

* The properties of linearity and time invariance that define this class lead to a remarkable set of concepts and techniques which are not only of major practical importance but are also analytically tractable and intellectually satisfying

Sec 1-1

* The information in a signal is contained in a pattern of variations of some form

* Figure 1.4 variations in brightness

* Speech : variations in acoustic pressure

* Signals are represented mathematically as functions of one or more independent variables.

* Time as an independent variable

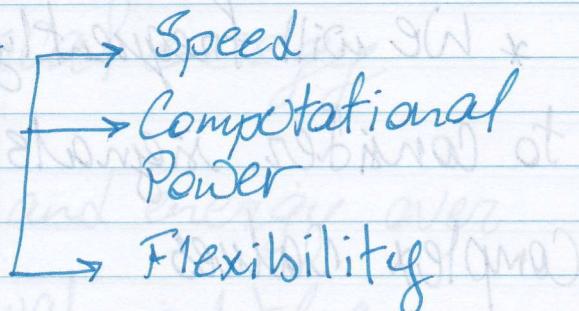
* Continuous-time and Discrete-time signals.

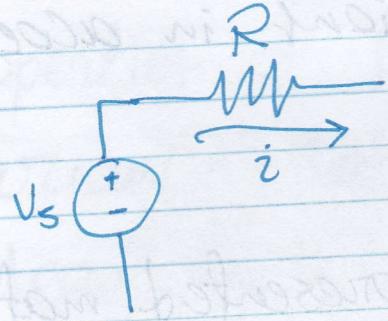
* $x(t)$ and $x[n]$

* Figure 1.1

* Sampling of continuous-time signals

* Digital Systems





* instantaneous power

$$p(t) = v(t)i(t) = \frac{1}{R}v^2(t)$$

Total energy over $t_1 \leq t \leq t_2$

$$\int_{t_1}^{t_2} p(t) dt = \int_{t_1}^{t_2} \frac{1}{R} v^2(t) dt$$

Average Power

$$\frac{1}{t_2 - t_1} \int_{t_1}^{t_2} p(t) dt = \frac{1}{t_2 - t_1} \int_{t_1}^{t_2} \frac{1}{R} v^2(t) dt$$

* We will frequently find it convenient
to consider signals that take on
Complex values

Instantaneous

Total energy over $t_1 \leq t \leq t_2$

$$\int_{t_1}^{t_2} |x(t)|^2 dt$$

Time-averaged power: dividing by the length $(t_2 - t_1)$

Discrete-time total energy:

$$\sum_{n=n_1}^{n_2} |x[n]|^2$$

Average power: dividing by $n_2 - n_1 + 1$

Terms are used independently of whether they represent physical energy

* Examining power and energy over an infinite time interval $\rightarrow L \neq \infty$

Continuous-time

$$E_{\infty} \triangleq \lim_{T \rightarrow \infty} \int_{-T}^T |x(t)|^2 dt = \int_{-\infty}^{\infty} |x(t)|^2 dt$$

Discrete-time

$$E_{\infty} \triangleq \lim_{N \rightarrow \infty} \sum_{n=-N}^N |x[n]|^2 = \sum_{n=-\infty}^{\infty} |x[n]|^2$$

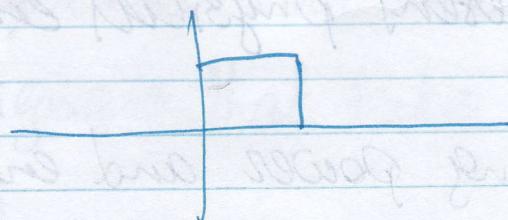
$$E_{\infty} < \infty ?$$

$$P_{\infty} \triangleq \lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T |x(t)|^2 dt$$

$$\triangleq \lim_{N \rightarrow \infty} \frac{1}{2N+1} \sum_{n=-N}^N |x[n]|^2$$

If $E_{\infty} < \infty$ then $P_{\infty} = 0$

$$P_{\infty} \leq \lim_{T \rightarrow \infty} \frac{E_{\infty}}{2T}$$



Signals with $E_{\infty} \neq \infty$ and $0 < P_{\infty} < \infty$

Signals with $E_{\infty} = \infty$, $P_{\infty} = \infty$

* Section 12 - Transformations of the independent variable

* We focus on ~~is~~ a very limited
but important class of elementary
signal transformations

Time shift

$$x(t-t_0) \quad x[n-n_0]$$

to positive delayed

to negative advanced

Figure 1.8

Time reversal

Figure 1.10

Time scaling

Figure 1.12

no forward shift seen \Rightarrow

$$x(t) \rightarrow x(\alpha t + \beta)$$

linearly stretched if $|\alpha| < 1$

linearly compressed if $|\alpha| > 1$

reversed in time if $\alpha < 0$

shifted in time if $\beta \neq 0$

Example 1.1