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ST solutions for robotics

Autonomous Ground Vehicle
Autonomous Mobile Robots

Introduction

- The advantages of Autonomous Ground Vehicles (AGVs) and Autonomous Mobile Robots (AMRs) are their flexibility and their customization to suit the specific application
- There are three basic form factors in the AGV & AMR sector: mouse, forklift and tugger. In the present document we mixed these form factors to show the ST solution for them.

Robot motor & sensor zones

Secondary link motors

Zone 3: 300 – 500 W

Traction motors

Zone 1: 800 – 2000 W

Precision motors

Zone 4: dual motor up to 150 W

Main link motors

Zone 2: 500 – 800 W

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Solution for zone 1

Solutions for zone 1
Motion & orientation

Traction motors

Zone 1: 800 – 2000 W

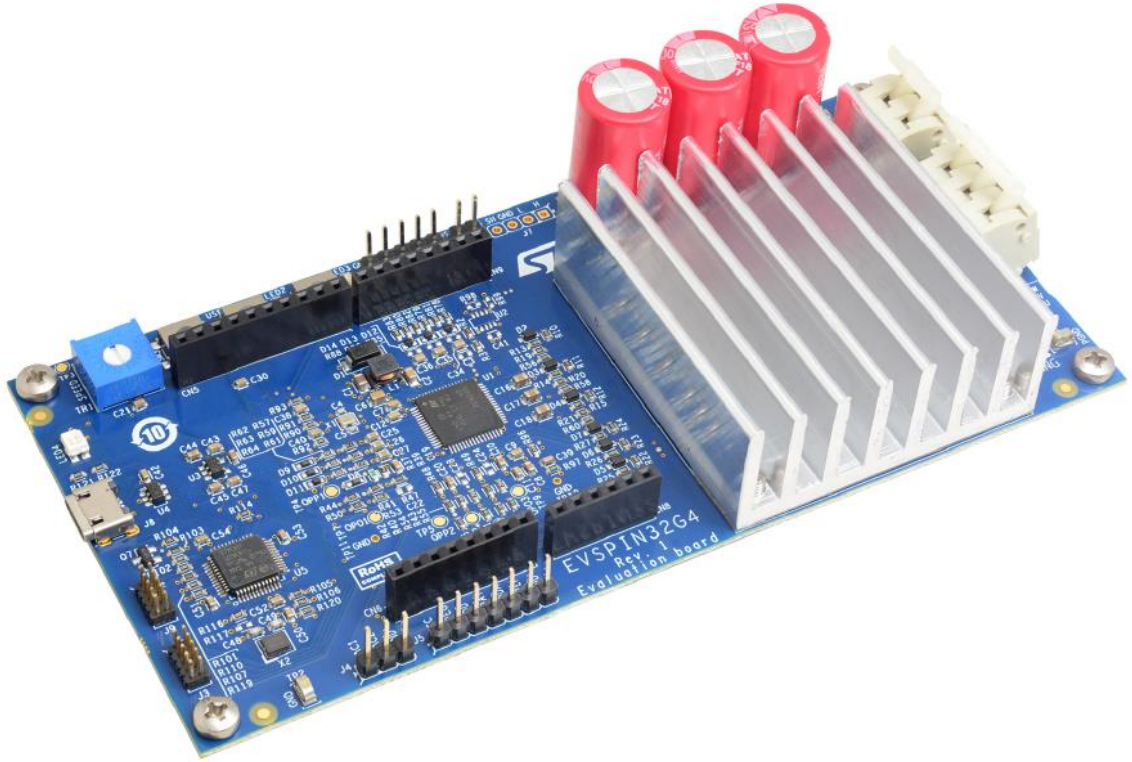
MEMS or ToF sensors

Speed: up to **30 km/h**

Range: up to **8 m**

EVSPIN32G4

Solution for three-phase brushless motors for e-vehicles



Main design challenges

- Motor control 10 – 75 V design with high scale integration
- Max power dissipation up to 1 kW

Key products

- **STSPIN32G4:** high performance three-phase motor controller with embedded STM32G431 Arm Cortex-M4 MCU+FPU)
- **STL110N10F7:** N-channel 80 V, 1.7 mOhm typ., 180 A STripFET F7 Power MOSFET

Key features

- CORDIC mathematical hardware accelerator for trigonometric functions
- 75 V rated gate drivers with 1 A sink / source current and embedded bootstrap diodes
- F7 power MOSFETs
- Three-shunt or single-shunt configurable current sensing
- V_{CC} buck converter up to 200 mA, with programmable output and embedded MOSFET
- 3.3 V LDO linear regulator up to 150 mA
- Full set of interfaces: I^2C, SPI, UART and CAN
- Digital Hall sensor and quadrature encored input
- Arduino UNO connector. Predisposition for CAN bus

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STEVAL-CTM009V1
5 kW low voltage high current inverter

Main design challenges

- Motor control 48 V design with high scale integration
- Max current up to 100 A

Key products

Composed of 4 boards:

- Power board – STEVAL-CTM004V1
- Bulk capacitor board – STEVAL-CTM005V1
- Driver board – STEVAL-CTM006V1
- Current sensing board – STEVAL-CTM008V1 (can be replaced by STDES-AKI003V1)

Key features

- **Power board**:
  - Hosts 36 STH31xN10F7 power MOSFETs
  - 3-shunt resistors ground referred for current sensing (optional)
- **Control board**:
  - Based on 3x L6491 gate driver with current capability up to 4 A sink/source
  - Over-current/temperature/voltage protection

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STDES-AKI003V1
Sigma delta ADC solution for industrial drive

Key products

- **ISOSD61:** 16-bit isolated Sigma-Delta modulator, single-ended and LVDS interfaces

Key features

- Solution Tailored for High End Servo drive
- Accurate current sensing for high end industrial motor control applications
- 6 kV Galvanic isolation
- Up to 25 MHz Σ-Δ clock
- Fast dynamic and response to load variations
- Field oriented control of PMSM motors
- Triple simultaneous current sampling via shunt resistor placed inline with the motor phases
- Fully compatible with DFSDM peripheral (STM32 F4/F7/H7)

Main design challenges

Create a motor control solution for achieving the FOC of a PMSM using an external Sigma Delta insulated analog to digital converter

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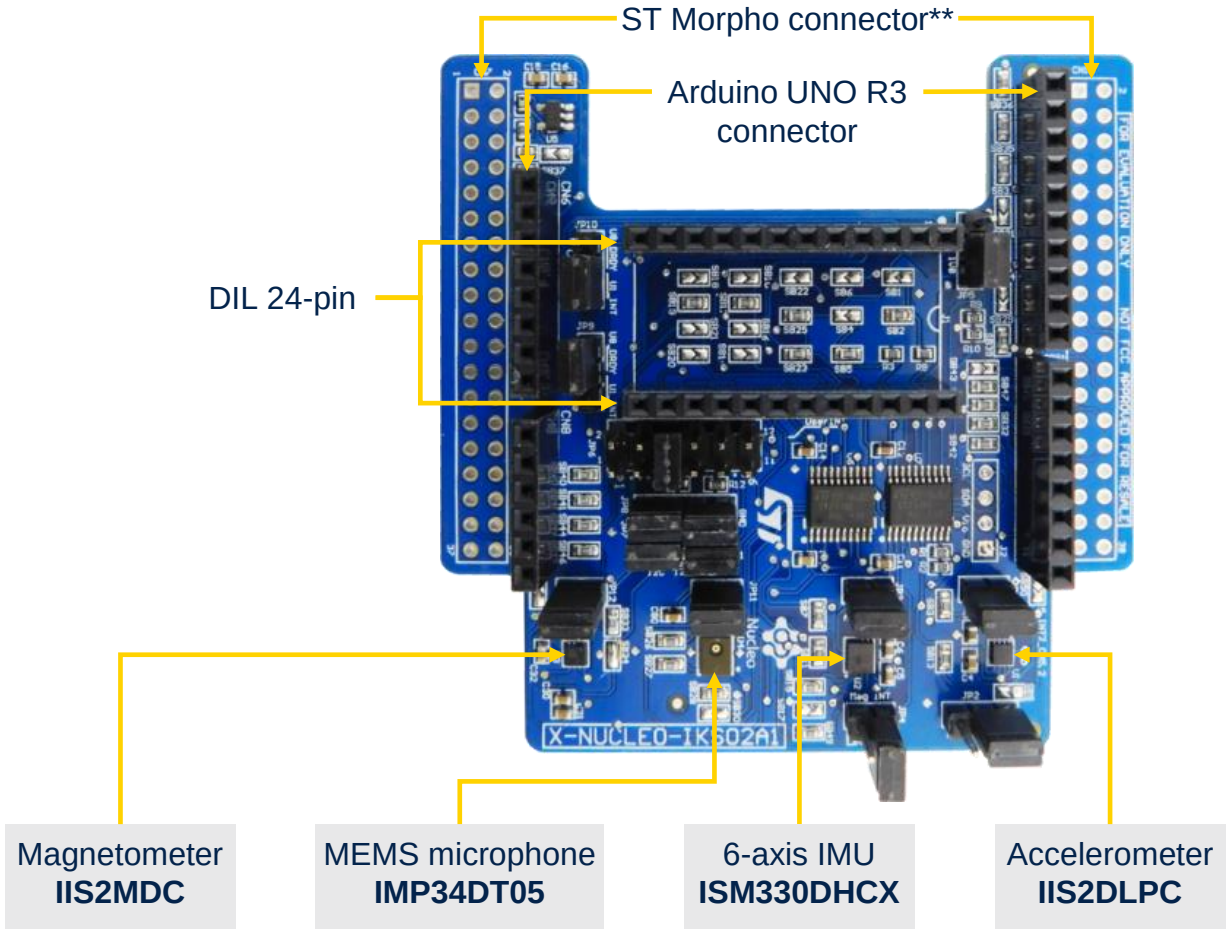
X-NUCLEO-IKS02A1
Industrial sensors extension



** Connector for the STM32 Nucleo Board

Key products

- **ISM330DHCX**: 6-axis IMU (accelerometer + gyroscope) to detect movement and rotation of the object
- **IIS2DLPC**: 3D accelerometer for low power wake-up from movement
- **IIS2MDC**: 3D magnetometer for absolute orientation of the object
- **IMP34DT05**: MEMS microphone for environment monitoring

Key features

- Motion MEMS and environmental sensor expansion board for STM32 Nucleo for Industrial
- DIL 24-pin socket available for additional MEMS adapters and other sensors
- I^2C, SPI support
- Available I^2C sensor hub features on ISM330DHCX
- Equipped with Arduino UNO R3 connector
- Free comprehensive development firmware library and samples for all sensors compatible with STM32Cube firmware

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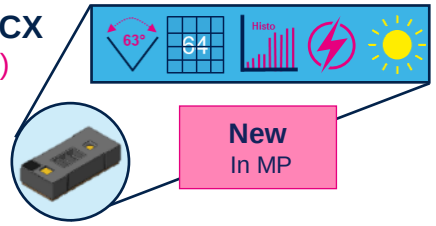
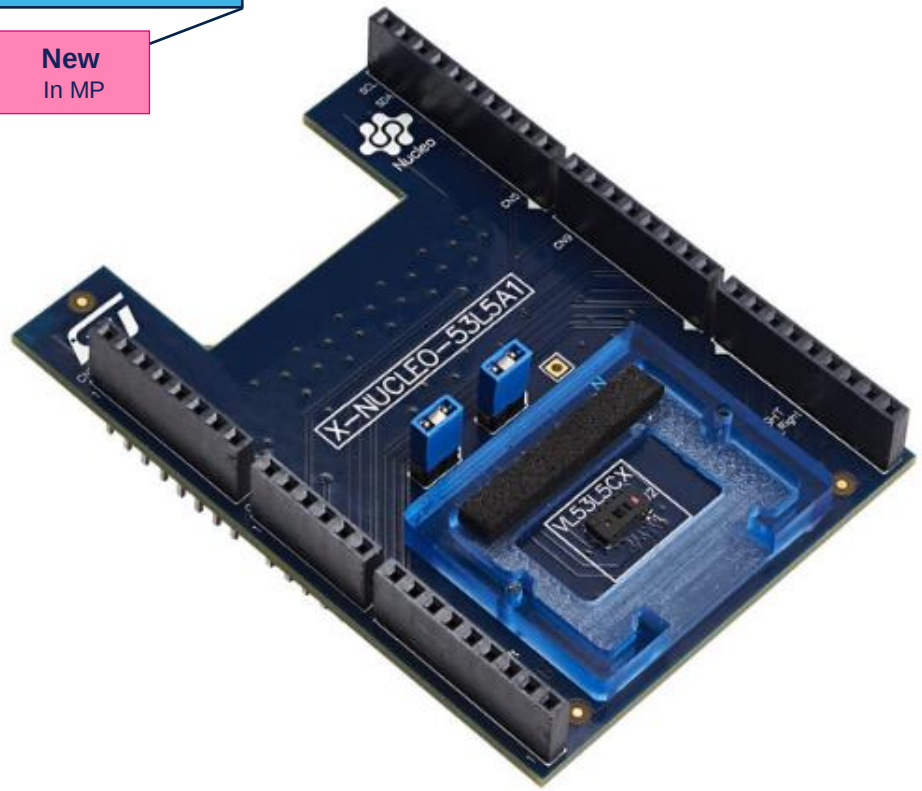
X-NUCLEO-53L5A1
Multi-zones ToF up to 4 m range for obstacle detection

VL53L5CX
(Gen4)





Key products

- **VL53L5CX**: Up to 4 m ToF with wide 63 deg FOV, 64 Region Of Interest, histogram information for multi-targets detection
- **Nucleo-F401RE** recommended motherboard with STM32F401 MCU, P-NUCLEO-53L5A1/ includes both

Key features

- **Parallel multizone ranging** output:**4x4 or 8x8 zones** separate regions of interest
- **Wide FoV**: 45° x 45° (**63° diagonal**) with possibility to use multiple units to extend the area (ease of integration)
- Up to **400 cm ranging:** Long range to detect obstacles for robot
- **Multi-target detection** and distance measurement in each zone
- **60 Hz** (4x4 zones) frame rate capability
- **Immunity to cover glass cross-talk** beyond 60 cm
- Detection thresholds mode available
- Robust to smudge, excellent under dirty cover glass
- Performance already proven for challenging industrial designs
- Full set of product documentation & SW tools available on st.com

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Solution for zone 2

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Solutions for zone 2
Main link movement

Motion MEMS and ToF sensors

Main link motors

Zone 2: 500 – 800 W

Max angular speed ≈ **0.5 rad/s**

Range: up to ≈ **1.2 m** (max. arm length)

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STEVAL-ETH001V1
Servo drive solution for multiaxial position control

Ensured compatibility with Master Ethercat (implemented using Twincat software tool by Bechkoff instead of hardware solution)

Main design challenges

- Motor control 48 V design with high scale integration
- Max power dissipation up to 700 W

Key products

- **STM32F767:** High-performance, Arm Cortex- M7 MCU with DSP & FPU
- **STDRIVE101:** Triple half-bridge gate driver
- **IPS160H:** Single channel IPS
- **CLT03-2Q3:** Dual channel digital input interface
- **ST3485:** RS485 / RS422 transceiver
- **TSV991ILT:** Wide-bandwidth rail to rail 5V CMOS Op-Amp
- **STH270N8F7-2:** N-channel 80 V, 1.7 mOhm typ., 180 A STripFET F7 Power MOSFET
- **L7987L (61 V 2 A asynchronous step-down switching regulator)**

Key features

- Real-Time Ethernet based on Ethercat protocol (NETX90 processor)
- Motor control driving powered by STDRIVE StripFET F7
- Digital Actuation for industrial load
- Driving power circuit with brake energy discharge circuit, to drive the rotor position and manage the energy discharge
- Power management circuit to generates all the reference voltage
- Quadrature encoder feedback signal input based on digital protocol like EnDat, BiSS and Ssi
- RS485 interface for digital sensors or other use

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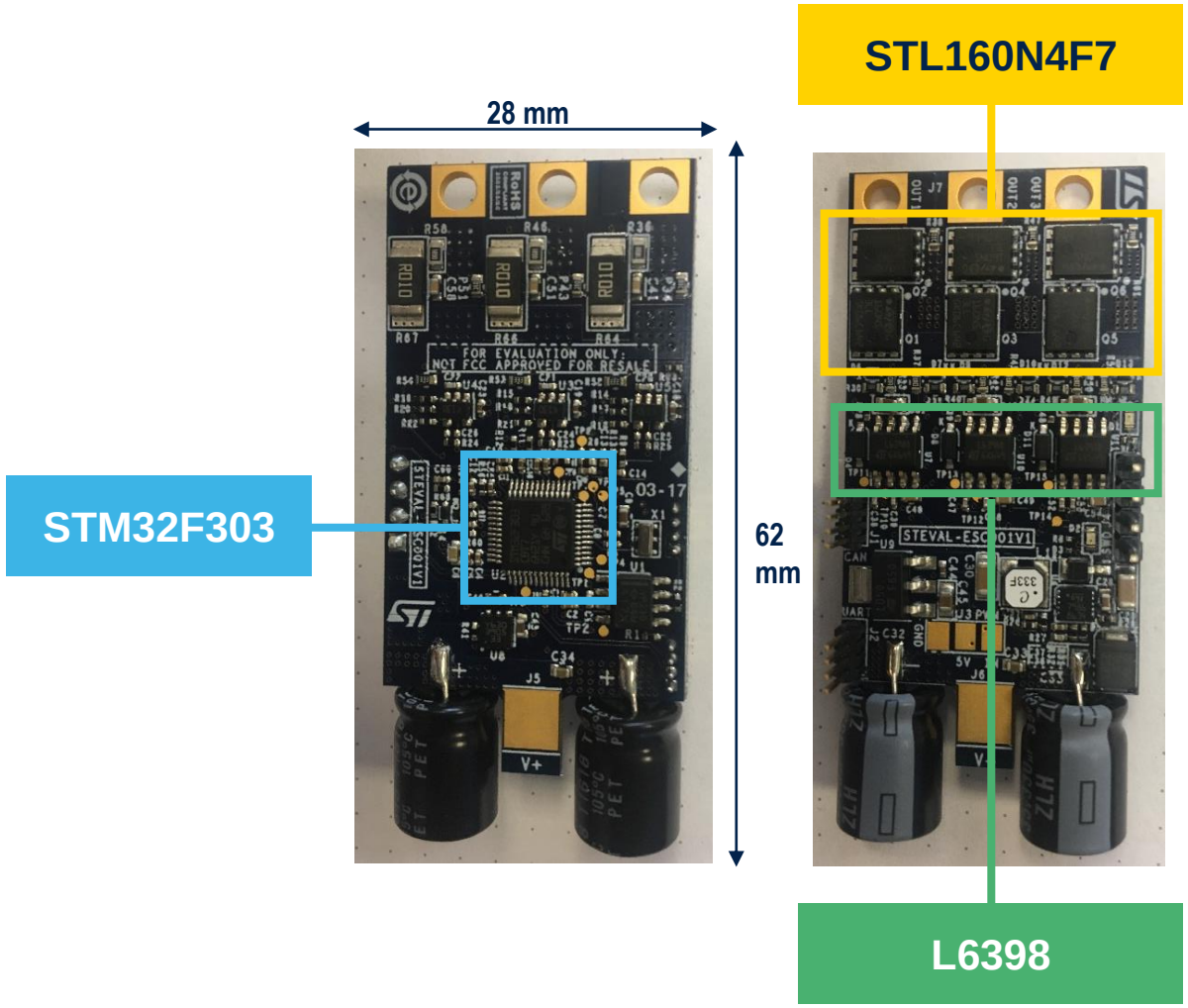
STEVAL-ESC001V1
The professional UAV ESC with CAN interface



Key products

- **STM32F303:** Arm Cortex- M4 MCU
- **L6398:** High-voltage gate drivers
- **STL160N4F7:** Low-voltage STripFET F7 series

Key features

- Implementing a sensorless FOC algorithm
- Designed for 6S pack of LiPo batteries (22.2V)
- Ready for communication with any standard FCU: PWM or CAN
- Temperature overheating protection
- BEC 5 V / 0.5 A for external receiver or FCU
- Complete pre-configured firmware package available (STSW-ESC001V1)
- Maximum rate 20 A, 400 W

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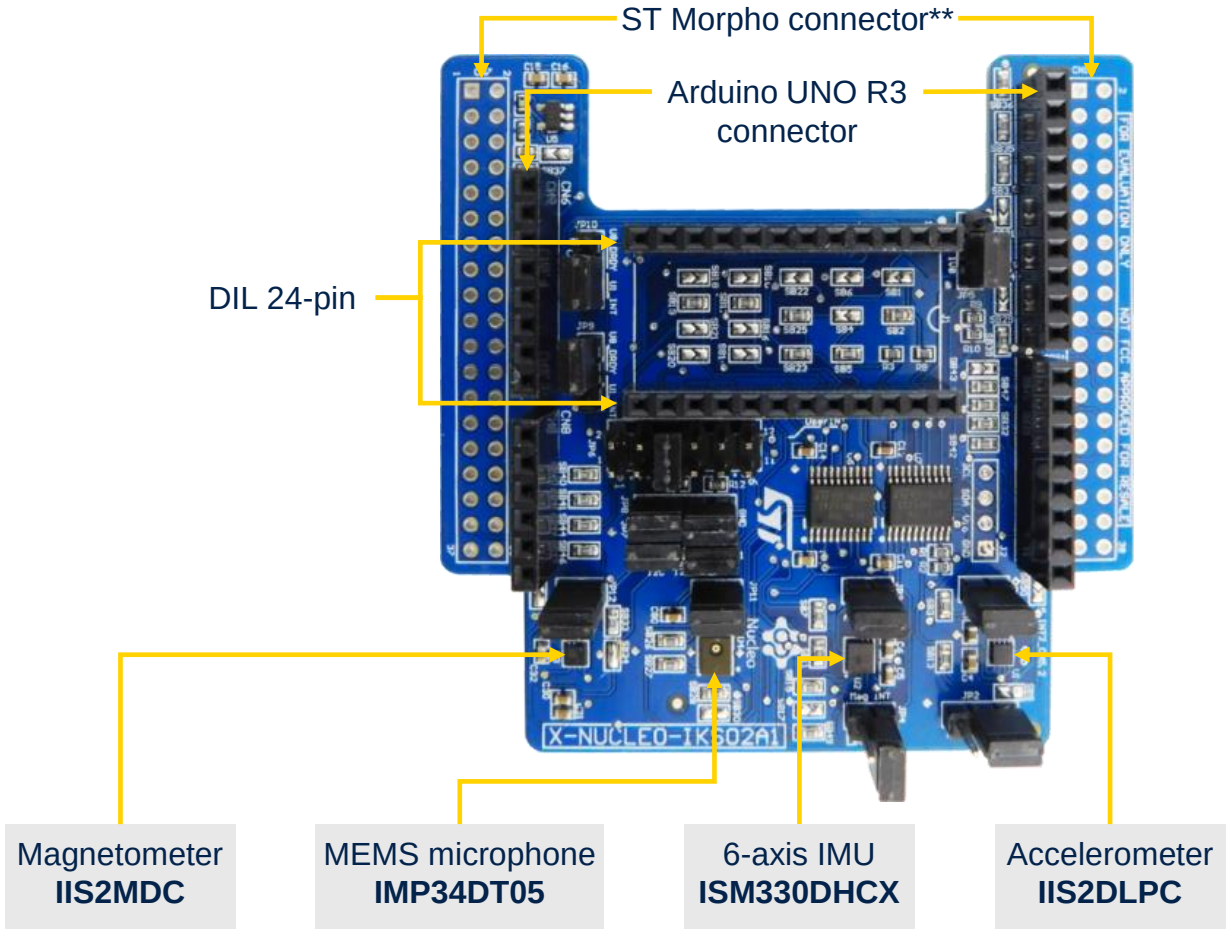
X-NUCLEO-IKS02A1
Industrial sensors extension



** Connector for the STM32 Nucleo Board

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- **IIS2MDC**: 3D magnetometer for absolute orientation of the object
- **IMP34DT05**: MEMS microphone for environment monitoring

Key features

- Motion MEMS and environmental sensor expansion board for STM32 Nucleo for Industrial
- DIL 24-pin socket available for additional MEMS adapters and other sensors
- I^2C, SPI support
- Available I^2C sensor hub features on ISM330DHCX
- Equipped with Arduino UNO R3 connector
- Free comprehensive development firmware library and samples for all sensors compatible with STM32Cube firmware

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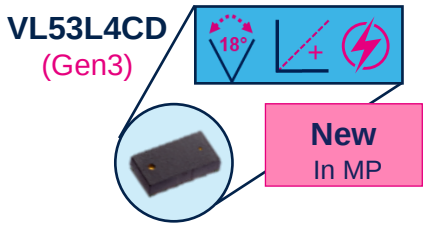
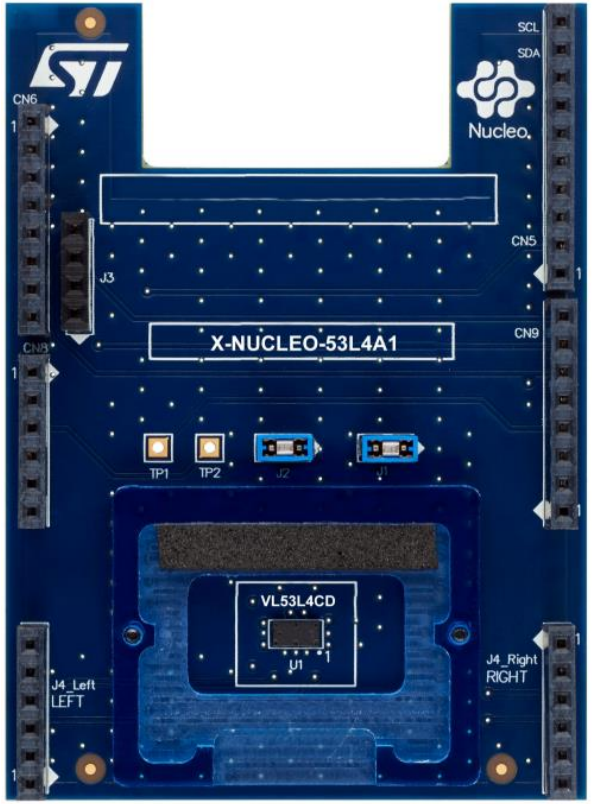
X-NUCLEO-53L4A1
ToF up to 1.2 m range for obstacle detection





Key products

- **VL53L4CD:** Up to 1.3m TOF with 18 deg FOV and excellent short distance linearity (>0.1cm)
- **Nucleo-F401RE** recommended motherboard with STM32F401 MCU, P-NUCLEO-53L4A1- includes both

Key features

- Full FoV ranging : **130 cm+** (white target, no IR)
- **Very high-performance proximity** sensor, for accurate obstacles detection in close proximity.
- Excellent **short distance linearity** (>0.1cm)
- **Low power autonomous mode** with interrupts thresholds for user / object detection
- **Fast ranging frequency** (up to 100Hz)
- Same pinout of VL53L0CX, VL53L1CX/CB, VL53L3CX and VL53L4CX
- Crosstalk compensation
- Low power mode available
- Full set of product documentation & SW tools available on st.com

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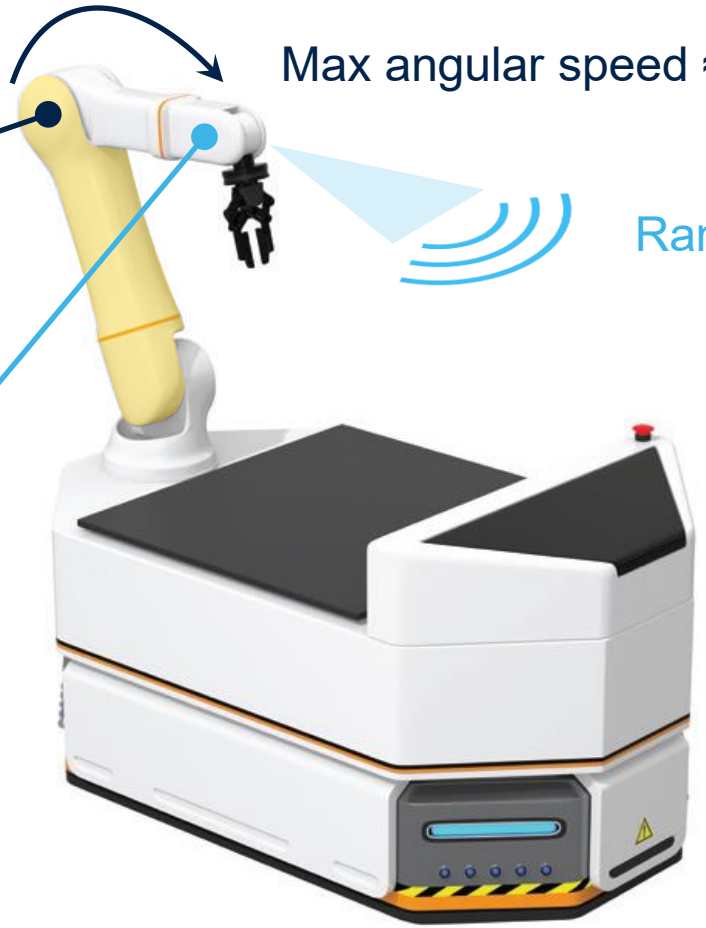
Solution for zone 3

Solutions for zone 3: Secondary link movement

Secondary link motors

Zone 3: 300 – 500 W

Motion MEMS and ToF sensors



Max angular speed ≈ **0.5 rad/s**

Range: up to ≈ **0.7 m** (max link excursion)

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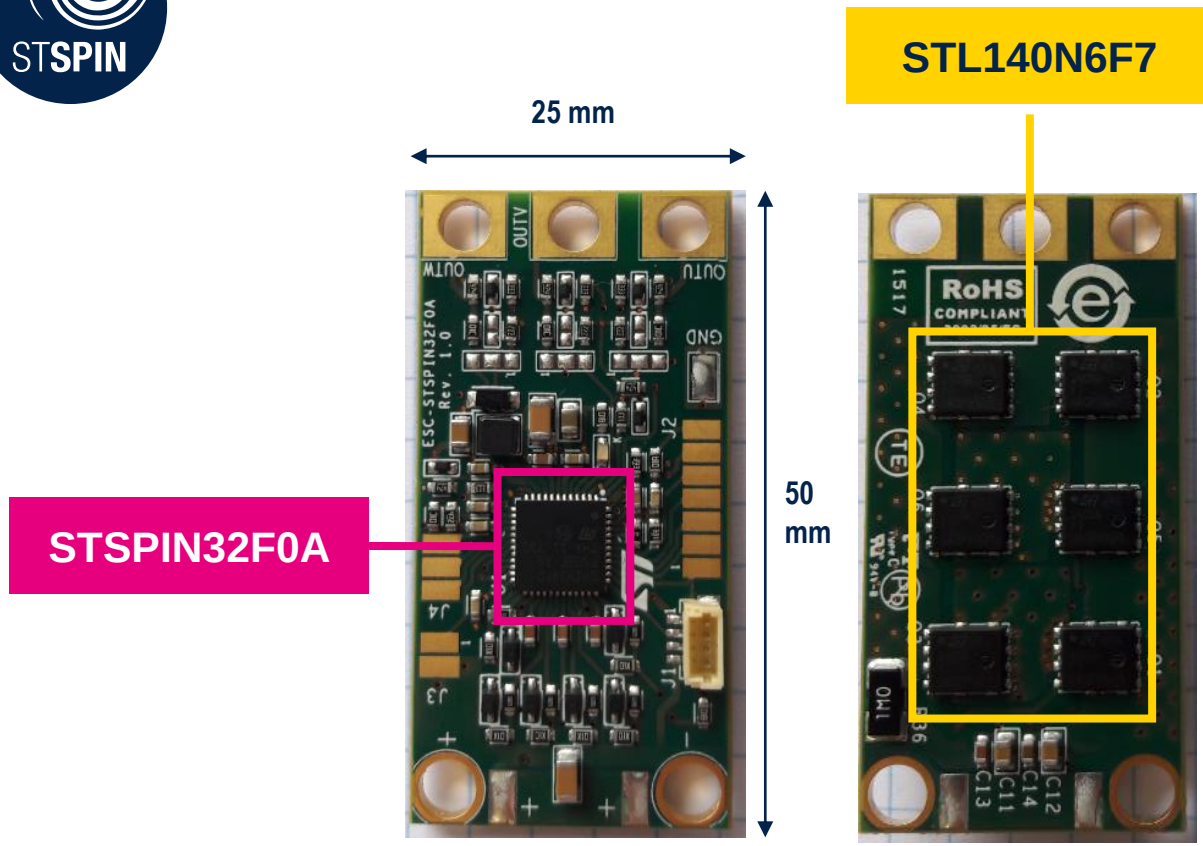
STEVAL-ESC002V1
Super compact turn-key solution for robots & drones

STSPIN



Key products

- **STSPIN32F0A:** Arm Cortex-M0 MCU + 3-phase gate driver
- **STL140N4F7:** 40 V 120 A STripFET F7 series

Key features

- Implementing a 6-step voltage mode algorithm
- Designed for 2S-6S pack of LiPo batteries
- Maximum Rate 45 V, 20 A
- Available soon: Support of BLHeli_32 FW adapted to STSPIN32F0A
- Complete pre-configured firmware package available (STSW-ESC002V1)

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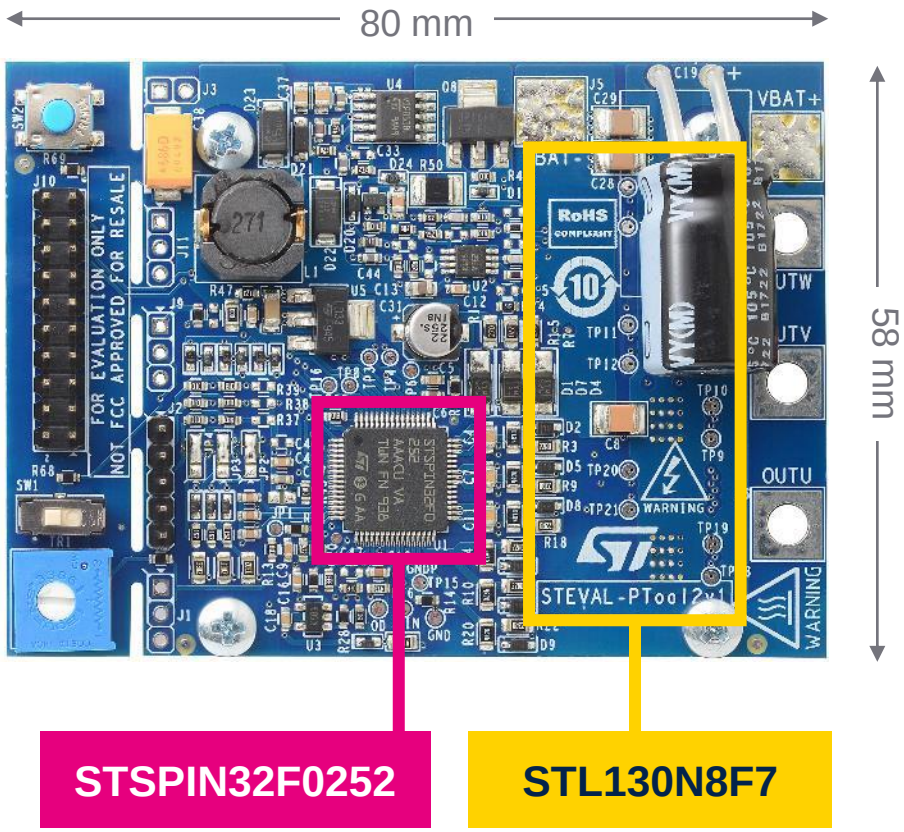
STEVAL-PTOOL2V1
High voltage solution for power tools



Key products

- **STSPIN32F0252:** Arm Cortex-M0 MCU + 3-phase gate driver. 250 V
- **STL130N8F7:** 80 V 120 A STripFET F7 series

Key features

- Implementing a 6-step voltage mode algorithm. 6-step single shunt with Hall sensors inputs
- Designed for 8S-15S pack of LiPo batteries
- Max operating ratings: 80 V, 15 A_{RMS}
- Very low stand-by power consumption
- Trigger, direction and speed inputs available
- Speed control potentiometer available
- Over current protection
- Mounting options for:
  - Field Oriented Control, sensorless / sensored
  - BEMF detection circuitry
- Ready to use dedicated 6-step firmware package
- Heatsink (54 x 54 x 20 mm)

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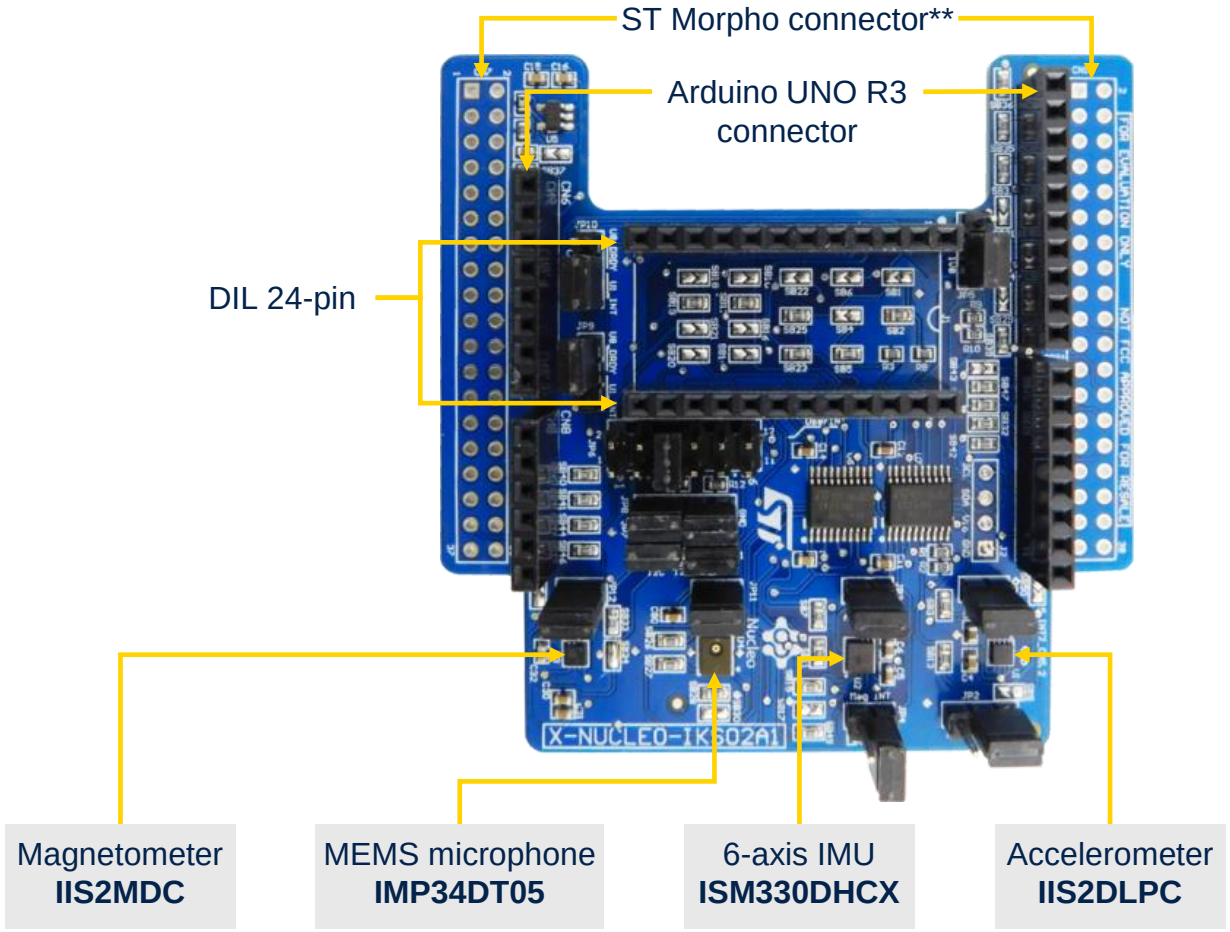
X-NUCLEO-IKS02A1
Industrial sensors extension



** Connector for the STM32 Nucleo Board

Key products

- **ISM330DHCX**: 6-axis IMU (accelerometer + gyroscope) to detect movement and rotation of the object
- **IIS2DLPC**: 3D accelerometer for low power wake-up from movement
- **IIS2MDC**: 3D magnetometer for absolute orientation of the object
- **IMP34DT05**: MEMS microphone for environment monitoring

Key features

- Motion MEMS and environmental sensor expansion board for STM32 Nucleo for Industrial
- DIL 24-pin socket available for additional MEMS adapters and other sensors
- I^2C, SPI support
- Available I^2C sensor hub features on ISM330DHCX
- Equipped with Arduino UNO R3 connector
- Free comprehensive development firmware library and samples for all sensors compatible with STM32Cube firmware

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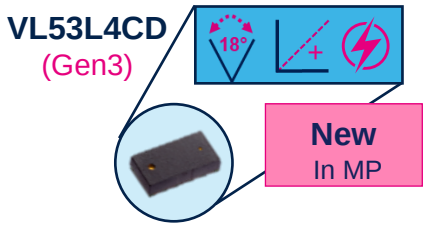
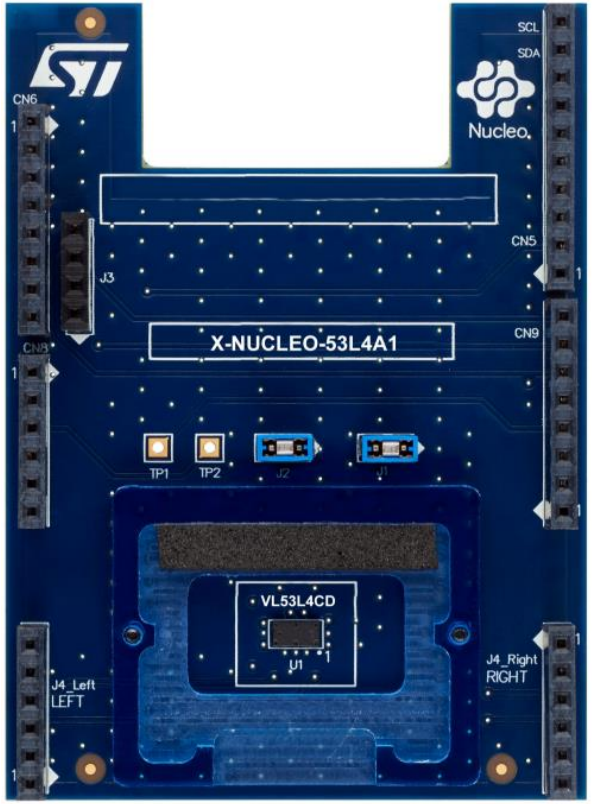
X-NUCLEO-53L4A1
ToF up to 1.2 m range for obstacle detection





Key products

- **VL53L4CD:** Up to 1.3m TOF with 18 deg FOV and excellent short distance linearity (>0.1cm)
- **Nucleo-F401RE** recommended motherboard with STM32F401 MCU, P-NUCLEO-53L4A1- includes both

Key features

- Full FoV ranging : **130 cm+** (white target, no IR)
- **Very high-performance proximity** sensor, for accurate obstacles detection in close proximity.
- Excellent **short distance linearity** (>0.1cm)
- **Low power autonomous mode** with interrupts thresholds for user / object detection
- **Fast ranging frequency** (up to 100Hz)
- Same pinout of VL53L0CX, VL53L1CX/CB, VL53L3CX and VL53L4CX
- Crosstalk compensation
- Low power mode available
- Full set of product documentation & SW tools available on st.com

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Solution for zone 4

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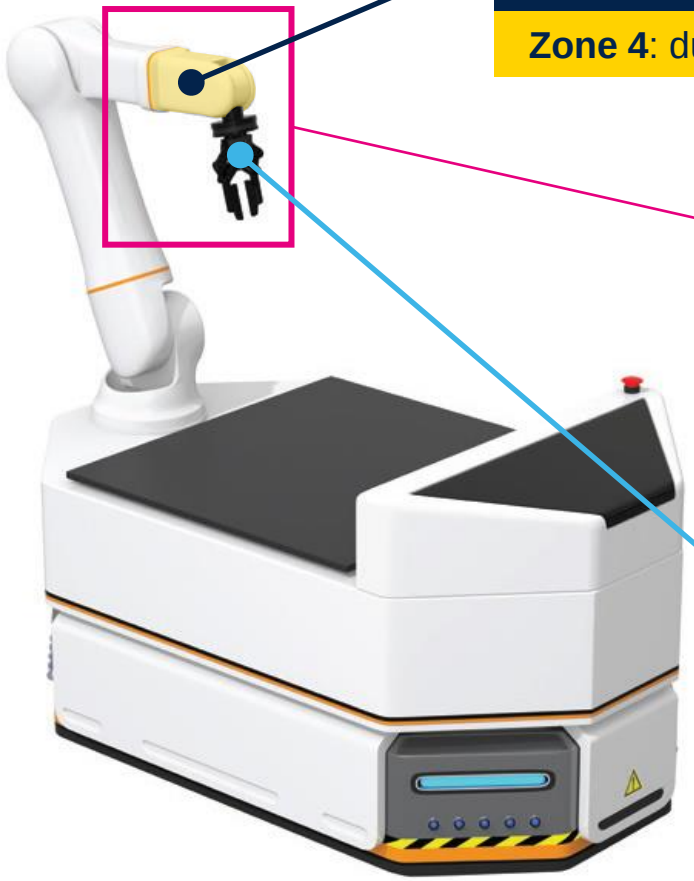
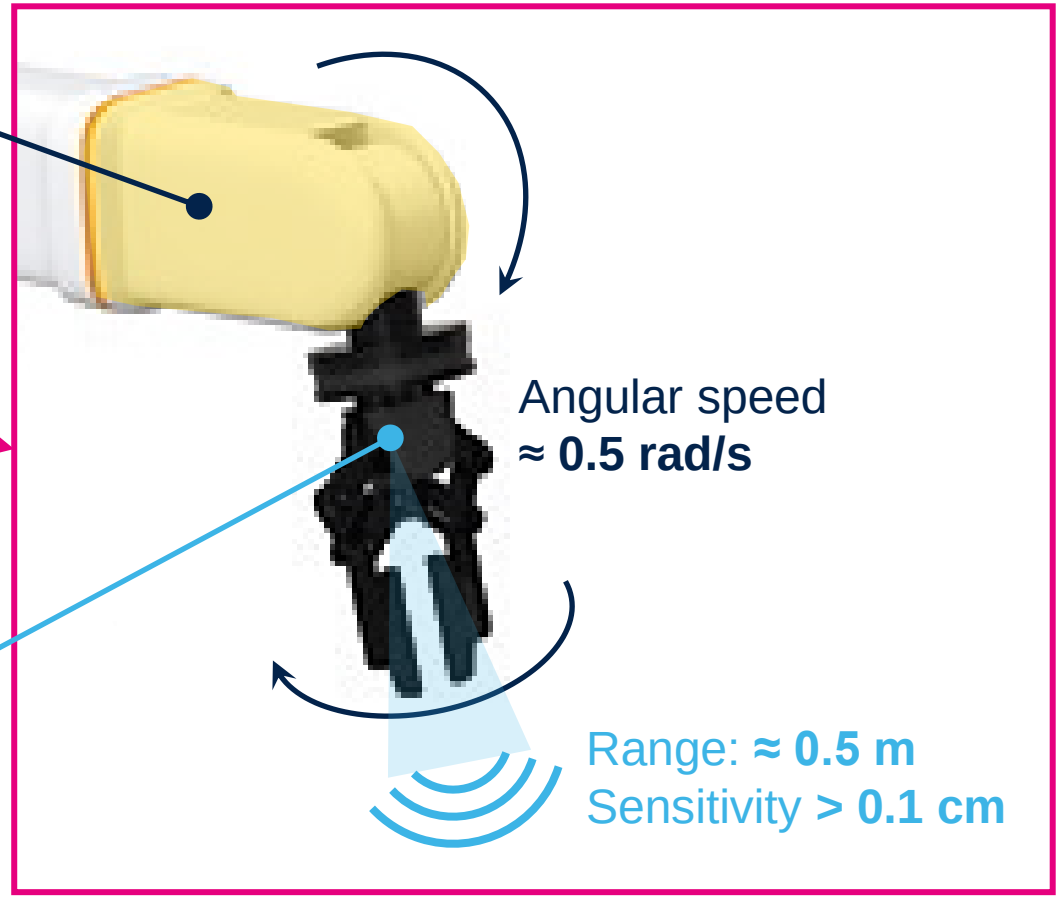
Solutions for Zone 4 Manipulator

Precision motors

Zone 4: dual motor up to 150 W



Motion MEMS,ToF & current sensing sensors



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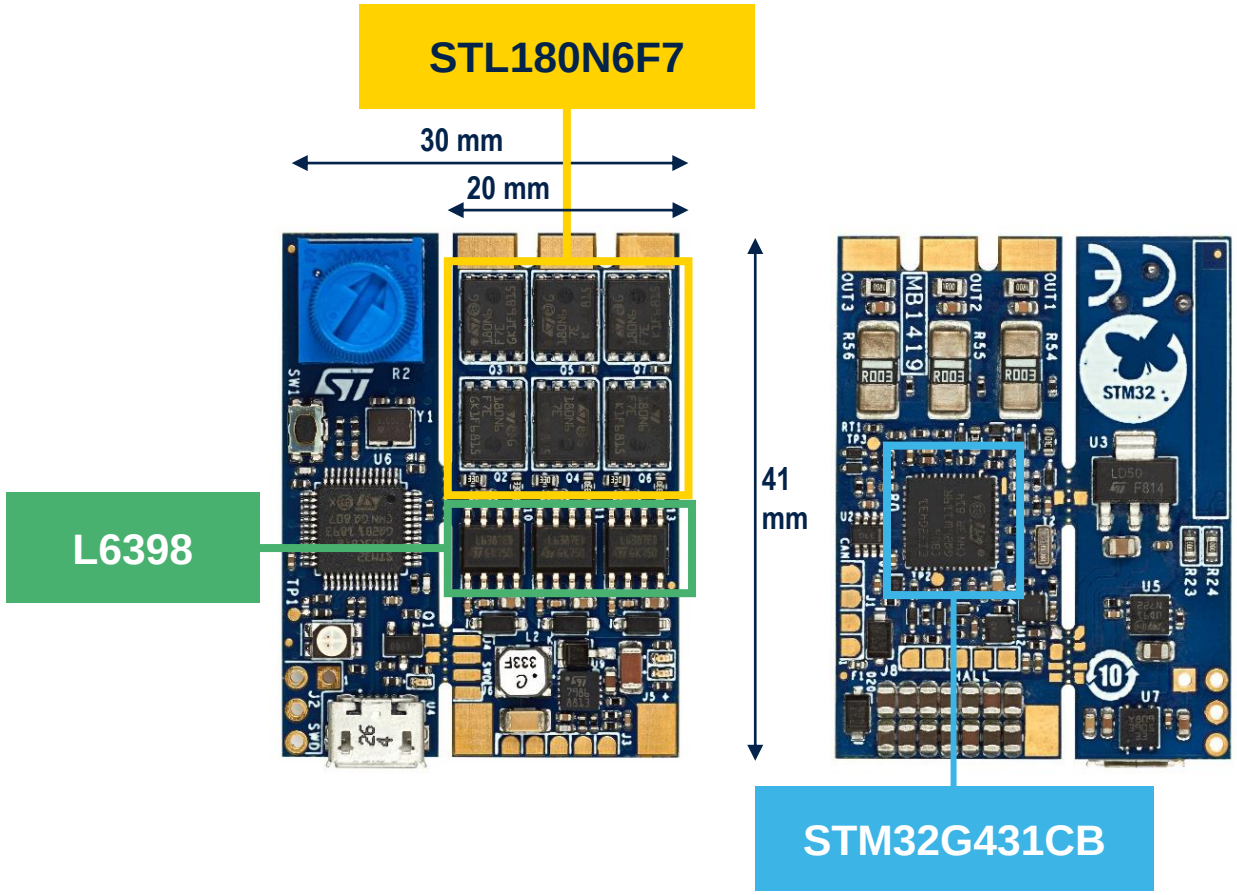
B-G431B-ESC1

Turn-key solution with sensorless FOC and 6-step control



Key products

- **STM32G431CB:** ARM Cortex- M4 MCU
- **L6398:** High-voltage gate drivers
- **STL180N6F7:** N-Channel 60 V, 120A STripFET F7 series

Key features

- Full reference design capable of both sensorless FOC and 6-step algorithm
- Ultra-compact solution
- Up to 6S LiPo battery pack or equivalent 11-24V DC supply
- On-board ST-LINK/V2-1 debugger/programmer detachable from the main board
- BEC available through the daughterboard
- Output peak motor current: 40 A
- Support for motor sensors (Hall or encoder)

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EVALKIT-ROBOT-1

Compact reference design kit for robotics and automation

Key products

- **STSPIN32F0A:** ARM Cortex-M0 MCU + 3-phase gate driver
- **STL7DN6LF3:** 60 V, 35 mΩ dual N-Channel MOSFETs

Key features

- 36 V/6 Apeak power stage
- Hall sensors
- Position control loop based on Field Oriented Control
- Extremely compact footprint (40 mm x 40 mm)
- MODBUS communication protocol through RS-485
- maxon EC-i 40 100 W 3-phase brushless DC motor
- maxon ENX 16 EASY 1024-pulse incremental encoder

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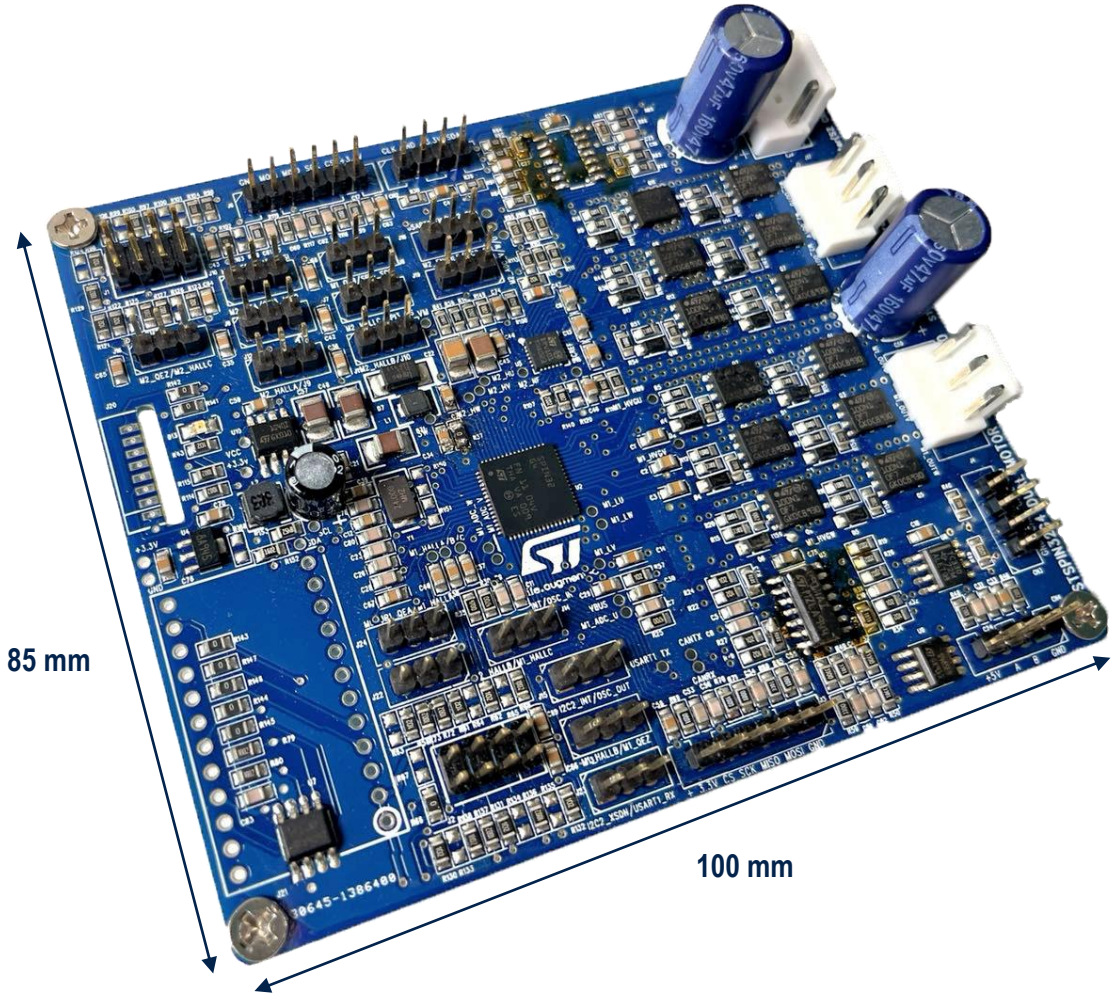
Light weight

STSPIN32G4 dual motor board
Dual motor PMSM FOC



Key products

- **STSPIN32G4:** 3-phase motor controller with embedded STM32G4 MCU
- **STDRIVE101:** Triple half-bridge gate driver
- **STL110N6F7:** 40V 108 A STripFET F7 series
- **TSV914:** Op-Amp
- **ST1S40IDIR:** Buck regulator
- **VL53CX:** Time of Flight sensor, optional
- **ISM330DHCX:** 3D Gyroscope, optional

Key features

- 5 – 75 V, 200 W
- FW & HW support for Dual Motor FOC sensorless / sensored
- Magnetic Encoder /QEI
- Hall sensors (Timer or No-Timer support)
- IMU & ToF data acquisition
- CAN, RS485 protocols
- If customized, size can be reduced up to 50%

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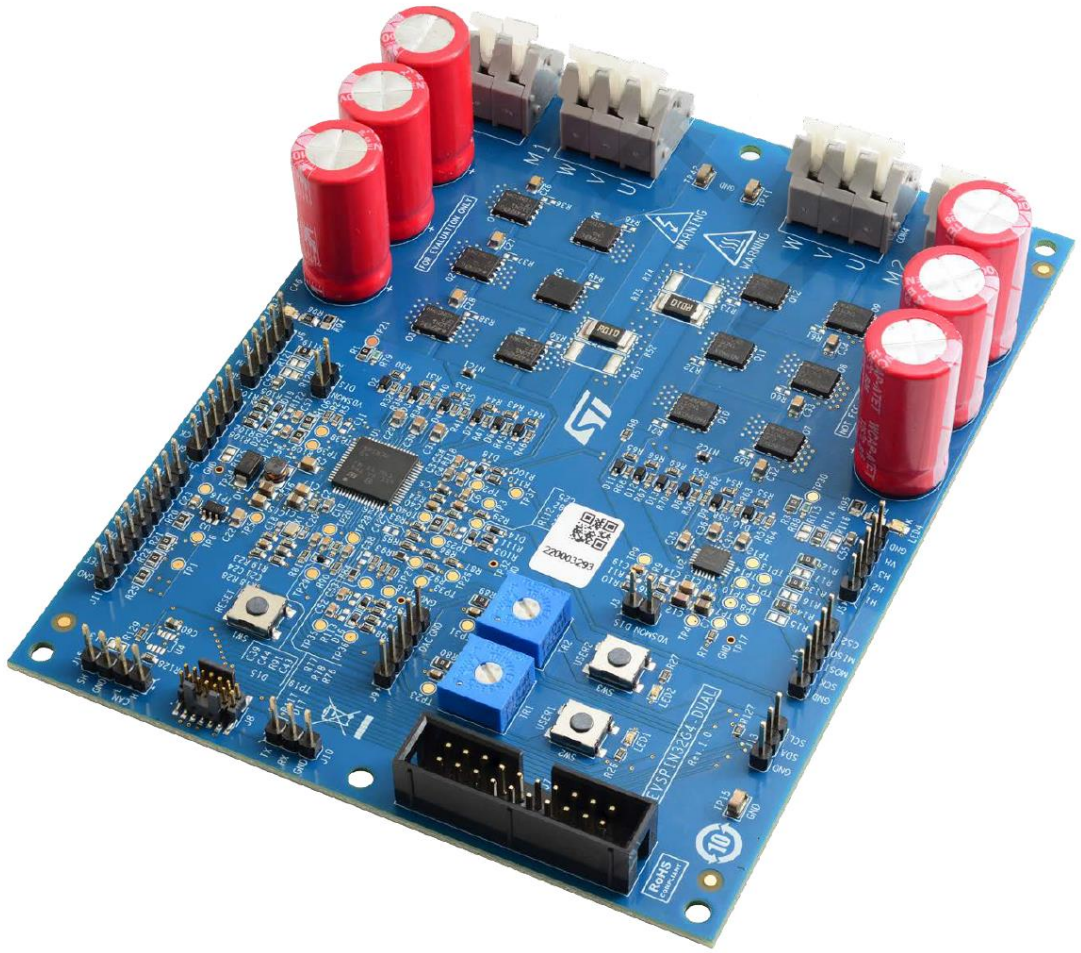
Light weight

EVSPIN32G4-DUAL
Dual motor PMSM FOC



Key products

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- **STDRIVE101:** Triple half-bridge gate driver
- **STL110N6F7:** 40V 108 A STripFET F7 series
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- **VL53CX:** Time of Flight sensor, optional
- **ISM330DHCX:** 3D Gyroscope, optional

Key features

- 5 – 75 V, 200 W
- FW & HW support for Dual Motor FOC sensorless / sensored
- Magnetic Encoder /QEI
- Hall sensors (Timer or No-Timer support)
- IMU & ToF data acquisition
- CAN, RS485 protocols (available on demand)

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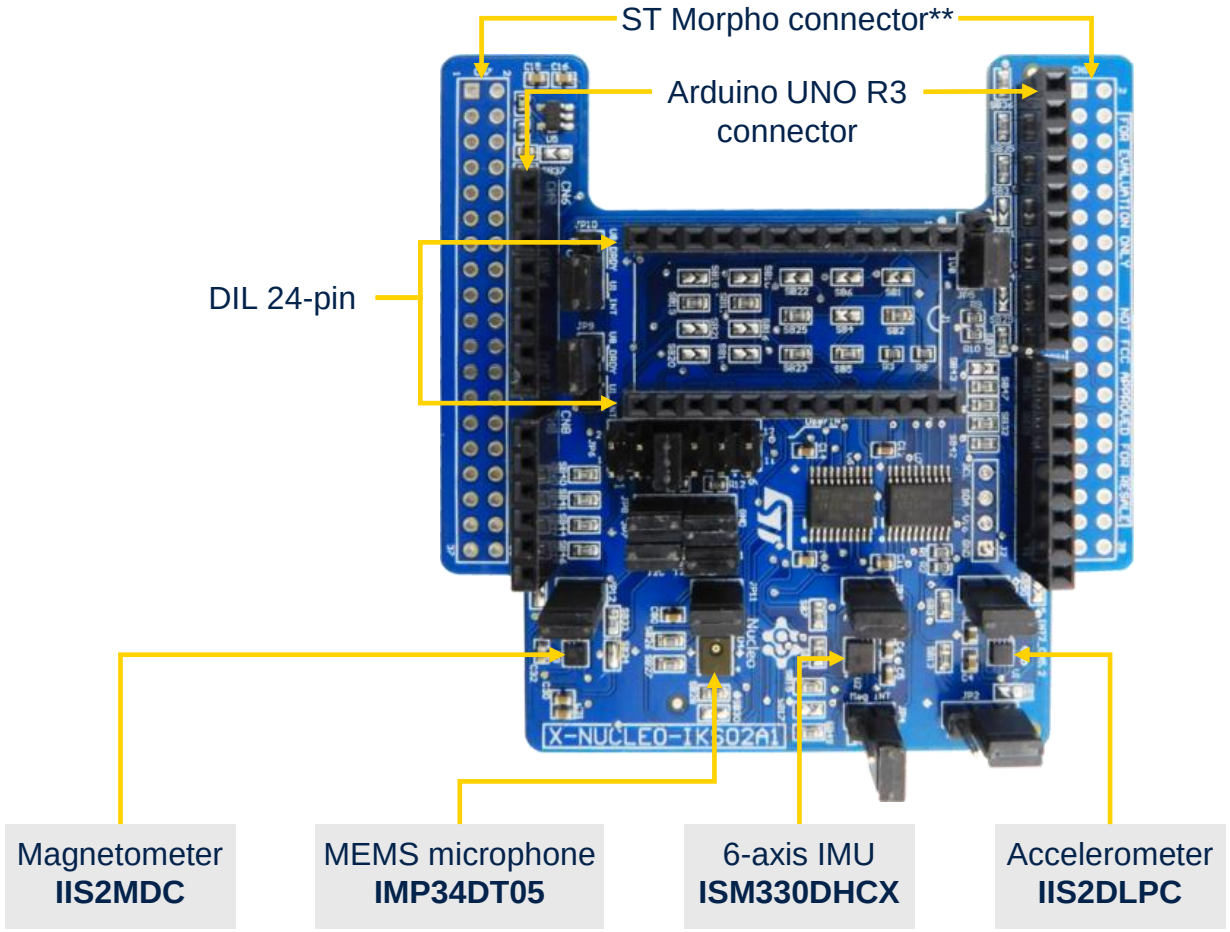
X-NUCLEO-IKS02A1
Industrial sensors extension



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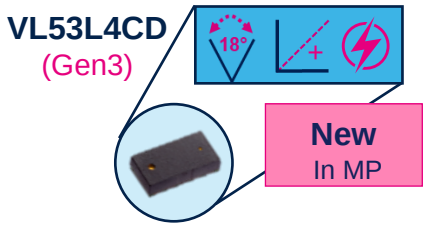
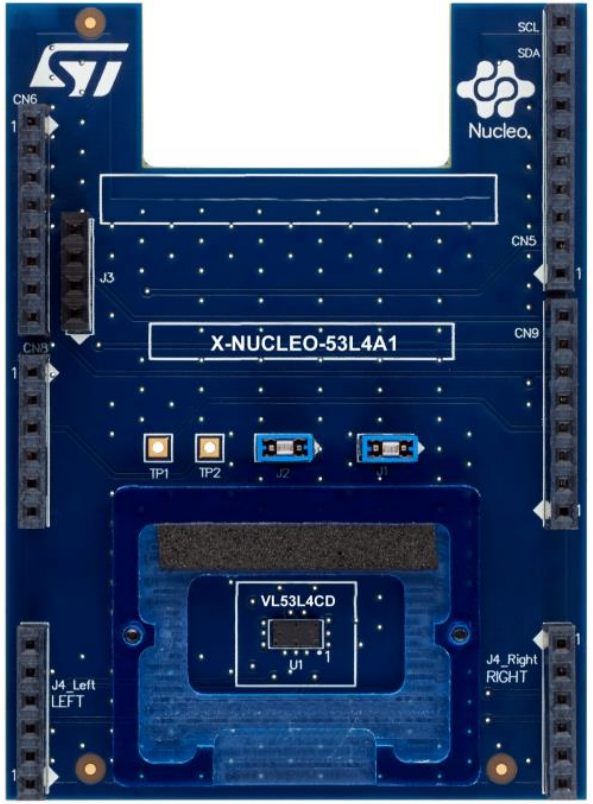
X-NUCLEO-53L4A1
ToF up to 1.2 m range for obstacle detection





Key products

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- **Low power autonomous mode** with interrupts thresholds for user / object detection
- **Fast ranging frequency** (up to 100Hz)
- Same pinout of VL53L0CX, VL53L1CX/CB, VL53L3CX and VL53L4CX
- Crosstalk compensation
- Low power mode available
- Full set of product documentation & SW tools available on st.com

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STEVAL-AETKT1V2
Bidirectional current sensing TSC201x evaluation kit

STEVAL-AETKT1V2 – includes all gain configurations daughter boards

Key products

- **TSC2010, TSC2011, TSC2012**: High voltage, precision, bidirectional current sense amplifier
- Different gain available
  - TSC2010: 20 V/V
  - TSC2011: 60 V/V
  - TSC2012: 100 V/V

Key features

- Can host different types of shunts
- Both SMD and THT
- Allows simple setting of V_{REF} and standby pin by jumpers
- Embeds RC filter. External wire connection
- TSC2010-2011-2012 on daughterboard
  - Wide input common mode voltage: - 20 to 70 V
  - Offset voltage: ± 200 µV max
  - 2.7 to 5.5 V supply voltage
  - Gain error: 0.3% max
  - Offset drift: 5 µV/°C max

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STEVAL-AETKT2V1
Bidirectional current sensing TSC21x evaluation kit

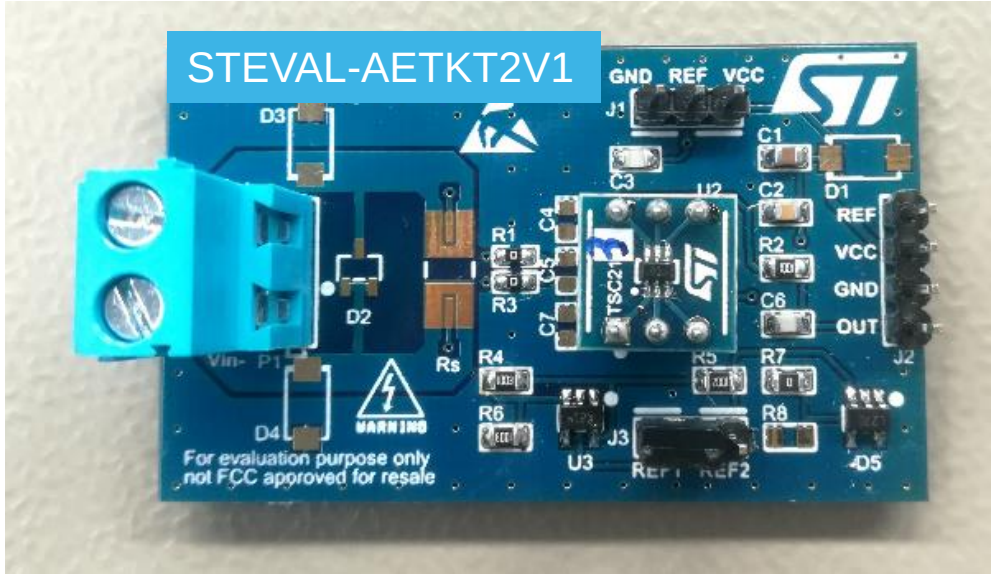

Table 1. - Example of current ranges with 3mOhm shunt over different gain, Vcc and Vref

Device	Vcc (V)	Vref (V)	Range I_1 (A)	Range I_2 (A)
TSC213	3,3	2,5	4,33	16
	5	2,5	15,66	16
TSC210	3,3	2,5	1,08	4
	5	2,5	3,91	4
TSC212	3,3	2,5	0,21	0,8
	5	2,5	0,78	0,8

STEVAL-AETKT2V1 – includes TSC210 and TSC213 daughter boards

Key products

- **TSC210, TSC211, TSC212, TSC213, TSC214, TSC215**: series of zero-drift current sense amplifiers
- Different gain available: TSC210 (200 V/V), TSC211 (500 V/V), TSC212 (1000 V/V), TSC213 (50 V/V), TSC214 (100 V/V), TSC215 (75 V/V)

Key features

- Test with on-board 2512 size shunt area or with connector to external shunt
- Allows simple set of VREF from internal precision op-amp, voltage reference or external source
- TSC21x on daughter board
  - Input common mode voltage: 26V
  - Offset voltage: 35 µV (100 µV max)
  - 2.7 to 26V supply voltage
  - Offset drift: 0.1 µV/°C max
  - Quiescent current: 100 µA max

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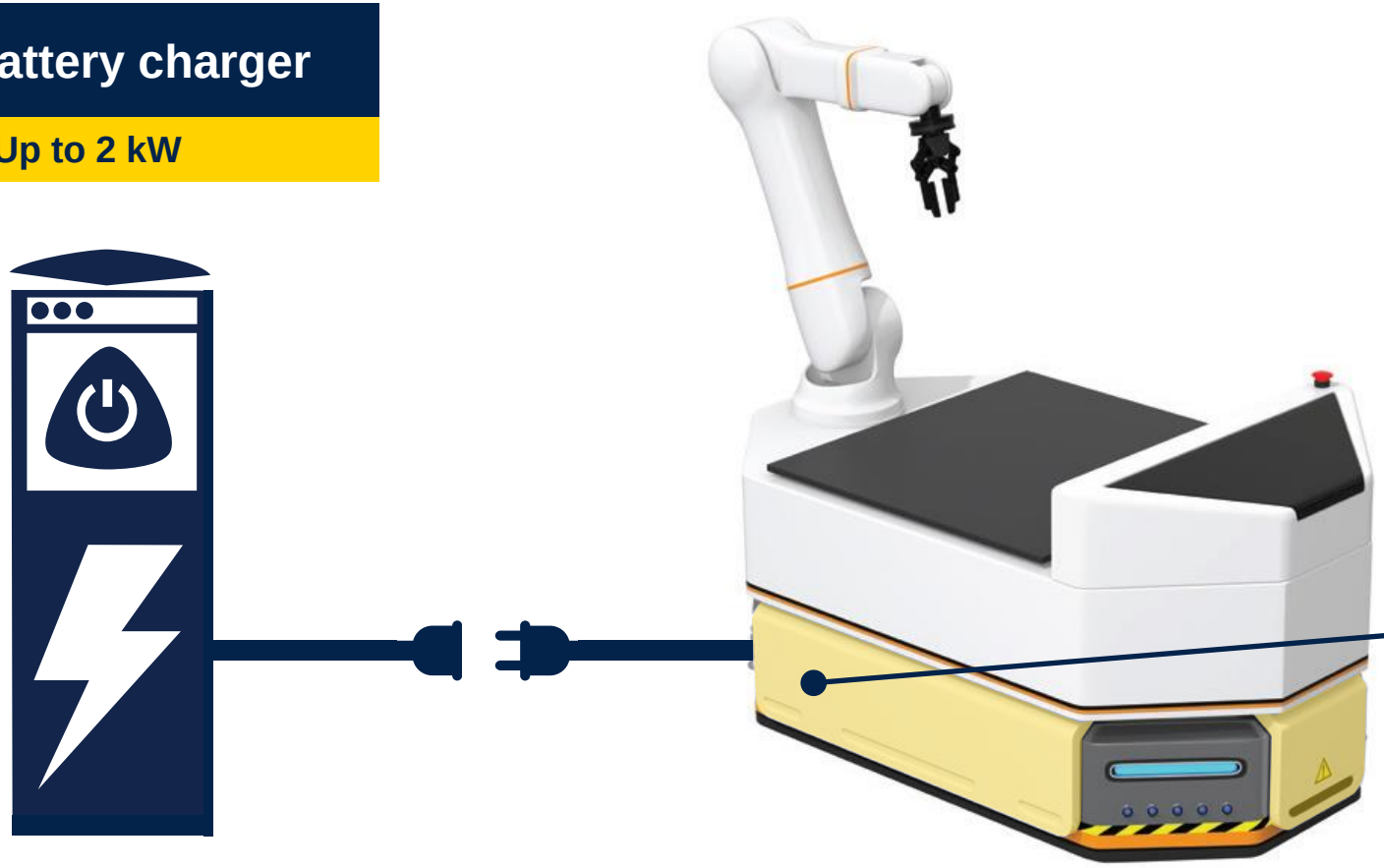
Power supply / Battery charger

LEV battery charger

Up to 2 kW



Battery pack

Up to 40 Ah

2.5 kW LEV charger

Main design challenges

- High-efficiency
- Thermal management

Key products

- **L4984D:** CCM PFC controller
- **L6699D:** LLC controller
- **STW57N65M5:** HV MOSFET - TO247
- **STO67N60DM6:** HV MOSFET - TO-LL pack
- **STPSC20H065CW:** SiC Diode
- **STM32G072CBT6:** MCU-ARM Cortex- M0+
- **L6491:** Half bridge gate driver
- **VIper16LN:** Off-line converter

Key features

- Input voltage range: 90 V AC to 265 V AC
- Multi battery chemistry charger design: lead-acid and Li-ion with a nominal voltage of 48 V (40 V DC to 60 V DC)
- PFC Efficiency: > 97.5 %
- LLC Efficiency : > 96%
- Power Factor (PF): > 0.9 from 10 % rated load
- THD: < 10% from 20 % of the load at high-line
- CAN Communication
- Battery chemistry selection: by switch and CAN/RS485
- Battery size: by MENU switch combination and CAN/RS485

Our technology starts with You

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