

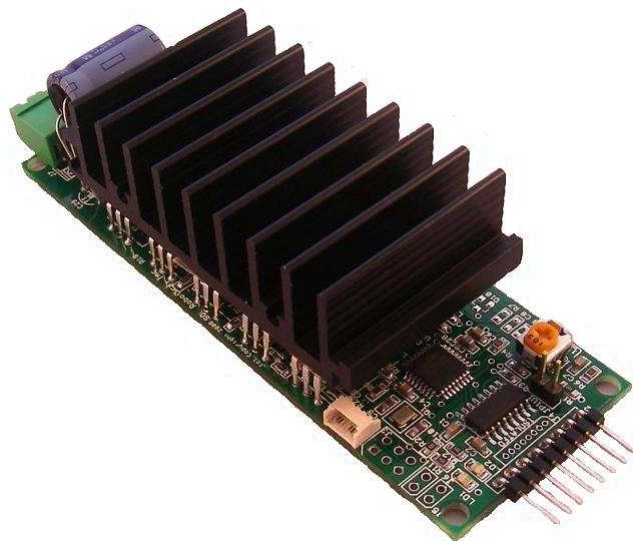
MM220 6A Bipolar Microstepping Driver

1/16th Microstepping 6A Bipolar Driver

Technical Reference Manual

PCB Rev 1.1

Motor Control Software Version 0.99



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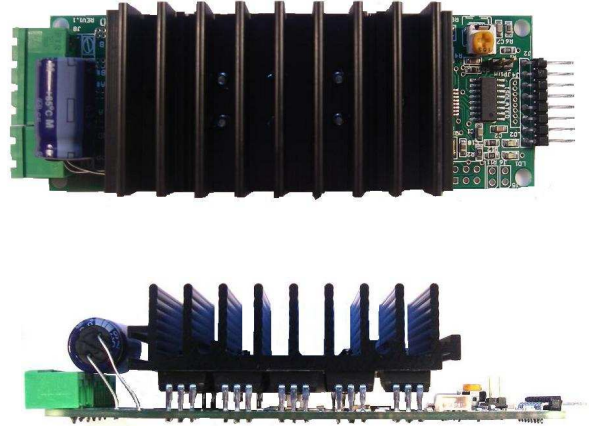
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1.0 Introduction

Features:

- 6A/phase Bipolar microstepping driver
- Optically Isolated inputs
- 20-48VDC Stepper Motor drive voltage
- ATmega168 onboard processor
- Integrated Heat Sink design
- Inline command processing
- 512 Internal EEPROM
- 512 Internal SRAM
- Aux digital IO on ISP port
- ISP Programming Port (requires CISP adapter)
- Small form factor (4.4x1.6 in)



Hardware

The MM220 is a 1/16th Microstepping bipolar 6A per phase stepper motor driver that converts step and direction signals to appropriate high voltage stepper motor drive signals. The board is designed to operate at 5VDC. Motor voltage can vary from 20-48VDC. The motor drive chip is controlled by a dedicated onboard 8 bit RISC processor (Atmega168) that provides various expansion and enhancement features. Applications can communicate with the board using encoded commands on the step and direction inputs. A Limit switch input is monitored and can be used to stop step operation.. An eStop input can also be monitored to stop step operation. The MM220 consumes about 12ma in active state not including motor drive current. All signal inputs are optically isolated.

Motor Control Software

The MM220 is shipped with a sophisticated software application burned into the on board Atmega168 processor that controls the A3986 driver chip, monitors step/direction inputs, limit switch state, encoded commands on the step/direction input lines. The MM220 can operate as a single axis G Code processing controller by acting on commands sent to it via the Step/Direction input signals. See the section on software operation for a full description of the complete command structure. A free application called GstepPP.exe can be used to send encoded commands to the MM220 on the Step/Direction lines.

At power up the two LEDs flash twice then the RED LED flashes slowly for 5 seconds after which both LEDs go out. While the RED LED is flashing the driver is in Command Recognition Mode. In Command Recognition Mode signals on the step and direction inputs are interpreted either as step commands or high level commands. High Level Commands can change driver configuration parameters or tell the driver to execute a set of functions. The specific encoding is described in the Technical Reference Manual along with a complete description of all high level commands. After 5 seconds the driver automatically switches to Pass Through Mode - in this mode encoded commands are not recognized and commands to change step mode, automatic shut off, etc are ignored. Re-powering the MM220 starts the 5 second process again.

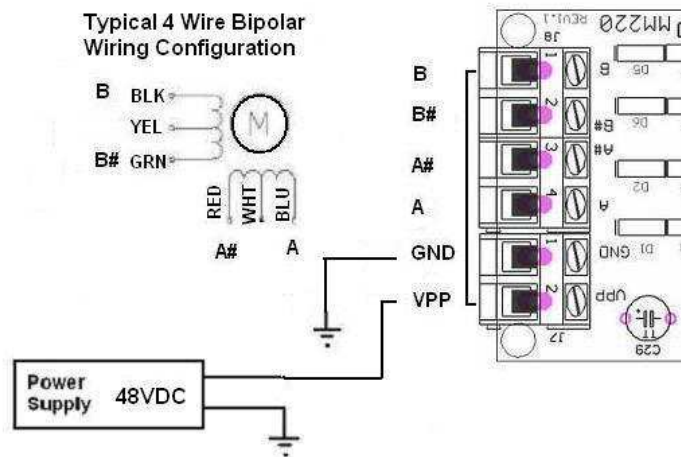
By default the MM220 software sets the step mode to quarter step, enable smart limit recognition, disables eStop recognition and switches to Pass Through Mode after 5 seconds.

The control program in the MM220 processor can be re-Flashed using programming cable Part No. MCM-8 and the appropriate host software (MK4Prog.exe).

Stepper Motor Connection

Motor Drive voltage should be between 10-44VDC. A potentiometer sets average current and should be adjusted while the board is running. A heat sink provides radiant cooling so forced air cooling is not required in most applications. Under extreme operating conditions forced air cooling should be used. The diagram below shows stepper motor connections for the SM2006 and SM3006 stepper motors – wire color for other stepper motors may vary although most coil phase diagrams are similar. It is a good idea to wire a fuse between the motor power supply and the MM220. Try not to turn motor power on if the logic side of the MM220 is not turned on. If the motor will not turn then check your wiring.

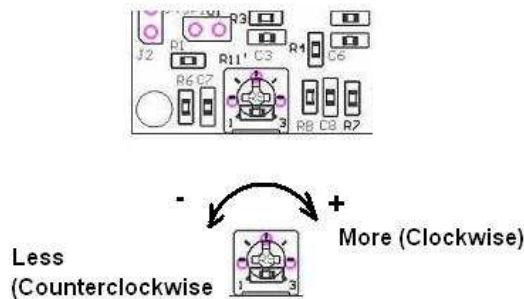
MM220 Motor Connection for SM2006/SM3006



Adjusting Motor Drive Current

The MM220 has a single potentiometer for setting motor drive current. Turning the potentiometer clockwise increases current while turning the potentiometer counterclockwise decreases current. By default the potentiometer is set in the middle of the range at the factory – this delivers 3.0 amps – fully clockwise delivers the maximum rating of the MM220 which is 6.0amps. The potentiometer should be set to deliver the rated current the motor requires. It is possible to set the potentiometer in such a way that the control chip delivers too much current to the motor resulting in motor overheating. If the motor missteps at high step rates then your motor maybe undersized for your application and can not develop enough torque – in this case use a bigger motor. Increasing drive voltage will increase maximum step rate. The maximum step rate of a stepper motor is determined by drive voltage, coil inductance and step mode. Changing step mode from half step to quarter step can reduce effective drive torque by 40%.

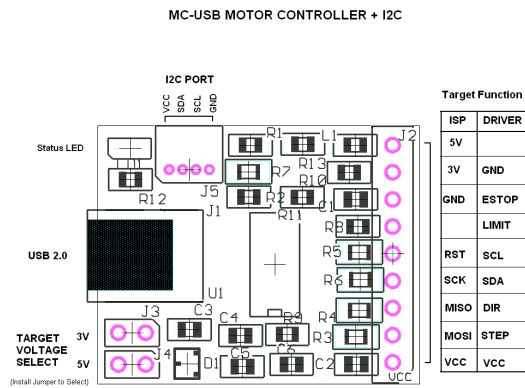
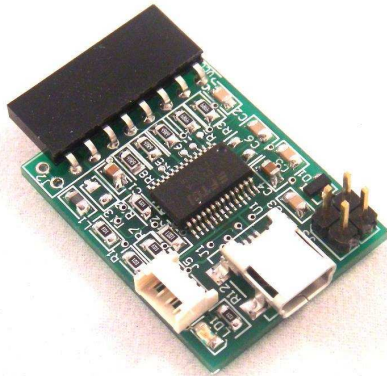
MM220 Current Potentiometer



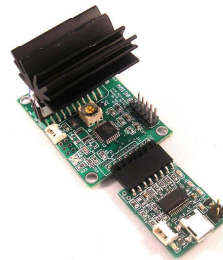
MM220 Controllers

Although the MM220 can operate standalone it usually requires a controller to send step and direction input signals to it. SOC Robotics has several controllers compatible with the MM220 - MC-USB, MK1, MK4, MK14, MK54 and MK200. Each controller supports increasing levels of sophistication and control flexibility. The MK1 is a simple breakout board that allows three MM220's to be attached and controlled. The MK4 is a four axis breakout board with four auxiliary output ports, four limit switch inputs and one Estop input. The MK14 is a special version of the MK4 with a USB 2.0 interface. The MK54 is a high performance G Code processor with 10/100BaseT, CAN and USB 2.0. The MK200 is an ultra high performance G Code processor with onboard vision processing. For more information on our line of controllers and to help determine which one is best for your application go to our web site or contact the firm.

With the MC-USB stepper motors can be controlled via a host PC USB port.



The MC-USB is a USB 2.0 based controller that generates the step/direction signals to control the MM220. An I2C communications bus allows a host PC to communicate with the MM220 in real time allowing step mode changes, limit switch detection and aux IO monitoring and control.



MM220 with MC-USB Controller

The MK4 is an optional parallel port controller with connectors for four MM220 drivers. The MK4 has four aux open collector outputs and five limit switch inputs all set/read via the parallel port. The MK4 is an excellent choice to attach up to four MM220's to a PC's parallel port and be controlled using Mach3.

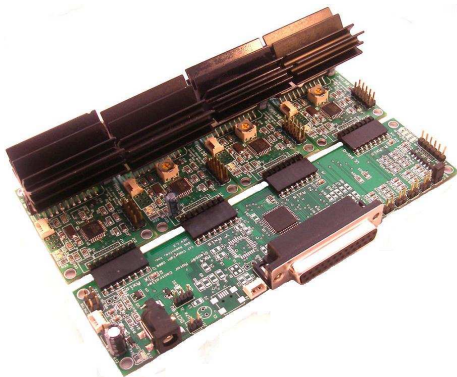


MK4 Controller

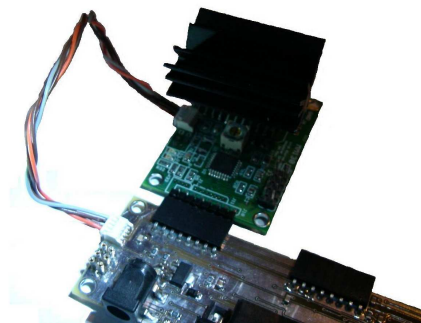
The MK14 is a USB 2.0 version of the MK4 with an onboard processor that accepts up to four MM220 drivers. The MK14 has four aux open collector outputs and five limit switch inputs all read via the parallel port. The onboard processor (AT91USB162) accepts step commands via USB and allows the host PC to communicate with the individual MM220 drivers and send high commands directly to each driver. In this case the parallel port interface can be bypassed and commands sent directly to each MM220 processor using a standard serial communications protocol.



MK14 Controller

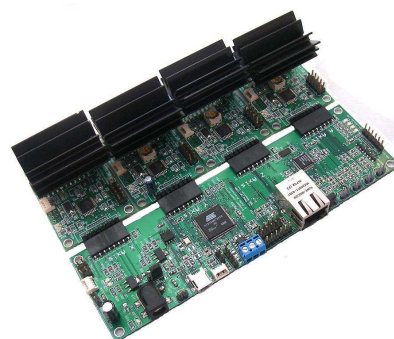
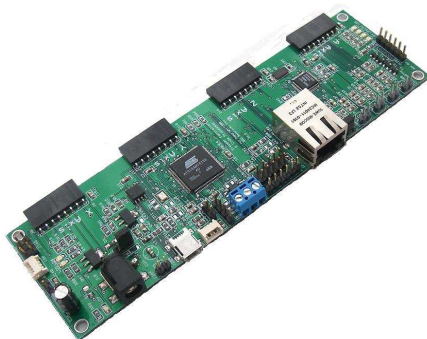


MK14 with 3 MM220's and MM133

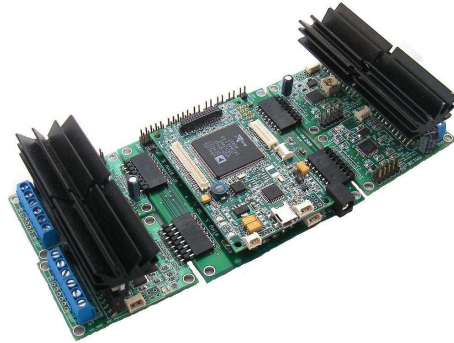


MM220 Programming Cable

The MK54 is a high end G Code processor with onboard ARM7 processor running 55MHz. The ARM7 processor executes G Code directly eliminating the need for a PC based G Code processor. The MK54 is capable of receiving commands via a USB 2.0 interface, 10/100BaseT Ethernet or CAN.



The MK200 is a high end DSP based G Code processing platform with built-in vision processing that is capable of driving the MM220's at their maximum rate of 80,000 microsteps/second. The MK200 is intended for high end applications that require extremely fast stepper motor operation and/or real time vision processing.



The correct controller for your application depends on many parameters. If you require help in choosing a controller or need additional information please contact the company.



2.0 MM220 Detailed Description

2.1 Introduction

The MM220 is a compact single axis stepper motor microstepping driver with a dedicated onboard processor. The processor responds to step/direction signals on the primary control input port, receives and interprets commands received on the I2C interface or encoded on the step/direction signal lines and processes sensor data received on the auxiliary IO port.

MM220 Connector Pin Assignment

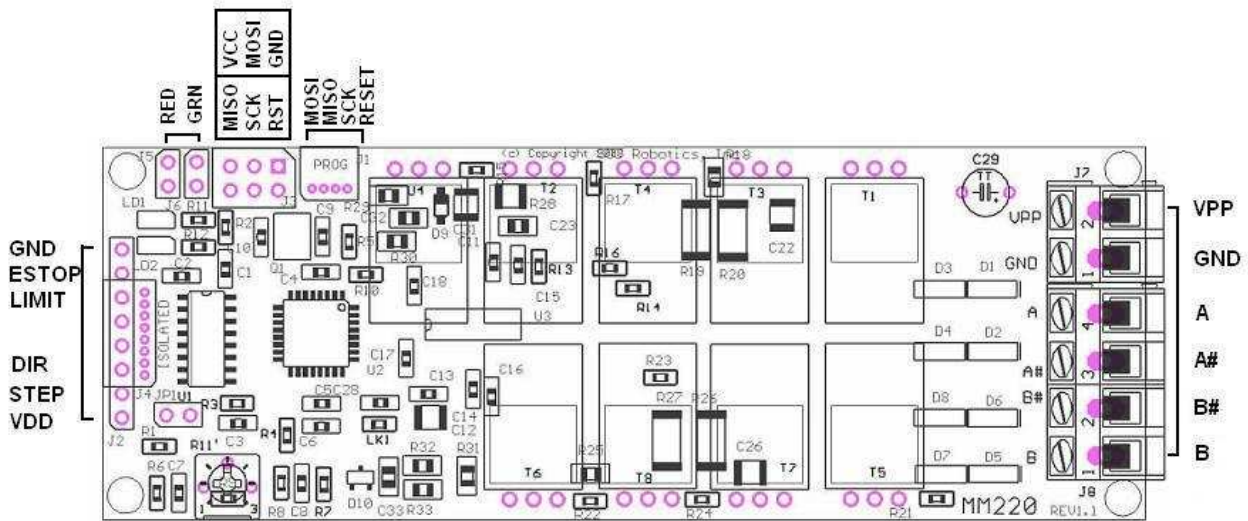


Figure 2-1. Primary Components on top and bottom sides of PCB.

2.2 Processor

The MM220 has an 8bit RISC AVR processor (ATmega168) running at 20MHz. Note that the Atmega168 requires 5VDC to run at 20MHz. The program running in the Atmega168 monitors the step/direction input lines and drives the A3986 microstepping driver chip. Commands supported by the processor firmware is described in the software operation section of this manual.

2.3 ISP Programming Port

The MM220 has two ISP programming ports – a 4 pin Molex connector and a 6 pin header. The MM220’s Flash can be programmed by attaching a 4 line cable from the MK4 programming port to the Molex connector. The 6 pin header is not installed but can be added as an optional component. Alternatively the MM220 flash can be programmed using a separately supplied ISP10 Programming Adapter and ISP610 adapter.

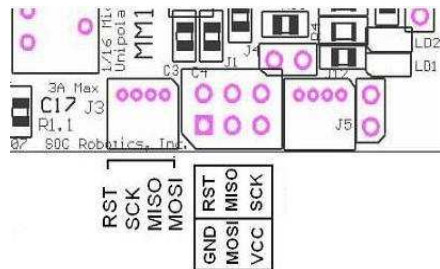


Figure 2-4. ISP610 ISP Adapter and correct attachment to the MM220 .

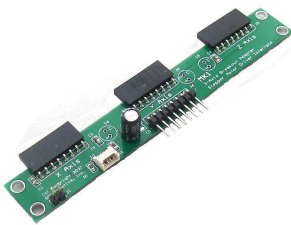
2.4 Molex Connectors

The MM220 uses a small Molex picoBlade 4 pin connectors with 1.25mm pin spacing (4 pin Molex Part No. 53048-0410 - Digikey Part No. WM1744-ND). The connector mate with female Molex 4 housing connector (4 pin housing Molex Part No. 51021-0400 - Digikey Part No. WM1722-ND).

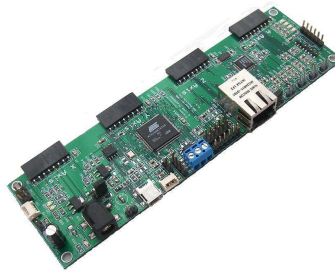
The housing connector's crimp terminal accepts 26-28AWG wire (Molex Part No. 50079-8000 - Digikey Part No. WM1722-ND - Crimp tool 63811-0300) or 28-32AWG (Molex Part No. 50058-8000 - Digikey Part No. WM1775-ND - Crimp tool 63811-0200).

2.5 Related Peripherals

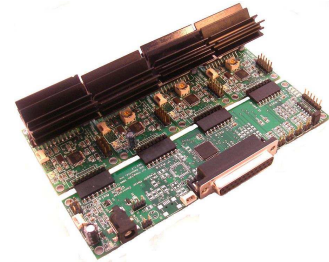
The MM220 can be controlled directly by the USB10, MK1, MK4, MK4USB, MK54 and MK200. The MK4 attaches to a PC parallel port and provides an attachment point for up to four MM220's. The MK4 also support limit switch inputs and EStop. The MK4USB is a version of the MK4 that has a USB 2.0 interface to allow direct communication between each attached MM220 and a host PC for both motion control such as step/direction and configuration control such as changing step mode.



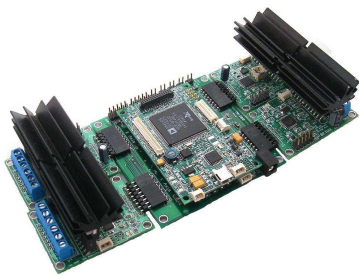
MK1



MK54



MK4 with 4 MM220's

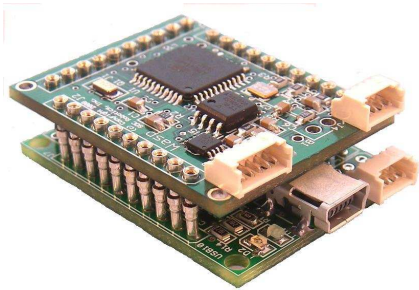


MK200 plus P0 DSP with four MM220's

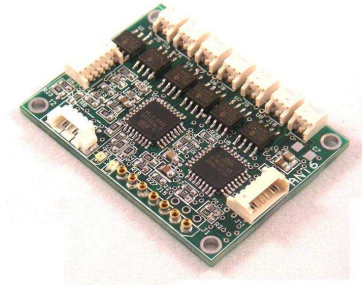


MK1 with Wasp and USB10 G Code processor

The MM220 can communicate with other SOC Robotics embedded processors such as the Wasp, WaspARM, SAM48, AmberM, SmartLCD, Ant6, Cricket and a host of other embedded processors.

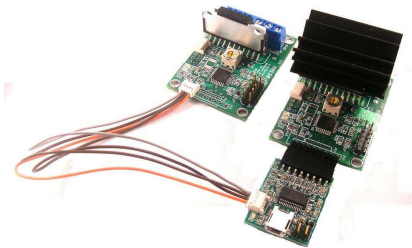


Wasp on USB10.



Ant6 6 Channel H-Bridge Controller

USB10 is a USB 2.0 device with an onboard AVR processor – the AT90USB162. The USB10 converts commands sent to it via the USB to step/direction commands that can drive the MM220.



Wasp mounted on a USB10 communications board.



Ant6 6 Channel H-Bridge Controller

2.6 Applications

The MM220 is a bipolar stepper motor driver that responds to step and direction signal inputs and monitors limit and eStop switch inputs.

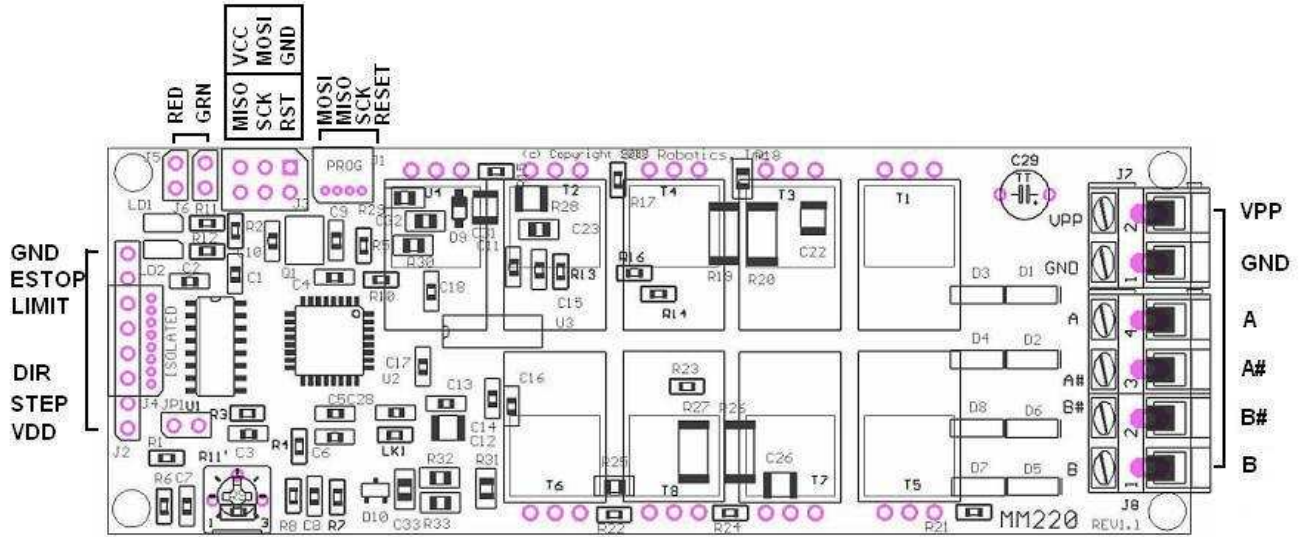
The MM220 also can accept sensor input on the ISP programming lines providing an upgrade to a closed loop design in which sensor feedback is used to tune stepper motor operation. An example of a possible external sensor is a rotary magnetic sensor and a linear capacitive position sensor.

3.0 MM220 Hardware Expansion Port Description

3.1 Introduction

The MM220 has two I/O ports: a motor control port and an ISP Programming port as shown in the connector layout diagram below. Two alternative configurations of the board are available: Configuration 1 replaces the 0.1" motor control port header with an 8 pin picoBlade Molex connector and configuration 2 replaces the motor 0.1" motor control port header with a 4 pin picoBlade Molex connector for the I2C port.

MM220 Connector Pin Assignment



3.2 Motor Control Port

Motor control port is routed to connector J2. Step and direction signals are fed to the board on this port along with main power (5V DC) and ground, I2C lines and limit switch inputs. The I2C lines (SDA, SCL) allow a controller such as the MK4USB, MK54 or MK200 to communicate with the MM220 and set configuration features such as step mode, limit switch recognition, step/direction polarity, etc. The I2C lines are also routed to a dedicated 4 pin connector. Under software control the limit switch inputs can be monitored and acted on or ignored by the MM220 directly without host intervention. Configuration commands can also be encoded in the step/direction lines using a special protocol described later.

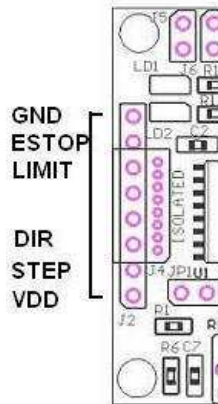


Figure 3-3. Step/Direction Control Port Pin Assignment J2.

3.3 ISP Programming Port

The MM220 has two ISP Programming ports – a six pin header compatible with the Atmel 6 pin header ISP programming standard and a four pin picoBlade Molex connector compatible with the USB10U, MK4, MK14, MK54 and MK200 controllers. The ISP programming port allows the onboard ATmega168 processor Flash to be reprogrammed. See the Atmel ISP programming specification for detailed ATmega168 programming procedures. In program the MM220 Atmega168 processor flash a shorting jumper must be installed on the two pin header JP1 – this jumper connects the logic ground with the programmer ground.

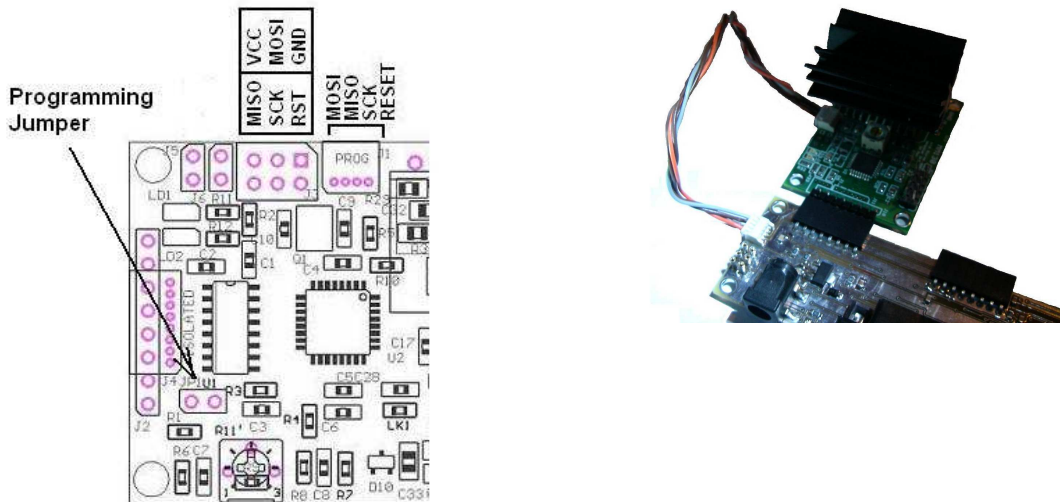


Figure 3-6. ISP Programming Port and MCM-8 programming cable.

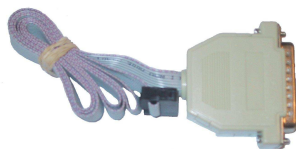


Figure 3-7. ISP10 Parallel Port programming adapter.

4.0 Software Operation

4.1 Theory of Operation

The MM220 is driven by step and direction signals applied to connector J2. The MM220 is shipped with quarter step mode enabled. The MM220 supports full, half, quarter, and one sixteenth step modes. Step mode can be changed by sending an encoded command on the step/direction signal lines. The direction signal must be set before the step pulse – the step pulse is a positive going raising edge that is held for at least 5useconds. The direction signal must not be changed during the step high level or the MM220 will enter Command Recognition mode.

The MM220 is shipped with a software application in which Command Recognition mode is enabled for the first five seconds of operation following power up after which Pass Through mode is activated. In Command Recognition mode all motion control and configuration setup commands are recognized. In Pass Through mode the step/direction signals are simply passed through the processor to the A3986 driver. In Pass Through mode commands sent to the MM220 are not longer recognized. The MM220 defaults to Pass Through mode after 5 seconds to make sure the application software driving the MM220 works reliably. If the application driving the MM220 can meet the strict step/direction signal setup and hold times then Pass Through mode is not required and the more flexible Command Recognition mode can be used. Pass Through mode should also be used if the cables supplying the step/direction signals to the MM220 are noise prone. Pass Through mode activation can be changed to Command Recognition mode in the first 5 seconds of operation using the free application GSTepPP.exe available from our web site www.soc-robotics.com.

The motor drive chip A3986 is a bipolar microstepping driver with external current sense resistors and logic to control drive current given a drive voltage. A potentiometer allows the user to set the operating current of the driver. The A3986 is designed to drive 2-3A motors but should be able to drive smaller motors without any trouble. Power for the board logic is taken from the motor power input and is regulated to 5V on the board. The standard board runs at 20MHz.

4.2 Step Drive Connector

The MM220 controls an attached stepper motor by converting Step and Direction input signals on connector J10 to four Power Mosfets in the A3986 chip. By default the step signal is an active high pulse lasting at least 5 useconds in Pass Through mode and 20useconds in Command Recognition mode with optional noise reduction logic implemented in software. A high level on the Direction input causes a clockwise step. Default step mode is quarter step – step modes can be changed by sending commands encoded in the step/direction signal lines. If you are experiencing erratic operation then the application driving the MM220 is probably not meeting the minimum setup and hold times and the MM220 should be switched to Pass Through mode. In command recognition mode the direction signal can not go low before the step signal goes low – this arms the command recognition logic.

J2 also has limit/eStop switch inputs. Limit/eStop Switch inputs by default are not recognized but can be enabled by the user.

4.3 Driver Commands

The MM220 accepts commands encoded on the step/direction lines (step/direction line toggling).

Command Features

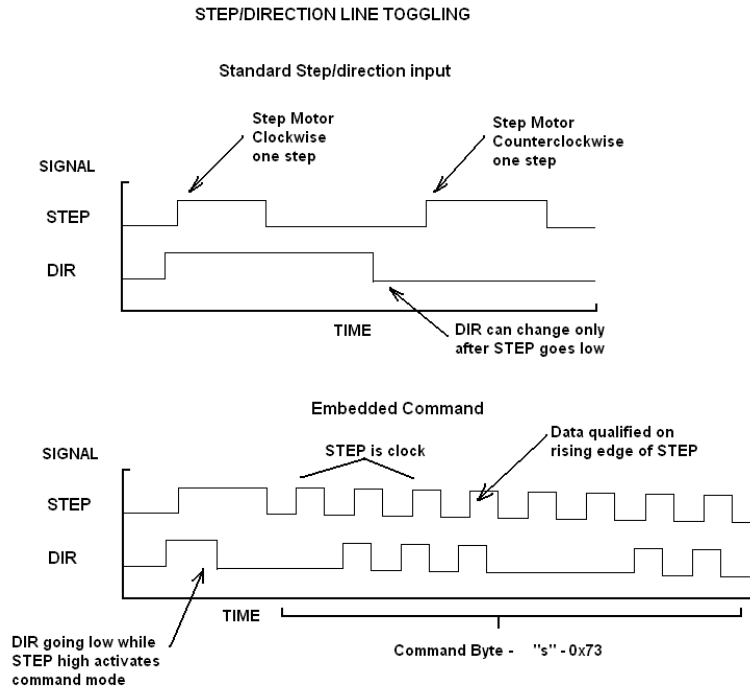
A script based parameter configuration utility allows the user to set the configuration options of each axis on an individual basis. Configuration parameters can be stored in on-chip EEPROM for automatic power up configuration control. A special built-in test/setup mode provides a simplified method for setting up the board. Configuration commands can be sent to the motor controller in real time using a special

communications protocol based on the Step and Direction lines. A bi-directional communication utility provides a real time link with MM220 processor allowing dynamic change and update of system parameters on the fly.

- New communication protocol for bidirectional data flow between the host and MM220 via the STEP/DIRECTION and Limit Switch lines and I2C
- The following parameters can be set by the user while the MM220 is operating:
 - o Pass through mode enabled for noisy environments
 - o Limit switch detection- enable, disable, smart enable, polarity settable
 - o EStop switch detection- enable, disable, polarity settable
 - o Step mode selection - wave, full, half, quarter, sixteenth
 - o Automatic motor shut off - enable, disable and time period settable
 - o Motor power - enable/disable
 - o Step rate, direction and number of steps to execute
 - o Maximum step rate
 - o Distance traveled for each step in inch or metric
 - o Feed Rate - ipm or cmpm
 - o Linear or rotary distance commands in inch or metric
 - o G1 G code commands accepted directly
 - o Single Step - Clockwise or counterclockwise
 - o Step Movement Direction Polarity - Clockwise or counterclockwise
 - o Direction polarity settable - high - clockwise, high -counterclockwise
 - o Backlash set
 - o Communication mode - enable/disable
 - o Save configuration settings in EEPROM
- Configuration parameters can be saved in EEPROM
- Stored configuration parameters can be read from the motor EEPROM using MK4Prog.exe and used to create a text based configuration script file

Step/Direction Line Toggling

Step/direction line toggling uses the step and direction signal lines to embed commands in step sequences. If the step and direction inputs are both high and the direction line is brought low before the step line is brought low the driver interprets this to mean a one byte command is about to be sent to the driver. The step line is then toggled as a clock input while data is encoded on the direction line. The driver does not interpret this pattern as a series of steps but as a command byte. By sending a string of bytes in this manner it is possible to send commands to the driver embedded within a stream of step signals. The exact format of the step/direction command byte is shown in the diagram below.



4.5 MM220 Command Overview

The MM220 processor responds to commands sent to it via the Step/Direction signal lines. Using a simple encoding procedure it is now possible to communicate with the Motor Controller via the Step, Direction and Limit switch lines. All commands are lower case letters and numbers. It is possible to change Motor Controller operation and configuration on the fly while the controller is running. Configuration changes take effect immediately.

The MM220 supports the following commands. A detailed description of each command follows. A command consists of two or more ASCII characters. Some commands require entry of integer or floating point numbers. A floating point number entered as an integer is interpreted correctly. Integer or floating point number must be terminated with a semicolon ";" character. Note that all commands are lower case characters. Commands are acted on immediately.

On power up the MM220 processor loads configuration settings from on chip EEPROM. If these settings are changed using the commands below the processor does not automatically store the new settings in EEPROM - the user must explicitly do this using the Save Settings command. If power is lost all changed settings will be lost if they have not been stored.

A desktop program called `GStepPP.exe` is used to send commands to the MM220. `GStepPP.exe` sends commands to a specific axis attached to a MK4 by entering the “c” character following by an axis identifier character (x,y,z,a) followed by one or more of the command sequences below all entered on one line. The command is sent to the driver when the enter key is pressed. Command Recognition mode must be enabled in the driver for commands to be recognized. An example of a command sequence is:

```
-cxs4  
-cxcss
```

The first command instructs the x-axis driver to set the step mode to quarter step. The following command then stores this new setting in EEPROM so the next time the driver is powered up quarter step mode is activated. A few of the command functions can be halted by entering the character sequence `cxq`.

If the control software driving the MM220 does not need to support command mode then for increased reliability in noisy environments command recognition mode can be disabled by sending the command mode disable command `cxcci`. Once Command Recognition mode has been disabled the only way to re-enable it is to re-flash the processor's flash memory using a special programming utility (`MK4Prog.exe`) and a special cable.

NOTE: The MM220 is shipped with Command Recognition mode enabled for the first 5 seconds to allow you time to change configuration parameters such as step mode, holding torque, shut-off delay, etc without re-flashing the board using `GstepPP.exe`. Re-flashing the board requires a special programming utility and optional cable. Pass Through mode is the most reliable mode in noisy environments or in situations where you do not know how the host software is manipulating the step/direction lines.

Command Summary

All commands are printable ASCII characters.

- s - Change step mode, 1-Full, 2-Half, 4-Quarter, 6-Sixteenth cxs4

- c - Enter Configuration Change mode:
 - s - Save settings to EEPROM (needs two 's') cxcss
 - t - Pass through mode, a-active, i-inactive
 - r - Reset Motor drive chip
 - h - Turn motor power off
 - c - Command Recognition mode, a-active, i-inactive
 - n - Noise reduction mode, a-active, i-inactive
 - l - loop count for noise reduction - default 2, (int)
 - f - Step/direction signals recognition enabled, y=yes, n-no
 - e - EStop switch recognition, y=yes, n-no
 - l - Limit switch recognition, y=yes, s-smart, n-no
 - p - Step polarity, p-positive, n-negative TBD
 - d - Direction polarity, c-clockwise, w-counterclockwise
 - a - Automatic motor power shut off mode, o-on, f-off
 - t - Time after which the motor power is shut off, seconds (float) cxcat25.5;
 - b - Set backlash (float) cxcb24;
 - x - Set acceleration parameter (float)
 - m - Step resolution parameters
 - r - Resolution (float), cxcmr0.000125;
 - n - Minimum pps (float), cxcmn20.0;
 - x - Maximum pps (float), cxcmx2300;
 - m - Ramp rate (float)

- d - Drive motors (enter direction and step rate), e-exit (entered at any time)
 - z - Zero absolute position
 - h - Go to Home position, n-near side, f-far side, o-offset (float)
 - i - Set feed rate (ipm), float cxdi10.0;
 - p - Pause execution (msec), int cxdp1000;
 - c - Step clockwise
 - w - Step counterclockwise
 - s - Set slow step rate (pps), float
 - f - Set fast step rate (pps), float
 - m - Constant step cxdmw220000;1300;
 - direction, stepmode, number of steps, step rate (pps)
 - x - Ramp for n loops using default low high pps cxdx220;2000;4;
 - stepmode, steps at each speed, constant step number, loops
 - r - Ramp between low and high pps cxdr2300;2000;20;2000;
 - stepmode, slow step rate, high step rate, step increment, constant steps
 - d - Distance mode cxdd21.25;6.27;
 - stepmode, new position, feed rate (ipm)

- t - Enter Test mode
 - t - Toggle back and forth - all step modes, hit any key to exit
 - x - Ramp low to high - high to low - all step modes, hit any key to exit
 - v - Ramp low to high - high to low - enter step mode, hit any key to exit

- l - Led mode, 1-mode1, 2-mode2, 3-mode3

- z - Enter record command mode
 - b - Begin recording
 - h - Halt recording
 - e - Execute stored commands
 - a - Arm pin PB5 (SCK) to trigger execution of stored commands , o-on, f-off cxzao

4.6 Detailed Command Description

Step Mode Command

Set the driver step mode. The MM220 is a microstepping bipolar stepper motor driver capable of full, half, quarter, and one sixteenth microstepping.

s - Change Step Mode, 1-Full, 2-Half, , 4-Quarter, 6-Sixteenth

Set the driver step mode. Step mode is set to full, full high power, half, half high power, quarter, eight or one sixteenth microstepping. The following characters set the step mode:

- 1 - Full step mode
- 2 - Half step mode
- 4 - Quarter step mode
- 6 - One sixteenth step mode

Examples: cxs1 cxs6

Note that changing step mode may not guarantee a smooth step transition. Step mode changes take effect immediately.

Drive Motor Commands

Set a motor driver state. The MM220 has a single axis G Code like feature that supports absolute position moves with backlash compensation and step resolution configuration setup.

- d - Drive motors (enter direction and step rate), e-exit (entered at any time)
 - z - Zero absolute position
 - h - Go to Home position, n-near side, f-far side, o-offset (float)
 - i - Set feed rate (ipm), float
 - p - Pause execution (msec), int
 - c - Step clockwise
 - w - Step counterclockwise
 - s - Set slow step rate (pps), float
 - f - Set fast step rate (pps), float
 - m - Constant step `cxdmw220000;1300;`
direction, stepmode, number of steps, step rate (pps)
 - x - Ramp for n loops using default low high pps `cxdx220;2000;4;`
stepmode, steps at each speed, constant step number, loops
 - r - Ramp between low and high pps `cxdr2300;2000;20;2000;`
stepmode, slow step rate, high step rate, step increment, constant steps
 - d - Distance mode `cxdd21.25;6.27;`

stepmode, new position, feed rate (ipm)

d - Drive Motors (enter direction and step rate), e-exit (entered at any time)

Enter drive motor command function. The drive mode allows step commands to be executed directly by the on board processor. Relative and absolute step position functions are supported. Most of the commands can be terminated early by entering the exit command: `cxe`

z - Zero Absolute Position

Set the internal position counter to zero. This command resets the home position. The absolute position command converts a distance command to the required number of steps based on the backlash and step resolution commands.

h - Go to Home Position

Move to the home position which is closest to the stepper motor with the limit switch activated. This command should be used in combination with the Limit Switch Smart setting. There are three parameters that set which end the home position is located at and an offset from the limit switch. The offset allows the home position to be located at any position between either end of the travel.

Example:

```
cxdhn      Home position located at near side
cxdhf      Home position located at far side
cxdho1.25; Home position is offset by 1.25 in from limit switch
```

i - Set Feed Rate (ipm)

Set the feed rate in inch per minute (ipm). This command sets the step rate based on the step resolution. The parameter is entered as an integer or floating point number.

Example: `cxdi12.25;` - Set feed rate to 12.25 inch per minute.

p - Pause execution (msec)

Pause execution for a period of time. The time period is entered as an integer and is in mseconds. This command allows precisely timed delays to be added to stored programs.

Example: `cxdp1000;` Pause for 1 second.

c - Step clockwise

Step clockwise one step using the existing step mode. Note that if the desired step direction is not clockwise use the Step Direction Polarity command to change the direction.

w - Step counterclockwise

Step counterclockwise one step using the existing step mode. Note that if the desired step direction is not counterclockwise use the Step Direction Polarity command to change the direction.

s - Set slow step rate (pps)

Set the slow step rate in pulses per second (pps). This command sets the slow speed step rate that is used by several other commands such as the ramp command. The parameter is entered as an integer or floating point number.

Example: `cxds1300;` - Set slow step rate to 1300 pps.

f - Set fast step rate (pps)

Set the fast step rate in pulses per second (pps). This command sets the slow speed step rate that is used by several other commands such as the ramp command. The parameter is entered as an integer or floating point number.

Example: `cxdf1300;` - Set fast step rate to 1300 pps.

m - Constant step

Step at a constant rate (pps) given an entered direction, step mode and number of steps. This command allows a set of step parameters to be entered. Variable length parameters such as step rate may be entered as an integer or floating point number. Direction is "c" or "w". Step mode is 1, !, 2, @, 4, 8 or 6.

Entered parameters: direction, stepmode, number of steps, step rate (pps)

Example: `cxdmw220000;1300;` - Step CCW, half step, 20000 steps at 1300 pps
`cxdmc41000;400;` - Step CW, quarter step, 1000 steps at 400 pps

x - Ramp for n loops using default low high pps

Ramp from a low step rate to a high step rate, step at the maximum step rate for the entered number of steps and then step from the high step rate to the slow step rate stepping the entered number of steps at each speed and repeat for the entered number of loops. The slow and fast step rate are entered using the "s" and "f" drive commands. Note variable length command parameters are terminated with a ";" character.

Entered parameters: stepmode, steps at each speed, constant step number, loops

Example: `cxdx220;2000;4;` - Ramp using half step, 20 steps at each ramp
increment, 2000 steps at max rate and loop
4 times
`cxdx410;20000;14;` - Ramp using quarter step, 10 steps at each ramp
increment, 20000 steps at max rate and loop
14 times

r - Ramp Between Low and High pps

Ramp from a low step rate to a high step rate, step at the maximum step rate for the entered number of steps and then step from the high step rate to the slow step rate stepping the entered number of steps at each speed and repeat for the entered number of loops. The slow and fast step rate are entered using the "s" and "f" drive commands. Note variable length command parameters are terminated with a ";" character.

Entered parameters: stepmode, slow step rate, high step rate, step increment, constant steps

Example: `cxdr2300;2000;20;2000;` - Ramp using half step from 300 pps to
2000 pps incrementing 20 steps per speed
change and step 2000 steps at the maximum
rate.
`cxdr1200;700;10;1000;` - Ramp using full step from 200 pps to
700 pps incrementing 10 steps per speed
change and step 1000 steps at the maximum
rate.

d - Distance Mode

Move to an absolute position at the entered feed rate (ipm) given an entered step mode. The new position is entered as inches, step rate is inch per minute and step mode is 1, !, 2, @, 4, 8 or 6. At first

power up the home is set to zero. Positive or negative absolute positions can be entered. Backlash compensation is applied automatically and step resolution defines the number of steps either clockwise or counterclockwise. The function automatically compensates for step mode changes so if a position command says move to absolute position 1.000 at full step and then step to 0.000 at half step the carriage will return the exact starting point.

Entered parameters: stepmode, new position, feed rate (ipm)

Example: `cxdd21.25;6.27;` - Ramp using half step from 300 pps to

Test Mode Commands

Enter test mode. Test mode commands drive the stepper motor through a series of direction toggle and ramp motions.

t - Enter Test mode

- t - Toggle back and forth - all step modes, hit any key to exit
- x - Ramp low to high - high to low - all step modes, hit any key to exit
- v - Ramp low to high - high to low - enter step mode, hit any key to exit

t - Enter Test Mode

Enter the test mode state and interpret any subsequent characters as test mode selections.

t - Toggle Back and Forth - All step modes, hit any key to exit

This command causes the drive to step the motor in the clockwise direction for a defined number of steps and then step in a counterclockwise direction the same number of steps at a pre-defined pps rate starting with full step mode and sequencing through all the step modes. Entering `cxq` caused the sequence to terminate.

x - Ramp Low to High/High to Low - All step modes, hit any key to exit

This command causes the driver to step the motor through a clockwise then counterclockwise motion while ramping the speed from a minimum pps rate to a maximum pps rate sequencing through all step modes from full to sixteenth step.

v - Ramp Low to High/High to Low - Hit any key to exit

This command causes the driver to step the motor through a clockwise then counterclockwise motion while ramping the speed from a minimum pps rate to a maximum pps rate at an entered step mode and loop count.

Entered Parameters: step mode, loop count

Example: `cxtv210` - Ramp in half step mode and repeat 10 times.

LED Display Mode Command

The user can set the display mode of the LEDs to one of three different display status modes. This function has not been implemented in the current software version. Mode 1 is active.

1 - Led mode, 1-mode1, 2-mode2, 3-mode3

Set the led display mode. Command character is "l". Sets mode 1, 2 or 3.

Mode 1 (Default mode in command recognition mode)

Green led displays status of stepper motor power: on - power being supplied to motor, off - no power to motor. Red led displays step rate and blinks when driver is waiting for a step signal- led blinks for each step signal sent to the motor. The slow blinking Red led indicates the driver processor is alive and waiting for a step command.

Mode 2 (Default mode if pass through mode active)

Green led displays status of stepper motor power: on - power being supplied to motor, off - no power to motor. Red led display step direction - on - clockwise, off - counterclockwise.

Mode 3

The on or off condition of the Green and Red LEDs is set using commands. The next character selects the Red or Green Led and the state (on or off).

Entered Parameters: led, state (on-o, off-f)

Examples:

- cxlro - Turn the Red Led on
- cxlgf - Turn Green Led off.

Configuration Change Commands

The configuration change commands set the basic default operating modes of the MM220. The user can turn command mode recognition on or off (if command recognition mode is turned off commands are no longer recognized), save settings to EEPROM, enable a noise reduction mode, enable step/direction recognition, set EStop and limit switch recognition, change direction polarity, automatically turn holding torque on/off and time, set backlash and step resolution, minimum and maximum pps and ramp rate.

c - Enter Configuration Change mode:

- s - Save settings to EEPROM (needs two 's') cxcss
- t - Pass through mode, a-active, i-inactive
- r - Reset Motor drive chip
- h - Turn motor power off
- c - Command Recognition mode, a-active, i-inactive
- n - Noise reduction mode, a-active, i-inactive
 - l - loop count for noise reduction - default 2, (int)
- f - Step/direction enable, y=yes, n-no
- e - EStop switch recognition, y=yes, n-no
- l - Limit switch recognition, y=yes, s-smart, n-no
- p - Step polarity, p-positive, n-negative TBD
- d - Direction polarity, c-clockwise, w-counterclockwise
- a - Automatic motor power shut off mode, o-on, f-off
 - t - Time after which the motor power is shut off, seconds (float) cxcat25.5;
- b - Set backlash (float) cxc24;
- x - Set acceleration parameter (float)
- m - Step resolution parameters
 - r - Resolution (float), cxcmr0.000125;
 - n - Minimum pps (float), cxcmn20.0;
 - x - Maximum pps (float), cxcmx2300;

m – Ramp rate (float)

c – Enter Configuration Change Mode

Top level command. Any characters entered after the “c” character are interpreted as configuration change commands.

s – Save Settings to EEPROM (needs two ‘s’) cxcss

Save all configuration parameters to EEPROM. Once saved in EEPROM the next power cycle of the board loads the new settings at power up. Note that if any configuration parameters are changed they remain in effect as long as the power is applied. Configuration changes are not automatically stored – the user must use this command to save any configuration changes. Note that two “s” characters are required.

t – Pass through mode, a-active, i-inactive

Set Pass Through Mode to active or inactive. Pass through mode is a special operating state of the MM220 that disables command recognition on both the I2C and Step/Direction lines. This mode when active ensures the step and direction signal levels are recognized under all conditions. If the setup and hold times for command recognition on the step/direction lines can not be guaranteed then the MM220 may accidentally enter command mode. This can also happen if there is excessive noise on the step/direction signal lines. Once Pass through mode is activated no commands are recognized – the only way to re-enable command mode is to re-flash the processor.

r – Reset Motor Drive Chip

Sets the motor drive chip to a known start state. Note that the motor rotor may be in an intermediate start position if any microstepping modes were selected.

h – Turn motor power off

This command turns motor power off. Motor power is reapplied on the next step input.

c – Command Recognition Mode, a-active, i-inactive

Command recognition mode is enabled or disabled by this command. Once command recognition mode has been disabled the only way to re-enable is to either re-powered to the board (if this setting was not saved) or re-program the processor. In noisy environments it may be necessary to disable command recognition mode so noise spikes on the step/direction lines are not mistakenly interpreted as step signals. By default command recognition mode is active. If a desktop application that is generating setup and holds times are not within specification then it may be necessary to turn Command Recognition mode off – note this applies to Commands encoded in the Step/Direction input lines only and not recognition of commands received on the I2C lines.

n – Noise Reduction Mode, a-active, i-inactive

l – loop count for noise reduction – default 2, (int)

In noisy environments a special noise reduction mode can be enabled. Noise reduction adds delay to the step pulse recognition logic. If step pulses are shorter than 5usec noise reduction mode should not be used. The loop count parameter sets the duration of the noise reduction period. By default noise reduction is disabled.

f – Step/Direction Enable, y=yes, n-no

Recognition of step/direction signals can be enabled or disabled. Step/direction signal recognition maybe disabled if step commands are encoded on the step/direction lines or I2C lines. By default Step/direction recognition is enabled.

e – EStop Switch Recognition, y=yes, n-no

EStop switch detection can be enabled, disabled. When disabled the state of the EStop switch has no effect on motor operation. If enabled the motor will stop immediately and remained stopped as long as the EStop switch is active. Motor operation will resume if the EStop switch active state is removed or EStop Switch detection is disabled. EStop switch inputs are pulled high with a 10K resistor so to activate an eStop event the switch must pull the high level to ground. By default EStop recognition is disabled.

l - Limit Switch Recognition, y=yes, s-smart, n-no

Limit switch detection can be enabled, disabled or smart enabled. When disabled the state of the limit switch has no effect on motor operation. If enabled the motor will stop immediately if the Limit Switch becomes active (a low level) and the motor must be moved manually off the stop position. Alternatively if a limit switch event has occurred then by disabling limit switch recognition it is possible to move the stepper motor. If Smart mode is enabled the motor will respond to move commands in the direction away from the switch. Limit switch inputs are pulled high with a 10K resistor so to activate a limit switch event the switch must pull the high level to ground. By default Limit switch recognition is disabled.

p - Step Polarity, p-positive, n-negative TBD

Change the polarity of the step input signal. This function has not been implemented in the current version of the software. By default step polarity is an active going high pulse.

d - Direction Polarity, c-clockwise, w-counterclockwise

Change polarity of the direction input signal. Sets the direction the stepper motor turns when the direction signal is high. Note that depending on how the motor was wired clockwise and counterclockwise directions may be flipped. This command allows the user to flip the direction of rotation. By default the high level selects clockwise rotation.

a - Automatic Motor Power Shut Off Mode, o-on, f-off

t - Time after which the motor power is shut off, seconds (float)

After a step operation completes holding torque can be activated or deactivated. If activated torque the time hold torque is applied can be set. The time duration is set in 0.1 second increments from a 1/10 of a second to 6000 seconds. Depending on the application if holding torque is applied for long time periods driver and motor overheating may result.

Example:

```
cxcao    - Enable automatic power shut off
cxcaf    - Disable automatic power shut off
cxcat1;  - Turn motor power off after 1 second
```

b - Set Backlash

If the backlash of the lead screw is known this command calibrates the absolute position command when direction changes. The backlash is the number of steps required to move the thrust nut in direction change operations.

Example: `cxcb24;` - Set backlash to 24 steps

x - Set acceleration parameter (float)

The acceleration parameter controls the rate of change of stepping. Stepper motors operate within a specific pull-in pull-out torque band. A stepper motor can not instantly change speed. The acceleration parameter sets the maximum rate of change. The parameter is a floating point number between 1 and 25,000. 1 gives very slow acceleration while 25,000 is almost instantaneous.

Example: `cxcx1000.0;`

m - Step Resolution Parameters

r - Resolution (float),	<code>cxcmr0.000125;</code>
n - Minimum pps (float),	<code>cxcmn20.0;</code>
x - Maximum pps (float),	<code>cxcmx2300;</code>
m - Ramp rate (float)	

The distanced traveled for a single step is used to calibrate the absolute position move command. Typically this parameter depends on the tpi of the lead screw and step mode. For example a 20tpi screw moves a carriage by 0.00025 inch in full step mode. The parameter is entered as a floating point number. The minimum pulse per second (pps) setting is used by the test and drive commands to set the slow step rate. The parameter is entered as a floating point number. The maximum pps setting is used by the test and drive commands to set the high step rate. The Ramp rate is a parameter that sets the acceleration for the test, drive and absolute position commands.

Record Commands Mode

The processor on the MM220 has approximately 1900 bytes of EEPROM storage space that can be loaded with a sequence of commands. For example, if the stepper motor needs to execute a sequence of commands to generate a specific motion turning on recording will store the commands as they are executed. Once the desired motion is finished enter the halt recording command. The stored motion can then be executed either by sending an execute command or the motion can be triggered by pulling the PC5 pin low on the expansion port.

z - Enter record command mode

b - Begin recording

h - Halt recording

e - Execute stored commands

a - Arm pin PB5 (SCK) to trigger execution of stored commands , o-on, f-off

Example:

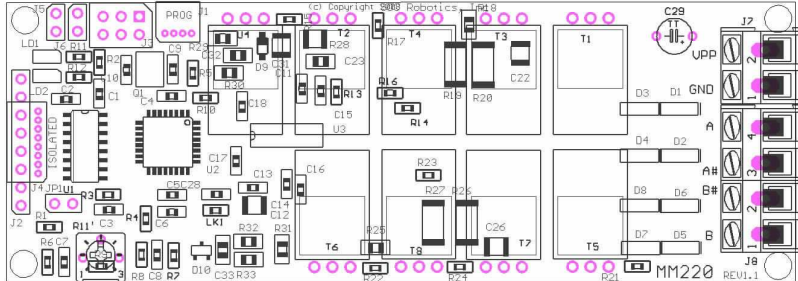
```
cxzb
cxdd21.00;5.45;
cxdd21.25;6.57;
cxdd21.00;6.57;
cxdd20.0;5.45;
cxzh
cxze
```

In the example above the store command mode is entered followed by a movement of the carriage from position 0 to position 1.00 at 5.45 inch/minute, then moves to 1.25 at 6.57ipm, then moves back to 1.00 at the same rate and finally returns to the starting position 0.00. Recording mode ends when the halt recording command is entered. The complete motion sequence is then executed by the start execution command.

4.0 Electrical and Mechanical Description

4.1 Component Layout

Components are mounted on both sides of the board. Not all components may be mounted.



4.2 Electrical Specifications

Electrical

Input power: 20-48VDC @ 6A

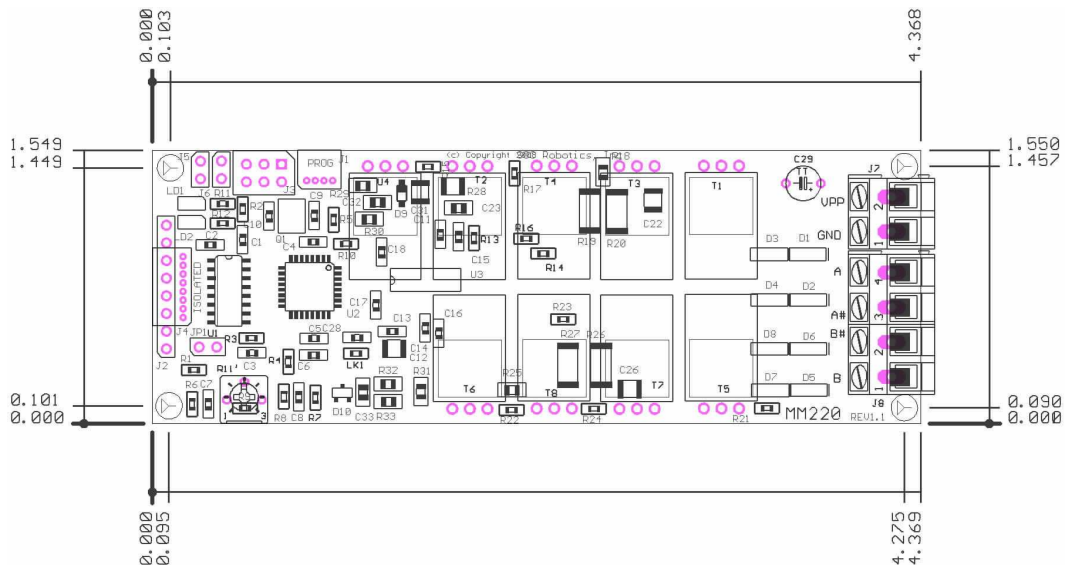
Mechanical

Dimensions: 4.4x1.6 in

Weight: 16 grams

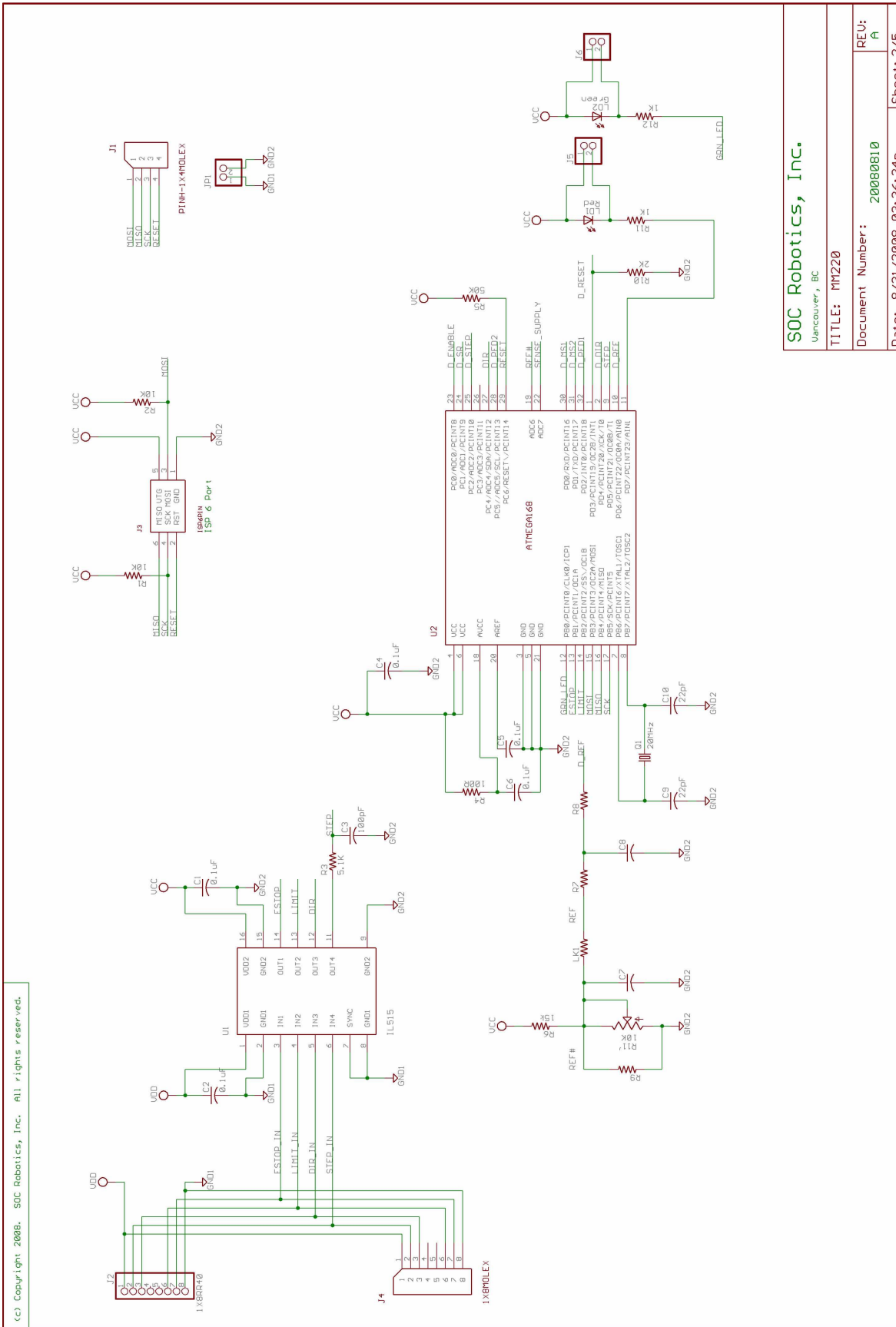
4.3 Mechanical Dimensions

Board dimensions are stated in inches.



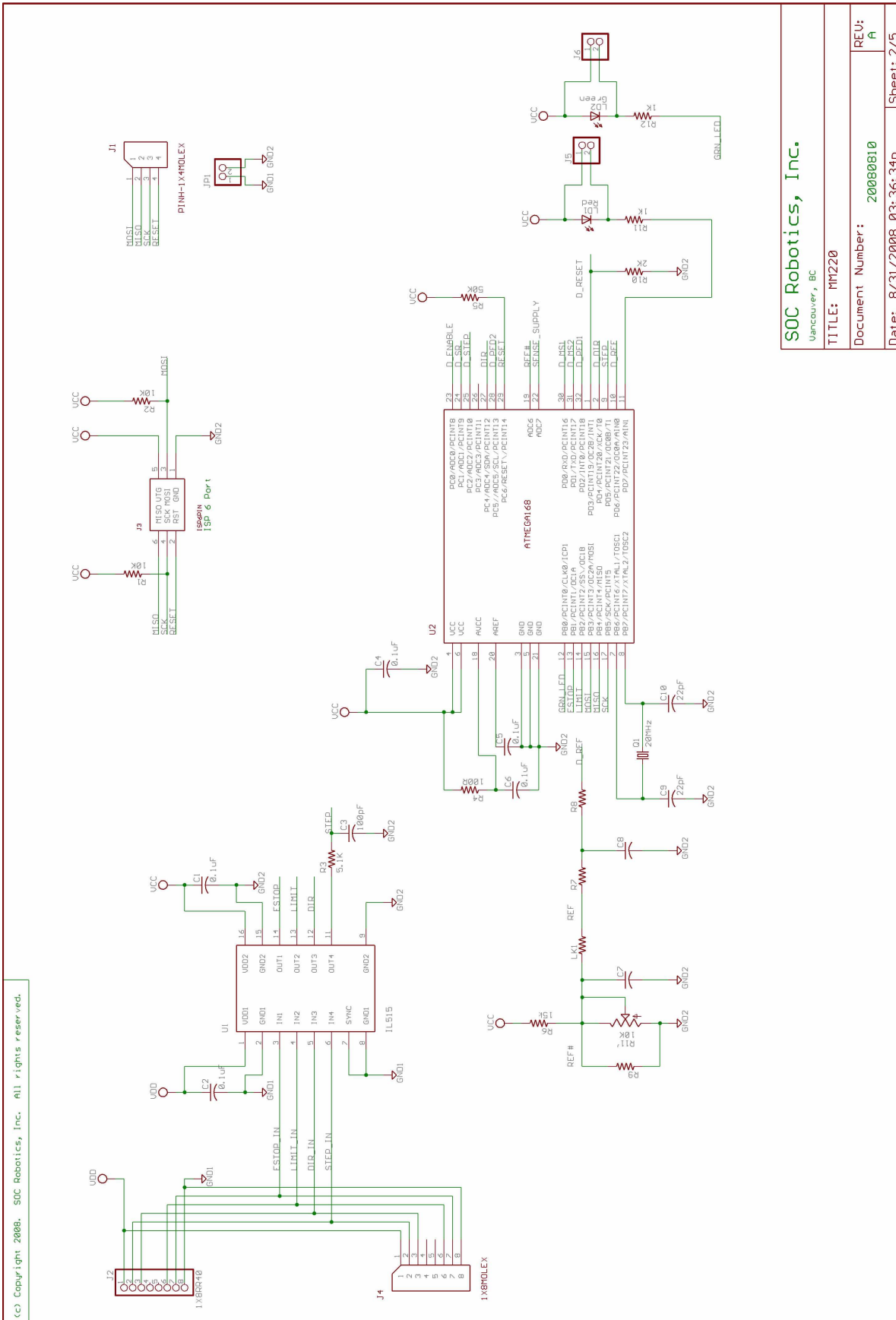
5.0 MM220 Circuit Schematics

<p style="font-size: small;">(c) Copyright 2008, SOC Robotics, Inc. All rights reserved.</p> <p style="text-align: center; font-size: 2em; color: green;">Bipolar Motor Controller</p> <p style="text-align: center; font-size: 1.5em; color: green;">MM220</p> <p style="text-align: center; font-size: 2em; color: green;">6A, 42V Microstepping Driver</p> <p style="text-align: center; font-size: 1.2em; color: green;">PCB Rev 1.1</p>	SOC Robotics, Inc. <small>Vancouver, BC</small>	
	TITLE: MM220	
	Document Number: 20080810	REV: A
	Date: 8/31/2008 03:36:34p	Sheet: 1/5

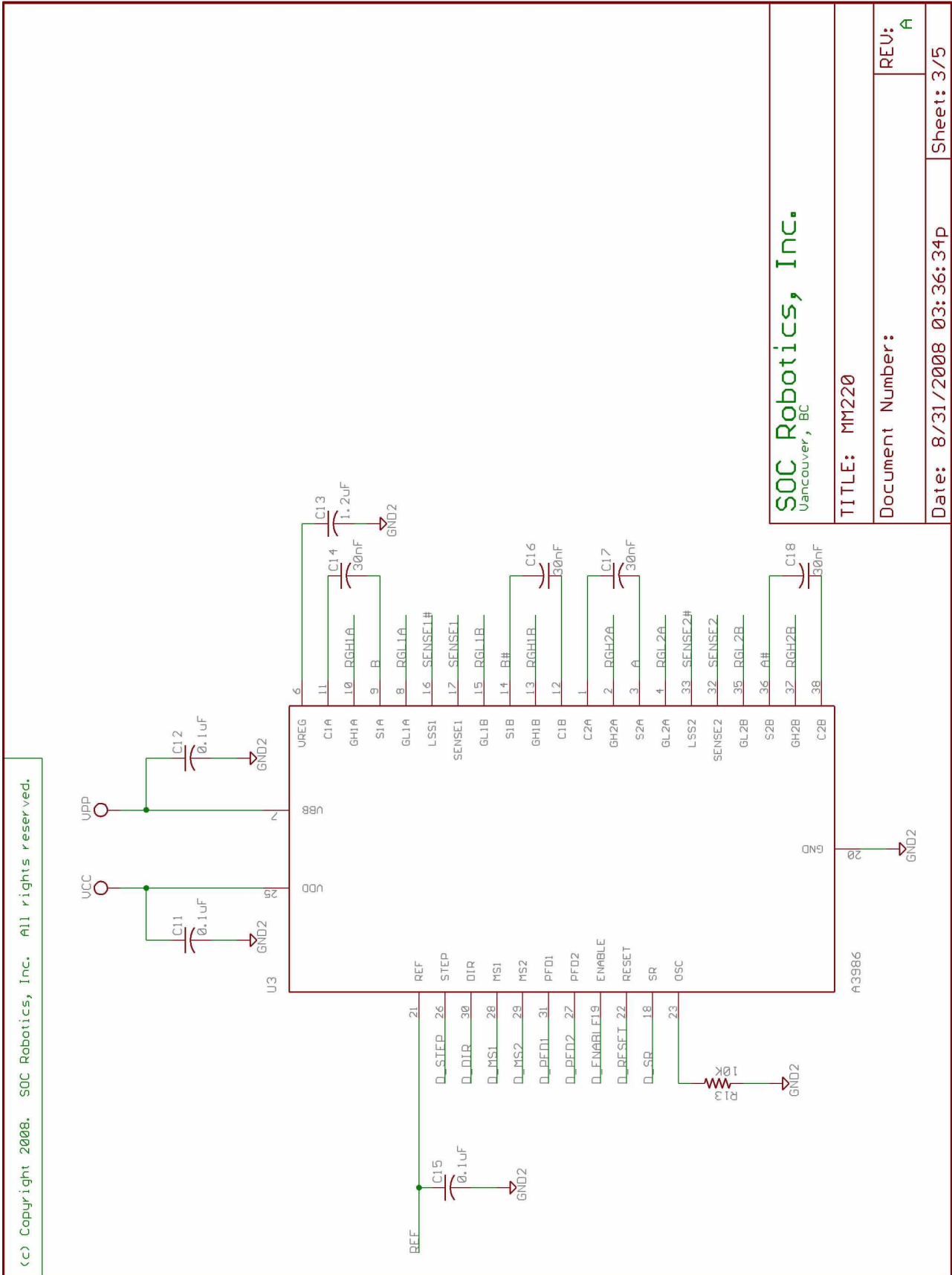


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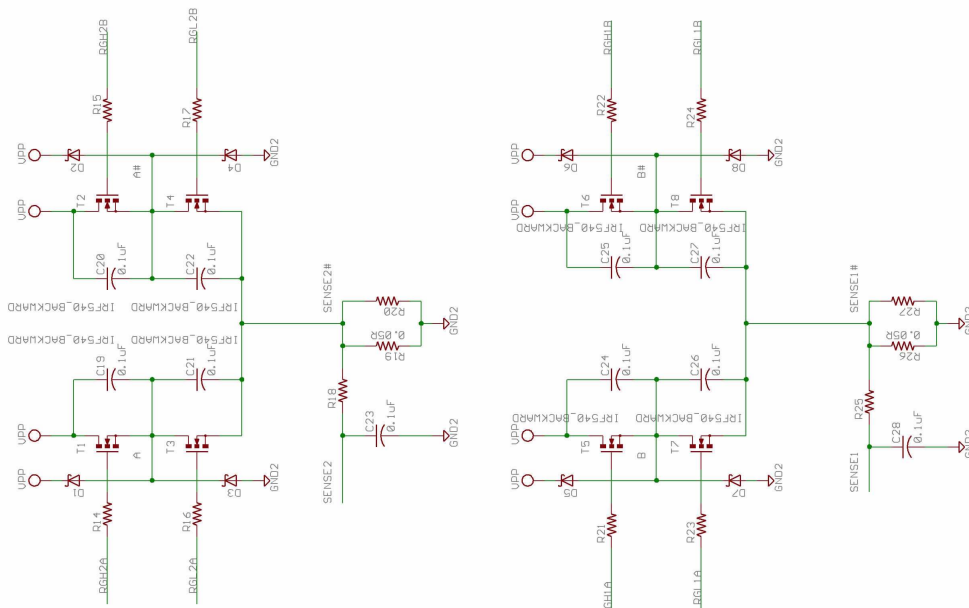
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 REV: A
 Sheet: 2/5



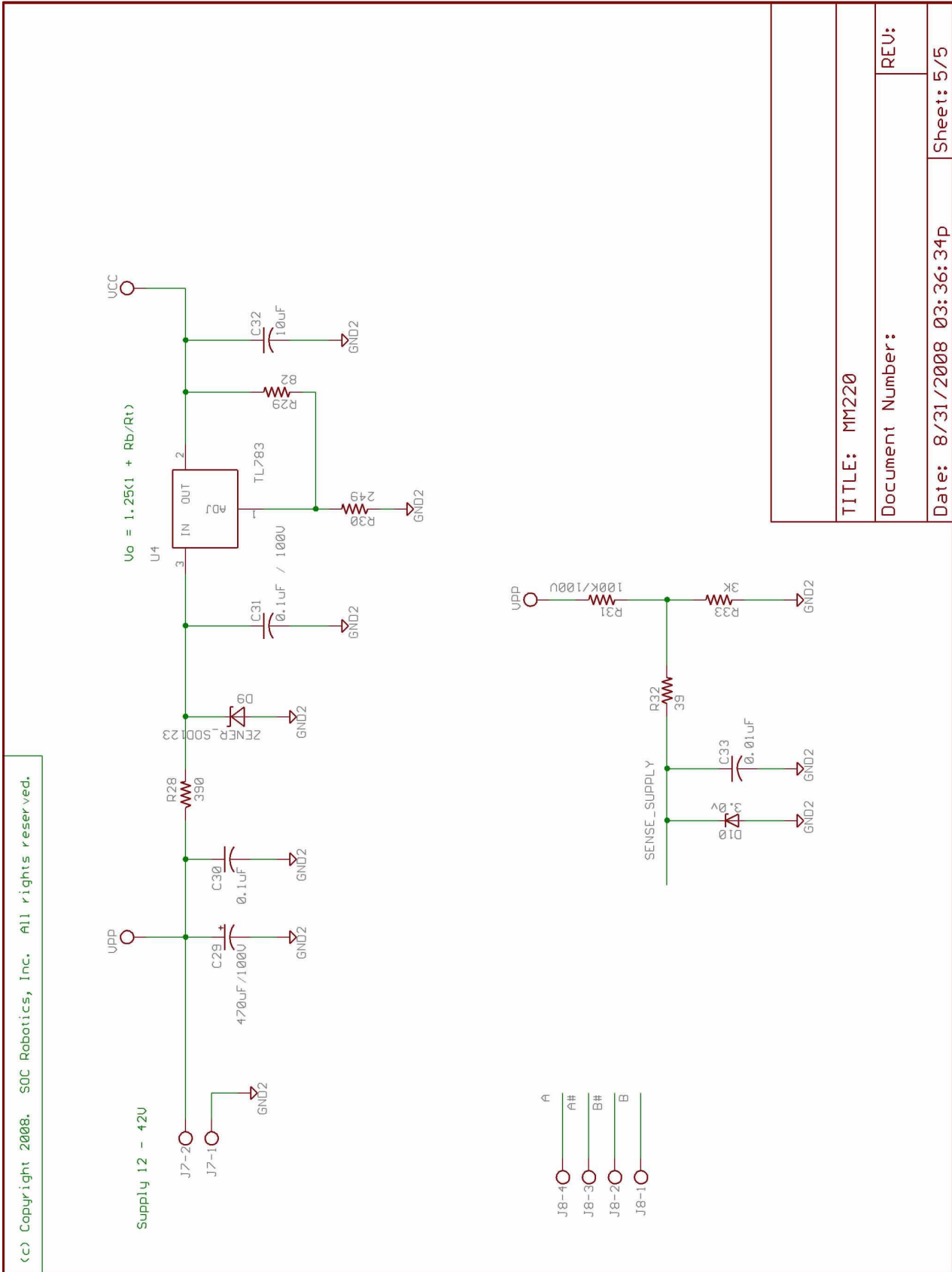
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Notes: