閉迴路無刷直流(BLDC)馬達控制

NuMicro® 8 位系列微控制器範例代碼介紹

文件資訊

代碼簡述	本範例代碼基於N76E003平台，使用PWM功能實現閉迴路無刷直流馬達控制
BSP 版本	N76E003_BSP_Keil_C51_V1.0.6
開發平台	NuTiny-N76E003

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1 功能介紹

1.1 簡介

本範例代碼基於N76E003平台，使用PWM功能控制閉迴路無刷直流馬達馬達。

脈衝寬度調制(Pulse Width Modulation, PWM)，是一種輸出方波的技巧，透過改變占空比來改變等效的輸出能量與電壓，例如馬達調速、閥門控制等都是透過這種方式控制的。要產生一個三相弦波，可以在PWM的基礎上改變調制脈衝的方式，將脈衝寬度時間的占空比按照正弦波規律排列，即可獲得正弦波輸出，以控制逆變器電路中的開關通斷，這種調制方式在現今的變頻器領域已經被廣泛地採用，可用於控制三相電動機等。

無刷直流馬達 (Brushless DC Motor, BLDC Motor) 在整流的處理上捨棄了傳統馬達所使用的電刷，以電子裝置取代，因此能夠提升其可靠度與耐用度。無刷直流馬達馬達其優勢為：體積比相同功率輸出的有刷馬達更小更輕、可靠度與耐用度高。無刷直流馬達馬達的缺點為：需要電子管理裝置(微控制器)才能夠運作。一個基本的無刷直流馬達會配有霍爾感測器，依照霍爾感測器回饋的轉子位置訊號，微控制器能夠輸出對應的控制訊號，因此一個三相馬達需要六組PWM控制上下臂，以及三條線接收霍爾訊號。

開迴路控制是一種控制器，使用系統數學模型與目前狀態產生控制訊號，閉迴路控制器則會加入回授信號來判斷系統是否已達到理想輸出狀態。在開迴路與閉迴路的差異上，開迴路的架構相對閉迴路簡單，系統穩定性較閉迴路差，但成本較低。若是系統比較不需要精準性控制，可採用開迴路系統實現。

本範例程式使用閉迴路的方式控制BLDC馬達，並使用可變電阻控制轉速。

2 代碼介紹

```
/*---------------------------------------------------------------------------------------*/
/* Pin Functions                                                                         */
/*---------------------------------------  ----------------------------------------------*/
//P07 - HALL Sensor W Phase, HALL_W
//P06 - HALL Sensor V Phase, HALL_V
//P05 - HALL Sensor U Phase, HALL_U
//P12 - Upper-arm MOS control of U phase, uh
//P14 - Lower-arm MOS control of U phase, ul
//P10 - Upper-arm MOS control of V phase, vh
//P00 - Lower-arm MOS control of V phase, vl
//P01 - Upper-arm MOS control of W phase, wh
//P03 - Lower-arm MOS control of W phase, wl
//P15 - Motor on/off switch
//P02 - UART RX
//P16 - UART TX
//P17 - ADC input
```

2.1 初始化 timer 2 捕捉目前馬達轉速

```
void InitTimer2forCapture(void)
{
    /* Initial the Timer2 for capture motor speed */
    TIMER2_CAP0_Capture_Mode;
    IC6_P05_CAP0_RisingEdge_Capture;
    TIMER2_DIV_512;
    /* Enable Capture interrupt */
    set_ECAP;
    /* Triger Timer2 */
    set_TR2;
}
```

2.2 於中斷副程式捕捉馬達轉速

```
void Capture_ISR(void) interrupt 12
{
    /* Clear capture0 interrupt flag */
    clr_CAPF0;
    /* Get the current motor speed */
    g_u16CurrentSpeed = (C0L + (C0H << 8));

    clr_TF2;
}
```

2.3 透過回授的目前轉速計算目標轉速

```
main()
{
……
    /* Calculate the differentiation between target and current speed */
    /*---------------------------------------------------------------------*/
    //    PWM frequency =  32KHz (0.03125 ms)
    //    Timer Capture (PWM clock number) * PWM clock Period = 1/2 Round
    // => Timer Capture (PWM clock number) * PWM clock Period : 1/2 Round = 60s (1min) : X
Round
    // => X(s16SpeedDiff) = ((1/2) * 60) / ( 1/32k * Timer Capture (PWM clock number) )
    /*---------------------------------------------------------------------*/
    s16SpeedDiff = (unsigned long int)u16TargetSpeed - ((unsigned long int)30000000 /
((unsigned long int)(g_u16CurrentSpeed) * 32));

    /* Modified the PWM duty for tracing the target speed */
    u16PWMDutyValue += ((s16SpeedDiff > 0) ? 1 : (-1));
……
    /* Set new PWM duty */
    PWM0H = HIBYTE(u16PWMDutyValue);
    PWM0L = LOBYTE(u16PWMDutyValue);
    set_LOAD;
……
}
```

3 軟體與硬體環境

- **軟體環境**
  - BSP 版本
    - N76E003_BSP_Keil_C51_V1.0.6
  - IDE 版本
    - Keil uVersion 5.26
- **硬體環境**
  - 電路元件
    - NuTiny-N76E003 * 1
    - 直流無刷馬達 BLDC Motor * 1
    - 可變電阻 Variable Resistor * 1
    - 開關 On/Off Switch * 1
    - 牛橋 Nu-Bridge * 1

■ 接線圖

依照下圖的方式連接，使用者可經由可變電阻改變轉速，以及開關來啟動/關閉馬達。

將N76E003的UART_RX(P0.2)、UART_TX (P1.6)連接至Nu-Bridge，打印訊息。設置終端機的COM Port與Baudrate，COM Port的編號可在裝置管理員中找到「NuBridge Virtual Com Port (COMX)」，Baudrate設置為115200。

Enable / disable motor	↔	I/O (P1.5)	I/O (P0.7)	↔	HALL_W
Motor speed control(VR)	↔	ADC (P1.7)	I/O (P0.6)	↔	HALL_V
User Control			I/O (P0.5)	↔	HALL_U
			PWM (P1.2)	↔	UH
			PWM (P1.4)	↔	UL
			PWM (P1.0)	↔	VH
UART RX	↔	TX(P1.6)	PWM (P0.0)	↔	VL
UART TX	↔	RX(P0.2)	PWM (P0.1)	↔	WH
			PWM (P0.3)	↔	WL
Nu-Bridge		N76E003			BLDC Motor

4 目錄資訊

- EC_N76E003_Close_Loop_BLDC_Motor_V1.00
  - Common — Common driver files
  - Include — Sample code header, SFR and device driver files
  - SampleCode
    - ExampleCode — Source file of example code
  - Startup — 8051 Startup file

5 如何執行範例程式

1. 根據目錄資訊章節進入 EC_N76E003_Close_Loop_BLDC_Motor_V1.00\Sample_Code\ExampleCode\Close_Loop_BLDC_Motor_V1.00，雙擊路徑中 CloseLoopBLDCMotor.uvproj 開啟專案。
2. 進入編譯模式介面
   a. 編譯
   b. 下載代碼至記憶體
   c. 進入 / 離開除錯模式
3. 進入除錯模式介面
   a. 執行代碼

6 修訂紀錄

Date	Revision	Description
Oct. 16, 2019	1.00	1. 初版

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