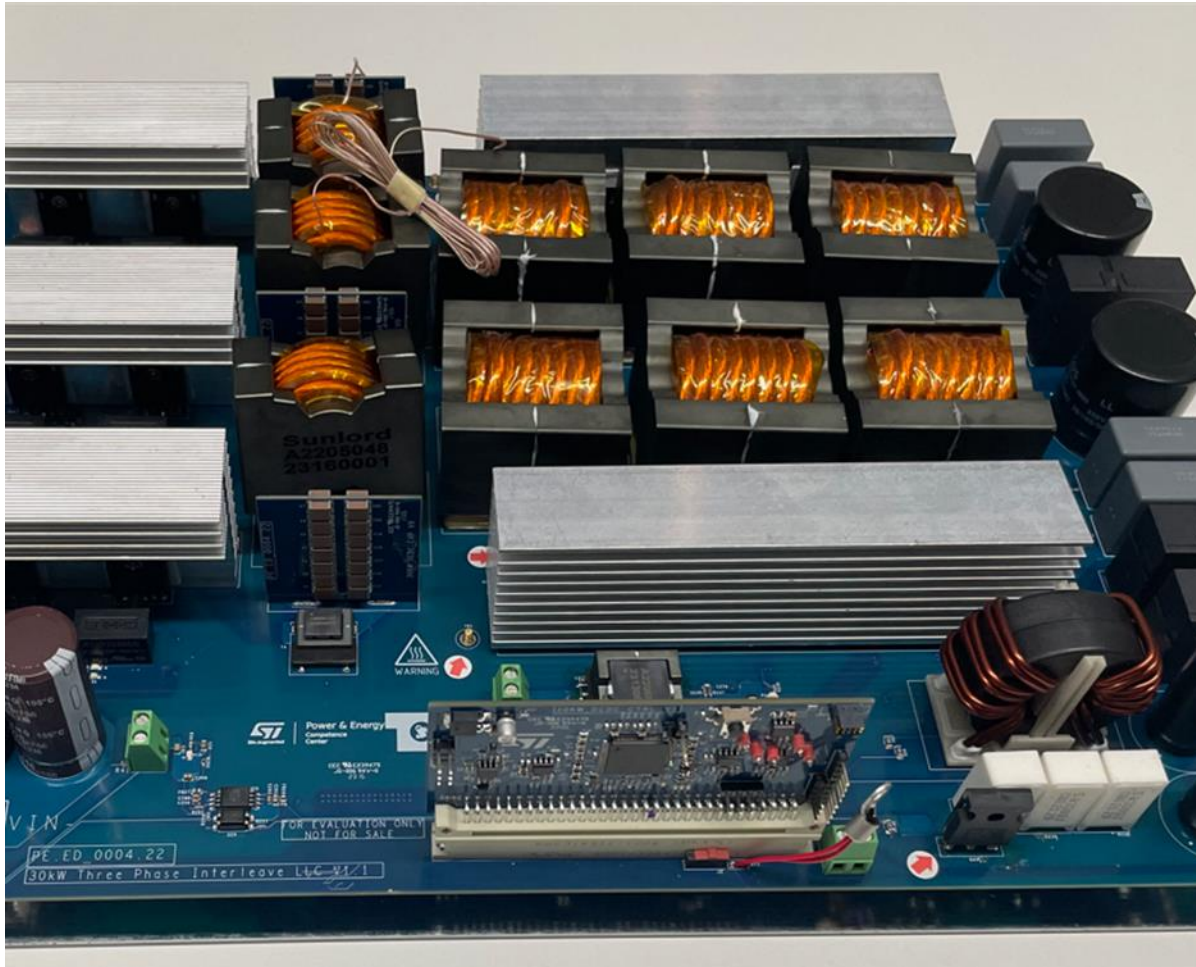


30 kW SiC MOSFET DC-DC with STM32G4 for EV Chargers



Trends



Topology Comparison



DC-DC

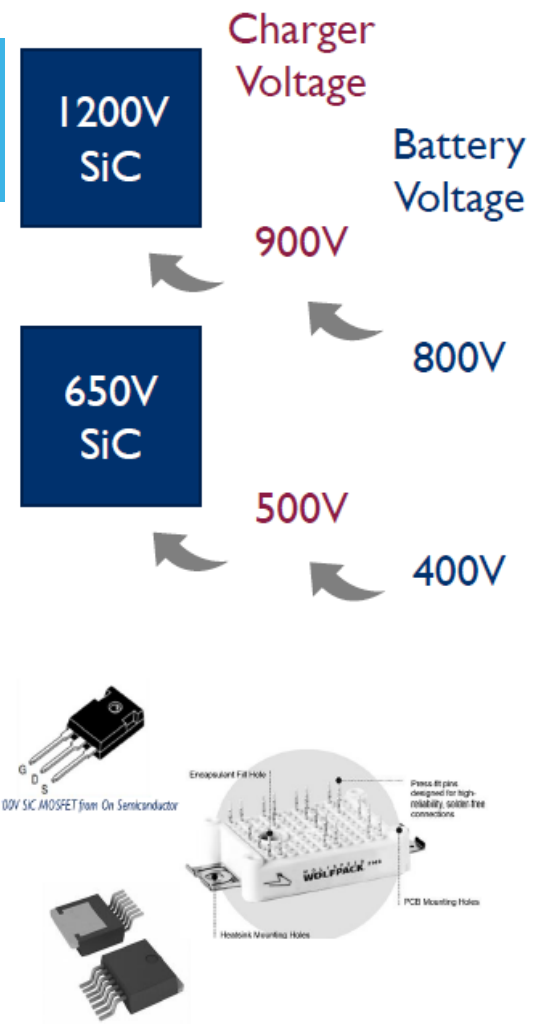
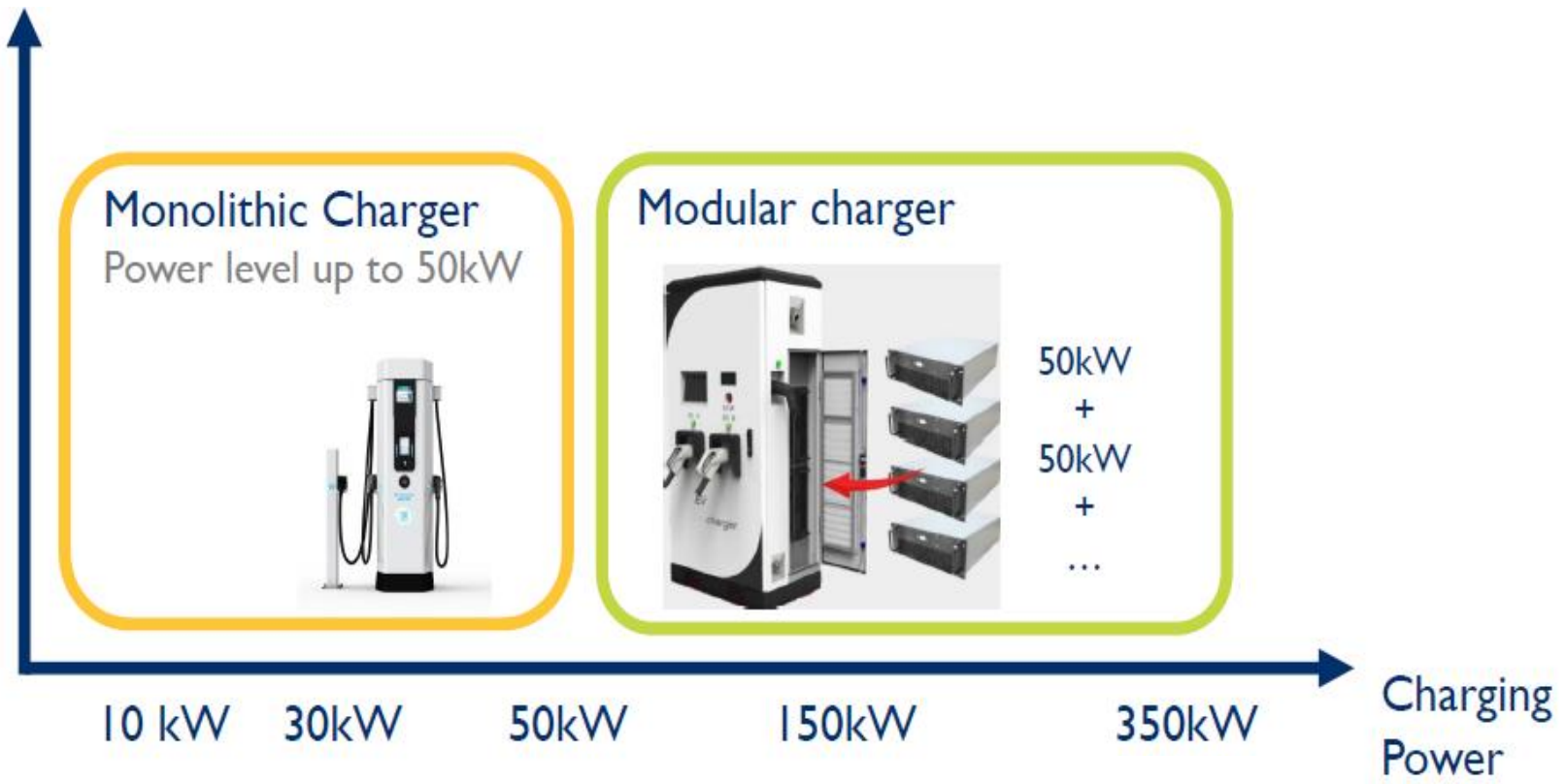


Summary



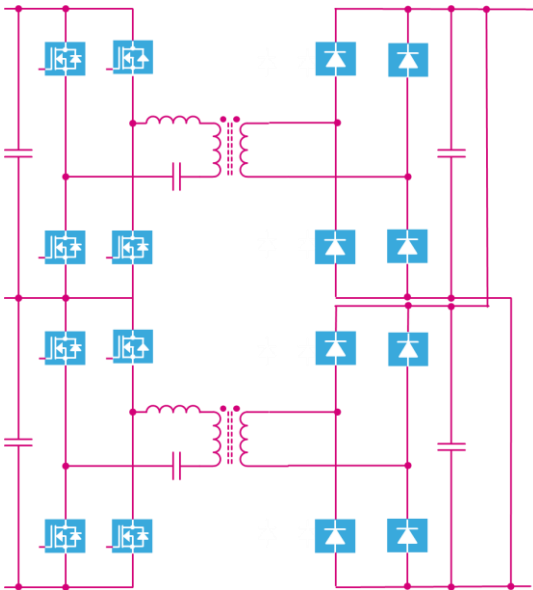
DC Charging Trends

DC charging comes in higher power and higher voltage



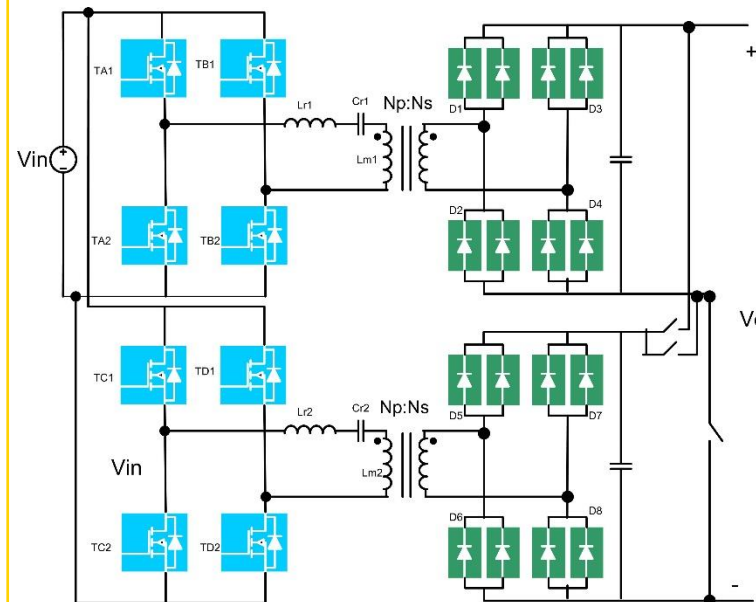
Topology Comparison

Full bridge Series LLC



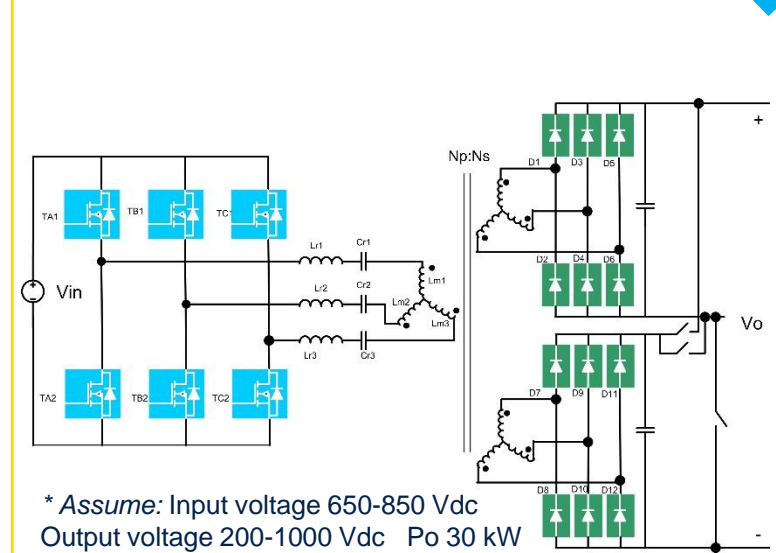
- Control complexity: high
- Component count: high
8 pcs 650 V Si Mos + 16 pcs Si diode
- Need control methods for current/voltage sharing
- Low efficiency
- High challenges on resonate devices design and cooling

Full bridge Parallel LLC



- Control complexity: high
- Component count: high
8 pcs 1200 V SiC Mos + 16 pcs Si diode
- + Control complexity: low
- + Middle challenges on resonate devices design and cooling
- + High efficiency
- Need control methods for current/voltage sharing

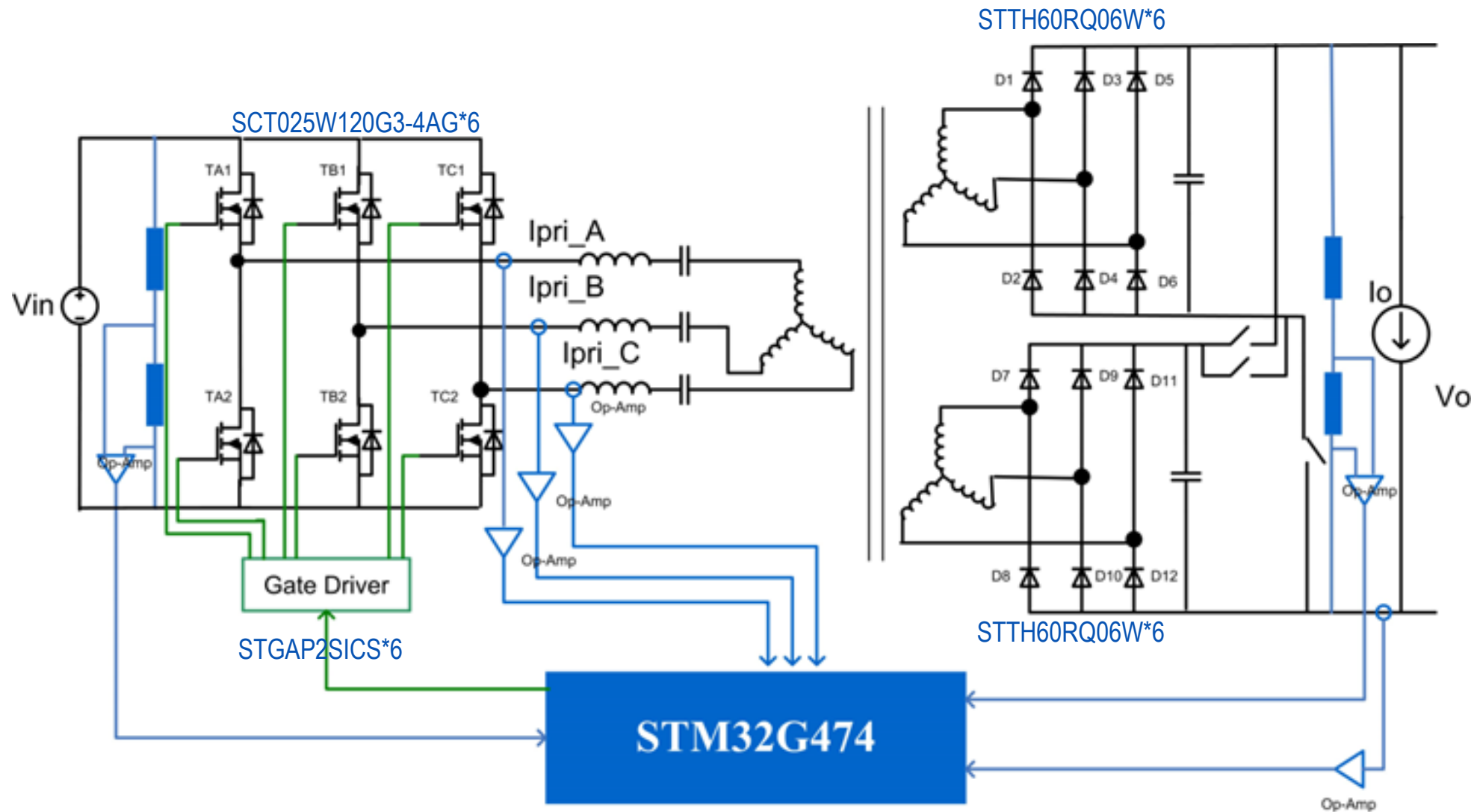
Three-phase interleaved LLC



* Assume: Input voltage 650-850 Vdc
Output voltage 200-1000 Vdc Po 30 kW
Unidirectional topology

- + Control complexity: low
- + Component count: low
6 pcs SiC Mos + 12 pcs Si diode
- + Natural current/voltage sharing
- + Low output ripple current
- + Middle efficiency
- Little challenges on resonate devices design and cooling
- Little challenges on range of Vo

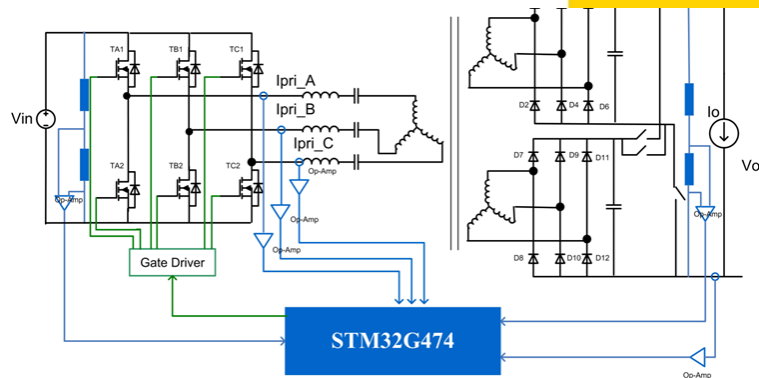
Simplified Block Diagram



30 kW Three-phase LLC Converter STDES-30KWLLC



Power & Energy
Competence
Center



Application key specification:

- Rated output power: 30 kW, switching frequency 100-300 kHz
- DC input voltage: 650 VDC – 850 VDC
- DC output: 200 VDC – 1000 VDC
- Peak efficiency: >98%
- STM32G474: High performance 32-bit MCU

Key products

MCU: STM32G474VET6,
SiC MOSFET: SCT025W120G3-4AG
Ultrafast diode: STTH60RQ06W
ASP product: STGAP2SICS, L6565
Schottky diodes: STTH1L06A, STPS1150A, STPS2H100A, STPS2L60A
GPA: LM393DT, LD29080DT50R, LD29080DT33R, TSV9121DT



Key benefits

- Higher efficiency achieved based on 1200 V SiC device and high switching frequency
- Less SiC MOSFET to achieve higher power with single LLC converter
- Wide range and high output voltage



Performance and Features

Input & output

- Input DC voltage: 650-850 VDC
- Output voltage range: **200-1000 VDC**
- Output power: **30 kW maximum**
- Maximum input current: 46A RMS
- Maximum output current: 100A RMS



Performance

- Efficiency: Peak 98%
- Vout ripple: less than 1% Vout >300 V no burst mode (not burst mode);
less than 3 V Vout <300 V no burst mode
- Vout load regulation: 1%
- Vout dynamic regulation: 5%

Features and protection

- Switching frequency: **100-300 kHz**
- Operation mode: PFM
- Input UVP, OVP
- Input OCP
- Output OVP
- Output OCP

STM32G474 digital platform



Configurations of key MCU functions

Arm® Cortex® -M4 up to 170 MHz

Floating-point unit (FPU)

- Control loop computation (reserved for future use)

32-Kbyte CCM-SRAM

- Zero wait-state for critical code execution

CORDIC for trigonometric functions acceleration

- Software phase-locked loop (reserved for future use)

FMAC filter mathematical accelerator

- Hardware digital filter (CPU off-load) for loop computation (reserved for future use)

Hi-Resolution PWM Timer (184 ps)

- For MOSFET control at 100-350 kHz switching frequency

Multiple ADCs (4 Msps) up to 5

- 3Ø AC voltage/current, DC voltage/current, and hotspot temperature sensing

Comparators and DACs up to 7

- Reducing the number of components

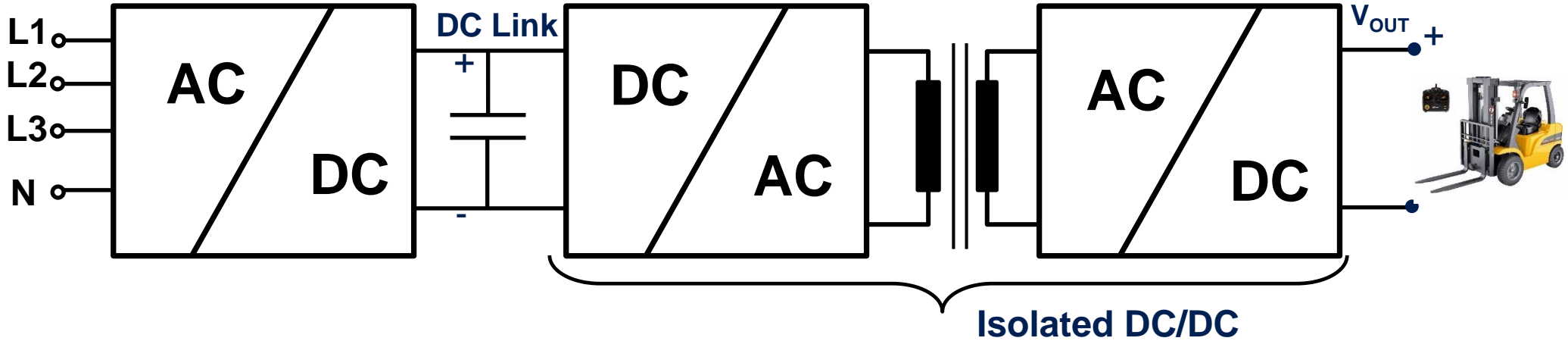
UART, SPI, CAN and USB

- UART for communication



Industrial On-board Charger System Concept

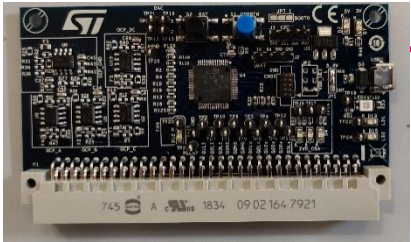
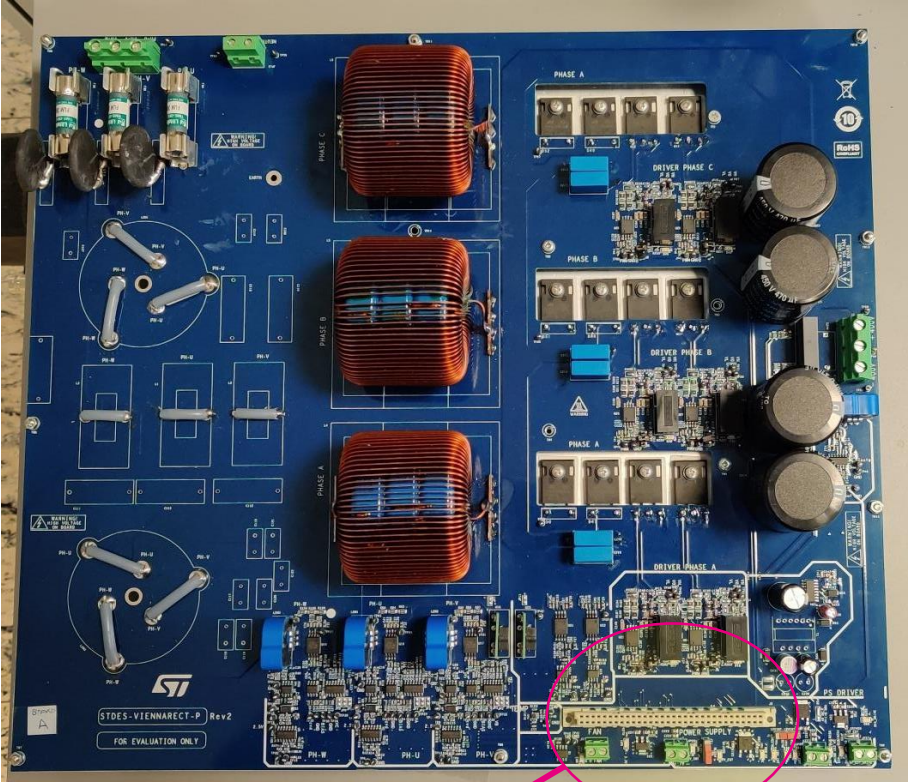
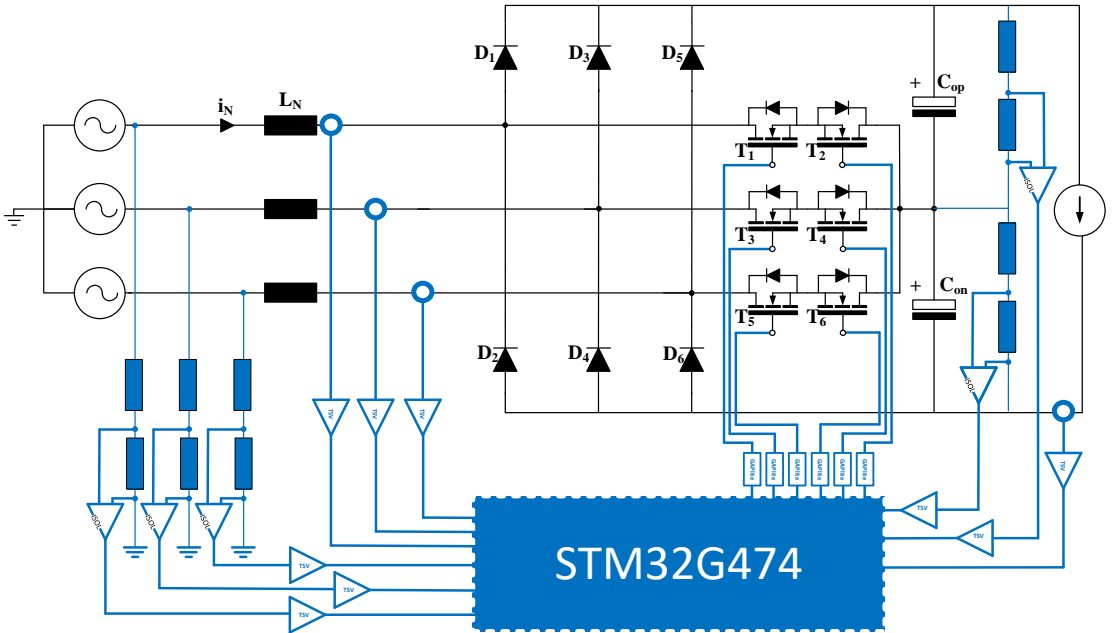
3-ph Outlet



Parameter	Value
Input voltage	$L_x-L_y \rightarrow 400 V_{AC}$ $L_x-N \rightarrow 230 V_{AC}$
DC Link Voltage	400..1000 V
Nominal Power	11..22 kW
Output Voltage	200..500 V_{DC} for 400 V_{DC} Batteries 500..900 V_{DC} for 800 V_{DC} Batteries

STDES-VRECTFD

V_{AC} Input	400 Vac
V_{DC} Output	800 Vdc
P_{Out_max}	15 kW
Switching Frequency	70 kHz
I_{ripple}	2.5A
V_{out_ripple}	10 Vpp
Power Factor	> 0.9
THD	< 5%



Control board

Save Export Restore Print Disclaimer

CONVERTER SPECIFICATIONS

MCU: STM32G474RETX
Topology: VIENNA
Input: 185 Vac - 265 Vac
Output 1: 800 V (2%) - 15 kW

[CHANGE SPECIFICATIONS >](#)

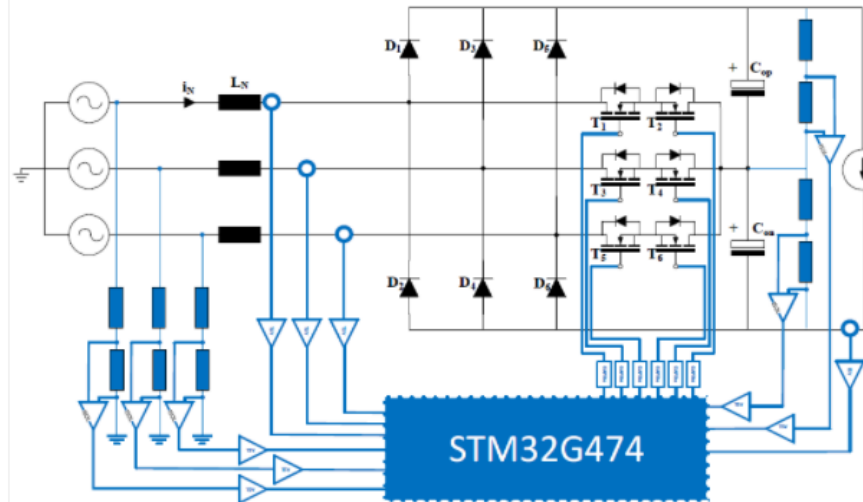
OPERATING CONDITIONS

min 185 V / max 265 V
@VinAC: V
 min 0 W / max 15 kW
@Pout: W

ACTUALS

Phase AC Input Current: 22.07 A
D1 Average Current: 6.28 A
D1 RMS Current: 12.9 A
T1 Average Current: 3.65 A
T1 RMS Current: 8.78 A

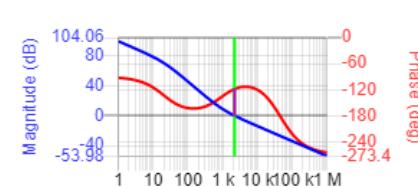
Circuit - Schematic



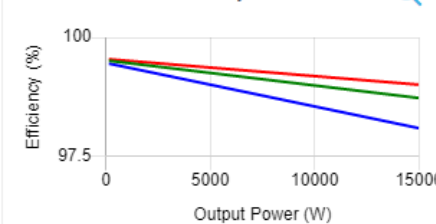
Circuit - BOM

Type	Ref	Value	Description
IC	IC	STM32G474RETx	STM32G...
Inductor	L1 to L3	381 µH	Boost in...
Diode	D1 to D6	STPSC20H12WL	SiC Powe...
MOSFET	T1 to T6	SCTW35N65G2V	SiC Powe...

Current Bode: fc = 2.18 kHz - phase margin = 61.4°



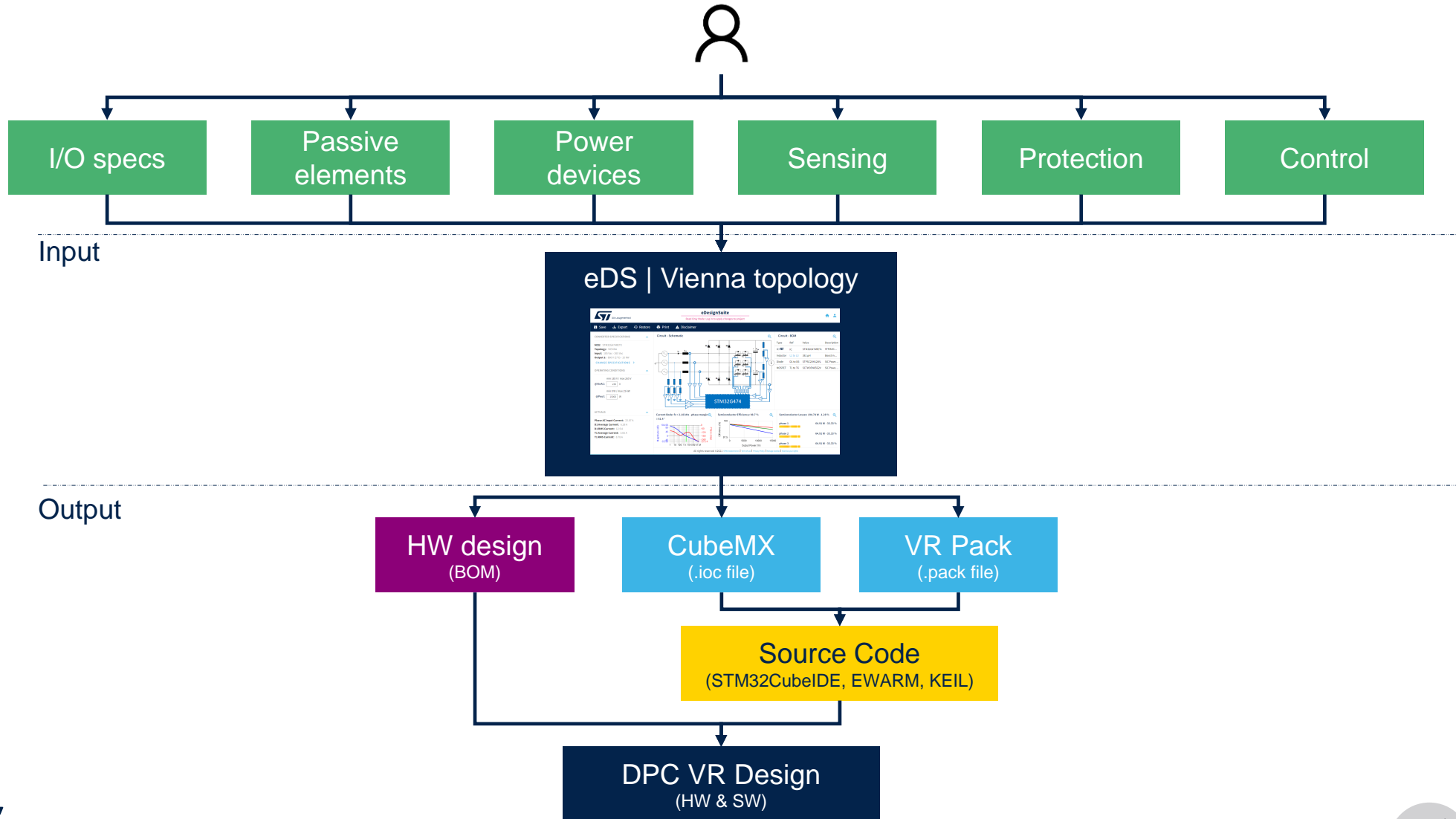
Semiconductor Efficiency: 98.7%



Semiconductor Losses: 194.74 W - 1.28%

Phase	Power (W)	Percentage (%)
phase 1	64.91 W	33.33 %
phase 2	64.91 W	33.33 %
phase 3	64.91 W	33.33 %

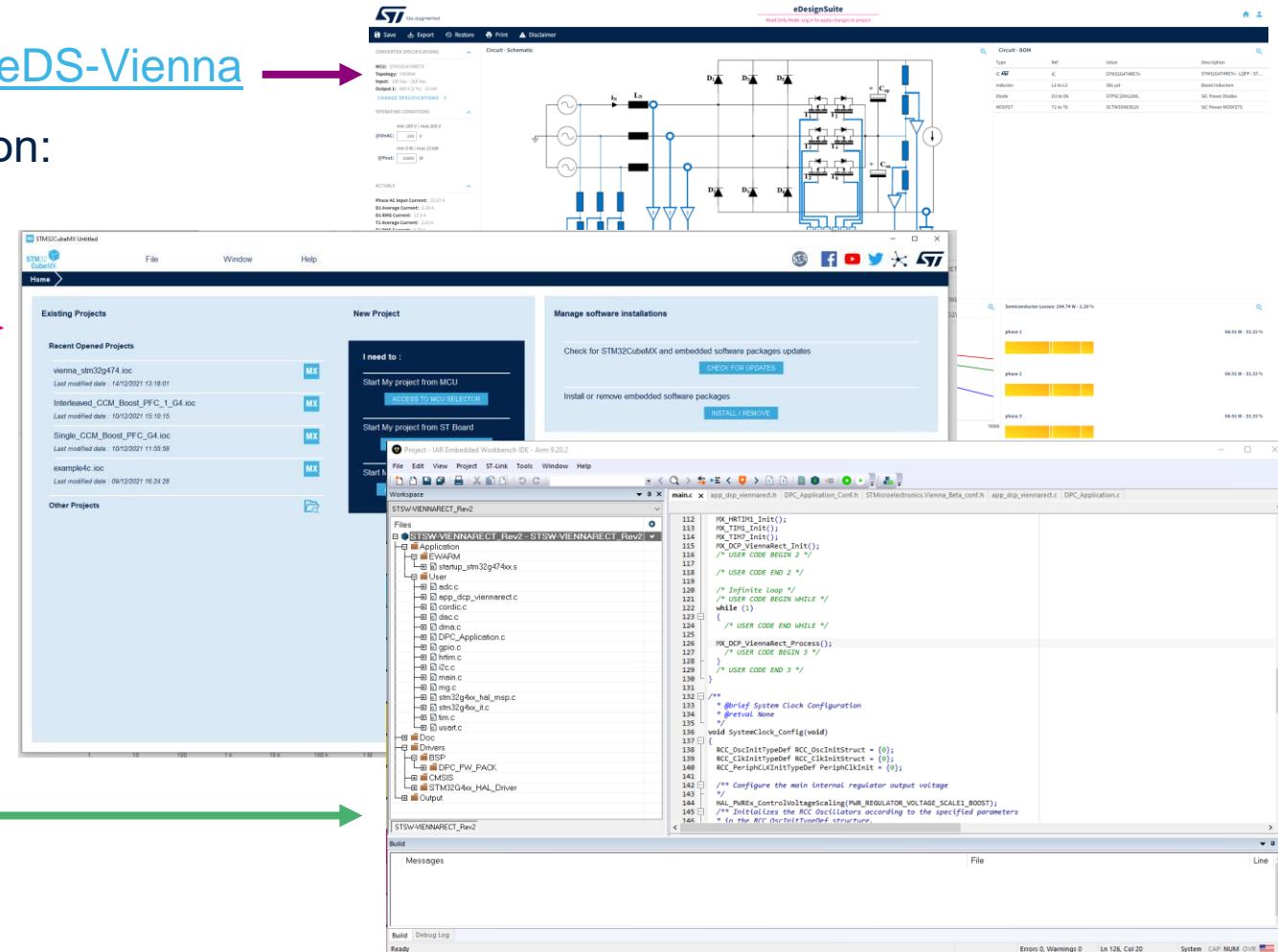
eDesignSuite Main Design flow



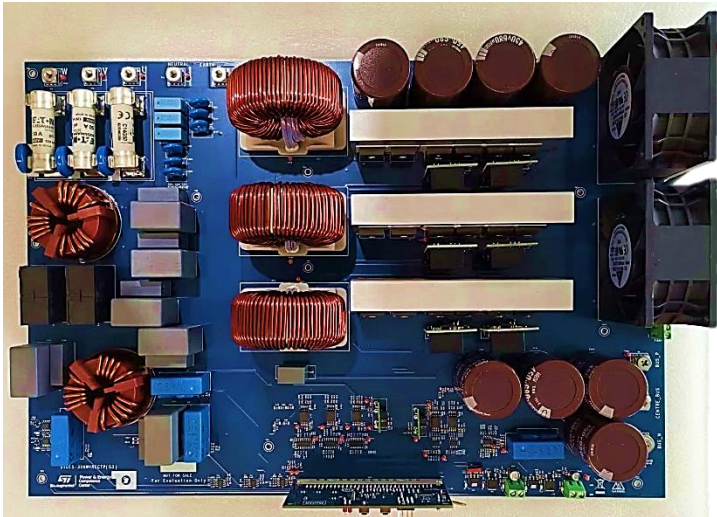
Application User Guide

Step by step flow

1. Open DPC Vienna topology in eDesignSuite - [eDS-Vienna](#)
2. Download DPC files from “FW download” section:
 - “IOC” file
 - “PACK” file.
3. Open STM32CubeMx tool
4. Install pack using local file in STM32CubeMx
5. Open IOC file
6. Select IDE
7. Generate code
8. Open Workbench project file
9. Build, download and run application



30 kW three-phase Vienna rectifier for EVCS



Application key specification:

- Input AC voltage: three-phase 345 VAC up to 460 VAC with 47 Hz up to 63 Hz
- Maximum input current: 55 ARMS
- DC output voltage 800 VDC, rated output power 30 kW, switching frequency 70 kHz
- Peak efficiency: >98.7%
- 0.99 power factor with lower than 5% THD @ full load operation
- STM32G474: High performance 32-bit MCU



Key products

MCU: STM32G474RET3

SiC MOSFET: SCT018W65G3-4AG

SiC diode: STPSC40H12C

Gate driver: STGAP2SICS

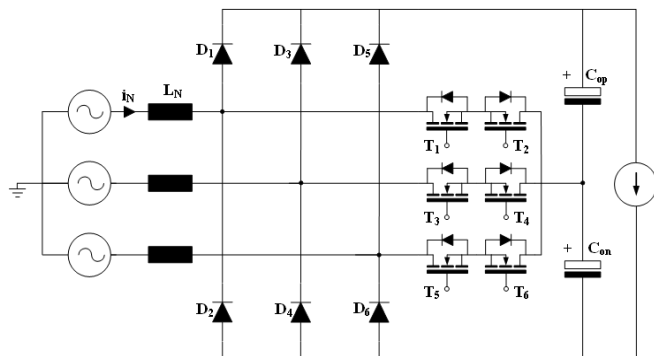
Schottky diodes: STTH1L06A, STPS1150A, STPS2H100A, STPS2L60A

GPA: LD29080S33R, LD29080DT50R, TSV912IDT, TSV912IDT



Key benefits

- Solution based on SiC device; higher efficiency achieved
- Very low THD (total harmonic distortion)
- Higher reliability
- Low design complexity



[Promotion slide](#)



[Test report](#)



[Design material](#)



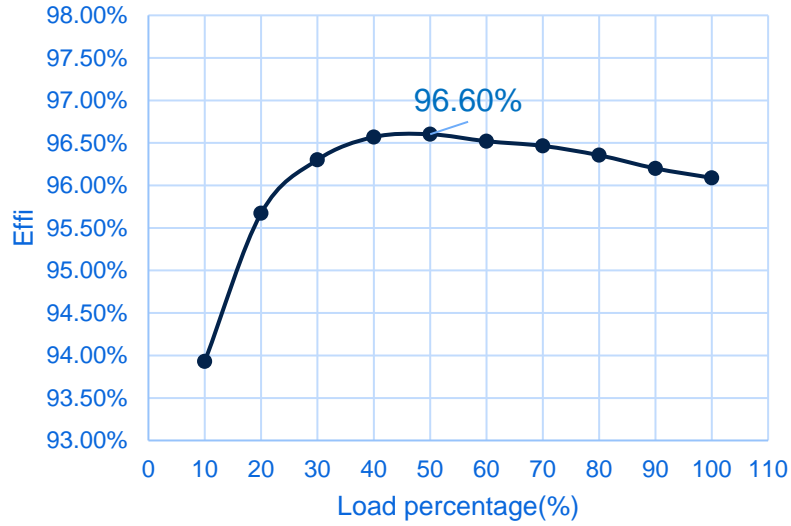
[Demo video](#)



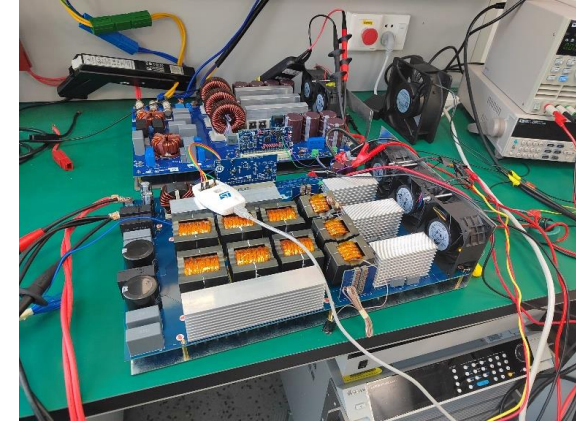


ST 30 kW total solution

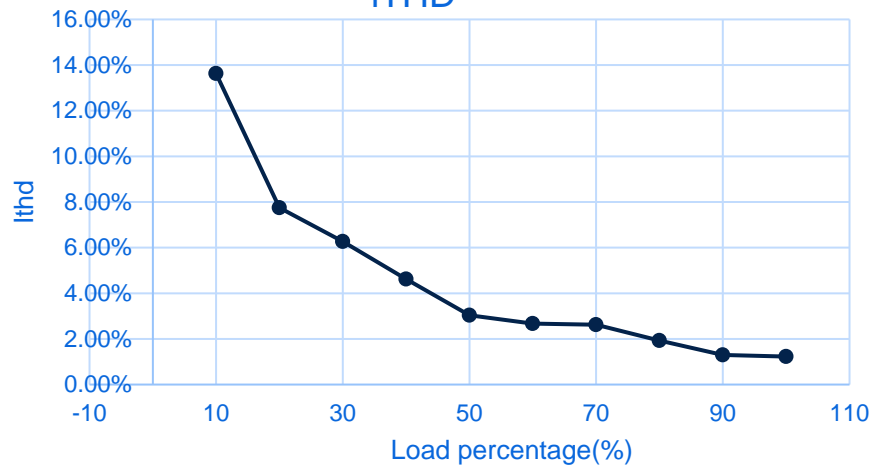
Efficiency



● 230Vac 700Vout



iTHD



● 230Vac 700Vout



- 96.6% peak and 96% high efficiency in full load





STM32G4 and ST SiC based solution help achieve high performance EV charger

ST achieved the total solution PFC+DCDC in high power EV charger

ST provides advanced total components to customer (SiC MOSFETs/SiC diode/STGAP/STM32)

ST 30 kW three-phase solution can achieve peak efficiency 98% @160 KHz 700 Vout half load

User manual and detailed design files refer to the link [STDES-30KWLLC](#) on ST.COM soon

