



Application guide Robotics

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- Market background
- Types of robot
- Principles of robotics
- Technical trends
- Robots in action

Challenges

- Speed & accuracy
- Wireless charging
- Self-positioning
- Sensing & detection
- Wireless remote control

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- AGV
- Robotic arm
- AC servo system

Murata innovation

- Power products
- Sensors
- Noise suppression filters
- Inductors
- Timing devices
- Capacitors

Market background

Robotics have been a fundamental part of the manufacturing process for decades now, but in recent years, the increased cost of human labor and immense leaps forward in technology such as 5G, Artificial Intelligence (AI) and the Internet of Things (IoT) have been driving a new era of factory automation.

A recent report suggests that there is a growing demand for these solutions, with experts predicting robust growth over the next half a decade.

The requirements of modern factories for rapid production and seamless supply chains mean that high levels of automation and adaptability are coming to the forefront of robotics technology. To ensure the best ROI for those who invest in robotics and to meet the demands of Industry 4.0., this new generation of robots must offer a triad of high productivity, cost-effectiveness and quality.

While in the past, robots were generally fixed function – meaning they were restricted to one task in one part of the production line – the world of robotics has shifted in the direction of agile manufacturing. This means that robots must not only



adapt to different tasks and parts of the production line, but also adapt to new factory configurations and be able to work alongside humans as ‘cobots’ with optimal safety and efficiency.

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Types of robot

In automated factories, there are two main types of robot used to carry out a wide range of functions. The first is the articulated robot, and the second is the Automated Guided Vehicle, or AGV for short.

Articulated robots are robots with rotary joints, or 'axes'. These are ideal for carrying out manufacturing tasks thanks to their wide range of motion. Consequently, they are used for a wide range of mechanical functions, such as welding, painting, actuators, assembly, and mounting semiconductors, boards and components.

AGVs, on the other hand, are autonomous robots that generally follow tracks around a warehouse, production or distribution center. Since their primary function is to transport objects, they are ideally suited to logistics and linear transport.



Hybrid

Combining the benefits of articulated robots and AGVs, hybrid robots can position themselves with accuracy within the factory environment to create multiple 'work envelopes'.

Articulated robots

Robots with rotary joints.



AGVs

Automated guided vehicles can move around the factory environment.

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Principles of robotics

Whether they are used for welding, painting, assembling or transporting products, the principles of robotics remain the same, divided into input, processing and output.

Input

Robots receive information from the world around them and human factory controllers using sensors, computing data and Human Machine Interfaces (HMI), which are generally screens that allow factory workers to input commands. These three ways of receiving information constitute the input phase.

Processing

Once the robot has received input data from the outside world, such as a command from an HMI or a signal that another robot or human is in the vicinity, it must then process this data. This is known as the processing phase.

Output

The processed data results in the robot's motor functions performing a certain action such as picking up an item or avoiding an obstacle. This constitutes the output phase.



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Technical trends

To form a fundamental part of the workforce in the smart factories of the future, robots are becoming more intelligent, more automated, more adaptable and more agile.

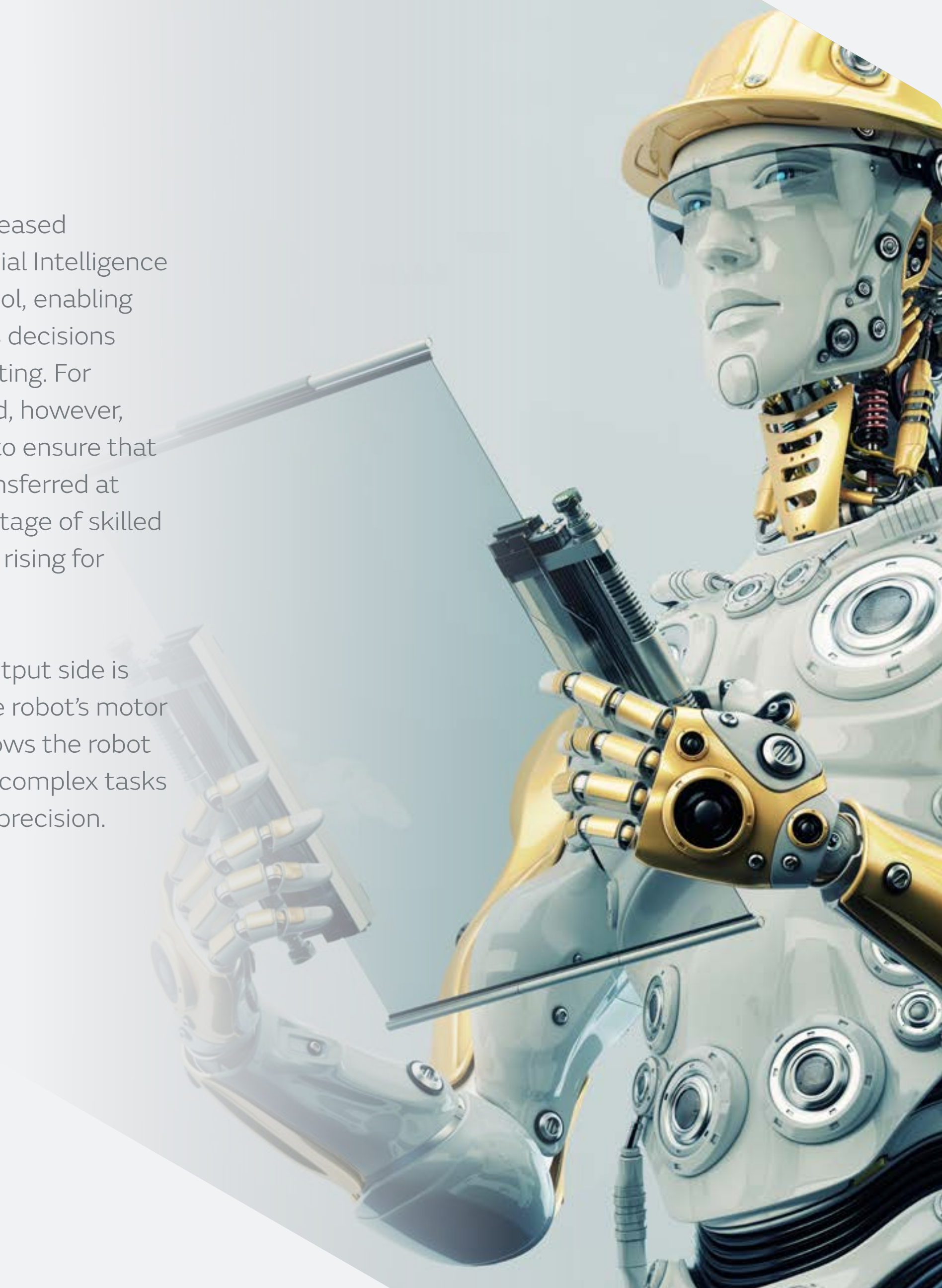
At present, the safety of robots is a major theme in engineering, ensuring that they can work more closely alongside humans as ‘cobots’ and avoid hazards in the workplace without the need for continuous oversight. This involves recognizing potential danger or collision zones and understanding whether they are in relation to other objects – and people – at all times, meaning that optimizing the input phase with effective, next-generation sensors is crucial.

By the same token, predictive maintenance aims to identify errors and malfunctions before they happen, sensing changes in atmosphere such as increased heat or a deterioration in the condition of the robot and relaying this information to maintenance teams to avoid downtime and increased repair costs.

This type of capability requires not only optimum sensor technology on the input side, but also the ability to process and interpret this data through AI in the processing phase.

In the drive towards the increased automation of robots, Artificial Intelligence has also become a crucial tool, enabling robots to make autonomous decisions within the smart factory setting. For robots to be truly automated, however, wide bandwidth is required to ensure that higher data rates can be transferred at speed. Equally, due to a shortage of skilled labor in factories, demand is rising for easily programmable robots.

Finally, a key trend on the output side is towards high accuracy in the robot’s motor control – a function that allows the robot to carry out a wide range of complex tasks requiring high dexterity and precision.



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Robots in Action

Amazon Robotics

A prime example of an AGV robot is the type used by Amazon Robotics (formerly Kiva Systems) in Amazon fulfillment centers to select items and transport them to packing stations.

These wheeled AGVs receive data assigning them products that have been ordered on Amazon and are tasked with locating boxes for these items – and the products themselves – and transporting them to parts of the warehouse to be sorted and placed in boxes by the human pickers.

They move around on a navigational grid system, scanning QR codes using in-built cameras to guide them around the warehouse and locate pods containing stacks of empty boxes and batches of products. Once the correct pod has been identified by scanning a QR code on the bottom of the shelving unit, the AGV picks it up using a corkscrew mechanism and transports it back to the working station of the human picker it has been assigned to, unscrewing it upon arrival.

Using algorithmic data and laser pointers, the AGV directs the picker to the item they need to pick up, who then scans the item and locates the correct box for it. After a certain number of completed tasks, the robot's software directs it to the charging station to briefly recharge.



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Speed & accuracy

With the transition from fixed functionality to agile manufacturing, robots are now expected to complete a much broader range of tasks with both precision and accuracy. In the past, robotic arms were used to carry out repetitive movements such as painting where a relatively large margin of error was permissible, but now they are trusted to perform extremely delicate and precise movements like wire welding along a seam.

Carrying out these movements as rapidly as possible with consistently high precision not only allows them to manufacture goods to a high standard at speed, but also creates a safer working environment within the factory.

To attain this level of continuous precision at high speeds, however, requires overcoming a series of engineering challenges. These include miniaturizing the gearbox and reducing the impact of both heat and vibrations in order to ensure that the robotic arm remains steady.

Aside from the mechanical features of the robot, its environment and software should also be optimized to ensure high accuracy and continuous improvement, recording each placement of the arm in comparison to the target, signalling errors with failure alarms, and updating software to ensure the best possible precision.



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Wireless charging

As factories become increasingly automated, AGVs will become an increasingly central feature of the smart factory set-up. With their ability to identify, load and transport goods at high speed, they could assist in the manufacturing process by delivering the materials required by machines along the assembly or production line.

While robotic arms are connected to a power source, AGVs – like the ones used by Amazon Robotics – require regular charging at docking stations. This means that, for a certain amount of time each day, each AGV will be essentially inactive.

In the future, as factories attempt to ramp up their manufacturing capacity and get the highest possible ROI for their investment in robotics, engineers will need to develop wireless charging solutions that allow AGVs to charge while moving around their workstations.



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Self-positioning

As their customers continue to show an appetite for variation in products, the demands placed on manufacturers are shifting. From an earlier era in which 'low mix, high volume' (LMHV) prevailed, these manufacturing companies are increasingly asked to shift to a more agile 'high mix, low volume' (HMLV) model and produce smaller quantities of diverse goods at speed.

To facilitate this model of production, factories must be incredibly adaptable, establishing flexible production lines or the means to modify the set-up of their production line whenever their customers require them to.

One of the best ways to enable a more flexible configuration within a factory while minimizing the burden on human workers is to utilize a series of highly mobile and highly automated AGVs to transport materials around the production line.

To ensure the success of this strategy, AGVs should be able to accurately self-position along an XYZ axis and instantly adapt to new environments and configurations. This level of self-positioning presents a serious technical challenge for the current generation of robotics engineers to overcome.



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Sensing & detection

In the past, factories were set up to ensure that the majority of robots used in production were fully isolated from employees to create the safest possible environment for human workers.

Nowadays, however, co-operative robots (otherwise known as ‘cobots’) are rapidly replacing traditional robots as the dominant variety in modern factories. With no need to divide the factory into spaces for either robotic or human production, cobots can reduce floor space and installation costs by approximately 25%.

Since the wellbeing of human employees is paramount, optimum levels of safety must be guaranteed in order for cobots to work alongside their human colleagues in the same part of the factory. For this reason, this type of robot must be equipped with the most high-performance sensing and detection technology, allowing the robot to not only identify where they are at all times, but also recognize where other objects and human beings are located within the factory setting.

If engineers can develop robots that deliver this level of safety, modern manufacturers will be able to optimize their floor space to build creative and flexible production lines utilizing both humans and cobots.



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Wireless remote control

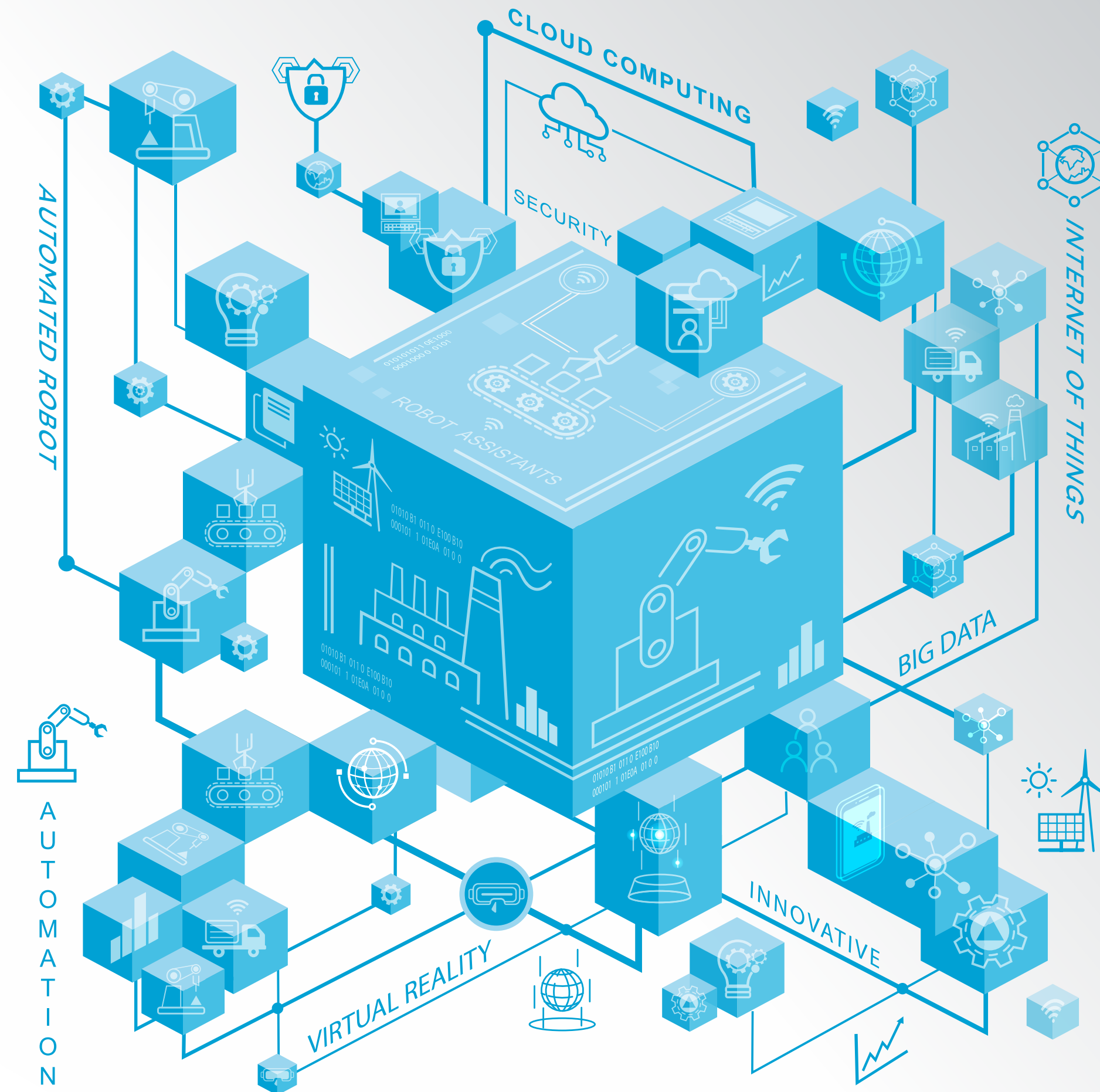
Aging populations and shortages of skilled labor have been two of the major driving forces of factory automation in recent years. In Asia, Europe and the United States, a large percentage of the prior workforce is now entering retirement, creating gaps for factory operatives that can be filled by remotely controlled robotics solutions.

Until recently, these solutions were held back by the limitations of wireless networks and technology, but with recent improvements in this technology, developers are starting to conceptualize solutions that would enable full control of the factory from a remote setting.

At present, remote verification experiments using Augmented Reality (AR) and Virtual Reality (VR) are being conducted, as well as attempts to monitor the status and activities of other factories from company headquarters. This type of remote solution could transform factory operations, but it requires the best low-latency networks to ensure its success. The expansion of 5G networks could therefore be transformative for the field of remotely controlled factory robotics.

As low latency 5G networks proliferate globally, the idea of controlling factory robots by 5G communication could become a reality. The challenge here is to develop simple interfaces

that could be taught to even unskilled employees and implement a system that would ensure both optimum safety and the highest possible level of oversight.



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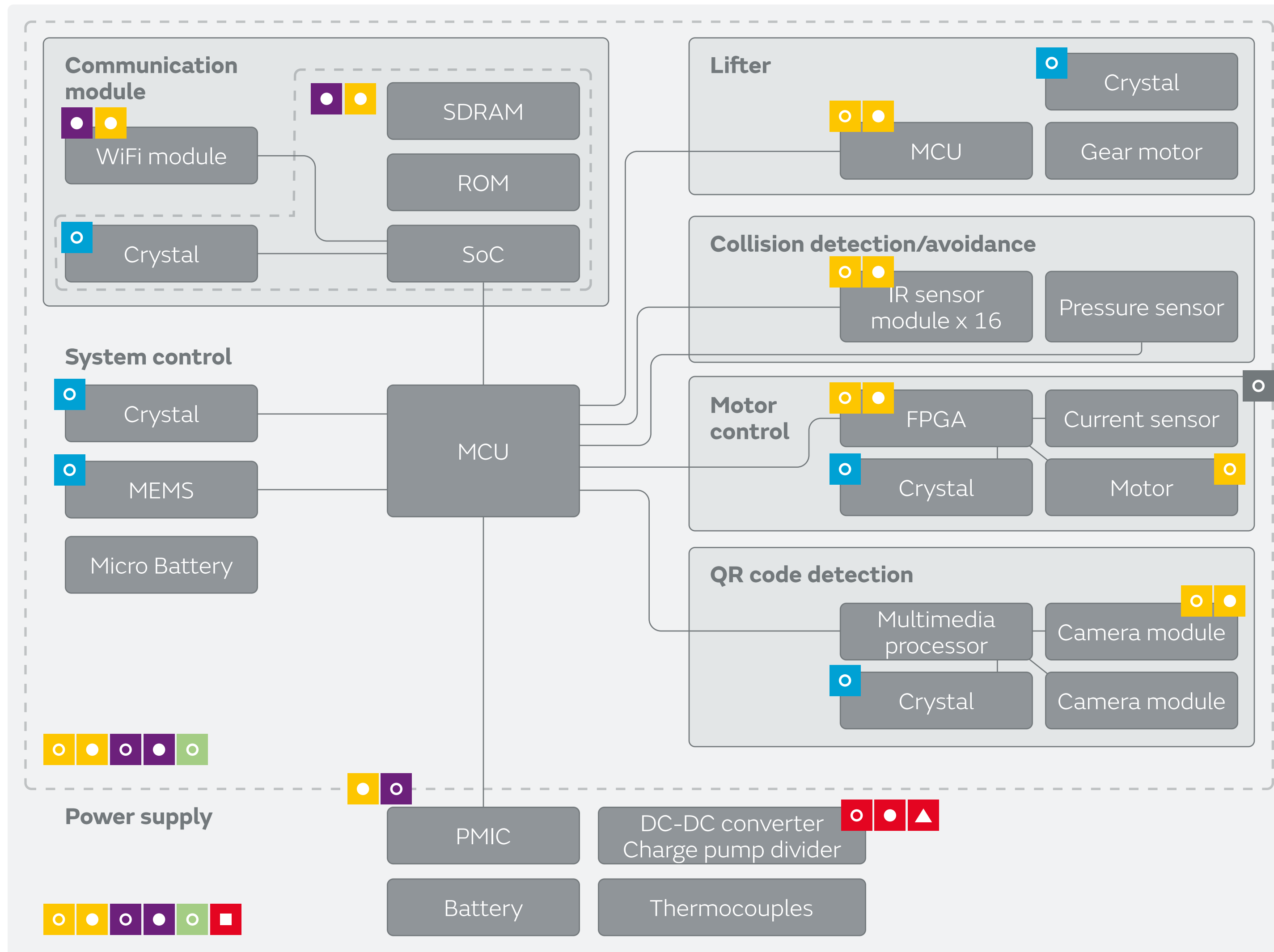
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Application - AGV



Note: Actual design depends on the customer.

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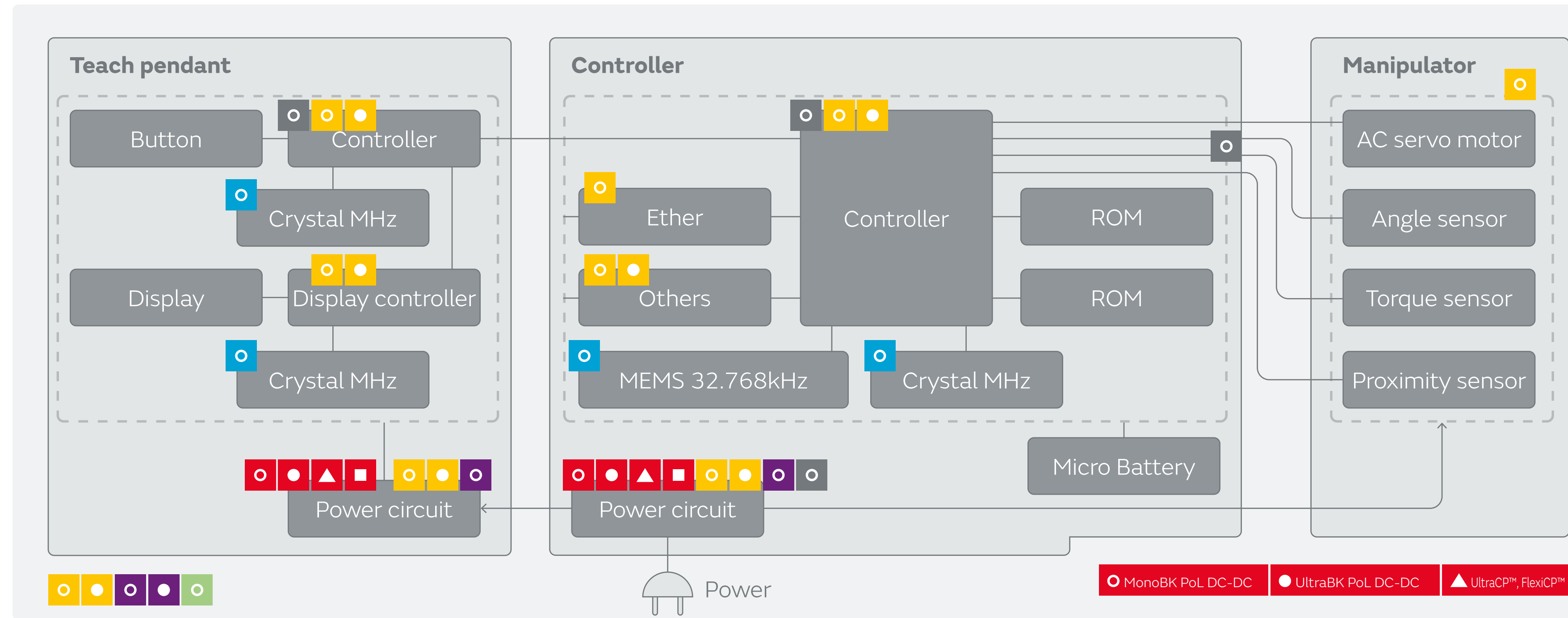
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○ MonoBK PoL DC-DC	■ Isolated high power
● UltraBK PoL DC-DC	○ Thermistors
▲ UltraCP™, FlexiCP™ DC-DC	● Chip ferrite beads
○ CMCs & filters	● RF inductors
○ Power inductors	○ MEMS resonator
	○ MLCCs

Application - robotic arm



Note: Actual design depends on the customer.

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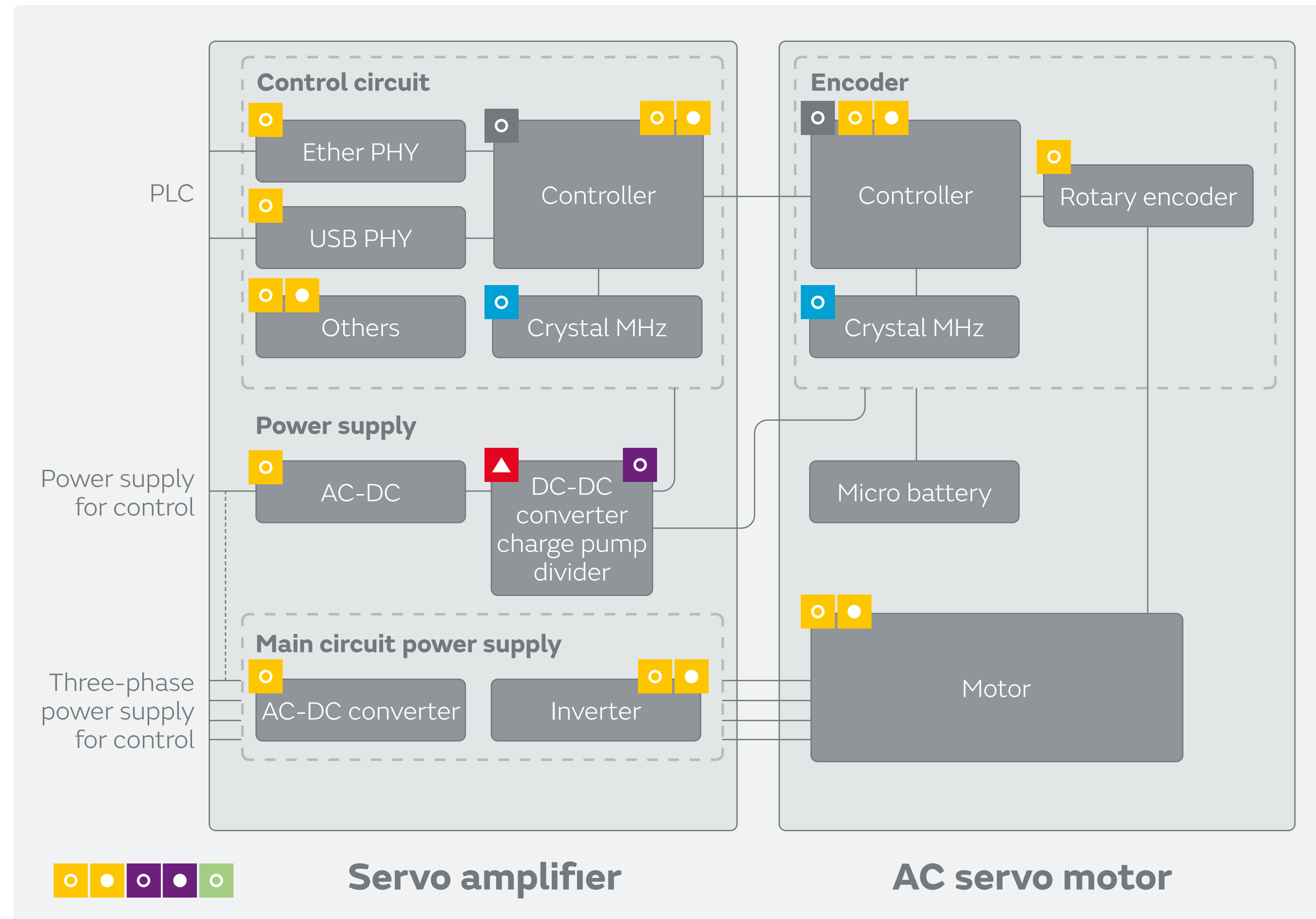
Applications

- AGV
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Application - AC servo system



Note:

1) Actual design depends on the customer.

2) Control circuit can be operated by three phase power supply and/or DC power supply

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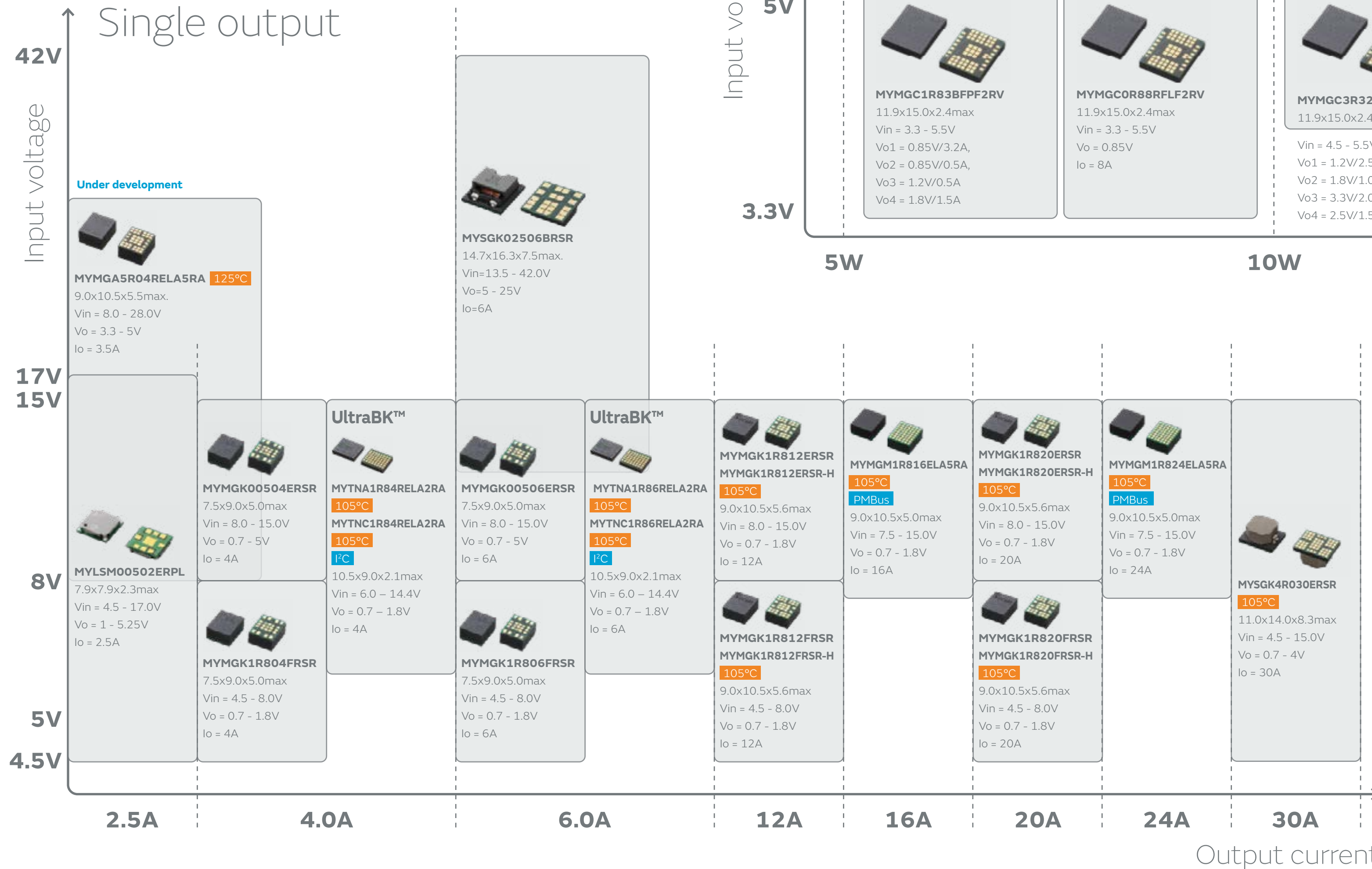
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▲ UltraCP™, FlexiCP™ DC-DC	
○ Thermistors	
○ CMCs & filters	○ Chip ferrite beads
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	○ MEMS resonator
	○ MLCCs

Power products

MonoBK™/UltraBK™ lineup



Power products

- MonoBK™/UltraBK™ lineup
- MonoBK™
- UltraBK™
- UltraCP™/FlexiCP™
- Isolated high power

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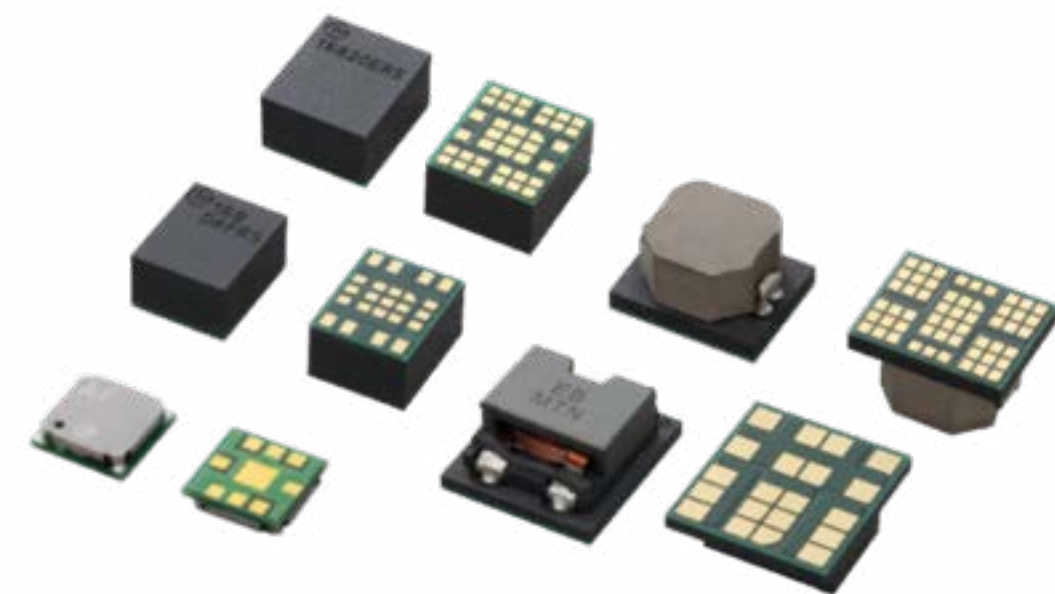
Power products

MonoBK™ - small POL DC-DC converter

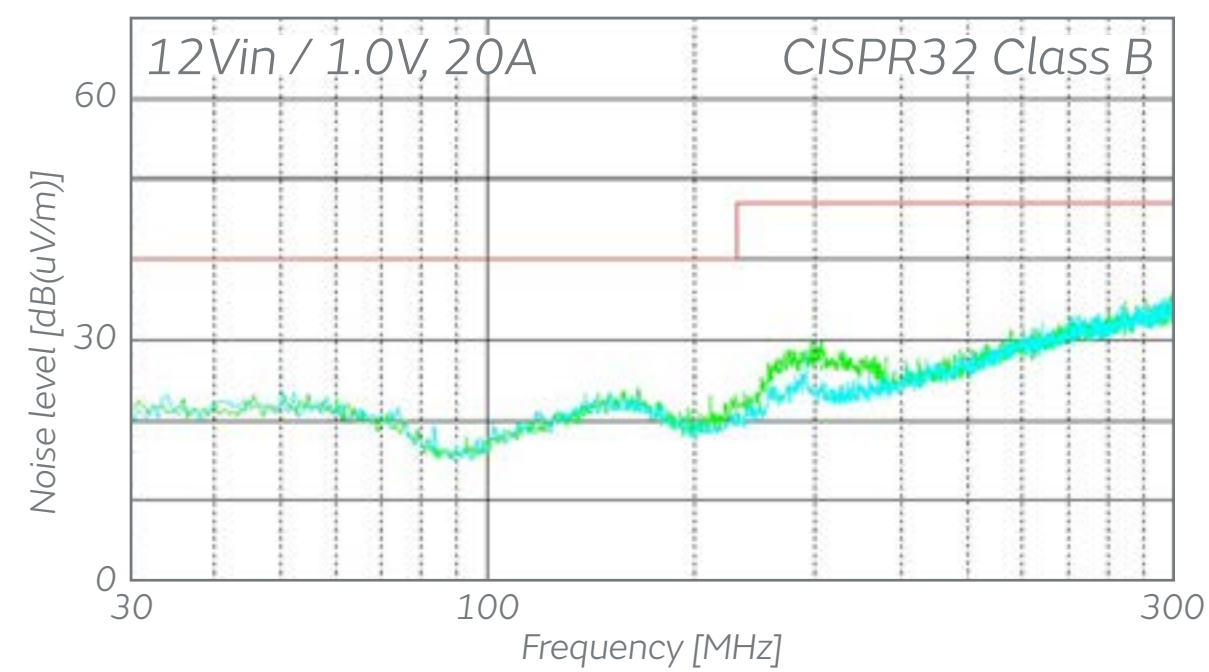
Key features

- Low noise
 - no need for noise filter
 - save cost and test resource
- Fast transient
 - fewer external capacitors
 - save capacitor cost
 - solve the L/T issue
- Small size
 - small footprint saves PCB cost

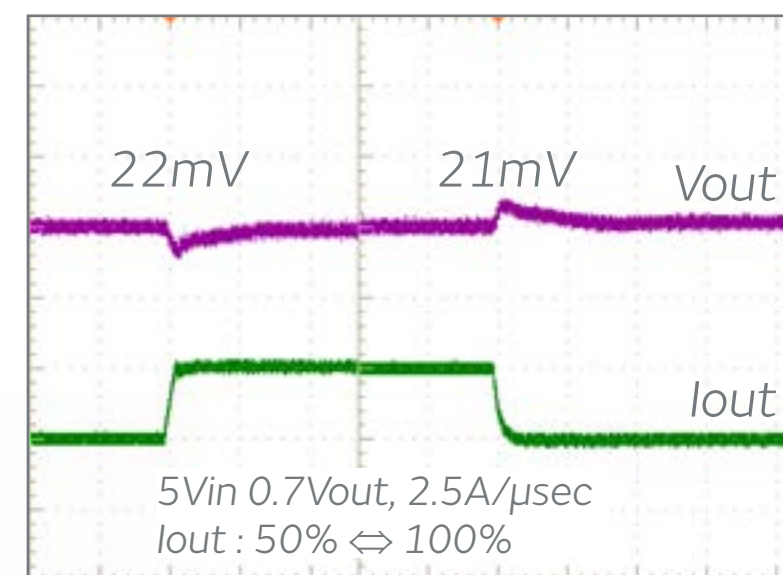
MonoBK™ is designed specifically to help designers get to market faster with validated, high performance solutions. In a small package, these power modules integrate inductors, FETs, compensation, and other passive components.



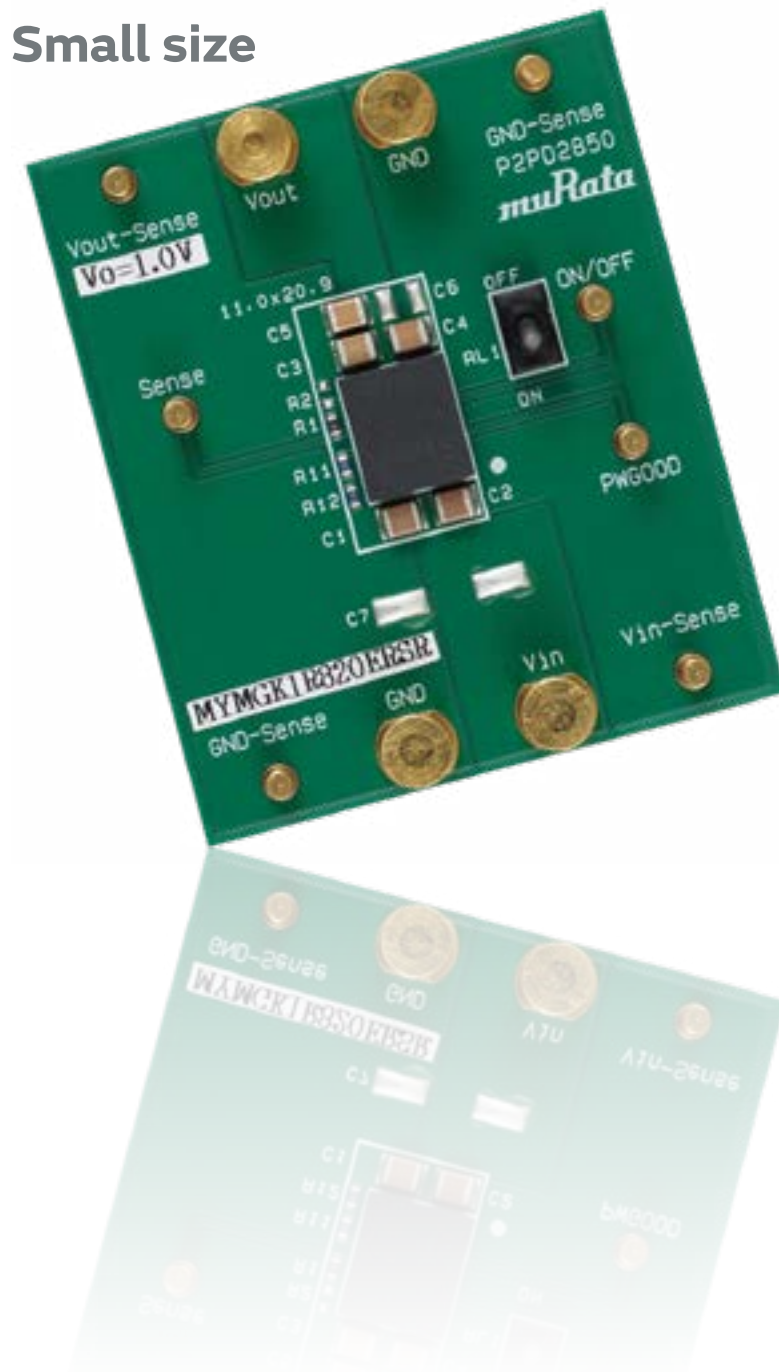
Low noise



Fast transient



Small size



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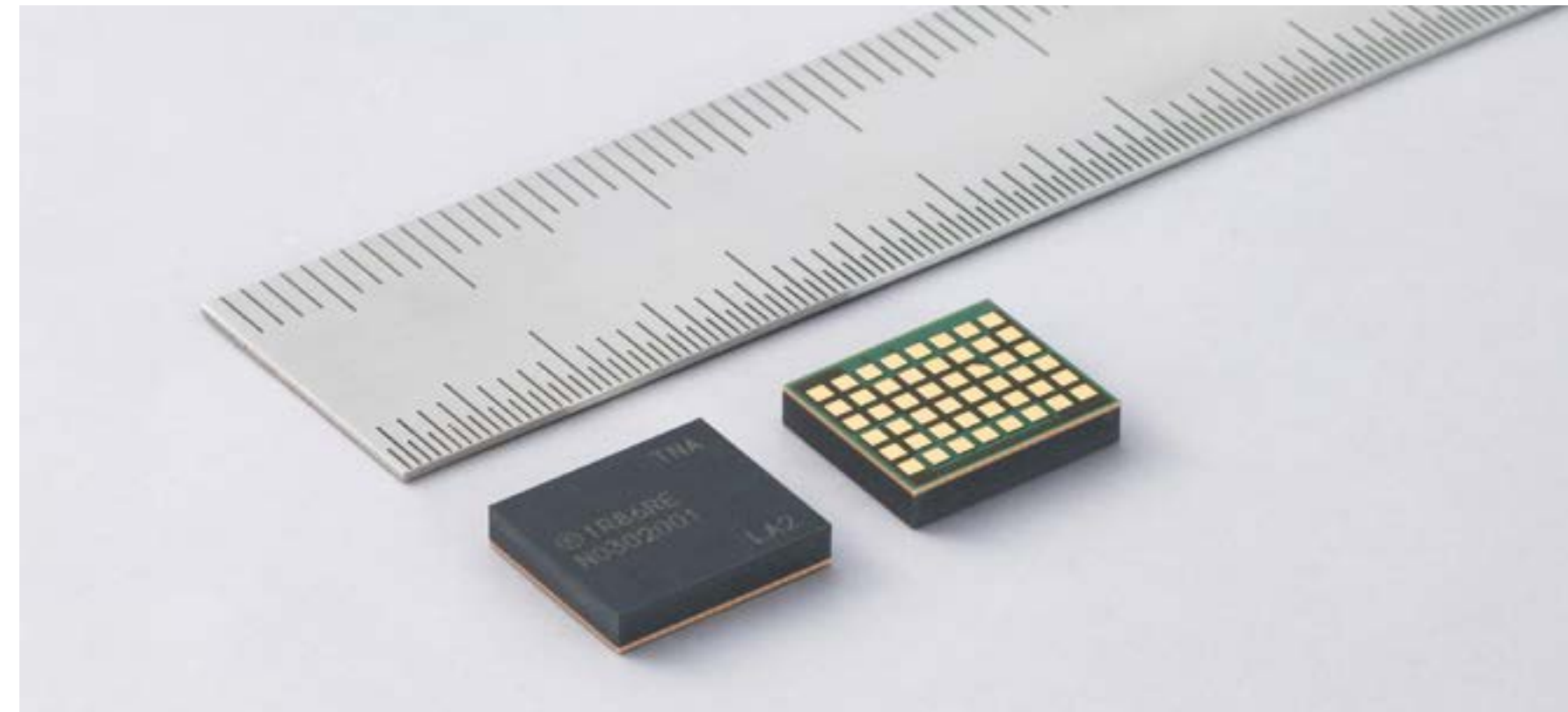
Power

UltraBK™

Features

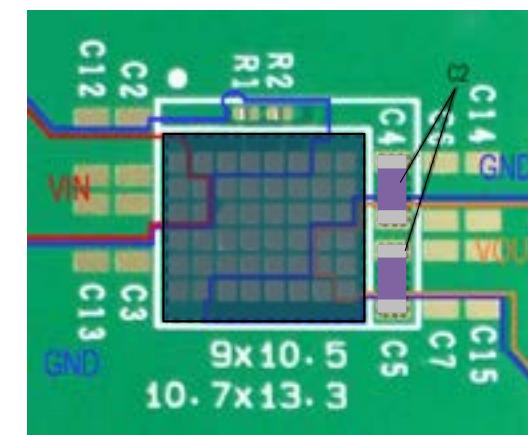
- Ultra-high efficiency
- Low profile - 2.1mm
- Smallest overall solution footprint
- 0.5-2MHz switching frequency
- I²C programmable with telemetry
- 5x lower input ripple
- Fast transient performance
- Low conducted & radiated EMI

World's highest efficiency & smallest PSiP



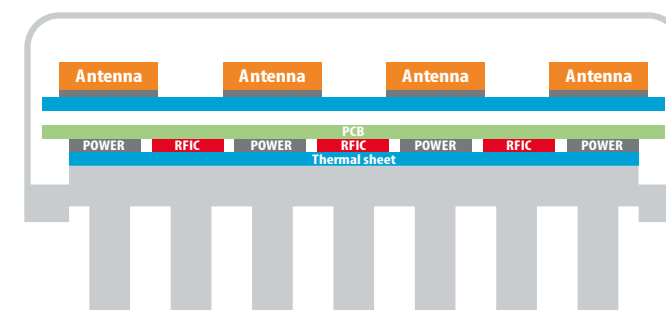
143mm² solution size

(package size: 9 x 10.5 x 2.1 mm)
This converter enables a power solution in only 143mm² including two external output capacitors only (no external input capacitors required).



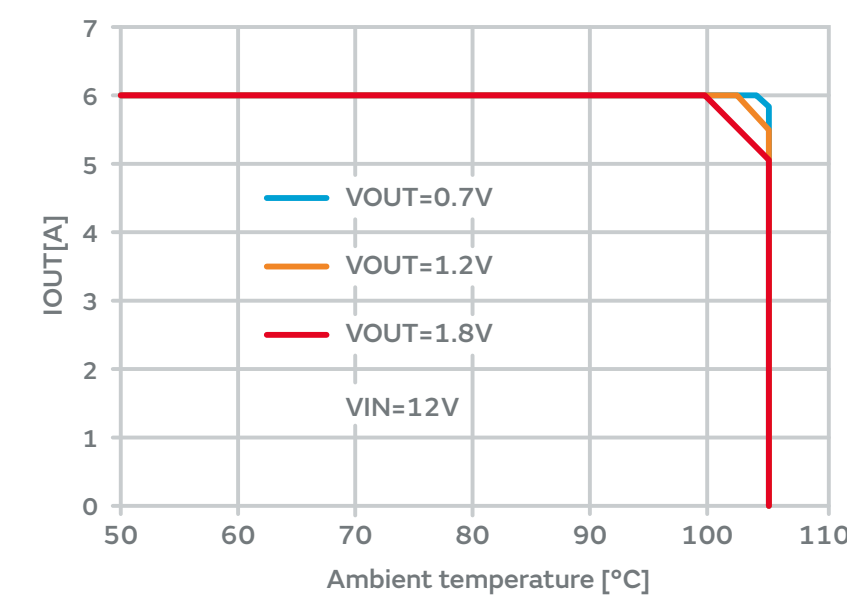
Only 2 external output capacitors required

Low profile



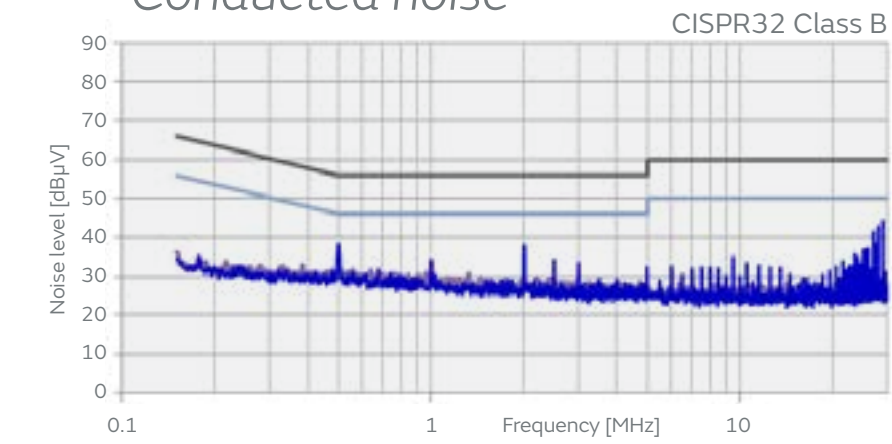
Low profile construction enables better performance at higher temperatures

Excellent thermal derating

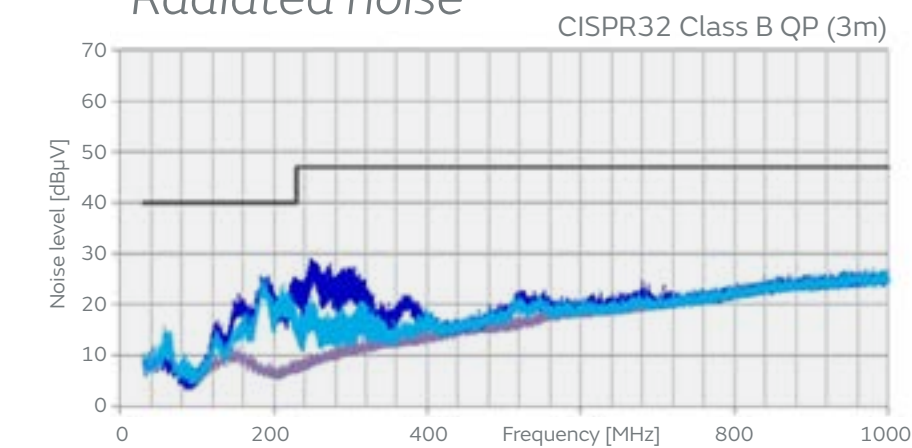


Low EMI

Conducted noise



Radiated noise



Measurement conditions: Vin: 12V, Vout: 1V, Iout: 6A, Cin:10uFx2 (MLCC), Cout:100uFx2 (MLCC)

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Power

UltraCP™ FlexiCP™

Features

- Virtually lossless - 98% DC transformer
- Phase interleaved, soft switching architecture
- Integer ratio (2,3 & 4) step-down
- Parallel capable with synchronization
- Available in IC or PSiP form



Ultra-high efficiency, integrated capacitor divider for intermediate bus conversion

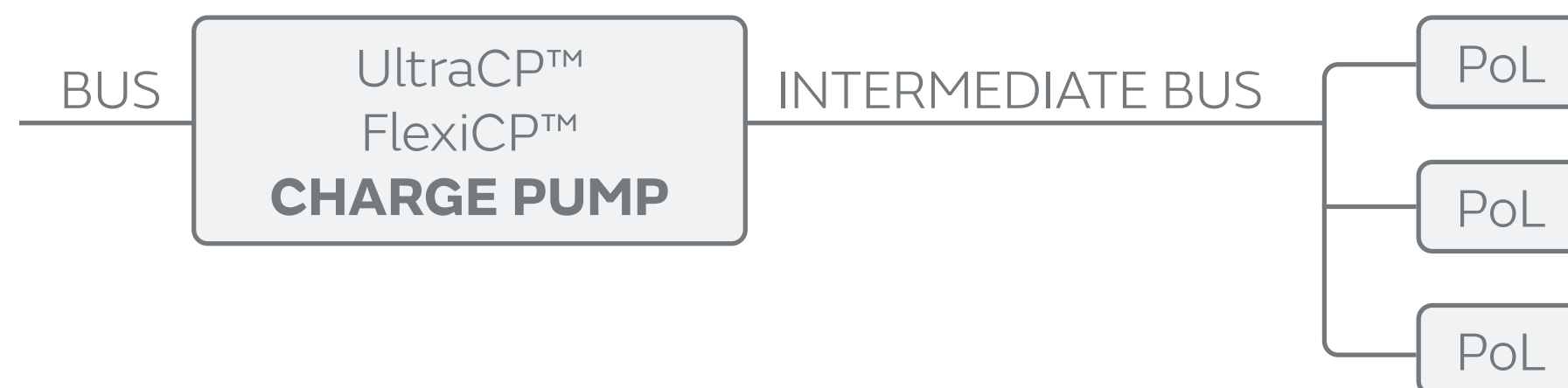
The FlexiCP™ PE252xx series of ultra-high efficiency, capacitor divider products is based on Murata's proprietary adiabatic - or lossless - charge pump technology.

The technology is ideally suited to providing 'lossless' step-down voltage conversion from 48V (PE25204) or 12V (PE25200) intermediate bus



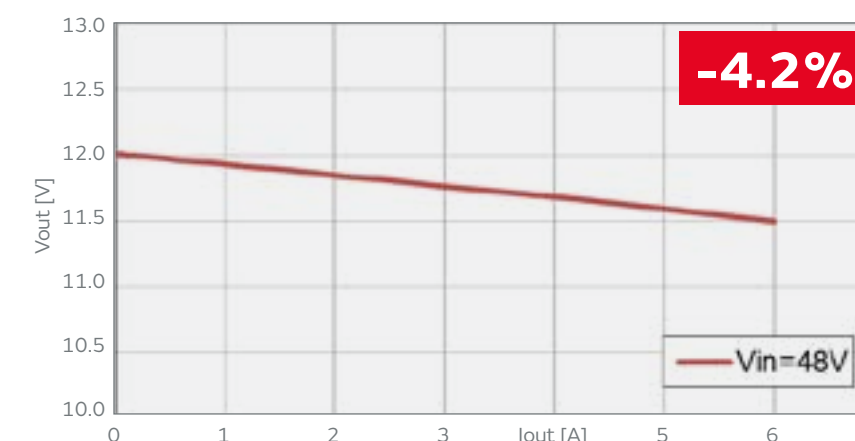
systems to support downstream Point-of-Load converters to enable highest system level efficiency.

The ICs are based on an interleaved charge pump control architecture with integrated FETs capable of delivering up to 72W of power. The devices can be connected in parallel for higher power system requirements and synchronized to eliminate noise issues. The divider products are available in IC form and in high density PSiP module form - UltraCP™ (MYCxx series) - for ease of use and placement in space constrained applications.

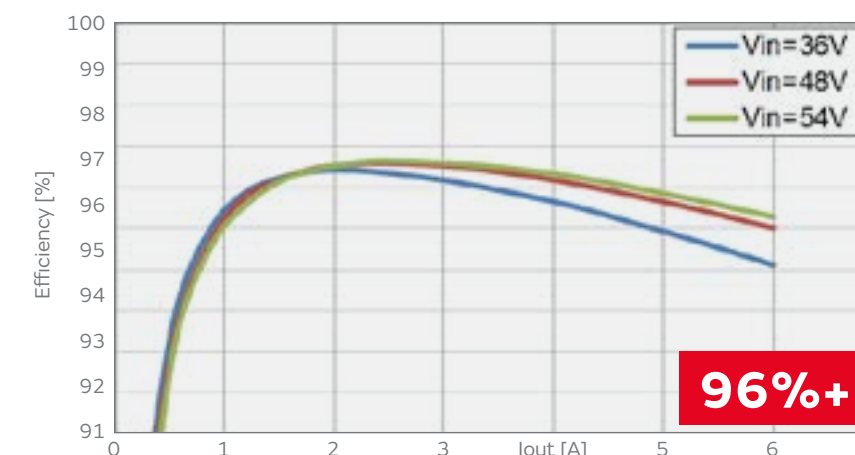


MYC0409 evaluation data

Load regulation



Efficiency



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Power

Isolated high power DC-DC converters



High reliability with high power density

- Industry Standard DOSA PMBus compliant
 - DSE - DOSA, W / PMBus, sense & trim
 - DAE - DOSA, W / sense & trim
 - DCE - DOSA 5 Pin IBC
- 2:1 Input voltage range: 36-75V
- High efficiency: typ. 95.5%
- 2250Vdc I/O isolation, with basic insulation
- Optional load sharing of two or more modules
- Configurable soft start/stop
- Precision delay and ramp-up
- Voltage sequencing and margining
- Voltage/current/temperature monitoring
- Wide output voltage trim range
- Telecom and wireless applications



UWS 54W Sixteenth Brick

- Single outputs:
- 3.3V/15A, 5V/10A,
- 12V/4.5A, 15V/3.3A, 24V/2A
- Open frame, light weight



UWE 120W Eighth Brick

- Single outputs:
- 5V/24A, 12V/24A,
- 15V/8A, 24V/5A
- Optional baseplate



DBE 300W Eighth Brick

- Single outputs:
- 12V/25A, 5V/40A, 3.3V/40A
- Optional baseplate



DSE 400W Eighth Brick

- Single outputs: 12V/33A
- With baseplate



DSQ 600W Quarter Brick

- Single outputs: 12V/50A
- With baseplate



DBQ 420W Quarter Brick

- Single outputs:
- 12V/35A, 5V/60A, 3.3V/60A
- Optional baseplate

Power products	
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●	UltraBK™
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- Timing devices
- Capacitors

Sensors

PTC Thermistor to protect I/O input and output circuitry

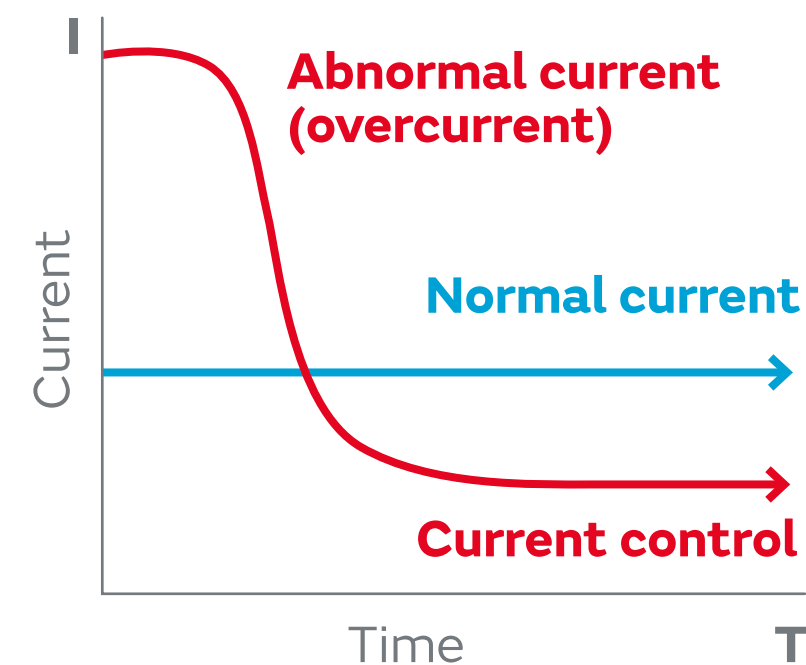
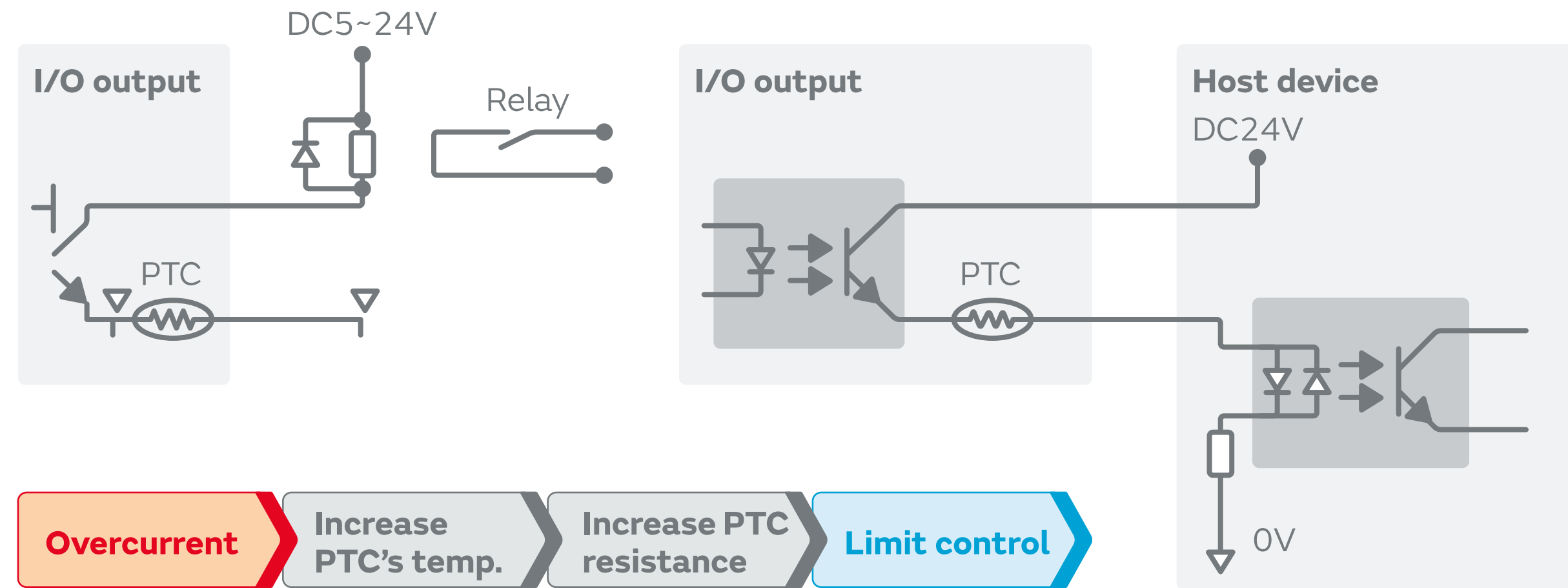
(Overcurrent protection due to ground faults in I/O input circuits, overcurrent protection due to misconnection without load on I/O output circuits)

Key features

- 0402, 0603, 0805 size SMD PTC thermistors
- When an overcurrent is detected, the resistance of the PTC thermistor instantly becomes high, suppressing the overcurrent to protecting the circuit and power supply.
- Removes the factor of overcurrent and, when restarted, the PTC thermistor returns to its original low resistance value. It is a resettable fuse that can be used repeatedly (no replacement such as a current fuse is required).
- Safety standard certifications: UL1434, E137188, IEC60738-1, IEC60730-1Annex.J

PRG series - SMD PTC thermistors

- Use for overcurrent protection applications
- lineup of 30V products for I/O circuits



- Sensors
- PTC thermistor

[Find out more >](#)

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Murata innovation	Power products
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Noise suppression filters

Common-mode choke coils/ common-mode noise filters

Common mode choke coils (CMCC) are filters that reduce common mode noise that is problematic in differential transmission lines (non-automotive use: USB, HDMI, Mipi, etc.), power lines and audio lines. They are ideal for suppressing common mode noise with frequencies ranging from several megahertz to several hundred megahertz with no adverse effect on the signals (upper cut-off frequency).



For signal circuits

	Signal speed										
	USB 2.0 (480Mbps)	MIPI D-phy Ver1.1 (1.5Gbps)	HDMI 1.4 (1.7Gbps)	MIPI C-phy Ver1.0 (2.5Gsym/s)	MIPI D-phy Ver1.2 (2.5Gbps)	USB 3.1 Gen1 (5Gbps)	HDMI 2.0 (6Gbps)	Display Port 1.4 (8.1Gbps)	USB 3.1 Gen2 (10Gbps)	HDMI 2.1 (12Gbps)	
0.45 x 0.3mm (018012/0403)	NFP0RSA242HL2				NFP0RSA242HL2	NFP0RSA242HL2	Red = NEW	Bold = Devices with equalization functions			
0.65 x 0.5mm (025020/0605)	DLM0QSN900HY2	DLM0QSN500HY2	DLM0QSB350HY2		DLM0QSB500HY2	NFG0QHB372HS2	NFG0QHB372HS2	NFG0QHB542HS2	NFG0QHB542HS2	NFG0QHB542HS2	
0.85 x 0.65mm (03025/0806)	DLM0NSN900HY2			NFG0NCN162HL3	DLM0NSN500HY2	DLM0NSN500HY2	DLM0NSB280HY2			DLM0NSB120HY2	
2.0 x 1.2mm (0805/2012)	DLW21HN900SQ2		DLW21SN900HQ2			DLW21HN900HQ2	DLW21SN900HQ2				

For power circuits

	Rated current								
	2A	4A	6A	8A	10A	12A	14A	16A	18A
4.0 x 4.0 x 1.5 max.mm (1515/4040)	DLW44SM_SK2 (-40 to +105°C)								
5.0 x 3.6 x 2.4 max.mm (2014/5036)	DLW5ATN_SQ2 (-40 to +85°C) DLW5ATN_MQ2 (-40 to +105°C) DLW5ATN_TQ2 (-40 to +105°C)								
5.0 x 3.6 x 4.3 max.mm (2014/5036)	DLW5AHNSQ2 (-40 to +85°C)								
5.0 x 5.0 x 2.5 max.mm (2020/5050)	DLW5BTM_SQ2 (-40 to +85°C) DLW5BTM_TQ2 (-40 to +105°C)								
5.0 x 5.0 x 4.5 max.mm (2020/5050)	DLW5BSM_SQ2 (-40 to +85°C) DLW5BSM_TQ2 (-40 to +105°C)								
5.0 x 5.0 x 5.0 max.mm (2020/5050)	PLT5BPH (-55 to +150°C)								
12.9 x 6.6 x 9.3 max.mm	PLT10HH (-55 to +105°C) PLT10HH (-55 to +125°C) PLT10HN_PO (-55 to +125°C) - leaded type								

Note: In regard to the rated current, derating may be necessary, depending on the operating temperature.

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Noise suppression filters

- Common-mode choke coils/ common-mode noise filters
- Chip ferrite beads

Common-mode chokes/filters >

Find out more - PLT10H >

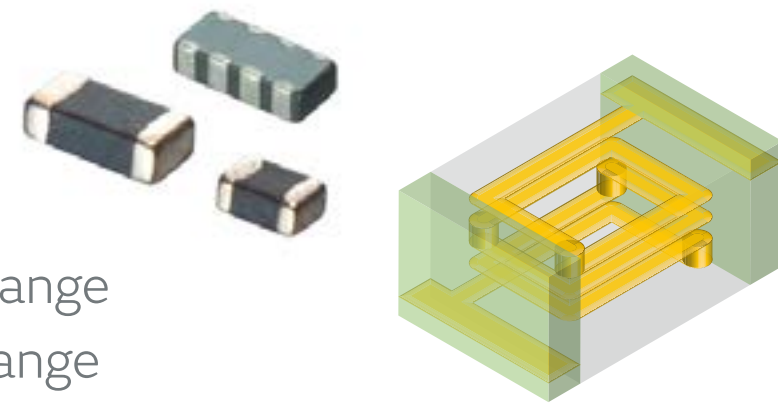
Technology case study >

Noise suppression filters

Chip ferrite beads

Key features

- Small size
- High performance
- Wide temperature range
- Extensive product range

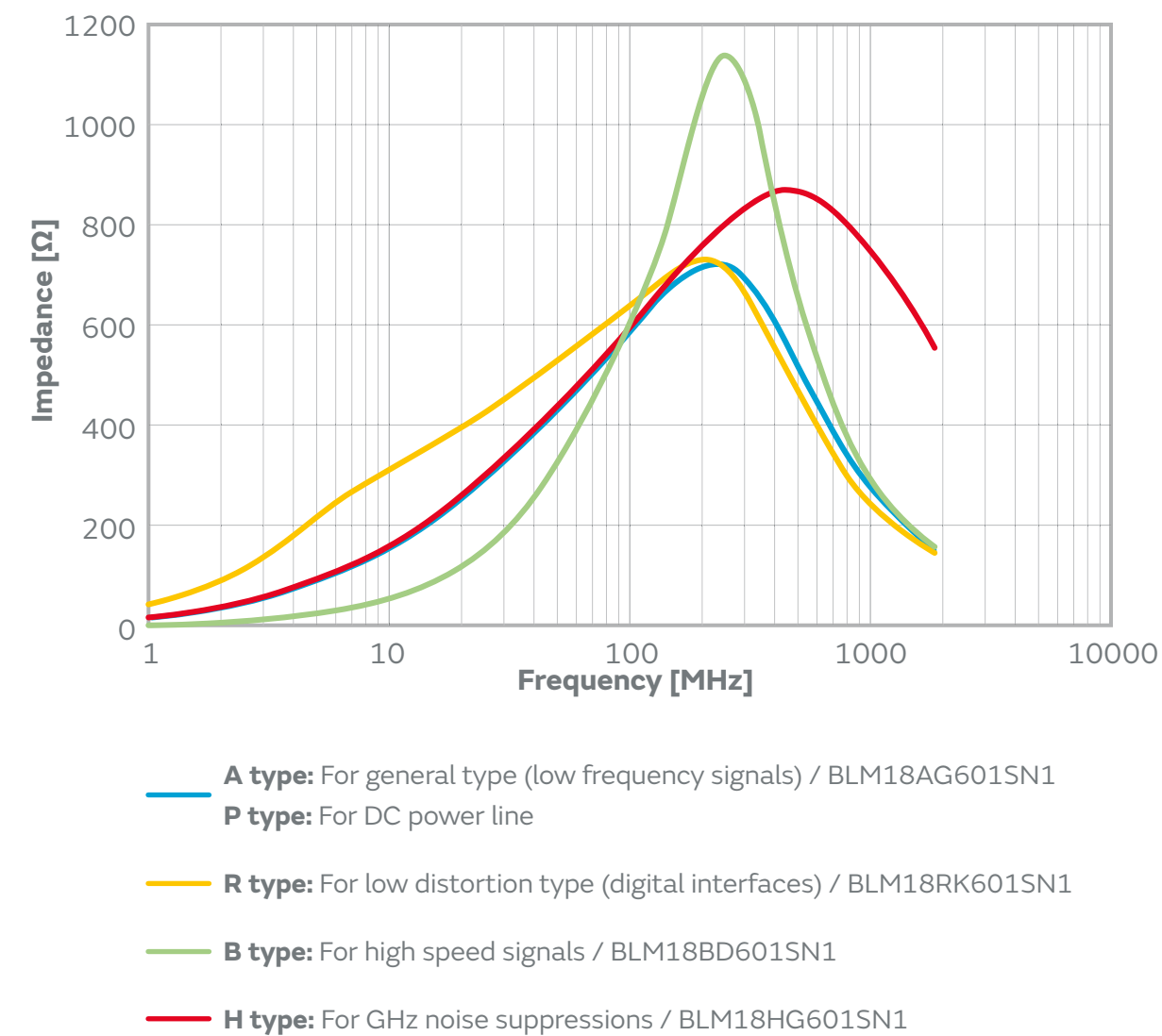


BLM & BLE series

Ferrite beads are Inductive EMI suppression filters that are effective from several MHz to several GHz. They can be widely used as general purpose noise suppression components. Inductive EMI filters work as in-

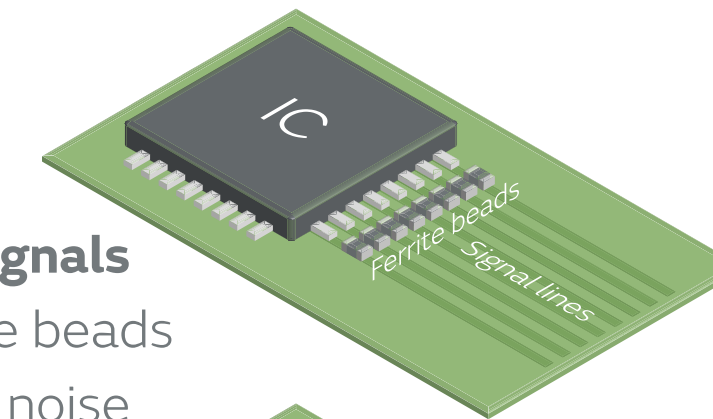
ductors at low frequencies, but impedance caused by resistance increases at high frequencies. When inserted in series into the noise conduction path, this resistance component prevents and absorbs noise conduction.

Characteristics example



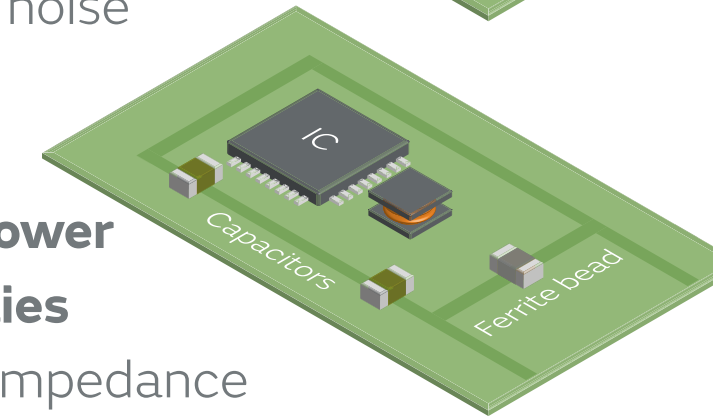
For signals

Ferrite beads block noise



For power supplies

High impedance transfers noise to ground



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Noise countermeasures - basics >

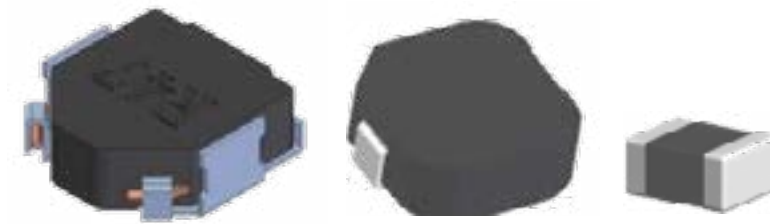
Murata chip ferrite beads >

Noise frequency band	High	High GHz band	BLM_G series BLM_GA For high-speed signal lines BLM_GG For general signal lines	BLM_D series BLM_DN For high-speed signal lines and power supplies
		GHz band	BLM_H series BLM_HB BLM_HD BLM_HE For high-speed signal lines BLM_HG BLM_HK For general signal lines	BLM_E series BLM_EG For general signal lines and power supplies BLM_EB For general signal lines and power supplies
		BLM standard line up	BLM_RK For digital interfaces BLM_AG For general signal lines BLM_B- For high-speed signal lines BLM_AX For general signal lines and power supplies	BLM_P, BLM_K, BLM_S & BLE series (for power lines) BLM_P- BLM_K- Maximum 6A BLM_S- Maximum 12A BLM_AX For general signal lines and power supplies BLE Maximum 10A
	Low		Low	High

Rated current

Inductors

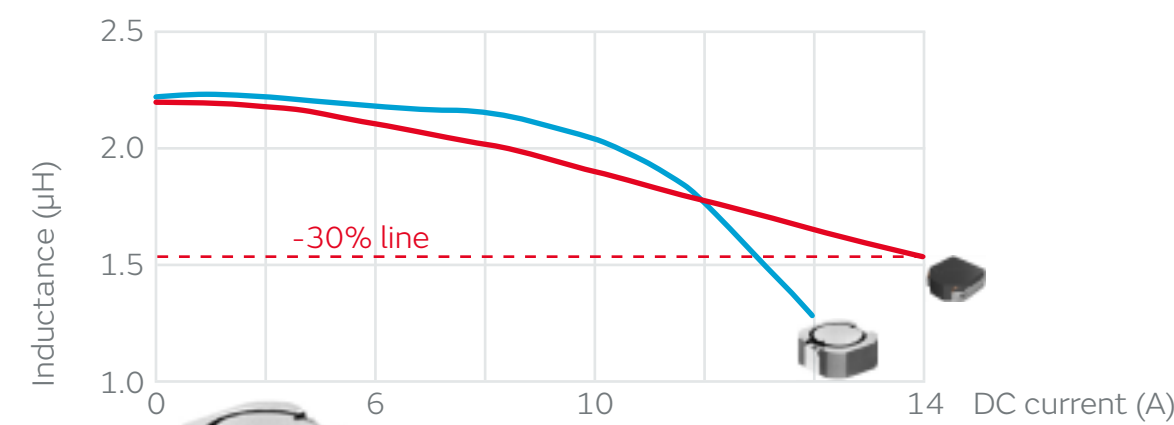
Metal alloy power inductors



Key features

- Higher Saturation Current
- Less inductance deviation over temperature
- Low magnetic flux leakage
- Low Audible noise

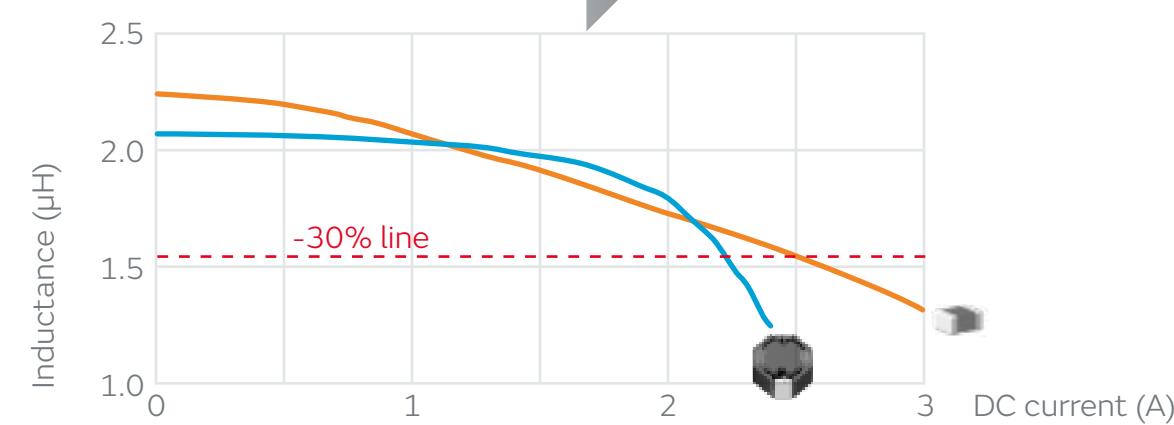
Size reduction vs ferrite



Ferrite
(DS104LC)
10.1 x 10.1 x 4.0mm

55% SPACE SAVING

Metal alloy
(FDSD0630)
7.0 x 6.6 x 3.0mm



Ferrite
(D52LC)
5.0 x 5.0 x 2.0mm

80% SPACE SAVING

Metal alloy
(DFE252012C)
2.5 x 2.0 x 3.0mm

Small package sizes

1210 (3225)	DFE322512F 0.33- 10µH	Isat; 1.7- 8.5A
1008 (2520)	DFE252010P 0.33- 4.7µH	Isat; 1.7- 5.7A
	DFE252010F 0.24- 10µH	Isat; 1.3- 7.2A
0806 (2016)	DFE201610P 0.24- 2.2µH	Isat; 2.0- 5.4A
	DFE201610E 0.24- 10µH	Isat; 1.0- 6.3A
0603 (1608)	DFE18SAN/SBN 0.24- 1.0µH	Isat; 2.0- 4.2A

0.16 µH 0.24 µH 0.47 µH 1.0 µH 2.2 µH 4.7 µH 10 µH 22 µH

Larger package sizes

4640 (116100)	FCUL1060 0.36- 0.56µH	Isat; 34- 41A	FCUL
4650 (115100)	FCUL1040 0.18- 0.42µH	Isat; 31- 38A	
2926 (7366)	FCUL0630 0.12- 0.68µH	Isat; 15- 32A	FSD
	FCUL0624 0.22- 0.47µH	Isat; 1.7- 8.5A	
2522 (6357)	FCUL0530 0.36- 0.47µH	Isat; 2.4- 6.8A	FSD
	FSD5018 0.68- 10µH	Isat; 3.2- 7A	
	FSD5015 1- 4.7µH FSD5012 1- 4.7µH	Isat; 2.3- 6.1A	
1515 (4040)	FSD0420 0.33- 10µH	Isat; 1.5- 1.9A	FSD
	FSD0415 0.22- 4.7µH	Isat; 2.5- 11A	
	FSD0412 0.33- 4.7µH	Isat; 2.9- 12A Isat; 2.5- 6.4A	

0.16 µH 0.24 µH 0.47 µH 1.0 µH 2.2 µH 4.7 µH 10 µH 22 µH

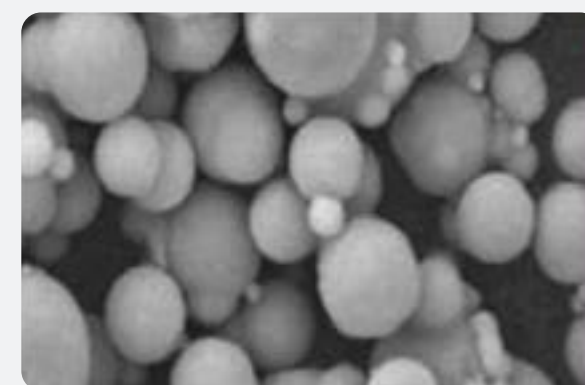


DC-DC Converter Design Support Tool

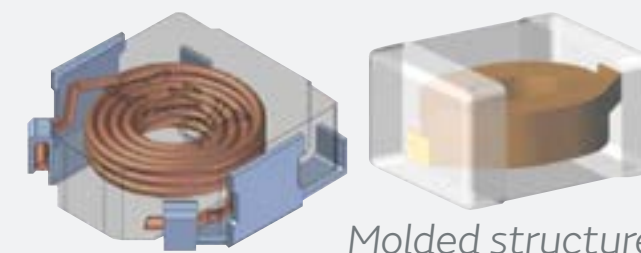
- Assist inductor/capacitor selection in terms of efficiency and ripple
- Available online - no download required

[DC-DC converter design tool](#)

Winding & metal alloy magnetic powder technologies



Metal alloy magnetic powder



Molded structure

[What is a metal alloy inductor?](#)

Inductors

- Power inductors
- RF inductors

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Inductors

RF inductors for high frequency circuits

Murata's lineup of inductors for high-frequency circuits features ultra-compact film-type inductors, general-purpose multilayer inductors, and high-Q, high-current supporting wire-wound type inductors, all of which are used in high-frequency circuits.

These inductors are recommended for all high-frequency circuits, including mobile phone RF modules, Wi-Fi modules, Bluetooth® modules, and various types of matching circuits.

Wire wound type



Excellent Q characteristics

More than twice the performance of the same size multilayer type inductor

Film type



Unique manufacturing method

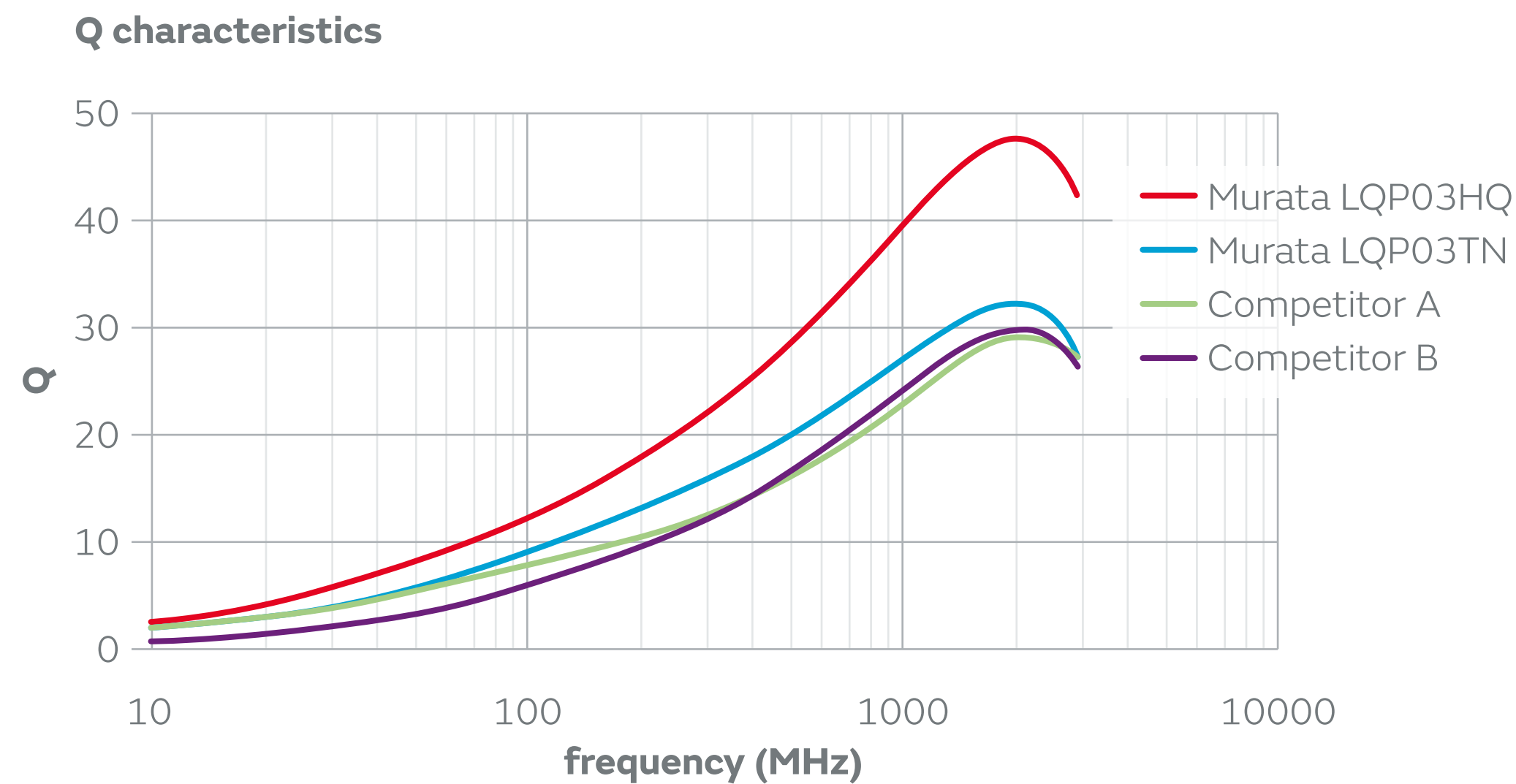
Manufacturing method commercialized only by Murata

Multilayer type



A history of miniaturization

Murata's speciality, the multilayer manufacturing method has commercialized up to the 1005 size



Comparison of Q characteristics between 0603 size, Murata products and multilayer products of other companies (both 10 nH)
 LQP03TN: multilayer type
 LQP03HQ: film type

- Inductors**
- Power inductors
 - RF inductors

- [Find out more](#)
- [See all Murata RF inductors](#)

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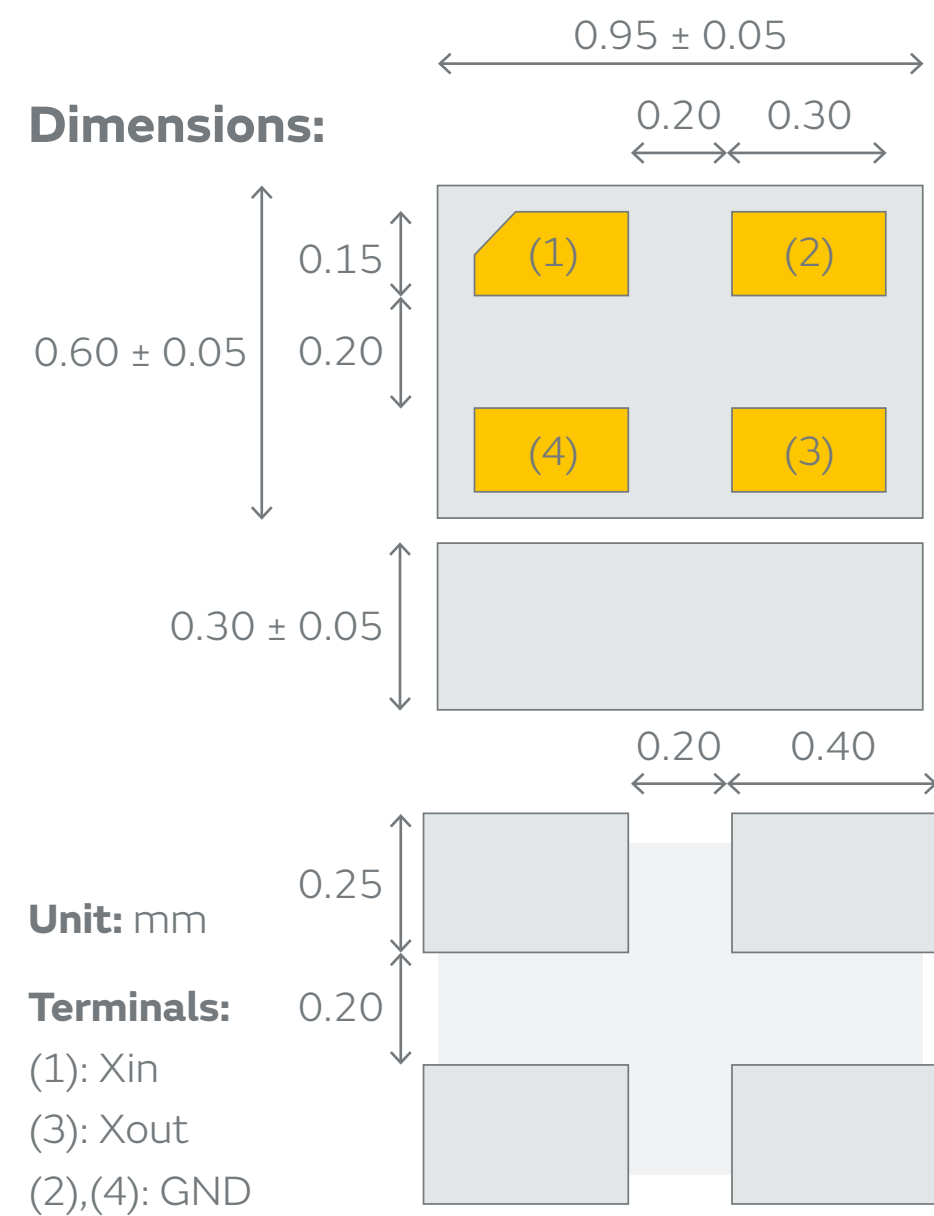
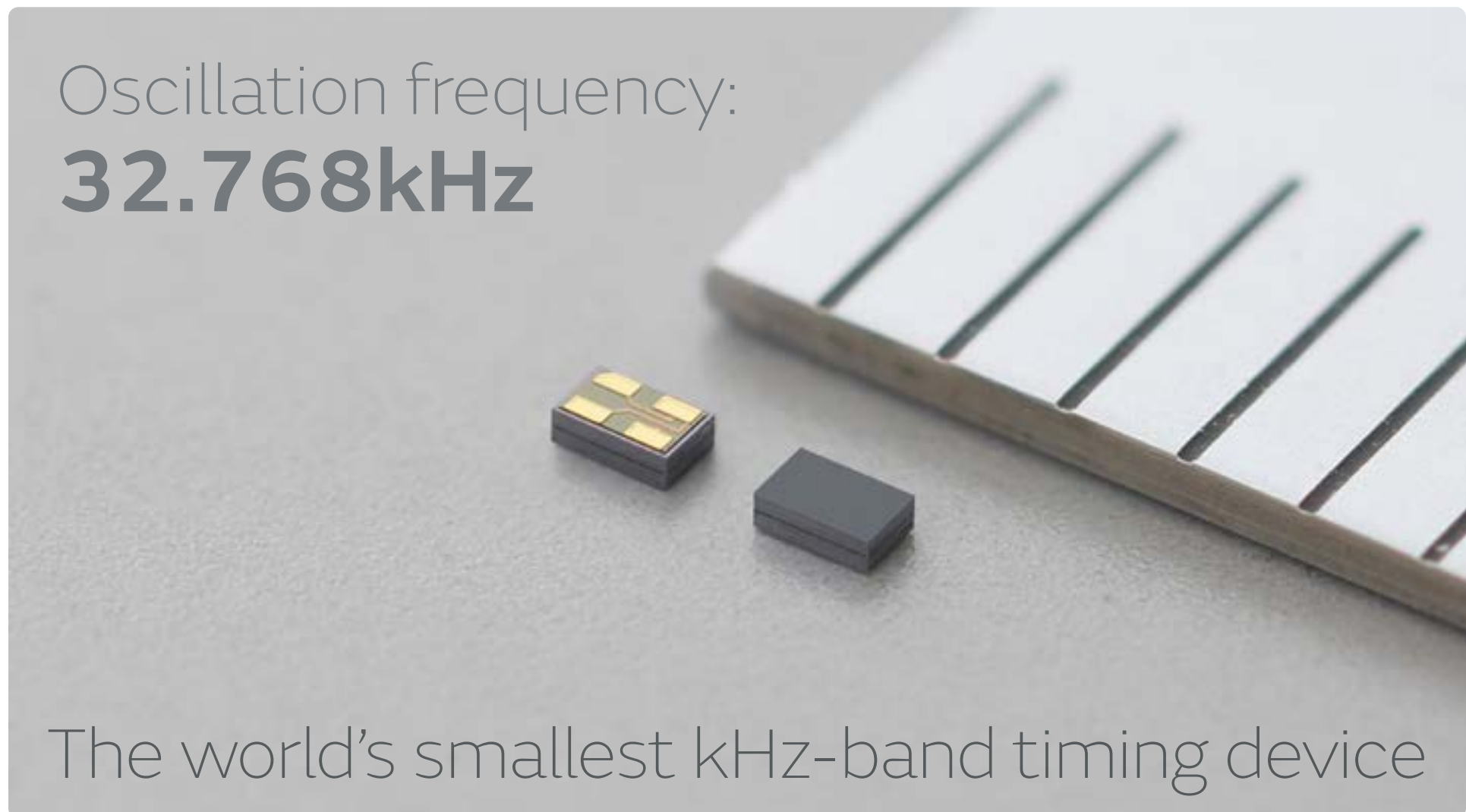
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Timing devices

MEMS resonator

Key features

- World's smallest size
- Low profile
- No external loading capacitance needed
- High performance
- High reliability



Specifications:

Package size	0.95 x 0.60 x 0.30mm
Operating temperature	-30 to +85°C (-40 to +125°C max.)
Nominal frequency	32.7680kHz
Frequency tolerance (at +25°C)	+/-20ppm
Frequency stability (-30 to +85°C)	-150 to +10ppm
Montional resistance (ESR)	75k ohm max.
Frequency aging	+/-3ppm
Drive level	0.2uW max.

Timing devices

- MEMS resonator

[Find out more](#)

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Capacitors

Large capacitance - MLCC & polymer aluminum

By adding polymer Al cap (the ECAS/ECNS series) to our line of multilayer ceramic capacitor (MLCC) products, we have further broadened the range of options available to customers.

As electronic devices gain ever-more-sophisticated functionality, stricter voltage control is needed for the power lines of the CPU, etc. Maintaining voltage line stability sometimes requires large capacitance. In the past we would have suggested using multiple MLCCs, but now in many cases we can propose combining ECAS/ECNS series capacitors with MLCCs in order to reduce both the quantity and cost of components.

Comparison table

Product type	MLCC	Polymer Al capacitor (PAC)
Appearance		
Low ESR	★ ★ ★	★ ★
Long-term reliability	★ ★ ★	★ ★
Temperature characteristics	★ ★	★ ★ ★
DC bias characteristics	★	★ ★ ★
Large capacitance	★ ★	★ ★ ★
High voltage	★ ★ ★	★
Compact & thin	★ ★ ★	★

High reliability MLCCs

Please see our extensive range of automotive-grade MLCCs

[See automotive-grade MLCCs >](#)



Capacitors

○ MLCC & polymer aluminum

[Find out more - MLCCs >](#)

[Polymer aluminum capacitors >](#)

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