CEL&ETL - Analog and Digital Systems
T005
Friday, 13/11/2015
14:00 – 17:00

WORKFORCE DEVELOPMENT AUTHORITY
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ADVANCED LEVEL NATIONAL EXAMINATIONS, 2015, TECHNICAL AND PROFESSIONAL TRADES

EXAM TITLE: **Analog and Digital Systems**

OPTIONS: **- Computer Electronics (CEL)**

- Electronics and Telecommunication ETL)

DURATION: **3hours**

INSTRUCTIONS:

The paper is composed of **three (3) Sections**:

Section **I**: Fifteen **(15)** questions, all **Compulsory**. **55marks**

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

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

Every candidate is required to strictly obey the above instructions. Punishment measures will be applied to anyone who ignores these instructions.

Section I. Fifteen (15) Compulsory questions. **55marks**

01. What are the names of three terminals from the figure 1? **2marks**

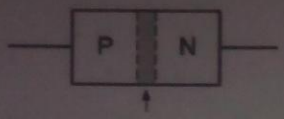


Figure 1

02. Divide 11011_2 by 100_2 **4marks**

03. Distinguish the four systems of arithmetic which are often used in digital circuits. **4marks**

04. Give the principal three types of multivibrators. **3marks**

05. Find the Boolean expression for the output of figure 2 and compute its value when A = B = C = 1 and X = 0 **5marks**

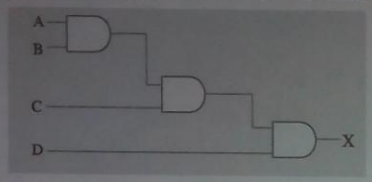


Figure 2

06. What are the three important classes of devices used to build digital electronic systems? **3marks**

07. List out the two broad categories of logic devices. **2marks**

08. Give the composition of a programmable logic array (PLA) device. **3marks**

09. Identify the two types of counters. **4marks**

10. Based on the method used to load data onto and read data from shift registers, classify them. **6marks**

11. Determine the number of flip-flops required to construct:

i. a MOD-10 ring counter,

ii. a MOD-10 Johnson counter. **6marks**

12. Draw a binary ladder network as the most widely used network for digital-to-analogue conversion. **4marks**

13. List the types of D/A Converters. **3marks**

14. Define a microprocessor. **2marks**

15. Depending upon the nature of the memory cell used, there are two types of RAM, what are them. **4marks**

Section II. Answer any three (3) questions of your choice (Do not choose more than three questions). **30marks**

16. i) A shunt motor runs 500r.p.m on a 200V circuit. Its in armature resistance is 0.5Ω and the current taken is 30A in addition to field current. What resistance must be placed in series in order that the speed may be reduced to 300r.p.m? The current in armature remains the same.

ii) A 500V shunt motor runs at its normal speed of 250r.p.m when the armature current is 200A.The resistance of armature is 0.12Ω.

Calculate the speed when a resistance is inserted in the field reducing the shunt field to 80% of normal value, and the armature current is 100A. **10marks**

17. a) Define rectification.

b) Design a half wave voltage rectifier circuit.

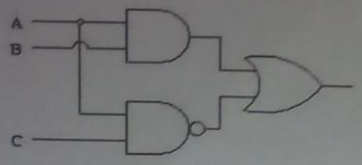
c) From the circuit you designed in (b) calculate V_{DC}.

d) How do we call the following electronic circuits?

i) A circuit that converts DC to AC

ii) A circuit that convert DC to DC **10marks**

18. (a) Write the Boolean expression for the circuit below.



(b) Draw the logic circuit diagram for this expression Y= (A + B) C. Draw the truth table for each logic gate you used in the circuit diagram. **10marks**

19. (a) A pressurized tank must maintain a gas at 325psi. A pressure sensor is used to measure the condition of the controlled variable. As the gas cools, the pressure in the tank decreases. When it drops to 300 psi, a valve is opened, which allows steam to flow to a heat exchanger inside the tank. The additional steam heats the gas and causes the pressure to rise. **4marks**

i) What is the controlled variable in this process?

ii) What is the manipulated variable in this process?

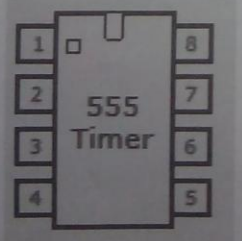
iii) What is the set point?

iv) What is the measured variable?

(b) What is the difference between a set point and a feedback signal? **10marks**

(c) List two examples of controlled variables for motion control applications and two examples for process control applications. **4marks**

20. a) Name the pins of 555 timer as they are respectively shown on the diagram below.



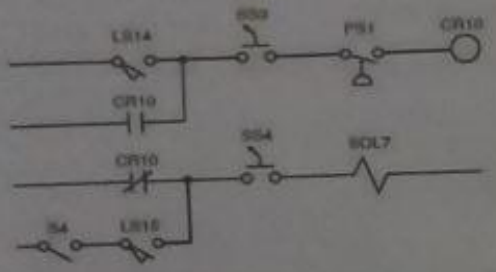
b) Monostable 555 Timer is required to produce a time delay within a circuit. If a 10uF timing capacitor is used, calculate the value of the resistor required to produce a minimum output time delay of 500ms. **10marks**

Section III. Answer any one (1) question of your choice (Do not choose more than one question). **15marks**

21. Using the circuit shown in Figure below and starting inputs at address 10_8, outputs at address 50_8, and internals at address 100_8:

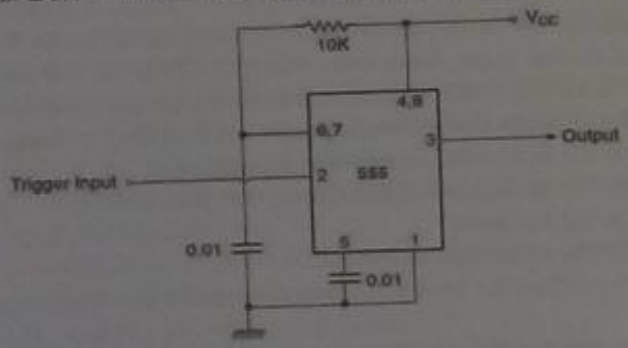
(a) Assign the I/O addresses;

(b) Draw the equivalent PLC ladder diagram



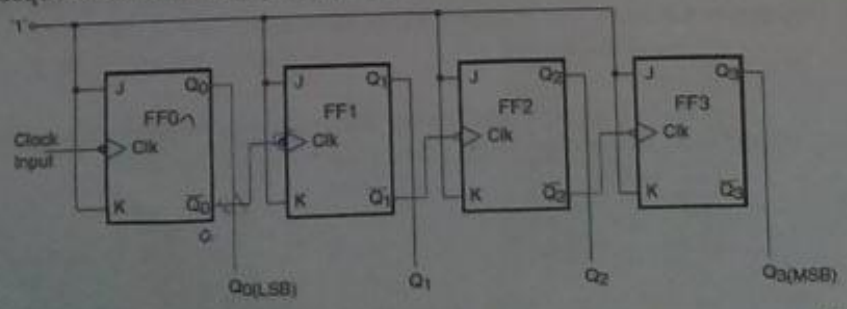
15marks

22. Consider the Monostable multivibrator circuit in Fig. below. The trigger terminal (pin 2 of the IC) is driven by a symmetrical pulsed waveform of 10 kHz. Determine the frequency and duty cycle of the Output waveform.



15marks

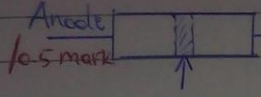
23. Refer to the binary ripple counter arrangement of Fig. below. Write its count sequence if it is initially in the 0000 state. Also draw the timing waveforms.



15marks

SECTION I

Q1)



/0.5 mark /0.5 mark

depletion region / layer / 1mark

2 ma

Q2)

11011	100
-100 / 101	110.11_2 / 1mark
/1mark -100 / 011	
-000 / 011	
/1mark -100 / 110	
-100 / 100	
-100 / 000	
/1mark	

4 ma

Q3) Four systems of arithmetic which are often used in digital circuits are:

* Decimal number / 1mark
* Binary number / 1mark
* octal number / 1mark
* Hexadecimal number / 1mark

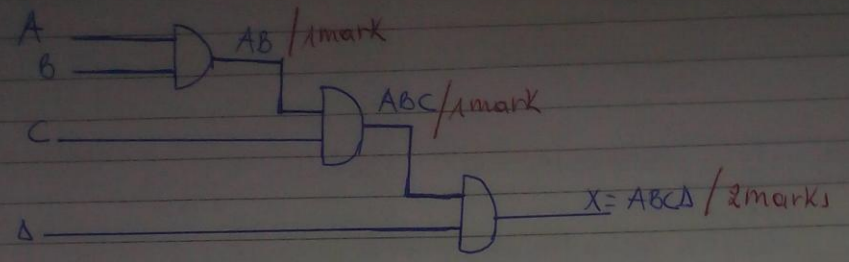
4 ma

Q4) 3 types of multivibrators are:

- Monostable multivibrator (one shot) / 1mark
- Bistable multivibrator / 1mark
- Astable multivibrator (Free running) / 1mark

3 ma

Q5) The boolean expression for the figure below:



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Find the value when A=B=C=D and X=0

X= ABCD
0 = 1.1.1.D
D = 0 /1mark

or [(AB)C]D = X. /4 marks

5 marks

Q6) The three important classes of devices used to build digital electronics systems are:
- logic devices /1mark
- Memory devices /1mark
- Microprocessors /1mark

3marks

Q7) The two categories of logic devices are:
- programmable logic devices or sequential devices/1mark
- Fixed logic or combination devices/1mark

2marks

Q8) Composition of a programmable - logic array (PLA) devices are:
- Input/0.5mark
- programmable AND array /1mark
- programmable OR array/1mark
- output/0.5mark

3marks

Q9) - Ripple (Asynchronous/serial) counter/2marks
- synchronous or parallel counter /2marks

4marks

Q10) The method used to load data onto and read from shifts registers are:

- SIPO: Serial input parallel output /1.5 marks
- SISO: Serial input ~~parallel~~ Serial out put /1.5 marks
- PISO: parallel input serial out put /1.5 marks
- PIPO: parallel input parallel out put /1.5 marks

6m

Q11) The number of flip-flop required to construct:

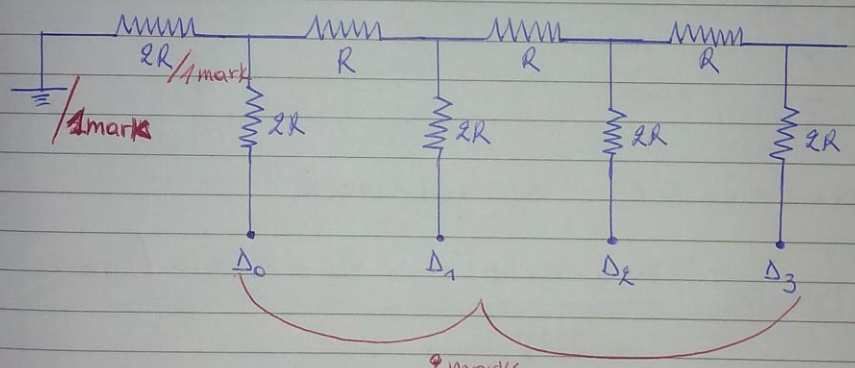
i) a MOD-10 ring counter is = 10 /3marks

ii) a MOD-10 Johnson counter is = 5 /3marks

6m

5 marks

Q12) Binary Ladder network used to convert digital to analogue is:



1mark

3marks

2marks

4ma

Q13) The types of D/A converters are:

- Multiplying system D/A Converter /1mark
- Bipolar output D/A Converter /1mark
- Companding D/A Converter /1mark

3marks

3ma

Q14) A microprocessor is a programmable device that accepts binary data (0.5 mark) from an input device processes, the data according to the instruction stored (0.5 mark) in the memory and provides (result as output). In other word (0.5 mark) the microprocessor

4marks

0.5 mark

executes the program stored in the memory and transfers data to and from the outside world through input output path. 1mark 1mark

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2 marks

Q15) The two types of RAM are:

- SRAM (Static Random Access Memory) /2marks
- DRAM (Dynamic Random Acess Memory) /2marks

4marks

SECTION II

Q16) i) since Field Current remains the same

$$\phi_2 = \phi_1 \quad /1\text{mark}$$

$$\frac{N_2}{N_1} = \frac{E_{b2}}{E_{b1}} \quad /1\text{mark}$$

$$E_{b_1} = 200V - (0.5 \times 30A) = 185V. \quad /1\text{mark}$$

$$300\text{rpm}/500\text{rpm} = \frac{(200V - 30R_t)}{185} \Rightarrow R_t = 2.97\Omega \quad /1\text{mark}$$

Addition resistance required = $2.97 - 0.5 = 2.47\Omega$ /1mark

~~ii) $E_{b_1} = V_t I_{a_1}$ $R_a = (500/200) \times 0.1\Omega = 0.76\Omega$~~

ii) $\phi_2 = \frac{80\phi_1}{100} = 0.8\phi_1$

$$\frac{N_2}{N_1} = \frac{E_{b2}}{0.8E_{b_1}} \quad /1\text{mark}$$

$$E_{b_1} = V - I_{a_1} \times R_a$$

$$E_{b_1} = 500 - (200 \times 0.1\Omega) = 476V \quad /1\text{mark}$$

$E_{b2} = V - I_{a2} \times R_a$

$E_{b2} = 500 - (100 \times 0.12)$

$E_{b2} = 500 - 12 = 488V$ /1mark

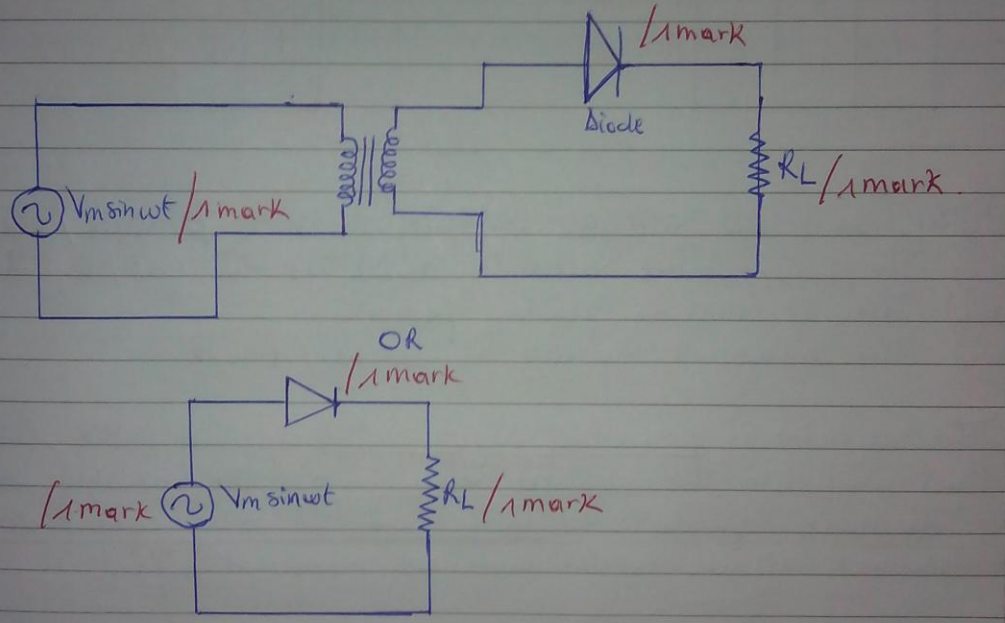
then $N_2 = \frac{N_1 \times E_{b2}}{0.8 E_{b1}} \Rightarrow N_2 = \frac{250 \times 488}{0.8 \times 476}$ /1mark

$N_2 = \frac{250 \times 488}{0.8 \times 476} = 320.38 rpm$ /1mark

10

Q17) a) Rectification is a process of converting from AC to DC by using rectifier (Diode). /2 marks

b)



OR

c) $V_{DC} = \frac{V_m}{\pi}$ /3marks where $V_m = V_{rms} \times \sqrt{2}$

where $V_m = V_{rms} \times \sqrt{2} - V_T$

OR

$V_{DC} = \frac{V_{rms} \times \sqrt{2} - V_T}{\pi}$ /3marks

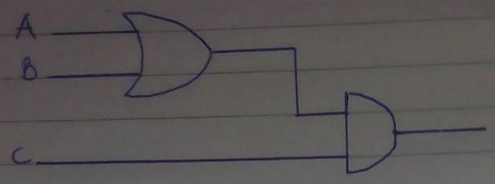
d) Conversion from DC to AC the circuit is called inverter circuit /1m

e) A conversion from DC to DC that circuit is called chopper circuit /1m

Q18) a) The boolean expression of the circuit below is:

$A = AB + \bar{A}C$ /3marks

b)



/3marks

OR Gate

A	B	A+B	
0	0	0	/0.5 mark
0	1	1	/0.5 mark
1	0	1	/0.5 mark
1	1	1	/0.5 mark

AND gate

A	B	AB	
0	0	0	/0.5 mark
0	1	0	/0.5 mark
1	0	0	/0.5 mark
1	1	1	/0.5 mark

/10 marks

Q19) a) i) The controlled variable in this process is pressure /1mark

ii) The manipulated variable ~~is this~~ is the gas /1mark

iii) The set point is 325 psi /1mark

iv) The measured variable is 300 psi /1mark

b) The set point is prescribed input value (0.5 mark) applied to the loop that indicates the desired condition of the variable, while the feedback signal is the output of the measurement device (0.5 mark), the feedback signal is the same as measured signal (1mark).

c) Example ~~of~~ for motion control :- position /1mark
- speed /1mark

Example for process control :- flow rate /1mark
- Temperature /1mark (only 2)
- pressure /1mark

/10marks

Q2c) a) pin 1: Ground /1mark
pin 2: Trigger /1mark
pin 3: output /1mark
pin 4: Reset /1mark
pin 5: Control voltage /1mark
pin 6: Threshold /1mark
pin 7: Discharge /1mark
pin 8: Supply (V_{cc}) /1mark

b) $T = 1.1 \cdot R_1 C_1$

$R = \frac{T}{1.1 \times C_1} = \frac{0.5}{1.1 \times 10 \times 10^{-6}} = 45.5\,k\Omega$ /1mark

/1mark

SECTION III

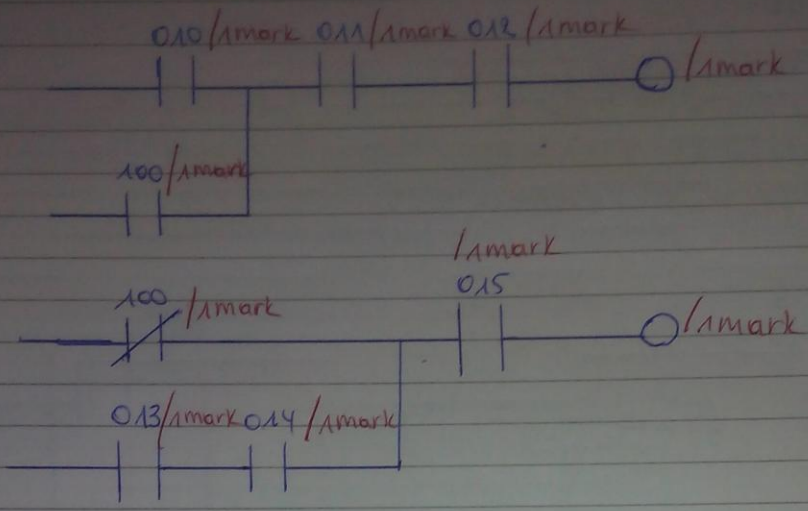
Q2i)

a) The I/O addresses

Module type	I/O addresses: Rock	Group	Terminal	Description
Input	0	1	0	LS14
	0	1	1	SS3
	0	1	2	PS1
	0	1	3	S4
	0	1	4	LS15
	0	1	5	SS4
	0	1	6	–
	0	1	7	–
output	0 ⋮	5 ⋮	0 ⋮	SOL 7
Internal	1	0	0	CR10

/1mark /1mark /1mark /1mark /1mark

b) The equivalent PLC ladder diagram



/15 marks

Q22) The frequency of the trigger wave form = 10kHz /1mark

$T_{trigger} = \frac{1}{f_{trigger}} = \frac{1}{10 \times 10^3} = 10^{-4}\,sec = 100\,\mu s$ /1mark

$T_{ON} = \underset{/1mark}{1.1}\,R.C = 1.1 \times 10^{4} \times 10^{-8} = 1.1 \times 10^{-4}\,sec = 110\,\mu s$ /1mark

Because we have symetrical pulse

$T_H = T_L$ /1mark

$T_H + T_L = T_{trigger}$

$T_L = \frac{T_{trigger}}{2\ /1mark} = \frac{10^{-4}}{2} = 0.5 \times 10^{-4}\,sec = 50\,\mu s$ /1mark

$f_{out} = \frac{f_{trigger}}{2\ /1mark} = \frac{10kHz}{2} = 5 \times 10^3\,Hz = 5kHz$ /1mark

$T_{out} = \frac{1}{f_{trigger}\ /1mark} = \frac{1}{5 \times 10^3} = 2 \times 10^{-4}\,sec = 200\,\mu s$ /2 marks

$d = \frac{T_{ON}}{T_{out}\ /1mark} = \frac{1.1 \times 10^{-4}}{2 \times 10^{-4}} = 0.55$ or $d = 55\%$ /2marks

/15 marks

Comments: The question number twenty-six

On this question the capacitor given doesn't have a unit. Reason why any student who will attempt it using formulas only will get maximum of marks.

(Q23)

pulses	Q_0	Q_1	Q_2	Q_3	
0	0	0	0	0	
1	1	1	1	1	1/0.5 mark
2	0	1	1	1	1/0.5 mark
3	1	0	1	1	1/0.5 mark
4	0	0	1	1	1/0.5 mark
5	1	1	0	1	1/0.5 mark
6	0	1	0	1	1/0.5 mark
7	1	0	0	1	1/0.5 mark
8	0	0	0	1	1/0.5 mark
9	1	1	1	0	1/0.5 mark
10	0	1	1	0	1/0.5 mark
11	1	0	1	0	1/0.5 mark
12	0	0	1	0	1/0.5 mark
13	1	1	0	0	1/0.5 mark
14	0	1	0	0	1/0.5 mark
15	1	0	0	0	1/0.5 mark
16	0	0	0	0	1/0.5 mark

The timing waveforms are shown below. Thus we have a four bit counter that counts in the reverse sequence, beginning with the maximum count. This is a down counter.

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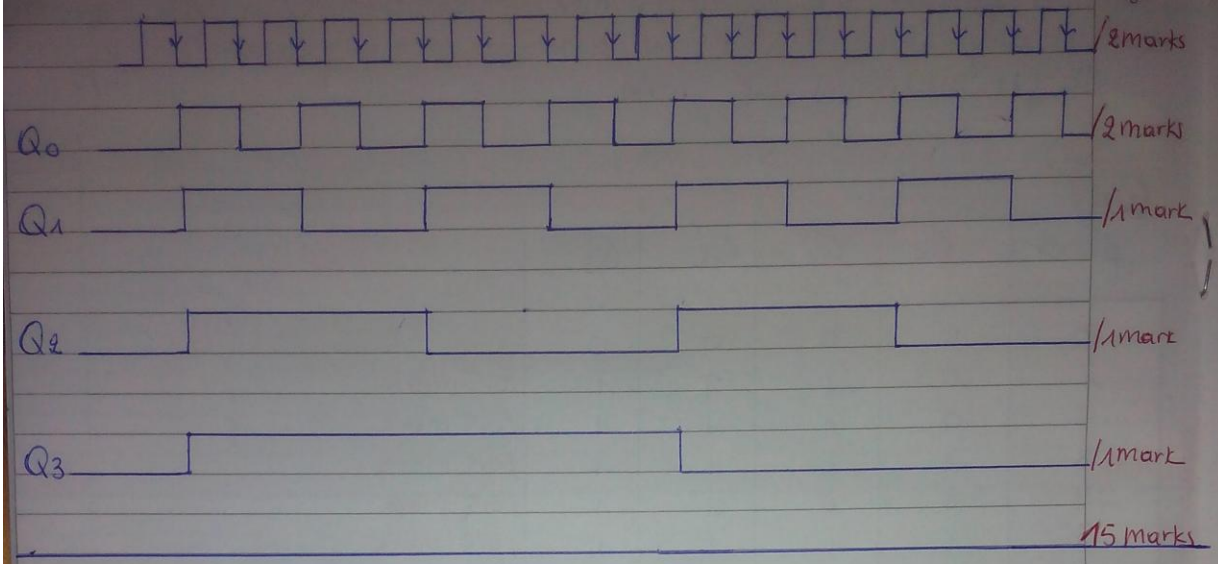

/2marks
/2marks
/1mark
/1mark
/1mark
/5 marks