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Power future microgrids with ST digital ESS

Chill YE

Power & Energy Competence Center, Asia-Pacific

Agenda

1 Carbon neutrality & microgrids

2 ST digital power ESS solution

3 Key products

4 Summary

Carbon neutrality & microgrids

Innovations contributing to carbon neutrality

Green energy generation

Electric power sector accounts for 40% of global carbon emissions

Fast DC charging For e-mobility

Transportation sector accounts for 23% of global carbon emissions

High efficiency for telecom & datacenters

Communications sector accounts for ~4% of global carbon emissions (14% by 2040)

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Challenges for the grid

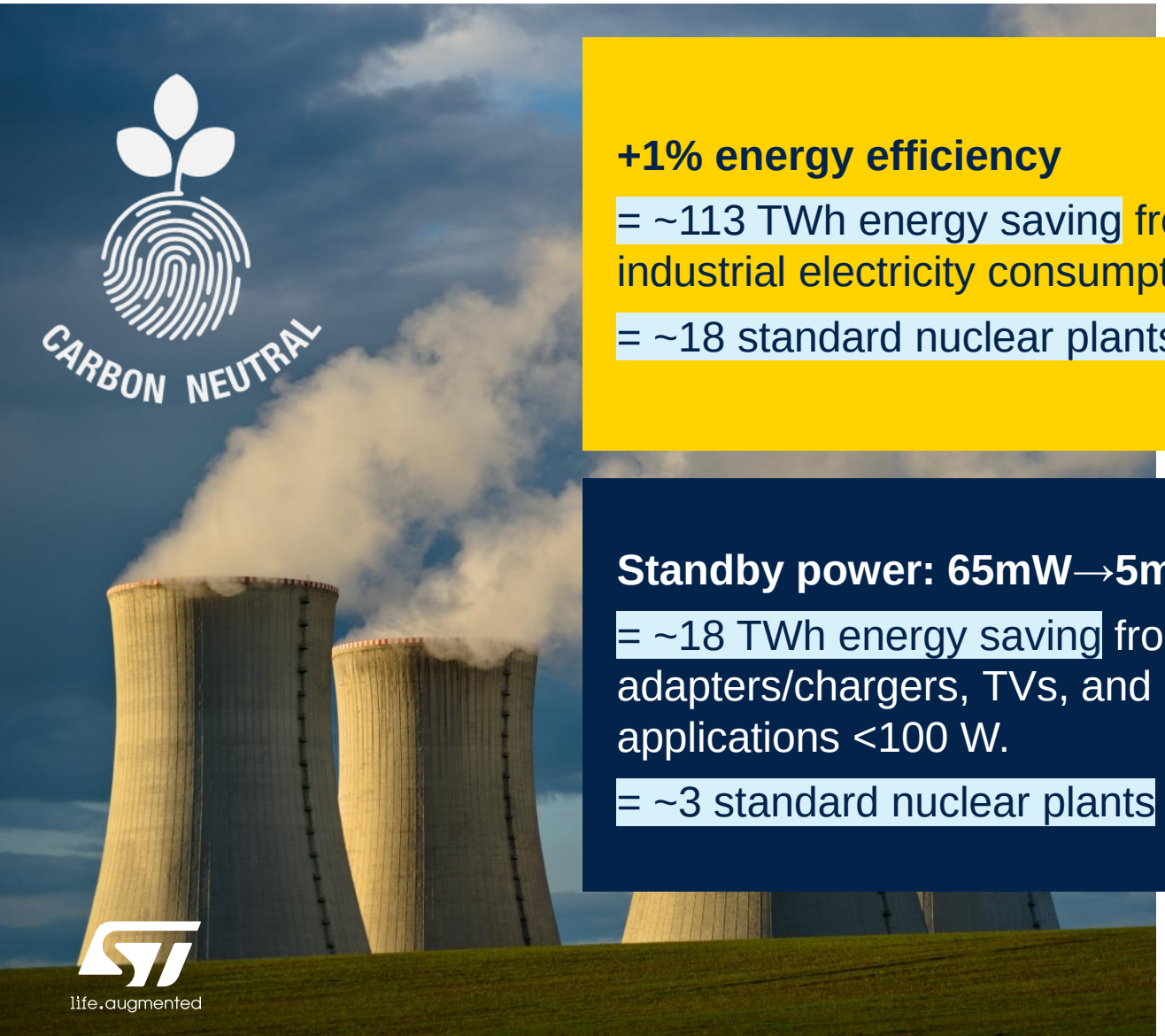
How to optimize investment in **energy transmission** upgrades?

How to manage **peak loads** as they become increasingly **unpredictable**?

How to set up **new grid infrastructure** in congested areas?

How to ensure a **reliable** supply to critical functions?

New semiconductor trends and opportunities



+1% energy efficiency

= ~113 TWh energy saving from industrial electricity consumption, e.g.

= ~18 standard nuclear plants

Standby power: 65mW→5mW

= ~18 TWh energy saving from adapters/chargers, TVs, and other applications <100 W.

= ~3 standard nuclear plants

SiC, GaN & SiP

Superior switching performance results in higher efficiency and lower system cost (higher density)

Adapter/charger

Server/datacenter (HV)

Hybrid energy system

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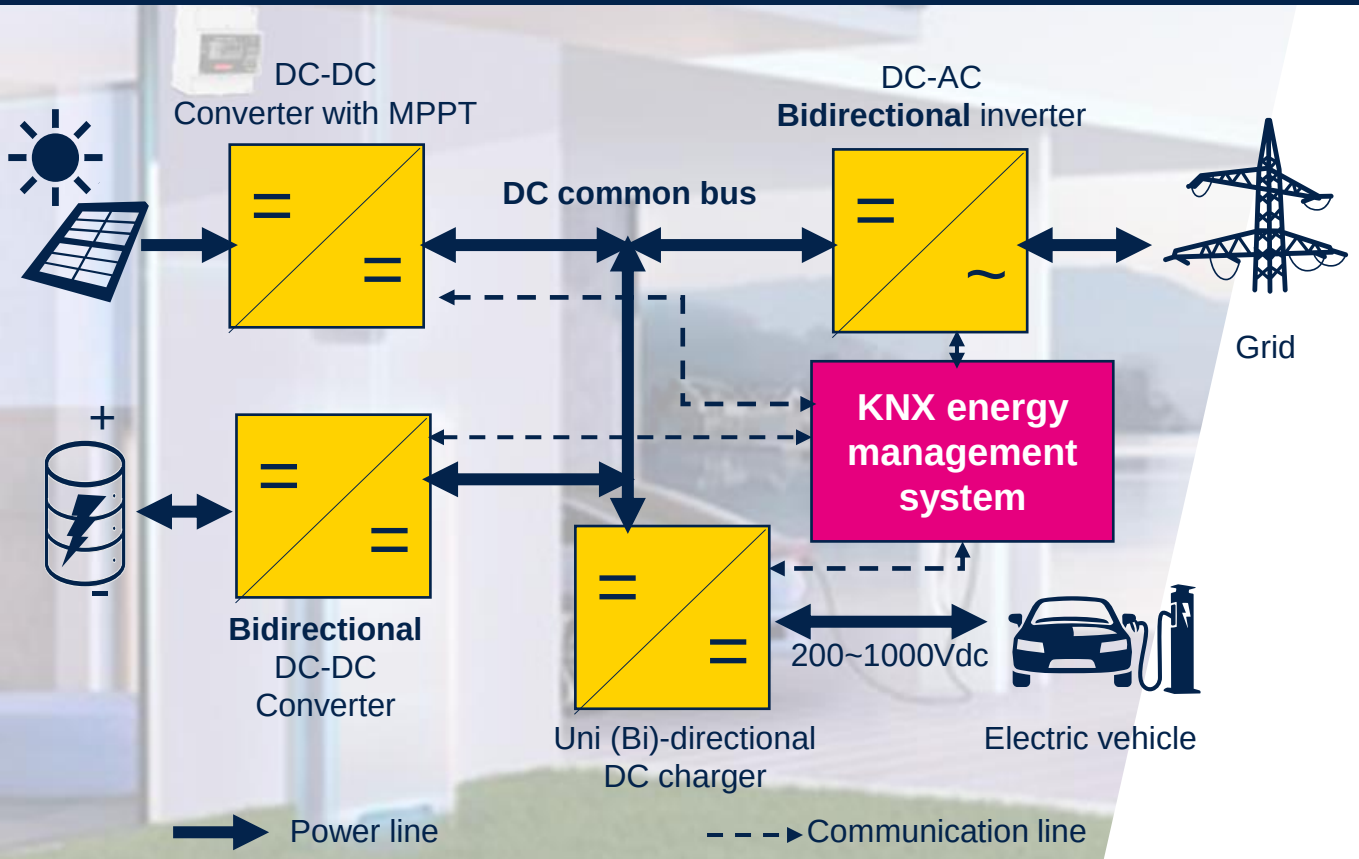
Electricity 4.0: enabling hybrid energy systems

Increase grid independence, lowering energy costs by up to 11%#

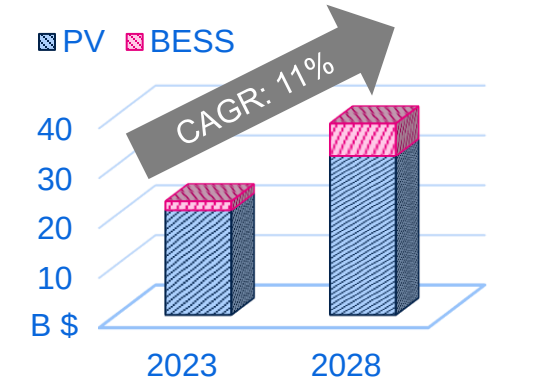


Integration of PV and energy storage

Energy storage for resilience

PV powering households

Power converter market split by application *



Source from Rolls Royce: Use case I Germany Electric vehicle charging hub

* Source from Status of the Power Converter Industry 2023 | Yole Development

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ST digital power ESS solution

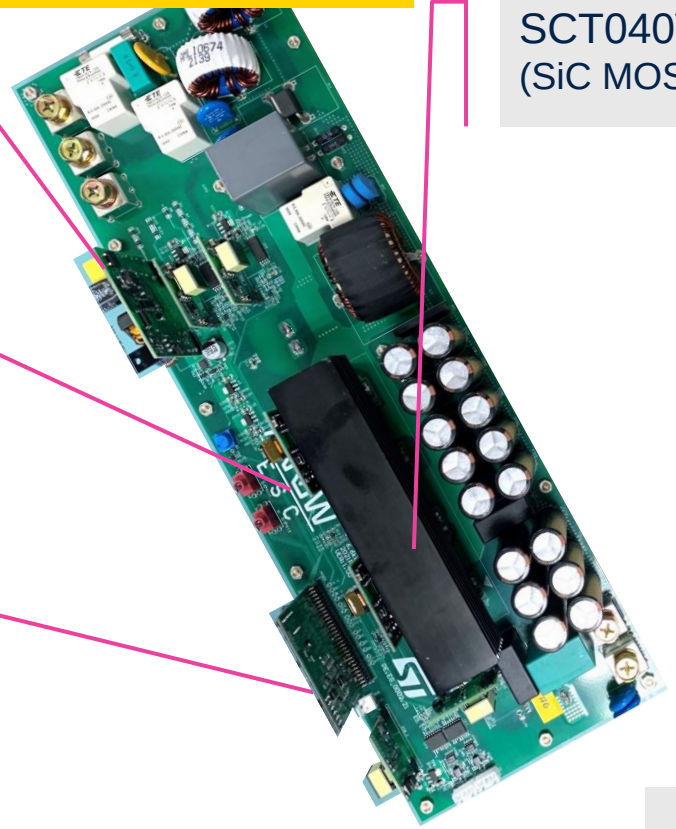
6.6 kW bidirectional AC-DC

Bidirectional CCM totem pole

VIPER319HD
(Aux. power)

STGAP2SICS
(Gate driver)

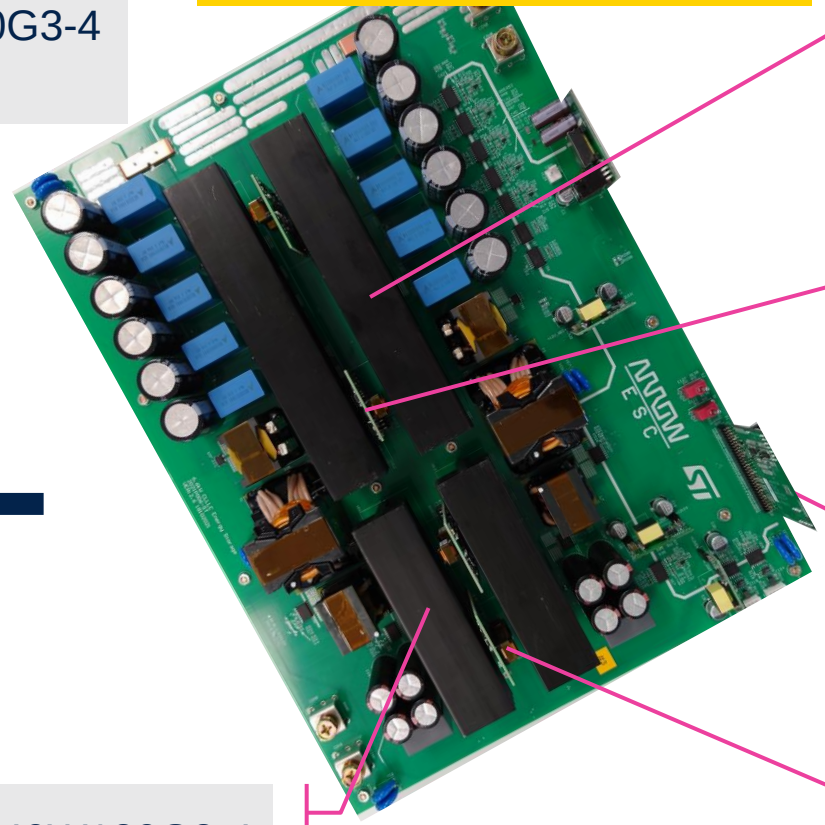
STM32G474
(MCU)



SCT040W120G3-4
(SiC MOSFET)

+

Bidirectional CLLLC resonant



STP75NF20
(LV MOSFET)

STGAP2SM
(Gate driver)

STM32G474
(MCU)

STGAP2SICS
(Gate driver)

SCT040W120G3-4
(SiC MOSFET)

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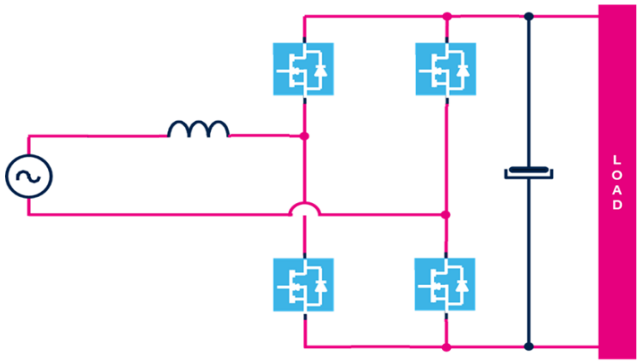
6.6 kW bidirectional PFC

Totem pole PFC



Key features:

- Grid voltage: 180-265 VAC
- DC bus voltage: 380-580 VDC
- Switching frequency: 100 kHz
- Operation mode: CCM
- Peak efficiency: 98.5% @230 VAC

- 6.6 kW power delivery in both of AC-DC/DC-AC operations including below modes:
  - ✓ AC to DC operation as rectifier mode
  - ✓ DC to AC operation as off-grid (UPS) mode
  - ✓ DC to AC operation as grid-connection mode

Key products	STM32G474VBT MCU SCT040W120G3-4AG SiC MOSFET STGAP2SICS, VIPER319HD TSZ181ILT, TS3022IDT, A6986, TL431ACL3T, LD1117SC-R
Key benefits	✓ Compatible with photovoltaic systems (regulated output voltage from 380 to 580 Vdc) ✓ SiC and full digital solution to achieve higher efficiency and higher power density

PFC digital platform - STM32G474

Configurations of MCU key functions on digital PFC

Arm® Cortex® -M4 up to 170MHz

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 (EPLL)

FMAC filter mathematical accelerator

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

Hi-Resolution PWM Timer (184 ps)

- Mainly for high frequency (HF) MOSFET control at 100kHz

Multiple ADCs (4 Msps) up to 5

- Grid voltage, inductor current, DC bus voltage/current and hotspot

Comparators and DACs up to 7

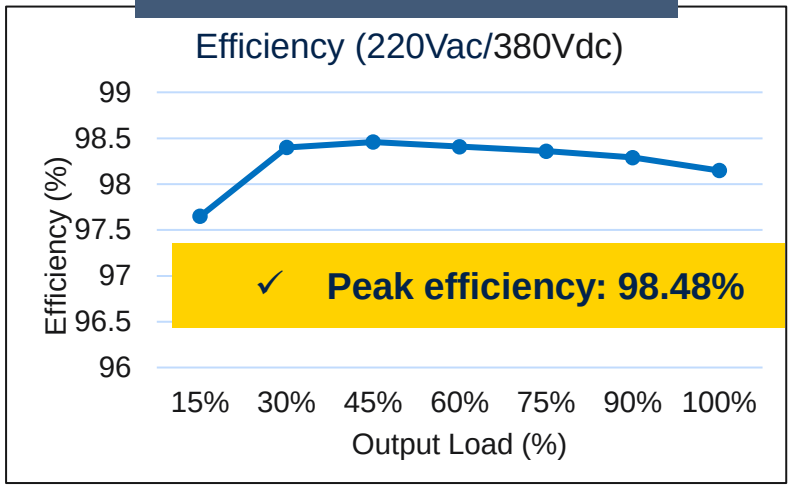
- PFC OVP / OCP

UART, SPI, CAN and USB

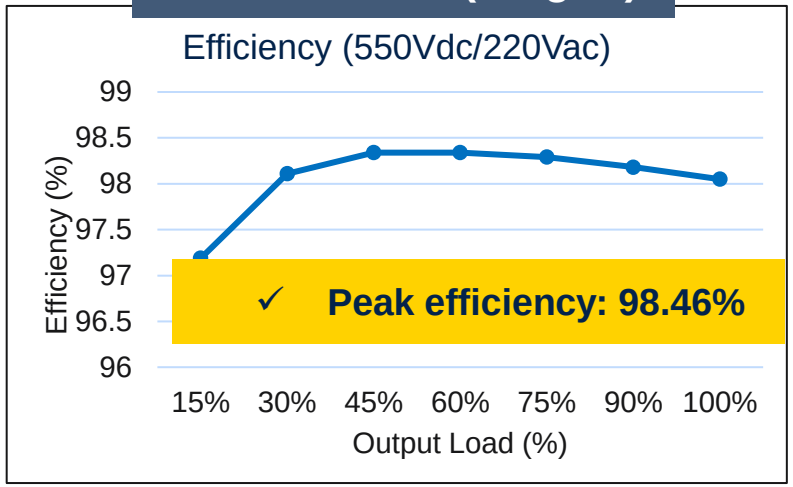
- CAN for internal/external communication

Experimental results

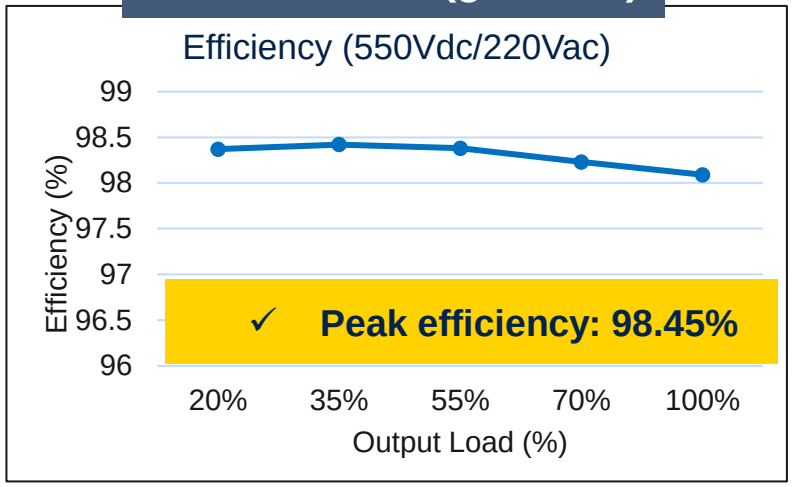
Rectifier mode



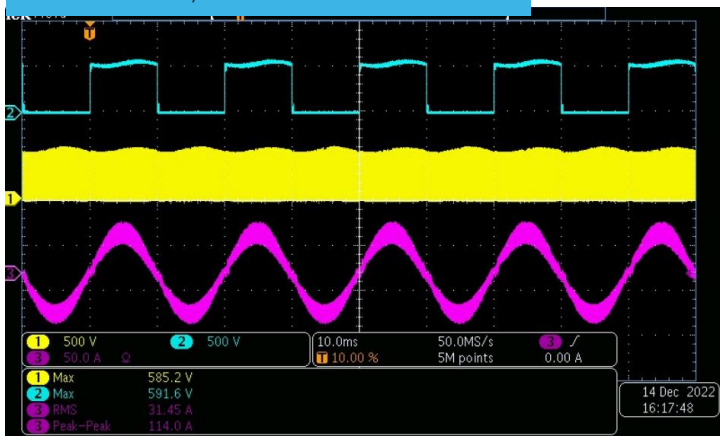
Inverter mode (off-gird)



Inverter mode (gird-tied)

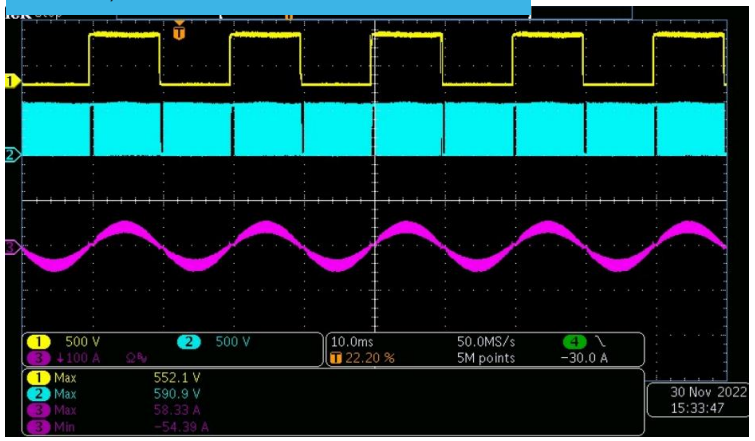


230Vac/50Hz, 550Vdc with 6600 W load



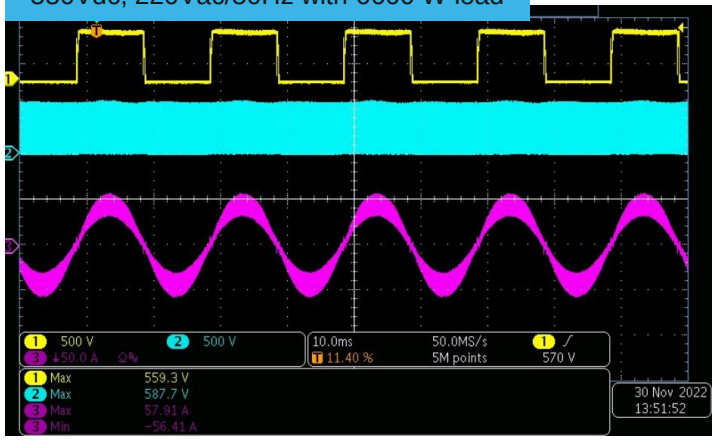
- *CH1 (yellow): Vds of upper high-speed MOSFET*
- *CH2 (blue): Vds of upper low-speed MOSFET*
- *CH3 (purple): Inductor current*

550Vdc, 220Vac/50Hz with 6600 W R load



- *CH1 (yellow): Vds of upper low-speed MOSFET*
- *CH2 (blue): Vds of upper high-speed MOSFET*
- *CH3 (purple): Inductor current*

550Vdc, 220Vac/50Hz with 6600 W load



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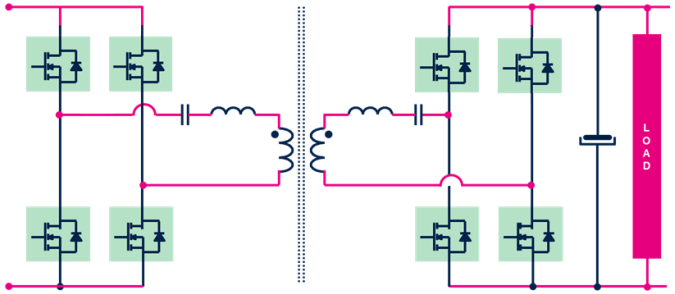
6.6 kW bidirectional DC-DC

Interleaved CLLLC



x2 (2-phase)
(Both primary/secondary are in parallel)

Key features:

- Battery voltage: 60-90 VDC
- DC bus voltage: 380-580 VDC
- Resonant frequency: 200k Hz (160-300 kHz)
- Peak efficiency: >96%
- 6.6 kW power delivery in bidirectional operations, including the following modes:
  - ✓ High voltage to low voltage charging
  - ✓ Low voltage to high voltage discharging

Key products	STM32G474VBT MCU SCT040W120G3-4AG, STP75NF20 power MOSFETs STGAP2SICS (DCDC-Hi), STGAP2SM (DCDC-Lo), VIPER319HD TSZ181ILT, TS3022IDT, A6986, TL431ACL3T, LD1117SC-R
Key benefits	✓ Compatible with photovoltaic systems (regulated output voltage from 380 to 580 Vdc) ✓ SiC and full digital solution to achieve higher efficiency and higher power density

DC-DC digital platform - STM32G474

Configurations of key MCU functions on digital DC-DC

Arm® Cortex® -M4 up to 170MHz

Floating-point Unit (FPU)

- Control loop computation

32-Kbyte CCM-SRAM

- Zero wait-state for critical code execution

CORDIC for trigonometric functions acceleration

- Hardware trigonometric calculation (reserved)

FMAC filter mathematical accelerator

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

Hi-Resolution PWM Timer (184 ps)

- Mainly for high frequency MOSFET control at 150kHz~400kHz

Multiple ADCs (4 Msps) up to 5

- DC voltage/current, tank current, and hotspot

Comparators and DACs up to 7

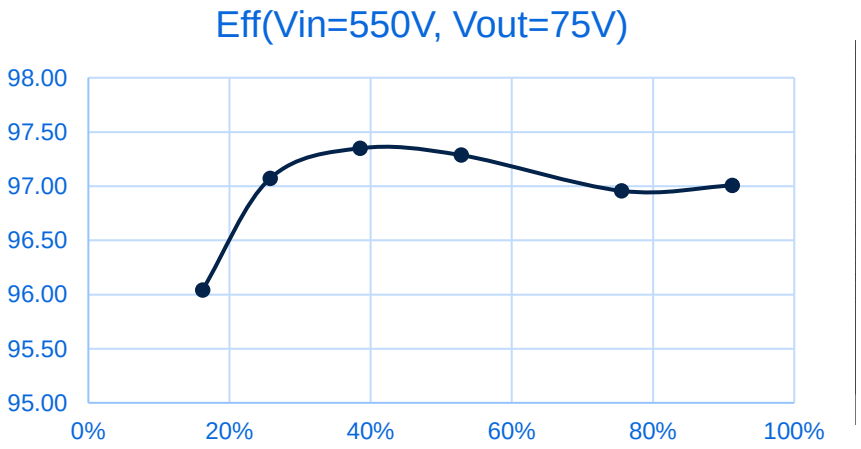
- Tank current OCP

UART, SPI, CAN and USB

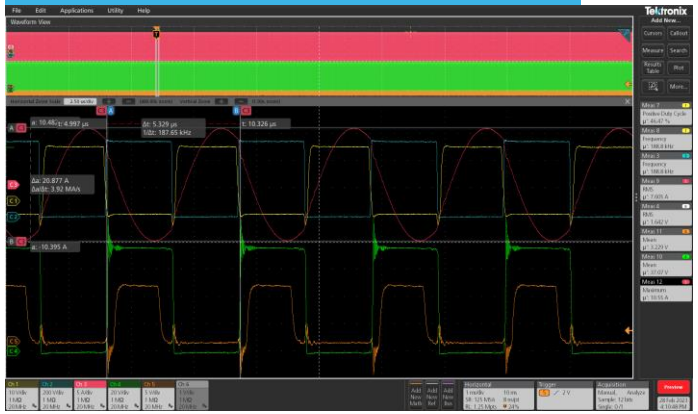
- CAN for internal/external communication

Experimental results

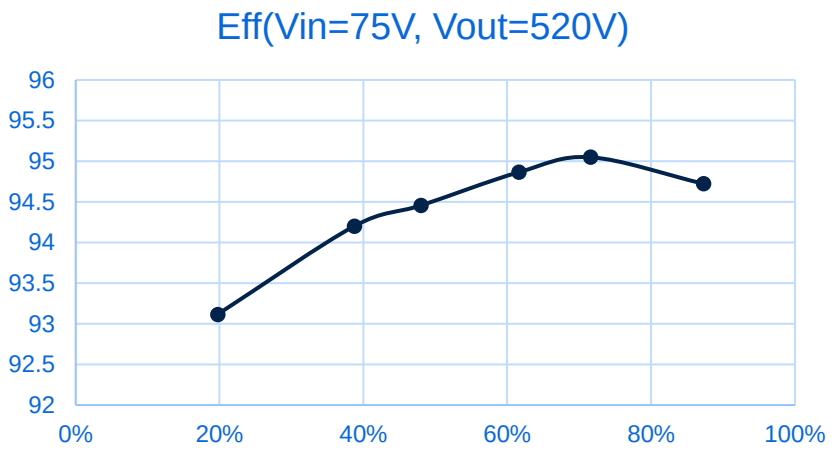
Charging mode



Vin=550 V, Iout=40 A, steady state



Discharging mode



Vin=70.5Vdc, Iout=4.2 A, steady state

CH1:	HV mos, Vgs, LLC1	CH3:	iTank, LLC1
CH2:	HV mos, Vds, LLC2	CH4:	LV mos, Vds, LLC1
CH5	LV mos, Vds, LLC2	CH6:	iTank, LLC2

Key products

STPOWER SiC MOSFET families

The best switching devices for high density applications

Gen1 **1200-1700 V**	Excellent **Ron vs. Tj** behavior: very suitable for SMPS and medium power motor drives Optimized @ **Vgs 20 V**
Gen2 **650, 1200 V**	Outstanding **Ron vs. Qg trade-off:** highly suitable for a broad range of automotive and industrial applications Optimized @ **Vgs 18 V**
Gen3 **650, 750, 900, 1200 V**	**The best Ron vs. Qg trade off:** highly suitable for very high frequency applications industrial & automotive Optimized @ **Vgs 18 V**, enables **15 V** gate drive also

SCT040W120G3-4 for PFC, DC-DC-High side

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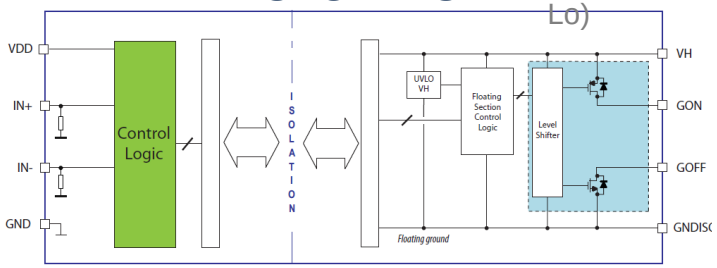
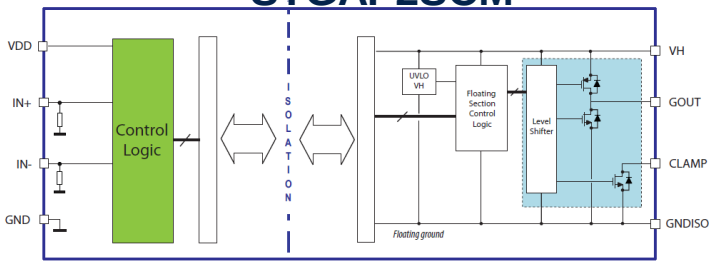
STGAP gate driver

1700 V, 6 kV galvanic isolated single & dual channel

STGAP2SM (6.6 kW DCDC-Lo)

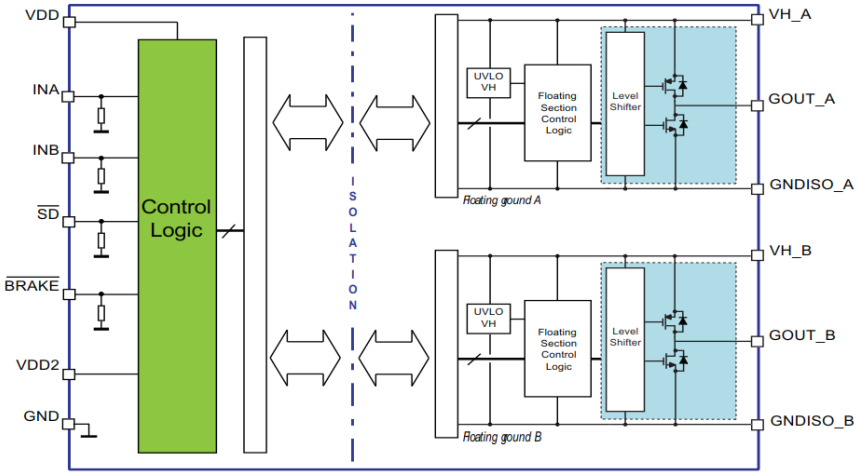


STGAP2SCM



- 3V3/5 V logic inputs
- **Up to 26 V supply voltage**
- **4 A sink/source driver current capability**
- 100 V / ns CMTI
- Propagation delay 80 ns
- Standby function
- High-voltage rail up to 1700 V
- Temperature shut down protection

STGAP2D



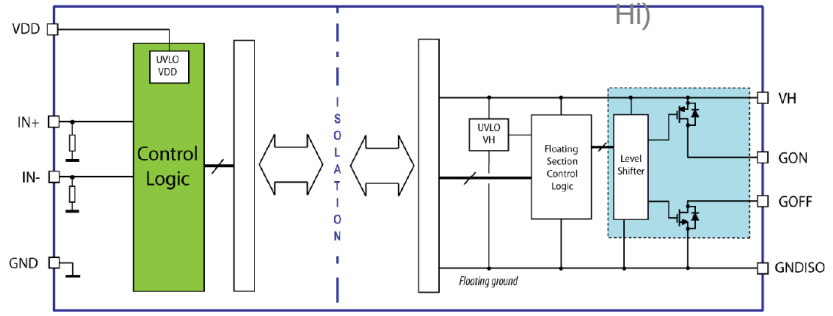
High performance

- Galvanic isolated up to 1700V

Robustness

- Interlocking
- Negative gate drive ability

STGAP2SICS (6.6 kW PFC, DCDC-HI)



High performance

- Galvanic isolated up to 6 kV optimized for SiC MOSFETs

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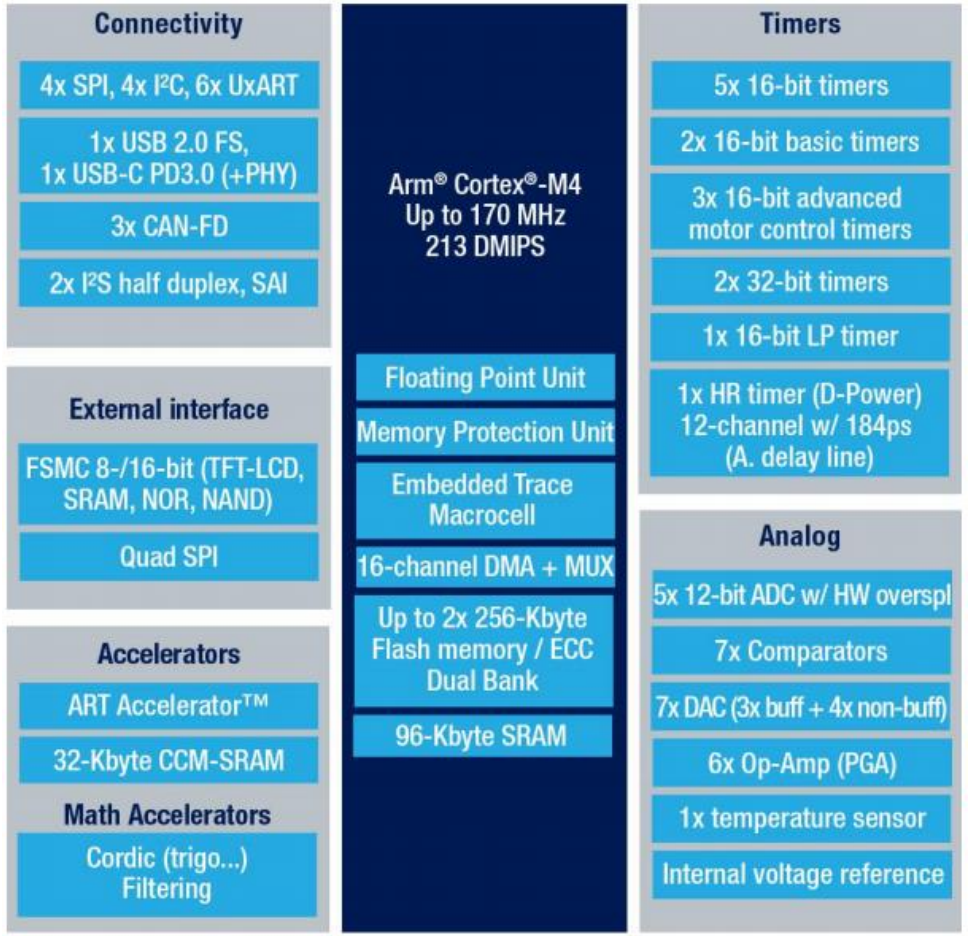
STM32G474 MCU

Hi-resolution PWM and comprehensive set of analog peripherals for digital control



- 170MHz 32-bit Arm® Cortex®-M4 core with FPU
- Routine booster of CCM-SRAM up to 32 KB
- Mathematic hardware accelerators (CORDIC / FMAC)
- High-resolution timer (184 ps) for precise PWM control
- Rich advanced analog
- USB Type-C Power Delivery (PD)
- ±1% internal clock

MAIN APPLICATIONS

Commercial, architectural and street lighting

Server/Telecom

Welding

Charging station

UPS & Data center Power supply

Solar inverters

Summary

Summary

Digital power ESS solution to power future microgrids

Energy transmission can be improved by establishment of microgrid systems with deployment of ESS solution

Technology of bidirectional power feature is a key to success for ESS applications

ST is ready to provide the solution and rich product portfolios for customers to focus on ESS product design

Our technology starts with You

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