

BLDC 控制 基于XMC1300&APP

2014英飞凌XMC 微控制器巡回研讨会



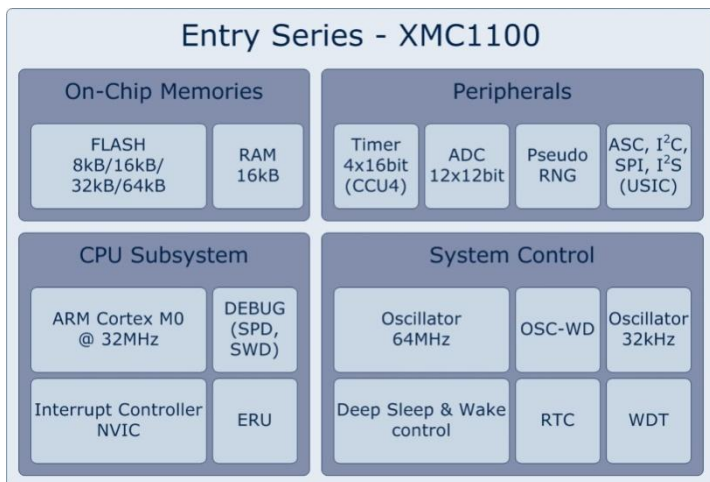
■ XMC1300介绍 --- 电机控制相关模块

■ BLDC APP使用方法 --- BLDC 3 Hall APP

XMC1000系列结构介绍

XMC 1000

Entry Series - XMC1100



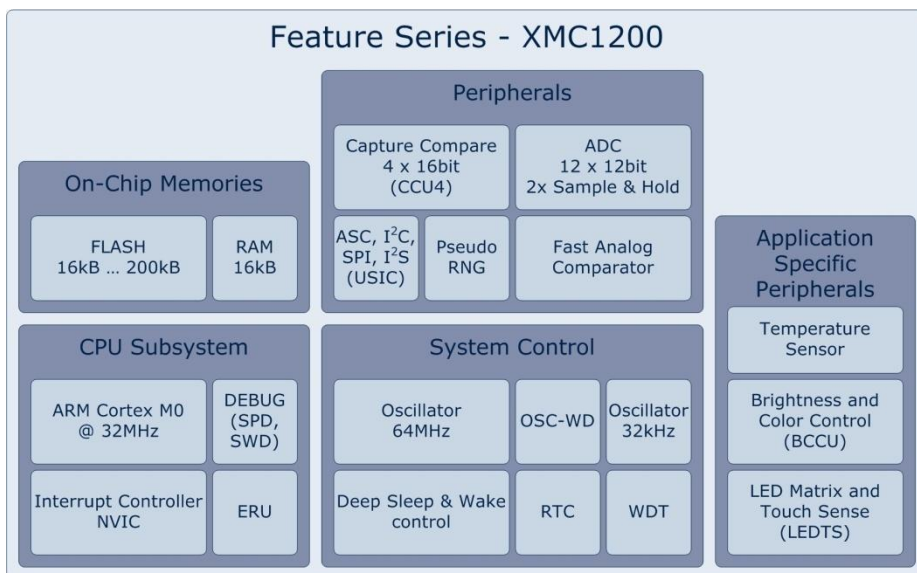
■ Entry Series: XMC1100

■ Feature Series: XMC1200

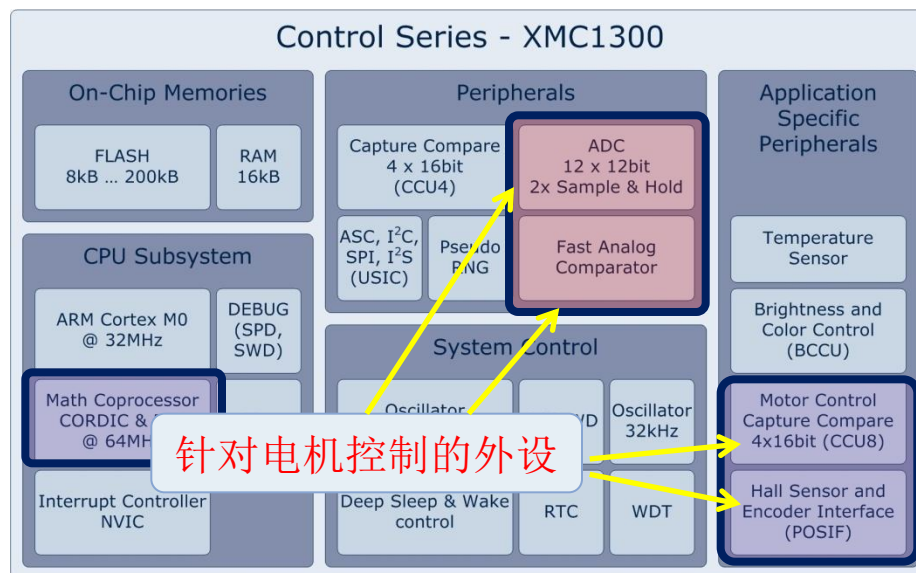


■ Control Series: XMC1300

Feature Series - XMC1200



Control Series - XMC1300



捕获比较单元4 (CCU4)

■ CCU4

- ❑ 多功能**16**位定时器组
- ❑ 4 个完全相同、独立运行的子单元
- ❑ 支持定时、比较、捕获操作

CCU4		Prescaler	Floating Prescaler	
Slice 0	Input Selection Filtering Edge Selection	Timer	Concatenate	Service Req
			Period	Output Mod.
		Dither	Compare	Active/Passive
Slice 1				
Slice 2				
Slice 3				

■ 每个子单元 (Slice)包含:

- ❑ 1个**16** 位定时器
- ❑ 独立的预分频器
 - 支持动态分频
- ❑ 4个捕获寄存器
- ❑ 1个比较寄存器 (PWM)
 - 1 路**PWM**输出
 - 支持抖频控制
- ❑ **16**路的外部信号输入
- ❑ 定时器级联单元
- ❑ 灵活的中断生成
- ❑ 信号输出调制

捕获比较单元4 (CCU4)

■ 灵活的功能配置

计时功能	比较功能	捕获功能
Free Running Mode Option: Reset / Gate	Edge Aligned Mode PWM generation	Time Measurement
计数功能	比较功能	单次工作
Option: Up/Down Count Control	Center Aligned Mode Symmetric or Asymmetric PWM	单次工作

捕获比较单元8 (CCU8)

■ CCU8 = CCU4++

□ 集成CCU4所有功能

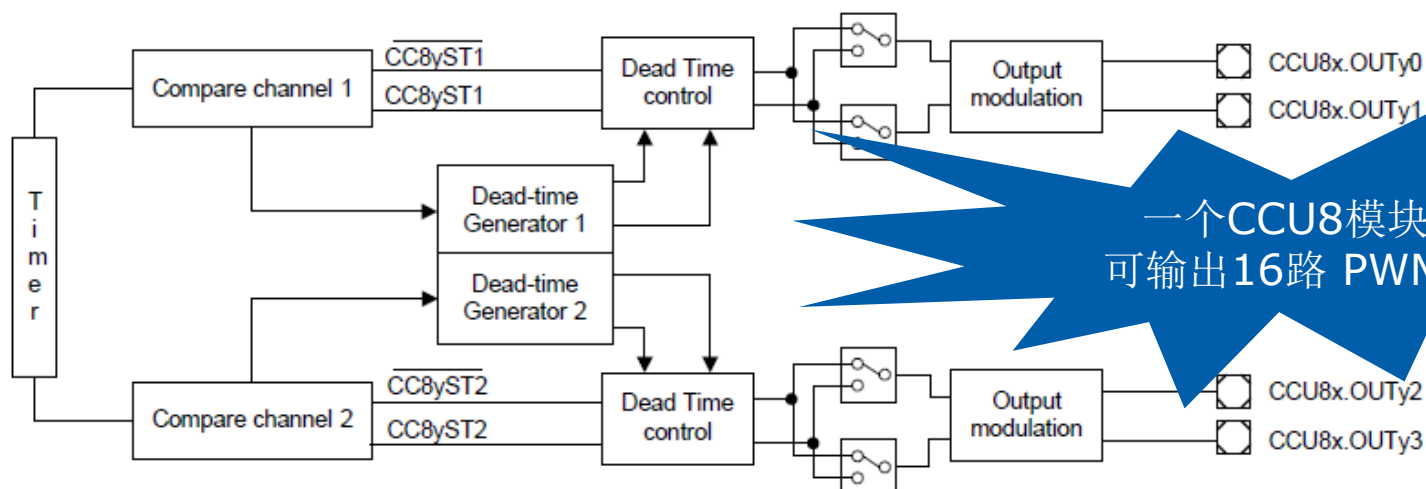
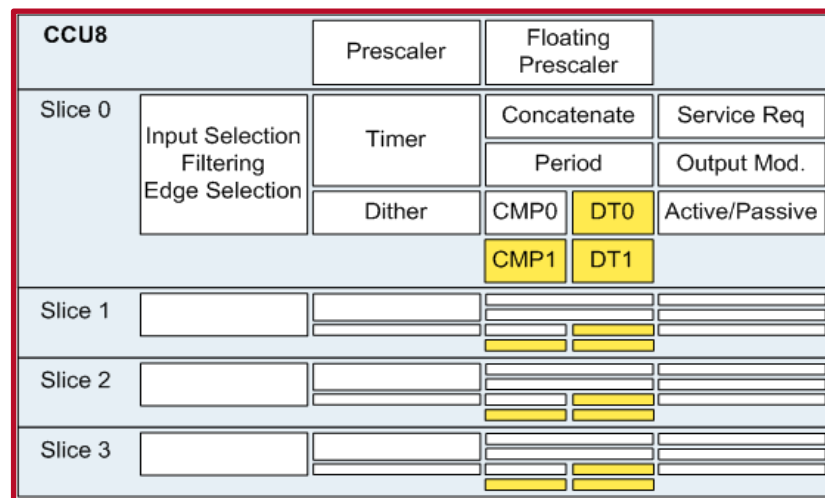
■ 与CCU4相比，每个子单元包含

□ 两路比较单元

□ 四路PWM输出（共两对）

□ 两个死区时间生成单元

（ different for rising & falling edge ）



捕获比较单元8 (CCU8)

■ CCU8 特色

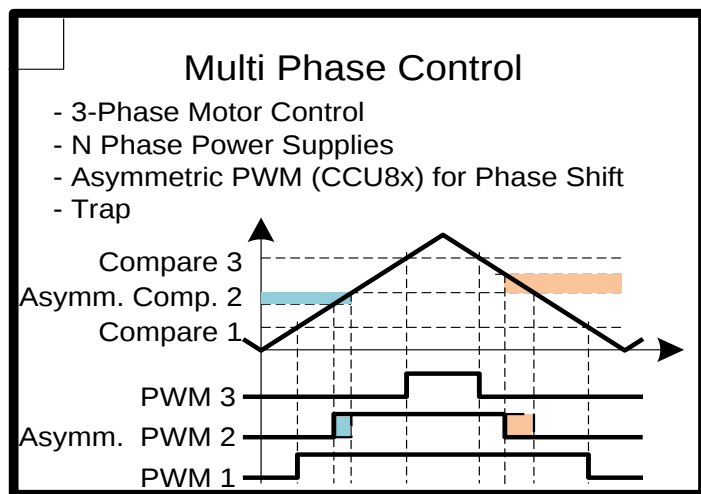
□ 灵活的比较模式，支持不同形式的PWM生成

▮ 对称/非对称PWM，单次/连续PWM，灵活死区时间生成

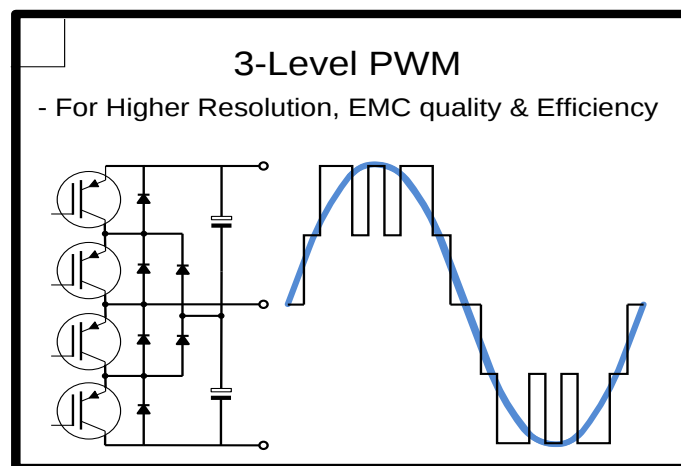
□ 丰富的比较通道，满足常见的各种应用的需要

▮ 半桥、三相全桥、三电平控制等

■ 非对称 PWM生成

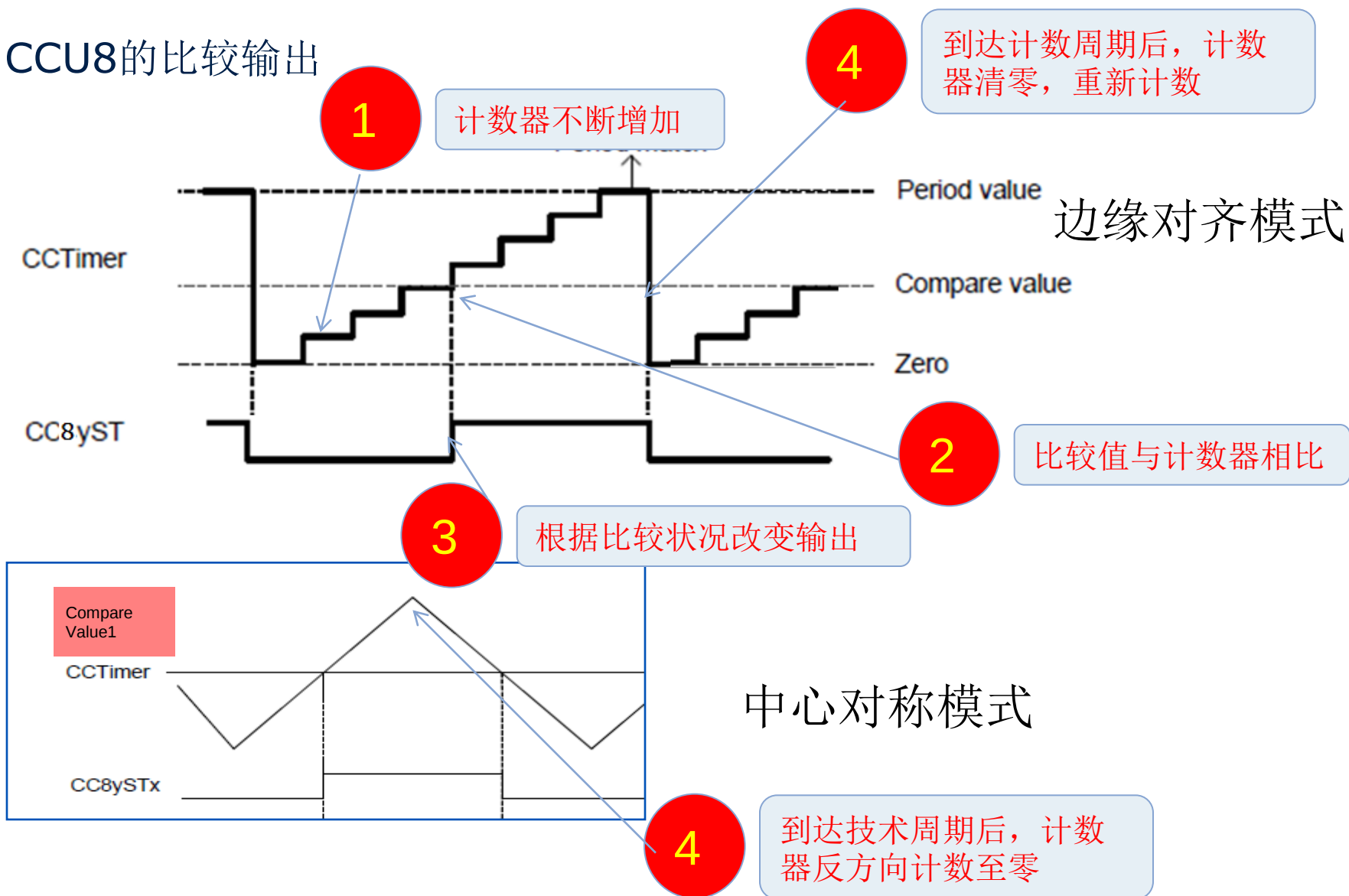


■ CCU8 - 业内唯一可直接驱动三电平拓扑的PWM单元



捕获比较单元8 (CCU8)

■ CCU8的比较输出



位置传感器接口(POSIF)

■ 电机位置信息接口单元

■ 工作模式

☐ 增量编码器模式

☐ 霍尔传感器模式

☐ 多通道模式

■ 支持输入信号滤波

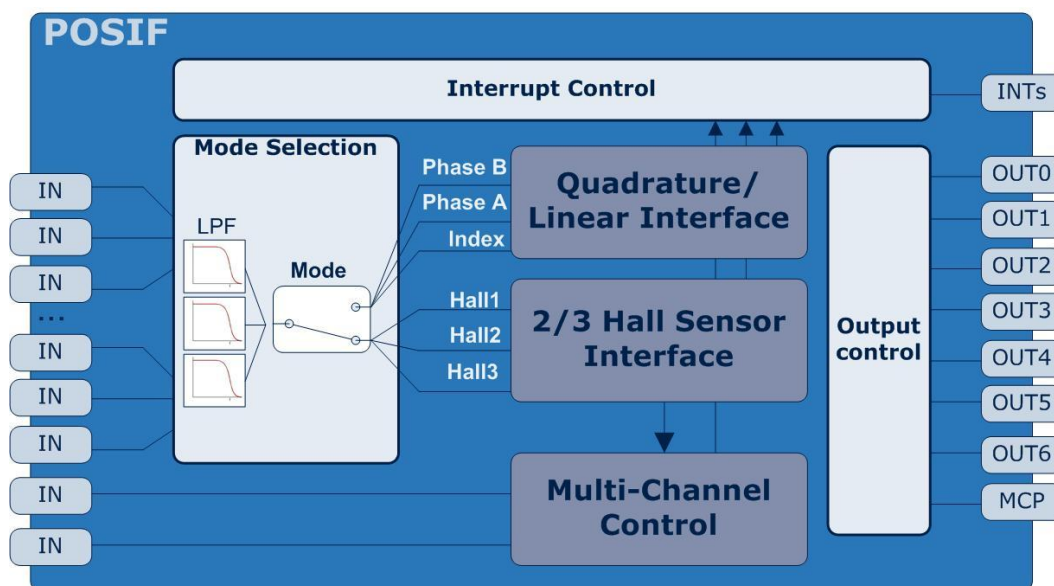
■ 与CCU4/8配合以实现

☐ 位置检测

☐ 速度捕获

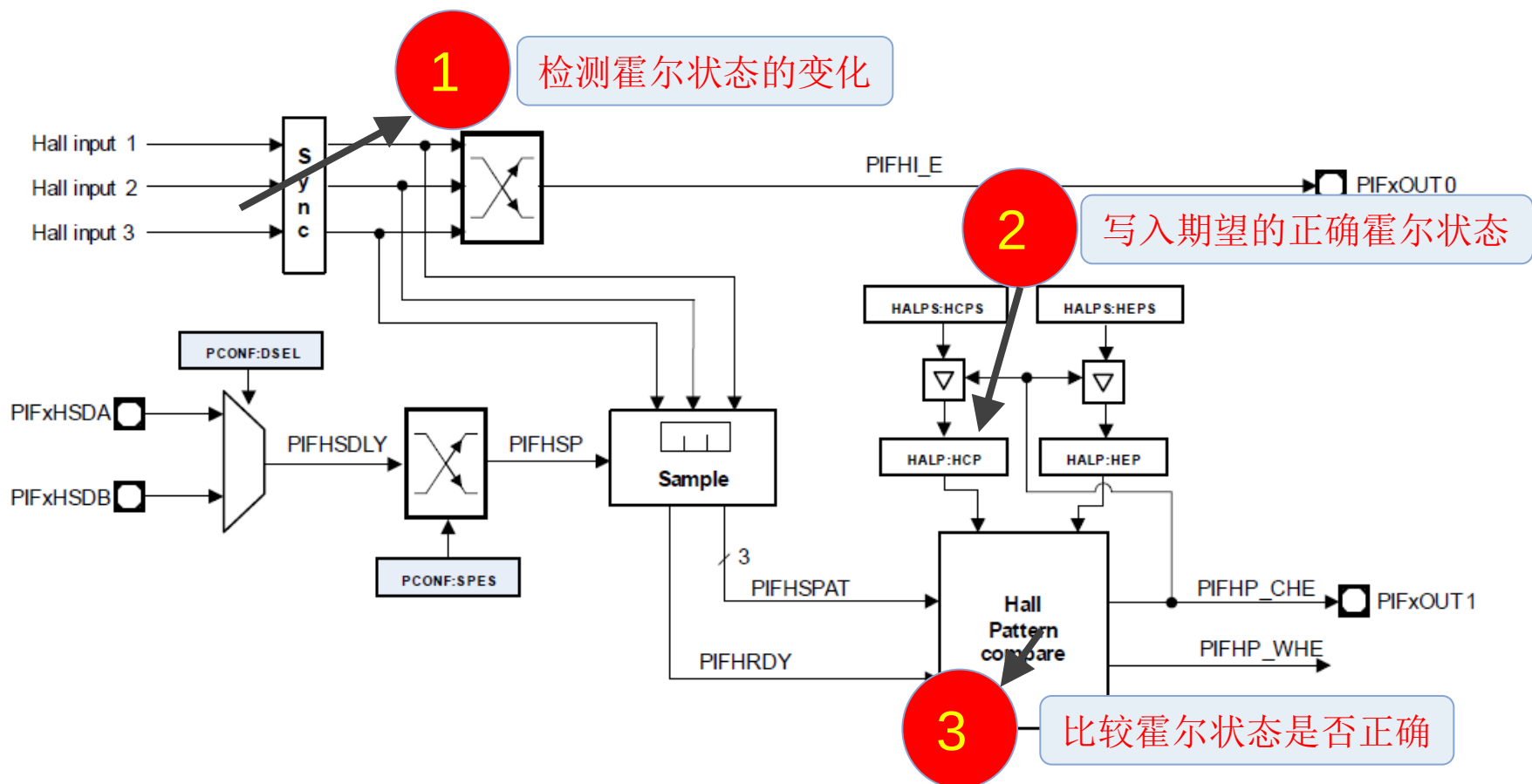
☐ BLDC控制

☐ ...



POSIF（霍尔传感器模式）

- POSIF的霍尔传感器模式可以检测3个霍尔的变化，并根据直流无刷电机6步工作模式下霍尔状态的变化，确定电机是否正确工作。



- POSIF的多通道模式用于连接霍尔正确状态输出和CCU8的通道使能。
- 可用于在直流无刷电机6步工作模式下根据霍尔状态更新各个桥臂的导通状态。



CCU8、CCU4和POSIF应用于直流无刷电机驱动 举例

1

POSIF检测霍尔变化

2

POSIF判断霍尔状态

3

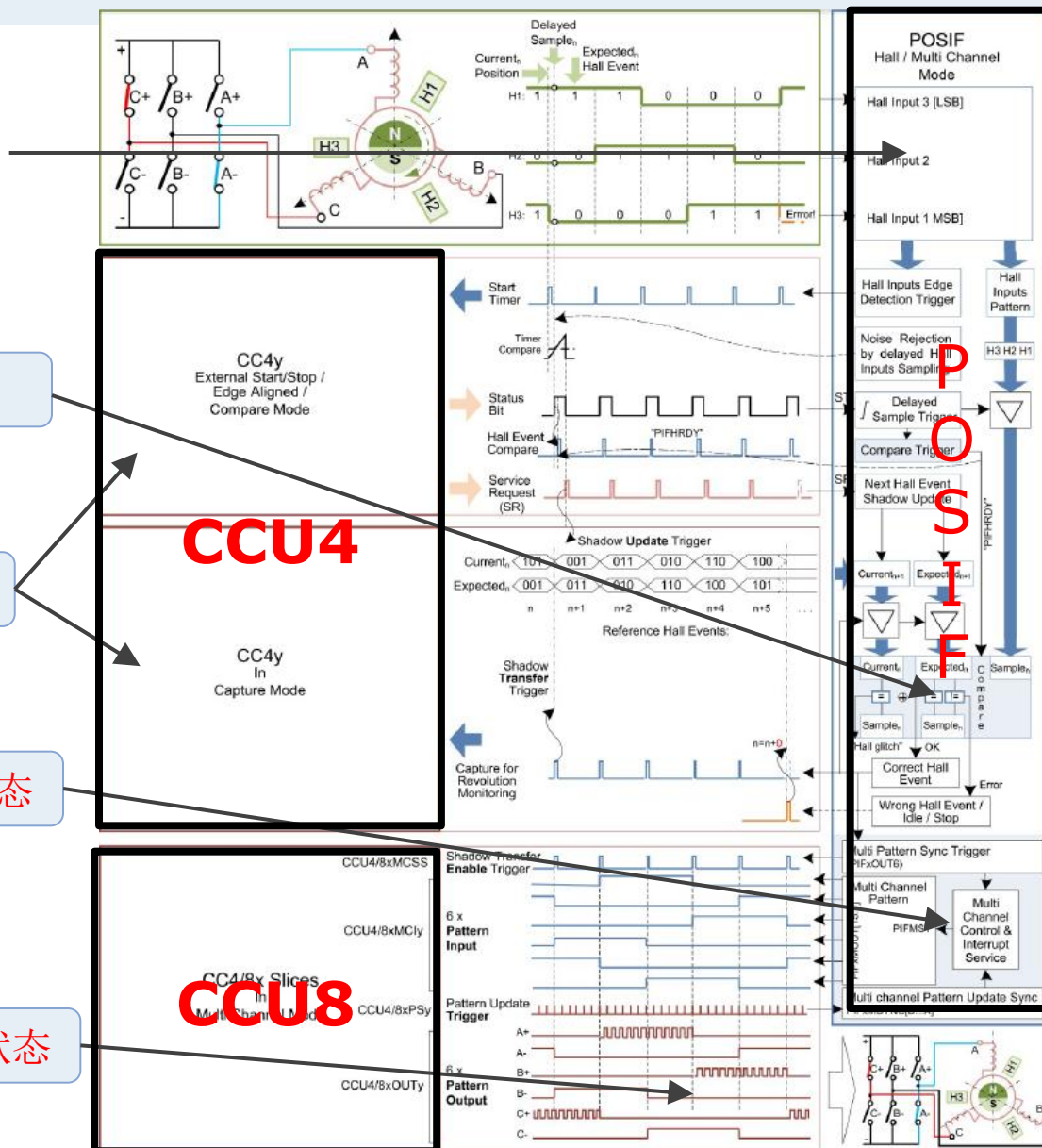
通过CCU4进行速度计算

4

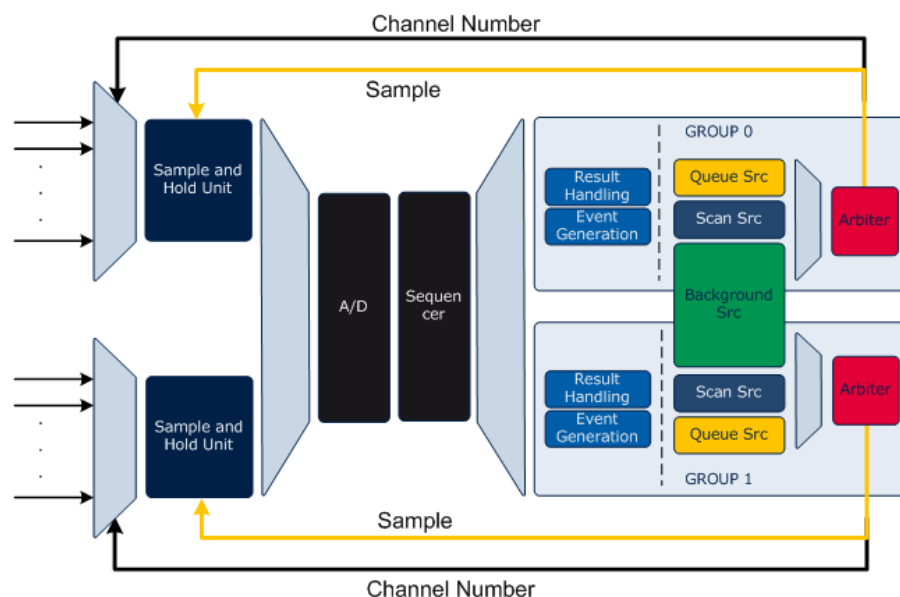
POSIF更新多通道输出状态

5

CCU8控制各个桥臂导通状态



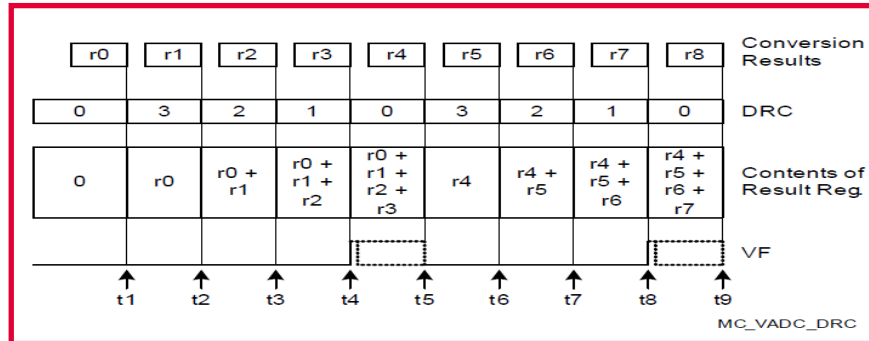
VADC – 多功能模数转换器



■ 多功能ADC模块

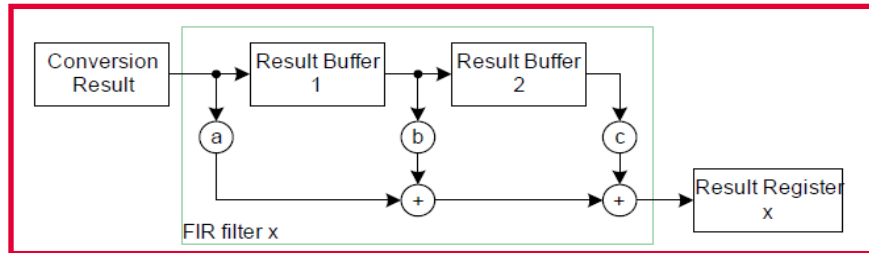
- ❑ 12通道，8/10/12位可选ADC
- ❑ 双采样保持单元（双通道同时采样）
 - ❑ XMC1200/1300
- ❑ 高转换速
 - ❑ 1.28MSPS calibrated
 - ❑ 1.88MSPS un-calibrated
- ❑ 增益可调
 - ❑ 1x, 3x, 6x, 12x
- ❑ 多种转换请求方式
 - ❑ 队列，扫描，Background
- ❑ 灵活的硬件触发机制
 - ❑ PWM, I/O 等等
- ❑ 丰富的中断资源

VADC – 多功能模数转换器

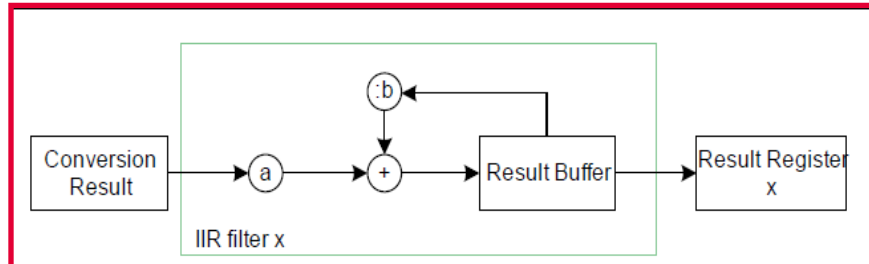


■ 16级结果FIFO

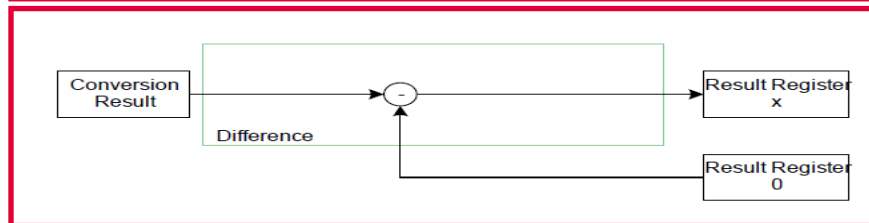
■ 数据累加模式



■ FIR模式

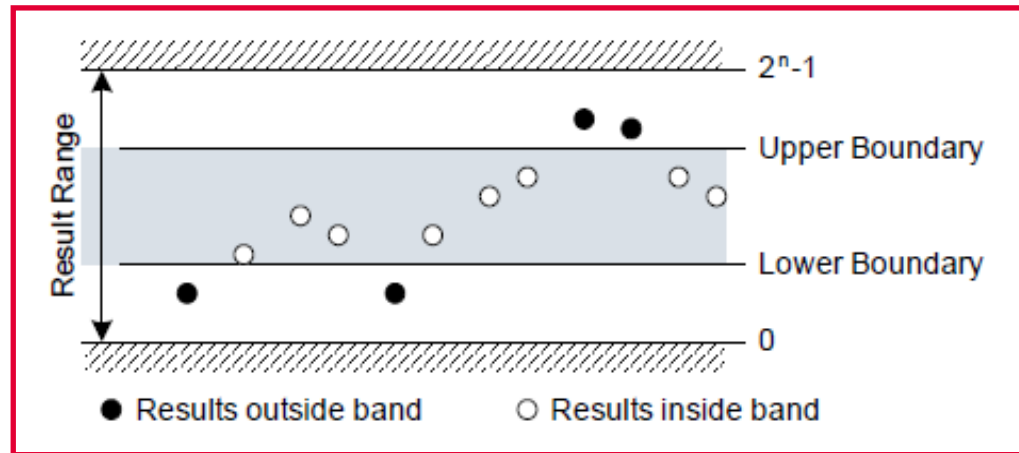


■ IIR模式



■ 差分模式

VADC – 多功能模数转换器



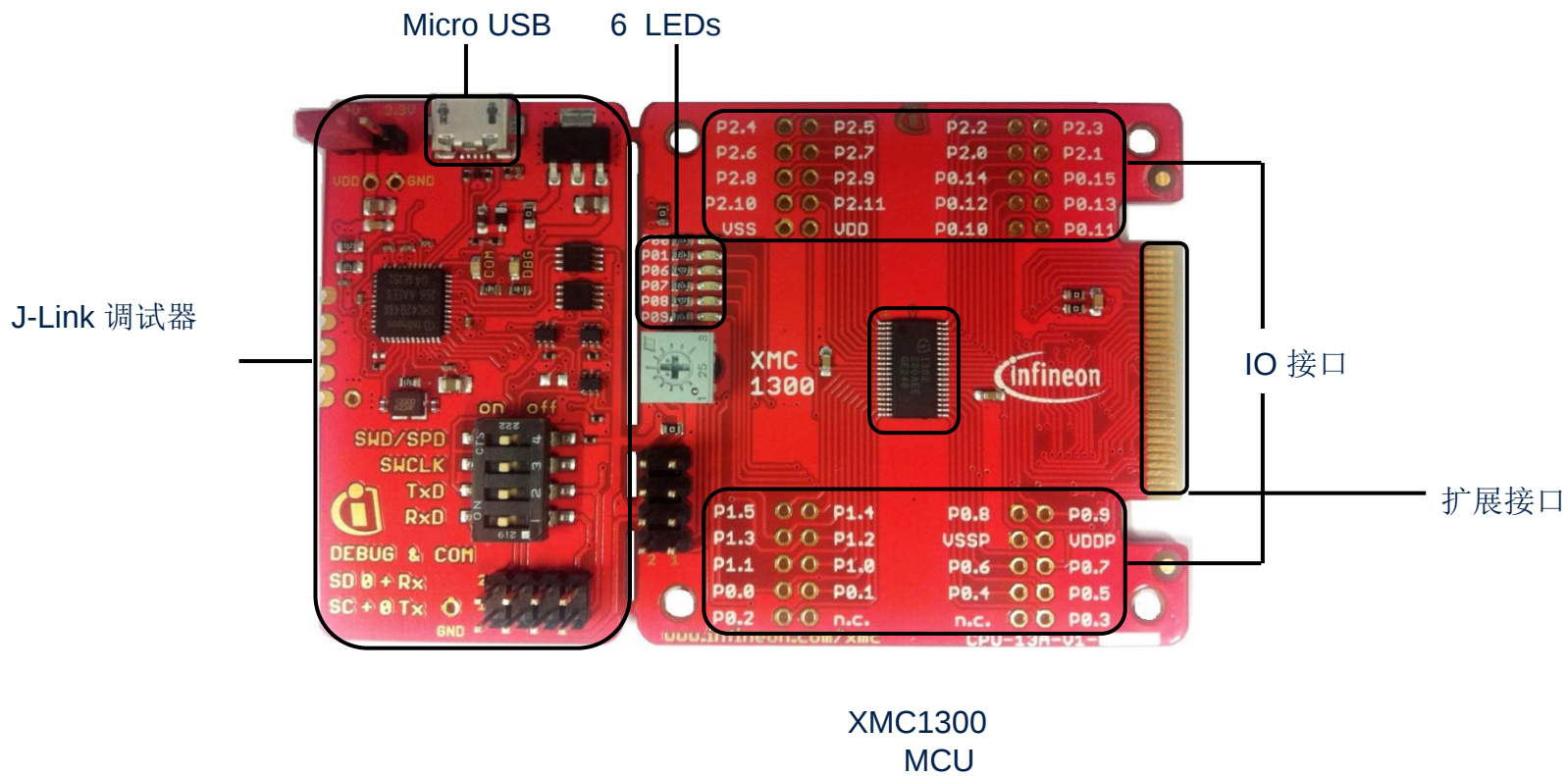
- 快速比较模式
- 结果边界比较模式

■ XMC1300介绍 --- 电机控制相关模块

■ BLDC APP使用方法 --- BLDC 3 Hall APP

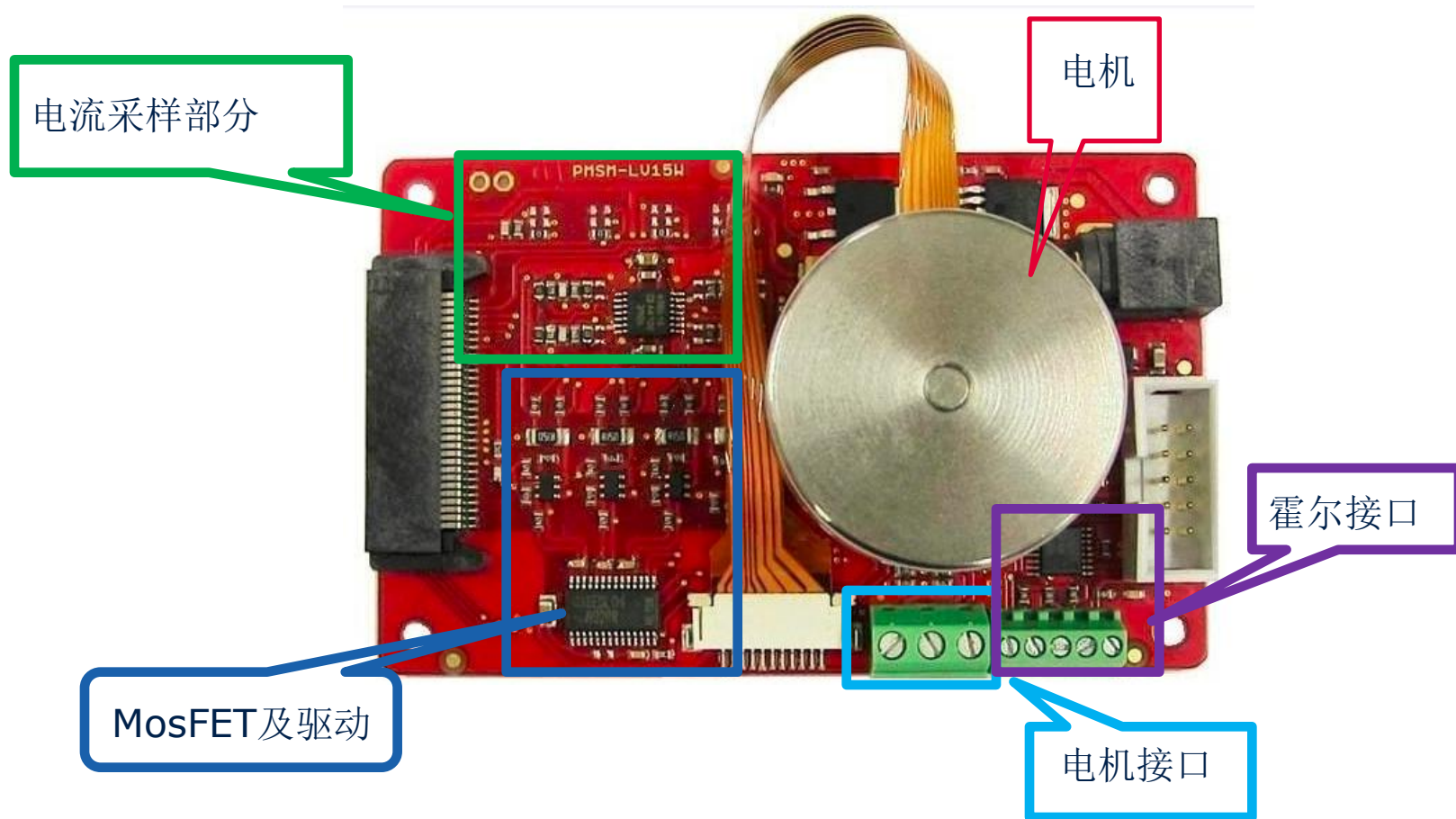
电机驱动板组件

■ XMC1300 Kit板



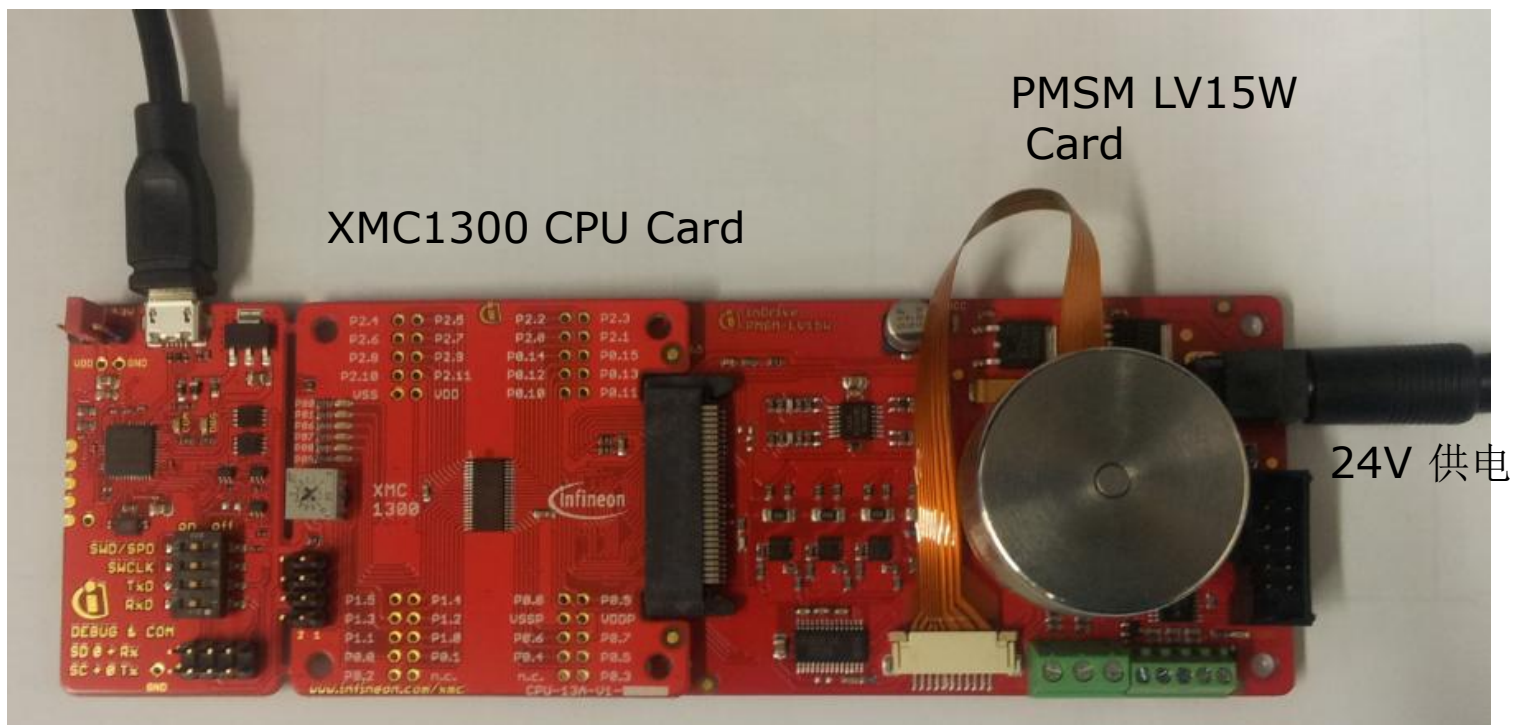
电机驱动板组件

■ 电机驱动板



组件连接

连接到PC



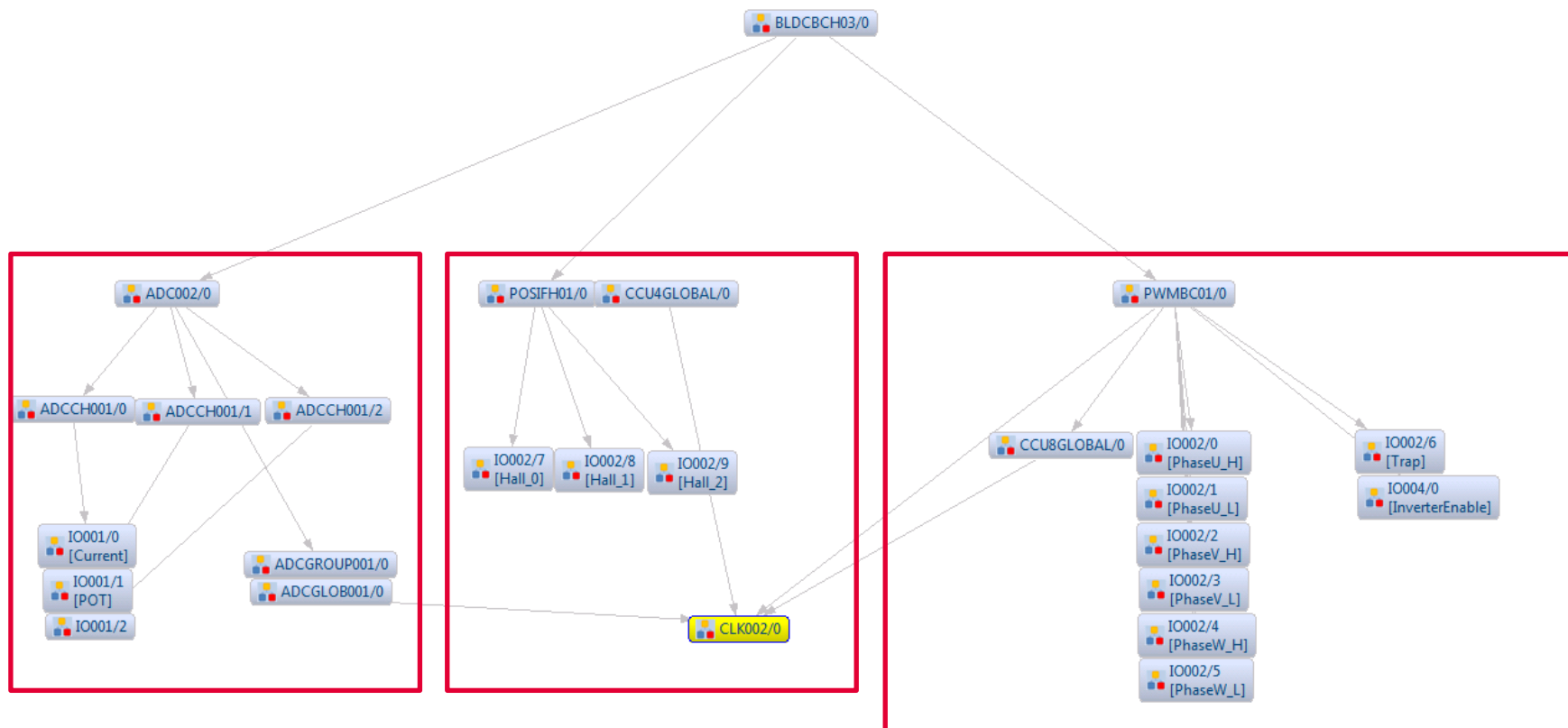
BLDC 控制APP

■ 基于XMC1300， Infineon推出了以下APP支持BLDC电机驱动

- ☐  BLDCBCH02 [1.0.10] 支持双霍尔传感器的BLDC控制
- ☐  BLDCBCH03 [1.0.12] 支持3霍尔传感器的BLDC控制
- ☐  BLDCBCSL01 [1.0.4] 支持无霍尔传感器的BLDC控制

BLDC 3霍尔控制

■ BLDCBCH03 软件结构图



ADC部分

POSIF&CCU4部分

CCU8部分

BLDC 3霍尔控制

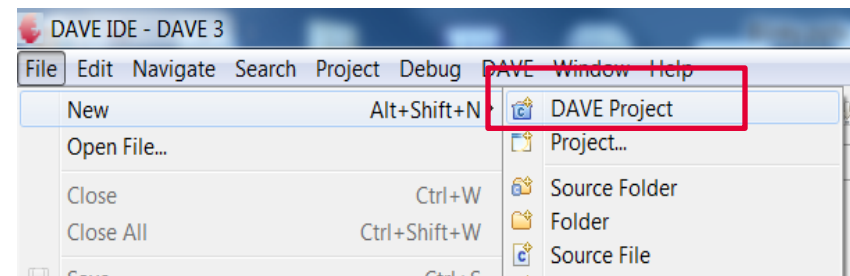
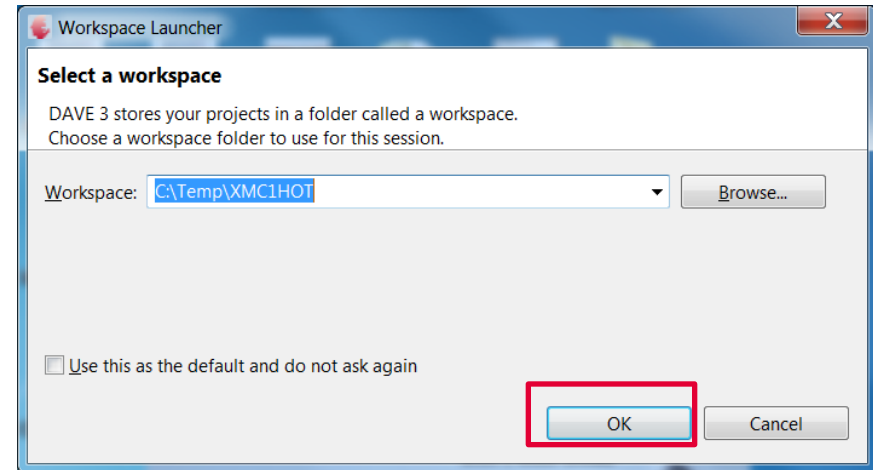
■ 打开 DAVE™



■ 选择Workspace

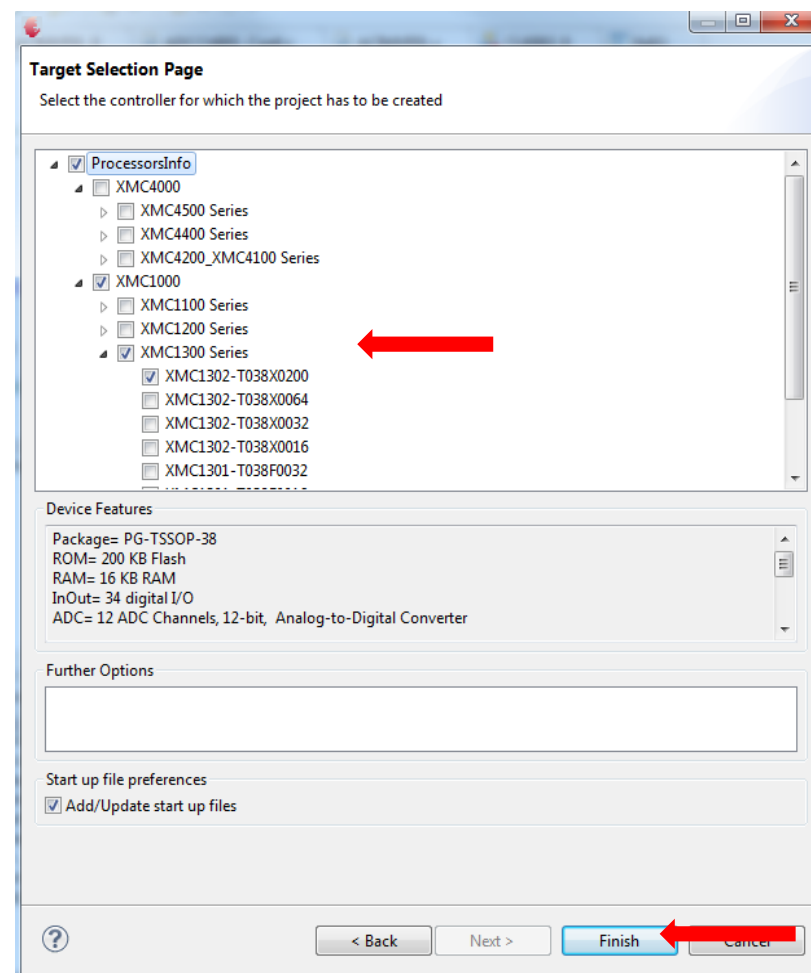
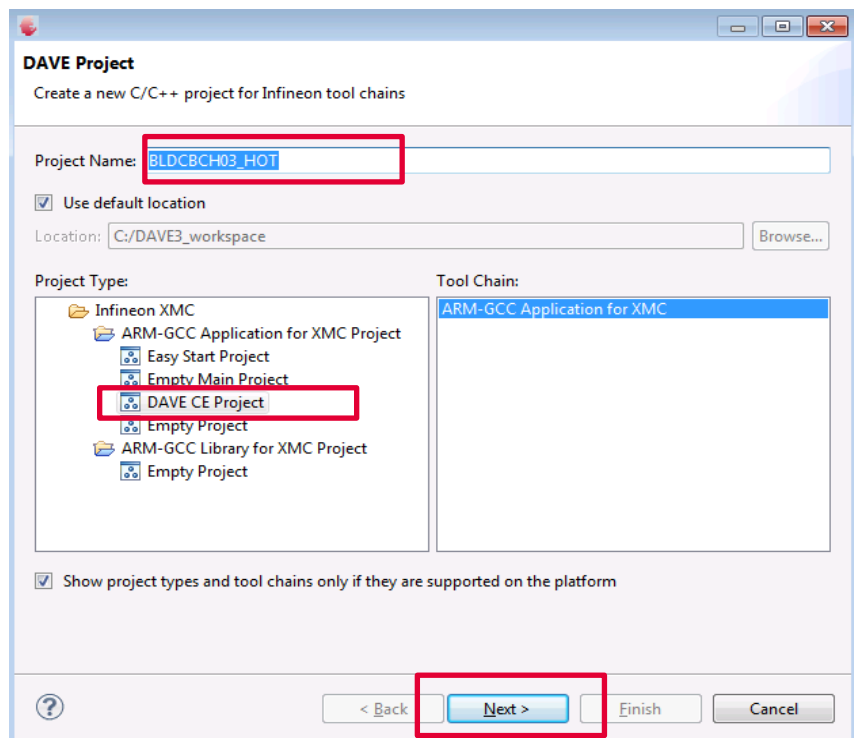
■ 点击 “OK”

■ 点击File → DAVE Project



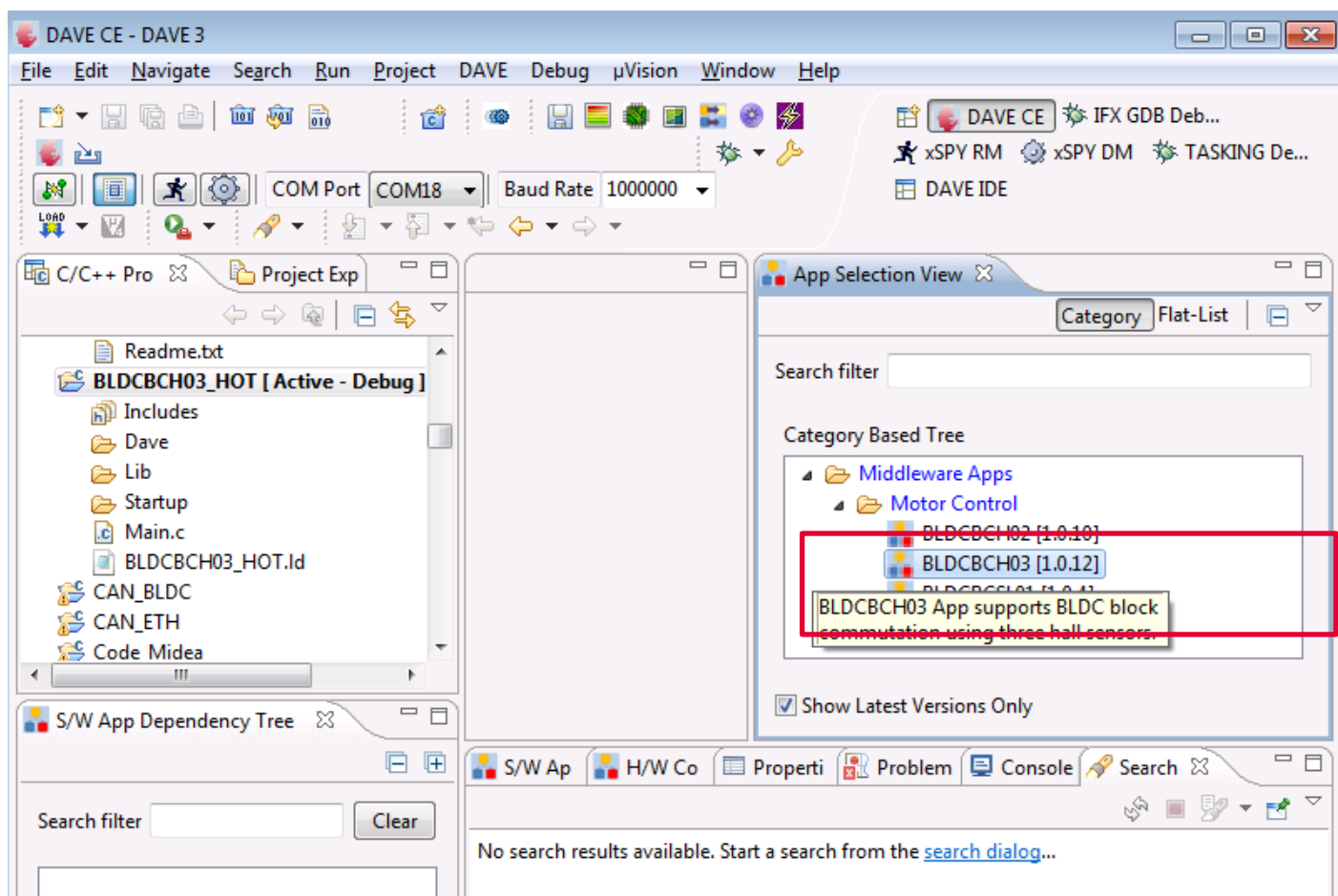
BLDC 3霍尔控制

- 输入 “**BLDCBCH03_HOT**”(任意) 作为工程名称
- 选择 “DAVE CE Project”
- 点击 “Next”
- 选择“**XMC1300-T038X0200**”



BLDC 3霍尔控制

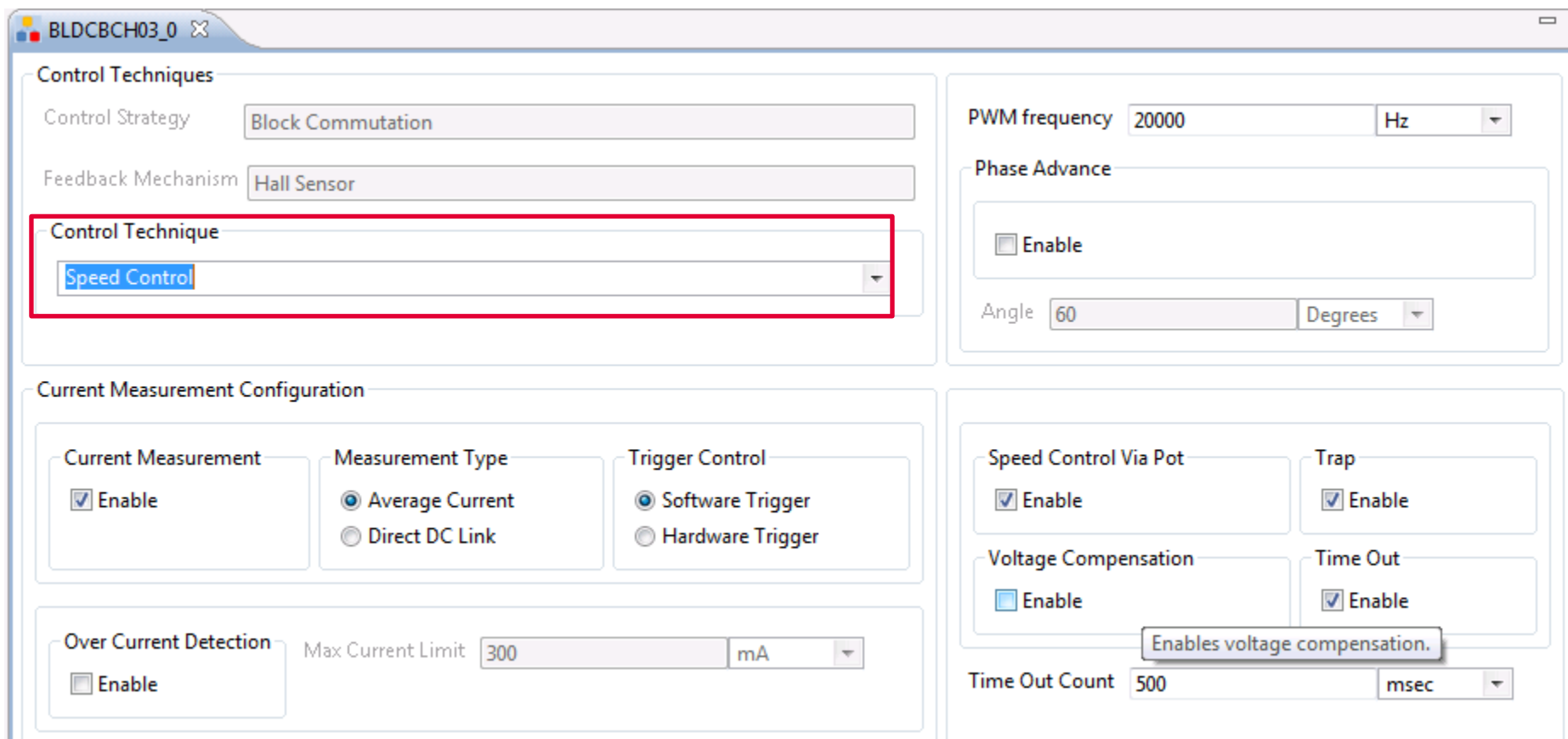
■ 双击 “BLDCBCH03” 加入BLDC控制APP



BLDC 3霍尔控制

■ Control Algorithm 页签,

□ 更改Control Technique为Speed Control, 启动速度闭环控制



The screenshot shows the BLDCBCH03_0 configuration window. The 'Control Techniques' section is highlighted with a red box, showing 'Speed Control' selected in the 'Control Technique' dropdown. Other settings include 'Block Commutation' for 'Control Strategy' and 'Hall Sensor' for 'Feedback Mechanism'. The 'Current Measurement Configuration' section shows 'Current Measurement' enabled, 'Average Current' selected for 'Measurement Type', and 'Software Trigger' selected for 'Trigger Control'. The 'Speed Control' section shows 'Speed Control Via Pot' and 'Trap' both enabled, 'Voltage Compensation' disabled, and 'Time Out' enabled. The 'Time Out Count' is set to 500 msec. A tooltip for 'Voltage Compensation' states 'Enables voltage compensation.'

Control Techniques

Control Strategy: Block Commutation

Feedback Mechanism: Hall Sensor

Control Technique: Speed Control

Current Measurement Configuration

Current Measurement: ☒ Enable

Measurement Type: ☒ Average Current, ☐ Direct DC Link

Trigger Control: ☒ Software Trigger, ☐ Hardware Trigger

Over Current Detection: ☐ Enable

Max Current Limit: 300 mA

Speed Control

PWM frequency: 20000 Hz

Phase Advance: ☐ Enable

Angle: 60 Degrees

Speed Control Via Pot: ☒ Enable

Trap: ☒ Enable

Voltage Compensation: ☐ Enable

Time Out: ☒ Enable

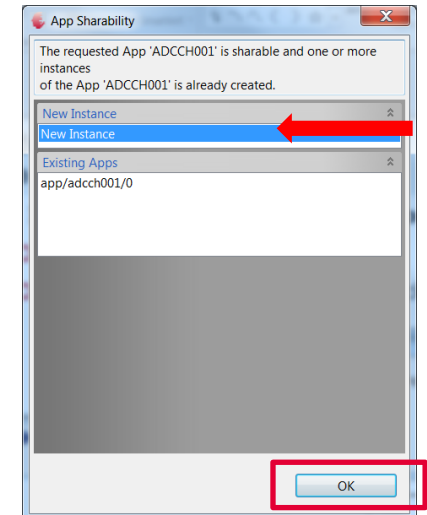
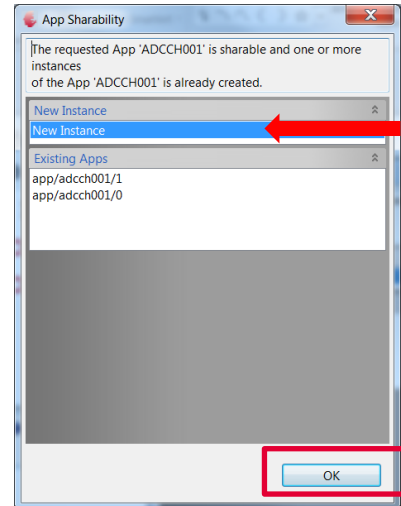
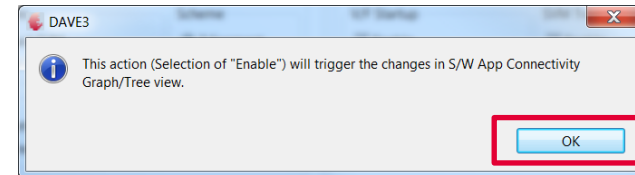
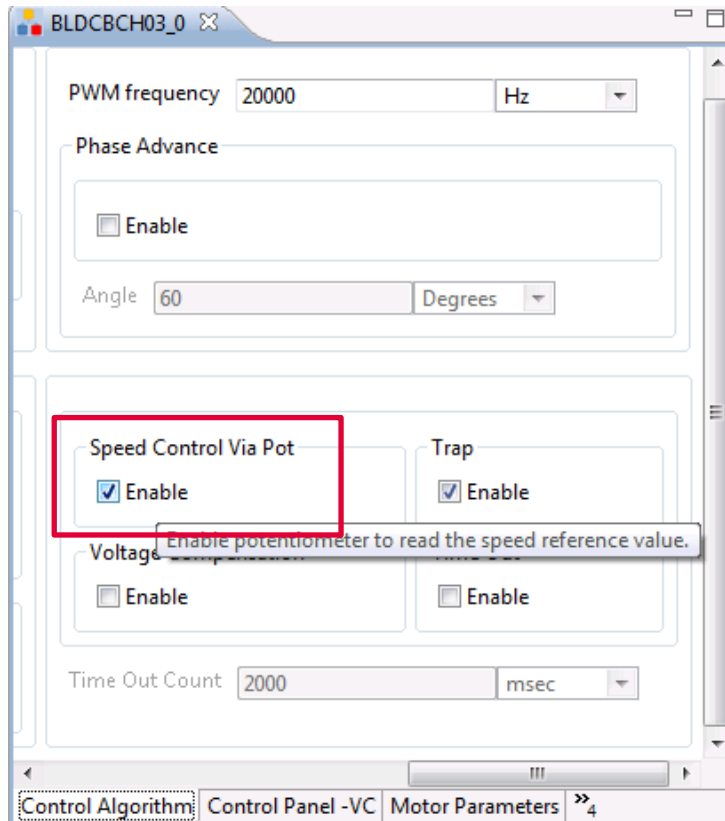
Time Out Count: 500 msec

Enables voltage compensation.

BLDC 3霍尔控制

■ Control Algorithm 页签,

□ 选中 **Speed Ref Via POT**

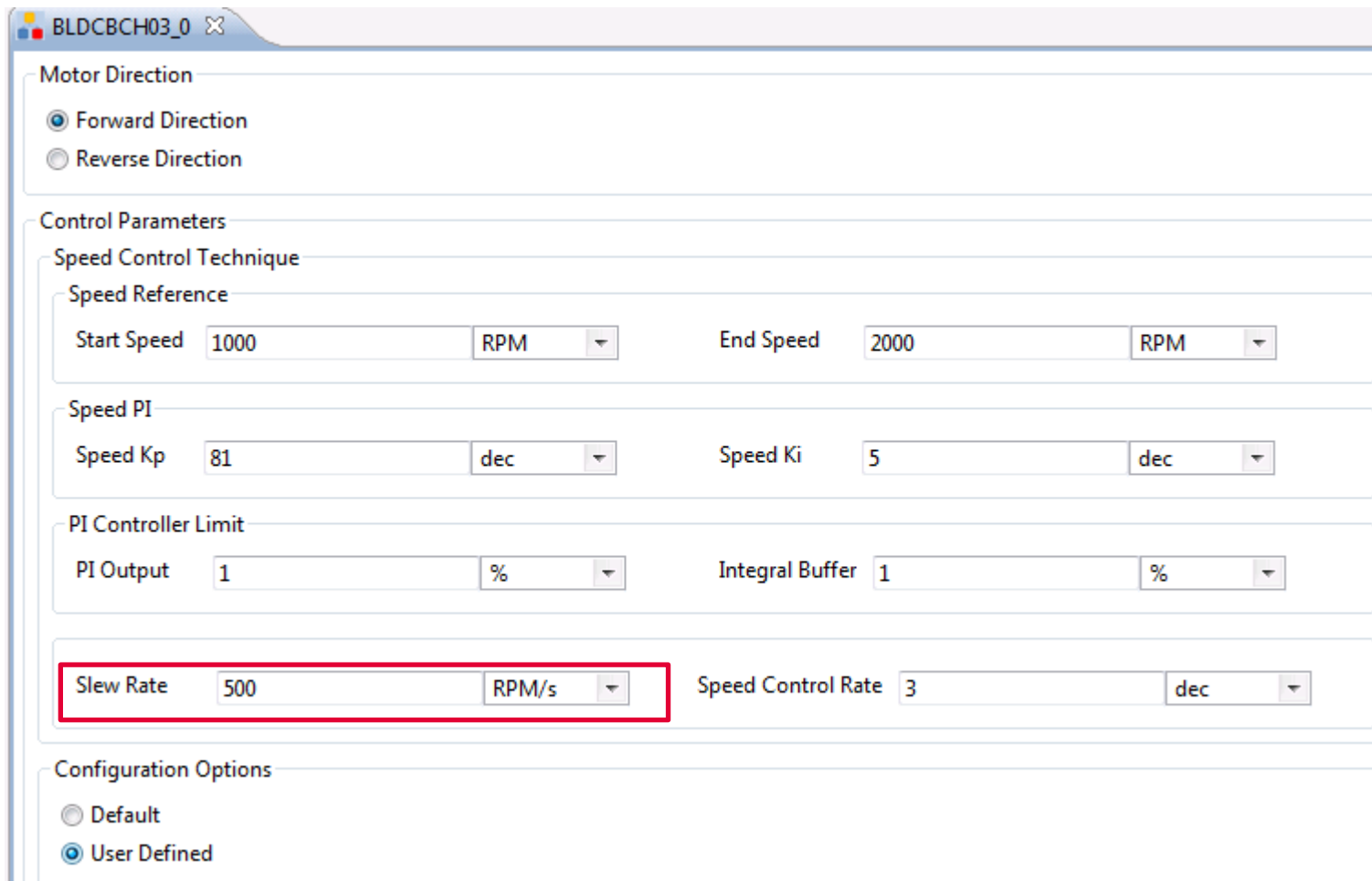


■ 点击 “New Instance” & “OK”

BLDC 3霍尔控制

□ Control Panel 页签,

Change Speed Slew Rate = **10 RPM/s**, 防止速度环震荡



BLDCBCH03_0

Motor Direction

☒ Forward Direction

☐ Reverse Direction

Control Parameters

Speed Control Technique

Speed Reference

Start Speed 1000 RPM End Speed 2000 RPM

Speed PI

Speed Kp 81 dec Speed Ki 5 dec

PI Controller Limit

PI Output 1 % Integral Buffer 1 %

Slew Rate 500 RPM/s Speed Control Rate 3 dec

Configuration Options

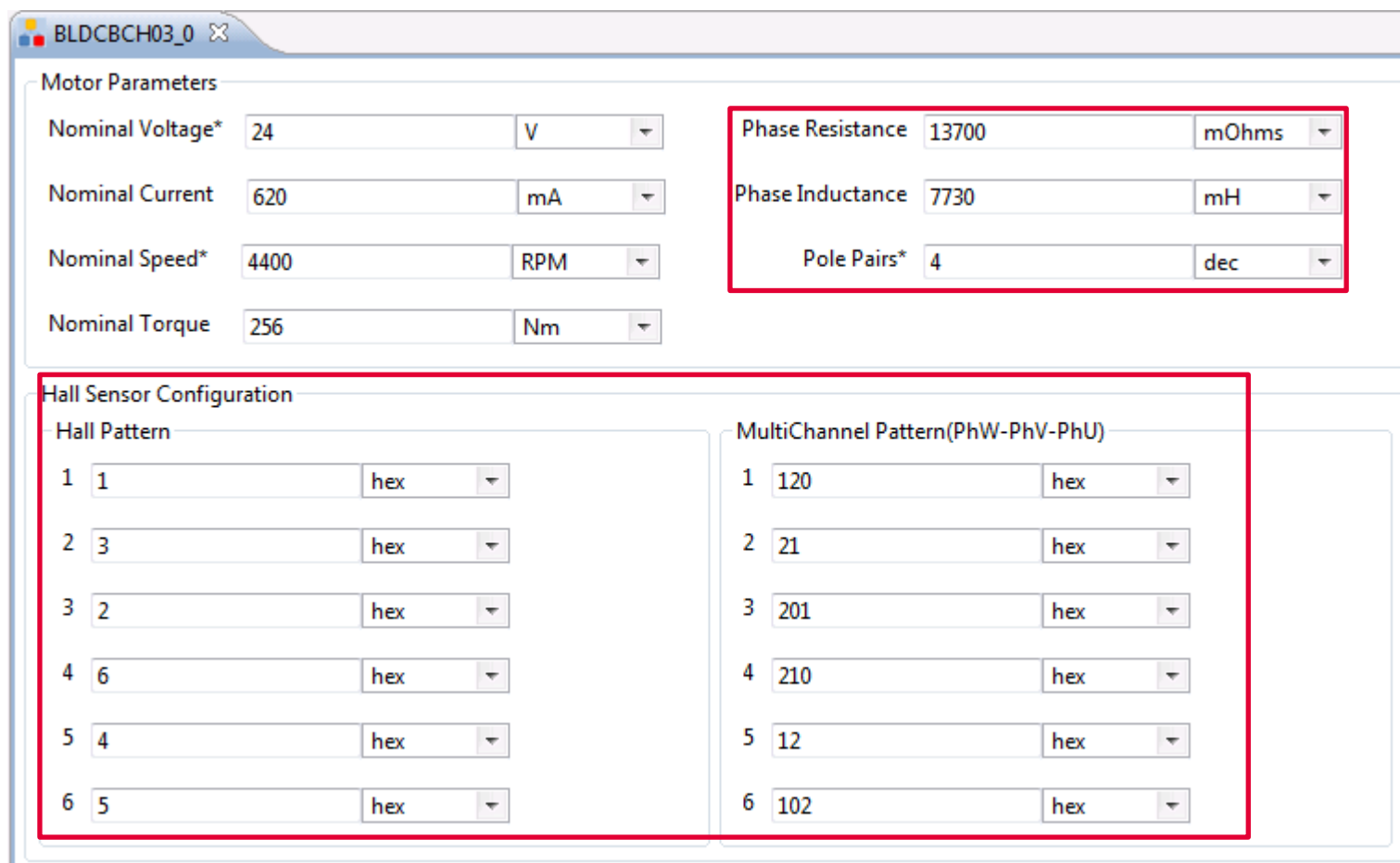
☐ Default

☒ User Defined

BLDC 3霍尔控制

□ Motor Parameters 页签,

- Phase Resistance为相电阻/相电感, 根据实际情况填写
- Hall Sensor Configuration为相关霍尔表格的填写处



The screenshot shows a configuration window titled "BLDCBCH03_0". It contains two main sections: "Motor Parameters" and "Hall Sensor Configuration".

Motor Parameters:

- Nominal Voltage*: 24 V
- Nominal Current: 620 mA
- Nominal Speed*: 4400 RPM
- Nominal Torque: 256 Nm
- Phase Resistance: 13700 mOhms
- Phase Inductance: 7730 mH
- Pole Pairs*: 4 dec

Hall Sensor Configuration:

Hall Pattern:

1	2	3
1	0	1
3	1	1
2	1	0
6	1	0
4	0	0
5	0	1

MultiChannel Pattern(PhW-PhV-PhU):

1	2	3	4	5	6
120	21	201	210	12	102

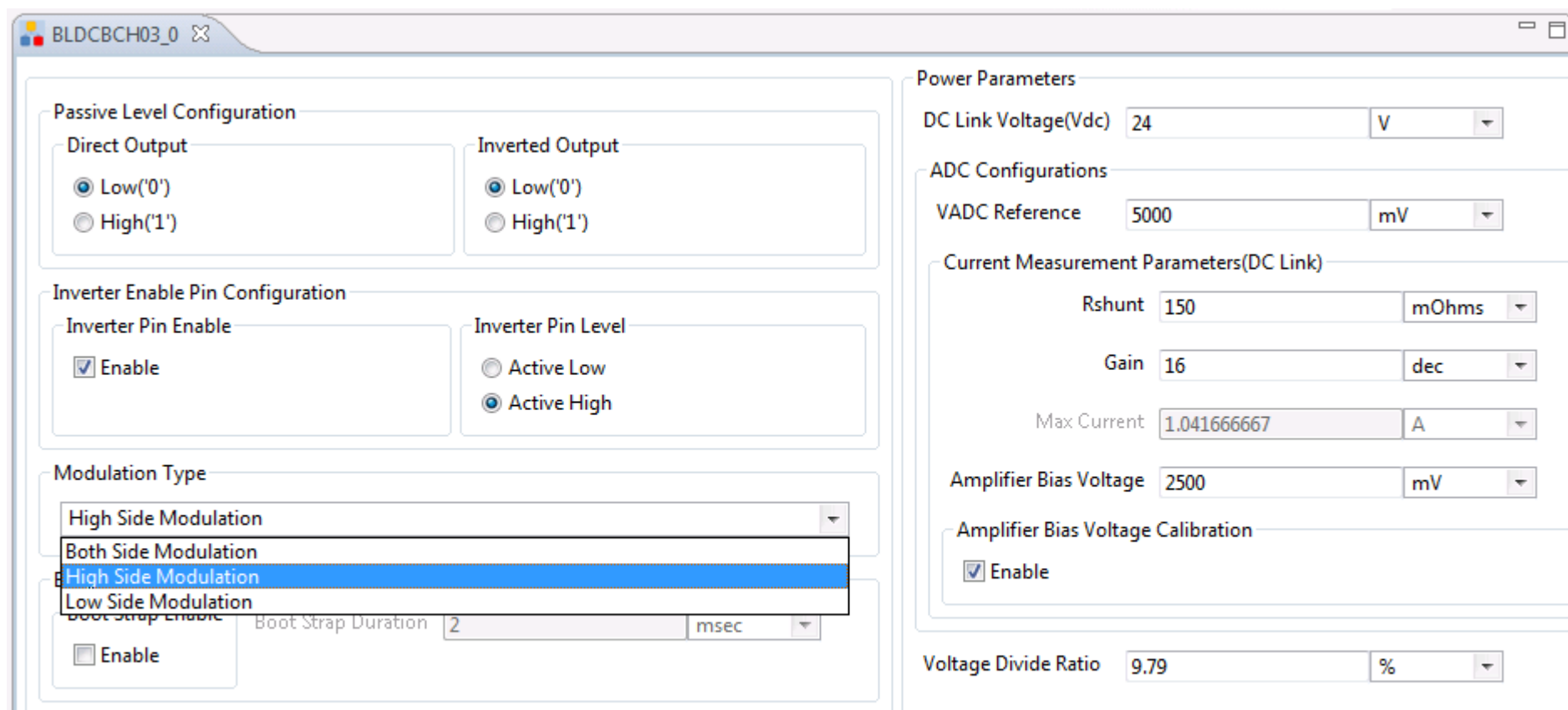
霍尔信号

#3	#2	#1
0	0	1
0	1	1
0	1	0
1	1	0
1	0	0
1	0	1

BLDC 3霍尔控制

❑ Power Board 页签,

- Modulation Type可以根据需要选择
- Rshunt为相电阻, Gain为放大电路放大系数, 根据实际情况填写



BLDCBCH03_0

Passive Level Configuration

Direct Output

- ☒ Low('0')
- ☐ High('1')

Inverted Output

- ☒ Low('0')
- ☐ High('1')

Inverter Enable Pin Configuration

Inverter Pin Enable

- ☒ Enable

Inverter Pin Level

- ☐ Active Low
- ☒ Active High

Modulation Type

- High Side Modulation
- Both Side Modulation
- High Side Modulation**
- Low Side Modulation

Boot Strap Enable

- ☐ Enable

Boot Strap Duration 2 msec

Power Parameters

DC Link Voltage(Vdc) 24 V

ADC Configurations

VADC Reference 5000 mV

Current Measurement Parameters(DC Link)

Rshunt 150 mOhms

Gain 16 dec

Max Current 1.041666667 A

Amplifier Bias Voltage 2500 mV

Amplifier Bias Voltage Calibration

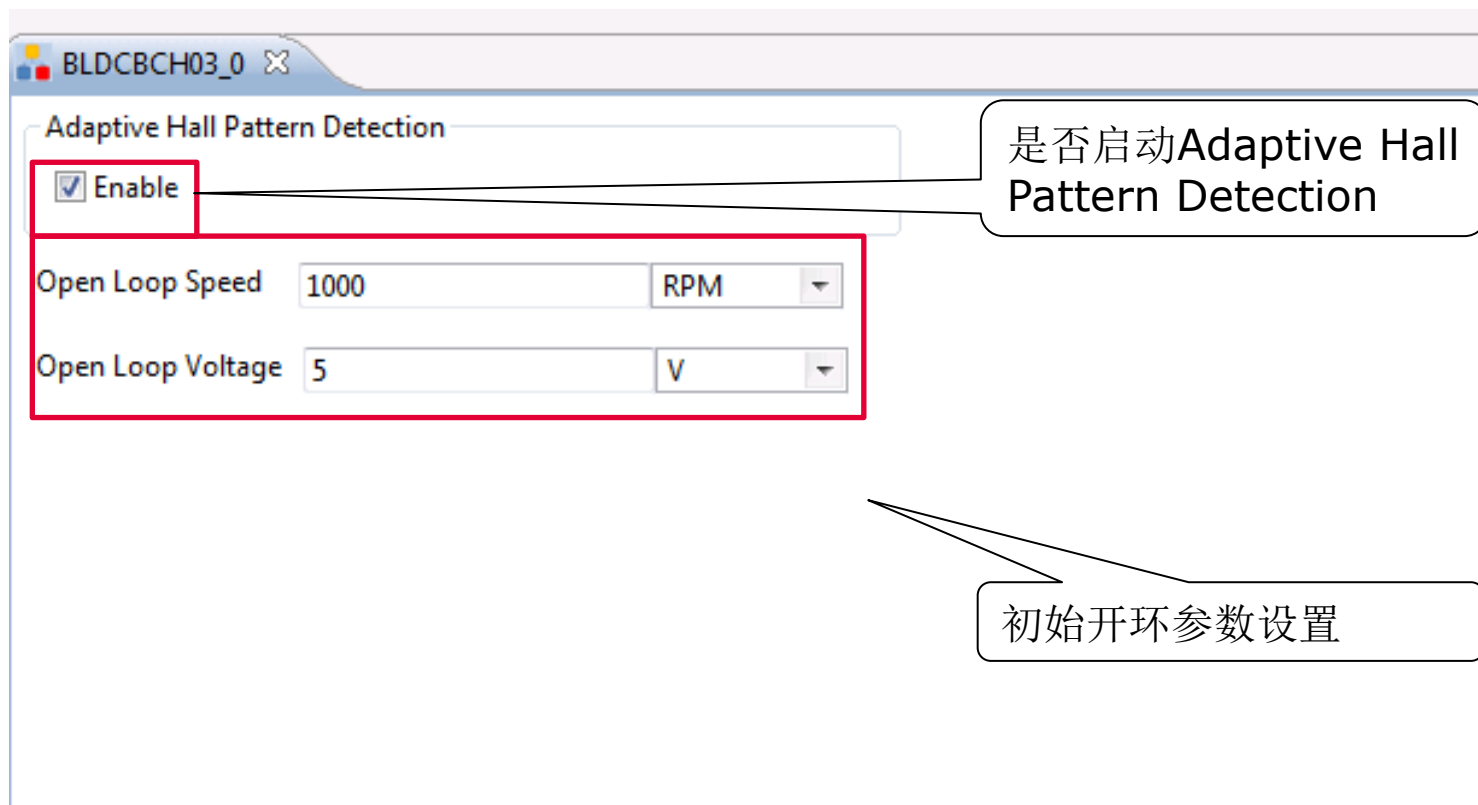
- ☒ Enable

Voltage Divide Ratio 9.79 %

BLDC 3霍尔控制

□ Adaptive HallPattern Detection 页签,

- Adaptive Hall Pattern 通过初始的开环工作来获取霍尔信号的顺序



The screenshot shows a configuration window titled "BLDCBCH03_0". Inside, there is a section for "Adaptive Hall Pattern Detection". A red box highlights the "Enable" checkbox, which is checked. Another red box highlights the "Open Loop Speed" and "Open Loop Voltage" fields. The "Open Loop Speed" is set to 1000 RPM, and the "Open Loop Voltage" is set to 5 V. Callout boxes provide additional context: one points to the "Enable" checkbox with the text "是否启动Adaptive Hall Pattern Detection", and another points to the "Open Loop Speed" and "Open Loop Voltage" fields with the text "初始开环参数设置".

BLDCBCH03_0

Adaptive Hall Pattern Detection

☒ Enable

Open Loop Speed 1000 RPM

Open Loop Voltage 5 V

是否启动Adaptive Hall Pattern Detection

初始开环参数设置

BLDC 3霍尔控制

■ 手动分配管脚



□ 点击  ，按照下表进行管脚分配

App	Pin Number
IO002/0 [U_H]	P0.0
IO002/1 [U_L]	P0.1
IO002/2 [V_H]	P0.7
IO002/3 [V_L]	P0.6
IO002/4 [W_H]	P0.8
IO002/5 [W_L]	P0.9
IO004/0 [Enable_Pin]	P0.11
IO002/6 [Trap_Pin]	P0.12
IO001/0 [I_DC]	P2.7
IO001/1 [POT]	P2.5
IO002/7 [HALL_0]	P0.13
IO002/7 [HALL_1]	P1.1
IO002/7 [HALL_2]	P0.15

BLDC 3霍尔控制

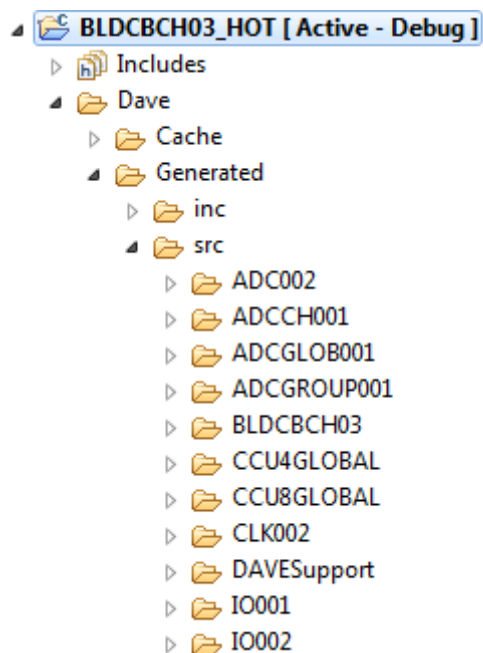
■ 点击 **Solve and Save**, 点击**Close**

■ 生成代码

□ 点击



□ 生成的代码将放在该Project的 ../Dave/Generated 里



BLDC 3霍尔控制

- 在main中调用以下API来启动电机

BLDCBCH03_MotorStart(&BLDCBCH03_Handle0)

```
#include <DAVE3.h>           //Declarations from DAVE3 Code Generation (includes SFR declaration)

int main(void)
{
    // status_t status;       // Declaration of return variable for DAVE3 APIs (toggle comment if required)

    DAVE_Init();             // Initialization of DAVE Apps

    /* Start the Motor */
    BLDCBCH03_MotorStart(&BLDCBCH03_Handle0);

    while(1)
    {

    }

    return 0;
}
```

BLDC 3霍尔控制

■ 编译项目

1. 单击 

2. 等待 **Build Finished**

```
S/W App Connectivity View | H/W Connectivity View | Properties | Problems | Console
CDT Build Console [ACCIMVF01_Example01]
'Invoking: ARM-GCC Create Flash Image'
"C:\Infinion\TIMM\DAVE-3.1.4_20130201\DAVE-3.1.4_20130201\ARM-GCC\bin/arm-none-eabi-objcopy" -O ihex "ACCIMVF01_Example01.hex"
'Finished building: ACCIMVF01_Example01.hex'
'Invoking: ARM-GCC Create Listing'
"C:\Infinion\TIMM\DAVE-3.1.4_20130201\DAVE-3.1.4_20130201\ARM-GCC\bin/arm-none-eabi-objdump" -h -S "ACCIMVF01_Example01.elf"
'Finished building: ACCIMVF01_Example01.lst'
'Invoking: ARM-GCC Print Size'
"C:\Infinion\TIMM\DAVE-3.1.4_20130201\DAVE-3.1.4_20130201\ARM-GCC\bin/arm-none-eabi-size" --format=berkeley "ACCIMVF01_Example01.elf"
text      data      bss      dec      hex      filename
27044      80      2152    29276    725c    ACCIMVF01_Example01.elf
'Finished building: ACCIMVF01_Example01.siz'
**** Build Finished ****
```

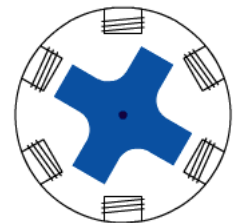
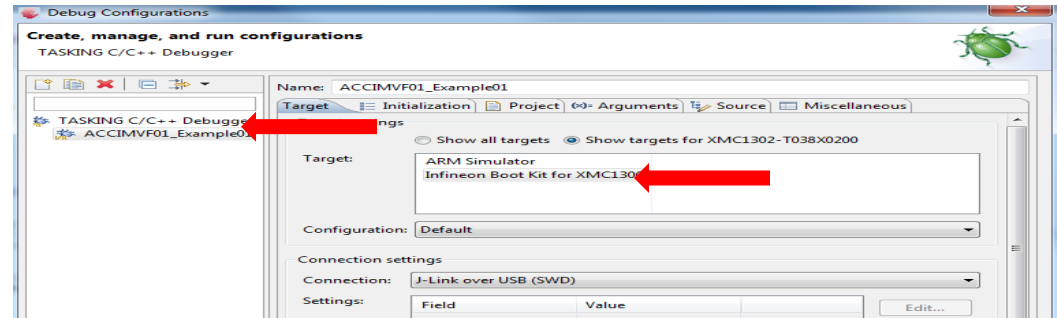
■ 加载代码

1. 单击 

2. 双击 **Tasking C/C++ Debugger** in **Debug Configuration**

3. 选择 **Infineon Boot Kit for XMC1300**, 并单击 **Debug**

4. 单击,  启动程序





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