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Safe and efficient control and drive solution for 48V industrial motors

STMicroelectronics

48V drive system: more efficiency and safety

- Introduction
- 5 kW Low Voltage Drive System
- STripFET F7 MOSFET Performance
- Conclusion

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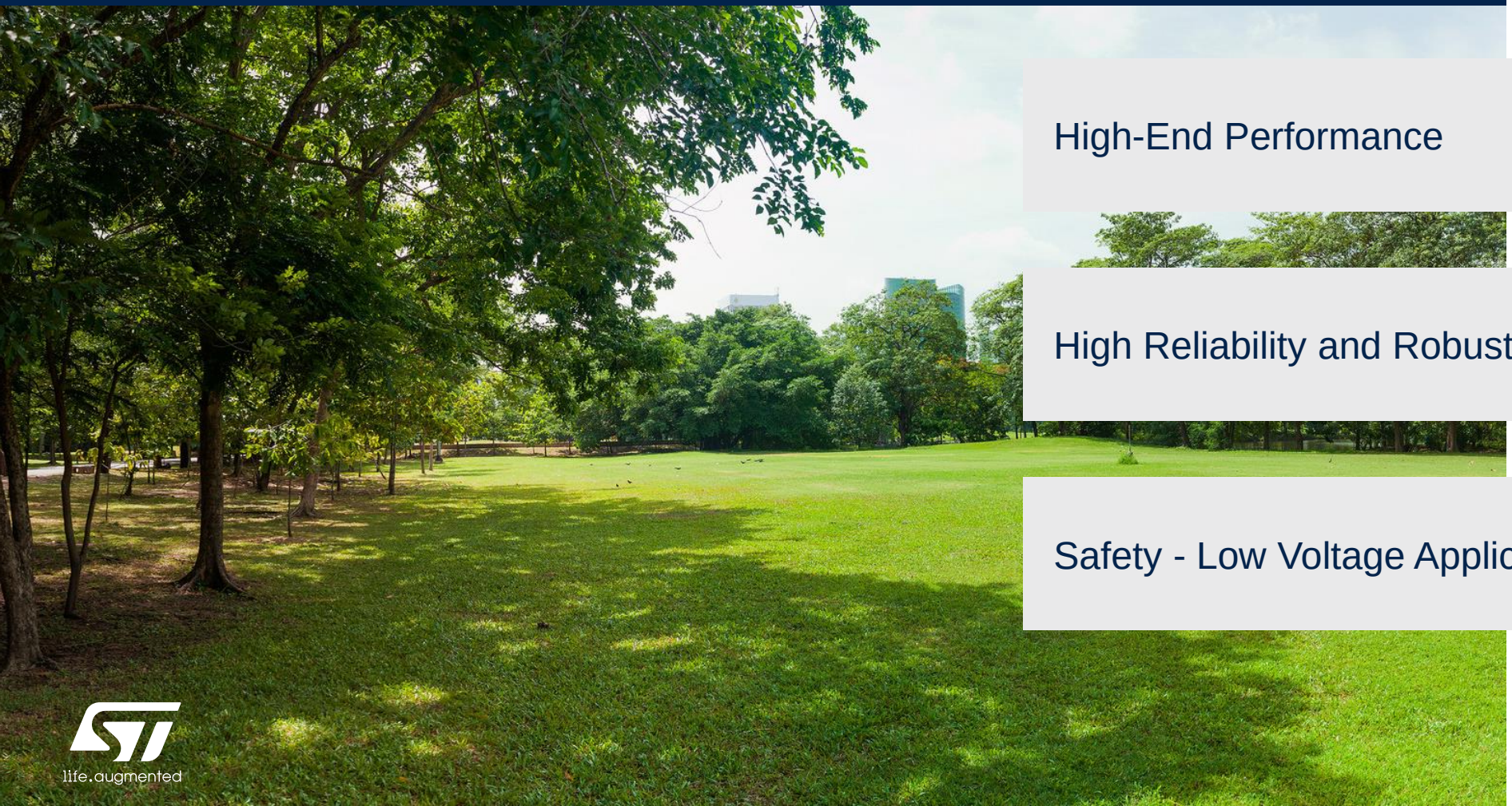
Introduction

Battery Operated Low Voltage Drive System



High-End Performance

High Reliability and Robustness

Safety - Low Voltage Application

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Low voltage drive system overview

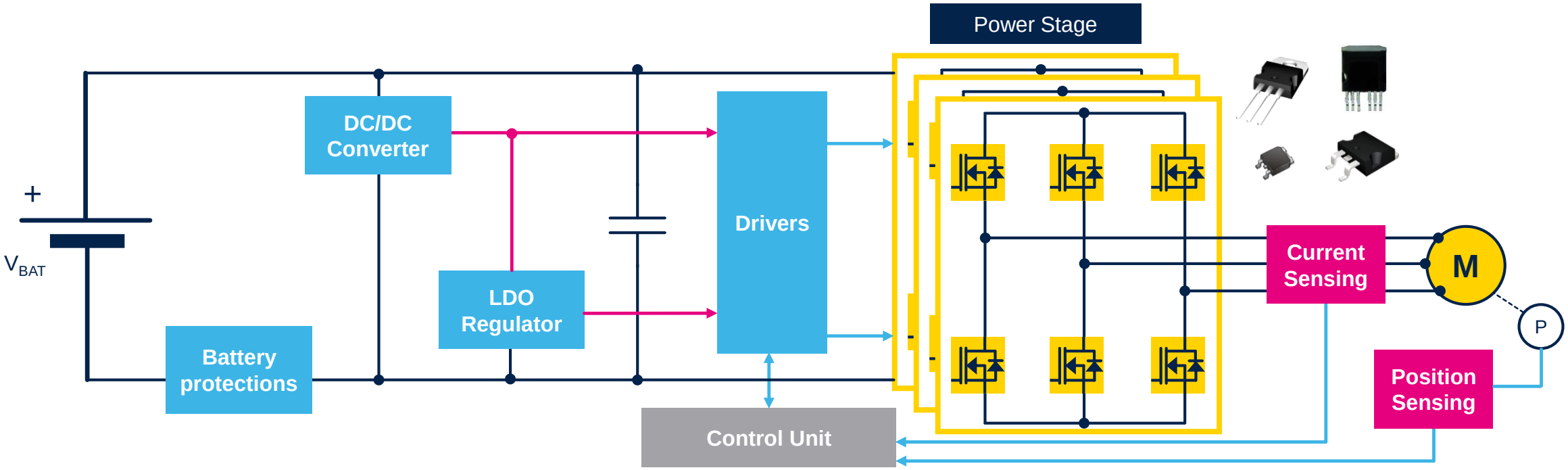
- Battery Operated LV Drive System
  - Higher Reliability
  - Improved Performance/Cost Ratio
  - Reduced Risk of Electric Injury

- Target Applications:
  - Forklifts and Golf Carts
  - Low Speed EV and E-Bikes
  - Professional Power and Garden Tools
  - Robots and Vacuum Cleaners

Typical drive system structure

Driver stage: High performance gate drivers, Smart shutdown, Interlocking

Power Stage: Reliability, Robustness



Control Stage: Driving algorithm, Safety procedures

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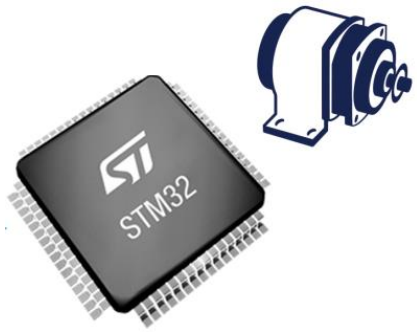
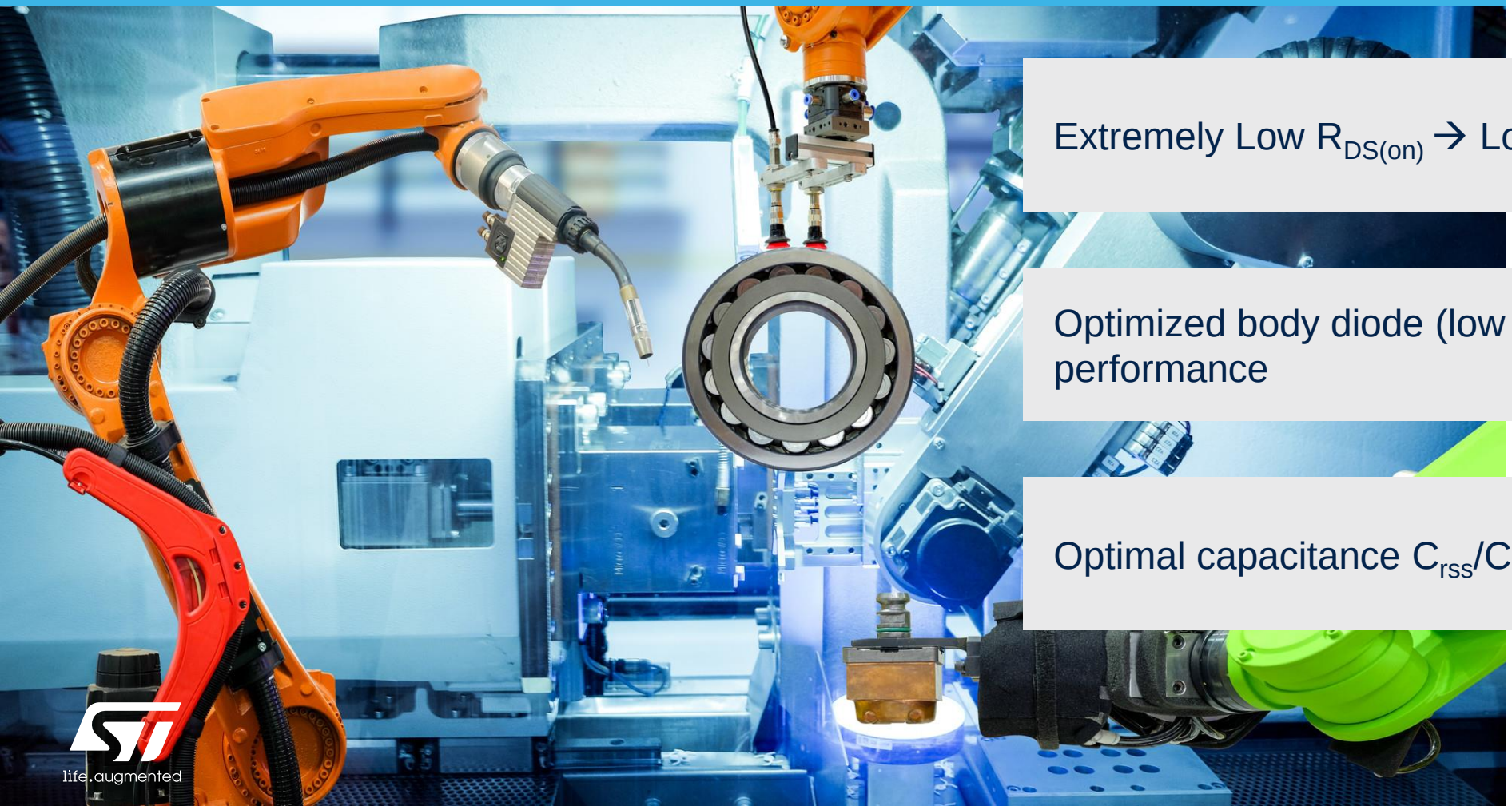
Drive system – key products

- STMicroelectronics is able to cover all the functional segments
- Power Stage - Power MOSFETs – STripFET F7 Technology
  - Enhanced trench gate structure offering a very low on-resistance
  - Optimized C_{rss}/C_{iss} ratio to reduce EMI emissions
- Driver Stage – High Performance Gate Drivers
  - High current capability and high switching performance
  - Smart protections – Smart shutdown, interlocking, comparators
- Control Stage – 32 bit Arm® core MCU
  - Computational power to execute FOC algorithm



40 ÷ 100 V STripFET F7 family

40 ÷ 100 V STripFET F7 Family optimized for LV Motor Control



Extremely Low $R_{DS(on)}$ → Low conduction losses

Optimized body diode (low Q_{rr}) → Excellent switching performance

Optimal capacitance C_{rss}/C_{iss} → No EMI issue

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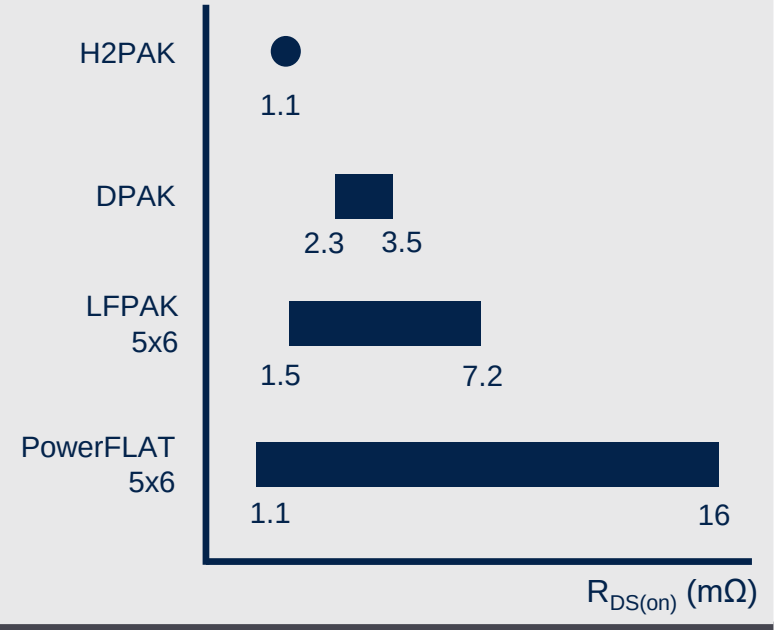
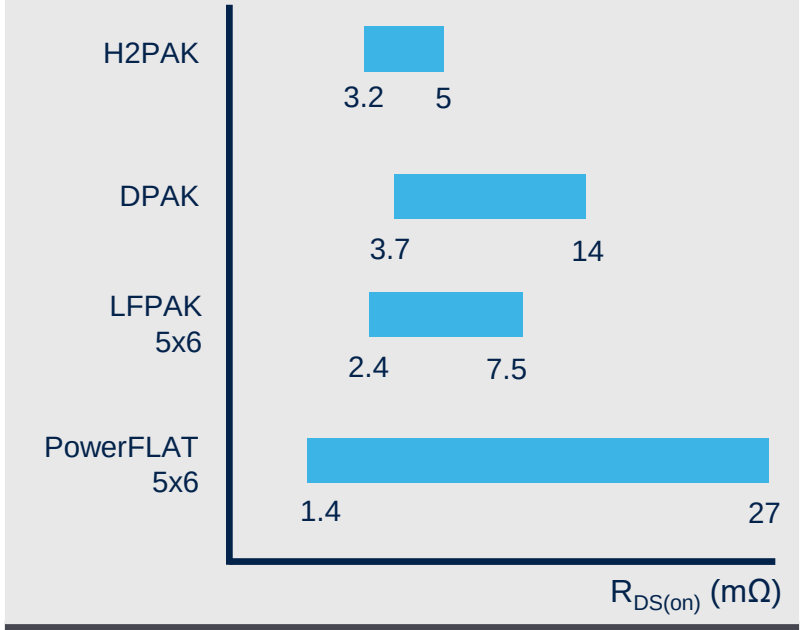
F7 product portfolio: +100 products

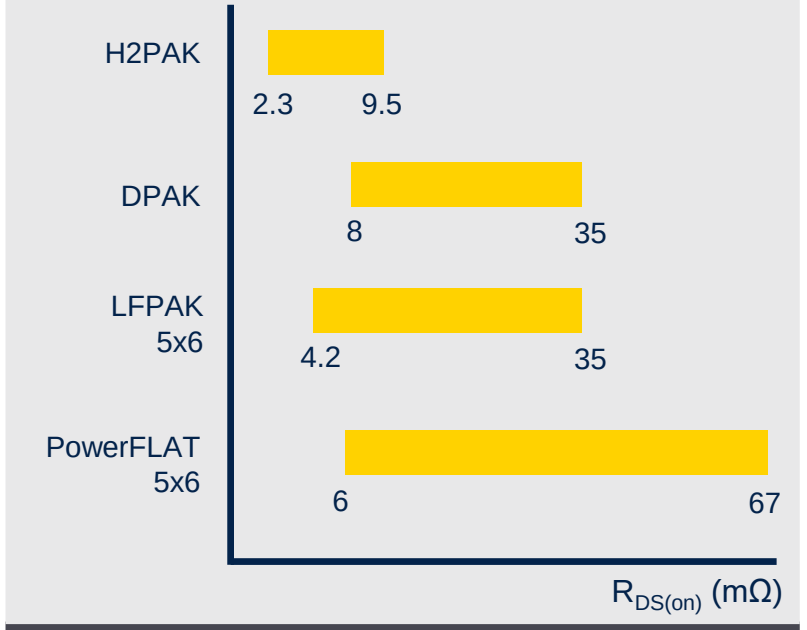
40V



60V – 80V



100V



ST MOSFET Finder

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5 kW low voltage drive system

5 kW Low Voltage Drive System Based on STripFET F7 Family

- Modular System
- High Flexibility
- Full Compatibility with ST Motor Control Ecosystem

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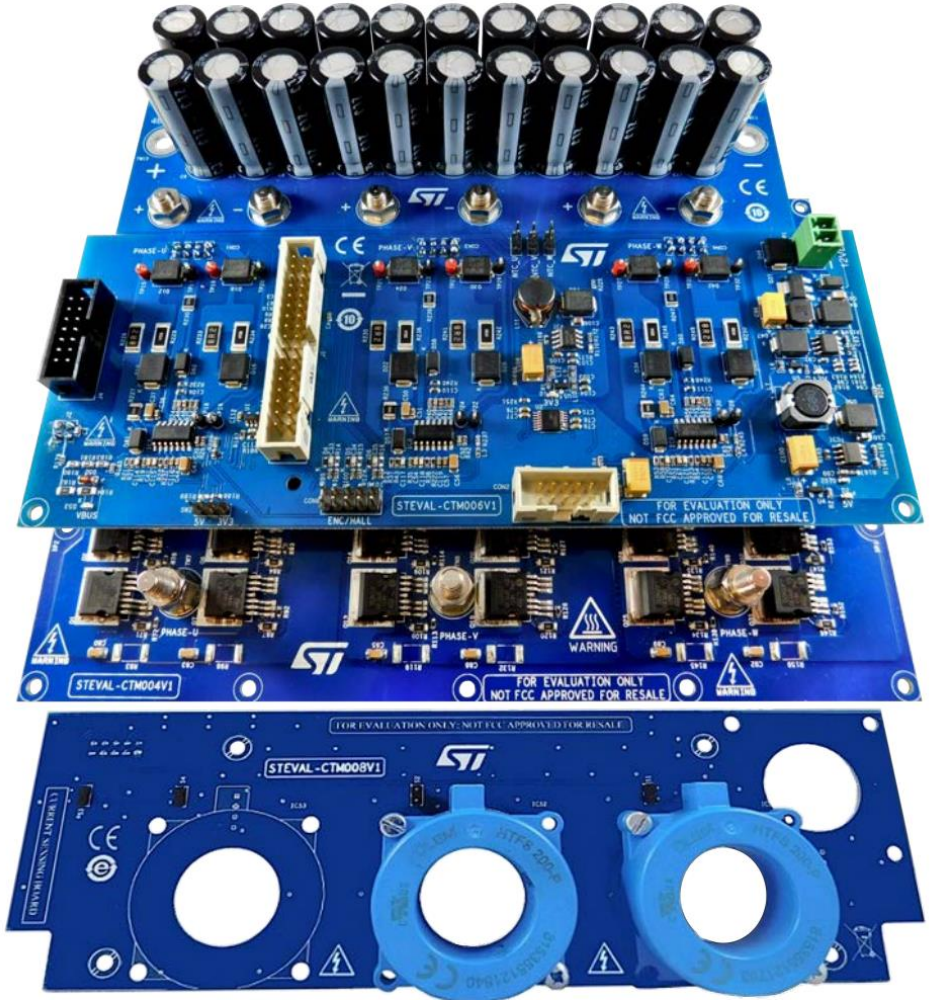
5 kW low voltage drive system - overview

- Stackable solution
  - Power stage
  - Bulk capacitor board
  - Gate driver board
  - Current sensing board
- Motor Control Connector
  - Enables easy interfacing between control and power board
  - Fully compatible with ST Motor Control FOC library
  - Sensored and sensorless operation
- IMS for better heat exchange
- Protections – OC, UV, OV and thermal protection



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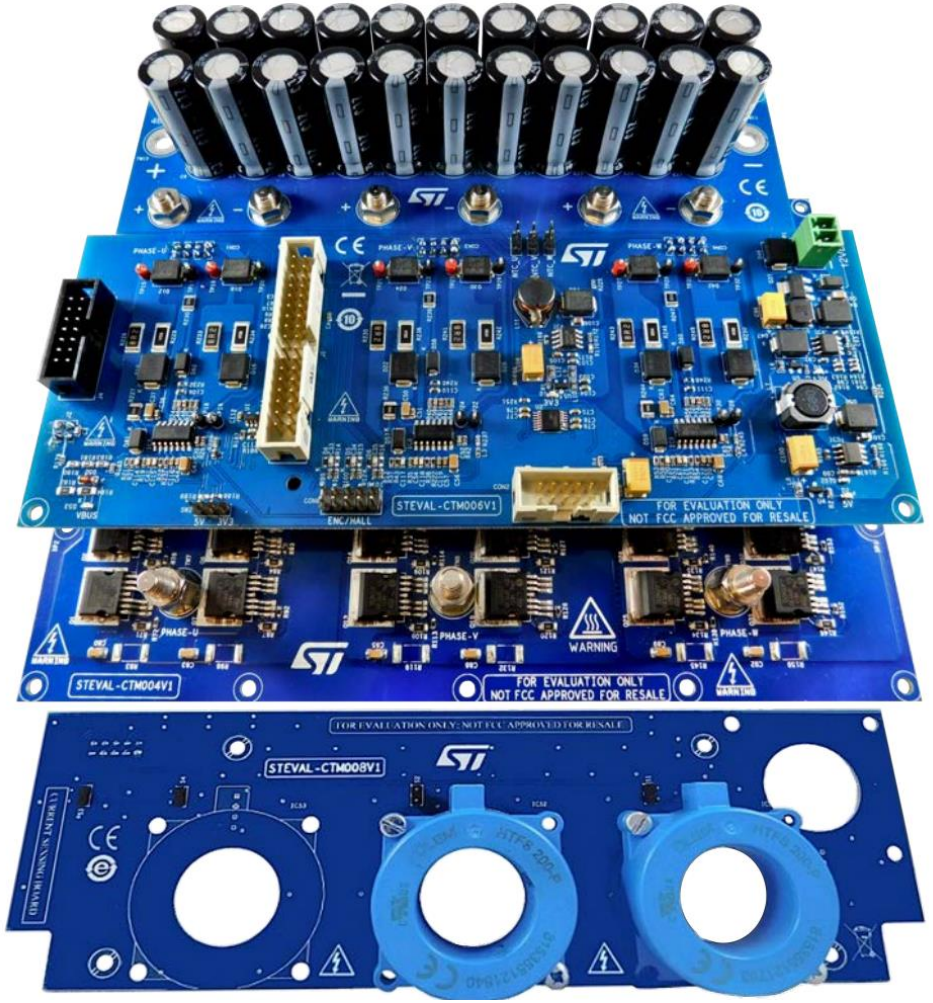
5 kW LV drive STEVAL-CTM009V1

- STEVAL-CTM009V1 Key Components:
  - STH310N10F7-6: 100 V F7 MOSFET - 6 in parallel
  - L6491: High Side and Low Side driver
  - A7986: Buck Boost switching regulator up to 3A
  - A6902: Buck switching regulator up to 1A
  - Also available in AG - STEVAL-TTM001V1



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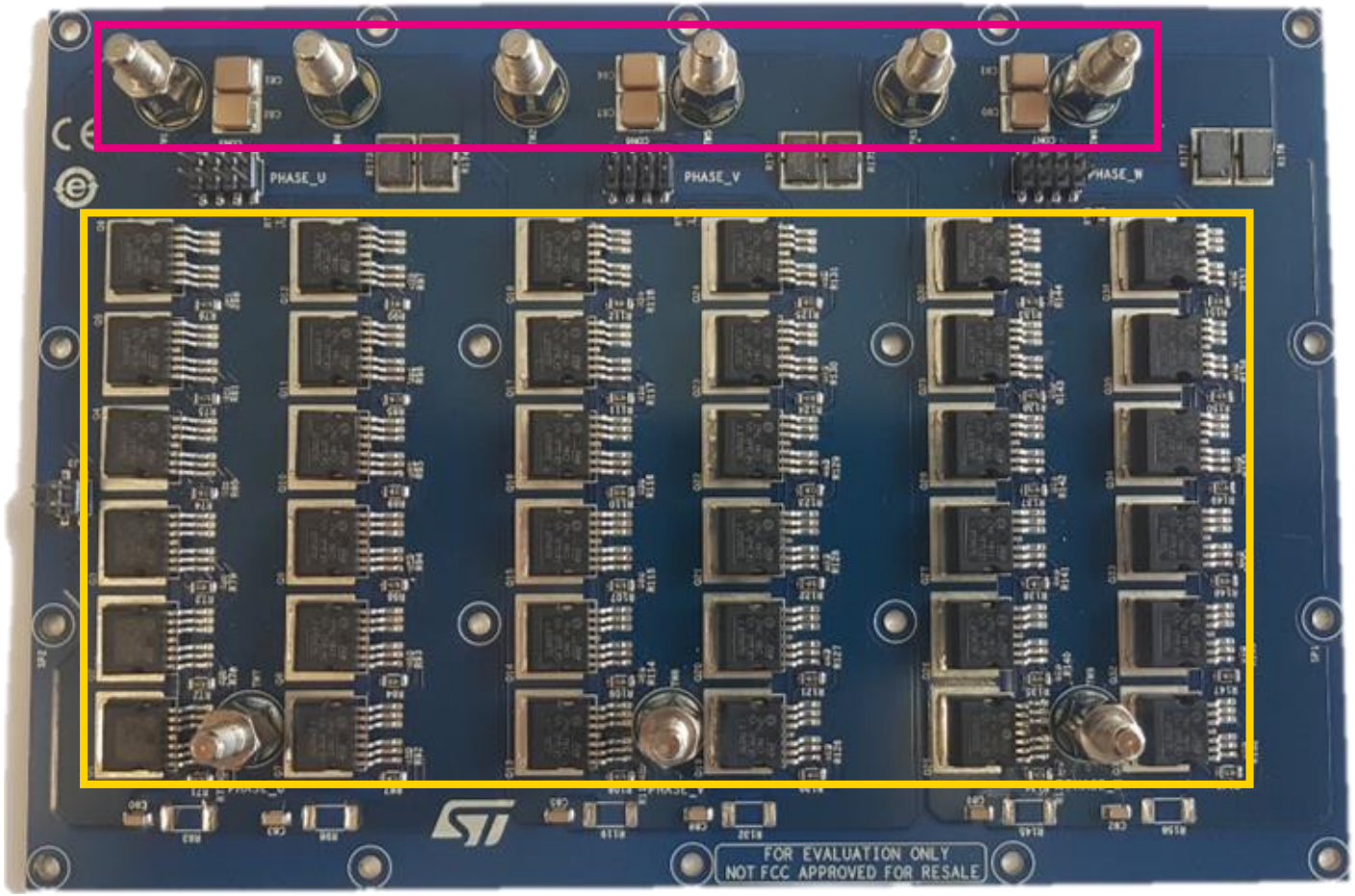
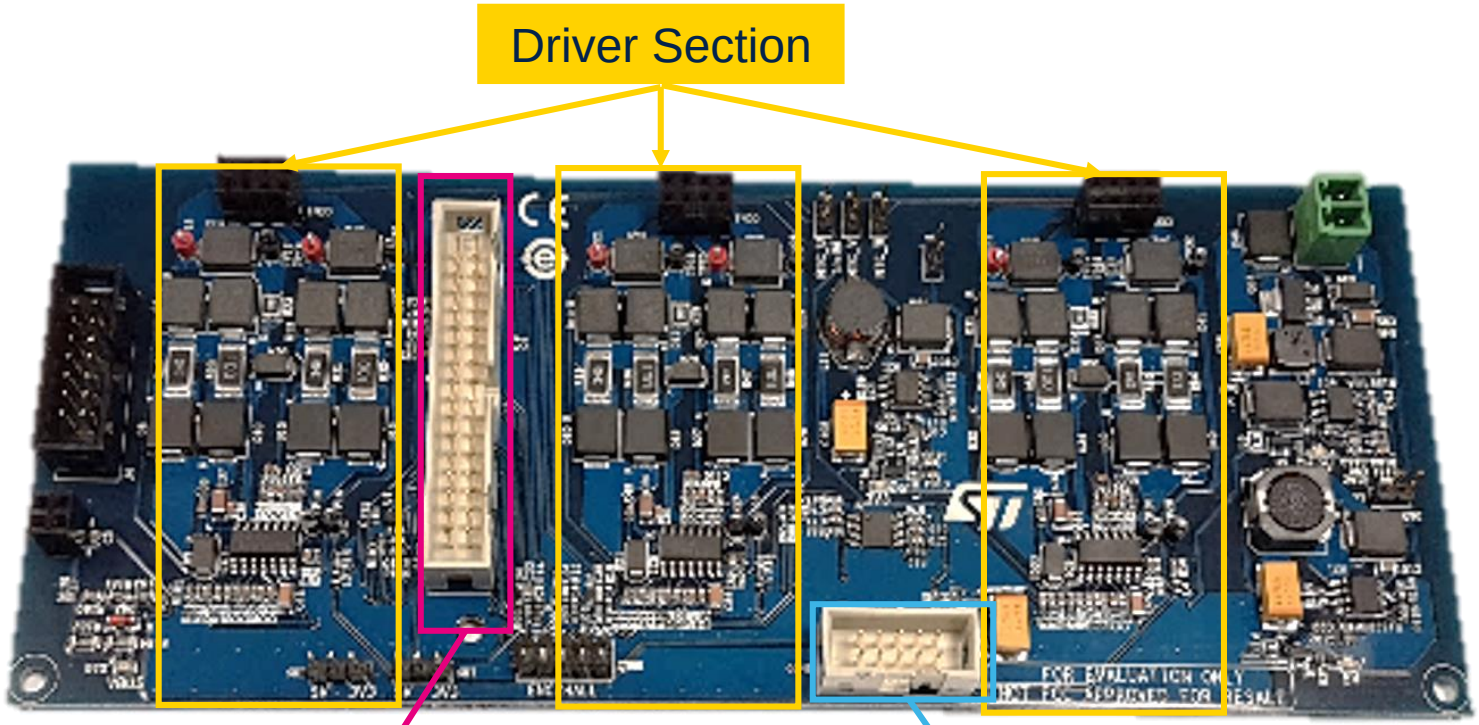
5 kW LV drive system – power board

- Key Features:
  - Insulated Metal Substrate (IMS) for a better heat distribution
  - 36x **STripFET MOSFETs** in **H2PAK-6**
  - 3 symmetrical power path for optimized switching (ringing reduced)
  - 3 Independent DC Bus connections (one on each leg)
  - Decoupling gate resistors (2.2 Ohm) on each gate MOSFET
  - 3 Shunt resistors ground referred (500 µOhm) for OC/SC protection
  - 3 NTCs for temperature monitoring and thermal protection
  - Snubber circuitry on each switch



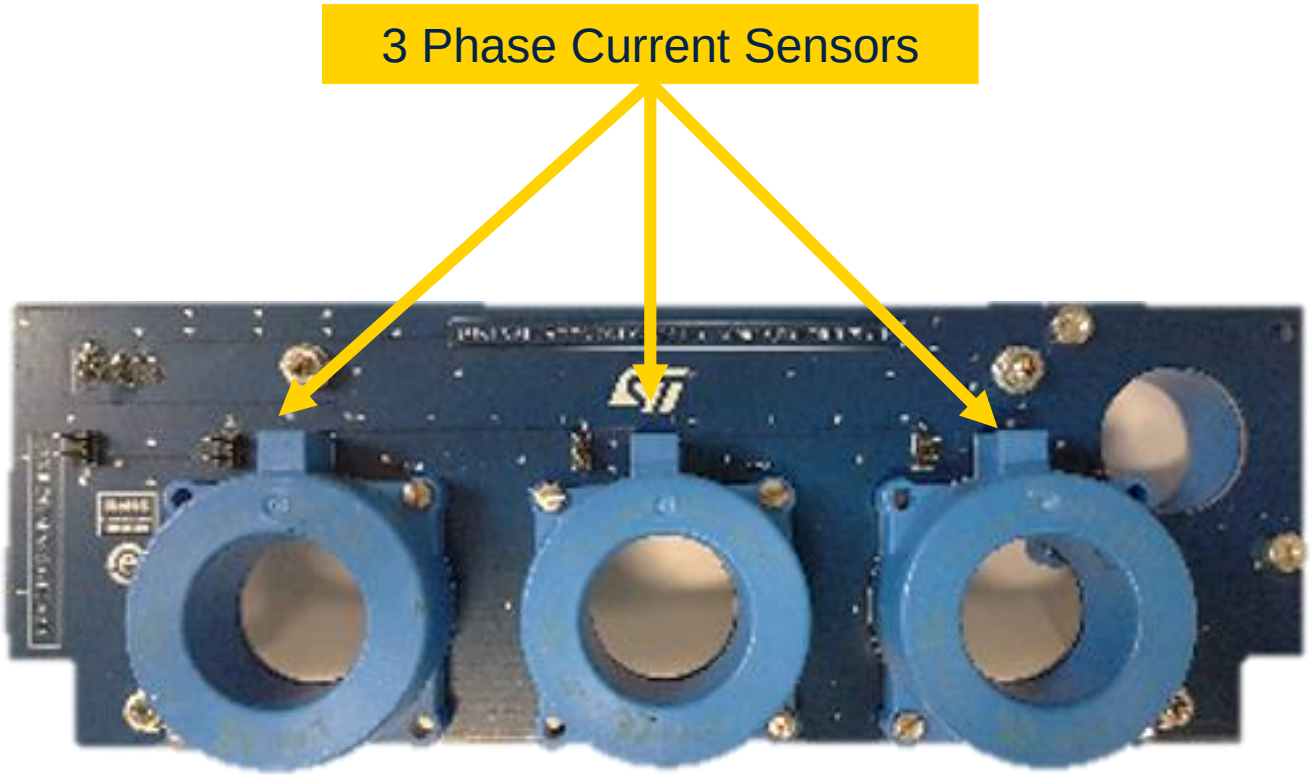
5 kW LV drive system – driver board

- L6491 half-bridge driver:
  - Current capability up to 4 A sink/source
  - Independent driving paths with optimized R_{gon} and R_{goff}
  - Integrated bootstrap diodes
  - Comparators for fault detection
  - Interlocking feature
  - Adjustable deadtime



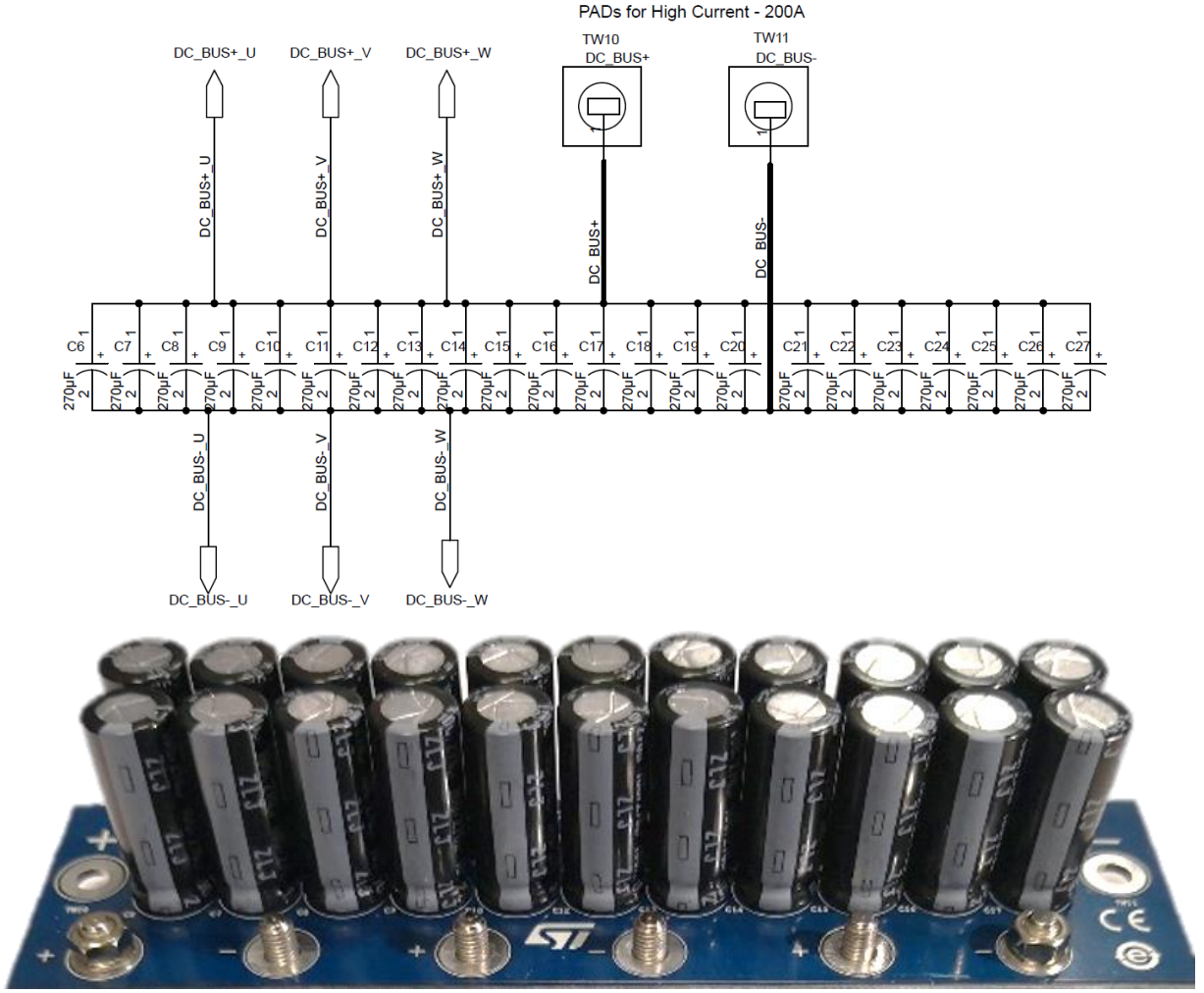
5 kW LV drive system – current sensing board

- Key Features:
  - Galvanic separation for improved signal to noise ratio (insulation not required for safety)
  - High immunity to external interference
  - Accuracy <1% at 200A
  - Non linearity error < 0.5%



5 kW LV drive system – bulk capacitor board

- Bus Link Capacitors:
  - Reduce current ripple
  - Suppress voltage spikes
  - Designed to withstand current ripple caused by low inductance motors



STripFET F7 MOSFETs performance

Experimental Results

- Performance in Parallelization
- Layout Optimization
- Well Balanced Current Sharing

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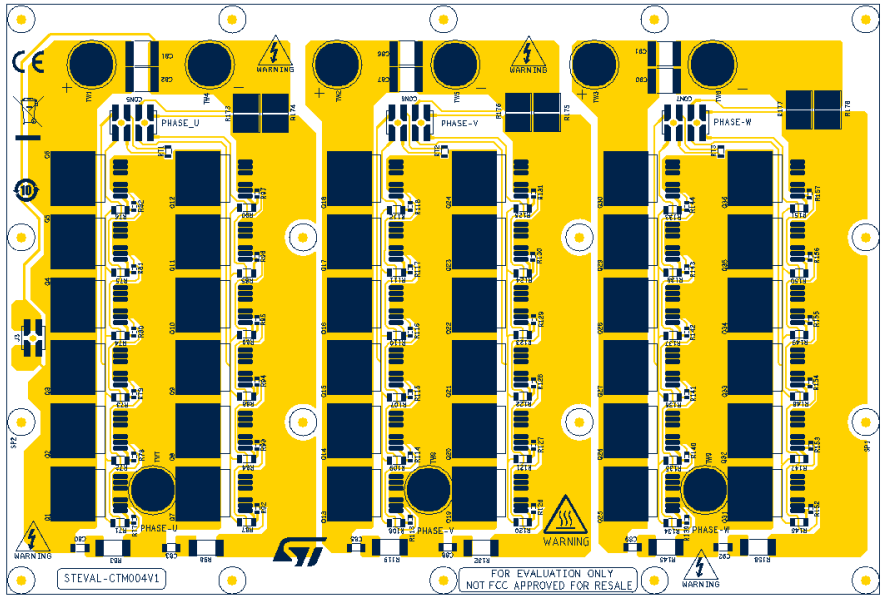
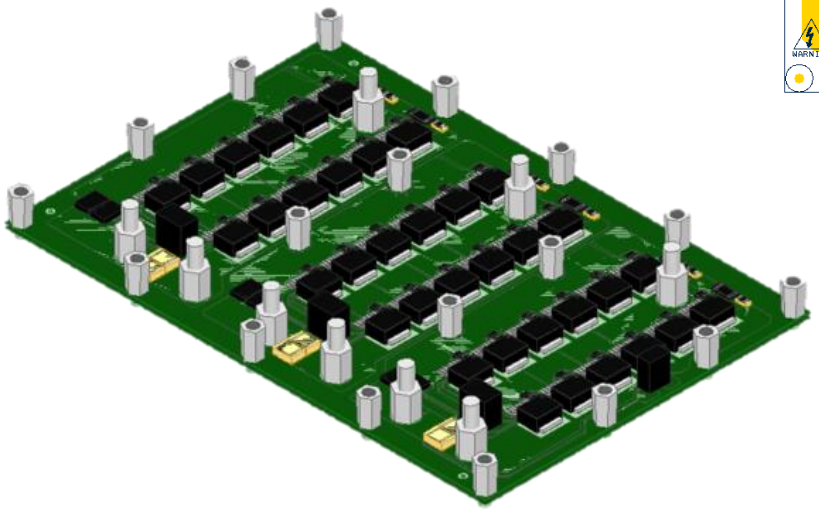
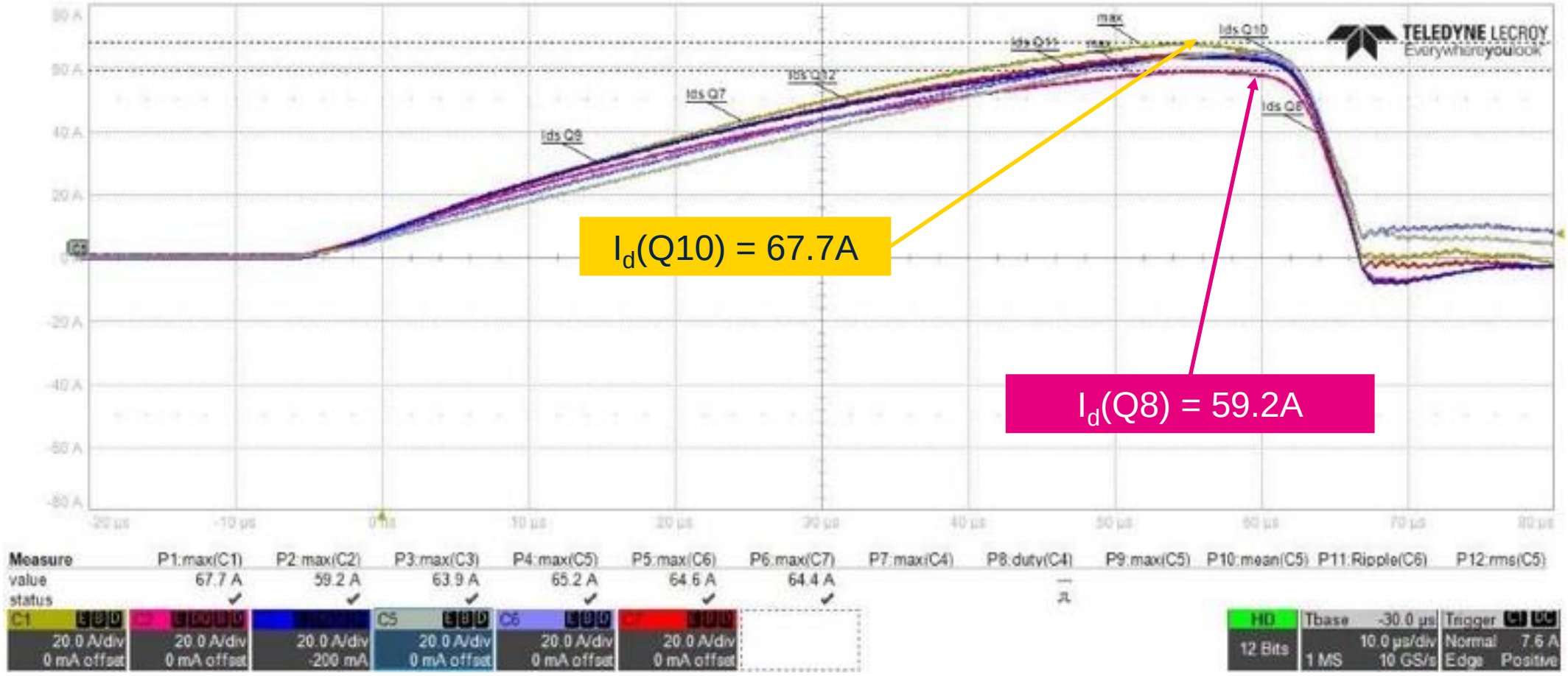
Design: layout optimization

- Requirements for proper parallelization:
  - Similar V_{gsth} (IC selection)
  - IC well displaced (thermally coupled)
  - Low parasitic inductance
  - Symmetrical path (power and driving path)
  - Asymmetric driving (different R_{gon} and R_{goff})



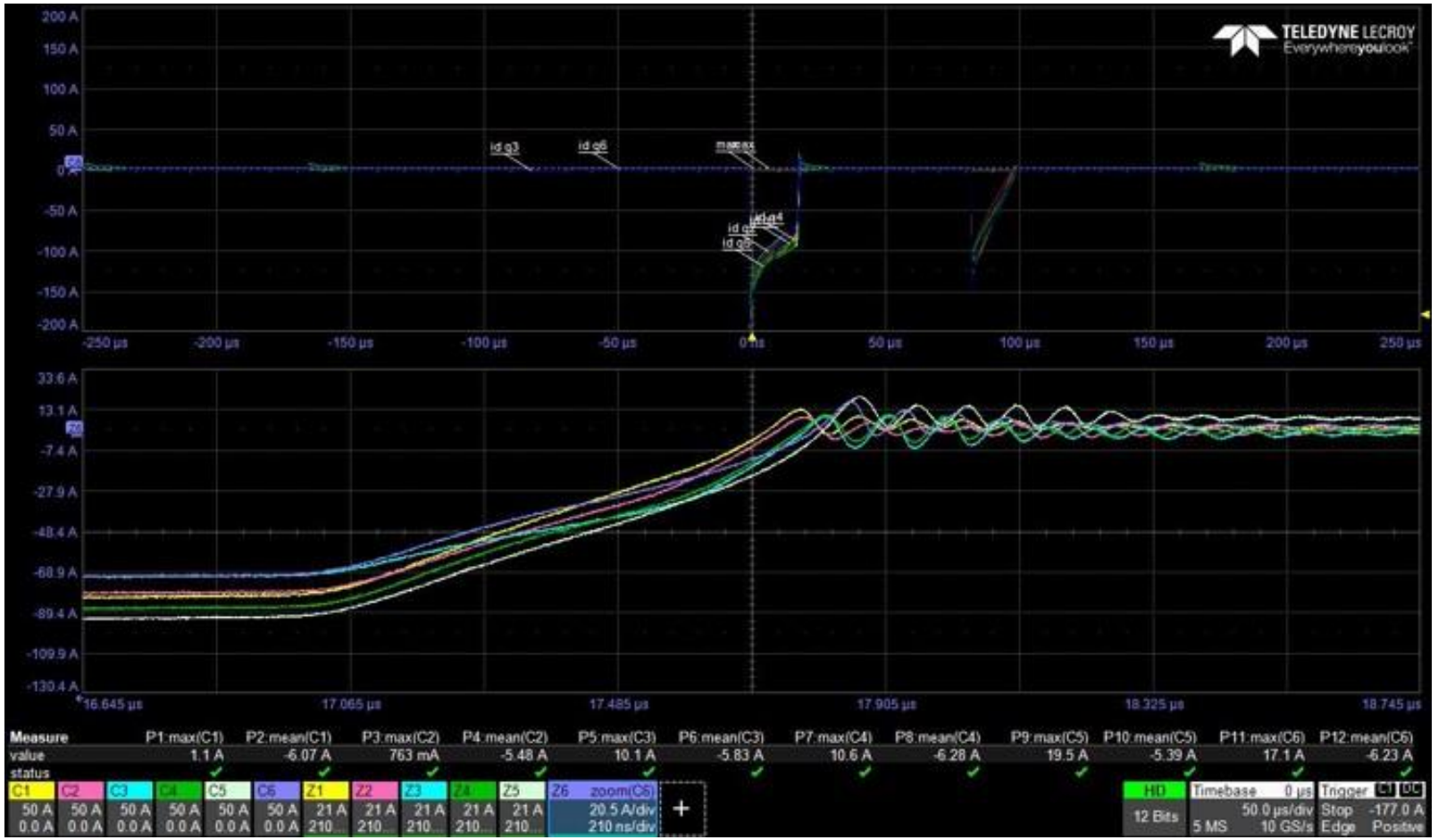


Current sharing in MOSFETs



Well balanced current sharing between the six MOSFETs in parallel

Current sharing in body diodes



Reverse recovery body drain currents are well balanced among the six MOSFETs in parallel

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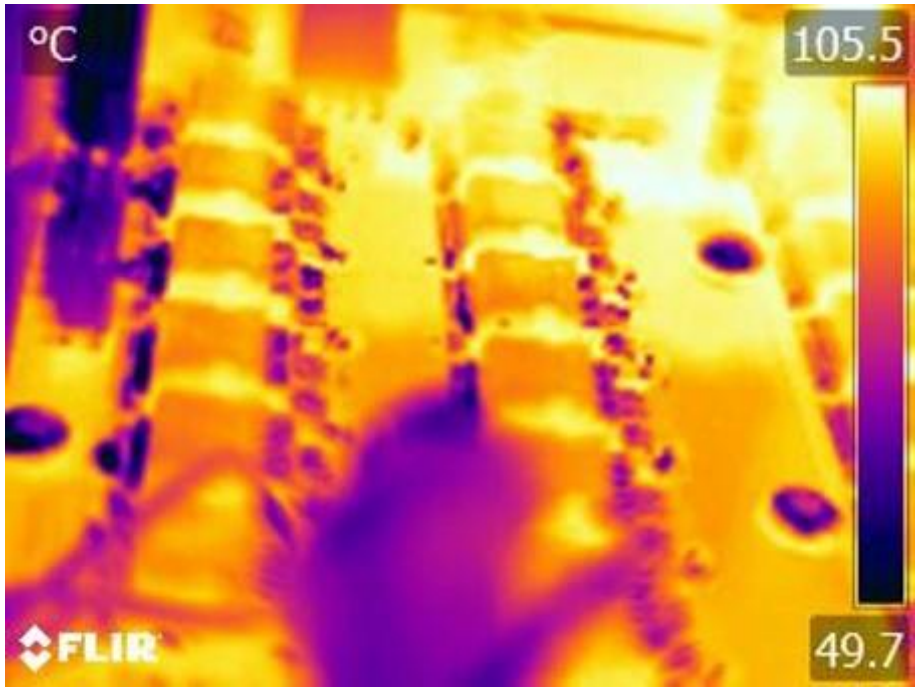
Thermal performance

- Test at 4.5 kW Output Power
- Picture after 40 minutes of operation
- Temperature safely below 175°C
- At the 90% of max load the max temperature is below 105°C.

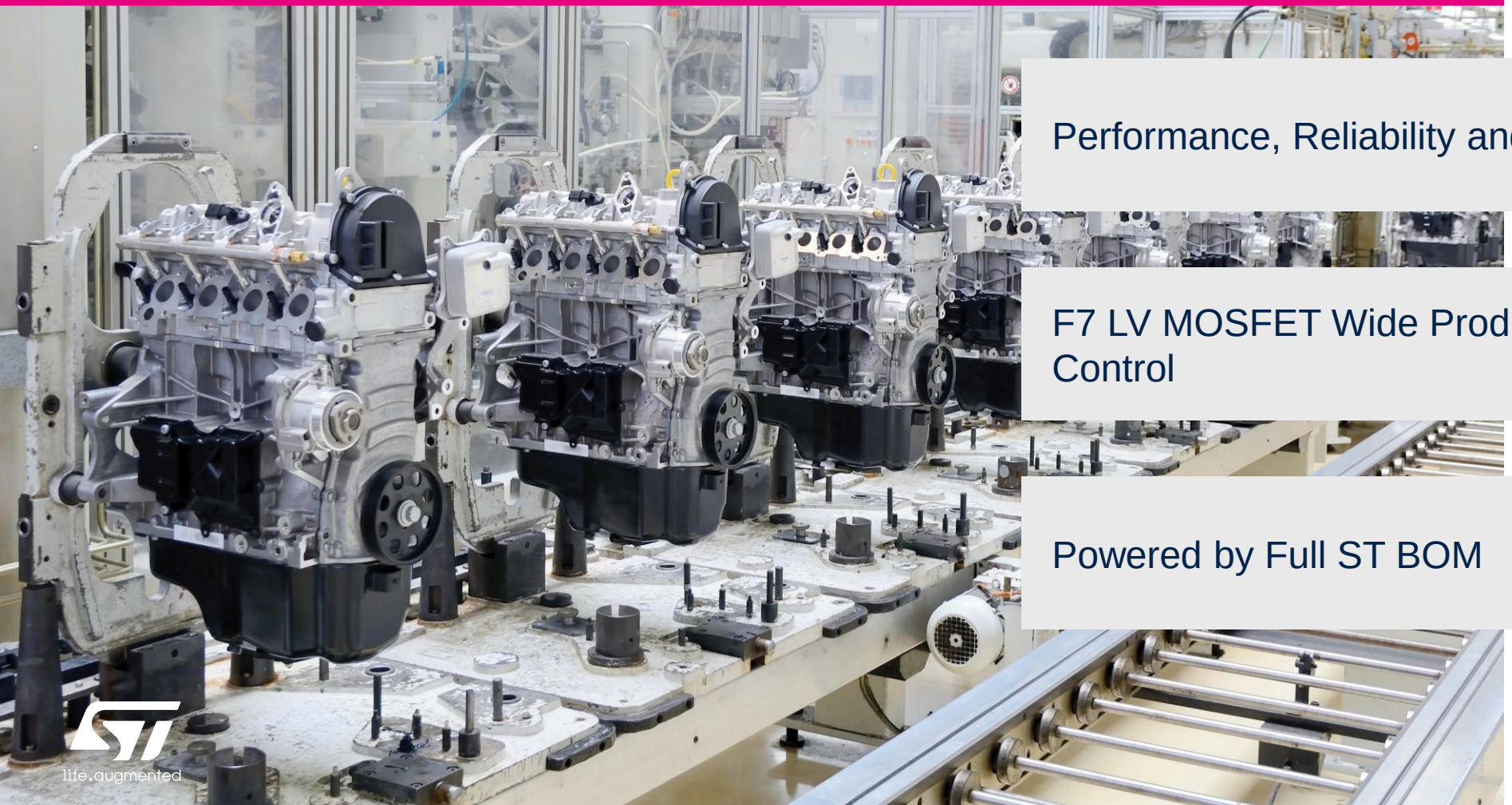


	Device: STH310N10F7											
	High Side U_{phase} MOSFETs						Low Side U_{phase} MOSFETs					
Case Temperature [°C]	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12
max.	99.5	99.8	100.4	101.2	102.4	101.5	98.5	101.9	103.4	104.5	104.3	104.9
min.	85.9	81.1	91.9	91.9	87.9	93.3	NA (*)	NA (*)	88.6	90.1	94.9	103.5
average	94.6	91.6	98.8	96.2	96.7	97.4	NA (*)	NA (*)	94.5	96.7	99.9	101.9

(*) due to an obstacle along the measurement line

Conclusion

High-Power LV Drive Flexible Modular Solution



Performance, Reliability and Robustness

F7 LV MOSFET Wide Product Range for Motor Control

Powered by Full ST BOM

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Thank you

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