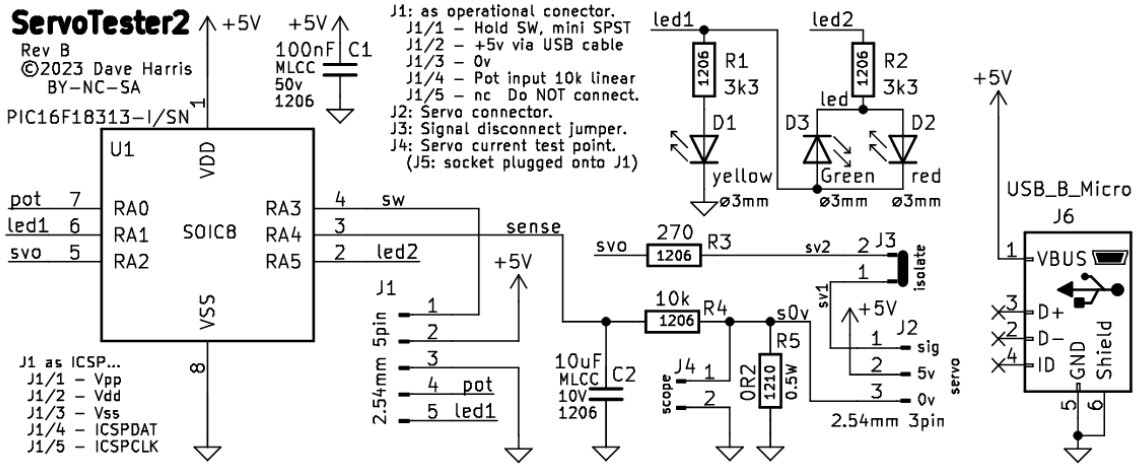
ServoTester2 Build Instructions (rev B1)

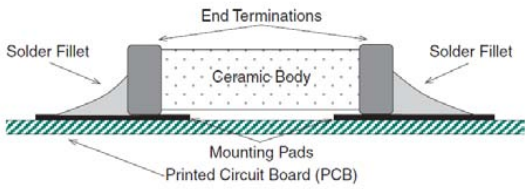
Dave Harris July'23

The rev B1 Printed Circuit Board (PCB) is a 2-layer, 50 mm x 33.3 mm, double sided with the control panel being one side and most components on the other side. About half the parts are Surface Mount Device (SMD) and the rest are Through Hole (TH).



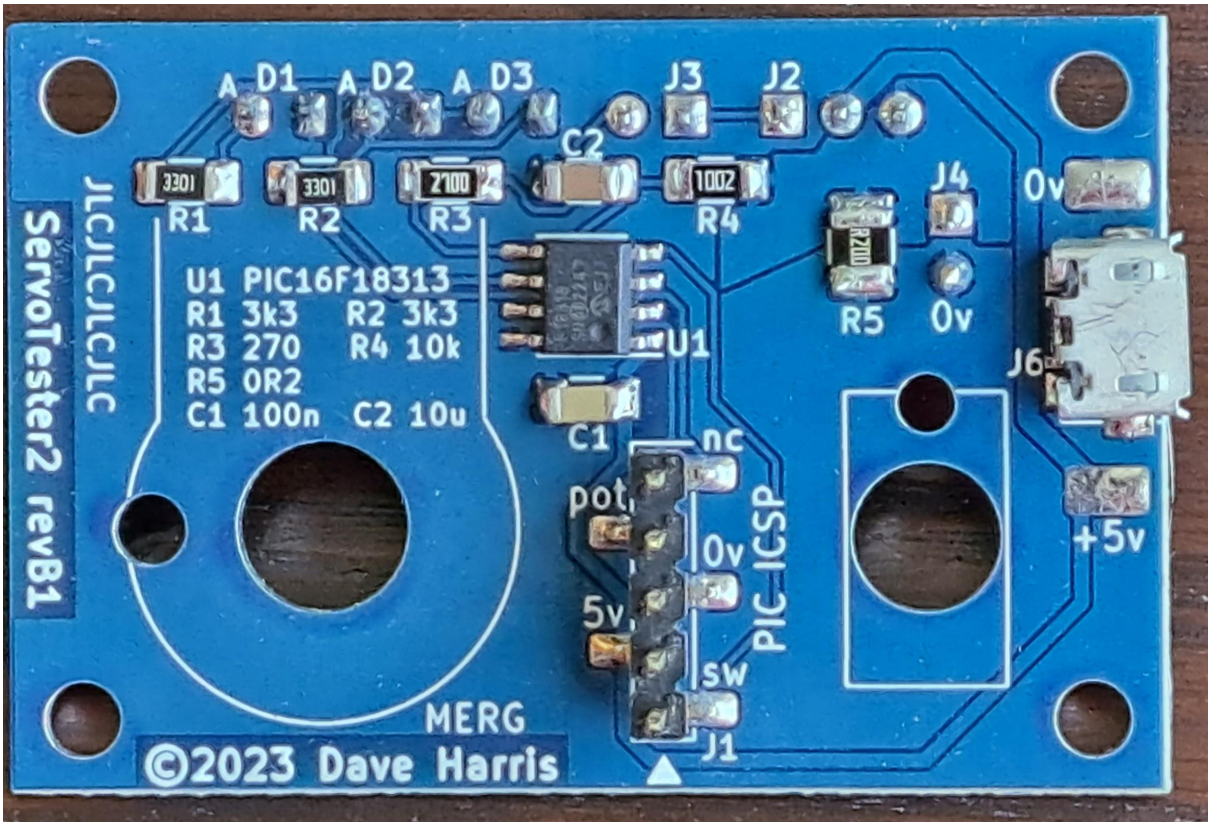
Not on the schematic above is a 0.1uF capacitor, between 0v and pot slider, on the pot itself. Rev B1 schematic is the same as the rev B shown above & is only board layout changes. Rev B is schematic and firmware changes from the prototype rev A.

These build instructions are for an SMD hand soldering method. The parts will be fitted in an order that ensures nothing impedes the fitting of any other part. The order is SMD parts, Light Emitting Diodes (LED), TH headers and lastly the Potentiometer (pot) and the toggle switch (sw) are fitted, along with their wiring.



For hand soldering SMD, the way I do it, put jelly flux on the mounting pads and place part. Carry solder on the soldering iron tip, to the component pad. The flux will draw the solder from the tip to flow around the pad and component termination to form a solder fillet joint.

There are several ways to hand solder SMDs and each way has pros and cons.
I strongly suggest that you check a few YouTube videos to get an idea on how it's done.
An alternative to using solder and jelly flux is to use solder paste, again, check it out.



Your part-built PCB, after a clean up with IPA and a small brush, should look a bit like this.

I shall be VERY picky here… J6 is not straight and C1 and R2 are off center!
So, do as I say and not as I did!
But that said, this example passed all tests OK and works fine.
Perfection is a target, but not essential!
"Place part, check position, solder one pad, re-check and then solder the other pads"

Required tools and materials

Temperature controlled soldering iron with a fine tip and fine solder.	SMD rework jelly flux, hypodermic. EG. Rapid 85-6648 (comes with fine solder)
General tools… Fine point tweezers, wire cutter, long nose plier, wire stripper, ruler, files.	
Magnifier or eyeglass, about x10	Headtorch or desk lamp
Isopropyl Alcohol (IPA) cleaning solution	An old tooth brush for scrubbing PCB clean
A shallow tray/dish for PCB cleaning	LED tester. *If your multimeter has more than a 5V battery inside, its 'Diode' test range should be able to test an LED. Try it…* Otherwise make your own tester using a 9V PP3 battery and a resistor of around 15k.
Toothpicks	
Multimeter - DC Volts & resistance	
Solder wick	USB power source, rated more than 2A
Micro USB-USB A cable, Fast Charge type	A known good working servo
PICKIT-4 and PC software (IPE or IDE). *Optional: the PIC in the kit may be pre-programmed*	

Parts in the kit

The first 12 items are on the parts sheet.

R1 3k3, SMD 1206	R2 3k3, SMD 1206	R3 270R, SMD 1206
C2 10uF 6V3, SMD 1206	R4 10k, SMD 1206	R5 0R2, SMD 1210
U1 PIC16F18313, SMD SOIC8	C1 0.1uF 50V, SMD 1206	D1 yellow LED 3mm, TH
D2 red LED 3mm, TH	D3 green LED 3mm, TH	C3 0.1uF 50V radial 0.1", TH
J1 5 way 0.1" header, SMD	J2/3/4 7 way 0.1" header, TH	J5 5 way 0.1" socket, TH
J6 Micro USB socket, SMD	Shunt strap 0.1" for J3	
10k linear pot, panel mount	Knob for the pot	Toggle sw SPST, panel mount
PCB ServoTester2 revB1	Strip board piece, cut 5x2 holes	
110 mm of black wire 7x0.2	100 mm of white wire 7x0.2	50 mm of red wire 7x0.2

*An 'SMD **1206'** indicates the parts outline size and equates to 0.0**12**" x 0.0**06**" in size.*

Build Steps

1 Start

Read these instructions twice.
Check all the parts are present.
Only detach a component from the parts sheet, WHEN it is needed.
The LEDs and capacitors have NO markings! Capacitor values can be identified using a good digital meter, although in this kit, the 10uF is taller than the 0.1uF. LEDs will need use of an LED tester. The resistors and chip markings will require the use of a magnifier to see & need decoding.

2 LED tester

If you already have a tester, goto step 3, or make yourself a simple LED tester…
Solder a ¼ W axial resistor of between 10k to 22k to a PP3 9V battery plus terminal. Solder a length of red wire to the free end of the resistor. Solder a length of black wire to the minus terminal of the battery. On the free ends of the 2 wires (*the 'test probes'*) strip 3 mm of insulation and 'tin' them to ensure the wire strands stay together.
In use, the LED to be tested is connected to the red and black wires. Dab the wires on the the anode, the longer leg, is red wire and the cathode, the shorter leg, the black wire.
An LED can also be tested while in circuit, with module power off.

3 Prepare PCB

In a shallow tub give the PCB a scrub clean using IPA and an old toothbrush.
Give the PCB a shake to remove excess IPA and allow it to air dry.

4 Generic SMD part fitting procedure

Remove selected part (as given in steps 5/6) from the parts sheet and place it on its PCB pads using tweezers, and with a magnifier ensure it is on the pads equally.
Hold part in place with downwards pressure from a toothpick.
Solder one pad only.
Re-check the part is still in the right place. If not then while reflowing the one solder joint, gently turn/push the part with tweezers where it should be.
If the position is good, solder the other pad(s).
With the magnifier check the solder flow is good around the pads.

5 Fit USB socket J6 first

USB J6 is not the easiest to solder, so take care with its soldering and the visual inspection. The case is metal for mechanical strength and is soldered on the copper etch ground plane (AKA a heatsink), so you may need to turn up the iron heat there.
Do NOT get flux inside the front or sides of the USB socket, as solder will be drawn in!
Note: Pins J6/2, J6/3 & J6/4 are not used, so if their solder is missing, don't worry about it!

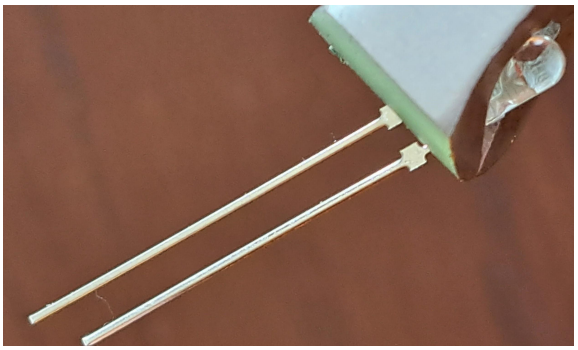
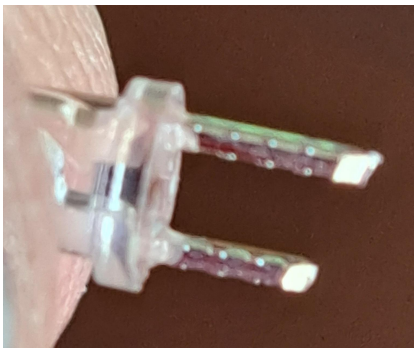
With just your finger tips, try to twist the socket. If it moves any, do the soldering again!
Plug in a powered USB cable and test that there is between 4.9V and 5.2V on the 0v and 5v pads. If not then diagnose and fix. *Most probably J6/1 or J6/5 solder joint is dry.*

6 Fit the rest of SMDs

Fit R1, R2, R3, C2, R4, R5, U1, C1 & lastly J1.

For U1 ensure its corner dimple, on the top of its body, is adjacent to the label 'U1' text.
R5 is on copper etch heatsink and may need more heat to get a good solder flow.
All other SMDs are orientation and polarity insensitive.

7 Fit TH LEDs

The square tags on both leads will prevent LED being fitted close to the PCB, so prepare them by cutting both leads at once, but maintain the short and long leg relationship by cutting at an angle.

Solder in the 3 LEDs, on the **panel side** of the PCB. Since the LEDs are clear plastic and have no ident, check each with the LED tester to confirm their light colour, before soldering. The longer LED leg is the anode pin (shown as 'A' on silk screen). When flush with the panel, solder the other leg.

8 Fit TH headers

Cut the header strip three ways, 3 pin, 2 pin and 2 pin.
Fit, on the panel side, the pin headers J2 (3 pin), J3 (2 pin) and J4 (2 pin).
Solder one pin first, if not vertical or is raised from PCB, apply toothpick pressure while reflowing the joint until it is. Then solder the other pin(s).
As J4 is only for a scope connection, my preference is to make its pins shorter.

9 Basic inspection and test

Scrub clean using IPA and an old toothbrush. *Removing the solder/flux residue from the PCB makes visual inspection easier.*
See image on page 2.

Visually check your work with a strong magnifier, looking for missing or incomplete joints.
If you see any, fix by adding flux and re-soldering the affected joints.
If you see solder bridges, these can normally be cleared by adding flux and with no solder on the iron tip, drag the clean tip across the fluxed joints. In bad cases, then use solder wick.

10 Electrical Testing

- Do NOT plug in a USB cable.
- Ensure the Shunt Strap is on J3 "signal isolate" and
- there is no servo connected.

Check the resistance readings between the points shown below…
One purpose of the tests is looking to find defective solder joints, the probe should be on the chip pins or component termination cap and NOT on the solder pads.
Another purpose is to ensure the component values are in the right places.
Choose the right meter range: looking for 0 Ω, on the MΩ range may show 0.0 MΩ when it's 500 Ω !
Hold your meter probes together to get a 0 Ω reading, some meters show between 0.5 Ω and 3 Ω !

Measure resistance with meter probe + to -	
Test 1. U1/1 pin to J1/2 pin '5v' = 0 Ω	Test 2. U1/2 to D2 anode = 3.3 kΩ ±5%
Test 3. U1/3 pin to J2/3 '0' = 10 kΩ ±5%	Test 4. U1/4 pin to J1/1 'sw' = 0 Ω
Test 5. U1/5 to J2/1 'S' = 270 Ω ±5%	Test 6. U1/6 pin to D1 anode = 3.3 kΩ ±5%
Test 7. U1/7 to J1/4 'pot' = 0 Ω	Test 8. U1/8 pin to J1/3 '0v' = 0 Ω
Test 9. J1/2 to J2/2 '5v' = 0 Ω	Test 10. J1/3 to J2/3 '0v' = 0.2 Ω ±1% *
Test 11. D1 anode to J1/5 'nc' = 3.3 kΩ ±5%	Test 12. +5v pad to 0v pad = greater than 2 MΩ

** Not all meters can measure 0.2 Ω, showing under 1 Ω will be good enough.*

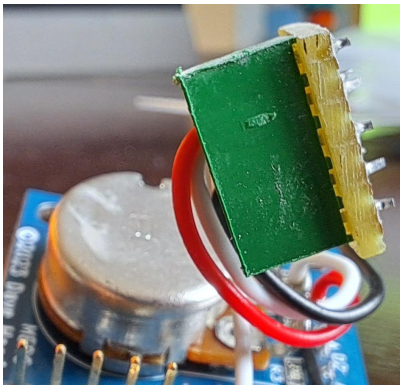
Using an LED tester check each LED lights with its correct colour, with plus wire on anode and minus wire on cathode.

If any test fails, do NOT proceed further. Diagnose and fix any faults before proceeding.

11 Panel controls

Fit the toggle switch and the pot and knob. When both are straight and tightened, place a small drop of glue on an edge of the nut where it meets the washer.

12 J5 connector



Solder the TH header socket into the piece of strip board (5x2 holes) to form J5.
Plug J5 onto J1 so that the empty holes are toward the pot.

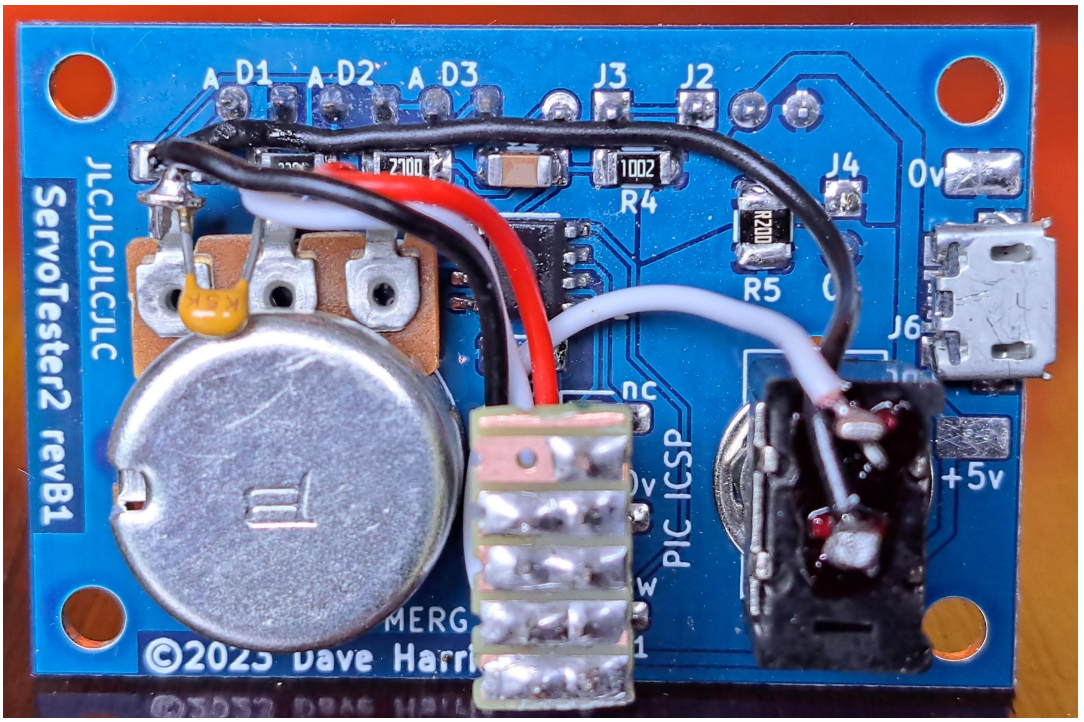
To enable the future fitting of the module into a box, the strip board edge nearest the main PCB edge needs to be filed back to be inline with the end of the J5 socket.

13 Wiring

Fit, but not solder, the 0.1uF radial capacitor to the pot, across the left hand & center lug. *It will get solder when the following wires are fitted.*
Solder lengths of 7 strand 0.2 mm wire (7/0.2) to this plan. Only strip only about 3 mm of insulation from each wire end and tin.

50 mm white wire from switch upper terminal to J5/1 (sw) *(J5/1 is next to the white arrow)*
50 mm red wire from pot right hand terminal to J5/2 (5V)
50 mm black wire from pot left hand terminal to J5/3 (0V)
60 mm black wire from the pot left hand terminal to switch center terminal (0V).
50 mm white wire from the pot center terminal to J5/4 (pot) *Note J5/5 (nc) has no connection.*

Route wires as shown in the next image...



14 Programming the PIC

The kit may be provided with a pre-programmed PIC chip. If so, goto step 15.

In your web browser, goto https://github.com/daveharrisuk/ServoTester2 and download the zip file named like `HEX_ServoTester2_v??` which contains firmware hex files.
At time of writing the code version is 1.1 and so its name is `HEX_ServoTester2_v11.zip`
Extract the hex file for rev B and this PIC `(ServoTester2_revB_v11_PIC16F18313.hex)`.
Unplug J5 from J1, this disconnects the pot and switch, allowing J1 to be used as the "In Circuit Serial Program" (ICSP) header for use by a PICKIT.
Push J5 to one side carefully and plug the PICKIT-4 onto J1. Pin 1 on each is shown by a white arrow. Using the Microchip (`microchip.com`) IDE or IPE program send the hex file to the PIC. See the Microchip documentation on IPE/IDE for this process. The software should be set to program a PIC16F18313.
The D1 yellow LED will flash while loading is in progress.

15 Operation Testing

Before applying power ensure…

- Knob is fully anti clockwise, 0 degrees (*No position offset from servo mid position*)
- Switch is set to || 'pause' (*No servo position oscillate*)
- J5 is on J1 (*The pot and switch are connected to PIC*)
- Shunt Strap is on J3 'signal isolate' (*the servo signal is NOT isolated*)
- No servo is connected.

Plug in the Micro USB cable. *It should be 'Fast Charge' rated type. The USB power source should be capable of supplying 2A*.
On power up the LEDs may flash and after that the yellow LED should light and the green and red should be dark.
Test the Voltage on the 0v and 5v pads, there should be between 4.9V to 5.2V, if not then fix.
With a temperature probe, check for any hot components (*I use the tip of my little finger, if it's hot, it may burn*!). Everything should be cool. If anything is hot, power off and investigate.
If other light patterns **and** previous tests have passed, then suspect the PIC. Contact me via my Github for guidance.

If all is well, then connect a known good servo to J2.
The signal wire (white, yellow or orange) goes next to the pin marked 'S'.
If connected the wrong way, no damage happens, but the servo won't function.
A horn mounted on the servo shaft will help movements to be seen.
The servo should, if not already, move to its center position.
The green LED will flash (*greater than 25 mA)* while the servo moves. If the green is lit most of the time while the servo is stationary, then it is probably the servo at fault.

Set the switch to 'Run' and gradually turn the knob clockwise. The servo should start a slow oscillating movement and the green LED will flash in time with the movement.

Intermittent red light (*greater than 250 mA)* can occur with larger servos or with a servo with something impeding its horn movement or of course a suspect servo.

To test the red LED, grip the moving servo horn with your fingers to force a temporary overload. *This sounds brutish but I've not had a servo break with this test.*
The yellow and green LEDs will go dark and the red LED will light.
If however all the LEDs go dark or the yellow LED flashes (*the USB 5V drops below 4.75*V), then the USB power source or the cable has not been able to supply enough current.
The modules over current protection is the USB source protection and the USB cable resistance.
*The red LED lights when there is more than 250 mA **average** current. However when the servo's internal Pulse Width Modulation turns on the servo motor, a repetitive **peak** current greater than an Amp can flow, in short durations. These peaks can reduce the USB power.*

End of Document