"We're in Control"

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Instruction Manual

NCC series controllers

NCC-35, NCC-50, NCC-60 and NCC-70

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, 4QD have a very full WWW site which has a large section giving answers to commonly asked technical questions.

Even if you do not have easy Internet access, you will find this well worth reading, so ask a friend who is connected or go to your local Internet Cafe or public library.

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

3rd January 2003

Do not

Solder to the power connectors: it makes it impossible for us to fit them to our test jig if it ever needs repair. Solder is a bad conductor of electricity and using it for power connections can be dangerous.

Remove the power connectors. Bolting to the circuit board is less reliable - and the controller will not be repairable as it won't fit our test jigs.

Let any metal object contact the circuit board. Even with battery disconnected the circuit can still be live as the main capacitor can store charge for several hours.

Drill the heatsink or do any grinding, drilling or filing near the motor or controller. Metal particles in motor or controller can cause failure and will immediately invalidate any guarantees!

Operate the controller for long if there is an evident fault. It will survive a shorted motor but only for a short time.

Disconnect the motor leads when the motor is running. The resulting arc may destroy the MOSFETs,

Do

House the controller properly so it cannot be contaminated by water, dirt or swarf.

Discharge the main capacitor before handling or working on or near the controller.

Use fully insulated power connectors.

Fit a motor Suppression capacitor. A 10n ceramic capacitor as close to the motor brushes as possible will increase reliability.

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, 36v) 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.

More information

A manual such as this cannot cover all the points everyone may need to know.

If you have access to the Internet check out 4QD's World Wide Web site on http://www.4qd.co.uk This contains a lot of information on battery motor control.

If you don't have access, you will surely know someone who does - or visit your local library. You won't regret it!

A full service manual is available from our www site http;//www.4qdtec.com.service/

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Contents

Introduction

4QD's NCC range 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 regenerative braking, independent, linear, adjustable acceleration and deceleration ramps, reverse speed reduction, dual ramp reversing, fault protection, thermal protection and electromagnetic brake driver.

Many of these features can be disabled if so required. Some features are optional on the smaller controllers. The NCC features a 'double ended' layout with the power components in the centre. This is physically slightly less convenient than, for instance, our Pro-120 controller but does result in a more economical controller.

The simplest possible configuration is shown on page 6. The NCC series have many other features so there is 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 may eventually fail.

Handling

The NCC series are open-card controllers. A very high proportion of controllers returned for repair have been damaged by mishandling!

Do not let any foreign body contact the board. That includes water, dirt, screwdrivers, nuts and bolts.

Use only fully-insulated power connectors.

The controller can be damaged by foreign body contact **if the main capacitor is still changed**.

Before handling the controller or unplugging the power or motor connections, disconnect the battery, then leave the ignition turned on *for at least one minute* **before** handling the controller, to discharge the main capacitor.

Otherwise, short out the battery inputs to the controller, to discharge the capacitor to make the controller safe to handle.

See also back page for dos and don'ts

The capacitor can only heat while the controller is actually working properly so capacitor failure is always simply down to overloading the controller in one way or another.

Overheating

If any electrical item is worked hard it can get hot. If it is overworked for too long it will simply get hotter and hotter until something fails. Depending on the nature of the installation and overloading, solder joints can melt, the main capacitor can vent and the MOSFETs may then fail. Fortunately such severe overheating is not common.

Sustained overheating causes the varnish around the heatsink and capacitors to discolour. This is not in itself harmful but can indicate problems.

No reverse.

If the controller won't reverse there are two distinct possibilities:

1 The motor still goes forward when reverse is selected.
2 The motor is dead when reverse is selected

The first fault will be a wiring fault: the reverse signal is not getting to the controlled. Measure the voltage on the black wire to pin C (measure with respect to battery –ve). If this is low(below about 6v) the controller will go forward. When high (above about 6v) the controller will reverse. The reversing switch connects this pin to battery positive to apply a voltage to reverse it.

The second fault is usually in the controller: if a relay clicks in the 'dud' direction, try cleaning the relay contact. One relay operates for forward, one for reverse. Current flows from battery positive, through the normally closed contact of the relay which hasn't moved, then through the motor and so through the now closed contact of the relay which has operated. Usually the normally closed contacts tend to get dirty easier (lower contact pressure). Clean with fine emery paper.

Service

We can of course repair damaged controllers. But please be sure that the controller is faulty before returning it as we may make a charge for handling controllers which are not faulty or which only have the fuse track blown.

There will be a charge made for repairing controllers with blown fuse track.

There is an additional handling charge made if controllers are returned in boxes. The box itself never requires and servicing!

Otherwise charges made will depend on the age and condition of the controller and on the fault as we tend to be fairly lenient in interpreting the guarantee!

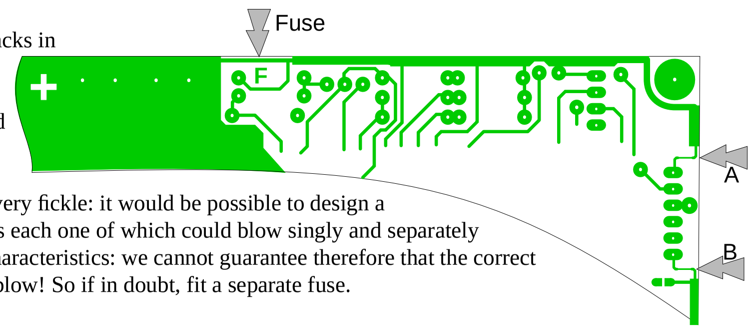
Make sure you include your name, address and details of the fault with the returned controller.

Fuses.

The main 'fuse' is a section of track indicated by the arrow in the drawing and the letter 'F' in the copper track. This is a thin 'waist' in the track on the edge of the solder side of the board just by the battery + connection.

If it fuses, solder a fine piece of wire over it - a single strand from 7/0.2 cable is fine.

There are also 'dog-leg' tracks in pin A & F of the 6 pin connector (arrowed 'A' and 'B') which are also intended to fuse.



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! So if in doubt, fit a separate fuse.

reduces (or increases) in proportion and the motor speed has to increase (or decrease) proportionally to compensate.

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.

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!

The vast majority of controllers returned have no fault, or simply a fuse track has been blown by a wiring fault (see back page for fuse information). Of the rest, most failures are due to misuse, albeit often through misunderstanding.

There is not a lot we can do about external wiring faults except to protect the controller as much as possible. However if a bad fault occurs in the controls (connected to the 6 pin input connector) something has to give and the controller has been designed to protect itself and minimise damage caused by user's mistakes. For instance, there are weak points (fuse tracks) in the controller intended to limit the damage- see opposite.

Sometimes wiring faults (e.g. a short between +24v and the pot) will feed current back into the controller and blow the 9v1 zener diode. This usually fails safe (short circuit) so that there is no voltage feed to the pot. This is probably a return to base repair - unless you feel confident with a soldering iron, in which case ask us for help.

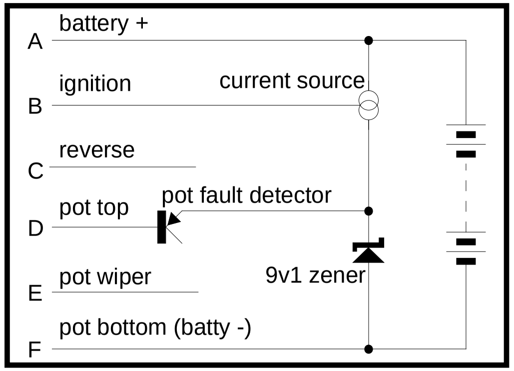
The zener can also be blown sometimes by mishandling, e.g. disconnecting the controller than putting it down on a metal object: the main capacitor stores charge for q considerable time.

Some problems are caused by the wrong wire in the IDC connectors.

MOSFETs do fail occasionally: 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.

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 9v1 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 9v1 line is 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, change the blue wire to pin E from 0v to 8.5v, depending on the pot setting.

Main capacitor:
Be aware that certain uses of the controller can cause this to heat, particularly if the battery leads are long. The main capacitor may get warm, but should not be allowed to remain hot to touch for too long. Heating will shorten the life of this capacitor and, if excessive, can cause it to vent. When it vents, the liquid electrolyte inside boils and vents. Although the capacitor failing does not do any direct damage (the controller simply looses power) the venting capacitor can expel hot electrolyte: if this gets on to the wrong part of the circuit board the controller may well fail.

Models

4 models are available, for different current ratings and with different options.
Each is available as 12v or 24v, but the 24v can be supplied with resistors in the relays for 36v operation. Also available are -48v versions.

NCC-35-12, -24, -36 & -48	35 Amps	50A max	
NCC-50-12, -24, -36 & -48	70 Amps	100A max	
NCC-60-12, -24, -36 & -48	70 Amps	100A max	see warning about relays, page 15.
NCC-70-12, -24, -36 & -48	70 Amps	100A max	

Slave versions of all versions are possible or two standard units can be interconnected in tandem

The NCC-60 is the same as the NCC-70 but without the thermal sensor and brake driver

The voltage is marked on the relays. Make sure these are correct as 24v relays will not operate from 12v and 12v relays will soon burn out their coils if used on 24v.

36 and 48v versions use the 24v relays but with a resistor in series with the relay coils and other components changed as appropriate.

A boxed option is also available.

Safety

It is normal practise, on passenger carrying vehicles, to include some means of disconnecting the battery or motor in an emergency. This is normally to guard against a failure in the controller or wiring which could theoretically cause the motor to run at an uncontrollable top speed. The NCC range controllers are protected so that such failure is very unlikely.

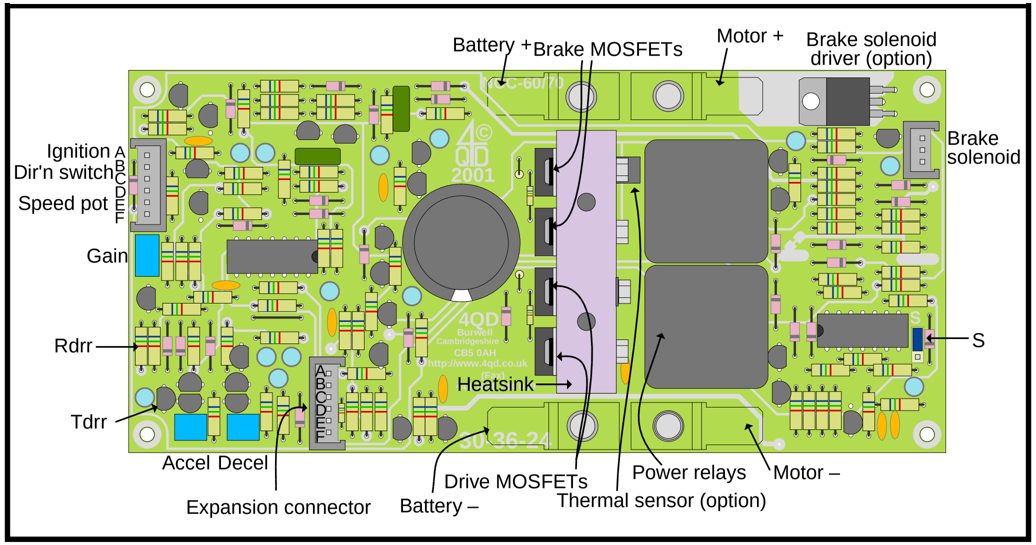
Experience also shows that, in the unlikely event of a power device failing, the device acts as its own fuse, removing drive from the motors. Also, as the demand speed is further turned down the relays will eventually disconnect and short out the motor to give full emergency braking.

Most ‘dangerous’ faults have been due to water splashes on the board - which is outside of our control. However, no manufacturer, however careful, can always guarantee what will happen in the event of a failure, so the constructor should consider what might happen in the event of such a fault and should consider fitting an emergency circuit breaker, relay, or battery disconnect switch or arrange the battery so it can quickly be disconnected (but see section on ‘Battery Connections, page 7).
All passenger carrying vehicles should, in any case, be fitted with a mechanical braking system for emergency use.

Reversing

On the NCC series controllers, reversing 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 ramp circuit and not by measuring the motor voltage so that, if the vehicle is reversed when going down a hill, the 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 if the gradient is steep depending on the setting of the ramp controls. The user is best advised therefore not to reverse on steep hills!

Features



The diagram above shows the NCC-70 which has four MOSFETs as does the NCC-60. The NCC-35 has two only.

The NCC-35 has different relays and power terminals but board layout is otherwise the same.

NCC-60 is the same as NCC-70 but without the overheat sensor and the parking brake driver.

Speed pot and reversing switch input is via a 6 pin connector, supplied.

Power & Motor connections are by blade connectors: 9.5mm on the rear of the NCC-60 and 70 and 6.3mm on the front of the NCC-35 controllers, when spare connections are provided for battery/motor +, battery - and motor -. These spares can be used for control wires or for extra motor wires as you wish. The 6.3mm terminals used will also accept 2.8mm connectors, which can be useful when using several small motors in parallel.

Also available is an expansion connector option, see page 12.

The diagram above is an issue 18 board: issue numbers above 7 are all quite similar.

Heat & Heatsinking

The rated current output of the controllers is with the heatsink hot. When cold they will give considerably more current. Thus the 35 amp version will in fact give about 50 amps when cold. This is OK because the MOSFETs used are rated at 60 amps continuous with a case temperature of 25°C. As the MOSFETs warm up their allowable current reduces so that at a case temperature of 100°C they can (only!) handle 42 amps each continuously. The current limiting used in 4QD's controllers senses the MOSFET temperature and automatically adjusts as the MOSFETs heat up. However, running the controllers at full current will cause speedy heating so the allowable continuous current will depend on the external heatsinking.

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

The NCC-70 and NCC-100 incorporate a thermal sensor (optional on other models) which cuts back the output current if the controller gets too hot. The NCC-70 cuts back to about 30 amps, when the MOSFETs will dissipate about 20 watts. This is still enough to overheat the controller if no external heatsink is used, so don't rely on it!

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 NCC is current limited you won't overload the 12v motor, provided it can handle the available (limited) current.

Shunt wound motors can be used if the field winding can be separated. Connect the field winding permanently across the supply and control the armature winding: the shunt would motor then behaves like a permanent magnet motor.

Series wound motors may also be used but they cannot give dynamic braking and are very inefficient at low speeds so are not ideal. To use them with the NCC series a modification must be made so the field can be correctly connected into the relay circuitry: contact the factory for details.

You can reverse a field-energised motor by simply swapping over the field windings. You should not do this when the motor is rotating as armature currents will then be very high. The field will draw much less current than the armature so a much smaller switch will suffice. A field energised motor, used on the wrong voltage, will normally still go approximately at its designed speed. This is because its field current

Torque mode

Current limit is pre-set: it can be altered by a value change, but this should only be undertaken by the technically proficient - 4QD's guarantee will not cover damage done by inexpert modification.

On the 'features' diagram is shown a resistor Ri. This controls the current: to reduce the limit, reduce this current. As supplied this resistor is 47K., giving a limit of about 50 amps on the -35 model and 100 amps on the 50 and 70 models.

Reducing this resistor will reduce the current limit. If in doubt, contact 4QD.

For constant torque applications you can run the controller in current limit mode but be careful: if the current limit resistor becomes open circuit, there will be no current limit which could prove destructive. Remember also that the current sensing is done in the MOSFETs - therefore it is affected by the MOSFET temperature. If the MOSFETs are allowed to run hot, the current will drop, so for good stability use a high current controller with the current limit set well back to minimise self heating.

Also overheat protection monitors the heatsink - but this is not the only part of the circuit which gets hot. Using the controller at high current can result in other components running too hot so please consult 4QD.

Expansion connector

This 6 way connector may be fitted as an option. This expansion connector has two main uses:

1 To fit a board to work with a tacho generator in a closed loop speed control system: this gives far better speed control range and improves performance (especially torque) at slow speeds.

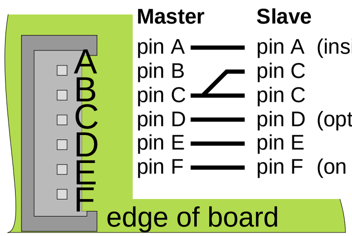
2 For ganging two NCC controllers together, either for a two motor vehicle or for occasional use, as when double heading a loco.

Double heading

When two standard controllers are ganged one is the master and the second is the slave. The master is connected normally and controls one motor and the parking brake (if fitted).

The slave controller needs only battery connections and connections to the second motor. If other controls are fitted, the speed will be ignored but the ignition and direction will affect both controllers.

The slave is connected to the master NCC via a 6 way cable between the two expansion connectors wired thus:



The 'demand speed' signal is fed from the master's pin B to pins C on both controllers.

When connected thus, the two controllers will work as one, controlling the two motors with the gain and ramp adjustments of the master controlling both motors.

The master's ignition and direction switch will also control the slave.

This slaving system can be used as a permanent controller for a two motor vehicle, when 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 NCC system, each motor may only draw up to 100 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

When the slaving is removed from the system, you must again link pins B and C on each controller. It pins B and C are not connected, the controller will not work.

¶ Specifications

Supply voltage		12v, 24v, 36v or 48v	different models.
Supply current		25mA	at zero speed
Motor speed	forward	0 to 100% full speed	adjustable
	reverse	0 to 50% full speed	reduction may be disabled
Output current	NCC-35	35A hot	50A cold
(typical)	NCC-50	70A hot	100A cold ‡
	NCC-60	70A hot	100A cold
	NCC-70	70A hot	100A cold
Overheat temperature		95°	on heatsink
Overheat current		20 amps	typical, NCC 50, 60 & 70
Switching frequency		20kHz	approximately
Size		175mm x 80mm x 45m	
Weight		260g	
Input		2k to 20k pot.	
Pot fault detect		greater than 25K	
Input voltage		3v to 20v for full speed	adjustable
Acceleration time		330mSec to 7 Sec	adjustable
Deceleration time		330mSec to 7 Sec	adjustable

Mounting

The NCC series are designed for mounting via the heatsink as in the diagram below. In most applications, full current is only drawn for short periods so little heating will be experienced. However, the NCC'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. The heatsink is not connected to the rest of the circuitry.

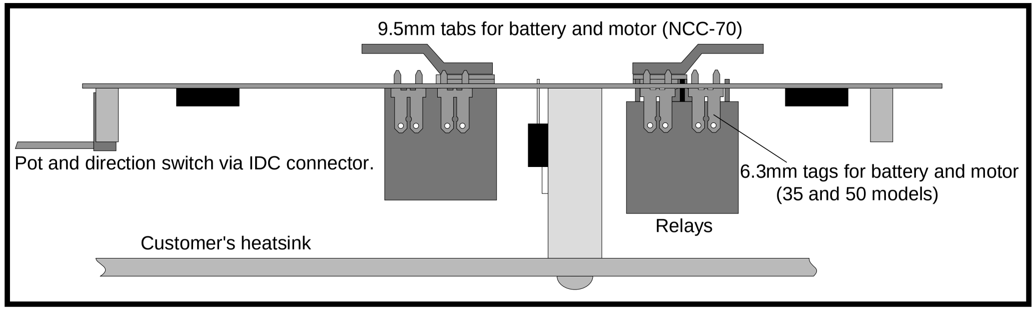
Mounting holes are tapped M4. Do not drill these out larger. It is unnecessary and you will contaminate the board with swarf, invalidating any guarantees.

For more information on heatsinking, see page 13

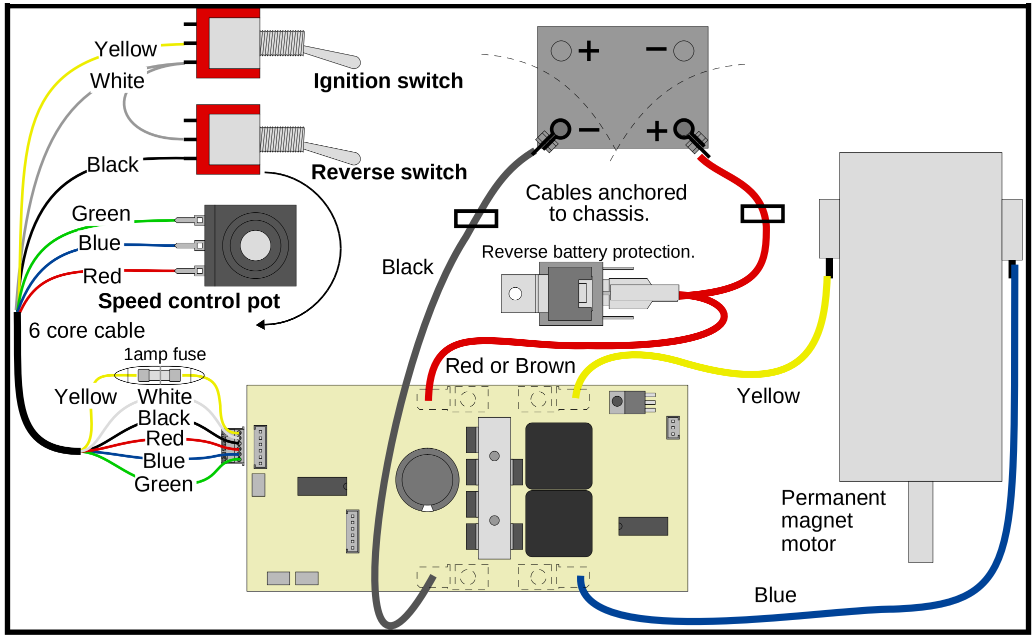
You can also mount the controller in a diecast aluminium box, e.g. Eddystone 26827PS.

Do not use the corner mounting holes as there is danger of shorting out to the printed track and damaging the controller. You may of course use these holes is you use insulating mountings 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.



Connections.



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

On the 6 way multicore control wire, 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!

Boxed version: Wire colours are as shown in the diagram above.

Notice the fuse in the yellow wire. If this is omitted and there is a mistake in the wiring, fuse tracks on the controller may blow. Controllers returned for repair with the fuse tracks blown will be subject to a handling charge, so if you are happy to repair these fuse tracks yourself, you do not need this fuse! See page 15.

Notice also the relay for reverse battery protection. See 'Polarity' of facing page.

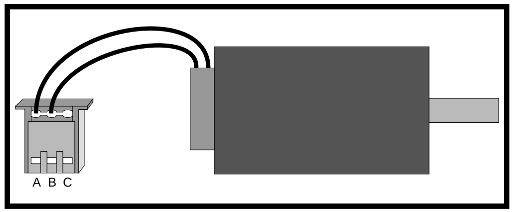
Braking

Regenerative motor braking is integral to the NCC 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 speed at which the braking acts is adjusted by means of the deceleration adjustment.

Regenerative braking does not work well at very 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 removed and when power is removed the brake is applied by a spring.

The NCC controllers have an (optional) 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 is via the 3 pin connector, shown on the diagram 'Features'. This feature is standard on NCC-70 but is optional on NCC-35, NCC-50 and NCC-60.



Adjustments

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.

Maximum setting of the gain preset will give full output for about 3v input.

Ramps

The NCC 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 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 normally 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 to reduce the acceleration, anticlockwise decreases the time, increases the acceleration. If the time is set too short (anticlockwise) the vehicle's acceleration will be limited by the current limit which does no harm but 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 normally 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, giving a jerk before the vehicle stops completely. This will also shorten the life of the relays.

Reversing switch

Reversing switch connections are shown in the diagram above. 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.

Reverse Speed reduction

¶ If reverse speed reduction is **not** required it can be disabled by moving the header marked ‘S’ on the board and in the ‘features’ diagram. This is a pinstrip with a shorting link which simply unplugs. As shown (bottom pin free) reverse is the same as full speed. As supplied (top pin free) reverse is at half speed.

Dual ramp reversing

¶ It is 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.

There are several ways of disengaging the dual ramp reversing: the best for you will depend on why you do not want dual ramp reversing.

Email support@4qd,co.uk for advice.

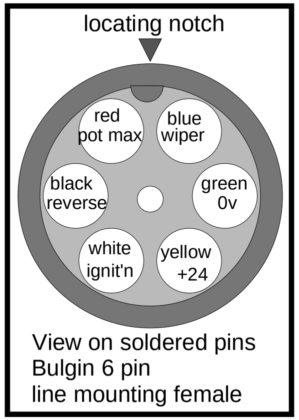
Reverse threshold

If you are reversing the controller from, for instance, a microcontroller, the threshold is around 5v. A voltage above this selects reverse, below the threshold selects forward.

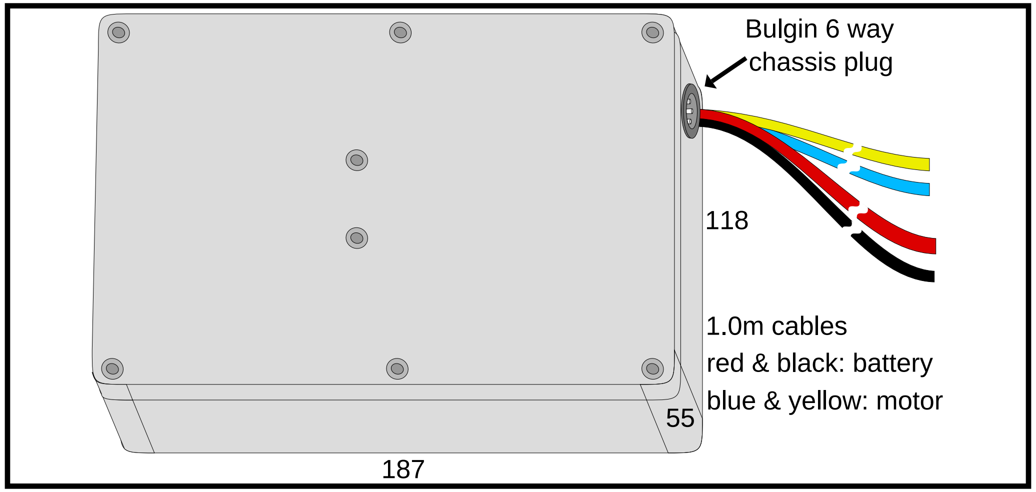
Boxed version: 6 way chassis plug

Connections to the line socket must be as shown in the diagram.

Note that this is a view looking at the soldered connections to the line socket, i.e. looking at the pins of the chassis plus mounted on the box, as seen by the line connector.



This is shown in the drawing below.



Power Connections

Battery wiring

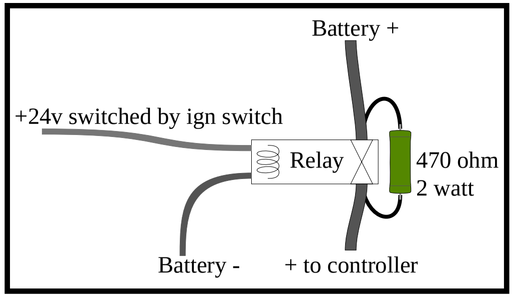
Battery connections to the controller are shown in the diagram opposite. Use only good quality battery connectors: the controller feeds current back into the battery during braking and if a battery connector falls off when braking this regenerated current can pump up the voltage on the dud battery connection.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

Note that there is a charging spark as the battery is connected and the main capacitors charge. The capacitors can retain charge for several hours, so the spark may not occur again if the batteries are disconnected and re-connected.

Polarity

Take great care: the drive is NOT POLARITY PROTECTED: any battery reversal will instantly destroy all the power MOSFET devices and many other components. This will not be covered by the guarantee! To avoid this possibility we suggest you anchor the battery wires to the chassis at a suitable distance such that, if the battery is turned round, the battery clips won’t reach the terminals which are now in the wrong position (shown by the empty circles). A suitable arrangement is shown in the diagram opposite.

If you wish to protect against reversed battery this can be done by wiring a suitable relay (one normally open contact) in the positive battery lead. One end of the coil connects to battery -ve and the other to pin B of the input connector which is also connected to the ignition switch. A resistor must be connected across the contacts as shown. When the ignition is off, there is no voltage on the relay coil and the relay contacts are open. The NCC’s main capacitor charges through the 470 ohm resistor.



If the battery is reversed the NCC’s MOSFETs short out the capacitor, so no voltage is present and the 470 ohm resistor limits the current to a safe value. When the ignition switch is closed the relay coil is connected across the capacitor: if there is voltage (battery correct) the relay operates and applies full power.

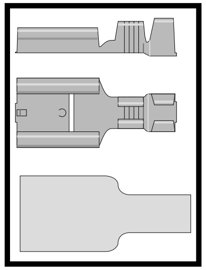
4QD can supply a suitable relay (**RLY-724**) for 24v only but a 12v version is common in car electrics.

Wire size. Use heavy duty wire for the battery 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 the 75 amp version and 4.0mm² for 50 and 35 amp versions. Thicker wire will cause no problems, so use the thickest you have.

Use of wire that is too long (and/or too thin) will cause loss of power, but more importantly the decoupling capacitor (see ‘features’ diagram above) will heat up. Heat will shorten the operating life of capacitors.

Crimp Contacts

It is ***very important*** that you use fully insulated crimps: the power connections are close to the board and uninsulated crimps may short out and destroy the controller. Best of all use ‘F type’ crimps with vinyl covers shown in the drawing.



4QD can supply these pre-crimped - they require a special crimp tool.

Also be aware that the main capacitor can store charge for a long time, up to 24hours even, so the potential for damage is there long after the battery has been connected.

Motor wiring

This is not so critical as battery wiring: too long and/or too thin wire will cause a loss of maximum current, will get hot 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.

Circuit breaker

A circuit breaker or fuse 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.

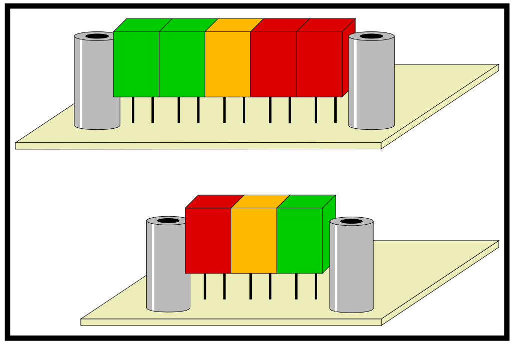
A suitable low value fuse can also give some protection to the MOSFETs in the event of a battery reversal, though this cannot be guaranteed! Use the lowest value fuse which does not give nuisance tripping in normal use.

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, free-wheeling 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.

Battery condition meter.

Pins A and F (yellow and green on the diagram) are directly connected to the battery so that you may use them to connect a battery condition meter.

The drawing shows 4QD's LED battery indicators.



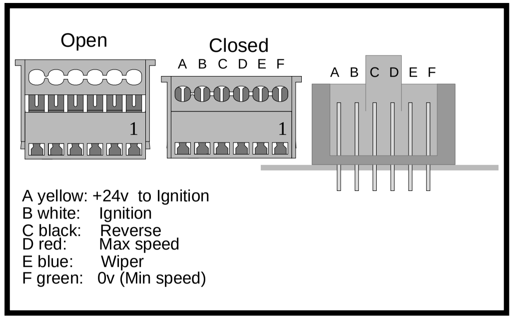
Controls

6 way connector.

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) which 4QD have chosen because it is so very easy to use and very dependable. - but only with the correct wire!



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 contact. Wire which is too thick will damage the tines.

Do not use single strand (telephone) wire: it will break and make unreliable contact.

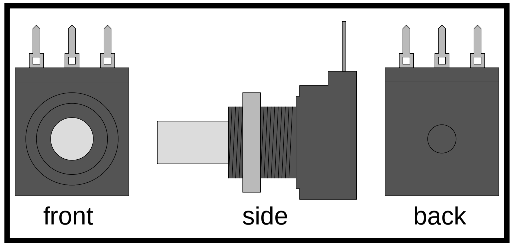
You can re-open a closed connector by gently moving the tabs at the sides of the top cover outwards to disengage the latches while lifting the cover slightly, one side at a time.

Speed pot.

We suggest 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.



The drawing shows the pot supplied by 4QD

With this pot you should only solder to the tips of the tags: the holes shown are not for soldering but as heat barriers to stop heat travelling up the tag and melting the plastic body.

¶ 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.

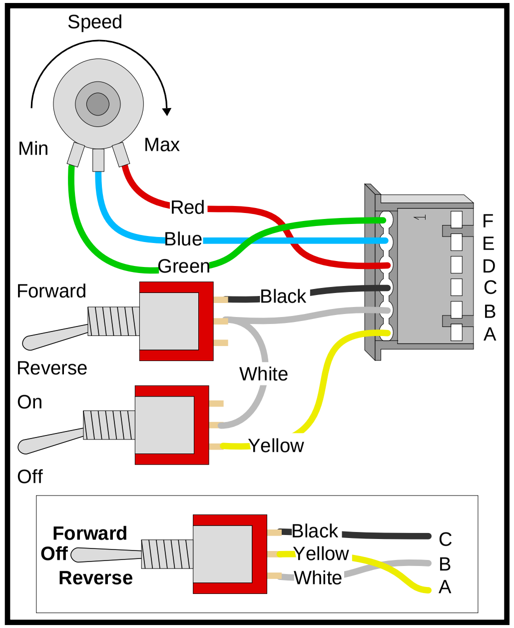
Ignition and reverse inputs are both high impedance (voltage controlled). High activates. Thresholds are around 5v for both.

On/Off switch

Circuitry in the controller switches it off (zero current consumption) unless there is a voltage on pin B or pin C.

There are two ways of wiring:
Ignition and reverse
Shown in the body of the diagram

Forward-off-reverse
shown at the bottom of the diagram.



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

If the switch changed is the reverse, it will then accelerate up to speed in the other direction. This process is quite safe (for the controller).

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.

With the *Forward-off-Reverse* wiring, the pot may be used as a preset speed and the controller operated by the switch, which could be two push buttons.