



Techday

Taiwan | 2023

OUR TECHNOLOGY STARTS WITH YOU

**Sub-track II –
Power & Energy Presentation**



life.augmented

ST servo drive architecture and new LV & HV servo solutions

Liam PARK

Motor Control Competence Center

STMicroelectronics

Motor Control
Competence
Center



Agenda

1 Market information

2 ST products portfolios

3 Software ecosystem

4 IP

5 LV servo solutions

6 HV servo solutions

Motor control competence center mission

to **Create and Promote** innovative, convenient and mature **motor control system Solutions**;
to design and **Partner** with our Regional Customers **in Asia**
in order to leverage on the **whole ST product portfolio**
for **Industrial Applications**,
in order to boost **revenues growth** in the market segment



SYSTEM R&D

- Hardware reference design, application boards
- Firmware application modules for the ST MC Library
- System solutions

CUSTOMER SUPPORT

- Evaluation & training with ST tools
- ST kit product selection (in cooperation with TM)
- Schematics; layout review; tuning (in cooperation with FAE)

PARTNERSHIP

- Overall motor control system expertise
- Partnership & new algorithms;
- Customer's IP porting to ST platforms

NPP, NSP, GAP

- Products validation in-application: feedback to divisions
- New product, new solution proposals: specification/roadmap
- Interdivisional/strategic MKT/Joint Labs: information & technology alignment



Motor control competence center major focus sectors

Home appliances & Air con



High energy efficiency - high power
New algorithms - AI

Motor drives & servo drives



Position control
Functional safety - predictive maintenance

Power tools & high-end consumer



High speed motors
High integration



Market size

Major home appliances: 2022 TAM 4.2B\$ *

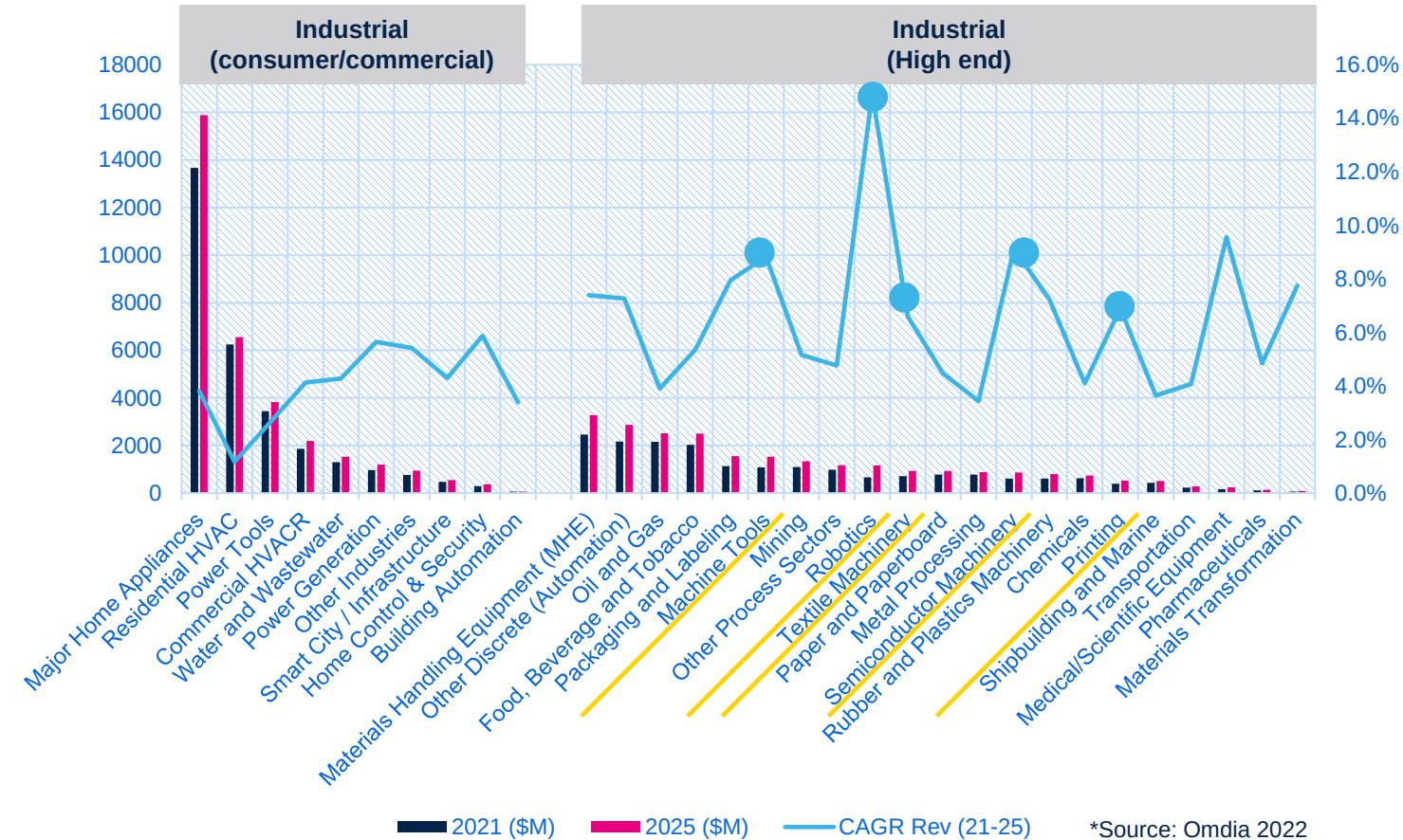
Motor drive: 2022 TAM: 5.1B\$ *

Power tools: 2022 TAM 1.2B\$ *

* Source: OMDIA: Industrial Semiconductor Market Tracker Q32022

Motor drive market analysis top CAGR in high end industrial

Motor drives shipment (\$M) & CAGR 21-25 (%) *



*Source: Omdia 2022

Robotics
CAGR 14.9%



Semiconductor machinery
CAGR 9.1%



Machine tools
CAGR 8.8%



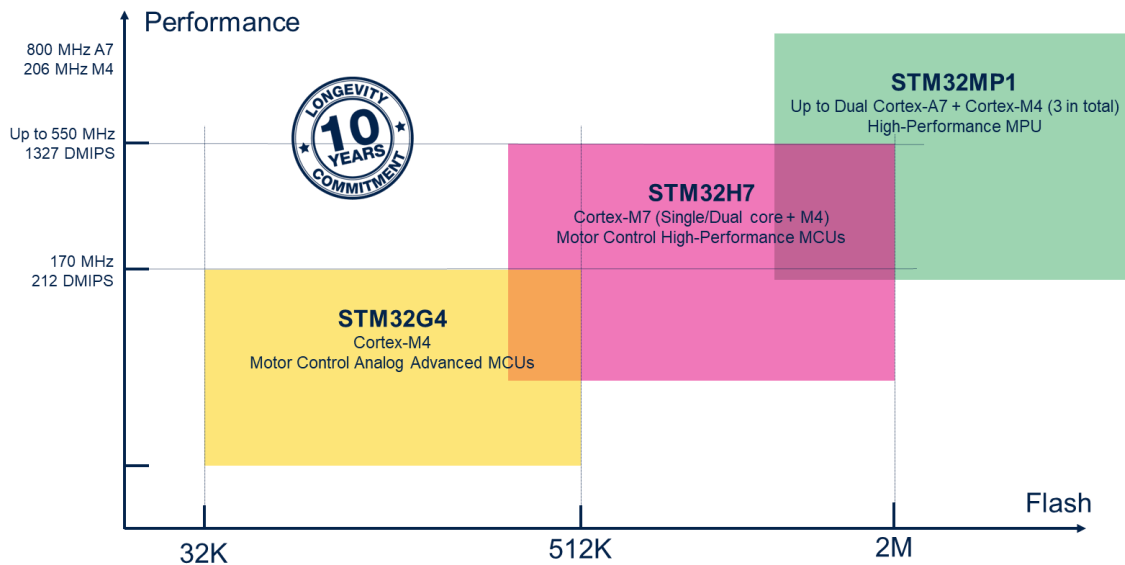
How can ST help you innovate an industrial motor control system?

- New ST motor control solutions
- In each industrial application



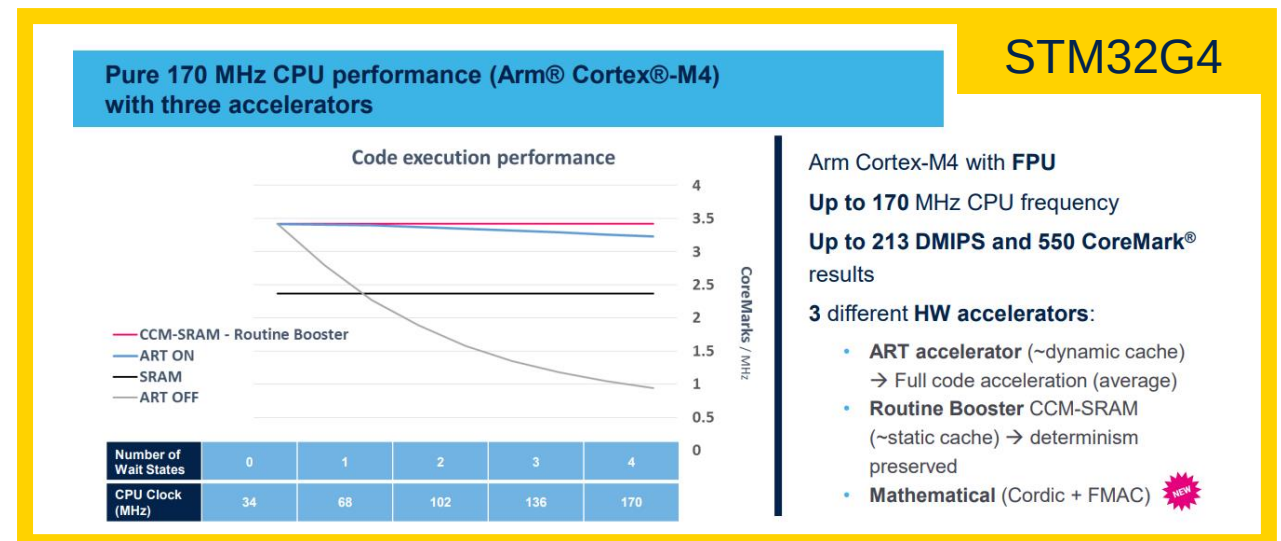
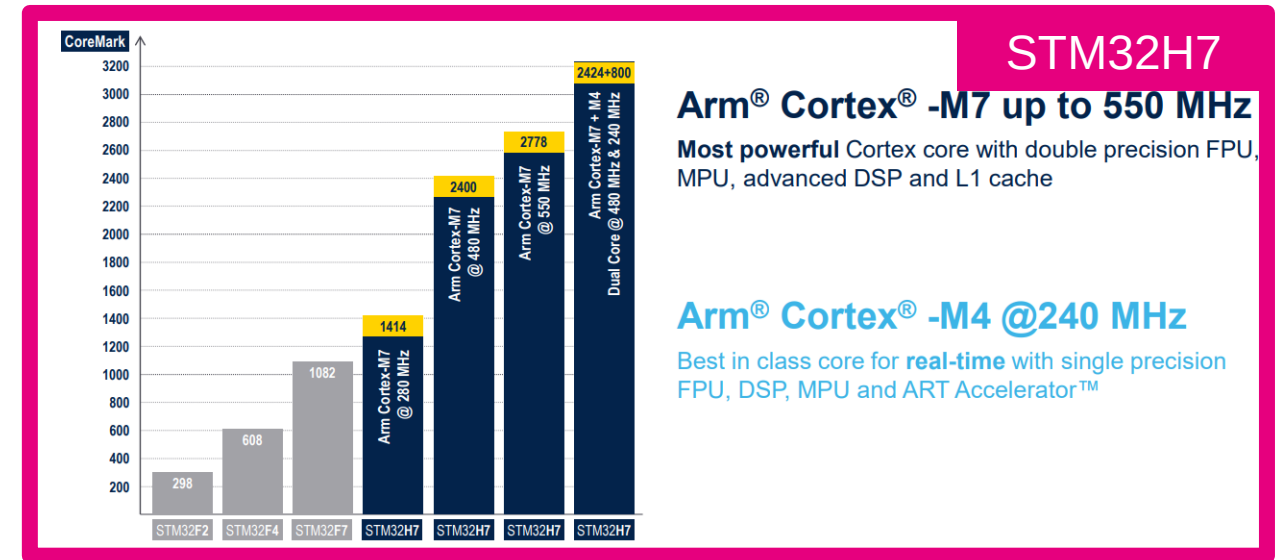
ST product portfolios





23% CPU load @16 KHz dual FOC @STM32G431

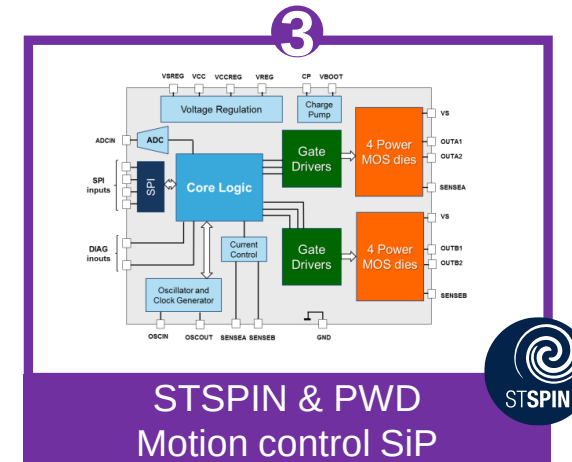
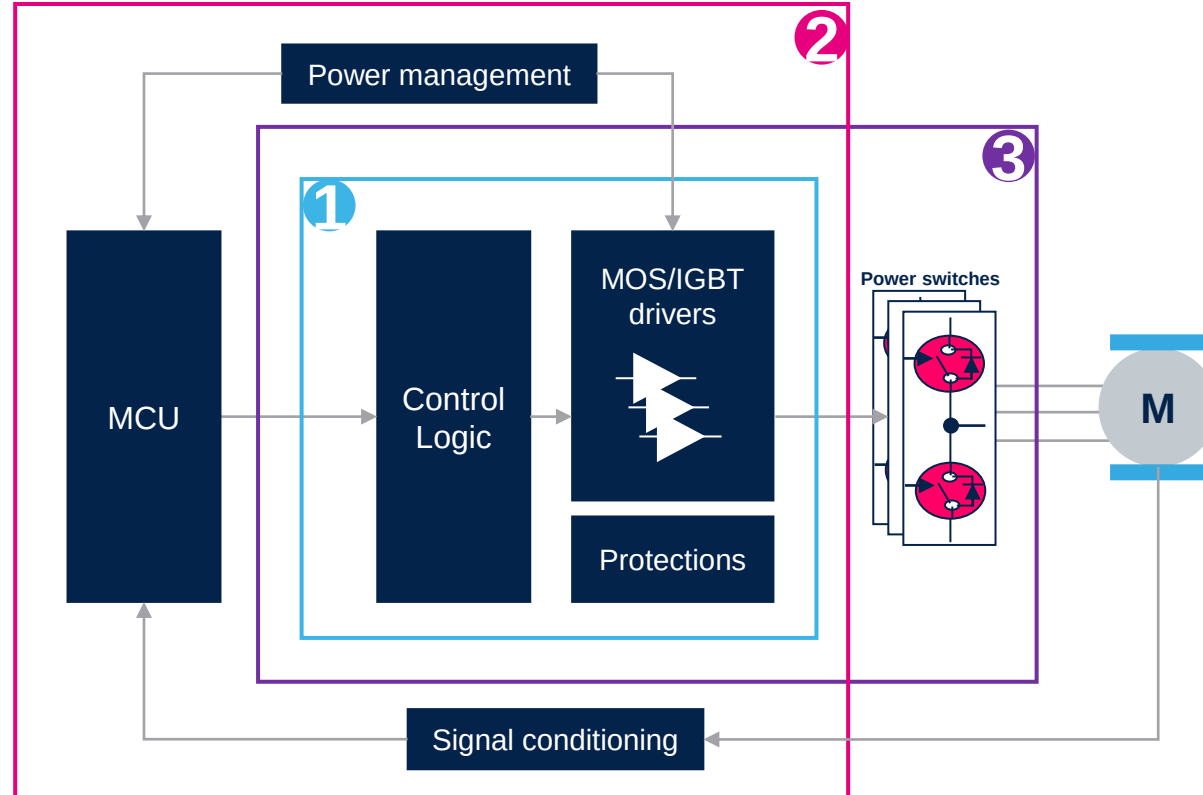
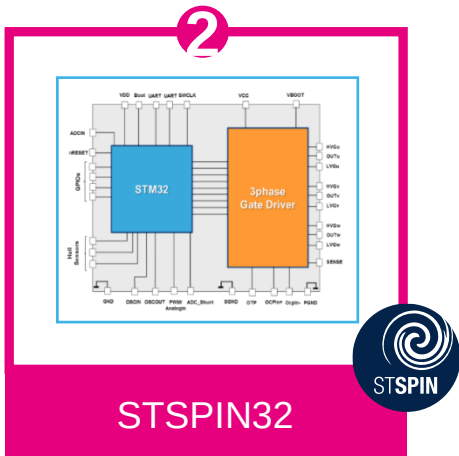
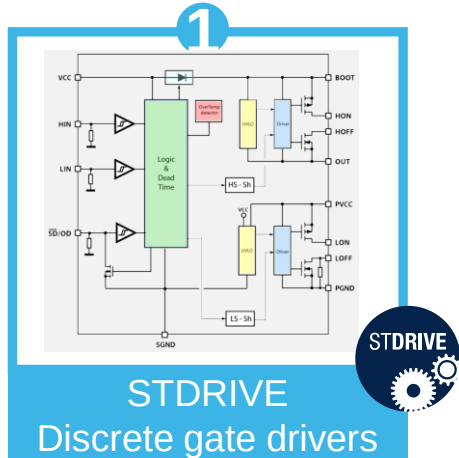
STM32 for motor control





Motion control products & architectures

Leading the convergence of analog and digital in motion control

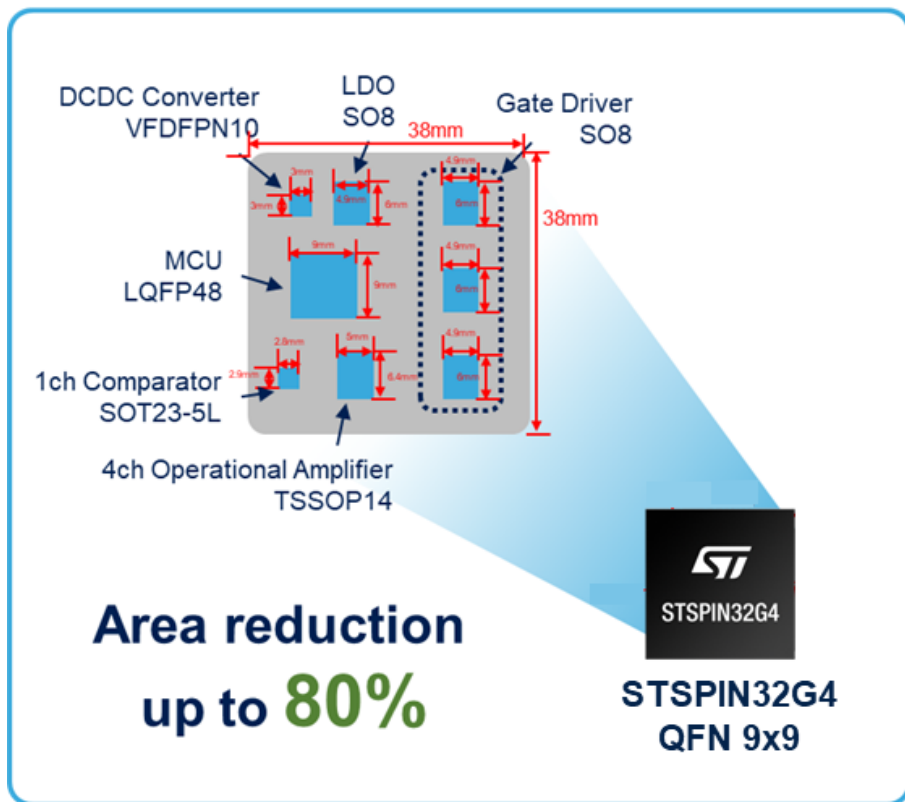




STSPIN32G4 SiP

5 ICs in 1, high integration motor control

STSPIN32G4 vs Discrete Solution



High integration

STM32G4 + gate drivers + power management
~80% space reduction

High performance 3-phase gate driver

5.5V-75V
1A driving capability

Dual motor FOC Ready
+ STDRIVE101 6-in-1 gate driver

Ultralow power BOR

Down to 15uA
lowest consumption

Smart driver

VDS monitoring of the power stage
Programmable VCC output
Protections: SC, UVLO, OL, thermal



QFN 9x9 mm
Up to 40 GPIO

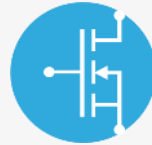


4x4mm QFN

Power device technology portfolio overview



High voltage
power MOSFET



Planar and
MDmesh
250 V to 1700 V

Low voltage
power MOSFET



STripFET
-100 V to 200 V

IGBT



IGBT
600 V, 650 V, 1200 V, 1250 V

Power bipolar



Power bipolar
15 V to 1700 V

Silicon carbide



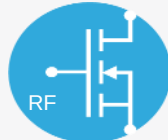
SiC MOSFET
650 V, 1200 V, 1700 V

GaN



GaN-on-Si
100 V, 650 V

Power RF



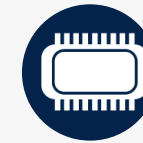
LDMOS, DMOS
28 V, 1000 V

Hi-Rel & Space



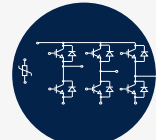
Rad-hard bipolar
and MOSFET
60 V, 200 V

Intelligent
power module



SLLIMM
500 V, 600 V

Power module



ACEPACK
650 V, 1200 V

Isolated interface product portfolio

Sensors & Amplifiers



ISOSD61

16-bit SD
TTL Version
86dB SNR
25MHz External Clock
SO16

Mass production



ISOSD61L

16-bit SD
LVDS Version
86dB SNR
25MHz External Clock
SO16

Mass production

6kV galvanic isolated high-accuracy and robust sensing devices for industrial market

Connectivity



STISO621W

1/1 channels
SO8 8mm Wide Body
6kVp Viotm
100Mbps

Mass production



STISO621

1/1 channels
SO8 Narrow Body
4.8kVp Viotm
100Mbps

Mass production



STISO620

2/0 channels
SO8 Narrow Body
4.8kVp Viotm
100Mbps

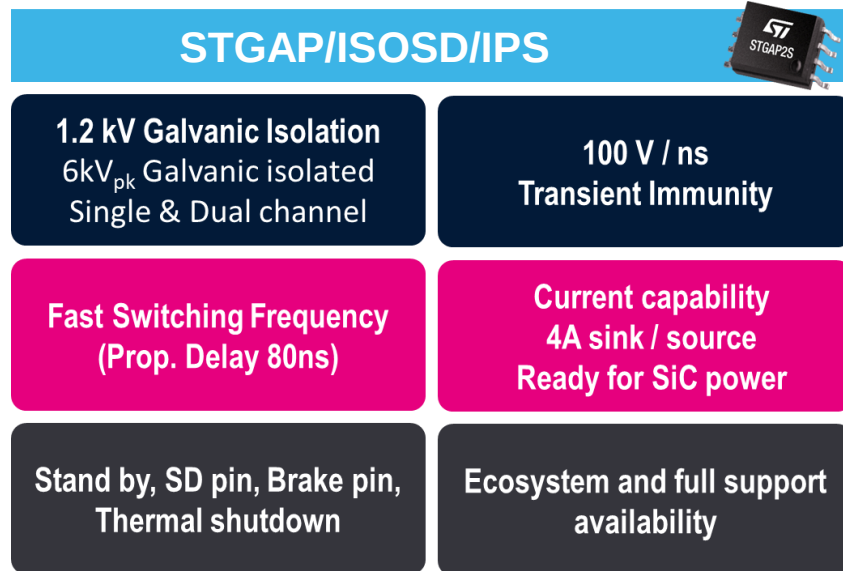
ES Available . Mat Q3 22

Up to 6kV galvanic isolated high speed standard digital isolators for a wide range of applications

Functional safety for industrial automation

IEC 61508

Galvanically isolated drivers and interfaces, sigma-delta converters, intelligent power switches

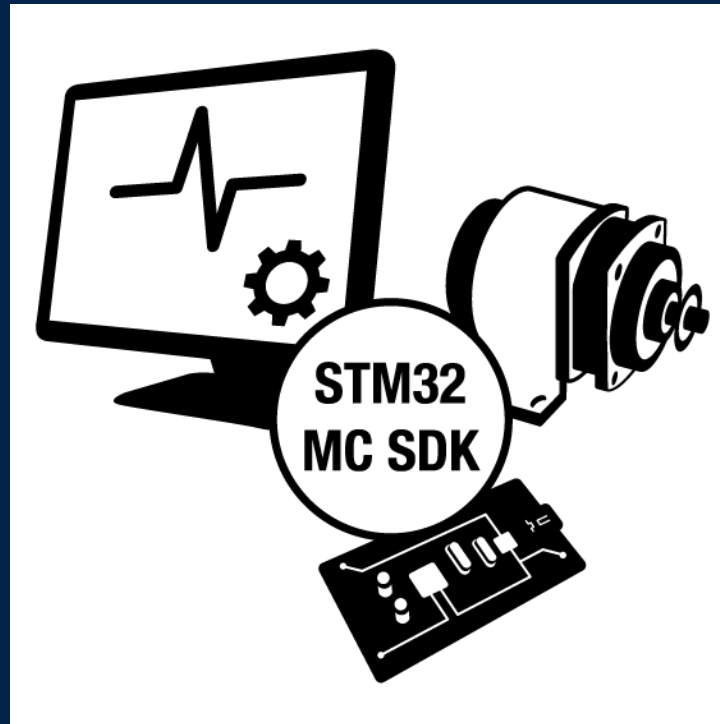


SIL ready enabled by native hardware features and safety libraries



- IEC 60747-5
(Optoelectronic devices, ratings, and characteristics)
- UL 1577
(Optical isolators)
- IEC 60747-17 (VDE 0884-10)
(Magnetic and capacitive couplers for isolation)

The breakthrough and updates of X-CUBE-MCSDK



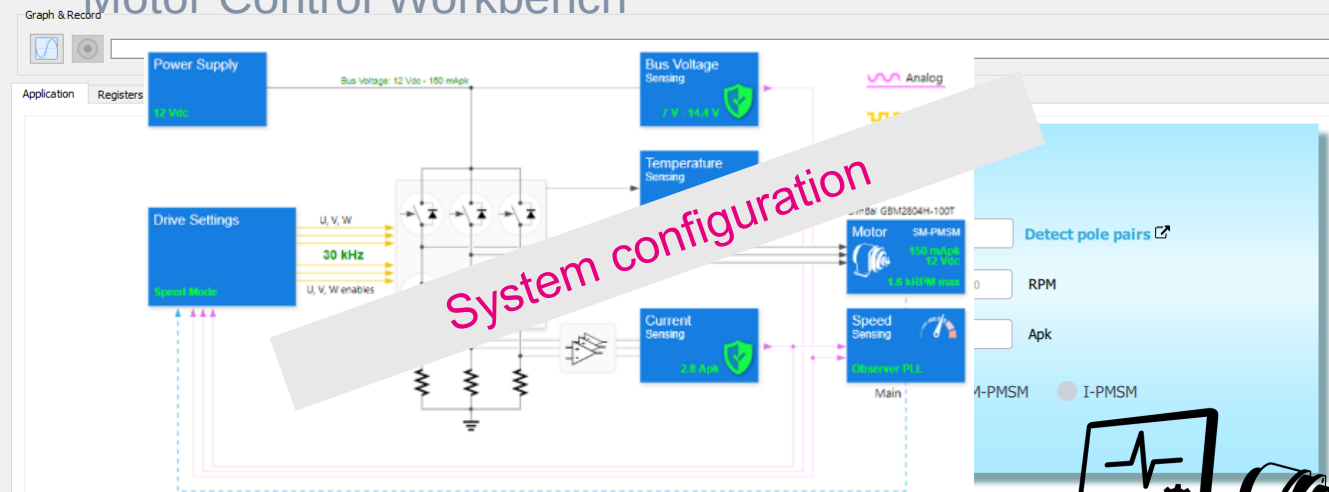
X-CUBE-MCSDK embedded SW and SW tools

Motor Pilot...

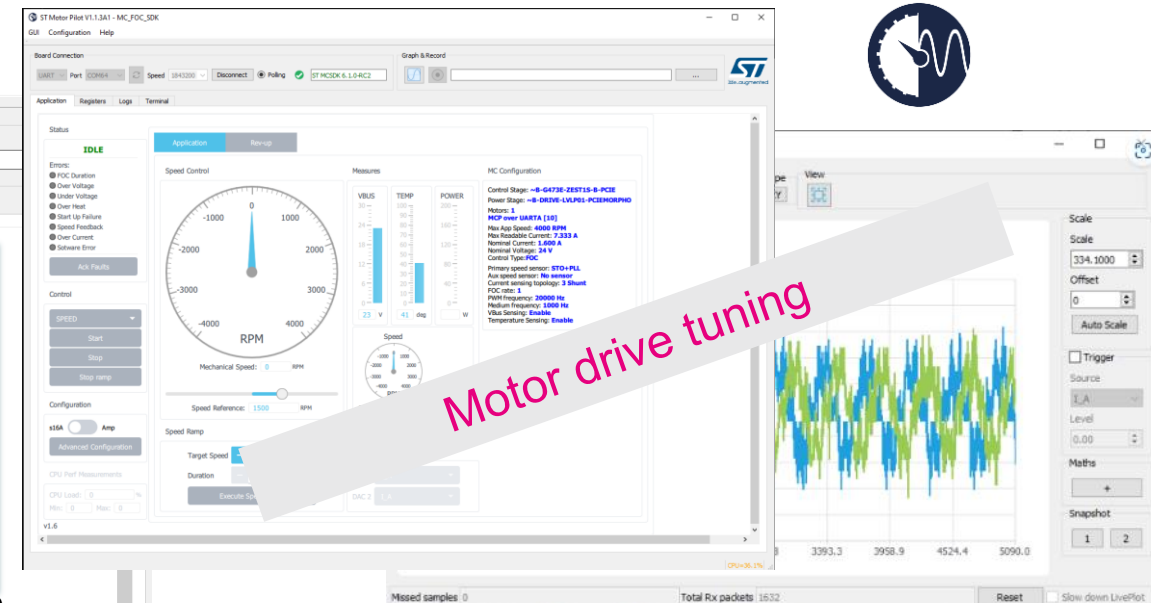
ST Motor Pilot V1.1.3A1 - profiler

GUI Configuration Help

Motor Control Workbench



System configuration

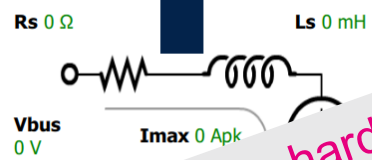


Motor drive tuning

Connect
Start profile
Start Hall pr...
Save

Electrical model

Mechanical model



Custom hardware board description

Hardware board features and parameters

JSON file



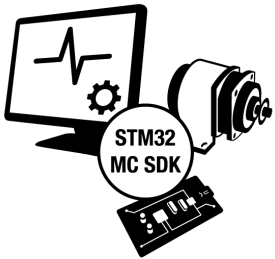
life.augmented

Embedded SW

```
#include "MC.h"
{
    CMCI oMCI = GetMCI(M1);
    MCI_ExecSpeedRamp(oMCI, final
speed, ramp duration);
    MCI_StartMotor(oMCI);
}
```

... including Motor Profiler

Motor characterization



X-CUBE-MCSDK new delivery: top additions

Available in www.st.com
X-CUBE-MCSDK v6.2

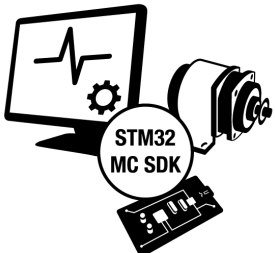
Improved sensor-less algorithm

STM32 large support

Dual motor capability

Support for customer boards

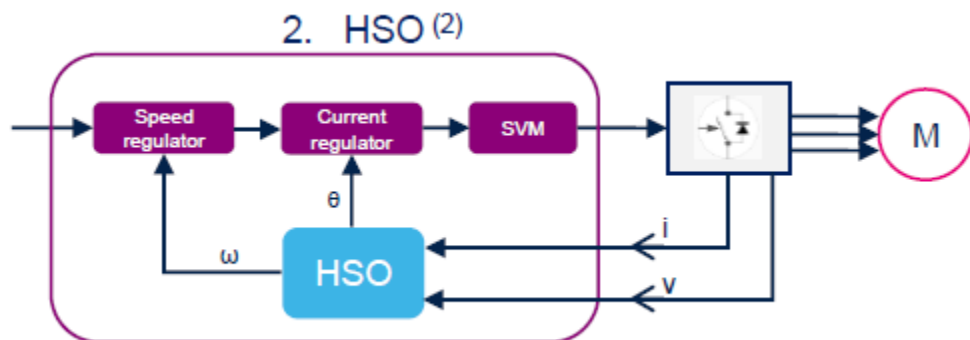
Monitoring and debugging capabilities



NEW

HSO high sensitivity observer

Improved sensor-less algorithm



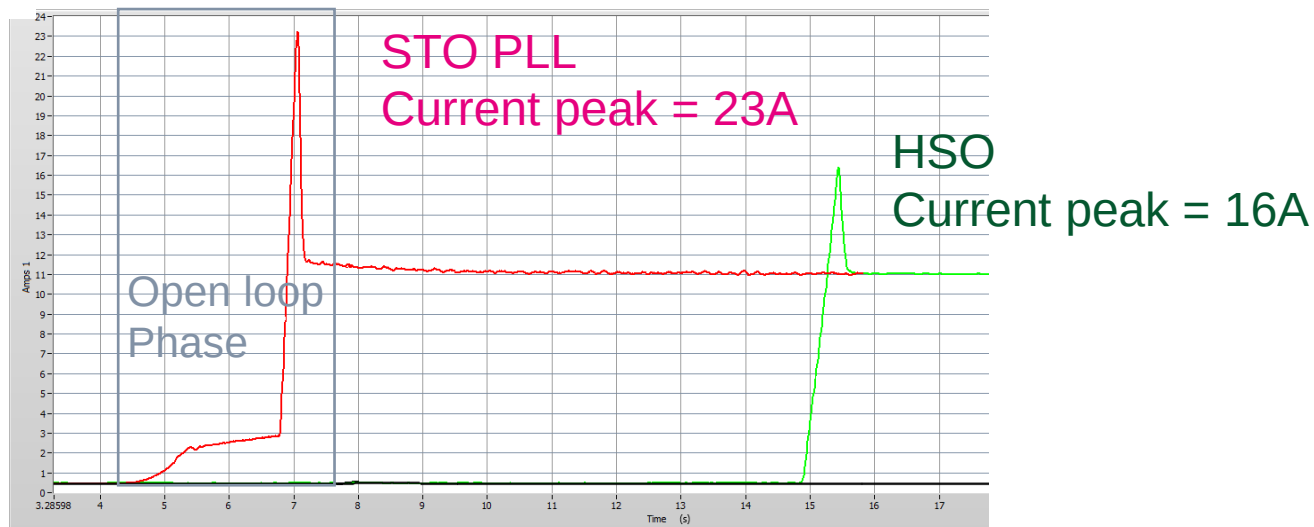
Hardware requirement:

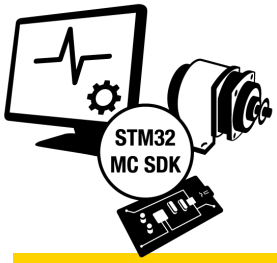
Voltage input + 2 ADC min
Necessary for HSO algorithm

Working configuration:

- 3 shunts
- STM32G4

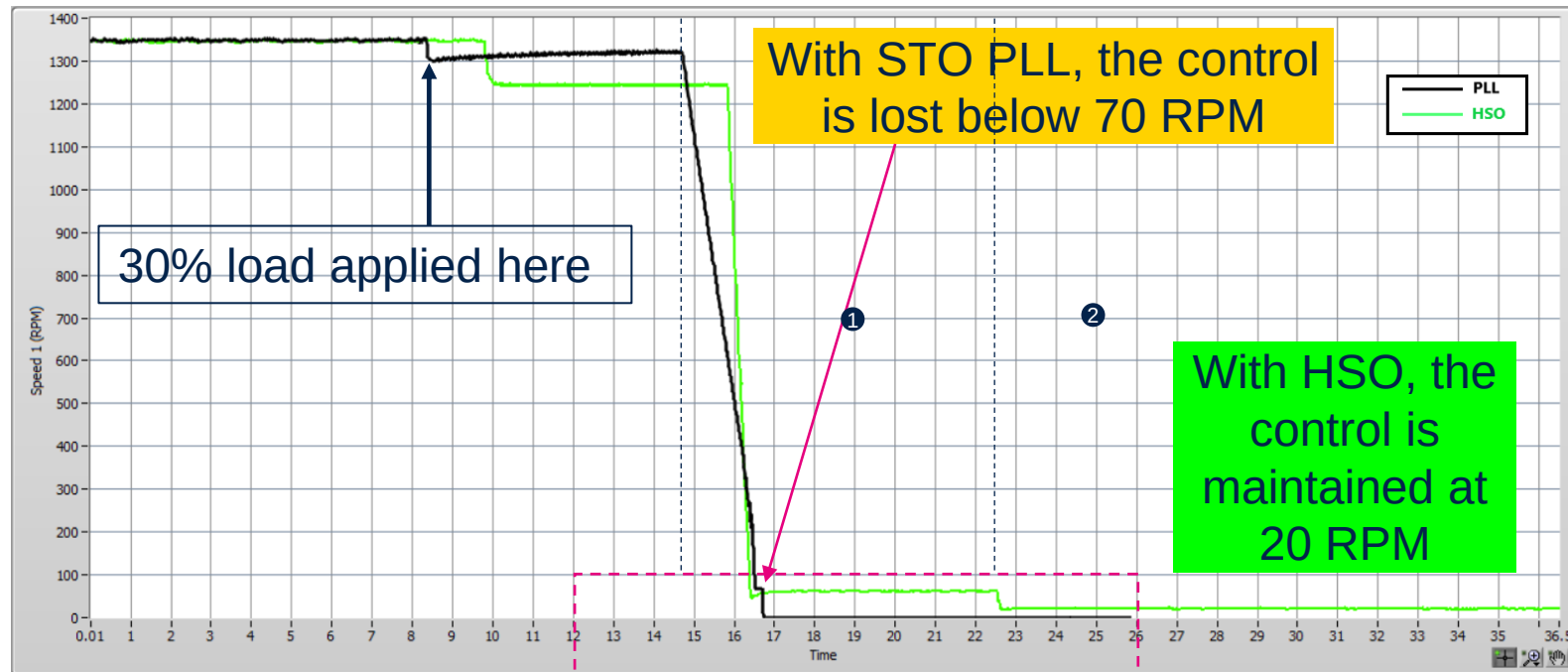
Current consumption during startup procedure
Between STO PLL and HSO





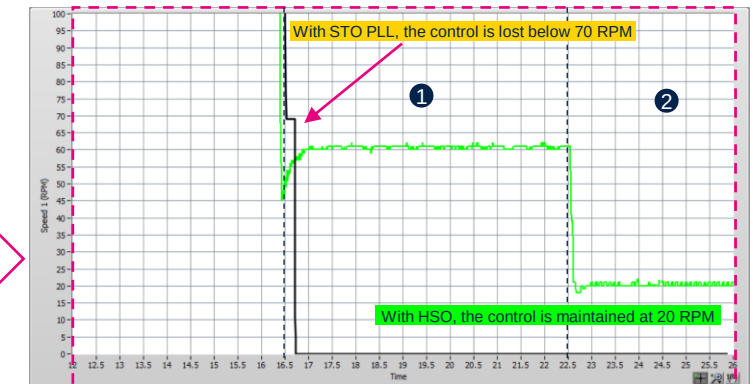
HSO: increasing low-speed performance

Improved sensor-less algorithm

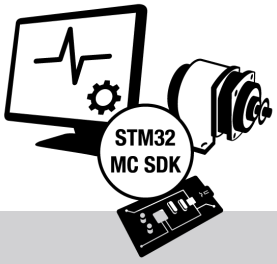


Speed curves comparison STO PLL vs HSO control at 30% load

- ① 1st speed command set to 60 rpm:
STO PLL lost at this step
- ② 2nd speed command set to 20 rpm:
HSO still running until this step



ZOOM



STM32 support

STM32 large support

STM32F0

STSPIN32F0

STM32F4

STM32L4

STM32F3

STM32F7

STM32G0

STM32G4

STSPIN32G4

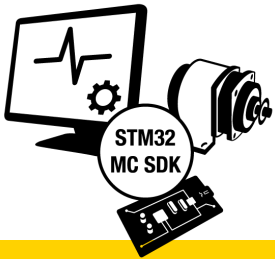
STM32H7

NEW

STM32C0

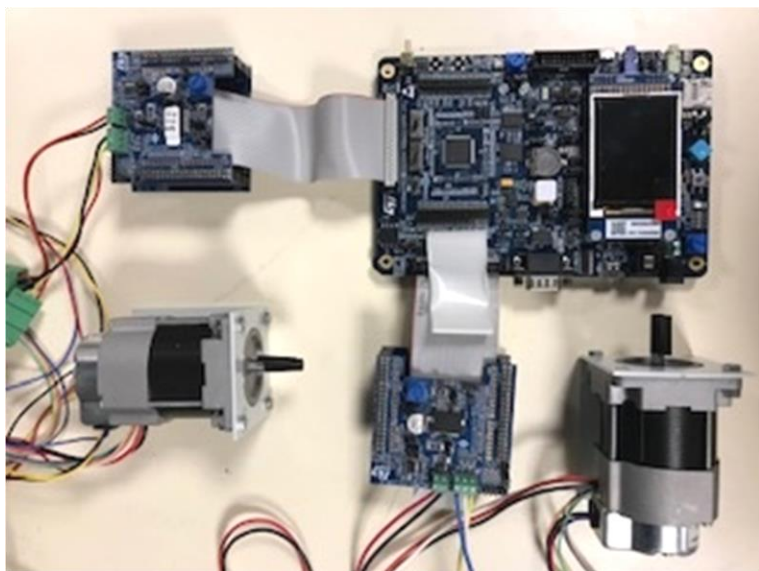
NEW

STM32H5



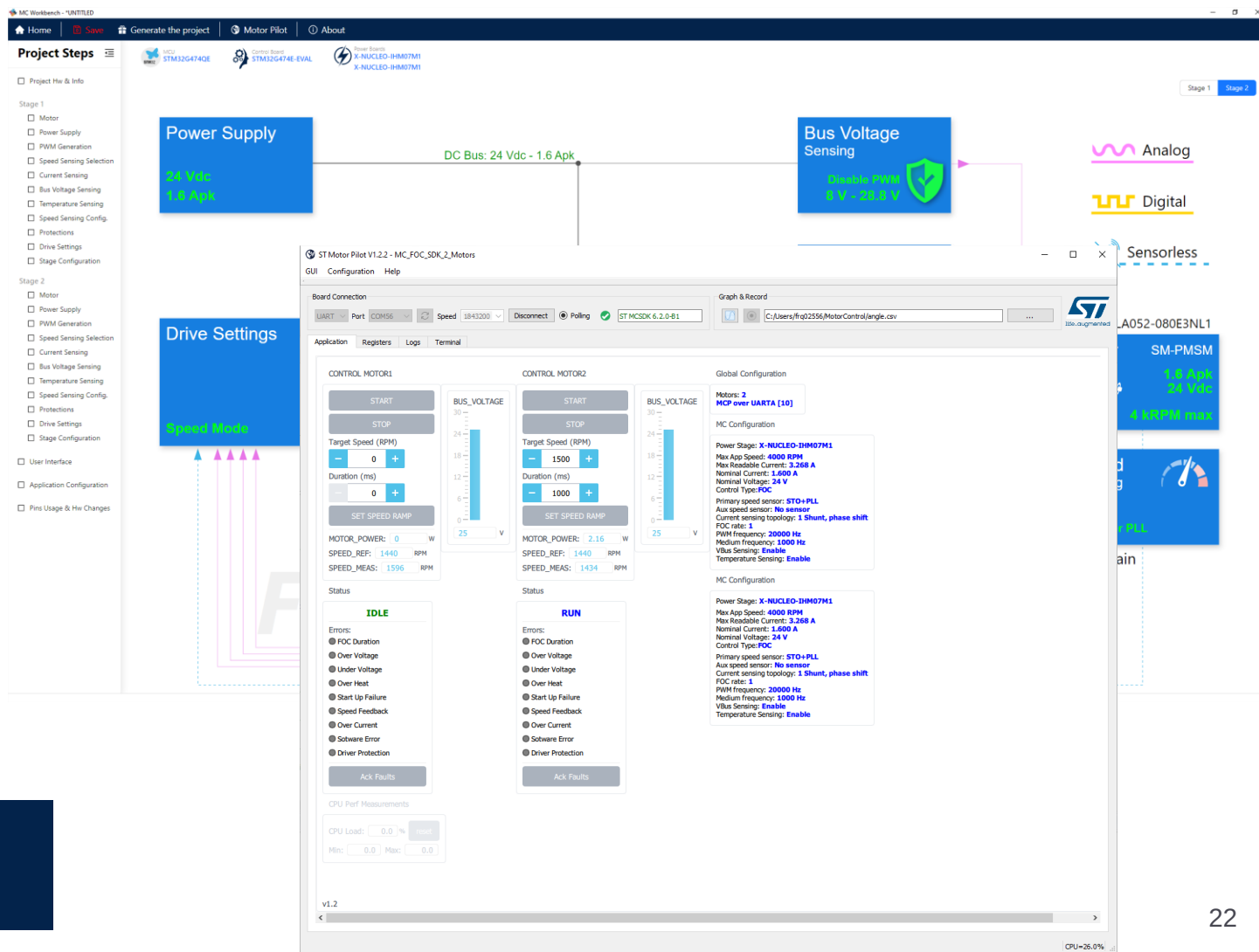
Dual motor capability

NEW



Support for STM32F3,
STM32F4, and STM32G4

Dual motor application is back



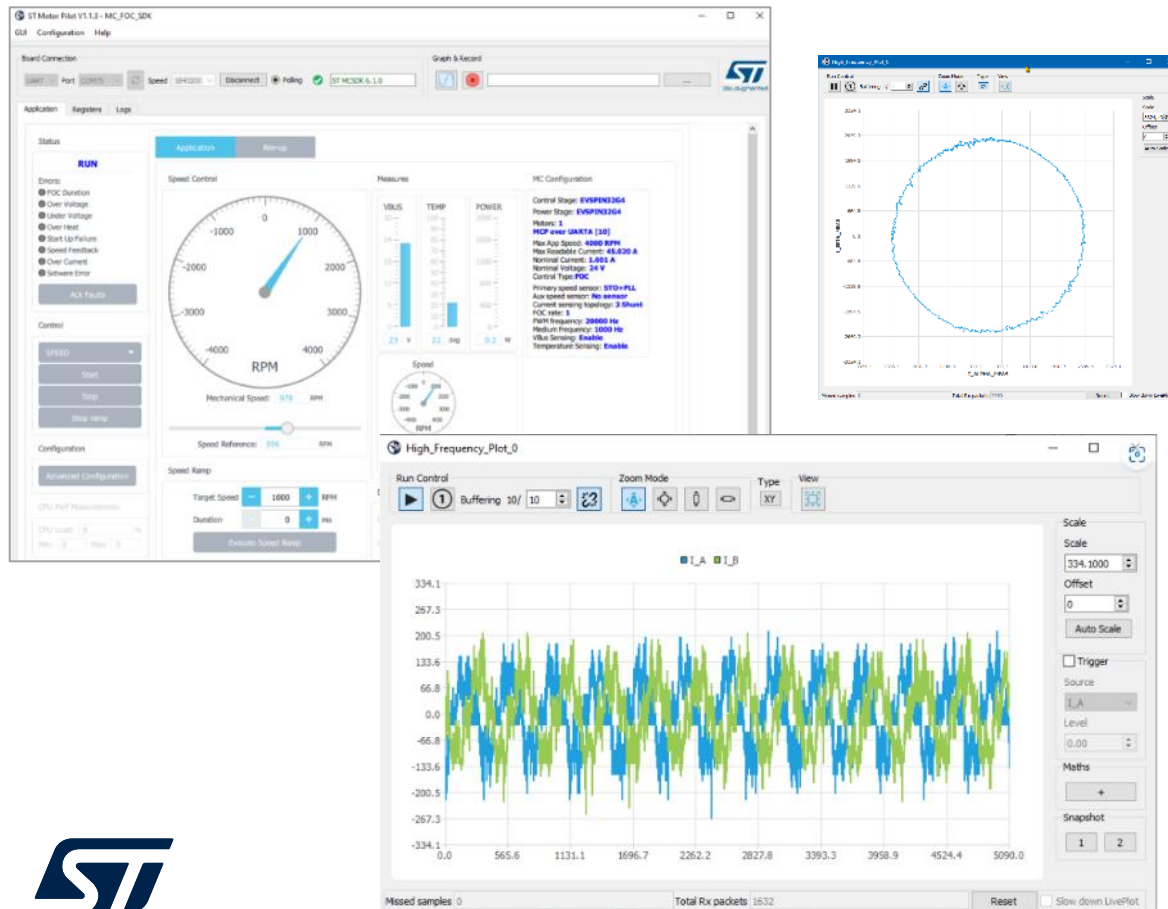
The screenshot displays the ST Motor Pilot V1.2.2 - MC_FOC_SDK_2_Motors GUI. The interface is divided into several sections:

- Project Steps:** A sidebar on the left lists project steps including Motor, Power Supply, PWM Generation, Speed Sensing Selection, Current Sensing, Bus Voltage Sensing, Temperature Sensing, Speed Sensing Config, Protections, Drive Settings, and Stage Configuration.
- Power Supply:** A blue box indicating "24 Vdc 1.5 Apk".
- Bus Voltage Sensing:** A blue box indicating "Disable PWM 8 V - 28.8 V".
- Drive Settings:** A blue box indicating "Speed Mode".
- CONTROL MOTOR1 and CONTROL MOTOR2:** Two identical control panels for each motor. Each panel includes a "START" button, a "STOP" button, a "SET SPEED RAMP" button, and a "BUS_VOLTAGE" graph. The "MOTOR_POWER" is set to 0 W. The "SPEED_REF" is 1440 RPM, and the "SPEED_MEAS" is 1596 RPM. The status for both motors is "IDLE".
- Global Configuration:** A section on the right showing "Motors: 2 MCP over UARTA [10]". It includes "MC Configuration" and "MC Configuration" sections with various parameters like Max App Speed, Max Readable Current, Nominal Current, Nominal Voltage, Control Type, Primary speed sensor, Aux speed sensor, FOC rate, PWM frequency, Medium frequency, VBus Sensing, and Temperature Sensing.
- ST Logo:** The ST logo is visible in the bottom right corner.



Monitoring and debugging: Motor Pilot

Control, monitor, tune, and debug your real time applications



Real-time monitoring: each sample can be plotted and recorded

GUI customization: any developers can easily customize motor Pilot GUI to fit application needs

Motor Profiler included and profiling possible with custom boards



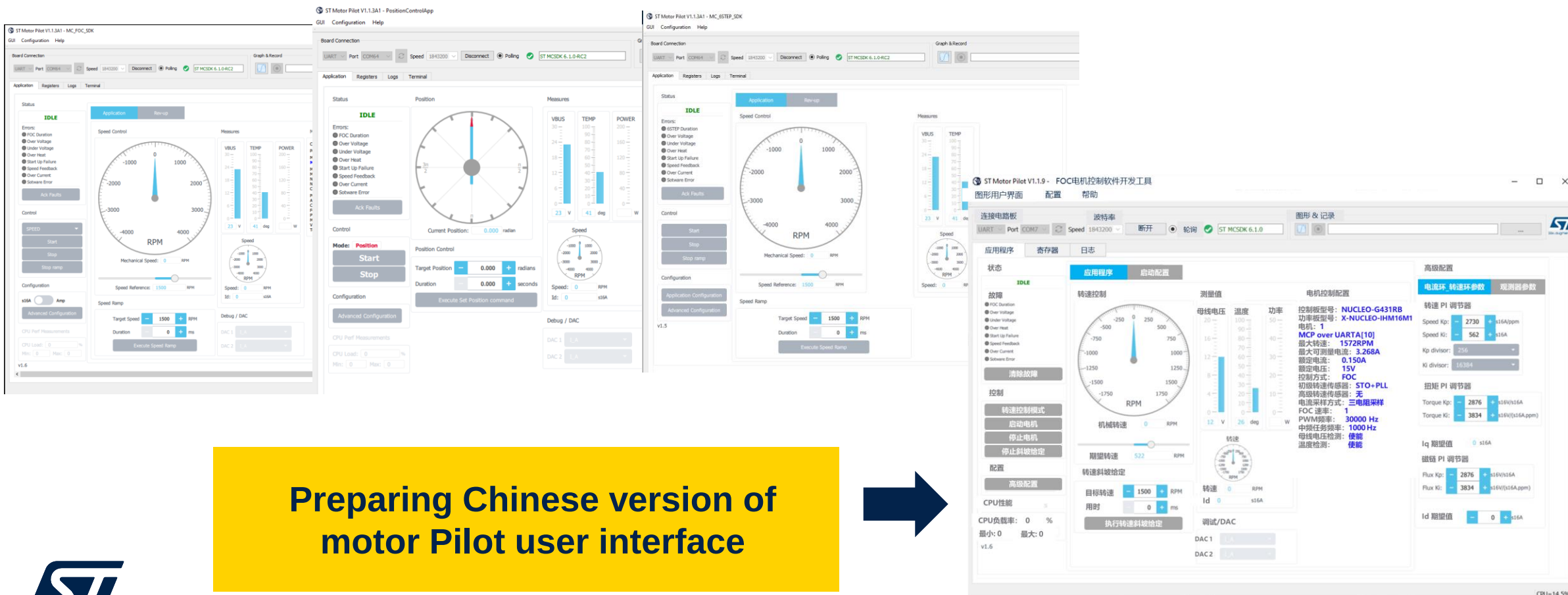
Motor pilot customizable UI

Monitoring and debugging capabilities

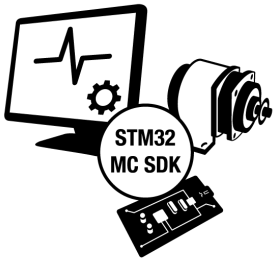
MCSDK FOC

MCSDK position control

MCSDK 6-Step



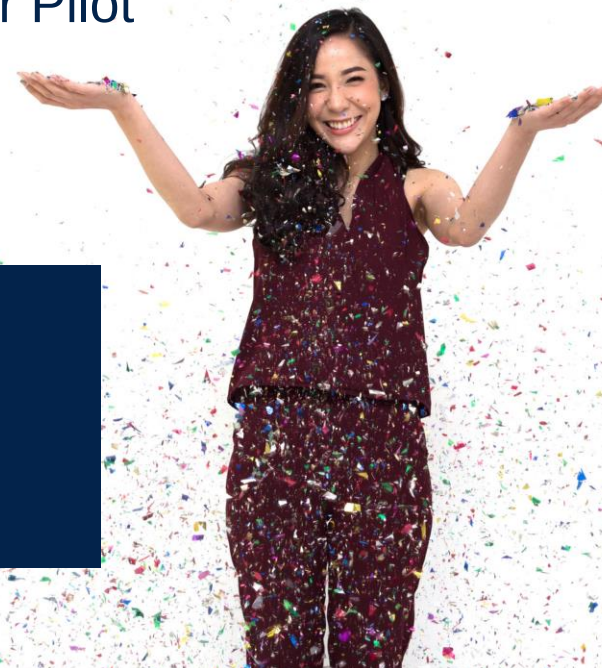
Preparing Chinese version of motor Pilot user interface



STM32 X-CUBE-MCSDK designed for you!

- Why to use STMicroelectronics X-CUBE-MCSDK?
 - New FOC sensor-less algorithm: high sensitivity observer
 - Possibility to tune code for YOUR hardware design
 - Great SW tools = MC Workbench + Motor Pilot

Visit the STM32 motor control dedicated web page:
www.st.com/content/st_com/en/stm32-motor-control-ecosystem.html



IPs

```
if(typed  
return  
} else {  
let tan = this.tangent(u, v);  
let bitan = this.bitangent(u, v);  
if(MathInternal.vecLength(bitan) === 0) {  
return tan;  
}  
if(MathInternal.vecLength(tan) !== 0) {  
if(tan.length !== 3 || bitan.length !== 3) {  
let dims = tan.length;  
let ret = MathInternal.vecZero(dims);  
tan = [tan[0] || 0, tan[1] || 0, tan[2] || 0];  
bitan = [bitan[0] || 0, bitan[1] || 0, bitan[2] || 0];  
const u = [0];  
ret[0] = u[0];  
ret[1] = u[1];  
ret[2] = u[2];  
ret[3] = slice(0, bitan[0], bitan[1], bitan[2]);  
return ret;  
}
```

ST US multimotor drive patents current sensing network optimizations

(12) United States Patent Costanzo et al.

(10) Patent No.: US 11,105,836 B2

(45) Date of Patent: Aug. 31, 2021

(54) INVERTER AND METHOD FOR
MEASURING PHASE CURRENTS IN AN
ELECTRIC MACHINE

(71) Applicants: STMicroelectronics S.r.l., Agrate
Brianza (IT); STMicroelectronics
(Shenzhen) R&D Co. Ltd, Shenzhen
(CN)

(72) Inventors: Dino Costanzo, Catania (IT); Cheng
Pan Cai, Shenzhen (CN); Xi Yu Xu,
Shenzhen (CN)

(52) U.S. Cl.

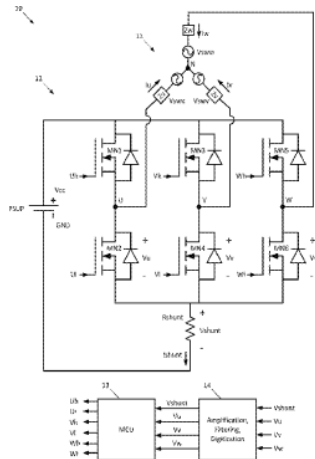
CPC G01R 19/25 (2013.01); G01R 15/146
(2013.01); H02M 1/00 (2013.01); H02M
7/53871 (2013.01); H02P 27/08 (2013.01);
H02M 2001/0009 (2013.01)

(58) Field of Classification Search

None
See application file for complete search history.

(56) References Cited

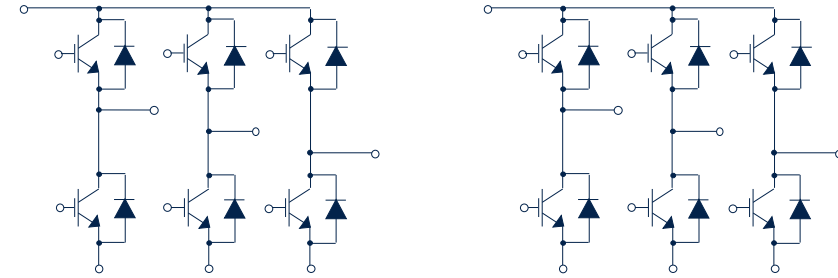
U.S. PATENT DOCUMENTS



New single shunt current sensing:
breaks all barriers of state-of-art

Achieves:

- no PWM distortion!
- Simultaneous sampling of two phase currents!



Shared current sensing network

New (patent pending)
Multimotor shared current sensing with shunt
resistors/ICS

Achieves:

- Savings on current sensors & network
- Savings on PCB space
- Savings on MCU pinout assignment

ST US multimotor drive patents

STM32G4 accelerators

(12) United States Patent Forte et al.

(10) Patent No.: **US 8,994,565 B2**
(45) Date of Patent: **Mar. 31, 2015**

(54) ANALOG TO DIGITAL CONVERSION APPARATUS WITH A REDUCED NUMBER OF ADCS

USPC 341/130-160; 345/96, 173, 589;
375/294, 355, 373, 327; 327/147, 148,
327/157, 45
See application file for complete search history.

(71) Applicant: **STMicroelectronics, Srl.**, Agrate
Brianza (MB) (IT)

(72) Inventors: **Gianluigi Forte**, Camporotondo Etneo
(IT); **Dino Costanzo**, Catania (IT);
StelloMatteo Bille', Catania (IT)

(56) **References Cited**
U.S. PATENT DOCUMENTS

(12) United States Patent Forte et al.

(10) Patent No.: **US 8,564,468 B2**
(45) Date of Patent: **Oct. 22, 2013**

(54) SEQUENCE ARBITER FOR ANALOG-TO-DIGITAL CONVERSIONS

(56) **References Cited**
U.S. PATENT DOCUMENTS

(75) Inventors: **Gianluigi Forte**, Camporotondo Etneo
(IT); **StelloMatteo Bille'**, Catania (IT);
Dino Costanzo, Catania (IT)

5,168,276 A 12/1992 Huston et al.
6,433,716 B2 * 8/2002 Arai et al. 341/141
6,486,809 B1 11/2002 Figoli

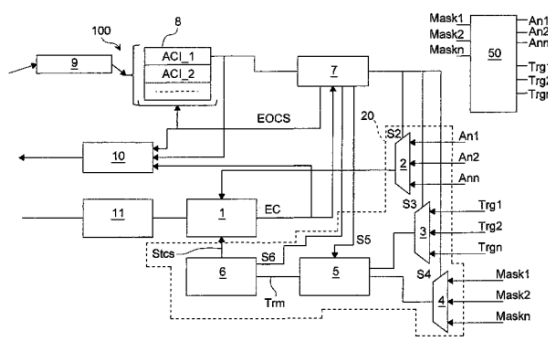
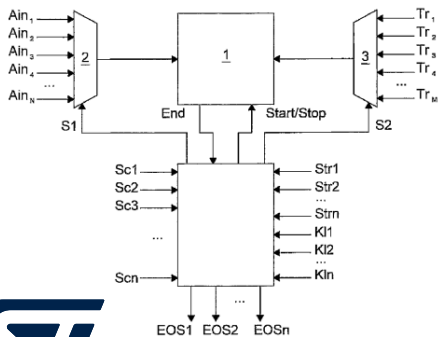
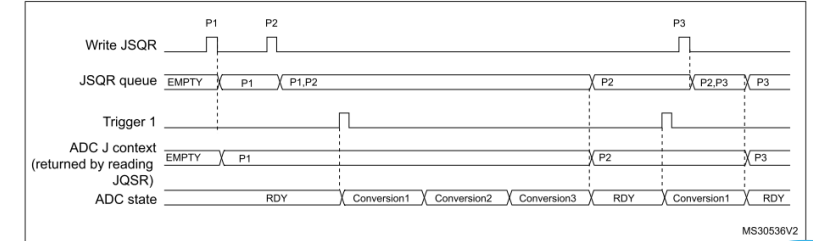
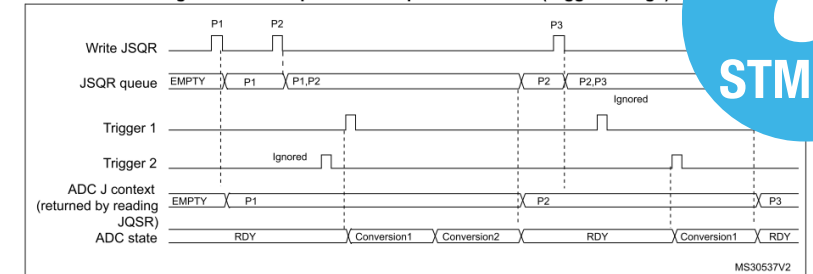


Figure 99. Example of JSQR queue of context (sequence change)



- Parameters:
P1: sequence of 3 conversions, hardware trigger 1
P2: sequence of 1 conversion, hardware trigger 1
P3: sequence of 4 conversions, hardware trigger 1

Figure 100. Example of JSQR queue of context (trigger change)



ADCS apparatus & sequence arbiter for multi-motor sampling sync

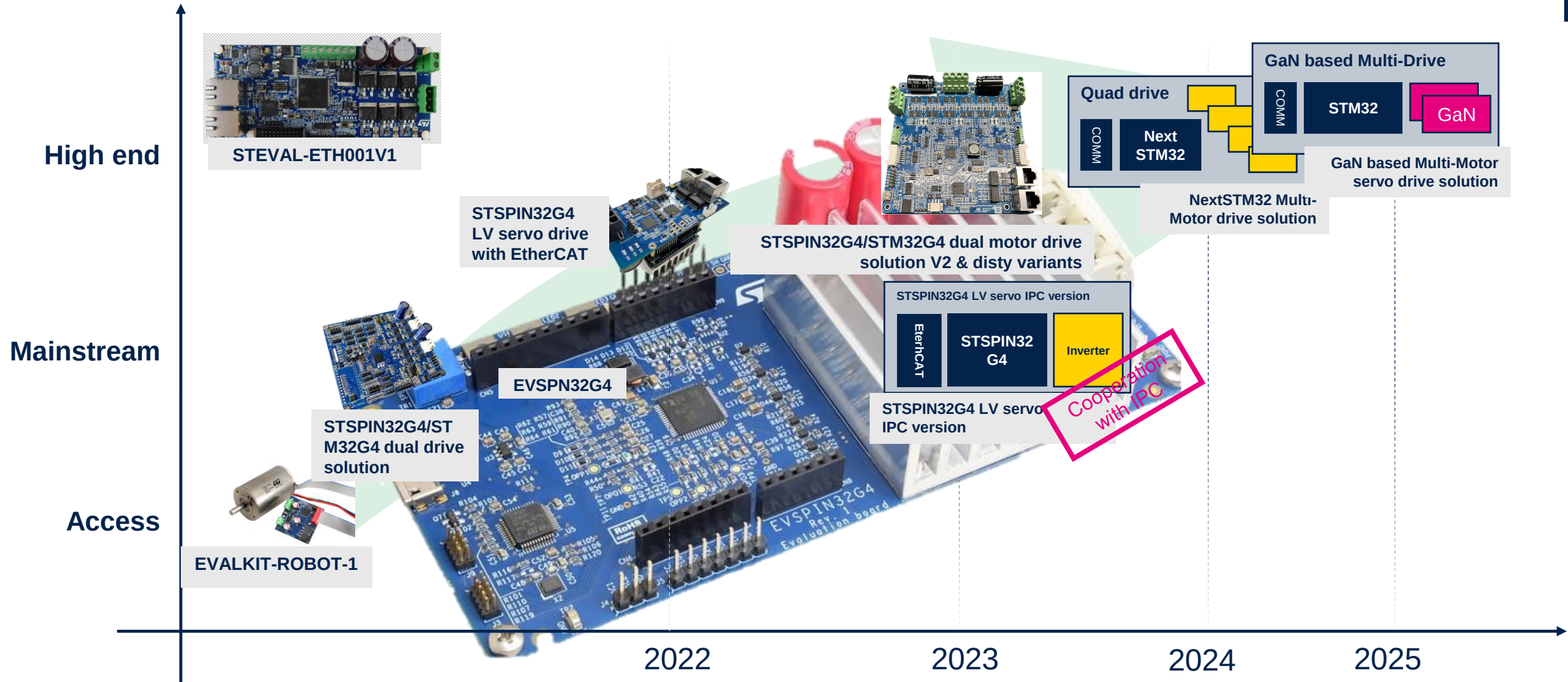
Achieves:

- No dead-band (max MI)
- No IRQ & CPU load for peripherals reconfig
- Robust, hardware based, peripherals transitions

LV servo solutions



ST LV servo drive solution roadmap



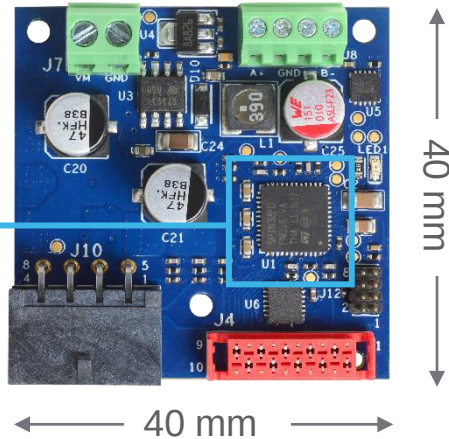


EVALKIT-ROBOT-1 compact brushless servo control kit

Position control loop based on FOC

STSPIN32F0A

45 V fully integrated
3-phase BLDC driver
(600 mA gate
current)
embedding
Cortex®-M0 MCU



STL7DN6LF3

60 V, 35mΩ
Dual N-channel
MOSFETs
in PowerFLAT 5x6
dual Island

- 36 V and 6 A_{PEAK} power stage
- Encoder + Hall sensors supported
- MODBUS com. protocol via RS-485



Maxon EC-i40

100 W 3-phase BLDC with 1024-pulse
incremental encoder

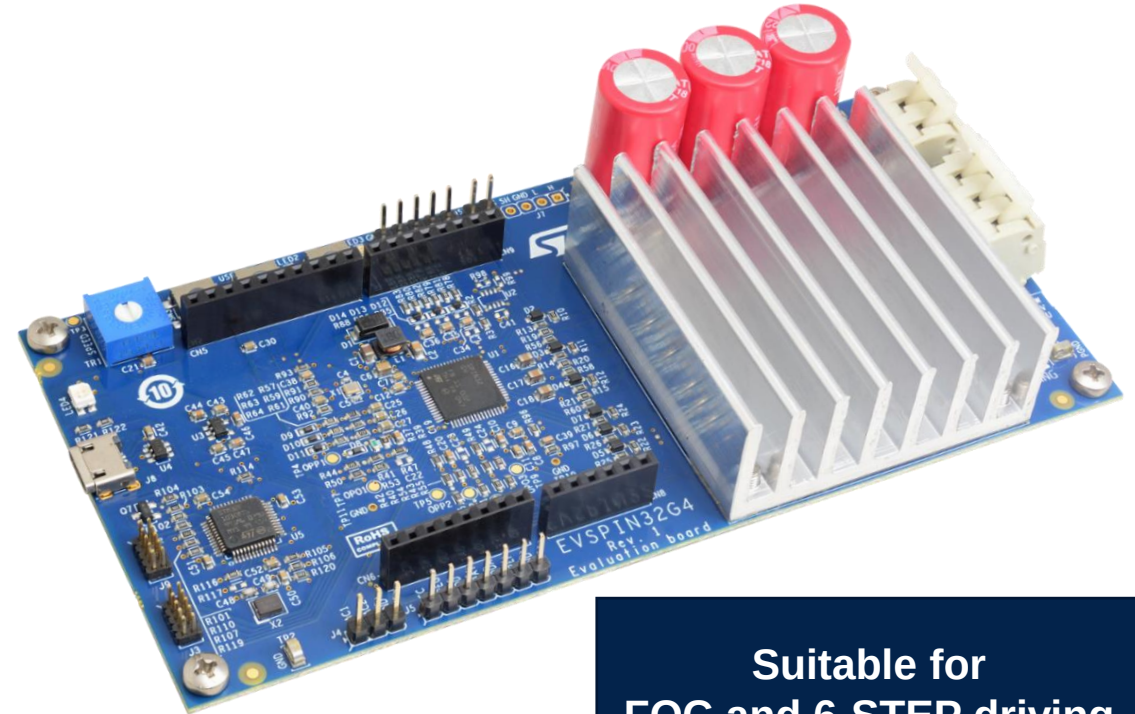
EVSPIN32G4/NH general purpose evaluation board

Key features

- Up to **75 V** and output current up to **20 A_{rms}**
- Three shunt topology
- Embedded OPAMPs used for current sensing
- BEMF sensing circuitry for sensorless driving
- Digital Hall sensors input management
- PCB temperature monitoring (NTC)
- Bus voltage monitoring
- CAN bus mounting option
- Embedded STLINK V2-1
- **Fully integrated in X-CUBE-MCSDK 6.x**

Documentation:

- Data brief: DB4420
- User manual: UM2850

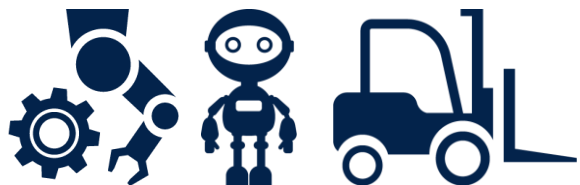


**Suitable for
FOC and 6-STEP driving**

Tested in high-speed applications with FOC 1 shunt up to 130 Krpm

EVSPIN32G4 eval board with heatsink

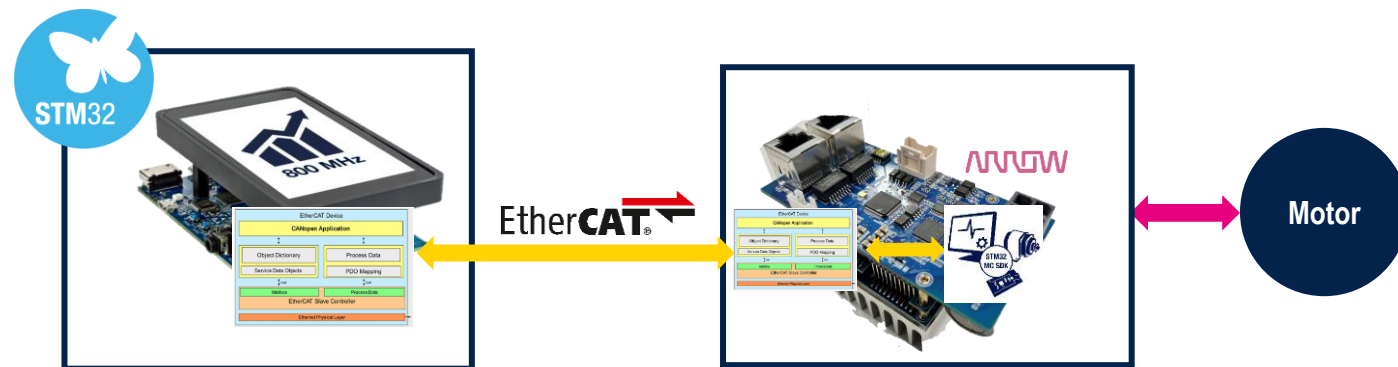
EVSPIN32G4NH eval board without heatsink



STSPIN32G4 LV servo drive solution

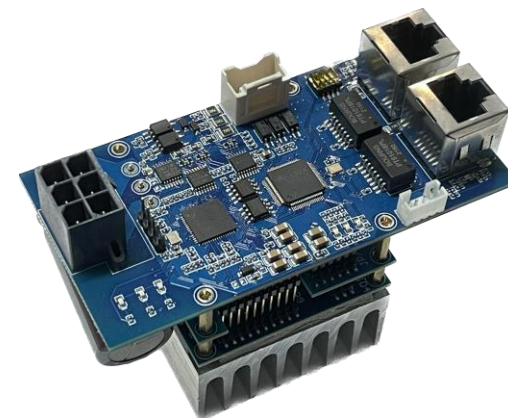
Solution dedicated for AGV, robotic

- Specs:
 - 50x100x50mm dimension
 - 1000 W output power without cooling fan
 - 20~60 VDC supply, 20 Arms, 50 A peak
- Features:
 - EtherCAT onboard
 - Capable of embedded to motor shell
 - Isolated pulse input
 - Isolated digital input x2
 - Isolated digital output x2

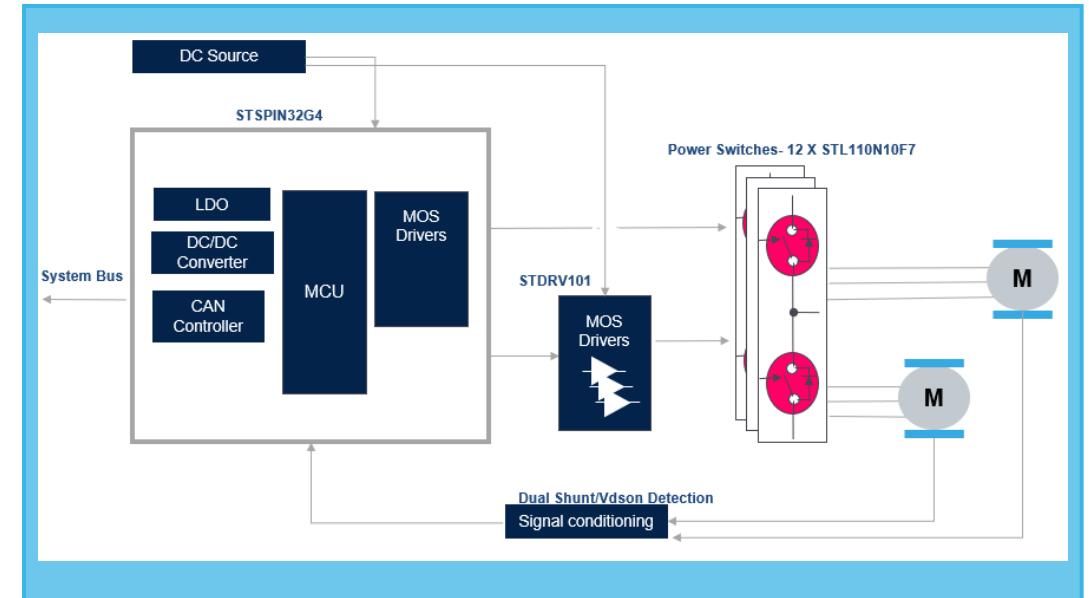
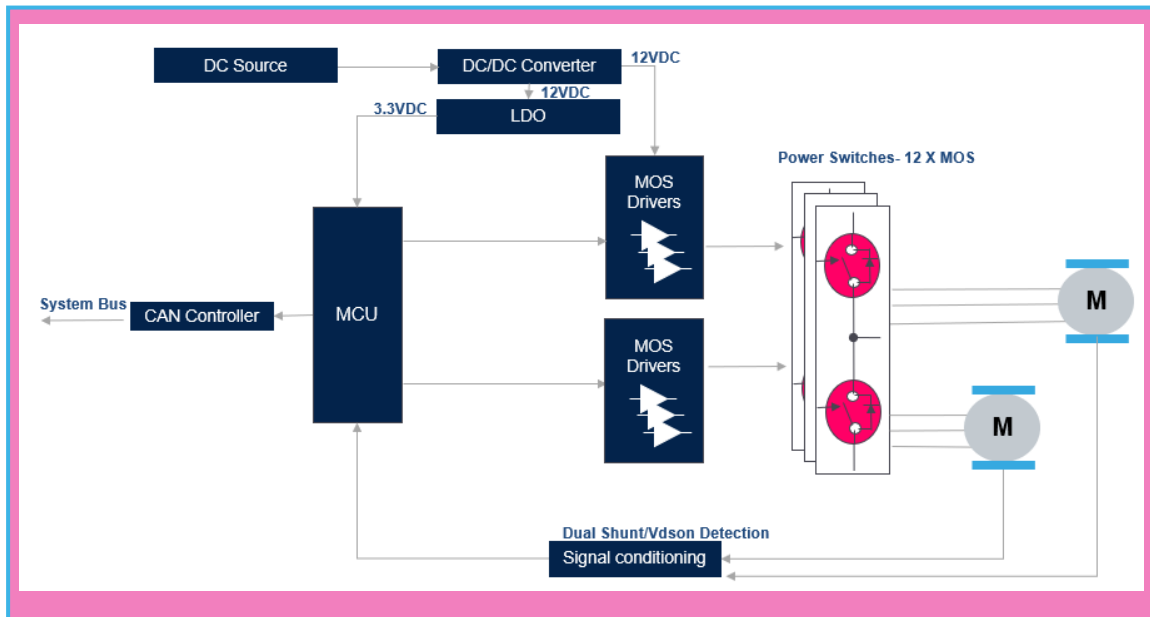


Key products:

- STSPIN32G4
- STL90N10F7 * 12
- ST26C32 * 2
- VIPER319HDTR
- LDK320ADU33R
- LDK320ADU50R



STSPIN32G4 dual motor control topology

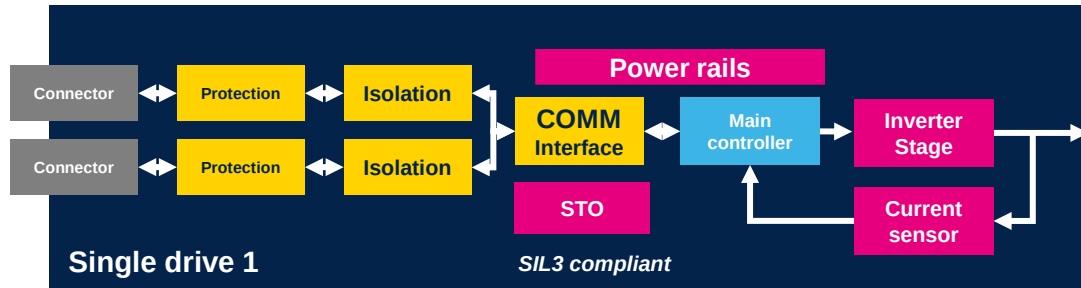


Key features

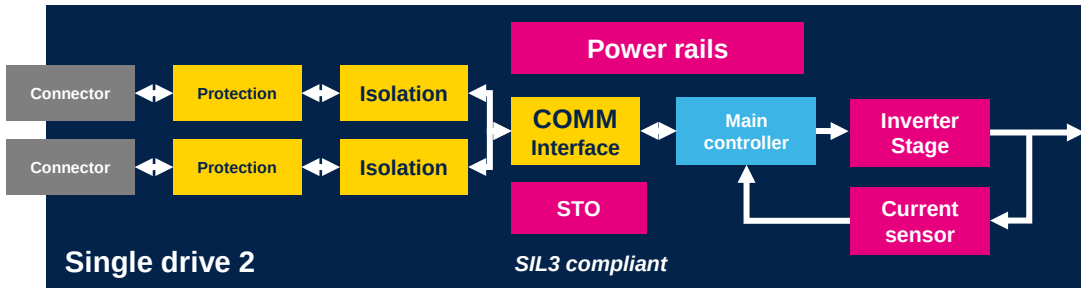
- Embedded DC-DC converter for driver supply and others
- Embedded LDO for MCU supply and others
- Embedded CAN controller for system bus communication
- Small PCB size and simple routing

Very compact
Easy design

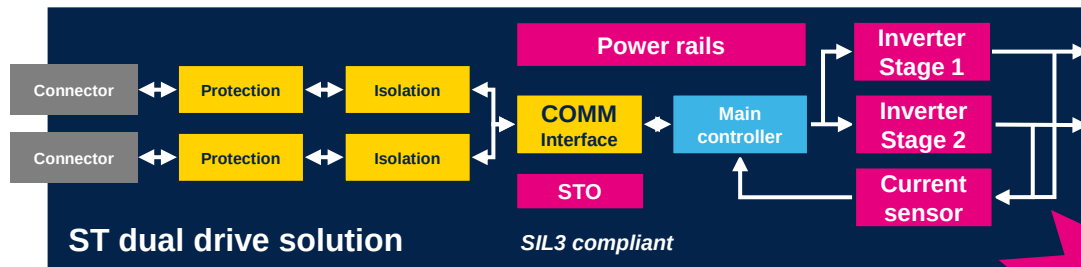
STSPIN32G4 dual drive solution V2



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Example: SIL 3 architecture/1.5 kW/310 VDC 220V

Component	Price (Average Price for 10KU)	Standard architecture servo motor drive x 2 (pcs/total price)	New ST solution dual servo drive (pcs/total price)
RJ-45	\$3	4/\$12	2/\$6
Protection device	\$1	4/\$4	2/\$2
Isolation	\$1	4/\$4	2/\$2
EtherCAT target controller	\$7	2/\$14	1/\$7
MCU	\$10	4/\$ 40	2/\$ 20
IPM + gate drivers	\$10	2/\$20	2/\$20
Power rails	\$6	4/\$24	2/\$12
Shunts/ICS	\$1	6/\$6	3/\$3
Total~		\$124	\$72

~40%
COST
SAVING



Lower cost



Higher
reliability



More
compact



Higher
performance



SDK ready

STSPIN32G4 dual drive solution

ToF sensor board



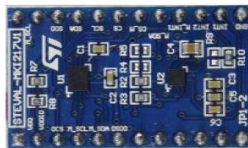
VL53L3CX-SATEL

IMU sensor board

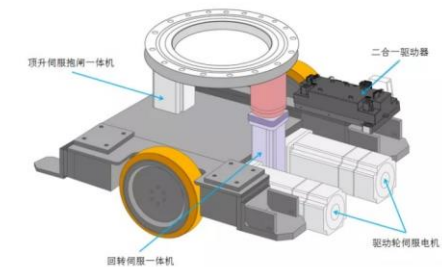
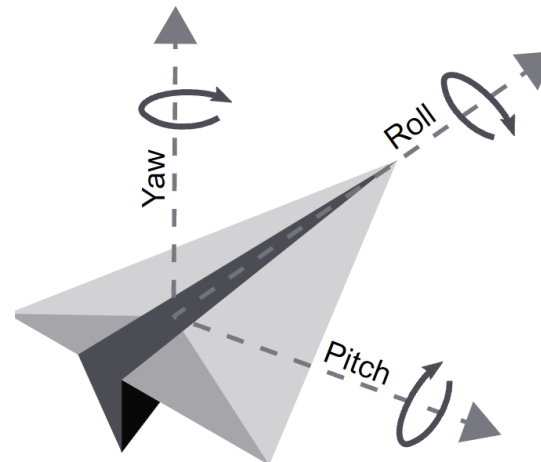
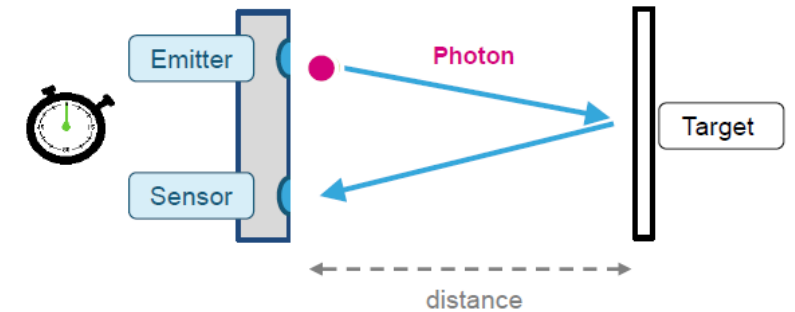
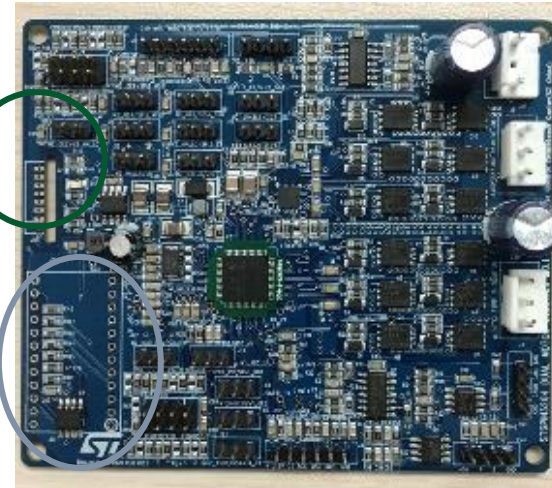


STEVAL-MKI207V1(6 axis)

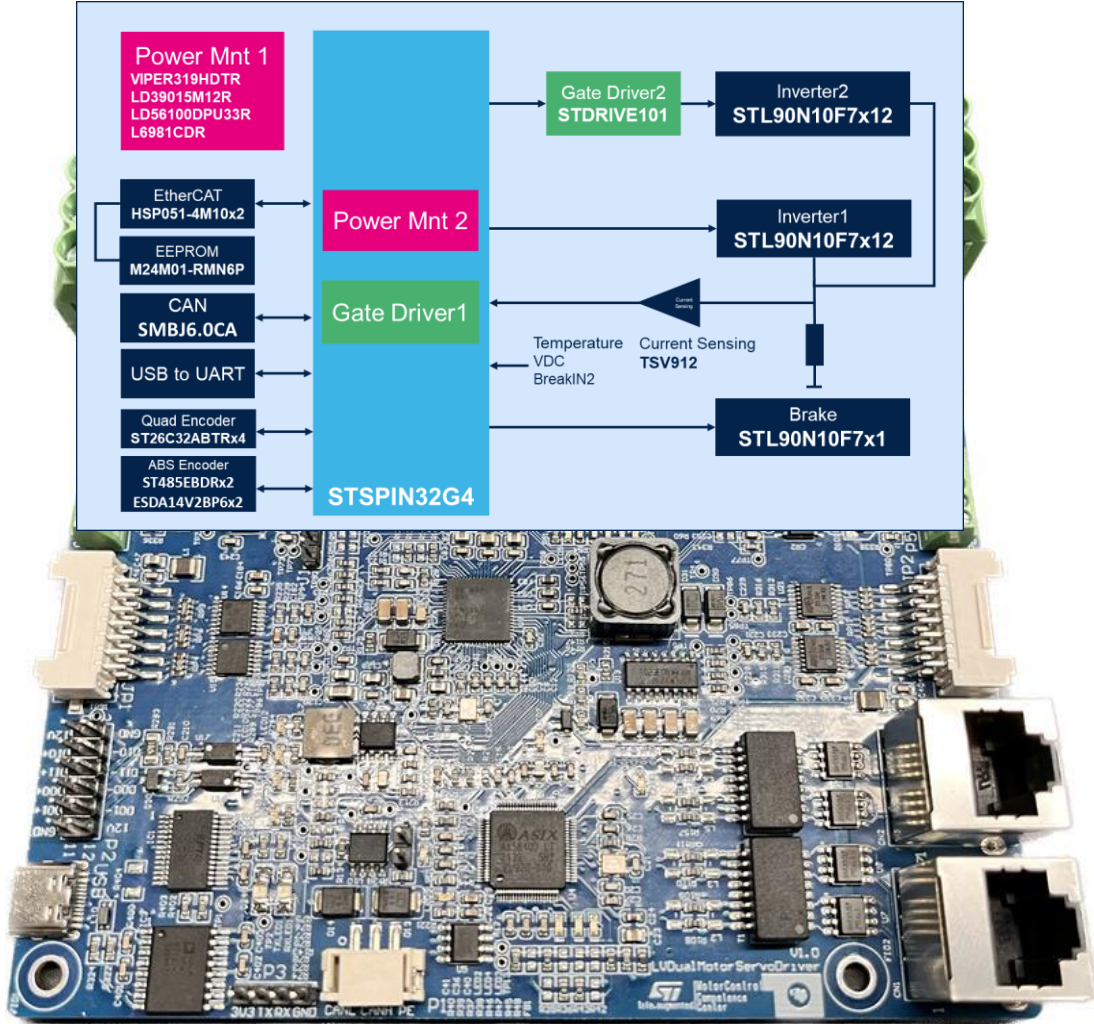
OR



STEVAL-MKI217V1(9 axis)



STSPIN32G4 dual drive solution V2



- Specs:
 - 130x130mm dimension
 - 1000 W output power each
 - 20 ~ 60 VDC supply, 20 Arms rating, 50 A peak
- Features:
 - Shared current sensing network
 - 2 switches in parallel per switch arm
 - EtherCAT or CAN onboard
 - RS232 onboard
 - Multiple selectable configurations:
 - Dual differential ABZ + Hall encoder
 - Dual ABS encoder
 - Isolated digital output x2
 - Isolated digital input x2
- Applications:
 - Robotic, AGV, or other position control applications

STEVAL-ETH001V1

High performance LV servo drive solution

Order code for SPM interface:
STEVAL-ETH001V1

Application board with DPM interface:
AB0035.B.01(*)

Key products

- STM32F767ZI - microcontroller
- STDRIVE101 - three phase gate drivers
- STH270N8F7 - power MOSFETS
- STL6N3LLH6 - power MOSFETS
- L7987L DC/DC - converter
- LD39150DT33 - low drop linear regulator
- L7805CD2T - linear regulator
- IPS160H - digital output
- CLT03-2Q3 - digital Input
- NETX-90 - network Ethernet controller

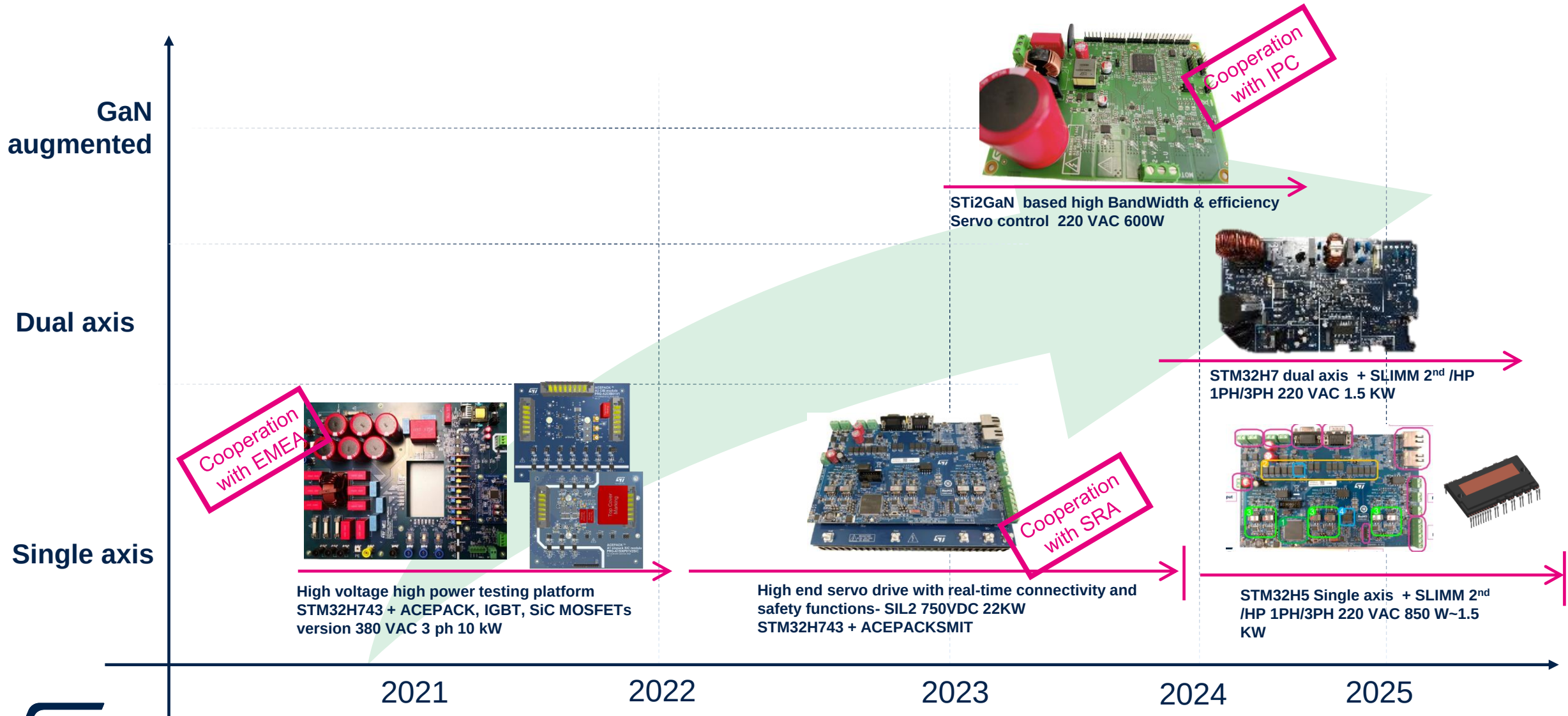


- Supply voltage range 20 V up to 56 V
- **700 W max output power**
- STM32 platform powered by **STM32F767ZI**
- Multiaxial position control algorithm and real-time connectivity based on EtherCAT stack embedded in the application firmware
- Multiprotocol supported using NETX90 network controller (PROFINET, EtherCAT, Ethernet IP, TSN)
- DPM and SPM interface between NETX90 and MCU
- Motor control power stage, powered by **STDRIVE101** and **STH270N8F7** power MOSFET
- Power management circuit powered by **L7987** switching converter

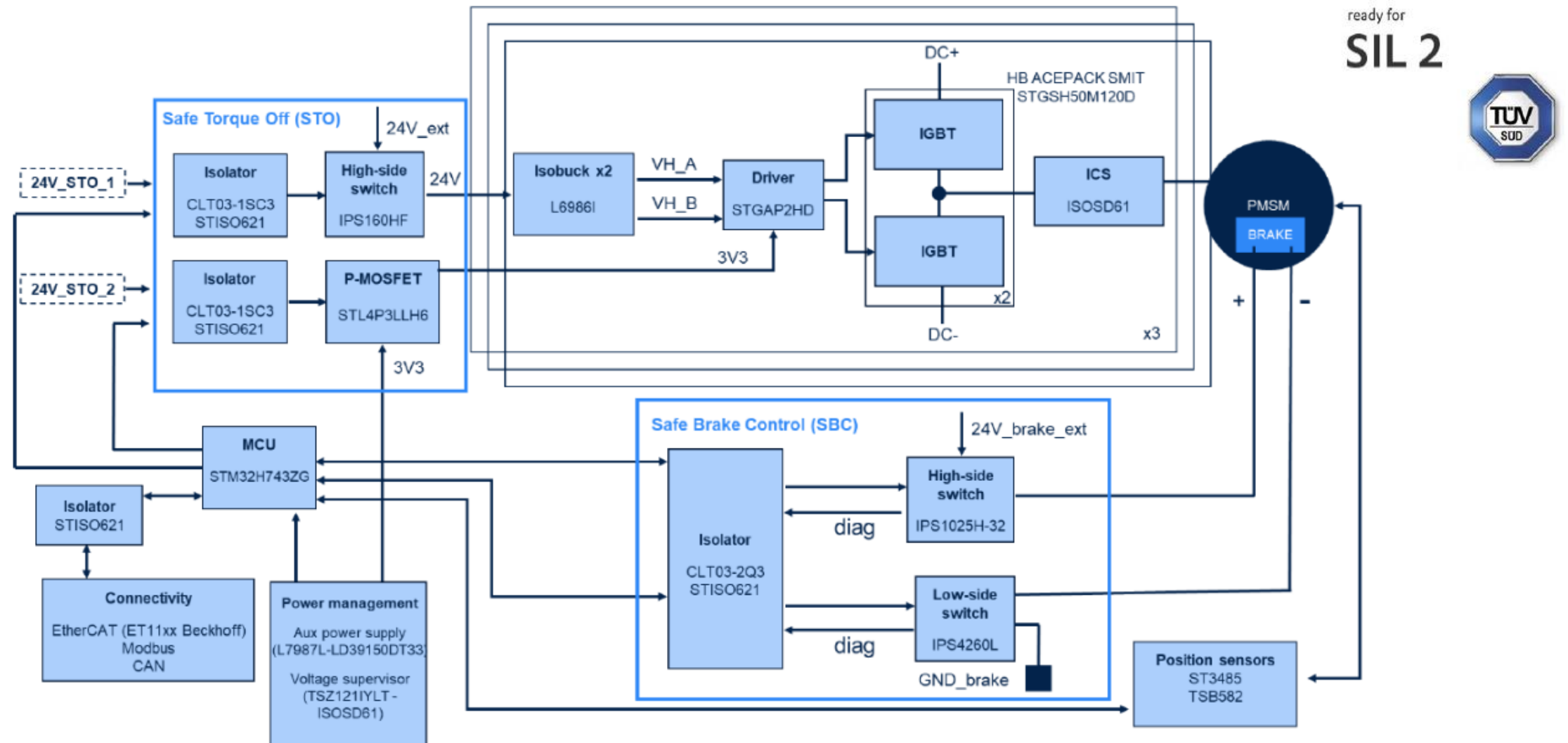
HV servo solutions



ST HV servo drive solution roadmap



High end servo drive block diagram and ST BOM



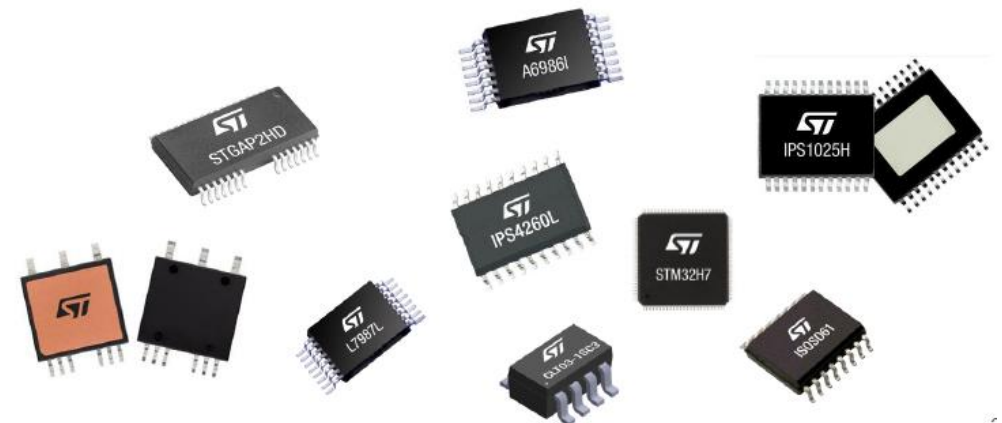
High end servo drive with real-time connectivity and safety functions

- Power stage IGBT based with **ACEPACK™ SMIT** package (1200V, 50 A HB)
- DC input up to 800V
- Planar transformers for aux power supply *
- Position sensors:
 - High-end serial encoder (EnDat 2.2, Hyperface, BiSS)
 - Resolver
 - Hall sensors
 - Incremental encoder
- Current sensing: Σ - Δ modulator
- Connectivity: EtherCAT, Modbus RTU, CAN
- Position control supported
- Modular solution (stacked):
 - Power board 21x10 cm
 - Control board 21x12 cm

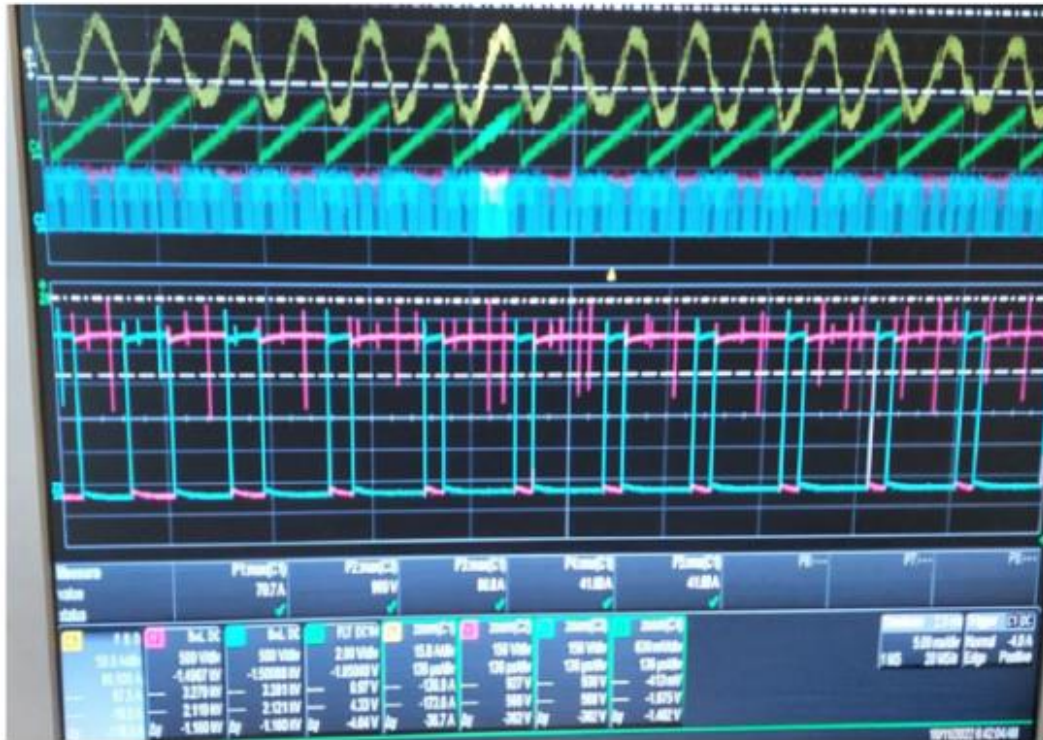
- Safety:
 - TUV assessment for SIL2 level ongoing
 - Diagnostic functionality for power supplies OV and UV detection
 - Voltage supervisor and Watchdog functionality
 - STL libraries for STM32H743ZG (not included in the example firmware)
 - Safe Torque Off (STO)
 - Safe Brake Control (SBC)

Key products:

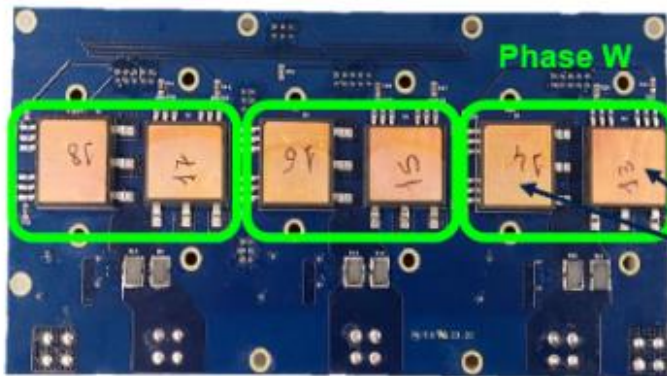
- STGSH50M120D 1200V, 50A Low Loss M series IGBT in ACEPACK SMIT (HB topology)
- STM32H743ZGT6 Arm®Cortex®
- STGAP2HD Galvanically isolated 4 A gate driver
- ET1100 (ET11002) Ethercat ASIC slave device
- STM802RM6F – voltage supervisor
- STISO621 – isolated UART
- L6986I - 38 V, 5W synchronous iso-buck converter
- ISOSD61 – isolated Σ - Δ modulator
- IPS1025H, IPS4260L, IPS160HF – Intelligent power switch
- CLT03-1SC3 – Digital Input



High-end servo drive power test @750 Vdc, 22 kW



NTCs values of two devices in parallel in the same leg → current well balanced



Power stage with two 1200V HB ACEPACK SMIT IGBTs (with embedded NTCs only for phase W) in parallel for each leg

T_{NTC} = 108°C (Thermal steady state reached)



Testing conditions:

- DC BUS: 750V
- Power input: 22kW
- Ph current: 41Arms
- Fsw: 8kHz
- dead time: 2.2us
- SPEED: 3200RPM
- T_{NTC}: 108°C
- Forced air cooling
- Heatsink Rth: 0.54 °C/W (natural convection)

Our technology starts with You

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