STM32在数字能源解决方案

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STM32 portfolio

LONGEVITY 10 YEARS COMMITMENT

MPU

STM32MP1
Up to 1 GHz Cortex-A7
209 MHz Cortex-M4

STM32MP2
Dual 1.5 GHz Cortex-A35
400 MHz Cortex-M33

High-performance MCUs

STM32F7
1082 CoreMark
216 MHz Cortex-M7

STM32H7
Up to 3224 CoreMark
Up to 600 MHz Cortex -M7
240 MHz Cortex -M4

STM32N6
MCU with neural processing unit

STM32F2
Up to 398 CoreMark
120 MHz Cortex-M3

STM32F4
Up to 608 CoreMark
180 MHz Cortex-M4

STM32H5
Up to 1023 CoreMark
250 MHz Cortex-M33

Mainstream MCUs

Mixed-signal MCUs

STM32F3
245 CoreMark
72 MHz Cortex-M4

STM32G4
569 CoreMark
170 MHz Cortex-M4

STM32C0
114 CoreMark
48 MHz Cortex M0+

STM32F0
106 CoreMark
48 MHz Cortex-M0

STM32G0
142 CoreMark
64 MHz Cortex-M0+

STM32F1
177 CoreMark
72 MHz Cortex-M3

Ultra-low-power MCUs

STM32L0
75 CoreMark
32 MHz Cortex-M0+

STM32U0
140 CoreMark
56 MHz Cortex-M0+

STM32L4
273 CoreMark
80 MHz Cortex-M4

STM32L4+
409 CoreMark
120 MHz Cortex-M4

STM32L5
443 CoreMark
110 MHz Cortex-M33

STM32U5
651 CoreMark
160 MHz Cortex-M33

Wireless MCUs

STM32WL
162 CoreMark
48 MHz Cortex-M4
48 MHz Cortex-M0+

STM32WB0
64 MHz Cortex-M0+

STM32WB
216 CoreMark
64 MHz Cortex-M4
32 MHz Cortex-M0+

STM32WBA
407 CoreMark
100 MHz Cortex-M33

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Latest product generation
Radio coprocessor only
New series or lines introduced in 2024
Pre-announcement

China D-Power 应用分类

- D-Power
  - a. Industry Power
    - 1. Telecom Power 基站电源
    - 2. Server Power 服务器电源
    - 3. UPS Power　不间断电源
  - b. Solar Inverter + ESS + BTS 光伏逆变器、储能系统、电池化成系统
  - c. EV Charger 充电桩

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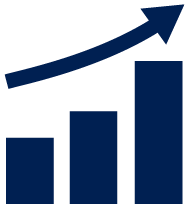
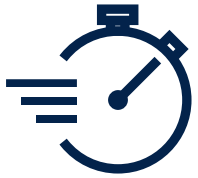
数字电源对主控的需求

数字电源需求

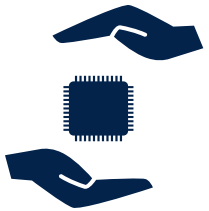


#1.高算力——从单一模块到系统集成
先进的内核，超高的主频、高执行效率和数学加速器



#2.采集精度高且快，控制精度高响应快
高精度多个独立ADC及多通道
高精度PWM和灵活的输出配置

#3.多样通讯
多种通讯接口（UART、I2C及CAN总线）



#4.高可靠性及安全性
安全加密机制
耐受恶劣高温125℃环境

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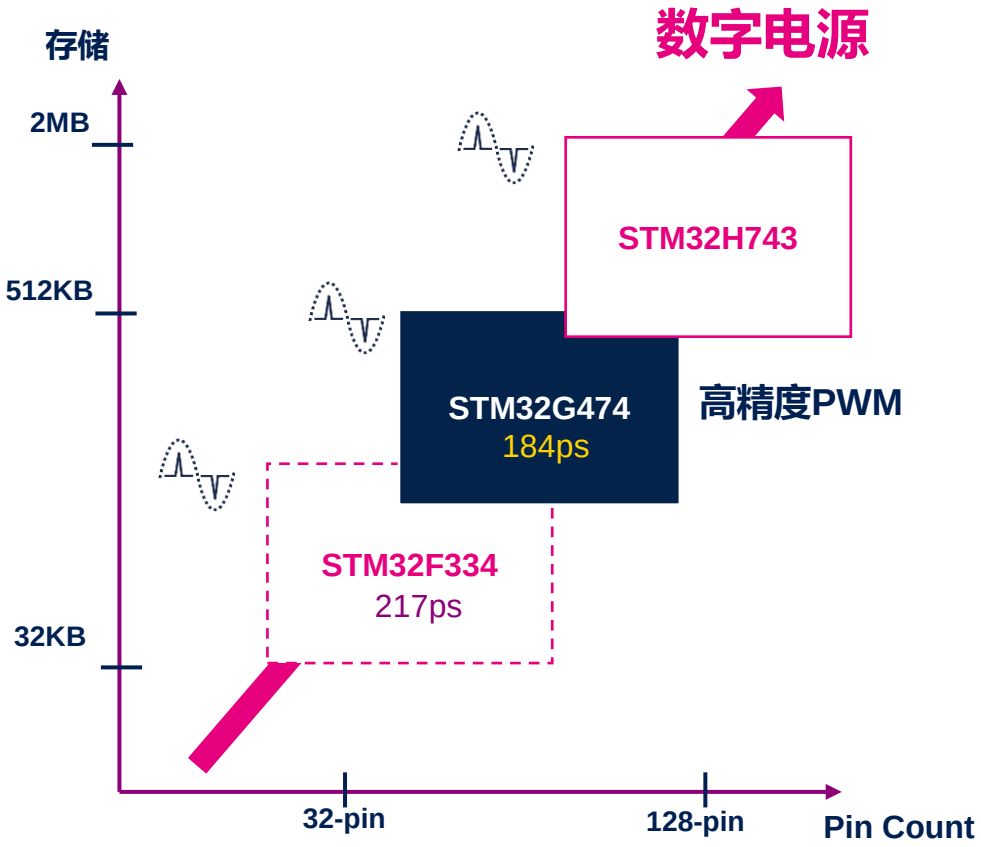
STM32平台化应用

STM32数字电源PCS核心逆变



STM32G474

ADC +MCU(170MHz+**Cordic**) + **PWM**

STM32H743

ADC + MCU(480MHz) + **PWM**

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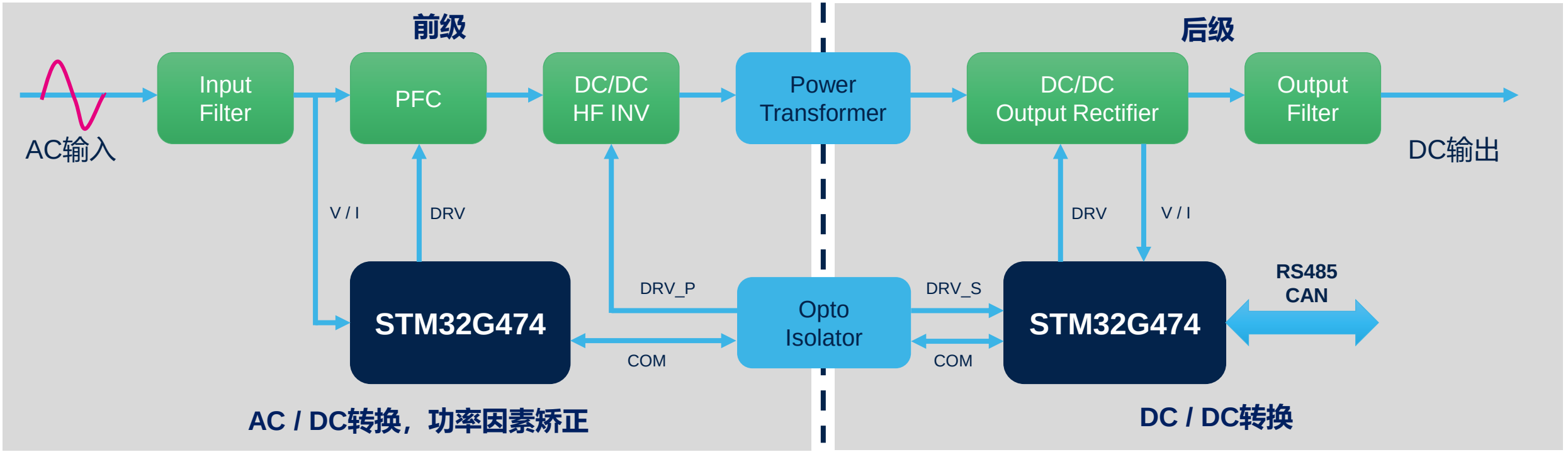
通信 / 服务器电源



- 高精度定时器高达12路高精度PWM输出，可支持PFC和后级DC/DC的各种拓扑
- 数学加速器，提升运算效率
- 内置高速ADC、DAC及比较器，轻松完成信号采样
- 多种通讯接口（UART、I2C及CAN总线）
- 耐受高温125℃

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PFC/ LLC- STM32G474
Configurations of MCU key functions on digital

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

Hi-Resolution PWM Timer (184 ps)

- Mainly for high frequency (HF) MOSFET control at 70kHz

Multiple ADCs (4 Msps) Up to 5

- AC voltage, voltage/current, and hotspot temperature sensing

Comparators and DACs Up to 7

- OVP and critical current protection

UART, SPI, CAN and USB

- UART for internal/external communication

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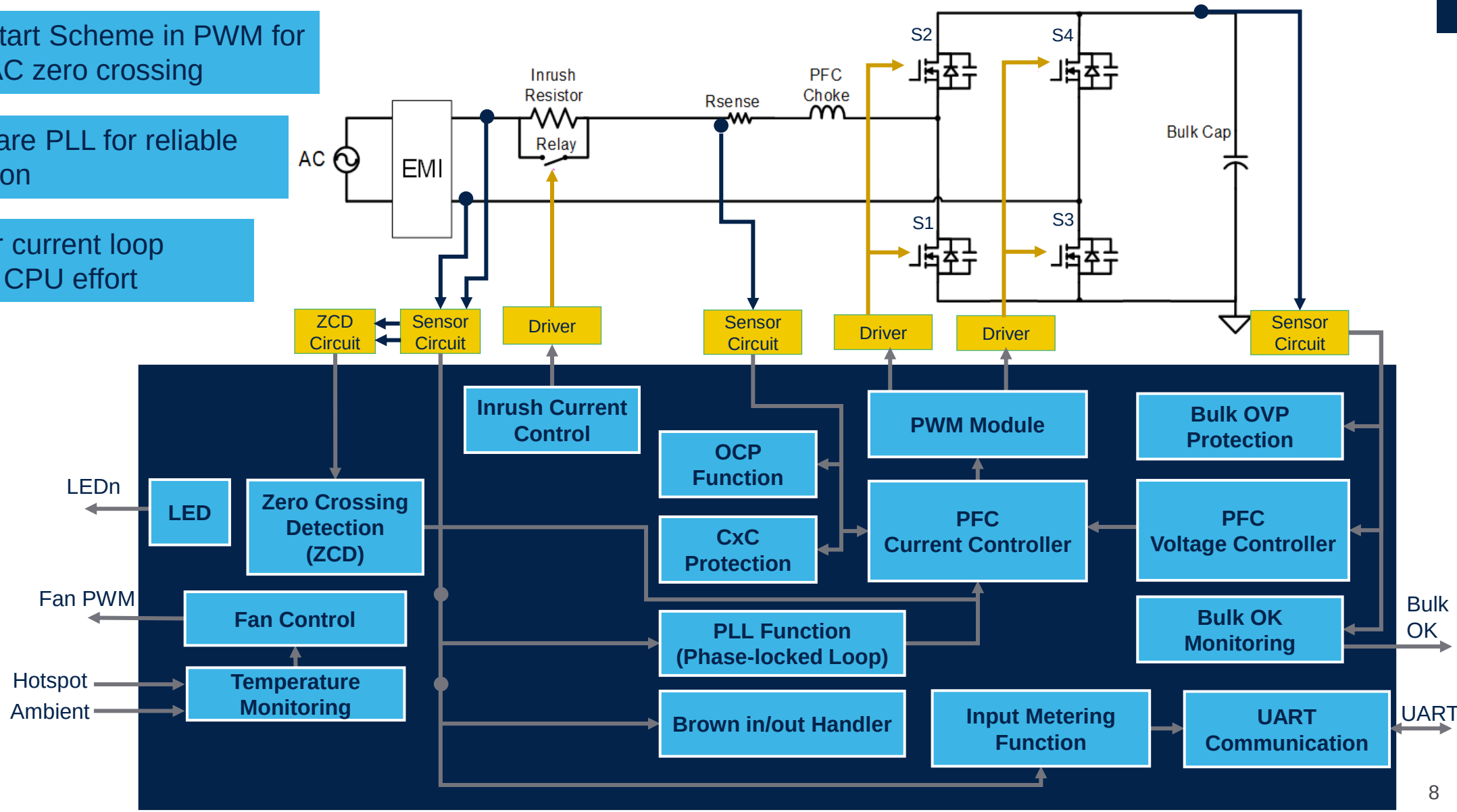
STM32G474-PFC 框图

Key firmware features

Blanking + Soft-start Scheme in PWM for current spike at AC zero crossing

HW ZCD + software PLL for reliable AC phase detection

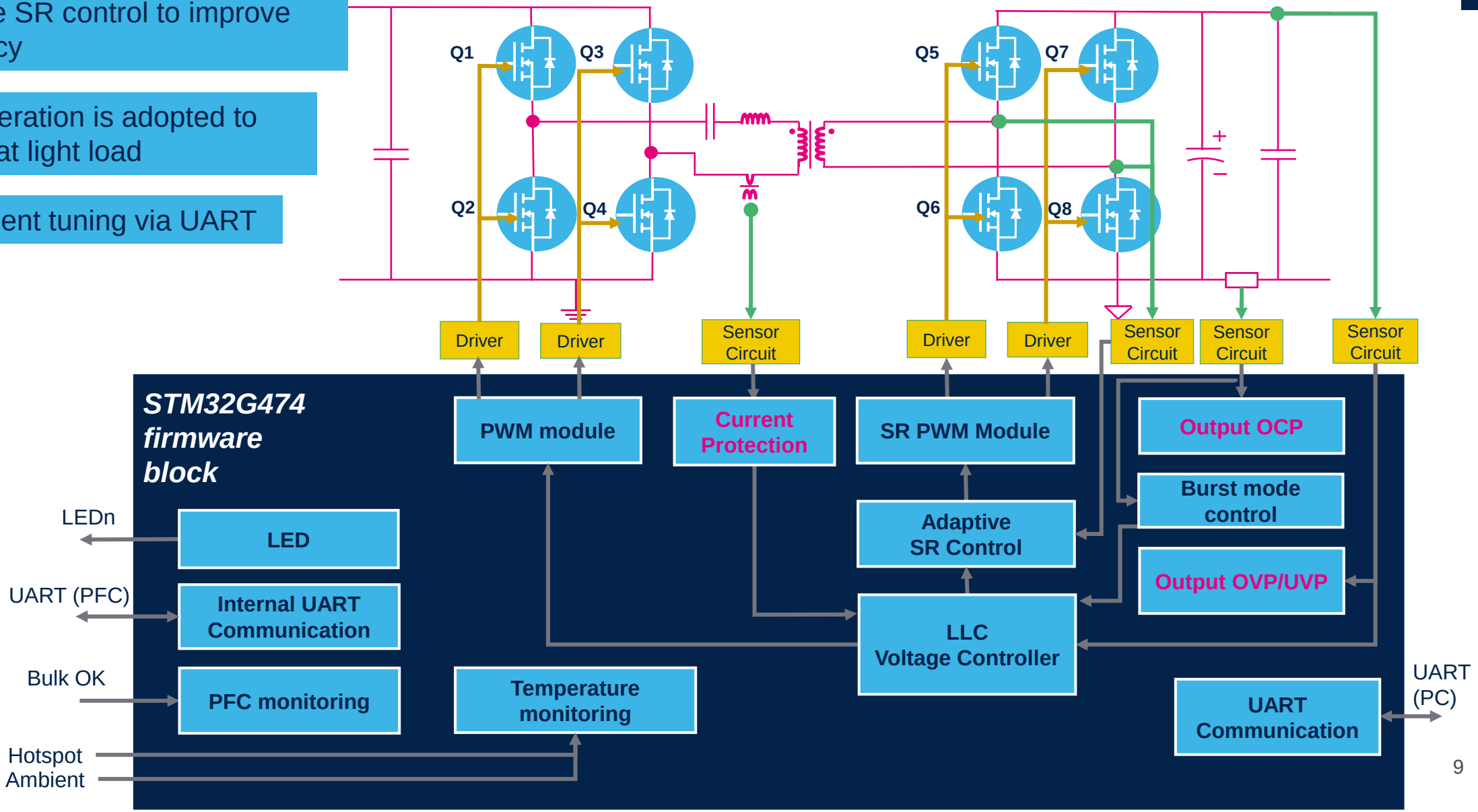
FMAC is used for current loop control to reduce CPU effort



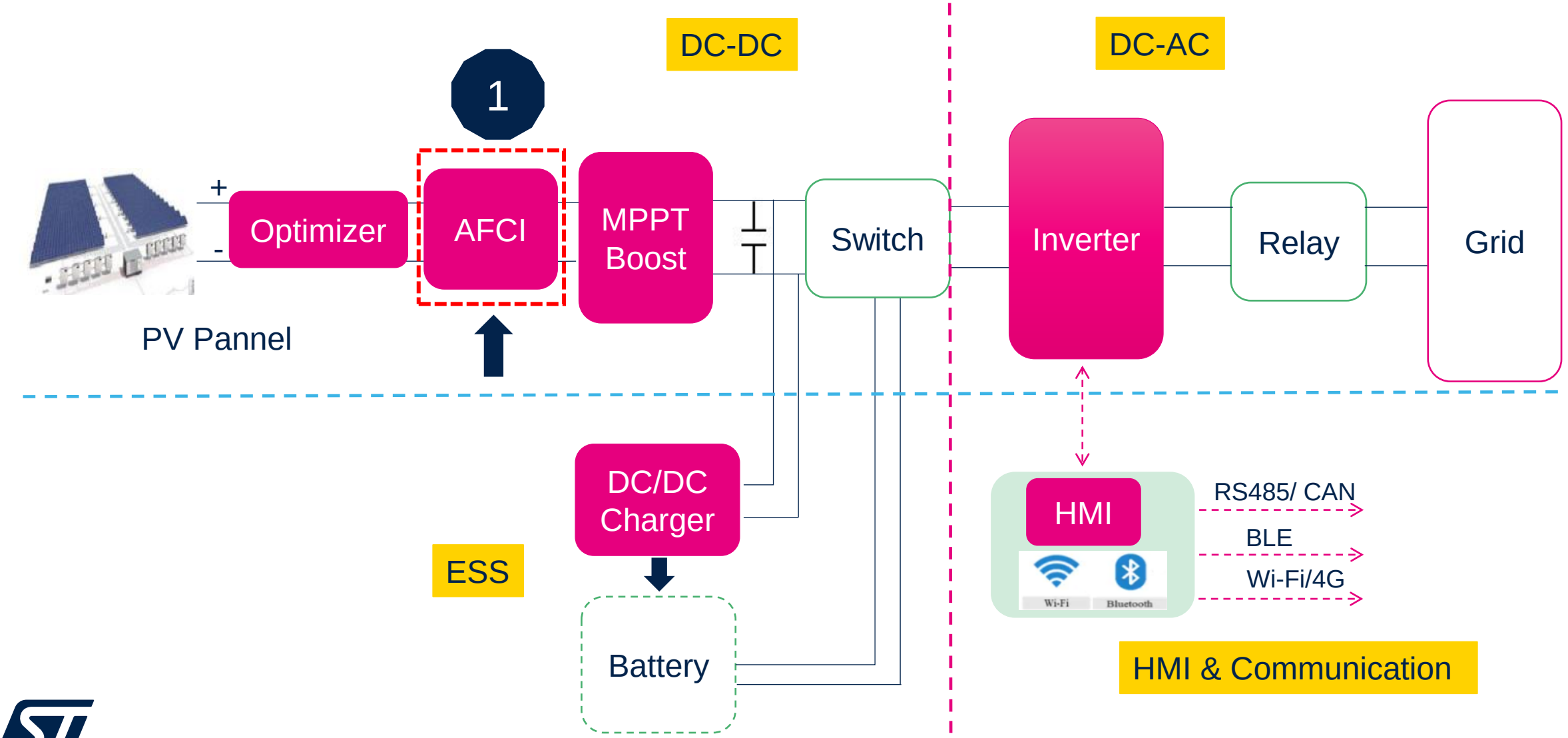
STM32G474-LLC框图

Key firmware features

- Digital adaptive SR control to improve overall efficiency
- Burst mode operation is adopted to reduce losses at light load
- On-line coefficient tuning via UART

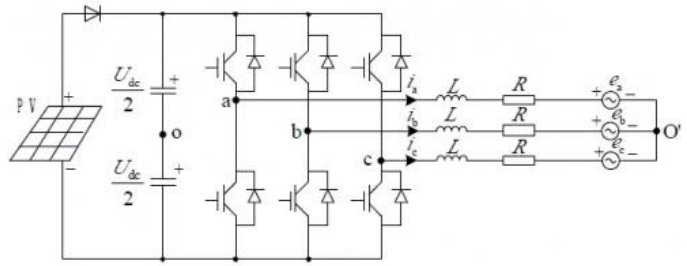


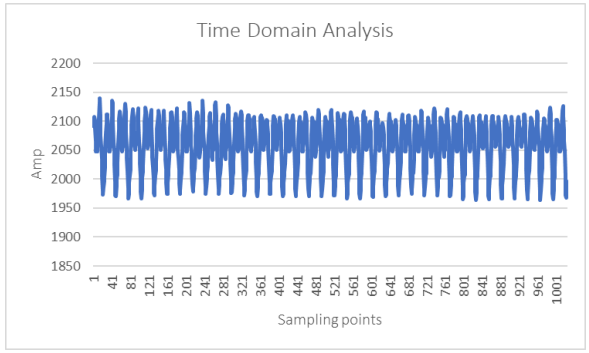
Solar inverter block diagram

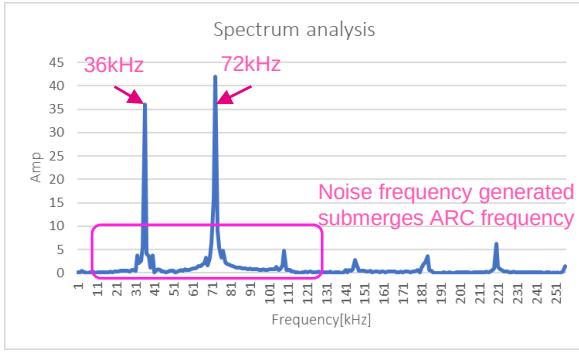


AFCI系统设计难点

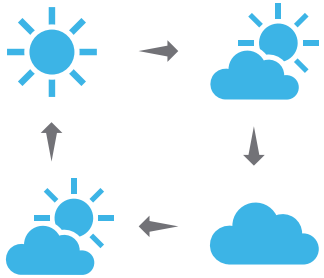
逆变器噪声

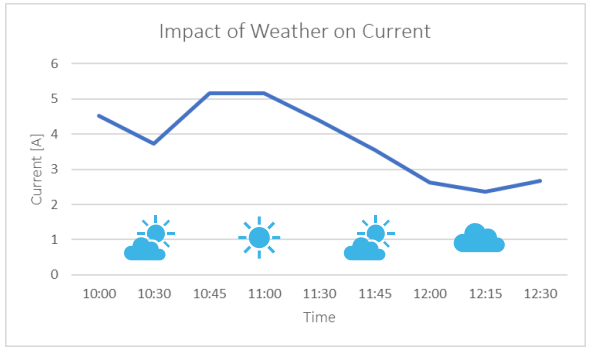






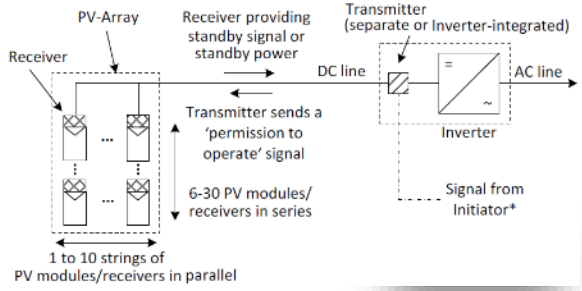
天气变化





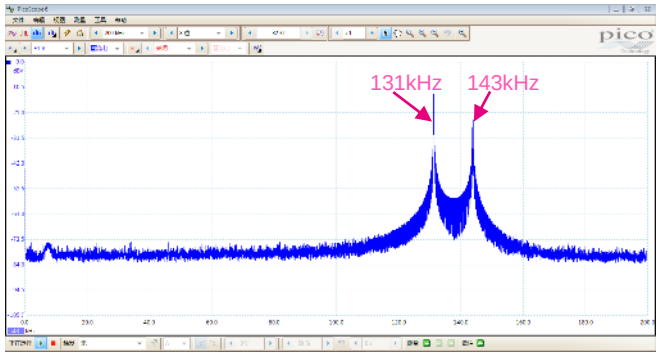
Date	Time	Weather	Voltage [V]	Current [A]	Power [KW]
15/07/2023	10.00	Nice, little cloudy	315	4.52	1.42
	10.30	Nice, little cloudy	277	3.74	1.04
	10.45	Nice, little cloudy	301	5.16	1.56
	11.00	Nice, little cloudy	300	5.16	1.55
	11.30	Nice, little cloudy	300	4.39	1.26
	11.45	Nice, little cloudy	320	3.55	1.10
	12.00	Cloudy	317	2.62	0.83
	12.15	Cloudy	334	2.36	0.79
	12.30	Cloudy	331	2.67	0.87

快速关断



Requirements of the Power Line Communication

Symbol	Transmitter Specification	Min.	Nom.	Max.	Unit	Remark
W_1	Logic 1 Code Word	{{-1, -1, -1, +1, +1, +1, -1, +1, +1, -1, +1}				+1 = mark, -1=space
W_0	Logic 0 Code Word	{+1, +1, +1, -1, -1, -1, +1, -1, -1, +1, -1}				+1 = mark, -1=space
F_M	Mark Frequency	131.236875	131.25	131.263125	kHz	6.25kHz × 21
F_S	Space Frequency	143.735625	143.75	143.764375	kHz	6.25kHz × 23
T_S	Average Bit Period	5.119488	5.12	5.120512	ms	(Time to complete one full duty cycle)/219
T_T	Transmission Period	168.943104	168.96	168.976896	ms	3 Words
T_Q	Quiet Period	901.029888	901.12	901.210112	ms	16 Words
T_C	Cycle Period	1069.972992	1070.08	1070.187008	ms	19 Words



AFCI 项目流程 - PoC 阶段

Awareness | Understanding | Acceptance | **Project kick-off** | **Project development**

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ST提供的AFCI开发包

AFCI硬件参考板1.0

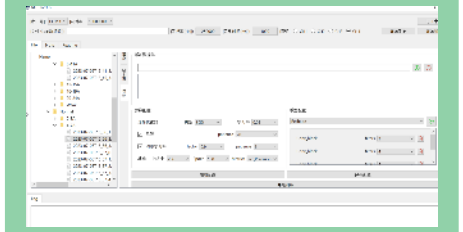
包含STM32G4和STM32H7的硬件线路板用于数据收集和测试

固件代码

- 数据记录工具
- 模型实时处理方法
- 相关的后处理

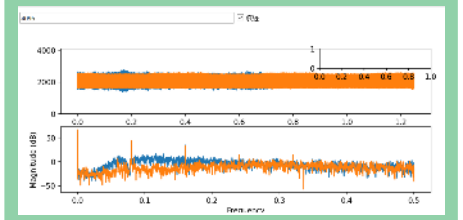
数据收集PC工具

- 数据收集程序
- 实时检测程序



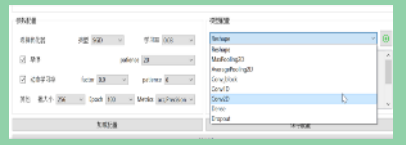
信号检测工具

用于分析采集到数据的信号质量



AFCI AI 模型训练 (exe 文件)

用于训练采集的数据来生成AI模型



❖ 技术支持， 使用文档

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ST 边缘AI 成功案例

NANOEDGE AI STUDIO

INDUSTRIAL | DEMO

Fan anomaly detection based on vibrations

Learn to detect abnormal behavior at the edge on a vibrating machine.

nke WATTECO

NANOEDGE AI STUDIO

INDUSTRIAL | CUSTOMER

AI solution for industrial predictive maintenance with NKE Watteco

Predictive maintenance solution for industrial equipment.

CROUZET

NANOEDGE AI STUDIO

TRANSPORTATION | CUSTOMER

AI solution for monitoring automatic doors with Crouzet

Predictive maintenance on motors for automatic door motors.

NANOEDGE AI STUDIO

INDUSTRIAL | DEMO

Anomaly detection in an electric motor

Current sensing to detect abnormal behaviors in motors.

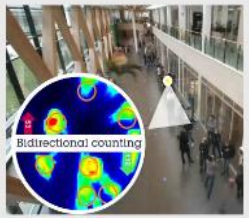
OXYtronic

NANOEDGE AI STUDIO

INDUSTRIAL | CUSTOMER

AI solution for industrial predictive maintenance with Oxytronic

Predictive maintenance solution for industrial equipment.



Schneider Electric

STM32 Cube.AI

SMART OFFICE | CUSTOMER

People flow counting Sensor with Schneider Electric

An innovative approach to measure people flows using an in-house thermal sensor.

STM32 Cube.AI

SMART CITY | DEMO

Acoustic scene classification

Identify different environments (indoor, outdoor, in-car) using a simple microphone.

STM32 Cube.AI

WEARABLES | DEMO

Human Activity Recognition

Easily identify 5 different activities with a 3D accelerometer.

STM32 Cube.AI

INDUSTRIAL | DEMO

People presence detection (visual wake word)

Human detection on high-performance MCU.

STM32 Cube.AI

INDUSTRIAL | DEMO

Aftermarket wireless digit reader

Equip meters with aftermarket wireless & low-power readers.

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Visit www.st.com/st-edge-ai-suite

Takeaways

基于AI的电弧故障分断器（AFCI) 助力于安全和可持续发展。

- Turnkey 参考设计方案，能有效快速部署最先进的AFCI方案
- 基于深度学习的检测器，可达到高检测准确率
- 高性能基于边缘计算的STM32G4 或是 STM32H7的MCU
- TSV7xx 运放带来更灵活和准确的信号处理
- 经验丰富的支持团队，提供成熟的材料和流程

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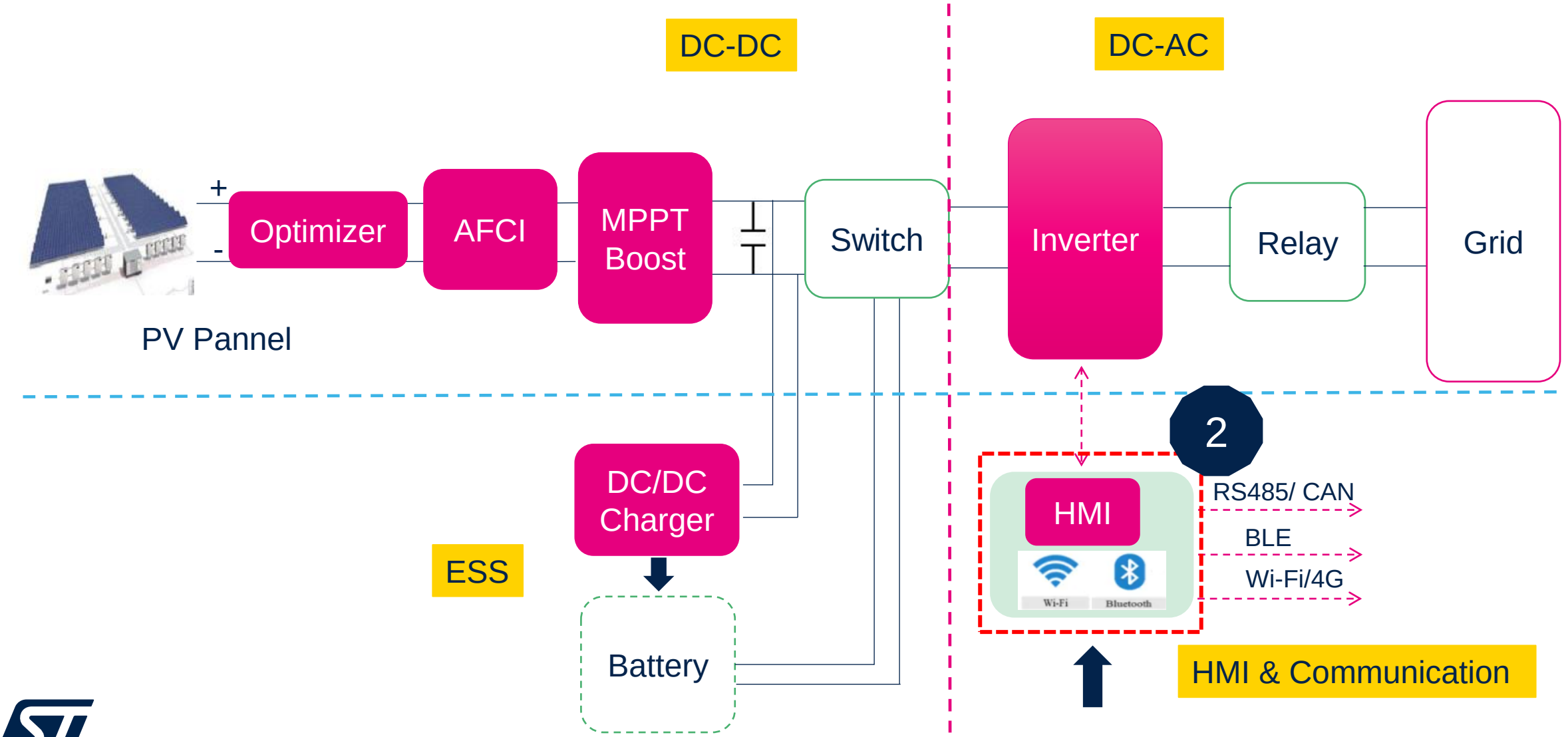
Solar inverter block diagram



STM32 high-performance MCUs

Up to 3224 CoreMark and a rich set of peripherals

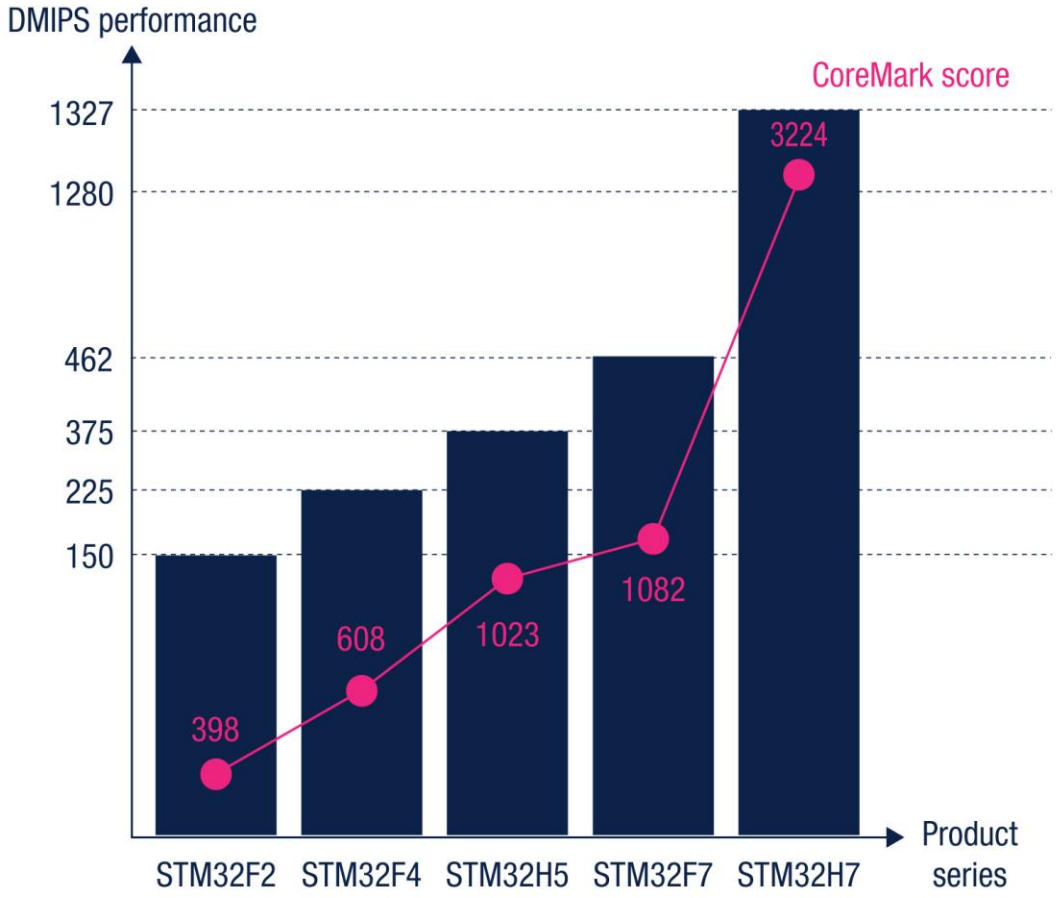
STM32H5
- Arm® Cortex®-M33 at 250 MHz – 375 DMPIS
- From 128 Kbytes to 2 Mbytes of Flash memory
- High performance, scalable security, affordable

STM32H7
- Arm® Cortex®-M7 + Arm® Cortex®-M4 FPU at 480 MHz – 1327 DMIPS and up to 600 MHZ - 1284 DMIPS on single core Arm® Cortex®-M7
- From 64 Kbytes to 2 Mbytes of Flash memory
- High Performance, scalable memory and security

STM32F7
- Arm® Cortex®-M7 + FPU at 216 MHz – 462 DMPIS
- From 256 Kbytes to 2 Mbytes of Flash memory
- Embedded flash & external memories

STM32F4
- Arm® Cortex®-M4 + FPU up to 180 MHz – 225 DMIPS
- From 64 Kbytes to 2 Mbytes of Flash memory
- Cost-effective and power efficiency

STM32F2
- Arm® Cortex®-M3 at 120 MHz – 150 DMIPS
- From 128 Kbytes to 1 Mbyte of Flash memory
- Foundation lines for performance and connectivity



Legend: Latest product series/lines generation

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STM32H5 系列亮点

性能提升

- Cortex-M33内核，1.5 DMIPS/MHz，4.09 CoreMark/MHz
- 先进的40nm工艺，使能
- 更高的系统主频
- 更快的flash访问

- 增强的系统架构

新特性，高集成，高性价比

借助40nm工艺:

- 更多的内部存储器 (FLASH+RAM)
- 更多的新特性外设
- 更小的面积

STM32F1/ F4 平台升级

功耗优化

- 40nm工艺优化动态功耗
- 静态功耗更低
- 其他功耗优化特征

先进安全功能

- Arm Cortex-M33内核与TrustZone®
- 产品生命周期
- 调试认证(Debug Authentication)
- 其他

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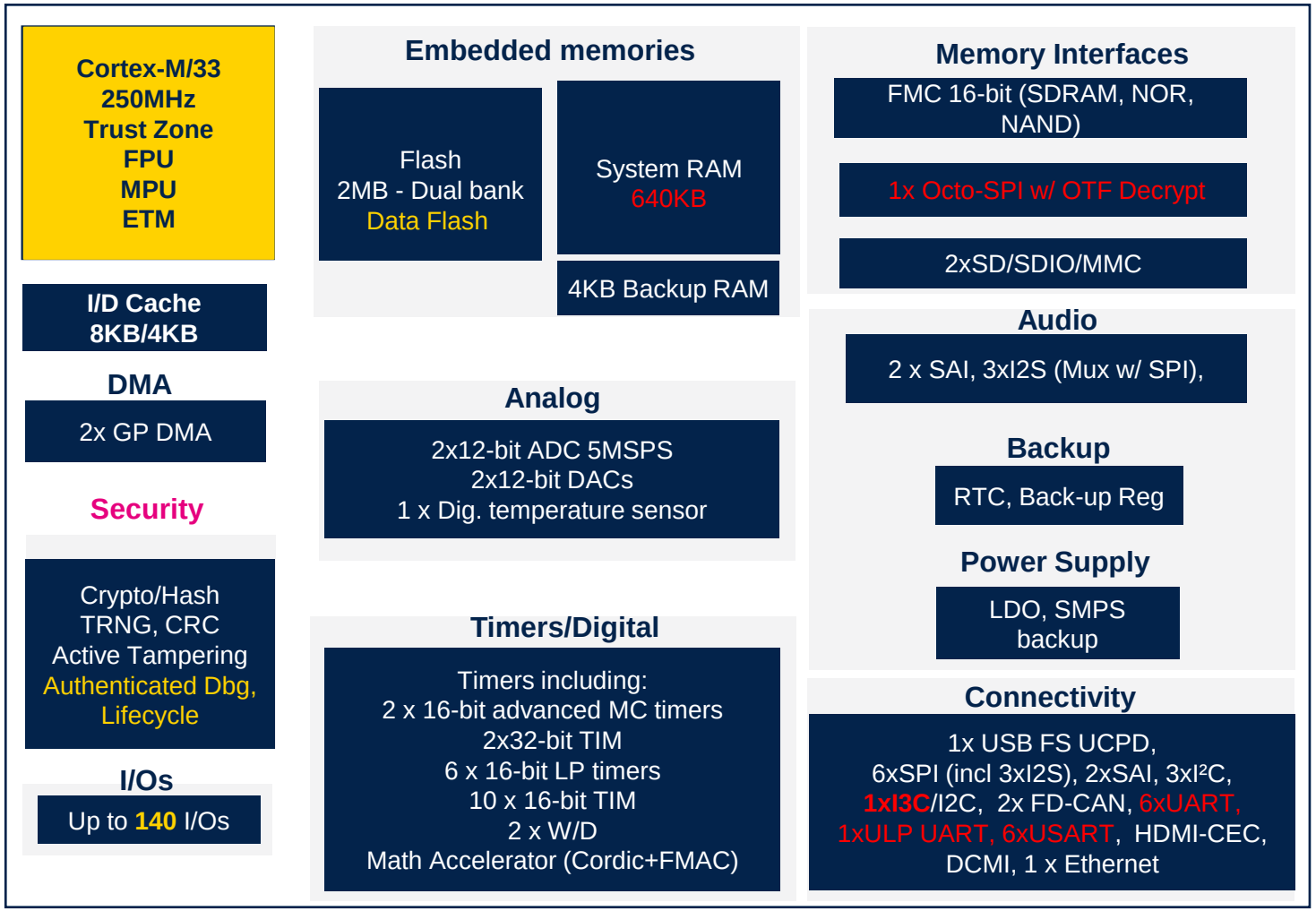
STM32H5-2MB

高性能 & 高性价比

- CM33内核，250Mhz主频， 375DMIPS
- TrustZone
- 集成丰富外设
- 先进安全特性和全新器件生命周期管理
- 高效动态功耗
  - 124uA/MHz w/ LDO
  - 64uA/MHz w/ SMPS
- VDD 1.71V to 3.6V
- TA: -40°C to 85°C/125°C
- 64 → 176pin



STM32H5

=

性能提升

+

功耗优化

+

新特性，新外设

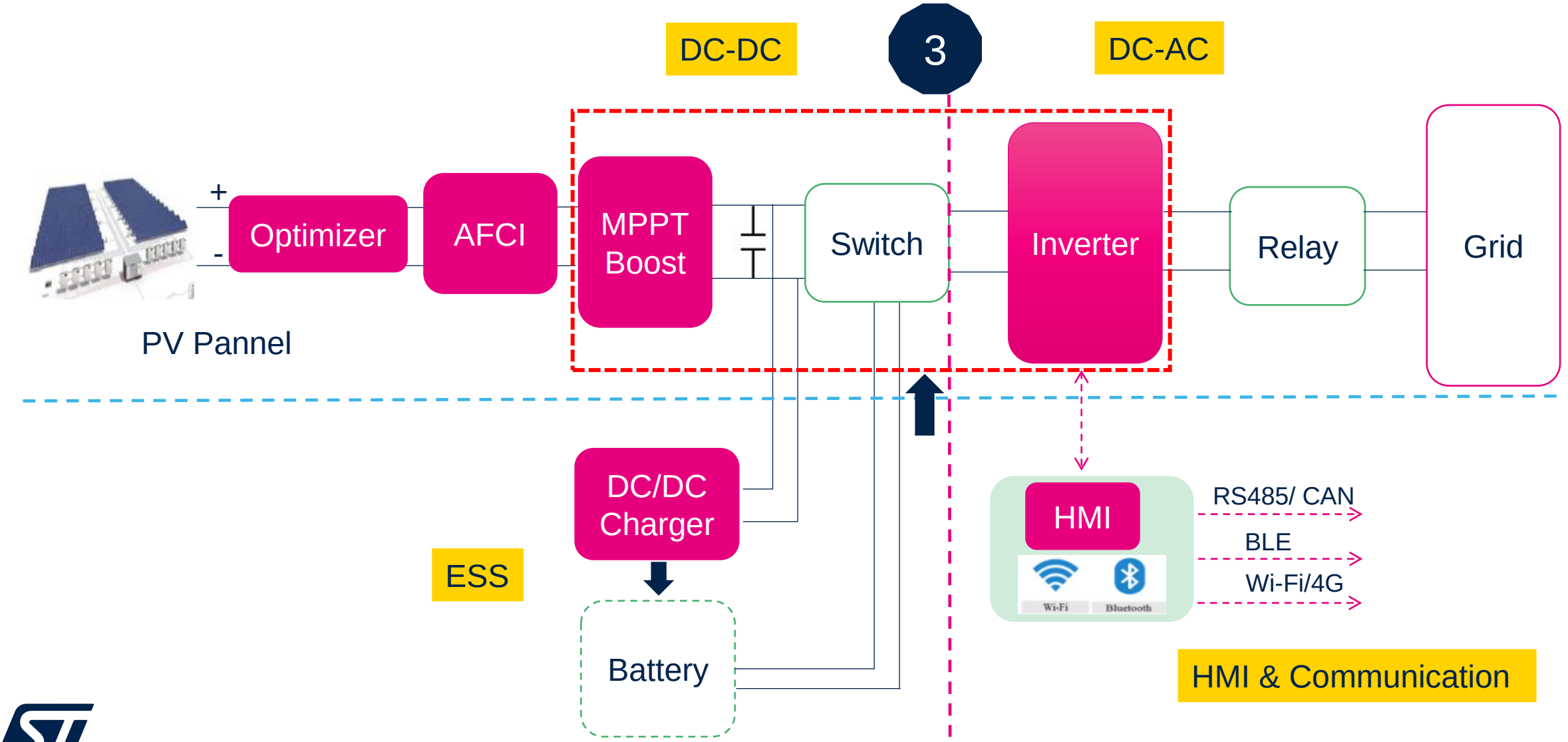
+

先进安全功能

平台升级

STM32H5系列不是简单替换F1/ F4系列！
而是带来更多应用特点

Solar inverter block diagram



STM32G4产品一览表

参数	★STM32G474 高精度PWM型	STM32G473 性能型	★STM32G491 入门型	STM32G431 入门型
内核, 主频	Arm Cortex-M4, 170 MHz			
Flash (max)	**512** Kbytes (2x256KB dual bank)		**512** Kbytes **single bank**	**128** Kbytes **single bank**
RAM (up to)	**96** Kbytes			**22** Kbytes
CCM-SRAM	**32** Kbytes		**16**Kbytes	**10** Kbytes
12-bit ADC SAR	**5x** 12-bit @4 MSPS		**3x** 12-bit @4 MSPS	**2x** 12-bit @4 MSPS
比较器	**7x (17纳秒)**		**4x (17纳秒)**	
运放 1% 精度	**6**		**4**	**3**
12-bit DAC	**7**		**4**	
USB FS Device	**1**			
CAN-FD	**3x**		**2x**	**1x**
高级电机控制定时器	**3x** (170 MHz)			**2x** (170 MHz)
12 通道 高精度定时器	**1x (184ps)**	-		
温度范围	-40 to 85°C / **-40 to 125°C**			
引脚数	48 to 128		32 to 100	

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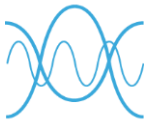
STM32G4 系列 – 关键词

性能

- Arm® Cortex®-M4 at 170 MHz
- 213 DMIPS and 550 CoreMark® results
- 优化动态功耗(163µA/MHz)

- ART Accelerator™ (动态缓存)
- 数学运算加速器（三角函数+数字滤波）
- CCM-SRAM Routine Booster (静态缓存)



丰富的内置数模外设

- 运放 (内置增益), DACs, 比较器
- 12-bit ADCs 4Msps （硬件过采样 16bit）
- CAN-FD (up to 8Msps bit rate)

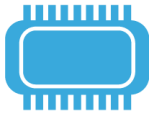
- 高精度定时器 V2 (184皮秒)
- USB type-C Power Delivery3.0
- 1%精度内置RC (-5~90dC), 2%(全温度范围)

功能安全与信息安全

- 双Bank Flash支持ECC (error code correction)
- 安全存储区域
- 硬件加密 AES-256
- SIL, Class-B
- SRAM支持奇偶校验

安全在线升级

功能安全设计包



完整的产品目录

- 补充已有STM32F3系列产品目录
- 环境温度范围-40dC 至 85 or 125dC

- 从 32 至 128-pin
- 从 32KB 至 512KB Flash

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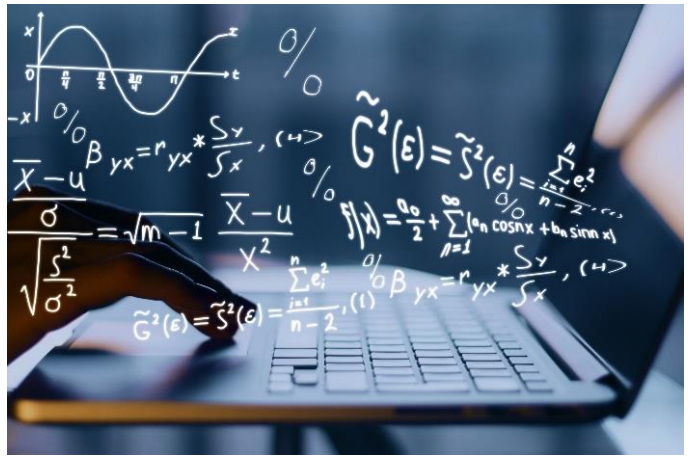
数学加速器

功能加速与减轻CPU负担

1. 三角函数 (Trigo)

- 非常有利于电机控制中所常用的的矢量运算(FOC)
- 精度可达20位

- 矢量旋转(极坐标到平面坐标): Sin, Cos
- 矢量转换(平面坐标到极坐标): 反正切Atan2, 模数Modulus
- 双曲正弦Sinh, 双曲余弦Cosh, 指数函数Exp
- 反正切Atan, 反双曲正切Atanh
- 平方根
- 常用对数 Ln



- 显著提高数学函数运算效率

➔ 比软件方式计算快**5倍**，精度高**10倍**以上，CPU负荷为**0%**

➔ 在电机驱动应用实例中，约提高**12%**控制环路速度

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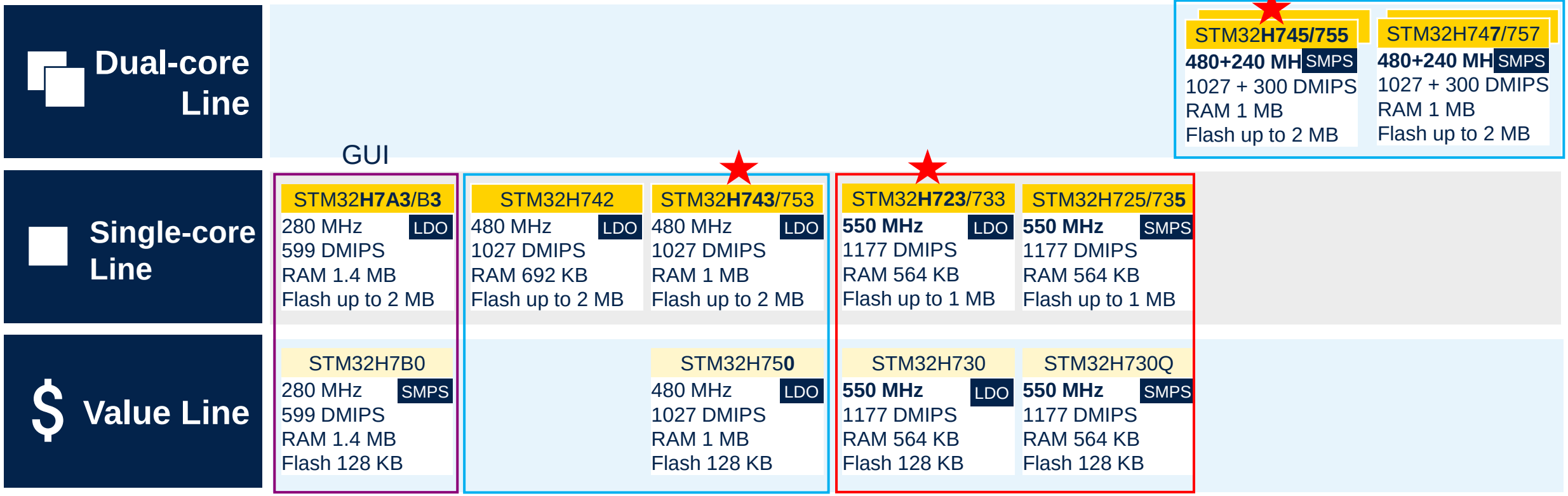
STM32H7系列延展

高性能与高性价比兼备



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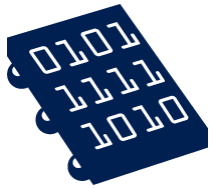
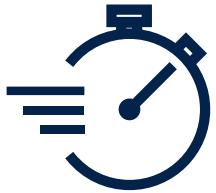
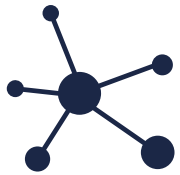
丰富的内部资源



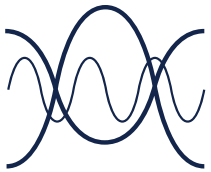
- 内置高达**2MB双区**的Flash，支持ECC校验
- 内置高达**1.4MB SRAM**（多达1MB连续地址空间），支持ECC校验
- 丰富的存储外扩接口：32bit FMC，SDMMC及**Octo-SPI**



- **高精度定时器**：精度高达**2.1ns**，10路PWM输出
- 2个高级定时器，可实现双电机控制
- 12个通用定时器及5个低功耗定时器



- 多达**11个U(S)ART**，6个高速 SPI 和5个 I2C
- 多达3个新一代 **FD-CAN**总线，通讯效率大幅度提升
- 2个USB OTG接口，支持高速和全速传输
- 10/100 以太网控制器
- DCMI 数字摄像头接口 和 4个 SAI 音频接口



- 3个**16位ADC**，采样速率高达**3.6MSPS**，共有36通道
- DFSDM 数字滤波模块
- 2个DAC、2个模拟比较器和2个运算放大器

STM32高精度定时器

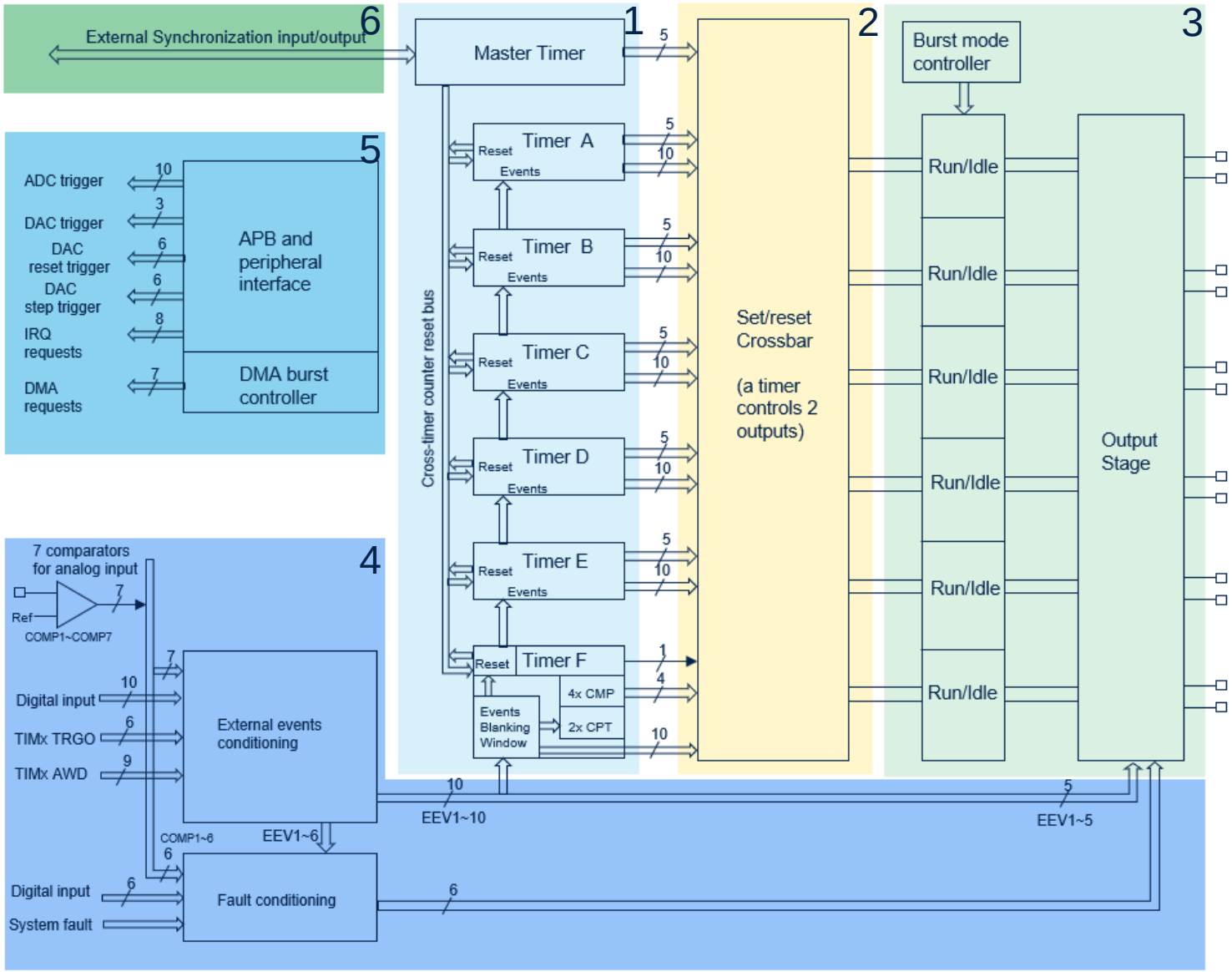
外部同步
- **片内定**时器同步
- **多芯片同步**

触发，
中断与DMA请求
- 10 ADC **触**发信号
- 3 DAC**触**发信号
- 8**中断** + 7 DMA

多种内/外部控制信号
10 事件
- 输出 set/reset
- 计数器reset
- 捕获

6 故障
- PWM shutdown

模拟与数字输入，可设定触发方式(边沿，电平，滤波)



总共7**个定**时器
- 7x 16-bit 计数器
- **独立分**频
- **每个定**时器可独立使用，**亦可与其他耦合使用**

交错互联总线 (crossbar)
输出set/reset**可由本定**时**器**单元控制，也可由:
- **外部事件**
- **其他子定**时器事件
- **主定**时器事件

32**种触**发源可选

输出状态管理，允许多种输出方式与逻辑
- **极性**
- **安全状**态
- **死区插入**，斩波

异步故障保护
硬件burst模式控制

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HRTIMer，不仅仅是高精度而已…

高精度PWM

- 12 通道PWM信号输出，频率和占空比精度可高达184ps
- 184ps 相当于 5.4GHz 定时器时钟
- 自带电压与温度补偿，保证精度不漂移

高灵活度PWM

- 7个独立时钟计数器（1主+6从），可相互配合生成灵活多样的PWM波形
- 可灵活配置成 6 组互补输出的 PWM 对
- 内置信号枢纽 Crossbar，单个 PWM 周期内最多可达 32个 set/reset 触发源
- 灵活角色可配Master/Slave，更适合多项控制

多事件响应

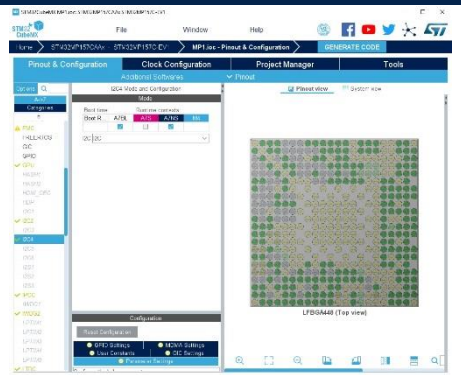
- 6个模拟与数字的错误输入源
- 10个事件输入源
- 事件响应可配置：计数响应，窗口内连续事件响应等

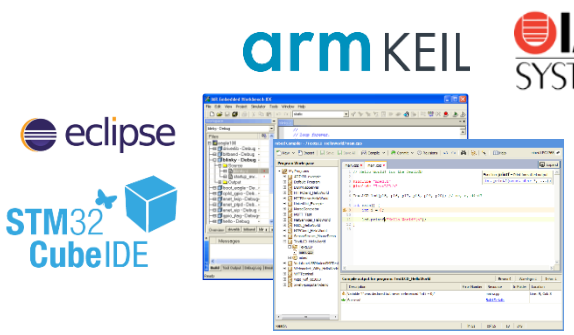
12个独立输出通道

- 可支持任意一种常见拓扑：
  1x 12 PWM (三项交错LLC)
  12x 1 PWM (多项独立 buck 调光控制器)
- 每一路定时器均有可配置参数DMA，整个HRTIM单元亦有高级DMA功能，可部分或整体更新参数

STM32 软件工具

完整支持Arm Cortex-M 开发生态





STM32CubeMX	IDEs Compile and Debug	STM32 Programming Tool
STM32CubeMX • 配置及初始化代码生成 • 解决资源配置冲突	**灵活的方案** • 第三方 IDE, 如 IAR、Keil • 免费的基于Eclipse的官方IDE STM32CubeIDE*	**STM32CubeProgrammer** • Flash 和/或 系统存储 读写 • 支持 GUI 或 命令行 界面

STM32数字电源开发支持

STM32
方便数字电源设计

数字电源开发SDK（支持PFC和PSU拓扑结构的例程生成器和固件驱动库）
硬件评估板，文档，开发工具

创新的产品，外设及软件算法

- 高精度定时器支持各类电源拓扑
- STM32集成丰富的高性能模拟外设
- 支持硬件协处理器加速计算性能
- Biricha 第三方数字电源设计培训 (ST 认证第三方)

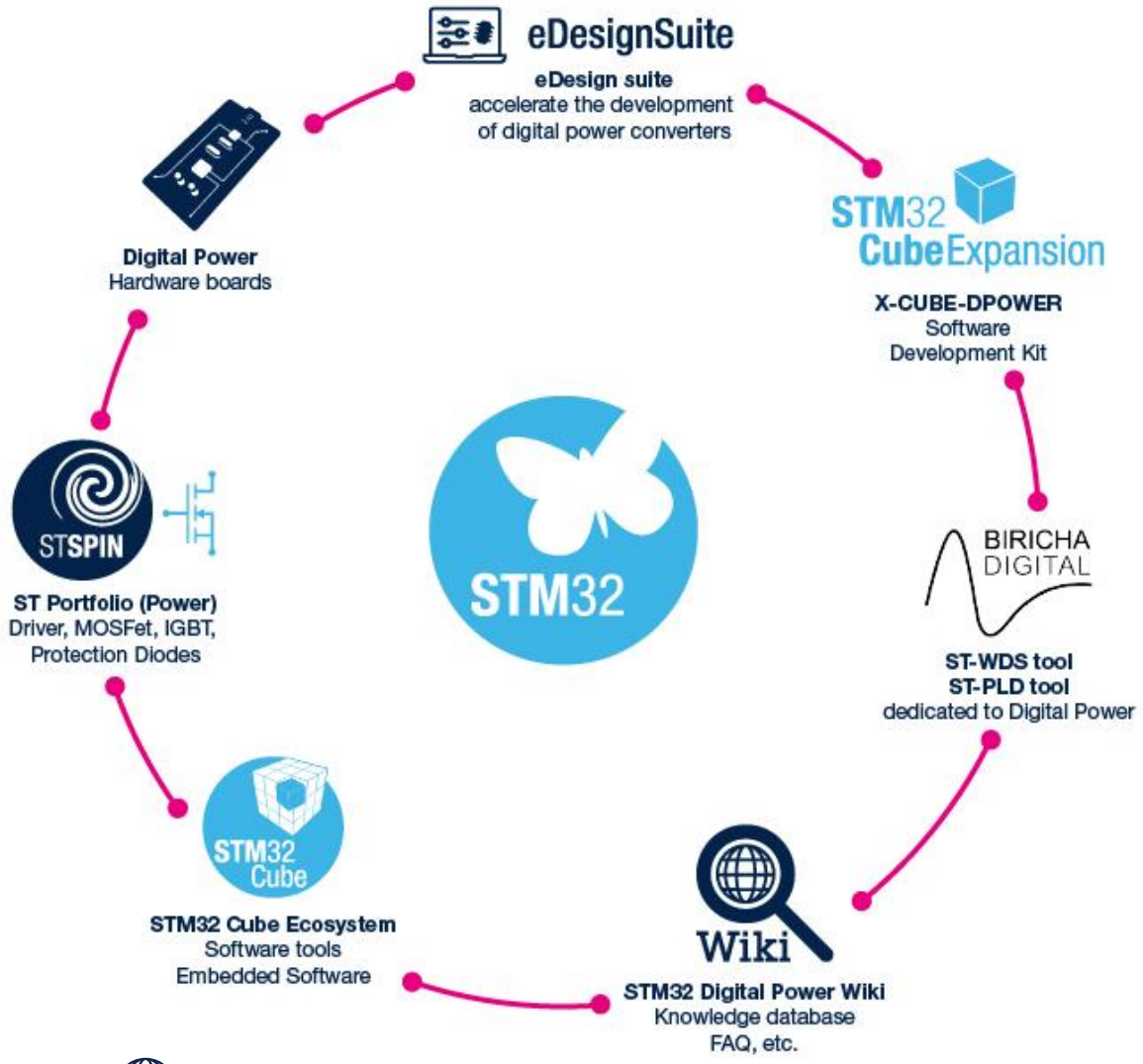
ST 宽泛产品线支持

更多的功率器件选择
基于STM32设计实现的端到端数字电源解决方案

支持PFC 和 PSU
STM32CubeMX

基于ST 评估板，支持电流或电压模式运行 的固件开发包，实现了 PFC 和 PSU 拓扑结构。

最新消息

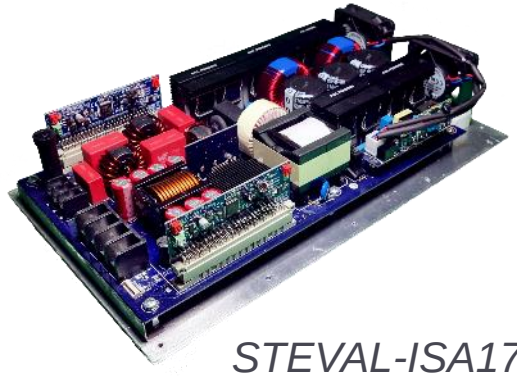


STM32数字电源

STM32CubeMX数字电源例程库 X-CUBE-DPOWER

支持的拓扑结构:

- 交错 Boost PFC 变换器， 平均电流模式
- 全桥移相 DCDC 变换器，恒流 / 恒压输出模式
- Buck 和 Boost 电源变换器，电压和电流控制模式



STEVAL-ISA172V3

基于零极点补偿(2P2Z, 3P3Z) 环路控制

- 卓越控制环路，提供更好的性能和稳定性
- 数字实现 III 型控制器
- 控制参数生成由 Biricha Digital公司提供的ST-WDS/ST-PLD工具完成
  - 对 STM32 用户免费

B-G474E-DPOW1

BIRICHA DIGITAL

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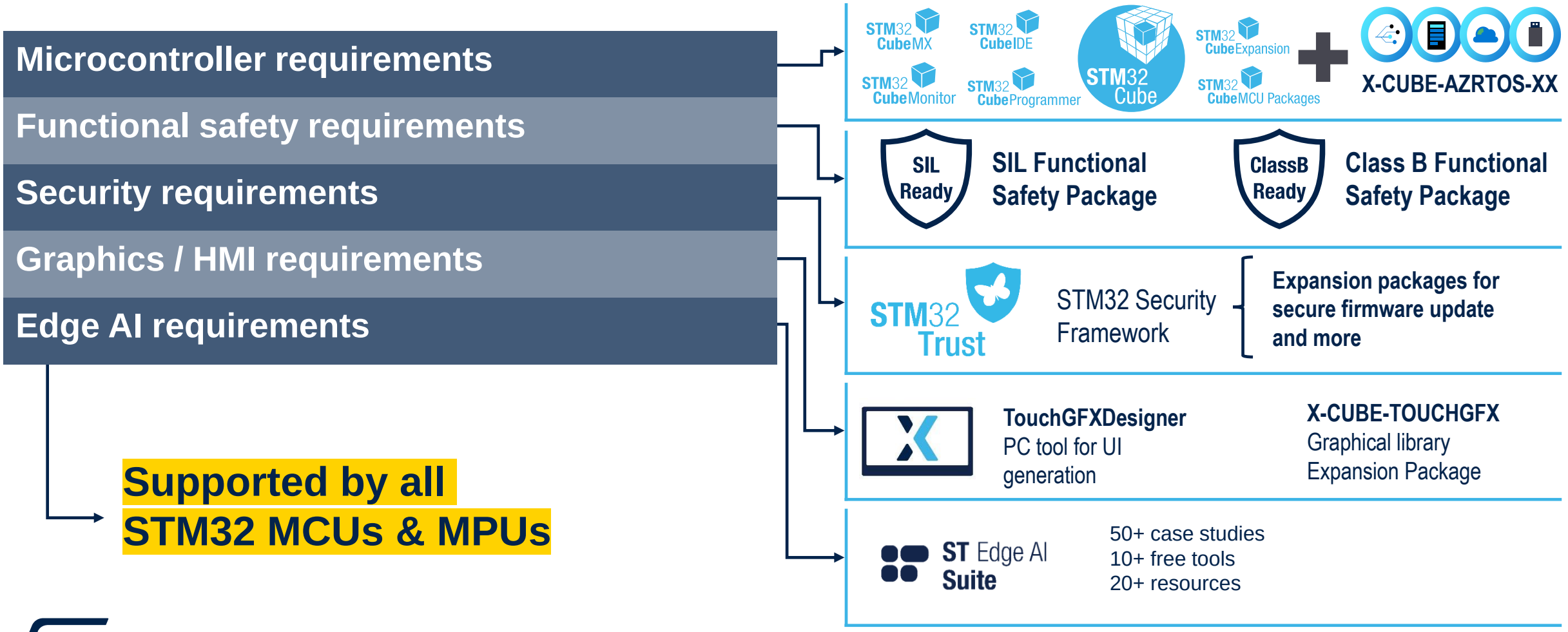
More Than Silicon: DSMPS use case



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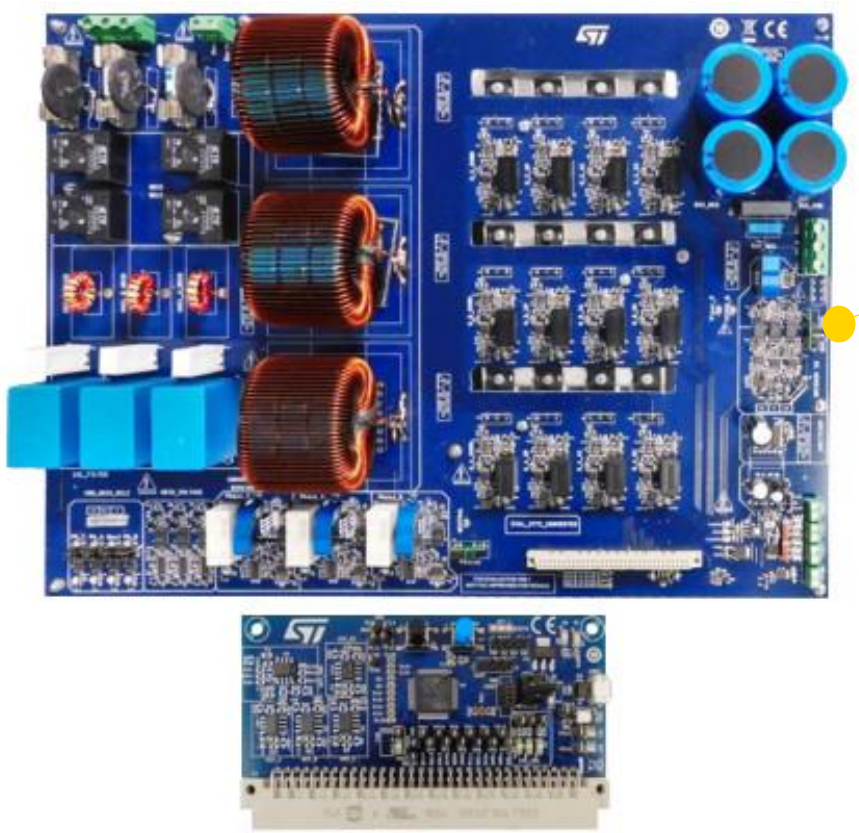
15 kW 3phase T-Type bi-directional PFC with SiC and digital control

STDES-PFCBIDIR



Enabling

- AC to DC rectifier mode:
  - Power factor control (PFC) PF > 0.99
  - THD < 5%
- DC to AC inverter mode:
  - Active and reactive power control
  - Integrated grid connection solution
- Passive components weight and size reduction

Based on several components:

- SCTW35N65G2V (55 mΩ 650 V SiC MOSFET)
- SCTW40N120G2V (75 mΩ 1200 V SiC MOSFET)
- **STM32G474RET3 (Cortex-M4 MCU)**
- STGAP2S (Galvanic isolated gate driver)
- VIPer26K (High voltage converter)
- STLM20W87F (Analog temperature sensor)
- TSV91x (Wide-bandwidth rail to rail Op-Amps)
- LD29080 (LDO)

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STM32 本地化资源，提供海量信息

ST 官网
www.ST.com

STM32 中文官网
www.STMCU.com.cn

STM32中文技术支持邮箱:
mpu.china@st.com
mcu.china@st.com

大学计划联络邮箱:
edu.china@st.com

技术培训报名网页:
www.stmcu.com.cn/training

ST 中文论坛
shequ.stmicroelectronics.cn

ST Community 全球论坛
https://community.st.com/s/

STM32 21ic论坛
http://www.21ic.com/stm32

STM32 MCUs Wiki 页面
wiki.st.com/stm32mcu

STM32 MPUs Wiki 页面
wiki.st.com/stm32mpu

STM32 GitHub页面:
github.com/STMicroelectronics

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线上课程平台

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Our technology starts with You

Find out more at www.st.com

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