Speed Control Basics
By Allan Wing

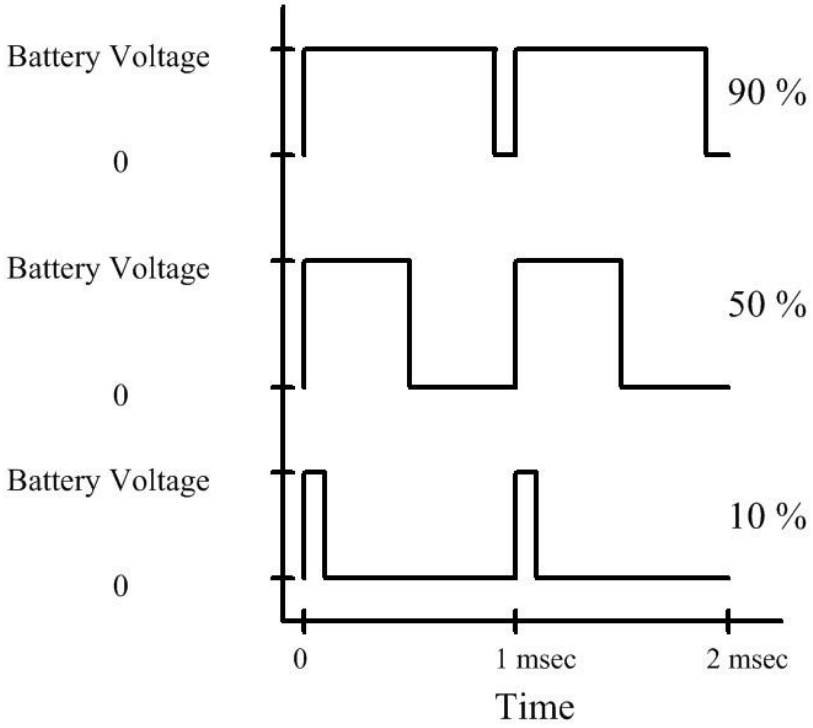
Last month I discussed the operation of a brushed DC motor. This month I will talk about the speed controls we use with the motors in our boats.

The first speed controls were a wire wound resister controlled by an arm on a servo. These controlled the speed of the motor by varying a resistor that was in line with the motor. The speed of a motor is proportional to the voltage across the motor. With a resistor in line with the motor some of the battery voltage is used by the resistor the rest by the motor. The greater the resistance of the speed control the higher the voltage is across the resistor and the less across the motor. The less the voltage across the motor the slower the motor runs.

Below is a picture of a Dumas resistor speed control. The Dumas resistive speed control is still be available today. It provides proportional control with both forward and reverse. There are several limitations with a resistive speed control. First the speed control should be matched with the motor for best operation. A motor that uses higher current would need a different control that has less resistance than a motor that uses less current. Today Dumas provides two speed controls, one for 6 volt operation and one for 12 volt operation, this is because their 6 and 12 volt motors use different amounts of current. Another limitation is that at half throttle the motor uses half the energy from the battery and the speed control uses half. Thus we lose some energy just heating the speed control. Also when starting out it may not be possible to get very slow or low end, control. If the motor draws very little current the largest resistance value may not reduce the voltage to the motor which is the desired amount for low speed operation. As a result most applications of the Dumas resistive speed control use the speed control with a matched Dumas motor.

In the late 1970's and 1980's with the advancement of electronics and the development of new kinds of transistors the Electronic Speed control or ESC was developed. The ESC provided a new way of controlling the voltage to the motor. This was done by switching the voltage to the motor and controlling the amount of time the voltage was applied and the amount of time it was turned off. For half speed the voltage was applied half the time. I looked at two current

ESC's to see exactly how this was done. Looking at the waterproof Proboat and the Viper Marine 20, Both ESC's are available at Galaxy Hobby.
Both ESC's use a technique called pulse width modulation. This is accomplished by providing a pulse to the motor at a set rate. The width of the pulse is changed to provide the control. If the motor is to run at half speed the pulse width is set so the voltage is provided half the time. This is repeated multiple times per second. The number of times per second is the frequency of the ESC. Most ESC's have a frequency of between 800 and 5,000 pulses per second. The Viper Marine 20 runs at 1,000 pulses per second and is illustrated below.



As can be seen the voltage is applied a proportion of the time equal to the requested speed. This gives the same result as providing a lower voltage to the motor. For example at 50% time using a 6 volt battery the motor is effectively getting equivalent of 3 volts and the motor will run at half speed. The same is true for other percentages. At stop the ESC does not pulse and is continually off. At full throttle the ESC does not pulse and is continually on. This has a couple of advantages over the resistive speed control. At slower speeds the heat loss in the speed control is much lower (almost zero). There is some heating in the ESC because the transistors used have a small resistance when turned on; this is only really noticeable when you use a high current motor. For example we found that some of the speed controls we were using in our polo Springers would get rather warm. The heating can be reduced by using an ESC with a higher current rating. For proper operation the speed control does not have to be matched to the motor. You now only have to make sure that the motor does not draw more current than the maximum rating of the speed control. The ESC gives more truly proportional control than the resistive speed control.

There is one exception to full proportional control when using the Proboat. Many of our members have stated that the Proboat does not provide good low speed control. In my testing

I found that the Proboat does not provide the same low speed control as the Viper illustrated above. When advancing the throttle on a Proboat ESC the smallest pulse provided is 33%, thus when using a 6 volt battery the slowest speed provides an average of 2 volts to the motor. Many of our motors will run faster than we want with 2 volts to the motor (4 volts if a 12 volt battery is used). I found the same thing when in reverse with one additional difference. In reverse the Proboat ESC will provide pulses from 33% to only 66%. As a result with a 6 volt battery the motor will get between 2 and 4 volts. This limited range works but you should be aware of the limitations. When providing pulses the Proboat runs at 800 pulses per second. This difference in pulse rate is not noticeable in our operations.

The electronic speed control has made it much easier to use a wide variety of motors in our boats.