CG1111 Engineering Principles and Practice I

Additional Practice Questions on DC Motors

1. A PMDC motor has the following parameters:

   Torque constant: 15 mNm/A

   Rotor coil's resistance: 2.7 Ω

   If the motor is powered by a 12 V supply, and assuming there is no friction loss, answer the following:

   a) What is the maximum speed possible?

   b) What is the maximum torque that the motor can produce?

   c) What is the maximum mechanical power that the motor can provide?

   Ans: a) 800 rad/s or 7639 RPM, b) 66.7 mNm, c) 13.3 W

   Hint for part c:

   $$P_{mech} = T\omega, \;\; T = KI, \;\; I = \frac{V}{R} - \frac{K\omega}{R}.$$

   Hence, $P_{mech} = \frac{KV\omega}{R} - \frac{K^2\omega^2}{R}$.

   Find ω that gives $\frac{dP}{d\omega} = 0$, and use it to find P_{mech}. You should get $P_{mech} = \frac{V^2}{4R}$.

2. A PMDC motor is powered by 15 V DC supply. When no mechanical load is attached, the motor shaft spins at the speed of 3750 RPM. If the shaft is clamped mechanically such that it doesn't spin, the current drawn by the motor is 0.75 A.

   a) Find the torque constant, and the rotor coil resistance.

   b) When a load is attached to the shaft, the speed drops to 2500 RPM, determine the torque load, and the power delivered to the load.

   Ans: a) 38.2 mNm/A, 20 Ω, b) 9.55 mNm, 2.5 W

3. A PMDC motor is connected to a 12 V DC supply. With a torque load of 10 mNm, the motor spins at 2500 RPM. When the torque load is doubled to 20 mNm, the speed drops to 1200 RPM. Determine the following:

   a) Torque constant

   b) Resistance of the rotor coil

   c) Stall torque

   d) No-load speed

   Ans: a) 30.2 mNm/A, b) 12.4 Ω, c) 29.2 mNm, d) 397.4 rad/s or 3795 RPM

   Hint:

   $T = KI, \;\; \omega = \frac{V}{K} - \frac{RI}{K}$

   Hence, $\omega = \frac{V}{K} - \frac{RT}{K^2}$

   Use the above to first solve for $\frac{R}{K^2}$ and subsequently the remaining parameters.

4. Consider a PWM controlled PMDC motor powered by a 24 V supply. The torque constant and the rotor coil resistance of this motor are 60 mNm/A and 50 Ω, respectively. The motor drives a torque load at the speed of 2500 RPM with 100% duty cycle. Answer the following questions:

   a) What is the torque load?
   b) If the duty cycle is now reduced to 60%, while the load remains the same, what will be the speed?

   Ans: a) 9.95 mNm, b) 101.8 rad/s or 972 RPM