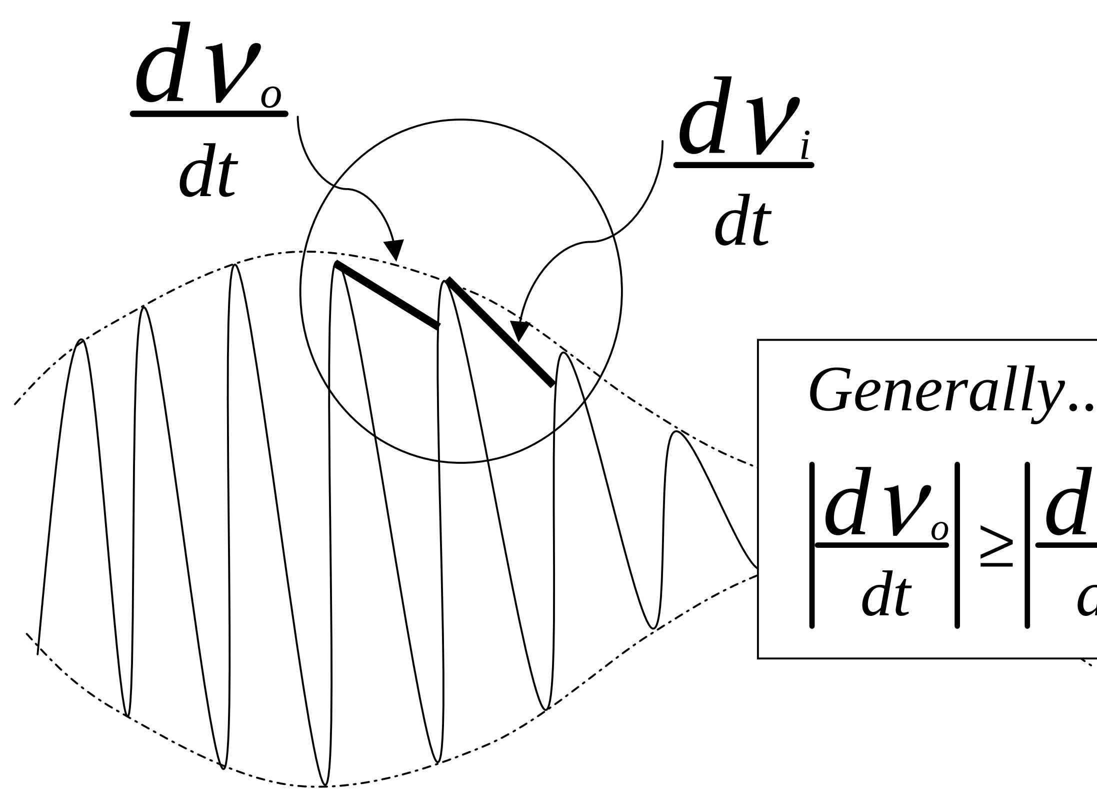
Highlight (Preview) Summary of:

1)"Optimal" RC and 2) Diode Loading



Generally..we..want :

$$\left|\frac{dv_o}{dt}\right| \geq \left|\frac{dv_i}{dt}\right|$$

Outline of Solution:

$$v_i = V_i\left(1 + m\cos\omega_m t\right)$$

$$v_o = Ve^{-t/\mathrm{T}_{RC}}$$

"Derivative inequality" gives

$$\frac{V}{\mathrm{T}_{RC}} e^{-t/\mathrm{T}_{RC}} \geq V_i m \omega_m \sin\omega_m t$$

Equating v_i=v_o (at some t) gives

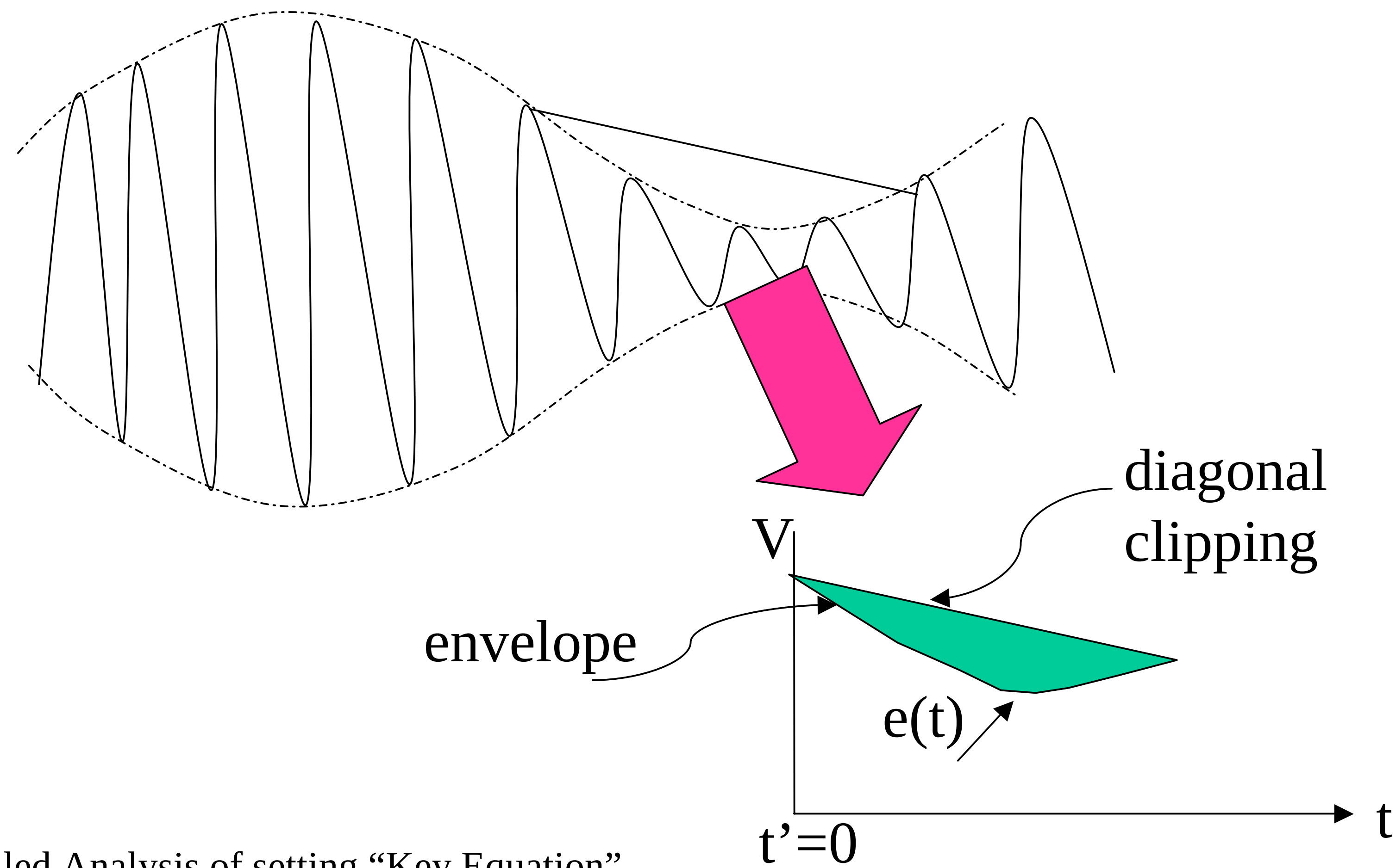
$$\frac{1 + m\cos\omega_m t}{\mathrm{T}_{RC}} \geq m\omega_m \sin\omega_m t$$

And, rearranging followed by some trigonometry to minimize LHS of inequality...

$$\frac{\left(1-m^2\right)^{1/2}}{m} \geq \omega_m \mathrm{T}_{RC} \quad \text{and, since } T_{RC} = RC,$$

$$\boxed{C \leq \frac{\left(1-m^2\right)^{1/2}}{m}\frac{1}{\omega_m R} = \frac{\sqrt{\left(1/m^2\right)-1}}{\omega_m R}}$$ $\Leftarrow$ KEY EQUATION

Diagonal Clipping



Detailed Analysis of setting "Key Equation"

$$\text{Envelope: } e(t) = Va(1 + m\cos\omega_m t)$$

The voltage across the capacitor when the diode is off is

$$v_o(t) = Ve^{-t'/\tau}$$, where $\tau \equiv RC$

t'=time since diode turn off

To avoid diagonal clipping require $\left|\frac{dv_o}{dt}\right| \geq \left|\frac{de(t)}{dt}\right|$ at $t' = 0$ i.e. $t = t'$

or $\frac{dv_o}{dt} \leq \frac{de(t)}{dt}$ since slopes are negative & sign is included in slope

$$\Rightarrow \; -\frac{V}{\tau} \leq -V_A m \omega_m \sin \omega_m t'$$

$$or \quad V_A m \omega_m \sin \omega_m t' \leq \frac{V}{\tau}$$

Note that $V = V_A\left(1 + m\cos\omega_m t'\right)$

$$\Rightarrow \mathrm{V_A} m\omega_m \sin\omega_m t' \le \frac{V_A}{\tau}\left(1 + m\cos\omega_m t'\right)$$

or

$$\frac{1 + m\cos\omega_m t'}{m\sin\omega_m t'} \ge \omega_m \tau$$

To ensure that this condition is satisfied make

$$\left.\frac{1 + m\cos\omega_m t'}{m\sin\omega_m t'}\right|_{\min} \ge \omega_m \tau$$

To obtain the minimum take derivative w.r.t. t' and equate to zero, i.e.,

$$-\omega_m \cos\omega_m t' \left(\frac{1+m\cos\omega_m t'}{m\sin^2\omega_m t'} \right) - \frac{m\omega_m \sin\omega_m t'}{m\sin\omega_m t'} = 0$$

$$i.e. -\omega_m \cos\omega_m t' - \underbrace{m\omega_m \cos^2\omega_m t' - m\omega_m \sin^2 \omega t'}_{-m\omega_m} = 0$$

$$i.e. \cos\omega_m t' = -m$$

$$\Rightarrow \sin\omega_m t' = \sqrt{1-m^2}$$

$$\therefore \text{minimum value is } \frac{1-m^2}{m\sqrt{1-m^2}} = \frac{1}{m}\sqrt{1-m^2}$$

$$\therefore \frac{1}{m}\sqrt{1-m^2} \geq \omega_m \tau = \omega_m RC$$

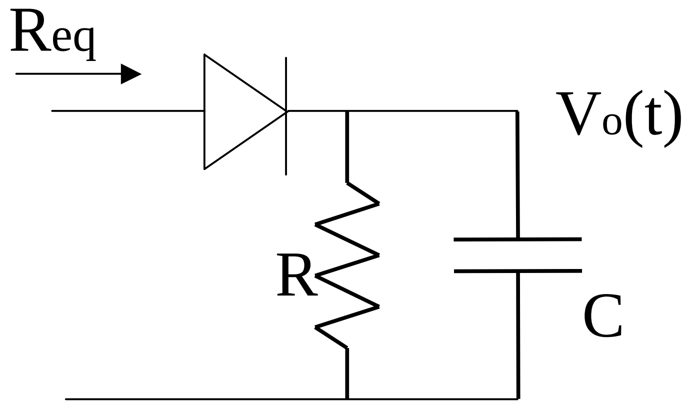
$$\boxed{\therefore C \leq \frac{1}{R\omega_m}\sqrt{\frac{1-m^2}{m}}} \Leftarrow \text{same "key equation"}$$

Remark

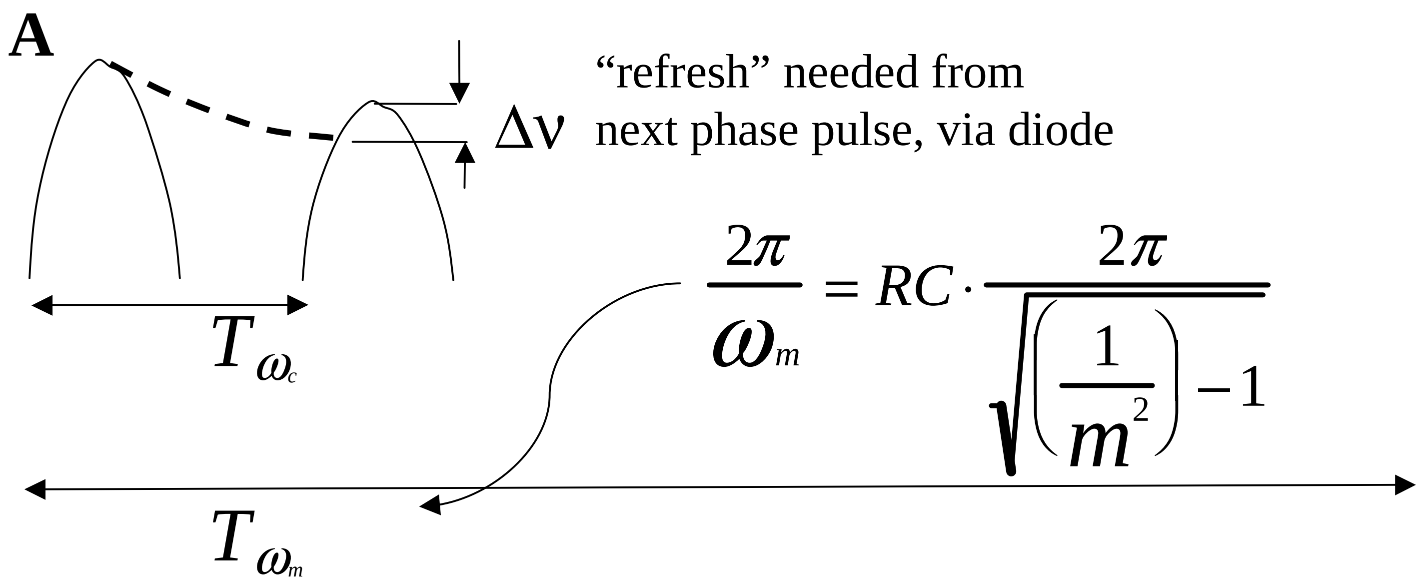
If C is increased above this value diagonal clipping or failure to follow distortion results.

Above notes provided by Prof. Karti MAYARAM of Oregon State Univ.

Equivalent Impedance of Diode/RC Load



What equivalent load is seen by the tank circuit due to diode and RC?



$$\frac{2\pi}{\omega_m} = RC \cdot \frac{2\pi}{\sqrt{\left(\frac{1}{m^2}\right) - 1}}$$

$$v_{out}(t) = Ae^{-t/RC} \approx A\left(1 - t/RC\right)$$

$$\Delta E = \frac{1}{2}C\left(V_i^2 - V_f^2\right)$$

$$= \frac{1}{2}C\left(A^2 - A^2\left(1 - \frac{2\mathrm{T}_{\omega_c}}{RC} + \frac{\mathrm{T}_{\omega_c}^2}{(RC)^2}\right)\right)$$

$$= \frac{1}{2}CA^2\left(\frac{2\mathrm{T}_{\omega_c}}{RC} - \frac{\mathrm{T}_{\omega_c}^2}{(RC)^2}\right) \text{and if } \mathrm{T}_{\omega_c} << RC$$

$$\approx \frac{1}{2}C\left(\frac{2\mathrm{T}_{\omega_c}}{RC}\right)A^2$$

From R_{eq} side $\Delta E = \frac{1}{2}\frac{A^2}{R_{eq}}\mathrm{T}_{\omega_c}$

$R_{eq} \approx R/2$ wow, simple result!