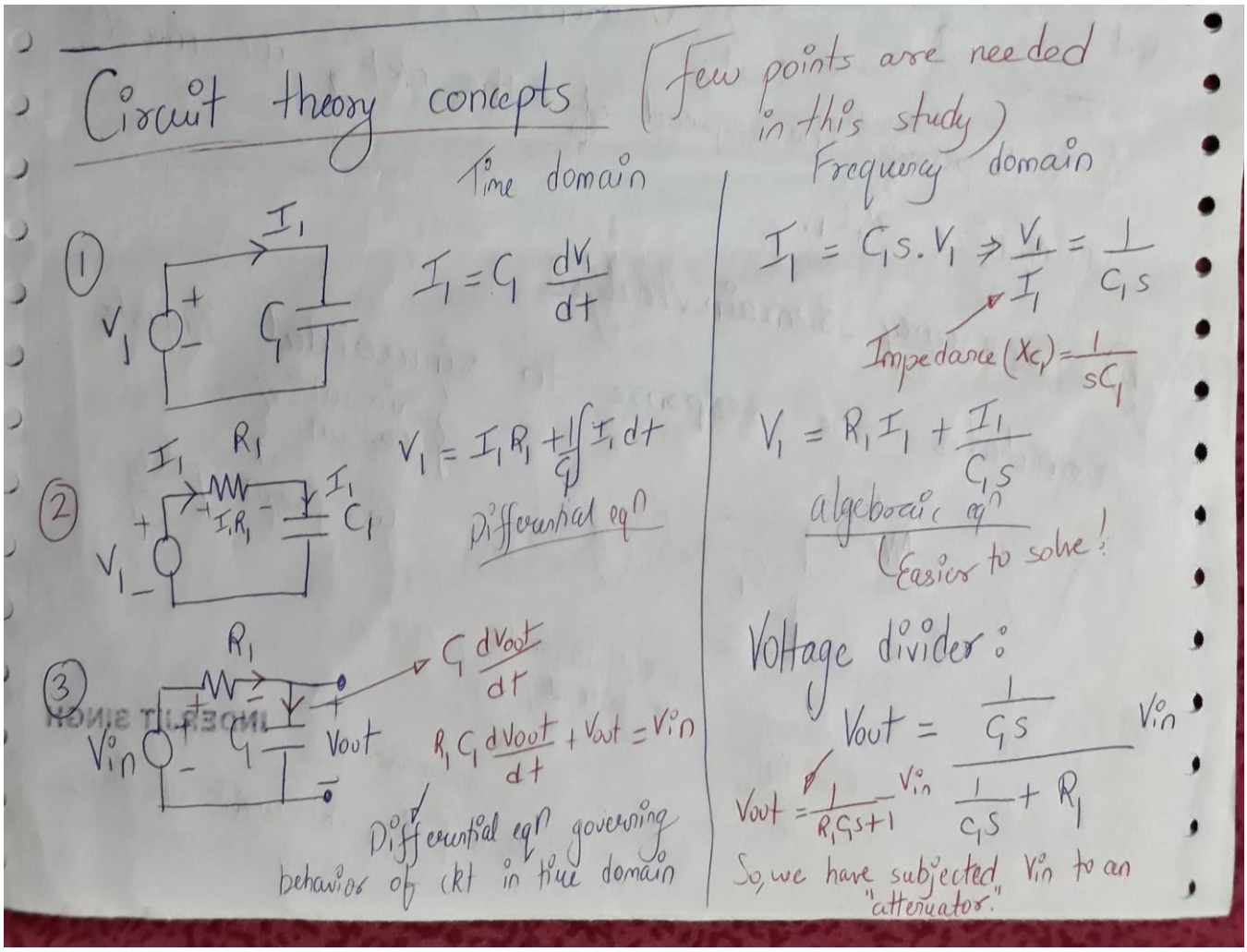
ECAD lecture 02 dated 11-01-2019

Topics Covered: Circuit Theory concepts (required as prerequisites for the topic of Frequency response), Our 1st Frequency response of a Simple RC circuit (Simple but intuitive), steps to compute frequency response, definition of bandwidth. LT Spice simulation for a simple RC circuit.

Module or sub-module covered: Covered Pre-requisites topics required for covering frequency response



$$V_{out} = \frac{1}{R_1 C_1 s + 1} V_{in}$$

Algebraic eqn → easier to handle.

→ Transfer function $H(s)$ of the ckt (It tell us how the I/P transfers to the o/p)

(4) s is generally a complex frequency.

But we can assume $\boxed{s = j\omega}$ if the signals of interest are sinusoids.

eg $H(s) = \frac{1}{R_1 C_1 s + 1}$ If V_{in} is a sinusoid,

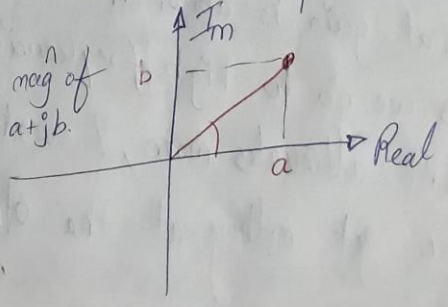
then $s = j\omega \Rightarrow \boxed{H(j\omega) = \frac{1}{R_1 C_1 j\omega + 1}}$

useful results.

(5) A complex number $a + jb$ can be represented in polar form:

Relevant to Freq response → Magnitude $:= \sqrt{a^2 + b^2}$ (length of line: mag of $a+jb$)

Phase $= \tan^{-1}\left(\frac{b}{a}\right)$



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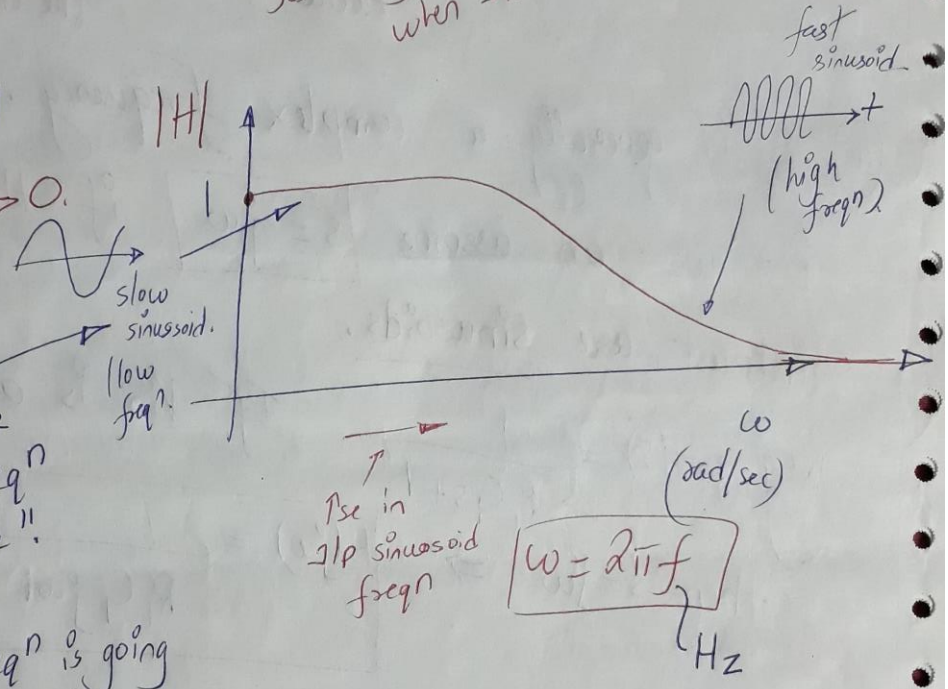
$$|H(j\omega)| = \frac{1}{\sqrt{R_1^2 C_1^2 \omega^2 + 1}}$$

Magnitude of Transfer function

↳ This function is telling us something about the o/p amplitude when i/p is a sinusoid.

$\omega = 0$; $|H(j\omega)| = 1$

$\omega \to \infty$; $|H(j\omega)| \Rightarrow 0$.



This is what we call the "Freqn response".

→ All of low-freqn is going to the o/p from I/P, so that gain is about 1.

→ As we go to high frequencies, ckt attenuates more, & eventually we get nothing at the o/p.

How to compute the freq. response?

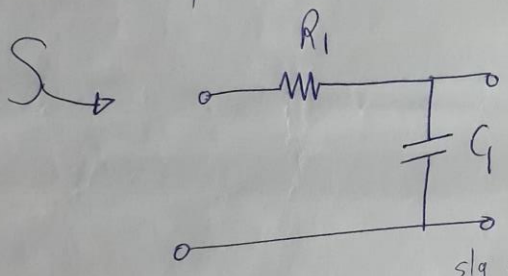
(1) Determine the transfer function $H(s)$

(2) Assuming ip is a sinusoid. Replace s with $j\omega \Rightarrow H(j\omega)$

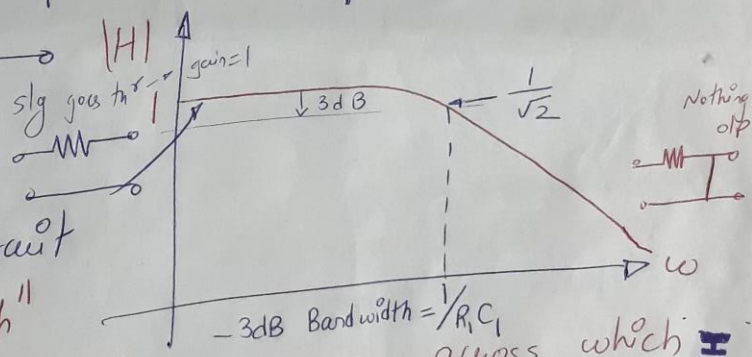
(3) Compute $|H(j\omega)|$ = Freq. Response. → one GIANT complex number have Nr 2 Dr

Example:

Simple ckt → but teaches a lot!



$$|H(j\omega)| = \frac{1}{\sqrt{R_1^2 C_1^2 \omega^2 + 1}}$$



→ One measure of the goodness of the circuit ie it's "Bandwidth" across which

→ Bandwidth means the frequency range the i/p sig. will go to the o/p.

→ Why does the ckt attenuate at these frequencies

$X_{C_1} = \frac{1}{j\omega C_1}$

At low f, X_{C_1} → v. large ⇒ o.c → ≃ C_1 by a o.c

At high f, X_{C_1} → v. small ⇒ s.c. → ≃ C_1 by a s.c

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