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DIE UNABHÄNGIGE WOCHENZEITUNG FÜR ELEKTRONIK

2023 | E

- *Passive & E-Mechanical Components*
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Editorial

Andreas Mangler

Change through growth

After 50 years as a distributor in the electronics market, we can look back on some significant milestones. Beginning with a focus on passive components in the 1970s, we take you through our entire portfolio in this special issue of RUTRONIKER. Our portfolio has become increasingly differentiated over the past five decades. In the 1980s, the great demand for microchips ensured rapid growth in the semiconductor industry. In the 1990s, the cell phone industry experienced its breakthrough with the introduction of the GSM network. Digital networks and the Internet, along with the applications associated with them, have forever changed our professional and private lives. Rutronik also expanded considerably in the 1990s by adding displays and systems to its portfolio to help shape the newly emerging markets. Around the turn of the millennium, Rutronik succeeded in becoming one of the leading broadline distribution companies in Europe and is today Europe's largest broadliner.

Technologically, the 2000s also set the course for innovations in wireless communications and information technologies. Digitalization took off. Another milestone in the 2010s were the significant changes in the automotive industry. This can be seen, above all, in innovations in the context of connectivity and Internet-based linking of vehicles, as well as in the development of alternative drive systems. All these developments were also the reason for establishing the Rutronik Automotive Business Unit in 2014, which focuses explicitly on the procurement and development structures of customers in the automotive sector. With artificial intelligence, Big Data, robotics and human-machine interfaces, automation and Industry 4.0, we are in the midst of the next technological transformation, one we are currently helping to shape and will continue to shape in the coming years. Across all sections of this issue of RUTRONIKER, we will show you how the latest developments and innovations in our various product areas are shaping the applications of today and tomorrow more than ever before. Our visual Future Market markers in this issue's articles will show how this is triggering new developments and innovative solutions in the various markets of Automation, Advanced Robotics, IIoT and Industry 4.0, as well as Future Mobility and Energy.

In the interview with our CEO Thomas Rudel, you can discover how Rutronik has always promoted growth through change over five decades. In addition to a review of important milestones in the company's history focusing on expansion of the global distribution network, you can read about the current situation in the distribution market. It also provides an outlook on Rutronik's strategic positioning as a broadline distributor and systems provider.

With our Rutronik System Solutions, we are fulfilling precisely this promise of a system provider and addressing the exact needs of our customers with our solutions. The aim is to shorten their time to market significantly. Since the last issue of RUTRONIKER, there have been new developments such as the market launch of two new base boards: the Rutronik Development Kits RDK3 and RDK4. Read more in the interview with Stephan Menze, Head of Global Innovation Management, about the designs, some of which are patented, that we bundle under the umbrella of our Rutronik Systems Solutions.

On behalf of the entire Rutronik team, I hope you enjoy reading this fascinating issue, which will provide you with valuable ideas and inspiration for your work!

Yours truly,

Andreas Mangler
Director Strategic Marketing and Authorized Representative at Rutronik

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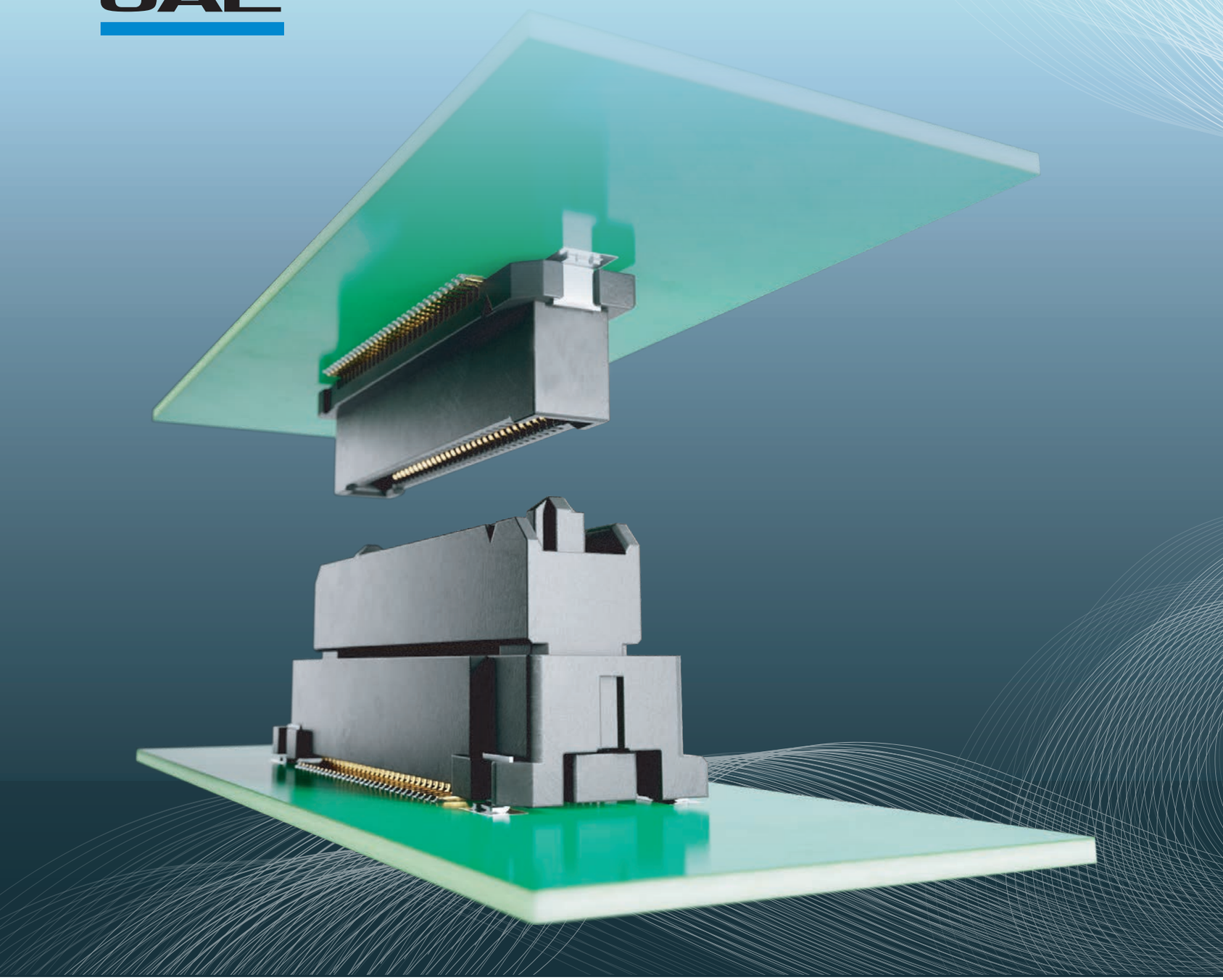
Technology to Inspire Innovation

JAE



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How it all began – the 1970s

The birth of Rutronik – and color TV

Color TVs became popular in the 1970s. And those were the years when Rutronik began its meteoric rise.

On August 25, 1967, Vice Chancellor Willy Brandt pressed a red button during the International Consumer Electronics Fair (IFA) in Berlin – marking the official start of color TV in Germany. But only a few people were actually able to enjoy a color TV picture: There were only around 6,000 color TV sets in Germany at that time, compared to around 13 million black-and-white sets. And not all programs were broadcast in color. The news program "Tagesschau" did not switch from black-and-white to color until the early 1970s.

Sales of color TV sets took off, with 1.4 million new sets arriving in German living rooms every year. Major events such as the 1972 Olympics and the 1974 Soccer World Cup in Germany prompted many people to make this investment.

Color TVs and other consumer electronics generally came from German companies, most notably Nordmende, Saba, Telefunken, Dual, Grundig, Loewe, Schneider, Schaub Lorenz, and Metz. They were also among Rutronik's most important customers at the time.

Helmut Rudel founds Rutronik

In 1973, Helmut Rudel founded Rutronik Passive Components in Ispringen, Germany. The choice of its location was not left to chance. His goal was to be as close to his customers as possible: The aim was to be able to reach the most geographically distant customers in Germany within a maximum driving time of two hours.

So Helmut Rudel drew a circle around the region in Germany that at the time accounted for almost 70 percent of German component demand. At the center of this circle was the town of Ispringen. Helmut Rudel then entered the electronics market as a one-man operation.

By the end of 1976, Rutronik already had five employees and generated a turnover of six million German Marks. The workforce soon moved into a newly constructed building in Ispringen, where Rutronik's headquarters – which have since been significantly expanded – are still located to this day.

As the company name suggested at the time of its foundation, the focus of Rutronik Passive Components was on the distribution of passive components. Turn to the next page to find out which passive components are important in switched-mode power supplies and what tasks they perform. The article on page 20 describes the progress made in the development of multilayer ceramic capacitors. And you can find out which properties connectors need to help create the metaverse on page 14.

Passive components in modern switched-mode power supplies

Hidden specialists

Switched-mode power supplies are often dismissed as low-budget applications, but they hide specialized components inside without which they are unable to operate efficiently. This technical article shows what these passive components are and how they can ensure operational reliability.

By Christian Kasper, Technical Expert Capacitors, Jürgen Geier, Technical Expert Ceramic Capacitors, Jochen Neller, Technical Expert Inductors, and Bert Weiss, Technical Expert Resistors, all at Rutronik

Although the design of modern switched-mode power supplies is often characterized by newer semiconductor technologies, in particular wide bandgap power semiconductors, a wide range of passive components is required for them to work. It is important to match the characteristics of the components to the respective application. Rutronik presents the most important passives for switched-mode power supplies.

Inductors

The high-frequency (HF) transformer and other inductors form the core of a switched-mode power supply (SMPS). Located in the input section, the interference suppression components ensure suppression of interference voltages and currents on the power supply lines.

Current-compensated chokes (common-mode chokes) suppress asymmetrical interference present on both lines in common mode. They are typically constructed with high-permeability ferrite cores or nanocrystalline core materials.

Linear filter chokes or differential mode chokes attenuate symmetrical interference. Most models have an iron-powder toroidal core or a ferrite EE core with an air gap, but open core designs such as bar or thread chokes are also possible.

In some cases, common-mode and differential mode chokes are combined into one component. This means fewer components and therefore less space requirement and lower

cost. In this case, the leakage inductance of the common-mode choke assumes the function of the differential mode choke; a magnetic bypass can act as an amplifier. Sumida offers this combination, for example through its RK17S and RK23S series.

Optionally, power factor correction (PFC) chokes can be added to the suppressor chokes to provide sinusoidal current consumption for power factor correction. Like the chokes, the active PFC stages contain either iron powder or ferrite cores with an air gap to smooth the output current.

Gate driver transformers (trigger transformers) are used to drive the power transistor (MOSFET and IGBT). Typically based on smaller ferrite core geometries than the chokes, they are characterized by low winding and coupling capacitance and low leakage inductance. Normally, they are rated for isolation voltages ranging from 1.5 kV to 5 kV and are available in THT or SMD versions.

Power transformers made of ferrite cores are the heart of a switched mode power supply. On the one hand, they ensure power transfer from the primary to the secondary side of the power supply, and on the other hand, they are responsible for the safe galvanic isolation of the primary and secondary sides. Since the output side of the power supply is often open, i.e. accessible, this isolation is required by safety standards and must be taken into account in the design of the transformer.

Sub-class	Nominal voltages (AC)	Impulse resistance (AC)	Test voltages
X1	275 V, 400 V, 440 V, 760 V	4 kV	2.5/2.6 kV (AC)
X2	250 V, 275 V, 400 V	2.5 kV	1075 V (DC), 1.5 kV (DC)
Y1	250 V, 300 V, 400 V, 500 V	8 kV	4 kV (AC)
Y2	250 V, 300 V, 400 V	4 kV	2.5/2.6 kV (AC)

Table 1: Classification into (sub-)classes for capacitors in switched-mode power supplies

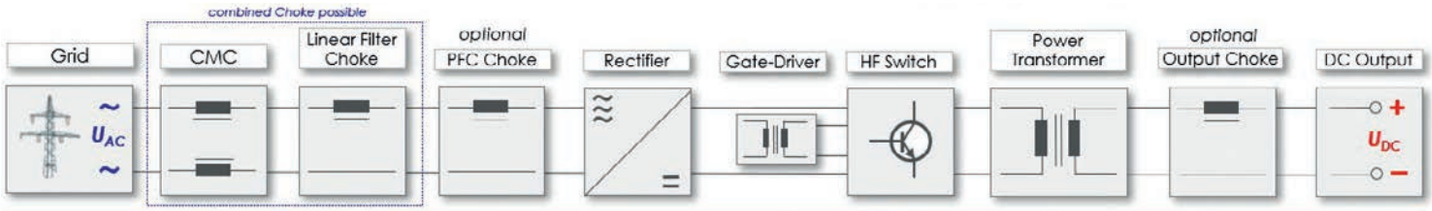
Grade (I) – Robustness under Humidity	
Test A: 40°C / 93% R.H. (relative humidity), 21 days rated voltage	Test B: 85°C / 85% R.H. (relative humidity), 168 hours rated voltage
Grade (II) – Robustness under High Humidity	
Test A: 40°C / 93% R.H., 56 days rated voltage	Test B: 85°C / 85% R.H., 500 hours rated voltage
Grade (III) – High Robustness under High Humidity	
Test A: 60°C / 93% R.H., 56 days rated voltage	Test B: 85°C / 85% R.H., 1000 hours rated voltage

Table 2: THB classes according to IEC 60384-14 AMD1:2016 (source: Vishay)

Proven soft magnetic and low-loss materials with high saturation flux density are used for the power transformers. Their size is reduced as the switching frequency of the power supply increases. For switching frequencies between 500 kHz and 1 MHz, the pulse transformers therefore require fewer raw materials, which has a positive effect on the environmental balance and sustainability of the power supply – an aspect that is increasingly coming into focus.

Customized inductors

In addition to standard inductors, application-specific ones are also available. For power transformers, for example, these are models with several different output voltages. Sumida specializes in this area. These can be variants of existing components that are tailored to a customer's specific application based on standard pre-materials and existing technologies. Standardized core shapes and magnetic materials (e.g. standard EE, UU, ETD, EVD, EFD, EP, RM, ER, PQ, toroid core shapes) and standard plastic components (coil formers,



	CMC Common Mode Choke	Linear Filter Choke	PFC Choke Power Factor Correction	Gate Driver (Trigger Transformer)	Power Transformer	Output Choke
Description	2 Line (3 Line) Common Mode Choke for **asymmetric** Noise Suppression	Choke for **symmetric** Noise Suppression	Correction of the leading Power- Factor, caused by a Capacitive Load.	Trigger Transformer for controlling the HF Switch (Transistor)	Power Transfer and Transformation from primary Winding to secondary Winding(s)	Reduces the Current-Ripple on the Output-Side of the Power Supply
Picture (Examples)						
Magnetic Core Material (typically)	Ferrite Nanocrystalline	Iron Powder (Ferrite – with Air-Gap)	Iron Powder	Ferrite	Ferrite	Iron Powder (Ferrite – with Air-Gap)
Design	2 Windings Toroid, - Frame, - EE, - UU - Core Solutions	1 Winding Mainly Toroid, - Drum, - or EE-Core Solutions	1 Winding Mainly Toroid or EE-Core Solutions	2 to 4 Windings Mainly Toroid or EE-Core Solutions	Multiple Windings on primary and secondary side possible Typically, EE or UU - Core Solutions Partially also Potting	1 Winding Mainly Toroid or Drum-Core Solutions for lower Power For higher Power POT-Core or EE-Core Solutions
	Combined Choke possible - SUMIDA RK17 and RK23 Chokes					
SUMIDA Position	Key Focus of SUMIDA	Key Focus of SUMIDA	Key Focus of SUMIDA	Key Focus of SUMIDA	Key Focus of SUMIDA	Key Focus of SUMIDA

Image: Sumida

Figure 1: Sumida covers all inductors for switched-mode power supplies and partially and fully implements application-specific components.

Images: Kemet

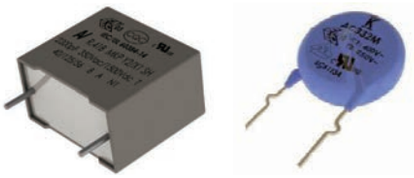


Figure 2: X-Y capacitors usually carry one or more test marks.

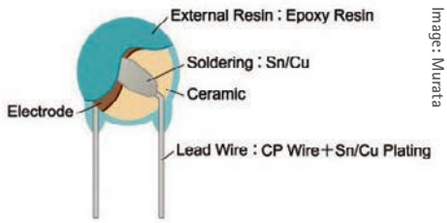


Image: Murata

Figure 3: Structure of a radial single-layer capacitor

packages, and base plates) are also used. For this purpose, Sumida can partly rely on its own MnZn and NiZn ferrites as well as iron powder cores, which the supplier produces in Obernzell, Germany. The nanocrystalline and amorphous core materials are purchased from specialized raw material producers.

Increasingly, however, there are requirements that can only be met with completely customer-specific components based on new magnetic core geometries and, in some cases, even new magnetic material compositions, proprietary plastic parts, and new manufacturing technologies. These completely application-specific geometries are only suitable for a very specific application – but they are perfect for that application in terms of both geometry and size as well as their electrical function. This applies, for example, to high-power transformers for half-bridge, full-bridge, or LLC topologies in a power range of up to 30 kW. They are used, for example, in photovoltaic inverters or DC/DC converters in e-vehicles or in high-power DC charging (HPC) applications.

Capacitors

Capacitors perform many functions in switched-mode power supplies. AC capacitors on the mains side (primary side) are mainly used to suppress or filter interference pulses. Ceramic or film capacitors can be used for this purpose. When they are connected between phase and neutral, it is important that they are X2 or X1 certified. For the connection between phase and protective conductor, a Y classification is mandatory. Since this provides greater electrical and mechanical safety than X capacitors, short circuits cannot occur due to a capacitor malfunction, for example.

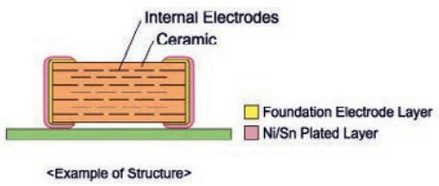


Image: Murata

Figure 4: Section through an MLCC

Since X capacitors are connected between phases or neutral conductors, they do not have the same high safety requirements as Y capacitors.

X and Y capacitors are further subdivided into different test/pulse voltages according to the requirements of IEC 60384-14 and are referred to as X2 and X1 or Y2 and Y1 types. The most common combinations are X1Y2 and X1Y1. Standard subdivisions are shown in Table 1.

In addition, test marks such as ENEC, VDE, UL, or CQC can be found on most X and Y capacitors, since the components must be tested with regard to these standards.

Robustness of film capacitors

Those who choose film capacitors should check if the application requires an increased temperature-humidity-biased (THB) class. This ensures that the capacitors are sufficiently robust against moisture – and therefore corrosion – to ensure the desired service life of the application.

The temperature-humidity bias test is a recognized standard for accelerated life testing. It involves accelerating the aging process of capacitors and measuring in two different tests whether they maintain their capacitance, dissipation factor, and isolation resistance at a given temperature, relative humidity, and nominal voltage over a defined period of time. Three levels (grades) are distinguished (Table 2).

Because of the relatively small capacitance values usually required, ceramic capacitors are mainly used as Y capacitors in a value range of between 10 pF and 4.7 nF. However, they are available with a maximum value of 22 nF.

In addition to the classifications mentioned so far, capacitors are also differentiated according to their target application (commercial, industrial, or automotive) and according to their design.

Image: Yageo

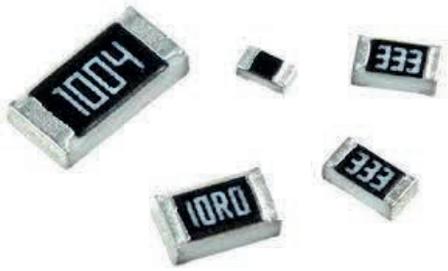


Figure 5: Various resistors are used in switched-mode power supplies for different tasks.

In terms of design, radial types as single layers are the most common and best known. These are ceramic single disks with spacing of 5 and 7.5 mm for X#Y2 and 10 and 12.5 mm for X#Y1 versions (Fig. 3).

In addition, many SMD types are now available as X2, Y2, or X1Y2 versions as multilayer ceramic capacitors (MLCC) and Y1 or X1Y1 versions as single-layer plastic-molded leadframes for surface mounting. Compared with the leaded, radial versions, these offer advantages above all in terms of smaller volume and lower overall height as well as higher suppression levels with the same capacitance values (Fig. 4).

In switched-mode power supplies, a high-voltage electrolytic capacitor is typically used as a buffer downstream of the AC filter on the input side and the first rectifier. Models with a low ESR and a long service life are recommended for this purpose.

On the secondary side, too, low capacitor ESR is also a priority. This allows high output currents and minimizes the residual ripple of the output voltage as much as possible. Low ESR electrolytic capacitors are usually used for this purpose. Additional parallel ceramic capacitors filter possible output-side RF interference.

Resistors

Resistors perform a variety of tasks in switched-mode power supplies: Among other things, they are used as bleeder or leakage resistors and as pre-charge resistors, for protection against overvoltages and overcurrents, and for current measurement.

Image: Yageo

Figure 6: Resistor elements made of solid metal are suitable for current measurements.

The bleeder resistor is used to discharge the capacitor, as this could otherwise cause an electric shock even when the power supply is switched off. It is not absolutely necessary in regulated low-voltage power supplies, and it is not needed in linear voltage regulators or switched-mode power supplies with fast duty cycle control to maintain a constant DC voltage. High-ohmic/high-voltage series are used for this application.

Axial, leaded safety resistors are typically used as pre-charge resistors for the buffer capacitors. This is because they bring low resistance value and high pulse strength.

In addition, resistors are used to detect the phase position of the AC voltage to achieve a more accurate divider ratio. Thin film MELF resistors with outstanding pulse load capability and flat chip precision resistors in thin film technology are suitable for this purpose.

Varistors "clamp" overvoltages to protect the non-inverting input of the comparator. Overvoltage metal oxide varistors perform this task. Thanks to their halogen-free, high-temperature-resistant silicone coating, they operate at an operating temperature of up to 125°C and have a maximum current-carrying capacity of 13 kA.

Resistors for overcurrent protection and current measurement

When powerful loads are switched on, very high currents occur for a short time, which can cause damage to the system. PTC and NTC thermistors are used as switch-on current limiters or overcurrent protection. They can also be used for temperature measurement since their electrical conductivity changes as a function of temperature.

The easiest way to limit high switch-on currents is to use low impedance power resistors. In normal operation, however, a relatively high power loss occurs at these resistors. For this reason, the use of NTC or PTC thermistors is recommended. When combined they offer the greatest advantages.

The most important selection criteria for the NTC thermistor are the maximum current and the nominal resistance (R25). The latter must be at least large enough, by circuitry in series with the load, to limit the current to a value that will not blow the fuse and cause damage to other components. The maximum current is determined by the power of the load. The derating of the NTC thermistor must also be taken into account.

PTC thermistors are suitable for safe current limiting with high-capacitance capacitors in DC intermediate circuits. Due to the high current flow, they heat up and become highly resistive and thus intrinsically safe. As a result, they limit the current to safe values in the event of a short circuit in the DC intermediate circuit. They are designed for DC voltages of 260 to 560 V, offer resistances of 22 to 1100 Ω at 25°C, and, depending on the type, have UL, IECQ, and VDE approvals as well as AEC-Q200 qualification.

Another application of resistors in switched-mode power supplies is current measurement. Low impedance shunt resistors are used for this purpose. The current flow can be detected and evaluated via the voltage drop at the resistor. Full metal resistor elements made of manganese-copper and nickel-chromium-aluminum alloys are ideal in this respect. Their material properties mean that they have very low temperature coefficients and are also low in inductance. If the resistive element is a metal strip, resistance values of as low as 15 µΩ can be achieved.

Summary

The importance of passive components in switched-mode power supplies should not be underestimated, as they perform a wide range of tasks. As their importance continues to grow, suppliers are working to improve their performance. As such, it remains exciting to see where the journey of technical developments will take us. All the components mentioned are available from Rutronik with a wide variety of choices in all designs and performance classes. Customer-specific solutions, especially for inductors, are of course also possible, depending on the required quantities. ■

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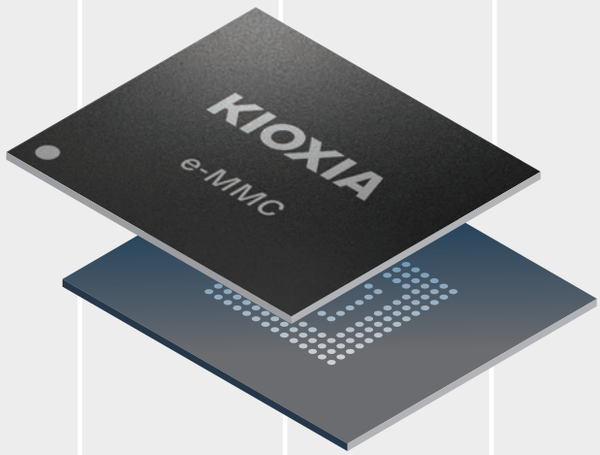

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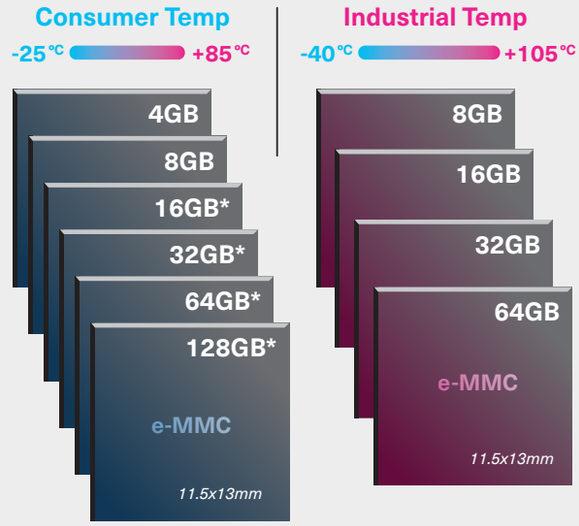

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e-MMC is one of the standard specifications of embedded flash memory defined by JEDEC.

v1.0

Electret condenser microphones, not just for voices

The world is full of sound

Speech or singing: These are the applications that first come to mind when most people think of the way microphones are used. But they can do much more. Electret condenser microphones in particular offer advantages in various applications.

By Jochen Neller,
Technical Expert Inductors
at Rutronik

Sensitive and waterproof microphones can be used to detect water leaks, for example. They pick up even the faintest sounds of leakage in water, making it possible to locate a leak at low sound intensities. They can also be used to be determine flow rates or to track the path of water through different rooms.

Microphones can also be used to record audio data in nature and in animal habitats, for example to obtain information for environmental protection or sustainability projects. For instance, audio collection points in a nature reserve can be used to determine its populations and migration patterns. In addition, natural sounds such as the wind in the trees or gentle rain can be electronically processed for use as a very popular relaxation and sleep aid.

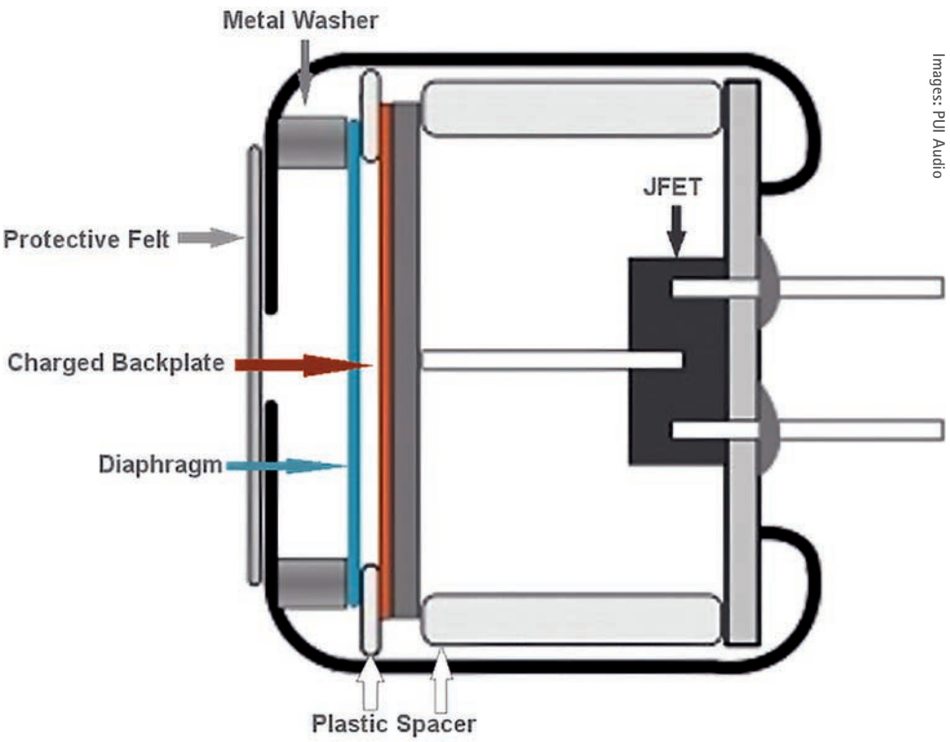
In addition, high-sensitivity microphones can supplement or in some cases even replace surveillance cameras. This is because they can detect sounds that indicate a security breach. If, for example, the breaking of a window or a gunshot is detected, the authorities or security services can be alerted immediately, enabling them to respond faster.

Microphones are available in various designs and with a range of functions. The newer microelectromechanical system (MEMS) microphones in particular offer many advantages. These include a small board area with integrated analog or digital processing electronics, precisely matched components, and easy reflow processing.

Design and operation of electret condenser microphones

For the applications described here, however, the long-established electret condenser microphones (ECMs) are the obvious choice due to the wide range of options available. In contrast to MEMS microphones, they have the advantage of being available with various directivities. This makes it possible to control the direction from which sound should be considered in the application. In addition, ECMs are available in different housing shapes and with flexible connection options.

They work as follows: When sound enters the ECM, either the electret diaphragm or the backplate is electrically charged (polarized). The sound pressure waves that move the diaphragm cause a change in capacitance that corresponds to the change in distance between the diaphragm and the backplate (Fig. 1). This also changes the voltage across this capacitor array. A junction field effect transistor (JFET) in the microphone housing serves as a preamplifier. To boost the signal to a usable output, it amplifies the change in ca-



Images: PUI Audio

Figure 1: Schematic diagram of an electret condenser microphone

pacitance and thus the change in voltage for further processing in the amplifier (Fig. 2).

Most ECMs have a very small package design, making them easy to integrate. They have high resolution and a very wide frequency response. Modern ECMs have a thin, lightweight diaphragm. This makes them more sensitive than dynamic microphones. However, compared to dynamic microphones, the smaller and thinner diaphragm of ECMs is usually also associated with a lower acoustic overload point (AOP). As a result, when the speech signal is weaker, other noise can cause more interference.

The path to the optimal ECM or every application

ECMs deliver clean sound – provided the specifications match the target application. The most important selection criteria are the microphone's sensitivity, polar pattern and robustness.

A microphone's sensitivity determines how well it picks up surrounding sound. For example, if a voice is speaking directly into the microphone, it does not need a highly sensitive microphone to pick it up. The situation is different when there is ambient noise in addition to the sound being picked up (e.g. birds chirping). In this case, a sensitive microphone is needed that can pick up and record this specific sound.

Another important factor is the position of the sound being recorded in relation to the microphone components. There are three basic directional patterns.

- Conventional unidirectional (cardioid directional) microphones pick up sound from one main direction, usually from the front. They are equipped with sound holes at the front and rear of the capsule. Inside the capsule, sound coming from the front has priority over sound coming from the rear. This partially cancels out sound coming from the rear, resulting in a unidirectional polar pattern. Unidirectional microphones are suitable for voice control in automotive applications, for example.

- Bidirectional (noise canceling) microphones pick up sound from two directions in a circular or spherical space around the microphone. Sound holes on the front and rear of the microphone capsule capture sound from these directions, while rejecting sound from the side of the microphone. Bidirectional microphones can be used to suppress lower frequencies from a distance (e.g. wind noise) or to record two different audio sources simultaneously.

- Omnidirectional microphones pick up sound from all directions. They therefore cover the widest range of all directional microphone types. Low frequencies are also picked up equally well from any distance and do not dominate other frequencies. An omnidirectional microphone is particularly suitable for applications where the direction of the sound source is not specified or where all sounds in an environment need to be picked up.

ECMs do not like it hot

In addition to choosing the optimal microphone for the application, careful workmanship is also critical to ensure optimal function. This is because ECMs can be damaged by heat and/or electrostatic charge. For this reason, they must be processed in an electrostatically protected environment and the specified soldering times and temperatures must be strictly adhered to.

Otherwise, there is a risk of damage to the internal JFET, the microphone diaphragm, and the internal plastic housing, all of which are very sensitive to heat. Damage here can lead to mechanical fatigue and sensitivity changes, increased audio distortion, and even total failure.

Wide selection from PUI Audio

PUI Audio offers a wide range of EMCs for a variety of applications. The most common sensitivities are available in sizes ranging from 4 mm to 10 mm in diameter and 1.2 mm to 7 mm in height. Some models feature internal 10 pF and/or 33 pF capacitors to reduce feedback. Connection options include a choice of solder pads (note: not SMD), pins, or variously configured cables, with or without plugs (Fig. 3).

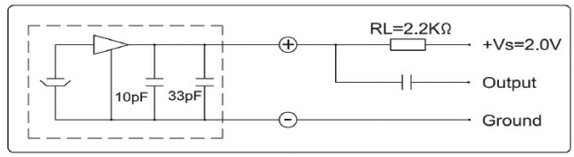


Figure 2: Amplifier circuit of an electret condenser microphone

In addition to the standard mounting options, the supplier offers ECMs with a rubber base and waterproof felt cover. These microphones are IP57-rated and waterproof. Special versions are also available for high-temperature applications. All components are quality tested to withstand the added stress of moisture and temperature without compromising audio quality. ■

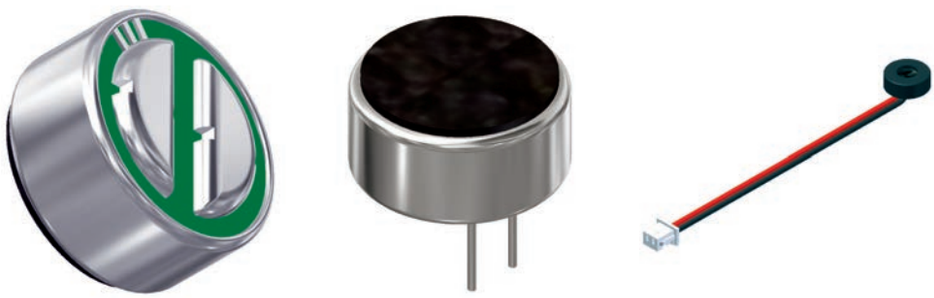


Figure 3: PUI Audio offers ECMs with solder pad, pin, or cable, with or without a plug.

Metaverse

Hardware for a world of data

The metaverse is poised to become the "next big thing". However, high-performance hardware is needed to make virtual worlds happen. This also applies to plug connectors for wired communication and data exchange.

By Sascha Walch, IT Systems Manager, and Martin Pfalzgraf, Technical Expert Connectors, both at Rutronik

The term metaverse comes from the Greek word "meta", meaning in the middle or between, and "verse", short for universe – a kind of parallel universe, in other words, in which the Internet comes very close to reality in the form of a 5D virtual reality space.

The metaverse was initially created in the early 1980s, but it is only now becoming real. Facebook's foray into the metaverse has not been very successful so far, but numerous other companies have now entered the development arena, including BMW, Caterpillar, DHL, and many others. For the gaming, entertainment, social media, and AR&VR hardware segments alone, Bloomberg Intelligence estimates the revenue potential at US$783 billion by 2024. But industry is also discovering the metaverse, merging the digital and physical worlds more and more to achieve the promised efficiency gains. After all, in addition to the virtual worlds in which people will meet friends in the future, there are numerous application scenarios for industry, such as remote support for repairing complex plants or creating a digital twin of production, including the supply chain, infrastructure, and value creation processes.

Potentials of a metaverse for companies

For companies and entire industries, the metaverse could add economic value especially where interaction and exchange play a crucial role: along the supply chain, in purchasing and after-sales, or in coordinating suppliers.

It will enable companies to save valuable time previously required for travel. This will have a major impact on customer service and sales. Collaboration between colleagues and with business partners can be optimized and the need for office space reduced. Interactive simulations can accelerate training and education and lead to better results by enabling employees to learn how to operate equipment as they would in the real world or practice a sales pitch to key accounts. Information on highly complex machinery

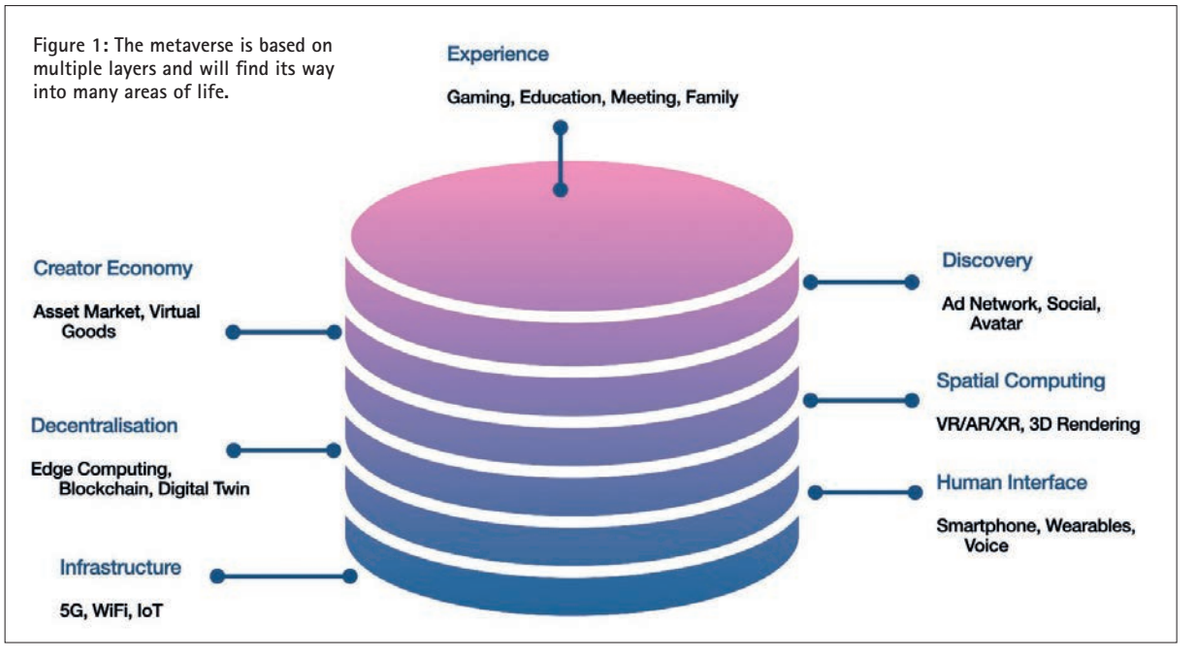


Figure 1: The metaverse is based on multiple layers and will find its way into many areas of life.

Image: Rutronik

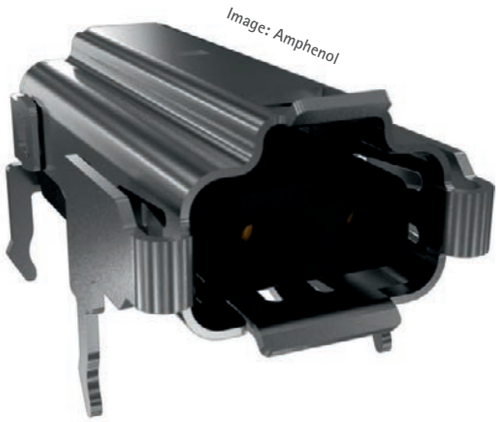


Figure 2: Amphenol's standard single-pair Ethernet jack with edge-to-cloud connectivity of 50 W power over data line.

and equipment no longer needs to be exchanged in the form of abstract data sheets; instead, machines can be viewed from any angle in a matter of seconds. This immediately creates a precise idea of their size, mode of operation, or integration into a production line.

Real building blocks for virtual worlds

Despite being virtual, the metaverse is based on hardware. To enter these worlds as an avatar and to interact with others, such as when a service technician from a plant manufacturer repairs a plant together with the customer, users need gadgets and computer hardware such as graphics cards, VR headsets, high-speed Internet connections, and high-end computers. However, most current components are not powerful enough for the immense amounts of data required.

Nor do today's Internet and data centers have the speed or capacity for truly permanent, immersive computing that people can access in real time. This would require a 1,000-fold increase in processing power over the current state of the art, according to Raja Koduri, Senior Vice President and General Manager, Accelerated Computing Systems and Graphics Group at Intel. And that will take time: A standard Moore's Law curve will only get us to about an eight or ten-fold growth over the next five years, Koduri said in an interview in late 2021.

Figure 3: Amphenol's DDR5 SO-DIMM socket offers data rates of up to 6.4 Gbit/s with single-ended pin assignment.

Moreover, to reduce communications latency to near zero, data centers must be located in close proximity to users. For a smart, secure, and decentralized network, edge and cloud computing devices and servers in multiple locations will be connected via the cloud. Cloud providers will likely connect dozens of distributed data centers in a single city to achieve the fast response times and the low latency required for new edge computing services.

As metaverse applications bring high-speed data closer to the end user, there is a growing need for server operators to create an open source-based infrastructure to meet metaverse performance requirements. That is because open source technologies and projects help organizations accelerate time to market for new applications, delivering faster payback on infrastructure investments. At the same time, this lays the groundwork for a collaborative industry model that enables the improved interoperability, scalability, and programmability required for metaverse applications.

Connectors for the transmission of enormous amounts of data

In order for the edge infrastructure to deliver metaverse applications, the need for hardware acceleration will also grow. To bring Ethernet to the edge, for example, edge server operators can turn to Amphenol's newly developed standard single-pair Ethernet jack. Its edge-to-cloud connectivity with 50 W power over data line makes it easy to connect numerous devices (Fig. 2).

Data-intensive metaverse applications that use AI and transfer audio, video, high-resolution images, and large files between multiple devices require enormous bandwidth and power. More data, in turn, requires faster and more reliable communication. Amphenol's DDR5 SO-DIMM socket, for example, is meets these needs. It offers data rates of up to 6.4 Gbit/s with single-ended pin assignment. For comparison, DDR4 DIMMs are only half as fast (3.2 Gbit/s). It is also only half the density of conventional models. With a lower memory voltage of 1.1 V, it consumes up to 20 percent less power and offers better thermal management. This also reduces the power consumption of edge centers (Fig. 3).

As the metaverse becomes more prevalent in industry, it will become increasingly important that components have a long service life – some plug connectors are not replaced for years. At the same time, they should be power efficient and as immune as possible to electromagnetic interference. Amphenol's new generation of high-density MCIO (Mini Cool Edge IO) plug connectors meets this demand. It can transmit high-speed signals of up to 64 Gbit/s over a distance of 1 m and meets the new PCIe Gen6 requirements. In addition, the MCIO plug connectors are a cost-effective, highly scalable and durable component, making them ideal for edge servers (Fig. 4).

Although it will be some time before the metaverse is a reality, it is already safe to assume that it will be the next big working platform. Rutronik accompanies its customers and suppliers as a partner on this digital journey and offers solutions that pave the way into the new virtual universe. ■

A special thanks from the RUTRONIKER editorial team goes to Mariarita Novelli for her support in preparing the technical article and the accompanying visual material.

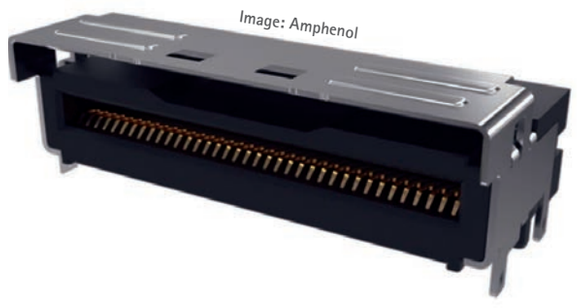


Figure 4: Amphenol's durable Mini Cool Edge IO (MCIO) plug connector can transmit high-speed signals of up to 64 Gbit/s over a distance of 1 m and meets new PCIe Gen6 requirements.

Thermal management

Everything you need to know about fans

For the proper functioning and longevity of electronic systems, the maximum operating temperature of any component must not be permanently and/or significantly exceeded. To ensure this, thermal management is often necessary, for example with a fan. The decisive factor here is the selection of the optimum model for the application in question.

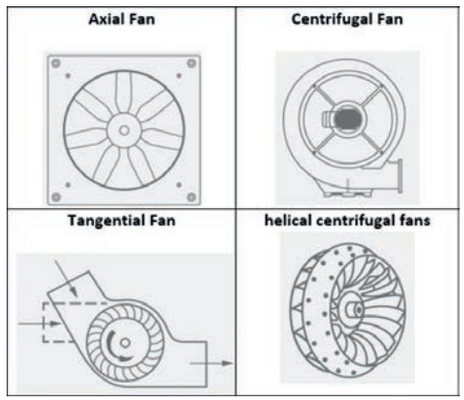
By Maurizio Foresta, FMBG (Fan and Thermal Management Business Group) Sales and Technical Support at Delta EMEA

A fan uses a motor to generate a rotation of the fan blades and thus a pressure difference, which in turn causes a continuous airflow. The fan consists of a rotating part, the impeller, and a fixed part, the package.

The different types of fans

There are numerous types of fans. If it is a question of using them to cool an electronic device, the most important criterion is the direction of the airflow. Accordingly, a distinction is made between:

- Axial fans (the airflow is parallel to the axis)
- Radial fans (the airflow is perpendicular to the axis)
- Tangential fans or cross-flow fans (their long package produces a wide, flat airflow perpendicular to the axis and tangential to the package)
- Spiral radial fans (the blades in the impeller are not straight as in radial fans, but have a spiral or helical structure; this allows them to produce an airflow that is some-



images: Rutronik

Figure 1: Fan types by direction of airflow

Image: stockphoto-graf/stock.adobe.com

where between that of an axial fan and a radial fan (Fig. 1))

In addition, fans are classified by their supply voltage as DC voltage or AC voltage fans. Current AC models are primarily electronically commutated (EC) fans. They achieve higher energy efficiency due to their brushless DC motor and electronic control.

The most important selection criteria

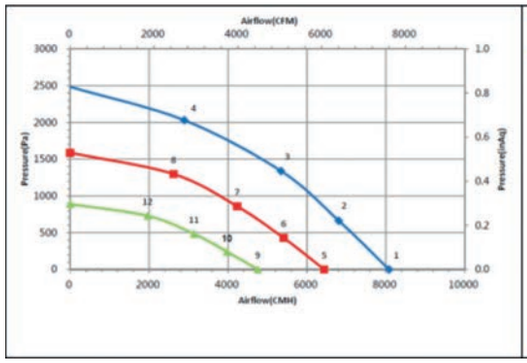
Airflow is also an important indicator for selecting a fan. It is characterized by the amount of air that is discharged from or introduced into an electronic system within a given period. This flow rate is usually expressed in cubic feet per minute (CFM) or cubic meters per hour (CMH; m^3/h). The relationship between CFM and CMH is 1 CFM = 1.699 CMH.

A certain force is required to move the volume of air. This force per unit area is called pressure. To create a specific airflow in a system, its airflow resistance must be known. This is caused by the friction of the air against the duct walls, bends, grilles, filters, slats, and other elements that may restrict air movement. This resistance, called pressure drop or pressure loss, is expressed in pascals (Pa) or millimeters or inches of water column (mm H_2O or inAq). These relate to each other as follows:

1 pascal = 0.102 mm H_2O
= $9.8692 \cdot 10^6$ atmosphere

1 pascal = 0.0040146 inch of water (4°C)

This makes it important to know the pressure drop in the system in order to select a fan that can provide the necessary pressure to overcome this resistance and maintain the desired airflow.



	P [Pa]	Q [CMH]	N [R.P.M.]	P1 [W]	I [A]	Lw [dB(A)]
1	0	8080	3500	1555	2.88	89.1
2	663	6807	3500	2438	3.99	
3	1339	5343	3500	3008	4.89	
4	2029	2894	3500	3037	4.92	
5	0	6437	2800	829	1.60	84.1
6	429	5412	2800	1282	2.27	
7	858	4233	2800	1558	2.68	
8	1298	2618	2800	1569	2.70	
9	0	4756	2100	398	0.96	77.1
10	241	3976	2100	594	1.26	
11	484	3135	2100	699	1.44	
12	729	1961	2100	701	1.43	

Figure 2: Suppliers usually specify several characteristic curves for their fans for operation at different speeds.

Fans impart the necessary pressure to an air mass to create a pressure differential and thus airflow. Three types of pressure are involved in this process:

- Static pressure (P_E) is the force exerted by the stationary air on the system walls perpendicular to it.
- Dynamic pressure (P_D) is the force per unit area and is used to overcome the resistance of the airflow in a system. It therefore ensures that the air moves and is generated by the rotational speed of the fan. It is always positive and has the same direction as the airflow.
- Total pressure (P_T) is the sum of P_E and P_D at a given point in the system. This is the pressure exerted by the air on a body resisting its motion at that point. It is important to note that the total pressure at different points in a system can vary due to the velocity and flow conditions of the air.

A fan's characteristic curve

Fan suppliers perform tests on their equipment to determine how much power the fan can transfer to the air it moves. This is done by operating it at a constant speed. Depending on the pressure drop to be overcome, different values for the airflow are achieved.

Plotting the various values for the airflow and the pressure determined in the laboratory tests on a coordinate axis yields the fan's characteristic curve. It is provided by the fan suppliers, usually with several curves for different constant speeds.

Such characteristic curves are shown in Fig. 2. The airflow is plotted on the X-axis and the pressure (in units Pa and in Aq) on the Y-axis. The pressure is highest when the airflow is zero. In this case, the fan works with high resistance to the airflow, and the maximum static pressure (P_E) is created. At the same time, the dynamic pressure (P_D) is zero, which means that no airflow is generated. At this point $P_T = P_E$.

Figure 2 also shows that when the pressure in the fan is zero, the maximum airflow is achieved. Since there is no resistance to the

airflow – i.e. an obstacle-free environment ($P_E = 0$) – the fan delivers the greatest possible airflow. The total pressure corresponds to the maximum dynamic pressure ($P_T = P_D$) generated by the corresponding speed.

Calculating a fan's operating point

To calculate a fan's operating point (OP), it is recommended to consult with the supplier, as they have the necessary technical means to perform simulations. However, the approximate OP can also be calculated. To calculate the operating point with the lowest power consumption, the power consumption and current values listed in the table (Fig. 2) are important data.

To calculate the operating point, the resistance conditions of the system, represented by the S curve (Fig. 3), must be known (OP is marked here as Q1 and Q2). A complex calculation using thermal equations is required to determine the optimum pressure and airflow values for cooling the system. It is recommended to measure the pressure drops in the system at different airflow rates, for example with pressure sensors and/or manometers. For each airflow rate, the pressure drop values are then recorded and plotted as in Figure 3 (airflow rate on the X-axis, pressure drop on the Y-axis). In addition, it is also important to continuously measure the temperature inside the system. For this purpose, temperature sensors are placed at strategically favorable locations. The optimum operating point is determined based on the airflow that cools the system most effectively.

If the operating point is at the intersection of the S curve and one of the fan's three characteristic curves (Fig. 3, Q1), the fan's speed, airflow, pressure, and power consumption (W and I) can be calculated using the measurement data provided by the supplier in Figure 3 (blue, 3,500 rpm).

If the operating point is not at an intersection with one of the three curves (Q2), the curve can be extrapolated (dashed curve) to determine the intersection with Q2. Alternatively, the data can be provided to the fan supplier to obtain the corresponding characteristic curve (dashed characteristic curve) for the Q2 operating point. The aim is to determine the fan's speed, airflow rate, pressure, and consumption values (W and I).

Factors influencing life expectancy

The most important factors influencing a fan's service life are its temperature profile and its type of bearing. In the case of a plain bearing, it again depends heavily on the lubricants used. A two-ball bearing consists of small metal balls in a raceway, allowing for lower friction and higher efficiency. More detailed information on the fan's operating temperature profile can typically be found in its data sheet.

Main markets

Fans are used in numerous industries to remove heat and maintain optimal temperatures. Major markets include:

- Electronics: For cooling internal components and preventing overheating.
- HVAC (heating, ventilation and air conditioning): For air circulation, indoor temperature regulation, and for generally improving air quality in buildings, homes, offices, and industrial facilities.
- Motor vehicles: For regulating the engine temperature and preventing overheating.
- Renewable energy: For use mainly in wind turbines and solar inverter cabinets.
- Industry: For keeping machines and equipment, e.g. in manufacturing, power generation, or petrochemical industries, at their optimal operating temperatures.
- Data centers: For ensuring cooling to remove heat generated by servers and other IT infrastructure. Fans are an important component of data center cooling systems.
- Consumer electronics: For refrigerators, air cleaners, or game consoles.
- Aerospace: For cooling systems and components.

Innovations – where do we start?

Further development of fans focuses on the following aspects:

Energy efficiency: Fan suppliers are working to improve the aerodynamic design of fan blades, reduce friction losses, and optimize motor efficiency to achieve higher overall energy efficiency. This includes the use of advanced materials and manufacturing techniques to reduce weight and increase performance.

Improved ball bearings: Suppliers are using newly developed bearing technologies to increase the reliability and service life of their fans. For example, fluid dynamic bearings (FDBs) and magnetic levitation bearings (MLBs) offer a longer service life and lower noise compared to conventional plain or ball bearings.

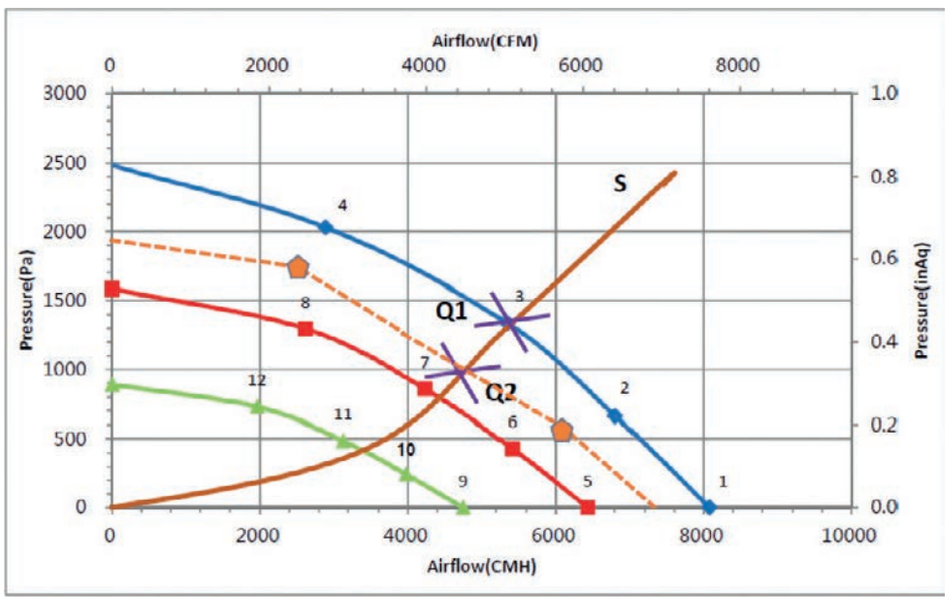


Figure 3: Resistance conditions within the system

Noise reduction: An important issue in fan applications, especially in environments where low noise levels are required. Technical development focuses on improved blade designs, optimized motor controls, and the use of noise-absorbing materials. Computational fluid dynamic (CFD) simulations and other modeling techniques are used to study and minimize noise.

Fan control systems: These play a major role in optimizing fan performance and overall system efficiency. Intelligent control algorithms that dynamically adjust the fan speed based on temperature, humidity, and other environmental factors ensure that fans operate at maximum efficiency while creating optimal cooling conditions.

Integration with cooling systems: Aiming to maximize the heat dissipation of the entire cooling system, fans are integrated with other cooling technologies such as heat sinks, radiators, and liquid cooling systems.

Smart and IoT-enabled fans: The Internet of Things (IoT) has enabled the development of smart fans with advanced features and connectivity. They can be monitored and controlled remotely and enable real-time adjustments based on environmental conditions and user preferences. In addition, IoT-enabled fans can provide valuable data on performance, energy consumption, and maintenance needs for their optimization and predictive maintenance.

All of these advances aim to further improve the cooling performance of fans, further reduce their energy consumption, and provide more reliable and efficient cooling systems for a wide range of industries.

Saving space with MLCCs

High capacities in a small footprint

The electronics market is demanding smaller and smaller applications or the integration of more and more functions into existing devices. This makes printed circuit board space increasingly valuable. Suppliers of multilayer ceramic capacitors have responded accordingly.

By Jürgen Geier,
Technical Expert Ceramic Capacitors at Rutronik

Multilayer ceramic capacitors (MLCCs) are compact, cost effective, and reliable. They have very low equivalent series resistance (ESR) values, which allows them to smooth high ripple currents. They are often used in place of and/or in parallel with electrolytic capacitors to improve system performance.

Due to increasing miniaturization demands, there is a growing need for capacitors with high capacitance and improved temperature performance in ever smaller dimensions. However, in the so-called HiCap range (≥ 1 µF) and in the mid/high-volt range (voltages from 200 V to over 450 V and 630 V up to 5 kV), they quickly reach their limits. This is because

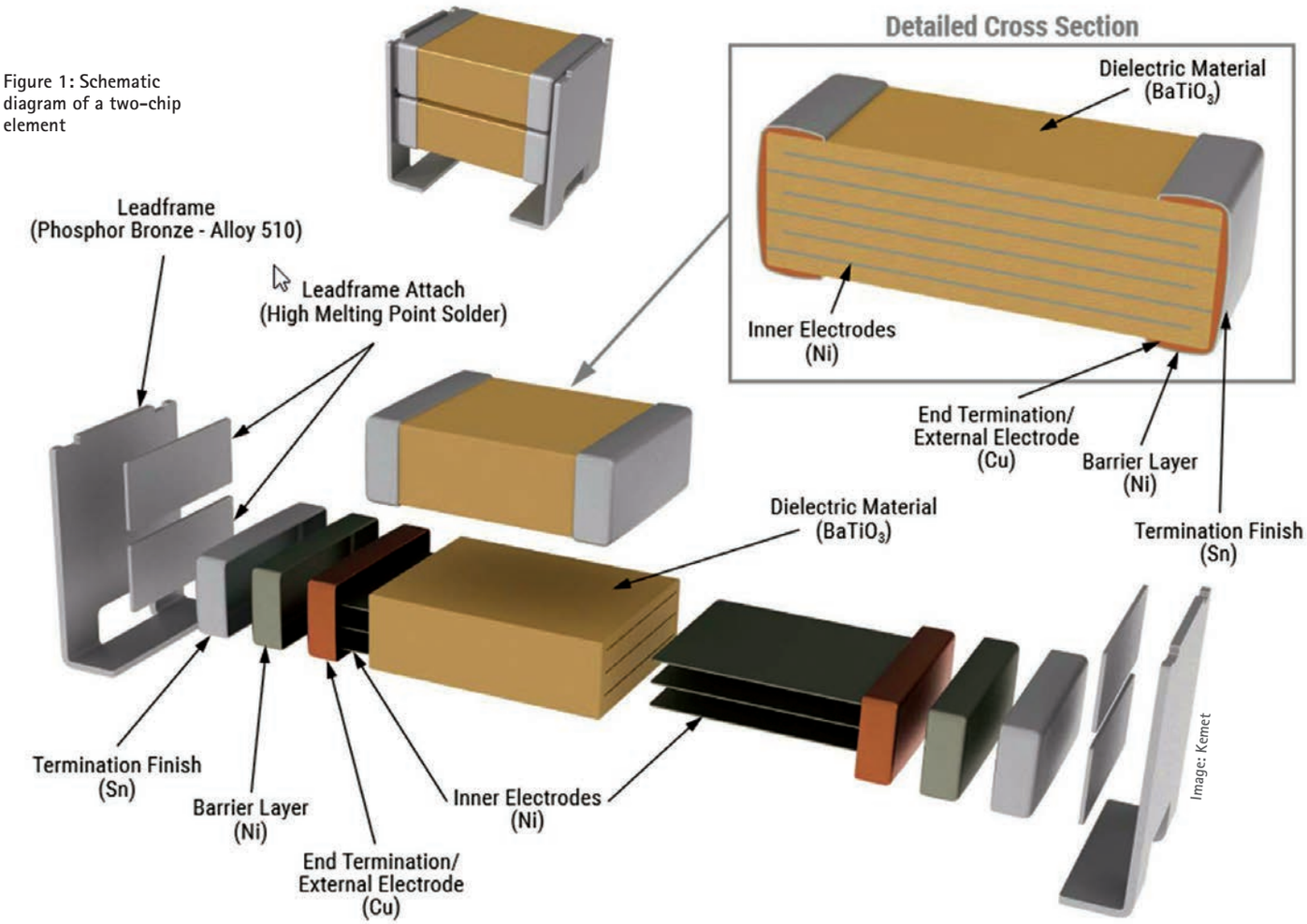


Figure 1: Schematic diagram of a two-chip element

Image: Kyocera AVX

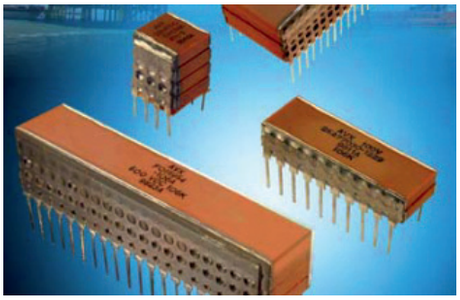


Figure 2: Two-chip element in through-hole design

Figure 3: The lead-frame gives the MLCC greater robustness against thermal and mechanical stresses.

Image: Murata

capacitors of size 1812 or larger (1825, 2220, 2225, 3640, ...) are required here. Even with size 1210, which represents a certain performance optimum, multiple parallel connections and/or connections in series are required, which in turn requires comparatively large areas.

In addition to the capacitors, there are usually other, taller components on the printed circuit board, so that in principle more height is available for the capacitors, but this is not used in single chip applications. To save space, several capacitors can be combined into one component. They are stacked and connected in parallel. Compared to a single element, this gives them a lower ESR and equivalent series inductance (ESL) as well as a several times higher capacitance corresponding to the number of chips used.

Two-chip elements are most commonly offered in sizes 1210, 1812, and 2220, although in extreme cases even they are available with up to ten chips and sizes up to approx. 30 mm × 50 mm. The individual chips are usually arranged horizontally with so-called J-lead-frames for surface mounting (Fig. 1).

Through-hole versions are also available (Fig. 2). However, they are used less frequently, partly because of the difficulty of automating assembly, which leads to higher costs and longer production times.

However, the structure of MLCCs with lead-frames can also be used to increase the performance and robustness of single chips against thermal and mechanical loads (Fig. 3).

Vertically stacked designs are also available for further optimization in terms of thermal stress and reduction of ESR and ESL (Fig. 4).

As a further special feature, Kemet also offers such parts without leadframes. For this purpose, the supplier has developed the so-called KONNEKT technology. It uses an innovative TLPS (transient liquid phase sintering) material to create a leadframe and lead-free multi-chip element. This guarantees further improvements in ESR and ESL as well as an increase in volume efficiency. These capacitors are also available with horizontally and vertically stacked chips.

In addition, special ceramics with positive DC bias are available from TDK – a specialty of the supplier. These CeraLink devices are suitable for high-frequency and high-temperature applications in power electronics, especially where space is limited and nominal currents, capacitance densities, and operating temperatures are high. The CeraLink capacitor consists of a PLZT (lead lanthanum zirconium titanate) ceramic in combination with copper inner electrodes. By balancing high current-carrying capacity and capacitance, CeraLink allows the number of capacitors required to be reduced compared to MLCC, taking into account overall cost. Unlike conventional ceramic capacitors, CeraLink capacitors have their maximum capacitance at the specified operating point (positive bias behavior), which increases proportionally to the ripple voltage ratio, making them the ideal capacitor for fast-switching wide-bandgap semiconductors such as SiC and GaN. ■

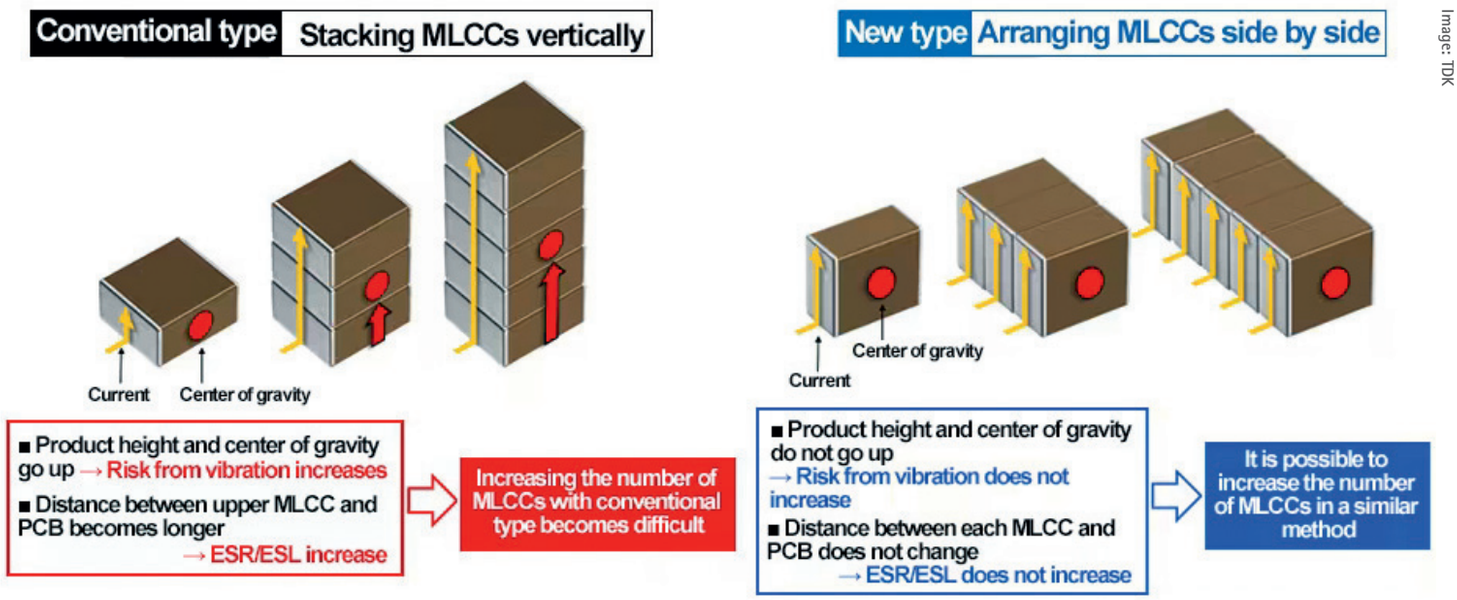


Image: TDK

Figure 4: MLCCs with multiple, vertically stacked chips offer low ESR and ESL and a wide temperature range.

The 1980s

The PC is here!

Microprocessors made the PC possible; Rutronik expanded its portfolio to include active components.

Affordable computer kits gave rise to a culture of IT hobbyists in the mid-1970s. Some of them formed the Homebrew Computer Club in Silicon Valley to realize the vision of a computer for everyone – an idea that was considered quite farfetched at the time. The rest is history: The personal computer (PC) shaped the 1980s in offices and homes, where it was most commonly found in teenagers' bedrooms.

In 1984, Apple released the first Macintosh, followed a few years later by the first successful PCs with graphical user interfaces. In 1985, Microsoft released Windows, which quickly became the world's most widely used operating system. In 1986, IBM unveiled its first PC, which became the standard for office applications.

This development would not have been possible without the microprocessor, which runs all the essential functions of the computer. Although the microprocessor was not a brand-new technology at the time, it did not really take off until the 1980s, when it had its breakthrough parallel with the PC. This spurred a number of innovations, and numerous advances were made in terms of performance, functionality, and design. One milestone came in 1986, with the introduction of Intel's 386, a 32-bit processor with significantly more memory than its predecessors. It enabled an entirely new generation of software. Read more about a current microcontroller on page 30.

Thanks to the new microchips, PCs could process images and sounds as well as text – the birth of electronic entertainment devices.

EDP and active components at Rutronik

At that time, digitalization was still called electronic data processing (EDP), and it also took hold at Rutronik: In 1982, the card index MRP procedure was converted to an EDP system. An external service provider operated the system, while Rutronik employees processed the orders at operator terminals.

Helmut Rudel brought the system to Rutronik with the first AS/400 from IBM; he also optimized the applications, screen masks and processes. The first PC was purchased in 1988, a PC XT with two floppy drives and a 200 MB hard drive.

Like the PC and microchip industry, Rutronik also continued to grow: In 1980, the company purchased Silec/RSC semiconductors. In 1984/85, the main building in Industriestrasse 2 in Ispringen was expanded to almost three times its original size. This was done with wise foresight: Just three years later, the number of employees doubled from 35 to around 70. One reason for this growth was the new product marketing segment. Technical consulting was added to sales, logistics, and scheduling.

In 1988, Rutronik won an order for one million German marks: The starting signal for the expansion of the product portfolio to include active components. ■

Smart home

Energy-efficient IoT with radar sensors

By combining radar technology and IoT sensors, the smart home not only becomes safer and more comfortable but also more energy-efficient.

By Vidya Sriram, Corporate Product Manager Analog & Sensor at Rutronik, and Okan Kamil Sen, Sensor Systems & IoT FAE at Infineon

The number of smart home applications and connected devices is growing rapidly – which is not surprising as they make everyday life more convenient. Statista estimates that there are already around 350 million smart homes worldwide – and the number continues to rise. The downside is high energy consumption. This is because many of the devices are permanently active or in standby mode in order to be ready for use at all times.

Deep sleep instead of standby mode

However, it is often unnecessary for a device to be in standby mode. For example, when residents are not at home, thermostats, smart speakers, and digital assistants could be put into deep sleep mode to reduce energy consumption. The potential savings range from a few watts to more than 100 watts. However, depending on the number of devices and time the amount of time they are in deep sleep, the savings can add up quickly. An example calculation shows: With five smart devices per household, you could save an average of 0.5 kWh per day. For 300 million households, that amounts to a saving of 55 TWh per year.

However, many devices do not have power-saving features such as sleep mode, or users disable them because they are inconvenient to use. This is because deep sleep mode, combined with high application functionality, often results in long startups and waiting times for the user.

Energy-efficient thanks to radar technology and IoT sensors

So how can ease of use be combined with intelligence and energy efficiency? The combination of radar technology with IoT sensors opens up new possibilities. For example, a radar sensor integrated into a smart home device can be used to detect the presence of people. If there are no such impulses, the smart device will automatically switch to deep sleep mode. Depending on the sensor and design, the actual radar module consumes only a few milliwatts and has a maximum power consumption level of just 0.1 W, which is well below the energy requirements of the ON or standard standby mode of many electronic devices.

The advantages of radar technology over other sensors (e.g. infrared) can be seen in the example of a ventilation system. It works most efficiently when combined with temperature and CO_2 sensors, and the system is only acti-

Images: Infineon

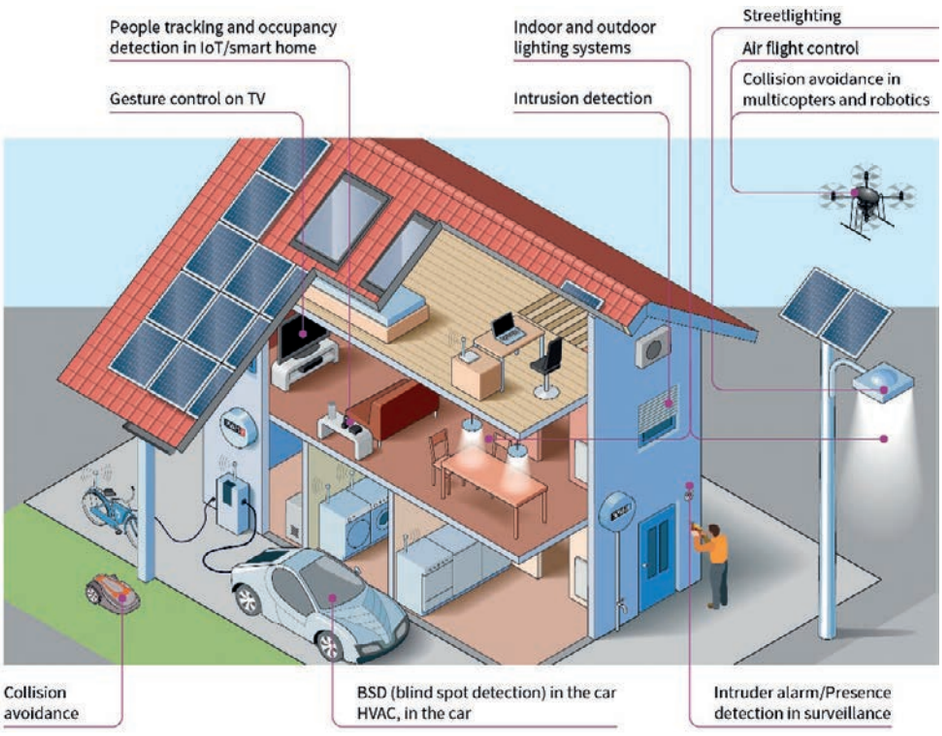


Figure 1: The growing number of sensors in smart homes also increases power consumption.

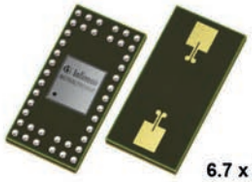
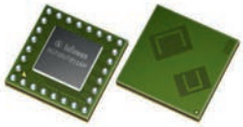
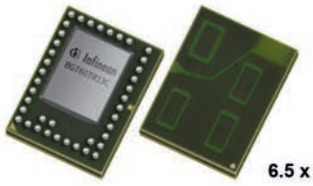
	BGT60LTR11AIP	BGT60UTR11AIP	BGT60TR13C
	 6.7 x 3.3 mm	 4.05 x 4.05 mm	 6.5 x 5.0 mm
Positioning	Smart & cost-effective **PIR replacement**	**Compact and cost-efficient** radar chip for FMCW operations	Enable **advanced radar sensing** including presence, tracking and gesture control
Operating Mode	**Doppler Radar** with integrated detectors	**FMCW** (5.5 GHz BW)	**FMCW** (5.5 GHz BW)
Main value proposition	**Completely autonomous mode:** Most convenient way to implement radar in your system	**Smallest 60 GHz chip** with integrated antennas on the market	**Maximum functionality and flexibility:** Develop the most demanding radar use cases
Target use cases	**Motion detection,** Presence detection (short range)	Presence detection, gesture control, vital sensing, 1D ranging, material classification	Presence detection, gesture control, vital sensing, segmentation, tracking, distance

Figure 2: Overview of the 60 GHz radar portfolio

vated when needed – i.e. when someone is present, the CO_2 level is too high, or the temperature exceeds the preset limit. Unlike other sensors, the radar detects not only whether people are present but also how many and where they are (at what distance from from the sensor). This enables the sensor to optimally adjust the airflow of the air conditioning system.

24 and 60 GHz radars enable a wide range of applications

Infineon Technologies offers a diverse portfolio of radar components for numerous applications. Among other things, the products enable precise motion and presence detection for smart lighting systems, gesture recognition for intuitive human-machine interfaces in smart home devices, contactless acquisition of vital data in health and well-being monitoring systems, and advanced object segmentation and tracking for optimizing industrial processes.

The 24 GHz radar family offers high flexibility in system design and covers a wide range of use cases: It can be used to determine motion and direction as well as the velocity, angle of arrival, and position of single and multiple targets.

For applications requiring wide bandwidth and higher accuracy, Infineon's portfolio includes low-cost and compact 60 GHz radars with low power consumption (Fig. 2).

In addition to applications such as short-range localization in surveillance, lighting, and smart home devices, the 60 GHz radar sensors are also used for vital data acquisition in consumer electronics, health care scenarios, driver assistance systems, and industrial applications. All 60 GHz IoT radar sensors are size-optimized and come with antennas in the package.

For example, the BGT60TR13C model has one transmitting and three receiving antennas. The L-shaped antenna arrangement allows horizontal and vertical angle measurements. The extremely high accuracy enables motion detection in the sub-millimeter range. The radar sensor is used, for example, for vital data acquisition in consumer electronics.

The BGT60LTR11AIP is a 60 GHz Doppler radar sensor with an integrated transmitting and receiving antenna and integrated motion and direction detectors. It supports multiple modes of operation, including a fully autonomous mode that requires no software or hardware design. In autonomous mode, the radar can detect a human at a distance of up to seven meters, consuming less than 5 mW. This makes the radar sensor ideal for motion detection, such as in smart lighting or climate control, automatic door opening or contactless switches, and smart security and alarm systems, including IP cameras.

The BGT60UTR11AIP is the latest member of the BGT60 family and, at just 4.05 mm × 4.05 mm, is the smallest and most compact radar on the market. Designed for demanding

Figure 3: Development kits complement the radars: 24 GHz demo Distance2goL (left), demo BGT60TR13C MMIC (center), and 60 GHz connected sensor kit (right).

Advantages of radar sensors

- They are compact, thus enabling the development of IoT systems with relatively small sizes.
- They are robust and operate in a variety of environmental and climatic conditions. Their operation is not significantly affected even by temperature fluctuations or lighting conditions.
- They transmit RF signals at high frequencies (24 or 60 GHz) that penetrate most materials (e.g. plastic, glass, and wood). As a result, they provide accurate readings even for objects behind walls or obstacles and can be concealed under product covers or packages.
- They offer high measurement sensitivity and can detect very small movements. This means they can be used to record vital data.
- They consume relatively little power, enabling energy-efficient IoT applications. Battery-powered devices can operate for a very long time on just one battery.

applications, it features the sensitivity and reliability of frequency-modulated continuous-wave radar technology.

Infineon supports development through development kits for embedded and PC-based evaluation, including comprehensive software development kits (SDKs) and examples for algorithm development, prototyping, and embedded implementation. ■

Static random access memory

A memory technology with a future

Many providers have pulled out of the SRAM market to focus on high-end, high-margin technologies. But there are still numerous applications where SRAMs are ideal. Reason enough to take a closer look at these memories.

By Chen Grace Wang, Corporate Product Manager Digital at Rutronik, Sue Macedo, Managing Director EMEA at Alliance Memory, and Ramesh Babu, Director of Central Engineering at Alliance Memory

Memories fall into two main categories:

- Non-volatile or read-only memory (ROM) –memory data are not lost when the power supply is turned off. The most familiar type of non-volatile memory is flash memory (NOR flash, NAND flash).
- Volatile or random access memory (RAM) –memory data are lost as soon as the power supply is turned off. A distinction is made here between dynamic random access memory (DRAM) and static random access memory (SRAM).

SRAM provides the fastest access to memory. However, the manufacturing cost per bit is higher than for DRAM because each memory cell consists of four or six transistors (4T or 6T architecture).

In contrast, DRAM has only one transistor and capacitor per memory cell. The disadvantage is that the data must be rewritten (refreshed) at certain intervals.

Industrial	POS	Communication	Consumer	Automotive	Medical
PLC	POS	Webspace Memory Management	Games	Sensor Modules	Dialysis Equipment
Power Control	E-POS	VOIP	Audio	Entertainment Systems	Medical Devices
Industrial Automation	IC Card Readers	Private Branch Exchanges	E-education Devices		Medical Test and Measurement Equipment
Weighing Systems	Barcode Scanners	Walkie-Talkies	Pocket Calculators		Fans
Safety & Security Systems	POS Printers	Bas Stations	LED Displays		
Motor Control	Moneychangers	GPS Modules	E-Books		
Sawing Machines	Coffee Machines	PON (Passive Optical Network)	Door Video Intercoms		
Recorder	Vending Machines	Transportation Tracking Recorders			
Server	Customer Activated Petrol Terminals				
Test Instruments	Washing Machines				

Table 1: SRAMs are suitable for numerous applications in various markets.

The different types of SRAM

Fast asynchronous SRAM: Asynchronous SRAMs are suitable as the main memory for small embedded processors without cache, such as those used in the industrial electronics industry and in measurement systems, hard drives, and network equipment. Fast asynchronous SRAM is characterized by particularly short access speeds of 8 to 20 ns. The trend here is toward lower operating voltages and away from parallel to serial interfaces.

Low-power SRAM: Low-power SRAMs have a similar design to fast asynchronous SRAMs but also a longer access time, typically between 50 and 70 ns. Thanks to their very low-level standby power consumption, they can support battery backup applications. They are also popular for their better data retention and lower failure probability (soft error rate). Low-power SRAMs are used in a wide range of applications, such as in industrial, communications, and cell phones. As with fast asynchronous SRAM, the trend is toward lower operating voltages and serial interfaces.

SRAM	DRAM
Easy in design	Requires complex design
All MCUs support the SRAM interface	Supported by most MCUs with additional control
Random and faster access	Requires permanent refresh
Lower current consumption	Higher memory density
High cost per bit	Low cost per bit

Table 2: The main differences between SRAM and DRAM

SRAM target applications

In addition to industry and telecommunications, SRAMS are increasingly used in automotive applications. Due to the enormous popularity of apps, the smartphone is set to remain a source of infotainment and connectivity in vehicles for the foreseeable future. The greatest opportunity lies with companies offering application processors, WiFi/Bluetooth/GPS/FM combo chips, and wearables/hearables.

For these applications, Alliance Memory will continue to offer a wide range of legacy fast and low-power SRAM products with long-term availability, in addition to new technologies. The supplier focuses on minimal die shrinks and stable, competitive pricing. The portfolio includes 3.3V and 5V asynchronous SRAMs used in popular digital signal processors (DSPs) and microcontrollers. Synchronous and low-power SRAMs as well as pseudo SRAMs are also available. ■

Security in Industry 4.0 applications

When microcontroller-based security is no longer enough

One consequence of the miniaturization of system-on-chips is that flash memory increasingly has to be implemented externally. This brings with it new security requirements that must be urgently met, especially in mission-critical networked systems.

By Chen Grace Wang, Corporate Product Manager Digital at Rutronik, and Slaven Dekic, Field Application Engineer Memory Solutions at Infineon

The rapid growth of networked systems around the world is leading to an ever-increasing need for system security. This is because every networked smart device is a potential target for cyber attacks. At the same time, advances in system-on-chips (SoC) are driving manufacturing technologies to the smallest process nodes practical to achieve the power and performance required for computationally intensive applications. However, non-volatile memory (NVM) integration is becoming increasingly difficult as process nodes shrink to 22 nm and below. In particular, embedded NOR flash has become exorbitantly expensive to implement in these small nodes. As a result, systems using high-performance SoCs need an alternative to embedded flash and are returning to external on-board memory (Fig. 1).

State-of-the-art SoCs require external flash memory

For decades and across industries, the typical strategy for electronic system development has been to integrate more functions – including greater memory capacity – into fewer chips. This trend led to SoC architectures that enable complex embedded systems on a single chip. To increase their performance and to reduce costs, SoC providers have relied on innovative manufacturing process nodes. However, advances in semiconductor technology have made it increasingly difficult to embed flash memory into an SoC, forcing system developers to store critical code and system data in external flash.

However, external flash designs also bring advantages: For example, the SoC can be chosen based on its performance alone, and the appropriate flash density for the specific design can be determined independently.

Code is getting bigger and current applications are storing and processing more data than ever before. Even if an SoC includes embedded NVM, in many cases additional external memory capacity is needed. If the most suitable capacity of external flash memory can be freely selected, system costs are reduced and the efficiency of the overall system is optimized.

Images: Infineon

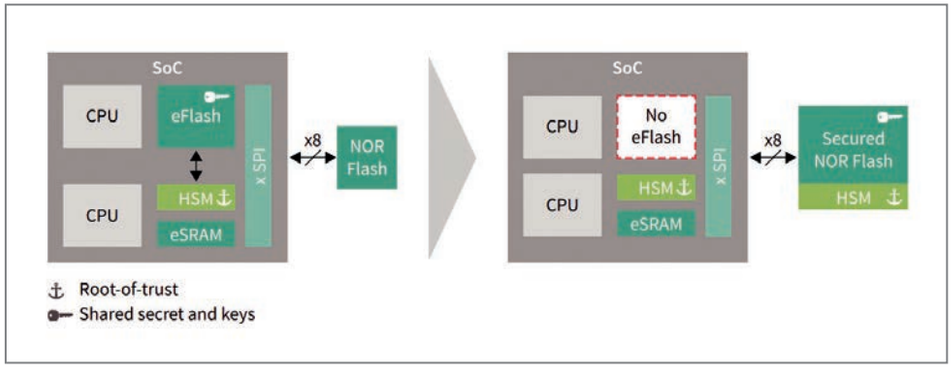


Figure 1: De-integration of embedded flash (eFlash) from the SoC.

External memory has different security requirements

On-chip memory is closely connected to the rest of the SoC in which it resides and is considered fundamentally more trustworthy than conventional external memory. This is because, as a standalone device it is more vulnerable to physical attacks. Even encrypted data residing in external flash memory can be an easy target for certain attacks. Some of the key threats to consider when securing external flash memory include:

- Impersonation of transactions to or from flash without authorization
- Tampering with stored code, stored data, parameters and logs
- Repeating transactions to revert the contents of flash memory to old, insecure versions
- Obtaining keys during deployment in an insecure environment
- Snooping attacks (man-in-the-middle) on transactions to/from flash devices
- Conducting side-channel attacks on a flash memory to observe or obtain its contents

To address all of these threats and other security vulnerabilities of external flash memory, the device must provide the following features:

- A hardware-based trust anchor (root-of-trust) to prevent modification or tampering, copying, or other effects of an attack on the code and/or data stored in the flash memory
- Secure updates from the microcontroller or the cloud through a combination of end-to-end protection with authenticated and encrypted transactions via the bus, secure regions with read/write access methods, secure key memory space, and non-volatile monotonic counters
- Low cost by eliminating the need for additional security devices (e.g. a trusted-platform module) and printed circuit board modifications, including support for popular flash serial interfaces

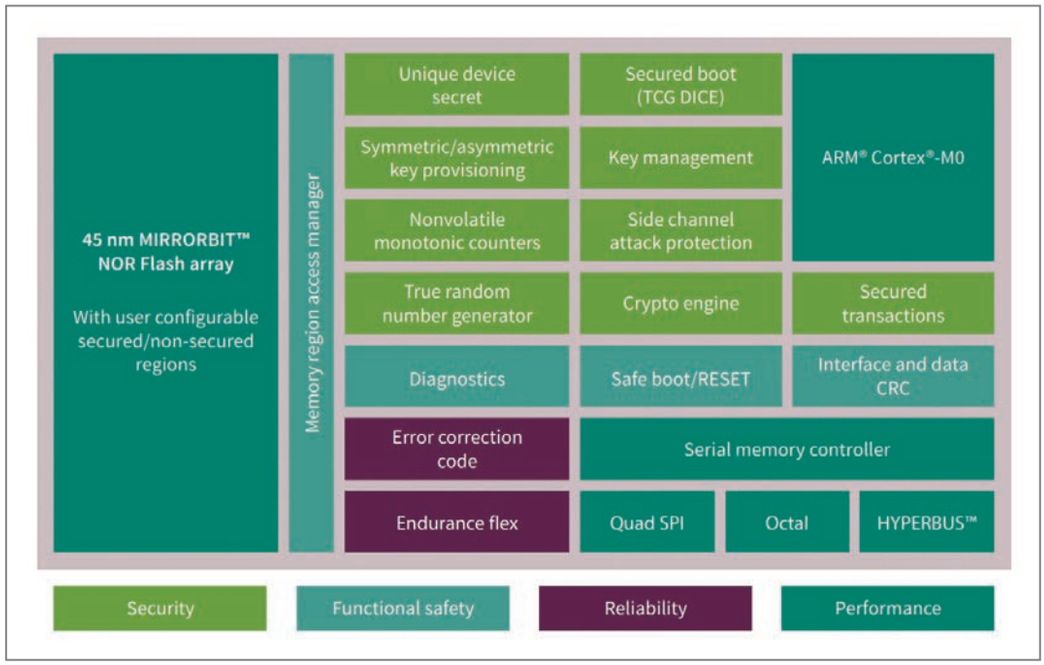


Figure 2: Architecture of Infineon's Semper Secure NOR flash family.

Secure flash memory for mission-critical applications

With Semper-Secure NOR Flash, Infineon offers what the supplier claims is the industry's most advanced, secure, and reliable flash memory. It is designed for functional safety, performs diagnostics and data correction, and complies with ISO 26262 requirements. On top of this, Semper Secure adds a hardware root-of-trust and options for asymmetric or symmetric cryptography. This combination of security and protection makes Semper Secure NOR Flash an ideal memory for mission-critical applications where failure is not an option.

External flash memories are connected to the host SoC via a serial memory interface and a bus. This makes them vulnerable to replay and man-in-the-middle attacks. Since critical data is exchanged between multiple semiconductor devices, it is not enough to protect only the host SoC. The external flash memory and the bidirectional communication between the two must also be secured.

Semper-Secure-NOR-Flash solves this problem by authenticating and/or encrypting transactions between the host SoC and the memory. This ensures authenticity, confidentiality, and data integrity as well as protects against replay attacks. Semper Secure extends the secure processing environment beyond the host SoC to the external NOR flash by supporting different types of secured transactions, including authenticated read, program, and erase as well as encrypted read, program, and erase. ■

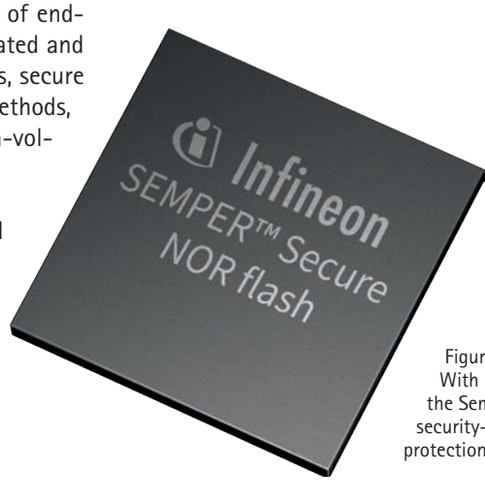


Figure 3:
With its security features, the Semper-Secure NOR Flash offers security-relevant systems a high level of protection against various threats.

Microcontroller for high-end industrial equipment

Technical diversity, maximum processing power, and security for industrial robots

Industrial plants pose numerous development challenges. To overcome them, the right microcontroller is crucial in addition to extensive up-front designs, rigorous testing, and compliance with industry standards and regulations.

By Andreas Heder, Field Application Engineer at Rutronik, and Panagiotis Venardos, Senior Manager of Industrial MCUs at Infineon

When developing high-end applications – such as robotics, industrial drives, and in applications for electric vehicles – energy, performance, efficiency, and security are of paramount importance. The choice of the optimal microcontroller contributes significantly to achieving these goals. It needs to be high-quality grade, flexible, powerful, and efficient and have features that allow it to adapt to

Image: hramovnick/Shutterstock

a demanding environment that is constantly changing.

The demands placed on controls in modern industrial plants are becoming increasingly complex and the volumes of data being processed are growing all the time. This poses enormous challenges for developers of such controls. Besides processing these volumes of data efficiently, the systems must also maintain the integrity of the data using robust security features. The efficient management and allocation of resources within the CPU as well as the use of the internal and external memory are of great importance.

In addition, there are various real-time specifications in industrial applications. To ensure that all tasks are performed safely and securely within these periods, delays and errors must be kept to an absolute minimum. In round-the-clock production, this can be difficult to implement, for example due to regular software updates, the frequency and duration of which are not always known.

For uninterrupted operation of the entire system in an industrial environment, several key functions and integrations are required to ensure reliability, performance, and compatibility with specific application requirements. This includes using industrial-grade components that are characterized by a long service life and an extended temperature and voltage range. The microcontroller must also support the right interfaces and associated communication protocols and be compatible with a wide range of industrial software tools and libraries.

One device that meets all these criteria is Infineon's 32-bit XMC7000 microcontroller. It is based on the Arm Cortex-M7 processor core and was primarily developed for industrial purposes. As such, it is equipped with various peripherals, such as CAN-FD, TCPWM, and Gigabit Ethernet, and features for hardware security. Its low-power modes extend down to 8 µA. Thanks to its wide temperature range of –40°C to +125°C, the XMC7000 offers a high level of resistance in harsh industrial environments. To meet design requirements as precisely as possible, the XMC7000 ensures high scalability in terms of the number of processor cores and the size of the flash memory and RAM and comes with four package/pin types and 17 part number variants.

A robust local communication network is required for reliable and secure interoperability of all the important components for motor and power control, such as motors, drives, controls, and sensors. For this purpose, the XMC7000 provides standardized communication interfaces such as CAN-FD, serial communication blocks (SCB), and Ethernet interfaces. An external memory, an SDHC interface, an I2S/TDM interface, and numerous I/Os facilitate integration and communication between various devices and platforms.

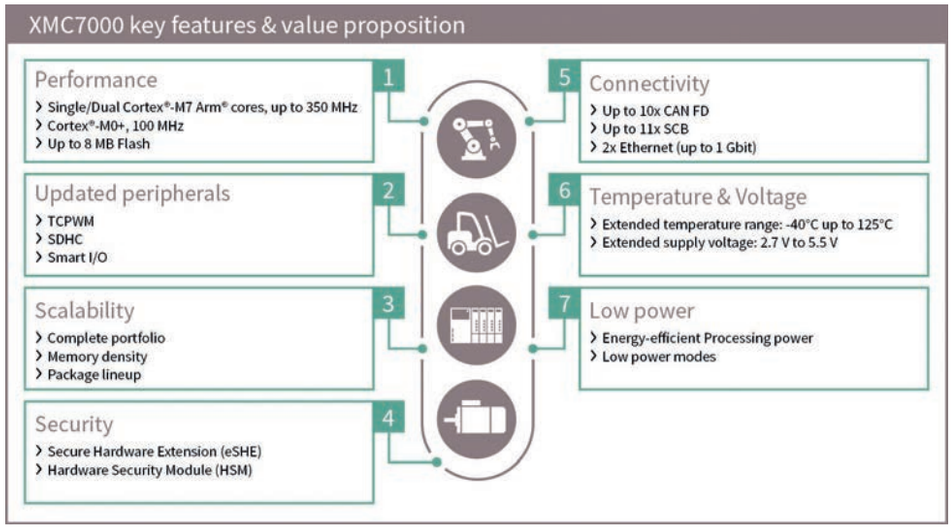


Image: following Infineon sources

Performance, energy efficiency, and security are the main focus when developing robotic applications, industrial drives, and applications for electric vehicles.

In most cases, tasks such as the acquisition of sensor data or the control of external power semiconductors must be performed in real time. To meet such requirements, the XMC7000 is equipped with up to two Arm Cortex-M7 cores with clock rates of up to 350 MHz, up to 8 MB Flash, and up to 1 MB SRAM. In addition, there is 256 kB of Work Flash, which, in contrast to the Code Flash, is optimized for significantly more frequent reprogramming.

Protection against cyber threats

Increasing connectivity and comprehensive data exchange in manufacturing and automation environments inevitably lead to cyber threats. Engine and power control systems are particularly vulnerable to these threats, and attacks can severely disrupt production processes and pose a great risk to sensitive data.

Given these risks, security measures such as secure-over-the-air (SOTA) firmware upgrades and secure boot are critical when it comes to ensuring the right firmware runs securely. Fixed anchors, including encryption, access controls, and intrusion detection systems, also

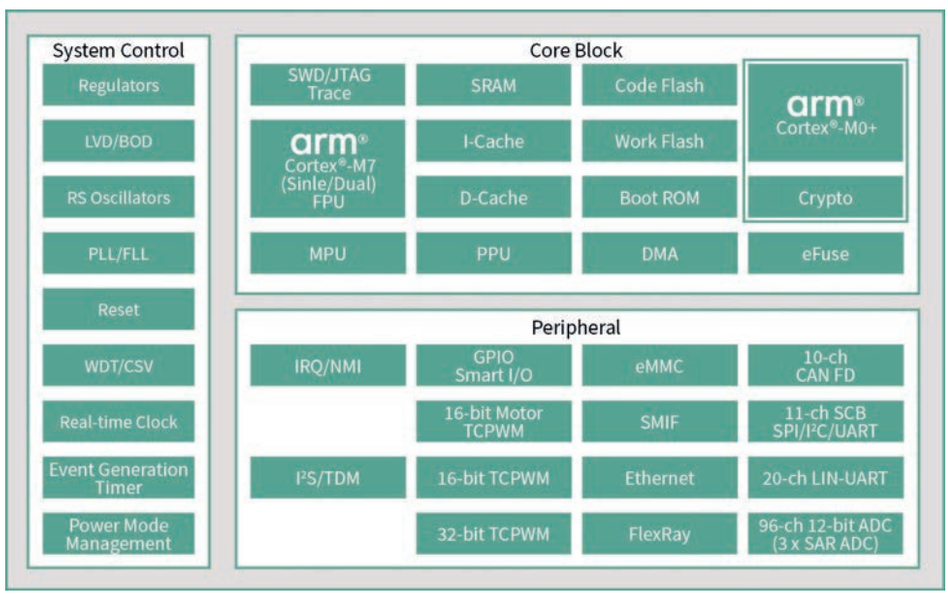


Image: following Infineon sources

The XMC7000 from Infineon has everything a microcontroller for industrial applications needs.

Key features of the XMC7000

- 32-bit MCU
- as a single or dual core based on the 350 MHz Arm Cortex-M7 and 100 MHz Arm Cortex-M0+ for cryptography
- up to 8 MB Flash, up to 1 MB SRAM, and I/D cache
- Voltage range: 2.7–5.5 V
- Extended temperature range, up to 125°C
- CAN FD with up to ten channels, SCB with up to eleven channels
- eMMC, SMIF (QSPI/HS-SPI), 10/100/1000 Mbit/s Ethernet with up to two channels

- Three SAR AD converters
- up to 96 channels based on three 12-bit A/D converters using the principle of a successive approximation register (SAR ADC)
- Motor control with up to 15 channels (16 bit), 87-channel 16-bit TCPWM (timer/counter/pulse width modulation), 16-channel 32-bit TCPWM
- Timer for event generation
- Package: 100/144 and 176-pin TQFP, LFBGA-272

Image: Infineon

help protect against these threats. These functions are performed by the integrated Arm Cortex-M0+, which executes these tasks in real time.

A/D converters, timers/counters, and PWMs (TCPWM) are essential components

To support applications with multi-axis drives and the synchronous sampling of analog sensor signals, the MCU has three independent ADCs with upstream multiplexers based on the principle of a successive approximation register (SAR) with the lowest latency for real-time sampling. The XMC7000 also has a high number of TCPWM blocks that can be used flexibly. For example, for driving three-phase asynchronous motors, the average voltage applied to the motor can be fine-tuned by cleverly adjusting the duty cycle of the PWM signal to achieve optimum performance and responsiveness. For this purpose, the TCPWM blocks are interconnected at hardware level and offer a variety of possibilities for parameterization. In addition, there are special PWM modules for motor control, which offer various functions, such as extended quadrature, asymmetrical PWM generation, and dead-time adjustment.

In addition, the XMC7000 has further special I/O features, referred to as smart I/Os. They can be parameterized as digital connection logic (AND, OR, XOR, and predefined lookup tables). Input signals can thus be processed without intervention of the CPU. This makes it possible, for example, to detect a certain pattern on one or more pins in the controller's energy-saving mode and to react to it (safety circuit).

Development tools

There are many software solutions for the XMC7000 that make it easier for the user to develop motor control or energy conversion applications, for example. Infineon provides the ModusToolbox development platform for this purpose, which contains software tools and resources to simplify the design process. It can be used as a stand-alone or fully integrated version with the Eclipse-based IDE. The user-friendly device configurator enables consistent development across multiple industry-standard platforms, such as Eclipse, VS code, and IAR. In addition, ModusToolbox includes a set of development tools, libraries, and embedded runtime assets. It is available free of charge and supports many other Infineon products. ■

The video linked to this QR code shows control of a robot arm with the XMC7000.

Enabling your innovation

Every day, in every part of the world, millions of people benefit from technologies which are enabled by Murata innovation.

Since 1944 Murata has been committed to developing components that help to advance the the benefit of electronics to society. In smartphones, smart homes, cars, computers, healthcare devices, wearables... in fact, wherever you find electronics, you'll find Murata innovation.

Feature product

UWB Modules

Ultra Wide Band (UWB) technology is good for secure and precise distance measurement which is based on Time of Flight (ToF) of radio waves.

Murata Type2AB module is designed as Ultra-small, high quality and lower power consumption UWB module. Ideally suited for small, battery operated IoT devices and applications.

Features:

- **75% less square area than CoB solution**
- **Integrated Wireless MCU**
- **Integrated 3-Axis sensor for saving battery**
- **Support Multi Antenna design and evaluation**
- **Integrated Filtering for UWB**

Feature product

AC-DC power supply PQU 650 AC-DC

Highly Efficient 650W AC-DC power supply available in **industrial and medical grade**.

Offers High efficiency at low load and overload function.

Features:

- **Efficiency 95% available at 30% of the load**
- **Overload 30s to 800W**
- **450W with no cooling**
- **12, 24, 28, 48 & 54V output PoE applicable**

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INNOVATOR IN ELECTRONICS

Growth through change

50 years of Rutronik for the future of electronics

Rutronik is celebrating a special anniversary this year – an occasion for CEO Thomas Rudel to look back and to the future, and to reveal a few things about the company's strategy.

Rutronik is celebrating its 50th anniversary this year. Can you briefly outline how Rutronik has developed over the last five decades?
Thomas Rudel: In 1973, my father Helmut Rudel founded Rutronik, strategically choosing Ispringen, near Pforzheim, as its location. With the aim of being able to reach the most geographically distant customers in Germany within a maximum driving time of two hours, he took a map and a compass. He then proceeded to draw a circle around the region in Germany that at the time accounted for almost 70 percent of German component demand.

In the center of that circle was the town of Ispringen, and thus the decision for the site of the headquarters was made. In the 1970s, my father started out by focusing on the sale of passive components, partly in response to the growing demand for color TV sets, which were becoming increasingly popular, especially due to the 1974 soccer World Cup in West Germany. Over the following decades, semiconductors, displays, and wireless technologies were added to the product ranges. In the 2010s, the Automotive Business Unit was established, and at the beginning of the 2020s, the Rutronik System Solutions initiative was added. And that is just a very brief outline of the key milestones in our corporate history.

As a distributor with 50 years of experience, we are an important player and an indispensable partner, especially for many medium-sized companies. We have a global presence to ensure local support for our customers, tailored specifically to their production sites. After all, building and maintaining personal relationships with our customers, suppliers, and business partners is still extremely important to us.

And where does Rutronik stand after 50 years on the electronics market in terms of hard facts such as sales and employee figures?
In the 2022 business year, our workforce of around 1,900 people worldwide generated combined sales of €1.28 billion. Rutronik has maintained continuous, sustainable, and robust growth over the past five decades. In 2016, we had around 1,500 people working for us. Since then, our workforce has increased by over a quarter. We have over 80 offices at around 40 locations around the world, and we continue to focus on self-financed growth.

Throughout this period, we have maintained a good balance between the tried and tested and important innovations and adjustments to market developments. Our structure as an owner-managed company has also enabled us to maintain our independence from external investors. In our anniversary year, we are all the more happy at what we have already achieved and look back on the past five decades with pride and gratitude.

And what makes Rutronik special? Where do you see its strengths?
Although Rutronik has long been a global player, it is still a family-owned company with its roots firmly in the SME sector and is the

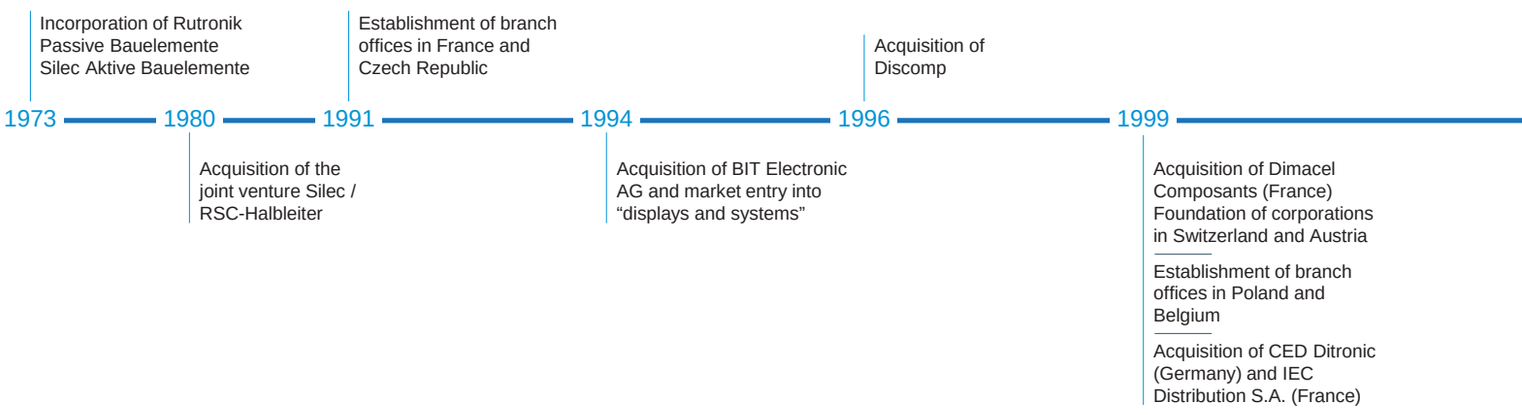


Image: Uli Deck/dpa/picture alliance

only European distributor among the world's top ten. This makes us the largest European distributor in a market dominated by US competitors.

A stable distributor network is critical for success, especially for the medium-sized customer structure in Europe. Our DNA is therefore: We are an owner-managed, independent family business and also a medium-sized company that speaks the language of our customers. Our goal is to serve our customers in the best possible way and to exploit synergistic effects from which both users and suppliers benefit. We are also transforming into a system provider, but still rely on broadline distribution as an important foundation for all these efforts.

Can you explain the system provider approach in more detail? What is it all about?

What is absolutely unique for a distributor is that we offer our customers evaluation or developer boards to support them in the pre-development of their applications, thereby shortening the time to market. In particular, we also work together with research institutes, higher education institutions, and universities as well as contribute our industrial expertise to the industry advisory boards of various research projects. We are continuously expanding our design centers in Lithuania and Singapore. Further, we also have a development team at our headquarters in Ispringen. We work closely with our top suppliers and industry specialists to develop our solutions, some of which are patented, and we are an important source of inspiration for our customers with regard to their applications.

In which markets are your customers active?

In terms of distribution, we are very industry driven, meaning we serve applications in the industrial goods sector but also in the automotive segment. As such, our Automotive Business Unit at Rutronik, which was founded in 2014, is also an important building block. In terms of the markets that are essential for electronic components, we have a 70/30 percent split between direct and distribution markets.

Hundreds of thousands of customers worldwide buy through distributors. At the same time, many suppliers focus solely on direct customers or OEMs. On the other hand, the suppliers who can handle distribution and the capital goods sector serve both with their business model. This is where our expertise at Rutronik24 (R24) comes into its own, enabling us to provide small and medium-sized customers with all-round advice and supplies in the spirit of "everything from a single source". Important applications that our customers are researching and bringing to market are in the areas of Industry 4.0, (I)IoT, Future Mobility, and Energy & Power.

The global economy has been developing very dynamically, especially in recent years. What is the situation like for European companies in this respect, and how are you meeting these challenges at Rutronik?

At Rutronik, we focus on the ongoing expansion of our research and development in the Rutronik System Solutions segment in order to further expand our competencies as a broadline distributor in the direction of a system provider. In doing so, we act as a bridge between science and industry, securing know-how through Rutronik IPs and patents. With Rutronik System Solutions, we are specifically working on the development of our own evaluation boards – with the aim of maximum customer orientation in order to also accelerate the pre-development of medium-sized customers – as well as on research projects with universities and higher education institutions in order to build up and expand know-how.

2000
- Establishment of the Dutch branch office Foundation of corporations in Hungary and Poland

2001
- Acquisition TTS (Ireland)

2002
- Foundation of sales offices in Denmark, Bulgaria, and Romania

2004
- Incorporation of Rutronik Italia S.r.l. Establishment of subsidiaries in Russia and Lithuania

2005
- Foundation of Rutronik Nordic AB (Sweden)
- Foundation of Rutronik Ltd. (GB)
- Establishment of sales offices in Norway and Finland
- Establishment of sales offices in Slowenia, Slowakia, and Portugal
- Expansion of sales organization in Denmark, Belgium, and the Netherlands

2007
- Establishment of sales offices in Estonia and Serbia

In addition, European companies and policymakers must work together to strengthen the European market. This is the only way to make Europe less dependent on others. Funding and investments at national and EU level should also be targeted and, above all, involve the entire European supply chain in the electronics market. From my point of view, important partners, such as suppliers and distributors, are often missing from the political debate. In particular, companies that pay their taxes in Europe should be eligible for EU subsidies. Otherwise, many companies may otherwise no longer consider Europe as a location for their headquarters in the future, which could lead to existing companies having to make critical decisions about where to locate their headquarters.

What else needs to be tackled to strengthen European companies?

In my view, politicians are presently focused on addressing multifaceted conflicts and crises with short-term solutions that suit their own interests, thereby prioritizing aspects that are easy to communicate in the media and allow them to establish a favorable position. However, medium-sized companies in particular need pragmatic and long-term political approaches. For me, this also includes simplifying and streamlining administrative processes, which many SMEs find difficult. Furthermore, all of this also has to do with the recognition of companies based here in Europe. They often play pivotal roles in regional value chains and in some cases are world leaders in their sectors. They are also very important employers in their respective regions. I have also noticed that SMEs in particular are not given enough political consideration, nor the platform they deserve. I would therefore like to see these key players in the European and German economy sitting down at the same table and working out concepts together to secure the future of the local economy.

And what about the distribution market in particular?

> *“We know the requirements and challenges of the industry and are constantly analyzing the market.”*

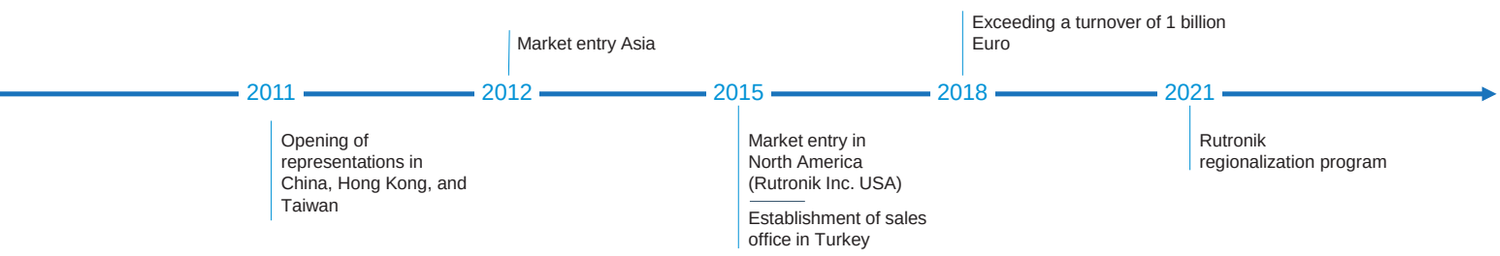
I see a specific need for action in the distribution market, as a stable distributor network is essential, especially in Europe, due to the customer structure here. In addition, because of their margins, European suppliers are often not in a position to make demands. The European automotive industry, for example, has a share of around three percent of the global market for electronic components. The entire European market has a share of just eight percent. By way of comparison: That is about as much as Samsung or Apple needs in electronic components alone.

Where do you see Rutronik in the future?

We know the requirements and challenges of the industry and are constantly analyzing the market. And, needless to say, we have excellent knowledge of the electronics market. We have a broad product portfolio and the expertise to know which technologies, components, and core software are best suited for each application, as well as which components are available today and will be in the long term. We are therefore focusing on aligning our product areas to our future markets and establishing and expanding the necessary supplier relationships.

We want to use our know-how to support the immediate developments of our customers. This also enables us to translate research findings into marketable and competitive solutions faster and in a more targeted manner. It is precisely this expertise, being a reliable partner at our customers' side as a broadline distributor and system provider, where I see Rutronik strengthening its position in the future.

In addition, we keep a close eye on the global markets to ensure we can identify and assess behavior and market trends at an early stage. We consistently position ourselves for the future by identifying and leveraging approaches with significant disruptive potential. We also see tremendous market potential outside of Europe in particular and are preparing for further shifts here in line with our regionalization strategy. As in the past, however, we will continue to support our partners with an extensive range of products that meet their needs. ■



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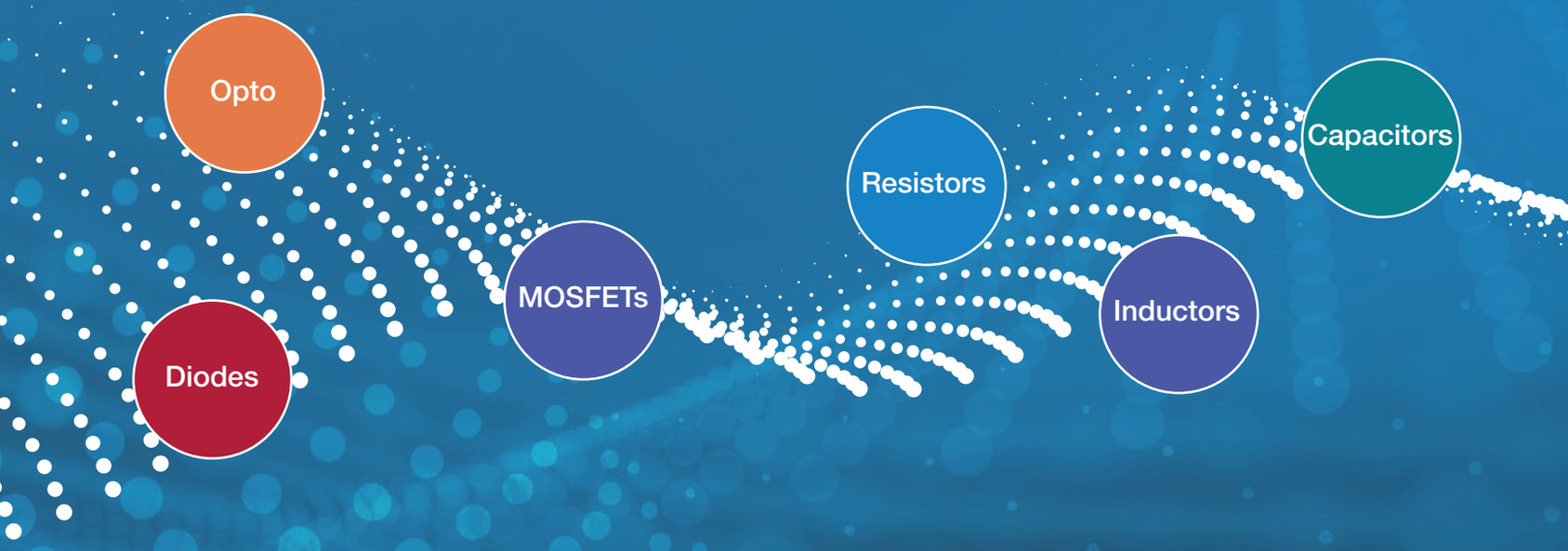

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The 1990s and 2000s

Pan-European mobile communications

Phones first went wireless, then smart, and Rutronik expanded in Europe.

Rapid advances in wireless technology characterized the 1990s. The first wireless phones were still very expensive and about the size of a brick, but with increasingly attractive dimensions and prices, they became visibly more widespread. A boost came in the form of the GSM network, which enabled cell phones to be used across networks and countries, as well as data services such as SMS and MMS.

The 1990s also saw the emergence of several new display technologies, some of which also transformed mobile devices. In addition to liquid crystal displays (LCDs), plasma screens, and organic light-emitting diodes (OLEDs), touchscreens were among the latest innovations.

The course toward mobile Internet was set at CeBIT 1999, when the wireless application protocol (WAP) was unveiled. Initially, it was slow and expensive, but new mobile communications standards with higher data transmission rates ensured faster mobile Internet, first GPRS (general packet radio service), and finally LTE (long term evolution). The article on the following pages reports on a current standard.

The birth of the smartphone was probably ushered in with a cell phone from Blackberry in 2002, which achieved sufficient connection rates for the first time. Blackberry's own protocol compressed the data so that it could be transferred quickly even via GPRS.

The first iPhone moment came in 2007 with the presentation of Apple's first smartphone. Its special feature: It was not operated via buttons or stylus like previous devices, but via a multitouch display.

Rutronik expands its footprint and portfolio

At Rutronik, the 1990s and 2000s were characterized by expansion in Europe: The first branch office outside Germany was founded in the Czech Republic in 1991; by 2008, Rutronik was already represented in around 25 countries, in some cases with newly founded subsidiaries. In that year, Rutronik also crossed the borders of Europe with branch offices in Mexico.

The expansion also included a number of company acquisitions: With BIT-Electronic, Rutronik entered the market for displays and systems and responded to the increasing demand for finished assemblies through participation in the manufacturing company BEK. In 1996, Rutronik took over Discomp, a year later the French company Dimacel Composants, and in 1999 CED Ditronic and IEC Distribution were added.

Sales and employee numbers climbed accordingly: In 1994, 170 employees generated sales of DM170 million. Two years later, this had more than doubled, and Rutronik was one of the ten largest distributors in Europe.

The product portfolio also expanded, and Rutronik became one of the first broadline distributors on the continent. Before the turn of the millennium, the logistics center in Eisingen was constructed as a logistics hub for the whole of Europe. ■

Wireless standard Matter

New boost for smart home devices

Lack of communication capability and security are still holding back demand for smart home devices. But, thanks to the new Matter standard, that could soon change.

By Torsten Killinger,
Corporate Product Manager Wireless at Rutronik

In December 2019, Project Connected Home over IP (CHIP) was unveiled as a new, open smart home standard. Behind it is a group of leading technology companies, including Amazon, Apple, Google, Samsung, and the Zigbee Alliance, now called the Connectivity Standards Alliance (CSA). In May 2021, they laid down the first specifications and gave the CHIP project its new name, Matter. In October 2022, the release of Matter 1.0 marked the start of certification for the first devices. The first update, Matter 1.1, was released as early as May 18, 2023. The CSA had already announced that it would adopt new versions of the standard twice a year.

The companies involved in Matter are pursuing several goals. By improving interoperability between smart home devices from various suppliers, the goal is to enable seamless integration and control. To this end, Matter supports multiple communication technologies, such as Wi-Fi, Ethernet, and Thread. Bluetooth is also used for the fast and user-friendly integration of new devices into the existing Matter network.

Users will also be able to connect their smart home devices directly and securely over the Internet without the need for additional equipment or components. Additionally, devices using Matter should be able to communicate seamlessly across various platforms and applications to make the smart home market even more accessible and user friendly.

One interesting feature is multi-admin operation. By enabling each Matter-enabled smart home ecosystem to have a pairing mode, Matter devices are no longer exclusively tied to one control, but are accessible through multiple systems in parallel. For example, a smart TV added to Apple Home with an iPhone can also be used by other family members or roommates through the Google Home app on their Android smartphones.

In addition to interoperability, Matter has numerous other benefits up its sleeve. These include its ease of use: Thanks to a user-friendly interface, users can control their smart home devices without using a myriad of apps and platforms. Further, its ability to also integrate future technologies and innovations makes Matter future-proof.

Cross-vendor data exchange

Matter is based on the IPv6 network protocol. This enables all devices to network with each other independently. A common data model also facilitates data exchange between various smart home devices. They can then communicate directly with each other without the need for a hub or any other type of gateway, provided the participants are in the same physical network.

With open standards such as Wi-Fi/WLAN (IEEE 802.11), Thread (IEEE 802.15.4), and Ethernet/LAN (IEEE 802.3), Matter supports a wide range of devices. A fourth added standard is Bluetooth Low Energy (BLE), which allows a smartphone or tablet to establish an initial wireless connection with the Matter device during installation – a method already used by many suppliers today. For example, new WLAN speakers are automatically displayed in the supplier's app when they are turned on. The smartphone then sends the WLAN access data to the speakers via Bluetooth to ensure they can log in to the home network.

A so-called Matter border router is required to communicate between Thread and Wi-Fi.

Image: microstock77/stock.adobe.com

Figure 1: Matter enables devices to talk to each other via Apple Home, Amazon Alexa, Google Home, and Samsung SmartThings, among others.

Some vendors have already released products that combine Matter controllers and border routers, such as Apple TV 4K, Apple Homepod Mini, Samsung SmartThings Hub, and numerous Amazon Echo devices.

Integrated security

Another important goal that vendors are pursuing with the Matter standard is to increase security and protect users from privacy attacks. When hackers try to gain access to smart home devices over the Internet, the devices are often poorly protected, running outdated software and offering very little resistance to attackers through the use of predictable passwords.

As a result, security concerns are the number one reason people do not purchase smart home devices: 47 percent of non-users fear hacker attacks, 37 percent are afraid of misuse of their personal data, and 29 percent worry about their privacy being compromised, according to a September 2022 survey commissioned by Bitkom.

To address these concerns, security requirements were already considered during the development of Matter according to the "Secure by Design" principle: The Device Attestation Certificate (DAC) protects against counterfeiting by ensuring that the hardware really comes from the original supplier. To protect against counterfeiting, there is also a supplier's certificate, signed by an official certification authority. In addition, there is tap-proof communication and secure control. Through PKI encryption and strong security protocols, Matter ensures user privacy and security.

Still only a few devices available

However, despite the many benefits of Matter, there are still a limited of number of devices available. Since Matter is still relatively new, the selection of compatible devices is still restricted, and it will be some time before more devices are available or until a software update is available for existing devices with IEEE 802.15.4-capable transceivers. For example, a software update is expected for many ZigBee-based devices, provided the internal memory is large enough to support a firmware update over the air (FOTA).

Given the benefits of the new standard, the market is expected to quickly fill with Matter-enabled devices as soon as more smart home providers introduce corresponding products. Smart home devices with proprietary connectivity technology are unlikely to have much of a future thanks Matter's technical sophistication and ease of use. After all, end users are not likely to want the hassle of border routers, protocols, and device profiles, preferring instead the simplicity of operating as many devices as possible via the same interface after a simple setup.

With Internet connectivity, offline functionality, and cross-device control capabilities, Matter relieves product suppliers of what is arguably the most challenging aspect of development. At the same time, this leaves suppliers with fewer options for differentiation. In the case of radiator valves, this could be the volume of the actuator motor, the size of the energy storage device, and the display. When redesigning a product for conversion to Matter, it is therefore advisable to give the product a facelift to signal to buyers that this is a highly innovative product. This is where the display really comes into its own as a human-machine interface.

It is important for suppliers of Matter-enabled products that have wireless capabilities, connect to the Internet, and process personal data or financial transactions to be aware of the new security requirements that will apply to sales within the EU single market from August 1, 2025. For more information, see the article "Greater security for the networked world" on page 52.

Matter-enabled chips and modules

Rutronik's portfolio already includes numerous products for the development of Matter devices: Infineon, Nordic Semiconductor, Panasonic, and InsightSiP are just some of the suppliers of corresponding chips and modules that Rutronik carries.

As a member of the CSA, Infineon offers Matter-capable components, such as the PSoC-6 family. Both the PSoC 62 and the PSoC 64 become Matter-capable in combination with a Wi-Fi IC. In general, any Wi-Fi IC that supports Matter can be used. If you use one from Infineon, such as the CYW43439, CYW43012, or CYW4373, the programming is completely supported by the IDE ModusToolbox. It can also be used to import and map the Matter stack to the PSoC-6 device.

For March 2024, Infineon has announced a chip (CYW30739) that will support Matter over Thread. In addition, it will use the convenient BLE commissioning in the Matter network. The chip will probably only be available to a manageable number of suppliers, but a mass market module incorporating it will be available to interested parties through Rutronik.

Infineon's security chips, such as Optiga Trust, are the ideal trust anchors for the customer-specific login information that every Matter-certified device must feature.

Like Infineon, Nordic Semiconductor is a member of the CSA and offers various chips for Matter, such as the nRF52840, the nRF5340 and the new nRF54 family, as well as Nordic's latest release in the Wi-Fi sector, the nRF7002. The nRF54 family will be available in 2024 (Fig. 4). With state-of-the-art security technologies, it is ideally suited for future Matter devices. Designed for PSA Certified Level 3, it features a physical unclonable function-based (PUF) root of trust, secure boot, firmware update and storage, as well as cryptography acceleration, side-channel protection, and tamper detection.

The nRF54H20 starts with two Arm Cortex-M33 processors running at up to 320 MHz to handle computationally intensive applications

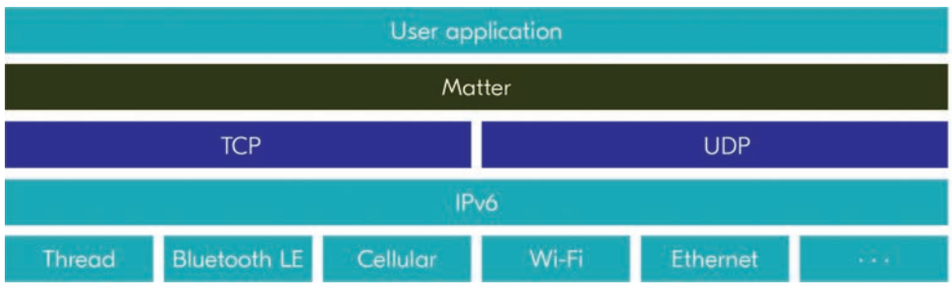

Image: Nordic Semiconductor

Figure 2: Matter protocol layers

and radio communications and two RISC-V co-processors for ultra-low-power tasks and software-defined peripherals. The 2 MB flash memory enables FOTA in most Matter-based applications without additional external memory.

While the nRF54 family as well as the nRF5340 and nRF52840 use Matter over Thread, the nRF7002 uses Matter over Wi-Fi. When combined with one of the BLE SoCs mentioned above, it can also be used for convenient BLE commissioning in the Matter network.

The Nordic nRF Connect SDK v2.4 supports the development of all kinds of applications, including those based on the latest Matter 1.1 version. This includes Periodic Advertising with Response (PAwR). Further, it allows devices that receive periodic advertisements to also send responses to the sender, creating bidirectional communication and enabling large one-to-many topologies.

In addition, Nordic already offers KNX integration on Github to also meet industrial building services standards. This will help the supplier maintain its lead among SoC suppliers for smart homes and smart buildings in the future.

Panasonic has Matter modules based on Nordic Semiconductor's chips. In the Matter over Wi-Fi segment, the PAN9028, is offered in two versions: either with or without an integrated power management IC (PMIC). PMICs for battery-powered devices – whether the application offers radio or not – also represent a very rapidly growing product genre from Nordic.

New Wi-Fi6 and Wi-Fi6E modules are the PAN9019 and PAN9019A, respectively. Both use Matter over Wi-Fi; the PAN9019A is additionally capable of Matter over Thread. Pure Matter-over-Thread modules are PAN1770 and PAN1780. They are based on Nordic's BLE chip nRF52840. Panasonic has announced a module based on Nordic's nRF5340 for December 2023 (PAN1783). It will be among the smallest nRF5340-based modules on the market and will be available with either bottom-pad or chip antennas.

InsightSIP also uses Nordic chips for its modules: Based on the nRF5340, the supplier offers the ISP2053-AX, for example. It uses the Matter-over-Thread connection, as does the ISP1807-LR, which is based on the nRF52840. InsightSiP's modules also already include crystals and certifications and are popular due to their extremely small size. They still look like a chip thanks to the patented internal antenna.

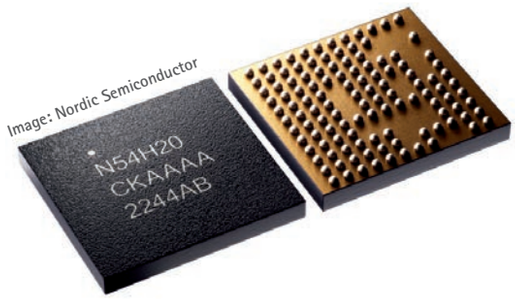

Figure 3: Nordic Semiconductor's nRF54 family features Matter over Thread and state-of-the-art security technologies. It will be available from 2024.

For price-sensitive devices, Rutronik offers similar modules from Minew, which is listed as an official module partner with Nordic. Matter-capable, for example, is the MS-45SF11, which is based on Nordic's nRF5340. Here, too, the Matter-over-Thread process is used. Minew's new flagship is the MS12SF1. The module has both the nRF5340 and the Wi-Fi companion chip nRF7002 built in, making it one of the first combo modules to support both Matter over Thread (nRF5340) and Matter over Wi-Fi (nRF7002) through its two chips.

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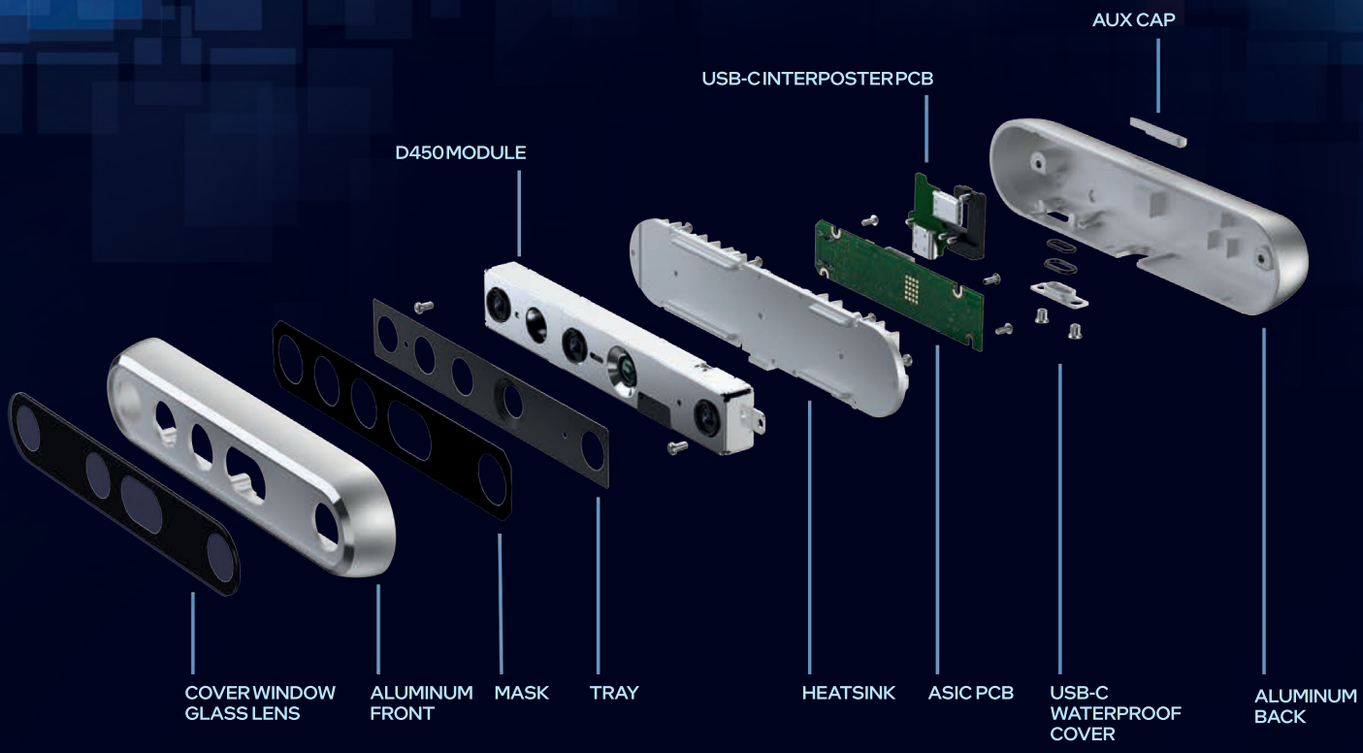

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Magnetometers

Exciting possibilities with TMR technology

Numerous applications would be inconceivable without magnetometers. Others gain improved or new functions through the addition of corresponding sensors. The new tunnel magnetoresistance technology now opens up even more possibilities.

By Maria Alejandra Salazar Martinez, Corporate Product Manager Analog & Sensors at Rutronik, and Thomas Block, Product Manager at Bosch Sensortec

Magnetometers measure a magnetic field or a magnetic dipole moment. A typical magnetometer is a compass. It measures the direction of a surrounding magnetic field, in this case the Earth's magnetic field. Various types of magnetic sensors, on the other hand, detect the direction, strength, or relative change of a magnetic field at a particular location.

Magnetometers have been used in the automotive industry and industrial applications for several decades; in consumer electronics, they are standard in smartphones, wearables, and augmented reality/virtual reality (AR/VR) glasses, for example, as well as in drones and robots, smart home devices, and IoT applications. In addition, there are exciting new application areas such as head orientation for 3D audio, improved indoor navigation, positioning, and speed detection. One way to implement these is with Hall sensors.

Hall sensors take up a large market volume

A Hall sensor is a sensing element for detecting the Hall effect or Hall voltage. Hall sensors can be traced back to a discovery made by Edwin Hall. In 1879, the scientist found that a magnet placed perpendicular to a current-carrying conductor pulls the electrons flowing in the conductor to one side, creating a charge difference (i.e. a voltage). The Hall effect is thus an indicator of a magnetic field near a conductor and its strength. It is used in sensors to indicate the presence, absence or strength of a magnetic field based on the resulting Hall voltage. Today's highly integrated Hall sensors incorporate various sensor signal conditioning functions, such as a differential array of Hall elements, instrumentation amplifiers, A/D converters, and even MCUs (depending on the version). So, although Hall sensors work by detecting a magnetic field, they can be used to measure many parameters, such as position, temperature, current, and pressure.

Due to their highly developed and low-cost production, Hall sensors have long had a significant market volume. They essentially consist of a thin piece of a rectangular p-type semiconductor material, such as gallium arsenide (GaAs), in-

Images: Bosch Sensortec

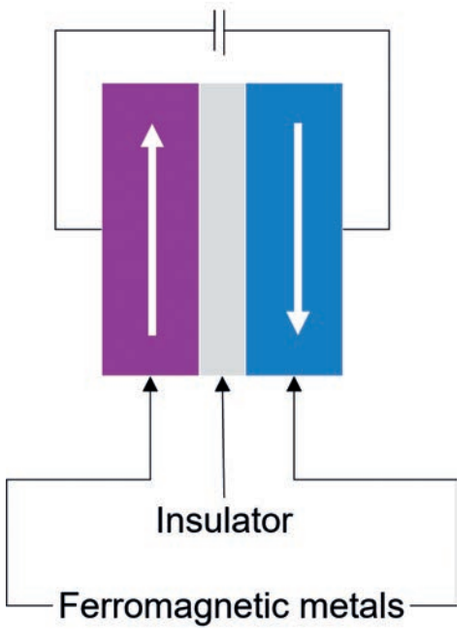


Figure 1: Schematic TMR arrangement with two ferromagnetic layers and an intermediate insulating layer

dium antimonide (InSb), or indium arsenide (InAs), through which a continuous current flows. When the sensor is in a magnetic field, the magnetic flux lines exert a force on the semiconductor material that deflects the charge carriers, electrons, and holes to either side of the semiconductor wafer. This movement of the charge carriers results from the magnetic force they experience as they pass through the semiconductor material. The output voltage of the Hall element, known as the Hall voltage (U_H), is proportional to the strength of the magnetic field penetrating the semiconductor material (output: α H). However, such silicon-based Hall sensors have limited output power, low accuracy, and a large offset.

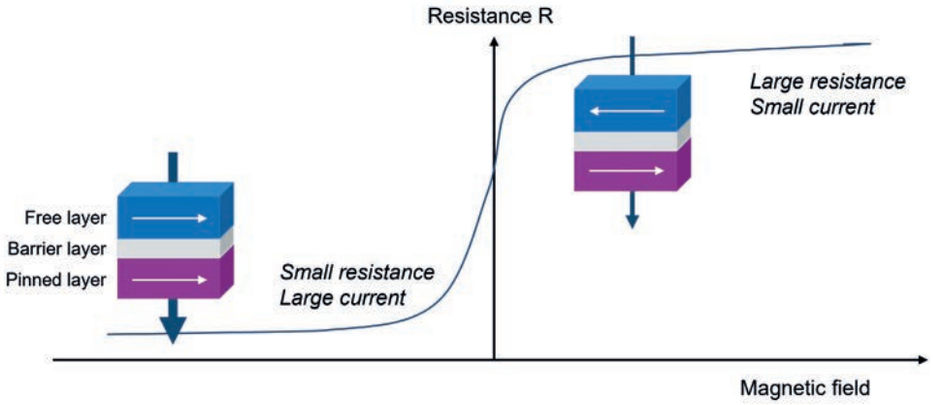


Figure 2: The TMR effect: If the magnetization directions of the free layer and the pinned layer run parallel, the resistance is low and a large current flows (left). If they run in opposite directions, the resistance is high and only a weak current flows (right).

AMR sensors with limited applications

An alternative to the Hall sensor is the anisotropic magnetoresistance (AMR) sensor. A magnetoresistance (MR) changes the electrical resistance of a conductor due to a magnetic field. When the electrical resistance decreases due to the magnetic field, it is called negative magnetoresistance.

Two definitions of percent magnetic resistance are commonly used: MR_0 is defined as the difference between the resistance with a magnetic field and the resistance without a field divided by the resistance without a field.

$$MR_0 = \frac{R_H - R_{0T}}{R_{0T}} \cdot 100$$

MR_P, on the other hand, is the difference between the resistance with a magnetic field and the resistance in the saturated field divided by the resistance in the saturated field. The maximum value can be arbitrarily large.

$$MR_P = \frac{R_{(\uparrow\uparrow)} - R_{(\uparrow\downarrow)}}{R_{(\uparrow\uparrow)}} \cdot 100$$

The AMR effect was discovered in 1856 and first used as a transducer to read magnetic tape in 1971. Honeywell developed magnetic random access memory (MRAM) based on the AMR effect.

An AMR sensor can also be used as a compass to measure the Earth's magnetic field. Other than that, its applications are somewhat limited. That is because although several semiconductor suppliers offer a range of AMR sensors, their magnetoresistance is typically less than five percent. Conventional AMR sensors also require additional circuitry or permanent magnets to restore the magnetization of the thin film after use. This complicates the packaging and adds extra costs.

GMR sensors for many applications

Then there is the giant magnetoresistance (GMR) effect, which Peter Grünberg and Albert Fert independently observed in 1986 as unusual magnetoelectronic behavior in Fe/Cr/Fe layers. Both were awarded the 2007 Nobel Prize in Physics for this discovery.

When two iron layers are ferromagnetically coupled via the non-magnetic chromium layer, the resistance is low because the electrons can transfer to the second iron layer without changing their spin. The MR ratio in the metallic spin-valve structure is typically about ten percent.

IBM soon used GMR sensors as magnetic read heads in hard disk drives to achieve higher storage capacities. GMR sensors are now being used in a variety of other applications as well.

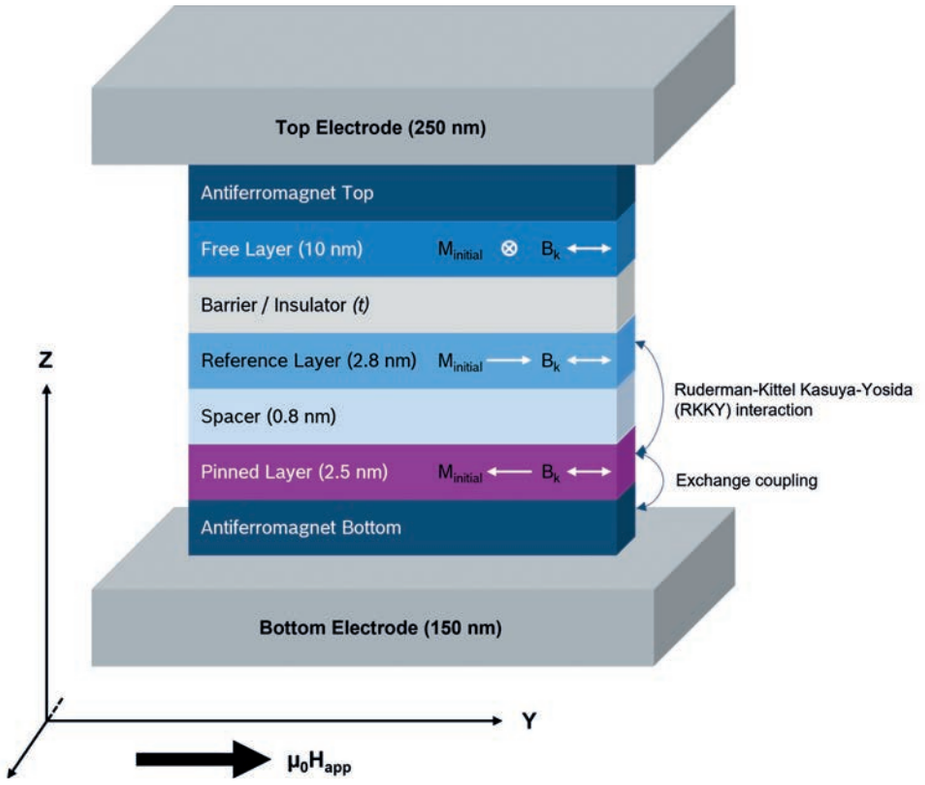


Figure 3: Schematic diagram of an MTJ stack and orientation of simulation input vectors relative to coordinate axes

TMR technology drives innovation

However, the development of magnetometers did not end there; tunnel magnetoresistance (TMR) magnetic sensor technology has since been innovated. It is more accurate, exhibits less noise, and consumes less power than previous magnetometer technologies. Thanks to these characteristics, it is set to increasingly replace Hall sensors.

The discovery of the TMR effect also opened up further possibilities for the use of magnetoelectronic phenomena in the computer industry, such as non-volatile data storage based on the MR effect in layered systems. The technical development of this MRAM can be traced back to IBM, among others. The first products came on the market around 20 years ago. Today, all modern hard drives use TMR read/write heads.

MRAMs combine the advantages of semiconductor memory – fast access times – and of magnetic materials – high storage density. In addition, these non-volatile memories are robust, energy-autonomous, and radiation-resistant. MRAMs also offer non-destructive reading and can even store data without power.

Currently, data storage with dynamic random access memory (DRAM) is still the predominant technology. However, it has the disadvantage of losing data in the event of a power failure. In addition, the storage systems require regular refreshing to prevent data loss. Although it appeared that silicon semiconductors in DRAMs were gradually being replaced by TMR technologies, MRAMs are still found only in niche applications and are still waiting for their commercial breakthrough. In recent years, however, their market share in the automotive, consumer, and industrial markets has grown disproportionately compared to other technologies such as Hall, AMR, and GMR.

The TMR effect

The TMR effect is based on an arrangement comparable to the GMR effect. It was first discovered by Michel Jullière in 1975 in Fe/GeO/Co junctions at 4.2 K. The relative resistance change was about 14 percent and did not attract much attention. In 1991, Terunobu Miyazaki found a change of 2.7 percent at room temperature. Three years later, Miyazaki found 18 percent in compounds of iron separated by an amorphous alumina insulator. Jagadeesh Moodera measured 11.8 percent in compounds with electrodes of CoFe and Co.

Unlike GMR, which has a non-magnetic layer, TMR involves inserting a non-conductive layer between two magnetic layers. This is done with a magnetic tunnel junction, a component consisting of two ferromagnets separated by a thin insulator (Fig. 1).

If the insulator layer is thin enough (typically a few nanometers), electrons can pass through the tunnel barrier from one ferromagnetic layer to the other. The probability of this also depends on the spin, leading to high MR values for parallel vs. anti-parallel magnetization of the spins in the magnetic tunnel junction layers. The largest effects are expected for materials with fully spin-polarized electrons.

Since the tunneling process is forbidden in traditional physics, TMR is a quantum mechanical phenomenon. The direction of the two magnetizations of the ferromagnetic layers can be changed by an external magnetic field. If the magnetizations are aligned in parallel, the electrons are more likely to tunnel through the insulating layer than if they are aligned in opposite (anti-parallel) directions. This means that it is possible to switch between two states of electrical resistance, one with low resistance and one with high resistance (Fig. 2).

Structure of a thin film stack

The TMR effect can be used for many applications. However, doing so requires building a thin film stack. The trick is to have only one free ferromagnetic layer.

The magnetic tunnel junction (MTJ) in Fig. 3 uses what is called exchange coupling. This TMR structure is an MTJ multilayer between two electrodes in a geometry where the current flows perpendicular to the plane. The complex stack consists of double exchange electrodes composed of a bottom electrode, a bottom anti-ferromagnet (AFM), a pinned layer (PL), a spacer, a reference layer (RL), a tunnel barrier, a sensing layer (SL), and the top electrode.

To increase the exchange field and to make the MTJ more thermally stable, a synthetic anti-ferromagnetic (SAF) structure can be used instead of a single ferromagnet (FM) in the pinned layer adjacent to the AFM. The SAF structure consists of two or more FM layers separated by thin ruthenium layers and coupled by the RKKY interaction. To fix the magnetization of the pinned layer in one direction,

the exchange coupling between the FM and AFM layers is employed. Only magnetic fields above the exchange field can reverse the magnetization of the pinned layer. The arrows in Figure 3 indicate the direction of the magnetization and the applied magnetic field.

The rate of change of the resistance of a multilayer stack was introduced as the MR ratio. Here, the MR values of conventional AMR and GMR elements are about five and ten percent, respectively. For the much more sensitive TMR element, it is 100 percent or more.

Why is the TMR so sensitive? As described, the GMR element consists of a non-magnetic metal (e.g. copper) sandwiched between two ferromagnetic layers. Electron transfer occurs by electrical conduction in the metal. In a TMR element, however, electron transfer occurs through a quantum mechanical tunneling effect. Therefore, when the pinned layer and the free layer are anti-parallel, a TMR element has an exciting property. This means the electrons are blocked and cannot pass into the tunnel barrier. In a GMR, on the other hand, it is difficult for the electrons to pass through the non-metallic barrier. As a result, a TMR element has an extremely large MR ratio and outputs very clear signals, e.g. yes/no or 1/0, depending on the spin polarization of the metals used.

New magnetometer based on TMR technology

The new BMM350 3-axis magnetometer from Bosch Sensortec is based on this TMR technology. Its much higher sensitivity compared to standard Hall, AMR, and GMR sensors results in significantly greater measurement accuracy. In addition, TMR sensors have better temperature stability and offer a faster response time (Fig. 4).

Thus, wearables and hearables, smartphones and tablets, AR and VR devices as well as vehicle applications can be achieved and improved with the BMM350. Due to its small size, the magnetometer is almost invisible: The wafer-level chip-scale package (WLCSP) measures only 1.28 mm × 1.28 mm × 0.5 mm.

Compared to the previous generation (BMM150), the BMM350 offers significantly improved performance. Its average power consumption is only 200 µA at a data rate of 100 Hz, which is twenty times lower than its predecessor. Noise on the x/y axis is three times lower, and measurement sensitivity is four times more accurate than with the BMM150. Its field shock recovery function makes the BMM350 very robust to external magnetic fields, ensuring high-level accuracy at all times.

The list of possible applications for TMR sensors, like the BMM350, is long. As position sensors (with one, two, or three axes), they can measure rotation or linear motion or the Earth's magnetic field as a compass.

In hearables, the BMM350 improves head orientation and recognition for 3D audio applications. In this case, the combination with inertial sensors and intelligent fusion software compensates for the rotation rate drift that always occurs. In commercially available AR and VR headsets, it is important that the magnetometer is combined with the accelerometer and the rotation rate sensor to reduce pixel latency. This improves the user experience and prevents nausea.

Figure 4: Due to its high sensitivity, the BMM350 3-axis magnetometer from Bosch Sensortec provides very accurate measurement results.

For indoor navigation where a GPS signal is not available, the BMM350 can act as a digital guide and increase position accuracy.

Its capability for speed measurement is not only of interest for automotive applications – with back-biased magnets or magnetic encoders, the TMR sensor can also measure the wheel speed on e-bikes.

Current measurement is another interesting application for TMR sensors. As non-invasive current measuring elements, they are ideal for many applications including in power distribution, power electronics, and drive technology. This is because they offer higher sensitivity and linearity than Hall, AMR, and GMR sensors.

In addition, they are stable, small, and highly integrable and feature low power consumption and typically a wide frequency bandwidth.

Summary

TMR technology, as used in Bosch Sensortec's BMM350, enables a better user experience for numerous applications as well as completely new, exciting use cases that cannot be implemented with other technologies.

Microcontroller combines NFC interface and motor driver

Opening smart locks via a smartphone

Smart locking systems are increasingly replacing traditional locks. For these innovative lock models, Infineon's NAC1080 fits like a key in a lock, as it combines NFC, motor control, and energy harvesting in one chip. This eliminates the need for an additional power source, which obviously reduces costs.

By André Becker,
Field Application Engineer
Semiconductor & Wireless Central
Europe at Rutronik

An electromechanical lock is called "smart" if it can be opened and closed by wireless communication with an electronic key. Mobile devices, such as smartphones, wearables, and other tokens, assume the role of a traditional key. Communication between the key and the lock is usually via Bluetooth, Wi-Fi, or near-field communication (NFC).

These smart locks allow secure and convenient access control by making physical keys a thing of the past. New keys can also be conveniently managed, which is a big advantage in buildings with multiple locks. This is one of the reasons why smart locks are a rapidly growing segment in the IoT sector. For example, the market research and consulting firm Grand View Research put the global market at US$ 1.95 billion in 2022. It is expected to grow at a compound annual growth rate (CAGR) of 19.6 percent between 2023 and 2030, driven by a growing adoption of advanced communication technologies, convenience, and increased interest in advanced security systems.

Structure and function of smart locks

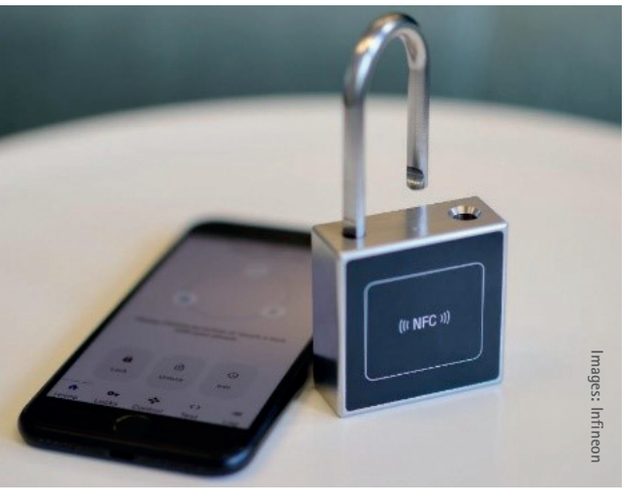
Smart locks essentially consist of a traditional mechanical lock and an electronic control unit. A microcontroller authenticates the user through a digital key exchange (e.g. via NFC) and passes the subsequently sent control commands to the motor drivers to lock or unlock a lock.

Previous applications with an electrical power source operate as active participants in NFC communication. As a result, the motors that control the mechanical part of the lock are also supplied with electricity by this power source.

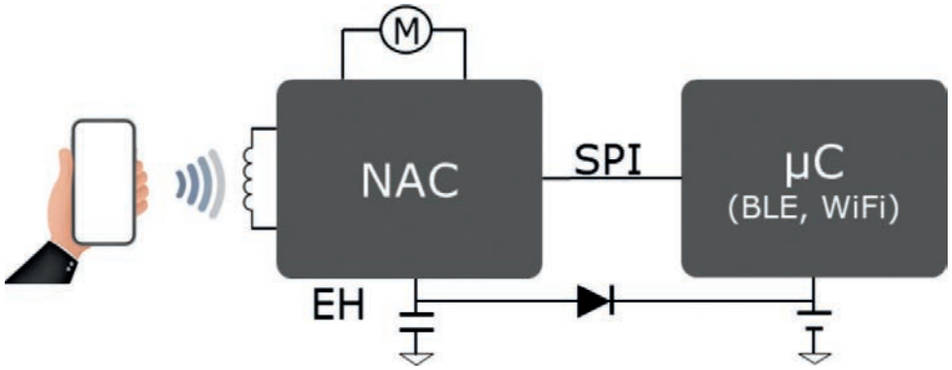
With the NAC1080, no additional power source is needed

A smart lock based on Infineon's NAC1080 NFC controller, which acts as a passive NFC participant, uses the voltage induced by the

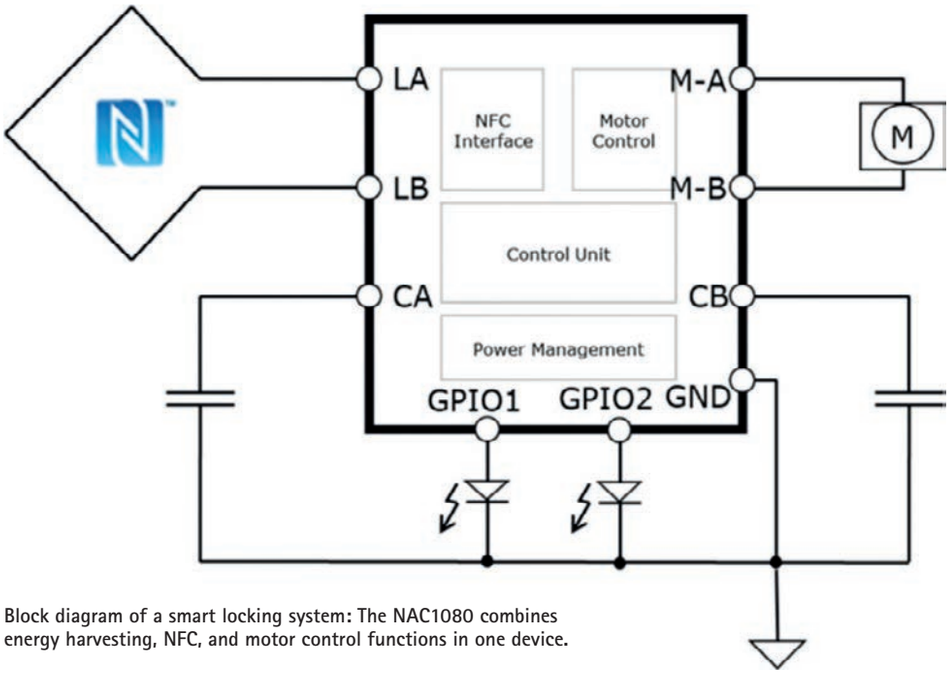
The NAC1080 can be used as a motor driver for battery-free padlocks.



Images: Infineon



Using an SPI interface, the NAC1080 can communicate with external devices.



Block diagram of a smart locking system: The NAC1080 combines energy harvesting, NFC, and motor control functions in one device.

active NFC participant for communication and to power the application, including the motor. With this energy (which is temporarily stored in the capacitor) and an integrated H-bridge driver, the NAC1080 can drive small motors in the milliwatt range (up to 250 mA load current). The combination of passive NFC operation and a double-layer capacitor eliminates the need for an additional power source, such as batteries or accumulators, thereby reducing costs. The actual charging process takes only a few seconds and does not require an additional battery management system.

When the NAC1080 is accessed by the user, the AES128 symmetric encryption method with a random number generator provides the required security. A universal asynchronous receiver/transmitter (UART) or serial peripheral interface (SPI) can be used to read documented log files. This makes it possible to assign the operation of the hardware to the users at any time.

The NAC1080 is based on a programmable 32-bit Arm Cortex M0 core operating at a CPU frequency of 28 MHz. It is available in DSO-16 (4 mm × 10 mm) and VQFN32 (5 mm × 5 mm) packages. An evaluation kit, included software libraries, and a cell phone app enable developers to carry out quick commissioning.

With this single-chip solution, compact locks that require only a low level of torque can be developed easily and cost effectively. Examples include office cabinets, bicycle locks, and mailboxes. They can be opened within a few seconds. Depending on the components and smartphone used, opening time can vary. In addition, other applications are also possible, such as sensors that are not directly accessible for tire pressure testing.

Operation and communication during a power failure

If the NAC1080 is integrated into larger locking systems and used as a passive component, it can continue to be used despite a power failure, empty batteries in the smart lock, or loss of keys. In this scenario, the IC also powers the door lock directly via the NFC interface. ■

Real-time kinematics

Centimeter-accurate positioning in real time

A near miss is still a miss – this is especially true for applications that require precise positioning, such as those for autonomous driving or surveying. Real-time kinematics, a technology that enables precisely this in real time, is now becoming commercially attractive.

By Filipe dos Reis,
Corporate Product Manager Wireless at Rutronik

Real-time kinematics (RTK) is a high-precision method of determining positions. This technology of the future will play an essential role in driverless applications, for example, but applications for many other industries can also benefit from real-time, centimeter-accurate measurements, including agriculture, construction, surveying, geology, robotics, and disaster control.

For such applications, conventional GNSS signals are too imprecise, with an accuracy of only three to ten meters. With the help of RTK, the accuracy can be improved to about 2 centimeters with no time delays. This ensures constant reproducibility of the position, which is essential for self-driving vehicles, not only on highways.

What are the advantages of RTK?

RTK offers a number of advantages over conventional GPS systems. The most important are:

1. Ten times greater accuracy: This makes RTK ideal for applications that require very precise positioning, such as autonomous vehicles.

2. Real-time positioning: As a real-time positioning technology, RTK is suitable for applications that require precise and fast position data, such as drones.

3. Weather resistant: Accuracy is not affected by varying climatic conditions.

4. Versatility: RTK can be used in many industries, including surveying and geology, mining and agriculture.

Image: pickup/stock.adobe.com

How does RTK achieve precise position determination?

RTK uses two GNSS receivers for positioning: a base receiver and a rover receiver. The base receiver is fixed in position and receives signals from satellites to obtain position information. These signals are referred to as correction data, as they contain information about deviations from the expected value, for example due to atmospheric conditions. For this purpose, the base receiver calculates its own location using the signals received from GNSS satellites and compares it with its known, fixed position. This allows errors and deviations to be detected and a correction signal to be generated, which is transmitted to the rover receiver in real time.

The rover is placed where the position is to be measured, e.g. in the vehicle. This means that it usually has a mobile position rather than a fixed one. Both receivers communicate with each other via a wireless connection. In this way, the rover receives the correction data from the base receiver and can increase the accuracy of the position calculation.

The two receivers communicate via a base receiver, meaning they only need an Internet connection to the receiver. The station with the strongest signal at the time of the request is always selected – even across state lines.

Detailed list of NTRIP providers

Several satellite positioning services provide their real-time positioning data via "Networked Transport of RTCM via Internet Protocol" (NTRIP). NTRIP is a method developed by the German Federal Agency for Cartography and Geodesy to provide GNSS correction data streams. It allows access to data from existing receiver stations to ensure suppliers who integrate RTK into their applications do not need their own receivers. They can access correction data using NTRIP via public or fee-based private networks, depending on the region. A detailed list of NTRIP providers is available at https://ntrip-list.com.

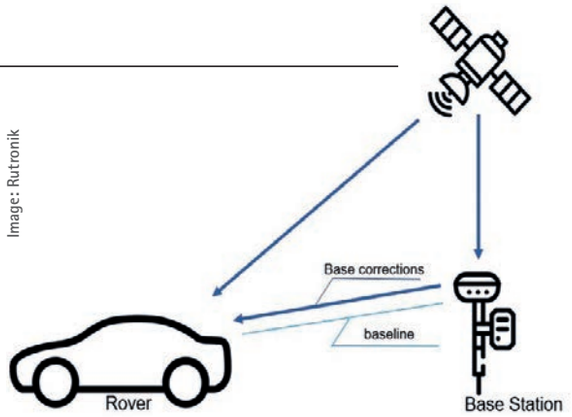
Especially for high-volume consumer products, such as robotic lawnmowers, an Internet connection and the use of third-party NTRIP data can often be avoided. For example, the base may be a charging station, which should be immovably fixed, but whose absolute position is irrelevant. Often the mover, in this case the robotic lawnmower, communicates directly with the base via a latency-free Wi-Fi connection. As a result, it navigates based on its relative reference to the base, rather than absolute position data.

Which components are already available?

The components needed to implement RTK applications are available from Rutronik's GNSS portfolio. The most promising products are currently Unicore and Minew. Unicore is one of the leading companies in China in the field of positioning. The company's customers includes some of the best-known Asian car manufacturers. In order to now also gain a foothold in the European market, Unicore is relying on a partnership with Rutronik.

In the field of high-precision positioning modules, Unicore offers various modules based on the latest generation of the NebulasIV GNSS chip and supporting different bands – also worldwide. The modules, such as the extremely compact UM960 (12.2 mm × 16.0 mm × 2.4 mm), support RTK positioning on all systems and multiple frequencies. A slightly larger module is the UM980, which also offers a higher data rate of 50 Hz (UM960: 20 Hz).

Image: Rutronik



Two GNSS receivers communicate via a base station to determine a position accurately.

Minew's MS34SN3 high-sensitivity GNSS module has an integrated RTK positioning engine that supports simultaneous multi-constellation positioning and L1+L5. With GPS, BeiDou, Glonass, Galileo, QZSS and RTK technology, the MS34SN3 achieves positioning accuracy in the centimeter range. At the same time, the module is very energy efficient, boasting a power consumption of only 15 mA. ■

Security ICs

Greater security for the networked world

Through wireless communication technologies such as 5G, more and more devices are now connected to the Internet. But for all the benefits, this also means increased access to personal data and a growing risk of cyberattacks. In the connected world, security is an issue suppliers cannot afford to neglect.

By Kerstin Naser,
Corporate Product Manager Wireless at Rutronik

In April 2023, Netgear and Bitdefender presented the "2023 IoT Security Landscape Report". For this report, they analyzed 2.6 million households worldwide that contain smart home devices protected by Netgear Armor and powered by Bitdefender security applications. The result: Roughly 3.6 billion security events were recorded in 2022 on a total of around 120 million IoT devices. Every day, an average of eight smart homes are impacted by cyberattacks.

Registering a whopping 52 percent, smart TVs were by far the most popular gateway into the home network (Fig. 1). Smart sockets (13 percent) followed at a considerable distance, followed by routers (9 percent), and smart video recorders (8 percent).

Figure 1: According to Bitdefender's analysis, smart TVs were by far the most common targets of cyberattacks on home networks in 2022.

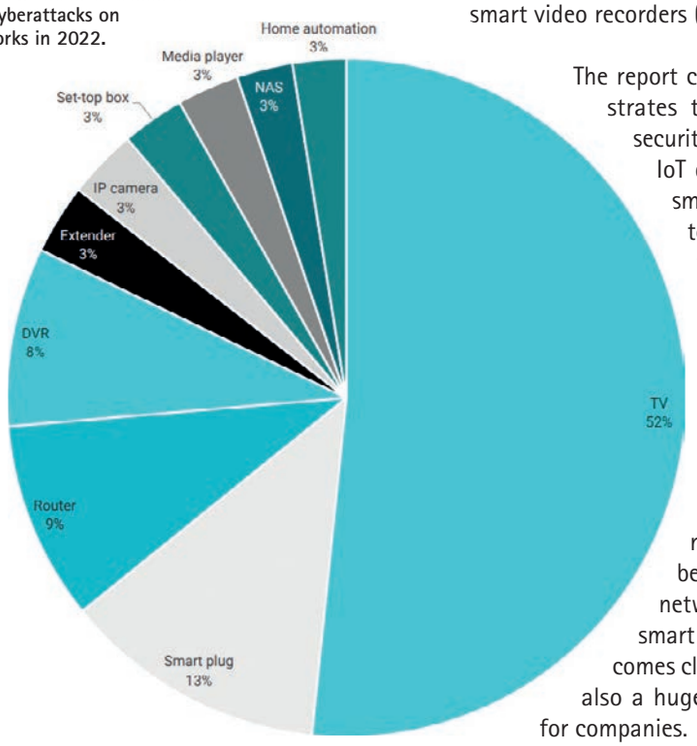


Image: Bitdefender

The report clearly demonstrates the enormous security risk posed by IoT devices in the smart home sector. Add to that the fact that the home office drive during the COVID-19 pandemic often resulted in a laptop full of company data now being part of the network alongside smart TVs, and it becomes clear that this is also a huge security risk for companies.

This is also shown by the CONCORDIA report (Cyber security cOmpeteNCe fOr Research anD InnovAtion), for which a European consortium of universities and companies investigated how COVID-19 has impacted cyber security. According to the report, cyber criminals are resorting to proven modi operandi and malware families to exploit the societal developments, emergency services, and supply shortages caused by the pandemic. This includes increased use of digital services and weakly protected personal IT devices such as WLAN routers in smart home environments.

The report by the German Federal Office for Information Security (BSI), "The State of IT Security in Germany 2022", comes to a similar conclusion: Overall, the already tense situation worsened further during the reporting period (June 1, 2021 – May 31, 2022). The threats in cyberspace are now higher than ever.

This increases the responsibility of suppliers of devices connected to the Internet to integrate sufficient security mechanisms into their products.

Requirements of the Radio Equipment Directive

The Radio Equipment Directive 2014/53/EU applies to almost all devices that transmit – regardless of whether they are transmitters or receivers. It provides the regulatory framework for making radio equipment available on the market and putting it into service, with the aim of enabling the free movement of goods within EU member states. The requirements include "an adequate level of electromagnet-

Image: Rutronik

Figure 2: Greatly simplified setup of an IoT device with additional security hardware

ic compatibility" and "effective and efficient use of radio spectrum so as to avoid harmful interference". In addition, the health and safety of users must not be endangered. However, these basic requirements of the RED previously only applied to devices that are not actually connected to the Internet.

For this reason, the EU Commission expanded the RED in January 2022 to include Articles 3.3 d), e), and f), which address network protection, user protection, and fraud protection for the following products:

3.3 d) Any equipment that can communicate with the Internet, either directly or indirectly

3.3 e) Any equipment that processes personal data:

- Equipment connected to the Internet
- Radio equipment for childcare or toys (Directive 2009/48/EC9)
- Portable equipment with radio function (wearables)

3.3 f) Any equipment that is connected to the Internet and which can be used for transferring money, monetary values, or virtual currencies.

A number of security requirements are defined for these product groups. Here are some examples:

- Products covered by Article 3.3 d), for instance, must be secured by default and by design, and must be equipped with the most current software and hardware at the time they are placed on the market.
- For all equipment defined in Article 3.3 e), such as software and firmware, integrity checks must be performed during system startup to provide timely warning to users in the event of degradation.
- For equipment covered by Article 3.3 f), it must be ensured, among other things, that only the appropriate access rights to financial data are assigned.
- For all products belonging to one of these three categories, any access data that is stored, transmitted, received, or otherwise processed must be protected against unauthorized storage, processing, access, or disclosure.

14 basic security requirements

The basic security requirements for consumer IoT equipment are defined in more detail in the European standard ETSI EN 303645 V2.1.0. It covers the following 14 basics:

1. No universal default passwords
2. The management or reporting process for security gaps and active security monitoring
3. Software updates
4. Secure storage of critical security parameters
5. Secure communication
6. Minimization of attack surfaces
7. Integrity of software
8. Security of personal data
9. Fail safety
10. Monitoring of telemetry data
11. Easy deletion of user data
12. Easy installation and maintenance
13. Validation of input data
14. Data protection

Using the corresponding test specification "Cyber Security for Consumer Internet of Things: Conformance Assessment of Baseline Requirements" (ETSI TS 103701), suppliers can self-evaluate or have a test body determine whether their products meet the requirements and recommendations of the standard.

However, there are devices to which these RED articles do not apply: Medical equipment and in vitro diagnostics, civil aviation, electronic road toll systems, and motor vehicles and trailers, including systems, components, and autonomous technical units for the safety and protection of vehicle occupants and road users, are all covered by other EU regulations.

Although it was decided in April 2023 to postpone enforcement of the RED by one year, suppliers of affected products should still prepare for its deployment in good time. This is because all products that are newly approved or enter the EU market on or after August 1, 2025, must be tested for the new cyber security requirements as formulated in the RED articles. All approved testing bodies in the EU are publicly listed.

In addition, suppliers must declare compliance with Delegated Regulation EU 2022/30 (which supplements the European Parliament's Directive 2014/53/EU). According to the classification described above, this applies in particular to smartphones and laptops but also to various smart home and smart building equipment, such as alarm systems and cameras, as well as to devices for monitoring babies or wearables with sensitive data on the user's location or health.

Security ICs enhance security

Most devices are equipped with protection mechanisms and encryption technologies implemented through software. Additional protection with increased security against cyberattacks is provided by integrating a hardware security IC (Figure 2). These ICs are tamper-proof and reinforced against physical attacks through active shielding, a random layout, and mechanisms that immediately interrupt operation in the event of unusual events. They also enable secure booting and firmware updates, thus contributing to endpoint security. In addition, the separate security chips ensure higher performance of the MCU, as it no longer has to perform complex decryption and encryption processes.

Image: Rutronik

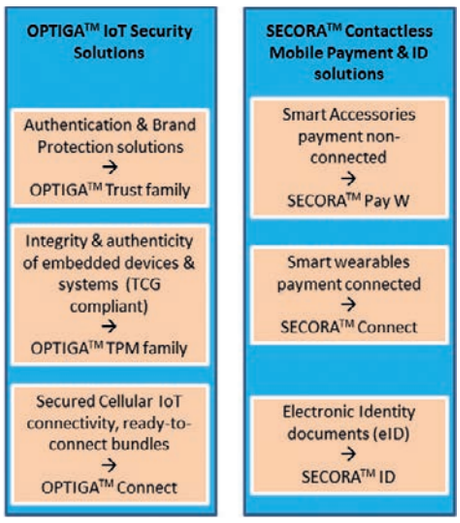


Figure 3: Hardware security products from Infineon

Rutronik offers such hardware security chips through the Optiga product families from Infineon. The supplier is also involved in the working group of the Comité Européen de Normalisation Electrotechnique (CENELEC, European Committee for Electrotechnical Standardization), which is responsible for standardizing RED security and data protection functions. As a result, Infineon is already well equipped to comply with the regulations. The company will also support its customers in this process through the Optiga product families. Moreover, Infineon's commercial products sold in the EU, such as WLAN and Bluetooth modules, will also meet the RED requirements in time for the change in legislation.

The Optiga Trust series includes turnkey products for smaller platforms as well as programmable solutions that meet individual embedded authentication and brand protection requirements.

The Optiga Trusted Platform Module (TPM) series includes standardized security controllers that protect the integrity and authenticity of devices and systems on embedded networks. The controllers are based on proven technologies and support the latest TPM 2.0 standard from the Trusted Computing Group (TCG) as well as special embedded certificates, security certificates (CC and FIPS), and various encryption algorithms. They are also tamper-proof, ensuring secure storage of security keys, certificates, and passwords and providing dedicated security key management.

The Optiga Connect series consists of turnkey embedded SIMs (eSIMs) for both consumer devices and for IoT devices with cellular connectivity. Optiga Connect Consumer is an eSIM specifically designed for small devices, such as smartwatches or fitness trackers. It securely authenticates them to the subscribed network operator. Remote SIM provisioning (RSP) allows users to change or add their mobile operator wirelessly, provided the device is equipped with a local profile assistant (LPA). The consumer product is fully compliant with the latest specifications of the Global System for Mobile Communications Association (GSMA) (SGP.22 V2.2.2) and the Trusted Connectivity Alliance (eUICC Profile Package V2.3.1).

The Optiga Connect IoT series comes with a pre-installed GSMA-compliant operating system and pre-integrated connectivity features. Through Infineon's collaboration with Tata Communications, it offers global cellular network coverage (2G, 3G, 4G, CATM, and other LTE services) with more than 640 networks in 200 countries. In addition, the Optiga Connect IoT series includes Common Criteria EAL5+ certified eSIM hardware.

For contactless payment by credit card, smartphone, smartwatch, and even wristband or ring, which has been booming ever since the COVID-19 pandemic, Infineon has secure near-field communication (NFC) products in its portfolio thanks to the Secora product family (Fig. 3). The family includes four variants: a Java card with world-class security for blockchain system implementation as well as a ready-to-use Java card optimized for electronic identification (eID) applications, a system for smart wearables with contactless secure payment, ticketing, or access applications via NFC, and a complete portfolio for everything from contact cards to smart payment accessories.

With this product portfolio, Infineon meets all RED 3.3 d), e), and f) requirements. ■

View of the electronics market

“An oscillating system needs damping – and distribution can provide it”

High volatility, long delivery times, full storage facilities, the missing “golden screw” – electronics supply chains have been in the spotlight a lot in recent months. We talk about the influencing factors, the current situation, and the prospects of the market with Jan Stoll, Business Development Manager at Rutronik, and Andreas Mangler, Director Strategic Marketing and authorized signatory at Rutronik.

How do you view the current situation on the electronics market?

Jan Stoll: It is impossible to answer the question without looking at the bigger picture. That means looking at the entire global economy, on the one hand, and developments over the last 20 or even 50 years on the other. From a macroeconomic perspective, we are currently in a recession, but in some countries it has bottomed out. This is shown by the PMI (Purchasing Managers' Index), which takes many factors into account and is therefore a good indicator of future market behavior. According to this index, the outlook for 2024 is positive, although there are regional or country-specific variances. For example, the situation in China is currently better than in many other countries, although the real estate crisis is hanging over the Chinese market like a sword of Damocles. Germany currently has one of the worst economic climates in the world. On the other hand, however, the positive upward trend in 2021 was also higher here.

What conclusions can you draw from this?

Andreas Mangler: It is the task of a company's risk management team to keep an eye on these global developments. Regionalization is therefore a key aspect for Rutronik: We will have more and more engineers in the countries to ensure that the country-specific trends even out as a result. For instance, our second largest team outside Germany is in China, allowing Rutronik to participate in the positive developments there. Our international customers also benefit from greater regionalization, as they receive even more local, on-site support. We can implement this easily and quickly, since we have relied on identical processes and IT systems worldwide right from the start. This is also an advantage for our customers with production sites in several countries. They receive everything from a single source, with the same processes and the same quality, wherever they are.

You mentioned the historical perspective earlier. What are the lessons learned from this?

Stoll: If you look back on the long history of the development of the components market, you see that while the current upward and downward trends are very pronounced, the crises of the last 10, 20 years – in other words, the bursting of the dot-com bubble at the turn of the millennium, the major banking crisis in 2009, and the COVID-19 crisis in 2019/2020 – have caused even more extreme trends. This means: Strong market trends are also the norm rather than the exception, at least when viewed over a longer period of time.

But there is a difference: We are currently experiencing relatively excessive trends, but they are not leading us into a massive crisis. The procurement behavior of the manufacturing industry in the components market is, therefore, showing a development which, viewed from a macroeconomic perspective, does not correspond to the real national and international economic cycles. The market was overheated, which was reflected in large customer store inventories. However, in combination with inflation, high energy prices, and other factors clouding the business environment, we are currently in a less precarious situation from a macroeconomic perspective than, for example, during the COVID-19 or banking crisis. But the procurement market in the manufacturing industry demonstrates planning behavior as if we were in a comparably deep crisis. And that is definitely not the case.

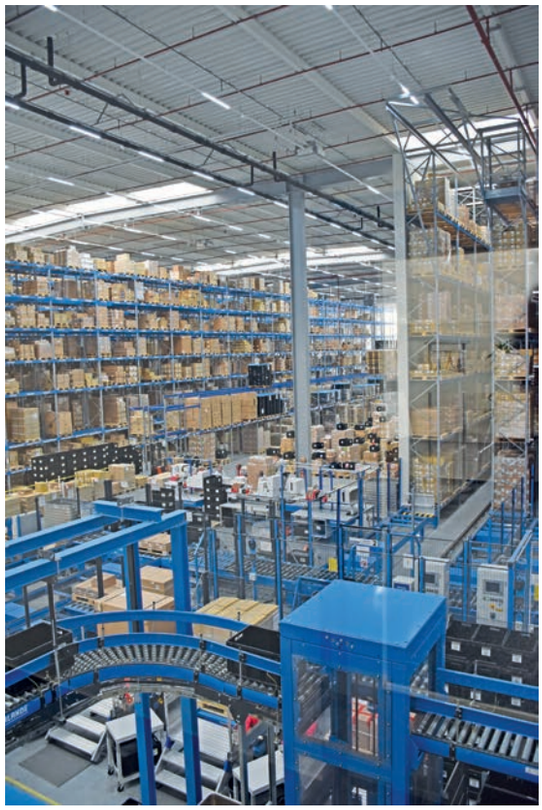
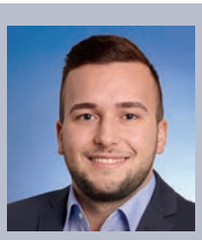


Image: Rutronik

View into Rutronik's logistics center in Eisingen



Jan Stoll, Business Development Manager

"The need to address climate change is a strong driver."

Andreas Mangler,
Director Strategic Marketing

"If the distribution channels become disconnected, the entire system begins to oscillate."

What the historical comparison also shows is that the frequency and amplitude of the trends are becoming higher and higher, and that shortages and surplus supplies are alternating more and more frequently.

To what do you attribute this?
Mangler: There are several influencing factors. For example, there is still the missing "golden screw", without which production cannot take place. But these are often ultra-high-tech products that make up the USP, or the product's technological competitiveness, and cannot simply be substituted.

And, needless to say, procurement behavior also plays a role. In boom phases, there is massive overbooking and storage facilities fill up quickly. This can lead to cash flow problems and ultimately to overproduction on the part of component suppliers. This trend is also supported by inadequately configured or parameterized ERP or inventory control systems, which sometimes overreact. Thus procurement progresses in leaps and bounds, whereas end markets and production sequences are rising and falling most of the time. This continues throughout the entire supply chain. Supply chain stakeholders manage things using a stop-and-go procurement principle but, in fact, want a continuous flow of goods. This simply cannot work. Modern, AI-based ERP systems can factor in many parameters and use statistical filters to achieve more intelligent results.

Currently, we are observing that store inventories at global EMS providers have fallen below last year's level, meaning a procurement phase is imminent. Our urgent appeal to customers is not to cancel now to avoid massive double bookings and all that they entail in 2024 and 2025. Maintaining consistency in your own actions is crucial when it comes to navigating the increasingly likely and frequent market trends. It is impossible to avoid them completely, as there are so many other factors involved.

What do you mean by that?
Mangler: The liquidity problem I mentioned early, caused by full storage facilities, is increasingly leading to mergers and acquisitions (M&A). Every merger significantly impacts sales and purchasing channels, often resulting in the consolidation of distribution and storage responsibilities into a single entity, rather than being divided between two. The number of decision-makers is also reduced, wih each manager dealing with larger volumes, which also contributes to greater fluctuations. In addition, production facilities are often relocated, integrated, or centralized, leading to delays in manufacturing and logistics. All this means greater dependency and less flexibility, plus regional concentration: In the high-tech sector, predominantly only US companies are organized regionally – much to the disappointment of European and Asian customers.

There is also a trend for suppliers to withdraw completely from distribution.
Mangler: That is true. I view it as a dangerous development. Since it means losing all the flexibility that distribution creates through its systems and storage opportunities. If the distribution channels become disconnected, the entire system begins to oscillate. And, as we in control engineering are well aware, oscillating systems require damping or buffers – and this can be achieved through distribution and its storage facilities and processes. This is a very important task for distribution.

Moreover, European customers in particular are at a disadvantage if they only have access to the direct channel. This is because we have a multi-segment market with predominantly medium-sized companies from greatly differing industries. Even if they achieve high sales, they often have a relatively low demand for electronic components compared to large international groups. On the global market, this makes them a small fish whose interests are hardly taken into account. This tendency already exists in the distribution sector, as it is also prone to concentration: Over 60 percent of all sales are managed by the ten largest distributors worldwide. This is where we see a key role for Rutronik.

What does that consist of?
Mangler: We want to strengthen medium-sized companies. We achieve this goal, for example, with Rutronik System Solutions. It is where we develop completely new approaches for solutions consisting of hardware and software, which we then make available to our established customers. This enables them to significantly shorten their development time and gain an innovative edge, even if they do not have hundreds of engineers at their disposal like large corporations do.

Speaking of innovations: Which areas do you believe are the strongest drivers of new approaches to solutions?
Stoll: The need to address climate change is a strong driver. The increased energy prices, resulting from the war in Ukraine, have further accelerated the willingness to invest in green technologies. The electronics market is benefiting from this fact, for example through updating heating systems and installing smart home devices and solar systems. Another example is the transformation toward alternative energy sources, such as fuel cell trucks or hydrogen-based processes in large-scale manufacturing industry. This is giving rise to a whole range of new applications, from sensor technology for fuel cells and electrolysis plants to pipelines. In the future, it may also encompass hydrogen tank leakage monitoring and safety systems for hydrogen filling stations.

According to forecasts, the mobility market will be saturated by 2035, but since the proportion of electronics in vehicles is steadily increasing, the electronics industry will continue to grow in the long term. The demand for electronics is also steadily increasing in agriculture. Ever more sensor technology is being used, for example to ensure that pesticides, fertilizers, and water are only used in a very targeted manner – perfected in vertical farming.

How do you assess the hype surrounding AI?

Stoll: We are witnessing a strong trend toward AI or machine learning (ML) at the edge. This has been propagated for quite some time. But now it is becoming clear through the activities of the big market players and the first big winners in this market segment, e.g. Nividia. Decentralized systems are being built – and in all areas, from consumer goods to robotics. This is also because more low-code AI and ML applications are available, making it easier to build intelligent systems. These are often image or camera-based systems, but also optical ones based on radar, lidar, or ultrasound. They need high-performance microcontrollers and FPGAs that enable fast decision-making, as well as VOC or other sensors, which is where the topic of sensor fusion also comes into play.

At the same time, AI tools like ChatGPT can reignite demand for servers, which plummeted after the widespread exit from cryptocurrencies. The corporations behind these AI applications – Microsoft, Amazon, Google, and Co. – ensure the capital to make large investments. However, this in turn can lead to the large foundries focusing on these products and to less manufacturing capacity being available for other markets, such as the mobility industry.

So the situation is complex. In conclusion, when you look at the big picture, are you optimistic or pessimistic?

Mangler: Definitely optimistic. I come back to looking at the long-term picture: Over the past five decades, the component industry has consistently grown at a rate of seven to eight percent annually – and it is expected to continue along this trajectory in the future. Our 50 years of market experience and market observations as a company tell us how things will continue. That is the beauty of it. ■

The 2010s

Future mobility

Europe today, the world tomorrow: Rutronik is going global.

In 2010, two professors founded Streetscooter to develop and build a low-cost electric vehicle for short trips. Four years later, the first Streetscooters were working as delivery vehicles for Deutsche Post. Their production has since ceased, but the shift toward electric mobility continued: In 2012, Tesla delivered its first Model S, the best-selling electric car worldwide between 2015 and 2017. In 2013, BMW unveiled its first production-ready e-car, with VW and Porsche following suit in 2019.

But it was not only electromobility that unleashed disruptive potential in the automotive sector. More and more companies were driving the development of autonomous vehicles, including some from outside the industry: Google received a US patent for a corresponding technology in 2011. At that time, the test fleet had already covered a good 1600 km autonomously, according to Google. Autonomous driving is still the exception, but vehicles are now equipped with increasingly comprehensive driver assistance systems that are paving the way to fully autonomous driving. An intelligent battery sensor for the safe supply of power to the control units of such assistance systems is described in the article on the following pages.

Car manufacturers also entered new markets: In 2011, BMW and Daimler introduced their car-sharing services, car2go and DriveNow, respectively. The new free-floating concept they introduced made car sharing hip. Both services are now on the market as Share Now.

Through the increasing digitalization and connectivity of all areas of life, vehicles have also increasingly become a second living room, featuring sophisticated entertainment offerings and comfort functions. Read on page 70 how to keep air quality inside your vehicle at optimum levels.

All these developments have led to a significant increase in the proportion of electronics in vehicles. Electronic systems have improved vehicle safety enormously over the course of their development, for example through airbags and antilock braking systems. Driver assistance systems and the electrification of the drivetrain have caused the proportion of vehicular electronics to skyrocket exponentially. According to Statista, the figure in 1990 was still only 15 percent; by 2030 it is forecast to be 50 percent, and the trend continues to rise.

Establishment of the Automotive Business Unit and global orientation

With the Automotive Business Unit (ABU) founded in 2014, Rutronik helps its customers meet the requirements associated with these trends. ABU has also developed its own reference designs for an efficient on-board charger – more on this on page 72 – and for a bidirectional HV switch, as well as applications for the 48V electrical system. Decision-makers, developers, and thought leaders from the automotive industry regularly gather at the Rutronik Automotive Congress.

In 2012 it was called Rutronik Electronics Worldwide. The establishment of the subsidiaries Rutronik Asia HK and Rutronik Electronics SZ with branch offices in Hong Kong, Taipei, Shanghai, Shenzhen, and Chengdu marked the transition from a European to a global company. In the following years, subsidiaries were added in the USA and Singapore, and sales offices were launched in Turkey, Thailand, India, and Malaysia.

Rutronik continued to grow accordingly: Between 2010 and 2019, the number of employees increased by more than 40 percent and sales by more than 65 percent. In 2018, Rutronik cracked the one-billion-euro sales mark.

Automotive-qualified shunts and matching evaluation electronics

Intelligent battery sensor consisting of two key components

Battery monitoring plays an essential role in ensuring a reliable power supply for high-availability control units in assistance systems – as does sensor technology. Two components are the key to an intelligent battery sensor.

BY RALF HICKL,
PRODUCT SALES MANAGER IN THE AUTOMOTIVE BUSINESS UNIT (ABU) AT RUTRONIK

Image: Casper1774 Studio/Shutterstock

Parameters such as battery current and voltage are measured to monitor the battery in the vehicle. The electronics use these parameters to calculate the residual energy stored in the battery, among other variables. Based on this, a control unit can decide which loads may be switched on or must be switched off to ensure that vital assistance functions remain available.

To measure the current, an important component in any battery sensor is the sensing element, such as shunt resistors, which are the focus of this article.

The advantage of shunt resistors is that they provide a simple linear relationship between the measurand and the output signal. According to Ohm's law, the voltage drop across the shunt is proportional to its constant resistance and the current flowing through it. This makes shunts suitable for DC and AC currents as well as for both current directions. The sensitivity to interference with respect to temperature is known from the data sheet and can be calculated if the actual temperature value is known.

One of the disadvantages is that the measurement signal of the shunt resistor – unlike cur-

Image: Vishay

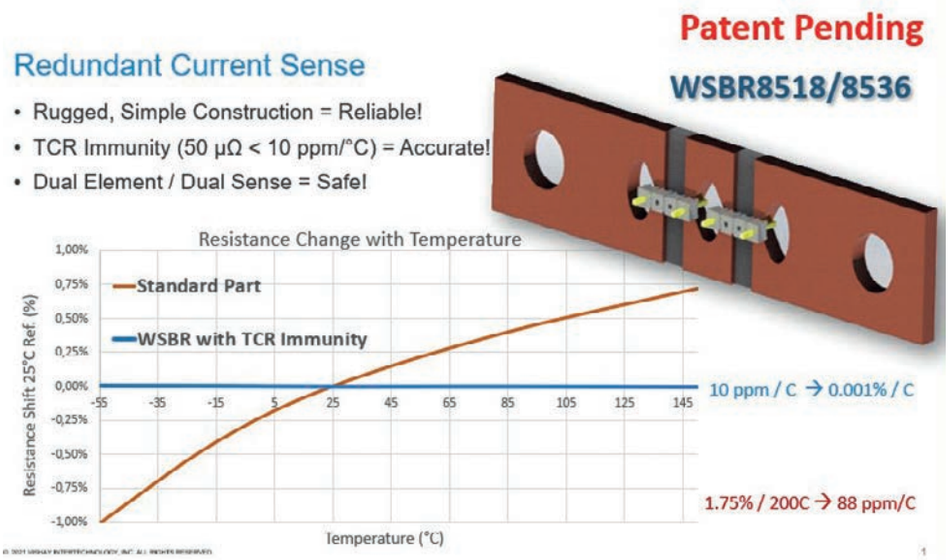


Figure 1: Thanks to its robust design, Vishay's WSBR series tandem shunt provides greater functional safety.

rent sensors based on the measurement of the magnetic field around a conductor – is at the potential of the current being measured. Therefore, current measurement in high-voltage systems still requires galvanic isolation of the measurement signal, which is an additional requirement. In addition, shunts dissipate power loss according to the formula $P_{tot} = R \cdot I^2$ and heat up and transfer the heat to their surroundings.

Types of shunt resistors

Shunt resistors come in a variety of designs depending on power and resistance; examples include thick film surface mount resistors (SMD) or metal surface mount resistors such as the Vishay Power Metal Strip resistor. Compared to thick film resistors, metal resistors offer a higher pulse load capability.

Image: Rutronik

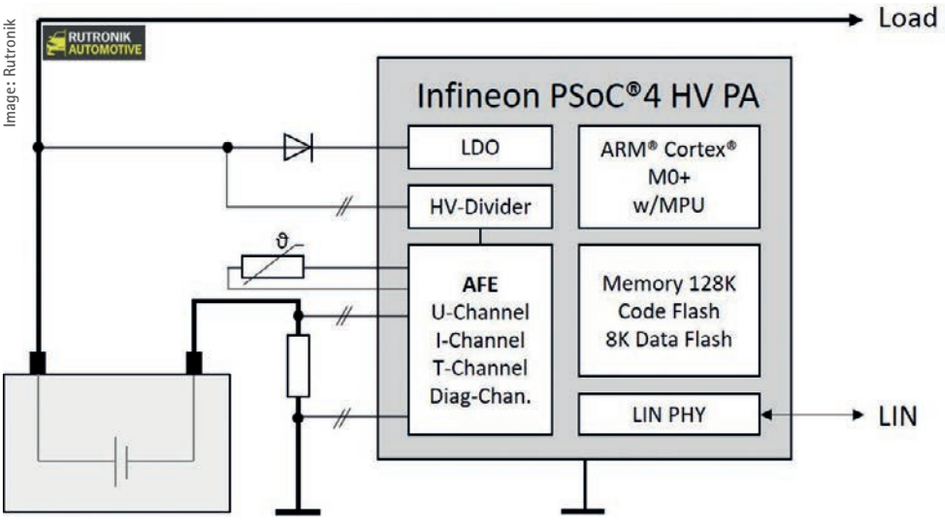


Figure 2: Block diagram of an intelligent battery shunt using Infineon's PSoC 4 HVPA 144K

Sizes for surface mount resistors range from 0603 to 5931. The higher the currents, the more the design changes toward metal brackets with screw connectors. This is especially true in the range up to several hundred amps.

The sensing element is made of a special alloy with the smallest possible temperature coefficient which is welded to two connecting elements made of copper. The position of the sensing taps is important: They should be as close as possible to the sensing element with the smallest possible current path in the copper to ensure the copper path with its higher temperature coefficient does not nullify the Wrende element and falsify the measurement result.

Tandem shunt from Vishay

Automotive-qualified shunts with screw connectors and power loss up to 36 W have long been offered by Vishay. These are the WSBS and WSMS series. Available are the low-inductance power metal strip versions with resistance values and temperature coefficients from 50 µΩ and 10 ppm respectively. In addition, other values are also available and can be requested from Rutronik.

New to Vishay's portfolio are the WSBE and WSBR series. The former extends the resistance range down to just 15 µΩ while maintaining a low temperature coefficient of up to ±10 ppm and a small thermoelectric voltage of up to 1.25 µV/°C. Since the power loss is proportional to the resistance of the shunt, the smaller resistance values of the WSBE shunts also allow higher currents to be measured.

The special feature of the new WSBR8518/8536 tandem shunt (Fig. 1) is its robust design with two independent measuring sections, which ensure high functional safety.

Verification can take place by comparing the voltage drops across the two independent measuring sections. In combination with appropriate evaluation electronics, applications with up to ASIL D classification can be achieved.

Evaluation electronics with Infineon's Automotive PSoC 4 HVPA

This shunt configuration is particularly well suited to evaluation electronics with a two-channel analog front end, such as Infineon's

Figure 3: Evaluation board CYHVPA-128K-32-001 for the Automotive PSoC 4 HVPA 144K

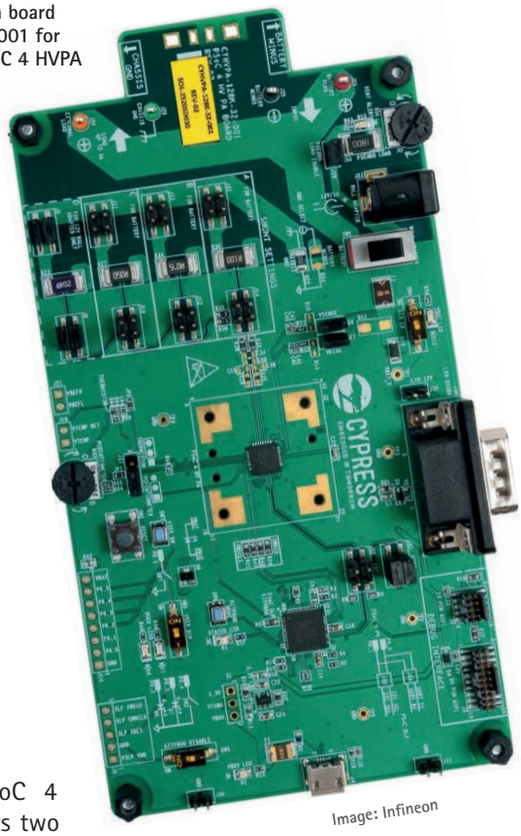


Image: Infineon

Automotive PSoC 4 HVPA (Fig. 2). Its two differential input pairs can be interconnected with the WSBR in such a way that they provide measurement results of the same magnitude but with reversed sign. This provides advantages in compensating for the offset.

The Automotive PSoC 4 HVPA has an internal voltage regulator (LDO) that can be connected directly to a 12 V battery. Its analog front end (AFE) with high-resolution delta-sigma ADCs is particularly suitable for input signals in the millivolt range, such as those that drop at a shunt resistor. The Automotive PSoC 4 HVPA communicates with a higher-level control unit via a LIN interface. The LIN transceiver is already integrated on the chip. Developed in accordance with ISO 26262, the Automotive PSoC 4 HVPA 144K model meets the requirements for a Safety Element out of Context (SEooC) in accordance with ASIL B.

The combination of shunt and Automotive PSoC 4 HVPA can be tested with the evaluation board CYHVPA-128K-32-001 from Infineon (Fig. 3).

Summary

The designs show: Vishay's tandem shunt WSBR and Infineon's Automotive PsoC 4 HVPA are an excellent pair for implementing a smart battery sensor. ■

Functional safety

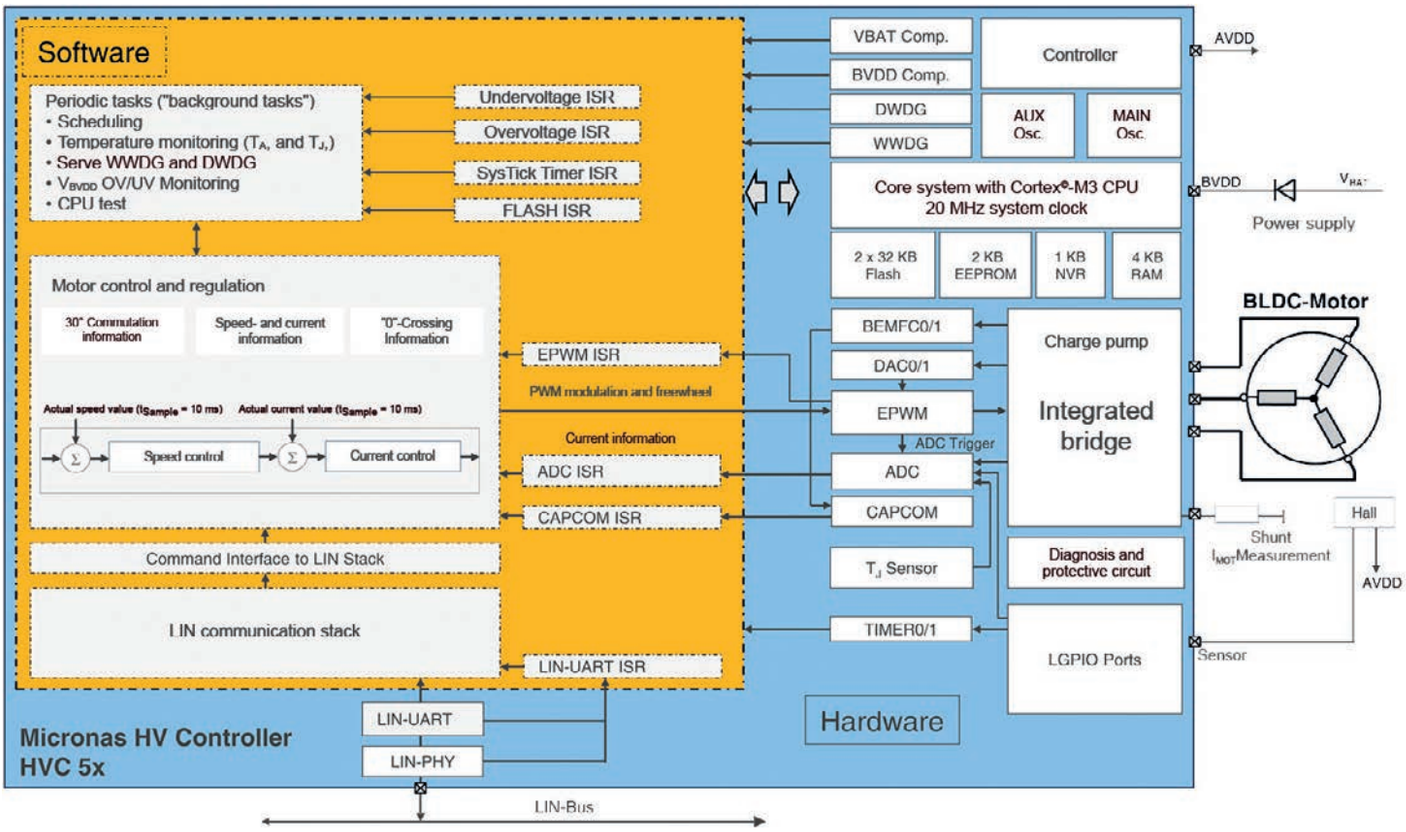
Motor controller with many diagnostic and protection functions

The growing importance of functional safety in electronic systems is placing increasing demands on the self-diagnostic capabilities of complex motor controller ASSPs. TDK-Micronas answers these challenges with the new HVC 5x family of embedded motor controllers.

BY GÜNTER WOLFENSBERGER, CONSULTANT STRATEGIC MARKETING AND LINE MANAGER AT RUTRONIK, AND ADRIANO DE ROSA, SYSTEM ARCHITECT HVC AT TDK-MICRONAS

The diagnostic and protection functions of the embedded motor controllers are mapped by software on the top application layer. Among other things, this application software evaluates voltages, currents, and temperatures measured by the A/D converter or other peripherals. In the layer below, software-independent protection and diagnostic functions are implemented in hardware. They can be partially configured by the application software, but their effect cannot be influenced. They bring the corresponding function block or the entire IC into a fail-safe state, for example by switching off the motor bridge due to an overcurrent event or by performing a system reset via the digital/window watchdog. By implementing the protection mechanisms described in the safety manual

Figure 1: Hardware and software system interaction with BLDC motor



Images: TDK-Micronas

with regard to programming, configuration, and wiring, the customer achieves defined diagnostic coverage.

Power supply from the 12 V electrical system

HVC 5x family devices can be powered directly from the 12V electrical system and are ISO pulse compliant (ISO 7637-2 and ISO 16750-2). Reverse polarity protection is provided, e.g., by an upstream diode. Controllers for the subordinate supply domains (analog, digital, and standby) are fully integrated.

Various diagnostic options are available for voltage monitoring. An important function is the continuous monitoring of the BVDD supply voltage with corresponding overvoltage and undervoltage interrupts. Voltage monitoring generates control signals for configuring the analog and digital power supply system for the different voltage ranges.

The HVC 5x motor controllers are functional up to a BVDD voltage of 4.8 V (typically). If the BVDD voltage drops further, the ICs enter what is known as retention mode. In this mode, all analog peripherals, including the analog controller and motor functions, are switched off, the digital peripherals and the CPU are reset, and a program is no longer executed. However, memory contents are retained. A system reset occurs when returning from retention mode. The application software can determine the cause of the most recent reset by reading a status register and take appropriate precautions. An overvoltage condition is also indicated by a system register flag. The IC is functional up to 40 V. However, pro-

- Supply monitoring
  - Voltage range (under-/overvoltages)
  - OV/UV interrupts
  - Monitoring by software
- Internal regulators and voltages
  - Undervoltage/overcurrent detection
  - Bandgap references, generation of reset
  - ADC measurement of internal regulators and bandgap
- Charge pumps Voltage
  - Overvoltage detection with automatic shutdown
- Monitoring of the T_J of the chip
  - In central position of the IC
  - Additional cyclical measurement of T_J with integrated temperature sensor via ADC

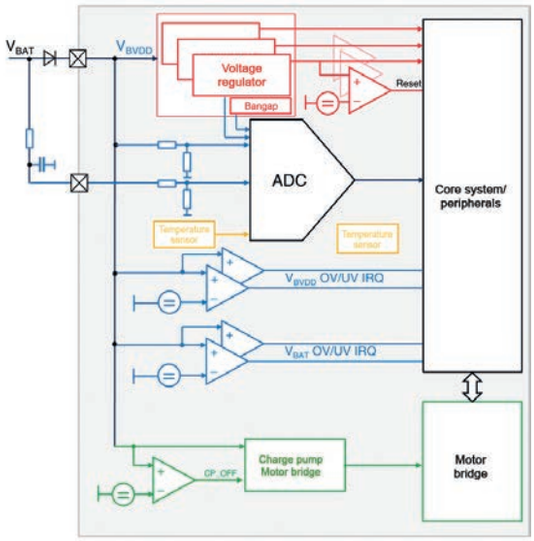


Figure 2: Voltage and temperature monitoring of HVC 5x family motor controllers

- Two independent oscillators
  - f_{MAIN} >> f_{AUX}
- Window watchdog (WWDG) is clocked by auxiliary oscillator (f_{AUX}) and monitors the main oscillator and the program execution
- WWDG is always activated. Can only be deactivated for debugging purposes by special keyword
- Digital watchdog clocked by the main oscillator monitors programme execution
- Memory
  - ECC, BIST

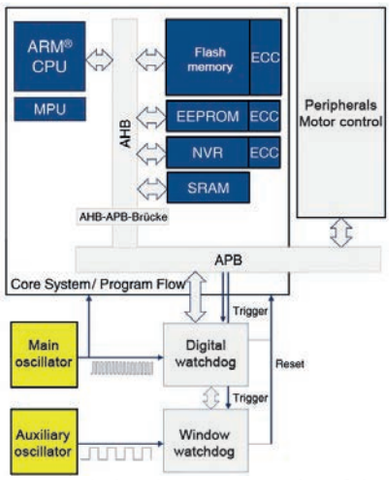


Figure 3: A window watchdog and a digital watchdog monitor the system clock and program execution of the motor controllers.

longed operation under overvoltage is critical due to the rising junction temperature and will shorten the IC's service life (Fig. 2).

The overvoltage flag is a software-based safety feature that should be used by the application software to, for example, limit power consumption and maintain the power loss budget. This can be done by switching off peripheral modules or by lowering the CPU clock frequency.

Additional software-based diagnostics of the supply voltage and controller voltages can be performed by the internal 12-bit ADC. The BVDD supply voltage can be measured cyclically, for example. It is also possible to measure the battery voltage (VBAT) using a suitably sized passive RC protection filter (e.g. via an LGPIO port).

By measuring both voltages, it is possible to respond to electrical system instabilities or overshoots before they affect the internal supply. Overvoltage and undervoltage conditions can thus be detected in good time and indicated by the existing interrupt sources in the software to ensure the IC can be put into a safe state. The 64 kB version of the HVC 5x family also allows measurements of the internal regulator and band-gap voltages, for example to detect relative voltage drifts over the service life.

Clock system with two oscillators

The clock system of the motor controllers has two independent on-chip oscillators, the main oscillator and the auxiliary oscillator. The main oscillator provides the system's 40 MHz main clock and serves as the basis for the clock of the analog and digital modules. The main oscillator is supplied by the analog controller, whereas the auxiliary oscillator is supplied independently of the standby controller. The auxiliary oscillator serves as the clock source for the window watchdog (WWDG), which monitors the oscillators and the program flow. Triggering the WWDG results in a system reset.

In addition to the WWDG, HVC 5x motor controllers also have a digital watchdog (DWDG) for monitoring correct program execution. Unlike the WWDG, the DWDG is clocked by the main oscillator. Any error in the program execution that prevents the DWDG from being re-triggered within a programmable time will result in a system reset (Fig. 3).

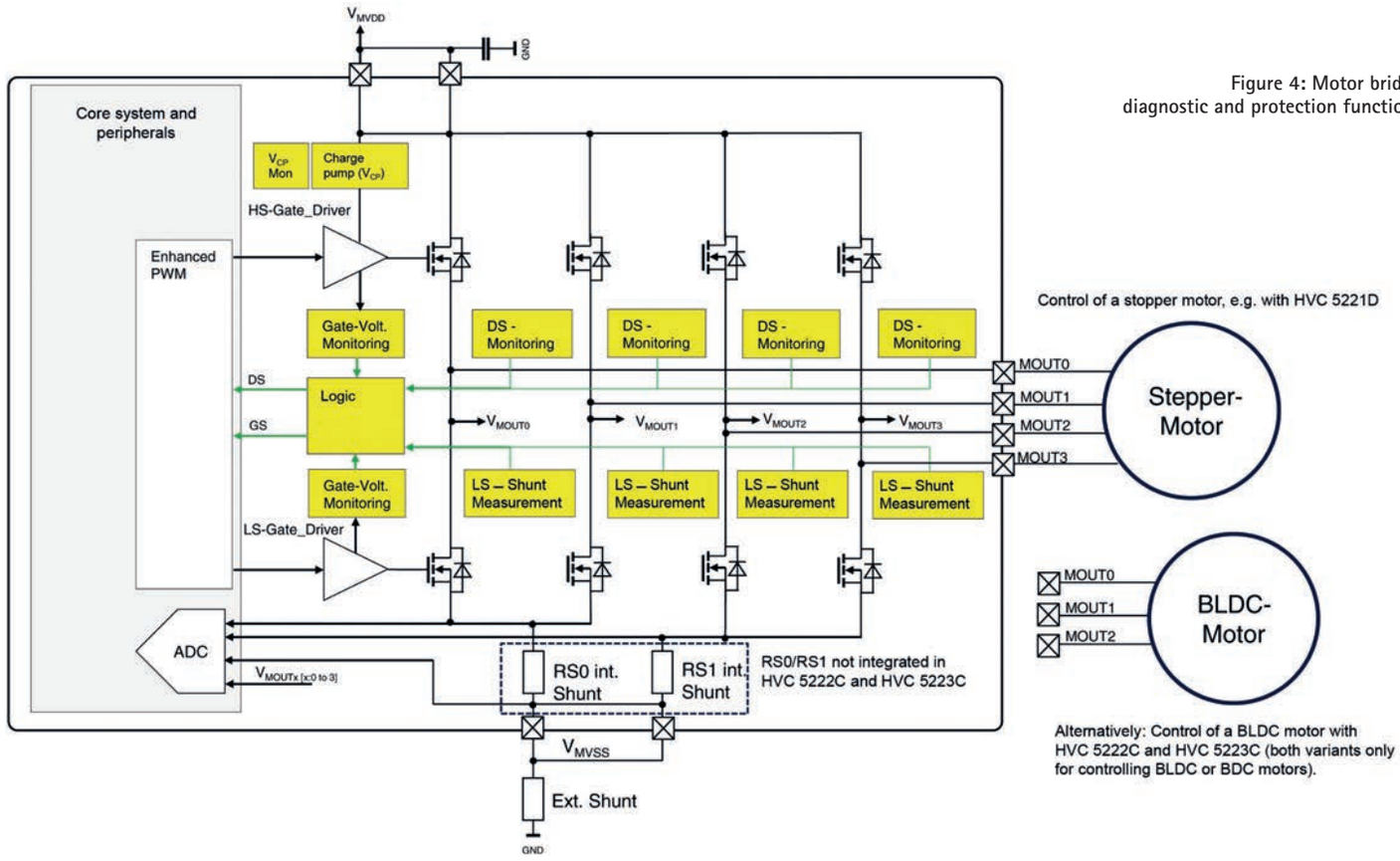


Figure 4: Motor bridge diagnostic and protection functions

In all cases, the cause of the most recent reset can be evaluated after startup by reading the system status. The WWDG is always enabled and can only be disabled for debug purposes with a special keyword.

I/O protection functions

The HVC 5x family has 3.3 V I/O ports (for debugging, digital/analog functions), a LIN bus interface and ports for direct BLDC, and stepper motor control. Depending on the actual version, the HVC 5x motor controllers support BLDC and stepper motors or BLDC motors only.

The AVDD controller output can be used, for example, to supply external sensors up to a rated output current of 15 mA. Among other things, the AVDD controller contains undervoltage detection and generates a reset if the voltage level is not achieved.

The LIN port is used for communication with external devices via the LIN bus and meets the requirements of ISO 17987 and SAE J2602. It can also be used for other communication protocols (e.g. PWM). It has 8 kV ESD protection and an overcurrent shutdown feature that switches the pin to a recessive state once the overcurrent limit has been reached. The LIN pin is automatically recessive in retention and power-saving modes during thermal shutdown and after a system reset.

An overcurrent event on the LIN port is indicated by an overcurrent flag in the port registers and can be evaluated accordingly by the application software. In addition, the application software can evaluate the overcurrent events by interrupts and immediately initiate appropriate safety measures.

Thermal safety functions

The HVC 5x motor controllers have three temperature sensors for monitoring the junction temperature: One temperature sensor directly triggers a thermal shutdown (TSD) of the IC when the overtemperature limit is exceeded. The TSD is a fail-safe state in which all analog and digital modules are shut down to minimize internal power loss and prevent device malfunction.

Another temperature sensor, supplied by the standby controller, monitors the junction temperature after a TSD to reactivate the IC when the temperature drops below a specified junc-

tion temperature. Upon return from the TSD, a system status flag is set that the application software can evaluate to then initiate appropriate actions such as a self-test.

The third temperature sensor can be read out via the A/D converter. Cyclic temperature monitoring allows the user to respond to a rising junction temperature by taking actions such as switching off certain modules, reducing the CPU clock frequency, or putting the device into one of the energy-saving modes.

Diagnostic and protection functions of the motor bridges

Depending on the variant, the ICs of the HVC 5x family have three (e.g. HVC 5222C, HVC 5223C) or up to four integrated half-bridges to which BLDC or stepper motors can be directly connected without any additional external components. Each port is equipped with internal overcurrent protection with programmable response time as well as interlocking by monitoring the gate voltages of the bridge transistors. Exceeding the overcurrent threshold results in an interrupt. Suitable flags identify the port where the overcurrent occurred. In response, either all or only the half-bridges affected by the overcurrent are deactivated. A half-bridge can then only be reactivated after the application software has cleared the overcurrent flag. To ensure the safe state, all bridge transistors are set to HiZ in retention, energy-saving, or TSD modes and after a system reset (Fig. 4).

In addition to the integrated diagnostic functions of the motor bridges, software-based safety functions are possible to adapt the IC to the specific motor or application.

The integrated back-EMF comparators allow the regenerative voltage of the motor to be evaluated and compared with the feedback from the rotor position sensors, for example. In addition, the connections to the motor phases can be checked by evaluating the back-EMF on the non-driven motor phase.

Especially for stepper motor applications (for HVC 5x variants with four MOUT ports), the 12-bit ADC can be used to measure the EMF voltages on both motor phases and thus to check the torque load on the motor. This makes it possible to implement tuned stall detection in the application software, for example. For practical ADC current measurements, integrated current shunts (RS0 and RS1) are available for the HVC 5x variants with four MOUT ports, as well as the measurement option via an external shunt resistor for all HVC 5x. These can be used, for example, for motor current control and diagnostic functions.

Memory protection and diagnostic functions

The ICs of the HVC 5x family offer several on-chip memory blocks. A 1 kB start-up ROM contains the start-up sequence, interrupt table, flash utility functions, and verification that IC trimming has been performed. The program data are stored in the internal SRAM (2–4 kB depending on HVC 5x version). A flash memory (32–64 kB depending on HVC 5x version) is available for application programs and diagnostic functions. The HVC 5x ICs also have 512–2048 bytes of EEPROM and 256–1024 bytes of NVR for storing non-volatile application data. Write protection prevents any data misuse. The flash main memory also contains write/erase protection. Flash, EEPROM, and NVR have ECC to detect double- and single-bit errors and to correct single-bit errors. In case of error detection, the specific error type and the affected memory can be read out. In addition, an interrupt can be triggered to ensure application software can respond quickly by performing an application-specific error analysis or correction.

Summary

The HVC 5x family from TDK-Micronas includes extensive diagnostic and protection mechanisms that enable its use in systems with safety-relevant functions. Conformity to industry standards such as ISO 26262 (automotive) or IEC 61508 (industrial) and their influence on the "Product Safety Life Cycle" is taken into account in its chip architecture.

Customers receive relevant data sheets for the design of their system and for the fulfillment of the "Safety Goal", an FMEDA summary report for failure mode, failure effect and failure diagnosis analysis and base failure rates as well as corresponding safety manuals. Coordinated diagnostic coverage is achieved through the interaction of hardware and software functions. This provides the customer with the ability to customize the ICs to application-specific functions and configurations to meet the safety requirements of the application. ■

Diagnostic and protection functions of the motor bridges

- Overcurrent monitoring with overcurrent interrupts
- Overcurrent filter with adjustable filter time
- Motor phase voltage and motor current monitoring
- Interlocking (gate voltage monitoring)
- Charge pump monitoring/shutdown
- Automatic bridge shutdown when switching operating modes
- Practical current measurement via internal shunts (HVC 5x with four MOUT only) and/or external shunt for additional diagnostics

Intelligent charging flap for electric vehicles

Drive electrically, charge conveniently

The Fraunhofer Institute for Systems and Innovation Research has determined that e-cars are charged 21 times a month on average. By contrast, combustion engine cars are only refueled two to four times a month, according to Statista. The charging flap of electric vehicles is therefore a central function to enable convenient operation.

By Rahul Naik, Field Application Engineer in the Automotive Business Unit (ABU) at Rutronik

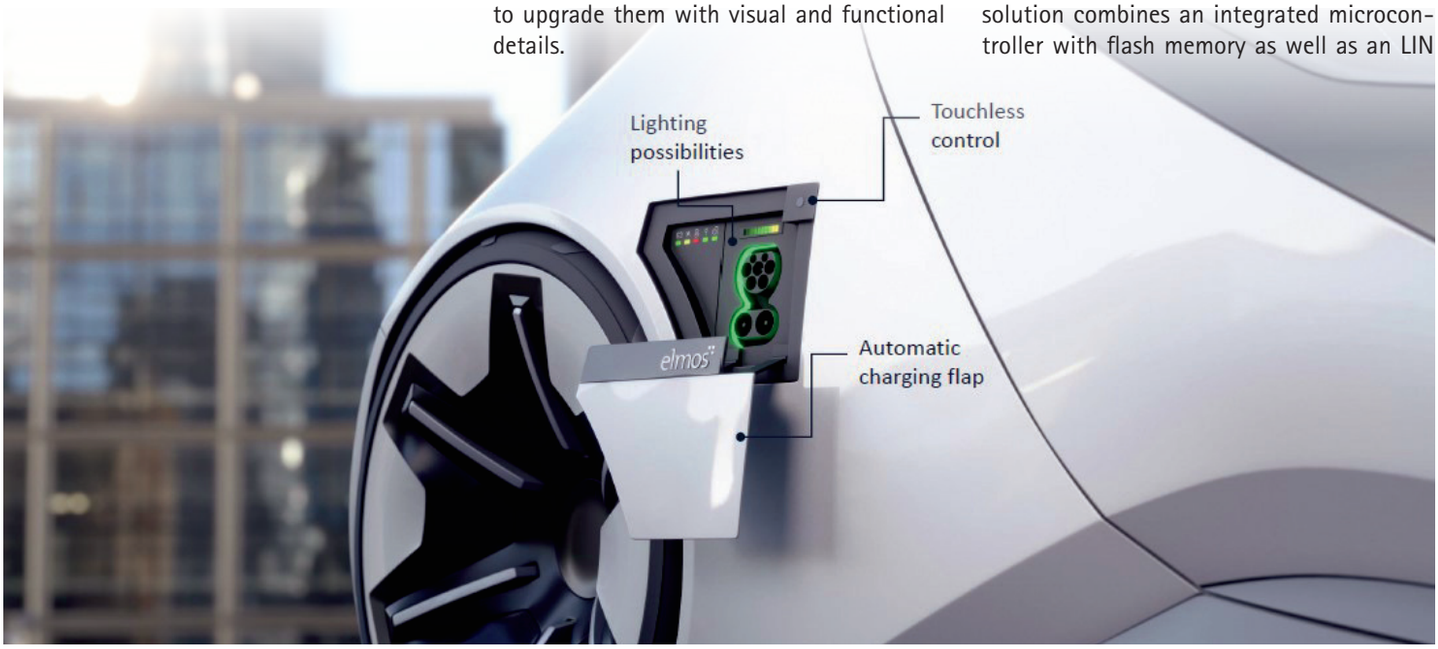
When people think of electric vehicles, they usually imagine a product that incorporates state-of-the-art technology. As such, the charging flap should also live up to these standards. After all, charging is unavoidable and occurs frequently in the everyday lives of electric vehicles. It should not only be safe, but also as convenient as possible.

The charging flap plays a decisive role here, as it initially gets in the way of the charging process. But it is also necessary to protect the charging port from environmental and other external influences and to extend its service life. In addition to the manually operated caps that dominate conventional vehicles, there are more and more electric charging flaps, especially in electric vehicles. Here, it makes sense to upgrade them with visual and functional details.

Lighting improves charging in the dark

When charging at dusk or in the dark, a light source directly at the charging port makes it much easier to insert the charging plug. Energy-efficient LEDs are recommended for this task, as they offer much greater design freedom. For example, the color and shape of the LED display can also be used to show information about the charging process and the battery's state of charge. To implement such functions, LEDs require dedicated IC drivers that control the colors and brightness of the LEDs.

One such driver for RGB and RGBW LEDs is the E521.39 from Elmos (Fig. 1). This one-chip solution combines an integrated microcontroller with flash memory as well as an LIN



Images: Elmos Semiconductors

transceiver and four integrated power sources. The LED driver supports LIN auto-addressing. Each of the four drivers can drive external loads with a current of up to 60 mA. This means that the E521.39 currently offers the highest output current per channel on the market. A pulse width modulation (PWM) generator with a resolution of 16 bit is available for each channel. The PWM duty cycle can be set individually for each output via the LIN interface. Temperature and voltage compensation ensures that the set color of the RGB LEDs is maintained. Equipped in this way, the E521.39 enables stable output colors in all weather conditions as well as varying colors depending on the vehicle's state of charge.

When in sleep mode, drivers typically use 15–30 µA of power across the entire temperature range. For automotive use, the required temperature range of –40°C to +125°C is maintained (AEC-Q100 qualification).

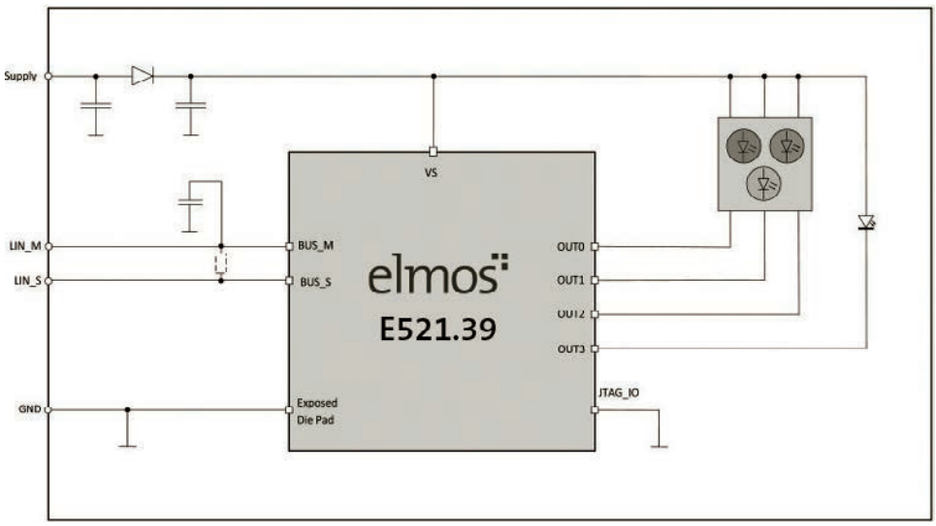


Figure 1: The E521.39 RGBW LED driver from Elmos Semiconductor features an integrated microcontroller and LIN transceiver, four PWM generators, and four current sources, as well as diagnostic capabilities.

Contactless control

Whether they have their hands full or just don't want to get them dirty, contactless opening and closing of the charging flap can be another real USP for the end customer.

The E909.21 controller from Elmos Semiconductor even enables the recognition of various gestures. It is based on Elmos' own proven Halios technology, which achieves reliable object detection by comparing the infrared light beam reflected by the object being detected with a reference light beam. The E909.21 is characterized by its high sensitivity and unbeatable immunity to ambient light of up to 200,000 lux, as well as the protection against rapid changes in ambient light. Moreover, it does not need to be calibrated over the vehicle's entire service life. The Halios frequency is scalable to 1 MHz, thereby eliminating interference with other optical systems (Fig. 2).

The E909.21 can connect two receiver drivers and four LED drivers with 100 mA driver power each, which can also be connected in parallel for higher currents. The integrated 16-bit microcontroller has flash memory, SRAM, High-Speed-I²C, and SPI, and is programmable via two or four-wire JTAG.

With the E909 product family, which includes the E909.21, Elmos Semiconductor also offers scalable products for other HMI concepts. The E909.23, for example, is optimized for gesture control applications with touch displays in vehicles. It is also based on Halios technology, boasting the advantages of high sensitivity, automatic calibration, and immunity to ambient light and rapid changes in brightness.

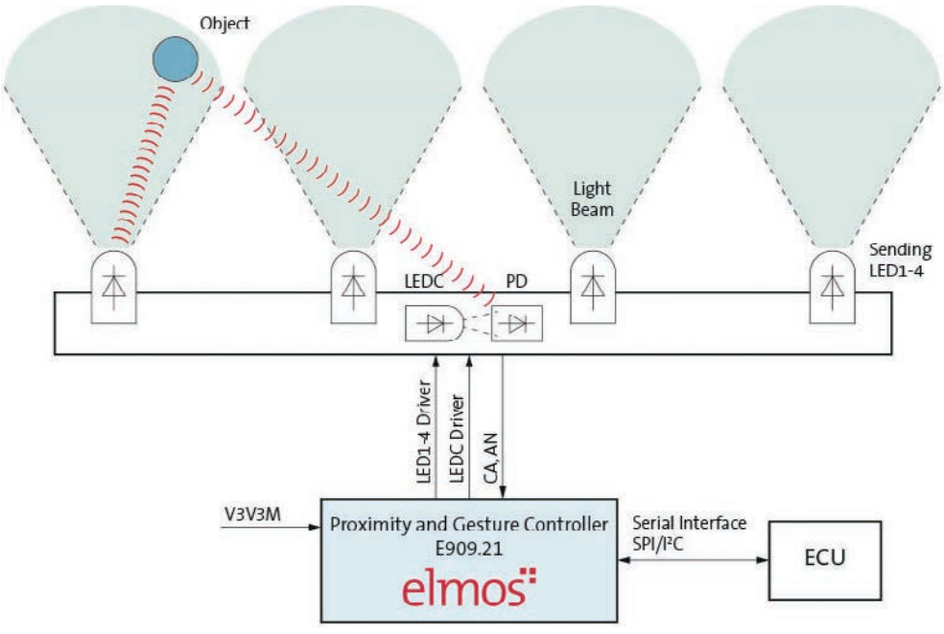


Figure 2: Using Halios technology, the E909.21 controller from Elmos Semiconductor achieves high sensitivity as well as immunity to ambient light and rapid changes in brightness.

Charging flap with actuator

Of course, an actuator is also required for contactless control of the charging flap. Typically, actuators consisting of a motor, a gear, and a corresponding IC driver are used. The IC drivers have the task of flexibly controlling the motor to open and close the flap smoothly. To always be able to determine optimal control of the motor, the position of the flap must also be monitored.

To do so, Elmos Semiconductor also has a cost-optimized chip in its portfolio, the fully integrated system-on-a-chip (SoC) controller E523.63 (Fig. 3). It enables high-precision motor control for drive currents up to 1 A. It is designed to drive a three-phase brushless motor (BLDC), a two-phase stepper motor, or up to two conventional DC motors. For this purpose, it combines a 32-bit Arm Cortex-M23 microcontroller and an analog motor driver in a small TSSOP16-EP package. Its integrated measurement system provides all the input signals for sensorless closed control loop com-

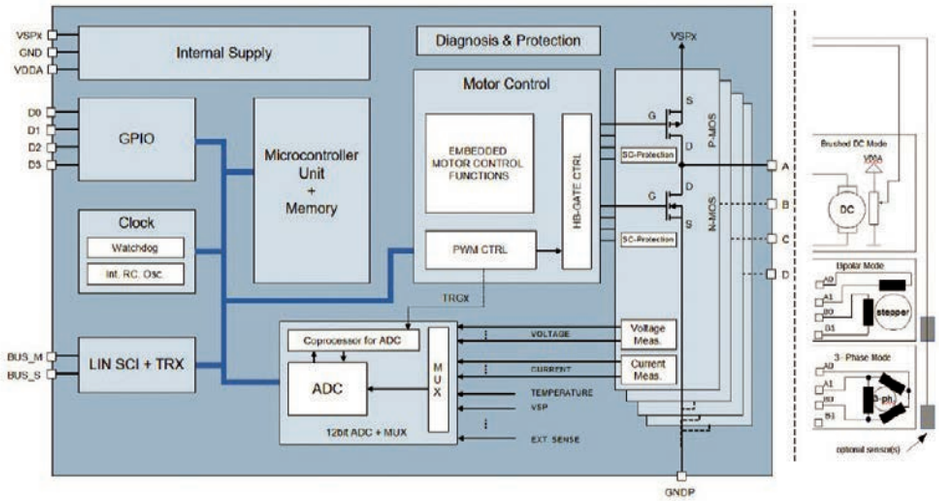


Figure 3: The E523.63 is an all-in-one chip for low to medium power actuator and fan applications.

mutation as well as numerous monitoring and diagnostic functions.

For higher levels of power with drive currents above 1 A, Elmos offers the E533.06. The SoC controller is based on a 32-bit Arm Cortex-M4 microcontroller and combines a 96 kB program memory, state-of-the-art co-processors, and the analog gate drivers in a QFN48 package. The integrated PWM and ADC accelerators improve performance for sensorless single-shunt motor control. This enables advanced control algorithms such as field-oriented control (FOC) with low CPU load. Both the E523.63 and the E533.06 are AEC-Q100 qualified and comply with the ISO 26262 standard (ASIL B). Their broad temperature range extends from –40°C to +150°C.

All the featured ICs can be flexibly adapted to new systems and innovations thanks to the implemented microcontrollers, making them well equipped for future requirements. ■

CO_2 sensor monitors air quality in e-cars

Increasing the efficiency of air conditioning systems

How CO_2 sensors in electric vehicles help maintain healthy air quality inside the vehicle while extending battery life and range.

By Edgar Schäfer,
Field Application Engineer in the Automotive Business Unit (ABU) at Rutronik

Among the biggest challenges facing electric vehicle users are battery life and range. One way to increase both is to improve the efficiency of the entire vehicle. However, there are major consumers in the car standing in the way. One of them is the air conditioning system. The electric powertrain has less power loss than an internal combustion engine and therefore has less waste heat that can be used to heat the interior. This means that in electric vehicles, additional electric heating is required to achieve or maintain the desired temperature.

Ways to create an efficient air conditioning system

One way to increase the efficiency of the air conditioning system is to reuse the air in the interior (recirculation). In the winter, heated air is reheated, while in the summer, conditioned air is recooled and fed back into the interior. Since only a smaller temperature difference needs to be bridged, less energy is required.

Images: Infineon

Figure 1: Infineon's Xensiv PAS CO2 sensor is based on PAS technology.

A major disadvantage of this method is that no fresh air is supplied to the interior. If the used air is not renewed, CO_2 levels increase and the air quality inside the vehicle gradually deteriorates. This may result in headaches, fatigue, and a less-than-ideal driving experience. This represents a potential source of danger in road traffic, as ventilation measures are necessary above CO_2 levels of 1000 ppm.

One solution is to use CO_2 sensors for control purposes. When integrated into the vehicle's air conditioning system, they monitor the air quality inside the vehicle. If CO_2 values are too high, a warning can be output or fresh air can be added directly to maintain healthy air quality.

Choosing the appropriate sensor for electric vehicle applications depends on several factors. These include the size of the vehicle, the desired measurement range, and the type of measurement. Furthermore, the dimensions, performance, and cost of the sensors are crucial.

Small and precise CO_2 sensor

A CO_2 sensor with a particularly small form factor (14 mm × 13.8 mm × 7.5 mm) is the Xensiv PAS from Infineon (Fig. 1). It reduces the space requirement by more than 75 percent compared to commercially available CO_2 sensors.

At the same time, it offers precise CO_2 measurements based on MEMS technology. For example, on a printed circuit board the Xensiv PAS CO_2 sensor integrates a photoacoustic converter, including a detector, an infrared source and an optical filter, a microcontroller for signal processing and algorithms, and a

MOSFET chip to drive the infrared source. The integrated microcontroller performs ppm calculations as well as advanced compensation and configuration algorithms. The result is the true CO_2 content and not just a correlation. In addition, various configuration options (e.g. measurement frequency, baseline calibration) and interfaces (UART, I^2C, PWM interface) are available. The spectrum for the CO_2 measurement covers a range from 0 ppm to 32,000 ppm. The accuracy is ±30 ppm ±3 percent of the read measured value. The supplier guarantees it for the measurement range of 400 to 5000 ppm, which is perfectly adequate for this range of applications. This is because a typical atmosphere has a CO_2 content of 400 ppm; the value inside the vehicle is typically higher.

Figure 2: PSoC 4100S Max microcontroller for data evaluation

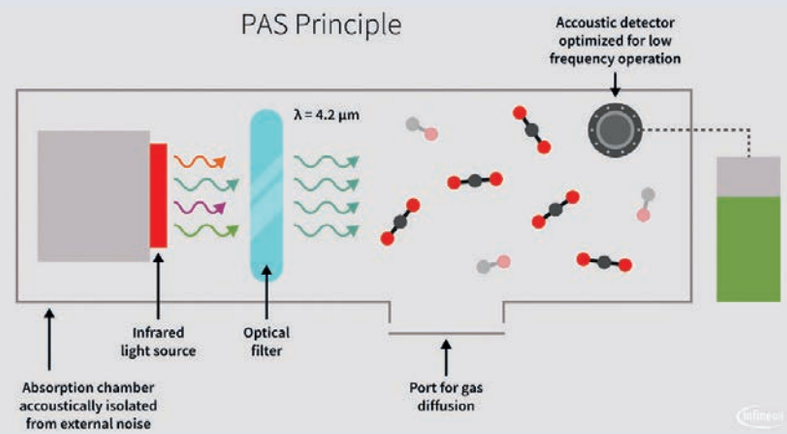
Further advantages for customers are to be found in the production process. Infineon claims to offer the first SMD-capable CO_2 sensor (SMD package, available on tape & reel) to comply with the international JEDEC standard for lead-free surface-mount reflow – for easy assembly as well as system integration even at high production volumes.

The Xensiv PAS CO_2 sensor also offers a high degree of flexibility thanks to a wide range of configuration options, enabling a fast time to market. An evaluation kit consisting of the Xensiv PAS and a microcontroller of the PSoC-4100S family for data evaluation are also available.

The features and capabilities of the Xensiv PAS make the sensor the ideal choice for intelligent control of air conditioning systems in e-cars. On the one hand, it ensures optimum air quality, contributing to passenger safety. On the other hand, it increases efficiency for improved battery life and range. ■

Photoacoustic spectroscopy (PAS)

The PAS method is based on the photoacoustic effect (Figure): Gas molecules absorb light of a certain wavelength, causing them to expand. In the case of carbon dioxide, it is the 4.2 µm wavelength. Light pulses are emitted in rapid succession by an infrared source. Only light with a 4.2 µm wavelength enters the sensor chamber via an optical filter that is specially adapted to CO_2 molecules. The CO_2 molecules in the sensor chamber absorb the energy. Rapid heating and cooling causes thermal expansion and contraction. This produces a change in pressure, which is detected by the highly sensitive MEMS detector. The higher the CO_2 concentration in the chamber, the stronger the signal. The signal is processed by an integrated microcontroller, which outputs the result in real time as ppm (parts per million). For the most accurate results, the acoustic detector is optimized for low frequencies and the absorption chamber is acoustically shielded from external noises.



Photoacoustic spectroscopy to determine the concentration of CO_2

Reference designs for 48 V low-speed electric vehicles

Micromobility is picking up speed

Many countries have committed to meeting climate targets. To achieve them, it is also important to make transportation in cities emission free. In addition to the electrification of passenger cars, low-speed electric vehicles can also make a significant contribution.

By Salvatore Potestia, Business Development Manager, and Ralf Hickl, Product Sales Manager in the Automotive Business Unit (ABU), both at Rutronik

Low-speed electric vehicles (LSEVs) are ideal for covering short distances in urban areas. In addition, stricter environmental protection requirements in more and more cities, for example in the form of restricted traffic zones, are likely to give these vehicles a considerable boost. For example, P&S Intelligence predicts that the global LSEV market will grow from $35.2 billion in 2017 $68 billion by 2025. Countries with large populations and many densely populated areas, such as China and India, will account for the largest share. Accordingly, the production of low-speed electric vehicles, for example in China, is also increasing: Research In China forecasts an increase of 15 million vehicles between 2021 and 2025.

Image: Scharfsinn/Shutterstock

To meet the increasing demand, the production of low-speed electric vehicles in China will increase significantly in the next few years.

Diversity of micromobility

Low-speed electric vehicles, which are also included under "micromobility", include a wide variety of vehicles. They can be used as commercial vehicles or for passenger transport in urban areas. Since they are below the passenger car class, the requirements regarding type approval differ significantly from those for traditional passenger cars.

One type of LSEV, for example, is a two-wheeled vehicle. These include e-scooters, e-bikes, and pedelecs, including two-, three-, and four-wheeled cargo bikes. The latter are particularly popular with service providers, such as couriers and delivery services, as well as families, as they allow fast movement in densely populated city centers and offer a certain amount of storage space.

Three-wheeled vehicles include motorcycles with sidecars for private use and small passenger cars, such as the Piaggio Ape. They are suitable for passenger transport, for example in the tourism sector, and are also used by postal services.

Four-wheeled models range from e-quads to small e-cars, such as the Renault Twizy, and small e-vans. Depending on their actual size and design, they are used for a variety of commercial and personal transportation applications.

Performance, speed, and range of small LSEVs

Depending on their vehicle class, low-speed electric vehicles can achieve a range of speeds and power ratings. Micromobiles and low-speed two-wheeled vehicles can reach top

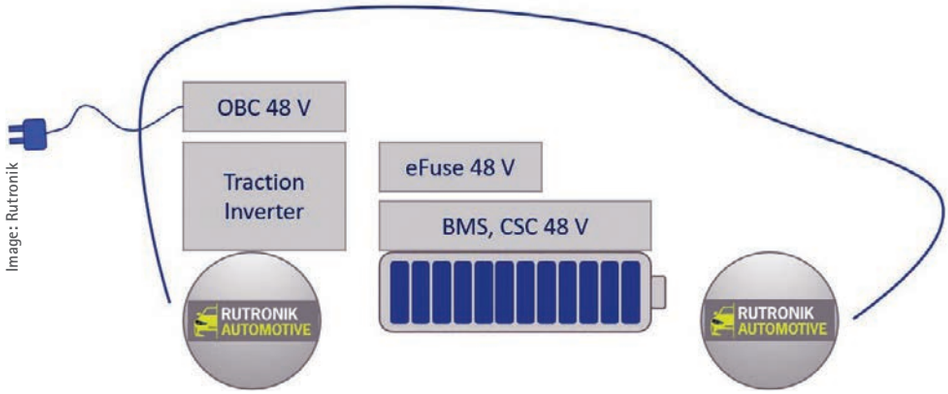


Image: Rutronik

The electronic power applications in an LSEV

speeds of 25 km/h. They typically have a rated power of 1 kW. The larger two and three-wheeled types generally have a maximum power rating of 4 kW and travel at up to 45 km/h. Low-speed four-wheeled vehicles also travel at this maximum speed; their rated power, however, can be as high as 6 kW. Heavy four-wheeled models, on the other hand, can reach top speeds of 90 km/h with a rated power of 15 kW. The range of low-speed electric vehicles varies depending on their power output; many can travel around 150 km on a single battery charge.

Reference designs for applications in low-speed electric vehicles

For these reasons, Rutronik's Automotive Business Unit (ABU) also sees great potential in low-speed electric vehicles. Following the successful reference design for a bidirectional HV switch for 800 V DC and 50 A, Rutronik is now working closely with Vishay to develop sample applications for low-speed electric vehicles with a 48 V electrical system. These are the on-board charger (OBC) for the 48 V battery system and the traction inverter. The designs focus on converter efficiency, compact design with low installation height, and automotive-grade quality. Integrated in a show car, it was first unveiled at electronica India in September 2023.

The on-board charger

The OBC provides a maximum charging power of 3.6 kW. Its key components are the new VS-ENM040M60P power modules, optimized power factor correction (PFC) coils, and a pulse transformer developed specifically for this application. A power module integrates a semi-controlled input rectifier, a diode and a MOSFET for power factor correction, and a half-bridge for the pulse transformer. The package used is Vishay's EMIPAK-1B. It enables higher power densities than a structure with discrete semiconductors and its press-fit contacts ensure fast assembly with secure connections to a PCB.

The passive components also play an important role, as their properties are a key factor in determining the efficiency of the circuitry. An integrated LLC transformer, such as the MTBB133971 from Vishay Custom Magnetics, is used as the pulse transformer. The resonant inductors are already incorporated.

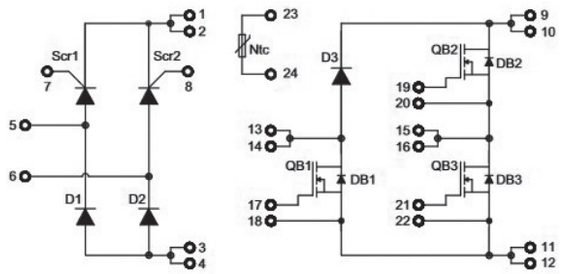


Image: Vishay

The components in Vishay's VS-ENM040M60P power module

The traction inverter

The traction inverter has a rated power of 15 kW with a short-term peak power of 25 kW. Vishay's N-channel automotive trenchFETs in the PowerPAK 8x8L Reverse package are used as power semiconductors. The top-side cooled package allows them to be thermally coupled directly to a heat sink rather than being cooled by the PCB. This reduces thermal resistance and improves heat dissipation.

Summary

The new reference designs for low-speed electric vehicles provide hardware developers with design templates that can significantly reduce the time-to-market of their own circuit designs. By using the latest high-performance components, the circuitry achieves high power density at low cost. ■

At a glance

Advantages of LSEVs

For developers/suppliers

- Less stringent safety regulations
- Lower cost of motor and electronic components compared to 400-V and 800-V vehicles
- Higher reliability of components compared to 400-V and 800-V vehicles
- No high voltage risks

For users

- Easy charging at standard sockets
- Convenient for short trips in urban areas
- Require little parking space
- Climate-friendly driving
- Permitted in some environmental protection zones

Rutronik System Solutions

The distributor as a development and research laboratory

While Rutronik is celebrating its 50th anniversary, Rutronik System Solutions is turning two. This relatively young segment allows the distributor to embark on a completely new path. Stephan Menze, Head of Global Innovation Management, and Andreas Mangler, Director Strategic Marketing and authorized signatory at Rutronik, explain how far Rutronik has already come and where it is heading.

What makes Rutronik System Solutions something completely new for Rutronik?
Stephan Menze: We are at home in classic component sales. This means that everything – from the actual product, sales, and support to logistics processes – is carried out at product level. With Rutronik System Solutions, we can now operate at system and/or solution level; in other words, far beyond the products. In some cases, this has fundamental implications.

Can you give us an example?
Menze: It starts with the fact that we develop boards and highly innovative solutions ourselves. This means unconventional development and research work, not only for Rutronik but for the entire distribution sector. When the systems are ready for sale, the process is usually the other way around: It often does not begin with a customer inquiry; instead, we typically initiate contact with the customer and present our solutions. That is the reason why we have not only done an incredible amount of development work over the past two years, but also set up new structures and processes. When I joined Rutronik back in 2015, it was still a completely different world. For our sales colleagues, this all means new tasks associated with complex systems that require a great deal of explanation. Internal communication and training sessions are therefore extremely important. We are currently in the process of gradually equipping all our sales offices with cases containing our entire board portfolio and training the sales teams accordingly. This process commenced in the DACH region, with a gradual expansion to other European countries, Asia, and the USA to follow. We have also developed an internal smartphone app that enables us to demonstrate our solutions in action to customers on site, for example using live measurements.

What has been the feedback from customers so far?
Menze: From most customers – but also from suppliers to whom we present our developments – you hear things like: "Nobody else does it this intensively." Developing something based on supplier boards is not unusual in the world of distribution, but creating your very own solutions definitely is. The positive feedback shows that we have chosen the right path. Infineon is so convinced of our boards that they have integrated them into their development software. This means that customers can select the Rutronik boards and our sample software directly in the Infineon development software. Normally, it is the other way around, with the Infineon products being available from Rutronik. So, in this case, the supplier has clearly recognized the added value of our solutions.

And what is that added value?
Menze: First and foremost, a significantly shorter time to market and a much lower investment in pre-development on the part of the customer. After all, Rutronik has already done most of the development work. How far this goes depends on whether the solution is at design level, advanced design level, or research level. Especially at the upper levels, our goal is to create solutions that help solve real pain points for our customers.

Andreas Mangler: The special thing about this is that we always think from the end customer's perspective, i.e. from the point of view of our customers' customers. By taking this next step in the value chain, our customers – OEMs and branded companies – also appreciate great added value for themselves. Our research-level developments are next-level, high-tech products that amaze even our contacts at large companies.

Can you give us some examples of these solutions?
Menze: There is HESS, for example, our hybrid energy storage system, or the electronic nose, which uses AI to detect specific substances. For example, we can use it to distinguish between different types of coffee.

What stage are these projects currently at?
Mangler: We have already patented them, and prototypes of both are now available and already being evaluated by very large, well-known pilot customers. After years of development work, this is a huge milestone. Even if not every pilot customer actually implements a project straight away, I am sure we will be talking about some specific details in a year or two.

What happens if a customer wants to implement the project?
Menze: To use Rutronik's patents, they must contractually commit to purchasing the board's key components exclusively from Rutronik for a certain period of time. This gives the customer access to our core know-how and the freedom to use our patented technology; we also support them when it comes to implementing their specific application. This support goes far beyond the products, and customers also benefit from the experience that our team has already gained during development.

Stephan Menze

“Developing something based on supplier boards is not unusual in the world of distribution, but creating your very own solutions definitely is. The positive feedback shows that we have chosen the right path.”

Is that the end of the research work for now?

Mangler: No, we are simultaneously pushing ahead with several projects. In the case of the wasp scare, for example, the laboratory tests at our partner universities did not deliver the desired results, prompting us to return the project to internal research and pre-development. Our goal is to bring all Level 4 projects to the point where we can offer our customers real added value. That is not always the case in the research field in which we work here.

Andreas Mangler

“We bridge the gap between research and industry. And although the result is next-level, high-tech solutions are created in the process, they are not boards full of “golden screws”. Instead, we deliberately use immediately available components from our franchise partners.”

What does that mean, "return the project to internal research"?
Mangler: We have been working very closely with universities and research institutions for a number of years now. As a result, we have good connections to top experts in various fields, with whom we exchange ideas at the highest level. Our task is, on the one hand, to pass on the industry's requirements profile to research to ensure the solutions created give companies a real competitive edge on the market. On the other hand, we translate research know-how into what is technically feasible. In other words, we bridge the gap between research and industry. And although the result is next-level, high-tech solutions, they are not boards full of "golden screws". Instead, we deliberately use immediately available components from our franchise partners.

What is happening at the other levels of Rutronik System Solutions?
Menze: At Level 3, we have our base boards. We released RDK2 in 2022, and RDK3 and RDK4 in 2023. Meaning we have also taken a big step forward here, too, and completed our portfolio for the time being. At the moment, we are concentrating on Level 2, which means we are combining suppliers' boards with our own and thus constructing specific sample applications.

What kind of applications?
Menze: One example is distance measurement. To do so, we connect a radar module from Infineon or Nisshinbo, a time-of-flight sensor from ams Osram or – for the simplest kind of presence detection – an infrared sensor from Vishay to our base boards. This allows the customer to immediately test several solutions that differ in terms of precision and price – and without any hassle with the development environment. If the supplier board has an Arduino interface, which we also use for the RDKs, it can simply be plugged onto the RDK2, 3, or 4. The customer also receives the development software from Rutronik. So we are gradually creating more and more specific use cases based on our boards, for which we also develop the corresponding user guides, app notes, and so on.

So the RDKs are technically interchangeable. What makes them different?
Menze: Exactly – we have intentionally designed the base boards without specific use cases in mind, thus ensuring their versatility and broad application. The difference is mainly found in the microcontroller and the interfaces. As a result, each board is geared to a specific market: The RDK2 is for industrial IoT or industrial robotics. The RDK3 has a microcontroller with security features and Bluetooth low-energy function. Further, it is much smaller and more compact than the RDK2. This makes it ideal for IoT wireless devices, for example for smart buildings, but also for healthcare scenarios, where security plays a role. The RDK4 is aimed at the automotive market, as it has an automotive-qualified microcontroller and corresponding interfaces. It also has the exact features that developers need to design small motor control units for vehicles.

Rutronik effectively relieves its customers of the burden of development and, in some cases, research work, off its customers shoulders. That requires an immense upfront investment.
Mangler: That is true. But we are convinced that we have chosen the right path. Since the market is demanding more and more system solutions and Rutronik will be able to offer more of these in the future. This clearly sets us apart in the distribution landscape. We have already talked about the fact that this has been very positively received by customers and suppliers. In the meantime, we now also have a fixed research budget. The Rutronik Executive Management is, therefore, fully behind these activities. We take great pride in our unprecedented achievements within the traditional component distribution sector.

Menze: This also applies to the entire Rutronik Systems Solutions segment. Two years ago, we started out with two people, and now there are six of us. This not only gives us more time resources, but also a strong team with outstanding expertise in various disciplines. This takes our work to a new level. We can drive developments forward much faster and the learning curve just gets steeper. The dynamics behind this are really fun!

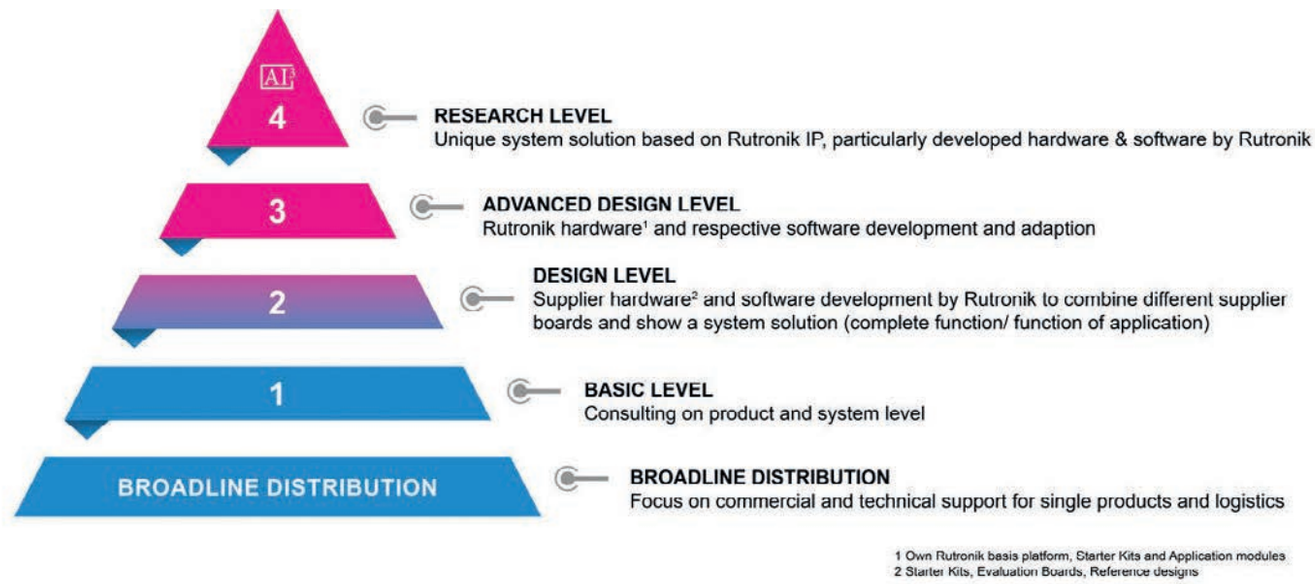


Image: Rutronik

Rutronik System Solutions comprises four levels, ranging from the foundation at product level to the top with self-developed, patented systems.

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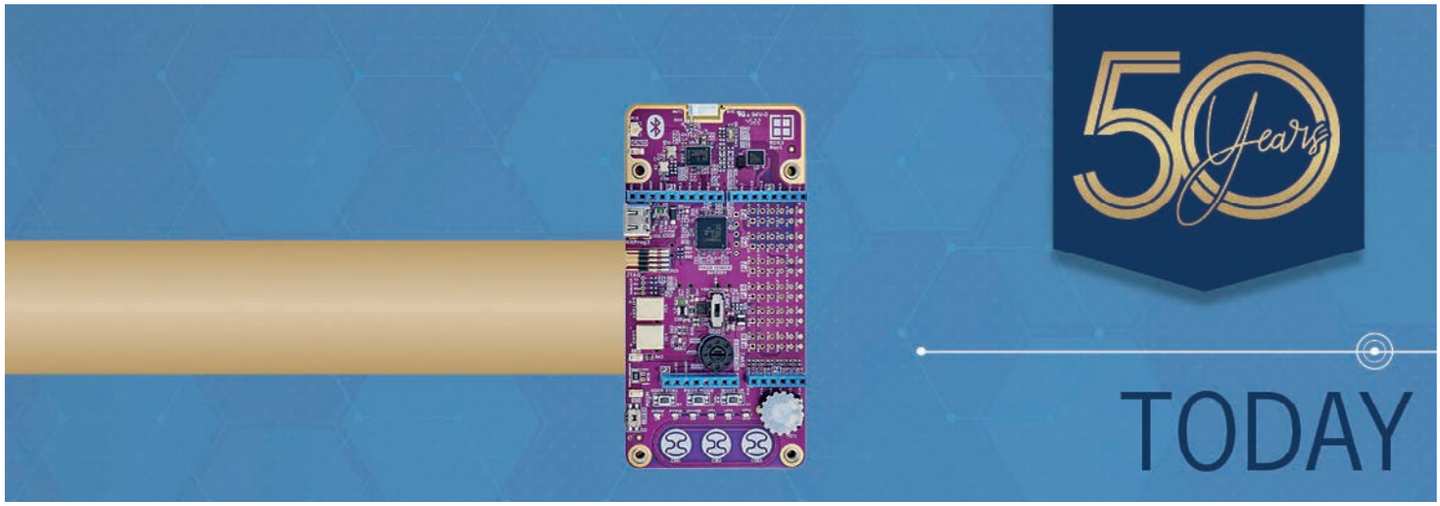
The 2020s

From components to systems



Artificial intelligence and Rutronik System Solutions are the current developments that the distributor is actively pursuing – according to the motto "everything from a single source".

In late 2022, OpenAI introduced ChatGPT, showcasing the rapid advancement and widespread adoption of artificial intelligence (AI) applications. At the same time, pictures of Angela Merkel and Barack Obama enjoying a day on the beach together generated widespread discussion about the possibilities and limitations of AI. In industry, it is being used in less headline-grabbing but no less impressive ways, for example for quality control and predictive maintenance, in construction, for demand forecasting, and in robotics.

The basis: Big Data. For AI applications to make predictions or recognize images, powerful microprocessors must be able to process immense amounts of data. The data often come from sensors and are sent to other systems via communication or wireless technologies. Since real-time data processing is often required in industry, edge computing, i.e. the integration of processing power at the periphery of the network, and (industrial) Ethernet are gaining popularity. Read from page 82 how storage suppliers are responding to increasing data volumes.

The electronics industry at the start of the 2020s was also defined by a shortage of semiconductors and supply bottlenecks for many other components as well. To find out how the current situation is changing things and what else we can expect, read the interview on page 55.

Rutronik System Solutions:
Added value for the entire value chain

Rutronik has been breaking new ground with "Rutronik System Solutions" since 2021: An in-house team develops – also in cooperation with universities, higher education institutions, and research institutes – highly innovative system solutions, some of which are patented. Read why Rutronik is developing them and what future initiatives are in store on page 74.

The interim conclusion after 50 years: More than 1,900 employees generated sales of €1.28 billion in the 2022 business year and served more than 40,000 customers. With more than 80 branches worldwide and logistics centers at its headquarters in Ispringen, Austin (Texas), Hong Kong and Shanghai (China), and Singapore and a comprehensive linecard with products from 150 suppliers, Rutronik is well positioned for future growth.

Would you like to learn more about Rutronik System Solutions and the boards? Find more information at: www.rutronik.com/innovations

Embedded designs – made in Europe

Advantages through proximity

Events such as the war in Ukraine, extreme weather conditions, and COVID-19 have shown how fragile global supply chains can be – and increasingly are. This makes systems and components from Europe all the more important.

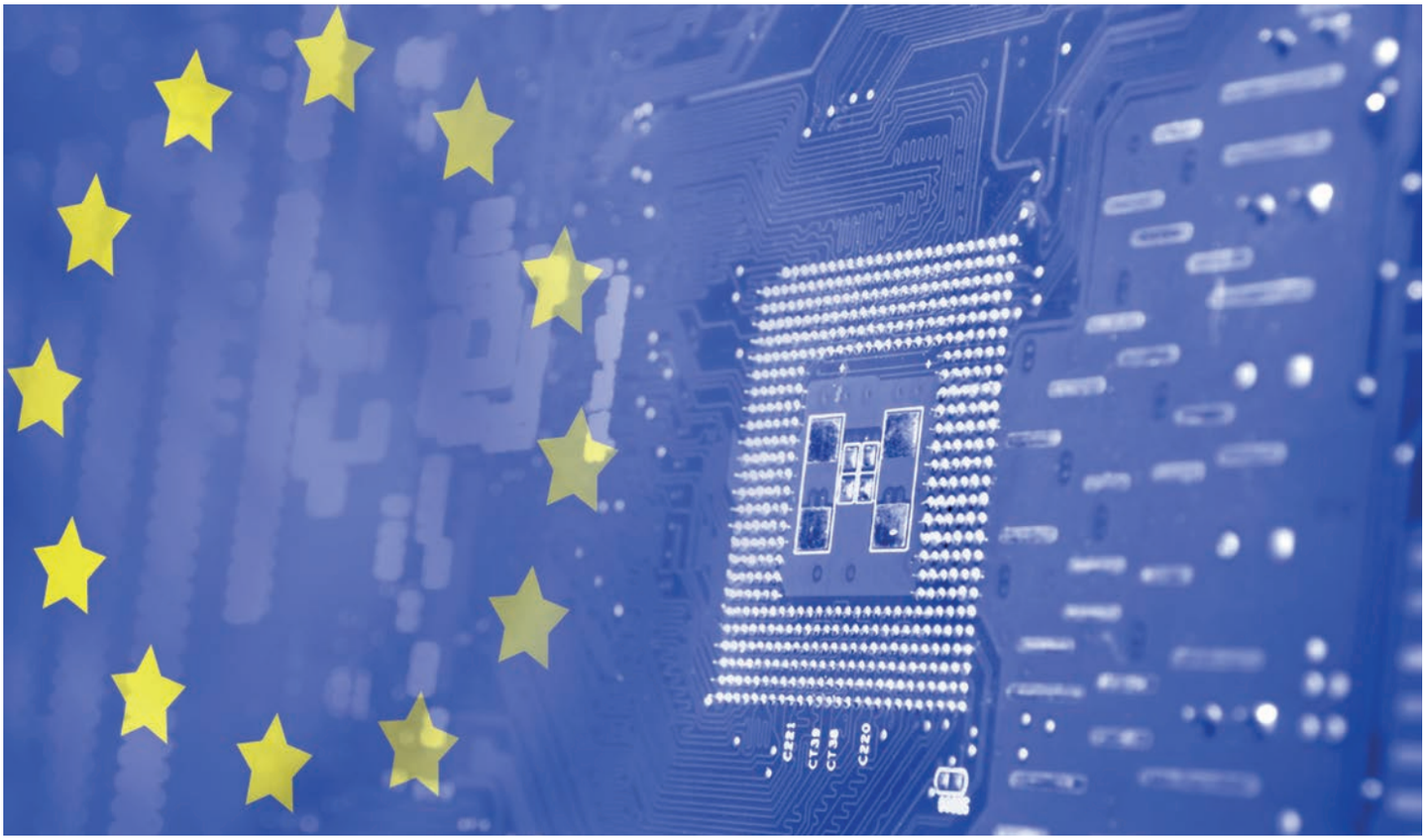


Image: Popel Arseniy/Shutterstock

By Johannes Gasde,
Corporate Product Manager
Embedded & Wireless at Rutronik

Companies utilizing European components in their embedded designs often enjoy greater resilience compared to those dependent on suppliers from the USA or the Far East. This is not only due to shorter transport routes, reliable political systems, and the often-preferred supply of customers on the same continent. Proximity and thus usually better communication between component or system providers, distributors, EMS, and companies also often make the decisive difference. Especially in times of higher volatility, it is indispensable to coordinate requirements, capacities, and delivery capabilities in the best possible way. With boards, numerous modules and systems, processors, flash memories and DRAM modules, as well as accessories, Rutronik has everything needed to create embedded designs. For the majority of components – with the exception of only the CPU – the linecard also includes an established supplier based and with production facilities in Europe. Reason enough to introduce them here.

Motherboards from Kontron

Kontron develops and produces a comprehensive portfolio of high-quality, durable, and competitive motherboards in Germany. They support the latest processors and platform chipsets and are available in Mini-STX, Mini-ITX, µATX, and ATX form factors. With their

Image: Swissbit

State-of-the-art production by Swissbit in Berlin

design for 24/7 continuous operation, a wide temperature range of 0°C to 60°C, and availability of up to seven years after market launch, they are suitable for a broad range of even demanding applications, from industrial automation, POS/POI and kiosk applications, digital signage, and casino gaming to medicine, video surveillance, and transportation. Rutronik, together with its franchise partner Kontron, also supports its customers with accessories such as package kits or add-on cards, as well as valuable services like detailed documentation, professional life-cycle management, and customization tools.

Computer-on-modules and SBCs from Seco

Seco combines all the processes and services required for the production of boards and electronic systems for various application areas at locations in Italy and Germany. Production at its roughly 9,000 m² headquarters in Arezzo (Italy) is focused on both energy efficiency and innovation. In Hamburg, production, development, administration, sales, and marketing are located at the company's approx. 8,000 m² plant. At its third large location in Wuppertal, close proximity between development and production enables rapid and straightforward implementation of prototypes, pre-series products, and small series. Seco's production installations are equipped with machines for SMT and THT PCB assembly as well as stations for washing, conformal coating, depaneling, and BGA rework. Critical processes in the production of electronic components can thus be comprehensively monitored by the supplier, who can respond quickly and effectively in the event of problems.

Modules and SBCs from F&S Elektronik Systeme

Founded as an engineering company in 1990, F&S Elektronik Systeme started producing its own modules in 1998. To date, every single module is produced in Stuttgart-Vaihingen on cutting-edge manufacturing equipment, functionally tested, and subjected to strict quality and compliance testing (ISO 9001, ISO 13485). In addition, the systems are characterized by scalable processing power and long-term availability of up to 15 years. Over 20 hardware and software developers provide fast and qualified support.

IT assembly in Germany by Extra Computer

With its own brands exone, Calmo, and Pokini, Extra Computer covers the entire field of computer systems: embedded box PCs, panel PCs, 19" industrial servers, boxed IPCs, and notebooks. At its main location in Giengen-Sachsenhausen, IT hardware is assembled by hand and on state-of-the-art production lines. The certified quality (EN ISO 9001) of the production and sales processes as well as comprehensive quality controls for each individual system guarantee a consistent design and the outstanding value of all the systems.

Storage and security components from Swissbit

The supplier of storage, security, and embedded IoT components, headquartered in Switzerland, manufactures up to three million items per month at its production facility in Berlin, which the company put into operation at the end of 2019. Roughly 2,600 m² of space is available here for chip-on-board (COB) and surface-mount device (SMD) production.

Swissbit's industrial memory and security products are characterized by long-term

Image: Wilk Elektronik

Wilk Elektronik manufactures the Goodram Industrial brand DRAM modules in southern Poland.

availability and high reliability. They are thus also suitable for demanding applications in the industry, NetCom, automotive, medicine, fiscal, and IoT sectors. Customers also receive appropriately optimized products for specific requirements.

Memories from Goodram Industrial

Goodram Industrial is a brand of the Polish supplier Wilk Elektronik. It offers memory cards, USB flash drives, SSDs, and memory modules for use in industrial applications that often operate in extremely harsh conditions. In-house development, a production line in Poland, which was put into operation in 2003, 30 years of market and production experience, and advanced quality control procedures (ISO 9001 quality management system certification for the production and sales of DRAM modules and flash memories) ensure innovative and high-quality products that Wilk also adapts to specific customer requirements.

Among other services, technical support includes the long-term availability of components, functional and environmental diagnostics, and individual training and consulting.

Other suppliers for accessory products

Rutronik also collaborates with other European-based suppliers who specialize in accessory products. This means that embedded designs can also be implemented with cooling technology (EKL, HSM Zamecki), packages (Emko), and power supplies (Recom) "Made in Europe".

Supply and support by Rutronik

Rutronik maintains good working relationships with all suppliers, which have grown over many years through personal contacts and joint technical support. In addition to ensuring on-demand supplies, Rutronik's technical experts in the Embedded & Wireless segment enhance the supplier service by conducting their own validated memory tests (MemTest86) for various motherboard-memory combinations. This means that customers can rely on their functionality. There are so many good reasons to choose "Made in Europe". ■

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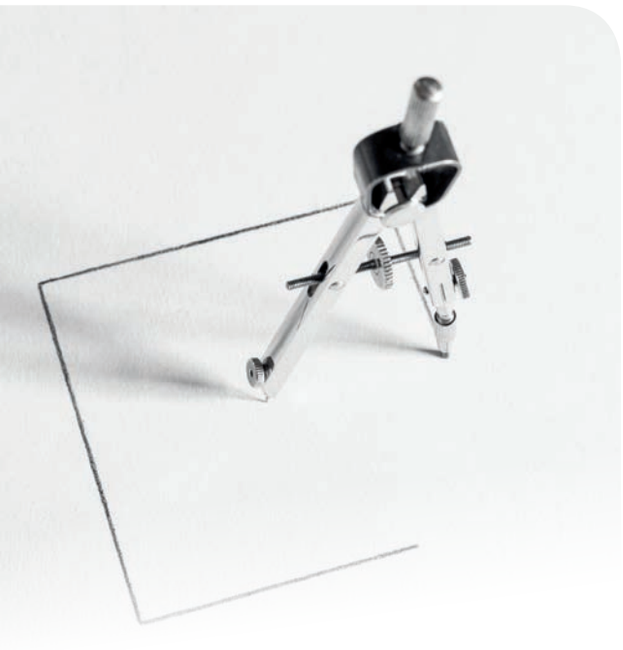
Pseudo-SLC combines advantages of SLC and TLC/MLC

Squaring the circle

The task of combining longevity and high performance with low costs is like squaring the circle. But this is exactly what pseudo-SLC technology makes possible in flash memories.



By Richard Klauser,
Corporate Product Sales Manager
Boards & Storage at Rutronik

Data volumes are growing exponentially in almost all sectors – and with them the demand for storage capacity. Single-level cell (SLC) flash memories are known to offer greater reliability, faster read and write speeds, and longer service life than other memory technologies. However, SLC memories are expensive and have low storage density, making them less suitable for applications that require higher storage capacities.

Multi-level cell (MLC) or triple-level cell (TLC) flash memories, on the other hand, offer high storage density at a lower cost. However, due to their limited durability, they are not suitable for all memory-intensive applications. Pseudo-SLC bridges this gap between the high performance and durability of SLC flash memories and the high density and low cost of MLC/TLC memories.

Higher memory density and durability at a lower cost per gigabyte

To achieve higher memory density and durability at a lower cost, pSLC technology, also known as emulated SLC or quasi-SLC, uses special programming algorithms and voltage levels. These modify the behavior of MLC or TLC flash memories to mimic the characteristics of SLC memories, such as more write/erase cycles, lower error rates, and faster access times. This results in higher reliability and durability without sacrificing memory density.

The table compares the P/E cycle (program/erase), W/R speed (write/read), and price per Gigabyte parameters of various NAND flash technologies for industrial applications.

Switching from TLC to pSLC is about three times more expensive for the same memory capacity, since three times the amount of flash memory is required. This makes pSLC significantly less expensive than comparable SLC memories, which are typically used for write-intensive applications and adverse environmental conditions: They cost about ten times as much as TLC memories. pSLC is thus an attractive alternative and the optimal compromise between low-cost TLC and expensive SLC memories, combining longer service life, excellent performance, and temperature insensitivity at a fraction of the cost of true SLC NAND.

This makes pSLC technology a promising option to meet the changing demands of modern storage systems. It is used in many areas where balancing performance and cost efficiency are essential, such as embedded systems, industrial automation, the automotive industry, and enterprise data storage.

With suppliers like Apacer, Swissbit, and Transcend in its portfolio, Rutronik offers pSLC products in all common form factors: SD/microSD cards, Compact Flash/CFast/CFExpress cards, SATA-SSD 2.5/mSATA- SSD/M.2-SATA-SSD (2230/2242/2280)/Slim SATA-SSD, M.2-PCIe-SSD (2230/2242/2280), USB flash drives, embedded USB modules, embedded MMC, BGA-PCIe-SSD. ■

NAND flash technologies in comparison
(source: Rutronik)

Industrial NAND Flash Type	Feature	P/E Cycle	W/R Speed	Price per GB
SLC	Single-Level Cell	Up to 60,000	++++	+
pSLC	Pseudo-SLC	Up to 100,000	+++	++
MLC	Multi-Level Cell	3,000	++	+++
TLC	Tri-Level Cell	3,000	+	++++

Image: Andreas Gruhl/stock.adobe.com

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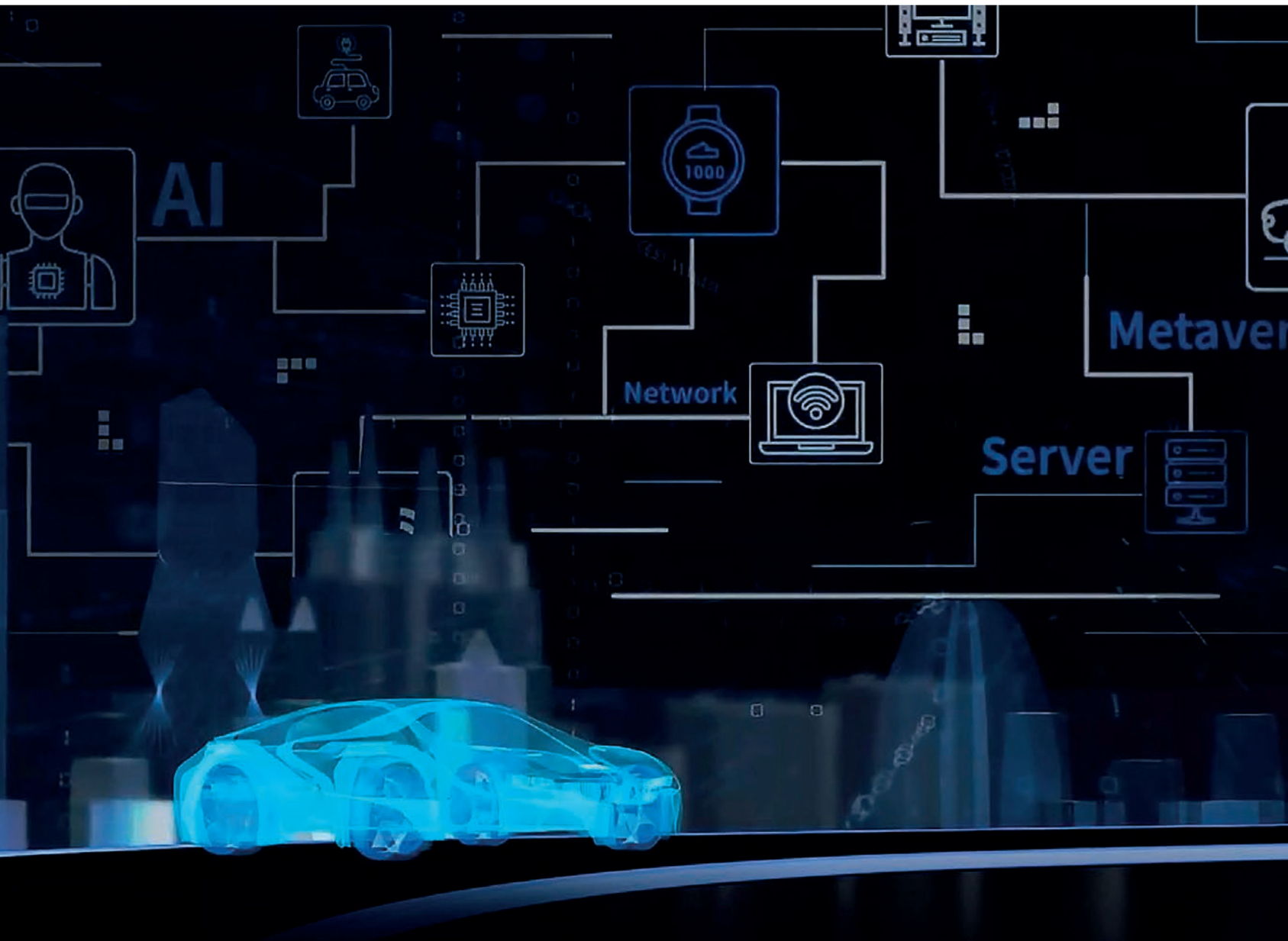

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