GPCET
Pioneering Innovative Education

G. PULLAIAH COLLEGE OF ENGINEERING AND TECHNOLOGY

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Department of
Electronics and Communication Engineering

Bridge Course
On
DIGITAL Logic Design

By

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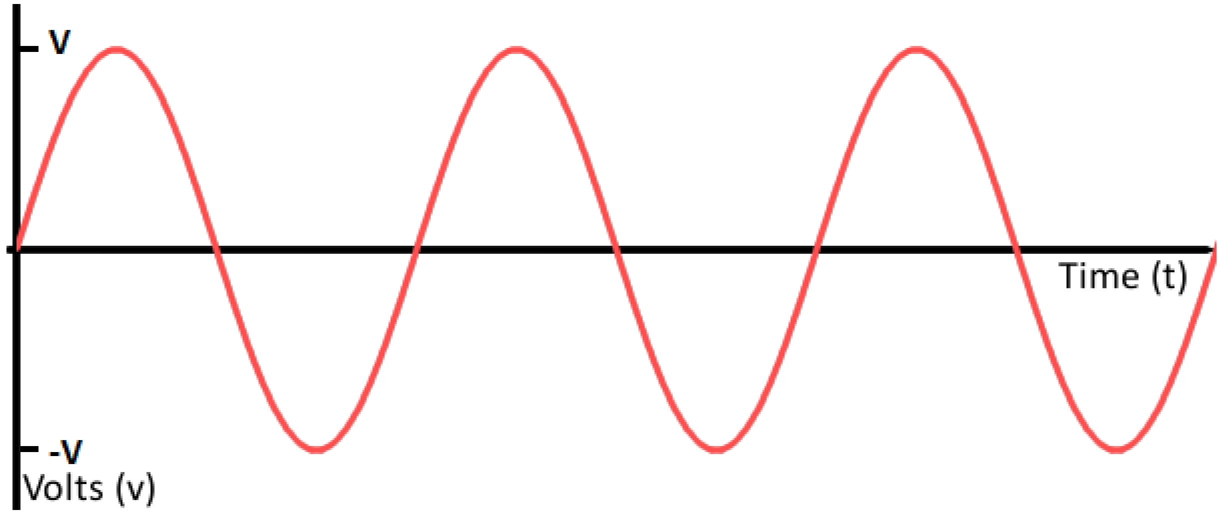
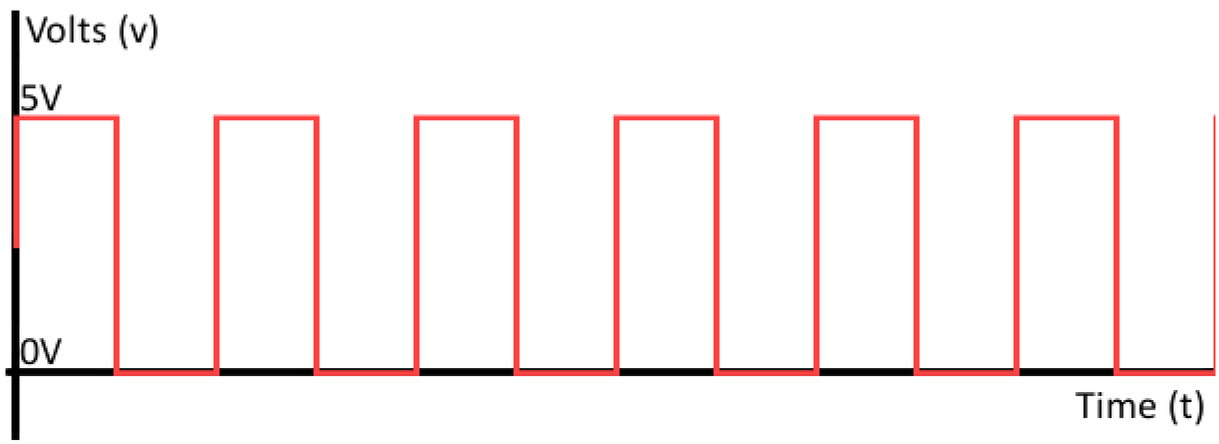
What is the Analog Signal?

An analog signal is any continuous signal for which the time varying feature (variable) of the signal is a representation of some other time varying quantity, i.e., analogous to another time varying signal.



What is the Digital Signal?

A digital signal is a discrete form. Digital signals are represented by square wave. In digital signals 1 is represented by having a positive voltage and 0 is represented by having no voltage or zero voltage as shown in figure.



Number system:

A system for representing (that is expressing or writing) numbers of a certain type. Example: There are several systems for representing the counting numbers. These include: The usual "base ten" or "decimal" system: 1, 2, 3… 10, 11, 12 … 99, 100... **(Or)**

A number system is a way to represent numbers. We are used to using the base-10 number system, which is also called decimal. Other common number systems include base-16 (hexadecimal), base-8 (octal), and base-2 (binary). **(Or)**

A numeral system (or system of numeration) is a writing system for expressing numbers; that is, a mathematical notation for representing numbers of a given set, using digits or other symbols in a consistent manner.We are using mostly the base-10 number system to rep. numbers, which is also called decimal.

Example:

Decimal Number system: The Decimal number system contains ten unique symbols. 0,1,2,3,4,5,6,7,8,9. Since Counting in decimal involves ten symbols its base or radix is ten. There is no symbol for its base i.e., for ten.

Roman Number system: The numbers 1 to 10 are usually expressed in Roman numerals as follows: I, II, III, IV, V, VI, VII, VIII, IX, X. Numbers are formed by combining symbols and adding the values, so II is two (two ones) and XIII is thirteen (a ten and three ones).

Symbol	I	V	X	L	C	D	M
Value	1	5	10	50	100	500	1,000

Activity

Before we get started, let's try a little activity for fun. There are many different ways to represent a color, but one of the most common is the RGB color model. Using this model, every color is made up of a combination of different amounts of red, green, and blue

Looking at Base-10

0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11... You've counted in base-10 all of your life. Quick, what is 7+5? If you answered 12, you are thinking in base-10. Let's take a closer look at what you've been doing all these years without ever thinking about it.

Let's take a quick look at counting. First, you go through all the digits: 0, 1, 2... Once you hit 9, you have no more digits to represent the next number. So, you change it back to 0, and add 1 to the tens digit, giving you 10. The process repeats over and over, and eventually you get to 99, where you can't make any larger numbers with two digits, so you add another, giving you 100.

Although that's all very basic, you shouldn't overlook what is going on. The right-most digit represents the number of ones, the next digit represents the number of tens, the next the number of hundreds, etc.

The Decimal Number system:

The Decimal number system contains ten unique symbols. 0,1,2,3,4,5,6,7,8,9. Since Counting in decimal involves ten symbols its base or radix is ten. There is no symbol for its base i.e., for ten. It is a positional weighted system i.e.,the value attached to a symbol depends onits location w.r.t. the decimalpoint. In this system, any number (Integer, fraction or mixed) of any magnitude can be rep. by the use of these ten symbols only. Each symbol in the no. is called a Digit. The leftmost digit in any no.rep, which has the greatest positional weight out of all the digits present in that no.is called the MSD (Most Significant Digit) and the right most digit which has the least positional weight out of all the digits present in that no. is called the LSD (Least Significant Digit).The digits on the left side of the decimal pt. form the integer part of a decimal no. & those on the right side form the fractional part. The digits to the right of the decimal pt. have weights which are negative powers of 10 and the digits to the left of the decimal pt. have weights are positive powers of 10. The value of a decimal number is the sum of the products of the digit of that no. with their respective column weights. The weights of each column is 10 times greater than the weight of unity or 10^0 i.e., the first digit (units digit) to theleft of the decimal pt. has a weight of 1 or 10^0, for the second 10 or 10^1& for the third 100or 10^2 like that the first digit to the right of the decimal pt. has a weight of 1/10 or 10^{-1}, for the second 1/100 or 10^{-2} & for the third 1/1000or 10^{-3}.In general the value of any mixed decimal no. is

$$d_n d_{n-1} d_{n-2} \dots\dots\dots\dots d_2 d_1 d_0 \,.\, d_{-1}\, d_{-2} \dots\dots\dots\dots\ d_{-k}$$

$$(d_n \times 10^n) + (d_{n-1} \times 10^{n-1}) + \ \dots\dots\ + (d_2 \times 10^2) + (d_1 \times 10^1) + (d_0 \times 10^0) + (d_{-1}\ \times 10^{-1})$$

$$+ (d_{-2} \times 10^{-2}) + \ \dots\dots\dots\ + (d_{-k} \times 10^{-k})$$

Naturals, Integers, Rationals, Irrationals, Reals:

The Natural Numbers:

The natural (or counting) numbers are 1,2,3,4,5, etc. There are infinitely many natural numbers. The set of natural numbers, {1, 2,3,4,5 ...}, is sometimes written N for short.

The **Whole Numbers** are the natural numbers together with 0.

(Note: a few textbooks disagree and say the natural numbers include 0.)

The sum of any two natural numbers is also a natural number (for example, 4+2000=2004), and the product of any two natural numbers is a natural number (4×2000=8000). This is not true for subtraction and division, though.

The Integers:

The integers are the set of real numbers consisting of the natural numbers, their additive inverses and zero.

{..., −5,−4,−3,−2,−1,0,1,2,3,4,5, ...}

The set of integers is sometimes written J or Z for short.

The sum, product, and difference of any two integers are also an integer. But this is not true for division... just try 1÷2.

The Rational Numbers:

The rational numbers are those numbers which can be expressed as a ratio between two integers. For example, the fractions 1/3 and −1111/8 are both rational numbers. All the integers are included in the rational numbers, since any integer ***z***can be written as the ratio ***z/1***.

All decimals which terminate are rational numbers (since 8.27 can be written as 827/100.) Decimals which have a repeating pattern after some point are also Rationals: for example,

0.0833333....=1/12.

The set of rational numbers is closed under all four basic operations, that is, given any two rational numbers, their sum, difference, product, and quotient is also a rational number (as long as we don't divide by 0).

The Irrational Numbers:

An irrational number is a number that cannot be written as a ratio (or fraction). In decimal form, it never ends or repeats. The ancient Greeks discovered that not all numbers are rational; there are equations that cannot be solved using ratios of integers.

The first such equation to be studied was $2=X^2$. What number times itself equals 2?

$\sqrt{2}$is about 1.414, because $1.414^2=1.999396$, which is close to 2. But you'll never hit exactly by squaring a fraction (or terminating decimal). The square root of 2 is an irrational number, meaning its decimal equivalent goes on forever, with no repeating pattern:

$\sqrt{2}$=1.41421356237309...

Other famous irrational numbers are:

$\frac{1+\sqrt{5}}{2}$=1.61803398874989...

π (pi), the ratio of the circumference of a circle to its diameter:

π=3.14159265358979...

and*e*, the most important number in calculus:

e=2.71828182845904...

Irrational numbers can be further subdivided into algebraic numbers, which are the solutions of some polynomial equation (like $\sqrt{2}$ and the others), and transcendental numbers, which are not the solutions of any polynomial equation. πand *e* are both transcendental.

The Real Numbers:

The real numbers is the set of numbers containing all of the rational numbers and all of the irrational numbers. The real numbers are “all the numbers” on the number line.

The Complex Numbers:

The complex numbers are the set $\{a + bi \mid$ *a* and *b* are real numbers$\}$, where i is the imaginary unit

Arithmetic operations:

The basic arithmetic operations are addition, subtraction, multiplication and division.

Addition (+):

Addition is the basic operation of arithmetic. In its simplest form, addition combines two numbers, the addends or terms, into a single number, the sum of the numbers (Such as 2 + 2 = 4 or 3 + 5 = 8).

Adding more than two numbers can be viewed as repeated addition; this procedure is known as summation and includes ways to add infinitely many numbers in an infinite series; repeated addition of the number 1 is the most basic form of counting.

Addition is **commutative** and **associative** so the order the terms are added in does not matter. The **identityelement** of addition (the **additive identity**) is 0, which is, adding 0 to any number yields that same number. Also, the **inverseelement** of addition (the **additive inverse**) is the opposite of any number, that is, adding the opposite of any number to the number itself yields the additive identity, 0. For example, the opposite of 7 is −7, so 7 + (−7) = 0.

Addition can be given geometrically as in the following example:

If we have two sticks of lengths 2 and 5, then if we place the sticks one after the other, the length of the stick thus formed is 2 + 5 = 7.

Subtraction (−):

Subtraction is the inverse of addition. Subtraction finds the difference between two numbers, the minuend minus the subtrahend. If the minuend is larger than the subtrahend, the difference is positive; if the minuend is smaller than the subtrahend, the difference is negative; if they are equal, the difference is 0.

Ex: 5–2 = 3, 6–8 = –2, 5–5 = 0

Subtraction is neither commutative nor associative. For that reason, it is often helpful to look at subtraction as addition of the minuend and the opposite of the subtrahend, that is a − b = a + (−b). When written as a sum, all the properties of addition hold.

Multiplication (× or · or *):

Multiplication is the basic operation of arithmetic. Multiplication also combines two numbers into a single number, the *product*. The two original numbers are called the multiplier and the multiplicand, sometimes both simply called factors.

Ex: 5*4 = 20

Multiplication is **commutative** and **associative**; further it is **distributive** over addition and subtraction. The **multiplicative identity** is 1, which is, multiplying any number by 1 yield that same number. Also, the **multiplicative inverse** is the **reciprocal** of any number (except 0; 0 is the only number without a multiplicative inverse), that is, multiplying the reciprocal of any number by the number itself yields the multiplicative identity.

The product of a and b is written as $a \times b$or $a \cdot b$. When a or b are expressions not written simply with digits, it is also written by simple: ab.

Division (÷ or /):

Division is essentially the inverse of multiplication. Division finds the quotient of two numbers, the dividend divided by the divisor. Any dividend divided by 0 is undefined. For distinct positive numbers, if the dividend is larger than the divisor, the quotient is greater than 1, otherwise it is less than 1 (a similar rule applies for negative numbers). The quotient multiplied by the divisor always yields the dividend.

Ex: 6/2 = 3 ⇨ 2 * 3 = 6, 2/4 = 0.5⇨ 4 * 0.5 = 2

Division is neither commutative nor associative. As it is helpful to look at subtraction as addition, it is helpful to look at division as multiplication of the dividend times the reciprocal of the divisor, that is a ÷ b = a × 1/b. When written as a product, it obeys all the properties of multiplication.

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ASCII TABLE:

ASCII (American Standard Code for Information Interchange) is the most common format for text files in computers and on the Internet. In an ASCII file, each alphabetic, numeric, or special character is represented with a 7-bit binary number (a string of seven 0s or 1s). 128 possible characters are defined.

Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char
0	00	Null	32	20	Space	64	40	@	96	60	`
1	01	Start of heading	33	21	!	65	41	A	97	61	a
2	02	Start of text	34	22	"	66	42	B	98	62	b
3	03	End of text	35	23	#	67	43	C	99	63	c
4	04	End of transmit	36	24	$	68	44	D	100	64	d
5	05	Enquiry	37	25	%	69	45	E	101	65	e
6	06	Acknowledge	38	26	&	70	46	F	102	66	f
7	07	Audible bell	39	27	'	71	47	G	103	67	g
8	08	Backspace	40	28	(	72	48	H	104	68	h
9	09	Horizontal tab	41	29	)	73	49	I	105	69	i
10	0A	Line feed	42	2A	*	74	4A	J	106	6A	j
11	0B	Vertical tab	43	2B	+	75	4B	K	107	6B	k
12	0C	Form feed	44	2C	,	76	4C	L	108	6C	l
13	0D	Carriage return	45	2D	-	77	4D	M	109	6D	m
14	0E	Shift out	46	2E	.	78	4E	N	110	6E	n
15	0F	Shift in	47	2F	/	79	4F	O	111	6F	o
16	10	Data link escape	48	30	0	80	50	P	112	70	p
17	11	Device control 1	49	31	1	81	51	Q	113	71	q
18	12	Device control 2	50	32	2	82	52	R	114	72	r
19	13	Device control 3	51	33	3	83	53	S	115	73	s
20	14	Device control 4	52	34	4	84	54	T	116	74	t
21	15	Neg. acknowledge	53	35	5	85	55	U	117	75	u
22	16	Synchronous idle	54	36	6	86	56	V	118	76	v
23	17	End trans. block	55	37	7	87	57	W	119	77	w
24	18	Cancel	56	38	8	88	58	X	120	78	x
25	19	End of medium	57	39	9	89	59	Y	121	79	y
26	1A	Substitution	58	3A	:	90	5A	Z	122	7A	z
27	1B	Escape	59	3B	;	91	5B	[	123	7B	{
28	1C	File separator	60	3C	<	92	5C	\	124	7C	|
29	1D	Group separator	61	3D	=	93	5D	]	125	7D	}
30	1E	Record separator	62	3E	>	94	5E	^	126	7E	~
31	1F	Unit separator	63	3F	?	95	5F	_	127	7F	□

Algebra:

What is the algebra?

It is an algebra dealing with letters (variables), numbers and operators.

It is a Mathematical system consisting of

- Set of elements
- Set of operators
- Axioms or postulates

It is a Mathematical system that uses equations containing letters (variables), numbers and operators.

Algebraic Expression: It is a Mathematical Expression that can contain ordinary numbers, variables (like x or y) and operators (like add,subtract,multiply, and divide).

Here are some algebraic expressions: $a^2+b^2+2ab, ax^2+bx+1, ax+1$....

Arithmetic on natural numbers

Set of elements: N = {1, 2, 3, 4 …}
Operator: +, –, *
Axioms: Associativity, Distributive, Closure, Identity Elements, etc.

Note: operators with two inputs are called binary

- Does not mean they are restricted to binary numbers!
- Operator(s) with one input are called unary

Basic Definitions

A set is collection of having the same property.

- *S*: set, *x* and *y*: element or event
- For example: *S* = {1, 2, 3, 4}
  - If $x = 2$, then $x \in S$.
  - If $y = 5$, then $y \notin S$.

A *binary operator* defines on a set *S* of elements is a rule that assigns, to each pair of elements from *S,* a unique element from *S.*

- For example: given a set *S*, consider $a*b = c$ and * is a binary operator.
- If (a, b) through * get c and $a, b, c \in S$, then * is a binary operator of *S*.
- On the other hand, if * is not a binary operator of *S* and $a, b \in S$, then $c \notin S$.

The most common postulates used to formulate various algebraic structures are as follows:

1. **Closure:** a set *S* is closed with respect to a binary operator if, for every pair of elements of *S*, the binary operator specifies a rule for obtaining a unique element of *S*.
   - *For example, natural numbers N={1,2,3,...} is closed w.r.t. the binary operator + by the rule of arithmetic addition, since, for any* $a, b \in N$*, there is a unique* $c \in N$ *such that*

- $a + b = c$
- But operator – is not closed for N, because 2-3 = -1 and 2, 3 $\in N$, but (-1) $\notin N$.

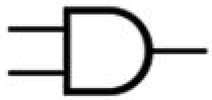
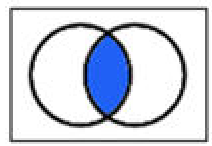
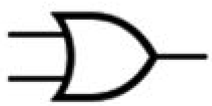
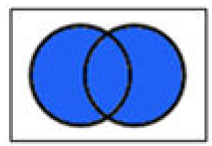
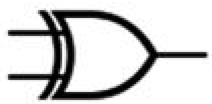
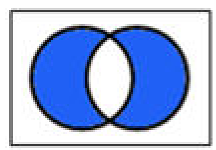
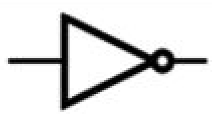
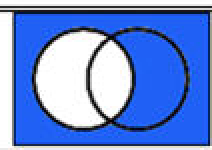
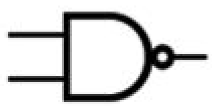
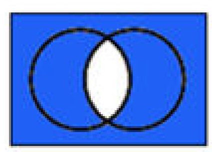
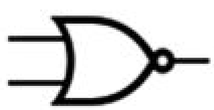
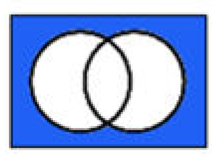
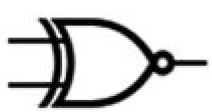
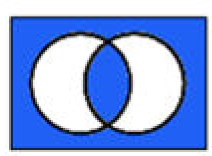
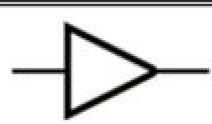
2. **Associative law:** a binary operator * on a set S is said to be associative whenever
   - $(x * y) * z = x * (y * z)$ for all $x, y, z \in S$
     - $(x+y)+z = x+(y+z)$
3. **Commutative law:** a binary operator * on a set S is said to be commutative whenever
   - $x * y = y * x$ for all $x, y \in S$
     - $x+y = y+x$

4. ***Identity element***: a set S is said to have an identity element with respect to a binary operation * on S if there exists an element e $\in S$ with the property that
   - $e * x = x * e = x$ for every $x \in S$
     - $0+x = x+0 = x$ for every $x \in I$. I = {…, -3, -2, -1, 0, 1, 2, 3 …}.
     - $1*x = x*1 = x$ for every $x \in I$. I = {…, -3, -2, -1, 0, 1, 2, 3 …}.
5. ***Inverse***: a set having the identity element e with respect to the binary operator to have an inverse whenever, for every $x \in S$, there exists an element $y \in S$ such that
   - $x * y = e$
     - The operator + over I, with e = 0, the inverse of an element $a$is (-a), since a+ (-a) = 0.
6. ***Distributive law***: if * and.   are two binary operators on a set S, * is said to be distributive over. whenever
   - x * (y. z) = (x * y).   (x * z)

Bitwise Operators – Bitwise operators are used to perform operations at binary digit level. These operators are not commonly used and are used only in special applications where optimized use of storage is required.

Operator	Meaning
<<	Shifts the Bits to Left
>>	Shifts the Bits to Right
~	Bitwise Inversion (One's Complement)
&	Bitwise AND
|	Bitwise OR
^	Bitwise XOR (Exclusive-OR)

Logic Gates

Name	Graphic Symbol	Venn Diagram	Algebraic Function	Truth Table
AND			$A \cdot B$	A B Output 0 0 0 0 1 0 1 0 0 1 1 1
OR			$A + B$	A B Output 0 0 0 0 1 1 1 0 1 1 1 1
XOR			$A \oplus B$	A B Output 0 0 0 0 1 1 1 0 1 1 1 0
NOT			$\overline{A}$	A Output 0 1 1 0
NAND			$\overline{A \cdot B}$	A B Output 0 0 1 0 1 1 1 0 1 1 1 0
NOR			$\overline{A + B}$	A B Output 0 0 1 0 1 0 1 0 0 1 1 0
XNOR			$\overline{A \oplus B}$	A B Output 0 0 1 0 1 0 1 0 0 1 1 1
BUF			A	IN Output 0 0 1 1

Venn Diagram for logic gates is a schematic representation of A and B overlapping each other inside a rectangle area, the diagram shows the relation of the boolean operators.