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PMSM Servo Motor Speed Control
User Manual
32-bit ARM Cortex-M4F based Microcontroller
MB9BF568x Series and S6E2HG Series

User Manual
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1. Introduction

1.1 Purpose

This user manual describes the speed-control solution of the SPANSION servo motor and how to use the inverter servo motor FW library. This document will help you quickly learn how to build a servo motor project and how to debug the motor with SPANSION inverter servo motor FW library. The document introduces the basic information of whole servo motor control system, including hardware, firmware, initial functions, basic motor setting functions and FOC drive modules. When you have understood the provided information, you can get an overview of a whole servo motor project. And you can run a motor following the demo project step.

1.2 Definitions, Acronyms and Abbreviations

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>API</td>
<td>Application Programming Interface</td>
</tr>
<tr>
<td>FOC</td>
<td>Field Oriented Control</td>
</tr>
<tr>
<td>FW</td>
<td>Firmware</td>
</tr>
<tr>
<td>HW</td>
<td>Hardware</td>
</tr>
<tr>
<td>I/O</td>
<td>Input and output</td>
</tr>
<tr>
<td>CW</td>
<td>Clockwise</td>
</tr>
<tr>
<td>CCW</td>
<td>Counter clockwise</td>
</tr>
</tbody>
</table>

1.3 Document Overview

The rest of document is organized as the following:

Chapter 2 explains System Hardware Environment
Chapter 3 explains Development Environment
Chapter 4 explains System Firmware Design
Chapter 5 explains Interrupt Function
Chapter 6 explains Demo System
Chapter 7 explains Additional Information
Chapter 8 explains Reference Documents
2. System Hardware Environment

The below shows the brief information of MCU used in servo motor inverter board.

CPU chip: Spansion MB9BF568R.
CPU Frequency: 160MHz.
MCU pin number: 120pin.
RAM Space: 128Kbytes.
Code Space: 1024Kbytes.
Demo HW version:
FSDC-FM3-314-1-0015-01 + FSDC-FM4-560-2-071200050
3. Development Environment

Table 3-1: MCU Development Environment

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Part Number</th>
<th>Manufacturer</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>IAR bedded Workbench 7.3</td>
<td>FW code edit, compile and debug</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>J-Link</td>
<td>Debug and Load FW by JTAG</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>SPANSION FLASH LOADER</td>
<td>Flash download program</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Source Insight</td>
<td>Source code edit</td>
<td>N/A</td>
<td>N/A</td>
<td>Editor</td>
</tr>
<tr>
<td>Eclipse</td>
<td>Source code edit</td>
<td>N/A</td>
<td>N/A</td>
<td>Editor</td>
</tr>
</tbody>
</table>
4. System Firmware Design

This chapter introduces the FW structure of the inverter servo motor project.

4.1 FW Feature

The features of the servo motor speed control solution are shown in Table 4-1.

Table 4-1: Feature List of servo motor speed control

<table>
<thead>
<tr>
<th>No</th>
<th>Feature</th>
<th>Description</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Encoder Zero-Check</td>
<td>Match encoder zero signal with electrical position</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Hardware Self-check</td>
<td>Check offset of current sampling</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Adjustable Carrier Frequency</td>
<td>Carrier frequency can be set by the corresponding variable in user interface</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Rapid speed acceleration</td>
<td>Motor can be accelerated from 0rpm to 5000rpm within 200ms</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Rapid speed deceleration</td>
<td>Motor can be decelerated from 5000rpm to 0rpm within 200ms</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>FOC Control</td>
<td>Using FOC control algorithm</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Speed regulate</td>
<td>This function is used to speed up or slow down a motor by the command from host via UART or debugger</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Speed precision</td>
<td>Accurate speed controlling with less than 1% target error.</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Brake</td>
<td>Stop motor by brake down</td>
<td>Slow down a motor by brake</td>
</tr>
<tr>
<td>10</td>
<td>Current sample</td>
<td>Three-phase hall-sensor for current sampling</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Protect</td>
<td>DC voltage protect</td>
<td>A/D offset protect</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lock rotor protect</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Over Current Protect</td>
</tr>
<tr>
<td>12</td>
<td>Bi-directional rotating</td>
<td>Motor can run in both directions.</td>
<td></td>
</tr>
</tbody>
</table>

4.2 FW Structure

There are 5 layers in the FW structure of IAR, which are shown in Figure 4-1.
Figure 4-1: Structure of FW

The C source and Header files which are included in each layer are shown in Table 4-2

<table>
<thead>
<tr>
<th>Layer</th>
<th>Folder</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>global</td>
<td>h01_global,</td>
<td>MCU system file</td>
</tr>
<tr>
<td></td>
<td>s01_global</td>
<td></td>
</tr>
<tr>
<td>driver</td>
<td>h02_driver,</td>
<td>MCU register setting function such as GPIO, interrupt, MFT, AD</td>
</tr>
<tr>
<td></td>
<td>s02_driver</td>
<td></td>
</tr>
<tr>
<td>module</td>
<td>h03_module,</td>
<td>Algorithm folder for basic motor control such as FOC frame transform,</td>
</tr>
<tr>
<td></td>
<td>s03_module</td>
<td>SVPWM, math, PID, filter</td>
</tr>
<tr>
<td>app</td>
<td>h04_app,</td>
<td>Application folder for the files of application functions such as speed and</td>
</tr>
<tr>
<td></td>
<td>s04_app</td>
<td>position generator by hall sensor, protection, motor start-up, field</td>
</tr>
<tr>
<td></td>
<td></td>
<td>weaken, brake and etc.</td>
</tr>
<tr>
<td>user</td>
<td>h05_user,</td>
<td>Customer interface folder for the files for motor Configuration and HW</td>
</tr>
<tr>
<td></td>
<td>s05_user</td>
<td>setting</td>
</tr>
</tbody>
</table>

Note: if you want to quickly start the motor, you can refer to the setting for user layer at 6.2.1 FW Interface Configuration and chapter 5 Interrupt Function.

The sub-files in each folder are shown in Figure 4-2, and the structure of header files is the same with C files.
Figure 4-2: Sub-files in Each Layer
The relationship between each layer is shown as the diagram in Figure 4-3.

4.3 Files Description

The detailed descriptions for each file are shown as Table 4-3.

<table>
<thead>
<tr>
<th>Folder</th>
<th>File</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>s01_global</td>
<td>N/A</td>
<td>No files temporarily.</td>
</tr>
<tr>
<td>S02_driver</td>
<td>N/A</td>
<td>No files temporarily.</td>
</tr>
<tr>
<td>s03_module</td>
<td>coordinate_transfrom.c</td>
<td>FOC axis convert</td>
</tr>
<tr>
<td></td>
<td>filter.c</td>
<td>One order low pass filter</td>
</tr>
<tr>
<td></td>
<td>math.c</td>
<td>The math module including the function such as SQRT,COS,SIN</td>
</tr>
</tbody>
</table>
The control flow for the motor is shown as Figure 4-4. There are 4 interrupts that are red highlighted for the motor FOC control, hall capture, AD converter. The timer events are executed in the end-less loop and the timers are generated in the zero detection interrupt ‘ISR_MFT_FRT’ of the free run timer 0.

![Diagram of the Control Flow](image-url)
5. Interrupt Function

5.1 Function List

Table 5-1: System Used Interrupt Function

<table>
<thead>
<tr>
<th>Prototype</th>
<th>Description</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>__root void HWD_Handler(void)</td>
<td>The HW watch dog ISR</td>
<td>s05_user/isr.c</td>
</tr>
<tr>
<td>__root void Swd_IsrHandler (void)</td>
<td>The software watch dog ISR</td>
<td>s05_user/isr.c</td>
</tr>
<tr>
<td>__root void Mft0_Frt0_ZeroIsrHandler (void)</td>
<td>The MFT zero detect ISR for the motor control</td>
<td>s05_user/isr.c</td>
</tr>
<tr>
<td>__root void Mft0_Wfg_IsrHandler (void)</td>
<td>The HW over-current ISR</td>
<td>s05_user/isr.c</td>
</tr>
<tr>
<td>__root void Adc_0_IsrHandler (void)</td>
<td>The ADC unit0 ISR, trigger at the zero point for the 3 shunts</td>
<td>s05_user/isr.c</td>
</tr>
</tbody>
</table>

5.2 Interrupt Priority Setting

Each interrupt priority can be set by the function `void InitMcu_Nvic(void)` which is located at the file 's05_user/init_mcu.c'. Users are not recommended to modify it. The priority used for motor control is shown in Figure 5-1. The lower the number is, the higher the priority is.

```c
void InitMcu_Nvic(void)
{
    //exception priority
    NVIC_SetPriority(WFG0_DTIF0_IRQn,0);
    NVIC_SetPriority(SWDT_IRQn,0);
    NVIC_SetPriority(ADC0_IRQn,1);
    NVIC_SetPriority(FRT0_ZERO_IRQn,2);
}
```

Figure 5-1: Interrupt Priority Setting
5.3 Interrupt Generation

The diagram of the interrupt used for the motor control is briefly introduced in this section.

5.3.1 MFT

The multifunction timer is used to generate the interrupt for the motor control algorithm execution, and trigger the AD sample at the zero point.

**ISR_MFT_FRT**
Free run timer 0, UP/DOWN mode, PWM cycle: 66.7 µs, 15K Hz

![Free Run Timer Interrupt Diagram](image)

Trigger AD unit0 and FOC interrupt

A/D unit0: sample U, V, W current

FOC interrupt to drive motor

**Figure 5-2: Free Run Timer Interrupt**

5.3.2 Encoder Capture

The PWC timer is used to capture the encoder A/B signal and calculate pulse-width of the edge of A/B.

Encoder A/B signal Voltage High or Low level

One motor mechanical cycle

Measure completion

Base timer Count Over Flow

![Encoder Capture with Base-Timer Diagram](image)

**Figure 5-3: Encoder Capture with Base-Timer**
5.3.3 DTTI

The DTTI0 is used to trigger the HW fault protection from the IPM. When the phase current is large enough to trigger the HW over-current fault, the interrupt is got and all of the drive signals for the motor control will shut off immediately.

**ISR_MFT_WFG**

IPM fault signal low voltage

---

**Figure 5-4: DTTI Interrupt**
6. Demo System

This chapter introduces one example of inverter servo motor project and help you run a motor quickly. The primary steps are shown as following:

- Hardware Connection
- FW Interface Configuration
- Encoder Check
- Run Motor
- Speed Acceleration and Deceleration

6.1 Demo System Introduction

The servo motor solution can be adaptive to any type of servo motor speed control which uses the PMSM or BLDC motor. The connection diagram for debugger is shown in Figure 6-1.

![System Connection](image)

Figure 6-1: System Connection
6.1.1 Hardware Connection

It is necessary to connect below 4 lines:

1. Connect motor’s encoder signal to inverter board, shown as below.

![Encoder port](image)

**Figure 6-2: Encoder Signal Line Connection**

The connection of the encoder signal line follows the definition in the below table.

<table>
<thead>
<tr>
<th>Motor’s line</th>
<th>Inverter Board Circuit Port</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encoder A</td>
<td>AIN</td>
</tr>
<tr>
<td>Encoder B</td>
<td>BIN</td>
</tr>
<tr>
<td>Encoder Z</td>
<td>ZIN</td>
</tr>
<tr>
<td>+5V</td>
<td>Vcc</td>
</tr>
<tr>
<td>GND</td>
<td>GND</td>
</tr>
</tbody>
</table>

**Table 6-1: Encoder Connection**

**Note:**
- Connection order between A and B is mixable.
- VCC and GND must be connected rightly, otherwise the encoder won’t work right and the motor will also not run.

2. Connect motor’s U, V, W phase lines to inverter board, shown as below.

![U, V, W](image)

**Figure 6-3: Motor Line Connection**

Motor’s U, V, W line can be optionally connected to Inverter’s output U, V, W. It has no constant define. Just connect it. And it is also recommended to connect according to the UVW definition of the motor.

3. Connect JTAG to Inverter, shown as below.
Note:
If there is no isolator between the J-link and the HW, you must unplug the AC power and use the battery of your laptop computer.
4. Connect AC power to inverter board, shown as below.

6.2 Motor Debug

After the hardware connection with the motor is completed, you can debug the new motor, as described in this section.
Click the IAR program to open the IAR, and open the ‘EWW’ file of the inverter servo motor workspace at the location you’ve stored on your computer as shown in Figure 6-6.
6.2.1 FW Interface Configuration

All of the variables reserved for the user interfaces are located in the file 's05_user/customer_interface.c' and the macro definitions are located in the file 'h05_user/customer_interface.h'.

6.2.1.1 UI_01 Motor Parameters

```
int32_t Motor_f32PolePairs = 2;
```

Set motor pole pairs. Set it to 3 if motor with 3 pole pairs is being used.
6.2.1.2 UI_02 Encoder Information

```
int32_t QPRCLineNumber = 360;
int32_t QPRC_times = 4;
```

QPRCLineNumber: indicating pulses per cycle for encoder signal A or B.
QPRC_times: indicating QPRC unit working mode for detecting encoder signal. This is set to 4 by default.
For more information about it, you can refer to MCU peripheral manual reading chapter QPRC for PC_Mode2 setting.

6.2.1.3 UI_03 Sample Resistor, Amplification, Carrier Frequency and Dead-Time

```
float32_t Motor_f32IuvwSampleResistor = 0.015;
float32_t Motor_i32IuvwAmplifierFactor = 5.0;
int32_t Motor_i32IuvwOffsetNormal = 2048;
int32_t Motor_i32IuvwOffsetRange = 150;
int32_t Motor_i32IuvwOffsetCheckTimes = 64;
float32_t Motor_f32DeadTimeMicroSec = 2.5f;
uint16_t Motor_u16CarrierFreq = 15000;
```

Table 6-2: Sample Resistor, Amplification, Carrier Frequency and Dead-Time

<table>
<thead>
<tr>
<th>Name</th>
<th>Explanation</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor_f32IuvwSampleResistor</td>
<td>Sample resistor</td>
<td>0.015Ω</td>
</tr>
<tr>
<td>Motor_i32IuvwAmplifierFactor</td>
<td>Amplification factor</td>
<td>5.0 times</td>
</tr>
<tr>
<td>Motor_i32IuvwOffsetNormal</td>
<td>ADC value for 2.5V offset</td>
<td>2.5V&lt;=&gt;2048</td>
</tr>
<tr>
<td>Motor_i32IuvwOffsetRange</td>
<td>Define offset range</td>
<td>150 : Offset range&lt;2048-150,2048+150&gt;</td>
</tr>
<tr>
<td>Motor_f32DeadTimeMicroSec</td>
<td>Dead-time</td>
<td>2.5us</td>
</tr>
<tr>
<td>Motor_u16CarrierFreq</td>
<td>Carrier frequency for PWM</td>
<td>15000Hz</td>
</tr>
</tbody>
</table>

- Sample resistor and amplification is related to hardware board, they must be written correctly.
- Dead-time is dependent on IPM, MOSFET or IGBT, the minimum dead-time can be found in its datasheet.
- Carrier frequency can be rewritten as requirement.

6.2.1.4 UI_04 Current PID and Speed Loop PID

```
float32_t Motor_f32LowSpdKi = 0.00023f;
float32_t Motor_f32LowSpdKp = 0.32f;
float32_t Motor_f32Dki = 0.5fr;
float32_t Motor_f32Dkp = 10.0f;
float32_t Motor_f32Qki = 0.5fr;
float32_t Motor_f32Qkp = 10.0f;
float32_t Motor_f32Skp = 0.322f;
float32_t Motor_i32ChgPiSpdHz = 0.00023f;
uint16_t Motor_u16ChgPiSpdHz = 25;
```

Table 6-3: Current PID and Speed PID

<table>
<thead>
<tr>
<th>Name</th>
<th>Explanation</th>
<th>These parameters are not fixed. Instead, they depend on motors and systems. Tune these parameters when changing motor.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor_f32LowSpdKi</td>
<td>Speed loop integration parameters when speed lower than Motor_u16ChgPiSpdHz</td>
<td></td>
</tr>
<tr>
<td>Motor_f32LowSpdKp</td>
<td>Speed loop proportion parameters when speed lower than Motor_u16ChgPiSpdHz</td>
<td></td>
</tr>
<tr>
<td>Motor_f32Dki</td>
<td>Current loop integration parameters in D-axis</td>
<td></td>
</tr>
<tr>
<td>Motor_f32Dkp</td>
<td>Current loop proportion parameters in D-axis</td>
<td></td>
</tr>
<tr>
<td>Motor_f32Qki</td>
<td>Current loop integration parameters in Q-axis</td>
<td></td>
</tr>
<tr>
<td>Motor_f32Qkp</td>
<td>Current loop proportion parameters in Q-axis</td>
<td></td>
</tr>
<tr>
<td>Motor_f32Skp</td>
<td>Speed loop integration parameters when speed</td>
<td></td>
</tr>
</tbody>
</table>
higher than Motor_u16ChgPtSpdHz
Motor_u16ChgPtSpdHz Switch speed loop PI parameters

Table 6-4: Motor Startup Parameters

<table>
<thead>
<tr>
<th>Name</th>
<th>Explanation</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor_i16Q8_OrientIqRef</td>
<td>Set current for orientation</td>
<td>Q8(1.0): 1A</td>
</tr>
<tr>
<td>Motor_i32OrientTime</td>
<td>Set orientation time</td>
<td>1.5</td>
</tr>
<tr>
<td>Motor_u16OpenLoopSpdIncHz</td>
<td>Speed acceleration rate in open loop</td>
<td>1Hz/s²</td>
</tr>
<tr>
<td>Motor_u16OpenLoopSpdInitHz</td>
<td>Initial mechanical speed in open loop</td>
<td>0Hz(0rpm)</td>
</tr>
<tr>
<td>Motor_u16OpenLoopSpdEndHz</td>
<td>Target mechanical speed in open loop</td>
<td>1Hz(60rpm)</td>
</tr>
<tr>
<td>Motor_u16OpenLoopLoopIqRef</td>
<td>Set current in open loop stage</td>
<td>Q8(2.0): 2A</td>
</tr>
</tbody>
</table>

Current setting in orientation and open loop stage is related to motor electrical parameter. Ensure that not exceeding motor rated current.

Table 6-5: Motor Close-Loop Parameters

<table>
<thead>
<tr>
<th>Name</th>
<th>Explanation</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor_u16CloseLoopTargetSpdHz</td>
<td>Initial target speed when getting in close loop</td>
<td>0Hz(0rpm)</td>
</tr>
<tr>
<td>RotationFlg</td>
<td>Initial rotation direction</td>
<td>CW or CCW</td>
</tr>
<tr>
<td>Motor_i16Q8_CloseLoopsMax</td>
<td>Maximum peak value for phase current</td>
<td>Q8(2.5): 2.5A</td>
</tr>
<tr>
<td>Motor_i16Q8_CloseLoopIqRefMax</td>
<td>Maximum value for q-axis</td>
<td>Q8(2.5): 2.5A</td>
</tr>
<tr>
<td>Motor_u16SpdMax</td>
<td>Maximum rotating mechanical speed</td>
<td>5000rpm</td>
</tr>
<tr>
<td>Motor_u16SpdMin</td>
<td>Minimum rotating mechanical speed</td>
<td>-5000rpm</td>
</tr>
<tr>
<td>Motor_f32SpdAccelerationHz</td>
<td>Acceleration rate</td>
<td>600Hz/s²</td>
</tr>
<tr>
<td>Motor_f32SpdDecelerationHz</td>
<td>Deceleration rate</td>
<td>400Hz/s²</td>
</tr>
</tbody>
</table>

6.2.1.7 UI_07 Protection Parameters

int16_t Motor_i16Q8CurrentMax = Q8(3.5);
uint16_t Motor_i16OverCurrentTimeSec = 1;
uint16_t Motor_i16VbusMax = 460;
uint16_t Motor_u16VbusMin = 260;
uint8_t Motor_ErrorTime = 16;
### Table 6-6: Protection Parameters

<table>
<thead>
<tr>
<th>Name</th>
<th>Explanation</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor_i16Q8CurrentMax</td>
<td>Soft current protection happens when peak of current is higher than this value</td>
<td>Q8(3.5): 3.5A</td>
</tr>
<tr>
<td>Motor_u16OverCurrentTimeSec</td>
<td>Define times of current continuously overpassing Motor_i16Q8CurrentMax. When times of overpassing higher than Motor_u16OverCurrentTimeSec, soft-over-current protection happens.</td>
<td>1 time</td>
</tr>
<tr>
<td>Motor_u16VbusMax</td>
<td>Define over-voltage protection point</td>
<td>400V</td>
</tr>
<tr>
<td>Motor_u16VbusMin</td>
<td>Define under-voltage protection point</td>
<td>200V</td>
</tr>
<tr>
<td>Motor_ErrorTime</td>
<td>Time for error flag maintaining. Motor error flag will be set, and will be cleared after Motor_ErrorTime.</td>
<td>10s</td>
</tr>
</tbody>
</table>

### 6.2.1.8 UI_08 Brake Enable

```c
int8_t Motor_BrakeCtrlEn = 0;
```

### Table 6-7: Brake Enable or Disable Flag

<table>
<thead>
<tr>
<th>Name</th>
<th>Explanation</th>
<th>Value</th>
</tr>
</thead>
</table>
| Motor_BrakeCtrlEn | Switch on or off controlling for fast braking function                      | 0: disable fast braking when target-speed is set to 0 to stop motor running  
                                                                   | 1: enable fast braking when target-speed is set to 0 to stop motor running |

### 6.2.2 Encoder Check

When the basic setting has been finished, the encoder information (zero-position A/B order) can be self-check by the encoder check module. Here take one servo motor for example. And if the encoder information has been known, this section can be ignored and the motor can be normal started now and taken the reference at section 0 Modify “SWAPBIT” definition in “hardware_config.h”, set it the same value as “Qprc_RunPars:i8_Swapbit”. Modify “QPRC_ZERO_ANGLE” definition in “hardware_config.h”. Set it the same value as “Qprc_RunPars:i32Q22_AngleToZeroInx”. Redefine “ZEROMATHCEN” to 1. Encoder check is complete. Run Motor.

#### 6.2.2.1 FW Setting

Set the variable as shown Figure 6-8 to make the control system in debug mode:

```c
#define QPRC_ZEROMATCH 0 //0: not match, 1: matched  
#define QPRC_SWAPBIT 1  
#define QPRC_ZEROANGLE 3406141
```

Figure 6-8: Macro Define for encoder

- QPRC_ZEROMATCH = 0: set encoder searching mode.
- QPRC_ZEROMATCH = 1: encoder searching mode end.
- QPRC_SWAPBIT = 0: no-change A/B order.
- QPRC_SWAPBIT = 1: exchange A/B order.
- QPRC_ZEROANGLE: zero position.
6.2.2.2 Encoder Check Run

Click the debugger button to connect the J-link, and pass the global structure 'Qprc_RunPars’ into the Live Watch in the IAR debug online.

Connect PC and hardware with J-LINK, and give motor any target speed more than 0 to run motor.

Wait until motor stops running, find structure “Qprc_RunPars” in file "observer_encoder.h", and record value of variable “Qprc_RunPars.i8_Swapbit” and “Qprc_RunPars.i32Q22_AngleToZeroInx”

Table 6-8: Global Structure for Encoder Check

<table>
<thead>
<tr>
<th>Encoder A/B order bit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero-match completion flg</td>
</tr>
<tr>
<td>Zero-position angle</td>
</tr>
<tr>
<td>Estimated speed by encoder</td>
</tr>
</tbody>
</table>

Modify “SWAPBIT” definition in “hardware_config.h”, set it the same value as “Qprc_RunPars.i8_Swapbit”.

Modify “QPRC_ZERO_ANGLE” definition in “hardware_config.h”. Set it the same value as “Qprc_RunPars.i32Q22_AngleToZeroInx”.

Redefine “ZEROMATHCEN” to 1.

Encoder check is complete.

6.2.3 Run Motor

When the encoder angle has been checked, the motor can be started for the demo show.

(1) Check the basic motor and HW parameter setting in the user interfaces. If the setting does not match the real HW and washing machine parameter, there will be an unexpected running error in the motor running.

(2) Compile project and download program to inverter board by the J-link.

① Click button A that is shown in Figure 6-9 to connect the J-link and download the FW into the MCU,
② Click button B shown in Figure 6-10 to run the FW online.
③ You can enter the none-zero speed value to start the motor in the structure that is shown as C in Figure 6-11.

For example, when the variable ‘MotorCtrl_stcRunPar.i16TargetSpeedRpm = 90’ by your online input, the speed of the servo motor will run to 90rpm.

Do not click button D in Figure 6-11 while motor in running status.
Figure 6-9: Download and debug by J-link

Figure 6-10: Motor Run by J-link

Figure 6-11: Motor in Running Status
6.2.4 Speed Acceleration and Deceleration

After run motor normally, you can run motor in any speed (-5000rpm ~ 5000rpm). The negative or positive indicates rotational direction.

6.3 Troubleshooting

6.3.1 Protection

When the motor is stopped without the normal stop command, the protection fault may appear, you can see the value of the variable ‘MotorCtrl_stcRunPar.u16FaultCode’ in the watch window and the code is assigned by the bit OR operation. The fault codes for each protection are shown as below. You can match the value with these fault codes to find what protection is performed.

```c
#define NORMAL_RUNNING  0x00  //no error
#define OVER_VOLTAGE    0x01  //DC bus over-voltage
#define UNDER_VOLTAGE   0x02  //DC bus under-voltage
#define SW_OVER_CURRENT 0x04  //over-current
#define MOTOR_OVER_CURRENT 0x08 //over-current of HW
#define MOTOR_LOSE_PHASE 0x10  //motor lose phase
#define NO_CONECT_COMPRESSOR 0x20 //no motor connected
#define AD_MIDDLE_ERROR  0x40  //current sample 2.5V offset error
#define SF_WTD_RESET    0x80  //FW watch dog reset
#define MOTOR_LOCK      0x100 //motor lock
#define UNDEFINED_INT   0x200 //undefined interrupt
#define HW_WTD_RESET    0x400 //HW watch dog reset
```

There may be different processing logic about the protection. The fault code may not be cleared except the DC bus voltage protection for the inverter DEMO. That is the FW may not run again when the protection fault happens. You can access the variable ‘Motor_stcRunParam.u16FaultCode’ to make your own protection processing logic.
7. Additional Information

For more Information on Spansion semiconductor products, visit the following websites:
English version address:
http://www.spansion.com/Products/microcontrollers/

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http://www.spansion.com/CN/Products/microcontrollers/

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Other: http://www.spansion.com/Support/SES/Pages/Ask-Spansion.aspx
8. Reference Documents
Colophon
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