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# 56F805 3-Phase AC Induction Motor V/Hz Control using Processor Expert™

Targeting Document

# 56F805
## Hybrid Controller

805ACIMTD/D
Rev. 0, 09/2003

MOTOROLA.COM/SEMICONDUCTORS

# 3-Phase AC Induction Motor Control V/Hz Application - Closed Loop

This application demonstrates a principal of the Volts per Hertz (V/Hz) control of the 3-Phase AC induction motor in closed-loop using the 56F805EVM board, Optoisolation board, and 3-phase AC BLDC high-voltage power stage.

## 1. Specifications

This application performs principal control of the 3-phase AC induction motor using the 56F805 processor. The control technique sets the speed (rpm or Hz) of the magnetic field and calculates the phase voltage amplitude according to a V/Hz table. This table is private to the application and reflects AC induction motor parameters (Base Voltage/frequency; Boost Voltage/frequency; DC Boost Voltage). The incremental encoder is used to derive the actual rotor speed.

The closed-loop system is characterized by a feedback signal (Actual speed), derived from a quadrature decoder in the controlled system. This signal monitors the actual behavior of the system, and is compared with the reference signal (Required Speed). The magnitude and polarity of the resulting error signal are directly related to the difference between the required and actual values of the controlled variable, which may be the speed of a motor. The error signal is amplified by the controller, and the controller output makes a correction to the controlled system, reducing the error signal.

Protection is provided against drive faults Overcurrent, Overvoltage, Undervoltage, and Overheating.

**System Outline**

The system is designed to drive a 3-phase AC Induction Motor (ACIM). The application has the following specifications:

- Volt per Hertz control technique used for ACIM control
- Closed-loop control
- Targeted for 56F805EVM
- Running on 3-phase AC induction motor control development platform at variable line voltage 115V AC and 230V AC (range -15% to +10%)
- Motor mode
- Generator mode
- DCBus brake
- Minimum speed 50rpm
- Maximum speed 2250rpm at input power line 230V AC
- Maximum speed 1200rpm at input power line 115V AC
- Power stage and optoisolation board identification
- Fault protection
- Manual interface (RUN/STOP switch; UP/DOWN push buttons control; LED indication)
- PC master software remote control interface (speed set-up)

- PC master software remote monitor — PC master software monitor interface (required speed; actual motor speed; drive fault status; DCBus voltage level; identified power stage boards)

### Application Description

The Volt per Hertz control algorithm is calculated on the Motorola 56F805 device. The algorithm generates the 3-phase PWM signals for AC induction motor inverter according to the user-required inputs, measured and calculated signals.

The concept of the ACIM drive incorporates the following hardware components:

- AC induction motor-brake set
- 3-phase AC/BLDC high voltage power stage
- 56F805EVM board
- Optoisolation box, which is connected between the power stage board and the 56F805EVM

The AC induction motor-brake set incorporates a 3-phase AC induction motor and attached BLDC motor brake. The AC induction motor has four poles. The incremental position sensor (encoder) is coupled on the motor shaft. The detailed motor-brake specifications are listed in **Table 1-1**.

**Table 1-1. Motor-Brake Specifications**

| Set Manufactured | EM Brno, Czech Republic | |
|---|---|---|
| Motor Specification | Motor Type | AM40V<br>3-Phase AC Induction Motor |
| | Pole-Number | 4 |
| | Nominal Speed | 1300rpm |
| | Nominal Voltage | 3 x 200V |
| | Nominal Current | 0.88A |
| Brake Specification | Brake Type | SG40N<br>3-Phase BLDC Motor |
| | Pole-Number | 6 |
| | Nominal Speed | 1500rpm |
| | Nominal Voltage | 3 x 27V |
| | Nominal Current | 2.6A |
| Position Sensor (Encoder) | Type | Baumer Electric<br>BHK 16.05A 1024-12.5 |
| | Pulses per revolution | 1024 |

The following software tools are needed for compiling, debugging, loading to the EVM, remote control and monitoring, RUN/STOP Switch and UP/DOWN Buttons:

- Metrowerks CodeWarrior 6.0
- PC master software
- Processor Expert v. 2.92

Measured quantities include:

- 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)
- Wrong hardware (PC master software error message = Wrong HW used)

The 3-phase AC Induction Motor V/Hz application can operate in two modes:

1. **Manual Operating Mode**
   The drive is controlled by the RUN/STOP switch (S6). The motor speed is set by the UP (S2-IRQB) and DOWN (S1-IRQA) push buttons (**Figure 1-1**). If the application runs and motor spinning is disabled (i.e., the system is ready), the green user LED (LED3; see **Figure 1-2** ) will blink. When motor spinning is enabled, the green user LED will be on and the actual state of the PWM outputs are indicated by PWM output LEDs. If Overcurrent, Overvoltage or Overheating occur, or if the wrong system board is identified, the green user LED starts to flash quickly and the PC master software signals the identified type of fault. 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. Refer to **Table 1-2** for application states.

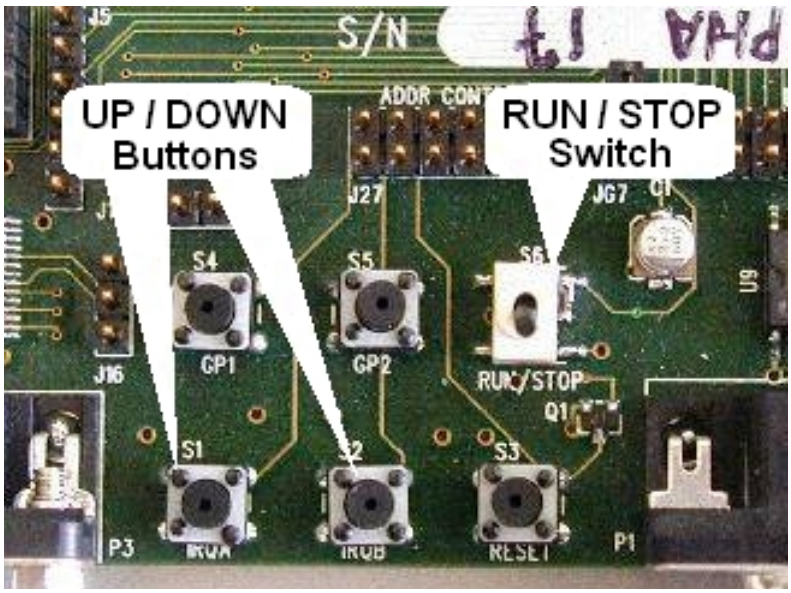


**Figure 1-1. RUN/STOP Switch and UP/DOWN Buttons**

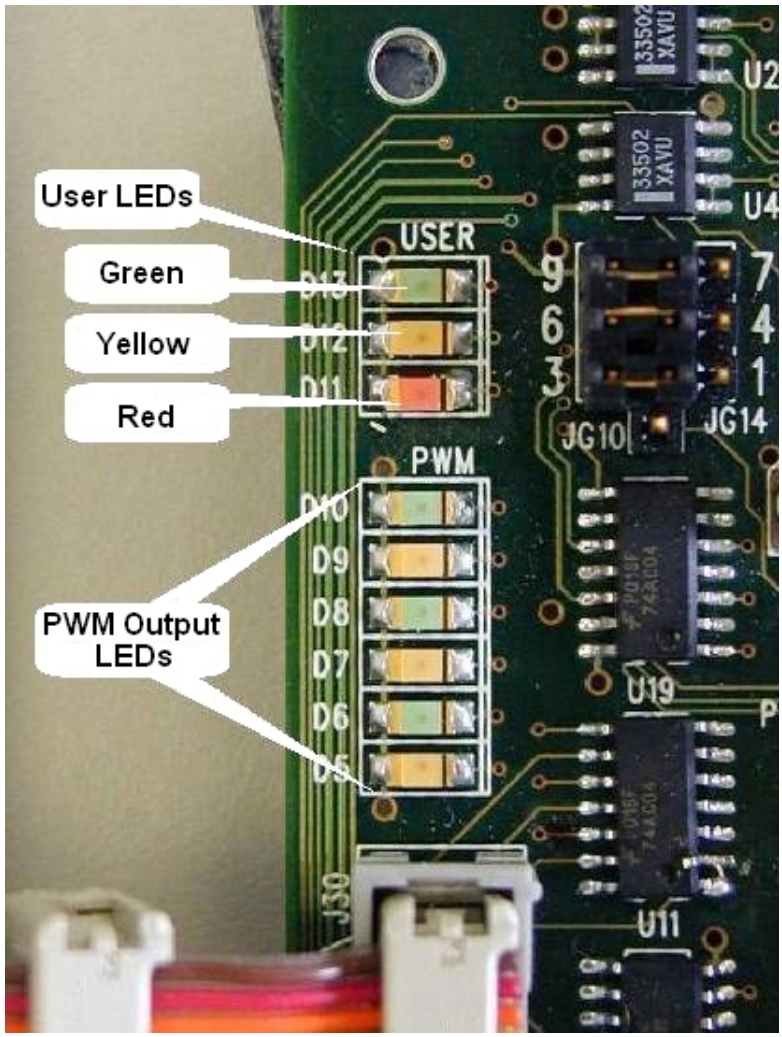


**Figure 1-2. USER and PWM LEDs**

**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 CPU device 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.

The following control actions are supported:

- Set the Required Speed of the motor
- Set Close/Open loop by checking/unchecking the "Close Loop" checkbox; see **Figure 1-3**

PC master software displays the following information:

- Actual and Required Speed of the motor
- Phase voltage amplitude (related to given DCBus voltage)
- Application mode - RUN/STOP
- DCBus voltage and temperature of power module
- Drive Fault status
- Identified hardware

If Overcurrent, Overvoltage, Undervoltage or Overheating occur, the internal fault logic is asserted and the application enters a fault state (the user LED will flash quickly). 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.

Project files for the PC master software are located in:

**..\PC_Master\external memory.pmp,** uses Map file to run in External Memory

**..\PC_Master\internal pROM-xRAM.pmp, ..\PC_Master\internal xROM-xRAM.pmp,** use Map file to run in Flash

Start the PC master software window's application and choose the PC master software project for the desired PC master software Operating Mode. **Figure 1-3** shows the PC master software control window for **internal pROM-xRAM.pmp**.

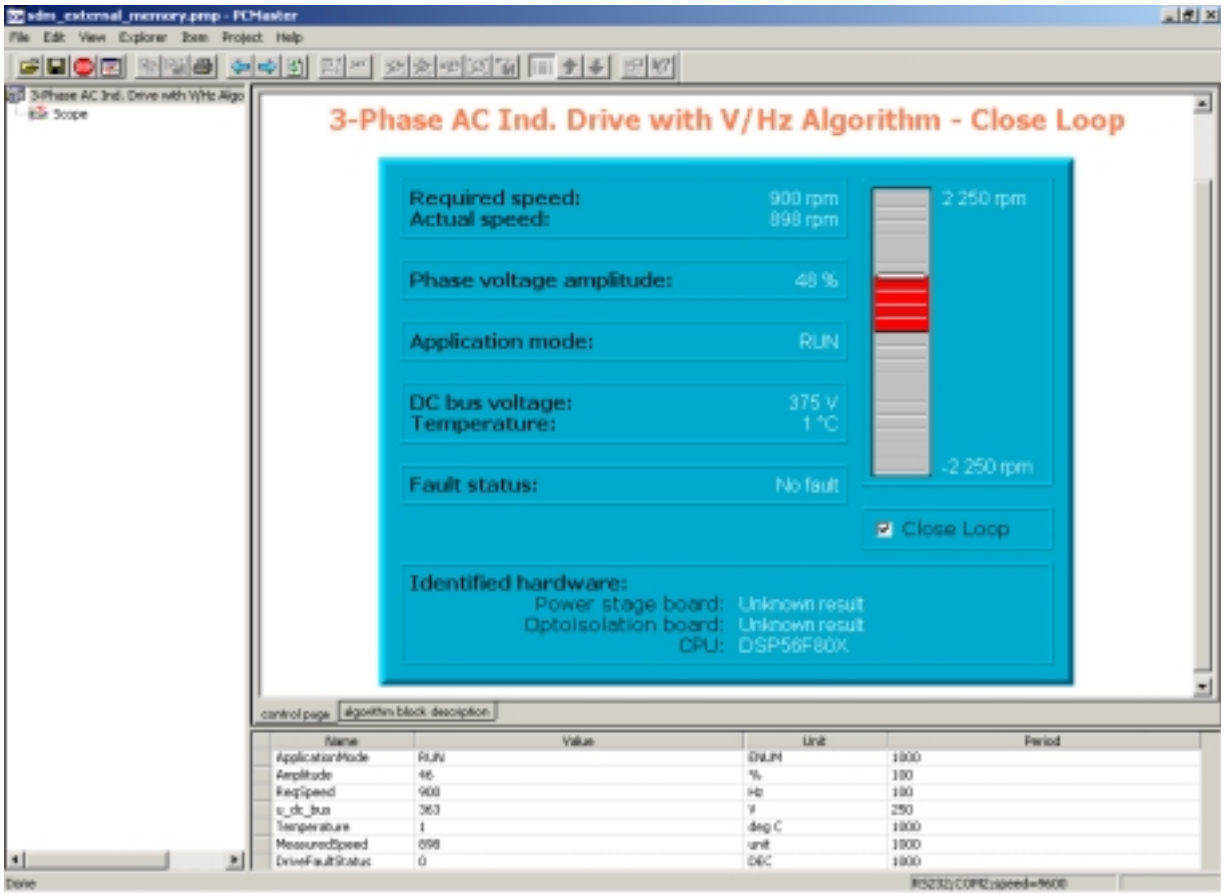


**Figure 1-3. PC Master Software Control Window**

# 2. Hardware Set-up

**Figure 2-1** illustrates the hardware set-up for the 3-phase AC Induction Motor Control V/Hz A Application - Closed Loop.

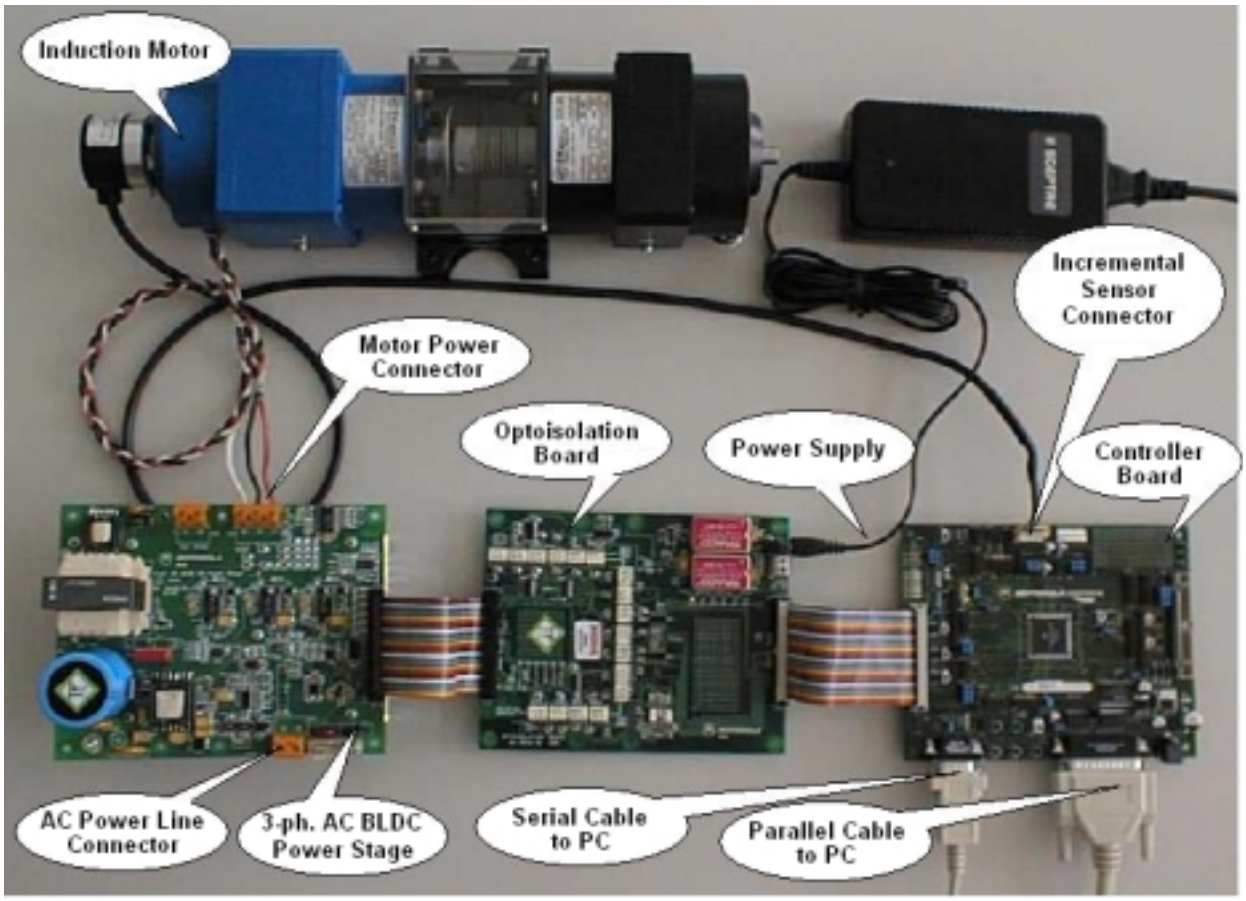


**Figure 2-1. Set-up of the 3-phase AC Induction Motor Control Application - Closed Loop**

The correct order of phases (Phase A, Phase B, Phase C) for the AC induction motor shown in Figure 2-1 is:

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

When facing a motor shaft, the phase order is: Phase A, Phase B, Phase C, the motor shaft should rotate clockwise (i.e., positive direction, positive speed).

For detailed information, see the **56F805 Evaluation Module Hardware Reference Manual**. The serial cable is needed for the PC master software debugging tool only.

## 2.1 EVM Jumper Settings

To execute the 3-phase AC Induction Motor Control V/Hz Application - Closed Loop, the 56F805 board requires the strap settings shown in Figure 2-2 and Table 2-1.

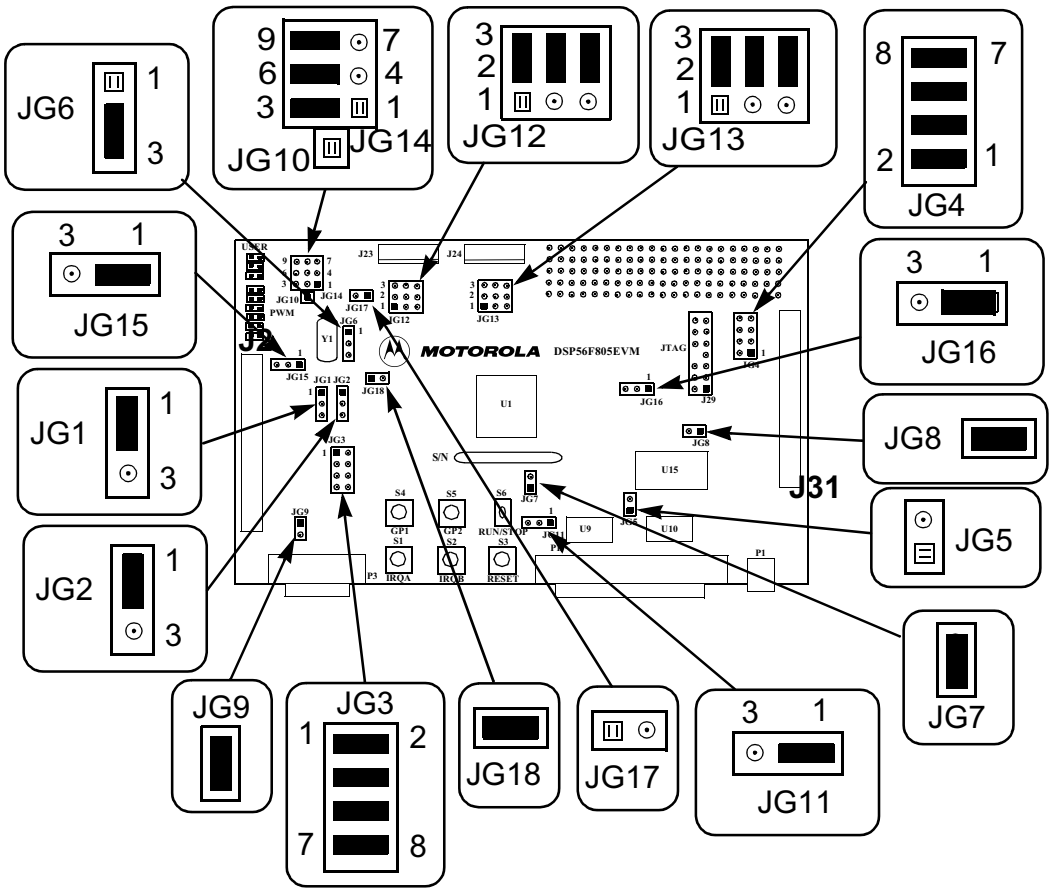


**Figure 2-2. 56F805EVM Jumper Reference**

**Table 2-1. 56F805EVM Jumper Settings**

| Jumper Group | Comment | Connections |
|---|---|---|
| JG1 | PD0 input selected as a high | 1-2 |
| JG2 | PD1 input selected as a high | 1-2 |
| JG3 | Primary UNI-3 serial selected | 1-2, 3-4, 5-6, 7-8 |
| JG4 | Secondary UNI-3 serial selected | 1-2, 3-4, 5-6, 7-8 |
| JG5 | Enable on-board parallel JTAG Command Converter Interface | NC |
| JG6 | Use on-board crystal for CPU oscillator input | 2-3 |
| JG7 | Select CPU's Mode 0 operation upon exit from reset | 1-2 |
| JG8 | Enable on-board SRAM | 1-2 |
| JG9 | Enable RS-232 output | 1-2 |
| JG10 | Secondary UNI-3 Analog temperature input unused | NC |
| JG11 | Use Host power for Host target interface | 1-2 |
| JG12 | Primary Encoder input selected for Quadrature Encoder signals | 2-3, 5-6, 8-9 |
| JG13 | Secondary Encoder input selected | 2-3, 5-6, 8-9 |
| JG14 | Primary UNI-3 3-Phase Current Sense selected as Analog Inputs | 2-3, 5-6, 8-9 |
| JG15 | Secondary UNI-3 Phase A Overcurrent selected for FAULTA1 | 2-3 |
| JG16 | Secondary UNI-3 Phase B Overcurrent selected for FAULTB1 | 1-2 |
| JG17 | CAN termination unselected | NC |
| JG18 | Use on-board crystal for CPU oscillator input | 1-2 |

**Note:** When running the EVM target system in a stand-alone mode from Flash, the JG5 jumper must be set in the 1-2 configuration to disable the command converter parallel port interface.

# 3. Build

To build this application, open the *3ph_AC_VHz_CL.mcp* project file and execute the *Make* command, as shown in **Figure 3-1**. This will build and link the 3-phase AC V/Hz Motor Control application and all needed Metrowerks and Processor Expert libraries.

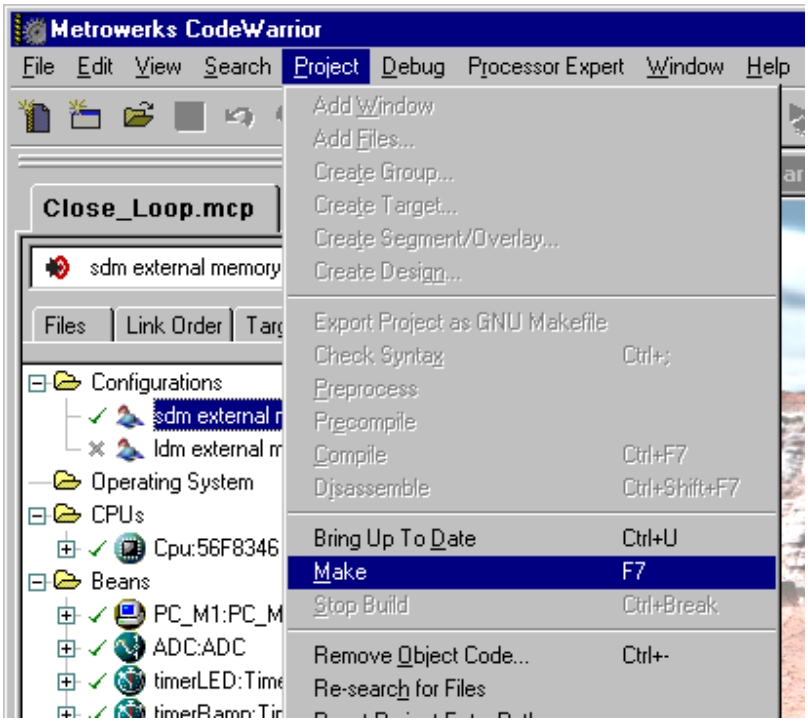


**Figure 3-1. Execute *Make* Command**

For more information about these commands, see:

**<...>\CodeWarrior Manuals\PDF\Targeting_56800.pdf**

# 4. Execute

To execute the 3-phase AC V/Hz Motor Control application, choose the *Program/Debug* command in the CodeWarrior IDE, followed by the Run command.

To execute the 3-phase AC V/Hz Motor Control application's internal Flash version, choose the *Program/Debug* command in the CodeWarrior IDE. When loading is finished, set jumper JG5 to disable the JTAG port and JG7 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_56800.pdf**

For jumper settings, see the **56F805 Evaluation Module Hardware User's Manual**.

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 AC Induction 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 stops, the green LED blinks at a frequency of 2Hz.

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