

1/3 HP- Phase Brushless DC (BLDC) Motor Controller Using IR3101/3/4

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TOPICS COVERED

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- System connection and GUI Operation
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Figure 1. IRADK31 Reference Design Kit

1. Overview

The IRADK31 Reference Design Kit (Figure 1) is an electronic controller for driving a 1/3HP (see Table 1) 3-phase Motor from either a single phase 120VAC or 230VAC. The circuit provides all the necessary functions, including software driven High performance Micro Controller, for starting and operating the motor. It also includes an AC on/off switch, EMI filter and the rectification stage with a buck-converter system that provides the auxiliary +15V and +5V supply. This controller is software driven through a Graphical User Interface (GUI) that enables the user to control the entire electrical system and motor parameters. In addition, it allows the user to monitor the DC Bus current, motor speed, and detects fault conditions.

2. Features

- Fused 120/230VAC input.
- AC input on/off switch and EMI filter.
- NTC inrush current limiter
- 3-Phase, variable voltage output.
- Opto-isolated RS-232 serial link interface to the Graphic User Interface software.

- Integral auxiliary power supply of +15V and +5V.
- Fault protection for over current condition.
- Stand-alone Mode and fully software driven (PC Mode) using Graphical User Interface.
- PIC18F2431 motor control MCU from Microchip Technology Inc. with Power PWM module and Hi-speed 10-bit A/D converter.
- RJ11 connector for MPLAB ICD2 that provides programming or In-Circuit debugger interface.

3. General Safety Note

This controller operates at high voltage to control rotating machinery. Qualified, skilled personnel conversant with all applicable safety standards must operate this equipment. **Do not connect any interface cables to the controller when power is present.**

4. Installation

This controller must be placed on an insulated surface. Proper mating cables must be used for the GUI and motor interfaces (refer to Figure 2). Do not make any alterations or soldered connections to the printed wiring board. Verify that the input selector switch matches the AC supply voltage.

5. Protection

Before handling the controller, check that the AC input voltage applied to J1 is turned off, and the AC on/off switch, SW4 is set to position "0".

CAUTION: High voltage is present on the motor connector J6 during operation.

6. System Description

6.1 Power Modules

The IR3101/3/4 are FredFET Half-Bridge with integrated driver IC for motor drive applications. The IR310X are developed for electronic motor control in appliance applications, such as Dishwashing machine pumps and Fan Motors. These 500V power modules (IR3101 and IR3103) contain 2 FredFETs with soft recovery commutation diodes, and one Half-Bridge IC driver. Note that the IR3104 is a 600V module.

6.2 Motor Controller

This motor controller is a single-phase 120V/230VAC input that can utilize 3 IR3101/03/04 modules that are used in a standard inverter configuration. The system is based on a high computational performance, 8-Bit Micro controller with 10-bit A/D converter, used to generate the PWM information and implement the motor control loop. The system operates in an open loop mode, as defined by the firmware. However, this controller has the provision to operate in closed loop mode.

This controller can be operated in Stand-alone Mode or PC Mode. It can be operated in Stand-alone Mode even after connecting the RS-232 cable into J5 but prior to connecting the GUI with the controller. Once the GUI is connected with the controller the system will become operational in PC Mode and the user cannot operate in Stand-alone Mode, until the system is reset again.

Refer to Section 7 and Appendix A for further explanation of Mode Operation.

Two LEDs (Green and Red) are used to monitor the status of the control board. Both LEDs will blink on and off at initial power on, indicating normal board operation. These LEDs have the following features:

- Green: Indicates the Hall sensors level, 3 hall sensors combined. If the motor shaft is rotated by hand, this LED will blink on and off. Once the motor ramps up at higher rate, the blink rate of this LED will increase.
- Red: In normal operation condition indicates the direction of rotation command. On for forward, Off for reverse. It will blink on and off when over current fault condition occurs.

When a Fault is detected the green light, below the Motor Speed Tachometer on the Control Panel, will turn Red. A detected fault guarantees PWM drive shutdown and complete protection for the power stage and the power modules. A fault condition is detected when an over current condition occurs. The firmware current limit can be set in the system limits from the setup parameters window (**refer to Fault Condition and Current Limit in section 8 for details**).

6.3 Auxiliary Power Supply

The auxiliary power supply uses an IR2153 self-oscillating half-bridge driver in a buck topology that delivers the +15V auxiliary supply. The 15V is fed through a linear regulator (LM7805) that delivers the +5V to the remaining circuitry. Both the +15V and +5V are referenced to the DC bus return. The auxiliary power supply operates with a constant on time at variable frequency. Voltage regulation is maintained over a DC bus voltage variation from 80V to 400V.

6.4 Connection Diagram

WARNING

SW1 is an AC Input Voltage Selector switch. DO NOT apply 230VAC when this switch is set to 115VAC – this will result in sever damage to the system and personal injury due to very high voltage produced by the voltage doubler circuit on the DC bus.

Figure 2 illustrates a typical connection block diagram. The printed wiring board has been designed to minimize ground loop currents with particular attention to reducing EMI generation.

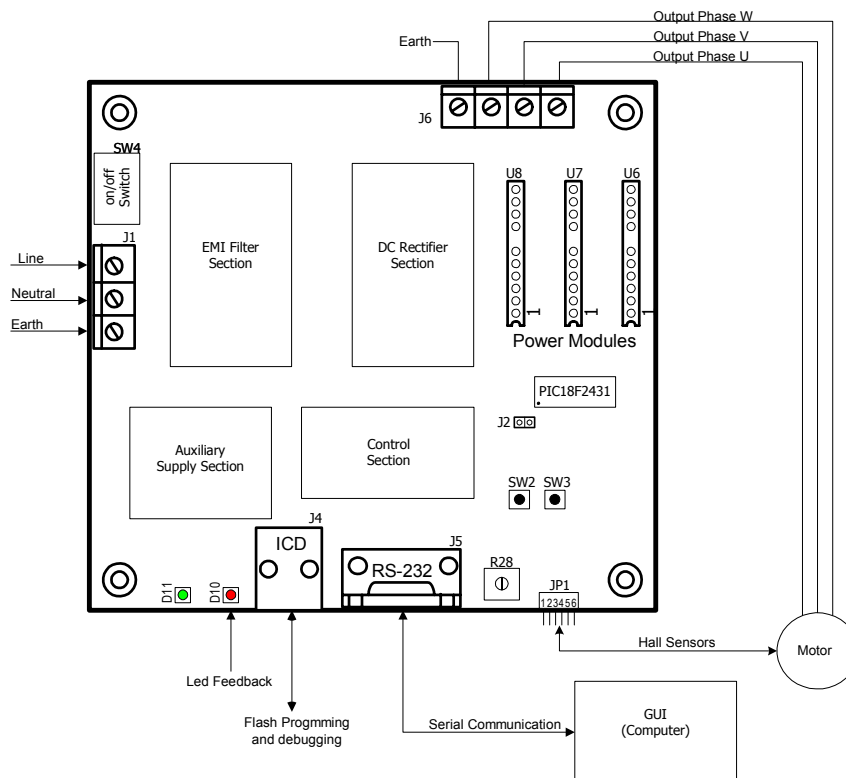


Figure 2. IRADK31 Typical Connection Diagram

6.5 GUI and Micro Controller

The use of the GUI enables the user to control motor speed and direction, monitors the DC Bus current and Fault conditions, and program motor parameters and other control factors. The GUI also enables the users to set motor and system parameters such as motor type, motor voltage and current, AC input voltage, and PWM frequency. In addition, it allows the

user to set the system limits such as current and motor speed. All the setup parameters are uploaded via serial link.

The PIC18F2431 MCU from Microchip Technology Inc. is responsible for all board functions, including communication through the RS-232 interface. Moreover, the Microcontroller introduces design enhancements that make it a logical choice for many high performance, power and motor control applications.

Special peripherals include:

- 14-bit resolution Power Control PWM Module (PCPWM) with programmable dead time insertion.
- Motion Feedback Module (MFM), including a 3-channel Input Capture (IC) Module and Quadrature Encoder Interface (QEI).
- High-speed 10-bit A/D Converter (HSADC).

The MFM Quadrature Encoder Interface provides precise rotor position feedback and/or velocity measurement. The MFM 3X input capture or external interrupts can be used to detect the rotor state for electrically commutated motor applications using Hall Sensor feedback, such as BLDC drives. The microcontroller also features Flash program memory and an internal RC oscillator with built-in Low Power modes, fail-safe clock monitoring and Enhanced USART module.

7. Mechanical and Electrical Description

The printed wiring board is a double-sided 122.7 x 127 mm board using a mixed technology of SMT and through-hole components. The layout of the connectors, indicators and user controls is shown in Figure 3.

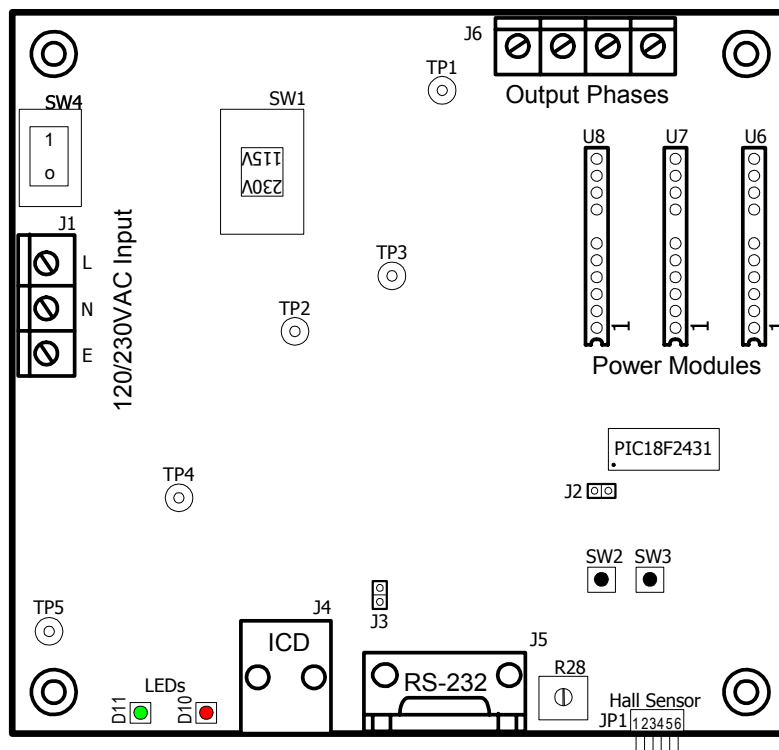


Figure 3. IRADK31 Connectors and indicators layout

Power Switch (SW4)

This is the AC on/off power switch. When set to position “0” power is disconnected from the board. When set to position “1” AC power will be applied to the board.

120/230VAC Input Terminal (J1)

This is the main connector for the AC 120/230VAC input power with earth ground connection. Main AC input power (Line, Neutral and Earth Ground) is to be connected as shown in Figure 2.

Line terminal: Input AC voltage (120V or 230V) phase.

Neutral Terminal: Input AC voltage (120V or 230V) neutral.

Earth: Ground connection (recommended connection to reduce the EMI noise).

115V/230V Selector Switch (SW1)

WARNING: SW1 must be operated ONLY when the AC power is disconnected from terminal J1. Ignoring this warning will result in damage to the board and/or severe personal injury.

This is the voltage selector switch to set the correct rectifier configuration to the AC input. Prior to connection the system to the AC input, carefully check the position of SW1.

Set to 115V when applying power from 110/120VAC source, or set to 230V when applying power from a 220/230VAC source.

Output Phases Terminal (J6)

This is the terminal for motor connection, output from 3-phase inverter circuit driven by PWM signals to the motor (i.e. motor voltages). These signals are referenced to the negative DC power rail, which is **NOT** a ground potential.

CAUTION: Beware of electric shock hazard. DO NOT connect any grounded test equipment such as an Oscilloscope to these test terminals. Always isolate your equipment from Earth Ground.

Connect the motor phase inputs (U, V, and W) from this terminal as depicted in Figure 2.

Hall Sensor connector (JP1)

This is Motor's Hall Sensors feedback connector that allows for detecting the rotor state and position.

RS-232 Port (J5)

A standard 9-pin D-shell female type connector (DB9F) that provides an Opto-isolated RS-232 serial link with the PC to control and monitor the development board.

RS-232 Serial Link:

A standard 9-pin D Female connector is used for the RS-232 serial link. The pins used on this connector are the RxD, TxD, GND, RTS, and DTR. The RTS and DTR signals provide sufficient current to drive the Opto-couplers. The current drawn from these pins is far below permissible limits for the RS-232 drivers.

The GUI should work with any of the available COM ports on the PC. There is no restriction on COM port. COM1 is the GUI's default port. The serial cable may be connected or disconnected at any time without having to restart your computer.

MPLAB ICD2 Connector (J4)

A 6-wire RJ-11 jack is provided as a programming or In-Circuit Debugger interface. This will also allow users to use development tools, such as MPLAB ICD2, while the board is under power. **Note that this connector is referenced to the –DC Bus.**

LEDs D10, D11, and SW2, SW3, R28

At initial power on, LEDs D10 (Red) and D11 (Green) blink on and off at a fixed rate. Rotating potentiometer R28 can change the blinking rate. Clockwise (CW) slows the blinking rate and counterclockwise (CCW) increases the blinking rate. When R28 is near the end position on CCW, both LEDs may look like they are on all the time because they are blinking at a faster rate. The functions of D10, D11, SW2, SW3, and R28 are as follows:

Stand-alone Mode (Also referred as Manual mode):

- Green LED: Indicates the Hall sensors level, 3 hall sensors combined when the motor rotates. If the motor shaft is rotated by hand, this LED will blink on and off.
- Red LED: In normal operation indicates the direction of rotation command. On for forward, Off for reverse. It will blink on and off, if hardware over current fault condition occurs (using the last downloaded parameters).
- SW2: This switch is used to toggle between Run and Stop.
- SW3: This switch is used to toggle between Forward and Reverse.
- R28: Used to control the Motor speed.

PC Mode (Also referred as GUI mode):

- Green LED: Indicates the Hall sensors level, 3 hall sensors combined when the motor rotates. If the motor shaft is rotated by hand, this LED will blink on and off.
- Red LED: In normal operation indicates the direction of rotation command. On for forward, Off for reverse. It will blink on and off if an over current fault condition occurs.
- SW2, SW3: They are not used in PC Mode. GUI command is used instead.
- R28: Not used with this mode.

Test Points (TP1 – TP5)

These test points are used for voltage and signal monitoring purposes.

TP1, TP2: For monitoring the +DC Bus and –DC Bus, respectively

- TP3: Current Feedback signal.
- TP4: +15V auxiliary power supply.
- TP5: +5V auxiliary power supply.

Jumper (J2)

This is the reset jumper to the microcontroller. When shorted, it resets the microcontroller and starts the firmware from beginning. This jumper is default to open.

Jumper (J3)

This jumper is connected across the diode of Opto-isolator, OP3. It allows the user to externally apply an Opto-isolated PWM signal into the microcontroller for debugging purposes.

Jumpers JX1 – JX3

These jumpers are used to connect or disconnect the Sensorless Feedback circuit. Their defaults are in the open position and not used with the current firmware version provided with this kit.

Connecting the inverter to the motor

WARNING

SW1 is an AC Input Voltage Selector switch. DO NOT apply 230VAC when this switch is set to 115VAC – this will result in severe damage to the system and personal injury due to very high voltage produced by the voltage doubler circuit on the DC bus.

Use a 3-phase connected BLDC motor, rated at 1/3 HP or less. Provide a 3-wire, 2A minimum rated cable for the motor connection, and a 3-wire 2A minimum rated cable for the AC mains connections. Ensure that the ground connection is also connected to the earth terminal of J1. The motor phases can be connected in any sequence, only the rotation direction will be affected. Make all necessary connections, including the serial link with the PC before applying AC power.

Note: Connecting both the RS-232 serial cable into J5 and the RJ-11 cable into J4 simultaneously will disable communication between the GUI and the system.

When operating the motor, only connect the serial link cable into J5 and when programming or debugging the microcontroller, only connect the RJ-11 cable into J4.

8. System Connection and GUI Operation

WARNING

When energized, the power produced by the IRADK31 Board – particularly from the 3-phase inverter – can cause severe equipment damage or personal injury. Always use the proper precautions when working around the board, or power electronic equipment. Whenever possible, use the IRADK31 Board with the safety shield installed.

Connect the IRADK31 board to the motor as illustrated in Figure 2. Ensure that the Voltage Select switch, SW1, is set to the appropriate voltage being supplied to the board. Set SW4 switch to position “1” to supply AC power to the board. Verify that the Red and Green LEDs are flashing, indicating that power to the board has been established.

Launch the Microchip Motor Control GUI (MotorControlIR2.exe). The first screen will appear is the Control Panel as illustrated in Figure 4.

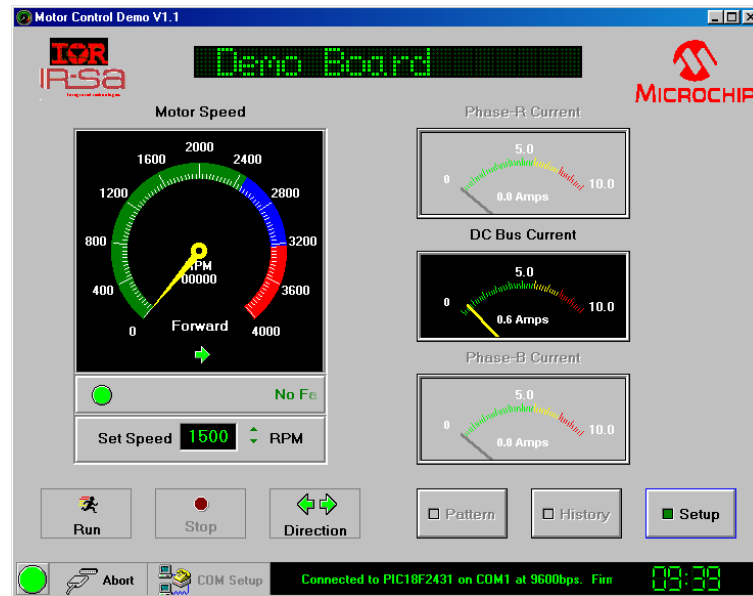


Figure 4. IRADK31 GUI Control Panel

This is the main display for the application. User can control motor speed and rotation direction in a way that is similar to Stand-alone Mode. The user can also monitor motor speed and DC Bus Current. The Control Panel also allows users to access to the Setup and Pattern Programming displays.

Main features:

- **Motor Speed:** This displays the actual speed of the motor in RPM, as determined by Hall sensors, in both tachometer and digital (text) formats.

The RPM speed is relative to the Hall sensor frequency and the number of pole pairs in the motor. It can be determined from the following equation:

$$RPM = \frac{(F_{hall}) \cdot (60)}{pole_pairs}$$

The full-scale value is determined by the speed limit defined in the Setup window plus an additional margin. The upper boundary of the green range represents the motor's rated speed. The upper blue boundary is set to scale the maximum safe speed well into the red area. This boundary is halfway between the rated and full-scale speeds. The values may be changed in the Setup Display to reflect the actual performance limitations of the motor.

- **Fault Display:** A scrolling text indicates the state of the fault conditions monitored by the board. Under normal conditions, it will display a scrolling "No Fault" message and a green

indicator. If an over current fault condition occurs, the indicator will change to blinking red; the text will also change to red, and the message will indicate “Over Current Fault”.

- **Fault Condition and Current Limit:**

Hardware – The trip level is determined by the threshold voltage (1.66V) at the input of comparator U5:B, set by resistors R30 and R35. With a gain of 4, set by U5:A, this becomes 0.415V (1.66V/4). When this voltage is across shunt resistor R2, the corresponding current is 0.415V/0.2Ω, or 2.075A at output “FAULTA”. Therefore, the maximum safe current limit for the hardware is 2.1A.

Firmware – This current feedback limit at output U5:A (IDC) is converted to voltage, filtered and fed into the microcontroller’s A/D port. The microcontroller detects when this limit is exceeded and determines when to shutdown the PWM signals if an actual over current condition occurs.

- **Set Speed:** The user can set the target run speed for the motor with this spin box by either direct entry or using the up/down controls. The motor speed can be changed while the motor is rotating. Since the algorithm is an open loop type, actual speed may vary depending on motor parameters and actual load.
- **Direction:** The direction indicator is shown with a left and right arrows, and text of the motor revolution to the default direction. The motor direction can be changed from either clockwise or counterclockwise while the motor is rotating. Doing so, the motor will ramp down and then ramp back up in the opposite direction.
- **DC Bus Current:** This displays the current drawn for the DC Bus in Amperes. Information is given in analog gauge and digital (text) format. As with the speed display, the different color zones represent average safe and hazardous operating ranges, based on the Current Limit defined in the Setup window. The actual safe operating range should be determined from the motor’s nameplate and maximum current rating of the power module being used. The maximum current rating of the modules used with this Reference Design Kit are as follows:
 - IR3101: 1.6A
 - IR3103: 0.8A
 - IR3104: 0.5A
- **Run/Stop:** Allows the user to start and stop the motor. Entering the desired speed value in the Set Speed display and pressing the <Enter> key will also start the motor.

To start the motor, click on the Run button and observe that the motor skips twice before it starts rotating in full speed. This is to allow the hall sensors to be aligned in the proper position before the motor fully accelerates.

- **Connect/Abort:** this button can establish or break a serial link connection with the board. When a link is established, the **Connect** label changes to **Abort**, and **COM Setup** becomes unavailable. When the link is broken; by clicking on **Abort**, **COM Select** becomes available for configuration.

Press the COM Setup and verify that the COM Port and Baud Rate are set as shown in Figure 5. Note that the COM port can be set to either COM1 or COM2 depending on where the serial link cable is connected on your PC.

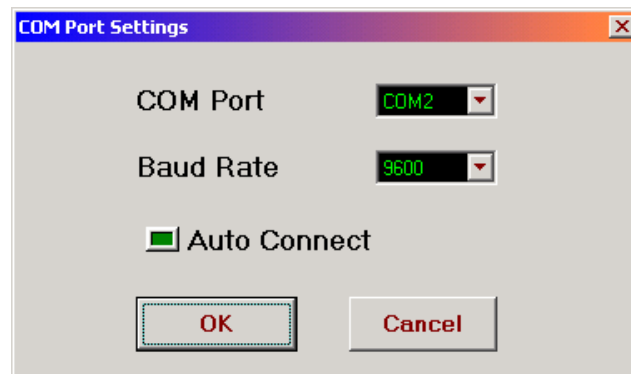


Figure 5. COM Port and Baud Rate Settings Dialog

Selecting the Auto Connect button can enable the Auto Connect feature. Once communication is established, the message “Connected to PIC18F2431 on COMx at xxxxbps (default value is 9600bps). Firmware Version: 1.0” will appear in the message window at the bottom of the control panel. (“x” represents the COM port actually selected; the actual baud rate depends on the setting used). Also, the message “Brushless DC Motor-Open Loop Control on IR31xx Demo board” will appear on the top of the control panel. The connection indicator in the lower left corner of the control panel window should change to solid green. You are now ready to work with the Motor Control GUI.

From the control Panel, press the Setup button and verify that the Motor Parameters Window is displayed as shown in Figure 6.

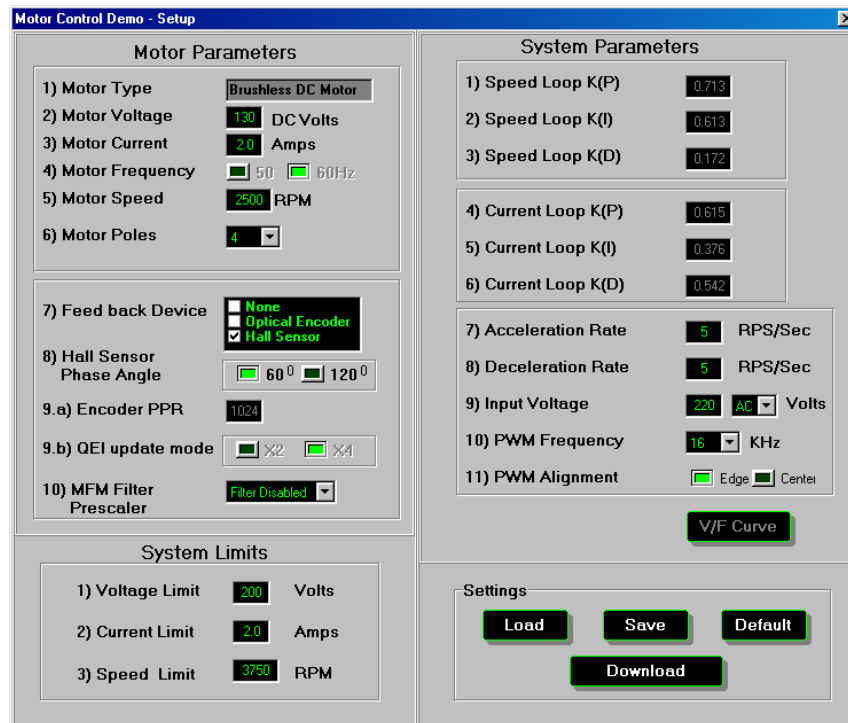


Figure 6. Typical Motor Parameters Setup Window

Users can define the individual settings for the motor being used. If the appropriate information is included in the firmware, most of the values will auto-populate, or at least be limited to a smaller subset of choices. Features or parameters that are not used will be masked or grayed out.

There are three categories that the user can modify:

- Motor parameters, which define the actual motor and sensor hardware that are used.
- System (control) parameters, which define the control variables.
- System limits, which define the hardware maximum ratings.

Controls are also provided to save or load parameters for later use, or restore default settings.

Note: Users have to download the settings to the connected board after any changes to see the effect of the new parameters.

The following parameters are masked out:

- Motor Parameter 9a.

- System Parameters 1 through 6.
- V/F Curve button (not available for the IRADK31 Motor Controller Board).

Motor Parameters

These are generally self-explanatory. Information on the motor hardware itself (items 1 through 6) can be found on the motor's nameplate or in its data sheet. The "Motor Type" filed is auto-populated with the motor type identified upon connection.

Selecting the appropriate check boxes in "Feed back Devices" selectively enables the configuration for motion feedback sensors. When only "Hall Sensor" check box is selected the sensor angle and Motion Filter Prescaler (MFM) may be configured; the other options are disabled. When optical encoders are enabled, the Encoder PPR (pulses per revolution), and MFM Filter may be configured; Hall Sensors configuration is unavailable. QEI update mode is default to X4 and cannot be changed. The recommended setting for the MFM Filter Prescaler to be used with the IRADK31 is "Filter Disabled".

Note that the Hall Sensors and optical sensors are not mutually exclusive. It is possible for some control methods to use both types at once. **For the IRADK31, only the Hall Sensor option is available.** Selecting the "None" option in "Feed back Devices" disables all sensor configuration options. Information on the sensor type and arrangement can be found in the motor data sheet.

System Parameters

The system parameters options can only be used with BLDC motors with the firmware provided with this demo kit.

Acceleration and deceleration rate are defined as RPS/sec for most applications.

Input voltage is the AC input voltage applied to the board. The input voltage should be kept at 220VAC, regardless of actual AC input applied. Because the board has a voltage doubler on the input rectifier side, when 115/120VAC is supplied, the DC Bus voltage would be 320V with voltage doubler circuit. When the input voltage is 220/230V AC, the DC Bus voltage would also be 320V without voltage doubler circuit.

The calculated DC Bus voltage supplied to the buck converter is given as 2 times the AC input (when 120VAC is applied) times 1.414, with the on-board voltage doubler enabled. When the on-board voltage doubler is not used and 230VAC is applied to the board the DC Bus voltage would be 230V times 1.414.

The PWM frequency determines the resolution of the control firmware. The drop-down combo box presents a fixed range of values.

System Limits

The system limits reflect the maximums of both the motor and the board being used.

Voltage limit: Not used by the firmware provided with this Kit.

Current Limit: Refer to the Fault Condition and Current Limit discussion in section 8.

Speed Limit: Is set at the value given in the motor's data sheet, or at a predetermined speed set by the particular motor data file.

CAUTION

Not all motors may be able to run at the maximum speed defined by the Speed Limit parameter. It should be regarded as an upper limit and not the motor's expected maximum speed.

Storing and Using Setting Profiles

Once the parameters for a particular motor are established, it would be nice to preserve them for future use. Users have several options from the Setup display to do just that.

Clicking on the **Save** button allows the current settings to be stored in a file, while clicking on the **Load** button selects and loads a file with saved settings. Both commands used the conventional Windows dialogs for opening and saving files. Setting profiles are saved as motor data files (.mcd extension). Neither of these affects the parameters currently in effect in the on-board firmware.

The **Default** button replaces all of the current settings with the default settings associated with the current motor type. This may be useful for quickly starting over when a set of parameters has been extensively modified and isn't working.

The **Download** button transfers the currently displayed parameters to the on-board firmware. It only changes the parameters, and not the control firmware itself.

Note 1: Attempting to load a motor data file that does not match the currently loaded motor and/or control method type will generate an error message.

2: Remember that downloading a profile to the IRADK31 Controller board only downloads variable values. It does not download new firmware. Similarly, loading and saving profiles only loads or saves the motor data file to the computer, but does not load or save the file on the on-board firmware.

9. Technical Data

Table 1 indicates the electrical specification of the IRADK31 Reference Design Kit.

Table 1. IRADK31 Electrical Specifications

| | |
|--------------------------------------|---|
| Input Voltage: | 120VAC / 60Hz and 230VAC / 50Hz. |
| Output Phases: | 3-Phase, 1/3 HP, 250W BLDC Motor (when 120VAC input is applied). 3-Phase, 2/3 HP, 520W BLDC Motor (when 230VAC input is applied). |
| Protection: | Fused AC line with on/off power switch, NTC, and Transient Suppression Varistor. Motor Over current shutdown |
| Filtering: | X and Y capacitors with Common Mode Choke. |
| Indicator and status Monitor: | Two LEDs for System communication and normal operation status, as well as Fault condition indicator (Red LED) and GUI for setting and monitoring system parameters. |
| RS-232 Interface: | Opto-Isolated RS-232 serial interface. |

10. Appendix A – MODE OPERATION

10.1 WHICH MODE TO USE?

Before setting up the development board, it is necessary to decide which operation mode is appropriate for what you want to do. There are two choices:

- **Stand-alone Mode:** The IRADK31 Board is connected to a power supply and a motor, but not to a computer. Motor operation is controlled through the two push buttons, SW2 and SW3 (Start/Stop and direction) and the potentiometer, R28 (Speed). This is a simple demonstration of the board's capability, and is useful for verifying the board's operation. It can also work as fast "sanity check" of newly programmed control firmware.
- **PC Mode:** The IRADK31 Board is also connected to a host computer through a serial interface. In this configuration, motor operation is controlled through a GUI application on the computer; speed cannot be controlled from the potentiometer on the board. The GUI allows more sophisticated motor operation, with controllable speed, and real-time monitoring of motor operation.

Since both modes start with the same set-up procedure, we will start by describing the set-up for the Stand-alone mode. Setting up the PC mode involves adding the serial interface to the Stand-alone mode, and is covered later in this discussion.

10.2 SETTING UP THE IRADK31 BOARD: STAND-ALONE MODE

For evaluating the IRADK31 Board, the simplest configuration is to use the board by itself, with no computer connection. This setup involves the following:

1. Connecting power to the board
2. Connecting the motor to the board (see Figure 2).
3. Verifying operation

For the sake of simplicity, we will assume that we are using the development board in its default configuration for BLDC. This means that board jumpers are not installed and the PIC18F2431 device has been programmed with BLDC control firmware. This also assumes the use of a motor with built-in sensors for commutation, spaced at 60°. Some motors have Hall sensors spaced at 120°. Correct Hall Sensor spacing can be found in the data sheet for the motor being used.

10.3 SETTING UP THE IRADK31 BOARD: PC MODE

While the Stand-alone mode is useful for simple testing, the PC mode allows more robust motor control. Configuring the IRADK31 Board for PC mode requires very little additional effort beyond the set up for Stand-alone mode.

10.3.1 Host Computer Requirements

To use the IRADK31 Board in PC mode, the computer being used must meet the following hardware and software requirements:

- PC-compatible system with an Intel Pentium® class or higher processor, or equivalent, with a minimum clock speed of 133 MHz.
- A minimum of 16 MB RAM.
- A minimum of 16 MB available hard disk space.
- CD-ROM drive (for use with the accompanying CD).
- One available standard serial port, with a matching COM port available through the operation system.
- Any 32-bit version of Microsoft Windows® (Windows 98, Windows NT®, Windows 2000 or Windows XP).

10.3.2 Installing the Motor Control GUI

The installation of the host software package is completely automated and does not require any user intervention or configuration once the process is started. The process is identical for all 32-bit Windows operating systems. Users with Windows NT-based desktops (NT 4.0, 2000 and XP) should not need administrative rights to their systems for this installation. Closing all background applications before proceeding is helpful, but not required.

Note: It is possible that some organizations may implement a desktop computer policy sufficiently restrictive to prevent the user from loading any software at all. In theory, this can be done with **any** 32-bit Windows operating system on a network – including Windows 95. If this describes your situation, contact your local Information Services provider for assistance installing this software.

To install the host software, insert the Software and Documentation CD into the CD-ROM drive. Open the CD in Explorer view, and locate the “GUI” folder. Unzip the file “Microchip MC_Rev2.zip” and copy its contents in to the folder “Microchip IRAD31 MC” that you create on your system.

International **IOR** Rectifier

IRADK31

The Microchip MC_Rev2 zip file contains the following files:

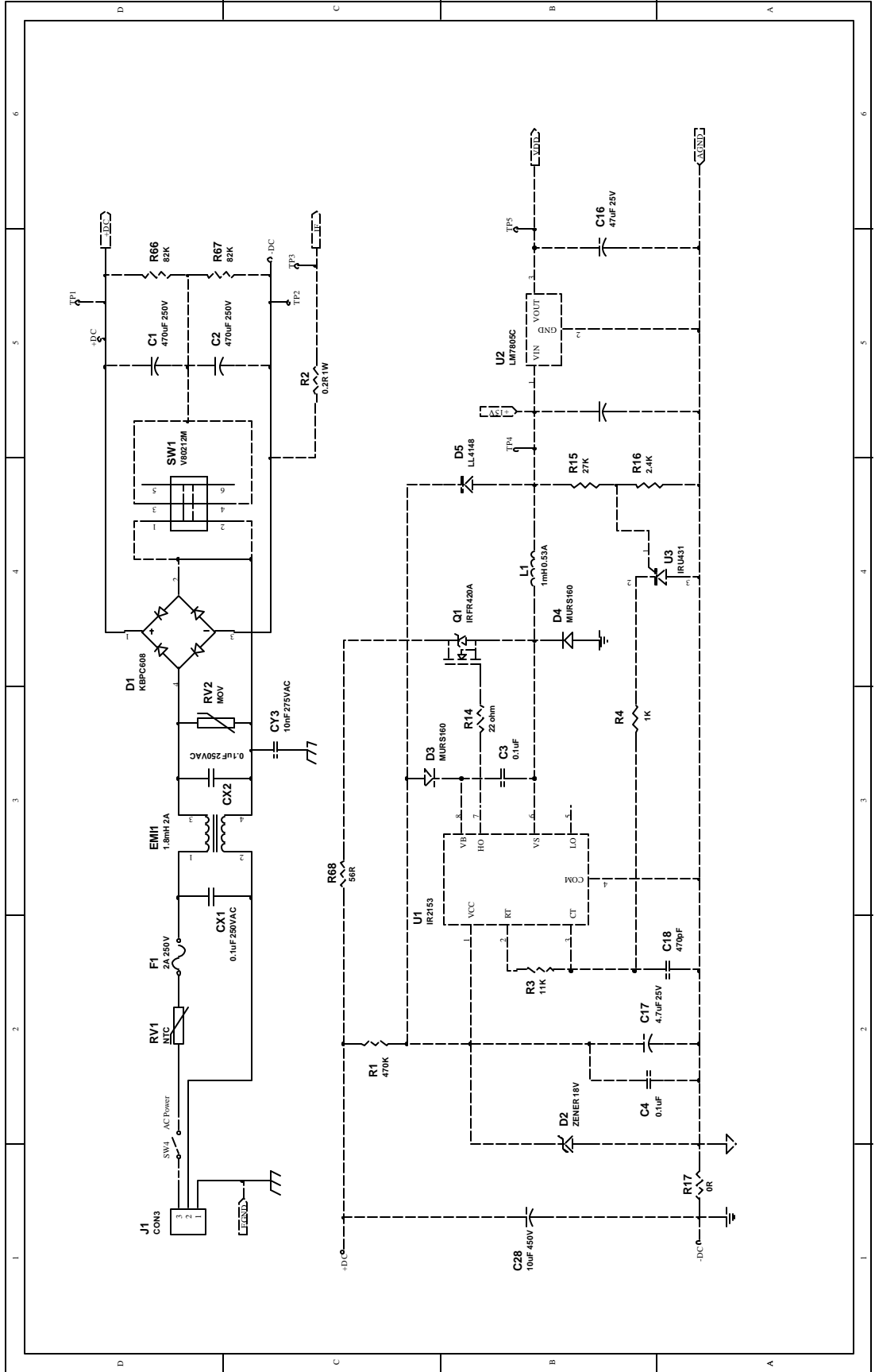
- ✓ MotorControlR2.exe
- ✓ PIC18_BLDC_OL.ini
- ✓ MCDemo.ini

You may wish to create other folders and copy valuable files from the CD such as the motor parameter data, the PIC18F2431 hex file, and data sheets for future reference.

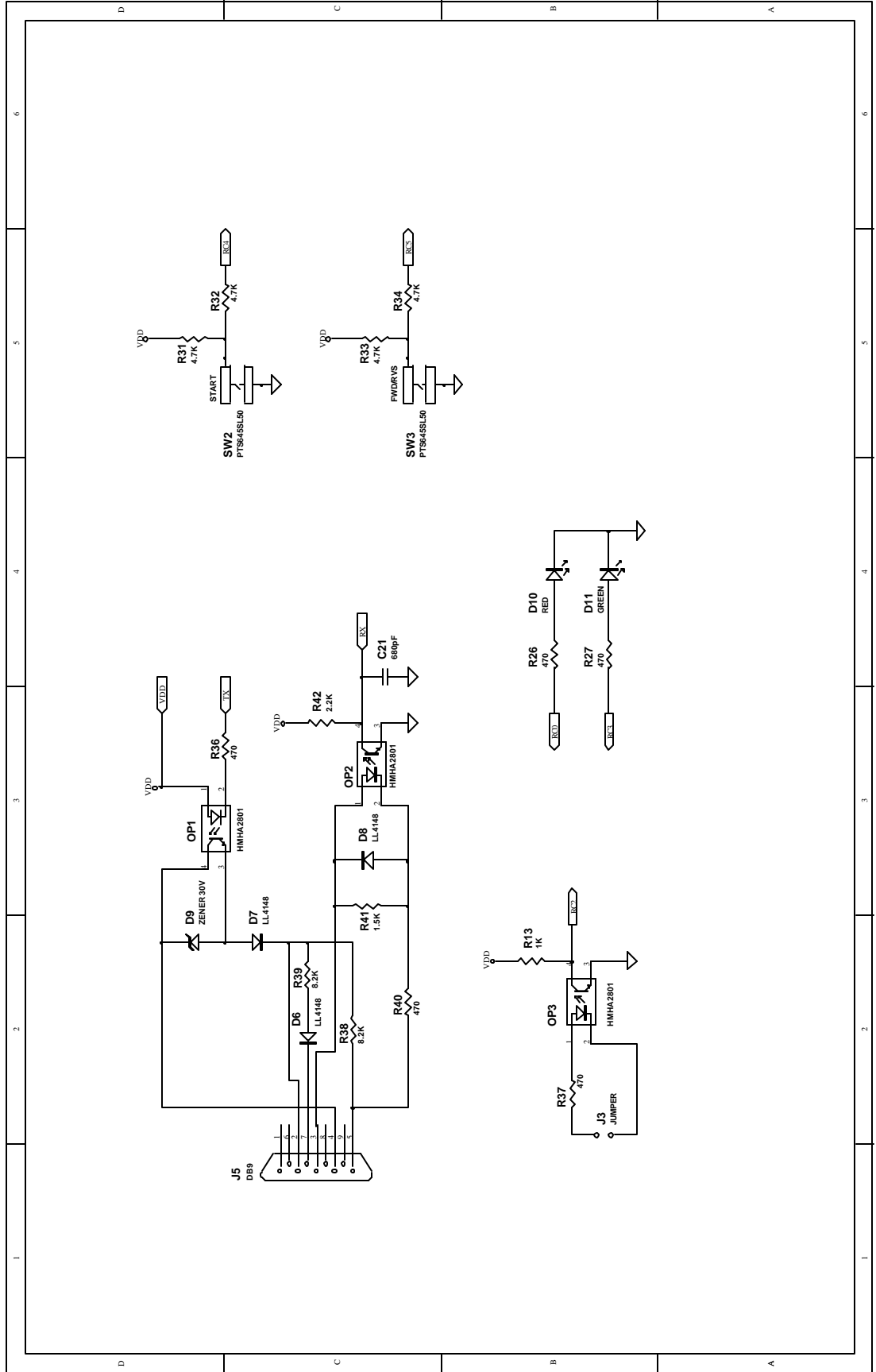
Create a short cut on your desktop for the MotorControlR2 file. Double-click on that file to launch the GUI control panel as shown in Figure 4.

Now you are ready to proceed with the operation of the GUI and controller as described in section 8 of this document.

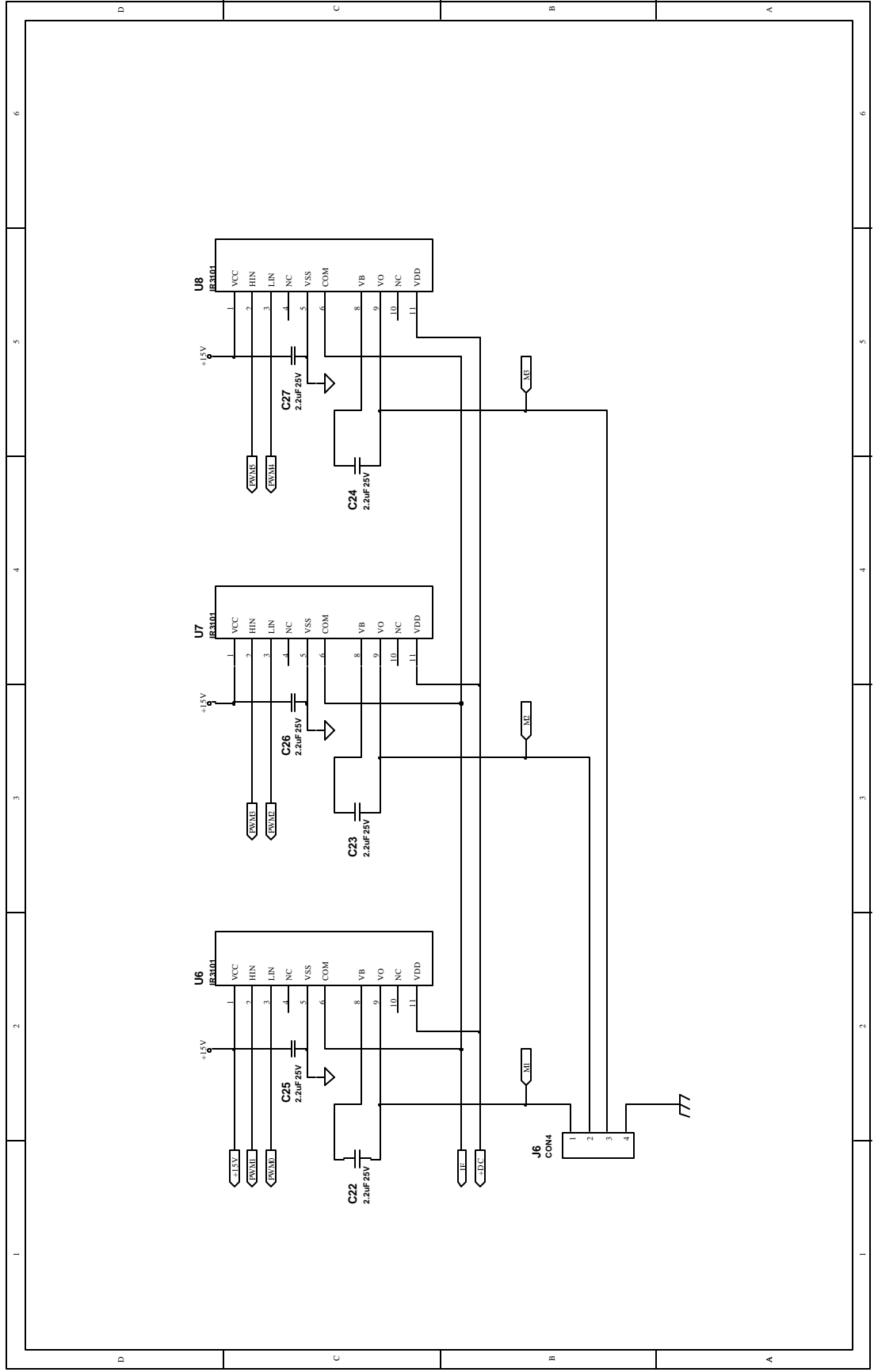
Power Supply



RS-232 Interface



Power Modules / PWM Outputs



Sensorless Feedback Circuit

