ELECTRONIC SPEED CONTROLLERS

REX BOYER EXPLAINS THEIR WORKING AND DESCRIBES EIGHT POPULAR TYPES

FOR SOME considerable time now, various types of device have been available for speed control of small high power, low voltage motors; main uses being for model cars or boats.

As the motors used in these models are almost universally permanent magnet (effectively shunt wound) direct current (DC), any sophisticated speed control using extra motor fixed windings as in fullsize practice is not really practical. So there remains only the system varying the voltage supplied to the motor and letting it decide on speed for a given supply voltage at a given load. Unfortunately, in the uses to which the motor is put, seldom is the load constant and therefore the current drawn, so the speed will vary, even with a steady voltage. In other words, the system is in *Open Loop Control*.

It could, of course, be possible to put onto the motor shaft a small tacho generator to give a voltage proportional to the speed of the motor, feed this signal through some suitable circuitry which in turn would alter the supply to the motor to hold the speed constant. This would then be a *Closed Loop System*. This principle is used extensively in fullsize DC motor speed control.

Original thoughts on the problem were to use big series resistors with a wiper rather like a huge potentiometer which in turn was moved by a servo. This system is still extensively and successfully used but being mechanical, has its drawbacks for reasons of maintenance and sheer bulk.

In an attempt to resolve some of these problems so called electronic speed controllers have been developed for sale by different companies and it is the purpose of this review to describe these devices and try to explain the differences.

Basically, the problem is that the device has to be connected to the car drive battery which is normally either a 6V or 7.2V Ni-Cad pack of some 1200mAH capacity (and therefore capable of giving very high currents), which supplies the motor with a voltage from 0 to 6V/7.2V as proportionally as possible and also supplies peak currents up to 25 Amps!

It should also be able to offer dynamic braking to the motor. This can either be achieved by short circuiting the motor, after turning off its supply, or applying a small opposite polarity voltage to it. In which case a lot of current is being either supplied or absorbed by the controller. Hence the 25 Amps; normal running current is in the region of 5-7 Amps, a less significant problem.

One major consideration is the dissipation of the unwanted power. Say for instance we have a car running flat out at full throttle, the supply voltage of 6v at say 7 Amps, there is bound to be a voltage drop across the supply (commonly 0.5 Volts), so the actual voltage to the motor will be 5.5V at 7 Amps which means that 0.5 Volts at 7 Amps is lost in the supply transistors, 3.5 watts, not too difficult to cope with.

Now suppose the driver suddenly decides to stop, then dynamic braking effort is required which puts a short circuit effectively on the motor. Instantly the motor will be generating almost the 5.5V figure it was being supplied with, let us say 5V. The current will still be at least 7 Amps but the watts will be 35! And as we all know, Watts is what makes things hot!

The even more horrifying case arises when instead of just going to 'stop', the driver decides to go from full forward to full reverse. The current will now reach astronomical figures and the duration in time will depend upon the kinetic energy of the car — if it's heavy then it could be many Watts for a comparatively long time. Hence a lot of heat.

No. 1. Smoothtronic Mk. 3R

This unit, which is housed in a pressed aluminium box size 60 × 40 × 30 mm and weighs 3oz. It is of the type with a reverse relay, i.e. half of the output bridge of transistors and utilises a single pole change-over relay.

In operation this relay is delayed so that an immediate forward/reverse of the motor is not possible. It does offer progressive braking on forward. That is if the car, say, is going forward, then by moving the control stick back through neutral, proportional degrees of brake can be achieved, but the car has to come to a full stop, then a short pause before the relay goes over before it can be put into reverse.

The system uses two very large tab type transistors with two small tab types bolted to the bottom plate which acts as a heat sink. The unit utilises two printed circuit boards, the top board containing the power regulator for the receiver supply which is 6V nominal. Also contained on this board are the two adjustment pots, one, as is to be expected, the neutral setting, the other is the full power adjust. This, it is suggested, is all set up by means of a 12V bulb in place of the motor, a good idea. Adequate instructions for setting up are given, and apart from the delay in the reversing, we felt this was a good unit.

On test the unit gave 0.4V drop at a load of 5 Amps in both forward and reverse directions.

Fifteen minutes running at a constant 5 Amps 7.2V input did not cause the unit to get very hot, so we feel the makers claim of 15 Amps a possibility but not for real *continuous* running. The peak rating of 25 Amps would also seem to be feasible, but not for many seconds.

Not an easy problem to solve; to start with the 0.5V drop we are likely to get from the transistors means speed loss which in competition this can be ill afforded. Hence in some of the controllers developed, there is a 'full speed' override relay which comes in at a predetermined percentage of stick travel. In most cases 85 per cent is suggested, which connects the battery directly to the motor. A relay does give a 'step function' to the acceleration of the car or boat and unless it is of a very good quality, the contacts can soon start arcing and pitting and we are back with a 0.5V drop again. If reverse is required we have to connect up another set of transistors to give the opposite polarity to the motor, so this type of controller would be rather like a three wire servo in its output stage, or what is known as a Bridge Circuit. The System unfortunately puts two transistors in the supply to the motor so we would expect a good 0.5V drop to the motor. An alternative selected by some manufacturers is to use a relay in place of one pair of transistors whose operation is set so that it just changes over when the control stick is in the neutral or stop position. This obviously gives a slight delay in going from full forward to full reverse in one case is definitely sluggish, giving the feeling of 'coasting along with a box full of neutrals!' An almost universal feature is the provision of a 5-6 V supply for the receiver, rated in most cases at 250 mA, sufficient to power both the receiver and the steering servo. This is usually derived from a solid state voltage regulator chip supplied from the main traction battery. This feature of course eliminates the need for a separate 4 cell battery pack for the receiver in the car or boat.

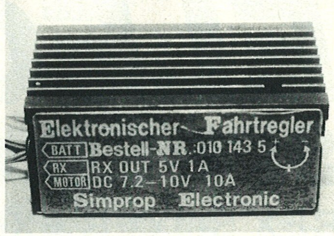
Dynamic braking is achieved in various ways, one unit using the changeover relay as the second pair of transistors. The circuit is so arranged that when the stick is in the centre position a diode effectively connected across one half of the other pair of the output transistors becomes biased 'on' and effectively shorts out the motor.

Depending on how you set up the neutral with this type of circuit, you can either get braking on forward travel on reverse but not *both*.

Another way of achieving this form of braking is to put a transistor across the motor leads and turn it on when the stick is at neutral. In all except one unit (*Futaba*) it has been necessary to use at least two transistors in parallel in the actual output stages in order to cope with the very high current flows as it is quite possible to get 35-40 Amps from a 6-7.2 V Ni-Cad. (it is also possible to get the same degree from the motor when it is acting as a generator). Agreed the current is transient or the fuse or cutout would blow, but remember it only takes seconds to blow up transistors.

Setting up the controls for any particular R/C equipment we found varied from simple to complicated. In all cases there was adequate movement on the controls to cover all forseeable applications.

It should be noted that on all the controllers tested, the input was for positive pulses of 1-2 milliseconds-length.



2. Simprop

This unit has been seen before under different brand names, and is of Japanese manufacture. It is a fully *electronic* controller in the full sense in that there are no relays or mechanical moving parts, and only one adjustment is given. This is the reversible setting pot.

Eight transistors are used in the output bridge, 4 PNP (2 × 2 in parallel) 4 NPN (2 × 2) in parallel. The unit also offers a 4.8V output to run the receiver and one servo. What a pity the instructions were all in German, but the picture and drawing of the set up was sufficient to get it to work.

The unit comes complete with an on/off switch for main motor which actually says ON-OFF (so often this is in German!). Main fuse and a 7.2V connector with a spare mating half.

Rated at 10 Amps continuous with a one minute rating at 15 Amps at a maximum short circuit rating of 20 Amps. Under test at 5A, we recorded a volt drop 0.7 Volts at 5 Amps with no apparent real heating of the massive finned heat sink. We did find that a series of full forward to full reverse actions, when connected to a motor, gave a good temperature rise so some constraint on this type of usage should be made.

This unit suffers from giving the highest volt drop at a steady load of 5A-0.72 Volts being recorded. Rather a high price to pay for shcer electricity.

Unit size is 67 × 36 × 32 mm and weighs 35oz.

3. Falcon

Again a competition orientated unit with proportional forward control but with a full throttle bypass relay fitted as standard. Operation is almost identical to the previous unit, the setting up is made a trifle easier by the incorporation of an LED to set up the neutral position. A further LED is fitted to indicate the operation point of the bypass relay. This is achieved by a second potentiometer. A third potentiometer is used to set up the reverse speed and degree of braking. The harder you require the brakes to go on, the faster the car will go in reverse! Once again we find the output is a half relay half transistor bridge circuit in a 2 × 2 set up.

As with the other units a 5V regulated supply is available for the receiver and one steering servo. A twisted pair of leads is also brought out to enable a receiver on/off switch to be fitted if felt desirable.

This unit again uses Tag type transistors mounted on the sturdy lid of the box and the unit is again for 7.2 V operation. The makers claim of 5 Amps running with a peak of 25A would seem to be fully justified from test results. Obviously with a bypass relay fitted the voltage drop at full throttle was negligible. No plugs or sockets are fitted to the unit, but the instructions are quite specific as to where all the wires go. Of interest it is the only unit which makes special reference to the motor with a 0.1 to 0.3 yf capacitor.

Physical size of the unit is 76 × 50 × 22 mm with a weight of 3.0oz.

Conclusions

As discussed in the preamble to the review of these units, there is not much scope for any dramatic circuit variations to obtain the desired results, and from the limited testing we carried out using similar loads and conditions for the average user there would not seem to be any wide variations in performance one to another.

For the serious racer the situation is different. The units fitted with bypass relays definitely give the highest speed providing the relays stand up to the treatment or are changed regularly.

None of the units are particularly cheap, mainly because the components used are not by definition cheap.

With the wide price range and varying facilities it would appear to be 'you pays your money and takes your pick'.

4. Demon 2

This unit, as with others, incorporates a relay for the reversing mode of operation and offers a fixed speed in this position. The manufacturers suggest the unit as a competition model, with some very explicit intructions on do's and don'ts, especially the don'ts.

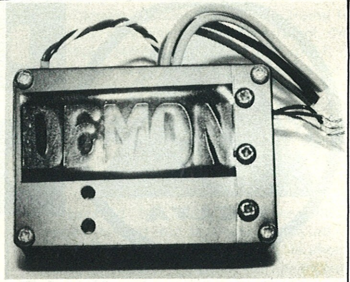
The unit is biased towards competition use and the reverse feature is, as the instructions suggest, mainly for negotiating obstructions, etc. As with one other units, the car will not go into reverse until it has come to a full stop. There is an inbuilt delay to prevent full forward/full reverse operation. The output transistors are of the usual tab construction and, judging by the very detail explanations, do at times get very hot, as with other units this controller features an output to feed the receiver and a steering servo, which is also protected against short circuits. No receiver switch wire is included. It is suggested the the receiver power lead be cut and a switch inserted should the need arise.

As well as fully proportional forward the unit also offers proportional braking as well, just by pulling the stick back from its operating position, but not by pulling it past neutral which results in free running of the car.

Obviously, this unit has had a lot of development put into it and the instructions are very explicit with all the faults one can expect, explained.

Two adjustment pots are fitted, one for neutral the other to set the reverse operating position, which it suggests should be a long way from neutral.

Supplies must be of at least 6 cell i.e., 7.2V, it is not designed for the 6V type of car. Makers claim of a voltage drop of less than 0.2V at 4Amp this could not be achieved. At 5A we obtained near 0.3V. No other figures are claimed except voltage drop of less than one volt at 12A, with a stall current of greater than 25A.



Physical size of the unit is 72 × 47 × 21 mm with a weight of about 3oz. Only additions were a battery socket. As an extra, a bypass relay unit is offered under the trade name of 'Turbo'.

5. AIL Type 1

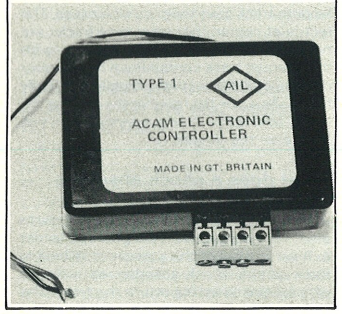
This unit which features forward proportional control with dynamic braking and is as would be expected from this specification the simplest of units the usual stabilised output for the receiver and steering servo is fitted but quoted at only 125 mA not really enough for a hefty servo motor, especially if it gets stalled.

One feature of this unit we did feel a little odd was that the heavy current connections both to the battery pack and to the motor came out to a terminal block and not the usual flying leads. Whilst we don't dispute the block was of excellent quality, it's just one more terminal to come loose or heat up.

Again, the output transistors were of the large Tag type, all except one being mounted on the metal lid, the fourth having a small piece of aluminium bolted to it to act as a heat sink. Weight 3oz.

Manufacturer claims 10A continuous and 20A peak with dynamic braking and only 0.25V drop. We found this latter to be a little optimistic. Our unit under a constant 5A load gave 0.4 Volts.

One setting-up potentiometer is provided, this is for the neutral position. We found the instruction sheet a little sparse.



6. Fleet FPS 14

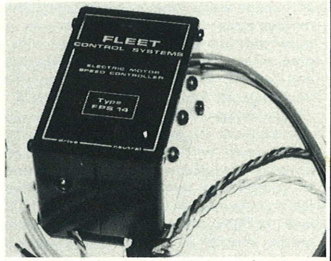
At first glance the FPS 14 appears to be a twin of the Smoothtronic unit, but in fact only the features of a relay for one half of the bridge, and four other transistors 2 × 2 in parallel are the same.

The *Fleet* relay is not 'delayed' and can go from full forward to full reverse at will; dynamic braking works normally in the forward mode and is achieved by using diodes forward biased.

We noted that the *Fleet* is the only unit to appear which makes any attempt to force the output transistors to share the load by fitting base resistors, the other units just rely on the mounting of the transistors.

In addition to the 4 Tab type output transistors, two further Tab type of smaller dimensions are used as drivers.

As with other units there is a regulated output to feed both receiver and steering servo. Two pots are provided for adjustment of neutral at full speed. We were a little surprised to find that if you had to take off the cover (4 small screws) in order to get at them which exposes all the insides.



Under tests at the normal 5A load, the unit became warm after a continuous speed run, which suggests that 10 Amps is not unreasonable as a maximum full load, with a 20-25 Amp peak (not too often).

A very nicely made unit which gave 0.41 Volts drop at 5 Amps which compares favourably with all the other hybrid electronic systems. The unit is of wrap round metal construction with top and bottom plastic covers. Size 65 × 42 × 37 mm and weighs 4oz.

CONTINUED ON PAGE 61

WHERE FROM AND HOW MUCH?

Name	Distributed by	Price
1. Smoothtronic MkIIIR	I & D Electronic Co. Ltd., 24 The Square, Vicarage Farm Drive, Peterborough, Cambs. 5E1 5TT. Tel: (0733) 49955	£38.50
2. Simprop 101435	Micro-Mold, Station Road, East Preston, Littlephampton, W. Sussex BN16 3AG.	£26.99
3. Falcon	Speedcon Control System, 2a Village Green Avenue, Biggin Hill, Westerham, Kent.	£35.50
4. Demon 2	Demon Products, 79 Northumberland Road, N. Harrow, Middlesex HA2 7RA. Tel: 01-866-5945.	£39.95
5. Acam 1	Acam Instrumentation Ltd.	£00.00
6. Fleet FPS-14	Fleet Control Systems, 47 Fleet Road, Fleet, Hants. Tel: Fleet 5011.	£28.75
7. Futaba MC-105	Ripmax Models, Green Street, Enfield, Middx EN3 7SJ.	£38.00
8. Trackmaster	Skyleader Radio Control, Airport House, Purley Way, Croydon, Surrey CR0 0XZ. Tel: 01-686 6688.	£29.95

CONTINUED FROM PAGE 57

7. Futaba

As to be expected from such a leading maker, the unit comes complete (as did the *Simprop)* fitted with on/off switch, fuse and holder 7.2 V type plus plug and spare socket.

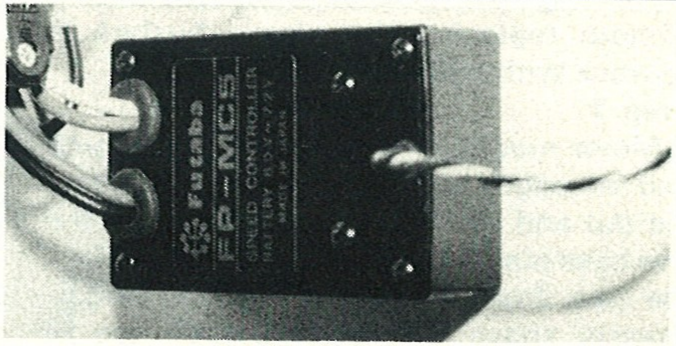
The instructions were straightforward with pictorial connecting-up diagram, all in reasonable English.

Electronically the unit is more "mechanical" than most. There is only one transistor in the system power line, a massive NEC double, top-mounted job. In addition there is a relay of double pole changeover type to achieve the forward reverse function plus a bypass relay to short out the transistor in the full power setting.

We felt the relay contact areas were a bit on the small size for the types of load mainly associated with this type of unit.

Again, it would appear the dynamic braking is achieved by a large size diode plus a set of four diodes connected from the input leads to the motor output leads. A regulated output for the receiver + steering servo is fitted.

The two pots for adjustment of the neutral and cut-in point of the stick at which the full power relay cut-ins are of micro miniature size without any slot to insert a screwdriver. We found them quite vulnerable to damage and would expect at least a skeleton type pot in a unit where these adjustments would have to be made quite often.



On test naturally with a bypass relay the volt drop was insignificant and it is possible to adjust the point where the relay came in.

A maximum current of 25A is claimed. With the size of transistor fitted. It is felt that 10Amps on a semi-continuous basis would be realistic.

8. Skyleader Track Master

The unit submitted was a forward only type. It is necessary to use an additional unit to obtain the reversing function. The unit is fitted with four hefty transistors on a substantial heat sink which also forms the base plate of the box. We were pleased to see load sharing resistors on the bases of the output transistors of substantial size of ceramic construction, which suggests the current drive to the output transistor is adequate to fully turn on the transistors for minimum volt drop.

As with the other units, 4.8 V stabilised output is available for operating the receiver and a servo and a switch lead are also incorporated.

We did find the wording of the setting-up instructions a little confusing as it would appear they are used for both the forward and the reversing unit and the potentiometer operation is reversed, but we got there in the end.

An LED is fitted to enable the unit to be set up whilst the motor is being connected. This LED is used to set up both the neutral position and the full power position. Again a third potentiometer utilises the LED to set up the maximum braking position. As we said before, a better worded set of instructions would, we feel, be helpful for the not too technical operator.

On our fixed 5A load test, we found the unit got warm but not hot. No claims are made as to the maximum running or peak power rating of the unit, but 10A continuous and 20A peak would not seem too unrealistic. We found the volt drop at 5A to be 0.38 Volts. Sizes of the unit 65 × 43 × 41 mm, weight 3.5oz.