

NXP MCU

- MOTOR CONTROL AND SMART POWER SOLUTIONS

CALVIN JI

2017



PUBLIC



SECURE CONNECTIONS
FOR A SMARTER WORLD

An abstract, vibrant splash of ink or paint in shades of yellow, orange, red, purple, and blue, creating a dynamic, organic shape on the left side of the slide.

AGENDA

- 电机控制MCU产品介绍
 - DSC
 - Kinetis V系列
 - Kinetis E系列
 - Su16系列
- 无线充电产品介绍
- 电机控制方案
- 智能电源参考方案



电机控制MCU产品介绍

NXP电机控制的多种选择

KV系列

全范围，高主频，
大存储，浮点运算，
接口丰富

ARM电机控制 – KV系列

Position: M0+, M4, M7 跨越多种内核
Feature: 75Mhz ~ 220MHz, 单核/双核,
浮点运算, 双CAN/以太网,
Fit For : 多电机, 多种接口



MC56F8xxxx

性能强大，
灵活易用

DSC 高性能电机控制

Position: 高性能电机/电源专用
Feature: 智能化外设, 低功耗, IO口5V
兼容, 成熟验证
Fit For : 无传感器FOC, 高动态/ 安静,
高性能及优化

基本电机控制 - Kinetis E

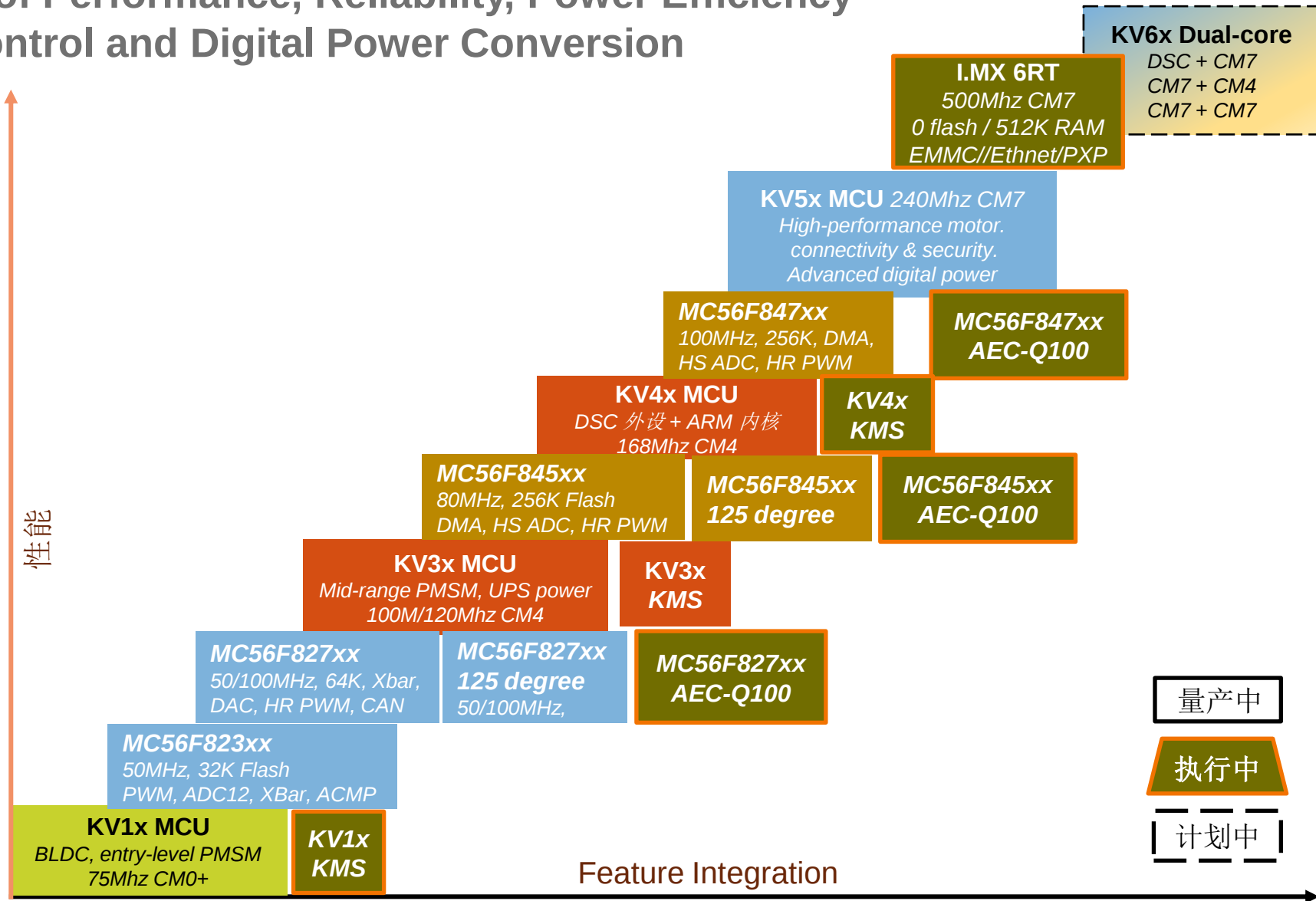
Position: 通用型电机控制
Feature: 纯5V, 稳定性高, GPIO多、
更多flash和引脚封装选择
Fit For : 高性价比

KE系列

5V供电，
可靠稳定

高压SOC

New Levels of Performance, Reliability, Power Efficiency for Motor Control and Digital Power Conversion



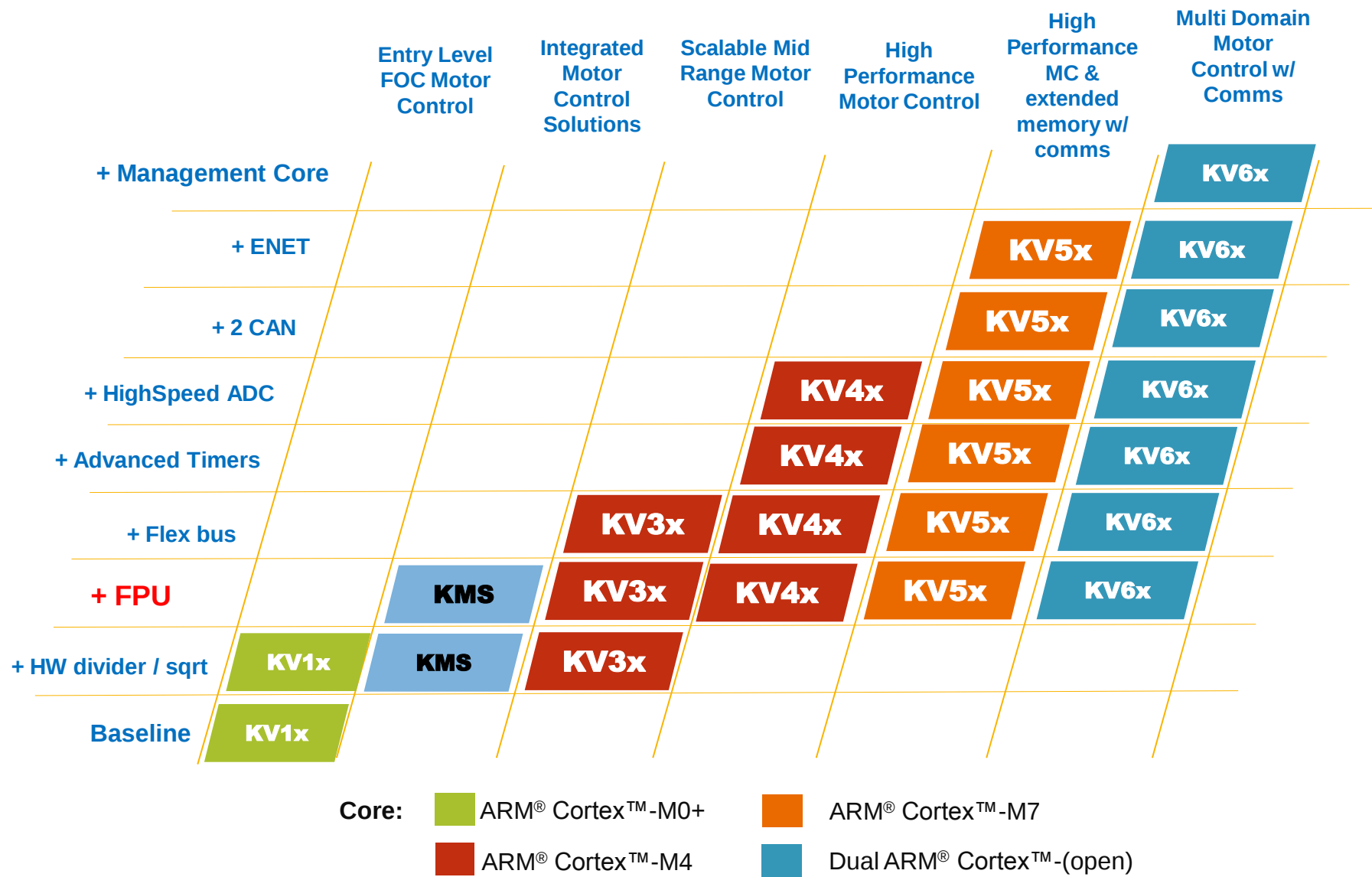
← NXP IDE, RTOS, Software Libraries and Motor Control Development Tools →





KV介绍

Kinetis V-Series: Motor Control



KV10 : 基础系列 2 ADC, 硬件除法器

KV11: 大flash, 小引脚, 带CAN

- 75MHz Cortex-M0+
- Hardware Divide & Square Root
- 4ch DMA
- 16/32KB Flash , 8KB SRAM
- 64/128KB Flash , 16KB SRAM
- 2 x 8ch,16-bit ADC
 - 1.2Msps in 12-bit mode (835ns)
- 1 x12-bit DAC
- 2 x ACMP with 6-bit DAC
- 1/2 x 6ch FlexTimer (PWM)
- 2/4 x 2ch FlexTimer (PWM/Quad Dec.)
- Low Power Timer
- Dual Watchdog
- Other**
- CAN
- 32-bit CRC
- Up to 54 I/Os
- 1.71V-3.6V; -40 to 105C

Packages

- 32QFN, 32LQFP, 48LQFP, 64pin

From \$0.99/\$1.1x at 10k units

Part Number	Package	Flash	SRAM	FlexTimers	CAN
MKV11Z128VLH7	64LQFP	128KB	16KB	2x6ch; 4x2ch	1
MKV11Z128VLF7	48LQFP	128KB	16KB	2x6ch; 4x2ch	1
MKV11Z128VFM7	32QFN	128KB	16KB	2x6ch; 4x2ch	1
MKV11Z128VLC7	32LQFP	128KB	16KB	2x6ch; 4x2ch	1
MKV11Z64VLH7	64LQFP	64KB	16KB	2x6ch; 4x2ch	1
MKV11Z64VLF7	48LQFP	64KB	16KB	2x6ch; 4x2ch	1
MKV11Z64VFM7	32QFN	64KB	16KB	2x6ch; 4x2ch	1
MKV11Z64VLC7	32LQFP	64KB	16KB	2x6ch; 4x2ch	1
MKV10Z128VLH7	64LQFP	128KB	16KB	2x6ch; 4x2ch	-
MKV10Z128VLF7	48LQFP	128KB	16KB	2x6ch; 4x2ch	-
MKV10Z128VFM7	32QFN	128KB	16KB	2x6ch; 4x2ch	-
MKV10Z64VLH7	64LQFP	64KB	16KB	2x6ch; 4x2ch	-
MKV10Z64VLF7	48LQFP	64KB	16KB	2x6ch; 4x2ch	-
MKV10Z64VFM7	32QFN	64KB	16KB	2x6ch; 4x2ch	-
MKV10Z32VLF7	48LQFP	32KB	8KB	1x6ch; 2x2ch	-
MKV10Z32VFM7	32QFN	32KB	8KB	1x6ch; 2x2ch	-
MKV10Z32VLC7	32LQFP	32KB	8KB	1x6ch; 2x2ch	-
MKV10Z16VLF7	48LQFP	16KB	8KB	1x6ch; 2x2ch	-
MKV10Z16VFM7	32QFN	16KB	8KB	1x6ch; 2x2ch	-
MKV10Z16VLC7	32LQFP	16KB	8KB	1x6ch; 2x2ch	-



KV3x : 性价比最高的CM4

第一颗内置KMS器件

Cortex-M4 @ 100/120MHz with FPU

- 4 or 16ch DMA

- 64/128/256/512KB Flash,

- 16/24/48/96KB SRAM

- FlexBus (512KB version only)

- Bootloader

Analog

- 2 x 16-bit ADC: 1.2Msps in 12-bit mode

- Up to 2 x 12-bit DAC

- 2 x ACMP with 6-bit DAC

Timers

- Up to 2x8ch FTM (PWM)

- 2x2ch FTM (PWM/Quad Dec.)

- Programmable Delay Block

- Low Power Timer

Other

- Up to 70 I/Os

- 6 high-drive I/Os (20mA) – SPI/I2C

- 1.71V-3.6V; -40 to 105C

Packages

- 32QFN, *48LQFP, 64/100LQFP

- *Alternative, non committed package

From **\$1.19** to **\$2.76** at 10k units

Part Number	Max. Freq.	Package LQFP	Flash	SRAM	DMA	PLL / FLL	FTMs	DAC	I/O w/ Digital Filters
MKV31F512VLL12	120MHz	100	512K	96KB	16-ch	PLL	2x8ch; 2x2ch	2	16
MKV31F512VLH12	120MHz	64	512K	96KB	16-ch	PLL	2x8ch; 2x2ch	2	16
MKV31F256VLL12	120MHz	100	256K	48KB	16-ch	PLL	1x8ch; 2x2ch	1	8
MKV31F256VLH12	120MHz	64	256K	48KB	16-ch	PLL	1x8ch; 2x2ch	1	8
MKV31F128VLL10	100MHz	100	128K	24KB	4-ch	FLL	1x8ch; 2x2ch	1	8
MKV31F128VLH10	100MHz	64	128K	24KB	4-ch	FLL	1x8ch; 2x2ch	1	8
MKV30F128VLH10	100MHz	64	128K	16KB	4-ch	FLL	1x8ch; 2x2ch	1	8
MKV30F128VLF10	100MHz	48	128K	16KB	4-ch	FLL	1x8ch; 2x2ch	1	8
MKV30F128VFM10	100MHz	32QFN	128K	16KB	4-ch	FLL	1x8ch; 2x2ch	1	8
MKV30F64VLH10	100MHz	64	64K	16KB	4-ch	FLL	1x8ch; 2x2ch	1	8
MKV30F64VLF10	100MHz	48	64K	16KB	4-ch	FLL	1x8ch; 2x2ch	1	8
MKV30F64VFM10	100MHz	32QFN	64K	16KB	4-ch	FLL	1x8ch; 2x2ch	1	8



KV4x : 最佳组合 (DSC外设 + ARM内核)

- 168MHz Cortex-M4F, FPU
- 64/128/256KB Flash
 - @ 128bits wide w/ 128Byte cache
- Bootloader
- Up to 2 x CAN
- 2 x 8ch 12-bit ADC
 - Sampling at up to 4.1MS/s
 - PGA x1, x2, x4
- 12-bit DAC
- 4 x ACMP with 6-bit DAC

Timers

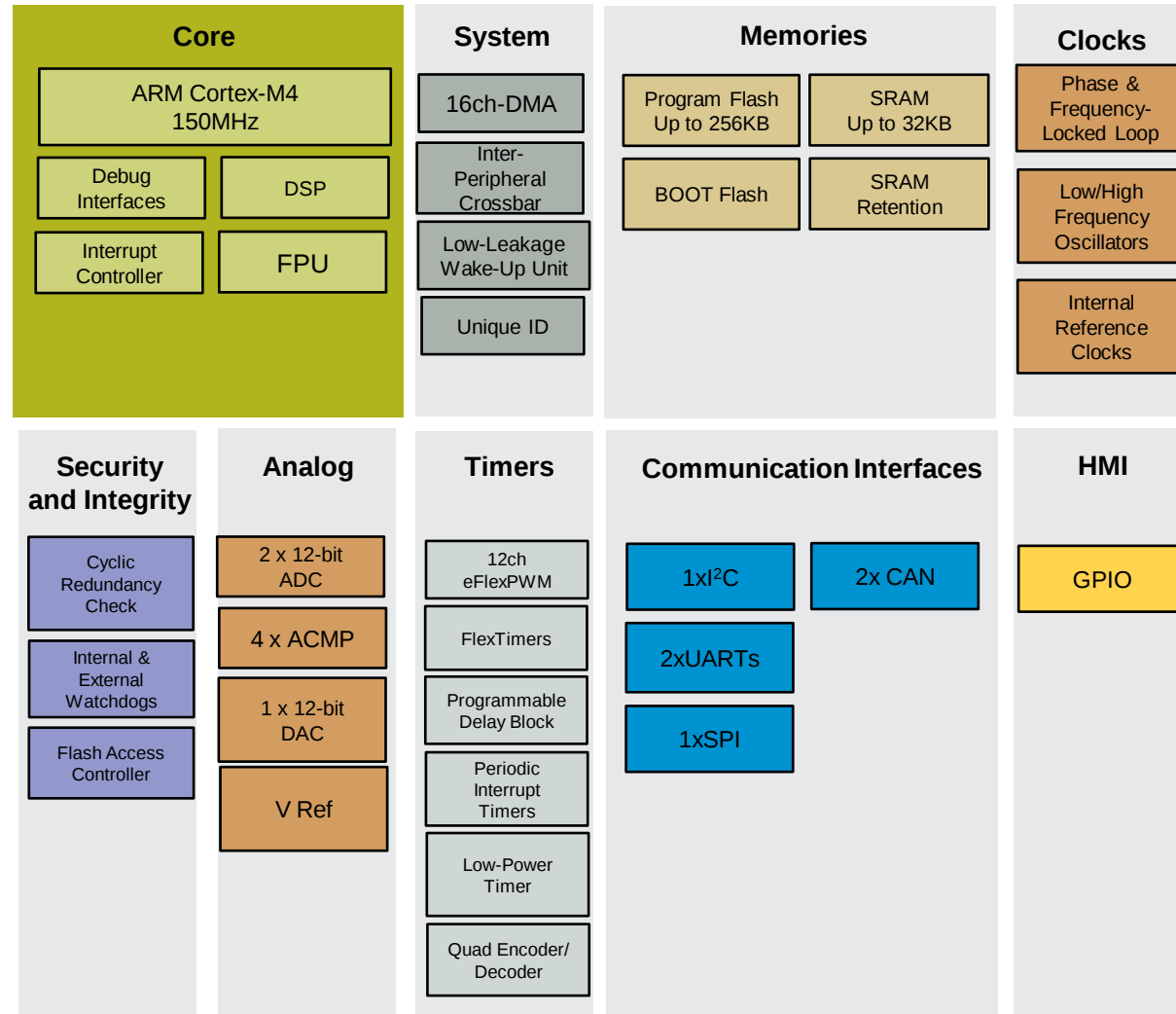
- 12ch eFlexPWM
 - Up to 312ps PWM and PFM
- 2x8ch + 1x2ch FlexTimer (PWM)
- Quadrature Encoder
- 2 x Programmable Delay Blocks
- Dual watchdog

Other

- 32-bit CRC
- Inter-Peripheral Crossbar with AOI
- Up to 56 I/Os
- 1.71V-3.6V; -40 to 105oC

Packages

- *48LQFP, 64 LQFP & 100LQFP



First MCU of industrial with DSC peripheral + ARM core.



KV4x: Family Overview

Part Number	Pins	Flash / SRAM (KB)	ADC		PWM eFlexPWM		PWM Nano-Edge	PWM FlexTimers			DAC	FlexCAN	
			ADCA	ADCB	PWMA PWMB	PWMX		FTM0	FTM3	FTM1		CAN0	CAN1
MKV46F256VLL16	100	256 / 32	18ch	20ch	1x8ch	1x4ch	Yes	1x8ch	1x8ch	1x2ch	1	1	1
MKV46F256VLH16	64	256 / 32	13ch	16ch	1x8ch	-	Yes	1x8ch	1x8ch	1x2ch	1	1	1
MKV46F128VLL16	100	128 / 24	18ch	20ch	1x8ch	1x4ch	Yes	1x8ch	1x8ch	1x2ch	1	1	1
MKV46F128VLH16	64	128 / 24	13ch	16ch	1x8ch	-	Yes	1x8ch	1x8ch	1x2ch	1	1	1
MKV44F256VLL16	100	256 / 32	18ch	20ch	1x8ch	1x4ch	Yes	-	-	-	1	1	1
MKV44F256VLH16	64	256 / 32	13ch	16ch	1x8ch	-	Yes	-	-	-	1	1	1
MKV44F128VLL16	100	128 / 24	18ch	20ch	1x8ch	1x4ch	Yes	-	-	-	1	1	1
MKV44F128VLH16	64	128 / 24	13ch	16ch	1x8ch	-	Yes	-	-	-	1	1	1
MKV44F128VLF16*	48	128 / 24	11ch	10ch	1x8ch	-	Yes	-	-	-	1	1	-
MKV44F64VLH16	64	64 / 16	13ch	16ch	1x8ch	-	Yes	-	-	-	1	1	1
MKV44F64VLF16*	48	64 / 16	11ch	10ch	1x8ch	-	Yes	-	-	-	1	1	-
MKV42F256VLL16	100	256 / 32	18ch	20ch	-	-	-	1x8ch	1x8ch	1x2ch	-	1	1
MKV42F256VLH16	64	256 / 32	13ch	16ch	-	-	-	1x8ch	1x8ch	1x2ch	-	1	1
MKV42F128VLL16	100	128 / 24	18ch	20ch	-	-	-	1x8ch	1x8ch	1x2ch	-	1	1
MKV42F128VLH16	64	128 / 24	13ch	16ch	-	-	-	1x8ch	1x8ch	1x2ch	-	1	1
MKV42F128VLF16*	48	128 / 24	11ch	10ch	-	-	-	1x8ch	1x8ch	1x2ch	-	1	-
MKV42F64VLH16	64	64 / 16	13ch	16ch	-	-	-	1x8ch	1x8ch	1x2ch	-	1	1
MKV42F64VLF16*	48	64 / 16	11ch	10ch	-	-	-	1x8ch	1x8ch	1x2ch	-	1	-



KV5 : 最强电机控制性能MCU

- 240MHz Cortex-M7

Memory

- 512KB/1MB Flash,
@256bits wide, 128 Bytes cache
- 128/256KB SRAM
- Boot Flash

Communications

- Multiple serial ports
- 3 x FlexCAN,
- Ethernet

Analog

- 4 x 8ch 12-bit ADC -- 5Msps Sample Time
- 1 x 16-bit SAR ADC
- 1 x12-bit DAC
- 4 x ACMP w/ 6b DAC

Timers

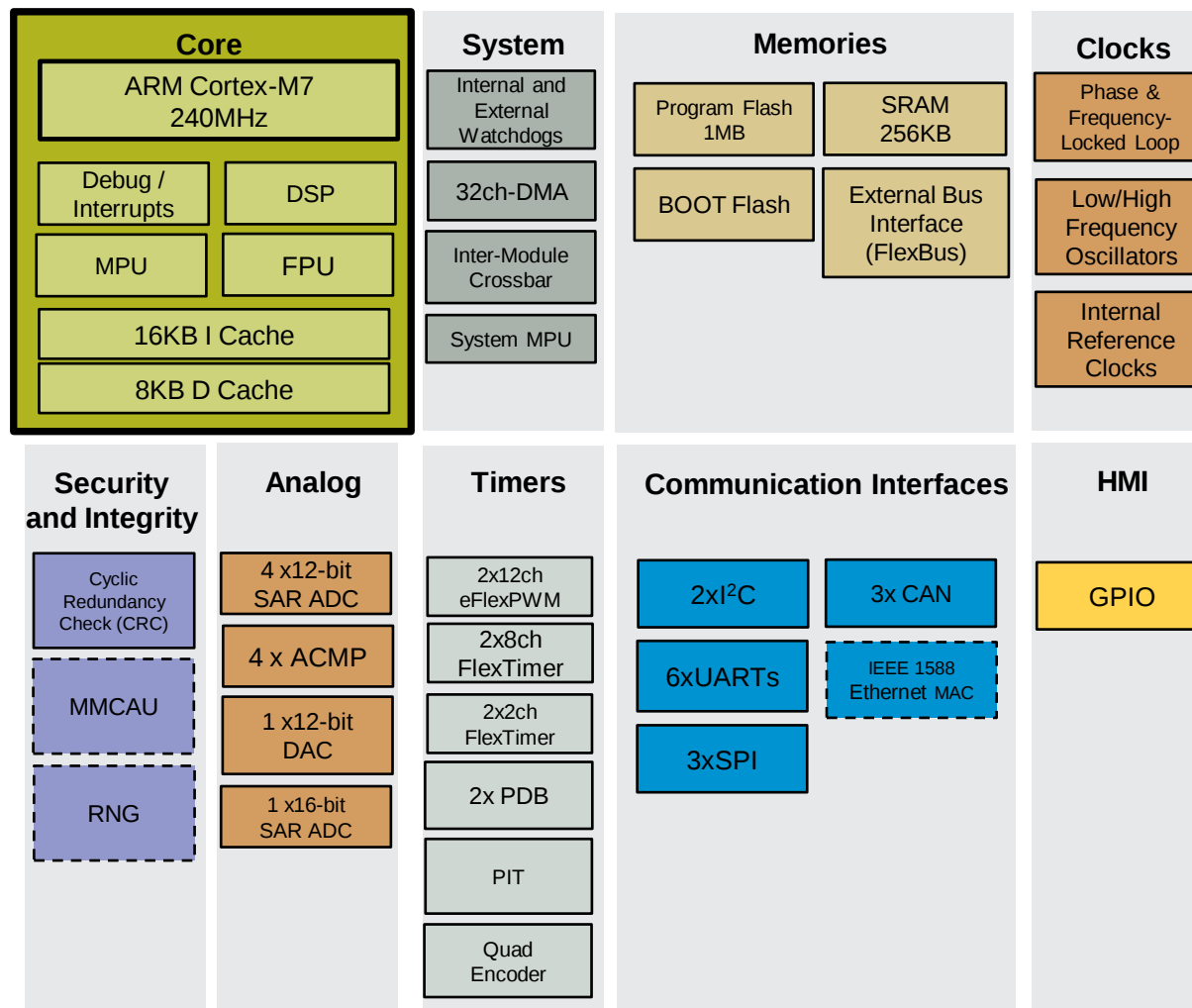
- 1 x 12ch Nano edge timer
 - 312ps PWM and PFM Resolution
- 1 x 12ch eFlexPWM
- 2x8ch + 2x2ch FlexTimer (PWM)
- Quadrature Encoder
- 2 x PDB, Low-Power Timer

Others

- MMCAU & RNG
- 32-bit CRC, MPU
- Inter-module Crossbar Switch with AOI
- 1.71V-3.6V; -40 to 105oC

Packages

- 100LQFP, 144LQFP, 144MAPBGA



Optional



KV5x: Family Overview

Part Number	Pins	Package	Flash / SRAM (KB)	Ethernet	CAN	GPIO
MKV58F1M0VLQ24	144	LQFP	1024 / 256	Y	3	111
MKV58F1M0VLL24	100	LQFP	1024 / 256	Y	3	74
MKV58F1M0VMD24	144	MAPBGA	1024 / 256	Y	3	111
MKV58F512VLQ24	144	LQFP	512 / 128	Y	3	111
MKV58F512VLL24	100	LQFP	512 / 128	Y	3	74
MKV58F512VMD24	144	MAPBGA	512 / 128	Y	3	111
MKV56F1M0VLQ24	144	LQFP	1024 / 256	N	2	111
MKV56F1M0VLL24	100	LQFP	1024 / 256	N	2	74
MKV56F1M0VMD24	144	MAPBGA	1024 / 256	N	2	111
MKV56F512VLQ24	144	LQFP	512 / 128	N	2	111
MKV56F512VLL24	100	LQFP	512 / 128	N	2	74
MKV56F512VMD24	144	MAPBGA	512 / 128	N	2	111



KV series product overview

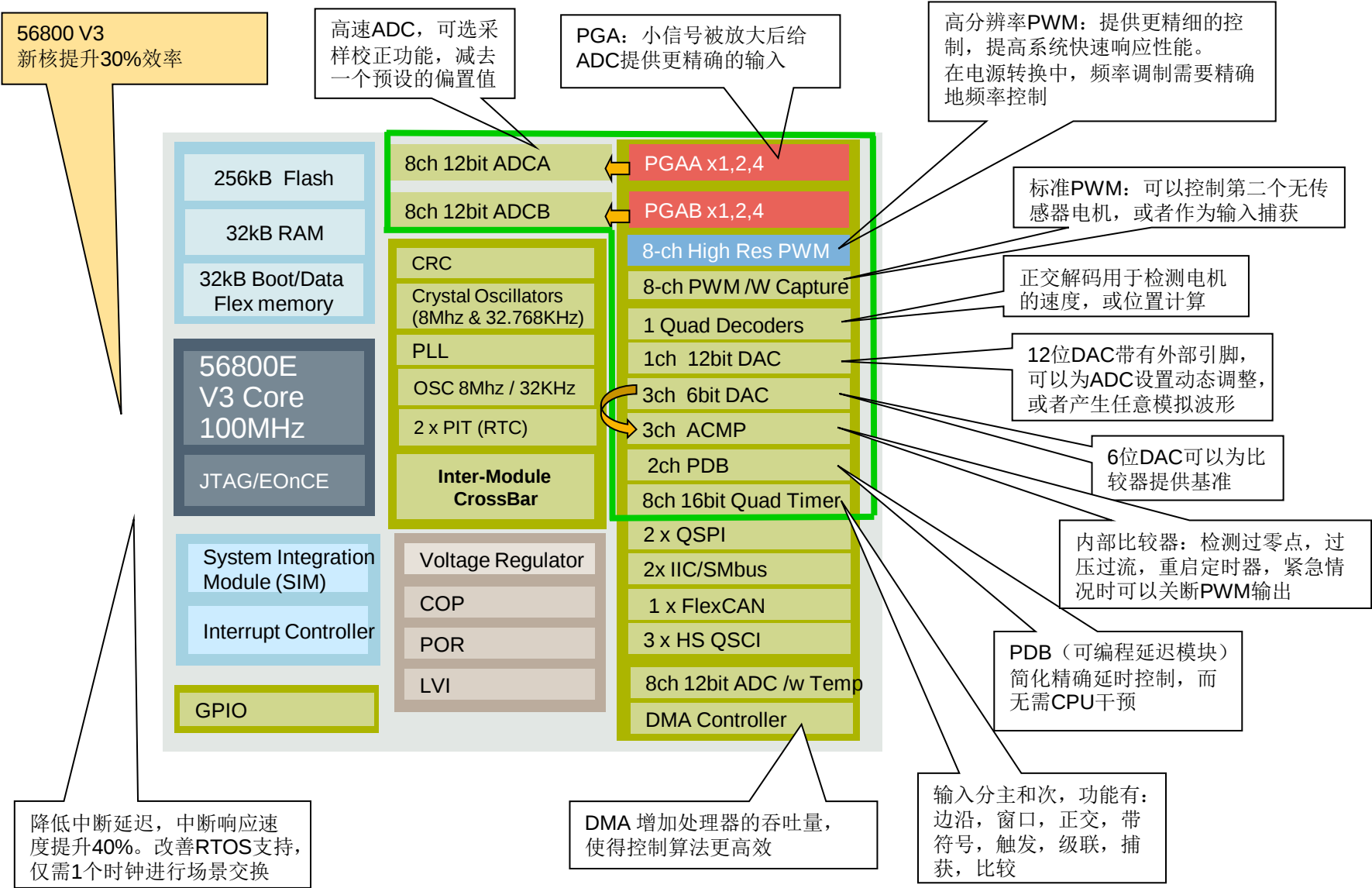
Key Peripherals for Motor and Power Control Applications										
MCU Family	Core	Memory	Motor Control Timers		ADC	DAC	ACMP	Comms.	Packages	
			Flextimer	eFlexPWM						
	KV5x	240MHz CM7 DSP + FPU	512kB-1MB Flash	2 x 8ch 1x 2ch FlexTimer	2 x 12ch eFlexPWM + Nano-Edge	4 x 12bit 5Msps, 1 x 16bit	1x 12-bit	4x ACMP with 6-bit DAC	Ethernet, 3 x CAN	144 pin 100 pin
	KV4x	160MHz CM4 DSP + FPU	64-256kB Flash	2 x 8ch 1x 2ch FlexTimer	12ch eFlexPWM + Nano-Edge	2x 12bit 4.1Msps / 1.9Msps	2x 12-bit	4x ACMP with 6-bit DAC	2 x CAN	100 pin 64 pin 48 pin
	KV3x	100/120MHz CM4 DSP + FPU	64-512kB Flash	2x 8ch 2x 2ch FlexTimer	-	2x 16-bit 1.2Msps	2x 12-bit	2x ACMP with 6-bit DAC	-	100 pin 64 pin 48 pin 32 pin
	KV1x	75MHz CM0+ H/W DIV & SQRT	16-32kB Flash	1x 6ch 2x 2ch FlexTimer	-	2x 16-bit 1.2Msps	1x 12-bit	2x ACMP with 6-bit DAC	1 x CAN	64 pin 48 pin 32 pin

Scalable performance, timing and analog functionality
based on application need

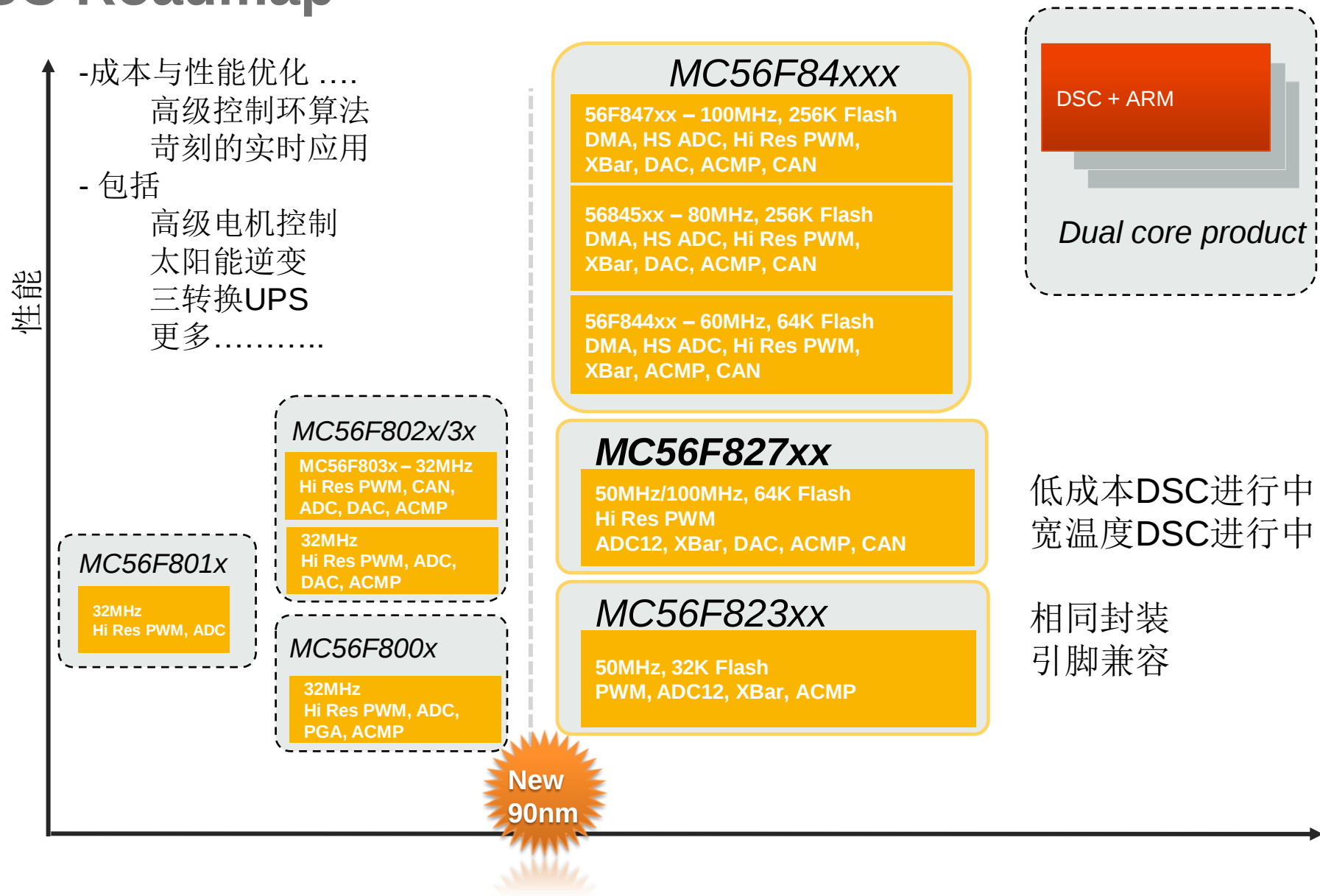


DSC介绍

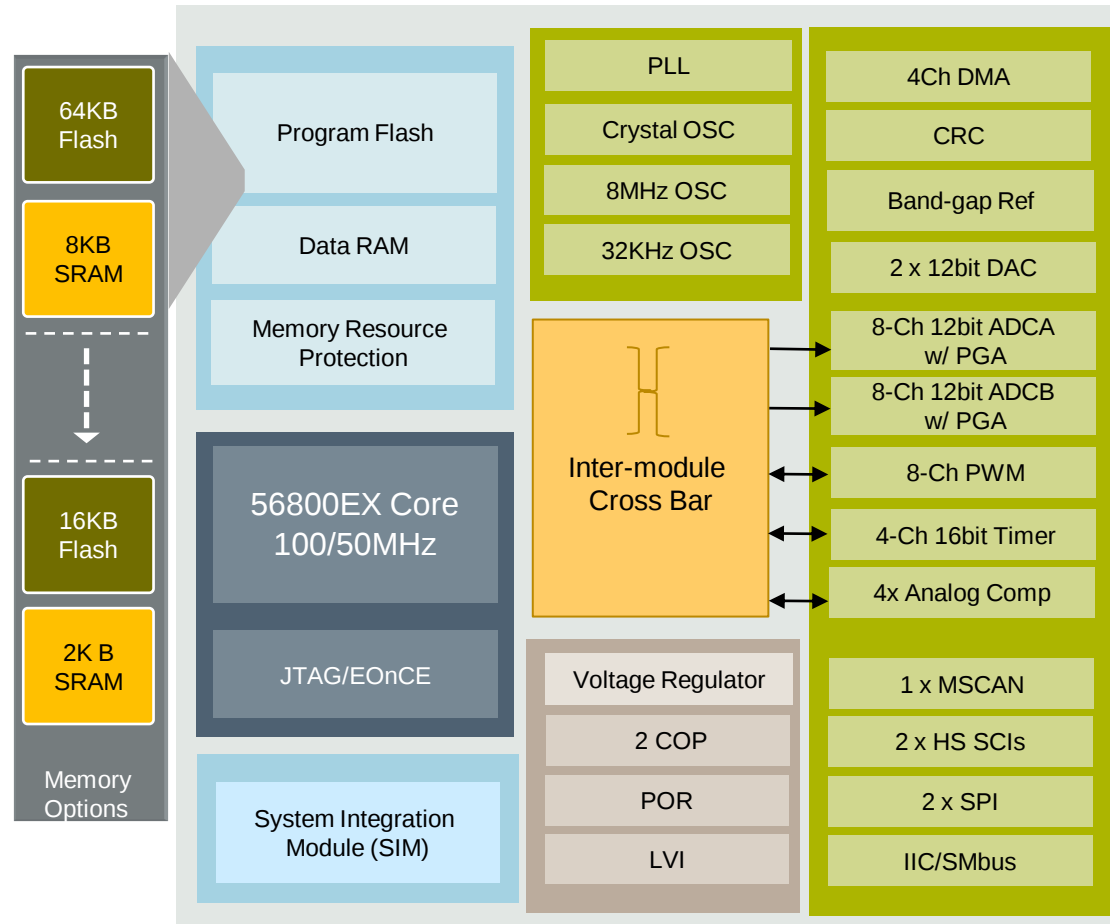
DSC外设模块 - 控制和测量



NXP DSC Roadmap



MC56F827xx 特征 (50/100Mhz)



32QFN, 32LQFP, 48LQFP & 64LQFP

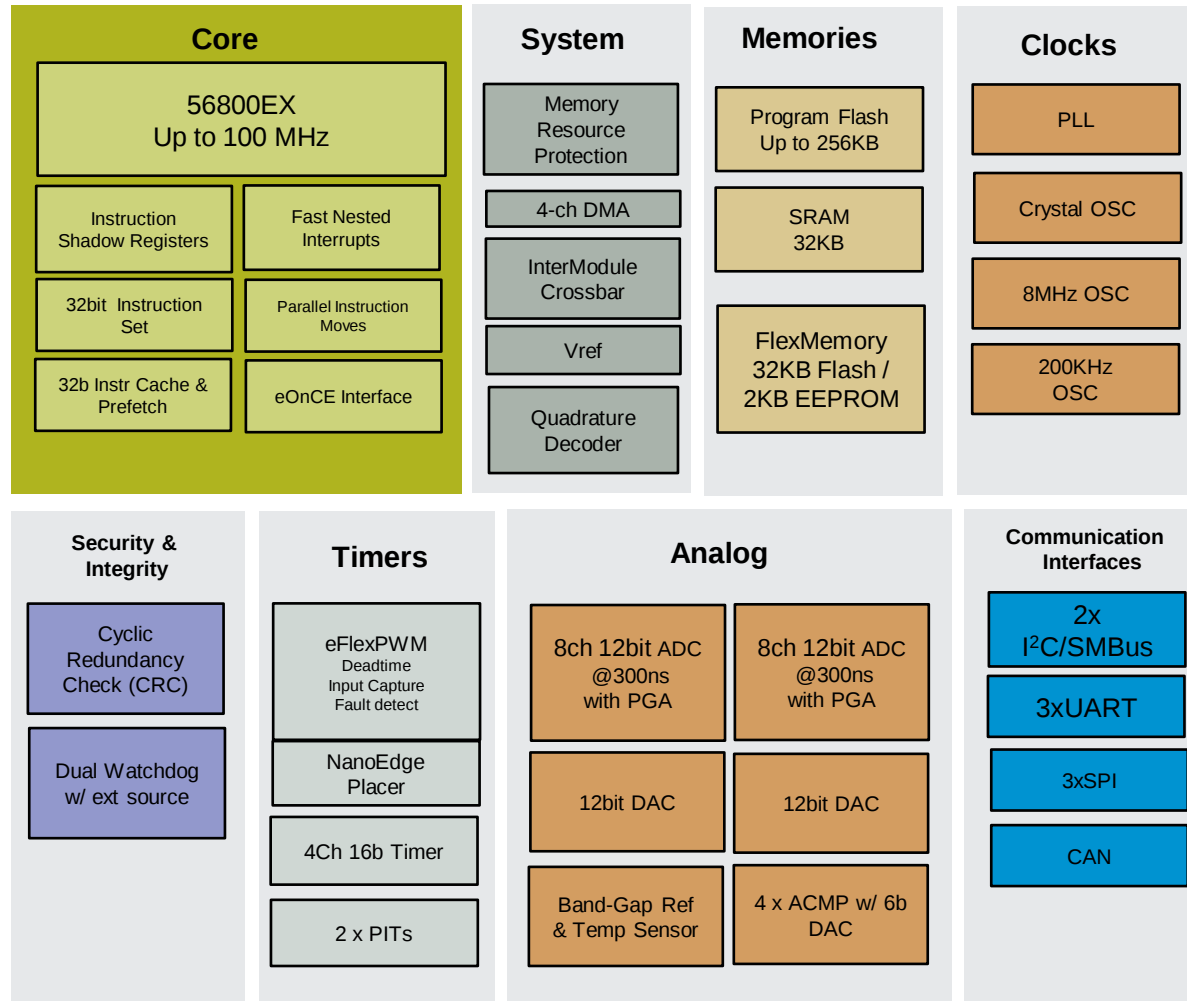
- 2.7~3.6V 操作, **5V IO兼容**
- cache & RAM 100MHz 运行
- 定时器和SCI外设运行于100 MHz
- 最高配置64KB / 8KB
- **2 x 12位 ADC (带有 PGA)**
 - 800ns 转换速率
 - 带隙基准参考
- **八通道Nano边沿PWM (312ps)**
 - 最多4路可编程故障保护输入
 - 输入捕获功能
- **内部cross-bar**
- 2 x 窗口看门狗, 外部看门狗监视器
- 4 x 16位增强型多功能定时器
- 2 x 12位 DAC
- **4 x 模拟比较器 (带有6位电压参考)**
- 2 x 高速SCI, 2 x SPI, 1x I²C
- 软件可编程PLL
- 多个时钟源
 - 外部晶振/谐振器
 - 8MHz/200KHz 可调内部振荡器
 - 32KHz内部RC 张弛振荡器
- 错误代码纠正
- 存储器资源保护单元

其他

- 工业温度等级: **-40C 至 105C** @ 50MHz
- 扩展温度等级: **-40C 至 125C** @ 40MHz



MC56F84xxx (256kB Flash, 100MHz)



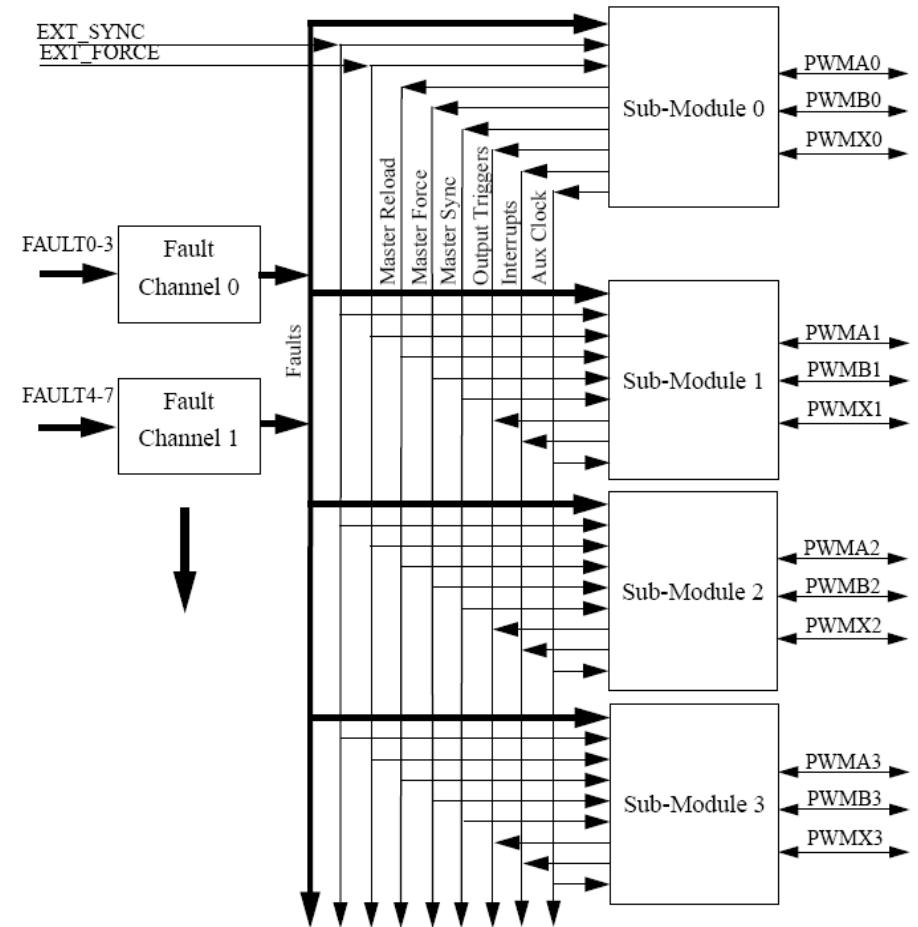
- 运行@100MHz, 超快的中断响应
- 2.7~3.6V 操作, 5V IO兼容
- FlexMem灵活的存储方式 (额外提供)
- 2 x 12位 ADC (带有 PGA)
 - 300ns 转换速率
- 16 x 16位 ADC
 - 连接高精度外部传感器
- 12通道eFlexPWM (312ps) + 12ch PWM
 - 半周期重载和整数重载设置
 - 深受客户好评的多种灵活配置功能
- 内部cross-bar可以连接所有的输入, 并支持逻辑功能 (AND/OR/XOR/NOR)
- 存储器保护单元可以增强安全鉴定
- 2 x 窗口看门狗, 外部看门狗监视器
- 8 x 16位增强型多功能定时器
- 2 x 12位 DAC
- 4 x 模拟比较器 (带有6位电压参考)
- 3 x 高速SCI, 3 x SPI, 2x I²C, 1xCAN
- 多个时钟源
 - 外部晶振/谐振器
 - 8MHz/200KHz 可调内部振荡器
 - 32KHz内部RC 张弛振荡器
- 错误代码纠正

其他

- 48LQFP, 64LQFP, 80LQFP, 100LQFP
- 工业温度等级: -40C 至 105C

增强型PWM (eFlexPWM)

- 四个独立子模块和一个时钟基准
 - 两个PWM输出 + 一个辅助PWM输入 / 输出
- 每个PWM输出的双沿独立控制
- 增强型双沿捕获功能
- 16位非对称PWM支持中央对齐和边沿对齐
- 精确延时可以增强PWM周期和边沿的分辨率
- 既可以成对互补操作，也可以作为独立操作
- 可以与外部硬件或其他PWM子模块同步
- 整数重载率是1至16，包括半周期重载
- 每个PWM周期可以设置触发多个输出事件
- 支持PWM输出的双切换（周期和占空比）
- 支持PWM输出的double switch (三相电流重构)
- 故障输入可以指定连接控制多个PWM输出
- 故障输入的可编程滤除
- 独立可编程的PWM输出极性
- 独立的上桥/下桥死区时间插入
- 通过FORCE_OUT事件的软件控制和交换特征



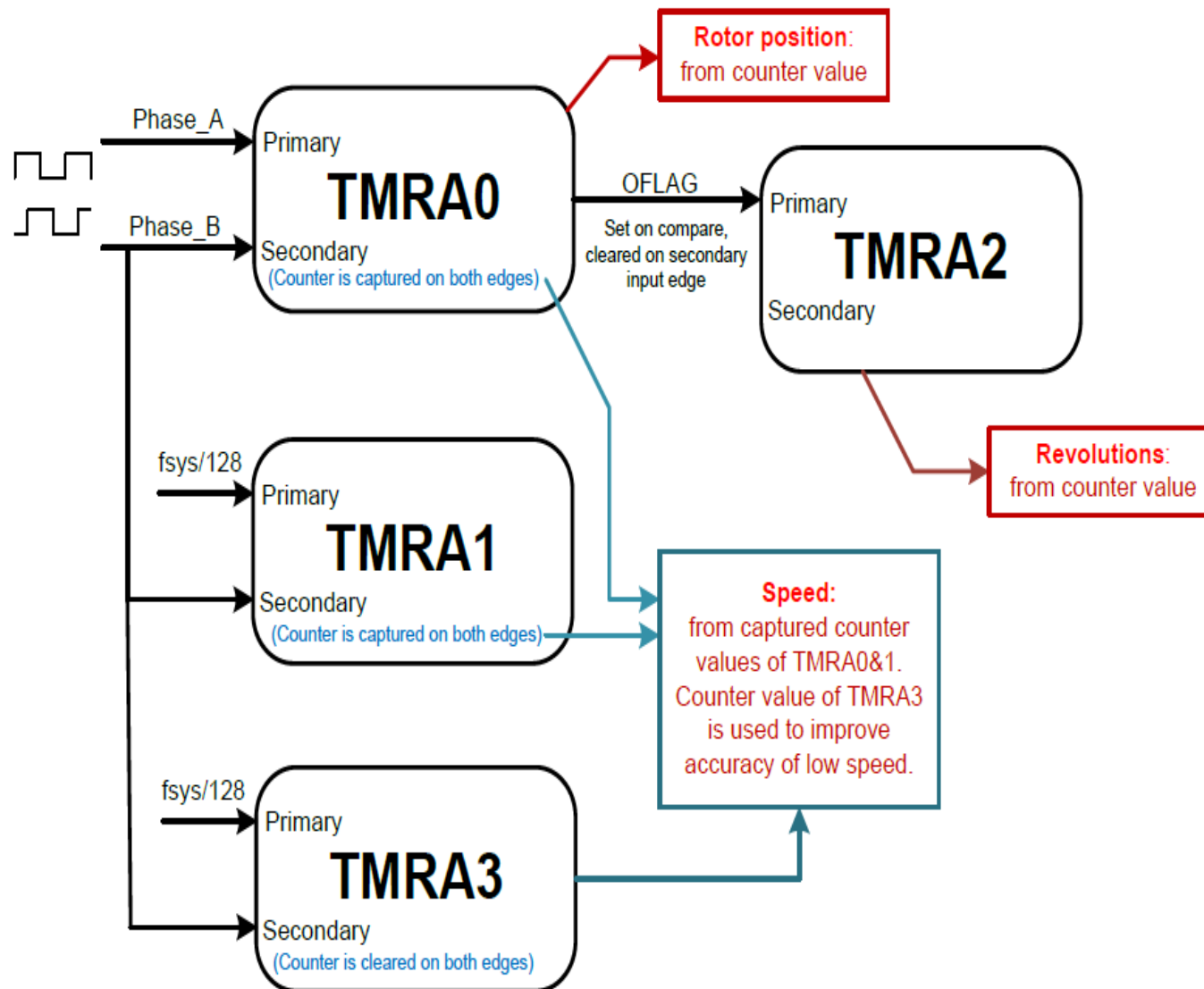
用Quad Timer A检测转子位置、转速和旋转圈数

TMRA0工作于正交记数模式，用于检测转子位置；

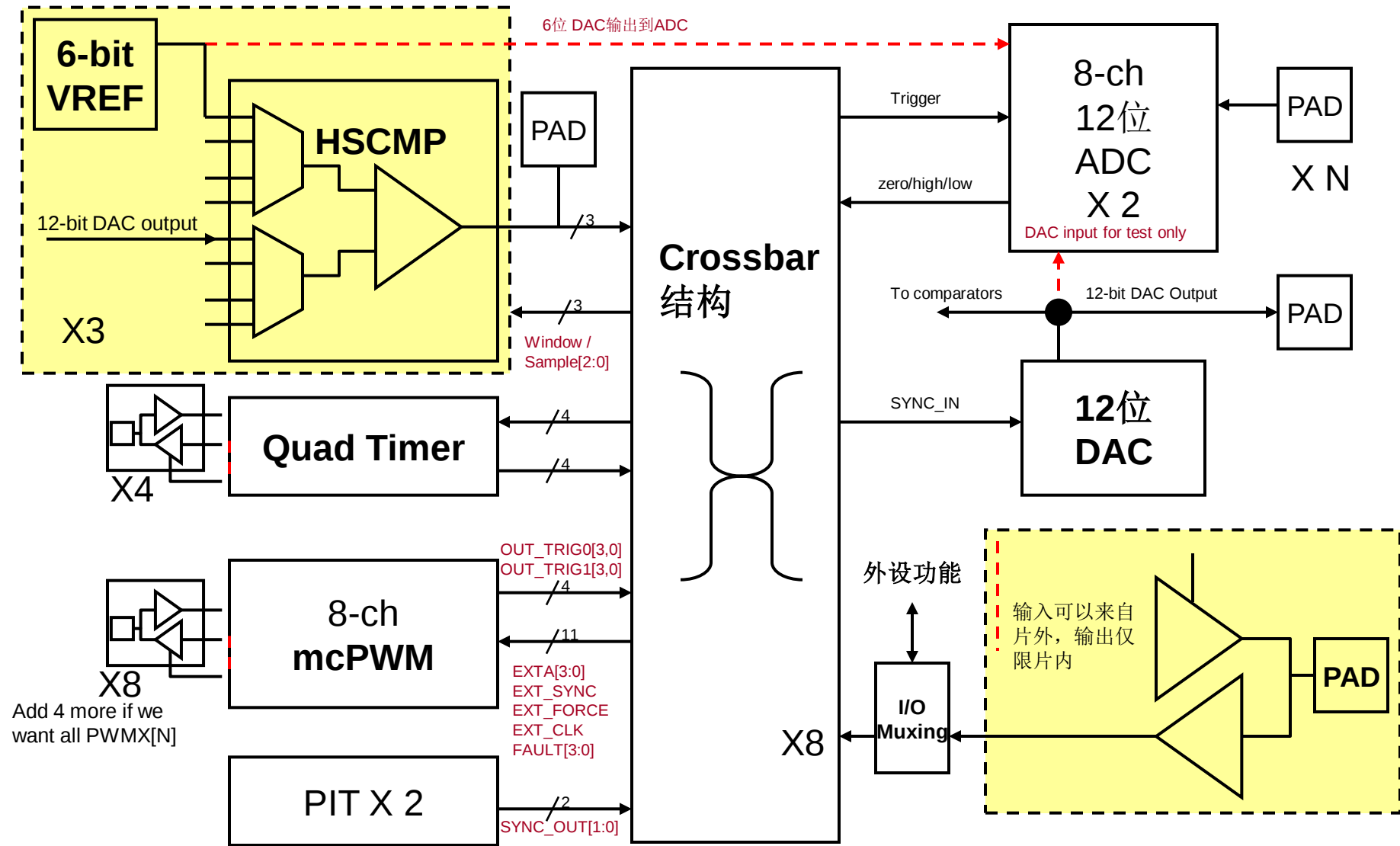
TMRA1工作于记数模式，结合TMRA0，通过捕捉TMRA0/1的计数器值来检测转速；

TMRA2工作于记数模式，用于检测转子旋转的圈数；

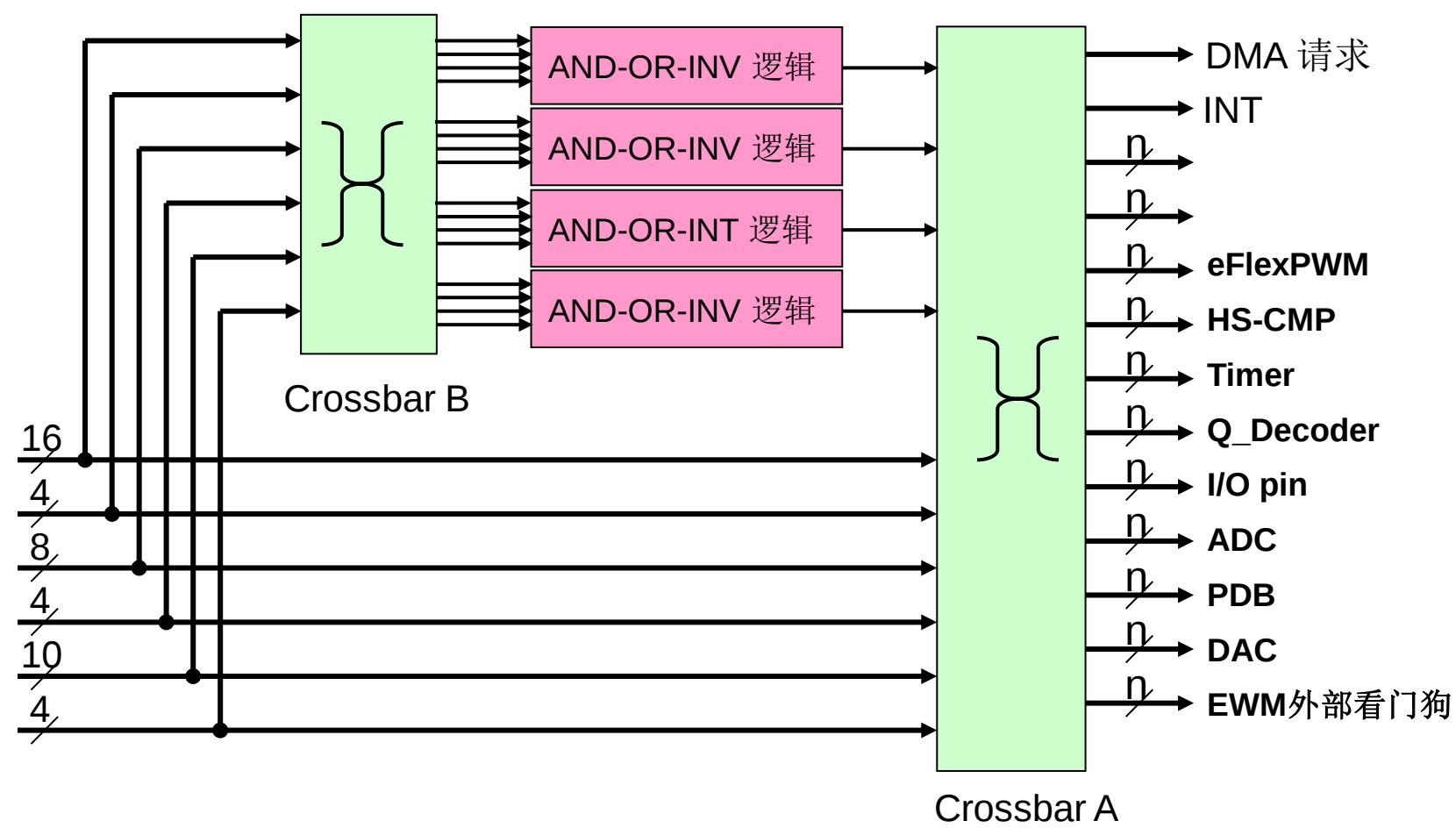
TMRA3工作于记数模式，用于提高低转速检测精度。



CrossBar – 内部互相连接



Crossbar的升级– MC56F84xxx



DSC性能对比- 功耗

	56F8002	56F82723	56F84789
内核	56800e V2	56800ex V3	56800e V3
总线速度	32MHz	50 / 100MHz	100MHz
Flash/ RAM	12K / 2K	32K / 6K	256kB / 32KB
EEPROM	仿真	无 (FlexMem)	FlexMem 32 / 2kB
PWM	3* system clock = 96M	312ps 分辨率, 100MHz	312ps分辨率
ADC	2*8ch*12b, 2500ns	2*8ch*12b, 800ns	2*8ch*12b, 300nS, 1*16ch*6b, w/ temp
PGA	X32 (max)	x1, x2, x4 in ADC	x1, x2, x4 in ADC
Timer	2*16 timer	4*timer, 1*quad, 2*PIT	2*quad, 1*QEI, 2*PIT
DAC & CMP	3*6b with CMP	2*12b + 3*ACMP	1*12b + 4*ACMP
接口	1*IIC, 1*SCI, 1*SPI	1*IIC, 1*SCI, 1*SPI	2*IIC, 3*SCI, 3*SPI, 1 FlexCAN
功耗@3.3V(Run), 25 摄氏度	41.5mA @32MHz 0.34mA @200KHz 0.16mA @32.768KHz	38mA @100MHz 27.6mA @50Mhz 2.8mA @2Mhz	64mA @100MHz 1.8mA @2Mhz 0.57mA @200KHz

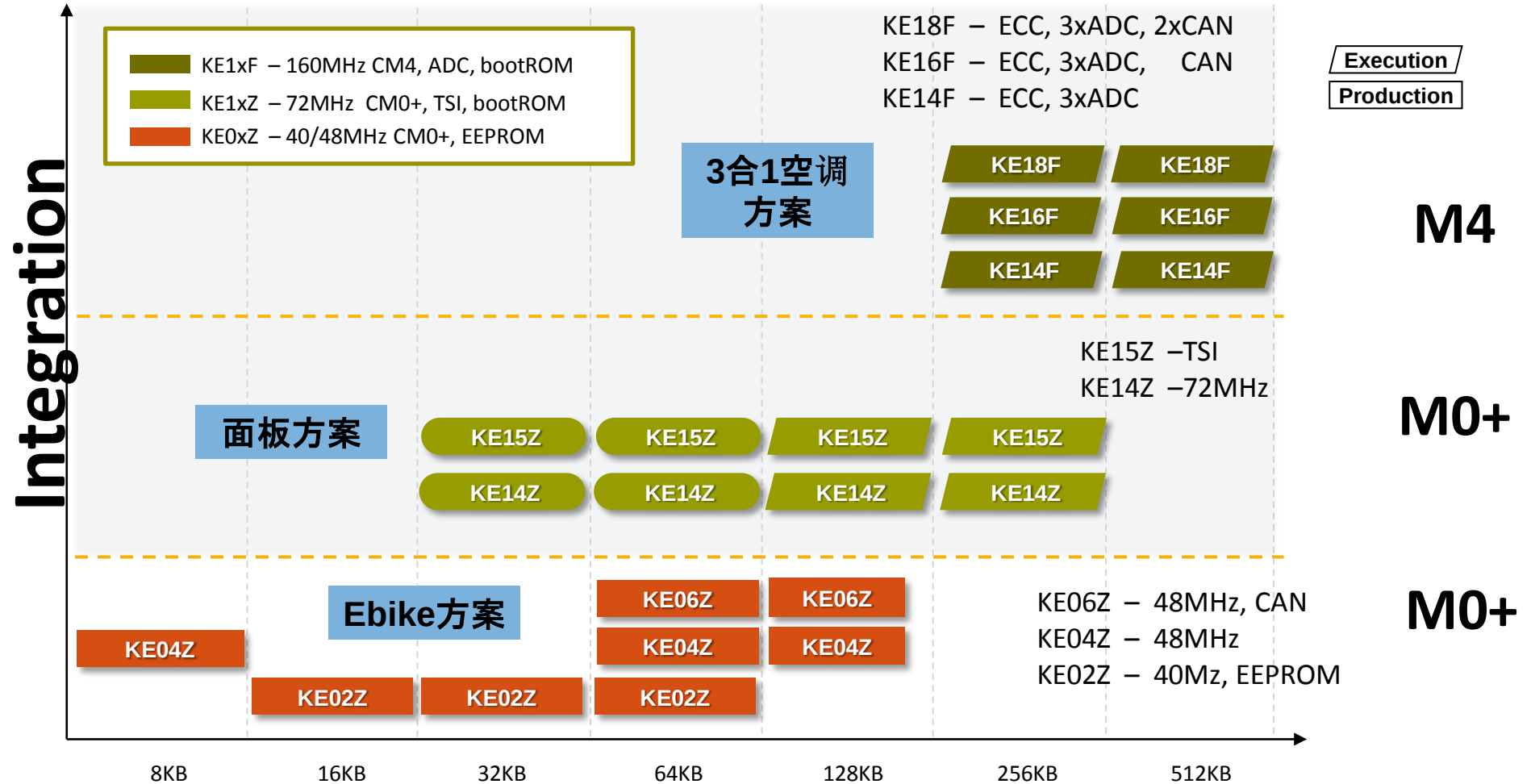
同等性能条件下，功耗仅为友商的50%



KE介绍

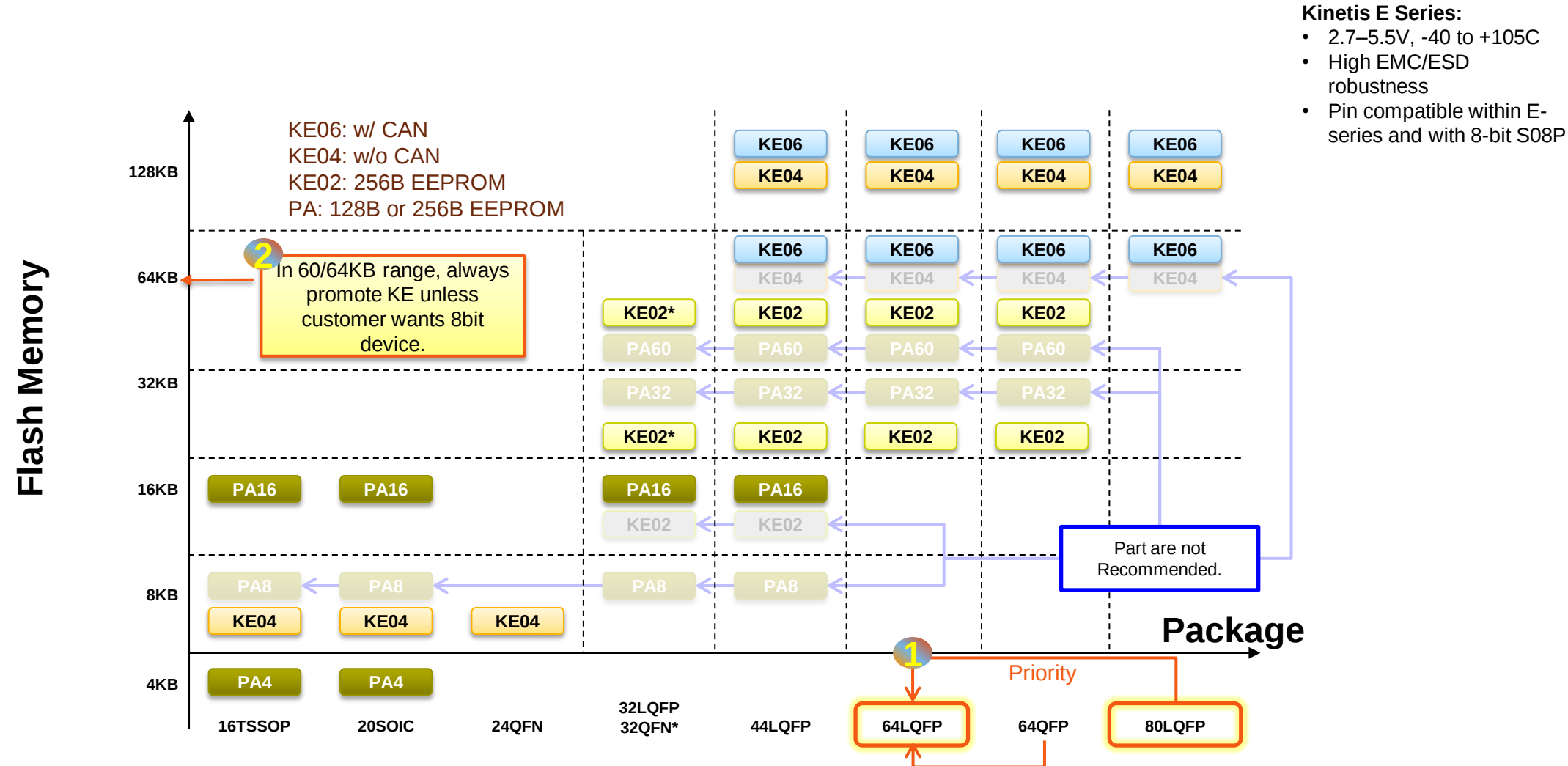
KE系列

BME
Single cycle GPIO



2.7-5.5V MCUs with high reliability and robustness

Promotion strategy: KE and PA product portfolio



- Kinetis E Series:**
- 2.7–5.5V, -40 to +105C
 - High EMC/ESD robustness
 - Pin compatible within E-series and with 8-bit S08P



Kinetis E EMC Performance

Robustness in EFT,PESD and AC Power Relay Tests

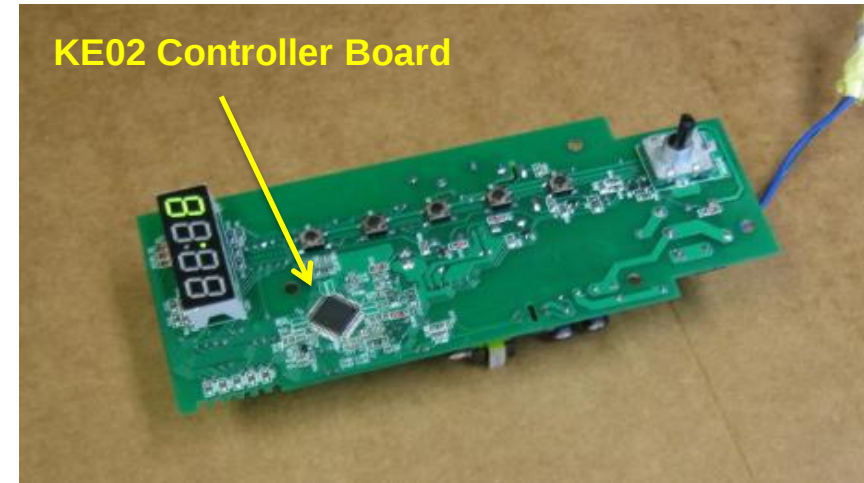
Test Conditions

- Microwave Oven Controller board with KE02 as main control MCU
- Board and System level tests based on
 - IEC 61000-4-4(EFT)
 - IEC 61000-4-2(PESD)
 - China Appliance local AC Power Relay test

Test Results

- Board level
 - IEC 61000-4-4(EFT): +/- 4.4kV*
 - IEC 61000-4-2(PESD): Indirect Contact Discharge +/- 20kV
 - China Appliance local test on AC Power Relay: 6-turns without Reset
- System level
 - IEC 61000-4-4(EFT): +/- 4.4kV*
 - IEC 61000-4-2(PESD): Contact Discharge(at the case) +/- 20kV
 - IEC 61000-4-2(PESD): Air Discharge(at the control panel) +/- 15kV

*Limited by the test equipment max output voltage

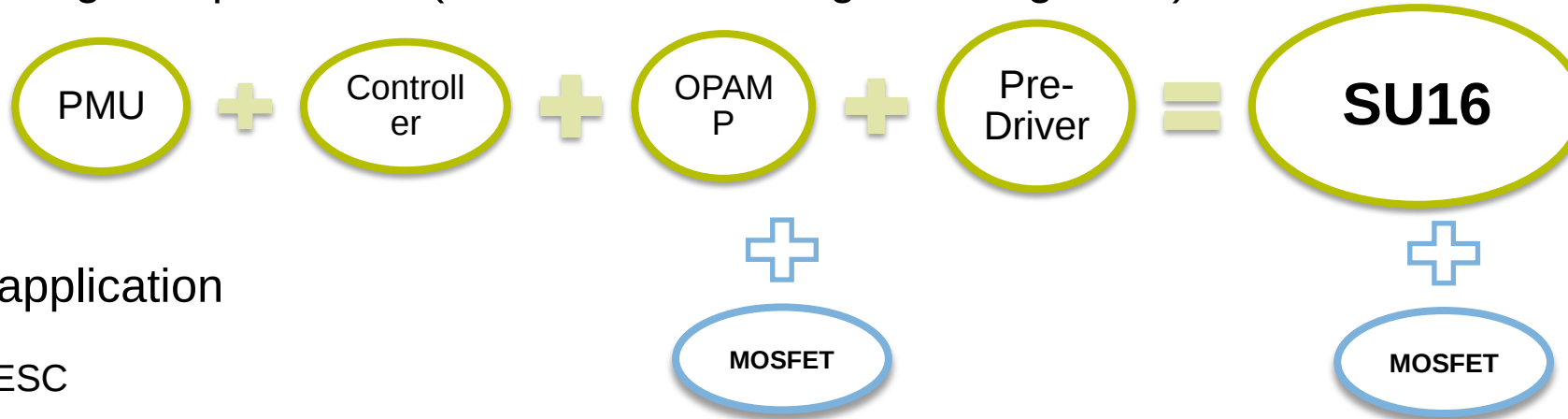




Su16介绍

Su16 – All in One Solution for Motor Control

- The low-end Motor Control market is dominated by discrete device solutions
- SU16 - Single chip solution (lower BOM cost, tighter integration)

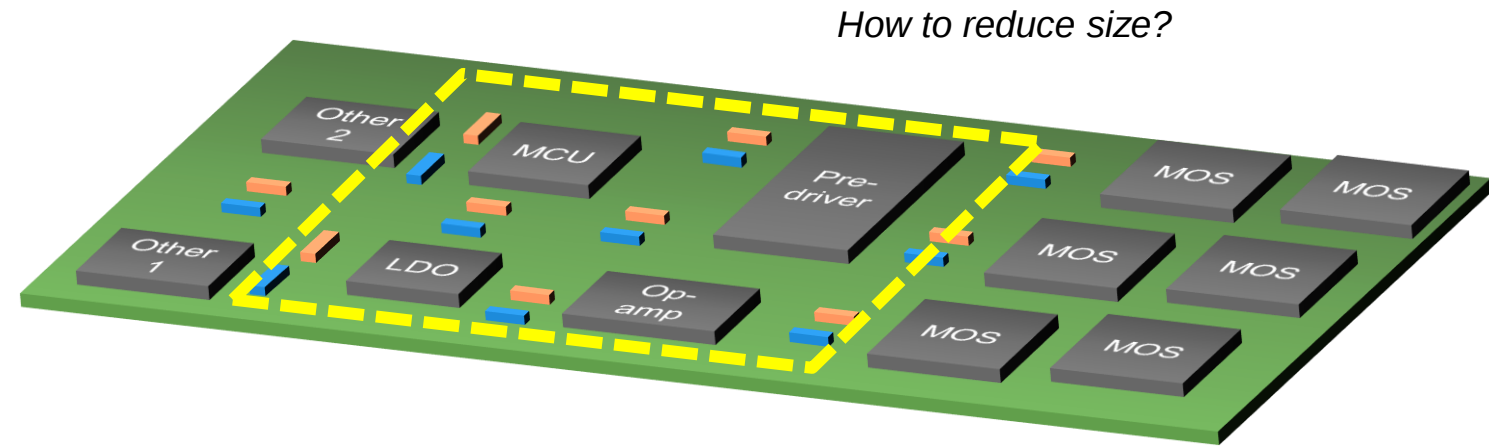


- Target application
 - Drone ESC
 - DC Fan
 - BLDC power tool
 - BLDC step motor
 - Health Care...

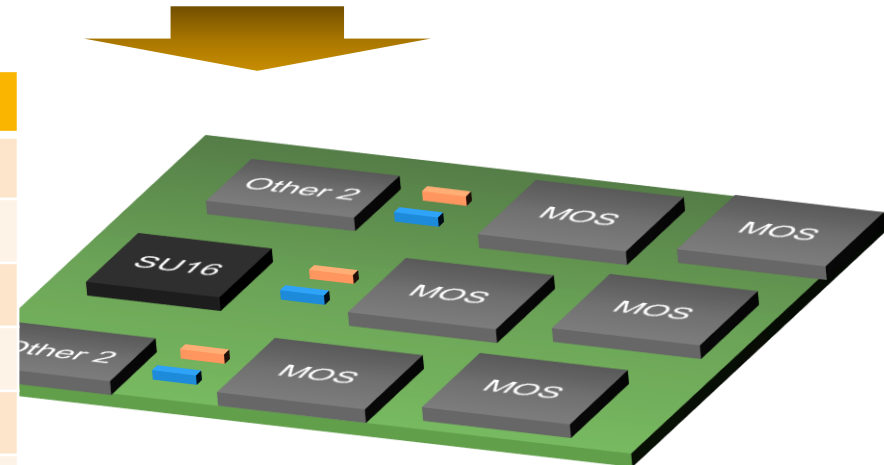
SU16 – Comparison with Discrete Solutions

Advantages

- **Save** about 50% PCB size and layer, **Perfect** for Size-Limited applications such as Power tools & Drone ESC
- **Competitive** BOM cost
- **Easy** to use and layout, 24QFN
- **GREAT support** with reference solution



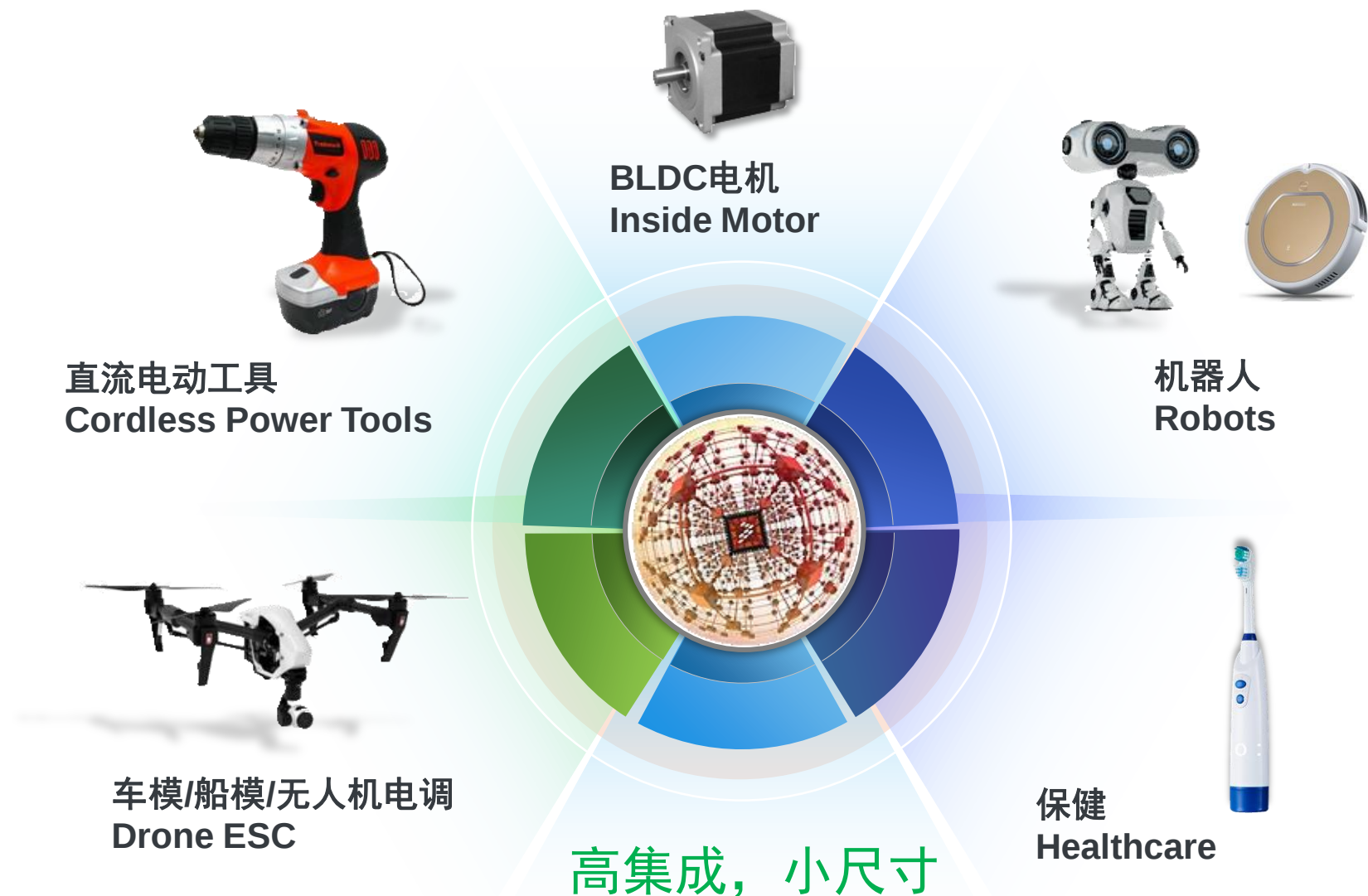
PCB Size Shrink Down !



	P-MOS	P/N
<10A	Alpha & Omega	AO4629
	DIODES	DMC3021LK4
>10A	Alpha & Omega	AOD4189
	Fairchild	NDP6030PL
	Alpha & Omega	AON6435
	TOSHIBA	TPCA8120

SU16 – 目标市场

面向面积受限，5~18V电源，BLDC电机应用



SU16 – One Page

Core / System

- S08L Core @40MHz
- Interrupt Priority Controller
- Inter Module Connection Module
- Cyclic Redundancy Check (CRC)
- Windowed COP watchdog (WCOP)

Memory

- Up to 16KB Flash
- 768B RAM

5V Analog

- 2x 12-bit ADC
- 4.2V Internal Voltage Reference
- 1x ACMP w/ internal 6-bit DAC

High Voltage Gate Drive Unit

- 3x high side PMOS pre-driver
- 3x low side NMOS pre-driver
- 3x phase comparator
- 1x voltage clamp
- 2x current sensing Op-Amp & OCP
- Vsup OVP

Timers

- 1x 6-ch MCPWM @40MHz
- 2x Programmable Delay Block (PDB) @40MHz
- 1x 16-bit FTM
- 2x 16-bit Pulse Width Timers (PWT)
- 1x 16-bit Module Timer (MTIM)

Communications

- 1x SCI
- 1x I2C/Smbus

Multiple Clock sources

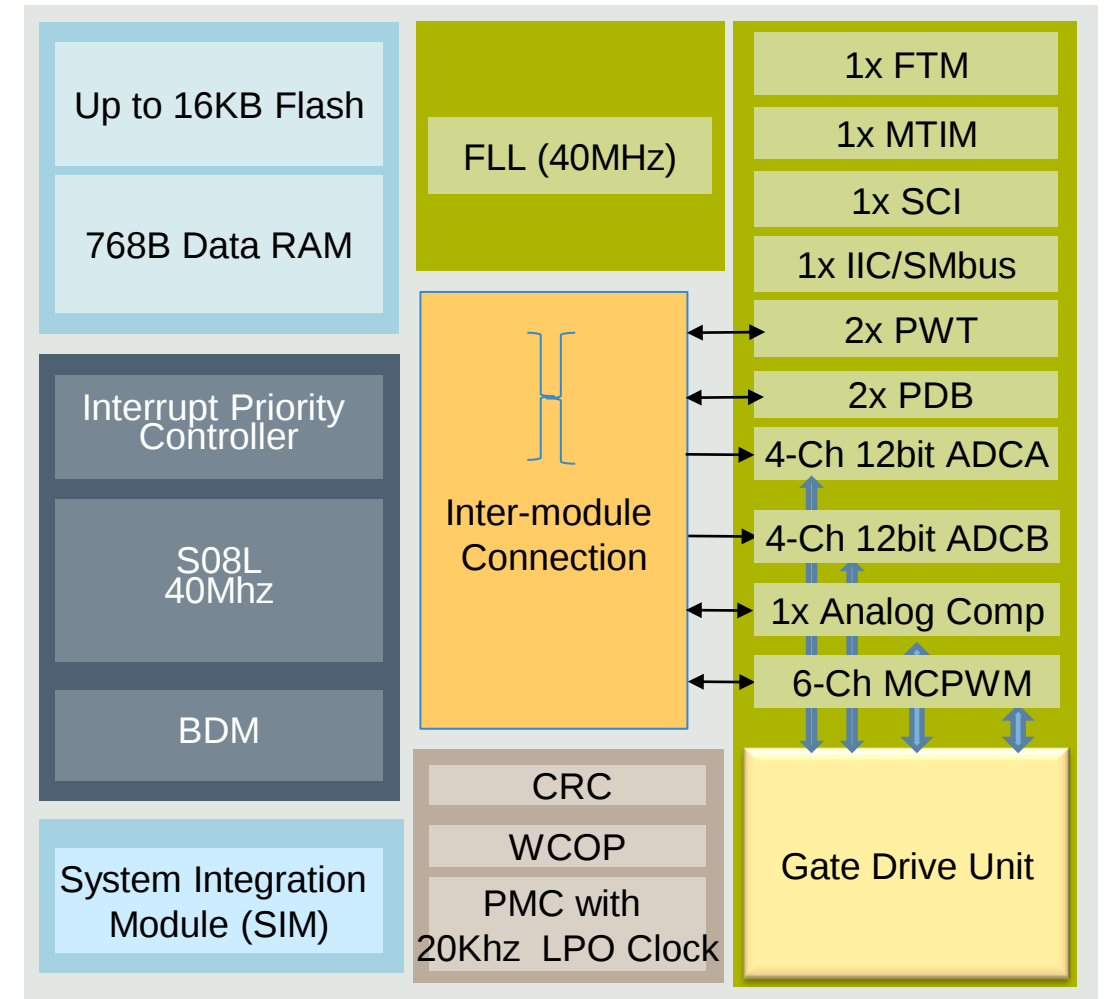
- External Clock Input
- 32Khz Internal RC Oscillator
- 20KHz Internal Low Power OSC

Others

4.5V~18V; -40C~105C

Packages

24QFN



SU16 Reference Design – Drone ESC

Features:

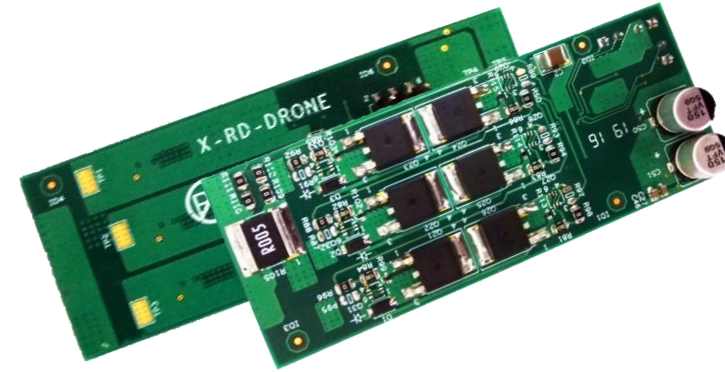
- Size 75 x 32 mm
- 3x A&O P+N MOSFET pair
- Single PWM speed control
- FreeMaster debug & control GUI

Document:

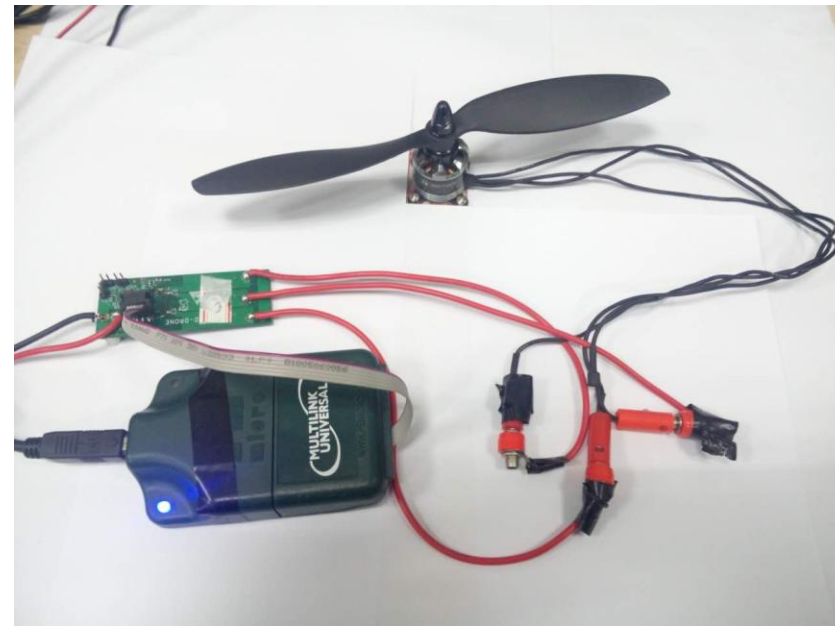
- Source code
- Schematic and Layout
- User Guide

Experimental:

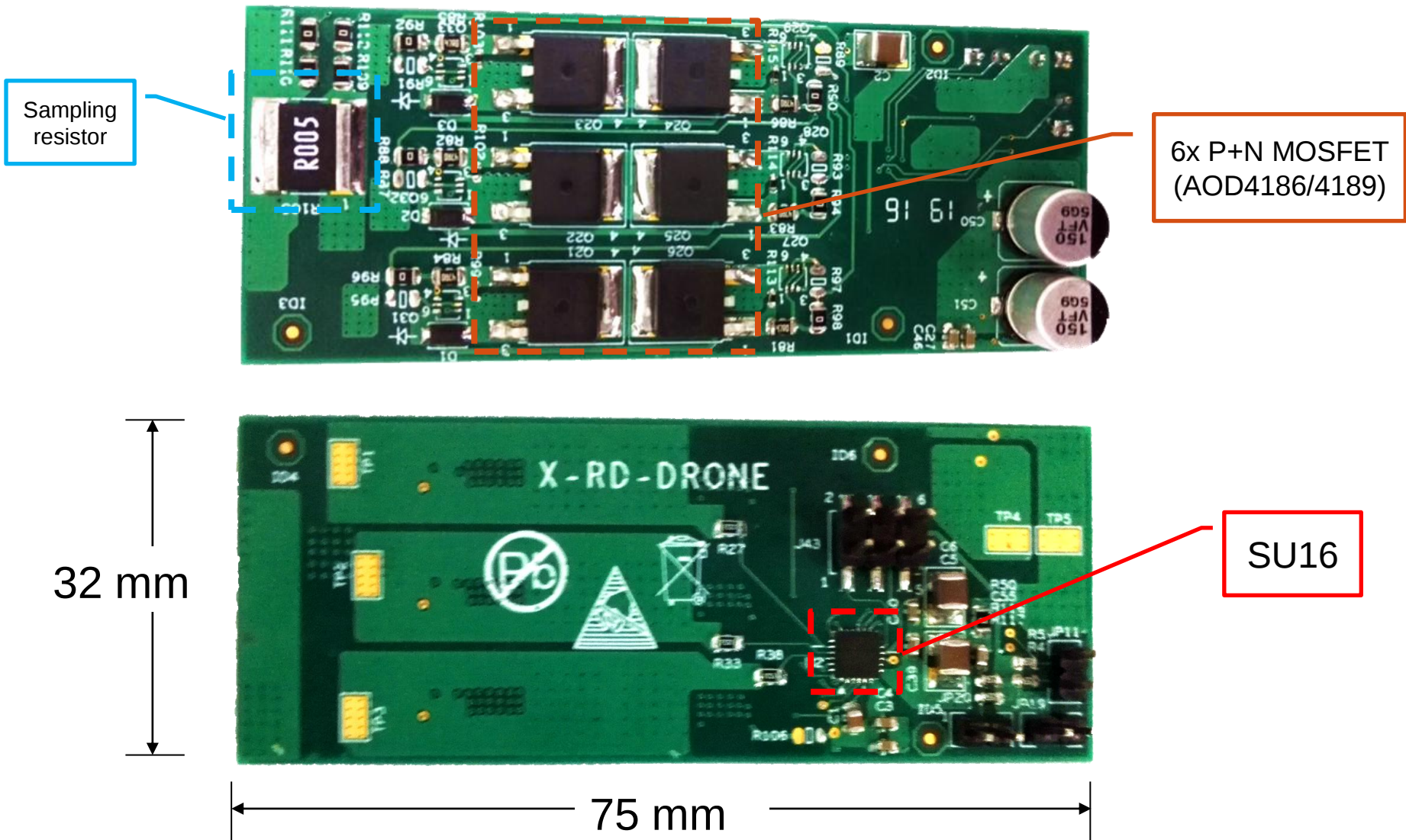
- Condition: emulated wind, tiger KV1100 motor, HobbyWing rotor wing
- Up to 11,000 RPM under 12V supply.
- Comparison with popular HobbyWing Skywalker 30A ESC



PCB board



SU16 Reference Design – Drone ESC





Wireless charging 介绍

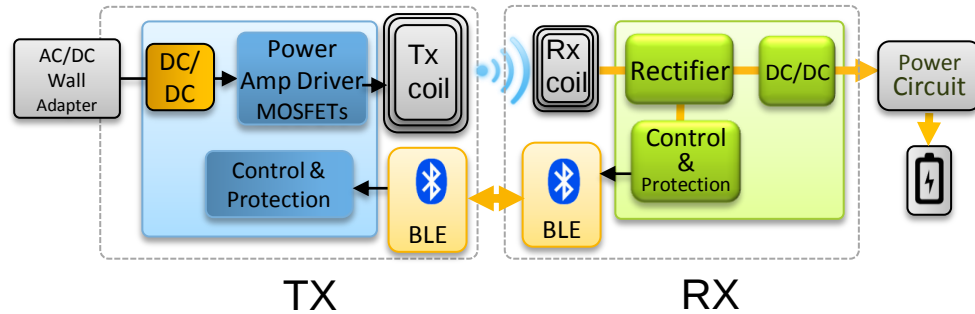
Wireless Power Alliance

Standard (Consortia)		Logo	Technology	Characteristics
Qi (WPC)			Inductive Coupling Resonant Coupling	– Frequency: 85-205kHz – 5W to 2.4kW – Communication via load modulation – Bi-directional
	PMA		Inductive Coupling	– Frequency: 105kHz – 476kHz – Bidirectional (load modulation)
	Rezence (former A4WP)		Resonant Coupling	– BT-LE Communication channel – Power transfer at 6.78 MHz

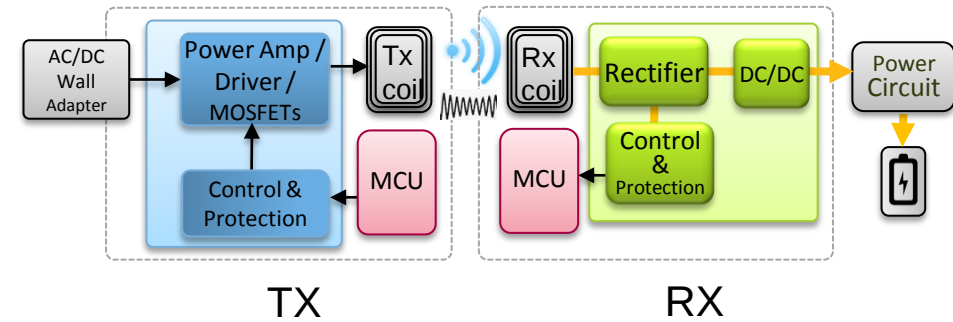
Two of the three standards have merged to form the AirFuel Alliance

Wireless Power System Level Overview & Comparison

rezenze (A4WP) System
Alliance for Wireless Power



Qi (Qi, PMA) System



	A4WP Rezenze	WPC Qi, PMA
Communication/Control	Bluetooth	In-band ASK
User Experience	Freedom of placement	Coil alignment needed
Coil Sizes	Customizable	Specified
TX: RX connections	Up to 8	1:1
Technology	Emerging	Mature

Receiver Group Based on Applications

- 5V/0.1A Applications

- As small as possible
- High integration with Analog and Charging



- 5V/1A Applications

- Must have good thermal performance
- Less thickness
- w or w/o charging controller for different application



- 5V/2A Applications

- Must have good thermal performance
- Less thickness
- w or w/o charging controller for different application
- 5W compatible



- Higher Power Applications

- 3 cells to 5 cells with output voltage: 12.6v to 21v
- Good thermal performance
- Accept additional charging controller for battery pack



Smart Phone Receiver Solutions



Sleeve

- Apple/RIM 3rd party accessory
- 35% → 14%
- Discrete solutions allowed
- Need less thickness & BOM



Back Cover

- Samsung/Nokia/Moto/HTC/Lenovo /Philips/Coolpad/ZTE/Huawei
- 30% → 60%
- Discrete solutions allowed
- Need less thickness & BOM



Battery Pack

- Panasonic/Sharp/Xiaomi
- 20% → 15%
- Discrete solutions allowed
- Need less thickness & BOM



Mainboard

- LG/Google
- 10% → 10%
- Need SoC
- Need less thickness & BOM



Universal Accessory

- PowerKiss
- 5% → 1%
- Need SoC
- Need less thickness & BOM

Transmitter Types on Market

- Standalone

- ❑ 65% → 20%
- ❑ Less BOM
- ❑ Lower cost



- Embedded

- ❑ 20% → 45%
- ❑ High performance
- ❑ Less BOM



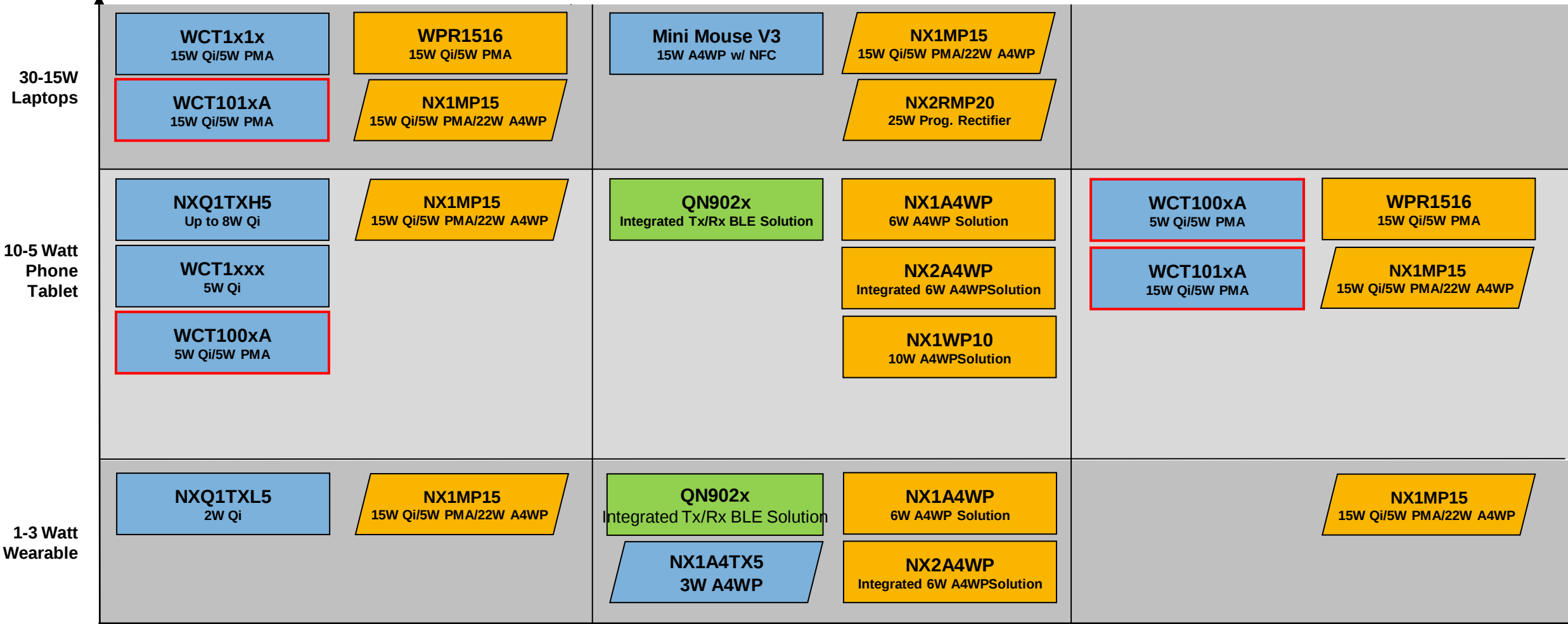
- Model/Furniture

- ❑ 15% → 35%
- ❑ Less BOM
- ❑ Lower Cost



NXP Wireless Power Solutions

Features



WPC Qi

A4WP Rezence

PMA

Transmitter

Receiver

Industrial/Auto

Production

Execution

Planning

Proposal



WPC Qi Everywhere

Mobiles	Cars	Consumer	
Samsung, Google, LG, Sony, HTC, Motorola, Microsoft, Nokia, ...	Toyota, Ford, Audi, VW, Skoda, Honda, Hyundai, BMW, Mercedes-Benz, ...	Dell, Ikea, Philips, Panasonic, McDonalds, AirCharge, PowerSquare, ...	
			

NXP is Key Contributor in WPC

Regular member of Qi Wireless Power Consortium (WPC)

Chair of Specification Working Group in WPC



Co-chair of 60W Working Group in WPC

NXP Qi Solutions are golden units in WPC specification

NXP Qi Solutions are part of certification interoperability test bed

NXP Wireless Power Solutions Platform

HW

- Reference design
- Optimized BOM

SW

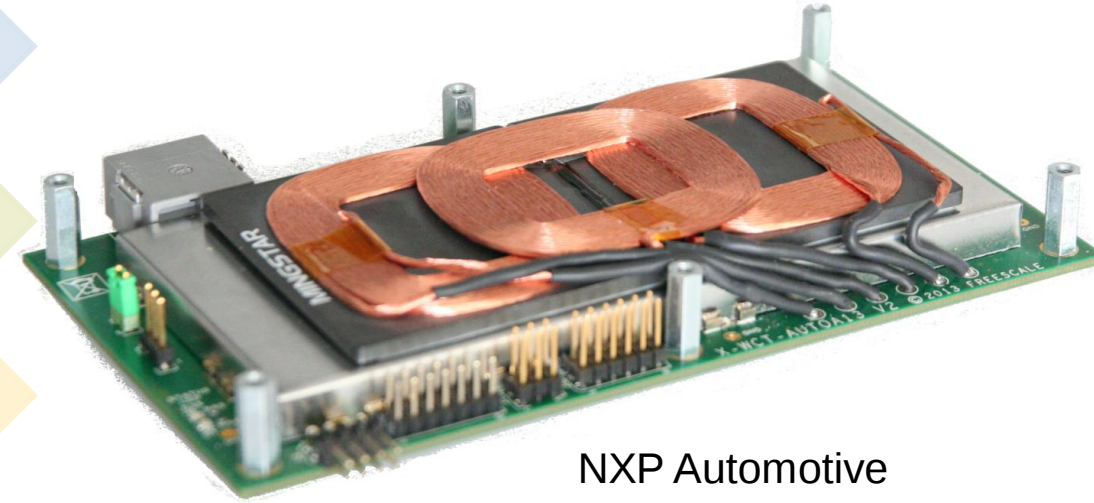
- Professional Grade Qi certified library
- Customizable application / clean API

Support

- Application Expertise
- On-site support up to production

Certification

- WPC consortium chair
- Available  1.2.2 certified solutions



NXP Automotive
Wireless Charging Tx
Solutions Platform

Customers Benefits:

- Reduced Time to Market
- Reduced Risk
- Reduced Development Cost

Built in Safety

Foreign Object Detection (FOD)

- Q-Factor – comparison of expected and measured resonance curve (conductive materials shifts resonance frequency)
- Power loss method – monitoring of unexpected losses in the system
- Surface temperature measurement

Over voltage/current/temperature protection with peripherals

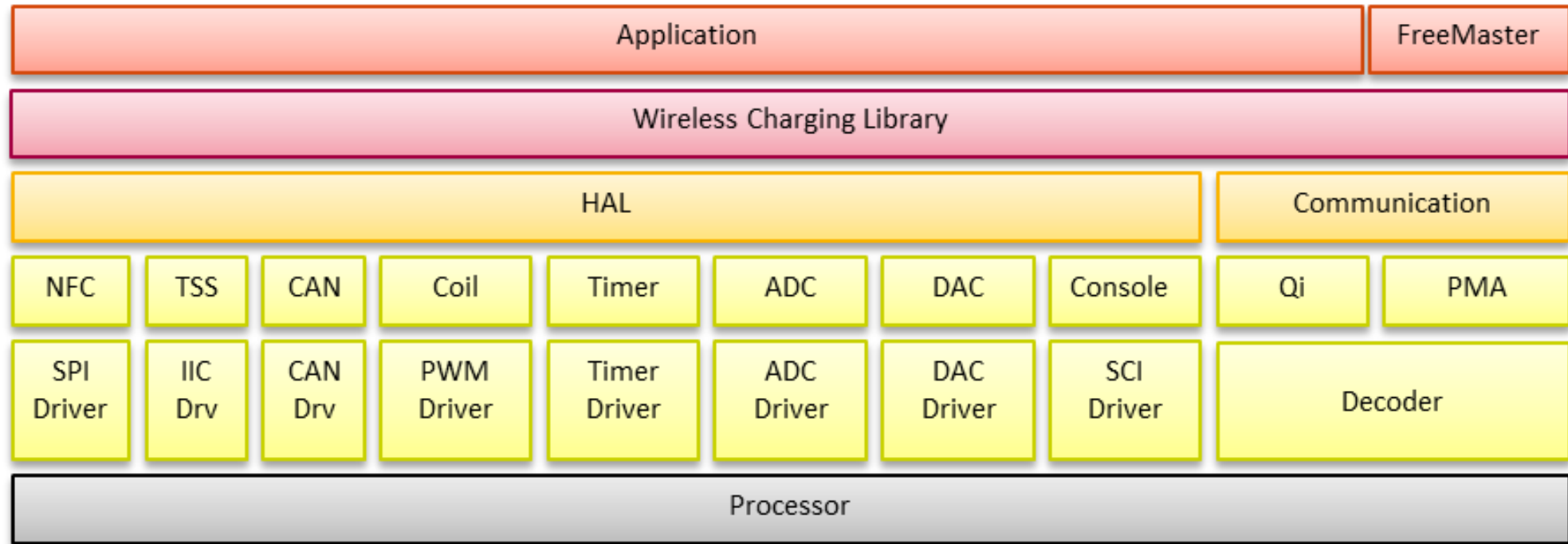
- Comparators connected directly to PWM module
- 100% safe even when the core is busy



Wireless Power Solutions SW

Qi certified library (after spec is ready) with advanced control algorithms (NXP IP)

Fully customizable application + HAL layer



Application Flexibility

- Custom FOD
- Additional application
- Qi disablement/enablement
- PMA disablement/enablement
- System/user interfaces definition
- Proprietary devices enablement
- Proprietary monitoring/protections
- Proprietary messages between Tx and Rx

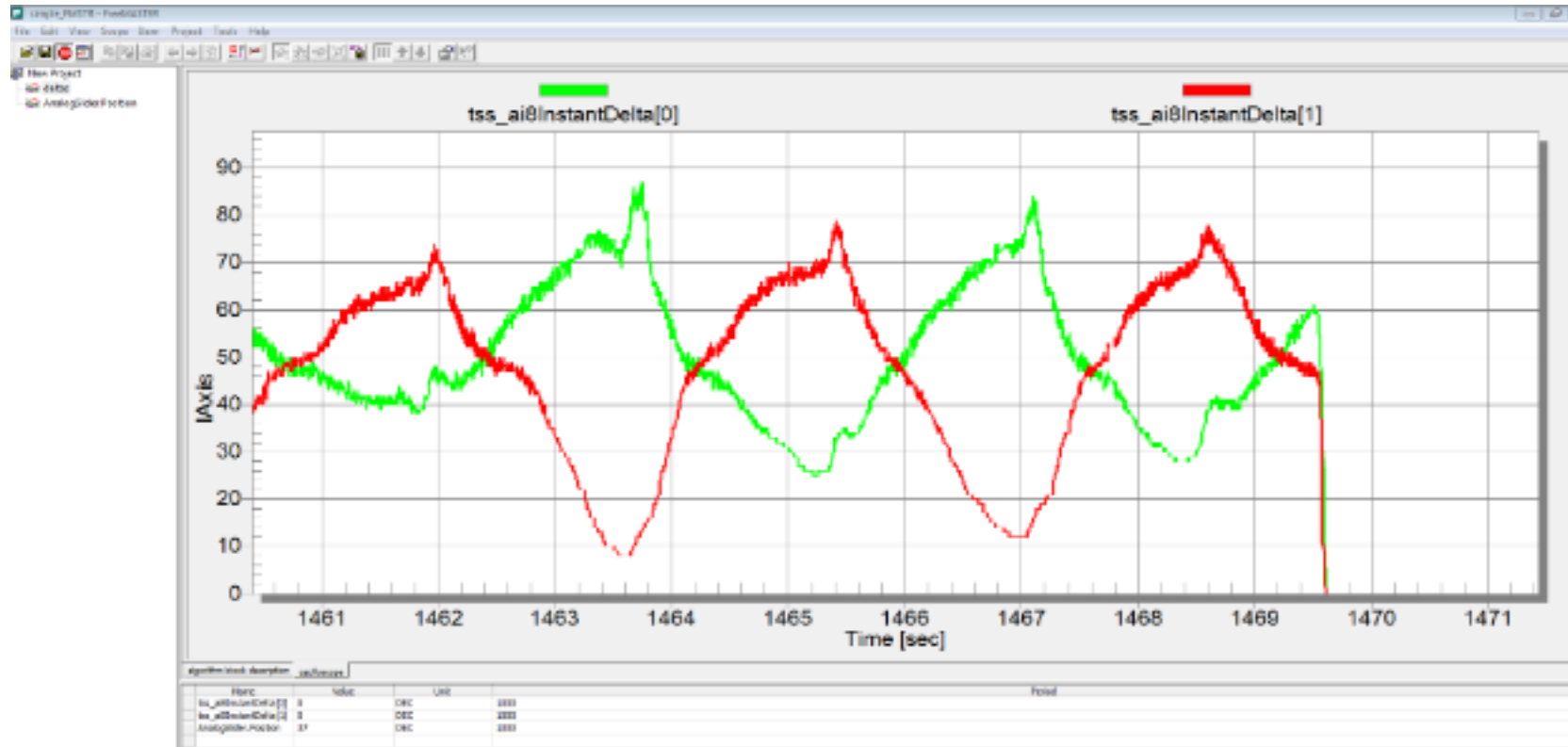


Development Tools

Eclipse based IDE

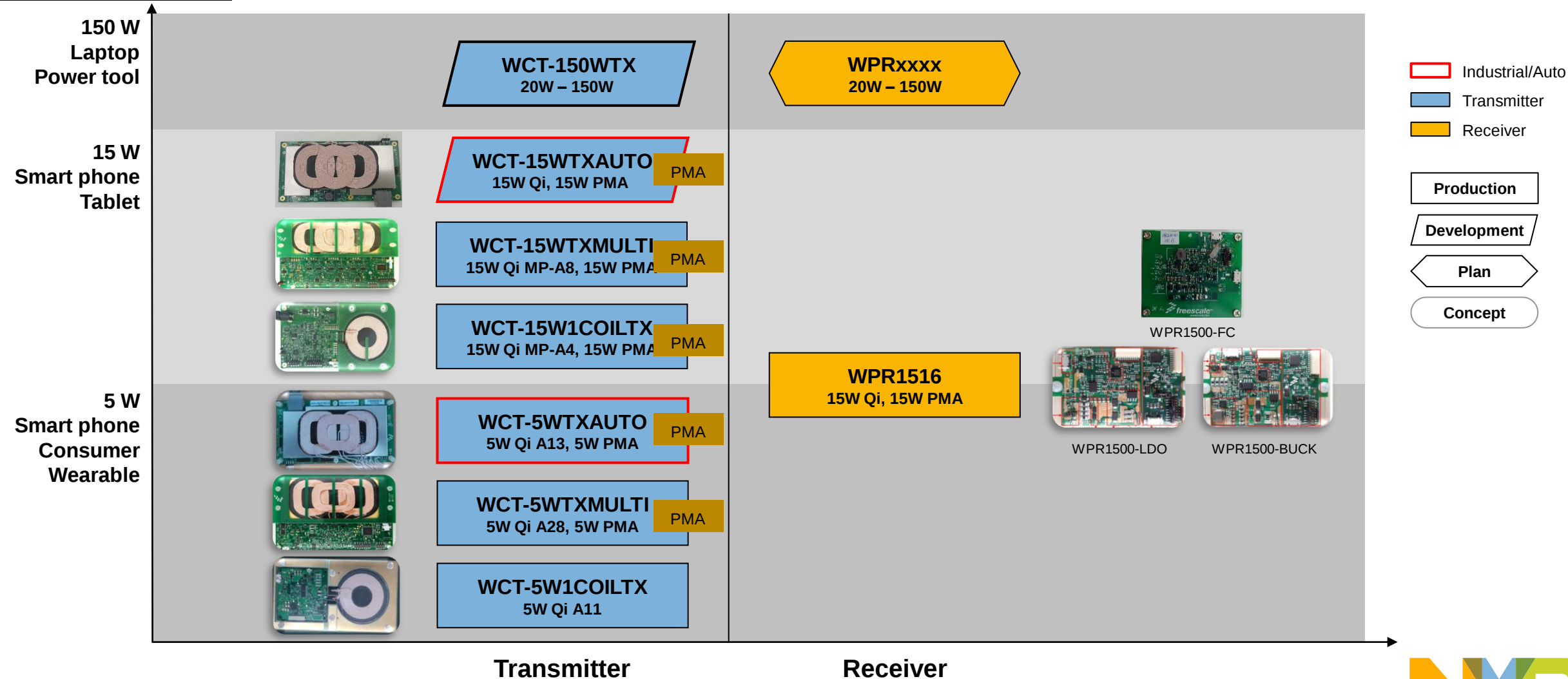
FreeMASTER GUI

- Monitoring
- Tuning
- Calibration
- Debugging



NXP WPC Qi Compliant Solution Platforms

Power / Application



NXP Qi Wireless Power Products on the Market



Automotive	
AUDI	Q7, A4
HONDA	Accord, Civic, CRV
BMW	5 Series, 7 Series
KIA	K5 JK, Sportage, K7
VW	Tiguan
HYUNDAI	Avante, Ecqus
SEAT	Ateca
SKODA	Superb, Octavia
Geely	GC9
JAC	S5

Consumer	
LG	G3 Phone Tx
Philips	S8860 Tx
PowerSquare	Tango Dual Tx
Belkin	Boost Up Tx



Our wireless charging products are industry compliant system solutions supported by the Wireless Power Consortium (WPC) and the Power Matter Alliance (PMA) standards for both transmitter and receiver wireless charging applications. These products offer a broad range of choices based on the needs of the end application. NXP® offers solutions from low power 5-Watt to medium power 15-Watt for the consumer, industrial, and automotive markets consisting of the transmit/receiver controller IC, associated software, evaluation boards and reference designs. The software contains all of the functionality to implement the core charging function, while also providing an API for customization and adding additional features. The transmitter/receiver ICs are highly optimized devices providing the wireless charge controller functionality in the system, as well as additional I/Os and memory for customization.

Email Link





电机控制参考方案

BLDC Motor Sensorless Drive Solution

Target Devices/Platforms:

- ☐ Brushless DC Motor (BLDC)
- ☐ KE02
- ☐ Motor Control Applications

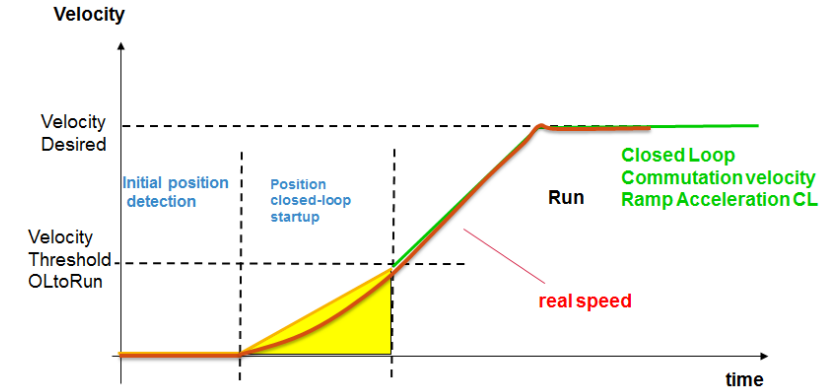
Applications Usage:

- ☐ Fans
- ☐ Pumps
- ☐ E-bike
- ☐ Power tool
- ☐ Fitness



Application Features:

- ☐ Targeted the MKE02Z32 low end 32-bit M0+ based microcontroller
- ☐ Sensorless 3-phase trapezoidal BLDC motor control with six-step commutation (60, 120 degree control) with speed and torque closed-loop control
- ☐ AD converter for BEMF zero-crossing sensing
- ☐ Start from any motor position with six pulses initial rotor position detection algorithm
- ☐ Rotor position closed-loop startup for more reliable motor startup performance
- ☐ Over-voltage, Under-voltage, Over-current, and Fault protection
- ☐ KE02 freedom board
- ☐ FreeMASTER software control interface and monitor



Availability:

- ☐ TWR-MC-LV3PH, available on web
- ☐ FRDM-KE02Z, available on web

PMSM Sensorless FOC Drive Solution

Target Devices/Platforms:

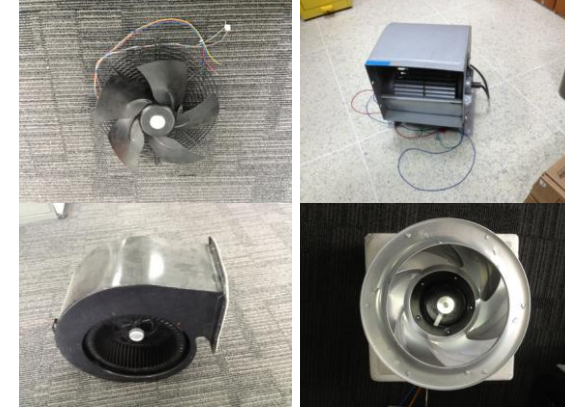
- ☐ PMSM/BLDCM
- ☐ KE02

Applications Usage:

- ☐ Fan/Blower
- ☐ Pump
- ☐ Industrial drives

Application Features:

- ☐ Targeted the MKE02Z32 low end 32-bit M0+ based microcontroller for sensorless FOC entry level
- ☐ Ultra low cost PMSM sensorless FOC drive solution
- ☐ Position and speed detection using extended Flux observer and DQ Back-EMF observer and tracking observer
- ☐ Low operating speed with extended Flux observer
- ☐ Very quiet startup with alignment
- ☐ Optional three-shunt and single-shunt current sensing algorithm
- ☐ Over-/under-voltage, over-current faults protection
- ☐ KE02 HVP daughter card and HVP platform
- ☐ FreeMASTER software control interface and monitor



Availability:

- ☐ HVP-MC3PH, available on web
- ☐ HVP-KE02, less internal boards
- ☐ AN5294, available on web

BLDC Drone ESC Solution

Target Devices/Platforms:

- ☐ BLDCM
- ☐ S08SU16

Applications Usage:

- ☐ DC Fan
- ☐ Drone ESC
- ☐ Power Tool

Application Features:

- ☐ Targeted the high integration MCU (LDO, Pre-driver and Signal conditioning) with NXP S08 core
- ☐ Low system BOM cost and small PCB footprint
- ☐ Sensorless 3-phase trapezoidal BLDC motor control with six-step commutation
- ☐ Reliable and fast startup even under free running
- ☐ Work well with different motors
- ☐ Play-ready solution for fast time-to-market
- ☐ Software based solution for maximum design freedom and product differentiation
- ☐ Over-voltage, Under-voltage, Over-current, and Fault protection
- ☐ FreeMASTER software control interface and monitor



Availability:

- Demo board available, less internal boards
- EVK will be available after launch on next Mar.
- Draft AN ready, will be available after launch

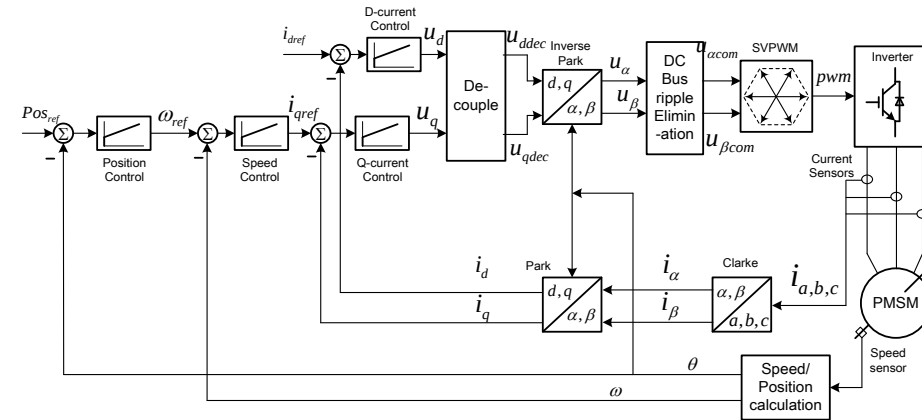
Simple Servo Motor Control Solution

Applications Usage:

- ☐ Industrial servo system
- ☐ Sewing machine
- ☐ Embroidery machine
- ☐ Knitting machine

Application Features:

- ☐ Can be expended to dual servo motors control on single chip
- ☐ Speed regulation: < 0.05% (from 0% to 100% load under nominal speed) with encoder and 32-bit speed control algorithm
- ☐ Speed ratio: 1 : 2000 with position and speed closed loop control – intelligent PID, the minimal operational speed is up to 0.5RPM
- ☐ Only low cost Quadrature Encoder (1000 lines) is required, HALL sensors removed
- ☐ System dynamic response: 90Hz for speed closed loop, and 30Hz for position closed loop – PID regulator
- ☐ Speed acceleration/deceleration: from 1 to 10,000ms (configurable)
- ☐ Brake function: regenerative braking, stop in one revolution
- ☐ Bidirectional operation: forward and reverse with speed and torque limitation
- ☐ Faults protection such as abnormal speed, over-/under-voltage, over-current etc.
- ☐ Communication protocols based on RS485
- ☐ FreeMASTER software control interface and monitor



Availability:

- MAPS available, limited internal boards
- DRM155, available on web

Micro-Step Stepper Motor Control Solution

Target Devices/Platforms:

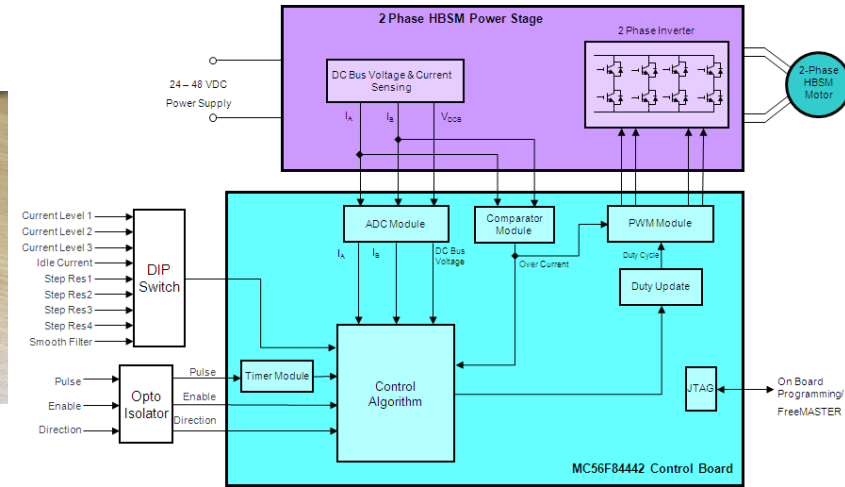
- ☐ Stepper
- ☐ MC56F84xxx

Applications Usage:

- ☐ Industrial servo system
- ☐ Gimbal system
- ☐ Sewing machine

Application Features:

- ☐ Two phases four wires stepper motor, expand to multiple motors control
- ☐ Motor self-adaptive function, auto motor parameters identification and control system adjustment
- ☐ Rated peak current selection by switch, the maximum current is up to 8 A
- ☐ Speed ratio: 1 : 1000 with position and speed closed loop control
- ☐ Current PID regulator
- ☐ Micro-step resolution selection by switch, the maximum resolution is up to 25600 steps/rev
- ☐ The maximum speed is up to 3000RPM with loading capability
- ☐ Pulse command mode: single pulse plus direction control
- ☐ Maximum 1 MHz pulse command input
- ☐ Smooth filter function for pulse command, enabled by switch
- ☐ Stop with half rated current
- ☐ FreeMASTER software control interface and monitor



Availability:

- ☐ Stepper drive board, one internal board
- ☐ Draft version AN completed

BPM Sensorless FOC Washing Machine Solution

Target Devices/Platforms:

- ❑ BPM/BLDCM
- ❑ MC56F8273x

Applications Usage:

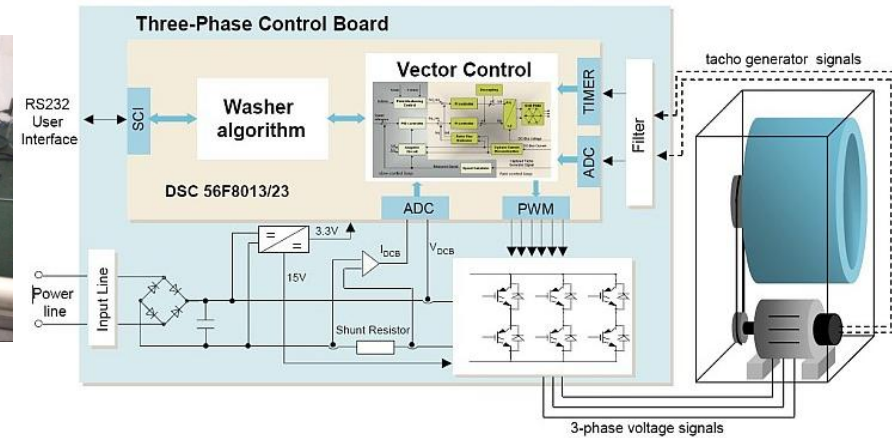
- ❑ Drum washing machine

Application Features:

- ❑ Three-Phase BPM drive with sensorless FOC
- ❑ IEC60730 certified controller
- ❑ Speed range 200RPM – 18000RPM (motor speed), 20RPM – 1600RPM (drum speed)
- ❑ Position and speed detection using extended Flux observer and DQ Back-EMF observer and tracking observer
- ❑ Non-recuperative braking and deceleration control
- ❑ Ultra low speed operation with rated torque, and ultra high speed operation with advanced field-weakening algorithm
- ❑ Over-current, over-temperature, over-voltage and under-voltage protection
- ❑ Serial RS232 control interface
- ❑ FreeMASTER GUI for easy debugging



NXP Ref. design



Availability:

- ❑ HVP-MC3PH, available on web
- ❑ HVP-56F82748, available on web
- ❑ Demo is ready on real washing machine

VF Refrigerator Compressor Control Solution

Target Devices/Platforms:

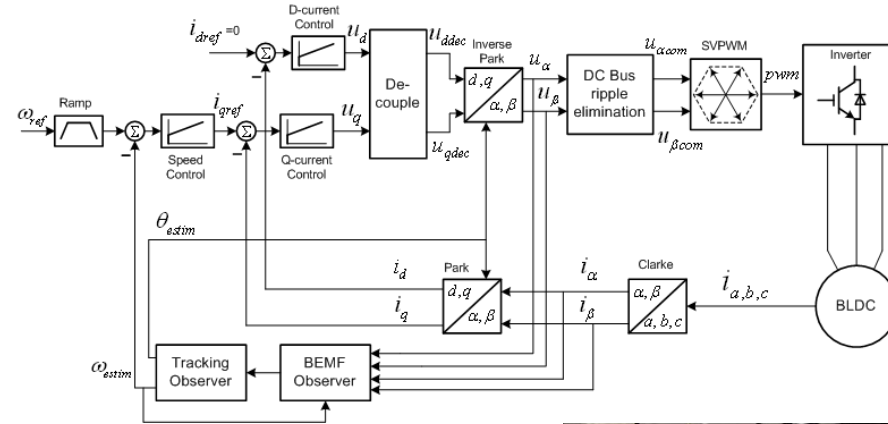
- ❑ PMSM/BLDCM
- ❑ MC56F82723/MKV10Z32

Applications Usage:

- ❑ VF refrigerator, auto compressor

Application Features:

- ❑ High energy efficiency solution with turn-key firmware
- ❑ IEC60730 certified controller
- ❑ Sensorless FOC control with speed and current closed-loop control
- ❑ Field-weakening control to increase maximum operating speed over motor rated speed
- ❑ Reliable startup strategy with extended flux observer under full loads and input voltage range
- ❑ Operating speed range from 1000rpm to 4800rpm
- ❑ Over-/under-voltage, over-current, over-temperature, over-input power protection, phase open and lock of rotor detection
- ❑ FreeMASTER GUI for easy debugging



NXP Ref. design

Availability:

- ❑ HVP-MC3PH, available on web
- ❑ HVP-56F82748/HVP-KV10Z32, available on web
- ❑ Basic function ready on KV10
- ❑ AN5387, available on web

3in1 Air-Conditioner Outdoor Unit Solution

Target Devices/Platforms:

- ❑ PMSM/BLDCM
- ❑ MC56F84xxx/MKE14Fxxx

Applications Usage:

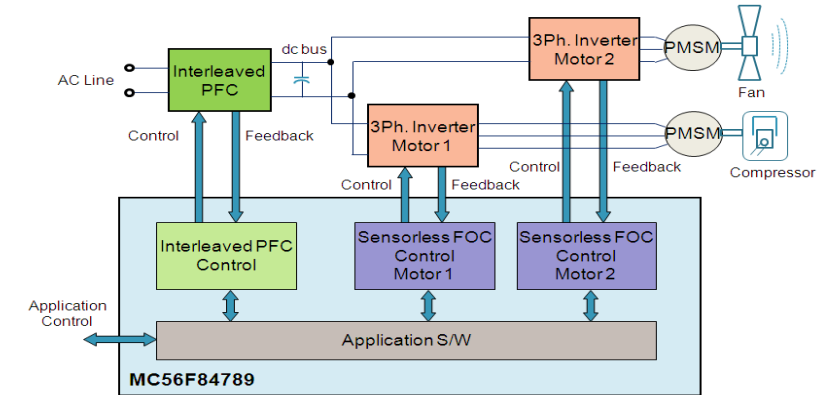
- ❑ VF air conditioner outdoor

Application Features:

- ❑ High performance, low cost all DC VF air-conditioner outdoor unit control system
- ❑ Three control objectives (interleaved single-phase PFC converter, fan and compressor) with one MCU device
- ❑ Input voltage range of 85 – 265VAC/40 – 70H
- ❑ Single-phase two channels interleaved PFC converter compatible with global mains input, 99.9% power factor, 8% input current THDi
- ❑ Sensorless FOC algorithm for both compressor and fan
- ❑ Anti-typhoon startup for fan, and on-line load torque compensation control for compressor to reduce system vibration and noise
- ❑ Reliable startup performance under full load and input voltage range
- ❑ Extreme low/high speed (from 1Hz to 150Hz) performance with extended flux observer
- ❑ Over-/under-voltage, over-current, over-temperature, over-input power protection and lock of rotor detection
- ❑ FreeMASTER GUI for easy debugging



NXP Ref. design



Availability:

- ❑ 3in1 drive board with control daughter card, less internal boards
- ❑ Demo is ready
- ❑ DRM152, available on web



Smart Power Reference Solutions

A11 5W Power Transmitter Solution



Availability:

- ☐ WCT-5W1COILTX, available on web
- ☐ All design docs available on web
- ☐ Got Qi v1.1.2 certification

Key Features:

Compliant with Wireless Power Consortium (WPC) low power specifications to support up to 5W power transfer

Integrated digital demodulation

Support any guided positioning single coil low power transmitter solutions using frequency and duty cycle control

Support both Resonance Shift and Power Loss FOD methods

Dynamic input power limit

Super low standby power consumption

Power transfer efficiency exceeds 75%

Voltage/current/temperature protection

Software based solution with Freescale embedded wireless charger software libraries to provide maximum design freedom and product differentiation

FreeMASTER GUI tool to enable customization and calibration

Got WPC Qi certification with WCT1000CFM

A28 5W Power Transmitter Solution



Availability:

- ☐ WCT-5WTXMULTI, available on web
- ☐ All design docs available on web
- ☐ Got Qi v1.1.2 certification

Key Features:

Compliant with Wireless Power Consortium (WPC) low power specifications to support up to 5W power transfer

Integrated digital demodulation

Support any free positioning multiple coils low power transmitter solutions using frequency and duty cycle control

Support both Resonance Shift and Power Loss FOD methods

Dynamic input power limit

Super low standby power consumption

Power transfer efficiency exceeds 70%

Voltage/current/temperature protection

Software based solution with Freescale embedded wireless charger software libraries to provide maximum design freedom and product differentiation

FreeMASTER GUI tool to enable customization and calibration

Support PMA v1.0 specifications

NXP IP in WPC specifications

Got WPC Qi certification with WCT1101CLH

A13 5W Automotive Power Transmitter Solution



Availability:

- ☐ WCT-5WTXAUTO, available on web
- ☐ All design docs available on web
- ☐ Got Qi v1.1.2 certification

Key Features:

Compliant with Wireless Power Consortium (WPC) low power specifications to support up to 5W power transfer

Integrated digital demodulation

Support free positioning multiple coils low power transmitter solutions using fixed frequency PWM control

Support both Resonance Shift and Power Loss FOD methods

Support key FOB and AM band avoidance

Low standby power consumption

Automotive applications design

Support PMA v1.0 specifications

AEC-Q100 grade 2 certification

Voltage/current/temperature protection

Software based solution with Freescale embedded wireless charger software libraries to provide maximum design freedom and product differentiation

FreeMASTER GUI tool to enable customization and calibration

Got WPC Qi certification with WCT1001AVLH

MP-A4 15W Power Transmitter Solution

Target Devices/Platforms:

- ❑ MWCT1011, 1111

Applications Usage:

- ❑ 15W single coil power TX

Application Features:

- ❑ Compliant with Wireless Power Consortium (WPC) latest extended power profile specifications to support up to 15W power transfer
- ❑ Support fast charging feature, PMA SR1E v1.0 specification compliant
- ❑ Integrated digital demodulation
- ❑ Power transfer efficiency exceed 80%
- ❑ Support two-way communication, transmitter to receiver by FSK and receiver to transmitter by ASK
- ❑ Support topology switch between full-bridge and half-bridge, frequency control, phase shift control and duty control algorithm
- ❑ Support quick charging feature
- ❑ Low standby power consumption
- ❑ Support MP FOD framework – Q factor and power loss FOD methods
- ❑ Support any guided positioning single coil extended power transmitter
- ❑ Voltage/current/temperature protection
- ❑ Software based solution with Freescale embedded wireless charger software libraries to provide maximum design freedom and product differentiation
- ❑ FreeMASTER GUI tool to enable customization and calibration
- ❑ NXP IP



Availability:

- ❑ WCT-15W1COILTX, available on web
- ❑ All design docs available on web
- ❑ Got Qi v1.2.2 certification

MP-A8 15W Power Transmitter Solution

Target Devices/Platforms:

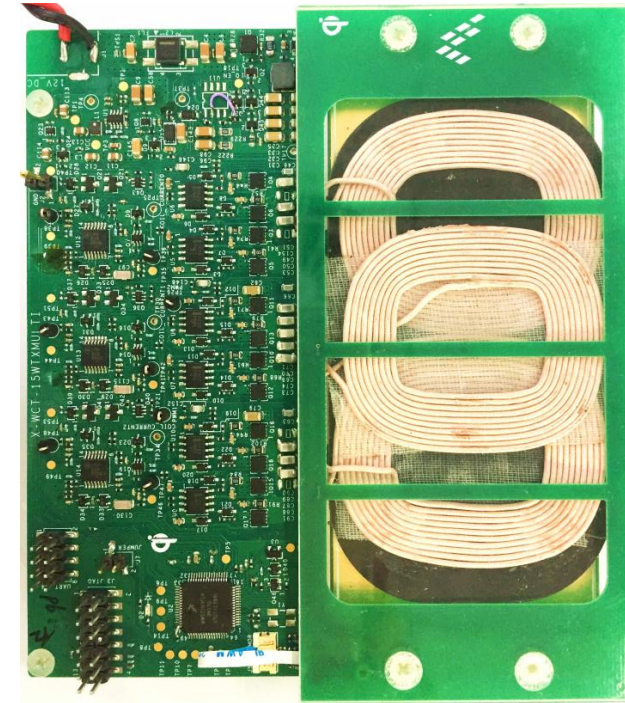
- ❑ MWCT1111

Applications Usage:

- ❑ 15W multi-coil power TX

Application Features:

- ❑ Compliant with Wireless Power Consortium (WPC) latest extended power profile specifications to support up to 15W power transfer
- ❑ Support fast charging feature, PMA SR1E v1.0 specification compliant
- ❑ Integrated digital demodulation
- ❑ Power transfer efficiency exceed 80%
- ❑ Support two-way communication, transmitter to receiver by FSK and receiver to transmitter by ASK
- ❑ Support topology switch between full-bridge and half-bridge, frequency control, phase shift control and duty control algorithm
- ❑ Support quick charging feature
- ❑ Low standby power consumption
- ❑ Support MP FOD framework – Q factor and power loss FOD methods
- ❑ Support any free positioning multi-coil extended power transmitter
- ❑ Voltage/current/temperature protection
- ❑ Software based solution with Freescale embedded wireless charger software libraries to provide maximum design freedom and product differentiation
- ❑ FreeMASTER GUI tool to enable customization and calibration
- ❑ NXP IP



Availability:

- ❑ WCT-15WTXMULTI, less internal boards
- ❑ All draft design docs are ready
- ❑ Qi v1.2.2 certification is ongoing

MP-A9 15W Automotive Power Transmitter Solution

Target Devices/Platforms:

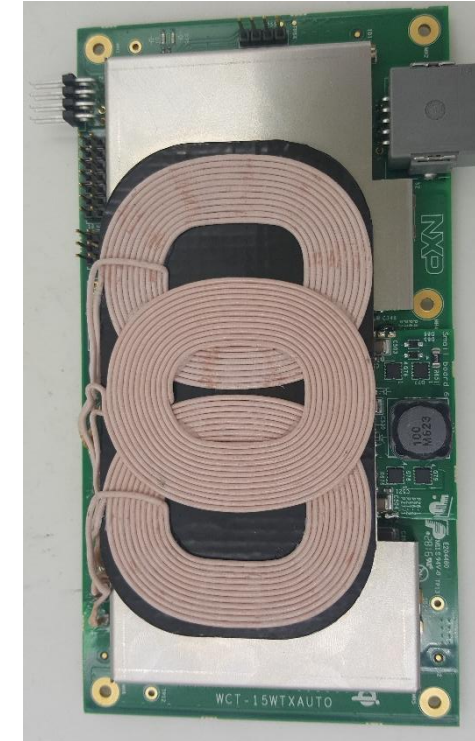
- ❑ MWCT1011A, 1013A

Applications Usage:

- ❑ 15W automotive multi-coil power TX

Application Features:

- ❑ Compliant with Wireless Power Consortium (WPC) latest extended power profile specifications to support up to 15W power transfer
- ❑ Support fast charging feature, PMA SR1E v1.0 specification compliant
- ❑ Integrated digital demodulation
- ❑ Power transfer efficiency exceed 70%
- ❑ Support two-way communication, transmitter to receiver by FSK and receiver to transmitter by ASK
- ❑ Rail voltage control strategy
- ❑ Support quick charging feature
- ❑ Low standby power consumption
- ❑ Support MP FOD framework – Q factor and power loss FOD methods
- ❑ Support any free positioning multi-coil extended power transmitter
- ❑ Voltage/current/temperature protection
- ❑ Software based solution with Freescale embedded wireless charger software libraries to provide maximum design freedom and product differentiation
- ❑ FreeMASTER GUI tool to enable customization and calibration
- ❑ AEC-Q100 grade 2 certification
- ❑ NFC, CAN enabled
- ❑ NXP IP



Availability:

- ❑ WCT-15WTXAUTO, less internal boards
- ❑ Plan to launch on July, 2017

MP-A9 15W Automotive Power Transmitter Solution (AUTOSAR)

Target Devices/Platforms:

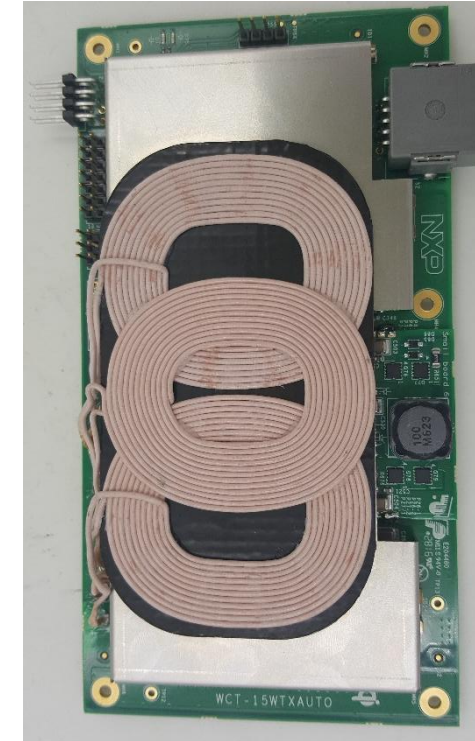
- ❑ MWCT1014S

Applications Usage:

- ❑ 15W automotive multi-coil power TX

Application Features:

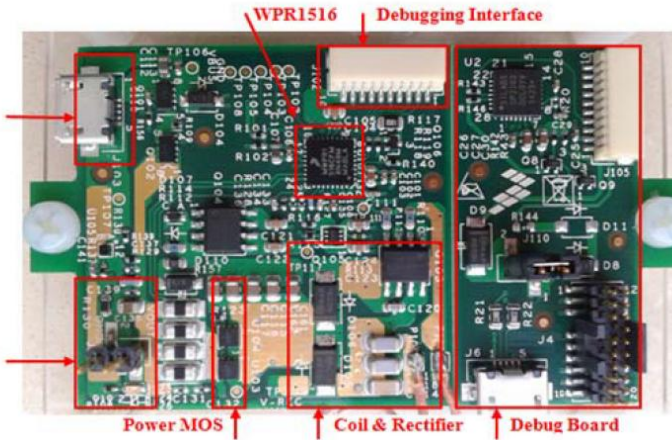
- ❑ Compliant with Wireless Power Consortium (WPC) latest extended power profile specifications to support up to 15W power transfer
- ❑ Support fast charging feature, PMA SR1E v1.0 specification compliant
- ❑ Integrated digital demodulation
- ❑ Power transfer efficiency exceed 70%
- ❑ Support two-way communication, transmitter to receiver by FSK and receiver to transmitter by ASK
- ❑ Rail voltage control strategy
- ❑ Support quick charging feature
- ❑ Low standby power consumption
- ❑ Support MP FOD framework – Q factor and power loss FOD methods
- ❑ Support any free positioning multi-coil extended power transmitter
- ❑ Voltage/current/temperature protection
- ❑ Software based solution with Freescale embedded wireless charger software libraries to provide maximum design freedom and product differentiation
- ❑ FreeMASTER GUI tool to enable customization and calibration
- ❑ Auto qualification device, Autosar and function safety enabled
- ❑ NFC, CAN enabled
- ❑ NXP IP



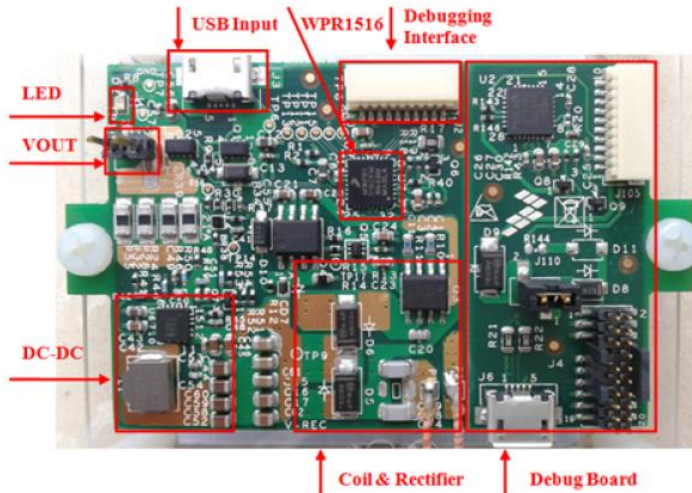
Availability:

- ❑ WCT-15WTXAUTOS, less internal boards
- ❑ Plan to launch in Q1, 2018

15W Power Receiver Solutions



WPR1500-LDO



WPR1500-BUCK

Key Features:

Compliant with latest Wireless Power Consortium (WPC) medium power specifications (Qi V1.2)

Input power (3.5 V ~ 20 Vac peak) from the transmitter via the receiver coil

Output power of 15 W (5 V @ 3 A)

Power transfer efficiency exceed 90% (RX only)

Support two-way communication, transmitter to receiver by FSK and receiver to transmitter by ASK

Hardware protection of rectifier voltage, output voltage and output current

Small PCB size (40 mm × 40 mm)

Open source reference solution with Freescale embedded wireless charger software libraries

USB/adaptor power switcher to charge products with wire and wireless with priority

FreeMASTER tool to enable customization and calibration

Supports quick charging feature

NXP IP

Selected as WPC golden MP receiver

Availability:

- ❑ WPR1500-LDO, WPR1500-BUCK, available on web
- ❑ All design docs available on web



Totem-Pole Bridgeless PFC Converter Solution

Target Devices/Platforms:

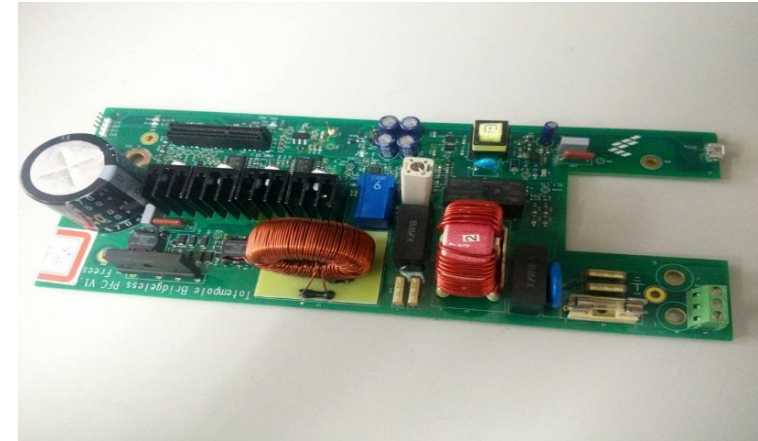
- ❑ MC56F82748

Applications Usage:

- ❑ Digital AC/DC power supply

Application Features:

- ❑ 12V/240W output with universal mains input
- ❑ Totem-pole bridge-less PFC converter
- ❑ Modular software and hardware design for convenient internal reuse and customer evaluation
- ❑ Flash updating from secondary side
- ❑ Isolated USB interface for FreeMASTER connection
- ❑ Isolated SCI communication between primary side and secondary side.
- ❑ $PF > 0.99@100\%$ load; $THDi < 5\%@50\%$ load.
- ❑ Over-current, over-/under-voltage, voltage brown-in, over-temperature, power limit protection functions



Availability:

- ❑ Less internal boards
- ❑ Demo is ready
- ❑ DRM174 available on web

LLC Resonant Converter with Sync Rectifier Solution

Target Devices/Platforms:

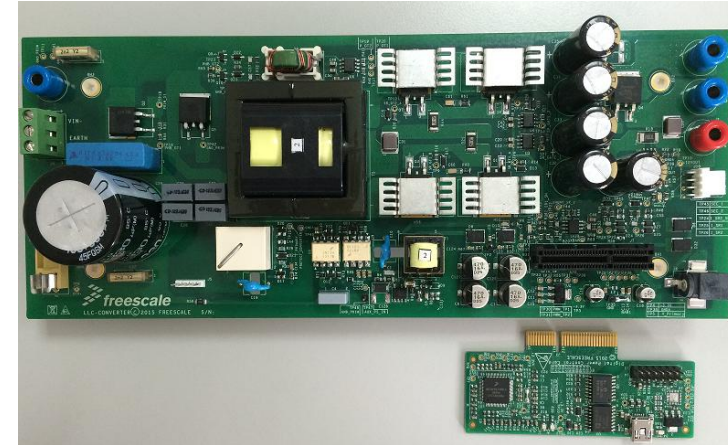
- ❑ MC56F82748

Applications Usage:

- ❑ Digital AC/DC power supply

Application Features:

- ❑ 12V/240W output with universal mains input
- ❑ Half-bridge LLC with synchronous rectifier
- ❑ Modular software and hardware design for convenient internal reuse and customer evaluation
- ❑ Flash updating
- ❑ Isolated USB interface for FreeMASTER connection
- ❑ Isolated SCI communication between primary side and secondary side; IIC interface is reserved for PMBus communication.
- ❑ 120mVp-p output ripple; Overshoot < 5%@0 to 65% load step; Hold up time 20ms@50% load, 15ms@100% load.
- ❑ Over-current, over-/under-voltage, voltage brown-in, over-temperature, power limit protection functions



Availability:

- ❑ Less internal boards
- ❑ Demo is ready
- ❑ DRM172 available on web



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