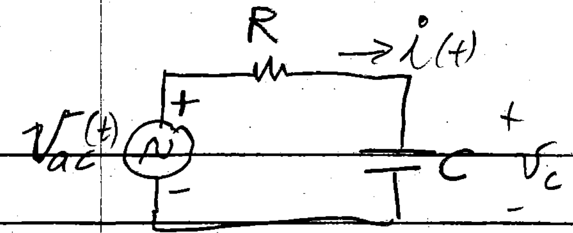
2021_0927a

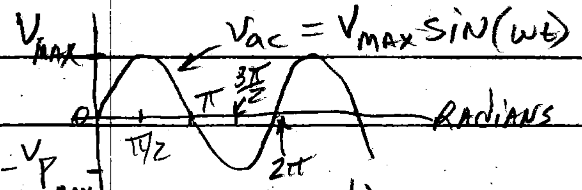


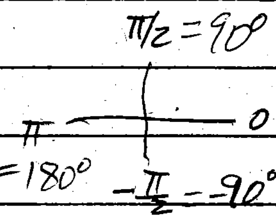
C properties,

$i_c(t) = C\frac{dv(t)}{dt}$

We'll use $i_c = C\frac{dv}{dt}$

[NO "(t)"]





$\omega = \frac{\text{RADIANS}}{\text{sec}}$, $360° = 2\pi$ RADIANS

1 cycle
$= 360°$
$= 2\pi$ RADIANS

$1\ Hz = 2\pi\ \frac{RAd}{sec}$

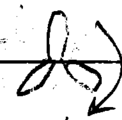
$= 1$ cycle/sec

$60\ Hz = 60$ cycles/sec $= 60 \times 60$ Rev/sec

So, power grid is equivalent to 3600 Rpm, $= 3600$ Rpm

Actual generators usually operate at 1800RMP with double set of windings to make each revolution produce two cycles

Wind farms about



one revolution per 3 sec. MAX.

Gear ratio and variable excitation convert it to 60 Hz.

Tip speed for max power is about 6 times wind speed.

Capacitors, $i = C\frac{dv}{dt}$ is linear because in steady state because the i of a freq. will produce only the same freq. of v, and vice versa. Excite it with F Hz, Response is only F Hz (In steady state)

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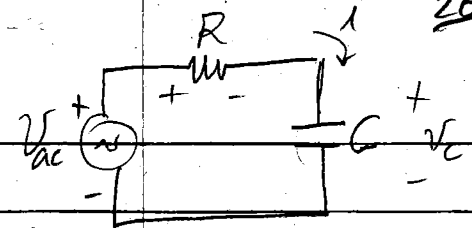


KVL, $-V_{ac} + R\,i + v_c = 0$

$$i = C\frac{dv_c}{dt}$$

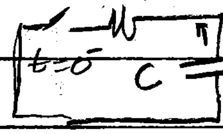
$$\text{So } -v_{ac} + R\left(C\frac{dv_c}{dt}\right) + v_c = 0$$

$$\frac{-v_{ac}}{RC} + \frac{dv_c}{dt} + \frac{v_c}{RC} = 0$$

$$\boxed{\frac{dv_c}{dt} + \frac{v_c}{RC}} = 0 + \boxed{\frac{v_{ac}}{R_C}}$$

KNOWN

Start with a simple case where $v_{ac} = 0$,



A volts

Close switch at $t = 0^+$

$$\frac{dv_c}{dt} = -\frac{v_c}{RC}, \text{ Hmmm!, try } v_c = Ae^{-\alpha t} + B$$

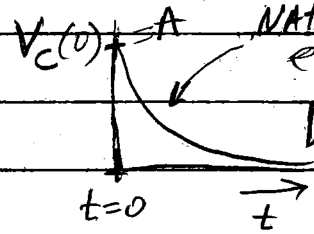
$$\frac{dv_c}{dt} = -\alpha A e^{-\alpha t}$$

$$-\alpha A e^{-\alpha t} = -\frac{1}{RC}\left[Ae^{-\alpha t} + B\right] = -\frac{A}{RC}e^{-\alpha t} - \frac{B}{RC}$$

$$-\alpha A e^{-\alpha t} = -\frac{A}{RC}e^{-\alpha t} - \frac{B}{RC}$$

So, if $\alpha = \frac{1}{RC}$ & $B = 0$, $v_c = Ae^{-t/RC}$

$v_c(0) = Ae^0 = A$, so $v_c = V_c(0)e^{-t/RC}$



NATURAL decay exponential, τ is "time constant"

Define $\tau = \frac{1}{\alpha}$, so $\boxed{\tau = RC \text{ seconds}}$

$t = \tau \quad e^{-\frac{\tau}{\tau}} = e^{-1}$

$t = 2\tau \quad e^{-2} =$

$t = 3\tau \quad e^{-3} =$

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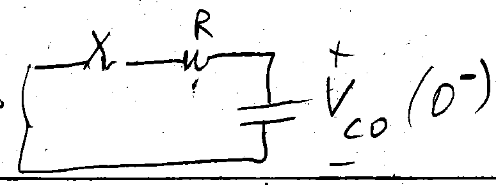
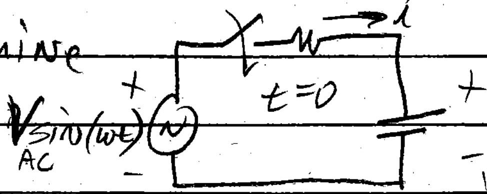
Now, instead of



We examine



$V_{CO}(0^-) = V_{CO}(0^+)$

Cap. Voltage cannot change instantly

$$-V_{ac} + Ri + V_c = 0$$

$$\underbrace{i = C\frac{dV_c}{dt}, \; i = \frac{V_{ac} - V_c}{R}}_{\text{combine}}$$

KVL $\quad C\frac{dV_c}{dt} = \frac{V_{ac} - V_c}{R}, \quad \boxed{\frac{dV_c}{dt} + \frac{V_c}{RC} - \overset{\text{Known}}{\boxed{\frac{V_{ac}}{RC}}} = 0}$

We can still expect there to be a component of V_c like $\left[Ae^{-t/\tau} + B\right]$. (Not same A, B as before)

And a component due to $V_F \sin(\omega t)$

There is only one equation that works, and if we find an equation that works, it is the solution. It will likely be necessary to add a phase shift in the sine wave. $V_F \sin(\omega t + \theta)$.

$$\frac{d}{dt}\underbrace{\left[Ae^{-t/\tau} + B + V_F\sin(\omega t + \theta)\right]}_{V_c}$$

$$+ \frac{1}{RC}\underbrace{\left[Ae^{-t/\tau} + B + V_F\sin(\omega t + \theta)\right]}_{V_c}$$

$$- \frac{V_{AC}\sin(\omega t)}{RC} = 0$$

2021-0929(b)

$$\left[-\frac{t}{\tau}Ae^{-t/\tau} + \omega V_F \cos(\omega t+\theta)\right]$$

$$+\left[\frac{A}{RC}e^{-t/\tau} + \frac{B}{RC} + \frac{V_F}{RC}\sin(\omega t+\theta)\right]$$

$$-\frac{V_{AC}}{RC}\sin(\omega t) = 0$$

goes to zero

Collect Terms — must be zero

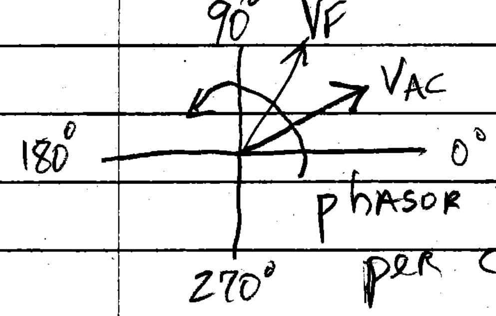
$$e^{-t/\tau}\left[-\frac{t}{\tau}+\frac{A}{RC}\right]+\boxed{\frac{B}{RC}}+V_F\left[\omega\cos(\omega t+\theta) + \sin(\omega t+\theta)\right]=0$$

When $t=0$, $\left[\frac{-0}{\tau}+\frac{A}{RC}\right]+\frac{B^{\to 0}}{RC}+V_F\left[\omega\cos(\theta)+\sin(\theta)\right]=0$

so $A=0$ $\rightarrow$ $= \frac{A+B^{\to 0}}{RC}+V_F\left[\omega\cos(\theta)+\sin(\theta)\right]=0$

When t is large, $e^{-t/\tau}\to 0$, then

so $\frac{B^{\to 0}}{RC}+\underbrace{V_F\left[\cancel{\omega\cos(\omega t+\theta)+\sin(\omega t+\theta)}\right]}_{\text{voltage on CAP}}=0$



phasor voltages revolving 360° per cycle. 60Hz, ~~60 revolutions/sec~~

Steinmetz - the genius who developed the concept of phasor analysis for S.S. A.C.