Chipsmall Limited consists of a professional team with an average of over 10 year of expertise in the distribution of electronic components. Based in Hongkong, we have already established firm and mutual-benefit business relationships with customers from,Europe,America and south Asia,supplying obsolete and hard-to-find components to meet their specific needs.

With the principle of “Quality Parts,Customers Priority,Honest Operation,and Considerate Service”,our business mainly focus on the distribution of electronic components. Line cards we deal with include Microchip,ALPS,ROHM,Xilinx,Pulse,ON,Everlight and Freescale. Main products comprise IC,Modules,Potentiometer,IC Socket,Relay,Connector.Our parts cover such applications as commercial,industrial, and automotives areas.

We are looking forward to setting up business relationship with you and hope to provide you with the best service and solution. Let us make a better world for our industry!

Contact us

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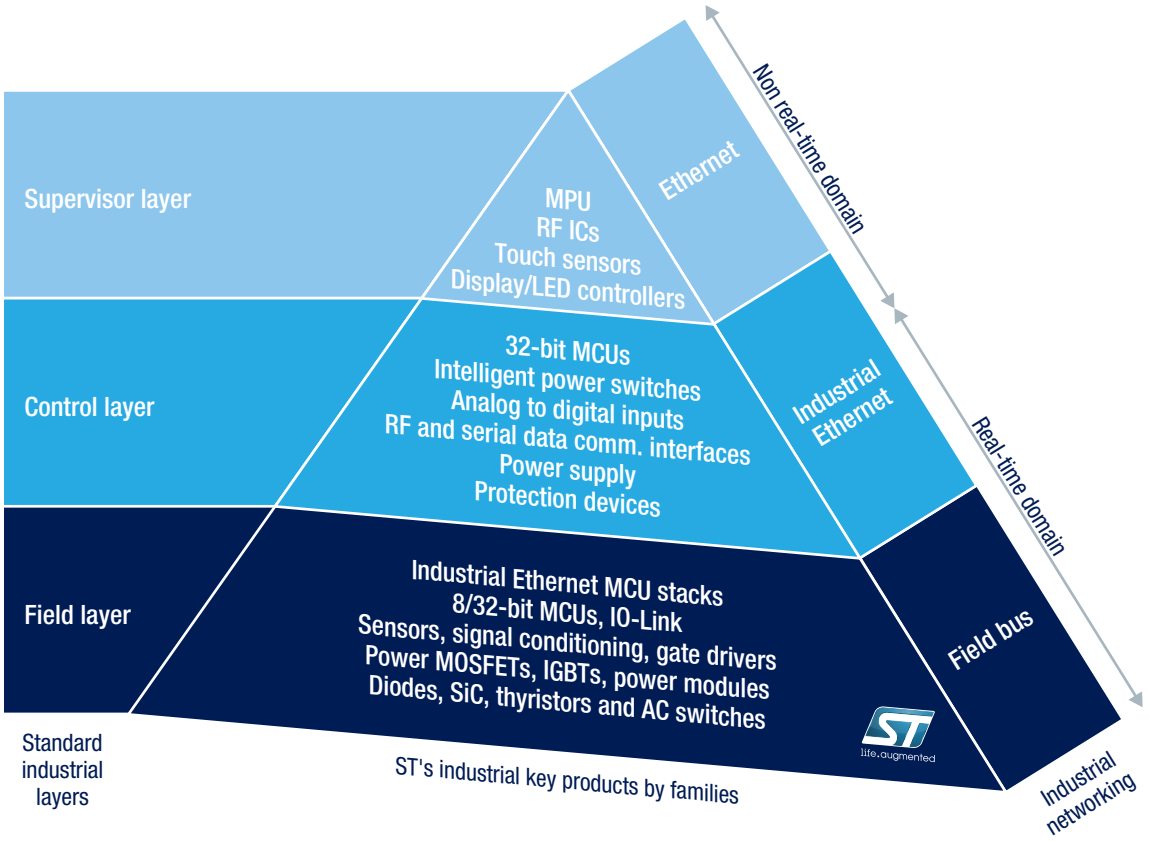
life.augmented

Products and solutions for Factory automation and control

Content

Introduction



Overview

Check-out STMicroelectronics' new brief handbook for factory automation and control!
Inside a lot of theoretical solutions are rapidly brought to implementation using ST ICs. In addition, cases of interest and success stories are discussed to demonstrate ST strong partnership with our customers.
ST is placing an increasing emphasis on factory automation and consider of vital importance the continuous comparison within the engineering community, even at university and hobbyist level.

The CIM model presented here was introduced in the 1980s to establish a hierarchy in the manufacturing industries.

www.st.com

THE “INDUSTRY OF THINGS”

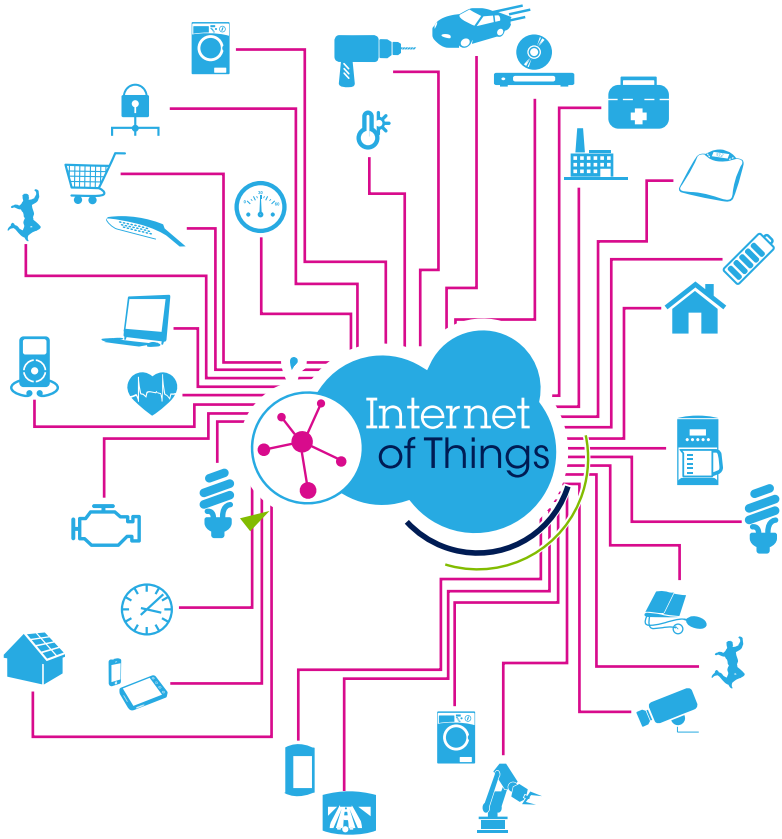
Factory Automation and wireless connectivity

Modifying the now famous phrase “Internet of Things” by replacing “Internet” with “Industry”, is not just to be amusing.

For many years, we have observed the extent to which smart technologies and energy efficiency are driving the factory automation and wireless connectivity segments, based on the consolidated concept of producing very long-life goods to ensure quality and cost depreciation.

Within this in mind, we can introduce wireless industrial modules that can be easily mounted in any smart industrial architecture. They may coexist with classic fieldbus and industrial Ethernet, of course, or better still may represent an extension of these timeless infrastructures.

These things make end applications smarter and more energy efficient, which is the goal of our customers. As this scenario becomes clearer, with the flexibility a company like ST can offer it is not difficult to associate the title of this chapter to the modules we can provide.



KEY STANDARDS

- IEC 61010: Safety requirements for electrical equipment for measurement, control and laboratory use
- EN61508: Functional safety of electrical/electronic/programmable electronic safety-related systems
- IEC 61800: Adjustable speed electrical power drive systems
- ISO 13849-1: machinery standard
- IEC 62061: dedicated to factory automation systems

The concept of modularity in factory automation applications is what we focus on to make our ICs the winning choice for our customers. Let’s consider, for example, the classic PLC, another timeless instrument in this sector. It is well known that the PLC is a mix of I/O capacity and computational performance.

ST offers both of these elements, with input (i.e. our CLT series of current-limited termination devices, like the new CLT01-38S) and output (the IPS series of intelligent power switches for high-side and low-side configurations, such as the VNI8200XP) front-ends capable of interfacing with the most common industrial tools like valves, industrial sensors and relays; and the computational performance offered by our powerful, scalable STM32 32-bit microcontrollers series. Everything above is available with stand-alone product evaluation boards or system evaluation boards that demonstrate product features and performance in a platform that functions as closely as possible to the final application.

EVALUATION BOARDS

Evaluation boards for the industrial segment can be found at:
http://www.st.com/industrial-tools

SAFETY MATTERS: STM32 FUNCTIONAL SAFETY PACKAGE

IEC61508 and SIL: ST has partnered with Yogitech for the STM32 Safety Package

ST and Yogitech have been cooperating to bring state-of-the-art functional safety solutions to STM32 customers.

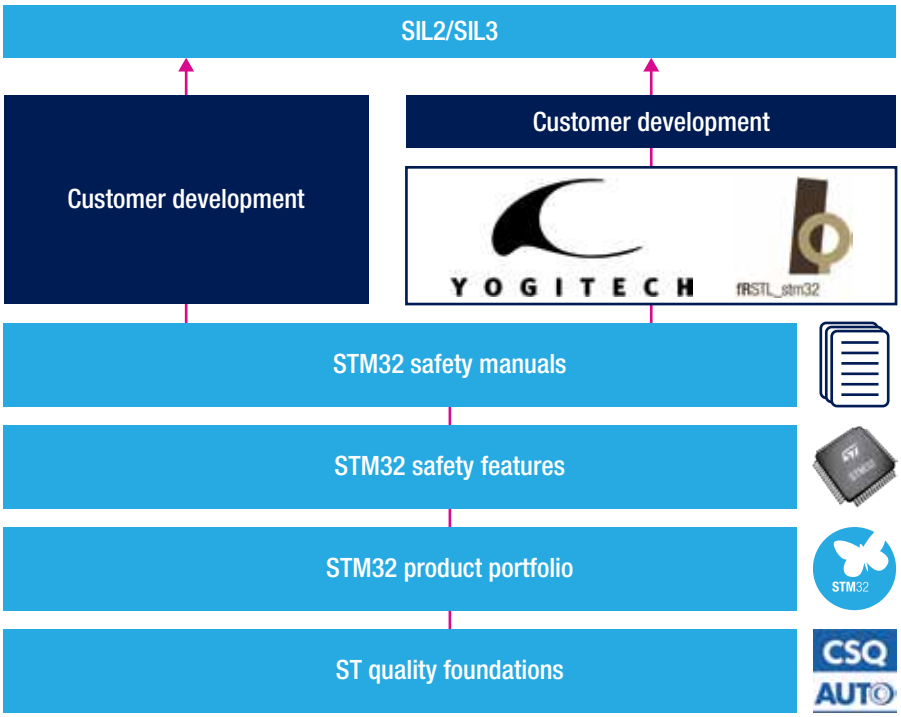
Yogitech has applied its well established fRMethodology to the STM32 design databases, performing in-depth analysis of the MCUs with regard to the IEC61508 standard and other functional safety standards.

The fRMethodology adopts a white-box approach, meaning that the analysis is carried out on the actual RTLs and netlists, which in turn allows for a degree of accuracy simply not possible using black-box techniques. This was made possible by the close collaboration between ST and Yogitech. The design database of all STM32 families has been shared to carry out the most in-depth analysis of all the HW features and to the lowest level of detail in the implementation of STM32 microcontrollers.

For each family in the STM32 series, the output of this activity has been two-fold: the STM32 safety manual, and an off-the-shelf software test library product to detect hardware random faults (Yogitech's fRSTL).

The STM32 safety manual contains all of the safety-relevant information, including the conditions of use that must be fulfilled in order to claim the targeted safety integrity level.

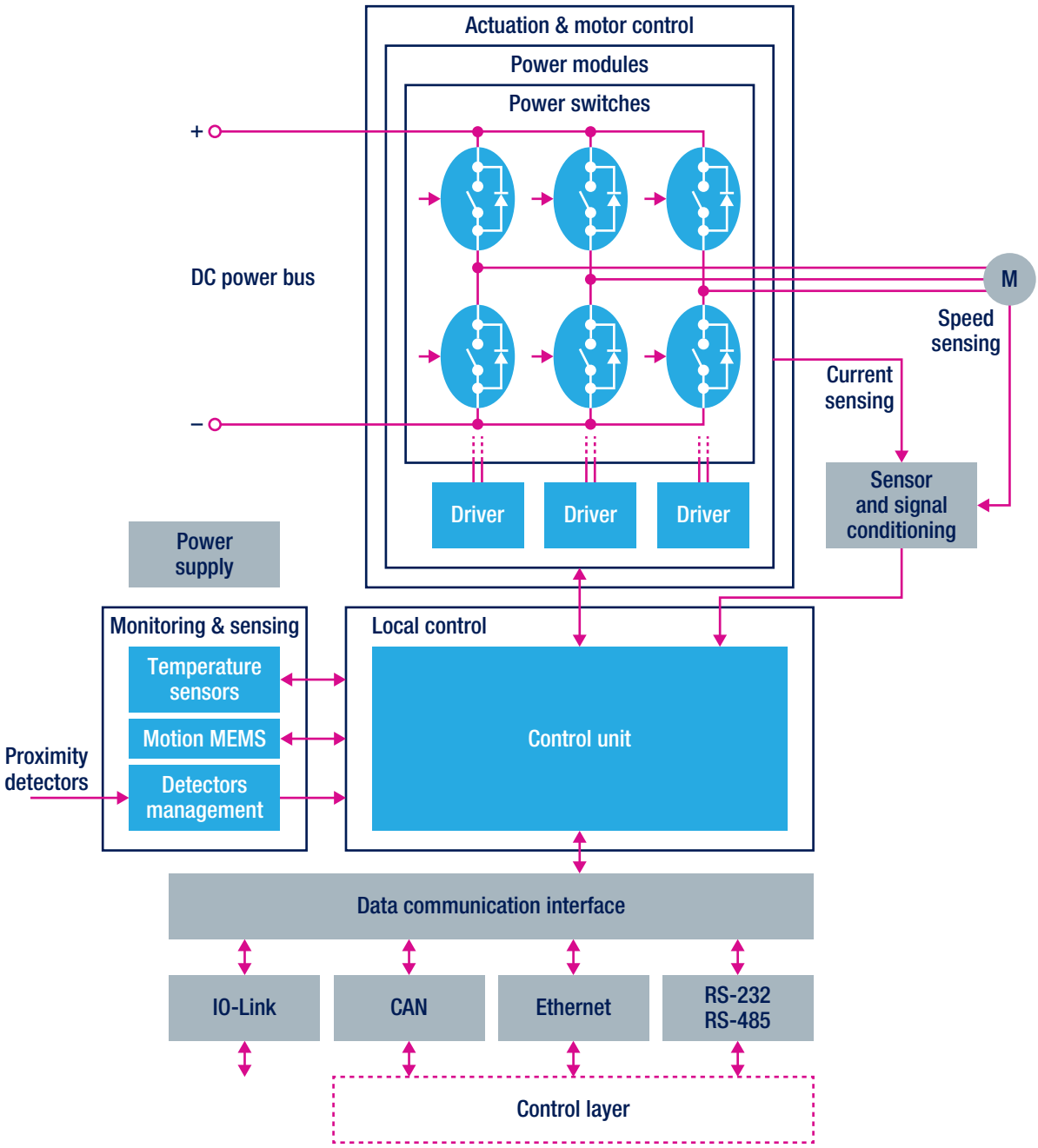
Conditions of use that can be fulfilled in an application-independent manner are addressed by Yogitech's fRSTL software test library. Written in C and Assembly and satisfying systematic capability 3 (SC3), fRSTL can be easily integrated into the end user application and allows users to reach SIL2 on single-channel and SIL3 on dual-channel safety architectures.



fRSTL software test libraries take full advantage of the white-box approach used during the analysis and are optimized in size and performance. Moreover, their coverage is verified using an extensive fault injection campaign, aimed at checking that the claimed coverage is actually reached.

Now available for the STM32F0 series, the safety manuals and fRSTL_stm32 libraries will soon be extended to the F1, F2, F3, F4 and L1 series.

Field layer



Commonly this is the level representing the operations performed in a given Industrial environment. The block diagram above is a clear abstraction, to make it recognizable, depending on the specific application, where ICs and solutions proposed here can be properly used. This approach will be followed also in the other sections of the document: the coexistence of ICs and solutions is to help the reader discover what is useful for his own purposes and to maintain logical links in this sometimes heterogeneous world. This chapter will deal with microcontrollers (from low to medium end), fieldbus, sensors and conditioning, and with the world of actuators and motor control, which could be discussed separately, but it is part of this chapter as it is intended peculiar of any field layer.

LOW AND MEDIUM-END MCUS FOR LOCAL CONTROL

This section highlights the devices commonly used in this layer. Traditionally, this is the field of simple control tasks, where a minimum set of peripherals and no great computational capacity is required for the control stage. Our powerful 8-bit MCU family is ideal here, while the STM32 F0 and L1 series from ST's 32-bit STM32 family finds a place in cost-effective, field layer applications.

A few examples for the industrial environment from our portfolio of around 120 devices are provided below (www.st.com/stm8s). The STM8L series, ST's 8-bit ultra-low-power MCU family, is proposed with devices embedding an LCD display controller (4 x 44/8 x 40) (www.st.com/stm8l).

The next chapter, dedicated to the control layer, gives an extended outlook of our MCU portfolio, where, following the philosophy of this document, MCUs with most advanced features and capabilities are introduced.

Part number	Flash size (Kbytes)	Internal RAM size (Kbytes)	Data EEPROM (bytes)	Package	Timer functions		ADC	DAC	I/Os	Serial interface				Supply voltage (V)	Supply current (I_{CC})		Maximum operating temperature range (°C)
					16-/32-bit timers	Others				CAN	SPI	I²C	UART (IrDA, ISO 7816)		Lowest power mode (µA)	Run mode (per MHz) (µA)	
STM8S003/005/007 Value line – 16 MHz CPU																	
STM8S003F3	8	1	128	TSSOP20, UFQFPN20	1x8-bit, 2x16-bit	2 x WDG, beeper	5x10-bit		16		1	1	1	2.95 to 5.5	230	421	-40 to +85
STM8S007C8	64	6	128	LQFP48	1x8-bit, 3x16-bit		10x10-bit		38		1	1	2	2.95 to 5.5	500	421	
STM8S103/105 Access line – 16 MHz CPU																	
STM8S103F2	4	1	640	SO20, TSSOP20, UFQFPN20	1x8-bit, 2x16-bit	2 x WDG, beeper	5x10-bit		16		1	1	1	2.95 to 5.5	5	230	-40 to +125
STM8S105C4	16	2	1024	LQFP48	1x8-bit, 3x16-bit		10x10-bit		38		1	1	1	2.95 to 5.5	5	430	
STM8S105S6	32	2	1024	LQFP44	1x8-bit, 3x16-bit		9x10-bit		34		1	1	1	2.95 to 5.5	5	430	
STM8S207/208 Performance line - 24 MHz CPU																	
STM8S207C6	32	6	1024	LQFP48	1x8-bit, 3x16-bit	2 x WDG, beeper	10x10-bit		38		1	1	2	2.95 to 5.5	5	500	-40 to +125
STM8S208C6	32	6	2048	LQFP48	1x8-bit, 3x16-bit		10x10-bit		38	1	1	1	2	2.95 to 5.5	5	500	
STM8S207M8	64	6	2048	LQFP80	1x8-bit, 3x16-bit		16x10-bit		68		1	1	2	2.95 to 5.5	5	500	
STM8S208R8	64	6	2048	LQFP64	1x8-bit, 3x16-bit		16x10-bit		52	1	1	1	2	2.95 to 5.5	5	500	
STM8S208RB	128	6	2048	LQFP64	1x8-bit, 3x16-bit		16x10-bit		52	1	1	1	2	2.95 to 5.5	5	500	
STM8S903 Application specific line - 16 MHz CPU																	
STM8S903F3	8	1	640	SO20, TSSOP20, UFQFPN20	1x8-bit, 2x16-bit	2 x WDG, beeper	5x10-bit		16		1	1	1	2.95 to 5.5	5	230	-40 to +125
STM8L series – ultra-low-power MCUs - 16 MHz CPU																	
STM8L151C2	4	1	256	LQFP48	1x8-bit, 2x16-bit	2 x WDG, AWU, RTC, beeper	28x12-bit		41		1	1	1	1.65 to 3.6	0.35	180	-40 to +125
STM8L152M8*	64	4	2048	LQFP80	1x8-bit, 4x16-bit		28x12-bit	2x12-bit	68		2	1	3	1.65 to 3.6	0.4	200	
STM8L162M8	64	4	2048	LQFP80	1x8-bit, 4x16-bit		28x12-bit	2x12-bit	68		2	1	3	1.65 to 3.6	0.4	200	
STM8L162R8	64	4	2048	LQFP64	1x8-bit, 4x16-bit		28x12-bit	2x12-bit	54		2	1	3	1.65 to 3.6	0.4	200	

Note: * this device is provided with a 4 x 44/8 x 40 display controller (LCD)

INDUSTRIAL COMMUNICATION

We look here at the devices and solutions to implement field buses. Architectures are based around MCUs and DSPs, and the following considerations are fundamental:

- Flexibility for the different protocols
- Real-time implementation
- Functional safety of the solution
- Power and space versus cost

These considerations result in the final implementation which can have different levels of scalability:

- MCU: lowest implementation cost
- MCU + FPGA: the use of an FPGA as glue logic enhances protocol flexibility and I/O extension
- MCU + ASIC or ASSP: a dedicated platform is often the result of consortium choices in building new standards
- System-on-chip: optimized solution resulting in best efficiency and performance

sercos the automation bus

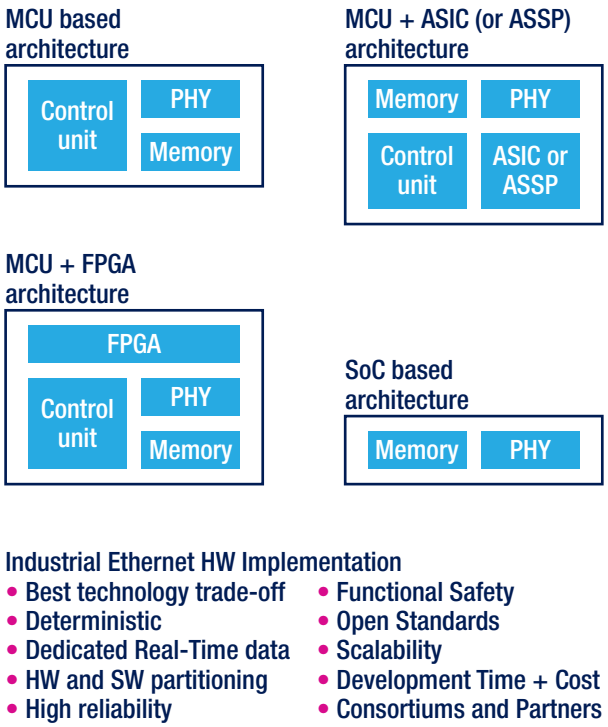
CANopen

PROFINET®

EtherCAT®

EtherNet/IP®

ETHERNET POWERLINK



Industrial Ethernet HW Implementation

- Best technology trade-off
- Deterministic
- Dedicated Real-Time data
- HW and SW partitioning
- High reliability
- Functional Safety
- Open Standards
- Scalability
- Development Time + Cost
- Consortiums and Partners

The diagram above is an attempt to define a very complex scenario, focusing on the four main architectural concepts previously introduced.

For designers involved in developing an industrial protocol stack, the question often concerns which MCU has the features that best fit the required protocol. To answer this question, we provide here a complete list of the industrial solutions with application field, provider and solution name (the protocol to be implemented), first for the STM32 family and then for our STM8 MCUs.

INDUSTRIAL COMMUNICATION SOLUTIONS WITH STM32 MCUS

Solution name	Provider	Application	Model	Cost
CANopen	eCosCentric	Factory Automation	Sources	License
CANopen	IXXAT	Automation, Medical	Source	License
CANopen	MicroControl	Factory Automation	Binaries	License + royalties
CANopen	Port	Factory Automation	Source	License
DALI	ST	Lighting	Source	Free
DeviceNet	IXXAT	Factory Automation	Source	License
DeviceNet	MicroControl	Factory Automation	Binaries	License + royalties
DeviceNet	Port	Factory Automation	Source	License
DLMS/COSEM	Andrea Informatique	Metering	Binaries	License
DMX	ST	Lighting/Home Building Automation	Source	Free
eCosPro-CAN	eCosCentric	Factory Automation	Sources	License
EtherCAT	IXXAT	Factory Automation	Source	License
EtherCAT	MicroControl	Factory Automation	Binaries	License + royalties
EtherCAT1	Port	Factory Automation	Source	License
Ethernet/IP	IXXAT	Factory Automation	Source	License
Ethernet/IP[1]	Port	Factory Automation	Source	License
Ethernet/IP	TMG	Factory Automation	Source	License + royalties
HART Master/Slave	MESCO	Process Automation	Source	License + royalties
IEEE 1588 PTP	IXXAT	Factory Automation	Source	License
IO-Link	TEConcept	Factory Automation	Binaries	License + royalties
IO-Link	TEConcept	Factory Automation	Source	License
J1939	IXXAT	Commercial vehicles	Source	License
Modbus	MESCO	Factory Automation	Source	License + royalties
Modbus RTU/ASCII	Embedded Solutions	Factory Automation	Binaries	License + royalties
Modbus RTU/ASCII	Port	Factory Automation	Source	License
Modbus TCP	IXXAT	Factory Automation	Source	License
Modbus TCP[1]	Port	Factory Automation	Source	License
µC/Modbus	Micrium	Factory Automation	Source	License
OPC-UA server	Embedded Labs	Factory and Building Automation	Binaries	License + royalties
openSAFETY	IXXAT	Factory Automation	Open source	Free
POWERLINK	IXXAT	Factory Automation	Source	License
POWERLINK[1]	Port	Factory Automation	Source	License
Profibus PA	MESCO	Factory Automation	Binaries	License + royalties
Profibus DP and PA	TEConcept	Factory Automation	Source	License
PROFINET	IXXAT	Factory Automation	Source	License
PROFINET	Port	Factory Automation	Source	License
PROFINET	TMG	Factory Automation	Source	License + royalties
PTPd	PTPd	Factory Automation	Open source (BSD)[2]	free
Sercos III	IXXAT	Factory Automation	Source	License

Note: 1: With external MAC or with ESC1100/1200 (EtherCAT)
2: PTPd ported on STM32 by ST

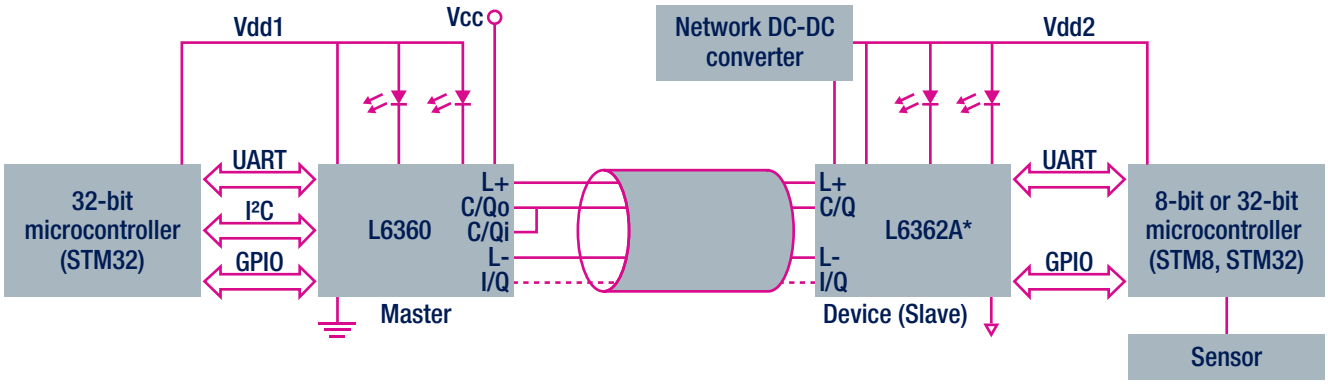
INDUSTRIAL COMMUNICATION SOLUTIONS WITH STM8 MCUS

Solution name	Provider	Application	Model	Cost
DALI	ST	Lighting	Source	Free
IO-Link	TEConcept	Factory automation	Binaries	License
IO-Link	TEConcept	Factory automation	Source	License
KNX	TAPKO	Building automation	Binaries	License + royalties

IO-LINK

In the industrial communication field, we would dedicate a special mention to the IO-Link protocol. Even if we are talking about a P2P communication, the effort spent in the last years in designing ICs both for Master and the Device side (as it is called the Slave side in the IO-Link domain) with the most advanced ST technologies, as well as the increasing importance this standard is covering in the industrial environments, give us the chance to put it in evidence.

The L6360 and L6362A* are the key products in the implementation of the IO-Link communication standard, inherent to the field layer.



Using our MultiPower BCD technology that allows the design of the logic part, and robust LV power MOSFETs in the same chip, ST offers an efficient, compact and cost-effective solution to drive any 3-wire digital sensor.

Modern sensors and actuators require:

- Remote service
- Standardization
- Sensor functionality verification
- Diagnostics
- Monitoring

The L6360 and L6362A* I/O industrial transceiver ICs meet all these requirements. These new ICs offer the market IO-Link sensors/actuators that work without special cables (standard M8 or M12 cables and connectors can be used). They feature an advanced solution that can be integrated even in old systems, that is neutral to any field bus, and keeps P2P communication.

Industrial transceiver ICs are designed to be compliant with burst tests, surge tests and ESD immunity tests, based on the IO-Link specification and SIO mode requirements.

Part number	Supply voltage (V)	V_{DD} (V)	Output current (A)	I_{max} linear reg. (mA)	Technology	Output channels	Input channels	Package
L6360 (Master)	18 to 32.5	3.3/5	0.5	65	Multipower BCD	2	2	QFN 26L 3.5 x 5
L6362A* (Device)	5 to 40	3.3/5	0.2	8	Multipower BCD	1	1	DFN 12L 3 x 3

In the following table, product evaluation boards are listed.

Order code	Description	Application notes
STEVAL-IFP016V2	IO-Link communication master transceiver demonstration board based on the L6360	AN4075
STEVAL-IFP017V2*	IO-Link communication device transceiver demonstration board based on the L6362A	-

Note: * under development

MONITORING AND SENSING

MEMS motion sensors

ST's MEMS (micro electromechanical sensors) portfolio includes accelerometers, gyroscopes, digital compasses and inertial modules (www.st.com/mems). ST is a worldwide leader in these devices thanks to:

- A unique sensor portfolio, from discrete to fully-integrated solutions, to meet every design need
- High-volume manufacturing capacity to provide cost-competitive solutions, fast time-to-market and security of supply
- High performance sensor fusion to improve the accuracy of multi-axis sensor systems to enable new emerging and highly demanding applications, such as indoor navigation and location based services
- High-level quality products, already tested in different application fields, including mobile, portable, gaming, consumer, automotive, healthcare and industrial segments (more than 3 billion pieces shipped worldwide)
- Multiple dedicated sites for MEMS foundry, assembly and testing lines, with complete in-house dual sourcing MEMS motion sensors (accelerometers, gyroscopes, digital compasses and inertial modules) are finding uses in advanced industrial applications, including:
  - Robotics and automation (accelerometers, gyroscopes)
    - Inertial navigation, to increase the accuracy of wheel encoders, self-balance robots
    - Condition monitoring of industrial equipment and transportation (high g accelerometers)
  - Asset and parcel tracking and monitoring (high g accelerometers, gyroscopes)
    - Impact detection and logging
  - Building and structure monitoring (accelerometers)
    - Vibration and tilt monitoring
  - Seismic exploration and geophones/idrophones (accelerometers)
    - Vibration monitoring
  - Drill (accelerometers, gyroscopes)
    - Safety, detecting excessive rotation on the body of the drill if chuck gets stuck
    - Tilt detection

Part number	Full scale	Noise density (Typ.)	Package size (mm)	Key features
Accelerometers				
LIS3DH	±2, ±4, ±8, ±16 g	220 µg/√Hz	3 x 3 x 1 LGA-16	12-bit, embedded FIFO
LIS3DSH	±2, ±4, ±8, ±16 g	150 µg/√Hz	3 x 3 x 1 LGA-16	16-bit, state machine, embedded FIFO
LIS331HH	±6, ±12, ±24 g	650 µg/√Hz	3 x 3 x 1 LGA-16	16-bit, up to ±24g full scale
H3LIS331DL	±100, ±200, ±400 g	1500 µg/√Hz	3 x 3 x 1 TFLGA-16L	16-bit, up to ±400g full scale, high shock survivability
LIS344ALH	±2, ±6 g	50 µg/√Hz	4 x 4 x 1.5 LGA-16L	Analog output
LIS2DH12	±2, ±4, ±8, ±16 g	220 µg/√Hz	2 x 2 x 1 LGA-12L	12-bit, embedded FIFO, board-compatible with compasses
Gyroscopes				
L3GD20H	±250, ±500, ±2000 dps	0.011 °/s/√Hz	3 x 3 x 1 LGA-16L	16 bit, immunity to audio noise, embedded FIFO
Magnetometer				
LIS3MDL	±4/ ±8/ ±12/ ±16 gauss	X, Y axes: 3.2* mgauss Z axis: 4.1* mgauss	2 x 2 x 1 LGA-12	16-bit data output, interrupt generator, self-test
Inertial modules				
LSM6DS0	±2, ±4, ±8, ±16 g ±250, ±500, ±2000 dps	80 µg/√Hz 0.016 °/s/√Hz	3 x 3 x 0.8 LGA-16L	6-axis system in package (SiP) compact and easy-to-assemble solution, with embedded FIFO, temperature sensor and programmable interrupt generators
INEMO-M1	±2, ±4, ±8, ±16 g ±250, ±500, ±2000 dps ±1.3 to ±8.1 Gauss	220 µg/√Hz 0.03 °/s/√Hz 2 mgauss (resolution)	13 x 13 x 2 PCB	9-axis system on board (SoB) with all the features and power of the STM32F103 32-bit MCU in a solderable small module
LSM9DS1	±2, ±4, ±8, ±16 g ±250, ±500, ±2000 dps ±4, ±8, ±12, ±16 gauss	80 µg/√Hz 0.016 °/s/√Hz 3.5 mgauss	3.5 x 3 x 1 LGA-24L	9-axis system in package (SiP) compact and easy-to-assemble solution, with embedded FIFO, temperature sensor and programmable interrupt generators
Digital compasses				
LSM303C	±2, ±4, ±8 g ±16 gauss	150 µg/√Hz 3.5 mgauss	2 x 2 x 1 LGA-12L	eCompass system in package (SiP) with embedded FIFO, temperature sensor and programmable interrupt generators. Board and software compatible with the latest generation of accelerometers, to offer maximum design flexibility

iNEMO® software engine features motion multi-sensor data fusion

The iNEMO® engine sensor fusion suite is a filtering and predictive software. It uses advanced algorithms to integrate outputs from multiple MEMS sensors in a smart way, independent of environmental conditions, to reach the best performance. Real-time motion-sensor data fusion is set to significantly improve the user experience, increasing accuracy, resolution, stability and response time in advanced motion-based applications in consumer, computer, industrial and medical fields. The iNEMO® engine can be combined with ST's iNEMO® inertial modules to create the industry's first complete and customizable hardware/software multi-axis MEMS sensor solutions for enhanced motion and accurate heading recognition. Equipment manufacturers across different market segments can now easily and quickly deploy robust and reliable high-performance motion detection systems with up to 10 degrees of freedom, comprising 3-axis sensing of linear, angular, and magnetic motion with barometer/altitude readings from a pressure sensor, enabling true augmented-reality applications.

www.st.com/inemo-engine

BENEFITS

- Absolute point tracking and motion tracking accuracy
- Immunity to magnetic interference for high performance in real-world conditions
- Few user-calibration interruptions, enabling innovative and longer game play
- Reliable compass heading for accurate navigation
- Accurate direction, enabling true augmented-reality applications

LIST OF iNEMO® SOFTWARE ENGINES:

Software version	Description	Sensor fusion library code
INEMO-ENG-M1LI3	LITE version for INEMO-M1: Based on the Kalman filter theory applied to MEMS sensors, iNEMO® M1 lite software library is a free source code that could be used for the STM32 and for customizable HW/SW solutions.	Source code
iNEMOENgine_PW8	Pro version: This firmware running on the STM32 manages sensors on Windows 8 using the standard human interface devices (HID) over USB/I²C. Allows sensor plug-and-play recognition and new application development using Windows 8 standard APIs. (Compatible with Intel x86 and ARM processors).	Compiled code
iNEMOEngine_PI3P Platform independent	Pro version: This firmware allows you to develop new custom applications running on the STM32 or to collect real-time sensor fusion data thorough Virtual COM from any platform (platform independent).	Compiled code
iNEMOENgine_PAAP	Pro version: This is a complete solution to support Android platforms by providing the hardware abstraction layer, sensor drivers and sensor fusion library.	Compiled code

MEMS sensor evaluation kit

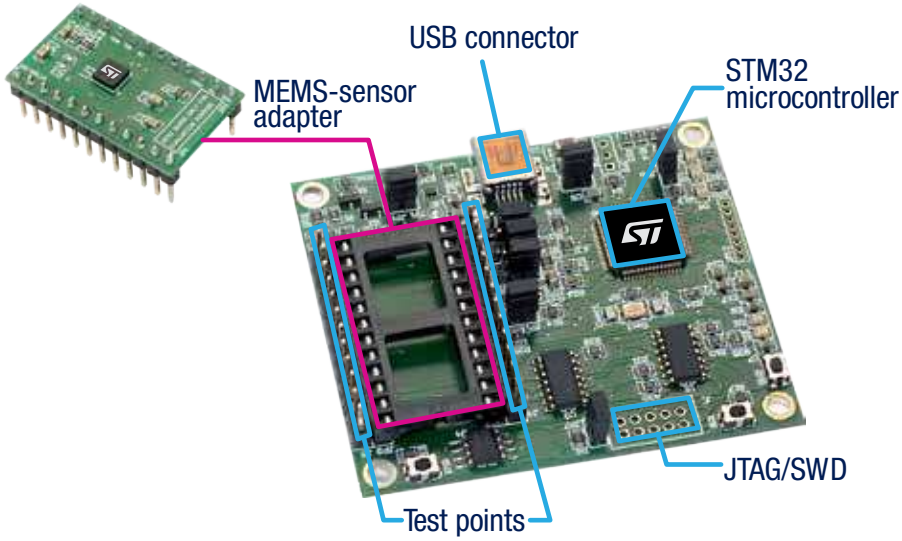
ST has deep expertise in sensor integration and new application development and can assist customers in design-in. ST's evaluation kits and firmware allow real-time evaluation of sensor performance in customer applications.

(www.st.com/mems-boards) and (www.st.com/mems-drivers)

EVALUATION KIT

ST offers a complete evaluation kit including:

- A motherboard compatible with all ST MEMS adapters, based on a high-performance 32-bit microcontroller (order code: STEVAL-MKI109V2)
- A full set of MEMS sensor adapters, that are complementary to the motherboard and can mount all sensors
- An innovative graphic user interface for direct and real-time access to the sensor configuration registers



Part number	Description	Board type
STEVAL-MKI119V1	Motherboard + adapter board: STEVAL-MKI119V1 kit includes STEVAL-MKI109V2 (motherboard) + STEVAL-MKI108V2 (9-axis module, L3GD20 and LSM303DLHC)	Development kit
STEVAL-MKI109V2	MEMS motherboard is based on STM32F103 high performance ARM 32-bit Cortex®-M3 MCU. Interfaces: USB connector, JTAG/SWD for debug. Ready to support iNEMO® Engine. DFU compatible for USB microprocessor firmware update, compatible with all ST MEMS adapters	Motherboard
STEVAL-MKI115V1	The system is ready for any wireless extension and external Bluetooth dongle is available	Extender board
STEVAL-MKI121V1	Evaluation board for INEMO(R)-M1 that includes an LPS331AP pressure sensor representing a complete 10-DoF open platform. USB and SWD connectors for debugging and programming	Discovery-M1
X-NUCLEO-IKS01A1	Expansion board for STM32-Nucleo universal hardware platform. It embeds 9-axis Motion sensors, Pressure, Humidity and Temperature sensors. It can be extended with a large variety of DIL24 Sensor adapters	Nucleo shield extender board

Temperature sensors

STMicroelectronics' temperature sensors include both analog and digital temperature sensor ICs. Both types are suitable for use in a wide range of applications, including the industrial segment. (www.st.com/tempsensors)

Part number	Full scale	Type	Resolution	Key features	Package size (mm)
STLM20	-55 to +130 °C	Analog	Accuracy: 1.5 °C max at 25 °C (±0.5 °C typ)	Ultra-low current 2.4 V precision analog temperature sensor	1 x 1.3 x 0.5 UDFN-4L 2 x 2.1 SOT323-5L
STTS751	-40 to +125 °C	Digital	Accuracy: ±1.0 °C (typ) 0 °C to +85 °C, ±2.0 °C (typ) -40 °C to +125 °C	2.25 V low-voltage local digital temperature sensor	2 x 2 x 0.5 UDFN-6L 2.9 x 2.8 SOT23-6L

Proximity detectors

Proximity sensors fall into three main categories: capacitive sensors, inductive sensors, and ultrasonic sensors.

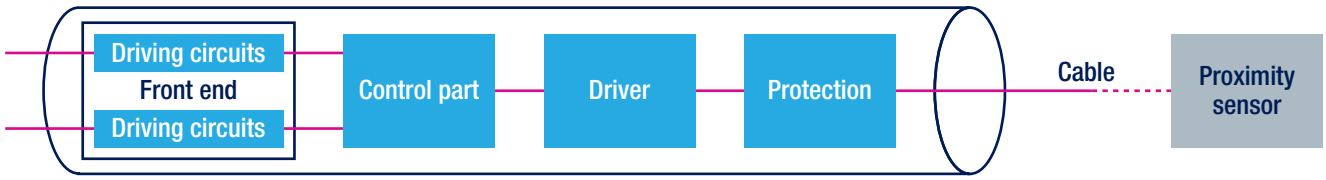
IO-Link technology is the first standardized IO technology worldwide (IEC 61131-9) for communication with these sensors, as well as actuators.

This powerful point-to-point communication is based on the long established 3-wire sensor and actuator connection, without additional requirements regarding the cable material. ST has developed physical layer interfaces according to the IO-Link system specification supporting this technology.

With our MCU families STM8 and STM32 plus IO-link stack, ST offers a unique product spectrum for this future technology.

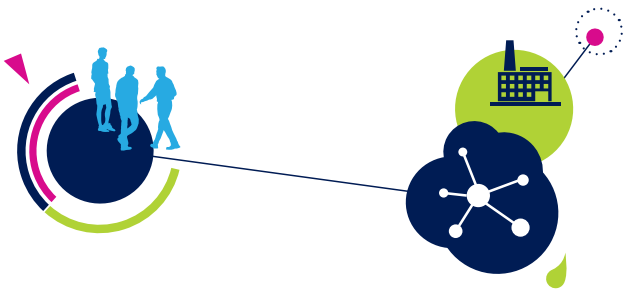
The simplified block diagram below presents a complete system compliant with the IEC 60947-5-2 design recommendation. ST offers, for the front end block, BCD smart-power technology, able to match most ASIC specifications.

Inductive proximity detectors block diagram



Part number	Function	Description	Package
STM8L	Control unit	8-bit MCU	LQFP, TFBGA, TSSOP 20, UFQFPN, WLCSP
STM32F0		32-bit MCU	LQFP, TSSOP 20, UFQFPN
TDE1707	Driver	Intelligent power switches	SO8
TDE1708DFT			DFN 4x4mm
L6362A*	Transceiver	IO-Link device	DFN 12L 3x3mm
SPT01-335DEE	Protection	Triple diode array for power bus protection	QFN3x3-6L 3x3x1 mm
SPT02-236DDB		Double diode array for switch protection and reverse blocking	µQFN-2L 3.3x1.5x0.8 mm

Note: * under development



ACTUATORS AND MOTOR CONTROL

Motor driving: performance, integration and efficiency for leading motion control solutions

ST offers a wide selection of ICs dedicated to motion control to match at best an application spectrum that spans widely across power ratings and motor types, not to mention system partitioning. All products have comprehensive built-in protection and diagnostic schemes to help attain the level of long term reliability and robustness requested to cope with the harsh factory automation environment.
To begin with this, a large selection within the different functional blocks is offered:

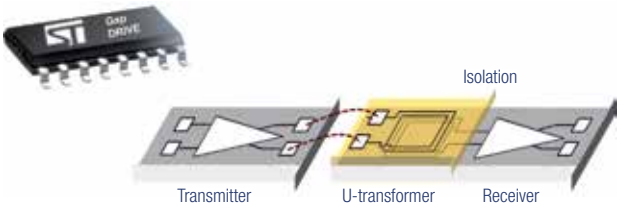
Fully integrated motor drivers, with a portfolio to cover stepper and three phase BLDC motors now expanding from monolithic to flat package modules with the new powerSTEP, packing and 85 V/10 A driver into a small form factor 14x11 mm QFN package.

Controllers and gate drivers, comprising single chip combination of high performance micro-stepping control with 85 V rated power MOSFET drivers.

Integrated power stages, with a range of full (H-bridge), dual full bridge and three phase bridges available in a number of package choices to fit at best the power ratings of the application.

MOSFET/IGBT drivers with a complete line up of high voltage (650 V) half-bridge drivers with added functionalities like comparators and op amps, now further expanding with the new STGAP1S galvanically isolated single IGBT driver rated 1.5 KV, including an extensive set of features to tailor solutions for the upper end power range.

- Input to output propagation delay: < 150 ns
- High-voltage rail: up to 1.5 kV
- Positive drive voltage: up to 36 V
- Driver current capability: 5 A sink, source current at 25 °C
- SPI interface for parameter programming and diagnostics, daisy chaining possibility
- Active Miller clamp and desaturation detection
- Overcurrent and over-temperature protection
- Output 2-level turn off



To give an idea of our products' range, a list motor driving ICs is reported.

Part number	Description	Package	$R_{DS(on)}$ (Ω)	Supply Voltage max (V)	Output Current RMS max (A)	Application
powerSTEP	System-in-package integrating microstepping controller and 10 A power MOSFETs	QFN 11x14	0.016	85	10	Stepper motor
L6470	Microstepping motor driver with motion engine and SPI	HTSSOP28; PowerSO 36	0.3	45	3	Stepper motor
L6472	Microstepping motor driver with motion engine and SPI	HTSSOP28; PowerSO 36	0.3	45	3	Stepper motor
L6480	Microstepping motor controller with motion engine and SPI	HTSSOP38	-	85	-	Stepper motor
L6482	Microstepping motor controller with motion engine and SPI	HTSSOP38	-	85	-	Stepper motor
L6474	Fully integrated microstepping motor driver	HTSSOP28; PowerSO 36	0.3	45	3	Stepper motor
L6460	SPI configurable stepper and DC multi motor driver	TQFP 64 10x10x1.0	0.3	38	2.5	Stepper motor
L6208	Fully Integrated Stepper Motor Driver	PDIP 24 .3; PowerSO 36; SO-24; VFQFPN 48 7x7x1.0	0.3	52	2.8	Stepper motor
L6228	DMOS Dual Full Bridge Driver With PWM current controller and decay selection	PDIP 24 .3; PowerSO 36; SO-24; VFQFPN 32 5x5x1.0	0.7	52	1.4	Stepper motor
L6506	Current controller for stepper motors	PDIP 18; SO-20	62	7	-	Stepper motor
L297	Stepper Motor Controller	PDIP 20; SO-20	-	7	-	Stepper motor
L6201	DMOS Full Bridge Driver	PowerSO-20; SO-20	0.3	48	1	DC Motor

Part number	Description	Package	$R_{DS(on)}$ (Ω)	Supply Voltage max (V)	Output Current RMS max (A)	Application
L6202	DMOS Full Bridge Driver	PDIP 18	0.3	48	1	DC Motor
L6203	DMOS Full Bridge Driver	MW 11L	0.3	48	1	DC Motor
L6205	Dual DMOS Full Bridge Driver	PDIP 20; PowerSO-20; SO-20	0.3	52	2.8	DC/Stepper motor
L6206	Dual DMOS Full Bridge Driver with Diagnostic	PDIP 24 .3; PowerSO 36; SO-24; VFQFPN 48 7x7x1.0	0.3	52	2.8	DC/Stepper motor
L6207	Dual DMOS Full Bridge Driver with PWM Current Controller	PDIP 24 .3; PowerSO 36; SO-24; VFQFPN 48 7x7x1.0	0.3	52	2.8	DC/Stepper motor
L6225	DMOS Dual Full Bridge Driver	PDIP 20; PowerSO-20; SO-20	0.7	52	1.4	DC/Stepper motor
L6226	DMOS Dual Full Bridge Driver with Diagnostic	PDIP 24 .3; PowerSO 36; SO-24; VFQFPN 32 5x5x1.0	0.7	52	1.4	DC/Stepper motor
L6227	DMOS Dual Full Bridge Driver With PWM Current Controller	PDIP 24 .3; PowerSO 36; SO-24; VFQFPN 32 5x5x1.0	0.7	52	1.4	DC/Stepper motor
L298	Dual Full Bridge Driver	MW 15L; PowerSO-20	-	36	2	DC/Stepper motor
L293D	Dual Full Bridges with Diodes and Thermal Protection; Push-Pull Four Channel Drivers with Diodes	PDIP 16; SO-20	-	36	0.6	DC/Stepper motor
L293E	Push-Pull Four Channel Drivers	PDIP 20	-	36	1	DC/Stepper motor
L293B	Push-Pull Four Channel Drivers	PDIP 16	-	36	1	DC/Stepper motor
L2293Q	Dual Bridge Driver with Thermal protection	VFQFPN 32 5x5x1.0	-	36	0.6	DC Motor
L6229	DMOS driver for three-phase brushless DC motor	PDIP 24 .3; PowerSO 36; SO-24; VFQFPN 32 5x5x1.0	0.7	52	1.4	BLDC Motor
L6230	DMOS driver for three-phase brushless DC motor	PowerSO 36; VFQFPN 32 5x5x1.0	0.7	52	1.4	BLDC Motor
L6234	Three Phase Motor Driver	PDIP 20; PowerSO-20	0.3	52	2.8	BLDC Motor
L6235	Three Phase Brushless DC Motor Driver	PDIP 24 .3; PowerSO 36; SO-24; VFQFPN 48 7x7x1.0	0.3	52	2.8	BLDC Motor

MOSFET AND IGBT DRIVERS' PRODUCT TABLE

Part number	Logic interface		V_{CC} max (V)	UVLO on V_{CC} (V)	UVLO on V_{BOOT} (V)	Interlocking - DT (µs)	Op amp	Comparator	# pins
	Input configuration	Configuration							
Half-bridge drivers									
L6384E	Single in, SD	5, 15 V	18	10/12	-	0.5 ÷ 2.7	No	No	8
L6385E	HIN and LIN	5, 15 V	18	8.3/9.6	8.2/9.5	-	No	No	8
L6386E L6386AD	HIN, LIN, SD	5, 15 V	18	10/12 8.3/9.6	9.9/11.9 8.2/9.5	9.9/11.9	No	Yes, uncommitted	14
L6387E	HIN and LIN	5, 15 V	18	5.5/6	-	Interlocking	No	No	8
L6388E	HIN and LIN	3.3, 5, 15 V	18	8.3/9.6	8.2/9.5	0.32	No	No	8
L6390	HIN, LIN, SD	3.3, 5, 15 V	21	10.5/12	10/11.5	0.18 ÷ 3	Yes	Yes, committed to fault + SSD	16
L6391	HIN, LIN, SD	3.3, 5, 15 V	21	10.5/12	10/11.5	0.18 ÷ 3	No	Committed to fault + SSD	14
L6392	HIN, LIN, SD	3.3, 5, 15 V	21	10.5/12	10/11.5	0.18 ÷ 3	Yes	No	14
L6393	Phase, brake, SD	3.3, 5, 15 V	21	8.0/9.5	8/9	0.18 ÷ 3	No	Yes, uncommitted	14
L6395	HIN and LIN	3.3, 5, 15 V	20	8.8/9.5	8/8.6	-	No	No	8
L6398	HIN and LIN	3.3, 5, 15 V	21	8.0/9.5	8/9	0.32	No	No	8
Single-channel drivers									
TD350E	Single in (opto/pulse trans compatible)	5 V	26	11	-	-	No	-	14
TD351	Single in (opto/pulse trans compatible	5 V	26	11	-	-	No	No	8
TD352	Single in (opto compatible)	5 V	26	11	-	-	No	No	8

A complete ecosystem to ease your designs

Designing motor control applications becomes much easier with the outstanding performance, features and full support of ST's portfolio of motor drivers making DC, stepper and brushless motor control designs more efficient in a variety of applications such as:

- Industrial robotics
- Textile, sewing and pick and place machines
- Stage lighting
- Printers
- Points-of-sale, ATM, vending machines
- Medical
- Security and surveillance

A complete offering of evaluation boards is provided, together with low cost plug and play discovery kits: ideal development tool for both beginners and experienced users, it is autonomous and can be used with a software interface or with a custom firmware thanks to the embedded microcontroller.

Schematics, BOM and Gerber files are available for facilitating your hardware design together with comprehensive technical documentation.

Software suites are also provided to enable quick and easy development of motor driving solutions.

For more information and free download, visit: www.st.com/stmotorcontrol

Part Number	Description	Core Product
X-NUCLEO-IHM01A1	Stepper motor driver expansion board for STM32 Nucleo	L6474PD
EVLPOWERSTEP01	System-in-package integrating micro-stepping controller and 10 A power MOSFETs	POWERSTEP01
EVAL6470H	Fully integrated stepper motor driver	L6470
EVAL6470H-DISC	Discovery kit: development tool to explore L6470 motor driver	L6470
EVAL6470PD	Fully integrated stepper motor driver mounting the L6470 in a high power PowerSO package	L6470
EVAL6472H	Fully integrated stepper motor driver based on the L6472	L6472
EVAL6472H-DISC	Discovery kit: development tool to explore L6472 motor driver	L6472
EVAL6472PD	Fully integrated stepper motor driver mounting the L6472 in a high power PowerSO package	L6472
EVAL6474H	Stepper motor driver mounting the L6474	L6474
EVAL6474PD	Stepper motor driver mounting the L6474 in high power PowerSO package	L6474
EVAL6480H	Fully integrated micro-stepping motor controller with motion engine and SPI	L6480H
EVAL6482H	Fully integrated micro-stepping motor controller with motion engine and SPI	L6482H
EVAL6460	SPI configurable stepper and DC multi motor driver	L6460
EVAL-IBU-STR7	Control interface board dedicated to the EVAL6460	L6460, STR7
EVAL6205N	L6205 DMOS Dual Full Bridge Driver	L6205
EVAL6206N	L6206 DMOS Dual Full Bridge Driver in PowerDIP Package	L6206
EVAL6206PD	L6206 DMOS Dual Full Bridge Driver in PowerSO Package Evaluation Board	L6206
EVAL6206Q	Dual full bridge with programmable overcurrent	L6206Q
EVAL6207N	L6207N DMOS Dual Full Bridge Driver with PWM Current Controller	L6207
EVAL6207Q	Dual full bridge with integrated PWM current controllers	L6207Q
EVAL6208N	L6208 DMOS Driver for Bipolar Stepper Motor in PowerDip Package Evaluation board	L6208
EVAL6208PD	L6208 DMOS Driver for Bipolar Stepper Motor in PowerSO Package Evaluation board	L6208
EVAL6208Q	Stepper motor driver mounting the L6208Q	L6208Q
EVAL6225PD	L6225 DMOS Dual full bridge driver	L6225
EVAL6226QR	L6226Q Dual full-bridge driver	L6226Q
EVAL6227PD	L6227 DMOS Dual Full Bridge Driver with PWM Current Controller	L6227
EVAL6227QR	Demonstration board using a dual full-bridge L6227Q for motor control applications	L6227Q
EVAL6228QR	L6228Q: Dual full bridge with PWM current control and translator for stepper reference design board	L6228Q
EVAL6229PD	L6229 DMOS Driver for Three-Phase Brushless DC Motor	L6229
EVAL6229QR	L6229Q DMOS driver for a three-phase BLDC motor control application	L6229Q
EVAL6235N	L6235 DMOS Driver for Three-Phase Brushless DC Motor	L6235
EVAL6235PD	L6235 three-phase brushless DC motor driver	L6235
EVAL6235Q	Three phase BLDC motor driver mounting the L6235Q	L6235Q
EVAL6393FB	Low voltage full bridge reference design board featuring L6393 advanced high-voltage gate driver	L6393
EVAL2293Q	L2293Q push-pull four channel driver with integrated diodes	L2293Q
STEVAL-IKM001V1	Evaluation kit based on the L6470H	L6470H
EVALPRACTISPIN	PractiSPIN Interface Board	-
STEVAL-PCC009V2	IBU Motor Control & IPS universal interface	STM32F103RBT6

The expansion board X-NUCLEO-IHM01A1 is a plug and play solution based on L6474 micro-stepping motor driver, to benefit from easySPIN advanced current control with adaptive decay for smooth and silent motion.

Fully protected and SPI configurable for diagnostics easySPIN is ideal for driving 3D and professional printers, stage lighting, vending machines, industrial equipment and robotics.

The X-NUCLEO-IHM01A1 is compatible with the Arduino UNO R3 connector and easily stackable in order to drive up to three stepper motors with a single STM32 Nucleo board.

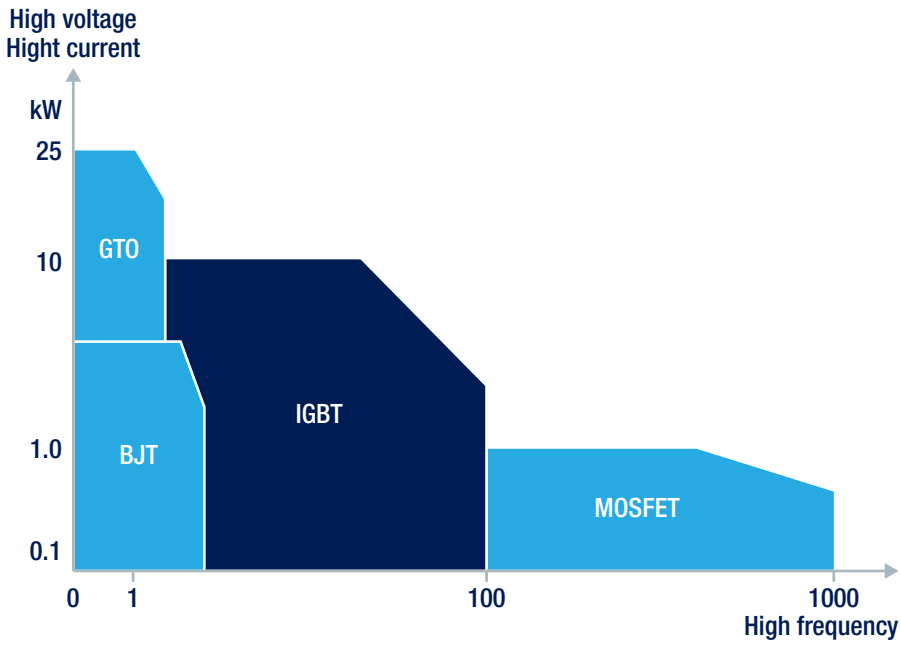
ST also provides a complete ecosystem for motor control, based on the STM32 MCU family, as it is deeply discussed in the Control layer chapter.

Power transistors

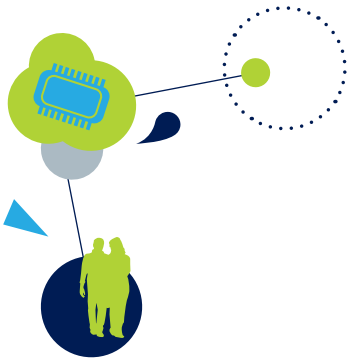
Leading-edge power technologies for low (<150 V), high (600/650 V) and very high voltage (1200 V and over) applications combined with a full package range and innovative die bonding technologies exemplify ST's innovation in power transistors.

Our portfolio includes MOSFETs ranging from -500 to 1500 V, silicon carbide (SiC) MOSFETs featuring the industry's highest temperature rating of 200 °C, IGBTs with breakdown voltages ranging from 350 to 1300 V and a wide range of power bipolar transistors.

For power applications up to 650 V, key ST technologies are the MDmesh™ M2 and MDmesh™ M5 (M2: best for LLC resonant converters with reduced switching losses through optimized Q_g, C_{iss}, C_{oss} and M5: the leading technology for hard switch, Industry's one of the lower $R_{DS(on)}$ in the Market)) for the MOSFETs and the V- and HB-series in Trench Field Stop technology for IGBTs, while the future is our GaN HEMT* (high electron mobility transistor) technology, approaching an ideal switch. This application range is also covered with our IGBTs in Trench Field Stop technology, with the "V" and the "HB" series.



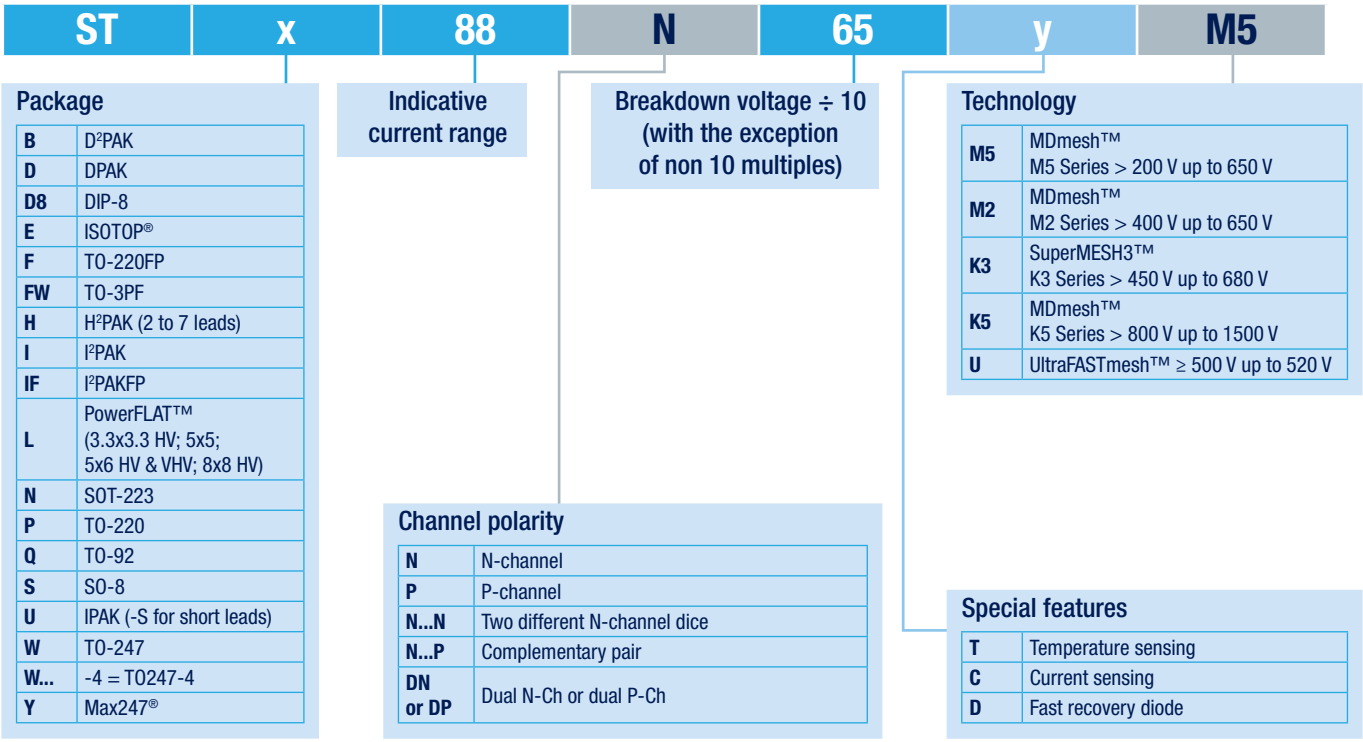
Very high voltage applications are traditionally the domain of IGBTs and now also of SiC MOSFETs. Newly developed technologies for Trench Field Stop IGBTs at 1200 V are the H-series for high frequency application and the M- and S-series respectively tailored for medium to low frequency motor control applications (all these series are 175 °C rated). SiC MOSFETs are addressed by a new technology with temperature ratings up to 200 °C.



Note: * in development

Power MOSFETs

ST's offering of power MOSFETs includes hundreds of devices. The table below presents a selection with different packages and our latest silicon technologies, with voltages up to 650 V (and over). The following diagram indicates part number assignment.



Part number	Package	V_{DSS} (V)	$R_{DS(on)}$ (@ V_{GS} = 10 V) max (Ω)	Drain current (Dc) (I_D) max (A)	Total power dissipation (PD) max (W)	Total gate charge (Q_g) V_{GS} = 4.5 V (nC)
STL220N3LLH7	PowerFLAT 5x6	30	0.0011	50	4.8	46
STH320N4F6-2	H2PAK-2	40	0.0013	200	300	160
STP160N4LF6	TO-220	40	0.0029	120	150	181
STP110N55F6	TO-220	55	0.0052	110	150	126
STP270N8F7	TO-220	80	0.0025	180	315	193
STH310N10F7	H2PAK-2L	100	0.0025	180	315	180
STD6N52K3	DPAK	400	1.2	4.4	70	17
STW36N55M5	TO-247	550	0.08	33	190	72
STY100NM60N	Max247	600	0.029	98	625	330
STW20N95K5	TO-247	950	0.33	17.5	250	40
STW6N120K3	TO-247	1200	2.4	6	150	34
STFW4N150	TO-3PF	1500	7	4	63	30

A wide choice of p-channel power MOSFETs, in a voltage range from -500 to -20 V, is also available (www.st.com/powermosfets).

Part number	Package	V_{DSS} (V)	$R_{DS(on)}$ (@ V_{GS} = 10 V) max (Ω)	Drain current (Dc) (I_D) max (A)	Total power dissipation (PD) max (W)	Total gate charge (Q_g) typ (nC)
STU10P6F6	IPAK	-60	0.16	-10	35	6.4
STL8P2UH7	SOT23-6L	-20	-	8	2.4	22

SiC MOSFETs

Based on the advanced and innovative properties of wide bandgap materials, ST's silicon carbide (SiC) MOSFETs feature very low $R_{DS(on)}$* area for the 1200 V rating combined with excellent switching performance, translating into more efficient and compact systems. Compared with silicon MOSFETs, SiC MOSFETs exhibit low on-state resistance* area even at high temperatures and excellent switching performances versus the best-in-class 1200 V IGBTs in all temperature ranges, simplifying the thermal design of power electronic systems.

The main features and benefits of our SiC MOSFETs include:

- Very high temperature handling capability (Tjmax = 200 °C) leading to reduced PCB form factors (simplified thermal management) as well as improved system reliability
- Significantly reduced switching losses (minimal variation versus temperature) resulting in more compact designs (with smaller passive components)
- Low on-state resistance (80 mΩ typical at 25 °C) resulting in higher system efficiency (reduced cooling requirements)
- Simple to drive (cost-effective network driving)
- Very fast and robust intrinsic body diode (no need for external freewheeling diode, thus more compact systems)

BV_{DSS} (V)	R_{DS} (Ω)	Max I_D (A)	Q_g (nC)	Sales Type	Main application	Packages
1200	0.1	45	103	SCT30N120	3-phase SMPS, Welding, Solar inverter, Motor control	H^2PAK, HiP247™

IGBTs

With breakdown voltages ranging from 350 V to 1300 V, ST's IGBTs feature the optimal trade-off between switching performance and on-state behavior due to their proprietary technology. They enable greater all round energy-efficient system designs in applications such as motor control, photovoltaics, UPS, automotive, induction heating, welding, lighting and others (www.st.com/igbt).

Some of the features of our IGBT portfolio are as follows:

- Low $V_{CE(SAT)}$ for reduced conduction losses
- Improved switch-off energy spread versus increasing temperature resulting in reduced switching losses
- Tight parameter distribution for design simplification and easy paralleling
- Co-packaged, tailored anti-parallel diode option for improved power dissipation and best thermal management

These IGBTs are based on both standard punch-through technology, ideal for white goods, and the newly introduced trench-gate field-stop technology which enables extremely fast turn-off times with minimal tail currents, stable behavior over temperature, and a low $V_{CE(SAT)}$ that, coupled with the positive de-rating with temperature, improves the applications' efficiency.

STG x 60 V 60 y DD F z

Package

B	D²PAK
D	DPAK
F	TO-220FP
FW	TO-3PF
I	I²PAK
L	PowerFLAT™ (8x8)
P	TO-220
Q	TO-92
S	SO-8
U	IPAK (-S for short leads)
W	TO-247
WT	TO-3P
Y	Max247®

Max continuos current @ 100 °C

Breakdown voltage ÷ 10

Technology generation

F	Trench gate field stop

IGBT technology speed

H	High speed (10 ÷ 35 kHz)
H...B	High speed improved (8 ÷ 50 kHz)
V	Very high speed (20 ÷ 120 kHz)
M	Low loss (up to 20 kHz)
S	Low drop (up to 4 kHz)

Special features

C	Current sensing
T	Temperature sensing
Z	Clamped by Zener diode
L	Logic level

Diode options

D	Very fast rescovery
DR	Ultra fast recovery
DL	Low fast voltage*

Note: * For soft switch applications only

Part number	BV_{CES} (V)	I_{CN} [1] (A)	$V_{CE(SAT)}$ [2] (V)	E_{off} [3] (mJ)	Max T_J (°C)	Switching frequency range	FRD option	Package						
								D²PAK	TO-220	TO-247	TO-3P	TO-247LL	Max247	TO-3PF
STGx30V60DF	600	30	1.85	0.23	175	V (20 - 120 kHz)	Very Fast	B	P	W	WT			FW
STGx40V60DF	600	40	1.8	0.41	175	V (20 - 120 kHz)	Very Fast			W	WT			FW
STGx60V60DF	600	60	1.85	0.55	175	V (20 - 120 kHz)	Very Fast			W	WT			
STGx40H65DFB	650	40	1.6	0.48	175	HB (8 - 50 kHz)	Very Fast			W	WT			
STGx60H65DFB	650	60	1.6	0.63	175	HB (8 - 50 kHz)	Very Fast			W	WT			
STGx80H65DFB	650	80	1.6	1.2	175	HB (8 - 50 kHz)	Very Fast			W	WT		Y	
STGx15H120DF2	1200	15	2.1	0.45	175	H (15 - 50 kHz)	Very Fast			W				
STGx25H120DF2	1200	25	2.1	0.8	175	H (15 - 50 kHz)	Very Fast			W				
STGx40H120DF2	1200	40	2.1	1.3	175	H (15 - 50 kHz)	Very Fast			W				
STGx15M120DF3	1200	15	1.85	0.9	175	M (4 - 20 kHz)	Soft, fast			W		WA		
STGx25M120DF3	1200	25	1.85	1.5	175	M (4 - 20 kHz)	Soft, fast			W		WA		
STGx40M120DF3	1200	40	1.85	2.3	175	M (4 - 20 kHz)	Soft, fast			W		WA		

Note: 1: I_{CN} : IGBT nominal collector current @ T_J = 100 °C
2: $V_{CE(SAT)}$: typical conduction losses @ I_{CN}, T_J = 25 °C
3: E_{off} : switching-off energy @ I_{CN}, T_J = 25 °C on capacitive load (33 nF)

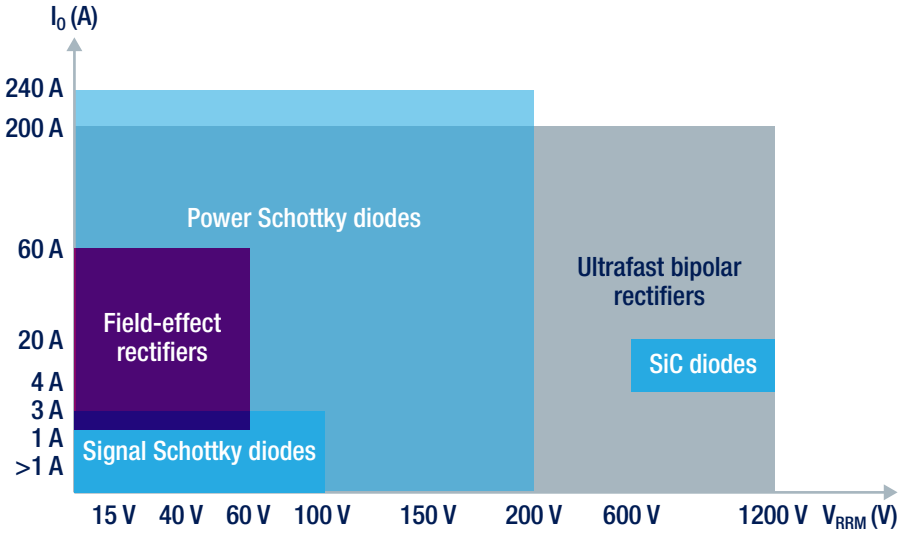
Diodes

We present here an overview of ST's diode offering. We recommend that you visit www.st.com/diodes, to get more information. The diagram below gives an idea of how many part numbers are available to fit all application needs.

ST offers Schottky and ultrafast rectifier solutions for all market requirements. ST's latest developments include our M series, based on Schottky technology, with improved avalanche rating and the integration of higher currents in low-profile PowerFLAT™ packages.

Our range of small-signal Schottky diodes with flip-chip and SOD-923 packages helps meet the most stringent space-saving requirements, especially for portable communication equipment.

For high-efficiency rectification or freewheeling functions, our new field effect rectifier diodes, the FERD family improve the power density capability of converters.



For power converter applications where silicon diodes reach the limits of their operating temperature and power density, ST's first- and second-generation silicon carbide devices offer optimal reliability.

ST	aa	bb	c	ddd	e	f	g	h

Technology

PS	Power Schottky
PSC	SiC
TH	Ultrafast

Current rating

Current: 0.5 A to 240 A

Code: 0.5 to 240

Connection type

Void	Two-lead configuration
C	dual common cathode
S	single in three-lead package

Automotive grade

Void	standard diode
-Y	automotive-grade diode

Series

For Schottky diodes (STPS)	
Void	medium V_F/I_H
H	high temperature (<120 V only)
L	low V_F from $I_0/2$ to I_0 (<120 V only)
M	low V_F from $I_0/4$ to $I_0 2$
S	low leakage current
SM	low V_F up to $I_0/4$
For ultrafast diodes (STTH)	
Void	medium V_F and Qrr
L	low V_F (600 V mainly)
R	low Qrr recovery
LCD transistor	transistor mode PFC
Nota:	R trade-off mainly used for 400 V and 600 V

Breakdown voltage

STPS (power Schottky)	
code:	V_{RRM} = 15 V to 600 V
STPSC (SiC)	
code:	V_{RRM} = 600 V
Void	first generation
H	Second generation with highet surge current capability
STPSC (SiC)	
code:	V_{RRM} divided by 100

200 V to 1200 V

02 to 12

Packing type

Through-hole packages	
Void	Axial: DO-41, DO-15, DO-201
D	TO-220AC
DI	TO-220I
T	TO-220AB
FP	TO-220FPAB
PI	DOP3I
R	I^2PAK
W	TO-247, DO-247
SMD packages	
A	SMA
U	SMB
S	SMC
B	DPAK
G	D^2PAK
TV1	ISOTOP (longitudinal)
TV2	ISOTOP (lateral)

Packing option

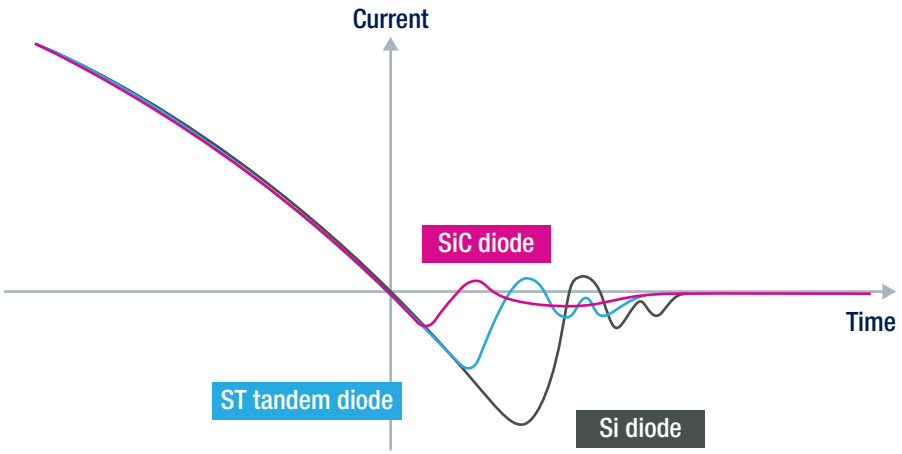
Void	for axis-bulk
Void	for SMA/B/C: tape and reel
Void	for other packages: tube
RL	tape and reel, for axial packages
TR	tape and reel, for other packages

ST's silicon-carbide diodes take advantage of SiC's superior physical characteristics over Si, with 4 times better dynamic characteristics and 15% less forward voltage, V_F.

Their low reverse recovery characteristics make ST's SiC diodes a key contributor to energy savings in SMPS applications and in emerging domains such as solar energy conversion, EV or HEV charging stations, and other applications such as welding equipment and air conditioners.

ST's SiC product portfolio includes a 20 A, 600 V diode, housed in a halogen-free TO-247 package, to extend its 4- to 12-amp, through-hole and SMD package offering.

ST's silicon-carbide diodes are now entering the second generation, with a 6 A, 1200 V device, and a 650 V series.



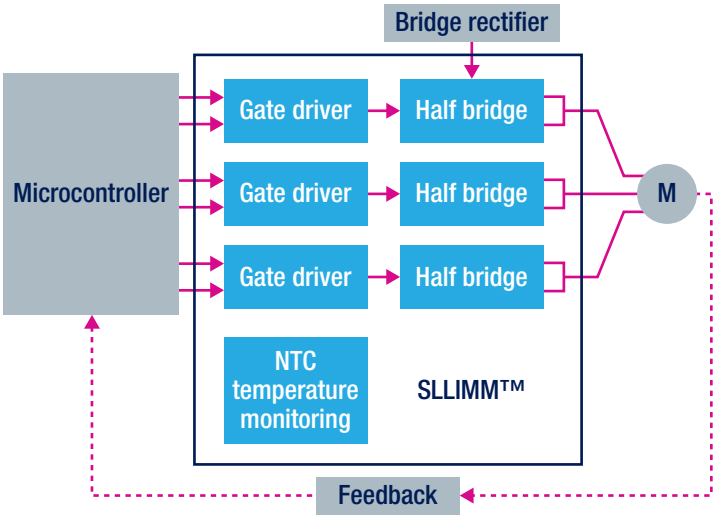
SiC diodes provide zero recovery time with negligible switching losses

Power modules

Starting from power switches, considered in die form, ST has also developed power modules (www.st.com/modules).

With the aim of benefitting from device integration and state-of-the-art materials to optimize thermal spread, electrical efficiency and bill of material, ST's offering today is based on molded modules as well as plastic packages. While the former are useful for power requirements up to 3 kW and can integrate some on-board intelligence, plastic power modules are suited for the industrial environment and are able to support currents of up to 100 A.

ST's family of small low-loss intelligent molded modules with power up to 3 kW is called SLLIMM™.



The key features of this first family of power modules are:

- DBC (direct bonded copper) and vacuum soldering process
- Smart shutdown function
- Comparators for fault protection against overcurrent and short circuit
- Integrated bootstrap diodes
- Deadtime and interlocking function
- Undervoltage lockout function
- Op amp for advanced current sensing
- NTC sensor for temperature control

A new plastic power module family called ACEPACK™ has been developed.

This new product family addresses mainly low power industrial applications like industrial motor drives, as well as solar panels, welding and power management (DC-DC, AC-DC converters for UPS, chargers, etc.). Two packages, ACEPACK™ 1 and ACEPACK™ 2 will be introduced and the first prototypes will be available very soon, both with Sixpack and converter inverter brake (CIB) topologies.

ACEPACK™1 module, dimensions: 33.8 x 48 mm

ACEPACK™2 module, dimensions: 48 x 56.7 mm

Thyristors and AC switches

ST offers a complete range of thyristors and AC switches with voltage ratings up to 1200 V, current ratings up to 120 A and a range of packages from miniature surface-mounted packages to high power dissipation isolated and non-isolated packages (www.st.com/thyristors).

To address the ever-increasing number of AC loads in industrial control, ST has developed overvoltage-protected AC switches combining robustness and reliability with a straightforward design, as described in the table below.

AC switch	$I_{T(RMS)}$ (A)	V_{DRM}/V_{RRM} (V)	I_{GT} (mA)	dV/dt (V/µs)	(dI/dt)c (A/ms)	T_J max (°C)	Package[5]
Overvoltage self-protected switch, V_{CL} = 850 V							
ACST210-8x[4]	2	800	10	500	0.5[2]	150	8, 4
ACST410-8x[4]	4	800	10	500	2[2]	150	8, 4
ACST435-8x[4]	4	800	35	1000	5[3]	150	8, 4
ACST610-8x[4]	6	800	10	500	3.5[2]	150	4, 5, 6, 7
ACST830-8x[4]	8	800	30	2000	8[3]	150	4, 5, 6
ACST1010-7x[4]	10	700	10	200	4.4[2]	150	4, 5
ACST1210-7x[4]	12	700	10	200	5.3	150	4, 5
ACST1035-8FP	10	800	35	4000/2000[1]	10[3]/5[1, 3]	150	4
ACST1235-8FP	12	800	35	4000/2000[1]	12[3]/6[1, 2]	150	4
ACST1635-8FP	16	800	35	1000/300[1]	12[3]/4[1, 3]	150	4

Note: 1: Specified at 125/150 °C
2: Snubber at 15 V/µs
3: Snubberless
4: Suffix x is related to the package. See package column: 4 = FP, 5 = T, 6 = G, 7 = R, 8 = B
5: Package: 4 = TO-220FPAB (Fullpack 1500 VRMS isolated, UL 1557 certified), 5 = TO-220AB, 6 = D^2PAK, 7 = I^2PAK, 8 = DPAK

KEY FEATURES

- Aut-protected against AC line overvoltage surges
- 150 °C operating temperature range
- Symmetric blocking voltage at 800 V
- 2 to 16 A current range

CURRENT RANGES

- 35 mA high key immunity series (dV/dt ≥ 2000 V/µs)
- 10 mA sensitive series defined at T_J = 125 °C

KEY BENEFITS

- Enables compliance with IEC 61000-4-4 and -4-5 disturbances
- No need for additional components (RC network, MOV)
- Easy control board design
- Sensitive series allows direct drive from an MCU

The ACST series, with its integrated overvoltage crowbar protection, eliminates the need for additional external protection to be compliant with IEC61000-4-5. The ACST series also renders the RC network snubber useless for switch-off. So by reducing the number of components, the ACST series makes the design phase easier, board sizes smaller and the project more cost-effective. With I_{GT} as low as 10 mA, the ACST series allows direct drive from MCUs.

The new T2550-12 Triac has been designed for industrial applications such as 3-phase motor soft-starters, contactors and protectors, with the market's first 25 A, 50 mA, 1200 V Triacs. The T2550-12G/T is aimed at replacing electromechanical contactors, prolonging their lifetime and extending the current rating of 3-phase motor starters and controllers.

Other benefits include:

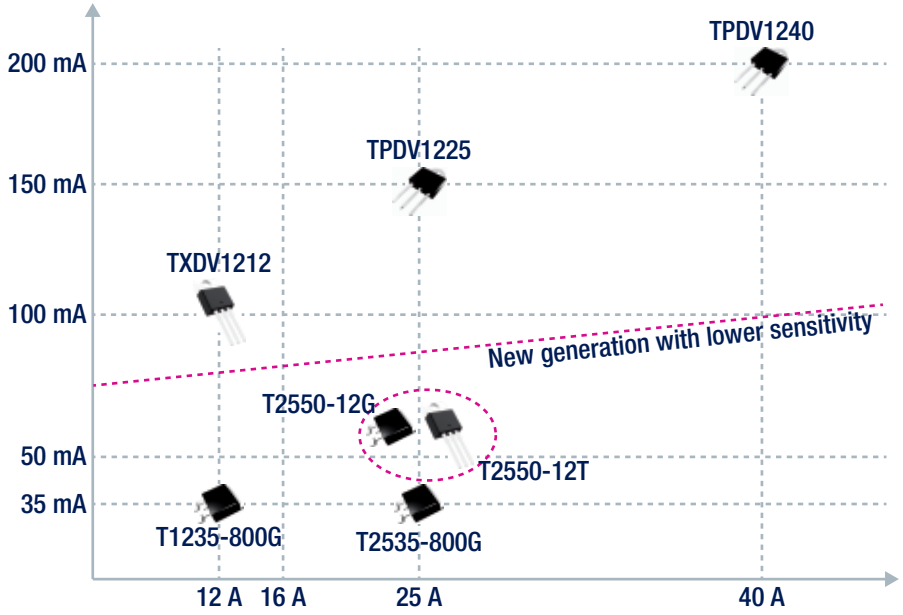
- Low I_{GT} of 50 mA (2 to 4 times lower than other medium-power Triacs available on the market)
- High robustness (withstands 6 million cycles of repetitive inrush current at 50 A, high immunity to AC line transients: 2500 V/µs min)

The T2550-12G/T features robust switching of up to 240 A of peak surge current and 1200 V blocking voltage. Housed in both D^2PAK (i.e. T2550-12G) and TO-220AB packages (i.e. T2550-12T), it allows a more compact design compared to mechanical contactors and offers higher performance with a high dV/dt, above 2500 V/µs and a maximum gate triggering current of 50 mA.

KEY PARAMETERS

- 25 A medium power Triac
- 1200 V symmetrical blocking voltage
- High inductive turn-off commutation
- 20 A/ms at 125 °C junction
- Standard I_{GT} gate triggering current
- 50 mA at room temperature
- 2.5 kV/µs transient immunity at 25 °C
- SMD D^2PAK and through-hole TO-220 packages
- Low thermal resistance $R_{TH(JC)}$ = 0.8 °C/W

The figure below shows the new generation of medium power Triacs.



VALUE PROPOSITION

- SMD high commutation switch
- Whole compact system
- SSR or rack compatible mounting
- High switching reliability
- Robust turn-off commutation and inrush start-up
- Lower cost and easy driving system

ST also offers the T series Triac family. The T series meets both immunity and high-commutation needs, offering a cost-sensitive solution. Both immunity (dV/dt) and commutation capability (dI/dt)c are specified at 150 °C for the 800 V series, with low gate current. This latter parameter is key, as it helps optimize power supplies and allows direct drive capability through a single resistor between the MCU and the Triac, for all 10 mA gate types.

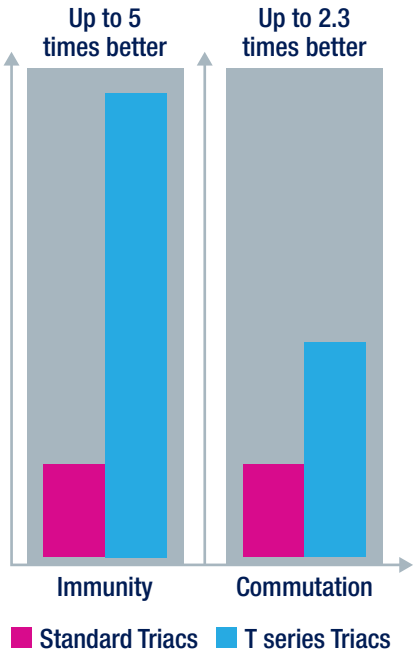
In addition, the trade-off of I_{TSM} versus immunity and commutation capability is improved. This is one step ahead of the usual offering, and a unique range on the market.

The key T series features are:

- T_{RMS} from 4 to 16 A
- V_{DRM}/V_{RRM} up to 800 V
- V_{DSM}/V_{RSM} up to 900 V
- T_J
  - 150 °C @ V_{DRM}/V_{RRM} up to 600 V (dual T_J devices only)
  - 125 °C for 220 V mains, V_{DRM}/V_{RRM} up to 800 V (dual T_J devices only)
- 4 ranges of I_{GT}
  - 10 mA directly driven from a microcontroller
  - 20 mA Snubberless™
  - 25 mA standard 4 quadrants
  - 35 mA Snubberless

T series Triacs have better noise immunity (dV/dt) up to 2 kV, which is up to 5 times above market standards. Commutation capability, (dI/dt)c, is increased up to 16 A/ms, which is up to 2.3 times above market standards. The table below compares a standard Triac (BTA08-600CWRG) with a T series Triac (T835T-8FP)

Part number	Current $I_{T(RMS)}$ (A)	Immunity dV/dt (w/o snubber) (V/µs)	Commutation (dI/dt)c (A/ms
T835T	8	400 → x 5 → 2000	4.5 → x 1.8 → 8
BTA08-600CWRG			



SIGNAL CONDITIONING

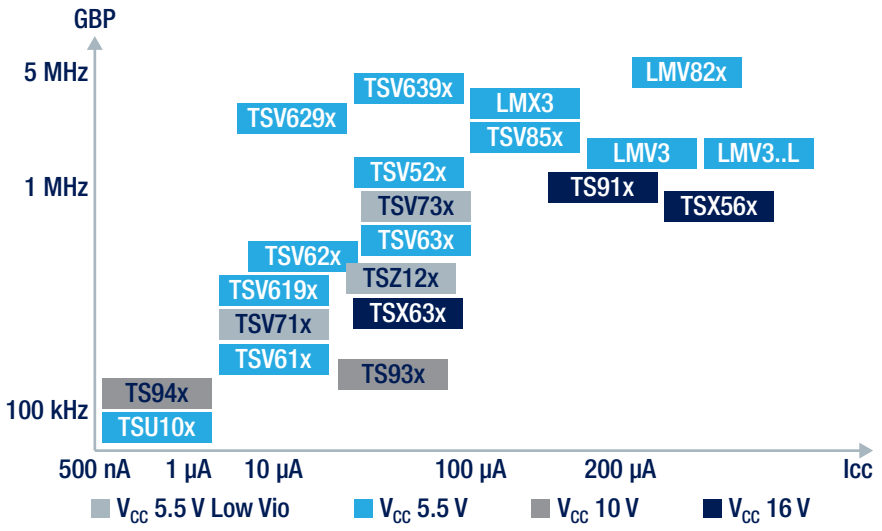
Operational amplifiers

ST is a reliable high-volume supplier of both standard and high-performance op amps (www.st.com/opamps):

- Complete 5 V and 16 V CMOS portfolio including precision and wide bandwidth op amps
- Space-saving packages, such as DFN, QFN, SOT-23 and SC-70

Our JFET, bipolar, CMOS and BiCMOS technologies allow our products to support:

- Wide supply range, from 1.5 V to 36 V
- High ratios of performance-to-power consumption

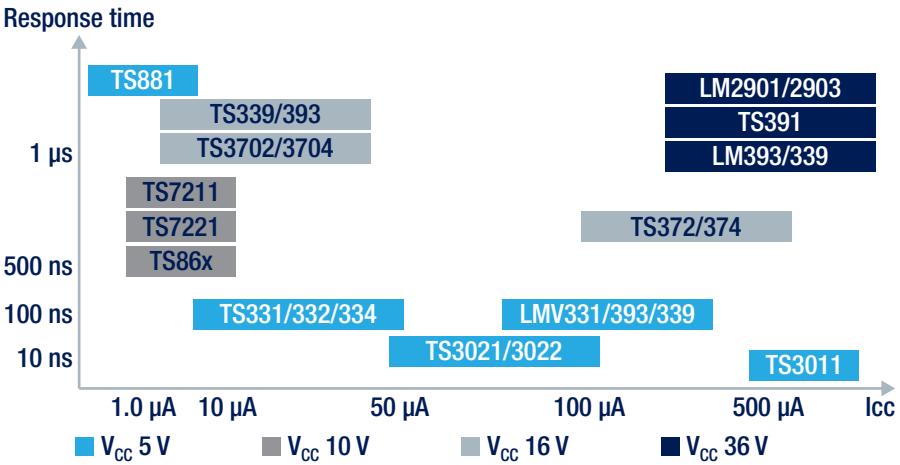


Op-amp series	Main features	Applications
TSV5 – TSV6 TSV8 – TSV9	Micropower, high merit factor, and wideband 5 V CMOS rail-to-rail	Sensor signal conditioning Battery-operated devices
TSV7 – TSZ12x	High precision Micropower 5 V CMOS	Sensor signal conditioning Handheld equipment
TSX5 – TSX6 – TSX7 TSX9	Micropower, high merit factor, wideband and precision 16 V CMOS rail-to-rail Excellent power/bandwidth ratio	Power applications (12 V, 15 V, +/-5 V) AFE for high-voltage sensors

Comparators

ST is a leading supplier of comparators, with a portfolio that offers:

- High-speed comparators with response times as fast as 8 ns
- Micropower comparators with operating currents as low as 210 nA
- High-temperature (150 °C) qualified devices
- Guaranteed specified min/max electrical performance



Comparators Highlight	Main features	Applications
TS881	Nanopower Very low voltage	Gas, CO detectors Battery-operated security systems
TS3011	Nano-second response time High efficiency	Optical modules High-frequency systems