IIT ROORKEE

NPTEL ONLINE CERTIFICATION COURSE

Microelectronics: Devices to Circuits

S-Domain Analysis, Transfer Function, Poles and Zeros

SUDEB DASGUPTA

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING



Outline

- S-Domain Analysis
- Transfer Function
- Bode Plot
- Short Circuit and Open Circuit Time Constant
- Recapitulation

S-Domain Analysis

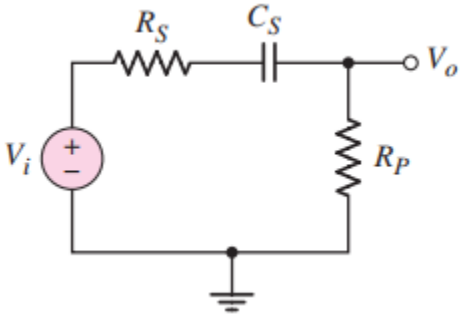
- A transfer function in S-domain is given by

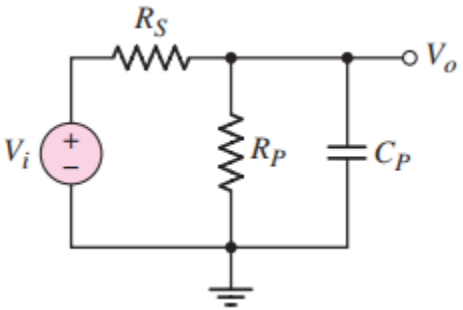
$$T(s) = K\frac{(s-z_1)(s-z_2)\cdots(s-z_m)}{(s-p_1)(s-p_2)\cdots(s-p_n)}$$

Where K is constant and Z_1, Z_2 ,Z_M are zeros and P_1, P_2, P_3 are poles of the transfer function

Source: Microelectronics Circuit Analysis and Design Donald A. Neamen, Fourth edition

Transfer Function





Voltage transfer function	$T(s) = V_o(s)/V_i(s)$
Current transfer function	$I_o(s)/I_i(s)$
Transresistance function	$V_o(s)/I_i(s)$
Transconductance function	$I_o(s)/V_i(s)$

$$\frac{V_o(S)}{V_i(S)} = \frac{R_P}{R_S + R_P \frac{1}{SC_S}} \qquad \frac{V_o(S)}{V_i(S)} = \frac{SR_PC_S}{1 + S(R_S + R_P)}$$

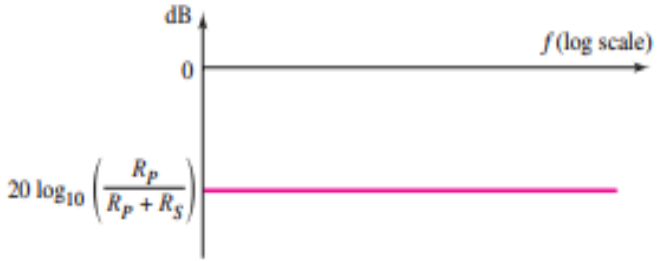
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Bode Plot

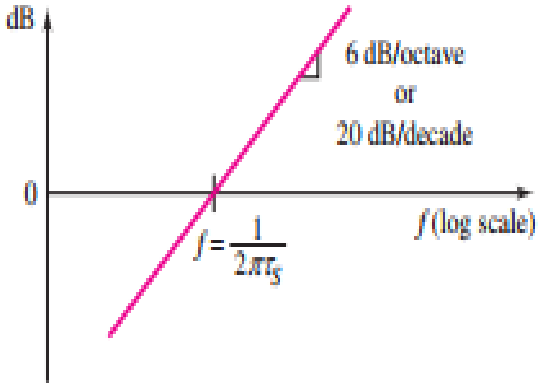
$$T(jw) = \frac{V_o(jw)}{V_i(iw)} = \left(\frac{R_P}{R_S + R_P}\right)\left[\frac{jw\tau_S}{1 + jw\tau_S}\right]$$

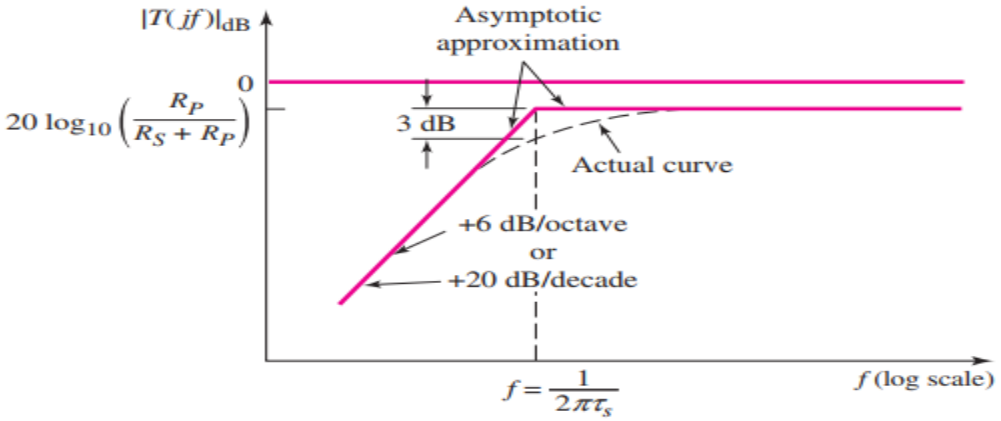
τ_S Time constant

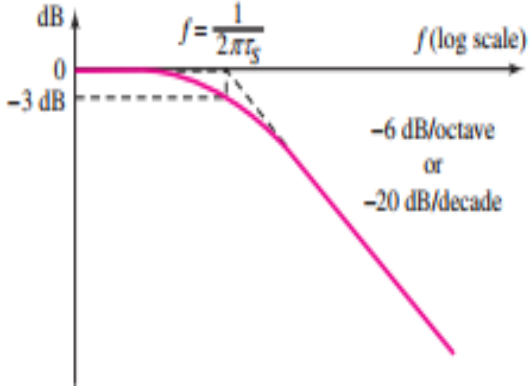
$$|T(jf)|_{dB} = 20\log_{10}\left(\frac{R_P}{R_p + R_S}\right) + 20\log_{10}(2\pi f\,\tau_S) - 20\log_{10}\sqrt{1 + (2\pi f\,\tau_S)^2}$$

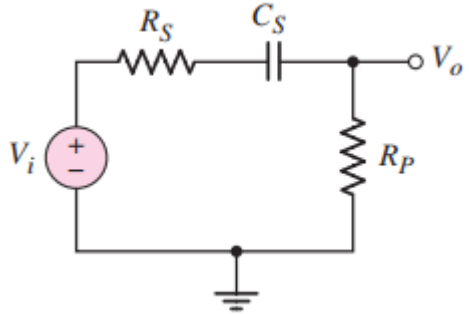


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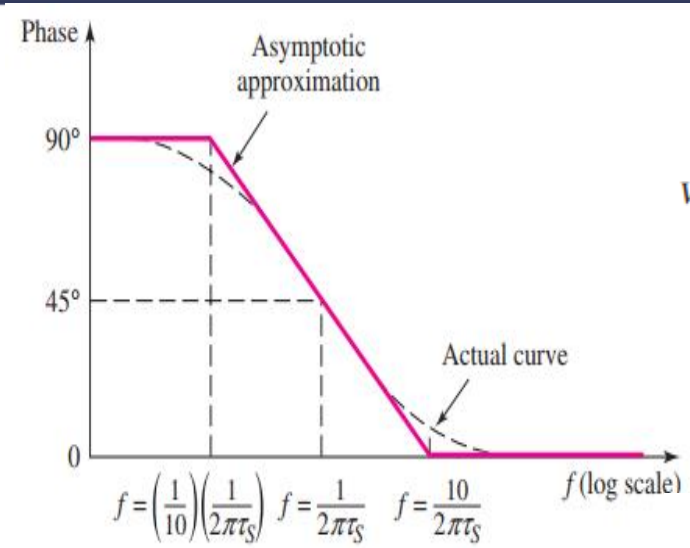


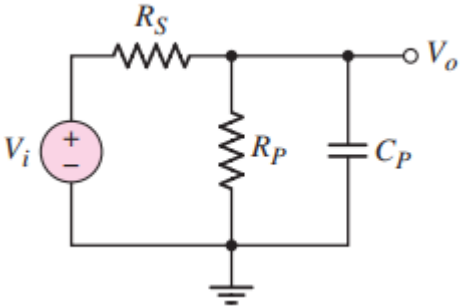


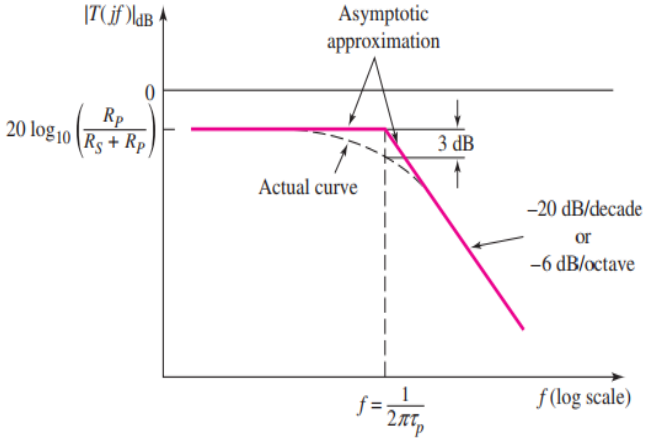


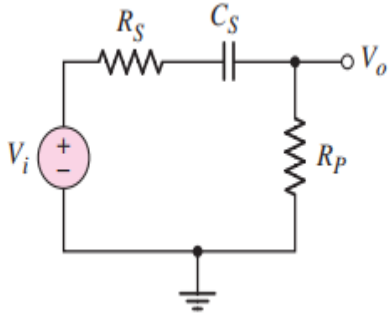


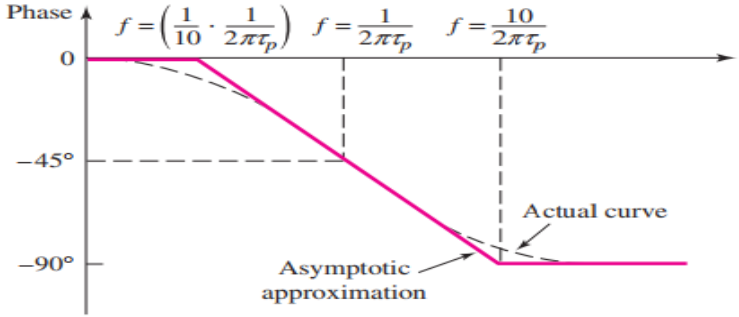
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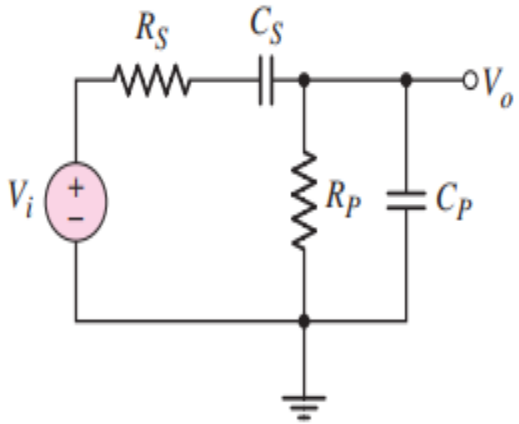






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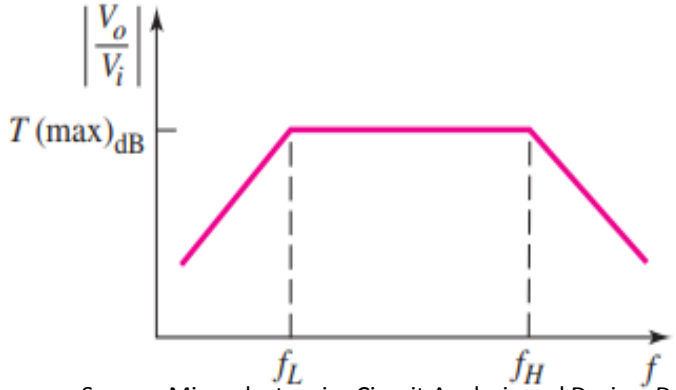
Short Circuit and Open Circuit Time Constant



$$\frac{V_o(S)}{V_i(S)} = \left(\frac{R_{PS}}{R_p + R_P}\right) \times \frac{1}{\left[1 + \left(\frac{R_P}{R_P + R_S}\right)\left(\frac{C_P}{C_S}\right) + \frac{1}{S\tau_S} + S\tau_P\right]}$$

$\tau_S = (R_P + R_S)C_S$ Open circuit time constant

$\tau_P = (R_P \parallel R_S)C_P$ Short Circuit time constant



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$$f_L = \frac{1}{2\pi\tau_S} \qquad f_H = \frac{1}{2\pi\tau_P} \qquad f_{BW} = f_H - f_L$$

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Recapitulation

- The amplifier gain is constant over a wide frequency range, called the mid-band.
- In mid-band frequency range, all capacitance effects are negligible and can be neglected in the gain calculations.
- At the high end of the frequency spectrum, the gain drops as a result of the load capacitance.
- At the low end of the frequency spectrum, the gain decreases because coupling capacitors and bypass capacitors do not act as perfect short circuits.

Source: Microelectronics Circuit Analysis and Design Donald A. Neamen, Fourth edition

Thank You