Boolean Algebra - Part I

Comprehensive Course on Digital Electronics

Vishal Soni • Lesson 1 • Apr 20, 2022

SYLLABUS (EE) "GATE"

Section 9: Analog and Digital Electronics

Simple diode circuits: clipping, clamping, rectifiers; Amplifiers: biasing, equivalent circuit and frequency response; oscillators and feedback amplifiers; operational amplifiers: characteristics and applications; single stage active filters, Active Filters: Sallen Key, Butterwoth, VCOs and timers combinatorial and sequential logic circuits, multiplexers, demultiplexers, Schmitt triggers, sample and hold circuits, A/D and D/A converters.

SYLLABUS (ECE)

"

Section 5: Digital Circuits

Number representations: binary, integer and floating-point- numbers. Combinatorial circuits: Boolean algebra, minimization of functions using Boolean identities and Karnaugh map, logic gates and their static CMOS implementations, arithmetic circuits, code converters, multiplexers, decoders.

Sequential circuits: latches and flip-flops, counters, shift-registers, finite state machines, propagation delay, setup and hold time, critical path delay.

Data converters: sample and hold circuits, ADCs and DACs.

"

Semiconductor memories: ROM, SRAM, DRAM.

Computer organization: Machine instructions and addressing modes, ALU, data-path and control unit, instruction pipelining.

SEQuence:

1. Boolean Algebra
2. Logic GATES (delay)
3. K-map.

9 mp

4. Comb^n Circuit
5. SEQ^n Circuit (delay) → Static Timing Analysis
6. ADC-DAC
7. Number System
8. Logic Family
9. Semiconductor M/M.
10. Multivibrator S/H Circuit

MARKS

→ GATE → 5-8 M (EE)
→ 5-8 M (ECE)

→ ESE → 10-15 Q (EE)
→ 10-15 Q (ECE)

RESOURCES

1.
→ CLASS NOTES
→ D.P.P.

2. Chapter completion: → PYQ (GATE) → EC, EE, IN, CS.
→ PYQ (ESE) → EC, EE
"LAST -15 year."

3. Weekly Quiz: (New Questions)

Subject completion:
(i) Kanodiya → Digital/control/signal (TRY)
x (ii) Bits & Bytes
x (iii) Kanodiya → Digital.

Books: → 1. A. Anand Kumar

ROUTINE

→ Consistency:
→ Revision: QR + PR

2 → 1
3 → 1, 2
4 → 1, 2, 3

→ Short Notes: Chapter ✓ + PYQ ✓ + weekly Quiz ✓
→ Subject wise test on completion.

CLASS FLOW

→ Topic

→ Doubts

i) comment ✓

ii) upload ✓

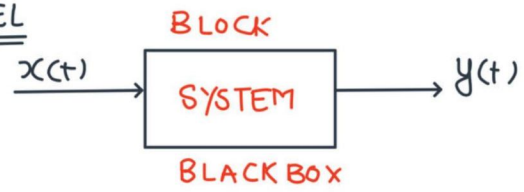
iii) Raise the hand →

→ Call invitation:

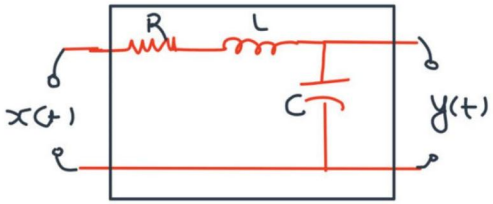
SYSTEM

→ It is the meaningful interconnection of components (R, L, C, logic GATE) or devices (diode, BJT, Multiplixer) which processes input signal and generates output signal.

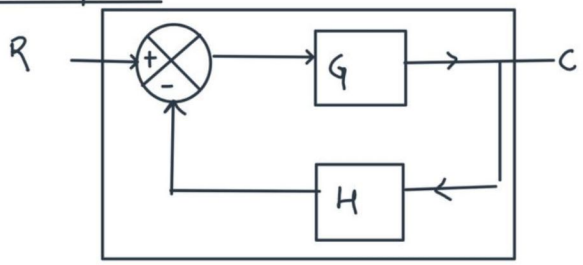
BLOCK LEVEL



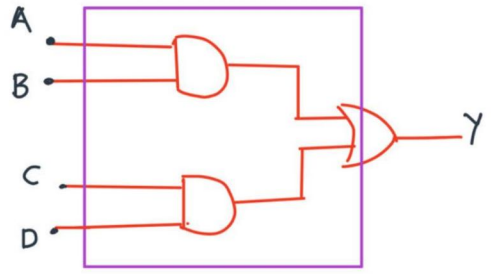
Electrical System:



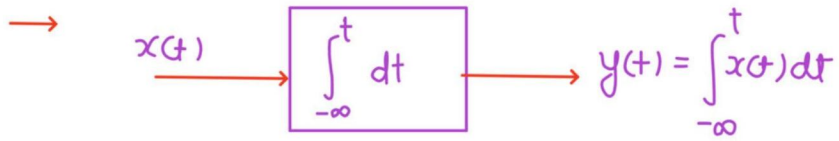
Control System:



Digital system :



Mathematical definition of SYSTEM



→ "Mathematical Relation between input and output represents System."

$$y(t) = \int_{-\infty}^{t} x(t)\,dt$$

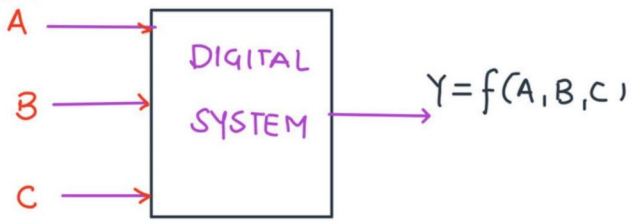
$y(t) = x^2(t)$ → system

$y(t) = \ln\{x(t)\}$ → system.

DIGITAL SYSTEM

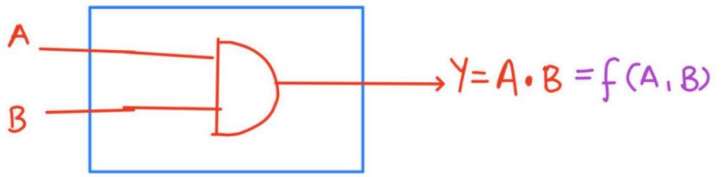
It is the meaningful interconnection of LOGIC GATES (NOT, AND, OR, NAND, NOR, EXOR, EX-NOR, Inhibitation, Implication) and Integrated Circuits (Multiplixer, Decoder, Encoder ···) which processes BINARY INPUT (0/1) and generates outputs (0/1/X). "X: Don't care"

BLOCK LEVEL



Mathematical definition of DIGITAL SYSTEM

"mathematical Relation between input variable and output variable defines digital system."



$Y=f(A,B)=A\cdot B$ → Representation of digital system.

$Y=f(A,B,C)$

Imp

→ Representation of digital system

→ output of digital system in terms of input variables

→ Logical Expression

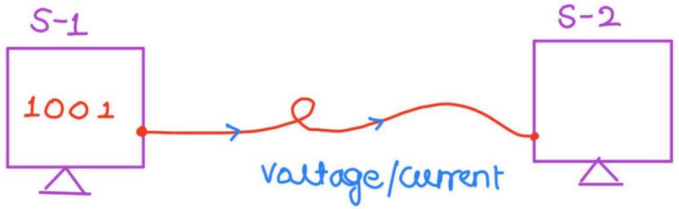
→ Boolean Expression

→ Boolean formula

Note:

1. Input variable of digital system can take · 0/1.
2. output variable of digital System can take :0/1/x

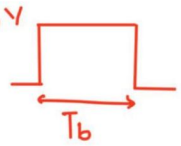
Digital signal vs Binary Signal



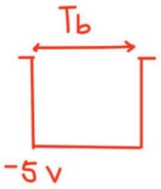
1001 → Binary signal

Each Binary digit is assigned a voltage level.

Logic 1 or digit 1 =

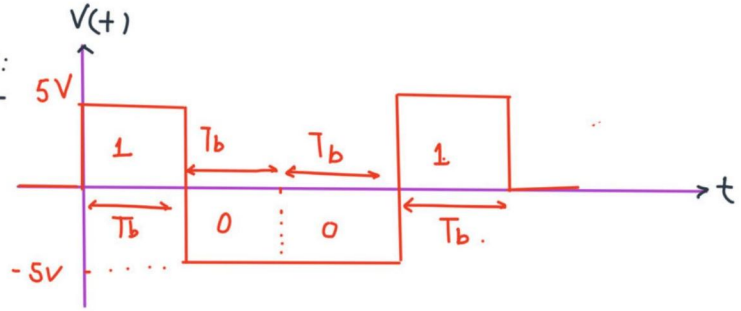


Logic 0 or digit 0 =



Binary signal: 1 0 0 1

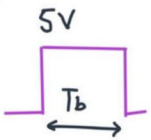
Digital signal:



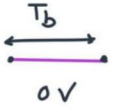
Binary to digital conversion:

(i) UNIPOLAR CODING:

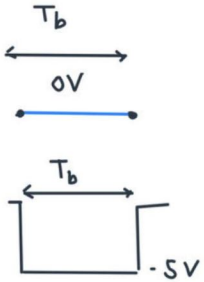
'1'



'0'

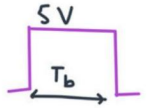


OR.

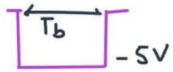


(ii) BIPOLAR CODING:

1



'0'



Logic '0'	Logic '1'
LOW	HIGH
FALSE	TRUE
NO	YES
OPEN	CLOSE
OFF	ON
0V	5V

Algebra vs Boolean Algebra

Algebra:

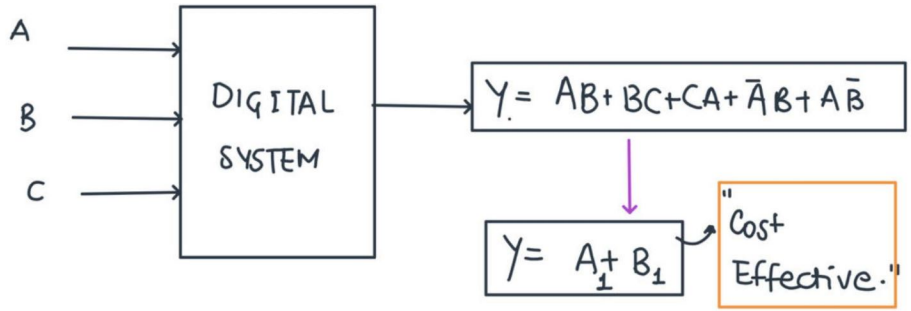
$A \cdot A = A^2$

$A + A = 2A$

$A \cdot A \cdot A + A + 1 = A^3 + A + 1$

$A \cdot A \cdot 0 + 1 = 1$

Boolean Algebra: "Minimization Technique of Logical expression. (Hardware Reduction) by keeping operation of digital system same."



Rules of Boolean Algebra

1. **NOT operation** : → Invert operation

→ $A \xrightarrow{NOT} \bar{A}$ or A'

→ $\bar{\bar{A}} = A$

$\bar{1} = 0$

$\bar{0} = 1$

NOT Operation

AND Operation

Symbol → •

→

$1 \cdot 1 = 1$

$1 \cdot 0 = 0$

$0 \cdot 1 = 0$

$0 \cdot 0 = 0$

→ $A \cdot 1 = ?$

$A = 0 \quad 0 \cdot 1 = 0$

$A = 1 \quad 1 \cdot 1 = 1$

$A \cdot 1 = A$

→ $A \cdot 0 = ?$

$A = 0 \quad 0 \cdot 0 = 0$

$A = 1 \quad 1 \cdot 0 = 0$

$A \cdot 0 = 0$

→ $A \cdot A = ?$

$A = 1 \quad 1 \cdot 1 = 1$

$A = 0 \quad 0 \cdot 0 = 0$

$A \cdot A = A$

→ $A \cdot \bar{A}$

$A = 1 \quad 1 \cdot 0 = 0$

$A = 0 \quad 0 \cdot 1 = 0$

$A \cdot \bar{A} = 0$

$A \cdot 1 = A$

$A \cdot 0 = 0$

$A \cdot A = A$

$A \cdot \bar{A} = 0$

NOTE:

1. $\underbrace{(XY)}_{A} \cdot \underbrace{\overline{(XY)}}_{\bar{A}} = 0$

2. $f(A,B,C) \cdot \overline{f(A,B,C)} = 0$

3. $A \cdot A \cdot A \cdot A \ldots = A$

4. $\bar{A} \cdot \bar{A} \cdot \bar{A} \cdot \bar{A} \ldots = \bar{A}$

OR Operation

Symbol: $+$

$0 + 0 = 0$

$0 + 1 = 1$

$1 + 0 = 1$

$1 + 1 = 1$

$A + 1 = ?$

$A = 0 \quad 0 + 1 = 1$

$A = 1 \quad 1 + 1 = 1$

$A + 1 = 1$

$A + 0 = ?$

$A = 0 \quad 0 + 0 = 0$

$A = 1 \quad 1 + 0 = 1$

$A + 0 = A$

$A + A = ?$

$A=0 : 0+0=0$

$A=1 : 1+1=1$

$\boxed{A+A=A}$

$A + \bar{A} = ?$

$A=0 \quad 0+1=1$

$A=1 \quad 1+0=1$

$\boxed{A+\bar{A}=1}$

$\boxed{\begin{aligned} A+0 &= A \\ A+1 &= 1 \\ A+A &= A \\ A+\bar{A} &= 1 \end{aligned}}$

Note:

1. $\underbrace{XY}_{A} + \underbrace{\overline{XY}}_{\bar{A}} = 1$

2. $f(A,B,C) + \overline{f(A,B,C)} = 1$

3. $A+A+A+A+\cdots = A$

4. $\bar{A}+\bar{A}+\bar{A}+\bar{A}+\cdots = \bar{A}$

5. $1 + f(A,B,C,D,E,F) = 1$

Transposition Theorem

STATEMENT: $f(A,B,C) = (A+B).(A+C)$

minimize above digital system.

$f = (A+B).(A+C)$

$f = A.A + A.C + B.A + B.C$

$f = A + AC + AB + BC = A(1+C+B) + BC = A + BC$