Sudan University of Science and Technology

College of Graduate Studies

Design &Implementation Of Explosive Circuit Using Diode Laser(695nm)

تصميم وتنفيذ دائرة تفجير باستخدام ليزرالثنائي (695nm)

The Thesis Submitted as Partial Fulfillment for the Requirement of the Degree of Master in Laser communication system engineering

Prepared By:

Mona Abd Alrhman Omer Hassan

Supervisor:

Dr. Abdelmoneim M. Awadelgied

Dr. Abdalla Salih Ali

2014

الأية

بسم الله الرحمن الرحيم

۞ اللَّهُ نُورُ السَّمَاوَاتِ وَالْأَرْضِ ۚ مَثَلُ نُورِهِ كَمِشْكَاةٍ فِيهَا مِصْبَاحٌ ۖ
الْمِصْبَاحُ فِي زُجَاجَةٍ ۖ الزُّجَاجَةُ كَأَنَّهَا كَوْكَبٌ دُرِّيٌّ يُوقَدُ مِن شَجَرَةٍ
مُّبَارَكَةٍ زَيْتُونَةٍ لَّا شَرْقِيَّةٍ وَلَا غَرْبِيَّةٍ يَكَادُ زَيْتُهَا يُضِيءُ وَلَوْ لَمْ
تَمْسَسْهُ نَارٌ ۚ نُّورٌ عَلَىٰ نُورٍ ۗ يَهْدِي اللَّهُ لِنُورِهِ مَن يَشَاءُ ۚ وَيَضْرِبُ
اللَّهُ الْأَمْثَالَ لِلنَّاسِ ۗ وَاللَّهُ بِكُلِّ شَيْءٍ عَلِيمٌ ﴿٣٥﴾

صدق الله العظيم

DEDICATION

To the soul of my grandfather professor Mohammed Belo…

To my parents ,brothers and sisters…

To my professors, teachers…

To the friends and partners…

To the people who love me and care…

To anyone who continued on this work further…

To you all…

ACKNOWLEDGMENTS

This project would not be possible without the loving support of so many people, mainly those to whom we owe this new heart and thus the opportunity of a life today.

This project could not have been written without help support and encouragement from **Dr. Abdalla Salih Ali** who not only served as my supervisor, and of course at the beginning of that supervision of **Dr. Abdelmoneim Mohammed Awadegied,** has been the seed where the results and progress of this project took place and planted.

My deep appreciation and thanks to **Ustz.Abd Alsakhi Suliman** who stood behind my success and helped me with his skills, also the thanks is extended to **Eng. Elzain Elmahi** for his practical work and essential inputs.

I would also thanks my family, everyone who helped me, did his best to comfort me and push me forward.

Thanks to all.

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Abstract

An explosive circuit was designed. It was consist of laser source, laser detector, digital counter and detonator. It is excited by laser diode beam (695nm) from a transmitter. The circuit operates when the laser beam was transmitted and received by diode laser. The circuit starts digital counting from 1,2 ……to 15 and when it reached the final count at 15 it sends a signal to detonator which produced the explosive action. This circuit can be used in many different fields such as mining.

المستخلص

صممت دائره تفجير تتكون من مصدر الليزر ،كاشف الضوئي ، عداد رقمي والمفجر. تتفعل من شعاع الليزرالثنائي(695nm) الي المرسل. الدائرة تعمل عندما يسلط عليها شعاع ليزر والتي يستقبلها ليزر الديود. الدائرة تبدأ العد الرقمي من ١ ،٢ ،.......الي ١٥ و عندما تصل إلى العد النهائي في ١٥فإنها ترسل إشارة إلى المفجر وعندها يحدث التفجير. هذه الدائرة يمكن استخدامها في العديد من المجالات المختلفة مثل التعدين.

Chapter One

Introduction and Basic concepts

1.1 General

An Explosive is a chemical compound, or mixture of compounds initiated by heat, shock, impact, friction, or a combination of these conditions. Once initiated, it decomposes very rapidly in a detonation producing a rapid release of heat and large quantities of high-pressure gases. The gases produced expand rapidly with sufficient force to overcome confining forces, such as the rock surrounding a borehole.

Depending on the prime source of energy; initiating devices fall into three basic types: electric, electronic, and non electric. Electric detonator systems have been in use in industry for many decades [1].

Electric detonators come in several types with the most common being the low firing current variety. An electric detonator consist of two leg wires embedded in a metal shell containing a high explosive base charge that is designed to initiate other explosives[2].

Electronic detonator systems are new and continually advancing technology for the initiation of the blasts in operations. Potential advantages for using electronic detonators are precise timing, reduced vibrations, a reduced sensitivity to stray electrical current and radio frequency, and a reduction in misfires through more precise circuit testing. Electronic blasting system typically permit blasting with detonator delay times having millisecond or better accuracy [1, 2].

There are two main types of non –electronic detonation system in uses today, shock tube and detonating cord. The main advantage of non – electric system is perceived to be their lack of susceptibility to initiation from extraneous electrical energy. The shortcoming of most non-electric systems is that they cannot be tested to ensure a complete circuit exists prior to detonation [3].

The earliest application of the laser was in active range-finding by measuring the time of flight of a laser pulse reflected from a target. Investigations in this direction started immediately after the discovery of the ruby laser [4].

The solid- state lasers provide the most versatile radiation source in terms of output characteristics when compared to other laser system. A large range of output parameters, such as average and peak power, pulse width, pulse repetition rate, and wavelength, can be obtained with these systems. Today we find solid-state lasers in industry as tools in many manufacturing processes, in research facilities as part of the diagnostic instrumentation, and in military systems as rangefinders, target designators, and infrared counter measure system [5].

Some of the specialized applications included drilling holes in diamonds that are used as die for drawing wires, another application was stress analysis by means of double pulse holography; in which surface deformation due to stress or temperature is measured inter ferometrically between two pulses[5].

The basic idea of designing explosive circuit is to use an electronic components forced by laser beam as a signal. The explosive circuit consists of four parts shown in figure (1-1). The first part is the laser source, the second part is the laser detector and the third part is the digital counter; and the final part is the detonator. The counter which will be used is up counter it operates which a certain frequency. The frequency will be determined so as the operator will be in save position.

The counter start counts after the laser beam is applied to the optical device. When the counter reach the final count the detonator will explosive [5, 6].

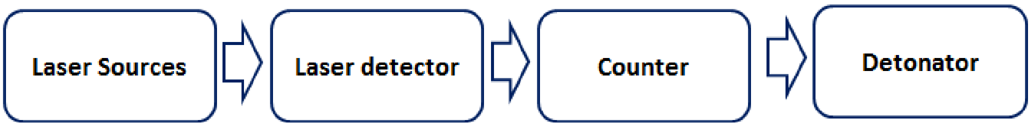


Figure (1-1): Explosive circuit

1.2 Problem statement

Is to design an explosive circuit force by laser beam as switching signal. The circuit design includes hardware; also safety of operation was considered.

1.3 Objective:

Is to design an explosive circuit using diode laser.

1.4 Methodology:

The designing circuit consist of:

-Electronic component.

-Laser source.

Define all component used in this project and design electronic circuit.

1.5 Literature review:

A- Near-Infrared Fiber Optics Gas Sensor for Remote Sensing of CH4 Gas in Coal Mines

Sanguo Li, Yan Zhang , Thomas Koscica, Hong-Liang Cui
Department of Physics and Engineering Physics
Stevens Institute of Technology
Hoboken, NJ 07030

(Methane, the dominant component of natural gas, is inflammable and explosive and from time to time methane explosions lead to the fatal accidents. Therefore its detection using reliable sensors is one of the most important safety issues in chemical facilities, gas plants, mines, and residential areas)[7].

B- The Mechanism and Dynamics of Explosive Combustion in Aerosol Fuels

Roger E. Miller and Tomas Baer
Department of Chemistry
University of North Carolina
Chapel Hill, NC 27599 rem(2)net.chem.unc.edu
baer(o)unc.edu

(This research investigates the explosive combustion of aerosol particles (diameter of 1-10 urn) in the high vacuum environment of a laser time-of-flight mass spectrometer as well as in the medium pressure (1-2 atmospheres) environment of a flow tube. Pulsed infrared radiation from a C02 laser initiates the reaction in both cases)[8].

1.6 Thesis layout

This project consists of five chapters:

- **Chapter one**: concern about general introduction of an explosive circuit; which includes problem statement, objective, methodology, and literature review.
- **Chapter two**: Consider general over views of electronic devices which includes; Digital system, logic gates, flip flops, registers, counters, combinational and sequential circuit.
- **Chapter three**: Designing explosive circuit with consume analyze for the circuit.
- **Chapter four**: Result of the testing and simulated.

- **Chapter five**: Introduce conclusion and recommendation for future work.

Chapter Two

Electronic Devices

2.1 Introduction

Electrical engineering, Computer science and computer engineering curricular each provide one or more causes for the study of digital logic.
George Boole's theoretical work in 1938 there has been unprecedented growth in the application of digital concepts. Each day digital concepts are being applied to problem that could only solved by analog methods several years ago. Fast reliable and modestly priced analog to digital and digital to analog converters are now available facilitate the application of digital concepts for solving complex analog problems [9] .
The basic elements of digital system are the logic gates. Then the digital system consists of two main parts which are combinational logic and sequential logic system. Also the sequential logic can be synchronous or asynchronous. Figure 2-1 shows the block diagram of a digital system.
The Combinational logic circuit is logic circuit in which the output depends on the input values. While the synchronous sequential logic circuits are consist of two parts combinational logic circuit part and memory element part .This type normally works with a master clock. The output is function of the input and present state of the system. Finally the asynchronous sequential logic also consists of two parts which are combinational logic part and delay element part. It does not use master clock and its output is the function of the current input and the previous history of the circuit [1, 6].

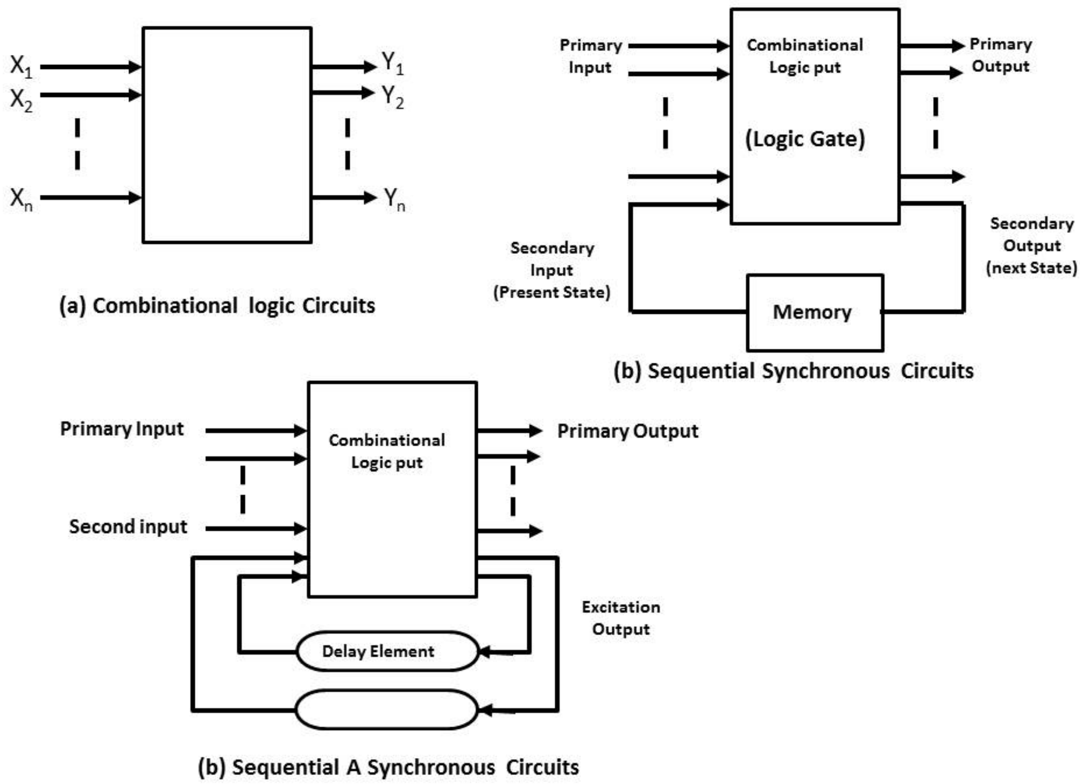


Figure (2-1) Digital system block diagram

2.2 Logic Gates

Logic gates are the basic elements of all functional logic circuits. There are many types of logic families, but the transistor transistor logic TTL family and complementary metal Oxide (CMOS) family are the ferias types of logic family [10].

There are seven types of logic gates, which are AND, OR, NOT, NAND, NOR, EX-NOR and EX-OR.

All logic elements were described by table called truth table.

- **AND Gate:**

The and gate can have two or more inputs and has only one output. It is called all or nothing gate. Its operation can be described as; the output will be at a high logic level if all inputs are at high level. Its output will be at low level if one or all inputs are at low level [10].

Its operation can be described by Boolean function:

$$Y = A.B \qquad \text{Equation (2-1)}$$

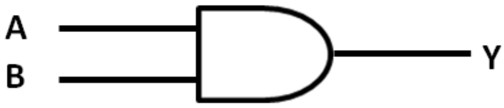


Figure (2-2) AND gate

- **OR gate:**

The OR gate can have two or more inputs and it has one output. It's operation can be described as; if one input or all inputs are high level the output will be at high level.

The output will be at low level only if all inputs are at low level. For this reason it is called the gate A any or all input[10]. Also the operation of the OR gate can be described by Boolean function as

$$Y = A+B \qquad \text{Equation (2-2)}$$

Figure (2-3) OR gate

- **NOT Gate:**

It is called an INVERTOR; it has one input and one output. The output is the complement of the input, if input A equals to 0 the output Y is equal to 1 and vice Versa. Figure (2-4) shows the symbol of the NOT gate.

The Boolean function is:

$$Y = \overline{A} \qquad \text{Equation (2-3)}$$

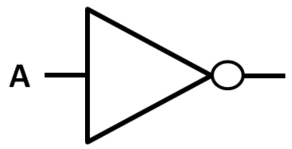


Figure (2-4) NOT gate

The part over the variable A is called the complement.

- **NAND Gate:**

The NAND gate can have two or more inputs and has only one output. The NAND gate is the complement of the AND gate. The output will be at high logic level if one or all input is low level. The output will be at low level if all inputs are at high level. Figure (2-5) shows the symbol of NAND gate [10]. The Boolean function is read as y equal NOT A AND B.

$$Y = \overline{A\,B} \qquad \text{Equation (2-4)}$$

Figure (2-5) NAND Gate

- **NOR Gate:**

The NOR gate is a complement of an OR gate. It may have two or more inputs and has only one output. Its output will be at high logic level only of all inputs are at low level, where the output will be as low level if one or all inputs are at high level[10].

$$Y = \overline{A+B} \qquad \text{Equation (2-5)}$$

Figure (2-6) NOR Gate

- **Exclusive OR Gate(EX-OR):**

It may have two or more input and one output. It is called inequality gate which means the output will be at high logic if and $A \neq B$ and at low level if $A = B$.

It is Boolean function is:

$$Y = A \oplus B \qquad \text{Equation (2-6)}$$

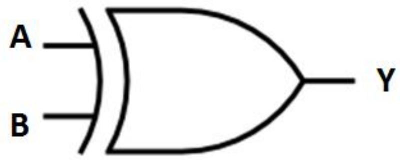


Figure (2-7) Exclusive OR gate

If EX-OR gate has more than two inputs its output will be at high logic level if the number of one's at the input are odd numbers.

- **Exclusive NOR Gate(EX-NOR):**

It is called an equality gate. This means that the output of an EX-NOR gate is a high level logic if inputs A equal input B (A=B). if the number of input are more than two the output will be at a high level if the number of one's at the input are even number[10]. The Boolean function is:

$Y = \overline{A \oplus B}$ Equation (2-7)

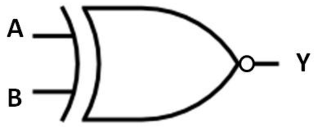


Figure (2-8) Exclusive NOR gate

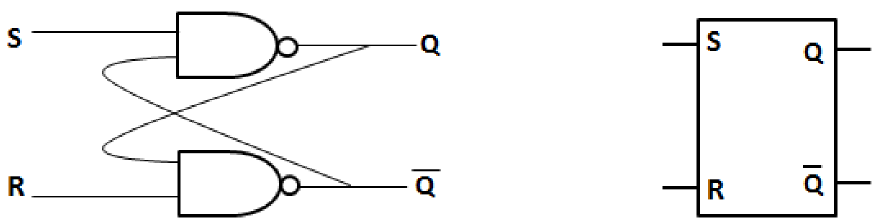
2.3 Flip Flops (FF)

Flip flop is the basic element of memory. Flip flop has two state HIGH or LOW. For this reason it is called a histable element. Flip flop also called a latch. There are several type of flip flop; the main difference between flip flop is the number of inputs. Flip flop is the main element of counter, register and all sequential logic circuits.

The main types of flip flops are unclocked RS, clocked RS, JK flip flop, D-type flip flop, T type flip flop and master state flip flop[6,9].

- **Unclocked RS Flip Flop:**

This is basic type of flip flop and it is unlocked type. Figure (2-9) shows the SR flips flop will two input S which mean SET and R which mean RESET. Also it has two output normal output Q and the complemented of the normal output $\overline{Q}$.



(a) SR Flip flop **(b) Symbol of SR Flip flop**

Figure (2-9) Unclocked RS FF

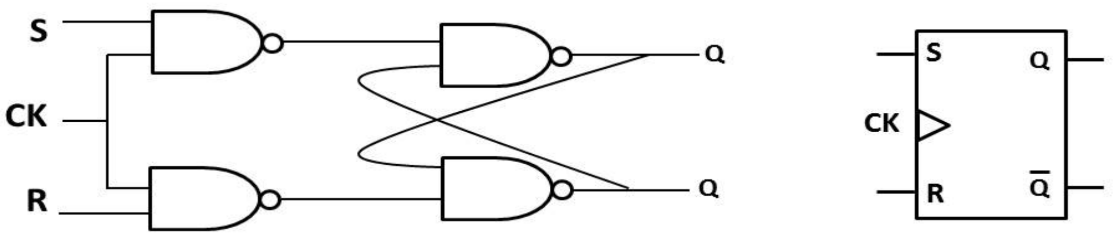
Table (2-1) SR Flip Flop

Input S R	Output Q Q	Mode of operation
0 0	1 1	Prohibit
0 1	1 0	SET
1 0	0 1	RESET
1 1	No charge	Hold

- **Clocked RS flip flop**

The basic RS flip flop is an asynchronous type it does not operate in step will a clock or timing device.

The clocked RS flip flop adds a valuable synchronous feature to the basic RS flip flop. It operates in step will clock or timing device. Figure (2-10) shows the clock RS flip flop.



(a) Clocked RS FF

(b) Symbol of clocked RS FF

Figure (2-10) RS Flip Flop

Table (2-2) clock RS FF Operation

CK	S R	Out put Q Q	Mode of Operation
	0 0	No charge	HOLD
	0 1	0 1	RESET
	1 0	1 0	SET
	1 1	1 1	Prohibital

- **D type Flip Flop:**

It has single input D and two outputs Q and Q. it is synchronous device. The output follow the input, that is to say if D=0 and the arrival of clock pulse Q=0, and if D=1 at the arrival of clock pulse Q=1. Figure (2-11) shows the symbol.

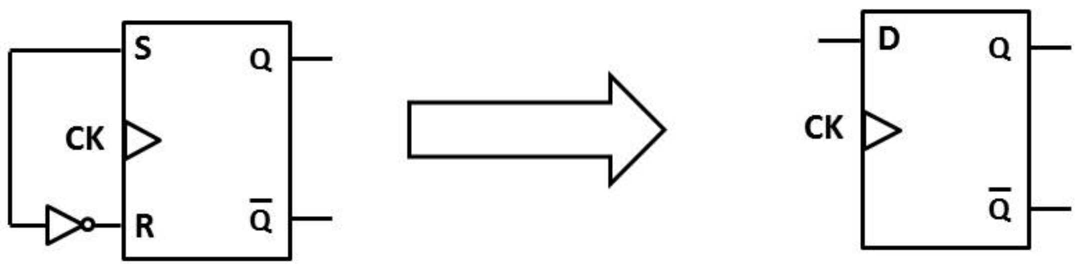


Fig (2- 11) D type Flip Flop

- **JK flip flop:**

The problem of the RS flip flop when SR=11 is over come in JK flip flop. This condition when JK=11 is called a TOGGLE state. Figure (2-12) shows the JK flip flop.

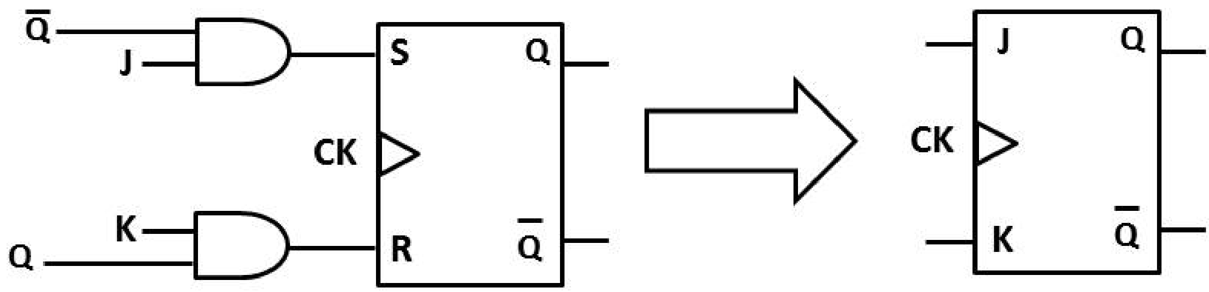


Fig (2-12) JK Flip Flop

2.4 Combinational logic circuit

Are made up from basic gates (AND, OR, NOT) or universal gates (NAND, NOR) gates that are "combined" or connected together to produce more complicated switching circuits. These logic gates are the building blocks of combinational logic circuits. An example of a combinational circuit is a decoder, which converts the binary code data present at the input into a number of different output lines, one at a time producing an equivalent decimal code at its output. In these circuits the outputs at any instant of time depends on the current inputs presented at the inputs. Also adders, comparators, Multiplexer, Demultiplexer, are combinational logic circuit which perform a certain logic function [6, 10]. When designing any combinational logic circuit the following steps can be followed:

- **Step1**: Obtain the specification of the circuit.
- **Step2**: Determine the number of inputs and output.
- **Step3**: From the specification obtain the truth table.
- **Step4**: Simplify the logic function obtained from the truth table.
- **Step5**: Write the simplified Boolean function and draw the logic diagram.

2.5 Sequential logic circuits

In digital circuit theory, sequential logic is a type of logic circuit whose output depends not only on the present value of its input signals but on the past history of the circuit, so the output which is a function of current input and present state. This is in contrast to combinational logic, whose output is a function of only the present input. That is, sequential logic has state have a memory while combinational logic does not. Or, in other words, sequential logic is combinational logic with memory .Sequential logic is used to construct finite state machines, a basic building block in all digital circuitry, as well as memory circuits and other devices. Virtually all circuits in practical digital devices are a mixture of combinational and sequential logic. Digital sequential logic circuits are divided into synchronous and asynchronous types [1, 10].

The synchronous sequential logic consists of two parts, as shown in figure (2-1.b).

Combinational part which has two inputs primary input and secondary input which called present state. Also it has two outputs, primary output which feed another circuit and secondary outputs which known as next state which represent the input to flip flop.

Memory part: this part consists of flip flops. While asynchronous sequential logic circuit also consists of two parts as shown in figure (2-1.c).

Combinational logic part: It consists of logic gate and two inputs which are primary input and secondary inputs. Also it has two outputs which are primary output and excitation out puts.

The second part is a delay element; this delay element may be a wire; each one foot has a delay of 10 nsec [1, 10].

2.6 Counters

There are two types of counters:

- Asynchronous counter.
- Synchronous counter.

All counters must have the following characteristics:

- Maximum number of count (modulus of counter).
- Asynchronous or synchronous counter.
- Up or down counter.
- Free running or self stopping.

- **Asynchronous counters:**

- In this type of counter the clock input is connected in series. It is implemented using either JK flip flop or T type flip flop for designing asynchronous counter. The following steps can be followed:
- Obtain the specification of the JK flip flop.
- Obtain the table which shows the sequence of count.
- Determine the number of JK flip flops.
- Put all J and K input at high logic level.
- If the clock is active HIGH all other flip flop must be connected from the complement output Q and if active LOW the connected will be from normal output Q.

Figure (2-13) as an example shows mod-16 asynchronous counter that JK flip flop clock active HIGH [10].

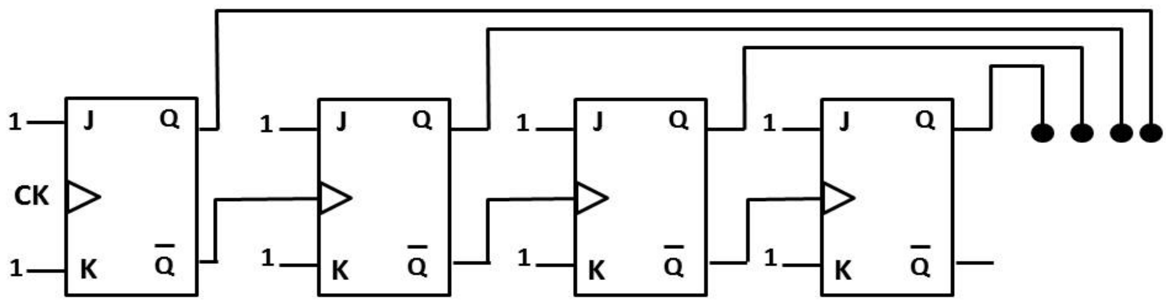


Figure (2-13) mod-16 ripple counter

The counter can be used as frequency divider. the main problem of asynchronous counter is the delay. The delay is due to the series connection of the clock pulse.

- **Synchronous counter:**

In a synchronous counter the series connection of the clock pulse restricted the counting speed. This problem can be avoided by connecting the clock pulse in parallel to all flip flops. In a synchronous counter all inputs of the JK flip flops put at high logic level. In synchronous counter the state of JK=11 is determine by combinational parts as shown in the figure (2-14)

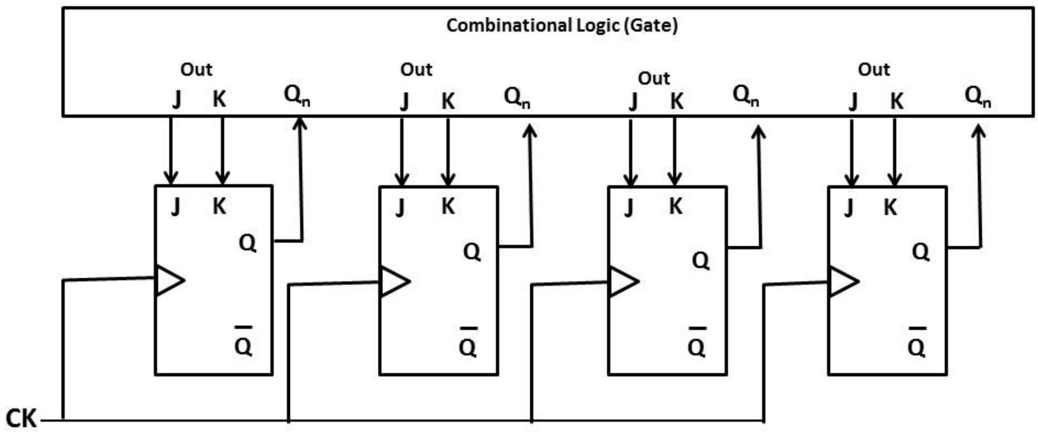
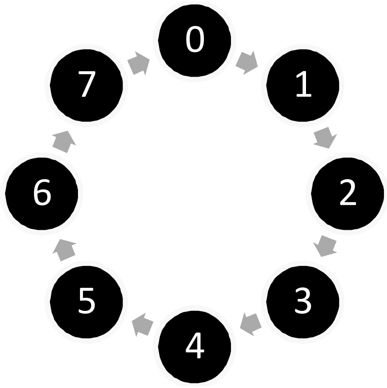


Figure (2-14) Synchronous counter

Steps of design:

- Obtain the specification.
- Draw the flow diagram which shows the sequence of count.
- Obtain the state assignment of the count.
- Obtain the state of the table.
- Obtain the y-map.
- Finally obtain the excitation table to obtain the Boolean function of flip flop input. As an example Design mod-8 synchronous counter.

The steps as shown in figure (2-15).



(a) Flow Diagram

State	Assignment
0	000
1	001
2	010
3	011
4	100
5	101
6	110
7	111

(b) State Assignment

Present state	**Next state**
0	1
1	2
2	3
3	4
4	5
5	6
6	7
7	0

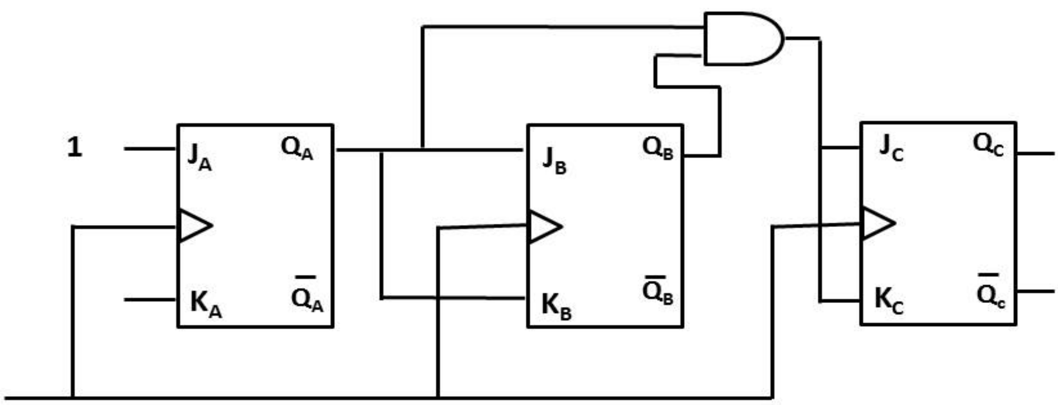
(c) State table

Present state QC QB QA	**Next state QC QB QA**
0 0 0	0 0 1
0 0 1	0 1 0
0 1 0	0 1 1
0 1 1	1 0 0
1 0 0	1 0 1
1 0 1	1 1 0
1 1 0	1 1 1
1 1 1	0 0 0

(d) y-map

Figure (2-15) Steps of Design

Finally is to obtain the excitation table for the y-map using the transition table of JK flip flop figure (2-15)



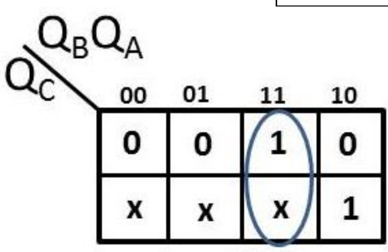
Figure(2-16) mod-8 synchronous counter

Table (2-3) excitation table for synchronous counter

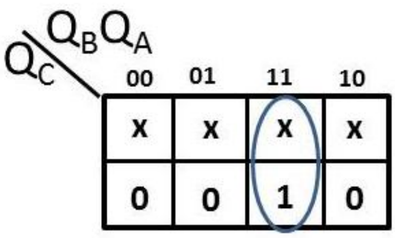
Present state QC QB QA	Next state QC QB QA	JC	KC	JB	KB	JA	KA
0 0 0	0 0 1	0	X	0	X	X	X
0 0 1	0 1 0	0	X	1	X	X	1
0 1 0	0 1 1	0	X	X	0	1	X
0 1 1	1 0 0	1	X	X	1	X	1
1 0 0	1 0 1	X	0	0	X	1	X
1 0 1	1 1 0	X	0	1	X	X	1
1 1 0	1 1 1	X	0	X	0	1	X
1 1 1	0 0 0	X	1	X	1	X	1

Table(2-4) excitation table of JK FF

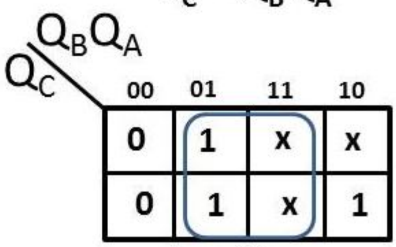
Q_t	Q_t+1	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0



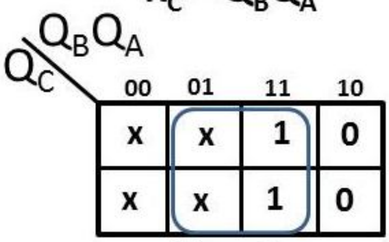
$J_C = Q_BQ_A$



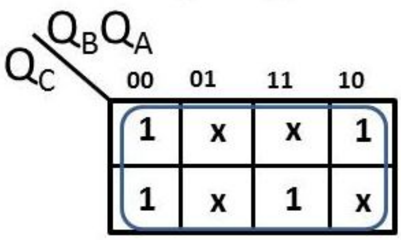
$K_C = Q_BQ_A$



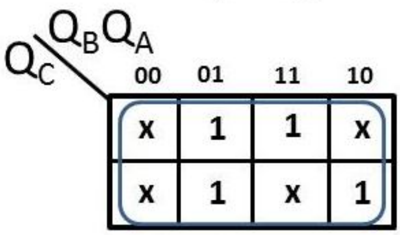
$J_B = Q_A$



$K_C = Q_A$



$J_A = 1$



$K_C = 1$

2.7 Registers

A register is basically a set of flip flops logically connected together to perform one or more specific functions. These specific functions usually become the base of their classification. Broadly there are two categories of registers:

- Storage or Buffer Registers: which are having provision of only storing the input data and outputting it whenever required.
- Shift Registers: which store an input data and can also shift the data left, right or in both the direction. So they are classified as per the direction of shift as follows:
  - Shift left register.
  - Shift right register.
  - Bidirectional shift register.

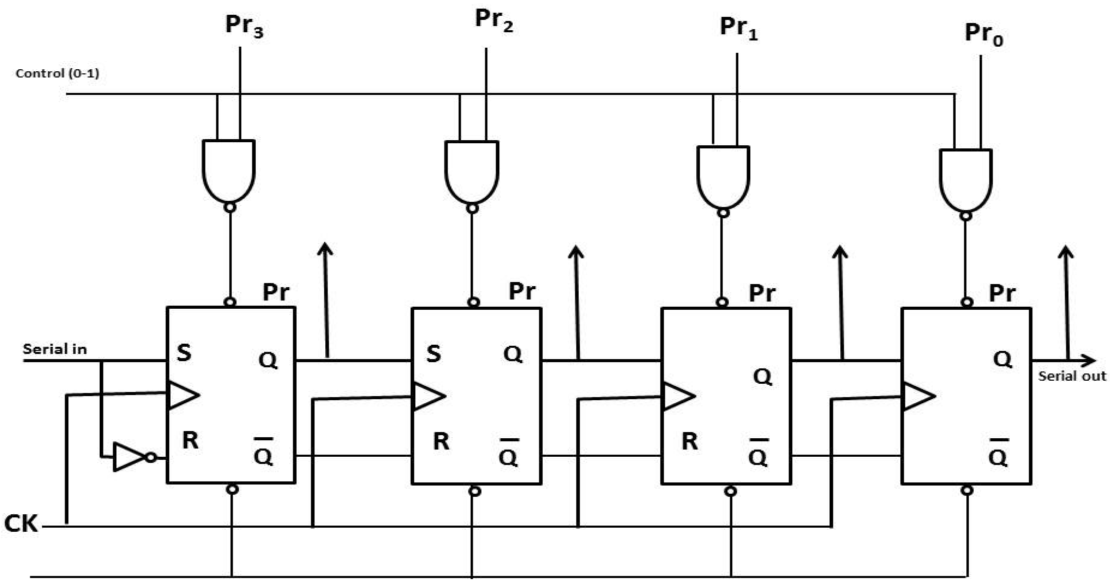


Figure (2-17) Register

Since a register takes data from an input device and transfers the data to an output device. So they are also classified as per mode of input and output [10]. This classification is:

- Serial in serial out (SISO).
- Serial in parallel out (SIPO).
- Parallel in serial out (PISO).
- Parallel in parallel out (PIPO).
- Universal.

2.8 Lasers

Laser is an economy of Light Amplification by Stimulated Emission of Radiation. Albert Einstein in 1917 established the theoretical foundations for the laser and the maser conceptually based upon probability coefficients (Einstein coefficients) for the absorption, spontaneous emission, and stimulated emission of electromagnetic radiation [11].

Ladenburg confirmed the existences of the phenomena of stimulated emission and negative absorption in 1928.

Maser, Townes produced the first microwave amplifier in 1953. A Device operating on similar principles to the laser, but amplifying microwave radiation rather than infrared or visible radiation.

Miamian operated the first functioning laser in 1960, Maiman's functional laser used a solid-state flash lamp-pumped synthetic ruby crystal to produce red laser light, at 694 nanometers wavelength [4].

2.8.1 Laser properties

The application of laser depends on the unique proprieties of laser. Ones that is different from the properties of light from conventional source. These properties include monochromaticity (narrow spectral line width) directional (good collimation of the beam), radiance or brightness (the capability to focus to small spot size) and coherent [12].

- **Monochromaticity**: Laser light is concentrated in a narrow range of wavelengths.

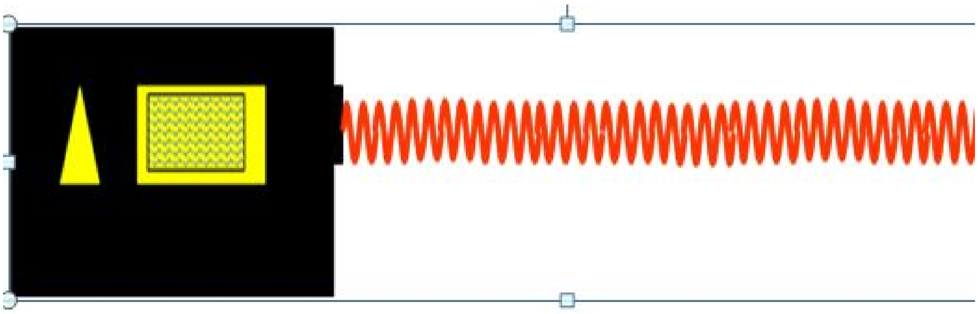
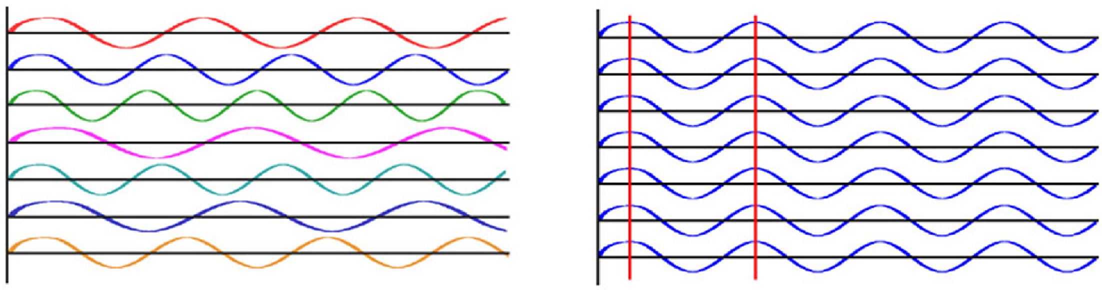


Figure (2-18) laser monochromaticity

- **Coherence**: All the emitted photons bear a constant phase relationship with each other in both time and phase.



Incoherent light waves Coherent light waves

Figure (2-19) laser coherence

- **Directionality**: laser light is usually low in divergence.

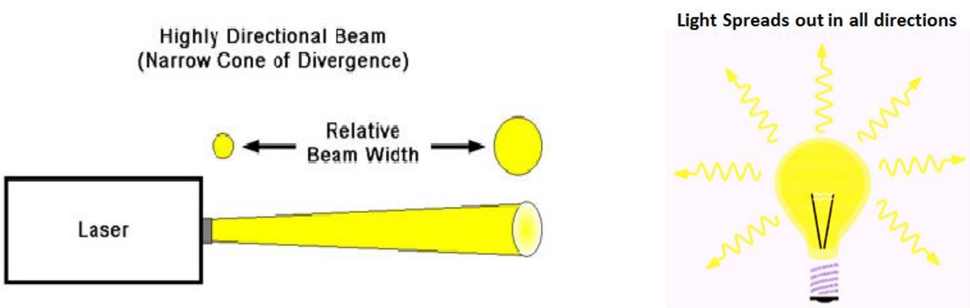


Figure (2-20) laser directionality

- **High Irradiance**: light possesses high radiant power per unit area.

2.8.2 Element of laser:

A laser generally requires three components for its operation:

a) An active medium in the form of a laser rod, with energy levels that can be selectively populated;

b) A pumping process to produce population inversion between some of these energy levels.

c) A resonant cavity containing the active medium which serves to store the emitted radiation and provides feedback to maintain the coherence of the radiation (Fig.2-21)

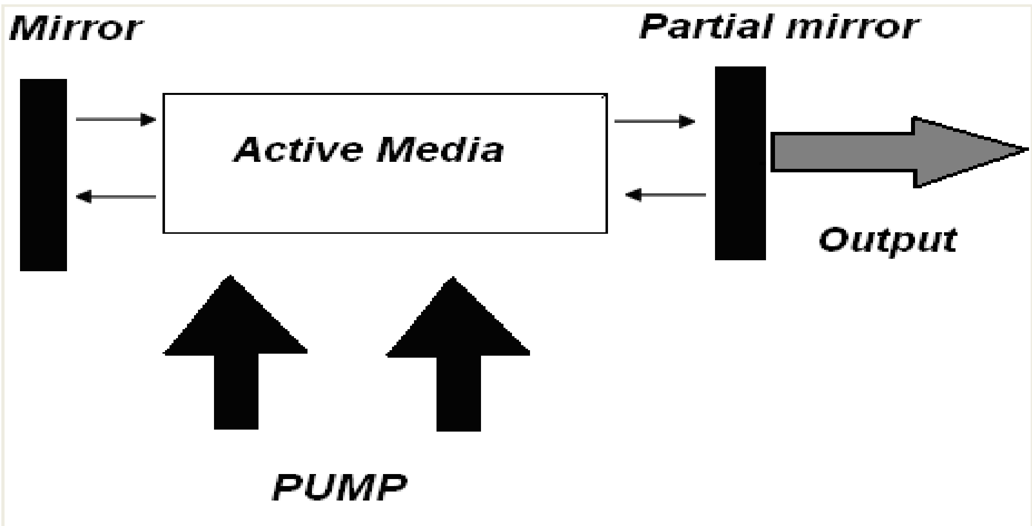


Figure (2-21) Laser principles

The main problem in designing a laser is to involve produces a sufficiently high population of atoms in the excited state. For this, many ingenious ways fully all have been evolved. The most common method of centre excitation is by pumping processing a container tube with a suitable gas. Only those materials which can be pumped to achieve population inversion are used to give laser radiation. The existence of states whose mean life times are relatively long so as to help pile up considerable energy in the excited levels, are necessary. Long life time of a level and the sharpness of the spectrum lines usually go together, and so, the materials that can be best used to give laser radiation are crystals with sharp lines, and gases at low pressure [13].

An important aspect of the laser operation involves the design of a resonator cavity to maximize the process of stimulated emission. Two carefully aligned mirrors, one having more than 99 percent reflectivity and the other having less reflectivity, are placed at either end of the cavity containing the laser rod and the flash lamp. The stimulated radiation multiplies by bouncing back and forth many times between the two mirrors and passing through the laser medium. And, when it exceeds a certain limit, the laser light comes out citation in the form of a narrow pencil beam through the semi-transparent mirror [14].

2.8.3 Types of Laser

Lasers can be categorized in several different ways including wavelength, material type and applications. In this section we will summarize them by material liquid, solid-state, and semiconductor lasers. Will be included only lasers that are available commercially since such lasers now provide a very wide range of available wavelengths and powers without having type such as gas to consider special laboratory lasers [14].

2.8.3.1 Gases laser

The gain medium is produced by passing a relatively low electrical current (10 mA) through a low pressure gaseous discharge tube containing of Gases. Atomic gaseous laser (e.g. He Ne). Molecular laser (e.g. Co2).

2.8.3.2 Liquid Laser Gain Media

Organic Dye Lasers. A dye laser consists of a host or solvent material, such as alcohol or water, into which is mixed a laser species in the form of an organic dye molecule, typically in the proportion of one part in ten thousand. A large number of different dye molecules are used to make lasers covering a wavelength range of from 320 to 1500 nm with each dye having a laser bandwidth of the order of 30 – 50 nm. The wide, homogeneously broadened gain spectrum for each dye allows laser tenability over a wide spectrum in the ultraviolet, visible, and near-infrared [14].

2.8.3.3 Dielectric Solid-State Laser Gain Media

Ruby Laser. The ruby laser, with an output at 694. 3 nm was the first laser ever developed. It consisted of a sapphire (Al_2O_3) host material into which was implanted a chromium laser species in the form of Cr^{+3} ions at a concentration of 0. 05 percent as the amplifying medium. The ruby laser involves a three-level optical pumping scheme, with the excitation provided by flash lamps, and operates either in a pulsed or CW mode [4].

2.8.3.4 Semiconductor Laser Gain Media

Semiconductor or diode lasers, typically about the size of a grain of salt , are the smallest lasers yet devised . They consist of a *p* - *n* junction formed in semiconductor crystal such as GaAs or InP in which the *p* -type material has an excess of holes (vacancies due to missing electrons) and the *n* -type material has an excess of electrons. When these two types of materials are brought together to form a junction, and an electric field in the form of a voltage is applied across the junction in the appropriate direction , the electrons and holes are brought together and recombine to produce recombination radiation at or near the wavelength associated with the band gap energy of the material . The population of electrons and holes within the junction provides the upper-laser-level population, and the recombination radiation spectrum is the gain bandwidth D … of the laser, typically of the order of 0. 5 to 1. 0 nm [15].

2.8.4 Diode Laser

The semiconductor or diode lasers are the smallest of all the known lasers; they have a size of a fraction of a millimeter. The laser consists of a semiconducting crystal, such as gallium arsenide, lead selenide, etc, with parallel faces at the ends to serve as partially-reflective mirrors. The entire laser package is very small and can be incorporated into an integrated circuit board, if required [15].

A semiconductor, as the name implies, is half-way between a conductor and an insulator (non-metal), so far as its electrical conductivity is concerned. The semiconducting materials containing gallium and arsenic compounds have been found to generate infrared rays when the current is passed through them. This implies that these semiconductors convert electrical energy into photons. But, these were ordinary incoherent light rays and were not produced by the' laser action, However, when the gallium arsenide crystal is through it, the laser action does take place. Many semiconductors serve as laser materials and they have been made to 'lase' under the stimulation of electricity instead of light which is used for the other solid-state lasers [15].

There are two types of semiconductors, viz., n-type and p-type. To understand the functioning of these devices, it is necessary to know the nature of the electronic energy states in a semiconductor. A typical semiconductor has bands of allowed energy levels separated by

Forbidden energy gap region. In an intrinsic semiconductor, there are just enough electrons present to fill the uppermost occupied energy band (valence band) leaving the next higher band (conduction band) empty. In an n-type semiconductor, a small amount of impurity is added intentionally so that the material is made to have an excess of electrons, which thus becomes negative. On the other hand, by adding a different type of impurity in a p-type semiconductor, the material can be made to have an excess of holes (vacancy of electrons), which thus becomes positive [16].

The semiconductor laser consists of a tiny block (about one square millimeter in area) of gallium arsenide Fig(2-22). When the p- and n-type layers are formed in an intimate contact, the interface becomes a p-n junction. When direct current is applied across the block, the electrons move ii across the junction region from the n-type material to the p-type material, having excess of holes. In this process of dropping of the electrons into the holes, recombination takes place leading to the emission of radiation. The photons travelling through the junction region stimulate more electrons during the transition, releasing more photons in the process. The laser action takes place along the line of the junction. Due to the polished ends of the block, the stimulated emission grows enormously and a beam of coherent light is emitted from one of the two ends. With a gallium arsenide laser, a continuous beam of a few militates power is easily obtained [16].

The semiconducting lasers are also called junction lasers or junction diode lasers because they produce laser energy at the junction of two types of impurities in a semiconductor .They are also called injection lasers because electrons are injected into the junction region [16].

The technology of semiconductor lasers has undergone considerable development with the important goal of achieving room-temperature operation, low threshold energy, high output powers, wavelength diversity and long lifetimes. In 1969, continuous operation at room temperature was achieved in a (gallium aluminum arsenide) double heterostructure laser. With further improved developments, device lifetimes of tens of years were obtained with output in the range of tens of mill watts .and with operating wavelengths from 0.7 to1.8 microns (1 micron = 10^{-4} cm). By constructing a row of p-n junctions positioned next to each other, all the separate gain media can be forced to emit together in a phased array to produce an effective combined power output. In this way, gallium aluminum arsenide diode lasers have been operated continuously at room temperature with output in the range of several watts. In addition, electrical to optical power conversion efficiencies of greater than 50 per cent have been obtained.

The semiconductor lasers, being simple in construction and light in weight with compact units and requiring little auxiliary equipment, are very suitable for applications where high powers are not required. They are primarily used in the area of communication in which the near-Infrared laser beams can be transmitted over

Long distances through low-loss optical fibers. In addition, they have found a large market as reading devices for compact disc players [16].

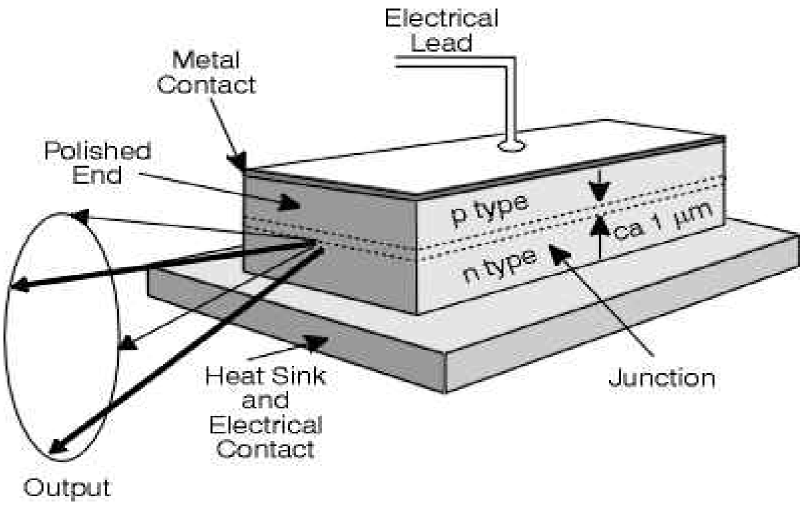


Fig (2-22) a closer look at laser diodes

The laser diode converts electrical energy into energy in form of light. The semiconductor materials that are used to create p-n junction diodes that emit light today are: Gallium arsenide, indium phosphide, gallium antimonide, and gallium nitride. The materials have to be heavily doped to create P – N regions [15].

2.8.5 Application of lasers

- Science – precise measurements, spectroscopy.
- Medicine – laser scalpel, eye surgery and other fields.
- Industry – cutting and welding, guidance systems.
- Telecommunications (fiber optics).
- Radars.
- Precise measurement of long distances (e.g. Moon).

2.8.5.1 Application Lasers in Communication

Fiber optic cables are a major mode of communication partly because multiple signals can be sent with high quality and low loss by light propagating along the fibers. The light signals can be modulated with the information to be sent by either light emitting diodes or lasers. The lasers have significant advantages because they are more nearly monochromatic and this allows the pulse shape to be maintained better over long distances. If a better pulse shape can be maintained, then the communication can be sent at higher rates without overlap of the pulses. Ohanian quotes a factor of 10 advantage for the laser modulators[17].

Telephone fiber drivers may be solid state lasers the size of a grain of sand and consume a power of only half a milliwatt. Yet they can sent 50 million pulses per second into an attached telephone fiber and encode over 600 simultaneous telephone conversations (Ohanian)[17].

Lasers also have been used in communications without optical fiber. “Laser communication is a very specific application -- satellite-to-satellite, terrestrial-to-satellite, terrestrial-to-airplane -- are very high bandwidth applications that lasers can do.” Boeing’s Rinn says. Lasers can be used for communication without any cables to communicate from huge distances, particularly in space. This practice, called free-space optical communications, uses laser beams that travel through the air, or through outer space, instead through optical fiber, and is generating substantial industry excitement for its potential in broadband data communications. Free-space optical communications send lasers operating at wavelengths not visible to the human eye to receivers for high-bandwidth line-of-sight communications. The benefit of free-space optical communication over radio signals is clear. Free-space optical communication does not experience interference from radio waves and is nearly impossible for an enemy to intercept or disrupt[17].

Inter-satellite communications links can send and receive data that are exponentially larger than RF signals can provide, while using less power. NASA’s own project, the Laser Communications Relay Demonstration, seeks to prove the long-term viability of free-space optical communication and increase current inter-satellite data rates by as much as a hundred times greater than current RF communication allows. The Laser Communications Relay Demonstration will be holding preliminary design review in 2013, with ground testing starting in 2014. The project will then fly as a commercial satellite payload in 2016.

Future laser technology

Laser technology has yet to mature, and many enhancements are left to be made. Everything lasers can do currently is still improving at a rapid rate and new techniques to improve lasers are still in the works. One such new technique is beam combining, which blends several laser streams into one high-power beam. “There are a lot of people chasing combining laser beams," says Boeing's Rinn. "There's a lot of research and technology growth going on there." Researchers are taking three approaches to combine laser beams: spectral beam combining, coherent beam combining and polarization beam combining.

Each approach has its own uses, benefits, and downsides. The goal of beam combining is to increase laser power and brightness to enable long-distance communications and laser weapons[17].

Chapter Three

Experimental Work

The Explosive circuit it is composed of five ingredients:

3.1 Integrated circuit SN7493A

The IC SN7493A is a binary counter which can be used, as mod-16 counter. Figure (3-1) shows the pin configurations.

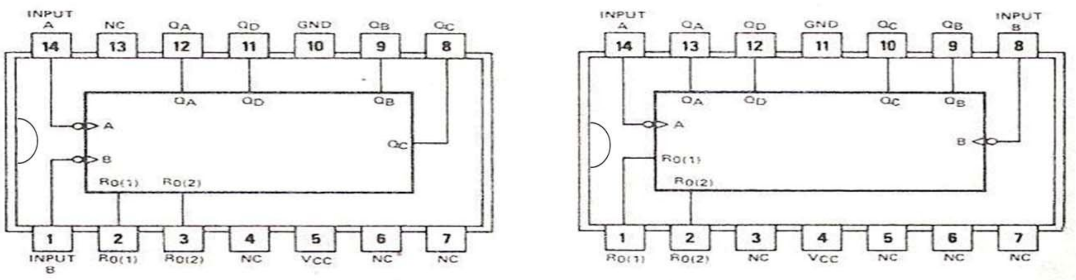
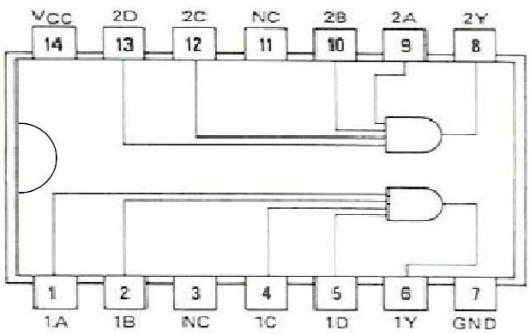


Figure (3-1) S N 7493A IC

The counter counts from 0000 up to 1111. The output of counter QD QC QB QA is fed to And gate. The IC of the AND gate is SN7421 which is a four input AND gate show in figure (3-2).



Figure(3-2) 937421 IC

The output of the counter (QD QC QB QA) is connected to input pins of SN7421 pins 1, 2, 4, 5. The output is at pin 6.The output is connected to the detonator, when the counter reach the count QD QC QB QA = 1111 the AND gate output is high and used to below the fuse of detonator.

3.2 The 555 Timer as an oscillator

The time 555 has many applications. It consist of two comparator, flip flop, a discharge transistor and a resistive voltage divider as shown in figure (3-3).

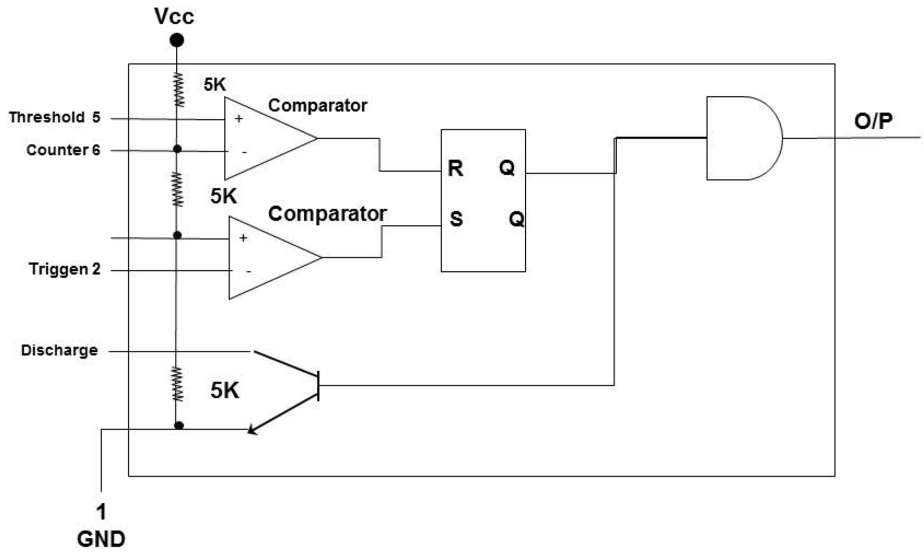


Figure (3-3) 555 time.

Here it is used to generate frequency for the counter.

Figure (3-4) shows the connection of the 555 timer.

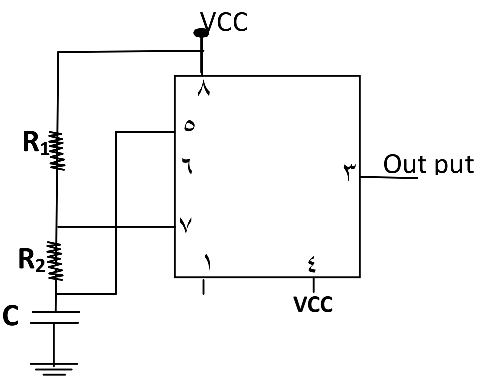


Figure (3-4) Connector of 555 timers

The frequency obtained is calculated form:

$$f = \frac{1.44}{(R1 + 2R2)C} \qquad (3-1)$$

3.3 Freewheeling diode:

A feedback diode (sometimes called a snubber diode, freewheeling diode, suppressor diode, suppression diode, clamp diode or catch diode) is a diode used to eliminate feedback, which is the sudden voltage spike seen across an inductive load when its supply voltage is suddenly reduced or removed [18].

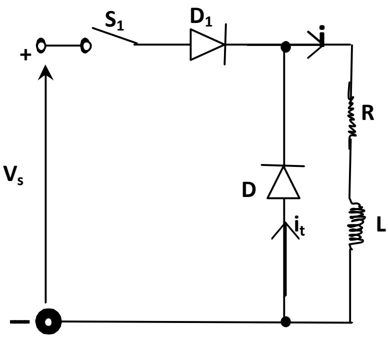


Figure (3-5) free welling diodes

Figure (3-5) feedback diode connection, the application of the free welling diodes is used whenever inductive loads are switched off by silicon components: in relay drivers, H-bridge motor drivers, and so on. A switched-mode power supply also exploits this effect, but the energy is not dissipated to heat and instead used to pump a packet of additional charge into a capacitor, in order to supply power to a load [18].

3.4 Relay

A relays are an electrically operated switches in which a charging a current in one electrical circuit switches a current ON or OFF in another circuit. When there is a current thought the solenoid of the relay, magnetic field is produced which attracts the iron armature, moves the push-rod and so closes the normally open (NO) switch contacts and opens the normally closed(NO)switch contacts figure(3-6)

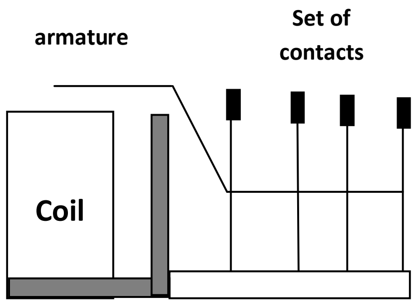


Figure (3-6) Relay

Relays often used in control system, the output from the controller is small current and a much larger current is needed to switch ON or OFF the final correction element [18].

Normally the relay used with a transistor as in figure (3-7).

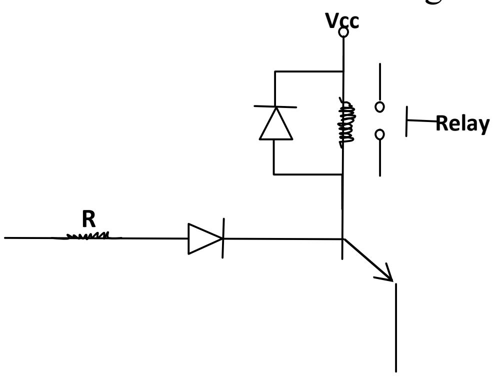


Figure (3-7) Relay using transistor

Because relays are inductances, they can generate a back voltage when the energizing current is switched off or when their input switches from a high to low signal.

As a result damage can occur in the connecting circuit, to overcome this problem a diode is connected across the relay, when the back emf occur the diode conduct and shouts it out[18].

3.5 Thyristor

A thyristor is a solid-state semiconductor device with four layers of alternating N and P-type material. They act as bistable switches, conducting when their gate receives a current trigger, and continue to conduct while they are forward biased (that is, while the voltage across the device is not reversed).

Some sources define silicon controlled rectifiers and thyristors as synonymous. Other sources define thyristors as a larger set of devices with at least four layers of alternating N and P-type material [19].

The first thyristor devices were released commercially in 1956. Because thyristors can control a relatively large amount of power and voltage with a small device, they find wide application in control of electric power, ranging from light dimmers and electric motor speed control to high-voltage direct current power transmission. Originally thyristors relied only on current reversal to turn them off, making them difficult to apply for direct current; newer device types can be turned on and off through the control gate signal. A thyristor is not a proportional control like a transistor but is only ever fully on or fully off, making them unsuitable for analog amplifiers [19].

The thyristor is a four-layered, three terminal semiconducting devices, with each layer consisting of alternately N-type or P-type material, for example P-N-P-N. The main terminals, labeled anode and cathode, are across the full four layers, and the control terminal, called the gate, is attached to p-type material near to the cathode. (A variant called an SCS—Silicon Controlled Switch—brings all four layers out to terminals.) The operation of a thyristor can be understood in terms of a pair of tightly coupled bipolar junction transistors, arranged to cause the self-latching action.

Thyristors have three states:

1. Reverse blocking mode — Voltage is applied in the direction that would be blocked by a diode.
2. Forward blocking mode — Voltage is applied in the direction that would cause a diode to conduct, but the thyristor has not yet been triggered into conduction.
3. Forward conducting mode — the thyristor has been triggered into conduction and will remain conducting until the forward current drops below a threshold value known as the "holding current".

Function of the gate

The thyristor has three p-n junctions (serially named J_1, J_2, J_3 from the anode).

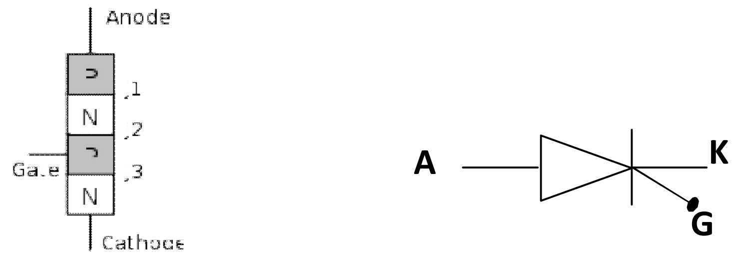


Figure (3-8) Layer diagram of thyristor.

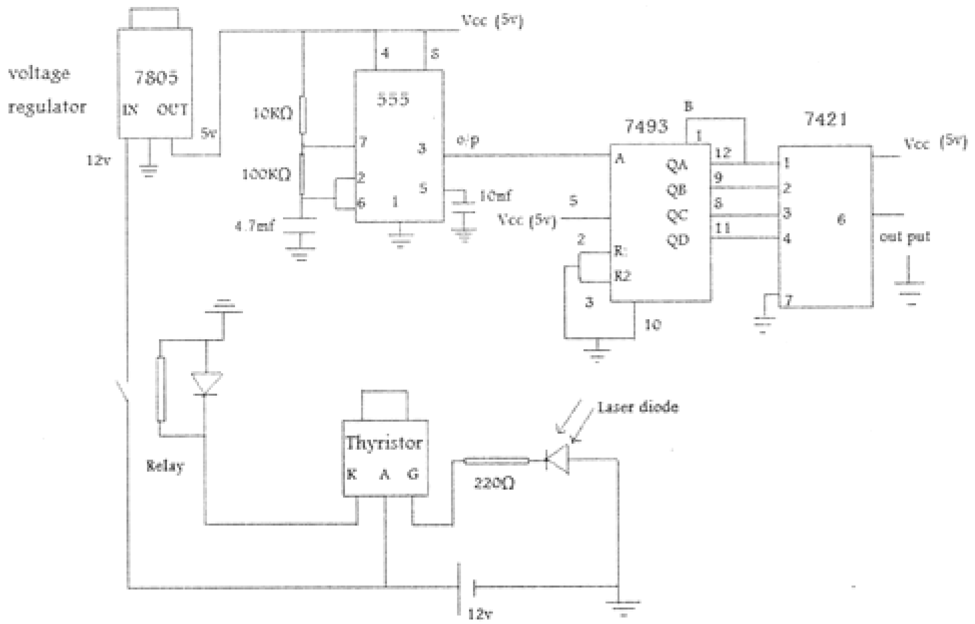
When the anode is at a positive potential V_{AK} with respect to the cathode with no voltage applied at the gate, junctions J_1 and J_3 are forward biased, while junction J_2 is reverse biased. As J_2 is reversing biased, no conduction takes place (Off state). Now if V_{AK} is increased beyond the breakdown voltage V_{BO} of the thyristor, avalanche breakdown of J_2 takes place and the thyristor starts conducting (On state).

If a positive potential V_G is applied at the gate terminal with respect to the cathode, the breakdown of the junction J_2 occurs at a lower value of V_{AK}.

By selecting an appropriate value of V_G, the thyristor can be switched into the on state suddenly.

Once avalanche breakdown has occurred, the thyristor continues to conduct, irrespective of the gate voltage, until: (a) the potential V_{AK} is removed or (b) the current through the device (anode−cathode) is less than the holding current specified by the manufacturer. Hence V_G can be a voltage pulse, such as the voltage output from a UJT relaxation oscillator [19].

These gate pulses are characterized in terms of gate trigger voltage (V_{GT}) and gate trigger current (I_{GT}). Gate trigger current varies inversely with gate pulse width in such a way that it is evident that there is a minimum gate charge required to trigger the thyristor [19].



Figure(3-9) Diagram of explosive circuit

Chapter Four

Results and Discussion

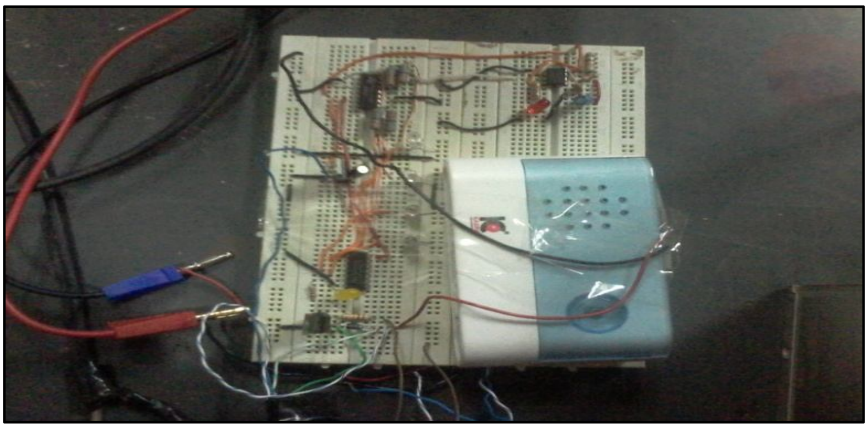
4.1 Introduction:

Designed control circuitry in the remote detonation via electronic components by shining laser light on them, and designed this circuit Ic7493 operating a counter and Ic 7421 as a starting point AND in addition to the microcontroller time Ic555 timer was transferred logic of this circuit to the detonator by freewheeling, thysistor, relay.

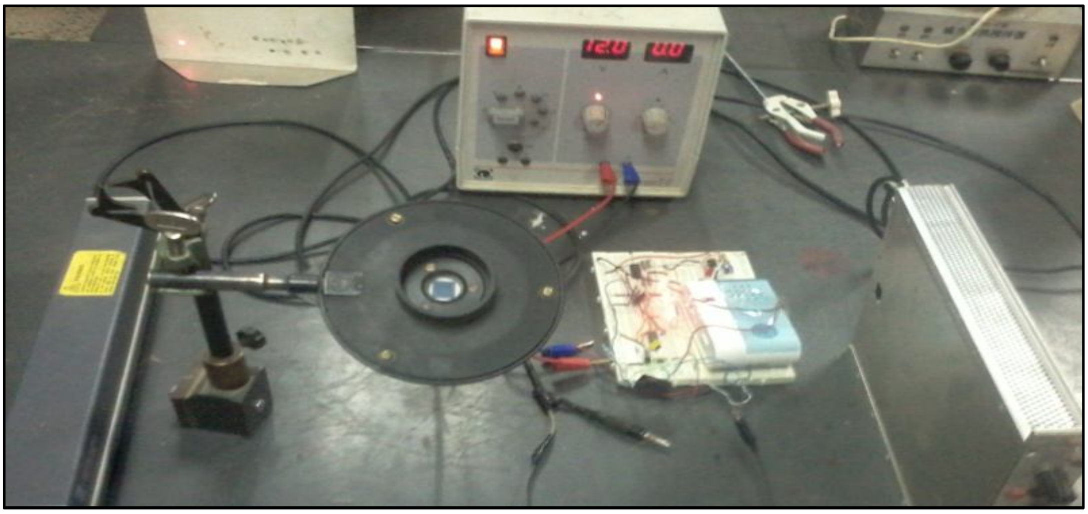
The main supply voltage used was 12 Dc voltage. But the counter 7493 AND gates ICs and timer are supplied by +5Dc volte, by using voltage regulator 7805.

The timer is used to generate the clock signal to the counter 7493. The frequency generated is calculated from

$$f = 1.44/ (R1 + 2R2)C$$



Figure(4-1) An Explosive Circuit



Figure(4-2) An Explosive circuit using laser

4.2 Analysis:

The electrical signal was processed via electronic components to be converted to the logic which bombing caused by it, and controlled by the laser. 12v were used to switch to logic time through Ic555timer, as well as the conversion effort of 5v to the logic of counting by Ic7493 and supporting the logic of counting by effort of 5v to give the AND logic by IC7421 .

After these transfers of electrical voltage to the electronic logic,Ic555timer ,Ic7493 ,IC7421 feed the part responsible to give the signal for the bombing.

4.3 Operation:

Controlled an Explosive circuit by logical electronic:

The circuit Is fed by electrical voltage of(12 V), this voltage fed all the constituents of the circuit.

The ICs 555 timer work as temporally timer by the equation:

$$f = 1.44/(R1 + 2R2)C$$

The IC 555 timer fed the IC9374, which count the logic of the AND gate that counted from the time ,the timer fed the counter gate through (Q_D,Q_C, Q_B, Q_A), which they are the input of the AND gate (IC7421)in the pins 1,2,4,5. The input of the AND gate is processed and give output in the pin 6; which is the explosive wire.

This circuit cannot work without supportive circuit , which consist of photocell (laser) connected with diode that energize the relay, which connected with thyristor. When the thyristor fed by the supply that connected to the circuit; the circuit operates.

Enable remote control in the bombing, which caused by the circuit to give more safety to users of explosives in mines, dig roads in mountainous areas and the construction of canals and tunneling.

4.4 Dissuasion:

Circuit designed as required and worked well. Department has required counting appropriately so given enough time for safety when the bombing. Been controlled in the circuit by remote laser to increase safety and security for users of explosives.

4.5 Conclusion

The Explosive circuit designed with cheap digital elements. The circuit was implemented and tested; the frequency one can be increased to high frequency and the counter can be mod 300 ,and this will increase the safety of the user.

4.6 Recommendations

By the end of this work one can recommend that:

- Using microcontroller for controlling different sites or mines.
- Comparing the result obtained using digital electronic and micro controller.
- To use mobile telephone and transceiver as switch to the explosive circuit.

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