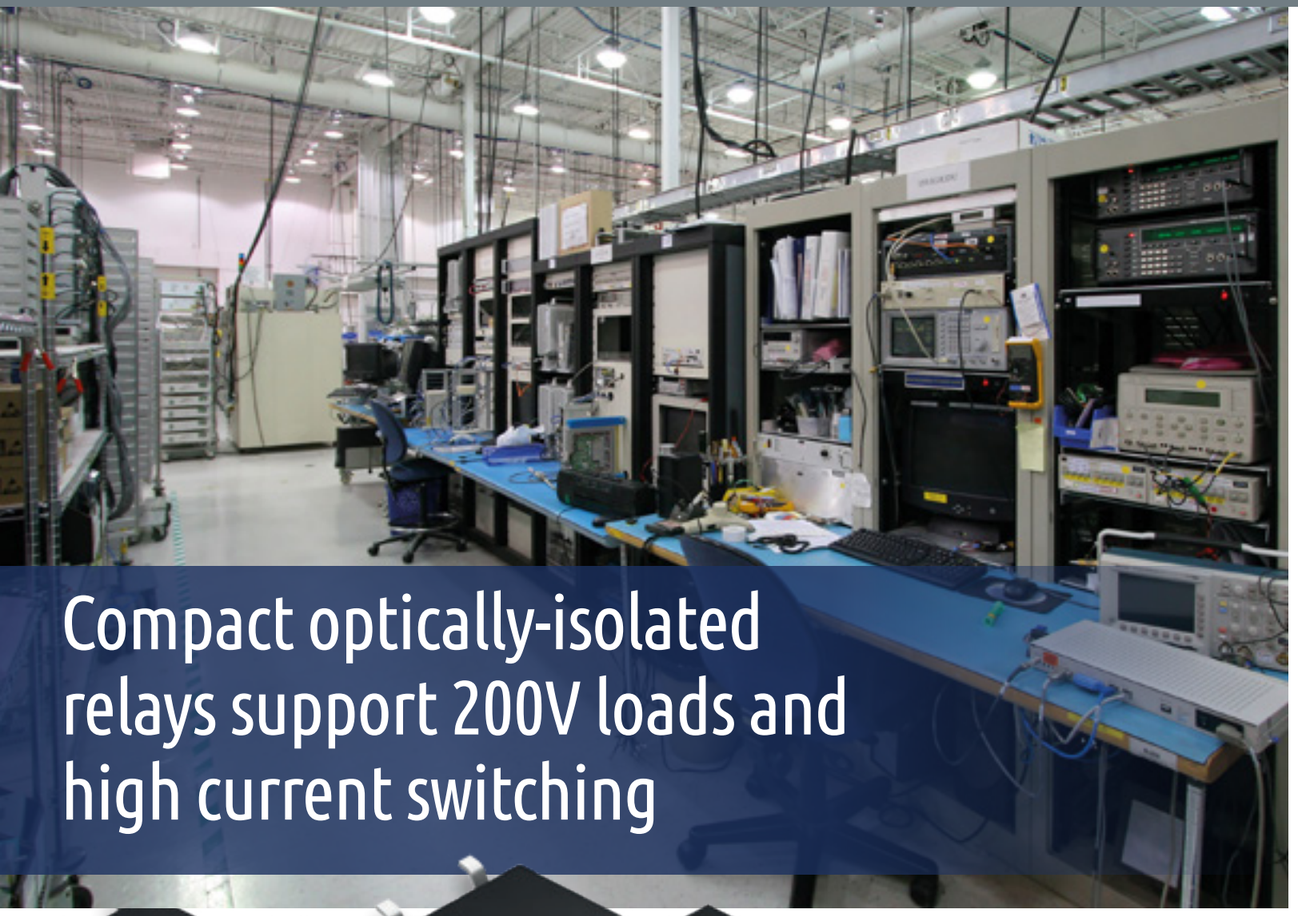

Compact optically-isolated relays support 200V loads and high current switching

Panasonic

Panasonic has introduced the AQY217GS, a new series of high-power PhotoMOS® optically-isolated relays in a small package which maintain a low on-resistance.

The 1 Form A AQY217GS relays, which are supplied in a four-pin SOP surface-mount package measuring 4.3mm x 4.4mm x 2.1mm, are capable of handling up to 400mA at 200V. They can handle both AC and DC loads.

The relays also feature low on-resistance of 1.8Ω, helping to reduce heat dissipation while accelerating turn-on activation. Typical turn-on time is 1.2ms, and turn-off time is 0.03ms.

Panasonic's PhotoMOS relays can sometimes be used in applications in which traditional electromechanical relays are used.

Replacing a standard electromechanical relay with a PhotoMOS device can provide additional benefits such as:

- Longer life cycle
- Better resistance to shock and vibration
- Lower on-resistance

This makes PhotoMOS relays a good solution for the test and measurement, electrical power and industrial markets.

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APPLICATIONS

- Electrical power systems
- Test and measurement instruments
- Security equipment
- Fire prevention systems
- Industrial machines
- Building automation systems

FEATURES

- High current switching
- 0.4A maximum load current
- 200V AC/DC load voltage rating
- 400mW maximum output power dissipation
- 1,500V_{rms} isolation voltage
- Operating-temperature range: -40°C to 85°C
- UL recognized

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Resettable fuse includes voltage clamp to maintain load circuit's operation

ON Semiconductor®

The NIS5820 from ON Semiconductor is a self-protected, resettable electronic fuse which can greatly enhance the resilience of electronic circuits against catastrophic failures and shut-downs.

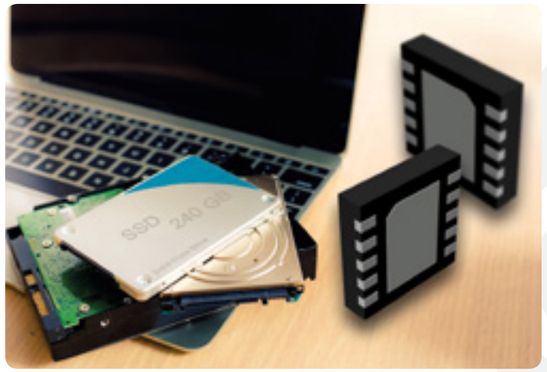
It contains circuits to monitor the input voltage, output voltage, output current and die temperature. Its function is to buffer the load against excessive input voltages which can damage sensitive circuits.

It includes an over-voltage clamp circuit which limits the output voltage during transients, but does not shut the unit down, thereby allowing the load circuit to continue its operation.

The low on-resistance of the NIS5820 fuse means that both conduction losses and the voltage drop for any given current are low. Low quiescent current reduces the overall bias current of the system.

The fuse also features a high continuous-current capability, which means that the system can drive large loads including capacitive loads without giving rise to safe operating area concerns.

The NIS5820 has a tri-state Enable/Fault pin, which allows fuses to be mounted in parallel, and to be turned on and off simultaneously.



ON Semiconductor's NIS5820: Improved protection from circuit failures and shut-downs

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APPLICATIONS

- Servers and motherboards
- Storage devices
- Power supplies
- Hot-plug fans
- Industrial systems
- Relay replacement

FEATURES

- On-resistance options: 14mΩ and 24mΩ
- Adjustable over-current protection
- Over- and under-voltage protection
- Reverse current protection
- Adjustable output slew rate
- Built-in current sensing
- Thermal shut-down for self-protection

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Miniature automotive MOSFETs offer higher power density

DIODES INCORPORATED

Diodes Incorporated has introduced new 40V-rated DMTH4008LFDFWQ and 60V-rated DMTH6016LFDFWQ automotive-compliant MOSFETs housed in a miniature DFN2020 package.

These 2.1mm x 2.1mm MOSFETs give a 90% saving in board footprint over MOSFETs supplied in larger packages such as the SOT223 type. This means that designers of DC-DC converter circuits in automotive applications can achieve higher power density.

The 40V DMTH4008LFDFWQ has a typical on-resistance of 11.5mΩ at a gate-source voltage of 10V, while gate charge is just 14.2nC. For the 60V DMTH6016LFDFWQ, these values are 13.8mΩ and 15.2nC.

Both devices are qualified for operation at up to 175°C. The sidewall-plated DFN2020 package makes them suitable for use in the high ambient temperatures found under the hood in vehicle systems.

When used in an application such as a 12V/5A buck converter, the DMTH4008LFDFWQ dissipates 20% less power than competing MOSFETs. This marked improvement in efficiency provides automotive designers with greater flexibility and the freedom to increase power density in new or existing automotive applications.

Diodes automotive MOSFETs: 175°C maximum operating temperature

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APPLICATIONS

- Power-management systems
- DC-DC converters
- LED backlights
- ADAS

FEATURES

- AEC-Q101 qualified
- PPAP support
- 0.6mm profile
- 3V maximum threshold voltage
- 100% unclamped inductive switching

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Gate driver supplies high-speed input to 1,200V power switches

ON Semiconductor®

ON Semiconductor's FAN73912, a half-bridge gate-drive IC, provides a high-voltage and high-speed drive input to MOSFETs and IGBTs which operate at up to 1,200V.

The gate driver offers various features which provide protection against operating faults, and give flexibility to the power-system designer.

For instance, the FAN73912 includes an advanced input filter at the high-side Input pin which protects against short-pulsed input signals caused by noise.

In addition, an advanced level-shift circuit supports high-side gate-driver operation at a high-side floating offset voltage of up to -9.8V, while providing a total high-side floating supply voltage of 15V.

The FAN73912 can drive both channels with 2A of sourcing current and 3A of sinking current.

FAN73912 gate driver is suitable for use with MOSFETs or IGBTs

ENERGY INDUSTRIAL LIGHTING MEDICAL TRANSPORT SECURITY CONSUMER TELECOMS

APPLICATIONS

- AC-DC power supplies
- Server power supplies
- Consumer devices
- Industrial motors
- Medical electronics
- Home appliances

FEATURES

- Floating channel for bootstrap operation at up to +1,200V
- Built-in shoot-through protection logic
- Common-mode noise-canceling circuit
- Under-voltage lock-out protection on both channels
- Matched propagation delay below 50ns
- Outputs in phase with input signal

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Half-bridge gate driver supports GaN transistors' fast switching operations

ON Semiconductor®

The NCP51820 from ON Semiconductor is a high-speed gate driver which is ideal for driving Gallium Nitride (GaN) power transistors in offline, half-bridge power circuits. It is suitable for use with the High Electron Mobility Transistor (HEMT) and Gate Injection Transistor (GIT) types of GaN power switch.

Use of the 650V NCP51820 to drive GaN transistors is especially beneficial in offline topologies including:

- Half-bridge
- Bridgeless PFC
- Single-ended, active clamp

The power stages in these circuits often perform zero-voltage switching, but can also operate under hard-switching conditions at voltages of around 400V. When driven by the NCP51820, GaN transistors can switch at frequencies of 1MHz or higher, with drain-source edge rates as high as 100V/ns.

The NCP51820 offers short and matched propagation delays with advanced level-shift technology providing a -3.5V to 650V common-mode voltage range for the high-side drive circuit, and -3.5V to 3.5V common-mode voltage range for the low-side drive.

In addition, the device provides stable operation rated for up to 200V/ns for both driver-output stages in high-speed switching applications.

To protect the gate of the GaN power transistor against excessive voltage stress, both drive stages employ a dedicated 5.2V voltage regulator to accurately maintain the gate-source drive signal's amplitude. The circuit actively regulates the driver's bias rails and thus protects against potential gate-source over-voltage events under various operating conditions. The device's leadless, 4mm x 4mm package offers low parasitic inductance.

NCP51820: Low-inductance 4mm x 4mm package

ENERGY INDUSTRIAL LIGHTING MEDICAL TRANSPORT SECURITY CONSUMER TELECOMS

APPLICATIONS

- Power supplys for OLED TVs and servers
- High-power gaming adapter
- Mobile phone/notebook travel power adapter
- Industrial inverter
- Motor drive

FEATURES

- 50ns maximum propagation delay
- Separate Source and Sink output pins
- Independent under-voltage lock-out protection
- Thermal shut-down protection
- Programmable dead-time control

FTM DEVELOPMENT BOARD

The NCP51820 half-bridge Gallium Nitride (GaN) driver evaluation board replaces the driver and power MOSFETs used in existing half-bridge or full-bridge power supplies.

The board demonstrates the performance of a GaN-based power circuit, and the small number of components required to efficiently and reliably drive two enhancement-mode HEMT power switches in a high-voltage, totem pole configuration.

Intended applications for this driver board include various offline power-converter topologies: LLC, Phase-shifted full-bridge, Totem pole PFC, Active clamp flyback, Forward dual active-bridge, Phi-2, High-voltage synchronous buck

Orderable Part Number: NCP51820GAN1GEVB

Available at FutureElectronics.com

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SiC Schottky diodes feature zero recovery current and high thermal performance

ON Semiconductor®

ON Semiconductor's Silicon Carbide (SiC) Schottky diodes benefit from the superior characteristics of this wide bandgap material to provide better switching performance and higher reliability than comparable silicon devices.

These characteristics include zero reverse- and forward-recovery current, temperature-independent switching behavior and excellent thermal performance. Use of ON Semiconductor's SiC diodes enables power-system designers to gain benefits including higher efficiency, faster switching, increased power density, reduced EMI and reduced system size and cost.

The diodes are rated for a maximum junction temperature of 175°C. They enable easy implementation of paralleled power circuits. They are also notable for their high surge-current capacitance.

ENERGY INDUSTRIAL LIGHTING MEDICAL TRANSPORT SECURITY CONSUMER TELECOMS

APPLICATIONS

- Automotive DC-DC converters
- Electric vehicle on-board chargers
- Industrial power supplies
- Power factor correction
- Solar inverters
- Uninterruptible power supplies
- Welding equipment

FEATURES

- Low forward voltage
- Positive temperature coefficient
- AEC-Q101 qualified
- PPAP support

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TECHNICAL VIEW FUTURE ELECTRONICS

How new motor-drive software enables an 8-bit MCU to control a PMSM

By Steffen Hering
Business Development Manager, Future Electronics

Read this to find out about:

- The efficiency, noise and reliability advantages of the PMSM motor type
- Future Electronics' innovative implementation of field-oriented control for an 8-bit MCU
- The operation of the SPINnaker motor-drive reference design board based on an STM8S MCU

Industrial, automotive and medical equipment manufacturers which want to replace legacy brushed DC electric motors or block-commutated Brushless DC (BLDC) electric motors with a superior Permanent Magnet Synchronous Motor (PMSM) have in the past faced an unattractive trade-off. In return for the superior efficiency, longer lifetime and higher reliability offered by the brushless PMSM, the designer had to accept a higher Bill-of-Materials (BoM) cost. This was because the complex mathematical calculations required to control an electronically commutated PMSM called for the high-speed data-processing capability of a sophisticated 32-bit microcontroller in most cases, and at the very least a 16-bit MCU.

This cost disadvantage put PMSMs out of reach of high-volume, low-margin applications. Now, however, Future Electronics has developed a form of Field-Oriented Control (FOC) for electronically commutating a PMSM which is hosted on a simple, low-cost 8-bit MCU. Suitable for motors rotating at a constant speed and subject to small load variations, the new SPINnaker motor-control reference system offers all the benefits of a PMSM of high efficiency, low noise and high reliability, at a BoM cost around half that of a 32-bit MCU-based implementation.

Now for the first time it is possible to implement a PMSM design running FOC commutation software in cost-constrained applications.

Commutation options

It is in fact already possible to implement electronic commutation of a brushless motor on an 8-bit MCU. Block commutation, the simplest way of driving electronically commutated motors, has a low mathematical complexity and can be implemented on a relatively low-speed CPU, and is today commonly used to control BLDC motors. A BLDC motor has a different winding arrangement from that of a PMSM and is better suited to block commutation. But block commutation has several drawbacks which reduce its appeal to motor-system designers, as shown in Figure 1:

- Relatively high torque ripple
- Reduced efficiency
- Acoustic noise

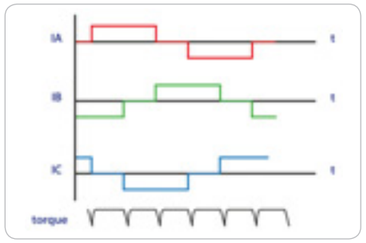


Fig. 1: A typical block commutation pattern showing the sequential switching of the three phases of a BLDC motor, and the torque ripple produced by the switching operations.

FOC is a more sophisticated method for controlling a motor drive which offers more attractive operating characteristics. Because the driver waveform is sinusoidal, the motor-drive system is quieter, more efficient, and produces no torque ripple.

This means that a PMSM is the best motor type to use when the application calls for precise control of a continuously spinning rotor, and when the motor needs to operate almost silently. Typical use cases will include a fan drive in the cabin of a car, in which the passengers value low acoustic noise; industrial production equipment, in which very precise control of position is essential; and when reliability is essential, such as in zero-maintenance or unrepairable pump drives, for instance in mining equipment.

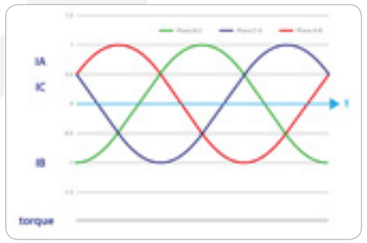


Fig. 2: Sinusoidal commutation, in which the motor drive's three phases are modulated for maximum torque and a flat torque profile at any rotor angle.

Attractive as the sinusoidal FOC method shown in Figure 2 is, it is computationally intensive. FOC software typically occupies a Flash memory footprint of between 24kbytes and 60kbytes. It is normally realised through a complex control algorithm which requires the use of floating-point operations, trigonometrical functions, complex numbers and matrix operations.

This would normally be the domain of a 32-bit MCU, yet Future Electronics, with the release of its SPINnaker motor-control reference design board, has developed a form of FOC software, operating on the Space Vector Modulation (SVM) principle, which runs on an 8-bit MCU.

The SPINnaker reference design system comprises a full-featured three-phase motor-driver daughterboard connected via a standard header to an STMicroelectronics STM8S-DISCOVERY development board for the STM8S family of 8-bit MCUs, as shown in Figure 3. Users can alternatively connect the motor-driver board to an STM8A-DISCOVERY board for the STM8AF and STM8AL families of automotive 8-bit MCUs, which are rated for a maximum junction temperature of 150°C.

In fact, the architecture of the SPINnaker software is MCU-agnostic and can be ported on request to other manufacturers' 8-bit MCUs as well.

Fig. 3: The SPINnaker motor-driver daughterboard.

The unique SVM algorithm developed by Future Electronics controls the rotor speed, the current (flux), and the angle between the rotor and stator. Implementing proportional-integral control emulation, it requires no divider or other complex mathematical functions and is as a result a very small body of code: it occupies only around 7kbytes of Flash memory and 1.2kbytes of RAM.

Maximum resolution is 384 steps per revolution; the user can configure the software to offer lower resolution at higher rotation speeds. The standard software uses a UART interface to communicate configuration and system-monitoring data, although it can also transfer data via an I^2C, SPI or LIN interface. The commutation software operates with a position indicator or sensor. Sensor-less operation is possible, but needs additional circuitry.

Of course, shrinking a complex control algorithm to fit constrained resources inevitably entails some trade-offs. Compared to a 32-bit MCU implementation, the SPINnaker FOC software responds more slowly to changes in the load and maintains less precise control when the rotor's speed changes rapidly. In addition, the system only provides data outputs once per revolution, not at every step as in a standard FOC system.

Nevertheless, as the performance test results below show, the SPINnaker control system maintains impressive speed control and stability when driving a motor at a constant speed and with little change in the load.

And the promise of BoM cost reduction is real: a Future Electronics comparison of a standard 32-bit MCU implementation with the SPINnaker system indicates that SPINnaker offers around a 50% cost saving.

Simple user configuration

The SPINnaker motor-control software is backed by a PC configuration tool which makes it easy for the system developer to configure the motor's operation, as shown in Figure 4. The GUI also displays graphs for monitoring the performance of the motor in real time.

Fig. 4: The configuration tool GUI provided by Future Electronics with the SPINnaker system.

The GUI includes sliders for selecting the required speed in rpm, the current in 256 steps/revolution, and the angle between the rotor and stator. 'Damping' is a feature which will be enabled in future versions of the SPINnaker software. The graphs on the right of the screen show the speed, angle and current relative to their maximum values.

Figure 4 shows the operation of the SPINnaker system under test conditions. A mechanical load increase induces a rise in the current value (1). After a brief and small variation in the field/rotor angle, the algorithm quickly brings it back to equilibrium (2). When the mechanical load is decoupled from the motor, the algorithm lowers the current (3), causing the angle between the rotor and stator to briefly diverge from its specified value before returning to equilibrium.

As well as supporting system monitoring, the SPINnaker configuration GUI enables the user to configure various motor characteristics, as shown in Figure 5. The control software also provides safety and protection features, such as automatic stall detection and overload shut-down, which generate user alerts in the configuration tool when active.

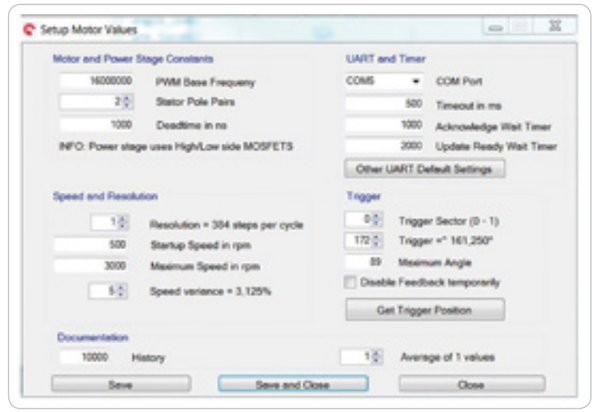


Fig. 5: The configuration tool provides many options for the user to modify the characteristics of the motor.

The SPINnaker system also provides for user monitoring of the data traffic between the control board and the motor-driver daughterboard, as shown in Figure 6. Detailed analysis of the data enables the developer to optimize the control sequences for specific operating conditions.

New opportunity to embed PMSMs in low-cost end products

The introduction of the SPINnaker system from Future Electronics makes it possible for the first time for a PMSM to be used in cost-sensitive and high-volume applications that previously were limited to the use of a brushed DC motor or block-commutated BLDC motor. Replacing these motor types with a PMSM enables the OEM to benefit from its attractive attributes: higher reliability, higher efficiency, lower EMI and lower acoustic noise.

Fig. 6: Data traffic between the STM8S MCU control board (in red) and the motor-driver daughterboard (in black).

Design engineers can obtain the SPINnaker board and software from Future Electronics, contact your local representative.

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

TO BUY PRODUCTS OR DOWNLOAD DATA
FUTUREELECTRONICS.COM/RESOURCES/FTM

TECHNICAL VIEW FUTURE ELECTRONICS

Right tools for the job? How semiconductor manufacturers are smoothing the process of implementing machine learning on their devices

By Future Electronics

Technology companies have dreamed about the potential applications for machine learning in mainstream electronics for decades. Wartime code-breaker Alan Turing was already thinking about the concept of machine learning in the 1940s. Practical progress was slow until the 1990s, however, when techniques for Optical Character Recognition (OCR) enabled machines for the first time to read handwriting. The technology was deployed commercially in the late 1990s, for instance, to read bank checks written by hand.

These limited breakthroughs in OCR did not, however, immediately herald a stream of new applications. The great leap forward came in 2012, when a team of researchers from Toronto won an annual machine learning developers' competition, achieving an image-recognition error rate of just 15%, some ten percentage points better than the next best competitor's score.

The Toronto team's success showed what had been holding back the adoption of machine learning: its hugely improved image-recognition capability stemmed from the decision to train its machine-learning algorithm on a much larger data set than had ever been used before, and to do so by training its algorithm on a large array of now affordable Graphics Processing Units (GPUs).

By 2012 it had become clear that the wider use of machine learning was going to depend on the availability both of data, and of cheap, high-speed processor chips.

These factors explain why machine learning has, in 2019, changed from being theoretically attractive, to being practically viable for any manufacturer of industrial or consumer electronics products. Training data sets are now large enough to support a wide range of applications such as speech recognition, image recognition, people counting and video analytics thanks to the huge stores of data generated by services such as YouTube, Facebook and the apps associated with smart watches and wristbands.

At the same time, today's microcontrollers, applications processors and FPGAs can perform inferencing at the edge, that is to say, without requiring a connection to an Artificial Intelligence (AI) service in the cloud, at high speed and with good accuracy. Silicon chip manufacturers have also introduced new tools to support the implementation of machine learning software on their devices.

An ecosystem for training machines has also emerged. Training frameworks such as Caffe™, TensorFlowLite™ and PyTorch are available to any OEM to train neural networks on its data set. The machine learning models that they produce are packaged in standard data formats that most MCU, processor and FPGA manufacturers support.

So now machine learning is ready to be implemented on the hardware that embedded developers are already familiar with: devices such as Arm® Cortex®-M-based microcontrollers, Cortex®-A based applications processors, or low-power FPGAs. But to what extent do the manufacturers of these hardware devices provide a bridge between the machine learning model produced by a framework such as Caffe or TensorFlow Lite, and the OEM's chosen MCU, processor or FPGA?

Read this to find out about:

- The reasons for the rapid adoption of machine learning technology in the embedded world
- The types of semiconductor hardware which can support artificial intelligence in embedded devices
- The development tools that semiconductor manufacturers provide to support machine learning applications

Diverse approaches to machine learning enablement

In fact, different manufacturers have taken different approaches to the porting of machine learning models to a hardware target. Some provide extensions to existing development tools to enable the developer to compile a machine learning model to a specific hardware device. Others have created a complete Integrated Development Environment (IDE) for machine learning.

Microchip Technology has taken a third route: rather than providing a specific set of machine learning tools for users of its PolarFire® FPGAs, it has partnered with a third party, ASIC Design Services, to perform conversion of the OEM's Neural Network (NN) model to an FPGA bitstream output. This output can then be compiled to a PolarFire FPGA target using Microchip's familiar Libero® SoC design suite.

The advantage of this approach is that an engagement with ASIC Design Services provides for consultancy as well as model conversion, and avoids the need for the PolarFire user to learn how to perform model conversion.

Another FPGA manufacturer, Lattice Semiconductor, provides a comprehensive set of services and tools, sensAI, to enable users of its iCE40 and ECP FPGAs to do the porting themselves, as shown in Figure 1. The sensAI stack incorporates modular hardware platforms, example demonstrations, reference designs, neural network IP cores, software tools for development, as well as custom design services.

This comprehensive stack is particularly useful for streamlining the development of applications supported by the Lattice reference designs, such as people counting: Lattice supplies ready-made training scripts and sample data sets to support model training in a standard framework such as Caffe, as well as the tools for compiling the finished model to the chosen hardware target.

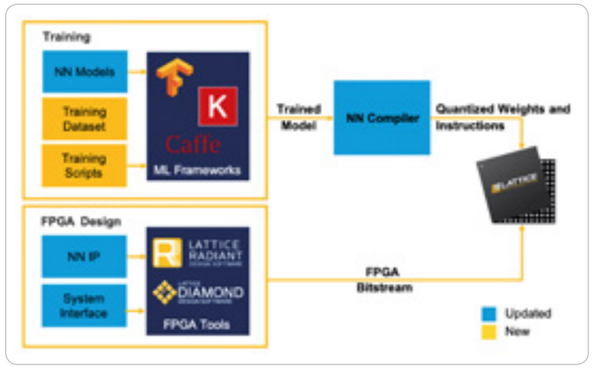


Fig. 1: Implementation flow on Lattice Semiconductor sensAI tools

A similarly comprehensive offering of tools, but for applications processors rather than FPGAs, is provided by NXP Semiconductors. Its eIQ™ ML Software Development Environment offers the key components required to deploy a wide range of machine learning algorithms. It includes inference engines, NN compilers, vision and sensor solutions, and hardware abstraction layers, as shown in Figure 2.

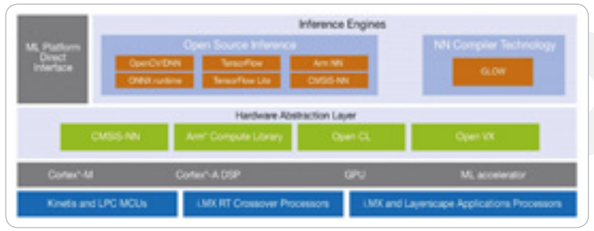


Fig. 2: NXP's eIQ platform for hosting an inference engine on an embedded processor or MCU

At launch, it supported the i.MX RT crossover microcontroller family and the i.MX family of applications processors, but NXP's intention is to deploy the platform to its complete range of processors and MCUs over time. Implementation is particularly well supported for NXP's eIQ application samples: face recognition, object detection, anomaly detection and voice recognition.

In addition, an NXP development kit for the i.MX 8M provides a useful demonstration of the potential for Alexa voice-recognition applications.

While NXP's eIQ platform is a discrete set of tools for machine learning, STMicroelectronics has chosen to support machine learning development through its existing STM32CubeMX design environment for 32-bit MCUs. With STM32Cube.AI, developers can convert pre-trained neural networks into C code that runs on the company's STM32 Arm Cortex-M-based MCUs.

The strength of the STM32Cube.AI package is that it is integrated with ST's portfolio of environmental and motion sensors. Predictive maintenance, which depends on accurate recognition of patterns in parameters such as vibration and temperature, is expected to be the killer app for machine learning. STM32Cube.AI is supplied with ready-to-use software function packs which include example code for two applications:

- Human activity recognition
- Audio scene classification

These code examples are immediately usable with the ST SensorTile reference board and the ST BLE Sensor mobile app. The SensorTile board features an accelerometer/gyroscope module, pressure sensor, microphone and Bluetooth® radio transceiver.

Machine learning framework built for the embedded world

The tool offerings from most semiconductor suppliers assume that the OEM's model will be trained in a standard third-party model-training framework such as Caffe or TensorFlow. These frameworks have their roots in the enterprise computing world, and their output, the inference engine they produce, is ideally suited to a cloud-based run-time environment featuring arrays of high-power processors, rather than for resource-constrained embedded hardware.

That's why the machine learning platform provided by QuickLogic and its SensiML subsidiary is so interesting to embedded developers. SensiML's Endpoint AI Toolkit, a complete model training tool suite, was built from the ground up for embedded hardware targets. Intended for use in typical embedded applications such as predictive maintenance, the SensiML toolkit does not assume that a neural network is necessarily the right type of inference engine for the intended application. SensiML maintains that:

- Slowly varying sensors, such as temperature or humidity sensors, can often use basic rules or threshold analysis
- Dynamic time-series data can nearly always be handled by machine learning classifiers
- Spatial (image) data typically requires neural networks

Offering a growing library of feature transforms and classifier algorithms, SensiML's toolkit automates the search for, and optimization of, the best approach for a given problem, rather than imposing a one-size-fits-all deep-learning approach, as shown in Figure 3. Benefits include the potential to occupy a much smaller code footprint, and performing model training with much less data than a neural network requires.

Crucially, it enables developers to build intelligent IoT sensing devices in just days or weeks without the expertise in data science or embedded firmware that frameworks such as TensorFlow or Caffe typically require. And because SensiML is part of QuickLogic, its sensor algorithms are optimized for implementation on QuickLogic's EOS™ S3 sensor processing system-on-chip, although they are also compatible with various other hardware targets including Arm Cortex-M-based MCUs.

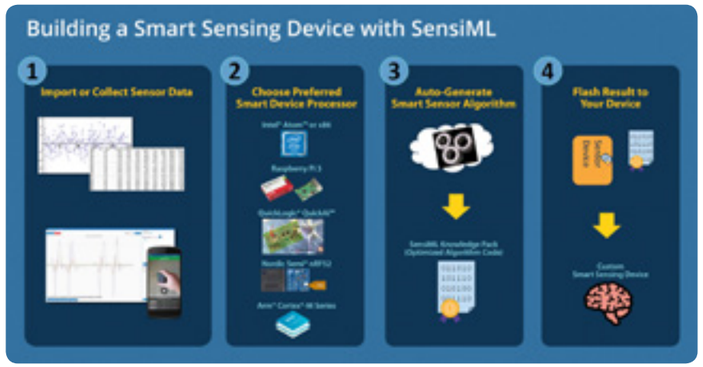


Fig. 3: The SensiML inference engine development flow

Rapid development in tool offerings

Manufacturers of MCUs, applications processors and FPGAs have already introduced a wide range of tools to support the needs of embedded developers who are implementing machine learning models. But this field is young, and intensive development continues. The performance of these tools is only going to get better and the features of them more sophisticated.

For embedded developers, this means that there has never been a better time to start experimenting with machine learning in real-world applications.

Thin-film precision resistor series sets new standard for reliability

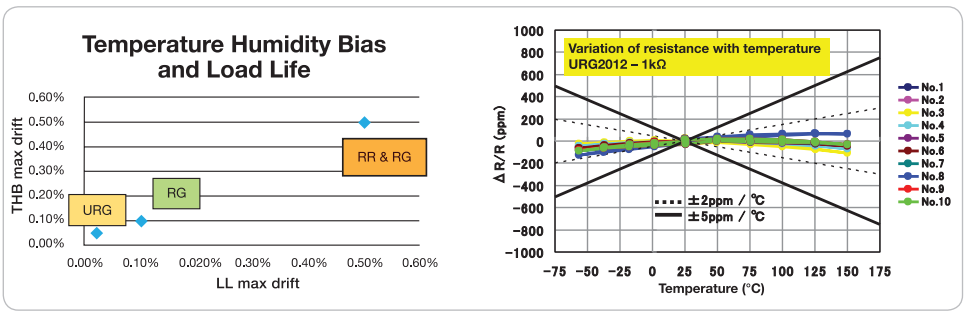
SSM SUSUMU
Thin Film Specialist and Innovator

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

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

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

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



Susumu's URG series: For applications requiring extreme precision and reliability

ENERGY INDUSTRIAL LIGHTING MEDICAL TRANSPORT SECURITY CONSUMER TELECOMS

APPLICATIONS

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

FEATURES

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

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