P94 DUAL ESC/MIXER MULTI CONTROLLER

Type: Dual ESC and Mixer Module. Equivalent to two fully operational ESCs and a mixer, all in the same case. Will suit most types of DC brushed motor used in model boats, including 7+ pole types.

No of channels required: 2

Motor voltage: 6v to 24v

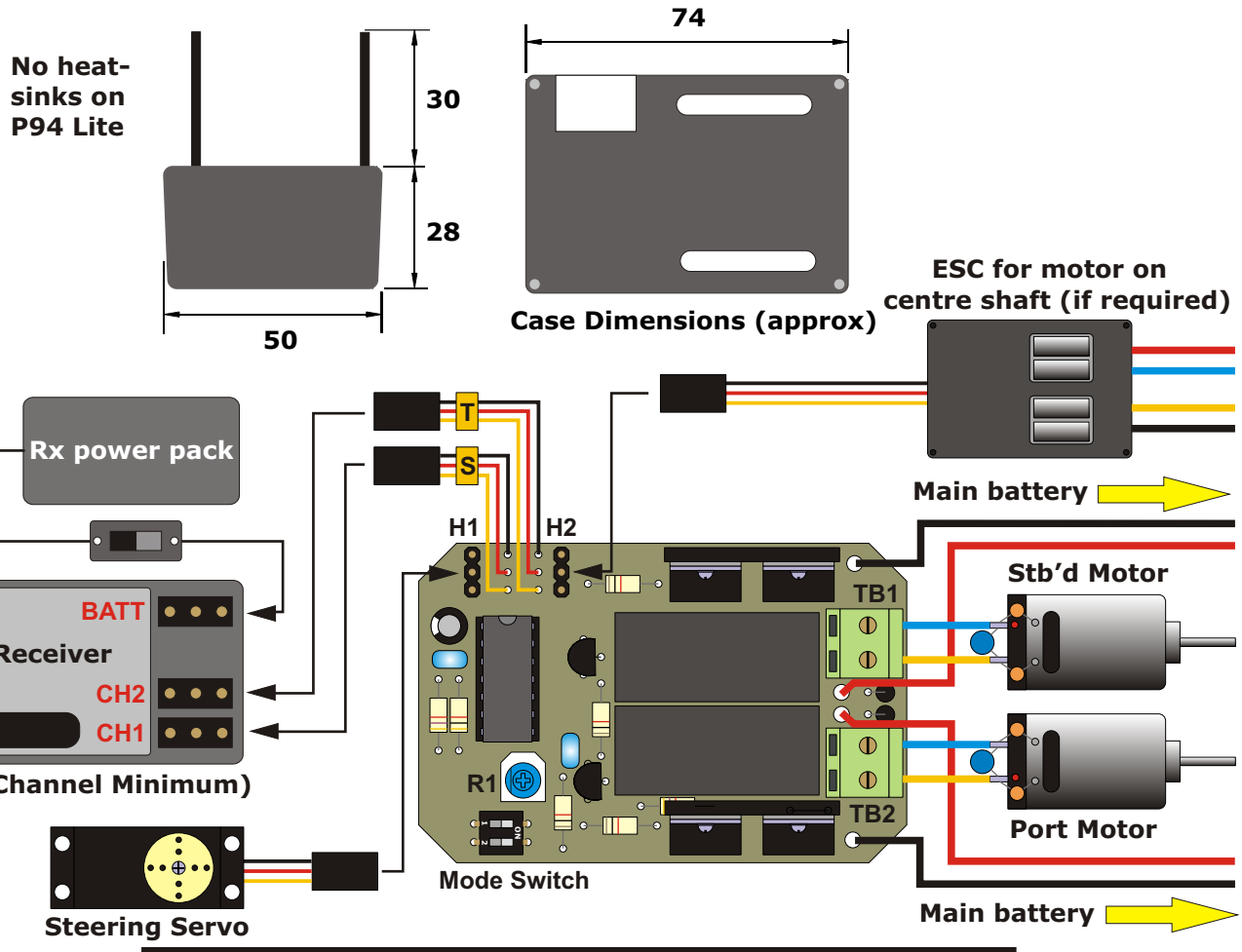
Maximum continuous current rating: 20A per ESC (P94 Lite = 10A per ESC)

Modes: 4 different modes of operation, selectable by user via on-board 2-way DIL switches:

Mode 1: Dual electronic speed controllers - Each ESC works from a separate channel i.e. "Tank Steering";
Mode 2: Dual thruster mode - Controls bow and stern thrusters. Skipper selects either Traverse (where thrusters work in the same direction and slew the model sideways) or Spin (where the thrusters work in opposite directions and spin the model on its own axis). Selection is done by "blipping" the rudder stick hard over and letting it go straight away. Both thrusters are also fully speed-controlled.
Mode 3: 0% - 100% Mixer. As Mode 4, except that inboard motor can be made to spin at full speed in reverse sense on full rudder command i.e. you can spin the model on its axis.
Mode 4: 0% - 50% Mixer. Applies differential speed control to the motors automatically as a rudder command is give. Adjustable from 0%, where there is no mixing of rudder and throttle signals, up to 50%, where the inboard motor just stops at full rudder command.

Other facilities:

Autoset..... P94 automatically sets neutral position of throttle and steering on powering up i.e. No "binding" or other setting up to do
Failsafe..... ESCs shut down motors on loss of signal.
Central Motor & Rudder connections..... 3-pin headers provided for connecting the steering servo and a separate speed controller to operate a centre motor.
Adjustable thruster output..... Allows the operation of commercial thrusters from higher-voltage main batteries.



SCHEMATIC OF INSTALLATION IN TWIN-ENGINED MODEL

Drawn by Dave Milbourn

P94

Dual ESC/Mixer Multi-controller

Installing the P94

Because of the high power of the P94 Multi-controller, care should be paid to the installation of the unit. Each ESC circuit can deliver 20A continuously (P94 Lite 10A) and the wiring installation should be designed with that in mind. The unit has two positive supplies and two ground connections. When installing the system, *it is very important to remember that the two ESC circuits within the P94 are not separate units and must be treated as a single entity.* ***Do not under any circumstances connect a separate battery pack to each pair of red and black wires - it may seem logical but you will very probably do fatal damage to the P94!***

Fig #4 shows a basic installation. The two grounds (black) wires must be connected together. The length of wire must be kept to an absolute minimum. Similarly, the positive (red) wires should be connected together and kept as short as possible. The wires should be joined close to the fuse-holder which is then connected to the battery. The fuse must be sized to be as small as possible without causing nuisance tripping. A 40A fuse, maximum, should be used to protect the unit (P94 Lite 20A). FIG#5 shows a more convenient way of connecting and fusing the P94 by using a P92 Power Distribution Board. P102 can be used where there are three motors installed.

If more than one battery is being used for the installation, they should be connected in parallel. This is best done by using a P103 Parallel Power Board. This will handle up to 15v @ 20A and prevents any possibility of one battery discharging into the other and causing damage or even fire to the wiring. See Fig #6. If you are using >15v then first connect the two battery positive terminals together and the two battery negative terminals together and then connect each of the joined pairs to the P92 etc.

When connecting the motors, suitably rated cable must be used and the lengths kept as short as possible. We recommend multi-strand cable of at least $2mm^2$ (16AWG). The wiring of the two motor connections is reversed with respect to each other, so that they rotate in opposite directions when ahead or astern commands are given. It is also recommended that the outputs from the ESCs are individually fused. P95 is ideal for this purpose; See Figs #2 & #3. Each fuse must be no more than 20A (P94 Lite 10A).

Terminal block TB1 is used for one motor or the bow thruster, and TB2 is used for the other motor or the stern thrusters (depending on the operating mode). Do NOT allow the two heat-sink tabs to touch each other or touch any other power wiring. Additional cooling in the form of extra heat-sinks or water-carrying tubes can be fitted to the aluminium tabs, but they must remain electrically isolated from each other.

When connecting the receiver to other servos or speed controllers there are two "straight-through" connections on the P94 in the form of 3-pin headers. See the Schematic Drawing on the Front Page of this manual. These eliminate the need for Y-leads from the receiver outputs. H1 would be used conventionally to connect the steering servo, while H2 will supply the throttle signal (unmixed) to a third electronic speed controller e.g. for a central motor. Header pins H2 can also be used to connect a digital engine sound unit to the system e.g. ACTion P100. The sound will then follow the throttle stick input and will not be affected by any degree of mixing.

Important!

1. Do not use a 5-cell NiCad/NiMH pack or a 6v lead-acid battery to power the receiver *direct*. Use either a 4-cell pack or a regulated power supply e.g. P19, P92, P99 or P102..
2. ALWAYS check your wiring before applying power to the circuit for the first time, and ALWAYS turn off ALL power before you make ANY changes to connections or any adjustments to switches etc. If you ignore this rule then you could cause damage to the unit.
3. Never work with a live battery in circuit, especially if the unit is out of its case. You risk shorting out the copper tracks on the reverse of the PCB.
4. Turn on your transmitter before the receiver, and turn off the receiver before turning off the transmitter.
5. Always fit suppressor capacitors to your motors (ACTion can supply a suitable set of components).
6. When setting up Modes 3 and 4, first use the Tx Servo Reverse Switch if necessary so that the steering servo operates the rudder(s) in the correct sense. Once you're satisfied with this, leave this switch alone throughout the rest of the setting-up procedure. If you need to reverse the rotation of either motor then do it by swapping over the two connections from the motor to the ESC terminals. If you find that the "wrong" motor slows down when you apply a steering command then simply swap over the two motors between terminals blocks TB1 and TB2.
7. If your transmitter has any form of inter-channel mixing on the steering and throttle channels, make sure it is switched OFF for the operation of a model fitted with a P94. Also ensure that any servo throw adjustment is set to 100% movement in both directions. See the manual for your radio for further information.

Modes of operation

As discussed earlier, P94 has four different modes of operation. These are selected with the small 2-way switch which is situated on the circuit board just below the microprocessor chip. Each of the two switches can be either ON or OFF. The unit is supplied in Mode 4 and the position of R1 has been set to the optimum position for this mode. **You may need to adjust the rudder trim lever on your Tx slightly to ensure that the two motors start exactly together.** The indicator LEDs of P95/2 are very useful here.

R1 controls the 'degree' of mixing. I**f you turn it all the way clockwise then the mixing function in Modes 2-4 will be totally disabled.** The following sections describe the four modes of operation, in conjunction with Figs #7, 8 & 9. Note that the props are shown in outwards contra-rotating configuration when viewed from the rear. If your model uses inward-turning props then set up the P94 as shown and, as a last step, swap over the connections between the P94 terminals and the motors to reverse their direction of rotation.

Mode 1: Dual ESC Mode (See Fig #7) Switch 1 = ON, Switch 2 = ON

In this mode the system operates as two independent ESCs, each rated at 20A (P94 Lite 10A). This is frequently referred to as "Tank Steering" as it mimics the controls used by the driver of a tracked vehicle to control its direction and speed. Many boat modellers prefer this 'manual' mode of mixing twin motors, and it is also widely used by builders of large-scale model tanks. In this mode there is no interaction between the two channels, and R1 is not used.

Mode 2: Thruster Mode (See Fig #8) Switch 1 = ON, Switch 2 = OFF

This mode is intended to control combined bow and stern thrusters. The thrusters can be run in the same direction to move the model sideways in the water ("slew"), or in opposite directions to rotate it around its own axis ("spin"). The output from terminal block TB1 is used to drive the bow thruster while TB2 controls the stern thruster. The thruster speed/direction channel is usually the LH Tx stick. Push it to the left for a rotation/slew to Port and to the right for a Starboard rotation/slew.

The RH side-to-side stick is the main steering control for the model and it is also used to switch the thrusters from Spin mode to Slew mode; the stick is "blipped" to the left with the thruster speed/direction control in the neutral position. To switch from Slew to Spin, the stick is blipped to the right. Note that the direction is only changed if the thruster speed control is at neutral (i.e. the thruster motors are not running) and the control is blipped to the limit for less than about 1 second. If it is held over for 1 second or more the direction is not changed. A P95/2 in the circuit will instantly show whether or not the directions have changed by the colour of its LEDs. Practise before you first sail the model! The changeover will only take effect when you apply an amount of thruster speed/direction i.e. it will not be indicated when you blip the Select stick.
R1 can be used to set the maximum voltage for the thrusters. This means, for example, that you can safely run 7.2v thruster units from 12v main motor drive batteries without causing them damage; See Fig #3. To set the thruster voltage, turn R1 fully clockwise. Connect a digital volt-meter across the brushes of the bow thruster motor; power the system up and move the thruster control to full speed (in either direction). Hold it there while you adjust R1 until the meter reads the rated voltage of the thruster. Graupner and Raboesch thrusters units are generally 7.2v while the Robbe ones are generally 6v.

Mode 3: 100% Mixer (See Fig #9) Switch 1 = OFF, Switch 2 = ON

The 100% Mixer mode is a "W-tail" type mixer. If turning to starboard, the port motor is speeded up and the starboard motor is slowed down. If turning to port the starboard motor is speeded up and the port motor slowed down. This mode allows the motors to reverse direction under the control of the steering command. The amount by which the motors change speed is controlled by R1; turn it anti-clockwise to increase the degree of opposite rotation of the inboard motor at full rudder command. Note that if you apply a rudder command *without* any throttle then the motors will go to full speed in forward+reverse; this allows you to spin the model on its axis with no forward speed.

The main throttle output from the receiver connects to P94 lead marked "T" with the steering output connected to lead marked "S". The rudder servo itself should be connected to header pins H1. If the model has a three-motor setup, the ESC to drive the third motor should be connected to header pins H2. Note that both of these connections are made with the Black (negative) wire in the plug onto the outer pins i.e. nearest the edge of the circuit board. **100% mixing is more suited to slow moving vessels that require the maximum degree of manoeuverability e.g. tugs, ferries, fishing vessels and other work-boats.**

Mode 4: 50% Mixer (See Fig #9) Switch 1 = OFF, Switch 2 = OFF

The 50% Mixer mode is more complex than the 100% mixing function, and is more suited to faster vessels e.g. fast luxury cruisers, MTBs and modern lifeboats. In this mode, the outer motor in the turn is not speeded up (unlike the 100% mix). The inner motor is slowed down - the amount by which is determined by the rudder input, but it is not allowed to change direction unless reverse throttle command is given. The sensitivity of the system to the rudder input is set using R1; turn it anti-clockwise to increase the amount of mixing. The connections for Mode 4 are the same as for Mode 3. Note that rudder command with no throttle will NOT start the motors in this mode.

Autoset operation - Overview

Your P94 is fitted with software which now includes full ACTion 'Autoset'. This means that P94 will automatically detect the positions of the transmitter throttle and rudder sticks when you switch on your system, and then lock onto them as its own neutral positions for that sailing session. The effect of this is that you will not need to adjust the transmitter trim levers (as with earlier versions of P94) in order to stop the motors at "dead stop" command or to start them together when you apply some throttle. It also allows the user to operate P94 with the cheaper 2.4GHz systems which have non-standard neutral signal values. We strongly recommend the fitting of spring-centring to the throttle stick of your transmitter; your radio dealer can advise on obtaining the requisite parts or you can contact the RC manufacturer's local service agent to have the job done for you.

NB THIS UNIT WILL NOT OPERATE WITH FUTABA 6J OR 2.4ghz SKYSPORT RADIOS. These sets have a different way of transmitting their signals which cannot be read by P94. The older Futaba 6EX 2.4GHz sets and the 40MHz Skysports are both OK.

Since introducing the Autoset software to P94 it has been apparent that the back-EMF caused by the two motors suddenly changing direction can, in some extreme circumstances, cause the power supply to the receiver to momentarily dip below its critical value. While this has no adverse effect on the receiver it does mean that the P94 software "thinks" that the receiver has been switched off and then back on again. It therefore goes through its full Autoset routine all over again. Unless the transmitter sticks are in the same positions as they were when you first switched on then this will change the neutral stick positions and make the model difficult to control.

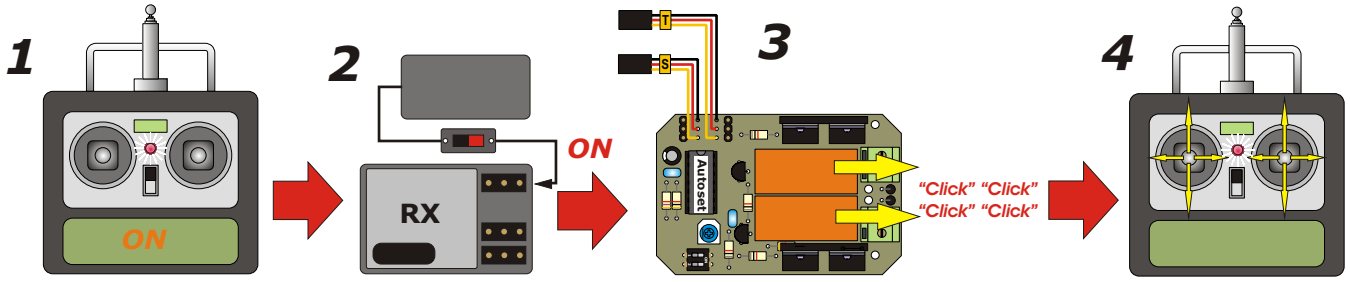
There are several ways to avoid this:

1. Only move the sticks gently and smoothly, especially in Mode 3 where the motors change direction very quickly between neutral and full steering commands. Avoid just letting go of the sticks and allowing them to spring back to neutral, or suddenly applying full throttle in one direction from either neutral or the opposite direction;
2. Do not use a regulated power supply (BEC) from the main motor battery to power the receiver e.g. via the 5v fly-lead on one of our distribution boards P92/P102. Use a separate 4-cell pack instead;
3. If you still have problems then we can supply a DIY-fit microprocessor with non-Autoset software. This simply replaces the plug-in microprocessor already fitted and will be free of charge if you return the original chip afterwards. Illustrated instructions are included to help you do what is a very straightforward job. Contact ACTion for details.

While we have optimised the P94 hardware and software as much as possible to reduce instances of ths problem, it remains a fact that motors will insist on producing a back-EMF when coasting or changing direction, and where there are two motors involved then the effect is doubled.

Autoset operation - Procedure

Follow the procedure shown in the diagrams below. Note that P94 will Autoset every time you switch on the radio; it isn't a one-off "binding" or "setting up" procedure. It is important not to move the transmitter sticks while the autoset is running or the system may not work correctly. After a few seconds - depending on how long your receiver and transmitter take to 'bind' - the relays will click rapidly several times and it is then OK to operate the transmitter as normal. If the model goes out of range then P94 will stop both of the motors, but when the model comes back into range then P94 will resume *with the same neutral positions that it had when you first switched on* i.e. It will NOT autoset again.



Switch ON transmitter *Switch ON receiver* *Wait until relays "click" rapidly* *OK to move sticks*

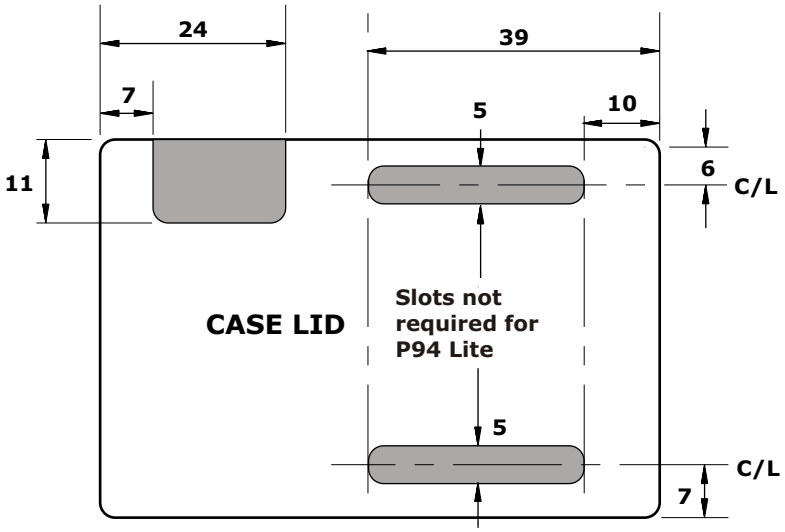
Recovery Service

A recovery or repairs service ensures that you will not be left with a dead unit for any reason.
The fixed price for this service is £22.00 including parts (also includes return shipping cost in the UK).
All returns should include full Credit Card details (Name & Address of cardholder, Account Number, Expiry Date, Card Security Number)

ACTION R/C ELECTRONICS, 1 Llwyn Bleddyn, Llanlechid, Bangor LL57 3EF, United Kingdom

P94

Page 1



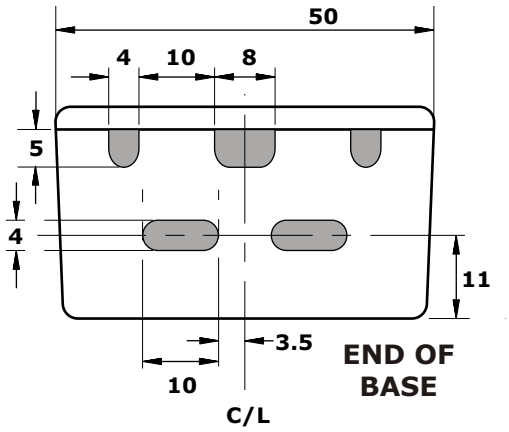
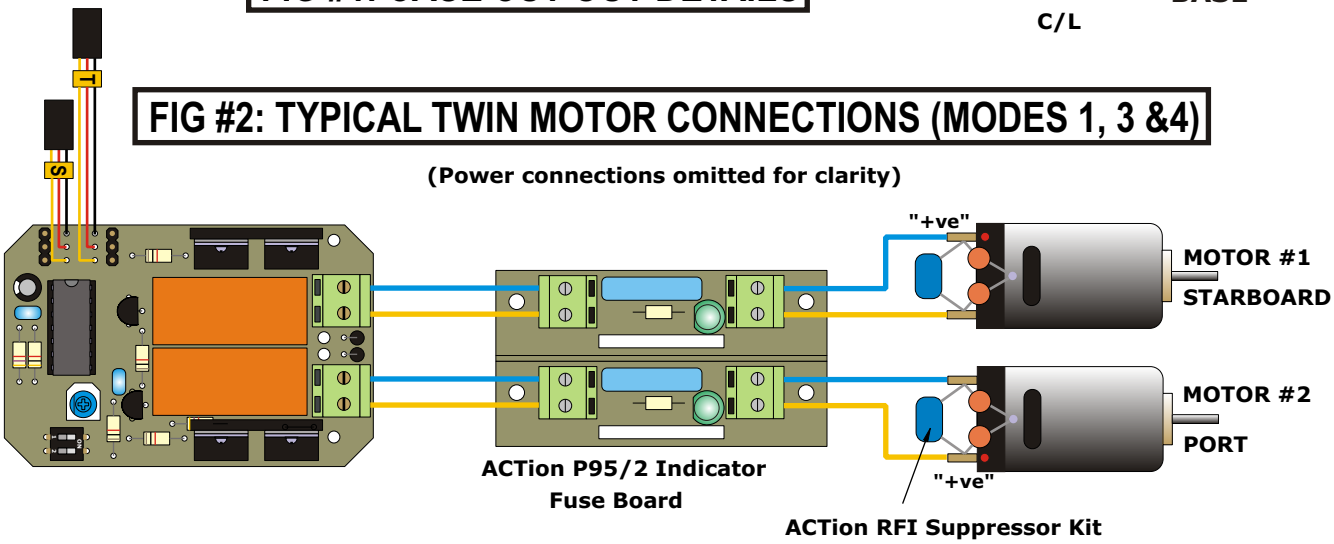


FIG #1: CASE CUT-OUT DETAILS

FIG #2: TYPICAL TWIN MOTOR CONNECTIONS (MODES 1, 3 &4)

(Power connections omitted for clarity)



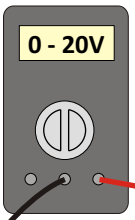
When connected as shown, the LEDs will both glow the same colour when the main drive motors rotate in opposite direction e.g. At Full Ahead speed.

Adjust rudder trim lever of transmitter until the two LEDs "fire up" together when slight forward throttle command is given (does not apply to Mode 1).

Start with R1 turned fully clockwise

ADJUSTING R1 where Vmainbattery>Vthruster

Apply full stick movement to thruster and adjust R1 slowly until Voltage reaches that specified for the thruster e.g. Graupner = 7.2v, Robbe = 6v



Connect digital multimeter across thruster motor brushes; set scale to read 0v - 20v

FIG #3: DUAL THRUSTER CONNECTIONS (MODE 2)

(Power connections omitted for clarity)

Commercial thruster units

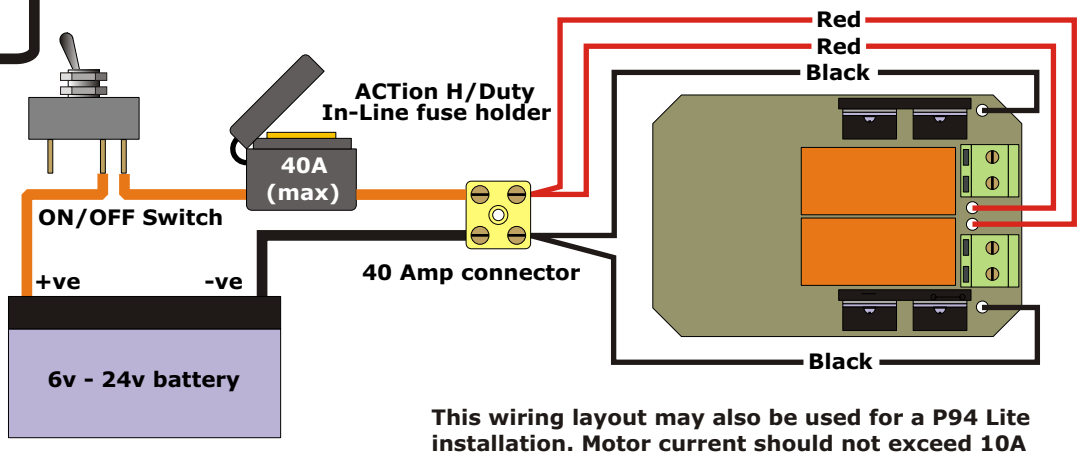
STERN

BOW

Drawn by Dave Milbourn

P94

Page 2



This wiring layout may also be used for a P94 Lite installation. Motor current should not exceed 10A each and a 20A fuse (max) should be used.

FIG #4: BASIC INSTALLATION WITH SINGLE BATTERY

(Receiver & motor connections omitted for clarity)

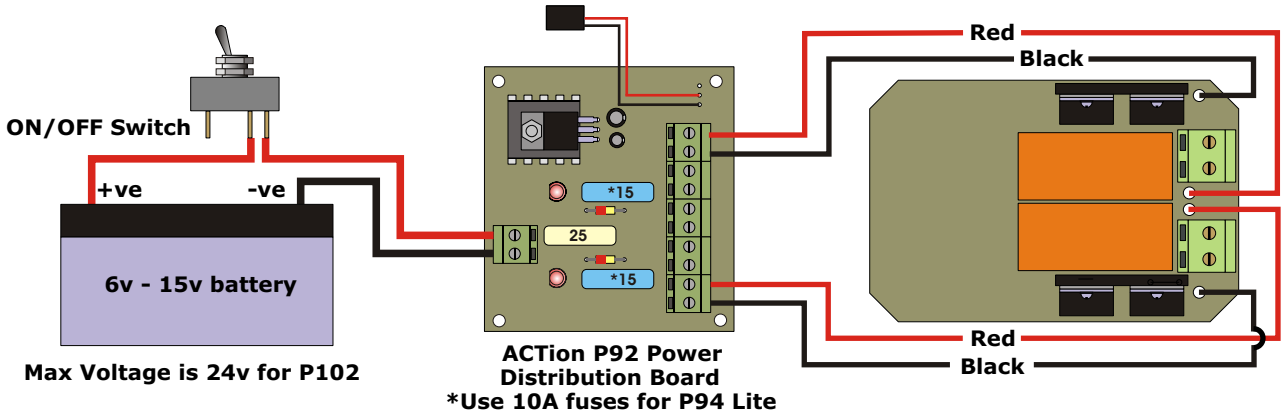
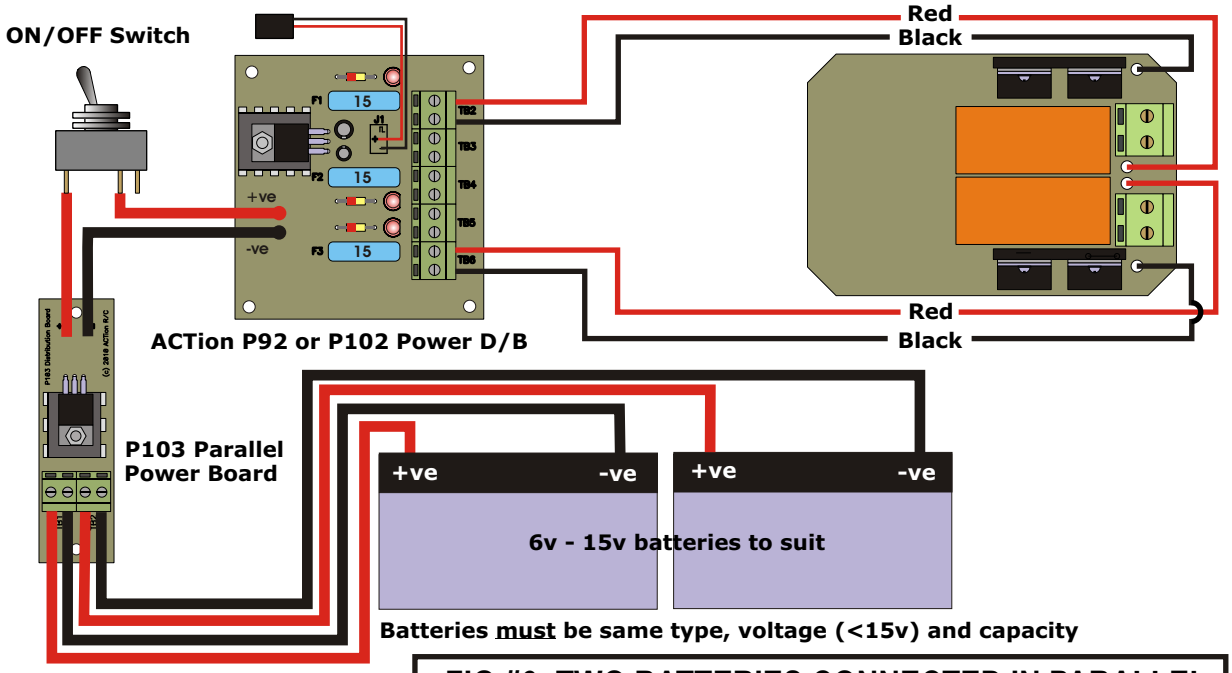


FIG #5: USING POWER DISTRIBUTION BOARD P92 OR P102

(Receiver & motor connections omitted for clarity)



Batteries must be same type, voltage (<15v) and capacity

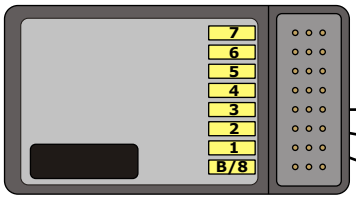
FIG #6: TWO BATTERIES CONNECTED IN PARALLEL

(Receiver & motor connections omitted for clarity)

Drawn by Dave Milbourn

P94

RECEIVER CONNECTIONS FOR MODE 1 (Futaba convention for numbering channels is shown)

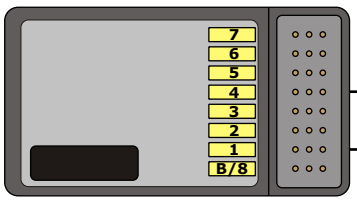


P94 "T" connection
P94 "S" connection
Steering Servo

Steering = RH stick Side/Side
Port Throttle = LH stick Up/Down
Stb'd Throttle = RH stick Up/Down

FIG #7: MODE 1 "TANK STEERING"

RECEIVER CONNECTIONS FOR MODE 2 (Futaba convention for numbering channels is shown)



P94 "T"
P94 "S"

Spin/Slew Select = RH stick Side/Side
Speed & Direction = LH stick Side/Side
Connect Steering Servo to H1 on P94

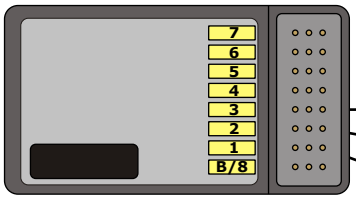
"Blip" Tx stick to Left < 1 second to change from Spin to Slew mode and to the Right to change back.
NB Thruster speed on LH stick MUST be at the neutral position when switching modes.

FIG #8: MODE 2 DUAL THRUSTERS

Drawn by Dave Milbourn

P94

RECEIVER CONNECTIONS FOR MODE 1 (Futaba convention for numbering channels is shown)

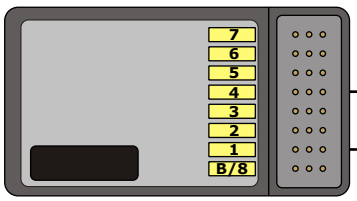


P94 "T" connection
P94 "S" connection
Steering Servo

Steering = RH stick Side/Side
Port Throttle = LH stick Up/Down
Stb'd Throttle = RH stick Up/Down

FIG #7: MODE 1 "TANK STEERING"

RECEIVER CONNECTIONS FOR MODE 2 (Futaba convention for numbering channels is shown)



P94 "T"
P94 "S"

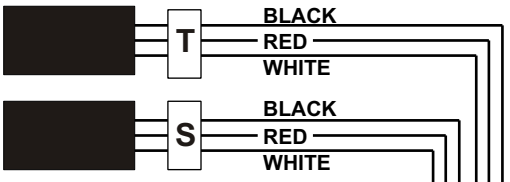
Spin/Slew Select = RH stick Side/Side
Speed & Direction = LH stick Side/Side
Connect Steering Servo to H1 on P94

"Blip" Tx stick to Left < 1 second to change from Spin to Slew mode and to the Right to change back.
NB Thruster speed on LH stick MUST be at the neutral position when switching modes.

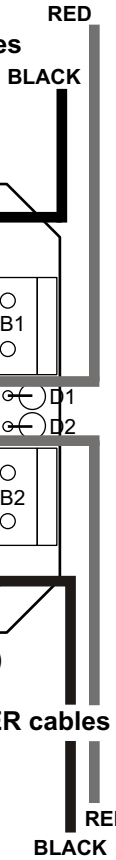
FIG #8: MODE 2 DUAL THRUSTERS

Drawn by Dave Milbourn

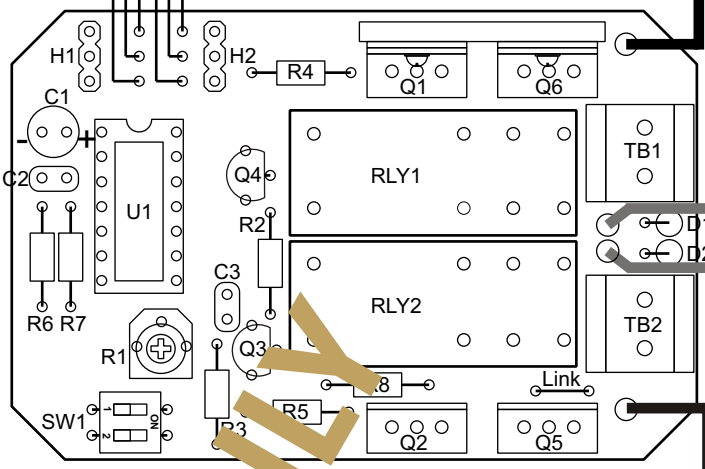
P94 KIT



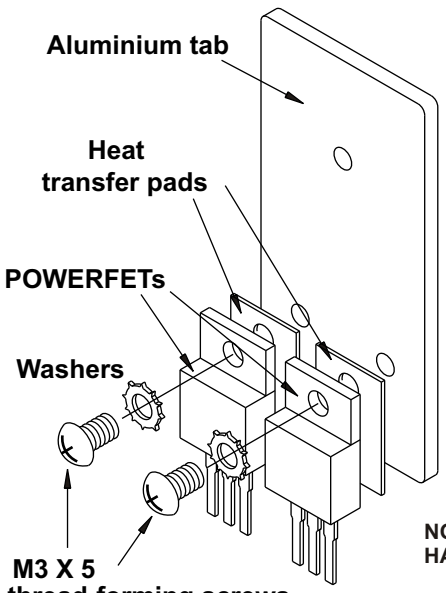
14AWG POWER cables



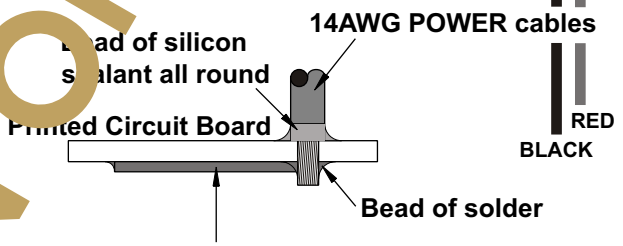
COMPONENT LAYOUT



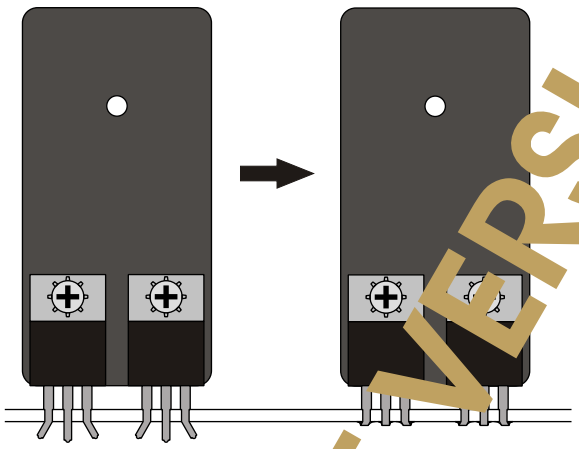
(Heat sink and Q5 not shown in this view)



NOTE: P94 LITE DOES NOT HAVE HEAT-SINKS.



FITTING HEAT-SINK TABS

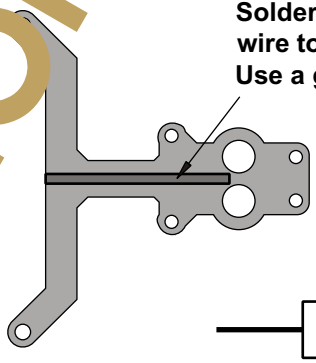


Fit tabs to FETs; push legs through board and bend slightly to secure

Solder, tighten screws and trim off surplus from legs

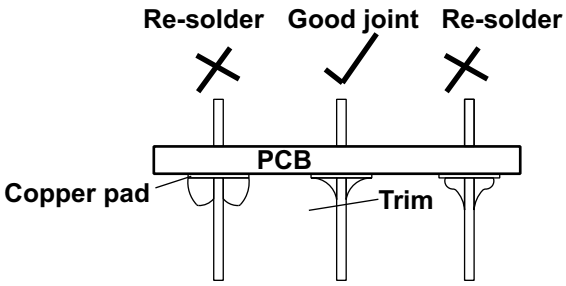
IMPORTANT!! YOU MUST FIT Q1 AND Q6 TO THE PCB BEFORE FITTING THE RELAYS.

Solder 13mm piece of copper wire to copper land as shown. Use a good bead of solder!



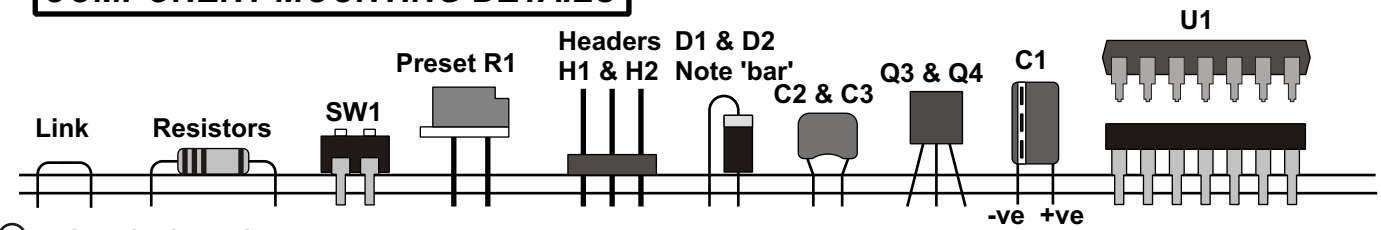
UNDERSIDE OF PCB

RESISTOR COLOUR BANDS



SOLDERING TIPS

COMPONENT MOUNTING DETAILS



P94 KIT INSTRUCTIONS

PCB
The PCB has an insulated (Component Side) and a tinned track side. Components are mounted on the insulated side and soldered on the track side. The PCB for this Project is fully prepared and requires no additional work. Look carefully at the area of the PCB you are working on when soldering to ensure that you do not apply an extra connection with a splash of solder.

TOOLS
For construction you will require a 25W soldering iron with a 3mm wedge or screwdriver-shaped bit and flux cored solder (22 SWG recommended); a small pair of wire cutters, a screwdriver to make connections and, of course, a good level of light. If you have a solder station then set the temperature at 300^{0}.

PARTS - DO NOT HANDLE ITEMS IN BLACK CONDUCTIVE FOAM UNTIL INSTRUCTED. (MOS DEVICES)

1/ The three-legged component with a blue, cross-slotted top is the variable resistor (or 'pot') R1. It should be fitted by inserting the ends of each leg into the PCB and gently rocking the pot from side to side while applying downward pressure to push the legs into the holes.

2/ The short, cream-coloured cylinders with coloured bands and a wire at each end are resistors R2 to R8. Their values are shown in the Parts List below, along with their respective three coloured bands. The other band, which is usually gold, signifies the tolerance and can be ignored.

3/ Diodes D1 and D2 are short black plastic cylinders with a thick wire at each end and a silver-coloured bar at one end. They MUST be fitted as shown in the drawing i.e. with the body of the diode nearest the edge of the PCB and the silver bar at the top. Both fit the same way around.

4/ The tubular electrolytic capacitor (C1) is marked with the value 2u2F (or 2.2uF); it also has a band down one side of the plastic sleeve with a (-) Negative sign on it which signifies which leg goes to the negative. The opposite leg of the capacitor, of course, goes to the positive. The negative lead is also the shorter of the two. Capacitor polarity (+ and -) are clearly shown on the drawing.

5/ The small blue or brown components with two wires are monolithic capacitors C2 and C3. They can be fitted either way round.

6/ The black cylindrical components with a flat on one side and three wire leads are MOSFETs Q3 and Q4 (that's Metal Oxide Semiconductor Field-Effect Transistor, if you want the long-hand version!). They are static-sensitive and should be handled in accordance with the note below. They must be fitted as shown, with the flat face towards the relays.

7/ The 14-pin PIC device (U1) is marked with its type code; see the drawing together with the Parts list. It is delivered in conductive foam and should be left in the foam until you are about to fit it. Being a MOS device, it can be damaged by static electricity and care must be exercised when handling. It is supplied with a socket. This will enable the builder to solder in the socket during construction, then fit the IC at the end of construction.

8/ The MOSFETs Q1, Q2, Q5 and Q6 have three legs and a black plastic body with a silver metal tab on one side. These are MOS devices and care must be taken in handling. They must also be fitted as shown, with the metal tabs all facing the top edge of the PCB when viewed with the screw terminals on the right. You will also find there are two black-anodised aluminium heat-sinks which are fitted one to each pair of FETs, using M3 x 5mm thread-forming screws, shake-proof washers and heat-transfer pads as shown in the Isometric sketch. DO NOT be tempted to leave these off; they are VITAL to cool the FETs when conducting high currents. You should take care not to allow the heat sinks to short electrically either together or with any of the wiring. NB The P94 Lite has INL44 MOSFETs with short tabs and does not require heat-sinks.

9/ The four-pin switch SW1 is used to select the operating mode. It should be fitted with the ON legend towards the terminal end of the PCB.

10/ The 2-way pale green screw connectors are TB1 and TB2, and are rated for 28A current. Make sure you fit them with the openings for the cable towards the outside edge of the board……..it has been known for folk to do this wrong!

11/ The headers H1 and H2 are 3-pin types with the legs on one side of the plastic body longer than those on the other. They are fitted with the shorter legs soldered through the PCB to the copper track below.

12/ The big black plastic blocks with eight pins underneath are the relays which reverse the direction of the current to the motors when the signal is given. They will only fit one way round.

CONSTRUCTION
NOTES ON CMOS DEVICE HANDLING. USE A SHEET OF ALUMINIUM OR TIN TO WORK ON; AN OLD METAL BISCUIT-TIN LID OR METAL COOKING FOIL WILL DO.

Place it on the work surface. Place the PCB, solder side down on it. Place the black conductive foam holding the semiconductor on it; touch the metal with the soldering iron tip and then rest your hands on it, holding them there while you read through this part of the instructions. The PCB, any tools, the MOS devices and you are now all at the same potential, i.e. statically neutral.

I would suggest that you fit the resistors R2 R8 and the short wire link next to Q5 first. Make the link from a piece of the surplus wire cut from one of the resistor legs once they have been soldered in place. Now fit the plastic 14-pin socket for the microprocessor chip U1. Note the small notch at one end of the socket moulding and ensure that it is fitted as shown in the drawing, soldering all pins carefully.

The monolithic capacitors C2 and C3 can be fitted either way round, but C1 (2.2 uF electrolytic) must be fitted with care. The negative marking on the sleeve faces the outside edge of the PCB. Fit the diodes D1 and D2, following the instructions above and on the drawing, followed by the headers H1 and H2 and MOSFETs Q3 and Q4. Next fit the DIL switch and the variable resistor R1.

Fit the MOSFETS Q1 and Q6 loosely to their heat-sink tab, following the anti-static routine already described. Fit the assembly into the PCB as shown in the drawing. The components' legs should be pushed right into the PCB up to the point where they widen to prevent them from going any further in. Finally tighten the screws (but not too much or you will strip the thread in the aluminium). If you don't fit these two FETs before you add the relays then it will be very difficult to tighten the screws afterwards……don't ask how we found out! The corresponding FETs Q2 and Q5 can now be fitted, as there is no restriction to access the screws holding their heat-sink. For P94 Lite, simply solder the four MOSFETs into the holes in the PCB, with the short metal tabs on the same side as those shown for the P94 MOSFETs.

Fit the two relays into their holes and solder, followed by the two terminal blocks TB1 and TB2.

Strip about 1cm of the covering from one end of the 14AWG red silicone-covered cables; twist the bare strands tightly together then tin them well with solder. Snip the ends off at about 45º, ease the tinned end through the PCB and solder underneath. Cut a 13mm length of tinned copper wire and solder it as shown to the copper track under the PCB, between the +ve lead inputs and the place where the track divides to feed both relays. Using a hot iron, apply a good bead of solder around the whole area here to help conduct the very high currents which might be encountered.

Fit the black power cables in a similar way. Before you put the unit into its case, you are advised to apply a bead of silicone sealant all around the power cables where they fit into the top of the PCB, to assist with their support. Also you should NOT subject them to any sharp bends inside the case, which might weaken or fracture the solder joints.

Strip about 6mm of insulation from the end of each wire on the receiver connector leads; twist the individual strands or each separate wire together and tin them with solder. Clip off the end at about 45 degrees then push them into their respective holes in the PCB and solder. MAKE SURE YOU FIT THEM IN THE RIGHT ORDER OR YOUR UNIT WON'T WORK. We have supplied a couple of appropriate cable markers for you to fit to these leads ("S" and "T"); it's easier if you do this BEFORE you solder them in place, but not impossible to rectify if you either forget or fit them the wrong way around initially!

The 14-pin IC should be plugged into the IC socket as the last operation of construction. Ensure that the notch at one end of the PIC corresponds with the notch in the plastic socket which you fitted earlier. Clip off all surplus component leads from underneath the board.

WARNING - DO NOT use the black foam as a packing foam in the finished unit, it is **CONDUCTIVE.**
The rear of the board can now be cleaned with something like an old toothbrush and some spirit cleaner. Meths will do but Isopropyl is very much better. Then check all over the soldered side of the board for good joints and no solder bridges between tracks or round pads. That's the PCB construction completed.

CASE
Refer to the dimensioned drawing. File out three slots at the top edge of one end of the case (not the flat part with the screw-holes, which is the lid, but the deeper box part) so that the main power connector cables can exit the case after the lid has been screwed down. Cut away the lid where shown for the receiver connecting leads. Mark and cut out the holes for the heat-sinks in the lid, and the main motor connections in the base. This is easiest if you stick masking tape to the case first and use a sharp pencil to mark out. Drill a series of small holes e.g. about 3mm diameter, just around the inside of the marked line; snip the web between the holes with your side-cutters and push out the waste material. Using a fine warding file, file back the ABS to the marked line; remove the tape and de-burr the edges of the holes with a sharp blade. If the heat-sink tabs foul on the case lid, you may bend the legs of the FETs *slightly* to realign the heat-sinks; be careful not to allow anything to short against anything else, however.

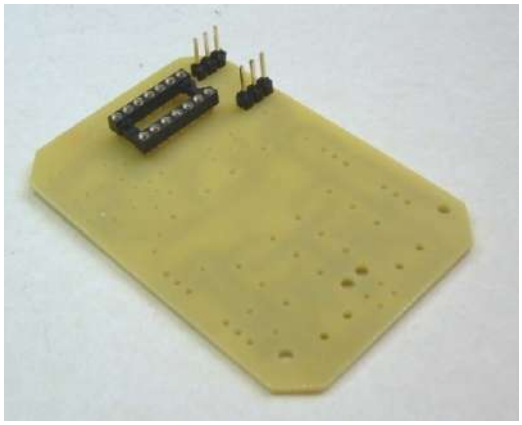
WIRING
See the notes on the accompanying leaflet. Use a good quality PVC- or silicone-insulated cable of at least $2mm^2$(16AWG) for the motors. If you adopt the single battery connection shown in Fig #4, you MUST use at least $4mm^2$(12AWG) cable for the connections from the block to the battery. ACTion list a heavy-duty ceramic connector block and also a high-current in-line fuse-holder. Check the latest lists for details.

PARTS LIST

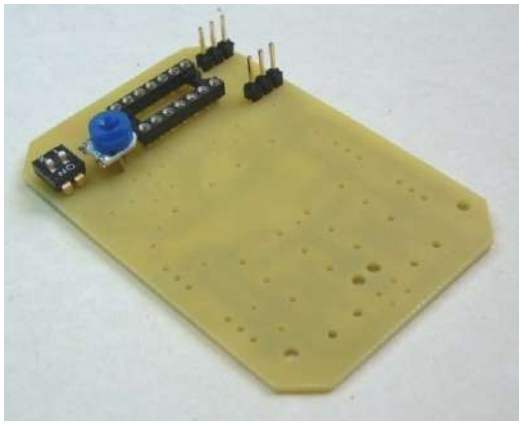
R1	10K variable resistor
R2, R3	100R 1/4W resistors BROWN/BLACK/BROWN
R4, R5	1K 1/4W resistors BROWN/BLACK/RED
R6 to R8	4K7 1/4W resistors YELLOW/**VIOLET**/RED
C1	2u2F 50v electrolytic capacitor
C2, C3	100nF (0.1uF) monolythic capacitors (Marked 104)
D1, D2	1N4007
Q1, Q2, Q5 & Q6	NDP6060L MOSFETs (P94 Lite = INL44)
Q3, Q4	2N7000
U1	PIC16F684 with 14-pin socket
SW1	2-way DIL switch
H1, H2	3-pin header blocks
TB1, TB2	2-way screw terminal blocks 28A
Relays (2)	8A 5v SRRHN-2CN-SL-5VDC type
Case	Rx 2010 with screws and ACTion sticker
Printed Circuit Board	P94 type 4oz copper track
Heat Sink Tabs (2)	Black anodised aluminium with M3 x 5 thread-forming screws, washers and heat-transfer pads
Rx Leads (2)	JR/Hitech type, with S and T cable markers (Futaba plug shell also supplied)
Power leads	2 each 14AWG x 200mm silicone-insulated (Red and Black); P94 Lite = 16AWG

P94 DUAL ESC/MIXER (Page 1)

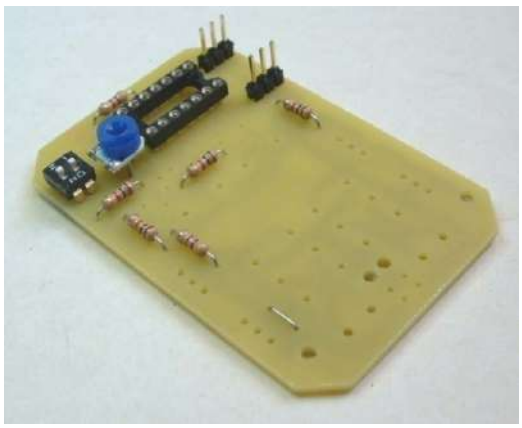
Assembly sequence for kit version



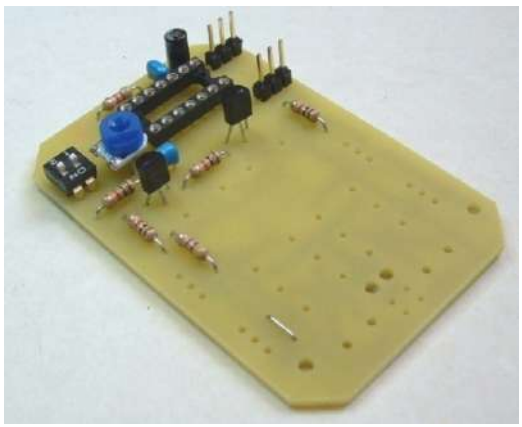
PICTURE 1: IC socket & headers fitted



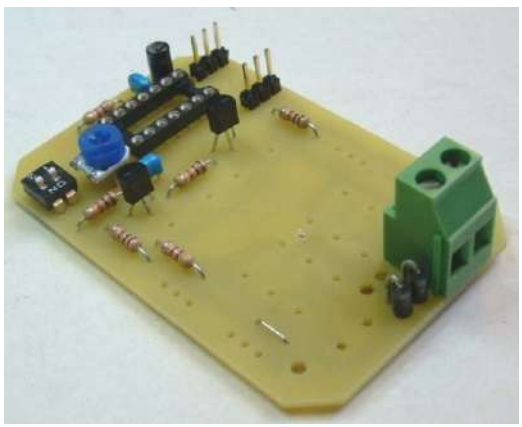
PICTURE 2: R1 preset and 2-way switch



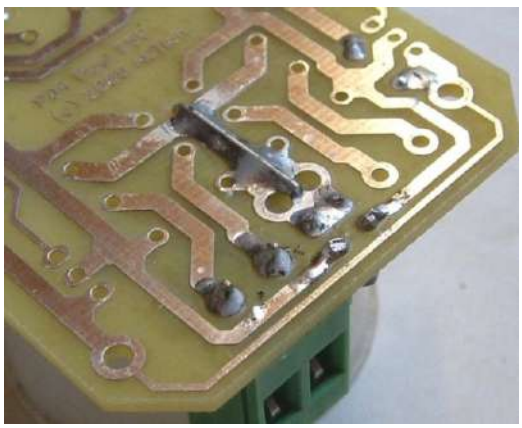
PICTURE 3: Resistors & wire link



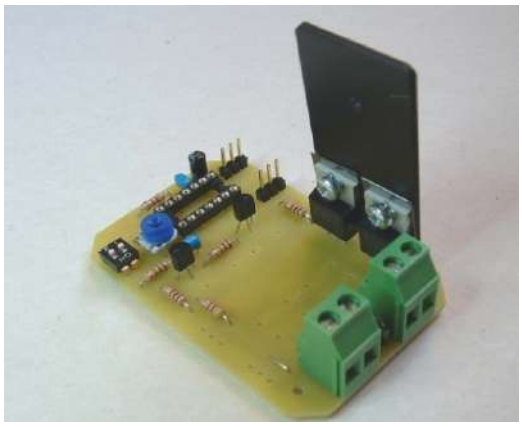
PICTURE 4: Capacitors & switching FETs



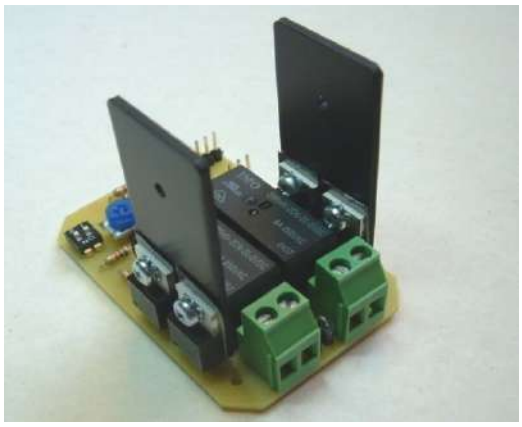
PICTURE 5: Diodes & terminal block TB1



PICTURE 6: Close-up of reverse of PCB showing copper wire shunt

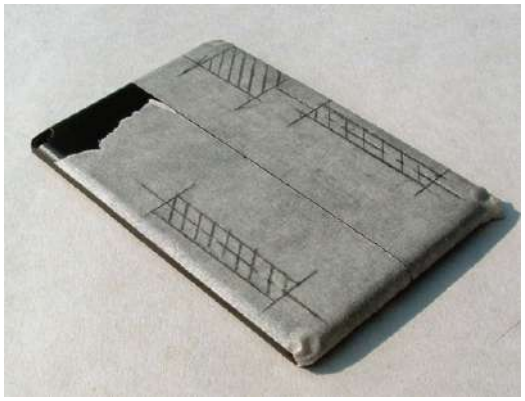


PICTURE 7: TB2 and first pair of MOSFETs with heat-sink tab fitted

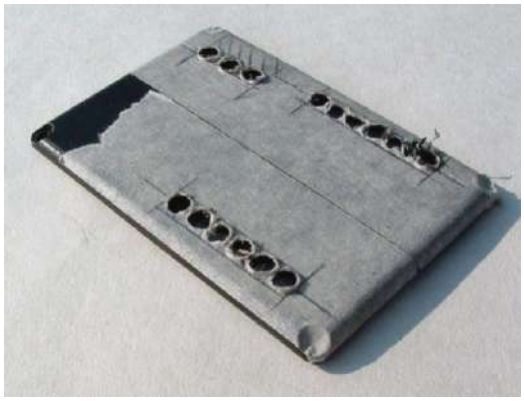


PICTURE 8: Relays & second pair of MOSFETs with heat-sink tab fitted

P94 DUAL ESC/MIXER (Page 2)



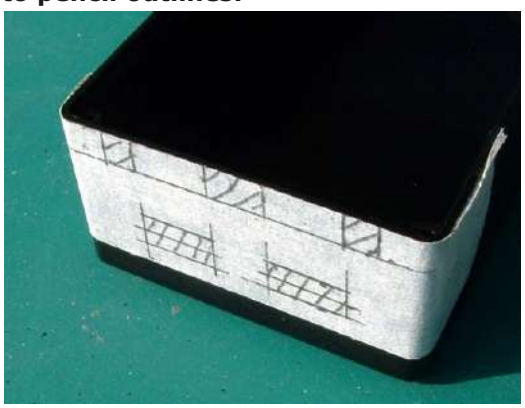
PICTURE 9: Cover lid with masking tape and mark cut-outs with sharp pencil



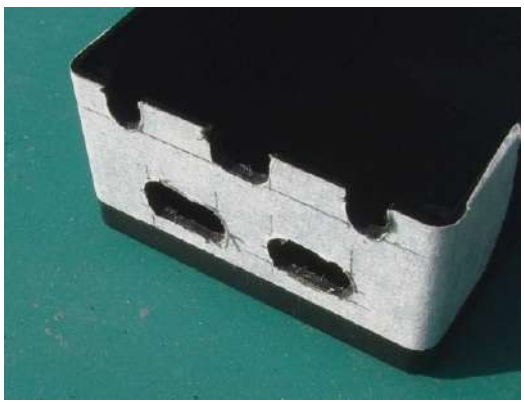
PICTURE 10: Drill a series of holes within outline of cut-outs

PICTURE 11: Snip between webs with side-cutters; push out surplus ABS. Use warding files to file back shape to pencil outlines.

PICTURE 12: Remove masking tape and clean up filed edges with a fine file or scrape smooth with a sharp knife-blade.



PICTURE 13: Tape and mark out holes for cables in end of case



PICTURE 14: Drill and file back to pencil outlines; clean up edges as shown