ARM® Cortex®-M

32-bit Microcontroller

NuMotor series
User's Manual

NUMOTOR USER MANUAL

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1. Introduction

This manual explains how to use the NuMotor example code, including how to switch between different control modes, the key parameters to be changed, and the external feedback circuit.

2. Control methods

2.1. Description of control methods

This example program contains the following control methods

I. FOC 1R : Magnetic Field Oriented Control, 1 shunt resistor is used for total current feedback.

II. FOC 2R : magnetic field orientation control, using two shunt resistors to feedback two-phase currents.

III. Six step square wave control(open loop) : open loop control (adjustment of duty command)

IV. Six step square wave control(close loop) : closed loop control (adjustment of speed command)

2.2. Control method switching

The example program will separate the control methods by #define. You can switch between different control methods by modifying the code in system_parameter.h. The following is an example.

I. FOC & SIX_STEP control switch : Corresponding control method. If define is 1, then the function is enabled; if 0, then it is disabled.

```
#define    P_FOC_CONTROL          1   // 1 : for P_FOC_CONTROL
#define    P_SIX_STEP_CONTROL     0   // 1 : for P_SIX_STEP_CONTROL
```

II. SIX_STEP control OPEN_LOOP & CLOSE_LOOP : 1 for On, 0 for Off

```
#define P_SIX_STEP_OPEN_LOOP        1
#define P_SIX_STEP_CLOSE_LOOP       0
```

III. FOC control 1R & 2R : Cancels the comment of the function you want to enable (//). Then turn on the mapping function.

```
 #define    P_1R_FOC          //For the system is 1R FOC
//#define   P_2R_FOC          //For the system is 2R FOC
```

3. Command Mode Switching

There are two types of control modes: VSP(external knob) and UART(Through the GUI).

3.1. VSP control mode

When the external knob (VSP) voltage is less than 2.5V when the system is initialized, the system issues the switch and speed control commands to the system via VSP

3.2. UART control mode

When the external knob (VSP) voltage is greater than 2.5V when the system is initialized, the system is commanded by UART to the system. Through the exclusive GUI, you can command the system and adjust parameters in time.

4. Motor parameter setting

When changing to a different motor, you need to change the following parameters according to the actual motor specification. The more critical parameters are listed in this section, and the detailed parameters are also described in the .h file.

I. Number of motor pole

```
#define     C_MOTOR_POLE            4       //Unit: Number of motor pole
```

II. Maximum rotor speed

```
#define     C_MAX_MOTOR_SPEED 3000  //Unit: rpm, maximum rotor speed.
```

III. Calculate the average rotation speed when the rotation speed is greater than the number of rpm.

```
#define     C_RPM_Do_Speed_Average      300     //Unit: rpm, When rotor speed is over it --> Do speed average.
```

IV. When using external VSP for speed command, set the maximum and minimum values of the command, and the minimum value is the starting speed of the motor.

```
#define     C_MAX_CMD_SPEED_rpm        3000    //Unit: rpm
#define     C_MIN_CMD_SPEED_rpm        200     //Unit: rpm
```

V. Hall sensor type : divided into type 0 and type 1, difference. as follows

type 0 : The rising edge of Hall U is aligned with the minimum voltage of U phase

type 1 : The rising edge of Hall U is aligned with the maximum voltage of U phase

```
#define     HALL_TYPE           1
```

5. Current feedback circuit parameters

The phase current and total current of the system are fed back to the MCU via an external OPA. The corresponding parameters are as follows

I. When the system is FOC 2R control, corresponding phase resistance parameter

```
#ifdef P_2R_FOC
    #define     SHUNT_R_mOhm  100    //Shunt R, unit=mohm
#endif
```

II. When the system is FOC 1R control, corresponding phase resistance parameter

```
#ifdef P_1R_FOC
    #define     SHUNT_R_mOhm  50     //Shunt R, unit=mohm
#endif
```

III. Gain of external OPA

```
#define     OP_Amp      5           //gain of OP-amp.
```

6. PI controller parameters

I. Current loop parameter, the format is Q31

```
#define   C_I_Kp    (5000)
#define   C_I_Ki    (1000)/1
```

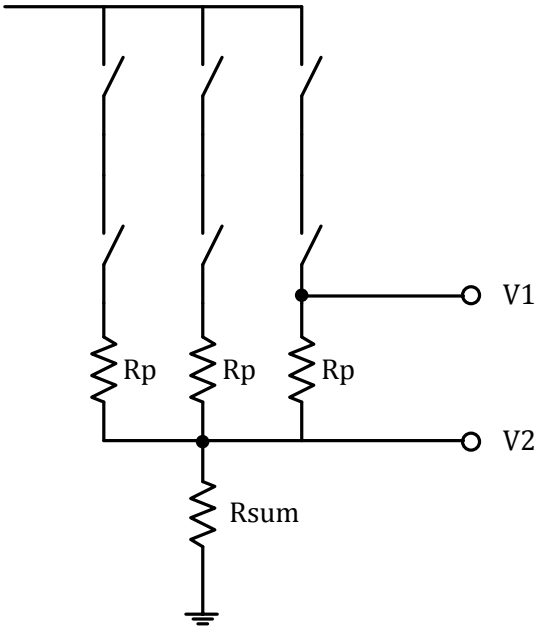
II. Speed loop parameter, the format is Q31

```
#define   C_SP_Kp   983040/8
#define   C_SP_Ki   3276/10*2
```

7. Description of current feedback

7.1. Driver circuit

The following figure is the motor driver circuit used in this example program. The current feedback is to detect the voltage on the phase resistance Rp

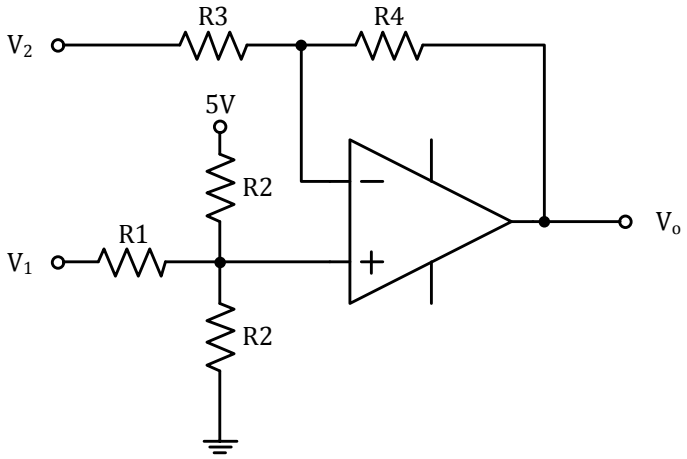


7.2. Current feedback circuit

Because the motor current is an AC value, the current feedback circuit needs to be leveled up and then amplified. The ratio can be calculated by adjusting the ratio of each resistor. The user can adjust the ratio according to the maximum current of the actual system. When the maximum current occurs, Vo does not exceed the VDD voltage of the MCU

If $\frac{R4}{R3} = \frac{R2}{2 \times R1} = G_v$

Then $V_o = G_v \times (V_1 - V_2) + 2.5$

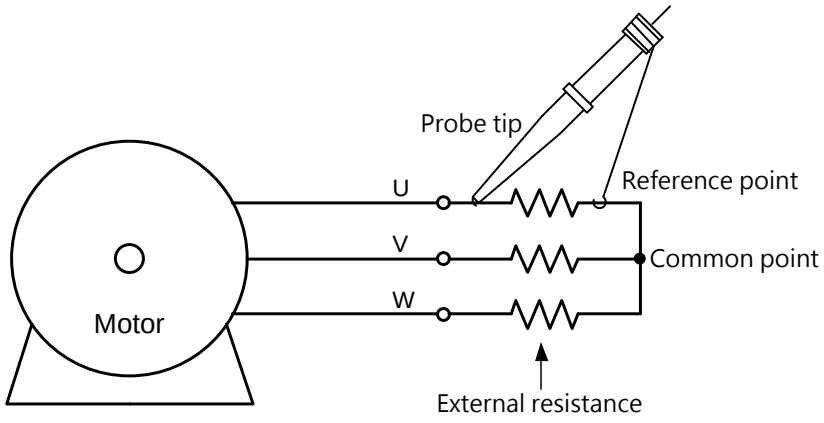


8. HALL sensor signal measurement description

Before operating the motor, it is necessary to confirm the correspondence between the Hall sensor signal and the back EMF. The following is an explanation of the phase voltage measurement

8.1. Description of phase voltage measurement

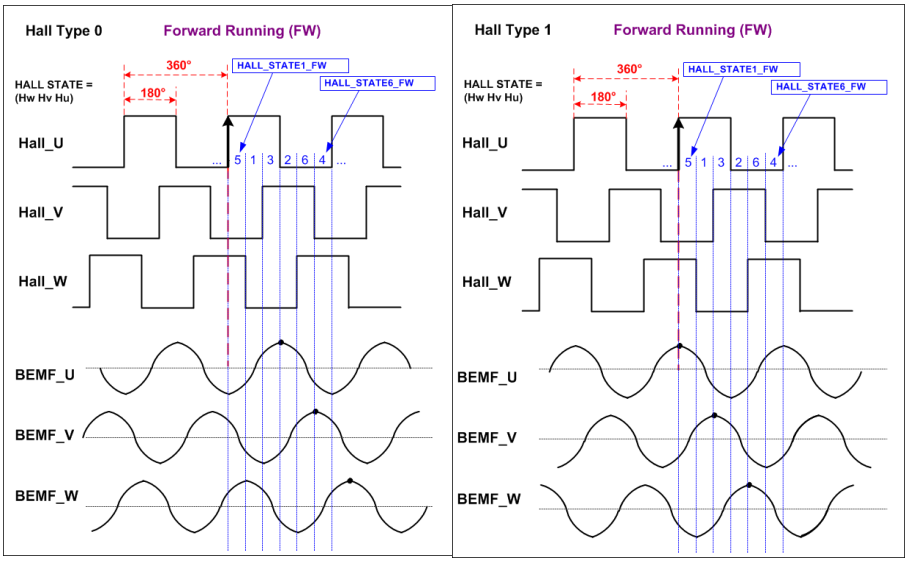
Connect the three wires of the motor to the external resistor, connect them into Y-connections, connect the positive end of the probe to the motor outlet, connect the negative end to the common point, manually turn the motor or external prime mover can measure the phase voltage.



8.2. Hall sensor signal correction

This example program divides the type of hall sensor signal into type 0 and type 1, as shown in the following figure, as shown in the figure below, type 0 is the minimum of the rising edge of the hall sensor signal to align the motor phase voltage, and type 1 is the minimum of the rising edge of the hall sensor signal to align the motor phase Maximum voltage.

The correction method is Hall U aligns U phase voltage, Hall V aligns V phase voltage, Hall W aligns W phase voltage



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