Industrial Automation

www.infineon.com/automation
# Content

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>4</td>
</tr>
<tr>
<td><strong>Automation Applications</strong></td>
<td>6</td>
</tr>
<tr>
<td>Industrial PCs</td>
<td>6</td>
</tr>
<tr>
<td>Human Machine Interface (HMI)</td>
<td>7</td>
</tr>
<tr>
<td>Programmable Logic Controller (PLC)</td>
<td>8</td>
</tr>
<tr>
<td>Micro PLC</td>
<td>9</td>
</tr>
<tr>
<td>Industrial Power Supply</td>
<td>10</td>
</tr>
<tr>
<td>Industrial Sensors</td>
<td>11</td>
</tr>
<tr>
<td>Motor Control and Drives</td>
<td>12</td>
</tr>
<tr>
<td>Industrial Communication</td>
<td>13</td>
</tr>
<tr>
<td>Linear Actuator</td>
<td>14</td>
</tr>
<tr>
<td><strong>Product Solutions – Power Supply</strong></td>
<td>15</td>
</tr>
<tr>
<td>CoolMOS™ – High Voltage Power MOSFETs</td>
<td>15</td>
</tr>
<tr>
<td>600V CoolMOS™ P6</td>
<td>15</td>
</tr>
<tr>
<td>600V and 650V CoolMOS™ C6/E6</td>
<td>17</td>
</tr>
<tr>
<td>650V CoolMOS™ CFDA</td>
<td>18</td>
</tr>
<tr>
<td>OptiMOS™ – Low and Medium Voltage</td>
<td>19</td>
</tr>
<tr>
<td>Power MOSFETs</td>
<td></td>
</tr>
<tr>
<td>Small Signal Power MOSFETs</td>
<td>20</td>
</tr>
<tr>
<td>SiC Schottky Diodes</td>
<td>21</td>
</tr>
<tr>
<td>650V thinQ!™ SiC Schottky Diodes</td>
<td>21</td>
</tr>
<tr>
<td>Generation 5</td>
<td></td>
</tr>
<tr>
<td>1200V thinQ!™ SiC Schottky Diodes</td>
<td>22</td>
</tr>
<tr>
<td>Generation 5</td>
<td></td>
</tr>
<tr>
<td>Silicon Power Diodes</td>
<td>24</td>
</tr>
<tr>
<td>Discrete IGBT</td>
<td>27</td>
</tr>
<tr>
<td>650V TRENCHSTOP™ 5 Discrete IGBT</td>
<td>27</td>
</tr>
<tr>
<td>600V and 1200V HighSpeed 3 Discrete IGBT</td>
<td>29</td>
</tr>
<tr>
<td>DC/DC Converters</td>
<td>31</td>
</tr>
<tr>
<td>DC/DC Voltage Regulator – DrBlade™ 2</td>
<td>32</td>
</tr>
<tr>
<td>RC-Drives and RC-Drives Fast</td>
<td>34</td>
</tr>
<tr>
<td>Voltage Regulators</td>
<td>35</td>
</tr>
<tr>
<td><strong>Product Solutions – Control</strong></td>
<td>36</td>
</tr>
<tr>
<td>XMC – 32-bit Industrial Microcontrollers</td>
<td>36</td>
</tr>
<tr>
<td>AURIX™ – 32-bit Microcontrollers</td>
<td>38</td>
</tr>
<tr>
<td>CAN Transceivers</td>
<td>40</td>
</tr>
<tr>
<td><strong>Product Solutions – Interface</strong></td>
<td>42</td>
</tr>
<tr>
<td>HITFET™ Low-Side Drivers</td>
<td>42</td>
</tr>
<tr>
<td>PROFET™ High-Side Drivers</td>
<td>44</td>
</tr>
<tr>
<td>SPIDER – Universal SPI Driver for Low-Current Loads</td>
<td>46</td>
</tr>
<tr>
<td>ISOFACE™ – Galvanic Isolated High-Side</td>
<td>48</td>
</tr>
<tr>
<td>Switches and Input ICs</td>
<td></td>
</tr>
<tr>
<td>Wireless Control</td>
<td>49</td>
</tr>
<tr>
<td>SmartLEWIS™ Family – Smart Low Energy</td>
<td>50</td>
</tr>
<tr>
<td>Wireless System</td>
<td></td>
</tr>
<tr>
<td>Current Sensors</td>
<td>51</td>
</tr>
<tr>
<td>Hall-Effect Switches</td>
<td>52</td>
</tr>
<tr>
<td>Linear Hall Sensors</td>
<td>53</td>
</tr>
<tr>
<td>Speed Sensors</td>
<td>54</td>
</tr>
<tr>
<td>Integrated Pressure Sensors ICs</td>
<td>55</td>
</tr>
<tr>
<td>iGMR Angle Sensors</td>
<td>56</td>
</tr>
<tr>
<td>Constant Current Relay Drivers (CCRD)</td>
<td>58</td>
</tr>
<tr>
<td><strong>Product Solutions – Security and Protection</strong></td>
<td>59</td>
</tr>
<tr>
<td>OPTIGA™ TPM (Trusted Platform Module)</td>
<td>59</td>
</tr>
<tr>
<td>OPTIGA™ Trust – Authentication Solution for Increased Security at Lower System Costs</td>
<td>60</td>
</tr>
<tr>
<td>OPTIGA™ Trust P – Programmable Device</td>
<td>61</td>
</tr>
<tr>
<td>Authentication Solution</td>
<td></td>
</tr>
<tr>
<td>SLM 97 – Machine-to-Machine (M2M) Portfolio</td>
<td>62</td>
</tr>
</tbody>
</table>
The Automation Advantage

The growing pace of industrial automation and networking across industrial control systems presents manufacturers with evolving challenges. They need industrial-grade components that can withstand harsh manufacturing environments, meet the latest energy efficiency standards and offer robust levels of security. A microcontroller, for example, that doesn’t support an extended temperature range is simply not fit for purpose. Other success factors include the right price/performance ratio, long-term availability thanks to guaranteed roadmaps and design support.

Here at Infineon, we are committed to making your automation designs as simple, energy-efficient, secure and reliable as possible. Not only do we cover the full automation design flow from power management through control to interfacing and security, we also support our high-quality, industrial-grade semiconductor offering with proven reference designs for easy design-in and rapid time-to-market. Backed by clear roadmaps, all of our products are engineered to give you a high level of integration while saving valuable space in energy-efficient packages.

Smart semiconductor solutions for smart factories
Our semiconductor solutions are also speeding the transition towards the fourth “Industrial Revolution” by optimizing processes and sharing information across the entire value chain. Accelerated by initiatives such as the German Government’s Industrie 4.0 (industrial internet) project, this stage of industrial development will see the growing emergence of smart factories powered by smart semiconductor solutions such as our microcontrollers, power devices and sensors. Driven by the internet and various information and communication technologies, Industrie 4.0 promises huge resource efficiency gains, individualized products and greater adaptability through the intelligent sharing and networking of information across the extended value chain. Industrie 4.0 also enables strong integration of customers and business partners.

However, an increasingly automated, connected environment presents new security challenges. Here, too, you can rely on our market-leading expertise in embedded security to meet growing demands for protection against attacks, counterfeits, manipulation and sabotage in the Industrie 4.0 manufacturing environment. Our hardware-based authentication systems and encryption solutions provide robust protection for product specifications, design blueprints, production schedules and industrial secrets as they fly through cyberspace.
Industrial Automation Solution Layers

Most industrial automation networks are divided into three solution layers – the supervisor level, the control level and the field level. The first focuses mainly on PC-based systems (desktop, rack-mounted and panel PCs), equipped with standard operating systems (such as Microsoft Windows) and supplier-specific industrial process control software for process parameterization and visualization.

The control level refers to the automation systems (programmable logic controllers or PLCs) where automation programs are executed. Control systems require robust real-time capability and usually have their own controller architecture and proprietary operating system.

Last but not least, the field level encompasses all terminal equipment such as sensors (optical, magnetic, thermal, etc.) and actuators (magnetic valves, power switches, motor starters, etc.) which work with a peripheral PLC or remote I/O system, collecting data and communicating it to the main PLC via a field bus.

Single-source Answer to all your Design Needs

Our portfolio gives manufacturers one-stop access to all the devices and solutions they need across all three solution layers. At the supervisor level, our semiconductor devices are designed to provide the necessary levels of robustness and security. For control applications, you will find our products in PLCs, human machine interfaces and field bus devices. And at the field level, customers can rely on our rich portfolio for micro PLCs, motor control devices, sensors and actuator drives.

As the leader in hardware-based embedded security, we also provide robust protection across software and hardware layers at all three levels. Complementing our OPTIGA™ TPM (Trusted Platform Module) security controllers to protect the integrity and authenticity of automation devices and systems in automation networks, our OPTIGA™ authentication solutions help you protect IP and avoid counterfeits.
Positioned at the heart of today’s complex, increasingly automated manufacturing environments, industrial PCs face a number of challenges. Generally responsible for process control and diagnostics (of software-based applications) and networked via standard Ethernet switches, industrial PCs have a direct impact on factory uptime. They must be designed for continuous operation in rugged manufacturing environments, featuring robust hardware and software security functionality in customizable housings scaling from mobile devices to 19” rack-mounted systems. Compatibility with industry-standard PC architectures and bus interfaces is also an important success factor, as industrial PCs are expected to outlive the short innovation cycles associated with consumer PCs and keep pace with the latest operating system or application updates. Last but not least, power efficiency is key as many industrial PCs need to operate without a fan.

We offer a wide portfolio of energy-efficient power semiconductors to meet all of your concrete industrial computing requirements. Highlights include our CoolMOS™ and OptiMOS™ solutions. As market leader in TPM-based PC security, we also deliver tailored solutions for trusted computing (TPM) and identification devices, contact-based and contactless chip card ICs, and ICs for USB security dongles. You can rely on our wide range of RF and protection devices and our wireless components (LNA, RF transistors) to protect sensitive interfaces. To ensure future compatibility, our dedicated CPU and memory power supply devices comply with Intel DrMOS specifications. Rounding off our impressive lineup, we offer dedicated application know-how and software support when you need it. You can even test your application on our special demonstrator platform to see how it performs for yourself.

For detailed product information please see the chapter Product Solutions from page 15 onwards.

DrMOS = Driver and MOSFET Integrated Module
Human Machine Interfaces (HMI)

Human machine interfaces (HMI) such as text displays, graphic panels and panel PCs must be particularly robust in harsh industrial settings. Looking beyond a rugged and secure design, they must also be easy to use and support granular access. Given the importance of interoperability across microcontrollers, power supplies and peripherals in complex manufacturing environments, a single-source offering – at the right price point – is often a must-have.

We offer a full lineup of high-quality solutions to meet all of your human machine interface needs. Our one-stop offering gives you the peace of mind you need that micro-controllers, power devices and interfaces will be seamlessly compatible. As a pioneer in embedded security, we can deliver the rich security functionality you need. You can build on our dedicated application know-how and proven track record in HMI innovations to design an HMI that is easy to use, efficient and secure. You can even test your HMI prototype on our demo platform based on the XMC4000 Application Kit – so you can experience the functionality and performance of our HMI semiconductor offering before you decide to invest.

For detailed product information please see the chapter Product Solutions from page 15 onwards.

www.infineon.com/human-machine-interface
Programmable Logic Controllers (PLC)

Programmable logic controllers (PLC) provide the computing power at the heart of nearly all industrial control and factory automation systems. As such, reliability is paramount. PLCs must be robust, resistant to environmental stresses and protected against water and dust to ensure 24x7 operation over a wide temperature range. Other key success factors include real-time capabilities, robust security functionality and seamless interoperability with connected automation systems.

We have a wide portfolio of dedicated semiconductors for PLC applications to answer all of these operational challenges. Our 8-, 16- and 32-bit microcontroller portfolio delivers enhanced real-time communication and comprehensive safety features for interfacing units in harsh industrial environments, also supporting various communication interfaces. Our unique ISOFACE™ family was designed specifically for industry automation systems, offering optional isolation and enhanced diagnostics. You can rely on our leading experience in security products and brand protection with solutions such as OPTIGA™ Trust, one of the best embedded security products on the market. Our power supply solutions are designed to meet even harsh automotive requirements. To experience the Infineon advantage for yourself, test your programmable logic controller prototype on our demo platform.

For detailed product information please see the chapter Product Solutions from page 15 onwards.

www.infineon.com/programmable-logic-controller
Micro PLCs

These programmable logic controllers (PLCs) manage low-end applications such as simple house-automation control systems or electronic points of sale (ePOS). Increasingly, manufacturers expect user-friendly, cost-sensitive devices that are both compact and power-efficient. Networking capabilities, an integrated design, high availability and robust security are also key priorities.

Our high-quality XMC1000 microcontroller family was designed to meet these challenges – at an attractive price point. Some members of the XMC1000 family are even equipped with optional software IP protection for particularly secured micro PLC applications. And our latest ARM® Cortex™-M4 32-bit microcontroller family is designed for the most robust performance requirements, with enhanced communication channels (Ethernet, USB, UART), interfacing to touch buttons and integrated high-current ports to drive LEDs. Drawing on our long-standing experience bundled in our OptiMOS™ product family, our MOSFET solutions offer lowest $R_{DS(ON)}$ and best-in-class FOM for the highest power efficiency and performance. For standard output interfaces, we offer a wide selection of low- and high-side switches covering several output current requirements. These are complemented by constant current relay drivers (CCRD) for energy-efficient operation of electromechanical relays.

For detailed product information please see the chapter Product Solutions from page 15 onwards.

www.infineon.com/micro-plc
Industrial Power Supply

The benchmark is high for power supplies in industrial settings. They must be reliable and efficient, resistant to load dumps and capable of delivering a stable output voltage over a wide input voltage range. In addition, they must ensure minimal power losses and remain stable over a wide temperature range.

Supporting all industrial power supply applications, we have a broad portfolio of high-quality industrial-grade products that reflect our lengthy experience in power supply technology. Our lineup extends from low-voltage MOSFETs (OptiMOS™), with best-in-class $R_{D\text{ds(on)}}$ and FOM values, through high-voltage MOSFETs (CoolMOS™) to discrete and integrated IGBT solutions.

Our integrated solutions (CoolSET™) are ideal for compact designs requiring especially low-power SMPS. Complementing dedicated power control ICs (PFC/PWM controllers), we offer a wide range of 8-bit microcontrollers (XC800 family), which are ideal for monitoring voltage, temperature or malfunctions. Our current sensors round off our power supply offering for point-of-load power supply applications.

Highlights of our power supply lineup include our unique thermal interface material (TIM) for lower thermal resistance and our leading packaging technologies for thermal optimization. You can also save time and effort with our power supply application boards and reference designs.

For detailed product information please see the chapter Product Solutions from page 15 onwards.

www.infineon.com/industrial-power-supply
In today’s high-tech factories, industrial sensors play a defining role in the precision and reliability of manufacturing systems. Typical applications include contactless switching, index counting, current measurement, level metering, and position, pressure or (large-area) motion detection. As automation equipment becomes increasingly powerful, specifications for industrial applications are growing in complexity. This calls for more intelligent sensors designed for higher accuracy and faster data transfer speeds, especially for contactless control systems, for instance.

In addition, sensors must be durable enough to perform reliably in an industrial environment – and small enough for the very limited space on an integrated printed circuit board (PCB). In addition, they must be designed to master degradation effects, in light barriers for instance.

Our high-quality industrial sensor semiconductors rise to these challenges with the added bonus of an optimum price/performance ratio. Our broad one-stop spectrum of solutions includes a rich portfolio of smart sensors to measure everything from angle and current to speed and pressure.

For detailed product information please see the chapter Product Solutions from page 15 onwards.

www.infineon.com/industrial-sensors
Motor Control and Drives

Modern motor control applications call for energy efficiency, stability and security. In addition, demands for power density are rising. The key to meeting these needs lies in the right semiconductor solutions.

With years of experience in motor control, we offer the industry’s most cost-competitive portfolio and the highest-quality semiconductor components for motor control and drive applications. Our offering covers a wide range of voltage and power classes, supporting a broad application spectrum across the industrial market. With our power products and microcontrollers, you can design efficient, robust and cost-effective control units for virtually all types of motors, from brushless DC and permanent magnet synchronous motors, through induction and stepper motors, to switched reluctance motors. This is complemented by various sensor products for reliable and efficient motor operation.

Highlights of our motor control portfolio include our SiC (silicon carbide diode) technology line and our proprietary TIM (thermal interface material) for the market’s lowest thermal resistance, especially for Power IGBT Modules in the range from Easy Modules to PrimePACK™ Modules. Our experts can help you develop tailor-made microcontrollers for your individual design challenges. For common applications, we offer motor control evaluation boards and demo kits.

For detailed product information please see the chapter Product Solutions from page 15 onwards.

www.infineon.com/motor-control
Networking and communication demands are growing in industrial settings as automation and complexity continue to rise. Today’s devices need to support real-time communication protocols, ensure robust, fail-safe and – above all – secure wireless communication and work with the growing diversity of machine interfaces that are appearing on the market.

Our dedicated semiconductor solutions are specifically engineered to support industrial communication applications. They are designed to enable fast time-to-market at a price point that fits your budget. Even more importantly, our OPTIGA™ made-to-measure embedded security solutions enable secured communication across networked IT infrastructures and production systems. Our LNAs for WLAN applications, for example, are the best way to improve system sensitivity and extend your system range. And our transceiver devices come with built-in CAN support. For your flexibility, our portfolio of transmitter, receiver and transceiver products for the sub 1GHz frequency bands extends from entry-level standard devices up to SmartLEWIS™ solutions for complex system and performance requirements. Supporting the full range of industrial communication standards and protocols, we back up our offering with demo platforms and comprehensive software and driver support.

For detailed product information please see the chapter Product Solutions from page 15 onwards.

www.infineon.com/industrial-communication
Linear Actuators

For top performance in industrial settings, a linear actuator must be robust and resistant to environmental stress.

You will find the perfect fit for your actuator needs from our wide range of high-quality products. All our actuators are designed to get your product to market on time, in budget and with the right feature set. Our offering extends from robust protected switches – such as the PROFET™ and HITFET™ families – to proven reference designs specifically for industrial linear actuators, like our relay unit for PLCs. We also offer several integrated solutions to drive actuators in industrial environments, including PWM-enabled drivers or constant current relay drivers (CCRD), both of which reduce local power losses and increase the energy efficiency of your overall system.

For detailed product information please see the chapter Product Solutions from page 15 onwards.

www.infineon.com/linear-actuator
CoolMOS™ – High Voltage Power MOSFETs

600V CoolMOS™ P6
Optimized High Voltage Power MOSFETs Merging High Energy Efficiency with Ease of Use

CoolMOS™ P6 is our seventh generation of high voltage power MOSFETs designed according to the revolutionary superjunction (SJ) principle. The new CoolMOS™ P6 series combines our experience as the leading SJ MOSFET supplier with our innovative strengths in designing high-efficiency solutions. The resulting P6 technology is engineered to provide high performance in hard- and soft-switching topologies (e.g. PFC, LLC) without compromising ease of use. P6 achieves extremely low conduction and switching losses, especially in light load conditions.

This enables switching applications that are more efficient and compact, with the added bonus of being lighter and cooler. In addition, with its granular portfolio, P6 addresses the specific needs of applications such as server and PC power supplies, telecom rectifiers, consumer devices as well as industrial automation systems. For all these and other applications, it offers the best price/performance ratio on the market today.

Key Features
- Reduced gate charge (Q_g)
- Optimized V_{th} for soft switching
- Good body diode ruggedness
- Optimized integrated R_s
- Improved dv/dt

Key Benefits
- Improved efficiency, especially in light load conditions
- Better efficiency in soft-switching applications due to earlier turn-off
- Suitable for hard- and soft-switching topologies
- Optimized balance between efficiency and ease of use; good control over switching behavior
- Highly robust and better efficiency
- Outstanding quality and reliability
- CoolMOS™ quality with over 12 years manufacturing experience in superjunction technology
CoolMOS™ – High Voltage Power MOSFETs

600V CoolMOS™ P6
Optimized High Voltage Power MOSFETs Merging High Energy Efficiency with Ease of Use

Product Portfolio

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<tr>
<th>$R_{\text{ON}}$ (@ $V_{\text{GS}} = 10\text{V}$) [mΩ]</th>
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</tr>
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<td></td>
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Efficiency

This plug and play measurement shows the benefit of CoolMOS™ P6 in comparison to CoolMOS™ E6 and CoolMOS™ CP. In this 300W continuous conduction mode (CCM) PC Silverbox, CCM operates after output power until 70W or higher, otherwise it works in DCM. Even in this light load condition, which is not a one to one comparison, P6 has a slight efficiency improvement. When the output power goes over 70W in CCM, P6 shows an efficiency gain relative to E6 of 0.2% to 0.3% in full load. This efficiency benefit is due to $Q_g$ reduction and relatively high $V_{th}$ values.
CoolMOS™ C6/E6 is our sixth generation of high voltage power MOSFETs designed according to the revolutionary superjunction (SJ) principle. The new CoolMOS™ C6/E6 series combines our experience as the leading SJ MOSFET supplier with best-in-class innovation. The resulting C6/E6 devices provide all the benefits of a fast-switching SJ MOSFET without sacrificing ease of use.

Key Features
- Lowest $R_{DS(on)}$ in DPAK, TO-220, TO-247
- Improved body diode ruggedness ($Q_r$ and $di/dt$)
- Significant $Q_g$ reduction
- Reduced energy stored in output capacitance ($E_{oss}$) @ 400V
- Integrated gate resistor
- Outstanding CoolMOS™ quality

C6/E6 achieves extremely low conduction and switching losses, enabling more efficient, more compact, lighter and cooler switching applications. In addition, it offers the best cost/performance ratio on the market today. C6 devices have been optimized for ease of use, while E6 devices have been optimized for the highest efficiency in DCM applications.

Key Benefits
- Higher power density
- Improved reliability
- Ideal for both soft- and hard-switching topologies
- Improved efficiency in hard switching applications
- Better light load efficiency
- Greater ease of use
- Reduced ringing due to PCB layout and package parasitic effects

Product Portfolio

<table>
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<tr>
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For full portfolio visit the dedicated family page.

C3 vs. E6 efficiency comparison in a CCM-PFC stage 190mΩ @ 130kHz

1) Significant light load efficiency improvement with E6 can then also be achieved compared to C3 due to the improved $Q_r$ and $E_{oss}$ values.

www.infineon.com/c6e6
CoolMOS™ – High Voltage Power MOSFETs

650V CoolMOS™ CFDA
Market-Leading 650V CoolMOS™ Power MOSFETs with Integrated Fast Body Diode

With the new 650V CoolMOS™ CFDA, we have launched our second generation of market-leading automotive-qualified high voltage CoolMOS™ MOSFETs, which are also suitable for industrial sensors in industrial automation applications. The new CoolMOS™ CFDA series provides an integrated fast body diode, making it ideal for resonant switching topologies requiring lower switching losses due to a low gate charge. The softer commutation behavior and clearly enhanced EMI performance give the CoolMOS™ CFDA series a clear advantage over competitor parts. In addition, limited voltage overshoot during hard commutation of the body diode facilitates both layout and design-in.

Key Features
- First 650V automotive-qualified technology with integrated fast body diode on the market
- Limited voltage overshoot during hard commutation – self-limiting di/dt and dv/dt
- Low gate charge ($Q_g$)
- Low $Q_{oss}$ at repetitive commutation on body diode and low $Q_{oss}$
- Reduced turn-on and turn-off delay times
- Compliant with AEC-Q101 standard

Key Benefits
- Increased safety margin due to higher breakdown voltage
- Reduced EMI performance and easy design-in
- Better light load efficiency
- Lower switching losses
- Higher switching frequency and/or duty cycle possible
- Outstanding quality and reliability

Product Portfolio

<table>
<thead>
<tr>
<th>$R_{\text{DS(on)}} ,[\text{m}\Omega]$</th>
<th>DPAK</th>
<th>D-PAK</th>
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<th>TO-247</th>
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</table>

Limited Voltage Overshoot by CoolMOS™ CFDA During Hard Commutation of Conducted Body Diode

- Limited voltage overshoot due to soft commutation behavior of CFDA contributes to higher reliability
- Significantly less voltage overshoot of CFDA compared to competition enables easier design-in

www.infineon.com/cfda
OptiMOS™ – Low and Medium Voltage Power MOSFETs
Leading-Edge Solutions for a Better Future

OptiMOS™ 40V–250V products set a new industry benchmark for efficiency. With leading on-state resistance \( R_{\text{DS(on)}} \) and switching behavior, they reduce power losses overall energy efficiency levels of 96%. This series is ideal for designers looking to raise energy efficiency performance and meet targets such as Energy Star Titanium Level. Very low \( R_{\text{DS(on)}} \) values enable high-current applications in space-saving packages (such as SuperSO8, S3O8, CanPAK™ and TO-Leadless). Previously, these designs were only possible in larger packages.

Key Features
- Reduced number of phases in multiphase converters
- Minimized system EMI, eliminating the need for external snubber networks
- Designed for highest efficiency with the world’s lowest \( R_{\text{DS(on)}} \)
- Highest power density
- Lowest power density

Key Benefits
- Lower overall system costs
- Reduced power losses and increased efficiency for all load conditions
- Space-saving packages (CanPAK™, S3O8) or system-in-package solution
- Easy design-in

Efficiency

Using Infineon products in synchronous rectification of 600W server power supply with 12V output raises your peak efficiency by 0.3%.

For full portfolio please visit the family pages.
Small Signal Power MOSFETs
Small Signal N-Channel, P-Channel and Complementary MOSFETs

Our Small Signal portfolio offers N-Channel and P-Channel enhancement products as well as depletion MOSFETs. The voltage ranges from -250 up to 800V in single, dual and complementary configurations. Four gate drive voltages are available in seven industry-standard packages (SOT223, SOT89, TSOP6, SC59, SOT23, SOT323, SOT363). Small Signal MOSFETs are ideal for many applications such as battery protection and management, DC/DC converters, LED drivers and industrial automation applications. They are also commonly used as load switches and level shifters.

NEW Small Signal OptiMOS™ 100V MOSFET in TSOP6 Space-Saving Packages for Fast-Switching Applications

We have launched three new 100V and one new 75V Small Signal MOSFETs in TSOP6 packages. These are new space-saving versions of industry-standard devices in the respective R_{DS(on)} Class. The low Q_g and low thermal resistance makes them the perfect fit for a number of applications including industrial automation, motor control, LED lighting and SMPS systems. All products are qualified to AEC-Q101, making them suitable for automotive applications and all applications demanding the highest levels of quality.

Key Features
- Voltage from -250V up to 800V
- Single, dual and complementary packages
- Seven industry-standard packages
- Four gate drive voltages (1.8 – 10V)
- 100V and 75V Small Signal MOSFETs in TSOP6 packages
- Low Q_g and low thermal resistance

Key Benefits
- Highest levels of quality
- Automotive certified to AEC-Q101
- Low power dissipation
- Fast switching
  - Easy to design-in
  - Space-saving packages

Product Portfolio Small Signal SFET 2 100V TSOP6

<table>
<thead>
<tr>
<th>Product Type</th>
<th>V_{ds}</th>
<th>R_{DS(on)} @ V_{gs} = 10V [mΩ]</th>
<th>I_{(max)} [A]</th>
<th>V_{GS(th)} [V]</th>
<th>Q_{G(th)} [nC]</th>
<th>R_{thJA} [K/W]</th>
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<tr>
<td>BSL716SN</td>
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</tr>
</tbody>
</table>

1) Device on 40mm x 40mm x 1.5mm epoxy PCB FR4 with 6cm² (one layer 70µm thick) copper area for drain connection. PCB is vertical in still air (t < 5s).

Block Diagrams

www.infineon.com/smallsignal
www.infineon.com/depletion
SiC Schottky Diodes

650V thinQ™ SiC Schottky Diodes Generation 5
Improved Efficiency and Price/Performance

thinQ™ Generation 5 is our leading-edge technology for SiC Schottky barrier diodes. Our proprietary diffusion soldering process, established since G3, is now combined with a new, more compact design and thin wafer technology. The result is a new family of products offering improved efficiency over all load conditions. This performance enhancement is enabled by both the improved thermal characteristics and a lower Figure of Merit \( (Q_c \times V_F) \). The new thinQ™ Generation 5 has been designed to complement our 650V CoolMOS™ families, meeting the most stringent application requirements in this voltage range.

Key Features
- \( V_{br} \) at 650V
- Improved Figure of Merit \( (Q_c \times V_F) \)
- No reverse recovery charge
- Soft switching reverse recovery waveform
- Temperature-independent switching behavior
- High operating temperature \( (T_{j, \text{max}} = 175°C) \)
- Improved surge current capability

Key Benefits
- Higher safety margin against overvoltage; best match with CoolMOS™ products
- Improved efficiency over all load conditions
- Reduced EMI
- Highly stable switching performance
- Reduced cooling requirements and increased system reliability

Efficiency

Experimental results
Efficiency comparison among the three IFX generations of 8A SiC diodes
a) Absolute values
b) Referred to thinQ™ Gen 5 (CCM PFC, High line, \( P_{\text{out max}} = 1800W, f_{\text{sw}} = 65kHz, T_{\text{j, min}} = 60°C \), MOSFET: IPW60R075CP)
SiC Schottky Diodes

650V thinQ™ SiC Schottky Diodes Generation 5
Improved Efficiency and Price/Performance

Product Portfolio

<table>
<thead>
<tr>
<th>$I_{D}$ [A]</th>
<th>TO-220 real2pin</th>
<th>TO-247</th>
<th>D²PAK real2pin</th>
<th>ThinPAK 8x8</th>
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</table>

1200V thinQ™ SiC Schottky Diodes Generation 5
New Level of Efficiency and Reliability in Single-Phase and 3-Phase Applications

Our new 1200V thinQ™ SiC Schottky Diodes Generation 5 diode portfolio offers designers of high-power single-phase and 3-phase applications new levels of efficiency and reliability. Generation 5 diodes come with a best-in-class forward voltage level ($V_f$), which is 30% lower than the previous generation. The lower $V_f$ provides significant system efficiency gains from 50% loads upwards, also providing outstanding efficiency during lower switching frequency operations. A second highlight is the extended surge current capability. The new Generation 5 offers up to 14 times nominal current (depending on the diode amp rating), ensuring robust diode operation during surge current events.

Key Features
- Best-in-class forward voltage ($V_f$)
- Mild positive temperature dependency of $V_f$
- Best-in-class surge current capability, up to 14 times nominal current depending on amp rating
- Excellent thermal performance
- New 40A rated diode

Key Benefits
- Highest efficiency gain during high load operation due to 30% drop in static loss compared with previous generation
- Improved system efficiency even at low switching frequencies
- Higher reliability during surge current events

www.infineon.com/sic-gen5
www.infineon.com/sicdiodes1200v
1200V thinQ™ SiC Schottky Diodes Generation 5
New Level of Efficiency and Reliability in Single-Phase and 3-Phase Applications

Efficiency

![Diode Losses Graph]

- Nominal power: 10kW
- Input voltage: 500V
- Output voltage: 800V
- Switching frequency: 20kHz
- Junction temperature: 125°C

- IFX Gen2
- IFX Gen5

Diode Losses

Product Portfolio

<table>
<thead>
<tr>
<th>Continuous Forward Current $I_F$ [A]</th>
<th>TO-247</th>
<th>TO-220 real2pin</th>
<th>DPAK real2pin</th>
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<td>IDH08G120C5(^1)</td>
<td>IDM08G120C5(^2)</td>
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<td>40</td>
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</table>

1) B = dual-configuration with common cathode
2) Release 2015

www.infineon.com/sicdiodes1200v
Silicon Power Diodes
New Rapid Diode Families

The Rapid Diode families complement Infineon’s existing high power 600V/650V diodes by filling the gap between SiC diodes and previously released emitter-controlled diodes. They represent a perfect cost/performance balance and target high efficiency applications switching between 18kHz and 100kHz. Rapid 1 and Rapid 2 are optimized to have excellent compatibility with CoolMOS™ and high speed IGBT (Insulated Gate Bipolar Transistor) such as the TRENCHSTOP™ 5 and HighSpeed 3.

Rapid 1 is forward voltage drop ($V_f$) optimized to address low switching frequency applications. Optimized for applications switching up to 40kHz.

**Key Features**
- Temperature stable forward voltage ($V_f$) of 1.35V
- 650V breakthrough voltage
- Low reverse recovery current ($I_{rrm}$)
- Soft reverse recovery for outstanding EMI behavior
- $t_{rr} < 50$ns

Rapid 2 is a $Q_{rr}/t_{rr}$ optimized hyperfast diode to address high speed switching applications. Optimized for applications switching between 40kHz and 100kHz.

**Key Features**
- Temperature stable forward voltage ($V_f$) of 1.6V
- $t_{rr} < 20$ns
- Soft reverse recovery for outstanding EMI behavior
- Excellent cost optimized alternative to silicon carbide (SiC) diodes
Block Diagrams

Boost PFC

85–285 VAC

IGBT/CoolMOS™

400V

Rapid Diode

Interleaved PFC

85–285 VAC

IGBT/CoolMOS™

400V

Common Cathode

Rapid Diode

Full Bridge

V_in

IGBT/CoolMOS™

IGBT/CoolMOS™

Rapid Diode

Common Cathode

V_in

3 Level Inverter

V_AC

IGBT/CoolMOS™

IGBT/CoolMOS™

Rapid Diode

IGBT

Rapid Diode

Rapid Diode

Rapid Diode

www.infineon.com/rapidiodes
## Silicon Power Diodes

**New Rapid Diode Families**

### Rapid Diode Portfolio

<table>
<thead>
<tr>
<th>Continuous Current I, $T_c = 100^\circ$C (A)</th>
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<th>TO-220 FullPAK</th>
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| Rapid 1 650V | | | | | |
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| 15 | IDP15E65D2 | IDV15E65D2 | | | |
| 20 | IDP20E65D2 | IDV20C65D2 | IDW20C65D2 | | |
| 30 | IDP30E65D2 | IDV30E65D2 | IDP30C65D2 | IDW30C65D2 | |
| 40 | IDP40E65D2 | | | IDW40E65D2 | |

| Rapid 2 650V | | | | | |
| 6  | IDP06E60 | | | | |
| 9  | IDP09E60 | | | | |
| 15 | IDP15E60 | IDD15E60 | IDB15E60 | | |
| 30 | IDP30E60 | IDB30E60 | IDW30E60 | | |
| 45 | IDP45E60 | | | | |
| 50 | | | IDW50E60 | | |
| 75 | | | IDW75E60 | | |
| 100| | | IDW100E60 | | |

### Emitter Control Diode Portfolio

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<thead>
<tr>
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| 1200V | | | | | |
| 4  | IDP04E120 | | | | |
| 9  | IDP09E120 | | | | |
| 12 | IDP12E120 | | | | |
| 18 | IDP18E120 | | | | |
| 20 | IDP20E120 | | | | |
| 30 | IDP30E120 | | IDB30E120 | | |
Discrete IGBT

650V TRENCHSTOP™ 5 Discrete IGBT
A Technology to Match Tomorrow’s High Efficiency Demands

Our TRENCHSTOP™ 5 IGBT offers market-leading switching and conduction loss performance. TRENCHSTOP™ 5 is the next generation of thin wafer technology for applications switching at frequencies above 10kHz. We have reduced wafer thickness by more than 25%, enabling a dramatic improvement in both switching and conduction losses, whilst providing a breakthrough voltage of 650V.

Key Features
- 650V breakthrough voltage
- Performance improvements on HighSpeed 3:
  - Qg down by a factor of 2.5
  - Switching losses reduced by a factor of 2
  - VCE(sat) reduced by 200mV
- Co-packed with Infineon’s new “Rapid” Si diode technology
- Low Coss/Eoss
- Mild positive temperature coefficient (VCE(sat))
- Temperature stability of Vr

Key Benefits
- Best-in-class efficiency, resulting in lower junction and case temperature
- Higher device reliability
- 50V increase in the bus voltage without compromising reliability
- Higher power density designs

Plug and play application tests show a reduction in package temperature of more than 25% relative to our previous best-in-class IGBT, the HighSpeed 3. Even more revolutionary, when a TO-247 HighSpeed 3 IGBT is replaced with a TRENCHSTOP™ 5 in a TO-220, case temperatures drop more than 10% for the TRENCHSTOP™ 5. This quantum leap in efficiency opens up new opportunities for designers to explore.

Efficiency

<table>
<thead>
<tr>
<th>PFC Efficiency - Low Line V_in = 115V</th>
<th>Boost Diode = Ultrafast Si 15A unless Specified</th>
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<tbody>
<tr>
<td>Efficiency [%]</td>
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</tbody>
</table>

Variant 1:
HighSpeed 5 – H5/High speed variant
- Plug & play/ease of use
- Designed for ease of use implementation to easily replace existing IGBTs in designs or where redesign resources are limited
- Optimized for gate resistor values down to 5Ω

Variant 2:
HighSpeed 5 Fast – F5/Highest efficiency
- Performance optimized for low inductance designs in combination with SiC diodes to offer 1% higher efficiency compared to the H5
- Requires higher design-in effort, but rewards are higher

www.infineon.com/trenchstop5
Discrete IGBT

650V TRENCHSTOP™ 5 Discrete IGBT
A Technology to Match Tomorrow’s High Efficiency Demands

TRENCHSTOP™ 5 Selection Tree

- **600V/650V**
  - Free Wheeling Diode (FWD)
  - **10–150kHz**
    - TRENCHSTOP™ 5 H5/F5
      - IGP20N65H5/F5
      - IGP30N65H5/F5
      - IGP40N65H5/F5
      - IW40N65H5/F5
      - IGW50N65H5/F5
      - PFC & PWM
    - < 18kHz
      - TRENCHSTOP™ 60T
      - IGP30N60T
      - IGW40N60T
      - IGW50N60T
      - PFC & PWM
    - > 18kHz
      - HighSpeed 3 H3
      - IGP30N60H3
      - IGW40N60H3
      - IGW50N60H3
      - PFC & PWM

- **10–150kHz**
  - TRENCHSTOP™ 5 H5/F5
  - < 18kHz
  - > 18kHz
  - HighSpeed 3 H3
  - Corresponding Best Fit IGBTs
    - IKP08N65H5/F5
    - IKP15N65H5/F5
    - IKP20N65H5/F5
    - IKP30N65H5/F5
    - IKP40N65H5/F5
    - IKP50N65H5/F5
    - IKW30N60T
    - IKW50N60T
    - IKW30N60H3
    - IKW50N60H3
    - PFC & PWM

- **< 18kHz**
  - TRENCHSTOP™ 60T
  - Corresponding Best Fit IGBTs
    - IKP15N60T
    - IKA15N60T
    - IKW30N60T
    - IKW50N60T
    - PFC & PWM

- **> 18kHz**
  - HighSpeed 3 H3
  - Corresponding Best Fit IGBTs
    - IKP20N60H3
    - IKP30N60H3
    - IKP40N60H3
    - IKW50N60H3
    - PFC & PWM

www.infineon.com/trenchstop5
600V and 1200V HighSpeed 3 Discrete IGBT
Optimized in Every Respect

Our 1200V and 600V 3rd generation HighSpeed IGBT family is optimized for hard- and soft-switching topologies. The family sets a new benchmark for switching losses and is recommended for topologies switching at frequencies above 20kHz. Very short tail current and low turn-off losses (25% less than the closest competitor) are key features of this new family. It has the ability to increase the efficiency of your design by up to 15%.

And thanks to our world-renowned TRENCHSTOP™ technology with its intrinsically very low $V_{CE(sat)}$ behavior, HighSpeed 3 keeps both switching and conduction losses extremely low.

The free-wheeling diode in the duo packs is a 4th generation emitter-controlled diode, optimized for fast recovery while maintaining a high level of softness. This provides excellent complementary high-speed switching performance, ruggedness and EMI behavior.

**Key Features**
- Lowest switching losses for switching frequencies above 20kHz
- Soft switching waveforms
- Low $V_{CE(sat)}$
- Low diode losses and fast recovery time
- Positive $V_{CE(sat)}$ temperature coefficient
- 10µs short circuit rating

**Key Benefits**
- High efficiency
- Excellent EMI behavior
- Low conduction losses
- RoHS compliance
- Low risk of thermal runaway and easy paralleling

**Power Dissipation**

$$P = V_{ds} \times I_c \times D + f_{sw} \times E_{sw,tot}$$

At 40A, $T_j = 150^\circ$C, the IFX device provides 15% lower losses

**Load Current vs Frequency**

Thanks to the higher $T_{max}$ and lower losses, for a fixed $T_j = 100^\circ$C the KW device can run up to 50% higher load current than best competitor’s device.

www.infineon.com/highspeed3
Discrete IGBT

600V and 1200V HighSpeed 3 Discrete IGBT
Optimized in Every Respect

HighSpeed 3 IGBT and Duo Pack
600V Product Family

<table>
<thead>
<tr>
<th>Continuous Collector Current Ic @ Tc = 100°C [A]</th>
<th>IPAK</th>
<th>DPAK</th>
<th>D'PAK</th>
<th>TO-220</th>
<th>TO-262</th>
<th>TO-220 FullPAK</th>
<th>TO-247</th>
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<tr>
<td>IGBT</td>
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<td>Duo Pack</td>
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HighSpeed 3 IGBT and Duo Pack
1200V Product Family

<table>
<thead>
<tr>
<th>Continuous Collector Current Ic @ Tc = 100°C [A]</th>
<th>IPAK</th>
<th>DPAK</th>
<th>D'PAK</th>
<th>TO-220</th>
<th>TO-262</th>
<th>TO-220 FullPAK</th>
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<tr>
<td>IGBT</td>
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<tr>
<td>20 IGW15N120H3</td>
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</tr>
<tr>
<td>Duo Pack</td>
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<tr>
<td>20 IKW15N120H3</td>
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</tbody>
</table>

www.infineon.com/highspeed3
DC/DC Converters

Robust Range of Converters for the Widest Application Spectrum

Our high-efficiency switching regulators and controllers help to reduce energy consumption. In addition to extending the operating time of battery-powered systems, they also significantly improve the thermal budget of the application. Overall, this translates into minimal operating costs. For your design flexibility, they are available as adjustable voltage variants as well as with dedicated fixed output voltage values.

**Key Features**
- Input voltage up to 60V
- Output currents going from 500mA up to 10A
- Switching frequencies ranging from 100kHz to 2.2MHz
- Shutdown quiescent current down to below 2µA
- Current limitation and overtemperature protection
- Enable feature

**Key Benefits**
- High-efficiency regulation
- Only a few external components needed for stable regulation
- Perfectly suited for regulation in pre-/post-regulation power supply architectures

---

### DC/DC Converters

<table>
<thead>
<tr>
<th>Product Type</th>
<th>Output Current Type</th>
<th>Output Current (A)</th>
<th>Product Features</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>IFX81481ELV</td>
<td>Adjustable Buck Controller</td>
<td>10.0</td>
<td>10A synchronous DC/DC adjustable Step Down Controller; f = 100 – 700kHz, N</td>
<td>PG-SSOP-14</td>
</tr>
<tr>
<td>IFX90121EL V50</td>
<td>Buck Converter</td>
<td>0.5</td>
<td>Vin up to 45V, 2.2MHz Step-Down Regulator with Low Quiescent Current</td>
<td>PG-SSOP-14</td>
</tr>
<tr>
<td>IFX80471SK V</td>
<td>Adjustable Buck Converter</td>
<td>2.3</td>
<td>Vin up to 60V; VQ adjustable from 1.25V up to 15V; external MOS</td>
<td>PG-DSO-14</td>
</tr>
<tr>
<td>IFX80471SK V50</td>
<td>Buck Converter</td>
<td>2.3</td>
<td>Vin up to 60V; external MOS</td>
<td>PG-DSO-14</td>
</tr>
<tr>
<td>IFX91041ELVJ</td>
<td>Adjustable Buck Converter</td>
<td>1.8</td>
<td>Vin adjustable from 0.6V up to 16V; Tolerance 2% up to 1000mA</td>
<td>PG-DSO-8</td>
</tr>
<tr>
<td>IFX91041EL V33</td>
<td>Buck Converter</td>
<td>1.8</td>
<td>Vin fixed to 3.3V; Tolerance 2% up to 1000mA</td>
<td>PG-DSO-8</td>
</tr>
<tr>
<td>IFX91041EL V50</td>
<td>Buck Converter</td>
<td>1.8</td>
<td>Vin fixed to 5.0V; Tolerance 2% up to 1000mA</td>
<td>PG-DSO-8</td>
</tr>
</tbody>
</table>

---

**Block Diagram IFX91041**

**Industrial DC/DC Buck Regulators (Selection Tree)**

---

www.infineon.com/industrial-dcdc-converters
DC/DC Voltage Regulator – DrBlade™ 2

DC/DC Voltage Regulation System Solution

DrBlade™ 2 Power Stage and Digital VR Controller

Our digital voltage regulation system solution combines a DrBlade™ 2 power stage and a 4th generation VR controller. It is designed to provide the highest configurability with a minimal external component count to meet the increasingly stringent voltage regulation requirements of new microprocessor generations. Small, highly efficient and thermally enhanced power stages in the novel RoHS 2016-compliant blade packaging technology maximize power density and save PCB real estate. Continuous innovation in FET, driver and controller technologies enable peak efficiencies above 95% for maximum system performance. The extensively validated system approach offers sense and protection features for superior system robustness as well as higher reliability. This device comes with a Graphic User Interface (GUI) to program controller parameters and tune the VR while in operation. Furthermore, our highly trained global engineering network provides high-quality support from design to manufacturing.

Key Features
- 60A max. average load current
- 4.5V to 16V input voltage
- Temperature sensing and thermal warning
- Load current sensing
- Digital configuration

Key Benefits
- High system stability and robustness
- Fast and easy system optimization
- Minimum solution footprint
- Peak efficiency in excess of 95%
- RoHS-compliant and lead-free

Efficiency

DrBlade™ 2 provides > 95% peak efficiency:
- \( V_{in} = 12V, V_{out} = 1.82V \)
- \( LL = 0\Omega, L_{out} = 150nH \) (Vitec)
- \( f_{switch} = 429kHz \)
- \( T_{amb} = 25^\circ C \)

No Air Flow
Included losses: Controller, power stage, inductor

Infineon’s system solution with 4th Generation VR digital controller and DrBlade™ 2 power stage in next generation package with integrated current sense achieves greater than 95% peak efficiency.
## Product Portfolio

<table>
<thead>
<tr>
<th>Product Type</th>
<th>Product Family</th>
<th>Max. Phases/Rail</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>TDA21320 DrBlade™ 2.0</td>
<td>Power Stage (driver + MOSFETs)</td>
<td>–</td>
<td>LG-WIQFN-38-1 (6.6 x 4.5 x 0.6mm³)</td>
</tr>
<tr>
<td>TDA21321 DrBlade™ 2.1</td>
<td>Power Stage (driver + MOSFETs)</td>
<td>–</td>
<td>LG-WIQFN-38-1 (6.6 x 4.5 x 0.6mm³)</td>
</tr>
<tr>
<td>PX7247HDN</td>
<td>Digital VR Controller</td>
<td>6 + 1</td>
<td>PG-VQFN-48 (6 x 6 x 0.9mm³)</td>
</tr>
<tr>
<td>PX7241HDN</td>
<td>Digital VR Controller</td>
<td>3 + 3</td>
<td>PG-VQFN-48 (6 x 6 x 0.9mm³)</td>
</tr>
<tr>
<td>PX7143HDN</td>
<td>Digital VR Controller</td>
<td>3 + 0</td>
<td>PG-VQFN-40 (5 x 5 x 0.9mm³)</td>
</tr>
<tr>
<td>PX7242HDM</td>
<td>Digital VR Controller</td>
<td>1 + 1</td>
<td>PG-VQFN-40 (5 x 5 x 0.9mm³)</td>
</tr>
<tr>
<td>PX7141HDM</td>
<td>Digital VR Controller</td>
<td>1 + 0</td>
<td>PG-VQFN-40 (5 x 5 x 0.9mm³)</td>
</tr>
<tr>
<td>PX8746HDN(1)</td>
<td>Digital VR12.5 VCore Controller</td>
<td>6 + 0</td>
<td>PG-VQFN-48 (6 x 6 x 0.9mm³)</td>
</tr>
<tr>
<td>PX8143HDM(1)</td>
<td>Digital VR12.5 DDR Controller</td>
<td>3 + 0</td>
<td>PG-VQFN-40 (5 x 5 x 0.9mm³)</td>
</tr>
</tbody>
</table>

1) Example from a broad range of VR12.5 controllers

---

## Application Diagram

Our power architectures address the need for more accurate and efficient power delivery to support the increasingly challenging requirements of today’s DC/DC computing applications.
RC-Drives and RC-Drives Fast
Cost-Optimized IGBTs

Our RC-Drives IGBT technology provides cost-optimized solutions for the price-sensitive consumer drives market, which demands outstanding performance for permanent magnet synchronous and brushless DC motor drives. Our reverse-conducting RC-Drives Fast family was developed to meet rising demand for low-power motor drives in consumer applications. IGBT and diode losses were reoptimized to reduce losses at frequencies of 4 ~ 30kHz. RC-Drives Fast enables high-efficiency designs for inverters above 16kHz, reducing audible noise to absolutely silent. Furthermore, ultra-precise vector control techniques can be used to provide more torque at low speed and high performance control dynamics at high speed. The small size of the components allows high power density designs at lower system cost.

Key Features
- Optimized $E_{on}$, $E_{off}$ and $Q_{rr}$ for up to 20% lower switching losses
- Operating range of DC to 30kHz
- Max. junction temperature 175°C
- Short circuit capability of 5µs
- Very tight parameter distribution
- Best-in-class current performance for package size
- Smooth switching performance for low EMI levels
- Complete product portfolio and PSpice models on the internet

Key Benefits
- Excellent cost/performance for hard-switching applications
- Outstanding temperature stability
- Very good EMI behavior
- Up to 60% space saving on the PCB
- Higher reliability due to monolithically integrated IGBT & diode (less thermal cycling during switching)

Product Specifications for RC-Drives and RC-Drives Fast

<table>
<thead>
<tr>
<th>Product Type</th>
<th>Power [W]</th>
<th>Recomm. Switching Freq. [kHz]</th>
<th>$V_{ce}$ [V]</th>
<th>$I_{c}$ [A]</th>
<th>$V_{cesat}$ [V]</th>
<th>$E_{on}$ [mJ]</th>
<th>$t_{sc}$ [µs]</th>
<th>$V_{i}$ [V]</th>
<th>$Q_{r}$ [µC]</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>IKD03N60RF</td>
<td>40 … 80</td>
<td>4 … 30</td>
<td>600</td>
<td>5</td>
<td>2.5</td>
<td>2.2</td>
<td>2.3</td>
<td>0.09¹</td>
<td>0.14¹</td>
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<tr>
<td>IKD04N60RF</td>
<td>80 … 150</td>
<td>4 … 30</td>
<td>600</td>
<td>8</td>
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<td>2.2</td>
<td>2.3</td>
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<td>IKD15N60RF</td>
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<tr>
<td>IKD04N60R</td>
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<td>DC … 5</td>
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<td>1.7²  1.7²</td>
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<td>IKD06N60R</td>
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<td>DC … 5</td>
<td>600</td>
<td>12</td>
<td>6</td>
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<td>IKD10N60R</td>
<td>250 … 600</td>
<td>DC … 8</td>
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<td>10</td>
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<td>1.7²  1.7²</td>
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<td>600 … 1kW</td>
<td>DC … 8</td>
<td>600</td>
<td>30</td>
<td>15</td>
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<td>0.9</td>
<td>1.25</td>
<td>5</td>
<td>1.7²  1.7²</td>
</tr>
</tbody>
</table>

1) Speed optimization      2) Conduction optimization

Efficiency

Due to different trade-off between conduction and switching losses, either RC-Drives or RC-Drives Fast can be offered depending on switching frequency.

www.infineon.com/rcdf
Voltage Regulators

Energy-Efficient Voltage Regulators and Trackers

Our linear voltage regulators and trackers help to reduce energy consumption, extending operating time and minimizing operating costs across all kinds of systems. The wide supply voltage range, low quiescent current, rich protective feature set and choice of packages make our devices the perfect fit across a broad application spectrum, even beyond typical automation designs. Our trackers are ideal as additional supplies for off-board loads to increase system reliability.

Key Features

- Input voltage up to 60V
- Output current up to 1.5A
- Output voltage adjustable or fixed to specific values
- Quiescent current down to 20µA
- Overload, overtemperature, short-circuit and reverse-polarity protection
- Low current consumption
- Extended temperature range -40°C ... +125°C

Key Benefits

- Pin-to-pin compatibility with industry-standard parts
- Very low dropout voltage
- Trackers for optimized heat distribution and external protection
- Trackers for maximum system cost reduction
- Small robust packages

Infineon Microcontroller Families and Industrial Voltage Regulators

<table>
<thead>
<tr>
<th>Microcontroller Family</th>
<th>Input Voltage [V]</th>
<th>Input Current (max.) [mA]</th>
<th>Voltage Regulator</th>
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<tbody>
<tr>
<td>XMC1000 Family</td>
<td>1.8 ... 5.5</td>
<td>&lt;100</td>
<td>IFX54211/IFX2931/IFX4949/IFX25001/IFX544xx</td>
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<tr>
<td>XMC4000 Family</td>
<td>3.3</td>
<td>&lt;500/300</td>
<td>IFX1763/IFX544xx/IFX1117</td>
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<tr>
<td>XC8xx</td>
<td>3.3 ... 5.0</td>
<td>200</td>
<td>IFX20001/IFX24401/IFX2931/IFX21401/IFX4949/IFX544xx</td>
</tr>
<tr>
<td>XE166/XC2000</td>
<td>1.5 and 3.3 or 5.0</td>
<td>100</td>
<td>IFX25401/IFX24401/IFX2931/IFX4949</td>
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<tr>
<td>TriCore™</td>
<td>1.5 ... 3.3</td>
<td>&gt;400</td>
<td>IFX27001/IFX8117/IFX91041/IFX80471/IFX25001/IFX1117</td>
</tr>
</tbody>
</table>

Industrial Linear Voltage Regulator (Selection Tree)

www.infineon.com/powersupply
Our XMC 32-bit microcontroller family gives you a real competitive advantage. This wide and scalable portfolio offers excellent real-time performance. Designed for quality and robustness, it offers configurable and fast peripherals which operate largely autonomously. This means the XMC can be adapted to the specific needs of different target markets such as building and factory automation, power and energy, home and professional computing and transportation. Customers benefit from a wide portfolio and ecosystem powered by an ARM® Cortex™-M0 (XMC1000 family) and Cortex™-M4 (XMC4000 family).

**Key Features**
- Integration of powerful peripherals
- Real-time and deterministic behavior
- Operation at up to 125°C ambient temperature

**Key Benefits**
- Industrial, cross-market microcontroller suited to widest application spectrum
- Excellent real-time performance
- Long-term product availability until 2027
- Easy design-in with DAVE™ IDE and DAVE™ Apps – advanced high-level GUI-based application-orientated programming using predefined, configurable and tested software components

**DAVE™ - Digital Application Virtual Engineer**
A complete set of development tools, ready-to-use software solutions and supporting services are available for XMC microcontrollers from Infineon and various third-party tool and software vendors. These tools and software products support the entire development cycle to ensure a highly efficient development process.

Infineon’s free and revolutionary Eclipse-based IDE (Integrated Development Environment) enables a simple and straightforward development flow for less risk and effort. This is achieved thanks to an intuitive graphical interface and more than 350 application-optimized, configurable, tested and well documented Apps and Examples. Use of DAVE™ generated source code with other tools from the wide ARM Ecosystem is supported.
# Infineon XMC 32-bit Microcontrollers based on ARM® Cortex™-M

<table>
<thead>
<tr>
<th>Parameter</th>
<th>XMC1000</th>
<th>XMC4000</th>
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<tbody>
<tr>
<td><strong>Core</strong></td>
<td></td>
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<tr>
<td>ARM® Cortex™-M</td>
<td></td>
<td>ARM® Cortex™-M4</td>
</tr>
<tr>
<td>Frequency</td>
<td>32MHz</td>
<td>80MHz</td>
</tr>
<tr>
<td>Math Coprocessor</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>DSP Instruction Set</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Floating Point Unit (FPU)</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Peripherals Speed</td>
<td>up to 64MHz</td>
<td>up to 80MHz</td>
</tr>
<tr>
<td>Programmable Hardware Interconnect Matrix</td>
<td>1x</td>
<td>1x</td>
</tr>
<tr>
<td>DMA</td>
<td>–</td>
<td>8 ch</td>
</tr>
<tr>
<td>MPU</td>
<td>Primitive Memory Protection (PAU)</td>
<td>Memory Protection Unit (8 Regions)</td>
</tr>
<tr>
<td>Watchdog</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Real-Time Clock</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Hibernate Domain</td>
<td>–</td>
<td>✓</td>
</tr>
<tr>
<td>Number of I/Os</td>
<td>14 / 22 / 26 / 34 / 35</td>
<td>34 / 49</td>
</tr>
<tr>
<td>Supply Voltage</td>
<td>1.8 to 5.5V</td>
<td>3.13 to 3.63V</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-40 ... 85°C / 105°C</td>
<td>-40 ... 85°C / 105°C / 125°C</td>
</tr>
<tr>
<td><strong>Memory</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flash</td>
<td>8 – 64KB</td>
<td>16 – 200KB</td>
</tr>
<tr>
<td>Error Correction Code (ECC)</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>RAM</td>
<td>16KB</td>
<td>16KB</td>
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<tr>
<td>Cache</td>
<td>–</td>
<td>1KB</td>
</tr>
<tr>
<td>Ext Memory Interface</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>System</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Timer</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SysTick</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>CCU4 (4 ch)</td>
<td>–</td>
<td>1x</td>
</tr>
<tr>
<td>CCUB (4 ch)</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Analog</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-bit ADC</td>
<td>up to 12ch, 1xADC (1 MSPS)</td>
<td>up to 12ch, 2xADC (1 MSPS)</td>
</tr>
<tr>
<td>12-bit DAC</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Comparator</td>
<td>–</td>
<td>Up to 3x</td>
</tr>
<tr>
<td><strong>Communication</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IEEE 1588 Ethernet MAC</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>USB</td>
<td>–</td>
<td>FS DEV</td>
</tr>
<tr>
<td>SDIO/SD/MMC</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>USIC (UART, SPI, QSPI, FC, J’S)</td>
<td>2 ch, 1x FIFO (64 word)</td>
<td>4 ch, 2x FIFO (64 word)</td>
</tr>
<tr>
<td>CAN 2.0 B</td>
<td>–</td>
<td>2 Nodes, 64 Message Objects</td>
</tr>
<tr>
<td><strong>Application</strong></td>
<td></td>
<td></td>
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<tr>
<td>Hi-Res PWM (150ps)</td>
<td>–</td>
<td>4 ch</td>
</tr>
<tr>
<td>∆Σ Demodulator</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>POSIF</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Capacitive Touch Control</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>LED Matrix Control</td>
<td>–</td>
<td>Up to 128 LEDs</td>
</tr>
<tr>
<td>Brightness Control Unit</td>
<td>–</td>
<td>Up to 8 ch</td>
</tr>
<tr>
<td><strong>DAVE™ Apps</strong></td>
<td>Code library with basic system, peripheral, and advanced application-oriented components for Motor Control, Power Conversion, Lighting, Communication, and many more applications</td>
<td></td>
</tr>
<tr>
<td><strong>IDEs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Debug and Trace</td>
<td>SWD, SPD</td>
<td>SWD, JTAG, Trace</td>
</tr>
<tr>
<td>Ecosystem (IDEs, Compiler, Debugger)</td>
<td>Infineon DAVE™ (free) and Partner ARM®/KEIL™ (free up to 128KB, XMC1000), Atollic, IAR Systems, Rowley Associates, TASKING</td>
<td></td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Packages</td>
<td>PG-VQFN-24/40</td>
<td>PG-VQFN-24/40</td>
</tr>
<tr>
<td></td>
<td>PG-TSSOP-16/38</td>
<td>PG-TSSOP-16/28/38</td>
</tr>
<tr>
<td></td>
<td>PG-VQFN-48</td>
<td>PG-LQFP-64</td>
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<tr>
<td></td>
<td>PG-VQFN-48</td>
<td>PG-LQFP-64</td>
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<tr>
<td></td>
<td>PG-LQFP-100/144</td>
<td>PG-LQFP-100/144</td>
</tr>
</tbody>
</table>

[www.infineon.com/xmc](http://www.infineon.com/xmc)  
[www.infineon.com/dave](http://www.infineon.com/dave)
AURIX™ – 32-bit Microcontrollers
32-bit multi-core TriCore™ – Safety joins Performance

AURIX™ is Infineon’s family of microcontrollers serving exactly the needs of industrial applications in terms of performance and safety. Its innovative multicore architecture, based on up to three independent 32-bit TriCore™ CPUs @300MHz, has been designed to meet the highest safety standards while increasing the performance at the same time.

The key strengths of the scalable AURIX™ family is to combine multiple worlds in one family, supporting safety and security as well as high-performance computing and the latest connectivity as well as innovative power supply concepts.

Key Features
- TriCore™ with DSP functionality
- Best-in-class real-time performance: triple TriCore™ with up to 300MHz per core
- Supporting floating point and fix point with all cores
- From single core to multicore
- Encapsulation feature allows software development without interference for multiple applications
- HW accelerators
- Up to 2.7MB of internal RAM, up to 8MB of Flash
- Innovative single supply 5V or 3.3V
- External memory interface
- IEC61508 conformance to support safety requirements up to SIL3
- Embedded EEPROM
- Advanced communication peripherals: CAN, LIN, SPI, FlexRay, Ethernet

Key Benefits
- High scalability gives the best cost-performance fit
- High integration leads to significant cost savings
- High integration leads to reduced complexity
- Innovative supply concept leads to best-in-class power consumption

Using the AURIX™ platform, developers will be able to implement applications like motor control and drives, PLC, or any other automation application with the scalable MCU platform. Developments using AURIX™ will require less effort to achieve the SIL/IEC61508 standard based on its innovative safety concept and multiple HW safety features.

The integrated hardware security module provides safety and also helps to prevent external interrupts. Furthermore, AURIX™ has enhanced communication capabilities to support communication between CAN, LIN, FlexRay™ and Ethernet buses.
### AURIX™ Family Package Scalability

<table>
<thead>
<tr>
<th>Series</th>
<th>Size</th>
<th>Cores</th>
<th>Packages</th>
</tr>
</thead>
<tbody>
<tr>
<td>9x Series</td>
<td>up to 8MB</td>
<td>Triple-Core</td>
<td>TC297, TC298, TC299</td>
</tr>
<tr>
<td>7x Series</td>
<td>up to 4MB</td>
<td>Triple-Core</td>
<td>TC275, TC277</td>
</tr>
<tr>
<td>6x Series</td>
<td>up to 2.5MB</td>
<td>Dual-Core</td>
<td>TC264, TC265, TC267</td>
</tr>
<tr>
<td>4x Series</td>
<td>up to 2MB</td>
<td>Single-Core</td>
<td>TC244</td>
</tr>
<tr>
<td>3x Series</td>
<td>up to 2MB</td>
<td>Lockstep-Core</td>
<td>TC233, TC234, TC237</td>
</tr>
<tr>
<td>2x Series</td>
<td>up to 1MB</td>
<td>Lockstep-Core</td>
<td>TC222, TC223, TC224</td>
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<tr>
<td>1x Series</td>
<td>up to 512KB</td>
<td>Lockstep-Core</td>
<td>TC212, TC213, TC214</td>
</tr>
</tbody>
</table>

- Upgrade/downgrade with pin-compatible packages

[www.infineon.com/aurix]
CAN Transceivers
Proven Quality for Automation Applications

Our CAN transceivers provide proven quality, reliable track records and high robustness in automation applications. Features include excellent electromagnetic performance and low levels of electromagnetic interference (EMI). They are also designed for ISO compliance. While our IFX1050G, IFX1050 GVIO and IFX1040SJ devices are optimized for high-speed communication, the IFX1054G variant is suited for fault tolerance at lower data rates, where a separate flag supports diagnostics.

Key Features
- Transmission rates up to 1Mbit/s
- ISO 11898 compliance
- Low-power modes
- Support of failure conditions
- Bus wake-up feature
- Receive-only mode
- Standby/sleep mode
- Thermal protection

Key Benefits
- Low current consumption
- Excellent EMC performance and EMI robustness
- Pin-to-pin replacements for industry-standard parts

Block Diagram IFX1050 GVIO
## Product Portfolio

<table>
<thead>
<tr>
<th>Product Type</th>
<th>Transceiver Type</th>
<th>Transm. Rate (Max)</th>
<th>Quiescent Current</th>
<th>Bus Wake-up Capability</th>
<th>Wake-up Inputs</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>IFX1050G</td>
<td>High Speed CAN, ISO11898-2</td>
<td>1Mbps</td>
<td>&lt;10µA @ 5V standby</td>
<td>No</td>
<td>No</td>
<td>PG-DSO-8</td>
</tr>
<tr>
<td>IFX1050GVIO</td>
<td>High Speed CAN, ISO11898-2</td>
<td>1Mbps</td>
<td>&lt;10µA @ 5V standby</td>
<td>No</td>
<td>No</td>
<td>PG-DSO-8</td>
</tr>
<tr>
<td>IFX1040SJ</td>
<td>High Speed CAN, ISO11898-2, ISO11898-5</td>
<td>1Mbps</td>
<td>&lt;10µA @ 5V standby</td>
<td>Yes</td>
<td>Yes, STB</td>
<td>PG-DSO-8</td>
</tr>
<tr>
<td>IFX1054G</td>
<td>Fault Tolerant CAN, ISO11898-3</td>
<td>125kbps</td>
<td>&lt;65µA Sleep Mode</td>
<td>Yes</td>
<td>Bus wake-up and wake-up pin</td>
<td>PG-DSO-14</td>
</tr>
<tr>
<td>IFX1021</td>
<td>LIN 1.3, 2.0, 2.1</td>
<td>20kbps</td>
<td>&lt;10µA Sleep Mode</td>
<td>Yes</td>
<td>Bus wake-up and wake-up pin</td>
<td>PG-DSO-8</td>
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</tbody>
</table>
Product Solutions

Interface

HITFET™ Low-Side Drivers
Bringing More Protection to Low-Side Applications

Our well-known and robust HITFET™ portfolio of protected low-side switches now includes innovations such as BTF3050TE. This is the first member of the HITFET™+ family, enabling higher switching speeds, handshake diagnosis and improved short-circuit robustness.

In addition, BTS3018TC is an ideal replacement for the non-green device BTS149.

Key Features
- Wide range of $R_{DS(on)}$ values (18 – 550mΩ)
- Logic level input
- Thermal shutdown with auto restart or latch behavior
- Status feedback via
  - increased input current (2nd Gen)
  - digital readout without ADC (for BTF3050TE)
- Current limitation (except BTS3160D)
- Overload and overvoltage protection

Key Benefits
- MOSFET-like package with integrated protective functionality
- Easy design-in
- Perfect fit for individual design challenge with scalable $R_{DS(on)}$
- Choice of packages to match individual application needs

Block Diagram BTF3050TE
## Product Portfolio

<table>
<thead>
<tr>
<th>Product Type</th>
<th>Product Family</th>
<th>Channels</th>
<th>$R_{\text{on}}$ (typ) [mΩ]</th>
<th>Nominal Load Current [A]</th>
<th>EAS [mJ]</th>
<th>Operating Voltage Range [V]</th>
<th>$I_{(\text{max})}$ (typ) [A]</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>BTS3018TC1)</td>
<td>HITFET™</td>
<td>1</td>
<td>18</td>
<td>6.0</td>
<td>1900</td>
<td>8 - 36</td>
<td>45</td>
<td>PG-TO263-3 (D²PAK)</td>
</tr>
<tr>
<td>BTS3028SDL</td>
<td>HITFET™</td>
<td>1</td>
<td>30</td>
<td>5.0</td>
<td>350</td>
<td>8 - 36</td>
<td>45</td>
<td>PG-TO252-3 (DPAK)</td>
</tr>
<tr>
<td>BTS3028SDR</td>
<td>HITFET™</td>
<td>1</td>
<td>30</td>
<td>5.0</td>
<td>350</td>
<td>8 - 36</td>
<td>45</td>
<td>PG-TO252-3 (DPAK)</td>
</tr>
<tr>
<td>BTF3050TE (New)</td>
<td>HITFET™+</td>
<td>1</td>
<td>50</td>
<td>3.0</td>
<td>120</td>
<td>8 - 28</td>
<td>45</td>
<td>PG-TO252-5 (DPAK 5-leg)</td>
</tr>
<tr>
<td>BTS3046SDL</td>
<td>HITFET™</td>
<td>1</td>
<td>50</td>
<td>3.6</td>
<td>140</td>
<td>8 - 36</td>
<td>21</td>
<td>PG-TO252-3 (DPAK)</td>
</tr>
<tr>
<td>BTS3046SDR</td>
<td>HITFET™</td>
<td>1</td>
<td>50</td>
<td>3.6</td>
<td>140</td>
<td>8 - 36</td>
<td>21</td>
<td>PG-TO252-3 (DPAK)</td>
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<tr>
<td>BTS3104SDL</td>
<td>HITFET™</td>
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<td>104</td>
<td>2.0</td>
<td>50</td>
<td>8 - 36</td>
<td>13</td>
<td>PG-TO252-3 (DPAK)</td>
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<td>BTS3104SDR</td>
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<td>104</td>
<td>2.0</td>
<td>50</td>
<td>8 - 36</td>
<td>13</td>
<td>PG-TO252-3 (DPAK)</td>
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<td>BSP75N</td>
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<td>550</td>
<td>0.7</td>
<td>550</td>
<td>8 - 36</td>
<td>1.5</td>
<td>SOT223</td>
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<tr>
<td>BTS3468G</td>
<td>HITFET™</td>
<td>2</td>
<td>550</td>
<td>0.55</td>
<td>800</td>
<td>8 - 36</td>
<td>1.5</td>
<td>PG-DSO-8</td>
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<td>BTS3800SL</td>
<td>HITFET™</td>
<td>1</td>
<td>800</td>
<td>0.35</td>
<td>65</td>
<td>8 - 28</td>
<td>1.5</td>
<td>SCT595</td>
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</tbody>
</table>

1) Production release in 2015
PROFET™ High-Side Drivers

Protected High-Side Switches

Our PROFET™ high-side switches sit between the supply and load in order to control the application. These high-side switches deliver a broad range of smart features, including various protective and diagnostic functions. Since PROFET™ devices can manage all kinds of resistive, capacitive and inductive loads, they can be used across a huge variety of industrial applications.

**Key Features**
- RoHS compliance
- Very low stand-by current
- ESD protection, optimized EMC
- PWM capability
- Very low power DMOS leakage current in OFF
- 3.3V and 5V compatible logic inputs
- Protection features: load dump, current limitation, thermal shutdown, loss of ground/battery protection, stable behavior at undervoltage, overvoltage, reverse polarity
- Diagnostic features: open-load in ON- and OFF state, short-circuit to battery and ground, overtemperature sense
- Diagnosis: digital or as proportional load current sense

**Key Benefits**
- Complete, built-in protection
- Flexible design for all kinds of resistive, capacitive and inductive loads

---

**Block Diagram**

![Block Diagram](image-url)

**Logic**
- Internal Power Supply
- ESD Protection
- Load Current Sense
- Gate Control & Charge Pump
- Open Load Detection
- Temperature Sensor
- Multi Step Load Current Limitation

**Input/Output**
- IN
- SP
- SEN or CLA
- GND
- V_{in}
- OUT
- R_{load}
<table>
<thead>
<tr>
<th>Product Type</th>
<th>Product Family</th>
<th>Number of Channels</th>
<th>$R_{DS(on)}$ (typ) [mΩ]</th>
<th>Nominal Load Current [A]</th>
<th>EAS [mJ]</th>
<th>Recommended Operating Voltage Range [V]</th>
<th>$I_{OL}$ (typ) [A]</th>
<th>Diagnosis</th>
<th>Package</th>
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<tbody>
<tr>
<td>ITS4060S-SJ-N</td>
<td>Industrial PROFET™ 1</td>
<td>50</td>
<td>3.1</td>
<td>900 @ 1.5A</td>
<td>5.0 … 34.0</td>
<td>17.0</td>
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<td>PG-DSO-8</td>
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</tr>
<tr>
<td>ITS4100S-SJ-N</td>
<td>Industrial PROFET™ 1</td>
<td>70</td>
<td>2.4</td>
<td>870 @ 1.0A</td>
<td>5.0 … 34.0</td>
<td>10.0</td>
<td>N/A</td>
<td>PG-DSO-8</td>
<td></td>
</tr>
<tr>
<td>ITS4200S-ME-O</td>
<td>Industrial PROFET™ 1</td>
<td>150</td>
<td>1.1</td>
<td>700 @ 0.5A</td>
<td>11.0 … 45.0</td>
<td>3.0</td>
<td>N/A</td>
<td>PG-SOT223-4</td>
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<tr>
<td>ITS4141D</td>
<td>Industrial PROFET™ 1</td>
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<td>1.1</td>
<td>12,000 @ 0.5A</td>
<td>11.0 … 45.0</td>
<td>3.0</td>
<td>N/A</td>
<td>PG-T0252-5</td>
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<tr>
<td>ITS4200S-SJ-D</td>
<td>Industrial PROFET™ 1</td>
<td>150</td>
<td>1.7</td>
<td>125 @ 1.0A</td>
<td>6.0 … 52.0</td>
<td>6.5</td>
<td>Digital</td>
<td>PG-DSO-8</td>
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</tr>
<tr>
<td>ITS4200S-ME-P</td>
<td>Industrial PROFET™ 1</td>
<td>150</td>
<td>2.2</td>
<td>160 @ 1.0A</td>
<td>11.0 … 45.0</td>
<td>3.0</td>
<td>N/A</td>
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</tr>
<tr>
<td>ITS4200S-ME-N</td>
<td>Industrial PROFET™ 1</td>
<td>160</td>
<td>1.2</td>
<td>500 @ 0.5A</td>
<td>5.0 … 35.0</td>
<td>1.5</td>
<td>N/A</td>
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<tr>
<td>ISP752T</td>
<td>Industrial PROFET™ 1</td>
<td>200</td>
<td>1.7</td>
<td>125 @ 1.0A</td>
<td>6.0 … 52.0</td>
<td>6.5</td>
<td>N/A</td>
<td>PG-DSO-8</td>
<td></td>
</tr>
<tr>
<td>BT6200-1EJA</td>
<td>PROFET™ 24V 1</td>
<td>200</td>
<td>1.5</td>
<td>20 @ 1.0A</td>
<td>5.0 … 36.0</td>
<td>9</td>
<td>Current Sense</td>
<td>PG-DSO-8 EP</td>
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<tr>
<td>ITS4300S-SJ-D</td>
<td>Industrial PROFET™ 1</td>
<td>250</td>
<td>0.8</td>
<td>800 @ 0.3A</td>
<td>5.0 … 34.0</td>
<td>1.2</td>
<td>Digital</td>
<td>PG-DSO-8</td>
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</tr>
<tr>
<td>ITS41K0S-ME-N</td>
<td>Industrial PROFET™ 1</td>
<td>1000</td>
<td>0.55</td>
<td>1,000 @ 0.15A</td>
<td>5.0 … 34.0</td>
<td>0.9</td>
<td>N/A</td>
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<tr>
<td>IT55215L</td>
<td>Industrial PROFET™ 2</td>
<td>90</td>
<td>2 x 2.0</td>
<td>178 @ 3.5A</td>
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<td>15.0</td>
<td>Digital</td>
<td>PG-DSO-12</td>
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<tr>
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www.infineon.com/profet
SPIDER
Universal SPI Driver for Low-Current Loads

Our SPIDER family offers a wide range of integrated smart multi-channel high- and low-side switches. The devices are designed to drive all kinds of low-current loads, such as relays, solenoids, unipolar stepper motors, valves and LEDs. Scalability across current capabilities and feature sets allows designers to create cost-optimized solutions for their individual designs. Comprehensive protection and safety features enable the devices to cope with harsh industrial conditions. This universal driver family is thus the perfect fit for a wide range of industrial applications, particularly in machine and process control.

Key Features
- PWM capability via direct inputs
- 16-bit SPI for diagnostics and output control
- 4- and 8-channel devices available
- Fail safe mode, limp home (partly)
- Digital supply voltage compatible with 3.3V and 5V microcontrollers
- Small packages and footprint
- Protection features: short circuit, overload, overtemperature, reverse polarity, ESD
- Diagnostic features: latched diagnostic information via SPI register, overtemperature monitoring, overload detection in ON state, open load detection in OFF state

Key Benefits
- Complete, built-in protection and diagnostic functionality
- Cost-optimized, compact designs
- Flexible design for all kinds of low-current loads

Block Diagram (Example 8 Channel Low-Side)
Product Portfolios

### SPIDER LS

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<thead>
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<th>High-Side</th>
<th>Small High-Side</th>
<th>Low-Side</th>
<th>Configurable</th>
<th>( R_{\text{on}} ) (typ) [( \Omega )]</th>
<th>( I_{\text{IL}} ) (nom) [mA]</th>
<th>Operating Range (SC prot.) [V]</th>
<th>Limp Home</th>
<th>Direct Inputs</th>
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<td>4.0 ... 28</td>
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### Application Diagram

- **VDD**
- **GND**
- **VCC**
- **VBat**
- **Limp Home signal**
- **Limp Home circuit**
- **CS**
- **SCLK**
- **SO**
- **SI**
- **VDDA**
- **CS**
- **SCLK**
- **SO**
- **SI**
- **I/O Register**
- **Low-Side Gate Control**

www.infineon.com/spider
ISOFACE™

Galvanic Isolated High-Side Switches and Input ICs

Our ISOFACE™ product family provides robust and intelligent galvanic isolation for industrial control applications such as programmable logic controllers, sensor input modules, control panels and general control equipment. The output switches are compact in design, enabling robust and reliable operation at low system cost. Ideal for high-speed applications, input ICs are equally robust, reliable and compact – also offering superior EMI robustness and diagnostics.

Key Features

**Isolated Output Switches**
- Integrated galvanic isolation (500V)
- 8 channels (0.6 or 1.2A, each)
- Inductive load switching
- Diagnostic feedback (overtemperature, overload)
- Serial and parallel MCU interface

**Isolated Digital Input ICs**
- Integrated galvanic isolation (500V)
- 8 channels (IEC Type 1/2/3)
- Up to 500kHz sampling speed
- Programmable input filters
- Channel-specific diagnostics (wire-break, undervoltage)

Key Benefits

**Isolated Output Switches**
- Robust and reliable design
- Compact system solution
- Lower system cost
- Directly interfacing with all MPUs and MCUs

**Isolated Digital Input ICs**
- Robust and reliable design
- Compact system solution
- High-speed applications
- Superior EMI robustness
- System status feedback
- Valuable maintenance support

Block Diagram Isolated Output Switch
Wireless Control
Sub 1GHz RF Solutions

We offer a comprehensive and complementary product portfolio of transmitter, receiver and transceiver products for the sub 1GHz frequency bands. Our offering extends from standard products for relatively simple application requirements to SmartLEWIS™ solutions for more complex system or performance demands.

Our standard portfolio comprises the TDA71xx transmitter and the TDA72xx receiver and transceiver variants for ASK and FSK modulation, all offering different feature sets and frequencies (315, 434, 868 and 915MHz).

Key Features
- Standard transmitter:
  ASK/FSK transmitter family for low/high power, temperature range -40 ... +85°C
- Standard receiver:
  ASK/FSK receiver family, temperature range -40 ... +105°C, PG-TSSOP package
- Standard transceiver:
  ASK/FSK transceiver family, single-channel, temperature range -40 ... +85°C, PG-TSSOP package

Key Benefits
- Very low current consumption
- Low system costs: only a few external components required
- Dedicated product variants for industrial and consumer applications (TDA-7 series) to meet an optimal feature/cost ratio
- Complementary product portfolio (TDA/TKD-5 series) for the highest quality standards
- Suited to harsh environments with temperatures up to 125°C

www.infineon.com/wirelesscontrol
SmartLEWIS™ Family
Smart Low Energy Wireless Systems

SmartLEWIS™ stands for Smart Low Energy Wireless Systems. This family of next-generation wireless control products offers the highest level of integration and functionality to reduce system complexity and current consumption – the intelligent way.

**Key Features**
- SmartLEWIS™ Tx: ASK/FSK transmitter, multi-channel, multi-band, multi-power
- SmartLEWIS™ MCU: ASK/FSK transmitter family with embedded 8051 microcontroller, 125kHz LF receiver and 3-channel ADC, temperature range -40 ... +125°C
- SmartLEWIS™ Rx+: High-sensitivity receiver family, single-/multi-channel, digital baseband with autonomous receive functionality and RF channel scanning, temperature range -40 ... +105°C
- SmartLEWIS™ TRx: High-sensitivity, multi-channel transceiver with digital baseband processing, up to +14dBm output power, wireless M bus support, temperature range -40 ... +110°C

**Key Benefits**
- Highest integration and functionality
- Very low current consumption
- Multi-protocol handling
- Low system costs – only a few external components required
- Only one device for all major frequency bands (315, 434, 868, 915MHz)
- Dedicated product variants for industrial and consumer applications (PMA-7 series) to meet an optimal feature/cost ratio
- Highest, automotive-proven, quality levels

**Block Diagram TDA5340**
Current Sensors

The Miniaturization Advantage

TLI4970 is a high-precision current sensor based on our proven Hall technology. Its coreless concept supports the miniaturization trend defining today’s sensor designs. It is a fully digital solution with the added bonus of ease of use. There is no need for any external calibration or other parts (such as A/D converters, OP amps, reference voltage sources), reducing the overall implementation effort, PCB space and cost significantly.

TLI4970 provides superior accuracy compared with existing open- or closed-loop systems with magnetic cores. It has additional functionality such as overcurrent detection and programmable filters, while offering a significantly smaller footprint and lower power consumption. Key applications include AC/DC inverters, DC/DC converters and PFC power supplies and drives.

Key Features
- AC & DC measurement range up to ±50A
- Highly accurate over temperature range and lifetime (max. 1.0% (0 h), 1.6% (over lifetime) of indicated value)
- Low offset error (max. 75mA over temperature and lifetime)
- High magnetic stray field suppression
- Fast overcurrent detection with configurable threshold
- Galvanic isolation up to 2.5kV max. rated isolation voltage (UL1577)
- 16 bit digital SPI output (13 bit current value)
- Small 7.0 x 7.0 mm SMD package

Key Benefits
- Ideal for automation applications
- Plug and play solution – no external calibration needed
- Much smaller footprint than existing solutions
- Reduced implementation effort, PCB space and cost
- Small package size and weight for SMD mounting

Block Diagram TLI4970

www.infineon.com/tli4970
Hall-Effect Switches
The Energy-Saving Option with Excellent Accuracy and Robustness

Our portfolio of Hall switches comprises unipolar and omnipolar switches, bipolar latches and double Hall switches. They are suited to a wide range of applications such as position sensing, index counting, BLDC motor control, etc. These devices show excellent accuracy and robustness against electrical disturbances and are available in a variety of packages.

Key Features
- Operating supply voltage 3 – 32V
- Reverse polarity protection (-18V)
- Overvoltage capability up to 42V without external resistor
- Low current consumption (1.6mA)
- Active error compensation
- High ESD performance, up to 7kV HBM
- Small SMD package SOT23
- Leaded package

Key Benefits
- Reduction of system power consumption
- Reduced system size
- Removal of protection devices
- Reliable system operation
- Increased motor efficiency
- Broad range of switching thresholds available for all applications
- Special industrial versions available

Hall Switch Types

Latch (Bipolar)  Uni-/Omnipolar Switches  Double Hall Speed/Direction Switches

Main application: BLDC Motor Commutation  Proximity Detection

Absolute position sensing in power operated systems
Linear Hall Sensors
Highly Accurate Angular and Linear Position Measurement

All products of our linear Hall family measure the vertical component of a magnetic field. The output signal is directly proportional to the sensed magnetic field. Building on these principles, our TLE499x family of linear Hall ICs has been designed specifically to meet the requirements of highly accurate angular and linear position measurement. They are also suited to current measurement applications.

Key Features
- Single supply voltage 4.5 – 5.5V
- Temperature range -40 ... +150°C
- Linear ratiometric output between -200mT and +200mT within three ranges
- Sensitivity offset and clamping programmable
- Digital temperature and stress compensation
- High-voltage capability and reverse polarity protection
- Low drift of output signal over temperature and lifetime
- 20-bit digital signal processing
- Analog and digital interfaces

Key Benefits
- Wear-free operation
- Highly accurate contactless position sensing
- In-system calibration
- Flexible system implementation

Block Diagram TLE4998

www.infineon.com/magnetic-sensors
Speed Sensors

Excellent Price/Performance in Automation Sensing

Our high-quality differential Hall-based magnetic sensor portfolio is extremely broad to ensure the perfect fit for all automation applications. These Hall sensors use a ferromagnetic gear tooth or encoder structure to measure linear or rotational speed and position. The ferromagnetic structure allows our contactless sensors to measure the vertical magnetic field that a component generates with high accuracy. Different switching algorithms ensure the optimal performance for individual automation applications. Highlights of our Hall offering include integrated capacitors (C types) for high EMC, ESD and temperature robustness. TLE4941plusC is the sensor of choice for many standard automation applications. Special versions with additional vibration suppression features are available to enable precise measurements even in the harshest industrial environments (e.g. TLE4957, TLE4951/54).

We also offer an integrated Back Bias (iBB) magnet package option (e.g. TLE4941plusCB) for magnetic sensor designs where a back bias magnet is required for the magnetic field (e.g. in gear wheel applications or applications using similar ferromagnetic gear tooth structures).

Key Features
- Highly accurate speed measurements over large operating air gaps and broad frequency ranges
- Use of the common 2-wire current interface
- Broad operating temperature range \( (T_s = -40^\circ C \ldots +150^\circ C) \)
- Options with high protection against reverse voltage, short circuit and overtemperature
- Option to use the innovative iBB package solution
- AEC-Q100-qualified

Key Benefits
- Highly robust
- Excellent price/performance
- Strong EMC robustness
- Good sensing performance
- High sensitivity

Typical Application of a Magnetic Differential Sensor (e.g. TLE4941plusC/B)

www.infineon.com/magnetic-sensors
Integrated Pressure Sensor ICs
Design Flexibility to Meet Evolving Market Demands

Our integrated pressure sensor family uses unique multiple surface micro-machined capacitive sensor cell arrays. These support powerful self-diagnosis features such as mechanical and electrical verification of sensor functionality. Monolithic integration onto a single chip enables state-of-the-art production using a standard automotive-qualified BiCMOS process. Sophisticated sensor cell design combined with fully digital signal conditioning and processing based on high-volume production flows ensures superior quality over the entire lifecycle.

These pressure sensors are ideal for a wide range of applications across industry, including industrial and process controls, gas flow meters, level meters, barometric pressure meters, altitude compensation systems, weather stations, engine management systems and medical equipment. The analog and digital interfaces, SPI (Serial Peripheral Interface) included, provide customers with a high degree of design flexibility to meet evolving market demands.

Key Features
- Wide pressure range up to 400kPa
- Wide temperature range from -40°C ... +150°C
- Outstanding accuracy of up to ±0.3kPa
- Support for different protocols
- Options for customized transfer functions for certain sensors
- Patented built-in diagnosis for pressure cells and circuitry
- SMD package (DSOF, 8 pin)

Key Benefits
- High measurement accuracy
- Low lifetime drift over a wide temperature range
- Support for state-of-the-art production

Product Portfolio

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1) x in product: indicates product family with multiple transfer functions available within the family
2) Except KP253HP

www.infineon.com/pressure
Our angle sensor family is based on integrated Giant Magneto Resistance (iGMR) technology. These sensors detect the orientation of an applied magnetic field by measuring sine and cosine angle components with monolithically integrated magneto-resistive elements. This allows them to easily determine the absolute orientation of the magnetic field between 0° and 360°. Data processing and communication interfaces are integrated on the same silicon chip as the sensing elements, allowing a compact design using small outline packages. Our angle sensor family offers a broad variety of communication interfaces, as well as different levels of data processing and self-test capabilities.

Ideal for functional safety-critical applications, our TLE5309D combines a TLE5009 iGMR with a TLE5109 iAMR chip, whereas the TLE5012BD combines two TLE5012B iGMR in one fully integrated dual-sensor package.

Target applications of our iGMR sensors include contactless angle measurement, rotational position measurement, steering angle measurement and BLDC motor commutation.

Features

- Integrated GMR (iGMR) technology
- 0 – 360° angle measurement with sine and cosine bridge
- Supply voltage 3.3 or 5.0V
- On-chip temperature compensation of amplitude and offset
- Temperature range -40°C ... +150°C
- PG-DSO-8 package

Product Portfolio

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<td>( V_{\text{coc}}: 3.3V ) (AMR &amp; GMR), TCO(^1), DualDie</td>
<td>Analog</td>
<td>SP001191262</td>
</tr>
<tr>
<td>TLE5309D E2211</td>
<td>( V_{\text{coc}}: 5.0V ) (AMR &amp; GMR), TCO(^1), DualDie</td>
<td>Analog</td>
<td>SP001191266</td>
</tr>
<tr>
<td>TLE5309D E5201</td>
<td>( V_{\text{coc}}: 5.0V ) (AMR) &amp; 3.3V (GMR), DualDie</td>
<td>Analog</td>
<td>SP001145340</td>
</tr>
<tr>
<td>TLE5009 EVALKIT</td>
<td>Evaluation Kit containing interface box (PGSISI-2) and Evaluation Board incl. magnet and software</td>
<td></td>
<td>SP000871462</td>
</tr>
<tr>
<td>TLE5009 EVALBOARD</td>
<td>Evaluation Board incl. magnet and software (interface box is not included, but is required for operation)</td>
<td></td>
<td>SP000871466</td>
</tr>
<tr>
<td>TLE5012B EVALKIT</td>
<td>Evaluation Kit containing interface box (PGSISI-2) and Evaluation Board incl. magnet and software</td>
<td></td>
<td>SP000912902</td>
</tr>
<tr>
<td>TLE5012B EVALBOARD</td>
<td>Evaluation Board incl. magnet and software (interface box is not included, but is required for operation)</td>
<td></td>
<td>SP000912898</td>
</tr>
</tbody>
</table>

1) TCO = Temperature Compensation
2) SPI = Serial Peripheral Interface
3) IIF = Incremental Interface
4) HSM = Hall Switch Mode
5) PWM = Pulse Width Modulation
6) SPC = Short PWM Code
Benefits TLE5009
- The analog sensor output signals can be directly connected to the analog inputs of a microcontroller
- The output signals are offset- and temperature-compensated
- Output signals can be read as single-ended or differential voltage
- Signal amplitudes are independent from supply voltage variations

Benefits TLE5012B
- Different digital interfaces available (SPI, PWM, HSM, IIF, SPC)
- Integrated angle calculation based on sine and cosine values
- Increased accuracy with auto-calibration functionality
- Prediction of output signal to compensate latency
- High-speed angle update rate up to 23.4kHz
Constant Current Relay Drivers (CCRD)

Smooth Migration Path to All-Electronic Switch Designs

Once mechanical relay switches and electromagnetic actuators (also known as solenoids) are turned on, current must continuously flow through their coils (hold current) to keep them closed. Our CCRD devices can reduce the hold current down to the necessary minimum to keep the coil closed. They thus help to cut overall current consumption. The coil current remains stable regardless of changes to the input voltage. With input voltages up to 30V, our CCRD devices are ideally suited to harsh industrial environments. Available in a PG-DSO-8 exposed pad package, they can be mounted on a PCB inside a relay or on an existing system PCB with either a high- or low-side switch, reducing design-in time and providing a migration path to an all-electronic switch design. They can drive relays with typical system voltages of 12V with a coil resistance of up to 180Ω. Typical applications include electromagnetic actuators in electric door locks, appliances, hydraulic valves, speaker coils, power relays, pinball/pachinko machines and manufacturing/automation systems.

Key Features
- High coil activation current
- Low hold current
- Suited to both low- and high-side switches
- Coil current not affected by input voltage variations
- Thermally enhanced PG-DSO-8 exposed pad package
- No EMI, unlike PWM relay drivers
- Support for freewheeling diode signal path for energy absorption when switching off

Key Benefits
- Reduced energy consumption and operational costs of system
- Significant reduction of power/heat dissipation
- Increased packing density in relay packs

CCRD Supplied by External Source

CCRD Supplied by Freewheeling Resistor

www.infineon.com/ccrd
Our OPTIGA™ TPM security controllers protect the integrity and authenticity of communication devices and systems in automation networks. With a secured key store and support for a variety of encryption algorithms, OPTIGA™ TPM provides robust protection for critical data. TPM can be used to provide machine components and devices with a unique and secured identifier.

Certified to Common Criteria standards, TPM is a hardware-based solution supporting the highest security demands with the added bonus of flexible integration. A standardized, turnkey design enables existing concepts to be reused while minimizing security risks. A turnkey solution for embedded security applications, TPM can be easily integrated using the SPI, I²C or LPC interface.

**Key Features**
- Extended temperature range (-40 ... +85°C) for a variety of applications
- Secured key storage
- Support for latest symmetric & asymmetric crypto algorithms (e.g. RSA & ECC, SHA-2)
- Built-in True Random Number Generator (TRNG)
- Common Criteria security certification
- Flexible integration with SPI, I²C or LPC interface

**Key Benefits**
- TPM 2.0 supports crypto agility for extended security lifetime
- Easy integration into all platform architectures based on standards
- Standardized, turnkey, high-security product
- Strong protection of machine & device identities

---

**Block Diagram**

```
<table>
<thead>
<tr>
<th>Endorsement Certificate</th>
<th>SRK Storage Root Key RSA 2048bit</th>
<th>Platform Configuration Registers (160bit x)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attestation Identity Keys (AIK)</td>
<td>NV Space</td>
<td>PCR 0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PCR 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PCR 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PCR 23</td>
</tr>
</tbody>
</table>
```

In addition to the above, TPM provides many more security features such as:

- **TickCounter**
- **True Random Number Generator**
- **Sensors**
- **Memory Encryption**
- **> 50 Security Features**

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www.infineon.com/tpm
OPTIGA™ Trust
Authentication Solution for Increased Security at Lower System Costs

OPTIGA™ Trust SLS 10ERE is our robust cryptographic solution, designed to assist system manufacturers in proving the authenticity, integrity and safety of their original products. As a turnkey solution, it provides enhanced protection against aftermarket counterfeit replacements and helps to maintain OEM authenticity. With its innovative asymmetric cryptography approach, it significantly reduces system costs while increasing the overall security of your solution. OPTIGA™ SLS 10ERE is designed for embedded systems requiring strong authentication features. It protects the systems against unauthorized accessories, replacement parts or disposables. Its data authentication feature offers protection against unauthorized re-use or re-provisioning of original parts.

Key Features
- Strong asymmetric cryptography with ECC 163 bit key length
- Turnkey solution including host-side software for easy integration
- 3.5kbit user NVM
- Easy to implement single-wire host interface
- Unique asymmetric key pair per chip
- Size-optimized PG-USON-3 package (2 x 3mm)

Key Benefits
- Increased security with asymmetric cryptography and chip-individual keys
- Easy integration based on full turnkey design
- Lower system costs due to single chip solution

Infineon OPTIGA™ Trust Typical SWI Application
OPTIGA™ Trust P
Programmable Device Authentication Solution

OPTIGA™ Trust P SLJ 52ACA is a high-security, feature-rich member of the OPTIGA™ Trust Authentication product family. As a fully programmable chip, it provides a highly flexible and secure solution for a full range of key functions such as authentication, secured updates, key generation and storage, protected storage, memory integrity, secured boot, and access control management. The OPTIGA™ Trust P is a trust anchor for embedded systems. As a hardware security microcontroller, it provides advanced and efficient protection against side-channel, fault-induction and physical attacks. It also provides physical separation and the option of access controls and memory integrity checks to protect against software attacks.

Key Features
- Common Criteria EAL 5+ (high) certification
- Programmable JavaCard operating system
- 150KB of user memory
- Reference applets for a wide variety of use cases
- Host-side support

Key Benefits
- Secured and certified solution
- Programmable solution with reference applets to simplify customizations and integration
- Protection of system integrity, communication and data

Block Diagram OPTIGA™ Trust P

www.infineon.com/optiga-trust
Secure connectivity across cellular networks is a key success factor and enabler of the next industrial revolution, where intelligent machines, systems and networks are capable of exchanging information to manage complete industrial processes (referred to as Industry 4.0 in Germany). In order to enable secure and reliable cellular connectivity in industrial environments, we have developed the SLM 97 family of industrial-grade security controllers, optimized for operation under difficult environmental and usage conditions. The SLM 97 product family fully complies with the Embedded SIM specifications according to ETSI and GSMA, increasing flexibility and simplifying the deployment of new M2M solutions.

Key Features
- Industrial-grade qualification (JEDEC)
- Extended temperature range: -40 ... 105°C
- Wide range of interfaces: ISO 7816, SWP, USB, I²C, SPI
- Standard embedded M2M delivery form: MFF2
- Symmetric and asymmetric crypto processors
- Common Criteria EAL 5+ (high)

Key Benefits
- High quality and strong security to enable reliable cellular connectivity for mission critical applications
- Implementation flexibility across all M2M vertical applications thanks to large size and wide range of interfaces
Ask Infineon. Get connected with the answers.

Infineon offers its toll-free 0800/4001 service hotline as one central number, available 24/7 in English, Mandarin and German.

Our global connection service goes way beyond standard switchboard services by offering qualified support on the phone. Call us!

- Germany ............... 0800 951 951 951 (German/English)
- China, mainland ...... 4001 200 951 (Mandarin/English)
- India ..................... 000 800 4402 951 (English)
- USA ..................... 1-866 951 9519 (English/German)
- Other countries ........ 00* 800 951 951 951 (English/German)
- Direct access ............ +49 89 234-0 (interconnection fee, German/English)

* Please note: Some countries may require you to dial a code other than “00” to access this international number, please visit www.infineon.com/service for your country!

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