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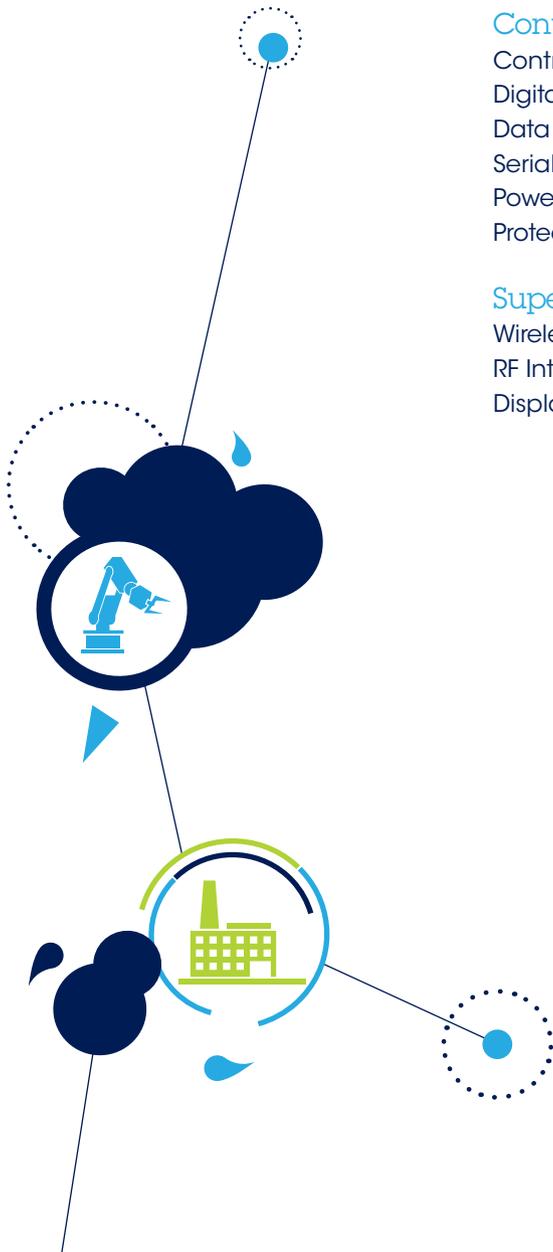
# Products and solutions for Factory automation and control

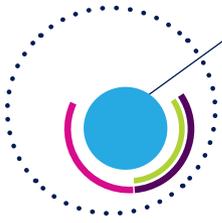




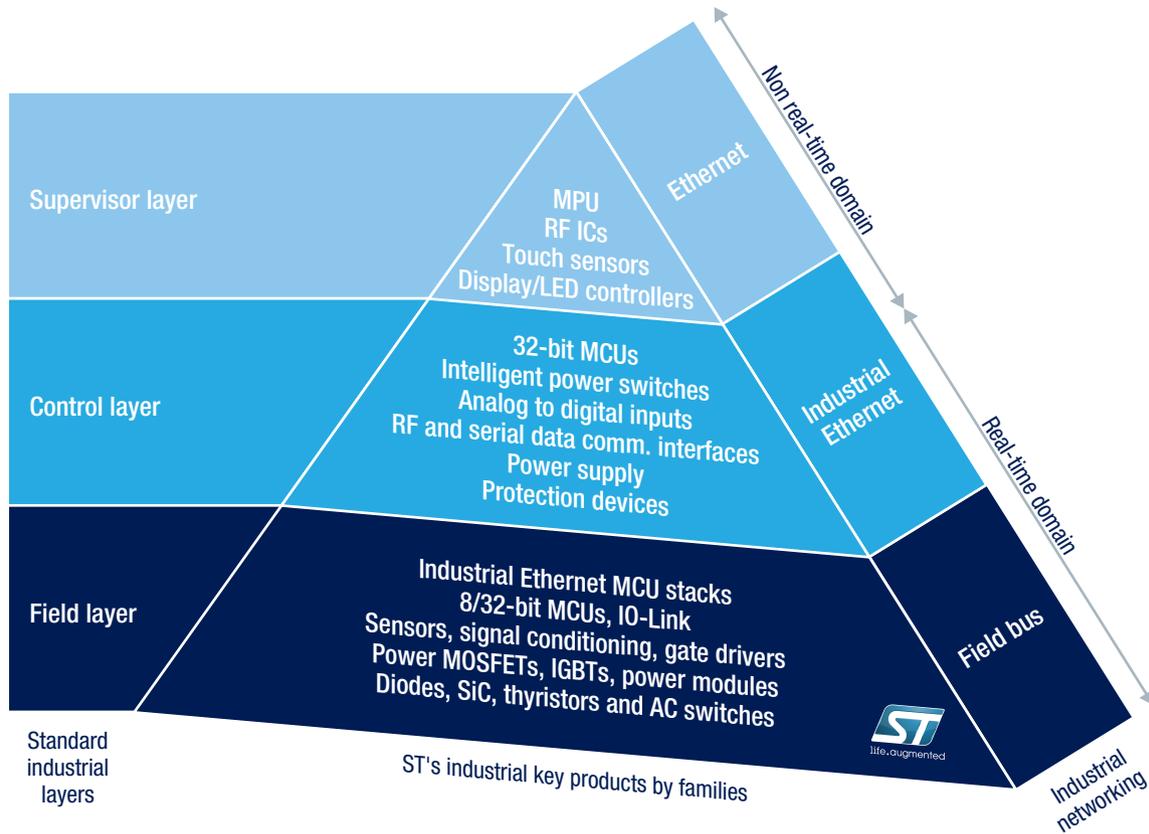
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# Introduction



## 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.

[www.st.com](http://www.st.com)

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



# 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.

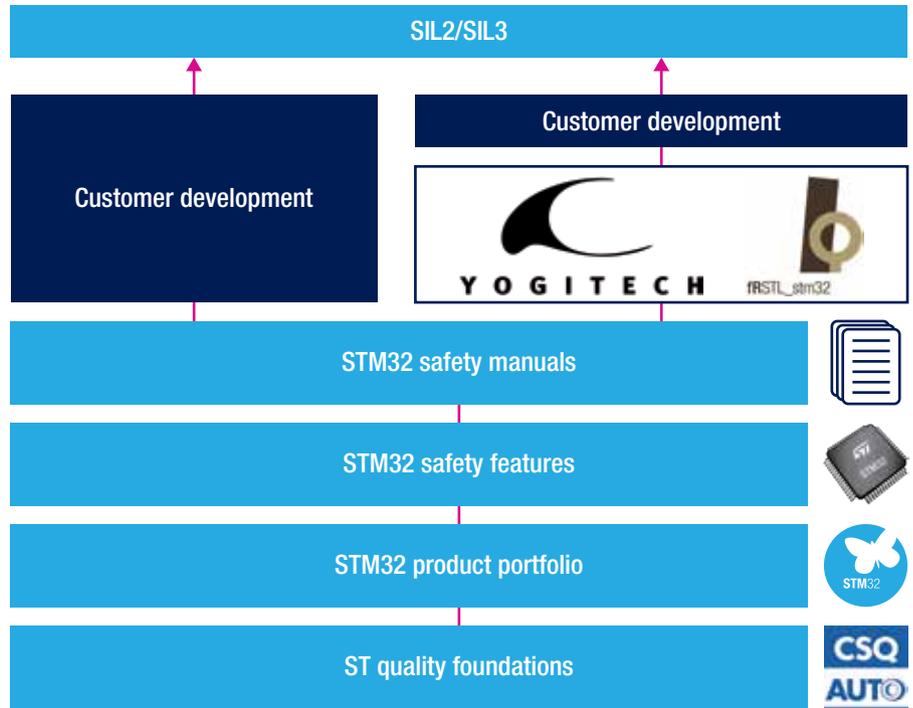
For each family in the STM32 series, the output of this activity has been two-fold: the STM32 safety manual, and an off-the-shelf software test library product to detect hardware random faults (Yogitech's fRSTL).

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.

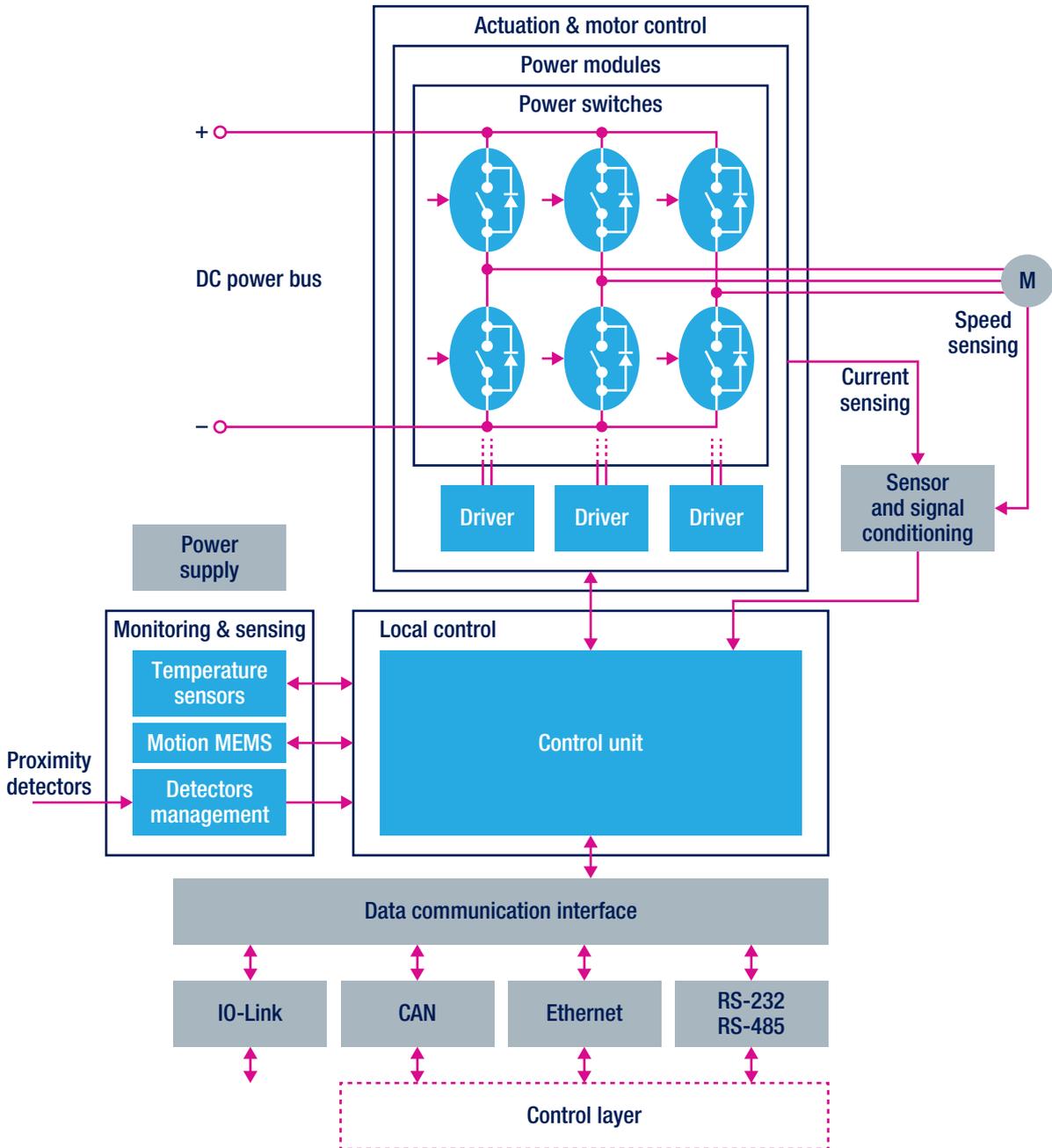
fRSTL software test libraries take full advantage of the white-box approach used during the analysis and are optimized in size and performance. Moreover, their coverage is verified using an extensive fault injection campaign, aimed at checking that the claimed coverage is actually reached.

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](http://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](http://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 <sub>cc</sub> )		Maximum operating temperature range (°C)
					16-/32-bit timers	Others				CAN	SPI	I <sup>2</sup> C	UART (IrDA, ISO 7816)		Lowest power mode (µA)	Run mode (per MHz) (µA)	
<b>STM8S003/005/007 Value line – 16 MHz CPU</b>																	
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	
<b>STM8S103/105 Access line – 16 MHz CPU</b>																	
STM8S103F2	4	1	640	S020, 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	
<b>STM8S207/208 Performance line – 24 MHz CPU</b>																	
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	
<b>STM8S903 Application specific line – 16 MHz CPU</b>																	
STM8S903F3	8	1	640	S020, 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
<b>STM8L series – ultra-low-power MCUs – 16 MHz CPU</b>																	
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)

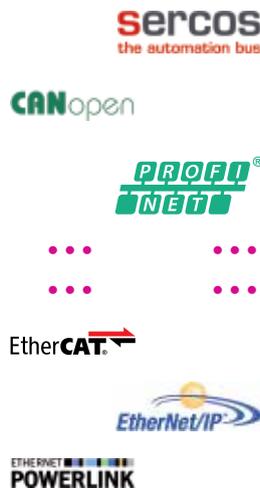
## INDUSTRIAL COMMUNICATION

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:

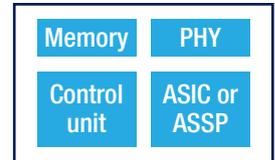
- MCU: lowest implementation cost
- MCU + FPGA: the use of an FPGA as glue logic enhances protocol flexibility and I/O extension
- MCU + ASIC or ASSP: a dedicated platform is often the result of consortium choices in building new standards
- System-on-chip: optimized solution resulting in best efficiency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



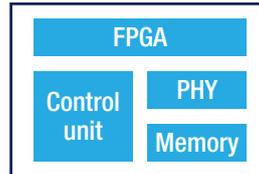
### MCU based architecture



### MCU + ASIC (or ASSP) architecture



### MCU + FPGA architecture



### SoC based architecture



### 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 <sup>1</sup>	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 <sup>1</sup>	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 <sup>1</sup>	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) <sup>2</sup>	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

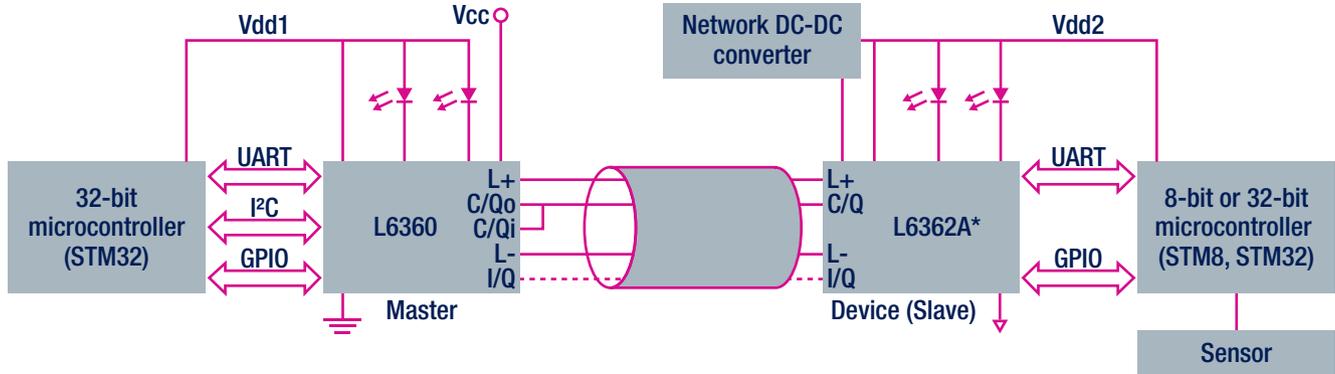
## INDUSTRIAL COMMUNICATION SOLUTIONS WITH STM8 MCUS

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 <sub>DD</sub> (V)	Output current (A)	I <sub>max</sub> 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](http://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
<b>Accelerometers</b>				
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
<b>Gyroscopes</b>				
L3GD20H	±250, ±500, ±2000 dps	0.011 °/s/√Hz	3 x 3 x 1 LGA-16L	16 bit, immunity to audio noise, embedded FIFO
<b>Magnetometer</b>				
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
<b>Inertial modules</b>				
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
<b>Digital compasses</b>				
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**

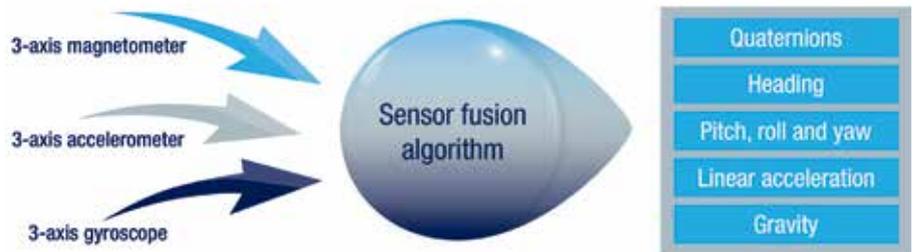
The iNEMO® engine sensor fusion suite is a filtering and predictive software. It uses advanced algorithms to integrate outputs from multiple MEMS sensors in a smart way, independent of environmental conditions, to reach the best performance. Real-time motion-sensor data fusion is set to significantly 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](http://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
<b>iNEMO-ENG-M1LI3</b>	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
<b>iNEMOEngine_PW8</b>	Pro version: This firmware running on the STM32 manages sensors on Windows 8 using the standard human interface devices (HID) over USB/I <sup>2</sup> C. Allows sensor plug-and-play recognition and new application development using Windows 8 standard APIs. (Compatible with Intel x86 and ARM processors).	Compiled code
<b>iNEMOEngine_PI3P Platform independent</b>	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
<b>iNEMOEngine_PAAP</b>	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

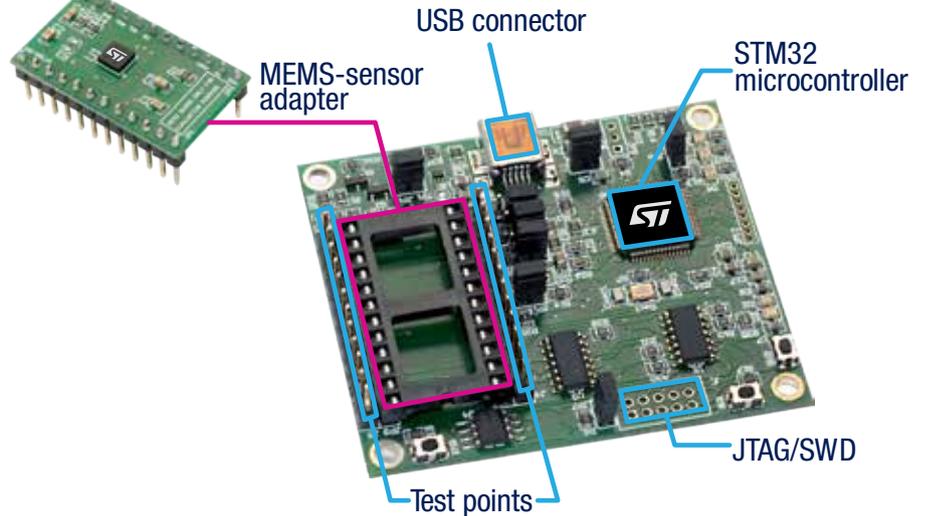
ST has deep expertise in sensor integration and new application development and can assist customers in design-in. ST's evaluation kits and firmware allow real-time evaluation of sensor performance in customer applications.

([www.st.com/mems-boards](http://www.st.com/mems-boards)) and ([www.st.com/mems-drivers](http://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
<b>STEVAL-MKI119V1</b>	Motherboard + adapter board: STEVAL-MKI119V1 kit includes STEVAL-MKI109V2 (motherboard) + STEVAL-MKI108V2 (9-axis module, L3GD20 and LSM303DLHC)	Development kit
<b>STEVAL-MKI109V2</b>	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
<b>STEVAL-MKI115V1</b>	The system is ready for any wireless extension and external Bluetooth dongle is available	Extender board
<b>STEVAL-MKI121V1</b>	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
<b>X-NUCLEO-IKS01A1</b>	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](http://www.st.com/tempsensors))

Part number	Full scale	Type	Resolution	Key features	Package size (mm)
<b>STLM20</b>	-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
<b>STTS751</b>	-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

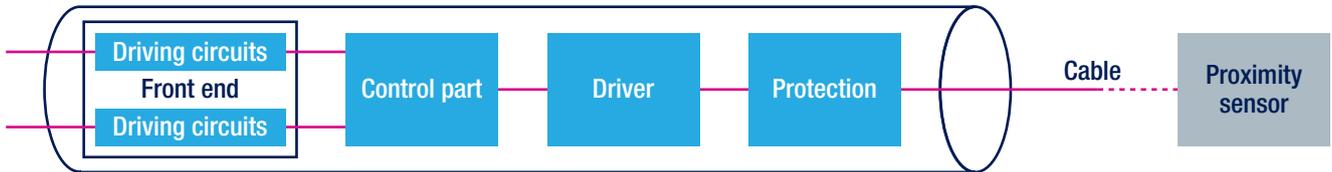
Proximity sensors fall into three main categories: capacitive sensors, inductive sensors, and ultrasonic sensors.

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.

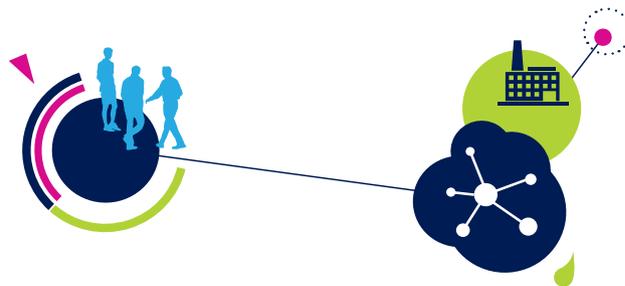
The simplified block diagram below presents a complete system compliant with the IEC 60947-5-2 design recommendation. ST offers, for the front end block, BCD smart-power technology, able to match most ASIC specifications.

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	S08
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:

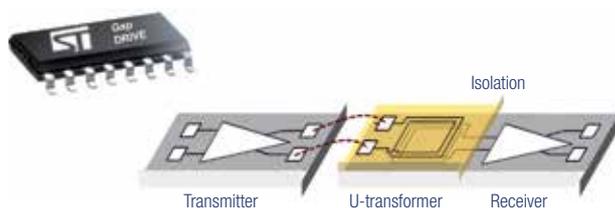
Fully integrated motor drivers, with a portfolio to cover stepper and three phase BLDC motors now expanding from monolithic to flat package modules with the new powerSTEP, packing and 85 V/10 A driver into a small form factor 14x11 mm QFN package.

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

Part number	Description	Package	R <sub>DS(on)</sub> (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 <sub>CC</sub> max (V)	UVLO on V <sub>CC</sub> (V)	UVLO on V <sub>BOOT</sub> (V)	Interlocking - DT (μs)	Op amp	Comparator	# pins
	Input configuration	Configuration							
<b>Half-bridge drivers</b>									
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
<b>Single-channel drivers</b>									
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](http://www.st.com/stmotorcontrol)

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

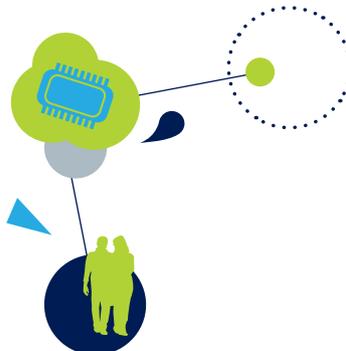
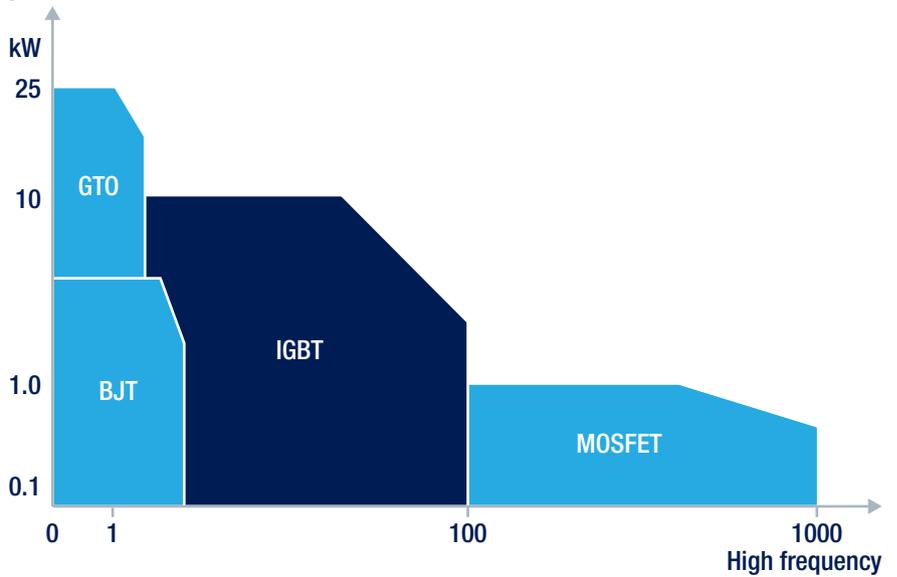
Leading-edge power technologies for low (<150 V), high (600/650 V) and very high voltage (1200 V and over) applications combined with a full package range and innovative die bonding technologies exemplify ST's innovation in power transistors.

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.

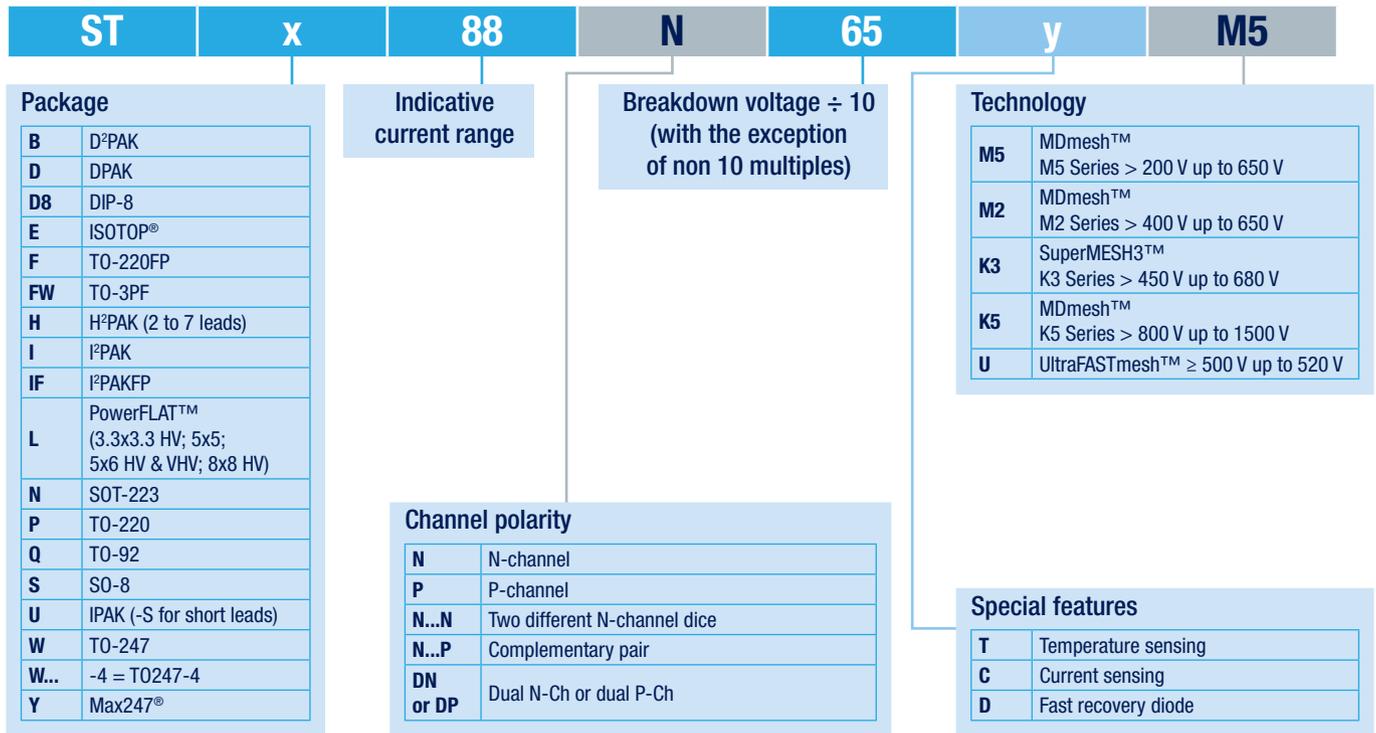
High voltage  
High current



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.



18

Part number	Package	V <sub>DSS</sub> (V)	R <sub>DS(on)</sub> (@ V <sub>GS</sub> = 10 V) max (Ω)	Drain current (Dc) (I <sub>D</sub> ) max (A)	Total power dissipation (PD) max (W)	Total gate charge (Q <sub>g</sub> ) V <sub>GS</sub> = 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](http://www.st.com/powermosfets)).

Part number	Package	V <sub>DSS</sub> (V)	R <sub>DS(on)</sub> (@ V <sub>GS</sub> = 10 V) max (Ω)	Drain current (Dc) (I <sub>D</sub> ) max (A)	Total power dissipation (PD) max (W)	Total gate charge (Q <sub>g</sub> ) typ (nC)
STU10P6F6	I <sup>2</sup> PAK	-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 ( $T_{jmax} = 200\text{ }^{\circ}\text{C}$ ) 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 m $\Omega$  typical at 25  $^{\circ}\text{C}$ ) 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)

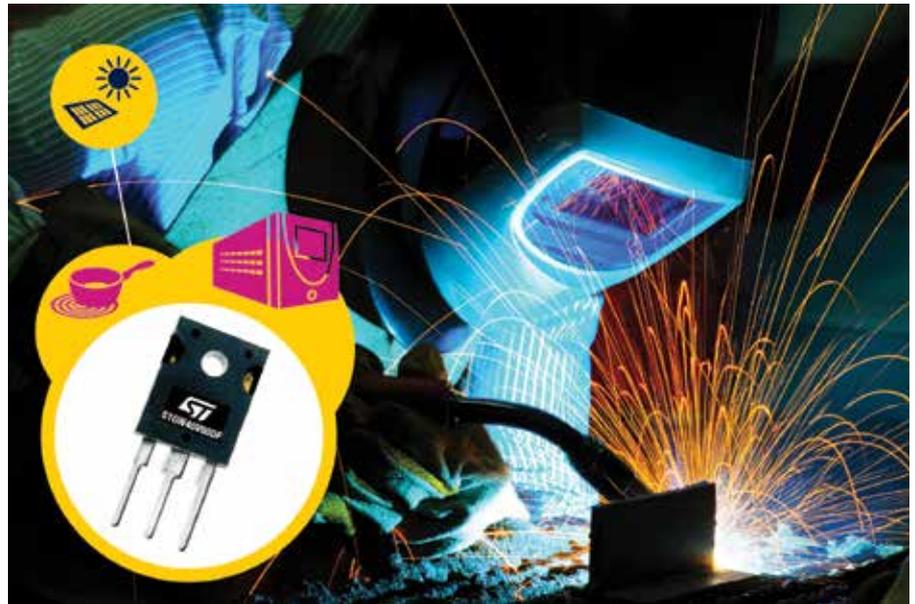
$BV_{DSS}$ (V)	$R_{DS}$ ( $\Omega$ )	Max $I_D$ (A)	$Q_g$ (nC)	Sales Type	Main application	Packages
1200	0.1	45	103	SCT30N120	3-phase SMPS, Welding, Solar inverter, Motor control	H <sup>2</sup> PAK, HIP247™

## IGBTs

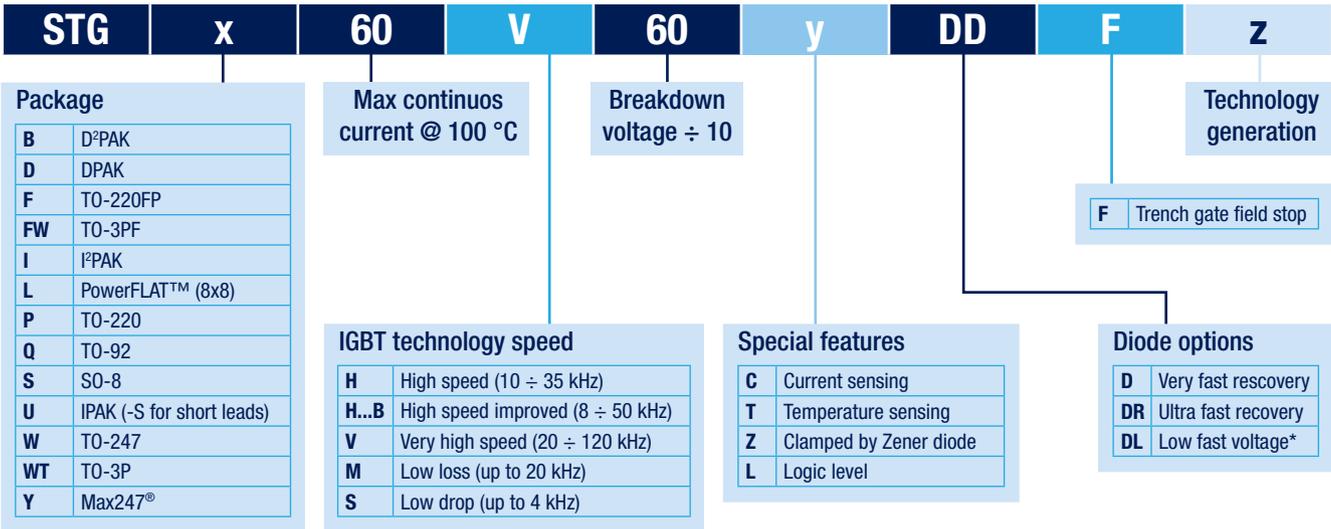
With breakdown voltages ranging from 350 V to 1300 V, ST's IGBTs feature the optimal trade-off between switching performance and on-state behavior due to their proprietary technology. They enable greater all round energy-efficient system designs in applications such as motor control, photovoltaics, UPS,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



Note: \* For soft switch applications only

Part number	BV <sub>CES</sub> (V)	I <sub>CN</sub> <sup>1</sup> (A)	V <sub>DE(SAT)</sub> <sup>2</sup> (V)	E <sub>off</sub> <sup>3</sup> (mJ)	Max T <sub>J</sub> (°C)	Switching frequency range	FRD option	Package							
								D <sup>2</sup> PAK	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<sub>CN</sub>: IGBT nominal collector current @ T<sub>J</sub> = 100 °C  
 2: V<sub>DE(SAT)</sub>: typical conduction losses @ I<sub>CN</sub>, T<sub>J</sub> = 25 °C  
 3: E<sub>off</sub>: switching-off energy @ I<sub>CN</sub>, T<sub>J</sub> = 25 °C on capacitive load (33 nF)

## Diodes

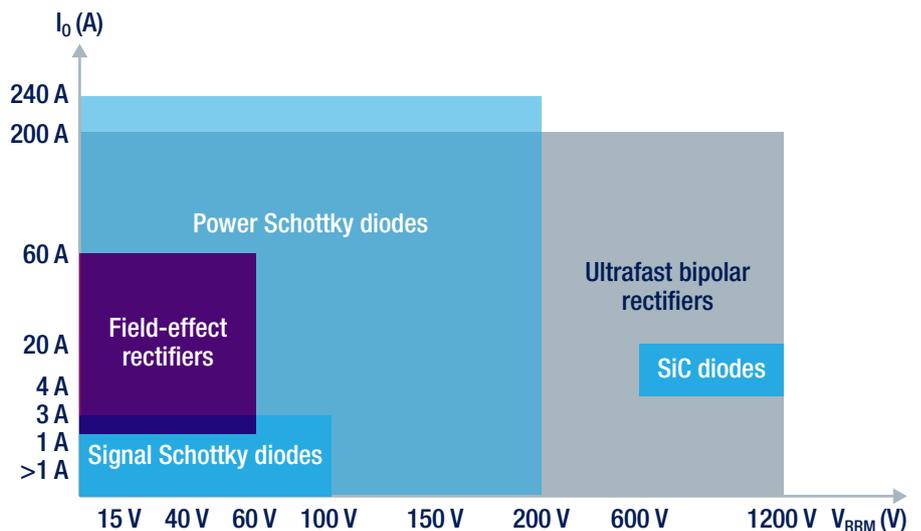
We present here an overview of ST's diode offering. We recommend that you visit [www.st.com/diodes](http://www.st.com/diodes), to get more information. The diagram below gives an idea of how many part numbers are available to fit all application needs.

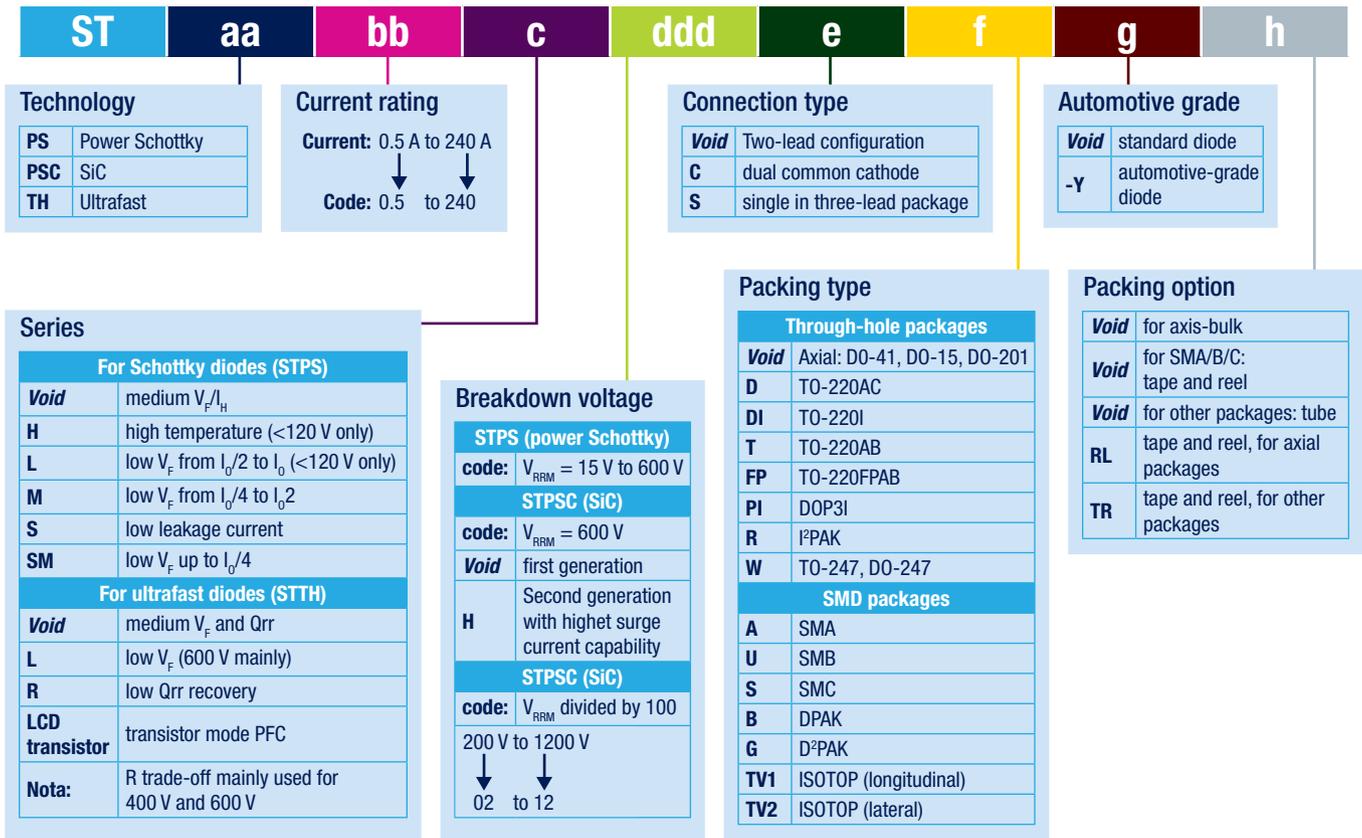
ST offers Schottky and ultrafast rectifier solutions for all market requirements. ST's latest developments include our M series, based on Schottky technology, with improved avalanche rating and the integration of higher currents in low-profile PowerFLAT™ packages.

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.



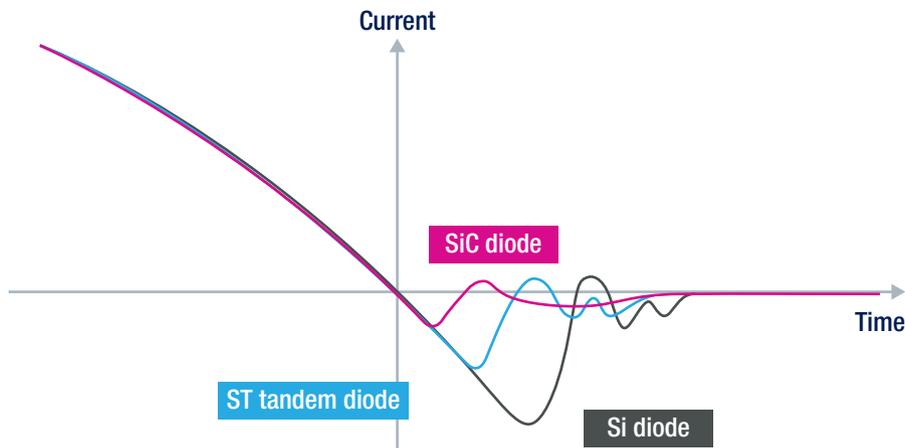


ST's silicon-carbide diodes take advantage of SiC's superior physical characteristics over Si, with 4 times better dynamic characteristics and 15% less forward voltage,  $V_F$ .

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.



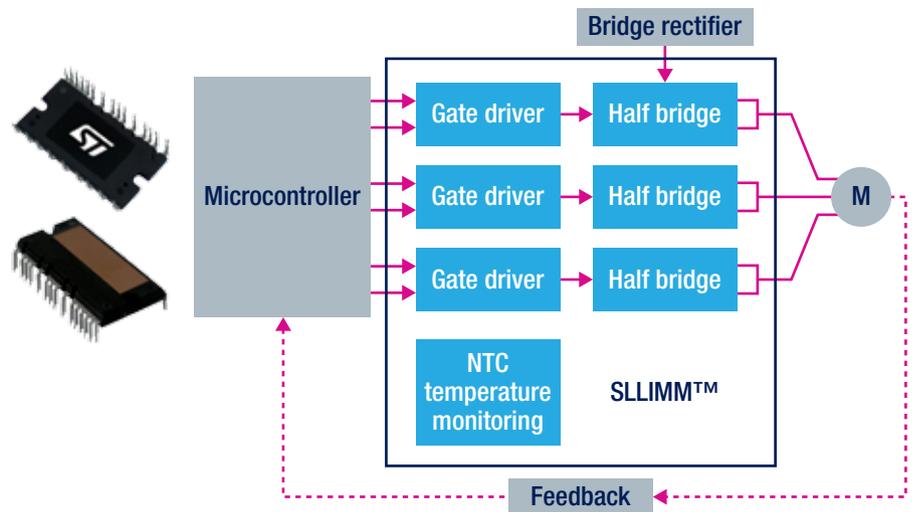
SiC diodes provide zero recovery time with negligible switching losses

## Power modules

Starting from power switches, considered in die form, ST has also developed power modules ([www.st.com/modules](http://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](http://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/ $\mu$ s)	(di/dt) <sub>c</sub> (A/ms)	$T_j$ max (°C)	Package <sup>5</sup>
<b>Overvoltage self-protected switch, <math>V_{CL} = 850</math> V</b>							
ACST210-8x <sup>4</sup>	2	800	10	500	0.5 <sup>2</sup>	150	8, 4
ACST410-8x <sup>4</sup>	4	800	10	500	2 <sup>2</sup>	150	8, 4
ACST435-8x <sup>4</sup>	4	800	35	1000	5 <sup>3</sup>	150	8, 4
ACST610-8x <sup>4</sup>	6	800	10	500	3.5 <sup>2</sup>	150	4, 5, 6, 7
ACST830-8x <sup>4</sup>	8	800	30	2000	8 <sup>3</sup>	150	4, 5, 6
ACST1010-7x <sup>4</sup>	10	700	10	200	4.4 <sup>2</sup>	150	4, 5
ACST1210-7x <sup>4</sup>	12	700	10	200	5.3	150	4, 5
ACST1035-8FP	10	800	35	4000/2000 <sup>1</sup>	10 <sup>3</sup> /5 <sup>1,3</sup>	150	4
ACST1235-8FP	12	800	35	4000/2000 <sup>1</sup>	12 <sup>3</sup> /6 <sup>1,2</sup>	150	4
ACST1635-8FP	16	800	35	1000/300 <sup>1</sup>	12 <sup>3</sup> /4 <sup>1,3</sup>	150	4

Note: 1: Specified at 125/150 °C

2: Snubber at 15 V/ $\mu$ s

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<sup>2</sup>PAK, 7 = I<sup>2</sup>PAK, 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  $\geq$  2000 V/ $\mu$ s)
- 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:

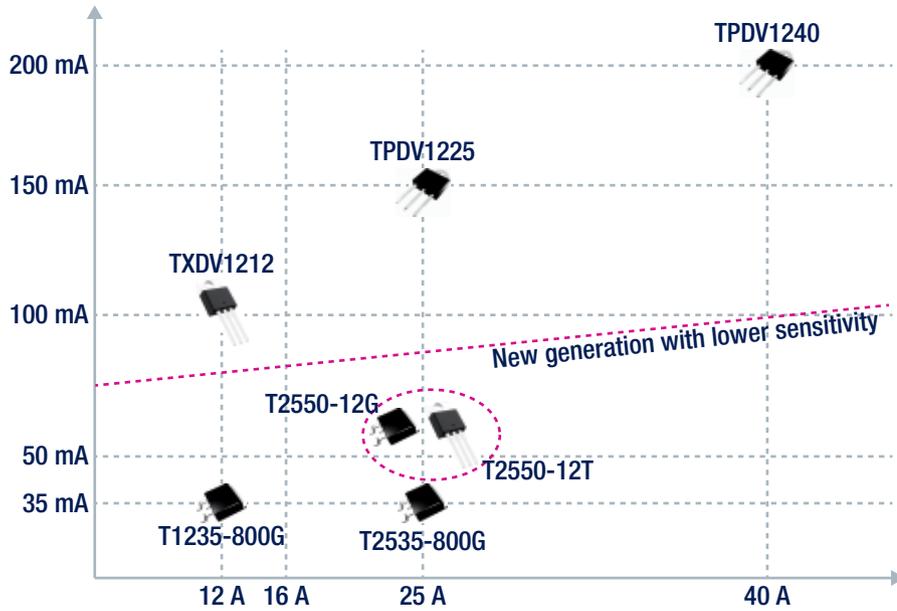
- Low  $I_{GT}$  of 50 mA (2 to 4 times lower than other medium-power Triacs available on the market)
- High robustness (withstands 6 million cycles of repetitive inrush current at 50 A, high immunity to AC line transients: 2500 V/ $\mu$ s min)

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<sup>2</sup>PAK (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/ $\mu$ s 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/ $\mu$ s transient immunity at 25 °C
- SMD D<sup>2</sup>PAK 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)<sub>c</sub> 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.

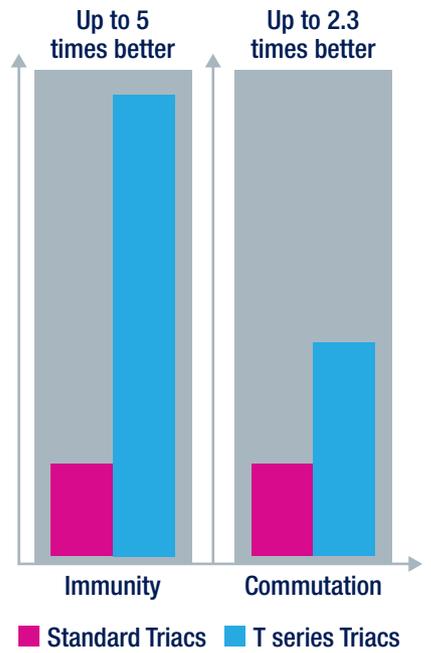
In addition, the trade-off of  $I_{TSM}$  versus immunity and commutation capability is improved. This is one step ahead of the usual offering, and a unique range on the market.

The key T series features are:

- $I_{RMS}$  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)<sub>c</sub>, 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) <sub>c</sub> (A/ms)
T835T	8	400 → x 5 → 2000	4.5 → x 1.8 → 8
BTA08-600CWRG			



# SIGNAL CONDITIONING

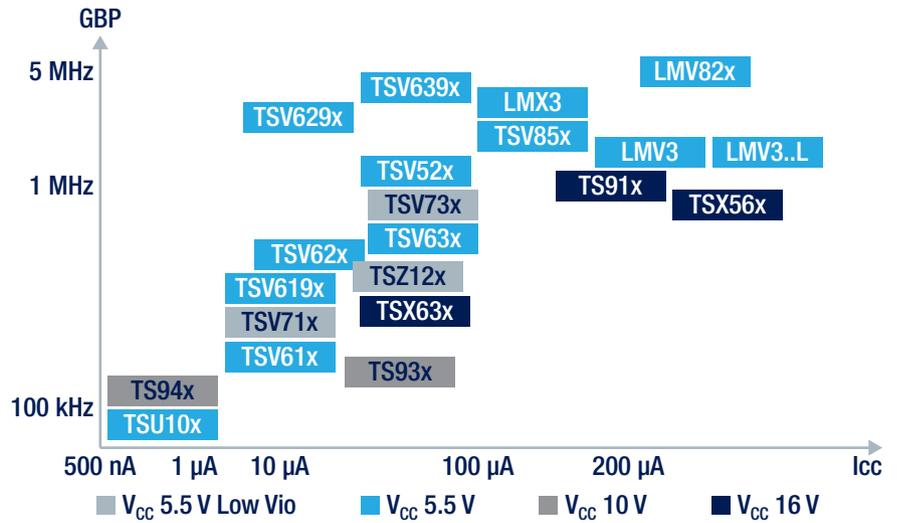
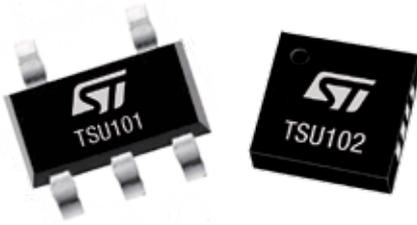
## Operational amplifiers

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

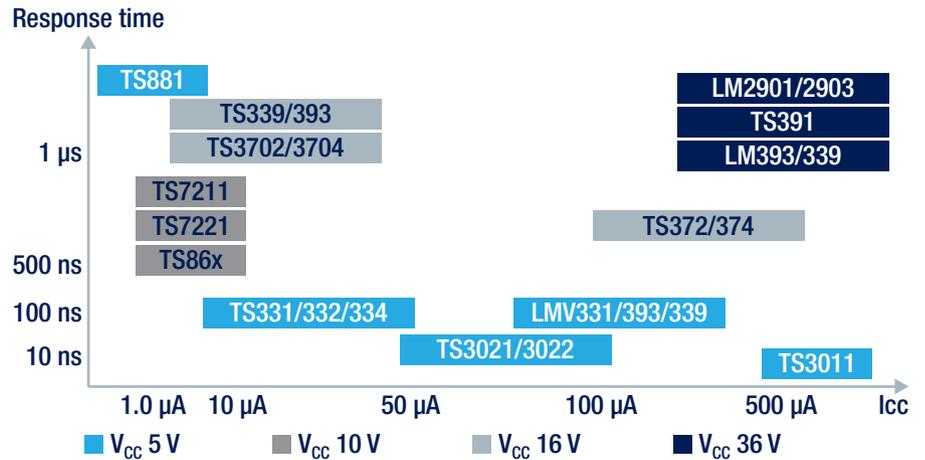


Op-amp series	Main features	Applications
TSV5 – TSV6 TSV8 – TSV9	Micropower, high merit factor, and wideband 5 V CMOS rail-to-rail	Sensor signal conditioning Battery-operated devices
TSV7 – TSZ12x	High precision Micropower 5 V CMOS	Sensor signal conditioning Handheld equipment
TSX5 – TSX6 – TSX7 TSX9	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



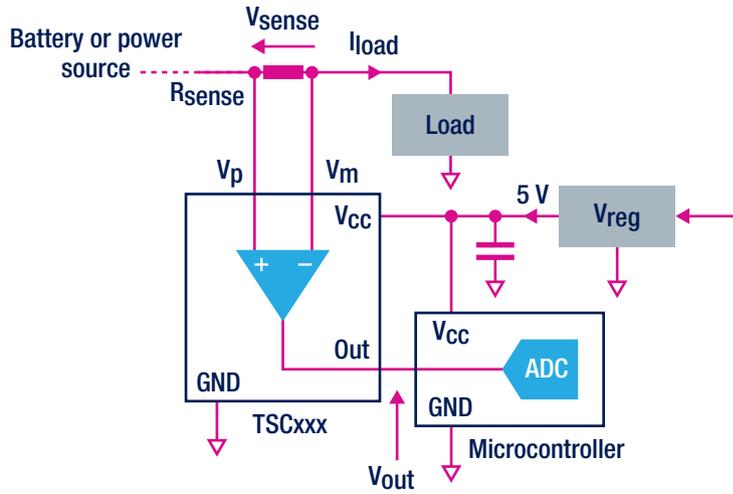
Comparators Highlight	Main features	Applications
TS881	Nanopower Very low voltage	Gas, CO detectors Battery-operated security systems
TS3011	Nano-second response time High efficiency	Optical modules High-frequency systems

## High-side current sensing (TSC series)

Accurate sensing of currents is central to enhancing application safety. Controlling the current within set boundaries avoids overheating and short circuits. Current measurement is also an essential part of energy metering.

The main features of our growing high-side current-sense amplifier portfolio are:

- Up to 70 V line monitoring
- Integrated solutions (for example, inclusion of EMI filtering on output) for faster design times and a reduced BOM
- Robust devices that do not require external protection
- Automotive-grade qualified current-sense amplifiers

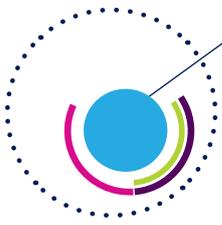


### HIGHLIGHT: TSC103

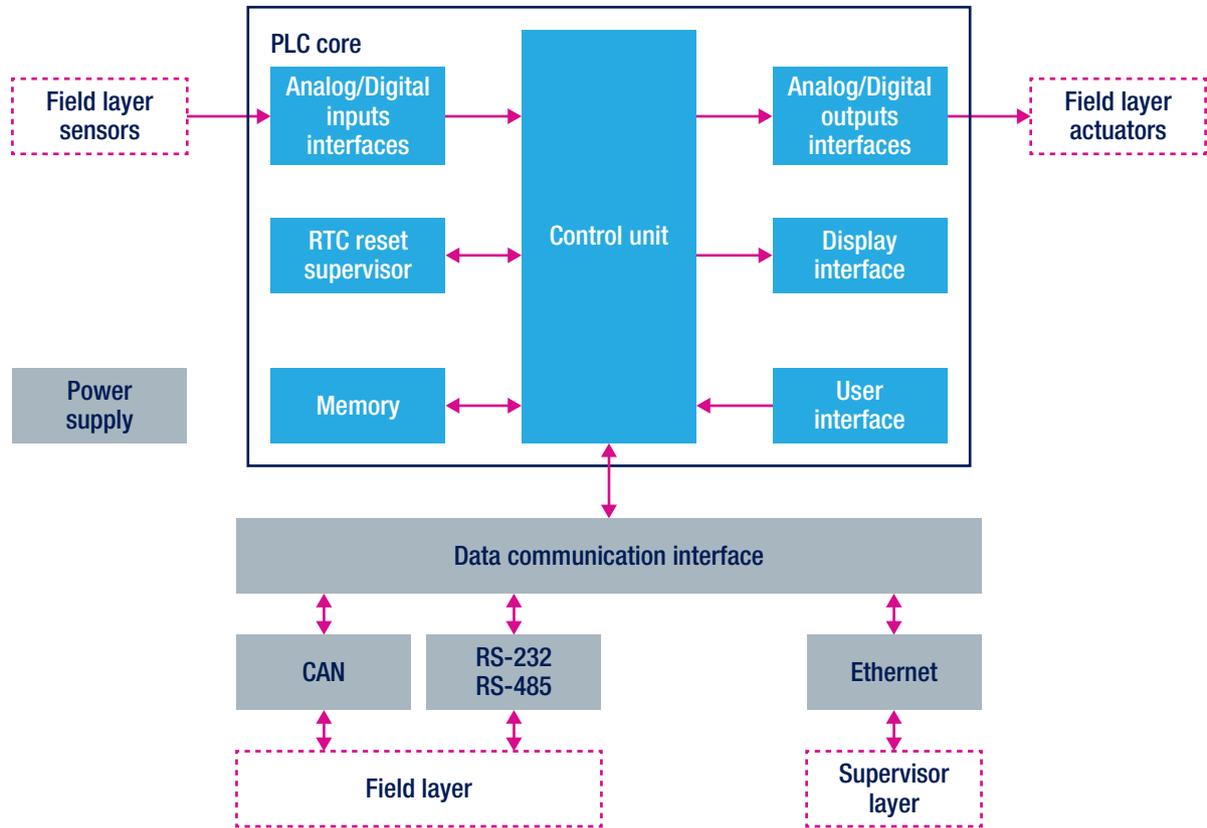
- Common-mode voltage: 2.9 to 70 V
- Optional dual-supply configuration to reach -2.1 V to 65 V common-mode range
- Rugged input pin sustain -16 to +75 V and 2.5 kV ESD
- Pin-selectable gain: 20 V/V, 25 V/V, 50 V/V, 100 V/V
- Low current consumption: 360  $\mu$ A

Order code	Description	Documentation
STEVAL-ISQ007V1	High-side current-sense amplifier demonstration board based on TSC101	AN2727
STEVAL-ISQ013V1	Low-side current sensing based on TS507	AN3222
STEVAL-ISQ014V1	Low-side current sensing based on TSZ121	UM1737





# Control layer



Over the years, ST has developed thousands of ICs dedicated to factory automation, and the current portfolio is the result of continuous improvements, compliance with the latest electrical and safety standards, customer needs and R&D activity.

In the picture above, a general block diagram representative of the control layer is shown, in which a typical PLC can be recognized. ST devices find a place everywhere in diagrams like this, with a wide vertical offering for each. Often, our evaluation tools and reference designs implement the solution the customer is looking for, with very minimal effort required to adapt it to a real application. However, the purpose of our evaluation tools are to provide a general platform for testing and evaluation, to help the designer to understand of our products.

The product families shown in the block diagram are covered in dedicated sections. See also [www.st.com/factory-automation](http://www.st.com/factory-automation).

# CONTROL UNIT

## MCU portfolio

By choosing one of ST's microcontrollers for your embedded application, you benefit from our leading expertise in MCU architecture, technology, multi-source manufacturing and support.

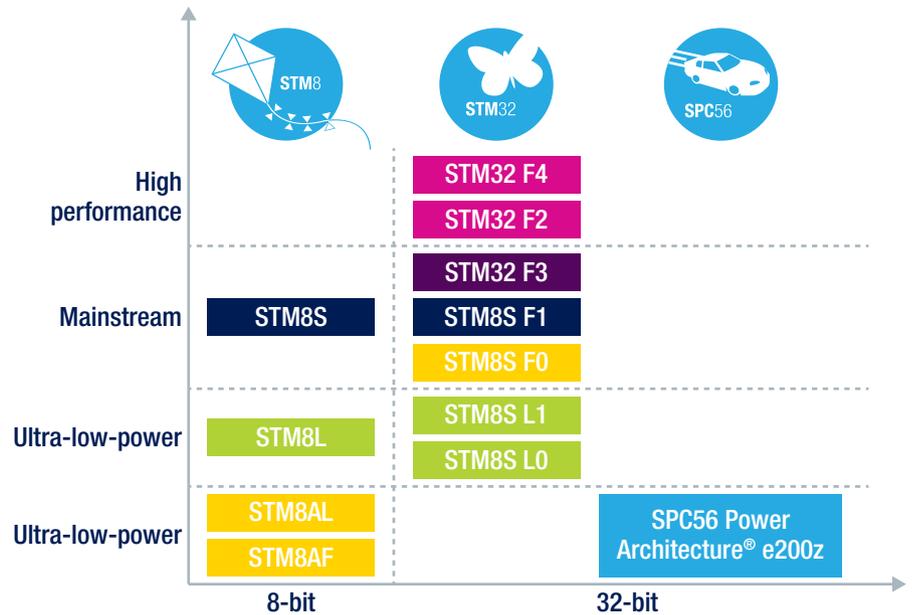
ST's product portfolio contains a comprehensive range of microcontrollers, from robust, low-cost 8-bit MCUs such as those in the STM8 family, up to 32-bit ARM®-based Cortex®-M0, Cortex®-M3, Cortex®-M4 Flash microcontrollers with a rich choice of peripherals, which STM32 family offers.

Only the STM32 family is covered in this section, while the STM8 is the subject of the field layer section.

Extensive support through a combination of flexible and powerful development tools, training courses, consultancy and web support will help you achieve a faster time-to-market.

## STM32 32-bit microcontrollers

The STM32 family of 32-bit Flash microcontrollers based on the ARM Cortex®-M processor is designed to offer new degrees of freedom to MCU users. By bringing a complete 32-bit product range that combines high-performance, real-time, low-power and low-voltage operation, while maintaining full integration and ease of development, the STM32 family helps you create new applications and to design in the innovations you have long been dreaming about.



Before presenting some of the MCUs from the STM32 family, the diagram below shows how our microcontrollers are designated.

<b>STM32</b>	<b>F</b>	<b>051</b>	<b>R</b>	<b>8</b>	<b>T</b>	<b>6</b>
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**Family**

STM32	32-bit MCUs
STM8	8-bit MCUs
STM8A	8-bit Automotive MCUs

**Product type**

F	Foundation
L	Ultra-low power
P	Pre-programmed
S	Standard
T	Touch sensing
W	Wireless

**Specific features (3 digits)**  
Depends on product series  
None exhaustive list.

STM32x...	
051	Entry-level
407	High-performance and DSP with FPU
152	Ultra-low-power
STM8x... / STM8Ax...	
103	Mainstream access line
52	Automotive CAN
31	Automotive low-end

**Pin count (pins)**

Y	16
F	20
E	24
G	28
K or G	32
L	34
T	36
D	38
H	40
J	42
S	44
C or 8	48
N	56
U	63
R or 9	64
M or A	80
O	90
V	100
W	128
Q	132
Z	144
I	176
B	208
X	336
P	420

**Code size (Kbytes)**

0	1
1	2
2	4
3	8
4	16
5	24
6	32
7	48
8	64
9	72
A	96 or 128*
B	128
Z	192
C	256
D	384
E	512
F	768
G	1024
H	1536
I	2048

Note:  
\* For STM8A only

**Packaging**

B	Plastic DIP*
D	Ceramic DIP*
G	Ceramic QFP
H	UFBGA or TFBGA
I	UFBGA
M	Plastic SO
P	TSSOP
Q	Plastic QFP
T	Plastic TQFP
U	UQFN
Y	CSP

\*Dual in-line package

**Temperature range**

6 and A	-40 to +85 °C
7 and B	-40 to +105 °C
3 and C	-40 to +125 °C
D	-40 to +150 °C

Including the low-power L series, the STM32 is divided into 6 product series and about 350 part numbers. More information is available on [www.st.com/stmcfinder](http://www.st.com/stmcfinder)



### Complete hardware tools and ecosystem

ST's microcontrollers are supported by a complete range of high-end and low-cost Discovery Kit evaluation tools. They implement the full range of device peripherals and features of each product line. The evaluation tools also come complete with third-party solutions that use an integrated development environment and in-circuit debugger/programmer featuring the JTAG application interface. Developers who are new to these microcontroller cores and families can also benefit from the range of starter kits that are specially designed to help developers evaluate device features and start their own applications.



	STM32 Nucleo	Discovery kits	Evaluation boards
<b>Typical use case</b>	Flexible prototyping, community	Prototyping, creative demos	Full feature evaluation
<b>Extension possibilities</b>	+++	++	+++
<b>Connectivity</b>	Arduino™ ST Morpho	ST	ST

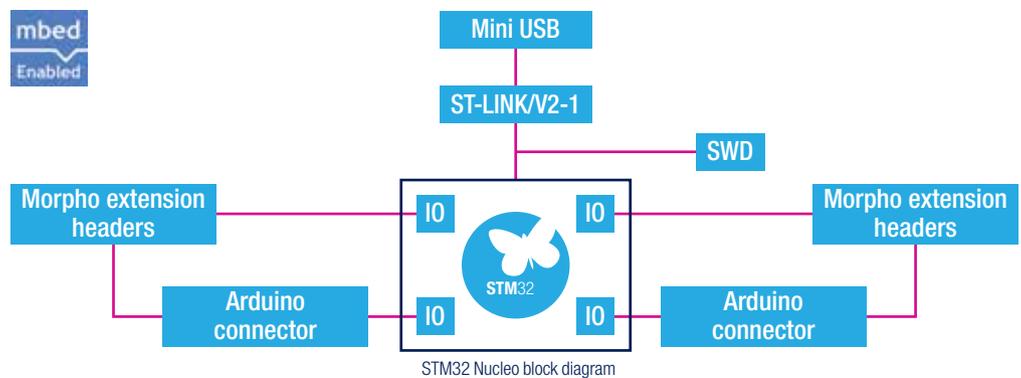
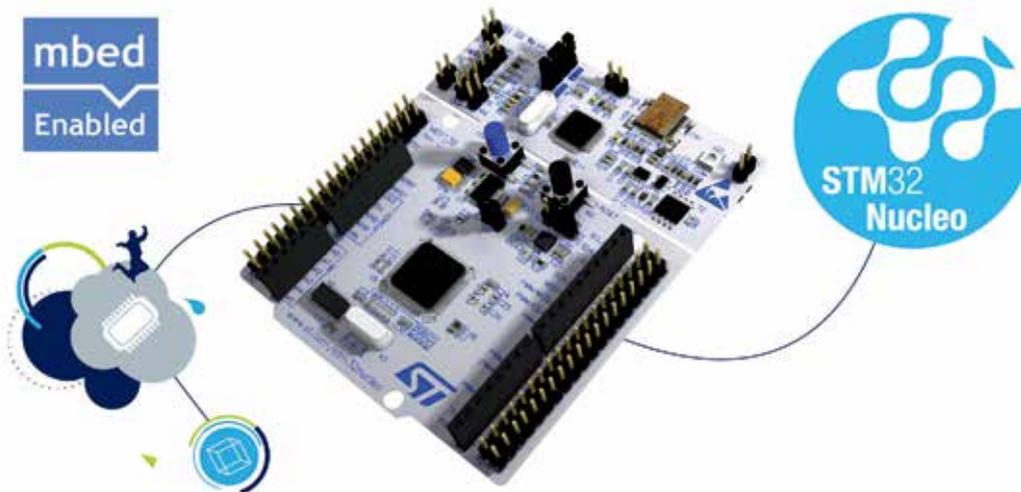
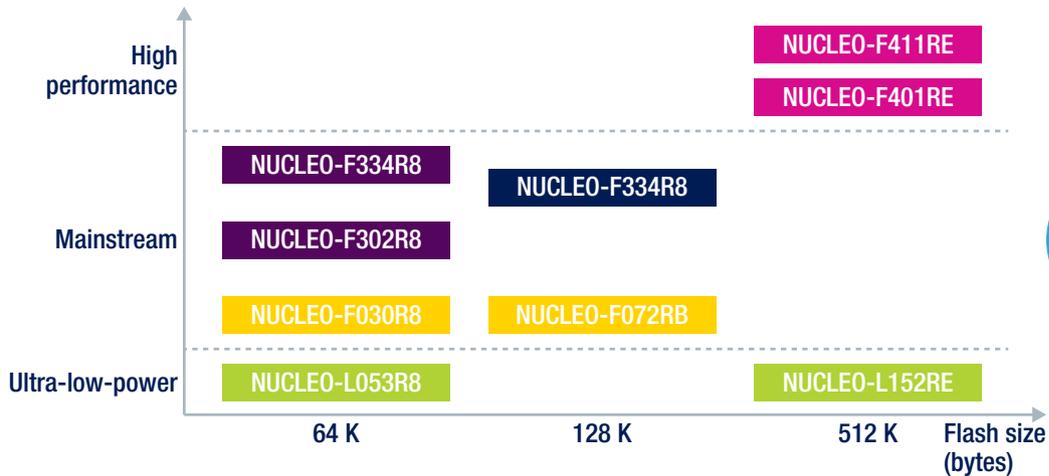
## STM32 development tools: STM32 Nucleo and STM32Cube™

ST is introducing two new hardware and software development platforms: the STM32 Nucleo and the STM32Cube.

STM32 Nucleo, the highly affordable STM32 boards, allow designers to try out new ideas and quickly create prototypes on any STM32 MCU. Sharing Arduino™ connectors and ST Morpho headers, STM32 Nucleo boards can easily be extended with a large number of application-related hardware add-ons. The STM32 Nucleo boards come with an integrated ST-Link debugger/programmer, so there is no need for an external probe.

The boards work in a wide range of development environments including IAR EWARM, Keil MDK, mbed, GCC-based IDEs (Atollic TrueStudio).

STM32 Nucleo users have free access to the mbed online compiler, the mbed online C/C++ SDK and the developer community at mbed.org, allowing them to build a complete application in only a few minutes. More at [www.st.com/stm32nucleo](http://www.st.com/stm32nucleo)

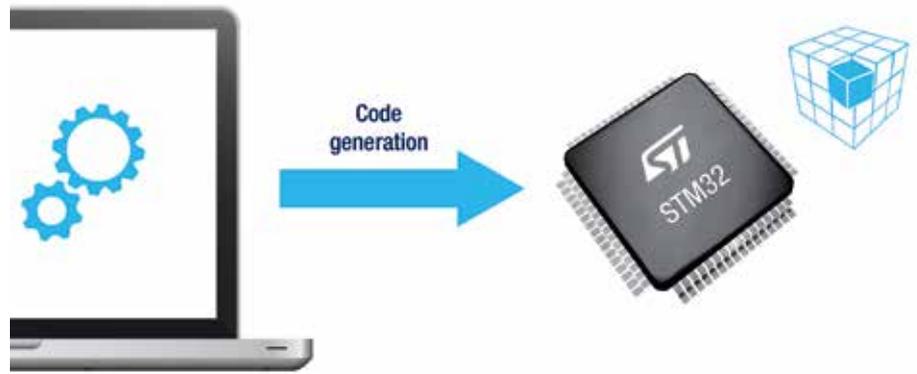


**STM32Cube™ is a powerful new free design tool and software for its STM32 microcontroller portfolio**

The new STM32Cube™ development platform comprises the STM32CubeMX graphical configurator and initialization C-code generator that provides step-by-step guidelines for users and a set of rich embedded software components that eliminate the need to integrate software from multiple sources.

The software includes a new Hardware Abstraction Layer (HAL) that simplifies porting from one STM32 device to another.

ST is also introducing STM32CubeF4 firmware, with middleware and HAL support, for the high-performance STM32 F4, with further releases rolling out during the course of the year. For more information, visit [www.st.com/stm32cube](http://www.st.com/stm32cube)



**STM32 Functional Safety Package**

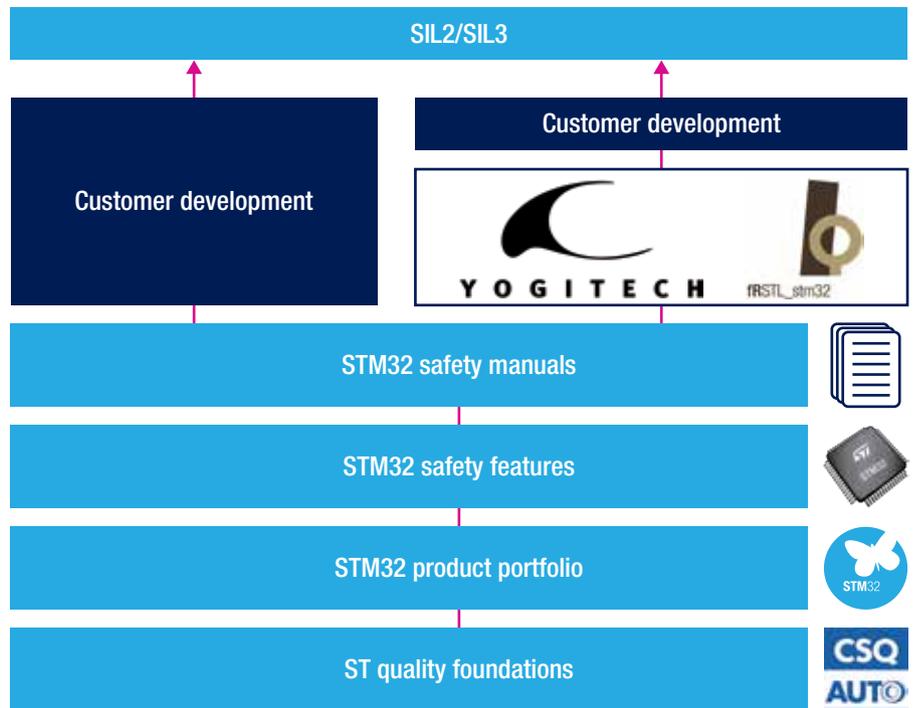
The STM32 Functional Safety Package helps designers to meet the functional safety requirements of the industry standard Safety Integrity Level (SIL). ST has partnered with Yogitech, a leading provider of services and solutions to silicon vendors and system integrators, to offer:

- MCU Safety Manuals: A detailed list of safety requirements (Conditions of Use) and examples to guide STM32 users in meeting the SIL2/3 requirements of IEC 61508. These are available on demand at [www.st.com/stm32](http://www.st.com/stm32)



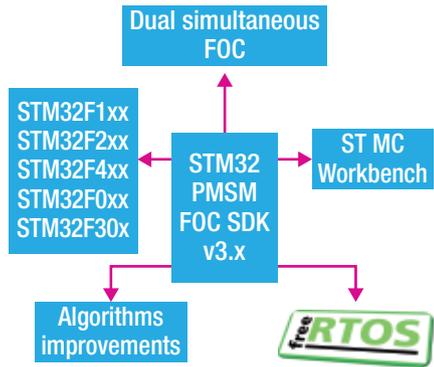
- fRSTL\_stm32 libraries: a consolidated standard software solution developed in strict accordance with IEC 61508 2nd edition, which provides a quick and effective means of detecting and flagging potentially dangerous failures in your STM32 microcontroller. The targeted SIL level can be reached with minimum of engineering costs and faster time-to-market. Visit [www.yogitech.com/frstlstm32](http://www.yogitech.com/frstlstm32)

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.



### STM32 dedicated Motor Control libraries

A complete Motor Control ecosystem (software, Hardware, Tools, documentations) helps to develop any Motor Control application faster. The STM32 PMSM FOC SDK v4.x is a Motor Control Software Development Kit (SDK) for 3-phase Permanent Magnet Synchronous Motors (PMSM) based on Field Oriented Control (FOC) supporting STM32F103, STM32F100, STM32F2xx, STM32F4xx, STM32F0xx and STM32F30x.



Key features of the the STM32 PMSM FOC SDK v4.x are:

- Single/Dual simultaneous vector control (FOC)
- Any combination of current reading topologies and/or speed/position sensors is supported
- Wide range of STM32 microcontrollers families supported
- Full customization and real time communication through PC software ST MC Workbench
- Wide range of motor control algorithms implemented for specific applications
- Application example based on FreeRTOS
- Increase code safety through
  - MISRA C rules 2004 compliancy
  - Strict ANSI C compliancy
  - New object oriented FW architecture (better code encapsulation, abstraction and modularity)

The partitioning below shows how the ST MC FOC SDK (version 4.0.0; order code: STSW-STM32100) is designed, in order to understand how it is tailored for the different MCUs, making it possible to choose the best trade-off in terms of resource usage and the characteristics of the final application.

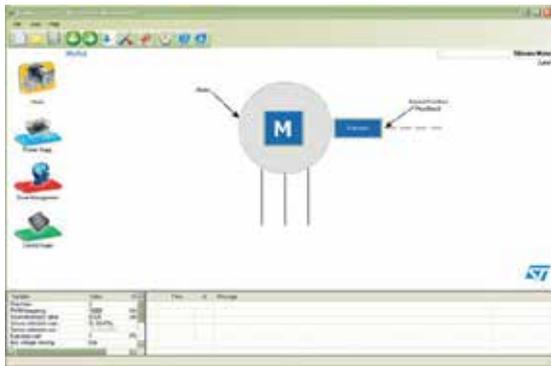
STM32F103x HD/XL, STM32F2xx, STM32F4xx, STM32F30x					
STM32F103x LD/MD					Dual FOC
STM32F100x, STM32F0xx			3shunt	Max FOC F103 ~23 kHz F2xx ~40 kHz F30x ~30 kHz F4xx ~50 kHz	
1shunt	Flux Weakening	IPMSM MTPA			
Feed Forward	Sensor-less (STO + PLL)	Sensor-less (STO + Cordic)			
Encoder	Hall sensors	Debug & Tuning			
ST MC Workbench support	USART based com protocol add-on	Max FOC F100 ~11 kHz F0xx ~12 kHz	FreeRTOS F103, F2xx	ICS	Max FOC dual F103 ~20 kHz F2xx ~36 kHz F30x ~27 kHz F4xx ~45 kHz
			Max FOC ~23 kHz		

The STM3210B-MCKIT motor control starter kit comes ready-to-run with a PMSM motor or an AC induction motor (accessory). You can modify the demonstration application and develop your own motor control applications using the dedicated software libraries provided in the starter kit in conjunction with a third-party IDE and C compiler. Also available are the ST MC Workbench (STSW-STM32003) PC GUI configuration tool for the STM32 PMSM FOC SDK motor control library (STSW-STM32100).

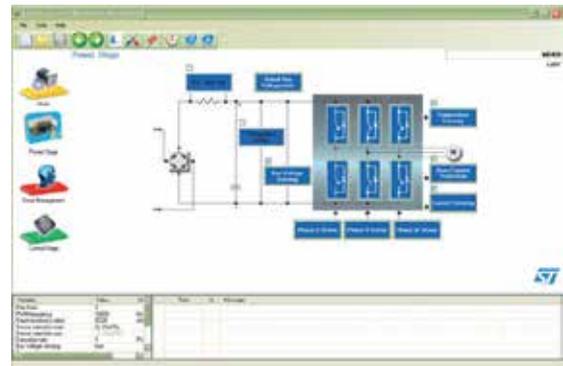


### ST Motor Control Workbench

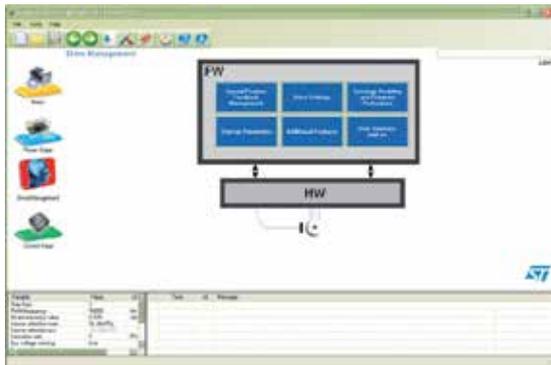
The ST Motor Control Workbench is a PC software making the STM32 PMSM FOC firmware library (order code: STSW-STM32100) configuration faster. According to the application needs, the user can set all the parameters and headers files through an intuitive PC GUI.



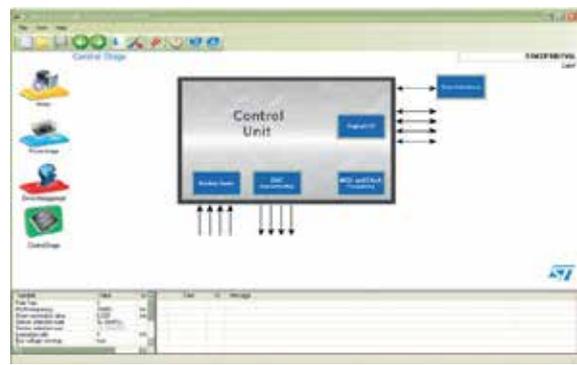
Motor



Power Stage

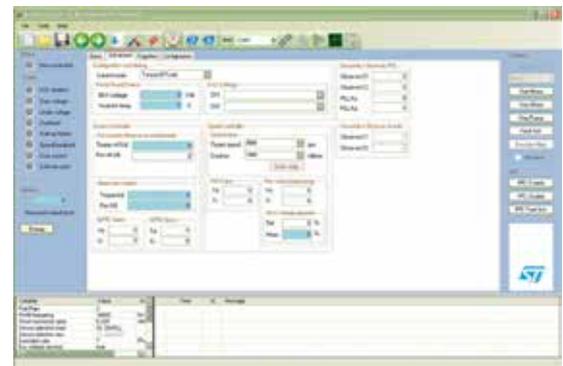


Drive Management



Control Stage

The ST Motor Control Workbench (order code: STSW-STM32003) allows real-time communication. For example, setting a speed ramp or sending start/stop commands is possible from the GUI for initial lab tests. Advanced tabs allow fine tuning of the parameters (i.e. PID control) as well as firmware debug, while it is possible to plot significant motor control variables, such as target or measured motor speed, using the embedded virtual oscilloscope.



## DIGITAL IO

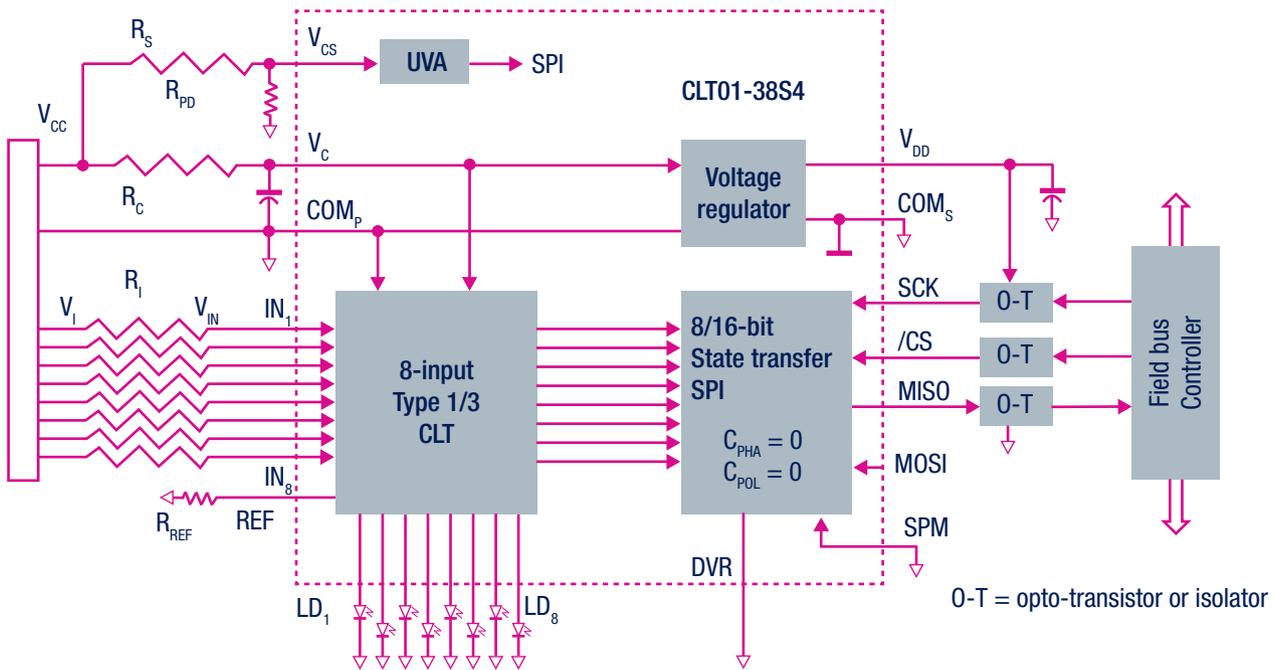
### Analog/Digital inputs

Modern control systems are highly complex applications. The trend is to use as many integrated solutions as possible in such designs, either to increase the density or to reduce the physical dimensions of the modules. Either way results in more stringent requirements regarding the total power dissipation of the module.

CLT devices form a new series of intelligent protected terminations designed for digital-input modules and proximity-sensor interfaces in industrial and building automation systems. Today's designers face the challenge of increasing the number of I/Os per volume unit and increasing the I/O-interface features. The CLT series offers highly robust EMC compliant solutions in accordance with:

- Surge IEC 61000-4-5: 1 kV
- ESD IEC 61000-4-2: 15 kV
- EFT burst IEC 61000-4-4: 4 kV

Robustness is also a key parameter for CLT devices, including the CLT01-38S4, which operates with all types of sensors compliant with IEC 61131-2, type 1 and 3, with a 2.35 mA limited current, and type 2, using two inputs per sensor with the correct  $R_{REF}$ .



O-T = opto-transistor or isolator

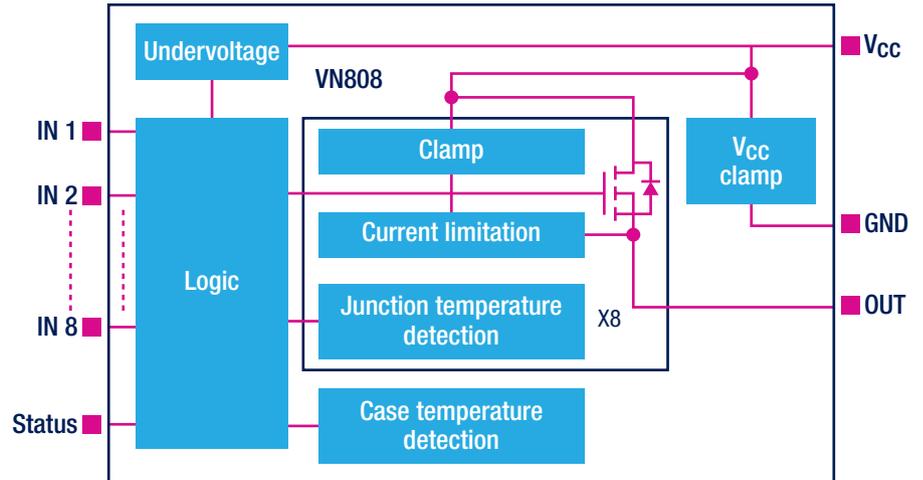
The CLT series and its related evaluation boards, as well as the basic documentation, is shown in the table below, together with the most important features of the devices. Additional information about current limiters is available at [www.st.com/protection](http://www.st.com/protection).

xGLT product	CLT3-4BT6	PCLT-2AT4	SCLT3-8	CLT01-38
Number of inputs	4	2	8	8
Input IEC 61131-2	Type 1 and 3	Type 1, 2 and 3	Type 1, 2 and 3	Type 1, 2 and 3
Output type	Isolated	Isolated, Non-isolated	Isolated, Non-isolated SPI serialized transfer	Isolated, Non-isolated SPI serialized transfer
Output drive	Opto transistor	Opto transistor, CMOS compatible	Opto transistor, Electromagnetic isolator CMOS compatible	Opto transistor, Electromagnetic isolator CMOS compatible
Input current limiter	2.8 mA	2.5 to 7.5 mA	2.35 mA	2.35 mA
Current tolerance	25%	18%	10%	10%
Front-end LED status	Yes, using type 1	Yes	Yes	Yes
Surge level	> 1 kV	Type 3: 1 kV Type 2: 0.5 kV	> 1 kV	> 1 kV
ESD level	8 kV	15 kV	15 kV	15 kV
Package	TSSOP-20	TSSOP-14	HTSSOP-38 QFN 7x7	HTSSOP-38 QFN 7x7
Input data rate	10 kbit/s	10 kbit/s	40 kbit/s	400 kbit/s
Application note	AN2527	AN2482	AN2846 and AN3031	-

Order code	Device series	Picture	Features
STEVAL-IFP007V1	SCLT3-8		Designed to meet real environment conditions <ul style="list-style-type: none"> <li>• EMI proof above 4 kV EFT</li> <li>• With opto-transistor</li> </ul>

### Digital outputs

In this large family of products, we find intelligent power switches (IPS). These integrate a control part (logic interface, high-side drivers, and protection) with a power stage. IPS's are based on ST-patented technologies, including bipolar, multipower BCD and VIPower M0 technologies. This provides increased system reliability, part count reduction, space saving and built-in protection, with smaller IPS devices that are housed in tiny, flat, no-lead plastic packages (DFN, QFN). The high thermal performance of the power packages such as PowerSO-36, PowerSSO24 and PowerSSO12 allows the absorption of high-energy pulses when an inductive load is driven without any external freewheeling diode. As an example, the block diagram below shows one of our latest IPSs, the VN808, designed using our proprietary VIPower technology.



A recent introduction to the IPS family is the ISO8200B, a galvanic isolated 8-channel driver featuring a very low  $R_{DS(on)}$  for the power stage.

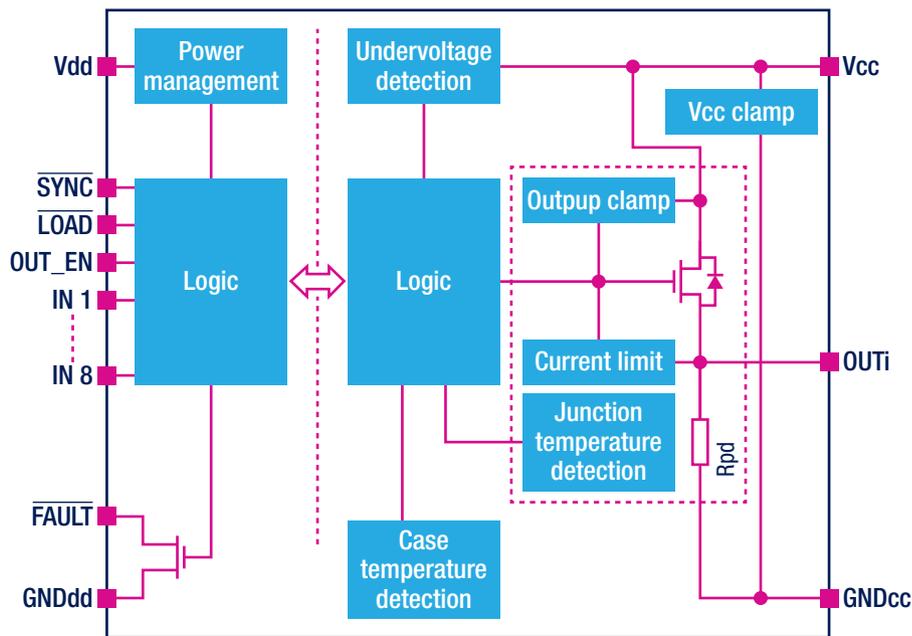
It contains 2 independent galvanic isolated voltage domains ( $V_{CC}$  for the power stage and  $V_{DD}$  for the digital stage). Additional embedded functions are loss-of-GND and loss-of-channel overtemperature protection and case overtemperature protection, undervoltage shutdown with hysteresis, reset function for IC output disable, overvoltage protection ( $V_{CC}$  clamping), direct and synchronous control mode, fast demagnetization for inductive loads, and ESD protection.

The IC is intended to drive any kind of load with one side connected to ground with 3.3/5 V compatible inputs. Active channel current limitation combined with thermal shutdown (independent for each channel) and automatic restart protect the device against overload and short circuits.

In overload conditions, if the junction temperature exceeds the threshold, the channel involved is turned off and then automatically on again after the IC temperature decreases below the reset threshold. If this condition causes the case temperature to reach the threshold limit, TCR, the overloaded channel is turned off and only restarts when the case and junction temperature decrease below the reset thresholds. Non-overloaded channels continue to operate normally. An internal circuit provides an OR-wired unlatched common fault indicator signaling the channel over-temperature. The fault pin is an open-drain active-low fault indication pin.



ISO8200B device



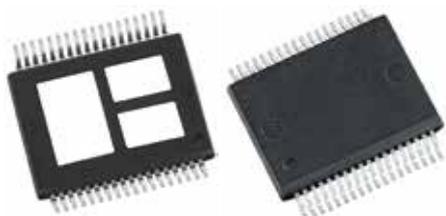
ISO8200B block diagram

## SOME SINGLE-CHANNEL IPSs

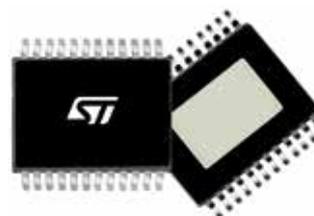
Part number	V <sub>CC</sub>	R <sub>DS(on)</sub> (Ω)	I <sub>OUT</sub> (A)	Technology	Package	Channels
TDE1737DP	8 ÷ 50	-	0.5/Adjust	Bipolar	DIP-8	Low side
TDE1747FP	10 ÷ 60	-	0.45/Adj.	Bipolar	SO-14	High side
TDE1787ADP	6 ÷ 60	-	0.3/Adjust	Bipolar	DIP-8	High side
TDE1798DP	6 ÷ 50	-	0.5/0.7	Bipolar	DIP-8	High side
L6370Q	9.5 ÷ 50	0.10	2.5/Adjust	MultiBCD	QFN 48L 7x7	High side
L6375D	8 ÷ 50	0.40	0.5/0.75	MultiBCD	SO-20	High side
L6377D	8 ÷ 50	0.40	0.5/Adjust	MultiBCD	SO-14	High side
VN751PT/S	5.5 ÷ 41	0.060	2/2.5	ViPower	PPAK/SO-8	High side

## SOME MULTI-CHANNEL IPSs

Part number	V <sub>CC</sub>	R <sub>DS(on)</sub> (Ω)	I <sub>OUT</sub> (A)	Technology	Package	Channels
VNI2140J	9 to 36	0.08	1.0	ViPower	PowerSSO-12	2
L6374	10.8 to 35	4.0	0.1	MultiBCD	SO-20	4
L6376	9.5 to 35	0.64	0.5	MultiBCD	PowerSO-20	4
VNI4140K	10.5 to 36	0.08	0.7	ViPower	PowerSSO-24	4
VNI4140K-32	10.5 to 36	0.08	1.0	ViPower	PowerSSO-24	4
VNQ860	5.5 to 36	0.27	0.25	ViPower	SO-20/PowerSO-10	4
VN808/-32	10.5 to 36	0.15/0.16	0.7/1.0	ViPower	PowerSO-36	8
VN808CM/-32	10.5 to 36	0.15/0.16	0.7/1.0	ViPower	PowerSO-36	8
VNI8200XP	45	0.11	0.7	ViPower	PowerSSO-36	8
IS08200B	45	0.11	0.7	MultiBCD + ViPower	PowerSSO-36	8



PowerSSO-36 package

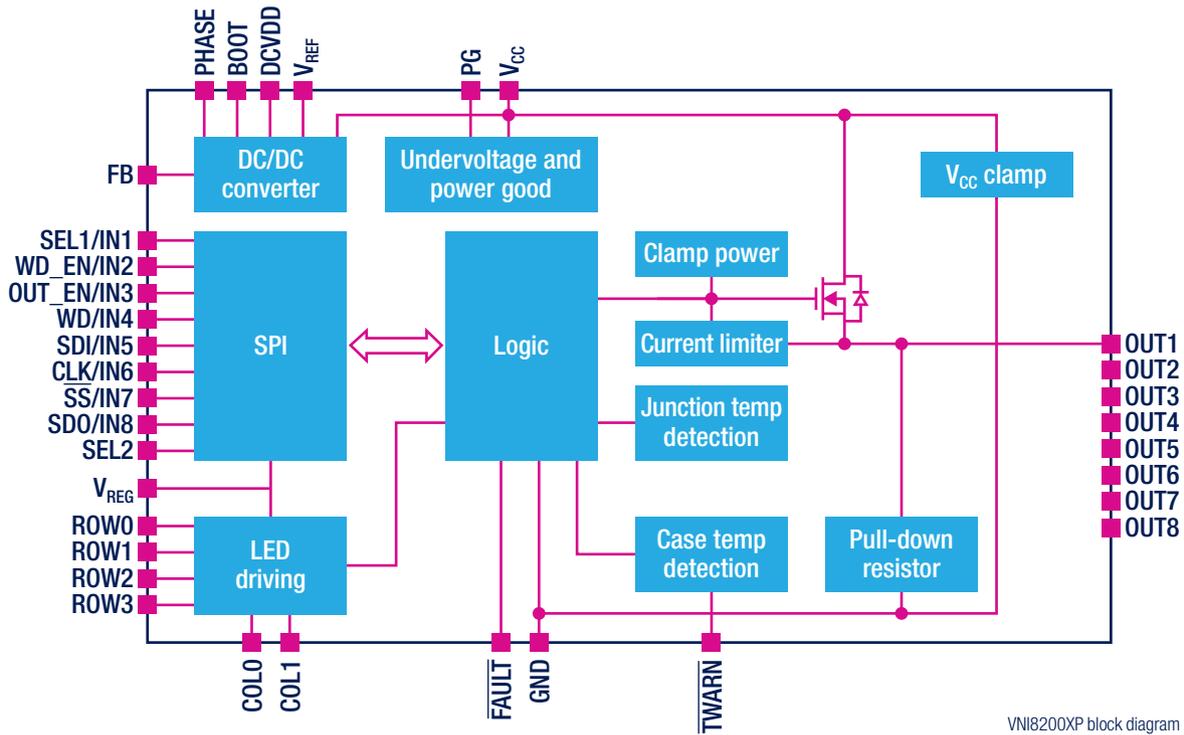


PowerSSO-24 package

A new generation of IPS is being developed using our proprietary BCD8SP technology, making it possible to implement both high-side and low-side drivers.

The VN18200XP is an octal, high-side smart power solid-state relay, with a serial/parallel selectable interface on chip (8-/16-bit SPI interface for IC command and control diagnostics). The IC, built using ST's VIPower™ technology, is designed to drive any kind of load with one side connected to ground.

Active channel current limitation combined with thermal shutdown, independent for each channel, and automatic restart, protect the device against overload. Additional embedded functions are loss-of-GND protection that automatically turns off the device outputs should ground be disconnected, undervoltage shutdown with hysteresis, power good diagnostic for valid supply voltage range recognition, output enable function for immediate power output on/off, and programmable watchdog function for MCU safe operation.



VN18200XP block diagram

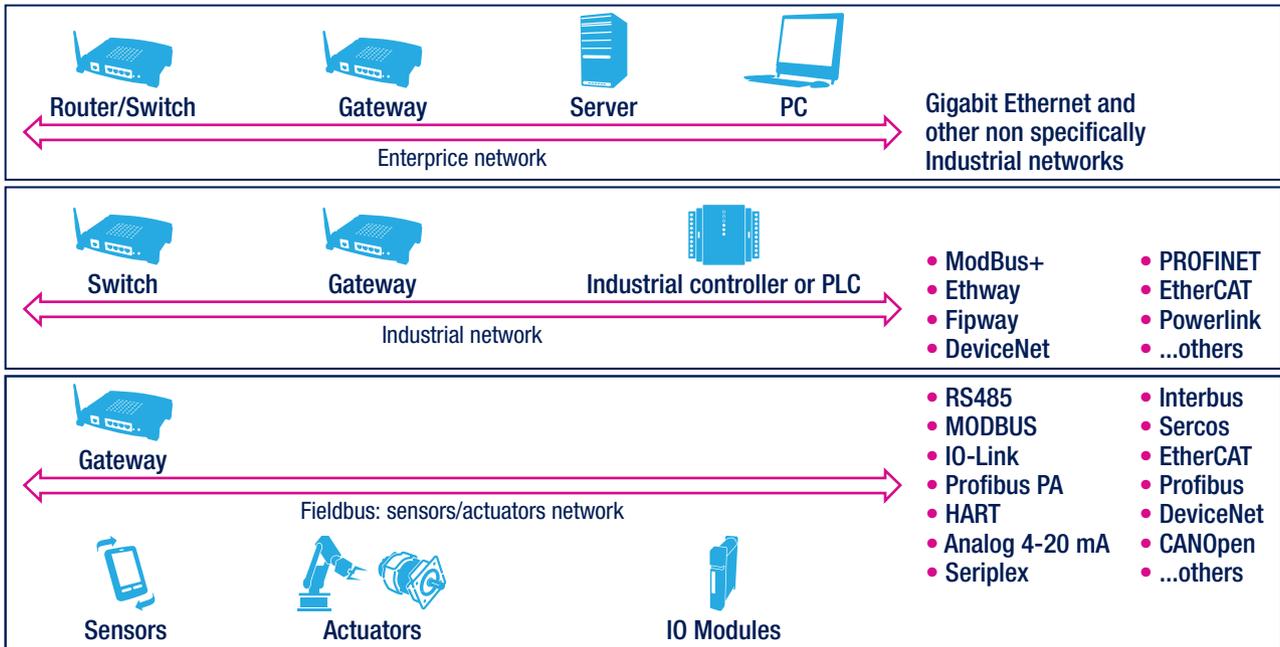
IPS devices are designed to safely drive every kind of load in low-voltage applications (up to 55 V), handling data in and out of the microcontroller by means of status/input signals. IPS devices are designed to comply with the following international standards:

- IEC 61000-4-4 (electrical fast transient/burst)
- IEC 61000-4-2 (ESD, immunity test contact/air)
- IEC 61000-4-5 (surge test immunity requirements)
- IEC 61000-4-6 (current injection test)
- IEC 61131-2 (programmable controller, equipment requirements and tests)

IPS devices come with evaluation boards available on Internet ([www.st.com/ips](http://www.st.com/ips)).

## DATA COMMUNICATION INTERFACE ICs

A PLC (or any modern control system) interfaces with several kinds of networks depending on overall system dimensions.



As can be seen from the diagram, there are many different types of networks. The different protocols developed over the years by consortiums, associations and private companies have become standard networks, sometimes complementing each other, or more often alternatives to each other. For more information, visit [www.st.com/communication](http://www.st.com/communication)

This section only covers communication interfaces, while implementation of the most common protocols in the industrial arena is part of the field layer section, in which various industrial Ethernet stacks are enabled through our most advanced MCUs.

In this complex world, ST is positioned as a key partner in several associations and as a solution provider, with a very wide offering:

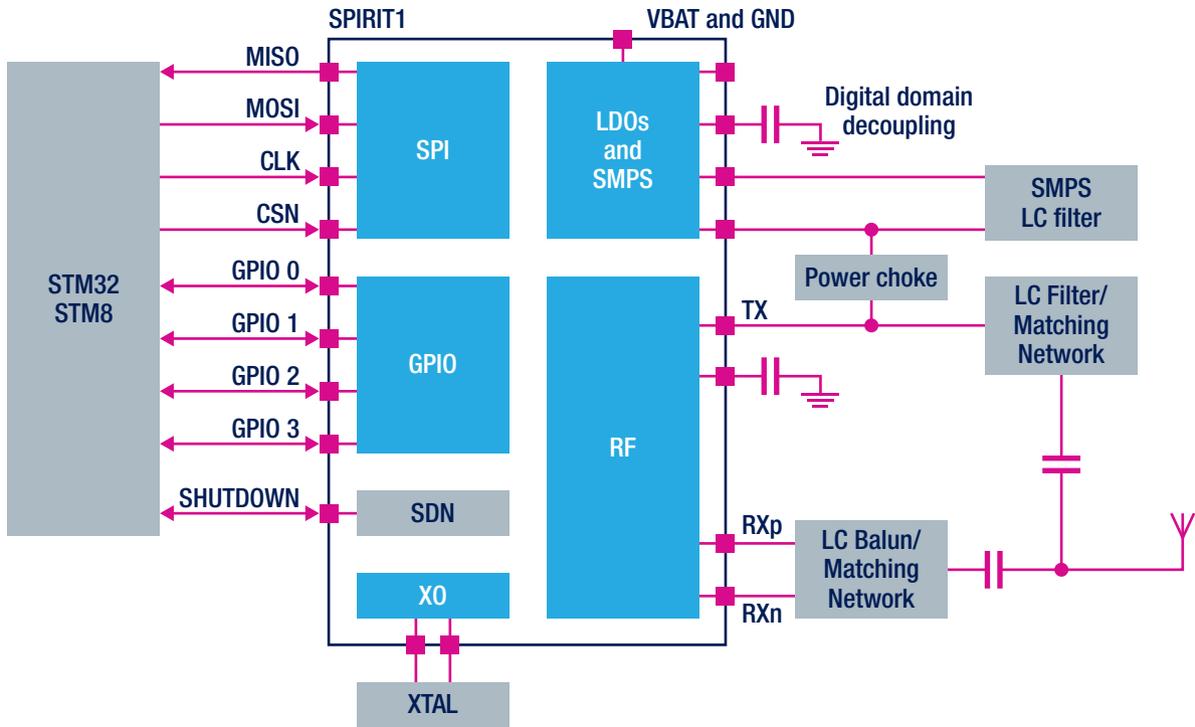
- I/O and network interface ICs
- Programmable transmitters
- Ethernet transceivers
- LAN adapters
- Routers and switches
- Data storage ASICs
- Power management ICs
- Dedicated circuits for Ethernet interfaces
- Powerful ARM Cortex MCUs
- Modem circuits
- ASI circuits
- Protection devices
- Wireless modules
- High-performance transceivers for sub-GHz applications

These latter devices are finding a place in the industrial monitoring field and are addressed by our SPIRIT1:

- Frequency bands: 169, 315, 433, 868, 915, 920 MHz
- Configurable data rate from 1 to 500 Kbit/s
- SPI interface
- Supply voltage: 1.8 to 3.6 V
- Modulation schemes: 2-FSK, GFSK, MSK, GMSK, OOK, ASK
- Suitable for systems targeting compliance
  - Wireless MBUS standard
  - ETSI EN 300 220, FCC CFR47 Part 15, ARIB STD-67
- Output power: -36 to +16 dBm, in 0.5 dB steps
- Excellent receiver sensitivity: -120 dBm (1.2 Kbit/s – 169 MHz)
- Adjacent channel selectivity: 55 dB at 12.5 kHz channel spacing (1% PER – 20-byte packet length)
- Integrated SMPS allows very low power consumption
- Integrated packet handler
  - Support for automatic acknowledgment, retransmission, low duty cycle protocol and timeout protocol
- Automatic clear channel assessment (CCA) engine
  - Channel access mechanism, based on the rule listen-before-talk systems; embedded CSMA/CA protocol
- Fully-integrated ultra-low-power RC oscillator
- AES 128-bit encryption coprocessor for secure data transfer
- Frequency hopping under MCU control
  - Calibration can be made each time the MCU changes frequency or MCU can save and restore calibration data to make the frequency hopping faster
- Separate 96-byte Rx/Tx FIFOs
  - Accessible via the SPI interface for host processing
- Supports automatic antenna selection through an integrated antenna diversity switching mechanism



The application diagram is shown below.



### BALF-SPI-01D3: dedicated Balun for SPIRIT1

Covering the 868÷915 MHz the BALF-SPI-01D3 is designed to reach an optimized trade-off between PCB optimization, compliant performance and filtering improvements.

#### KEY BENEFITS FOR THE BALF-SPI-01D3 (868÷915 MHZ)

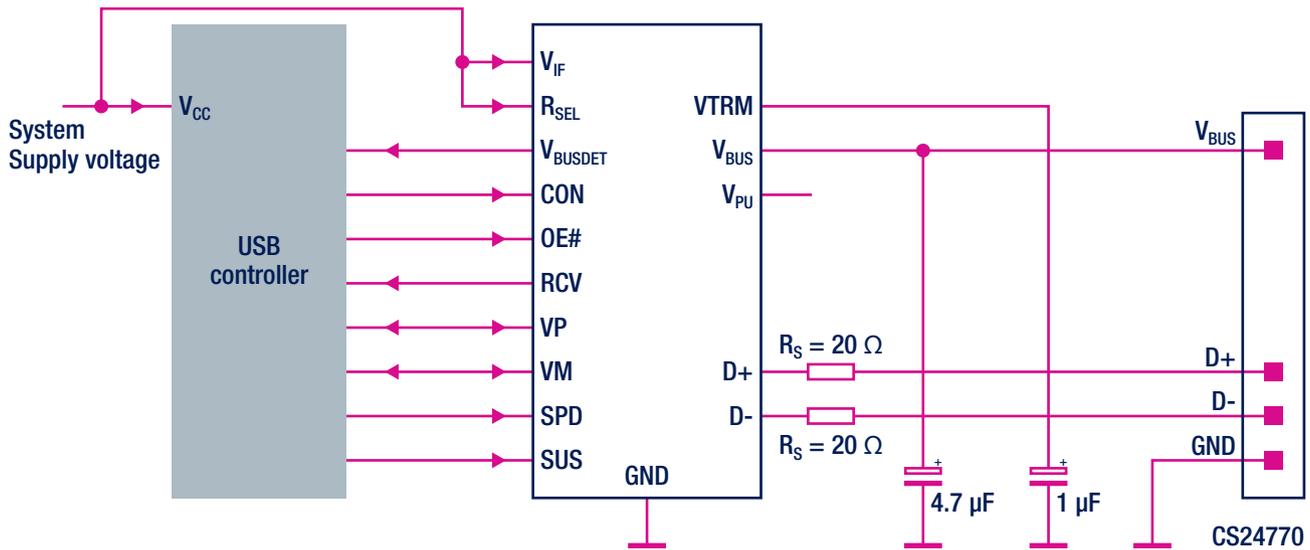
- Simplifies RF complexity
  - 1 component versus 15 components
- Shrink Balun matching PCB occupation
  - 2.8 mm<sup>2</sup> versus 37 mm<sup>2</sup>
  - No need for twisting layout
- Increased performance
  - better P<sub>out</sub> versus SMD solution
- Improved filtering
  - Minimizes unwanted harmonics versus SMD
- Faster design

The results using the BALF-SPI-01D3 instead of a common SMD matching are quite impressive: we get a 15x smaller area going from 37 mm<sup>2</sup> (7 x 5.3 mm) to 2.8 mm<sup>2</sup> (2 x 1.4 mm).

## USB transceivers and interfaces

ST's USB interface family includes high-speed USB OTG ULPI transceivers, full speed OTG transceivers and USB charger detection interfaces. They provide a complete solution to connect a digital USB-OTG and ULPI controller to the physical universal serial bus.

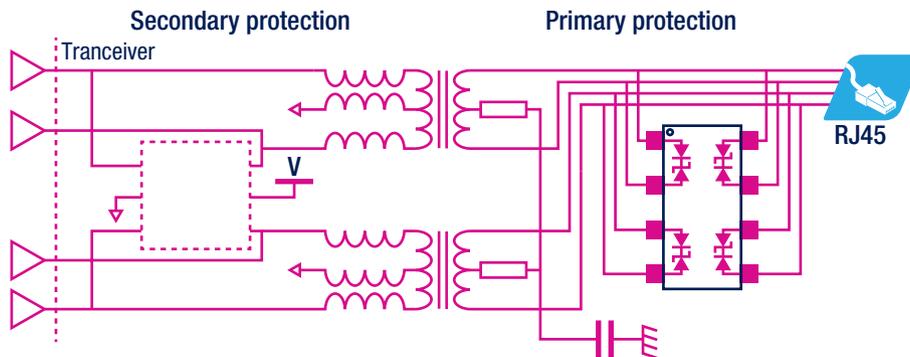
For example, the diagram below shows a typical application circuit using the STUSB03E.



The STUSB03E is a single-chip transceiver that complies with the physical layer specifications of the Universal Serial Bus (USB) v2.0 standard. It has an integrated 5 V to 3.3 V regulator which allows direct powering from  $V_{BUS}$ . The transceiver has an integrated voltage detector to detect the presence of  $V_{BUS}$  and features an internal D+ pull-up resistor implemented in accordance with the 27% resistor ECN.

For advanced protection devices, the SLVU2.8 series has been designed to protect Ethernet lines. Their low capacitance makes them compatible with gigabit Ethernet.

In this family, the SLVU2.8-4A1 is designed to be compatible with gigabit Ethernet and gigabit PoE by using two S0-8 packages, and can be used on 10/100 Mbit/s Ethernet with a single device. Surge capability is compatible with IEC 61000-4-5 class 2 (1 kV, 42  $\Omega$ , 24 A).



The diagram shows the use of the SLVU2.8-4A1, implementing 10/100 Mbit/s Ethernet protection.

The following table presents some examples of decreasing complexity of dedicated ICs, such as the ST485Ex, a family of  $\pm 15$  kV ESD protected, low-power RS-485/RS-422 transceivers, for industrial applications ([www.st.com/interface](http://www.st.com/interface)).

Part number	Temperature range ( $^{\circ}\text{C}$ )	Supply voltage(V)	Data rate min (Mbit/s)	Communication standard supported	Number of nodes	Number of drivers/receivers	Package
ST485EBDR	-40 to 85	5	5	RS485, RS422	256	1/1	S0-8
ST485EXDR	-55 to 125	5	5	RS485, RS422	256	1/1	S0-8
ST232EB	-40 to 85	4.5	230 (Kbaud)	RS232	-	2/2	S0-16, TSSOP 16

## SERIAL REAL-TIME CLOCK (RTC) ICS AND MEMORIES

### Widest portfolio of RTC offers unlimited design solutions

In applications where the clock must not drift, and time has to be kept over long periods while unplugged and with minimal battery backup, a standalone RTC offers significantly higher performance than an embedded RTC in the MCU. An extended range of products with the latest technological innovations is available, including ultra-low-power devices, embedded crystals, analog and digital calibration. RTC functions include programmable alarm, battery switchover and many useful supervisory functions that enhance the application's reliability such as oscillator fail detect, battery low detect, early power fail warning, reset, watchdog, and more ([www.st.com/rtc](http://www.st.com/rtc)).

### RTC KEY PRODUCTS

Sub-families	Parts	Key features	Applications
Low Power	M41T6x	Low standby current World's smallest RTC with crystal Small packages	Portable HMI
Enhanced industry standard	M41T81S M41T00S M41T01 M41T80 M41T11 M41T82/83/93 M41T00CAP	Automatic battery switchover Analog calibration Embedded crystal	Sub-metering HMI
Highly-integrated	M41ST85W M41T94 M41T00AUD M41ST87W	Embedded NVRAM Internal and external RAM clear MCU supervisor functions Tamper detect with timestamp	PLC Local control Servers Data storage Security
Battery with crystal	M4T28 M4T32	Battery backup power Keyed insertion Removable battery	Sub-metering Portable HMI Local control

### Compact non-volatile memories

ST offers a wide range of non-volatile memories. The serial EEPROM family ranges from 1 Kbit to 2 Mbits and offers different serial interfaces: I<sup>2</sup>C, SPI and Microwire. The wide range of products is also automotive compliant, and very thin packages are available for applications where space is critical.

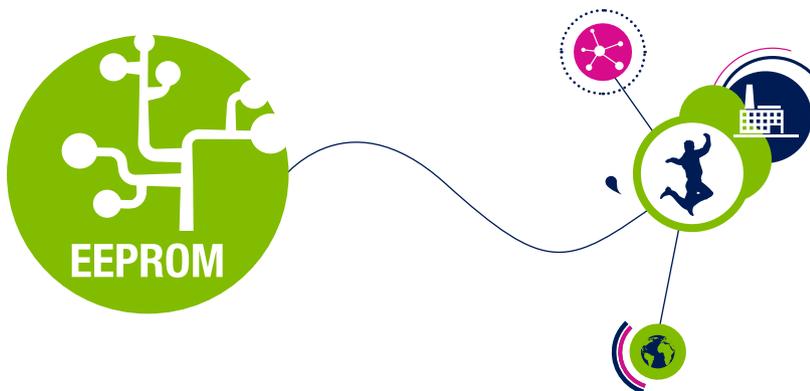
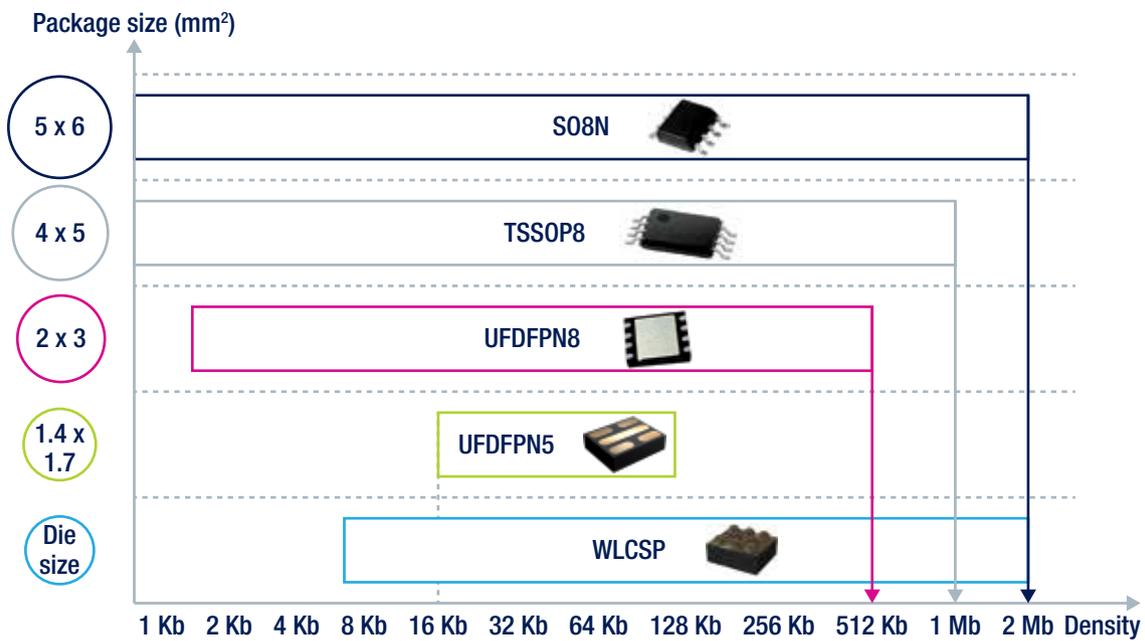
NVRAMs are battery-backed SRAMs that range from 16 Kbits to 256 Kbits, housed in DIP packages that include a battery, or surface-mount SOIC packages that allow for a SNAPHAT replaceable battery. Timekeeping and clock functions are also available. [www.st.com/memories](http://www.st.com/memories)

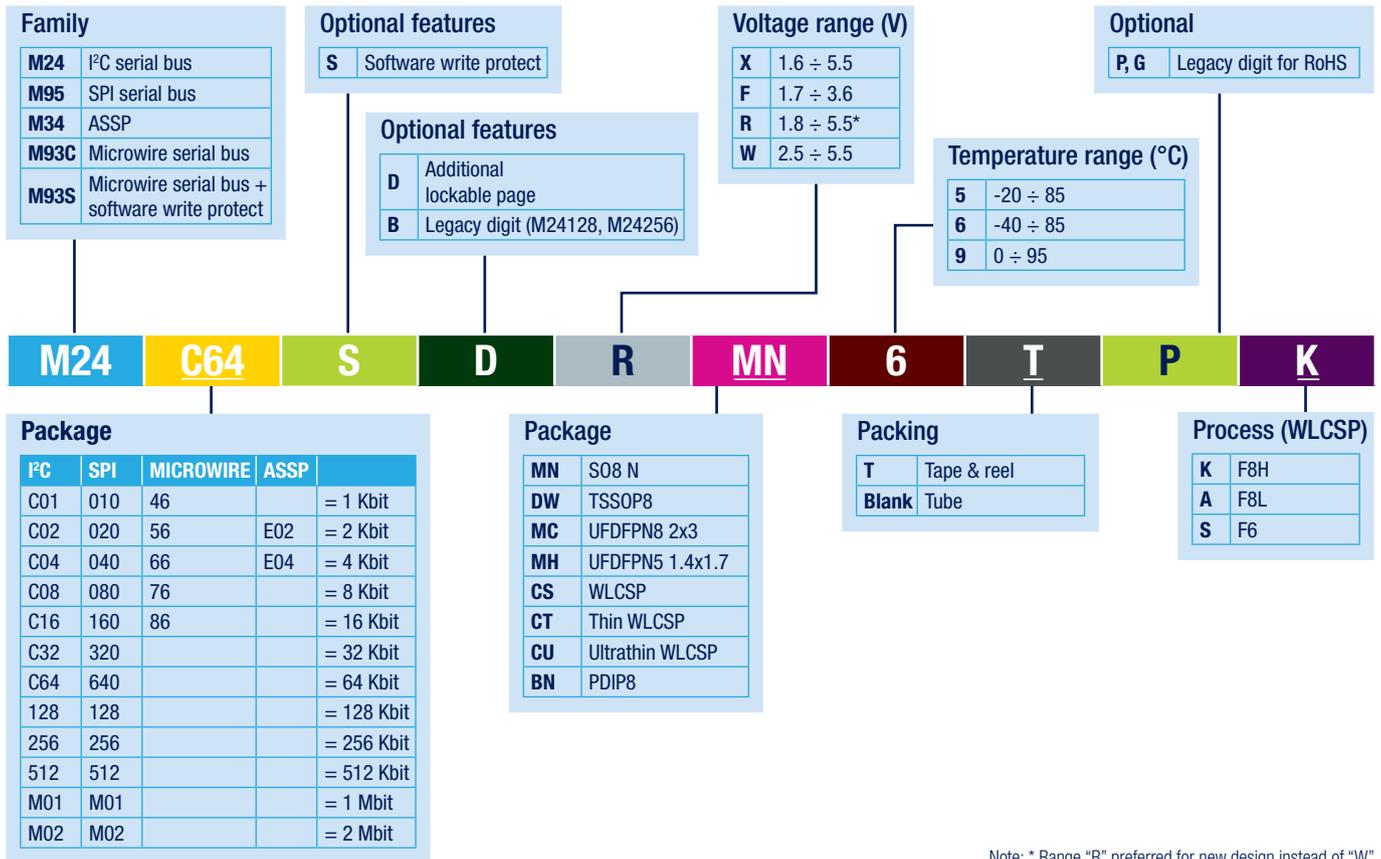


#### ST'S STANDARD SERIAL EEPROM PORTFOLIO OFFERS:

- Industry's largest memory size, 2 Mbits
- Smallest standard package UDFPN5 (60% smaller than UDFPN8)
- Smallest and ultrathin WLCSP packages (0.3, 0.33 and 0.6 mm)
- A guarantee at 4 million erase/write cycles and 200 years data retention
- M24 Series I<sup>2</sup>C from 1 Kbit to 2 Mbits, up to 1 MHz bus
- Miniature packages (WLCSP, thin and ultrathin WLCSP, UDFPN8, UDFPN5) and small packages (S08, TSSOP8)
- Operating voltage from 5.5 V to 1.7 V, (even 1.6 V for some parts)
- Specific features
  - Lockable Identification Page (I<sup>2</sup>C or SPI bus),
  - Programmable block protection (Microwire bus)

Family	Sub-families	Parts	Key features	Applications
Serial EEPROM	Standard serial EEPROM	M24 series	I <sup>2</sup> C, with densities ranging from 1 Kbit to 2 Mbits, and a bus speed of 1 MHz or 400 kHz	Portable HMI HMI PLC Local control Servers Data storage
		M95 series	SPI, a faster bus that features a chip select input, with densities ranging from 1 Kbit to 2 Mbits, and a bus speed from 2 MHz to 20 MHz (depending on V <sub>cc</sub> )	
		M93 series	Microwire, a legacy bus, with densities ranging from 1 Kbit to 16 Kbits	
	Application specific serial EEPROM	M34Exx	Serial presence detect (SPD) for DRAM modules 2 and 4 Kbits	
		M34F04	Half array write protect 4 Kbits	
		M35B32	Fast write operations 32 Kbits	
NVRAM	ZEROPOWER	M48Zxx	ST's ZEROPOWER products integrate low-power SRAMs with a power-fail control circuit and a long-life lithium battery (available in CAPHAT or SOIC plus SNAPHATS packages). From 16 to 256 Kbits	
	Battery Options	M4Zxx-BR00SH	Two SNAPHATS packages (compatible with SOIC) which embed 48 or 120 mAh lithium batteries	





Note: \* Range "R" preferred for new design instead of "W"

## POWER SUPPLIES

### Focus on industrial DC-DC converters

ST's power management devices enable energy-saving, high-power density and lower standby power design solutions. Our product portfolio includes highly-integrated AC-DC converters, switching DC-DC converters, linear voltage regulators, battery management ICs, LED drivers, photovoltaic ICs, MOSFET and IGBT drivers, motor drivers and more. These integrated solutions reduce the design cycle and ST's eDesignSuite ([www.st.com/edesign](http://www.st.com/edesign)) allows you to rapidly select and simulate the optimal configuration for your power management design, bringing a further advantage in time-to-market ([www.st.com/powermanagement](http://www.st.com/powermanagement)).

Matching the requirements of the industrial market, ST provides a complete family of step-down monolithic DC-DC converters with an input voltage range compliant to 24 V buses, and able to provide a continuous output current up to 3 A with high switching frequency (up to 2 MHz). A full set of protection features is embedded (overcurrent, overvoltage, over-temperature) to increase the MTBF and reduce the number of external components ([www.st.com/dcdc](http://www.st.com/dcdc)).

ST's DC-DC converters for industrial buses offer a wide choice of input voltage ranges

( $V_{IN(max)}$  from 38 V to 61 V) and features. The new 61 V series (L7987/L) has been designed to provide maximum reliability in fail-safe applications.

The new synchronous DC-DC converter for industrial applications, the L6986, is the best choice when efficiency is of prime importance, both at full load (thanks to synchronous rectification) and at light load (thanks to the low standby consumption). Evaluation boards are available upon request. There are multiple package options, all offering compactness and high thermal performances to fit different applications.



The following table orders this wide offering according to the different voltage bus levels, while some examples are provided further on.

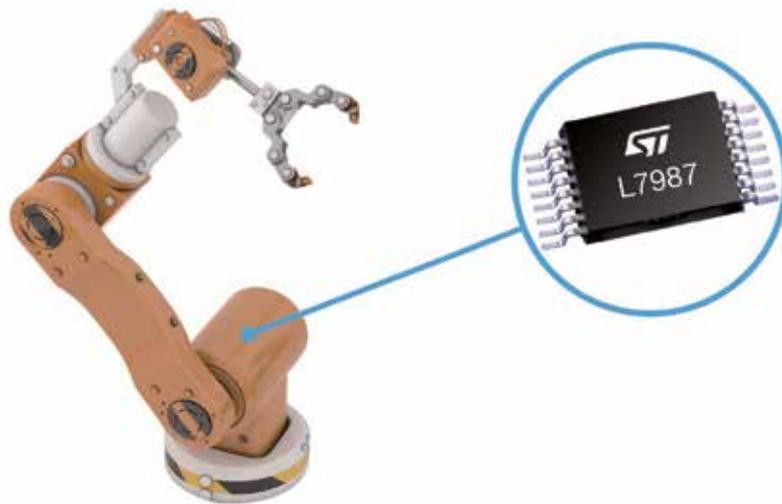
Voltage bus range	Device family	Maximum output current	Synchronous rectification	Low consumption at light load	Package
4.5 ÷ 38	L7985/6	2 ÷ 3	No	No	HSOP8, VFQFPN10-3x3
4 ÷ 38	L6986	2	Yes	Yes	HTSSOP16
5.5 ÷ 48	ST1S14	3	No	No	HSOP8
4.5 ÷ 61	L7987/L	2 ÷ 3 A (with adj. current limit)	No	No	HTSSOP16
4.5 to 36 V	L6984/A	0.4 A	Yes	Yes	VFDFPN10-4x4, VFDFPN10-3x3

### L7987/L FEATURES

- 4.5 to 61 V input voltage range
- 3 A DC output current (2 A for L7987L)
- Adjustable peak current limit
- Adjustable switching frequency (250 kHz to 1.5 MHz) with synchronization capability
- Adjustable soft start
- Power good

### L6986 FEATURES

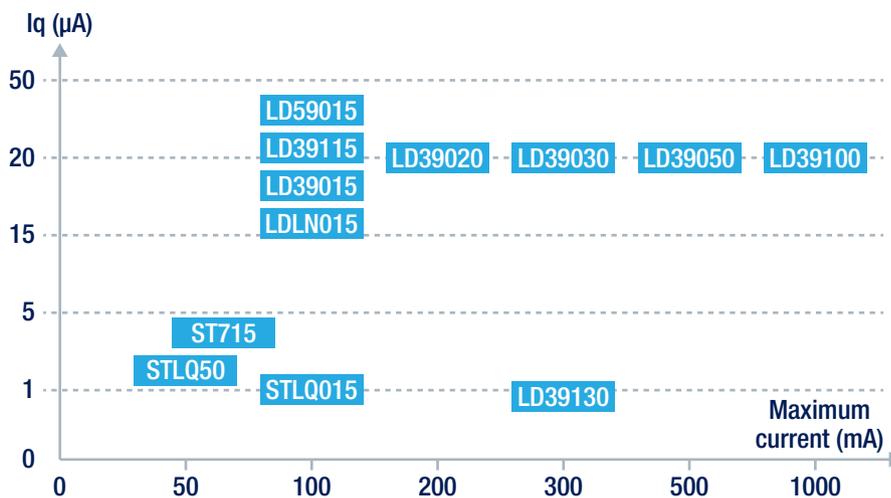
- 4 to 38 V input voltage range
- Up to 2 A DC output current
- Synchronous rectification
- Very low quiescent current (~30 µA typ.)
- Adjustable switching frequency (250 kHz to 2 MHz) with synchronization capability
- Adjustable soft start
- Power good with adjustable delay



### Linear voltage regulators

ST offers fixed and adjustable output linear regulators featuring an optimal combination of low drop-out voltage, quiescent current, transient response and low noise. They are ideal for battery-powered applications (i.e. industrial hand-held equipments) where both optimum heat dissipation and small dimensions are key factors.

ST's series of low quiescent current LDO regulators is ideal for portable consumer and battery-powered applications where they extend the application's battery lifetime and keep good dynamic performance, all in a small footprint. Package options include the SC70, SOT666, CSP 4 bumps and DFN6L-2x2.



As a first highlight, the LD39200, is a high PSRR, ULDO with reverse current protection:

- Input voltage: from 1.25 V to 6 V
- Output current: 2 A
- 1% output voltage accuracy at 25 °C
- Ultra low drop voltage: 200 mV at 2 A
- Fixed and adjustable  $V_{out}$  from 0.5 V
- High PSRR: 70 dB at 1k Hz
- Fast transient response
- Enable and power good pins
- Reverse current protection
- Package: DFN 8L- 3x3 mm, S08P

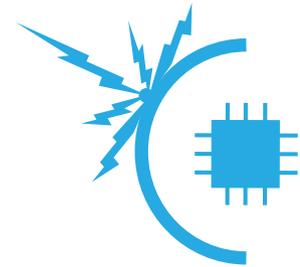
Finally, the new LDFM, LDF series, are the new, very low drop linear regulators:

- Input voltage: from 2.5 V to 16 V
- Output current: 0.5 A and 1 A
- Very low dropout voltage: 300 mV at 500 mA output current
- Low quiescent current:
  - 200  $\mu$ A @ full load
  - 50  $\mu$ A max in off mode
- Wide output voltage range choice: ADJ ( $V_{ref} = 0.8$  V) or fixed from 0.8 V to 12 V
- Logic controlled enable pin
- Power good function
- Stable with low ESR ceramic capacitors

## PROTECTION DEVICES

### Power and data line protection

In harsh factory automation environments, protection devices are the key to system reliability. ST offers a wide range of protection devices dedicated to power lines or data lines. More at [www.st.com/protection](http://www.st.com/protection)



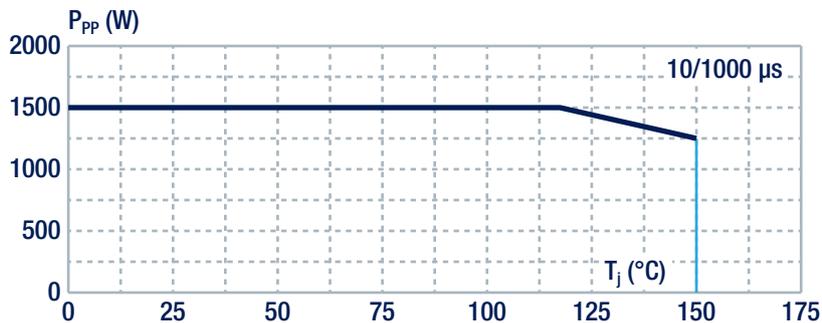
### Power lines

Overvoltages and glitches appearing on power mains are modeled by the IEC 61000-4-5 international standard, also known as 8/20  $\mu$ s current waveform. Able to protect up to 500 A (8/20 $\mu$ s), the STIEC45 series is the ideal surge suppressor solution for factory automation power lines.

Order code	VBR @IR			VCL @IPP 8/20 $\mu$ s, 1.2/50 $\mu$ s		
	Min.	Typ.	Max.		Max.	
	V			mA	V	A
STIEC45-24AS	26.7	28.2	29.5	1	42	500
STIEC45-26AS	28.9	30.3	31.9	1	45	500
STIEC45-27AS	30	31.6	33.2	1	47	500
STIEC45-28AS	31.1	32.6	34.3	1	49	500
STIEC45-30AS	33.3	35	36.8	1	55	500
STIEC45-33AS	36.7	38.6	40.6	1	59	500

As well as the robust and reliable performances during voltage surges, ST's discrete TVS (transient voltage suppressors) exhibit an excellent power derating versus temperature. As an example, ST's SM15T series (1500 W, 10/1000  $\mu$ s) operates at full performance up to 115 °C.

Peak pulse power dissipation versus initial junction temperature (printed circuit board)

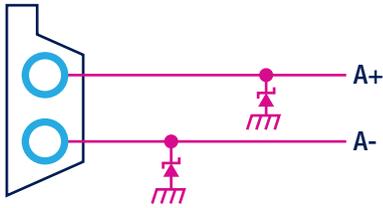


## Data lines

Communication buses, with long wire lengths, are particularly sensitive to electrostatic discharge (ESD). ST proposes multiline solutions in a single package, with various parasitic capacitance and voltage compromises, to address a wide range of industrial communication interfaces as shown below.

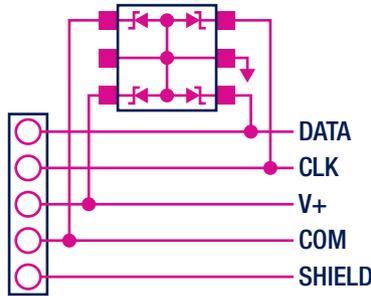
### ASI interface

Actuator and sensor Interface



**SMM4F33A**  
ESD with +/- 30 kV contact

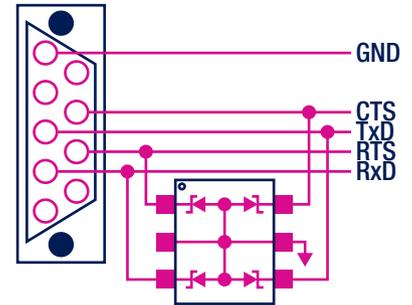
### Seriplex interface



**ESDA14/25xx**  
ESD protection in SOT666/323/23

### RS-232 interface

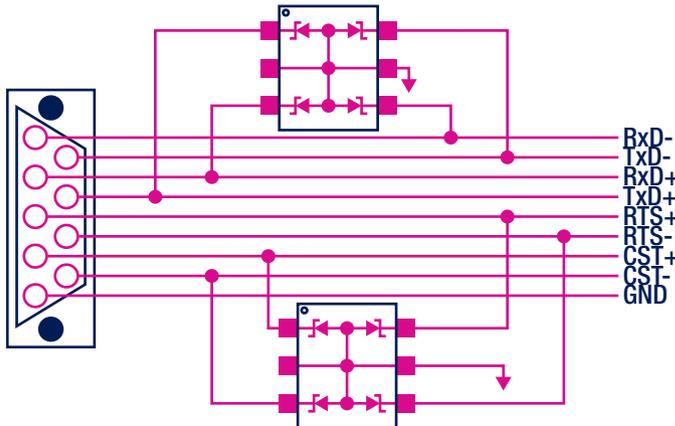
Modbus®



**ESDA6V1/14/25xx**  
ESD protection in SOT666/323/23

### RS-422 and RS-485 interface

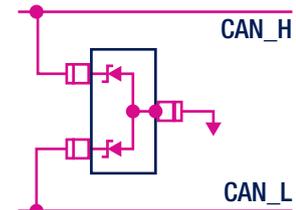
Modbus®, Modbus Plus™, PROFIBUS®



**ESDA6V1/14/25xx**  
ESD protection in SOT666/323/23

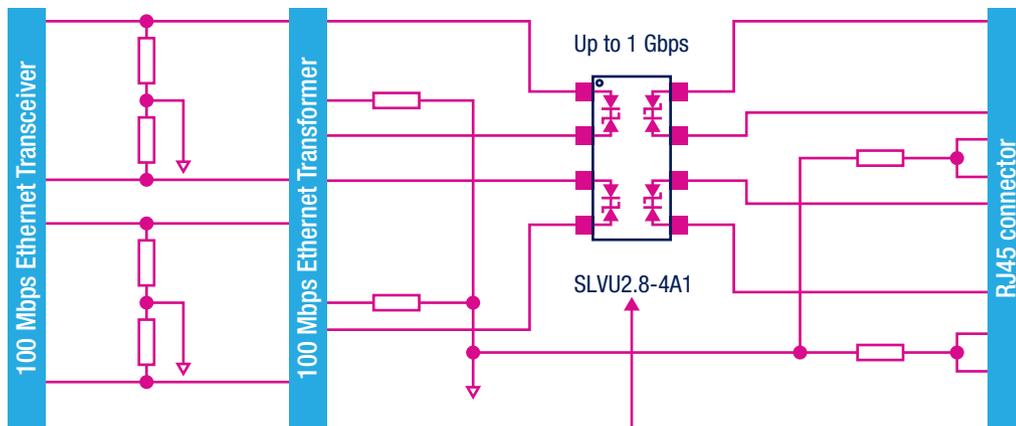
### CAN interface

CANopen, DeviceNet™



**ESDA6V1L / ESDALC6V1**  
ESD protection in SOT666/23

### Ethernet protection



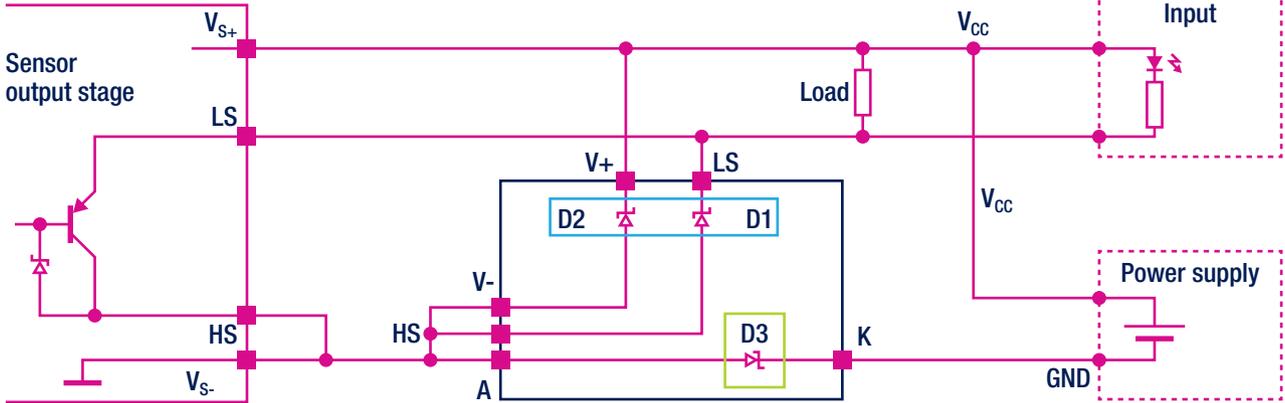
S0-8

**SLVU2.8 or DSL01**  
3 triple Trisil in one S08/  
Transil + Trisil in one package

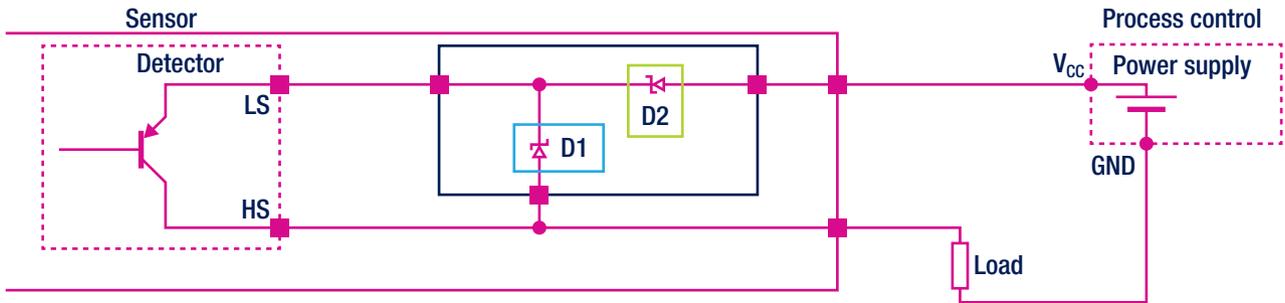
## Proximity sensor protection

ST has developed specific and dedicated 200 W (10/1000  $\mu$ s) multi-line TVS for 2 and 3-wire proximity sensors. The SPT series provides reverse polarity and surge protection in compliance with IEC 61000-4-5, IEC 61131-2 and EN 60947-5-2.

### 3-wire sensor: SPT01-335DEE



### 2-wire sensor: SPT02-236DDB



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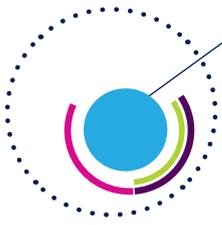
## 2 FEATURES:

- Surge protection
- Reverse battery protection

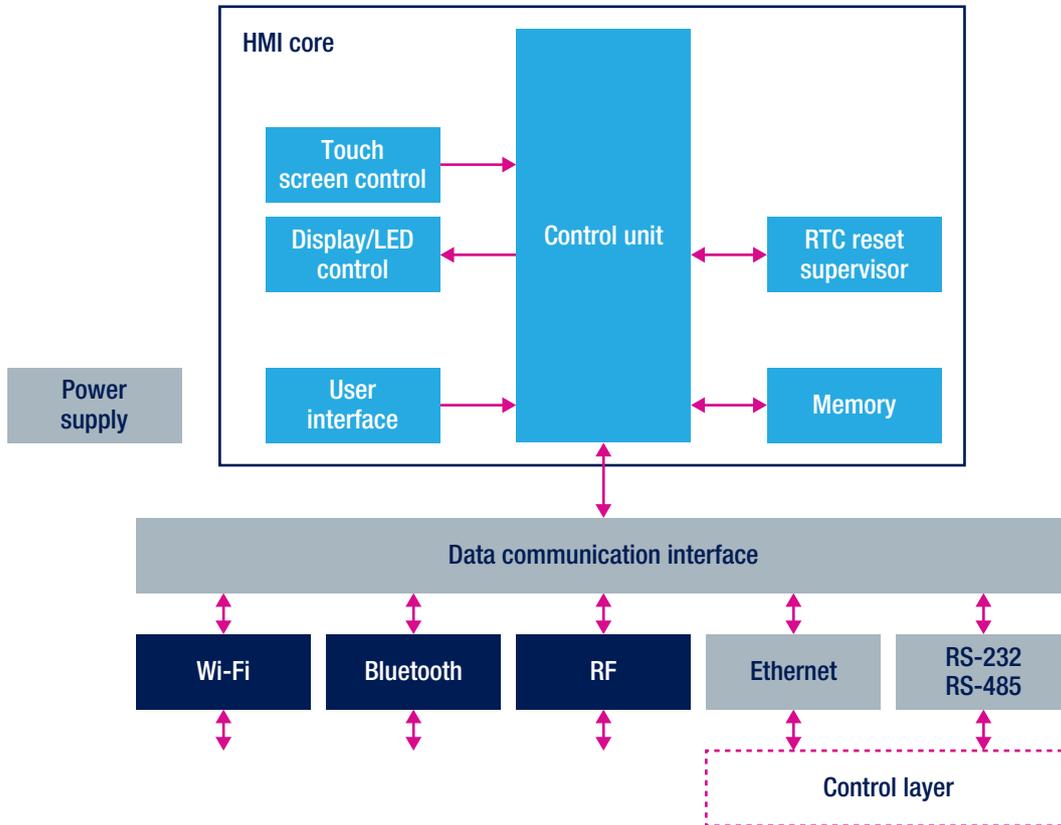
## FACTORY AUTOMATION NEEDS:

- 2-/3-line protection
- 36 V  $V_{RM}$  required (even if  $V_{supply} = 24$  V typ)
- $V_{CL} @ IPP = 46$  V @ 2 A
- Diode specified in forward mode





# Supervisor layer



The above is a typical supervisor layer. At this level, we will not find typical industrial components, but all the facilities to manage data, assets and infrastructures.

To this end, the most advanced wireless technologies, display and LED controllers, as well as the introduction of NFC (near field communication) technology in factory automation are main topics.

The aim is to simplify and shorten execution time for the first level commands associated with the supervisor.

Other parts functional to this level, such as the control unit, data communication interfaces or power supply, but are also common to the other levels, have been discussed in the previous chapters.

## WIRELESS MODULES

### SPBT2632 series, smart communication embedded in a qualified Bluetooth v. 3.0 solution

ST's Blue Module range of wireless modules is based on the latest Bluetooth Classic 3.0 specification and implements leading-edge Bluetooth technology. The modules are designed for maximum performance while taking up minimal space. They include high-speed UART, general-purpose I/O lines and high data throughput. An optimized design allows the integration of a complete Bluetooth modem, enabling low-power mode capability with the minimum size.

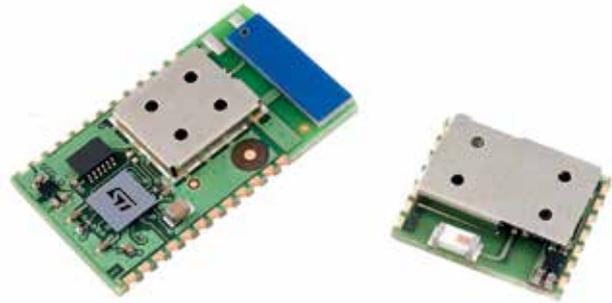
All Blue Modules are BQE qualified and listed on the SIG website. The SPBT2632 series with on-board antenna is fully certified FCC, IC and CE, and the SPBT2632C2A.AT2 is also TELEC certified.

Blue Modules support the AT command interface based on SPP (Serial Port Profile), featuring fast and secure, transparent serial data transmission and simple automatic connection between predefined devices through smart cable links. In addition, the AT2 FW version supports IAP (IPOD accessory protocol) for communication with smartphones and Apple iOS Bluetooth-enabled devices.

#### TARGETED APPLICATIONS

- Wireless cable replacement
- M2M
- Smartphones
- Service diagnostics
- Data acquisition equipment
- Mobile health

### Smart communication embedded in a qualified Bluetooth solution



Key features	Key benefits
Compliant with latest Bluetooth 3.0 specification	Future-ready module, enhanced security, easier pairing, compatible with Apple products
SPBT2632 series is BQE end-product qualified and the relevant QDIDs are listed on SIG website	Recalling ST QDID, you can apply for declaration of IO listing on the SIG website; no further BQE certification is required for your product
Pre-qualified, pre-tested RF design fully integrated in a unique device	Highly reliable solution, easier design saves development resources and time, shortens time-to-market
Low-power mode supported	Reduces power consumption, increasing final application battery life
Smart cable and remote mode supported	Ensures easy automatic connection and remote mode control over Bluetooth link
Micro-sized form factor	SMD-like component to fit miniaturized applications

Part number	Description	Bluetooth version	FW release	Certification	Dimensions (mm)
SPBT2632C2A.AT2	Class 2, on-board antenna	3.0	AT2 command supporting, M2M, smartphone and Apple iOS	B/QE, TELEC, CE; FCC, IC	11.6 x 13.5 x 2.9
SPBT2632C1A.AT2	Class 1, on-board antenna	3.0	AT2 command supporting, M2M, smartphone and Apple iOS	BQE, CE, FCC, IC	15.2 x 26.9 x 2.9

### Sub 1 GHz modules

Sub 1 GHz modules add wireless capability to any electronic device without requiring RF experience. Available now, the SP1ML series supports both 915 MHz and 868 MHz and offers a fully embedded, RF tested and certified Sub giga modem, based on ST's Spirit1 RF transceiver. A series of pure RF modules to enable connectivity on your existing solution will be available soon.



## RF INTERFACES AND NFC FOR AUTOMATION

### BlueNRG: Bluetooth 4.0 Low Energy Network Processor

Targeted for security and proximity applications, the BlueNRG is a very low power Bluetooth Low Energy (BLE) single-mode network processor, compliant with Bluetooth specification v4.0.

Ultra low-power sleep modes and very short transition times between operating modes allow very low average current consumption, resulting in longer battery life.

For fast prototyping and easy evaluation, the BlueNRG expansion for STM32-Nucleo boards are also available (order code: X-NUCLEO-IDB04A1).



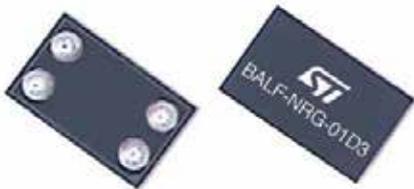
Features include:

- Bluetooth specification v4.0 compliant master and slave single-mode Bluetooth low energy network processor
- Embedded Bluetooth low energy protocol stack: GAP, GATT, SM, L2CAP, LL, RF-PHY
- Bluetooth low energy profiles (provided separately)
- Operating supply voltage: from 2.0 to 3.6 V
- 8.2 mA maximum TX current (@0 dBm, 3.0 V)
- Down to 1.7  $\mu$ A current consumption with active BLE stack
- Integrated linear regulator and DC-DC step-down converter
- Up to +8 dBm available output power (at antenna connector)
- Excellent RF link budget (up to 96 dB)
- Accurate RSSI to allow power control
- Proprietary application controller interface (ACI), SPI based, allows interfacing with an external host application microcontroller
- Full link controller and host security
- High performance, ultra-low power Cortex-M0 32-bit based architecture core
- On-chip non-volatile Flash memory
- AES security co-processor
- Low power modes
- 16 or 32 MHz crystal oscillator
- 12 MHz ring oscillator
- 32 kHz crystal oscillator
- 32 kHz ring oscillator
- Battery voltage monitor and temperature sensor
- Compliant with the following radio frequency regulations: ETSI EN 300 328, EN 300 440, FCC CFR47 Part 15, ARIB STD-T66
- Available in QFN32 (5 x 5 mm) and WCSP34 (2.6 x 2.6 mm) packages
- Operating temperature range: -40  $^{\circ}$ C to 85  $^{\circ}$ C

### The BALF-NRG-01D3 is a Balun companion chip for the BlueNRG network processor

ST companion chip Baluns are outsmart components designed to boost RF performance while simplifying the complexity of implementation, with exceptional compactness.

The BALF-NRG-01D3 simplifies and reduces IC-to-antenna matching complexity. Here is an example of how much space can be saved in a common design with our BlueNRG network processor and the new BALF-NRG-01D3:



#### BENEFITS

- Simplifies RF complexity: 1 component versus 8 components
- Shrink Balun matching PCB occupation
  - 1.2 mm<sup>2</sup> versus 32 mm<sup>2</sup>
  - No need for twisty layout
- Increased performance: same P<sub>out</sub> as SMD solution
- Improved filtering: up to +10 dB Harmonic rejection versus SMD
- Faster design: copy-paste design recommendation

A design with our BlueNRG network processor used in conjunction to the new BALF-NRG-01D3 results in unprecedented space saving: in average we go from a calculated area of about 32 mm<sup>2</sup> (typical PCB area for Antenna SMD matching with a standard design) down to 1.2 mm<sup>2</sup> of the solution using the BALF-NRG-01D3.

## NFC/RFID for automation with our M24LR and M24SR

NFC/RFID memory and transceiver products are based on the 13.56 MHz carrier frequency and support the ISO 14443 and ISO 15693 RFID standards. ST offers one of the most comprehensive NFC/RFID device portfolios, which includes:

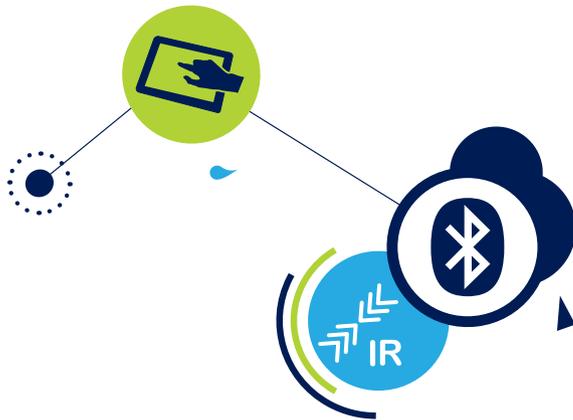
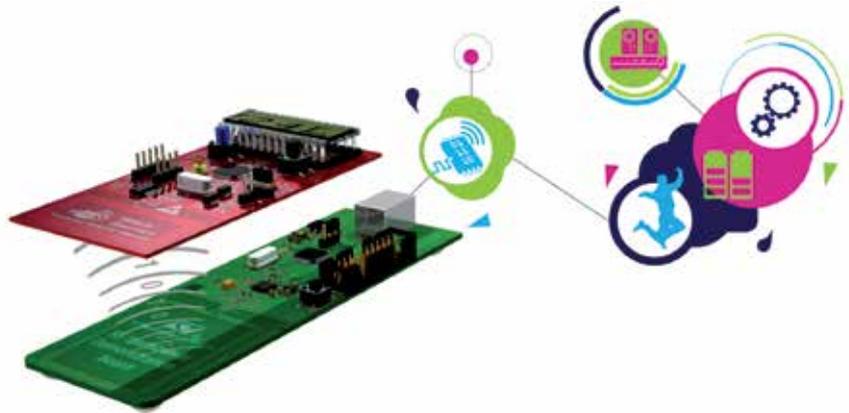
- Dynamic NFC/RFID tags (also known as Dual Interface EEPROM)
- NFC/RFID transceivers
- NFC/RFID tags

ST's dynamic NFC/RFID tags feature an EEPROM memory bank that can be accessed either through a low-power I<sup>2</sup>C interface or an NFC/RFID interface operating at 13.56 MHz. The M24LR, M24SR; SRTAGxx-D series provide designers with a wide range of features.

- NFC forum tag type 4 or ISO 15693 RF interface
- I<sup>2</sup>C serial interface
- Several options to control the application (RF disable, energy harvesting, password protection, control output, digital output for external chip wakeup)
- Simple antenna design, compatible across M24LR, M24SR and SRTAGxx-D series

The M24LR series offers a long-range RFID interface compatible with ISO 15693-capable NFC phones. It features an innovative energy harvesting function that enables battery-less designs. It can be used in a wide variety of applications, including consumer electronics, computer peripherals, home appliances, industrial automation and healthcare products.

- ISO 15693 tag RF interface
- 400 kHz I<sup>2</sup>C serial interface operating from 1.8 to 5.5 V
- EEPROM memory density from 4 Kbits to 64 Kbits
- Energy harvesting
- 32-bit password protection
- RF WIP/busy output pin
- Simple antenna design, backward compatible with M24SR series



The M24LR-DISCOVERY is one evaluation board associated with the M24LR series.

It is a ready-to-use kit, which features the M24LR04E-R dual interface EEPROM IC. It addresses a wide range of applications such as industrial or medical equipment and consumer electronics. This kit contains two different boards (see illustration above):

- The M24LR board is battery-less and is powered by RFID readers or NFC-enabled phones supporting ISO/IEC 15693.
- The RF transceiver board is an RFID reader evaluation board and is composed, among other parts, of a CR95HF 13.56 MHz multi-protocol contactless transceiver IC with SPI and UART serial access.

This board can be plugged into a PC and comes with a demonstration software.

The M24LR board also works with Android NFC phones supporting ISO/IEC 15693. An application called NfcV-Reader is available on Google Play. Performance may vary depending on the NFC phone's RF management.

System requirements

- Windows PC (2000, XP, Vista, 7)
- ISO/IEC 15693 capable NFC phones

The M24SR series provides an NFC forum tag type 4 RF interface and supports the NFC data exchange format (NDEF). This enables NFC use cases such as simple Bluetooth pairing and other connection handovers, automatic links to URLs, storage of Vcard and other types of information. It can be used in a wide variety of applications, including consumer electronics, computer peripherals, home appliances, industrial automation and healthcare products.

- NFC forum tag type 4 based on ISO 14443 RF interface
- 1 MHz I<sup>2</sup>C serial interface operating from 2.7 to 5.5 V
- EEPROM memory density from 2 Kbits to 64 Kbits with built-in NDEF message support
- RF disable pin allowing the application to control RF access from NFC phones
- 128-bit password protection
- General-purpose output pin allowing flexibility for the applications (wakeup on several types of events)
- Simple antenna design, backward compatible with M24LR series

The M24SR-DISCOVERY is a demonstration kit to evaluate the features and capabilities of the M24SR series and is based on the M24SR64 device. Two versions of this kit are available: the Standard Edition and the Premium Edition.

The Premium Edition includes all of the Standard edition features, plus a headset and a Bluetooth module to demonstrate the convenience of pairing it with a smartphone via NFC.

The M24SR64 device is a dynamic NFC/RFID tag IC with a dual interface. It embeds a 64 Kbits EEPROM memory. It can be operated from an I<sup>2</sup>C interface or by a 13.56 MHz RFID reader or an NFC phone.

The I<sup>2</sup>C interface uses a two-wire serial interface, consisting of a bidirectional data line and a clock line. It behaves as a slave with respect to the I<sup>2</sup>C protocol.

The RF protocol is compatible with ISO/IEC 14443 Type A and NFC Forum Type 4 Tag.

The board is powered through the USB bus. It also includes a microcontroller STM32F103 to drive the EEPROM via I<sup>2</sup>C and the LCD screen via SPI bus.

The M24SR-DISCOVERY (MB1138) schematics, BOM, gerber files, drivers and firmware can be downloaded from [www.st.com](http://www.st.com).

## Dynamic NFC/RFID tags



The X-NUCLEO-NFC01A1 is a dynamic NFC tag evaluation board to allow expansion of STM32 Nucleo boards. It is compatible with the Arduino UNO R3 connector layout and is designed again around the M24SR64-Y.

The board is powered through the Arduino UNO R3 connectors. It also includes three LEDs for general-purpose use.

This overview on our NFC solutions for industrial automation concludes with the ST95HF, an integrated transceiver IC for contactless applications.

The ST95HF manages frame coding and decoding in Reader, Card Emulation and Peer-to-Peer modes for standard applications such as near field communication (NFC), proximity and vicinity standards.

The ST95HF embeds an analog front end to provide the 13.56 MHz air interface.

The ST95HF supports ISO/IEC 14443 Type A and B communication in Reader and Card Emulation modes, ISO/IEC 15693 (single or double subcarrier in Reader mode only) and ISO/IEC 18092 protocols in Reader and Card Emulation modes.

It also supports the detection, reading and writing of NFC Forum Type 1, 2, 3 and 4 tags.

The EVAL-ST95HF kit provides a means to evaluate the features of the STMicroelectronics ST95HF.

The EVAL-ST95HF board is powered through the USB bus. It consists of a ST95HF transceiver on a 47 x 34 mm -4 turn and 13.56 MHz inductive etched antenna and associated tuning circuit components. The ST95HF communicates with the STM32F103RGT6 and LCD screen via SPI bus.

In Tag emulation mode, it could be used with an NFC reader (NFC smartphone, CR95HF or with another ST95HF) to exchange NDEF messages (URI, VCARD, URL) or establish a P2P communication. The communication protocol is based on ISO/IEC 14443 Type A.

In Reader mode, the ST95HF supports ISO/IEC 14443 Type A and B communication, ISO/IEC 15693 and ISO/IEC 18092 protocols.

The mode can be selected on-screen using a joystick.



## DISPLAY AND LED CONTROLLERS

### LED Drivers and Monitor platform ICs

ST offers a large portfolio of energy-efficient LED drivers for general lighting, display backlighting, signage and industrial panels. Ideal for both parallel and series configurations, they enable high-efficiency, high-current accuracy, low-noise and small-size solutions. Topologies include buck regulator LED drivers, boost regulator LED drivers, offline LED drivers, and more ([www.st.com/led](http://www.st.com/led)).

ST's extended portfolio of monitor platform ICs is available at [www.st.com/displays](http://www.st.com/displays).





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