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Motor control solutions augmented by ST

Sirichai Jaipachr
Motor Control Competence Center
industrial Applications(APeC)

Agenda

1 Motor Control Competence Center

2 Motor Control ecosystem for STM32

3 GaN & SiC Based Solution by ST

4 Ready Solution

Motor Control
Competence
Center

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 using whole ST product portfolio for Industrial Applications,

SYSTEM R&D

- HW Reference Design, Application Boards
- FW 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

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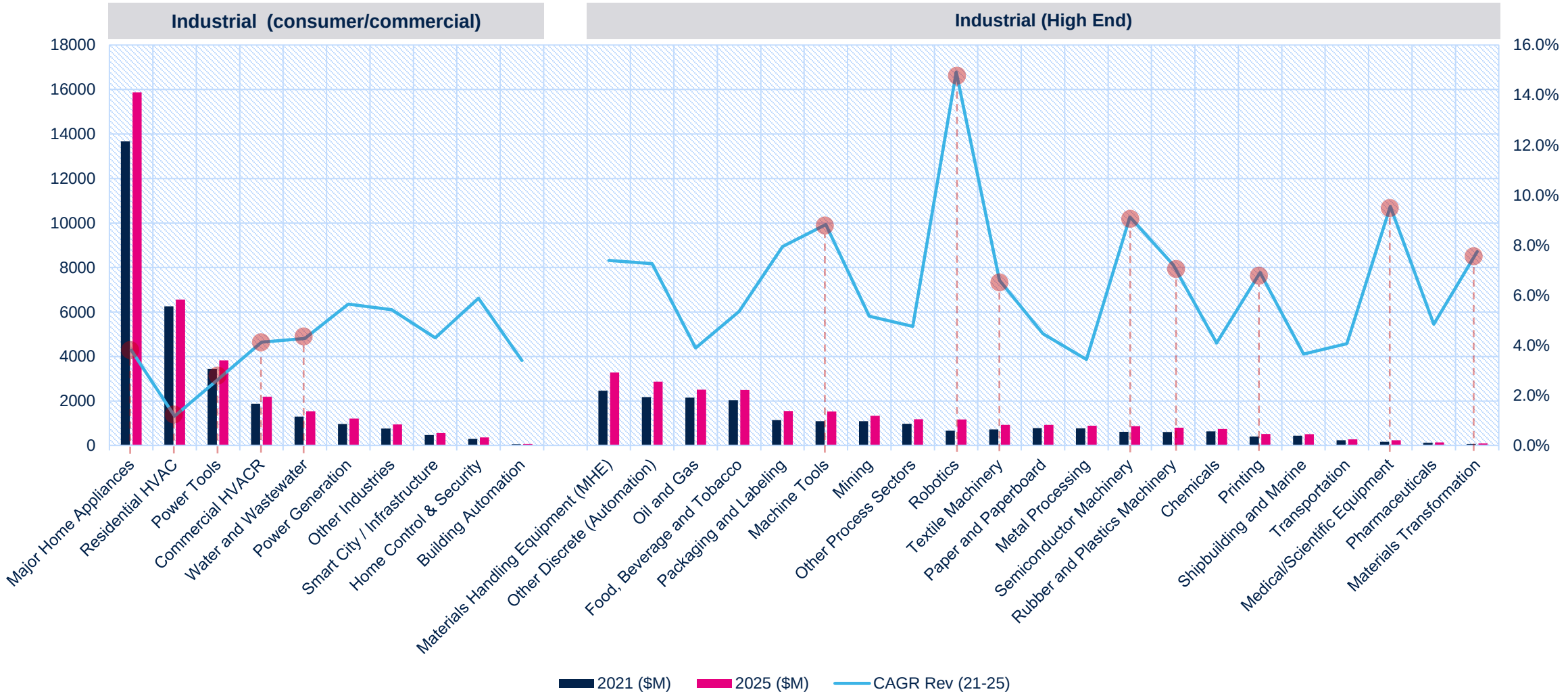
Motor drive shipments ($M) & CAGR 21-25 (%)



*Source: Omdia 2022

Motor Control
Competence
Center

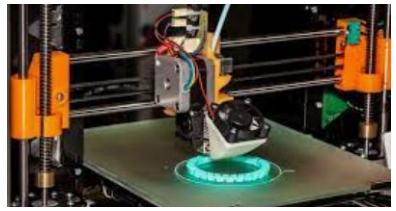
Focus segments and key solutions

Home appliances & aircon

AI MC washing machine

World-Class Breakthrough
Efficiency and Saving

Motor drives & servo drives



Servo drive orchestra

#1 Ensemble in Industry
STM32 - SiC - GaN – MEMS - IoT

high-end consumer power tools @ battery power

Sensorless drill power tools

ZeST : Impossible made possible
& More Powerful & More Integrated

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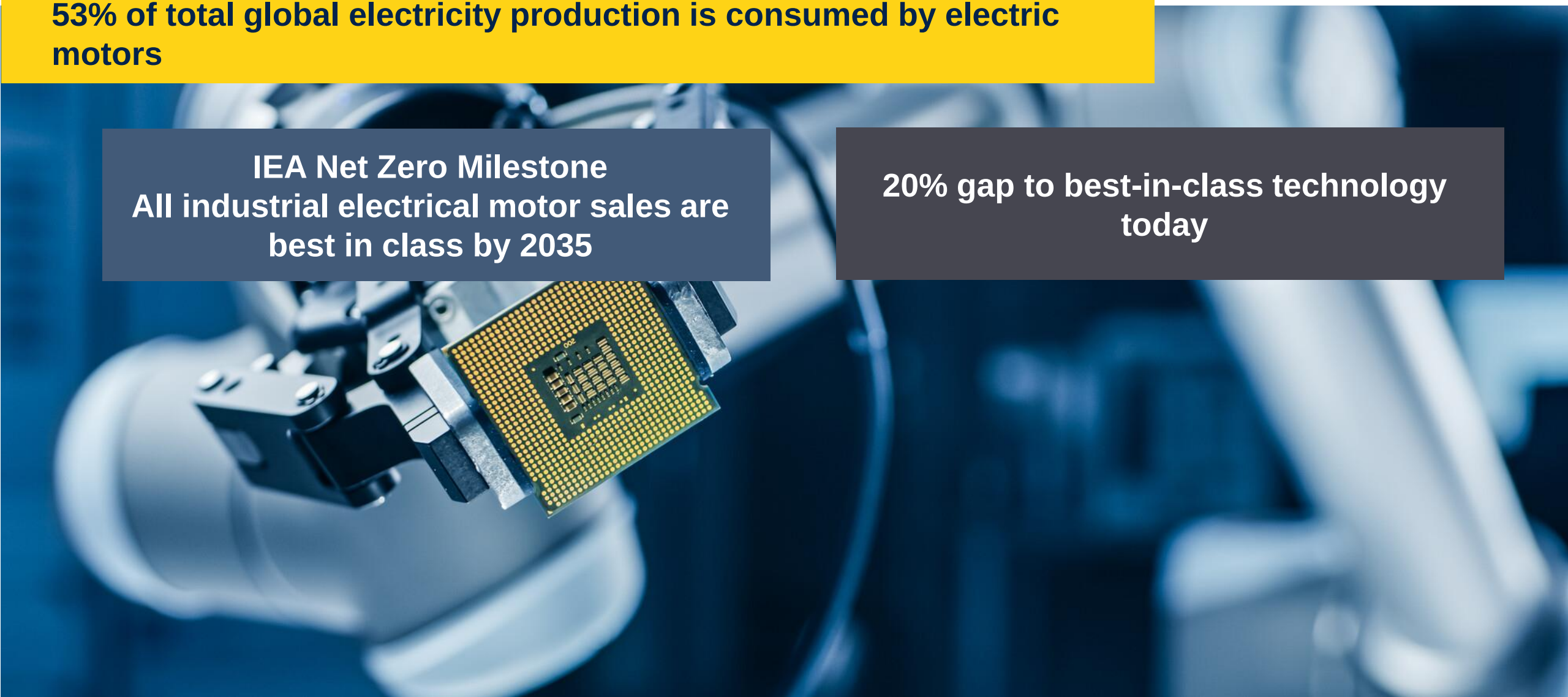
Motor control landscape

53% of total global electricity production is consumed by electric motors

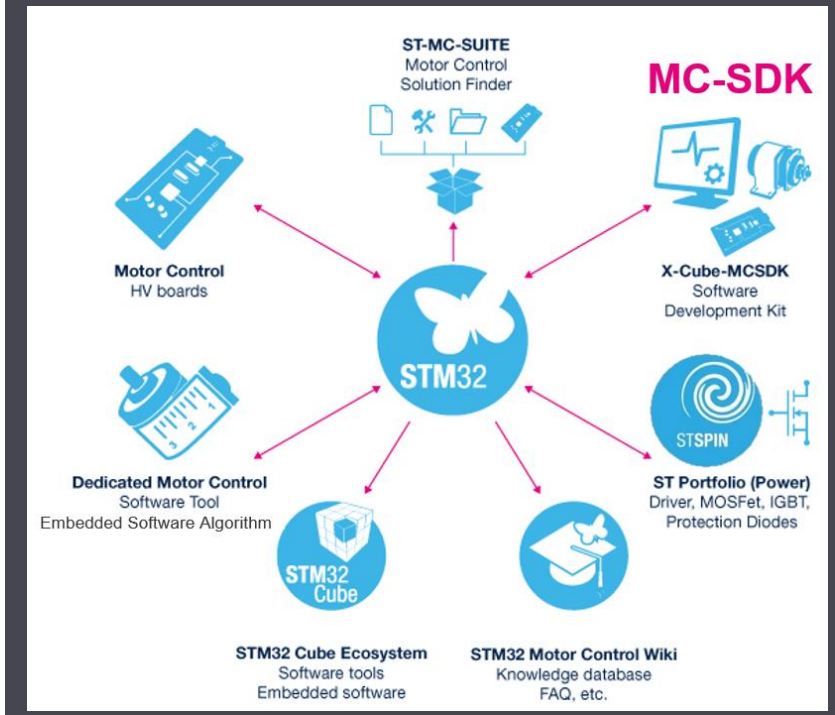


IEA Net Zero Milestone
All industrial electrical motor sales are best in class by 2035

20% gap to best-in-class technology today

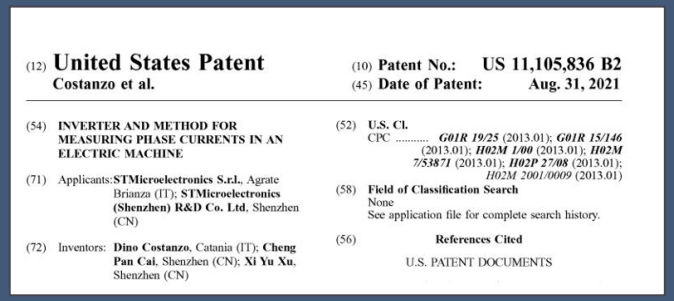
Innovation and market transformation

STM32 Motor Control Ecosystem



Technological innovations

New ST IPs



(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**

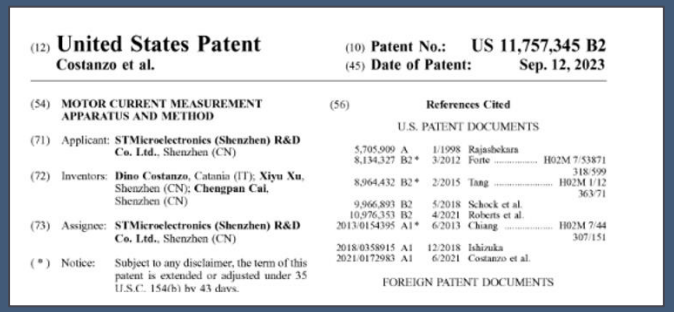
(71) Applicants: **STMicroelectronics S.r.l.**, Agrate Brianza (IT); **STMicroelectronics (Shenzhen) R&D Co. Ltd**, Shenzhen (CN)

(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



(12) **United States Patent**
Costanzo et al.

(10) **Patent No.: US 11,757,345 B2**
(45) **Date of Patent: Sep. 12, 2023**

(54) **MOTOR CURRENT MEASUREMENT APPARATUS AND METHOD**

(71) Applicant: **STMicroelectronics (Shenzhen) R&D Co. Ltd.**, Shenzhen (CN)

(72) Inventors: **Dino Costanzo**, Catania (IT); **Xiyu Xu**, Shenzhen (CN); **Chengpan Cai**, Shenzhen (CN)

(73) Assignee: **STMicroelectronics (Shenzhen) R&D Co. Ltd.**, Shenzhen (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 43 days.

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

5,705,909	A	1/1998	Rajsbokara	
8,134,327	B2 *	3/2012	Forte	H02M 7/53871 318/599
8,964,432	B2 *	2/2015	Tang	H02M 1/12 363/71
9,966,893	B2	5/2018	Schock et al.	
10,976,353	B2	4/2021	Roberts et al.	
2013/0154395	A1 *	6/2013	Chiang	H02M 7/44 307/151
2018/0358915	A1	12/2018	Ishizuka	
2021/0172983	A1	6/2021	Costanzo et al.	

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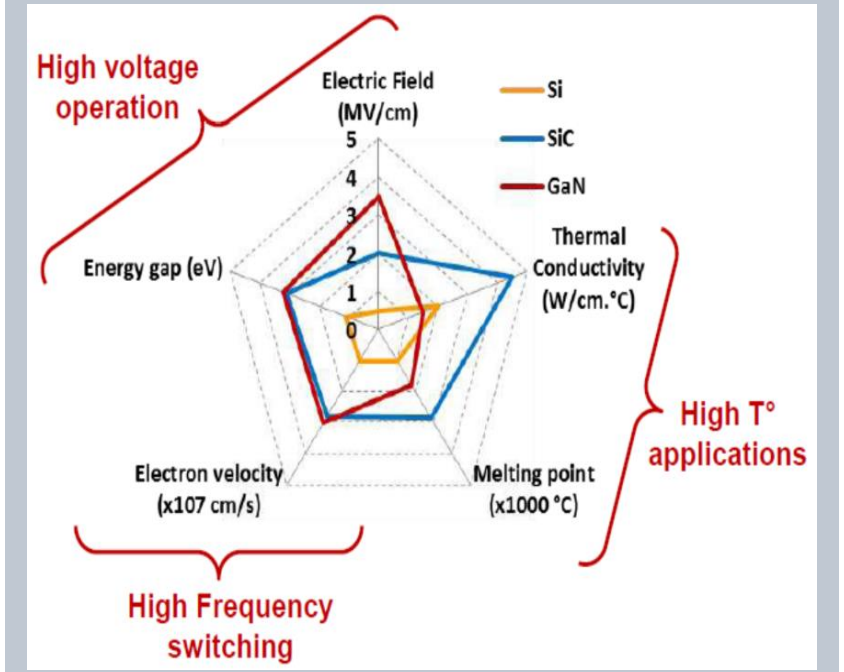
New Semiconductor Technologies



Motor Control ecosystem for STM32

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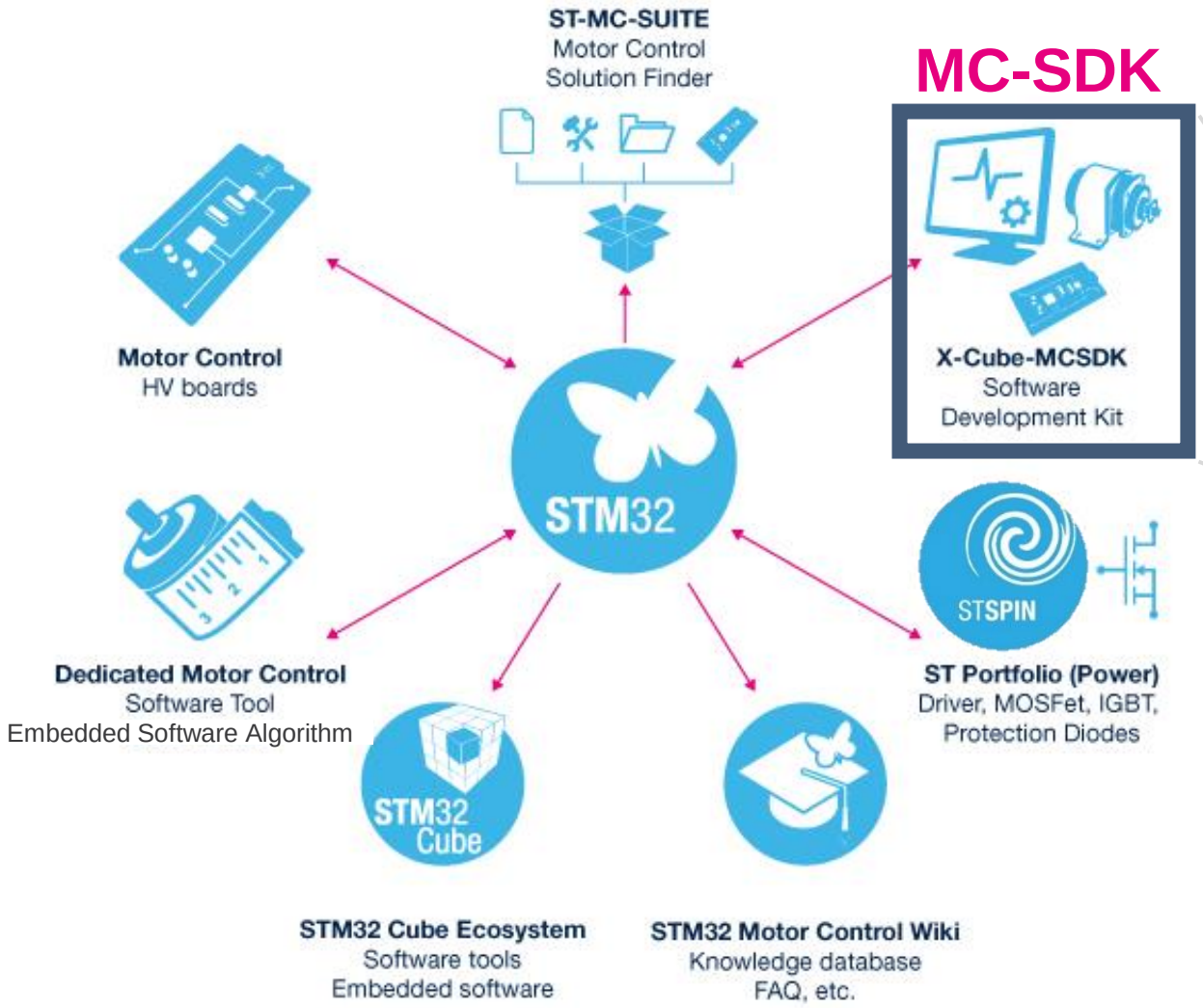
STM32 Motor Control Ecosystem



Motor Control Suite (ST-MC-SUITE)

- Online tool that provides easy access to motor-control resources in the our MCU ecosystem - for STM32, STSPIN32 and STM8 MCUs.

Motor Control SW Development Kit (X-CUBE-MCSDK)

- Motor Control FW lib: full feature library
- Motor Control Workbench: Graphical (GUI) configurator/monitor
- For STM32(MCU), STSPIN32 (MCU+GateDriver)

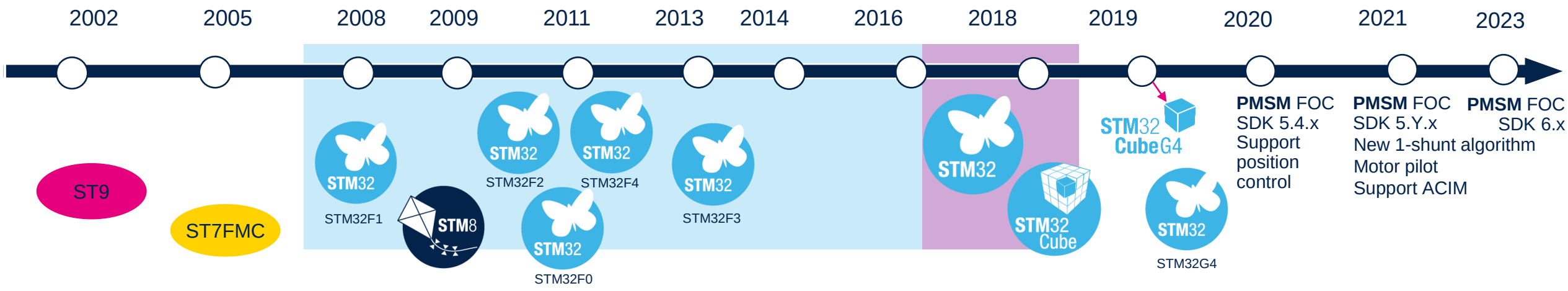
STM32Cubexx

- Embedded software bricks
- Most of STM32 series supported (STM32G4 = Motor Ctrl flagship)

Motor Control Profiler

- Automatic detection of key parameters (Rs, Ls, Ke)
- Zero equipment required
- For STM32 MCUs.

Twenty years of FOC & 6-step for 3-phase motor drives



8/16-bit MCU for ACIM with dedicated library

8-bit MCU for MC scalar and 6-step control with MC HW & SW kit

32-bit CM3 MCU & sensor-less FOC library v1.0

8-bit MCU & MC kit for scalar and 6-step control

FOC SDK v3.0 - dual motor FOC control & MCWB

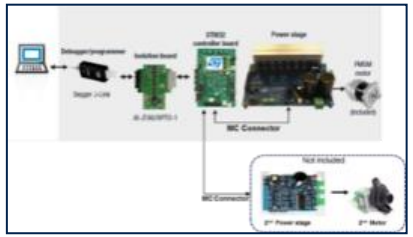
FOC SDK v3.4 - new analog & HW accelerator

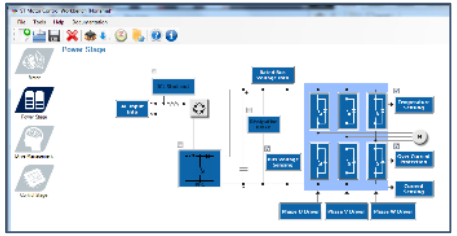
FOC SDK v4.0 - high frequency injection, MTPA, …

FOC SDK v4.3 - Motor Profiler, one-touch tuning, startup on the fly

FOC SDK v5.0 - STM32Cube compatible & simplified FW architecture

PMSM FOC SDK 5.4 Support STM32G4





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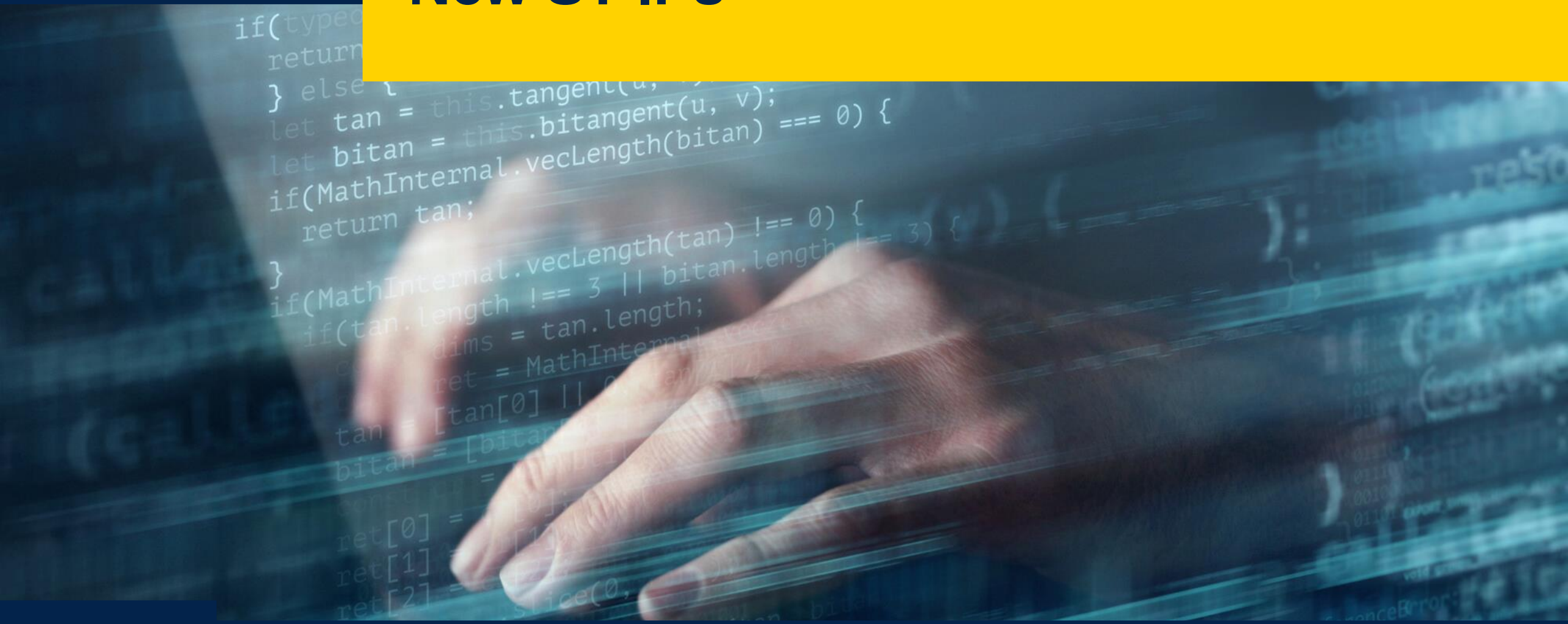
MC-SDK – MC FW lib: new features in v6.2

Key features		STM32 series compatibility
Current sensing and overcurrent protection (OCP)	Current 1-shunt and/or 3-shunt	F0 F3 F4 F7 L4 G0 G4 H7 C0 H5 STSpin32F0/G4
	Insulated current sensing (ICS)	G4 STSpin32G4
	Embedded Comparators OCP, OPAMPs	F3 G4
Speed & position sensing	Sensors (Hall, Encoder), Sensor-less	F0 F3 F4 F7 L4 G0 G4 H7 C0 H5 STSpin32F0/G4
Bus voltage sensing/protection (UVP & OVP)	Vbus reading, Under and Over voltage protection	F0 F3 F4 F7 L4 G0 G4 H7 C0 H5 STSpin32F0/G4
Temperature sensing/protection (OTP)	Temperature measurement, Over Temperature Protection	F0 F3 F4 F7 L4 G0 G4 H7 C0 H5 STSpin32F0/G4
Field oriented control (FOC)	Single	F0 F3 F4 F7 L4 G0 G4 H7 C0 H5 STSpin32F0/G4
	Dual (Couple ADCs per motor)	F3 F4 G4
	Dual (Sharing ADCs resources for both motors)	F3 F4 G4
Six-step	Full support	F0 G0 G4 C0 STSpin32F0/G4
ACIM	Configured through WB, Example only	G4
Control mode	Torque, Speed or position control	F0 F3 F4 F7 L4 G0 G4 H7 C0 H5 STSpin32F0/G4
Sensorless mode	STO/PLL, STO/Cordic (Luenberger)	F0 F3 F4 F7 L4 G0 G4 H7 C0 H5 STSpin32F0/G4
	HSO (High Speed Observer)	G4
Other features	MTPA, Flux weaken, Feed Forward	F0 F3 F4 F7 L4 G0 G4 H7 C0 H5 STSpin32F0/G4
	PFC – FW support	not yet supported
	Discontinuous PWM	F0 F3 F4 F7 L4 G0 G4 H7 C0 H5 STSpin32F0/G4
	Over Modulation and Single shunt phase shift	F0 F3 F4 F7 L4 G0 G4 H7 C0 H5 STSpin32F0/G4
	Monitor control pilot - MC Protocol V2	High bandwidth 1.84mbd
	IOC reading capability	F0 F3 F4 F7 L4 G0 G4 H7 C0 H5 STSpin32F0/G4

Major new features in MC-SDK v6.2

HW compatibility	✓C0 support for FOC 3 shunts and 6 steps ✓H5 support for FOC 3 shunts and 1 shunt ✓Add support of all MCUs part number of F3/G4/G0 series
Motor control features	✓Support of new HSO (High Sensitivity Observer) algorithm ✓Support of Dual drive for F3/F4/G4 ✓Addition of ICS (Insulated Current sensor)
Tools	✓Improve user guidance with accurate inline documentation about board's modifications ✓Improve user flow with IOC reading capability: • MCWB is now able to re-open solution (.IOC file) created in previous loop = closed loop development process

New ST IPs


tan = this.tangent(u, v);
bitan = this.bitangent(u, v);
if(MathInternal.vecLength(bitan) === 0) {
return tan;
}
if(MathInternal.vecLength(tan) !== 0) {
if(tan.length !== 3 || bitan.length !== 3) {

US patents on multimotor drive 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**

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(58) **Field of Classification Search**
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(56) **References Cited**

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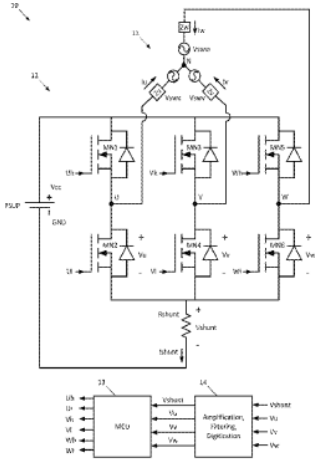

Single shunt current sensing:
breaks all barriers of state-of-the-art

Achieves:
- **no PWM distortion**
- **Simultaneous sampling of two phase currents**

(12) **United States Patent**
Costanzo et al.

(10) **Patent No.: US 11,757,345 B2**
(45) **Date of Patent: Sep. 12, 2023**

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8,964,432	B2 *	2/2015	Tang	H02M 1/12 363/71
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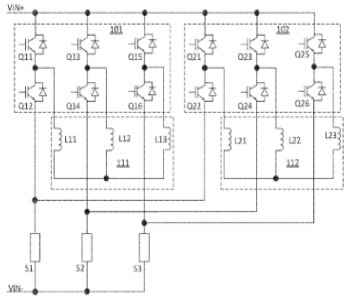
10,976,353	B2	4/2021	Roberts et al.	
2013/0154395	A1 *	6/2013	Chiang	H02M 7/44 307/151
2018/0358915	A1	12/2018	Ishizuka	
2021/0172983	A1	6/2021	Costanzo et al.	

FOREIGN PATENT DOCUMENTS



Multimotor shared current sensing
With shunt resistors/ICS

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

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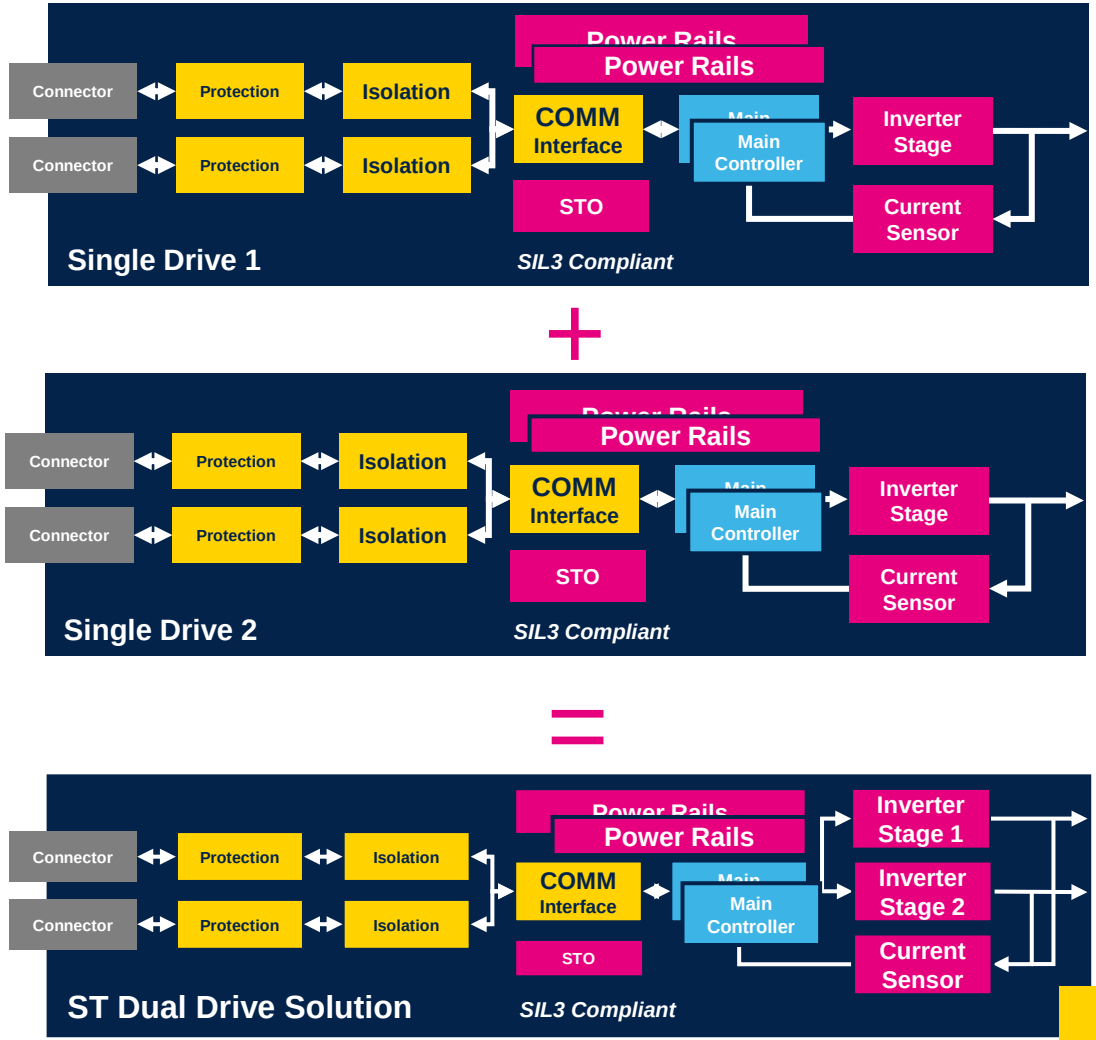
STSPIN32G4 Dual drive solution V2



~40% Cost saving

Example: SIL 3 architecture / 1.5 kW / 310 VDC

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 Slave 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**

LOWER COST

HIGHER RELIABILITY

MORE COMPACT SIZE

HIGHER PERFORMANCE

SDK READY

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US patents on multimotor drive 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**

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

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

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.

(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**

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

(56) **References Cited**

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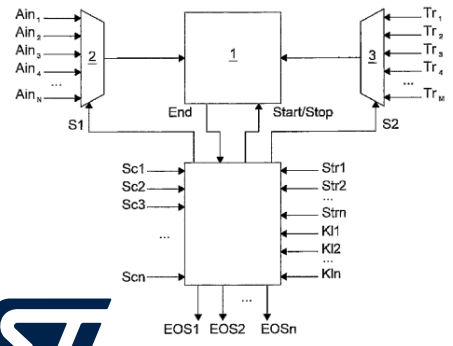
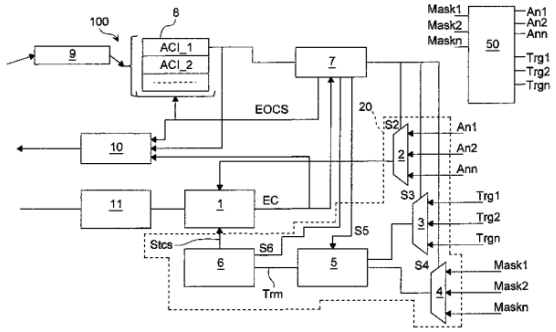
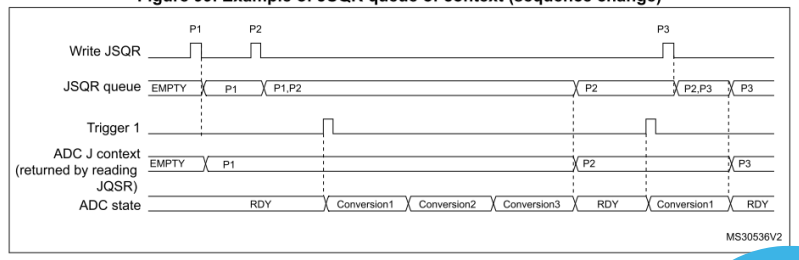
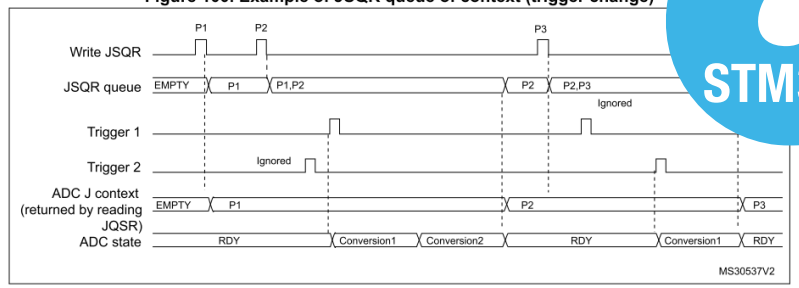






1. Parameters:
P1: sequence of 3 conversions, hardware trigger 1
P2: sequence of 1 conversion, hardware trigger 1
P3: sequence of 4 conversions, hardware trigger 1



1. Parameters:
P1: sequence of 2 conversions, hardware trigger 1
P2: sequence of 1 conversion, hardware trigger 2
P3: sequence of 4 conversions, hardware trigger 1

ADC apparatus & sequence arbiter for multimotor sampling sync

Achieves:
- **No dead-band (max MI)**
- **No IRQ & CPU load for peripherals reconfigure**
- **Robust, HW based, peripheral transitions**

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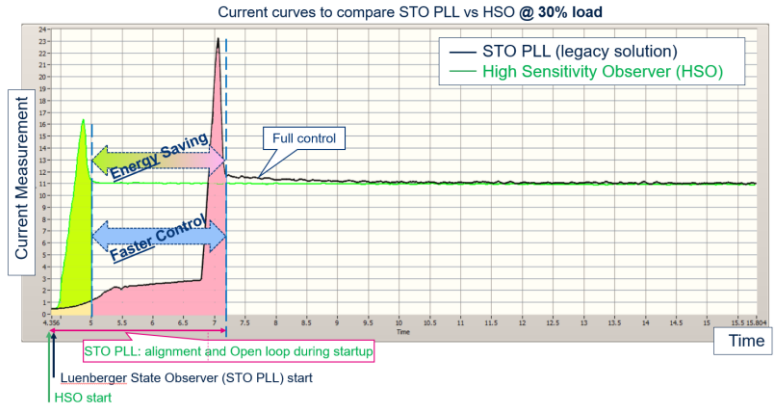
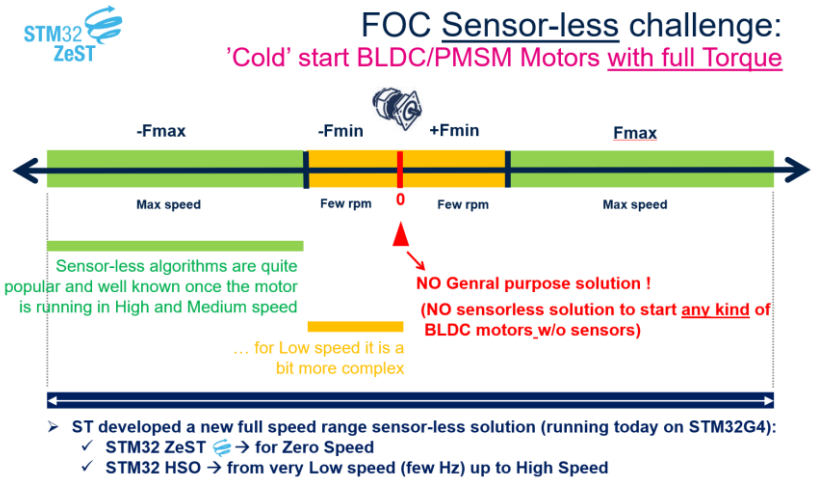
Key features updates on MCSDK V6.2x

- **Full speed range sensorless algorithms (FOC) to enhance motor control**:
  1. **HSO** – high sensitivity observer
     - Including **PolePulse** (rotor position detection)
  2. **STM32 ZeST** – zero speed full torque
  3. **Motor Profiler V2**
     - Motor's resistance estimated at run-time for more efficient control
- **Benefits in applications** (beside the full torque @ zero speed w/o sensors)
  - No Sensors:
    - ✓ Lower BOM cost
    - ✓ Higher PCB robustness
  - Start in closed loop (even from HSO only):
    - ✓ No high peak current = Energy saving
    - ✓ Faster control
  - Control @ very low speed (few rpms) thx to new HSO

HSO → Energy saving & Faster control !








Using STM32 ZeST* to run a smart, power-efficient washing machine

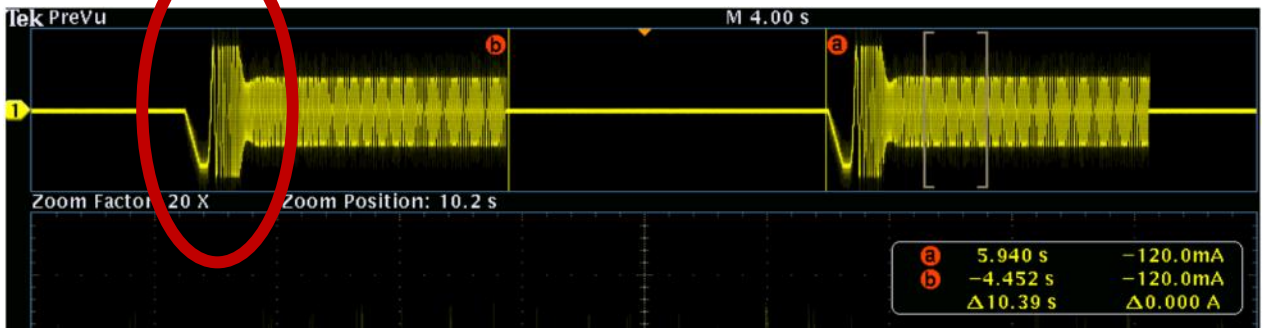
Zero speed full torque sensorless algorithm

Energy saving per washing cycle ~ 15-40%

Standard (open loop) sensorless startup

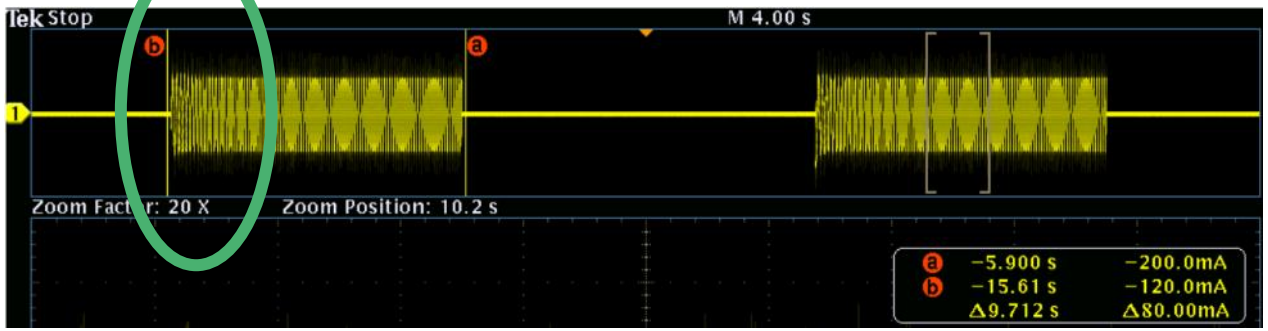
STM32 ZeST startup

High peak current



Energy saving !

- ✓ No high peak current
- ✓ Shorter start-up



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GaN & SiC based solution

SiC & GaN benefits

Positioning in power conversion

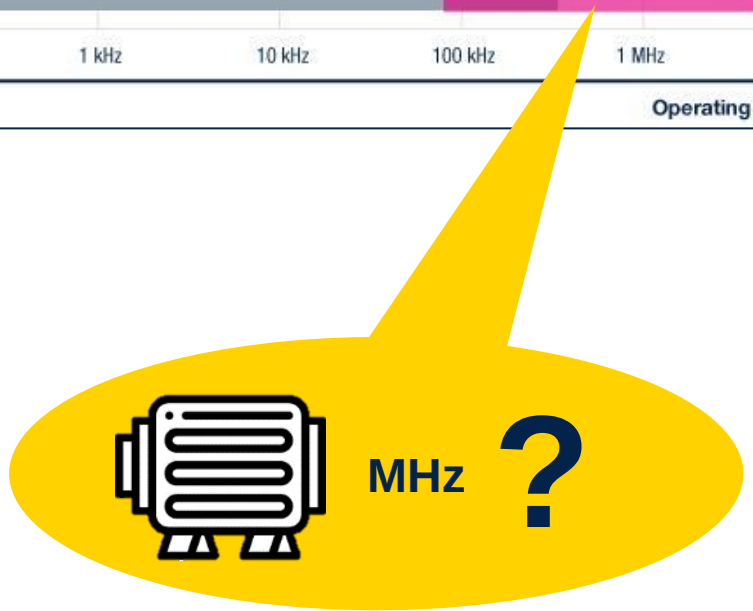
Low charge FET

↓

Efficiency @ high f_{sw}

↓

Size reduction



Motor dv/dt max

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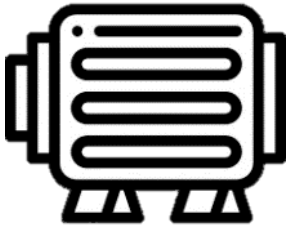
GaN in motor control



Max dV/dt

~10V/nsec

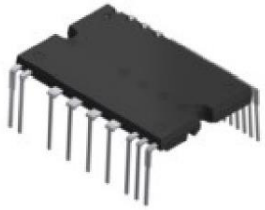
Zero Q_{RR}

Higher efficiency @ any F_{SW}

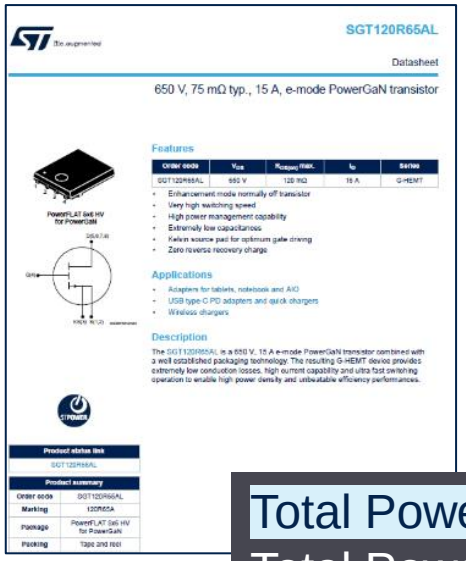
Δη ?

Estimated power losses in 1000 W inverter

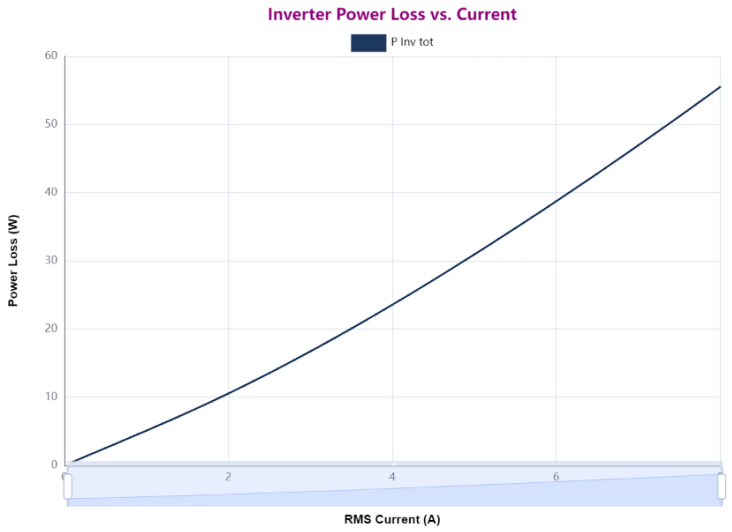
T_{AMB}=55 C
I_{PHASE}=3.5 A RMS
V_{DC}=330V
F_{SW}=15KHz



STGIF5CH60TS-L (IGBT based solution)



SGT120R65AL
$R_{TH\ J\text{-}AMB}$ = 35 C/W



Parameter	STEP_0	
	T	D
Conduction Loss (avg)	1.83 W	492.73 mW
Switching EON/Err Loss (avg)	702.75 mW	83.33 mW
Switching EOFF Loss (avg)	477.45 mW	-
Total Loss (avg)	3.01 W	576.05 mW
T+D Total Loss (avg) (W)	3.59 W	-

	STEP_0
System Total Loss (avg) (W)	21.55 W
Case Temperature (max) (°C)	90 °C
Heatsink Rth (°C/W)	1.86 °C/W

IPhase(RMS) A	RDSon(25 °C) ohm	RDSon(TJ° 120 C) ohm	Eon(Ipk Turn ON) J	Eoff(Ipk Turn Off) J	Thermal resistance j-A	Freq Hz	MOTOR ripple current	Vbus
3.5		*1.70E-01*	1.00E-04	7.00E-05	3.50E+01	15000	0.00E+00	330
Iphase(pk) A	**Iphase(pk turnON) A**	**Iphase(pk turnOFF) A**	**IMOSFET(RMS) A**	**Etot(pk) J**	**Etot(Av mosfet) J°**	**Psw W**	**Pcond W**	
4.9497	4.95E+00	4.95E+00	2.47E+00	1.70E-04	5.41E-05	8.12E-01	1.04E+00	
Tot Power losses	**T ambient °C**	**TJ**			**Tj max**			
1.85E+00	55	1.20E+02			1.20E+02			

Total Power losses in GaN solution =11.1 W
Total Power losses in IGBT SLLIMM solution= 21.55 W

Gan SW losses	IGBT SW losses	Gan conduction losses	IGBT conduction losses
812 mW	1.262 W	1.04 W	2.32 W

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Strategic Development: GaN in Motor Control
Segmentation, identified applications

GANSPIN Power SiP — ASP STSPIN

100W

GANSPIN2
VIPer
Analog

GANSPIN Power SiP — ASP STSPIN

300W

GANSPIN1
VIPer
Analog

GaN Discrete — ASP STDRIVE — NMPS GaN BU

800W

STDRIVE for GaN
GaN Discrete
VIPer, Analog

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Orchestra of scalable servo drive solutions

Key Products

- STM32G4 MCU / STSPIN32G4 SiP
- 100V STripFET F7 Power MOSFET
- Wide-bandwidth rail to rail Op-Amps

Features

- High Integration SiP for reduced PCB size and BOM
- High Power Density
- Ready solution with Realtime Fieldbus

Key Products

- STM32H7 MCU
- 650V e-mode PowerGaN
- High Speed Half-bridge drivers for GaN
- VIPerPlus high voltage converter

Features

- System-level High Energy Efficiency
- Reduced Torque Ripple
- Reduced PCB size
- Optimized GaN driving voltage and transients

Key Products

- STM32H7 MCU
- 1200V SiC MOSFET in ACEPACK SMIT package
- STGAP2SICS galvanic isolated gate drivers

Features

- High Power Density
- Reduced losses at high temperatures
- Overall reduction of system cost

Key Products

- STM32H7 MCU
- 1200V IGBT in ACEPACK SMIT package
- STGAP2HD galvanic isolated gate drivers
- Galvanic isolated Sigma-Delta modula-

Features

- SIL2 certification assessment from TÜV
- Currents sensing SigmaDelta modulators
- SafeTorqueOff (STO) SafeBrakeControl (SBC)

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STM32 STPOWER STSPIN STDRIVE VIPer ST Op Amps ST PROTECT STGAP

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Solving dV/dt impact on motor with SiC

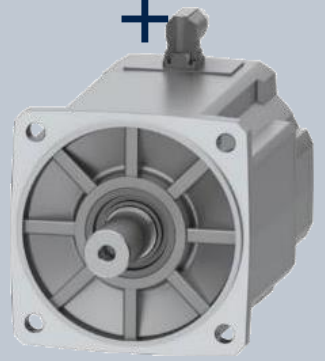
Conventional topology

Inverter

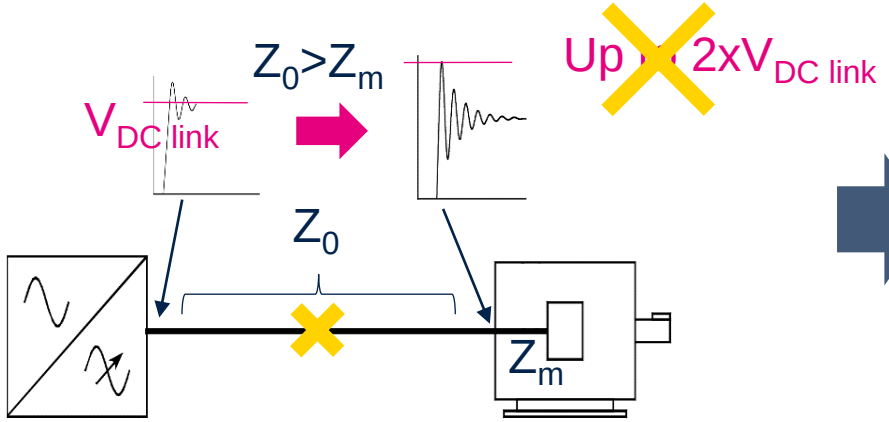
+

Cable

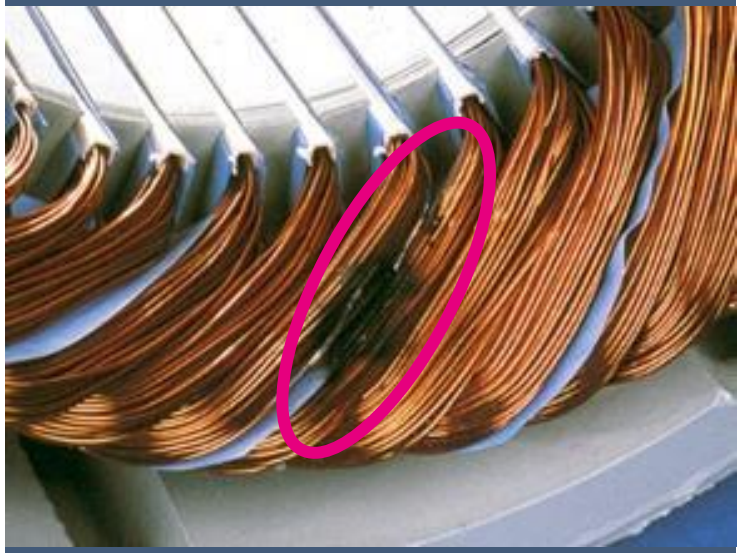
+



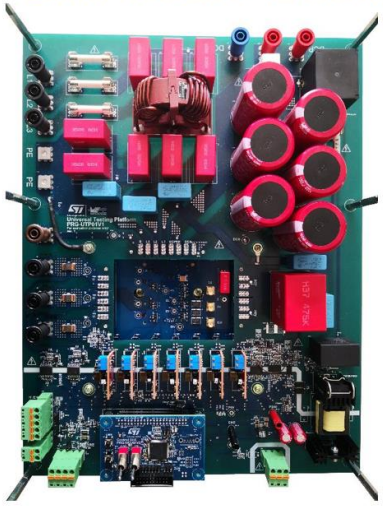
Motor

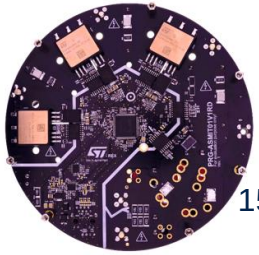


Partial discharge burns the windings

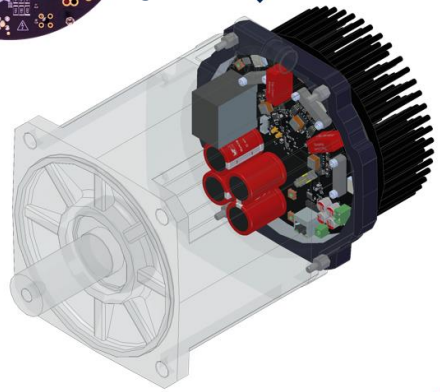


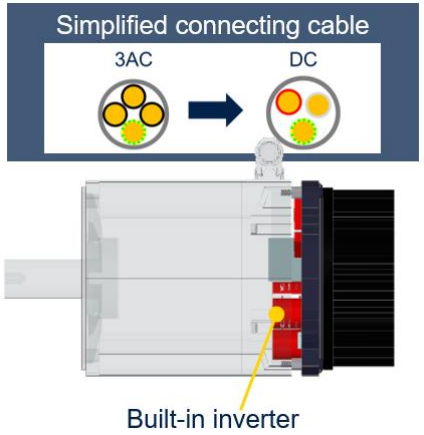
Universal Platform Conversion to built-in Inverter



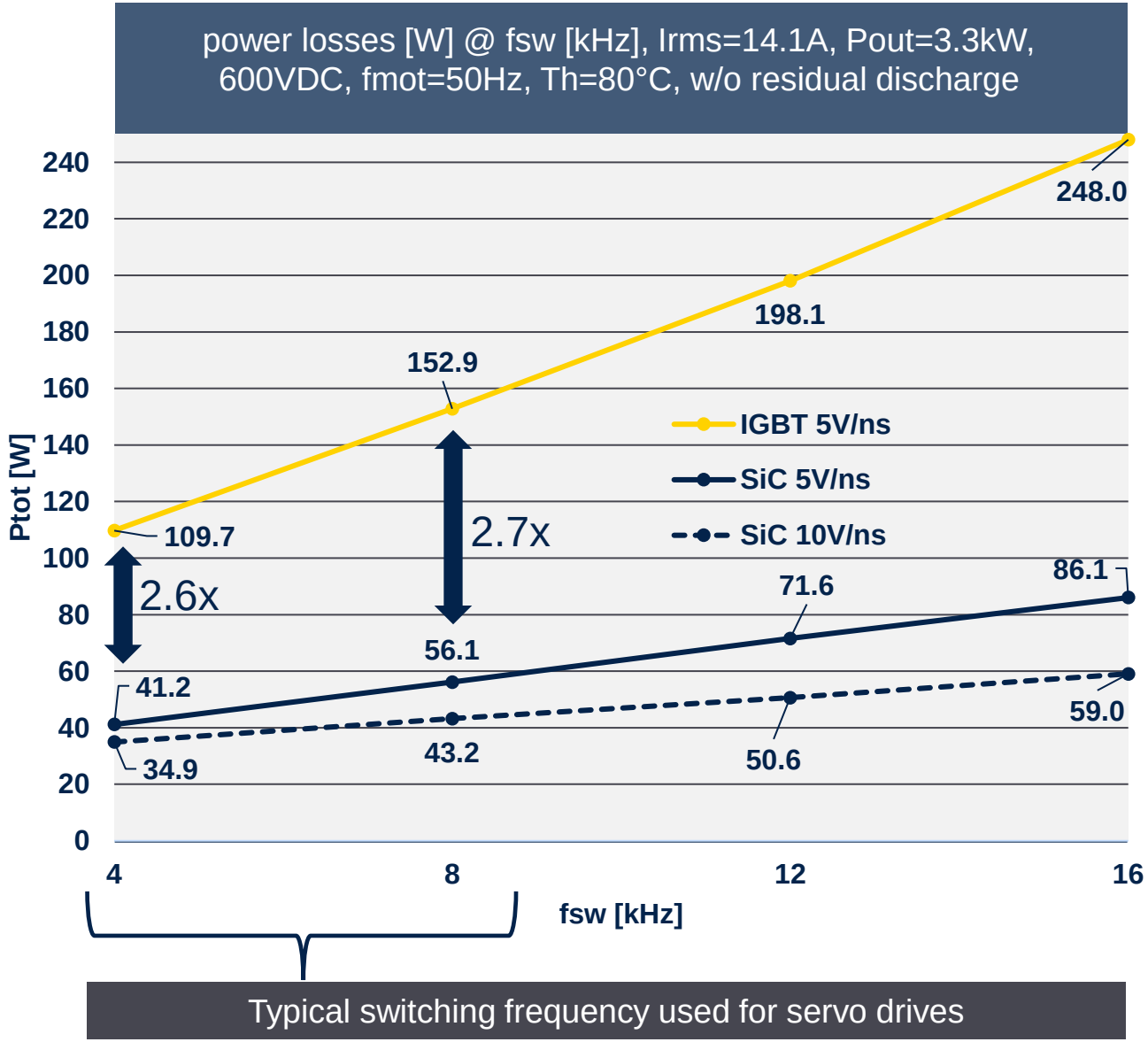


15KW





Inverter loss measurements in the lab



SiC MOSFETs efficiency @ same dV/dt

- +1.9% at 4 kHz
- +2.7% at 8 kHz

165 days duty to pay back delta price

SiC MOSFETs losses @ same dV/dt

- 2.6x lower at 4 kHz
- 2.7x lower at 8 kHz

Opportunity:

- Increase power density
- Reduce frame size

Motor Control
Competence
Center

500 W HV motor drives based on GaN

GaN high-voltage servo motor drive

Available on demand

Key features:

- GaN ready solution for motion control
- 10 V dV/dt both hard-on and hard-off
- Overcurrent protection integrated in the gate driver
- FOC supported
- Designed for 230 V AC mains
- HEMT GaN 650 V, 75 mΩ typ R_{DSon}

Specifications:

- 500 W+ max output power without cooling fan
- RS485 for absolute position encoder
- SPI, I²C
- Hall sensor & encoder

Key products	• **STDRIVEG611** • **SGT120R65AL** • **TSV791ILT** • **VIPER06HS**	• **STM32H730VBT6** • **LDK320ADU33R** • **ST715MR** • **ST3485EBDR**
Applications	• **Home appliances** • **Servo drives** • **High speed motors & tools** • **Miniaturized motors**	

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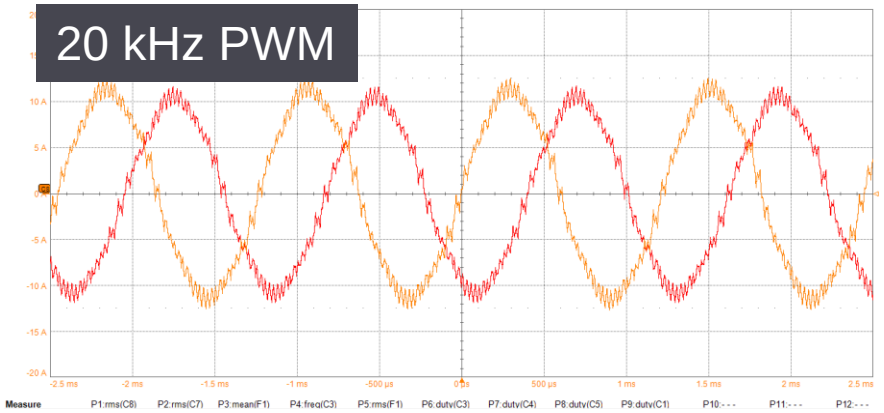
Increasing PWM frequency for efficiency gains

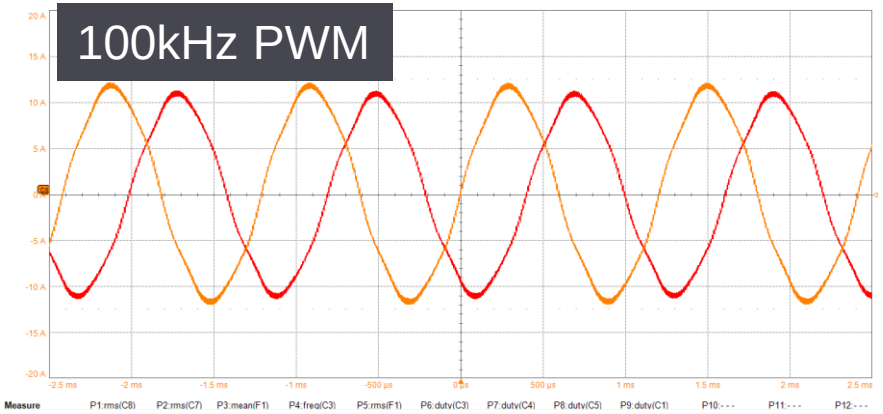
20 kHz PWM



Peaks	Frequency	Amplitude
1	750 Hz	6.5713 A
2	40.75 kHz	269.4 mA
3	39.25 kHz	248.8 mA
4	3.76 kHz	248.1 mA
5	21.50 kHz	159.0 mA
6	18.50 kHz	135.4 mA
7	122 Hz	115.7 mA
8	17.00 kHz	113.4 mA
9	23.00 kHz	102.3 mA
10	1.46 kHz	98.8 mA

Not producing active torque

100kHz PWM



Peaks	Frequency	Amplitude
1	750 Hz	6.6455 A
2	3.75 kHz	251.8 mA
3	199.24 kHz	85.2 mA
4	5.25 kHz	74.2 mA
5	98.50 kHz	44.4 mA
6	101.49 kHz	37.8 mA
7	103.00 kHz	31.1 mA
8	97.00 kHz	28.6 mA
9	196.24 kHz	11.4 mA
10	49.24 kHz	7.7 mA

	Si @20kHz	GaN @100kHz
Inverter efficiency	98.28%	98.68%
Motor efficiency		+4%
Overall efficiency		+4.12%

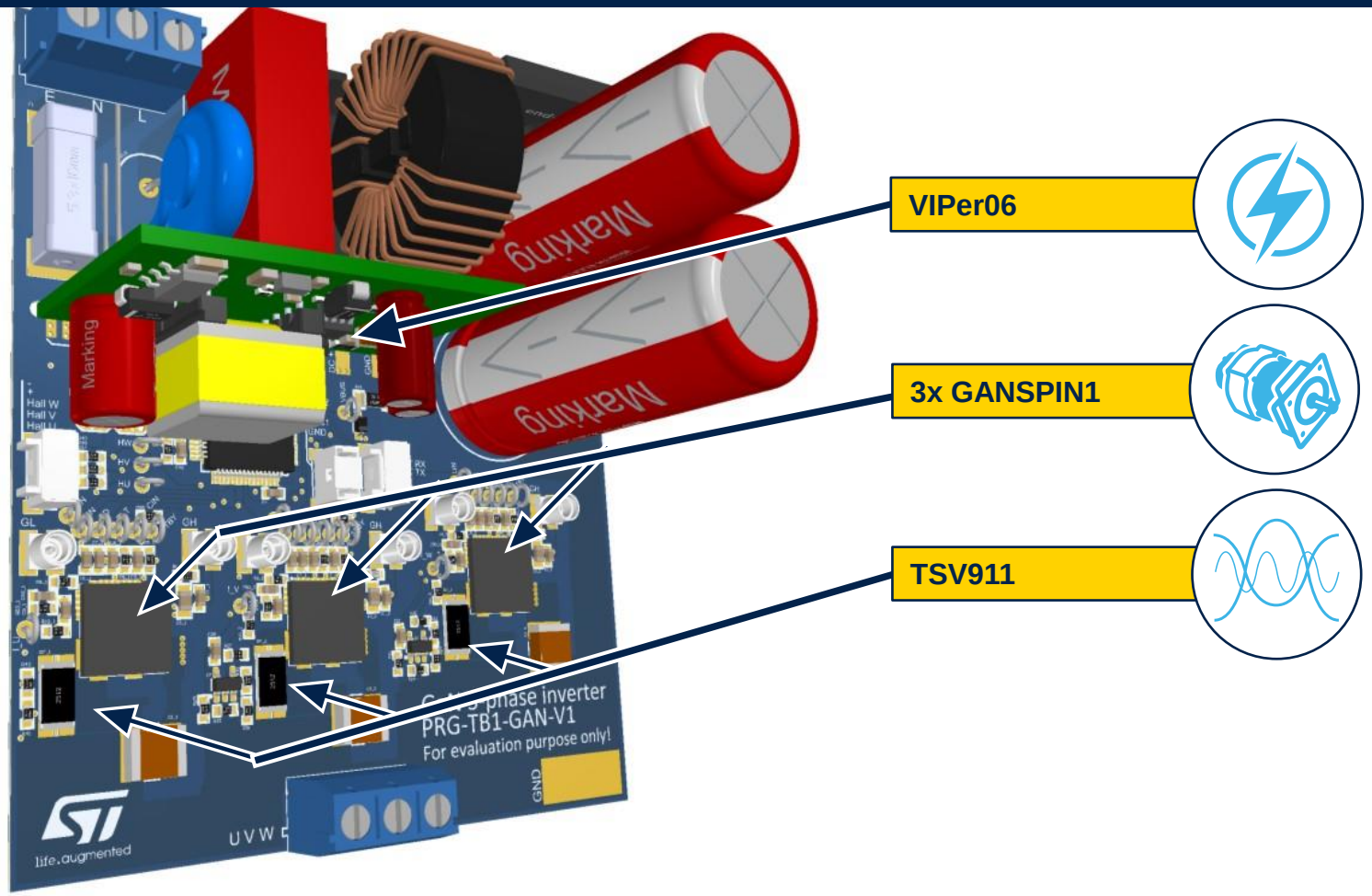
COP test for HV fridge compressor

Compressor motor:
- Phase resistance: 10 Ω
- Ls: 200 mH

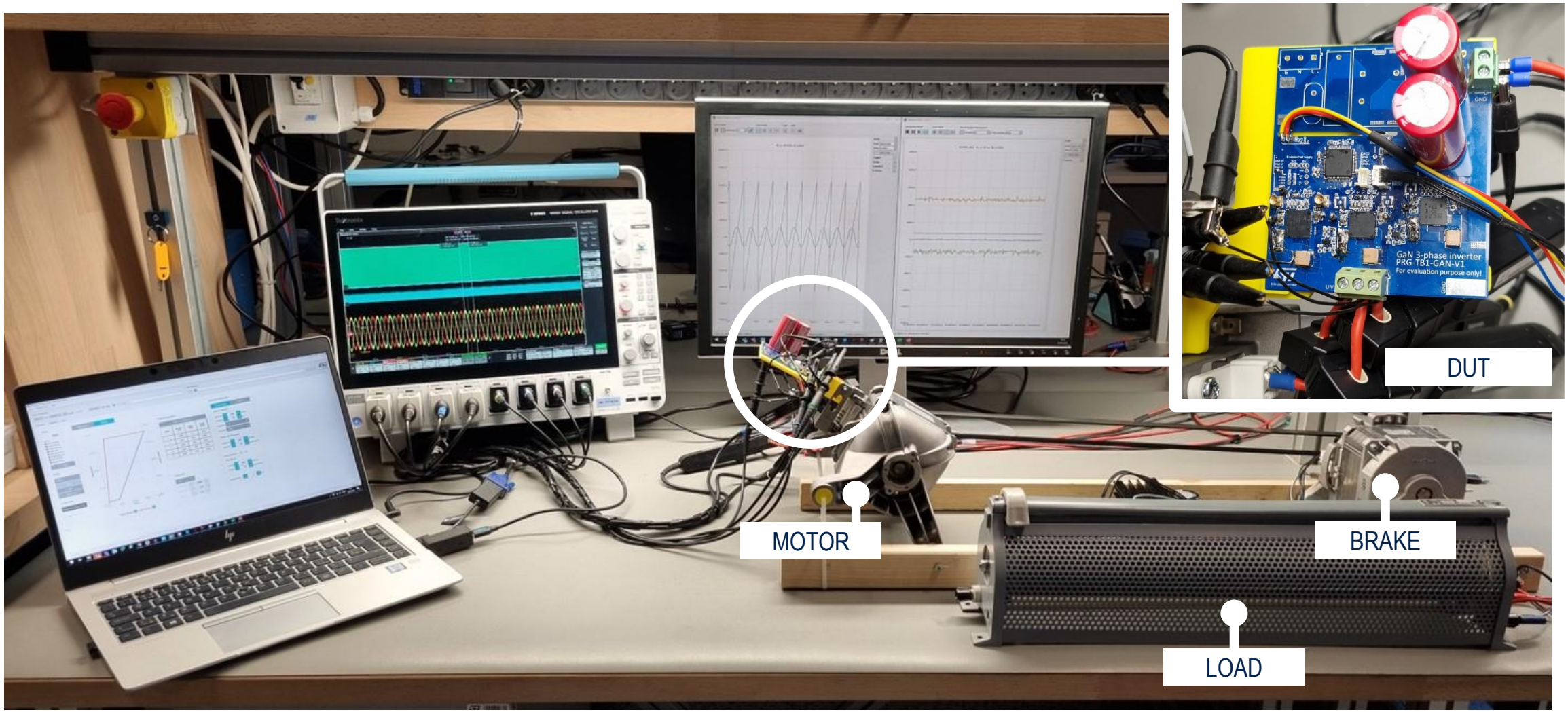
Power devices	Fpwm (kHz)	Nominal speed [rpm]	Cooling capacity [W]	Input power [W]	COP	COP increased
Leading solution STD8N60DM2	5	1200	65.793	34.681	1.897	
		3000	167.208	89.78	1.862	
		4500	232.425	145.847	1.594	
New ST GaN solution SGT120R65AL	5	**1200**	66.814	34.451	1.939	+2.2%
		3000	169.875	90.313	1.881	+1.0%
		4500	233.945	146.26	1.600	+0.3%
	8	1200	66.379	34.852	1.905	+0.4%
		3000	168.538	89.869	1.875	+0.6%
		4500	233.182	146.394	1.593	0

First inverter prototype with GaNSPIN

Motor control inverter designed with full ST BOM, including 3x GANSPIN and MCU



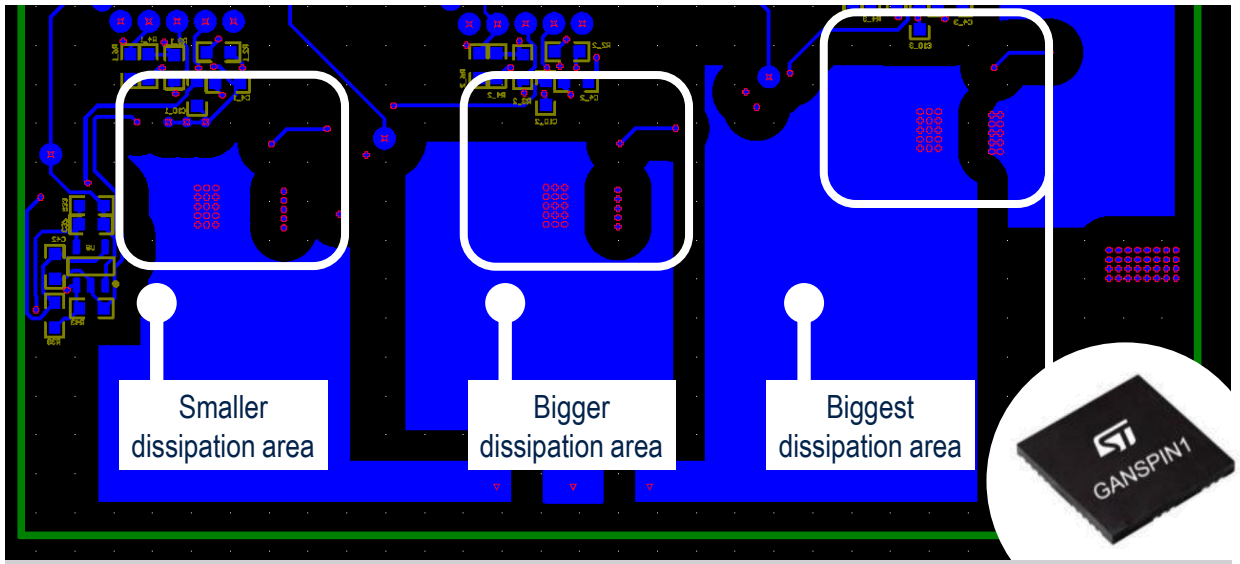
Test setup for a BLDC motor



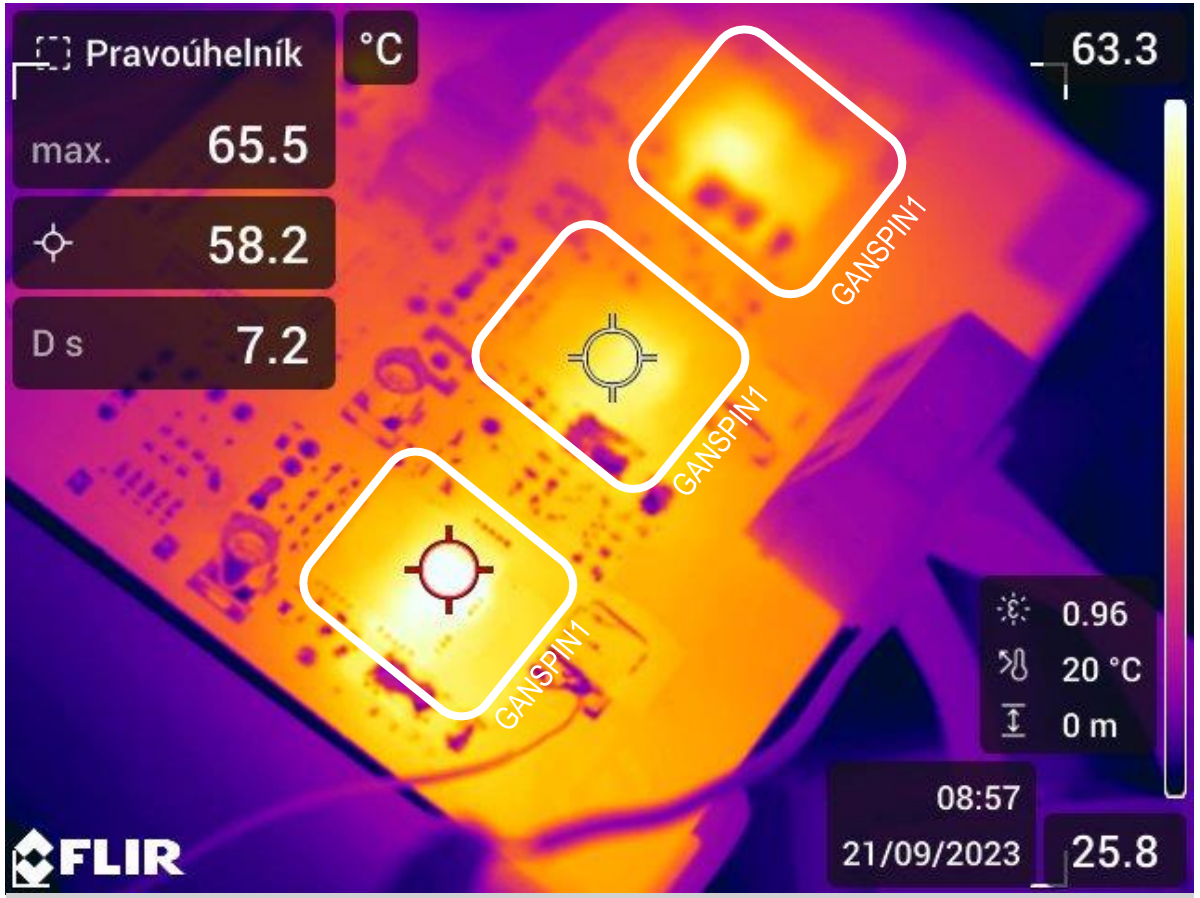
Thermal performance of GANSPIN inverter layout

- Infrared thermal camera used for temperature measurements
- GANSPIN mounted on the left side of the PCB produces the most heat, due to a smaller dissipation area

→ PCB layout has big influence on maximum output power!



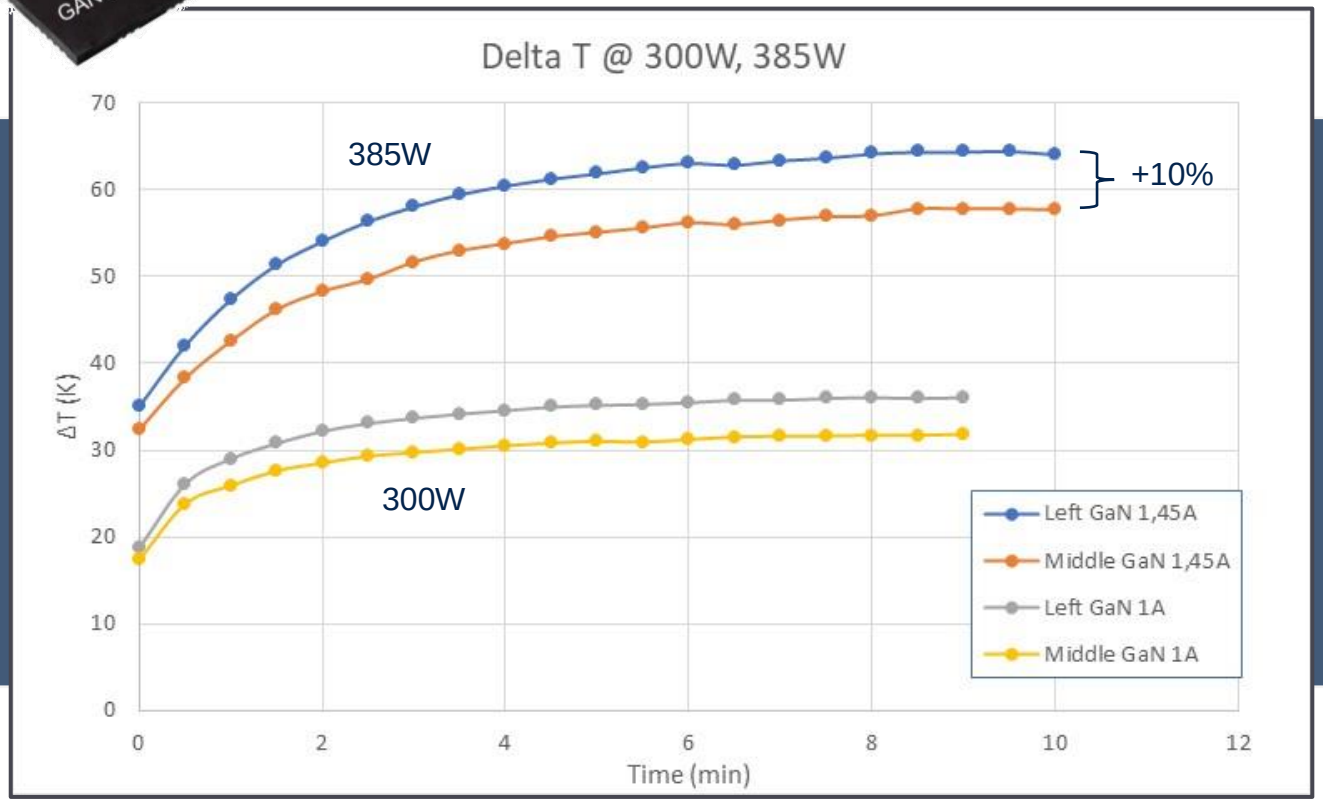
Heat pads on PCB (large blue areas) used for power dissipation



Infrared camera monitoring the case temperature of GANSPIN

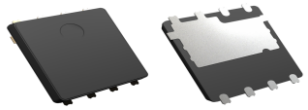
Thermal performance of GANSPIN inverter layout

- Very good performance at 300 W output power:
  - Temperature rise only ~35°C above T_{amb}
  - Suitable for application with high T_{amb}
- Max output power reached is now 385 W:
  - Switching losses contributing for 65% of total losses
  - Heat dissipation area also influencing the performance

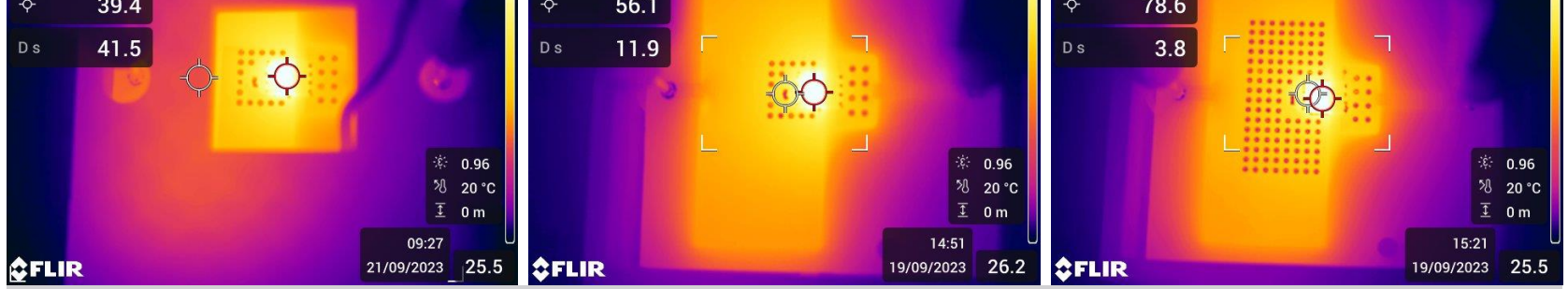


Heat dissipation of GaN in PowerFLAT package

- Evaluation of heat dissipation in GaN PowerFLAT
- Cooling through **PCB only**
- Testing several layout setups:
  - 2-layer and 4-layer PCB
  - Different copper areas
  - Different vias count
- Goal: evaluate power losses dissipation without the use of a conventional heatsink

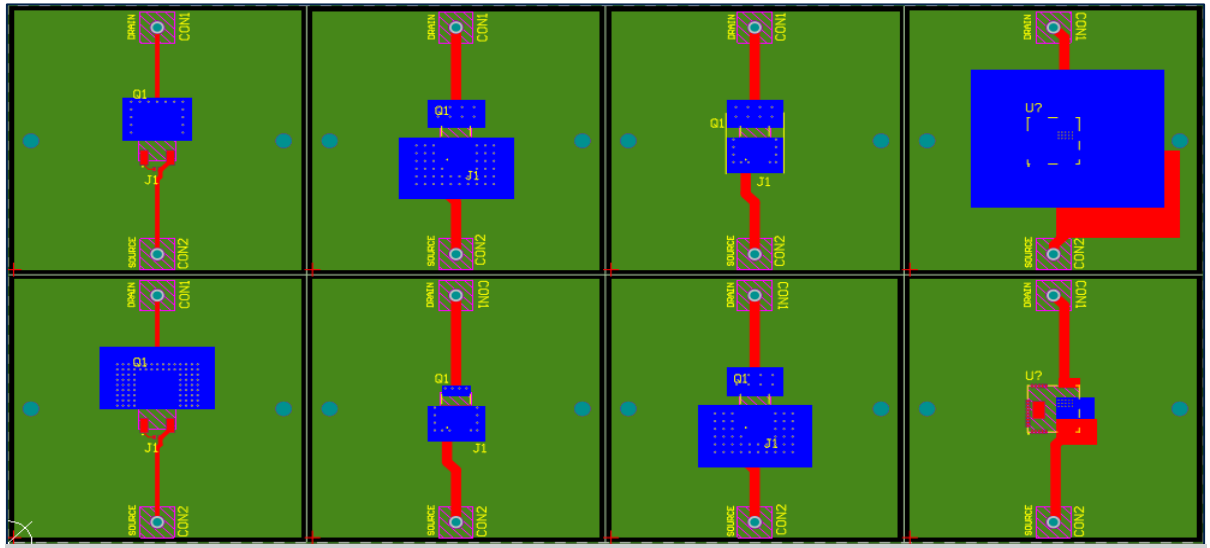


GaN Transistor in PowerFLAT5x6 mm



Infrared camera snapshots monitoring the case temperature of the GaN

Testing enclosure manufactured with our 3D printer



Multiple PCB layouts with different cooling areas designed in Prague

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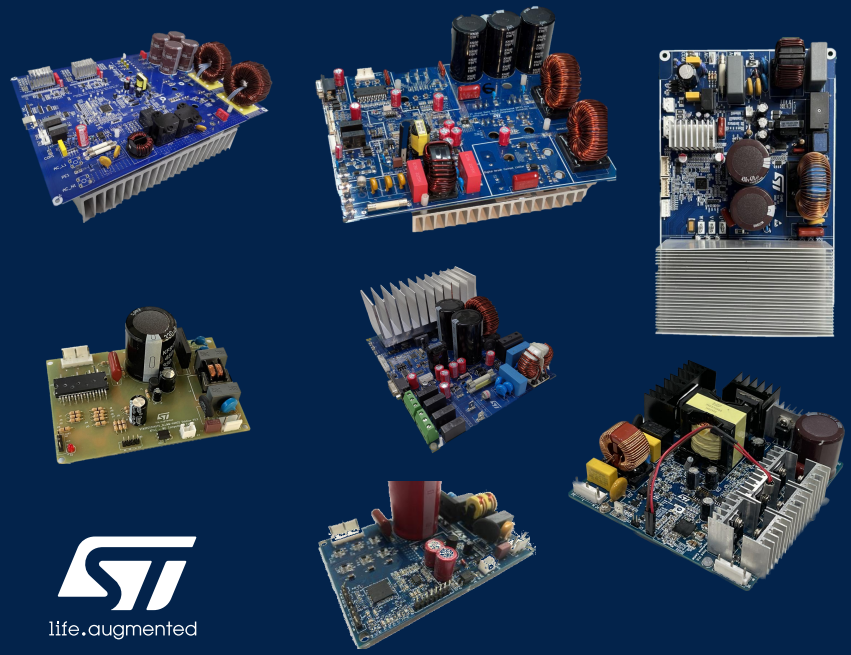
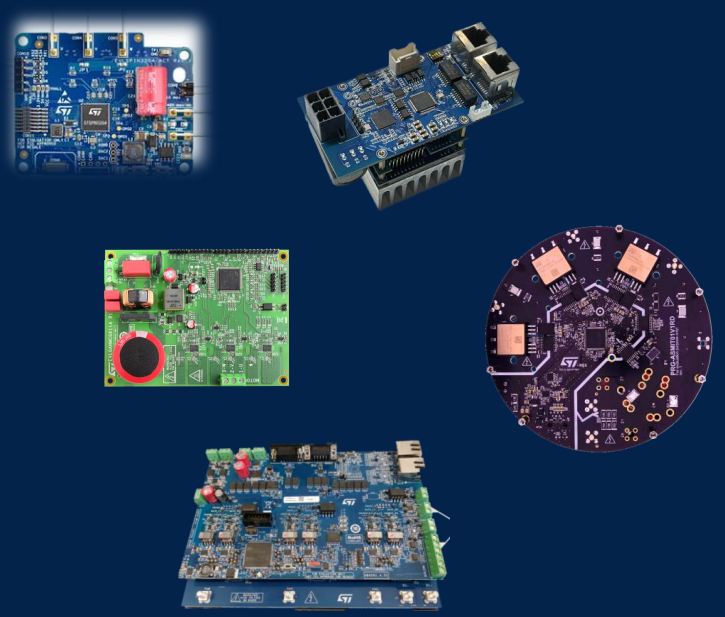
Ready solutions

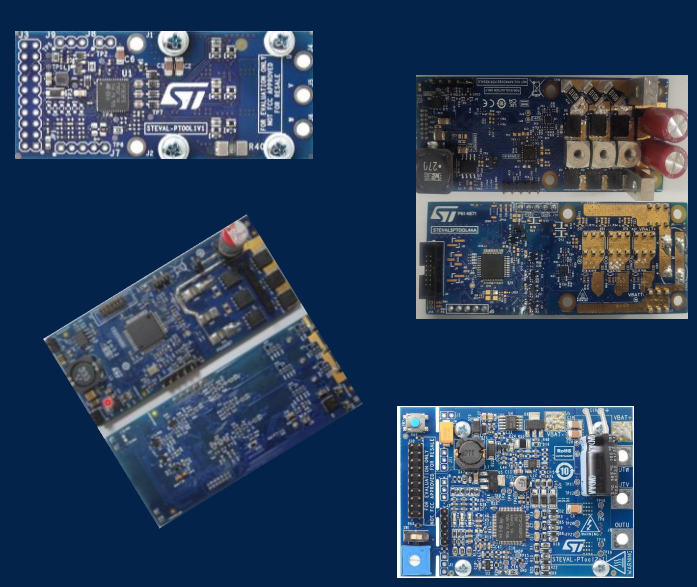
Home appliances & aircon



Motor drives & servo drives



Power tools & high-end consumer



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Motor Control
Competence
Center

Solutions for aircon/heatpumps

Complexity / energy efficiency

Part numbers in this slide are just example: final BOM to be agreed with Marketing

3xFOC Vienna

3xFOC d-IntPFC

2xFOC d-IntPFC

2xFOC d-PFC

FOC d-PFC

1kW

2kW

4kW

7kW

10kW

24H2

10kW Commercial
STM32G4 /
STGAP + ACEPACK
+ 2x SLLIMM HP HV
+ 3phase AC
(Vienna option)

Available @ MCCC

7kW Commercial
STM32G4 + STGIK50
TripleMC + d-IPFC

Available @ MCCC

3.5kW Commercial
STM32G4 + STGIB30
SLLIMM™
DualMC + d-I-PFC

Available @ MCCC and (F3-based) as STEVAL-CTM010v1

2kW RAC
STM32G4 +
STGIB10x
DualMC + d-PFC

Available @ MCCC

2kW RAC
STM32G0
+STGIF10 + dPFC

Completed

Ongoing and roadmap

STPOWER

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Part numbers are indicative only. Final BOM to be agreed with ST's Sales & Marketing local representatives

Motor Control
Competence
Center

Motor control solutions for refrigerators

Part numbers in this slide are just example: final BOM to be agreed with Marketing

BOM value

Completed
Available solution & kit

Available @ MCCC
300W

STM32G0 +VIPER
3xL638x+TSVx+
6xTG IGBT/DM2

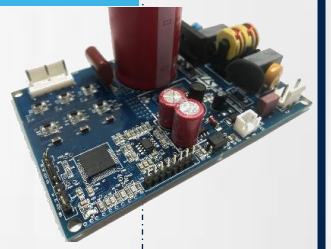
14 IC

Available @ MCCC
300W

STM32G0 +VIPER
STDRIVE601 +TSVx
6x TG IGBT/DM2

11 IC

Available @ st.com
STEVAL-CTM011v1
STEVAL-CTM012v1
300W



STSPIN32F0601 +
VIPER /LDO + TSVx
+ 6x IGBT/DM2

Ref sln for
STSPIN32G0
in 24H1

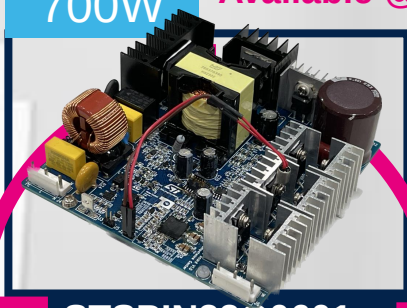
10 IC

Available @ MCCC
300W

STM32G0
VIPER/LDO + TSVx
SLLIMM™ nano IPM

5 IC

700W **Available @ MCCC**



STSPIN32G0601
VIPER/LDO + TSVx
6x IGBT/DM2
+ dPFC

Completed
Ongoing and roadmap

STM32 STSPIN

Integration

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Low voltage servo drive solutions

GaN based

Quad Axis

Dual Axis

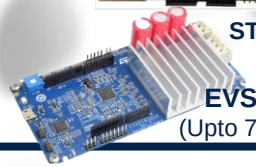
Single Axis

Available @ MCCC

STSPIN32G4 /
STM32G4 dual drive
(Upto 75V/ 200W)each)

EVALKIT-ROBOT-1
(Upto 36V/6Apk)

STEVAL-ETH001V1
(upto 48V / 700W)

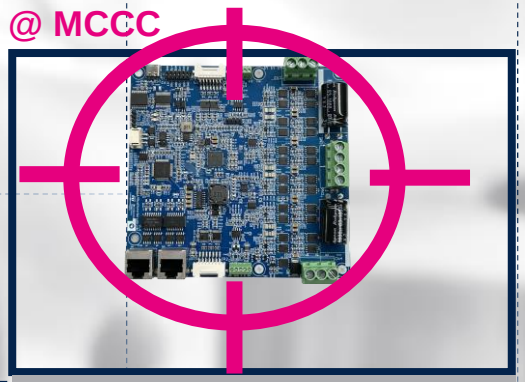


EVSPN32G4
(Upto 75V/20Arms)

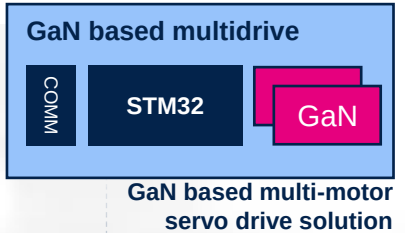
Available @ MCCC

STSPIN32G4
LV Servo with Ether CAT
(Upto 60V / 20Arms)

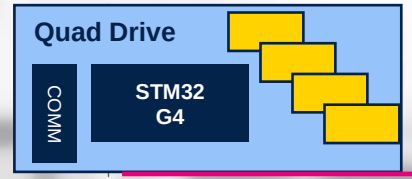
Available
@ MCCC



STSPIN32G4 / STM32G4
1kW Dual Servo with EtherCAT
(Upto 60V / 20Arms each)



GaN based multi-motor
servo drive solution



STM32G4
Multi Motor Drive

2021 2022 2023 2024 2025

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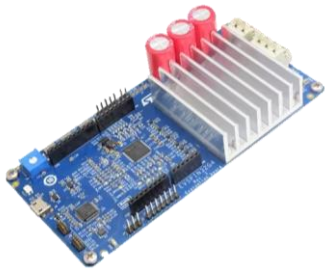
Motor Control
Competence
Center

Battery-powered applications

Reference Solutions

B-G431B-ESC1
Based on STM32G431
FOC – HSO sensorless



EVSPIN32G4NH
Based on STSPIN32G4
FOC – HSO sensorless

EVSPIN32G4-DUAL
Based on STSPIN32G4
FOC – STO sensorless

STEVAL-ESC002V1
Based on STSPIN32F0A
6step – sensorless

Performance

Integration

Dual motor

Easiness

IPs

(12) United States Patent
Costanzo et al.
(10) Patent No.: US 11,105,836 B2
(45) Date of Patent: Aug. 31, 2021

Single shunt current sensing: breaks all barriers of state-of-art

Achieves :

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

(12) United States Patent
Costanzo et al.
(10) Patent No.: US 11,757,345 B2
(45) Date of Patent: Sep. 12, 2023

Dual motor shared current sensing

Achieves:

- **Savings on current sensors**
- **Savings on PCB space**
- **Savings on MCU pinout assignment**

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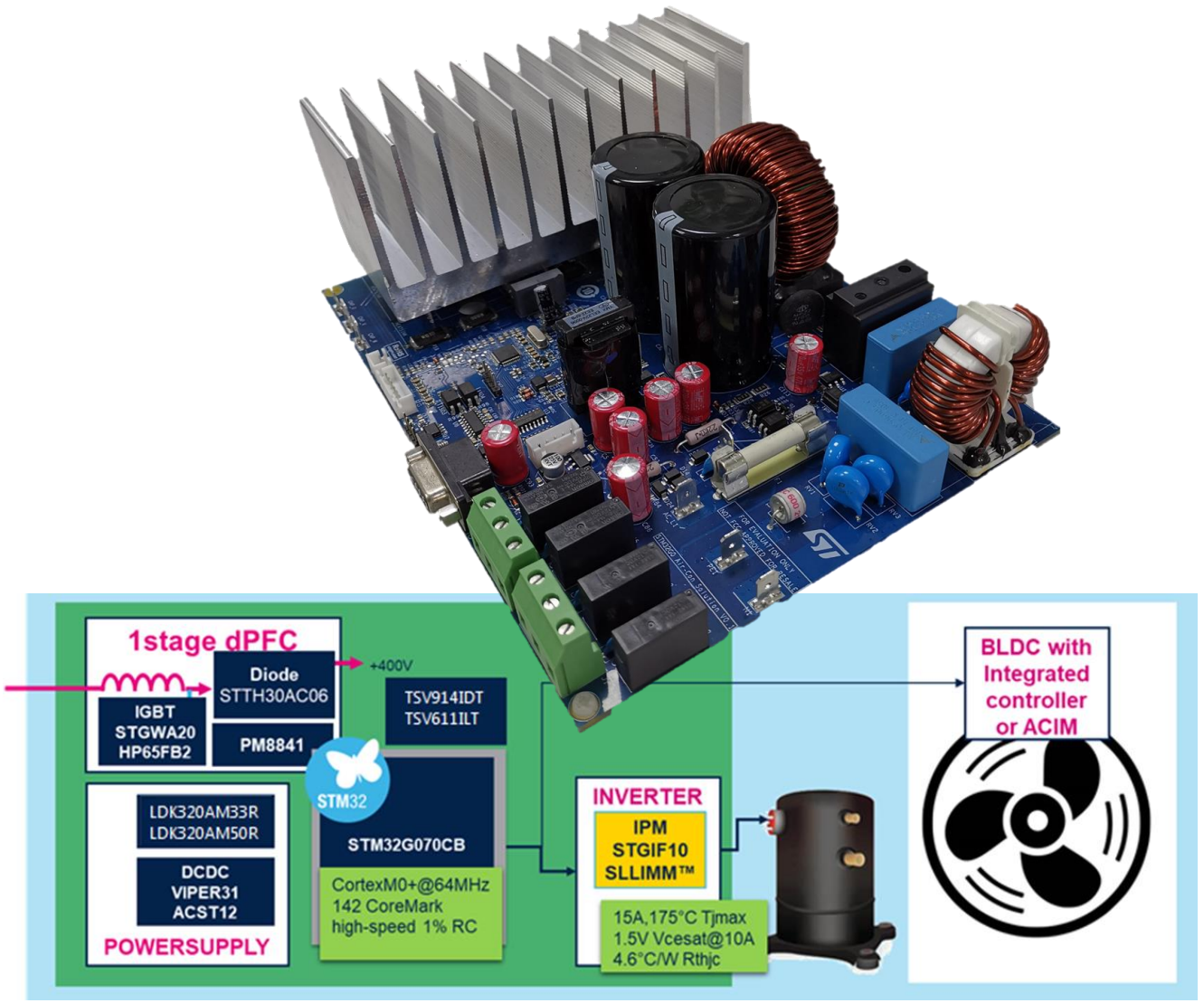
Single FOC + d-PFC
2 kW STM32G0 room aircon solution



- STM32G0 MCU drive all functions
- Compatible with all architectures
  - BLDC fan with 5 wires
  - ACIM fan
- Innovative FW architecture for integration of MC and dPFC
  5kHz / 40kHz ; 65~ CPU load
- FW module for 5 wires fan control
- ST SLLIMM IPM
  - High Energy Efficiency
  - DBC / FM wide portfolio
- High Frequency 40kHz dPFC
  - IGBT TFS
  - Ultrafast “AC” rectifier

Motor Control
Competence
Center

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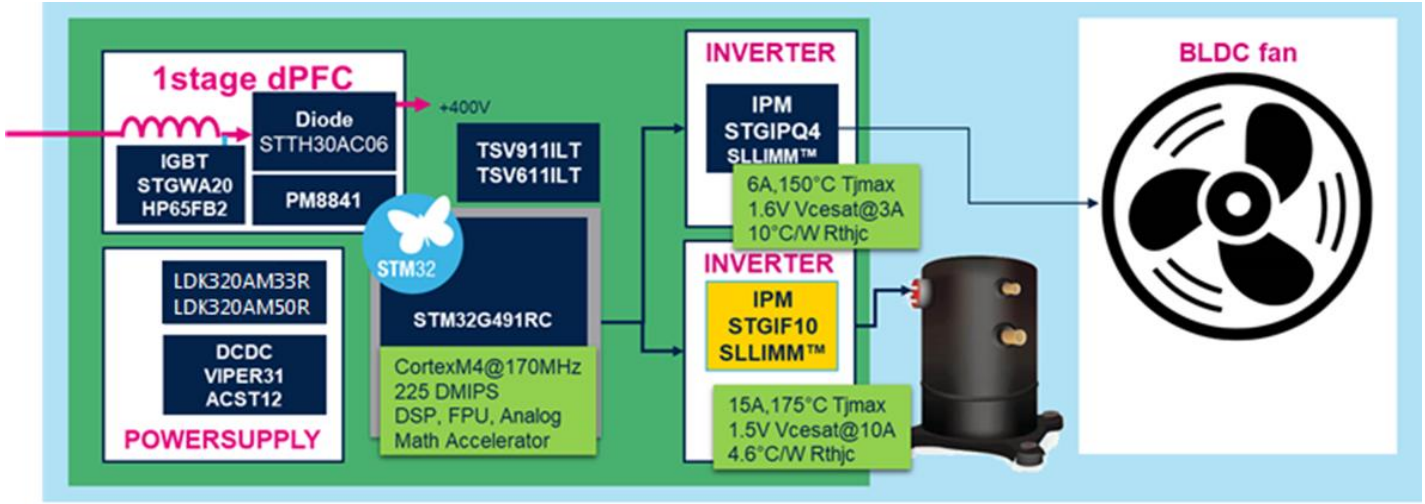
Dual FOC + d-PFC
2 kW STM32G491 room aircon solution



- One STM32G4 MCU only to drive all functions
  - Reduced number of components
  - No need sync between controllers
  - One FW workspace only
  - MC SDK v5.Y
- ST SLLIMM IPM
  - High Energy Efficiency
- High Frequency dPFC 60kHz
  - SJ MOSFET / IGBT
  - SiC diodes

Motor Control
Competence
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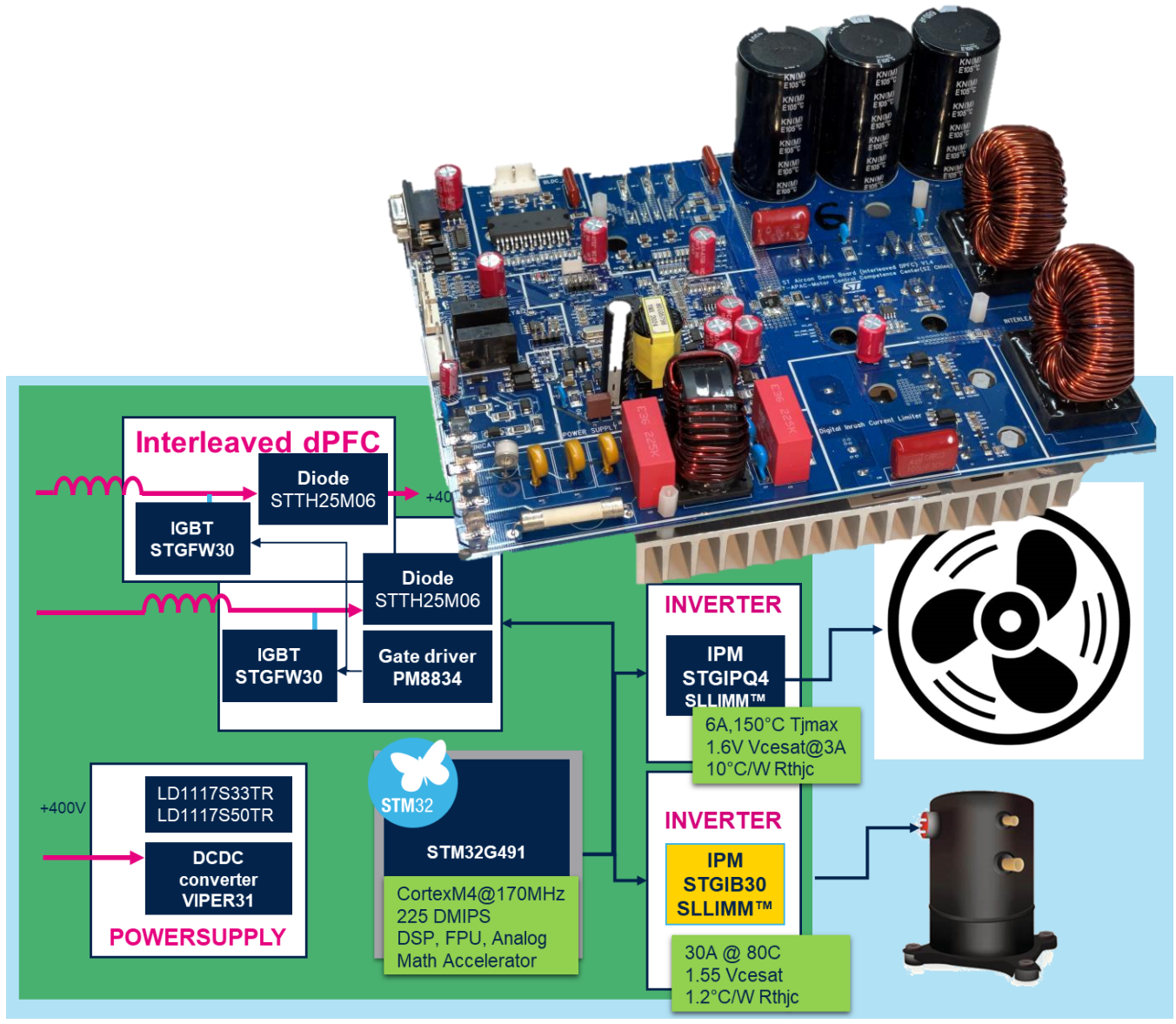
Dual FOC + d-I-PFC
4 kW STM32G4 commercial aircon



- One STM32G4 MCU only to drive all functions
  - Reduced number of components
  - No need sync between controllers
  - One FW workspace only
  - MC SDK v5.Y
- ST SLLIMM IPM
  - High Energy Efficiency
- High Frequency d-i-PFC 60kHz
  - SJ MOSFET / IGBT
  - SiC diodes

Motor Control
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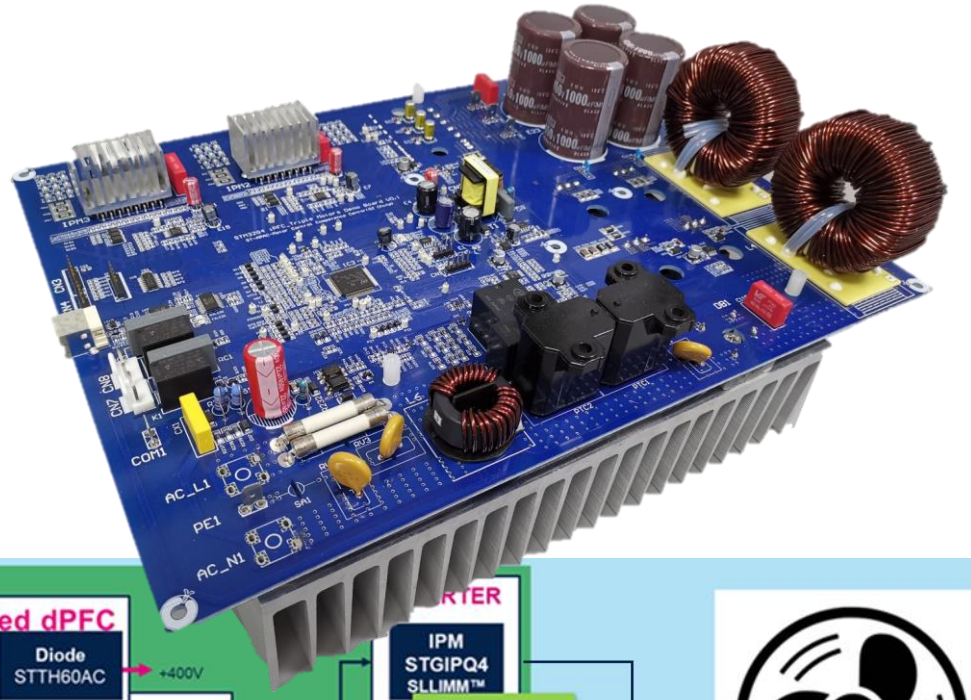
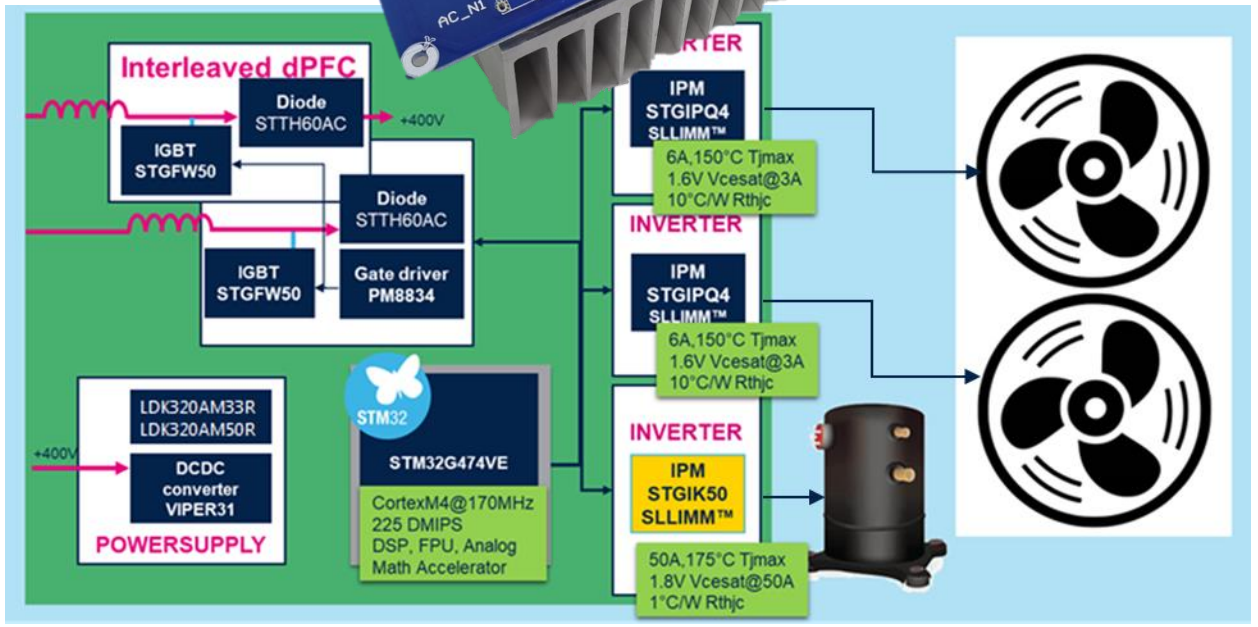
Triple FOC + d-I-PFC
7 kW STM32G4 world class comm aircon





- One STM32G4 MCU only to drive all functions
  - Reduced number of components
  - No need sync between controllers
  - One FW workspace only
  - MC SDK v5.Y
- New ST HP SLLIMM 50A
  - High Energy Efficiency
- High Frequency d-i-PFC 60kHz
  - SJ MOSFET / IGBT
  - SiC diodes

Motor Control
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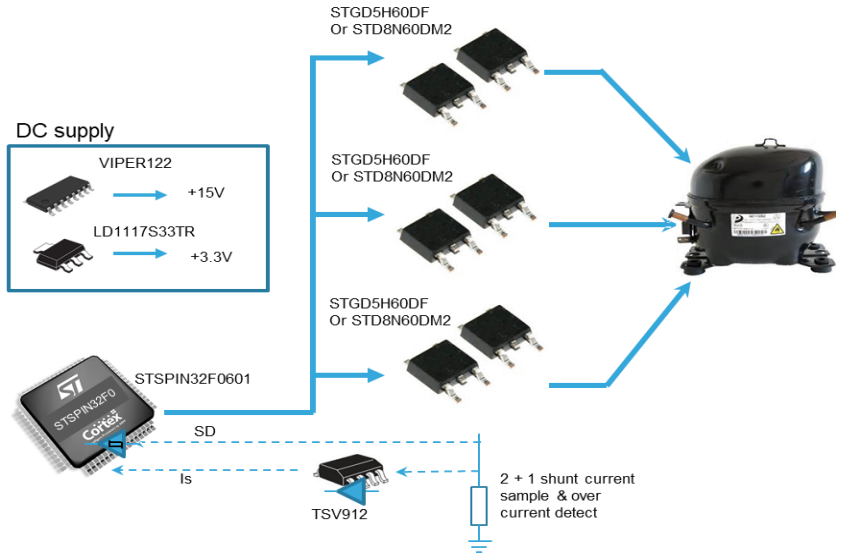
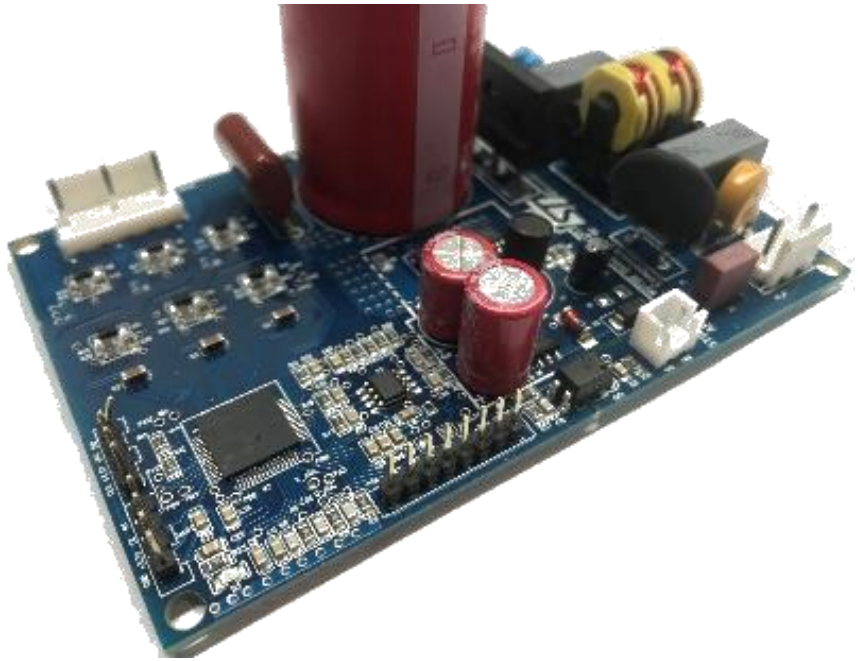
STSPIN32F0601 + TGFS IGBT/SJ MOS 250 W MC fridge solution





- High Integration SiP, with embedded HW protections OCP & UVP
- High Energy Efficiency with TGFS IGBT / SJ MOSFET
- STSPIN32F0601 -40C to 125C
- Standby power<30 mW @ 230 VAC

Motor Control
Competence
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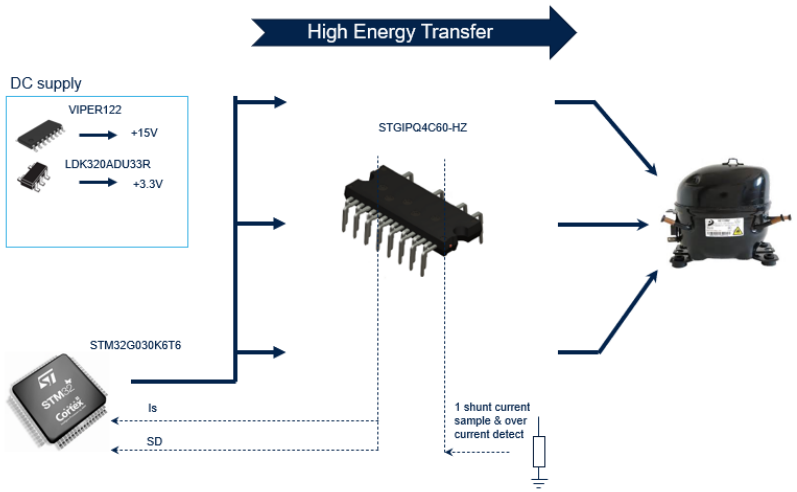
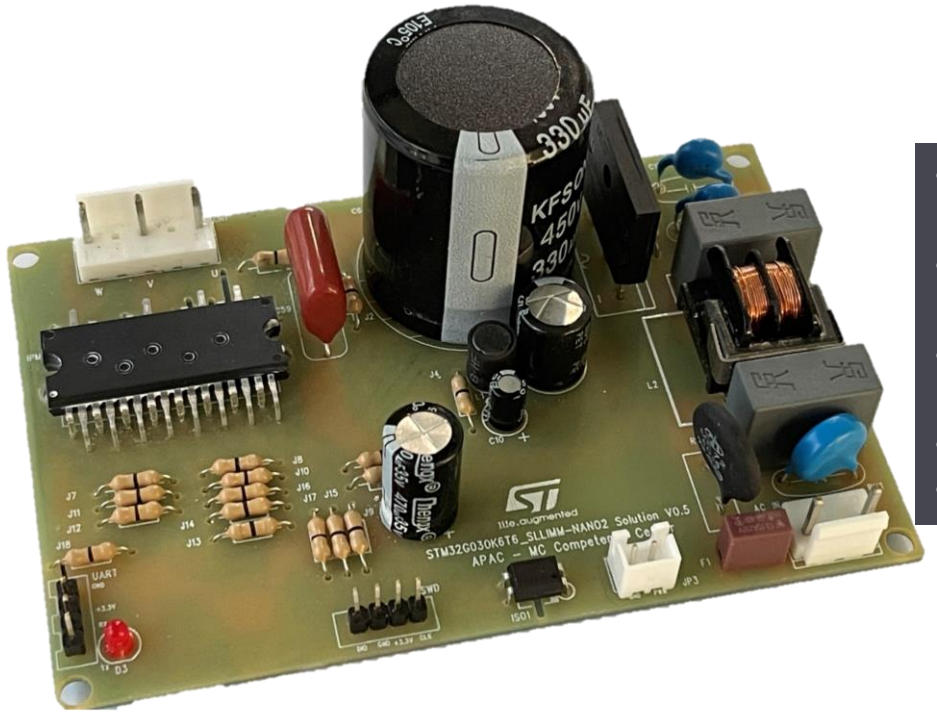
STM32G0 + SLLIMM nano IPM 250 W MC fridge solution





- High Integration Fridge Solution STM32G0 + SLLIMM 6A IPM
- Embedded OCP & OPAMP embedded in SLLIMM nano
- High Energy Efficiency with TGFS IGBT
- Single Layer PCB
- Standby power<30 mW @ 230 VAC

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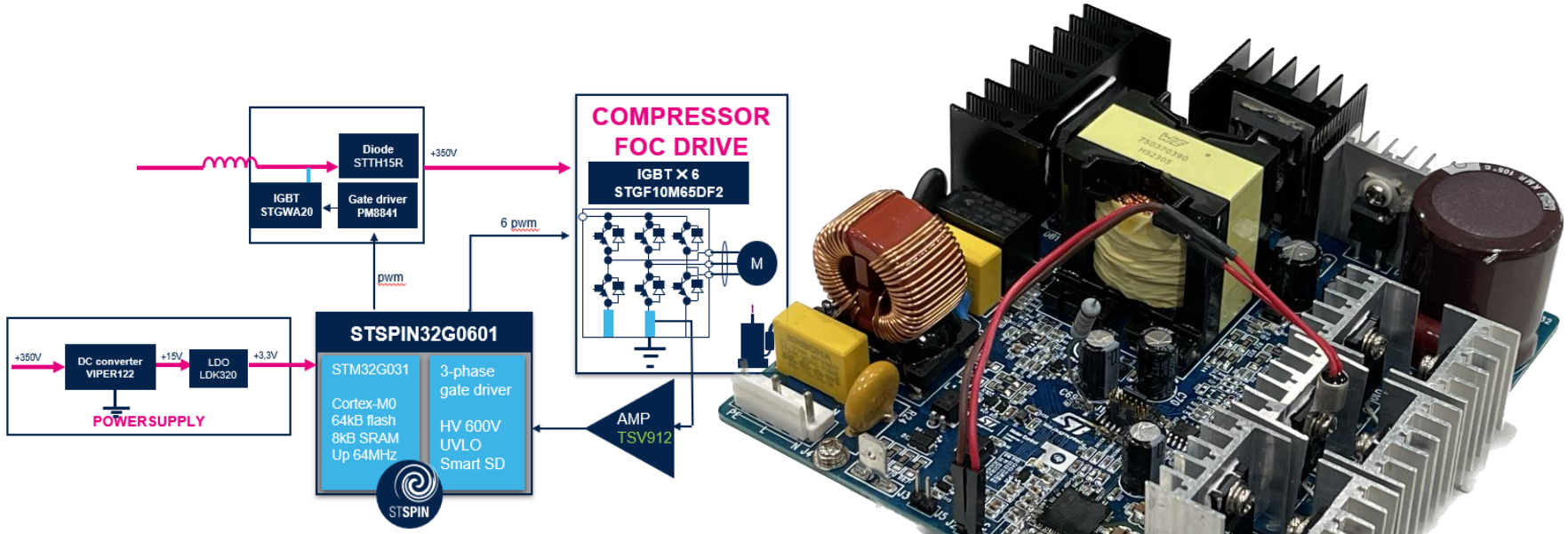
STSPIN32G0601 + TGFS IGBT
700 W commercial fridge MC & dPFC CCM



- STSPIN32G0 drive all functions, MC and CCM dPFC
- Qualified dPFC IEC 61000-3-2
- Innovative FW architecture for integration of MC & dPFC @40kHz
- High Integration SiP, with embedded HW protections
- High Energy Efficiency with TGFS IGBT and Ultrafast rectifier
- MC Switching Frequency 4~6.6 kHz
- Standby power<30 mW @ 230 VAC

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Servo drives orchestra
Scalable Solutions

EVLSPIN32G4-ACT
Smart Actuators
interfacing with STWIN.box





Key Products

- STM32G4 MCU / STSPIN32G4 SiP
- 100V STripFET F7 Power MOSFET
- Wide-bandwidth rail to rail Op-Amps

Features

- High Integration SiP
  for reduced PCB size and BOM
- High Power Density
- Ready solution with Realtime Fieldbus

Key Products

- STM32H7 MCU
- 650V e-mode PowerGaN
- High Speed Half-bridge drivers for GaN
- VIPerPlus high voltage converter

Features

- System-level High Energy Efficiency
- Reduced Torque Ripple
- Reduced PCB size
- Optimized GaN driving voltage and transients

Key Products

- STM32H7 MCU
- 1200V SiC MOSFET in ACEPACK SMIT package
- STGAP2SICS galvanic isolated gate drivers

Features

- High Power Density
- Reduced losses at high temperatures
- Overall reduction of system cost

Key Products

- STM32H7 MCU
- 1200V IGBT in ACEPACK SMIT package
- STGAP2HD galvanic isolated gate drivers
- Galvanic isolated Sigma-Delta modula-

Features

- SIL2 certification assessment from TÜV
- Currents sensing SigmaDelta modulators
- SafeTorqueOff (STO) SafeBrakeControl (SBC)

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STM32 STPOWER STSPIN STDRIVE VIPer ST Op Amps ST PROTECT STGAP

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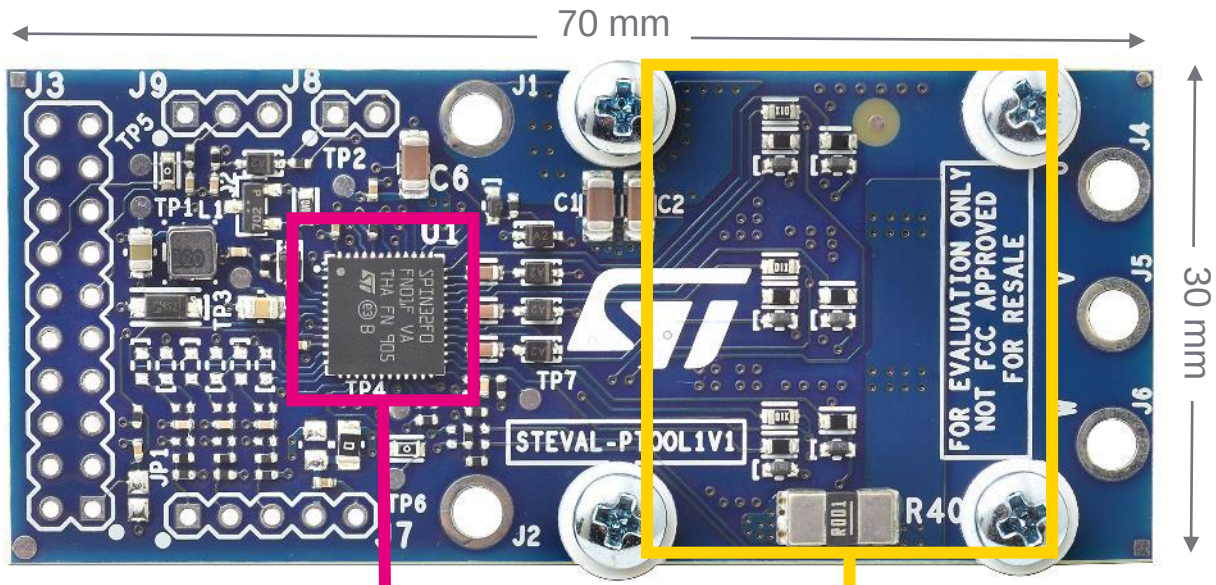
36 V

STEVAL-PTOOL1V1
Low voltage solution for power tools



STSPIN32F0B
45 V fully integrated
3-phase BLDC driver (600 mA)

STL180N6F7
60 V, 1.9 mΩ MOSFET
(Bottom side)

Key products

- **STSPIN32F0B:** Arm Cortex®-M0 MCU + 3-phase gate driver 0.6 A
- **STL180N6F7:** 60 V 1.9 mΩ MOSFET F7 series

Key features

- 6-step single shunt with Hall sensor inputs
- Designed for 2S-6S pack of LiPo batteries
- Max operating ratings: 45 V, 15 A_{RMS}
- Very low standby power consumption
- Trigger, direction, and speed inputs are available
- Speed control potentiometer available
- Over current protection: programmable VTH
- Mounting options for:
  - Field oriented control, sensorless / sensored
  - BEMF detection circuitry
- Ready-to-use dedicated 6-step firmware package
- Heatsink option

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36 V

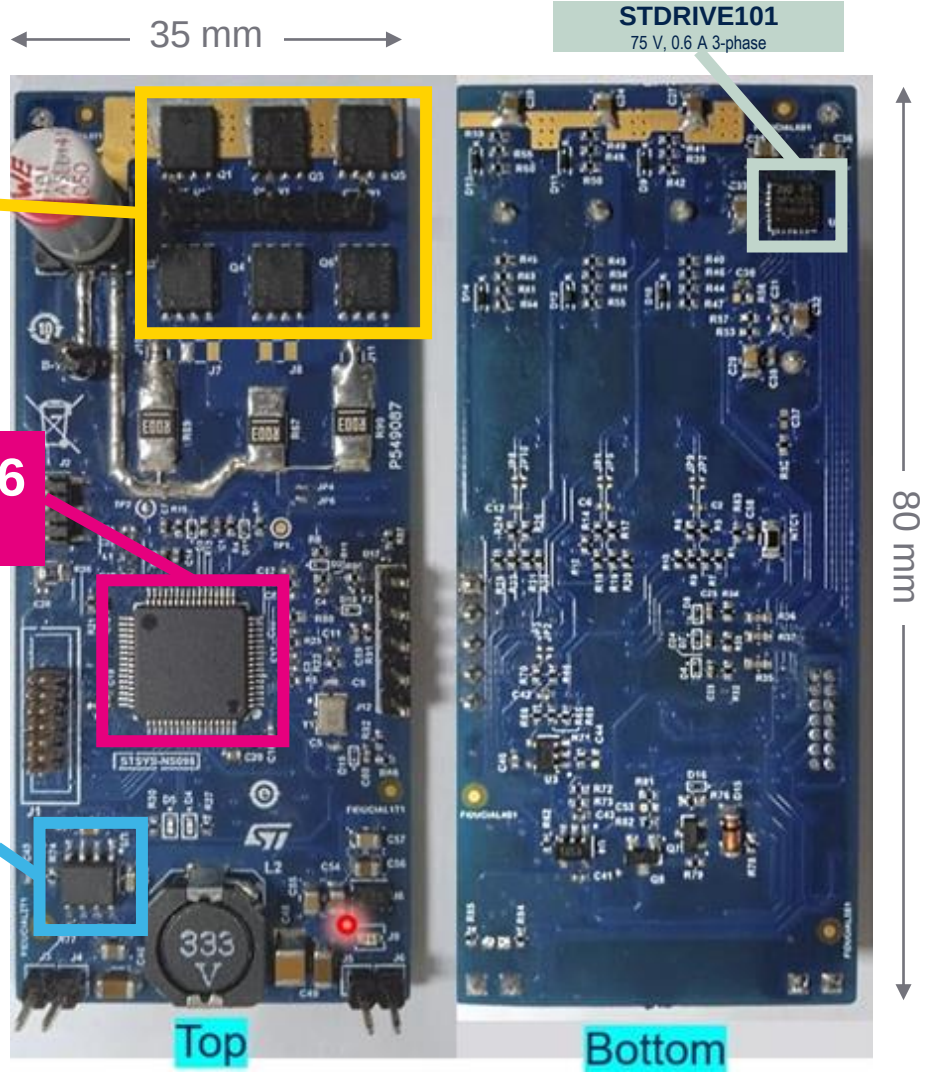
STDRIVE

STDES-PTOOL3A low voltage solution

STL220N6F7
60 V, 1.2 mΩ MOSFET

STM32G431RBT6
(M4+core @170 MHz)

L6981NDR
(38 V, 1.5 A, DC-DC converter)



Key products

- **STM32G431:** Arm Cortex®-M4 MCU @ 170 MHz
- **STDRIVE101:** 3-phase gate driver. 75 V, 0.6 A
- **STL220N6F7:** 60 V 1.2 mΩ MOSFET F7 series
- **L6981NDR:** 38 V, 1.5 A, DC-DC converter

Key features

- Field oriented control, three/single shunt
- ZeST firmware for torque maximization at very low speed
- Designed for 5S-6S pack of LiPo batteries
- Max operating ratings: 38 V, 18 A_{RMS}
- Very low standby power consumption
- Trigger, direction, and speed inputs are available
- VDS protection
- Over current protection
- Mounting options for:
  - 6-Step sensor less control (cycle-by-cycle CL)
  - BEMF detection circuitry
- 1 UART, 1 I²C, and 1 SPI interface for debugging, I/O expanders, Bluetooth Low Energy, LCD, GNSS, MEMS
- Heatsink (optional)

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48 V

Available in Q1’24

STEVAL-PTOOL4A
Low-medium voltage solution

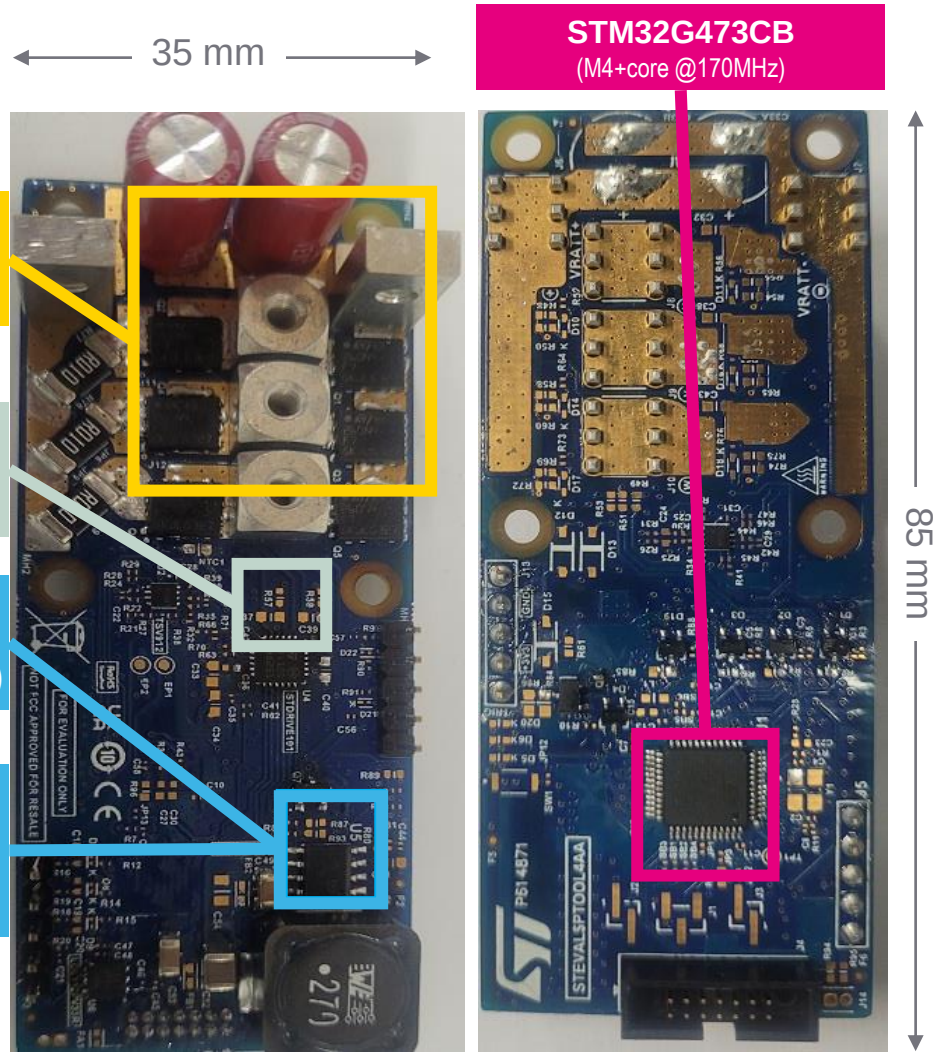
STL220N6F7
60 V, 1.2 mΩ MOSFET

STDRIVE101
75 V, 0.6 A 3-phase

L6981NDR
(38 V, 1.5 A, DC-DC converter)

OR

L7987L
(61 V, 2 A, DC-DC converter) daughterboard



Key products

- **STM32G473:** Arm Cortex®-M4 MCU@170Mhz
- **STDRIVE101:** 3-phase gate driver. 75 V, 0.6A
- **STL220N6F7:** 60 V 1.2 mΩ MOSFET F7 series
- **L6981NDR** 38V, 1.5A, DC-DC converter, option for L7987L 61V, 2A

Key features

- Field oriented control, three/single shunt
- ZeST firmware for torque maximization at very low speed
- Designed for 5S-6S pack of LiPo batteries
- Max operating ratings: 48 V, 18 A_{RMS}
- Very low standby power consumption
- Trigger, direction, and speed inputs are available
- VDS protection
- Over current protection
- Mounting options for:
  - 6-Step sensor less control (cycle-by-cycle CL)
  - BEMF detection circuitry
- 1 UART and 1 SPI interface for debugging, I/O expanders, Bluetooth Low Energy, LCD, GNSS, MEMS
- Heatsink (optional)

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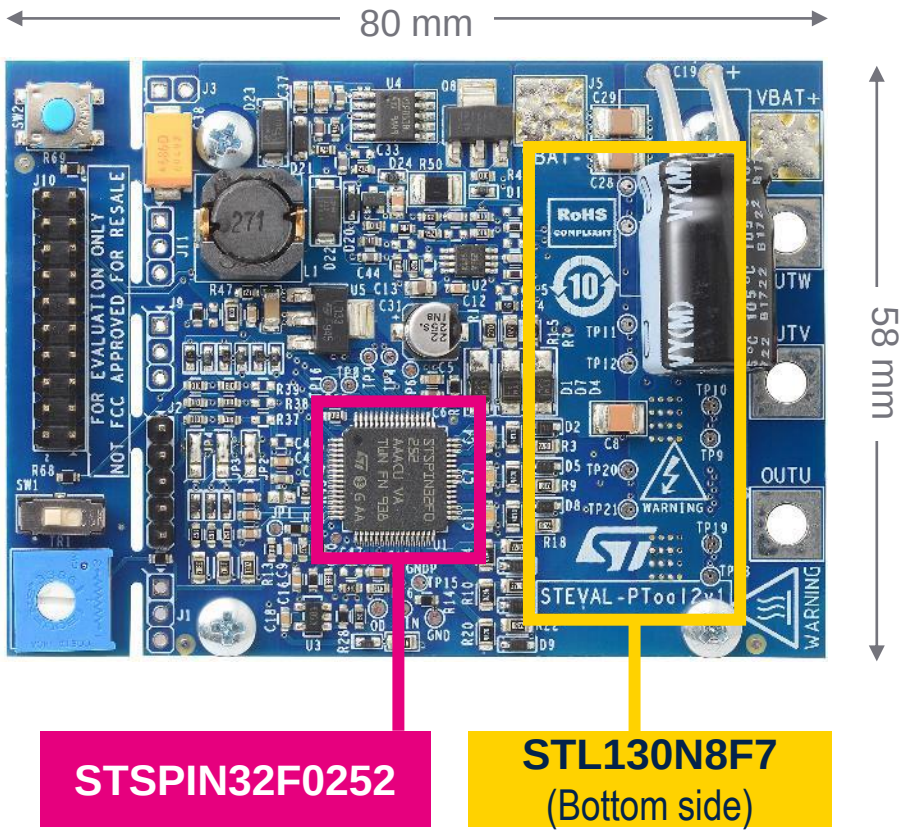
60 V

STEVAL-PTOOL2V1
High-voltage solution



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 sensor inputs
- Designed for 8S-15S pack of LiPo batteries
- Max operating ratings: 80 V, 15 A_{RMS}
- Very low standby power consumption
- Trigger, direction, and speed inputs are available
- Speed control potentiometer available
- Over current protection
- Mounting options for:
  - Field oriented control, sensor less / sensored
  - BEMF detection circuitry
- Ready-to-use dedicated 6-step firmware package
- Heatsink (54 x 54 x 20 mm)

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Our technology starts with You

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