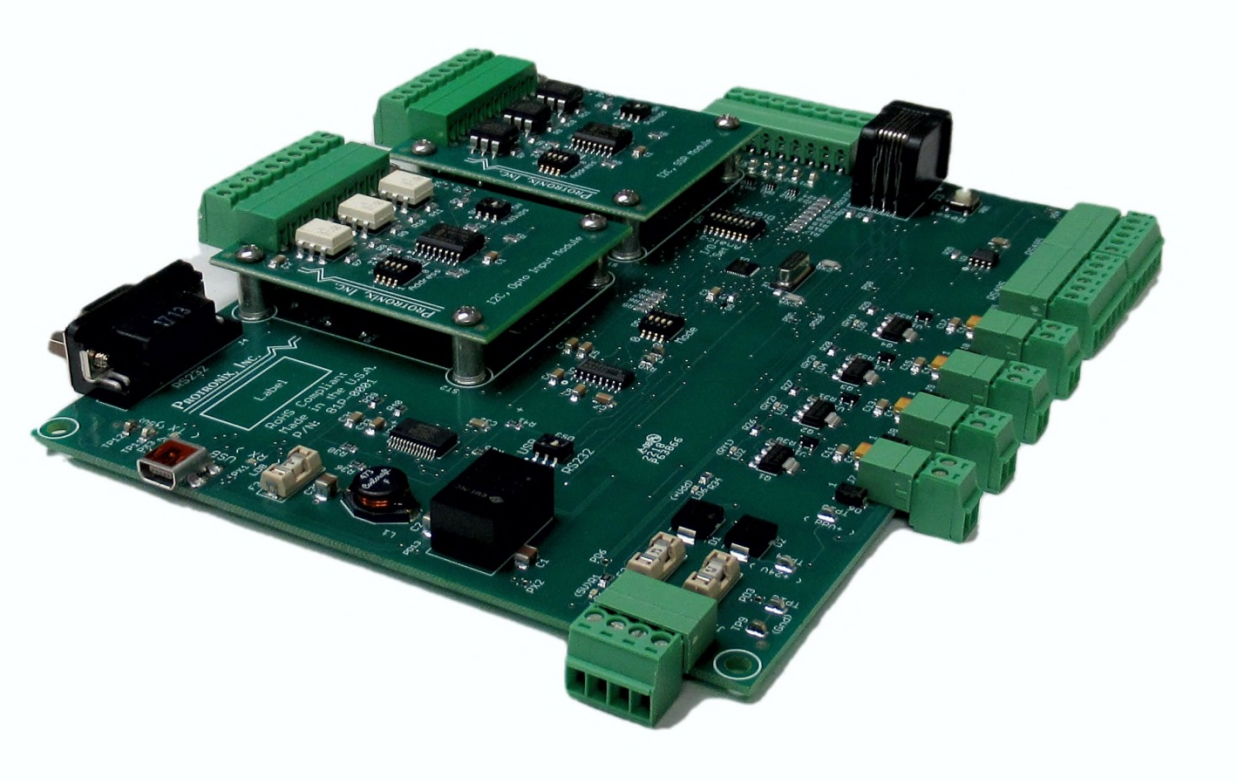
81 Control Board

P/N: 81P-0001

Rev –
2 AUG 2019

Graves Electronics, LLC



Symbols used in this manual:

CAUTION: This indicates a situation where if certain requirements are not followed, damage or unsafe conditions may occur.

WARNING: This indicates a situation where if certain requirements are not followed, damage or unsafe conditions WILL occur.

If you are having problems getting the board to work properly, BEFORE calling the factory, please visit the FAQ page at http://www.graveselectronicsapps.com/faqs.html, and/or throughly read section 9.0 of this manual. If you are still having problems, please download the test code from http://www.graveselectronicsapps.com/downloads-.html and run the code. If you are still having issues after reading the help section and trying the test code, please contact the factory. We kindly ask that you please e-mail us at graveselectronics@gmail.com. Please clearly state your problem along with a call back phone number. One of our technicaians will call you after we have reviewed your issue and have come up with some solutions.

This manual, as well as test code, can be downloaded at http://www.graveselectronicsapps.com/downloads-.html.

Contact Information:

Customer Service, Sales, Technical Assistance:

graveselectronics@gmail.com or call us at 860-295-3074

Warrenty & Legal:

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1.0 Overview

The 81 control board is a unique platform that bridges the gap between the hobbyist "maker" boards and having a custom designed circuit board. Built around the powerful PIC18F46K22-I/MV microcontroller chip from Microchip, the 81 board offers a host of features that you would expect from an industrial controller board. Some of these features are standard RS-485 communication, RS-232, eight I/O lines that can be set as analog, protected and buffered digital input, or digital output, and four dedicated MOSFET outputs. In addition, two expansion module ports allow various add-on modules to be added to the control board to increase its functionality. Unlike the modules on the hobbyist boards which use valuable I/O lines for communication, the 81 board uses the SPI or I^2C bus to communicate with its modules. This setup keeps the I/O lines to being just that; I/O.

The 81 board comes with pluggable headers for the input power, I/O, MOSFET outputs, and RS-485 lines. This feature allows all wiring to be done independently of the board. In addition, in a field service situation, to remove the board, simply unplug the headers. There is no need to unscrew and remove each wire from the terminal block and vice-versa to install a new board.

The RS-232 is an industry standard female DB-9 connector.

One of the greatest features of the 81 board that set it apart from the hobbyist boards or PLCs, is that the software can be written in any language that you wish, using any compiler that you wish, and be programmed using any programmer that you wish. All that is needed is the hex file and a compatible programming cable.

For complete specifications and operations of Microchip's PIC18F46K22, please refer to the PIC18F46K22 datasheet.

2.0 Electrical Specifications

	Min	Typical	Max
Input Voltage (V)	9	24	30
Input Current (A)	-		1
I/O Voltage (V)	-0.3	-	5.3
I/O Sourcing Current (mA)	-	-	25
I/O Sinking Current (mA)	-	-	25
MOSFET Voltage (V)	-	24	40
MOSFET Output Current (A)	-	0.25	0.5

2.1 Fuses

Location	Value	Mfg. & Part Number
F1	1A, Time Delay	Littelfuse, 0454001.MR
F2	4A, Time Delay	Littelfuse, 0454004.MR

WARNING: Replace fuses with recommended manufacturer and part number ONLY! Failure to do so could lead to fire or shock hazards and will void the warranty.

3.0 MCU

The 81 board uses Microchip's PIC18F46K22-I/MV microcontroller as its brain power. Please consult the Microchip datasheet for all relevant information on this particular chip.

3.1 Crystal

The PIC18F46K22-I/MV can utilize an internal oscillator or the 11.0592 MHz crystal on the board. The choice is up to the programmer as to which configuration would be best suited for the application. For further information on determining which option is best, please refer to the Microchip datasheet, section 2.0.

3.2 In-Circuit Programming

The 81 board is equipped with an in-circuit programming jack, J3. It is through this jack that programs are loaded into the PIC18F46K22.

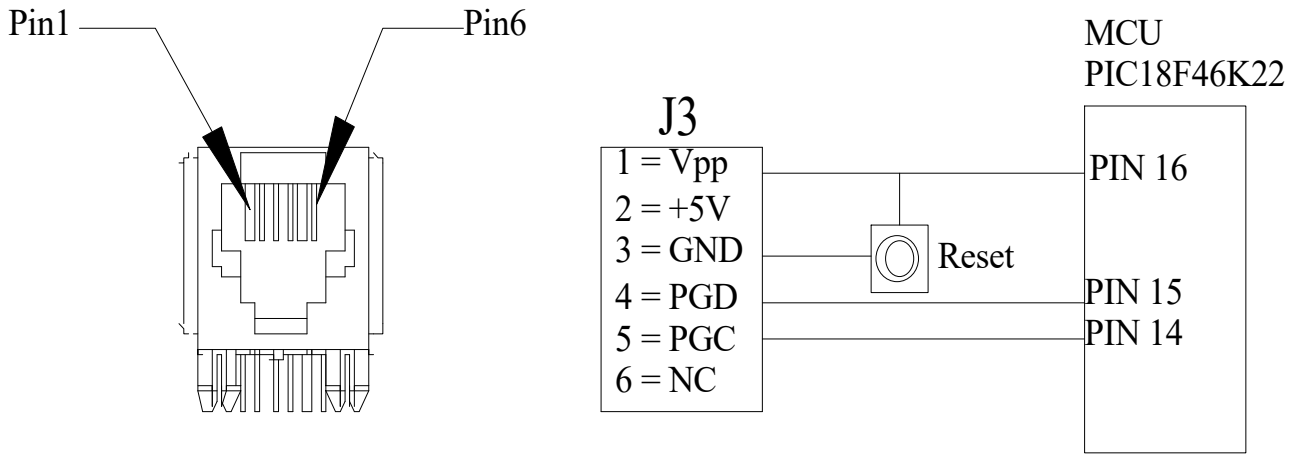
CAUTION: It is recommended to program the board while the board is un-powered. If programming is done while the board is powered up, it may cause damage to the programmer.

J3 is a standard "RJ12 type" telecom jack. Microchip's ICD 3 is configured to use this jack. If another programmer is used, please consult the following table for pinout information.

Pin on J3	Function
1	Vpp (programming voltage)
2	+5V
3	Ground
4	PGD (Programming Data or ICSPDAT)
5	PGC (Programming Clock or ICSPCLK)
6	No Connect

NOTE: If it is necessary to fabricate an in-circuit programming cable, recommended mating plugs for J3 are Assmann part number A-MO-6/6-F50 or Stewart part number 940-SP-3066. These plugs, as well as pre-made in-circuit programming pigtails and cables, are available from the factory. Please consult the 81-Series Accessories Catalog for more information. Holding the plug with the locking tab away from you, pin 1 is located on the left.

3.2.1 In-Circuit Programming Block Diagram



3.3 Mode Switch

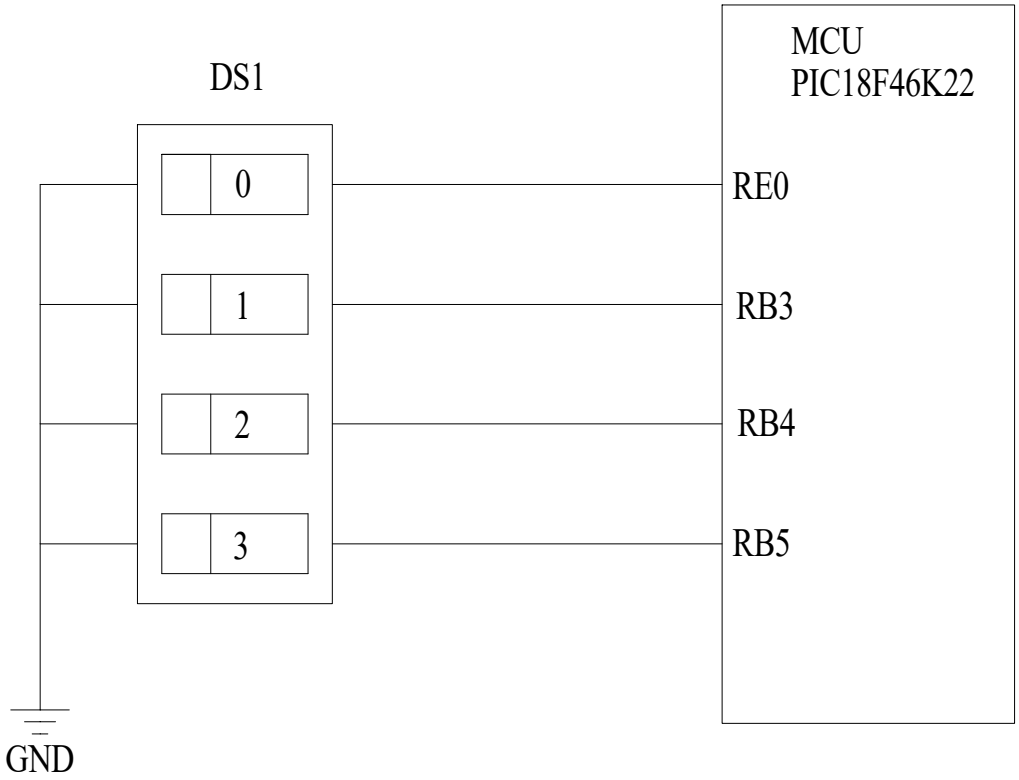
The 81 board is equipped with a four position mode selection switch, DS1, which allows for sixteen unique combinations. The purpose of the switch is to allow the user to write different programs for different applications and then use the switch to select which program to run on the board. A good example would be a machine that has two optional functions. In base mode, no optional functions present, the mode switch is set so that "0" is on. If option 1 is installed, the mode switch can be set so that "1" is on. If option 2 is installed, the mode switch can be set so that "2" is on. If both options are installed, the mode switch can be set to "3". Of course this is just an example, and any combination of switch settings may be utilized, or the switch can be completely ignored if desired.

To select one of the modes, slide the switch towards the numbers next to the switch. This grounds the I/O line on the PIC18F46K22. Each switch line has an external pull up resistor.

Mode Switch Setting	Bit
0	RE0
1	RB3

2	RB4
3	RB5

3.3.1 Mode Switch Block Diagram



4.0 Power Supply

Power is supplied to the board via pluggable header J1. Position 3 is the positive voltage and position 4 is the negative voltage. The board uses a DC-DC converter which allows the input voltage to be anywhere from 9 to 30V DC. There is a 1A fuse located at F1 which protects the board power supply circuit.

The output of the power supply is 5V, which is used to power the logic circuits on the board. When the power supply is functioning normally, the 5V LED located at LD1 will be lite.

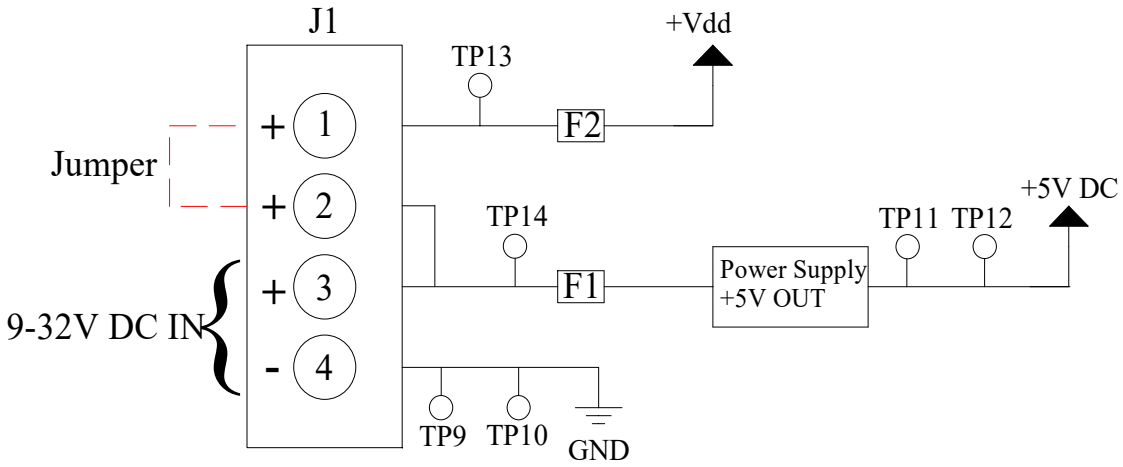
There are five test points in the power supply circuit. Positive main input voltage is measured at TP14. The +5V rail is measured at TP11 and TP12. Ground is TP9 and 10.

CAUTION: Exceeding the recommended input voltage could cause the power supply circuit to overload and fail.

WARNING: Inputting a voltage lower than 9V will cause erratic operation of the power supply circuit.

WARNING: Input voltage MUST be DC! Applying AC voltage WILL damage the power supply circuit and void the warranty!

4.1 Power Supply Block Diagram



5.0 I/O Channels

There are a total of eight I/O channels on the board. Each channel can be independently configured to be an analog input, digital input, or digital output. The choice between analog or digital is made by setting switch DS2. The channels are all 5V logic level. In addition to each channel being either analog or digital, channels 6-8 can also be used as interrupt inputs. Comparator module C2 of the PIC18F46K22 can be used as a three-channel comparator, with C12IN2- not being used.

Each channel has a pair of protection diodes that prevent voltage spikes from damaging the inputs. In digital mode, a Schmitt triggered buffer and pull-up resistors are switched into the input circuit path.

There is a test point for each I/O channel. They are TP1-TP8, respectively.

WARNING: The I/O channels are rated for 5V DC ONLY! Applying a voltage higher than 5V WILL damage the inputs!

CAUTION: Do NOT leave inputs floating. Inputs need to be either pulled high or low. Floating inputs can cause erratic operation and/or excessive current draw.

5.1 Analog Input

To enter analog input mode, set the switch corresponding to the appropriate channel on DS2 to "Analog". In analog mode, the Schmitt trigger buffer and pull-up resistors are removed from the input circuit.

5.2 Digital Input

To enter digital input mode, set the switch corresponding to the appropriate channel on DS2 to "Digital". In digital mode, a Schmitt trigger buffer is switched into the circuit. The purpose of the Schmitt trigger buffer is to prevent false triggering of the microcontroller due to a slow rise time, or unstable signal, at the input. In addition to the buffer, a 4.7KΩ pull-up resistor is switched in as well. This negates the need to use the microcontroller's internal software pull-up resistors.

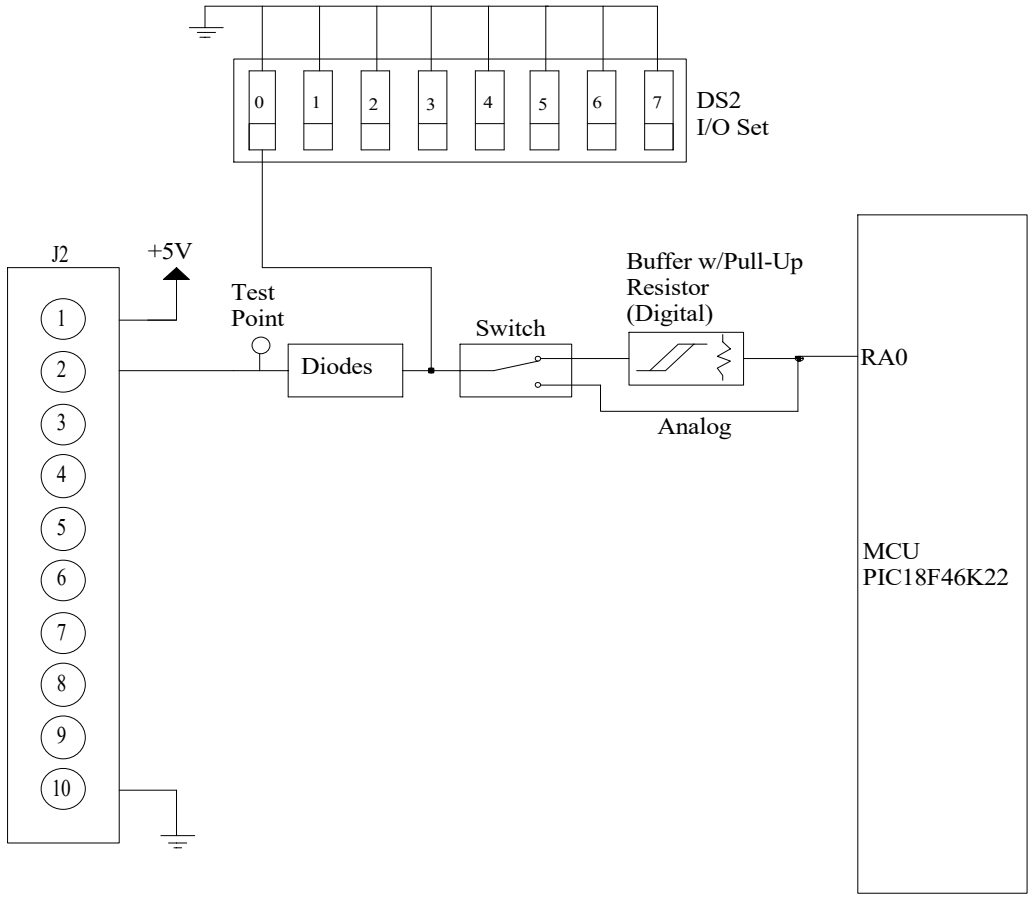
5.3 Digital Output

To enter the digital output mode, set the switch corresponding to the appropriate channel on DS2 to "Analog". Set the software to configure the port as a digital output.

5.4 I/O Assignments

Channel	Terminal Block Position	Function
1	J2-2	RA0/AN0/ C12IN0-
2	J2-3	RA1/AN1/ C12IN1-
3	J2-4	RA2/AN2/ C2IN+
4	J2-5	RA3/AN3
5	J2-6	RA5/AN4 /C2OUT
6	J2-7	RB0/AN12/INT0
7	J2-8	RB1/AN10/ C12IN3-/INT1
8	J2-9	RB2/AN8/INT2
+5V	J2-1	+5V
GND	J2-10	Ground

5.5 I/O Block Diagram



(Only one channel shown for clarity)

6.0 MOSFET Output

The 81 board is equipped with four MOSFET outputs. All four MOSFETs have their drains tied to a common voltage rail ("wet" type output). The voltage for this rail (VDD) is supplied through position 1 on pluggable header J1. If it is desired to have the VDD voltage and the main supply voltage be the same, a jumper can be inserted into positions 1 and 2 of J1. This configuration allows for VDD rail to be supplied independently of the main board supply, if so desired. The VDD rail is protected by fuse F2.

The MOSFETs are set up as low side drivers with the source tied to ground. Setting the gate of each MOSFET high grounds the output circuit allowing current to flow through the connected device.

Each MOSFET is capable of driving a 0.5A DC load at the VDD voltage. They are labeled RY1 through RY4 on the board. The VDD voltage cannot exceed 40V DC. Each MOSFET circuit has a LED to indicate which one is active. The LEDs are labeled RY1 through RY4 (LD2-LD5, respectively).

CAUTION: If the VDD voltage is set independently of the Main Input voltage, the VDD voltage

CAN NOT exceed 40V! If more than 40V is applied, damage to the MOSFETS can occur.

WARNING: MOSFETs are designed for DC voltage ONLY! DO NOT apply AC voltage to the VDD Input!

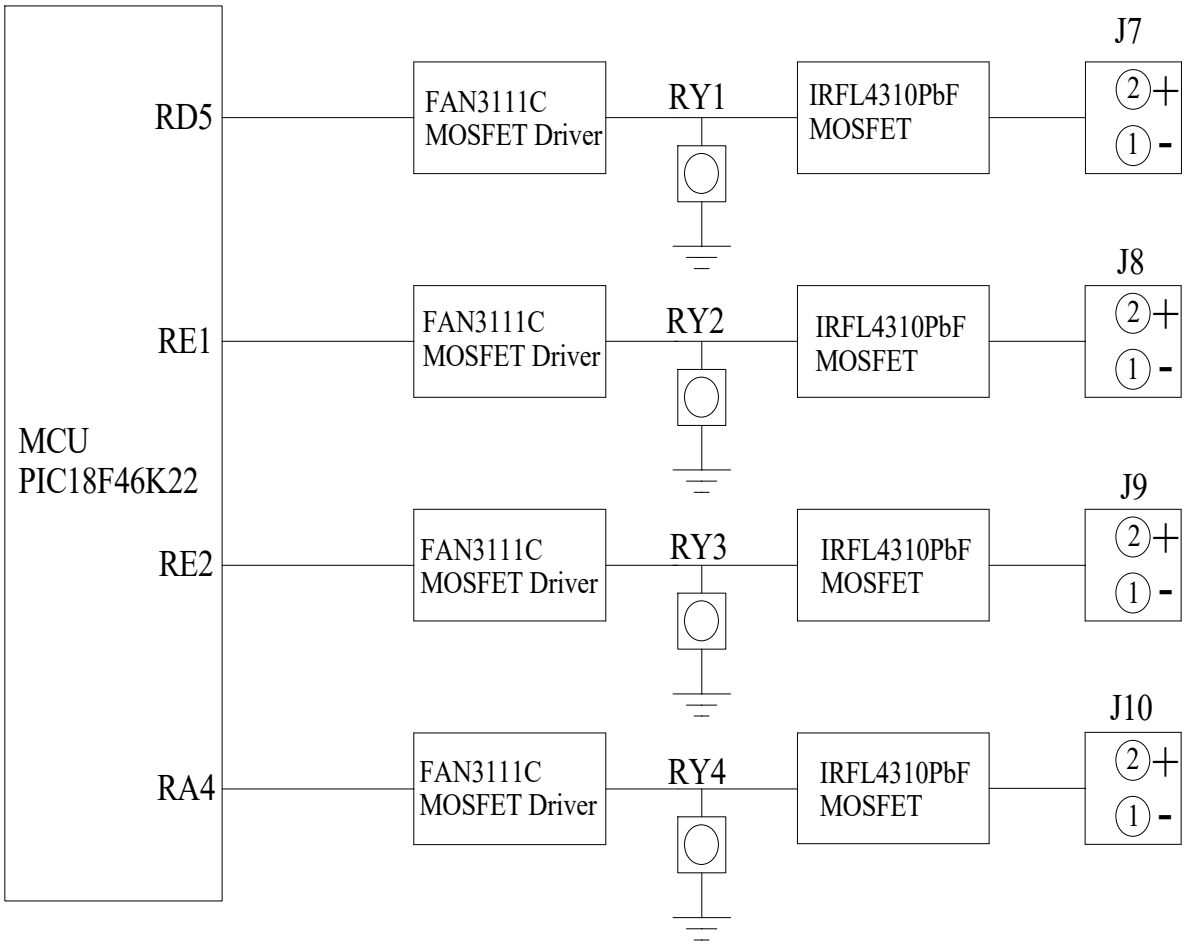
6.1 MOSFET Assignments

Bit	MOSFET
RD5	RY1
RE1	RY2
RE2	RY3
RA4	RY4

6.2 MOSFET Terminal Block Connections

MOSFET	Terminal Block
RY1 +	J7-2
RY1 -	J7-1
RY2 +	J8-2
RY2 -	J8-1
RY3 +	J9-2
RY3 -	J9-1
RY4 +	J10-2
RY4 -	J10-1

6.3 MOSFET Block Diagram



7.0 Communications

The 81 microcontroller board comes standard with RS-232 and RS-485 communications ports.

7.1 RS-485

The board uses Texas Instruments part number SN75HVD08D for the RS-485 transceiver. This chip is connected to EUSART1 on the PIC18F46K22. Please refer to section 16.0 in the Microchip datasheet for further information on using the EUSART. The connections to the board are made via pluggable headers J5 and J6, which are tied together to enable setting up a communications loop.

The receiver enable and driver enable are both independent of each other and must be set appropriately for receiving or transmitting. The receiver enable is active low and is controlled by PortC, bit RC5. This bit must be set low in order to receive data over the RS-485 network. The driver enable is controlled by PortC, bit RC4. This bit must be set high in order to transmit data over the network.

The “A” lines of the RS-485 chip are tied to pins 1 and 2 on J5 and J6. The “B” lines are tied to pins 3 and 4 on J5 and J6. Pins 5 and 6 on J5 and J6 are ground.

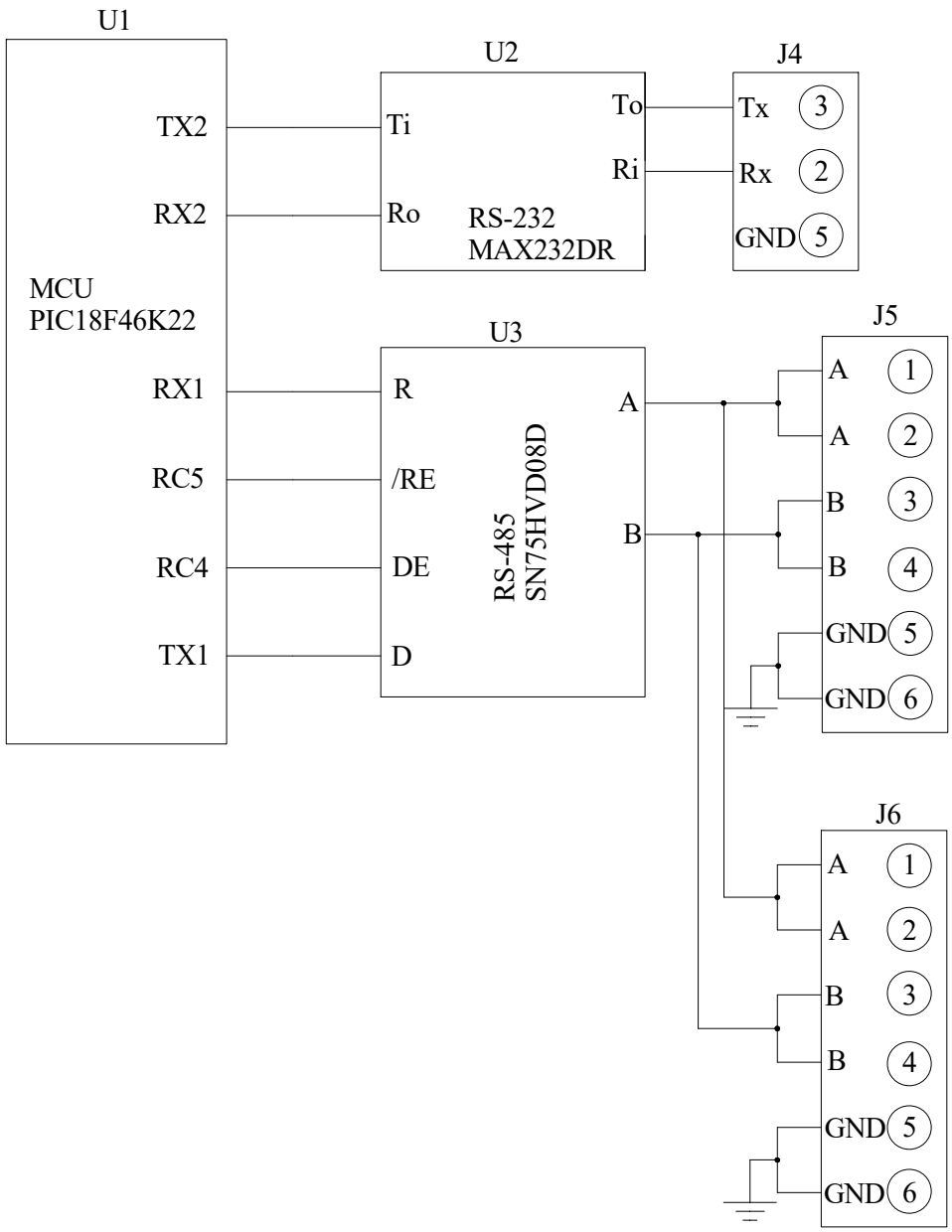
7.2 RS-232

The 81 board has a standard DB-9 interface, as well as a USB mini-AB interface for the RS-232. The RS-232 only uses the Rx and Tx lines. The board does not support handshaking or any other RS-232 control functions. Tx is on pin 3 and Rx is on pin 2. Pin 5 is the ground. The board uses Texas Instruments part number MAX232DR for the RS-232 communications chip. This chip is connected to EUSART2 on the PIC18F46K22. Please refer to section 16.0 in the Microchip datasheet for further information on using the EUSART.

The USB interface is supported by a FTDI USB-to-RS232 converter chip. In order to use the interface, Virtual Com Port drivers must be downloaded from FTDI's website onto the computer that is communicating with the 81 board. The drivers can be found at this link: https://ftdichip.com/drivers/vcp-drivers/. The drivers are available for Windows, Mac, and Linux.

The DB9 and the USB can NOT be used at the same time. Only one or the other may be use. To switch between the DB9 and the USB, move switch DS3 to the preferred connection.

7.3 Communications Block Diagram



8.0 Modules

The 81 board offers a convenient way to expand their capabilities by the addition of add-on modules. There are two module ports on the board, MODULE1 and MODULE2. Communications to the modules is done serially, using either the SPI bus or the I²C bus. Both of these busses are part of the Master Syncronous Serial Port (MSSP) modules in the microcontroller. The PIC18F46K22 has two of these module, MSSP1 and MSSP2. Please refer to the Microchip datasheet, section 15.0 for more information on setting up the MSSPs to be used for SPI or I²C communication.

There are three control lines that go to each module as well as a spare slave select line. Please refer to the instructions that come with the module to determine if these lines are needed.

More information on individual plug-in accessory modules is available in the Protronix Product Catalog.

CAUTION: The 81 Board uses **MSSP2 ONLY!** Both the SPI and the I²C protocols use MSSP2. You can use **EITHER** I²C **OR** SPI. **YOU CAN NOT USE BOTH!!**

8.1 SPI (Serial Peripheral Interface)

SPI enabled modules can use the SPI bus to communicate with the PIC18F46K22. The following table shows the pins and their related functions for the SPI bus. Please refer to the module instructions for which chip select line to use and any limitations on the speed of the serial clock. The SPI bus uses module MSSP2 in the PIC18F46K22.

Bit	Function	Description
RD0	SCK2	Serial Clock
RD4	SDO2	Serial Date Out
RD1	SDI2	Serial Data In
RC0	/CS1	Chip Select 1 (active low)
RC1	/CS2	Chip Select 2 (active low)
RC3	CTRL-1	Control 1
RC2	CTRL-2	Control 2
RD2	CTRL-3	Control 3
RD3	/SS2-Spare	Spare

8.2 I²C (Inter-Integrated Circuit)

I²C enabled modules can use the I²C bus to communicate with the PIC18F46K22. The following table shows the pins and their related functions for the I²C bus. All modules on the I²C bus are designed for the standard 100KHz bus speed. Please refer to the instructions with module for device addresses. The I²C bus uses module MSSP2 in the PIC18F46K22.

Bit	Function	Description
RD0	SCL2	Serial Clock Line
RD1	SDA2	Serial Data Line
RC3	CTRL-1	Control 1
RC2	CTRL-2	Control 2
RD2	CTRL-3	Control 3

For more information on the I^2C bus, please refer to NXP document UM10204.

9.0 Pluggable Terminal Blocks

The board is equipped with pluggable terminal blocks for power, I/O, and communications. The chart below shows the Phoenix Contact part number of the pluggable block. If more plugs are needed, they may be purchased from any distributor that sells Phoenix Contact, or they may be purchased from the factory (Protronix part number is also listed).

Location	Circuit Size	Phoenix Contact P/N	Protronix P/N
J7-10	2	1840366	32P-0081
J1	4	1840382	32P-0078
J5-6	6	1840405	32P-0080
J2	10	1840447	32P-0079

10.0 Troubleshooting

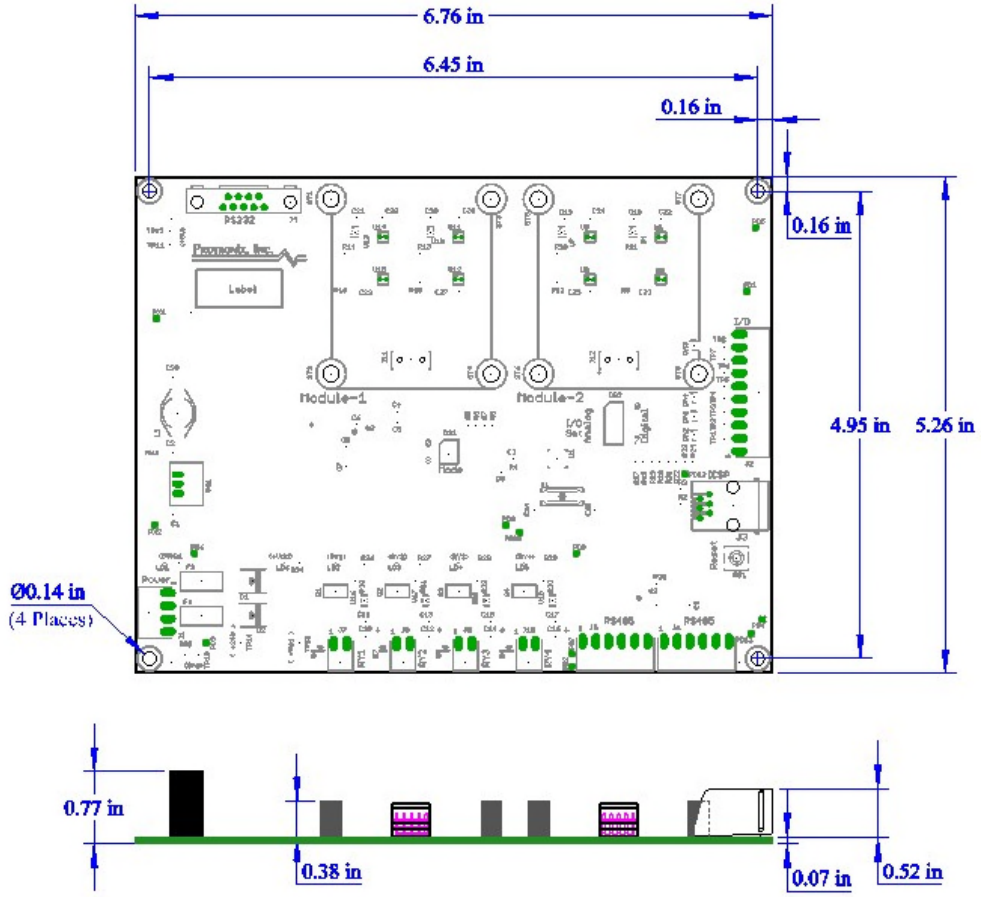
Problem	Possible Cause(s)	Possible Solution(s)
Board will not operate	No incoming power.	Check to see that power is being supplied to the board.
	Main power is the wrong polarity.	Check to make sure the positive and negative wires are attached to J1 correctly.
	Fuse(s) blown.	Check F1 and/or F2.
Erratic operation	Input left floating.	Set inputs as outputs in software.
		Set unused inputs to digital mode via switch DS2.
	Main power below 9V.	Apply a voltage level between 9 and 30 to board.
	Chip configured incorrectly.	See datasheet for proper

		setup of the PIC18F46K22.
		Set I/O are set for how they are intended to be used. Digital for digital and analog for analog. Input for input or output for output.
	Software bug.	Consult a software engineer.
	Rx and Tx wires are not attached correctly.	Rx on the board needs to go to Tx on the peripheral and Rx on the peripheral needs to go to Tx on the board.
RS-232 not functioning	EUSART setup incorrectly.	Refer to section 16.0 in the Microchip datasheet for proper setup of the EUSART.
	Lack of time delay after initialization.	The EUSART needs at least a 100ms delay after initialization before it is ready to transmit or receive data.
RS-485 not functioning	A and B wires are reversed.	Check that A is wired to A and B is wired to B.
	Receive Enable (/RE) and Driver Enable (DE) in software is not set correctly.	/RE and DE need to be LOW to receive. /RE and DE need to be HIGH to transmit.
Relay Outputs not functioning or are erratic	Check polarity.	Pin 1 is Ground and Pin 2 is Positive.
	Wrong voltage type applied at VDD terminal.	MOSFET outputs are DC Voltage ONLY.
	F2 blown.	Check F2.
	VDD voltage is over 40V.	Lower VDD voltage to 40V or under.
	VDD voltage is below periphery operating voltage.	Check that the voltage needed by the peripheral matches the VDD voltage.

	MOSFETs being switched to rapidly.	Ensure that output frequency is below maximum specified limits. See Section 2.0 of this manual.
Cannot program board	Bad programmer.	Try another programmer.
	Programmer hooked up incorrectly.	Refer to Section 3.2 in this manual.

11.0 Mechanical

The 81 board has four mounting holes, one in each corner. The holes are sized for a #6 machine screw (not included with the board).



(Terminal blocks and other components omitted for clarity.)