

Operations on a Signal ⇒

When the processing of signals, may undergo several manipulations involving the independent variable, i.e. we need the transformation of independent variables. Some manipulations or transformations of independent variables are as under:

- (i) Time-Shifting
- (ii) Time-Scaling
- (iii) Time reversal or Time-Inversion or Folding.

1. Time Shifting ⇒

A signal $x(t)$ may be shifted in time i.e. a signal may be either advanced or delayed in the time-axis.

The shifted signal is represented by $x(t-T)$ or $x(t+T)$ i.e. the time shift of a signal by T , we replace t with $(t-T)$ or $(t+T)$

Now,

$$x(t) \longrightarrow x(t-T)$$

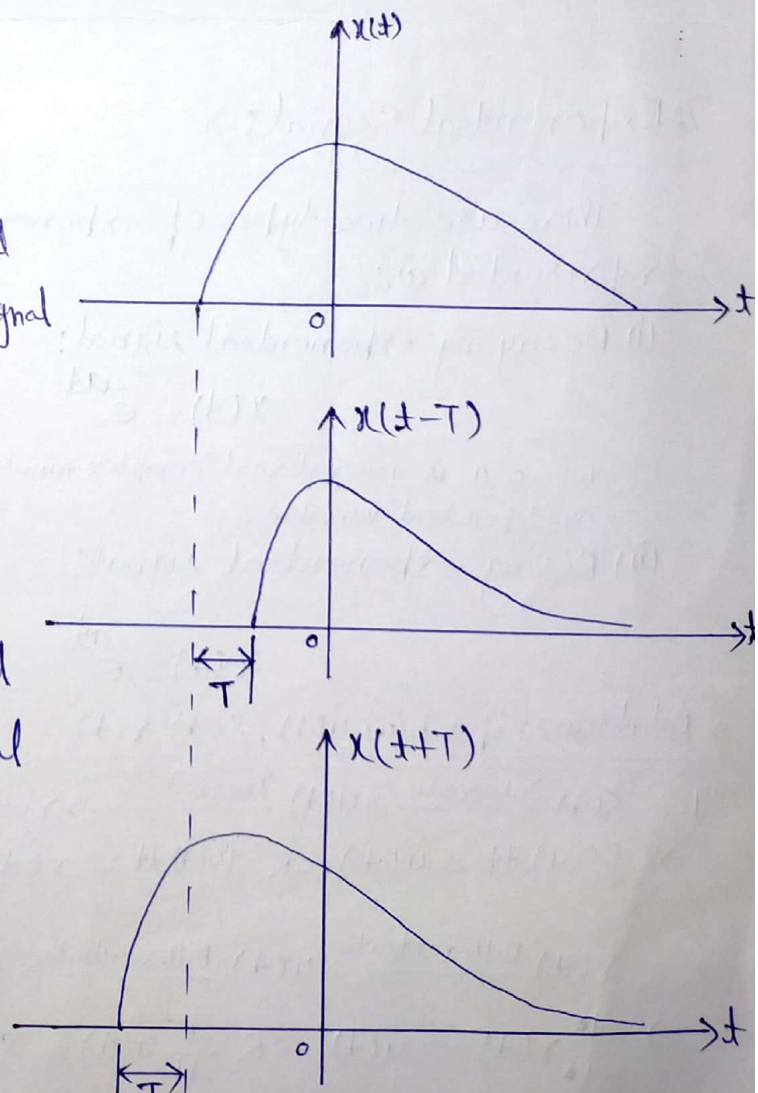
time shifted by T second

hence, T is positive, the signal $x(t)$ shift to the right. i.e. the signal $x(t)$ is delayed.

and,

$$x(t) \longrightarrow x(t+T)$$

hence, T is negative, the signal shift to the left. i.e. the signal $x(t)$ is advanced.



2. Time Scaling: \Rightarrow

The expansion or compression of a signal in time is called as time scaling.

Now,

$$\rightarrow x(t) \longrightarrow x(2t)$$

~~the~~ i.e. the signal $x(t)$ compressed in time by a factor 2.

This means that whatever happens in $x(t)$ at some instant t , also happens in $x(2t)$ at the instant $(t/2)$.

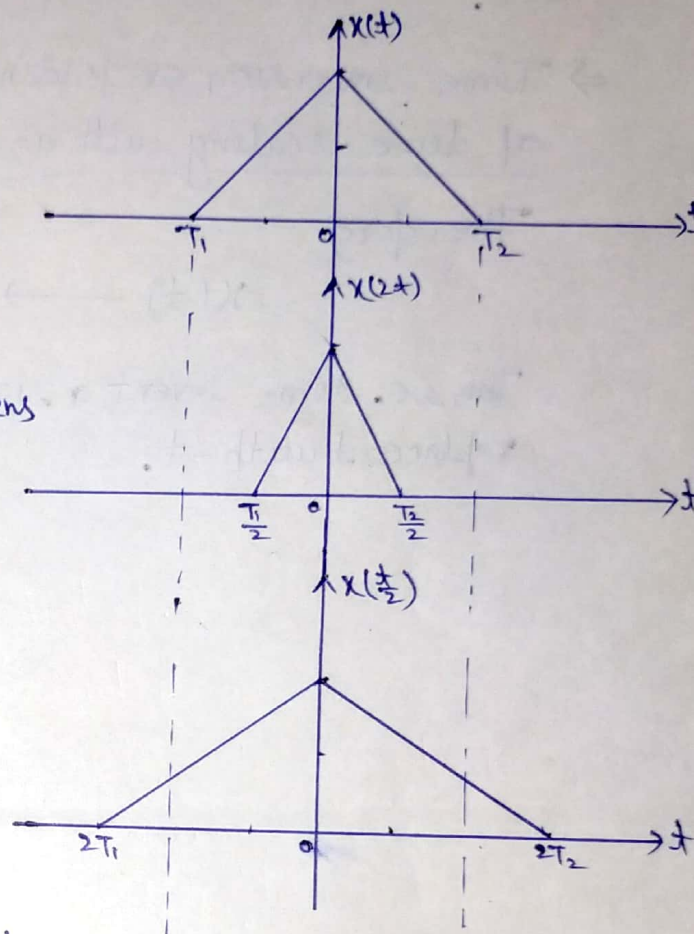
In general, if $x(t)$ is compressed in time by a factor a ($a > 1$), the resulting signal (Scaled-signal) will give by $x(at)$

and,

$$\rightarrow x(t) \longrightarrow x\left(\frac{t}{2}\right)$$

i.e. the signal $x(t)$ expanded in time by factor 2.

In general, if $x(t)$ is expanded in time by a factor a ($a > 1$), the resulting signal (Scaled-signal) will given by $x(t/a)$.



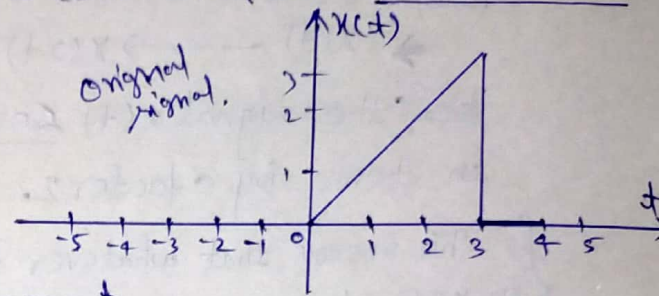
3. Time Inversion \Rightarrow

Time inversion is achieved by replacing the independent variable t by $(-t)$. This results in folding of a signal about the origin i.e. $t=0$.

\Rightarrow Time-inversion or folding may be considered as a special case of time-scaling with $a = -1$

Therefore

$$x(t) \longrightarrow x(-t)$$



~~This~~ i.e. time-invert a signal $x(t)$, we must replace t with $-t$.

