Multi-channel Signal

Signals are generated by multiple source or multiple sensor. These signals can be represented by vector form.

ECG (Electrocardiogram) are often used 3-channel and 12-channel.

- As the name indicates, multichannel signals are generated by multiple sources or multiple sensors.
- The resultant signal is the vector sum of signals from all channels

Example: A common example of a multichannel signal is ECG waveform. To generate ECG waveform; different leads are connected to the body of a patient. Each lead is acting as an individual channel. Since there are n number of leads; the final ECG waveform is a result of the multichannel signal. mathematically final wave is expressed as,

$$X(t) = \begin{bmatrix} X_1(t) \\ X_2(t) \\ X_3(t) \end{bmatrix} \leftarrow if\ \ three\ leads\ are\ used$$

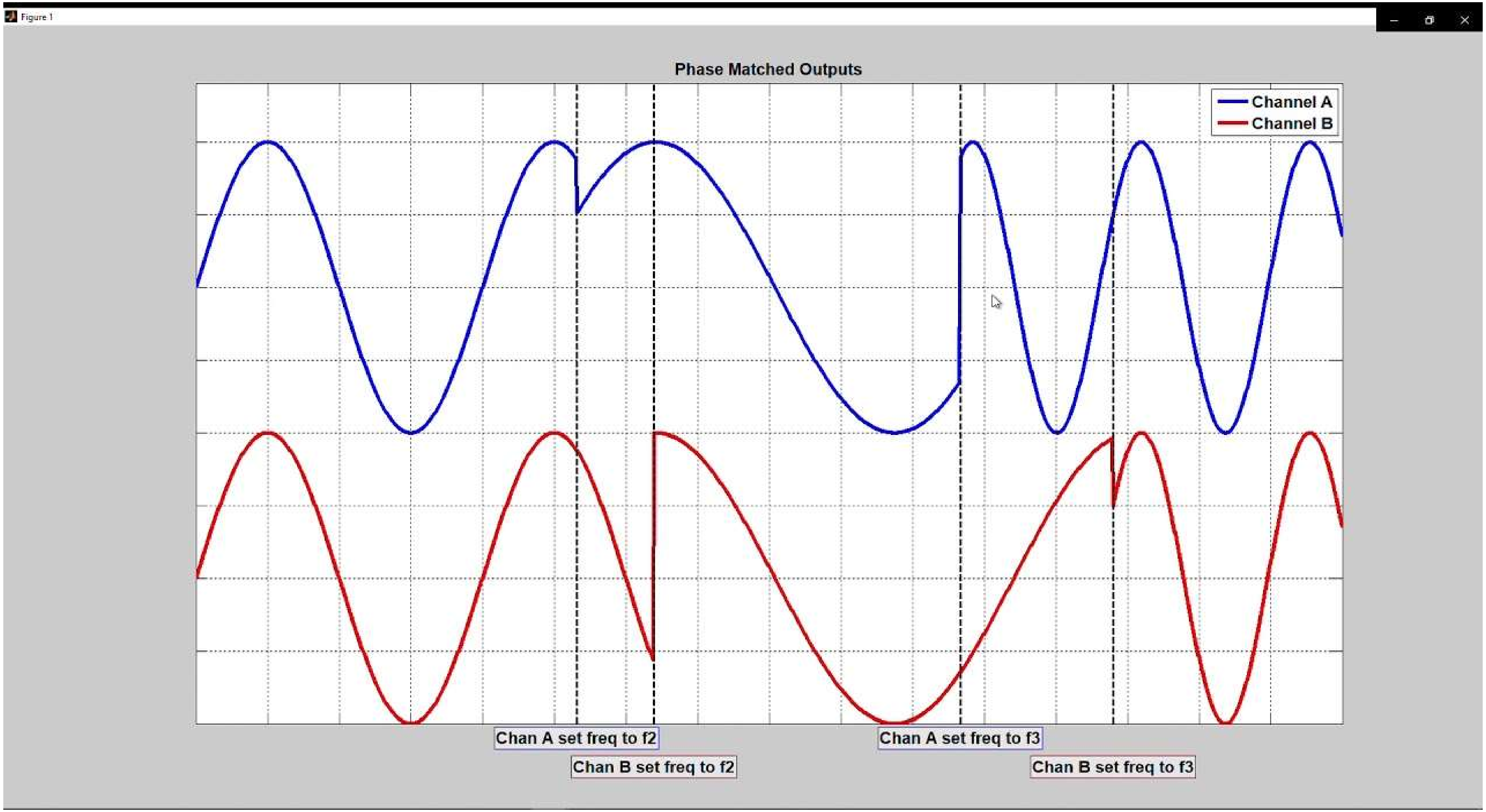


Figure 1
Phase Matched Outputs
Channel A
Channel B
Chan A set freq to f2
Chan B set freq to f2
Chan A set freq to f3
Chan B set freq to f3

Figure 1

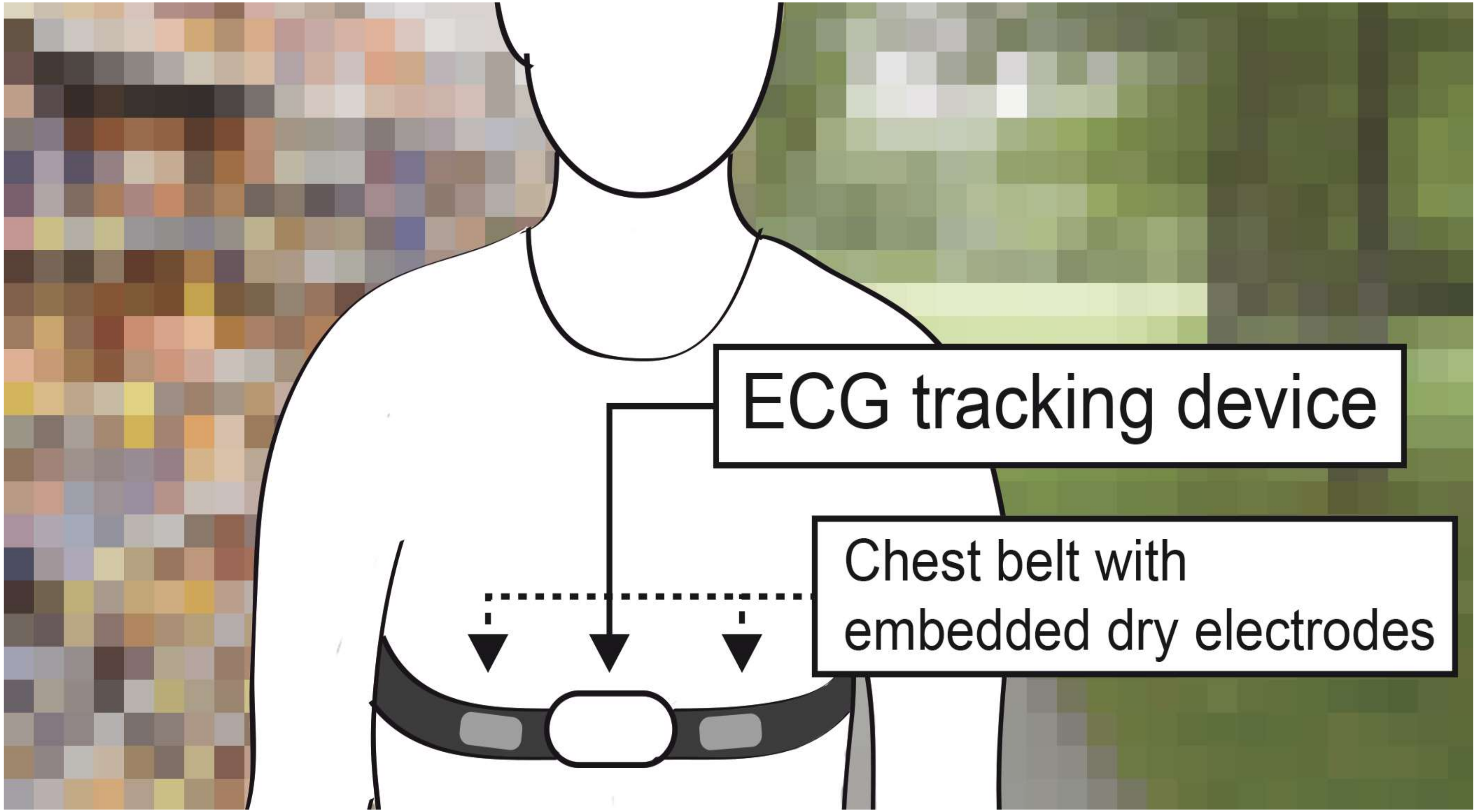
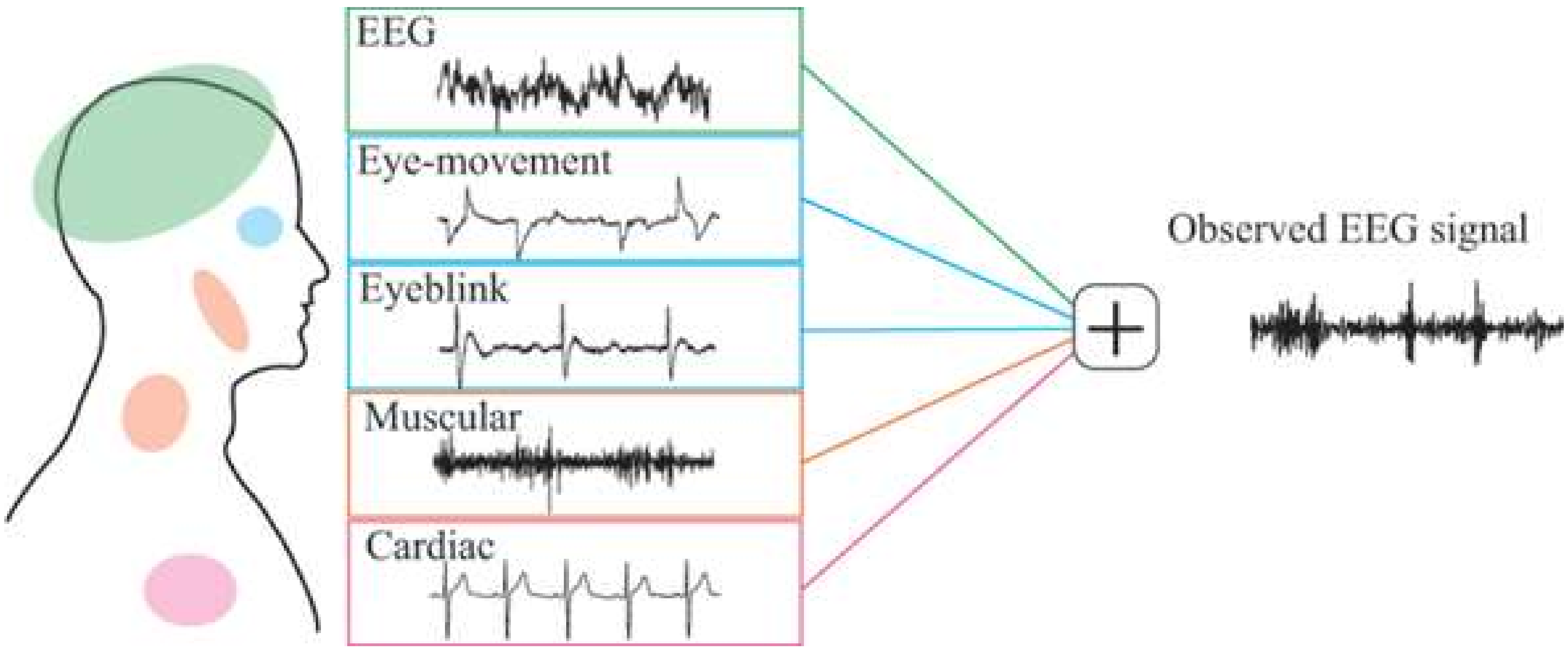

ECG tracking device
Chest belt with
embedded dry electrodes

Figure 2



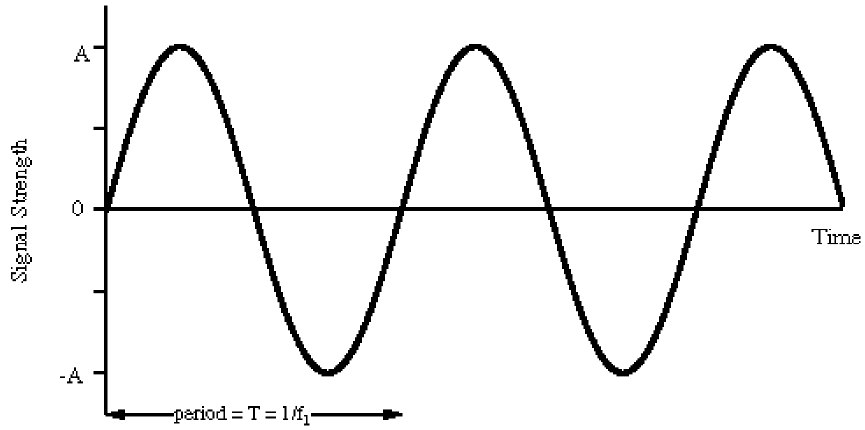
ELECTROENCEPHALOGRAPHIC

Figure 3

Multidimensional Signal

- If the signal is a function of a single independent variable, the signal is called a one-dimensional signal.
- On the other hand, a signal is called M-dimensional if its value is a function of M independent variable.
- The gray picture is an example of a 2-dimensional signal, the brightness or intensity is a function of two independent variable at each point i.e., $I(x,y)$.
- The black & white TV picture [$I(x,y,t)$] is a three dimensional since the brightness is a function of time.

Another **example of a three dimensional signal** is a cube or a volumetric data or the most common **example** would be animated or 3d cartoon character. The mathematical representation of **three dimensional signal** is: $F(x,y,z)$ = animated character.



(a) Sine Wave

Figure 4

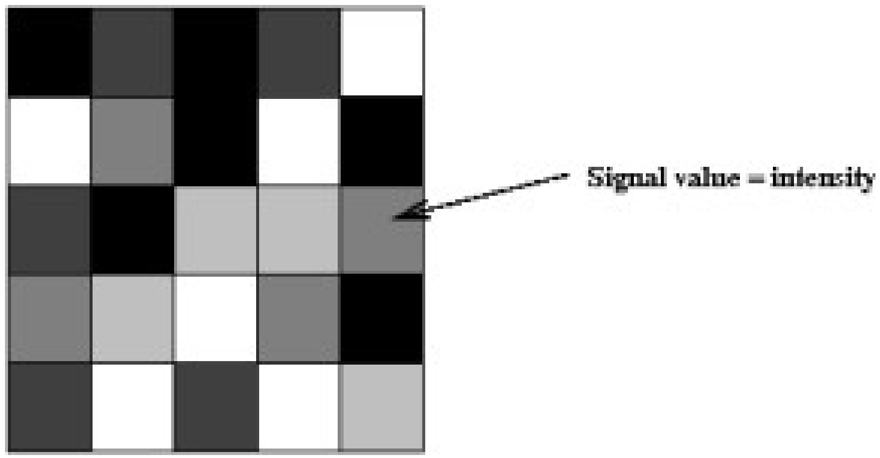


Figure 5

Basic Continuous Time signals

Unit Step Function:

Figure 6 shows a step-function.

The value of the function is zero for $t < 0$

and its value is unity for $t \geq 0$.

Mathematically, it is given by

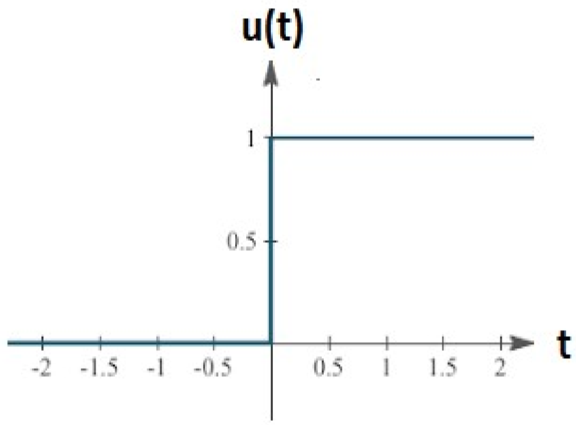


Figure 6

$$u(t) = \begin{cases} 0 & \text{for } t < 0 \\ 1 & \text{for } t \geq 0 \end{cases} \qquad (11)$$

Shifting of u(t) to right

u(t-a):

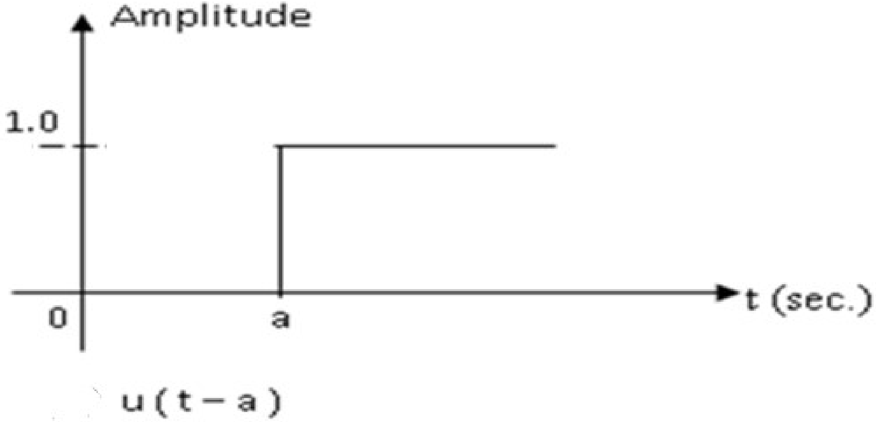


Figure 7

$$u(t-a)=\begin{cases}0 & t<a\\ 1 & t\geq a\end{cases}$$

Shifting of u(t) to left

u(t+a):

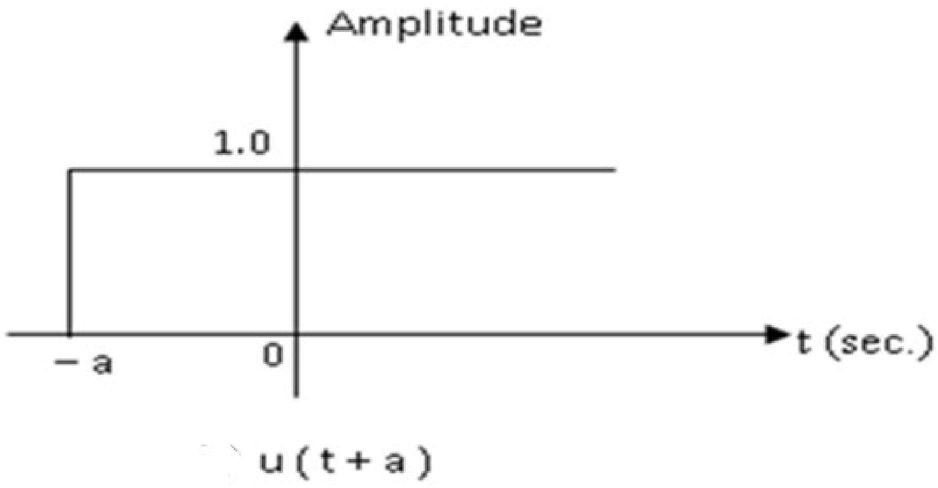
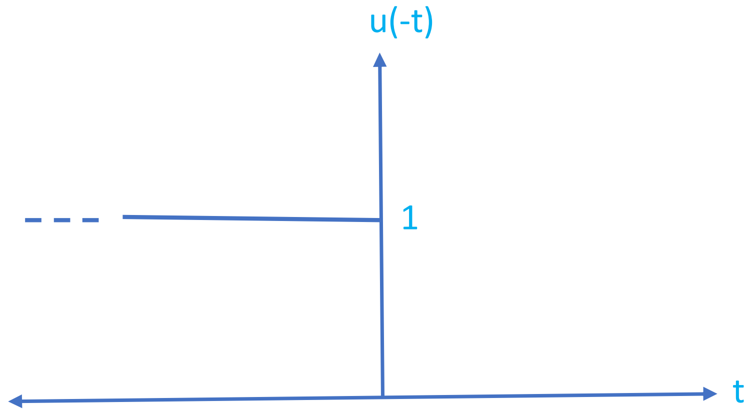


Figure 8

$$u(t+a)=\begin{cases}0 & t<-a\\ 1 & t\geq -a\end{cases}$$

Reversal of u(t):

u(-t):



u(-t) = 1 for t ≤ 0

Figure 9

u(-t) = 0 for t > 0

Shifting of u(-t) to right

u(a-t) i.e., u(-t+a):

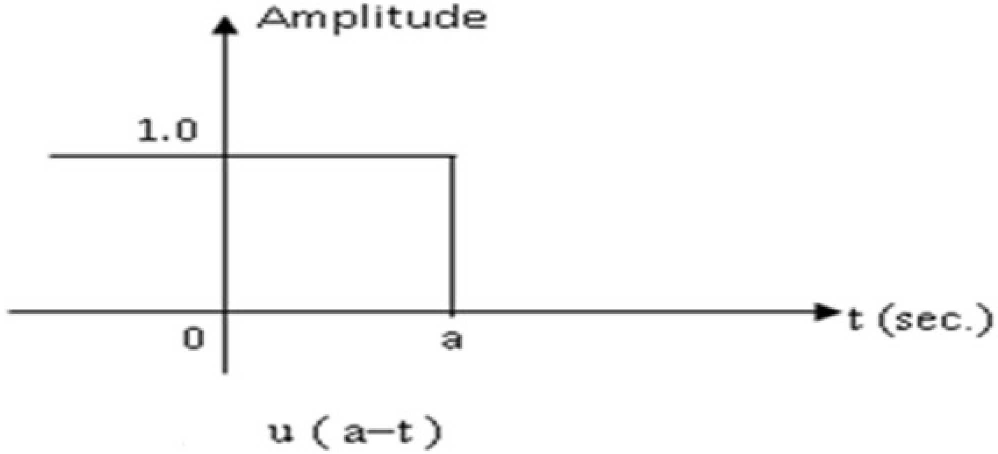


Figure 10

$$u(a-t)=\begin{cases}0 & t>a\\ 1 & t\leq a\end{cases}$$

Shifting of u(-t) to left

- u(-a-t)

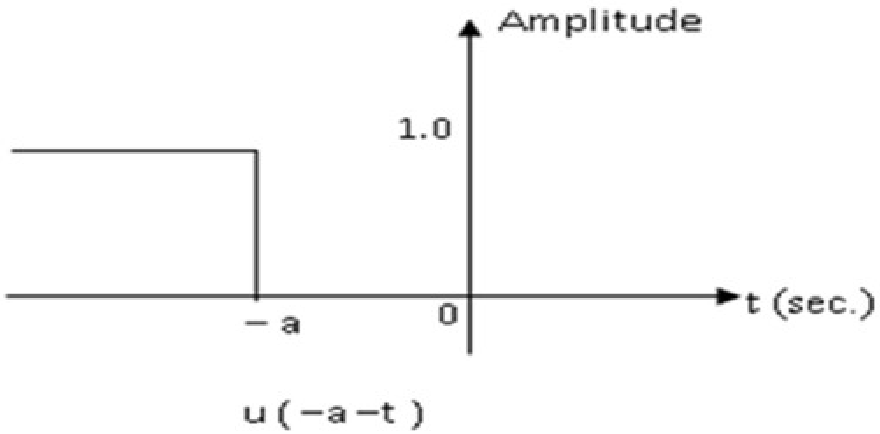


Figure 11

$$u(-a-t)=\begin{cases}0 & t>-a\\1 & t\le -a\end{cases}$$

Shifting of u(t) and u(-t)

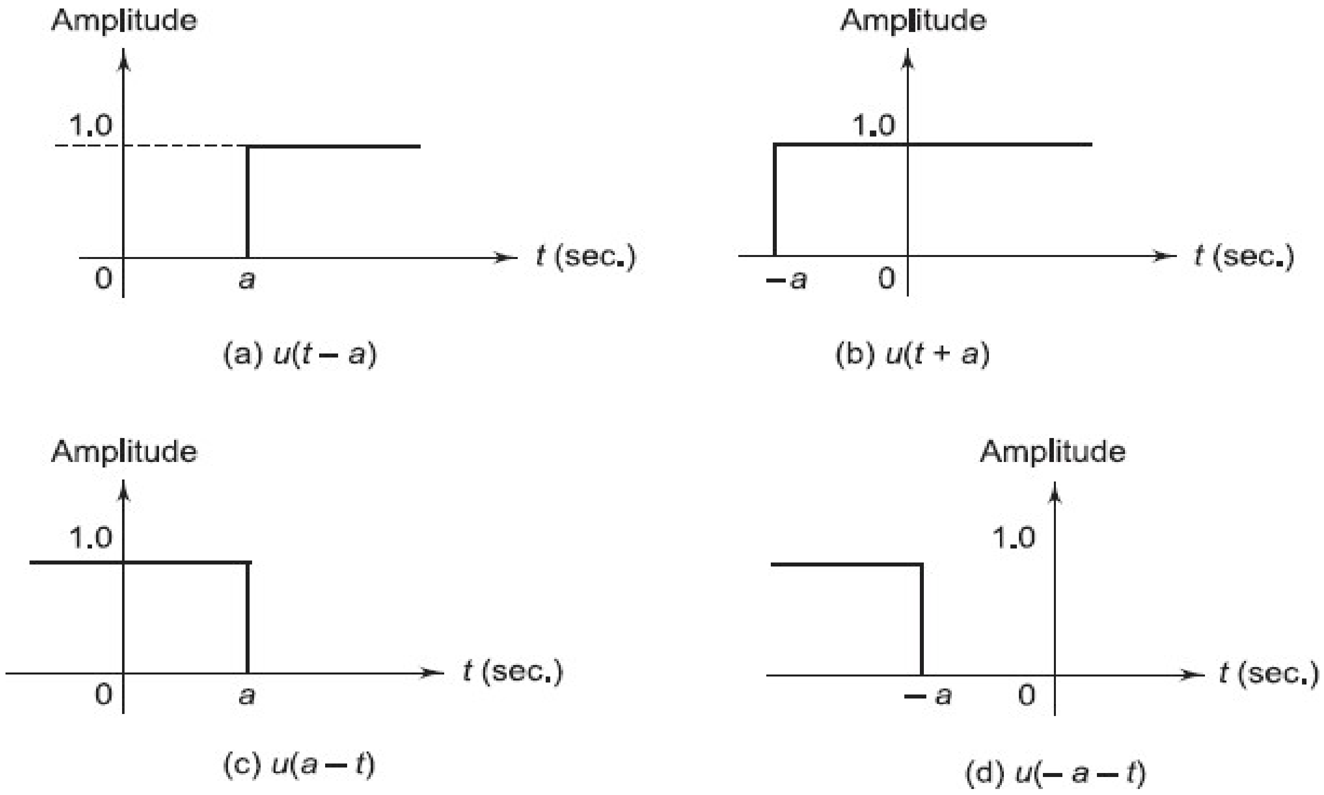


Figure 12

Ramp Function

Figure 13 depicts a ramp function. The value of ramp function is zero for $t < 0$ and after $t \geq 0$, it linearly increases with time.

Mathematically, it is given below.

$$r(t) = \begin{cases} 0 & \text{for } t < 0 \\ t & \text{for } t \geq 0 \end{cases} \qquad (13)$$

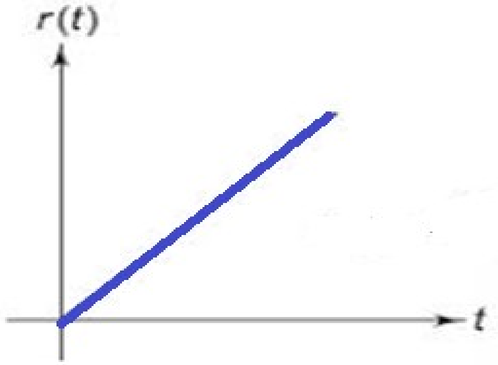


Figure 13

Find whether the signal $x(t) = Ae^{-j\omega t}$ is energy or power signal

Here

$$x(t) = Ae^{-j\omega t}$$

$$\left|x(t)\right| = A\left|e^{-j\omega t}\right| = A$$

$$E = \underset{T\to\infty}{Lt} \int_{-T}^{T} \left|x(t)\right|^2 dt = \underset{T\to\infty}{Lt} \int_{-T}^{T} A^2 dt = \underset{T\to\infty}{Lt}\, 2A^2T = \infty$$

$$\mathrm{P} = \underset{T\to\infty}{Lt} \frac{1}{2T} \int_{-T}^{T} \left|x(t)\right|^2 dt = \underset{T\to\infty}{Lt} \frac{1}{2T} 2A^2T$$

$$= A^2$$