

39B

CIRCUIT BREAKER, TIMER AND POWER CONTROL

39.1 INTRODUCTION

You know the importance of safety systems used in industries, household systems, machines, gadgets and where not. Similarly for specific purposes and operation of systems timers are used. For example if one wants to operate system after a gap of every fifteen minutes, timers can be used to switch on or switch off accordingly. Washing machine, VCR & Television are a few examples. The third most important aspect is control of power in a system means an optimum use of power using electronic devices/systems. In the present lesson you will learn about these systems. We have been using different types of calculators for various calculations and atomic clocks for measuring time without bothering about their principle of working. In the present lesson you will learn about the basic principle of these devices also.

39.2 OBJECTIVES

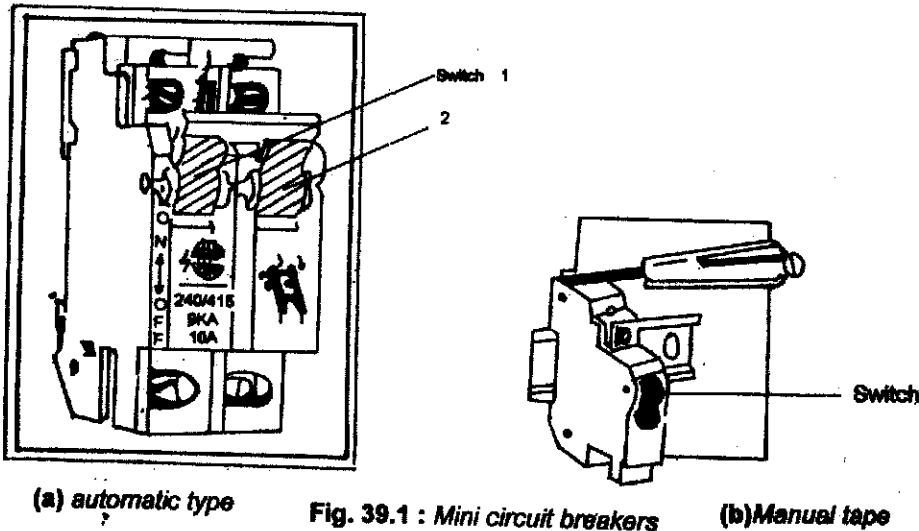
After studying this lesson, you should be able to :

- *explain various circuit breakers used in electronic circuits;*
 - *describe integrated circuits;*
 - *explain the working principle and application of timers;*
 - *recognise the mechanism of electronic power control; and*
 - *state the working principle of the calculator and atomic clock.*
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39.3 CIRCUIT BREAKERS AND MCB

You must be familiar with a fuse system attached with mains in your house or in a building to supply electricity. Fuse is also fitted in electrical/electronic systems/devices as a safety measure. (safety of instrument of system against high current/short circuit/overload etc). Fuse is a simplest form of circuit breakers and its main purpose is to break the circuit under the condition of short circuit/overloading. Basically it is a very thin wire of very high resistance. When current more than its rating passes through it, it gets burnt and circuit breaks thereby saving the system, wiring etc. Some circuit breakers are spring type also which on passage of high current (higher than rated value circuit) break the circuit.

Nowadays *relay type* electrically & electronically operated circuit breakers are used. These are also called *Mini Circuit Breakers (MCB)* figure 39.2. It has a relay which connects or disconnects the system with mains as required to protect short circuiting automatically. Normally in all MCBs the circuit breaks automatically but one has to reset or switch it on to restart the circuit again. Semiconductors are used in MCB nowadays.



39.4 INTEGRATED CIRCUITS (ICs)

In previous lesson you have already learnt about microprocessor(s) and its applications. The need of the hour is miniaturisation and you will be surprised to know that an old day computer which was housed in 6 rooms has been replaced by a miniature and better version (speed wise, performance wise, ease of handling) on desk top or lap top.

IC is integration or putting together various discrete components (like resistor, capacitors, transistors, diodes etc.) on a single chip. An IC looks like fig 39.2 from inside & outside.

39.4.1 Types of ICs

ICs are mainly of two types-

- **Linear IC-** They are used in amplifier, oscillator etc.
- **Digital IC-** They are used in computers, logic circuits etc.

Digital circuits are used as switches i.e. they are either 'on' or 'off' and not in between.

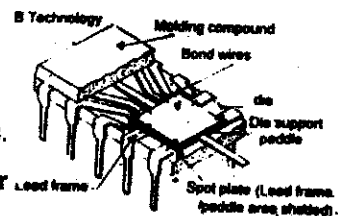


Fig. 39.2 : An integrated circuit (IC)

In linear circuits different input levels give corresponding output and input - output relationship is linear.

These ICs are used in almost all electronic systems now a days e.g. TV, VCR, computer, washing machines at household level and in big industries for automation and control. From a Monolithic IC we mean (*mono*-single, *lithic*-chip) and one example of IC is putting above 35 transistors, 30 resistors and a few capacitors, their interconnections on 1.65 mm chip of silicon.

Following is an example of various types of integrations

- (i) **Small scale integration (SSI)** -> 1-12 gates per chip, used in NAND/NOR gates
- (ii) **Medium scale integration (MSI)** -> 13-99 gates per chip-bipolar, MOS, used in Counters, decoders etc.
- (iii) **Large scale integration (LSI)** -> 100 gates per chip-MOS, used in ROM, RAM coders.
- (iv) **Very large scale integration (VLSI)**- >100K gates per chip- MOS, used in high capacity memory
- (v) **Ultra large scale integration (ULSI)**- > 10^6 gates per chip
- (vi) **Extra large scale integration (ELSI)**- > 10^6 - 10^7 gates per chip

ICs have been fabricated and find application in almost all walks of life like household, industry, communication, electronic control system etc. VLSI can have more than 10^5 - 10^6 components per square cm. And the devices are called submicron (Length 10^{-6} m) devices. We shall discuss in detail about an IC-555 (Timer) in this lesson. IC -723 is used for voltage regulation and IC -741 is operational Amplifier. IC-7400 is used as 2-input NAND gate.

39.4.2 IC - Technology Fabrication

For fabricating IC some stringent controlled conditions must be fulfilled. For example, you know that in a transistor you have *npn* or *pnp* structures having two junctions. For making a transistor you need following process to be done.

1. *diffusion* - for making junction
2. *oxidation* - for isolation-separating one structure from other
3. *metallisation* - for taking contacts.
4. *stripping* - removal of unwanted portion
5. *photolithography* - for making pattern or interconnections on chip

When the size of device / structure is sub-micron then the presence of even a single dust particle (size micron) will hamper the whole circuit.

Hence, for making an IC one needs,

- dust free clean room
- high vacuum system
- controlled temperature
- controlled pressure
- controlled light - for photolithographic process when a pattern is transferred on a chip

- de-ionized water - high resistivity water free from ionic impurities.

In IC fabrication the initial cost of creating infrastructure, equipment etc. is very high and it is only batch processing that brings down the price. Here 50-100 wafers are processed together and given process may have even more than 100 individual steps depending upon type and number of devices to be integrated.

39.4.3 Advantage of IC Over a Discrete Circuit

A discrete circuit contains various components (transistor, resistor etc.) separately connected by wires, whereas

- IC is compact in size & small in weight.
- Due to batch processing cost is reduced.
- No solder joints hence much more reliable.
- Because of shorter connecting leads better high frequency response is obtained.

39.4.3 Limitations of IC Technology

On the one hand when IC technology has number of advantages, at the other it has certain limitations too. They are as follows,

1. Fabrication of inductors, transformer is difficult.
2. Tolerance of passive components is as large as 20% or so.
3. Costly for small quantity production. Initial cost is very high.
4. Power dissipation capacity is small.

INTEXT QUESTIONS 39.1

1. *What do you mean by IC? Where does it find application?*
.....
2. *Name IC's used for*
(i) Voltage regulator (ii) Timer (iii) Operational amplifier
.....
3. *What are the main process used in fabrication of an IC?*
.....
4. *What do you mean by clean room?*
.....
5. *Linear IC's are used in.....whereas digital IC's find application in.....*

In the following section you will find application of one of the ICs timer IC - 555.

39.5 TIMERS

Timers are used for controlling operation of a machine or a circuit. For example you have seen neon lights for advertising in the night. During day time these are switched off. The purpose of switching on and switching off (when desired) can be served by using a device called timers. In earlier days mechanical and electromechanical timers were used.

Here is an example of mechanical timer: your alarm clock gives \ switches on alarm at desired time. Now a days solid state timers or IC (integrated circuit) timers are used and one of these is IC-555. It can produce accurate time delays and the time period is controlled by external resistance-capacitance combination.

$$t \propto RC$$

The pin diagram of IC - 555 is shown in fig. 39.4. It can be used as timer/ clock pulse generator and can work in different frequency ranges. Its size is very small (1cm. \times .5 cm. \times .2 cm.). Combination of timers-IC-556 etc. all find application for time regulation of one or more systems.

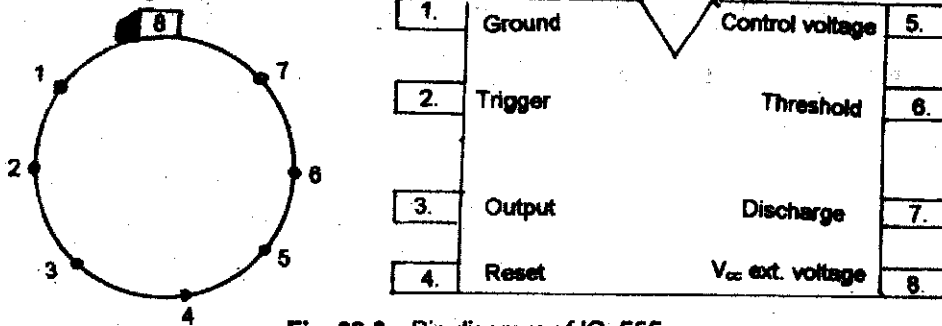


Fig. 39.3 : Pin diagram of IC-555

39.5.1. Principle and Working of a Timer

The basic principle of a timer is first to accurately measure the time delay and then operate the desired system either by giving mechanical contact, electric contact, electronic signal depending upon the type of device and circuit used. Now a days in electronic circuits integrated circuits are used having logic gates, flip flops, comparators, amplifiers for getting precise clock pulse. The description of these systems is beyond the scope of this book. However in the text books of Physics you will find their brief details. The block diagram of IC-555 is given in fig 39.5.

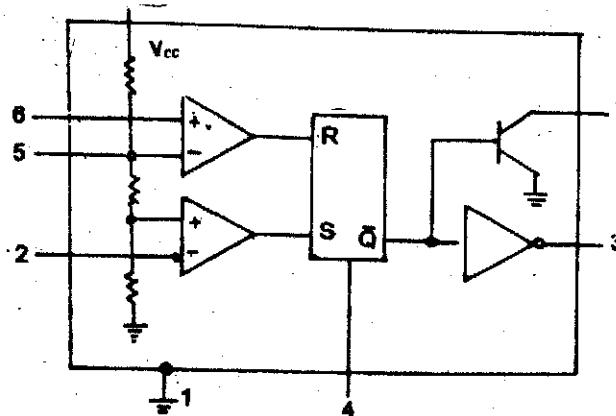


Fig. 39.4 : Block diagram of IC-555

39.5.2. Applications of Timers

Timers find application in many electrical and electronic gadgets in day to day life including military, medical, sports etc. A few of them are given here:

1. In TV, VCR programmable time systems (having IC timers) for desired datewise, timewise, daywise operation (recording, switching on / off, sleep switch etc.)

are available. These are very accurate and carry out desired operation without fail (manual error nil).

2. In industries, where time control of circuits / systems (feeding, bottling plants, washing machines etc.) the timer plays a very useful role.
3. Medical - In intensive care unit for automatic switching on /off crucial life saving systems is provided by timers.
4. Military - For accurate calculation (like object velocity / position, missile attack etc.) electronic timers play very important role.
5. In sports timer / clock for accurate determination of time are used.

INTEXT QUESTIONS 39.2

1. *What is meant by a timer and what for it is used?*
.....
 2. *How will you control the time in the circuit/system? (which parameter is varied)*
.....
 3. *Name the IC used for timer application.*
.....
-

39.6 POWER CONTROL

In present day context of energy crisis, there is a need of optimum use of electrical power in any system. Scientists and R & D organization are trying hard to build systems, where the wastage of power could be stopped by controlling electronically the consumption without hampering the performance of the device, gadget, system. As in example, if you look at old fan regulators and compare with the present day ones, you will observe-

- 1) Older one is bigger in size and the modern ones very small.
- 2) In older system the resistance wires were used to control, the current and hence the fan speed, whereas the modern system is based on solid state device like SCR's diacs and triacs.

An intermediate category of regulators were transformer controlled, which was better than resistance controlled in the sense that the power consumption was little less. In resistance controlled system the power consumption was same for all speed of fan. In the latest power controlled systems comprising of SCR a part of ac cycle is used hence a part of the input power is used to control the speed of a motor or a fan. Therefore, the power consumption is very small because a fraction of ac input cycle is used. Further the size also become very handy.

39.6.1 Principle of Working

An SCR is four layered semiconductor device with three terminals (fig.39.5) anode cathode and gate. The gate current is used to trigger it at a suitable point depending upon the power required. A combination of two SCR's or a triac is more efficient and can be used for full wave rectification with a power control. The operation of SCR can be explained on the basis of two transistor analogy (but it is beyond the scope of this book).

Different types of SCRs are available in the market. LASER (light activated SCR) can be controlled by light. SCR acts like a switch which can be operated in such a manner that only a part of ac cycle (shaded) is used for operating a particular circuit (electric/electronic). Thus power is saved. (Which depends upon conduction angle.)

39.6.2. Applications of Power Controlled Devices

Power controlling devices are used in industries, controlling speed of motors and fans (e.g. small regulator-SCR or Triac controlled) and many other systems. These are also used for controlling light intensity on stages and stadiums (dimmer system).

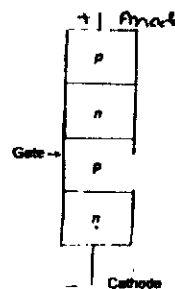


Fig. 39.5 : SCR for Power Controlled System

INTEXT QUESTIONS 39.3

1. What is meant by power control of a system?
.....
2. Which device is used for power control?
.....
3. What is the difference in regulating fan speed by an old resistance type regulator and a SCR controlled system?
.....

39.7 CALCULATOR

You must be familiar with 'abacus', an original continuing machine (fig-39.6) which your parents should have given when you were too young (1-2 year. old). Later with requirement of calculation to multiply, divide, add, subject other manual type systems and machines (manually operated) were developed. Slide rules and FACIT machines are older version of a simple calculator. These machine had many limitations, the method were cumbersome and on the top of it, the speed was very slow. Further it was not possible to calculate complex mathematical, trigonometrical and statistical functions.

(Ten balls to count)
1-10

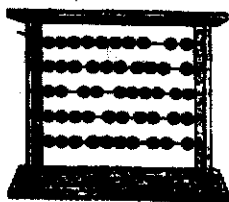


Fig. 39.6 : Abacus

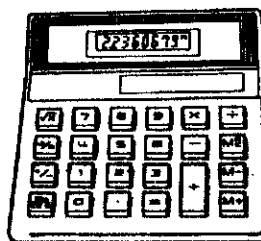


Fig. 39.7 : Simple Calculator

With the advancement in the field of electronics, electronic calculators (a simple one shown in fig-39.7) have been developed. If you visit a stationary shop, you will find different types of calculators (a big range- from simpler one to programmable one). A programmable calculator may also be treated as a mini computer.

A layout of a typical simple calculator has already been shown in figure 39.7 It has a key board with push button for each of 0-9 digit, decimal, $+$ $-$ \times \div $=$ $1/x$

Memory **[M]**, Memory Recall **[MR]** etc. depending upon the type of calculator. There is a screen displaying results and entries in terms of numbers, sign. The old displays were LED (light emitting diode) types, but now a days LCD (liquid crystal display) are used (already discussed in lesson 36). In fact LCD consume very small power. The calculators available these days are mostly button cell powered or solar cell powered.

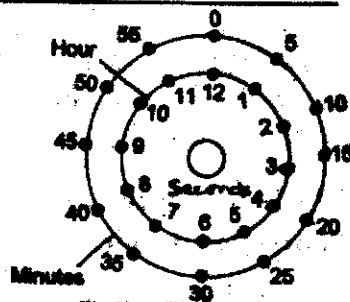


Fig.39.8: Electronic Clock

INTEXT QUESTIONS 39.4

1. Why LCD type calculators are preferred to the LED type calculators?
.....
2. What are the limitations of older type of calculating machines?
.....
3. In an electronic dial clock if the inner circle glows corresponding to 45 and outer circle glows corresponding to
.....
4. What is the time shown by the clock?
.....

39.8 ELECTRONIC DIAL CLOCK

Using the concept of counters, multiplexes and demultiplexes, a novel type of electronic dial clock is shown in Figure (39.8). As the name suggests, the display is in the form of a dial with LED's indicating the hours and minutes. In the figure (39.8), we see that 12 LEDs on outer circle form the minutes indicator, while the 12 LEDs in this under circle form the hour indicator. Seconds are indicated by the center LED. The time is read as follows; suppose in the hour circle the LED corresponding to 2 glows, and in the minute circle the LED corresponding to 15 glows, then the time is 2:15 The minute LED stays on for five minutes and then switches over the next slot.

39.9 WHAT YOU HAVE LEARNT

- introduction of circuit breaker, timers and power control systems.
- The circuit breakers find applications in industries and household electricity supply as a preventive measure against short circuiting.
- Timers have been classified in mechanical, electrical and electronic ones and find application in advertisements(Neon sign), industries and many home appliances like washing machines etc.
- In power control systems , now a days, many solid state devices like SCRs, Triacs etc. are used. They also find application in industries, dimmer circuits, speed of motor control circuits etc.

39.10 TERMINAL QUESTIONS

1. What do you mean by an IC? Mention the functions of an IC-timer?
2. What are circuit breakers? For what purpose are they used? Give an example of simplest form of circuit breaker.

3. Distinguish between the manual and automatic circuit breakers.
4. What is basic difference between linear and digital ICs?
5. What steps are used for making a transistor?
6. Explain the conditions for fabricating an IC.
7. How an integrated circuit is better than a discrete circuit?
8. Explain the role of circuit breaker in industry and house hold supply.
9. Explain principle and working of IC-555. How it is different from IC-556?
10. Mention the parameters which control the time delay.
11. Name the device most commonly used for power control.
12. What are applications of LCD and LED? Give advantages and disadvantages of each
13. Explain the principle and working of a timer. Also mention its applications in the field of medicine.
14. Write principle of a calculator and name a few type of calculators.
15. Explain how LEDs are used in electronic dial clock?

ANSWER TO THE INTEXT QUESTIONS

Intext Question 39.1

1. IC is an integration of various discrete components on a single chip. ICs are used in almost all electronic systems like TV, VCR, Computers etc.
2. IC - 723 is used for voltage regulation
IC - 555 is used for timer.
IC - 741 is used for operational amplifier.
3. Main processes used in fabrication of an IC are - diffusion, oxidation, metallisation, stripping and photo lithography.
4. By clean room we mean a room free from dust and the room should be at controlled humidity temperature pressure etc.
5. amplifier, computers.

Intext Questions 39.2

1. Timer is a device used for controlling operation of a machine or a circuit.
2. By using solid state timers or IC timer or by using external resistance-capacitance combination.
3. IC - 555 is used for timer applications.

Intext Questions 39.3

1. Power control of a system means an optimum use of electrical power in a system.
2. SCR is used for power control.
3. The old resistance type regulator is bigger in size whereas SCR is very small.

Intext Questions 39.4

1. Because LCD type calculators consume very small power.
2. Their speed was very slow and the methods were cumbersome.
3. Time is 3.45