

**CEL & ETL – Analog and  
Digital Systems**

**T005**

**Friday, 31/10/2014**

**01:30 - 04:30 PM**

**WORKFORCE DEVELOPMENT AUTHORITY**



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**ADVANCED LEVEL NATIONAL EXAMINATIONS, 2014  
TECHNICAL AND PROFESSIONAL TRADES**

**EXAM TITLE: Analog and Digital Systems**

**OPTIONS:**

- **Computer Electronics (CEL)**
- **Electronics and Telecommunication (ETL)**

**DURATION: 3hours**

**INSTRUCTIONS:**

The paper consists of **three (3) Sections** :

Section I: Fourteen **(14)** questions, all **Compulsory**. **55marks**

Section II: Five **(5)** questions, **Choose any Three (3)**. **30marks**

Section III: Three **(3)** questions, **Choose any One (1)**. **15marks**

**SECTION I. FOURTEEN (14) COMPULSORY QUESTIONS.**

01. Find the canonical form of the following Boolean expression :

$$F(A,B,C) = AB + BC.$$

**3marks**

02. Design a D flip-flop from a J-K flip-flop.

**2marks**

03. What should be done to unused inputs on TTL gates?

**5marks**

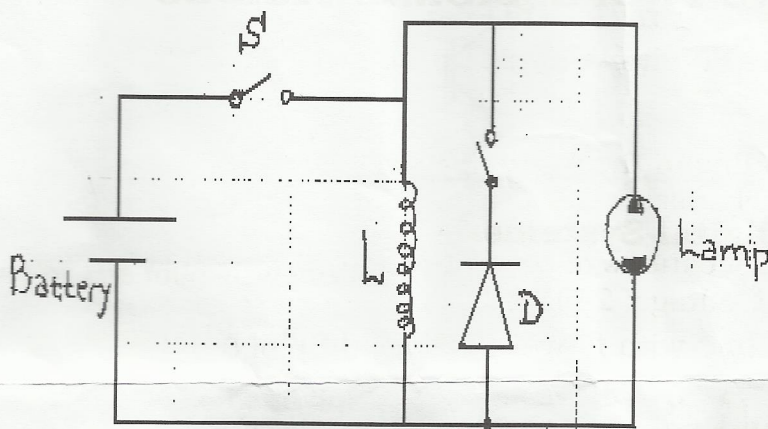
04. Which functions a GTO gate drive circuit has to fulfill?

**4marks**

05. Identify two (2) different methods to represent basic logic functions.

**2marks**

06. Explain the functioning of the following circuit by turning ON and switch off quickly that circuit :



a) Without diode;

b) With diode mounted.

**4marks**

07. Identify the component of a typical transducer measurement system bloc (output digital).

**5marks**

08. Identify the components of the 555 timer.

**5marks**

09. Identify any five (5) methods of thyristor turn on.

**5marks**

10. Specify two (2) different methods of voltage control inverters.

**2marks**

11. Describe the function of freewheeling diode in a controlled rectifier circuit.

**3marks**

12. Identify any five (5) characteristics of an amplifier that are modified by negative feedback.

**5marks**

13. Simplify the following expression using Boolean algebra technique

$$Z = AB + A(B + C) + B(B + C).$$

**5marks**

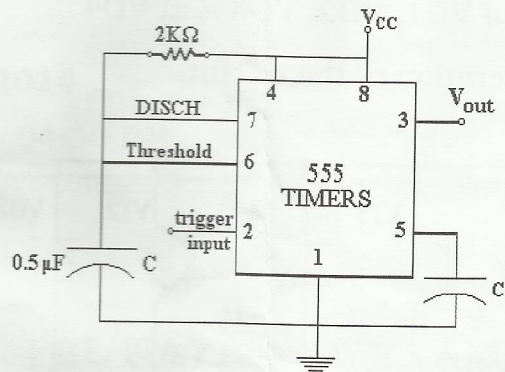
14. Identify five (5) applications of AC voltage controllers.

**5marks**

**SECTION II. ATTEMPT ANY THREE (3) QUESTIONS.**

15. a) Find the period (in msec) of the output pulse in the circuit shown below and give a name at this circuit.

**5marks**



- b) Show how a full adder may be implemented by using two half adders.

**5marks**

16. Describe the basic operation of a single-slope analog to digital converter.

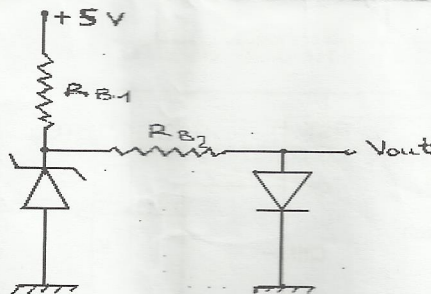
**10marks**

17. Identify the logic families according to the technology they are built with and specify which family is widely used.

**10marks**

18. In the following circuit, the specifications of zener diode at 25°C are: (1°) bias current: 10mA; (2°) output voltage: 2495mV

The diode is forward biased at 2mA with forward voltage drop of 0.55V;



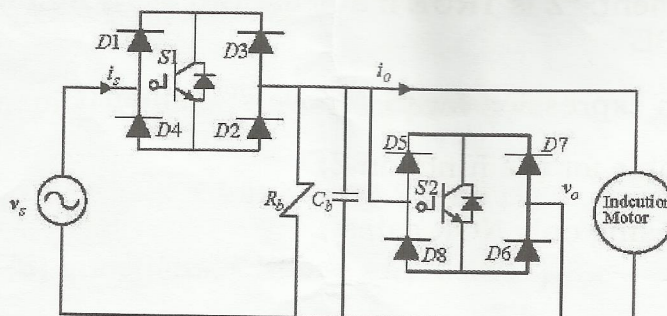
Determine  $R_{B1}$  and  $R_{B2}$  and select both values of resistors from the list of 1% decade values.

**10marks**

19. a) For the circuit below, determine the function performed; the role of S1, Rb, Cb and S2.

- b) Determine different modes of operation of that circuit.

**10marks**

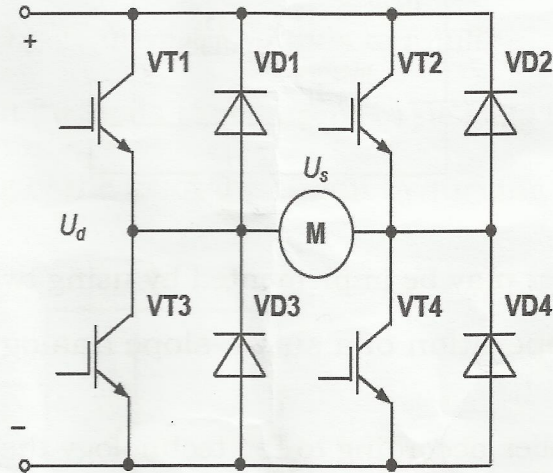


**SECTION III. ATTEMPT ANY ONE (1) QUESTION.**

**20.** Consider the circuit below and answer to the following questions :

- Determine the type of circuit and its characteristics
- What is the function of VD1, VD2, VD3 and VD4
- Explain briefly the operation of the circuit.

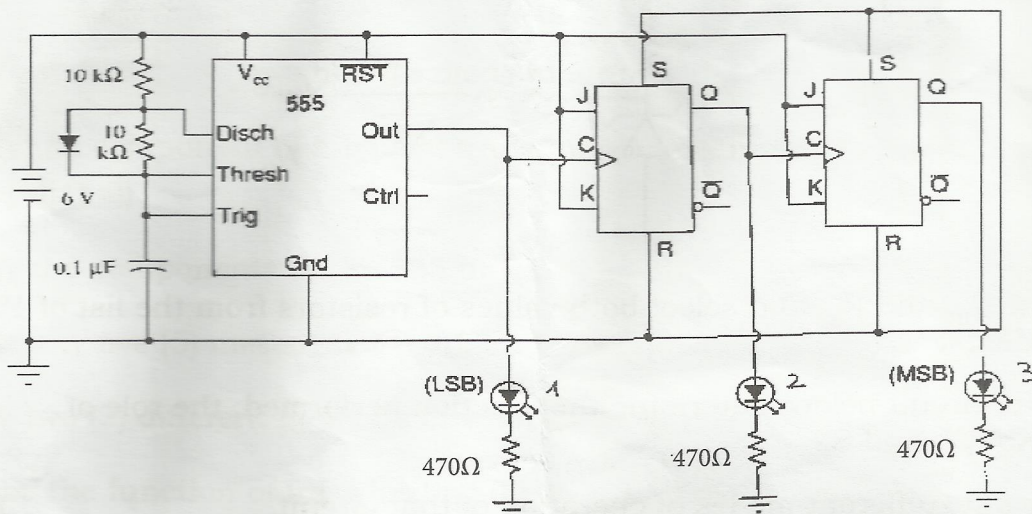
**15marks**



**21.** For the following circuit,

- Identify the main functional parts.
- Study the behavior.

**15marks**



**22.** Consider the statement: "Z is TRUE if at least two of W, X and Y are TRUE", otherwise Z is FALSE".

- Write a Boolean expression for the above statement.
- Write a truth table for the function Z;
- Implements Z using only NOR gates.

**15marks**

# SECTION I.

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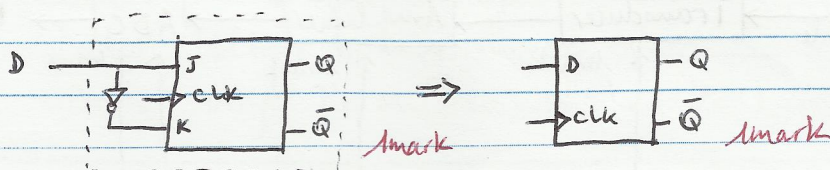
01.  $F(A, B, C) = AB + BC$

canonical form:

$$\begin{aligned}
 AB + BC &= AB(C + \bar{C}) + (A + \bar{A})BC && \text{1 mark} \\
 &= ABC + AB\bar{C} + ABC + \bar{A}BC && \text{1 mark} \\
 F(A, B, C) &= ABC + AB\bar{C} + \bar{A}BC && \text{1 mark}
 \end{aligned}$$

3 marks

02. D Flip-Flop from a J-K Flip-Flop.



1 mark

1 mark

2 marks

03. • Unused AND & NAND inputs should be tied to  $V_{cc}$  through a 1k $\Omega$  resistor 1 mark
- Unused OR & NOR inputs should be grounded. 1 mark

5 marks

04. GTO gate drive circuit has to fulfill the following functions:

- 1) Turn ON the GTO 1 mark
- 2) Turn OFF the GTO 1 mark
- 3) Maintain conduction 1 mark
- 4) Reinforce the blocking 1 mark

4 marks

05. Methods to represent basic logic functions are:

- Truth table 1 mark
- Boolean algebra expression 1 mark
- Traditional graphic logic symbols 1 mark
- Timing diagrams 1 mark
- Logical statement 1 mark

choose only two

2 mark

06. a) without diode :

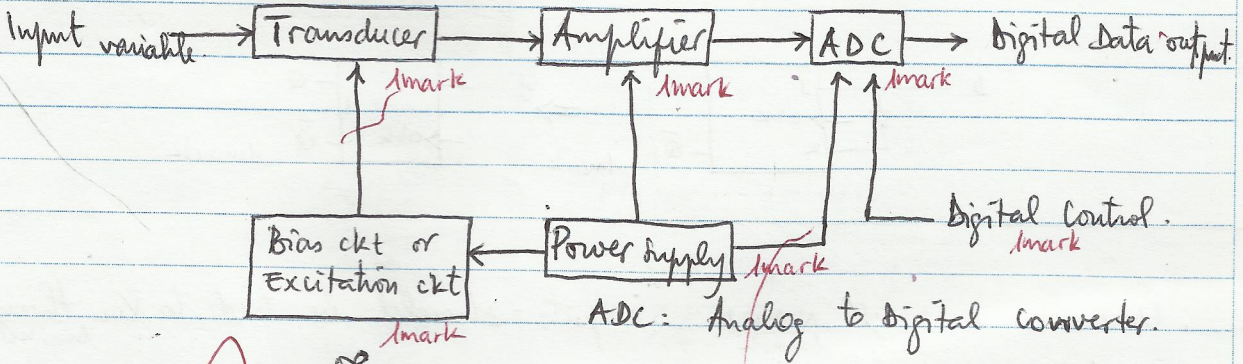
when the switch is opened after it was closed, the lamp will flash from the effect of inductive kick back

b) With diode mounted

Quickly close and open the circuit, this time the lamp will not flash, because the diode eliminates the kick back effect creating a short circuit for the lamp.

4 marks.

07.



- OR
- 1) Transducer 1 mark
  - 2) Amplifier 1 mark
  - 3) A.D.c 1 mark
  - 4) Power supply 1 mark
  - 5) Bias circuit or excitation circuit 1 mark
  - 6) digital control 1 mark

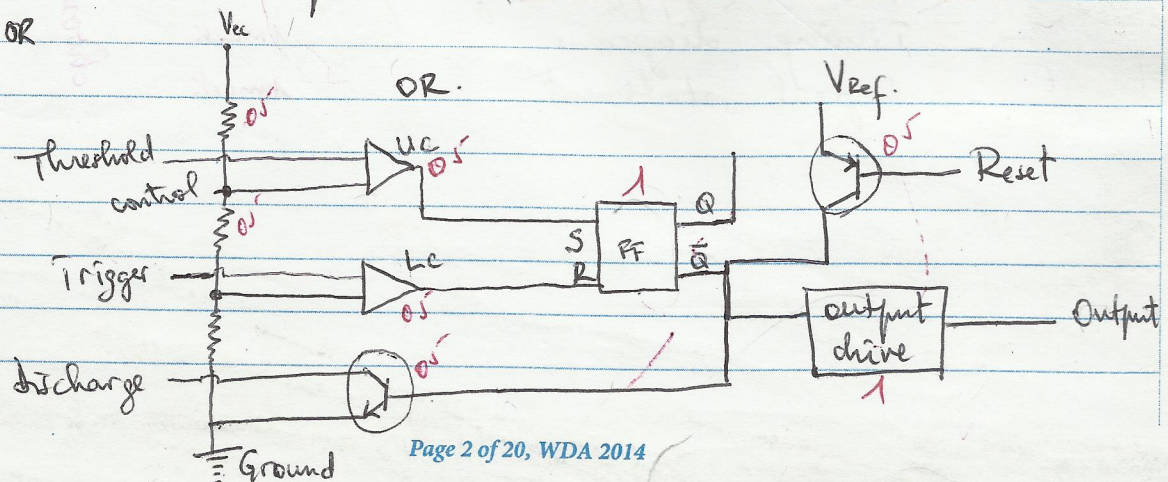
choose only five

5 marks.

08. Components of 555 timer

- Resistors (3) 1 mark
- Comparators (2) 1 mark
- Transistors (2) 1 mark
- Flip Flop (1) 1 mark
- output drive (1) 1 mark

5 marks.



9. Thyristor turn on methods :

- Forward voltage triggering 1mark
- Gate triggering 1mark
- Temperature / thermal triggering 1mark
- light triggering 1mark
- $dv/dt$  triggering 1mark

5marks

10. Methods of voltage control inverters :

- Control DC input voltage 1mark
- Control AC output voltage 1mark
- Control voltage within inverter 1mark
- Control using PWM (pulse width modulation) 1mark

Choose only two

2marks

11. The function of freewheeling diode :

- It prevents the output voltage from becoming negative 1mark
- The load current is transferred from the main thyristors to the freewheeling diode, thereby allowing all of its thyristors to regain the main blocking states. 1mark

3marks

12. Characteristics of an amplifier modified by negative feedback :

- Sensitivity of transfer characteristics 1mark
- Non linear distortion 1mark
- Frequency ~~distortion~~ response (harmonic) 1mark
- Noise 1mark
- Bandwidth 1mark
- Input & output impedance of amplifiers. 1mark
- Gain of voltage 1mark

Choose only five

5marks

13.  $Z = AB + A(B+C) + B(B+C)$

$$= AB + AB + AC + BB + BC \quad 1mark \quad BB = B$$

$$= AB + AC + B + BC \quad 1mark$$

$$= AB + AC + B(1+C) \quad 1mark \quad \because B(B+C) = B \cdot 1 = B$$

$$= B(A+1) + AC + 1mark \quad \because A+1 = 1$$

$$= B + AC \quad 1mark$$

5marks

14. Applications of voltage controllers :

- Lighting (dimmer) 1mark
- Induction motor 1mark
- Inverters 1mark
- Automatic voltage Regulator (AVR) compensation 1mark
- Aircraft 1mark

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5marks.

SECTION II.

15. a) The name of given circuit is : Monostable multivibrator 2marks

- The period of output pulse :

$$T = 1.1 \cdot RC = 1.1 \times 2 \times 10^3 \times 0.5 \times 10^{-6}$$

1mark =  $1.1 \times 10^3 \text{ sec.}$  1mark

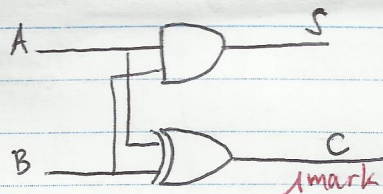
=  $1.1 \text{ msec.}$  1mark

b) Construction of Full adder from two Half adders :

- Half adder : Truth table

i/p		o/p	
A	B	S	C
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

logical circuit of Half adder



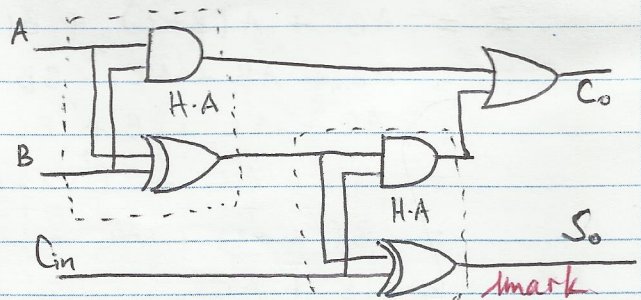
Sum (S) =  $A \oplus B$  1mark

Carry (C) =  $AB$

- Full adder is a combination of two Half adders :

i/p			o/p	
A	B	Cin	So	Co
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

logical circuit of full adder



Sum (So) =  $A \oplus B \oplus Cin$  1mark

Carry (Co) =  $AB + Cin(A \oplus B)$  1mark

Note: The final circuit merits all marks.

10marks



16. Single-slope Analog to Digital Converter :

A ramp generator is used to enable a counter through the comparator. When the ramp voltage equals to the input voltage, the counter is latched and then reset. The counter reading is proportional to the input voltage since the ramp is changing at a constant voltage per second rate.

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10mark

Q17. The logic families are :

- |                       |   |  |       |                      |
|-----------------------|---|--|-------|----------------------|
| Bipolar logic family  | - | RCIL: Resistor capacitor Transistor logic                              | 1mark | } Choose only eight. |
|                       | - | DC TL: Direct coupled Transistor logic                                 | 1mark |                      |
|                       | - | RTL: Resistor Transistor logic   | 1mark |                      |
|                       | - | DTL: Diode Transistor logic  | 1mark |                      |
|                       | - | HTL: High Threshold logic  | 1mark |                      |
|                       | - | TTL: Transistor Transistor logic                                       | 1mark |                      |
|                       | - | I <sup>2</sup> L: Integrated Injection logic (merged Transistor logic) | 1mark |                      |
|                       | - | STTL: Schottky Transistor Transistor logic                             | 1mark |                      |
| Unipolar logic family | - | MOS (n-mos & p-mos): Metal oxide semiconductor                         | 1mark | } 10marks            |
|                       | - | CMOS: Complement metal oxide semiconductor                             | 1mark |                      |
- The widely used family is MOS. 2marks.

18. We determine I through R<sub>B1</sub> :

$$I = I_Z + I_D = 10 + 2 = 12 \text{ mA} \quad \text{1mark}$$

$$R_{B1} = \frac{E - V_Z}{I} = \frac{5 - 2.495}{0.012} = 208 \Omega \quad \text{1mark}$$

$$R_{B2} = \frac{V_Z - V_D}{I_D} = \frac{2.495 - 0.55}{0.002} = 972.5 \Omega \quad \text{1mark}$$

In list of 1% decade values :

$$R_{B1} = 208 + (208 \times 1\%) = 210 \Omega \quad \text{1mark}$$

$$R_{B2} = 972.5 + (972.5 \times 1\%) = 982 \Omega \quad \text{1mark}$$

10marks

19. a) \* The function performed is to control (run) the motor in two directions (forward & reverse). 1mark

\* Role of:

S<sub>1</sub>: Switching device used in forward direction 1mark

S<sub>2</sub>: Switch which control the reverse motion 1mark

R<sub>b</sub>: (Resistor used for) regulation of voltage or protection

C<sub>b</sub>: Shunt filter. 1mark against overcurrent 1mark

b) Modes of operation: - Forward operation 2marks  
- Reverse operation 2marks

### SECTION III

20. a) The type of the circuit is: - H-bridge

- Inverter 2marks

- DC motor direction control

Characteristics: - 4 switches: V<sub>T1</sub>, V<sub>T2</sub>, V<sub>T3</sub>, V<sub>T4</sub>. 1mark

- Two diagonal switches work simultaneously i.e. V<sub>T1</sub> + V<sub>T4</sub> and V<sub>T2</sub> + V<sub>T3</sub>. 1mark

- The source power is DC signal 1mark

- The output power is AC signal (square wave) 1mark

- It has 4 protective diodes (V<sub>D1</sub>, V<sub>D2</sub>, V<sub>D3</sub>, V<sub>D4</sub>) 1mark

b) The function of V<sub>D1</sub>, V<sub>D2</sub>, V<sub>D3</sub>, V<sub>D4</sub>: is for protection of switches against back voltage 2marks

c) According to shown polarities, when the gate signals are applied correctly, V<sub>T1</sub> & V<sub>T4</sub> will run the motor M in forward direction. In this case V<sub>T2</sub> & V<sub>T3</sub> are off. 1mark

After V<sub>T1</sub> & V<sub>T4</sub> are switched OFF by removing the gate signal, then V<sub>T2</sub> & V<sub>T3</sub> will be switched ON by triggering them. This means that the motor will run in reverse direction. 1mark

OR

Forward motion (direction): + V<sub>T1</sub> → M → V<sub>T4</sub> → - 1mark 1mark 1mark

Reverse motion: + V<sub>T2</sub> → M → V<sub>T3</sub> → - 1mark 1mark 1mark

5 marks

5 marks

15 marks

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21. a) Main functional parts:

- clock pulse generator with 555 IC 1mark
- Modulo 4 Counter with J-K FF 1mark
- Display unit : LED 1mark
- Power supply : 6V 1mark

b) Circuit behavior:

- The 555 timer (IC) powered generates pulses. 1mark
- The pulses are applied on the 1<sup>st</sup> J-K FF which is connected as a divider 2, then it will change state when it receives a pulse. The output of 1<sup>st</sup> FF is used as clock pulse for the second Flip Flop which is also connected as divider 2. It will change state also when it receives clock pulse from JK Flip Flop 1. 1mark
- The LED<sub>2</sub> & LED<sub>3</sub> show the state of FF<sub>s</sub>. 1mark
- The LED<sub>1</sub> shows frequency of pulse generator. 1mark
- The circuit is an asynchronous counter. (ripple) 1mark

15 marks

22. a) boolean expression:  $\bar{W}xy + W\bar{x}y + Wx\bar{y} + Wxy$ . 1mark 1mark 1mark 1mark

b) Truth table:

W	X	Y	Z
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

c) Simplify Boolean expression (Using K-map)

	xy	00	01	11	10
w	0			1	
	1		1	1	1

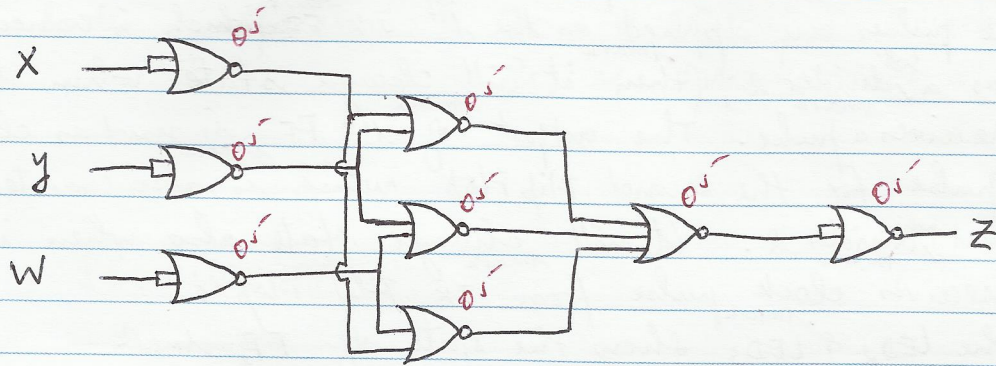
$Z = xy + w\bar{y} + wx$ . 1mark.

Implementation using NOR gates.

$$Z = \overline{\overline{xy + wx + wz}} \quad \text{1 mark}$$

$$= \overline{(\overline{x+y})(\overline{w+y})(\overline{w+x})} \quad \text{1 mark}$$

$$= \overline{\overline{x+y}} + \overline{\overline{w+y}} + \overline{\overline{w+x}} \quad \text{1 mark}$$



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15 marks