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.

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.

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.

Ask for our selection guide **PUB-SEL**

We also have an 'Accessories' list: **PUB-ACC**.

20 More information

A manual such as this cannot cover all the points everyone may need to know. If you require more information 4QD will gladly answer individual queries. Alternatively we have available a publication 'Battery Motors and Controllers' which is compiled to answer virtually all the questions we have ever been asked on the subject. It should therefore answer all the questions you wish to ask as well as a lot you didn't even realise you could ask. It is available for a small charge.

Ask for **PUB-BMC**

This manual was designed and produced using an Acorn Risc PC StrongARM 32 bit computer (the world's fastest personal computer) with a Calligraph direct-drive laser printer system. The drawings were produced with Vector and the DTP was done with Ovation Pro. If you want advise on this futuristic computer system please contact 4QD.

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Instruction Manual

Pro-120 series controllers

Issue 5

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

19th December 2001

Contents

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 simplest possible configuration is shown in section 7. However because of the features and versatility of our controllers we give a lot of extra information in this manual - which may make it seem to be more complicated than it is so we've marked the more technical sections ¶ so you may ignore them. Please don't be put off but read the manual quickly through before you start. This should introduce you to what you can do with our controllers and clarify what we are trying to say.

Our drives are protected: provided you don't actually connect them wrongly or short them out, they will survive almost any type of motor - we regularly use a 12v starter motor as a test load, stalling it with a monkey wrench. The drives survive this but will get hot and therefore will eventually fail.

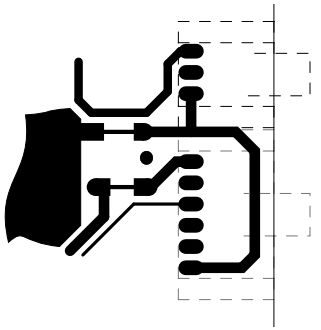
17 Common faults

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.

Fuse tracks

There is not a lot we can do about external wiring faults: if such a fault occurs in the controls or the brake (connected to the 6 pin and 3 pin input connectors) there are two special sections of track which should blow. These are situated beneath the input connectors on the back of the board. They are thin 'waists' in the track and are is 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.



In practise fuse tracks are very fickle: it would be possible to design a board with 5 different fuses each one of which could blow singly and separately under different overload characteristics: we cannot guarantee therefore that the correct piece of track will always blow!

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.

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 te 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 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).

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.

The cover has a strip of foam already fitted to help sealing between cover and board. However you must not let water get onto the board - at the very least electrolytic corrosion will occur - so take a moment to consider what will happen if water runs down the leads to the controller: put a kink in the leads so water drops off at that point.

If mounting the controller on its side, remember that if water gets into the mouth it could sit inside the controller and could easily touch the circuit board. Either make sure water cannot enter or else drill a drainage hole in the bottom side of the cover, at the mouth, so water can escape. We also suggest you seal the splash plate to the side of the cover with silicone rubber.

16 Choice of motor

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.

Most modern d.c. motors use permanent magnets. These are the best for battery operation. However, other types can be used: at 4QD we regularly use a 12v car starter motor for testing (even with our 24v 150 amp drives) since these are a far worse load than is ever likely to be met. Into such a motor (stalled) the controllers simply deliver their maximum current and get hot. It is virtually impossible to damage the controllers by an unsuitable motor (the controller will simply get hot quickly), so don't be afraid to experiment.

There is no reason why you cannot use a 24v motor from 12 volts - it will only go at half its design speed. Also, if you use a 12 volt motor from 24v, it will go at twice its rated speed. Since the Pro is current limited you won't overload the 12v motor, provided it can handle the available (limited) current.

Shunt wound motors are suitable - they react as a permanent magnet one.

Series wound motors are not suitable for the standard controller because they will not reverse by normal armature control. However a modified version of the Pro can be supplied. Contact the factory for details.

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.

2 Models

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

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 or shunt wound motors but a modified version suitable for series wound motors is also available

3 Safety

MOSFETs tend intrinsically 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.

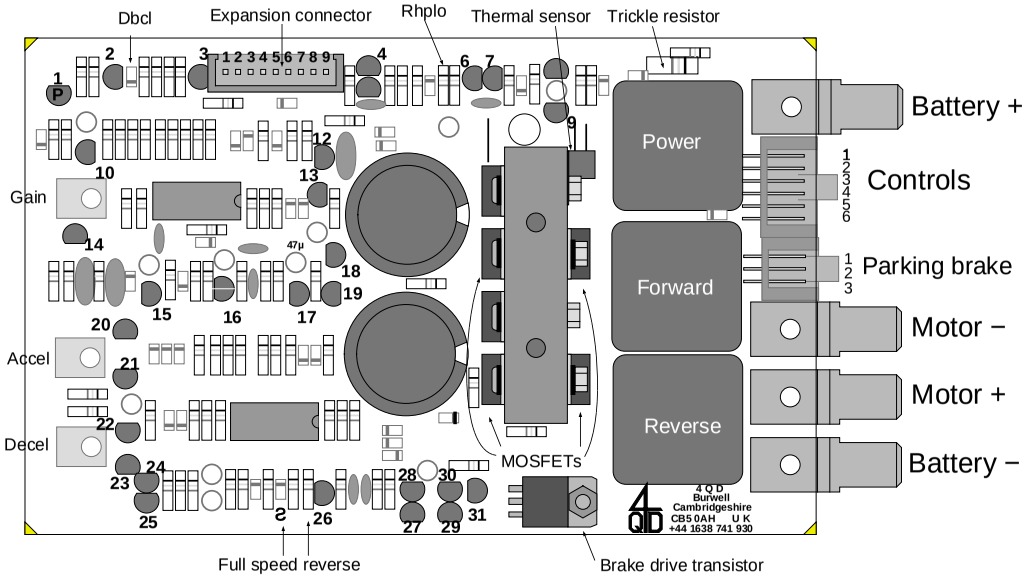
The Pro has a power disconnect relay and special sensing circuitry. If the ignition switch is switched off at full speed then internal circuitry ramps the controller down, slowing the machine.When the controller's output stops switching (i.e. at zero speed), the power relay switches off.

In the event of a fault causing loss of speed control, then the controller's output will be at full speed, not switching. Switching the ignition off under such a fault condition will cause all three power relays to drop out - bringing the vehicle to a sudden emergency stop. Thus some measure of control is retained under extreme fault conditions to maximise safety. This feature is unique to 4QD's NCC Professional.

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!

4 Features

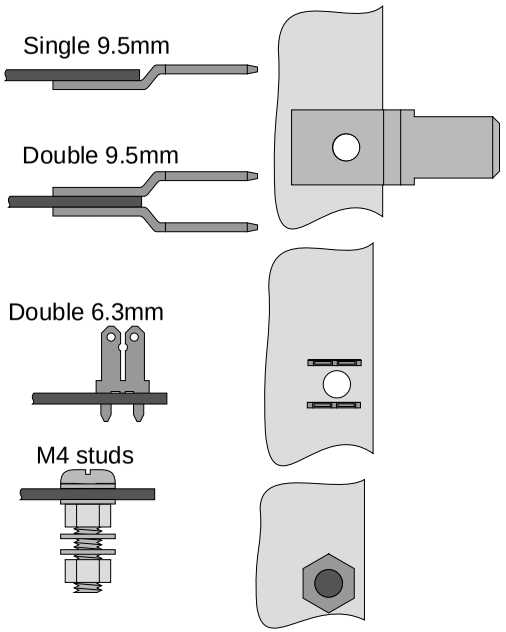


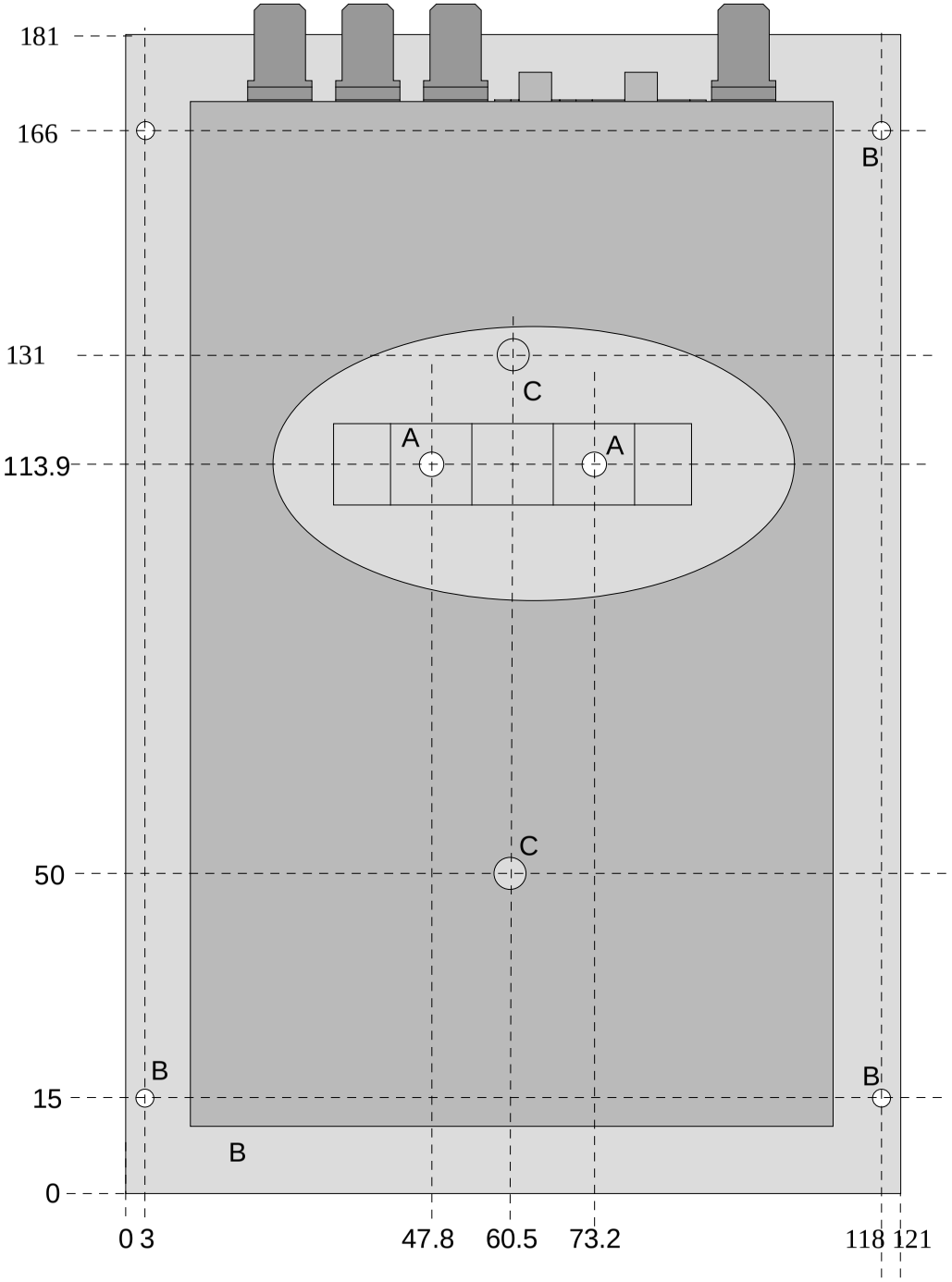
The diagram shows the standard Pro-120 (issue 05) which has eight 9.5mm tabs fitted: doubles motor tabs, for one or two motors and double battery tabs so one set may be used to connect a charger or for similar purpose.

Optionally the controller can be supplied with different arrangements of 9.5mm tabs, or the 9.5mm tab to be replaced by two 6.3mm tabs (third diagram, right). These 6.3mm tabs can each accept two 2.8mm push-on terminals, useful for connecting many smaller motors in parallel.

The final option is with M4 brass studs fitted in place of the tabs, bottom diagram right.

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 buildup of heat in the heatsink. The controller will give over 110 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.

Mounting the cased controller.
Mounting holes are pre-drilled in the base plate but if alternative mounting points are required and there are virtually no restrictions on positioning.

The supplied holes are M5 tapped.

You can of course clamp mount the controller by metal plates clamping onto the periphery of the controller.

5 ¶ Specifications

Supply voltage
12v or 24v (different models)
36v and 48v to order.
Supply current
30mA at zero speed
Motor speed
forward 0 to 100% full speed
(adjustable)
reverse 0 to 50% full
speed reduction may be disabled
Output current (typical)
Current limit 125 amps min
135 typical
1 minute rating 100 amps
without additional heatsink!
2 minute 60 amps
without additional heatsink!
continuous 30 amps or more:
this is heatsink dependant. With no heatsink, over heat typically occurs after 15 minutes at 30 amps.

Regenerated current limit 100 amps

Overheat temperature
95° on heatsink
Overheat current
25 amps typical, factory adjustable

Switching frequency
20kHz approximately

Size 160 x 102mm x 40mm *(board only)*
Weight 325g

Input 1k to 25k pot.

Pot fault detect greater than 30K

Input voltage 0.3v minimum (adjustable)

Acceleration time 330mSec to 7 Sec
(adjustable)
Deceleration time 330mSec to 7 Sec
(adjustable)

6 Mounting

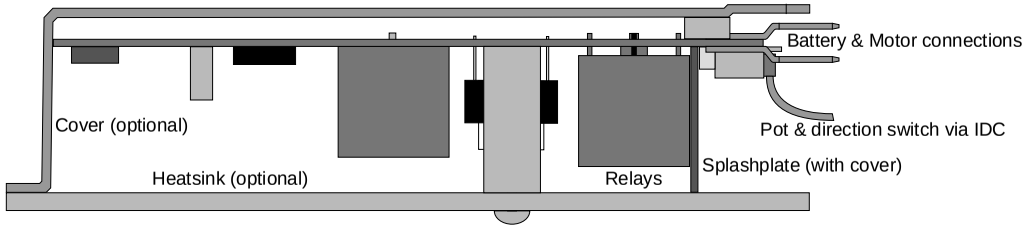
The NCC Pro is designed for mounting via the heatsink as in the diagram below. This also shows a section through the optional base and cover . This mounting will normally be on to a metal chassis which will act as additional heatsinking but, in most applications, full current is only drawn for short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

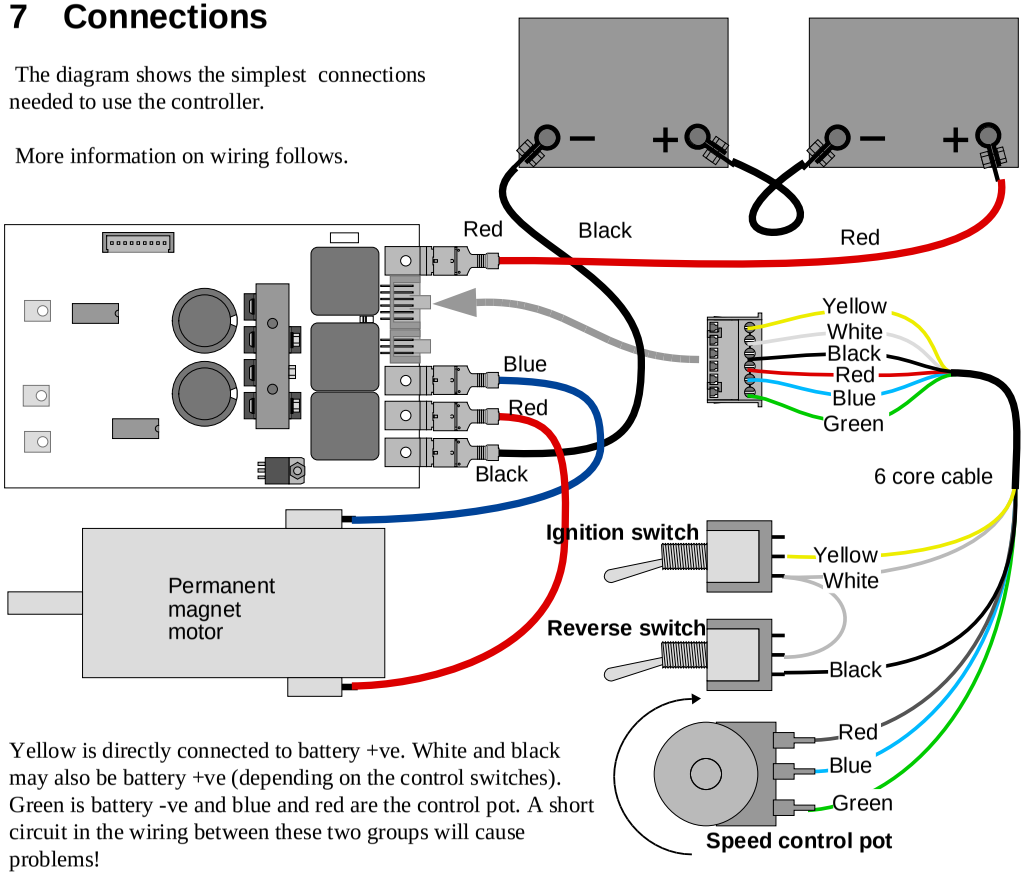
Whatever you do, make sure the controller can't get wet and, if it does, *don't connect the battery* until you have dried the controller thoroughly. The water won't cause damage unless the unit is connected to the battery, when electrolytic corrosion will occur. See also section 15.



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!

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 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.

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.

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 and the speed pot turned to zero. If the speed is not at zero, then the high pedal lock out will operate on the slave, which will not work. See section 9.04.

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:

pin 1 -	pin 1
pin 2 -	do not connect
pin 3 -	pin 3
pin 4 -	do not connect
pin 5 -	pin 5
pin 6 -	pin 6 (optional)
pin 7 -	pin 7
pin 8 -	do not connect
pin 9 -	pin 9

When connected thus, the speed of both controllers will reduce when connected together: if this is undesirable (for instance when double heading two independent locos) it can be altered. Contact the factory for details.

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.

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

11 Adjustments

11.01 Gain

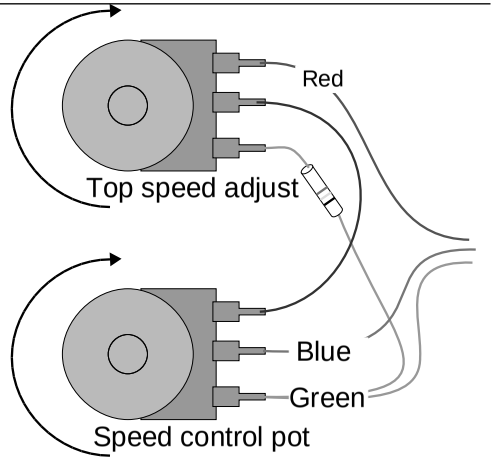
This is marked 'Gain' on the diagram 'Features'. Set this so that, at maximum required pot range, the controller just reaches full speed: this is easiest to do with the motor unloaded. Set the speed pot to your required maximum point (e.g. full up) then, listening to the motor, adjust the preset. It it 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).

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.

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 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%

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 time is set too short (clockwise) 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

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

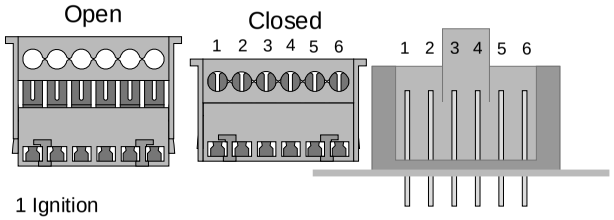
A circuit breaker may be fitted if required. The main advantage is that it will enable the battery or motor to be disconnected in the event of an emergency or for security. A circuit breaker will not protect the drive in the event of a fault: MOSFETs fail far faster than a circuit breaker can operate.

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 2 and 6 (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



1 Ignition
2 Ign & Reverse common
3 Reverse
4 Max speed
5 Wiper
6 Min speed

Connections are shown in the diagram.
The mating connector supplied is suitable only for 7/0.2 (flexible) wire. It is an Insulation Displacement Connector (IDC): do not strip the insulation from the wires, simply push them into the top part of the open connector 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

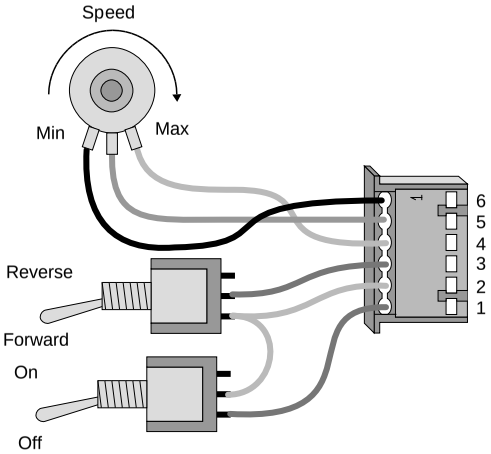
You can re-open a closed connector by gently moving the tabs at the sides of the top cover outward to disengage the latches while lifting the cover slightly, one side at a time.

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 rotary pot.

The simplest speed control is an ordinary rotary pot: this won't give any 'dead man' control as the pot won't return to zero when it is released.



4QD can supply a spring return to zero hand control.

Alternatively 4QD can supply a plunger operated pot (linear position sensor), suitable for incorporating into a foot pedal.

9.02 ¶ Use as voltage follower

Instead of a pot the input may be fed from a variable voltage. 0v (common) to pin 6, signal input (+ve) to pin 5. A resistor (10k) should be connected from pin 4 to pin 6 to over-ride the internal pot fault detector circuit. Zero speed will be for zero voltage input and full speed voltage may be adjusted (by the pre-set) to be from 3v to above 20v.

9.03 On/Off switch

Circuitry in the controller switches it off (zero current consumption) unless pins 1 and 2 of the connector are joined. Therefore a switch must be fitted.

Do not permanently link these pins: the ignition relay will not pull in 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 freewheel properly the motor should be disconnected.

The NCC-Professional 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 Rhplo on the diagram 'features' - section 4.

9.05 ¶ Battery Discharge Protection

This feature is not fitted as standard to 12v controllers. Its purpose is to protect the the battery from damage that would be done by over-discharging it.

To do this, the voltage *at the controllers battery terminals* is monitored and the performance is reduce as this voltage falls.

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 by linking out the zener diode marked Dbcl on the features diagram. Take care when doing this as inexpert modification could invalidate the guarantee.

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.

If reverse speed reduction is not required it can be disabled by cutting through the link on the board marked 'S' (for Symmetrical). This is beneath the board in the position marked on diagram 4 by the words 'Full speed reverse'. Alternatively you can remove the resistor arrowed in the diagram.

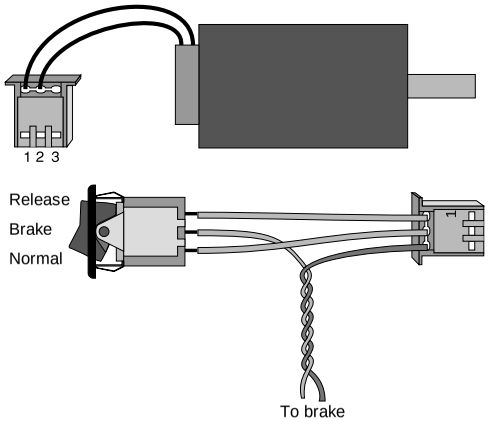
It is also possible to disable the 'dual ramp' reversing when the reversing becomes 'pre-select' so that, if the reverse switch is operated at speed, nothing will happen until the demand speed is reduced to zero. Reversing will now occur when the demand speed is turned up again. In this mode a push switch 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

Regenerative motor braking is integral to the Pro series controllers. When the demand speed is reduced below the actual motor speed, the controller starts braking, returning as much of the braking energy as possible back into the battery. The rate at which the braking acts is adjusted by means of the deceleration adjustment.

For maximum energy recovery, use gentle braking. Turning the speed control to zero for maximum braking, shorts out the motor via the relays so there is then no energy recovery.

Regenerative braking does not work well at slow speeds, simply because it relies on the motor turning to provide braking energy. Therefore, if the motor is only turning slowly it cannot give a lot of braking, so a vehicle may creep if parked on a hill. To stop this creeping you can get motors fitted with an electro-magnetically operated **parking brake**.



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.

Parking brake drive is via the 3 pin connector, shown on the diagram 'Features'.

This should be wired as in the top diagram (left)

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 lower diagram