

ET-19

ROBOT

ARM/MOTOR

TESTER

(H2KTST)

HERO 2000 ROBOT
&
ROBOT ARM TRAINER BASE
Arm/Motor Tester
(H2KTST)



By Robert L. Doerr

<http://www.robotworkshop.com>

© 2004

Manual Revision 1.2

NOTE: This diagnostic tool has been tested with several HERO 2000 robots and robot arms with excellent results. Although every effort has been made to ensure the compatibility with the widest range of devices (and the accuracy of the documentation) there are no guarantees expressed or implied that it will work under all circumstances.

Table of contents

INTRODUCTION	3
CIRCUIT ASSEMBLY	3
OPERATION	7
SPECIFICATIONS	7
CABLE PINOUT MATRIX	8
MOVEMENT MATRIX	9
ENCODER/LIMIT SWITCH MATRIX	9
IN CASE OF DIFFICULTY	9
CIRCUIT DESCRIPTION	10
SCHEMATIC DIAGRAM	10
REPLACEMENT PARTS LIST	11
SPECIAL THANKS.....	11

HERO 2000 Arm/Motor tester

INTRODUCTION

This handy diagnostic tool makes it easy to troubleshoot and control any of the arm, torso, or main drive base motors for the HERO 2000 robot. It works equally as well for the Arm Trainer base which uses the same arm as the HERO 2000 robot. By viewing the five LED's you can easily see if there are any problems with the motor/encoder being tested. It has a single 10-pin connector on the top that matches the connectors used on the motor controller boards. Each motor is tested and moved one at a time. The two green LED's on the left show the status of the encoder. By rotating the encoder you can see each LED light in sequence. If either light is out then there is a problem with the associated wiring or encoder. The two red LED's on the right show the status of the limit switches (only on arm and torso) or show the second encoder when testing the gripper. There are no limit switches on the main drive motors so the red LED's will not light during those tests. The LED in the center is a bi-color red/green LED that shows which direction the motor should move and only lights when the toggle switch is moved. The other four LED's will show their status as long as power is applied to the tester.

NOTE: The tester comes with a power cord with clips to connect it directly to the HERO 2000 12v battery. You may also use a standard DC wall power supply with an output of 12vdc @ 1amp. With a recent modification that adds a bridge rectifier to the tester, polarity no longer matters when connecting power to the tester. Early versions can be easily upgraded by adding the bridge rectifier.

If the HERO 2000 Arm/Motor tester is already assembled, please proceed to the operation section.

CIRCUIT ASSEMBLY

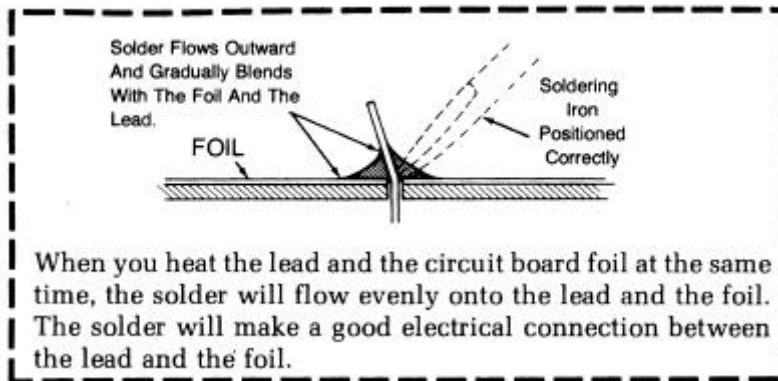
(Kit version only)

At this time the HERO 2000 Arm/Motor tester is only available in assembled form. In the future kit versions may be offered. The following assembly instructions are included for reference only.

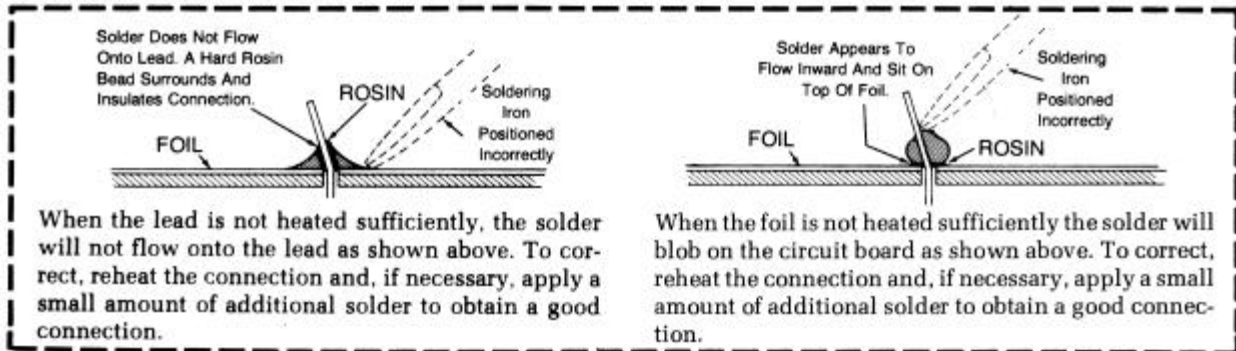
This kit should be built using standard construction methods. The following items are required to build the kit: diagonal cutter, needle nose pliers, soldering iron (pencil type) with fine tip, 60/40 Rosin core solder, and some patience. For assembling the case you also need a ¼" drill, assorted files (both flat and round), a utility knife, and a small saw to help with the cutout for the motor connector. Follow the instructions carefully and read the entire step before performing each operation. To successfully assemble this kit you must have good soldering skills. A good solder connection will form the electrical connection between two parts, such as a component lead and a circuit board foil. Care also needs to be taken to ensure that there are no solder bridges causing shorts. A bad solder connection could prevent an otherwise well-assembled kit from operating properly.

During assembly make sure you keep the soldering iron tip clean. Wipe it often on a wet sponge or cloth; then apply solder to the tip to give the entire tip a wet look. This process is called tinning, and it will protect the tip and enable you to make good connections. When the solder tends to "ball" or does not stick to the tip, the tip needs to be cleaned and retinned. The following illustrations show a good solder connection as well as a couple examples of ones that are poor and need to be redone.

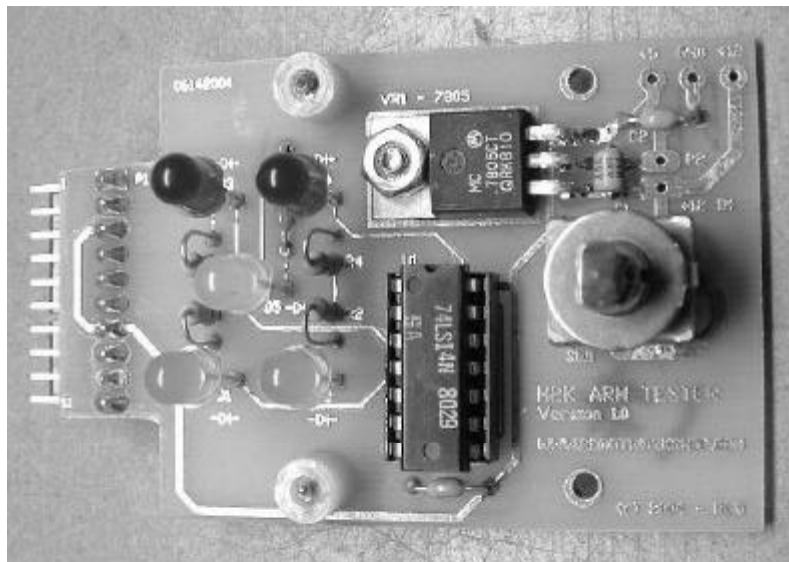
A GOOD SOLDER CONNECTION



POOR SOLDER CONNECTIONS



The component side of the board says "H2K ARM TESTER" on the bottom right. All of the components (except the connector P1) will be mounted on the component side of the board. During construction the connector (P1) should be on the left. After installing each component at the specified location solder it in place before proceeding to the next. When installing DIP socket it works best if each of the two opposing corners is soldered first. Then gently press on the center of the socket while warming the solder on those corner pins with the soldering iron to make sure the socket is properly seated. Finally solder the rest of the leads on the socket. This method gives the board a much cleaner look than if the leads on the sockets have been folded over to hold it in place before soldering.



HERO 2000 Arm/Motor tester

NOTE: A small axial capacitor will be soldered just to the bottom of U1. The spacing is slightly wider between the pads for the capacitor and the pads for the chip. This was done to prevent the chip socket from being accidentally installed into the spot for the capacitor. Make sure that the notch in the socket is orientated up and that pin one goes into the pad with the square foil.

- Install the two .1uf monolithic axial capacitors at locations C2 and C3. These can be inserted in either direction since polarity does not matter.
- Install the 470 ohm ¼ watt resistor at location R5. This can be inserted in either direction since polarity does not matter.
- Install the 14-pin socket at location U1. The notch should point upward.
- Install the 7805 Voltage regulator at location VR1. Bend the leads at a 90-degree angle so that they go into the board and the screw hole for mounting the regulator lines up. Fasten with a 4-40 x ¼" screw, nut, and lock washer.
- Install the .33uf monolithic axial capacitor at location C1. Bend the leads straight down right next to the body of the capacitor. This can be inserted in either direction since polarity does not matter.
- Install the 10-pin connector at location P1. The side of the connector with the bent leads is inserted into the board from the **solder side**. Make sure the connector is level with the board. Proper alignment is important for alignment with the case. Solder both sides of the connector for good support.
- Install the four 330 ohm ¼ watt resistors at locations R1, R2, R3, and R4. One lead should be folded down the side of each resistor so they can be mounted vertically. The body of each one should go toward the center of the board.
- Install SW1 from the top of the board. Make sure the body of the switch is level before soldering. It is best to solder one pin first to check alignment. I adjustments need to occur just warm the solder on that one pin and line up the switch. Once lined up solder the remaining leads.
- OPTIONAL:* Fill in the via with solder. These are the left over holes that connect top traces to traces on the other side of the board. Over time and from expansion/contraction of the board material (Not to mention flexing of the board) small cracks can develop in the via's. In order to prevent this from happening it is best to fill them in with solder. It might be necessary to heat both sides of the via in order to get a clean connection.
- OPTIONAL:* De-flux and clean the board. This step is not required but when properly cleaned the board's appearance is better and it is easier to spot cold solder joints and solder bridges. Depending upon the type of flux used, this can be done economically using common rubbing alcohol and an old toothbrush.
- Solder the short red and black power leads to location P2. The red wire goes in the hole of +12v and the black wire goes to ground.
- Install the 74LS14 chip in socket U1. The notch should point upward.
- Install the two green LED's at locations D1 and D2 but don't solder. The flat goes toward the switch. A diode symbol is also etched on the board to show polarity.
- Install the two red LED's at locations D3 and D4 but don't solder. The flat goes toward the switch. A diode symbol is also etched on the board to show polarity.

HERO 2000 Arm/Motor tester

- Install the bi-color LED at location D5 but don't solder. The flat goes toward the switch. A diode symbol is also etched on the board to show polarity.
- Remove the nut and lock washer from the toggle switch but leave the large washer in place.
- Drill six ¼" holes in the upper case using the template. Five are for the LED's and one is for the switch. The holes are based on the center point of the switch and LED's.
- Drill/ream hole in lower case shell for power plug. This goes on the right side near the bottom.
- Cut & file rectangular cutout on end of case (both upper and lower shells) to allow clearance for P1.
- Install five LED clips in upper shell and slightly spread the tabs on the inside to ease the insertion of the LED's.

NOTE: Lineup the LED's in the LED clips and push into place while installing the board in the step below.

- Use two nylon spacers and screws in the holes near the LED's to mount the PCB in the case. The nut and lock washer is reinstalled on the switch to secure it on top.
- With all the LED's locked in place solder each one and trim excess leads.
- Install power connector in bottom shell. Optionally glue connector to lower case shell.
- Bend up all four leads on the bridge rectifier (RD805). The center two leads (AC) should extend out about ¼" past the positive and negative leads. These center leads will mate up with the power connector and will be trimmed to the height of the connector. The outer leads will be trimmed to the height of the part.
- Glue the bridge rectifier to the bottom case so that the center two leads (for AC) make contact with the two leads from the power plug. Solder both leads to power plug. Marine GOOP works well as an adhesive to glue the bridge rectifier to the case.
- Twist red/black wires together except for the last 1" at end.
- Solder red and black wires to bridge rectifier. Red goes to the + while the black goes to the - lead.
- Screw case together using 4 screws.
- Install sticker for power requirements to side near power plug.
- Install two clips on end of 6' power cable. Red goes on the stripped lead, which is for the +12v.

This concludes the Assembly procedures for the HERO 2000 Arm/Motor tester. Congratulations! Before proceeding, look over the board and verify the correct location and orientation of all parts. Also check to make sure there are no solder bridges or poor solder joints. Some of the traces are very close together and it is easy to accidentally create a solder bridge across a trace or two.

HERO 2000 Arm/Motor tester

OPERATION

By viewing the five LED's you can easily see if there are any problems with the motor/encoder being tested. It has a single 10-pin connector on the top that matches the connectors used on the motor controller boards. Each motor is tested and moved one at a time. The two green LED's on the left show the status of the encoder. By rotating the encoder you can see each LED light in sequence. If either light is out then there is a problem with the associated wiring or encoder. The two red LED's on the right show the status of the limit switches (only on arm and torso) or show the second encoder when testing the gripper. There are no limit switches on the main drive motors so the red LED's will not light during those tests. The LED in the center is a bi-color red/green LED that shows which direction the motor should move and only lights when the toggle switch is moved. The other four LED's will show their status as long as power is applied to the tester.

To use it connect the two power leads to any 12v battery or the main HERO 2000 battery. Then just plug in the connector for the axis you wish to test. The two green LEDs on the left show the status of the encoder and the two red LEDs on the right show the status of the limit switches (or finger encoder for the gripper). If you move an encoder wheel by hand you should see each green LED turn on and off in sequence. Turning the wheel in reverse should show the opposite sequence. For the arm the top red LED shows if the limit switch is active and the bottom red LED shows the status of the limit by the wrist for either wrist motor. The Main drive base motors have no limit switches.

At any time you can drive the motor around by using the switch and when power is applied the center LED (bi-color) will light and change color depending upon polarity. When moving a motor via the switch both green LEDs should appear lit.

When testing the gripper the two green LED's show the encoder for the motor and the two red LEDs show the status of the fingers. If you manually move the fingers you should see the red LED's change sequence. By driving it with the tester you can easily watch all four of the encoder LEDs go through their sequence. If any do not light then there is a problem with the wiring or encoder. The robot knows when the fingers are fully open/closed since the motor encoder keeps changing but the finger encoder stops moving. By keeping count of how much more the motor moves after the fingers stop it can estimate how much force is applied.

If the movement of the motor is smooth when driven by the arm tester but shakes violently when driven by the HERO 2000 controller card then either the polarity of the motor leads are reversed or the two encoder wires are reversed. This causes the motor to move in the opposite direction that the robot thinks it is supposed to move and compensates for it. As a result the motors have an extremely violent and jerky operation. It is usually obvious when this is the case. If what you see instead is a small surging in the main HERO 2000 drive base motors don't be alarmed. The main drive motors may not run perfectly smooth under no load conditions. This is normal. Once a load is placed on them or they have to move the robot around they will smooth out.

NOTE: If the motors have seen a lot of use then they might need to be cleaned out. After years of service carbon deposits can build up in the area of the brushes and could cause unwanted feedback. This can cause intermittent problems whenever the motors are running.

SPECIFICATIONS

Power: 12v, 2.5mm power plug, 1amp (1000ma), center positive (no polarity for version with bridge)
Diagnostic LED's: 5 total, 2 for encoder, 2 for limit switches (or second encoder), and one for motor.
Movement switch: on-(off)-on momentary double pole switch
Motor/Encoder connector: 10-pin connector for motor, encoder, and limit switches.

HERO 2000 Arm/Motor tester

CABLE PINOUT MATRIX

Below is a matrix that shows the pinout of the HERO 2000 arm and base motor connectors. It is very useful as a troubleshooting aid when using the tester.

SHOULDER cable pinout										
Pin #	1	2	3	4	5	6	7	8	9	10
F	BRN	RED	ORG	YEL	GRN	BLU	-	VIO	-	BLK
C	BRN	RED	ORG	YEL	GRN	BLU	To SHOULDER limit switch			

ELBOW cable pinout										
Pin #	1	2	3	4	5	6	7	8	9	10
G	RED	BRN	ORG	GRN	YEL	BLU	-	VIO	-	BLK
B	BRN	RED	ORG	YEL	GRN	BLU	To ELBOW limit switch			

WRIST RIGHT cable pinout										
Pin #	1	2	3	4	5	6	7	8	9	10
H	BRN	RED	ORG	YEL	GRN	BLU	-	VIO	ORG	BLK
E	BRN	RED	ORG	YEL	GRN	BLU	To WRIST RIGHT & WRIST limits			

WRIST LEFT cable pinout										
Pin #	1	2	3	4	5	6	7	8	9	10
J	RED	BRN	ORG	GRN	YEL	BLU	-	VIO	GRN	BLK
D	BRN	RED	ORG	YEL	GRN	BLU	To WRIST LEFT & WRIST limits			

GRIPPER cable pinout										
Pin #	1	2	3	4	5	6	7	8	9	10
K	RED	BRN	ORG	VIO	GRY	BLU	-	YEL	GRN	-
A	BRN	RED	ORG	YEL	GRN	BLU	VIO	GRY		

TORSO cable pinout										
Pin #	1	2	3	4	5	6	7	8	9	10
P6A	BLU	BRN	RED	VIO	GRN	BLK	-	YEL	-	ORG
P7B	BLU	BRN	RED	GRN	VIO	BLK	To TORSO limit switch			

BASE RIGHT cable pinout										
Pin #	1	2	3	4	5	6	7	8	9	10
P5A	BRN	BLU	RED	GRN	VIO	BLK	-	-	-	-
P5B	BLU	BRN	RED	GRN	VIO	BLK				

BASE LEFT cable pinout										
Pin #	1	2	3	4	5	6	7	8	9	10
P7A	BLU	BRN	RED	VIO	GRN	BLK	-	-	-	-
P6B	BLU	BRN	RED	GRN	VIO	BLK				

HERO 2000 Arm/Motor tester

MOVEMENT MATRIX

AXIS	CONNECTOR	TO	Switch Up (RED)	Switch Down (GREEN)
SHOULDER	F	C	Extend	Retract
ELBOW	G	B	Retract	Extend
WRIST RIGHT	H	E	Down	Up
WRIST LEFT	J	D	Down	Up
GRIPPER	K	A	Open	Close
TORSO	P6A	P7B	Left	Right
BASE RIGHT	P5A	P5B	Forward	Backward
BASE LEFT	P7A	P6B	Forward	Backward

ENCODER/LIMIT SWITCH MATRIX

AXIS	Upper RED LED	Lower RED LED
SHOULDER	On = Limit active retracted	N/A
ELBOW	On = Limit active retracted	N/A
WRIST RIGHT	On = Limit @ cam groove	N/A
WRIST LEFT	On = Limit @ cam groove	On = Limit @ wrist active
GRIPPER	2 nd encoder	2 nd encoder
TORSO	On = Limit active (Right)	N/A
BASE RIGHT	N/A	N/A
BASE LEFT	N/A	N/A

IN CASE OF DIFFICULTY

PROBLEM	POSSIBLE CAUSE
Arm/Tester does not power up.	<ul style="list-style-type: none"> - Verify 12V power source. - Check for solder bridges and cold solder joints. - Check for bent/folded pins on 74LS14. - Check for proper operation of the 5V regulator. - Check Bridge rectifier
Switch moves motor but no encoder/limit switch LED's light	<ul style="list-style-type: none"> - Check for solder bridges and cold solder joints. - Check for bent/folded pins on 74LS14. - Check for proper operation of the 5V regulator. - Check for proper orientation of LED's.

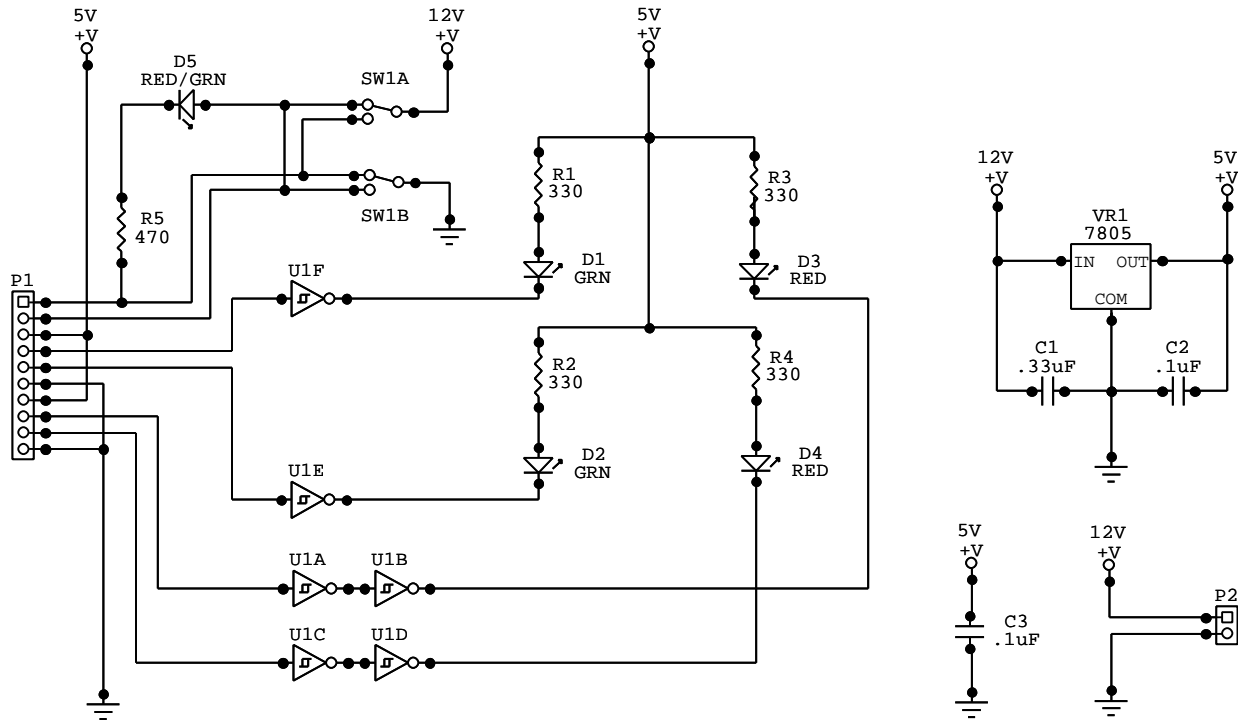
HERO 2000 Arm/Motor tester

CIRCUIT DESCRIPTION

The circuit for this tester is relatively straightforward and can be broken down into a few sections. The first is merely a double pole switch (with center off) that is used to apply power to the motor being tested and also selects the polarity. A bi-color LED with current limiting resistor are wired in parallel with the motor to show when power is present and which direction it is flowing. The next is a 7805 voltage regulator and filter capacitors, which bring down the 12v supply to 5v for use with the encoders and the status LED's. The remaining portion consists of the four status LED's, their current limiting resistors, and the 74LS14 used to buffer the encoder/limit switch signals and condition them. There are two inverters on the LED's for the limit switches so they will light when they are in an active state.

SCHEMATIC DIAGRAM

The switch (SW1) is a double pole toggle switch on-(off)-on that is shown in an active state.



HERO 2000 Arm/Motor tester

REPLACEMENT PARTS LIST

Components

Quantity	Description	Location
1	14 pin DIP socket	U1
1	74LS14 – Hex Inverter	U1
1	7805 - +5v 1amp voltage regulator TO-220 case	VR1
2	GREEN LED T-1 3/4	D1, D2
2	RED LED T-1 3/4	D3, D4
1	bi-color RED/GREEN LED T-1 3/4	D5
4	330 ohm 1/4 watt resistors	R1-R4
1	470 ohm 1/4 watt resistor	R5
1	.33uf monolithic axial capacitor	C1
2	.1uf monolithic axial capacitors	C2, C3
1	10-pin (1x10) right angle connector (gold plated)	P1
1	Double pole switch (center off) on-(off)-on	SW1
1	2.5mm power plug	P2
5	LED mounting clips T- 1 3/4 (for plastic case)	D1-D5
1	RS805 8A 600v Bridge Rectifier	
2	Nylon spacers w/screws for mounting PCB in case	
1	6' 2.5mm power cord	
2	Power clips (red and black)	
2	2.5" wires (red and black)	

Custom components

Quantity	Description	Location
1	Custom Printed Circuit Board (through hole plated) Version 1.1	
1	3.60" x 2.25" x 1.5" box Almond color (w/screws) LMB #401	

Revision History

Breadboard - Initial prototype of arm/motor tester built on breadboard. Design worked well.

Version 1.0 - First version on actual PCB

Version 1.1 – Second run of PCB. Updated hole sizes. Also added Bridge rectifier so power polarity is no longer a concern.

SPECIAL THANKS

A note of thanks to the following people who helped with the project:

All the users who have responded with their feedback!