EECE 2150 Final Exam Notesheet
December 10, 2024

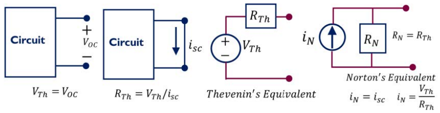
Fundamentals

KCL: $\sum i_{in} = 0$, **KVL:** $\sum v_n = 0$
Ohm's Law: $V = iR$
Resistances: $\frac{1}{R_{eq}} = \sum \frac{1}{R_i}$ (parallel), $R_{eq} = \sum R_i$ (series)
Power: $P = iV = i^2 R = \frac{V^2}{R}$

Thevenin/Norton Equivalent

$V_{Th} = open\ circuit\ voltage$
$R_{Th} = V_{th}/i_{sc}$
R_{Th} *is also the equivalent resistance seen between the terminals when all independent sources are set to zero*

Norton's Equivalent circuit can be obtained from Thevenin's equivalent circuit using source transformation



Voltage and Current Decision

Voltage Division:

$$v_x = v_s \frac{R_x}{R_1 + R_2 + \cdots + R_n}$$

Distributes voltage across resistors in series proportionally to their resistance.

Current Division:

$$i_x = i_s \frac{R_{eq}}{R_x}$$

where $R_{eq} = R_1 \parallel R_2 \parallel \cdots \parallel R_n$.

Current through a branch:

$$i_x = i_s \frac{R_{total}}{R_x + R_{total}}$$

If resistances are combined in parallel and a current source is applied. These principles aid in determining how voltage or current is shared across circuit components.

Capacitor and Inductor

Capacitor

$$i = C\frac{dv}{dt} \qquad v = \frac{1}{C}\int_{t=t_0}^{t} i(t)dt + v(t_0)$$

$$P = iv \quad w = \frac{1}{2}Cv^2$$

Transient analysis for first order RC , general solution

$v(t) = V_F + (V_0 - V_F)e^{-\frac{t}{\tau}}$ $\quad t \geq 0$

$i(t) = I_0 e^{-\frac{t}{\tau}}$ $\quad t \geq 0^+$

$\tau = RC$

$\Rightarrow v(0^-) = v(0) = v(0^+) = V_0$

Sinusoidal Steady State Analysis

$\tilde{V} = Z\tilde{I} \qquad Z = \frac{1}{j\omega C}$

$v(t) = V_m cos\ (\omega t)$, $\quad i(t) = I_m \cos(\omega t + 90^o)$

Current leads voltage by 90^o

Capacitors in parallel $C_{eq} = \Sigma C_i$

Capacitor in series $\frac{1}{C_{eq}} = \Sigma \frac{1}{C_i}$

Inductor

$v = L\frac{di}{dt} \qquad i = \frac{1}{L}\int_{t=t_0}^{t} v(t)dt + i(t_0)$

$P = iv \quad w = \frac{1}{2}Li^2$

Transient analysis for first order RL circuits, general solution

$v(t) = V_0 e^{-\frac{t}{\tau}}$ $\quad t \geq 0^+$

$i(t) = I_F + (I_0 - I_F)e^{-\frac{t}{\tau}}$ $\quad t \geq 0$

$\tau = \frac{L}{R}$

$i(0^-) = i(0) = i(0^+) = I_0$

Sinusoidal Steady State Analysis

$\tilde{V} = Z\tilde{I} \qquad Z = j\omega L$

$i(t) = I_m \cos(\omega t) \qquad v(t) = V_m cos\ (\omega t + 90^o)$

Current lags voltage by 90^o

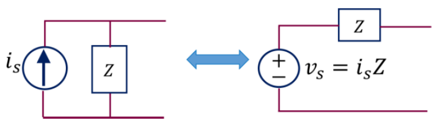
Inductors in parallel $\frac{1}{L_{eq}} = \Sigma \frac{1}{L_i}$

Inductors in series $L_{eq} = \Sigma L_i$

Phasor Transform

$$v(t) = V_m \cos(\omega t + \theta_v) \rightarrow \tilde{V} = V_m \angle \theta_v = V_m e^{j\theta_v}$$

Source Transformation



Sampling and Quantization

Sampling rate $f_s \geq 2f_{max}$, minimum sampling rate is called the Nyquist rate

$N = number\ of\ bits, \quad L = number\ of\ quantization\ Levels$

$\Delta = quantization\ step, \quad q_e = quantization\ error$

$V_{FS} = full\ scale\ range\ of\ the\ analog\ to\ digital\ converter, A/D$

For a digital system of N bits, the number of discrete levels $L = 2^N$

Quantization step $\quad \Delta = \frac{V_{FS}}{L} = \frac{V_{FS}}{2^N}$

V_{FS} *is the full scale range of A/D* $\quad V_{FS} = V_{max} - V_{min}$

V_{max} is the maximum allowed input level for A/D

V_{min} is the minimum allowed input level for A/D

Quantization error $q_e \leq \frac{\Delta}{2}$ if signal is within A/D range

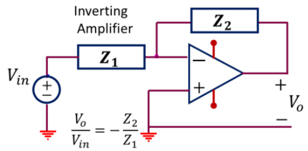
If the signal exceeds the A/D full scale range, the error will be given by

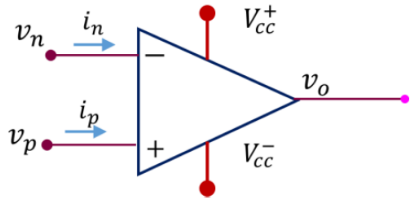
$q_e = V_{signal} - \left(V_{max} - \frac{\Delta}{2}\right) \quad for\ V_{signal} > V_{max}$

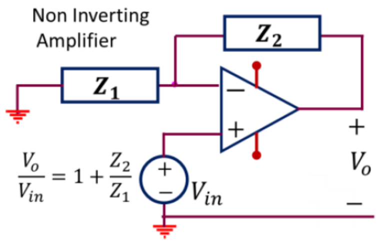
$$q_e = \left(V_{min} + \frac{\Delta}{2}\right) - V_{signal} \quad for\ V_{signal} < V_{min}$$

Ideal Op-Amps

- $i_n = 0, i_p = 0 \quad v_n = v_p$
- Infinite resistance looking into the inverting or non-inverting terminal
- Infinite bandwidth
- For linear mode of operation $V_{cc}^- \leq v_0 \leq V_{cc}^+$







Transfer Functions and the frequency response of linear systems

$$H(j\omega) = \frac{V_o}{V_{in}}$$