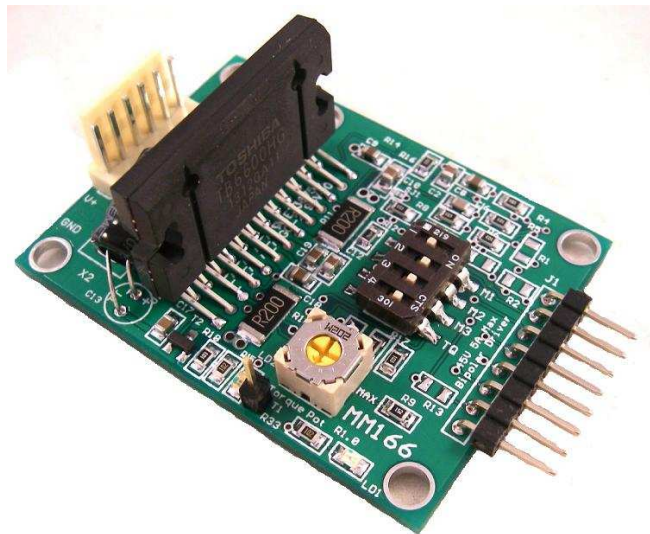S O C
R O B O T I C S

MM166   Single Axis Stepper Motor Driver

1/16th Microstepping 5A/45V Bipolar Driver
Technical Reference Manual
PCB Rev 1.0

www.soc-robotics.inc

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1.0   Introduction

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- Bipolar 5A Stepper Motor Driver
- Maximum motor drive voltage 45V
- Full, half, quarter, eighth and sixteenth micro stepping
- Maximum 5 A per phase
- DIP switch setting for step mode, decay and torque
- Green Power On LED
- Red thermal overload LED
- TB6600 Bipolar Driver chip
- Transient Voltage Suppression Diodes on Motor Signals
- Over temperature and over current protection
- Small form factor (2.10x1.56 in)
- 5VDC @ 12ma Power input for logic
- Motor drive input 10-45VDC at 5A
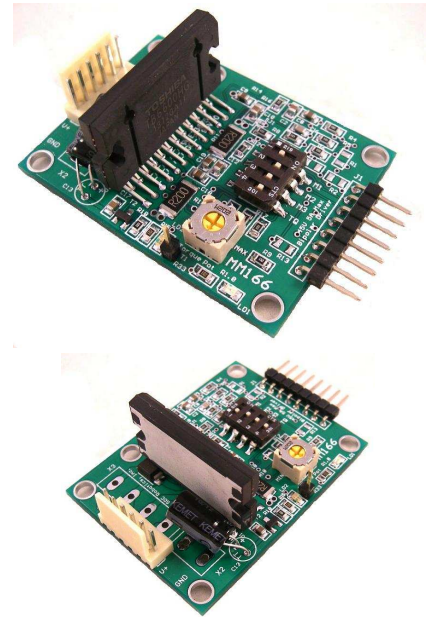
Hardware

The MM166 is a 1/16th micro stepping bipolar 5A per phase stepper motor driver that converts step and direction signals to the appropriate high voltage stepper motor drive signals. The board logic is designed to operate at 5VDC.   Motor voltage can vary from 10-45VDC. A DIP switch sets step mode (full, half, ¼, 1/8th and 1/16th) and torque level (100%, 30%). Optional resistors can be installed that route signals from the logic drive connector to allow step mode and driver chip reset and enable to be controlled by an external controller.

The MM166 consumes about 12ma in active state not including motor drive current.

Stepper Motor Connection

Motor Drive voltage should be between 10-45VDC. Average drive current (torque) is set using a potentiometer. The motor drive chip TB6600 has a 0.4ohm RDSon, which means that the chip requires forced air-cooling under most operating conditions. The diagram below shows a typical stepper motor connection – wire color is representative and may vary for other stepper motors although most coil phase diagrams are similar. It is good practice to insert a fuse between the motor power supply and the MM166. Do not turn motor power on if the logic side of the MM166 is not powered – damage to the TB6600 driver chip may result. If the motor will not turn then check your wiring. Never attach or detach stepper motor wires with power supply power turned on. The MM166 comes with a connector housing and wire pins – be sure to solder the pins after crimping.


MM166 Stepper Motor Wiring
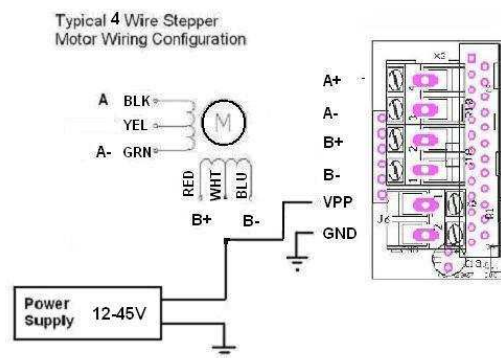
Adjusting Motor Drive Current

The MM166 motor drive current is set by a Potentiometer on the board. Default setting is 2.5A – the mid-range setting. The potentiometer sets current in a linear manner from maximum current (5A) to off (0A). The TQ DIP Switch selects 100% or 30% of the potentiometer current setting.

Adjusting Driver Current

MIN - 0A   MAX - 5A

Turn Potentiometer Counter Clockwise to increase current
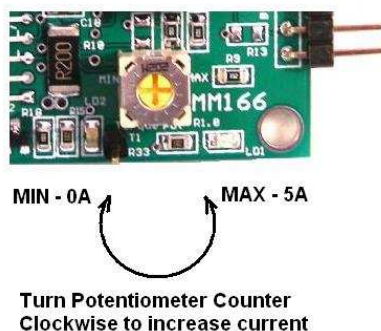
It is possible to set the motor current in such a way that the control chip delivers too much current to the motor resulting in motor overheating. If the motor missteps at high step rates then the motor maybe undersized for your application and can not develop enough torque – in this case use a bigger motor. The stepper motor may also misstep if the rate of change of speed (acceleration) is too high exceeding the motors pull-in/pull-out torque. 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 full step to half step can reduce effective drive torque by 40% so when selecting micro stepping modes remember that effective torque is reduced accordingly and may result in miss stepping.

MM166 Controllers

SOC Robotics has several controllers compatible with the MM166 - USB10M, MK1, MK4, MK5, MK14. Each controller supports increasing levels of sophistication and control flexibility. The MK1 is a simple breakout board that allows three MM166'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. 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.
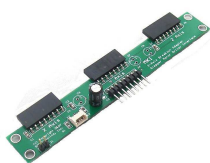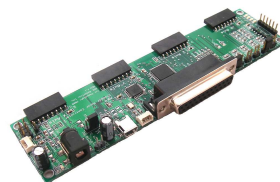
MK1   MK4c + 4 MM166   MK14 USB   MK5 + 5 MM166

Heat Sink Option and Mounting Plate

An optional 4-axis or 5-axis heat sink with integrated fan is available along with a mounting plate that accepts a MK4 and four MM166's or MK5.

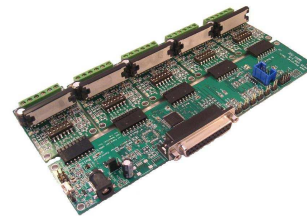## 2.0 MM166 Detailed Description

2.1 Introduction

The MM166 is a compact single axis bipolar 5A/phase stepper motor micro stepping driver with step and direction inputs, DIP switch settable step mode (full, half, quarter, eight and sixteenth) and torque (100%, 30%). The stepper motor driver IC is a TB6600 manufactured by Toshiba. The TB6600 converts step and direction signals to Pulse Width Modulated high voltage drive signals that send the appropriate current to the four coils of a bipolar stepper motor. The TB6600 is capable of driving stepper motors continuously at 4.5A and up to 45VDC.

The MM166 has two I/O ports: a motor control port and motor drive port shown in the connector layout diagram below.   The motor control port accepts step and direction inputs which are routed to the TB6600 driver chip. The motor drive port is connected to the stepper motor coils and motor power. Note that motor power should not be turned on unless logic power (VCC, GND) is also turned on. A Green Power LED and Red Thermal Overload/Over Current LED indicate Power status and thermal shutdown state. Optional resistors connect TB6600 RSTS, ENABLE, M1 and M2 to the motor control port.

Optional 0 ohm resistors R1, R2, R3 and R13 connect port J10 pins to the TB6600 Reset, Enable and M1,M2 signals. Reset when pull low forces the TB6600 micro step state machine to a know state. Enable when pulled low turns all Power MOSFET coils drivers off. M1 and M2 select the micro step mode.
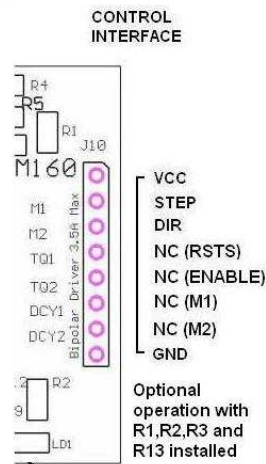

MM166 Connector Pin Assignment
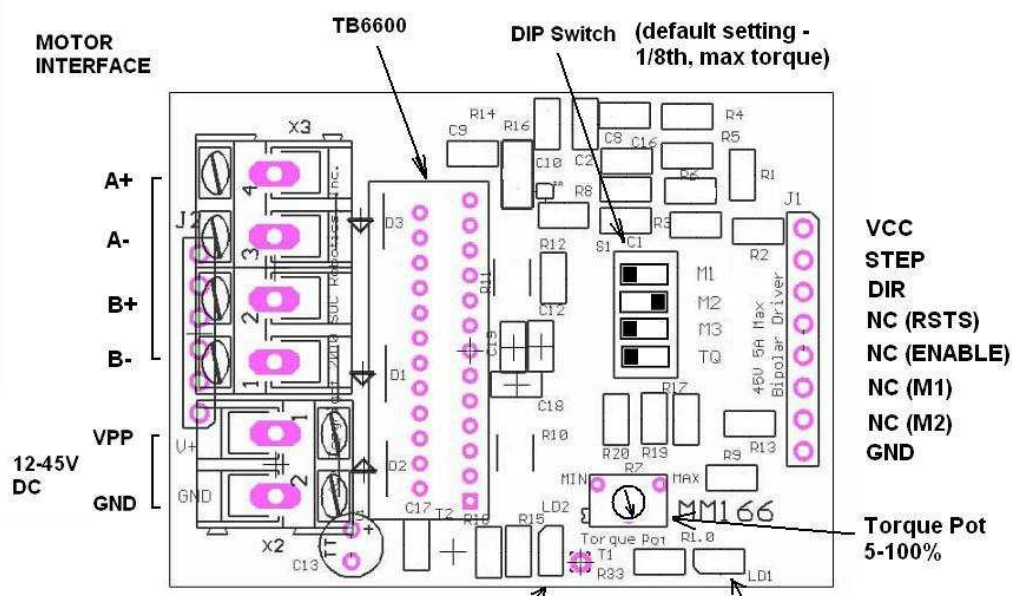
2.2 Motor Control Port

Motor control port is routed to connector J1. Step and direction signals are fed to the board on this port along with main power (5V DC) and ground and optional control signals (see description of optional control signals in section 2.5).

The 5V DC power must be applied to the MM166 before or at the same time that motor power is applied and the ground between the logic and motor ground must be common. If motor power is applied before 5V power the MM166 could be damaged.

A positive going pulse on the Step input activates a step operation. The pulse must remain high for at least 2useconds before going low. Pulse durations less than 2useconds may yield unpredictable results. The direction signal is sampled when the Step pulse goes high so it should be set and stable before activating the step pulse. Direction of rotation depends on how the stepper motor has been wired. The polarity of step and direction is typically set by desktop software.

Figure 2-2. Step/Direction **Control Port Pin Assignment J10.**

2.3 DIP Switch Settings

A DIP switch is used to set step mode (full, half, quarter, eight and sixteenth) and torque (30% or 100%). The diagram below shows the various settings, default setting is eight step and 100% torque. When a DIP switch is set to "ON" the respective signal is pulled to ground. DIP switch changes should be made with power off so the correct selection is active at power up.

The MM166 supports six different step modes set by DIP switch M1, M2 and M3 shown in the diagram above. There are two half step modes: type A and type B. Type A energizes the coils with a 0%, 71%, 100% pattern while Type B supports a 0%, 100% mode. Setting M1, M2 and M3 all ON or all OFF puts the TB6600 into standby mode with the Power MOSFETs off.

The output current is set by a potentiometer from 0-5A. The TQ DIP switch sets 100% or 30% of the potentiometer setting.

2.4 Thermal Considerations

The MM166 uses 0.20 ohm sense resistors – these resistors ensure the maximum current rating of 5A is reached. When using a stepper motor with a lower current rating set the current potentiometer to the correct level for the motor.

At the maximum torque setting 5A a 5A stepper motor will cause the TB6600 to overheat in a few minutes and shut down unless forced air cooling is used. A RED led on the board turns on when the TB6600 enters thermal shutdown which occurs when the die temperature reaches 170deg C +- 20deg C and all outputs shutoff. The RED led goes out once the temperature falls to a safe operating level.

The TB6600 typically runs hot so forced air-cooling is mandatory under most operating conditions. For example, with a 3.0A NEMA23 stepper motor attached to the MM166, no heat sink and no forced air the TB6600 will reach maximum operating temperature and shut down in just over two minutes. A small brushless DC 24V 0.1A 2.5" diameter fan blowing air across the TB6600 keeps the package at a constant operating temperature of 75C which is 60C less than without forced air cooling. Adding a heat sink lowers the operating temperature by another 15C to 60C.

Consult the factory for a recommend heat sink or the obtain specifications on the SOC heat sink kit for the MM166.

2.5 Transient Voltage Suppressor (TVS)

Three bidirectional TVS 600W diodes are installed across A+, A-, B+, B- and VPP, GND. These diodes conduct when the voltage across them exceeds 47 volts and have a turn on time of less the 1 picosecond. They are designed to protect the driver chip from excessive inductive voltage spikes. The TVS diodes used on the MM166 are made by Littlefuse part number P6SMB47CA.

2.6 Optional Resistors

Optional 0R resistors can be installed to map M1,M2, RSTS and Enable signals from the TB6600 driver to connector J10. RSTS is the TB6600 Reset input, ENABLE turns the driver MOSFETS on or off and M1/M2 set step mode. If R3 and R13 are installed then the Step mode DIP switch should be set to 1/16th step mode so the external controller can control these lines.

The MK4c controller allows OUT3 and OUT4 to control RSTS and ENABLE via the host PC.

3.0 Electrical and Mechanical Description

3.1 Component Layout

Components are mounted on the top side of the board. Not all components may be mounted. See the section on optional components for more information.
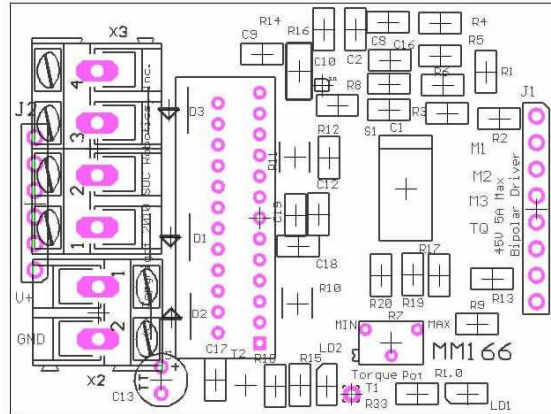
3.2 Electrical Specifications

Electrical

Input power: 5VDC @ 12ma plus 12-45VDC @4.5A

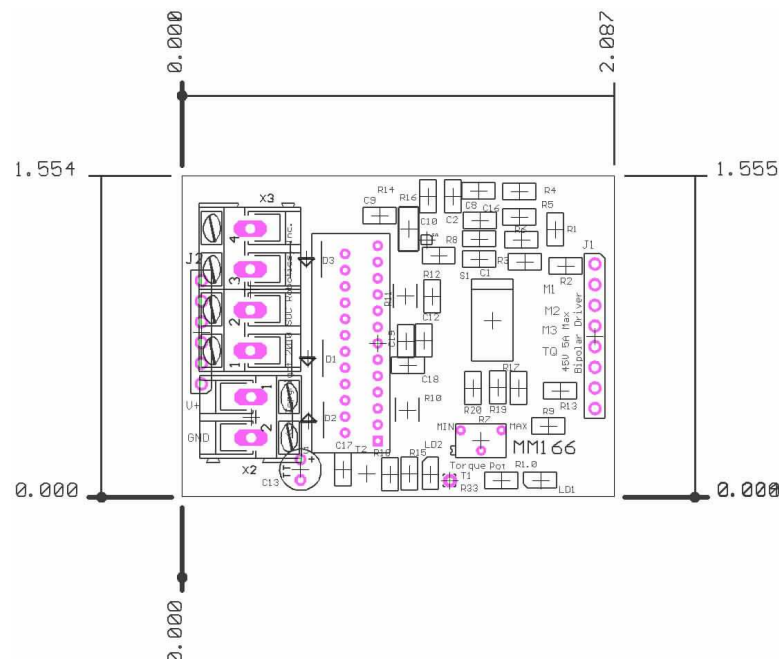### Mechanical
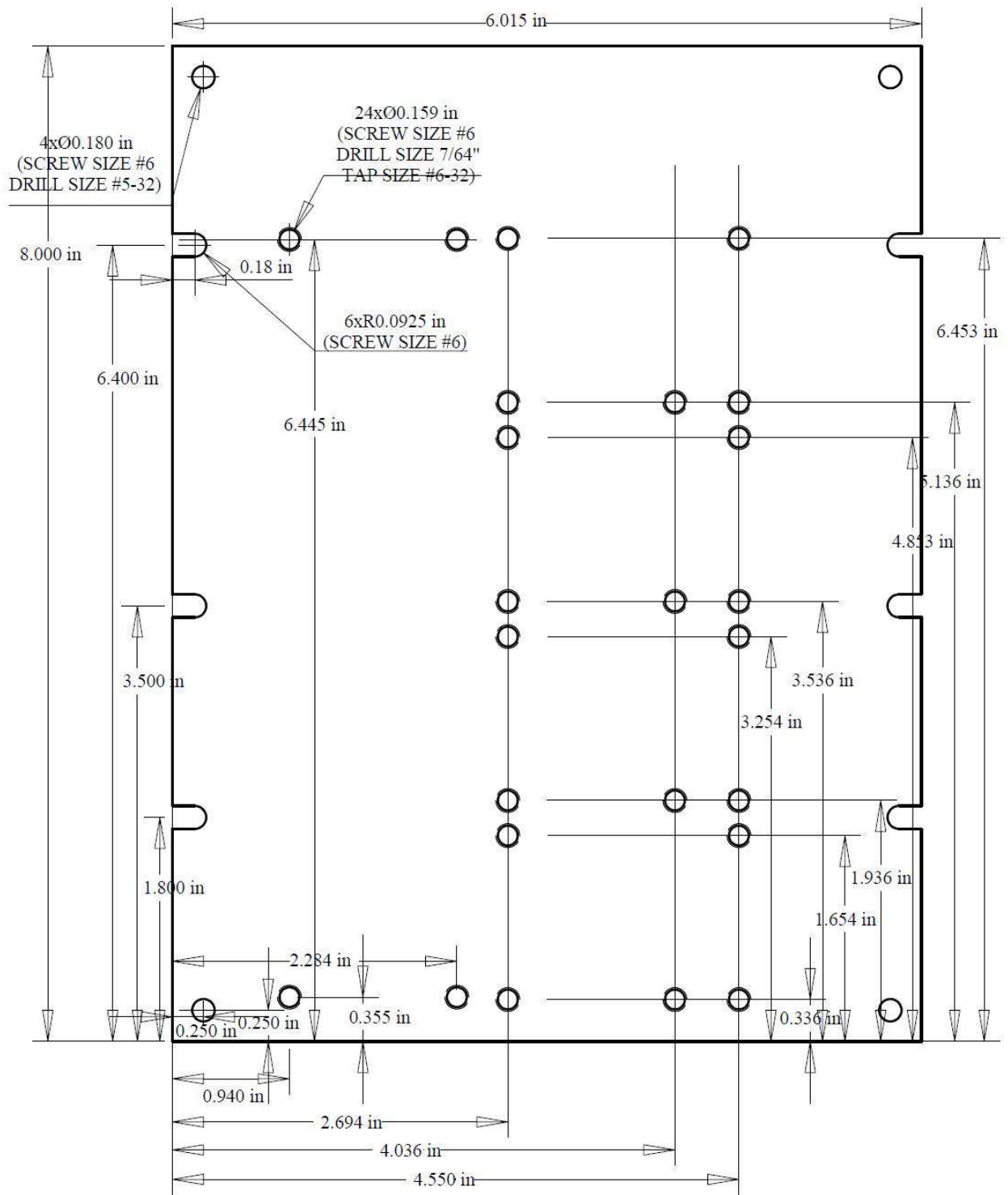
Dimensions: 2.1x1.56 in (one mounting hole)
Weight: 19 grams

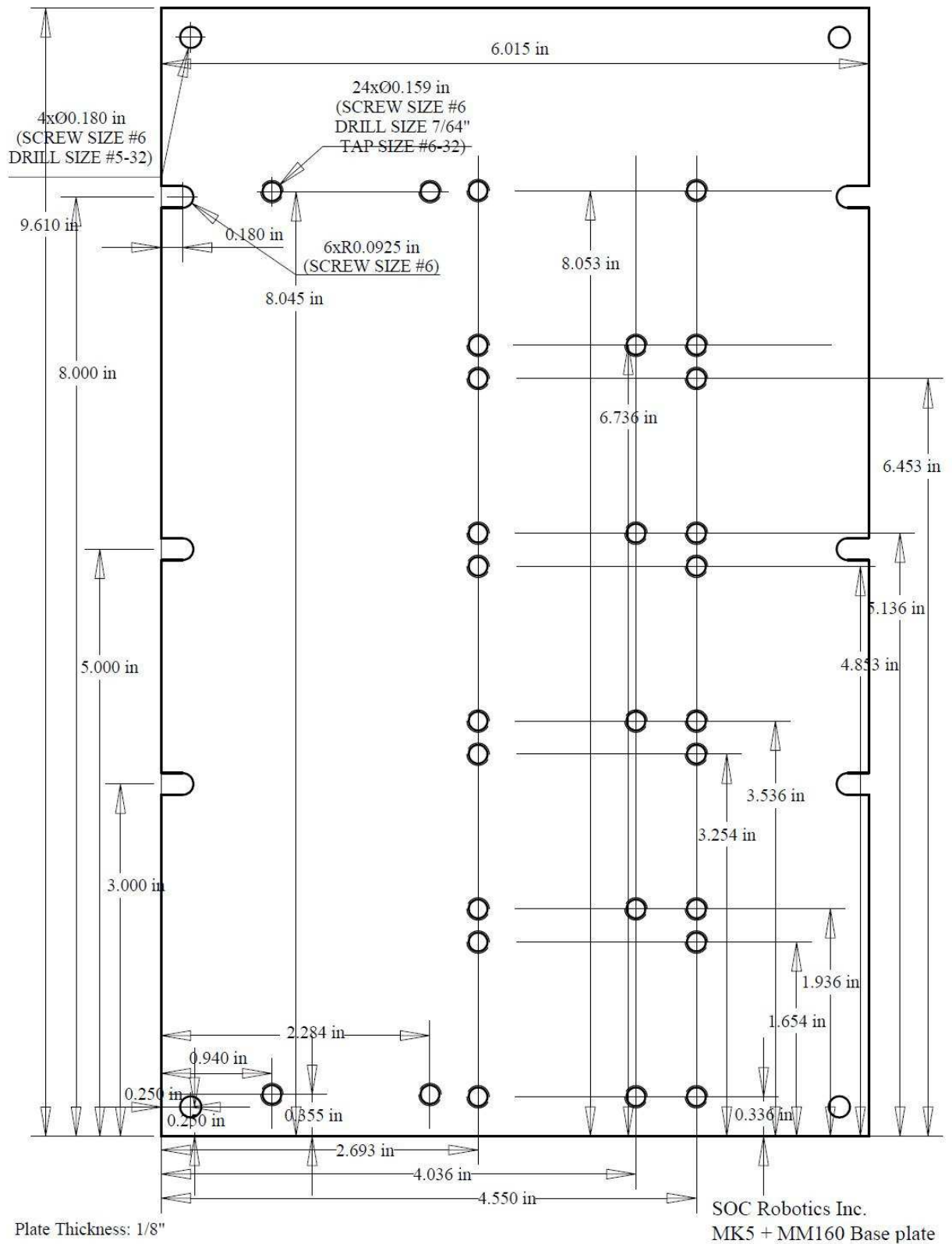## 3.3 Mechanical Dimensions

Board dimensions are stated in inches.

3.4 Mounting Plate for MK4 and MK5 with MM166's (not to scale).

Thickness: 1/8"

SOC Robotics Inc.
MK4 + MM160 Base plate

4xØ0.180 in
(SCREW SIZE #6
DRILL SIZE #5-32)

24xØ0.159 in
(SCREW SIZE #6
DRILL SIZE 7/64"
TAP SIZE #6-32)

6xR0.0925 in
(SCREW SIZE #6)

6.015 in

9.610 in

0.180 in

8.045 in

8.000 in

8.053 in

6.736 in

6.453 in

5.000 in

5.136 in

4.853 in

3.536 in

3.254 in

3.000 in

1.936 in

1.654 in

2.284 in

0.940 in

0.250 in

0.250 in

0.355 in

0.336 in

2.693 in

4.036 in

4.550 in

SOC Robotics Inc.
MK5 + MM160 Base plate

Plate Thickness: 1/8"

4.0 MM166 Circuit Schematics

MM166 1-Axis

Bipolar Stepper Motor Driver 5A

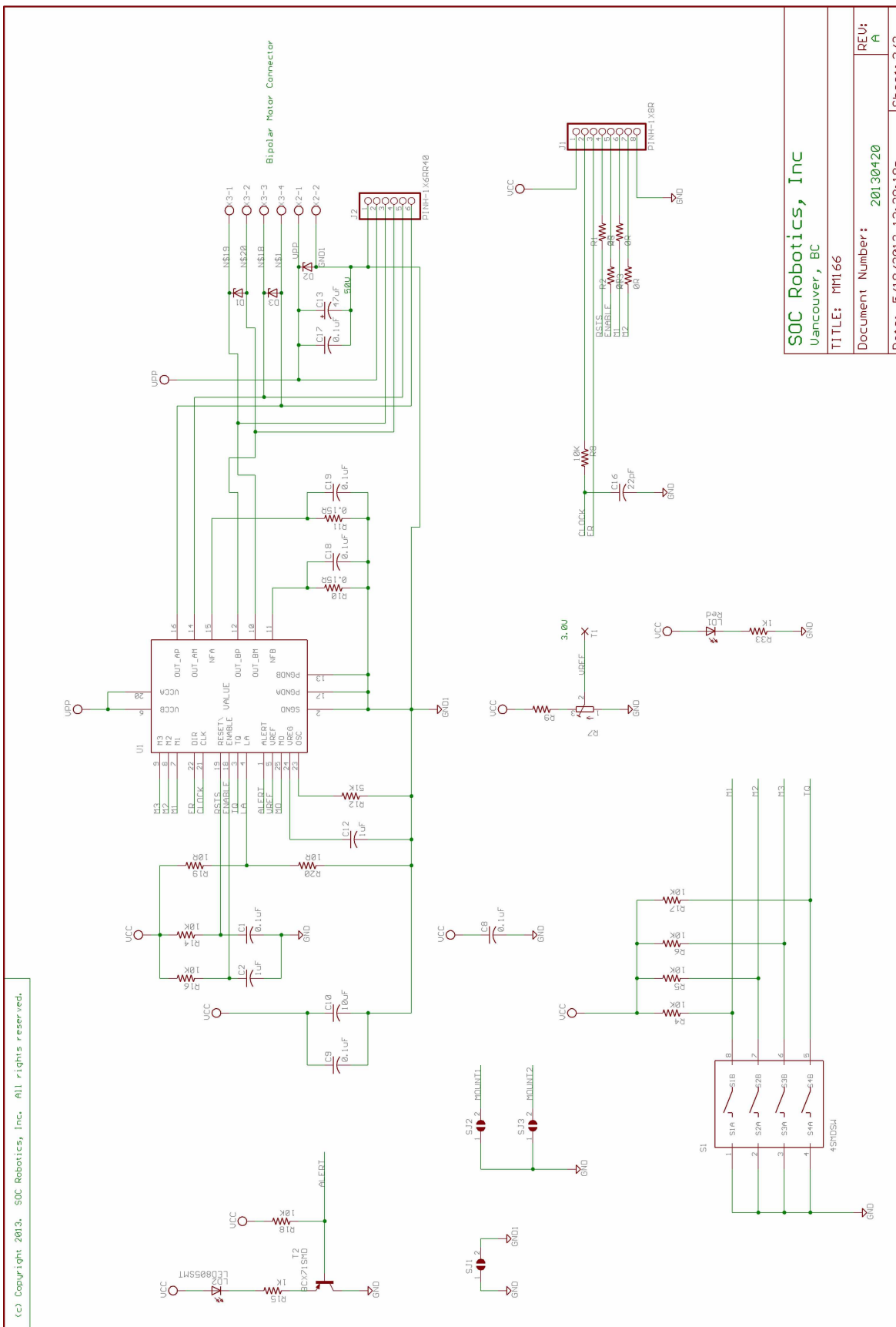PCB Rev 1.0

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Vancouver, BC

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Notes: