

**Component Focus: Pages 3-4**

WAGO's 2604 and 2606 CAGE CLAMP® terminal blocks give easier termination of wiring connections

**Application Spotlight: Pages 5-13**

ON Semiconductor's FFSBx0120A SiC diodes offer lower switching losses than equivalent silicon parts

**Technical View: Pages 14-15**

How Renesas' digital power modules are meeting complex power requirements

AMERICAS EDITION

Application Spotlight on:

## Power & Power Management

### New superjunction MOSFETs support energy-saving power topologies

STMicroelectronics' new MDmesh™ M6 series of 600V superjunction transistors provide high efficiency in medium-power resonant and hard-switching converter topologies.

The threshold voltage, which is optimized for soft switching, makes the new transistors ideal for LLC resonant converters and boost-PFC converters in energy-conscious applications. MDmesh M6 devices also perform efficiently in hard-switching topologies.

### Efficient DC-DC converter for telecoms equipment

Murata Power Solutions has released the 1kW DRQ-11.4/88-L48 series of quarter brick, intermediate bus DC-DC converter modules, to meet the growing power requirements of high-reliability networking and telecoms equipment.

The fully regulated modules provide an output voltage of 11.4V at 88A from an input voltage ranging between 36V and 60V DC. This fully regulated, fixed-frequency 1kW bus converter offers industry-leading efficiency of 97%. It conforms to the standard DOSA high-power quarter brick specification.

### 12W medical power adaptor complies with US and EU efficiency standards

MEAN WELL has released a 12W medical-grade wall plug adapter. The GSM12E/U series of wall-mount adapters comes with mains plug options suitable for either EU (E Type) or North American (U Type) applications.

The GSM12 adapters comply with the specifications of the US Department of Energy's Level VI and the European Union's ErP efficiency regulations. They provide isolation consistent with two Means of Patient Protection (MOPP). Leakage current is <100µA. They are qualified to the European EN60601-1-11 and the North American ANSI/AAMI ES60601-1-11 home healthcare safety standards.

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## Wave of change in power electronics as safety and efficiency regulations come into force

**Designers of power electronics systems come into 2019 facing twin pressures that are forcing many to re-design part or all of their legacy circuit designs.**

One pressure is the continuing push for higher efficiency, codified in standards such as the US Department of Energy's Level VI regulation and the European Union's CoC rules. In response, power-system designers have experimented with various techniques for reducing losses and improving efficiency, such as new topologies and control methods.

The most promising approach to increasing efficiency today, however, is the replacement of silicon transistors and diodes with equivalent devices made from a wide bandgap semiconductor material, Silicon Carbide (SiC) or Gallium Nitride (GaN). These materials, which offer outstanding properties such as near-zero reverse recovery charge and high-temperature operation, produce dramatically lower losses than conventional silicon components.

The Application Spotlight in this issue of FTM features new SiC diodes from ON Semiconductor which have a 1,200V rating and a maximum junction temperature of 175°C. Their minimal switching losses help designers in their pursuit of ever higher system-level efficiency.

Change is also on the horizon in the field of safety regulation. The new IEC 62368-1 regulation governing the safety of electronic equipment comes into force on 20 December 2020, replacing the existing IEC 60950-1 and IEC 60065 standards. Product designers need to be aware that the new standard applies not only to end products, but also to important components and sub-systems embedded in it, such as power supplies.

After 20 December 2020, it will be illegal to sell in the US or in any EU member state any product which has not been qualified for compliance with the IEC 62368-1 standard and this compliance requirement applies equally

to external power supplies or power supplies embedded in end products. This deadline is less than two years away.

It is therefore prudent for designers to immediately submit for re-qualification to the new standard any legacy power supply in existing product designs. This gives them time to cope should the power supply fail compliance testing, in which case a new, compliant power supply will have to replace it. Clearly all new design projects should also be using power supplies that comply with the terms of IEC 62368-1.

Future Electronics' supplier line-up gives customers a great choice of compliant power adapters and embedded power supplies: Delta Power, RECOM and CUI are all well advanced in their programs to qualify their products for compliance with IEC 62368-1. FTM features the compliant power supplies of CUI, which today are available in maximum power ratings ranging from 3W to 250W.

For help with implementing an IEC 62368-1 compliance program or any other aspect of your power-system design, contact the field applications engineers at your local branch of Future Electronics or call 1.800.FUTURE.1 for help.



**Edwin Kluter**  
Business Development Manager  
Future Electronics – Power Solutions





# Triad Magnetics WS Series Wall Plug-In Transformers



Triad's WS Series Wall Plug-In Power Supplies combine a state-of-the-art design, superior performance and outstanding quality with excellent energy efficiency to reduce power demand for a sustainable green-friendly environment.



They meet or exceed the requirements of U.S. EISA 2007, California CEC and ECD 2005/32/EC, including Level VI energy efficiency requirements. They're also available in an interchangeable package configuration providing user versatility.



## KEY SPECIFICATIONS

- Power: 6.75W to 36W
- Input: 100 to 240V<sub>AC</sub> at 50/60Hz
- Output: 4.5V<sub>DC</sub> to 24V<sub>DC</sub>
- Typical six-foot long cord
- Interchangeable input plugs available
- Barrel connector output

## APPLICATIONS

- Low voltage DC devices or circuits
- Laptops, PCs, printers, phones
- Audio, appliances, lighting and more

## Take a Look Inside the WS Series

When compared to traditional 50-60Hz power supplies, the WS Series is 25% more efficient, 50% smaller and 70% lighter. With its ROHS-compliant surface-mount components, the WS Series provides a clean and compact lower density layout, which is ideal for automated assembly and so reliable that they come with Triad's superior 5-year warranty.



The WS Series also features Class B EMI certification with power isolation to filter out noise and provide common mode signal rejection. With safety pre-approvals, no testing is necessary.

## Custom WS Plug-In Power Supplies

From a special output connector to a unique case color, to a full blown custom design, Triad has the capability to provide a custom WS Series Wall Plug-In Power Supply that will satisfy any requirement.



You can change the output connector with a production run of as few as 100 pieces. Triad can provide a custom case color for as few as 500 pieces. Triad can provide a complete custom design with a minimum 1,000 piece order per year.



Triad has designed custom wall plug-in power supplies for touchless faucets, decorator lighting controls, motorized window shades that adjust all day long following the sun and many more unique applications.

## Triad's California Design Center

Triad's innovative California design center speeds your custom wall plug-in power supply, internal power supply, inductor or transformer from design to prototype, to testing, to full production within weeks.



## Expert Engineering Staff

With decades of expertise, the Triad design engineering staff works directly with you. They know the complexities of combining cores, laminations and bobbins into custom power supplies and a wide variety of other magnetic components.

Triad engineers can suggest changes in design or materials to optimize your design. For some projects, long-life might be the most important thing. In other cases, material changes can reduce costs.

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# High-temperature inductor offers high current density in multi-phase power supplies

**VISHAY**

Vishay Intertechnology has introduced a new part in its IHSR series of high-temperature commercial inductors.

Intended for use in multi-phase, high-current power supplies and filters, the IHSR-4040DZ-51 offers a 50% reduction in DC resistance compared to competing power inductors. Its 4040 package has a 4mm profile, at least 20% lower than that of similar ferrite products, enabling developers to realize slimmer end-product designs.



IHSR inductors: 20% height savings

The IHSR-4040DZ-51's low DC resistance of  $0.52\text{m}\Omega$  and inductance of  $0.13\mu\text{H}$  allow for higher current density than competing devices. Rated current is 92A. The IHSR-4040DZ-51 handles high transient-current spikes without saturation.

The inductor features a high standard tolerance of DC resistance of  $\pm 5\%$ . Parts with  $\pm 3\%$  tolerance are available for applications requiring more accurate current sensing.

Rated for a frequency range up to 5MHz, the IHSR-4040DZ-51 is suitable for the energy-storage function in DC-DC converters, and for high-current filtering up to the device's self-resonant frequency of 151MHz.



## APPLICATIONS

- Computing equipment
- Industrial equipment
- Telecoms equipment
- Distributed power systems

## FEATURES

- Low acoustic buzz noise
- 72A heat rating current
- 63A saturation current
- High resistance to thermal and mechanical shock and to moisture
- $155^\circ\text{C}$  maximum operating temperature

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# PCB terminal blocks for power circuits make wire termination easy and intuitive

**WAGO**

WAGO has introduced PCB terminal blocks for power electronic circuits which offer easy termination of wire connections.

The new Push-in CAGE CLAMP® with Lever terminal blocks include:

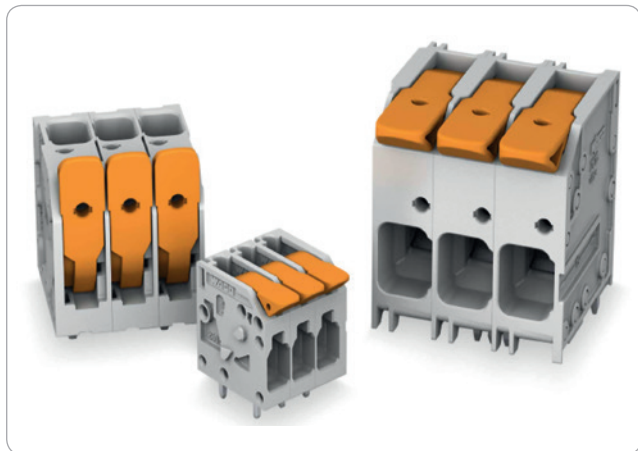
- The 2604 series for AWG 12 wire, rated for currents up to 20A
- The 2606 series for AWG 8 wire, rated for currents up to 31A

The CAGE CLAMP blocks provide for faster and easier wiring. The use of a lever to terminate

wiring is intuitive and eliminates the need for a dedicated wiring tool. When the lever is operated, it gives an audible click and detent for clear indication of its position, either open or closed.

Solid and ferruled conductors may be simply pushed into the block to terminate them. For terminating stranded wires, the operator simply lifts the lever, inserts the wire and then returns to the lever to the closed position, securing the connection.

The blocks are available in versions supporting top entry, at  $90^\circ$  to the PCB, and side entry, at  $0^\circ$  to the PCB.



WAGO terminal blocks: Lever terminates wires



## APPLICATIONS

- Electric motors and servo drives
- Power supplies
- Electronic circuit breakers
- Wind turbines
- Power converters
- Machine control devices and robots
- Solar inverters
- Uninterruptible power supplies
- Energy storage systems
- Electric vehicle charging stations
- Smart metering

## FEATURES

- Pin spacings:
  - 2606 series: 7.5mm
  - 2604 series: 5mm, 7.5mm or 11.5mm
- Two test access points when PCB mounted
- Option to print on top or on wire-entry side
- Conforms to IEC/EN 60335-1 requirements
- Surge voltage ratings:
  - 2604: 4kV
  - 2606: 8kV

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# Schottky rectifiers benefit from superior thermal performance of CFP package

## NEXPERIA

Nexperia has developed the Clip-bonded FlatPower (CFP) package for a portfolio of Schottky rectifiers to help designers to implement efficient and space-saving designs in automotive, industrial, computing and consumer electronics applications.

High-power rectifiers in the CFP package style offer a superior alternative to the standard SMA package, and provide better thermal performance. The Nexperia portfolio of CFP rectifiers includes high-efficiency trench rectifiers featuring a combination of low forward voltage and low reverse current, even at high ambient temperatures. These devices are for applications fitting these specifications:

- 40V to 60V maximum reverse voltage
- 1A to 15A maximum forward current

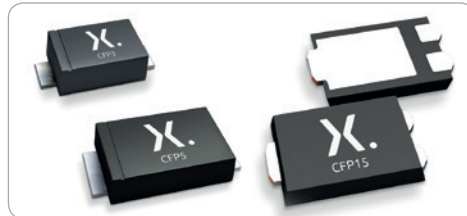
Functions for which these devices are well suited include polarity and back drive protection, and blocking and ORing.

Nexperia also offers a group of low-leakage CFP planar rectifiers which offer ultra-low reverse current. They provide very good protection against the risk of thermal runaway. The specifications include:

- 60V to 100V maximum reverse voltage
  - 1A to 10A maximum forward current
- They are well suited to DC-DC boost conversion in automotive applications.

The Nexperia rectifiers, in forward voltage ratings ranging from 30V to 100V, are available in:

- CFP3 package measuring 2.6mm x 1.7mm x 1.0mm
- CFP5 package measuring 3.8mm x 2.5mm x 1.0mm
- CFP15 package measuring 5.8mm x 4.3mm x 0.8mm



Nexperia Schottky rectifiers: Three CFP package options



### APPLICATIONS

- High-temperature automotive applications
- Transmission units
- Engine control units
- Automotive LED lighting
- LED display backlighting
- Powertrain systems in hybrid vehicles

### FEATURES

- 175°C maximum junction temperature
- AEC-Q101 qualified
- CFP package features:
  - Solid copper clip for high thermal performance and power dissipation
  - Reduced package inductance for improved switching behaviour
  - Innovative silicon and reduced package resistance for better electrical performance

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# Low-cost digital modules offer efficient power supply for FPGAs, DSPs, ASICs and memory

## RENESAS

Renesas Electronics Corporation has introduced a family of encapsulated digital DC-DC converter modules with a PMBus™ interface. The five RAA210xxx modules offer advanced digital telemetry and high performance, and are as easy to use as Renesas' analog power modules.

They are complete step-down regulated power supplies which operate from industry-standard 12V or 5V input power rails and produce an output of as much as 70A. The RAA210xxx family is intended for use as Point-of-Load (PoL) power supplies for FPGAs, DSPs, ASICs and memory.

Each device integrates a PWM controller, MOSFETs, inductor and passives in a thermally-efficient High Density Array (HDA) encapsulated package. All that is needed to complete the power supply are input and output bulk capacitors.

The RAA210xxx is a lower-cost, simplified digital power module family which is pin-compatible with Renesas' full-featured ISL827xM series of digital power supplies.

The RAA210xxx simple digital power modules offer run-time digital programmability, full telemetry, and system monitoring. If more advanced digital control is later required, upgrading to the pin-compatible ISL827xM modules will enable current sharing with multiple modules connected in parallel, access to all PMBus commands using the PowerNavigator™ tool, and non-volatile memory for configuration storage.

The RAA210xxx power modules use Renesas' patented ChargeMode™ control architecture which achieves up to 96% peak efficiency, and better than 90% efficiency under most conditions. They also provide a single clock-cycle fast response to output-current load steps, which reduces capacitance and saves cost and board space.

To read the Technical View featuring the RAA210xxx family, please turn to page 15.

Part Number	Output Current	HDA Package Dimensions
RAA210825	25A	19mm x 17mm x 3.55mm
RAA210833	33A	19mm x 17mm x 3.55mm
RAA210925	Dual 25A	18mm x 23mm x 7.5mm
RAA210850	50A	18mm x 23mm x 7.5mm
RAA210870	70A	18mm x 23mm x 7.5mm



### APPLICATIONS

- Servers
- Data storage equipment
- Optical networking equipment
- Telecoms equipment

### FEATURES

- Input-voltage range: 4.5V to 14V
- Programmable output voltage range: 0.6V to 5V
- ±1.2% output-voltage accuracy over line, load, and temperature
- Selectable switching frequency options from 296kHz to 1.06MHz
- No requirement for forced-air cooling or heat-sink
- Under-voltage, over-voltage, output-current and temperature protection functions with fault logging

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# 40A power connectors in compact 8mm-high form factor

## TE CONNECTIVITY

TE Connectivity's ELCON Mini power interconnects enable greater design flexibility, offering connectors in vertical and right-angle mount versions, and in press-fit as well as through-hole options. For easier routing, ELCON Mini cable assemblies are available in standard metal-latch or plastic pull-tab designs.

Offering a combination of low resistance and a highly reliable interface, TE's ELCON Mini power interconnects help instill a high level of confidence in system performance.

ELCON Mini power interconnects are just 8mm high. The form factor is around the same size as

a space-saving HDMI connector. Nevertheless, they support higher current than similar-sized solutions, up to 40A per contact. They are also rated for voltages up to 400V AC or DC.

Other features include optional coding contacts for sense/detect functionality, use of industry-proven crimp contacts, and an excellent price-to-performance ratio.



ELCON Mini: Available with metal latch or plastic pull tab



### APPLICATIONS

- Power distribution
- Power supplies
- Data centers
- High-performance computing
- Storage equipment
- Servers
- Switches and routers
- Industrial electronic equipment cabinets
- Telecoms base stations
- Factory automation systems
- Medical diagnostic equipment

### FEATURES

- 2, 3, 4 and 6 position configurations
- Touch-proof contacts
- Third pin for protective grounding
- 14 to 10 AWG cable sizes
- 0.3mΩ maximum contact resistance
- Metal latch supports pull forces up to 100N
- 50 mating cycles
- Operating-temperature range: -40°C to 130°C

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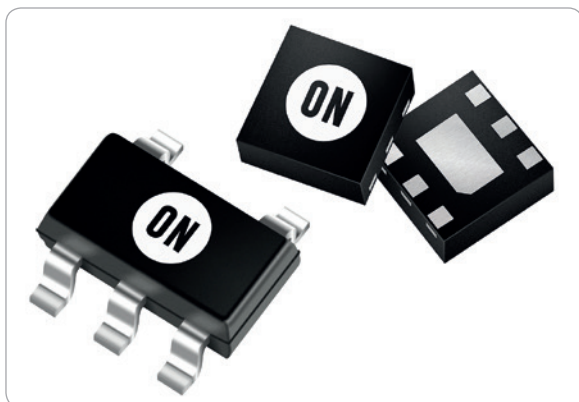
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# 24V LDO for industrial applications has low quiescent current

## ON SEMICONDUCTOR

The NCP718 from ON Semiconductor is a Low Dropout (LDO) linear regulator which produces a maximum output current of 300mA from an input of up to 24V.

A stable and accurate device, the NCP718 typically draws a very low quiescent current of 4μA over the full operating-temperature range. A choice of fixed output voltages is offered in 100mV increments between 1.2V and 5.0V. ON Semiconductor also supplies an adjustable-voltage version providing an output between 1.2V and 5.0V.



NCP718 LDO: 60dB power-supply rejection ratio

The NCP718 is well suited to use in the power circuit for RF and sensor circuits because of its high power-supply rejection ratio of 60dB and its low-noise performance, typically 36μV<sub>RMS</sub> from 100Hz to 100kHz.

The regulator incorporates several protection features, including thermal shut-down and current limiting. For low-power applications such as smoke detectors and proximity sensors, the NCP718 is supplied in a TSOP-5 package. For applications operating at higher pulsed or continuous power levels, it is provided in a 2mm x 2mm WDFN-6 package.



### APPLICATIONS

- Industrial power supplies
- Power tools
- Multi-cell batteries
- Smart meters
- Low-power wireless networking equipment
- LED dimming circuits
- Wireless chargers

### FEATURES

- Input-voltage range: 2.5V to 24V
- ±2% load and line accuracy
- Stable with small 1μF ceramic capacitor
- 150°C maximum junction temperature
- Active discharge function for fast turn-off
- Soft-start

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# Ruggedized energy-storage capacitors offer long life and high moisture resistance

VISHAY

Vishay Intertechnology has introduced a new series of ruggedized ENYCAP™ Electrical Double-Layer Capacitors (EDLCs) for energy harvesting and power back-up applications in harsh and humid environments.



Winner of a 2018 AspenCore World Electronics Achievement Award

ENYCAP EDLCs: Range of cylindrical case sizes

The Vishay 225 EDLC-R ENYCAP capacitors are the industry's first to offer useful life of 2,000 hours at 85°C, and to meet the requirements of the toughest test of moisture resistance: the biased 85°C/85% relative humidity 1,000-hour test.

The long useful life of the devices is double that of standard EDLCs, giving scope for OEMs to design for maintenance-free operation.

Available in eight small case sizes ranging from 16mm x 20mm to 18mm x 40mm, the 225 EDLC-R ENYCAP capacitors offer high power density of as much as 4.1Wh/kg.

Part Number	Capacitance	Package (mm)
MAL222591003E3	20F	16 x 20
MAL222591006E3	25F	16 x 25
MAL222591004E3	25F	18 x 20
MAL222591007E3	30F	18 x 25
MAL222591002E3	35F	16 x 31
MAL222591001E3	40F	18 x 31
MAL222591008E3	50F	18 x 35
MAL222591009E3	60F	18 x 40



## APPLICATIONS

- Industrial equipment
- Renewable energy equipment
- Automotive systems and robots
- Smart meters
- Emergency lighting

## FEATURES

- Rapid charge and discharge
- Maximum rated voltage of 2.7V
- Ruggedized for operation in high humidity
- Operating-temperature range: -40°C to 85°C

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## High Power Density of DC-DC Converters For Space-Critical Applications • MDWI10 Series

- High Power Density Up to 63.5 W/in<sup>3</sup>
- Ultra-wide 4:1 Input Voltage Range
- I/O Isolation 1500VDC
- Low No Load Power Consumption



**General Industrial Power Solutions**

**1-60W** DC-DC Converter  
**2-60W** AC-DC Power Supply

**Ultra-high Isolation Power Solutions**

**1-60W** DC-DC Converter

**Railway Certified Power Solutions**

**3-150W** DC-DC Converter

**Medical Safety Power Solutions**

**1-20W** DC-DC Converter  
**24-60W** AC-DC Power Supply

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# Broad array of PCB headers and receptacles

## TE CONNECTIVITY

**TE Connectivity (TE) supplies a wide range of headers and receptacles to provide durable and cost-effective connections to a PCB.**

Connection options from TE span the range from a straight, single-position header to a right-angle header with multiple rows and 150 positions.

Features that the system designer can choose from include keying options, locking features, color coding and materials choices.



TE's PCB connectors: Choice of locking features and colors

The product families featuring wire-to-board connectors include:

- **Economy Power (EP) connectors**  
TE offers EP II connectors with up to 12 positions and EP 2.5 connectors with up to 20 positions, to supply power to the circuit board when space is limited.
- **Grace Inertia connectors**  
TE's Grace Inertia connectors offer a compact, high-current design to provide connectivity between circuits.
- **RAST connectors**  
TE offers a range of connectors complying with the RAST 2.5 and the RAST 5 standards.
- **Signal Double Lock (SDL) connectors**  
A discrete wire interconnect available in 2 to 13 position wire-to-board and 2 to 10 position wire-to-wire versions.
- **MTA connectors**  
The MTA-100 IDC connector system is a wire-to-board and wire-to-wire system with contacts in a single row on a 0.1"/2.54mm centerline. The design features wire feed-through capability for daisy-chain applications.



### APPLICATIONS

- Air conditioners and heaters
- Home and kitchen appliances
- Garage door openers
- Vending machines and coin changers
- Fitness equipment
- Industrial equipment
- Lighting
- Gaming systems

### FEATURES

- Polarized housing to help prevent incorrect mating
- Protective housings for safety and contact protection
- Contact insulation for applications with long life cycles
- Designed for board space-saving
- Rugged, large-scale systems available

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# DC-DC buck converters offer best-in-class EMI performance

## DIODES INCORPORATED

**Diodes Incorporated has introduced the AP63200 series of 2A synchronous DC-DC buck converters, which provide class-leading EMI performance across a range of input and output voltages.**



AP63200 series: 88% efficiency in light-load conditions

The converters use a Frequency Spread Spectrum (FSS) technique and proprietary gate-driver technology to reduce the device's electromagnetic emissions. This design supports single-layer board layouts, and can eliminate the need for vias, which are sometimes required in board designs to reduce EMI.

The fully integrated devices feature high- and low-side MOSFETs with very low on-resistance. Employing Pulse Frequency Modulation (PFM), the AP63200 series converters offer high efficiency of up to 88% under light-load conditions, at an output current of 5mA. Quiescent current is as low as 22µA.

The AP63200 series devices operate over a wide input-voltage range of 3.8V to 32V.

Two parts, the AP63200 and AP63201, provide a variable output voltage of between 0.8V and the input voltage. The AP63203 supplies a fixed 3.3V output. The fixed output of the AP63205 is 5V. All devices can supply a maximum continuous output current of 2A.

The AP63200/AP63201 devices can also operate as an LDO regulator by employing a duty cycle of 100%, providing a stable output voltage to within 1% of an unregulated input voltage.



### APPLICATIONS

- Home appliances
- Industrial electronics
- Telecoms equipment
- Power tools
- Office equipment
- TVs
- Set-top boxes

### FEATURES

- 40V maximum input surge voltage
- TSOT26 package

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# High-performance power

## MIL-COTS

BCM6123TD0G5030M00

30A, 97% efficiency

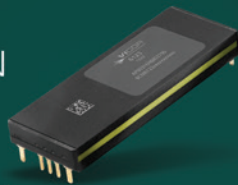
200 - 400V<sub>IN</sub>

Isolated fixed-ratio

High-voltage  
DC-DC converter

2.5 x 0.9 x 0.3in

63.3 x 22.8 x 7.2mm



## HIGH POWER

DCM4623TD2H53E0T00

500W

200 - 420V<sub>IN</sub>

93% peak efficiency

Isolated regulated

DC-DC  
converter

1.8 x 0.8 x 0.2in

47.9 x 22.8 x 7.2mm



## HIGH CURRENT

PI3325-00-LGIZ

>94%  
efficiency

14 - 42V<sub>IN</sub>

4 - 6.5V<sub>OUT</sub>, 20A

Cool-Power  
buck regulator

10 x 14 x 2.6mm



PI3740-00-LGIZ

Up to 96%  
efficiency

8 - 60V<sub>IN</sub>

10 - 50V<sub>OUT</sub>, 140W

Cool-Power  
ZVS buck-boost  
switching regulator

10 x 14 x 2.6mm



# VICOR

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# 600V MOSFET lowers conduction and switching losses to give higher efficiency in power-conversion circuits

VISHAY

The fourth generation of the Vishay Siliconix 600V E series power MOSFETs offers high efficiency in telecoms, industrial and enterprise power-supply applications.



SiHP065N60E: 74nC maximum gate charge

The introduction of the N-channel SiHP065N60E MOSFET now extends the appeal of Vishay's E Series. The SiHP065N60E features the industry's lowest gate charge times on-resistance, a key figure of merit for 600V MOSFETs used in power-conversion applications.

Maximum gate charge for the SiHP065N60E is rated at 74nC. On-resistance is 57mΩ at a gate-source voltage of 10V. This gives a figure of merit 25% lower than that of the closest competing MOSFET in the same class.

The device is able to achieve this outstanding performance because it is built on Vishay's latest energy-efficient E series superjunction technology. This cuts on-resistance by 30% compared to previous 600V E series MOSFETs, while producing gate charge which is some 44% lower.

## Efficiency and density in high-voltage power converters

With the SiHP065N60E and other members of the fourth-generation 600V E Series family, Vishay is addressing the need for efficiency and power-density improvements in the first stages of AC-DC power-system architectures: Power Factor Correction (PFC) and subsequent high-voltage DC-DC converter blocks.

### Key product benefits include:

- Ultra-low on-resistance and gate charge reduce conduction and switching losses to save energy
- Low effective output capacitance improves switching performance
- Standard TO-220AB package
- RoHS-compliant
- Halogen-free
- Designed to withstand over-voltage transients in the avalanche mode with limits guaranteed through 100% UIS testing



## APPLICATIONS

- Power factor correction
- Hard-switched DC-DC converter topologies
- Server and telecoms power supplies
- Switch-mode power supplies
- High-Intensity Discharge (HID) lighting fixtures
- Fluorescent ballasts
- Welding equipment
- Motor drives
- Battery chargers
- Solar power inverters

## FEATURES

- 600V drain-source voltage
- 5V maximum gate-source threshold voltage
- 93pF effective energy-related output capacitance
- 593pF effective time-related output capacitance
- 0.5°C/W maximum junction-to-case thermal resistance

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

## RENESAS

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

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

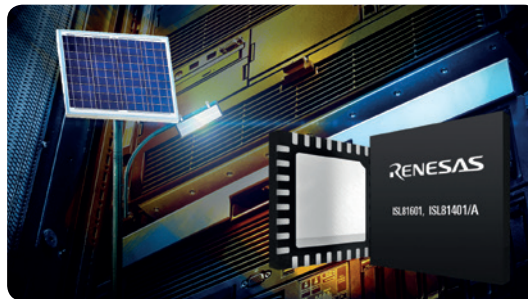
The ISL81601 has a wide input-voltage range of 4.5V to 60V and produces a 0.8V to 60V output. This is compatible with most industrial batteries, which typically operate at 12V, 24V, 36V or 48V. Also available is the ISL81401, which has a 4.5V to 40V input range and 0.8V to 40V output range, and a unidirectional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

The ISL81601 and ISL81401's bi-directional peak current-sensing capability eliminates the complex external circuitry

required for charging and discharging a battery that supplies power to loads. Their proprietary algorithm provides smooth transitions between buck, boost and buck-boost modes, while reducing low frequency ripple at the output. This produces minimal disturbance during line or load transients. The algorithm also maintains a predictable ripple voltage under all conditions.

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

**To read the Technical View featuring the ISL81601, please turn to page 14.**



ISL81601: Wide 4.5V to 60V input-voltage range



### APPLICATIONS

- DC power back-up
- Medical equipment
- Industrial systems
- Telecoms equipment

### FEATURES

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

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# Mobile battery connectors give flexible design and assembly options

## TE CONNECTIVITY

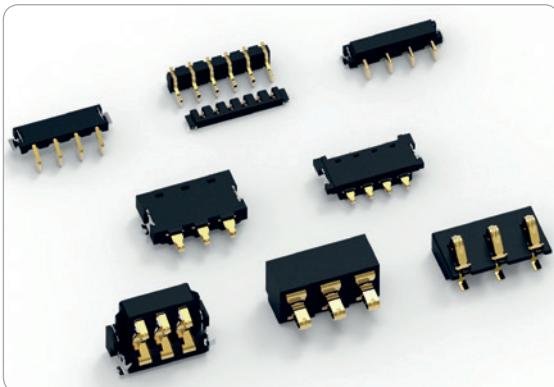
**TE Connectivity's (TE) series of mobile battery connectors consists of types including low-profile battery connectors, leaf battery connectors and a Floating Battery Interconnection System (FBIS II).**

These products have been widely adopted in end products such as mobile phones, tablet PCs, digital cameras and other mobile devices.

The TE mobile battery connectors offer product designers the benefits of low cost, high reliability and durability, a low profile, and design flexibility.

This design flexibility enables them to be used, for example, in mobile phones with removable batteries: they may be scaled up or down regardless of position, working height and contact pitch.

The low-profile battery connector series saves bill-of-materials cost by reducing the number of components needed and the size of the tooling platform. They are designed to accommodate position extensions and height changes. They offer a choice of assembly options, including either surface-mount or DIP-type soldering, and standard-mount or mid-mount fitting.



TE battery connectors: Working height as low as 0.4mm



### APPLICATIONS

- Mobile phones
- Tablet PCs
- Mobile media players
- Digital cameras
- Video cameras
- Navigation systems
- Gaming consoles
- Navigation systems

### FEATURES

- Can be used in mobile phone with removable battery
- Centerline range: 2.5mm to 6.5mm
- Working height range: 0.4mm to 6.7mm
- Current-rating range: 1.5A to 5A

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# Industry's first top-side-cooled surface-mount devices for high-power applications

## INFINEON

**Infineon Technologies has developed Double DPAK (DDPAK), the industry's first top-side-cooled surface-mount package suitable for high-voltage power semiconductors.**

This new package technology enables the production of power devices such as MOSFETs and diodes which can perform fast switching and achieve high efficiency. This helps designers to reduce the size and weight of power systems at a lower total cost of ownership.

The development of the DDPAK package is a response to the demand for surface-mount power semiconductors in high-voltage power supplies. These devices require higher power capability and more efficiency in a smaller space. But thermal management of today's surface-mount Switch-Mode Power Supply (SMPS) designs remains a barrier to efficiency.

The top-side-cooled DDPAK package provides an answer to this efficiency problem. The thermal decoupling of the PCB and the semiconductor enables higher power density and longer system lifetime.

Two families of Infineon devices demonstrate the advantages of the DDPAK technology in high-power system designs.

The 600V CoolMOS™ G7 superjunction MOSFET family provides efficiency, switching

and density benefits in SMPS designs. Key features include:

- Higher efficiency due to the improved CoolMOS G7 technology
- Faster switching, a result of the package's low parasitic source inductance of around 1nH, and its 4th pin Kelvin source configuration
- Improved power density: the CoolMOS G7 MOSFETs are notable for their low on-resistance. Compared to existing designs based on power switches in through-hole packages or on paralleled surface-mount packages, a CoolMOS-based design can handle higher power outputs in a smaller board footprint.
- Production cost reduction and faster assembly results from the replacement of through-hole devices with surface-mount ICs

The 650V CoolSiC™ G6 Schottky diodes offer the best price-performance ratio and customer value in the market. The CoolSiC G6 diodes benefit from Infineon's advanced silicon carbide (SiC) production facilities, a solid track record and outstanding production quality.

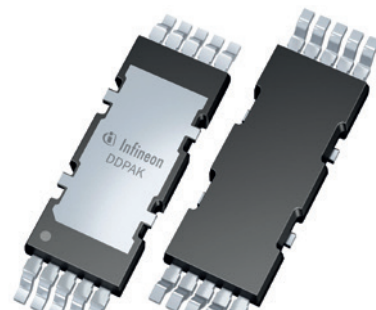


### APPLICATIONS

- Servers
- Telecoms equipment
- Solar power generation equipment
- Power supplies for high-end PCs

### FEATURES

- Very low 1.25V forward voltage
- Best-in-class figure of merit ( $Q_c \times V_F$ )
- No reverse-recovery charge
- Temperature-independent switching behavior
- High dV/dt ruggedness
- Optimized thermal behavior



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# GaN HEMTs offer ultra-high efficiency in high-voltage power-conversion circuits

**Infineon's CoolGaN™ enhancement-mode High Electron-Mobility Transistor (e-mode HEMT) portfolio, fabricated in the Gallium Nitride (GaN) wide bandgap semiconductor material, offers industry-leading field performance. Power-system designers can use these GaN transistors to implement robust and reliable designs at an attractive system cost.**

The CoolGaN products offer the most reliable and highly qualified GaN solution currently available on the market. Predicted lifetime is longer than 15 years, at a failure rate less than 1 F.I.T. (Failure In Time).

The CoolGaN HEMTs benefit from the attractive performance benefits of the GaN material. These include low gate charge and excellent dynamic performance in reverse conduction, far superior to those of equivalent silicon FETs.

When used in Power Factor Correction (PFC) circuits, Infineon's 600V CoolGaN devices provide very high efficiency of higher than 99.3% for a 2.5kW PFC system, and high density of more than 160W/in<sup>3</sup> in a 3.6kW LLC converter at >98% efficiency.

The CoolGaN portfolio is built around high-performance bottom- and top-side-cooling surface-mount packages which support high-frequency operation. Low parasitics and good thermal performance enable power-system designers to fully exploit the benefits of the CoolGaN HEMTs.



### APPLICATIONS

- Servers and telecoms equipment
- Hyper-scale data centers
- Wireless chargers
- Chargers and adapters
- Switch-mode power supplies

### FEATURES (IGOT60R070D1)

- Ultra-fast switching
- No reverse-recovery charge
- Capable of reverse conduction
- 5.8nC gate charge
- 70mΩ maximum on-resistance
- 31A maximum drain current
- 600V maximum drain-source voltage
- 1.6V maximum gate-source threshold
- Qualified for industrial applications according to JEDEC standards JESD47 and JESD22

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# 1,200V SiC diodes offer faster switching speeds and lower switching losses

## ON SEMICONDUCTOR

The FFSB10120A and FFSB20120A from ON Semiconductor are 1,200V Schottky diodes made from wide bandgap Silicon Carbide (SiC) material which provides superior switching performance and higher reliability than equivalent silicon diodes.

The FFSB10120A provides a maximum 10A output current and the FFSB20120A is rated for 20A.

The switching losses incurred by SiC diodes are dramatically lower than those of silicon diodes, because SiC diodes have almost no reverse-recovery charge or time. The thermal characteristics of SiC-based diodes are also very attractive to power-system designers: the switching characteristics are constant over the operating-temperature range, and the maximum junction temperature of the FFSBx0120A diodes is 175°C.



FFSBx0120A: 175°C  
maximum junction temperature

The combination of fast switching capability, very low switching losses and high-temperature operation means that power-system designers can achieve very high efficiency and high power density. Fast switching allows for the use of smaller inductors and capacitors, and the high temperature capability can reduce or eliminate the need for cooling devices.

High surge current capacity means that these SiC diodes from ON Semiconductor are able to conduct more current in forward bias mode.



### APPLICATIONS

- High-efficiency power circuits
- Switch-mode power supplies
- Solar inverters
- Uninterruptible power supplies

### FEATURES

- Ease of paralleling
- Positive temperature coefficient
- Excellent avalanche rating
  - 100mJ for FFSB10120A
  - 200mJ for FFSB20120A
- Total capacitive charge at 800V:
  - FFSB10120A: 62nC
  - FFSB20120A: 120nC

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# Range of external power supplies conforms to new IEC 62368-1 safety standard

## CUI INC

CUI's Power Group has upgraded the majority of its external AC-DC power supplies to the new IEC 62368-1 standard for Information and Communications Technology (ICT) and Audio-Visual (AV) equipment.

Set to supersede the outgoing IEC 60950-1 and IEC 60065 standards on 20 December 2020, IEC 62368-1 will introduce fundamentally different guidelines founded on hazard-based safety engineering principles. This means that IEC 62368-1 is more important than a simple merger of the two standards, and marks an important transition for ICT and AV equipment.

Similar to previous standards, IEC 62368-1 will apply not only to the end system, but also to components such as external power supplies. CUI has updated its product range to comply with these forthcoming standards. The compliant line of power supplies features maximum power ratings between 3W and 250W, as well as the latest in green power technology. The power supplies are produced in wall plug-in, multi-blade and desktop versions, all available with a variety of DC output plug options.

The models also meet the latest global efficiency standards, including the US Department of Energy Level VI and the EU's voluntary CoC Tier 2 requirements.

Power supplies compliant with IEC 62368-1 standard

Series Part Number	Power Rating	Input Connector Type	Power-supply Type
SWI3-E	3W	European	Wall plug adapter
SWI3-N	3W	N American	Wall plug adapter
SWI6-N	6W	N American	Wall plug adapter
SWI12-N	12W	N American	Wall plug adapter
SDI18-U	18W	Three-prong C14	Desktop adapter
SDI18-UD	18W	Two-prong C8	Desktop adapter
SMI18	18W	Interchangeable	Wall plug adapter
SWI18-N	18W	N American	Wall plug adapter
SDI24-U	24W	Three-prong C14	Desktop adapter
SDI24-UD	24W	Two-prong C8	Desktop adapter
SMI24	24W	Interchangeable	Wall plug adapter
SWI24-N	24W	N American	Wall plug adapter
SDI36-U	36W	Three-prong C14	Desktop adapter
SDI36-UD	36W	Two-prong C8	Desktop adapter
SMI36	36W	Interchangeable	Wall plug adapter
SDI50-U	50W	Three-prong C14	Desktop adapter
SDI50-UD	50W	Two-prong C8	Desktop adapter
SDI65-U	65W	Three-prong C14	Desktop adapter
SDI65-UD	65W	Two-prong C8	Desktop adapter
SDI90-U	90W	Three-prong C14	Desktop adapter
SDI120-U	120W	Three-prong C14	Desktop adapter
SDI200-U	200W	Three-prong C14	Desktop adapter
SDI250-U	250W	Three-prong C14	Desktop adapter



### APPLICATIONS

- ICT equipment
- AV equipment

### FEATURES

- Power-ratings range: 3W to 250W
- IEC 62368-1 certified
- High efficiency
- Full suite of safety approvals
- Configurations for global use

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# Designing with a bi-directional DC-DC converter in energy-storage devices

RENESAS

**Infrastructure underpinning the information economy such as data centers and telecoms systems operates 24 hours a day: unplanned loss of power is not acceptable. Energy-storage devices are therefore needed to provide a source of back-up power.**

An energy-storage device collects and stores energy by charging itself from an electrical power source, and then supplying the stored power to the loads by discharging itself. The charge and discharge processes need to be precisely managed to ensure the safety, reliability and long life of the storage devices. In most applications, the charge and discharge functions are controlled by two separate power trains to implement the different control specifications, such as a smaller charge current in contrast with a larger discharge current for a lithium-ion battery.

However, a fast charge-to-discharge or fast discharge-to-charge transition is needed for some applications. For example, a DC battery back-up system used in a data center server needs to implement a fast charge-to-discharge transition to provide seamless power delivery. A motor drive's braking operation, on the other hand, calls for a fast discharge-to-charge transition.

A single powertrain on-the-fly bi-directional charge and discharge converter is needed for these applications to achieve a seamless fast transition between charge and discharge operations. By combining the charge and discharge powertrain, the designer can realize a compact design and the system cost can be minimized. This approach can also be of benefit in applications which do not require a fast charge and discharge transition.

The ISL81601 four-switch buck-boost controller provides an easy and reliable solution for on-the-fly bi-directional DC-DC power conversion. Figure 1 shows two different systems for bi-directional operation controlled by the ISL81601:

- 1a is a battery charge/discharge bi-directional operation system
- 1b is a supercapacitor back-up system

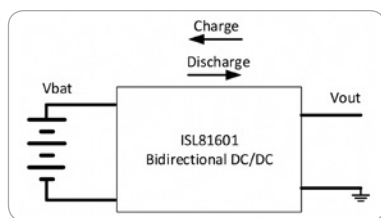


Fig. 1a: Battery pack with a charge/discharge bi-directional DC-DC converter

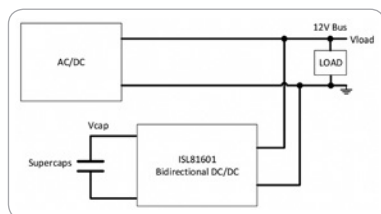


Fig. 1b: Supercapacitor DC back-up system

In a battery charge/discharge system, the bi-directional DC-DC converter can be a four-switch buck-boost converter when the output voltage is close to the battery operating voltage; or it can be a boost converter when the output voltage is always higher than the battery voltage; or it can be a buck converter when the output voltage is always lower than the battery voltage.

The four-switch buck-boost converter achieves the best efficiency because it uses power devices with a lower voltage rating and lower operating current. It can also ensure safe battery operation because of its ability to provide full over-current

and short-circuit protection on both charge and discharge operations.

## Implementation in a battery pack

In a charge/discharge bi-directional DC-DC converter for a battery pack, as shown in Figure 1a, Constant Current/Constant Voltage (CC/CV) control is needed in both directions. Figure 2 shows the battery pack DC-DC converter block diagram. The battery pack is connected to the input end of the DC-DC converter. In the forward battery-discharge direction, the output voltage's CV control is performed by Gm1, and the output current's CC control is performed by A2 and Gm4.

When charging the battery in the reverse direction, the CC and CV charge control can also be implemented by adding two op amp circuits (A3 and A4) to the ISL81601 controller.

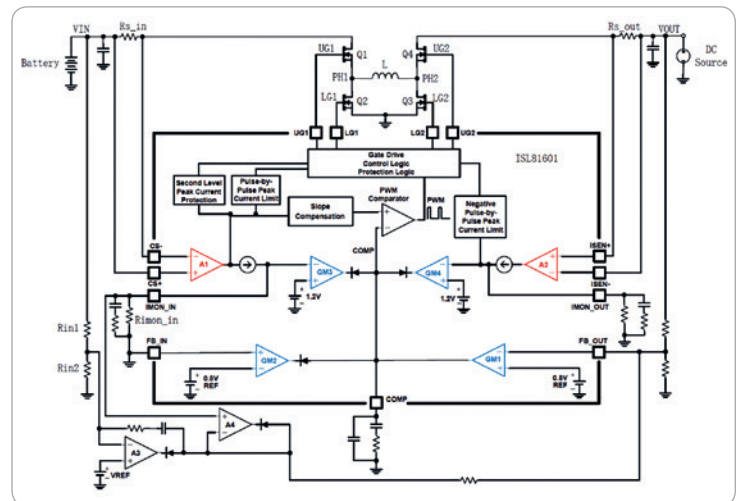


Fig. 2: How the ISL81601 implements CC/CV control of battery charge/discharge operations

Figure 3 shows the waveforms generated by battery charge and discharge operations. When the DC source is removed at T1, the battery starts to discharge to output the power to the load immediately on the fly. When the DC source is reapplied at T2, the DC-DC converter immediately changes its direction on the fly to charge the battery. The battery is charged in CC mode when the voltage is lower than the input-voltage regulation set point, and in CV mode when the voltage reaches the set point.

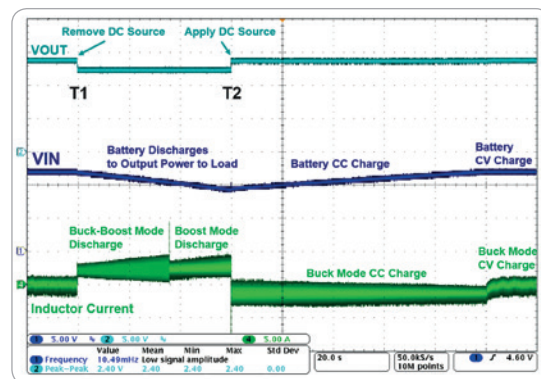


Fig. 3: Waveform generated by battery charge/discharge operations

and reverse directions in a four-switch buck-boost DC-DC converter.

This capability provides a simple, reliable and flexible solution for on-the-fly bi-directional DC-DC power conversion.

**For more information on the ISL81601 and ISL81401 bi-directional four-switch synchronous buck-boost controllers, please turn to page 11.**

## Summary

The Renesas ISL81601 is a highly integrated bi-directional buck-boost PWM controller. The device's unique system architecture makes it easy to control both voltage and current at the output and input ends in forward



# Simple Digital' modules: highly integrated solutions for complex power applications

## RENESAS

It is a great challenge for power-supply designers to convert power from a distributed bus to individual Points-of-Load (PoLs). For instance, FPGAs and ASICs in industrial and infrastructure systems need to deliver maximum efficiency and peak performance at a reduced bill-of-materials cost, and with the smallest possible board footprint.

Power modules provide a way to fulfil these requirements, since they integrate the controller, synchronous MOSFETs, inductor, compensation network and protection circuitry in one compact package.

But design engineers face the dilemma of whether to go the analog or digital route in an effort to achieve the right balance between functionality and cost effectiveness. There is a need for a solution that combines the merits of both analog and digital domains without incurring additional cost and complexity.

Now a new option offers a way to achieve this balance: the 'Simple Digital' family of parts from Renesas, which fits between the spheres of true analog and full-featured digital power modules.

### Simple power solution

The Simple Digital power module family bridges the gap between the analog and digital domains. Simple Digital power modules provide a similar design-in experience to an analog power module, while retaining the digital PMBus™ interface for telemetry and configuration during real-time operation. They offer the full benefits and flexibility of a digital control architecture, and can be fully configured via pin-strap settings as can traditional analog power products. A programmability option with pin-strap resistors provides for a plug-and-play solution.

The unprecedented ease of design with a real-time system-monitoring capability and control via the industry-standard PMBus interface makes the Simple Digital module a unique solution. Full power-supply telemetry, including data on the output voltage, output current, fault status and thermal management, is supported, which improves reliability and system uptime.

Customers can also use the PMBus interface to validate their designs without the inconvenience of switching resistors and capacitors every time a function needs to be adjusted or modified, reducing the development time and overall cost of implementation.

### Simple to use

Simple Digital modules do away with RC time constants, which are used to set delay and ramp times in traditional analog controllers. They also use the telemetry available in digital controllers and provide the capability to monitor critical data for early fault detection, creating a more robust and reliable solution. Temperature monitoring can safeguard against thermal failures by identifying hot spots and improving the overall thermal management of the system.

Simple Digital power modules bypass digital programming by providing a comprehensive selection of resistor pin-straps for configuring the power module. The system designer simply needs to select a resistor to program features such as output voltage, frequency, input under-voltage lock-out, ramp times, and soft-start/stop, as well as sophisticated features such as voltage tracking, external clock synchronization and phase-spreading.



The PMBus interface for a Simple Digital power supply offers a huge advantage during the development phase by enabling the designer to rigorously test for various combinations of output voltages, switching frequency, ramp times, and soft-start/stop without the inconvenience of changing hardware. This reduces the time required for testing considerably, while simultaneously ensuring that design integrity is not compromised.

### Simplifying applications

Renesas' pin-strap-configurable step-down PMBus-compliant DC-DC power supply modules are suitable for various powertrain architectures, particularly for FPGAs, DSPs and microcontrollers which require a current input ranging between 25A and 70A at the point-of-load. The modules provide similar high power densities to those of a full digital module in multi-rail applications.

Because of these modules' thermally-enhanced High Density Array (HDA) packaging technology, the need for cooling airflows or additional heat-sinking is eliminated, further reducing system cost and size.

The RAA210xxx Simple Digital module family simplifies configuration and control of Renesas' digital power technology while offering an upgrade path to full PMBus configuration through the pin-compatible ISL827xM family.

The RAA210925 is a dual-channel module which can greatly enhance the support to various power architectures, particularly FPGAs, DSPs and microcontrollers. The RAA210925 complements Renesas' single-channel offering, providing up to 25A per channel and providing high power density in multi-rail applications.

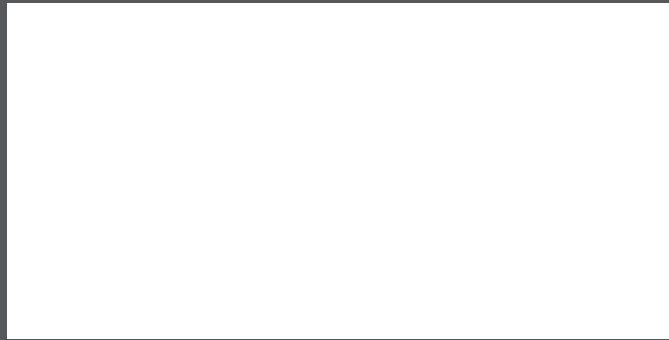
All digital power modules from Renesas are supported by the PowerNavigator™ GUI, which is a user-friendly tool to help support PMBus communication.

**For more information on the RAA210xxx family of encapsulated digital DC-DC converter modules, please turn to page 5.**

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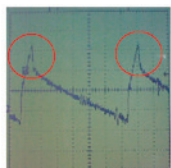


# World's Smallest Low Noise Current Sensing Resistor

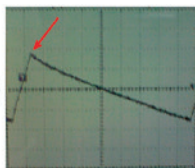


In high frequency electronics, unwanted noise added by the components themselves can become a significant issue. In order to address this, Susumu offers longer side terminal low resistance chip current sensing resistors.

Their equivalent series inductance is so small that the signal integrity is preserved without adding extra noise. Susumu's current sensors are also known to be the best in market in heat distribution and heat dissipation.

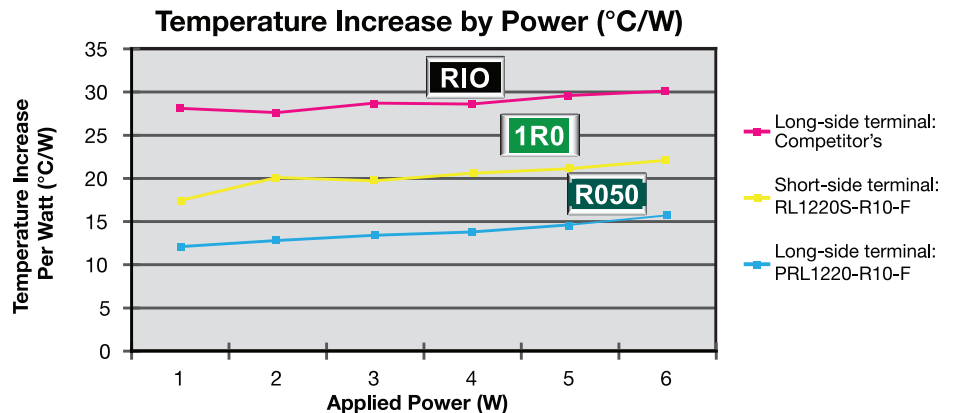


Picture 1 with short-side terminal



Picture 2 with long-side terminal

Reduced Noise



## FEATURES

- Smallest for wattage
- Excellent heat dissipation
- Low ESL – low noise
- Excellent current-surge tolerance
- Offered in sizes: 0402-4320
- Resistance range 1mΩ to 100Ω
- Resistance tolerance as low as ±0.5%
- RoHS compliant
- Offered in two configurations – longer and shorter side terminal

## APPLICATIONS

- Any application that requires current sensing raw resistance resistors such as protection and control circuits

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