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.

Current charges sre available from the Service section of our WWW site.

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 in-house by 4QD, 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.

4QD

"We're in Control"

Office
30 Reach Road
Bu rwell
Cambridgeshire, CB5 0AH
Fax: 01638 744 080

Stores
Unit 6A, Warbraham Farm
Heath Road, Burwell
Cambridgeshire, CB5 0AP

"We're in Control"

See us via the Internet: http://www.4QD.co.uk Email to: support@4QD.co.uk

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Instruction Manual

Scoota series controllers

issue 3

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.

There is a large section of our www site dedicated to technical assistance. If you need more help, please visit it.

Applications

4QD's Scoota range of 2 quadrant controllers are well suited to general purpose speed control applications where reversing is not required. They are used extensively by hobbyists and industry.

The Scoota series form an extension to our 2QD series, for higher current use or where more features are required.

The Scoota also forms an extension to our Pro series where reversing is not required.

10th February 2005

Contents

2 Models

The Scoota is available in two current output versions, Sco-80 and Sco-120. Both can be supplied either for 24v operation or for 12v operation. Models can also be supplied for 36v and 48v

The voltage is marked on the relay. 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

1 Introduction

4QD's Scoota series are non 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, 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.

Overheating

Beware of sustained overheating: the heatsink can operate at 95°C but not a lot more. 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!

Wire size.

Some problems are caused by the use of the wrong wire size or type in the IDC connectors.

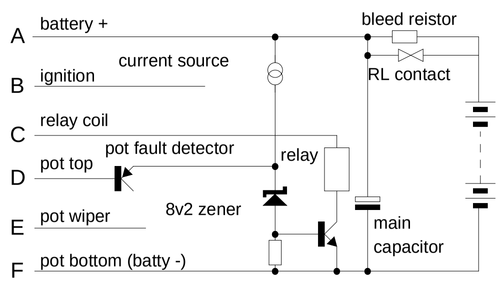
MOSFETs

MOSFETs very rarely fail: they are however doing an enormous amount of work and sometimes one simply gives up: the drive MOSFETs cause their drive resistors to burn up - a sure sign the MOSFET has failed.

Internal powering

An understanding of the internal powering arrangements may help you find problems (both in the controller and in your wiring).

Connecting the ignition to battery positive turns on a current source (about 30mA) which powers all the internal circuitry, using a 8v2 zener diode as a regulator. This system is very reliable as it tends to fail safe: zeners when overloaded usually fail short



circuit, which removes all internal power.

The zener also feeds a transistor which turns on the power relay as soon as the internal 9v rail establishes. The relay coil is fed from the main capacitor (via pin C of the input connector, which must be connected to pin A) which has already charged up through the bleed resistor. The relay shorts out the bleed resistor applying full power to the circuit.

Two pins are used, one for ignition and one for the relay so that pin B can be used as a 'refresh' input for models with automatic ignition time-out.

If the battery is reversed, or there is any serious fault, the capacitor will never charge so the relay won't operate.

High pedal lockout.

There is also high pedal lockout which operates on the relay driver: is the pot is not at zero when switched on, the relay will not operate.

The 9v line is also fed to the top of the pot via a transistor (which detects open circuit pot wiring), so when the internal supply is powered up you can measure about 8.5v across the pot. Operating the pot will, then, vary the voltage on the blue wire to pin E from 0v to 8.5v, depending on the pot setting.

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.

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.

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.

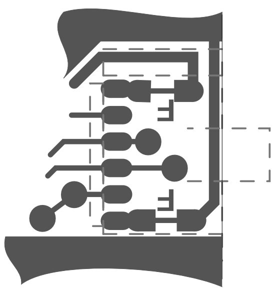
17 Common faults

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.

Fuses

In the event of a fault in the external wiring (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 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 repairing these tracks we suggest you include a 1A fuse in the positive control wire, as shown in section 7.

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 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 Scoota 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.

The controller can be supplied with a choice of ignition circuitry: one version has ramp down and automatic power off at ignition switch off, the other version has automatic switch off if the throttle is not operated within a few seconds of operating the ignition switch.

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 Scoota 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.

When the charger is inserted, the link is made, shorting the wiper of the throttle pot to battery negative. Even is 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!

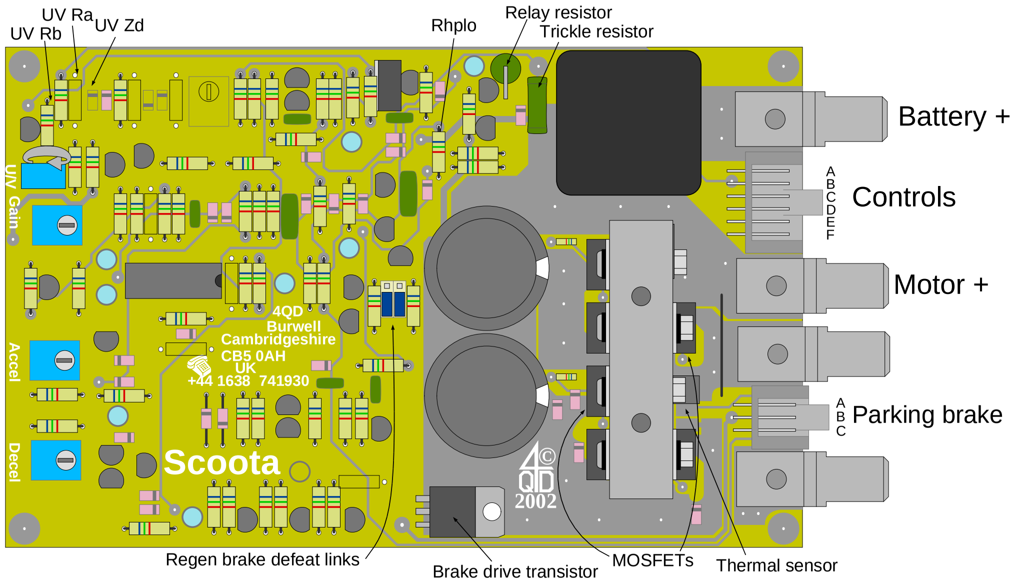
Regen Braking

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.

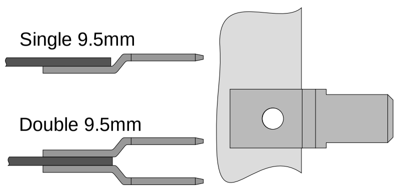
The full battery situation is only likely if you either live at the top of a steep hill, or if you transport your vehicle for instance, to a golf course which starts with a long downhill run.

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!

4 Features



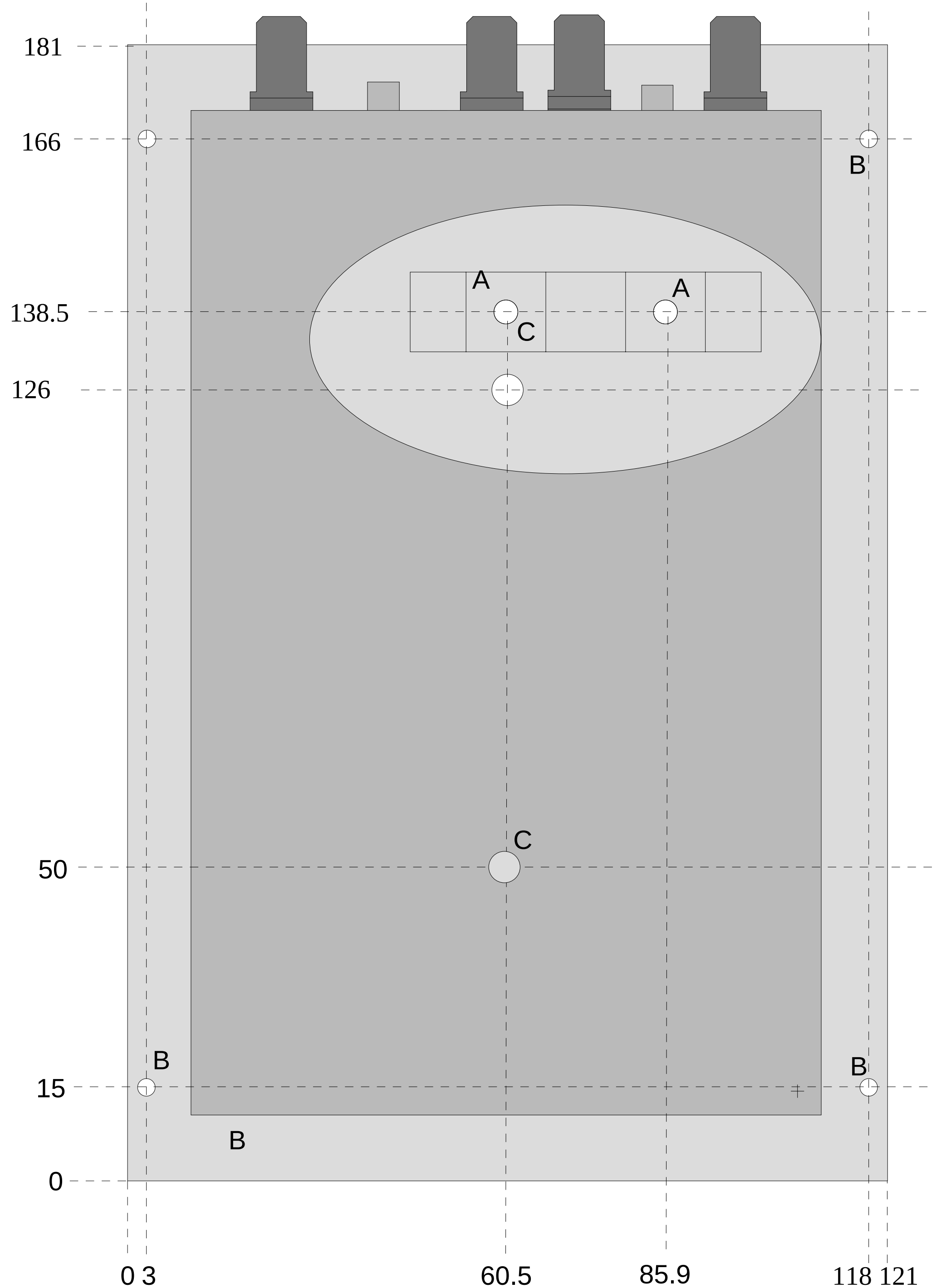
The diagram above shows the standard Sco-120 which has six 9.5mm tabs fitted: singles for the battery and doubles (for one or two motors) as shown above and in the top diagrams to the right.



Optionally, for quantity orders, the controller can be supplied with different arrangements of 9.5mm tabs.

Regen braking may be disabled by changing (or removing) the two links indicated above. These are shown with regen braking enabled (bottom pins linked). Move the headers to link the top pins (or simply remove the header links completely) to disable regenerative braking.

Optionally parking brake can be supplied as a brake light driver.



14 Base and cover option.

(opposite page)

The diagram shows the dimensions of 4QD's base which is available as an option and fits the Scoota or Pro-120 controller. The cut-out shows the Scoota fitted.

Two A holes are for mounting the Scoota'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 Scoota'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 'C' holes are M5 tapped.

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

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.

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)

Output current (typical -120 version)
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

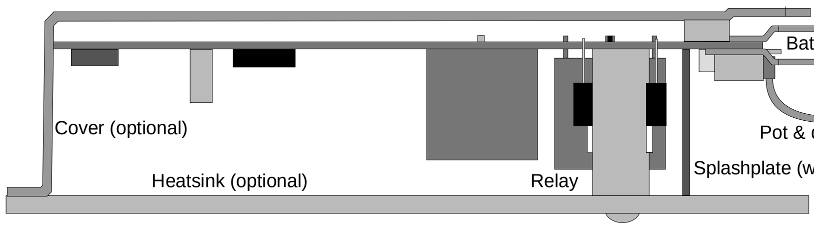
The Scoots is designed for mounting via the heatsink as in the diagram below. This also shows a section through the optional base and cover . This mounting will normally be on to a metal chassis which will act as additional heatsinking but, in most applications, full current is only drawn for short periods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

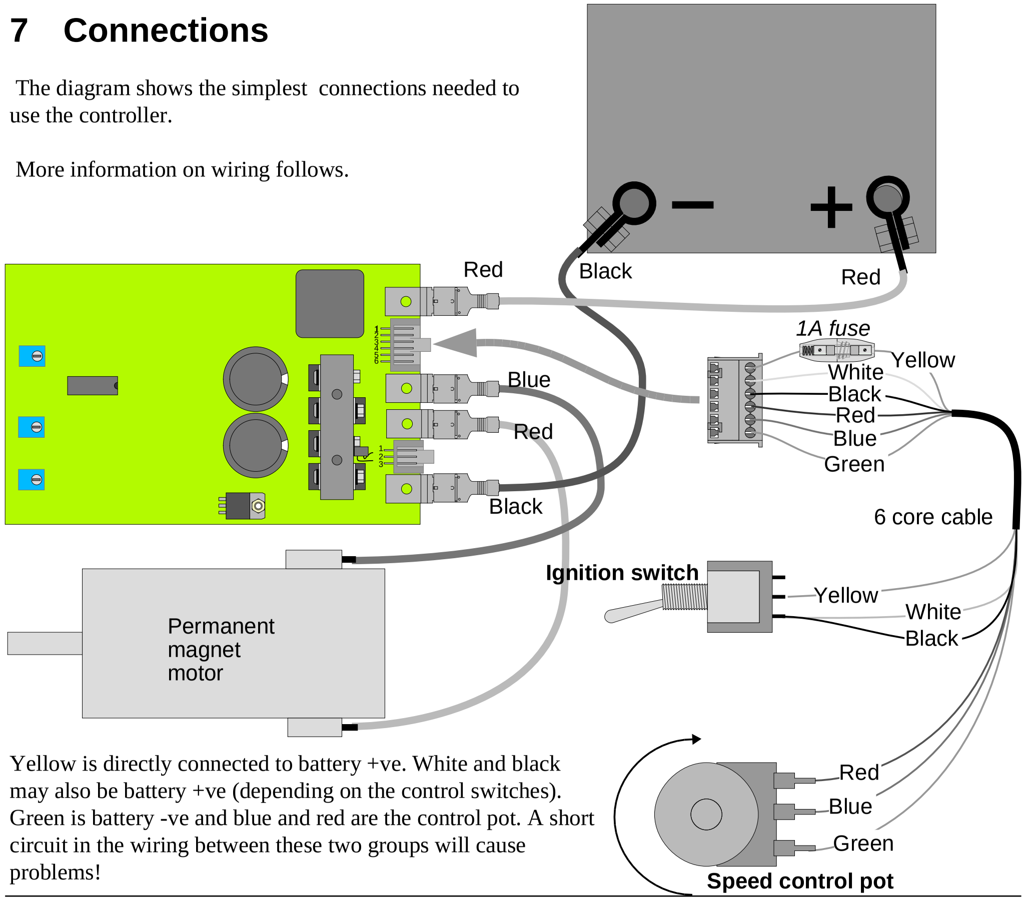
Whatever you do, make sure the controller can't get wet and, if it does, *don't connect the battery* until you have dried the controller thoroughly. The water won't cause damage unless the unit is connected to the battery, when electrolytic corrosion will occur. See also section 15.



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 6.0mm² (10awg) wire for battery connections. 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.

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.

11.05 Undervoltage protection

Battery undervoltage protection is fitted and is adjustable by means of the U/V preset.

There are two 'ranges' of undervoltage:

Low 6	(8)	16	for 12v controllers
High 15	(20)	40	other voltages

The bracketed figure is the approximate voltage at centre rotation.

There is a scratch-through link on the solder side of the board beneath UV Rb (see diagram, page 4) which is broken to engage the High range.

Maximum protection is with the preset adjusted in the direction of the arrow shown in the diagram on page 4. (clockwise, viewed from the top of the diagram

The controllers are normally supplied with the undervoltage adjusted to minimum (effectively disconnected)

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 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.

The Scoota incorporates 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!

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.

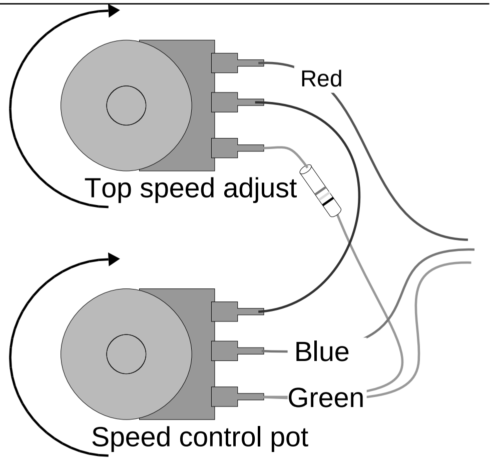
Maximum setting of the gain preset will give full output for about 3v input. The sensitivity can be increased by fitting a resistor: contact the factory for details.

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 Scoota 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

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

Fuse

Note the 1 amp fuse in the yellow wire. This is optional but id you do not have it, a fault in your control wiring may blow the fuse track on the controller. If you are happy to repair this tack yourself you do not need the fuse!

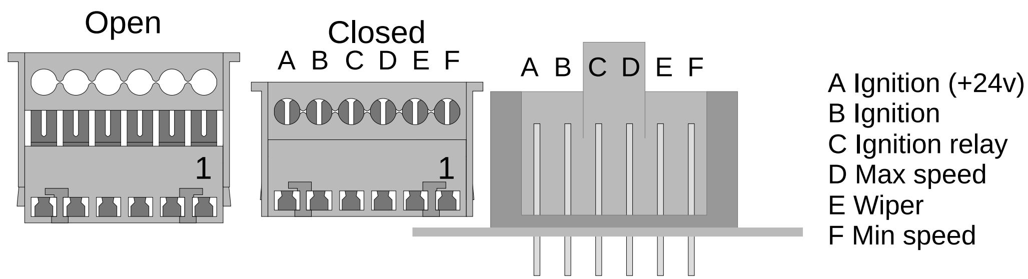
See section 17

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, right. 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 F, signal input (+ve) to pin E. A resistor (10k) should be connected from pin D to pin F 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 A and B of the connector are joined. Therefore a switch must be fitted.

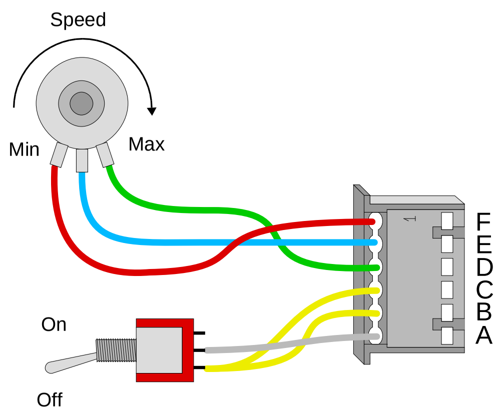
Do not permanently link these pins: the ignition relay will not pull in as its operation relies on the Pro's internal capacitor charging through a bleed resistor before the ignition switch is closed.

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 MOSFETs short out the motor in one direction so freewheeling is not possible. To freewheel properly the motor should be disconnected.

The Scoota 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.

A modified version of this power down circuit enables it to be used as an automatic power-down which switches the controller off if the throttle is not engaged within a few seconds of operating it. For this reason the ignition relay coil is brought out to be operated by a keyswitch. It follows that the controller will not function unless pins C and A are connected together as shown.



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. It can be disengaged by simply cutting out the resistor marked Rhplo on the diagram 'features' - section 4.

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. If the motor is only turning slowly then it cannot give a lot of braking, so a vehicle will creep if parked on a hill. To stop this you can get motors fitted with an electromagnetically operated 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 Sco 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 bottom 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 below

An option is for this brake driver to be supplied factory wired to be a 'braking' light driver. In this case small bulbs or LEDs are connected instead of the solenoid coil.