Building PiDroidAlpha

PiDroidAlpha Build Manual v0.80

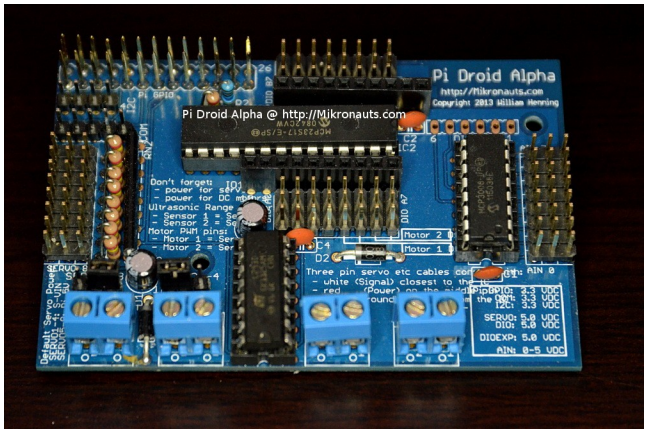


Photo 1: Fully assembled PiDroidAlpha v1.00

The most up to date documentation will always be available at:

http://www.mikronauts.com/raspberry-pi/pi-droid-alpha/

Table of Contents

Introducing PiDroidAlpha

PiDroidAlpha was designed specifically for STEM robotics education and hobbyists at home.

Costs were kept low by

- using the Raspberry Pi software to generate PWM and servo signals
- supplying PiDroidAlpha in kit form

Kits also add the satisfaction of building your own controller, you will have more pride in your robot!

Features

- 8 servo headers for up to eight servos, PWM outputs or digital I/O
- 16 servo compatible headers for 5V digital I/O via MCP23S17
- 8 servo compatible headers for an eight channel 0-5V MCP3008 analog to digital converter
- L293D dual h-bridge motor driver (shares two servo headers and four digital I/O headers)
- screw terminals for servo power, motor power, motor 1 and motor 2
- uses 26 pin stacking GPIO header for compatibility with 26 and 40 pin Raspberry Pi's
- two ten-pin Mikronauts I/O module expansion connectors for the MCP23S17 I/O expander
- 4 pin I2C expansion header for the Raspberry Pi
- 5 pin HCOM connector (optional)
- 6 pin SPI connector for up to seven additional MCP23S17 I/O expanders (optional)
- silk screened "cheat sheet" for voltages and I/O connections on the PCB
- mounting holes matching Rev.2 Model A and Model B
- Mikronauts EZasPi prototyping board can stack below Pi Droid Alpha
- Mikronauts Pi Jumper can stack on top of Pi Droid Alpha
- Mikronauts SchoolBoard][and other Propeller products are compatible with Pi Droid Alpha

Compatibility

Pi Droid Alpha is compatible with the following Raspberry Pi models:

- Raspberry Pi 2 Model B
- Raspberry Pi Model A
- Raspberry Pi Model B
- Raspberry Pi Model A+
- Raspberry Pi Model B+

Pi Droid Alpha is currently supported for Raspbian with the pigpio library.

Pi Droid Alpha should be compatible with any operating system on the above model Raspberry Pi's as long as the pigpio library is available for the users choice of operating system.

Other single board computers that have a 26 pin Raspberry Pi compatible header are electrically compatible with Pi Droid Alpha, however if pigpio and/or servo blaster has not been ported to the other SBC, servo and PWM functionality will not be available.

Parts List

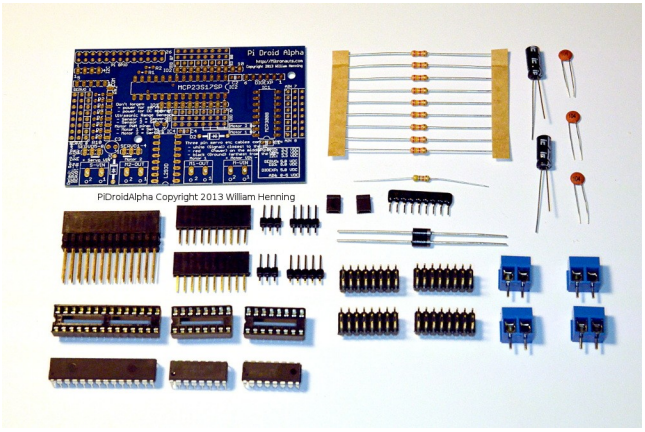
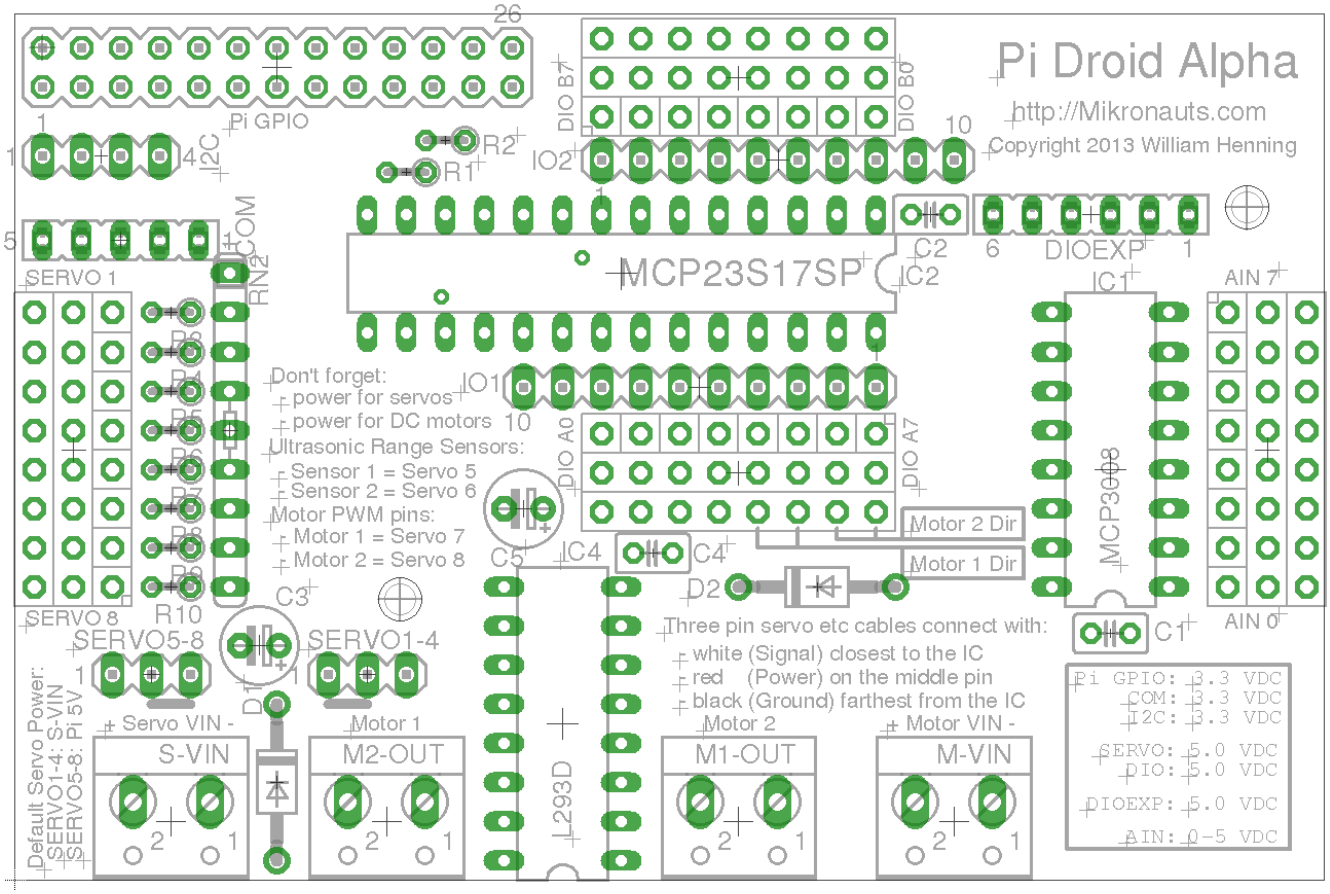


Photo: contents of the Pi Droid Alpha kit

Qty	Item	Name	Digikey p/n	Description
1	PCB		n/a	Pi Droid Alpha printed circuit board
1	L293D	IC4	296-36098-5-ND	Motor driver
1	MCP3008	IC1	MCP3008-I/P-ND	ADC
1	MCP23S17	IC2	MCP23S17-E/SP-ND	Digital I/O expander
4	3x8 servo hdr	SERVO, DIO, AIN	n/a	Servo header
0	1x6M mcp opt	DIOEXP	SAM1035-06-ND	optional digital i/o spi header
0	1x5M com opt	COM	SAM1035-05-ND	optional hcomm header
1	1x4M i2c hdr	I2C	SAM1035-04-ND	i2c expansion header
2	1x3M header	SERVO 1-4, 5-6	AM1035-03-ND	servo voltage selector
2	2pin shunt		3M9580-ND	servo voltage selector
2	10x1F header	IO1, IO2	SAM1122-10-ND	minimod header
2	Dip 16 skt	IC1, IC4	ED3046-5-ND	ic sockets
1	Dip 28 skt	IC2	ED3050-5-ND	ic sockets
3	100nF ceramic	C1, C2, C4	BC1148CT-ND	bypass caps
2	33uF-100uF	C3, C5	P10320-ND	power filter caps
9	2k4 resistor	R1	CF18JT2K40CT-ND	voltage divider resistors
1	4k7 resistor	R2-R10	CF18JT4K70CT-ND	voltage divider resistor
1	8R 9pin 4k7 RN	RN2	4609X-101-472LF-ND	voltage divider resistors
2	RL-205-TP	D1,D2	RL207-TPCT-ND	polarity protection
4	Wago 2scr .2”	SVIN,MVIN,M1,M2	A97996-ND	motor/battery connectors
1	Pi Stacking Hdr	Pi GPIO	n/a	

Printed Circuit Board

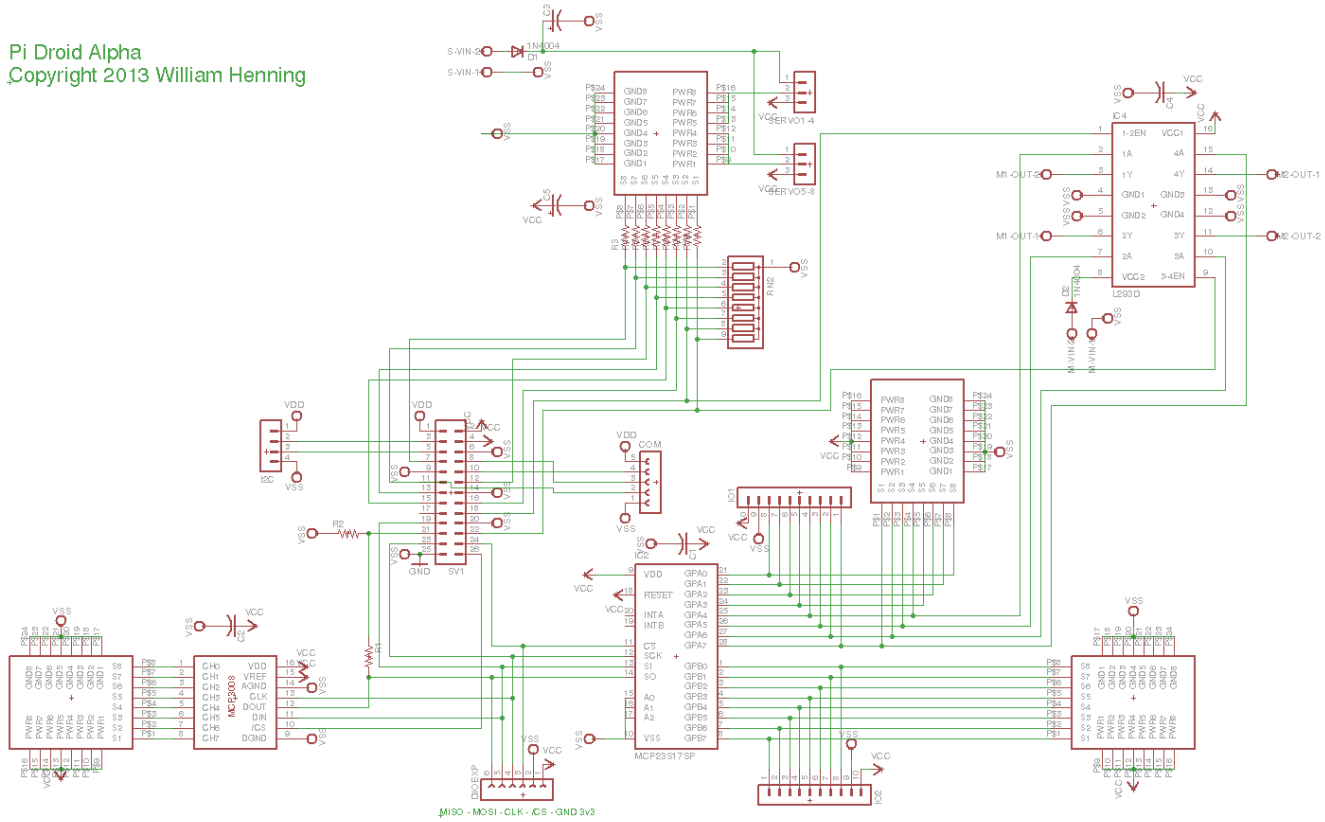


The image above shows the parts layout of Pi Droid Alpha.

You can refer to this image while assembling your Pi Droid Alpha.

Schematics

The schematic below shows you how Pi Droid Alpha works, and if you run into any problems while you build your Pi Droid Alpha, the schematic can be used to find any issues.



General Guidelines

- You should assemble PiDroidAlpha in the order of shortest part to tallest part
- Use a clean soldering iron with a good tip
- after you have assembled the board, make sure that
  - there is no short between 5V and GND
  - there is no short between 3.3V and GND
  - there is no short between 5V and 3.3V

Assembling PiDroidAlpha

In order to help you assemble your Pi Droid Alpha, the photographs in the manual circle the parts that are to be added at each step in red.

Required Tools

- 25W-40W fine tip soldering iron or temperature controlled soldering station
- solder sucker
- de-soldering braid
- wire snippers
- phillips screw driver
- pliers
- multi-meter

How to Solder

CuriousInventor has a great video on YouTube that will teach you to solder:

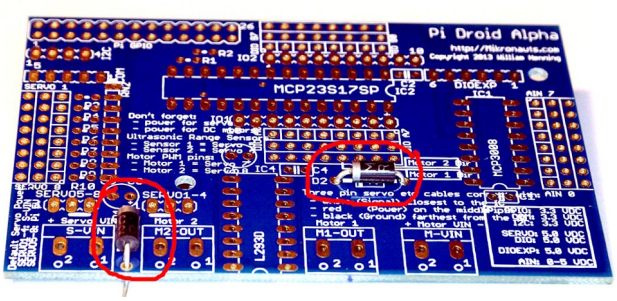
How to Solder Electronics @ https://www.youtube.com/watch?v=IpkkfK937mU

How to de-solder (and fix mistakes)

CuriousInventor also has a great video on YouTube that will teach you to de-solder:

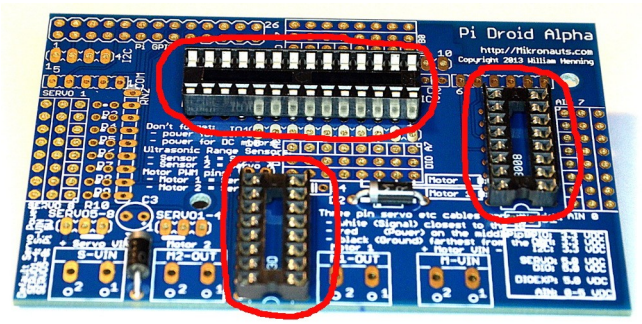
How to Desolder Through-Hole Parts @ https://www.youtube.com/watch?v=Z38WsZFmq8E

RL-205-TP diode (D1, D2)



The two diodes provide protection against connecting servo and motor power incorrectly.

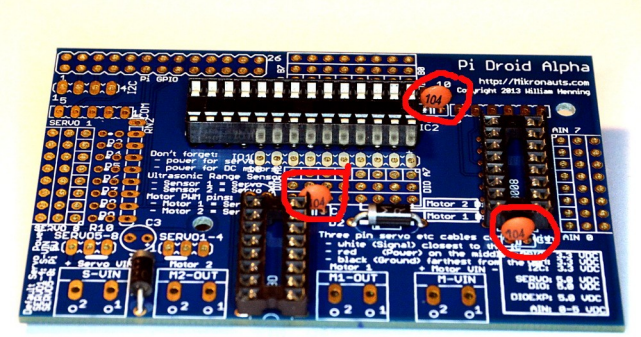
16 pin and 28 pin IC sockets (IC1, IC2, IC4)



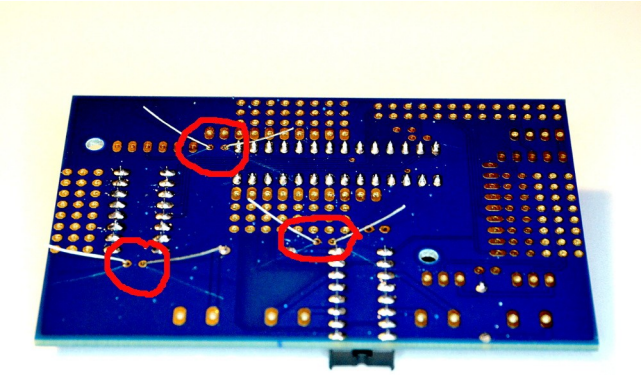
The dip sockets for the integrated circuits are the lowest profile parts after the diodes.

DIP stands for “Dual In-line Package”

100nF ceramic capacitors (C1, C2, C4)

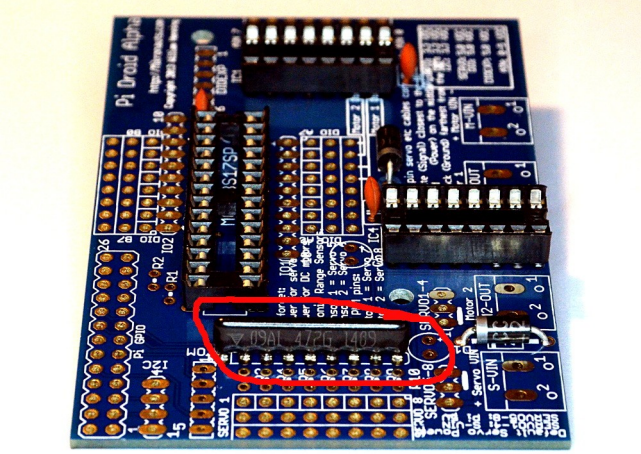


The three decoupling capacitors are installed next.



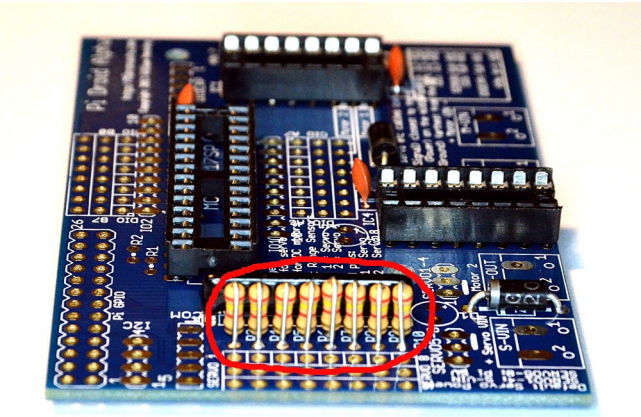
These capacitors filter noise from the power supply right at the integrated circuits.

9 pin 4k7 SIP resistor network (RN2)



This resistor network has a common ground connection, and is part of the voltage divider used to convert 5V input signals to 3.3V, which is the maximum safe input voltage for Raspberry Pi pins.

8 4k7 resistors (R3 - R10)



These resistors form the other half of the voltage divider for every pin.

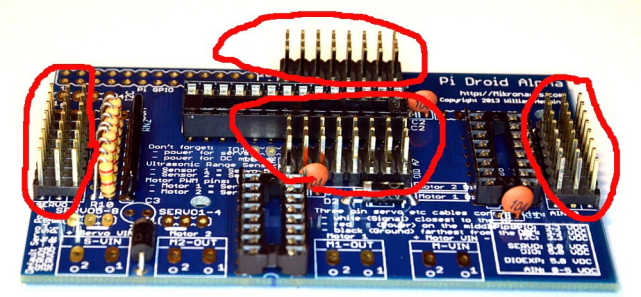
For more information on voltage dividers, please see

https://en.wikipedia.org/wiki/Voltage_divider

and you can find a handy voltage divider calculator at

http://www.raltron.com/cust/tools/voltage_divider.asp

3x8 servo headers (SERVO, DIO A, DIO B, AIN)



The servo headers are used to connect standard servos, and other 5V input and output signals.

- SERVO1-SERVO8 are connected to Raspberry Pi pins through a voltage divider
- DIO A0-A7 and DIO B0-B7 are connected to the MCP23S17 I/O expander pins.
- AIN 0-7 are connected to the MCP3008 analog to digital converter.

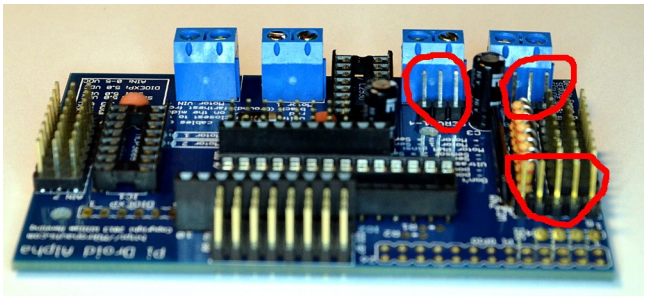
1x6M Optional DIO Expansion header (DIOEXP)

If you need more digital I/O, you can use this optional header to connect up to seven more MCP23S17 I/O expanders.

1x5M HCOM header (COM)

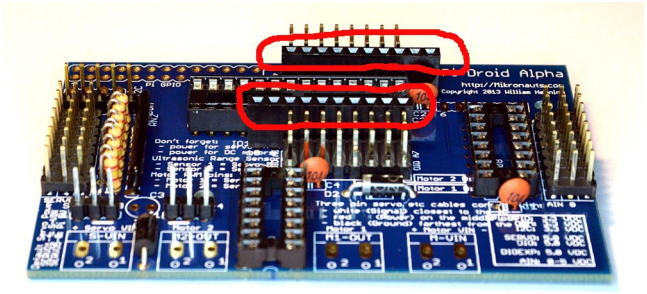
You can use this connector to connect a RS232 or RS485 level translator – this connector is the blurry 5 pin connector towards the bottom of the photo below.

1x3M Voltage selection headers (SERVO1-4, SERVO5-8)



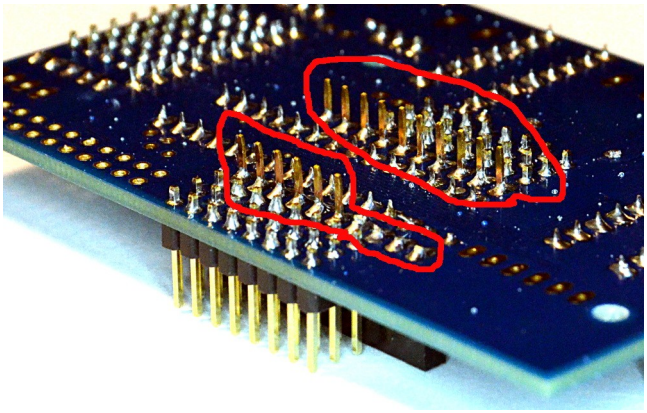
The two 3 pin power selection jumpers towards the top of the photo that allow you to select the power source for four servo connectors each. Use the external servo selection for powering servos.

10x1F Expansion headers (IO1, IO2)



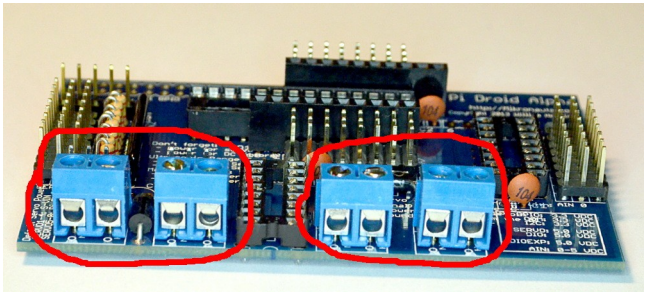
The 10 pin female expansion headers are a handy way of connecting:

- a breadboard using Dupont female-to-male jumper wires
- future Mikronauts 10 pin modules



As you can see the 10 pin headers have long pins, and you need to trim them to be the same height as the other pins next to them – otherwise you may short out some signals if the long pins touch metal below them.

Wago Screw Terminals (Servo VIN, Motor VIN, Motor 1, Motor 2)



There are four screw terminals on Pi Droid Alpha.

From left to right:

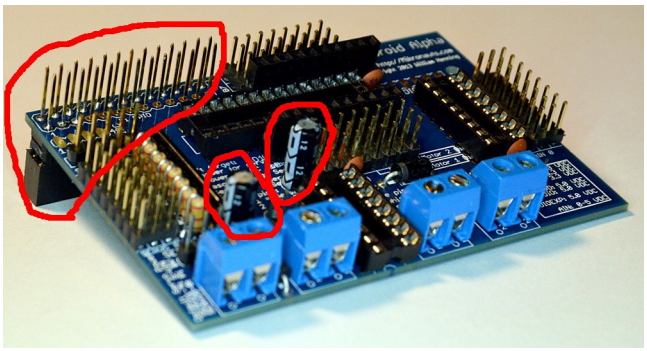
- Servo VIN – external power for servo motors
- Motor 2 – connector for motor 2 of the L293D dual h-bridge motor driver
- Motor 1 – connector for motor 1 of the L293D dual h-bridge motor driver
- Motor VIN – external power for the motors connected to Motor 1 & Motor 2

Please note that Servo VIN and Motor VIN have protection diodes in case you accidentally connect the batteries in reverse.

- Servo VIN should not exceed the maximum voltage for the servos you are using by more than 0.7V, for example 6.7V is the maximum Servo VIN if all your servos support 6V
- Motor VIN should not exceed the maximum voltage for the gear motors you are using > 1.4V, so for example if your motors maximum voltage is 6V, do not exceed more than 7.4V

100uF Electrolytic capacitors (C3, C5)

2x13 stacking Raspberry Pi header

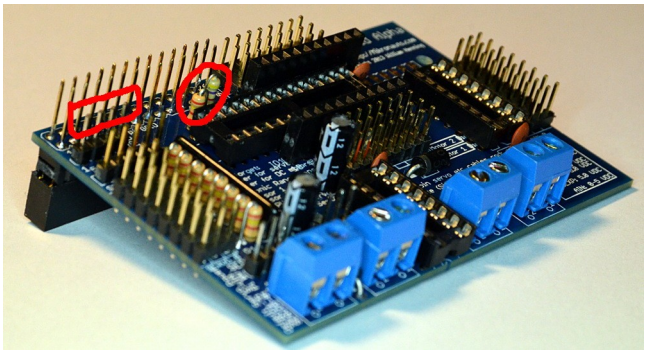


Install the capacitors before installing the header.

Please make sure that the Raspberry Pi header is seated fully, and is at a right angle to the Pi Droid Alpha printed circuit board – otherwise there will be problems mounting the board on a Pi.

2k4 (R1) and 4k7 resistors (R2)

1x4M I2C header (I2C)

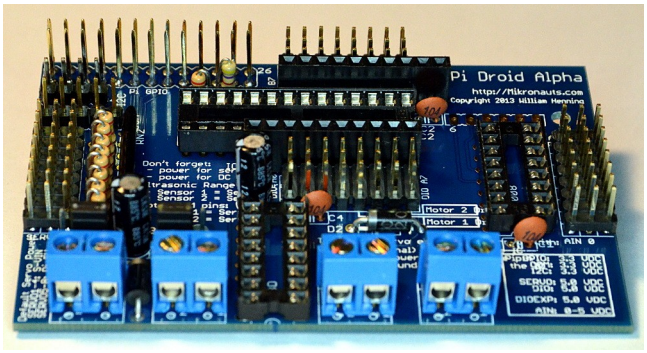


The I2C header is for future expansion modules for your robot such as compass modules.

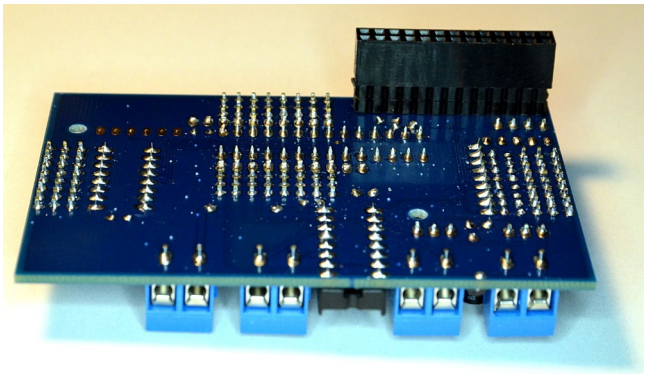
R1 and R2 form a voltage divider so that the 5V MISO signal from the digital I/O expander and the analog to digital converter is divided down to 3.3V in order not to harm the Raspberry Pi.

Completed Printed Circuit Board

Here is what the top of the completed circuit board looks like:



And here is the bottom showing all the soldering (and trimmed leads of the 10 pin connectors)



You can clean the solder flux off the back of the printed circuit board using a new toothbrush and pure isopropyl alcohol (often sold at drug stores as rubbing alcohol).

Make sure the printed circuit board is totally dry before testing it.

Testing PiDroidAlpha

Before trying to install the integrated circuits, you have to test to make sure there are no shorts on the board.

DO NOT SKIP THESE TESTS!

• test for short between 5V and GND on Pi header

• test for short between 3v3 and GND on Pi header

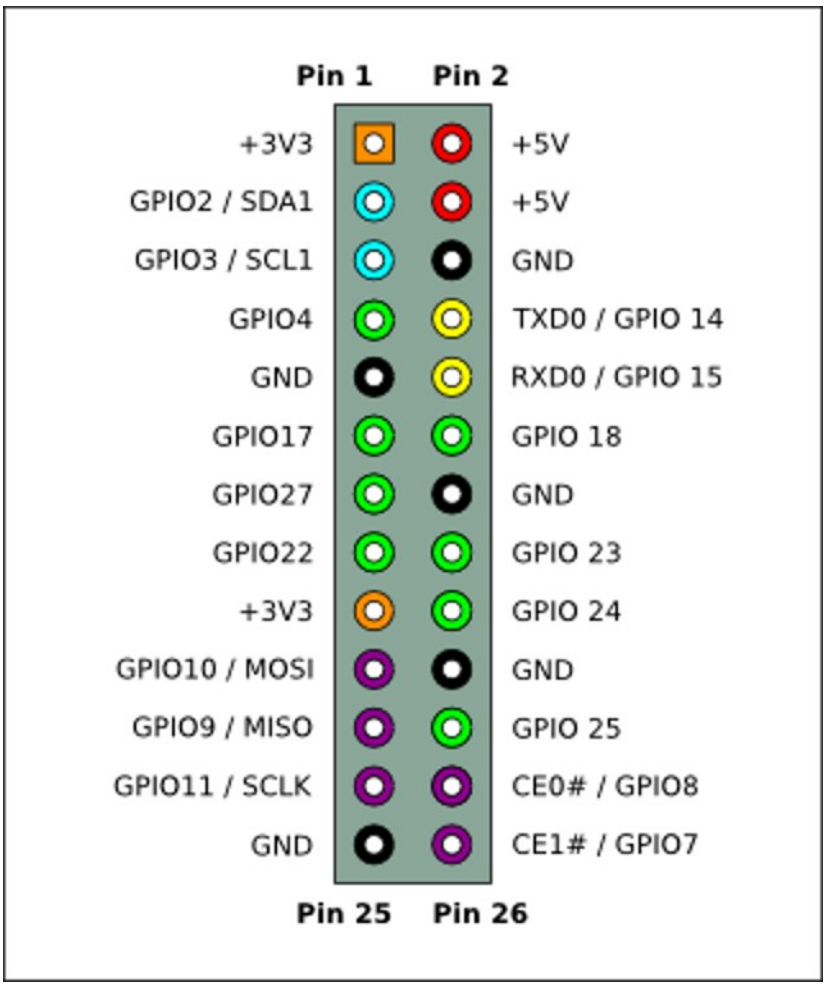
• test for short between 3v3 and 5V on Pi header

If you find a short, you have to find and fix the problem before proceeding, otherwise you may damage your Raspberry Pi.

Don't worry about if you read a high resistance (caused capacitors) but anything less than 4k ohms may indicate a problem.

GPIO pinout

26 pin Raspberry Pi GPIO connector: (first 26 pins are the same on the 40 pin GPIO connector)



(image courtesy of elinux.org)

You can find this, and many other nice diagrams at:

http://elinux.org/RPi_Low-level_peripherals

https://www.raspberrypi.org/documentation/usage/gpio/

IMPORTANT

- DO NOT install the integrated circuits until you have tested for shorts as per previous page
- Ground yourself before touching the integrated circuits as static electricity can destroy ic's
- make sure you install the integrated circuits facing the correct direction

Adding the MCP3008 Analog to Digital Converter (IC1)

Carefully insert the MCP3008 integrated circuit in the IC1 socket.

Make sure that pin 1 (indicated by a dot, and a half moon shape on the ic) faces in the same direction as the half-moon on the printed circuit board (towards the Wago screw terminals)

Adding the MCP23S17 Digital I/O Expander (IC2)

Carefully insert the MCP23S17 integrated circuit in the IC2 socket.

Make sure that pin 1 (indicated by a dot, and a half moon shape on the ic) faces in the same direction as “Pi Droid Alpha” text on the printed circuit board.

Adding the L293D Motor Driver (IC4)

Carefully insert the L293D integrated circuit in the IC4 socket.

Make sure that pin 1 (indicated by a dot, and a half moon shape on the ic) faces in the same direction as the half-moon on the printed circuit board (towards the Wago screw terminals)

Choosing Servo power source with shunts

SERVO1-4 & SERVO5-8

Do not try to run the motors from the Pi's 5V supply!

Programming PiDroidAlpha

Please see the PiDroidAlpha User Manual for more detailed information on programming your PiDroidAlpha based robot.

PiDroidAlpha I/O pin definitions

PCB	Pi GPIO	Shared with
Servo 1	GPIO4	
Servo 2	GPIO17	HCOM
Servo 3	GPIO18	
Servo 4	GPIO27	
Servo 5	GPIO22	
Servo 6	GPIO23	
Servo 7	GPIO24	Motor1PWM
Servo 8	GPIO25	Motor2PWM

The L293D motor driver uses Servo 7 & 8 and DIO B4-B7

If you use HCOM, Servo 2 is not available.

AIN0 – AIN7 are not shared and are fully available for use as 5V analog inputs

DIO Header A pins (DIO A0 – DIO A7) are not shared and fully available for 5V I/O

DIO Header B pins (DIO B0 – DIO B3) are not shared and fully available for 5V I/O

DIO Header B pins (DIO B4 – DIO B7) are shared with motor 1 and 2 direction pins as follows

Header	Shared with
DIO B4	Motor1DirA
DIO B5	Motor1DirB
DIO B6	Motor2DirA
DIO B7	Motor2DirB

Raspbian

Please download the latest version of Raspbian from http://www.raspberrypi.org/downloads/

Then follow the instructions you can find at the link below to install Raspbian.

https://www.raspberrypi.org/documentation/installation/installing-images/README.md

After you have installed Raspbian, please type the following into a terminal session:

sudo raspi-config

From the 'advanced menu', please enable SPI and I2C, and then choose

'expand filesystem', finish and re-boot.

pigpio

Please follow the instructions at the link below to install pigpio

http://abyz.co.uk/rpi/pigpio/download.html

The PiDroidAlpha demos require that pigpio is installed on your Raspberry Pi.

ServoBlaster

ServoBlaster is an alternate way of driving servos with PiDroidAlpha

http://www.novitiate.co.uk/?p=72

Please note that while ServoBlaster will work, we suggest you use **pigpio** instead.

wiringPi

You can also use WiringPi with PiDroidAlpha, follow the instructions at the link below

https://projects.drogon.net/raspberry-pi/wiringpi/download-and-install/

Note: You will also need ServoBlaster, as wiringPi does not provide precise servo control

Scratch

We plan on supporting Scratch at a later date. For now, see

https://scratch.mit.edu/discuss/topic/34754/

Appendix A: Data Sheets

MCP3008 Analog to Digital converter

http://ww1.microchip.com/downloads/en/DeviceDoc/21295C.pdf

MCP23S17 Digital I/O expander

http://ww1.microchip.com/downloads/en/DeviceDoc/21952b.pdf

L293D motor driver

http://www.st.com/st-web-ui/static/active/en/resource/technical/document/datasheet/CD00000059.pdf

Appendix B: Support

Please visit our forums at:

http://forums.mikronauts.com

Once you register there, you can get support for Pi Droid Alpha in its support forum

Appendix C: Frequently Asked Questions

Q: Where can we buy PiDroidAlpha?

A: Currently you can buy PiDroidAlpha:

Directly from us – please email us at mikronauts@gmail.com with desired quantity and postal address, we will be happy to send you a quote. We accept PayPal from verified buyers.

From our Ebay store – please visit us at out Mikronauts Ebay store!

<add actual URL>

Distributors and dealers are welcome to contact us for quantity discounts – we would love to have you on-board!

Q: Are quantity and educational discounts available for PiDroidAlpha?

A: Yes! We are happy to offer quantity based discounts to our educational users and distributors.

Please contact us for a custom quote.

Q: Can we make our own PiDroidAlpha printed circuit boards?

A: I am afraid not. While PiDroidAlpha is an open platform in that it is fully documented, with source code

available for its libraries and demo applications, PiDroidAlpha is a commercial product, and may not becopied.

Q: Can we use the MCP3208 12 bit analog to digital converter instead of the MCP3008?

A: Yes, you can – but the driver needs to be modified, and the PiDroidAlpha libraries and demo programs assume that an MCP3008 is used.

Q: Do you have any distributors in <name of country>?

A: We are working hard to set up our distribution network. Please email your favorite web stores and have them contact us if they are interested in PiDroidAlpha.