MIT- TUTORIAL: 2 ①

COUNTER AND TIME DELAYS

U19CS012 [BHAGYA VINOD RANA]

1.> Calculate the delay in the following loop assuming the system clock period = 0.33 μs.

LABEL	Instruction	T-states	# no. of times execute
Outer Loop (T_0)	LXI B, 12FFH → 4863	10	①
DELAY	DCX B 4862 → 12FE	6	Loop is repeated
(exchange stack top with HL)	XTHL	16	12FF H
	XTHL	16	$= (1*16^3) +$
	NOP	4	$(2*16^2) +$
	NOP	4	$(\overset{15}{F}*16^1) +$
	MOV A, C A = FE	4	$(F*16^0)$
	ORA B	4	
	JNZ DELAY	10/7	= 4863 times

Clock Period (T) = 0.33 μs —①

{ Problem with DCX instruction, DCX doesn't set zero flag }

Additional techique (MOV A, C / ORA B) is used to set Zero flag }

T_0 = time to execute ~~outer~~ outside loop instruction

= (10 T-states) * (0.33 μs)

$\boxed{T_0 = 13.3 \mu s}$ —②

T_L = time delay in Loop

= T * (Loop T-states) * N_{10}

T: Clock Period

N_{10}: Equivalent decimal number of hexadecimal Count in delay register

= (0.33 μs) * (6+16+16+4+4+4+4+10) * (4863)

= $(0.33 * 10^{-6})$ (64) * (4863)

= $102706.56 * 10^{-6}$ seconds

= $\boxed{102706.56 \mu s}$ — ③

If we calculate delay more accurately,

If $JNZ = true$, then T-states $= 10$

$JNZ = false$, the T-states $= 7$

difference of $(10T - 7T) = 3T$ is extra

$\therefore$ Delay generated by last clock cycle $= (3T) * (\text{clock period})$

$= 3T * (0.33)\,\mu s$

$\approx \boxed{1\ \mu s}$ — ④

Accurate Loop delay

$T_{LA} = T_L -$ delay generated by last clock cycle

$= 102706.56\ \mu s - 1\ \mu s$

$= \boxed{102705.56\ \mu s}$ — ⑤

Total Delay = time taken to execute outside Loop + Time taken to execute loop instruction

$T_D = T_O + T_{LA}$

$= 3.3\,\mu s + 102705.56\ \mu s$ (Using ② & ⑤)

$= \boxed{102708.86\ \mu s}$

Answer: $\boxed{\text{Delay in given loop} = 102708.86\ \mu s = 0.10270886\ sec}$

2.> Specify the number of times the following loop is executed

a)
```
      MVI A, 17H
LOOP: ORA A
      RAL          Rotate left through carry
      JNC LOOP
      if (CY=0)
```

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2.) (a) $(17)H = (0001 \quad 0111)_2$

(i) ORA A ; A remains same (A OR A = A)

RAL $[0010 \quad 1110]$ CY 0

($CY = 0$) 0 0001 0111

∵ $CY = 0$ goto Loop

(ii) ORA A CY 0

RAL $[0101 \quad 1100]$ 0 0010 1110

∵ $CY = 0$ goto Loop

4 times

(iii) ORA A CY 0

RAL $[1011 \quad 1000]$ 0 0101 1100

∵ $CY = 0$ goto Loop CY 1 ~~0~~

(iv) ORA 1 1011 1000

RAL $[0111 \quad 0000]$

∵ $CY = 1$, condition = false, come out of Loop.

Therefore, the Loop was executed $\boxed{\text{4 times}}$.

2.) (b) 'ORA' instruction clears the CY and AC.

Therefore, when JNC instruction is executed, CY will always be zero.

```
      MVI  A, 17H
LOOP :     RAL
           ORA A     →  Always Reset CY & AC flag ie CY = 0, AC = 0
           JNC LOOP  →  if CY == 0 goto Loop
```

Therefore, the Loop will be executed $\boxed{\infty \text{ (infinite) times}}$

(Never come out of Loop)

Q2.) C)

	LXI	B, 1000H	(BC) reg-pair = (10 00) H
LOOP:	DCX	B	; decrement (BC), but Z flag unaffected
	NOP		; No operation
	JNZ	LOOP	

The problem with DCX instruction, DCX doesn't set zero flag.
Additional technique { MOV A, C ; ORA B } is used to set zero flag

∴ In NOP Instruction, register and flags are unaffected.

∴ Z flag will never set & Loop will never terminate.
∴ The Loop will run for infinite (∞) times.

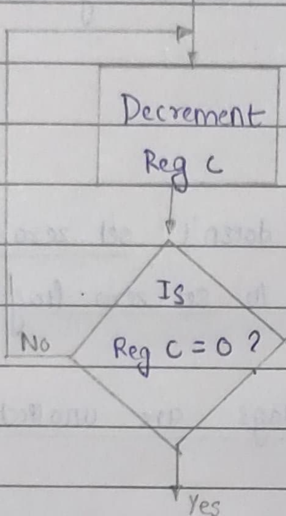
Q3.) In following figure, load register C with 00H and register B with C8H. Calculate the loop delay in LOOP1 and LOOP2 (Clock period = 325 ns)

Based on Flowchart Diagram

Label	Opcode	Operand	T-states
	MVI	B, C8H	7T
LOOP2:	MVI	C, 00H	7T
LOOP1:	DCR	C	4T
	JNZ	LOOP1	10/7 T
	DCR	B	4T
	JNZ	LOOP2	10/7 T (True) (False)

Clock period = 325 ns = 0.325 μs

(A) Calculating delay of inner LOOP1 : T_{L1}



Label	Opcode	Operand	T-states
LOOP1 :	DCR	C	4T
	JNZ	LOOP1	10/7T

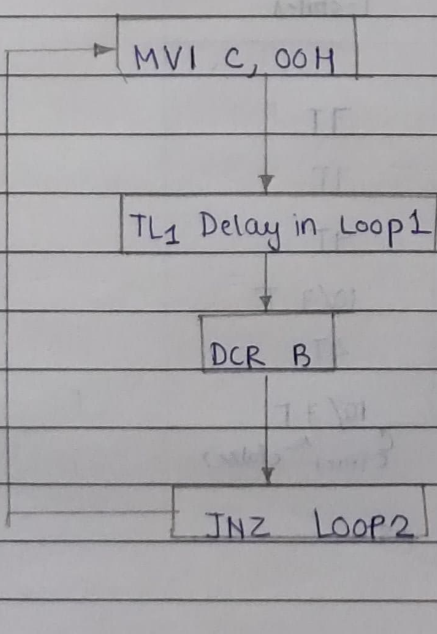
$$T_L = T * \text{Loop T-states} * N_{10}$$
$$= (0.325\ \mu s) * (14) * (256)$$
$$= \boxed{1164.8\ \mu s}$$
$$= 1.1648\ ms$$

Last JNZ takes 7T-cycles (subtract time by extra 3T cycles)

$$T_{LA} = T_L - (3T \text{ states} * \text{clock period})$$
$$= 1164.8\ \mu s - (3 * 0.325\ \mu s)$$
$$= \boxed{1163.825\ \mu s}$$

∴ Delay of Loop 1 : $\boxed{T_{Loop1} = 1163.825\ \mu s = (1.163825\ ms)}$

(B) Calculating delay of outer LOOP2 : T_{L2}



Label	Opcode	Operand	T-states
	MVI	B, C8H	7T
LOOP2 :	MVI	C, 00H	7T
Delay of Loop 1			= 1163.825 µs
	DCR	B	4T
	JNZ	LOOP2	10/7T

Counter B : $(C8)_{16} = (200)_{10}$

Loop2 is executed $(7+4+10)\ T$

$= 21$ T-states

$$T_{Loop2} = (200)_{\text{times}} * \left(T_{Loop1} + ((21\ T\text{-states}) * (0.325\ \mu s)) \right)$$

$$= 200\ (1163.825\ \mu s + 6.825\ \mu s)$$

$$= 234130\ \mu s$$

$$\boxed{T_{Loop2} = 234.130\ ms}$$

Ans :

$$\boxed{\begin{aligned} T_{Loop1} &= 1163.825\ \mu s = 1.163825\ ms \\ T_{Loop2} &= 234130\ \mu s = 234.13\ ms \end{aligned}}$$

4.) a)

```
        MVI B, 64H
LOOP:   NOP
        DCR B
        JNZ LOOP
```

// Initialise the counter B = 64H = 6*16 + (4) = 96 + 4 = 100

till (Z==0) goto loop, once 'B' reaches zero (Z flag = 1) & Loop terminates.

(NOP does not affect any flags.)

∴ Loop run's for (64)H = 100 times

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b)

```
        ORA A
        MVI B, 64H
LOOP:   DCR B
        JNC LOOP
```

① ORA A; CY and AC Flags are cleared +
② 'DCR' instruction does not affect "(CY)".
(All flag except CY are affected !)
③ So, CY = 0 CY will remain zero and would not be able to come out of Loop.
∴ Loop will run for infinite times (∞)

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4.) (C)

```
        MVI A, 17H
LOOP:   ORA A
        RRC
        JNC LOOP
```

CY = 1

A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0
0	0	0	1	0	1	1	1

CY = 1 ✓

After RRC

1	0	0	0	1	0	1	1

$(17)_H = (0001\ 0111)$

In first RRC operation, carry flag is set to "1".

ANS: ∴ Loop will run only once [1 time].

5.) Calculate the COUNT to obtain a 100 µs delay, and express the value in Hex. (Use the clock frequency of your system)

		T-States
	MVI B, COUNT	7T
LOOP:	NOP	4T
	NOP	4T
	DCR B	4T
	JNZ LOOP	10/7 T

Frequency of my Laptop (f) = 1.60 GHz = 1.6×10^9 Hz

Clock Period = $T = \frac{1}{f} = \frac{1}{1.6 \times 10^9} = 0.625 \times 10^{-9}$ seconds

Delay Required = 100 µs

$100 * 10^{-6}$ sec $= T_{\text{outside Loop}} + T_{\text{inside Loop}}$

$= (7T) * 0.625 \times 10^{-9}) + [22 * (\text{count}) - 3T * (0.625 \times 10^{-9})]$

$(10^{-6+2}) = (4 * 0.625 \times 10^{-9}) + (22 * (\text{count}) * 0.625 \times 10^{-9})$

$10^{-4} = (0.625) \times 10^{-9} (4 + 22 * \text{count})$

$\frac{10^9}{10^4} (1.6) = (4 + 22 * \text{count})$

$1.6 * 10^5 = 4 + 22 * \text{count}$

$\text{count} = \frac{(160000 - 4)}{22} = 7272.54 \approx (7273)_{10} = (1C69)_{16}$

Ans: Value of COUNT for my Laptop = $(1C69)_{16}$

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