Timpdon Electronics

Technical Note - No. 22

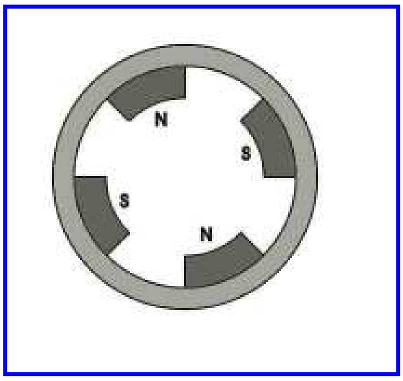
Coreless Motors

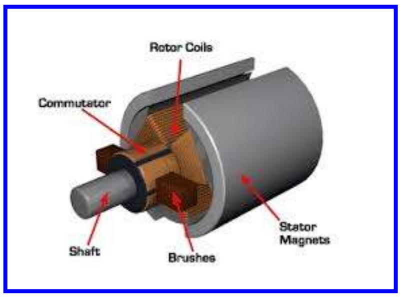
Introduction

For many years, the only practicable electric motor for railway modelling has been the d.c. permanent magnet motor. In the last few years, however, significant interest has been shown in the use of coreless d.c. motors for model railway vehicles.

This Technical Note describes the major differences between the two types, discusses the advantages and disadvantages of each, and considers the changes to motor control techniques needed for coreless motors.

Standard Motor





In a standard d.c. motor, the armature comprises a solid laminated iron core, with a number of windings wound in slots along the core. Each separate winding is connected to the commutator and the number of windings represents the number of poles.

The magnetic flux is produced by arc shaped permanent magnets mounted around the armature on the inside of the outer casing of the motor.

The presence of the heavy iron armature results both in significant eddy current losses within the motor, high moment of inertia, and high motor inductance. The motor efficiency of a small motor rarely exceeds 65% maximum.

One advantage of the standard motor, however, is that they are normally capable of accepting significant short period overloads without damage.

Coreless Motor

In a coreless d.c. motor, the armature windings do not have a solid core. They are either wound either on a light plastic former, or simply encapsulated in epoxy resin to provide rigidity.

The magnetic flux is provided by a tubular cylindrical magnet mounted within the rotating core, fixed to the motor housing at one end only.

The motor commutator is at the other end, connected to a plastic support for the armature coils, also at one end only. The whole rotating armature is then supported on a shaft passing through the magnet with bearings at each end.

Because the rotating armature is iron free, the moment of inertia is very low, there are no eddy current iron losses, and the armature inductance is very low.

The lack of eddy current losses results in much improved motor efficiencies, up to 90% maximum on some small motors, usually very low motor starting currents, and very fast response.

However, the reduced armature inductance and low inertia can cause problems with speed control, and the lack of an iron armature, and low thermal capacity of the motor can result in a much reduced overload capacity before motor damage results.

Motor Parameter Comparison

	Standard	**Coreless**
Motor Inertia	High	Low
Inductance	High	Low
Efficiency	65% Max	90% Max
Starting Current	High	Low
Overload Capacity	High	Low
Cost	Low	High

Speed Controllers for Coreless Motors

Almost all electronic speed controllers for railway modelling use pulse width modulation [PWM] to vary the voltage applied to the motor, as this is the only practicable way of achieving small size and high efficiency.

In a PWM controller, full battery voltage is applied to the motor in short pulses at a high repetition rate. As the ratio of pulse on time to the repetition period time is varied from zero to 100%, the average motor voltage is varied from zero to full battery voltage.

In order to maintain motor current during the off periods, a freewheel diode is normally fitted in reverse polarity across the motor. This has two functions. It reduces the voltage spikes across the motor by limiting the rate of change of motor current as voltage is removed and provides a path for the energy stored within the motor inductance to maintain motor current during the off period, thus reducing torque pulsing.

For standard d.c. motors, the PWM frequency of speed controllers is normally between 1 and 4 kHz, and provides perfectly adequate control, because of the high motor inductance and high inertia of the motor, although as these frequencies are within audible range, the audible whine caused by physical vibrations of motor windings from pulsing motor currents can be annoying to some people.

For coreless motors however, their low motor inductance causes high rates of change of current when full voltage spikes are applied to the motor which, when coupled with the low inertia, results in pulsing motor torque and poor motor control, especially at low speeds.

PWM control of coreless motors is perfectly possible, however, but needs a much higher PWM frequency, in the order of 20 kHz. High frequency speed controllers for model motors are available from a few manufacturers, including *Timpdon Electronics*.

Most of the *Timpdon Electronics* range of speed controllers, for ***UltraRad*** and ***GigaRad*** radio control, and for standard radio control, have now been updated to 20 kHz PWM operation, and are thus perfectly suitable for both standard and coreless d.c. motors.

The recently introduced Model ***GSC4*** speed controller, for ***GigaRad*** and Standard radio control has been specifically designed with coreless motors in mind, and has been extensively tested on these motors, with excellent performance, particularly at low speeds.