Electronic Speed Controllers

Part 1

by Nic Marson

In this two part article we will be looking at the following features:
a. Advantages and disadvantages offered by electronic controllers.
b. Basic insight into their operation.
c. Their evolution—from the speed controller of yesterday to the expensive F.E.T. controllers of today, as used widely in the 1/12th World Championships and rumoured to cost in excess of £100.
d. Finally an in-depth description of an F.E.T. speed controller recently featured in the German Model Magazine *RC-Elektronik* by Heiner Martin. It is available in kit form — called the Joker MCS and described as 'Ein„ Intelligenter" Fahrtregler'! Try pronouncing that! Sections (c) and (d) will constitute the second article.

Why an Electronic Speed Controller?

A lot of modellers I meet are unsure about using these magical black boxes. I find this rather curious, admittedly with a mechanical controller a failure may be detectable and rectified at the track—fortunate since mechanical arrangements are inherently less reliable than their electronic counter parts. Nevertheless the sceptic takes for granted his radio control system which is infinitely more complex than an electronic controller. Familiarity breeds contempt!

Generally, mechanical speed controllers fall into two categories:
a. The switched resistor type that typically offers something in the order of three forward and three reverse speeds plus neutral or a fixed amount of brake, eg Mardave, Tamiya.
b. The sweep resistor type, eg. Parma. This is a non-competition orientated type that offers more forward speed selection, neutral, selectable brake and reverse with the addition of a micro switch.

In addition one also needs a servo to operate the speed controller, something small and light for competition work such as a Novak Bantam. From the cost point of view a Novak plus Parma resistor and micro switch is about the same as most electronic speed controllers marketed today.

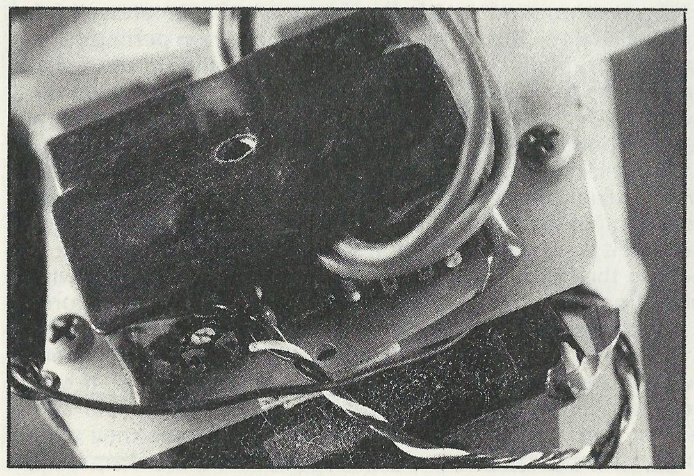
Most electronic speed controllers today offer the following features.

a. Battery eliminator, this allows the car radio to run off the 1.2AH nicad supply. Most eliminators continue working until the nicads haven't enough energy left to move the car. Early regulators would stop working before the car, not very satisfactory as the car would then carry on until it hit something sold enough to stop it. The êliminator that is used in the Joker MCS is even smarter. When the nicads fall to approximately four volts the drive is removed from the motor, thus eliminating reverse charging the nicads—this is a phenomenon I may cover in a future article on nicads. This eliminator may well be of interest to model aircraft electric flight followers, as sufficient energy would be left in the nicads to control the craft to a safe landing.

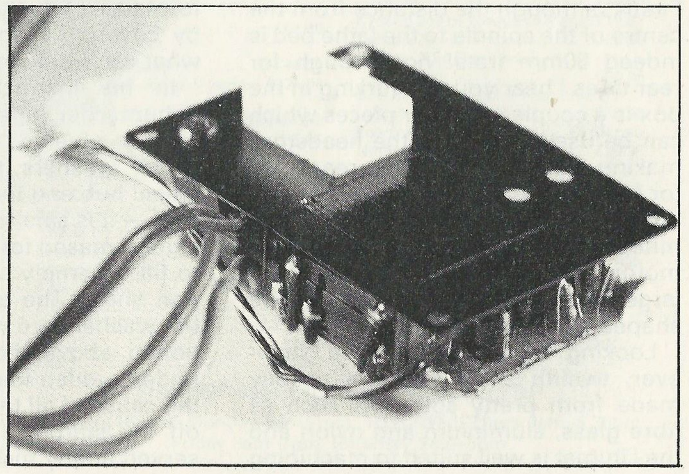
b. Instantaneous response from zero to fullpower is approximately 1/50th of a second which is about ten times faster than a Novak and a bit quicker than your thumbs, that is unless you are Andy Dobson.

c. Fully proportional control of the motor. The effective voltage to the motor is variable from zero to flat out.

The 'Firefly' controller manufactured by Intronics is seen here fitted to an Associated RC121 car. Like the Demon it features top speed relays.



The Demon electronic speed controller has been a firm favourite with both 1/12 and lately with 1/10 off road racers.



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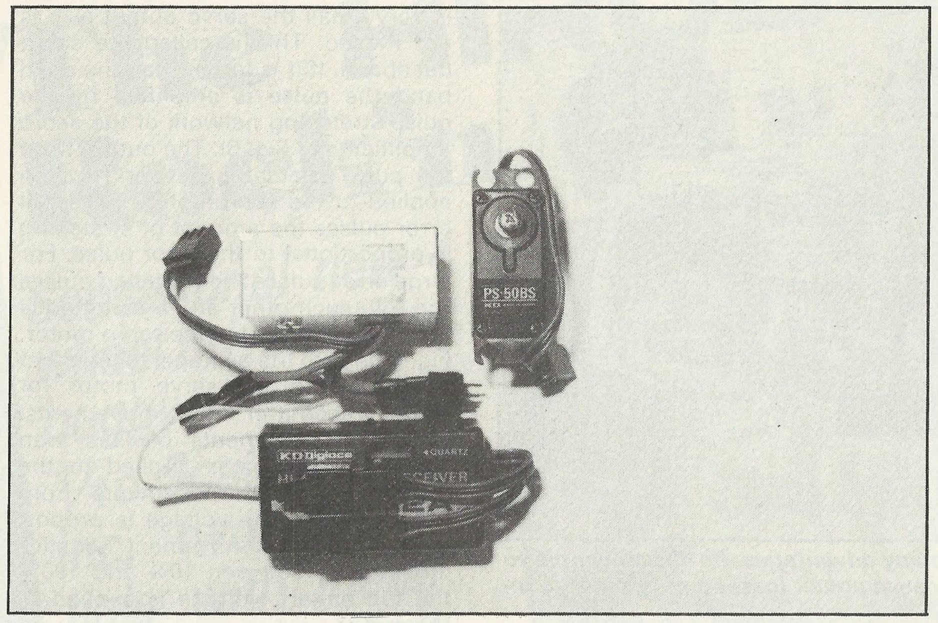
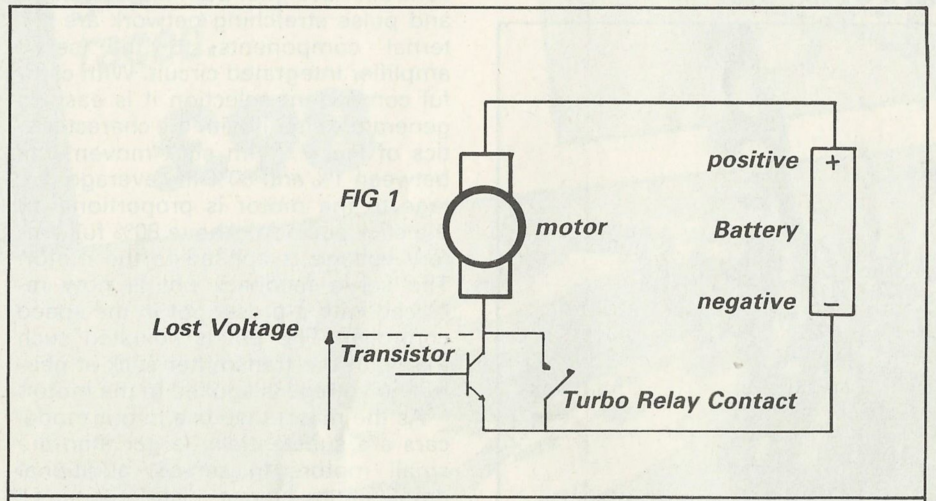
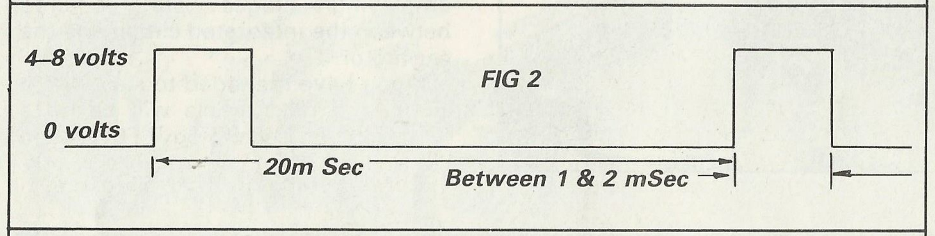
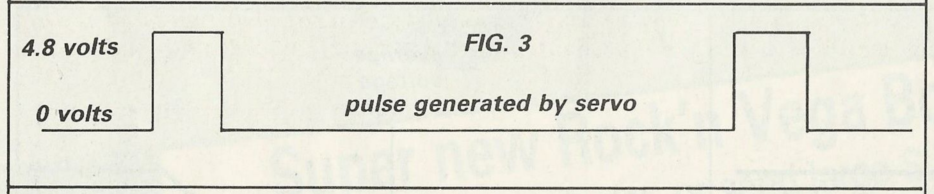
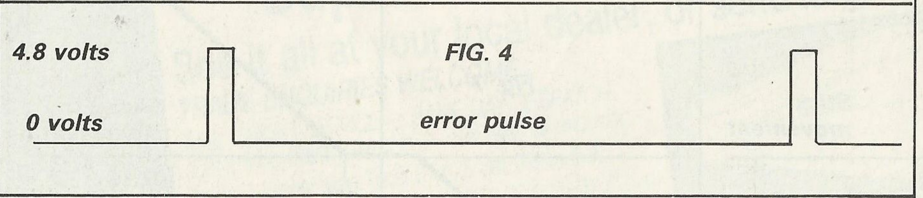


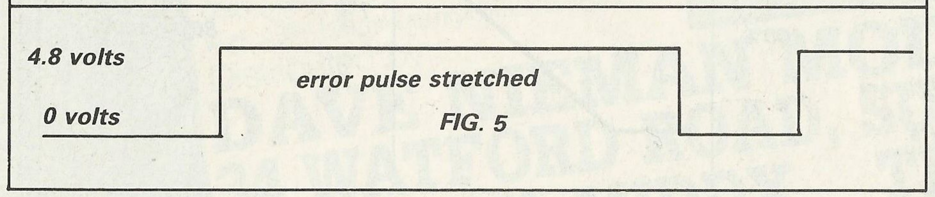
The K.O. Digi ace controller is small and compact. This here is the entire R/C package used by Australian Craig Bowring.











I will explain 'effective' in the next section. Most controllers offer:

1. Fully proportional forward

2. Fully proportional brake whilst the car is in forward motion. Once the car has stopped the electronics sense this and reverse the voltage to the motor, thus reversing the car.

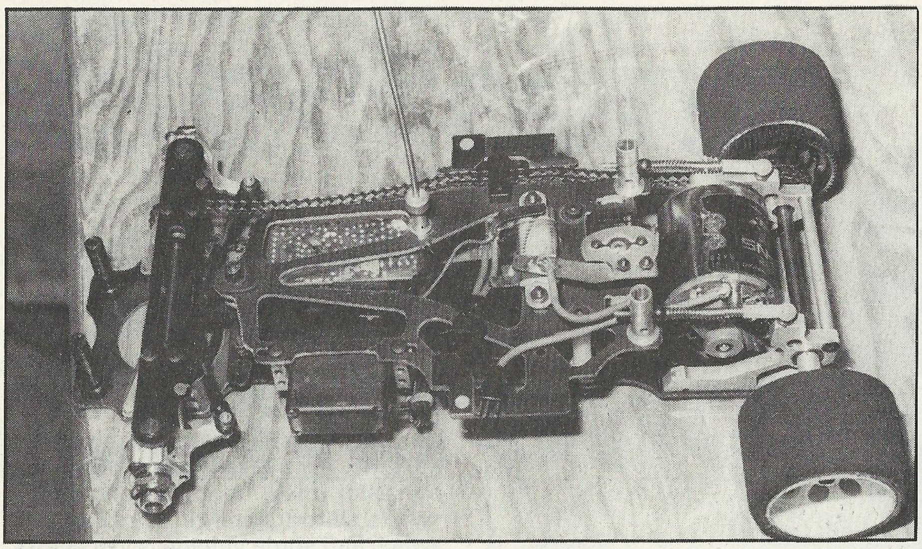
d. Turbo relay. With the exception of the modern F.E.T. speed controllers the motor is controlled by a transistor. When full speed is demanded by the throttle stick on the transmitter the controlling transistor is turned on all the time. For the sake of simplicity the transistor may be considered as a switch. Unfortunately it is not a perfect switch and some voltage is lost across the transistor (see Fig. 1). This is easily overcome by arranging for a relay contact to be wired in parallel with the transistor. The electronics sense when full power is demanded and operate the relay. Another disadvantage of the transistor is that it needs to be supplied with about 1 amp (base drive for the technically minded) to switch it sufficiently on. Unfortunately the 1amp base drive does not go through the motor so this is lost energy. However another smart trick employed by some speed control manufacturers is to remove the base drive current when the Turbo relay is operated. These two techniques lead to an efficient speed controller.

Basic Operation

The heart of any speed controller is a servo amplifer integrated circuit. The two most commonly used are
1. Ferranti SRC419P. This was originally specifically designed for Skyleader Radio Control.
2. Signetics NES44

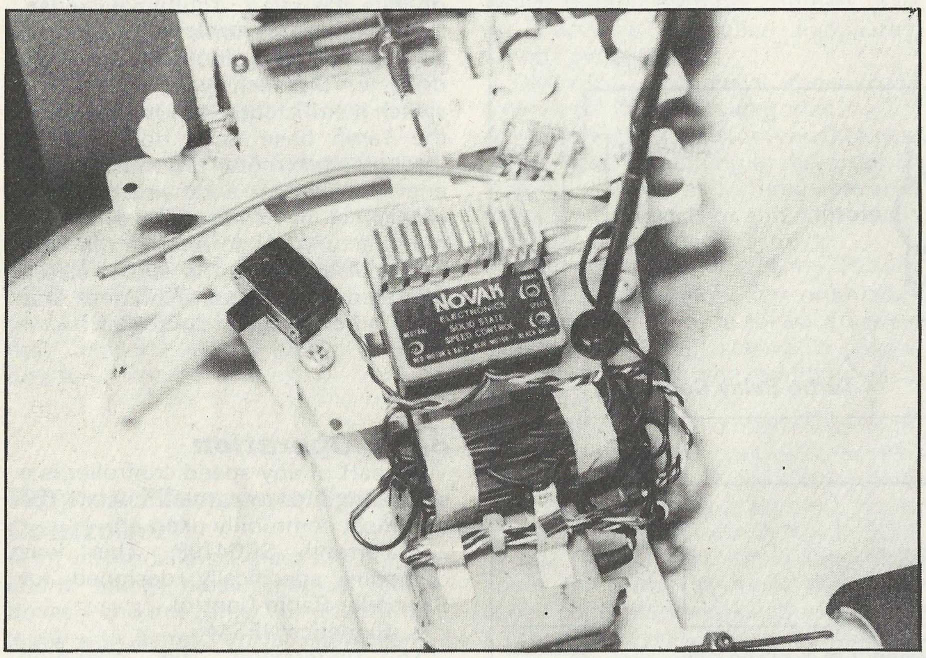
To understand the operation perhaps a few words on how a servo amplifier works are called for:

The servo receivers, from the decoder in the receiver, a voltage pulse every 20 milli seconds (1 millisecond is one thousandth of a second). The width of this voltage pulse is determined by the position of the transmitter, stick. Normally this pulse can vary between 1 and 2 milliseconds, with 1.5 milliseconds representing transmitter stick at neutral (see Fig. 2). On receipt of this pulse the servo amplifier generates a pulse of its own. The width of this pulse is governed by the position of the servo output arm which is connected to the servo feedback pot (see Fig. 3). The amplifier subtracts these two pulses and ends up with an error pulse (Fig. 4). The width of the error pulse is a measure of how far the output arm is from the desired position. for stability reasons, if the error pulse



The simple resistor speed controller has many advantages. Its cheap, simple to use and faults are easy to trace but it can cause power losses and be slow to respond.

The new Novak F.E.T. speed controller has been used with considerable success by top Associated driver Mike Lavacott. But it is expensive.



is very small the servo output arm is not moved. This is called the servo deadband. If it is larger than the dead band the pulse is amplified by the pulse stretching network of the servo amplifier (see Fig. 5). The output from the pulse stretching network is then applied to the servomotor. For small error pulses the amount of stretching is proportional to the error pulse. For large error pulses the stretched pulses run into each other and a continuous 4.8 volts is applied to the servo motor. Fig. 6 depicts the average voltage that is applied to the servo motor for given transmitter stick movements. For stick movements of less than 0.25% no voltage is applied to the motor. For stick movements from 0.25% to 10% the voltage is proportional to the stick movement. For stick movements between 10% and 100% the full battery voltage is applied to the motor.

Fortunately for the electronic speed controller designer both the deadband and pulse stretching network are external components to the servo amplifier integrated circuit. With careful component selection it is easy to generate a circuit with the characteristics of Fig. 7. With stick movements between 1% and 80% the average voltage to the motor is proportional to the stick position. Above 80% full battery voltage is applied to the motor. The servo feedback pot is now replaced with a preset pot in the speed controller. The pot is adjusted such that with the transmitter stick at neutral no voltage is applied to the motor.

As the motors we use in our model cars are substantially larger than the small motors in servos, additional amplifying stages are required between the integrated circuit and the car motor.

If you have managed to stay with it so far the next article will be on a 'Forefront of Technology' FET speed controller.