Review Lecture:

1. PWM Generation Circuit:

1) If we change the frequency of the pulse signal from NE555, will it affect the duty-cycle of the pulse from pin 7 of the comparator?

   No, the duty-cycle is determined by "B", the fixed input to the comparator.

2). Will it change the frequency of the pulse out-put from pin 7?

   Yes. actually they have of relation $f_{NE555} = 16 \cdot f_{pin\,7}$.

3) What if we use pin 5 and 6 of the comparator?

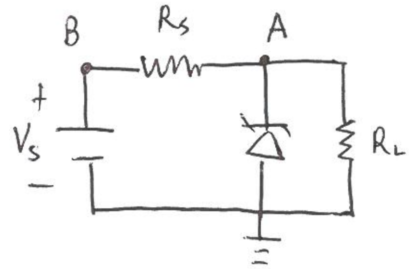
   For pin 6, the duty cycle will be fixed to $1/16$.

   For pin 5. it works similarly as pin 7.

4) What is purpose of the resistors?

   To avoid shot-circuit.

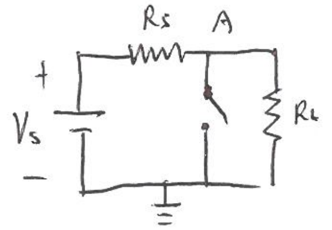
2. Zener Diode



1) what is the minimum V_s that will activate the zener diode?

If we want to break the zener diode down, the voltage across the zener should be greater or equal to the magnitude of the breakdown voltage $|V_{BD}|$.

when V_s is small, the zener is off. Thus, the equivalent circuit is



Thus, $V_A = \frac{V_s}{R_s + R_L} \cdot R_L = |V_{BD}|$

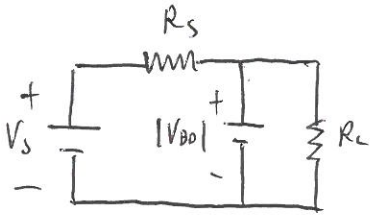
$\Rightarrow$ The minimum $V_s = \frac{R_s + R_L}{R_L} |V_{BD}|$.

2) Given V_s, what is I_L, the current through R_L?

When $V_s < \frac{R_s + R_L}{R_L} |V_{BD}|$, the zener is off.

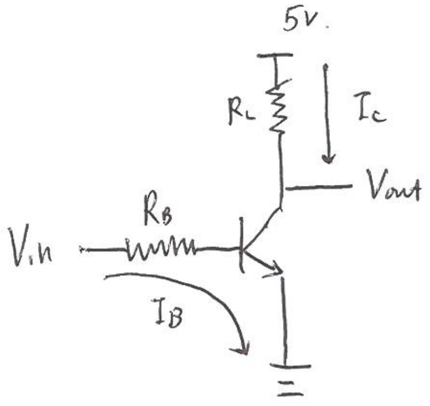
$\Rightarrow I_L = \frac{V_s}{R_s + R_L}$.

When $V_s \geq \frac{R_s + R_L}{R_L} |V_{BD}|$, the zener provides a fixed voltage $|V_{BD}|$



$\Rightarrow I_L = \frac{|V_{BD}|}{R_L}$.

3. Transistor Circuit.



How will V_{out} change with respect to V_{in} ?

$$I_B = \frac{V_{in} - 0.7}{R_B}$$

$$I_C = \beta \cdot I_B .$$

$$I_{Cmax} = \frac{5V}{R_L}$$

$0 < V_{in} < 0.7$ $\quad I_B = 0 \Rightarrow I_C = 0 \Rightarrow V_{out} = 5 - R_L \cdot I_C = 5V$

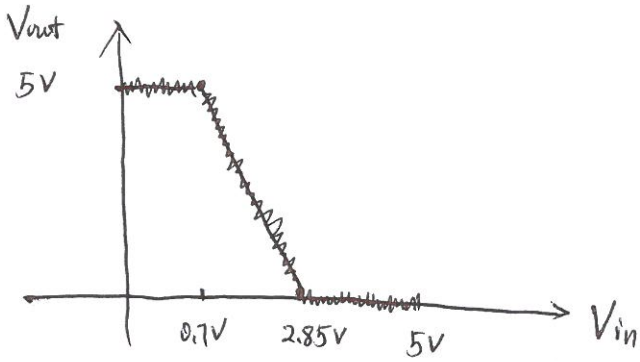
$0.7 \leq V_{in} < V_{Lin}$ $\quad$ The transistor works in the linear region. What is V_{Lin} ?

V_{Lin} is the voltage that makes $I_C = I_{Cmax}$.

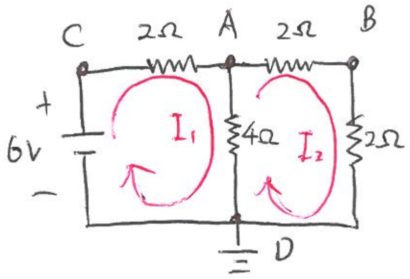
$$\beta \cdot \frac{V_{Lin} - 0.7}{R_B} = \frac{5}{R_L} \Rightarrow V_{Lin} = 2.85V$$

$2.85 < V_{in}$ $\quad$ Saturated $\Rightarrow V_{out} = 0$

To summarize :



4. KVL/KCL



For $V_s = 6V$, and $V_s = 12V$, Compute V_A & V_B.

KVL: Step 1: Label Loop current I_1, I_2.

Step 2: Set up KVL eqs for Loop 1 & Loop 2.

① $V_{AD} + V_{DC} + V_{CA} = 0$

② $V_{AB} + V_{BD} + V_{DA} = 0$

Step 3: Translation $V \Rightarrow I$

① $4(I_1 - I_2) - 6 + 2I_1 = 0$

② $2I_2 + 2I_2 + 4(I_2 - I_1) = 0$

Step 4: Solve it. ① $6I_1 - 4I_2 = 6$

② $8I_2 - 4I_1 = 0$

① ×2 + ② $\Rightarrow 8I_1 = 12 \Rightarrow I_1 = \frac{3}{2}A \Rightarrow I_2 = \frac{3}{4}A$

$\Rightarrow V_A = 4(I_1 - I_2) = 4 \times (\frac{6}{4} - \frac{3}{4}) = 3V$

$V_B = 2 \cdot I_2 = 1.5V$.

Actually, $V_B = \frac{2}{2+2} V_A = \frac{1}{2} V_A$

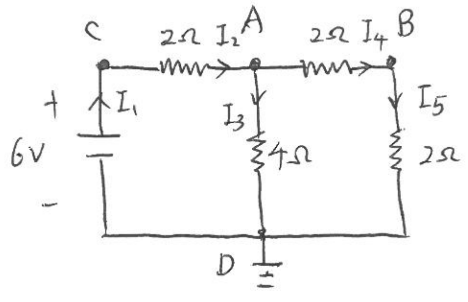
$V_A = \frac{4 \| 4}{4 \| 4 + 2} V_s = \frac{1}{2} V_s$ "4||4" means 4Ω in parallel with 4Ω.

Thus, V_s: $6 \rightarrow 12$

V_A: $3 \rightarrow 6$

V_B: $1.5 \rightarrow 3$.

KCL:



Step 1: Out of the 4 nodes, pick one as GND. We pick D.

Step 2: Set up KCL eqs at nodes A, B, C. (remaining nodes)

① Node C: $I_1 = I_2$

② Node A: $I_2 = I_3 + I_4$

③ Node B: $I_4 = I_5$

Step 3. Translate "I" ⟹ "V"

① $I_1 = \frac{V_C - V_A}{2}$

② $\frac{V_C - V_A}{2} = \frac{V_A}{4} + \frac{V_A - V_B}{2}$

③ $\frac{V_A - V_B}{2} = \frac{V_B}{2}$

Step 4. Solve it. From the circuit, we know $V_C = 6V$.

Thus. ① $I_1 = \frac{6 - V_A}{2}$

② $\frac{6 - V_A}{2} = \frac{V_A}{4} + \frac{V_A - V_B}{2}$

③ $\frac{V_A - V_B}{2} = \frac{V_B}{2}$

I am sure you know how to solve it.

But, comparing KVL and KCL for this case, which one is easier?