➢ *Minimization of the Total Capacitance*:

- From the previous analysis, we note that ***C_E sees the least Thevenin resistance across its two terminals***

  $\Rightarrow$ ***Let's choose C_E to contribute the DP f_d***, and let ***C_C and C_B each contribute poles at $f_d/10$***

  $$\Rightarrow 48.8 = \sqrt{f_d^2 + 2\left(f_d/10\right)^2}$$

  $$\Rightarrow f_d = 48.3 \text{ Hz and } f_d/10 = 4.83 \text{ Hz}$$

- Thus:

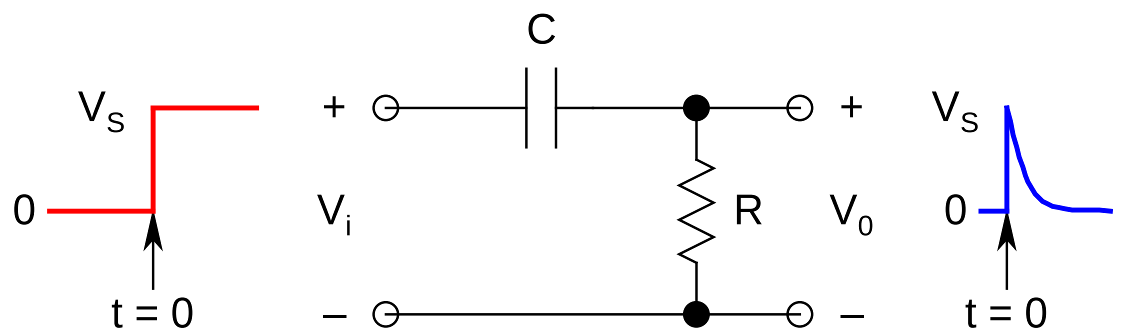
  $$C_E = 1\Big/\left(2\pi f_d R_E^\infty\right) = 101.1\ \mu\text{F}$$

  $$C_B = 1\Big/\left[2\pi\left(f_d/10\right)R_B^\infty\right] = 11\ \mu\text{F}$$

  $$C_C = 1\Big/\left[2\pi\left(f_d/10\right)R_C^\infty\right] = 4.7\ \mu\text{F}$$

- Thus, the ***total capacitance*** requirement comes out to be ***116.8 μF***, for the ***same f_L of 48.8 Hz***
- The ***original circuit*** had a ***total capacitance*** of ***200 μF***
- Thus, this approach gave a ***cost saving*** of almost ***42%*** in terms of the ***capacitors***
- As an ***exercise***, you can pick ***either C_C or C_B*** to ***contribute f_d***, and find the ***total capacitance*** requirement for each case
- Finally, after all, this is a ***heuristic***
- To get the ***absolute minimum value*** of the ***total capacitance***, we need to ***formulate the problem***, and ***find the minima of the function mathematically***

- ***Tilt/Sag***:
  - For ***pulse/square wave excitation***, f_L dictates the amount of ***tilt/sag*** present in the ***output***
  - ***Due to f_L***, the circuit effectively behaves like a ***HPF***, represented by a simple ***RC circuit***
  - Under ***step input***, the ***output*** would be a ***spike***



- Thus:

  $V_0 = V_S \exp(-t/\tau_L)$

  $\tau_L = RC = 1/\omega_L \quad (\omega_L = 2\pi f_L)$

- For $t << \tau_L$:

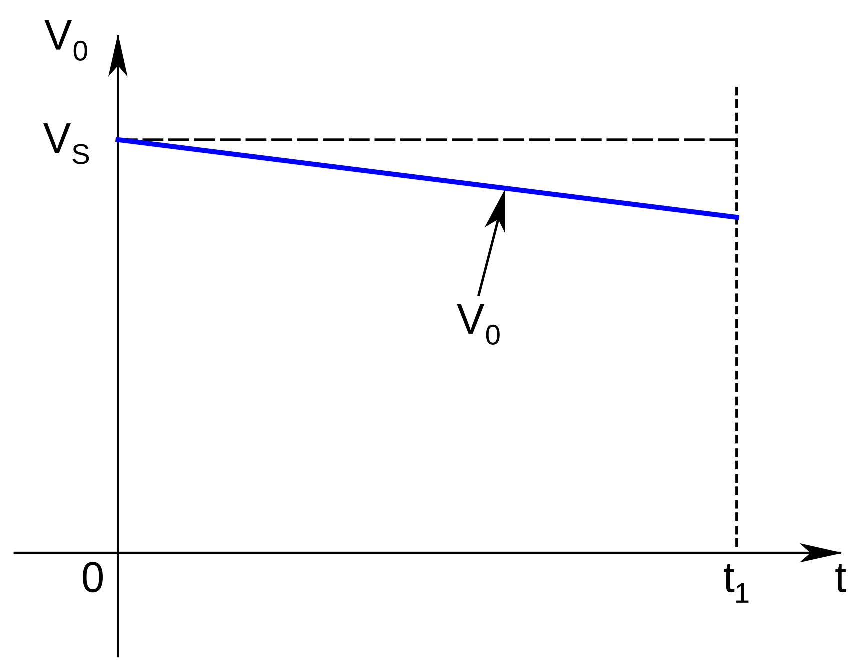
  $V_0 \approx V_S(1 - t/\tau_L)$

  $\quad = V_S(1 - \omega_L t)$

  $\quad = V_S(1 - 2\pi f_L t)$

- Thus, ***V_0 drops linearly with time***

- ***Quantified by percent tilt/sag*** (P)



- $P = [(V_S - V_0)/V_S] \times 100\%$

  $= (t_1/\tau_L) \times 100\%$

  t_1 = ***Time at which the tilt is measured***

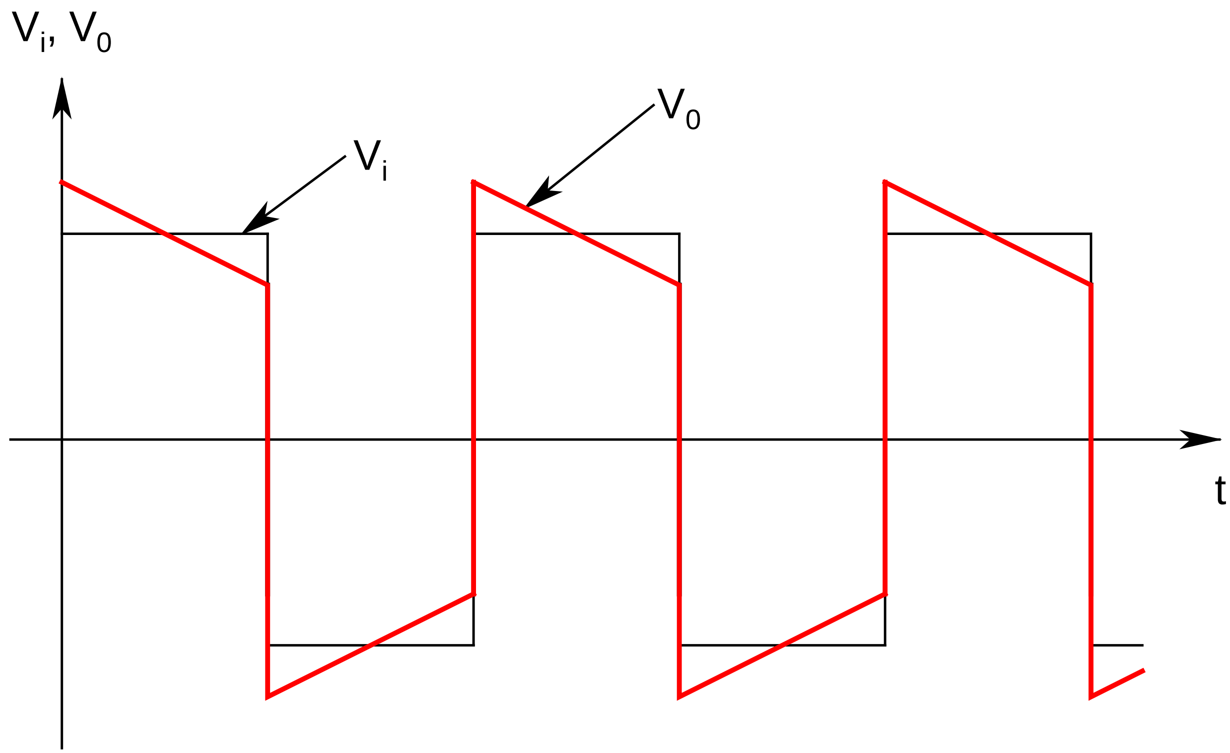
- For ***square wave input***, $t_1 = T/2$ (T = ***period*** = 1/f, f = ***cycle frequency***)

  $\Rightarrow P = [T/(2\tau_L)] \times 100\% = [\omega_L/(2f)] \times 100\%$

  $= (\pi f_L/f) \times 100\%$

- ***Note***: ***P is directly proportional to f_L*** and ***inversely proportional to f***

  $\Rightarrow$ ***Circuits having low f_L, will show significant amount of tilt/sag at low frequencies***



Tilt/Sag

High-Frequency Response

- Will consider ***3 methods***:
  - ***Exact Analysis***:
    - The ***most accurate*** and the ***most rigorous***
    - ***Gives information about all poles and zeros of the system***
  - ***Miller Effect Approximation***:
    - ***One level of approximation***
    - ***Gives information about the Dominant Pole (DP) and one Non-Dominant Pole (NDP)***

- ***Zero-Value Time Constant (ZVTC) Technique***:
  - ***The easiest one***
  - ***Information regarding only the DP***
  - ***Suppresses information about all other poles and zeros of the system***
  - ***Reasonable accuracy***
  - ***Underestimates f_H slightly*** (***better than overestimating and not achieving it***!)
  - ***Based on heuristic***
  - ***Similar to the IVTC technique***, ***based on an algorithm***