Adjustments

Gain

There is only one adjustment on the board: sensitivity. 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 then, listening to the motor, adjust the preset. It it usually quite easy to tell when the motor stops accelerating.

Current limit

This 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 limit: to reduce the limit, reduce this resistor. As supplied it is 33K (or other value, depending on MOSFETs used), giving a limit of about 57 amps on the 35a model (115 amps on the 70a model).. Values lower that about 22K will cause malfunction. It is also possible to remove this resistor entirely and fit a 47K preset in the position marked 'Current'.

Torque mode

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.

Acceleration ramp

This is also preset: it is present to make the speed change smoothly when the speed pot is altered suddenly. It can be altered by a value change. For those with electronic experience, the ramp is controlled by a 1µ capacitor and a 220K resistor, beside the sensitivity adjustment (shown as Cr and Rr in the features diagram). The 1µ may be decreased (or even removed for really fast response), or increased for slower response. Be warned that inexpert modifications may invalidate the guarantee so don't attempt modifications unless you are proficient with a soldering iron!

"We're in Control"

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Instruction Manual

2QD series controllers

4QD's range of 2 quadrant controllers are well suited to general purpose speed control applications. They are used extensively by hobbyists and industry. Amongst other applications our controllers have been successfully used in the following:

Aerial rotators
Camera dollies
Caravan shifters
Carnival floats
Conveyors
Electric boats
Electric bicycles
Electric library trolleys
Electric wheelbarrows
Factory stores vehicles
Floor cleaning machines
Golf caddies
Kiddie cars
Lathes & milling machines
Miniature railways, 3", 5" and 7¼ gauge
Mobile targets
Mountain rescue vehicles
Potter's wheels
Remote controlled vehicles
Ride on golf buggies
Voltage dropper for battery lighting
Winches
Window cleaning machines

Wherever battery motor speed control is required.

Introduction

4QD's 2QD range are motor speed controllers for battery operation covering the range of currents up to 120 amps. Two voltage options are commonly available, the 24v version, for 12v to 24v operation and the 36v version for voltages from 12v to 36v. A 48v version can also be supplied. 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, reliability and battery economy.

The simplest possible configuration is shown in section 7. However our drives are used for many different purposes and we therefore give a lot of extra information in this manual - which may make it seem to be more complicated than it is. 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. If you have any queries, please contact us at 4QD since it is only by listening to your comments that we can improve our product and the instructions we give.

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 to measure the current limit. The drives survive this, just getting hot, though they will fail eventually from excessive heating. The mark 7 controller also includes protection so that, if a battery connection fails, the controller cannot destroy itself by regenerating power into a non existent battery. Also included is current limit on the regenerative braking.

Models

2 models are commonly available, for different current ratings. Each is available as 12-24v or 12-36v options

12-24v	12-36v	Current
2QD-35A-24v	2QD-35A-36v	35 Amps
2QD-70A-24v	2QD-70A-36v	70 Amps

we can also manufacture versions to work from 48v, 60v and even 72v.

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 cause the motor to run at an uncontrollable top speed. The 2QD range controllers are protected so that such failure is very unlikely but 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 in the unlikely event of a controller failure. All passenger carrying vehicles should, in any case, be fitted with a mechanical braking system for emergency use.

Braking

Braking is integral to the 2QD range and is usually a desirable feature whenever a controller is used from batteries. However for fixed use, from a mains power supply, braking may prove a problem since, during braking, energy is returned to the power supply where it can pump up the power supply to about 36v(for the 24v version), which could cause failure of some power supplies. It is possible to disable the regen braking: contact the factory for assistance.

Reversing

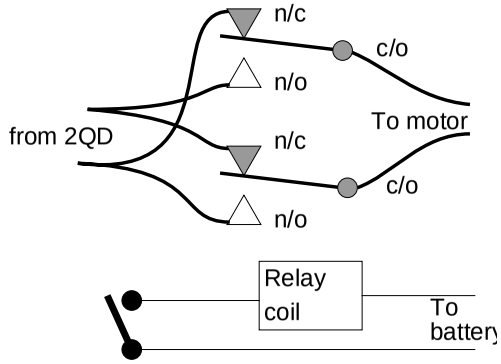
The 2QD controllers are only single direction. Reversing can be done by a heavy duty switch or relay (but you should not operate the switch while the motor is rotating as this will do no good to the mechanics). You can also use two 2QD controllers to make a 4 quadrant controller by using two back-to-back application note available).

4QD also manufacture the VTX range of reversing controllers which are based on the 2QD series, but with many enhancements and are designed to decelerate and reverse the motor properly even is the reversing switch is operated at high speed.

Switch or relay.

You will require a double pole changeover switch to swap the armature connections. The diagram shows the relay or switch wiring.

The normally open contact of one pole connects to the normally closed contact on the other pole and vice versa.



Note that motor connects to the moving contacts. If one pole of the switch jams the moving contacts can short together which might damage the controller but will not harm the motor.

IMPORTANT: the switch or relay must not be operated whilst the motor is running. To do so will place great stress on the motor and mechanics. To avoid this, put the reversing switch somewhere so that it cannot easily be operated from the normal driving position.

This is the main reason that reversing controllers are available: they are configured so that reversing is safe (to the controller) under all conditions, even when the reversing switch is operated at full speed.

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 they can (only!) handle 45 amps continuous. The current limiting used in 4QD's controllers senses the MOSFET temperature and automatically adjusts. However, running the controllers at full current will cause speedy heating.

However, at some temperature (well above 100°C) the MOSFETs will become unsafe, so we suggest that, during initial use, you keep a note of the heatsink temperature and, if it becomes much too hot to touch, take appropriate steps, either by mounting the 2QD onto additional heatsinking or, better still, fit a higher rated drive since heat is wasted battery power and a larger drive will waste less. When using an external heatsink remember that steel does not conduct heat well: aluminium is far better.

Controls

Speed pot

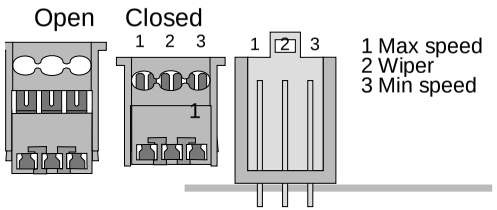
We suggest a 10K linear pot, although other values from 1K to 100K, linear or log, can be used.

The 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 pot with lever, suitable for a hand control (we use it as a hand throttle control for golf buggies). Alternatively 4QD can supply a plunger operated pot (linear position sensor), suitable for incorporating into a foot pedal or a hand throttle mechanism.

Connections

are shown in the diagram.



The mating connector supplied is suitable only for 7/0.2 wire (7 strands of 0.2mm² wire). It 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 contact. Wire which is too thick will damage the tines.

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.

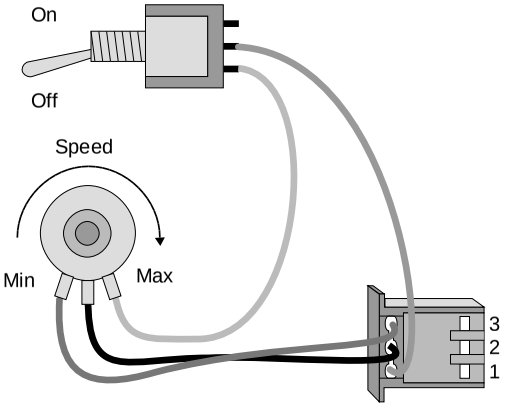
Use as voltage follower

Instead of a pot the input may be fed from a variable voltage. 0v (common) to pin 3, signal input (+ve) to pin 2. A resistor (10K) should be connected from pin 1 to pin 3 to operate the internal 'ignition switch' 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. If more gain is required (for lower input voltages) a resistor may be added in the position shown Rs on the 'Features' diagram. 10K will halve the input voltage, 1K will reduce it to .3v for full speed.

On/Off switch

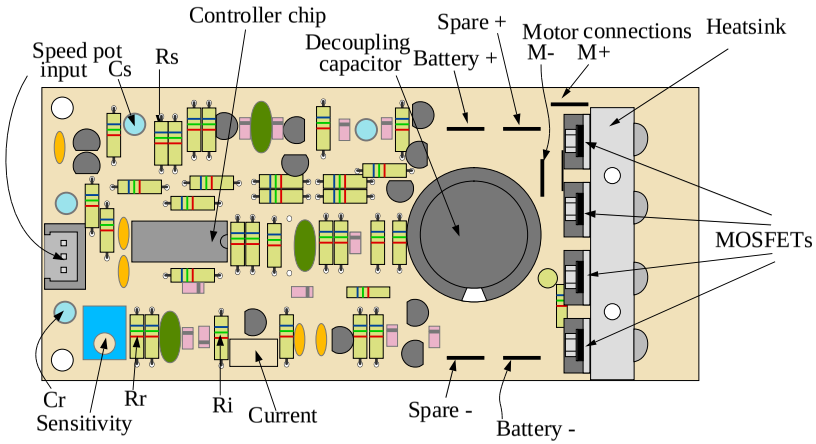
If the potentiometer is disconnected, circuitry in the controller switches it off (zero current consumption). Therefore a switch in series with the top of the speed pot (pin 1 of the IDC) will act as an 'ignition' switch.



Beware of opening the switch when the motor is running: the motor will quite quickly be braked to a halt with possible high stress on the mechanics. The Mk 7 2QD has regen current limit, so it will not be damaged by this.

With the ignition off, or even with the battery disconnected, one of the MOSFETs will act as a diode connected across the motor: freewheeling will be possible in one direction only. To freewheel properly the motor should be disconnected.

Features



The diagram shows the 70 amp model. The 35 amp version is the same, but with only 2 MOSFETs.

Speed pot input is via a 3 pin connector, supplied.

Power & Motor connections are by means of 6.35 blade connectors. Spare connections are provided for battery/motor +, battery - and motor -. These can be used for control wires or for extra motor wires as you wish. The terminals used will also accept 2.8mm connectors, which can be useful when using several small motors in parallel.

Specifications

Supply voltage	10v to 30v	all 24v versions	
	10v to 50v	all 36v versions	
Supply current	20mA	at zero speed	
Output voltage	0 to 100% full speed		
Output current, drive	2QD-35A	40A hot	55A cold
(typical)	2QD-70A	80A hot	110A cold
	2QD-100	1100A hot	130A cold
Output current, regen	2QD-35A	40A	
(typical)	2QD-70A	80A	
	2QD-100	120A	
Switching frequency	20kHz	approximately	
Size (board only)	110mm x 55mm x 30mm		
Size (with heatsink)	170mm x 55mm x 35mm		
Weight	100g		
Input	10k to 100k pot.		
Input voltage	3v to 20v for full speed (adjustable)		
Integral heatsink	5.6°C per watt		in free air

Mounting

Most customers use a controller larger than necessary, so no heating will be experienced. If so mounting is not critical and we are sure many controllers will end up wrapped in polythene bags and 'stuffed' somewhere convenient. 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.

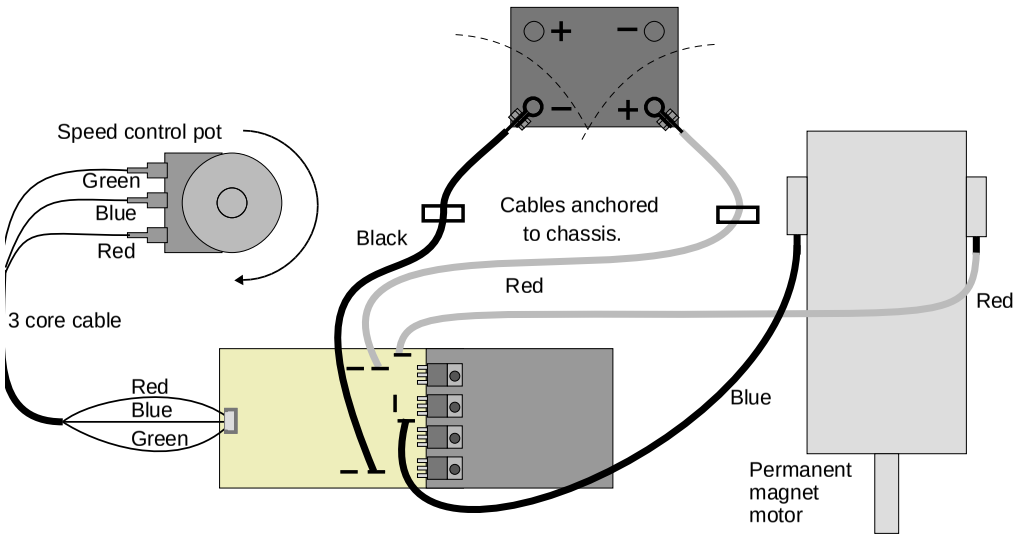
However, if you want to mount the unit properly, mounting holes are provided in the heatsink. The heatsink is not connected to the rest of the circuitry so it may be safely screwed down to metalwork etc. Take care that there is adequate clearance between the underside of the board and any metalwork: if the board or any components touch metal this could cause a failure. Corner mounting holes are also present if required.

If convenient, especially at higher currents, mount the heatsink in intimate thermal contact with the metalwork: this will aid cooling and increase the length of time the controller can operate at high currents. For high current use, where heating will occur, we advise the use of heatsink compound between the 2QD's heatsink and the metalwork to assist heat flow.

See also section on heatsinking.

Connections

The diagram shows the simplest connections needed to use the controller. More detailed information on wiring follows.



Power Connections

Battery wiring

Battery connections to the controller are shown in the diagram above. 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.

Polarity

Take care: the drive is NOT POLARITY PROTECTED: any battery reversal will instantly destroy all the power MOSFET devices. 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 connectors 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 above.

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 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 doubled lengths of 4.0mm² or 6.0mm² for the 100 amp version, 6.0mm² wire for the 75 amp version and 4.0mm² for the 35 amp version. 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 and may also cause the decoupling capacitor (see 'features' diagram above) to heat up. Under extreme conditions (especially with the 100 amp version) the capacitor can disintegrate. Heat will also shorten the operating life of this capacitor. Once the capacitor fails the current output will fall dramatically.

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 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. Never open the breaker while the drive is operating as the drive regenerates into the battery: if the battery is disconnected damaging high voltages can be generated.