

56F8300 3-Phase Switched Reluctance Motor Control

With Hall Sensors using Processor Expert

Targeting Document

MC56F8300
16-bit Digital Signal Controllers

8300SRMHSTD
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Document Revision History

Version History	Description of Change
Rev 0	Initial public release

3-Phase Switched Reluctance Motor (SRM) Control with Hall Sensors on Processor Expert

This application exercises control of a 3-phase Switched Reluctance Motor (SRM) with Hall Sensors, using Processor Expert (PE), a 56F8346, 56F8357 or 56F8367 EVM board and a 3-phase SRM high-voltage power stage.

Applications developed for this demonstration board were not designed for the 56F8100 devices. The 56F8300 demonstration board does, however, fully support 56F8100 software development.

Note: The PC master software referenced in this document is also known as Free Master software.

1. Specifications

System Outline

The system is designed to drive a 3-phase switched reluctance motor. The application has the following specifications:

- 3-phase switched reluctance motor control using Hall sensors for position determination
- Targeted for a 56F8346EVM, 56F8357EVM or 56F8367EVM board
- Runs on a 3-phase SR High Voltage (HV) or Low Voltage (LV) power stage at 180W
- Uses an optoisolation board for high voltage application
- Speed control loop
- Motor mode allowing rotation in a single direction
- Minimum speed of 700rpm
- Maximum speed of 1000rpm
- Manual interface (RUN / STOP switch, UP / DOWN push buttons control, LED indication)
- Overvoltage, undervoltage and overcurrent fault protection
- PC remote control interface (speed set-up)
- PC master software remote monitor
 - Software monitor interface provides information about:
 - Applied voltage
 - Required voltage
 - Required and Actual Speed
 - State of the START/STOP switch
 - Fault status
 - Software speed scope observes actual and desired speed, currents:
 - Active
 - Desired
 - Discharge
 - Output duty cycle

Application Description

The 3-phase SR Motor Control Application performs principal control of the 3-phase SR motor with Hall sensors on the 56F8300 processor. The control technique sets the motor speed (rpm) to the required value using the speed closed-loop with Hall position sensors to derive the proper commutation action / moment. It also provides protection against Overcurrent, Overvoltage, Undervoltage, and overheating drive faults.

The application can run on:

- External RAM or Flash
- 3-Phase SR high-voltage power stage powered by 115V or 230V AC
- 3-Phase SR low-voltage power stage powered by 12V DC
- Manual or PC master software operating mode

The SRM drive hardware components are:

- SRM motor-brake set
- 3-phase SRM high-voltage power stage
- 56F8346EVM, 56F8357EVM, or 56F8367EVM board
- Legacy Motor Daughter Card (LMDC) board
- Optoisolation board (for HV Set-up only)

The voltage level is identified automatically and the appropriate constants are set.

Note: The switched reluctance motor-brake set incorporates a 3-phase switched reluctance motor and an attached BLDC motor brake. The Hall sensor is coupled on the motor shaft. Detailed motor-brake specifications are listed in [Table 1-1](#).

Table 1-1 Motor Brake Specifications

Motor	Motor Type	3-phase SR Motor		
	Pole Number	6 / 4 (Stator / Rotor) Poles		
	Nominal Speed	< 5000rpm		
	Nominal Voltage	High-Voltage Motor	300V	
		Low-Voltage Motor	10V	
	Nominal Current	High-Voltage Motor	3 x 1.2A	
		Low-Voltage Motor	3 x 28.5A	
Brake	Brake Type	SG40N 3-Phase BLDC Motor		
	Pole Number	6		
	Nominal Speed	1500rpm		
	Nominal Voltage	3 x 27V		
	Nominal Current	2.6A		
Position Sensor (Hall Sensor)	Type	3-phase Hall Sensors		
	Number of Disc Segments	8		
	Sensor Layout	Sensors distributed at 60° mechanical angles to each other		

The drive can be controlled in two operating modes:

- In the **Manual operating mode**, the Required Speed is set by the UP / DOWN push buttons and the drive is started and stopped by the RUN / STOP switch on the EVM board
- In the **PC master software operating mode**, the Required Speed is set by the PC master software active bar graph and the drive is started and stopped by the START MOTOR and STOP MOTOR controls

Measured quantities:

- DCBus voltage
- Power module temperature
- Rotor speed

The faults used for drive protection:

- Overvoltage (PC master software error message = *Overvoltage fault*)
- Undervoltage (PC master software error message = *Undervoltage fault*)
- Overcurrent (PC master software error message = *Overcurrent fault*)
- Overheating (PC master software error message = *Overheating fault*)

The following software tools are needed to compile, debug, and load to the EVM, and to use remote control and monitoring, and the RUN / STOP Switch and the UP / DOWN Buttons:

- Metrowerks CodeWarrior v. 6.1.2
- PC Master software
- Processor Expert v. 2.94

The 3-phase Switched Reluctance Motor Control Application can operate in two modes:

1. Manual Operating Mode

The drive is controlled by the RUN/STOP switch (S3) on the Legacy Motor Daughter Card (LMDC). The motor speed is set by the UP (S1) and DOWN (S2) push buttons on the LMDC; see [Figure 1-1](#). In this application, the PWMA module's output LEDs are employed as USER LEDs. If the application runs and the motor spinning is disabled (i.e., the system is ready), the GREEN USER LED (LED2, shown in [Figure 1-2](#)) will blink. When motor spinning is enabled, the USER LED is *On*. Refer to [Table 1-2](#) for application states. The actual state of the PWM outputs is indicated by PWMB output LEDs. If overcurrent, overvoltage or overheating occur, the GREEN USER LED (LED2) starts to flash quickly and the PC master software signals the type of fault identified. This state can be exited only by an application reset. It is strongly recommended that you inspect the entire application to locate the source of the fault before starting it again.

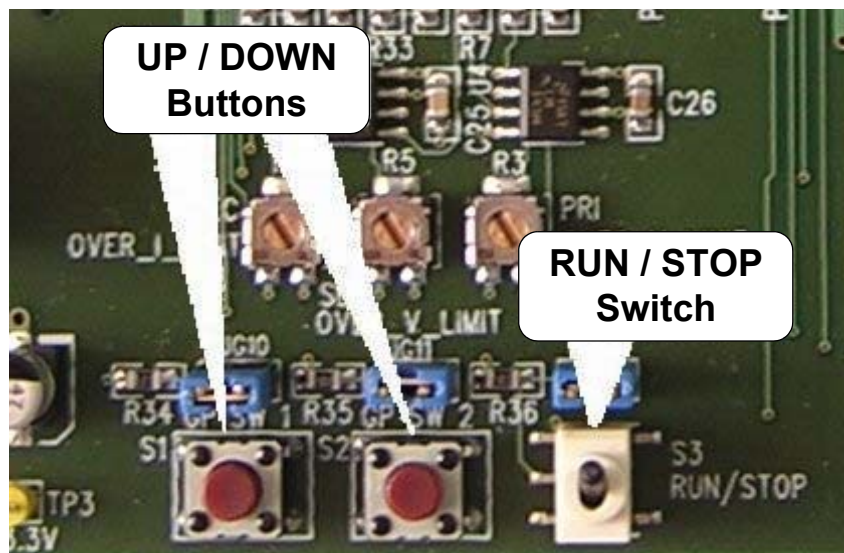


Figure 1-1 RUN/STOP Switch and UP / DOWN Buttons on the Legacy Motor Daughter Card (LMDC)

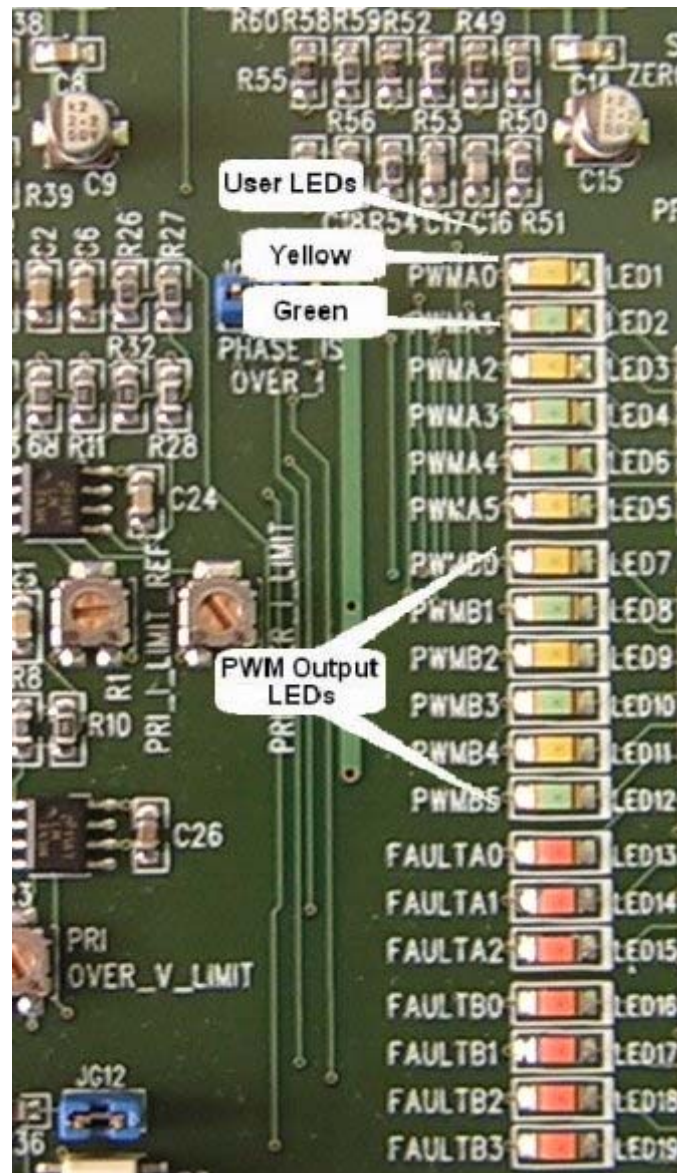


Figure 1-2 USER and PWM LEDs on the Legacy Motor Daughter Card (LMDC)

Table 1-2 Motor Application States

Application State	Motor State	Green LED State
Stopped	Stopped	Blinking at a frequency of 2Hz
Running	Spinning	On
Fault	Stopped	Blinking at a frequency of 8Hz

2. PC Master Software (Remote) Operating Mode

The drive is controlled remotely from a PC through the SCI communication channel of the hybrid controller via an RS-232 physical interface. The drive is enabled by the RUN / STOP switch, which can be used to safely stop the application at any time. PC master software enables the user to set the motor's Required Speed.

The following PC master software control actions are supported:

- Set the motor control system's PC master software mode
- Set the motor control system's manual mode
- Start the motor
- Stop the motor
- Set the motor's Required Speed

PC master software displays the following information:

- The motor's Required Speed
- The motor's Actual Speed
- Application status
 - Init
 - Stop
 - Run
 - Fault
- Identified line voltage
- Fault Status
 - No_Fault
 - Overvoltage
 - Overcurrent
 - Undervoltage
 - Overheating

Start the PC master software window's application, *3srm_hall.pmp*. **Figure 1-3** illustrates the PC master software control window after this project has been launched.

Note: If the PC master software project (*.pmp* file) is unable to control the application, it is possible that the wrong load map (*.elf* file) has been selected. PC master software uses the load map to determine addresses for global variables being monitored. Once the PC master software project has been launched, this option may be selected in the PC master software window under *Project / Select Other Map File Reload*.

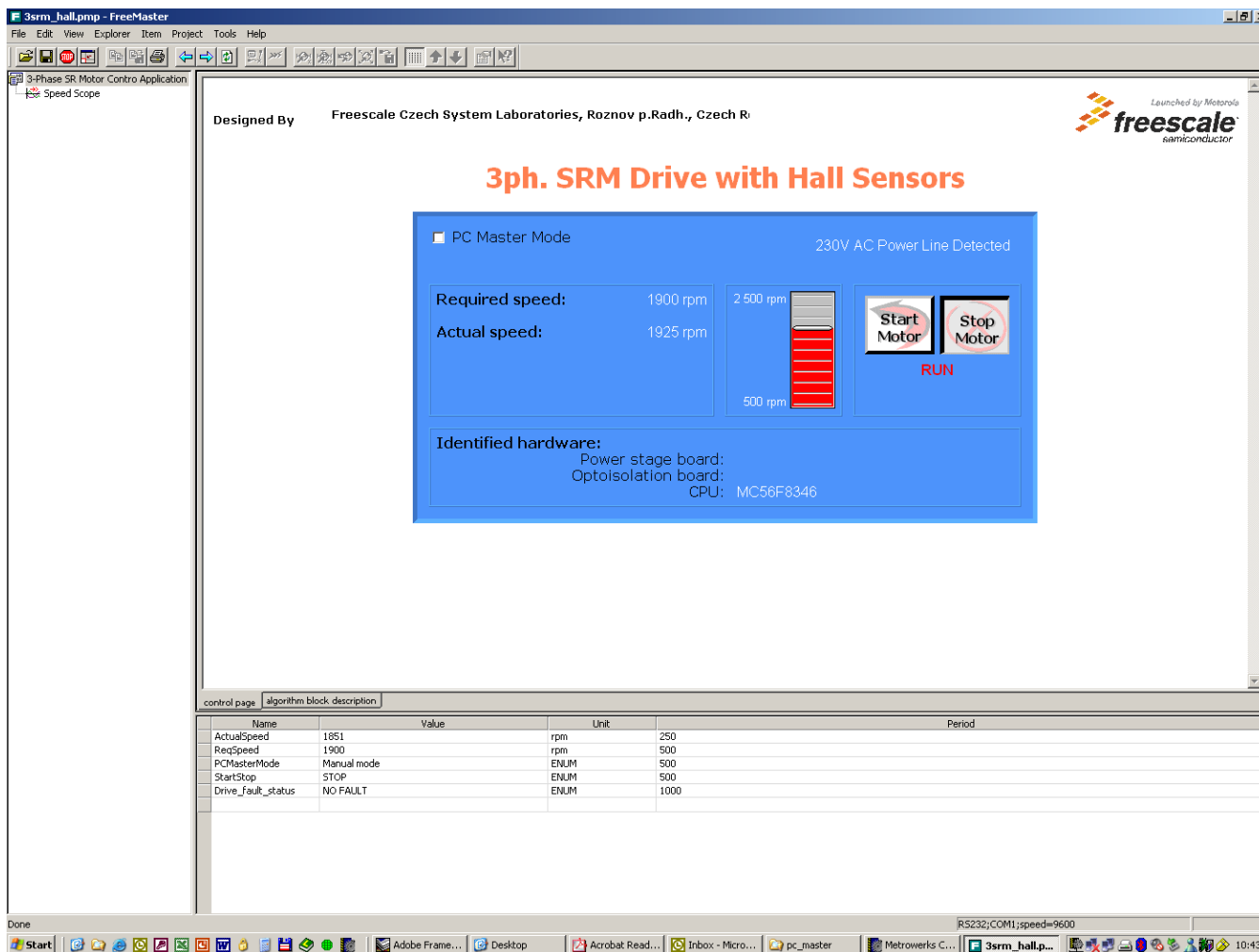


Figure 1-3 PC Master Software Control Window

2. Hardware Set-Up

Figure 2-1 and **Figure 2-2** illustrates the hardware set-up for the 3-phase Switched Reluctance Motor Control Application.

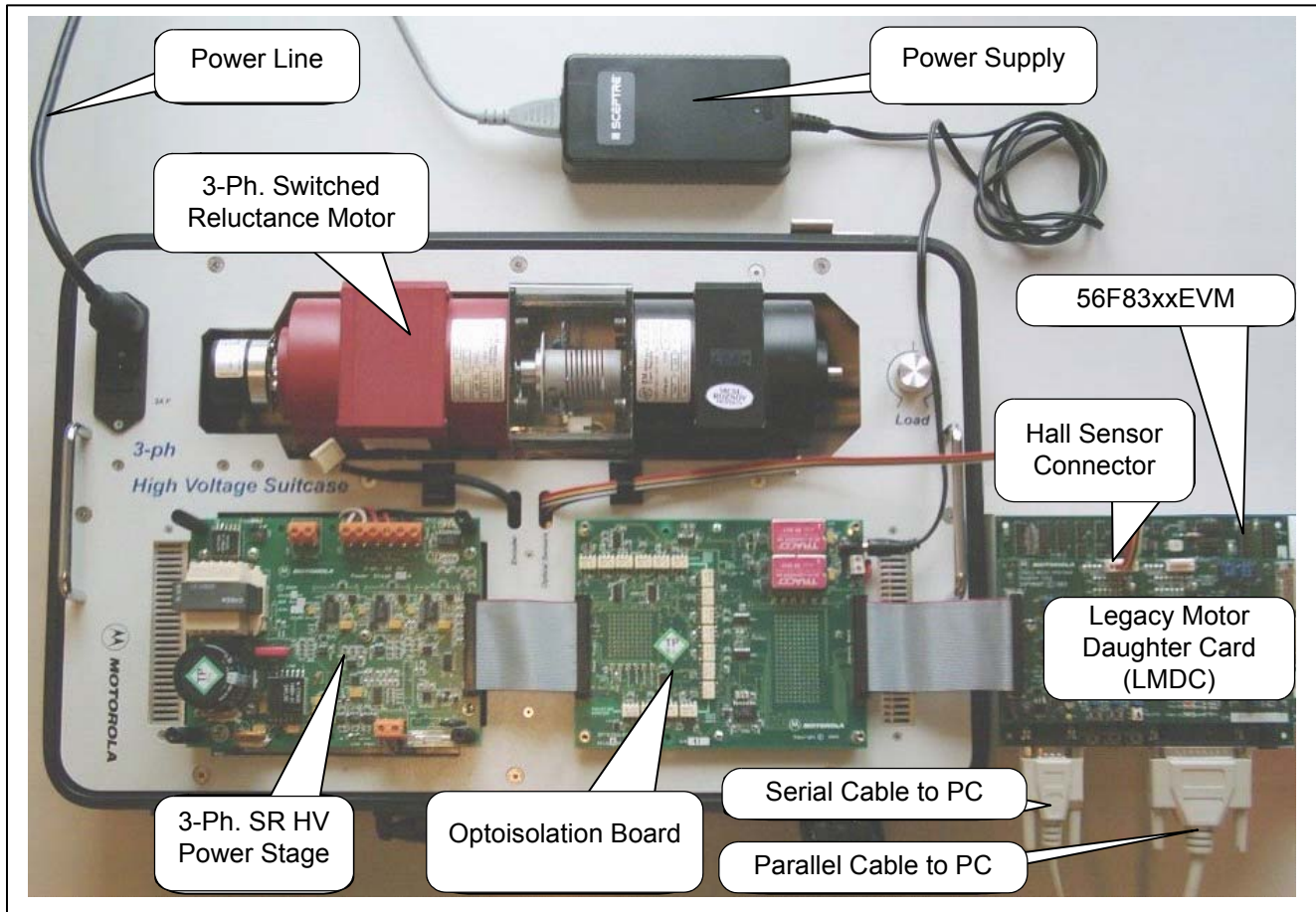


Figure 2-1 Application Set-Up for 3-Phase HV SR Motor Control Application

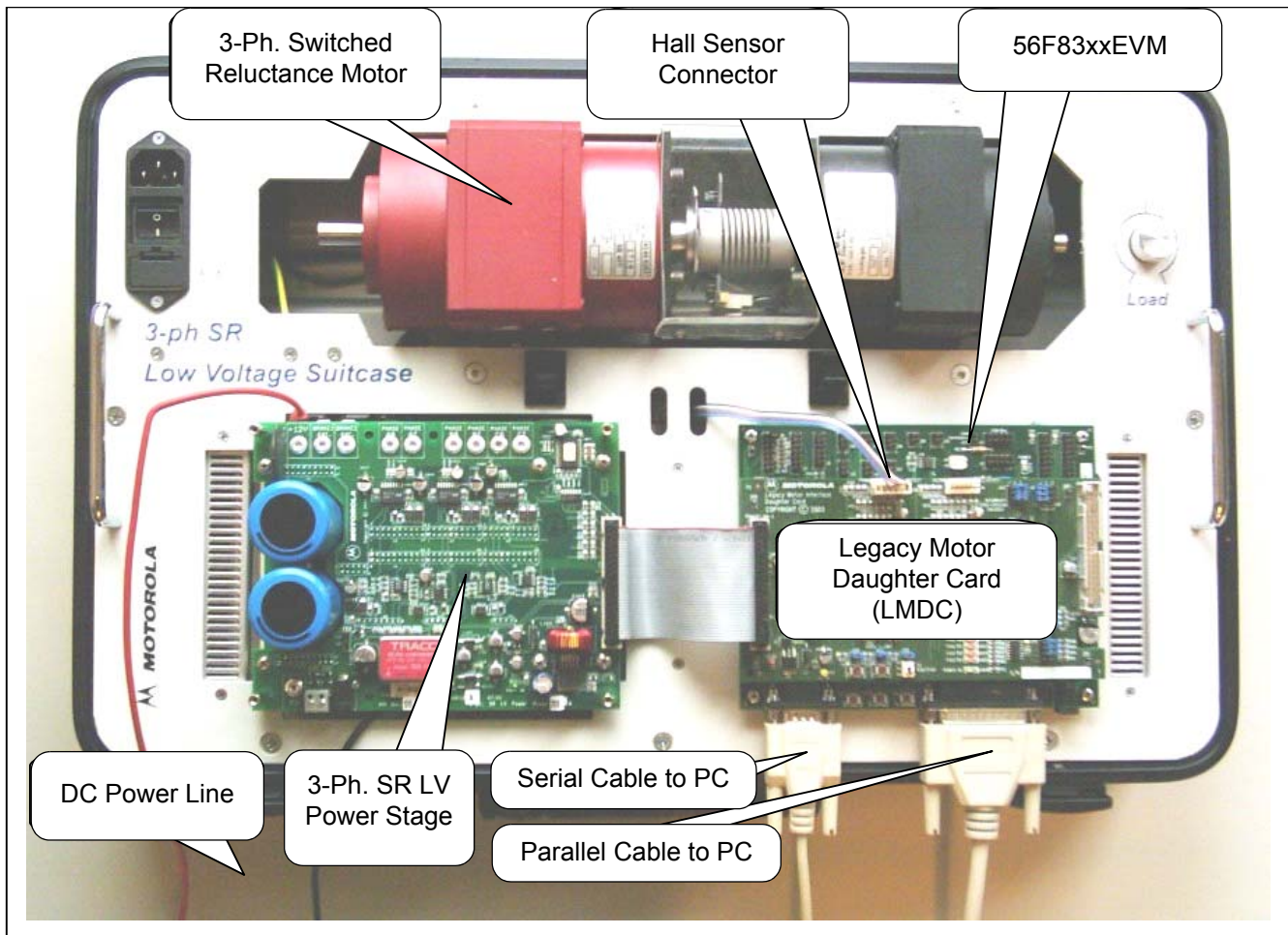


Figure 2-2 Application Set-Up for 3-Phase LV SR Motor Control Application

The correct order of phases for the SR motor is:

- Phase A = white wire
- Phase B = red wire
- Phase C = black wire

When facing a motor shaft, the motor shaft should rotate clockwise (i.e., positive direction, positive speed).

The system comprises these components:

- Switched reluctance motor Type 40V or 40N, EM Brno s.r.o., Czech Republic
- Load Type SG 40N, EM Brno s.r.o., Czech Republic
- 3-phase SR HV or LV Power Stage, 180W
- Optoisolation Board (For HV set-up only)

- 56F8346EVM, 56F8357EVM, or 56F8367EVM
- A serial cable, needed only for the PC master software debugging tool
- A parallel cable, needed to debug Metrowerks Code Warrior and load software

For detailed information, refer to the **56F83xx Evaluation Module Hardware User's Manual** for the device being implemented.

2.1 EVM Jumper Settings

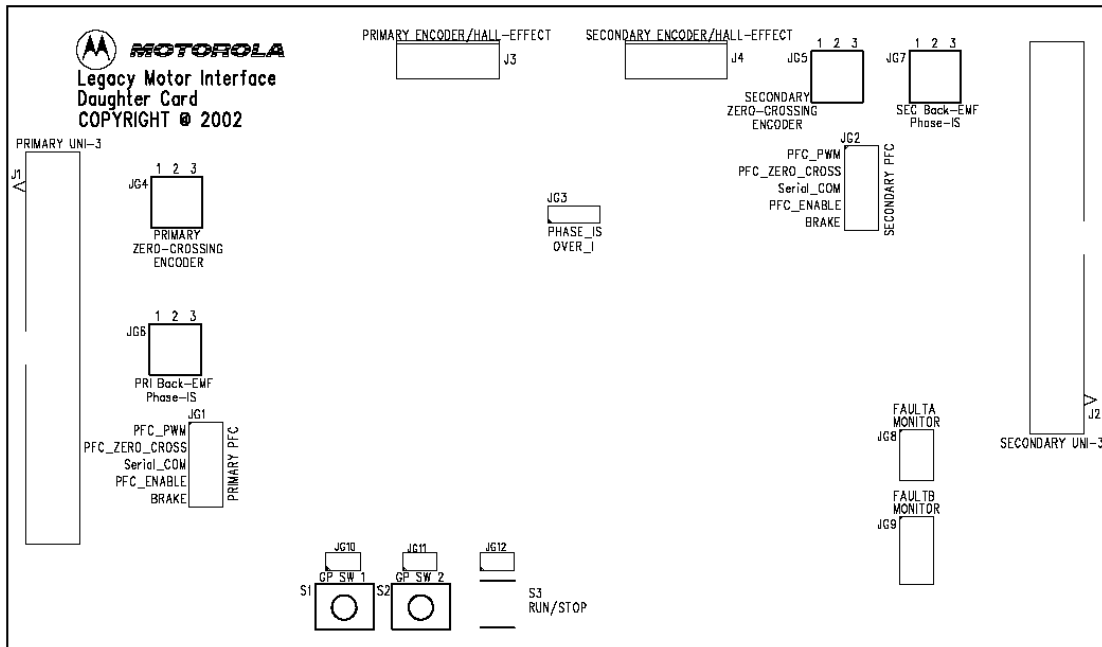
For jumper settings, see the **56F8346 Evaluation Module Hardware User's Manual**, **56F8357 Evaluation Module Hardware User's Manual** or **56F8367 Evaluation Module Hardware User's Manual**.

Note: When running the EVM target system in a stand-alone mode from Flash, in the **56F8346EVM**, the **JG9** jumper must be set in the 1-2 configuration to disable the command converter parallel port interface. In the **56F8357EVM** or the **56F8367EVM**, the **JG3** jumper must be set in the 1-2 configuration to disable the command converter parallel port interface.

For a detailed description for jumper settings, see the **56F83xx Evaluation Module Hardware User's Manual** for the device being implemented.

2.1.1 Daughter Card (LMDC Board) Jumper Settings

To execute the 3-phase SRM Hall Sensors Application - the MC56F8300 Daughter Card (LMDC Board) requires the strap settings shown in [Figure 2-3](#) and [Table 2-1](#).


Figure 2-3 56F8300EVM LMDC Jumper Reference
Table 2-1 56F8300EVM LMDC Jumper Settings

Jumper Group	Comment	Connections
JG1	Primary PFC	1-2 & 3-4 & 5-6 & 7-8 & 9-10
JG2	Secondary PFC	NC
JG3	Phase_IS / Over_I	2-3
JG4	Primary Zero-Crossing / Encoder	2-3 & 5-6 & 8-9
JG5	Secondary Zero-Crossing / Encoder	2-3 & 5-6 & 8-9
JG6	Primary Back-EMF / Phase-IS	1-2 & 4-5 & 7-8
JG7	Secondary Back-EMF / Phase-IS	1-2 & 4-5 & 7-8
JG8	Fault A Monitor	1-2 & 3-4 & 5-6
JG9	Fault B Monitor	1-2 & 3-4 & 5-6
JG10	Switch 1 (Up)	1-2
JG11	Switch 2 (Down)	1-2
JG12	Switch 3 (Run / Stop)	1-2

3. Build

To build this application, open the `3srm_hall_56F83xx_onPE.mcp` project file and execute the *Make* command, as shown in **Figure 3-1**. This will build and link the 3-phase Switched Reluctance Motor Control with Hall Sensors Application and all needed Metrowerks and Processor Expert libraries.

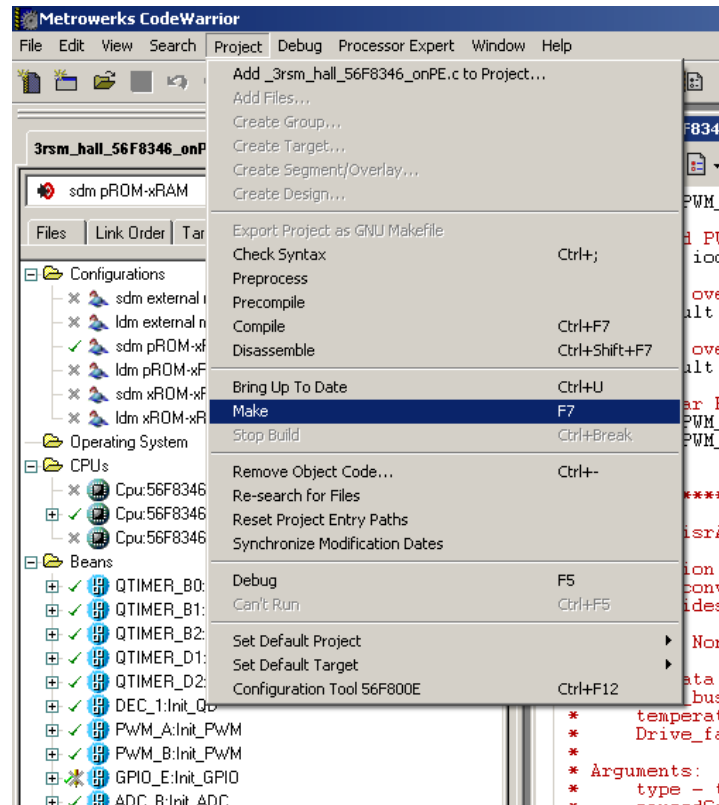


Figure 3-1 Execute *Make* Command

4. Execute

To execute the 3-Phase Switched Reluctance Motor Control with Hall Sensors application, select *Project / Debug* in the CodeWarrior IDE, followed by the *Run* command.

If the *Flash* target is selected, CodeWarrior will automatically program the internal Flash of the hybrid controller with the executable generated during *Build*. If the *External RAM* target is selected, the executable will be loaded to off-chip RAM.

To execute the 3-Phase Switched Reluctance Motor Control with Hall Sensors Application's **internal Flash** version, choose the *Program / Debug* command in the CodeWarrior IDE and, when loading is finished, in the **56F8346EVM**, set jumper JG9 to disable the JTAG port and JG3 to enable boot from internal Flash, then push the RESET button. In the **56F8357EVM** or the **56F8367EVM**, set jumper JG3 to disable the JTAG port and JG4 to enable boot from internal Flash, then push the RESET button.

For more help with these commands, refer to the CodeWarrior tutorial documentation in the following file, located in the CodeWarrior installation directory:

<...>\CodeWarrior Manuals \ PDF \ Targeting_56800E.pdf

For jumper settings, see the **56F83xx Evaluation Module Hardware User's Manual** for the device being implemented.

Once the application is running, move the RUN / STOP switch to the RUN position and set the Required Speed with the UP / DOWN push buttons. Pressing the UP / DOWN buttons should incrementally increase the motor speed until it reaches maximum speed. If successful, the 3-phase Switched Reluctance Motor will be spinning.

Note: If the RUN / STOP switch is set to the RUN position when the application starts, toggle the RUN / STOP switch between the STOP and RUN positions to enable motor spinning. This is a protection feature that prevents the motor from starting when the application is executed from CodeWarrior. You should also see a lighted green LED, which indicates that the application is running. If the application is stopped, the green LED will blink at a 2Hz frequency. If an undervoltage, overvoltage, overcurrent, or overheating fault occurs, the green LED will blink at a frequency of 8Hz.



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