Chapter 1 - Basics

- **Electric current = (i):** time rate of change of charge, measured in amperes (A).
- **Charge = (q):** integral of i
- **Voltage (or potential difference) = (V):** energy required to move a unit charge through an element
- **Power** = (W): vi = (i^2)R
- **Passive sign convention:** when the current enters through the positive terminal of an element (p = +vi)

Remember:

+Power absorbed = -Power supplied --> sum of power in a circuit = 0

- **Energy (J)** = integral of P

Chapter 2

Ohms Law: v=iR

Conductance (G) = 1/R = i/v

Branch: single element such as a voltage source or a resistor.

Node: point of connection between two or more branches

Loop: any closed path in a circuit.

Kirchhoff's current law (KCL): algebraic sum of currents entering a node (or a closed boundary) is zero.

Chapter 2 (cont)

Kirchhoff's voltage law (KVL): algebraic sum of all voltages around a closed path (or loop) is zero.

Voltage D: v1 = ((R1) / (R1 + R2)) * v

Voltage D: v2 = ((R2 / (R1 + R2)) * v

Current D: i1 = (R2 * i) / (R1 + R2)

Current D: i2 = (R1 * i) / (R1 + R2)

Chapter 3 - Methods of Analysis

Nodal Analysis: want to fine the node voltages

Step 1:
select reference node
- assign voltages v1 --> vn to remaining nodes

Step 2:
apply KCL to each node
- want to express branch currents in
terms of voltage

Step 3:
solve for unknowns

Important:

current flows from high to low (+ ==> -)

SuperNode Properties

1. The voltage source inside the supernode provides a constraint equation needed to solve for the node voltages
2. Supernode had no voltage of its own
3. Supernode requires the application of both KCL and KVL

Mesh Analysis

Chapter 3 - Methods of Analysis (cont)

Step 1:
Assign mesh currents or loops

Step 2:
Apply KVL
- use OHMS LAW to express voltages in terms of the mesh current

Step 3:
Solve for the unknown

Supermesh

- when two meshes have an independent or dependent CURRENT source between them

Chapter 4 - Circuit Theorems

Superposition

principal states that the VOLTAGE ACROSS or CURRENT THROUGH an element in a linear circuit is the SUM of the VOLTAGES OR CURRENTS that are caused after solving for each INDEPENDENT source separately

How to solve a superposition circuit

Step 1: Turn OFF ALL independent sources except for ONE ==> find voltage or current

Step 2: Repeat above for all other independent sources

Step 3: Add all voltages/currents together to find final value

Thevenin's Theorem

V(th) = V(oc)

Chapter 4 - Circuit Theorems (cont)

circuit with Load: I(L) = V(th) / (R(th) + R(L)) ==> V(L) = R(L) *I (L) ==> (R(L) / ((R(th) + R(L))* V(th))

Norton's Theorem

R(n) = R(th)

I(n) = i(sc) ==> (sc) = short circuit

I(n) = V(th) / R(th)

Maximum Power Transfer

max power is transferred to the LOAD RESISTOR when the LOAD RESISTOR is EQUAL to the THEVENIN RESISTANCE:

R(L) = R(th)

p(max) = $V(th)^2$ / 4R(th)

Chapter 6 - Capacitors and Inductors

Capacitors

q = C * v

capacitance: ratio of the charge on one plate to the voltage difference between the two plates

i(t) = C(dv/dt)

v(t) = 1/C [Integral: i(T)dT + v(t0))]

T = time constant

energy (w) = $.5Cv^2$

Important:

VOLTAGE of a capacitor cannot change instantaneously

Capacitors in Series: 1 / Ceq = 1/C1 + 1/C2 + 1/Cn

Capacitors in Parallel: Ceq = C1 + C2 + Cn

Inductors

v = L(di / dt)

Chapter 6 - Capacitors and Inductors (cont)

i = (1/L) [Integral: (v(T)dT + i(t0)]
energy (w) = .5Li^2

Important:

CURRENT through an inductor cannot change instantaneously

Inductors in Series:

Leq = L1 + L2 + Ln

Inductors in Parallel:

1/Leq = 1/L1 + 1/L2 + 1/Ln

Chapter 7 - First Order Circuits

Source Free RC Circuits

v(t) = V0 * e$^{-t/T}$ ==> T = RC

How to Solve SOURCE FREE RC CIRCUITS

Step 1: Find v0 = V0 across the capacitor

Step 2: Find T (time constant)

Source Free RL Circuits

i(t) = I0 * e$^{-t/T}$ ==> T = L / R

vr(t) = iR = I0 * Re$^{-t/T}$

How to Solve SOURCE FREE RL CIRCUITS

Step 1: Find i(0) = I0 through the inductor

Step 2: Find T (time constant)

Step response of an RC circuit

v(t) = V0 when t < 0

v(t) = Vs + (V0 - Vs)e$^{-t/T}$ when t > 0

v = vn + vf ==> vn = V0e$^{t/T}$, vf = Vs(1-e$^{-t/T}$)

OR

v(t) = v(infinity) + [(v(0) - v(infinity)]e$^{-t/T}$

Chapter 7 - First Order Circuits (cont)

How to solve a STEP RESPONSE OF AN RC CIRCUIT

Step 1: Find initial capacitor voltage v0 (t < 0)

Step 2: Find final capacitor voltage v(in) (t > 0)

Step 3: Find T (time constant) (t > 0)

Step response of an RL circuit

i(t) = i(infiniti) + [i(0) - i(infinity)]e$^{-t/T}$

How to solve a STEP RESPONSE OF AN RL CIRCUIT

Step 1: Find initial inductor current i0 (t = 0)

Step 2: Find final inductor current i(inf) ==> (t > 0)

Step 3: Find T (time constant) (t > 0)

Chapter 8 - Second Order Circuits

Source Free RLC Circuits

v(0) = 1/C [integral (idt = v0) from 0 to -infinity]

i(0) = I(0)

Determining Dampness

(alpha) = R / (2L)

(omega w0) = 1 / sqrt(LC)

1 - Overdamped (a > w0)

i(t) = Ae^{s1t} + Be^{s2t}

2 - Critically Damped (a = w0)

s1 = s2 = a

i(t) = (A + Bt)e^{-at}

3 - Underdamped (a < w0)

i(t) = e^{-at}(Acos(w0t) + Bsin(w0t))

Chapter 8 - Second Order Circuits (cont)

Source Free Parallel Circuits

roots of characteristic euqation

s1,2 = -a (+-) sqrt(a^2 + w0^2)

a = 1/(2RC)

w0 = 1/sqrt(LC)

1 - Overdamped (a > w0)

i(t) = Ae^{s1t} + Be^{s2t}

2 - Critically Damped (a = w0)

s1 = s2 = a

i(t) = (A + Bt)e^{-at}

3 - Underdamped (a < w0)

i(t) = e^{-at}(Acos(wd(t)) + Bsin(wd(t)))

Step Response of a SERIES RLC Circuit

1 - Overdamped (a > w0)

v(t) = Vs + Ae^{s1t} + Be^{s2t}

2 - Critically Damped (a = w0)

s1 = s2 = a

v(t) = Vs + (A + Bt)e^{-at}

3 - Underdamped (a < w0)

v(t) = Vs + e^{-at}(Acos(wd(t)) + Bsin(wd(t)))

Step Response of a PARALLEL RLC Circuit

1 - Overdamped (a > w0)

i(t) = Is + Ae^{s1t} + Be^{s2t}

2 - Critically Damped (a = w0)

s1 = s2 = a

i(t) = Is + (A + Bt)e^{-at}

3 - Underdamped (a < w0)

i(t) = Is + e^{-at}(Acos(wd(t)) + Bsin(wd(t)))

Chapter 9 - Sinusoids and Phasors

w = omega

T = 2*pie / w

freq = 1 / T (Hertz)

v(t) = v(m)*sin(wt + theta)

v1(t) = v(m)*sin(wt)

v2(t) = v(m)*sin(wt + theta)

sin(A +- B) = sinAcosB +- cosAsinB

cos(A +- B) = cosAcosB +- sinAsinB

Acos(wt) + Bsin(wt) = C*cos(wt - theta)

C = sqrt(A^2 + B^2)

theta = tan^{-1} (B/A)

Complex Numbers

rectangular form: z = x + jy

polar: z = r < (theta)

expolar: z = re$^{j(theta)}$

sin: r (cos(theta) + j*sin(theta))

z = x + jy

z1 = x1 + jy1 == r1 < (theta)1

z2 = x2 + jy2 == r2 < (theta)2

operations

addition: z1 + z2 == (x1 + x2) + j*(y1 + y2)

subtraction: z1 - z2 == (x1 - x2) + j*(y1 - y2)

multiplication: z1*z2* == *r1*r2 < ((theta)1 + (theta)2)

division: z1/z2 == r1/r2 < ((theta)1 - (theta)2)

reciprocal: 1/z = 1/r < -(theta)

square: sqrt(z) = sqrt(r) < (theta)/2

Chapter 9 - Sinusoids and Phasors (cont)

complex conjugate: z* = x - jy = r < -(theta) = $re^{-j(theta)}$

real vs. imaginary

$e^{+-j(theta)}$ = cos(theta) +- j*sin(theta)

cos(theta) = REAL

jsin(theta) = IMAGINARY

voltage-current relationship

R v = Ri (time domain) v = RI (frequency domain)

L v = L(di/dt) (time) v = jwLI

C i = C(dv/dt) (time) V = I / jwC

Impedance vs. admittance

R Z = R (impedance) Y = 1 / R

I Z = jwL Y = 1 / jwL

C Z = 1 / jwC Y = jwC

Complex Numbers with Impedance

Z = R + jx = |Z| < (theta)

|Z| = sqrt(R^2 + X^2)

(theta) = tan^{-1}(X / R)

R = |Z|*cos(theta)

X = |Z|*sin(theta)

Chapter 10 - AC Circuits

Analyzing AC Circuits

Step 1: Transform circuit to phasor or frequency domain

Step 2: Solve Using Circuit Techniques

Step 3: Transform phasor ==> time domain