闭回路无刷直流(BLDC)马达控制

NuMicro® 8 位系列微控制器范例代码介绍

文件信息

代码简述	本范例代码基于N76E003平台，使用PWM功能实现闭回路无刷直流马达控制
BSP 版本	N76E003_BSP_Keil_C51_V1.0.6
开发平台	NuTiny-N76E003

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1 功能介绍

1.1 简介

本范例代码基于N76E003平台，使用PWM功能控制闭回路无刷直流马达马达。

脉冲宽度调制(Pulse Width Modulation, PWM)，是一种输出方波的技巧，透过改变占空比来改变等效的输出能量与电压，例如马达调速、阀门控制等都是透过这种方式控制的。要产生一个三相弦波，可以在PWM的基础上改变调制脉冲的方式，将脉冲宽度时间的占空比按照正弦波规律排列，即可获得正弦波输出，以控制逆变器电路中的开关通断，这种调制方式在现今的变频器领域已经被广泛地采用，可用于控制三相电动机等。

无刷直流马达 (Brushless DC Motor, BLDC Motor) 在整流的处理上舍弃了传统马达所使用的电刷，以电子装置取代，因此能够提升其可靠度与耐用度。无刷直流马达马达其优势为：体积比相同功率输出的有刷马达更小更轻、可靠度与耐用度高。无刷直流马达马达的缺点为：需要电子管理装置(微控制器)才能够运作。一个基本的无刷直流马达会配有霍尔传感器，依照霍尔传感器回馈的转子位置讯号，微控制器能够输出对应的控制讯号，因此一个三相马达需要六组PWM控制上下臂，以及三条线接收霍尔讯号。

开回路控制是一种控制器，使用系统数学模型与目前状态产生控制讯号，闭回路控制器则会加入回授信号来判断系统是否已达到理想输出状态。在开回路与闭回路的差异上，开回路的架构相对闭回路简单，系统稳定性较闭回路差，但成本较低。若是系统比较不需要精准性控制，可采用开回路系统实现。

本范例程序使用闭回路的方式控制BLDC马达，并使用可变电阻控制转速。

2 代码介绍

```
/*---------------------------------------------------------------------------------------*/
/* 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 捕捉目前马达转速

```
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 于中断子程序捕捉马达转速

```
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 透过回授的目前转速计算目标转速

```
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 软件与硬件环境

- 软件环境
  - BSP 版本
    - N76E003_BSP_Keil_C51_V1.0.6
  - IDE 版本
    - Keil uVersion 5.26
- 硬件环境
  - 电路组件
    - NuTiny-N76E003 * 1
    - 直流无刷马达 BLDC Motor * 1
    - 可变电阻 Variable Resistor * 1
    - 开关 On/Off Switch * 1
    - 牛桥 Nu-Bridge * 1

■ 接线图

依照下图的方式连接，使用者可经由可变电阻改变转速，以及开关来启动/关闭马达。

将N76E003的UART_RX(P0.2)、UART_TX (P1.6)连接至Nu-Bridge，打印讯息。设置终端机的COM Port与Baudrate，COM Port的编号可在设备管理器中找到「NuBridge Virtual Com Port (COMX)」，Baudrate设置为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 目录信息

- 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 如何执行范例程序

1. 根据目录信息章节进入 EC_N76E003_Close_Loop_BLDC_Motor_V1.00\Sample_Code\ExampleCode\Close_Loop_BLDC_Motor_V1.00，双击路径中 CloseLoopBLDCMotor.uvproj 开启专案。
2. 进入编译模式接口
   a. 编译
   b. 下载代码至内存
   c. 进入 / 离开除错模式
3. 进入除错模式接口
   a. 执行代码

6 修订纪录

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

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