ECE 363 QUIZ 4 (F19) **NAME:** Solutions

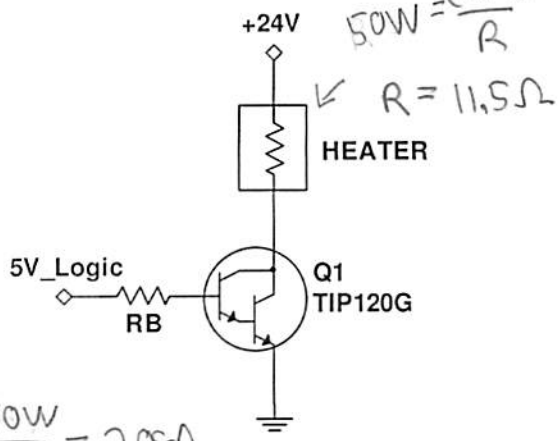
2 problems for 20 pts

Problem 1: BJT Switch

A microcontroller with 5V logic output operates a Darlington switch for a heating element (i.e. a resistor) rated at 24V @ 50W.

(a) Choose the appropriate 5% value for R_B under typical Q1 conditions.

(b) Assuming worst-case Q1 conditions, would a 15 °C/W heat sink be adequate for Q1?

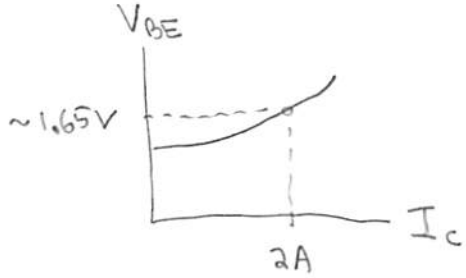


$50W = \frac{(24V)^2}{R}$ ← $R = 11.5\Omega$

(a) Load: 24V @ 50W $\quad P = IV \rightarrow I = \frac{50W}{24V} = 2.08A$

+5

TIP120: Typical $V_{BE} = 1.65V$



Want $I_B \sim \frac{I_C}{250}$ for Darlington

$\frac{5-1.65}{R_B} \sim \frac{2.08A}{250} = 8.3mA$

$R_B = .404K$ Choose $\boxed{R_B = 430\Omega}$ ← 390Ω also OK (harder saturation)

+5

(b) Worst case:

$V_{CE(sat)}$: max 2V ?

Typ 1.15V 1V

3A 2A

$\max V_{CE} = \frac{2}{1.15} \times 1 = 1.74V$

$I_C = \frac{24-1.74}{11.5\Omega} = 1.94A$

$I_B = \frac{5-2.3}{430} = 6.3mA$

$V_{BE(sat)}$: max 2.5V ?

Typ 1.8 1.65

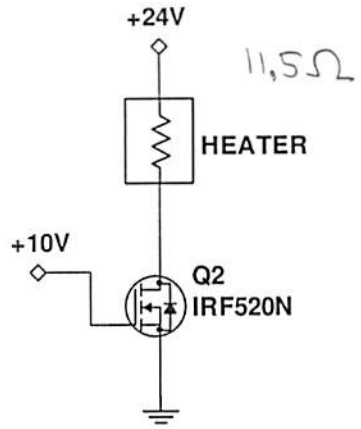
3A 2A

$\max V_{BE} = \frac{2.5}{1.8} \times 1.65 = 2.3V$

$P = (.0063)(2.3) + (1.94A)(1.74V)$

$= 3.39W \rightarrow T_J = 25°C + 3.39W(1.92 + .5 + 15) = \boxed{84°C}$ ← Just enough!

Problem 2: MOSFET Switch



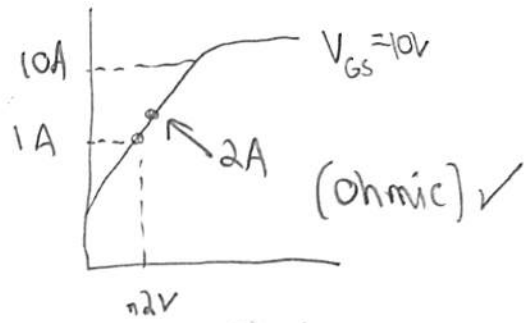
Consider a power MOSFET for the same type of heating element (rated at 24V @ 50W). The control comes from a logic level shifter producing 0 to 10V logic.

(a) Compute the load voltage and load power dissipation under typical Q1 conditions.

(b) Assuming worst-case Q2 conditions, does Q2 need a heat sink?

(a)

$R_{DS,on} \sim \frac{.2V}{1A} = .2\Omega$



$I_D = \frac{24}{11.5 + .2\Omega} = 2.05A$

+5

$V_{LOAD} = (2.05A)(11.5\Omega)$

$= \boxed{23.6V}$ $\quad P = (2.05A)(23.6V) = \boxed{48.4W}$

(b) Q_2: max $R_{DS,on} = 0.27\Omega$

$I_D = \frac{24}{(11.5 + .27)} = 2.04A$

+5

$P_{Q2} = (2.04)^2(.27) = 1.12W$

$T_J = 25 + 1.12W \times 62°C/W = 94.4°C > 85°C$

Yes, but would probably be OK without one.