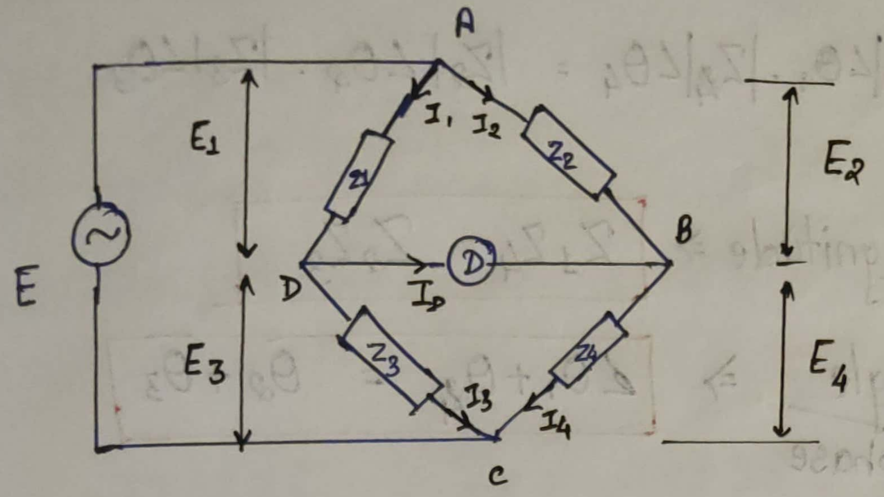
A.C. Bridges

08/oct/24



Detector (D) ⇒

- ↳ Head phones : 100 Hz - 4KHz
- ↳ Vibrational Galvonometers : 10Hz - 1KHz ⟶ for Low frequency (f ≤
- ↳ Tunable ckt : 100Hz - 10KHz
- ↳ CRO : High frequency

→ Bridge Balanced ⟶

(i) $I_D = 0$

(ii) $V_B = V_D$

(iii) $E_1 = E_2$ & $E_3 = E_4$

$$E_1 = E_2$$

$$Z_1 I_1 = Z_2 I_2$$

$$Z_1 \frac{E}{Z_1 + Z_3} = Z_2 \frac{E}{Z_2 + Z_4}$$

$$\cancel{Z_1 Z_2} + Z_1 Z_4 = \cancel{Z_1 Z_2} + Z_2 Z_3$$

$$\boxed{Z_1 Z_4 = Z_2 Z_3}$$

↳ for bridge to be balanced

$Z = A + iB$

$Z = M\angle\theta$

$= Me^{j\theta}$

$Z_1Z_4 = Z_2Z_3$

$|Z_1|\angle\theta_1 . |Z_4|\angle\theta_4 = |Z_2|\angle\theta_2 . |Z_3|\angle\theta_3$

Magnitude $\Rightarrow$ $\boxed{Z_1Z_4 = Z_2Z_3}$

Angle / phase $\Rightarrow$ $\boxed{\angle\theta_1 + \theta_4 = \theta_2 + \theta_3}$

eg $\Rightarrow$ $Z_1 = 400\angle 50°$, $Z_3 = 800\angle -50°$

$Z_2 = 200\angle 40°$, $Z_4 = 400\angle 20°$

$\Rightarrow$

$Z_1Z_4 = 160000$ $\qquad$ $\theta_1 + \theta_4 = 70°$

$Z_2Z_3 = 160000$ $\qquad$ $\theta_2 + \theta_3 = -10°$

$\theta_1 + \theta_4 \neq \theta_2 + \theta_3$

Bridge is $\hookrightarrow$ imbalance

eg) An A.C. bridge ckt working at 1000Hz as shown in fig arm AB is 0.2 µF (Pure Capacitance), arm BC = 500 Ω (Pure Resistance) arm CD contain Unknown impedance & arm DA = 300 Ω in parallel with 0.1 µF Capacitor. Find R & C ~~for~~/Rt constants of arm CD. Consider it is a series ckt.

(Bbalanced)

$\Rightarrow f = 1000 Hz$ $\omega = 2\pi f$ 08/oct/24

AB $\rightarrow$ $\cancel{Z_2}$ $C_2 = 0.2\ uF$ $\Rightarrow$ $Z_2 = \frac{1}{j\omega C} = -7957.7j$

BC $\rightarrow$ $Z_4 = 500\Omega$

CD $\rightarrow$ Z_3

$\cancel{DA \rightarrow Z_1 = 300 \| 0.1\ uF = 300 \| \frac{1}{j\omega C}} = \cancel{300 \| -15915.5j}$

$Z_2 = -7957.7j$, $Z_1 = 299.95 \angle -1.079°$

$= 7957.7 \angle -90°$

$Z_1 Z_4 = Z_2 Z_3$

$149973 \angle -1.0798° = Z_3 \cdot \cancel{(-7957.7} (7957.7 \angle -90°)$

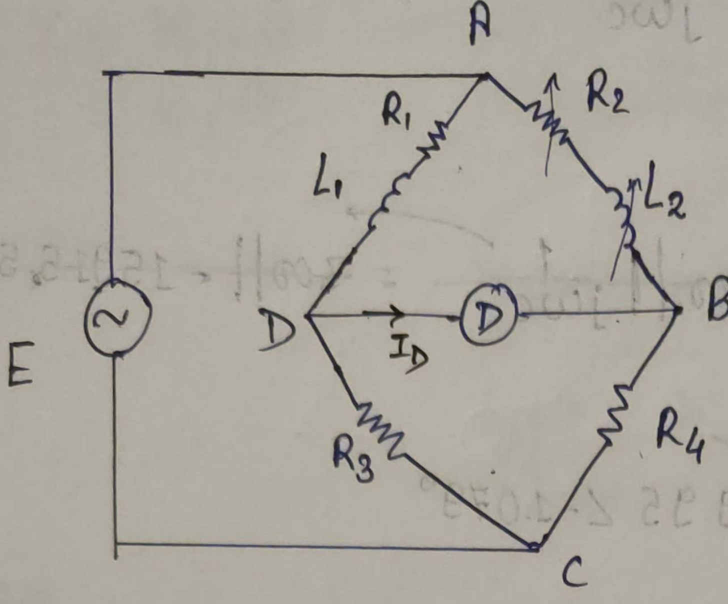
$Z_3 = 18.846 \angle 88.92°$

$Z_2 = -795.7j$, $Z_1 = 300 \| 0.1\ uF = 300 \| \frac{1}{j\omega C}$

$= 300 \| -1591.55j$

$Z_1 =$

Maxwell's Inductance Bridge :-



R_1 ; L_1 are Unknowns

$$Z_1 Z_4 = Z_3 Z_2$$

$$(R_1 + j\omega L_1) R_4 = R_3 (R_2 + j\omega L_2)$$

$$R_1 R_4 + j\omega R_4 L_1 = R_2 R_3 + j\omega R_3 L_2$$

Equating real & imaginary part

$$R_1 R_4 = R_2 R_3 \quad , \quad R_4 L_1 = R_3 L_2$$

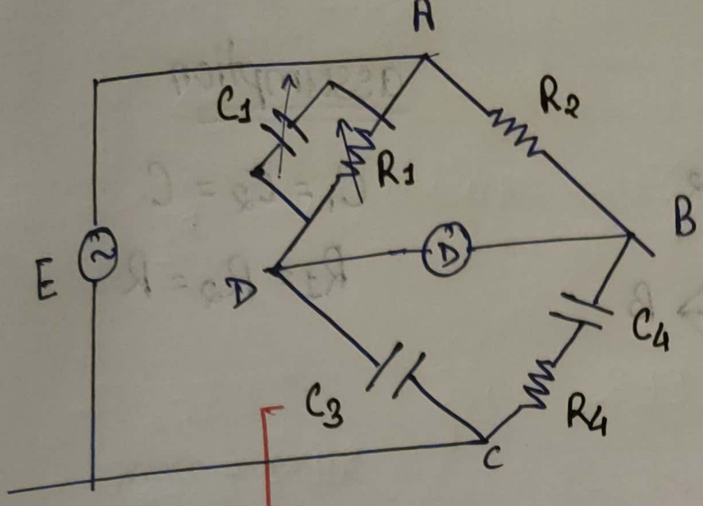
$$\boxed{R_1 = \frac{R_3}{R_4} \cdot R_2} \qquad \boxed{L_1 = \frac{R_3}{R_4} \cdot L_2}$$

#) Schering Bridge ⇒

08/oct/24

(capacitance Measuring)

R_4, C_4 are Unknowns



Standard Capacitor

$$Z_1 = \frac{R_1\left(\frac{1}{j\omega C_1}\right)}{R_1 + \frac{1}{j\omega C_1}}$$

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

→ opposite arm should have parallel & series combinatⁿ of R&C.

Balanced Bridge

$$Z_1 Z_4 = Z_2 Z_3$$

$$\frac{R_1}{1 + j\omega R_1 C_1} \cdot \left(R_4 + \frac{1}{j\omega C_4}\right) = R_2\left(\frac{1}{j\omega C_3}\right)$$

$$R_1 R_4 + \frac{R_1}{j\omega C_4} = \frac{R_2 (1 + j\omega R_1 C_1)}{j\omega C_3}$$

Real

$$\cancel{R_1} R_4 = \frac{\cancel{R_1} R_2 C_1}{C_3}$$

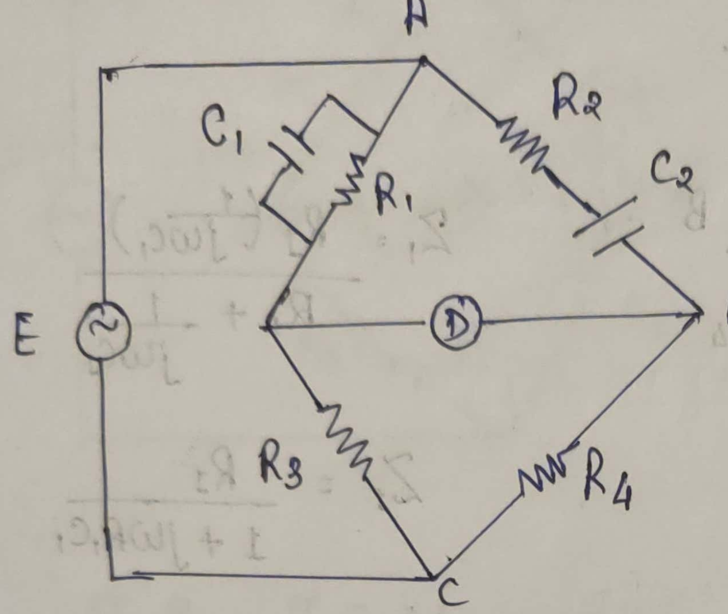
$$\boxed{R_4 = \frac{C_1}{C_3} \cdot R_2}$$

imag

$$\frac{R_1}{\cancel{j\omega} C_4} = \frac{R_2}{\cancel{j\omega} C_3}$$

$$\boxed{C_4 = \frac{R_1}{R_2} \cdot C_3}$$

Measurement of freq. Using Wein's Bridge ⇒



assumption

$C_1 = C_2 = C$

$R_1 = R_2 = R$

↳ Adjacent arm series & parallel combinatn of R & C

Balanced Bridge

$$Z_1 Z_4 = Z_2 Z_3$$

$$\frac{R_1}{1+j\omega R_1 C_1} \cdot R_4 = \left(R_2 + \frac{1}{j\omega C_2}\right) R_3$$

$$\frac{R R_4}{1+j\omega RC} = R R_3 + \frac{R_3}{j\omega C}$$

$$R R_4 = R R_3 + j\omega R^2 R_3 C + \frac{R_3}{j\omega CR} + \frac{R R_3}{R}$$

Real

$$R R_4 = R R_3 + \frac{R_3}{R}$$

$$R R_4 = 2 R R_3$$

$$R_4 = 2 R_3$$

imag $j\omega \cancel{R}^2 \cancel{R_3} C - j\frac{\cancel{R_3}}{\omega RC} = 0$

$$\omega R^2 C = \frac{1}{\omega RC}$$

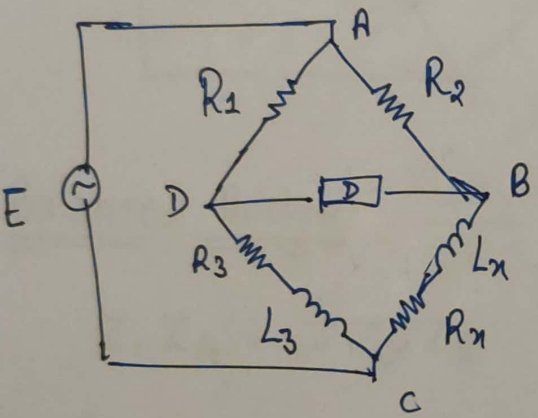
$$\omega^2 R^3 C^2 = 1$$

→ emf = current x resistance

→ mmf = flux x reluctance $= \phi . R$

$\phi = \frac{ni}{R}$ $\qquad R = \frac{l}{\mu A}$ $\qquad \mu = \mu_r \mu_0$

#) Maxwell Inductance Bridge ⇒



$Z_1 Z_4 = Z_2 Z_3$

$\cancel{E}_{AD} = \cancel{E}_{AB}$

$$\frac{R_1}{R_3 + j\omega L_3} = \frac{R_2}{R_x + j\omega L_x}$$

$$R_1 [R_x + j\omega L_x] = R_2 [R_3 + j\omega L_3]$$

Equating

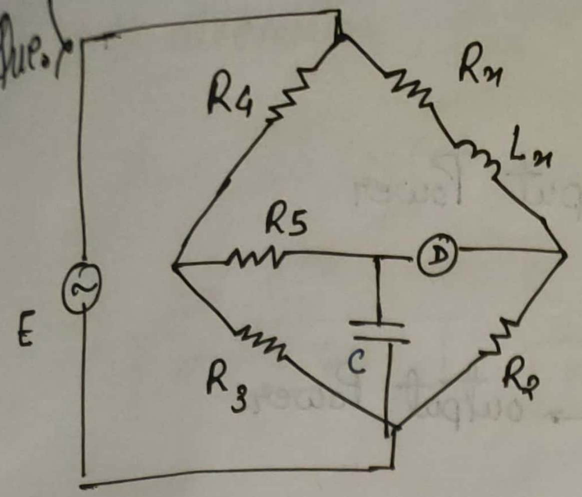
Real Part ⟶ $R_1 R_x = R_2 R_3$

$$\boxed{R_x = \frac{R_2 R_3}{R_1}}$$

Imag Part ⟶ $j\omega R_1 L_x = j\omega R_2 L_3$

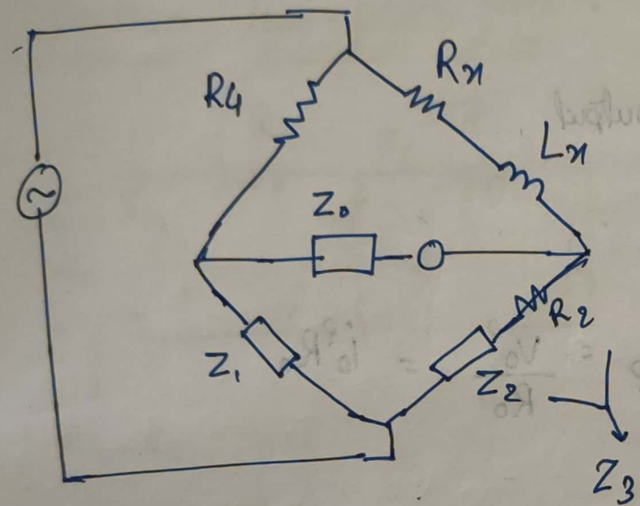
$$\boxed{L_x = \frac{R_2}{R_1} L_3}$$

Que.)



R_x, L_x ?

⇒



$$Z_0 = \frac{R_5 X_C}{R_5 + R_3 + X_C}$$

$$Z_1 = \frac{R_3 R_5}{R_3 + R_5 + X_C}$$

$$Z_2 = \frac{R_3 X_C}{R_3 + R_5 + X_C}$$

$$Z_3 R_4 = (R_x + L_x) Z_1$$

$$\left(R_2 + \frac{R_3 X_C}{R_3 + R_5 + X_C}\right) R_4 = (R_x + L_x) \frac{R_3 R_5}{R_3 + R_5 + X_C}$$

$$X_C = \frac{1}{j\omega C}$$

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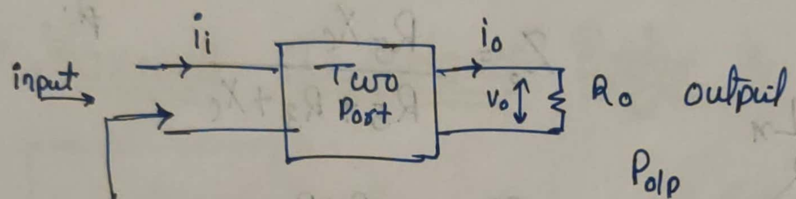
Attenuator ⇒

$$\text{Attenuation} = 10 \log \left(\frac{P_{i/p}}{P_{o/p}} \right)$$

$P_{i/p} \rightarrow$ input Power

$P_{o/p} \rightarrow$ output Power

Matched



$P_{o/p}$

$R_i = R_o \rightarrow$ for matched

$$P_{I/P} = \frac{V_{in}^2}{R_o} = i_i^2 R_o \quad , \quad P_{o/p} = \frac{V_o^2}{R_o} = i_o^2 R_o$$

$$\frac{P_i}{P_o} = \left(\frac{V_{in}}{V_o} \right)^2 = \left(\frac{i_i}{i_o} \right)^2$$

- $$\text{Attenuation} = 10 \log_{10} \left(\frac{V_{in}^2}{V_{o/p}^2} \right) = 10 \log \left(\frac{i_i^2}{i_o^2} \right)$$

$$= 20 \log \left(\frac{V_{in}}{V_{op}} \right) = 20 \log \left(\frac{i_i}{i_o} \right)$$

$$\boxed{K = \frac{V_{in}}{V_{op}} = \frac{i_{in}}{i_{op}}}$$

Eg) 10dB attenuator, find K ?

⇒

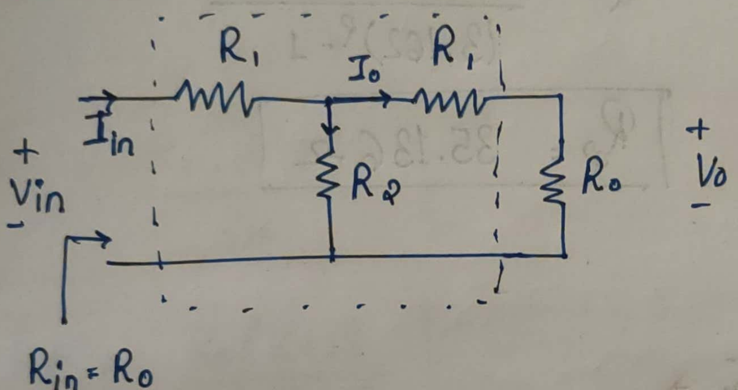
$$10 = 20 \log_{10}(K)$$

$\cancel{K = e^{1/2}}$ $K = 10^{1/2}$

$\boxed{\cancel{K = 1.64}}$ $\boxed{K = 3.162}$

i) T-Section Two-port N/K :-

$\boxed{R_0 = 50\Omega}$



find R_1 & R_2 in terms of K & R_0.

(i) $(I_{in} - I_0) R_2 = I_0 (R_1 + R_0)$

$$I_{in} R_2 = I_0 (R_1 + R_2 + R_0)$$

$$\frac{I_{in}}{I_0} = K = \frac{R_1 + R_2 + R_0}{R_2} \quad \text{--- (1)}$$

(ii) $R_{in} = R_1 + R_2 \| (R_1 + R_0)$

↳ $R_0 = R_1 + \dfrac{R_2(R_1 + R_0)}{R_1 + R_2 + R_0}$ ⇒ $R_0 = R_1 + \dfrac{R_1 + R_0}{K}$

$$\left(1 - \frac{1}{K}\right) R_0 = \left(1 + \frac{1}{K}\right) R_1$$

$\boxed{R_2 = \dfrac{2KR_0}{K^2 - 1}}$ ✓ ⇐ $\boxed{R_1 = \left(\dfrac{K-1}{K+1}\right) R_0}$ ✓

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Q.) For a 10dB loss attenuator T-network find R_1, R_2.

$\Rightarrow$ $R_0 = 50\,\Omega$

$$10 = 20 \log_{10}(K)$$

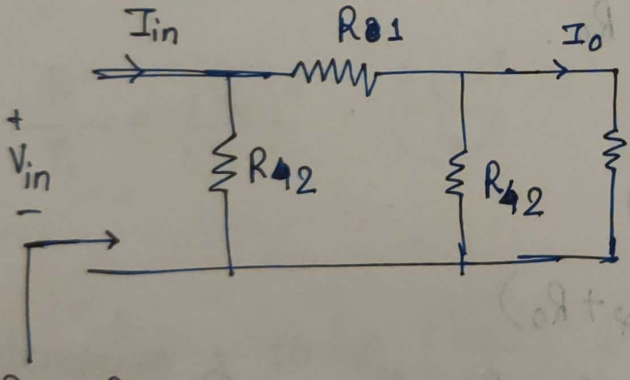
$$K = 10^{1/2} \Rightarrow \boxed{K = 3.162}$$

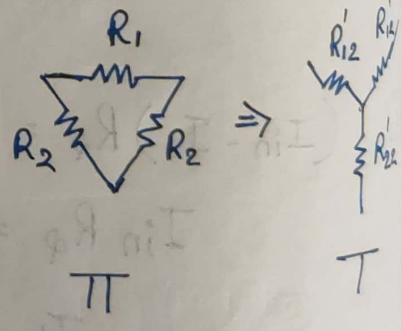
$$R_1 = \left(\frac{K-1}{K+1}\right) R_0 \qquad R_2 = \frac{2KR_0}{K^2-1}$$

$$R_1 = \frac{2.162}{4.162} \times 50 \qquad R_2 = \frac{2 \times 3.162 \times 50}{(3.162)^2 - 1}$$

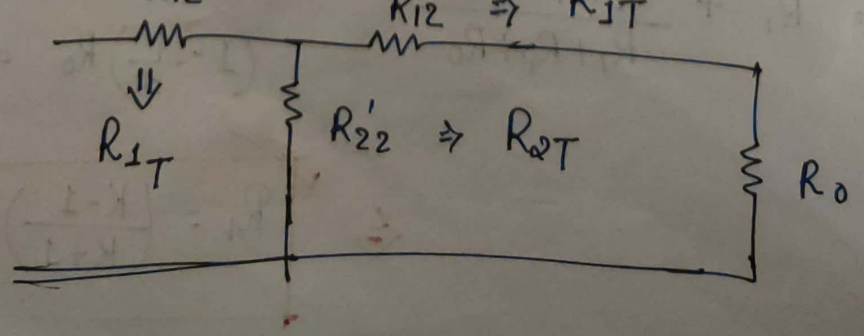
$$\boxed{R_1 = 25.974\,\Omega} \qquad \boxed{R_2 = 35.136\,\Omega}$$

$\Rightarrow$ π - Section Attenuator $\Rightarrow$





$$R_{12}' = \frac{R_1 R_2}{R_1 + 2R_2} \quad , \quad R_{22}' = \frac{R_2^2}{R_1 + 2R_2}$$



$$R'_{12} = \left(\frac{K-1}{K+1}\right) R_0$$

$$R'_{22} = \frac{2KR_0}{K^2-1}$$

$$\frac{R_1 R_2}{R_1 + 2R_2} = \left(\frac{K-1}{K+1}\right) R_0$$

$$\frac{R_2^2}{R_1 + 2R_2} = \frac{2KR_0}{K^2-1}$$

$$\frac{R_1}{R_2} = \left(\frac{K-1}{K+1}\right) \times \frac{(K^2-1)}{2K} \Rightarrow \frac{R_1}{R_2} = \frac{(K-1)^2}{2K}$$

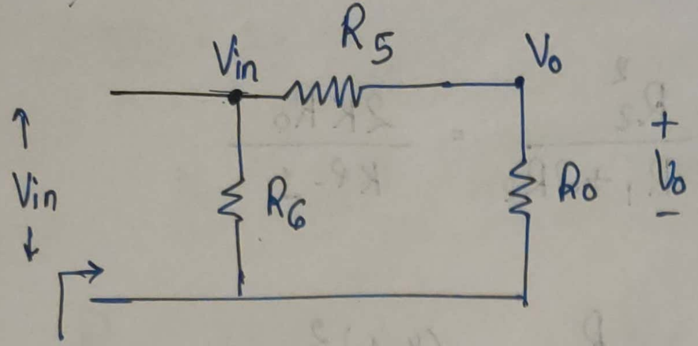
$$\frac{R_1}{\frac{R_1}{R_2} + 2} = \left(\frac{K-1}{K+1}\right) R_0$$

$$\boxed{R_1 = \frac{R_0(K^2-1)}{2K}}$$

$$R_1 = \left(\frac{(K-1)^2}{2K} + 2\right)\left(\frac{K-1}{K+1}\right) R_0$$

$$\boxed{R_2 = \frac{R_0(K+1)}{(K-1)}}$$

L - section Attenuator →



$R_{in} = R_o$.

$$R_{in} = R_6 \parallel (R_5 + R_o)$$

$$R_o = \frac{R_6(R_5 + R_o)}{R_5 + R_6 + R_o}$$

$$(R_5 + R_6) R_o + R_o^2 = R_6 R_5 + R_6 R_o$$

$$R_o R_5 + \cancel{R_o R_6} + R_o^2 = R_6 R_5 + \cancel{R_6 R_o}$$

$$\cancel{R_5 = R_o R_6 + R_o^2 - R_6 R_o}$$

$$\boxed{R_5 = \frac{R_o^2}{R_6 - R_o}}$$

Nodal Analysis

$$\frac{V_o - V_{in}}{R_5} + \frac{V_o}{R_o} = 0$$

$$V_o \left(\frac{1}{R_5} + \frac{1}{R_o} \right) = \frac{V_{in}}{R_5}$$

$$1 + \frac{R_5}{R_o} = K$$

$$\boxed{R_5 = (K-1) R_o}$$

$$(R_6 - R_o)(K-1)\cancel{R_o} = R_o^{\cancel{2}}$$

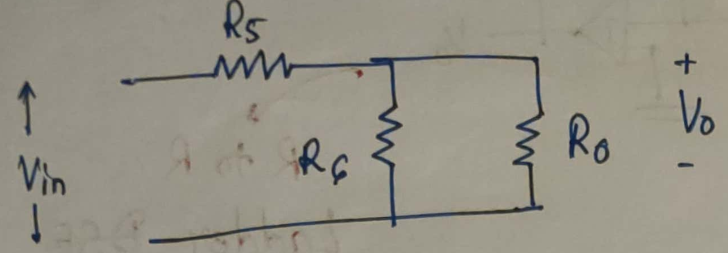
$$R_6 - R_o = \frac{R_o}{K-1}$$

$$R_6 = R_o + \frac{R_o}{K-1}$$

$$\boxed{R_6 = \frac{K R_o}{K-1}}$$

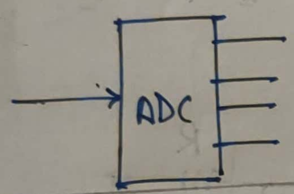
$\frac{a(1-r^n)}{1-r}$ $1-1/2$

#)



#) Analog to digital convertor →

2



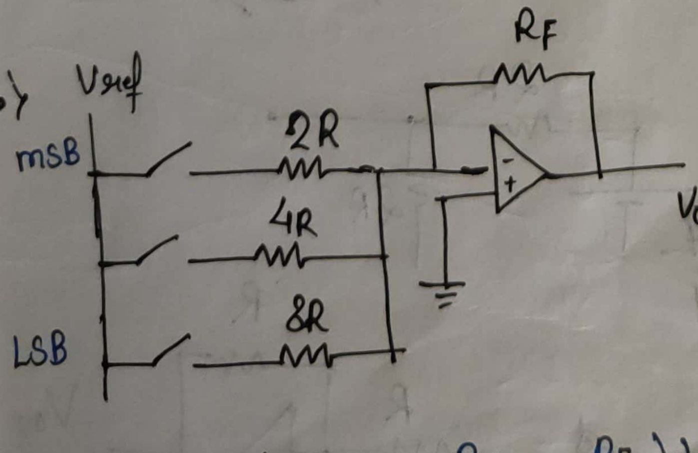
DAC $\quad V_0 = V_{ref}\left(b_1 2^{-1} + b_2 2^{-2} + b_3 2^{-3} + \dots + b_n 2^{-n}\right)$

4 bit → $V_0 = V_{ref}\left(\frac{1}{2}+\frac{1}{4}+\frac{1}{8}+\frac{1}{16}\right) = 0.94\, V_{ref}$

8 bit → $V_0 = \dfrac{\frac{1}{2}\left(1-\frac{1}{2^8}\right)}{\frac{1}{2}} = 1 - \frac{1}{2^8} = 0.996\, V_{ref}$

Digital to Analog

•)

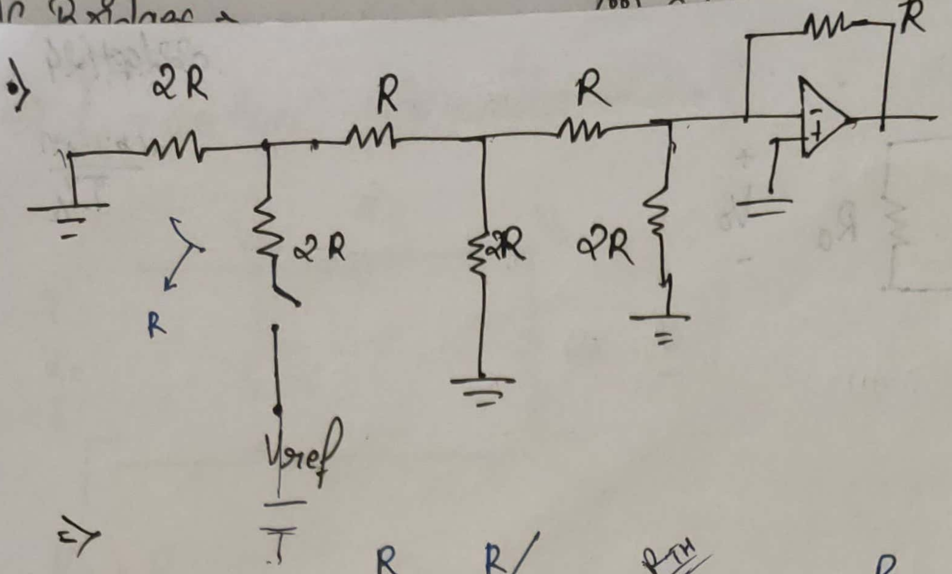


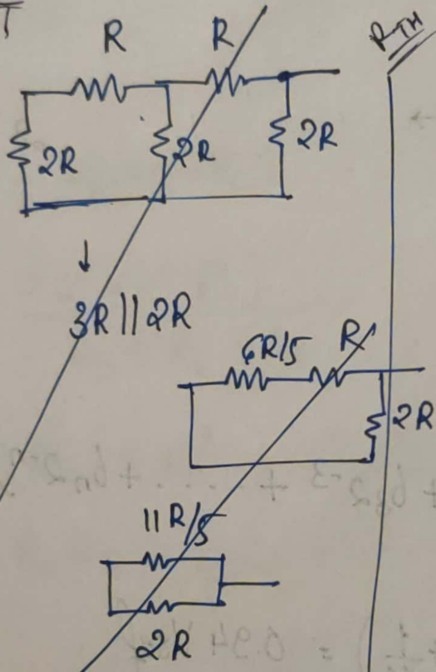
→ Binary weighted DAC

$V_0 = -\left(\frac{R_F}{2R} + \frac{R_F}{4R} + \frac{R_F}{8R}\right) V_{ref}$

Vo ?

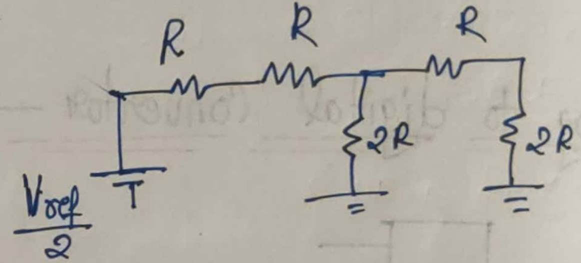
R to R Ladder ~~DSE~~ DAC

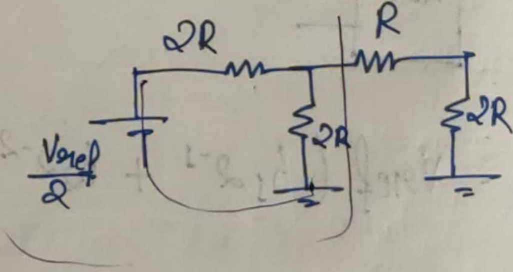


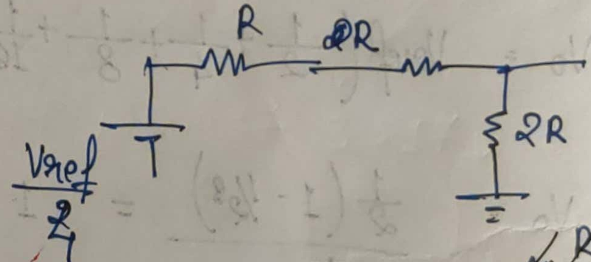


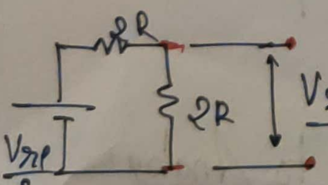
$\frac{6R}{5}$

$$\frac{\frac{11}{5} \times 2}{\frac{11}{5} + 2} = \frac{22}{21}$$



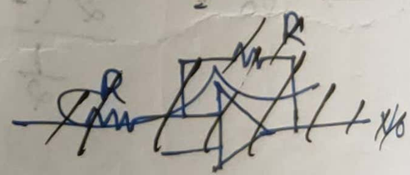


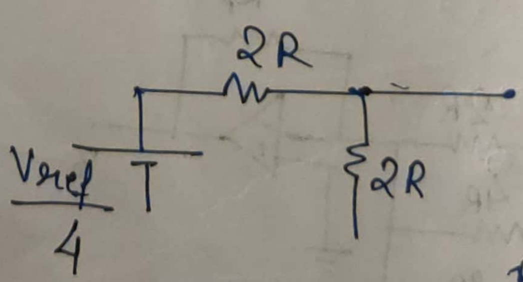


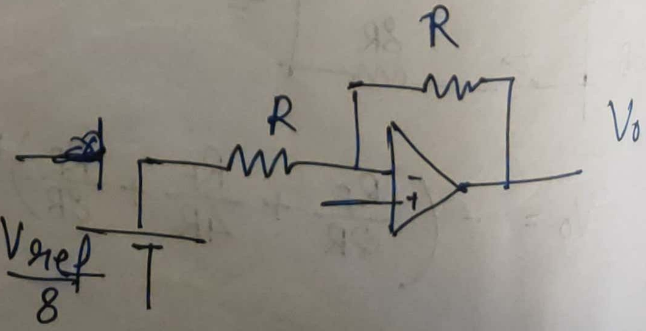


$\frac{V_{ref}}{8} = V_{TH}$

R_{TH}







$$V_0 = -\frac{V_{ref}}{8}$$

Ans

22/oct/24

Que) Find o/p Voltage ~~Voltage~~ for 1010, 0111 ↳ 8 bit

$V_{ref} = 5\,V$ ~~BS~~ ~~DSE~~ DAC

⇒

$$V_0 = -V_{ref}\left(\frac{1}{2} + 0 + \frac{1}{8} + 0\right)$$

$$= -5 \times \frac{5}{8}$$

=

$$\frac{1}{8} + \frac{1}{4} = \frac{3}{8}$$

$$V_0 = +V_{ref}\left(\frac{1}{2} + 0 + \frac{1}{8} + 0 + \frac{1}{2^6} + \frac{1}{2^7} + \frac{1}{2^8}\right)$$

~~$V_0 = +5\times$~~

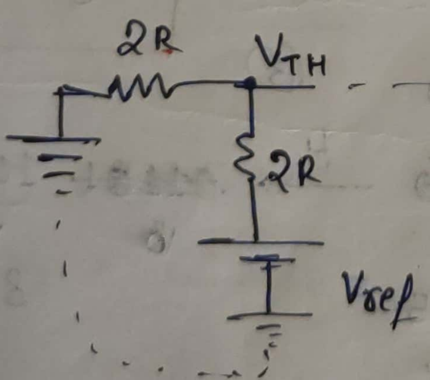
$$\boxed{V_0 = 3.26\,V}$$

Alternate → $V_0 = \frac{D}{2^n} V_{ref}$

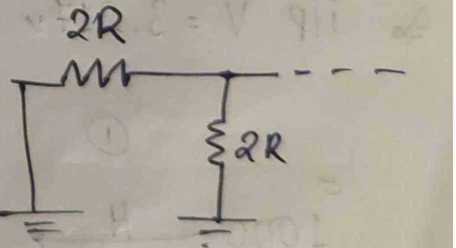
$D = $ ~~D of~~ Decimal of $(10100111)_2$

$D = 167$ $\boxed{n = 8}$ ↓ 8 bit

$$V_0 = \frac{167 \times 5}{2^8} = 3.26\,V$$

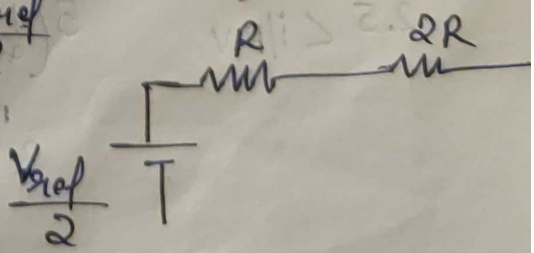


RTH →



$$V_{TH} = \frac{V_{ref}}{2}$$

⇓



$$V_0 = -\frac{R_f V_i}{R}$$

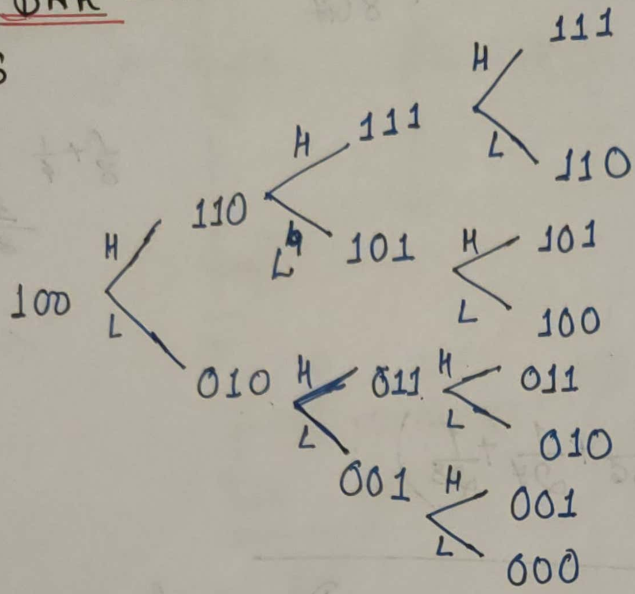
$LCS \rightarrow$ Logic Control Sequential

$SAR \longrightarrow$ Sucessive Approximation Resistor

ADC

i) SAR $\longrightarrow$

(S



Given i/p ~~100~~

if High ↓

_ _ _

~~make~~ add 1 to next MSB

if i/p is Low ↓

~~make MSB 0~~

~~& next MSB 1~~. Low

make 1st (1) (High) from ~~left~~ right 0 & next bit 1.

Que. 1)

SAR of 4 bit Vref = 5V, i/p is ~~3.17~~ 3.217 V. Show me the o/p for each step

⇒ i/p V = 3.217 v

$\boxed{\text{4-Cycle (bcu 4 bit)}}$

① 1000 $\xrightarrow{H}$ ② 1100 $\xrightarrow{L}$ 1010 ③ $\xrightarrow{H}$ ~~0110~~ 1011 $\xrightarrow{L}$ ④ 1010

1000 ⇓ 2.5 < i/p v

1100 ⇓ $5\left(\frac{1}{2}+\frac{1}{4}\right)$ = 3.75 > i/p V

1010 ⇓ ~~1.25~~ ⇓ 3.125 < i/pv

1011 ⇓ 3.4375

$\boxed{3.125}$ ⇐ 1010

Ans

28/oct/24

Single Slope ADC →

$$V_o = \frac{-1}{RC}\int_0^T -V_{ref}\, dt$$

$$V_o = \frac{T V_{ref}}{RC}$$

$V_{in} \propto T$

+ve is higher ⇒ o/p of Comparator 1

-ve ——,—— ⇒ o/p = 0.

Que.) A 10 bit DAC with ref. of 10 v, ① i/p $(0B5)_H$

② o/p is 6.5 v, what i/p should be apply.

⇒

$V_{ref} = 10\,V$

$(0B5)_H \longrightarrow 0010110101$

$\longrightarrow \cancel{(265)_D}$

$(181)_D$

$D = \cancel{265}\ 181$

$$V_o = \frac{D \cdot V_{ref}}{2^n} = \frac{\overset{181}{\cancel{265}}}{2^{10}} \times 10\,V$$

$\boxed{\cancel{V_o = 2.58\,V}}$

① Ans $\boxed{V_o = 1.767\,V}$

(ii) ⇒ $V_o = \frac{D\, V_{ref}}{2^n}$

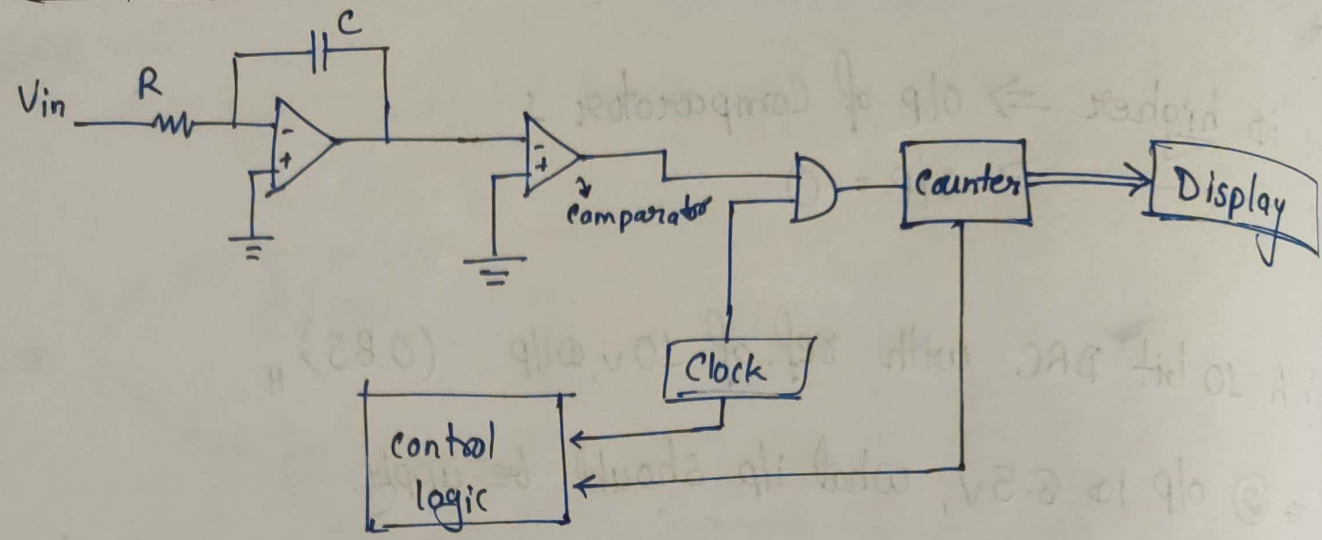
$D = 6.5 \times 2^{10}$ ⟶ 6656

$D = 665.2$?

o/p = H = $299 + \frac{2}{16}$

$= (299)_H$ Ans

★ Dual slope ADC ⇒



$$V_o = \frac{-1}{RC}\int_0^{T_2} -V_{ref}\,dt + V_{initial}$$

$$V_{initial} = \int_{-T_1}^{0} \frac{V_{in}}{RC}\,dt = \frac{-T_1 V_{in}}{RC}$$

$$V_o = \frac{T_2 V_{ref}}{RC} - \frac{T_1}{RC} V_{in}$$

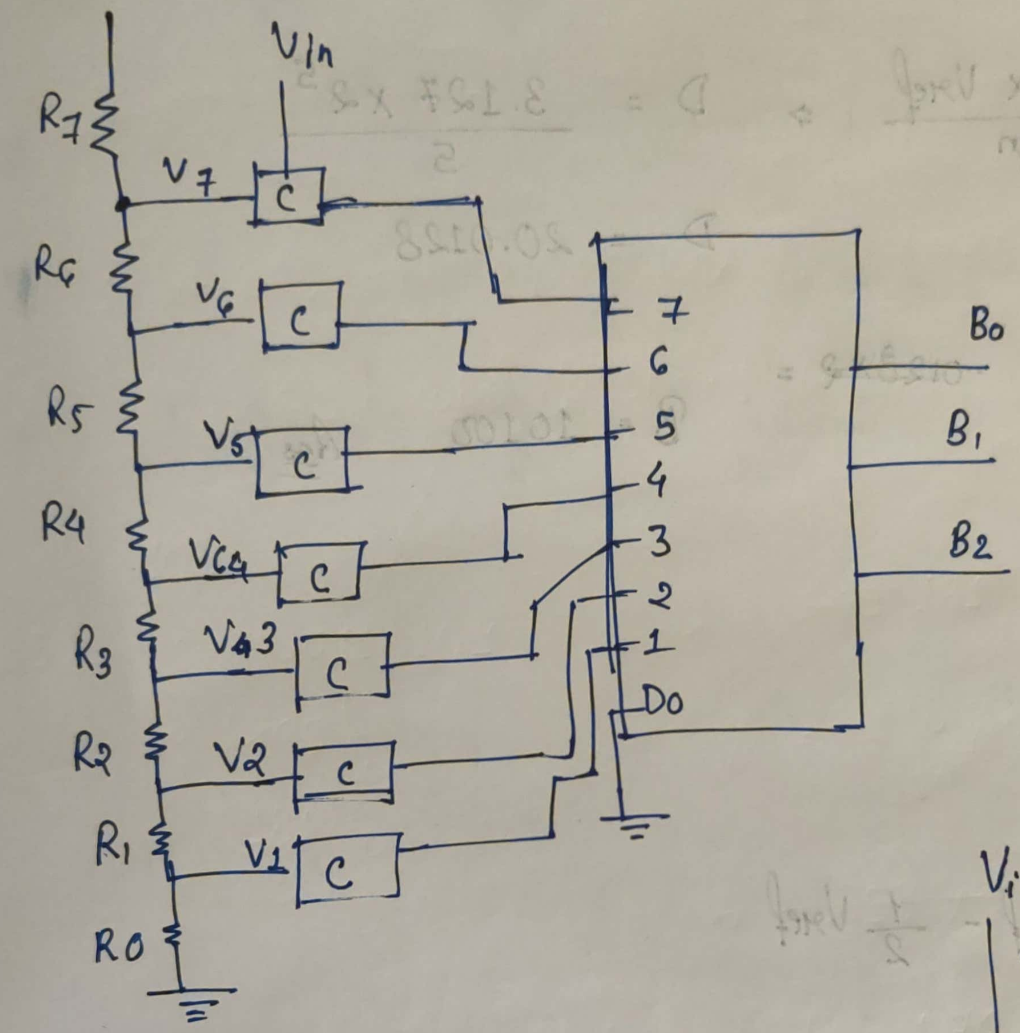
$V_o = 0$

↳ $\cancel{T_2}\ T_2 = T_1 . \frac{V_{in}}{V_{ref}}$

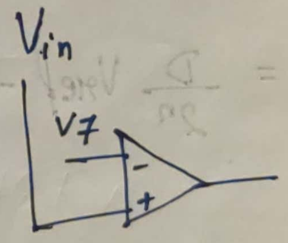
↳ It overcomes the disadvantge of Single slope ADC ⟶ as RC term is not there

*) Flash Type ⇒

24/oct/24



$V_1 = \frac{R}{R+7R} \times V_{ref}$



↳ Comparator

$V_{ref} = 8v$

if $V_7 =$

$V_7 < V_{in} \xrightarrow{o/p} 1$

$V_7 > V_{in} \xrightarrow{o/p} 0$

⋮

$V_1 < V_{in} \xrightarrow{o/p} 1$

$V_1 > V_{in} \xrightarrow{o/p} 0$

N = no. of bits.

↳ In flash type Comparator $2^N - 1$ Comparator

2^N Registors

Que.) Ref → 5 V

5 bit ADC

3.127 V

⇒

$$V_0 = \frac{D \times V_{ref}}{2^n} \Rightarrow D = \frac{3.127 \times 2^5}{5}$$

Decimal value

$$D = 20.0128$$

2	20	
2	10	0
2	5	0
2	2	1
	1	0

10100

~~.0128×2~~ =

B = 10100 Ans

* Bipolar

$$V_0 = \frac{D}{2^n} V_{ref} - \frac{1}{2} V_{ref}$$

$D = 2^n - 1$

$$V_0 = \frac{2^n - 1}{2^n} V_{ref} - \frac{V_{ref}}{2}$$

$$V_0 = V_{ref} - \frac{V_{ref}}{2^n} - \frac{V_{ref}}{2}$$

$$V_0 = \cancel{V_{ref}} \left(\frac{1}{2} - \frac{1}{2^n}\right) V_{ref}$$

Que.) 10 bit ~~ADC~~ DAC

$V_{ref} = 5V$

Digital i/P
1. 0_H
2. $(04F)_H$

⇒

(i) ⇒

$$V_0 = \frac{0 \cdot V_{ref}}{2^{10}} - \frac{V_{ref}}{2}$$

$$V_0 = -\frac{5}{2}$$

$$V_0 = -2.5$$