

瑞萨电子高性能 32位电机控制MCU

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MAY 2022

BIG IDEAS
FOR EVERY SPACE

认识瑞萨电子

瑞萨电子集团 是一家全球半导体供应商，提供专业可信的创新嵌入式设计和完整的半导体解决方案，旨在通过使用其产品的数十亿联网智能设备改善人们的工作和生活方式。

作为全球微控制器、模拟功率器件和SoC产品供应商，瑞萨电子为汽车、工业、基础设施及物联网等各种应用提供综合解决方案，期待与您携手共创无限未来。



集团总部
东京，日本



约21,000人
全球员工数*



运营覆盖
30+国家和地区



9944亿日元
2021年销售额

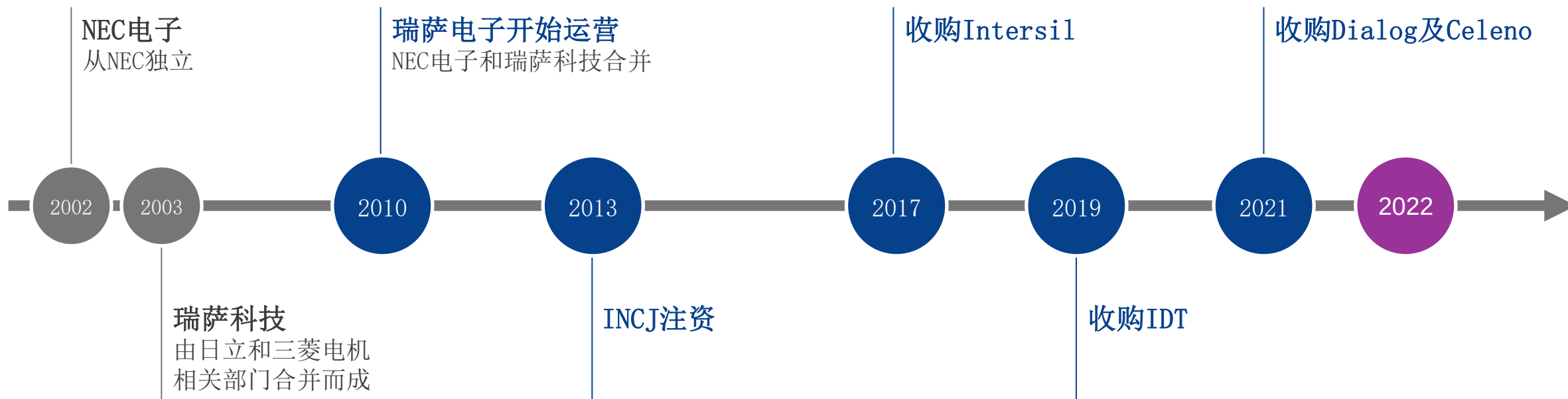


约20,000项
已获得及申请中专利

SoC: System-on-a-chip * Consolidated, as of December 31, 2021

公司沿革

瑞萨电子建立在日立，三菱电机以及NEC的强大技术创新基础上。自2017年起，我们先后收购了Intersil、IDT、Dialog以及Celeno来强化模拟产品阵容。瑞萨电子将不断成长为面向高增长市场的嵌入式解决方案全球领导者，包括汽车、工业/基础设施和物联网。



Intersil: Intersil Corporation, IDT: Integrated Device Technology, Inc., Dialog: Dialog Semiconductor Plc, Celeno: Celeno Communications

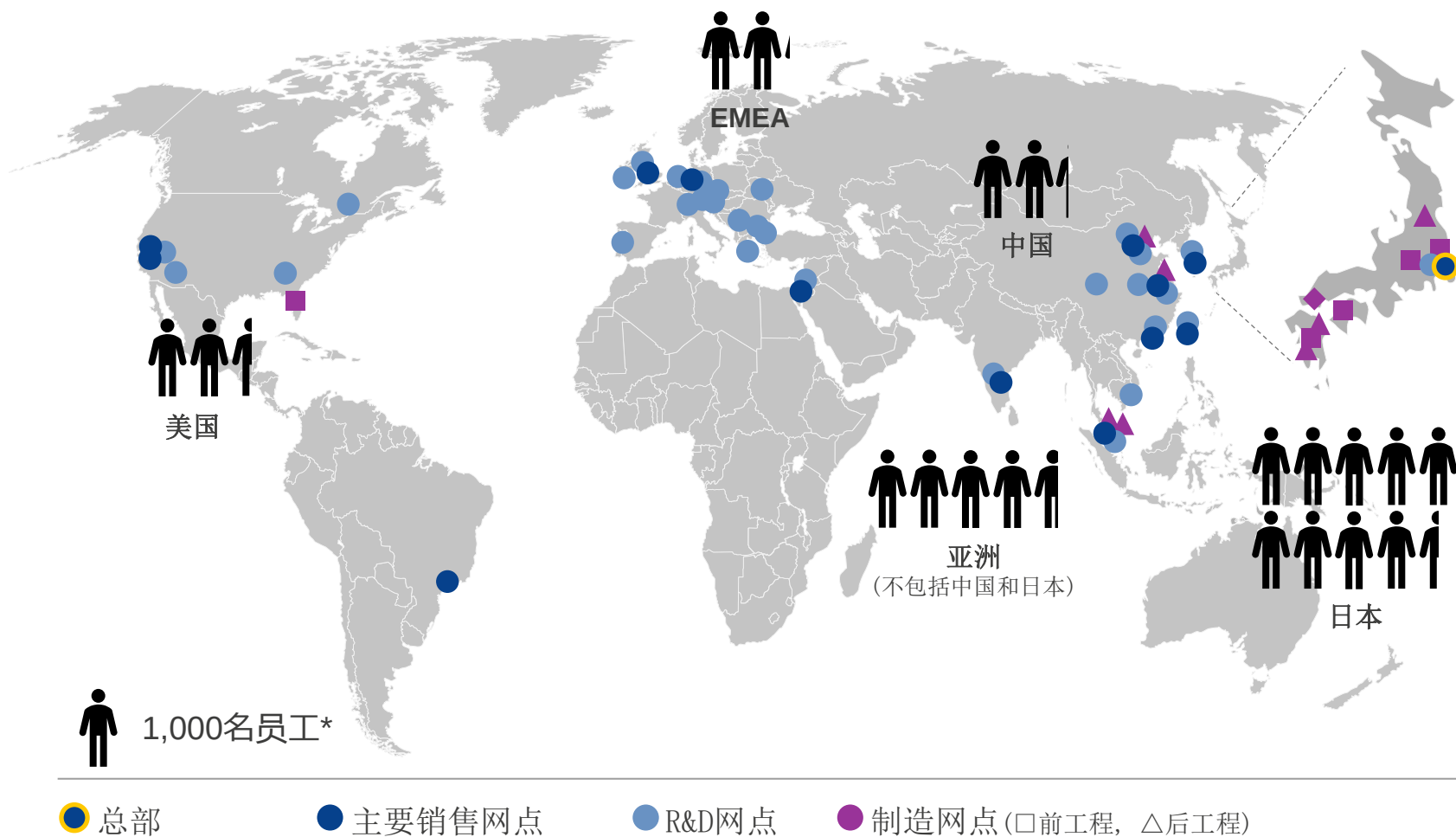
公司愿景

让生活更轻松

为人类赋能



全球网络



1,000名员工*

● 总部 ● 主要销售网点 ● R&D网点 ● 制造网点 (□前工程, △后工程)

* Consolidated, as of December 31, 2021

全球销售网络
遍布20多个国家和地区

完善的研发能力可在全球范围内
提供无缝支持

在日本、中国、东南亚和美国
设有 13 家制造工厂

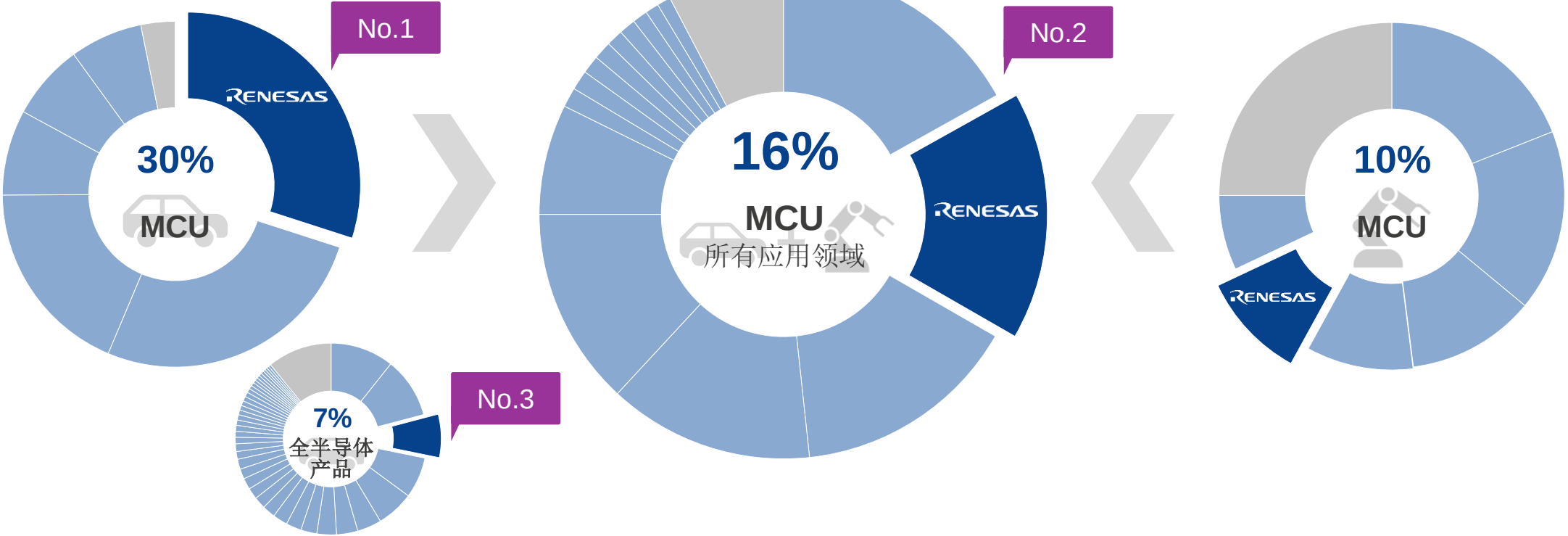
全球合作伙伴如 TSMC (台积电)
和 GLOBALFOUNDRIES (格芯)

全球市场定位(2021)

瑞萨电子持续以稳定增长拓展各应用市场业务。

汽车电子

非汽车电子



Graphs created by Renesas based on Gartner Research. Source: Gartner®, Market Share: Semiconductors by End Market, Worldwide, 2021, Andrew Norwood et al., 31 March 2022
Total semi = Total Semiconductor, MCU = Total Microcontroller, Non-Auto = All Application – Automotive
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解决方案

我们的使命是通过为四个重点应用领域：汽车、工业、基础设施和物联网，持续提供智能产品及解决方案来开发一个更安全、更健康、更环保和更智能的世界。这些应用领域对我们的日常生活都至关重要，这意味着我们的产品和解决方案无处不在。



汽车

高度可靠的车辆控制，
具备功能安全和网络安全
的自动驾驶，
绿色环保的电动车



工业

精益求精，灵活
和智能工业



基础设施

强大基础设施，
实现安全和高效



物联网

通过物联网实现舒适、
安全和健康的生活方式

产品分类

从传感器到执行器，瑞萨在整个信号链上提供了丰富大量的半导体产品，帮助我们的客户实现完整的系统解决方案。



广泛且丰富的MCU产品阵容

微控制器及微处理器	模拟及功率器件	SoC
Arm®内核  先进32位MCU Arm生态系统, 先进安全性, 智能物联网  高端32/64位MPU 高分辨率HMI, 工业网络及实时控制  超低功耗32位MCU 创新制程工艺 (SOTB), 能量采集  基于32位MCU的Renesas Synergy平台 经认证的软件及工具 Renesas自有内核  高效32位MCU 电机控制, 电容式触摸, 功能安全, GUI  超低能耗8/16位MCU 蓝牙®低功耗, SubGHz, 基于LoRa®的解决方案 汽车执行器与传感器, 低端ECU  40nm/28nm制程车用32位MCU 丰富功能安全及嵌入式安全性能	■ 模拟产品 ■ 时钟与计时器 ■ 接口与连接 ■ 存储与逻辑 ■ 电源与电源管理 ■ 可编程混合信号, ASIC与IP产品 ■ RF产品 ■ 传感器 ■ 太空与恶劣环境	 Factory automation
	■ ASIC ■ 电池管理 ■ 时钟与计时器 ■ 功率器件	 Automotive computing

瑞萨电子中国支持网络

瑞萨电子（中国）有限公司
瑞萨集成电路设计（北京）有限公司
瑞萨半导体（北京）有限公司



瑞萨半导体（苏州）有限公司



瑞萨电子管理（上海）有限公司



瑞萨电子（中国）有限公司
深圳分公司



瑞萨电子香港有限公司



- 销售公司 : 3
- 分公司 : 4
- 制造工厂 : 2
- ◆ 设计及应用技术公司 : 2

瑞萨电子高性能 32位电机控制MCU

BIG IDEAS
FOR EVERY SPACE

瑞萨电子电机MCU路线图

* : 开发中

Renesas Core	32-bit MCU  Power Efficiency RX13T, 23T, 24T, 24U, 66T, 72T, 26T* Features : •RxV2/V3 high performance core •High integration •Broad lineup	8/16-bit MCU  Low Power G1G, G1F, G14, G24* Features : •RL78 16bit Core •Low power •Low pin count lineup available
Arm® Core	32-bit MCU  Arm Ecosystem RA6T1, 6T2, 6T1*, 4T1* Features : •Arm ecosystem •High integration •Advanced security •Flexible Software Package	

电机驱动推荐MCU

家族	产品系列	管脚数量	ROM (KB)	RAM (KB)	操作频率	电源电压	特点
RL78	RL78/G1G	30 至 44	8/16	1.5	24MHz	2.7 至 5.5V	RL78内核、小封装
	RL78/G1F	24 至 64	32/64	5.5	32MHz	1.6 至 5.5V	RL78内核、小封装、内置比较器和 PGA*2
	RL78/G14	30 至 64	16 至 64	2.5 至 5.5	32MHz	1.6 至 5.5V	RL78内核、通用电机控制、丰富阵容
		80 至 100	96 至 512	12 至 48			
RX	RX13T	32 至 48	64 至 128	12	32MHz	2.7 至 5.5V	RXv1内核, FPU*1、5V 操作电压、内置 PGA*2
	RX23T	48 至 64	64 至 128	12	40MHz	2.7 至 5.5V	RXv2内核、FPU*1、5V 操作电压
	RX24T	64 至 100	128 至 512	16 至 32	80MHz	2.7 至 5.5V	RXv2内核、FPU*1、5V 操作电压、内置 PGA*2、2 电机控制
	RX24U	100 至 144	256 至 512	32	80MHz	2.7 至 5.5V	RXv2内核、FPU*1、5V 操作电压、内置 PGA*2、3、2 电机控制
	RX66T	64 至 144	256 至 1024	64 至 128	160MHz	2.7 至 5.5V	RXv3内核、FPU*1、5V 操作电压、内置 PGA*2、3、4 电机控制、安全模块
	RX72T	100 至 144	512 至 1024	128	200MHz	2.7 至 5.5V	RXv3内核、FPU*1、5V 操作电压、内置 PGA*2、3、内置 TFU*4、4 电机控制、安全模块
RA	RA6T1	64/100	256/512	64	120MHz	2.7 至 3.6V	Arm Cortex-M4、内置 PGA*2、3、2 电机控制、安全模块
	RA6T2	48 至 100	256/512	64	240MHz	2.7 至 3.6V	Arm Cortex-M33、内置PGA*2、3、内置 TFU*4、2 电机控制、安全模块

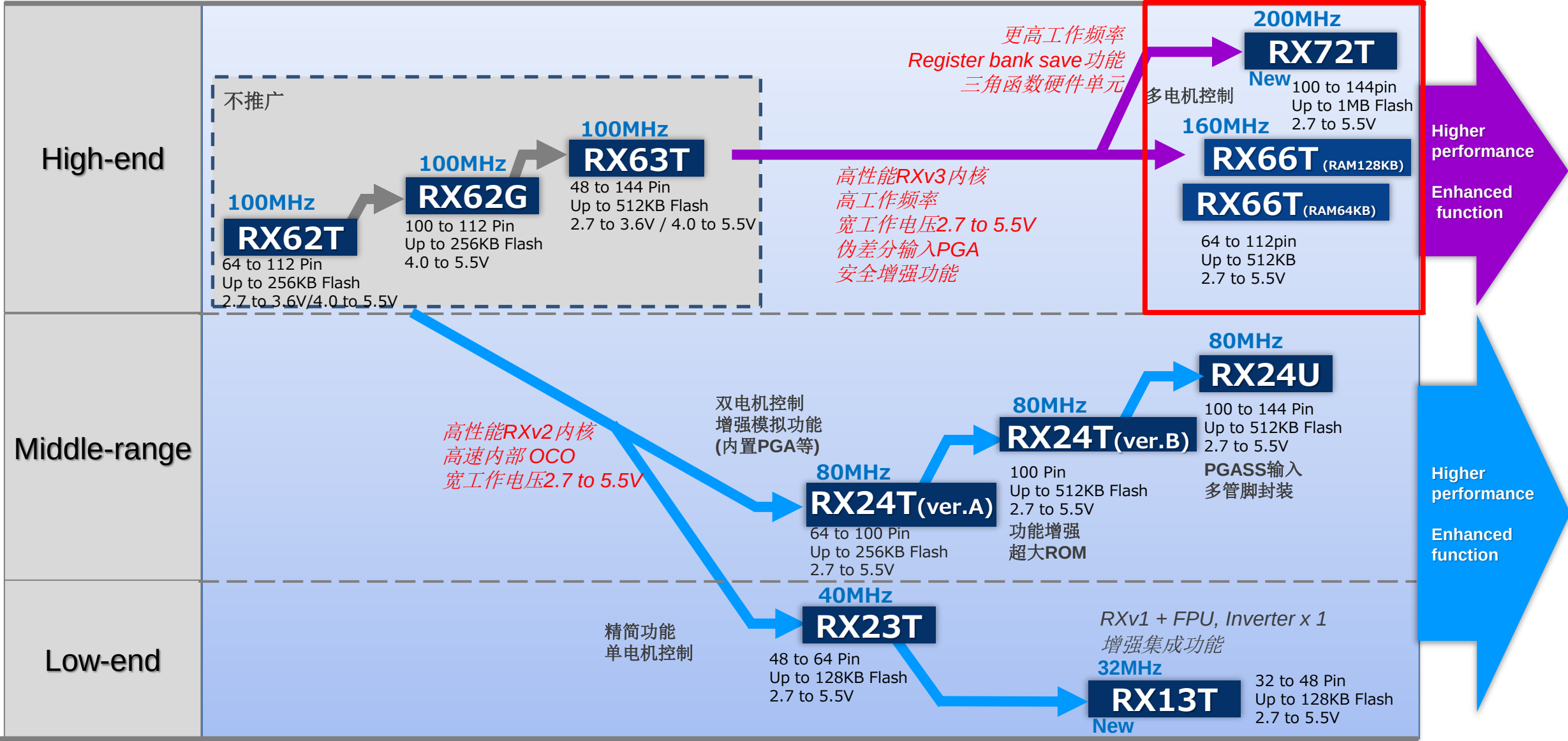
*1: 浮点运算单元
*2: 可编程增益放大器
*3: 伪差分可编程增益放大器
*4: 三角函数运算单元



RX高性能电机控制MCU

RX66T/RX72T

RX66T/72T在RX电机控制MCU中的定位



RX66T特征一览

实现高精度和高效的电机控制



性能

- 928Coremark : 在支持5V电压的MCU中处于领先水平
- 比以往产品高出2.5倍的高性能

* Value is measured by field oriented control program of Renesas.

变频控制外设

- 160MHz PWM (Max: 3相互补4通道或者五相互补两通道或者单相互补10通道)
- 支持最小195皮秒调节的高分辨率PWM

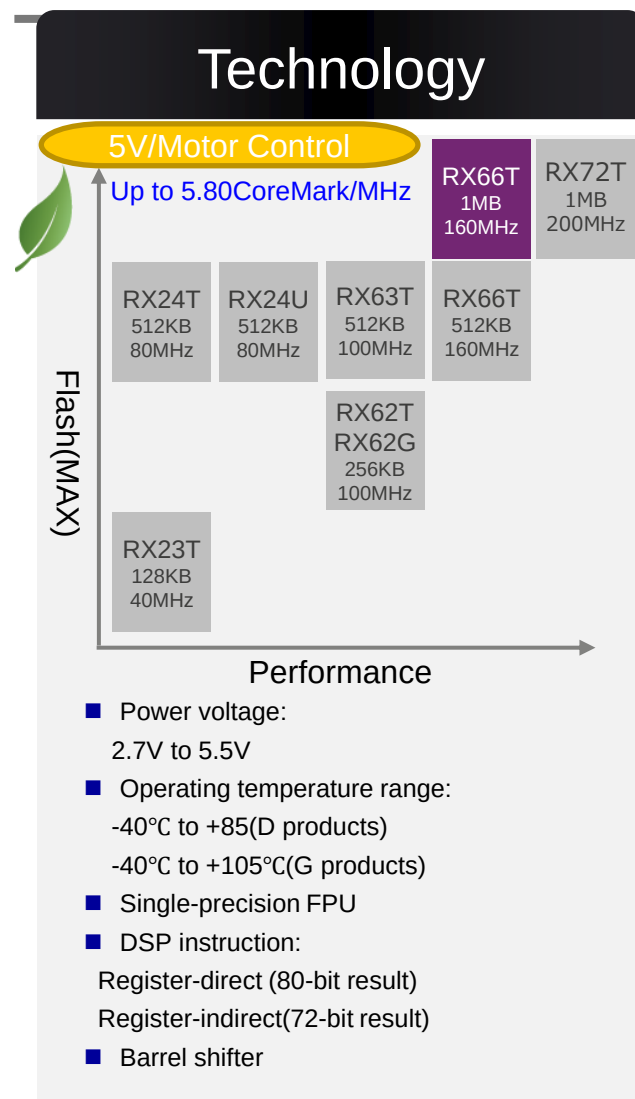
功能安全

- 电机系统安全硬件保护单元
- 专门的硬件加密模块, 极大程度地提高了系统安全性

电机解决方案

- 多种电机相关的应用例程和开发辅助工具, 方便用户更快更好进行电机控制开发
- 支持实时调试的辅助工具Renesas Motor Workbench 2.0

RX66T功能框图



This table shows the maximum specification. The details depends on the part no.
*1 : Back Ground Operation, *2 : High-resolution PWM : 4ch

RXv3 Core 160MHz

RX66T (RAM 128KB)

Memory - Code flash (1MB) - SRAM 128KB - Data flash (32KB) *1 - SRAM with ECC 16KB	Analog 12bit A/D converter 3unit(8ch, 8ch, 14ch) 3 ch simultaneous S&H for 2unit only Pseudo-Differential programmable gain amp (6ch) 12bit D/A converter 2ch - Temperature sensor - Comparator x 6ch	System, Power Management - DMAC x 8ch, DTC - Interrupt controller 16 level 16pin + NMI - On-chip oscillators - Power-on reset (POR) - Voltage detection circuit(LVD) - Event link controller	Security & Encryption - Trusted Secure IP Lite (AES/TRNG) Key management, Access management - Code protect(flash access limited) - Trusted Memory(flash access limited) - Unique ID
Connectivity - USB2.0 Full Speed Host/Function 1ch - CAN x 1ch - SCI x 7ch (with FIFO 1ch) - I2C x 1ch - RSPI x 1ch 8/16bit external bus	Timers - Multifunction timer pulse unit (MTU3d) 16bit x 9ch - General-purpose PWM timers 32bit x 10ch *2 8bit timers 4unit(2ch x 4ch) - Compare match timer 16bit x 4ch	Safety Functions - Memory protection unit - Register write protection unit - Clock frequency accuracy measurement circuit - Oscillation-stop detection - CRC32 calculator - Data operation circuit(RAM test assist) - A/D self-diagnostics(fault detection) - A/D disconnection detection 14-bit watchdog timer 14-bit independent watchdog timer - Port Output Enable	Human-Machine Interface(HMI)
			Package LFQFP 100/144

RX72T特征一览

实现高精度和高效的电机控制



性能

- 1160Coremark : 在支持5V电压的MCU中处于领先水平
- 三角函数数学运算单元, 优化坐标变换/位置控制/相位控制

电机控制外设

- 200MHz PWM (max : 3相互补4通道或者五相互补两通道或者单相互补10通道)
- Register save bank提升中断响应速度

功能安全

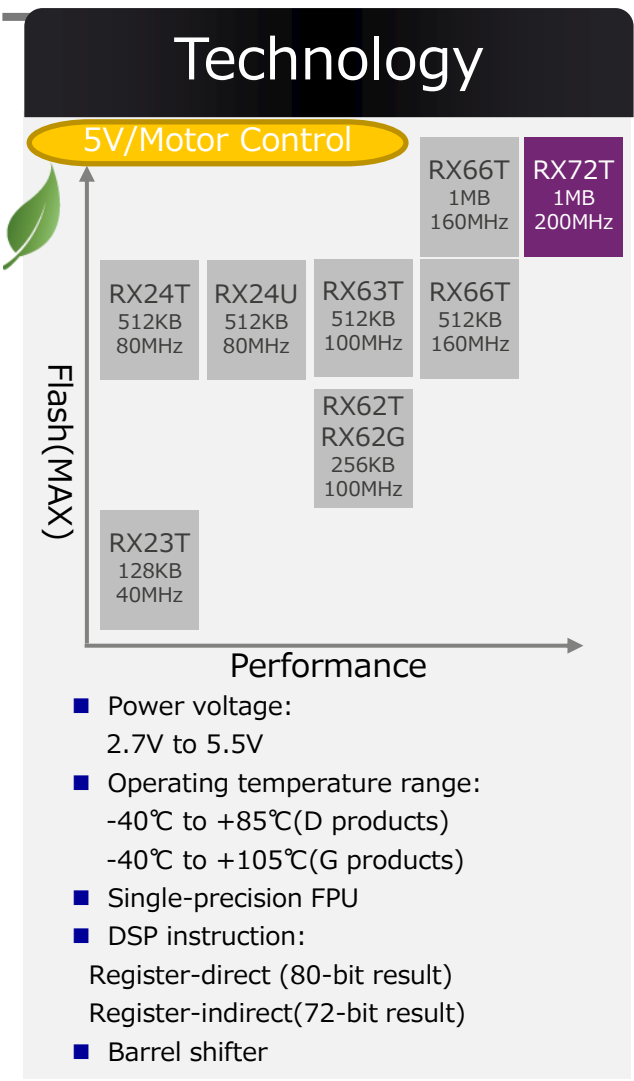
- 电机系统安全硬件保护单元
- 专门的硬件加密模块, 极大程度地提高了系统安全性

电机控制方案

- 多种电机相关的应用例程和开发辅助工具, 方便用户更快更好进行电机控制开发
- 支持实时调试的辅助工具Renesas Motor Workbench 2.0

This table shows the maximum specification. The details depends on the part no.
*1 : Back Ground Operation, *2 : High-resolution PWM : 4ch (When this is used over 160MHz, there is a restriction.)

RX72T功能框图



RXv3 Core 200MHz w/ register bank save function

RX72T

Trigonometric function

Memory

- Code flash (1MB)
- SRAM 128KB
- Data flash (32KB) *1
- SRAM with ECC 16KB

Analog

- 12bit A/D converter
3unit(8ch,8ch, 14ch)
3 ch simultaneous S&H for 2unit only
Pseudo-Differential programmable gain amp (6ch)
- 12bit D/A converter 2ch
- Temperature sensor
- Comparator x 6ch

System, Power Management

- DMAC x 8ch , DTC
- Interrupt controller
16 level 16pin + NMI
- On-chip oscillators
- Power-on reset (POR)
- Voltage detection circuit(LVD)
- Event link controller

Security & Encryption

- Trusted Secure IP Lite (AES/TRNG)
Key management, Access management
- Code protect(flash access limited)
- Trusted Memory(flash access limited)
- Unique ID

Connectivity

- USB2.0
Full Speed Host/Function 1ch
- CAN x 1ch
- SCI x 7ch (with FIFO 1ch)
- I2C x 1ch
- RSPI x 1ch
- 8/16bit external bus

Timers

- Multifunction timer pulse unit (MTU3d)
16bit x 9ch
- General-purpose PWM timers
32bit x 10ch *2
- 8bit timers 4unit(2ch x 4ch)
- Compare match timer
16bit x 4ch

Safety Functions

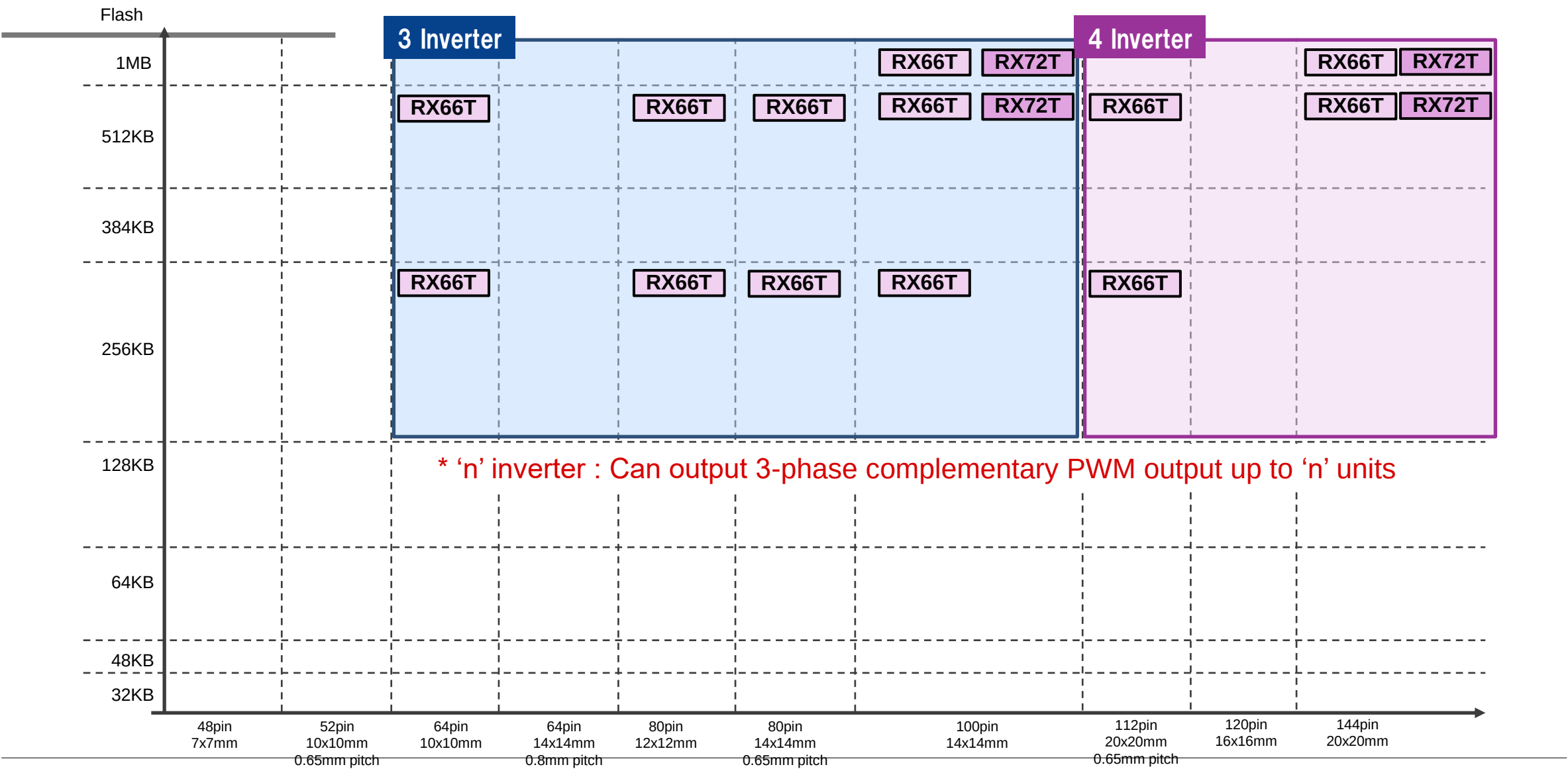
- Memory protection unit
- Register write protection unit
- Clock frequency accuracy measurement circuit
- Oscillation-stop detection
- CRC32 calculator
- Data operation circuit(RAM test assist)
- A/D self-diagnostics(fault detection)
- A/D disconnection detection
- 14-bit watchdog timer
- 14-bit independent watchdog timer
- Port Output Enable

Human-Machine Interface(HMI)

Package

LFQFP 100/144

产品路线图



RX66T/RX72T主要特征

- CPU/Accelerator性能
- RX66T/RX72T 系统构造示例
- 定时器功能单元
- 模拟功能单元
- 功能安全

RX CPU内核一览

RXv3 CPU Core Delivers Industry-Leading Performance at 5.8 CoreMark®/MHz

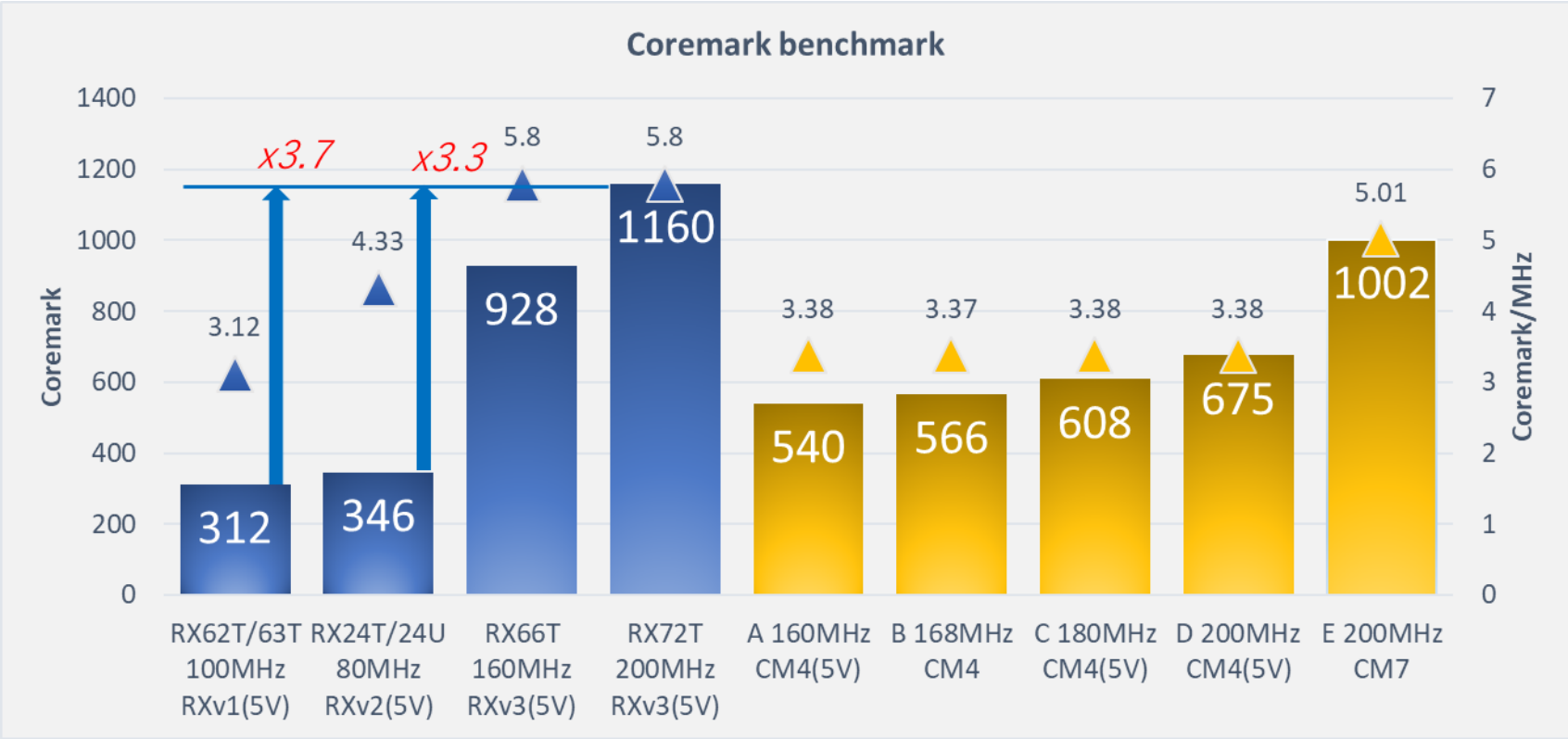
32-bit RX MCUs address real-time performance and enhanced stability required by motor control and industrial applications

Red font : Enhancements of RXv2 core Blue fonts : Enhancements of RXv3 core

Item	RXv1	RXv2	RXv3
Architecture	32bit CISC, Harvard architecture		
General-purpose registers	32bit x 16ch		
Compatibility	RXv1	Downward compatible with RXv1	Downward compatible with RXv1/RXv2
Instruction set	90 instruction	109 instructions (RXv1 instruction + 19 instructions)	113 instructions (RXv2 instruction + 4 instructions) *2 of instructions for register save bank function
Pipeline	5-stage	5-stage Improved IPC through enhanced pipeline (enhanced performance through parallel execution of memory access and operations)	5-stage Improved IPC through enhanced pipeline (enhanced performance through improved combination of simultaneously executable instructions)
DSP function instruction	Accumulator × 1	single-cycle MAC instructions added (32-bit × 32-bit + 72-bit), accumulator added for a total of 2	
FPU (single-precision)	Support for IEEE 754 conformant data types and exceptions, pipeline processing		
Performance	Up to 3.12CoreMark/MHz	Up to 4.55CoreMark/MHz	Up to 5.8CoreMark/MHz
Other	-	-	Register bank save function(optional) Double-precision floating-point operation instruction(optional) *Availability depends on the product specifications

超越其他32位MCU性能的RX66T/RX72T

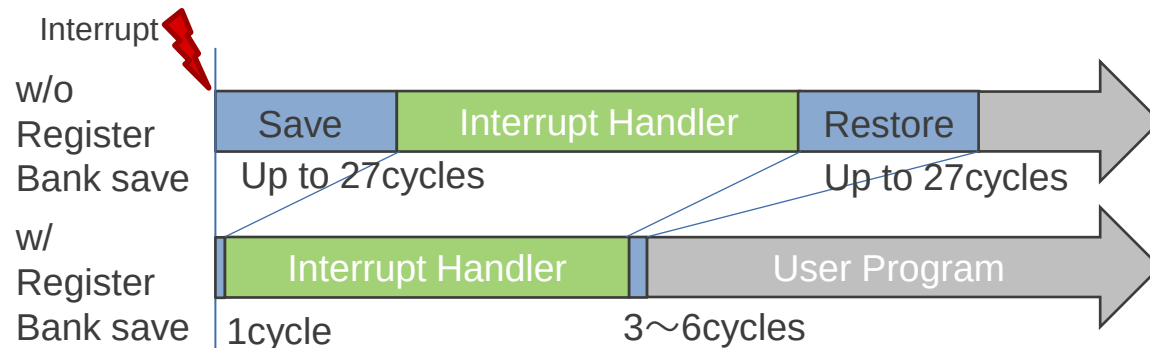
- RX66T性能高达928CoreMark，RX72T更是高达1160CoreMark的业界领先性能
- 业界领先的MCU配合5V工作电压，特别适合高性能的电机控制系统



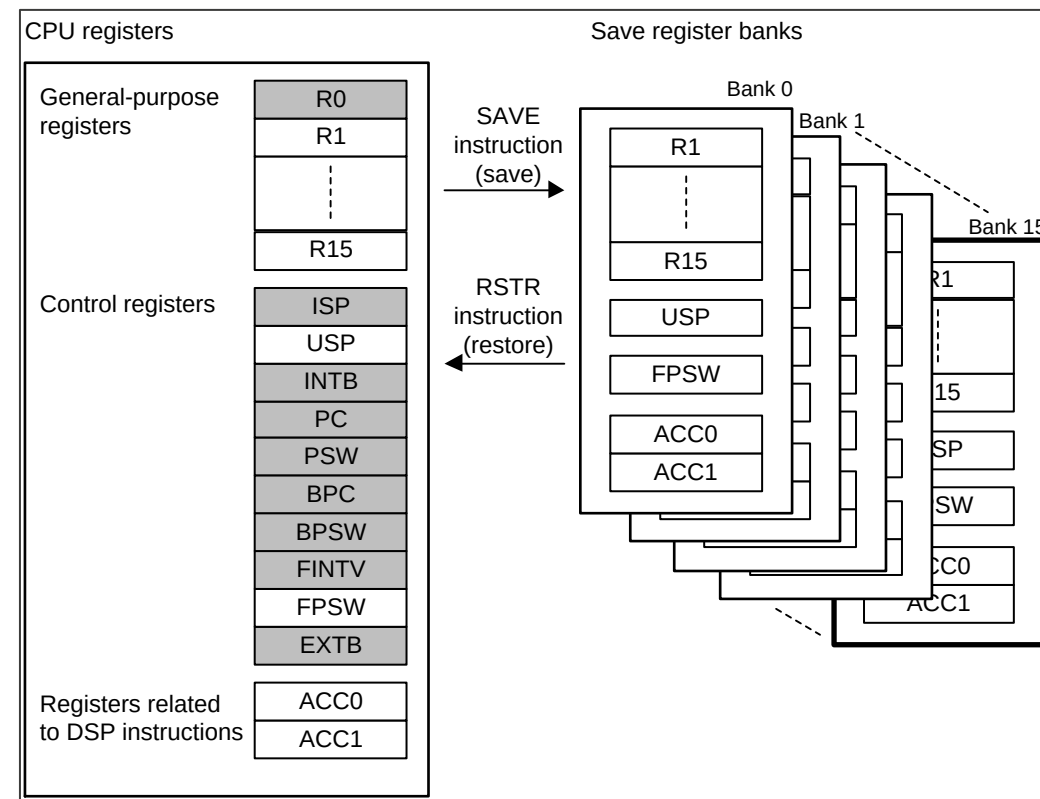
REGISTER BANK SAVE功能 [RX72T]

提升对紧急事件的响应速度

- 通过加速对寄存器存取，提升响应速度
- 专有的Save Register bank
- 只有SAVE 和 RSTR 指令可以访问Save Register bank
- Save Register bank的数量：16 in RX72T
- 减少响应时间，高效处理程序
 - save : 1 cycle, restore : 3 – 6 cycle



Comparison with conventional product (saving data to all register)

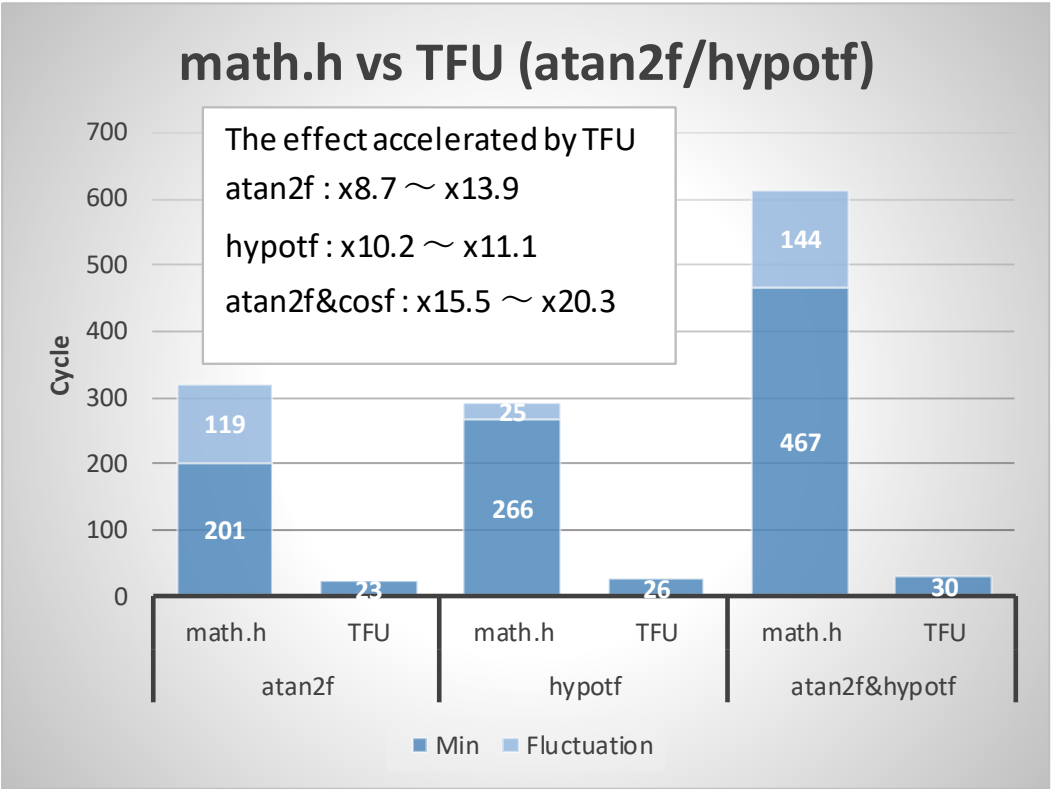
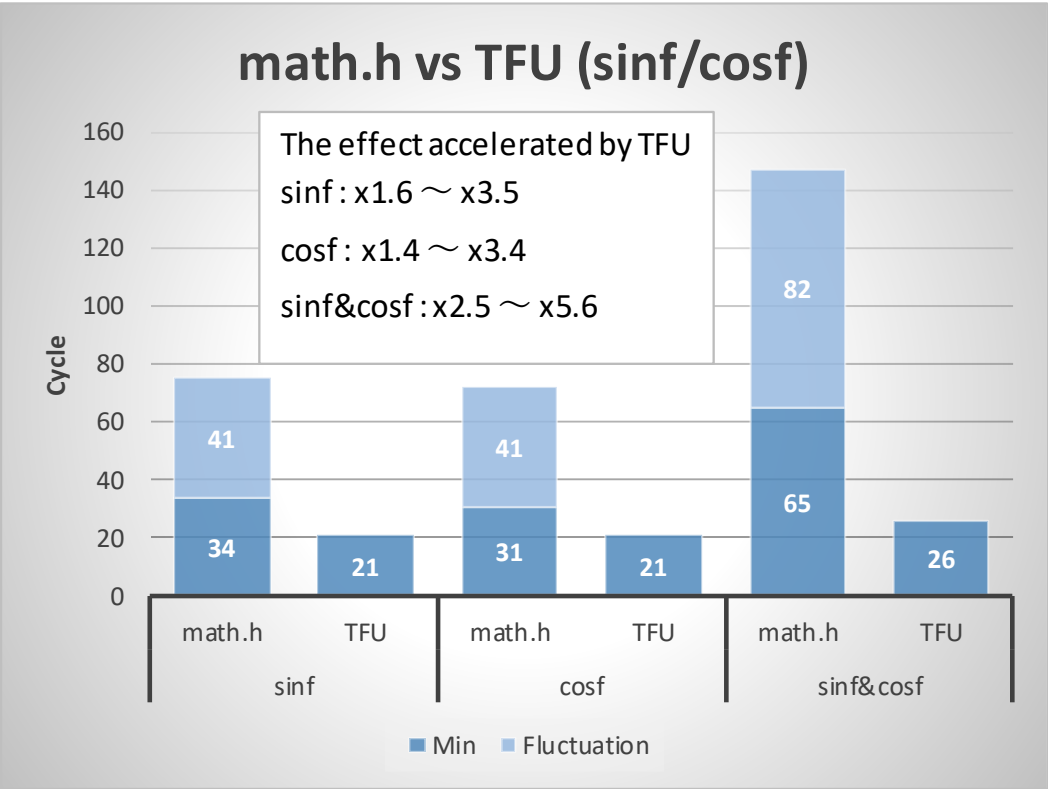


Save Register bank's target CPU registers
General-purpose registers(R1-R15), USP, FPSW,
Accumulator(ACC0、ACC1)

三角函数数学运算单元 (TFU) [RX72T]

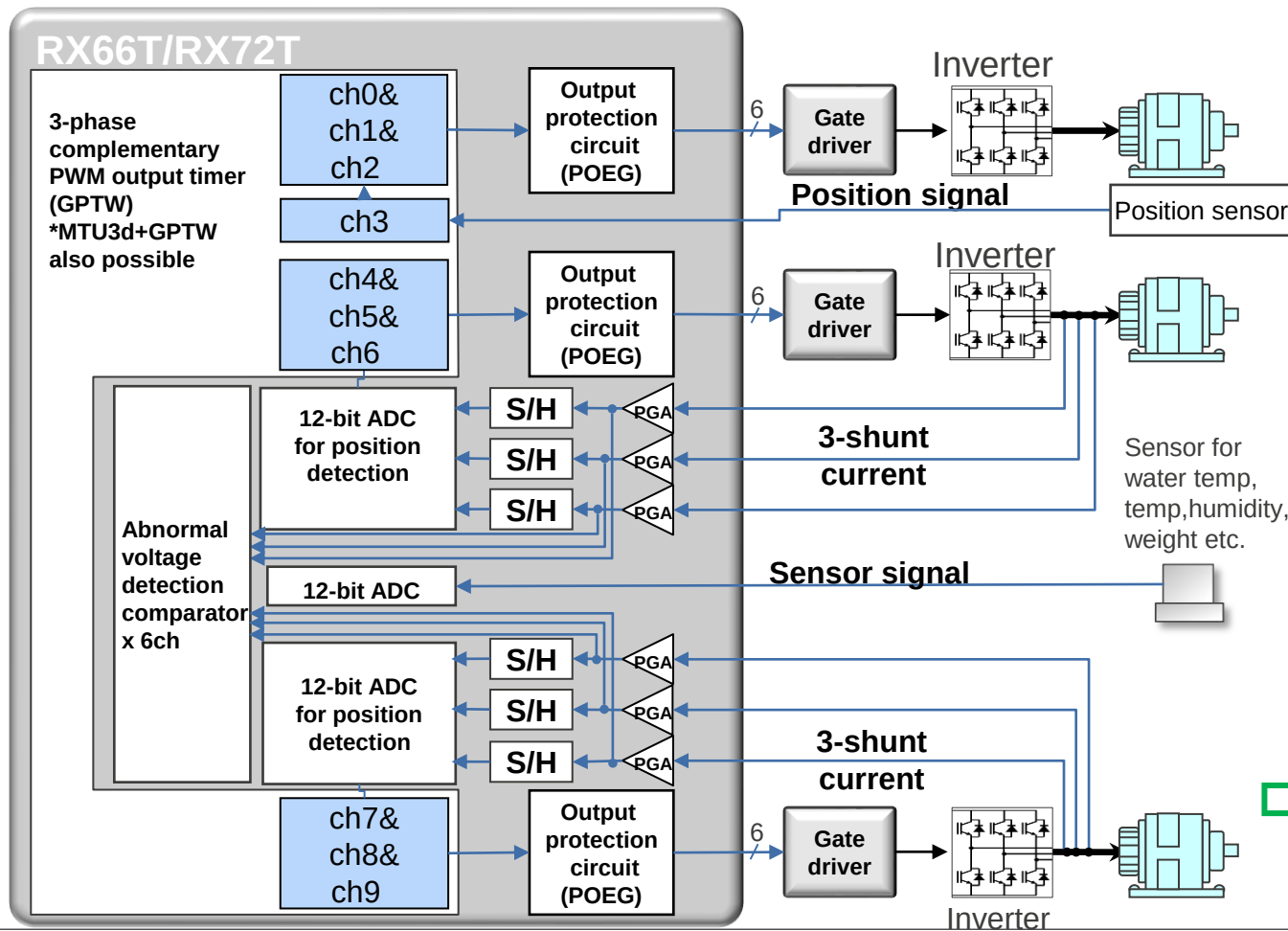
提供快速/固定周期的操作: $\sin f \& \cos f$ $\times 2.5 \sim \times 5.6$, $\text{atan}2f$ $\times 8.7 \sim \times 13.9$

- This result is reference value measured by CC-RX V3.01 and this is no an exhaustive input value.



RX66T/RX72T 应用示例

- 单芯片实现 3-phase inverter x 3 或 x4 !



1. 单芯片实现3-phase inverter x 3 或 x4 !

GPTW timer 提供多功能的3-phase互补PWM输出(3个电机驱动)

*MTU3d 也可以驱动2 个电机

*MTU3d+GPTW 可以驱动多达4 个电机(only 112/144pin)

2. 同步处理 3-shunt x 2 电流检测 !

- 通过 PGA & S/H x 6可实现同步处理3-shunt × 2. PGA (差分输入方式) 可减少外部噪声干扰
- 3个独立的ADC单元

3. 减少外部元器件!

内置 reset 电路, E2PROM, op-amp, comparator

4. 功能优化, 实现安心的电机控制 !

- Comparator x 6ch可检测异常情况
- 输出保护电路 (POEG)可强制关断PWM输出

5. 增强的安全性!

集成功能, 支持IEC60730 安全标准Class B (Fail-Safe)
实现系统自动防故障, 减少软件负担

目标应用:

高端变频空调, 洗衣机, 通用变频器, 机器人等等

PGA: Programmable gain amp, S/H: sample & hold circuit

* The left figure only shows an image, not the actual layout.

MTU/GPT定时器功能一览

✓ 通过两个定时器单元 (MTU3, GPT) 支持多种控制方式 , 减少软件负担

Function	Item	MTU3	GPTW
Basic function	The number of channels	9ch	10ch (32bit)
	①Complementary PWM output operation (channels)	✓ 3-phase 2ch	✓ Single-phase 10ch (3-phase 3ch+single-phase 1ch)
	②Max. operating frequency	The same as CPU frequency	The same as CPU frequency
	③Channel synchronization operation	✓	✓
Common function	④PWM Mode Output Protection Function (POE)	✓	✓
	⑤Left-right asymmetric triangular wave PWM	✓	✓
	⑥Simultaneous transfer buffer register	✓	✓
	⑦A/D trigger dedicated compare match : 2 parts	✓	✓
	⑧ADC conversion skipping function	✓	✓
	⑨Interrupt skipping function	✓	✓
Other unique function	⑩120 degree waveform auto-generation from hall sensor input	✓(AC synchronous motor drive mode)	—
	⑪Rotary encoder input count	✓(Phase counting mode)	✓(Phase counting mode)
GPT unique function	⑬Sawtooth wave complementary PWM w/deadtime	—	✓
	⑫Left-right deadtime control	—	✓
	⑬Phase shift start between channels	—	✓
	⑭Inverter control by external trigger	—	✓
	⑮Negate control for PWM	—	✓
	⑯High resolution PWM output (PWM output delay function)	—	✓
	⑰GPTW-dedicated PWM output protection function for safe motor driving	—	✓

丰富的模拟功能 (ADC, Comparator, PGA)

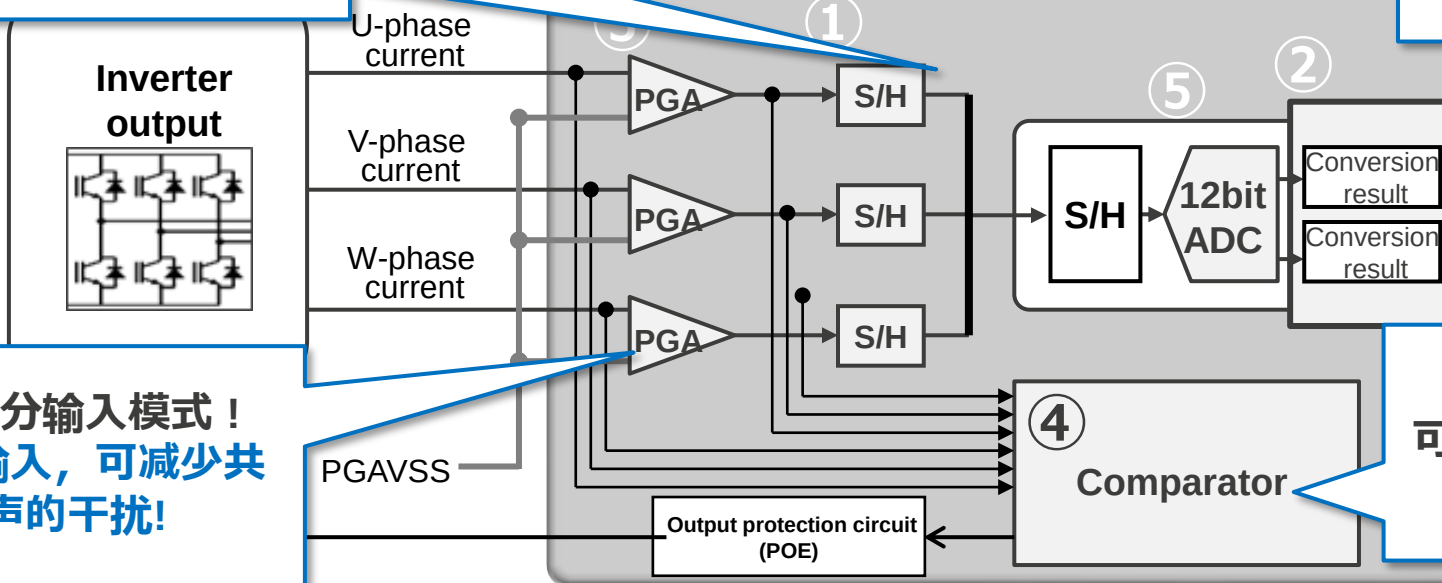
✓ 增强的模拟功能单元，易于使用！

同步连续采样功能！
3通道同步采样保持电路，减少
ADC转换时间！

PGA伪差分输入模式！
支持负端输入，可减少共
模噪声的干扰！

3个12位ADC单元，
支持三路采样保持功能
非常适合多电机的控制！

12位DAC支持参考电压！
可选择4个模拟输入信号或4个参考输
入信号！



PGA : programmable gain amp S/H : sample&hold

安全功能



✓ RX66T RX72T提供了工业级的高安全性功能

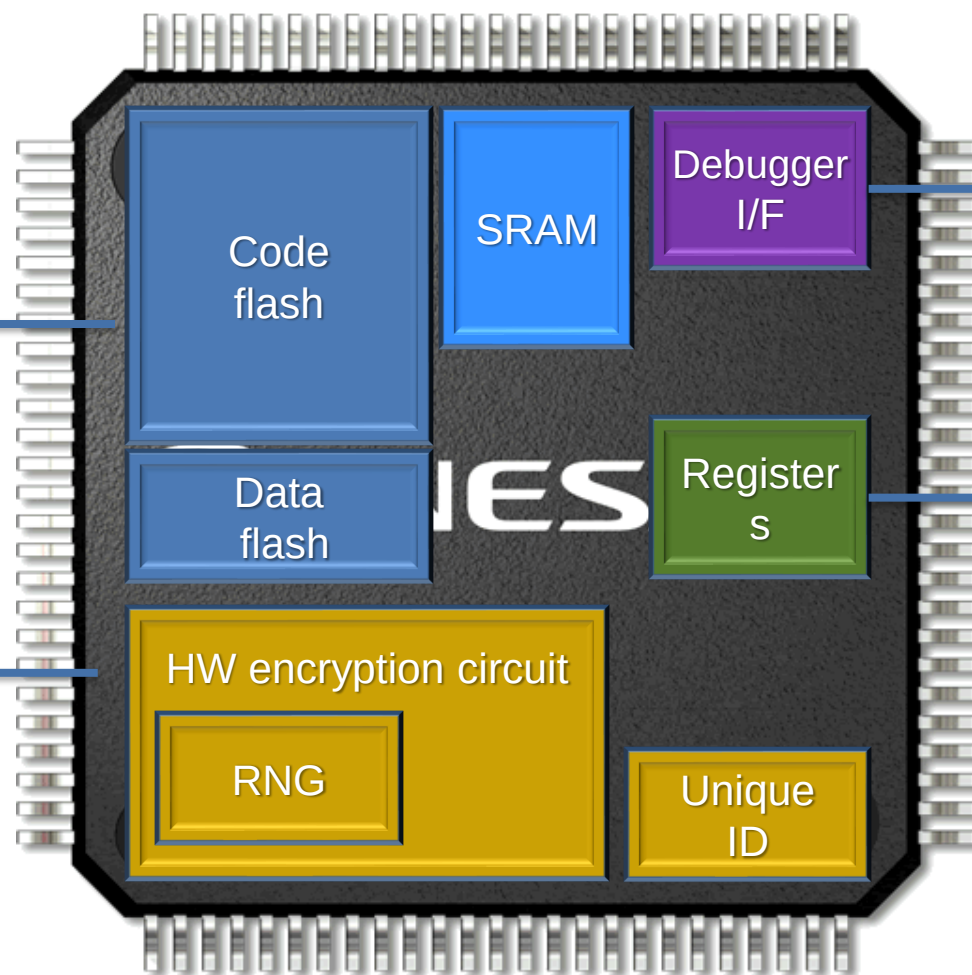
■ 闪存保护

- Trusted Memory



■ 加密功能

- 硬件加密电路
 - TSIP-Lite (AES, RNG)
- 其他
 - Chip Unique ID

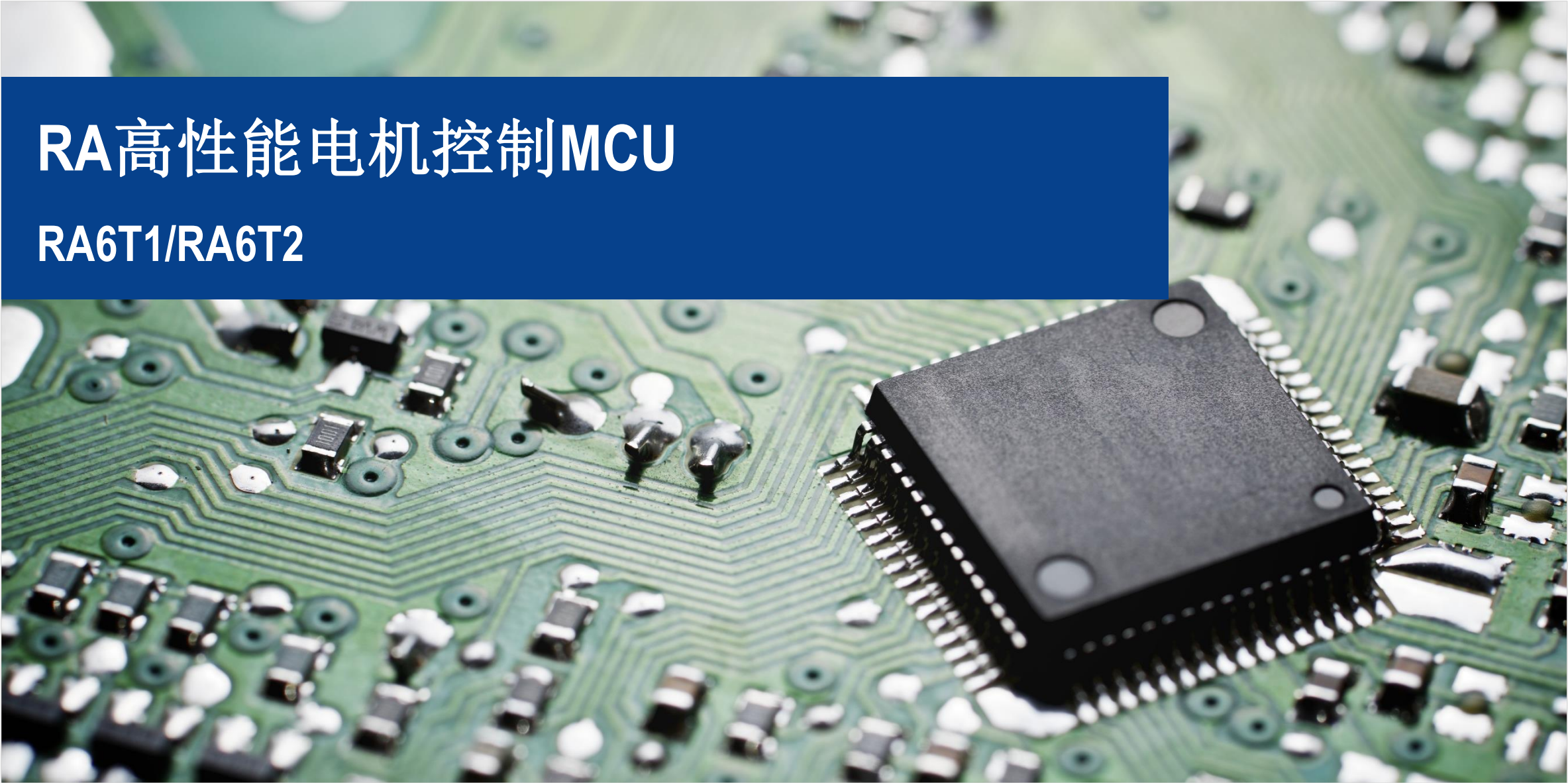


■ 防止外部非法访问

- ID code保护
- On-chip调试器保护
- ROM code保护

■ 访问保护

- Register写入保护
- Memory保护单元

A close-up photograph of a green printed circuit board (PCB) populated with various electronic components. A large, black, square microcontroller unit (MCU) is the central focus, mounted on the right side of the frame. It has numerous gold-colored pins visible along its edges. The PCB is covered with intricate green circuit traces, several small black surface-mount components, and numerous silver solder points. The background is slightly blurred, emphasizing the MCU and the immediate circuitry.

RA高性能电机控制MCU

RA6T1/RA6T2

RA-T电机控制MCU概述

RA-T系列保持CPU和外围设备的可扩展性，以便电机控制解决方案的拓展。

RA-T系列具有独特的电机控制硬件单元，支持工具和解决方案。

Group	Frequency	CPU	Flash ROM	Data Flash	SRAM	Basic Peripherals	Motor Control Timer	Motor Control Analog				Motor Control H/W Accelerator	
RA6T2	240MHz	CM33 (FPU)	512kB	8kB	64kB	Communi- cation I/F (Serial, SPI, I2C) etc	GPT32	12bit ADCx2	3 S/H x2	4x PGA	4x Comp	Trigonom- etric Unit	Bi-Quad Filter
RA6T3	200MHz	CM33 (FPU)	256kB	4kB	40kB		GPT16E	12bit ADCx1	3x S/H	3x PGA	3x Comp		
RA6T1	120MHz	CM4 (FPU)	512kB	8kB	64kB		GPT32	12bit ADCx2	3 S/H x 2	6x PGA	6x Comp		
RA4T1	100MHz	CM33 (FPU)	256kB	4kB	40kB		GPT16E	12bit ADCx1	3x S/H	3x PGA	3x Comp	Trigonom- etric Unit	

RA6T1 / RA6T2在RA电机MCU中的定位

FLASH / RAM Size	512kB / 64kB			2 Inverter				
				RA6T2	RA6T2	RA6T2	RA6T2 RA6T1	RA6T2 RA6T1
	256kB / 64kB			RA6T2	RA6T2	RA6T2	RA6T2 RA6T1	RA6T2 RA6T1
		1 Inverter						
	256kB / 40kB	RA6T3 RA4T1	RA6T3 RA4T1	RA6T3 RA4T1	RA6T3 RA4T1		RA6T3 RA4T1	
	128kB / 40kB	RA4T1	RA4T1	RA4T1	RA4T1		RA4T1	
Pin Count		32pin	32pin	48pin	48pin	64pin	64pin	100pin
Package		QFN	LQFP	QFN	LQFP	QFN	LQFP	LQFP
Size in mm		5x5	7x7	7x7	7x7	8x8	10x10	14x14
Pitch in mm		0.5	0.8	0.5	0.5	0.4	0.5	0.5

RA-T 系列主要特点

●为电机和电源应用而优化的规格和产品系列

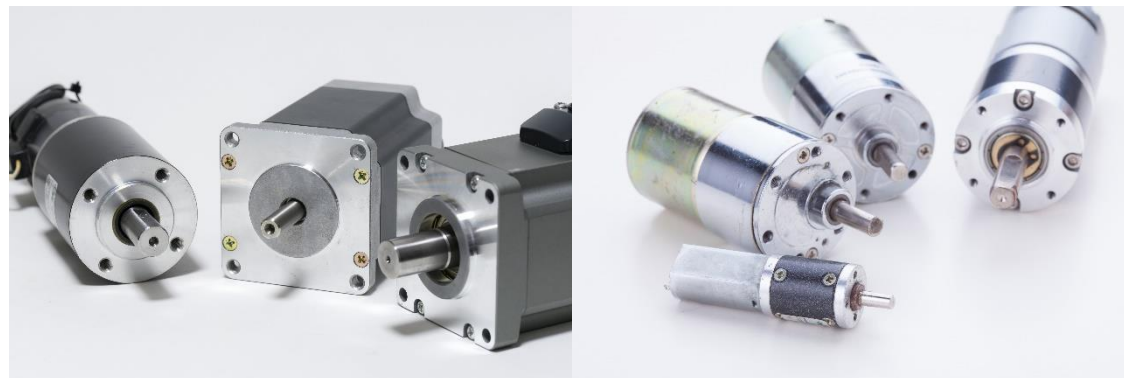
- 最佳结构 (ARM Cortex-M内核, PWM 定时器, A/D 转换器, 比较器)
- 丰富的通信功能, 利于系统控制拓展
- 有助于实时应用的高速内存
- 外围功能保持兼容性

●电机控制加速器单元 (RA6T2, RA6T3, RA4T1)

- 加速电流矢量控制、滤波操作
- 减少CPU负载以实现更多附加功能

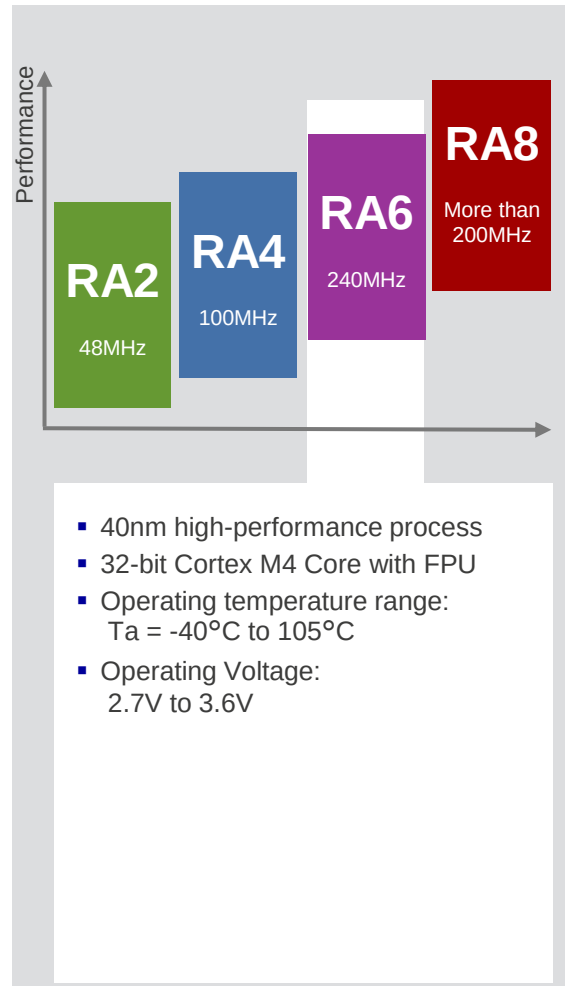
●开发环境

- 电机解决方案, 加速上市时间
- Motor Workbench, 仿真环境
- Model base development support



RA6T1 GROUP

ARM CORTEX M4 - 512KB FLASH WITH 64KB RAM



RA6T1
120MHz 32-Bit Arm® Cortex®-M4 Core

NVIC | JTAG | SWD | ETM

Memory - Code Flash (256kB, 512kB) - SRAMHS (64kB) Parity - Data Flash (8kB)	Analogue 12-bit A/D (11ch) 3S/H 12-bit A/D (8ch) 3S/H 12-bit DAC (2ch) 3ch PGA for each ADC - High Speed Comparator (6ch) - Temperature Sensor	Timers - GPT HighRes 32-bit (4ch) - GPT Enh. 32-bit (4ch) - GPT 32-bit (5ch) - Low Power GPT (2ch) - WDT	
Communication - CAN x1 - I2C x2 - SCI x7 - SPI x2	System - DMA (8ch) - DTC - Clock Generation - On-Chip Oscillator HOCO (16,18,20MHz), MOCO (8MHz), LOCO (32kHz), ILOCO (15kHz) - Low Power Modes - ELC - Interrupt Controller	Safety - Memory Protection Unit - SRAM Parity Check - POE - Clock Frequency Accuracy Measurement - CRC Calculator - IWDT - Data Operation Circuit - Flash Area Protection - ADC Self Test	Security - AES (128/192/256) - TRNG - GHASH - SHA1/SHA224/SHA256 - ECC/RSA/DSA 3DES/ARC4
			Package LQFP 64, 100

RA6T1 产品型号分布

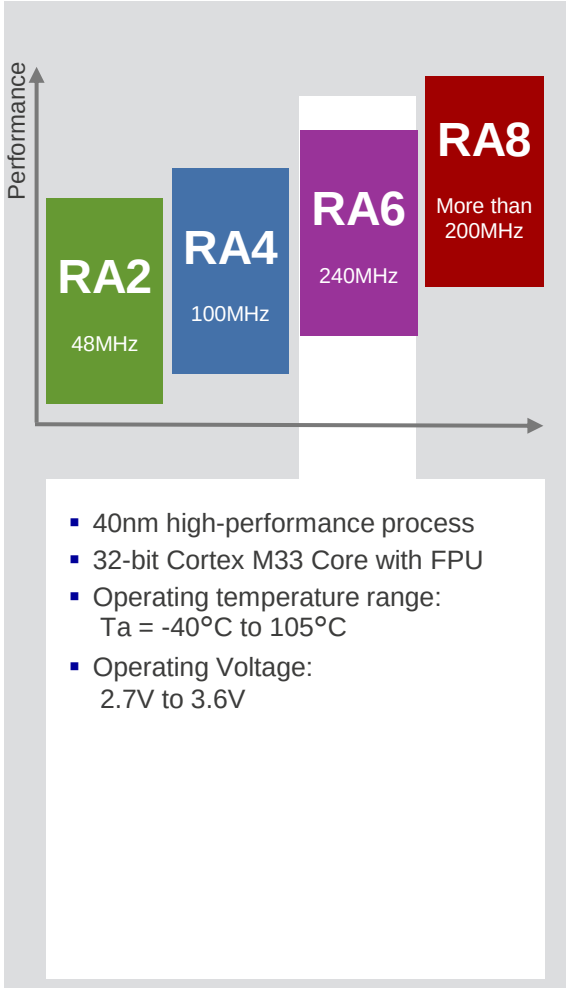
FLASH / RAM	512kB / 64kB	RA6T1	RA6T1
	256kB / 64kB	RA6T1	RA6T1
Pin Count Package		64pin LQFP	100pin LQFP

Part name	Flash	RAM	DataFlash	Operating Temperature	Package	Package dimensions	Pin Pitch
R7FA6T1AD3CFP	512kB	64kB	8kB	-40 to +105 degree	LQFP 100pin	14x14mm body; (16x16mm)	0.5mm
R7FA6T1AD3CFM					LQFP 64pin	10x10mm body; (12x12mm)	
R7FA6T1AB3CFP	256kB				LQFP 100pin	14x14mm body; (16x16mm)	
R7FA6T1AB3CFM					LQFP 64pin	10x10mm body; (12x12mm)	

(included lead)

RA6T2 GROUP

ARM CORTEX M33 - 512KB FLASH WITH 64KB RAM



RA6T2 240MHz 32-Bit Arm® Cortex®-M33 Core

NVIC | JTAG | SWD | ETM

Memory

- Code Flash (512KB)
- SRAM (64KB)
- Data Flash (16KB)

Analogue

- 12-bit ADC (total 29ch, 2unit, w/ 3ch S/H x2)
- 12-bit DAC (4ch)
- Comparator (4ch)
- PGA (4ch)

Timers

- GPT 10ch
- LPGPT 2ch
- WDT

Motor Accelerator

- Trigonometric Unit
- Bi-Quad Filter

Communication

- CAN FD x1
- I2C x2
- SCI x6
- SPI x2

System

- DMA
- DTC
- Clock Generation
- On Chip Oscillator
- Interrupt Controller
- ELC

Safety

- Memory Protection Unit
- ECC in SRAM
- POE
- Clock Frequency
- Accuracy Measurement
- CRC Calculator
- IWDT
- ADC Self test

Security

- AES 128/256
- TRNG
- Unique ID

Package

- LQFP 48, 64, 100
- QFN 48, 64
- LGA 100 (planning)

RA6T2 产品型号分布

RA6T2 Cortex-M33 240MHz

Memory size 2 types

Flash 512KB RAM 64KB
Flash 256KB RAM 64KB

Functional option 2 types

RA6T2	w/ CAN-FD
RA6T2	w/o CAN-FD

Note : CAN2.0B is supported in each option

Total 20 types line-up

FLASH / RAM	512KB / 64KB	RA6T2	RA6T2	RA6T2	RA6T2	RA6T2	RA6T2	RA6T2	RA6T2	RA6T2	RA6T2
	256KB / 64KB	RA6T2	RA6T2	RA6T2	RA6T2	RA6T2	RA6T2	RA6T2	RA6T2	RA6T2	RA6T2
Pin Count		48pin			64pin			100pin			
Package type		QFN		LQFP		QFN		LQFP		LQFP	

Specifications of products under development are subject to change without notice.

RA6T2 新的硬件特性

■ RA6T2 为下一代电机控制所加入的特性

RA6T2准备了高性能和电机控制独特的硬件单元。客户可以利用节省下的CPU功耗实现额外的优势功能。

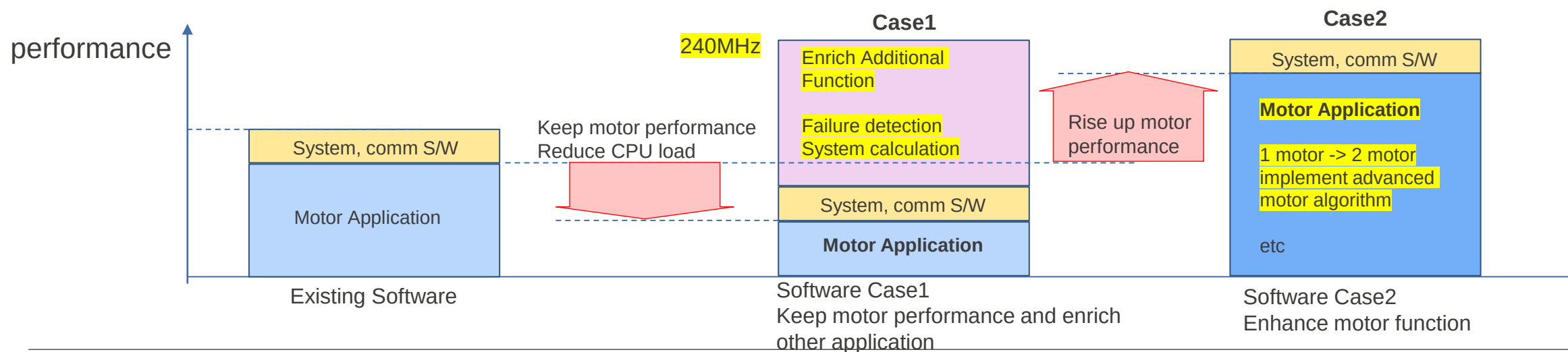
● 加速器

• **Trigonometric Function Unit 三角函数单元**

TFU单元支持快速/精确/低波动的数学运算，相比于传统的查表方式，可降低20%左右的运算时间以及占用更小的ROM空间

• **Bi-Quad Filter 双二阶滤波器 (IIR 滤波器)**

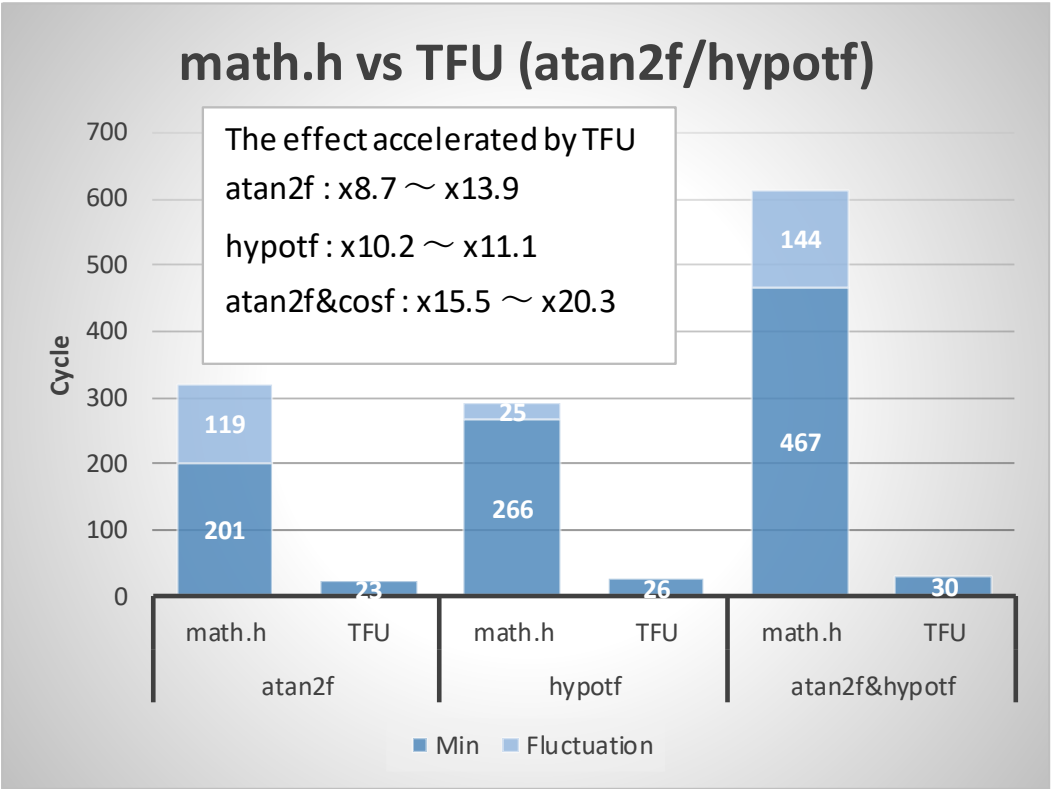
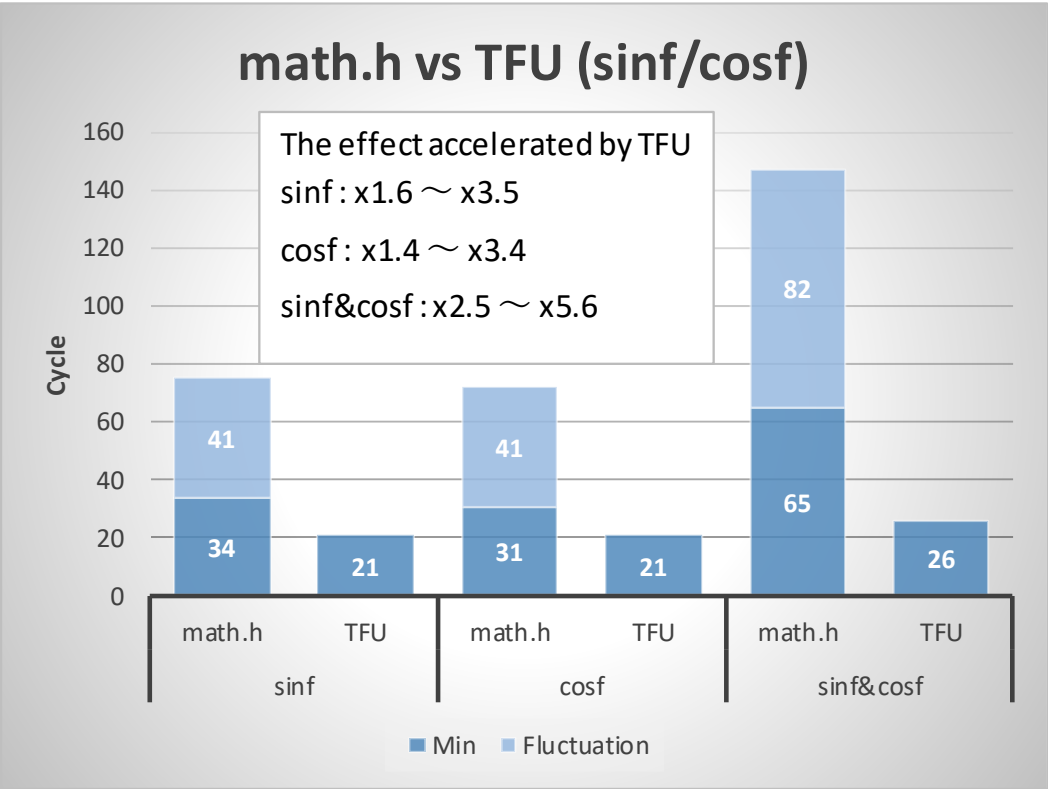
双二阶滤波器在速度环和电流环控制中可以起到重要的辅助作用，减少40%*左右的处理时间
(* :取决于每个客户的算法和计算方法)



TFU三角函数运算单元

提供快速 / 固定周期的操作: $\sin f \& \cos f \times 2.5 \sim \times 5.6$, $\operatorname{atan} 2 f \times 8.7 \sim \times 13.9$

- This result is reference value measured by CC-RX V3.01 and this is no an exhaustive input value.



BI-QUAD FILTER 双二阶滤波器 (IIR FILTER)

IIR Bi-Quad signal flow

$$y(n) = a_0x(n) + a_1x(n-1) + a_2x(n-2) + b_1y(n-1) + b_2y(n-2)....$$

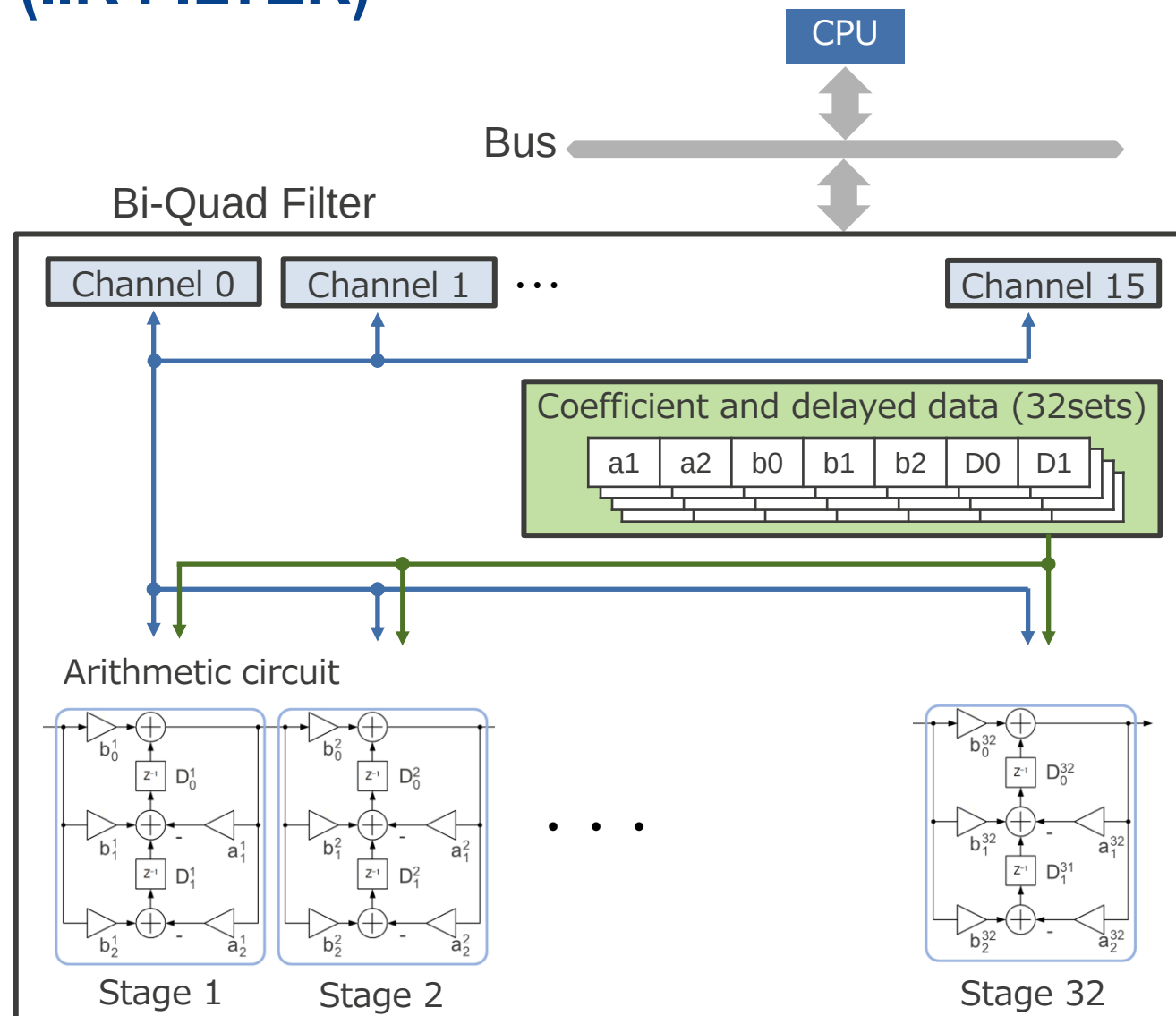
■ Features

- 通过专门的本地寄存器区域来设置延迟数据和系数，可以为16个通道的每个通道实现32级数据滤波
- 不需要在数学运算电路中单次设定

实现数据传输时间的减少并大幅加快计算速度

CPU:13 cycles -> Bi-Quad:5 cycles

(Number of cycles per stage. Compare execution cycles@200MHz)



RA-T的主要特性

RA-T电机控制一览

高性能 (Arm Cortex + FPU)

高速矢量计算

- 高速CPU处理
- 通过FPU支持高速浮点运算

多种外设配合，实现安全而精确的电机控制

定时器功能：通用PWM定时器（GPT）

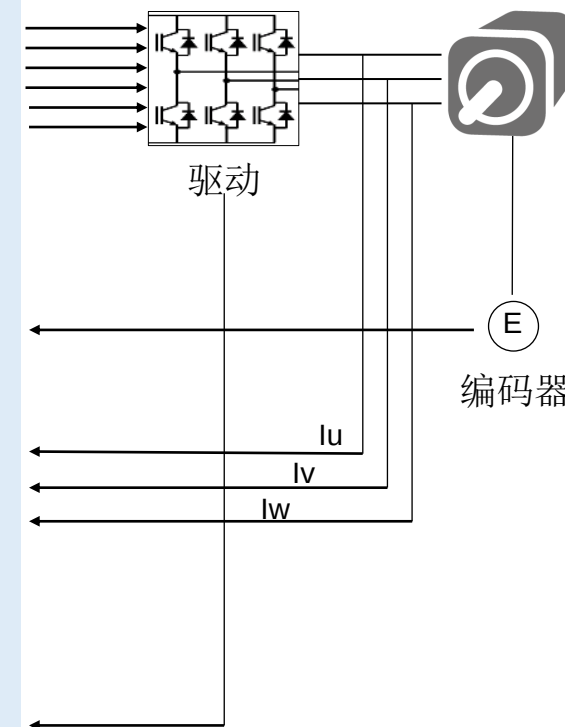
- A) 支持多种PWM输出模式
- B) 三相互补PWM输出的同步控制
- C) 输出 0%、100% 占空比功能
- D) 比较器寄存器支持双缓存功能
- E) 高精度PWM输出
- F) 相位计数功能

模拟功能：反馈控制

- G) 高速12位AD转换器（2个单元）
- H) 采样保持功能
- I) 可编程增益放大器
- J) 模拟比较器

安全功能：GPT端口输出使能（POEG）

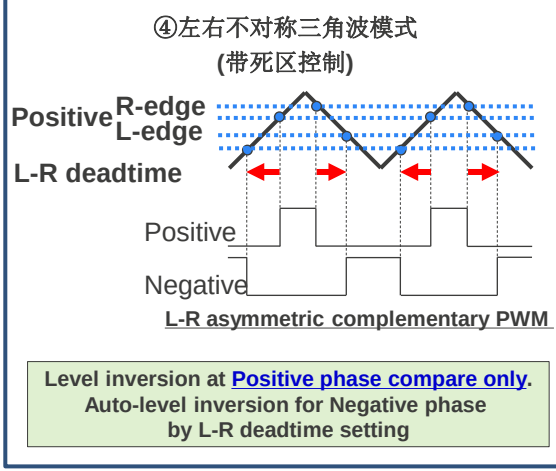
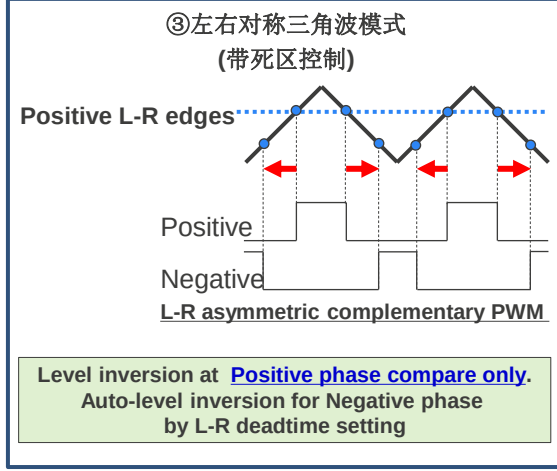
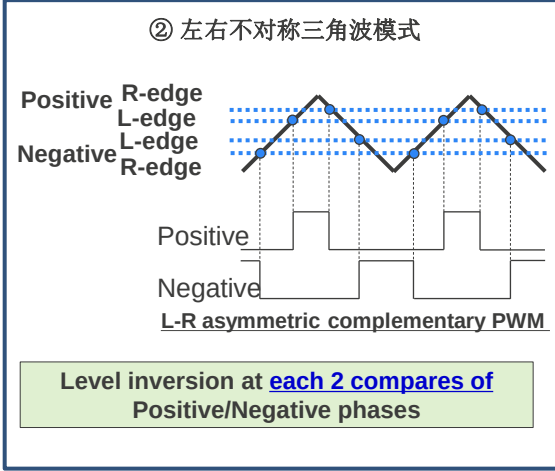
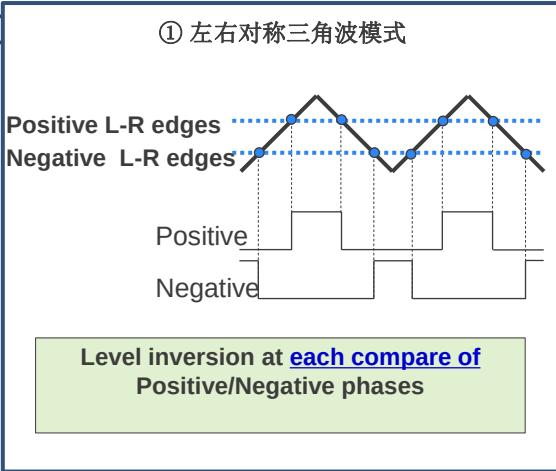
- K) PWM输出关断功能



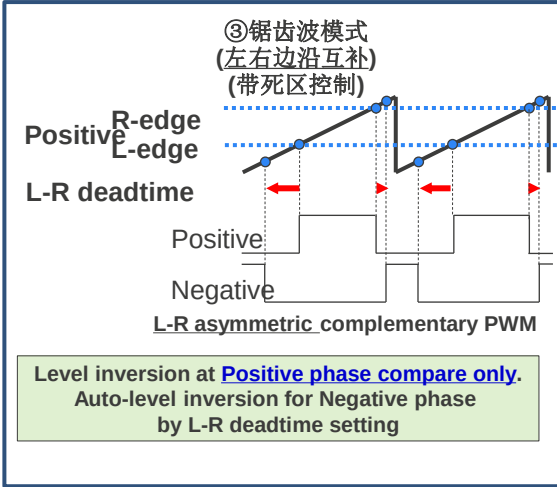
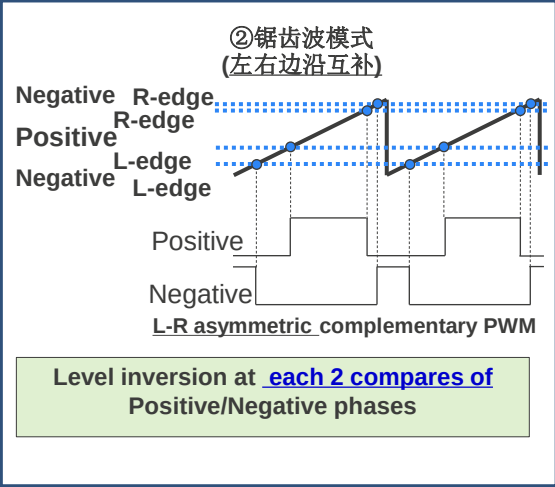
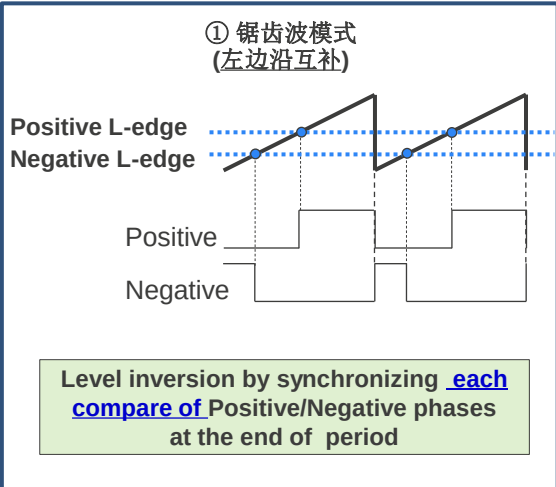
定时器功能: GENERAL PWM TIMER (GPT)

各种PWM输出模式 (总共7种类型)

■ 全波(三角波)模式
总共4种互补PWM输出模式



■ 半波(锯齿波)模式
总共3种互补PWM输出模式



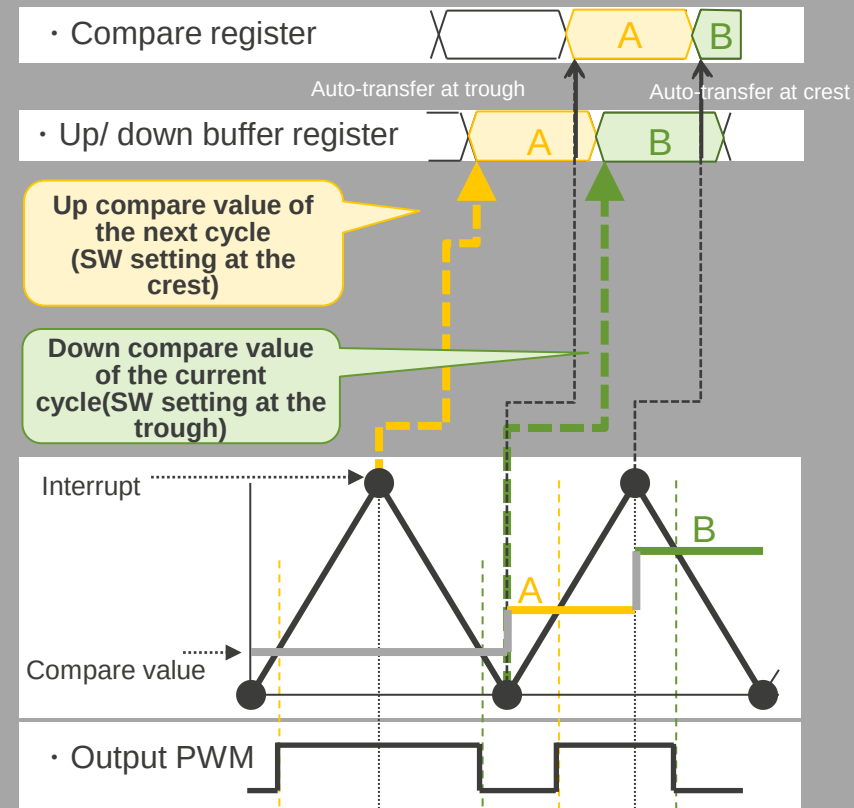
为支持各种控制设计理念，提供总共7种互补PWM模式，包括三角波和锯齿波载波生成

定时器功能: GENERAL PWM TIMER (GPT)

比较寄存器的双缓冲功能

传统的, 当使用单缓冲模式的定时器

1个载波周期总共需要2次波峰/波谷中断

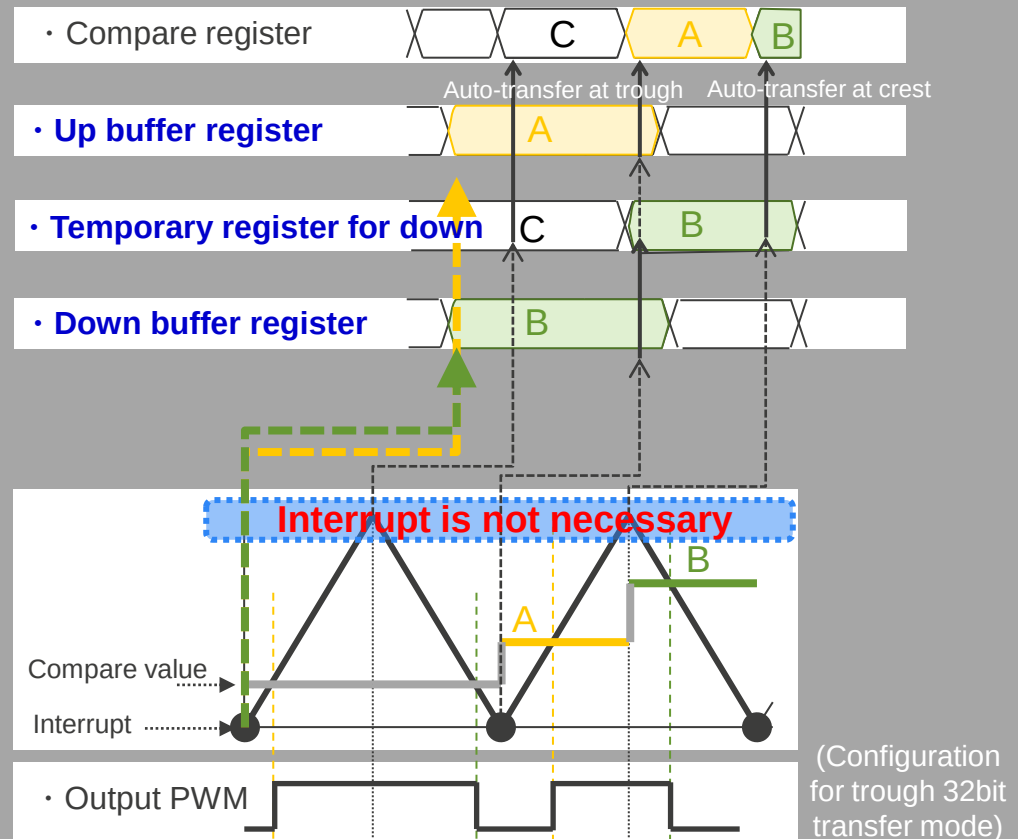


中断数减半
≡
软件负荷减半

双缓冲的优势:
使用向上/向下缓冲寄存器可将中断次数减少一半。使用更少软件负荷实现了左右不对称互补PWM

当使用GPT双缓冲功能

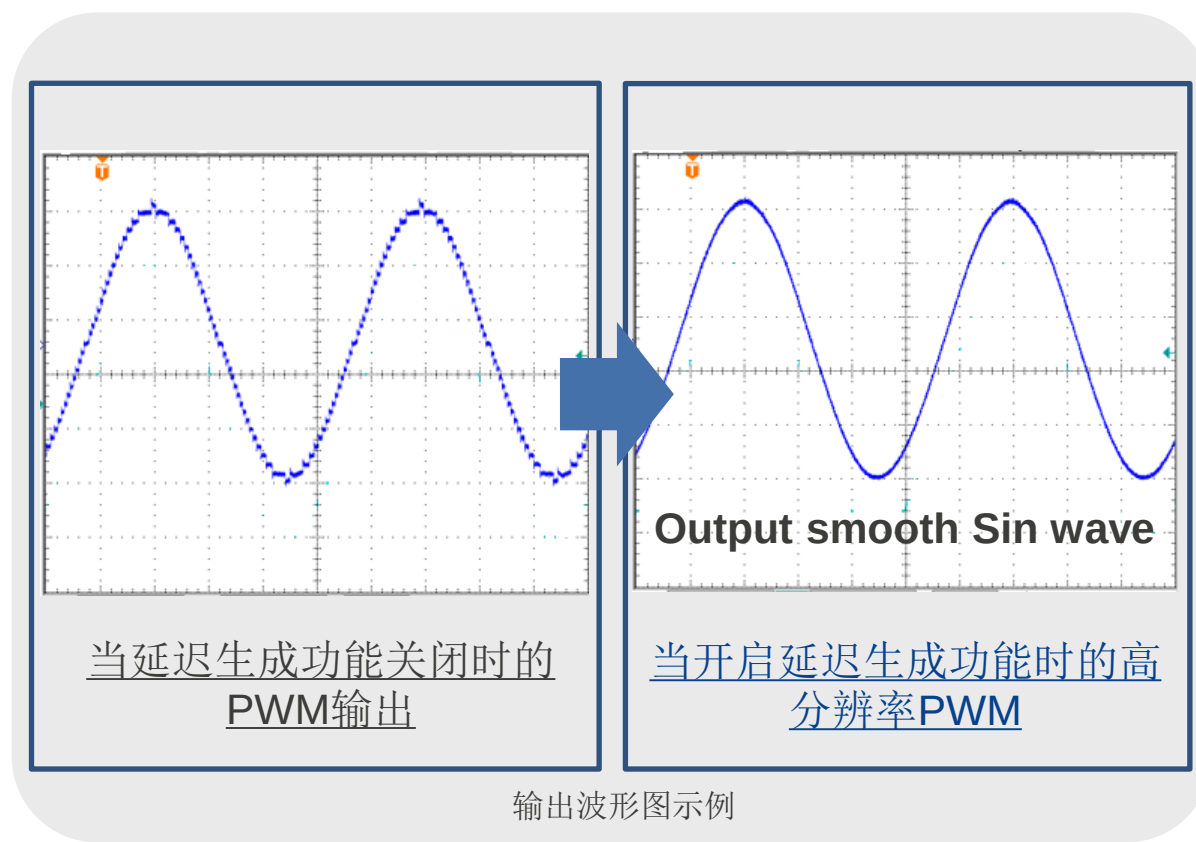
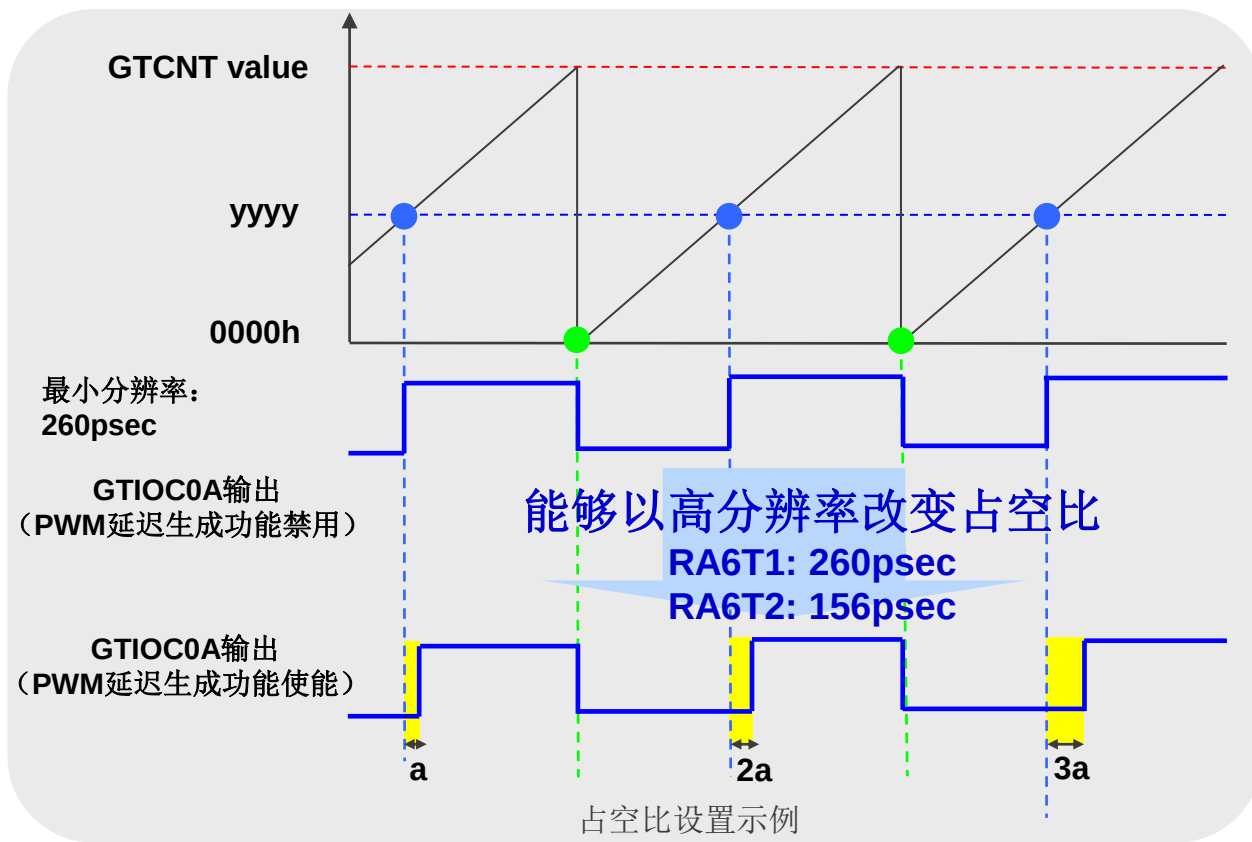
仅在1个载波周期的波谷中断



定时器功能: GENERAL PURPOSE PWM TIMER (GPT)

高分辨率PWM 输出功能

当使用高分辨率PWM^(*1)时，可以使用GPT供给时钟的1/32分辨率设置占空比设定值（参考值）。
从而可实现更理想的波形输出

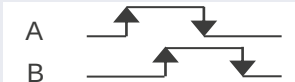
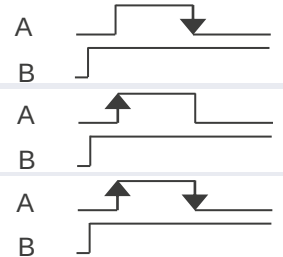
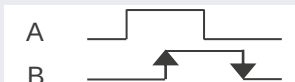
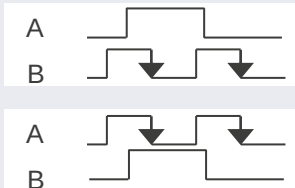
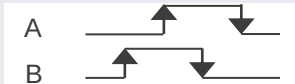
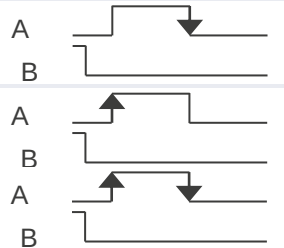
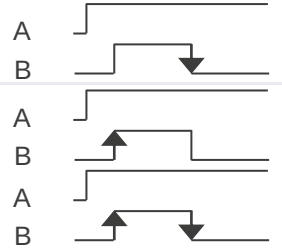
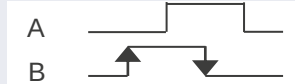


(*1)允许延迟产生电路

定时器功能: GENERAL PWM TIMER (GPT)

相位计数模式

支持各种相位计数模式，能够响应各种类型的脉冲和编码器输入

Count direction	Mode 1		Mode 2		Mode 3		Mode 4		Mode 5*1	
	Count condition	Count edge	Count condition	Count edge	Count condition	Count edge	Count condition	Count edge	Count condition	Count edge
Add (forward)	Phase A > B	A and B rise/fall	B is high	A fall	B is high	A fall	Phase A > B	B rise/fall	A is high/low	B fall
				A rise		A rise			B is high/low	A fall
				A both edges		A both edges				
										
Subtract (reverse)	Phase A < B	A and B rise/fall	B is low	A fall	A is high	B fall	Phase A < B	B rise/fall	None	None
				A rise		B rise				
				A both edges		B both edges				
									None	

12BIT ADC SPECIFICATION

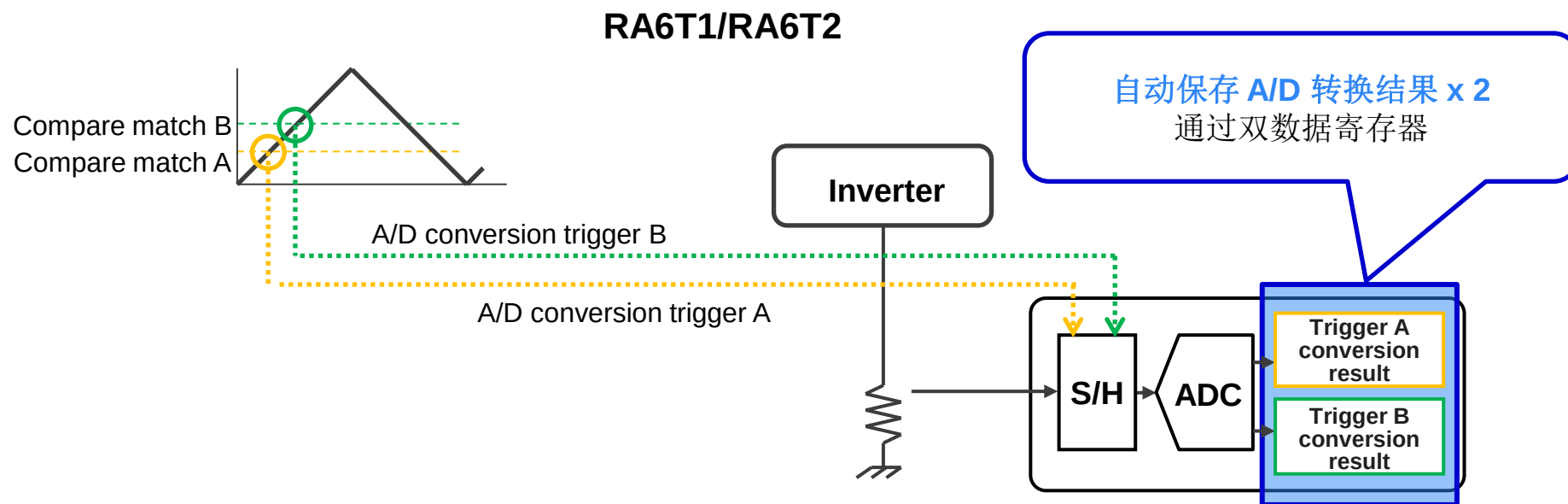
Items		RA6T2	RA6T1
12bit ADC	Resolution	12bit	12bit
	Sampling rate(Max)	6.25MSPS	2.5MSPS
	Conversion time	0.16us	0.4us ^(*1)
	Number of channel, Number of unit	100pin	Up to 17 input channels Unit0 : 11ch w/ 3ch S/H Unit1 : 8ch w/ 3ch S/H 2 input channels are shared by Unit0 and 1 (*2)
		64pin	Up to 8 input channels Unit0 : 7 ch w/ 3ch S/H Unit1 : 3 ch w/ 3ch S/H 2 input channels are shared by Unit0 and 1 (*2)
		48pin	N/A
3 S/H		2unit	2unit

Note1 : this case is use AN003/AN005/AN006 and not use Channel-dedicated sample-and-hold function.

Note2 : Input channels of each ADC unit are shared to same port.

用于电流检测的A/D 双数据寄存器

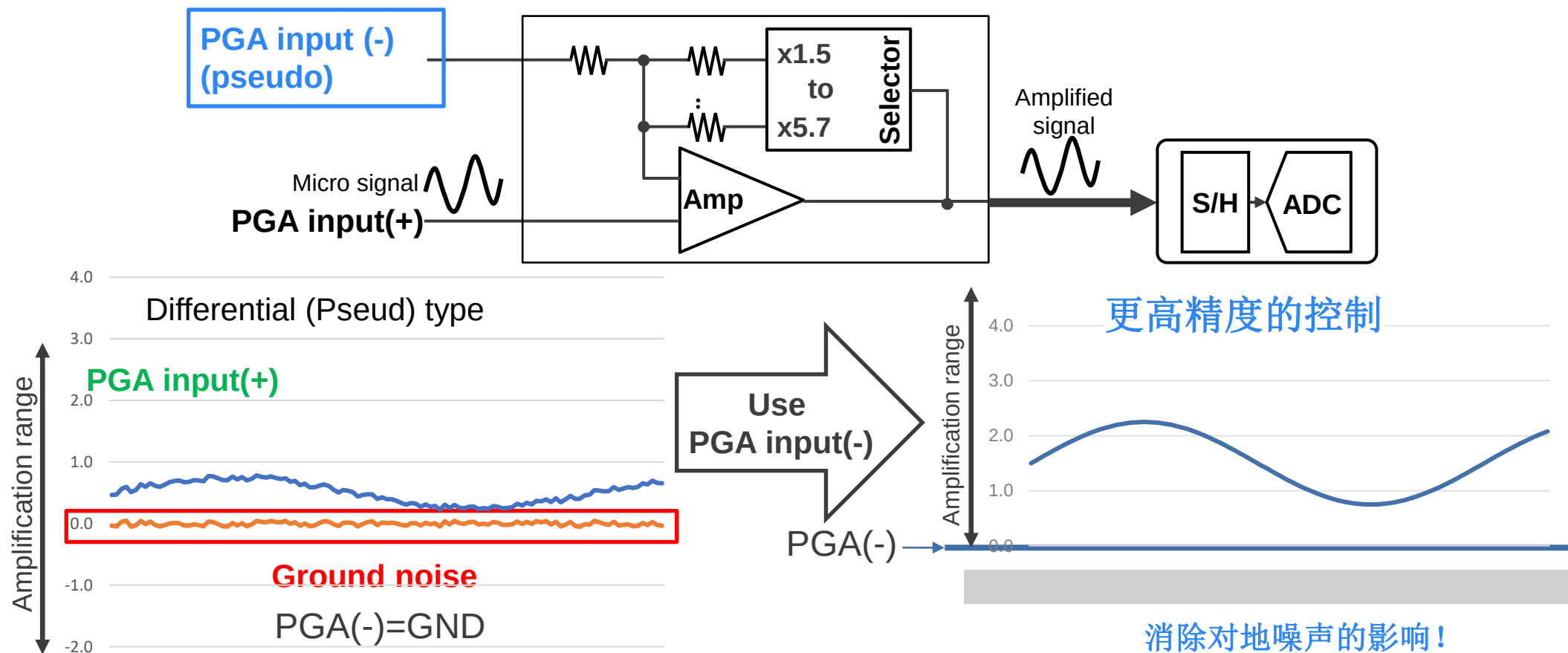
- ✓ 无需通过软件重复电机电流的A/D转换结果
- ⇒ 在连续转换期间减少CPU负荷



伪差分可编程增益放大器

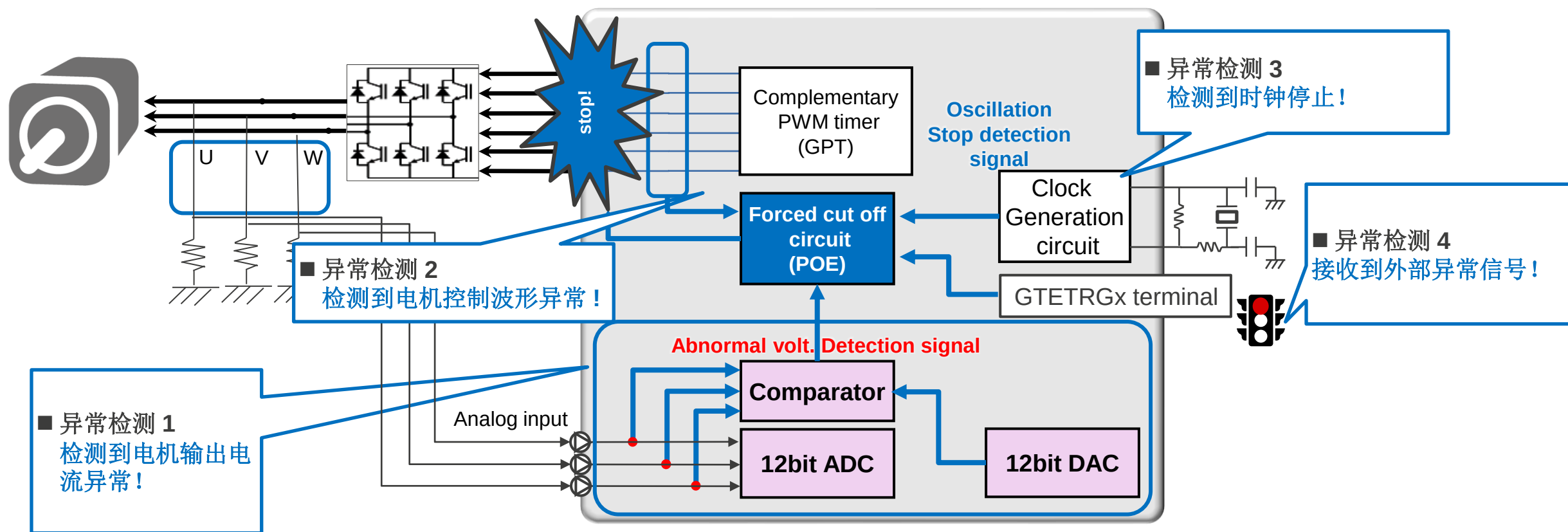
- ✓ 可编程增益 (single mode: x2 to x13.3, Pseudo mode: x1.5 to x5.7)
- ✓ Slew Rate 10V/us (min)
- ✓ 采用PGA负端输入(-)*可减少对地噪声

* Ref.GND port for gain setting.



安全功能: 模拟比较器和PWM输出关断功能

- 当检测到异常情况时，无需CPU参与即可关断PWM输出，即时保护电机和变频电路



瑞萨的安全加密引擎 SECURE CRYPTO ENGINE (SCE)

SCE 是一个由专用控制逻辑管理和保护的子系统

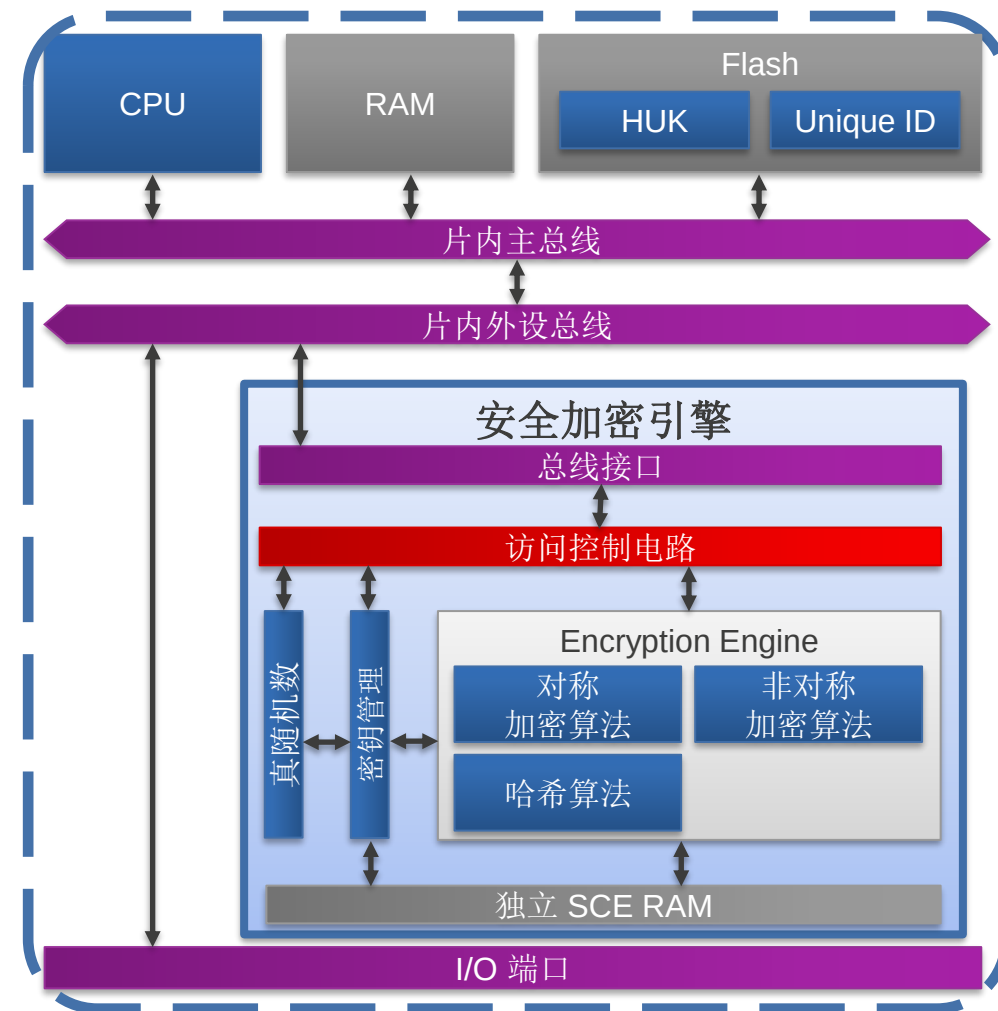
- 瑞萨提供驱动软件，以正确的步骤来访问SCE
- 通过CPU或调试器进行非常规访问时，会锁死SCE管理访问电路，直到器件被复位

物理隔离的加密操作

- 独立的 SCE RAM
- 明文密钥不会暴露到任何CPU可以访问的总线上

高级密钥管理功能

- MCU硬件（HUK/UID）绑定的封装密钥，克隆无效
- 可以简单而安全的存储封装密钥
- 密钥安装机制通过工厂封装密钥来实现



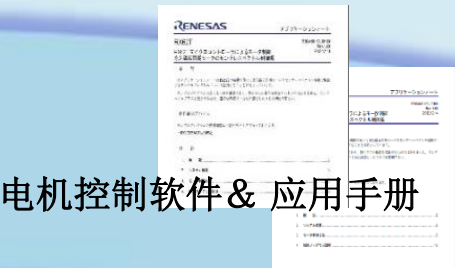
瑞萨电子电机控制解决方案

- 瑞萨电子完善的电机解决方案为您的开发提供强大的支持！

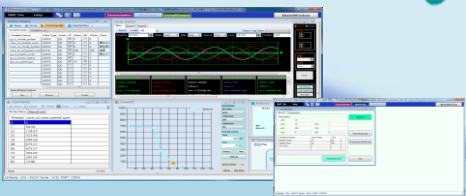
<https://www.renesas.com/us/en/application/home-building/motor-control-solutions>

解决方案

软件 & 工具

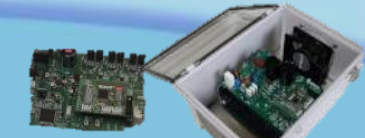


电机控制软件& 应用手册



电机控制开发支持工具

硬件 & 开发套件



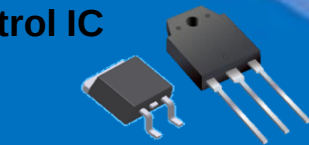
变频控制评估板



瑞萨解决方案学习套件

芯片

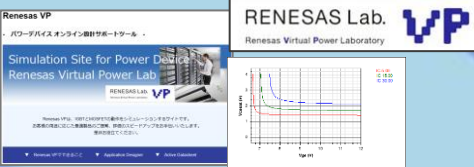
MCU &
Motor control IC



Analog & Power Devices



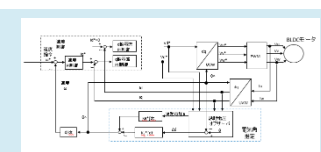
解决方案套件



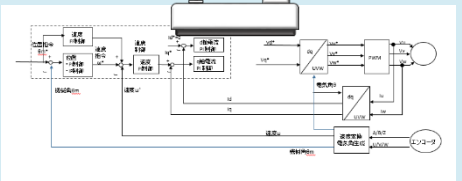
网页版设计仿真工具



集成开发环境IDE



无传感器电机控制方案



位置控制方案



旋转变压器方案

The background of the slide features a city skyline at sunset, with a network of blue lines and dots overlaid on the sky, suggesting a digital or technological theme.

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