Scorbot ER-III

Reference Manual

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github.com/ethanleep/robotic-arm

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Chapter 1

Operating Instructions

Part 1: Warnings and General Information

- If the arm stops moving while under automatic control, unplug the power cord immediately, plug it back in, and move the arm to a safe position using the joysticks before using automatic control again.
- If you send a command to the arm and it does not start moving, it may be jammed and you will need to repeat the above steps.
- While using automatic control, start off with small values such as 50 or 100 to get an idea on how far the arm moves with those values so the arm does not get jammed.
- The joysticks can be used if the arm isn't moving and the position will be tracked so automatic control can be resumed later.
- There are 6 motos total numbered 0 through 5

Part 2: Startup Procedures

- Place the robotic arm on a flat, smooth surface.
- Connect the DB-50 cable from the robotic arm to the port on the side of the control box.
- Plug the AC power cord from the control box into power.
- Wait 5 seconds.
- Try to move the arm using the joysticks.
- If the arm moves then it’s ready for use.
- If the arm doesn’t move then unplug the AC power cord and plug it back in.

Part 3: Manual Movement

- Complete steps in Part 2.
- See Figure 1 for joystick mapping.
- Once you’re done with the arm then unplug the power and unplug the arm from the control box.

Figure 1:
Joysticks are numbered from left to right starting at 0

	Axis 1 Forward	
Rotate clockwise	Joystick 0	Rotate counterclockwise
	Axis 1 Backwards	

	Axis 2 Forward	
Axis 3 Rotate Up	Joystick 1	Axis 3 Rotate Down
	Axis 2 Backwards	

	Claw Close	
Axis 4 Rotate Down	Joystick 2	Axis 4 Rotate Up
	Claw Open	

Part 4: Automatic Movement

- Complete steps in Part 2.
- Plug the USB cable into a computer.
- Open a serial terminal (ex: the Arduino IDE one) and connect to the available serial port at 9600 baud.
- Use commands to move the arm.
- If the arm ever stops responding to commands, unplug the USB cable, plug it back in, restart the serial terminal, and retry commands.
- Once you're done with the arm then unplug the power and unplug the arm from the control box.

Part 5: Available Commands

- For similar info on the arm type **help**

- To find the position of a motor type p<motor number> ex: **p2** to find the position of motor 2
- To send a motor to a position type m<motor number>:<position number> ex: **m2:100** would move motor 2 to position 100
- To home an axis and find its 0 position (**EXPERIMENTAL AND ONLY TO BE USED ON AXIS 0 AND 2**) type h<motor number> ex: **h0** would home axis 0
    - Note: Homing axis 0 will cause it to automatically rotate clockwise so ensure that the limit switch is to the right of the center pole

Chapter 2

Components and Specifications

Part 1: The Arm

A. Motors: There are 6 total motors on the arm numbered 0 through 5. They run at approximately 12 volts and draw around 400mA under normal operation. They have gearboxes with a step down ratio of 127.7 to 1.

B. Encoders: Every motor on the arm has a built in rotary encoder. The encoder outputs two pulses with a 90 degree phase shift relative to the direction of rotation. The pulses are used to determine direction and how far each motor has rotated in order to track the arm's movement. They have built in ultraviolet LEDs that run at 2.3 volts and dual optical gates that, when active, short to ground pulling their pins low thus working in a pull-down condition.

C. Limit Switches: The arm has 5 limit switches that can be used to "home" the arm to a known position. Currently these are only used for axis 0 and 2 but can be expanded to be used later. The limit switches connect to ground when active and thus work in a pull-down configuration.

D. Connector Cable: The arm has one connector cable with a DB-50 connector connected on the end to break out all pins. A pinout table is included below in Figure 2.

Figure 2:

Pin #	Function	Pin #	Function
1	Axis 1 Rotary Encoder Pin 2	25	Claw Rotary Encoder VCC
2	Rotary Axis Rotary Encoder Pin 2	26	Axis 3 Rotary Encoder VCC
3	Axis 4 Rotary	27	Axis 1 Rotary

	Encoder Pin 2		Encoder VCC
4	Axis 2 Rotary Encoder Pin 2	28	Claw Rotary Encoder GND
5	Rotary Axis Rotary Encoder Pin 1	29	Axis 4 Rotary Encoder GND
6	Limit Switch 5	30	Axis 3 Rotary Encoder GND
7	Limit Switch 2	31	Axis 2 Rotary Encoder GND
8	Limit Switch 4	32	Axis 1 Rotary Encoder GND
9	Axis 4 Rotary Encoder VCC	33	Rotary Axis Encoder GND
10	Axis 2 Rotary Encoder VCC	34	Claw Rotary Encoder Pin 2
11	Rotary Axis Rotary Encoder VCC	35	Axis 3 Rotary Encoder Pin 2
12	Axis 5 Motor Pin 1	36	Axis 2 Rotary Encoder Pin 1
13	Axis 4 Motor Pin 1	37	N/A
14	Axis 3 Motor Pin 1	38	N/A
15	Axis 2 Motor Pin 1	39	N/A
16	Axis 1 Motor Pin 1	40	N/A
17	Rotary Axis Motor Pin 1	41	N/A
18	Axis 4 Rotary Encoder Pin 1	42	N/A
19	Claw Rotary Encoder Pin 1	44	N/A
20	Axis 3 Rotary	45	Axis 5 Motor Pin 2

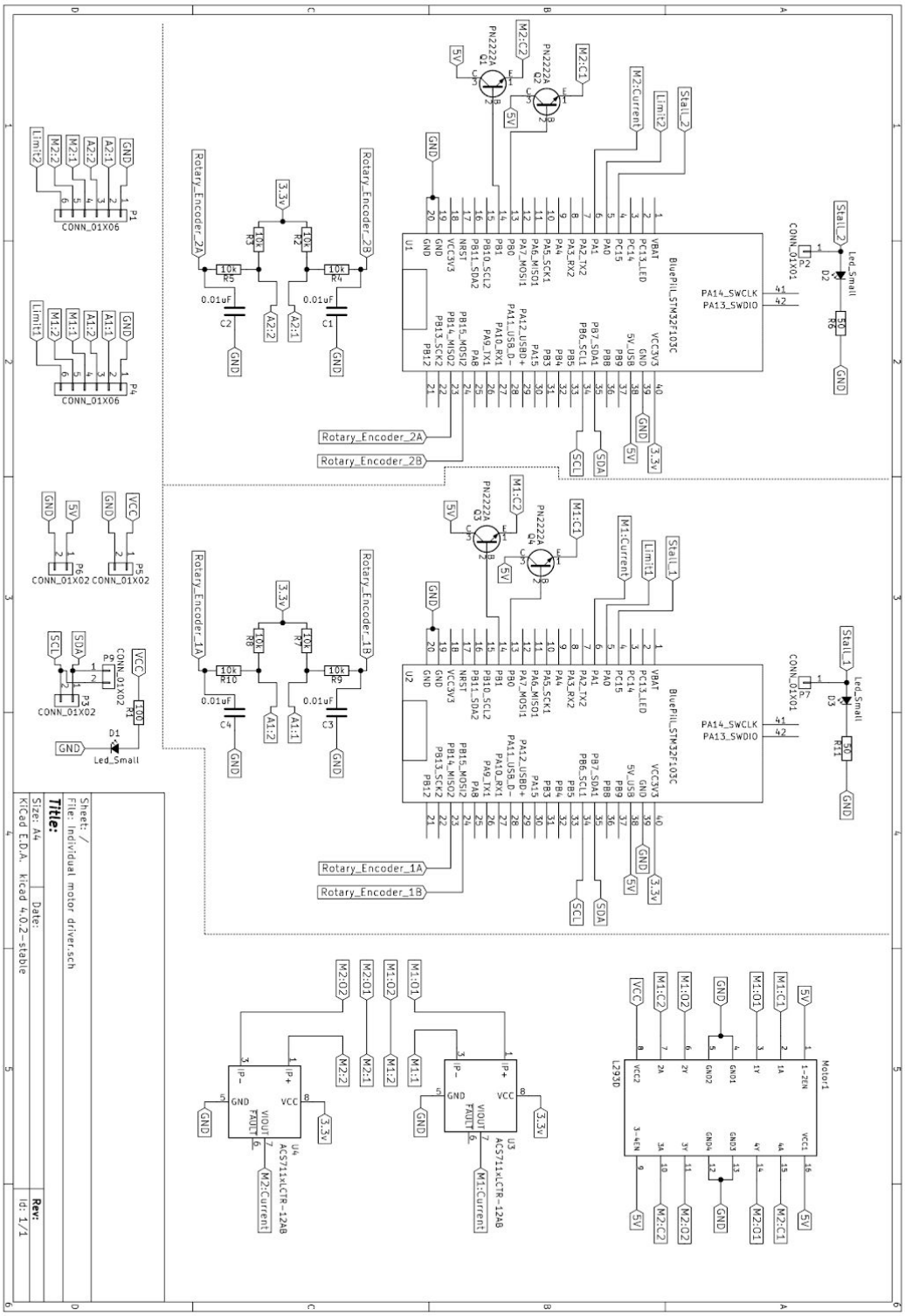
	Encoder Pin 1		
21	Axis 1 Rotary Encoder Pin 1	46	Axis 4 Motor Pin 2
22	N/A	47	Axis 3 Motor Pin 2
23	Limit Switch 1	48	Axis 2 Motor Pin 2
24	Limit Switch 3	49	Axis 1 Motor Pin 2
25	Claw Rotary Encoder VCC	50	Rotary Axis Motor Pin 2

Part 2: The Controller

A. Power Supply: There is a single mains voltage to 14v DC power converter used for the main power supply. That 14v power is fed directly to the motor drivers to drive the motors. The 14v is also fed to a smaller power converter board with two switching buck converters that produce 2.4v DC for the LEDs and 5v for other electronics including microcontrollers and motor drivers.

B. Controller Boards: There are 3 controller boards total. They are each made up of one L239D motor driver IC, two STM32 “Blue Pill” microcontrollers, and filter circuitry for the rotary encoders. Each control board can control two motors with respective encoders. The output pins for the motors are designed to be mated with the DB-50 breakout board which is mentioned in depth in Part D. Each microcontroller controls two control pins on the L239D motor driver to drive the two poles on each motor. The received rotary encoder signals are then fed through a small filter circuit in order to smooth out the signals and any other debouncing of the signals is done in software on the microcontrollers. The control pins of the L239D is also broken out on the final version so the joysticks can directly control the motors. A schematic of the controller board is included

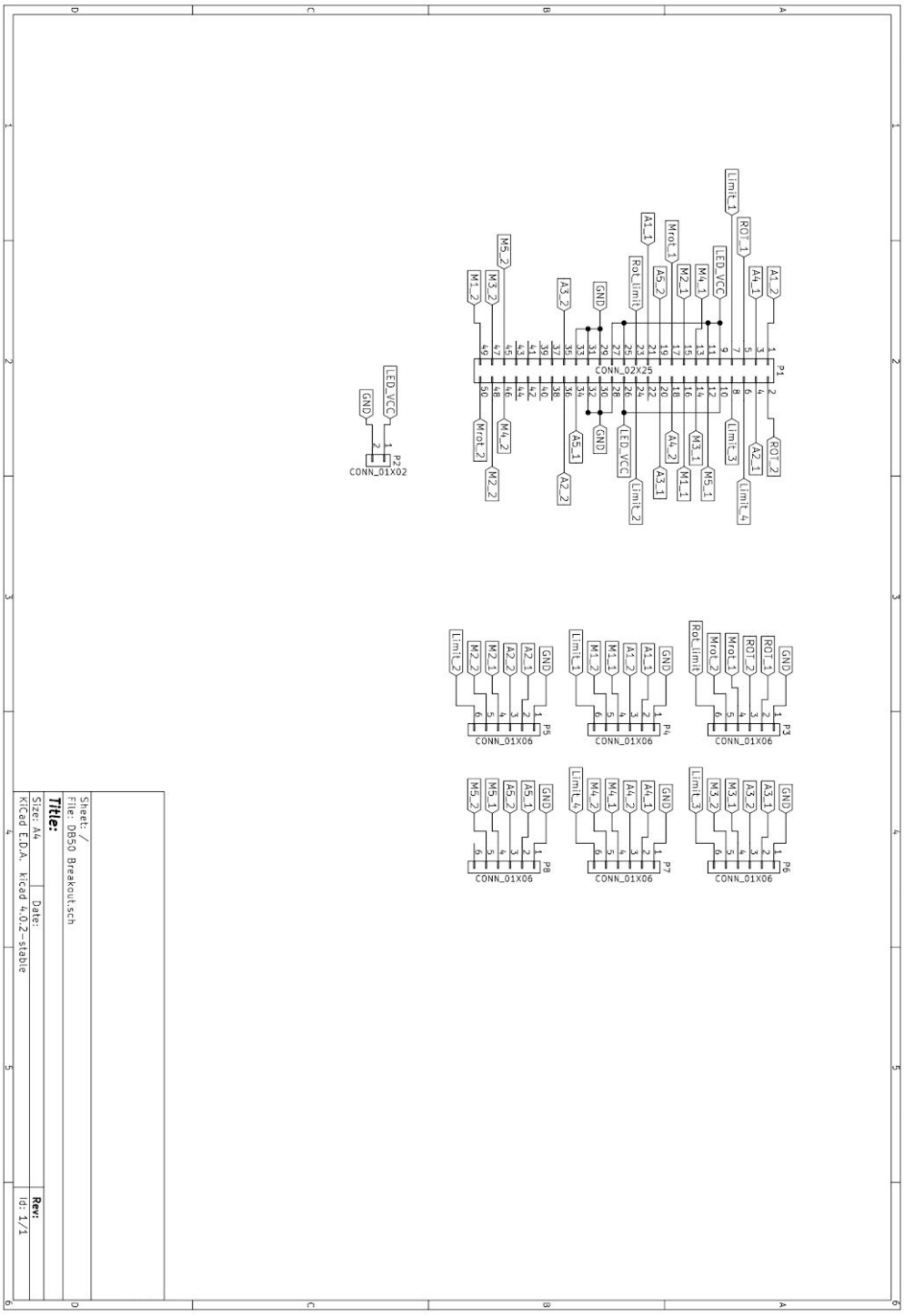
below.


Stall_2
Led_Small
D2
CONN_01X01
P2
50
R8
GND
PA14_SWCLK
PA13_SWDIO
BluePILL_STM32F103C
U1
M2:Current
Limit2
M2:C2
M2:C1
PN2222A
Q1
Q2
5V
3.3v
SCL
SDA
Rotary_Encoder_2A
Rotary_Encoder_2B
10k
R5
R4
R3
R2
0.01uF
C2
C1
A2:1
A2:2
P1
CONN_01X06
Limit2
M2:2
M2:1
A2:2
A2:1
GND
P4
CONN_01X06
Limit1
M1:2
M1:1
A1:2
A1:1
GND
Stall_1
Led_Small
D3
50
R11
M1:Current
Limit1
M1:C2
M1:C1
PN2222A
Q3
Q4
U2
Rotary_Encoder_1A
Rotary_Encoder_1B
10k
R10
R9
R8
R7
0.01uF
C4
C3
A1:2
A1:1
P6
CONN_01X02
P5
CONN_01X02
P9
CONN_01X02
P3
CONN_01X02
VCC
100
R1
D1
Led_Small
Motor1
L293D
1-2EN
1A
1Y
GND1
GND2
2Y
2A
VCC2
3-4EN
3A
3Y
GND3
GND4
4Y
4A
VCC1
M1:C1
M1:C2
M1:O1
M1:O2
M2:C1
M2:C2
M2:O1
M2:O2
M1:1
M1:2
M2:1
M2:2
IP+
IP-
GND
VCC
VIOUT
FAULT
U3
ACS711xLCTR-12AB
U4
Sheet: /
File: individual motor driver.sch
Title:
Size: A4
Date:
KiCad E.D.A. kicad 4.0.2-stable
Rev:
Id: 1/1

C. **PC Communication Board:** The PC communication board is another STM32 “Blue Pill” board that is used as the “master” controller. Using a USB to TTL converter board a computer can connect to the to the arm through USB. The communication board then uses I2C to communicate with all of the controller microcontrollers and to coordinate the movement of the arm. It does not have its own power supply and is only powered when plugged into a computer.

D. **Controller Cable Breakout:** The DB-50 cable, due to its high pin count, is broken out using a special circuit board that breaks out all controls to 6 pin headers specially designed for each controller board. It contains a ground connection, both motor connections, both rotary encoder connections, and a connection to the limit switch for that respective axis. The breakout board also provides power to all rotary encoder LEDs and respective ground connections. A schematic is

included below.



E. Joysticks: The joysticks on the box are simple two axis limit switch based joysticks. When active, they connect their pins to 5V causing the motor driver to activate. The joysticks have one large cable running to the controller cable breakout board where it has a removable connector for easy removal of the top. There is also a power supply line that can be easily disconnected. The controller cable breakout board then breaks out to each controller board to its respective pins in order to ensure that each limit switch on the joysticks control one part of the motor.