NUMBER SYSTEMS AND CODES

- Review of Binary, Octal and Hexadecimal number systems

- Conversion methods: Complements, Signed and Unsigned Binary numbers

- Binary codes: Weighted and non-weighted codes

- Error detecting and error correcting codes

- Hamming codes

- Code converters: Binary to gray, gray to binary, gray to binary, bcd to excess 3 code.

1.1 ANALOG AND DIGITAL REPRESENTATIONS

Quantities are measured, monitored, recorded and manipulated arithmetically, observed, and in som other way utilised in most physical systems

1.1.1 WAYS OF REPRESENTING NUMERICAL VALUE

There are two ways of representing the numerical value of quantities

1. Analog 2. Digital

ANALOG REPRESENTATION: A quantity is represented by continuously variable, proportional indicator. Example an automobile speedometer from classic muscle cars of the 1960s and 1970s or a wall clock.

Analog systems contains devices that manipulate physical quantities that are represented in analog form.

By default, the real world uses analog systems.

The graph like a sign function is continuous at every point.

DIGITAL REPRESENTATION: The quantities are represented by symbols called digits. It is discrete at different points. Example, digital indoor/outdoor thermometer

A digital system is a combination of devices designed to manipulate logical information and physical quantities that are represented in digital form.

Note: Analog is continuous, Digital is discrete (step by step)

ADVANTAGES OF DIGITAL TECHNIQUES

1. Digital systems are generally easier to design. The circuits used in digital systems are switching circuits

2. Information storage is easy.

3. Accuracy and precision are easier to maintain throughout the digital system.

4. Operations can be programmed

5. Digital circuits are less affected by noise

6. More digital circuiting can be frabicated on IC chips.

LIMITATIONS OF DIGITAL TECHNIQUES

1. The real world is analog and digitalising always introduces some errors

2. Processing digitised signals takes time

To take advantage of digital techniques when dealing with analog inputs and outputs, some steps must be followed

1. Convert te physical variable to an electrical signal (analog)

2. Convert the electrical (analog) signal into digital form

3. Process (operate on) the digital information

4. Convert the digital outpus back to real-world analog form

DECIMAL SYSTEM

This is a system that is composed of 10 numbers or symbols. They are 0,1,2,3,4,5,6,7,8,9

Decimal system is also called base-10 system. It is a positional-value system in which the value of a digit depends on its position.

For example, if we look at 453

4 represents hundreds

5 represents tens

3 represents units

4 carries the most weight of the 3 digits, it is referred to as most significant digit (MSD), 5 carrries the least weight and is called the least significant digit (LSD). Notice that the decimal position values are expressed as powers of 10

2745.214

2->10^3

7->10^2

4->10^1

5->10^0

2->10^-1

1->10^-2

4->10^-3

BINARY SYSTEM

Binary system is also a positional value system, wehrein each binary digit has its own value or weight expressed as a power of 2

1011.101

When dealing with a switch (switching circuits), it is usually ON or OFF, so we can use two bits (1 and 0)

BINARY COUNTING

We are using, four-bit binary numbers to illustrate binary couting. The sequence begins with all bits at 0. That is called the zero count

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| WEIGHTS | | | | DECIMAL EQUIVALENT |
| 2^3=8 | 2^2=4 | 2^1=2 | 2^0=1 |
| 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 1 | 1 |
| 0 | 0 | 1 | 0 | 2 |
| 0 | 0 | 1 | 1 | 3 |
| 0 | 1 | 0 | 0 | 4 |
| 0 | 1 | 0 | 1 | 5 |
| 0 | 1 | 1 | 0 | 6 |
| 0 | 1 | 1 | 1 | 7 |
| 1 | 0 | 0 | 0 | 8 |
| 1 | 0 | 0 | 1 | 9 |
| 1 | 0 | 1 | 0 | 10 |
| 1 | 0 | 1 | 1 | 11 |
| 1 | 1 | 0 | 0 | 12 |
| 1 | 1 | 0 | 1 | 13 |
| 1 | 1 | 1 | 0 | 14 |
| 1 | 1 | 1 | 1 | 15 |

BINARY TO DECIMAL CONVERSION

DECIMAL TO BINARY CONVERSION

HEXADECIMAL NUMBER SYSTEM

The hexadecimal number system uses base-16. It has 16 possible digit symbols. It uses the digit 0 through letters A, B,C,D,E,F as 16 digit symbols.

The digit positions are weighted as powers of 16. A through F are equivalent to the decimal values 10 through 15

|  |  |  |
| --- | --- | --- |
| Hexadecimal | Decimal | Binary |
| 0 | 0 | 0000 |
| 1 | 1 |  |
| 2 | 2 |  |
| 3 | 3 |  |
| 4 | 4 |  |
| 5 | 5 |  |
| 6 | 6 |  |
| 7 | 7 |  |
| 8 | 8 |  |
| 9 | 9 |  |
| A | 10 |  |
| B | 11 |  |
| C | 12 |  |
| D | 13 |  |
| E | 14 |  |
| F | 15 |  |

HEX TO DECIMAL CONVERSION

DECIMAL TO HEX CONVERSION

423 div 16 → 27 rem 7

27 div 16 → 1 rem 10=A

1 div 16 → 0 rem 1

HEX TO BINARY CONVERSION

9 → 1001

F → 1111

2 → 0010

COUNTING IN HEXADECIMAL

When counting in hex, each digit position can be incremented (increase by 1) from 0 to F.

Once a digit position reaches the value F, it resets to 0 and the next digit position is inremented

COUNTING SEQUENCE EXAMPLES

a. 38, 39, 3A, 3C, 3D, 3E, 3F, 40, 41, 42

b. 6F8, 6F9, 6FA, 6FB, 6FC, 6FD, 6FE, 6FF,700

ASSESSMENTS

1. to decimal. Answer: 9422\_10

2. Convert 3117 to hex, then from hex to binary

3117 → C2D → 110000101101

3. 1001011110110101 to hex. Ans: 97B5

4. 3527\_16 to base 2. Answer: 11010100100111

5. The range of decimal values that can be represented by a four digit hex number is 0 to 65535. The smallest four-digit hexadecimal number 0000(0 in decimal) and the largest is FFFF.

BCD – Binary Coded Decimal

When numbers, letters or words are represented by a special group of symbols, we say they’re being encoded, and the group of symbols is called a codee.

In BCD, each decimal digit is represented by some code in 1’s and 0’s and we can only have decimal numbers 0 to 9.

137\_10 in binary = 10001001\_2

137\_10 in BCD = 000100110111

1’s and 2’s Complements

They are used to deal with signed bits that allow us to find the opposite sign of the bits.

In 1’s complement of a binary number is obtained by toggling all of the bits in it

The 2’s complement of a binary number, is 1 added to the 1’s complement of the binary number

SWITCHING CIRCUITS

A Switch is a device used to control the current in an electric circuit.

If the switch is open (i.e. it is off) current doesn’t flow through the circuit and vice-versa

SWITCHING CIRCUIT DESIGN

This means two points of electric circuit connected by wires and consisting of a finite number of switches

WAYS OF CONNECTING SWITCHES

Parallel arrangement:

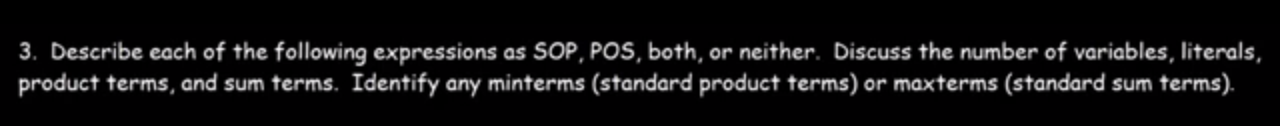
In parallel connection, current will be passed if either one of the switches is closed. That is to say that there is an “OR” operation in parallel arrangement

Series Arrangement:

For switches in series, all the switches have to be closed for current to pass therefore making the operation in series arrangement an “AND” operation

EQUIVALENT CIRCUITS

These are two switching circuits if in all positions the closure conditions are the same. If two circuits A and B are equivalent, we can write it as





This is a sum of products

Four product terms

We have four variables, x, y, z, w

We have 12 literals

A minterm (standard product terms) is a term that contains all variables x’yzw is the minterm



Product of sums

3 variables

Max term (standard sum term) is (x + y + z’)



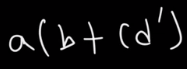
This is both an SOP (Sum of one product term) and a POS (Product of four sum terms)

We have four variables (w, x, y, z)

We also have four literals (w, x, y’, z)



This can be called an SOP or a POS



This is neither “a sum of products” nor a product of sums

TEXTBOOKS AND REFERENCES:

1. Digital systems: principles and applications by Ronald J Tocci/ Neal Widmer/ Greg Moss