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CHAPTER – 1

INTRODUCTION

1.1 Numerical Representation

The two digits in the binary system '1' & '0' are called bits, which is a contraction of the words "binary digit". In digital circuit, two different voltage levels are used to represent the two bits. Generally, 1 is represented by the higher voltage, which is referred to as HIGH and '0' is represented by the lower voltage, which is referred to as LOW. This is called positive logic. If in another system, '1' is represented by LOW and '0' is represented by HIGH, it is negative logic. The voltage used to represents a '1' & '0' are called logic levels. Ideally, one voltage level represents a HIGH (e.g., 5V) and another level represents a LOW (e.g., 0V).

Particularly, HIGH is the voltage between specified minimum value and maximum value, and LOW is the voltage between specified minimum and maximum value. There is no overlap between HIGH levels and LOW levels.

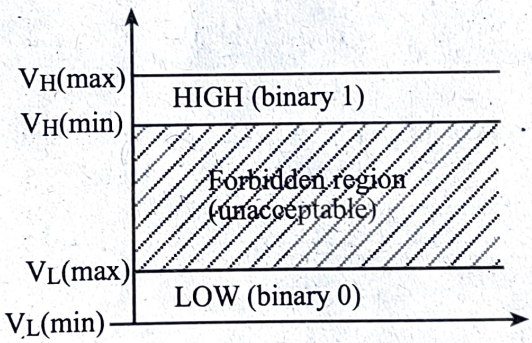


Fig.: Logic level profile

Nowadays, the majority of digital circuit families utilize a single +5V DC power supply, and the two voltage levels are used are +5V DC and 0V DC.

1.2 Digital Number System

Digital wave forms consist of voltage levels that are changing back and forth between the HIGH and LOW level as states.

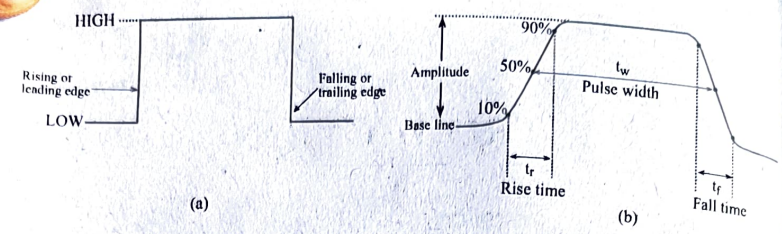
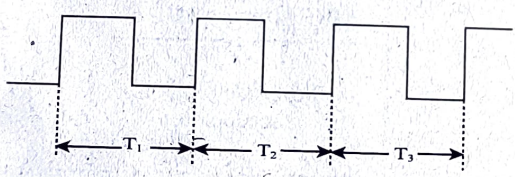


Fig.: (a) Ideal pulse (b) Non-ideal (practical) pulse

Fig. (a) shows that a single positive-going pulse is generated when the voltage (or current) goes from its normally LOW level to its HIGH level and then back to its LOW level. In practice, these transitions never occur instantaneously, although for most digital work, we can assume ideal pulse. Fig. (b) show a non-ideal pulse.

- **Rise time (t_r)**: The time required for the pulse to go from its LOW level to its HIGH level is called rise time (t_r). In practice, it is common to measure rise time from 10% of the pulse amplified to 90% of the pulse amplitude.
- **Fall time (t_f)**: It is the time required for the transition from high level to low level. It is the time from 90% to 10% of the pulse amplitude.
- **Time period (T)**: It is the time over which a signal repeats itself.
- **Frequency (f)**: It is the rate at which signal repeats itself. Its unit is Hz.



Period = T1 = T2 = T3 = ...Tn

Frequency (f) = $\frac{1}{T}$

- **Duty cycle:** Duty cycle is the ratio of the pulse width (tw) to the period and can be expressed as percentage.

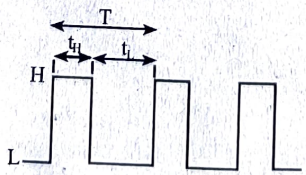


Fig.: Asymmetric signal with period T.

Duty cycle for H

Duty cycle for L

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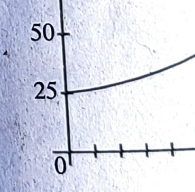


Fig.: (a) An

Duty cycle for $H = \frac{t_H}{T} \times 100\%$

Duty cycle for $L = \frac{t_L}{T} \times 100\%$

1.3 Digital and Analog System

Electronic circuits and systems are broadly divided into two categories: analog and digital circuits. Analog circuits are designed for use with small signals while digital circuits are generally used with large signals. An op-amp with a voltage gain of 5 is an analog circuit. An example of a digital circuit is a remote control circuit that switches the lights in a room on in the evening and turns it off in the morning.

Any quantity changing with time either can be represented as an analog signal or digital signal. In order to understand this, let's apply heat to a container of water and measure the temperature. We can record the water temperature over a period of time in two different ways. In fig. (a), the temperature is recorded continuously, and it changes smoothly from 25°C to 100°C. While being heated, the water temperature passes through every possible values between 25°C and 100°C. This is an example of an analog signal. Analog signals are continuous where all possible values are represented. In fig. (b) the temperature is recorded once every two minutes, and the recorded temperature is not continuous. There are only a finite number of values between 25°C and 100°C (6 values in this case). Here, temperature is recorded as a series of distinct (discrete) points, and is said to be sampled. This is an example of a digital signal. Digital signals represent only a finite number of discrete values. Virtually, all naturally occurring physical phenomena are analog signals (e.g., temperature, pressure, velocity, sound).

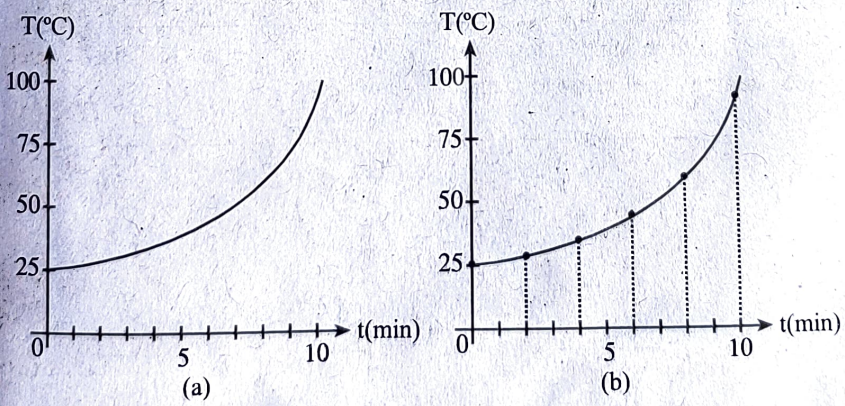


Fig.: (a) An analog (continuous) signal (b) A digital (discrete) signal.

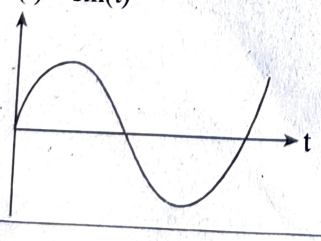
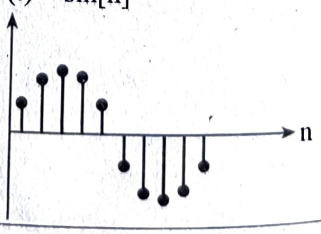
Advantages of digital systems:

1. Digital data can be transmitted more efficiently and is more reliabl than analog data.
2. Digital data can be stored in memory.
3. It is less affected from the noise.
4. The transmission is more secure with encryption.

Disadvantages of digital system:

1. Use more energy than analog circuits to accomplish the same tasks, thus producing more heat as well.
2. Digital circuits are often fragile, in that if a single piece of digital data is lost or misinterpreted, the meaning of large blocks of related data can completely change.
3. Digital computer manipulates discrete elements of information by means of a binary code.
4. Quantization error during analog signal sampling.

Differences between Analog and Digital Signal

Analog Signal	Digital Signal
1. It is a continuous wave which changes over time period.	1. It is a discrete wave that carries information in binary format.
2. It has infinite range.	2. It has finite range.
3. It is relatively less noise immune.	3. It is relatively more noise immune.
4. An analog signal transmits data in form of wave.	4. A digital signal transmits data in binary format (0 and 1).
5. The processing is more difficult.	5. It is easy to process digital signals.
6. It is difficult and more time consuming to retrieve analog signal.	6. It is easier to retrieve digital signal.
7. Example: $f(t) = \sin(t)$ 	7. Example: $f(t) = \sin[n]$ 

SOLUTIO

1. **Define digit its analog c**

Solution:

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2. Digita
3. Digita
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SOLUTIONS TO IMPORTANT AND EXAM QUESTIONS

1. Define digital system. Why do you prefer digital systems against its analog counterpart? [Fall 2020]

Solution:

Digital system is the system which operates on digital signal or discrete states/information. Digital system is represented in binary digits (0 and 1). Some examples of digital system are: registers, flip flops, microprocessor etc.

We prefer digital systems against its analog counterpart because there are lots of advantages of digital system over analog system. Those advantages are listed below:

1. Digital signals can be transmitted more efficiently and is more reliable than analog signal.
2. Digital signals are more immune to noise and interference.
3. Digital data can be stored in memory.
4. Many digital signals can be multiplexed together.
5. Regenerating repeaters can be used to regenerate the same signal time and again in case of digital signals.
6. The transmission is more secure with encryption in digital signals.