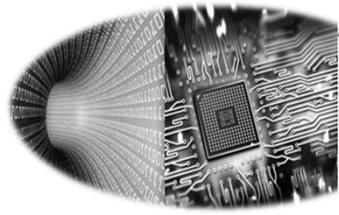


DIGITAL ELECTRONICS

Lecture Note 01: Introduction to Digital Electronics



Dr. Tushar Kanti Bera

Department of Electrical Engineering
National Institute of Technology Durgapur (NITD)

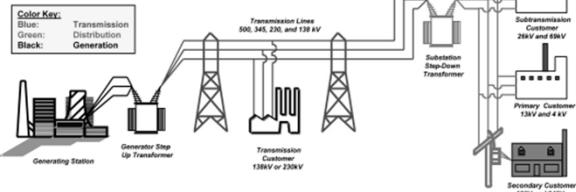
Mahatma Gandhi Rd, A-Zone, Durgapur, West Bengal 713209, India
Date: Jan - Jun, 2020

Electrical Power System

Electrical Power

- Generation
- Transmission
- Distribution
- Utilization

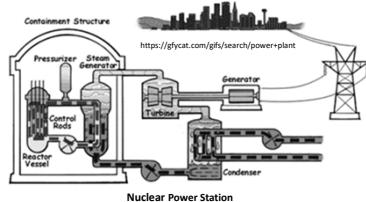
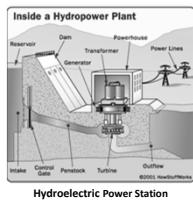
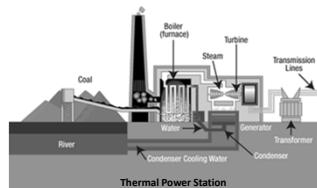
Basic Structure of the Electric System



Electric Power Generation: Conventional

Electric Power Station

- Thermal
- Hydroelectric
- Nuclear
- Non-Conventional



Electric Power Generation: Conventional

Solar



Solar irradiance from the sun

<https://www.acidesk.com/products/acidesk-flat-solar-cell-module/>



Solar Power

Wind



Wind energy

<https://gfycat.com/gf/search/power+plant>



Wind Power

Geothermal



Geothermal energy



Geothermal Power

Tidal



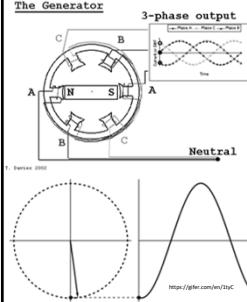
Tidal energy



Tidal Power

Voltage, Current, Frequency, Phase

- Electric Signal
 - Voltage,
 - Current,
 - Frequency,
 - Phase



COUNTRY	VOLTAGE	FREQUENCY
America	120V	60 Hz
Australia	230V*	50 Hz
Canada	120V	60 Hz
France	230V	50 Hz
Germany	230V	50 Hz
India	230V	50 Hz
Italy	230V	50 Hz
Japan	100V	50 Hz (EJ)/60 Hz (WI)
Korea, South	220V	60 Hz
Saudi Arabia	127/220	60 Hz
South Africa	220-250	50 Hz
USA	110V	60 Hz
UK	230V	50 Hz

http://www.exportbureau.com/telephone_codes/electric2.html
<http://www.andreconsulting.com/Voltages.pdf>

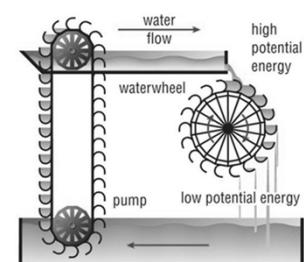
Electronics: Voltage, Current, Power

Electronics

- Analog electronics
- Digital electronics

A Model for Electric Potential Energy

For centuries people have used the energy of falling water to push waterwheels. This is possible because water above the wheel has more gravitational potential energy than it does below the wheel. **Potential energy** is the energy stored in an object.



Impedance Based Monitoring: Electrical Impedance (Z)

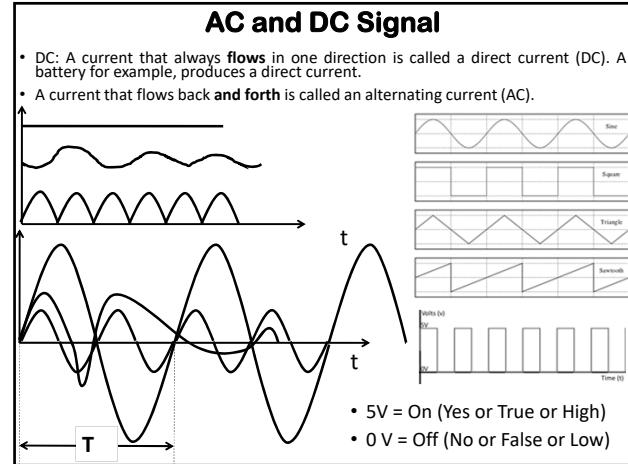
- In DC circuit, the material's electrical property, called Resistance (R) opposes the electrical current flow through the conductor.
- Amplitude (for pure dc) and Polarity: Constant over t**

In AC circuit, the conducting material produces an electrical property, called Impedance (Z) to opposes the alternating current flow through the conductor.

- Amplitude and polarity: Varies over t**

Graph details for Sinusoidal Waveform:

- Amplitude = 1
- Phase = 0
- Frequency = $\frac{1}{T}$
- Angular Frequency = $\omega = \frac{2\pi}{T}$
- Instantaneous Values: $A_{\text{inst}} = A_{\text{max}} \sin(\omega t)$
- Periodic Time (T): $T = \frac{2\pi}{\omega}$
- Angular Position: $\theta = \omega t$
- Maxima: $A_{\text{max}} = A_0 \sqrt{2}$
- Minima: $A_{\text{min}} = -A_0 \sqrt{2}$
- Half-Cycles: $\frac{T}{2} = \pi$
- Full-Cycles: $\frac{2\pi}{\omega} = 2\pi$



Digital Electronics

Digital Electronics = Digital + Electronics

- Digital: Related with "Digits": 0, 1, 2, 3, 4, 5, 6, 7, 8, 9**
- Electronics: Related with "Electrons"**
- Digital Electronics:** A subdomain of electronics which deals with the electronics related to digitized states of electrical signals such as high (denoted by 1) and low (denoted by 0)

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Electronics: Atomic Structure

Atomic Structure

- Nucleus**
- Electrons**
- Protons**

Size	Name	Mass (kg)	Charge (C)
Large	Proton	1.67×10^{-27}	$+1.602 \times 10^{-19}$
Medium	Neutron	1.67×10^{-27}	0
Small	Electron	9.11×10^{-31}	-1.602×10^{-19}

Atom structure:

- Proton
- Neutron
- Electron

Atomic structure:

- Protons and neutrons are located in the nucleus of the atom.
- Electrons are located in energy levels surrounding the nucleus.

sub-atomic particle	relative charge	relative mass
proton	+1	1
neutron	no charge	1
electron	-1	$1/2000$

Electron Spinning: Cloud Concept

Cloud Theory of Electrons

The electron cloud model predicts clouds of probability around the atom.

Actual Model

Electron "Cloud"

Nucleus

Cloud of electrons

Proton

Neutrons

Note: Not to Scale!

M. Strassler 2013

Electric Current: Electrons and Holes

Atomic Structure

- Nucleus**
- Electrons**
- Protons**

- electron

- hole

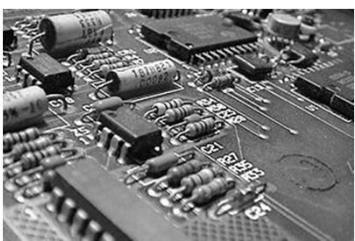
ElectronHole.com

Electronics

❑ Electronics

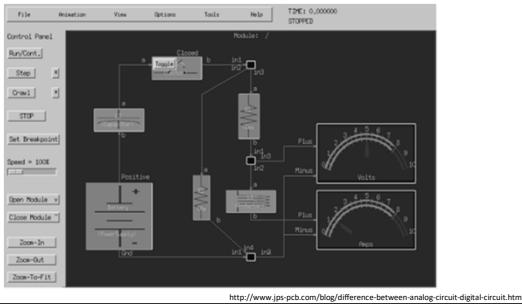
❑ Electronics is a “field of study” which...

- ❑...comprises the physics, engineering, technology and applications which...
- ❑...deal with the emission, flow and control of electrons in vacuum and matter.
- ❑Electronics is widely used in information processing, telecommunication, and signal processing.



Measurements: Analog Quantities

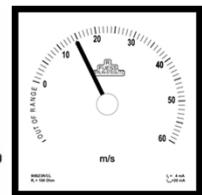
- Most of the entities we encounter in our daily lives are analog entities.
- An analog circuit is a circuit that manipulates or operates on analog data.



Analog and Digital Instruments

• Measurement

- Analog
 - No storage
 - No memory
- Digital
 - No storage
 - No memory



Applications of Electronics

❑ Electronics

- ❑ Analog electronics
- ❑ Digital electronics



Digital Electronics Applications

• Measurement

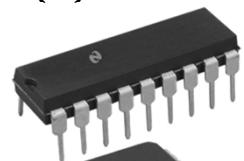
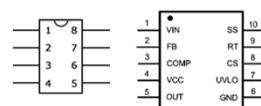
- Computer
- Mobile Phone
- Notebooks
- Camera
- Handycam
- Memory Devices
- Other applications

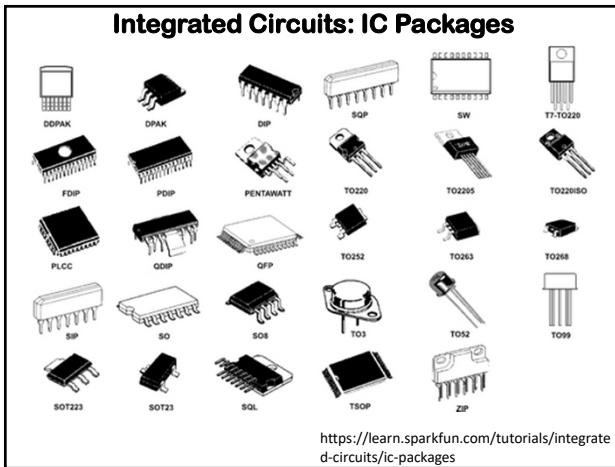


Integrated Circuits (IC)

- ❑ An **integrated circuit (IC)** is an electronic circuit manufactured by microelectronics technology (deposition, lithography, and etching) into the surface of a thin substrate of semiconductor material.

- ❑ Additional materials are deposited and patterned to form interconnections between semiconductor devices.





Integrated Circuits: Data Sheet

ANALOG DEVICES

60 MHz 2000 V/ μ s Monolithic Op Amp AD844

FEATURES

- Wide bandwidth
- 60 MHz at gain of -1
- 33 MHz at gain of -10
- Slew rate: 2000 V/ μ s
- 20 MHz full power bandwidth, 20 V p-p, $R_o = 500 \Omega$
- Fast settling: 100 ns to 0.1% (10 V step)
- Differential input offset voltage: 1.5 μ V maximum
- Differential phase error: 0.16° at 4.4 MHz
- Low offset voltage: 150 μ V maximum (B Grade)
- Low quiescent current: 6.5 mA
- Available in tape and reel in accordance with EIA-481-A standard

APPLICATIONS

- Flash ADC input amplifiers
- High speed current DAC interfaces
- Video buffers and cable drivers
- Pulse amplifiers

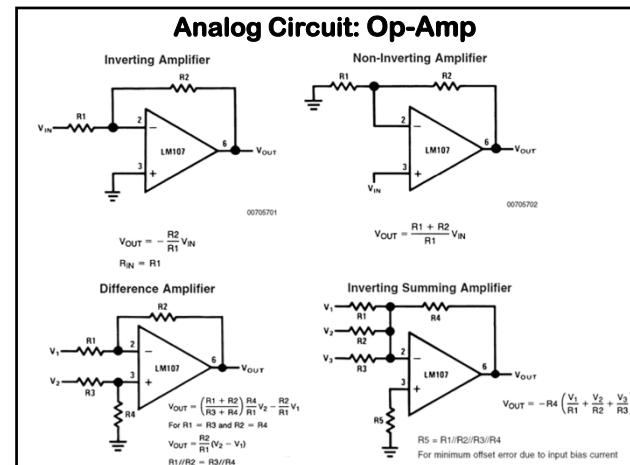
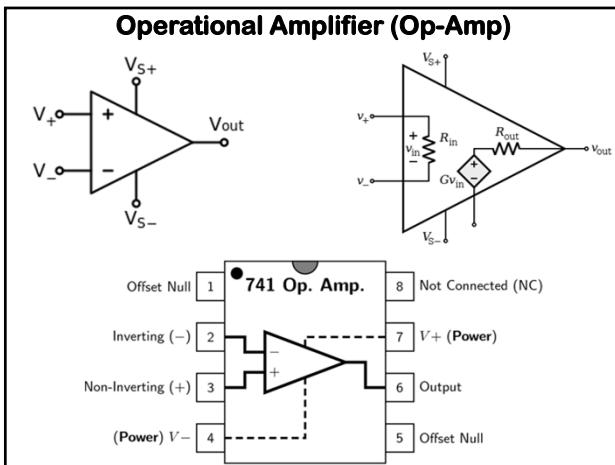
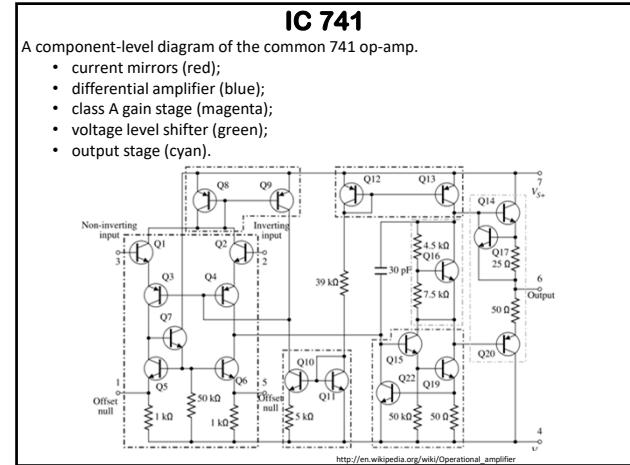
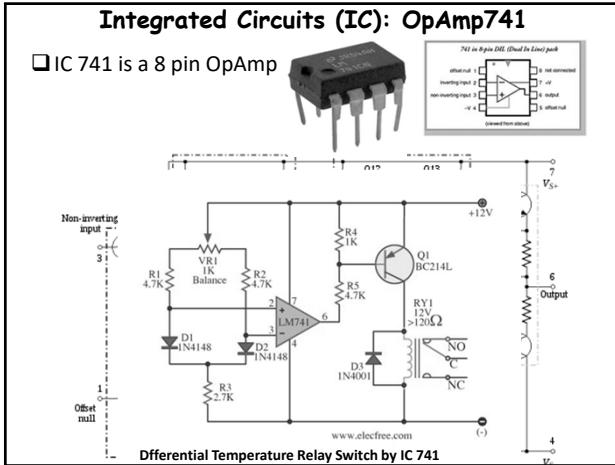
GENERAL DESCRIPTION

The AD844A and AD844B are specified for the industrial temperature range of -40°C to +85°C and are available in the CERDIP (Q) package. The AD844A is also available in an 8-lead PDP (N). The AD844S is specified over the military temperature range of -55°C to +125°C. It is available in the 8-lead CERDIP (Q) package. A and S grade chips and devices processed to

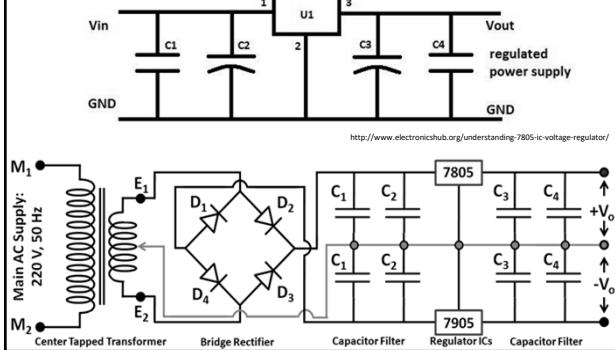
FUNCTIONAL BLOCK DIAGRAMS

Figure 1. 8-Lead FDP (N) and 8-Lead CERDIP (Q) Packages

Figure 2. 16-Lead SOIC (R) Package

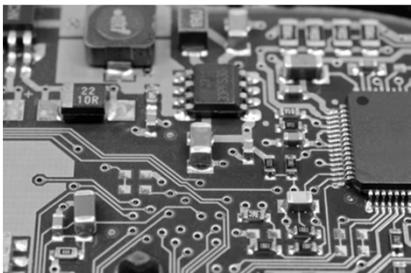


Analog Circuit: Voltage Regulator



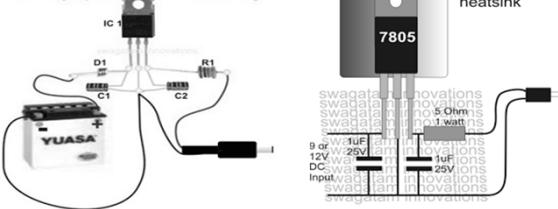
Circuits: Analog and Digital

- Analog circuits and digital circuits are one way of classifying electronic circuits. The concept of analog versus digital is a very important concept discussed in physics, engineering, electronics, computing, instrumentation, mathematics and various other fields.



Analog Circuit: Cell Phone Charger

Battery Operated Cell Phone Charger



- Parts List

1. R1 = 5 Ohm, 2 Watt,
 2. C1, C2 = 10uF/ 25V,
 3. D1 = 1N4007,
 4. IC1 = 7805, mounted on a heatsink,
 5. Battery, any 12 volt automobile battery

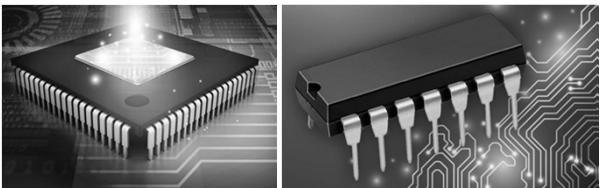
Measurements: Analog and Digital

- Analog signals can be detected and analyzed using instruments such as cathode ray oscilloscopes, voltmeters, ammeters and other recording devices.
 - If an analog signal has to be analyzed using a computer, it has to be converted into a digital signal.
 - This is because computers are only capable of handling digital signals.
 - Analog computing can be done using devices such as operational amplifiers and transistors.



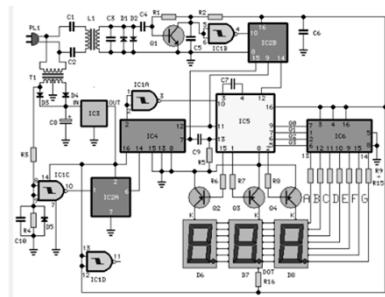
What is Digital Circuits?

- For example, the logic levels of 1 and 0 are digital values. A logic level between 1 and 0 or “true” and “false” doesn’t exist.
 - If a digital signal is digitized with values very close to each other and with a large number of values, it can be said that the signal is a fine approximation for the corresponding analog signal.



What is Digital Circuits?

- The term “digital” is derived from the word “digit” which means a specific number. A digital circuit is a circuit that handles and operates on digital data.
 - Even though a digital circuit operates on digital data, the components are based on analog electronics. A digital signal can take only discrete values.



Comparison: Analog and Digital

- Analog Signal Application
- Digital Signal Application
- Electronic Hardware: electronic components connected on a Printed Circuit Board (PCB).
- Example
 - PC Mother Board: The primary or central board that makes up a complex electronic system like modem computer is known as a motherboard. It is actually like the mother of the computer system. Baseboard, system board, main boards are some of the different words that are made use for motherboards. Further, in Apple Computers, it is also known as logic board and sometimes abbreviated as 

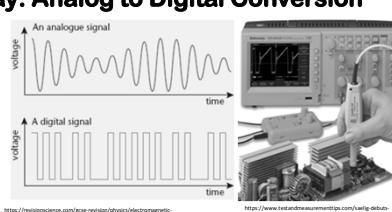



ECG Amplifier PCB PC Mother Board

Difference Between Analog and Digital Circuits	
Analog Circuits	Digital Circuits
These circuits operate on continuous valued signals (commonly referred to as analog signals).	These circuits operate on signals that exist only at two levels i.e. 0's and 1's (binary number system).
Analog circuits are difficult to design since each component has to be placed by hand as automation techniques for designing these circuits fail to do the job efficiently.	On the other hand digital circuits are easy to design since automation technique can be applied at various levels of circuit design. This involves minimum human interaction.
No conversion of input signals are required before processing i.e. input signal is analog, the circuit directly performs various logical operations and produces an analog output.	In digital circuits, the input signals are converted from analog to digital form before it is processed, i.e. the digital circuit is capable of processing digital signals only and produces output which is again converted back from digital to analog signals so that the output gives meaningful results that can be understood by humans.
In analog circuits, since there are no conversions involved at the input or at the output side there is no loss of information that is available for processing.	Due to the conversion process at the input side (analog to digital) and at the output side, some amount of information is lost during the conversion process.
The man power available to design analog circuits is very low, this results in long time to market the finished products.	The available man power to design digital circuits is significantly large compared to that of analog circuit designers.
Analog circuits are mostly custom made and lacks flexibility.	Digital circuits have high degree of flexibility.

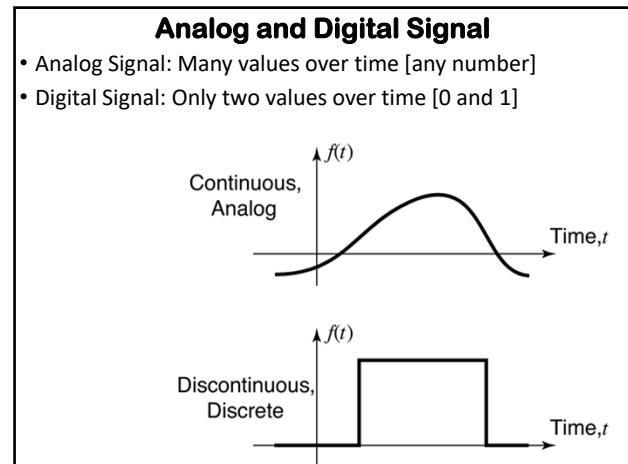
Digital Display: Analog to Digital Conversion

- Measurement
 - Analog signal input
 - Analog to Digital Conversion
 - Digital Signal Processing
 - Display

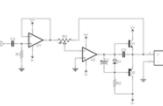
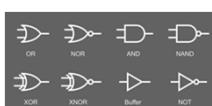


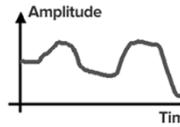
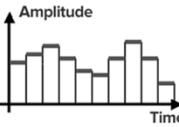
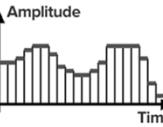

Analog to Digital Conversion Diagram: Shows an analog signal (voltage vs. time) being converted into a digital signal (series of vertical bars representing discrete values over time). <https://revelscience.com/gear-revision/physics/electromagnetic-radiation/wave-communication> <https://www.testandmeasurement.com/analog-debug-unique-circuit-trace-current-probe/>

Prueba del Módulo Solar. Corriente en Corte Circuito: A person is using a multimeter to measure current through a solar panel circuit. The circuit includes a junction box and MC connectors with a clamp meter. [8.5Amps](#)



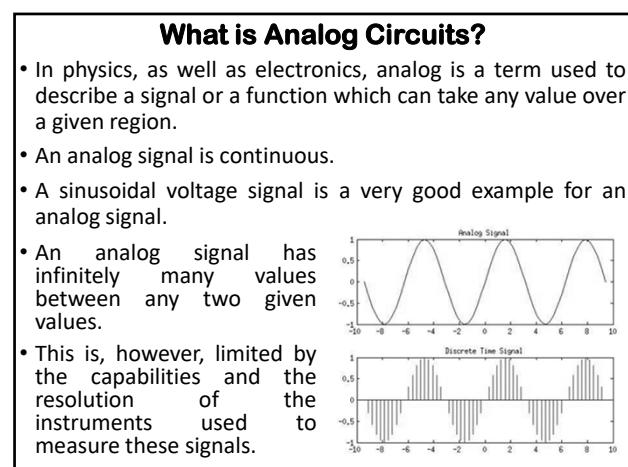
Analog and Digital Signal

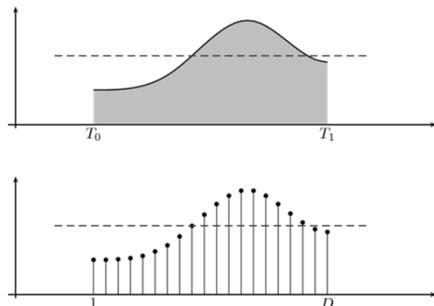
Amplitude vs. Time graphs for Analog Signal (All Micro-Variants Captured), Digital Signal Variants Replicated w/ Smaller Sample Rate, and Digital Signal Details Replicated w/ Larger Sample Rate.

<https://www.rpi.edu/dept/phys/SciT/informationtransfer/sigtransfer/signalcharacteristics.html>



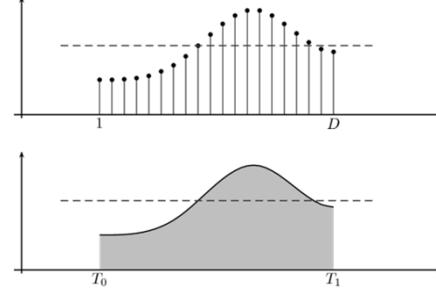
Analog and Digital Signal

- How Computer understands an Analog signal?
 - Analog to Digital



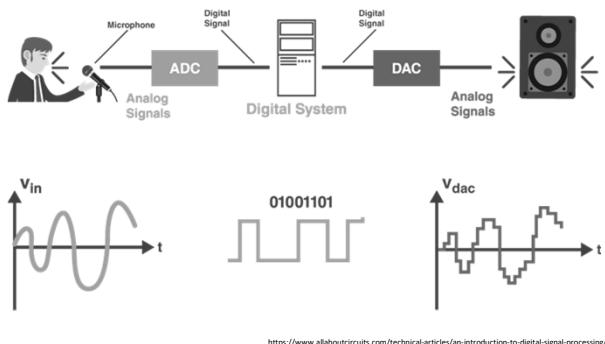
Analog and Digital Signal

- How Computer understands an Analog signal?
 - Digital to Analog



Analog to Digital Conversion: Example

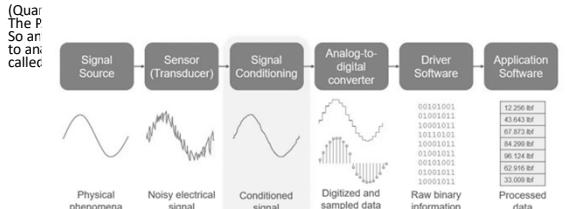
- Analog to Digital



Quantization and Binary Representation

- Quantization is the process of converting an infinite number of possibilities to a finite number of conditions. Analog signal is smooth and continuous; it represents infinite number of actual voltage levels and practically it is not possible to convert all analog samples to a precise proportional binary number. Figure shows the voltage range of 0-15V so there are total 16 levels. Here if analog input is 8V, its binary equivalent is 1000. But if analog input is 11.7 as shown in figure, then the approximate value i.e. 12 V will produce binary value 1100.

What is Signal Conditioning?

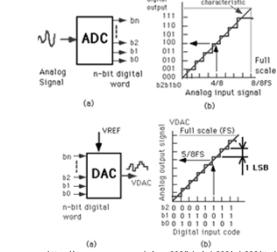
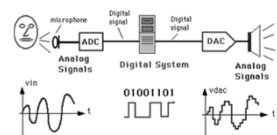


<https://www.youtube.com/watch?v=tSHXxFigz8>

ADC and DAC

- **ADC:** An ADC takes an analog input and generates a digital output as shown in Figure 2a.

- The more bits the output word has the better the resolution.
- For a 3-bit ADC, the number of steps will be 8 while a 10-bit ADC will divide the analog signal up into 1024 ($=2^{10}$) steps.

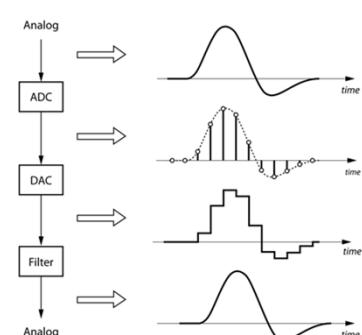


- **DAC:** The input to a DAC is a binary word of n-bits and the output is an analog value, as schematically shown in Figure 3a.

<https://www.seas.upenn.edu/~ese206/labs/adc206/adc206.html>

Signal Reconstruction

- Signal is digitized
- Digitized signal is converted to Analog
- Analog signal is displayed



<https://www.seas.upenn.edu/~ese206/labs/adc206/adc206.html>

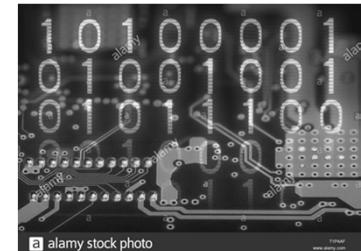
What is Digital Circuits?

- Electronic instruments/equipments uses two types of signals
 - Analog
 - Digital
 - Mixed signal
- Most of the other equipment use analog signals.
- Computers use digital signals in their internal circuits but
- The real voltage of these depends on the physical circuits used.
- These two leveled signals are known as binary signals.



What is Digital Circuits?

- A decimal signal has 10 voltage levels, and a hexadecimal signal has 16 voltage levels.
- The analog circuit responsible for handling digital data is produced so that a range over the exact digital value is detected as the analog value itself.
- This is due to errors of the signal and deformation by components.



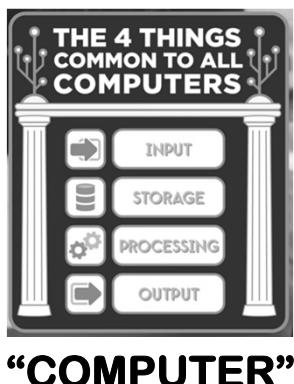
<http://www.ps-pcb.com/blog/difference-between-analog-circuit-digital-circuit.html>

History of Computer

- The word "computer" was first recorded as being used in 1613 and originally was used to describe a human who performed calculations or computations.



<https://www.lifehack.org/articles/money/how-to-compute-your-business-income.html>



<https://www.computerhope.com/issues/ch000984.htm>

Automatic Computing Engine

- In 1822, Charles Babbage conceptualized and began developing the **Difference Engine**, considered to be the first automatic computing machine.
- The Difference Engine was capable of computing several sets of numbers and making hard copies of the results.
- Babbage received some help with development of the Difference Engine from Ada Lovelace.
- Ada Lovelace is considered to be the **first computer programmer** for her work and notes on the Difference Engine.



Charles Babbage
https://simple.wikipedia.org/wiki/Charles_Babbage



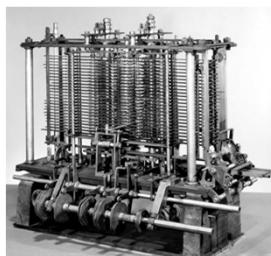
Ada Lovelace
<https://www.biography.com/people/ada-lovelace-20252523>



<https://www.computerhope.com/issues/ch000984.htm>

Analytical Engine

- In 1837, Charles Babbage proposed the first general mechanical computer, the **Analytical Engine**.
- The Analytical Engine contained
 - An ALU (Arithmetic Logic Unit),
 - Basic flow control
 - Punch cards
 - Integrated memory
- It is the first general-purpose computer concept*.
- In 1910, Henry Babbage, Charles Babbage's youngest son, was able to complete a portion of this machine and was able to perform basic calculations.



Analytical Engine: first general mechanical computer

<http://collection.sciencemuseum.org.uk/objects/co02245/babbages-analytical-engine-1834-1871-trial-model-analytical-engines>

<https://www.computerhope.com/issues/ch000984.htm>

ENIAC: First General-Purpose Electronic Computer

Electronic Numerical Integrator and Calculator (ENIAC) was the first electronic computer used for general purposes:

- solving numerical problems.
- It was invented by J. Presper Eckert and John Mauchly at the University of Pennsylvania to calculate artillery firing tables for the United States Army.



Electronic Numerical Integrator and Computer (ENIAC)

UNIVAC: The First Commercial Computer

- UNIVAC (Universal Automatic Computer) is a line of electronic digital stored-program computers.
- It was founded in 1949 by J. Presper Eckert and John Mauchly, in their Electronic Controls Company which later became Eckert-Mauchly Computer Corporation (EMCC) and released a series of mainframe computers under the UNIVAC name.
- In 1950, the UNIVAC 1101 or ERA 1101 is considered to be the first computer that was capable of storing and running a program from memory.

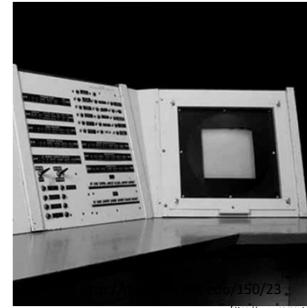


UNIVAC 1101

<https://www.computerhope.com/issues/ch000984.htm>

The First Transistor Computer

- The TX-0 (Transistorized Experimental computer) is the first transistorized computer to be demonstrated at the Massachusetts Institute of Technology (MIT) in 1956.



<https://www.computerhope.com/issues/ch000984.htm>

<https://www.computerhope.com/issues/ch000984.htm>

The First Microprocessor

- Intel introduces the first microprocessor, the **Intel 4004** on November 15, 1971.
- The **Intel 4004** is a 4-bit central processing unit (CPU) released by Intel Corporation in 1971. It was the first commercially available microprocessor by Intel,^[2] and the first in a long line of Intel CPUs.



<https://www.computerhope.com/issues/ch000984.htm>

<https://www.computerhope.com/issues/ch000984.htm>

The first IBM personal computer

- IBM introduced its first personal computer, the **IBM PC**, in 1981. The computer was code-named **Acorn**. It featured an **8088** processor, 16 KB of memory, which was expandable to 256 and used **MS-DOS**.
- The **first IBM PC** ran on a 4.77 MHz Intel 8088 microprocessor. The PC came equipped with 16 kilobytes of memory, expandable to 256k. The PC came with one or two 160k floppy disk drives and an optional color monitor. The price tag started at \$1,565.



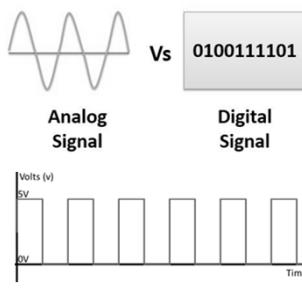
<https://www.boridahistorynetwork.com/aug-1981---developed-in-boeing-first-pc-released-by-ibm.html>

<https://www.computerhope.com/issues/ch000984.htm>



Digital Circuits from Analog Component

- Transistor could be used as a switch
- In its switching mode, it could be either on or off.

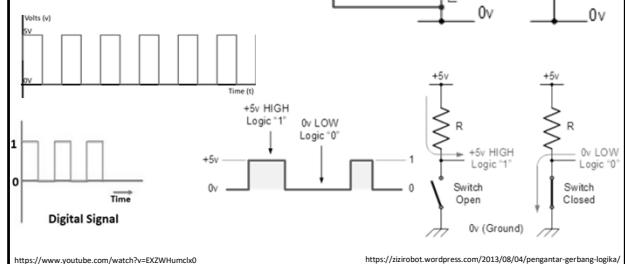


<https://learn.sparkfun.com/tutorials/transistors/all>

<https://www.youtube.com/watch?v=EX2WhUmcI0>

Transistor Switching: 1s and 0s

- Transistor could be used as a switch
- In its switching mode, it could be either on or off.

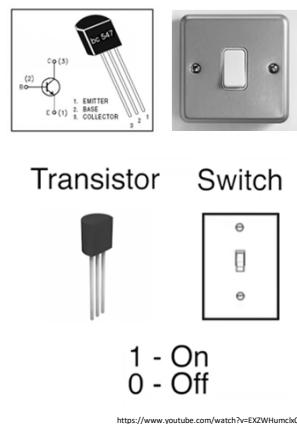


<https://www.youtube.com/watch?v=EX2WhUmcI0>

<https://zirirobot.wordpress.com/2013/08/04/pengantar-gerbang-logika/>

Why to Make all into 1s and 0s

- Transistor could be used as a switch
 - In its switching mode, it could be either could be on or off.
 - On and off could be represented as voltage high (5 V) and voltage low (0 V)
 - Analog 5 V and 0 V could be represented as 1 and 0 respectively



Program or Source Code: Instructions

Program or Source Code

- ❑ Structured Instruction
 - ❑ PC Understands
 - ❑ Meaningful
 - ❑ Logical
 - ❑ Sequential

Example

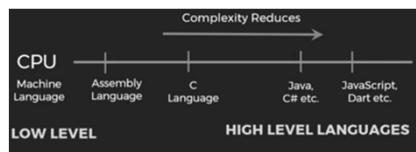
Task: Go somewhere by taxi

- Take a mobile
 - Book a cab
 - Locate the place where cab came
 - Identify the booked cab
 - Go



Source Code with Numbers

- All the codes readable by the computers are made with the combinations of numbers.
 - These number based codes called low level languages are difficult to understand
 - Thus to make it simpler the computer high level languages are made to understand the number based codes



Example - 00 AA EE 32 54 23 52 88 33 02 23 49 23 48 20 23

42 34 22 34 23 BB CD 39 A5 E3 05 D3 1D 2E 3C 1A

<https://www.youtube.com/watch?v=c1UvFHCfLs>

Computer Operation: Computer Language

Computer Language is used to operate PC

- ✓ Computer Language: it instructs the PC
 - ✓ Computer Language: it communicates with the PC

Program or Source Code

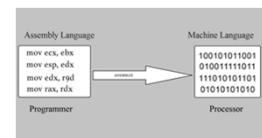
- Computer does not have biological brain.
 - We have developed computer.
 - We have developed its brain and given to the computer to make it perform different tasks.
 - We need to instruct it to do some work.
 - The instruction is given through a set of instructions called computer program.
 - We need to develop his language in which we write the program.



Low Level and High level Language

❑ Machine language

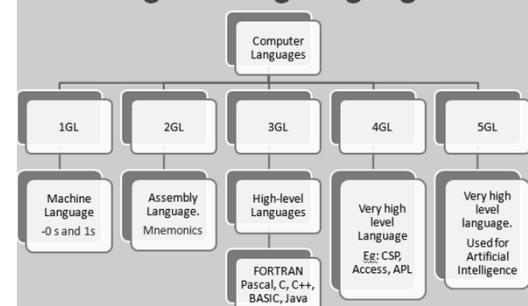
- ❑ Computer is a machine.
 - ❑ Computer only understand the machine language.
 - ❑ Machine language (Language of machine) is developed with codes what only computer can understand.
 - ❑ PC's brain is CPU
 - ❑ Hence different CPU will have difference machine languages.
 - ❑ Machine language is very tough to understand by a human being.
 - ❑ It is also tough to write the machine language to directly instruct the PC.



Machine language may contain several arrays of numbers, digits and symbols

Low Level and High level Language

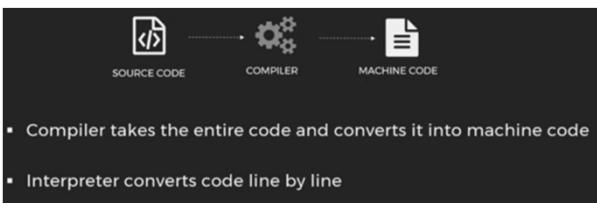
Programming Languages



<http://www.icteducatoronline.com/index.php/ict/grade-6/computer-languages>

Compiler

- We write the codes in high level language
- But, computer understands in low level languages
- Therefore, a translator is required to convert the high level language to the low level language (machine language)
- Thus, compiler and interpreter comes in the picture



<https://www.youtube.com/watch?v=cIuVfHClrc>

Machine Language: Number System

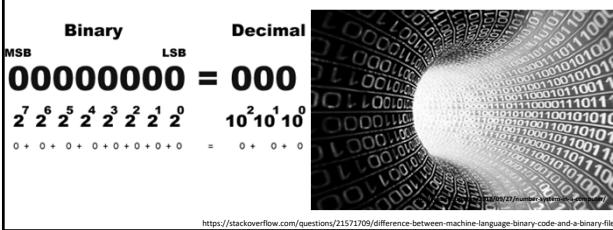
Machine language

- Machine code and binary are the same - a number system with base 2: either a 1 or 0.
- Machine code can also be expressed in hex-format (*hexadecimal*) - a number system with base 16.
- Binary and hex numbers are interrelated and easily to converted from one to another.
- As hex is much more readable and useful than binary - it's often used and shown.
- Let us take a binary sequence: 1001111000001010 : it can easily be converted to hex by grouping in blocks - each block consisting of four bits.

1001 1110 0000 1010 => 9 14 0 10 which in hex becomes: 9E0A.

Number Systems: Conversion

- Computer understands only binary
- Binary is required in a computer
- Decimal is familiar to us
- Binary is large in format so sometimes conversion is required to save space/memory.
- Therefore, conversion of numbers are essential.



<https://stackoverflow.com/questions/21571709/difference-between-machine-language-binary-code-and-a-binary-file>

Binary Number Representations

Example: 4-Bit Binary Number

Binary number system - a system that denotes all numbers and combinations of two digits.

The binary system uses two digits to represent the numbers 0 and 1.

©1999 Addison Wesley Longman

Decimal representation	Binary representation
0	0
1	1
2	10
3	11
4	100
5	101
6	110
7	111
8	1000
9	1001
10	1010
11	1011
12	1100
13	1101
14	1110
15	1111

<https://slideplayer.com/slide/400/195/>

Bit Dependent Binary Numbers

- 1-Bit Binary Number (0, 1)
- 2-Bit Binary Number (00, 01, 10, 11)
- 3-Bit Binary Number (000, 001, 010, 011, 100, 101, 110, 111)
- 4-Bit Binary Number (0000, 0001, 0010, 0011, 0100, 0101, 0110, 0111, 1000, 1001, 1010, 1011, 1100, 1101, 1110, 1111)
- Etc.

$$L_{\text{Binary}} = 2^n$$

D0	D1	D0	D2	D1	D0
0	0	0	0	0	0
1	0	0	0	0	1
0	1	0	0	1	0
1	0	1	0	1	1
0	1	1	0	0	0
0	0	1	1	0	1
0	1	0	1	1	0
0	0	0	0	1	1
1	0	0	0	0	0
1	0	0	1	0	0
1	0	1	0	1	0
1	1	0	0	1	0
1	0	1	1	0	1
1	1	1	0	0	1
1	1	0	1	1	1

$$L_{\text{Binary}} = 2^1 = 2$$

$$L_{\text{Binary}} = 2^2 = 4$$

$$L_{\text{Binary}} = 2^3 = 8$$

$$L_{\text{Binary}} = 2^4 = 16$$

Note: All Complete Binary Number Series starts from binary 0

Applications: Binary Counters

Binary Numbers

A binary counting sequence for numbers from zero to fifteen is shown.

Notice the pattern of zeros and ones in each column.

Digital counters frequently have this same pattern of digits:



Floyd, Digital Fundamentals, 10th ed

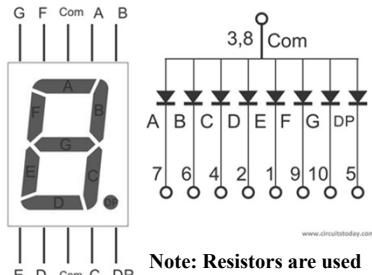
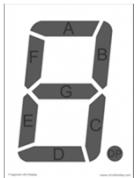
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Decimal Number	Binary Number
0	0 0 0 0
1	0 0 0 1
2	0 0 1 0
3	0 0 1 1
4	0 1 0 0
5	0 1 0 1
6	0 1 1 0
7	0 1 1 1
8	1 0 0 0
9	1 0 0 1
10	1 0 1 0
11	1 0 1 1
12	1 1 0 0
13	1 1 0 1
14	1 1 1 0
15	1 1 1 1

Applications : Seven Segment Display

Seven Segment Display

A seven segment display is a LED based electronic display component which is used for displaying numbers and letters



Note: Resistors are used to limit the current through the LEDs

https://en.wikipedia.org/wiki/Seven-segment_display

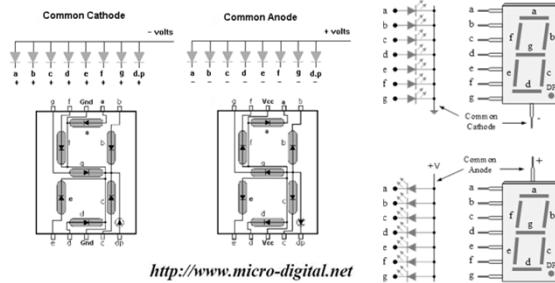
7 Segment Display - Pin Out Diagram

http://www.circuitstoday.com/7-segment-display-no-and-7-segment-display

Applications : Seven Segment Display

Seven Segment Display

SSD can be made either common cathode and common anode as shown below:



<http://www.micro-digital.net>

Floyd, Digital Fundamentals, 10th ed

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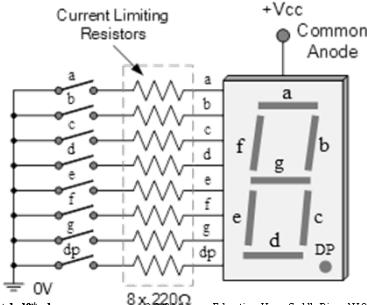
http://www.crossfithartford.com/dummies_74ls47_circuit_diagram.php

http://www.electronics-tutorials.ws/blog/7-segment-display-tutorial.html

Applications : Seven Segment Display

LED Driving with Series Resistors

Display of numbers could be obtained by feeding the voltage signal (5V) as shown below:



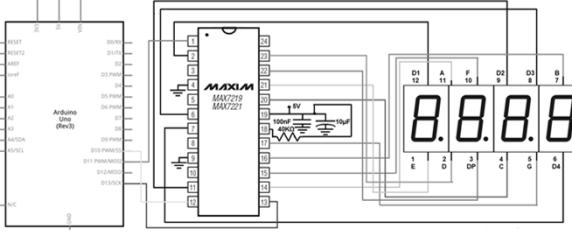
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Applications : Multiple Seven Segment Display

Seven Segment Display

Display of numbers could be obtained by feeding the voltage signal (5V) as shown below:



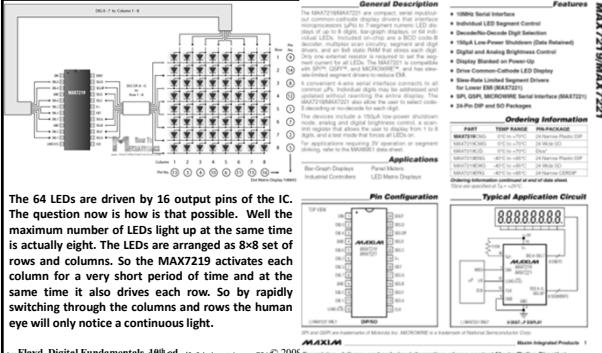
https://www.crossfithartford.com/dummies_even_segment_led_circuit_diagram.php

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Applications : Multiple Seven Segment Display

MAX 7219: Serially Interfaced, 8-Digit LED Display Drivers



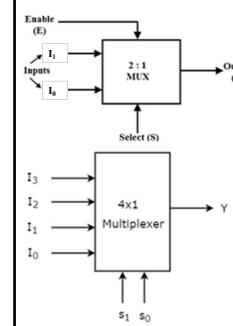
The 64 LEDs are driven by 16 output pins of the IC. The question now is how is that possible. Well the maximum number of LEDs light up at the same time is actually eight. The LEDs are arranged as 8x8 set of rows and columns. So the MAX7219 activates each column for a very short period of time and at the same time it also drives each row. So by rapidly switching through the columns and rows the human eye will only notice a continuous light.

<https://www.maximintegrated.com/en/design/technical-downloads/doc/APPLICATIONS/8x8-led-matrix-max7219.pdf>

Applications: Multiplexers

Multiplexers

Sequential Switching could be obtained by multiplexers and demultiplexers.



Selector Signal	Activated Channel
0	I ₀
1	I ₁

S ₁	S ₀	Activated Channel
0	0	I ₀
0	1	I ₁
1	0	I ₂
1	1	I ₃

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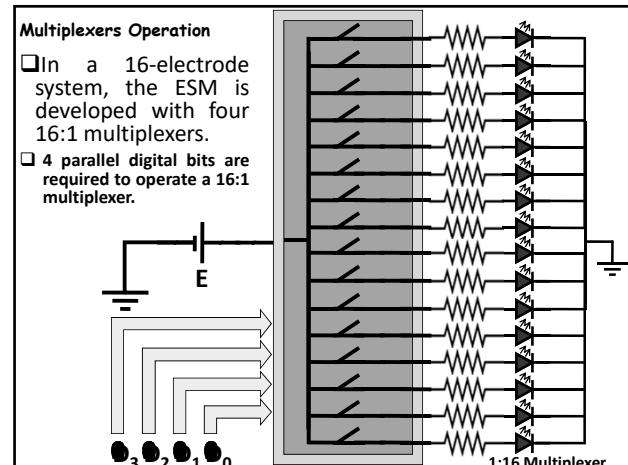
Applications : 8:1 Multiplexers

Multiplexers

Sequential Switching could be obtained by multiplexers and demultiplexers.

S ₃	S ₂	S ₁	S ₀	Activated Channel
0	0	0	0	I ₀
0	0	0	1	I ₁
0	0	1	0	I ₂
0	1	0	0	I ₃
1	0	0	0	I ₄
1	0	0	1	I ₅
1	0	1	0	I ₆
1	1	0	0	I ₇

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Data Representation in a Computer

- Computer understand binary language (0 & 1) for the data representation.
- There are two types of data which are stored and processed by computers
 - Characters,
 - Numbers.
- Character includes: letters and special symbols
- Numbers include: digits(binary/octal/decimal/hexadecimal).
- Character and Numbers both are converted to binary numbers (0 & 1) inside the computer.
- Hence, all kind of data (i.e. alphabet, numbers, symbols, audios or videos) are represented in terms of 0 & 1.

<https://examstop.com/2018/09/27/number-system-in-a-computer/>

How Computer Works: Image Display

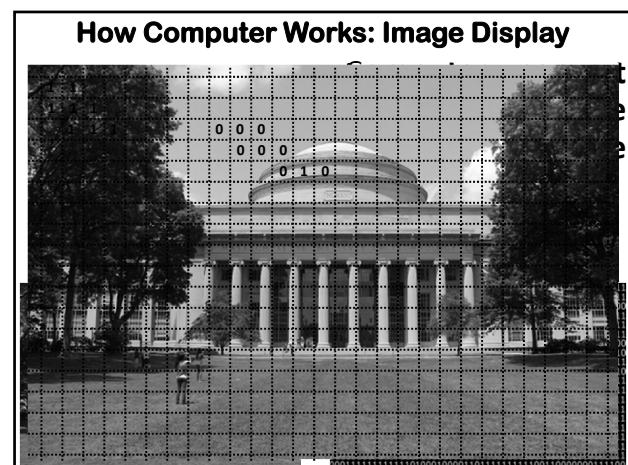
- How text is represented/sent in a computer system?
- Basic terminology of data representation.
 - Data is: raw facts, no context, just numbers, and text.
 - Information is: meaningful data (data with contextual meaning).
 - Computers uses a binary number system for representing data (because PC recognize only two discrete states: on or off).

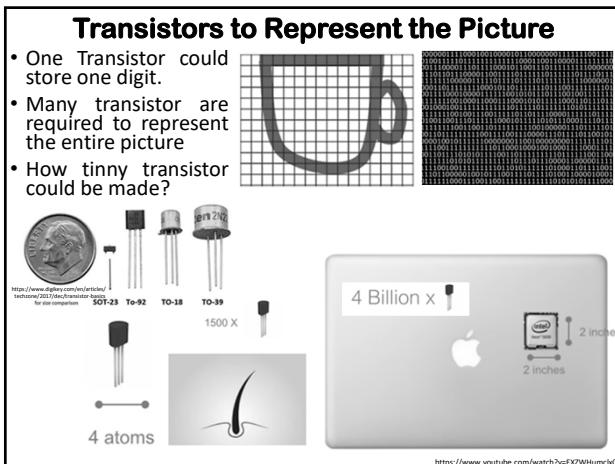
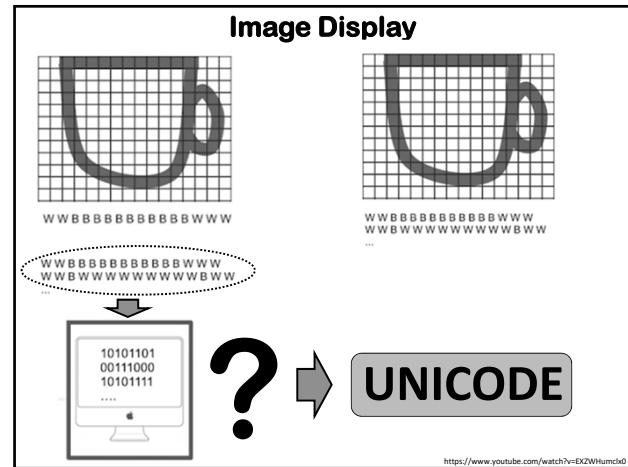
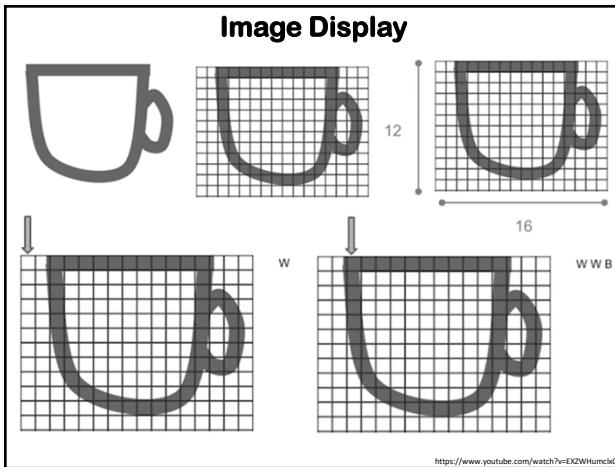
<https://www.youtube.com/watch?v=vc1UvHClrJc>

How Computer Works: Image Display

- Files/data are fed to the PC through interface devices (Keyboard, Mouse, Jaw stick, etc.)
- Each data file is converted to binary numbers to process further

<https://www.howtogeek.com/367931/ttg-explains-how-does-a-cpu-actually-work/>





Unicode: Maps the Letters/Symbols to Numbers

- Unicode is a computing industry standard for the consistent encoding, representation, and handling of text expressed in most of the world's writing systems.
- The standard is maintained by the Unicode Consortium.
- As of June 2018 the most recent version, Unicode 11.0, contains a repertoire of 137,439 characters.
- Covers 146 modern and historic scripts, as well as multiple symbol sets and emoji.

Letter	Binary Code	Letter	Binary Code
A	01000001	a	01100001
B	01000010	b	01100010
C	01000011	c	01100011
D	01000100	d	01100100
E	01000101	e	01100101
F	01000110	f	01100110
G	01000111	g	01100111
H	01001000	h	01101000
I	01001001	i	01101001
J	01001010	j	01101010
K	01001011	k	01101011
L	01001100	l	01101100
M	01001101	m	01101101
N	01001110	n	01101110
O	01001111	o	01101111
P	01010000	p	01100000
Q	01010001	q	01100001
R	01010010	r	01100010
S	01010011	s	01100011
T	01010100	t	01101000
U	01010101	u	01101001
V	01010110	v	01101010
W	01010111	w	01101011
X	01011000	x	01110000
Y	01011001	y	01110001
Z	01011010	z	01110010

<https://www.youtube.com/watch?v=EXZWHumch0>

