Text book Review

Chapt 1 - reference directions

- power and energy $P = v(t)\, i(t)$

  phasor $v(t) = \frac{V}{2} e^{i\omega t} + c.c.$

  V complex

  $i(t) = \frac{I}{2} e^{i\omega t} + c.c.$

  I complex

  $P = \frac{VI^*}{2}$ → complex power - to handle energy stored (C and L)

  Real $P = \frac{VI^*}{4} + \frac{V^*I}{4} = \frac{|V||I|}{2} \cos(\angle V - \angle I)$

  $j \, \mathrm{Im}\, P = \left(\frac{VI^*}{4} - \frac{V^*I}{4}\right) = j$(reactive power flow)

  $\frac{|V||I|}{2}\sin(\angle V - \angle I)$

  (e.g. capacitor $= -j\frac{\omega C |V|^2}{2}$)

  energy $\int_0^t v(t)\, i(t)\, dt$

  $\boxed{\frac{|V||I|}{2} \text{ Apparent power}}$

- KCL + KVL

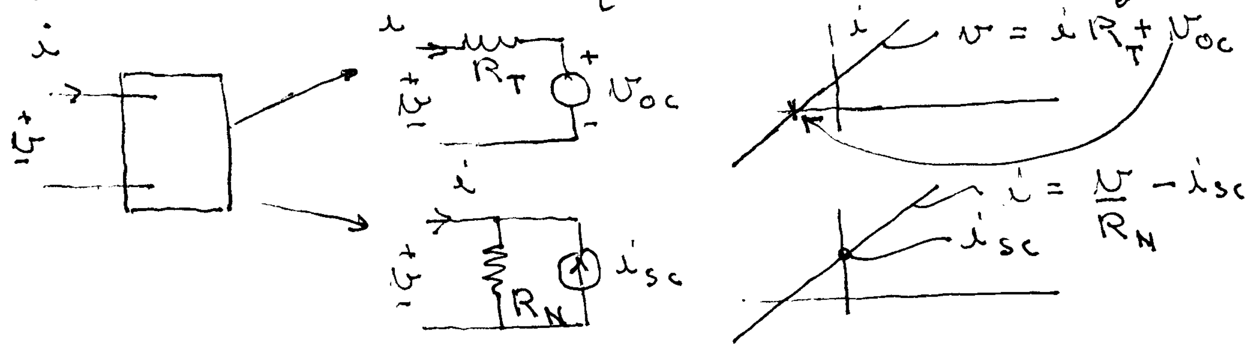
  conservation of charge

  uniqueness of voltage

- Dependent voltage and current sources
- Resistors Resistance ∝ length/(Area)

Chapt 2 - Resistive Circuits. - Voltage Divider and Current Divider.

- Node & Mesh Analysis.
- Thevenin + Norton Equivalent (2.6)



Equivalent: Thus

$R = R_N = R_{Th}$ $\quad i_{sc} = \frac{v_{oc}}{R}$

- Can use the same logic for phasors and circuits having C's and L's superposition

- Calculate response due to one source at a time
- Take care with dependent sources (must be considered for each independent source)
- Review wheatstone bridge

Solving several Simultaneous Equations

- Cramers Rule
- Flow Graph Proceedure
- Substitution

Chapt. 3 L & C

$i = C\frac{dv}{dt} = Cpv$; $v = Lpi$ $\left[\begin{array}{l} q = Cv \\ \text{Flux} = Li \end{array}\right]$

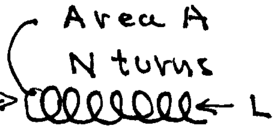
for steady state sinusoid $p = j\omega$ use only $e^{+j\omega t}$ part of v and i and use superposition

stored energy $\int_0^t v\, i\, dt$

e.g. inductor $= \int_0^t L\frac{di}{dt}\, i\, dt = \frac{1}{2}L\, i^2(t)$

capacitor $= \frac{1}{2}C v^2 = \frac{q^2}{C}$

$C = \epsilon\frac{A}{t}$; $L = \mu N A / L$ ← Area, ← length



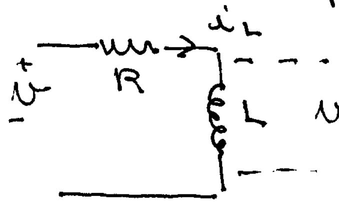
Mutual Inductance (3.7) for problem 4 PSet 6

Chapt 4 RC & RL Circuits - transients.

4.1 time constant RC - dimensional argument

$R/L \quad \frac{[\Omega]}{[H]} = \frac{[\Omega]}{[\text{volt}]/\frac{[\text{Amp}]}{[\text{sec}]}} = [\text{sec}]$

differential operator



$v_L = \frac{pL}{pL + R}v$

$L\frac{dv_L}{dt} + Rv_L = L\frac{dv}{dt}$

$\frac{dv_L}{dt} + \frac{R}{L}v_L = \frac{dv}{dt}$

e.g. $i(0^-) = 1$ Amp

$i(0^+) = 1$ Amp

$\therefore [v_L(0^+) = v(t'=0^+) - i(0^+)R]$

$v_L = \int_{0^+}^{t}\frac{dv}{dt}e^{(t'-t)R/L}dt'$ ← complementary

homogeneous → $+\, v_L(0^+)e^{-R/L\, t}$

1) D.C. Steady State – $p = 0$ L – short
C – open

2) Initially ⌐ $v = L p i$ $p \to \infty$ L open
$i = C p v$ $p \to \infty$ C short

Complementary solution – solution due to ~~source~~ source (forced)
Homogeneous Solution – natural solution (needed to satisfy initial conditions

page 171 Transient solution of an RC circuit with sinusoidal source – includes transient and steady-state

4.5 (175) Second order circuits. – needs 2 initial conditions
critical-, under- and over-damped
Use p-operator to obtain D.E. – solve
Homogeneous + forced (complementary) solutions
Can shorten calculations by using

$$\cos(j\omega t) = \cosh(\omega t)$$
$$\sin(j\omega t) = -j\sinh(\omega t)$$

Excitation with a constant source – page 180
go through 1 case!

Chapt 5 Phasors and Steady-State

Neglect 3 phase circuits

Phasors – Component of Fourier Series

$$v(t) = \frac{V}{2} e^{j\omega t} + c.c. \quad : \quad V \text{ complex} = |V| e^{j\angle V}$$

$$= |V| \cos(\omega t + \angle V)$$

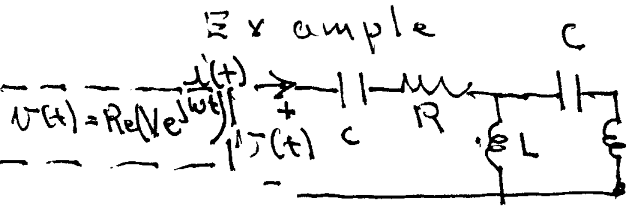
To analyze use $r(p)$ – set $p = j\omega$

Argument : for $e^{j\omega t}$ $p(e^{j\omega t}) = j\omega e^{j\omega t}$

$$\frac{1}{p}(e^{j\omega t}) = \frac{1}{j\omega} e^{j\omega t}$$

Thus $p = j\omega$

Example



Find I

$$r(p) = \left(\frac{1}{pC} + R\right) \| \left(pL \| \left(\frac{1}{pC} + pL_1\right)\right)$$

Evaluate & set $p = j\omega$

$$I(\omega) = V / r(j\omega) \triangleq V / Z(j\omega)$$

Chapt. 6 - Look at 6.1 and recall problem Set 5 (Op Amp with Diodes) (only pages 270 and 271)

6.2. Low Pass Filter - Just RC Steady-State Analysis

Skip 284 - 288

6.4 - 6.7 - Good Review of Steady-State sinusoidal analysis

6.8 - Also from the point of view of steady-State analysis.

Chapter 7 - All

Note Synthesis - SOP's POS's

POS's take complement of Karnaugh map

	AB \ C	00	01	11	10
	0	0	1	0	1
compliment $\bar{K}$	1	1	0	1	0

$$\bar{K} = \bar{A}\bar{B}C + \bar{A}B\bar{C} + ABC + A\bar{B}\bar{C}$$

$$\therefore K = \overline{\bar{A}\bar{B}C}\;\overline{\bar{A}B\bar{C}}\;\overline{ABC}\;\overline{A\bar{B}\bar{C}}$$

$$= (A+B+\bar{C})(A+\bar{B}+C)(\bar{A}+\bar{B}+\bar{C})(\bar{A}+B+C)$$

parallel in serial out shift register

ripple counter

counter design

state diagrams

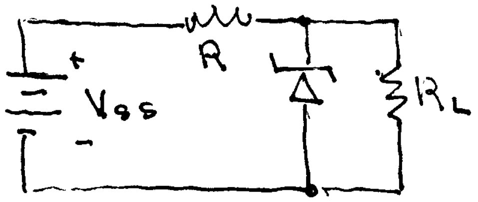
Flip Flops < R,S / D / J,K clocked. RS and the de-bounced switch as example

gates.

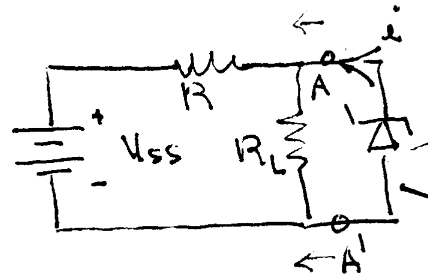
Chapt 8 - Forget

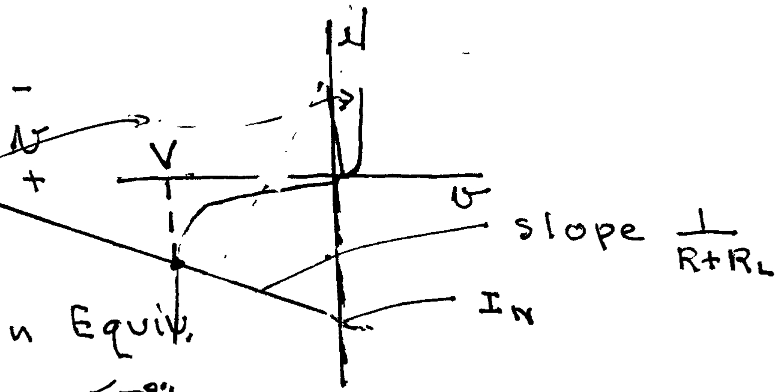
Chapt 9 - Forget

Chapt 10 - Diodes 10.3 Load Line Analysis of Zener Diode Circuit as example

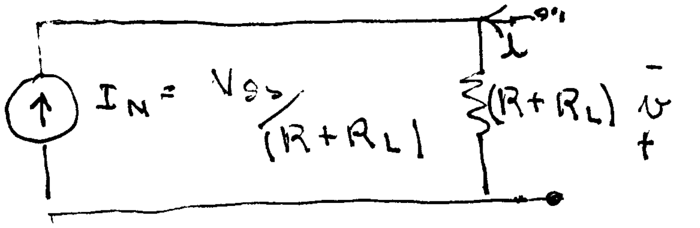


Look for Thevenin Equivalent





From AA' Norton Equiv.

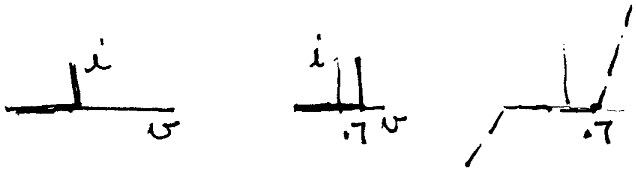


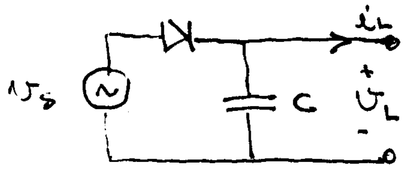
$$i = +\frac{v}{R+R_L} - I_N$$

10.4 - Ideal Diode

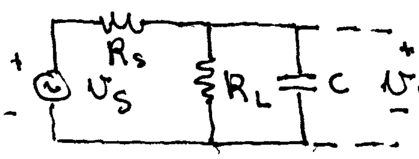
10.5 - Piece-wise Models

10.6 - Rectifier Models





During cap charging



$$v_L = Re\left(\frac{pC \parallel R_L}{pC \parallel R_L + R_s} V e^{j\omega t}\right)$$

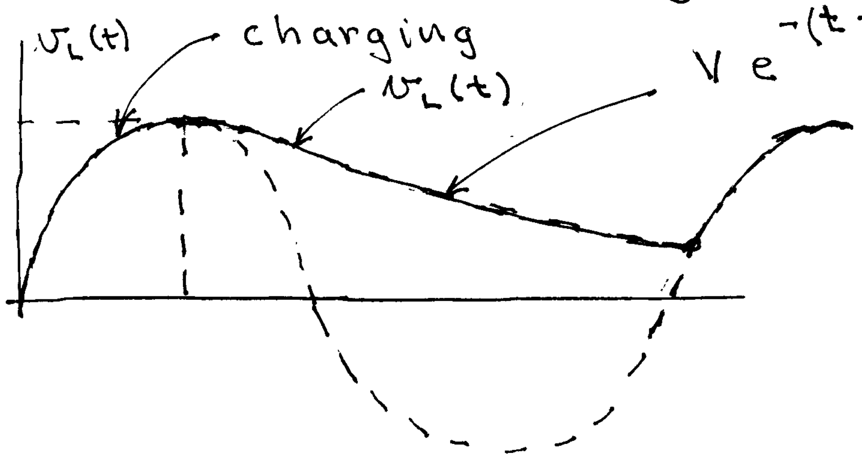
$$= Re \frac{R_L}{R_L + R_s(1+pCR_L)}$$

$v_s = V\cos\omega t$

$$\text{Thus } v_L = Re\left[\left(\frac{1/R_s}{\left(\frac{R_L+R_s}{R_sR_L}\right)+pC}\right)Ve^{j\omega t}\right]$$

For $R_L \gg R_s \simeq Re\left(\frac{V}{R_s}e^{j\omega t}\right)$ → so follows $v_s(t)$

During cap discharging



10.8 - small signal equivalent - Based on Taylor Expansion (6)

page 499 - recommended notation

v_D = total instantaneous voltage

V_{DQ} = Expansion point (d.c. quiescent voltage)

$v_d = (v_D - V_{DQ})$ - Taylor expansion variable

$= \Delta v_D$

Uses diode as example

$$i_D = I_s(e^{v_D/V_T} - 1)$$
$$= I_s(e^{(V_{DQ}+v_d)/V_T} - 1)$$
$$\approx \underbrace{I_s(e^{V_{DQ}/V_T} - 1)}_{} + \underbrace{I_s e^{V_{DQ}/V_T}\frac{v_d}{V_T}}_{i_d}$$
$$= I_{DQ} + i_d$$

so $i_d = v_d/r_d$

$r_d = \dfrac{V_T}{I_{DQ}}$

Ignore voltage controlled attenuator (pge 500)

Chapt 11 - Amplifiers

11.1 - 11.3 Basic - Dependent Sources

Ignore 11.8 - end just realize two voltage sum can be written as $v_1 + v_2 = v(t)$

$$v_1 = \underbrace{\frac{v_1+v_2}{2}}_{\text{common mode}} + \underbrace{\left(\frac{v_1-v_2}{2}\right)}_{\text{differential mode}}$$

(operational Amplifier)

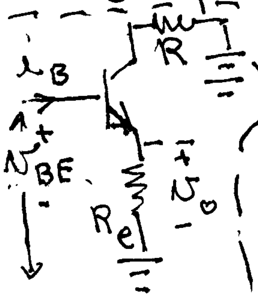
$$v_2 = \left(\frac{v_1+v_2}{2}\right) - \left(\frac{v_1-v_2}{2}\right)$$

Chapt 12 - FET's

12.1 - 12.5

12.7 CMOS Inverter NAND Gate NOR Gate

Chapt 13 - BJTs



Active Region, Cut-off, Saturation

Emitter Followers and Common Emitter

Amplifiers as examples of dependent sources

Small signal - base-emitter a pn junction

$$i_b = (r_b)^{-1} v_{be} \qquad r_b = V_T / I_{BQ}$$

$v_o \approx v_{BE}$ Emitter Follower

Since $i_C = \beta i_B$ $\quad \Delta i_C = i_c = \beta \Delta i_b = \beta i_b$

so $i_c = (\beta / r_b) v_{be}$ - voltage controlled current source

Chapt 14

Neglect 14.5 - 14.7, 14.10 (Active Filters)
except for problem Set 5 - RC filter

Appendix A - complex numbers

For Final General Comments

a) Review Problem Sets

b) Review Midterms

c) Final Covers the full course

d) One or two problems will be modified
Midterm 1 or 2 problems

e) There will be six problems

General Areas Thus:

Chapt 1 KVL KCL, power
Chapt 2 Resistive circuits Thevenin & Norton
Chapt 3, 4 L, C, RC & RL transients
Chapt 5 "Phasors" + steady state - (complex numbers)
(rcp)
Chapt 6 From point of view of lg - lg plot and phasors (sinusoidal analysis) [If Bode plot asked for it would be couched in terms of logs - Review LTSpice RC frequency behavior problem - problem set 3]
Chapt 7 logic design
Chapt 10 Diode - Ideal Piecewise linear. Zener diode discussion - good review of load line. Page 5 of these notes for <u>Rectifier problem</u> with capacitor
Chapt 11 Amplifiers
Chapt 12 FET CMOS Inverter
Chapt 13 BJT's