EECS192 Mechatronic Design Laboratory

Worksheet 2 Solutions: MOSFET and Motor

Ducky

1 General

Given the parameters, the circuit can be simplified into a +7.2v source, a 0.12Ω resistor (combining the motor and battery resistances), and a MOSFET in series. Because the motor is not spinning (stalled), there is no back EMF to worry about.

2 Problem 1

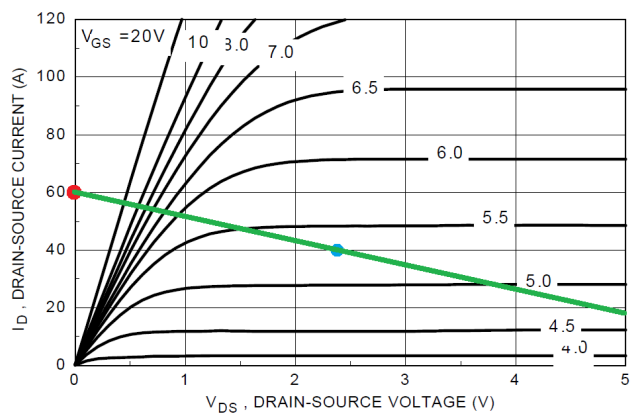
At $V_{DS} = 0$, the combined 0.12Ω resistor sees the full $7.2V$, leading to $\frac{7.2V}{0.12\Omega} = 60A$ through the motor (or circuit).
The power through the motor is then $P = I^2 R_{MOT} = (60A)^2 \times 0.06\Omega = 216W$.
Since R_{BAT} and R_{MOT} forms a resistive divider, the voltage at the battery terminals is halved, so the battery voltage is $3.6V$.
The power supplied by the battery is the combined power dissipation of the circuit, which is $P = I^2(R_{MOT} + R_{BAT}) = (60A)^2 \times 0.12\Omega = 432W$.

3 Problem 2

At $V_{DS} = 2.4V$, the equivalent resistors sees an effective voltage difference of $7.2V - 2.4V = 4.8V$. The current is then $\frac{4.8V}{0.12\Omega} = 40A$ through the motor (or circuit).
The power dissipated in the motor is then $P = I^2 \times R_{MOT} = (40A)^2 \times 0.06\Omega = 96W$.
The power dissipated in the MOSFET is then $P = V_{DS} \times I = 2.4V \times 40A = 96W$

4 Problem 3

From the problems above, we can plot the points $V_{DS} = 0, I = 60A$ (red point) and $V_{DS} = 2.4, I = 40A$ (blue point) on the on-characteristics chart. If we then draw a line through both points (in green), we get the load-line chart.



Looking at the I_D vs. V_{DS} curve for $V_{GS} = 5.5V$, the intersection is at around $V_{DS} = 1.5, I_D = 50A$. Using the same strategy as above, we have $P = I^2 \times R_{MOT} = (50A)^2 \times 0.06\Omega = 150W$ from the motor and $P = V_{DS} \times I = 1.5V \times 50A = 75W$ from the MOSFET.

5 Problem 4

The intersection for $V_GS = 20V$ is at around $V_{DS} = 0.5, I_D = 54A$. Using the same strategy as above, we have $P = I^2 \times R_{MOT} = (55A)^2 \times 0.06\Omega = 181.5W$ from the motor and $P = V_{DS} \times I = 0.5V \times 55A = 27.5W$ from the MOSFET.