# ELE 361: Haberleşme Sistemlerine Giriş

1. Giriş: Sinyaller, sistemler, R.M.S., Desibel (Ch1)
2. Kablolu , kablosuz optik sistemler: Frekans izgesi, kablolama, darbe şekillendirme, senkronizasyon, iletim hattı, RF izgesi, yayılımı, optik haberleşme (Ch2)
3. Kipleme ve kipçözümü: Genlik kiplemesi, Frekans ve Faz kiplemesi, güç analizi, güç analizi (Ch 3)
4. Kipleme ve kipçözümü: IQ sinyalleri ile kipçözümü, sayısal kipleme, dik sinyaller, QAM, FDM, OFDM
5. Veri iletimi ve doğruluk: Hata fonksiyonu, bit hataları ve analizi , Hamming kodları, CRC , Evrişimsel kodlar (Ch 6)
6. Nicemleme ve kodlama: Düzgün ve düzgün olmayan, skaler ve vektörel nicemleme, Huffman kodlaması, PCM, İmge ve ses kodlama (Ch 5)
7. Internet protokolleri ve algoritmaları: Veri yapıları, paket, protokol yığıtı, katmanlı mimari, WiFi, Ethernet, IPv4, IPv6, NAT, ARP, DHCP, TCP, UDP, Yol atama (Ch 4)

# ELE 361

Konu 1: Sinyaller ve Sistemler

# 1.2 Giriş

- Sinyal: zamanla değişen bir değer
  - Örnek?
- Bir haberleşme kanalının bir ucundan diğer ucuna bir bilgi iletmeye yarar
  - Modülasyon  - kipleme
  - Sinyaller üzerinde pek çok işlem yapılabilir ve bir takım bloklarla ifade edilebilir.
- Örnek: faz kaydırma (periyodik sinyaller)
  - Ör. 90 derece ileride olmak ne demek?
    - 270 derece geride olmak

# 1.3 Faz Kaydırma

- Bu sinyalleri matematiksel olarak yazalım

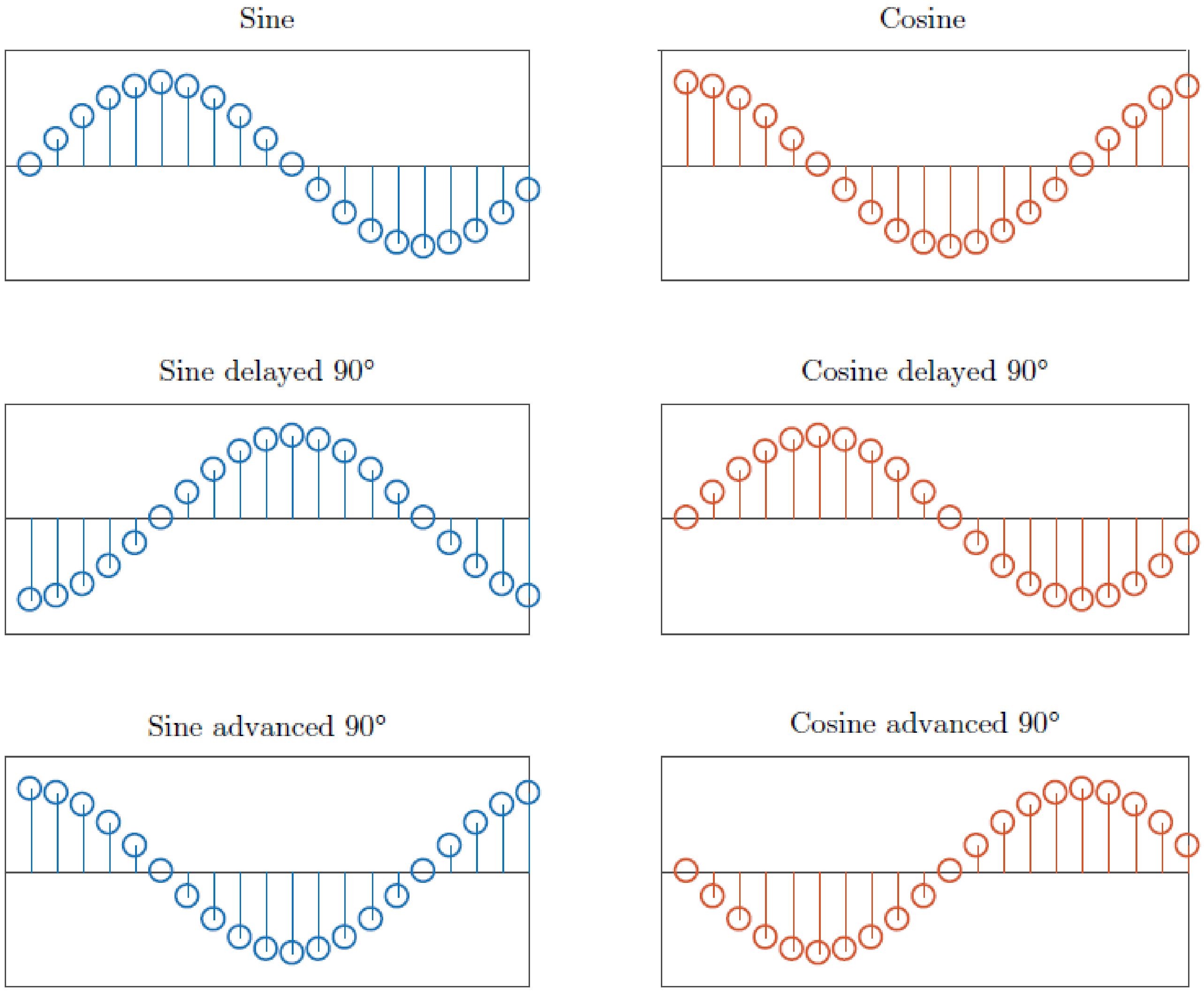



**Figure 1.1** Sine and cosine, phase advance, and phase retard. Each plot shows amplitude $x(t)$ versus time $t$.

```
T=1;
t = linspace(0,T,1000);
w = 2*pi*1000;
x = sin(w*t - pi/2);
stem(x, 'b');
```

# 1.4 Sistem Yapı Taşları (ELE 371)

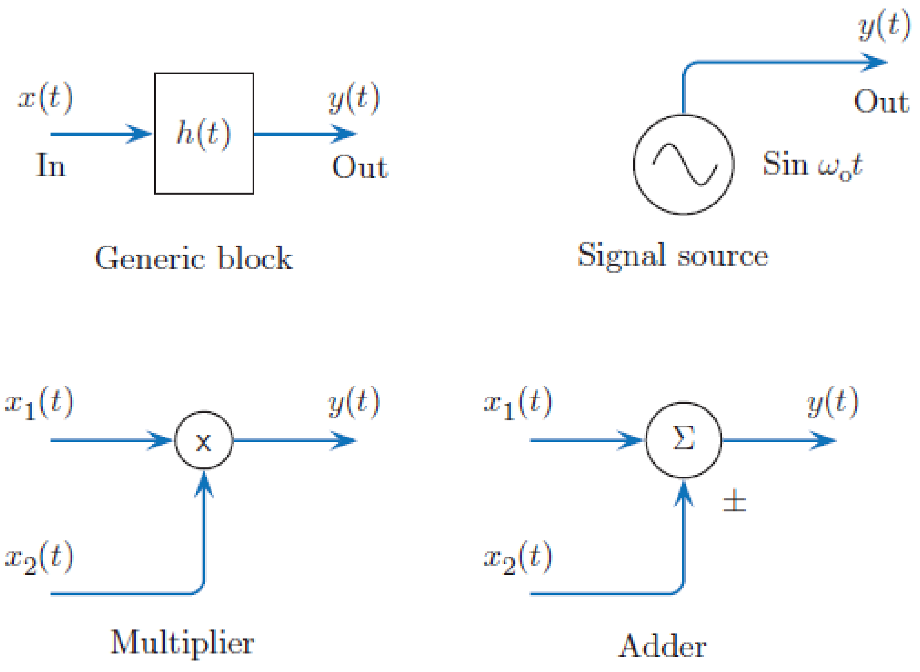



**Figure 1.2** Basic building blocks: generic input/output, signal source, adder, and multiplier.

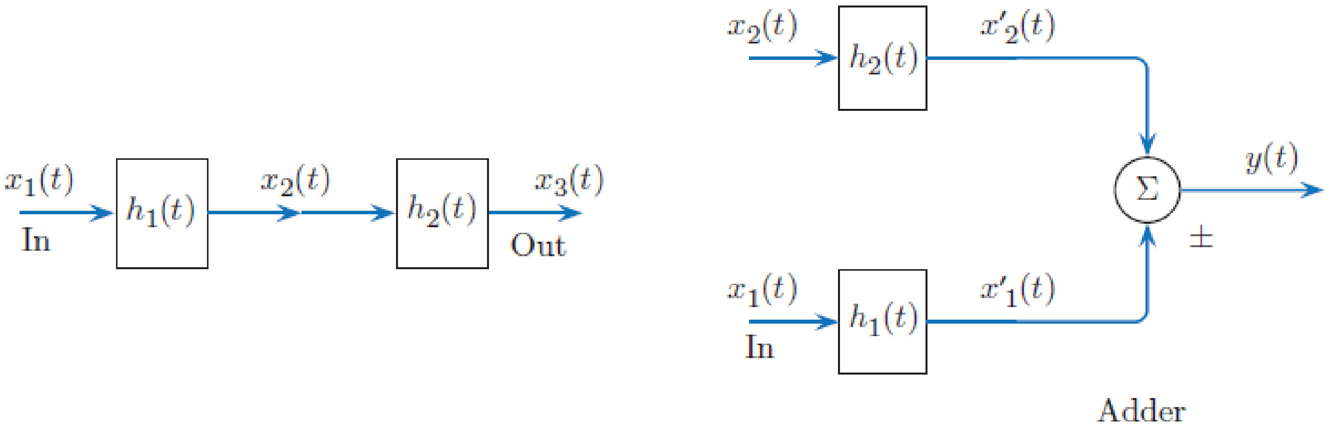



**Figure 1.3** Cascading blocks in series (left) and adding them in parallel (right).

# 1.4.2 Faz Kaydırma

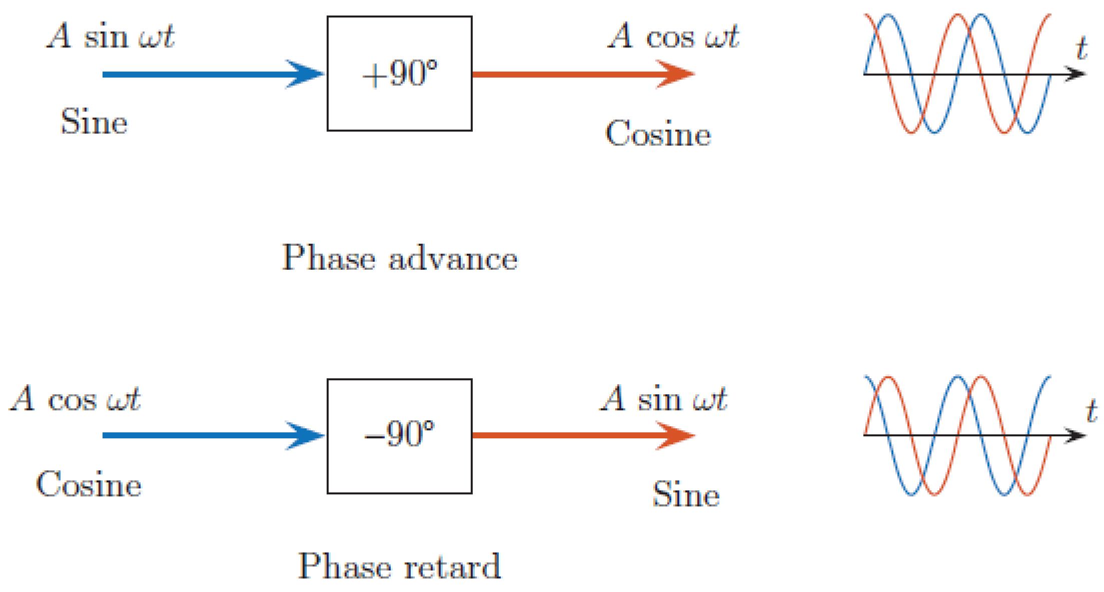



**Figure 1.4** Phase shifting blocks. Note the input and output equations.

# 1.4.3 Doğrusal Sistem Karakteristiği

- Kazanç
- $y(t) = \alpha x(t)$

- $x(t) = A \sin \omega t$
- $y(t)$

- Örnek: ideal yükselteç
- Örnek: RLC devresi

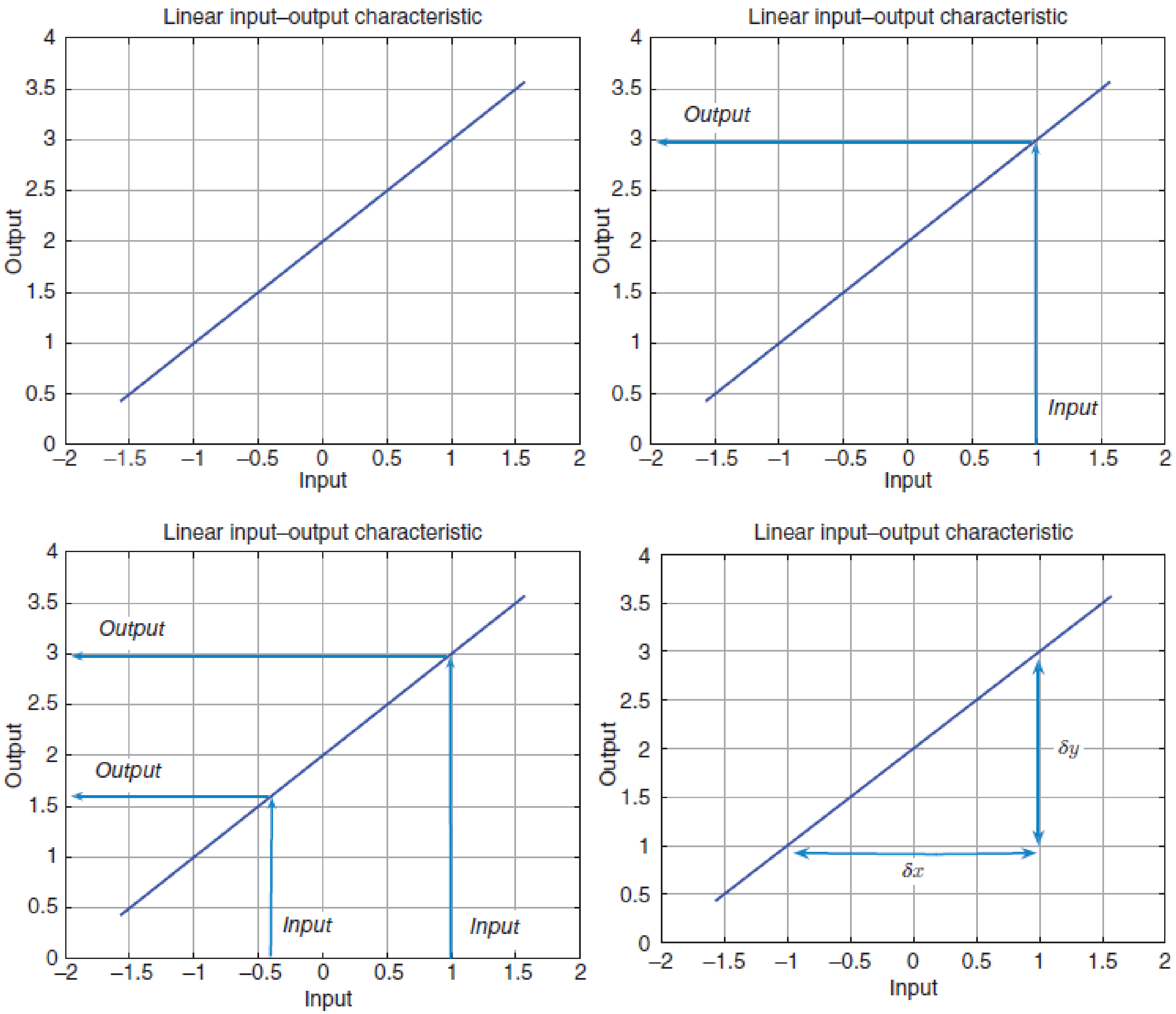
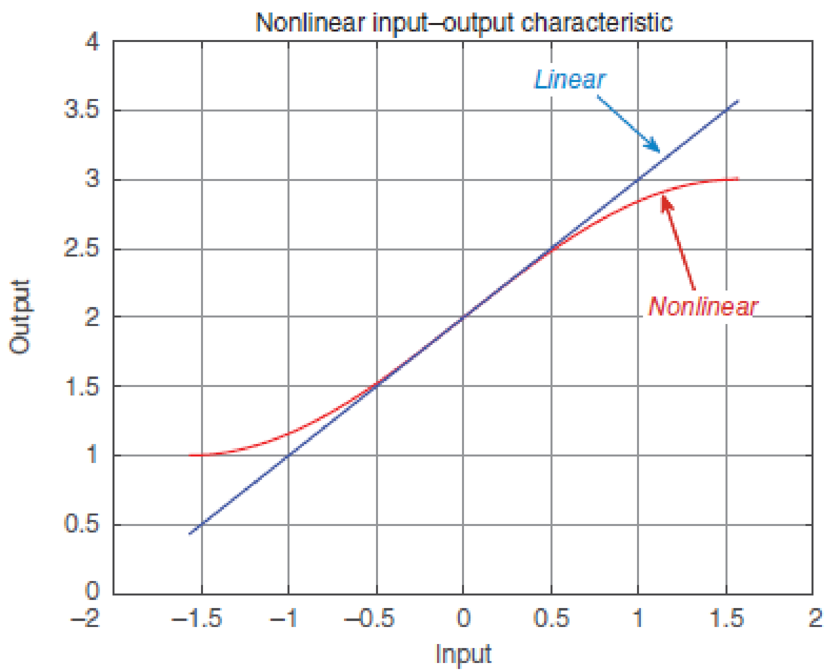
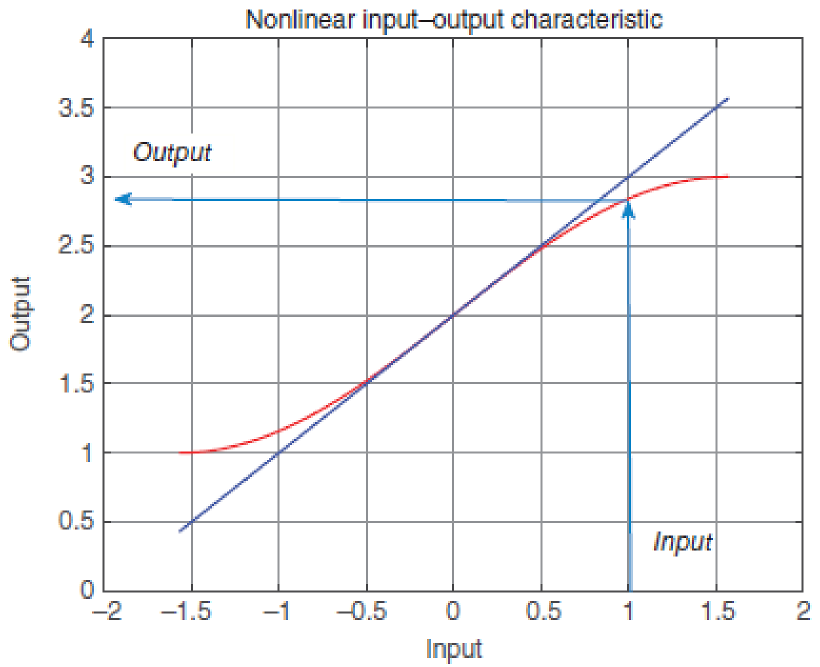



**Figure 1.5** The process of mapping an input (horizontal axis) to an output (vertical), when the block has a linear characteristic. The constant or DC offset may be zero, or nonzero as illustrated.

# 1.4.3 Doğrusal Olmayan Karakteristik

- Örnek: Diyot, transistör (ELE 224)
- Girdi: $x(t) = A \sin \omega t$
- Çıktı: $\mathrm{y(t)} = \alpha x(t) + \beta x^2(t)$
- Trigonometrik özellikleri kullanalım…



# 1.4.4 Filtre Blokları (ELE 202’den biliyoruz)

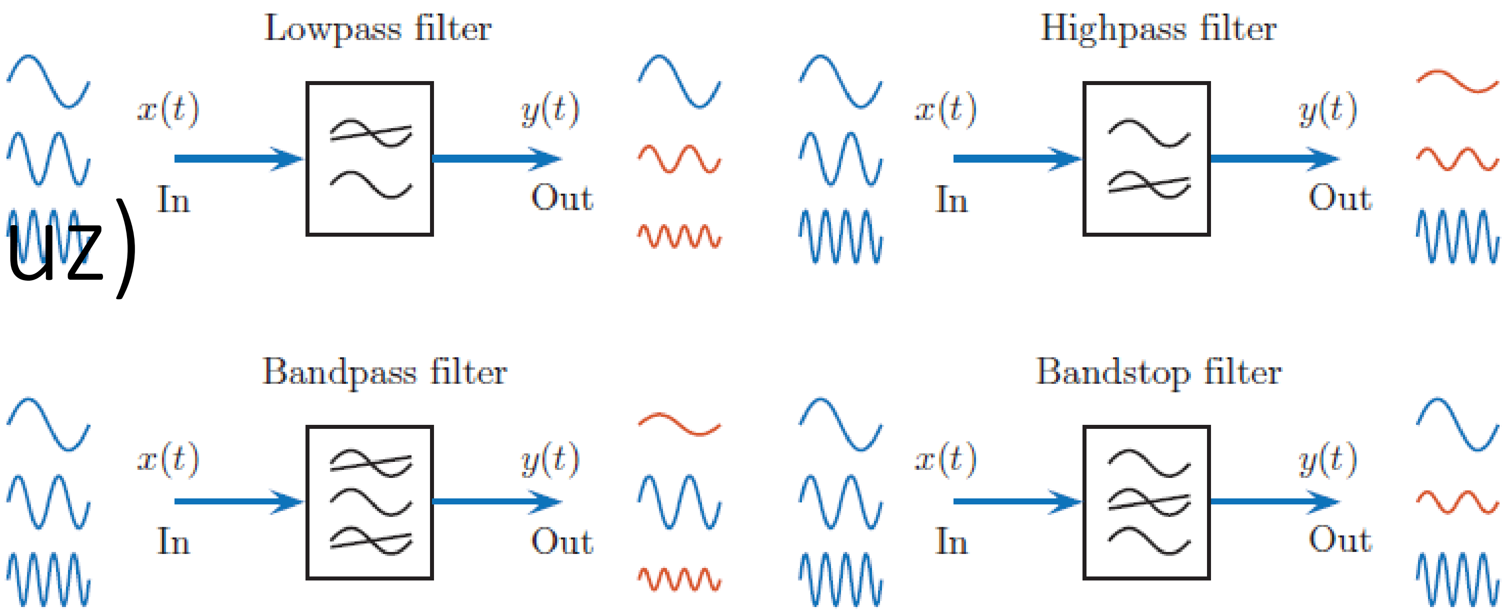
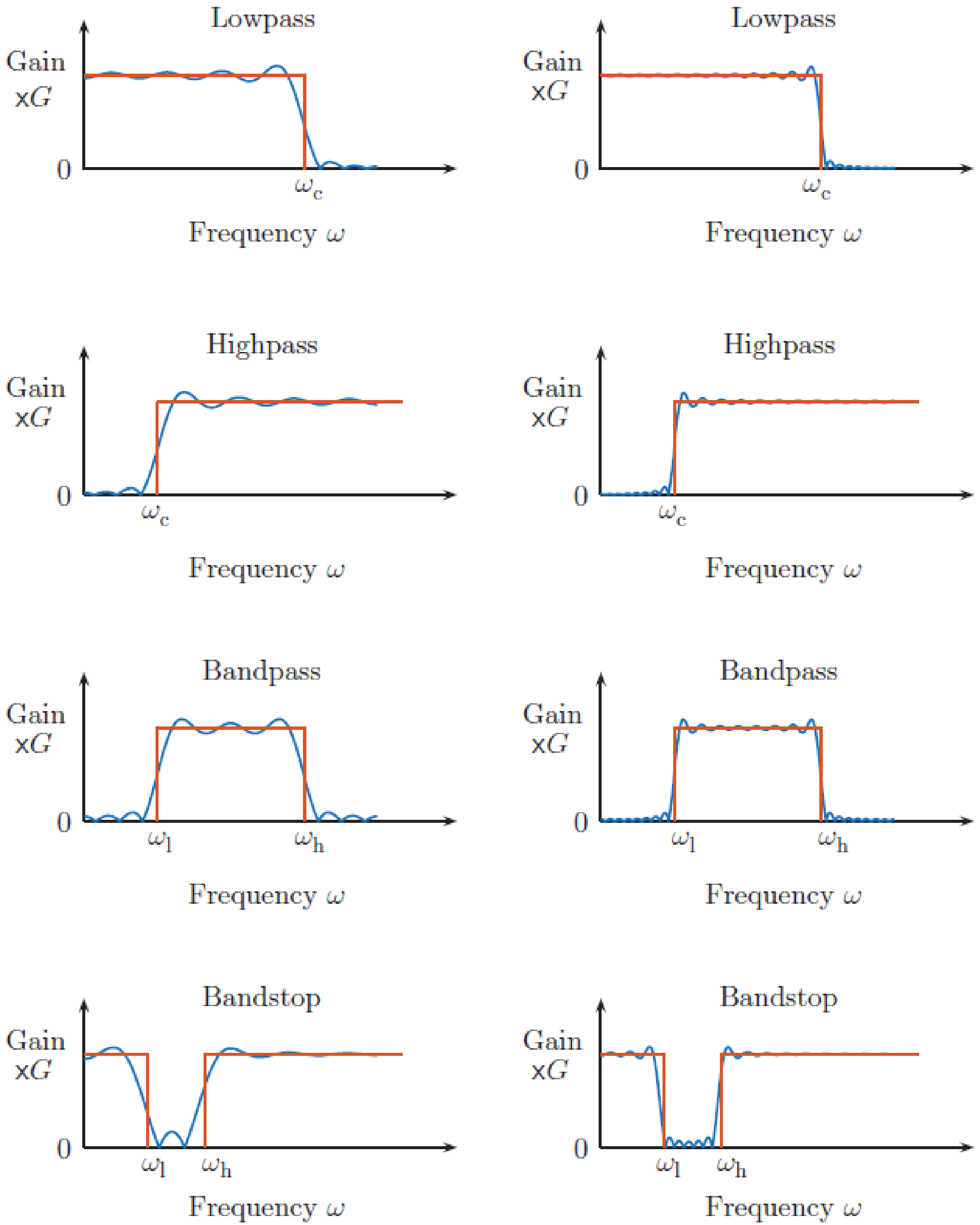



**Figure 1.7** Some important filter blocks and indicative time responses. The waveforms and

- Alçak geçirgen filtre kullanımı
- Yüksek geçirgen filtre
- Bant geçirgen filtre kullanımı

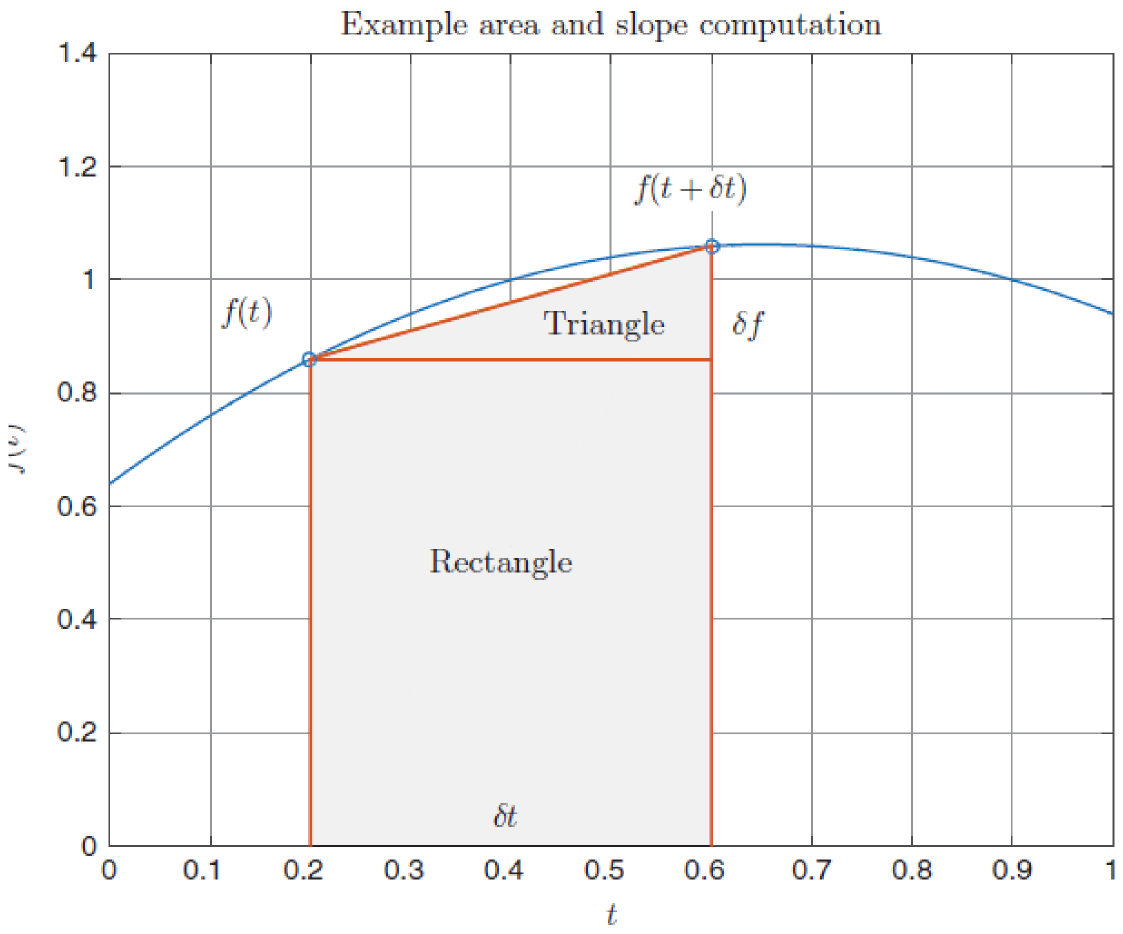
# 1.4.4 Filtreler

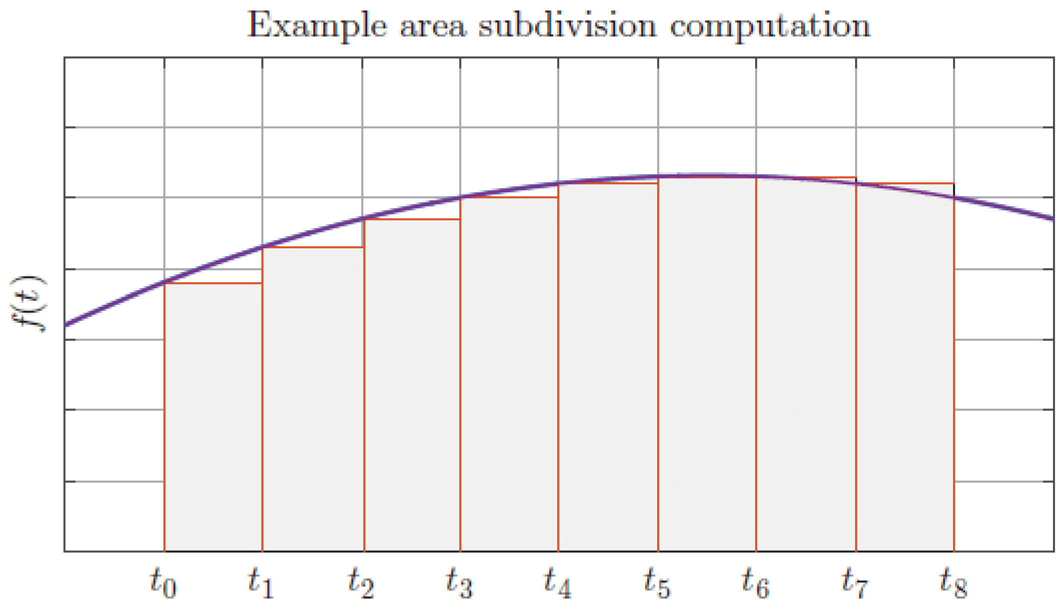
- Geçirme bandı
- Durdurma bandı
- Kesim frekansı
- Filtre derecesi



# 1.5 Türev ve Integral

- Integral: örneklenmiş sinyalin zamanda toplamı,
- Türev: zamanda değişim hızı



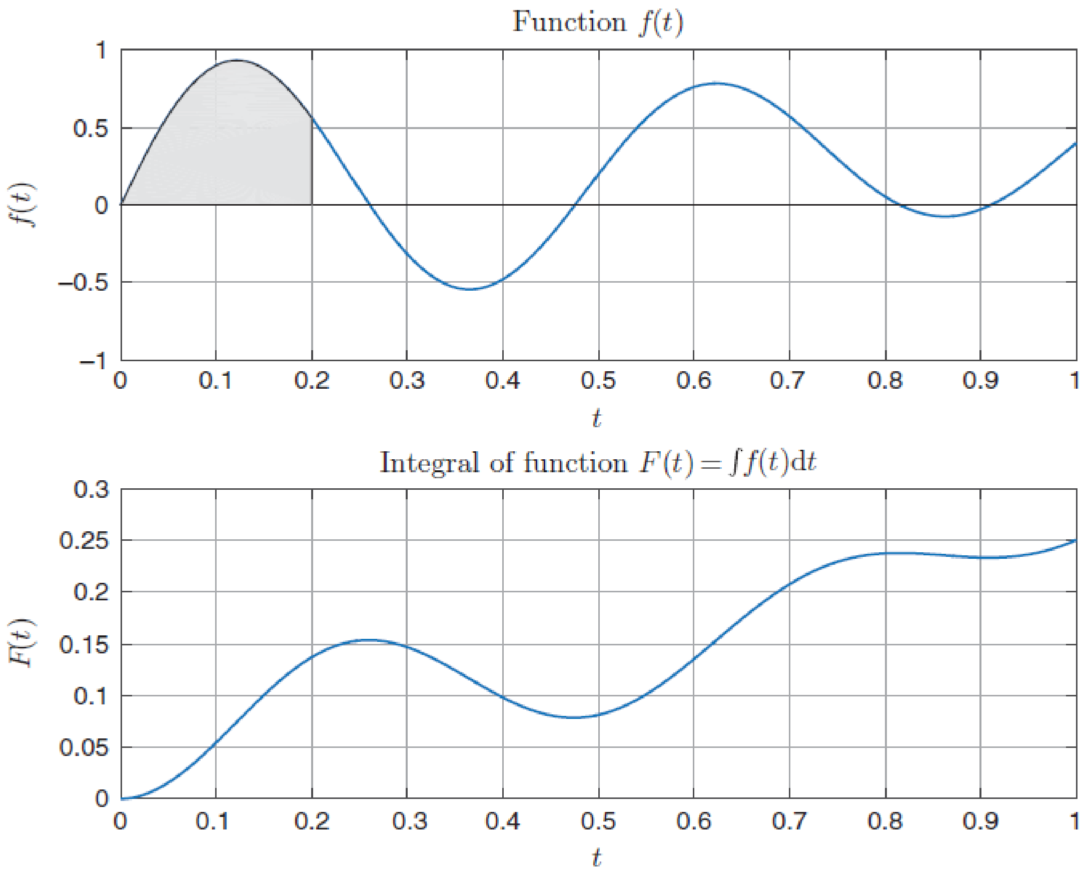



**Figure 1.13** The cumulative area under $f(t)$. Each point on $F(t)$ represents the area up to the right-hand side of the shaded portion at some value of $t$ (here $t = 0.2$ for the shaded portion). Note that when $f(t)$ becomes negative, the area reduces.

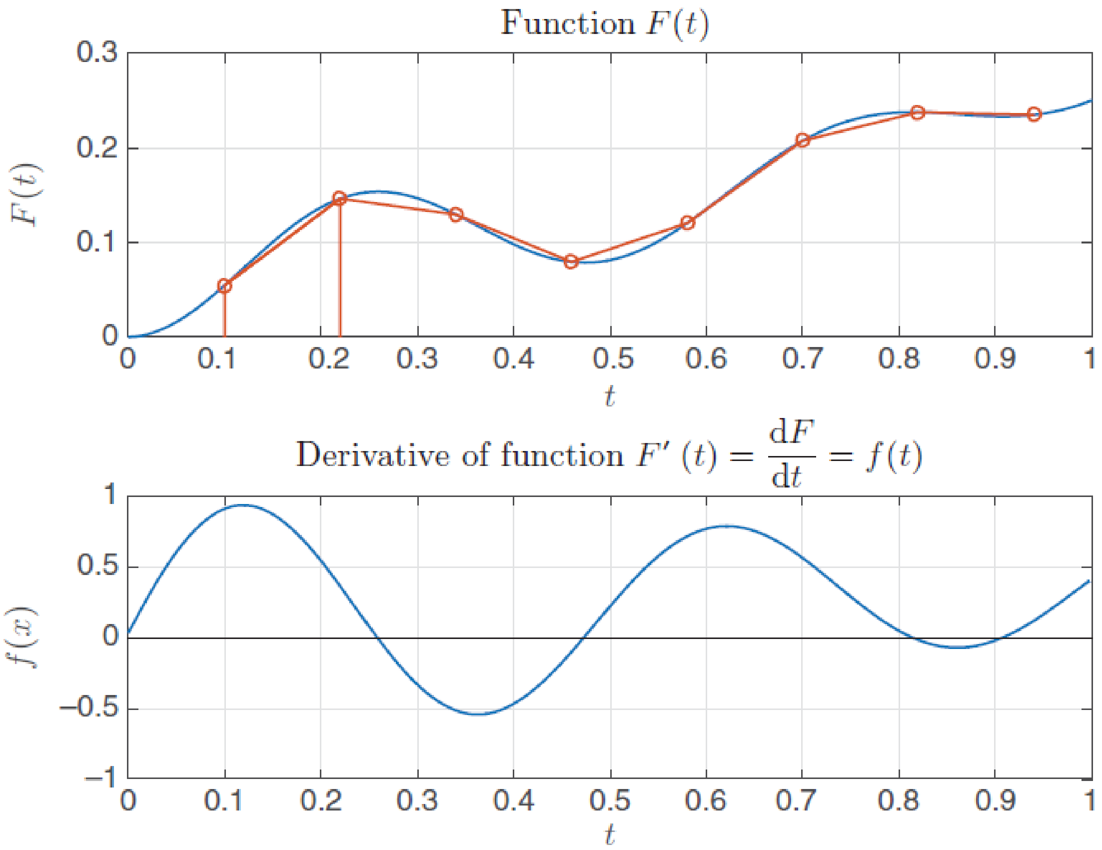



**Figure 1.14** The derivative of $f(t)$ as a function. It may be approximated by the slopes of the lines as indicated, though the spacing is exaggerated for the purpose of illustration.

# 1.7 Güç – R.M.S.

- DC sinyal: $P = \frac{V^2}{R}$
- AC sinyal: $\mathrm{p(t)} = \frac{v^2(t)}{R}$
  - Ortalama güç (sinüzoidal $\mathrm{x(t)} = \mathrm{Asin}\,\omega t$): ?

```
% waveform parameters
dt=0.01;
tmax=2;
t=0:dt:tmax;
f=2;
% generate the s i gna l
x=1*sin(2*pi*f*t);
plot(t,x);
% c a l c u l a t e the s ignal ' s RMS value
sqrt ((sum( x.*x )*dt)/tmax)
```

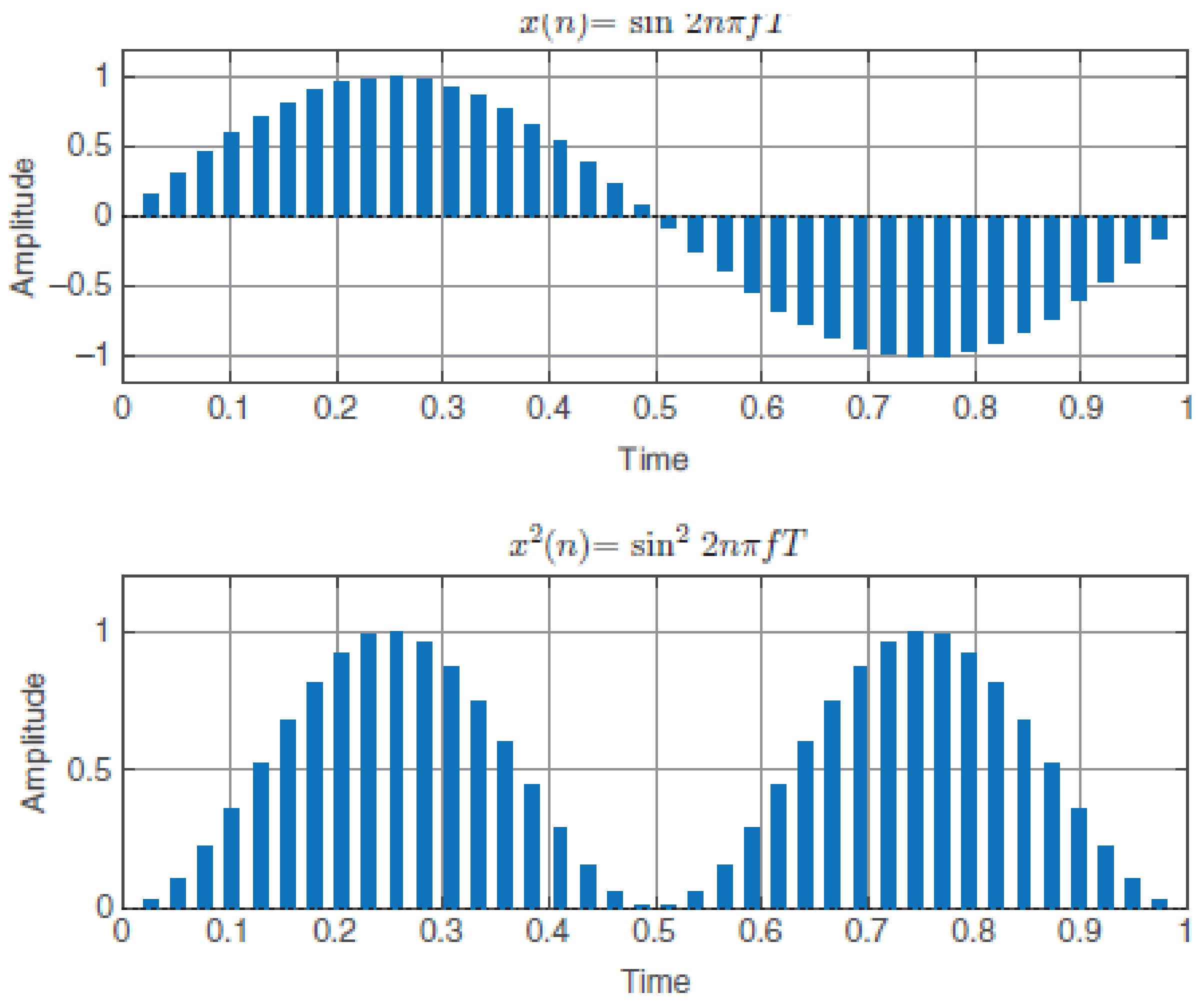
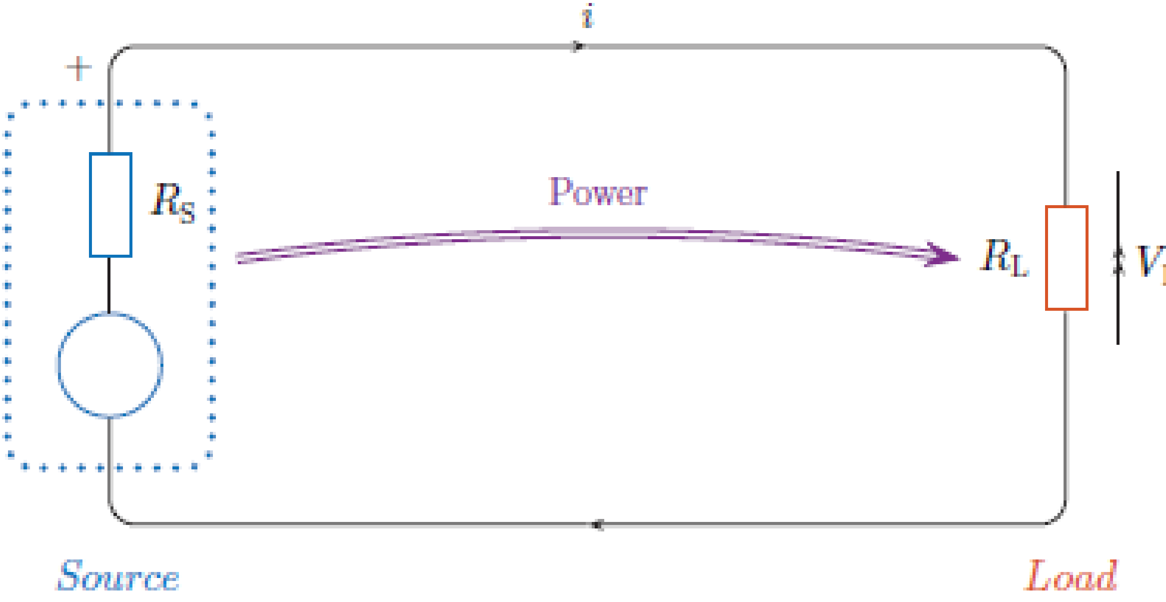



**Figure 1.21** Imagining RMS calculation as a series of bars, with each bar equal to the height of the waveform at that point. The period between samples is *T*, with sample index *n*. The substitution required is then $t = nT$.

# 1.7.2 Desibel (dB)

- Haberleşmede sıkça karşımıza çıkar
  - Büyüklük ve güç
- Güç:$P_{dB} = 10\log_{10}\left(\frac{P}{P_{ref}}\right)$
  - dBW:
  - dBm:
  - Ör: 1mW güç, 50 Ohm anten
  - 2 kat:
  - 4 kat:
- Büyüklük: $P_{dB} = 10\log_{10}\left(\frac{P}{P_{ref}}\right) =$
  - Filtre kazancı (ELE 202)

# 1.7.3 Maksimum Güç Transferi




- $R_s$: Kaynak direnci
- $R_L$: Yük direnci (ör. anten)
- $V_s$: Kaynaktaki gerilim
- $V_L$: Yükteki gerilim

- $P_L$: Yüke aktarılan güç

```
% parameters of the simulation
Vsrc = 1;
Rsrc = 0.8;
% load resistance range
Rload = linspace(0,4,1000);
% equations
Req = Rsrc + Rload ;
i = Vsrc./Req;
Pload=(i.*i).*Rload ;
% pl o t t i n g
plot(Rload,Pload);
xlabel('Load Resistance R_{load}')
ylabel('Power Transferred P_{load}')
```

# 1.8 Gürültü

- Termal gürültü (ısınan elektronların hareketi)
- Atmosferik gürültü (uydu)
- Jammer
- Termal Gürültü gücü: $\mathcal{N} = kTB$
- Sinyal Gürültü oranı (SGO, SNR)
  - ..
  - dB…
- Noise ratio (F)
- Noise Figure

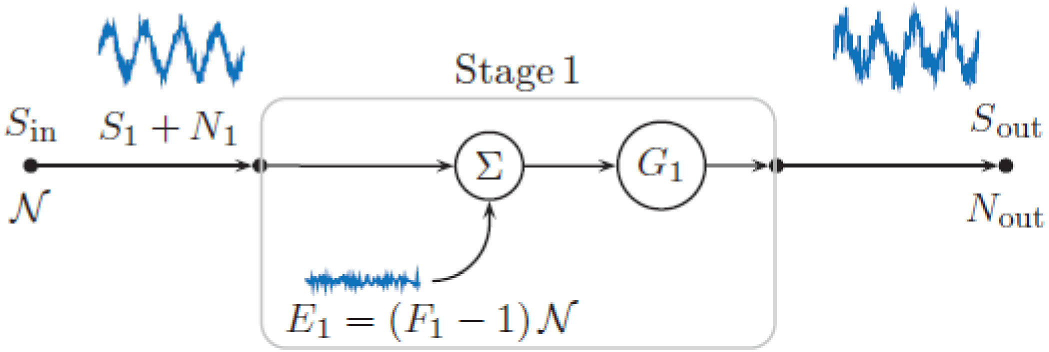



**Figure 1.24** Modeling the noise transfer of a system. The noise at the input of the first block is $\mathcal{N} = N_1$, and this is used as a "noise reference" when subsequent blocks are added after the first. The quantity $E$ is the excess noise added by the stage.

# Noise figure

# 1.8 Kaskat Sistemlerde Gürültü

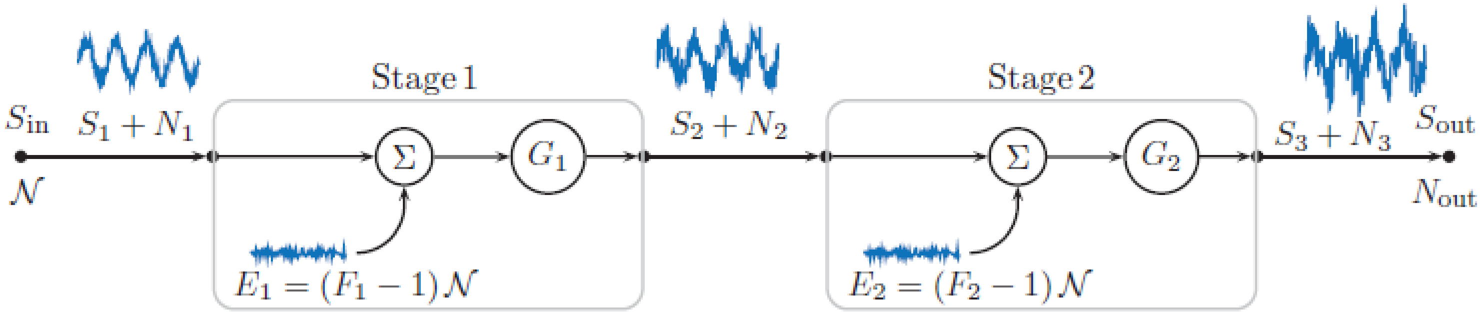


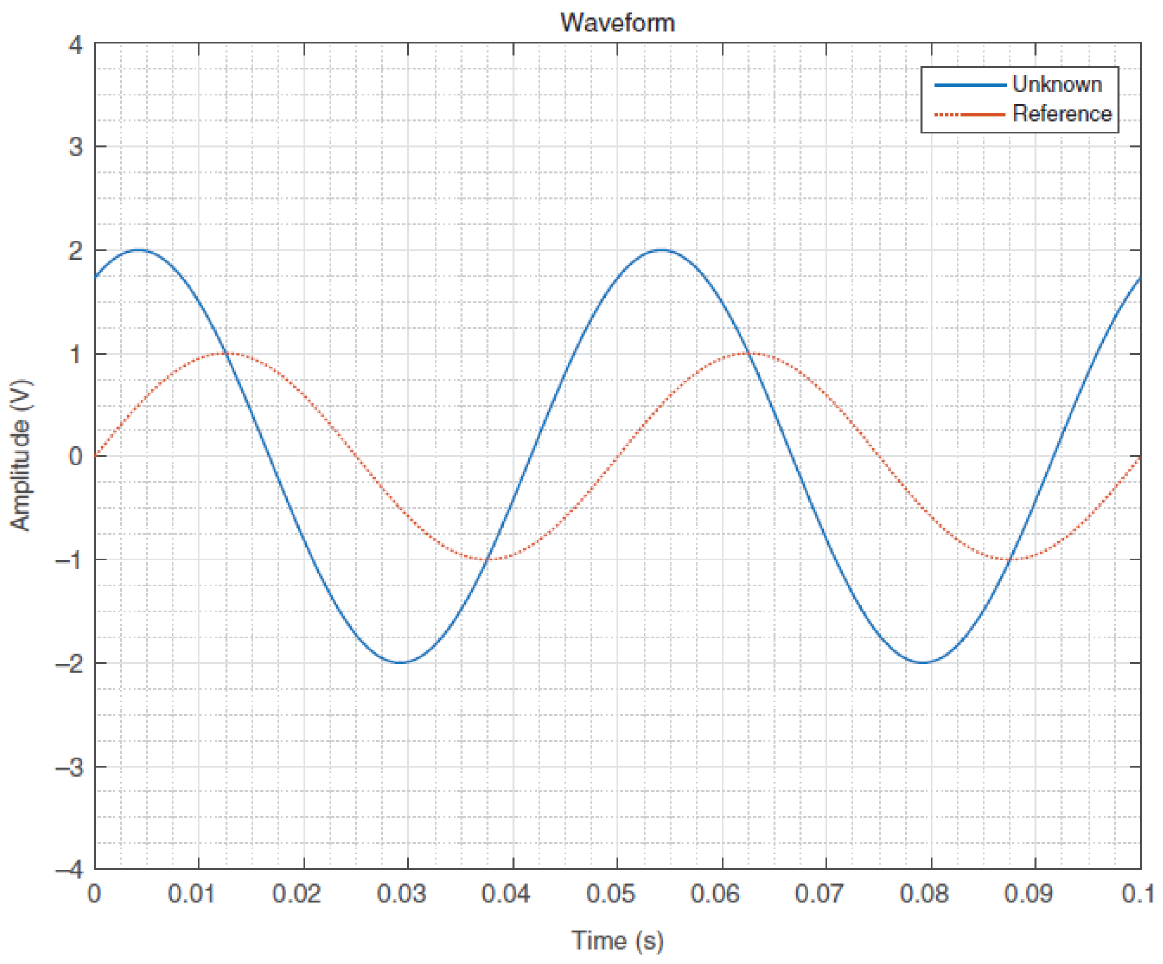

**Figure 1.25** Analysis of two systems in cascade. The *E* values refer to the hypothetical noise added if referred back to the input of the first stage, whose noise is $\mathcal{N}$.

- $F_{12} = F_1 + \frac{F_2 - 1}{G_1}$

**1.1** The decibel requires the calculation $10\log_{10}\left(\frac{P_{out}}{P_{in}}\right)$. Using $P = \frac{V^2}{R}$ and assuming $V_{out}$ is the voltage at the output, $V_{in}$ the voltage at the input, and that the impedances of both are R Ω, show that an equivalent calculation is $20\log_{10}\left(\frac{V_{out}}{V_{in}}\right)$.

**1.2** The input to a Radio Frequency (RF) spectrum analyzer states that the input impedance is 50Ω, and that the maximum input power is +10dBm. What would be the maximum safe voltage in that case?

**1.3** A copper communications line has a noise level of 1 mV RMS when a signal of 1 V RMS is observed. What is the SNR?




Determine the parameters (amplitude, phase, and frequency) of the waveform shown in Figure.

**1.6** Given a signal equation and the system transfer function, we can work out the output for both linear and nonlinear systems.

a) Given the system transfer function $y(t) = \alpha\, x(t)$, show that for an input $x(t) = A \sin \omega t$, the output is $y(t) = \alpha\, A \sin \omega t$. Is this system linear?

b) Given the system described by $y(t) = \alpha\, x(t) + \beta x^2(t)$, show that for an input $x(t) = A \sin \omega t$, the output can be simplified to the summation of a constant (or DC) term, a term at the same frequency as the input, and a term at twice the frequency of the input. Is this system linear? *Hint: You may need the trigonometric identity* $\sin^2\theta = (1/2)(1 - \cos 2\theta)$.

c) From the above results, can you infer what might happen if you had cubic-form transfer function, such as $y(t) = \gamma x^3(t)$?

**1.9** Many concepts in telecommunications deal with very large or very small signals or cover a very wide range of values. In these cases, a *logarithmic* scale is useful rather than the usual linear scale. A good example is the decibel for measuring power. Suppose the frequency response of a certain system is defined by a function $g(f) = 1/(f + 1)$.

a) Explain what is deficient in the following approach, and suggest a better way.

```
f = 0.01:1:100;
g = 1./(f + 1);
plot(f, g, 's-');
set(gca, 'xscale', 'log');
grid('on');
```

b) Noting that the exponents of 10 on the frequency axis go from −2 to +2, change the code to

```
r = -2:0.04:2;
f = 10.^r;
g = 1./(f + 1);
plot(f, g, 's-');
set(gca, 'xscale', 'log');
grid('on');
```

Why does this give a proportional spacing of the data points, and hence a better plot?

c) Investigate the difference between the MATLAB functions `linspace()` and `logspace()` and briefly comment on why they are useful.

**1.10** An amplifier has an SNR of 50 dB and Noise Figure of 3 dB. Determine the output SNR.

**1.11** This question investigates the extension to two-stage systems as shown in Figure 1.25, in order to find an expression for the cascaded noise figure.

a) Draw a block diagram for this system, labeling all the "useful" signals and the unwanted noise signals.
b) Show mathematically that the noise factor for a three-stage system is

$$F = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 G_2}$$