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CPAP and medical artificial ventilators

Disclaimer for critical applications

- Product(s) indicated in this presentation are sold under ST terms and conditions and they are not designed, intended or authorized for use as a critical component in life support systems, or any FDA Class 3 medical devices or medical devices with a similar or equivalent classification in a foreign jurisdiction, or any devices intended for implantation in the human body.
- Contact ST Sales Offices for any further details.

CPAP and medical artificial ventilators

Continuous Positive Airway Pressure (CPAP) helps patients breathe by holding open the alveoli and preventing them from completely collapsing during expiration phases.

The most important aspect in a CPAP system is the air flow control that needs to be adjusted to compensate for altitude, mask movements, and leaks as well as features including heated, humidified, airway respiratory support.

Normally, CPAP is suitable for use in institutional, home, and portable settings. It is not intended for use in Emergency Medical Service (EMS) such as an emergency transport.

Medical artificial ventilators are a machines supporting patient breath by providing mechanical ventilation by pushing air into and out of the lungs, to supply breaths to a patient who is tangibly unable to breathe or breathing insufficiently.

Modern ventilators are computerized controlled machines, mainly used in Intensive Care Unit (ICU), in Emergency Medical Service (as standalone units) and in Anesthesiology (as a component of an anesthesia machine).

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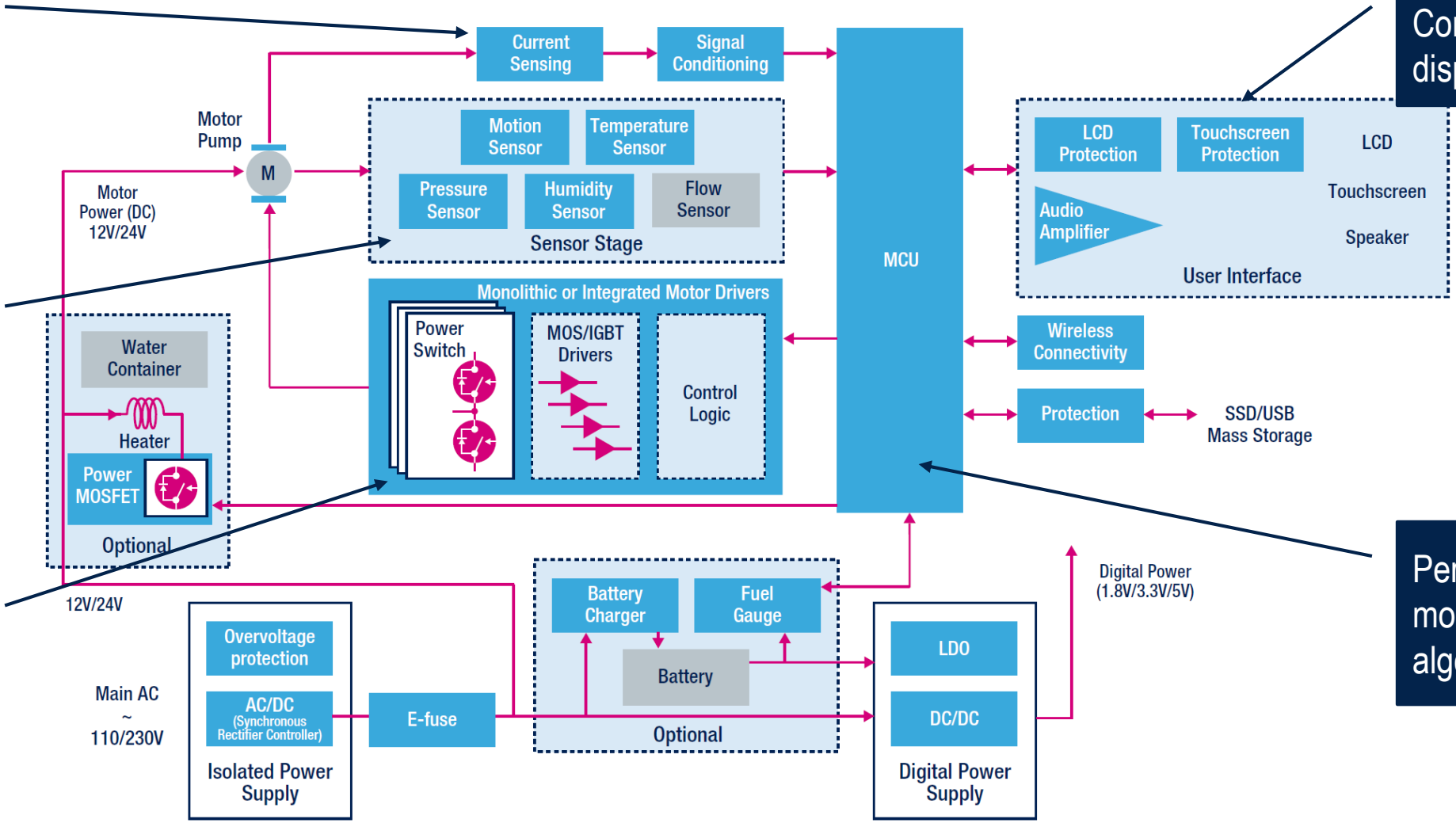
Block diagram - Ventilators

Enhance application safety

Sense the injected air flow

Drive pumps and valves



Commands & display

Perform precise motor control algorithms

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Patient monitoring in ICU

Patient monitoring equipment provides medical staff with the means to continuously observe a patient's vital signs, such as the heart's electrical activity (with an electrocardiogram), over an extended period.

They come in a variety of designs including bed-side monitors for hospital use and portable devices for home use.

In Intensive Care Unit (ICU) they become life sustain devices including a series of on-fly checks which alerts the medical staff in case of anomalies in the patient vital signs.

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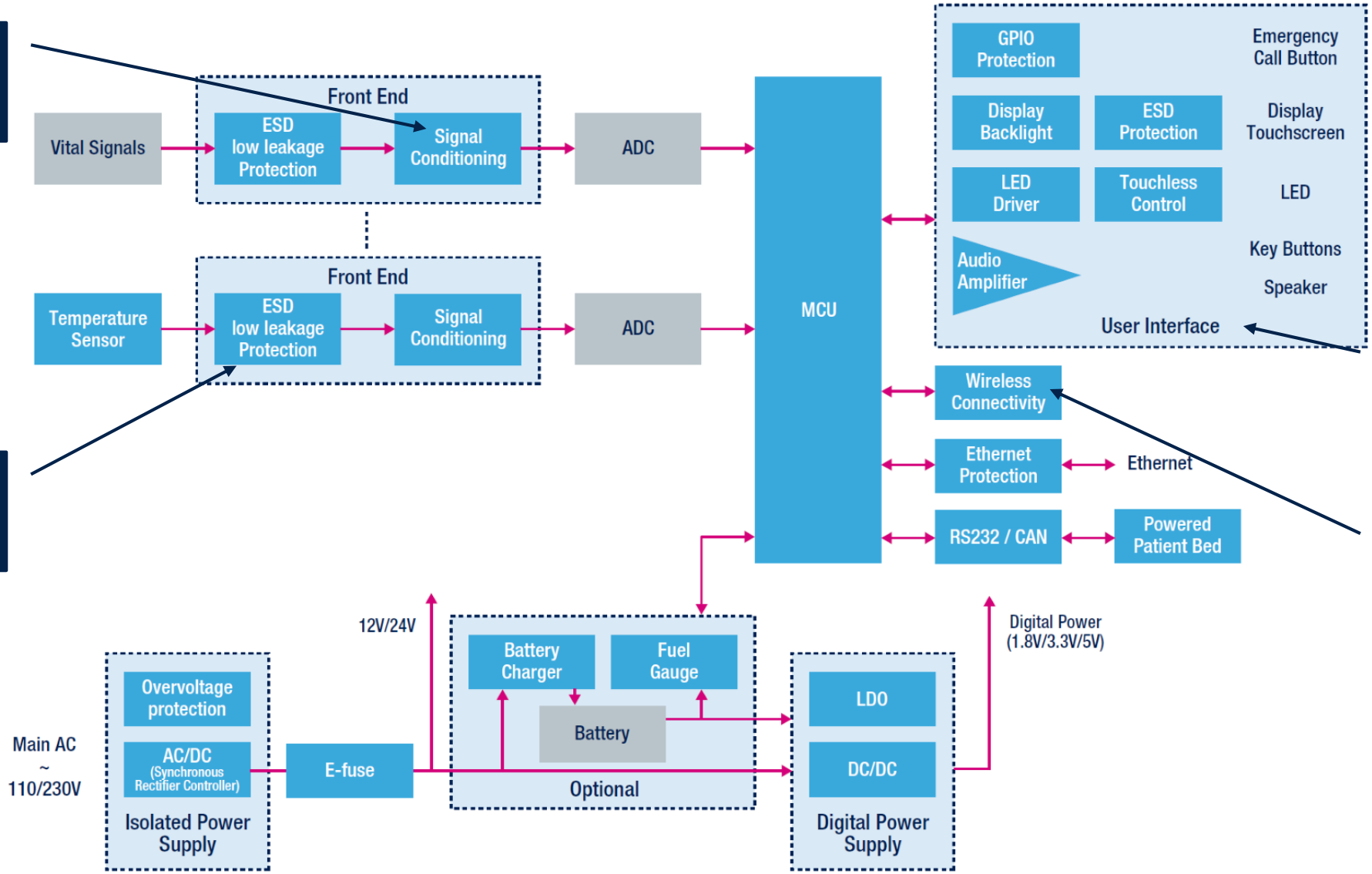
Block diagram – Patient monitoring

Read and monitor

Protect signal conditioning circuit



Show patient vital signs

Connect and alert medical staff

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ST offer in healthcare
CPAP and medical artificial ventilators

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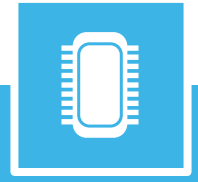
ST product offering for healthcare

ST is a trusted provider of high-quality technical solutions enabling the development of breakthrough medical systems

Acquiring data

- Sensors for Imaging
- MEMS* & measurement ICs
- Electronic interfacing



Processing data

- Powerful microcontrollers
- Artificial Intelligence at the edge
- Specially developed devices

Motion Control

- Precise and reliable motor driver
- Leadership in High Voltage MOSFET
- Wide bandgap transistors (SiC & GaN)

Security

- Secure element for medial data integrity
- M2M-SIM for authentication and confidentiality
- Enabling Blockchain transactions

Connectivity

Short-range low-power BLE, NFC

Long range IoT (Sigfox, LoRa)

Cellular broadband, narrowband

Targeting a broad range of applications

- Medical Imaging
- Focused Ultrasound
- Energy Harvesting and Neurostimulators
- Non-Destructive testing
- Electrocardiography (ECG)
- Photoplethysmography (PPG)
- Galvanic Skin Resistance (GSR)
- Bio Impedance functionalities
- Oxygen saturation
- Respiratory Rate
- Skin Temperature

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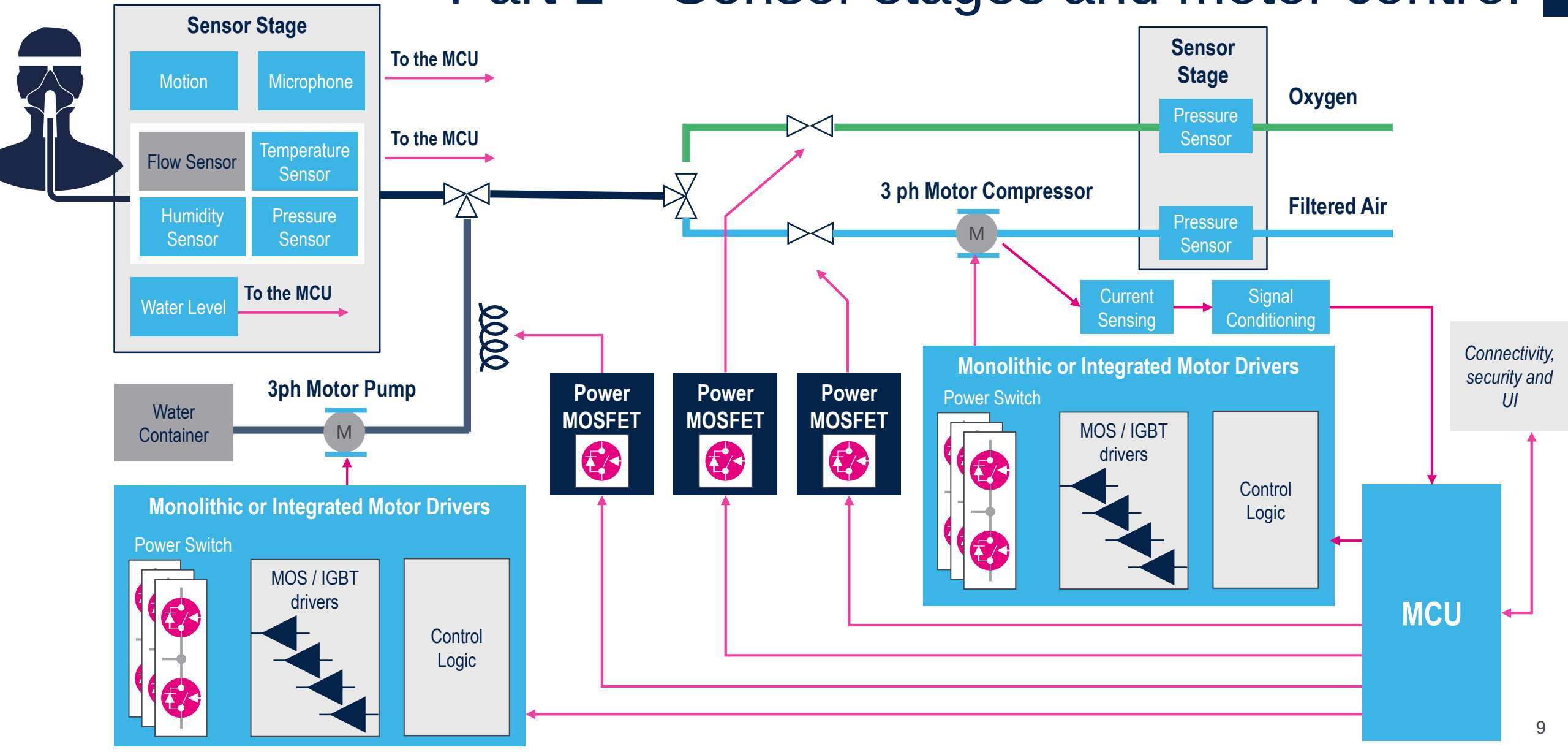
*MEMS = Micro-Electro-Mechanical Systems fabricated at Silicon level

Ventilator detailed block diagram
Part 1 – Sensor stages and motor control



Acquiring data

Sensors to boost the performance and increase the comfort

Motion sensors	**Accelerometer** [IIS2DLPC] **6X IMU** [ISM330DLC]	• Ultra compact size, Low power, digital, cost effective • Enable the monitoring of posture and movements of the mask and patient head and optimize the airflow • Guaranteed for 10 years availability
Pressure sensors	**Barometric sensor** [LPS22HH] **Water resistant** [LPS27HHW, LPS33HW]	• Ultra compact size, high robustness and reliability, Low power, digital, cost effective • Enable monitoring the breathing to optimize the airflow
Microphones	**Digital MEMS microphone** [IMP34DT05]	• High performance, digital • Enable voice command and, together with pressure sensor, allow the monitoring of the breathing to optimize the airflow • Guaranteed for 10 years availability
Temperature & humidity sensors	**Temperature** [STTS2H] **Temperature + humidity** [HTS221]	• High accuracy, Ultra compact size, digital • Monitoring environmental conditions (temperature & humidity) enable to optimize the airflow and improve the comfort of the patient

Imaging sensors

Time of Flight Sensors to monitor water level in the tank and Mask positioning

Time of Flight

Proximity [VL6180]

Distance Sensors [VL53L0X] [VL53L1X]

- Measure Water Level
- Monitor Mask Distance from face
- People counting or Presence detection

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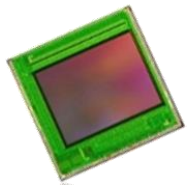
Complementary uses of Imaging Sensors

Ambient Light and Color sensors
Tiny color sensors for Lux/CCT and Flicker capture

Advanced Imager for computer vision
Global Shutter, High Sensitivity Vis and nIR, HDR, flicker free



Applications

- Proximity, ranging and Presence detection
- Gesture control
- Computer vision (BareCode scanning…)
- Screen brightness control for patient comfort

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Current Sensing and Signal Conditioning

...

Low / High side current sense amplifier [TSC1xx, TSC2xx]

- wide range of common mode voltages from -0.3 to +26 V
- Offset voltage: ±35 µV max
- Gain drift: 20 ppm/°C max

Operation Amplifiers [TSV9xx, TSV6xx, TSZ1xx]

- Low-side current measurement for motor control
- Very-high-accuracy, (5 µV) zero-drift, micropower 5 V op amp

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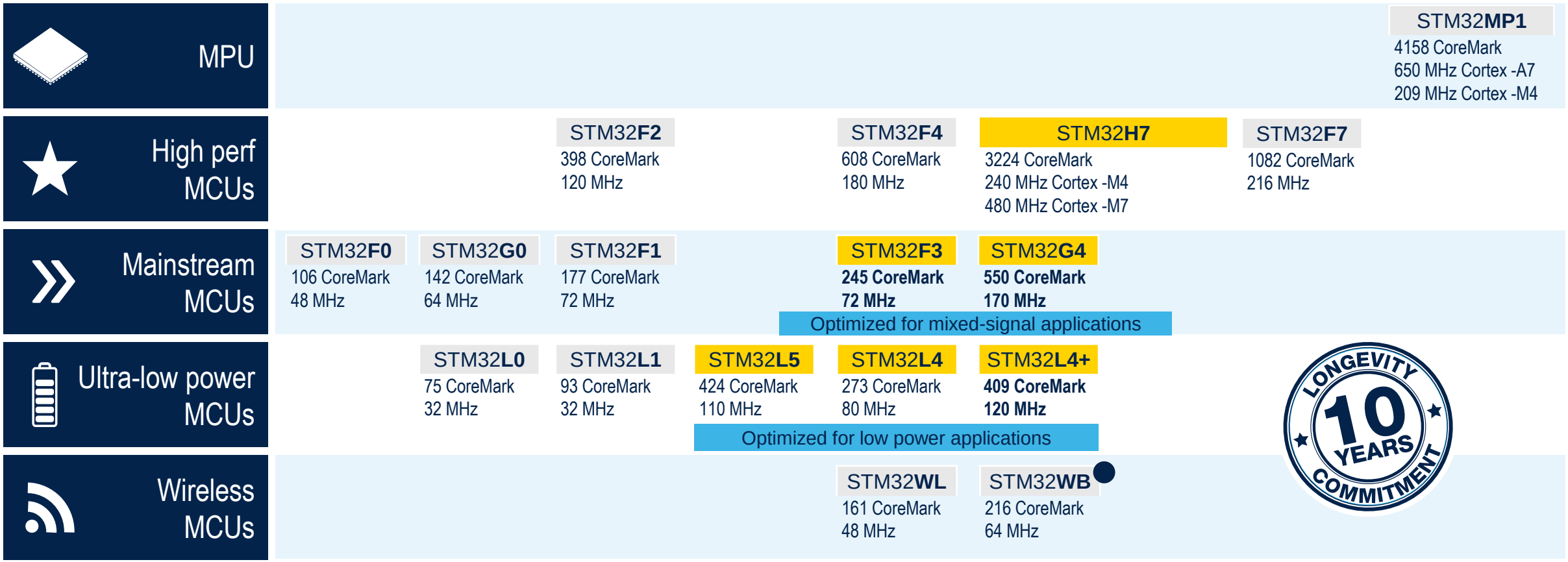
STM32 for healthcare application
A broad offering



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STM32G4 series

Ideal for applications requiring an MCU that offers advanced and rich analog peripherals

STM32**G4**

Performance

- 213 DMIPS and 550 CoreMark® results
- Better dynamic power consumption (163 µA/MHz)
- Mathematical accelerators

Rich Integrated Analog and Digital

- Op-Amps (Built-in gain), DACs, Comparators
- 12-bit ADCs 4Msps with hardware oversampling
- High resolution timer (184 ps)
- USB type-C Power Delivery 3.0

Safety and security focus

- Dual Bank Flash with ECC (error code correction)
- Securable Memory Area
- Hardware encryption AES-256
- SIL, Class-B
- SRAM with Parity bit

Secure Live Upgrade

Functional safety design packages

KEY BENEFITS FOR VENTILATORS

- Easy interfacing with motor drivers and sensor stages
- Low power consumption to address portable devices
- Built-in security features

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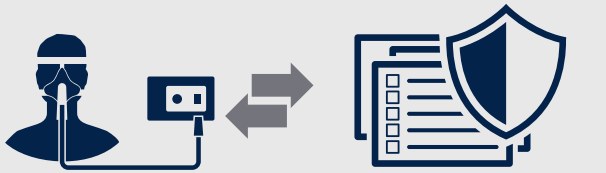
STM32L5 series

Ideal for applications requiring an MCU that offers advanced and rich analog peripherals

STM32L5

Security focus

Protection from hackers



Electronic Medical Records

Very power consumption

Long lifetime, small battery size

Integration, size & performance

Best fit to application requirements

Security: TrustZone for isolation

STM32**L5**

	Un-Trusted	Trusted
Privileged	Un-Trusted & Privileged RTOS	Trusted & Privileged Secured Keys Secured Boot
Un-Privileged	Un-Trusted & Un-Privileged RF Stack	Trusted & Un-Privileged Secured data Sensor IP

RF

Sensors

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STM32H7 series

The best choice for controls, indicators, and interfaces of ventilators

STM32**H7**

New performance record

2424 + 800 CoreMark (Cortex©-M7 @480Mhz + Cortex©-M4 @240Mhz)

Display nice graphics

The Chrom-ART Accelerator and MJPEG coded, offload the CPU by more than 90%

Advanced security features

Crypto Hash, Cortex©-M7 Security services

Rich eco-system to speed-up your design

SW tools, HW boards, community and partners

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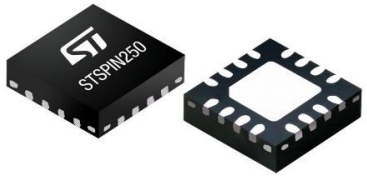
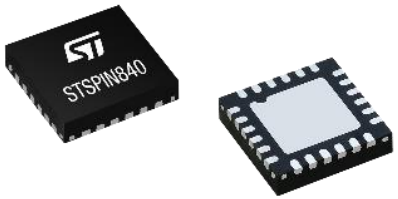
Motor control

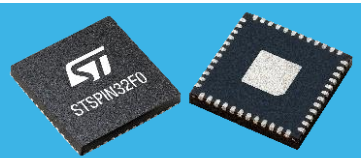
Leading integration, performance, efficiency





Monolithic Low Voltage	Monolithic	Monolithic	System-in-Package
STSPIN2 Series	**STSPIN8** Series	**L647** Series, **L620, L622** Series	PowerSTEP Series

Controllers: **STSPIN32 Series, L648 Series**



Applications up to 10 W	Applications up to 70 W	Applications up to 500 W

- **Wide V & I ranges supported**
  - 1.8 V – 85 V
  - 0.6 A_{RMS} – 3 A_{RMS}
- **Intelligent top class 3phase BLDC drivers**
- **State of the art products and features for Stepper motors**

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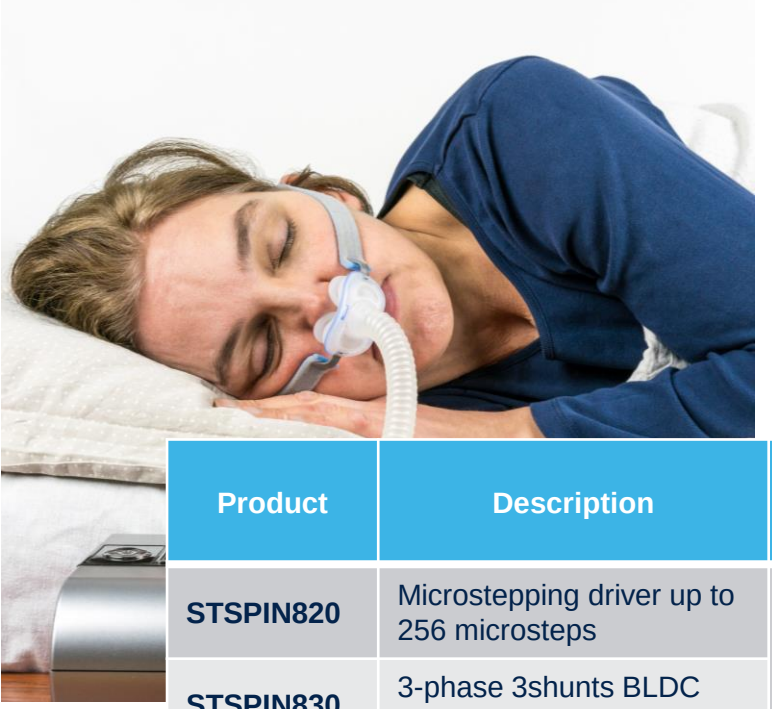
STSPIN800 series motor drivers

Compact, energy conscious and cost-competitive motor drivers



Product	Description	V_{IN} min (V)	V_{IN} max (V)	R_{DSON} HS+LS (Ohm)	I_{OUT} max (Arms)
STSPIN820	Microstepping driver up to 256 microsteps	**7**	**45**	**1**	**1.5**
STSPIN830	3-phase 3shunts BLDC motor driver				
STSPIN840	Dual brushed DC motor driver	**7**	**45**	**1 (0.5 *)**	**1.5 (3 *)**

(*) Features allowed in parallel mode driving

KEY BENEFITS FOR VENTILATORS

High efficiency

- Standby mode to minimize power consumption in idle state (<50µA)

Smooth and silent motion

- Smooth and silent motion thanks to I control and 256 µsteps
- FOC & 6-step FW support

Reliable thanks to full set of protections

- UVLO, non-dissipative over-current and thermal protection

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Stepper motor solutions: L647x & L648x

Highly autonomous solutions using high-level motion commands from system host

Topology	Product	Description	V_{IN} min (V)	V_{IN} max (V)	R_{DSON} (Ohm)	I_{OUT} max (Arms)
Motor Drivers	L6470	Voltage mode driving algorithm (1/128 µstep)	8	45	0.3	3
	L6472	Predictive current control Adaptive decay (1/16 µstep)				
	L6474	Adaptive decay(1/16 µstep)				
Controllers	L6480	Voltage mode driving algorithm (1/128 µstep)	7.5	85	not applicable	
	L6482	Predictive current control Adaptive decay (1/16 µstep)				

KEY BENEFITS FOR VENTILATORS

System stability and low noise

- System stability and low noise:
- Adaptive auto regulated decay (slow /fast /mixed decay) (*)

Accurate positioning and control

- Predictive current control (*)

Smooth & very silent motion

- Voltage mode control (*) ensure driving performance similar to BLDC ones

Power Scalability

- Using L648x controller with ST power MOSFET (F7 family)
- (*) ST patented features

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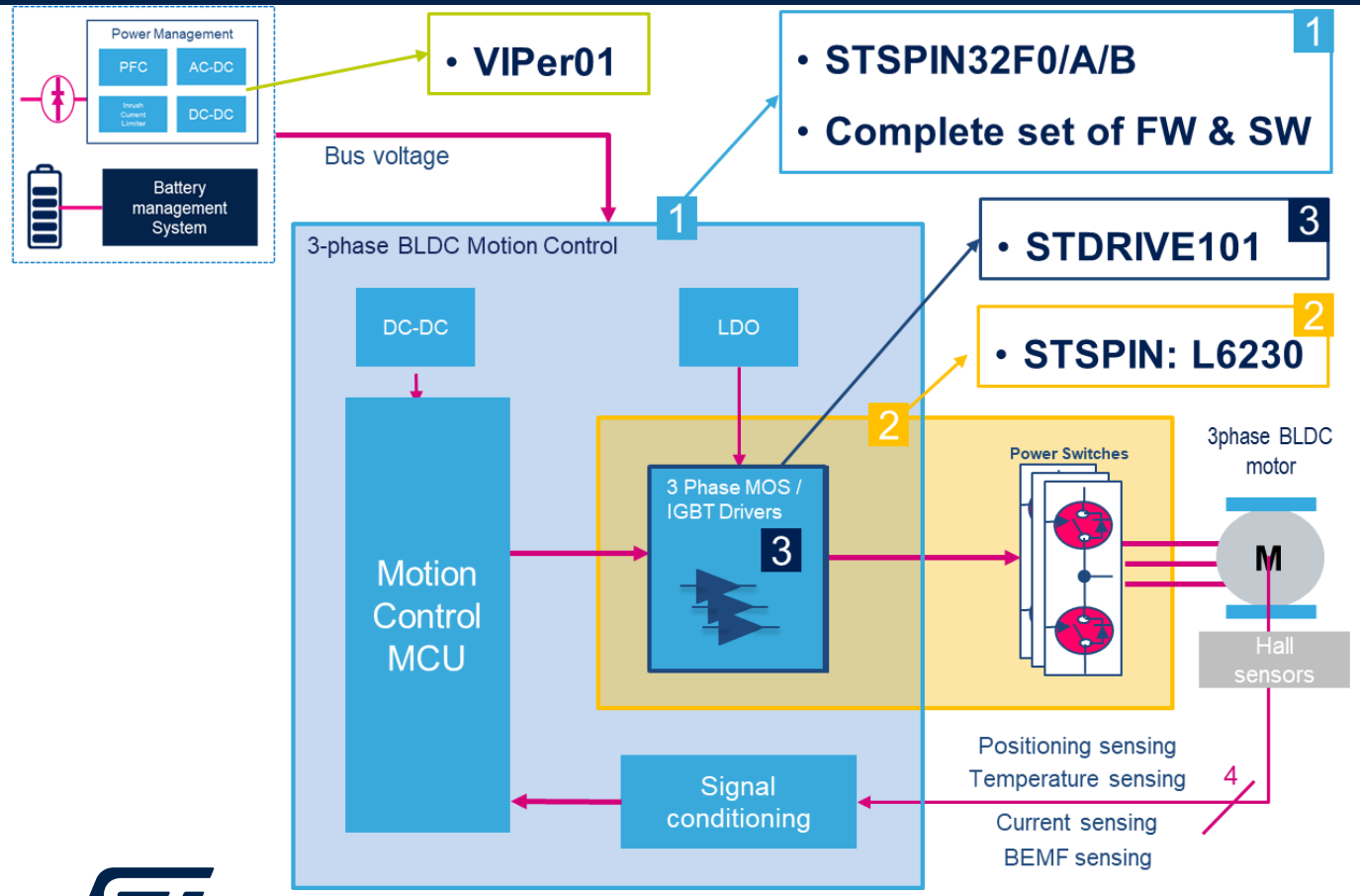
Motion Control Architecture

Best Fit for BLDC: combining Power Density and Intelligence



Architecture	Benefits
1 **STSPIN32** MCU + Driver	• High integration (MCU + 3 Ph. Driver + DC-DC + LDO + Protection) • High performance control • High speed sensorless FOC
2 **STSPIN L6230** Driver + MOS	• Integrated Power Stage & Protections • Good cost-performance trade-off
3 **STDRIVE** Discrete	• Best flexible partitioning • Good cost-performance trade-off

KEY BENEFITS FOR VENTILATORS

Address all architectures of CPAP and Respirators

Cost effective sensor-less systems or accurate control with Hall-effect sensor feedback

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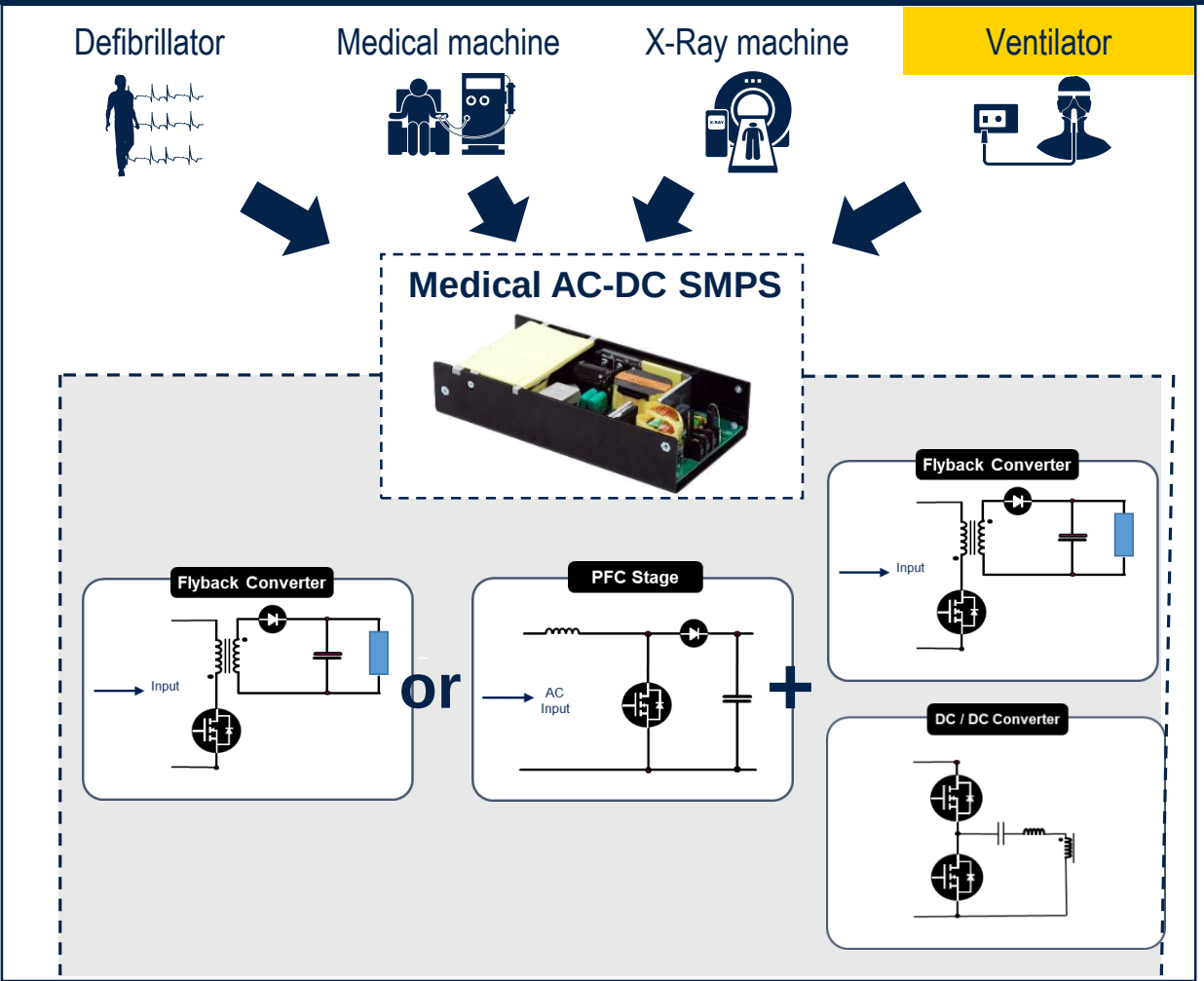
MDmesh™ family: Super-junction power MOSFET

Leader in High Voltage Silicon MOSFET



Complete family with wide product portfolio in terms of $R_{DS(on)}$, BV_{dss} and packaging to reach the right mix for high efficiency and compactness solution

MDmesh™ series:

- M2, M5 on **PFC section**
- M2, DM2, on **DC/DC section**
- NM, K5 on **flyback**

Main Products

- STF18N60M2
- STF40N60M2
- STY112N65M5
- STY145N65M5
- STP11NM80
- STD3N80K5
- STW40N95K5

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Customers:

Delta, Edan, Megmeet, Plexus, Hechuan, Mindray, Medtronic, Philips, GE

High voltage silicon MOSFET series Super-junction MDmesh™

Breakdown Voltage

600V	650V	800V – 1700V

MDmesh series

M2	M6	DM2	DM6	M5	DM2	DM6	K5

Focus Topology

Flyback, PFC/LLC resonant conv.	Flyback, PFC/LLC high efficiency	HB / FB, ZVS, LLC	HB / FB, ZVS, LLC high efficiency	Hi-end-power PFC and hard switching topologies	HB / FB, ZVS, LLC high power level	HB / FB, ZVS, LLC high power level high efficiency	Flyback topology

Focus Applications

Charger adapters Led lighting, Medical	Server, 5G, Consumer, Adapters, Solar, Medical	Solar, Server, Telecom SMPS, EV-Car/Charging, Medical	LED driver, LED lighting, auxiliary SMPS, EV-Car, Medical

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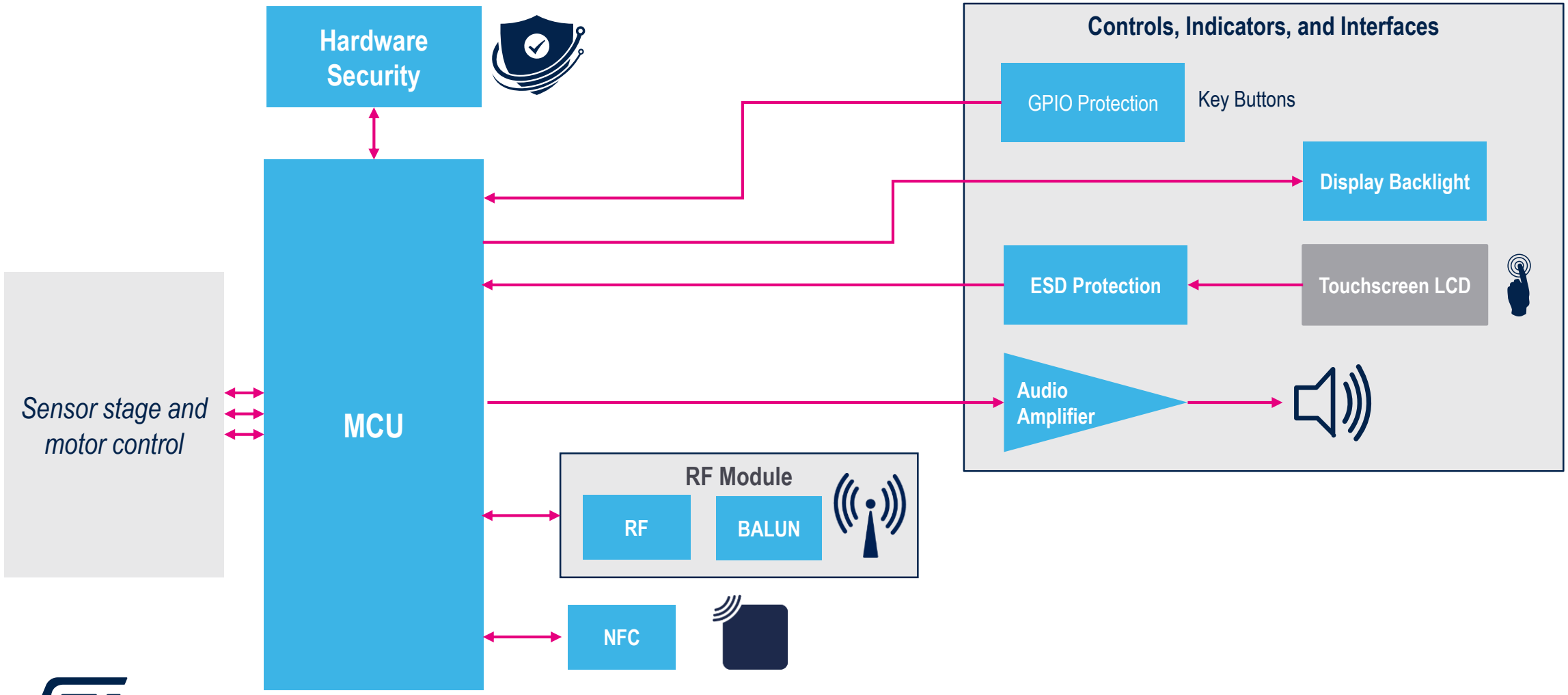
Ventilator detailed block diagram
Part 2 – Connectivity, security and User Interface



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Secure Element: STSAFE-A

Secure element for brand protection and secure connections

Secure the connected devices

- Authentication
- Secure connection
- Secure data storage
- Signature verification
- Common criteria certified

Protect your brand (consumables / peripherals)

- Digital Motion Engine
- High-level motion commands

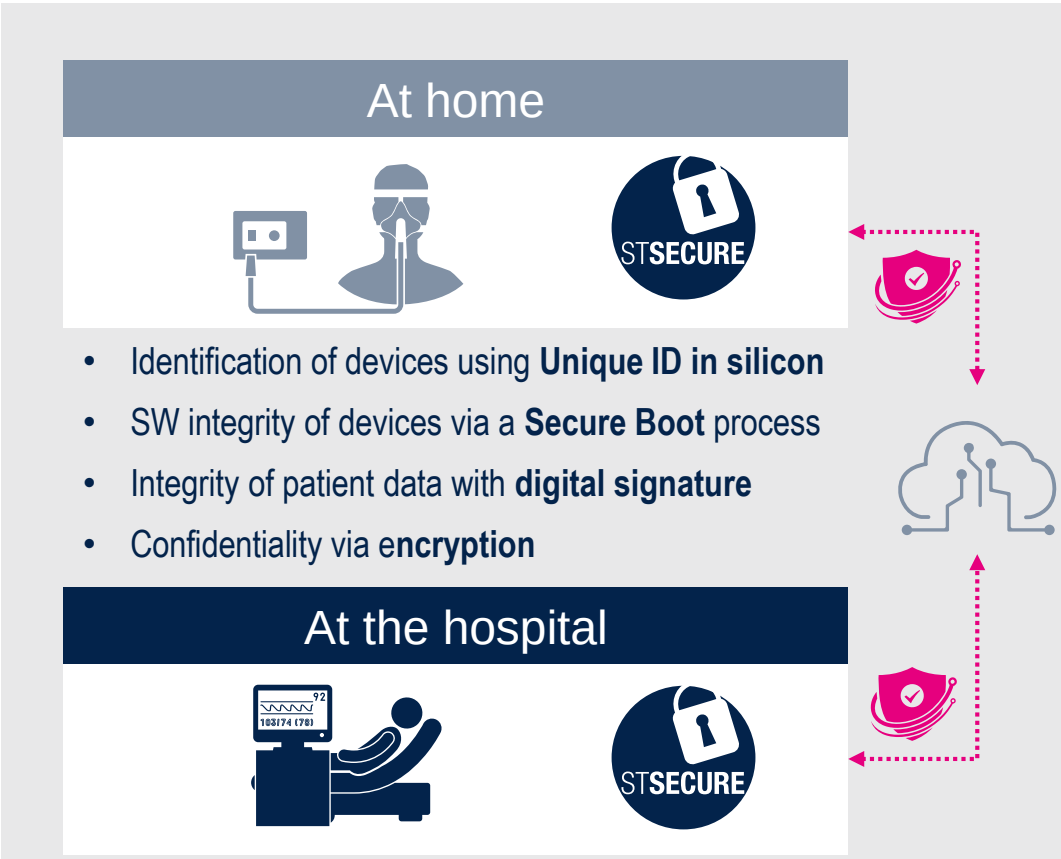
STSAFE-A110

Enriched secure connection & LPWAN

- Generic pre-personalized samples
- STM32 Nucleo Expansion board
- STM32Cube Software package

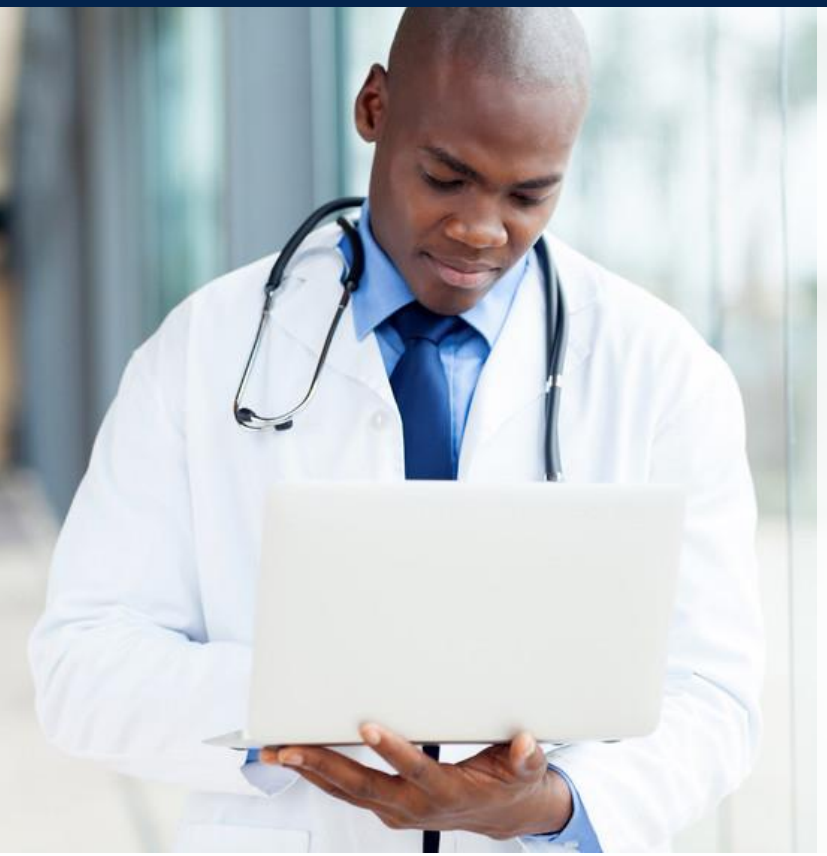
STM32 Open Development Environment

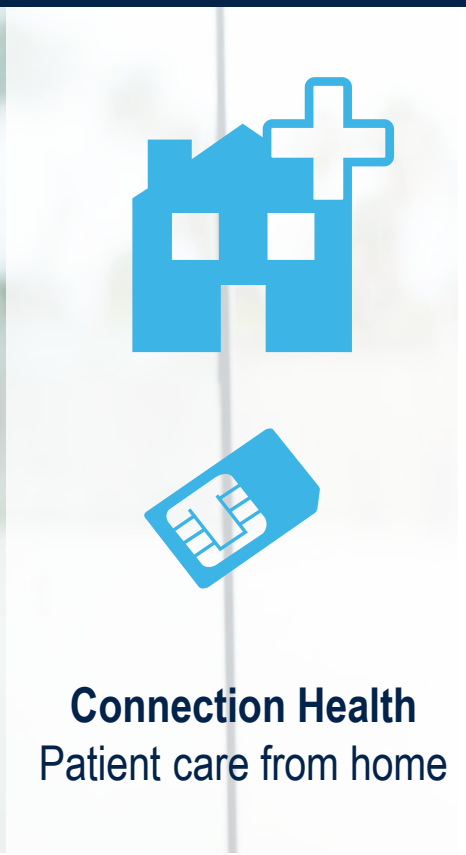
Available @ distribution



M2M-eSIM: ST4SIM solution

A wide range of cellular connectivity solutions





Connection Health
Patient care from home

ST4SIM

- Wide range SIM/eSIM solutions based on Basic, Cryptographic and GSMA SGP.02 configurations
- GSMA eSIM certified and interoperable with MNOs & Subscription Management platform
- Complete ecosystem with trusted partners for connectivity & Subscription Management Platform
- Industrial & automotive grade solutions (T° & reliability)
- Multiple packages format (4FF, MFF2, WLCSP, TSSOP20)

NFC main use cases & benefits

NFC Tag usage in medical

Configuration & Data logging

NFC

- Product configuration and parameter settings through NFC
- Data log transferred, processed and plotted on NFC phone

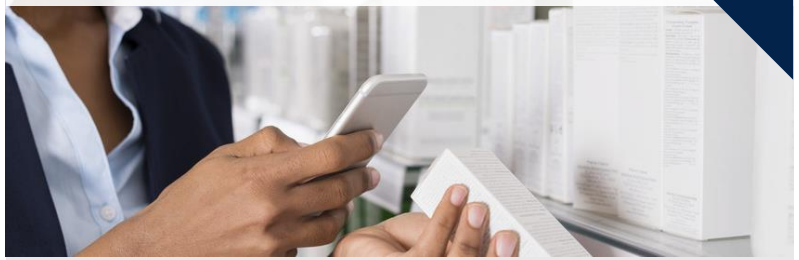
Servicing & Maintenance

NFC

- Contactless access to maintenance records
- Update parameters even if device is powered off thanks to NFC phone
- Quick firmware upgrade via fast transfer mode

Enhanced user experience

NFC



- Wireless pairing
- Access to web page (URL) or get link for Android (AAR) or iOS application
- E-warranty card & customer registration
- Device control with mobile phone
- User identification & personalized settings

- Interactive and zero power technology (Tag powered by Reader)
- Convenient product configuration and maintenance
- Simple and flexible

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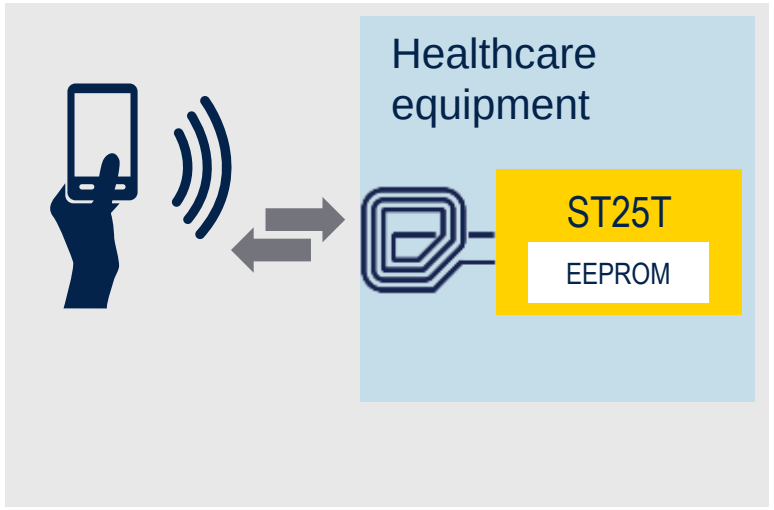
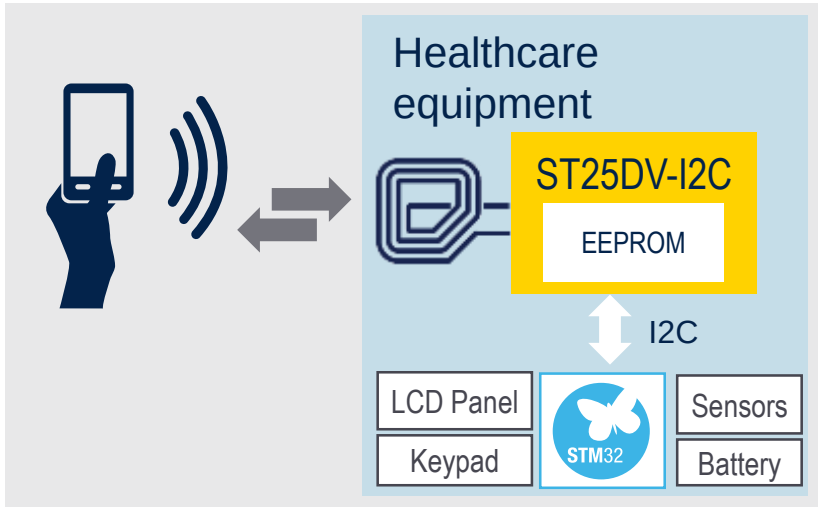
Typical NFC tag block diagrams and use in medical



ST25TV02K / ST25TA02KB

TruST25 digital signature
Passwords
Easy & fast data transfer

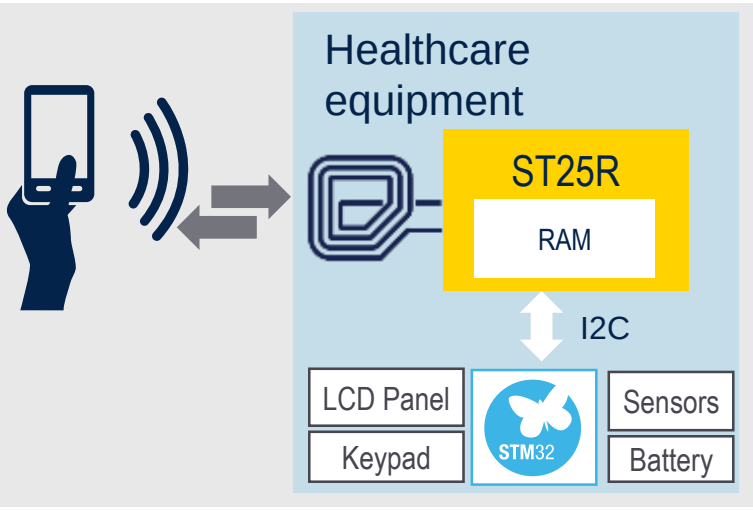
Enhanced user experience



ST25DV04K / 16K / 64K

I²C fast interface
Fast Transfer Mode
Large memory storage

Configuration & data logging
Servicing & Maintenance
Enhanced user experience



ST25R3911B / 12 / 13

High output power
Low power consumption
Automatic antenna tuning

Configuration & data logging
Servicing & Maintenance

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UHF main use cases & benefits

Real-time patient tracking

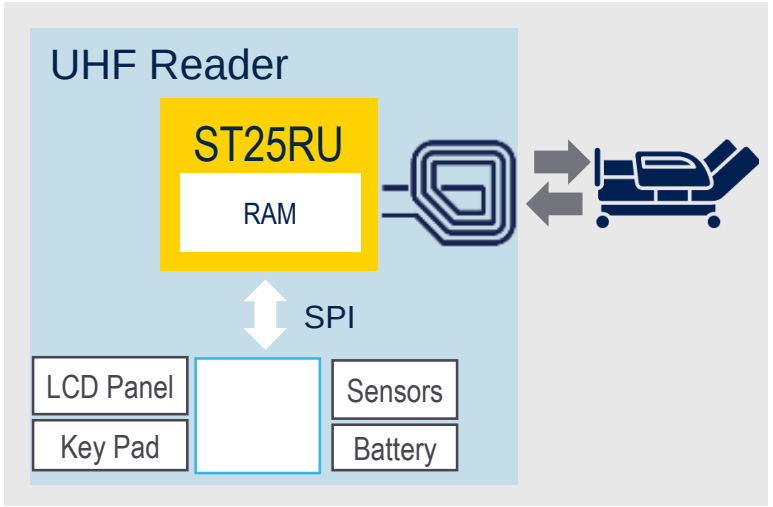
UHF

- Log & monitor the progress of a person
- Locate people in real time
- Speed up bed turnover to admit more patients efficiently

Asset management

UHF

- Locate medical equipment
- Update parameters
- Speed up inventory management



- Fast detection and long read range
- Possibility of identifying more than 200 tags without constraint of positioning
- Cheapest tag to manufacture

ST25RU3993

Long read range
Low power consumption
Fast read speeds

Real-time patient tracking
Drug asset management

ST low-power RF product lines connectivity, efficiency and robustness

Enabling the Sensor-to-Cloud wireless connectivity

BlueNRG Family

BlueNRG

Ultra Low Power ARM-Based
Bluetooth Low Energy Processors

BlueNRG-MESH

Companion Balun and Filter
BALF-NRG-01D3
BALF-NRG-02D3

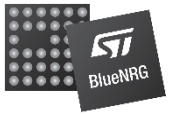
- Simplified HMI
- Easy customization
- Remote reading
- Service and maintenance
- Firmware upgrade
- Added-value services

Bluetooth® 5 Certified

LONGEVITY 10 YEARS COMMITMENT

QFN48
6 x 6 mm

QFN32
5 x 5 mm



WLCSP34
2.66 x 2.56 mm

Scalable packages

S2-LP family overview

SPIRIT Family

SPIRIT

Sub-1GHz Radio Transceivers and LPWAN networking

sigfox

M-Bus wireless

6LoWPAN

Companion Balun and Filter
BALF-SPI2-01D3
BALF-SPI2-02D3

Performance

Sub 1GHz

S2-LP / S2-LPCB / S2-LPTX

- 413-479 MHz / 826-958 MHz
- 452-527 MHz / 904-1055 MHz (**)
- -40°C to +105°C
- QFN24 4x4x1

Radio performance

- 100 bps to 500 kbps
- -130 dBm @ 0.3kbps (*)
- +16 dBm output power

Ultra low-power consumption

- Sleep / Shutdown: 700nA / 2.5nA
- Rx peak: 7 mA (*)
- Tx peak: 10 mA @+10dBm

(*) RX Feature only available on transceivers: S2-LP and S2-LPCB
(**) Frequency bands only available on S2-LPCB

Protocols

sigfox

6LoWPAN
IPv6-based Low-power Wireless Personal Area Networks

M-Bus wireless

KNX

Wi SUN

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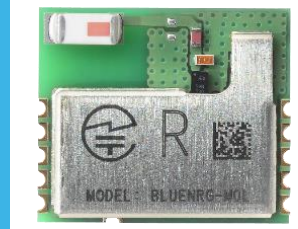
Low power RF modules

BlueNRG

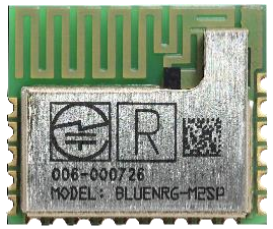
BlueNRG-M0L
BlueNRG-M0A



- Based on BlueNRG-MS
- BLE4.2 certification
- Including high efficient chip antenna, filter and balun **BALF-NRG-01D3**

LONGEVITY 10 YEARS COMMITMENT

BlueNRG-M2SA
BlueNRG-M2SP



- Based on BlueNRG-2
- BLE5.0 certification
- Including high efficient chip antenna [-M2SA] or PCB antenna [-M2SP], filter and balun **BALF-NRG-02D3**

SPIRIT

SPSGRF-868
SPSGRF-915

- Antenna option
- Two carrier frequency versions: 868 MHz & 915 MHz
- Including filter and balun BALF-SPI-02D3 for the SPSGRF-868.

SPSGRFC-433
SPSGRFC-868
SPSGRFC-915

- Connector option
- Three carrier frequency versions: 433 MHz, 868 MHz and 915 MHz
- Including filter and balun BALF-SPI-01D3 for the SPSGRF-433.

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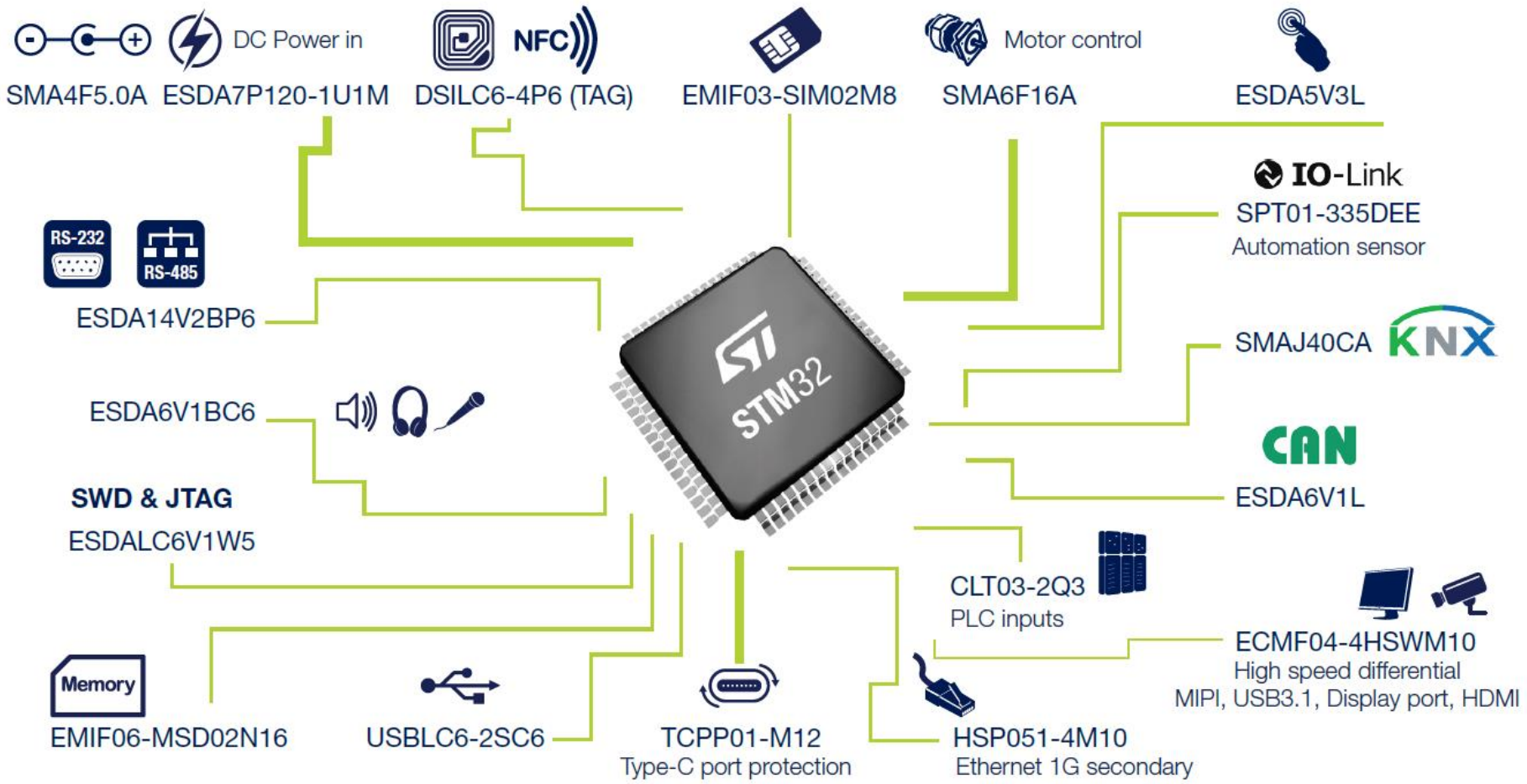
ST protections increase EMC robustness

High system immunity for all MCU interfaces



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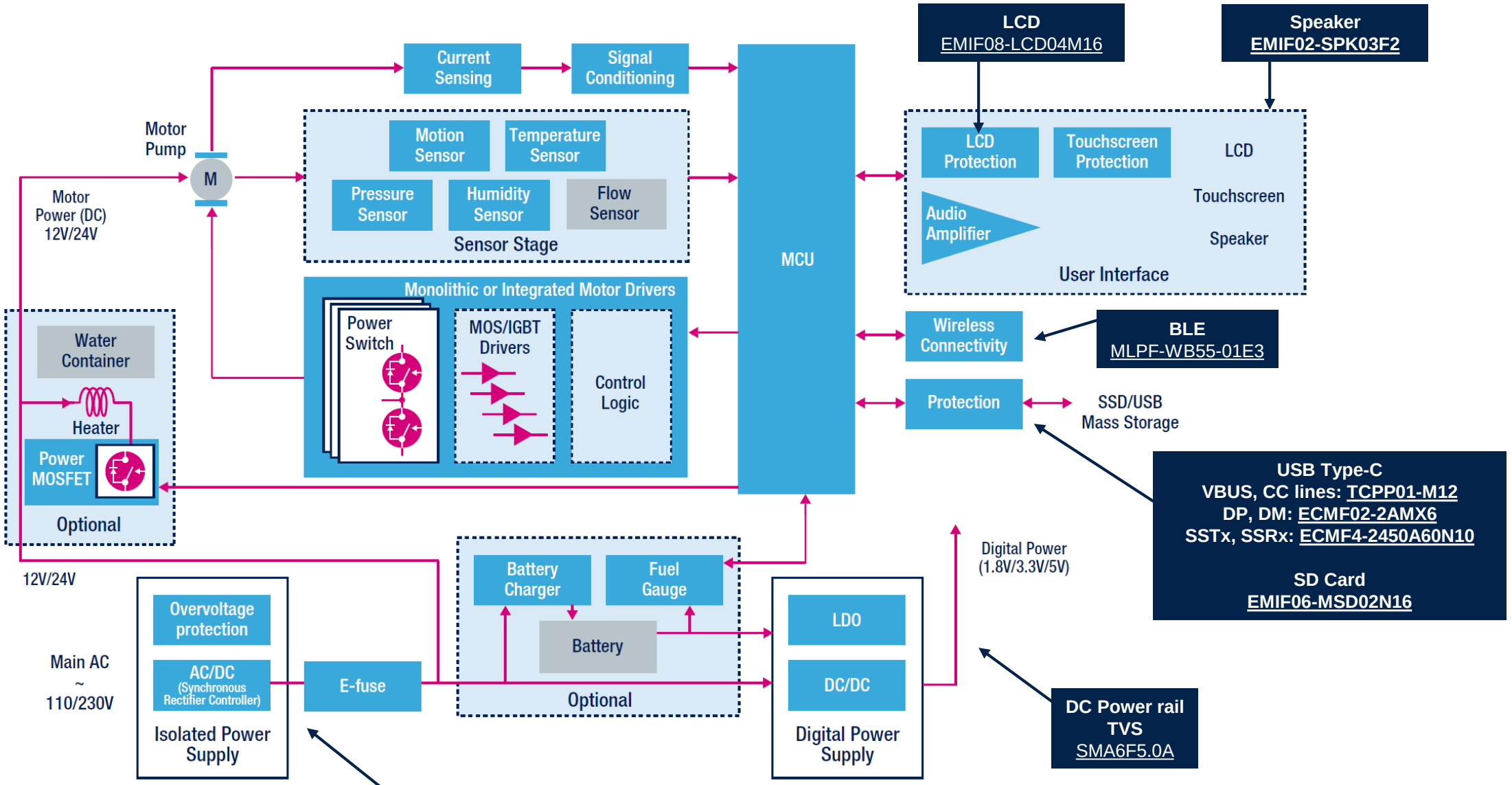
Protections and filters in ventilators



Thank you

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