

FUTURE TECHNOLOGY MAGAZINE

20-ii EMEA

**TELL US ABOUT YOUR NEXT DESIGN PROJECT AND YOU COULD QUALIFY FOR A FREE DEVELOPMENT BOARD FROM NXP SEMICONDUCTORS**

There are 10 NXP LPC55S69-EVK and 10 MIMXRT1010-EVK development kits to give away.

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**FEATURE**  
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SOFTWARE  
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**LATEST**

New ZS polymer  
hybrid capacitors from  
Panasonic a viable  
alternative to MLCCs

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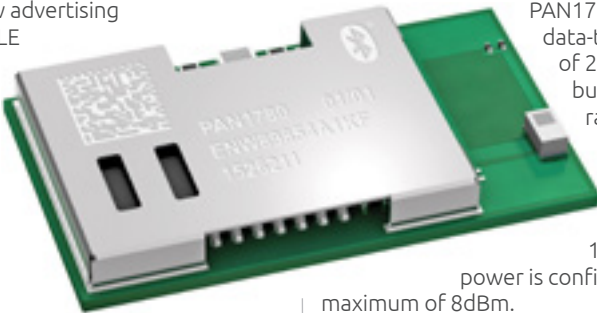




# Multi-radio Bluetooth Low Energy module supports mesh networking

**Panasonic**  
INDUSTRY

Fully compliant with the standard Bluetooth 5.0 specifications, including a mesh networking protocol, the PAN1780 also supports the IEEE 802.15.4 and NFC-A radio technologies. In addition, the new advertising extensions in the BLE specification allow for much larger amounts of data to be broadcast in connectionless scenarios. Featuring an Arm® Cortex®-M4F processor core, the PAN1780 provides 256kbytes of RAM and 1Mbyte of Flash memory. This means that it can easily be used in stand-alone mode, eliminating the need for an external processor.



This reduces the complexity of the board design, saves space and reduces system cost. Based on the Nordic nRF52840 single-chip radio controller, the PAN1780 offers a data-transfer rate of 2Mbits/s via its built-in high-speed radio transceiver. Sensitivity is -95dBm at 1Mbit/s and -103dBm at 125kbits/s. Output power is configurable up to a maximum of 8dBm. The PAN1780's surface-mount package measures 15.6mm x 8.7mm x 2.1mm. Its outline is the same as that of the Panasonic PAN1026A and PAN1762 radio modules.

APPLICATIONS

- Industrial IoT
  - Smart city infrastructure
  - Industrial mesh networks
  - Robotics
- Smart homes and buildings
  - Building automation
  - Smart locks
  - Metering
- Medical devices
  - Smart health equipment
  - Secure medical peripherals

FEATURES

- Arm TrustZone® CryptoCell® 310
  - Supports secure boot including root-of-trust capability
- 4.8mA Transmit current at 0dBm output power
- 4.8mA Receive current at 1Mbit/s
- Up to 48 general-purpose I/Os
- USB 2.0 Full-Speed interface
- Supply-voltage range: 1.7V to 5.5V
- Operating-temperature range: -40°C to 85°C
- Built-in temperature sensor

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REFERENCE NUMBER **20-ii 05**

# Compact chip provides comprehensive protection for USB Type-C ports



STMicroelectronics' TCPP01-M12 is a protection device for USB Type-C™ ports, enabling system designers to quickly and safely replace older Type-A or Type-B ports with the latest, high-speed and high-power USB technology.

Features provided by the TCPP01-M12 include protection against a defective power adapter, to prevent damage to the host equipment if a faulty power supply applies the wrong power profile. The product also provides short-circuit protection between the power bus pins and Configuration Channel (CC) lines.

TCPP01-M12 allows quick and safe migration to USB Type-C connector

FREE DEVELOPMENT BOARD

The X-NUCLEO-USBPD1 is an expansion board for the NUCLEO-G071RB and NUCLEO-G474RE development boards, or for any STM32 Nucleo development board equipped with a USB Type-C peripheral. It provides a straightforward means to evaluate USB Power Delivery operation over a USB Type-C connection in Sink mode using the TCPP01-M12. This expansion board is associated with the X-CUBE-USBPD1 software package available online from STMicroelectronics.

Orderable Part Number: X-NUCLEO-USBPD1

Apply at: [www.my-boardclub.com](http://www.my-boardclub.com)

APPLICATIONS

- Industrial PCs
- Mobile point-of-sale terminals
- Medical devices
- Gateways
- Smart speakers
- Gaming terminals
- Audio/video systems

FEATURES

- Over-voltage protection adjustable up to 22V
- ESD protection:
  - ±8kV for contact discharge in accordance with IEC 61000-4-2 level 4
- Integrated gate driver
- Zero current when no USB cable attached

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REFERENCE NUMBER **20-ii 06**



# New hybrid polymer electrolytic capacitors offer higher capacitance and ripple current ratings

**Panasonic**  
INDUSTRY

Panasonic Industry has extended its range of conductive polymer hybrid capacitors with the addition of the new ZS series, which offers higher capacitance and double the ripple current capability. These improved specifications entail no sacrifice in operating lifetime: the new parts are rated for 4,000 hours' endurance at 125°C.

The new ZS parts are supplied in surface-mount case formats which have a diameter of 10mm. The standard parts are 16.5mm long, while the anti-vibration products, which have a part number ending 'V', are 16.8mm long. Notable for their low Equivalent Series Resistance (ESR) as well higher ripple-current ratings up to 4.0A, the ZS capacitors enhance the performance of filter and DC link circuits in automotive control and powertrain applications. In fact, these polymer hybrid capacitors can now be treated as effective replacements for larger Multi-Layer Ceramic Capacitors (MLCCs), devices which are in short supply and are soon to be phased out. They also offer a reliable and proven alternate to electrolytic capacitors in space-constrained applications, and to tantalum capacitors in high-frequency circuits.

Part Number	Voltage Rating	Capacitance	Ripple Current Rating at 100kHz
EEH-ZS1E561P	25V	560µF	4.0A
EEH-ZS1E561V	25V	560µF	4.0A
EEH-ZS1H221P	50V	220µF	3.7A
EEH-S1H221V	50V	220µF	3.7A
EEH-ZS1J151P	63V	150µF	3.5A
EEH-ZS1J151V	63V	150µF	3.5A
EEH-ZS1V471P	35V	470µF	4.0A
EEH-ZS1V471V	35V	470µF	4.0A

APPLICATIONS

- Automotive systems
  - Powertrain
  - Body electronics
  - Electric power steering
  - Braking systems
  - ADAS

FEATURES

- Stable characteristics over temperature and frequency
- Operating-temperature range: -55°C to 125°C
- 4,000 hours endurance at 125°C
- ±20% capacitance tolerance
- 0.01CV or 3µA DC leakage current, which ever is greater
- AEC-Q200 qualified

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REFERENCE NUMBER **20-ii 07**



# Combined MEMS accelerometer and gyroscope in a single compact package



The ISM330DHCX from STMicroelectronics, a motion sensor system-in-package featuring a high-performance 3D digital accelerometer and 3D digital gyroscope, is tailored for Industry 4.0 applications. The micromachined sensing elements of the accelerometer and gyroscope are implemented on the same silicon die, providing superior stability and robustness.

The ISM330DHCX has a full-scale acceleration range of  $\pm 2g/\pm 4g/\pm 8g/\pm 16g$ , and features an extended angular rate range up to  $\pm 4,000$  degrees/s. It offers embedded functions and interrupts including tilt detection, free-fall, wake-up, 6D/4D orientation, click and double-click detection.



ISM330DHCX: Built-in AI capability for motion recognition

The design and calibration of the ISM330DHCX have been optimized to provide outstanding accuracy and stability as well as low noise and full data synchronization.

A rich set of embedded features includes a Machine Learning Core, FIFO, sensor hub to collect data from external sensors,

programmable finite state machine, event decoding and interrupts. Machine Learning Core is a unique feature which enables movement recognition supporting AI capabilities and great improvement on power consumption at system level

The ISM330DHCX is available in a 14-lead plastic land grid array package measuring 2.5mm x 3.0mm x 0.8mm. ST supplies the product as part of its 10-year longevity program.



- APPLICATIONS
- Industrial IoT
  - Optical image and lens stabilization
  - Antennas
  - Platforms
  - Robots
  - Drones
  - Industrial automation equipment
  - Navigation systems
  - Telematics systems
  - Vibration monitoring

- FEATURES
- Supply-voltage range: 1.7V to 3.6V
  - Embedded self-test
  - Survives severe shocks
  - Operating-temperature range: -40°C to 105°C
  - Embedded compensation for high stability over temperature

FREE DEVELOPMENT BOARD

The STEVAL-MKI207V1 adapter board can be plugged into a standard DIL 24 socket. It provides access to all the ISM330DHCX's pins, and is supplied ready to use with the required decoupling capacitors on the power supply line.

This adapter board is supported by the STEVAL-MKI109V3, which has a 32-bit MCU functioning as a bridge between the sensor and a PC.

Orderable Part Number: STEVAL-MKI207V1

Apply at: [www.my-boardclub.com](http://www.my-boardclub.com)

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REFERENCE NUMBER **20-ii 08**

# High-voltage current sense amplifier offers high precision



The TSC2011 from STMicroelectronics is a bi-directional current sense amplifier for use with a shunt resistor to measure current with a high degree of precision and accuracy.



TSC2011: Performs low- or high-side current sensing

The TSC2011 can perform high- or low-side current sensing, and is also suitable for other functions such as over-current protection, current monitoring and feedback loops.

It operates over a wide range of common-mode voltages from -20V to +70V, regardless of the supply voltage. Featuring gain of 60V/V, the TSC2011 is able to sense voltage drops as low as 10mV full-scale. Its maximum offset voltage is just  $\pm 200\mu V$ .



- APPLICATIONS
- Data acquisition and instrumentation
  - Test and measurement equipment
  - Industrial process control
  - Motor control
  - Solenoid control

- FEATURES
- 0.3% maximum gain error
  - 5 $\mu V/^{\circ}C$  maximum offset drift
  - 10ppm/ $^{\circ}C$  maximum gain drift
  - 20 $\mu A$  quiescent current in shut-down mode
  - Supply-voltage range: 2.7V to 5.5V
  - Operating-temperature range: -40°C to 125°C

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REFERENCE NUMBER **20-ii 09**

# Synchronous buck regulators in compact package offer peak efficiency up to 98%

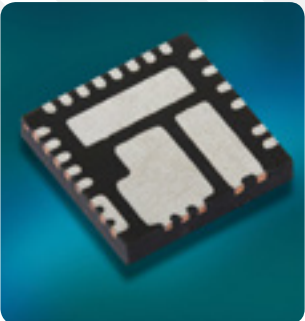


Vishay Intertechnology has introduced two new families of 2A to 12A microBUCK® synchronous buck regulators which operate at very high efficiency of up to 98%.

Both families of regulators operate over a wide input-voltage range: 4.5V to 55V for the SiC476/77/78/79 parts, and 4.5V to 60V in the case of the SiC466/67/68/69.

Combining rugged, high-performance N-channel trench MOSFETs with a controller in a thermally-efficient 5mm x 5mm x 0.75mm PowerPAK® package, these devices enable system designers to realise power circuits which achieve high power density with no heat-sink.

The SiC4xx regulators also benefit from internal compensation which eliminates the need for external resistor-capacitor networks. They share the same controller IC and footprint, but feature MOSFETs with different continuous-current ratings of between 12A and 2A.



SiC4xx: PowerPAK package only 0.75mm high

The microBUCK® regulator's large safe operating area also gives designers the flexibility to support a wide range of operating-temperature and current requirements. This can result in a smaller board design, simpler thermal management and reduced system costs.

The microBUCK® architecture provides a very fast response to transient voltages with minimal output capacitance, while giving tight ripple regulation at light loads. It also maintains loop stability regardless of the type of output capacitor used.

Part	Maximum Continuous Current
SiC469	2A
SiC468	4A
SiC467	6A
SiC466	10A
SiC479	3A
SiC478	5A
SiC477	8A
SiC476	12A



- APPLICATIONS
- Industrial and factory automation
  - Home automation
  - Industrial computing
  - Base station power supplies
  - 5G network equipment
  - Small cells
  - Wall transformer regulation
  - Robotics
  - Drones
  - Battery management systems
  - Power tools
  - Vending and cash machines

- FEATURES
- Output-voltage range: 0.8V to 24V
  - Adjustable switching-frequency range: 100kHz to 2MHz
  - Adjustable soft-start
  - Adjustable current limit
  - Over-voltage protection
  - Under-voltage lock-out
  - Short-circuit protection
  - Over-temperature protection

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REFERENCE NUMBER **20-ii 10**

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6-10W · DC-DC Converter

- The Package of Chassis and DIN-Rail Mounting Version
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REFERENCE NUMBER **20-ii 11**

MINIMAX POWER SOLUTIONS 1-150W

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RAILWAY CERTIFIED

MEDICAL SAFETY

1-60W DC-DC Converters

2-60W AC-DC Power Supplies

1-60W DC-DC Converters

3-150W DC-DC Converters

1-20W DC-DC Converters

24-60W AC-DC Power Supplies



# BLDC motor reference design features compact FOC control board

**STMicroelectronics' EVALKIT-ROBOT-1 kit provides a ready-to-use Brushless DC (BLDC) servo motor reference design based on the highly integrated STSPIN32F0A motor controller system-in-package.**

**Plug-and-play servo control dev kit for drives, robotics and automation**

The kit's motor control board provides a power stage which features an analog circuit for current sensing and over-current protection, and a microcontroller with an Arm® Cortex®-M0 core which runs Field-Oriented Control (FOC) software with closed-loop position measurement. The board's footprint is just 40mm x 40mm. The STSPIN32F0A board controls a three-phase, 100W BLDC motor supplied in the kit. The motor includes magnetic Hall position sensors which provide accurate position measurements in combination with a 1,024-pulse incremental encoder. These help the system to achieve high torque density and low cogging torque.

**APPLICATIONS**

- Robotics
- Industrial equipment

**FEATURES**

- 36V/6A peak power output
- Control board supply-voltage range: 12V to 45V
- 3,950rpm nominal motor speed
- 207mNm nominal motor torque
- Dual 60V STL7DN6LF3 MOSFETs in power stage
- MODBUS communication through RS-485 interface

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REFERENCE NUMBER **20-ii 12**

**FREE DEVELOPMENT BOARD**  
 Orderable Part Number: EVALKIT-ROBOT-1  
 Apply at: [www.my-boardclub.com](http://www.my-boardclub.com)

# Integrated system-in-package provides complete PoE power stage

**STMicroelectronics' PM8805 is a system-in-package which provides a smart power supply to Power-over-Ethernet (PoE) Powered Devices (PDs) consuming up to 99.9W.**

The PM8805 consists of two active bridges and their drivers, a charge pump to drive the high-side MOSFETs, a hot-swap MOSFET, and an IEEE 802.3bt/at/af standard-compliant Ethernet interface. The device performs physical layer classification to correctly identify the type of Power-Sourcing Equipment (PSE) to which it is connected. The MOSFET in each active bridge is a 100V N-channel device which features 0.2Ω total path resistance. The hot-swap MOSFET is a 100V high-side N-channel device with 0.1Ω resistance. The PM8805 works with power either from the Ethernet cable or from an external power source such as a wall adapter. It is ideal as the interface section of PoE switch-mode power supplies which are required to meet very high efficiency targets. It provides a PGD signal which can be used to enable a PWM controller, a DC-DC converter or an LED driver.

**FREE DEVELOPMENT BOARDS**  
 The STEVAL-POE002V1 reference design is a two-stage converter for a powered device. It can provide up to 40W at 5V DC/8A from an appropriate four-pair PSE or an external auxiliary supply.  
 Orderable Part Number: STEVAL-POE002V1  


---

 This reference design is a 12V DC/8A converter with a PoE-PD interface and a DC-DC active clamp forward converter.  
 Orderable Part Number: STEVAL-POE005V1  
 Apply at: [www.my-boardclub.com](http://www.my-boardclub.com)

**APPLICATIONS**

- High-power wireless data systems
- Security cameras
- Access points
- Public information displays
- PoE lighting systems

**FEATURES**

- Supports 12V auxiliary sources
- Programmable classification current with 3.3ms delay
- Optional Autoclass feature
- Two-step hot-swap current protection
- Controlled pre-charge of the output capacitor
- Thermal shut-down protection

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REFERENCE NUMBER **20-ii 13**

# Miniature reed sensors offer long lifetime in position-sensing applications

**Littelfuse's 59166 series is a popular range of miniature, overmolded reed sensors which are typically used in electronics devices to detect the position of mechanical components such as doors or lids.**

This series of reed sensors is well suited to position and limit sensing, security applications, and door and window alarm systems. The 59166 sensors can be used in equipment which is exposed to high levels of moisture or contamination. They operate best when paired with Littelfuse's 57045 actuator. The 59166 sensors are supplied in a 16mm x 2.4mm x 2.4mm package with straight or gull-wing leads. They are configured as single-pole, single-throw switches which are normally open. The sensors' reed contacts last for millions of operating cycles when subject to the logic-level loads supplied by a microcontroller's signal outputs.

Part Number	Switching Power	Maximum Switching Voltage	Magnetic Sensitivity
59166-1-S-00-C	10W	200V DC	10-15 AT
59166-1-S-00-D	10W	200V DC	10-15 AT
59166-1-T-00-C	10W	200V DC	15-20 AT
59166-1-T-00-D	10W	200V DC	15-20 AT
59166-1-U-00-C	10W	200V DC	20-25 AT
59166-1-U-00-D	10W	200V DC	20-25 AT

# Ring-lug sensors perform accurate measurement of surface temperatures

Littelfuse offers a broad choice of probes with a ring lug assembly suitable for surface temperature measurement. For instance, the **USUR1000 series** products are UL recognized, ring lug thermistor probes manufactured using stable Negative Temperature Coefficient (NTC) chips. They are potted into a ring lug housing with thermally conductive epoxy. Providing a rapid thermal response and excellent long-term stability, these devices can be used in a wide range of surface temperature-sensing applications. The **USW3866** is a high-accuracy Resistance Temperature Detector (RTD) temperature probe with a ring lug suitable for a #10 mounting hole. Supplied with a PVC insulated lead wire, it provides a plastic strain-relief mechanism. Its maximum operating temperature is 105°C.



**RTDs**  
 Platinum Resistance Temperature Detectors (RTDs) are temperature sensors which have a positive, predictable and nearly linear change in resistance when subject to a change in their body temperature.

**NTC thermistors**  
 Thermistors are thermally sensitive resistors which produce a large, predictable and precise change in electrical resistance when subject to a change in body temperature. The resistance of a Negative Temperature Coefficient (NTC) thermistor falls when the body temperature rises. The resistance of a Positive Temperature Coefficient (PTC) thermistor rises when temperature rises.

**APPLICATIONS**

- Position and limit switching
- Security
- Door switch

**FEATURES**

- Two-part, magnetically-operated proximity sensor
- Molded stand-off allows for board washing
- Customer-defined sensitivity
- Suitable for reflow soldering
- Suitable for pick-and-place assembly

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REFERENCE NUMBER **20-ii 14**



# Switching regulator module operates over wide input-voltage range up to 72V DC

RECOM

A new high input-voltage switching regulator module, the R-78HE5.0-0.3 from RECOM, provides excellent versatility and quality for use in industrial equipment powered by a 48V battery.



The R-78HE5.0-0.3 supplies a regulated 5V output

RECOM's R-78HE5.0-0.3 is a low-cost industrial-grade regulator supplied in a classic 3-pin SIP format. It accepts an input voltage of up to 72V DC, and provides a tightly regulated 5V output at a maximum 300mA current. It includes built-in short-circuit protection.

The module operates over a wide ambient-temperature range of -40°C to 105°C without load de-rating. It is also exceptionally reliable: mean time before failure is 15 million hours. Consistently high quality is assured, as production is carefully controlled in an IATF 16949-certified factory.



## APPLICATIONS

- Industrial CAN bus devices
- 36V/48V lithium-ion battery-powered equipment
- Off-grid solar power supplies
- Remote powered units with long supply cables

## FEATURES

- ±1% output voltage tolerance
- High efficiency
- Low ripple and noise
- 100V surge capability

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REFERENCE NUMBER **20-ii 15**

# New six-axis inertial measurement module features machine learning core



The new LSM6DSRX from STMicroelectronics is an Inertial Measurement Unit (IMU) which features a three-axis digital accelerometer and a three-axis digital gyroscope with an extended full-scale range up to ±4,000 degrees/s. It is suitable for applications which need high accuracy and high stability over temperature and time.

The LSM6DSRX embeds a broad range of advanced activity-recognition capabilities, including a pedometer, step detector and step counter, for use in wearable and programmable sensors based on the Android™ mobile operating system. It also performs standard interrupt functions such as free-fall, wake-up, 6D/4D orientation, and click and double-click detection.

In response to growing demand for the application of artificial intelligence in embedded systems, ST provides a machine learning core in the LSM6DSRX, enabling developers to implement software through which the device can classify motion data based on known patterns.

The machine learning processing capability allows the designer to implement motion-detection algorithms for functions such as fitness logging, wellness monitoring, personal navigation and fall detection on the sensor rather than on an application processor. This reduces power consumption and latency in motion-based applications.



LSM6DSRX: Outputs are stable over time and temperature

## FREE DEVELOPMENT BOARD

The STEVAL-MKI195V1 adapter board can be plugged into a standard DIL 24 socket. It provides access to all the LSM6DSRX's pins. It is supported by the STEVAL-MKI109V3 motherboard, which has a high-performance 32-bit microcontroller functioning as a bridge between the sensor and a PC.

Orderable Part Number: STEVAL-MKI195V1

Apply at: [www.my-boardclub.com](http://www.my-boardclub.com)



## APPLICATIONS

- Motion tracking and gesture detection
- Sports and activity equipment
- Virtual and augmented reality equipment
- Sensor hubs
- Indoor navigation
- IoT and connected devices
- Camera image stabilization
- Robotics and machine control
- Vibration monitoring and compensation

## FEATURES

- Smart FIFO up to 9kbytes
- ±2g/±4g/±8g/±16g full-scale accelerometer range
- ±125°/±250°/±500°/±1,000°/±2,000°/±4,000° per second full-scale gyroscope range
- ±0.007%/°C change of angular rate sensitivity over temperature
- Analog supply-voltage range: 1.71V to 3.6V
- SPI, I²C and MIPI I3CSM serial interfaces
- Supports S4S sensor synchronization on Qualcomm processors
- Significant motion detection
- Tilt detection
- Programmable finite state machine
- Embedded temperature sensor

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REFERENCE NUMBER **20-ii 16**

# New space-saving board-level connectors have 2mm centerline



TE Connectivity (TE) has expanded its range of AMPMODU interconnection solutions with the introduction of board connectors which have a 2mm centerline. These new connectors occupy 38% less space than traditional 2.54mm centerline products.



AMPMODU: Surface-mount and through-hole versions

The AMPMODU parts are intended for use in applications in which space constraints are of particular concern. The new 2mm offerings include breakaway headers and board-to-board receptacles, both supporting automated surface-mount, through-hole reflow (Pin-in-Paste), and traditional through-hole mounting processes. The 2mm board-to-board receptacles use phosphor bronze contacts with dual cantilever beams which are available in three gold plating thicknesses. The dual-beam design provides for an increased contact surface area between the header pin and the receptacle contact, ensuring reliable signal transfers. The AMPMODU portfolio includes various top- and dual-entry vertical and horizontal receptacles which offer multiple options for board-to-board stacking of header and receptacle combinations. The 2mm breakaway headers can be mounted on to boards with thicknesses of 1.6mm and 2.4mm, providing customers with a wide range of options for PCB assembly. They are molded in a flame-retardant, UL 94V0-recognised thermoplastic material which is resistant to reflow soldering temperatures, and provides for safe operation in harsh environments.



## APPLICATIONS

- Programmable logic controllers
- Industrial I/O devices
- Servo drives
- Materials handling equipment
- Building and home automation devices
- Industrial robotics
- Instrumentation and test equipment

## FEATURES

- Single- and double-row options
  - Up to 25 positions per row
- 2A maximum current rating
- 650V AC dielectric withstanding voltage
- 125V DC operating voltage
- Operating-temperature range: -40°C to 125°C

FOR PRICING AND SAMPLES E-MAIL: [INFO@MY-FTM.COM](mailto:INFO@MY-FTM.COM)

REFERENCE NUMBER **20-ii 17**

TE Connectivity, TE, TE Connectivity (logo), and AMPMODU are trademarks



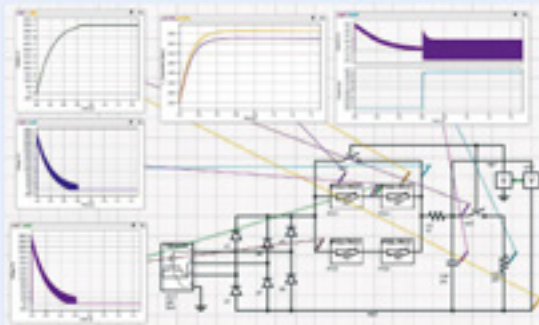
# PTCEL INRUSH CURRENT LIMITING THERMISTORS THROUGH-HOLE HIGH ENERGY CERAMIC DISCS

## APPLICATIONS

- AC/DC and DC/DC converters
- Load dump and DC-Link circuits
- Battery charging equipment
- Welding equipment
- Motor drives

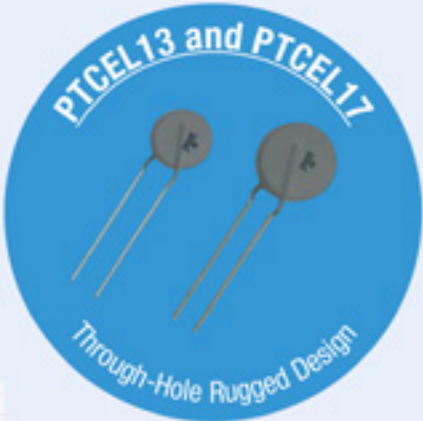


INRUSH CURRENT LIMIT / LOAD DUMP /  
SAFE EMERGENCY DISCHARGE / PRE-CHARGE  
Simulation on SystemVision® Cloud



FOR MORE DETAILS AND DATA E-MAIL: [INFO@MY-FTM.COM](mailto:INFO@MY-FTM.COM)

REFERENCE NUMBER **20-ii 18**

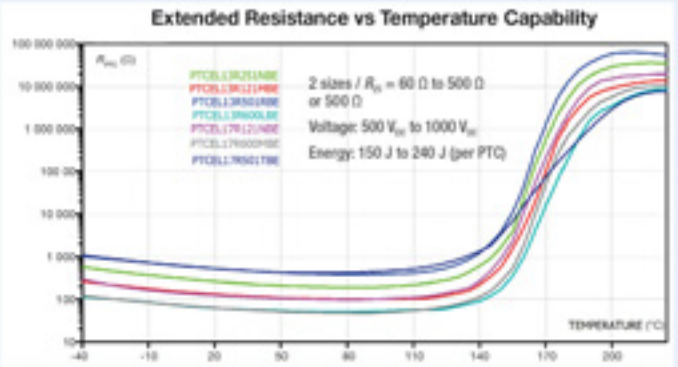


## SPECIAL FEATURES

- Up to 1000 V withstanding
- Up to 105 °C ambient temperature
- Self-protected against overheating

## MULTIPLE DESIGN TOOLS AVAILABLE

- LTspice® models available with Monte Carlo tolerances [\(online\)](#)
- VHDL-AMS models available (live tunable design [online](#) on SystemVision® Cloud website)
- 3D models available [\(online\)](#)





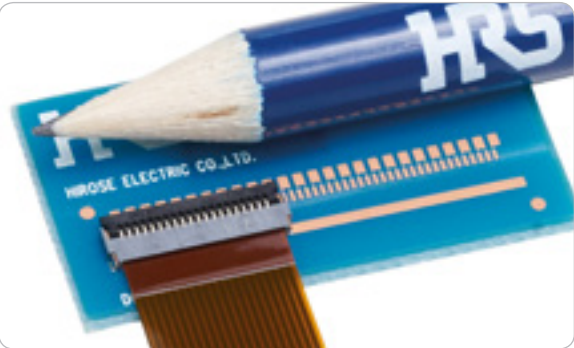
# Back-flip FPC/FFC connectors offer board layout flexibility

**HIROSE ELECTRIC EUROPE B.V.**  
 Hirose's FH34SRJ series of Flexible Printed Circuit (FPC) and Flexible Flat Cable (FFC) connectors provide a way for the PCB designer to gain flexibility in board layout.

The FH34SRJ connector, which is available in versions offering between four and 50 contacts, accepts FPC and FFC in both top- and bottom-contact formats. A short mounted depth of only 3.2mm is required with a 0.5mm pitch, saving board space.

Despite the FH34SRJ's light weight of just 0.098g, the contact has a unique structure which offers high retention force. The horizontal pull-force for the six-contact version is 3.0N for the top contact and 6.0N for the bottom contact. A retention tab holds the actuator from above to ensure it is securely held when rotated.

Furthermore, the contact has a unique curved shape which supports the actuator axle. The user-friendly actuator lock is supplied in the open position, and only a two-step operation is required: inserting the FPC/FFC, followed by closing the actuator.



FH34SRJ: High retention force

APPLICATIONS

- Small medical devices
- Notebook and tablet PCs
- Smartphones
- Portable gaming equipment
- Portable music players

FEATURES

- 1mm height
- Protocol compatibility:
  - USB 3.1
  - eDP 1.3
  - MIPI D-PHY 1.1
- 0.5A maximum rated current
- 50V AC/DC rated voltage
- Operating-temperature range: -55°C to 85°C
- 20 mating cycles

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REFERENCE NUMBER **20-ii 19**

# New snap-cap connector enhances power and signal transmission in harsh environments

**TE Connectivity** has extended its DEUTSCH DT range of connectors for use in harsh conditions, introducing a wire-to-wire snap-cap design. This means that the DT 2/3 series now includes three versions: the existing standard version, the welded seal cover, and the new snap-cap design.

The new DT Snap-Cap plugs include an enhanced front seal retention and secondary wedge-lock design.

At the same time, the interface plug's front seal is fully serviceable in the field if a replacement is needed, a key advantage over non-replaceable, molded-in designs.

The new connectors offer interface compatibility with all previous mating connectors and interfaces, enabling a seamless transition from legacy products to future designs.

The DT Snap-Cap series is used for wire-to-wire connections on integrated header modules for low power transmission and signal-level communications. The new connectors share the rugged, circular common contact system found in other DEUTSCH connector products.

The DEUTSCH DT 2/3 position connectors provide for easy contact insertion and removal and uncomplicated mating and unmating.



DEUTSCH DT connectors: Plug's seal can be replaced in the field

APPLICATIONS

- Transportation
- Marine equipment
- Industrial systems
- Aerospace and defence equipment

FEATURES

- 13A maximum continuous current
- 7.5mΩ maximum contact resistance
- Improved wire alignment to maximize seal performance under wire side-load conditions
- IP67 or IP68 protecting ratings
- Operating-temperature range: -55°C to 125°C

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REFERENCE NUMBER **20-ii 21**

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# Tantalum capacitors in small case sizes offer new low resistance values

**VISHAY**  
 Vishay Intertechnology's T55 and TR3 series of tantalum capacitors provide developers with two options for integrating capacitance with low equivalent series resistance into system designs.

The T55 series of vPolyTan™ surface-mount polymer tantalum chip capacitors has recently been extended to include new devices in the D case size (EIA 7343-31). These new parts offer low ESR values from 9mΩ down to 7mΩ.

Previously only found in larger case sizes, the single-digit ESR values of these new capacitors are as much as 5mΩ lower than those typically found in devices housed in a D case. The low ESR of these T55 capacitors results in a lower voltage drop, better frequency response, and



T55/TR3 capacitors are available in capacitance values up to 1,000µF

higher ripple-current ratings up to 5.67A<sub>rms</sub>, cutting the number of capacitors required on the PCB.

The T55 series parts range in capacitance from 3.3µF to 1,000µF over voltage ratings from 2.5V to 63V, with a capacitance tolerance of ±20%. The devices are optimized for power management, battery decoupling and energy storage.

Vishay's TR3 series of solid tantalum capacitors are available in the A, B, C, D, E and W case sizes. Offered with voltage ratings ranging from 4V to 75V and with capacitance values from as low as 0.47µF to as high as 1,000µF, they feature ESR values as low as 45mΩ.

Maximum ripple-current handling capability at 100kHz spans the range from 0.1A to 2.5A. In the C, D and E case size variants, the TR3 capacitors are 100% surge-current tested.

The TR3 devices are intended to perform decoupling, smoothing, bulk energy-storage and filtering functions.

APPLICATIONS

- Servers
- Telecoms infrastructure equipment
- Solid-state drives
- Wireless transceivers
- Power distribution systems
- Gaming equipment
- Video systems
- Smart meters
- Lighting

FEATURES (T55)

- High ripple-current capability
- Stable capacitance across operating-temperature range
- Good capacitance stability over frequency range
- No wear-out effect
- Operating-temperature range: -55°C to 105°C

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REFERENCE NUMBER **20-ii 20**

# Through-hole inductor offers stable inductance and saturation at up to 180°C

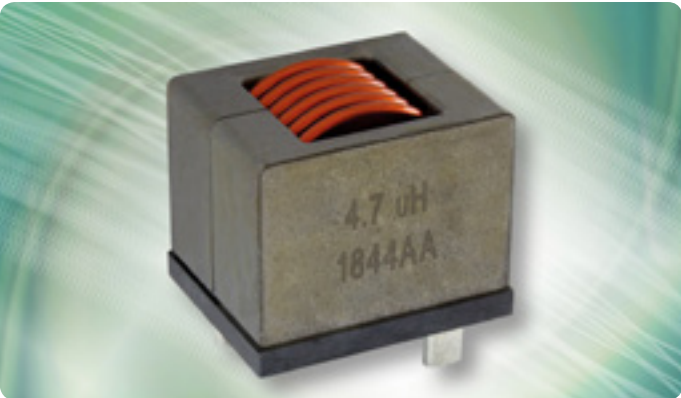
**VISHAY**  
 Vishay Intertechnology has introduced a new IHDM edge-wound, through-hole inductor which is rated for current up to 150A and for high-temperature operation at up to 180°C.

Featuring a powdered iron-alloy core, the Vishay IHDM-1008BC-30 provides stable inductance and saturation over an operating-temperature range of -40°C to 180°C. Its rated current and saturation current are 30% higher at 125°C than those of competing ferrite-based inductors.

The IHDM-1008BC-30's low DC resistance minimizes power losses for increased efficiency in applications such as DC-DC power conversion, inverters, and noise suppression in motors and switch-mode power supplies. Soft saturation provides a predictable inductance decrease as current increases, independent of temperature.

Inductance values for the IHDM-1008BC-30 parts range from 1.2µH to 10µH. Heat rating current ranges from 30A to 80A.

Custom mounting options are available on request.



IHDM-1008BC-30: Higher ratings than ferrite-based inductors

APPLICATIONS

- Inverters
- Electric motors
- High-power switch-mode power supplies
- Industrial solar power generators
- Electric vehicle charging stations
- Military systems

FEATURES

- Case size: 25mm x 20mm x 23mm
- DC resistance range: 0.25mΩ to 1.70mΩ
- 350V maximum operating voltage
- Stripped and tinned terminals for through-hole mounting

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REFERENCE NUMBER **20-ii 22**



# Condition monitoring: a comparison of vibration sensor technologies



 **By Bjorn Ryden**  
Global Product Manager, Vibration Sensors,  
TE Connectivity

In the past, accelerometers were primarily used for heavy, high-end machinery such as windmills, industrial pumps, compressors and Heating, Ventilation and Air-Conditioning (HVAC) systems. Driven by increased automation, demand is rising for use in smaller systems produced in higher volume, such as machine spindles, conveyor belts, sorting tables and machine tools which require better predictive maintenance.

Machine downtime in these applications has an important effect on the customer experience and on profitability. Digital systems for condition monitoring can help extend operating lifetimes and eliminate unplanned downtime. An accelerometer is a key component of condition monitoring circuits. This Design Note compares the principal accelerometer technologies used today in industrial condition monitoring systems.

## Key performance indicators of vibration monitors

For industrial condition monitoring and predictive maintenance applications, a small number of vibration measurement parameters are of critical importance.

**Wide frequency response** – to detect all possible failure modes of an electric motor, the frequency response of the accelerometer should be 40 to 50 times the motor speed expressed in revolutions per minute (rpm). For fans and gearboxes, the minimum upper limit of the accelerometer should be 4 to 5 times the blade passing frequency.

**Resolution and dynamic range** – the resolution of the vibration sensor is a function of the amplitude of the output signal to the broadband noise of the onboard electronics. An accelerometer with a superior signal output will allow the measurement of smaller vibrations. A sensor which can measure vibration of a lower amplitude enables the end user to predict a fault earlier than a sensor which has a lower dynamic range. As a general rule, reliable measurement calls for an output signal 10x stronger than the noise generated by the sensor.

**Long-term stability** – drift is a shift in the sensitivity and/or the measurement output when the input is zero. A shift in the sensitivity of the accelerometer could over time lead a monitoring application to issue a false alarm. A shift in the zero-output measurement will have the same effect. Piezoelectric sensors do not provide a DC response, so they are not susceptible to zero-output drift, only to sensitivity drift. A MEMS accelerometer can suffer from both zero-output drift and sensitivity drift over time.

## The two principal types of accelerometer technology

**Piezoelectric accelerometers** incorporate piezoelectric crystals which supply a signal when stressed by external excitation such as vibration. Most piezoelectric sensors are based on lead Zirconate Titanate (PZT) ceramics which are polarized to align the dipoles and make the crystals piezoelectric. PZT crystals are ideal for condition monitoring applications since they offer a wide operating-temperature range, broad dynamic range, and wide frequency bandwidth of >20kHz.

**Variable Capacitance (VC) vibration sensors** derive their acceleration measurement from a change in capacitance of a seismic mass moving between two parallel capacitor plates. The change in capacitance is directly proportional to the applied acceleration. VC accelerometers require an IC to be closely coupled to the sensing element to convert the very small capacitance changes into a voltage output. This conversion process can result in a poor signal-to-noise ratio and limited dynamic range.

VC sensors are typically manufactured from silicon wafers and are fabricated into miniature Micro-Electromechanical Systems (MEMS) chips.

## Technology comparison

Tests performed by TE Connectivity (TE) reveal the important differences in performance between the two types of accelerometer. The tests were conducted with a piezoelectric and a VC accelerometer which both had a full-scale range of  $\pm 50g$ .

## Frequency response

The frequency response of the two accelerometers was tested on a SPEKTRA CS18 HF high-frequency shaker with a range of 5Hz to 20kHz. The sensors were securely mounted to ensure accurate results over the full test range, as shown in Figure 1. Three sensors of each technology were tested.

A maximum  $\pm 1dB$  amplitude deviation is assumed as the usable bandwidth, although a tighter deviation of  $\pm 5\%$  is often used for bandwidth tolerance.

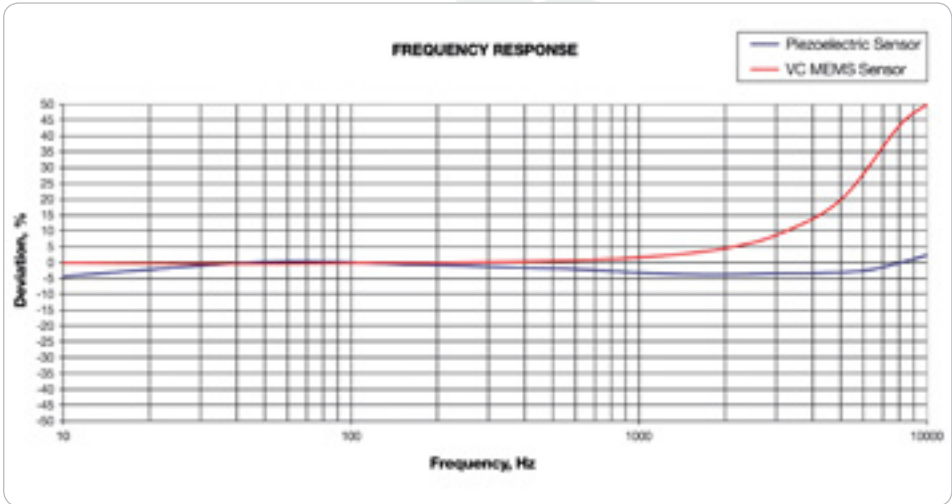


Fig. 1: Comparison of the typical frequency response of piezoelectric and MEMS accelerometers

RESIDUAL NOISE COMPARISON AT VARIOUS BANDWIDTH				
Model	0.03 ~ 300Hz $\mu V_{rms}$	0.03 ~ 1KHz $\mu V_{rms}$	0.03 ~ 3KHz $\mu V_{rms}$	0.03 ~ 10KHz $\mu V_{rms}$
Piezoelectric #1	27.2	30.8	39.5	57.6
Piezoelectric #2	25.1	31.7	38.6	56.3
MEMS #1	377.6	405.2	412.7	498.2
MEMS #2	415.7	430.2	453.9	532.1

Fig. 2: Measurements of noise tests on piezoelectric and MEMS accelerometers

MEASUREMENT RESOLUTION COMPARISON					
Model	Resolution $mg_{rms}$	Residual Noise $\mu V_{rms}$	Spectral Noise $\mu g_{rms}/\sqrt{Hz}$	Dynamic Range dB	Resolution Bit
Piezoelectric #1	1.4	57.6	14.4	88	14.6
Piezoelectric #2	1.4	56.3	14.1	88	14.6
MEMS #1	12.5	498.2	124.6	69	11.5
MEMS #2	13.3	532.1	133.0	68	11.4

Fig. 3: Comparison of the resolution of the piezoelectric and MEMS sensor types

The data indicate that the VC MEMS sensor has a usable bandwidth up to 3kHz, while the piezoelectric sensor has a usable bandwidth of >10kHz.

It is worth noting that the low frequency cut-off for the piezoelectric sensor was at 2Hz, while the MEMS sensor operates down to 0Hz since it is a DC-response device.

## Measurement resolution and dynamic range

To determine the measurement resolution and dynamic range of the piezoelectric and VC MEMS sensors, the samples were tested in a noise-isolated chamber with high-resolution measurement equipment. The units were installed in the same chamber and tested at the same time to eliminate any errors from outside environmental interference.

The measurements were conducted at four distinct bandwidth settings, and the residual noise was measured at each setting, as shown in Figure 2.

The measurement resolution and dynamic range were calculated based on a 0.03 to 10kHz bandwidth, as shown in Figure 3. The resolution of the piezoelectric sensors is around nine times better than that of the VC MEMS sensors. This results in a markedly better dynamic range, which enables the end user to detect potential problems much earlier.

## Long-term stability

The long-term stability of piezoelectric sensors is well documented: these devices have been operating in the field for more than 30 years.

Piezoelectric crystals are inherently stable over time. The long-term drift parameters depend on the crystal formulation used, so an actual value is difficult to present. Quartz has the best long-term stability, but it is rarely used in condition monitoring applications because of its limited output and high cost.

PZT crystals are the most commonly used type in piezoelectric accelerometers, and are increasingly becoming the crystal of choice for most other applications.

VC MEMS accelerometers also have wide specification limits for long-term drift depending on the MEMS design structure. A bulk micromachined MEMS sensor will have the best long-term drift but will also be markedly more expensive, and typically only used in inertial applications.

For condition monitoring, MEMS vendors offer surface-micromachined VC MEMS sensors, which are much less expensive, but the end user will sacrifice measurement resolution and long-term stability. The MEMS structure of surface-micromachined designs is less stable than that of bulk-micromachined MEMS sensors.

## Sensor output options

Depending on the installation and application, a choice of sensor output-signal options may be necessary. Most current predictive maintenance installations require an analog signal from the sensor, so the end user can decide on which parameters to monitor for a particular type of machinery.

Typically, the signal output is driven by the data acquisition device's or programmable logic controller's interface; an analog output of  $\pm 2V$  or  $\pm 5V$  is the most common choice. In installations requiring long cable lengths, however, loop-powered 4 to 20mA sensors are also common.

In the digital factory of tomorrow, digital output signals will become more widely required, as will smart sensors with onboard microprocessors which can make immediate maintenance decisions for the end user.

Both these output-signal options are available in piezoelectric and VC MEMS sensors.

## Summary of the technology comparison

All or some of the performance parameters discussed above will help the customer make an intelligent decision on the right technology for the condition monitoring installation. Table 1 provides an overview of the factors to consider.

In condition monitoring applications, products from TE Connectivity offer superior performance, high reliability and a long operating lifetime. Examples include:

- 820M1, a single-axis, surface-mount piezoelectric accelerometer which has a bandwidth of >10kHz, and which offers a choice of dynamic ranges from  $\pm 25g$  to  $\pm 500g$
- 830M1, a triaxial, surface-mount piezoelectric accelerometer which has a bandwidth of >10kHz, and which offers a choice of dynamic ranges from  $\pm 25g$  to  $\pm 500g$

Key Parameter	Piezoelectric	MEMS VC
Wide Frequency Response	●	–
Long-term Signal Stability	●	–
Dynamic Range	●	–
Operating Temperature Range	●	●
Packing Options	●	●
Ease of Installation	●	●
Sensor Output Options	●	●

Table 1: Summary of the benefits of the two vibration sensor

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**20-ii 23**

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# How to design an efficient DC-DC converter which has a wide input-voltage range



By Roy Shoshani  
Vice President, Power and Linear IC Division,  
Vishay

One of the biggest challenges in system design is powering the next generation of microprocessors, DSPs, FPGAs and ASICs used in servers, telecoms equipment and IoT devices. Maintaining high performance and a high power output becomes even more difficult as processors get faster, the available space contracts, and power requirements increase. This is the challenge in applications such as 5G small cells, radio units, and robots.

These emerging applications demand efficient DC-DC conversion with high power density. So system designers need a DC-DC converter solution which is simple to work with, while providing features such as a wide input-voltage range and ultra-fast transient response. The best solutions will integrate multiple functions into a single, compact package.

Designers have many options to choose from, varying not only by supplier but also by the level of integration. At one end of the spectrum are traditional solutions which are comprised of a controller IC, discrete MOSFETs, and numerous passive components. This discrete approach provides a high level of flexibility and potentially a lower bill-of-materials cost, but takes longer to design and validate. It is a riskier strategy too, given the high level of technical expertise it requires.

More recently, solutions have emerged which integrate the controller IC and power MOSFETs into a single package. This approach provides higher efficiency while enabling faster switching and more features and protection functions included in a compact package.

At the far end of the integration spectrum are power modules in which both active and passive devices are combined into a single package. Until now, however, they have remained out of reach of many applications because of their higher prices, a result of a module's large size and low production volume, which tend to increase manufacturing costs.

Semiconductor manufacturers are working to improve product performance and to lower costs with innovations in silicon and the use of new wide-bandgap materials such as silicon carbide or gallium nitride. This same process enables manufacturers to implement converter designs in smaller packages.

A smaller package comes at a cost, however. One of the main challenges in DC-DC converters is the dissipation of heat. As the component's cross-section shrinks, component density is pushed higher and thus the PCB temperature rises, since most of the component's heat is dissipated through the PCB even when a heat-sink is available.

With this challenge in mind, Vishay engineers have developed a new type of DC-DC converter module, the microBRICK™ module, in which the package's footprint is barely bigger than that of the inductor alone. In other words, the real estate occupied by the IC and the power MOSFET has been shrunk to nearly zero, yet they still provide better performance than many competing solutions.

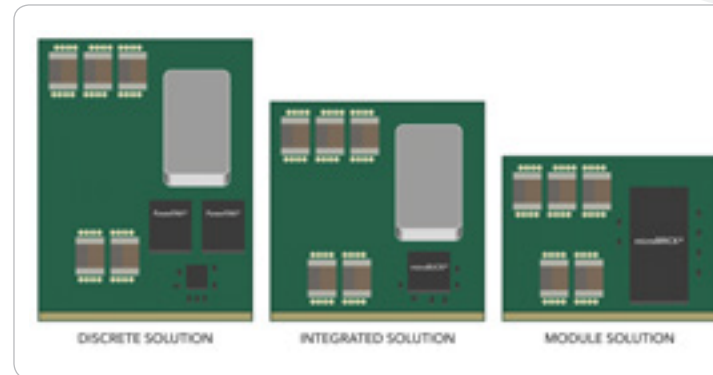


Fig. 1: How integration has advanced in DC-DC converters

An innovative solution, the microBRICK package offers several advantages, both thermal and electrical. It addresses the problem of heat dissipation in two ways: first, the hottest component, typically a power MOSFET, is thermally coupled to a larger, cooler component, the inductor. This thermal structure is better because the inductor acts like a built-in heat-sink.

The second advantage, which is also thermal, is the better use of the large area under the inductor for dissipating heat from the MOSFET. Placing the MOSFET underneath the inductor allows a much larger cross-section to the PCB without occupying any additional area.

From an electrical perspective, the 3D structure of the Vishay module eliminates the resistance in PCB interconnect between the inductor and the switching node. This parasitic resistance is governed by the thickness of the PCB's top copper layer, which is typically specified as less than 2oz (57g). This resistance is often as high as that of the MOSFET's on-resistance and the inductor's DC resistance.

This unique structure provides lower conduction losses and superior thermal performance, which results in a lower junction temperature.

Meanwhile, the lower temperature of the high-efficiency microBRICK module enables improved reliability and a larger safe operating area, to support higher ambient temperatures or to compensate for smaller board space.

Measuring only 10.6mm x 6.5mm and with an industry-low 3mm profile, Vishay's microBRICK module offers a 30% smaller area and >50 % smaller volume when compared to the closest competing module. Unlike BGA and LGA packages, the device's wettable-flank power QFN package improves board-level reliability, and simplifies assembly and testing, while providing production operations with automatic inspection capability.

Perhaps most impressively, a microBRICK module such as the Vishay SiC931 is capable of delivering 20A continuous current at a switching frequency of up to 2MHz, while providing an adjustable output voltage of as low as 0.6V from an input rail of 4.5V to 24V. Additionally, the architecture supports ultra-fast transient response with minimal output capacitance and tight ripple regulation at very light loads.

The efficiency of the SiC931, as shown in Figure 3, was measured at room temperature on a 2" x 2" six-layer PCB with no airflow.

Building a high-efficiency DC-DC converter with a wide input-voltage range is made much simpler by use of a microBRICK module, which integrates the controller, power stage and inductor in a single compact package. Only a small number of off-the-shelf resistors and capacitors are required to complete the design.

The smaller size of a circuit based on a microBRICK product provides a more affordable total solution compared to other modules, while still offering better performance in parameters such as efficiency and transient response.

The SiC931 is the first member of Vishay's microBRICK family. Other members, sharing the same form factor, include the SiC967 and SiC951. The SiC967 features a 4.5V to 60V input-voltage range with output current of 6A.

The SiC951 offers a 4.5V to 20V input-voltage range and 20A output current, and supports a PMBUS 1.3-compliant digital interface with full configuration and telemetry capabilities.

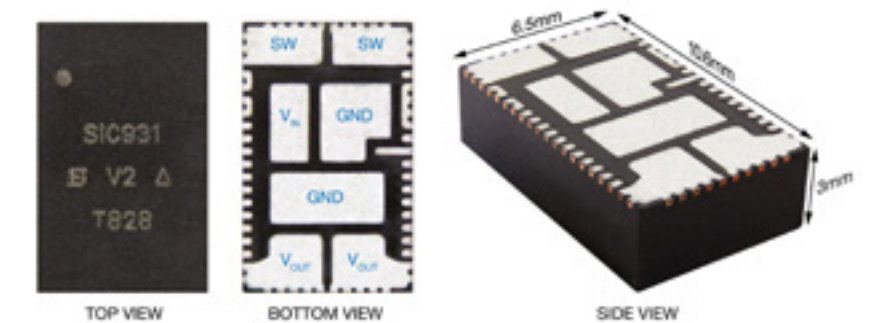


Fig. 2: The microBRICK package

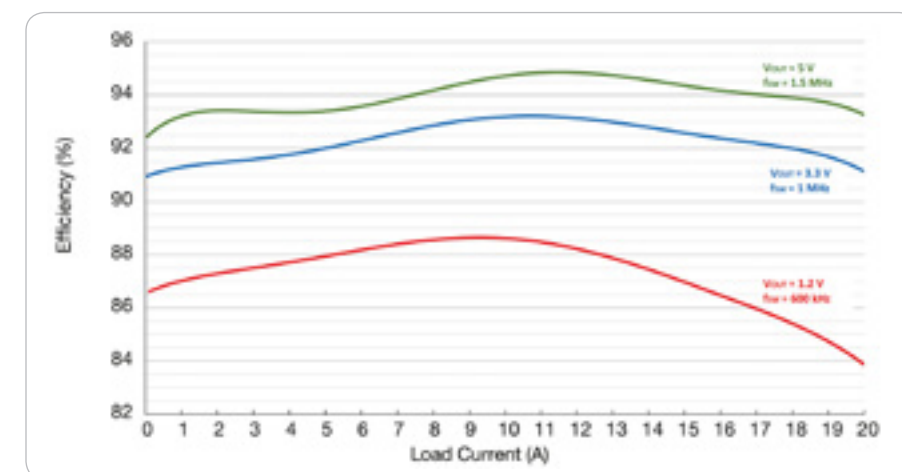
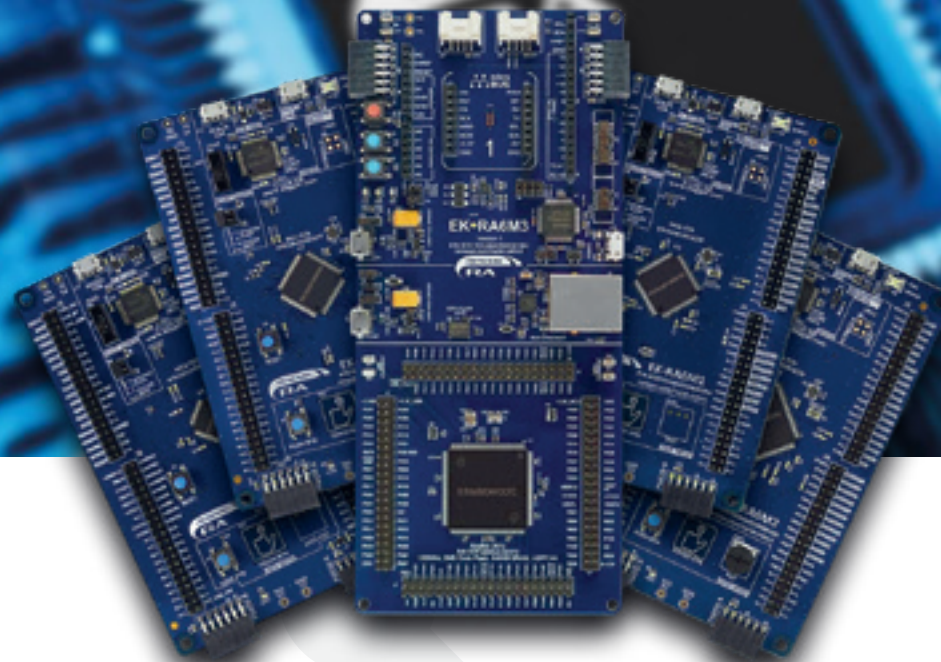


Fig. 3: Efficiency of the SiC931 microBRICK module

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**20-ii 24**





## Broad new family of Arm Cortex-M-based MCUs offers high security and software flexibility

**The Renesas RA family is a new range of 32-bit MCUs which is based on the Arm® Cortex®-M core architecture, and which benefits from Renesas' best-in-class technology for embedded system peripherals.**

The RA family includes the RA2, RA4 and RA6 series, giving users a wide choice of performance ratings and features. Designers using the Renesas RA family can meet the requirements for scalability, power consumption and performance of almost any embedded end product.

The launch of the RA family offers a new option for designers working in an Arm Cortex-M environment, and who want to retain existing software assets.

It is an alternative to the Renesas Synergy™ family of MCUs, which includes parts based on various Arm Cortex-M cores. Synergy is an excellent solution for customers wanting a complete off-the-shelf software platform solution, giving them very fast time to market.

The RA family is an alternative for customers who want the freedom to choose their own software environment and to be able to reuse their existing software assets.

Now the addition of the RA MCU family gives designers a Renesas option which offers the flexibility to use existing and legacy software for the Arm Cortex-M architecture.

Compared to competing Arm Cortex-M-based MCUs, the RA family provides stronger embedded security, superior CoreMark® performance, and lower-power operation. Certification for Arm's Platform Security Architecture provides customers with the confidence to quickly deploy secure IoT endpoint and edge devices, and smart factory equipment for Industry 4.0 applications.

There is broad feature and pin compatibility across the three series of RA MCUs.

This provides scalability and easy code re-use between one device and another. The RA family includes:

- RA2A1, offering highly integrated, high-accuracy analog capabilities and an Arm Cortex-M23 core

- RA4M1, for control applications which drive a segment LCD panel. It offers low-power operation and high performance thanks to its Arm Cortex-M4 core
- RA6M1, ideal for IoT endpoint devices because of its high-level security features
- RA6M2, suitable for automation applications. Upward-compatible with RA6M1 devices.
- RA6M3, offering the highest performance specifications in the family, with the largest memory options and a rich feature set including TFT LCD controller, 2D graphics engine, Ethernet connectivity and Hi-Speed USB. Like the other RA6 devices, the RA6M3 is based on an Arm Cortex-M4 core.

The RA family MCUs include an integrated capacitive touch-sensing unit for display control.

The Renesas RA Flexible Software Package (FSP) gives a quick and versatile way to build secure connected IoT devices, and provides production-ready peripheral drivers to help users take advantage of the RA FSP ecosystem.

## Dev kits provide rich evaluation environment for Renesas RA series microcontrollers

**Renesas provides full-featured development kits for each of the series of products in its new Renesas RA family of 32-bit microcontrollers, which are based on the Arm® Cortex®-M core architecture.**

The RA family includes the RA2, RA4 and RA6 series, giving users a wide choice of performance ratings and features. Designers using the Renesas RA family can meet the requirements for scalability, power consumption and performance of almost any embedded end product.

The range of RA family evaluation kits includes:

- **EK-RA2A1** (RTK7EKA2A1S00001BU), which features the R7FA2A1AB3CFM, a 48MHz MCU based on an Arm Cortex-M23 core. The MCU includes 256kbytes of code-storage Flash and 32kbytes of RAM.
- **EK-RA4M1** (RTK7EKA4M1S00001BU), which features the R7FA4M1AB3CFP, a 48MHz MCU based on an Arm Cortex-M4 core. This also includes 256kbytes of code-storage Flash and 32kbytes of RAM.
- **EK-RA6M1** (RTK7EKA6M1S00001BU), which features the R7FA6M1AD3CFP, a 120MHz MCU based on an Arm Cortex-M4 core. This includes 512kbytes of code-storage Flash and 256kbytes of RAM.
- **EK-RA6M2** (RTK7EKA6M2S00001BU), which features the R7FA6M2AF3CFB, a 120MHz MCU based on an Arm Cortex-M4 core. It has 1Mbyte of code-storage Flash and 384kbytes of RAM.
- **EK-RA6M3** (RTK7EKA6M3S00001BU), which features the R7FA6M3AH3CFC, a 120MHz MCU based on an Arm Cortex-M4 core. It has 2Mbytes of code-storage Flash and 640kbytes of RAM. It also includes an Ethernet interface and a USB Hi-Speed Host and Device interface.
- **EK-RA6M3G** (RTK7EKA6M3S01001BU), a special version of the EK-RA6M3 development kit which includes extra support for a graphics interface. It has a graphics expansion board featuring a 4.3" TFT color LCD with capacitive touch overlay.

Each board provides native access to the MCU's pins via four 40-pin male headers. It also provides current-measurement points for monitoring the current through the MCU.

All these boards support up to two PMOD connections. The EK-RA6M3 and EK6M3G kits also offer additional expansion options to popular platforms, including Seeed Grove® system (I²C), Digilent Pmod™ (SPI and UART), Arduino™ (Uno R3) or MikroElektronika™ mikroBUS connectors.



### APPLICATIONS

- Home automation
- Industrial automation
- Building automation
- Energy management systems
- Healthcare equipment
- Industrial IoT devices

### FEATURES

- Supported by open Flexible Software Package (FSP)
  - Based on FreeRTOS
  - Can be replaced by any other RTOS or middleware
- IDE support:
  - Renesas e²studio
  - KEIL® MDK
- Supports GNU Arm Compiler version 6
- Emulator support:
  - Segger J-Link
  - Renesas E2 emulator, E2 Lite emulator
- Renesas PG-FP6 Flash memory programmer or third-party solutions

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REFERENCE NUMBER  
**20-ii 25**



# Security MCUs offer improved efficiency and signal processing

**NXP** Semiconductors has added new products to its LPC5500 series of microcontrollers to add higher efficiency and better signal processing to the existing rich set of security features.



Like earlier LPC5500 MCUs, the LPC5556x devices are based on an Arm® Cortex®-M33 core running at up to 150MHz, a secure processor which supports Arm's TrustZone® technology, and provides many cryptographic functions. The new LPC5556x MCUs take advantage of the new Armv8-M architecture to offer higher performance and more advanced security capabilities, including TrustZone-M and co-processor extensions. A proprietary DSP accelerator which cuts the number of clock cycles by a factor of 10 produces more efficient signal processing. An optional Cortex-M33 co-processor offers the flexibility to balance high performance and power efficiency. The LPC5556x MCUs are intended for use in applications which require strong protection of the host device, and of user data and privacy.

Their security capabilities include:

- PRINCE module which performs real-time encryption and decryption of data stored on-chip
- AES-256 cryptography engine
- Secure Hash Algorithm (SHA2) module supporting secure boot with dedicated DMA controller
- Physical Unclonable Function using a dedicated SRAM
- Random number generator
- 128-bit unique device serial number for identification
- Secure general-purpose I/O

The MCUs' CASPER co-processor also enables hardware acceleration for various functions required for certain asymmetric cryptographic algorithms. The LPC5556x parts are backed by NXP's MCUXpresso software and tools ecosystem and a choice of low-cost development boards.



APPLICATIONS

- Building control and automation
- Consumer electronics
- Diagnostic equipment
- Industrial IoT
- Machine learning
- Security applications

FEATURES

- Up to 640kbytes of Flash program memory
- Up to 320kbytes of SRAM
  - 288kbytes on system bus
  - 32kbytes on core bus
- 1Msamples/s, 16-bit ADC with five differential channel pairs or ten single-ended channels
- Integrated temperature sensor
- Comparator with five input pins and external or internal reference voltage

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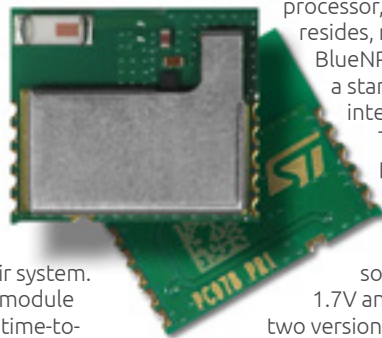
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REFERENCE NUMBER **20-ii 26**

# Certified Bluetooth Low Energy radio module provides for fast time-to-market

**STMicroelectronics' BlueNRG-M0 is an easy to use Bluetooth® Low Energy master/slave network processor module which supports multiple roles simultaneously, and can act at the same time as a Bluetooth Low Energy sensor and hub device.**

The BlueNRG-M0 module provides a complete short-range RF platform in an ECOPACK package which has a small 11.5mm x 13mm footprint. Based on ST's BlueNRG-MS radio processor chip, the BlueNRG-M0 module also includes an antenna and high-frequency and low-power oscillators, providing an easy way for designers with no RF experience to embed Bluetooth connectivity into their system. Comprehensively certified, the module enables OEMs to achieve a fast time-to-market for Bluetooth-enabled applications. Conforming to the specifications of the Bluetooth v4.2 standard, the BlueNRG-M0 module includes the entire Bluetooth Low Energy stack and protocols. An external host processor, where the application resides, may be connected to the BlueNRG-M0 module through a standard serial peripheral interface. The BlueNRG-M0 can be powered directly from a standard 3V coin cell battery, a pair of AAA batteries, or any power source supplying between 1.7V and 3.6V. It is available in two versions: the BlueNRG-M0A with an embedded DC-DC converter, and the BlueNRG-M0L, which requires an external 1.8V DC-DC converter.





APPLICATIONS

- Watches
- Fitness, wellness and sports equipment
- Consumer medical equipment
- Security
- Remote controls
- Home and industrial automation
- Assisted living
- Mobile phone peripherals
- PC peripherals

FEATURES

- Up to 8dBm output power
- -88dBm maximum sensitivity
- In-field stack upgrading available via SPI
- AES security co-processor
- Certificates: CE qualified, FCC, IC modular approval, TYPE qualified, BQE qualified
- Operating-temperature range: -40°C to 85°C

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REFERENCE NUMBER **20-ii 28**

# Complete power supply for i.MX 8M Nano processors in a single chip









**ROHM Semiconductor** has introduced the BD71850MWV, an integrated Power Management IC (PMIC) which provides a comprehensive set of power rails for the i.MX 8M Nano family of application processors from NXP Semiconductors.

The BD71850MWV is the latest addition to ROHM's portfolio of PMICs for NXP's i.MX application processors: the BD71837MWV already supports the high-performance i.MX 8M Quad and Dual applications processors, and the BD71847AMWV supports the i.MX 8M Mini series. Drawing on ROHM's expertise in analog power control and its advanced semiconductor fabrication process, the BD71850MWV provides all the power rails required by the processor as well as a power supply for external DRAM. The PMIC's DC-DC converters operate at high efficiency of up to 95%. The device features a programmable power sequencer for flexible power control and management, and a seamless hardware control interface to the i.MX 8M Nano. Use of an integrated, tailored power circuit for the i.MX 8M Nano enables the designer to shorten development time, lower system cost and minimize board footprint.

NXP's i.MX 8M Nano applications processor features up to four Arm® Cortex®-A53 microprocessor cores and one Cortex-M7 microcontroller core. It is a pin-compatible, scalable alternative to the popular i.MX 8M Mini. NXP's i.MX 8M Nano applications processor enables OEMs to incorporate a voice interface in audio and video streaming devices at low cost. It also supports high-definition video processing, 2D/3D graphics, advanced audio functions, and various high-speed interfaces.



BD71850MWV: Programmable power sequencer for starting up i.MX 8M Nano



APPLICATIONS

- Power circuit for i.MX 8M Nano

FEATURES

- Six buck regulators operating at up to 2MHz
- Six linear regulators
- Supply-voltage range: 2.7V to 5.5V
- Power multiplexer
- 32.768kHz crystal oscillator driver
- Power button detector
- Soft-start
- System protection:
  - Power rail fault detection
  - Under-voltage lock-out
  - Over-voltage protection
  - Thermal shut-down
- Programmable output voltage
- I²C interfaces

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REFERENCE NUMBER **20-ii 27**

# Integrated Bluetooth Low Energy radio supports mesh networking

**ON Semiconductor®** Mesh networking capability was introduced to the Bluetooth® Low Energy specifications in July 2017 by the Bluetooth Special Interest Group (SIG) as a means of supporting large-scale networks requiring many-to-many node connections.

Designers who wish to take advantage of this capability can use the RSL10 from ON Semiconductor, a multi-protocol, Bluetooth 5.0-certified radio System-on-Chip (SoC) which offers the lowest power consumption in its class. The RSL10 is for use in devices which require advanced wireless features such as Bluetooth mesh networking, while occupying a small board footprint and extending battery run-time. For faster system development, the RSL10 SoC may be supplied integrated into a System-in-Package (SiP). The ready-to-use RSL10 SiP includes an antenna, the RSL10 SoC, and all passive components in a single, miniature package. ON Semiconductor provides RSL10 software to allow for rapid development of ultra low-power Bluetooth Low Energy mesh networking applications. Sample code enables easy configuration and deployment of mesh networks with any combination of proxy nodes (to connect a mobile phone), relay nodes, friend nodes and Low-Power Nodes (LPNs), with support for multiple LPNs per friend. Documentation explains the process of configuring and provisioning an RSL10-based mesh network.

Part Number	Description
NCH-RSL10-101Q48-ABG	RSL10 SoC in QFN
NCH-RSL10-101WC51-ABG	RSL10 SoC in WLCSF
NCH-RSL10-101S51-ACG	RSL10 SiP
BLE-SWITCH001-GEVB	Energy-harvesting BLE switch reference design
RSL10-002GEVB	Radio SoC evaluation board
RSL10-SENSE-DB-GEVK	RSL10 sensor development kit with debugger
RSL10-SENSE-GEVK	RSL10 sensor development kit
RSL10-SIP-001GEVB	RSL10 SiP development board
RSL10-SOLARSENSE-GEVK	RSL10 solar cell multi-sensor platform
RSL10-USB001GEVK	RSL10 USB dongle



APPLICATIONS

- Building and home automation
- Sensor networks
- Smart lighting and smart locks
- Asset tracking
- Environmental monitoring
- Automotive systems

FEATURES

- Industry's lowest-power LPN
  - 25nA Sleep current
- Sample application code for friend nodes and LPNs
- Ready-to-use stand-alone node applications
- Source code provided for sample applications
- Full suite of development tools including an Eclipse-based integrated development environment

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## High-performance MCU integrates Bluetooth 5.0 radio and USB, CAN connectivity

**RENESAS**  
BIG IDEAS FOR EVERY SPACE

**Renesas' new RX23W is a wireless microcontroller which is based on the high-performance, 54MHz 32-bit RXv2 CPU core, and which offers full Bluetooth® 5.0 networking functionality.**

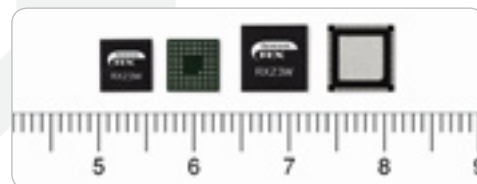
It provides an ideal way for RX family MCU users to add Bluetooth 5.0 connectivity to their designs, and for designers to implement secure wireless point-to-point or mesh networking. The RX23W supports the full set of Bluetooth Low Energy single-mode functions specified in the Bluetooth 5.0 standard: it transfers data at rates up to 2Mbps/s, and over a long range of up to 400m.

The RX23W's RXv2 core provides higher performance than the Arm® Cortex®-M4 processor used in many competing wireless MCUs. The RX23W's powerful core supports the operation of a rich set of peripherals including a USB 2.0 controller and a CAN controller, as well as capacitive touch sensing.

Security is another strong suit of the RX23W: Trusted Secure IP (TSIP) in the RX23W MCU provides strong key management and advanced encryption capability.

The MCU is notable for its excellent power efficiency. It features lower peak power consumption than any competing wireless MCU, with just 3mA in Receive mode. It also offers industry-best sensitivity of -105dBm at 125kb/s.

Renesas has made the RX23W easy to implement in end-product designs. No external parts are required for the RF antenna line because the RX23W integrates a complete on-chip matching circuit and the RF oscillator adjustment circuit.



RX23W: Available in BGA (left) and QFN (right) packages



### APPLICATIONS

- Healthcare equipment
- Home appliances
- Building automation
- IoT devices
- Industrial products

### FEATURES

- Memory provision:
  - 512kbytes maximum program Flash
  - 64kbytes maximum SRAM
- 14-channel, 12-bit ADC
- Supply-voltage range: 1.8V to 3.6V
- Operating-temperature range: -40°C to 85°C

### FREE DEVELOPMENT BOARD

Renesas supplies target boards for devices in the RX family to provide a means to evaluate the MCU and develop prototypes based on it. The target board incorporates an emulator circuit, and provides through-holes for Arduino®-style pin headers which give access to all the MCU's signal pins.

Orderable Part Number: RTK5RX23W0C00000BJ

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## Development kit provides easy route to integration of Alexa voice assistant



**NXP Semiconductors has introduced a comprehensive reference design platform which provides the hardware and software that OEM designers need to integrate the Amazon Alexa voice assistant into an end product.**

Based on NXP's i.MX RT106A audio crossover microcontroller, the SLN-ALEXA-IOT reference design is supplied with Amazon-qualified software for immediate implementation of Alexa Voice Service (AVS) technology.

It includes both the MCU and an NXP smart audio amplifier with speaker protection. It comes with all far-field audio-processing algorithms including noise suppression, echo cancellation, beam-forming and barge-in capabilities to enable use in acoustically difficult environments.

Also included is the Amazon Alexa client application and a machine-learning inference engine for detection of the 'Alexa' wake word.

This cost-effective, easy to use AVS implementation helps manufacturers to respond to demand for voice control in a

diverse variety of products across the home, commercial and industrial sectors. It eliminates the need to deploy dedicated stand-alone voice control devices such as smart speakers or smart displays.

The i.MX RT106A processor is licensed to run NXP's turnkey voice-assistant software solutions, which include:

- Machine learning far-field audio front end
- Acoustic echo cancellation
- Ambient noise reduction
- Playback process
- Codecs
- Wake word inference engine
- Media player/streamer



SLN-ALEXA-IOT

## Ready-made platforms speed development of face and speech recognition

**NXP Semiconductors has developed reference designs for face and speech recognition which provide designers with a comprehensive platform for implementation of these machine learning-based applications.**

NXP's microcontroller-based SLN-VIZN-IOT provides OEMs with a fully integrated, self-contained, software and hardware implementation of face recognition. The solution is based on the i.MX RT106F, an EdgeReady member of the i.MX RT crossover MCU family.

It includes the NXP face and emotion recognition run-time library, a set of machine learning algorithms, and the drivers required for peripherals such as a camera, memories and connectivity. Supplied with fully tested, documented and supported software, the SLN-VIZN-IOT solution accelerates time to market and reduces design complexity for OEMs and ODMs.

The i.MX RT106F crossover processor features NXP's advanced implementation of the Arm® Cortex®-M7 core operating at speeds up to 600MHz, to provide high CPU performance and real-time response. In addition to supporting face-recognition functions, the i.MX RT106F has spare processing capability and peripherals, making it suitable to be the main processor in many applications.



SLN-VIZN-IOT

NXP's SLN-LOCAL-IOT is a software and hardware solution for local voice commands. It comes with an Automatic Speech Recognition (ASR) engine for the local recognition of commands and a wake word. It also runs far-field audio-processing algorithms including noise suppression, beam-forming and echo cancellation, to enable use in acoustically difficult environments.

Features of these reference designs include:

### SLN-VIZN-IOT

- i.MX RT106F crossover processor
- 802.11 b/g/n Wi-Fi® radio
- Bluetooth/Bluetooth Low Energy v4.2
- Two digital MEMS microphones
- MC3461 battery charger
- PCAL6524EV I/O expander
- PIR sensor

### SLN-LOCAL-IOT

- i.MX RT106L audio crossover processor
- Audio amplifier
- 32Mbyte HyperFlash memory
- 802.11 b/g/n Wi-Fi® radio
- Bluetooth/Bluetooth Low Energy v4.2
- Three digital MEMS microphones



SLN-LOCAL-IOT



### APPLICATIONS

- Smart switches
- Smart lighting, shade and fan controls
- Smart plugs and outlets
- Smart appliances
- Set-top boxes and residential gateways
- Alarm and access control panels
- Point-of-sale terminals
- Bluetooth beacons
- Industrial automation

### FEATURES

- i.MX RT106A audio crossover processor
- Audio amplifier
- 32Mbyte HyperFlash memory
- 802.11 b/g/n Wi-Fi® radio
- Bluetooth®/Bluetooth Low Energy v4.2
- Three digital MEMS microphones

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### APPLICATIONS

- Smart appliances and countertop appliances
- Home comfort devices
- Safety/security/alarm devices
- Smart industrial devices

### FREE DEVELOPMENT BOARD

The i.MX RT1060-EVK evaluation kit from NXP Semiconductors is a four-layer through-hole USB-powered PCB for evaluation of the i.MX RT1060 series of crossover MCUs. This series of MCUs is used in various NXP machine-learning reference designs, including its face recognition, speech recognition and Alexa Voice Services solutions.



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# Breakthrough in power density of USB power adapters: how new GaN power switches play a starring role



By Edwin Kluter, EMEA Business Development Manager (Power Solutions), Future Electronics and Eric Moreau, Product and Application Director, Exagan

The market for standard packaged power transistor products fabricated in the wide-bandgap semiconductor material Gallium Nitride (GaN) is developing at a rapid pace as manufacturers of AC-DC power converters and other power electronics applications discover that they can achieve remarkably high system efficiency with them. Commercial GaN power transistors are now available with power and voltage ratings which make them suitable both for consumer devices using <100W, and for higher-power applications in industrial and communications equipment.

In applications which traditionally would have used a silicon superjunction MOSFET or an IGBT, a GaN transistor's higher switching speed, negligible switching and conduction losses, and tolerance of high-temperature operation enable designers to realise power-converter designs which are:

- More efficient
- Smaller
- Lighter
- Often, cheaper at the system level (even if the unit cost of a GaN transistor is higher than that of a silicon transistor with a similar voltage rating)

The use of GaN transistors is already enabling manufacturers of power adapters for consumer devices to make extraordinary advances in power density. In the period 1980 to 2015, improvements to silicon-based switch-mode power supply technology raised the typical power density of AC-DC converters from 1.5W/in<sup>3</sup> to 10W/in<sup>3</sup>. But in just the five years since 2015, following the commercial introduction of GaN power transistors, the power density of the best-performing AC-DC converters has risen from 10W/in<sup>3</sup> to 30W/in<sup>3</sup>. To take full advantage of the superior characteristics of GaN transistors in a power converter, however, the designer should perform a fundamental review of the topology which is best suited to the technology and the application. The system architecture of a superjunction MOSFET-based converter will rarely be equally suitable for a converter which uses GaN transistors.

	650V Silicon Superjunction MOSFET: Normalised Performance	650V GaN Transistor's Superiority	Benefit to the Power-system Designer
On-resistance x Current	1	>10x	Smaller die. Lower conduction losses
On-resistance x Output Capacitance	1	>6x	Lower switching losses when hard switching
Reverse-recovery Current	1	>40x	Lower switching losses when hard switching
On-resistance x Gate-charge	1	>10x	Lower driver losses
Temperature De-rating of On-resistance	1	>1.2x	Component optimization

Fig. 1: Comparison of the operating characteristics of silicon- and GaN-based power transistors

## Read this to find out about:

- A comparison of the performance characteristics of GaN and silicon power transistors
- The choice of topologies for a 60W AC-DC power adapter which complies with the USB Power Delivery specifications
- The thermal and electrical performance of a 60W adapter reference design which uses G-FET GaN transistors

To illustrate the case, this article describes a new reference design for a 60W AC-DC power converter which complies with the latest USB Power Delivery (PD) 3.0 specifications. Benefiting from the very high efficiency of the G-FET™ GaN transistors from Exagan, this USB PD 3.0 reference design board can be supplied in an enclosure which has internal dimensions of 36mm x 34mm x 30mm, a design which achieves power density of 29W/in<sup>3</sup>.

## GaN v silicon superjunction: a substantial difference?

The properties of wide-bandgap materials such as GaN and Silicon Carbide (SiC) are known to produce superior operating characteristics in power-converter systems. But is the difference between a commercial GaN transistor and a MOSFET fabricated in silicon sufficient to justify the design effort involved in migrating to the newer technology? The scale of the difference from the best-performing superjunction type of silicon power MOSFET is shown in Figure 1. In general, the use of GaN transistors affords the following benefits:

- High switching frequency
- True soft switching at high frequency
- Low-loss hard switching
- Low power losses
- Easier thermal management

In general, the higher conversion efficiency which can be achieved with the use of GaN transistors means that they run cooler for any given power load, reducing or eliminating the need for a heat-sink or other cooling mechanism and enabling the converter to operate safely in a smaller enclosure with more restricted airflow. Operating at a higher switching frequency enables the use of smaller magnetic components and capacitors, resulting in higher power density as well as reducing the cost of the passive components.

## Realising the benefits of GaN in a real-world application

To gain the greatest possible benefit from these superior operating characteristics, the power-system designer needs to recognise the scope that a GaN transistor provides for a different mode of operation. In a USB PD 3.0 power adapter, for instance, the system requires the flexibility to handle a wide range of loads, including the low power requirements of USB-connected peripheral devices such as headsets. The USB PD protocol supports optimized power management across multiple peripherals, providing

a communications channel as well as a power channel so that each peripheral can request only the power input that it requires. A USB power adapter will therefore ideally offer a high level of conversion efficiency across the load range. In developing its new G-MODULE™ reference design for a 60W USB adapter, Exagan, the Grenoble, France-based manufacturer of GaN transistors, evaluated two flyback topologies commonly used in silicon MOSFET-based designs. Its study showed that both offer substantially lower power efficiency than a third, the active clamp flyback topology, which can be implemented effectively with a pair of GaN transistors. The features of these three topologies are shown in Figure 2.

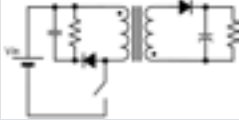
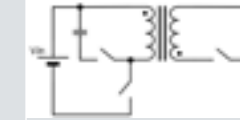
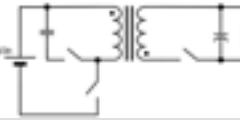
Topology	Flyback CCM	Flyback QR or PSR	Active Clamp Flyback
Schematic			
Pros	<ul style="list-style-type: none"><li>• Simple structure</li><li>• Single switch</li><li>• Good regulation with optocoupler</li></ul>	<ul style="list-style-type: none"><li>• Simple structure</li><li>• Single switch</li><li>• Saves optocoupler cost in PSR</li></ul>	<ul style="list-style-type: none"><li>• Highest efficiency of 92 to 95%</li><li>• Soft switching (ZVS, ZCS)</li><li>• Low EMI</li></ul>
Cons	<ul style="list-style-type: none"><li>• High EMI</li><li>• Low efficiency of around 82%</li></ul>	<ul style="list-style-type: none"><li>• Good efficiency of 85 to 92%</li><li>• Poor regulation in PSR</li></ul>	<ul style="list-style-type: none"><li>• Double switch on primary side</li><li>• Complex regulation</li></ul>

Fig. 2: Comparison of flyback topologies suitable for a <100W AC-DC power adapter. CCM = Continuous Conduction Mode. QR = Quasi-Resonant. PSR = Primary-Side Regulation.

While the active clamp flyback topology is a more complex circuit than the quasi-resonant or continuous conduction-mode topologies, the higher component count is offset by the elimination of the need for EMI counter-measures, since the soft-switching operation of the active clamp flyback circuit produces low electromagnetic emissions. The principal reason for selecting the active clamp flyback topology for a USB PD power adapter, however, is its very high efficiency. This facilitates compliance with tight energy-efficiency standards such as the US Department of Energy's Level VI regulations. It also keeps thermal losses to a minimum, enabling fanless operation without a heat-sink inside a tiny enclosure. The breakthrough in power density that Exagan has achieved with its 60W USB PD reference design has enabled the creation of a new, small form factor for USB power adapters, answering the call from consumers for ever smaller, lighter and sleeker consumer devices and peripherals. Happily, a smaller end product design also reduces the adapter manufacturer's materials and shipping costs.

## A higher-performing USB power adapter

The benefit of using GaN transistors and an active clamp flyback topology is borne out by study of the performance characteristics of the G-MODULE™ 60W USB PD adapter board, as shown in Figure 3. Operating from a 90V to 265V AC input range, the board produces a 3A output at the USB PD-specified voltage values of 5V, 9V, 12V or 20V DC. The board incorporates an RM8 transformer core featuring planar winding, as well as a microcontroller which performs cycle-by-cycle current-mode control of the active clamp flyback circuit. The adapter features a comprehensive set of protection functions, including:

- Output over-current
- Output reverse polarity
- Input over-voltage
- Transistor-level thermal shut-down

Fig. 3: The Exagan G-MODULE™ board, a 60W USB PD power adapter

Compared to a typical 60W USB PD design using silicon superjunction MOSFETs, the Exagan adapter cuts power losses in half, and achieves a 3x improvement in power density. System efficiency of the G-MODULE™ adapter peaks at 95% when supplying a full load from a 240V AC input. The higher conversion efficiency and reduced power losses also result in superior thermal efficiency: the 650V G-FET™ switches in the G-MODULE™ operate at a temperature some 10°C to 15°C lower than superjunction silicon MOSFET switches in equivalent adapter designs, as shown in Figure 4.

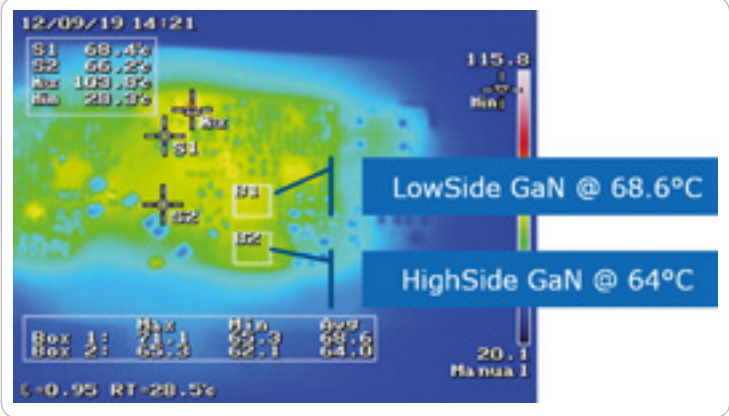


Fig. 4: Heat map of the G-MODULE™ board when supplying a 60W load

Product tests performed by Exagan reveal that silicon superjunction MOSFETs operate at 86°C in a larger design offering power density of 17W/in<sup>3</sup>, and at 89°C in a more compact design offering power density of 27W/in<sup>3</sup>. In a design which uses a different manufacturer's GaN transistor, the switch operates at 74°C, some 4°C higher than the low-side G-FET™ switch in the G-MODULE™ board. This highlights one of the key advantages of the G-FET™ transistor used in the G-MODULE™ adapter: its ultra-low switching and conduction losses, which are the reason for the cooler operation of the switch in the G-MODULE™ board. In addition, the G-FET™ is easier to implement in a power-system design: unlike rival GaN transistors, it can be driven by a conventional gate driver for a silicon MOSFET. It works with a standard 10V analog gate-drive signal. There is no gate leakage, and it does not require a negative voltage to force it into the Off state. The robust gate handles a maximum voltage of ±20V. By contrast, other GaN transistors require a dedicated driver IC, which restricts component choice and increases bill-of-materials cost. The G-MODULE™ 60W USB power adapter from Exagan, then, provides an ideal demonstration of the type of high-efficiency, high-density circuit that it is possible to implement with an off-the-shelf GaN transistor such as the G-FET™ product. It is also suitable for implementation as a commercial USB power adapter which achieves a new combination of 29W/in<sup>3</sup> power density, high efficiency and simple thermal management.



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# Artificial intelligence off-the-shelf: how OEMs can easily build in machine learning capability



By Future Electronics

The conditions are ripe for embedded developers to create their own Artificial Intelligence (AI) applications:

- Component technology, even a 32-bit microcontroller, supports neural network inferencing at the edge. Tools introduced recently by component manufacturers provide for efficient targeting of trained machine learning tools to their hardware.
- A broad range of model training frameworks is available for embedded developers to use
- Third parties can provide large sets of labelled generic data sets such as images, or OEMs can use tools and hardware for collecting and curating their own custom data set

But in such a new and complex field, it is likely that OEMs' engineering teams will need to undergo an intensive process of education before building an AI-based product. Figure 1 shows the many elements in the process of developing an AI application. A full-custom AI development project starting today could be expected to take a minimum of two years before a finished product gets to market. This time could be considerably longer for an OEM with no previous experience in machine learning techniques and technologies.

Microprocessor, microcontroller and FPGA manufacturers are now introducing sophisticated toolchains to support the development of inference engines and their compilation on their products, in an effort to ease and accelerate the AI development process.

## Read this to find out about:

- The types of generic AI-based applications for which off-the-shelf solutions exist today
- How NXP enables local speech recognition with no cloud connection in its comprehensive reference design solutions
- Two low-power implementations of people counting which run on a Lattice FPGA

But in fact it is possible to embed machine learning capability in a new production-ready design within weeks rather than years, provided your product needs to perform one of a small number of common, generic AI functions.

This is possible because semiconductor suppliers have recognized that many OEMs share a common requirement for AI-enabled applications such as speech recognition, image recognition, and people detection and counting. They have responded to this need by providing ready-made, off-the-shelf reference designs for these applications. As we shall see, some of these designs are production-ready systems that can be dropped into existing product designs with no or little modification.

## Machines which hear speech – a hit with consumers

The adoption of technologies such as Amazon's Alexa Voice Service, Apple's Siri® voice recognition software and the Google Assistant™ virtual personal assistant shows that consumers are comfortable with speaking their commands to a machine. Speech recognition is a classic field for AI, since it involves distinguishing common patterns of sound that are masked by numerous variations in the pitch and volume of the voice, accent, and enunciation, while filtering out extraneous audible noise.

The conventional development pathway for this application would involve the collation and curation of a large set of voice samples, and then using it to train, validate and test a bespoke learning model.

It would be much easier and quicker to embed a speech-recognition system already developed by a third party and this is exactly what NXP Semiconductors enables with its speech-recognition reference design, the SLN-LOCAL-IOT, featured in this issue, as shown in Figure 2. NXP also provides a similar system, the SLN-ALEXA-IOT, for implementing Amazon's Alexa Voice Service technology. The reference design boards consist of a production-ready i.MX Voice Solution Board, backed by software for audio signal capture and processing, and for speech recognition, all running on a low-cost i.MX RT1060 family crossover microcontroller.

It enables OEMs to easily and cheaply add local voice control to any end product, with no connection to the internet required. With this NXP reference design, OEMs can quickly add voice controls to home thermostats, washing machines, fridge-freezers, light switches and many other types of device. NXP will support the implementation of custom wake words and commands.



Fig. 2: NXP's i.MX RT106x Voice Solution Board

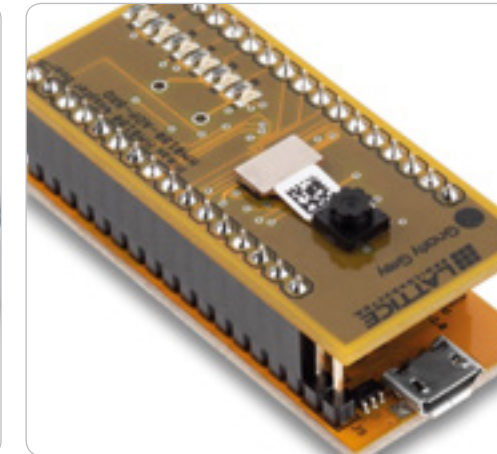


Fig. 3: The Himax HM01B0 UPduino Shield hosts Lattice's people detection AI application

The i.MX Voice Solution Board itself is small, and because it requires no SRAM, eMMC storage or Power Management IC (PMIC), it also has a reasonable bill-of-materials cost. According to NXP, the cost is some \$10 lower than that of a typical speech recognition system based on an applications processor.

People detection is a different application for machine learning, but like voice control requires the recognition of a common pattern: the image of a human body in countless variations. Like NXP, Lattice Semiconductor has succeeded in implementing a complex AI application on a highly constrained piece of hardware: a small, ultra-low power iCE40 FPGA.

Lattice provides the reference design as a complete hardware/software kit. The hardware platform is a Himax HM01B0 UPduino Shield, as shown in Figure 3. It is based on the UPduino 2.0 board, a rapid prototyping development board in the Arduino form factor offering the performance and I/O capabilities of the iCE40 UltraPlus FPGA: 5,280 Look-Up Tables (LUTs), 1Mbit of embedded memory, 120kbits of block RAM and eight multiply-accumulate blocks. It also includes the Himax HM01B0 low-power image sensor module and two I<sup>2</sup>S microphones, supporting AI applications that use either visual or audio inputs or both.

The reference designs are fully supported in the latest version 2.0 of Lattice's SensAI™ development environment: SensAI provides project files and documentation for human presence detection using Compact Convolutional Neural Networking (CNN) IP for the Lattice FPGA.

The performance of the iCE40-based people detection application is impressive, especially given that it consumes as little as 1mW of power when sampling at a frequency of one or two frames per second. It can detect a person as far as 5m away from the camera, and even if the person's image occupies as little as 10% of the total frame area.

Helpfully, Lattice supplies with the reference design software its training data set and the input files that it uploaded to the model training framework. This means that the reference design can be used not only as an off-the-shelf solution for people detection, but as the basis for an OEM's own, custom people detection system: developers can take the Lattice data set and run their own model training process to change the speed, accuracy, range or hardware footprint of the inference engine in the iCE40.

Lattice supplies the same, production-ready hardware and software for people counting, an application that it runs on its larger ECP5-85 FPGA. This FPGA offers much greater hardware capabilities than the iCE40 with 85,000 LUTs and 3.7Mbits of block RAM. This people-counting reference design is hosted on Lattice's Video Interface Platform, a system which consumes less than 1W and which provides multiple video interfaces such as MIPI CSI-2, eDP, HDMI, GigE Vision and USB 3.0.

Lattice's people counting application can detect and count multiple people in a frame. It can detect the image of a body as small as six pixels, and can detect people as far as 8m away from the camera at various orientations. As with the people detection application on the iCE40, this people counting application is a production-ready design, supplied with the training data set and the input files to the machine learning framework.

## A growing range of ready-made solutions

The NXP i.MX RT voice control reference design could be of interest to manufacturers

of home appliances, home automation equipment, consumer electronics devices such as set-top boxes and wireless access points, lighting equipment and many other device types.

Likewise, the people detection and counting applications from Lattice could be useful in building automation, access control, security and surveillance and building automation and control systems.

But these are not the only AI designs that can be applied broadly, and electronics manufacturers can expect to see the emergence of more ready-made implementations of machine learning technology.

For example, demonstrations provided by Lattice for its iCE40 and ECP5 FPGAs include applications for hand gesture recognition, face detection, face tracking, and speed sign detection. And NXP has released a reference design for face recognition in end products such as home appliances, the SLN-VIZN-IOT, which is featured in this issue of FTM.

Running on an i.MX RT1060 family crossover microcontroller, it offers an inference time of <750ms and can recognise more than ten different users' faces. It is supplied with production-grade face recognition algorithms.

## Fastest route to AI implementation

While much of the literature about AI in the embedded world shows the developer how to master the complex process of acquiring training data sets, training a model and implementing the model in an inference engine, some OEMs might choose to completely bypass the long AI development workflow and take advantage of the designs that NXP, Lattice and others have already developed.

The availability of these reference designs is a reminder that the implementation of AI does not have to be difficult, risky or time-consuming.

## From data collection to inferencing

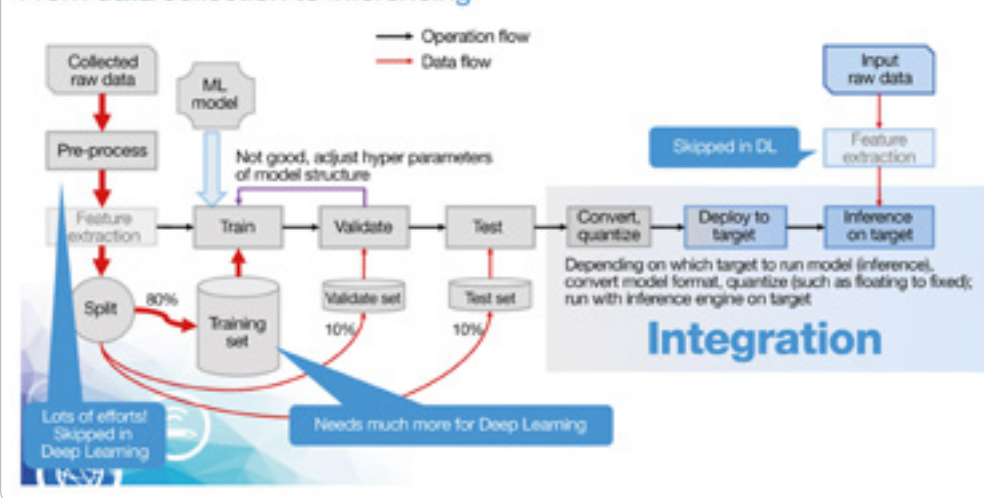


Fig. 1: The process for developing a new machine learning application to run on embedded hardware. (Image credit: NXP Semiconductors)

## FREE DEVELOPMENT BOARDS

Orderable Part Numbers:  
NXP Semiconductors SLN-ALEXA-IOT  
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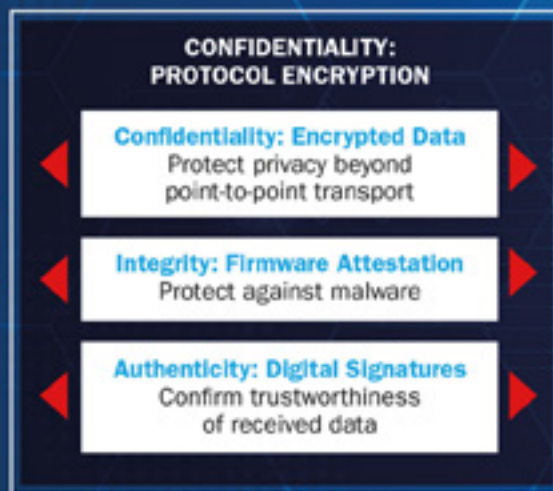
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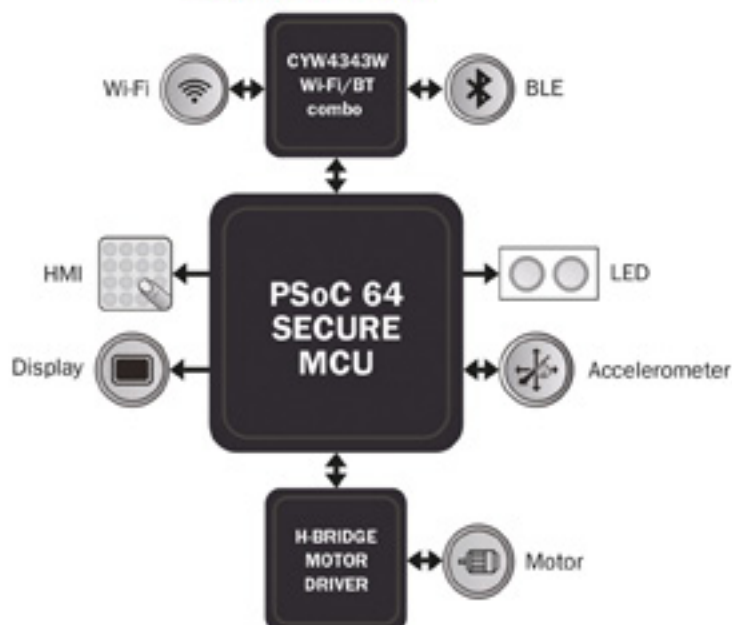
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