POWER ELECTRONICS NEWS

DEC 2017

A quick and easy way to design sensorless FOC motor controls

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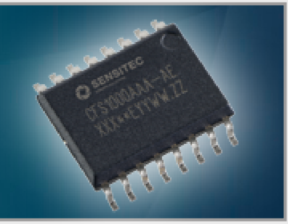

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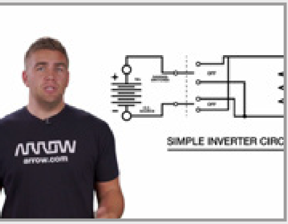

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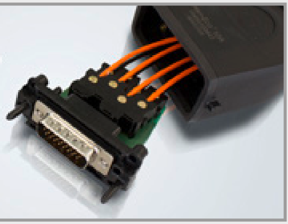

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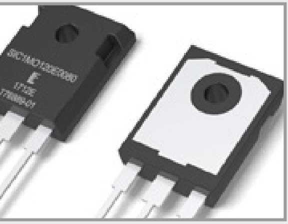

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VIEW POINT

Alix Paultre, Editor

Dear Readers,

The recent Wide-Bandgap Power Conference 2017 in Munich at the Airport Hilton was a great success, with more than 20 presentations on the topic of wide-bandgap semiconductors. The result of an event partnership between Bodo’s Power Systems and ASPENCORE Europe, the conference dealt with topics from materials to manufacturing. Presentations such as the one on GaN Power ICs with on-chip integrated drivers from Steven Oliver at Navitas, to a talk on fast switching and the challenges it presents to power module packaging and system design by Stefan Häuser of Semikron, the information presented gave today's engineers the tools they need to get a handle on one of the fastest-developing and challenging disruptive technology around.

Yours Sincerely,

Alix Paultre
Editor Power Electronics News


FORTE
THE INTELLIGENT BOM TOOL
Master your Bill of Materials with greater intelligence
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Efficiency, improved power density, and lower cost for low power applications

Compatible solutions with SOT-223

Consumer demand is driving the development of power supplies that are more efficient, smaller, and less costly than ever before. This need for increased efficiency, improved power density, and lower cost without *negatively impacting other key requirements is pushing designers to find new and innovative alternatives to the traditional design choices. One area where significant cost savings can be found is in MOSFET design and packaging choice.*

THE COOLMOS™ P7 IN SOT-223

The CoolMOS™ P7 in SOT-223 is the latest member of the CoolMOS™ family. The SOT-223 package was selected to address the need for cost reduction in price sensitive applications while maintaining similar thermal performance and one-to-one footprint compatibility with DPAK packages. As shown in Figure 1, the leads of the SOT-223 package fit directly on the DPAK footprint allowing it to be used as a one-to-one replacement in existing PCB designs. The SOT-223 is also 25 percent lower and 35 percent shorter than the DPAK.

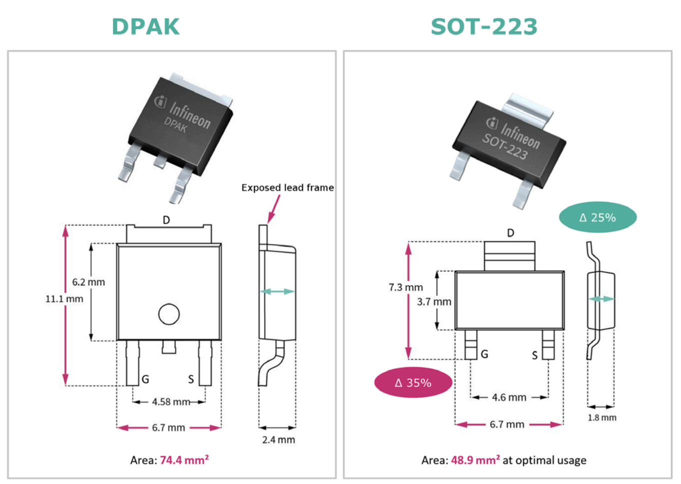


Figure 1: Size comparison of the CoolMOS™ in DPAK and SOT-223

Extensive testing has shown that the SOT-223 package can be used as a plug-and-play replacement for DPAK, although there are a few limitations. If the power losses are greater than 250 mW, additional copper around the drain pad must be added in the PCB design to help keep the device cool. A standard DPAK package with the recommended copper area will operate at 85 °C (point A in Figure 2). On the same PCB, a SOT-223 package will operate at 89 to 90 °C (point C). With 20 mm² to 40 mm² additional copper placed around the drain pad, the operating temperature of the SOT-223 device drops to the same level as the DPAK device (point D).

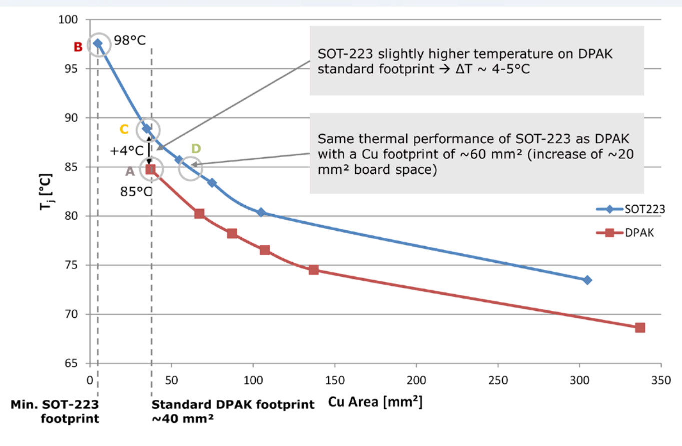


Figure 2: Thermal simulation of junction temperature @ 250 mW (Tj vs. Copper area)

THERMAL PERFORMANCE IN REAL-WORLD APPLICATIONS

To test the benefits of the new CoolMOS™ P7 technology compared to the former CoolMOS™ CE series in SOT-223, a comparison was done on an 18 W mobile phone charger. Table 1 shows the basic specifications of the charger.

Testing was done at 90 VAC, at a stabilized ambient temperature of 25 °C. The temperature was measured with a FLIR 645sc. The efficiency was measured:

- P_{in} with a Yokogawa WT310
- V_{out} with an Agilent 34980A
- I_{out} via a 200Ω shunt resistor and an Agilent 34980A

Description	Specification
Input	90 V – 265 V_{AC}
Output	9 V V_{DC} 2.0 A at 18 W
Topology	Flyback
Original device	IPN70R1K5CE
Switching frequency	25 – 76 kHz 76 kHz @90 $V_{AC, FL}$ 57 kHz @230 $V_{AC, FL}$
PCB dimensions L x W x H	45 mm x 35 mm x 13.5 mm
Copper around drain pad	30 mm²

Table 1:
18 W mobile phone charger specifications

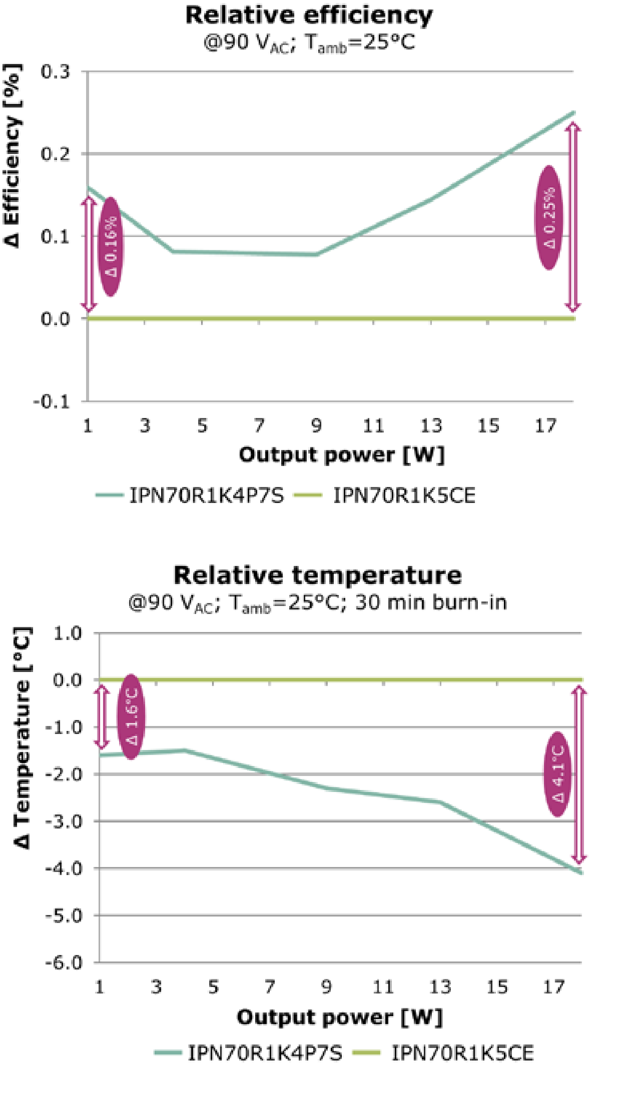
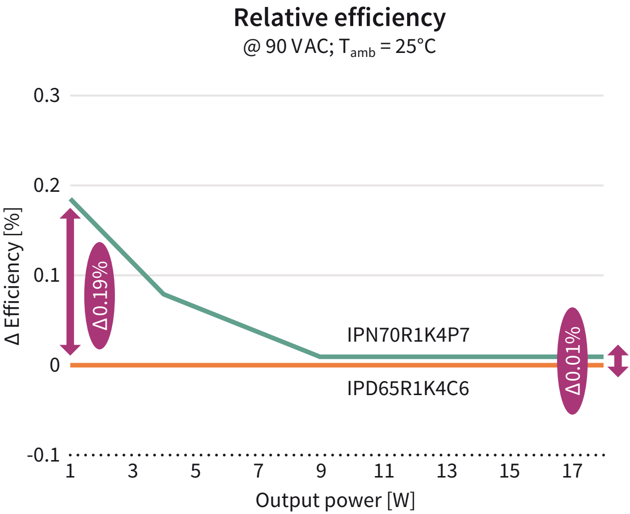


Figure 3: Efficiency and temperature test results, CoolMOS™ CE in SOT-223 vs CoolMOS™ P7 in SOT-223

Figure 3 compares the original CoolMOS™ CE in SOT-223 (IPN70R1K5CE) with a CoolMOS™ P7 in SOT-223 (IPN70R1K4P7S). When the CoolMOS™ P7 is used, there is a notable efficiency improvement at full load of around 0.25 percent, and it is 4.1 °C cooler than the original device. This test shows that the CoolMOS™ P7 in SOT-223 is more efficient and has better thermal performance than the CoolMOS™ CE.

The second test used a CoolMOS™ C6 in DPAK (IPD65R1K4C6) as a new baseline compared to the CoolMOS™ P7 in SOT-223.

700 V CoolMOS™ CE/P7 in SOT-223



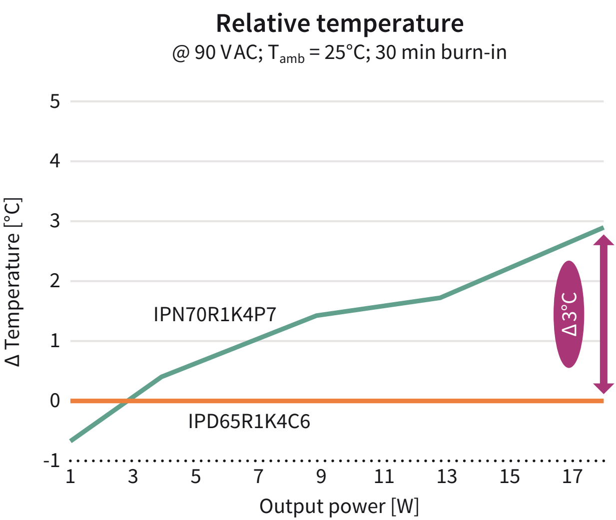


Figure 4: Efficiency and temperature test results, CoolMOS™ C6 in DPAK vs CoolMOS™ P7 in SOT-223

At full load the efficiency is almost the same. The operating temperature of the CoolMOS™ P7 is 3 °C higher due to the small copper area. Increasing the copper area would reduce the operating temperature.
This test shows that the CoolMOS™ P7 in SOT-223 functions well as a drop-in replacement for DPAK packages.

THE COOLMOS™ P7 IN SOT-223 PORTFOLIO

The CoolMOS™ P7 in SOT-223 is available in three voltage classes, 600 V, 700 V, and 800V. The 600 V and 700 V devices are standard grade products and the 800 V devices are fully qualified as industrial grade. The 600 V devices are perfect for PFC, flyback, and LLC stages in half-bridge or full-bridge configurations. The 700 V and 800 V devices are only suitable for PFC or flyback topologies where there is no hard commutation of the body diode.

CONCLUSION

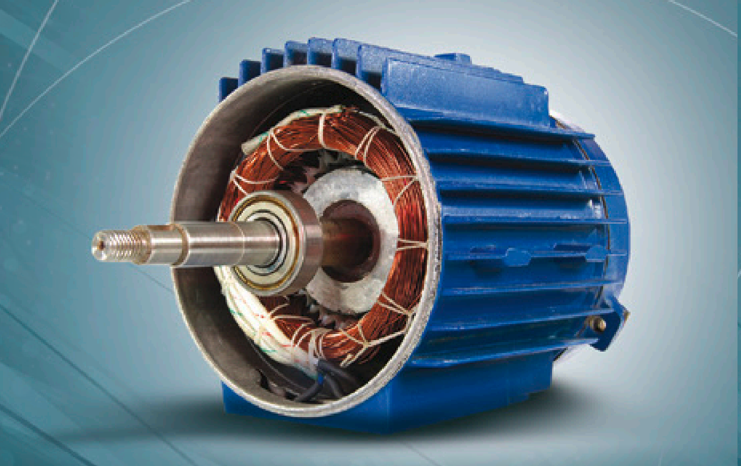
The CoolMOS™ P7 in SOT-223 provides all the benefits and high efficiency of the Superjunction MOSFET technology in a low-cost package that fits into existing DPAK-based designs. The thermal characteristics are within an acceptable range if you use the minimum DPAK copper area requirements. If space allows, adding extra copper improves the thermal performance bringing it close to a DPAK-based solution.

The CoolMOS™ P7 in SOT-223 provides designers with an excellent balance between performance, ease-of-use, small application footprint, and price. Additional information on CoolMOS™ P7 in SOT-223 can be found at www.infineon.com/sot-223. ■

Stefan Preimel, Concept Engineer for MOSFETs, Infineon Technologies AG

More info

- www.infineon.com/sot-223
- Learn more
- Watch eLearning
- Watch video
- CoolMOS™ P7 MOSFET Family



Motor Control and Drive Design Solutions

Electric motors are estimated to consume around 45% of all electricity in the world today according to International Energy Agency (IEA). Electric motors are everywhere – in your washer, dryer, refrigerator, car, fan, pumps, air conditioner, etc. They make our lives easier, so it is important that they run as efficiently as possible.

ADRESSING MANY DIFFERENT MOTOR TYPES

Microchip provides products and solutions (hardware and software) to address the many different motor types, including brushed DC, stepper, brushless DC, permanent magnet synchronous, AC induction and switched reluctance motors. You can shorten your development cycle by using our free motor control software with application notes and tuning guides. Our scalable motor control development tools promote rapid prototyping for low-voltage and high-voltage systems including dual motor control options.

Microchip's PIC® Microcontrollers (MCUs), dsPIC® Digital Signal Controllers (DSCs) and SAM Cortex® series devices contain innovative motor control PWM peripherals including complimentary waveforms and dedicated time base.

For applications that require variable speed with constant torque and field-oriented control for greater efficiency, the high-performance PIC32MK and dsPIC DSC core devices includes DSP instructions for more precise control. Our single-chip motor control and motor drive solutions enable simpler designs and decrease board space, and are often used as companion chips with PIC MCUs, dsPIC DSCs and ARM® based MCUs. ■

Reference Designs and GUI Tools

- Application note library with code
- Low-cost development tools
- Software GUIs for motor tuning
- Real-time motor parameter updates

Technical Support

- Web design center
- Webinars
- Regional training center classes
- Motor control experts

Silicon Solutions

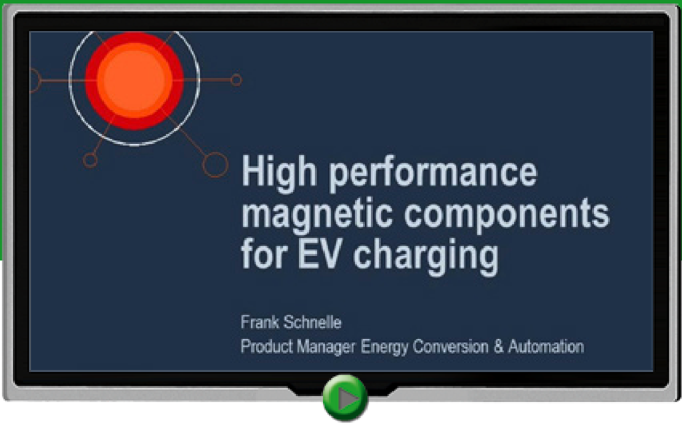
- Cost competitive
- Superior architecture
- Large compatible family

Algorithms

- ACIM/BLDC/PMSM
- Brush DC/stepper
- Sensor/sensorless control
- Field-oriented control
- Power factor correction

High performance DI-sensor for EV charging

VACUUMSCHMELZE offers a new all-current sensitive differential current (DI) sensor, called BeVAC. This new device is optimized for the use in an IC-CPD (Mode 2) or wallbox (Mode 3) for measuring DI currents between 0 and 300 mA from DC to 2 kHz with a resolution of 0.2 mA.



Webinar about EV charging

When charging at home with a standard charging cable or through a wallbox, one has to face the risk of DC fault currents which might drive the standard household type A RCCB into saturation and could compromise electrical safety. Accordingly, from 2018 onwards it will be compulsory in Europe to meet IEC 62752 requiring to have an appropriate safety circuit breaker device.

The new differential current sensor BeVAC is optimized for such applications and is available with different switching levels: The European standard requires 6 mA for DC and 30 mA for AC fault currents, whereas UL 2231 requires 5 mA/20 mA AC.

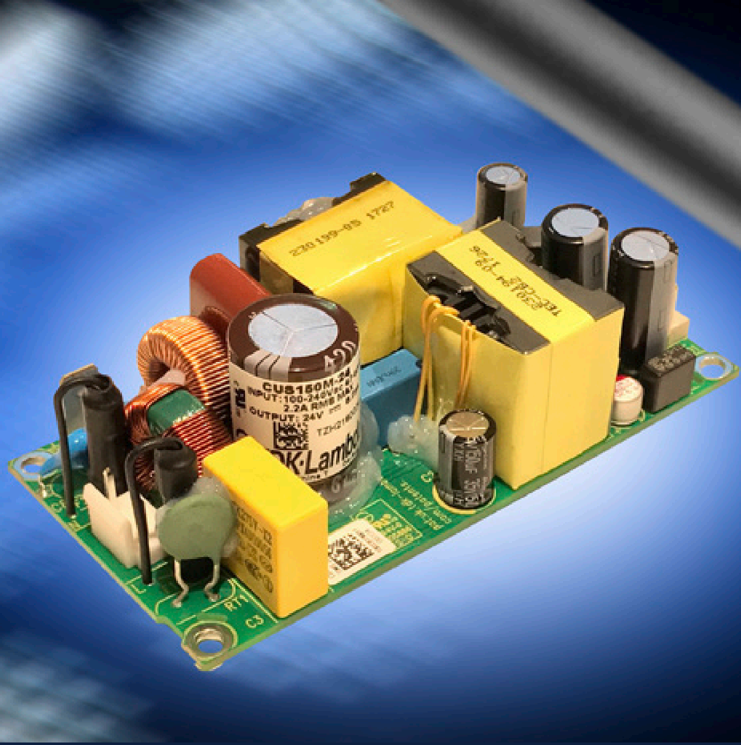
Moreover, BeVAC is available with a feed-through opening and with integrated primary conductors, the latter with variants for single-phase and three-phase systems. BeVAC is the state-of-the-art solution for safety in IC-CPD or wallbox.

WEBINAR ABOUT EV CHARGING

This recorded webinar shows how advanced magnetic components help to realize product safety, reliability and high performance for the evolving electric vehicle charging infrastructure. The focus will be on all relevant EV charging modes covering AC charging via IC-CPD or wallbox (Modes 2 & 3), as well as DC fast charging (Mode 4) and inductive charging. The technical requirements of each charging mode will be shown and briefly described. View Now

More info

- VAC DI sensor webpage
- DI sensors brochure
- EV charging Pocket Guide
- EV charging Webinar



Fan-less class I or II medical and industrial power supplies

Capable of operating in ambient temperatures of up to 85°C without the need for forced air cooling

The TDK-Lambda CUS150M series of AC-DC power supplies are vailable in four package types and delivering up to 150 W output power. The power supplies are suitable for use in both Class I or Class II (double insulated) installations. Target application areas include home healthcare, medical, dental, test and measurement, broadcast and industrial equipment.
The U-channel models measure 64 x 116 x 38.5 mm (WxLxH) and can be conduction cooled using a cold plate to provide 150 W at 50 °C, 100 W at 70 °C and 50 W at 80 °C. With just 1m/s airflow the output power can be increased to 140 W at 70 °C and 75 W at 85 °C. The open frame version has the industry standard 50.8 x 101.6 mm (2″ x 4″) footprint and a height of 31.5 mm. With convection cooling the output power is 120 W at 40 °C and with forced air cooling it can also deliver 150 W at 50 °C, 140 W at 70 °C and 75 W at 85 °C. An optional cover or a top mounted fan is also available.
Currently, the CUS150M is available with 12 V, 24 V and 48 V outputs, with 15 V, 18 V, 28 V and 36 V outputs to be released early 2018. All models can operate from a wide range 85 to 264 Vac input, have efficiencies of up to 94 % and an active average efficien-

cy of >91%. No load power consumption is <500 mW. The Power Supplies are safety certified to IEC/EN/ES 60601 1, IEC/EN/UL 60950 1 with CE marking for the Low Voltage and RoHS2 Directives. ■

More info

- CUS150M Datasheet
- TDK-Lambda website
- Phone: +49 (0)7841 666 0

New current sensors for high power density power electronics

Fig. 1: CFS1000 current sensor: programmable SMD housed AMR current sensor from Sensitec.

The new programmable current sensor CFS1000 has been developed for the highly dynamic electronic measurement of DC, AC or pulsed current with integrated galvanic isolation. It consists *of an anisotropic magnetoresistive (AMR) sensor element and a specific ASIC (fig. 1 + fig. 2). The current sensor exhibits no hysteresis as observed in iron core based Hall-sensor solutions. Due to the high sensitivity of AMR sensors, a flux concentrator is not necessary. It is designed for high resolution and very fast electronic measurement. The described sensor enables a differential magnetic field measurement by an advanced geometry of the magnetoresistive elements. Due to this arrangement the sensor is immune to homogeneous interference fields. By variation of the geometry of the external primary current conductor the system can be adapted to different current ranges and applications.*

The sensor device consists of an AMR sensitive sensor chip, a signal conditioning circuit and two biasing permanent magnets. The latter are for maintaining the initial magnetization direction of the AMR structures in the cases of high overcurrent spikes. The permanent magnets material and the AMR-sensitive sensor material are applied on wafer substrates by a special process, thus can be processed further on with standard semiconductor methods, concerning singulation or assembly. A special leadframe as well as an advanced assembly technique enable a “system in package” (SIP) solution.

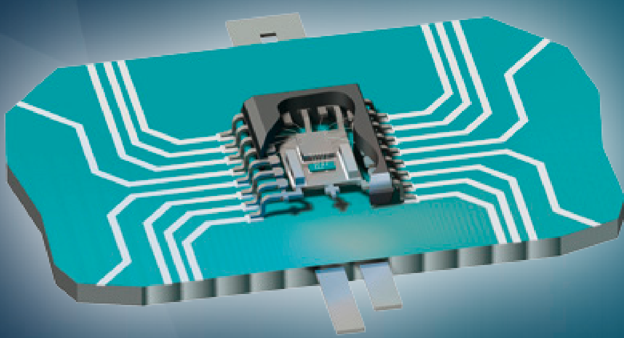


Fig. 2: CFS1000 current sensor consisting of AMR sensor chip, signal processing circuit and two bias magnets.

All system components are overmolded within a JEDEC compliant SOIC16 housing. The product can be mounted with standard pick-and-place equipment onto a PCB and subsequently reflow soldered.

The sensor is measuring the field gradient of a magnetic field H. The field gradient can be created in general by two arbitrarily shaped current lines with opposed flow directions. This primary current conductor is typically U-shaped with its straight parallel parts underneath the sensor. The primary current to be measured is fed below the sensor on a PCB or through a busbar. Using a U-shaped conductor allows the generation of a differential magnetic field that reduces the influence of external magnetic stray fields. Due to the high sensitivity of the AMR sensor an excellent signal resolution can be achieved without using a flux concentrator. The external primary current conductor concept provides on the one hand a very good dielectric isolation towards the sensor, and secondly enables a flexible design concerning different current ranges. The sensor system works in closed loop operation, providing high linearity and a low temperature dependency. An adjustable fast overcurrent alarm output ensures immediate reaction to overload events to protect connected devices. In order to optimize the overall system accuracy, the CFS1000 allows end-of-line calibration directly in the end device. For low currents, the primary current conductor can be placed directly underneath the current sensor package, on the top side of the PCB. For high currents in the range of up to 1000 A, copper bars are used as conductors onto which the PCB with the current sensor on top is attached to. Hence, only one current sensor needed to be developed that can be used for different applications and current ranges. Typical applications for the CFS1000 currents sensor are in the automotive sector, electrical speed drives (industry, e-mobility), in frequency converters, for battery management and renewable energy.

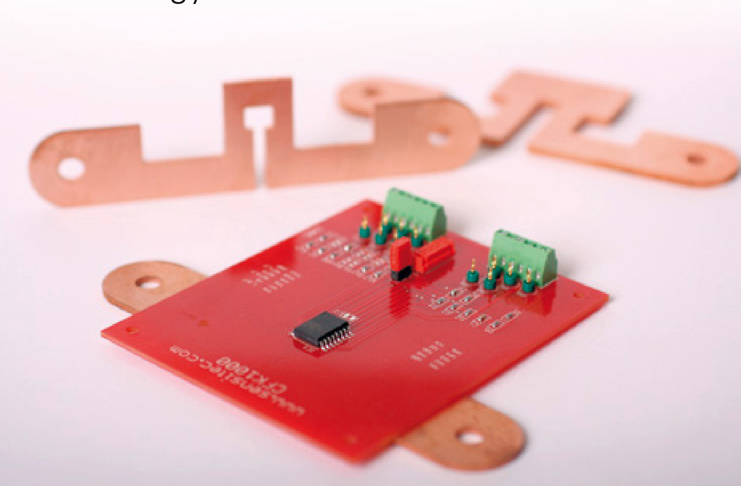


Fig. 3: CFK1000 Demoboard: offers the opportunity to learn the features and benefits of the CFS1000 current sensors in a quick and simple manner.

The high bandwidth combined with high precision enable users to achieve a higher power density in their power electronics, particularly when the sensor is used in combination with new wide band gap power transistors, e. g. SiC or GaN.
For those new to the technology or fascinated by the potential: Sensitec offers with the CFK1000 evaluation board the opportunity to learn the features and benefits of the CFS1000 current sensors in a quick and simple manner (fig. 3).

ABOUT SENSITEC

Sensitec is a leading manufacturer of sensors based on the magnetoresistive (MR) effect. The sensors are used for the precise measurement of angle, length, current or magnetic fields. ■

i More info

- www.sensitec.com
- Current measurement

Beyond Lithium-Ion: Future Battery Concepts

By Mouser Electronics

Mobile technology hinges upon the availability of batteries to support it. This is something most of us know all too well, as we charge up our mobile devices every night.

Lightweight, cost-effective, rechargeable, and providing far higher energy density than other commercial battery chemistries, Lithium-ion (Li-ion) is the acknowledged workhorse for powering today's mobile devices. Developed in the 1970s, Li-ion battery technology is unfortunately nearing its theoretical limits though.
The hunt for a better battery technology is gaining greater urgency as existing options are now gating not only consumer electronics, but also the electric car industry and related clean energy initiatives. Mouser has published an article that looks at the different battery technologies which are starting to emerge. It covers the following types:

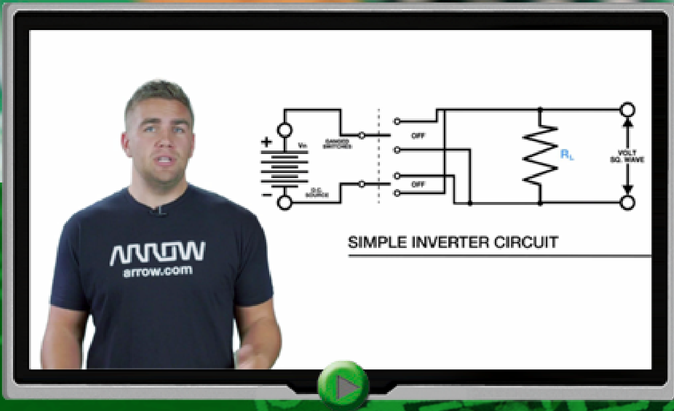
- Tin Nanocrystal Li-Ion Batteries – Which convert chemical energy into electrical energy by sharing a common carrier electron, with electrodes that are made from a tin-based nanomaterial. The result is a doubling of battery energy capacity compared to conventional Li-Ion.
- Metal-Air Batteries – Where metal electrodes (made from sodium, lithium, aluminium or zinc) react with oxygen in the air, instead of a liquid, to produce an electrical current. There is the potential for 5x to 10x higher

specific energy than with Li-ion batteries, and this is proving particularly attractive to the electric car sector.

- Liquid Metal Batteries – These use a molten salt electrolyte to separate two liquid metal electrodes, with the difference in composition between the electrodes creating a voltage. As well as exhibiting strong energy storage capabilities, this approach has the potential to be very cost effective, as the proposed electrode materials are relatively commonplace and inexpensive.

More info

Read the full article on the Mouser Electronics website



Know the difference between Inverter, Converter, Transformer and Rectifier

Knowing the difference between an inverter, converter, transformer and rectifier is essential when designing for specific power supply inputs and outputs. Here's a quick comparison outlining the functions of each to help clear up any confusion.

INVERTERS

Inverters ultimately have only one job – take in DC current and turn it into AC current. In theory, this is very easy, because a simple switch and some creative wiring can give you an alternating square wave operating at the frequency that you flip the switch.

But in reality, square waves are very damaging to nearly all modern electronics that rely on AC power. So the real question is: How do you take AC power and turn it into something useable? The answer is, you can filter the square wave using precisely selected inductors and capacitors to create a sine wave, or at least something close to a sine wave.

Oftentimes, inverters will also feature a transformer. This is done so that the AC voltage out can actually be different from the DC voltage in, depending on the number of coils on the primary and secondary winding.

There two common types of inverters:

- **Pure Sine Wave Inverter (PSW)**

The output of a pure sine wave inverter is, you guessed it, a pure sine wave. It is very difficult to achieve a perfect sine wave as an output, and the designs to do so can be very complex.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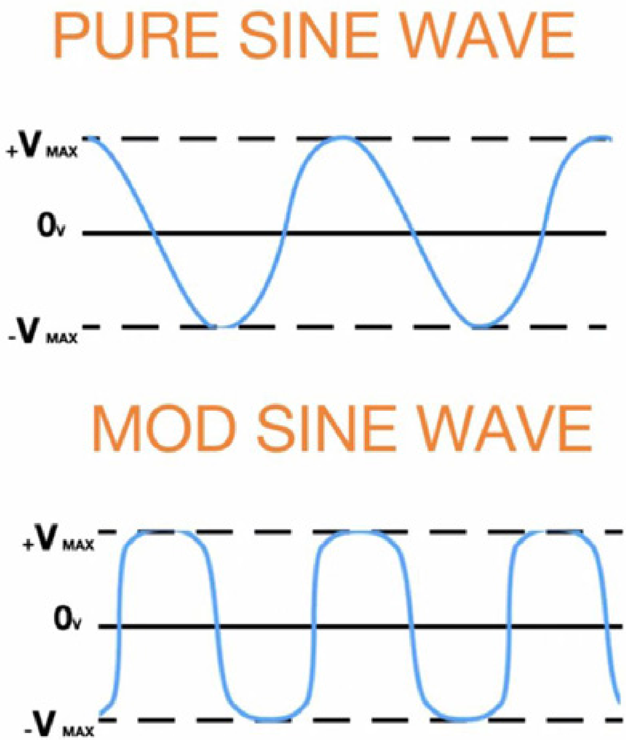

PURE SINE WAVE
+V MAX
0v
-V MAX
MOD SINE WAVE
+V MAX
0v
-V MAX

- **Modified Sine Wave Inverter (MSW)**
These can use thyristors, diodes and other passives that produce a rounded-off square wave, and they actually get very close to outputting a pure sine wave. Oftentimes, MSWs can be used for high power electro-mechanical equipment.

CONVERTERS

Converters also have only job: convert AC power to DC power. But the word "converter" is very generic, and you may often see it being used incorrectly. For example, if someone says "DC to AC converter," that makes logical sense even though the correct terminology is "DC to AC inverter." The same argument can be made by saying "DC to DC converters." AC to DC converters are also regularly referred to as power supplies.

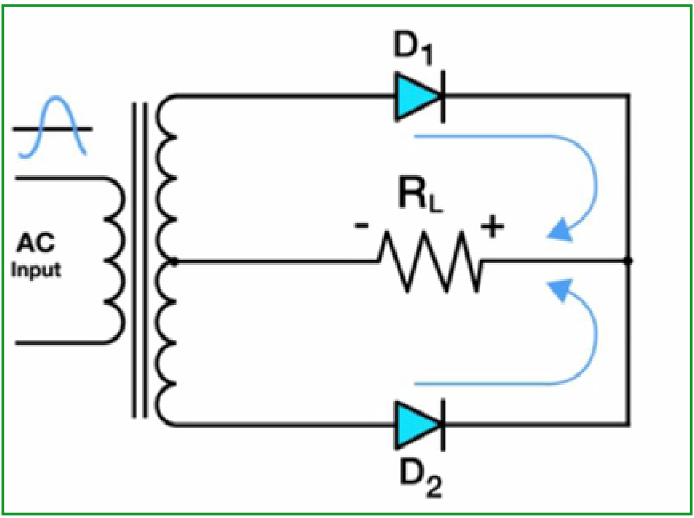
There are two common types of converters:

- **Half-wave rectifier:** These are generally only used in low-power applications because their signal is not very uniform by nature. Since half of the AC signal is lost, the output amplitude is roughly 45 % of the input amplitude, meaning that power is heavily wasted during the negative half-cycle of the input. Even when putting a large capacitor over the load, there is still an excessive ripple during the down cycle of the AC input.

- **Full-wave rectifier:** Design engineers use a full-wave rectifier to combat this signal loss and to get a much cleaner signal. They capture both positive and negative cycles of the AC source and are used for applications that need a steady and smooth DC voltage source.

RECTIFIERS & TRANSFORMERS

You'll usually see a full-wave rectifier circuit designed in one of two ways: The first utilizes a multiple winding transformer that creates a purely positive signal and can then be



Example of a full-wave rectifier

smoothed out with a capacitor over the load. The second is called a full-wave bridge rectifier, which effectively does the same thing as the transformer full-wave rectifier but it is a smaller configuration because there is no transformer involved. Either choice is essentially the same strategy as the half-wave rectifier except that there is double the frequency of the AC input and the input nearly never reaches zero.

So you can see how rectifiers and transformers make up parts of the greater converter vs. inverter conversation. Hopefully this video will help you choose the right part for your design.

More info

- View Quick Comparison Video
- Arrow Power Transformers Website
- Arrow AC to DC Power Supply Website

DC/DC railway converters with wide input range

When planning a universally applicable railway device typically at least three versionsof the same design are necessary to cover all standard supply voltages in railway vehicles ranging from a nominal 24VDC to 110VDC. This causes additional complications, which can be avoided by using RECOM's newly developed DC/DC railway converters with ultra-wide input voltage, which allow for all-in-one solutions.

The half-brick DC/DC converters RPA100H and RPA200H series are designed for railway rolling stock and high voltage battery applications. By accepting a 10:1 input volt-

age from 14.4VDC to 156VDC, these converters can be considered for any railway design without worrying about voltage tolerances, voltage dips or the local supply voltage. Their ultra-wide input voltage range covers all input voltages from nominal 24VDC up to 110VDC (including EN50155 transients and brownouts) in a single product and they offer isolated and regulated 12V or 24VDC outputs. The converters have a consistently high efficiency over the entire input voltage and load range, and come with a metal baseplate to permit a wide operating temperature range from -40°C up to +97°C (when suitably cooled).
For high reliability, no tantalum capacitors are used internally and the casing has threaded inserts to allow secure mounting to the PCB or bulkhead for use in high shock and vibration environments. The converters are fully compliant to EN50155, certified to UL/IEC/EN60950 and come with a three year warranty. ■

i **More info**

- DC/DC Converters
- RPA100H/200H Series

In conjunction with D-Sub and Han Eco® 10 A, "electrical connection – optical transmission" is ready for automation.

New avenues in IGBT control: electrical connection and optical transmission

IGBT semiconductor devices control high-performance electrical drives whose connection to the required insulation is realized via polymer optical fibre. However, this solution is space-sensitive and sensitive. HARTING offers users a new, miniaturised solution option in IGBT control.

Electro motors with up to several kW and even MW of power consumption are used for almost all types of industrial drive technology. At constant speeds, their control technology is quite simple. However, it is often necessary to regulate the speed of the motors, which in turn makes everything more complicated.
Speed regulation in the larger power classes is realized with IGBT semiconductors. These can switch large loads using very low control powers. The necessary signals for IGBT control are transmitted with polymer optical fibres (POF) since very high insulation and voltage requirements must be met. The POF achieve disturbance-free and galvanically isolated signal transmission.

SIGNIFICANT SPACE REQUIRED

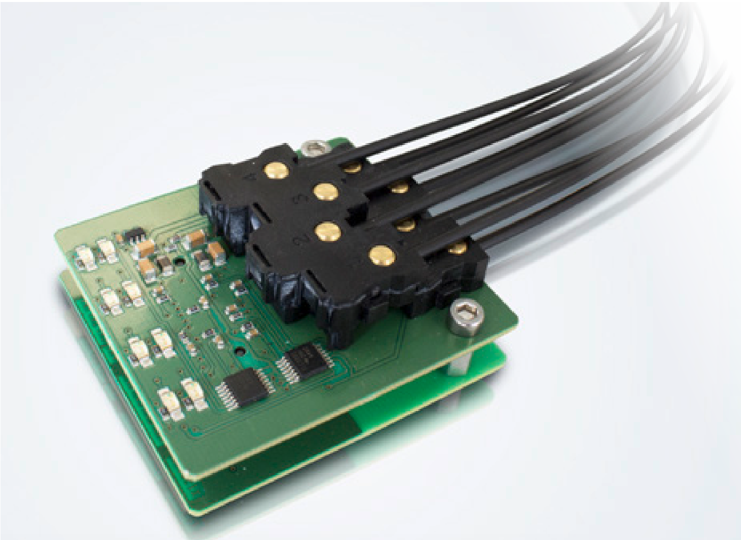
The connection to date between controller and driver board, i.e. the control and motor side, has been handled by individual fibres. The electro-optical conversion of the signals takes place in the transceivers of the circuit board, whereby optical contacts establish the connection to the fibres. Each optical fibre has a single connection on both the driver and the controller board, in which the transceivers are located. With this previous solu-

tion, all transmit and receive elements on the controller board require significant space, which makes the board unnecessarily large. A further shortcoming is the mandatory correct positioning of the various POF fibres in the event of servicing or during installation, in order to ensure the individual connection between each driver and controller board. This assignment must be carried out with attention and requires a certain carefulness and time. Transmitter and receiver must not be mixed up if correct operation is to be ensured. In order to guarantee the quality of the fibre end surfaces, prefabricated cables are used which can also be installed on site by the customer.
Commonly used optical elements are developed for industrial use with wide temperature ranges and increased vibrations, but provide only simple strain relief for the fibres. It is also important that the optical interface be consistently protected from dirt, and in an unplugged state protective flaps are even required. Cleanliness and correct connection are therefore the chief requirements - even with the at times numerous connections. This is expensive and non-service-friendly, in particular if a part of this transmission unit is damaged during operation and the entire board has to be replaced.

THE NEW SOLUTION FOR AUTOMATION

In order to solve these problems, HARTING has developed a transmission principle which involves relocating the transceivers of the controller board into a pluggable module and thus integrates the optical interface according to the principle of "electrical plugging and optical transmission".

HARTING uses solutions from the Han-Eco® 10 A series in automation for electrical plugging and as a system housing. The Han®

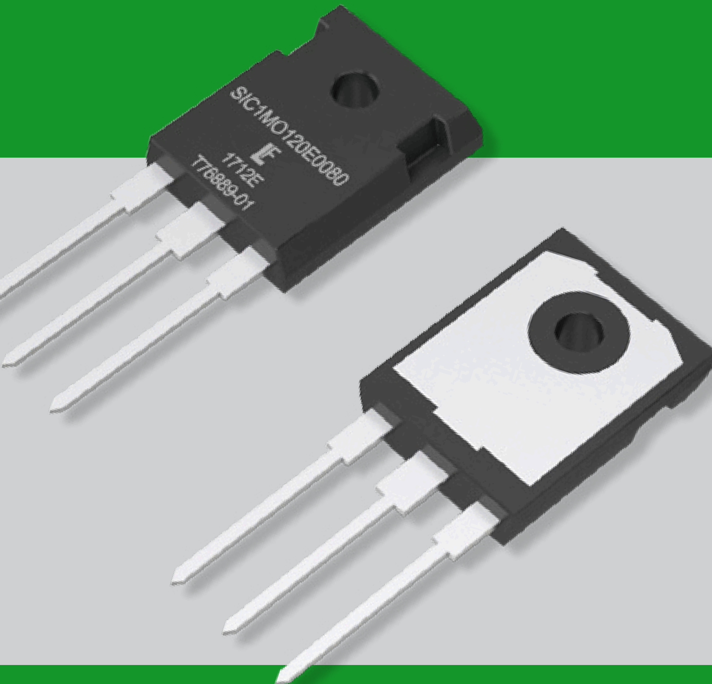


With har-flex, the principle of "connect electrically – transmit optically" extends into the device all the way to the printed circuit board.

housing fulfils the increased requirements of the automation market and integrates optimal kink protection and strain relief for the fibres. In addition, the printed circuit board in the Han® housing can accommodate series resistors and supporting capacitors if required, in order to control the optical elements without error and prevent interference. The electrical contacts of the electrically connecting D-Sub mating face also resist wear caused by microvibrations and rougher shocks. ■

More info

- Connection Technology for Automation Applications
- Product Information about Han-Eco Connectors
- Product Information about Har-flexicon PCB connectors



Ultra-fast switching with first Littelfuse SiC MOSFET

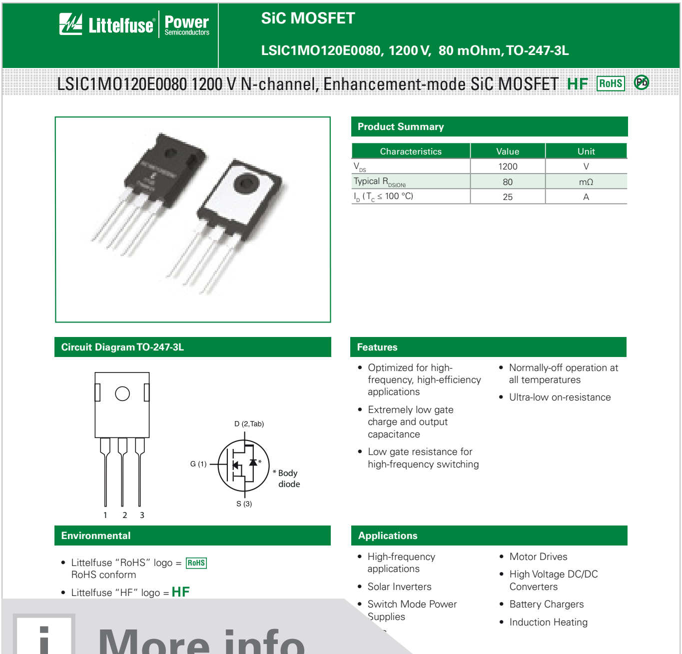
Littelfuse introduces its fir SiC MOSFETs which combines low switching losses, high efficiency and robustness, even at high temperatures.

In March 2017, Littelfuse made a majority investment in the well-respected SiC technology development company, Monolith Semiconductor Inc. The LSIC1MO120E0080 Series, with a voltage rating of 1200 V and ultra-low (80 mΩ) on-resistance, is the first organically designed, developed, and manufactured SiC MOSFETs to be released by this partnership. This device is optimized for high-frequency switching applications, providing a combination of ultra-low switching losses and ultra-fast switching speeds that's unavailable with traditional power transistor solutions.

When compared with silicon devices that have the same rating, the SiC MOSFET Series enables substantially greater energy efficiency, reduced system size/weight, and increased power density in power electronics systems. It also offers superior robustness and exceptional performance, even at high operating temperatures (150 °C). Typical applications for these new SiC MOSFETs include power conversion systems such as solar inverters, switch mode power supplies, UPS systems, motor drives, high voltage DC/DC converters, battery chargers and induction heating.

The LSIC1MO120E0080 Series SiC MOSFET

is available in TO-247-3L packaging and provided in tubes in quantities of 450. Sample requests may be placed through authorized Littelfuse distributors worldwide.



Littelfuse Power Semiconductors

SiC MOSFET

LSIC1MO120E0080, 1200 V, 80 mOhm, TO-247-3L

LSIC1MO120E0080 1200 V N-channel, Enhancement-mode SiC MOSFET HF RoHS Pb

Product Summary

Characteristics	Value	Unit
V_{DS}	1200	V
Typical $R_{DS(ON)}$	80	mΩ
I_D ($T_C \leq 100$ °C)	25	A

Circuit Diagram TO-247-3L

Features

- Optimized for high-frequency, high-efficiency applications
- Extremely low gate charge and output capacitance
- Low gate resistance for high-frequency switching
- Normally-off operation at all temperatures
- Ultra-low on-resistance

Environmental

- Littelfuse "RoHS" logo = RoHS RoHS conform
- Littelfuse "HF" logo = HF

Applications

- High-frequency applications
- Solar Inverters
- Switch Mode Power Supplies
- Motor Drives
- High Voltage DC/DC Converters
- Battery Chargers
- Induction Heating

More info

- LSIC1MO120E0080 Series SiC MOSFET product page
- LSIC1MO120E0080 Datasheet

Single-channel, isolated, IGBT and MOSFET gate driver deliver up to 5 A

Boosters allow scalable drive up to 60 A peak gate current; full protection features included

The SID1102K is the newest member of Power Integrations' SCALE-iDriver IC family, SID1102K. It is a single-channel, isolated, IGBT and MOSFET gate driver in a wide-body eSOP package. Featuring a peak drive current of up to 5 A, the new part is able to drive 300 A switches without boosters; external boosters can be used to cost-effectively scale gate current up to 60 A peak. This device provides N-channel drive for both the low and high side booster MOSFET switches which reduces system cost, minimizes switching losses and increases power capability.

Reinforced galvanic isolation is provided by Power Integrations' innovative, solid insulator FluxLink™ technology which eliminates the need for optocouplers, improving reliability and ruggedness. SCALE-iDriver technology simplifies design and manufacturing by reducing BOM count; complete drivers can be built using a SID1102K IC and just eight external components. Devices deliver system-level protection features including undervoltage lock-out, rail-to-rail stabilized output voltage – from a single supply rail, high common-mode transient immunity and 9.4 mm creepage and clearance.

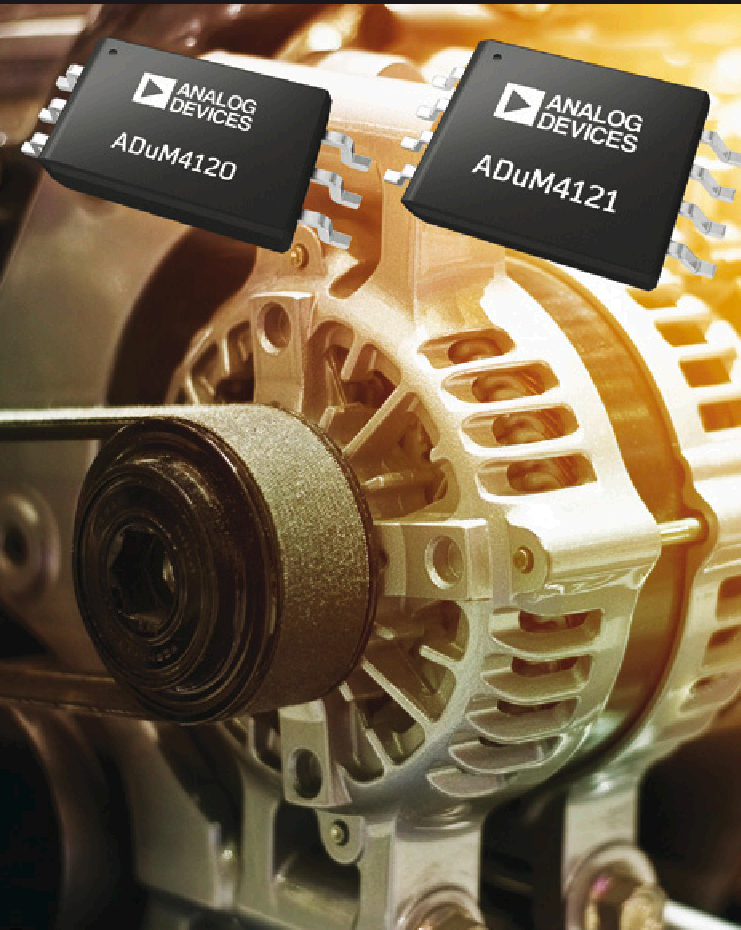
Key applications include UPS, standard AC drives and VFDs, photovoltaic/solar systems, commercial air conditioners, DC chargers and welding equipment. Devices are available now priced at $ 1.52 in 10,000 piece quantities. ■

More info

- Technical support for SID1102K ICs

Selecting sense resistors for motor control with reinforced isolation

By Cathal Sheehan, Bourns Electronics and Nicola O'Byrne, Analog Devices



This article summarizes the differences in standards between traditional optocoupler-based technologies and inductive and capacitive technologies for reinforced isolation. It describes a system using digital control of a motor drive that incorporates current sense resistors for sensing winding current,and recommends how to select the best resistor for this application.

The use of current sense resistors is part of a trend in motor control system design that benefits from adopting new digital isolation technologies. These technologies offer higher reliability levels to designers based on the introduction of the component level standard IEC 60747-17, which specifies the performance, test, and certification requirements for capacitive and magnetically coupled isolators. Digital isolation offers other benefits such as faster loop responses, allowing for integrated overcurrent protection, as well as narrower dead times. This enables smoother output voltages that, in turn, provide better control of torque. Designers of motor drives are most likely aware of the need to comply with international standards for isolation. Isolation is necessary for a number of reason. 1) It prevents electrical noise from the ground connection of a high-power circuit being induced onto a low power signal line. 2) It provides electrical safety for end users by preventing dangerous voltages and currents from transferring to a benign, low voltage environment.

The IEC 61010-1 Edition 3 standard specifies that the system-level designer must be aware of the distances between conductors, through air (clearance) and over surfaces (creepage).

Specification	IEC 60747-17		IEC 60747-5-5
	Basic Isolation	Reinforced Isolation	Reinforced Only
Partial Discharge Test	1.5 × VIORM	1.875 × VIORM	1.875 × VIORM
Working Voltage (VIORM)	Based on TDDB* analysis	Based on TDDB* analysis	Based on PD** test
Minimum Rated Lifetime	26 Years	37.5 years	Not defined
Failure Rate over Lifetime	1000 ppm	1 ppm	Not defined

*Time dependent dielectric breakdown.
**Partial discharge.

Table 1.
Key differences between optocoupler and non-optocoupler-based isolation

It also stipulates they must know the separation between conductors and metallic parts in potting, molding compounds, and thin film insulation. A designer should ensure that the chosen components guarantee a certain level of safety if they are being used on systems compliant to IEC61010-1, according to the industry accepted time-dependent dielectric breakdown (TDDB) analysis, which then helps to extrapolate the device lifespan and continuous working voltage (VIORM).

While IEC 60747-17 (DIN V VDE V 0884-11) was adopted to specifically define insulation using inductive and capacitive technologies, the well-established IEC 60747-5-5 standard was used to define the insulation using optocoupler technologies.

However, IEC 60747-5-5 does not specify the TDDB analysis to determine the continuous working voltage or lifetime. It relies on the partial discharge voltage test to establish the working voltage, but does not define the working lifetime of the device. Hence, inductive and capacitive technologies have a minimum rated lifetime of 37.5 years, while there is no definition for optocoupler-based isolators. Table 1 summarizes the key differences between optocoupler and non-optocoupler-based standards. The conclusion is that non-optocoupler-based standards will gain more acceptance over time as they offer greater security to design engineers and longer operating lifespans.

Figure 1 shows a typical three-phase permanent magnet motor drive using sense resistors for measuring the winding current and with feedback through the Analog Devices AD7403 isolated Σ-Δ modulator and a sinc3 filter. The AD7403 uses a single second-order modulator digitizing circuit that con-

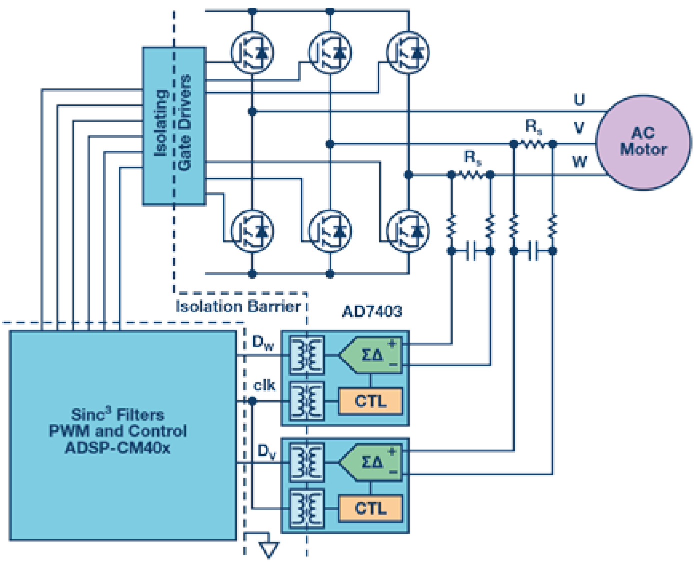


Figure 1. Block diagram of three-phase motor drive with digital isolation and sense resistors

verts the analog signal from the sense resistor into an isolated single-bit pulse stream, which scales according to the full-scale input voltage range. The sinc3 filter then extracts the average value of the current, while eliminating noise created by inverter switching. It can store a 16-bit integer representing the current in memory and, at the same time, it can compare the number with a reference representing current limits and send an alert via a separate pin during overload conditions. The use of shorter filters for overload monitoring, in parallel with the measurement filter, allows alert latencies to be reduced.
The AD7403 has reinforced isolation allowing the current sense resistor voltage to be measured directly by the modulator with no extra components apart from a simple, discrete, low-pass filter, comprising a resistor and capacitor. The specified maximum operating voltage of the modulator is ±250 mV, which requires that the resistance value of the current sense resistor to be less than 250 mV/I_{MAX}.

Given that the output of the AD7403 is a 16-bit number, the potential accuracy of the current measurement is limited not by the ADC conversion, but by the voltage reading itself.

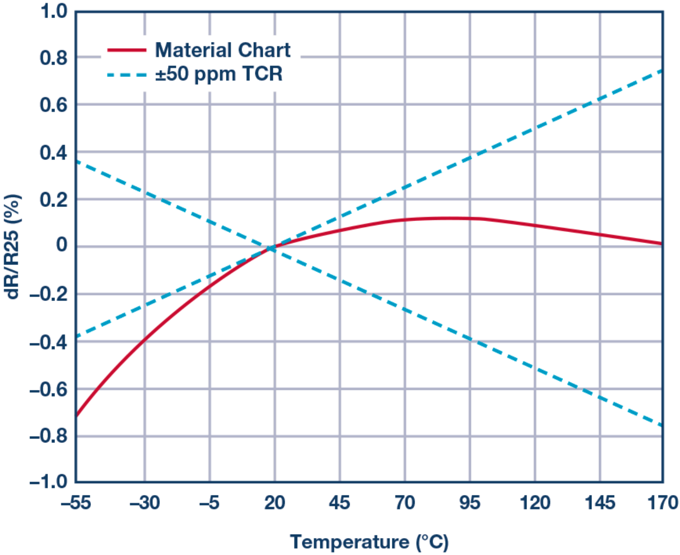


Figure 2. Parabolic TCR curve of Bourns model CSS4J-4026R current sense resistor

The drift of the resistance with temperature will vary depending on the material used in the resistor element, as well as the power rating and the actual physical size of the component. Resistive elements made up of special alloys of nickel, copper, and manganese have parabolic resistance drift curves, as shown in figure 2. These alloys are the most accurate materials used for current sensing applications. Figure 2 also shows the upper and lower limits of resistance drift of a

Bourns model CSS4J-4026R resistor, corresponding to a temperature coefficient of 50 ppm/°C. This gap is caused by the copper terminals of the resistor, which increase drift due to the high TCR of copper (4000 ppm/°C). The Bourns model CST0612 series is a 1 W, 4-terminal resistor made from a special alloy. It measures 3.2 mm × 1.65 mm, has a TCR of ±100 ppm/°C, and the difference in TCR between Bourns model CST0612 and model CSS4J-4026R can be explained by the proportion of copper, with respect to the resistive element. The additional copper with its low thermal resistance helps the component absorb the high power without overheating. This example demonstrates the trade-off between the size of the component, the power rating, and the drift in the resistance value over temperature. Let us use Bourns part number CSS4J-4026R-L500F for calculating the resistance drift at full power and at an ambient temperature of 70 °C.

CSS4J-4026R-L500F is a 0.5 mΩ (±1 %) sense resistor rated to 5 watts of power, at a maximum ambient temperature of 130 °C.

It derates from 100 % power to zero W at 170 °C. The thermal resistance of the component therefore, is 8 °C/W. At full power and an ambient temperature of 70 °C, we can expect the surface temperature of the component to reach 110 °C (70 °C + 8×5 °C). The drift in resistance at 110 °C can be taken from figure 2, which is +0.45 % of the nominal value at 25 °C. The absolute tolerance is ±1 % and therefore, the accuracy of the current measurement will be a maximum of +1.45 %.

Motor drives will experience short circuits from time to time, and the current sense resistor must be able to handle short overloads without being damaged. Using the Bourns model CST0612 current sense resistor as an example, it is possible to calculate the mass of this component from the material data sheet on the Bourns website at 0.0132 g. Alternatively, it can be calculated from the dimensions, and the density of copper and alloys (8.4 g/cm^3). The rate of rise in temperature can be calculated by the following:

$$\frac{dT}{dt} = \frac{P}{mC}$$

Where P is power (watts), m is the mass of the component (g), and C is the specific heat capacity of the metal alloy. An overload of 50 A in a resistance of 1 mΩ, would create

a 462°C per second temperature slew rate. Assuming a steady state temperature of 50 °C, the width of the short circuit period cannot exceed 0.22 seconds. This can be extended by increasing the overall mass through copper plating on the circuit board. A thicker, larger part such as model CSS4J-4026 with a mass of 0.371 g would have a temperature slew rate of 16.5 °C per second, given the same overload. Assuming the component had a surface temperature of 100 °C, it would handle the energy for up to four seconds before the surface temperature reached the maximum allowed value of 170 °C.
The AD7403 has a full-scale input of ±250 mV from the resistor. The following matrix outlines the voltage drop at maximum current across Bourns high power, current sense resistor models. The designer can compensate for lower voltages by adjusting the scaling factor.

According to IEC60747-17, the minimum lifetime of a digital isolator rated to reinforced isolation should be 37.5 years.
While there is no such reference for more traditional optocoupler technologies, designers should feel more confident about work-

ing with digitally isolated systems in the future. Current sense resistors made using special alloys have low resistance drift over temperature, and produce output voltages which can be read with an adjustable scaling factor by an isolated Σ-Δ modulator, such as those using Analog Devices iCoupler technology. The accuracy of the current measurement will depend on the temperature of the resistor, which in turn depends on the power as a proportion of the power rating, as well as on the ambient temperature. ■

More info

- Current Sense Resistor Series CSS4J-4026 (PDF)
- Current Sense Resistor CST0612 (PDF)
- Mixed-Signal Control Processors ADSP-CM4xx
- 16-Bit, Isolated Sigma-Delta Modulator AD7403

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