# Battery Operated (BO) Motors

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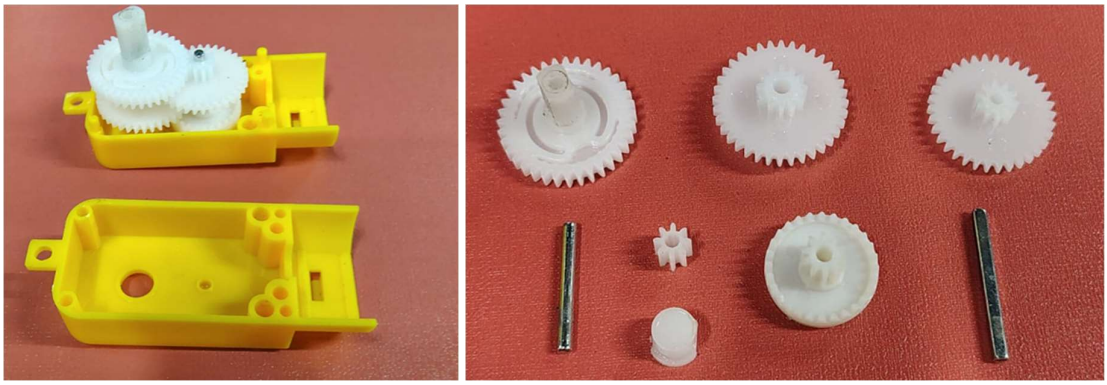
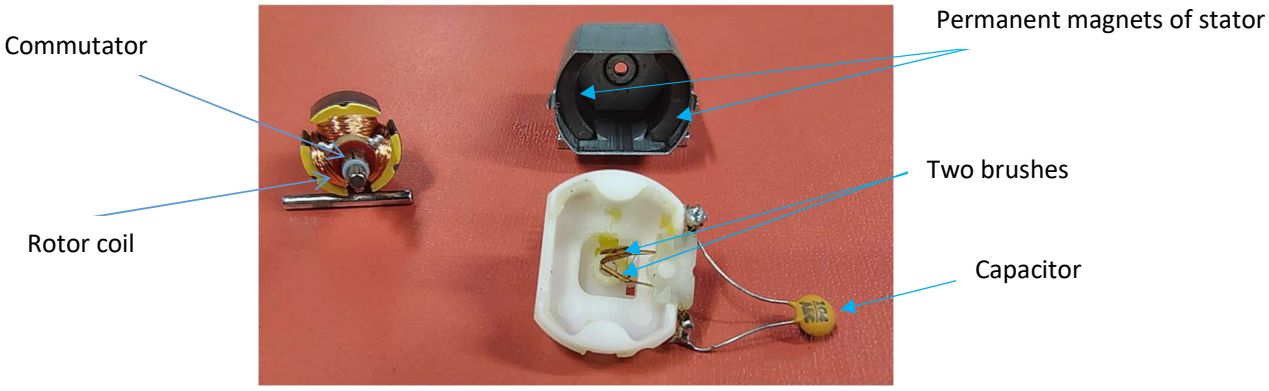
In experiment 4 of MS101 Lab, we are going to drive a brushed BO (DC) motor and control its speed as well as direction using a variable DC supply realized using the Pulse Width Modulation (PWM) technique and an H-bridge converter. For a detailed understanding of the working principle of a BO motor, a link to a video on brushed DC motors is given at the end*. For ready reference, a brief description of the BO motor used in the experiment is given below.

A brushed BO motor is a geared DC motor that is commonly used in many applications such as automation and robotics projects. A BO motor with its gearbox assembly is shown in Fig. 1.



a. Gearbox b. Gears




c. Parts of a BO motor

Fig. 1 A BO motor with its gearbox assembly

Through the gearbox the speed of the motor is reduced via more than one gear (from about thousands of RPM at the motor shaft to a few hundred RPM at the output shaft of

the motor-gearbox system). Since the power is proportional to the product of torque and speed, the speed reduction increases the torque accordingly, which is useful in many high-torque applications.

The BO motors are controlled by a driver L298 in experiment 4. L298 controls both the speed and the direction of rotation of the BO motor. It uses the PWM technique to vary the applied voltage and an H-Bridge to rotate the motor either in the clockwise or anti-clockwise direction.

Let us understand briefly the working principle of a BO motor (for a detailed explanation, see the video*). The stator (fixed part) consists of two permanent magnets (N and S) and the rotor has coils (Fig. 2) in a conventional DC motor or the rotor has a set of coils resulting into electromagnets when currents flow through them in a BO motor. The direction of currents flowing in them is changed appropriately through the commutator-brush arrangement to produce unidirectional torque in accordance with Fleming's Left-Hand Rule as explained in the video for a conventional DC motor or in accordance with the fact that like poles of the stator and rotor repel and the opposite poles attract each other in a BO motor.

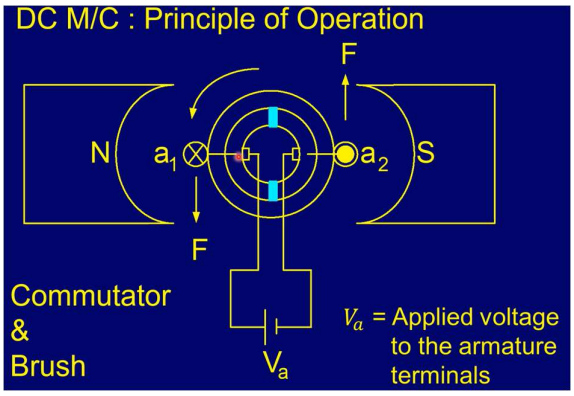



Fig. 2 DC motor or BO motor working principle (slide 7 of the video)

When the current is being reversed in a coil, due to its inductance (and the associated time constant) the current may get reversed before it becomes zero; this results in the interruption of non-zero current and sparking between the commutator segment and the brush (stored energy in the inductor of the motor-system appears as a voltage spike across the stray capacitance between the two parts). To mitigate the effect of sparking (voltage spikes) on the connected electronic components in the circuit, a suitable capacitor is connected across the BO motor terminals as can be seen in Fig. 1.

As explained in the video, the speed of a BO motor can be varied by changing the applied DC voltage ($V_a$) using the PWM technique. The direction of the rotation can be

controlled by using an H-bridge and keeping two of the four switches (either S1, S2 or S3, S4) OFF, as explained in Fig. 3.

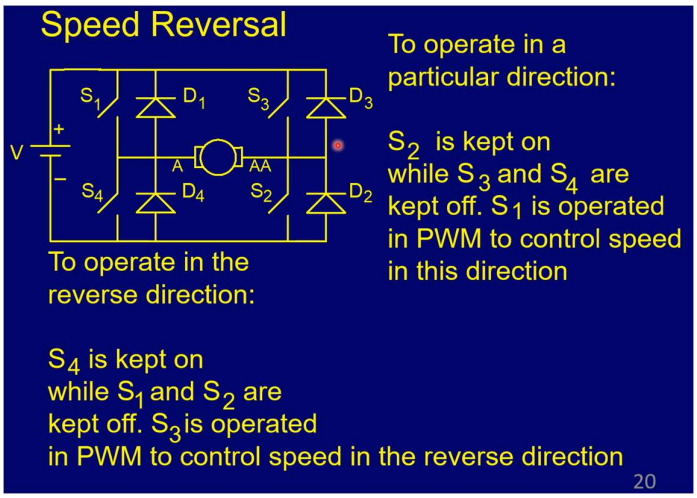



Fig. 3 Speed control and reversal of a BO motor (slide 20 of the video).

Variable voltage is applied by adjusting the turn-ON time of S1 with S2 in ON condition for rotation in one direction (S3 and S4 are kept OFF). To change the direction of rotation, the polarity of the applied voltage has to be reversed, which is achieved by using S3 and S4 (with S1 and S2 OFF) and varying the turn-ON time of S3.

In steady-state operation, the developed torque is exactly balanced by the load on the motor shaft (including the friction and windage torques). When the developed torque exceeds the load torque, the speed increases and vice-versa, till a new equilibrium condition is reached.

⋆ Video:
https://docs.google.com/presentation/d/1s1Fsvb0INAqGS9AAog9YmkMy3jo-zmj6/edit?usp=sharing&ouid=111902402391197382365&rtpof=true&sd=true
(To listen to the video, first download the shared PPT file, and then put it into slide show)