Course Summary

Embedded Electronics IE1206

Module 1: Resistive Circuits

Ohm's law, KCL and KVL:

Adding two parallel resistors:

$$R_T = \frac{R1 * R2}{R1 + R2}$$

Voltage division:

VR1 = Seeked voltage.
VS = Voltage source

$$VR1 = VS\left(\frac{R1}{R1 + R2}\right)$$

Current division:

$$IR1 = IT\ (\frac{R2}{R1 + R2})$$

Node Voltage Method

- Assign a potential (V_1, V_2 ….. V_N) to all nodes in the circuit
- Assign 0 to one of the nodes (ground)
- Use KCL in ever every node and express the currents in the node potentials
- Solve the equations to find all node potentials (V_1, V_2 ….. V_N)
- Determine all voltages and currents from the known potentials (V_1, V_2 ….. V_N)

Mesh Current Method

- Assign a mesh current (I_1, I_2 ….. I_N) to all loops in the circuit
- Use KVL in the loop and express the voltages in the loop using the defined currents
- Solve the equations to find all the mesh currents
- Determine all voltages and currents from the now known mesh currents

Superposition

- The voltages/currents in the circuit is the sum of the individual contributions from each source in the circuit

Thevenin and Norton Equivalents

1. Open the load resistor.
2. Calculate / measure the open circuit voltage. This is the **Thevenin Voltage (V_{TH})**.
3. Open current sources and short voltage sources.
4. Calculate /measure the Open Circuit Resistance. This is the **Thevenin Resistance (R_{TH})**.

If only independent sources, kill all the sources and find Req by summing all active.
Voltage → short
Current → $open$
R_{TH} can always be found by $\frac{V_{TH}}{I_{SC}}$

Operational amplifier:

$$Currents\ going\ in = 0$$

$$V_{out} = A(V^{+} - V^{-})$$

$$V_{out} = AV_{in}$$

$$V_{in} = V^{+} - V^{-}$$

$$When\ V_{in}^{+}\ increase \rightarrow\ V_{out}\ increase$$

$$When\ V_{in}^{-}\ increase \rightarrow\ V_{out}\ decrease$$

$$When\ V_{in}^{+}\ decrease \rightarrow\ V_{out}\ decrease$$

$$When\ V_{in}^{-}\ decrease \rightarrow\ V_{out}\ increase$$

Capacitors

Energy in capacitor = $\frac{1}{2}CV_c^2$

Voltage in capacitor is continous

$$I_C = C\frac{dV_c}{dt}$$

Voltage in capacitor at time t

$$V_c(t) = V_c(\infty) + \left(V_c(0) - V_c(\infty)\right) e^{-\frac{t}{\tau}}$$

$$\tau = Rth * C$$

Passive circuit elements in frequency domain

Phasor transform:

$Z_R = R$ $\quad Z_L = jwL$ $\quad Z_C = \frac{1}{jwC}$

$\hat{V} = Z * \hat{I}$

$V_S = V_m \cos(wt + \theta)$

$\widehat{V_S} = V_m < \theta$

Convert from polar to complex

$V_m(\cos\ \theta + j\ sin\ \theta)$

$e^{jx} = \cos x + \mathrm{j} \sin x$

Example: $56.00 < 27.00° = 49.00 + 25.42j$

Example: $50.00 < \ -90° = 0 - 50j$

Example:

Frequency for blue curve:
$f = \frac{1}{T} = \frac{1}{4 * 10^{-3}} = 250\ Hz$
Amplitude for blue: 2V
Blue curve peak at t = 0s so θ = 0°
$V = 2 < 0° = 2$