

MOSFETs

MOSFETs do fail occasionally, but in practise failures are very rare. They are doing an enormous amount of work and sometimes one simply gives up: commonly the drive MOSFETs cause their drive resistors to burn up - a sure sign the MOSFET has failed.

Relay drop-out

A flat battery or wiring which is too thin can cause excessive voltage drop. If the supply voltage gets to low then, on the 24v controllers, the battery discharge protection operates and reduces controller performance.

On the 12v controllers, discharge protection is not

18 Service & Guarantee

All 4QD's products carry the normal 12 month guarantee. Outside the guarantee period, or when the fault is caused by misuse, we will repair the controller at a fixed price.

Service charge, Pro-120 £22.50

If the fee is prepaid, 4QD will pay VAT but if an invoice has to be raised, carriage and VAT will be charged extra.

19 Other products

4QD manufacture a full range of controllers: from our Eagle and 1QD series through to our high current 4QD series (up to 300 amps, 48v) as well as a range of extras such as LED voltmeters for 12v and 24v, joystick interfaces and a timer for 'stand-off' operation in golf caddies. We also manufacture controllers for golf caddies, golf buggies, kiddie cars, wheelbarrows, conveyors and other battery motor uses.

fitted as standard - so the internal 9v rail can drop. If it does, the relay will drop out, switching off the controller. The controller will work happily down to 10.5v (the minimum you should discharge a battery).

Sticky relays.

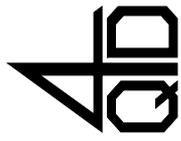
The power relays are switched by the controller at low current so are very reliable. However a wiring error can cause an arc at the contacts which are delicately balanced against the spring to maximise contact pressure. So a small arc can, on occasion, cause a relay to stick. If a relay does not click when expected, it is worth tapping it with a screwdriver handle, to see if it is sticking.

This offer does not apply if the controller has been modified in any way or if the controller is returned attached to any customer's metalwork: such alterations/additions mean the controller won't fit 4QD's test jigs and an extra charge will be made for handling and postage, even when the controller is covered by the guarantee.

It also saves postage (both ways) if the controller is returned without the base plate attached.

20 More information

A manual such as this cannot cover all the points everyone may need to know. If you require more information, the best source is 4QD's Internet site, where there is a wealth of 4QD technical information on motor control.



"We're in Control"



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Instruction Manual

Pro-120 series controllers

Issue 8 and above

Foreword

4QD try to write a manual which is readable. If we succeed and you don't read it there is not a lot more we can do. However if you try to read it and don't understand it (or even don't like our style) - then we have failed so please tell us. Only by means of your criticisms and suggestions that we can improve our publications! To help you, we have marked the more technical sections ¶ so that you may ignore them.

If you have any problems or queries, 4QD pride ourselves on our level of technical advice and if we put as much information into this manual as we could many would find it too long. If you require more information, please ask. Alternatively we have a publication called 'Battery Motors & Controllers' (PUB-BMC) which contains answers to 'Frequently Asked Questions'. This is available for a small payment and answers all your questions including the ones you didn't know you needed to ask!

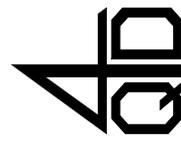
Applications

4QD's Pro range of 4 quadrant controllers are well suited to general purpose speed control applications where reversing is required. They are used extensively by hobbyists and industry.

Amongst other applications our controllers have been successfully used in the following:

Camera dollies
Caravan shifters
Carnival floats
Conveyors
Factory stores vehicles
Floor cleaning machines
Golf buggies
Invalid scooters
Kiddie cars
Miniature railways, 3", 5" and 7¼ gauge
Mobile targets
Mountain rescue vehicles
Remote controlled vehicles
Ride on golf buggies
Winches

In fact wherever battery motor speed control is required



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30th January 2003

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1 Introduction

4QD's NCC-Pro-120 is a reversing motor speed controller for battery operated vehicles covering currents up to 120 amps. They are available for operation on voltages ranging from 12v to 48v. They are high frequency chopper drivers giving control of motor speed both in drive mode and in braking mode. They use MOSFETs in state-of-the-art high frequency circuitry to give best possible performance and battery economy. The controllers incorporate many advanced features such as reverse polarity protection, regenerative braking, independent, linear, adjustable acceleration and deceleration ramps, controlled performance at power down, reverse speed reduction, dual ramp reversing, pot fault protection, thermal protection and electromagnetic brake driver. Many of these features can be disabled if so required.

The Pro-120 is available either for 24v operation or for 12v operation. Models can also be supplied for 36v and 48v

2 Models

The voltage is marked on the relays. Make sure this are correct as 24v relays will not operate from 12v and 12v relays will soon burn out if used on 24v. 4 different power terminal options are available.

The standard model is suitable for permanent magnet

The nameplate current quoted for motors is normally a continuous rating; most motors will safely take an overload of about 400% for short periods.

The current the motor actually requires is determined by the mechanical loading, not by the controller or the motor. If the motor is too small, it will overheat and if the controller is too small, then it will overheat. For more information on motors, contact 4QD.

17 Common faults

There are no 'common' faults: as soon as 4QD find a fault which occurs often enough to recognise it as a problem, we try to alter the design to eliminate it. This policy makes it difficult to give you sensible fault finding tips - but it does improve our product!

Most controllers returned for attention are either nor faulty or have been damaged by 'foreign bodies': nuts and bolts in the works or water or something similar.

Controller appears to be dead

Check the High Pedal lockout and the pot you are using. HPL0 and pot fault detector are intended to detect faults and stop the controller from working.

Fuse and fuse tracks

These are present to prevent major damage to the controller is there is an external wiring fault.

They are two special sections of track which should blow if a major fault occurs in the controls or the brake (connected to the 6 pin and 3 pin input connectors). They are situated beneath the input connectors on the back of the board. They are thin 'waists' in the track and are as shown in the diagram, right. If one fuses, solder a fine piece of wire over it - one strand from 7/0.2 cable is fine.

If you cannot cope with fixing the fuse track, should it blow, then you should fit the fuse shown in the 'Connections' diagram, page 7. Use a 1 amp fuse.

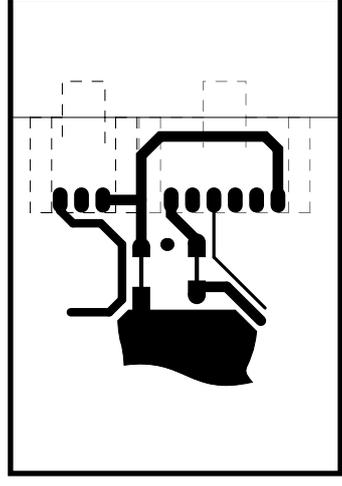
Overheating

Beware of sustained overheating: the heatsink can operate up to 95°C but not more (the overheat sensor will operate).. The main decoupling capacitors may get warm, but should not be allowed to remain too hot to touch for too long.

The other limit is the soldering to the relays: the current is limited just below that required to cause the solder to melt!

IDC wire size

Some problems are caused by the use of the wrong wire size or type in the IDC connectors. Wire that is too thin may make poor contact. If it is too thick(16/0.2) it may cause shorts. Single stand wire can break.



15 Waterproofing

The cover is a vacuum forming which is waterproof. The circuit board is varnished - this resists humidity and condensation. The cased assembly is best mounted with the heatsink at the bottom: water may run over the aluminium base with no problem - in fact water on the base would have to be about 10mm deep before it touched anything electrically live.

In the mouth of the cover you should fit a splash plate (supplied with the cover) in the position shown in diagram 6. The splash plate should be sealed/glued in place with suitable silicone rubber (Dow Corning 734 RTV) between plate and circuit board. Run a fillet of rubber along the top edge of the plate and push it up to the relays. Leave the assembly board-side down while the rubber sets so that it runs down to the circuit board forming a seal. When supplied as a controller with case, 4QD will fix the splash plate in position.

16 Choice of motor

All speed controllers should only be used with good quality motors. Old, dirty motors can have damaged, worn brushgear and this causes arcing. On occasion arcs at the brushes can cause seemingly random controller failure. Fortunately this effect is quite rare, but it's best to be careful.

Ideally the motor should include an internal suppression capacitor, a ceramic type of 10n value is ideal. If the motor does not include this you are advised to fit one across the brushes as close as possible to the motor body. The controller will work without this capacitor, but it can lengthen the life of the system.

A word of warning: many car type motors have the chassis connected to one terminal. Take great care with these as you could easily short the controller out - which would be fatal. It is best to avoid these motors. Otherwise either make sure the motor is mounted on insulation (including the drive shaft), or make certain that no other point of the control system can be earthed to chassis. If in doubt contact 4QD.

3 Safety

Handling

Before handling the controller, disconnect the batteries and short out the controller's battery input terminals. This will discharge the main capacitors, which otherwise can store charge for many hours. If any foreign body contacts the board while these capacitors are still charged, the controller may be damaged.

MOSFETs tend to fail safe (i.e. open-circuit) so failure to full speed is very unlikely. However, if the controller is not mounted properly water might get onto the board: no designer can make a controller operate properly under these conditions.

The Pro has a power disconnect relay and special sensing circuitry. If the ignition switch is switched off at full speed then internal circuitry ramps the controller down, slowing the machine. When the controller's output stops switching (i.e. at zero speed), the power relay switches off.

Reversing on the Pro series controllers is 'dual ramp'. This means that, when the reversing switch is operated at speed, the controller slows down under control of the deceleration ramp, automatically reverses and accelerates again under control of the acceleration ramp. If the ramp controls are set for quick response this process can be quite violent.

Also, reversing is done by monitoring the demand speed, after the ramping circuit and not by measuring the motor voltage. Therefore, if the vehicle is reversed when going down a hill, motor will still be rotating and the vehicle will be travelling when reversing occurs. Reversing can therefore be accomplished on any hill but it will be more or less violent depending on the setting of the ramp controls. The user is however best advised therefore not to reverse at speed - though this will not damage the controller. We make no guarantees about the mechanical effects!

Regen Braking

Regenerative braking is generally very reliable. However, it works by feeding power back into the battery. If your battery is already fully charged then regen braking may have difficulty in operating as it has to overcharge the battery. A similar problem exists if the battery is disconnected, or the wiring faulty.

There are several options as to how the controller should react under such fault conditions so if in doubt, ask!

In any case, all passenger carrying vehicles should be fitted with mechanical brakes: it is unwise to rely on the battery as an emergency brake!

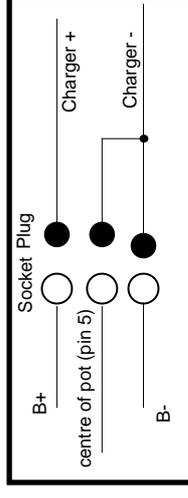
Charger Inhibit

Some machines have in-situ battery charging. Other machines are designed so that the batteries have to be removed for charging. Where the batteries are left connected during charging, it may be considered desirable to stop the user driving off before disconnecting. This is the function of 'Charger inhibit'.

The Pro-120 has no separate inhibit input, so it is necessary to be a little clever with the existing inputs. Ideally you could use a switched socket for the charger. This is a socket with an auxiliary switch which is broken when the (charger) plug is inserted. Such a break switch should be wired in-series with the ignition switch, so the ignition cannot be activated when the charger is connected.

Failing this, you can use a third pin on the charger connector, wired as shown below.

When the charger is inserted, the link is made,

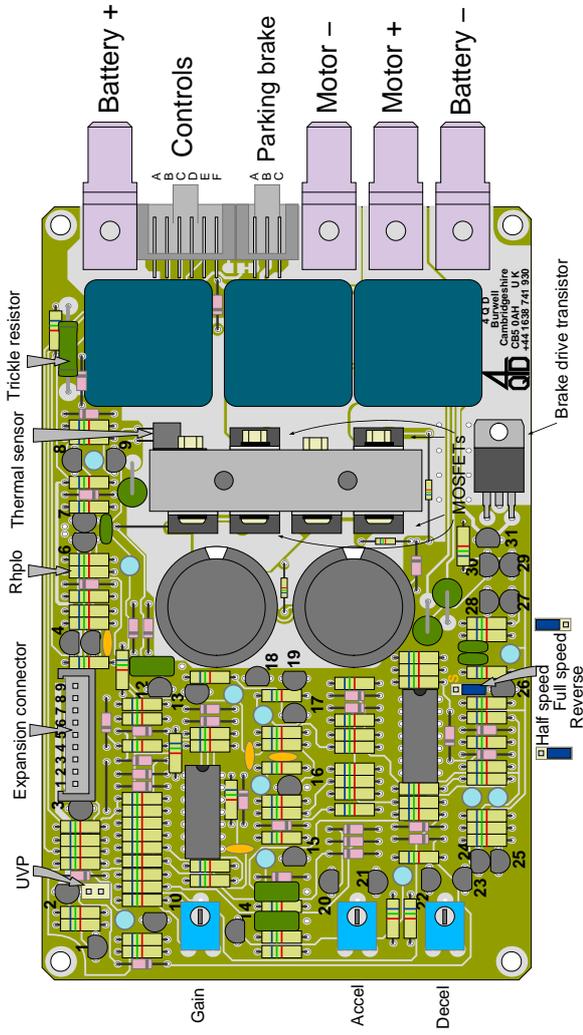


shorting the wiper of the throttle pot to battery negative. Even if the ignition is now switched on, no speed can be selected so the machine cannot drive.

The female part should be on the vehicle with its sockets arranged so no metal object can touch them when the charger is unplugged.

Most 3 pin connectors have one pin advanced so that it is the first to make contact. This pin should be battery negative since, if any other pin made contact, battery positive could be applied back to the pot wiper with destructive consequences!

4 Features

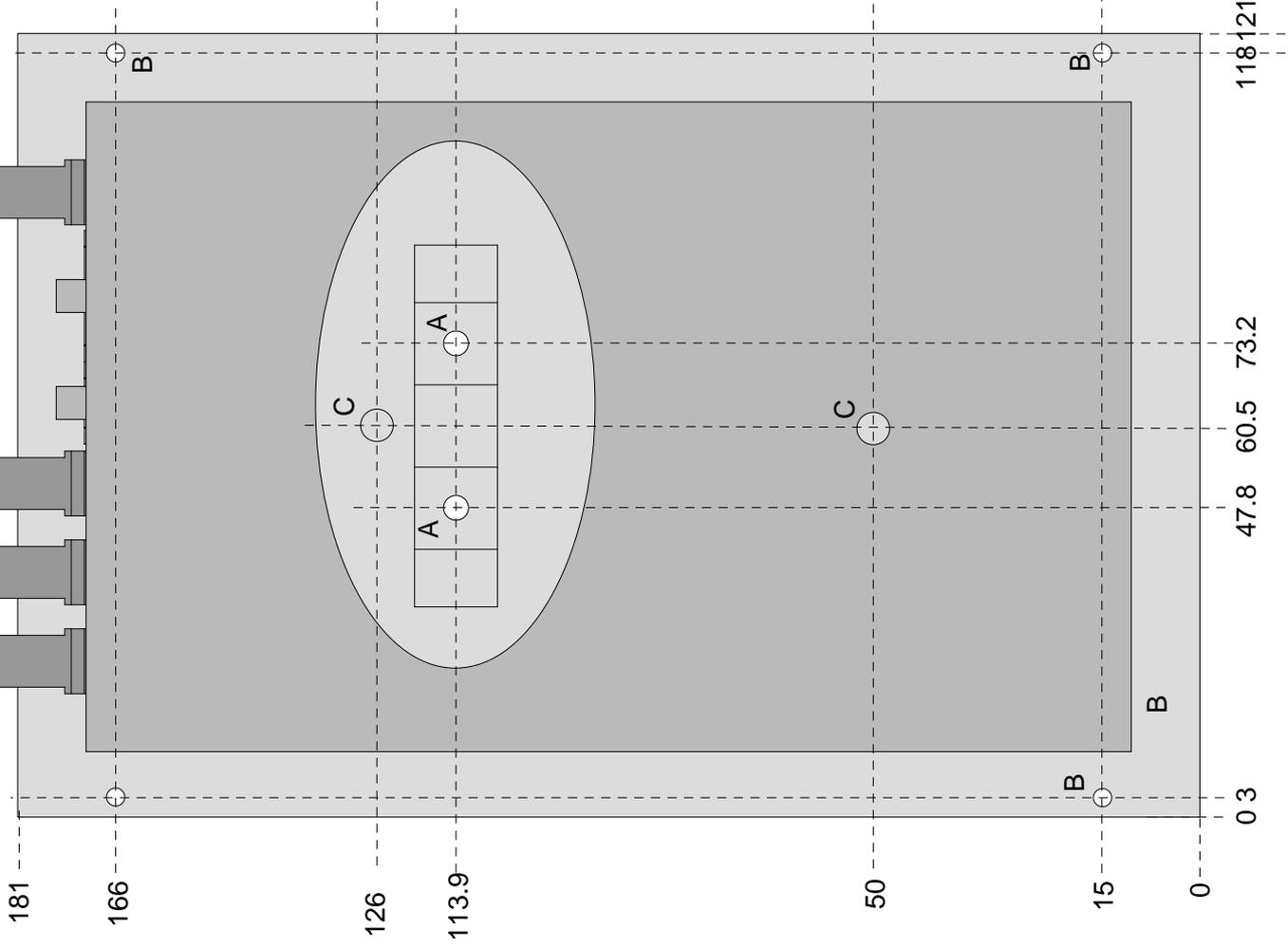
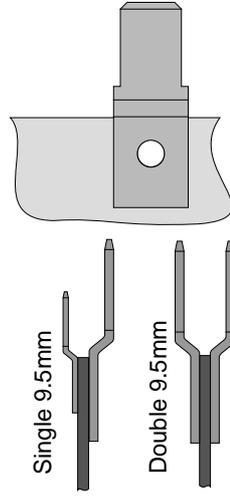


For shipping, the connectors are inserted into the sockets on the board.

The diagram shows the standard Pro-120 (issue 08 and higher) which has double 9.5mm motor tabs, for one or two motors and single 9.5mm battery tabs. Also fitted on the battery terminals is a set of 6.3mm blades, to connect a charger or for similar purpose.

Optionally the controller can be supplied with other tags, for quantity orders.

Also available is an expansion connector option as shown above, see section 12.



13 Heat & Heatsinking

The long time current the controller can give is limited by the build up of heat in the heatsink. The controller will give over 10 amps for one minute - this is limited by the heatsink and by heating in the printed wiring, relays and other components. For periods of more than a minute you need an external heatsink to remove heat. The available continuous current will depend on this external heatsink.

Steel is not a good heatsink material: heat does not flow easily in steel. Aluminium or copper is far better. If you have a steel plate, sandwich an aluminium sheet between the steel and the Pro to

spread the heat.

For really arduous use we suggest heatsink compound between the Pro's heatsink and your own: this helps heat flow across the join. Make sure both surfaces are flat and free of grit.

NCC-Pro-120 incorporate a thermal sensor which cuts back the output current if the controller gets too hot (95°C) so the available current is (only) about 25 amps. At this current the MOSFETs will dissipate about 20 watts. This is still enough to keep the heatsink hot so don't rely too heavily on it!

14 Base and cover option.

(opposite page)

The diagram shows the dimensions of 4QD's base which is available as an option.

Two A holes are for mounting the Pro-120's heatsink onto the base plate.

Four B holes are for mounting the cover.

Two C holes are mounting holes in the baseplate.

The board is shown cut away (the oval hole) to show the position of the Pro 120's heatsink block.

Base and cover are available separately so you may use your own base.

The cover is supplied with four plastic 'push rivets' which locate in the 'B' holes.

Alternatively the cover may be fixed by using double sided adhesive tape around the rim of the cover.

5 Specifications

Supply voltage	12v or 24v or 36v or 48v	different models
Supply current	30mA	at zero speed
Motor speed	forward reverse	adjustable speed reduction may be disabled
Output current (typical)	Current limit 135 typical 100 amps 60 amps 30 amps or more:	without additional heatsink! without additional heatsink! heatsink dependant.
Regenerated current limit	100 amps	on heatsink
Overheat temperature	95°	factory adjustable
Overheat current	25 amps typical,	approximately
Switching frequency	20kHz	board only
Size	160 x 102mm x 40mm	
Weight	325g	
Input	5k to 25k pot.	adjustable
Input voltage	3v minimum for full speed	greater than 30K
Acceleration time	Pot fault detect	adjustable
Deceleration time	330mSec to 7 Sec	adjustable
Battery discharge Protection 15v	330mSec to 7 Sec	inactive

6 Mounting

The NCC Pro is designed for mounting via the heatsink as in the diagram below. This also shows a section through the optional base and cover. This mounting will normally be on to a metal chassis which will act as additional heatsinking but, in most applications, full current is only drawn for short periods so little heating will be experienced.

However, the Pro's heatsink is a thick block of aluminium which won't cool down quickly to the air if it does get hot so some heatsinking should be used. A suitable metal plate which will usually be the vehicle's chassis.

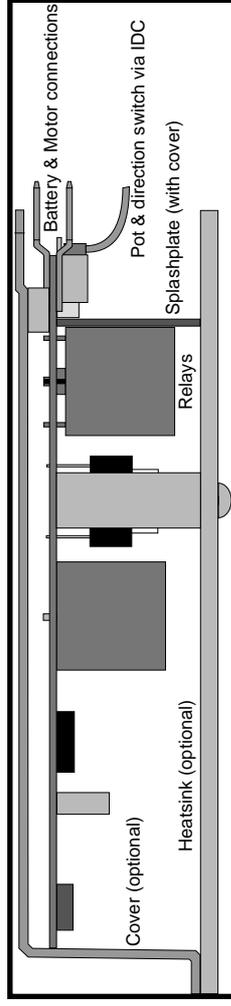
For sustained high current use you must use a substantial extra heatsink with heatsink compound on the joint between the Pro's block and your heatsink. The Pro 120's heatsink is not connected to

the rest of the circuitry. Mounting holes are tapped M3. You can also mount the controller in a diecast aluminium box, e.g. Eddystone 26827PS.

Optionally a base/heatsink and cover is available for the NCC-Professional - see section 14.

Corner mounting holes are also provided if required but the additional support is unnecessary so we recommend mounting only by the heatsink.

Whatever you do, make sure the controller can't get wet and, if it does, *don't connect the battery* until you have dried the controller thoroughly. The water won't cause damage unless the unit is connected to the battery, when electrolytic corrosion will occur. See also section 15.

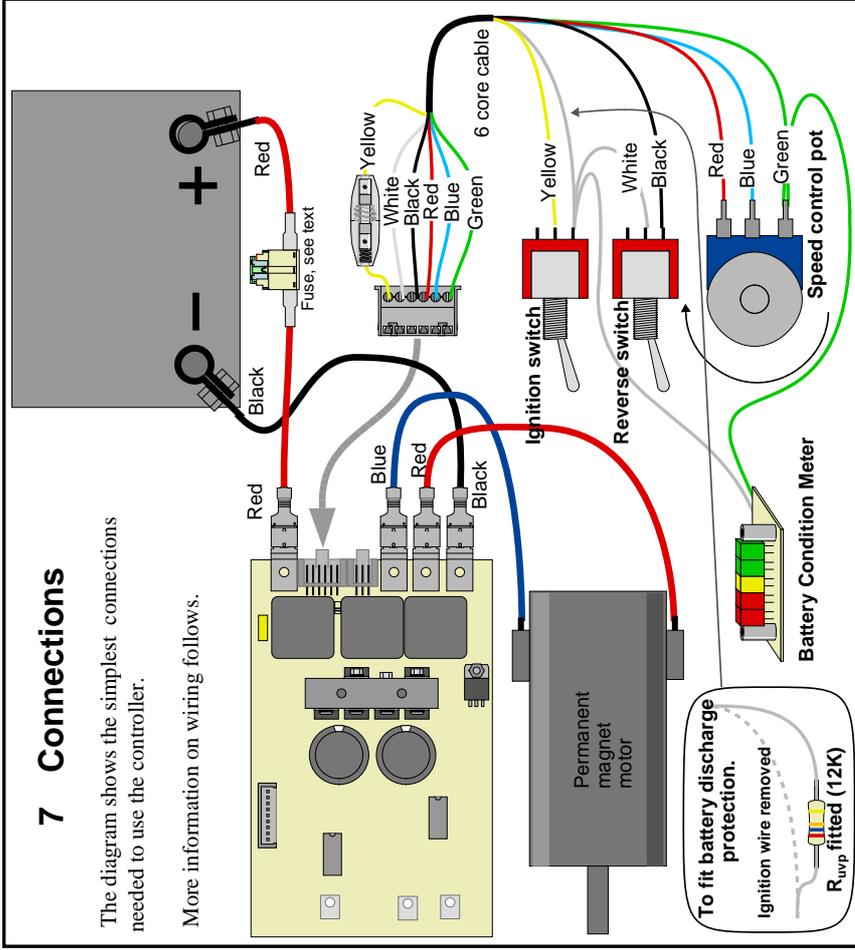


Pro-120 controller instructions

7 Connections

The diagram shows the simplest connections needed to use the controller.

More information on wiring follows.



Yellow is directly connected to battery +ve. White and black may also be battery +ve (depending on the control switches). Green is battery -ve and blue and red are the control pot. A short circuit in the wiring between these two groups will cause problems!

Fuse in yellow wire is optional! See p 15.

8 Power Connections

8.01 Battery wiring

Battery connections to the controller are shown in the diagram above. Use only good quality battery connectors: the controller feeds current back the battery during braking and if a battery connector falls off when braking this regenerated current can pump up the voltage on the dud battery connection. Although the controller is protected against damage, this is not advised since control is lost. The same will happen if a fuse or circuit breaker opens during braking.

Wire size.

Use heavy duty wire for the battery leads and make them as short as possible. This also applies to the battery linking wire on 24v systems.

4mm (12awg) wire is 'officially' rated to handle 41 amps continuously. At 100 amps it gets too hot to touch within about 60 seconds. We therefore suggest you use at least 6.0mm² (10awg) wire for battery connections.

On the 12v controllers, voltage loss in the wire is important and you may need to use two lengths of

11.04 ⚡ Current limit.

Current limits (on drive and on regeneration) are pre-set: they can be altered by value changes, but this should only be undertaken by the technically proficient — 4QD's guarantee will not cover damage done by inexpert modification. Contact the factory for details.

12 ¶ Expansion connector

This 9 way connector may be fitted as an option. Additional features (such as tachogenerator closed loop control and IR compensation) can be added here. It is also for ganging two Pro-120 controllers together, to drive two motors simultaneously, when the combination can control up to 240 amps of motor current, making the combination quite suitable for even high performance ride-on golf buggies. For quantity orders 4QD can supply a slave version - contact the factory for more information.

Double heading

When two standard controllers are used, one is the master the second is the slave. This combination might be used, for example, in an electric railway for 'double heading' a train with one engine at each end. The controller which is to be the slave should have its ignition switched off, it will be controlled by the master.

The slave controller need have only battery connections and connections to the second motor. It is connected to the master Pro by a 6 way cable between the two expansion connectors. This cable should join as follows:

Master	Slave
pin 1 -	pin 1
pin 2 -	do not connect
pin 3 -	pin 3
pin 4 -	do not connect
pin 5 -	pin 6
pin 6 -	pin 6
pin 7 -	pin 7
pin 8 -	do not connect
pin 9 -	pin 9

Pin numbers are printed on the circuit board.

Note that the master's pin 5 must connect to pin 6 on both controllers.

The two controllers will work as one, controlling the two motors together with the gain and ramp adjustments of the master controlling both.

The two motors will perform identically but with independent current limits. If two motors are used off one single 200 amp controller, then the full 200 amps current is available to drive either motor in stall conditions. With the Pro-120, each motor may only draw up to 120 amps, limited by its own controller. The system therefore offers more protection to the motors. Also, if one motor gets disconnected, the second motor will still be protected. Lastly, if there is a failure in one controller the chances are that the vehicle may still be operable on the other controller, providing an emergency 'get you home' service, albeit at reduced performance.

Note that the expansion connector is supplied with a link fitted between pins 5 and 6: this link must be refitted when the double heading is removed, to restore normal operation.

This expansion connector is designed to allow additional facilities to be fitted - so there are many possibilities!

Note that the expansion connector on issue 7 boards is slightly different from earlier issues!

11 Adjustments

11.01 Gain

This is marked 'Gain' on the diagram 'Features'. Set this so that, at maximum required pot range, the controller just reaches full speed: this is easiest to do with the motor unloaded. Set the speed pot to your required maximum point (e.g. full up) then, listening to the motor, adjust the preset. It is usually quite easy to tell when the motor stops accelerating. Too low a setting and the motor will not reach full speed (this can be useful to restrict top speed).

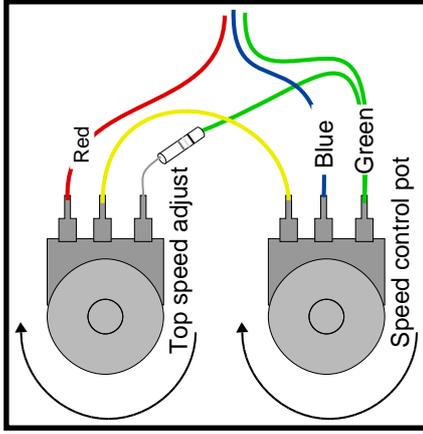
Maximum setting of the gain preset will give full output for about 3v input. The sensitivity can be increased by fitting a resistor: contact the factory for details.

11.02 Full speed

Where user adjustment of the top speed is required the 'gain control' is not satisfactory. In this case the arrangement (right) can be used.

Both pots should be the same value (10K). The resistor shown in the green lead to the top speed adjust pot is optional: if left out the top speed will adjust between 50% and 100% no resistor: 50% to 100%
 10K resistor: 33% to 100%
 4K7 resistor: 25% to 100%
 3K3 resistor: 20% to 100%
 2K2 resistor: 15% to 100%
 1K2 resistor: 10% to 100%
 link wire: 0% to 100%

Or you can simply fit a resistor in the top of the pot (red wire) but the value of this resistor plus the pot should not exceed 20K.



Too high a setting and there will be a 'flat' spot at maximum speed where the control has no effect. This will also confuse the special 'power down' circuitry so you will get a bumpy ride if you switch off at speed.

Maximum setting of the gain preset will give full output for about 3v input. The sensitivity can be increased by fitting a resistor: contact the factory for details.

6mm² wire for the battery - depending on their length. Excessive voltage loss will cause the voltage at the controller to fall so low that the controller detects a fault condition and the relay will switch off.

On the 24v versions, use of wire that is too long (and/or too thin) will cause loss of power but will not harm the controller although the decoupling capacitor (see 'features' diagram above) may heat up. Heat will shorten the operating life of capacitors.

Crimp Contacts

You must use fully insulated crimps: the power connections are close to each other and uninsulated crimps may short out and cause damage. Best of all use 'F' type' crimps with vinyl covers. 4QD can supply these pre-crimped only as they require a special crimp tool.

8.02 Motor wiring

This is not quite so critical as battery wiring: too long and/or too thin wire will cause a loss of performance, it will get and will waste battery power but will not damage the controller. However, wire which is too thick will do no harm either so we recommend the same wire for the motor as for the battery.

8.03 Circuit breaker

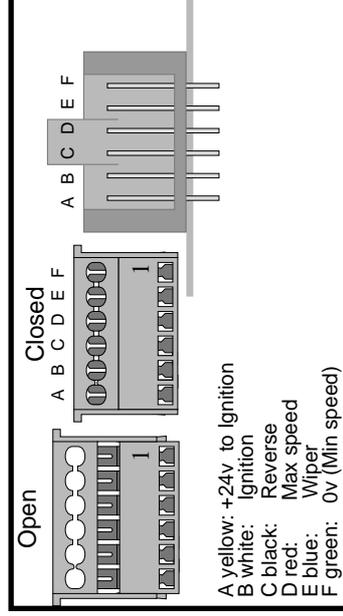
A circuit breaker may be fitted if required. The main advantage is that it will enable the battery or motor to be disconnected in the event of an emergency or for security. A circuit breaker will not protect the drive in the event of a fault: MOSFETs fail far faster than a circuit breaker can operate.

You could fit a breaker in the battery lead: take care not to increase the wiring length too much. Also, certain types of breaker can have the same effect as increased battery lead length. A breaker in the motor may therefore be best: it will enable you to quickly disconnect the motor in an emergency. Also with the motor disconnected, freewheeling becomes possible. It is also possible to get a battery isolator switch - these are normally fitted to lorries, buses and boats to isolate the battery in an emergency - but this is not required as the Pro-120 has a power relay which effectively disconnects the battery (except for a small bleed resistor).

8.04 Battery condition meter.

This should connect between Pins B and F (white and green on the diagram). White is connected via the ignition switch to battery positive and green is always connected via the wiring to the battery negative.

9 Controls



Do not strip the insulation from the wires, simply push them into the top part of the open connector, from the front (visible in the diagram) and squeeze it closed in a vice or with suitable parallel action pliers.

As you do this, the tines of the contacts bite through the insulation to make contact with the conductors.

Wire which is too thin will not make good contact.

Wire which is too thick will damage the tines which may short to each other
 Solid wire will quickly break

You can re-open a closed connector by gently moving the tabs at the sides of the top cover outward to disengage the latches while lifting the cover slightly, one side at a time.

Connections are shown in the diagram.

The mating connector supplied is suitable only for the correct size of wire.

Acceptable wire sizes are:

7 stranded 0.22-0.25mm²

Equivalent 24 AWG (7/32 AWG)

It is an Insulation Displacement Connector (IDC):

time is set too short (anticlockwise) the vehicle's acceleration will be limited by the current limit which does no harm (except that repeated accel/decel will cause over heating) but it means that acceleration is not being controlled properly, so will vary depending on the gradient.

Deceleration ramp

This is shown as 'Decel' on the Features diagram: it is present to make the vehicle decelerate smoothly when the speed pot is reduced suddenly. As supplied it is at half setting (about 3 seconds). Adjust it as you require to give smooth deceleration. You will usually find you require a lower setting (more anticlockwise) for Decel than for Accel. If the Decel time is set too low (anticlockwise) then the relays will drop out and short out the motor before regenerative braking has finished. This may give a jerk before the vehicle stops completely and may also shorten the life of the relays

11.03 Ramps

The Pro series controllers incorporate very sophisticated ramps (we are not aware of any controller with a better system, nor do we know of any way the existing system could be improved) to control the maximum acceleration and deceleration rates. These are user adjustable and, to get best performance from your machine, you should adjust them!

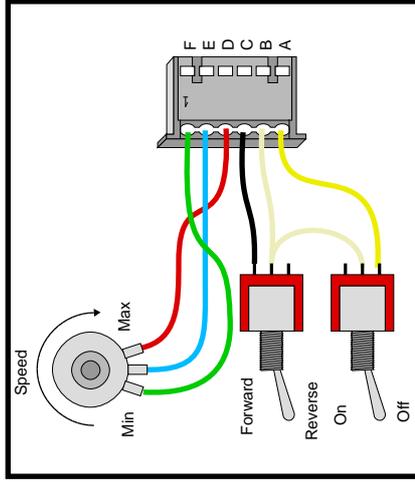
Acceleration ramp

This is shown as 'Accel' on the 'Features' diagram. It is present to make the vehicle accelerate smoothly when the speed pot is increased suddenly so as to avoid sudden surges and shocks to the mechanics. As supplied it is at half setting so that the motor takes about 3 seconds to accelerate. Adjust it as you require to give smooth acceleration. Clockwise increases the time (reduces the acceleration) anticlockwise decreases the time (increases the acceleration) If the

9.01 Speed pot

We advise a 10K linear pot, although other values from 4K7 to 20K, linear or log, can be used.

The gain adjustment on the controller alters the amount of rotation required before full speed is reached: this enables a simple lever operated control by means of a lever arm screwed onto a standard



is turned on before power is applied then the ignition relay may not pull in properly when the battery is connected as its operation relies on the Pro's internal capacitor charging through a bleed resistor *before* the ignition switch is closed.

Beware of opening the switch when the motor is running: the motor will brake to a halt more or less quickly, depending on the deceleration ramp setting.

With the ignition off, or even with the battery disconnected, the relays short out the motor so free-wheeling is not possible. To free-wheel properly the motor should be disconnected.

The Pro controller has special circuitry so that the controller operates properly if the ignition is switched off even at full speed. The motor will be braked to a stop (under control of the deceleration ramp) and only when it has stopped will the ignition relay switch off. For this to work properly it is important that the 'Gain' control is not turned up too far - see section 11.01.

9.04 High Pedal lock-out

This feature switches off the ignition if it is activated with the speed pot other than at minimum speed to guard against the vehicle taking off because the ignition is activated with the throttle up.

In some applications this feature may be undesirable. e.g. with a Joystick Interface when the system will not power up unless the stick is central at switch on - this can cause confusion!. It can be disengaged by simply cutting out the resistor marked R_{hplp} on the diagram 'features' - section 4.

9.05 Battery Discharge Protection

this can be used to protect the the battery from damage that could be done by over-discharging it. To do this, the voltage *at the controllers battery terminals* is monitored and the performance is reduced as this voltage falls.

It is not fitted as standard to 12v controllers. The standard 24v controllers have the level set to a low voltage (about 15v) so it is effectively disabled. To enable it, fit the 12K resistor R_{bvp} shown in the 'Connections' diagram (page 7). For variable cutback, you could fit a variable resistor. Or you could use a switch to enable/disable the feature. The level at which it works is controlled by the value of

the external resistor.

The controller cannot know the difference between a flat battery and losses caused by very high battery current in wiring that is too thin, so in some applications it may have undesired effects. It can be disabled completely by linking out the pinstrip marked UVP on the features diagram. Spare 'jumpers links' are available from 4QD (JLK-001).

9.06 Reversing switch

Reversing switch connections are shown in the diagram (facing). Reversing is 'dual ramp' which means that, if the vehicle is reversed at speed, it automatically slows down under control of the deceleration ramp then reverses and speeds up under control of the acceleration ramp.

Whenever the vehicle is in reverse, a speed reduction circuit operates, so that (if the gain adjustment has been set up sensibly) full reverse speed is half of full

forward speed.

9.07 Half Speed Reversing

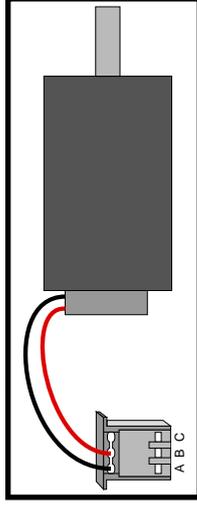
As supplied, reverse speed is half of forward speed. If reduction is not required it can be disabled by moving the 'jumper' on the pinstrip shown in the features diagram.

9.08 Dual Ramp Reversing

It is also possible to disable the 'dual ramp' reversing when the reversing becomes 'pre-select' so that, if the reverse switch is operated at speed, nothing will happen until the demand speed is reduced to zero. Reversing will now occur when the demand speed is turned up again. In this mode a push switch can be used for reversing: push the switch as you move the speed control from zero to engage reverse and release it when the vehicle is moving. Then, when the speed control is again reduced to zero, the controller will drop back into forward. Contact the factory for details.

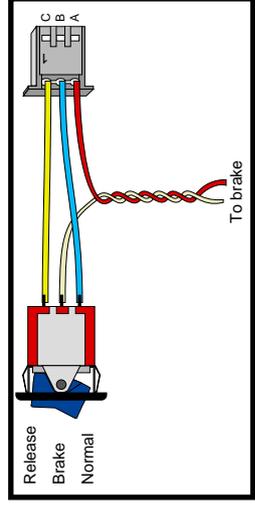
10 Braking

Parking brake drive is via the 3 pin connector, shown on the diagram 'Features'. This should be wired as in the first diagram.



The 3rd pin is battery negative so you can use a 3 position switch to give Release—Brake—Normal (brake override facilities), as shown in the diagram below.

The brake driver is not protected: if the brake (or wiring) fails short-circuit it can damage the board so if there is any likelihood of such a fault we suggest you fit a fuse (less than 1 amp) in series with the brake coil.



Parking Brake

When power is applied to this, the brake is released and when power is removed the brake is applied by a spring. The Pro series controllers have a circuit to drive such a brake: power is applied to the solenoid as demand speed is increased above zero and when the demand speed returns to zero, power is removed.