

EECS192 Mechatronic Design Laboratory

Worksheet 2 Solutions: MOSFET and Motor

Ducky

1 General

Given the parameters, the circuit can be simplified into a $+7.2\text{V}$ 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 $\frac{7.2\text{V}}{0.12\Omega} = 60\text{A}$ through the motor (or circuit).

The power through the motor is then $P = I^2 R_{MOT} = (60\text{A})^2 \times 0.06\Omega = 216\text{W}$.

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 $P = I^2(R_{MOT} + R_{BAT}) = (60\text{A})^2 \times 0.12\Omega = 432\text{W}$.

3 Problem 2

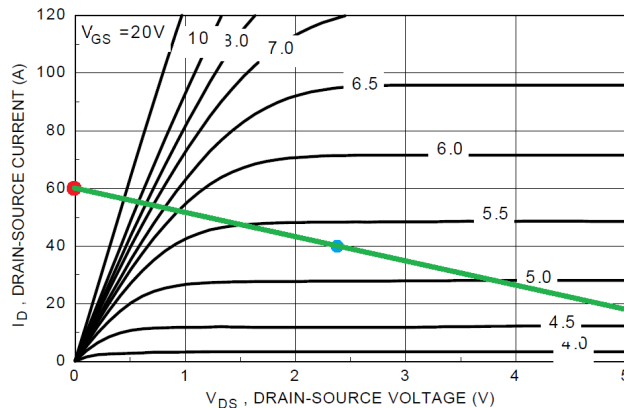
At $V_{DS} = 2.4\text{V}$, the equivalent resistors sees an effective voltage difference of $7.2\text{V} - 2.4\text{V} = 4.8\text{V}$. The current is then $\frac{4.8\text{V}}{0.12\Omega} = 40\text{A}$ through the motor (or circuit).

The power dissipated in the motor is then $P = I^2 \times R_{MOT} = (40\text{A})^2 \times 0.06\Omega = 96\text{W}$.

The power dissipated in the MOSFET is then $P = V_{DS} \times I = 2.4\text{V} \times 40\text{A} = 96\text{W}$

4 Problem 3

From the problems above, we can plot the points $V_{DS} = 0, I = 60\text{A}$ (red point) and $V_{DS} = 2.4, I = 40\text{A}$ (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 $V_{GS} = 5.5\text{V}$, the intersection is at around $V_{DS} = 1.5, I_D = 50\text{A}$. Using the same strategy as above, we have $P = I^2 \times R_{MOT} = (50\text{A})^2 \times 0.06\Omega = 150\text{W}$ from the motor and $P = V_{DS} \times I = 1.5\text{V} \times 50\text{A} = 75\text{W}$ 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 $P = I^2 \times R_{MOT} = (54A)^2 \times 0.06\Omega = 181.5W$ from the motor and $P = V_{DS} \times I = 0.5V \times 54A = 27.5W$ from the MOSFET.