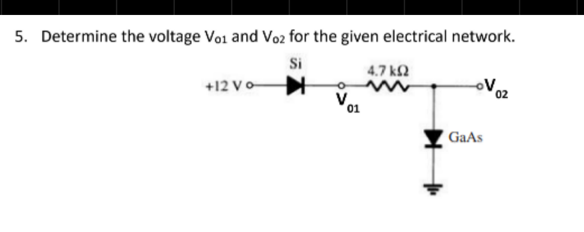
Tutorial 3

Q5)

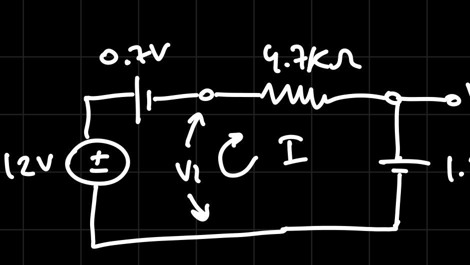


5. Determine the voltage V_{o1} and V_{o2} for the given electrical network.

also calculate the series current of the circuit

input: DC 12V

Si diode : on
GaAs diode : on



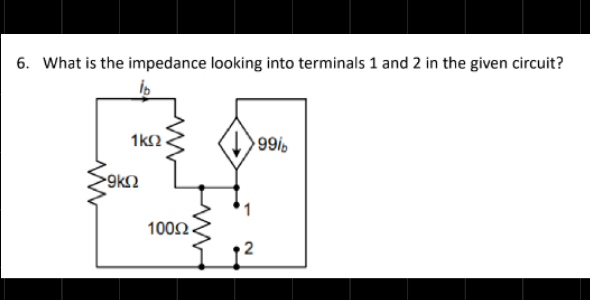
$$-12+0.7+4700I+1.3=0$$

both the diodes are on
it means that both the diodes are replaced by cutoff voltage

$$I = \frac{10}{4.7} \text{ mA} = 2.12\text{mA}$$

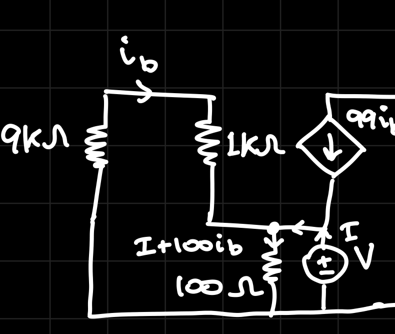
$$V_2 = 1.3V$$
$$-12+0.7+V_0 = 0$$
$$V_1 = 11.3V$$

Q6)



6. What is the impedance looking into terminals 1 and 2 in the given circuit?

Thevenin Equivalent
but dependent src
so, add a test voltage source of V



no independent source is present in the network.
So, we apply a test src across terminal 1 and 2
either a current or voltage src

$$10k\, i_b + 100I + 10k\, i_b = 0$$

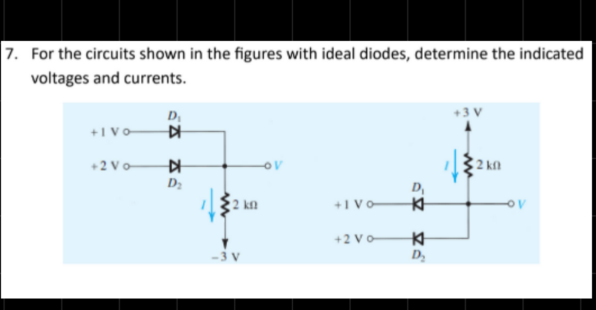
$$-V + 100I + 10k\, i_b = 0$$

let test src → V volts
I current

$$I = -200 i_b$$
$$\frac{I}{-200} = i_b$$

$$V = 100I + -50I \Rightarrow \frac{V}{I} = Z_{Th} = 50\Omega$$

Q7)



7. For the circuits shown in the figures with ideal diodes, determine the indicated voltages and currents.

(a) which diode will conduct first?
D2

now D1 will not conduct because its n side has 2V and p side has 1V

(b) D1 will conduct first
D2 will not conduct

in reverse bias, the lesser potential one will conduct

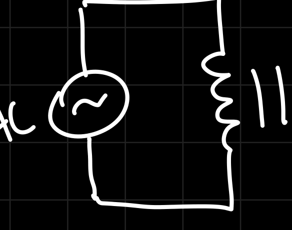
rectifier: AC → pulsating DC

AC: varies with time : bidirection ±
DC: const with time : unidirection +/−

Rectifier
↳ half wave
↳ Full wave
  ↳ Centre Tap
  ↳ Bridge
    ↳ Better

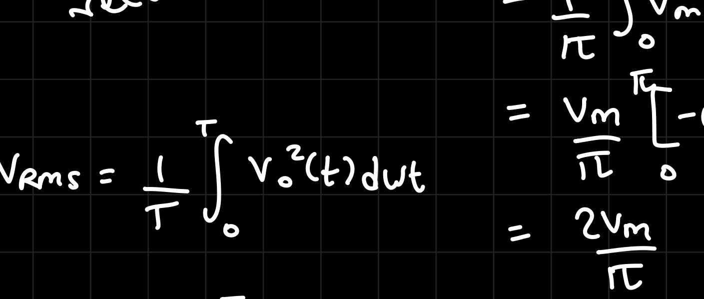
Transformer doesn't work with DC

$$\frac{V_2}{V_1} = \frac{N_2}{N_1} = \frac{I_1}{I_2}$$

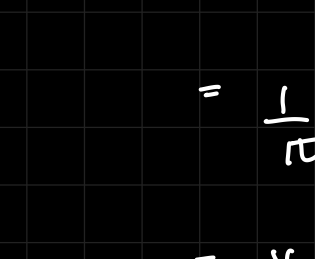


transformer
↳ step up
↳ step down

generally, used for power transformation



+ve half cycle → D2, D4 on
−ve half cycle → D1, D3 on



pulse repetition time:
originally: 2π
rectified: π

$$V_{avg} = \frac{1}{T}\int_T V_m \sin\omega t \, d\omega t$$
$$= \frac{1}{\pi}\int_0^{\pi} V_m \sin\omega t \, d\omega t$$
$$= \frac{V_m}{\pi}\left[-\cos\omega t \, d\omega t\right]_0^{\pi}$$
$$= \frac{2V_m}{\pi}$$

$$V_{RMS} = \frac{1}{T}\int_0^T V_o^2(t)\, d\omega t$$
$$= \frac{1}{\pi}\int_0^{\pi} V_m^2 \sin^2(\omega t)\, d\omega t$$
$$= \frac{V_m^2}{2\pi}\int_0^{\pi} (1-\cos(2\omega t))\, d\omega t$$

$$\cos(2A) = 1 - 2\sin^2 A$$
$$\sin^2 A = \frac{1-\cos(2A)}{2}$$

$$= \frac{V_m^2}{2\pi}\left[\omega t - \frac{\sin(2\omega t)}{2}\right]_0^{\pi}$$
$$= \frac{V_m^2}{2\pi}(\pi + 0 + 0 + 0)$$
$$= \frac{V_m^2}{2}$$

for half wave rectifier,

V_{avg} / DC value $= \frac{V_m}{\pi}$

and Rms value: $V_{RMS} = \frac{V_m}{2}$

NOTE: for full wave bridge rectifier, two diodes conduct at a time. Thats why we always consider two cutoff voltages

And for center tapped rectifier, only one diode conducts at a time

Q1)

1. A full-wave bridge-rectifier circuit with a 1k load operates from a 120V(rms) 60-Hz house hold supply through a 12 to 1 step-down transformer having a single secondary winding. It uses four diodes, each of which can be modelled to have a 0.7 V drop for any current. What is the peak value of the rectified voltage across the load? For what fraction of a cycle does each diode conduct? What is the average voltage across the load? What is the average current through the load?

$$N_1 = 12$$
$$N_2 = 1$$

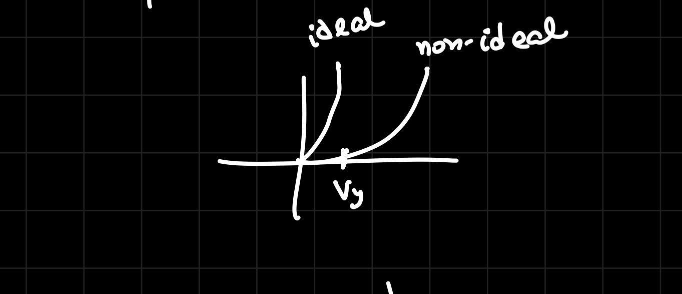
$$\frac{V_2}{V_1} = \frac{1}{12} \Rightarrow V_2 = \frac{120}{12} = 10V_{RMS}\ 60Hz$$

$$V_{peak} = 10\sqrt{2} = 14.14V$$

$$R_L = 2000\Omega$$

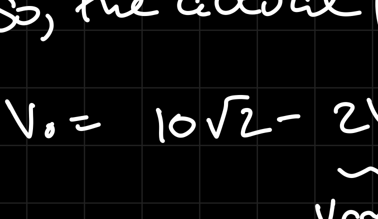
The given bridge rectifier is Si based

$$V_\gamma = 0.7V$$

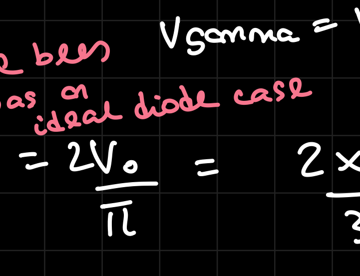


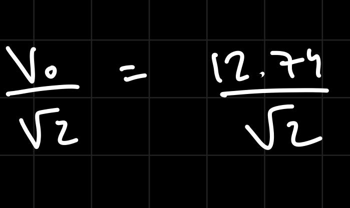
120V_{RMS}
60Hz

$$V_2 = \frac{N_2}{N_1} \times V_1 = \frac{1}{12} \times 120V_{RMS} = 10V_{RMS}$$
$$= 14.14V$$



→ This result is for ideal analysis





● : non ideal
● : ideal

phase angle diff?

So, the actual peak voltage is

$$V_o = 10\sqrt{2} - 2V_\gamma = 14.14 - 1.4 = 12.74V$$

$V_{gamma} = V_{threshold}$ of diode

This would have been correct if it was an ideal diode case

$$V_{avg} = \frac{2V_o}{\pi} = \frac{2 \times 12.74}{3.14} = 8.11V \times$$

$$V_{RMS} = \frac{V_o}{\sqrt{2}} = \frac{12.74}{\sqrt{2}} \simeq 9V$$

$\omega t \to \phi$

$$V_{avg}\Big|_{non\text{-}ideal} = \frac{1}{\pi}\int_{\theta}^{\pi-\theta} (V_m \sin\phi - 2V_\gamma)\, d\phi$$

$$\theta = \sin^{-1}\left[\frac{2V_\gamma}{V_m\sqrt{2}}\right] = \sin^{-1}\left[\frac{1.4}{10\sqrt{2}}\right]$$

$$\theta = 0.991 \text{ rad}$$

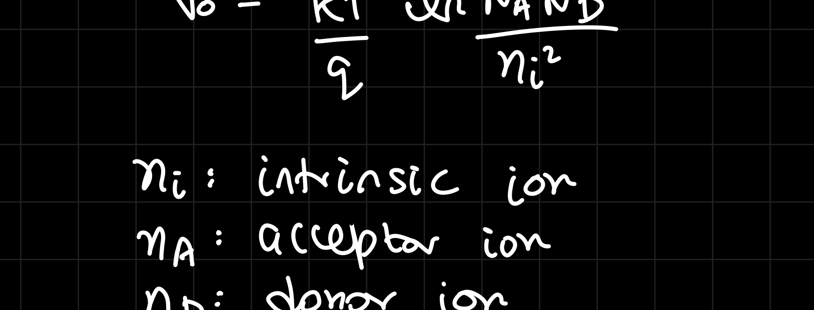
$$V_{avg} = \frac{1}{\pi}\int_{\theta}^{\pi-\theta} (V_m \sin\phi - V_\gamma)\, d\phi$$

$$r_{ac} = r_f = \eta \frac{V_T}{I_L}$$

ZENER DIODE

depletion width: $W = \sqrt{\frac{2\epsilon}{q}\left(\frac{1}{N_A} + \frac{1}{N_D}\right)(V_0 - V)}$

$$E = \frac{|V_R|}{W}$$



excess holes
p

excess e^-
n

$W = \sim 0.5\mu m$

trivalent impurity

pentavalent impurity

acceptor ion N_A

donor ion N_D

$$V_0 = \frac{KT}{q}\ln\frac{N_A N_D}{n_i^2}$$

n_i : intrinsic ion
n_A : acceptor ion
n_D : donor ion

highly doped PN junction diode
reverse biased