THERMAL ANALYSIS

JUNCTION TEMPERATURE

SINCE POWER TRANSISTORS DISSIPATE LARGE AMOUNTS OF POWER
$\Rightarrow$ THEY GET **HOT**

THE JUNCTION TEMP SHOULD NOT EXCEED T_{JMAX}

$$T_{JMAX} \approx 150°C \rightarrow 200°C$$

THERMAL RESISTANCE

GIVEN $P_D \Rightarrow$ POWER DISSIPATION OF TRANSISTOR [WATTS]

$\theta_{JA} \Rightarrow$ THERMAL RESISTANCE BETWEEN JUNCTION + AMBIENCE (SAY AIR) [°C/W]

THEN

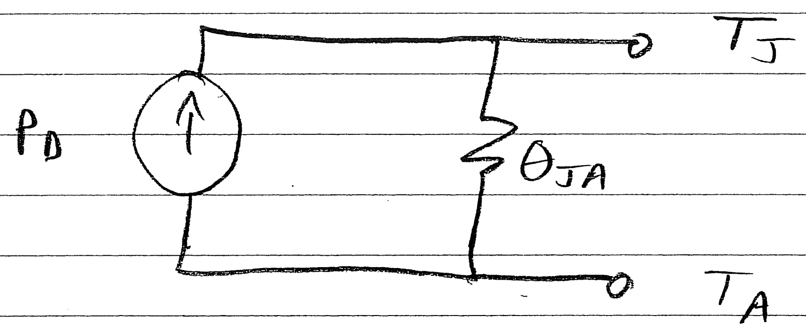
$$T_J - T_A = \theta_{JA} P_D \qquad (1)$$

T_J ← JUNCTION TEMP

T_A ← AMBIENT TEMP

① IS LIKE OHM'S LAW

WITH $T \Rightarrow$ VOLTAGE
$P_D \Rightarrow$ CURRENT
$\theta_{JA} \Rightarrow$ RESISTANCE



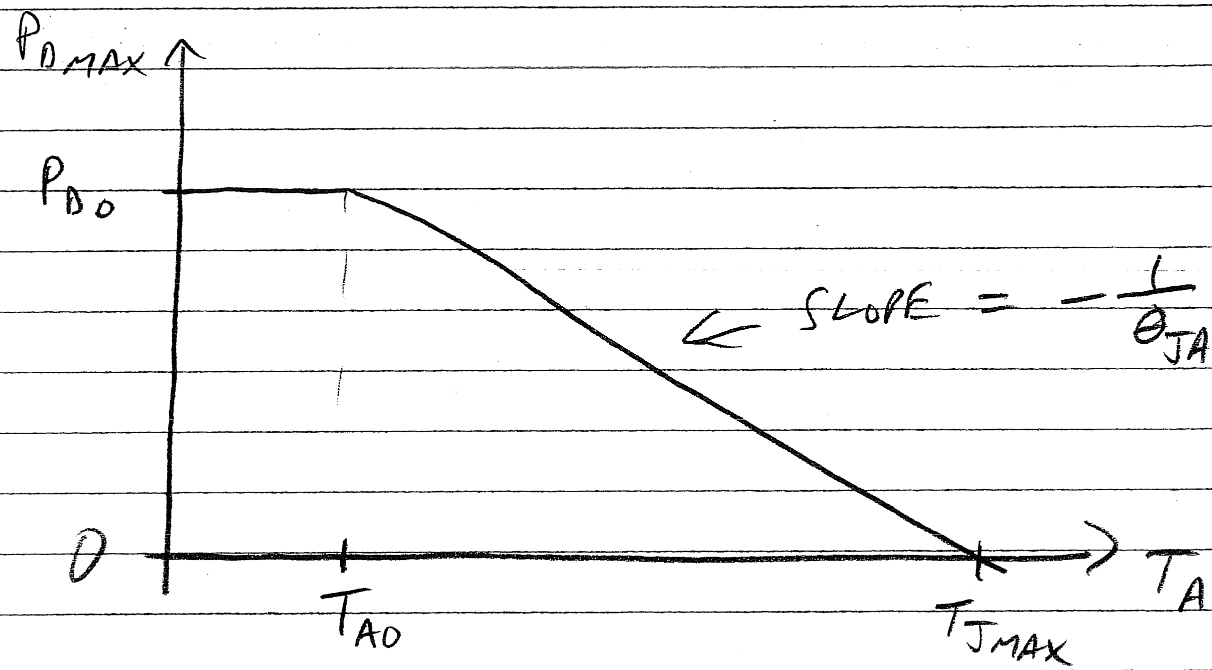
FOR A DEVICE
USUALLY GIVEN

MAX JUNCTION TEMP, T_{JMAX}

MAX POWER AT AN AMBIENT TEMP (T_{A0}), P_{D0}

& THERMAL RESISTANCE θ_{JA}

IN GRAPH FORM



BELOW T_{A0} DEVICE CAN SAFELY DISSIPATE P_{D0}

ABOVE T_{A0} => CAN USE CURVE TO DETERMINE HOW MUCH POWER CAN BE DISSIPATED

AT $T = T_{JMAX}$ $P_{DMAX} = 0$

SINCE AMBIENT IS T_{JMAX}

$$\theta_{JA} = \frac{T_{JMAX} - T_{A0}}{P_{D0}}$$

& $$P_{DMAX} = \frac{T_{JMAX} - T_A}{\theta_{JA}}$$

EX A TRANSISTOR HAS $P_{D0} = 2W$ AT T_{A0} OF $25°C$

& $T_{JMAX} = 150°C$

$\Rightarrow$ $\theta_{JA} = \frac{150 - 25}{2} = 62.5$ °C/W

$\Rightarrow$ IF $T_A = 50°C \Rightarrow P_{DMAX} = \frac{150 - 50}{62.5} = 1.6W$

$\Rightarrow$ IF $T_A = 25°C$ & $P_D = 1W$

THEN $T_J = T_A + \theta_{JA} P_D$

$T_J = 25 + (62.5)(1) = 87.5°C$

JUNCTION TEMP ($\uparrow T_J$)

THERMAL RESISTANCE OCCURS BETWEEN

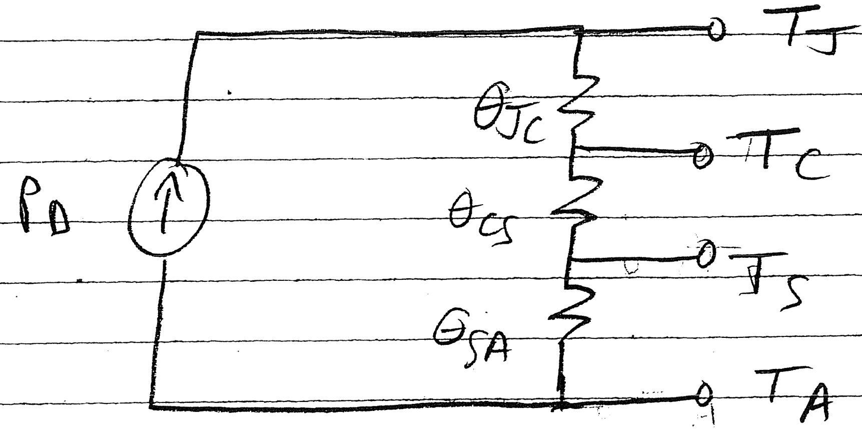
θ_{JC} JUNCTION → CASE (TRANSISTOR CASE)

θ_{CS} CASE → SINK (HEAT SINK)

θ_{SA} SINK → AMBIENT

- OFTEN USE THERMAL PASTE TO REDUCE θ_{CS} (MAKES GOOD THERMAL CONTACT BETWEEN CASE & SINK)
- OFTEN USE FAN TO REDUCE θ_{SA}

$$\theta_{JA} = \theta_{JC} + \theta_{CS} + \theta_{SA}$$



Ex TRANSISTOR HAS $T_{JMAX} = 150°C$

& CAN DISSIPATE FOLLOW MAX POWER

40 W AT $T_C = 25°C \Rightarrow \theta_{JC} = 3.12\ °C/W$

2 W AT $T_A = 25°C \Rightarrow \theta_{JA} = 62.5\ °C/W$

ABOVE 25°C $\theta_{JC} = 3.12\ °C/W$

$\theta_{JA} = 62.5\ °C/W$

FIND

a) P_{DMAX} IF IN FREE AIR $T_A = 50°C$

b) P_{DMAX} IF $T_A = 50°C$ & HEAT SINK WHERE $\theta_{CS} = 0.5\ °C/W$ & $\theta_{SA} = 4°C/W$

FIND T_C & T_S

c) P_{DMAX} IF INFINITE HEAT SINK USED & $T_A = 50°C$

(TH7)

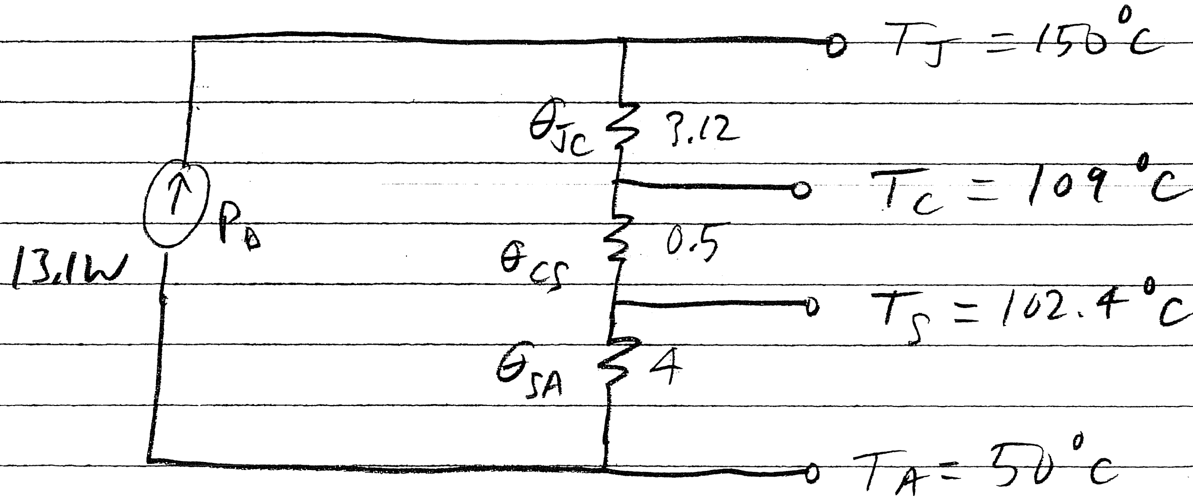
a) $P_{DMAX} = \dfrac{T_{JMAX} - T_A}{\theta_{JA}}$

$= \dfrac{150 - 50}{62.5} = \underline{\underline{1.6\ W}}$

b) $\theta_{JA} = \theta_{JC} + \theta_{CS} + \theta_{SA}$

$= 3.12 + 0.5 + 4 = 7.62\ °C/W$

$P_{DMAX} = \dfrac{150 - 50}{7.62} = 13.1\ W$



c) IF INFINITE HEAT SINK $\theta_{CS} + \theta_{SA} = 0$

$P_{DMAX} = \dfrac{T_{JMAX} - T_A}{\theta_{JC}} = \dfrac{150 - 50}{3.12}$

$= \underline{\underline{32\ W}}$