Tutorial-7

Question-1(Pre Tutorial Question): Three star connected impedances Z1 = 20 +j37.7 Ω per phase are in parallel with three delta connected impedances Z2 = 30 – j159.3 Ω per phase. The line voltage is **398 volts rms.** Find the line currents, power factor, power and reactive volt ampere taken by the combination. **(Hint: Convert impedances connected in delta into their equivalent star connected configuration. For a balanced network, $Z_{Star} = \frac{Z_{Delta}}{3}$)**

Solution: Converting delta connected load to star connected load $Z_2^{/} = \frac{Z_2^2}{3Z_2} = \frac{Z_2}{3} = 10 - j53.1$

Total impedance per phase = $\frac{Z_1\, Z_2^{/}}{Z_1 + Z_2^{/}} = \frac{(20 + j37.7)(10 - j53.1)}{30 - j15.4} = 68.38\angle 9.89^0\ \Omega$

a) Line current = $\frac{398}{\sqrt{3}} \times \frac{1}{68.38\angle 9.89^0} = \mathbf{3.36\angle -9.89^0}$ **A**

b) P.F. = $\cos 9.89^0 = \mathbf{0.985}$ **lagging**

c) Total power = $\sqrt{3}\, V_L I_L^* = \sqrt{3} \times 398 \times 3.36\angle 9.89^0$

Reactive VA = **397.83 VAR**

Question-2: In the balanced three phase system of Fig. 1, let Z_P = 12 + j5 Ω and $\mathbf{I_{bB}} = \mathbf{20\angle 0^0}$ **A rms** with (+) phase sequence. If the source is operating with a power factor of 0.935, find (a) R_w (b) $\mathbf{V_{bn}}$ (c) $\mathbf{V_{AB}}$ (d) complex power supplied by the source.

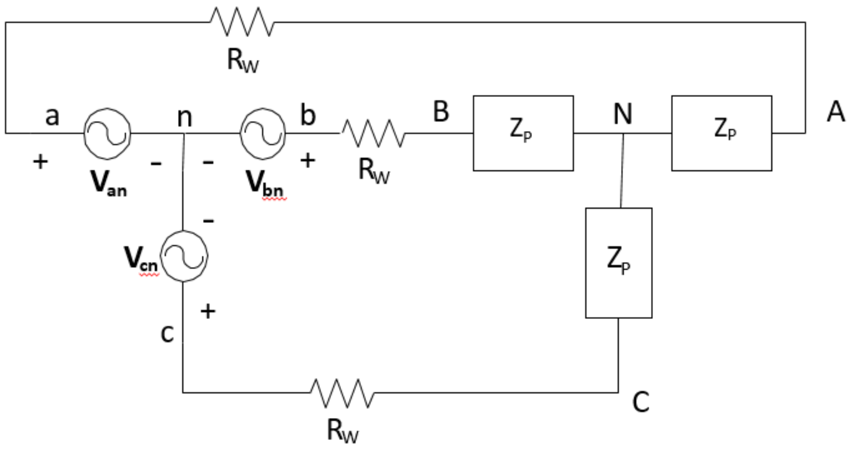
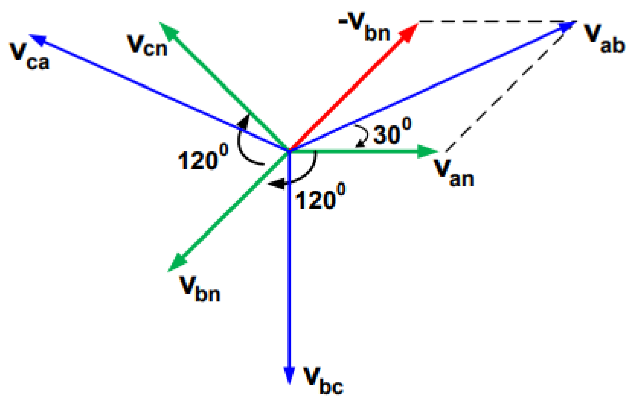


Figure -1

Solution:



(Phase and Line voltages for a balanced star connected 3-Ø circuit)

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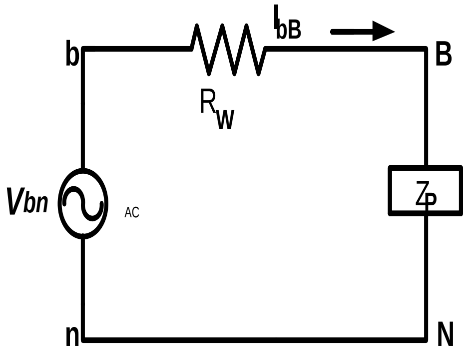
a) Considering only phase b-B, the equivalent circuit is:



b) n-N is the virtual neutral line

$Z_P = 12 + j5\ \Omega$
I_{bB} = $\mathbf{20\angle 0^0}$ A
Source power factor is 0.935 which corresponds to an angle of 20.77^0 ($\cos^{-1} 0.935$)
P.F. angle = 20.77^0 , Power factor angle is the angle of load.

As this is the source power factor, this angle corresponds to the angle of load Z_P and line resistance R_W.

So, $\tan^{-1}\left(\frac{5}{12+R_w}\right) = 20.77^0 \Rightarrow \frac{5}{12+R_w} = 0.38 \Rightarrow 13.18 = 12 + R_w \implies \boldsymbol{R_w = 1.18}\ \Omega$

b) **V_{bn} = I_{bB}** (Z_P + R_W) = $\mathbf{20\angle 0^0}\ (\mathbf{12} + \boldsymbol{j}\mathbf{5} + \mathbf{1.18})$ **=** $\mathbf{20}\ (\mathbf{13.18}\ + \boldsymbol{j}\mathbf{5}) = \mathbf{263.6} + \boldsymbol{j}\ \mathbf{100} =$ $\mathbf{282\angle 20.77^0}$ **V.**

Since, for a balanced star connected 3-phase circuit,

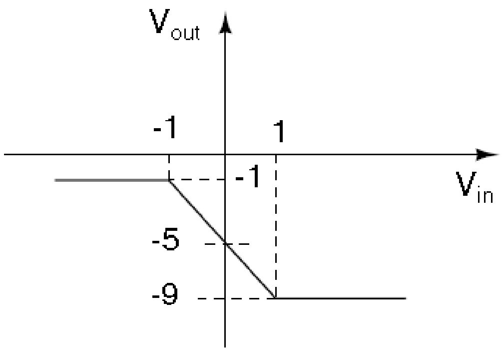
$|\boldsymbol{V_{line}}| = \sqrt{\mathbf{3}}\ |\boldsymbol{V_{phase}}|$ and it leads corresponding phase voltage by 30°.

V_{BC} = $\sqrt{\mathbf{3}} \times \mathbf{282\angle(20.77^0 + 30^0)}$ **=** $\mathbf{488.44\angle 50.77^0}$ **V**

c) **V_{AB} =**$\mathbf{488.44\angle 170.77^0}$ **V**

d) Total complex power supplied by the source **=** $\sqrt{\mathbf{3}}$ **V_L I_L =16.92 KVA**

Question-3: Transfer characteristics of a circuit are shown below.



Draw the output (as a function of time) of this circuit for the following inputs: 5+cosωt, 0.2cosωt, 1.2cosωt

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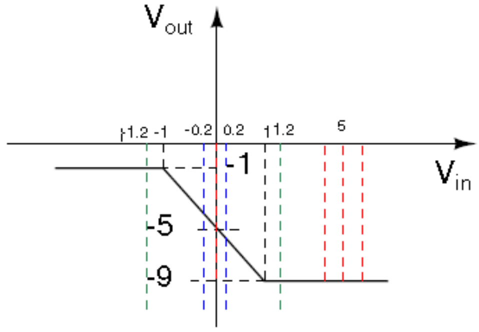
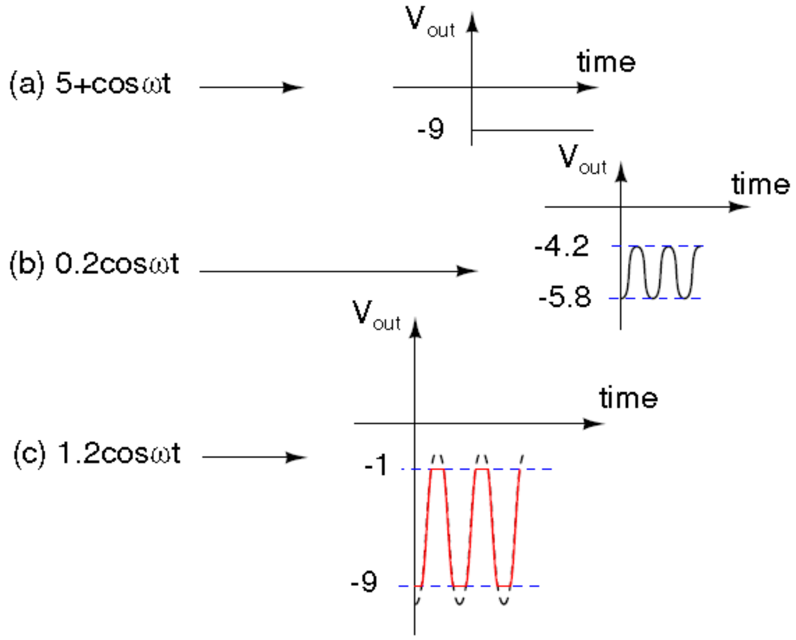
Solution:

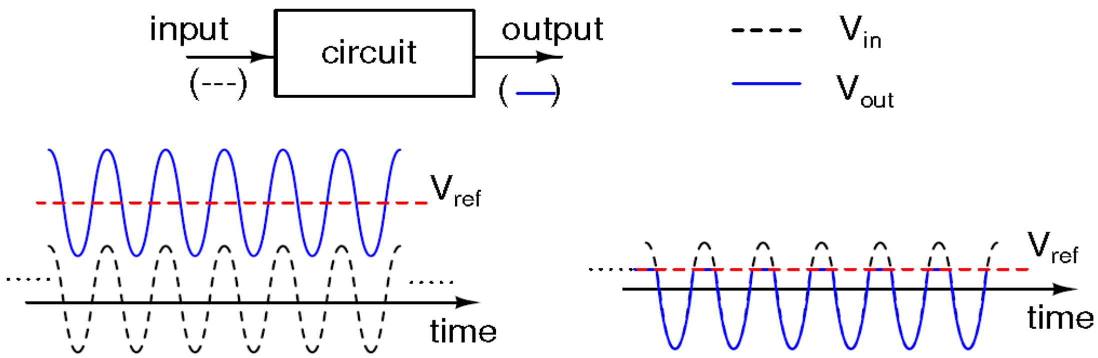


$$V_{out} = \begin{cases} -1 \text{ for } V_{in} \le -1 \\ -5-4V_{in} \text{ for } -1 < V_{in} < 1 \\ -9 \text{ for } V_{in} \ge 1 \end{cases}$$

Inputs: $5+\cos\omega t$, $0.2\cos\omega t$, $1.2\cos\omega t$



Question-4:



Clamper (dc level shifter)

(a)

Clipper (amplitude limiter)

(b)

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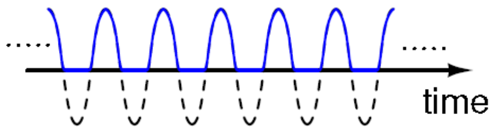
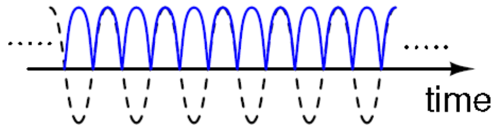


Half-wave Rectifier

(c)

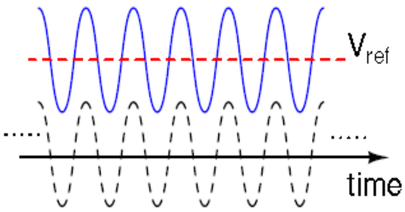
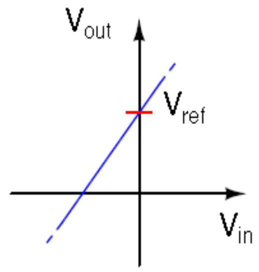
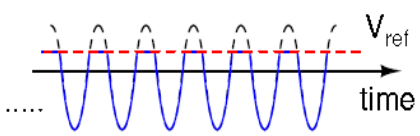
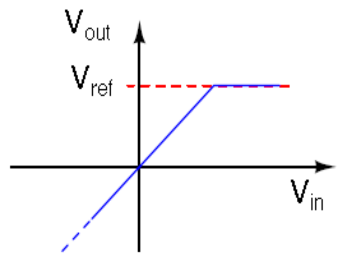
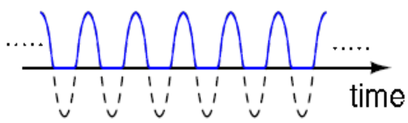
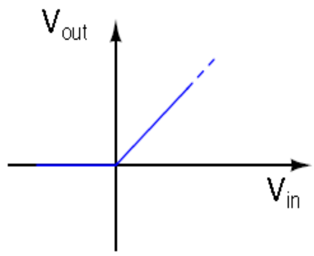
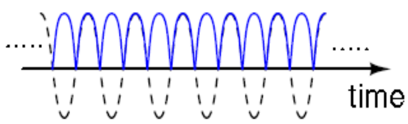
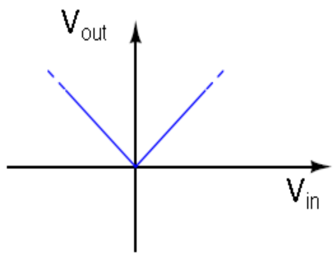


Full-wave Rectifier

(d)

Draw the transfer (output amplitude w.r.t. input amplitude) characteristics of the above circuits.

Solution:

 Clamper (dc level shifter) (a)	$V_{out} = V_{in} + V_{ref}$	
 Clipper (amplitude limiter) (b)	$V_{out} = \begin{cases} V_{in} \text{ for } V_{in} < V_{ref} \\ V_{ref} \text{ for } V_{in} > V_{ref} \end{cases}$	
 Half-wave Rectifier (c)	$V_{out} = \begin{cases} V_{in} \text{ for } V_{in} \geq 0 \\ 0 \text{ for } V_{in} < 0 \end{cases}$	
 Full-wave Rectifier (d)	$V_{out} = \begin{cases} V_{in} \text{ for } V_{in} \geq 0 \\ -V_{in} \text{ for } V_{in} < 0 \end{cases}$	

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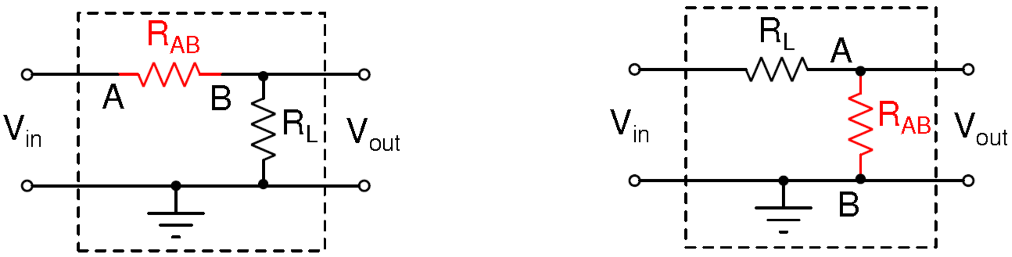
Question-5:

A voltage controlled resistor R_{AB} has the following characteristics.

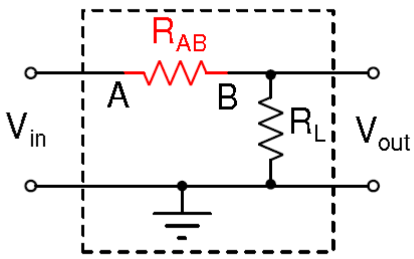
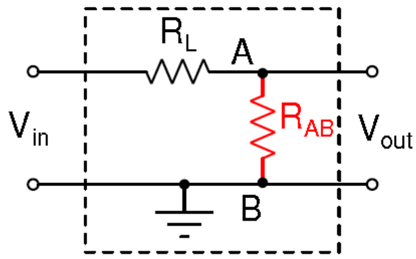
$$R_{AB} = \begin{cases} \infty & \text{for } V_{AB} < 0 \\ 0 & \text{for } V_{AB} \geq 0 \end{cases}$$

Plot the transfer characteristics of the following circuits. R_L is a normal resistor.



(a) (b)

Solution:

Circuit	 (a)	 (b)
Math. Relation	$V_{out} = \{R_L/(R_L+R_{AB})\}\ V_{in}$ $V_{out} = \begin{cases} V_{in} & \text{for all } V_{in} \geq 0 \\ 0 & \text{for all } V_{in} < 0 \end{cases}$	$V_{out} = \{R_{AB}/(R_L+R_{AB})\}\ V_{in}$ $V_{out} = \begin{cases} 0 & \text{for all } V_{in} \geq 0 \\ V_{in} & \text{for all } V_{in} < 0 \end{cases}$
Transfer Characteristics