Digital Logic Test I

Number of Questions: 25 **Section Marks: 30**

Directions for questions 1 to 25: Select the correct alternative from the given choices.

1. Assume the propagation delay time of 2 input gates as EXOR-20 ns, AND – 10 ns, OR-10 ns, the propagation delay time for sum and carry output of a full adder circuit are respectively, when all the data inputs are applied simultaneously?
(A) 30 ns, 20 ns (B) 40 ns, 30 ns
(C) 40 ns, 20 ns (D) 20 ns, 20 ns

2. The minimized POS expression of the function $f(A, B, C, D) = AB + A\bar{C} + C + AD + A\bar{B}C + ABC$
(A) $A + \bar{C}$ (B) $\bar{A} + \bar{B}$
(C) AC (D) $A + C$

3. The signed two's complement representation of $(-783)_{10}$ is (in HEX):
(A) 830FH (B) 04F1H
(C) FCF1H (D) F3F1H

4. The two numbers represented in signed 2's complement form are:
P = 11011101 and Q = 11100101, if Q is subtracted from P, the value obtained in signed 2's complement form is?
(A) 11110111 (B) 11000010
(C) 11111000 (D) 00000111

5. The subtraction of a binary number B from another binary number A, done by adding the 2's complement of B to A, results in a binary number without carry, this implies that the result is:
(A) negative and is in normal form
(B) positive and is in normal form
(C) negative and is in 2's complement form
(D) positive and is in 2's complement form

6. $f(a, b, c) = ab + b^1c$ in the canonical POS form is represented as:
(A) $(a + b + c)(a + b + c^1)(a + b^1 + c)(a^1 + b^1 + c)$
(B) $(a + b^1 + c)(a + b^1 + c^1)(a + b + c)(a^1 + b + c)$
(C) $(a + b + c)(a^1 + b^1 + c)(a + b^1 + c)$
(D) $(a^1 + b + c)(a^1 + b^1 + c)(a + b + c)(a + b^1 + c)$

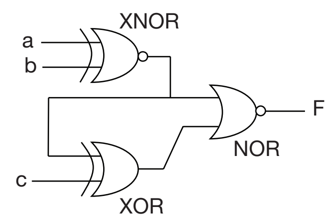
7. The Essential prime Implicants of the function
$f(A, B, C, D) = \bar{A}C + ABD + \bar{A}B + B\bar{D} + \bar{A}\bar{B}C\bar{D}$ are:
(A) $BD, \bar{B}\bar{D}, \bar{A}$ (B) $\bar{A}C, \bar{B}\bar{D}, B$
(C) $BD, \bar{A}C, \bar{B}$ (D) $\bar{A}\bar{B}, \bar{B}\bar{D}, C$

8. A combinational circuit has 3 inputs x, y, z and three outputs A, B, C. When the binary input is 4, 5, 6 and 7, the binary output is 2 less than the binary input. When the binary input is 0, 1, 2 and 3, the output is 4 more than the binary input the Boolean expression for output A and C respectively are:
(A) $x^1 y, z$ (B) $x + y^1, z^1$
(C) x, z (D) $x^1 + y, z$

9. In the above problem statement, how many number of NOR are gates required implement output B.
(A) 3 (B) 4
(C) 5 (D) 6

10. A combinational circuit takes 2 inputs and output is the 2's complement of input binary number. Consider the inputs as a and b and output as x and y, the equations of x and y respectively?
(A) $a \odot b, b$ (B) $a^1 b, a \odot b$
(C) $a^1 b, ab^1$ (D) $a \oplus b, b$

11. The output F in the digital logic circuit shown in the figure is:



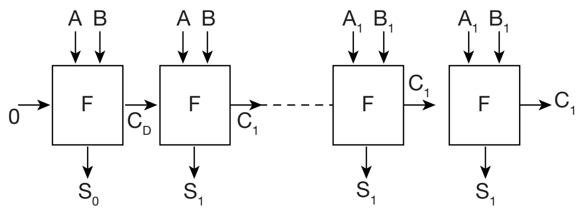
(A) $a^1 bc + ab^1 c$ (B) $a^1bc^1 + ab^1c^1$
(C) $a^1b^1c + abc$ (D) $a^1b^1c^1 + abc$

12. To construct a 5 to 32 line decoder, how many numbers of 3 to 8 line decoders and 2 to 4 line decoders are required respectively without using any extra hardware?
(A) 3, 2 (B) 4, 1
(C) 2, 4 (D) 2, 2

13. Parity is a common error detection mechanism that is often used in data reception or retrieval systems. Consider a parity encoder that is used for data transmission or storage. If a word contains an even number of 1's, the parity bit is 0. If the word has odd number of 1's the parity bit is 1. If the data is w, x, y, z then the min terms for parity bit is?
(A) $\sum m(1, 2, 4, 7, 8, 11, 13, 14)$
(B) $\sum m(0, 3, 5, 6, 9, 10, 12, 15)$
(C) $\sum m(0, 1, 3, 5, 8, 10, 13, 15)$
(D) $\sum m(1, 3, 5, 7, 9, 11, 13, 15)$

14. Consider the Boolean functions
$f_1(A, B, C, D) = AC + BD$
$f_2(A, B, C, D) = \sum m(4, 5, 6, 7, 10, 11, 14, 15)$
Then find $f_1 + f_2$ in minimized POS form
(A) $(\bar{A} + \bar{B})(B + D)(\bar{A} + \bar{B} + C)$
(B) $(A + B)(B + C)(\bar{A} + C + D)$
(C) $(A + \bar{B})(B + D)(\bar{A} + C + D)$
(D) $(A + D)(B + C)(\bar{A} + B + C)$

15. A 16-bit ripple carry adder is realized using 16 identical full address as shown in figure. The carry propagation delay of each FA is 15 ns and the sum propagation delay of each FA is 18 ns.
The worst delay of this 16-bit adder will be:



(A) 243 ns (B) 228 ns
(C) 240 ns (D) 270 ns

16. For an n-variable Boolean function, the maximum number of prime implicants is:
(A) $\frac{n}{2}$ (B) $2^n - 1$
(C) 2^{n-1} (D) 2^n

17. If the Boolean function $f(a, b, c, d) = a + b + c + d$ has to be implemented with only 2 input NAND gates, then how many NAND gates are required?
(A) 6 (B) 7
(C) 8 (D) 9

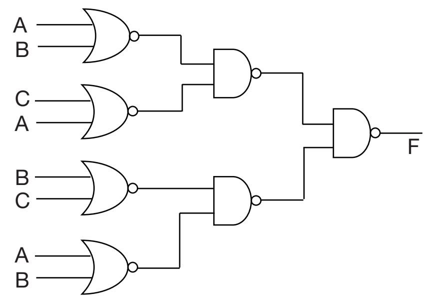
18. The following expression is valid for the number system with base _______ $\frac{302}{20} = 12.1$.
(A) 6 (B) 5
(C) 4 (D) 8

19. P is a 16 bit signed number integer, the 2's complement representation of P is $(FB8A)_{16}$. The 2's complement representation of $8 \times P$ is:
(A) $(B8\,A0)_{16}$ (B) $(C\,7B4)_{16}$
(C) $(ABCD)_{16}$ (D) $(DC50)_{16}$

20. For a 4 bit magnitude comparator with two inputs each of 4 bit $A(a_3, a_2, a_1, a_0)$ and $B(b_3, b_2, b_1\, b_0)$, the Boolean equation for $A < B$ is:
(A) $a_3^1 b_3 + a_2^1 b_2 + a_1^1 b_1 + a_0^1 b_0$
(B) $a_3 b_3^1 + (a_3 \oplus b_3) a_2 b_2^1 + (a_3 \oplus b_3)(a_2 \oplus b_3) a_2 b_1 + (a_3 \oplus b_3)(a_2 \oplus b_2)(a_1 \oplus b_1) a_0 b_0$
(C) $a_3^1 b_3 + (a_3 \odot b_3) a_2^1 b_2 + (a_3 \odot b_3)(a_2 \odot b_2) a_1^1 b_1 + (a_3 \odot b_3)(a_2 \odot b_2)(a_1 \odot b_1) a_0^1 b_0$
(D) $a_3^1 b_3 + (a_3 \oplus b_3) a_2^1 b_2 + (a_3 \oplus b_3) a_1^1 b_1 + (a_3 \oplus b_3)(a_2 \oplus b_2)(a_1 \oplus b_1) a_0^1 b_0$

21. The simultaneous equations on the Boolean variables a, b, c and d.
$a + b + c = 1$
$ab = 0$
$ac + d = 1$
$ab + \bar{c}\bar{d} = 0$
have the following solutions for a, b, c and d respectively:
(A) 1011 (B) 1100
(C) 1000 (D) 1101

22. What is Boolean expression for output (F) of the combinational logic circuit of NAND-NOR gate given below?



(A) $\overline{A + B}$ (B) $\overline{A + C}$
(C) $\overline{ABC}$ (D) $\overline{A + B + C}$

23. Let $f(A, B, C, D) = \sum m(0, 2, 3, 4, 5, 7, 9, 13, 15)$
Which of the following expressions is not equivalent of f?
(P) $\bar{A}\bar{B}\bar{D} + \bar{A}B\bar{C} + \bar{A}CD + A\bar{C}DBD$
(Q) $\bar{A}\bar{C}\bar{D} + \bar{A}\bar{B}C + A\bar{C}D + BD$
(R) $\bar{A}\bar{B}\bar{D} + \bar{A}B\bar{C} + BCD + A\bar{C}D$
(S) $\bar{A}\bar{B}\bar{D} + \bar{A}CD + ABD + A\bar{C}D$
(A) only Q (B) only S
(C) P and S (D) P and Q

24. The range of integers that can be represented by an 'n' bit 2's complement signed number system is:
(A) -2^{n-1} to $+(2^{n-1} - 1)$
(B) $-(2^{n-1} - 1)$ to $+(2^{n-1} - 1)$
(C) $-2^{n-1} + 1$ to $+2^{n-1}$
(D) -2^{n-1} to $+2^{n-1}$

25. The minimized POS expression for k-map shown is:

CD \ AB	00	01	11	10
00	0		0	X
01	X		X	X
11	0		0	0
10	0		0	0

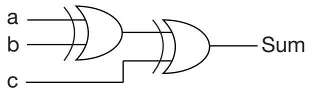
(A) $\bar{A} + B$ (B) $\bar{A}B$
(C) $\bar{A} + \bar{B}(\bar{A} + B)(A + B)$ (D) $\bar{A}(A + B)$

Answer Keys

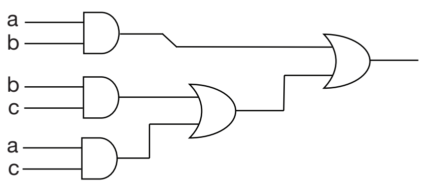
1. B	**2.** D	**3.** C	**4.** C	**5.** C	**6.** B	**7.** A	**8.** D	**9.** C	**10.** D
11. B	**12.** B	**13.** A	**14.** B	**15.** A	**16.** C	**17.** D	**18.** C	**19.** D	**20.** C
21. A	**22.** D	**23.** D	**24.** A	**25.** B					

Hints and Explanations

1. Sum = $a \oplus b \oplus c$
Carry = $ab + bc + ac$



20 + 20 = 40 ns



10 + 10 + 10 = 30 ns
Two level exor gate for sum
So 20 + 20 = 40 ns
Carry will be implemented with 2 input gates in 3 levels, so 10 + 10 + 10 = 30 ns Choice (B)

2. $f = AB + A\bar{C} + C + AD + A\bar{B}C + ABC$
$= AB + A + C + AD + AC$
$= A(B + 1 + D + C) + C$
$= A + C$ Choice (D)

3. 783 = 512 + 256 + 8 + 4 + 2 + 1 = 1100001111
+783 = 0000 0011 0000 1111 (add 0's to MSB)
– 783 = 1111 1100 1111 0001 (2's complement of +783)
In $HEX \Rightarrow FCF1$ Choice (C)

4. P = 11011101
00100011 (by taking 2's complement)
P = –35
Q = 11100101
00011011 (By taking 2's complement)
Q = –27
$P – Q$ = –35 – (–27) = –8 = 1111 1000 (in signed 2's complement form)
(or)
P = 1101 1101
Q = 1110 0101 (direct subtraction)
1111 1000 Choice (C)

5. $A – B$ has to be performed
So, the 2's complement of B (which is $2^n – B$, n = no. of bits in B) is added to A
So result is $A + 2^n – B$; and there is no carry
$A + 2^n – B = 2^n – (A – B)$
So, the result is negative and it is in 2's complement form. Choice (C)

6. $f(a, b, c) = ab + b^1 \cdot c$
$= (ab + b^1)(ab + c)$ $[x + yz = (x + y)(x + z)]$
$= (a + b^1)(a + c)(b + c)$
$= (a + b^1 + c \cdot c^1)(a + b \cdot b^1 + c)(a \cdot a^1 + b + c)$
$= (a + b^1 + c)(a + b^1 + c^1)(a + b + c)(a + b^1 + c)(a + b + c)$
$(a^1 + b + c)$
$= (a + b^1 + c)(a + b^1 + c^1)(a + b + c)(a^1 + b + c)$
Choice (B)

7. $f(A, B, C, D) = \bar{A}C + ABD + \bar{A}B + \bar{B}\bar{D} + \bar{A}\bar{B}\bar{C}D$

Product term	Equivalent	Min terms
$\bar{A}C$	0X1X	0010, 0011, 0110, 0111
ABD	11X1	1101, 1111
$\bar{A}B$	01XX	0100, 0101, 0110, 0111
$\bar{B}\bar{D}$	X0X0	0000, 0010, 1000, 1010
$\bar{A}\bar{B}\bar{C}D$	0001	0001

$f(A, B, C, D) = \sum m(0, 1, 2, 3, 4, 5, 6, 7, 8, 10, 13, 15)$

AB \ CD	00	01	11	10
00	1	1	1	1
01	1	1	1	1
11		1	1	
10	1			1

$f(A, B, C, D) = \bar{A} + BD + \bar{B}\bar{D}$
Essential prime implicants are $\bar{A}, BD, \bar{B}\bar{D}$
Choice (A)

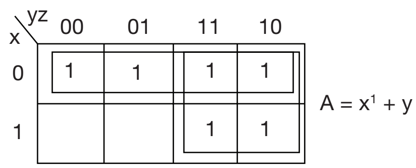
8. The truth table is:

x	y	z	A	B	C
0	0	0	1	0	0
0	0	1	1	0	1
0	1	0	1	1	0
0	1	1	1	1	1
1	0	0	0	1	0
1	0	1	0	1	1
1	1	0	1	0	0
1	1	1	1	0	1

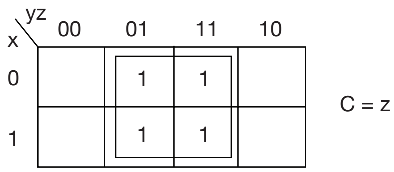
output is 4 more than input
output is 2 less than input

$A(x, y, z) = \sum m(0, 1, 2, 3, 6, 7)$
$B(x, y, z) = \sum m(2, 3, 4, 5)$
$C(x, y, z) = \sum m(1, 3, 5, 7)$

The k map for A

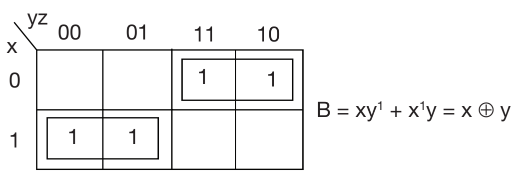


The k map for C



Choice (D)

9. $B(x, y, z) = \sum m(2, 3, 4, 5)$



2 input XOR required 5 NOR gates. Choice (C)

10. a, b are inputs of 2's complementer, and x, y are the outputs.
So truth table is

a	b	x	y
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	1

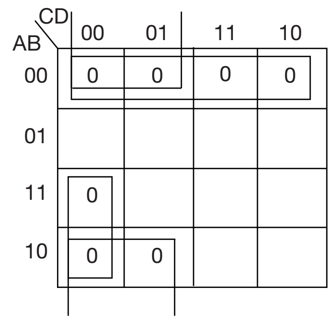
$x = a^1b + ab^1 = a \oplus b$
$y = b$ Choice (D)

11. Output of XNOR $= a \odot b = a^1b^1 + ab$
Output of XOR $= [a \odot b] \oplus c =$
Output of NOR gate $= [a \odot b \oplus c + (a \odot b)]^1$
$(x \oplus y + x) = x^1y + xy^1 + x = x + y$
$[(a \odot b) \oplus c + (a \odot b)]^1 = (a \odot b + c)^1$
$= (a \odot b)^1 \cdot C^1 = (a \oplus b)\, c^1 = a^1bc^1 + ab^1c^1$
Choice (B)

12. 5 to 32 line decoder will have 32 output lines
So 4, 3 to 8 line Decoders are required, these 4 decoders will be selected by one 2 to 4 lines decoder.
So 4, 3 to 8 line decoder and 1, 2 to 4 line decoder
(or)
5 to 32 line decoder will have 32 output lines
So 8, 2 to 4 line Decoders are required, to select one of these 8, one 3 to 8 line Decoder is required.
8, 2 to 4 Decoders, and 1, 3 to 8 Decoder. Choice (B)

13. For even number of 1's parity bit is 0.
So even parity,
Even parity can be implemented by XOR gate
XOR of even 1's given output 0.
XOR of add 1's gives output 1.
So parity bit $P = w \oplus x \oplus y \oplus z$
$P = \sum m(0001,\ 0010,\ 0100,\ 0111,\ 1000,\ 1011,\ 1101,\ 1110)$
$= \sum m(1, 2, 4, 7, 8, 11, 13, 14)$ Choice (A)

14. $f_1(A, B, C, D) = AC + BD$
$= AC(B + \bar{B})(C + \bar{C}) + (A + \bar{A})(C + \bar{C})BD$
$= \sum m(5, 7, 10, 11, 13, 14, 15)$
$= \Pi M(0, 1, 2, 3, 4, 6, 8, 9, 12)$
$f_2 = \sum m(4, 5, 6, 7, 10, 11, 14, 15)$
$= \Pi M(0, 1, 2, 3, 8, 9, 12, 13)$
$f_1 + f_2 = \Pi M(0, 1, 2, 3, 8, 9, 12)$ [common max terms of f_1 and f_2]

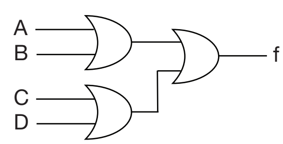


$f_1 + f_2 = (A + B)\,(B + C)\,(A + C + D)$ Choice (B)

15. The final carry we will get after n times of the delay of the carry of each full adder. But sum has more propagation delay. To get the carry of last but one, stage (C_{14}) we required $15 \times t$ carry $= 15 \times 15 = 225$ ns
The next carry C_{15} we get after another 15 ns, but sum S_{15} we get after another 18 ns (= 243 ns)
The worst delay $= (n - 1)t_{carry} + t_{sum} = (16 - 1) \times 15 + 18$
$= 243$ Choice (A)

16. Choice (C)

17.



Each 2 input OR gate required 3–2 input NAND gates
So total 9 NAND gates are required. Choice (D)

18. $\dfrac{(302)_r}{(20)_r} = (12.1)_r$

Convert to decimal number system

$$\frac{3r^2 + 0r^1 + 2r^0}{2r^1 + 0 \cdot r^0} = 1r^1 + 2r^0 + 1\frac{1}{r}$$

$$-\frac{3r^2 + 0 \cdot r^1 + 2 \cdot r^0}{2r^1 + 0 \cdot r^0} = 1 \cdot r^1 + 2 \cdot r^0 + 1 \cdot \frac{1}{r}$$

$$\frac{3r^2 + 2}{2r} = r + 2 + \frac{1}{r} \Rightarrow 3r^2 + 2 = 2r^2 + 4r + 2$$

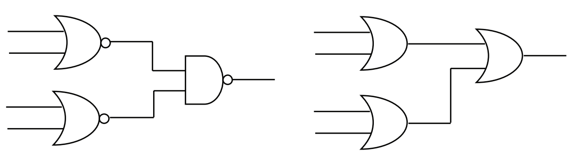
$\Rightarrow \quad r^2 = 4r \Rightarrow r = 0$ or 4
$r = 4$ is valid Choice (C)

19. $P = FB8A = 1111101110001010$
$8P = 2^3\ P \to P$ shifted to left by 3 bits,
$8P = 1101\ 1100\ 0101\ 0000$
$= (DC50)_{16}$ Choice (D)

20. If $A(a_3\ a_2\ a_1\ a_0)$ and $B(b_3\ b_2\ b_1\ b_0)$ are the two inputs the $A < B$ is possible only when the bits in A are 0 and the bits in B are 1. So we can check MSB by using $a_3^1 b_3$, if the MSB bits are equal, then we check next bits $(a_3 \odot b_3)\ a_2^1\ b_2$ and if the higher order bits are equal then we move to next bits so $(A < B) = a_3^1 b_3 + (a_3 \odot b_3)$ $a_2^1 b_2 + (a_3 \odot b_3)\ (a_2 \odot b_2)\ a_1^1 b_1 + (a_3 \odot b_3)(a_2 \odot b_2)$ $(a_1 \odot b_1)\ a_0^1\ b_0$. Choice (C)

21. $a + b + c = 1$
$ab = 0 \to$ by substituting in 4th equation
$ab + \bar{c}\bar{d} = 0 \Rightarrow 0 + \bar{c}\bar{d} = 0 \Rightarrow \overline{c + d} = 0$
$\Rightarrow \quad c + d = 1$
$ac + d = 1 \Rightarrow (a + d)\ (c + d) = 1$
already $c + d = 1$ so $a + d = 1$
So we have now $a + b + c = 1$, $ab = 0$, $c + d = 1$, $a + d = 1$ by verification option (A) is valid for all the four equations. Choice (A)

22. NOR–NAND is equivalent to OR-OR



So output of 1st NOR-NAND structure $= A + B + C + A$
$= A + B + C$

Similarly output of 2nd NOR-NAND structure
$= A + B + C$
So output $F = \overline{A + B + C}$ Choice (D)

23. We can verify by writing the min terms

(P) $\bar{A}\bar{B}\bar{D} + \bar{A}B\bar{C} + \bar{A}CD + A\bar{C}D + BD$
00X0 010X 0X11 1X01 X1X1
$\Sigma m(0, 2, 3, 4, 5, 7, 9, 13, 15)$

(Q) $\bar{A}\bar{C}\bar{D} + \bar{A}\bar{B}C + A\bar{C}D + BD$
0X00 001X 1X01 X1X1
$\Sigma m(0, 2, 3, 4, 5, 7, 9, 13, 15)$

(R) $\bar{A}\bar{B}\bar{D} + \bar{A}B\bar{C} + BCD + A\bar{C}D$ 00X0, 010X, X111, 1X01
$\Sigma m(0, 2, 4, 5, 7, 9, 13, 15)$ – min term 3 missing

(S) $\bar{A}\bar{B}\bar{D} + \bar{A}CD + ABD + A\bar{C}D$ 00X0, 0X11, 11X1, 1X01
$\Sigma m(0, 2, 3, 7, 9, 13, 15)$ – min terms 4, 5 missing.
Choice (D)

24. Choice (A)

25. Two octates present so minimized expression is $\bar{A} \cdot B$

CD \ AB	00	01	11	10
00	0		X	X
01	X		X	X
11	0		0	0
10	0		0	0

Choice (B)