Intro to Elctronics S 2024 Crib Sheet Exam 1 Hayden Fuller

Basic:

Voltage divider: $V_2 = \frac{R_2}{R_1+R_2}$ Current divider: $I_2 = I\frac{G_2}{G_1+G_2}$

Capacitor: $Z_C = \frac{1}{jwC}$, $I = C\frac{dV}{dt}$, $E = \frac{1}{2}CV^2$ Inductor: $Z_L = jwC$, $V = C\frac{dI}{dt}$, $E = \frac{1}{2}LI^2$

LCR: resonance: $w = \frac{1}{\sqrt{LC}}$

Superposition: Short voltage, open current, analyze the thing, add.

Voltage to current: $I_{IS} = V_{VS}$, $R_{CS} = \frac{1}{RVS}$

OP AMP: Inverting Amp: $A = \frac{V_{out}}{V_{in}} = -\frac{R_F}{R_in}$

Summing Inverting Amp: $V_{out} = -R_F(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3})$

Subtraction: Inverting amp with voltage divider on plus: $V_{out} = V_{plus}\frac{R_G}{R_{in,plus}+R_G} \cdot \frac{R_{in,minus}+R_F}{R_{in,minus}} - V_{minux}\frac{R_F}{R_{in,minus}}$

H response: $H(w) = \frac{V_{out}}{V_{in}}$

Integrator: R_F is a capacitor, $V_{out} = -\frac{1}{R_{in}C}\int_0^t V_{in}dt$

Detailed amplification: op amp

diff: $V_{out} = A_{diff}(V_+ - V_-)$

CM: $V_{out} = A_{CM}(V_+ + V_-)$

total amplification: $V_{out} = A_{diff}(V_+ - V_-) + A_{CM}(V_+ + V_-)$

CMRR: common mode rejection ratio: $\frac{A_{diff}}{A_{CM}}$, $20\log(CMRR)dB$

Gain Bandwidth Product: Gain $\cdot$ Bandwidth, $A \cdot f$

Constant gain at low frequency, decreases linearly because slew rate at high frequency

knee frequency: $w = \frac{1}{RC} = \frac{1}{T} = \frac{1}{2\pi RC}$, $=>$ $H(w) = \frac{1}{\sqrt{2}}$, $-3dB$

above knee frequncy: $H(w) = \frac{1}{wRC}$, $-20dB$ per decade

high pass: $H(w) = wRC$, $20dB$ per decade, slope multiplied by N stages.

Slew rate: $= dV_{out}/dt$

ex: $SR = 1V/us$, pulse $0 - 2V$, $T = 2us$, 1V triangle wave

good sine wave: $SR >= 2\pi f V_0$

DIODES: forward bias, apply +V to holes, push holes(p) and electrons(n) together, get conduction

IV: $I = I_0(e^{\frac{V}{V_t}} - 1)$

Thermal voltage: $V_t = \frac{kT}{e} = 26mV$

Threashold voltage: $V_{th} = 0.7V$

Reverse saturation current: I_0 around 10^{-10}

For $V >> V_t$, $I = I_0 e^{\frac{V}{V_t}}$

Differential resistance: $r_D = \frac{V_t}{I}$ (I from above equation)

Basic DR circuit: $V_B = IR + V_D$, $I = I_D = I_0 e^{\frac{V}{V_t}}$

Graphically solve: $V_B = I_0 e^{\frac{V}{V_t}} R + V_D$, $V_B - V_D = I_0 e^{\frac{V}{V_t}}$

Approximate analytic solution: $V_D = V_{th} = 0.7V$, $I = \frac{V_B - 0.7}{R}$

Linearization: $r_D = \frac{V_t}{I_D}$, can treat as this resistor for an AC signal, just account for DC offset with superposition. find I with DC (probably $\frac{V-0.7}{R}$), and $r_D = \frac{.026}{I}$, then add AC signal with r_D

Rectification: $P = V_{th}I$ AM: through diode and R and past C to filter out frequency, left with audio.Also LED and solar cell.

ZENER DIODE: width of depletion region changed with doping

Breakdown: at $V = V_{breakdown} = V_Z$

IV: turn on at $V_{th} = 0.7$, reverse turn on at $-V_Z$, typically used backwards, so flip V, expect + |< − $V < V_Z$ $=>$ $r_Z = \frac{dV}{dI} = \infty$ OR $V >= V_Z$, $r_Z = \frac{dV}{dI} = 0$

$I = I_0 e^{\frac{V - V_Z}{V_t}}$

Basic ZDR circuit:

Graphical: $V_{Bat} - IR = V_Z(I)$

Approx analytical assume V_Z =constant, $I = \frac{V_B - V_Z}{R}$

Voltage stabalization: $V_{out} = V_Z =$ constant, wastes power, must have significant R_Load

Voltage clipper: two parallel to load, facing away, V clipped at $V_Z + V_{th}$

Voltage shifter: one series, cuts V_Z off of input