GENERAL CERTIFICATE OF EDUCATION BOARD
Technical and Vocational Education Examination

JUNE 2025   KAWLO   **INTERMEDIATE LEVEL**

Specialty Name and Acronym	ELECTRONICS – ELN
Subject Title	Electronic Systems
Subject Code No.	5260
Paper No.	2

Duration: Three Hours

Answer Question One and Any Three Questions.

Show all the steps in your calculations giving your answer at each stage and indicating the units and symbols used.

All sketches must be neat and clear.

You are allowed to use non programmable calculators

You are reminded of the necessity for good English and orderly presentation in your answers.

THEME: ELECTRONIC CONTROL OF A PISTOL

The device uses electronics to eject a bullet. Generally, when the trigger of the pistol is activated, a pulse is generated to trigger a monostable multivibrator and to activate a buzzer. The output of the monostable serves as the control input of the the first astable multivibrator. The output of the first astable serves as the control input of the second astable multivibrator. The output of the second astable multivibrator is used to drive a circuit made up of two transistors. The collector of the two transistor circuit is found an infrared diode. This diode emits infrared rays that is receives by a receiver circuit. The signal receives by the receiver is processed and is counted when the bullet hits the required target A loudspeaker produces sound when the required target is hit. The user observed that the device no longer operates as required. He then seeks your expertise to eliminate the problem. This equipment whose circuit diagram is represented in figure 1 on page 7 contains amongst other electronic functions those of power supply, timing circuit, counting, interfacing and display circuits. In your capacity as a qualified electronic technician, you have been charged to carry out repairs on this equipment. Extract of some technical documents, represented on page 6, have equally been placed at your disposal to facilitate your task. Carefully exploit these documents and answer the questions in the following two sections.

1. **Power supply**

   Figure 2 shows the circuit diagram of the power supply used in this system.

   1.1 Draw the block diagram of the linear regulated power supply. **(3 marks)**

   1.2 Name three types of linear regulated power supply. **(3 marks)**

   1.3 Calculate the transformation ratio of the transformer. **(2 marks)**

   1.4 What is the role of the transformer in this linear regulated power supply? **(1 mark)**

   1.5 Calculate the peak inverse voltage across the diode labelled D1. **(1 mark)**

   1.6 Calculate the maximum voltage at the input to the integrated regulated power supply. **(1 mark)**

   1.7 Deduce from the following the voltage rating of the capacitor labelled C1: 10V, 16V and 25V. **(1 mark)**

   1.8 Sketch the waveform obtained at the input of the integrated regulator. **(2 marks)**

   1.9 If the diode D2 is open, sketch the waveform obtained at the input of the integrated regulated power supply. **(2 marks)**

   1.10 Give the role of each of the following capacitors:
   - C1 **(1 mark)**
   - C2 **(1 mark)**
   - C3 **(1 mark)**

   1.11 If the forward current of the LED is 30mA and the threshold voltage across the LED is 2V, calculate the resistance of the resistor R1 and standardize its value from the E12 series. **(3 marks)**

   1.12 It was observed that the supply from ENEO is on but the red LED is OFF. Use flow chart to troubleshoot and repair the system. **(3 marks)**
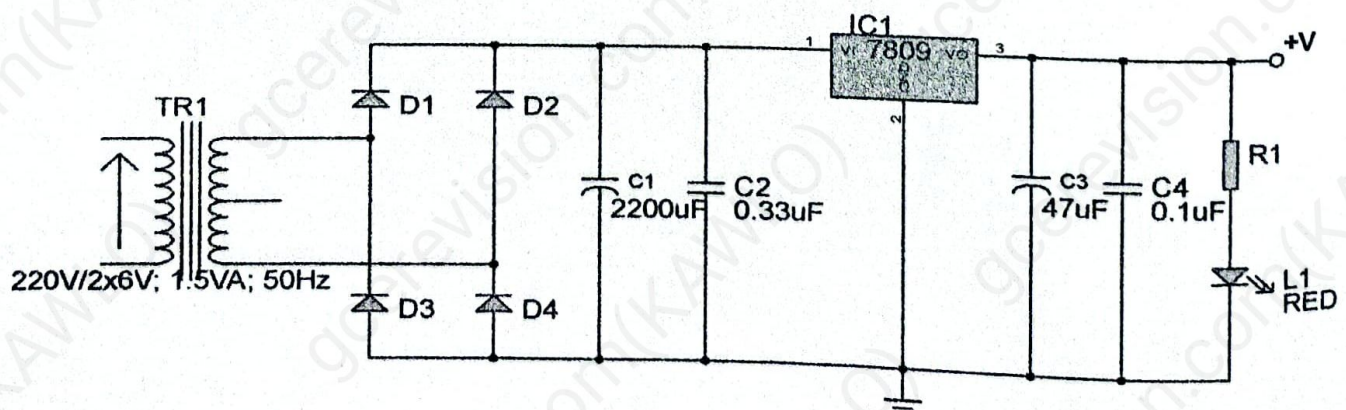
(Total = 25 marks)

2. **The emitter circuit**

It is made up of the bullet generation impulse circuit, the time base circuits, and the sound generation circuit.

2.1 **Bullet impulse generation**

The impulse is generated when the trigger is activated.

2.1.1	Identify the circuit block made up of NAND I and II of IC1, C4 and R3.	**(1 mark)**
2.1.2	What is the role of C3 to this circuit block?	**(1 mark)**
2.1.3	What is the logic state at pin 6 of IC1 at steady state?	**(1 mark)**
2.1.4	If C4 = 1μF and R4 = 100KΩ, calculate the pulse width of the signal produced at pin 4 of IC1.	**(3 marks)**
2.1.5	When the output of the bullet impulse generation circuit is high, the buzzer starts producing sound.	

2.1.5.1 Give the name of the circuit implemented with IC3. **(1 mark)**

2.1.5.2 If R11 = R13 = 10KΩ and C11 = 15nF, calculate the period of the signal produced at pin 3 of IC3. **(1 mark)**

2.1.5.3 Deduce the frequency of the signal produced at pin 3. **(1 mark)**

2.2 **Time base circuits**

The output of the bullet impulse generation circuit serves as the control input to the first time base made up of NAND I and II of IC2, R5, R6, C6 and D1.

2.2.1	What is the role of the diode D1?	**(1 mark)**
2.2.2	If R5 = 470KΩ, R6 = 47KΩ and C6 = 22nF, calculate the period of the signal obtained at pin 4 of IC2.	**(2 marks)**
2.2.3	Deduce the frequency of the signal obtained at pin 4 of IC2.	**(1 mark)**
2.2.4	The output of the first time base serves as the control input to the second time base which is made up of NAND III and IV of IC2, R7 and C8.	

2.2.4.1 Copy and complete the wave form below. **(6 marks)**
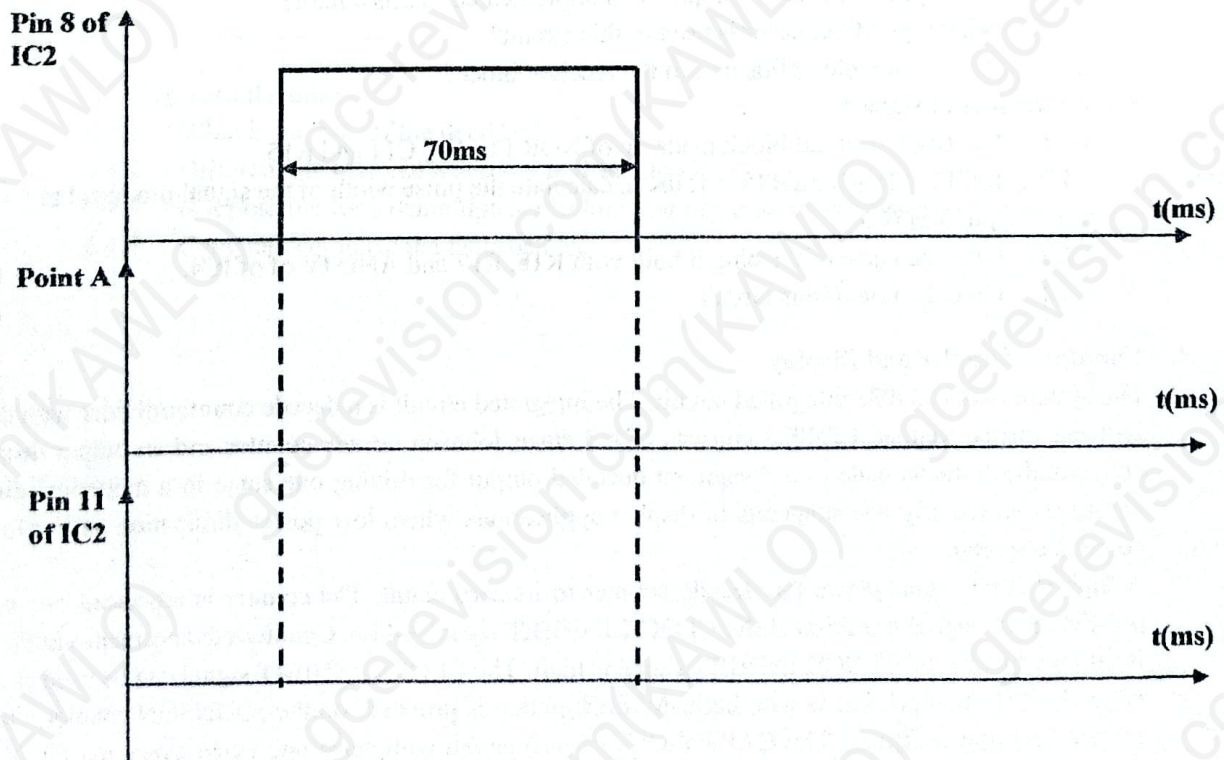
Turn Over

2.2.4.2 Calculate the period of the signal produced at pin 11 of IC2. **(1 mark)**

2.3 The signal at pin 11 is used to drive a two – transistor circuit.

    2.3.1 Give the name of this circuit block. **(1 mark)**

    2.3.2 Give the role of this circuit block. **(1 mark)**

    2.3.3 Choose from the list in table 1 the reference of the transistor labelled T2. **(2 marks)**

    2.3.4 Give the role of the capacitor labelled C9. **(1 mark)**

3. Reception and Amplification Circuits

The infrared rays emitted by the emitter is received by the receiver circuit.

3.1 Opto receiver

    3.1.1 What is the role of R2 in this system? **(1 mark)**

    3.1.2 Identify the component labelled PHD. **(1 mark)**

    3.1.3 Explain the operation of the component labelled PHD. **(4 marks)**

3.2 Amplification by operational amplifier

The output from the opto receiver is used to drive the amplifier circuits

    3.2.1 If R5 = R6 = 10KΩ, calculate the voltage obtained at the non – Inverting input e^+ of the operational amplifier. **(2 marks)**

    3.2.2 Give the expression of the voltage gain of this amplifier. **(2 marks)**

    3.2.3 If R3 = 1KΩ and R4 = 10KΩ, calculate the voltage gain of this amplifier. **(2 marks)**

    3.2.4 The output of the first operational amplifier serves as the input to the second operational amplifier.

        3.2.4.1 Give the expression of the voltage gain of this amplifier. **(2 marks)**

        3.2.4.2 If R7 = 1KΩ and R8 = 100KΩ, calculate the voltage of this amplifier. **(2 marks)**

3.3 Transistor amplifier

    3.3.1 Identify the type of transistor biasing used in this circuit. **(1 mark)**

    3.3.2 What type of transistor amplifier is implemented in this circuit? **(1 mark)**

    3.3.3 What type of transistor is used in this circuit? **(1 mark)**

    3.3.4 What is the role of this unit to the receiver block? **(1 mark)**

3.4 Processing of signals

    3.4.1 Identify the circuit block made up of NOR I and II, C11 and R15. **(1 mark)**

    3.4.2 If C11 = 15nF and R15 = 150KΩ, calculate the pulse width of the signal produced at pin 3 of IC3. **(2 marks)**

    3.4.3 Give the name of the circuit built with R16, R17 and AND IV of of IC4. **(1 mark)**

    3.4.4 Give the role of this circuit. **(1 mark)**

4. Counter – decoder and Display

The system uses CD4033 integrated circuit. The integrated circuit is a decade counter/divider with decoded 7 – segment display output. CD4033 consists of a 5 stage Johnson decade counter and an output decoder which converts the Johnson code to a 7 segment decoded output for driving one stage in a numerical display. This device is particularly advantageous in display applications where low power dissipation and/or low package count is important.

A high RESET signal clears the decade counter to its zero count. The counter is advanced one count at the positive clock signal transition if the CLOCK INHIBIT signal is low. Counter advancement via the clock line is inhibited when the CLOCK INHIBIT signal is high. The CLOCK INHIBIT signal can be used as a negative-edge clock if the clock line is held high. Antilock gating is provided on the JOHNSON counter, thus assuring proper counting sequence. The CARRY-OUT (Cout) signal completes one cycle every ten CLOCK INPUT cycles and is used to clock the succeeding decade directly in a multi-decade counting chain.

4.1 What is the MOD number of the counter? **(1 mark)**

4.2 If the frequency of the clock signal is 100KHz, what is the frequency of the output wave form of the counter? **(2 marks)**

4.3 If the initial count is zero, copy and complete the table below. **(4.5 marks)**

Clock	Clock inhibit	RESET	Count
0	0	0	0
↑	0	0	
↑	0	0	
↑	1	0	
↑	0	0	
↑	0	0	
↑	0	1	
↑	0	0	
↑	1	0	
↑	0	0	

4.4 7 – Segment decoder.

4.4.1 What is the role of the decoder? **(1 mark)**

4.4.2 Differentiate between a decoder and an encoder. **(3 marks)**

4.4.3 Is it possible for a demultiplexer to function like a decoder? Explain your answer. **(2 marks)**

4.4.4 Copy and complete the table below. **(5.5 marks)**

Turn Over

Clock	Clock inhibit	RESET	Count	a	b	c	d	e	f	g
0	0	0	0							
↑	0	0								
↑	0	0								
↑	0	0								
↑	0	0								
↑	0	0								
↑	0	0								
↑	0	0								
↑	0	0								
↑	0	0								
↑	0	0								
↑	0	0								

4.5 Display circuit

4.5.1   Is the display a common anode or a common cathode display? Explain your answer. **(2 marks)**

4.5.2   Give two advantages that LCD has over LED display. **(2 marks)**

4.5.3   What is the maximum count of this display? **(2 marks)**

(Total = 25 marks)

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5.   The electronic control of the pistol can sometimes be designed with a programmable controlled system like a computer.

5.1   Differentiate between each of the following

- SRAM and DRAM   **(2 marks)**
- EPROM and EEPROM   **(2 marks)**
- Coaxial and fiber optic cable   **(2 marks)**

5.2   Identify each of the ports in the following diagram.   **(7 marks)**
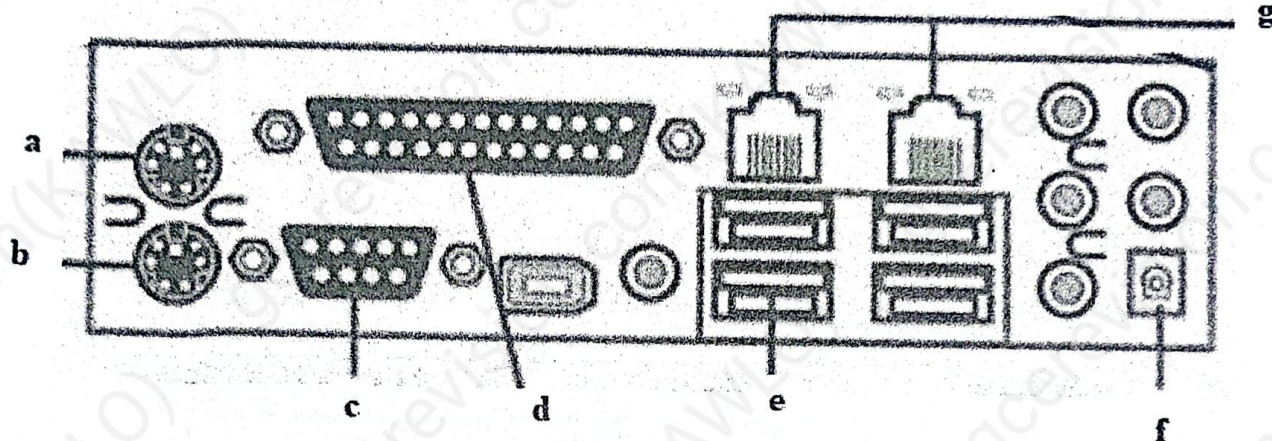
5.3 Give three functions of an operating system. **(3 marks)**

5.4 Name three types of operating systems. **(3 marks)**

5.5 Name two types of expansion slots. **(2 marks)**

5.6 Explain each of the following transmission methods
- Synchronous transmission. **(1.5 mark)**
- Asynchronous transmission. **(1.5 mark)**

(Total = 25 marks)

| NPN transistors								
Code	Structure	Case style	I_C max.	V_{CE} max.	h_{FE} Min/max	P_{tot} max.	Category (typical use)	Possible substitutes
BC107	NPN	TO18	100mA	45V	125-500	300mW	Audio, low power	BC182 BC547
BC108	NPN	TO18	100mA	20V	125-900	300mW	General purpose, low power	BC108C BC183 BC548
TIP31A	NPN	TO220	3A	60V	10	40W	General purpose, high power	TIP31C TIP41A

Table 1: Specifications of transistors

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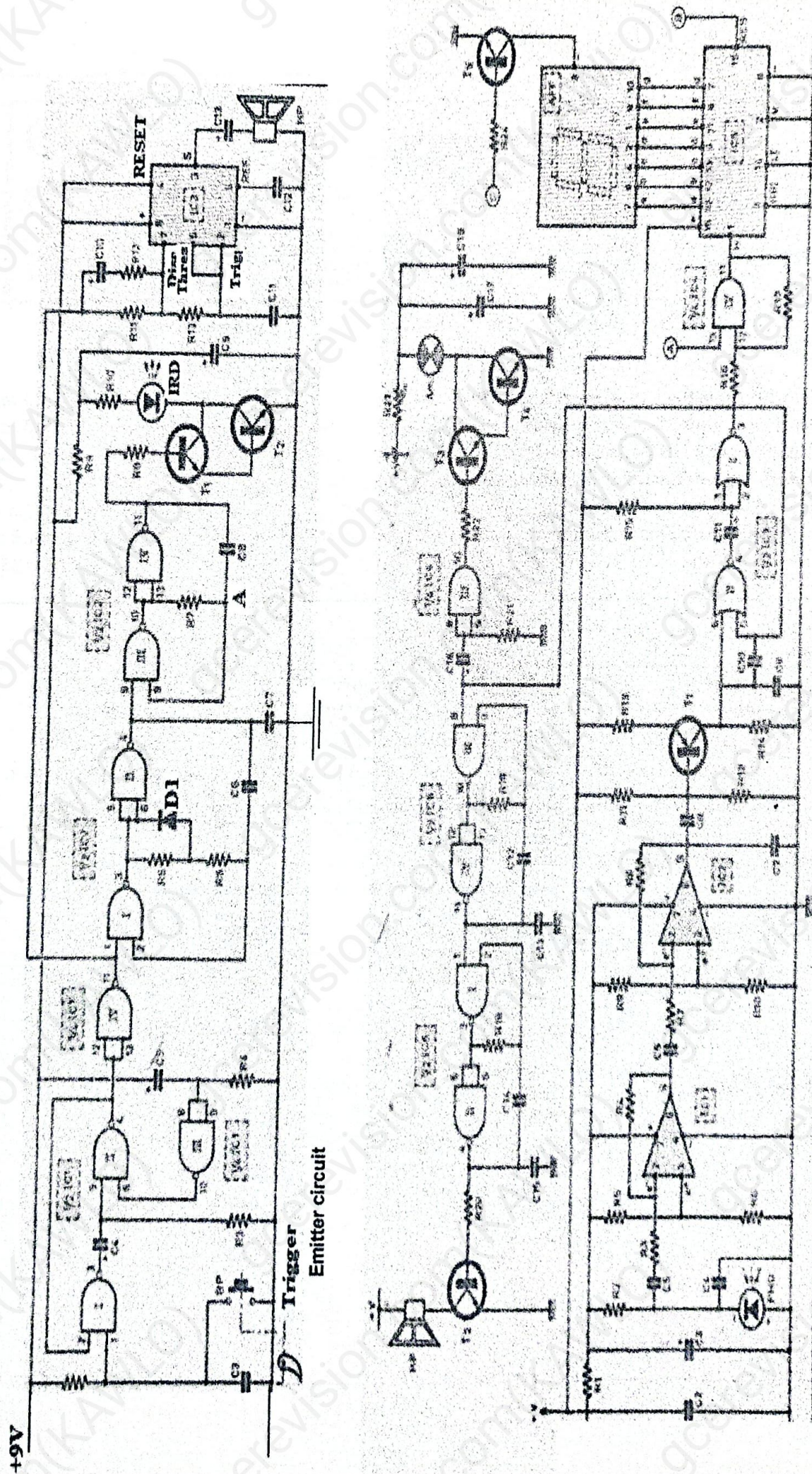
Figure 1 : Circuit diagram of the electronic control of a pistol

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