(*iii*) Logical 1 output voltage 3.0 V
(*iv*) Noise immunity 1.0 V
(*vii*) Fan-in 10
(*viii*) Power dissipation 10 mW/gate

1.11 SUMMARY

In this unit, you have learned about digital computers which are electronic devices capable of manipulating numbers and symbols. This is done by a set of instructions known as a computer program. You have learned about the classification of digital computers which is based on their speed of operation, memory capacity, hardware facilities and processor. Digital computers are classified on the basis of the processing hardware mainframe computers, minicomputers and microcomputers. Mainframe computers support a large number of users and help to access a wide variety of software applications. These are also termed as organizational computers as these are basically used by large organizations. Minicomputers are the scaled-down version of mainframe computers, whereas microcomputers have developed from advanced computer technology and are most widely used now-a-days. These are also known as home computers or personal computers and are available in many forms—desktop, laptop, notebooks, personal digital assistant, etc.

You have also learned about the binary number system, which is a number system that uses only two digits, 0 and 1. Two numeric values, 0 and 1, used as symbols are known as bits or binary digits. Different number systems have different bases. You have also learned about other types of number systems such as octal and hexadecimal. An octal number system has 8 as the base and a hexadecimal number system has 16 as the base. You can convert from one number system to another and use the double-dabble method for converting from decimal to binary. You have learned to convert from octal to decimal, decimal to octal, binary to octal, hexadecimal to binary, hexadecimal to decimal and octal to decimal. You have learned how to use binary codes to communicate with a digital computer. A code is a symbol or group of symbols that is used to represent a letter, word or phrase. Hence, it is a representation of discrete elements of information. The binary bits 1 and 0 are used in groups. These codes are used to communicate information to a digital computer and to retrieve from it. You also know how binary digits are stored in a binary cell. This binary cell is a flip-flop that maintains either of two stable states that represent zero (0) or one (1). You have learned the importance and significance of error detecting codes. In order to detect and correct such errors, two types of codes—error-detecting codes and error-correcting codes—are used. You have learned that an integrated circuit also called IC or silicon chip, is a tiny device that contains a number of electronic components/circuits. It contains thousands of electronic parts on a paper-thin chip of silicon, and includes resistors, capacitors, diodes and transistors. Integrated circuits are classified into two general categories–linear and digital. Linear integrated circuits operate with the help of continuous signals and function such as amplifiers, voltage comparators, etc., whereas digital integrated circuits operate with the help of binary signals.

Finally, in this unit, you have learned about various logic families, which are further categorized according to the IC fabrication process and are called bipolar and metal oxide semiconductor (MOS). The main elements of a bipolar IC are resistors, transistors and diodes. The bipolar logic families derived from logic

circuits are DTL (Diode Transistor Logic), RTL (Resistance Transistor Logic), DCTL (Direct Coupled Transistor Logic), CML (Current Mode Logic) and TTL (Transistor Transistor Logic).

1.12 KEY TERMS

- **Computer:** It is an electronic device capable of manipulating numbers and symbols under the control of a set of instructions known as computer program.
- **Mainframe computer:** It supports a number of users to access a variety of software applications and are also called organizational computers because they are used in large organizations.
- **Minicomputer:** It is a scaled-down version of the mainframe and are also called workgroup systems.
- **Microcomputer:** It is developed from advanced computer technology and are called home computers, personal computers, laptops, personal digital assistants, etc.
- **Binary number system:** It is a number system that uses only two digits, 0 and 1 known as bits or binary digits. It is a base 2 (two) system.
- **Decimal number system:** It is a number system which utilizes ten distinct digits, i.e., 0, 1, 2, 3, 4, 5, 6, 7, 8 and 9. It is a base 10 (ten) system.
- **Double-dabble method:** This method is used to convert the decimal number to binary and is also known as divide-by-two method.
- **Octal number system:** It is a number system that uses eight digits, 0, 1, 2, 3, 4, 5, 6 and 7. It has base 8.
- **Hexadecimal number system:** This number system groups numbers by sixteen and powers of sixteen and are used in microprocessor. It uses 16 digits from 0 to 9 and then A, B, C, D, E and F. It has 16 as its base.
- **1's complement:** To get 1's complement of any binary number, change each 0 in the number to 1 and each 1 to 0.
- **2's complement:** To get 2's complement of any binary number, first get 1's complement and then add 1 to the rightmost digit.
- **Non weighted codes:** These codes are not weighted by position. Excess-3 and Gray codes are the examples of non weighted codes.
- **Alphanumeric codes:** These codes represent alphabetic characters (letters), punctuation marks and other special characters represented on a computer keyboard.
- **ASCII code:** The abbreviation ASCII stands for the American Standard Code for Information Interchange. It is a 7-bit code used in transferring coded information from keyboard and to computer display and to printer.
- **Parity check:** It is the most simple and commonly used error detecting method where an extra parity bit is included with the binary message to make total number of 1s either odd or even. The parity bit can be placed at either end of the code word, such that the receiver should be able to differentiate between the parity bit and the actual data.

- **Checksum:** Th
pinpoint erroneo
- **Integrated circ**
a number of ele
includes resisto

1.13 ANSWERS

1. A computer is
symbols under
2. These are:
(*iii*) Microcom
3. Mainframe com
applications. T
in large organi
4. Minicomputer
smaller workg
5. Microcomput
unit. These a
Microcomput
as desktops,
6. It is a numbe
7. This is a meth
by-two metho
divided by 2
coefficient
successive d
8. We follow d
Step 1: Divi
Step 2: Div
Step 3: Div
Step 4: Div
Step 5: Div
We start by
equivalent
9. First from
written as
$1 \times 2^7 + 1$
$= 128 + 6$
10. A number
octal num
11. We follow
divide by

- **Checksum:** The check sum method is used to detect-double errors and pinpoint erroneous bits.
- **Integrated circuit:** An integrated circuit or IC is a tiny device that contains a number of electronic components/circuits on a paper-thin chip of silicon. It includes resistors, capacitors, diodes and transistors.

1.13 ANSWERS TO 'CHECK YOUR PROGRESS'

1. A computer is an electronic device capable of manipulating numbers and symbols under the control of a set of instructions known as computer program.
2. These are: *(i)* Mainframe computers, *(ii)* Minicomputers and *(iii)* Microcomputers.
3. Mainframe computers support a number of users to access a variety of software applications. These are called organizational computer because these are used in large organizations.
4. Minicomputers are also called workgroup systems because they are used by smaller workgroups within a large organization.
5. Microcomputer is a computer having microprocessor as its central processing unit. These are commonly used in home, classroom and in the workplace. Microcomputers are called home computers or personal computers and come as desktops, laptops, notebooks, personal digital assistants, etc.
6. It is a number system that uses only two digits, 0 and 1. It has two as its base.
7. This is a method for converting decimal to binary and is also known as divide-by-two method. The decimal number, to be converted into binary, is repeatedly divided by 2, and the remainder after each division is used to indicate the coefficient of the binary number to be formed. After completing these successive division, binary number derived, is written from the bottom up.
8. We follow double-dabble method as follows:

   Step 1: Divide 51 by 2. Quotient is 25 and remainder is 1.

   Step 2: Divide 25 by 2. Quotient is 12 and remainder is 1.

   Step 3: Divide 12 by 2. Quotient is 6 and remainder is 0.

   Step 4: Divide 6 by 2. Quotient is 3 and remainder is 0.

   Step 5: Divide 3 by 2. Quotient is 1 and remainder is 1.

   We start by writing last remainder first and first remainder last. The binary equivalent of decimal number is 110011.
9. First from the rightmost place is 2^0, second is 2^1 and so on. The number is written as follows:

   $1 \times 2^7 + 1 \times 2^6 + 1 \times 2^5 + 0 \times 2^4 + 0 \times 2^3 + 1 \times 2^2 + 1 \times 2^1 + 0 \times 2^0$

   $= 128 + 64 + 32 + 4 + 2 = 230$
10. A number system that uses eight digits, 0, 1, 2, 3, 4, 5, 6 and 7 is called an octal number system. It has base 8.
11. We follow the continuous division like double-dabble method. But here, we divide by 8 instead of 2.

We divide 256 by 8. Quotient is 32 and remainder is 0.

Again we divide 32 by 8. Quotient is 4 and remainder is 0.

Next division gives 4 as remainder. We stop here and write remainders from bottom side. Octal equivalent of 256 is 400. This is written as $256_{10} = 400$

12. The hexadecimal number system uses 16 digits; 0 to 9 and then A, B, C, D, and F. It has 16 as its base. It groups numbers by sixteen and powers of sixteen.

13. We follow the division method. We go on dividing by 16 till quotient is less than 16. We divide 280 by 16. We get 17 as quotient and 8 as remainder. We again divide 17.

We get 1 as quotient and 1 as remainder. We again divide 1 by 16. Quotient is zero and remainder is 1. We write result from bottom which is 18. Hence, the hexadecimal equivalent of decimal is written as, $280_{10} = 18_{16}$.

14. In hexadecimal system, first rightmost place has weight 16^0, second has 16^1 and third is 16^2. So the number in decimal is $C \times 16^2 + 8 \times 16^1 + E = 12 \times 256 + 8 \times 16 + 14 = 3072 + 128 + 14 = 3214$. Thus, $C8E_{16} = 3214_{10}$.

15. We get 1's complement of any binary number by changing each 0 in the number to 1 and each 1 to 0.

16. We change 1 to 0 and 0 to 1. Therefore 1's complement of 11000101 is 00111010.

17. To get 2's complement of any binary number, first get 1's complement and then add 1 in the rightmost digit.

18. First we find 1's complement. It is 00111010. We add 1 to it and get 00111011. Hence, 2's complement of 11000101 is 00111011.

19. Binary codes are representation of information in form of combination of discrete elements.

20. Weighted binary codes obey the positional weight principle. Each position of a number has a specific weight. Bits at respective positions are multiplied by the weights indicated by that position and the sum of the weighted bits gives the decimal digit.

21. It is a weighted binary code. The 8421 code is in form of a binary coded decimal (BCD). Each digit is composed of four bits representing the decimal digits 0 through 9. The designation 8421 represents the binary weights of the four bits (23, 22, 21, 20). Only 10 digits are used for each nibble number. Thus, no digit exceeds 1001 and hence, 1010, 1011, 1100, 1101, 1110 and 1111 are not used in BCD.

22. Decimal number 825 is converted to the BCD code as 1000 0010 0101. Symbolically, it is written as $825_{10} = 1000\ 0010\ 0101_{BCD}$.

23. Non weighted codes are not weighted by position. Excess-3 and Gray code are the examples of non-weighted codes.

24. The Excess-3 is a non weighted digital code and is used to express decimal numbers, derived by adding 3 to each decimal digit and then converting the result to four bit binary. This is also written as XS-3 code.

25. Decimal number 456 in normal BCD is 0100 0101 0110. In XS-3 code it is written as 0111 1000 1001.

26. Gray code belongs to a class of codes called minimum change codes. In this coding system, only one bit in the code group changes when going from one step to the next. It is not an arithmetic code.

27. Alphanumeric codes are the codes that represent alphabetic characters (letters), punctuation marks and other special characters and functions that are found on a computer keyboard.

28. ASCII stands for the American Standard Code for Information Interchange. It is a 7-bit code used in transferring coded information from keyboards and to computer display and printers. This code is used to represent numbers, letters, and punctuation marks as well as control characters.

29. The abbreviation EBCDIC stands for the Extended Binary Coded Decimal Interchange Code. It is an 8-bit code is which the decimal digits are represented by the 8421 BCD code preceded by 1111.

30. It is the most simple and commonly used error detecting method. In this method an extra parity bit is included with the binary message such that the total number of 1s is either odd or even. The parity bit can be placed at either end of the code word, such that the receiver should be able to differentiate between the parity bit and the actual data.

    (*i*) When the total number of 1s in the code group (including the parity bit) is even number then it is even parity check.

    (*ii*) When the total number of 1s in the code group (including the parity bit) is an odd number then it is odd parity check.

31. Checksum is a method to detect double errors and pinpoint erroneous bits. In this method, initially word A 10110111 is transmitted; next the word B 00100010 is transmitted. The binary digits in the two words are added and the sum obtained is retained in the transmitter. Then, a word C is transmitted and added to the previous sum and the new sum is retained. In the same manner, each word is added to the previous sum and after transmission of all the words, the final sum, called the check sum, is also transmitted. The same operation is done at the receiving end and the final sum obtained here is checked against the transmitted check sum. If the two sums are equal, then there is no error.

32. It is a coding system in which one or more parity bits are added to the data character for the purpose of detecting and correcting error.

33. Hamming distance between two code words is defined as the number of bits changed from one code word to another. It checks the places that differ in bits in two binary codes having fixed numbers of bits. This is termed as Hamming distance. If there are two codes 11011010 and 11010100 then differences of bits are at positions 2, 3 and 4. Hence, Hamming distance is 3.

34. An integrated circuit is a tiny device that contains a number of electronic components/circuits.It contains thousands of electronic parts on a paper-thin chip of silicon. It includes resistors, capacitors, diodes and transistors.