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 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