



Powerful Processors – Easy to Use™

# R8C/Tiny BLDC Motor Control Evaluation Kit (YMCRPR8C25)

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## User's Manual

Rev. 1.1  
March 2008

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# Limited Guarantee and Support

Renesas Technology America, Inc. warrants the YMCRPR8C25 kit to be free from component or assembly defects for a period of 90 days from the date of purchase. Settlement is limited to repair or replacement of the product only. Renesas Technology America, Inc. does not assume any liability arising out of the application or use of any product, circuit or procedure described herein. No other liability or warranty applies, expressed or implied. Software warranty is limited to replacement of the CD only. While every attempt has been made to ensure accurate documentation, Renesas Technology America, Inc., cannot be held responsible for errors or omissions, and reserves the right to make changes without prior notice.

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# 1.0 Introduction

The YMCRPR8C25 kit is a low-cost Evaluation Kit for evaluating the R8C/25 MCU for use in 3 phase BLDC motor applications. Renesas firmware is included for evaluating motor drive capabilities of the R8C family of processors.

The kit comes with a complete software development tool chain for Renesas MCUs, including the High-performance Embedded Workshop (HEW), which includes an Integrated Development Environment (IDE), Graphical User Interface (GUI), the M16C C-compiler, assembler and linker.

## 2.0 Kit Contents

This section describes the contents of the YMCRPR8C25 product package. When unpacking your YMCRPR8C25, please check to see that all items listed below are included.

### 2.1. YMCRPR8C25 Kit Item List

Table 2-1 lists the items included in the YMCRPR8C25.

**Table 2-1 YMCRPR8C25 Item List**

Item Name	Quantity	Remarks
YMCRPR8C25 PC board	1	R8C/25 MCU mounted on the board
Motor	1	Emerson/HURST 24V BLDC Motor
Power Supply	1	24VDC, 5A power supply.
Line Cord	1	"figure 8" to AC plug
4 Conductor Motor Wire Harness	1	White Molex to green 4 pos. Phoenix screw connector
5 Conductor Hall Sensor Harness	1	Black inline to green 5 pos. Phoenix screw connector
E8a	1	On-chip Debugging Emulator
USB Cable	1	E8A > PC Connection
14 Pin Ribbon Cable	1	E8A > YMCRPR8C25 Connection
9 pin RS232 serial cable	1	for serial data, YMCRPR8C25 > PC Connection
3 pin Phoenix Connector	1	For use with Bench-top Power Supply
Fuse, 5A	1	Spare fuse
YMCRPR8C25 Quick Start Guide	1	
YMCRPR8C25 Kit Packing List	1	
YMCRPR8C25 CD-ROM	1	Auto-install program HEW (IDE & debugger) Motor Evaluation Code M16C C-compiler, assembler, and linker FDT (Flash Development Tool) Manuals Tutorials Sample programs

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### 2.1.1. CD-ROM

The CD-ROM contains the electronic manuals and software necessary for developing programs. Insert the enclosed CD into your computer; the installer should auto-start. The installer program will create the C:\Workspace folder on your PC. HEW is installed in the C:\Program Files\Renesas folder by default.

## 3.0 System Overview

The following hardware and software products are required to use the YMCRPR8C25 Kit.

- Host Computer (supplied by user)
- YMCRPR8C25 board.
- 24V BDLC Motor
- AC Adapter, 24VDC 5A, center positive
- 9-pin Serial cable
- Software Tools (HEW IDE, FDT, Compiler/Linker) installed on host computer
- E8a On-Chip Debugging Emulator (supplied with kit)

### 3.1. Host Computer Requirements

The minimum requirement to be able to use the software that comes with the YMCRPR8C25 kit is a PC with a serial port and Microsoft Windows 2000, or XP. For debugging with the optional (user supplied) E8a in-chip debugging emulator, the PC also needs a USB port.

### 3.2. YMCRPR8C25 Board

The YMCRPR8C25 board consists of the main board and a 2x8 character based LCD pre-assembled together. The microcontrollers flash is factory programmed with the Hall Based Application (also included on the CD) so you can drive the motor right out of the box without loading code.

### 3.3. Driver and Support Software

The YMCRPR8C25 includes sample drivers for the peripherals used as part of the Project. These provide working examples for use in driving motors. For details, see Chapter 5.0.

### 3.4. Development Tools

The installer program installs the development tools. For details on installation, see the QuickStart Guide. A brief description of all the included tools follows. Please refer to the individual tool manuals for detailed information.

#### 3.4.1. E8a On-Chip Debug Emulator

The E8a is an On-Chip Debug Emulator for downloading, executing, and debugging code. It connects to the PC via a USB cable and to the motor control board via a 14-pin ribbon cable. The E8a combined with the included software development tools provides a complete evaluation and development environment for the motor control platform.

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### 3.4.2. HEW (High-performance Embedded Workshop)

HEW provides a Graphical User Interface (GUI) that integrates the software development tools and includes the C-compiler, assembler, linker, debuggers and editor. E8a debugger components are included with this install of HEW.

### 3.4.3. M16C Evaluation Version C Compiler

The evaluation version of the M16C C-compiler provides the same functionality as the commercial version except that link size will be restricted to 64 Kbytes after 60 days from when you begin using the compiler. Contact your local sales representative if you wish to purchase a full license.

### 3.4.4. FDT

FDT is a Windows based application that can be used to program the flash on R8C/25 MCU's via a COM port on your PC or through a debugger. FDT (Flash Development Toolkit) is installed by default as part of HEW. For using this kit, we program the R8C/25 chip with the E8a debugger within HEW, but FDT is a handy utility for other situations, such as self-programming through the UART, or with external flash chips.

### 3.4.5. Renesas AutoUpdate

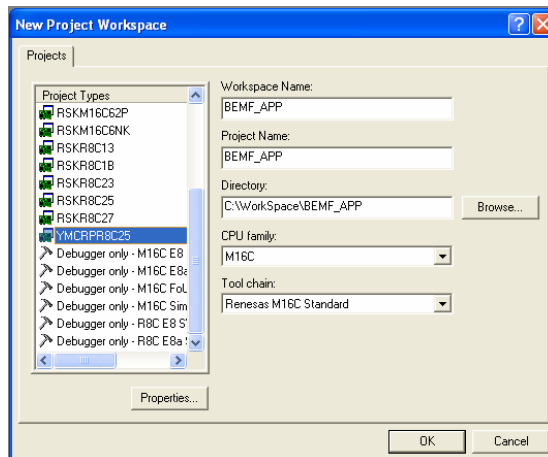
Included with HEW 4.0 and later is the Renesas AutoUpdate utility. This utility can be configured to search our website automatically for updates of the Renesas tools installed on your PC. See the HEW User's Manual on how to use this feature.

### 3.4.6. Documentation, Sample Projects and Project Generators

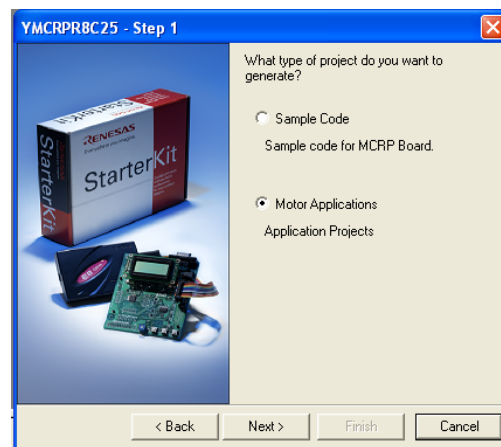
The YMCRPR8C25 includes a full set of user documentation and project generators (a project generator is a template to create a project.). After installing the CD, documentation can be browsed by using the "Manual Navigator" from the Start menu (Start > (All) Programs > Renesas > High-performance Embedded Workshop > Manual Navigator).

All the sample code is contained within the project generator "YMCRPR8C25". By using the project generators, the user can name the workspace and project and gives flexibility on where the files are copied onto the PC.

Within HEW, start a new project workspace, and select YMCRPR8C25 for Project Type. See the Quick Start Guide for detailed steps to creating a project with project generators.



New Project Workspace Wizard



All YMCRPR8C25 Sample Projects Can Be Accessed From This Window

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The download modules for the YMCRPR8C25 demos are included under Sample Code in the “YMCRPR8C25” project generator.

### 3.4.7. Software Build Process Overview

The YMCRPR8C25 kit allows the user to write or modify the provided code to evaluate the R8C/25 Motor Control solution. Code can be compiled and downloaded to the MCU. Debugging can be accomplished with E8a On-chip debugging Emulator. The figure below illustrates the steps required to create a working application on the YMCRPR8C25 hardware.

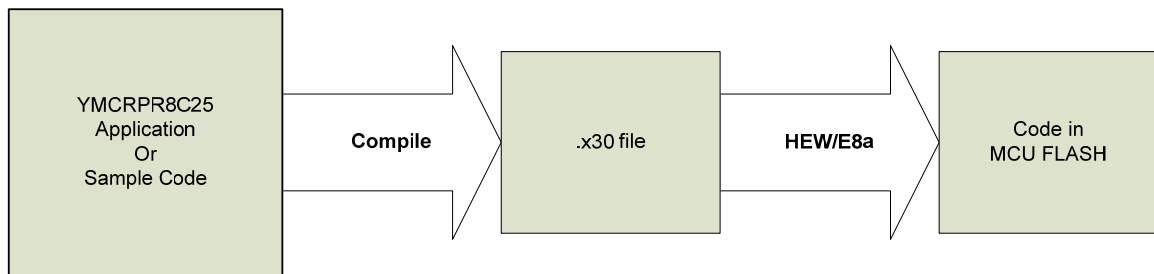


Figure 6.1: Steps to Create a Working YMCRPR8C25 Application

### 3.4.8. Using the evaluation version (64K) of the M16C compiler

The kit includes a free evaluation version of the compiler. After 60 days, the compiler is restricted to compiling projects (code and data) to 64K bytes. The MCRP25 uses the R8C/25 which has 64k bytes, so any project for this device will work with the evaluation version.



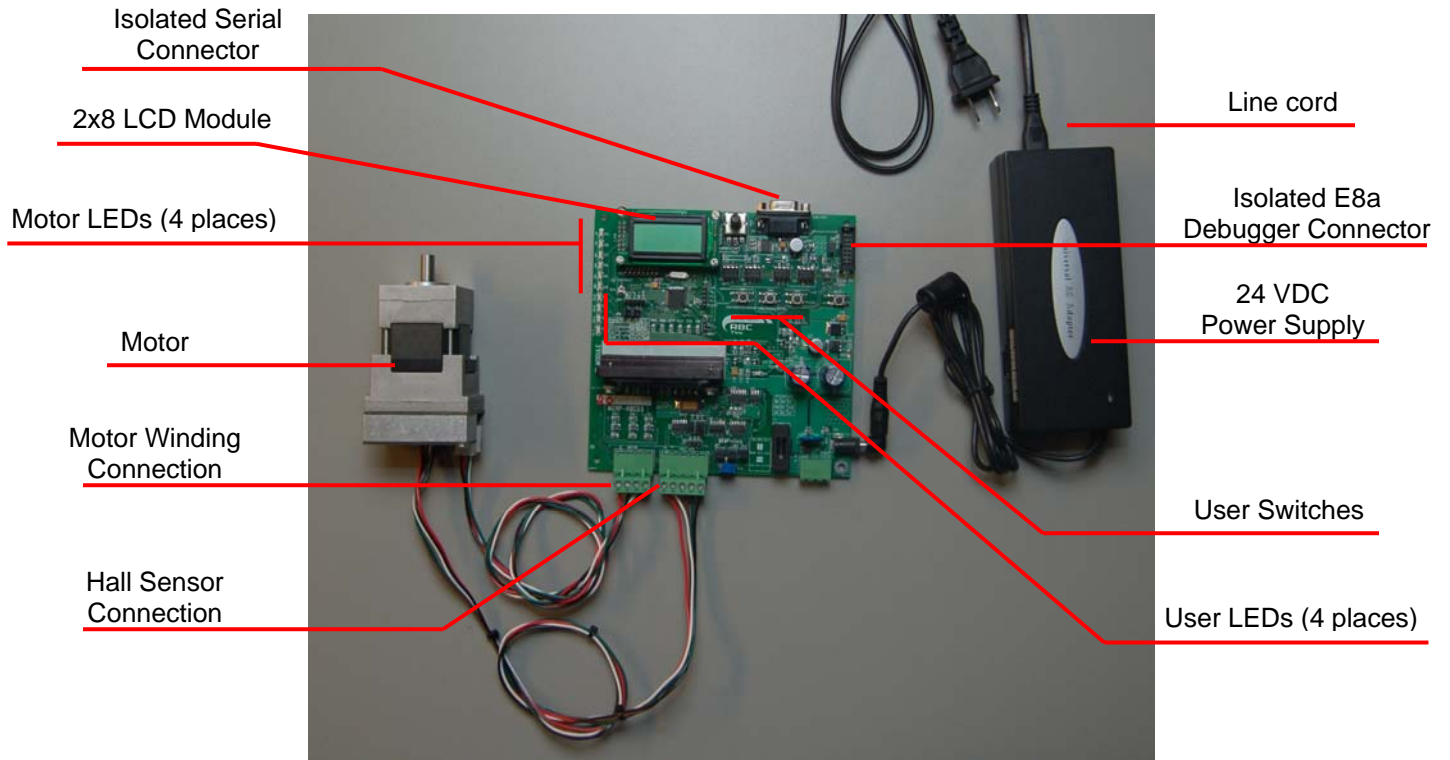
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# 4.0 Hardware

## 4.1. YMCRPR8C25 System Overview

Figure 4-1 shows the YMCRPR8C25 Hardware with major components identified.



**Figure 4-1: YMCRPR8C25 System Components**

## 4.2. YMCRPR8C25 System Block Diagram

The YMCRPR8C25 board incorporates an R5F21258 (R8C/25) in a 52-pin QFP package from the R8C/Tiny group of microcontrollers, designated as U17.

Figure 4-2 shows the YMCRPR8C25 block diagram.

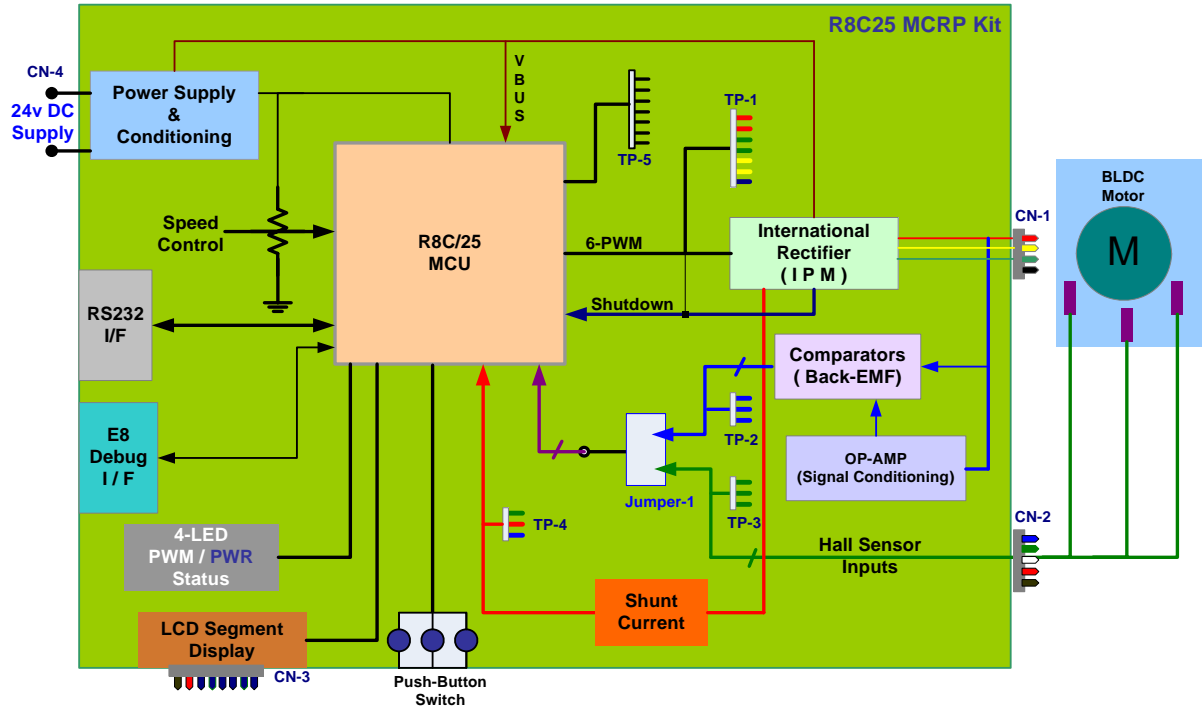


Figure 4-2: YMCRPR8C25 Block Diagram

## 4.3. The YMCRPR8C25 System Component Descriptions

The YMCRPR8C25 System consists of the R8C/25 MCU, an Integrated Power Module and supporting circuitry, and an LCD module all mounted on a single PCB to drive the included Motor. Below is a detailed description of the system components.

### 4.3.1. YMCRPR8C25 Board

The YMCRPR8C25 includes the R8C/25 and support circuitry. Note that to operate the motor the jumpers must be set correctly for the method selected: sensor (Hall) or sensor-less (Back-EMF). The board is shipped with the jumpers in the Hall Sensor mode. For details on the jumpers, please consult section 4.5 of this YMCRPR8C25 User's Manual.

#### 4.3.1.1. Jumper Settings

Jumper	Default setting	Description
JP4	1-2	Hall W connected to /INT3.
JP5	1-2	Hall V connected to /INT2.
JP6	1-2	SW1 Connected to I/O port 1, bit 2 (p1_2).
JP6	3-4	Over-current Circuit connected to /INT0 for PWM Shutdown and interrupt generation.
JP6	5-7	Hall U connected to /INT1.
JP1	1-2, 3-4	Don't change
JP2	1-2, 3-4	Don't change
JP3	1-2, 3-4	Don't change

Table 4.3.1: Hall based Operation

Jumper	Default setting	Description
JP4	2-3	BEMF W comparator connected to /INT3.
JP5	2-3	BEMF V comparator connected to /INT2.
JP6	1-2	SW1 Connected to I/O port 1, bit 2 (p1_2).
JP6	3-4	Over-current Circuit connected to /INT0 for PWM Shutdown and interrupt generation.
JP6	5-7	BEMF U comparator connected to /INT1.
JP1	1-2, 3-4	Don't change
JP2	1-2, 3-4	Don't change
JP3	1-2, 3-4	Don't change

Table 4.3.2: BEMF based Operation

#### 4.3.2. Emerson Motor

The Emerson Motor included with the kit is a 3-phase BLDC motor. Data sheet is included in the Utilities Directory of the Install CD under Non-Renesas.

#### 4.3.3. Power Supply

The power supply is a 24VDC, 5A power supply with Center positive barrel connector. The power supply is intended only to power the system with the motor that is included in the kit.

**IMPORTANT:** The board does provide a connection for a bench-top power supply. It is recommended the user review all schematics and take all necessary precautions when trying to use the system with voltages and currents beyond those required for the motor included with the kit.

#### 4.4. R8C/25 Group of MCUs

The R8C/25 group of 16-bit single-chip Flash microcontrollers (MCU) is part of the R8C/Tiny Family. The hardware and software manuals for the R8C/25 group of microcontrollers can be found from the Start menu *Start > (All) Programs > Renesas > High-performance Embedded Workshop > Manual Navigator* after software installation.

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# 5.0 Motor Control Demo and Support Software

## 5.1. Overview

The YMCRPR8C25 kit includes two Motor Control Demonstration Application Projects and several Sample Code projects. These are all accessible through the HEW project generator when creating new projects.

## 5.2. Motor Control Demos

### 5.2.1. HALL Sensor Based BLDC Demo

The HALL Sensor based motor drive algorithm can be generated and built using the Project Generator installed during the YMCRPR8C25 Kit installation process. Simply launch HEW and Select YMCRPR825 under Project and on the subsequent screen select Application followed by HALL\_APPL. The USER is referred to the Application note on HALL based motor control included with this kit for further details.

**NOTE:** This algorithm relies on the HALL sensors built into the motor. Please be sure to check the jumper settings per table 4.3.1.

### 5.2.2. BEMF (Sensor-less) BLDC Demo

The BEMF (Sensor-less) motor drive algorithm can be generated and built using the Project Generator installed during the YMCRPR8C25 Kit installation process. Simply launch HEW and Select YMCRPR825 under Project and on the subsequent screen select Application followed by BEMF\_APPL. The USER is referred to the Application note on BEMF (sensor-less) motor control included with this kit for further details.

**NOTE:** This algorithm relies on comparator circuits designed into the board (refer to Appendix B for details). Please be sure to check the jumper settings per table 4.3.2.


## 5.3. Sample Code

There are additional pieces of Sample code included with the kit that will help you evaluate different peripherals within the R8C microcontroller. Simply launch HEW and Select YMCRPR825 under Project and on the subsequent screen select Sample code followed by sample code for the peripheral you wish to use.

## 5.4. Windows GUI YMCRPR8C25 Control Program - LEM

### 5.4.1. OVERVIEW

In order to facilitate motor control and test, the Kit includes a Graphical User Interface program called LEM which can start and stop the motor and plot various pieces of information about the motor while it is running. The plots can include such things as speed, current, IPM temperature, etc...

While you have HEW open and connected to the YMCRPR8C25 board through the E8a, launch the GUI by simply browsing to `C:\Workspace\YMCRPR8C25\Utilites` and double click on MCRP GUI icon  (lem.exe). The GUI will launch and take control from the pot and switches on the PCB.

**NOTE:** Initial screen will ask you to verify the jumpers for the chosen Algorithm

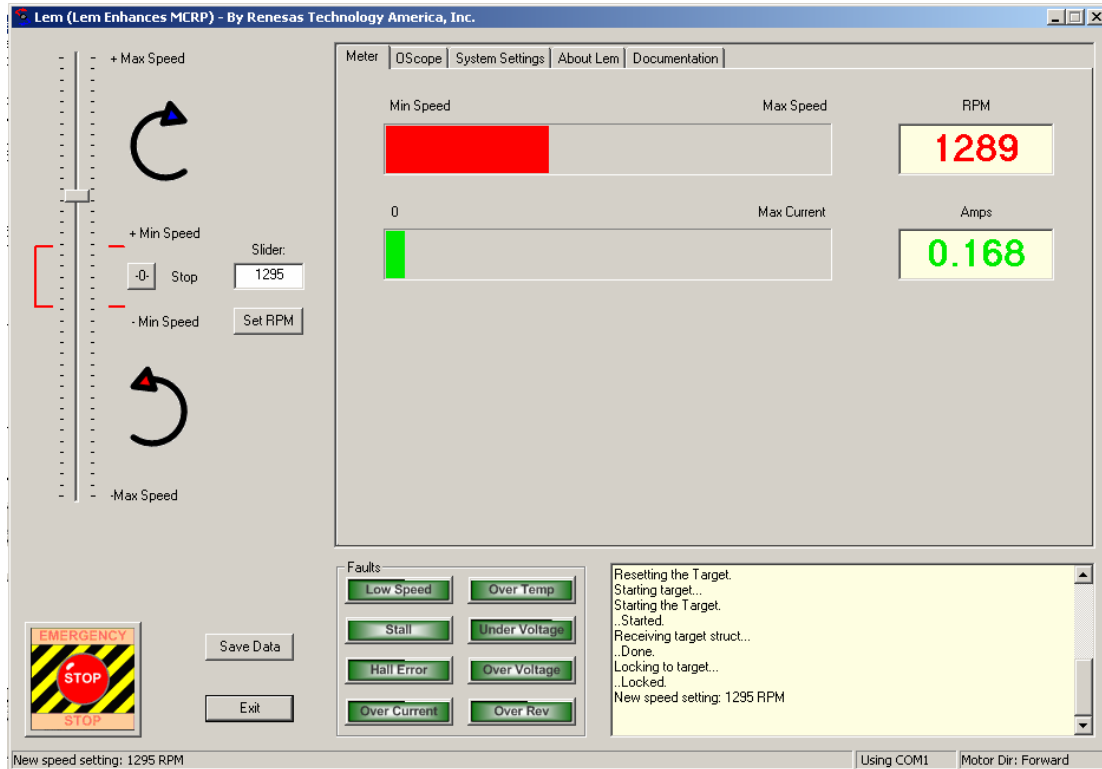


Figure 5.4.1: LEM GUI Meter Window

### 5.4.2. Running Motor

Grab the Speed slider bar and move it above or below the stop point depending on the direction you wish the motor to rotate. Moving the slider down means to rotate CCW as you face the shaft; moving the slider up means to rotate CW as you face the motor shaft. Values below the minimum speed of the selected algorithm will not cause the motor to spin. Returning the slider to 0 will stop the motor. In addition, the motor may be stopped by selecting the STOP Button. This will also cause the slider to return to the 0-RPM selection point.

The E-Stop button flag is sampled at the lowest level of the algorithm. Clicking on it will stop the motor and return slider to 0-RPM selection point.

### 5.4.3. Plotting Data

Near real-time data can be plotted in one of the panes of the motor control GUI. Click on the OScope tab, select the variable to plot and start the motor. See figure 5.4.2 for details. The sample rate of the data points is 400uS per data value plotted. So if you are plotting four items (variables), you are sampling at  $400\mu\text{S} * 4$ , or 1600uS (1.6mS) update rate.

This data may also be captured in a CSV file for plotting or analyzing under Excel.

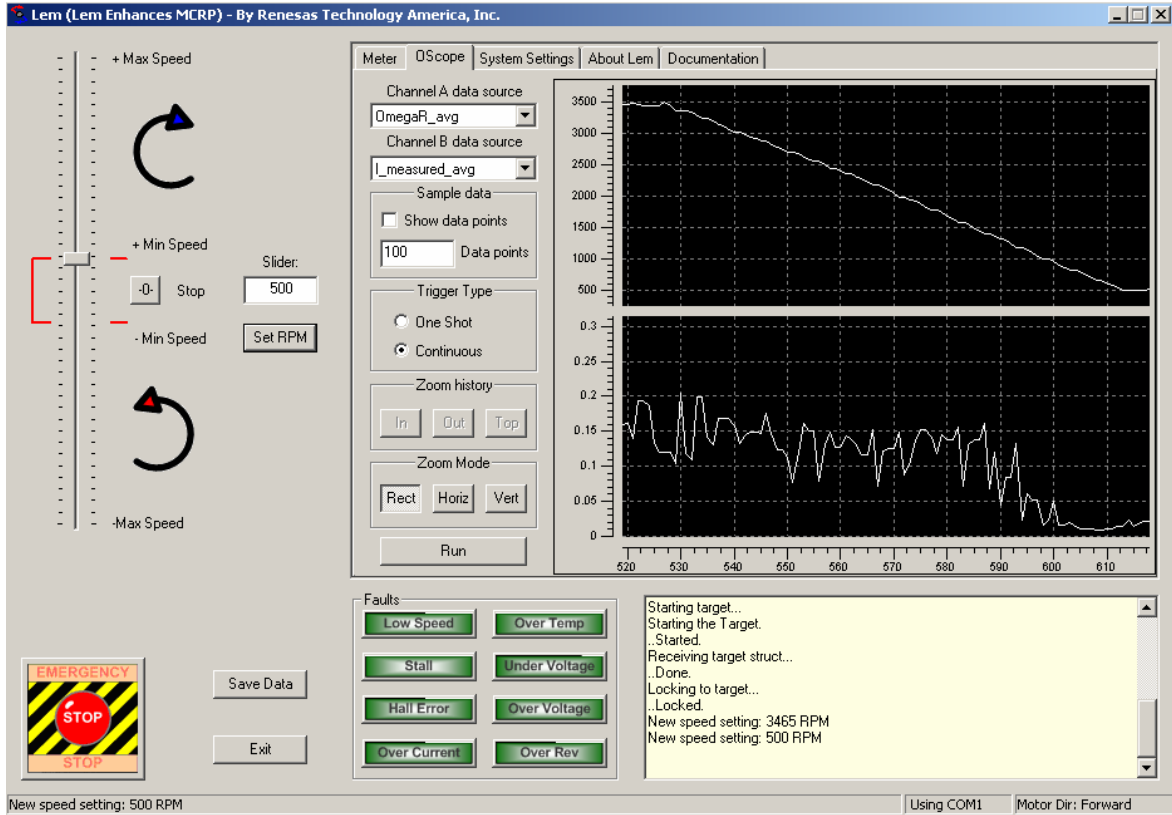


Figure 5.4.2: LEM GUI OScope Window

## 6.0 System Details

### 6.1. Hardware Specifications

Table 6-1 lists the specifications of the YMCRPR8C25 Board.

**Table 6-1: YMCRPR8C25 Board Specifications**

Item	Specification
MCU	R5F21258, Max clock frequency 20MHz
Clock	Main Clock: crystal 20 MHz
Memory	RAM: 3kB Flash ROM: 64kB
IPM	10A, IGBT based Power Module

### 6.2. Power Supply Requirements

The YMCRPR8C25 Board requires a supply voltage of 24.0V DC, and will draw approximately 0.5 amps when running the included motor with *no load*. Running the motor under load will require more current. The kit includes a 120-watt power supply (24VDC @ ~5A) which will drive the motor correctly under moderate loads. A bench top supply may be used to power the board with other motors.

**IMPORTANT:** The absolute operating range for the boards power supply input is +18 to +35 VDC. Connecting to power supplies outside of this range may cause permanent damage to the board.

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### 6.3. Operating Environment

The table below lists the environmental conditions for using and storing the YMCRPR8C25 board. Store the board in a conductive bag inside the original factory packaging.

**Table 6-3: Operating and Storage Environments**

Environmental Condition	Ambient Temperature	Ambient Humidity
Operating	0 to 55°C (No corrosive gas allowed)	30 to 80% (non-condensing)
Storage	-30 to 75°C (No corrosive gas allowed)	30 to 80% (non-condensing)

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# Appendix A. Reference Documents

## A.1 Table - Renesas Documents

Item	Title	Description
1.	<b>YMCRPR8C25 Quick Start Guide</b>	Document that will help you get started on using the YMCRPR8C25 Starter Kit.
2.	<b>YMCRPR8C25 User's Manual</b>	This document.
3.	<b>YMCRPR8C25 Board Schematic</b>	Schematic diagram for RSK board.
4.	<b>M16C Series Software Manual</b>	Instruction set for the M16C/R8C series CPU cores.
5.	<b>R8C/25 Group Hardware Manual</b>	Operation and Specifications for the R8C/25 MCU
6.	<b>E8a Emulator User's Manual</b>	E8A Debugger Manual
7.	<b>HEW User's Manual</b>	Document that describes installation and operation of this Integrated Development Environment for Renesas' Tools.

**NOTE:**

These manuals can be viewed using the Manual Navigator by clicking on *Start > (All) Programs > Renesas > High-performance Embedded Workshop > Manual Navigator*, and expanding the entry for YMCRPR8C25.

## A.2 Table - Other Documents

Item	Title	Description
1.	<b>HEW Target Server QSG</b>	QuickStart guide for HEW Target Server
2.	<b>LCD Data Sheet</b>	Data sheet for ACM0802C LCD
3.	<b>Emerson/HURST Motor Data Sheet</b>	Data Sheet for DMB0224B10002 24VDC BLDC Motor
4.	<b>HEW Target Server Sample code</b>	Various samples of HEW Target Applications for the PC.

**NOTE:**

These documents are contained in the Utilities Folder on the YMCRPR8C25 Install CD.



# Appendix B. Hardware Notes

## B.1 Over-Current Circuit

The YMCRPR8C25 makes current measurements on the low side of the IPM through a 0.05 ohm, non-inductive resistor. This shunt voltage is fed into the gain stage (node SU in figure B-1). The gain is set at 2.2.

R120 sets the “trip” threshold on the over-current monitor to provide an “over-current” signal (node FO).

The FO signal is fed to the INT0 pin of the R8C/25 to generate an interrupt and shutdown the PWM signals to the motor. The Hardware shutdown is to provide fast protection to the power stages in your motor design, the software signal is to provide a methodology for your software to “recover” or “notify” in the event of an over-current fault.

The circuit comes from the factory with the trip point (pin 2 of R120) set to 1.0 Volts, which equates to a trip point of about 4.9A at 85% duty cycle on the PWM.

**NOTE:** this circuit measures the Bus current which in 6-step is typically the same as motor current. For other modulation methods, this may not be the case and customer is advised to analyze their requirements when utilizing other modulation methods.

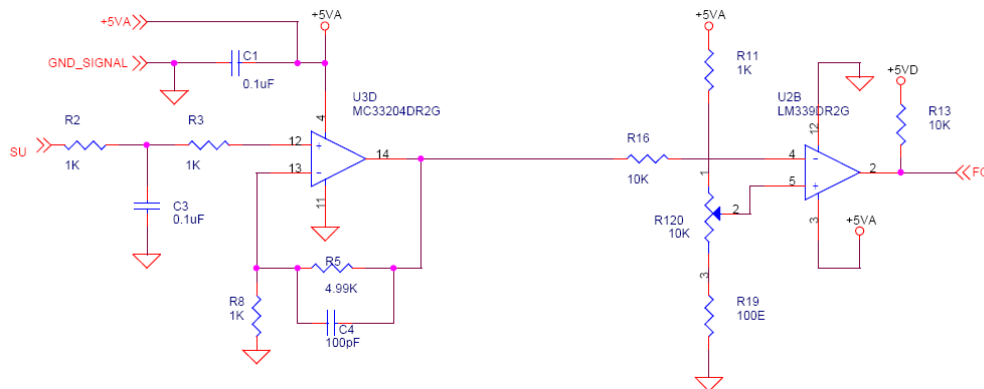
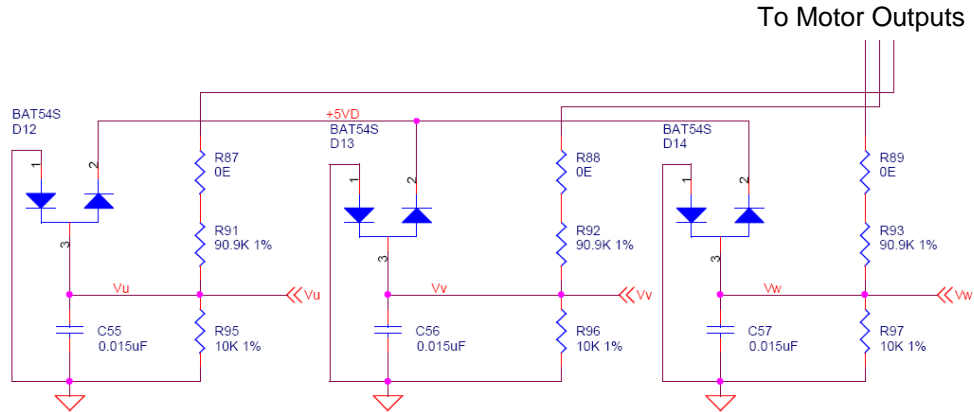


Figure B-1: Over-current Circuit

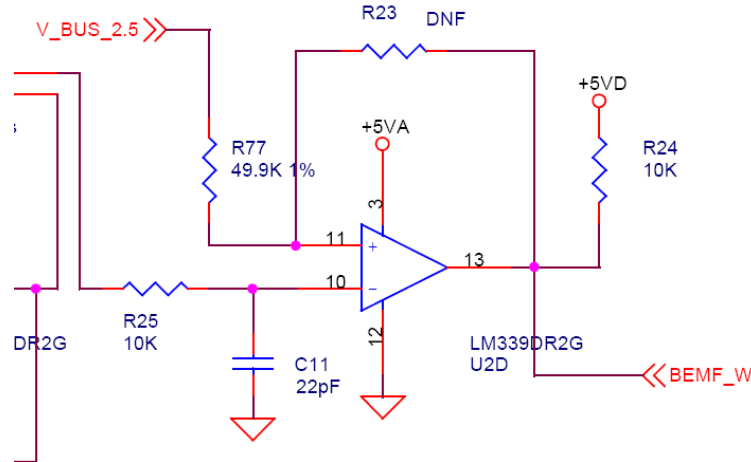
## B.2 Back-EMF Detect Circuit

The YMCPR8C25 uses filters, divider resistors and comparators to detect the Back-EMF in hardware. Figure B-2 shows the Filter/Divider combination.



**Figure B-2: Back-EMF divider and filters**

The outputs are then fed to comparators to detect the correct threshold for “zero-cross” in the motor. One typical circuit is shown in Figure B-3.



**Figure B-3: Back-EMF comparator**

## B.3 Temperature Sensor

The IPM (Intelligent Power Module) includes a Thermistor on the same substrate as the IGBTs. This is used to measure the temperature of the transistor module, as is shown on the LEM GUI Display.

# Appendix C. PCB Component Layout

## C.1 Component Placement - Top

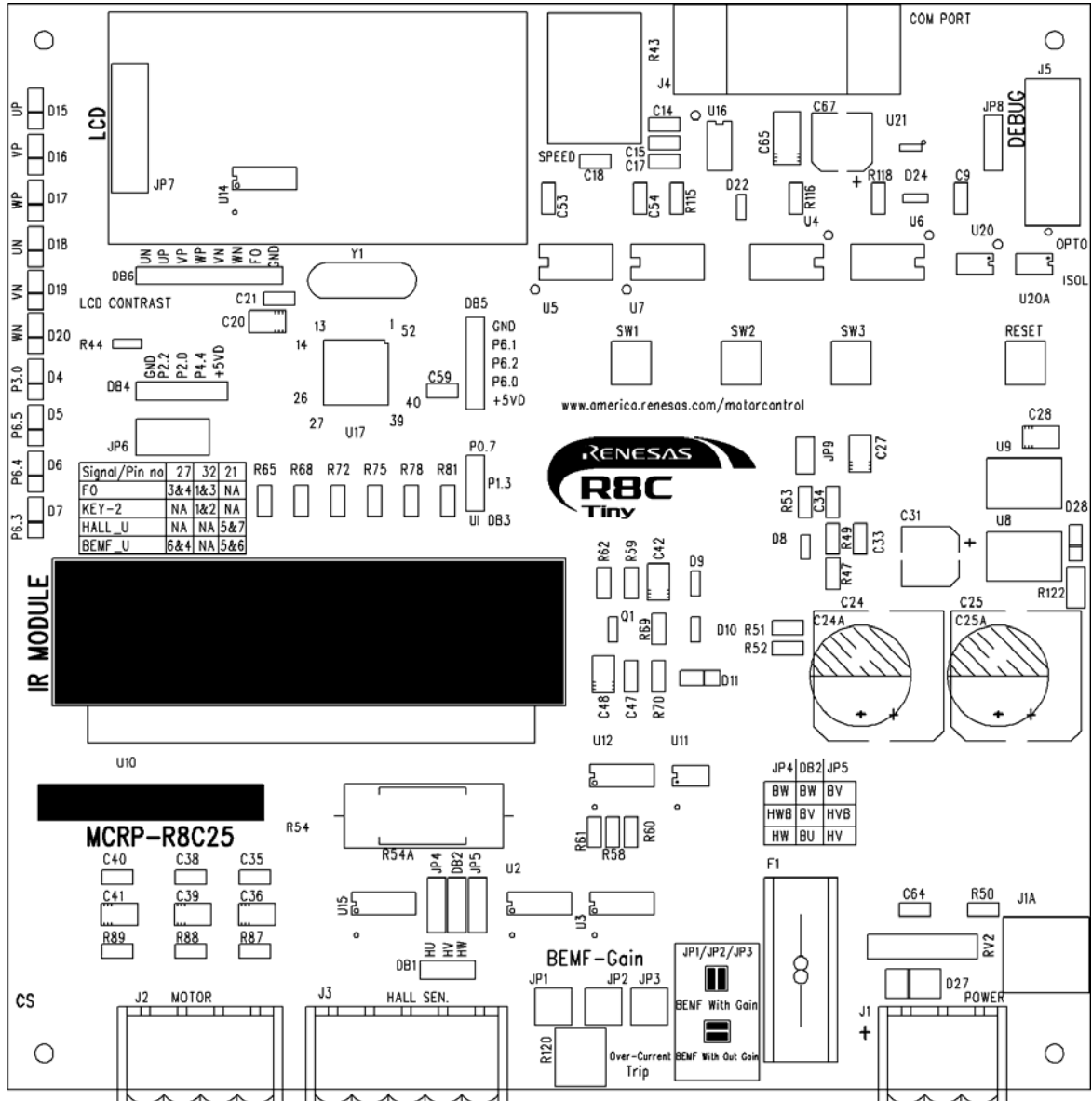


Figure C.1: Component Placement – Top

## C.2 Component Placement - Bottom

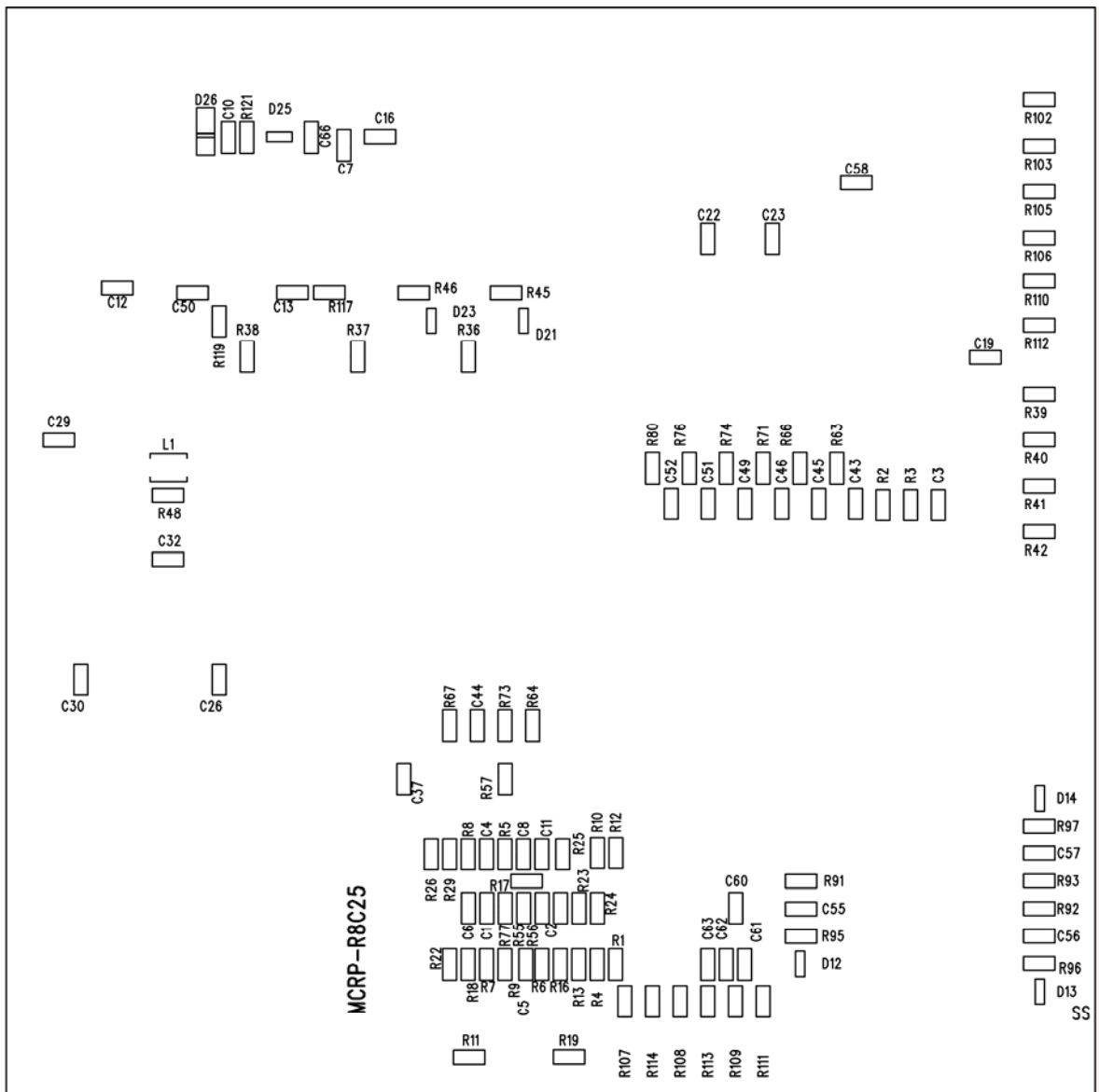


Figure C.2: Component Placement - Bottom

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# Appendix D. Troubleshooting

## D.1 Serial Communications

The YMCRPR8C25 board requires the E8a debugger and an operational COM port in order to run the board from the LEM GUI. The COM port can be a problem on some computers that do not have a hardware COM port, or which do not have it on COM1.

### D.1.1 Setting the COM Port Number

If the COM port available is not COM1, then change the default port in lem.ini. Open lem.ini with a text editor. Find the ComPort=1 field (line 29), and change the number 1 to the actual port being used. This port must be in the range of 1 through 9. Save the file and run LEM.exe again.

### D.1.2 USB COM Ports

Using a USB COM port will often change the port number on each time the PC is booted or the USB COM port is plugged in. Find the actual port used in Hardware Manager. Set lem.ini ComPort setting to match the actual port, or change the USB port to match the .ini file.

### D.1.3 LEM Serial Errors

LEM attempts to get rapid updates from the YMCRPR8C25 board through the serial COM port. When the COM settings do not allow this, the program may report an Overrun Error. The first thing to check is the port settings in Hardware Manager, Properties, Port Settings, Advanced, FIFO. Make sure the FIFO option is enabled.

For USB-Serial adapters, the Advanced port settings vary widely, depending on the adapter. Try the FIFO option first, if available. If you have a Latency option, set it to minimum. If you have timeout options, try setting them to minimum. If your options vary from these and you still have problems, it is recommended you write down the default settings, and try other options that might reduce the time delay between the PC serial interface. This might include closing other Windows applications.

If there is a COM port conflict, such as when a PDA sync program is running, it might be necessary to change the COM port channel or temporarily disable the conflicting program.

Some Serial adapters simply cannot provide the lowest latency communication link to the LEM program. This may result in the LEM GUI showing locked display data, reporting communication errors, numerous fault indicators lighting, or the OScope images not changing with commands. For these situations, the best option may be to reset the communication channel when a fault occurs, which can be done by sending a new speed command by sliding the Speed bar, or hitting the "Set RPM" button.

## D.2 LEM Hangs

If during startup of LEM, it hangs or reports the board is not connected, it may be that HEW Target Server (HTS) is not registered in HEW. Follow the directions in the HTS manual for registering, found in the Manual Navigator. It may be necessary in some cases to un-register a previous version of HTS before registering the new one.