# EECS192 Mechatronic Design Laboratory <br> Worksheet 2 Solutions: MOSFET and Motor <br> Ducky 

## 1 General

Given the parameters, the circuit can be simplified into a +7.2 v source, a $0.12 \Omega$ 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 $V_{D S}=0$, the combined $0.12 \Omega$ resistor sees the full $7.2 V$, leading to $\frac{7.2 V}{0.12 \Omega}=60 A$ through the motor (or circuit).
The power through the motor is then $P=I^{2} R_{M O T}=(60 A)^{2} \times 0.06 \Omega=216 \mathrm{~W}$.
Since $R_{B A T}$ and $R_{M O T}$ forms a resistive divider, the voltage at the battery terminals is halved, so the battery voltage is 3.6 V .
The power supplied by the battery is the combined power dissipation of the circuit, which is $P=I^{2}\left(R_{M O T}+\right.$ $\left.R_{B A T}\right)=(60 A)^{2} \times 0.12 \Omega=432 W$.

## 3 Problem 2

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

## 4 Problem 3

From the problems above, we can plot the points $V_{D S}=0, I=60 A$ (red point) and $V_{D S}=2.4, I=40 A$ (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. $V_{D S}$ curve for $V_{G S}=5.5 \mathrm{~V}$, the intersection is at around $V_{D S}=1.5, I_{D}=50 A$. Using the same strategy as above, we have $P=I^{2} \times R_{M O T}=(50 A)^{2} \times 0.06 \Omega=150 \mathrm{~W}$ from the motor and $P=V_{D S} \times I=1.5 \mathrm{~V} \times 50 A=75 \mathrm{~W}$ from the MOSFET.

## 5 Problem 4

The intersection for $V_{G} S=20 V$ is at around $V_{D S}=0.5, I_{D}=54 A$. Using the same strategy as above, we have $P=I^{2} \times R_{M O T}=(55 A)^{2} \times 0.06 \Omega=181.5 \mathrm{~W}$ from the motor and $P=V_{D S} \times I=0.5 \mathrm{~V} \times 55 \mathrm{~A}=27.5 \mathrm{~W}$ from the MOSFET.

