IMPROVE ELECTRIC DRIVE CONTROL & EFFICIENCY WITH ADAPTIVE COMPUTING

OPTIMIZE MOTOR PERFORMANCE AND USE LESS POWER WITH ADVANCED DRIVE CONTROL TECHNIQUES

AMD

together we advance_

Executive Summary

Electric motors are everywhere: in elevators, escalators, robotics drives/actuators, electric vehicles, trains, medical equipment, aerial systems, home appliances (like washing machines and garage door openers), and much more.

Many factories have hundreds of motors powering robotics that drive assembly lines and other equipment. It is estimated that around 70%[1] of the total global electrical use by the industrial sector is tied to electric motors and motor-driven systems. If you increase the efficiency of your drives by even just 1%, it can have a significant positive impact on operational expenses and the environment.

Reducing power consumption, mitigating motor noise, avoiding vibration, predicting the right maintenance time and detecting potential failures before they happen, are paramount, and you can employ over-the-air updates for a longer service life with every motor.

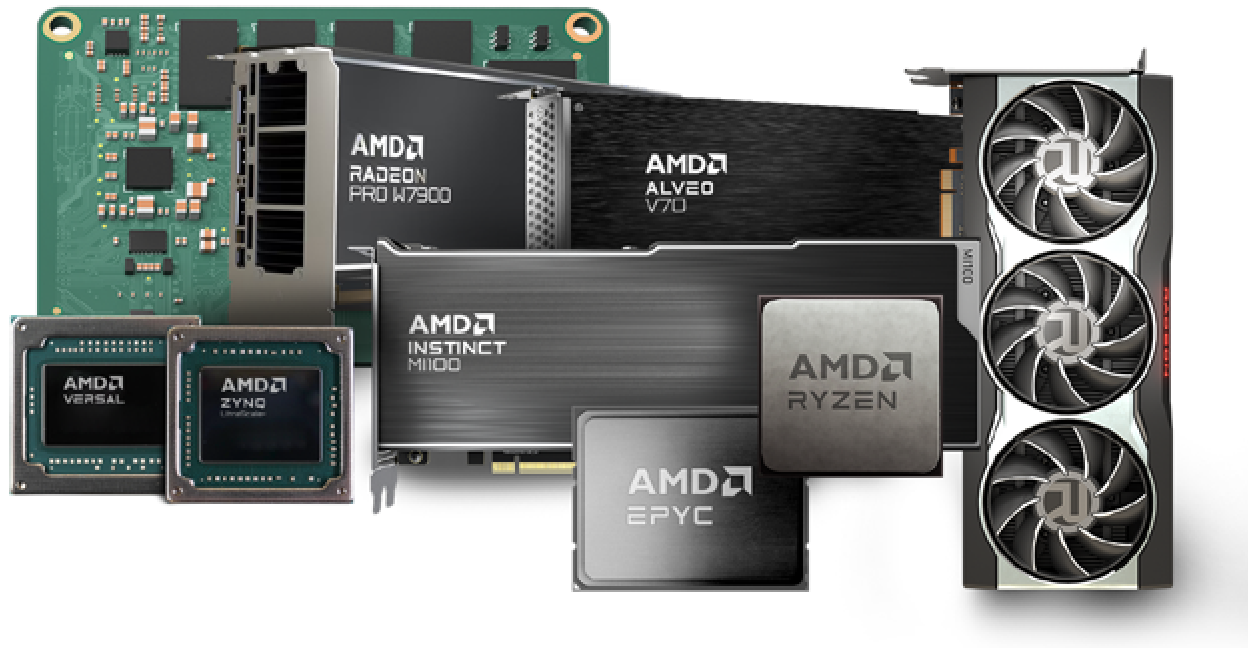
Kria™ system-on-modules (SOMs) from AMD play an important role in electric drive control. They can optimize performance, help motors run more efficiently, and provide better scalability and reliability. Adaptive motor control solutions can also enable higher levels of integration, which reduces component count and cost.

In this eBook, you'll learn about the evolution of electric motors and the performance parameters that can be addressed with motor control. We'll also introduce you to the concept of motor control and the different ways that it can be implemented. Additionally, we'll explore the use of motor control techniques for efficient vehicle charging. Finally, we'll introduce you to some cutting-edge technology from AMD and show you how some of our customers are using this technology for a variety of motor control applications.

Who We Are

AMD IS A GLOBAL SEMICONDUCTOR COMPANY THAT DESIGNS AND DELIVERS PRODUCTS FOR FOUR PRIMARY MARKET AREAS:

- Industrial, vision, healthcare, and other embedded markets, which primarily include embedded microprocessors, FPGAs, and adaptive SoC products.
- Data Center, which primarily includes server microprocessors, GPUs, DPUs, FPGAs and adaptive SoCs for data centers;
- Client, which primarily includes microprocessors, accelerated processing units that integrate microprocessors and graphics, and chipsets for desktop and notebook personal computers;
- Gaming, which primarily includes discrete GPUs, semi-custom SoC products and development services.



For more than 50 years AMD has driven innovation in high-performance computing, graphics and visualization technologies. AMD employees are focused on building leadership high-performance and adaptive computing products that push the boundaries of what is possible. Billions of people rely on AMD technology daily to improve how they live, work and play.

We operate in more than 50 locations worldwide, including engineering facilities, sales and business service sites, and corporate offices.

Introduction to Electric Motors and Their Evolution

MOTOR TYPES AND HOW THEY WORK.

Electric motors are used in a wide array of applications from large industrial equipment to cars, trains, escalators, cordless power tools, and household appliances. An electric motor transforms electric power into mechanical motion, and it can also turn mechanical motion into electric power. When you drive a motor with mechanical force, it produces electricity. If you drive with electricity, it creates a force that produces movement.

To give you an example, when you drive a car up a hill, you are *using* energy, but when you are coasting down the hill, you are *generating* it.

BRUSHLESS SERVO MOTOR

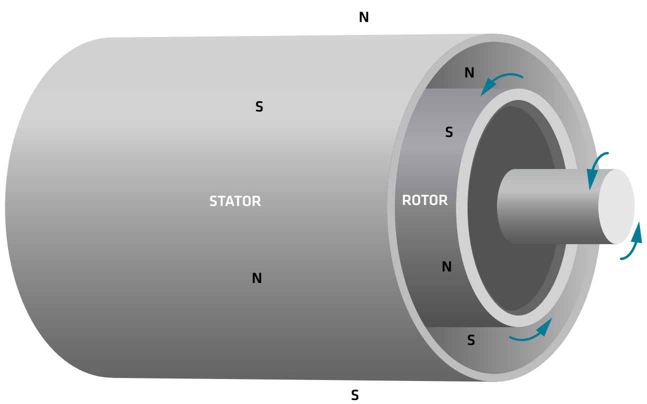


FIGURE 1. In a brushless motor, a rotating magnetic field created in the stator interacts with the magnetic field of the rotor producing torque that turns the rotor.

There are many types of electric motors, including brushed and brushless motors, stepper motors, induction motors, switched reluctance motors, and servo motors. All such varieties of motors require specific control techniques. Brushed motors are mechanically commuting current into the motor, brushless motors are driven by electronically commuting current into the motor. Reluctance motors operate based on the principle of magnetic reluctance, which is the non-uniform magnetic property of a material. In these motors, the rotor tends to move from a position of high reluctance (or magnetic resistance) to a position of low reluctance. Simply put, the rotor aligns itself in a way to minimize the magnetic resistance, thus creating rotational motion.

For simplicity in this eBook we will be mostly focusing on brushless motors, but AMD technology is used in all of the electric motors listed above. Compared to brushed motors, brushless motors are more energy efficient, quieter, and tend to have a longer operating life. Compared to reluctance motors, brushless motors can be manufactured with better precision especially for high-performance motion control applications.

Regardless of how they are powered, electric motors produce torque, which is the force that makes the rotor move, either in a constant rotational or linear direction. Torque is created by a magnetic field inside the motor. Each brushless motor has permanent magnets at the rotor. When the stator (a stationary core wrapped in a coil of insulated wire) introduces a rotating magnetic field into the motor, the rotor follows it (as shown in Figure 1 on the previous page). Motor efficiency is measured by the ratio of how much of the supplied electrical energy is converted into kinetic energy. The more precise and the more frequent the magnetic fields in a motor are controlled, the higher the efficiency can be.

EVOLUTION OF ELECTRIC DRIVES

An electric drive is a collection of systems put together for motion control. These edge devices are made up of the power source, power converter, motor, mechanical load, and controller. Modern electric drives also use industrial Ethernet to exchange command and status with system-level controllers, like PLCs and motion controllers that govern the system the electric drive is connected to.

Over the years, the operation of electric drives hasn't changed much. They have fieldbus connectivity (the ability to connect multiple machines), positioning control, speed control, torque control, and power staging (modulating the power supply to minimize stress on the motor). In 2006, Ethernet connectivity was introduced to drives, and then around 2010, integrated safety mechanisms were added. This led to the introduction of the IEC 61508 functional safety in manufacturing specification, and the ISO 13849 machine safety standard. Around 2016, the industry introduced cloud connectivity and time-sensitive networking (TSN), and since then, the complexity of electric drives has continued to grow.

Along with the evolution of the drive, there have been constant changes to software and systems over the past few decades. Prior to the 1990s, most things were programmed in Assembly or C language. By the middle of the decade, C++ had become well-established, Python was gaining in popularity, and Simulink from MATLAB was starting to take hold. Additionally the Linux operations system had become mainstream for managing drive systems. Since then, these platforms and tools have continued to expand, with Simulink 6 in 2004, for example, and Python 3 in 2008.

In addition to the evolution of software, silicon carbide (SiC) and gallium nitride (GaN) technologies have appeared in the market. Among their advantages, SiC and GaN can sustain higher voltage than silicon alone. They can provide very fast switching mechanisms and operate at very high temperatures and frequencies, making them ideal for use in high-voltage motors for high-power and performance applications.

SiC and GaN allow faster switching, and only fast control circuitry with deterministic behavior can take full advantage of the benefits of this technology. That's why adaptive computing with programmable logic provides the needed speed and determinism that allows the best efficiency of the control loop. This is hardly achievable in microprocessors because there is a high interaction between the control loop that is interrupt driven, and the application that executes the motion creating the non-deterministic behavior. We'll talk more about adaptive computing later in this eBook.

What is Motor Control?

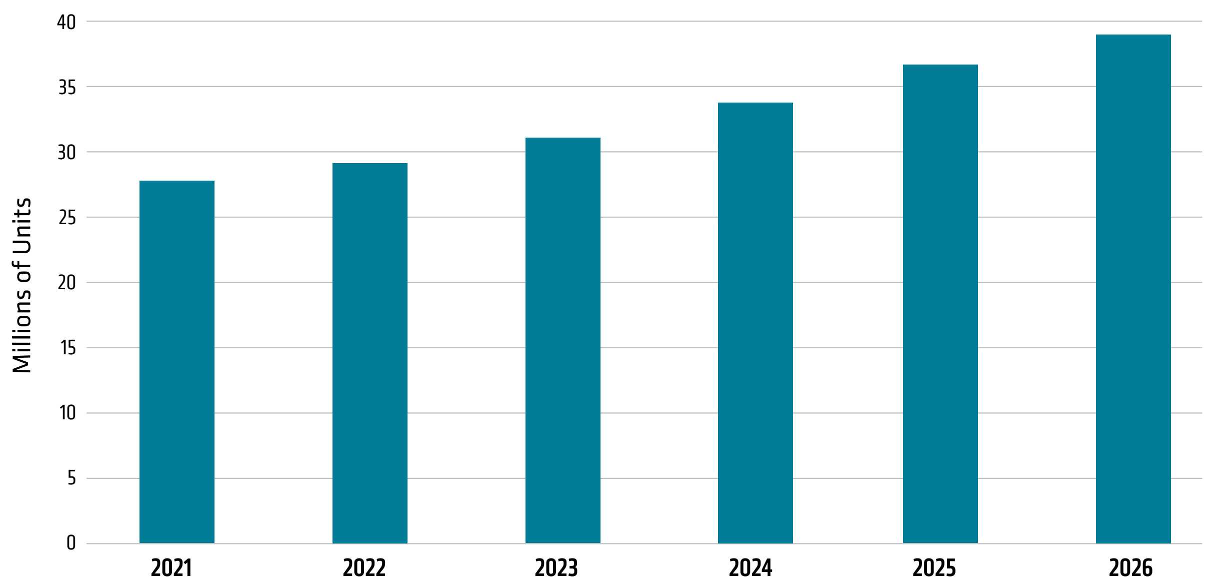
HOW ELECTRIC DRIVES CONTROL MOTOR PERFORMANCE

Electric drives are used in motors to control the motor's output and performance. Omdia Research estimates that global shipments of electric drives is expected to approach 40 million units by 2026, as shown in *Figure 2*, continuing a steady increase since 2021.[2]

Motor control is the process of continuously regulating the magnetic fields in the motor depending on current measurements, rotor position measurements, and deviation from the desired setpoint. It determines speed, torque, and position, and protects the motor by keeping all parameters in the motor's operational range.

This dynamic process continuously measures currents and the position of the rotor. When a motor runs slower, the voltage created through motor control will drive the rotor to follow that pace and not run ahead of it. Motor control reads data from the motor and when the rotor is behind or ahead of its expected position, it reacts quickly to synchronize.

MOTOR DRIVES UNIT SHIPMENT VOLUME



Source: Omdia

FIGURE 2. Omdia estimates the global industrial motor drives market will reach nearly 40 million shipped units by 2026

Motor control creates accurate input/output parameters, again and again—the faster, the better. The more calculations you can assign exclusively to the motor, the more precise your results will be. If you can accurately calculate what the next voltage will be, you'll have a better chance at precisely controlling the motor's angle of force. A motor should always build a magnetic field that is in the best alignment to move the rotor. The moving field should always be precisely angled and optimized to match the torque or speed you want to create. This can help to ensure that the energy is transformed into torque to the rotor and not wasted. When you can very precisely manage a motor with a controller, you can reduce acoustic noise and vibration and minimize electromagnetic emissions.

As mentioned earlier, the operation of an electric motor relies on the production and control of magnetic fields. This means that an imperfect magnet may require adjustments through motor control at every rotation of the rotor. Every magnet has its own special pattern of behavior, so the better you can measure magnetic force, the better performance you will be able to achieve out of your motor. Correcting inconsistencies in every revolution of the rotor can give you better efficiency, and have a direct impact on the service life of the motor.

Parameters That Can be Addressed with Motor Control

There are many variables that can impact the performance of an electric motor. Here are just a few examples that can be measured and adjusted with motor control:

Electromagnetic interference (EMI), is electric "noise" that comes from equipment. Traditionally, motors have intelligent pulse-width-module-based control that helps you avoid peaks and distribute noise a bit better. We can show peaks are at a lesser energy level when we use modulation to control EMI.

Torque can also be addressed with motor control. Torque refers to how much power or force you get out of your engine when you put electricity in. When you use motor control, you can adjust power or force or influence efficiency by adjusting the angle of the rotor.

Synchronization of motors – You can distribute the load of multiple motors when you can control them with the same chip. Using motor control, you can, for example, run four motors in parallel and synchronize them. All motors can run at the same speed and at the same rotor angles. In many cases, four smaller, synchronized motors can provide a more durable and reliable solution than one larger motor.

Safety – Safe drive is normally a motor control unit with extra area that monitors if the motor is running within an expected range. There is a safety-limited position or speed with extra circuitry or area on the chip that monitors whether the motor is running at the speed you are expecting. When a motor runs too fast or too slow, you can switch it off as a safety feature. You can also put this feature on the same device using an isolation design flow and let it run in parallel with the motor control.

Extension of Service Life – You can extend the service life of a motor with predictive maintenance powered by motor control. You can view feedback from the motor and monitor it for changes. The currents you send to the motor may not be the same on all the wires that go to the motor. When the interval is different due to a loose or broken cable, you can be notified, and with predictive maintenance, you can do something to fix it before it results in a massive failure. Motors have magnets and wound copper coils that are expensive and use steel and aluminum, and other natural resources for their enclosures. They also need durable bearings and lubrication. Predictive maintenance helps you extend the service life of a motor, which means fewer motors need to be built, using fewer natural resources.

Energy Efficiency – One of the most-promising uses cases for industrial motor control is driving energy efficiency. It's estimated that 70% of energy used in a factory is consumed by motors, so any improvement in motor efficiency can have a significant impact on a factory's bottom line.

Acoustic Noise Control – Torque ripple, magnetic interference, and vibration are often the cause of acoustic noises in motors. Motor control techniques can be used to mitigate both noise and vibration in various applications where this is an issue.

SIDEBAR

Motor Control Methods in EV Chargers

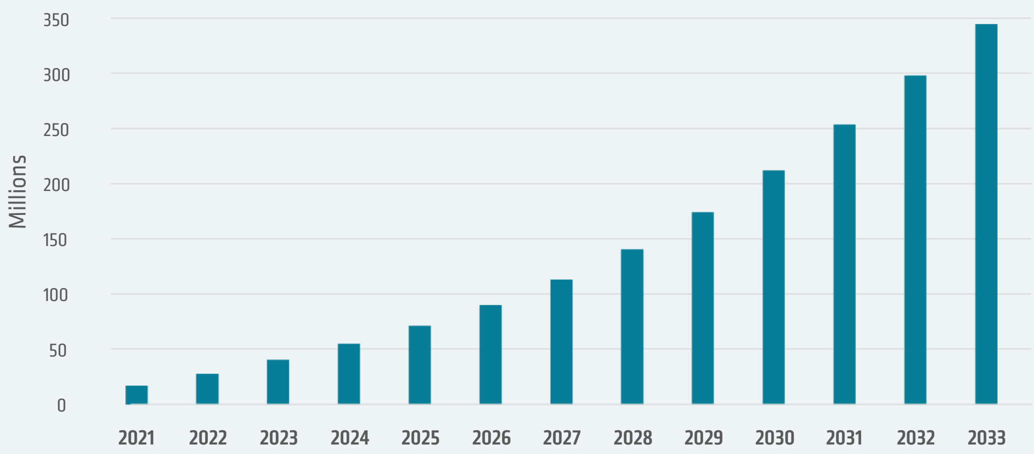
One of the biggest challenges in the electric vehicle (EV) industry is the time it takes to recharge the batteries. Depending on where you go, it can take anywhere from 30 minutes to several hours to achieve a full charge.

Well, it turns out the same technology that is used to manage and control motors can also be used to build fast EV charging stations. AMD technology can improve EV charging in four key areas:

- **Power and Control** – AMD adaptive system-on-chip and system-on-module devices offer complete control of the power system, independent from the underlying software updates in the main controller. They also offer fast control loops that enable fast switching to deliver power to a vehicle's batteries more efficiently and rapidly than alternative approaches.
- **Simulation** – AMD helps minimize the risk of additional necessary hardware iterations and optimizes the control system and converter performance.
- **Safety and Security** – AMD solutions use a hypervisor and multicores to bound different criticalities, and are safety certifiable to automotive and industrial standards, including ASIL D and SiL3.
- **Cloud and Web** – AMD enables integration with cloud services, Python support, JavaScript offloading and acceleration, and Ethernet connectivity.

Beyond EV charging, AMD motor control methods can also be used for vehicle-to-grid (V2G) charging. AMD allows electric and hybrid vehicle users to reverse the current from their car to provide home power in the event of a power outage—or even to sell power back to the grid. Figure 3, shows the rapid worldwide growth of electric vehicles, as estimated by the market research firm, ABI Research. The firm sees demand for electric vehicles increasing at a compound annual growth rate (CAGR) of 26% between 2021 and 2033.

REGISTERED ELECTRIC VEHICLES WORLDWIDE



Source: ABI Research, Vehicle and Mobility Services, August 21, 2023

FIGURE 3. ABI Research estimates the number of registered EVs worldwide will reach more than 340 million units by 2033.

Different Ways to Approach Motor Control

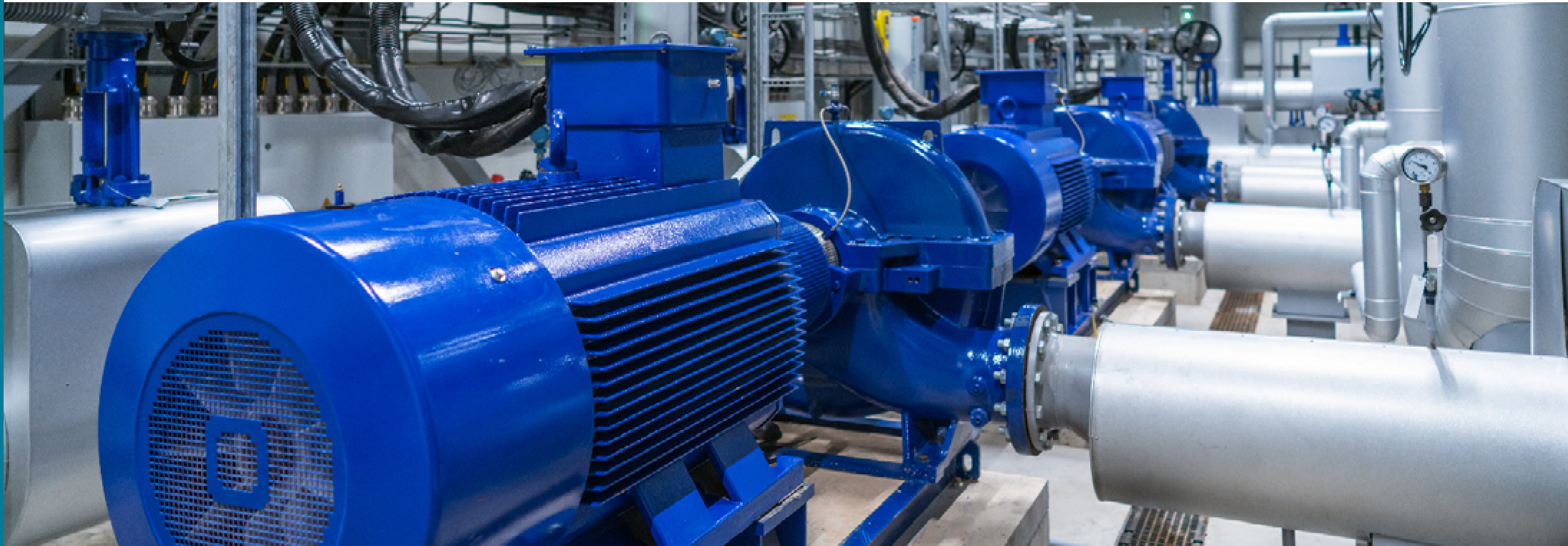
WHICH FACTORS SHOULD YOU CONSIDER?

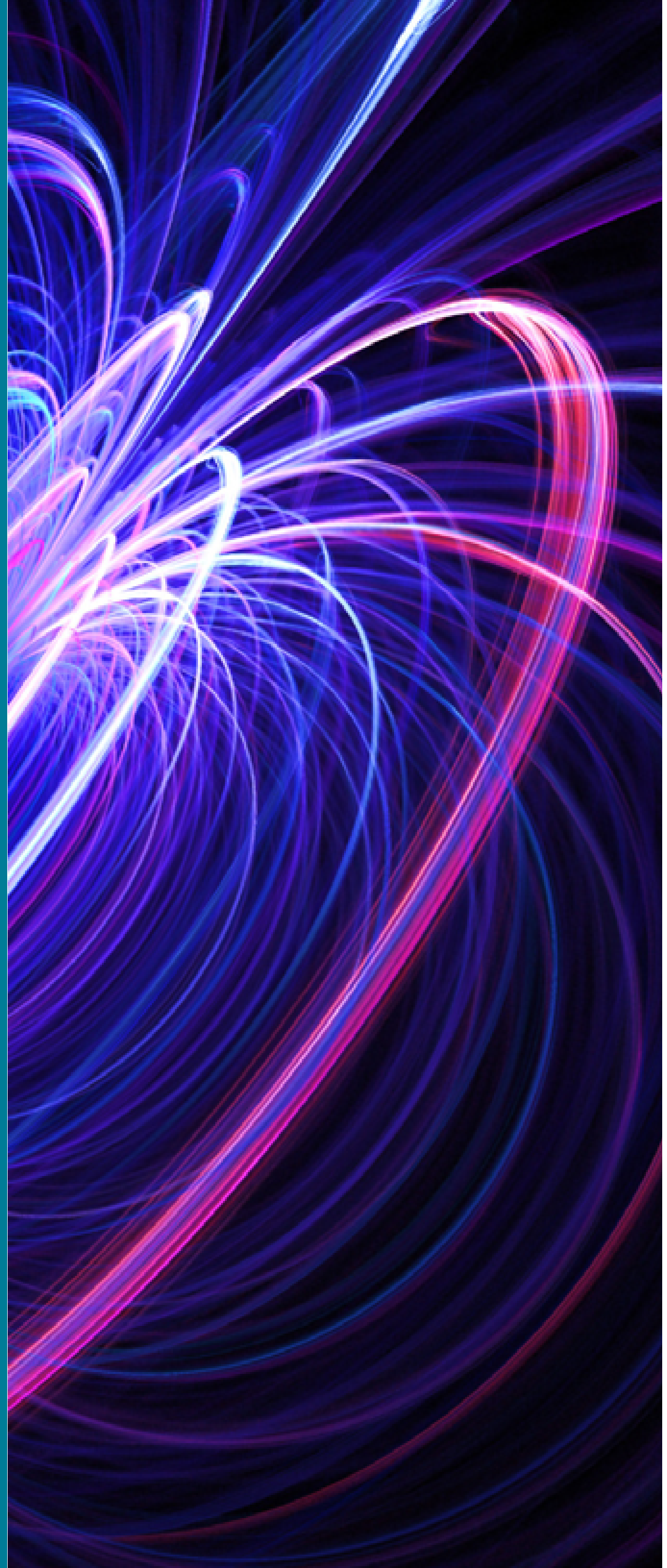
Brushless motors need electronics to control electric currents so that precise motor behavior can be achieved. For this, design engineers typically implement one of three approaches:

1. CPU + DSP: This approach uses discrete CPU and digital signal processor (DSP) devices with each assigned different tasks and working in concert with one another to achieve the desired behavior
2. System-on-Chip (SoC) features an on-board MCU and that has needed components integrated on one chip
3. System-on-Module (SOM) supported by dedicated logic optimized for motor control that enables you to create higher frequencies and fine-tune precision.

The decision about which approach would work best for your situation often depends on several factors, including:

1. Board Space – Do you have room for discrete components, or will a more highly integrated solution meet your needs better?
2. BOM Costs – How important are bill-of-materials costs vs. the value the solution brings to your overall project?
3. Functional Safety – How important is functional safety, and do you need external units to achieve it?
4. Motor Efficiency – How efficient do you need the motor to be, and which solution will provide you with the level of precision that you need?
5. Connectivity – Integration of CAN, Fieldbus, Industrial Ethernet, TSN, or even wireless.





An Adaptive Approach is Best

ADAPTIVE COMPUTING DELIVERS FLEXIBILITY THAT ELEVATES MOTOR PERFORMANCE.

FPGA-based adaptive system-on-chip (SoC) devices are used for motor control in electric drives. The SoC helps control the magnetic field generated in the stator so that interference between it and the rotor is minimized at any time and you can produce motion, instead of just heat. Adaptive SoCs help to optimize the drive of the stator component.

PRECISE CURRENT CONTROL

In an electric motor, there are three phases of currents that are injected to a power stage and they need to be controlled precisely in microseconds. When you apply a specific algorithm, it reads the currents you are injecting into the stator, and it tries to figure out the currents that are being used in the motor so that it can estimate the torque. This control mechanism is called “field orientation.” It means you are orienting the mathematical field in an optimal way. Adaptive SoCs create optimal control so the force to the rotor is in the optimal direction at any time. This is tough because you don’t always know where the rotor is. In order to identify the position of the moving rotor, the controller uses a sensor that is attached to the stator that provides the angled position of the rotor based on an agreed reference point. In short, it’s reporting an angle measurement. Based on this angle, the controller tries to optimize the drive, creating the proper amount of current for every phase of the motor, and enabling the motor to operate at maximum efficiency.

Without this information, the motor would spin inefficiently, consuming a lot of current, and eventually overheating, or it would spin and not efficiently produce the maximum amount of torque possible.

PREDICTIVE MAINTENANCE

The electric drive controller optimizes these parameters in a motor—and it does even more. It also can be used for predictive maintenance to detect if the current produced by the rotor is in the proper condition or to estimate if there are any other issues, such as the ball bearings not being properly aligned. Adaptive SoCs allow you to acquire current measurements through the windings of the motor continuously and processes them in real time.

MODULATION

Another thing that’s important to motors is precision voltage control. Adaptive SoCs are particularly good at modulating voltage and electromagnetic interference (EMI) with built-in pulse-width modulation. Using this feature, you can switch the motor on pulses to control motor speed. You can also use it to mitigate EMI by spreading the “noise” over a wider bandwidth. With FPGA-based devices, you can create more sophisticated modulators with greater scalability and the architectural flexibility to minimize EMI noise.

AMD

Why AMD for Motor Control?

AMD ADAPTIVE SOLUTIONS OFFER MANY ADVANTAGES OVER OTHER TYPES OF OFFERINGS.

HARDWARE-BASED

AMD solutions enable motor control in hardware–without software interference. With our current control executed in programmable logic, you can decouple some of the issues you might normally have with software. From a controller point of view, it's removing one big headache because if you have the controller in hardware running without any software interference, it's a huge advantage. Control engineers may be hesitant to go into the interrupt routine that is driving the motor because of concern that the motor might not run properly. When the implementation is run within AMD programmable logic, you can decouple software and, in particular, the interrupt routines for a simpler and easy-to-use solution.

AI-BASED DATA HANDLING

AMD motor control solutions also enable the ability to collect multiple control variables, such as currents, power, and movement information–and analyze that data for predictive maintenance, data logging, and anomaly detection. If you do data processing with a standard processor, it takes a massive amount of computation. Using AMD, you can enter into the domain of AI applications.

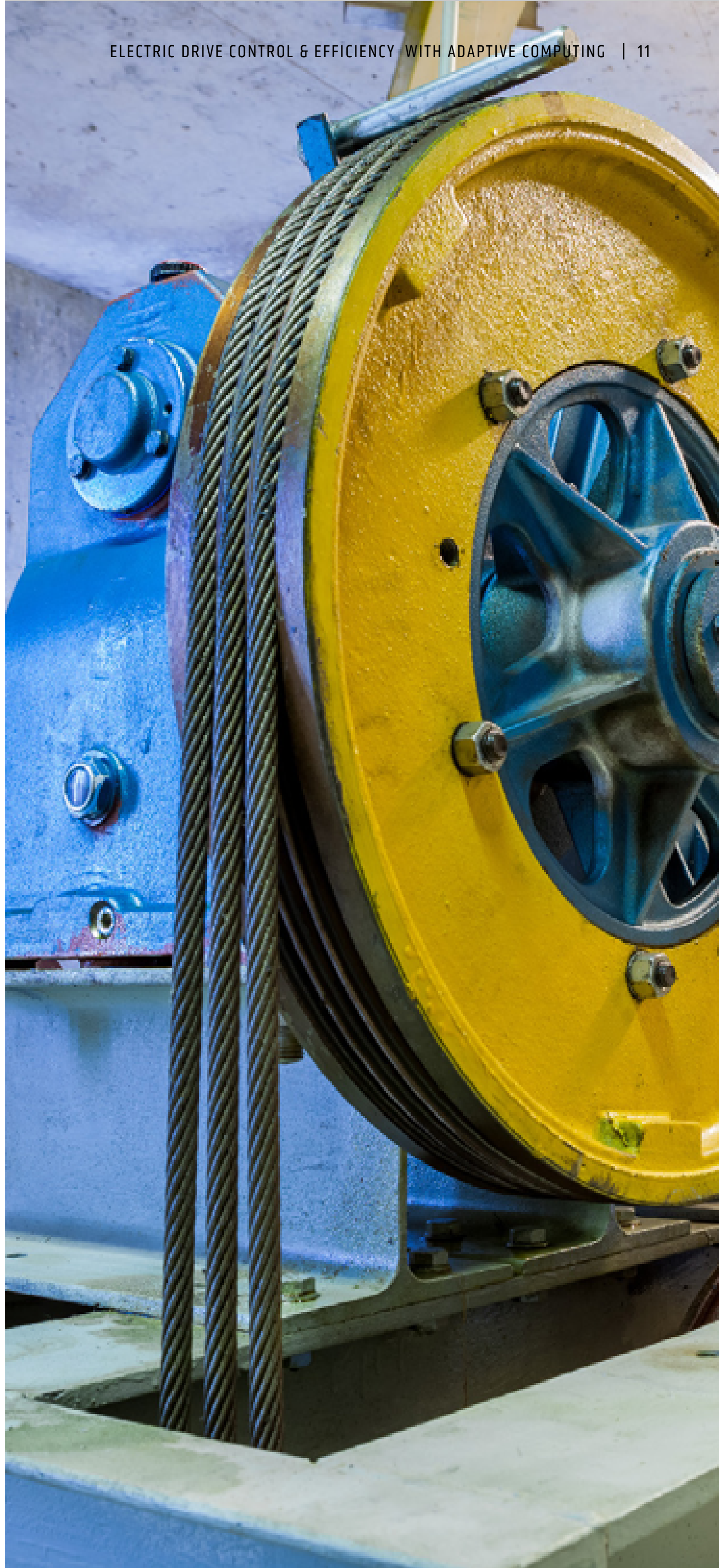
AI requires data. If you don't provide the data for such a system, like predictive maintenance or functional safety, the system may not be able to detect all of the anomalies or weaknesses. AMD solutions provide the compute power to collect the cards voltages, angles, and commands, creating a database that can be funneled to whatever system you choose in real time, so you can predict what the motor will do.

MULTI-MOTOR CONTROL

When you start to extend to multiple motors – like six axis motors with a single controller, things start to get really complex acquiring and manipulating the data. But AMD technology can handle this with ease in programmable logic. We can run multiple motors in sync using a feature called "parallelism."

MULTIPROTOCOL SUPPORT

Many control engineers today are less concerned about full system flexibility. Instead, they tend to want to build a single system, and have the flexibility to support different incarnations of it, leveraging several emerging standards like EnDat, BISS or Hiperface DSL. Every sensor manufacturer has a specific protocol. With our technology, you can instantiate the different protocols inside programmable logic so you can sample things faster. This is one element of flexibility that we offer, and a main reason why many of our customers choose AMD as a basic element for acquiring and controlling data.



EFFICIENT DATA PROCESSING

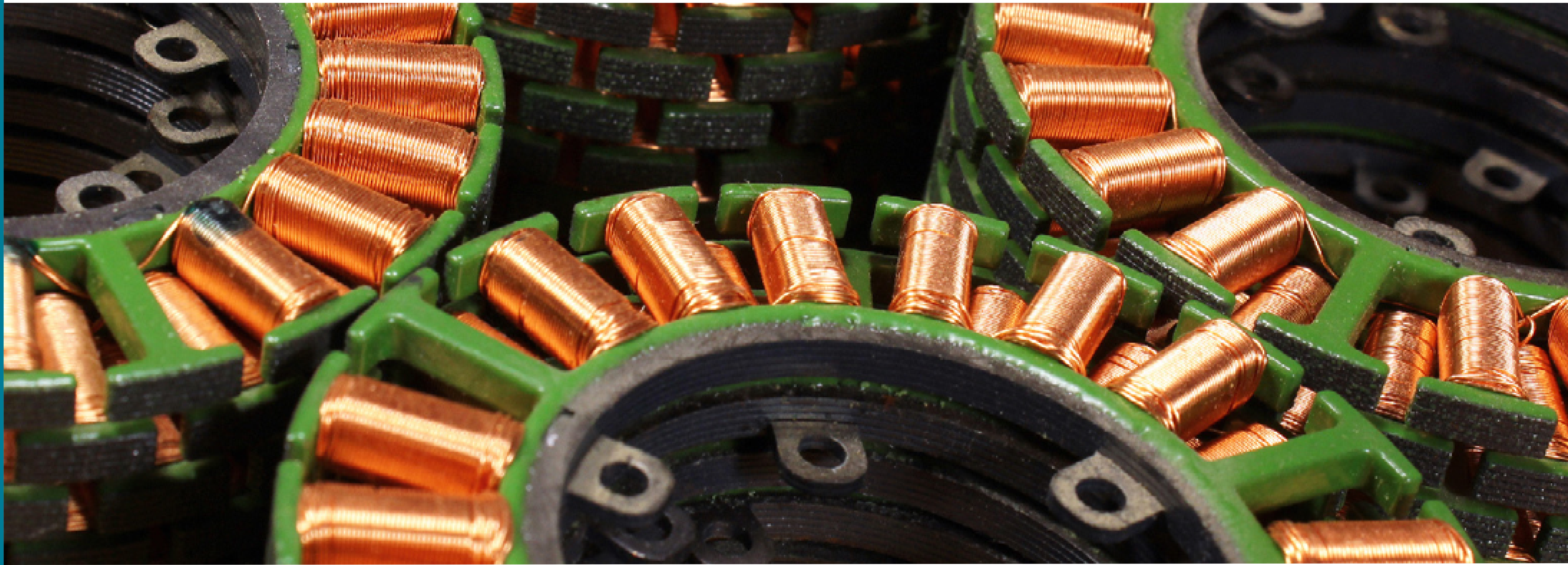
Another advantage of AMD technology is that it allows the integration of network and control. With Time-Sensitive Networking (TSN) you can extract out of the hardware all the synchronization information needed for the motor without passing it through the processor. This is a very efficient way of handing data for enabling real-time processing.

FLEXIBLE AND SCALABLE DATA ACQUISITION

AMD technology also excels in its ability to help you collect and sample data that are useful for predictive maintenance, motor diagnostics, and in general for keeping the motor operating at peak efficiency with an effective control strategy. AMD technology has unique features with its programmable logic that can connect the data acquisition of position and speed sensors and analog-to-digital converters, directly in the main DDR memory of the processing system. This capability allows real-time acquisition without taxing the CPU, and provides full synchronous data logging to capture even the tiniest event that happens in the motor.

AMD devices can handle many different types of data and can expand or adjust to whichever sensor or data set is available. Moreover, using the programmable logic digital signal processing capabilities, the acquired data can be processed on-the-fly to alleviate the CPU of hard, real-time constraints. Certain combinations of data and algorithms deployed in programmable logic make it possible to apply machine learning techniques to extract features and additional information from the data stream in real-time that will be deposited into the DDR memory. All-in-all, this capability makes it possible for AMD technology to provide high-performance data acquisition and processing at an affordable cost.

AMD solutions are also flexible in their performance efficiency. In a typical system, you might need three ADCs for the current and three for the voltage. You might also need a converter for the power supply and current, and additional converters for the feedback sensors and communication busses. If you have to get all this information collected and transferred into DDR memory/storage, like you would with a typical motor control system, it would take a while, because the processor would need to sample each data point separately. The AMD solution can sample each of these at the same time and transfer enormous amounts of information all at once.



When you need performance and flexibility AMD technology makes sense. And as the application gets more complex and moves into the direction of AI processing, AMD becomes an even more compelling choice vs. the competition. With AMD, the DPU is fed with all of the data that is collected in real time. The DPU can detect anomalies immediately. It's a much better process than sampling data one by one.

FASTER, SMALLER MOTORS

AMD solutions help designers build smaller motors with very high speed. To control these, you need to be able to sample the rotor angle at very fast speeds. AMD allows a very high sampling rate. We can drive motors that standard microcontrollers can't. And this is not limited to industrial automation, this also applies to cars as well. Our advantage is in the determinism of controls. Running it in hardware, you can have every step of the control perfectly timed, along with the speed that you need.

APPLICATION OF MODERN SWITCHING TRANSISTOR TECHNOLOGY

As detailed in Chapter 3, AMD technology allows you to use state-of-the-art power switches such as SiC and GaN. Why are SiC and GaN relevant for power electronics? Miniaturization of power electronics is paramount to reduce weight--especially in transportation systems. Additionally, SiC and GaN are capable of operating at higher temperatures than standard silicon. Silicon operates reliably at up to 140 C° while SiC and GaN can happily reach 175 C° or more. Withstanding high temperatures, the cooling system is smaller and the system can be packaged into more compact enclosures. However, SiC and GaN require fast control to get the best of their capabilities in terms of power and minimizing dynamic losses. AMD programmable logic can be tightly coupled with the driver stage of SiC and GaN providing almost instantaneous drive and response times that are necessary to operate them at the highest efficiency. Modern techniques like model predictive control can also be applied without CPU intervention, combining fast reaction with fast calculation executed totally in hardware, providing a resulting performance close to the speed of an analog system without the burden of analog components because it is realized fully with digital methods.

SECURITY FEATURES

AMD motor control solutions offer multiple layers of security features, from tamper monitoring to license management.

MULTIPLE INDUSTRIAL NETWORKING PROTOCOL SUPPORT

AMD solutions support multiple industrial networking protocols to deliver high levels of design flexibility.

FUNCTIONAL SAFETY

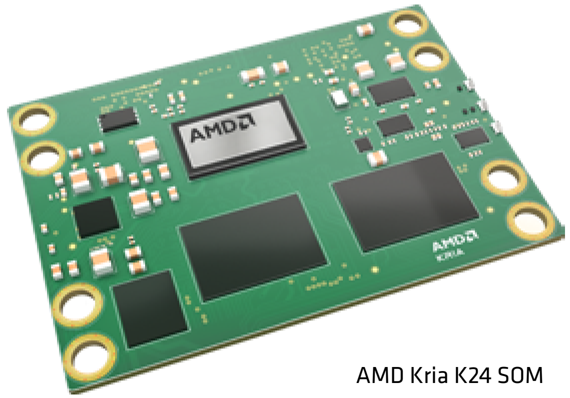
AMD solutions are built to support the latest functional safety standards, Should a localized or system failure occur, the fault will be quickly detected and addressed so that impact is minimized.

LOW LATENCY

AMD motor control solutions deliver very low latency between IT and operational tasks for remarkably fast performance.

Introducing the Kria™ K24 SOM for Motor Control

AMD KRIA K24 SOM DELIVERS OPTIMIZED COMPUTING, SCALABILITY, AND EASY SIGNAL PROCESSING.



AMD Kria K24 SOM

Embedded system architects need to deliver efficient performance for digital signal processing (DSP)-intensive applications at the edge.

The small-form-factor AMD Kria™ K24 SOM and motor control application-focused KD240 Drives Starter Kit offer a power-, performance-, and cost-optimized solution within the Kria SOM portfolio.

SOMs house the core components of an embedded processing system on a single production-ready printed circuit board.

The benefits vs. chip-down solutions include:

- Reduced manufacturing time and materials
- Simplified product life cycle management
- Accelerated development with low design complexity
- More efficient use of valuable engineering resources
- Simplified operational flows and reduced operating costs
- Improved power efficiency

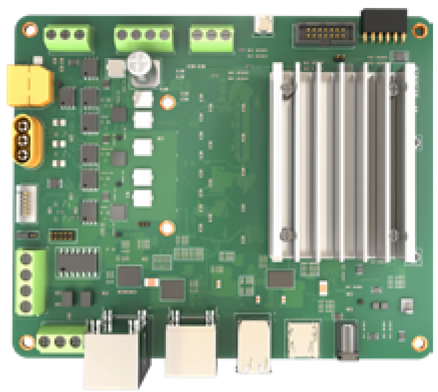
The AMD Kria K24 SOM is built to simplify the design of innovative industrial and commercial edge solutions. It delivers optimized computing, scalability/adaptability, and easy signal processing that helps customers build sustainable solutions for a wide array of edge applications from robotics drives and actuators to industrial motors and Ethernet gateways.

The Kria K24 SOM delivers a competitive balance of cost, power, performance, and size. It features scalable hardware that allows customers to fine-tune power, cost, and performance levels without changing their PCB. The solution comes pre-certified for use in industrial environments and its easy signal processing supports many design flows, including familiar design tools like MATLAB Simulink and languages like Python with its extensive ecosystem and support for the PYNQ™ framework.

Some of the key benefits of the Kria K24 SOM for motor control include:

FAST PERFORMANCE

Kria enables extremely fast control loops (100,000 loops per second, per motor.)



AMD KD240 Drives Starter Kit

ON-CHIP MEMORY

The Kria K24 SOM features on-chip Block Random Access Memory (BRAM) which is ideal for diagnosis or predictive maintenance. It can be used to look at data you've captured over the last half second or second. Our architecture with both BRAMs and URAMs (Unified Random Access Memory) gives you memory on the chip that you can use to capture data of a certain interval, which is useful for health monitoring of the motor.

TSN INTERFACE

Not every device with motor control has an interface with Time-Sensitive Networking (TSN) as Kria does. Bringing that capability into the same device, and not needing to have an extra controller, can help save money and reduce the board footprint.

STANDARD INDUSTRIAL NETWORKING

K24 can support, in addition to TSN, other industrial networking standards, like EtherCAT®, PROFINET®, EtherNet/IP®, and many more.

STANDARD FIELDBUS

K24 supports the CAN interface and the KD240 offers a connector that carries the CAN 2.0 interface.

AMD

APPLICATIONS

With the Kria SOM, you can download applications from our app store and add features and functionality to your design. Coupled with the KD240 starter kit, designers have the tools they need to achieve success.

MODULATION

Microcontroller-based solutions are slower and when you run out of modulators, you need to add another device. With our adaptive SOC-based Kria SOM, you can simply add another instance into the FPGA to provide additional modulation. Moreover, with programmable technology is it possible to provide special modulators that have the ability to spread harmonics generated during the modulation process into a larger band, shaping the noise such that its content is so spread out that its effect becomes negligible. This is an enormous advantage because not only is the acoustic noise suppressed, but also the torque ripple, that is an undesired effect of standard modulation methods, is minimized.

COMPATIBILITY WITH NEW POWER SWITCHES

Motor control solutions based on standard CMOS microcontrollers are limited when it comes to switching frequency. But with our Kria SOM, you can adapt to modern switching silicon with higher frequency, like silicon carbide (SiC). Silicon carbide is ideal for experimenting with permanent magnet motors. The Kria K24 solution uses programmable logic for the field-oriented control, and enables deterministic and fast control loops to take advantage of the high switching frequencies that silicon carbide enables.

SECURITY FEATURES

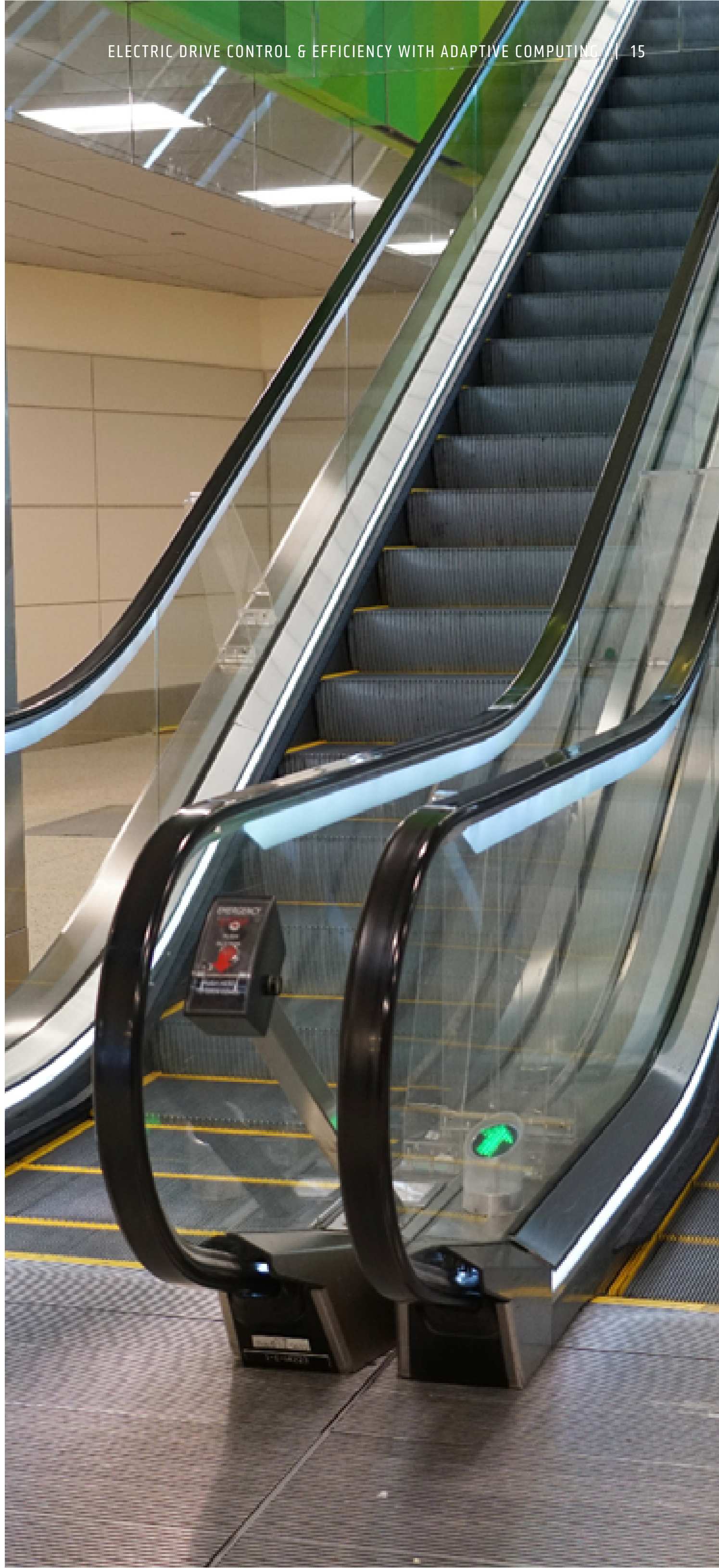
With the Kria SOM, you can extend the life of the motor by easily adding software and security updates over the air. The Kria SOM provides two levels of security features with dedicated hardware built into the MPSoC and an on-board trusted platform module (TPM) device. Together they enable implementation of tamper monitoring and hardware-accelerated cryptographic functions. With the TPM technology built-in, you can secure connections and add license management for added security.

RELIABILITY

Kria SOMs lets you synchronize multiple motors and offers on-board error correction (ECC) and system monitoring. AMD also releases bi-annual reliability reports about our devices.

DESIGN FLOW

Another differentiation is our design flow. When you are using AMD-only, you have an advantage in that you do your entire development in one tool. Putting everything in our unified software (including Python and MATLAB support) is much better and can help you more-easily meet safety requirements as well.



AMD

Motor Control Applications

HOW OEMS ARE LEVERAGING TECHNOLOGY TO ACHIEVE DIFFERENTIATION

There are many examples of customers that are using AMD adaptive computing for motor control. For example, AMD technology is embedded in high-performance race cars and EVs because it can get more data and performance out of the car's battery and motor.

AMD 16nm Zynq™ UltraScale+™ MPSoCs or 28nm Zynq 7000 SOCs are used for efficient battery management and motor control. We can make sophisticated waveforms that allow a better power transfer between the switching gear to the motor—or from an external charger to the battery. AMD technology is also used to transfer battery power onto the motor while driving. Our motor control technology can improve efficiency, which leads to a longer battery life, less wasted energy, and a more sustainable platform.

There are some other related areas where AMD technology is being used. For example, if the driver wants to model what the battery life will look like in one mile, or after a longer period of time, AMD technology can help make that happen. Drivers can run sophisticated models in the car, comparing them to models from previous races or academic institutions. This capability can help the driver determine which combinations of the model will make the battery perform at its best.

In diesel trains, you may be surprised to learn that it's not the diesel fuel that's turning the wheels, but instead, an electric motor. The diesel fuel powers the electric traction motors, but it's actually the traction motors that produce the torque that turns the wheels. Thus, motor control plays an important role in train operations. Modern trains have built-in intelligence that makes rail transport fast, safe, reliable, and comfortable. Innovation across all aspects of on-board and wayside system design improves performance and efficiency while also enhancing safety and security. On-board control systems process data from a large variety of cabin components including doors, lighting, cameras, air conditioning, brakes, lavatories, displays, diagnosis functions and power management – often in real time and always with resilient methods. Wayside objects facilitate safe traffic control with intelligent signaling and manage the power distribution along the tracks and on platforms, provide secure video surveillance, and supports the passenger on the platform with displays and other information systems. Enhanced requirements concerning availability and built-in diagnostics as well as the compatibility to networks are mandatory. AMD combines scalable processing performance, deterministic programmable logic, certified design flows for functional safety, and state-of-the-art security with long-term reliability over harsh conditions.

MATHWORKS WORKFLOWS SIMPLIFY DESIGN

MathWorks has developed motor control workflows that are ideal for use with AMD Kria SOM development boards. These workflows make it easier for you to prototype your design. You can build all the algorithms for your chip without having to learn new skills. Click here to learn more about how you can get plugged into these workflows.

MathWorks®

AMD POWERING COLLABORATIVE ROBOTS

In the industrial space, AMD electric drives and motor control solutions are inside **ABB Robotics'** GoFa™ collaborative robots. This category of robots is designed to safely work alongside humans in manufacturing and assembly lines and other applications. The adaptive Zynq controllers from AMD allow users to scale from single- to multi-axis control with determinism, performance, and power efficiency. The solution has allowed ABB to develop algorithms in software and optimize in hardware using the AMD Vivado™ design suite. It also offers a flexible interface to changing companion chips, and functional safety features that enable compliance and reduce system cost and risk, while accelerating time-to-market.

MOTOR ACCESSORY PACK POWERED BY AMD

Rev Robotics has developed the REV Robotics 2-in-1 Motor Accessory Kit – a set of accessories that are compatible with the Kria KD24 0 Drives Starter Kit. This accessory pack enables developers to seamlessly evaluate motor control-focused accelerated applications based on Vitis™ Motor Control Libraries. The motor accessory pack includes a motor + encoder solution from REV Robotics, a flywheel assembly for launching foam balls, and arm for position control to help you get started with the KD240 kit. Click here to learn more about the kit.

AMD

Summary

IMPROVING ELECTRIC DRIVE CONTROL AND EFFICIENCY

Electric motors are inside many of the devices that humans engage with on a daily basis. Whether used in power generation, robotics, EV charging, medical imaging, patient care, or public transportation, adaptive drive control solutions from AMD can help electric motors run more efficiently.

Based on the AMD Zynq UltraScale+ MPSoC device, the AMD Kria K24 SOM delivers high reliability, and integration to optimize motor performance and extend its service life.

AMD adaptive computing solutions enable developers to process data quickly with downloadable applications that allow users to easily add features and functionality to their designs.

For more information, please visit us online at https://www.xilinx.com/products/som/kria.html.

MORE RESOURCES

- *AMD Kria K24 SOMs*
- *AMD KD240 Drives Starter Kit*

ENDNOTES

1. Energy Efficiency 2022 (windows.net) page 64, International Energy Agency, December 2022
2. Motors & Drives Vertical Applications Intelligence Service, Omdia Research, 2023
3. Vehicle and Mobility Services, ABI Research, August 27, 2023