Measurement of Brushed DC Electric Motor Constants

Equipment:

Power supply, with adjustable voltage.
Ammeter.
Voltmeter.
Strobe for RPM measurement

Measurement Procedures:

- Hook up the motor to a power supply, with an Ammeter in the loop.
- Hook up a Voltmeter across the motor terminals.
- Mount a prop adapter on the shaft to better see shaft rotation (optional)
- Measure the three motor constants $\mathcal{R}$, i_o, K_v as follows.

$\mathcal{R}$ — **motor resistance**, in Ohms.

This is the resistance of the electrical path between the two motor terminals. Because $\mathcal{R}$ is usually small, a common Ohmmeter is not suitable. So we use Ohm's Law instead.

a) While holding the motor shaft fixed (using fingers is OK for small motors), ramp up the power supply to send a moderate current through the motor. For a Speed-400 motor, 2–3 Amps is appropriate, and will require about 1 Volt.

b) Simultaneously read off the actual current i and voltage v. Compute the resistance:

$$\mathcal{R} = v/i$$

The readings will vary somewhat as the motor shaft is held in different rotation positions, so take several readings and average the resulting $\mathcal{R}$'s.

i_o — **no-load current**, in Amps.

This is the current drawn by the motor when turning freely. Measure as follows:

a) Ramp up the power supply voltage with the motor spinning freely.

b) Record the no-load current i_o. This should not vary significantly with speed (i.e. with voltage). If it does vary, take the measurement at the expected operating speed. For the Speed-400 motor this will be at about 6000 RPM (at around 3 Volts without any load).

K_v — **motor speed constant**, in RPM/Volt, or rad/s /Volt.

This is the ratio of motor speed Ω to the back-EMF v_m. It controls the dependence of the motor's zero-load speed Ω_o on the applied voltage v:

$$\Omega_o = v_m K_v = (v - i_o \mathcal{R})\, K_v$$

a) Mark one side of the shaft with a Sharpie or White-out so it's visible under the strobe.

b) Set the strobe to one of several RPM values within the expected operating range. Speeds of 4000, 6000, 8000 RPM are appropriate for the Speed-400 motor. Then:

i) Ramp up the power supply to match the motor's RPM with that of the strobe. As the motor speeds up, you must catch the first visual stoppage of the shaft under the strobe. If you miss this, you will likely pick up the next stoppage which has a 2× aliasing error (i.e. a 4000 RPM shaft appears stopped under a 2000 RPM strobe)

ii) Measure the motor voltage v with the Voltmeter

iii) Compute the motor speed constant in RPM/Volt units.

$$K_{\mathrm{v}} = RPM/(v - i_o\mathcal{R})$$

c) Repeat b) for next RPM value. The resulting K_{v}'s should not change appreciably with RPM.

Traditionally, K_{v} is quoted in RPM/Volt units. But for motor modeling calculations, specifying K_{v} in rad/s/Volt units is much more convenient:

$$\begin{aligned}\Omega_o &= RPM \times \pi/30 \\ K_{\mathrm{v}} &= \Omega_o/(v - i_o\mathcal{R})\end{aligned}$$