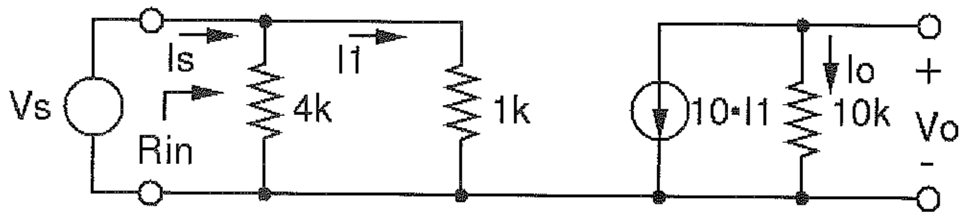
Name ....

1) Linear Circuit Theory



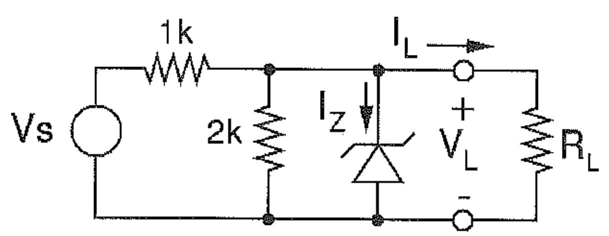
V_S is an **ideal** dc or ac **voltage** source.

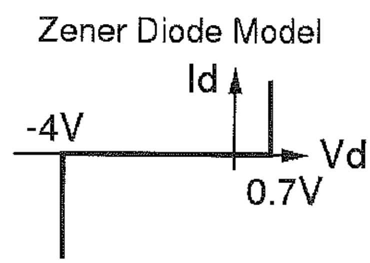
a) Find a value for the equivalent **input resistance R_{in}** seen by the source Vs.

b) What is the **value** of the output voltage **Vo** if **Vs=50 mV**?

c) Derive a **value** for the **current ratio Io/Is** as determined by the given circuit elements.

2) Voltage Limiter with Zener Diode





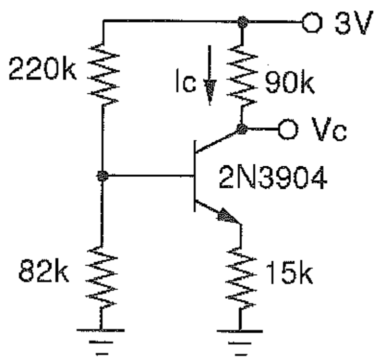
V_S is a sinusoidal voltage source of **10 V** amplitude.

a) What is the **minimum value** of the current $\mathbf{I_L}$ if $\mathbf{R_L}$**=2 kΩ?**

b) Find a **value** for the **current I_Z** flowing through the **Zener diode** if the source voltage is at its peak of 10 V ($\mathbf{R_L}$**=2kΩ**).

c) Determine the **peak power** provided by the **source V_S** if $\mathbf{R_L}$**=2 kΩ** (Hint: look at both the positive and the negative peak of the source voltage).

3) BJT Biasing



@ T=300K
$V_{BEQ} = 0.65$ V
$\beta = 150$
$V_T = 26$ mV

a) Find **values** for the **current Ic** and the **power P_T** dissipated by the 2N3904 **transistor**.

b) If we know that **V_{BE} drops** by approx. **1.7 mV** per degree C increase in temperature, what is the **value** of **Ic** at **330 K**?

c) Derive an **expression** for the differential quotient **dV_C/dT** and find its **value** for the given resistor values and transistor parameters. (Hint: relate the quotient dV_C/dT to the known temperature coefficient of V_{BE}, i.e., dV_{BE}/dT=-1.7 mV/C).

4) Quick Answer Questions

a) The **output port** of a **BJT** behaves like a

Answer (controlled) current source — 5

b) **Diodes** can be used to (mark all that apply)

A) **Amplify** signals ○

B) **Limit** voltage excursions ⊗ — 1

C) **Illuminate** a room ⊗ — 1

D) **Sense** light ⊗ — 1

c) In order to **quadruple** (times 4) the **current** of a silicon diode at room temperature (assume V_T=26 mV), the diode voltage has to be increase by

Answer 36 mV — 4

10

1) a) $\| R_{in} = 4k \| 1k = 800\Omega \|$ 2

b) $V_o = -10 \cdot I_1 \cdot 10k$ (1)

$I_1 = \frac{V_S}{1k}$ (2) 1

$\therefore \; V_o = -10 \cdot V_S \frac{10k}{1k} = -100 V_S$

If $V_S = 50mV$ $\| V_o = -5V \|$ 3

c) $I_o = -10 \cdot I_1$ (1)

$I_S \cdot R_{in} = I_1 \cdot 1k$ (2) 2

From (2) $I_1 = I_S \cdot \frac{R_{in}}{1k} = 0.8 \cdot I_S$

$\therefore \; I_o = -10 \cdot I_S \cdot \frac{R_{in}}{1k}$

or

$\left\| \frac{I_o}{I_S} = -10 \frac{R_{in}}{1k} = -8 \right\|$ 2

10

2) a) I_{Lmin} ∴ $V_S = V_{Smin} = -10V$

$R_L = 2k$ ∴ $V_L = -0.7V$

$\| I_{Lmin} = \frac{V_L}{R_L} = -0.35mA \|$

3

b) $V_S = 10V$ and $R_L = 2k$

∴ $|V_L = 4V|$

$I_S = \frac{V_S - V_L}{1k} = 6mA$

$I_2 = \frac{V_L}{2k} = 2mA$

$I_L = \frac{V_L}{R_L} = 2mA$

$\| I_Z = I_S - I_2 - I_L = 2mA \|$

3

c) $V_S = +10V$ ∴ $I_S = 6mA$

2

$V_S = -10V$ $I_S = \frac{-10V + 0.7V}{1k} = -9.3mA$

∴ $\| P_{Smax} = 93mW \|$

2

10

3) a) $$I_C = \frac{V_{CC}\cdot\frac{82k}{302k} - V_{BE}}{\frac{R_B}{\beta} + R_E\left(1+\frac{1}{\beta}\right)} = \frac{0.815 - 0.650}{0.4k + 15.1k}$$ 1

$$I_C = 10.6\,\mu A$$

$$P_T \cong \left[V_{CC} - I_C(R_C + R_E)\right]\cdot I_C = 20\,\mu W$$ 3

b) $$I_C(330k) = \frac{0.815 - 0.599}{0.4k + 15.1k} \cong 13.9\,\mu A$$ 2

c) $$V_C = V_{CC} - I_C R_C$$

$$\frac{dV_C}{dT} = -\frac{dI_C}{dT}R_C = +\frac{\frac{dV_{BE}}{dT}R_C}{\frac{R_B}{\beta} + R_E\left(1+\frac{1}{\beta}\right)}$$ 2

$$\therefore \frac{dV_C}{dT} = -1.7\,\frac{mV}{C}\cdot\frac{50k}{0.4k + 15.1k} = -9.9\,\frac{mV}{C}$$ 2

2

10