

NM18017應用範例- 24V風扇



2021/Dec

系統簡介

NM18107 FOC/1-shunt

24V/2A/50W

調速界面

- VSP
 - 0V~5V
- UART

命令種類

- Speed control
 - 200~2000rpm

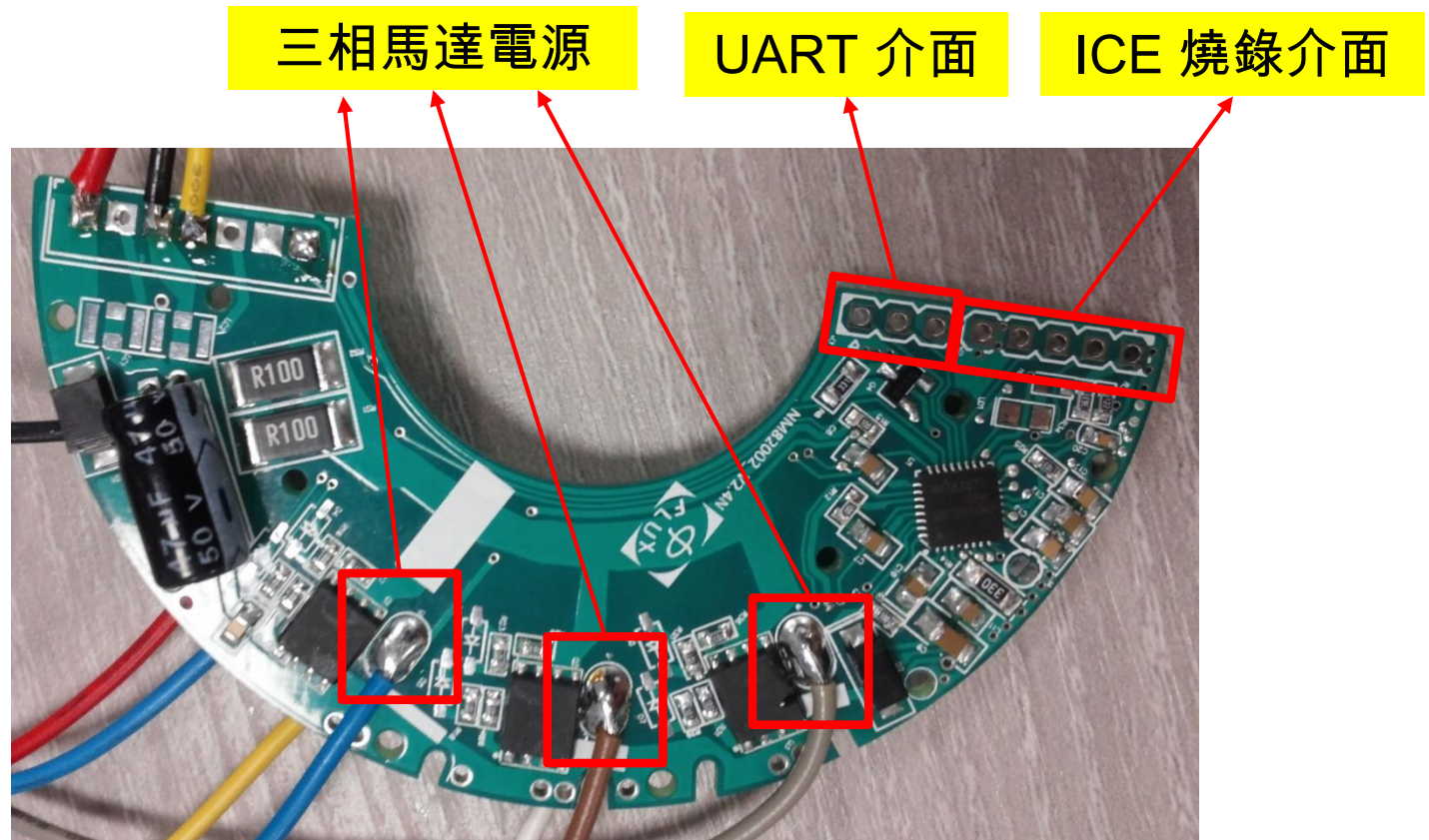
保護功能

- 堵轉保護
- 過/低壓保護
- 過流保護
- 霍爾斷線偵測

其他功能

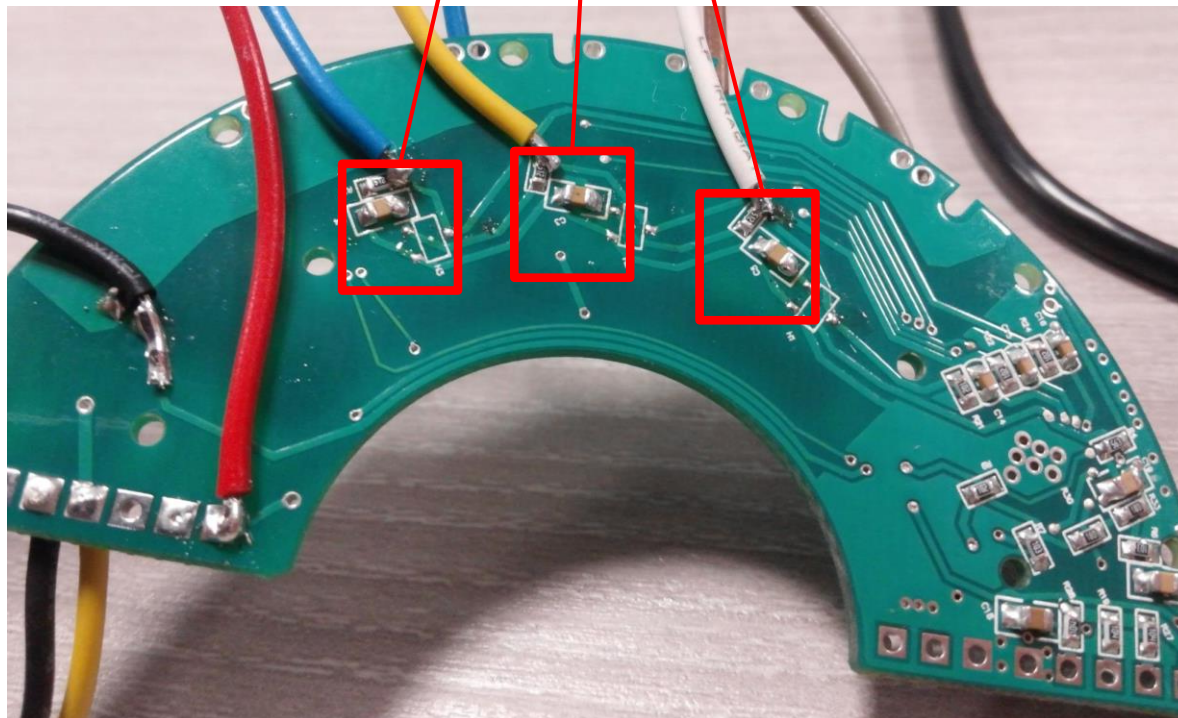
- 順逆風啟動
- 正/反轉
- 啟動/停止
- FG輸出

電路板配置

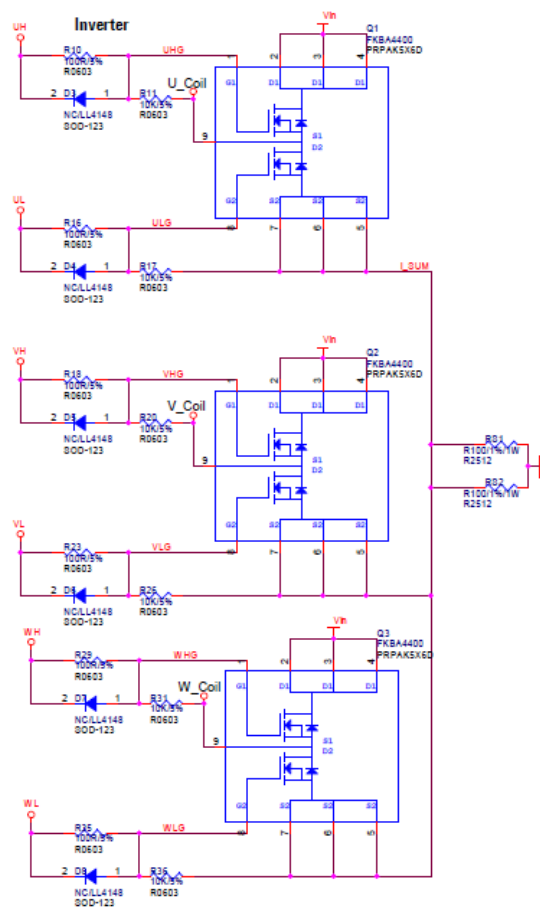
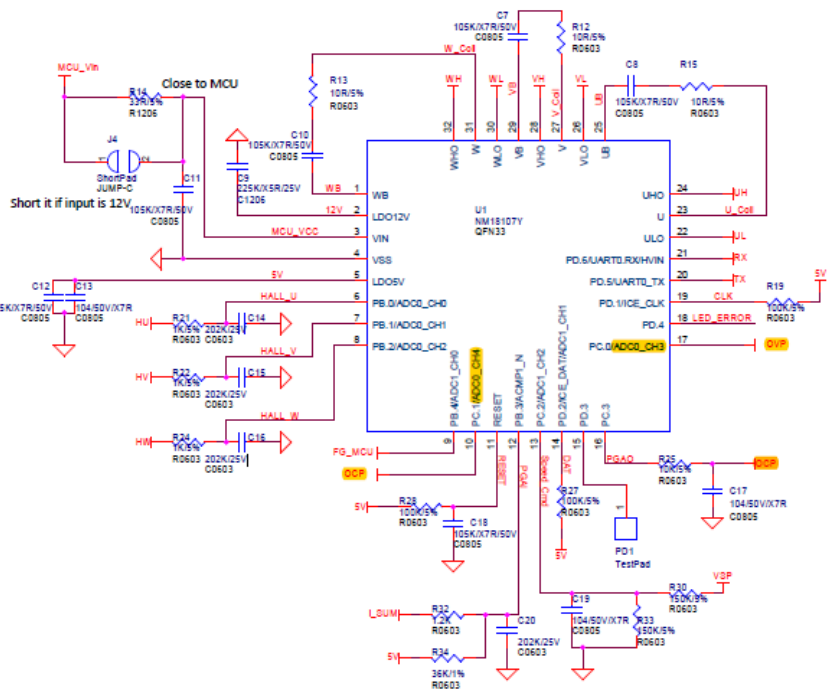
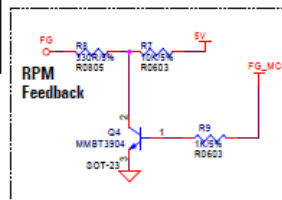
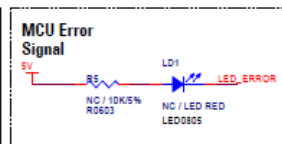
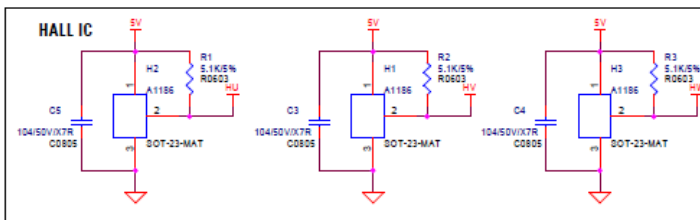
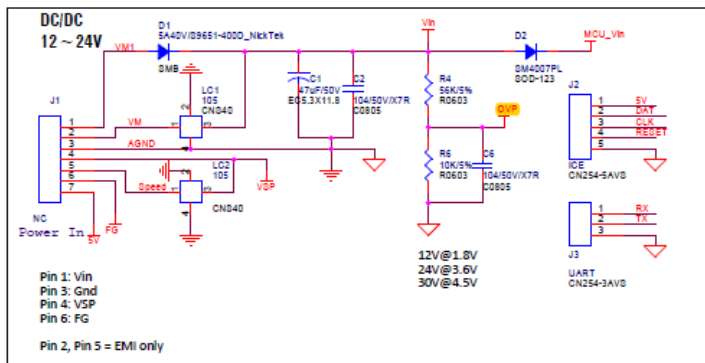


電路板配置

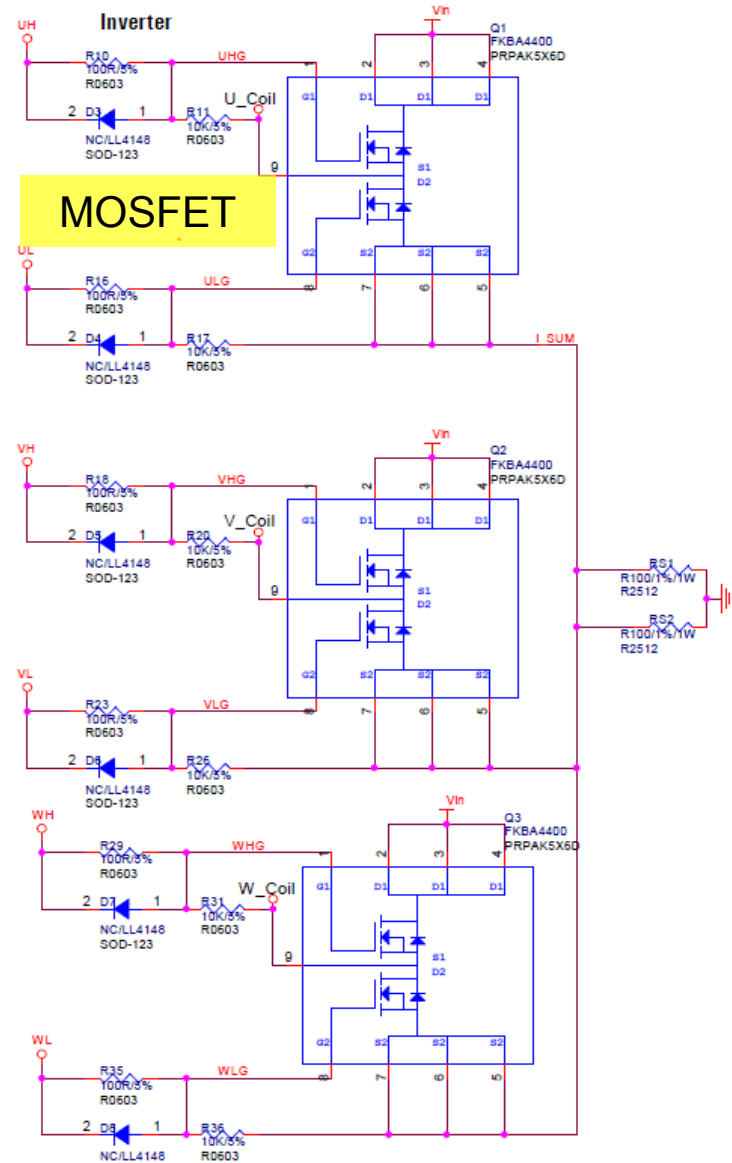
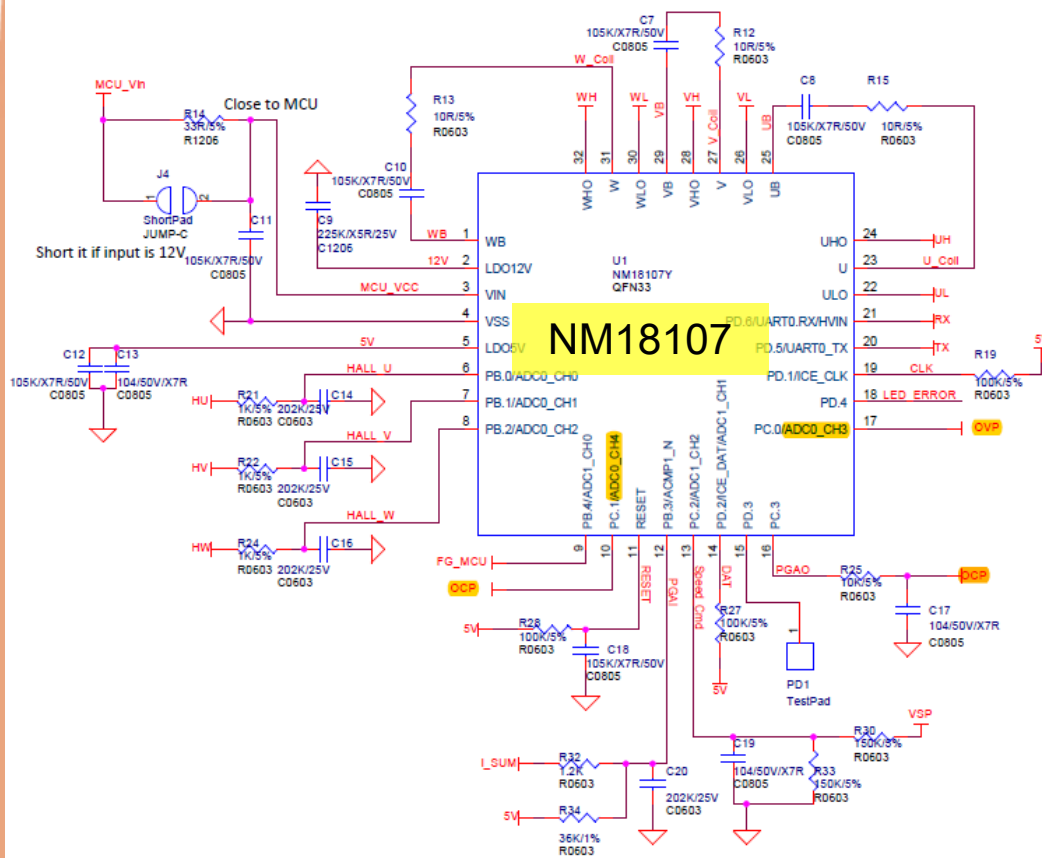
Hall signal from
motor
W U V



參考電路



驅動電路

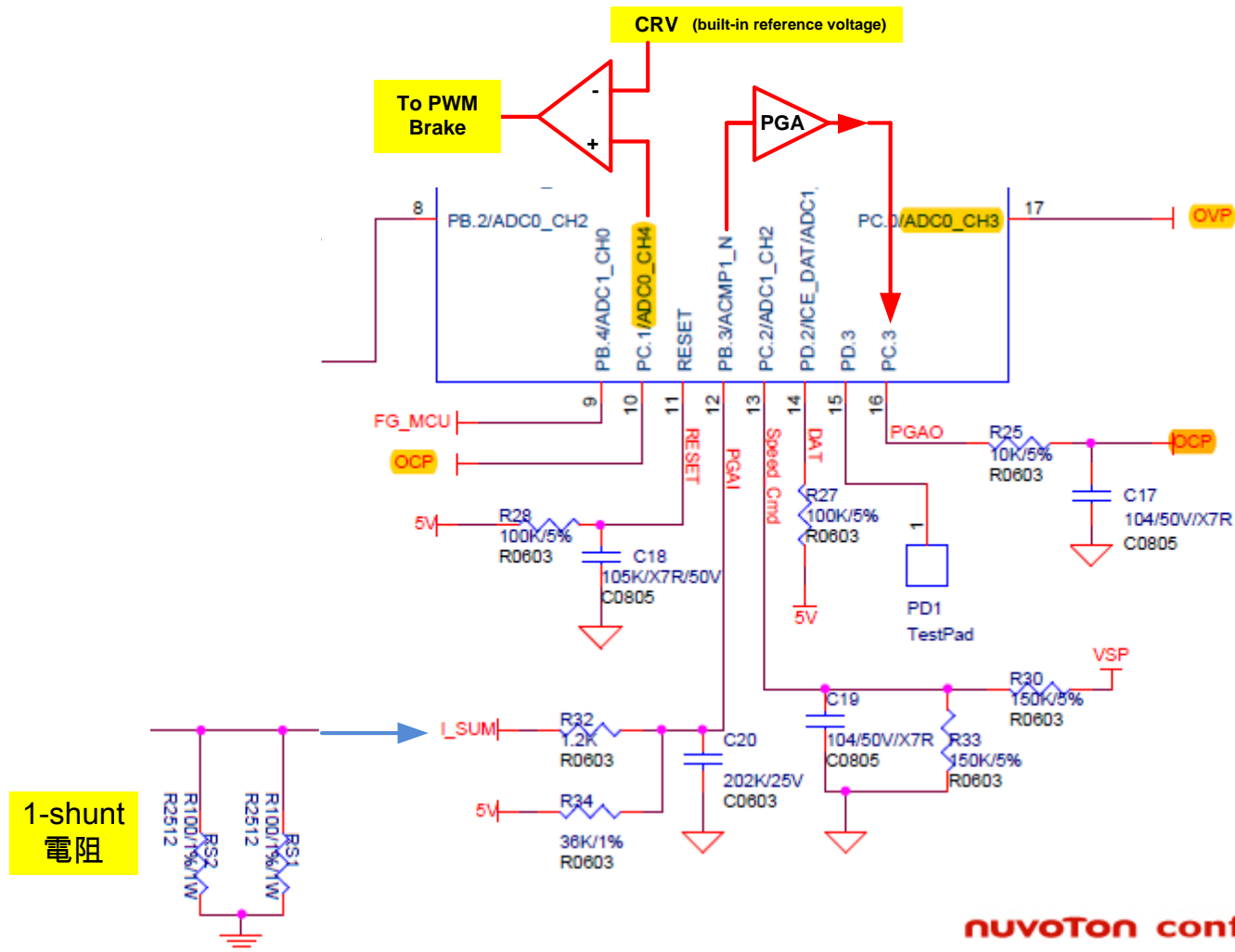


nuvoTon confidential

- NM18107 = MCU + Gate-Driver
- 6 discrete MOSFET

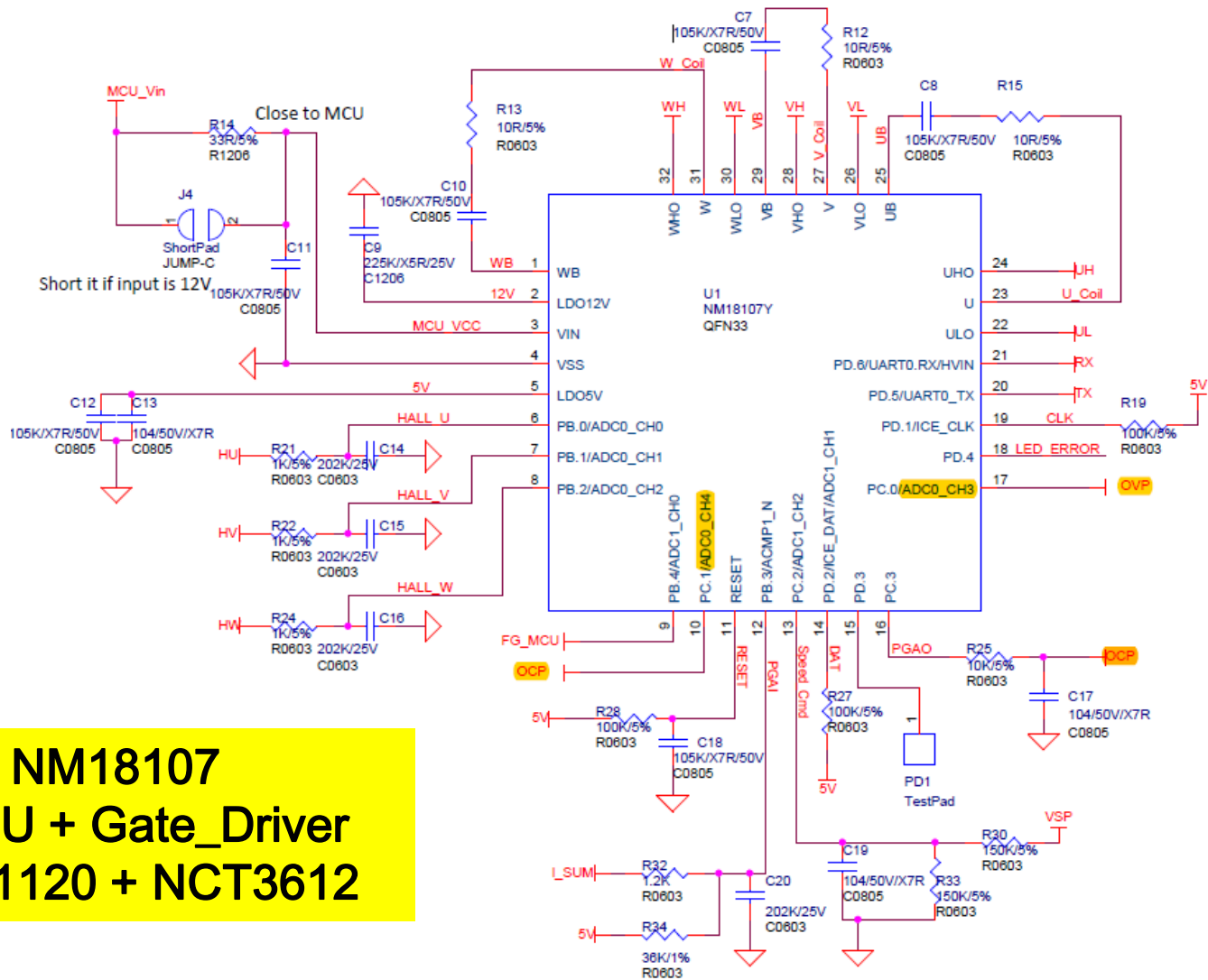
內建PGA & 比較器

- 內建PGA(Programmable Gain Amplifier)及比較器，整體的PCB佈局較為簡單，且 BOM cost也較低。



MCU

- 應用範例採用NM18107具有32個管腳合封的MCU + Gate-Driver。



NM18107
= MCU + Gate_Driver
= NM1120 + NCT3612

腳位功能描述

Pin Define		Function	Description
MCU	PA.0 [*]	UH	High side PWM for U
	PA.1 [*]	UL	Low side PWM for U
	PA.2 [*]	VH	High side PWM for V
	PA.3 [*]	VL	Low side PWM for V
	PA.4 [*]	WH	High side PWM for W
	PA.5 [*]	WL	Low side PWM for W
PGA	PB.3	PGAI	PGA input for shunt Isum
	PC.3	PGAO	PGA output for OCP
Hall	PB.0	Hall U	Hall sensor aligned to U
	PB.1	Hall V	Hall sensor aligned to V
	PB.2	Hall W	Hall sensor aligned to W
ADC	PC.0	DCV	Bus voltage detection
	PC.1	I_Bus	Bus current detection
IO	PD.4	LED_Error	LED index for error
	PD.3	TestPad	User defined I/O for test use
	PB.4	FG_MCU	Frequency output for motor speed
	PC.2	VSP	Analog speed CMD input
	PD.5	TX	UART Tx
	PD.6	RX	UART Rx
	PD.2	DAT	User defined I/O

* MCU PWM output pins are wired to gate-driver in the chip

腳位功能描述

Pin Define		Function	Description
PWM Out	UHO	Gate-driver PWM Output	Drive high side MOS in phase U
	ULO	Gate-driver PWM Output	Drive low side MOS in phase U
	VHO	Gate-driver PWM Output	Drive high side MOS in phase V
	VLO	Gate-driver PWM Output	Drive low side MOS in phase U
	WHO	Gate-driver PWM Output	Drive high side MOS in phase W
	WLO	Gate-driver PWM Output	Drive low side MOS in phase W
3-phase Coil	U	U_Coil	U-Phase input
	V	V_Coil	V-Phase input
	W	W_Coil	W-Phase input
Bootstrap Cap.	UB	Bootstrap Cap U	High-side Cap-U bootstrap supply
	VB	Bootstrap Cap V	High-side Cap-V bootstrap supply
	WB	Bootstrap Cap W	High-side Cap-W bootstrap supply
Power	VIN	Power input	24V Power input
	VSS	Ground	Ground for digital circuit
	LDO5V	5V LDO output	LDO for MCU power
	LDO12V	12V LDO output	LDO for gate driver

異常狀態

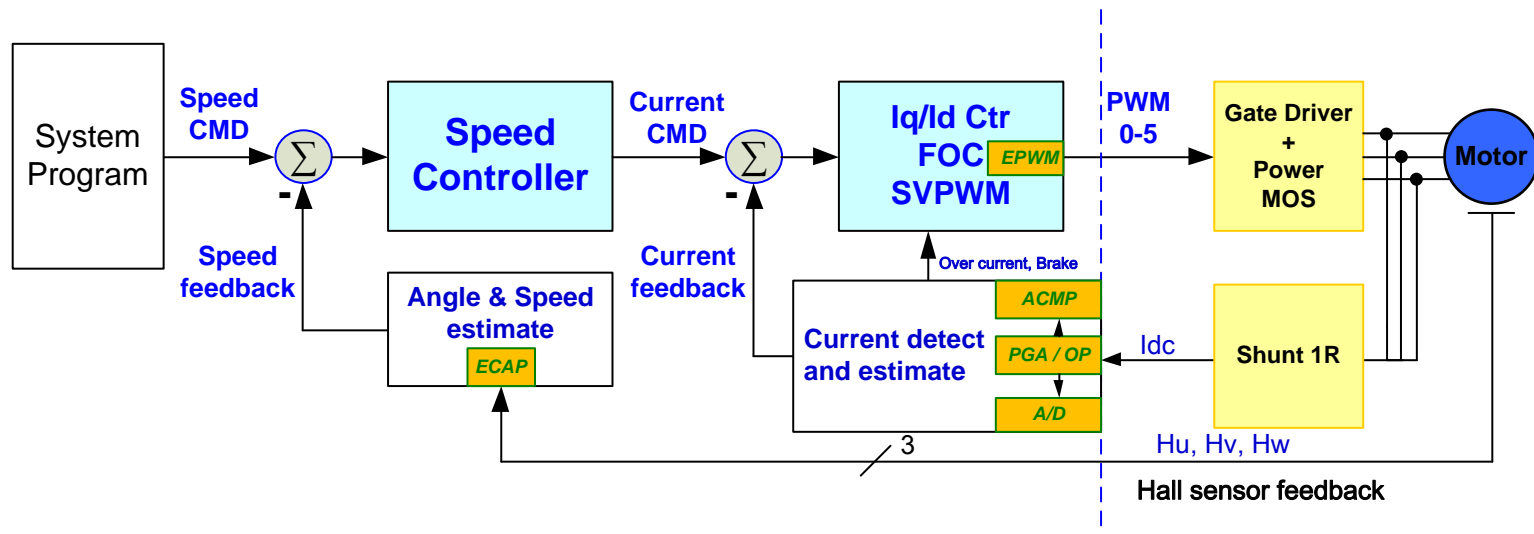
狀態	LED	判定條件
正常	以0.5秒的速度亮滅	-
異常	恆亮	當DC偵測電流高於DAC0的設定值
	恆亮後回復正常閃爍，如連續三次觸發，則保持恆亮	馬達運行時，若轉速低於C_MIN_SPEED_LOCK_ROTOR
		馬達運行時，若轉速低於C_MIN_SPEED_LOCK_ROTOR 且 電流高於C_IDC_BC_Q15_MAX
	恆亮	Hall訊號為0或7
	恆亮	輸入電壓低於C_DCBUC_LV_ADC_VAL
	恆亮	輸入電壓低於C_DCBUC_LV_ADC_VAL
	恆亮	shunt電阻偵測的電壓高於C_IDC_Bus_OC_Q15_MAX
	恆亮	1. 當Lock_Rotor_Err或LSC_Err連續成立C_NumberOfRestarts次， 2. 前述 每次發生的間隔不超過10秒，如超過10秒則重新計算。
	恆亮	相電流高於C_Phase_OVER_CURRENT_1_0_A
	恆亮	相電流高於C_Phase_OVER_CURRENT_1_0_A
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異常狀態

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驅動方式-FOC

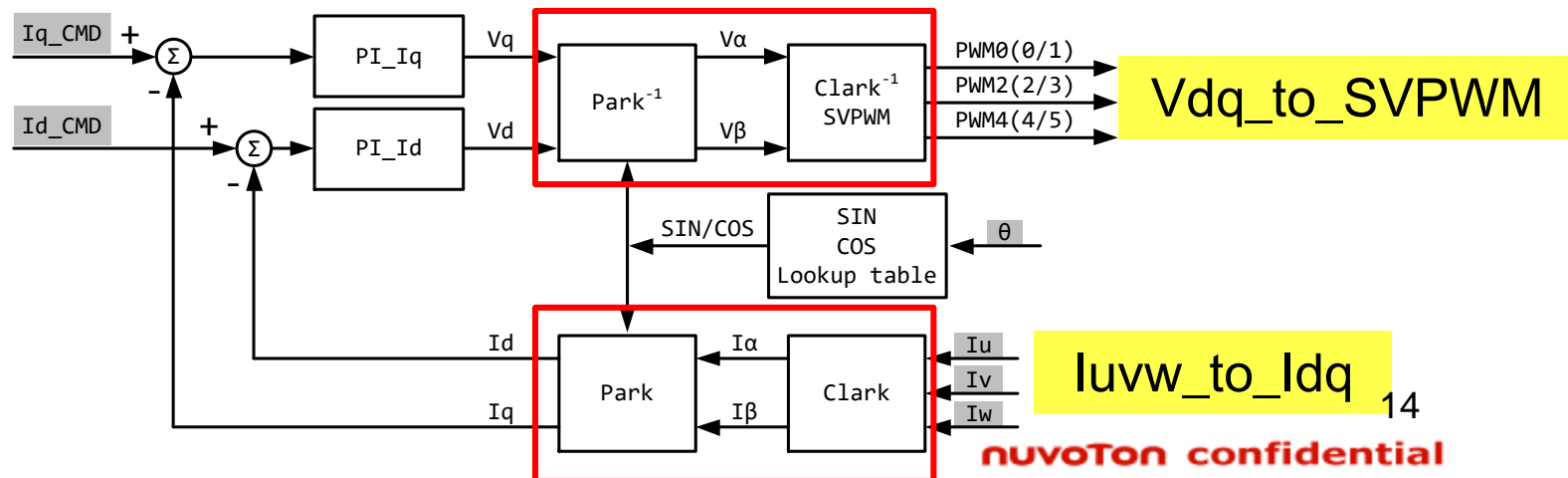
- ▶ Demo System : Sine-wave
- ▶ Current Feedback: $1R$ (R : current shunt resistance)



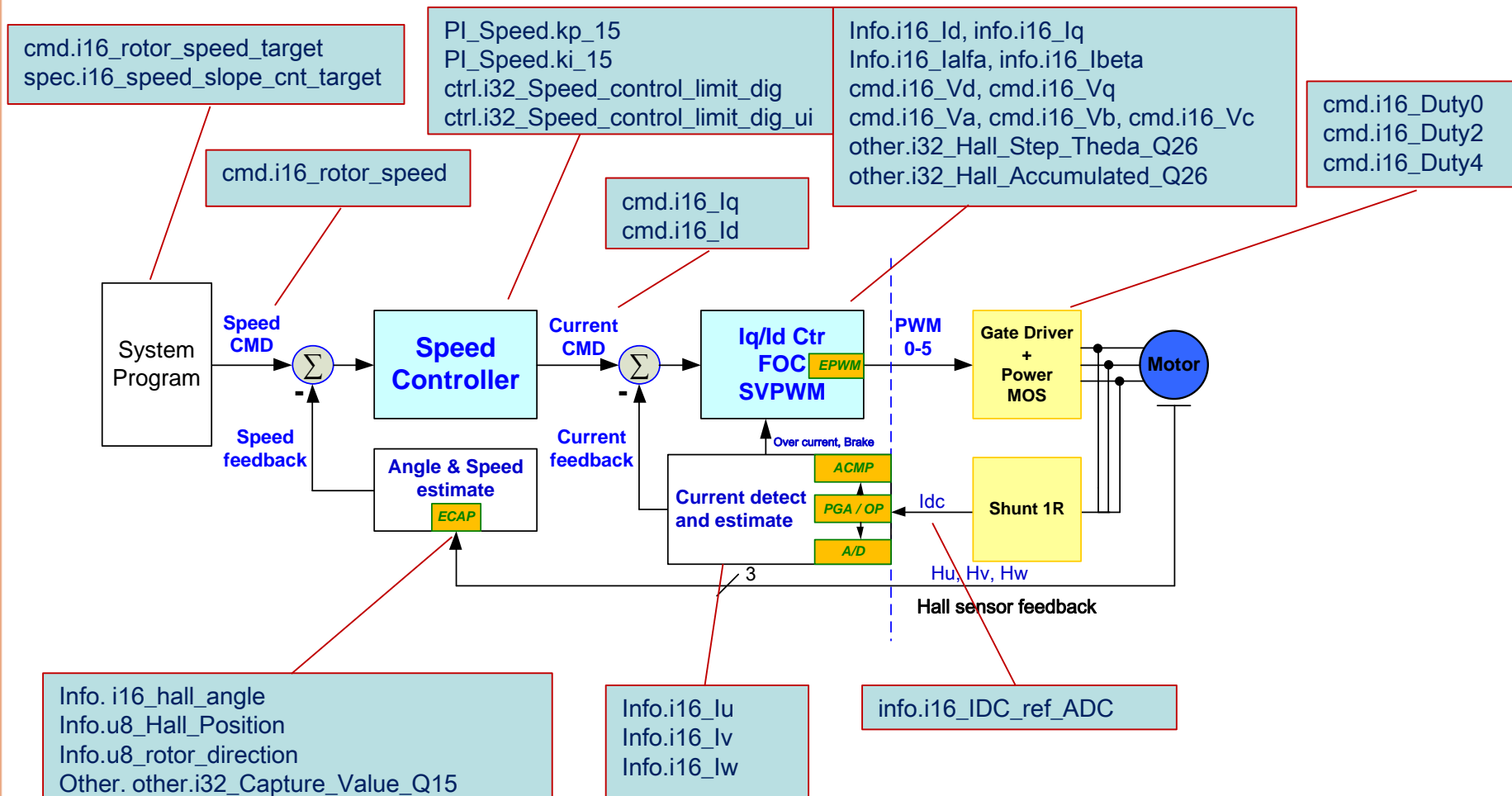
Demo System
Hall + FOC + 1R

FOC相關副程序

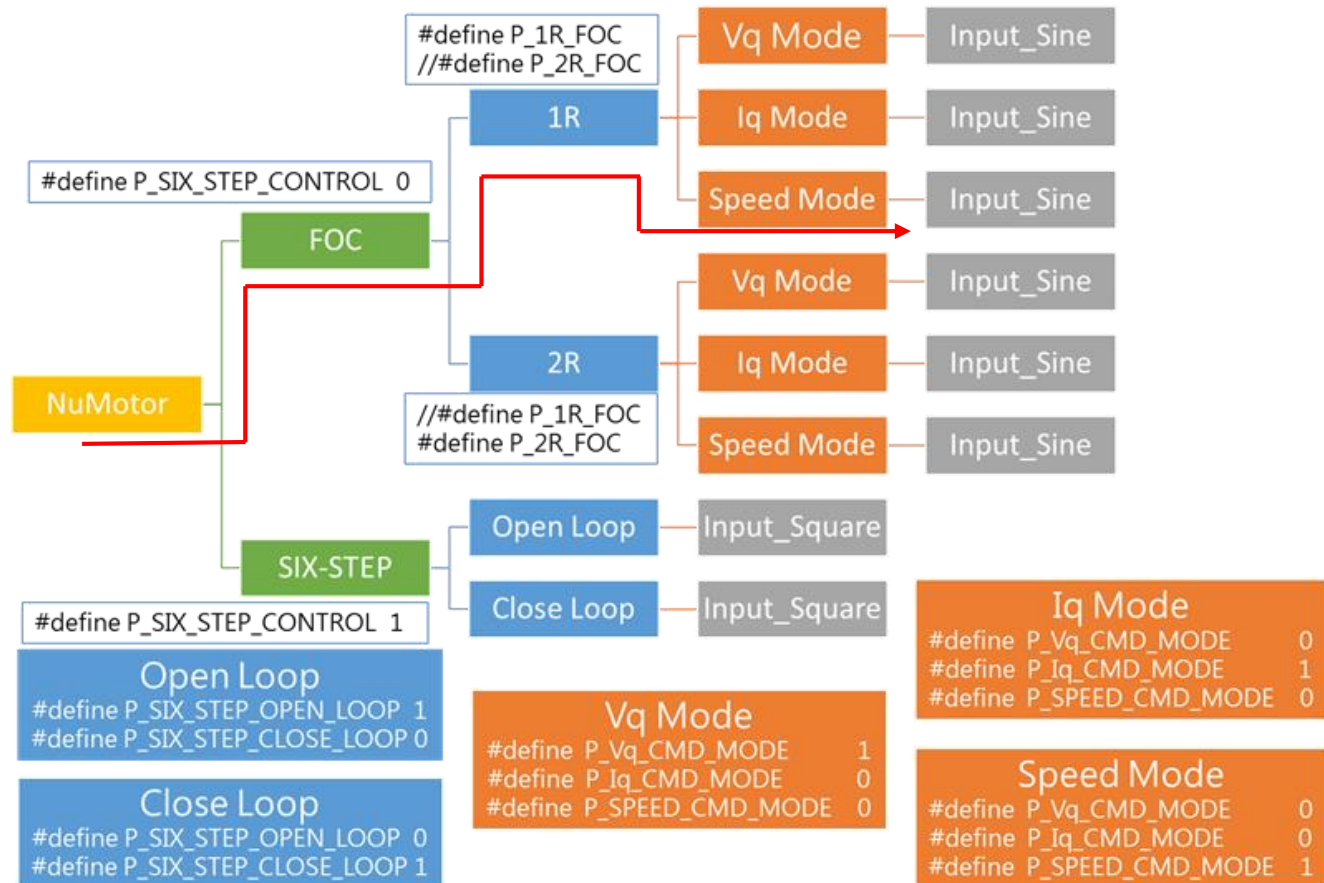
- ▶ void **luvw_to_Idq_Transfer**(AMotor* Motor, int32 sin, int32 cos)
 - Do **Clark Transfer**: Transfer Iu/v/w to Ialfa/beta
 - Do **Park Transfer**: Transfer Ialfa/beta to Id/q
- ▶ void **Vdq_to_SVPWM_1R**(AMotor* Motor, EPWM_T* epwm, int32 pwm_full_scale, int32 pwm_max_duty, int32 sin, int32 cos)
 - Do **Inv_Park Transfer**: Transfer Vd/q to Valfa/beta
 - Do Modified **Inv_Clark Transfer**: Transfer Valfa/Vbeta to Vrefx/y/z
 - Do **SVPWM** calculation to produce Duty0/2/4
 - **Update duty** to EPWM->CMPDAT[0/2/4]



控制器重要參數示意



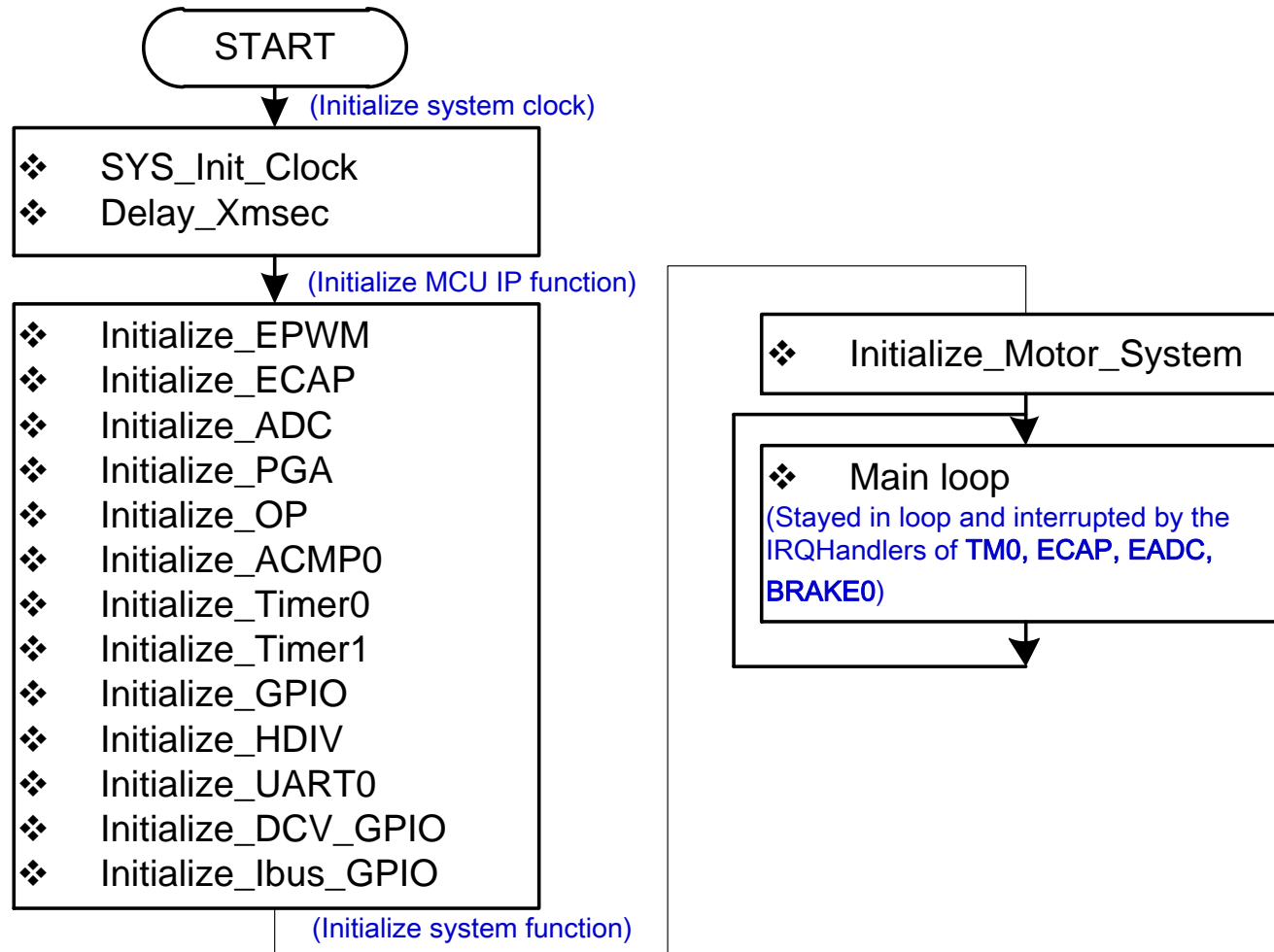
馬達驅動控制模式@system_parameter.h



目前預設的控制模式為速度控制。

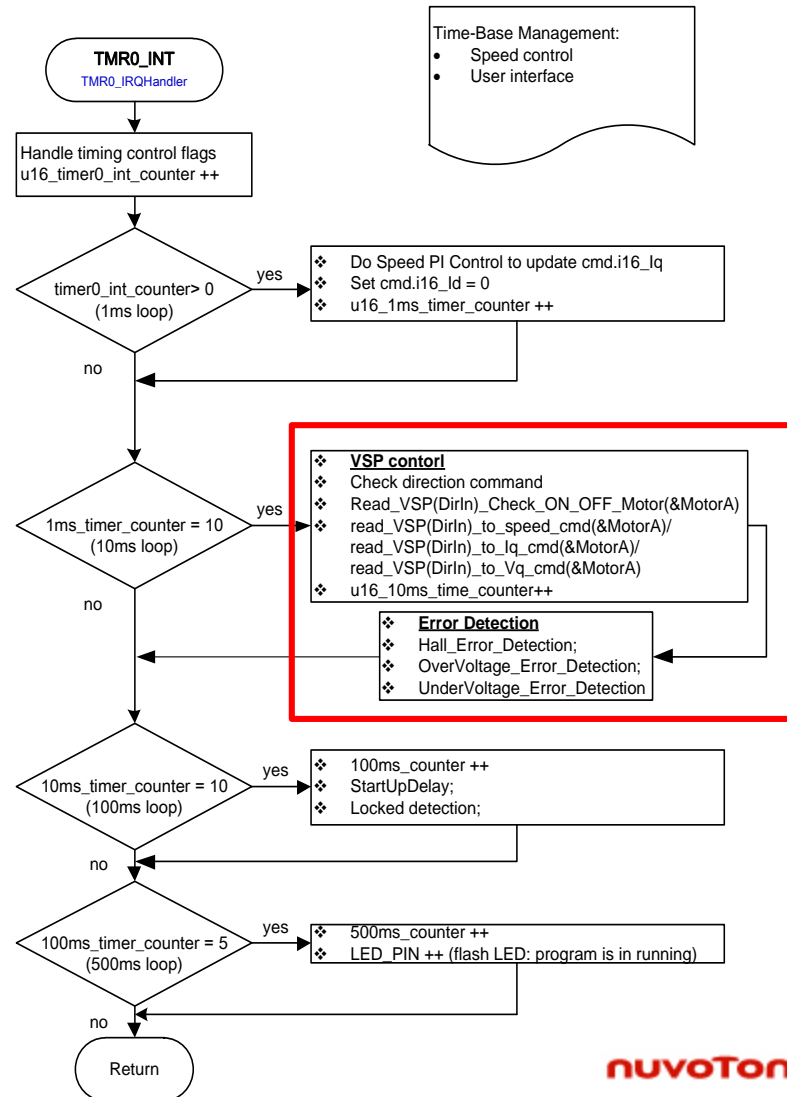
Flow Chart of main.c

► Main program to initialize MCU and system



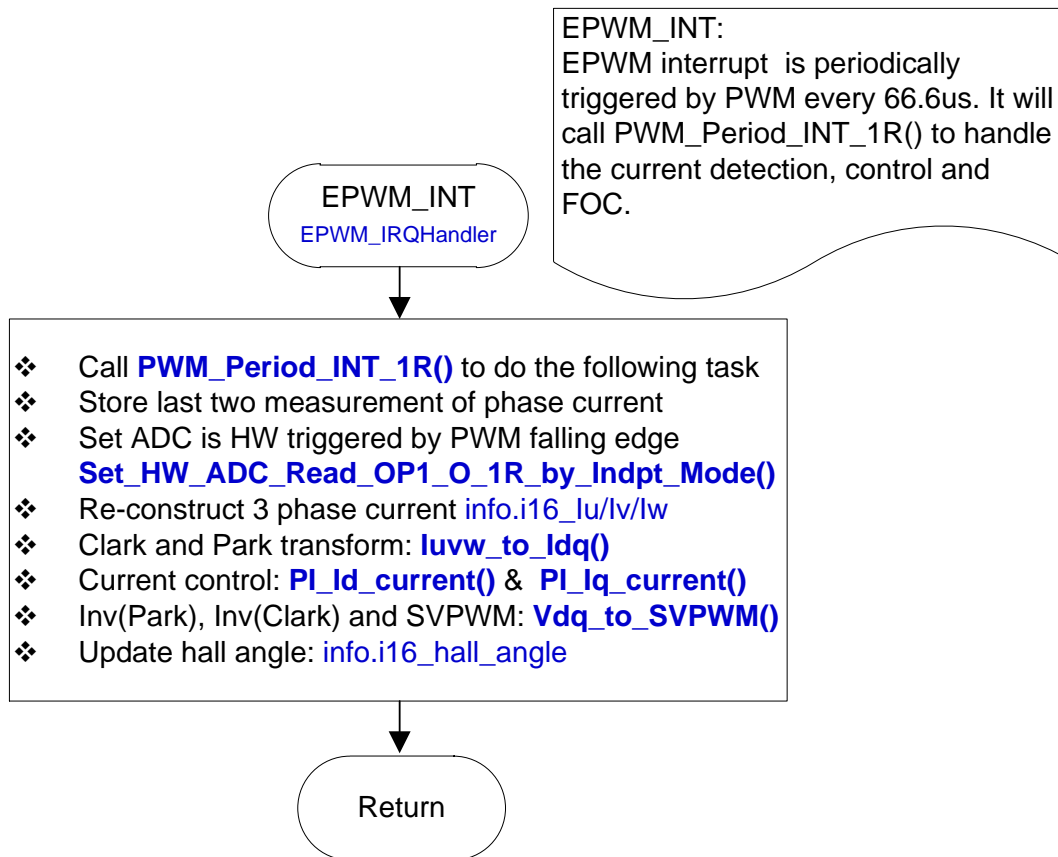
Flow Chart of TMR0_INT (for FOC)

- ▶ Timer0 INT for system timer handles the user interface and speed control



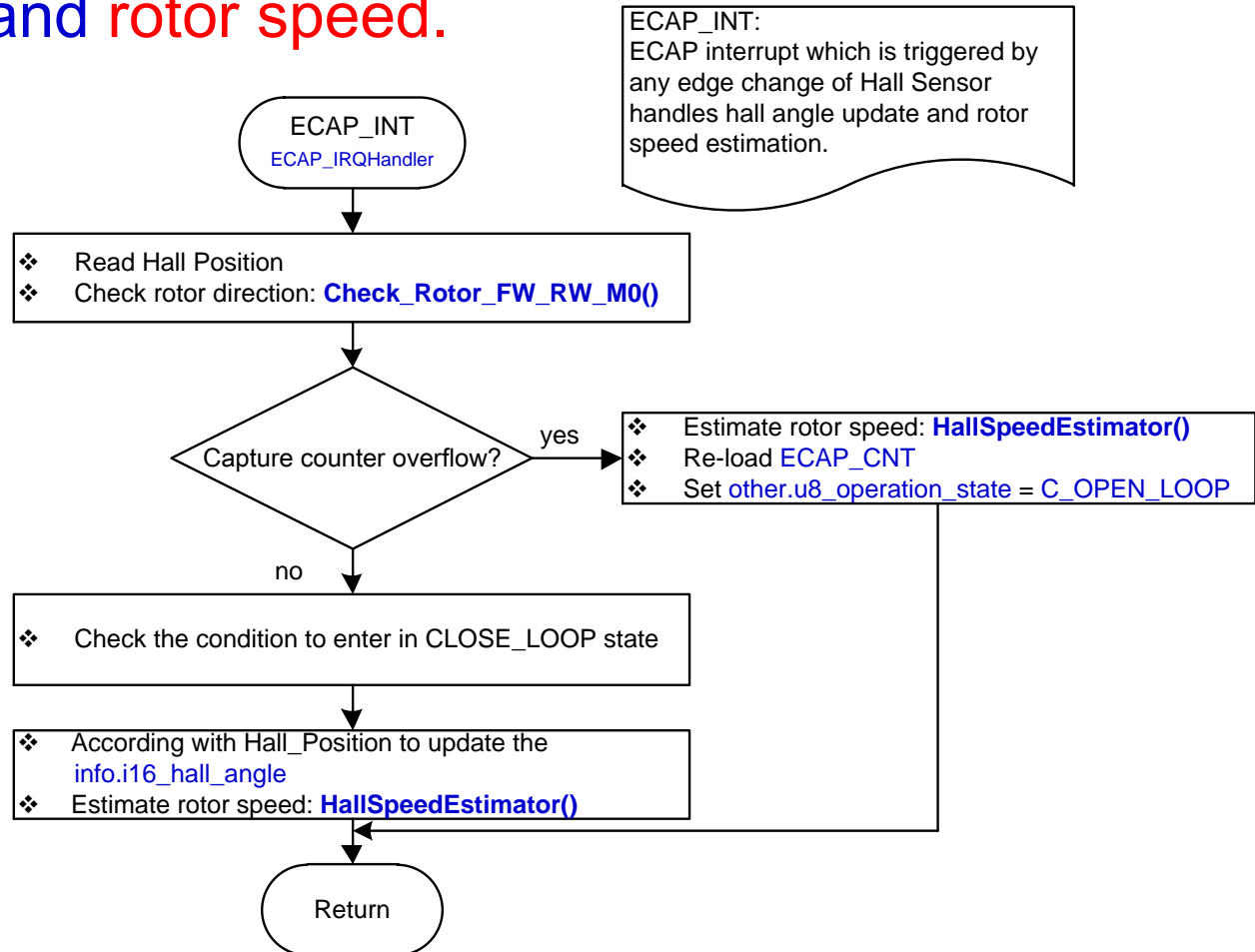
Flow Chart of EPWM_INT (for 1R)

► EPWM INT: for current control and FOC (1R)



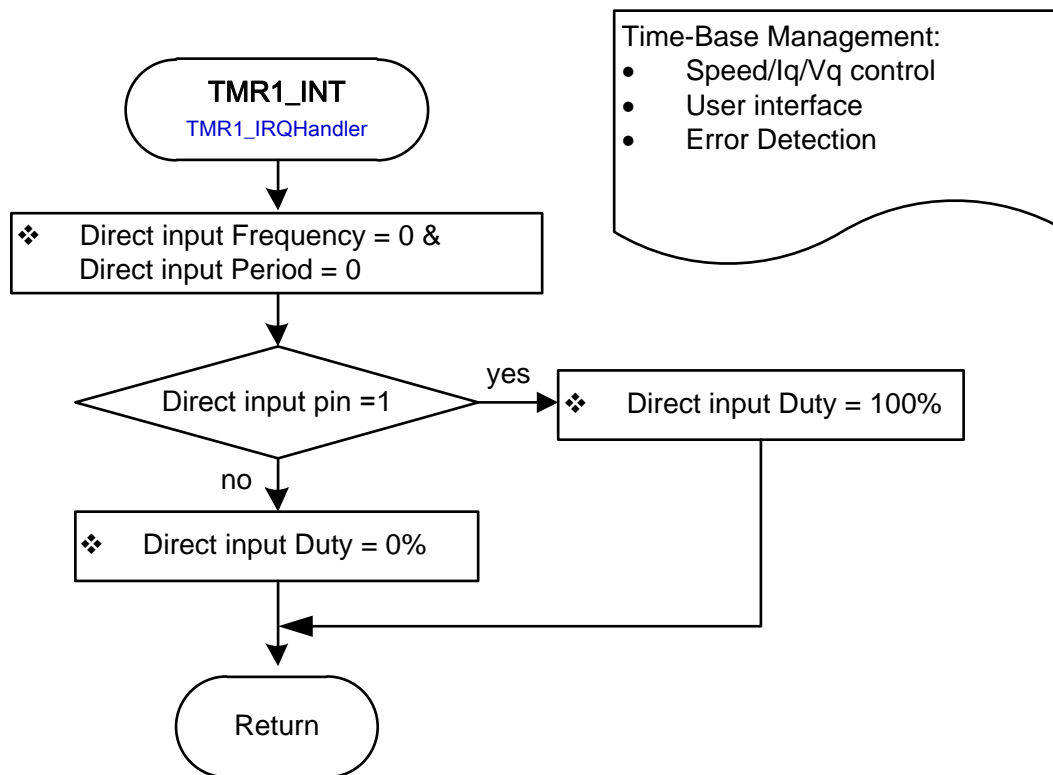
Flow Chart of ECAP_INT(for FOC)

- ▶ ECAP INT for capturing hall sensor signals to update the hall angle and rotor speed.



Flow Chart of TMR1_INT (for CCAP Time Out)

TMR1_IRQ(CCAP TIME-OUT CHECK)

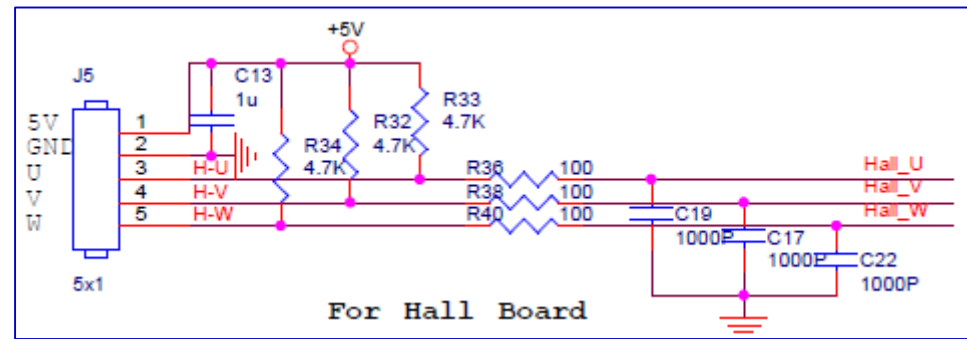
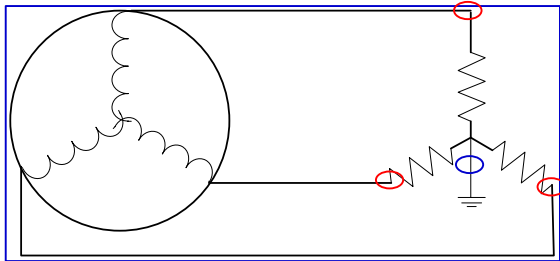


如何將此範例應用於其他馬達

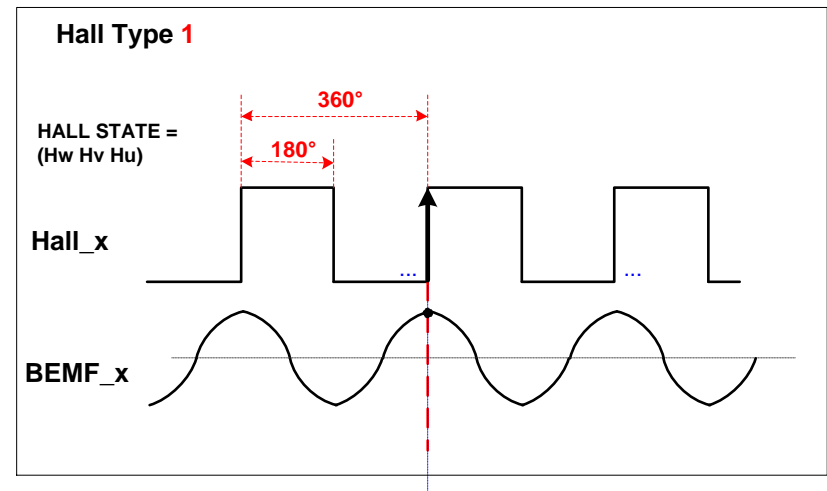
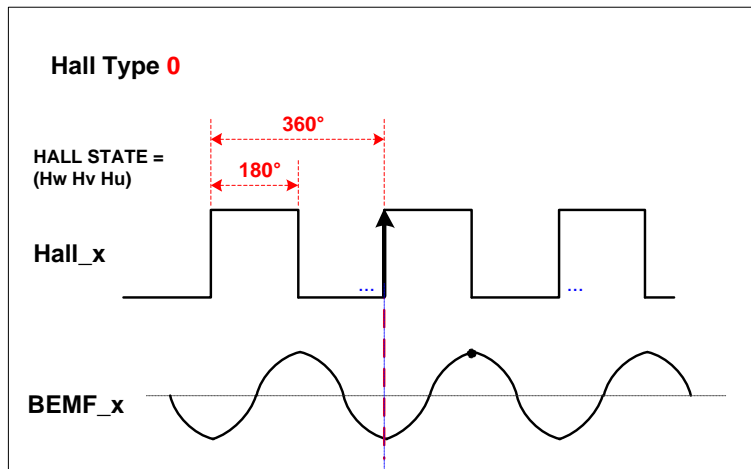
Step1:確認馬達相線與霍爾的關係

馬達

外接星形電阻



- 如左上圖，以外力帶動馬達，用探棒量測紅色對藍色的電壓波形。
- 在此同時，同步量測電路板中Hall_U/Hall_V/Hall_W(右上圖)，藉此確認BEMF與Hall訊號的關係，以設定Hall Type，如下方兩圖。



- 最後再依序將馬達相線與電路板上對應的U/V/W接點配對。

Step 2: 確認馬達極數

- 可以從馬達規格書獲得此資訊。
- 轉動馬達轉軸，計數轉軸轉動一圈的頓挫次數。
- 將前述數值填入 `C_MOTOR_POLE`。(in `"system_parameter.h"`)
- 目前Demo的馬達為8極。

Step 3: 填入命令參數

- 選擇VSP當作命令輸入模式@system_parameter.h
- 填入欲設計的輸入命令頻率範圍@Tuning_Parameter.h及轉速範圍(目前輸入頻率與馬達輸出轉速預設為線性關係)：

命令輸入模式設定

```
#define Read_CMD_From_VSP 1
#define Read_CMD_From_DirIn_Freq 0
#define Read_CMD_From_DirIn_Duty 0
```

VSP電壓對應速度命令與加速斜率設定

```
#define C_MAX_VSP_12b_ADC 4000 //4095 //12bit ADC value: 0~4095
#define C_MIN_VSP_12b_ADC 600 //12bit ADC value: 0~4095
#define C_VSP_SPEED_CMD_SLOPE ((C_MAX_SPEED_CMD_rpm - C_MIN_SPEED_CMD_rpm)*32768/(C_MAX_VSP_12b_ADC - C_MIN_VSP_12b_ADC))
```

馬達轉速範圍設定

```
#define C_MAX_SPEED_CMD_rpm 2000 //Unit: rpm
#define C_MIN_SPEED_CMD_rpm 200 //Unit: rpm
```

```
#define C_VSP_SPEED_CMD_SLOPE  
((C_MAX_SPEED_CMD_rpm - C_MIN_SPEED_CMD_rpm)*32768/(C_MAX_VSP_12b_ADC - C_MIN_VSP_12b_ADC))
```

Step 4:動態特性調整

- 依照系統需要的動態特性確認電流迴路的PI控制器參數(C_Iq_Kp/C_Iq_Ki/C_Id_Ki/C_Id_Ki)
- 調整速度迴路PI控制器(C_SP_Kp/C_SP_Ki)



END