Q.1(a) $G(s)H(s) = \frac{s+2}{s(s+1)}$

$\Rightarrow \frac{C(s)}{R(s)} = \frac{s+2}{s^2+s+s+2} = \frac{s+2}{s^2+2s+2}$

$\Rightarrow 2\xi\omega_n = 2 \; ; \quad \omega_n^2 = 2$

Now $\omega_n = \sqrt{2}$ rad/s or $\omega_n = 1.414$ rad/s

& $\xi = \frac{2}{2\times\sqrt{2}} = \frac{1}{\sqrt{2}} = 0.707$

Now Peak overshoot time $= \frac{\pi}{\omega_d}$

$= \frac{\pi}{\sqrt{2}\cdot\sqrt{1-(0.707)^2}}$

$= \pi$ sec

or $t_p = 3.14$ sec

Now $M_p = e^{-\pi\xi/\sqrt{1-\xi^2}} = 0.04325$

or $M_p = 4.32\%$

Q.1(b)

$V_s = \frac{330}{\sqrt{2}}$ or $V_m = 330V$

$\alpha = 45^\circ$; $I_0 = 5A$; $V_0 = 140V$.

$$I_0 = \frac{V_m}{2\omega L_s}\left(\cos\alpha - \cos(\alpha+\mu)\right)$$

$$\& \quad V_0 = \frac{2V_m}{\pi}\cos\alpha - 4fL_s I_0$$

$$= \frac{2V_m}{\pi}\cos\alpha - 4fL_s \cdot \frac{V_m}{2\omega L_s}\left(\cos\alpha - \cos(\alpha+\mu)\right)$$

$$5 = \frac{330}{2\times 100\pi L_s}\left(\frac{1}{\sqrt{2}} - \cos(45+\mu)\right)$$

$$\Rightarrow 5 = \frac{0.525}{L_s}\left(\frac{1}{\sqrt{2}} - \cos(45+\mu)\right)$$

$$5 = \frac{0.525}{8.552\times 10^{-3}}\left[0.707 - \cos(45+\mu)\right]$$

$$\cos(\alpha+\mu) = 0.626$$

$$\text{or } \alpha+\mu = 51.28^\circ$$

$$\Rightarrow \boxed{\mu = 6.28^\circ}$$

$$\& \quad 140 = \frac{2\times 330}{\pi}\times\frac{1}{\sqrt{2}} - 4\times 50\times L_s\times 5$$

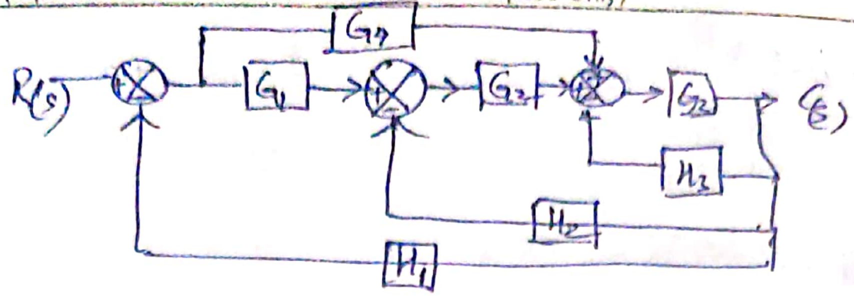
$$140 = 148.552 - 1000L_s$$

$$\Rightarrow 1000L_s = 8.552$$

$$\text{or } \boxed{L_s = 8.552\,mH}$$

Now Load resistance $= \frac{V_0}{I_0} = \boxed{28\Omega}$

Q.1(c)



Q.1(d) $f = 2MHz \Rightarrow T = 0.5\mu s$

MVI B, 10H — 7 t-states
Loop 2: MVI C, FFH — 7 t-states
Loop 1: DCR C — 4 t-states
JNZ Loop 1 — 7/10 t-states
DCR B — 4 t states
JNZ loop 2 — 7/10 t states
RET — 10 t states.

Now Loop 2 runs 16 times & for each run of loop 2, loop 1 runs 255 times.

Now for each loop 1 execution:
It takes (4 + 10) t states 254 times & (4+7) t states 1 times.

For each Loop 2 execution.
It takes (4+10) t states 15 times & (4+7) 1 times.

$\Rightarrow$ total T states $= 7 + 15[7 + 14 + 254[14] + 1[11]] + 1[7 + 10 + 254 \times 14 + 11]$

+ 10 t states

So, total t states = 57421

So, total time = 0.0287 sec

or 28.7 ms

Q.1(e)

RISC	CISC
1) Stands for reduced instruction set computer	1) Stands for complex instruction set computer
2) supports less addressing modes.	2) Supports more addressing modes
3) Contain more registers	3) Contain less register
4) CPI =1	4) CPI ≠ 1
5) Super computer type	5) General purpose type
6) Fixed length instruction	6) Variable length
7) Very fast	7) Comparatively slow
8) Supports successful pipeline	8) Supports unsuccessful pipeline

Q5(a) $r(t) = 2[u(t) - u(t-10) + u(t-20) - u(t-30) + \dots$

$r(t) = 2[u(t) + u(t-20) + u(t-40) + \dots] - 2[u(t-10) + u(t-30) + \dots]$

$$R(s) = 2\left[\frac{1}{s} + \frac{e^{-20s}}{s} + \frac{e^{-40s}}{s} + \dots\right] - 2\left[\frac{e^{-10s}}{s} + \frac{e^{-30s}}{s} + \dots\right]$$

$$= \frac{2}{s} \cdot \frac{1}{1-e^{-20s}} - \frac{2}{s} \cdot \frac{e^{-10s}}{1-e^{-20s}}$$

$$= \frac{2}{s} \cdot \frac{1-e^{-10s}}{1-e^{-20s}}$$

Now $G(s) = \frac{400(s+1)}{(s+2)(s+8)}$

$$\Rightarrow e_{ss} = \lim_{s \to 0} sE(s) = \lim_{s \to 0} \frac{s \cdot \frac{2}{s}\left(\frac{1-e^{-10s}}{1-e^{-20s}}\right)}{1 + \frac{400(s+1)}{(s+2)(s+8)}}$$

$$= \frac{2}{400/(8 \times 2)} \cdot \lim_{s \to 0} \left(\frac{1-e^{-10s}}{1-e^{-20s}}\right)$$

$$= \frac{2 \times 2 \times 8}{400} \cdot \lim_{s \to 0} \frac{10 \cdot e^{-10s}}{20 \cdot e^{-20s}}$$

(L'hopital rule)

$$= \frac{2 \times 2 \times 8 \times 10}{400 \times 20}$$

$$\boxed{e_{ss} = 0.04}$$

Q.5(b) (i) $V_o = V_s \cdot \frac{\alpha}{1-\alpha}$

$= 12 \times \frac{0.6}{1-0.6} = \boxed{18V}$

(ii) Avg. inductor current $= I_s \cdot \alpha + I_o(1-\alpha)$

$= \frac{\alpha}{1-\alpha} \cdot \alpha \cdot I_o + I_o \cdot (1-\alpha)$

where $I_o = \frac{V_o}{R} = \frac{18}{10} = 1.8A$

$\Rightarrow I_{L_{avg}} = \frac{(0.6)^2}{0.4} \times 1.8 + 1.8 \times 0.4$

$= \boxed{2.34 A}$

Now $\Delta I = \frac{\alpha V_s}{fL} = \frac{0.6 \times 12}{200 \times 10^3 \times 10 \times 10^{-6}} = 3.6A$

So; $I_{max} = 2.34 + \frac{3.6}{2} = \boxed{4.14 A}$

& $I_{min} = 2.34 - \frac{3.6}{2} = \boxed{0.54 A}$

(iii) $\Delta V_o = \frac{\alpha V_o}{fRC} = \frac{0.6 \times 18}{200 \times 10^3 \times 10 \times 20 \times 10^{-6}}$

$\boxed{\Delta V_o = 0.27 V}$

Q.5(c) Addressing modes –

1) Immediate addressing: Data given with instruction. Eg: MVI B, 10H

2) Register addressing: Data is to be operated in accumulator. Eg: MOV A, B or general register.

3) Direct addressing: Operand is given by an address where data is present.
Eg: LDA 2500H

4) Indirect addressing: Instruction points at an address or memory location to fetch data but doesnt explicitly show address; Eg: MOV M, A

5) Implied addressing: Operand is implicit & not given explicitly.
Eg: RLC or RAR

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Q.5(d) $V_s = 200\,V$; $V_o = 600\,V$

$\Rightarrow \quad 600 = \frac{200}{1-\alpha} \Rightarrow 1-\alpha = \frac{200}{600}$

or $\boxed{\alpha = \frac{2}{3}}$

Now $f = 25000\,Hz$

& pulse width of o/p = T_{off}

$= \left(1-\frac{2}{3}\right) \times \frac{1}{25000}\,s$

$= \boxed{13.33\,\mu s}$

Now new $T_{off} = \frac{13.33}{2} = 6.67\,\mu s$

$\Rightarrow \quad \alpha = 1 - \frac{T_{off}}{T} = 1 - \frac{6.67}{40} = \frac{5}{6}$

Now $(V_o)_{new} = \frac{200}{1-\frac{5}{6}} = \frac{200}{1/6}$

or $\boxed{(V_o)_{new} = 1200\,V}$

Q.5(e) (i) Program is a sequence of instruction along with data required to execute those instructions.

(ii) Machine cycle is no. of CPU clock cycles or t-states required to complete the momory or I/O operation.

(iii) Micro-operation is an elementary programme in the base hardware.

(iv) Micro instruction is a collection of one or more micro operation with data to perform some task

(v) Microprogram Sequence of micro instructions with data to perform some required action

Q.2(a) $G_p(s) = \frac{2}{s(s+5)}$

Current steady state error with ramp i/p

$$= \lim_{s \to 0} sG(s) = \frac{5}{2}$$

To take it to zero; we need one more "s" in denominator.

Now new complex poles have $\omega_n = 3$ rad/s & zero is at -2

$\Rightarrow$ system is of the form $\frac{(s+2)}{(s+P)(s^2+2\xi\omega_n s+\omega_n^2)}$

$$= \frac{s+2}{(s+P)(s^2+6\xi s+9)}$$

Let controller be of the form $\left(K_p + \frac{K_i}{s}\right)$

$$\Rightarrow G_p(s) = \left(K_p + \frac{K_i}{s}\right)\left(\frac{2}{s(s+5)}\right)$$

$$= \frac{(K_i + sK_p)\,2}{s^2(s+5)}$$

Now for closed loop :- $\frac{2(K_i + sK_p)}{s^2(s+5) + 2(K_i + sK_p)}$

$$= \frac{2(K_i + sK_p)}{s^3 + 5s^2 + 2sK_p + 2K_i}$$

Now comparing; we get :-

$$\boxed{K_p/K_i = 1/2}$$

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also $(s+P)(s^2+6\xi s+9)$

$$= s^3+6\xi s^2+9s+Ps^2+6\xi Ps+9P$$

$$= s^3+s^2(6\xi+P)+s(9+6\xi P)+9P$$

comparing, we get $5 = 6\xi+P$

$$2K_p = 9+6\xi P$$

$$2K_i = 9P$$

$\Rightarrow P = (5-6\xi)$

& $K_i = 2K_p$

$\Rightarrow 2K_p = 9+6\xi(5-6\xi)$

& $2\times 2K_p = 9(5-6\xi)$

or $2\times(9+30\xi-36\xi^2) = 45-56\xi$

$$18+60\xi-72\xi^2 = 45-56\xi$$

$$72\xi^2-60\xi-18+45-56\xi = 0$$

$$72\xi^2-116\xi+27=0$$

$\Rightarrow \boxed{\xi = 0.282}$

& $P = 5-6\xi = 3.308$

$\Rightarrow K_i = \frac{9}{2}P = \boxed{14.886}$

& $K_p = \frac{K_i}{2} = \boxed{7.433}$

So; controller is $7.443\left(1+\frac{2}{s}\right)$

Q.2(b) $V_s = 120$; $V_m = 120\sqrt{2}$

$R = 10\,\Omega$; $L = 20\,mH$; $\alpha = 60°$

(i) Now $V_o = \frac{1}{\pi}\int_{\alpha}^{\beta} V_m \sin(\omega t)\, d(\omega t)$

$= \frac{1}{\pi} \cdot V_m \cdot (-\cos(\omega t))\Big|_{\alpha}^{\beta}$

$= \frac{V_m}{\pi}(\cos(\alpha) - \cos(\beta))$

Now $I_o = \frac{V_o}{R}$ (since avg. value of inductor voltage is zero in steady state)

$I_o = \frac{V_m}{\pi R}(\cos\alpha - \cos\beta)$

Now $V_m = 120\sqrt{2}$; $R = 10\,\Omega$

$\Rightarrow I_o = \frac{120\sqrt{2}}{\pi \times 10}(\cos 60° - \cos\beta)$

$I_o = 5.402\left(\frac{1}{2} - \cos\beta\right)$

Now <u>extinction angle</u>:- this happens when current decays back to zero before next pulse

If load current is continuous:-

$\beta < \pi + \alpha$ or $\beta - \alpha < \pi$

& for β to $\pi+\alpha$; $V_o = 0$

~~$L\frac{di}{dt} + Ri = V_m \sin\omega t$ for $\alpha \le \omega t < \pi$~~

$$\Rightarrow \frac{V_m}{Z}\sin(\beta-\phi) + \sin\phi \, e^{\beta/\omega\tau} = 0$$

$$\omega\tau = 2\pi \times 50 \times \frac{20\,mH}{10} = 0.628$$

$$\Rightarrow \frac{120\sqrt{2}}{\sqrt{10^2+4\pi^2}} \cdot \sin(\beta - 32.14^\circ) = -0.532 \times e^{1.592\beta}$$

Now $\sin(\beta - 32.14^\circ) = -0.037 \cdot e^{1.592\beta'}$

for $\beta' = 60^\circ \Rightarrow \beta = 20.837^\circ$

for $\beta' = 20.837^\circ \Rightarrow \beta = 28.35^\circ$

for $\beta' = 28.35^\circ \Rightarrow \beta = 27.47^\circ$

$\Rightarrow$ $\boxed{\beta \approx 27.9^\circ}$ or extinction angle $= \boxed{207.91^\circ}$

Since this angle $< 180 + 60$ ($= 240$)

So current is **discontinuous**

$$I_o = 5.402\left(\frac{1}{2} - \cos(207.91)\right) = \boxed{7.47A}$$

or **average load current = 7.47A**

Q2(c) DAA instruction deals with the BCD addition. All flags are altered

Contents of the accumulator are changed from binary value to two 4-bit binary code decimal digits.

Here BCD = Binary Code Decimal.

This instruction required 1 machine cycle ~~and~~ or 4 t states for execution which is used for opcode fetch.

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Q.8(a) For given motor :-

Power = 150 HP = 150×746 = 111.9 kW

$V_t = 650V \Rightarrow I_a = 172.153A$

Now for this rated value; $(R_a + j\omega L_a) =$
$(0.099 + j0.229)\Omega$ or $|Z_a| = 0.25\Omega$

Now $E_a = 650 - 170 \times 0.099 = 633.17 V$

(i) For $\alpha = 0°$:-

$$V_t = \frac{3V_{ml}}{\pi}\cos 0° = \frac{3 \times 460\sqrt{2}}{\pi} \times 1 = 621.22V$$

Now $I_a = 17A$

$\Rightarrow E_a = V_t - I_a r_a = 621.22 - 17 \times 0.099$

$E_a = 619.535 V$

$$\Rightarrow \omega_m = \frac{619.535}{0.33} \text{ rpm} = \boxed{1877.38 \text{ rpm}}$$

For $\alpha = 30°$:-

$$V_t = \frac{3 \times 460\sqrt{2}}{\pi}\cos 30° = 537.99V$$

$E_a = 537.99 - 17 \times 0.099 = 536.31V$

$$\omega_m = \frac{536.31}{0.33} = \boxed{1625.18 \text{ rpm}}$$

(ii) Now for $\omega_m = 1750$ rpm & $I_a = 170V$

$\Rightarrow E_a = K_m \omega_m = 577.5\,V$

& $V_t = 577.5 + 170 \times 0.099$

$V_t = 594.33\,V$

$\Rightarrow \frac{3 \times 460\sqrt{2}}{\pi} \times \cos\alpha = 594.33$

$\cos\alpha = 0.957$

$\boxed{\alpha = 16.92^\circ}$

Also supply power factor $= \frac{594.33 \times 170}{\sqrt{3} \times 460 \times 170\sqrt{\frac{2}{3}}}$

$\boxed{pf = 0.9136 \text{ lag}}$

(iii) For speed regulation for $\alpha = 16.92^\circ$

$\Rightarrow E_a = 594.33 - 17 \times 0.099$

$= 592.647$

$\Rightarrow (\omega_m)_{nl} = \frac{592.647}{0.33} = 1795.9$ rpm

Now % speed reg. $= \frac{1795.9 - 1750}{1750} \times 100\%$

$= \boxed{2.62\%}$

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Q.8(b) For the given system:-

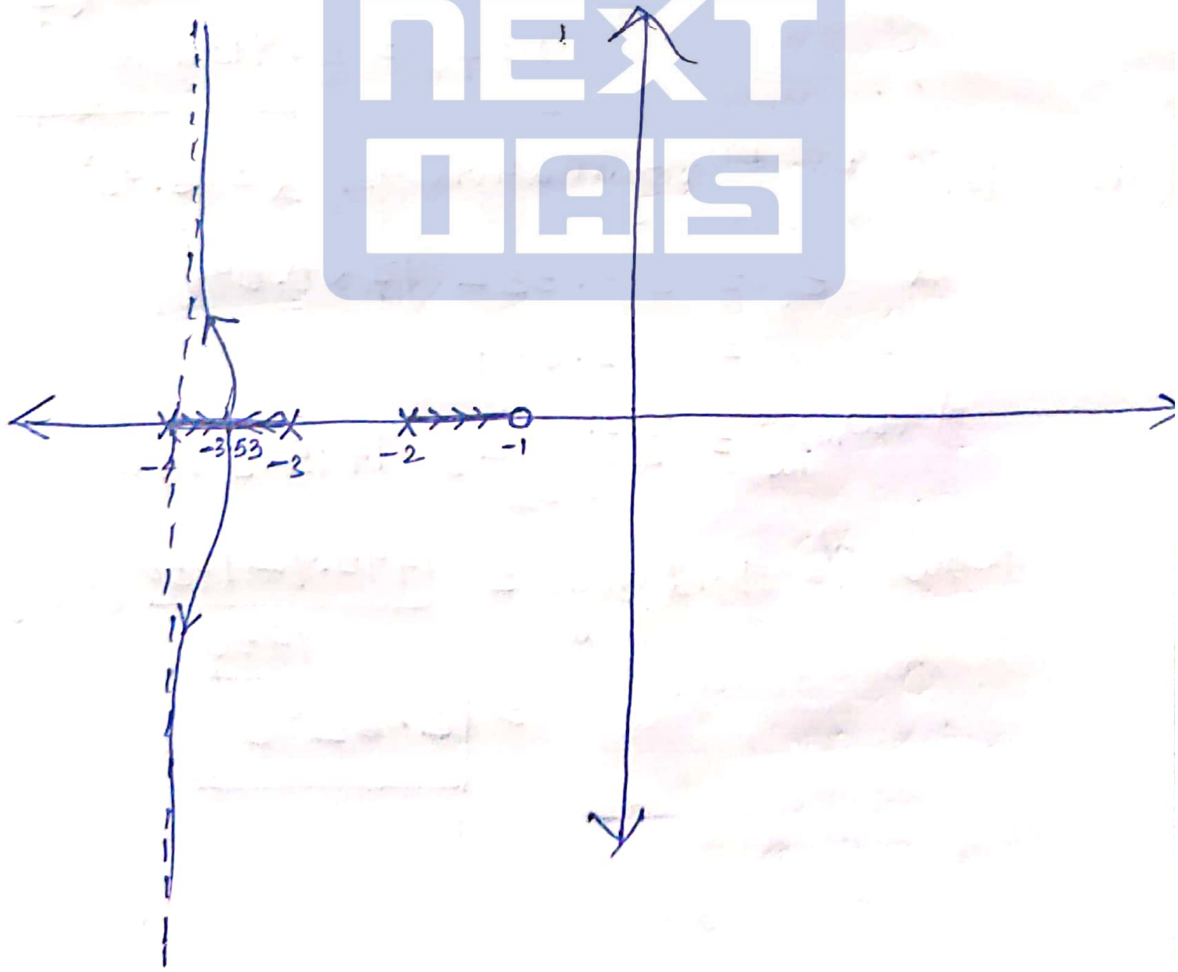
$$G(s)H(s) = \frac{K(s+1)}{(s+2)(s+3)(s+4)}$$

Now $\#p = n = 3$
$\#z = m = 1$

$\Sigma p = -2-3-4 = -9$
$\Sigma z = -1$

$\Rightarrow \sigma = \frac{\Sigma p - \Sigma z}{n-m} = \frac{-9+1}{3-1} = -4$

asymptote angles $= \left(\frac{2q+1}{n-m}\right)\pi = \frac{\pi}{2}, \frac{3\pi}{2}$



Now for breakaway points:—

$$\frac{dK}{ds} = 0 \Rightarrow \frac{d}{ds}\left[\frac{(s+2)(s+3)(s+4)}{(s+1)}\right] = 0$$

$$\frac{d}{ds}\left[\frac{(s^2+5s+6)(s+4)}{(s+1)}\right] = 0$$

$$\frac{d}{ds}\left[\frac{s^3+4s^2+5s^2+20s+6s+24}{(s+1)}\right] = 0$$

$$\frac{d}{ds}\left[\frac{s^3+9s^2+26s+24}{s+1}\right] = 0$$

$$(s+1)(3s^2+18s+26) - s^3-9s^2-26s-24 = 0$$

$$3s^3+18s^2+26s+3s^2+18s+26-s^3-9s^2-26s-24=0$$

$$2s^3+12s^2+18s+2=0$$

$$s^3+6s^2+9s+1=0 \Rightarrow s = -0.121; -2.347; \boxed{-3.532}$$

only $\boxed{s = -3.532 \text{ is valid}}$

⟶ Addition of open loop zero to this system if done to the right half plane can disturb the stability ⇒ make it unstable

⟶ Addition to left half plane can improve transient response for higher K if added to the left of $(s=-4)$

8(c)

```
        LXI H, XX50H
        MVI B, 03H
Loop3:  MOV C, B
Loop2:  MOV A, M
        INX H
        MOV D, M
        CMP D
        JC Loop 1
        MOV M, A
        DCX H
        MOV M, D
        INX H

Loop 1: DCR C
        JNZ Loop 2
        DCR B
        JNZ Loop 3
        HLT
```

87H
56H
42H

B	C	A
3	3	87H

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Answer Questions in NOT MORE THAN the Word Limit specified for each in the Parenthesis.
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Q.4(a) $f = 400H$; $V_s = 220V$

$T_e = 30Nm$; $\omega_m = \frac{1000 \times 2\pi}{60} = 104.72 rad/s$

Now $K_m = 1.5 \; Vs/rad$

$\Rightarrow I_a = \frac{T_e}{K_m} = 20A$

$E_a = K_m \omega_m = 157.08V$

Now for the chopper :-

$V_t = 157.08V$ Since voltage net across inductor $= 0$

Now for chopper;

$$I_{max} = \frac{V_s}{R}\left[\frac{1-e^{-T_{on}/T_a}}{1-e^{-T/T_a}}\right] - \frac{E}{R}$$

But here $R = 0$

$\Rightarrow V_L$ during $T_{on} = L\frac{di}{dt} = V_s - V_o$

$$L\frac{\Delta I}{T_{on}} = (220 - 157.08)$$

$$\text{or } \Delta I = \frac{220 - 157.08}{L} \times \frac{\alpha}{400}$$

But $V_o = \alpha V_s \Rightarrow \alpha = \frac{157.08}{220} = 0.714$

$\Rightarrow$ $\boxed{\Delta I = 5.616A}$

Hence $I_{max} = I_o + \frac{\Delta I}{2} = \boxed{22.808A}$

& $I_{min} = I_o - \frac{\Delta I}{2} = \boxed{17.192A}$

(ii) During chopper on period:–

$$V_L = 220 - 157.08 = 62.92$$

$$\Rightarrow L \cdot \frac{di}{dt} = 62.92$$

$$\Rightarrow \int_{17.192}^{i} di = \frac{62.92}{20mH} \cdot \int_{0}^{t} dt$$

$$\Rightarrow (i - 17.192) = 3146t$$

$$\text{or} \quad \boxed{i(t) = 3146t + 17.192}$$

During chopper off period.

$$V_L = -V_0 = -157.08$$

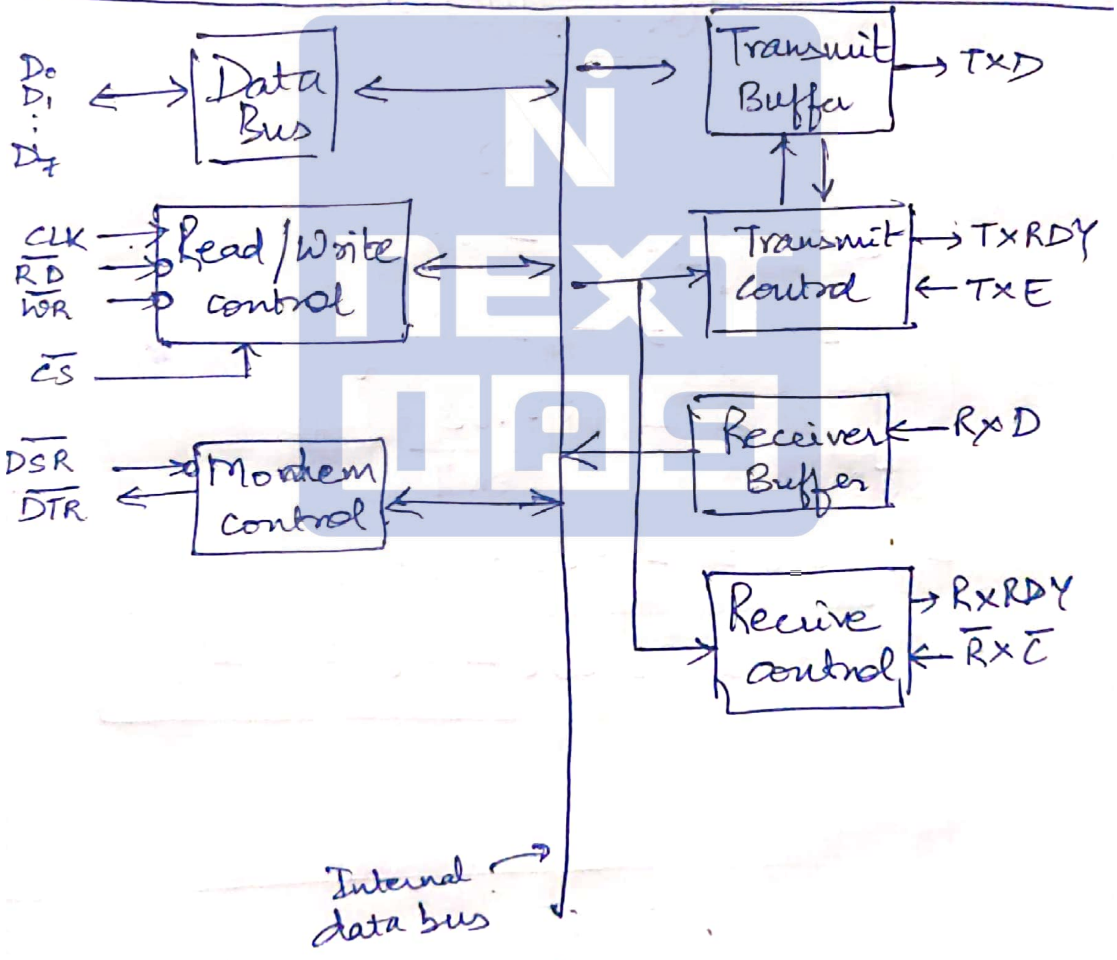
$$\Rightarrow L \cdot \frac{di}{dt} = -157.08$$

$$\int_{22.808}^{i} di = -\frac{157.08}{20mH} \cdot \int_{T_{on}}^{t} dt$$

$$i - 22.808 = -7854(t - T_{on})$$

$$\text{or} \quad \boxed{i(t) = 22.808 - 7854(t - T_{on})}$$

Q.4(b) USART stands for universal synchronous/asynchronous receiver/transmitter. It accepts parallel data & converts it to serial data and vice versa as required by the CPU. This is also called the duplex mode of operation.



Pins: 1) D_0 to D_7 for connecting to system data bus

2) $\overline{RD}$ to read data from 8251.

3) $\overline{WR}$ to write data to 8251
4) CLK for internal timing.

RS232 stands for recommended standard 232. It is used for serial communication b/w Data Terminal equipment (DTE) and Data Communication Equipment (DCE).

It supports a wide range of baud rate from 110 to 230400 — speed at which data is sent from transmitter to receiver.