直流无刷电机（BLDC）概述

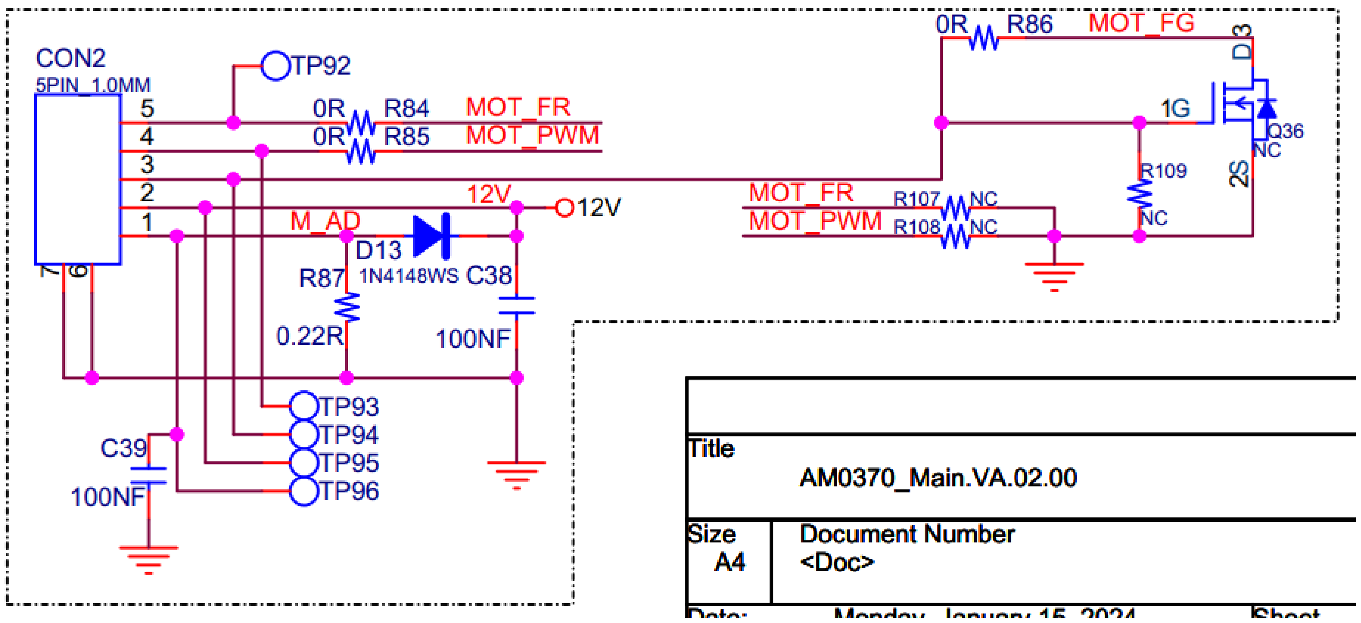
无刷直流电机（Brushless Direct Current Motor, BLDCM）克服了有刷直流电机的先天性缺陷，以电子换向器取代了机械换向器，所以无刷直流电机既具有直流电机良好的调速性能等特点，又具有交流电机结构简单、无换向火花、运行可靠和易于维护等优点。无刷直流电机的实质是直流电源输入，采用电子逆变器将直流电转换为交流电，有转子位置反馈的三相交流永磁同步电机。

描述中几个关键性词解释：

- 有刷直流电机的先天性缺陷：有刷电机的结构复杂，可靠性差，故障多，维护工作量大，寿命短，换向火花易产生电磁干扰等。
- 电子换向器：即电子逆变器。直流电通过逆变电路生成三相交流电驱动电机运转。

BLDC在项目中的应用场合

原理图



驱动代码

驱动示例链接：https://git.breo.cn/804590/n5-mini-pro/-/tree/main/code/main_board/app/driver?ref_type=heads

- `drv_pwm_input.c` `drv_pwm_gpio.c`
- `drv_pwm_input.h` `drv_pwm_gpio.h`

```
// drv_pwm_gpio.h 接口文件

int timer_gpio_init(ETIMER_SOURSE tim,ETIMER_REMAP remap,ETIMER_CH
channel,ETIMER_MODE mode);
```

```c
// drv_pwm_input.h 接口文件

typedef enum{
    ETIMER_1 = 1,
    ETIMER_2,
    ETIMER_3,
    ETIMER_4,
    ETIMER_5,
    ETIMER_6,
    ETIMER_7,
    ETIMER_8
}ETIMER_SOURSE;

typedef enum{        //bit[11:10]
    ETR_REMAP_0 = 0,
    ETR_REMAP_1,
    ETR_REMAP_2,
    ETR_REMAP_3
}ETIMER_REMAP;

typedef enum{
    ETIMER_CH_1 = 1,
    ETIMER_CH_2,
    ETIMER_CH_3,
    ETIMER_CH_4
}ETIMER_CH;

typedef enum{
    ETIMER_MODE_NONE = 0X00,
    ETIMER_MODE_PWM = 0x01,
    ETIMER_MODE_INPUT = 0x10
}ETIMER_MODE;

typedef enum{
    EC_CMD_SET = 1,
    EC_CMD_GET
}ECONTROL_CMD;

typedef enum{
    EINPUT_NONE = 0,
    EINPUT_DONE = 1,
    EINPUT_TIMEOUT = 2
}EINPUTEVENT;

struct ec_pi_config
{
    uint32_t psc;               /* 预分频 0~0xFFFF */
    uint32_t period;            /* 计数值  0~0xFFFF */
    ETIMER_MODE channel[4];     /* channel 1~4; 参考ETIMER_MODE选择模式 */
    uint32_t value[4];          /* pwm模式下pluse, input模式下FREQ */
};

struct ec_pwm_input_config
```

```
{
    uint8_t channel;    /* channel 1~4 */
    uint32_t psc;       /* 预分频 1~65536 */
    uint32_t period;    /* 计数值    0~0xFFFF */
    uint32_t value;     /* pwm模式下pluse: 在period范围内, input模式下FREQ */
};

struct  ec_tim_device
{
    TIM_Module* tim_handle;
    uint32_t int_clock;
    struct ec_pi_config pwm_input;
};

struct capture_list
{
    uint16_t ic_readvalue1;
    uint16_t ic_readvalue2;
    uint32_t captureflag;
    uint32_t capture;
    uint32_t timfreq;
    uint32_t timenterirqcnt;
    uint8_t first_input;
    uint8_t input_done;
    uint8_t timeout_flag;
    uint8_t timeout_status;
    uint32_t timeout;
};

int drv_hw_pwm_input_init(ETIMER_SOURSE tim,ETIMER_REMAP remap,ETIMER_CH
channel,ETIMER_MODE mode);          //初始化
int drv_pwm_input_control(ETIMER_SOURSE tim, ETIMER_MODE mode, ECONTROL_CMD
cmd,struct ec_pwm_input_config *pi);    //参数配置
int drv_pwm_input_enabled(ETIMER_SOURSE timx, ETIMER_CH channel,ETIMER_MODE
mode,bool enable);              //pwm/inputcap使能
int drv_set_pwm_pulse_percent(ETIMER_SOURSE timx, ETIMER_CH channel,uint8_t
percent);                   //设置百分占空比
int drv_set_pwm_pulse_Thousandths(ETIMER_SOURSE timx, ETIMER_CH channel,uint16_t
Thousandths);               //设置千分占空比
int tim_user_get_callback(ETIMER_SOURSE tim,ETIMER_CH channel,EINPUTEVENT
event,uint32_t timfreq);            //inputcap开启后触发的回调函数
```

如何使用（示例如下）

驱动示例链接:https://git.breo.cn/804590/n5-mini-pro/-/blob/main/code/main_board/app/user/user_board.c?ref_type=heads

- `PWM/INPUTCAP`初始化

```
#define PWM_DEV_MOTOR1_HANDLE           ETIMER_4
#define PWM_DEV_MOTOR1_CH               ETIMER_CH_1
#define PWM_DEV_MOTOR1_REMAP            ETR_REMAP_0

#define INPUT_DEV_MOTOR1_HANDLE         ETIMER_4
#define INPUT_DEV_MOTOR1_CH             ETIMER_CH_2
#define INPUT_DEV_MOTOR1_REMAP          ETR_REMAP_0

struct ec_pwm_input_config info1 = {PWM_DEV_MOTOR1_CH,2,1799,1800};
//20K,input和pwm一个通道需调整input超时时间
drv_hw_pwm_input_init(PWM_DEV_MOTOR1_HANDLEPWM_DEV_MOTOR1_REMAP,PWM_DEV_MOTOR1_CH
,ETIMER_MODE_PWM);
drv_pwm_input_control(PWM_DEV_MOTOR1_HANDLEETIMER_MODE_PWM,EC_CMD_SET,&info1);
drv_pwm_input_enabled(PWM_DEV_MOTOR1_HANDLEPWM_DEV_MOTOR1_CH,ETIMER_MODE_PWM,ENAB
LE);
info1.channel = INPUT_DEV_MOTOR1_CH;
drv_hw_pwm_input_init(INPUT_DEV_MOTOR1_HANDLEINPUT_DEV_MOTOR1_REMAP,INPUT_DEV_MOT
OR1_CHETIMER_MODE_INPUT);
drv_pwm_input_control(INPUT_DEV_MOTOR1_HANDLEETIMER_MODE_INPUT,EC_CMD_SET,&info1)
;
drv_pwm_input_enabled(INPUT_DEV_MOTOR1_HANDLEINPUT_DEV_MOTOR1_CH,ETIMER_MODE_INPU
T,DISABLE);
```

- 应用接口代码封装

```
#define PIN_MOTOR1_FR               53

void board_motor_dir_set(int8_t ch,bool en)     //设置电机方向，IO口初始化略
{
    if(ch == 0)
    {
        pin_set_func(pin_handle(PIN_MOTOR1_FR), en);
    }
}

void board_motor_ch_set_en(int8_t ch, bool en)      //使能
{
    if(ch == 0)
    {
//
drv_pwm_input_enabled(PWM_DEV_MOTOR_HANDLE,PWM_DEV_MOTOR_CH,ETIMER_MODE_PWM,
(MCENABLE)en);

drv_pwm_input_enabled(INPUT_DEV_MOTOR1_HANDLE,INPUT_DEV_MOTOR1_CH,ETIMER_MODE_INP
UT,en);
    }
}

#define MOTOR_PWM_REVERCE   1   //PWM值与转速正比：0，反之：1
void board_motor_ch_set_duty_cycle(int8_t ch, int8_t value) //设置电机占空比
```

```
{
    if (value < 0){
        value = 0;
    }
    if (value > 100){
        value = 100;
    }
    uint8_t real_percent;
#if MOTOR_PWM_REVERCE
    real_percent = 100 - value;
#else
    real_percent = value;
#endif

    if(ch == 0)
    {
//      logVerbose("ch0,value=[%d]",value);

drv_set_pwm_pulse_percent(PWM_DEV_MOTOR1_HANDLE,PWM_DEV_MOTOR1_CH,real_percent);
    }
}

static uint32_t timfreq_value[1];
static uint32_t tim_getcnts[1];
int tim_user_get_callback(ETIMER_SOURSE tim,ETIMER_CH channel,EINPUTEVENT
event,uint32_t timfreq) //编写输入捕获回调函数
{
    if(tim == ETIMER_4)
    {
        if(event == EINPUT_DONE)
        {
            tim_getcnts[0]++;
            timfreq_value[0] = timfreq;
//          logDebug("T5 channel=%d,timfreq=%d",channel,timfreq);
        }else if(event == EINPUT_TIMEOUT)
        {
            timfreq_value[0] = 0;
//          logDebug("T5  failed!");
        }
    }
    return 0;
}

uint32_t board_motor_ch_get_input_capture(int8_t ch)    //获取电机输入捕获频率
{
    uint32_t motor_input_freq = 0;
    if(ch == 0)
    {
        motor_input_freq = timfreq_value[0];
    }
    return motor_input_freq;
}

uint32_t board_motor_inputap_cnts_get(int8_t ch)    //获取电机输入捕获次数
{
```

```c
    uint32_t motor_cnts = 0;
    if(ch == 0)
    {
        motor_cnts = tim_getcnts[0];
    }
    return motor_cnts;
}
```

- 应用于电机等模块