ASSIGNMENT-4

BASICS OF ELECTRONICS ENGINEERING

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SECTION : C-72
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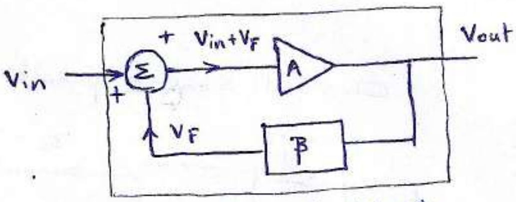
Q1. Derive expression of closed loop gain of a negative feedback amplifier.



negative feedback amplifier

Let A : open loop gain of Amplifier
β : feedback ratio provided by feedback circuit

$V_{out} = A(V_{in} + V_F)$

$= AV_{in} + AV_F$

$(V_F = \beta V_{out})$

$V_{out} = AV_{in} + A\beta V_{out}$

$V_{out} = \frac{A}{1-A\beta} V_{in}$

$\frac{A_{out}}{V_{in}} = \frac{A}{1-A\beta} = A' =$ close loop gain for positive feedback

for negative feed back, $A\beta \sim -A\beta$.

$$\therefore \boxed{A' = \frac{A}{1+A\beta}}$$

Q2 Prove that the change in closed loop gain is less than change in open loop gain in a negative feedback amplifier.

The principal advantage of feedback systems compared with open loop systems is that feedback provides method for reducing the sensitivity of the system to changes in the gain of certain element.
The equation for negative feedback shows that it lowers the magnitude of gain of an amplifier since β is increased from zero the magnitude of close loop gain decreases if A_{OL} & β have the same sign.

$$A_{CL} = \frac{A_{OL}}{1+\beta A_{OL}}$$ for -ive feedback amplifies

Taking ~~differential~~ fractional change on both sides.

$$\frac{dA_{CL}}{A_{CL}} = \frac{dA_{OL}}{A_{OL}}\left[\frac{1}{1+\beta A_{OL}}\right]$$

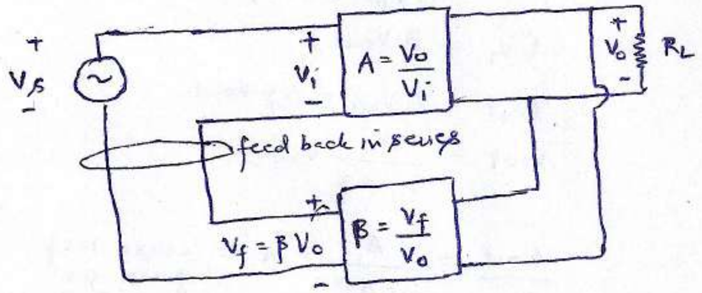
since $|\beta A_{OL}| > 1$.

$$\frac{dA_{CL}}{A_{CL}} < \frac{dA_{OL}}{A_{OL}}$$

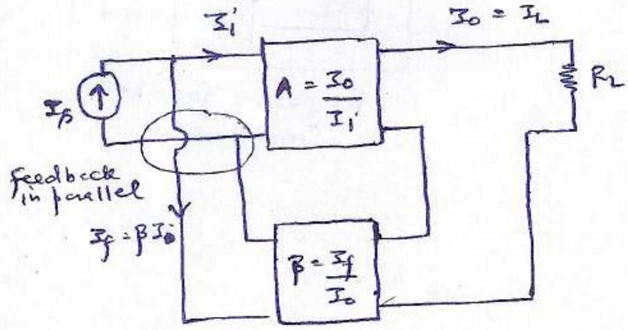
∴ change in closed loop gain is less than open loop gain for -ive feedback amplifier.

Q3. Explain the following circuits
(a) Voltage series.
(b) Current shunt.

Voltage series feedback



Current shunt feedback



Voltage here refers to connecting output voltage as input to the feedback network.

~~Series refers to tapping off~~
Series refers to connecting the feedback signal in series with the input signal voltage.

Series feedback connections tend to increase input resistance

Voltage feedback tends to decrease the output impedance

used in cascade amplifiers where high input impedance is required to not load source and lower output impedance is required to lower voltage drop wastage.

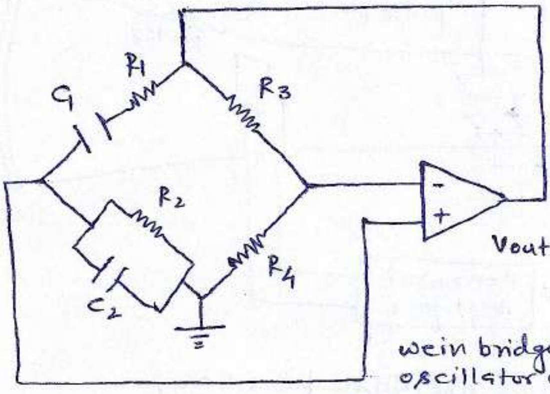
Current refers to tapping off some output current through the feedback network

Shunt refers to connecting the feedback signal in shunt (parallel) with an input current source.

Shunt feedback connections tend to decrease input res.

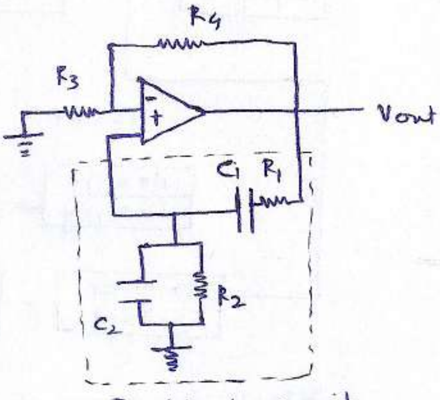
Current feedback tends to increase output impedance.

Q4. Derive the expression of frequency of oscillation of wien bridge oscillator.

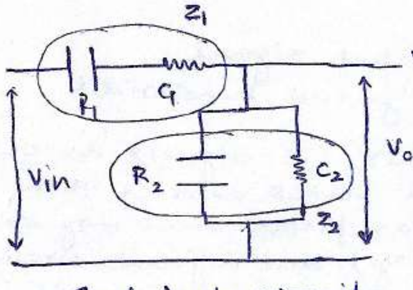


wein bridge oscillator ckt.

Redraw →



Feedback circuit



feed back circuit

$$\frac{V_o}{V_{in}} = \frac{Z_2}{Z_1 + Z_2} \quad \text{(voltage divider)}$$

$$Z_2 = R_2 \parallel \left(\frac{1}{j\omega C_2}\right) = \frac{R_2}{1 + j\omega R_2 C_2}$$

$$Z_1 = R_1 + \frac{1}{j\omega C_1}$$

$$\frac{V_o}{V_{in}} = \frac{R_2}{1 + j\omega R_2 C_2} \Big/ R_1 + \frac{1}{j\omega C_1} + \frac{R_2}{1 + j\omega C_2 R_2}$$

$$\frac{V_{out}}{V_{in}} = \frac{R_2 (j\omega C_1)}{R_1 (j\omega C_1)(1 + j\omega C_2 R_2) + 1 + j\omega C_2 R_2 + j\omega R_2 C_1}$$

$$= \frac{j\omega R_2 C_1}{1 - \omega^2 R_1 R_2 C_1 C_2 + j\omega (R_1 C_1 + R_2 C_2 + R_2 C_1)}$$

Since by barkhausen criteria net phase shift is zero,

$$1 - \omega^2 R_1 R_2 C_1 C_2 = 0$$

$$\omega^2 R_1 R_2 C_1 C_2 = 1$$

$$\omega = 1 / \sqrt{R_1 R_2 C_1 C_2}$$

$$f = 1 / 2\pi \sqrt{R_1 R_2 C_1 C_2}.$$

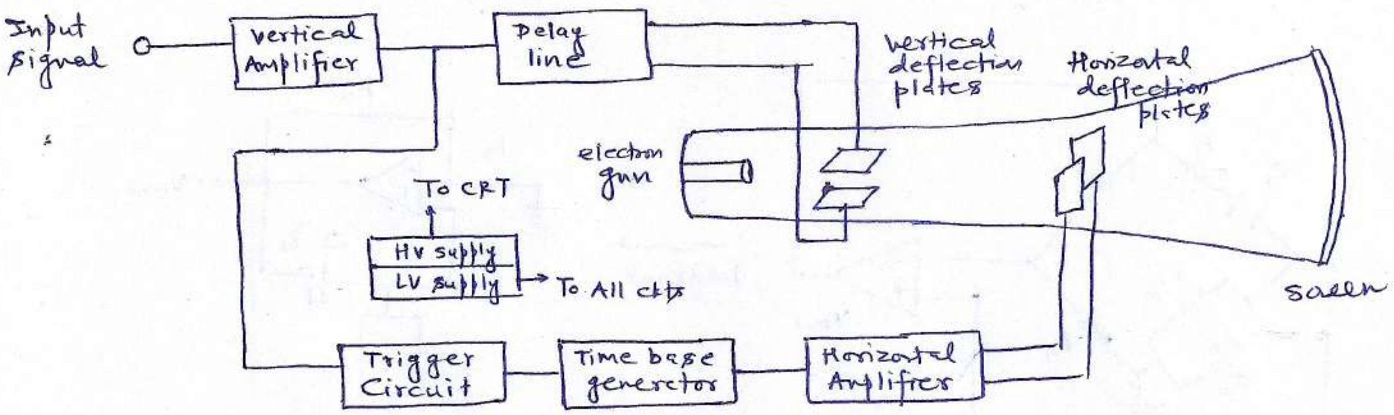
if $R_1 = R_2 = R$; $C_1 = C_2 = C$

$$f = 1 / 2\pi \sqrt{R^2 C^2}$$

$$\boxed{f = 1 / 2\pi RC}$$

↙ frequency of oscillation of wien bridge oscillator

Q5 Explain the block diagram of CRO



Block diagram of a Cathode ray oscilloscope (CRO)

Vertical Amplifier : Amplifies weak input signal
Decides sensitivity and bandwidth

Delay Line : Small delays occur (ie signals reach vertical deflection plates earlier than horizontal deflection plates which may cause distortion in display) due different circuit paths for vertical & horizontal signals.
Delay line adds delay to early vertical signals. to synchronise both signals.

Trigger Circuit : Generate trigger pulses & synchronises input signal and horizontal deflections.

Timebase Generator : Generates sawtooth waveforms.

- Applied to horizontal defletion plates so that electron beam varies at constant speed.
- x-axis of CRO can be caliberated in terms of time & input. Input is displayed wrt time.

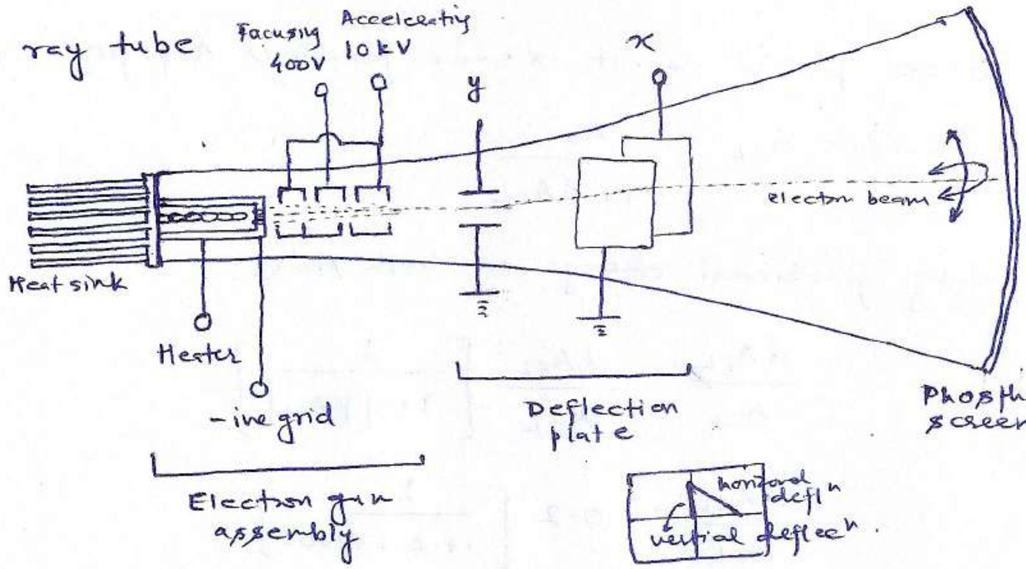
Horizontal Amplifier : To amplify strength of sawtooth signal to sufficient levels to cause required deflection

Power supply : Generates two levels of DC supply voltage

Low voltage
used to power electronic circuitry

High voltage (1000 - 1500 V)
used to create electron beam and accelerate and focus it.

Cathode ray tube



Heater : Heats cathode to emit electrons by thermionic emission.

controle Grid : Repels -ive charge, generates a narrow beam. By controlling the -ive voltage applied to control grid, we can control intensity of beam

Accelerating Anodes : Increase velocity of e⁻ beam

Focusing Anodes : concentrates e⁻ beam in one direction
The focus and speed of e⁻ beam can be controlled by varying voltage.

screen : - electrons strike the screen with very high speed
- Inner side of screen is coated in phosphor which converts electrical energy into light energy.
- Generates bright spots on e⁻ strike and the beam moves so fast that it appears like a waveform on screen.

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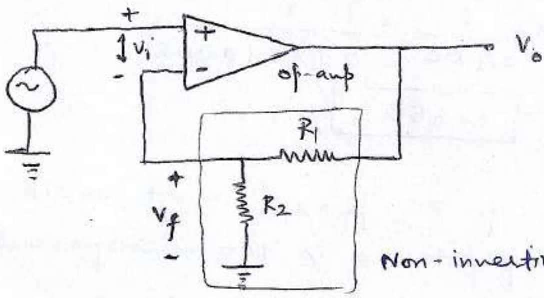
Part 1 end.

Q1. Calculate the feedback amplifier gain of the circuit for op-amp with $A = 10^6$, $R_1 = 200\Omega$, $R_2 = 1.8\,k\Omega$.



Non-inverting -ive feedback amplifier.

feedback fraction $\beta = \dfrac{R_2}{R_1 + R_2}$ $\left[\text{ie } \beta = \dfrac{V_f}{V_o} = \dfrac{R_2 V_o}{(R_1 + R_2) V_o}\right.$ voltage divider$\left.\right]$

-ive feedback amplifier gain $A' = \dfrac{A}{1 + A\beta}$

$$= \frac{10^6}{1 + 10^6 \times \frac{1800}{1800+200}} = \frac{10^6}{1 + 10^6 \times \frac{18}{20}}.$$

$$\approx \frac{10^6}{9 \times 10^5} = \boxed{1.11}$$

Q2 voltage gain with feedback is 60dB and voltage gain without feedback is 80dB. Calculate value of feedback factor

$$a_{CL} = 20\log_{10} A_{CL}$$

$$60/20 = \log_{10} A_{CL}$$

$$A_{CL} = 10^3 = 1000$$

$$a_{OL} = 20\log_{10} A_{OL}.$$

$$80/20 = \log_{10} A_{OL}.$$

$$A_{OL}' = 10^4 = 10000$$

$$A_{CL} = \frac{A_{OL}}{1 + \beta A_{OL}}$$

$$1 + \beta A_{OL} = \frac{A_{OL}}{A_{CL}} = \frac{10^4}{10^3} = 10$$

form factor $\boxed{\beta A_{OL} = 9}$

Q3. Determine frequency of oscillation of wien bridge oscillor if $R = 6\Omega$ and $C = 0.003F$

frequency of oscillation of wien bridge is given by.

$$f = \frac{1}{2\pi RC} = \frac{1}{2\pi \times 6 \times 0.003}$$

$$\approx \boxed{8.85\ hz}$$

Q4. Find frequency of RC phase shift oscillator if resistence is 13Ω and capacitence is 100 microfarad.

frequency of oscillation of RC phase shift oscillator

$$f = \frac{1}{2\pi RC\sqrt{6}} = \frac{1}{2\pi \times 13 \times 100 \times 10^{-6}\sqrt{6}}$$

$$= \frac{1}{2\pi \times 13 \times 10^{-4}\sqrt{6}} \approx \boxed{50.006\ Hz}$$

Q5. If an amplifier with gain $A = 1000$ and feedback of $\beta = -0.1$ has a gain change of 20% due to temperature, calculate the change in gain of feedback amplifier.

$$A' = \frac{A}{1+A\beta}$$

$$A'_{initial} = \frac{1000}{1 - 1000[-0.1]}$$

$$= \frac{1000}{101}$$

A_{final}

$$A' = \frac{A}{1 - A\beta} \rightsquigarrow \frac{1}{A'} = \frac{1 - A\beta}{A}$$

$$\therefore A'^{-1} = A^{-1} - \beta \text{ const}$$

$$-\frac{\Delta A'}{A'} = -\frac{\Delta A}{A}$$

$$-\frac{\Delta A'}{A'} = -\frac{0.2A}{A} \rightsquigarrow \frac{\Delta A'}{A'} = .20$$

$$\rightsquigarrow \Delta A' = 0.2A'$$

$$\therefore \%\text{ change in } A' = \frac{\Delta A'}{A} \times 100 = \boxed{20\%}$$

(8)

A-5 since $\beta < 0$ ⇝ it is -ive feedback Amplifier

$$\therefore \quad A_{CL} = \frac{A_{OL}}{1 + \beta A_{OL}}$$

Taking fractional change on both sides.

$$\frac{dA_{CL}}{A_{CL}} = \frac{dA_{OL}}{A_{OL}} \left[\frac{1}{1 + |\beta A_{OL}|} \right]$$

$$\frac{dA_{CL}}{A_{CL}} = 0.2 \left[\frac{1}{1 + 0.1 \times 1000} \right]$$

percentage change.

$$\frac{dA_{CL}}{A_{CL}} = \frac{0.2}{101} \times 100 = \boxed{1.98\%}$$

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