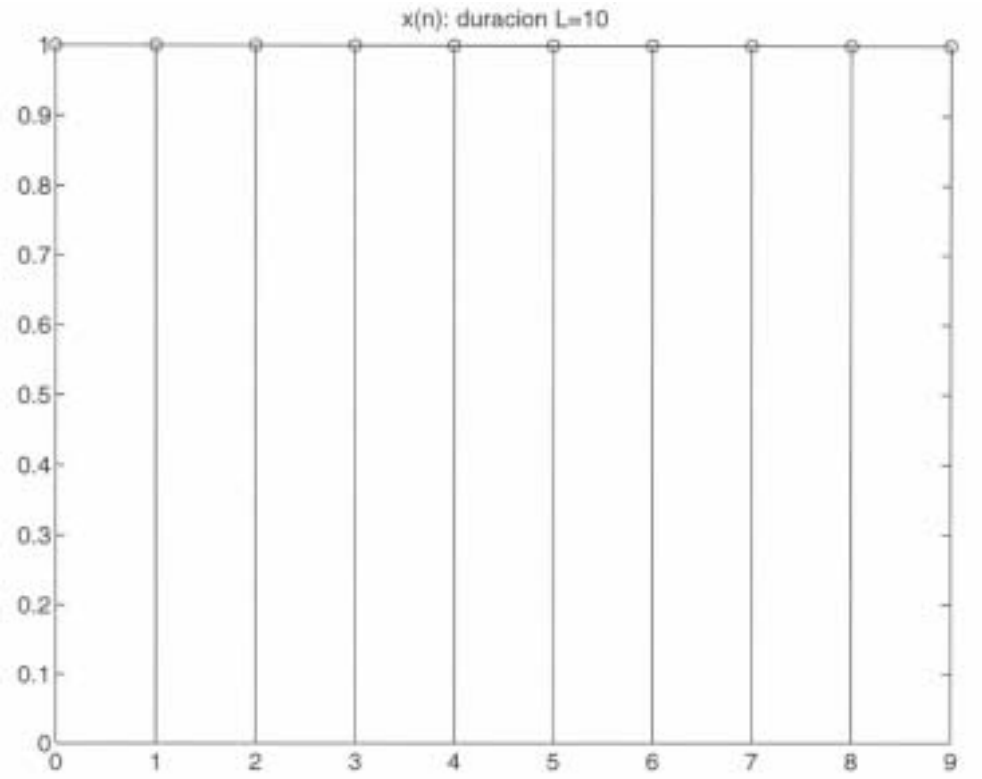
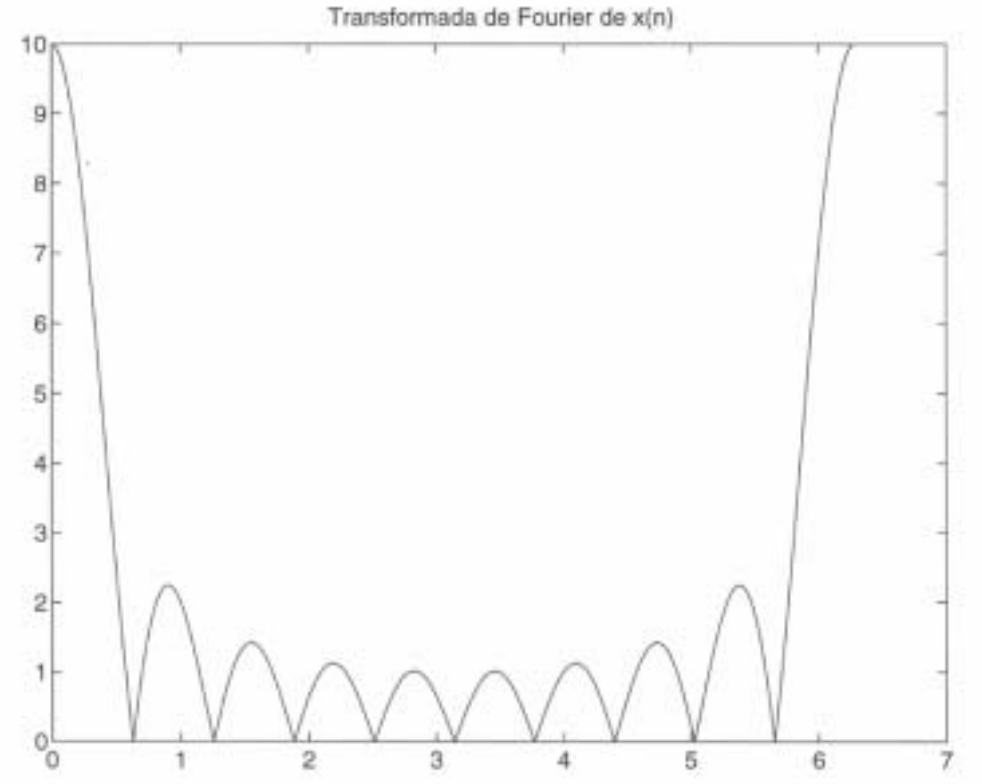
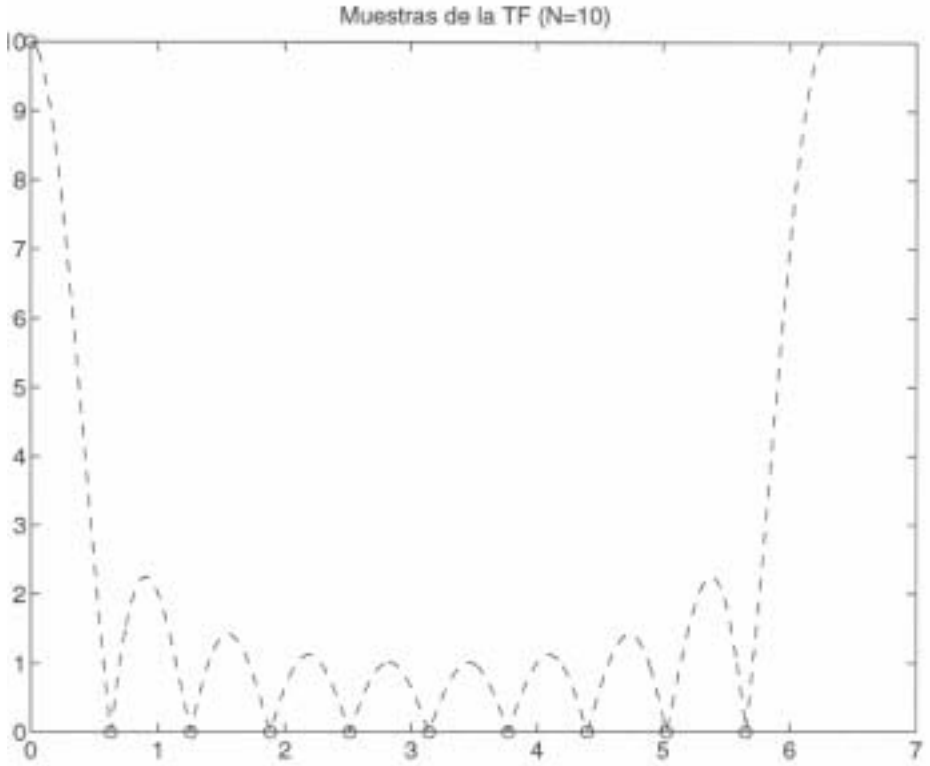
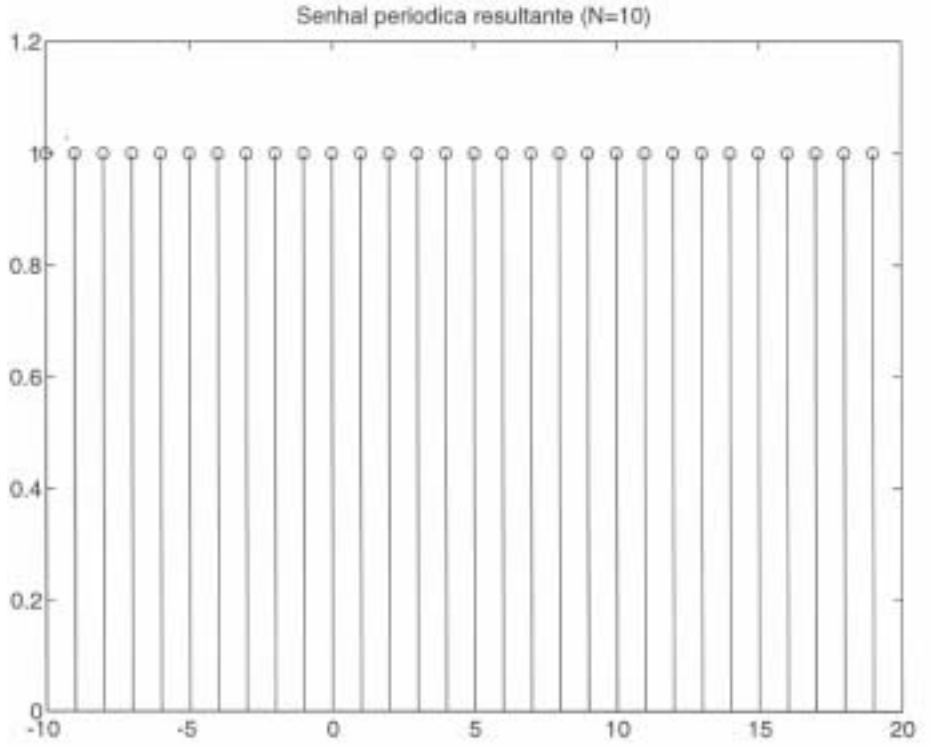
Tratamiento Digital de la Señal

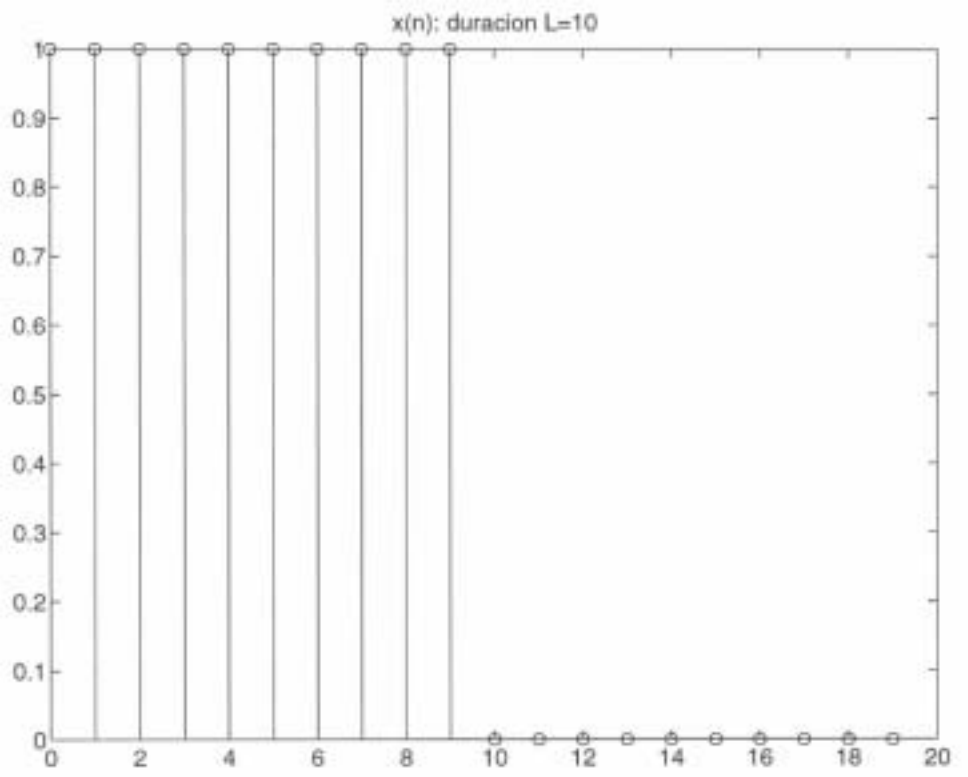
Tema 3

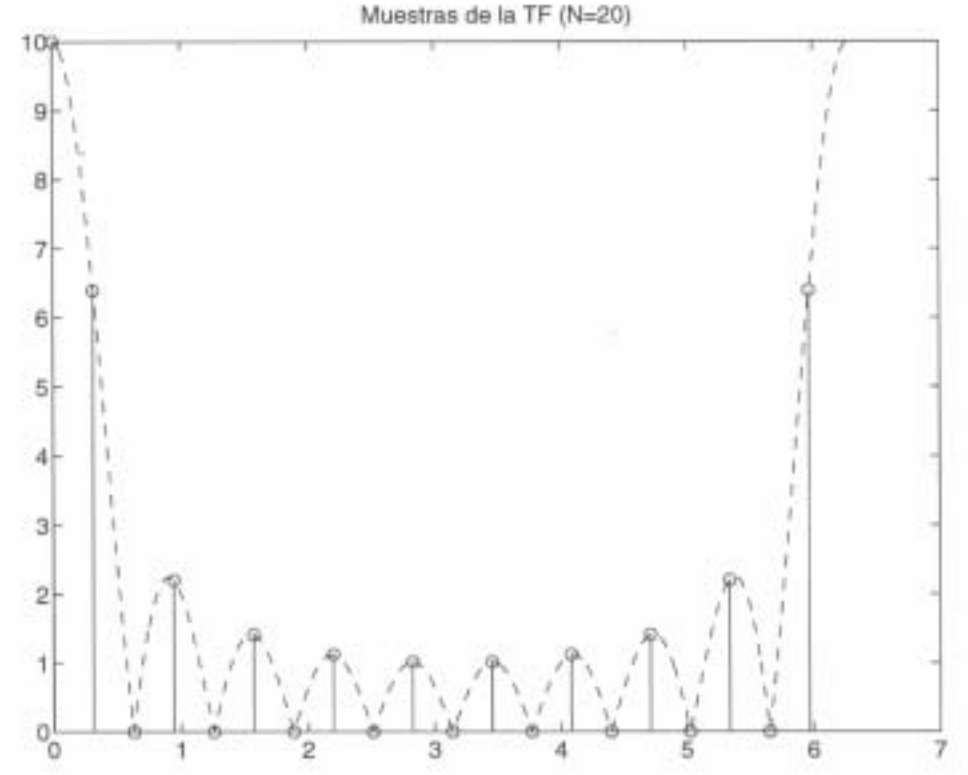

x(n): duracion L=10
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
1
2
3
4
5
6
7
8
9

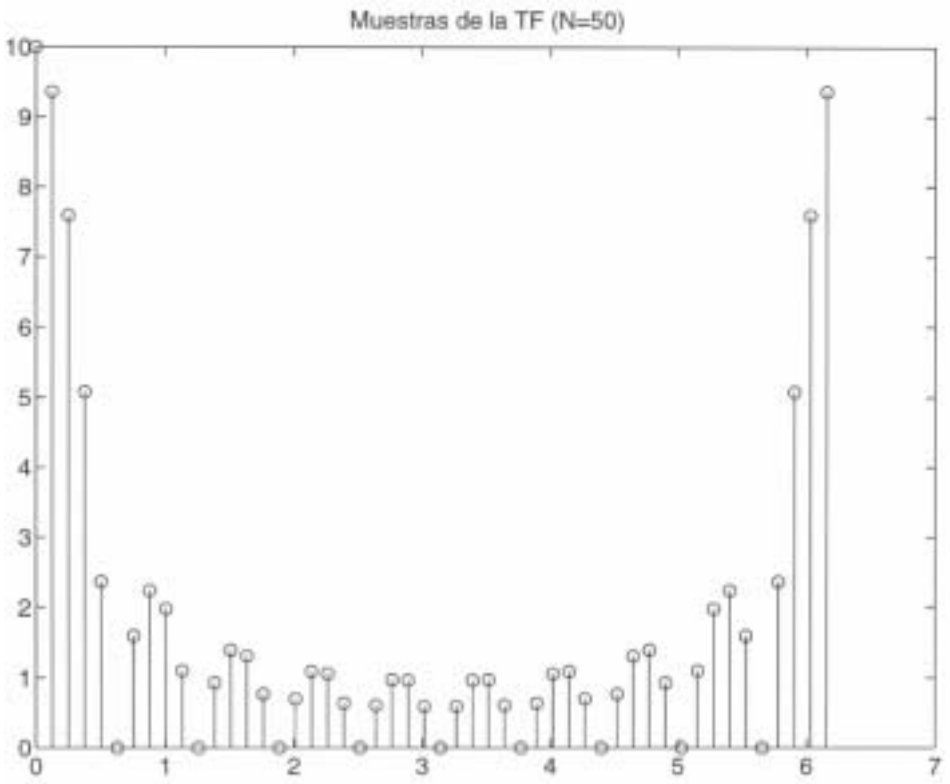

Transformada de Fourier de x(n)
10
9
8
7
6
5
4
3
2
1
0
0
1
2
3
4
5
6
7

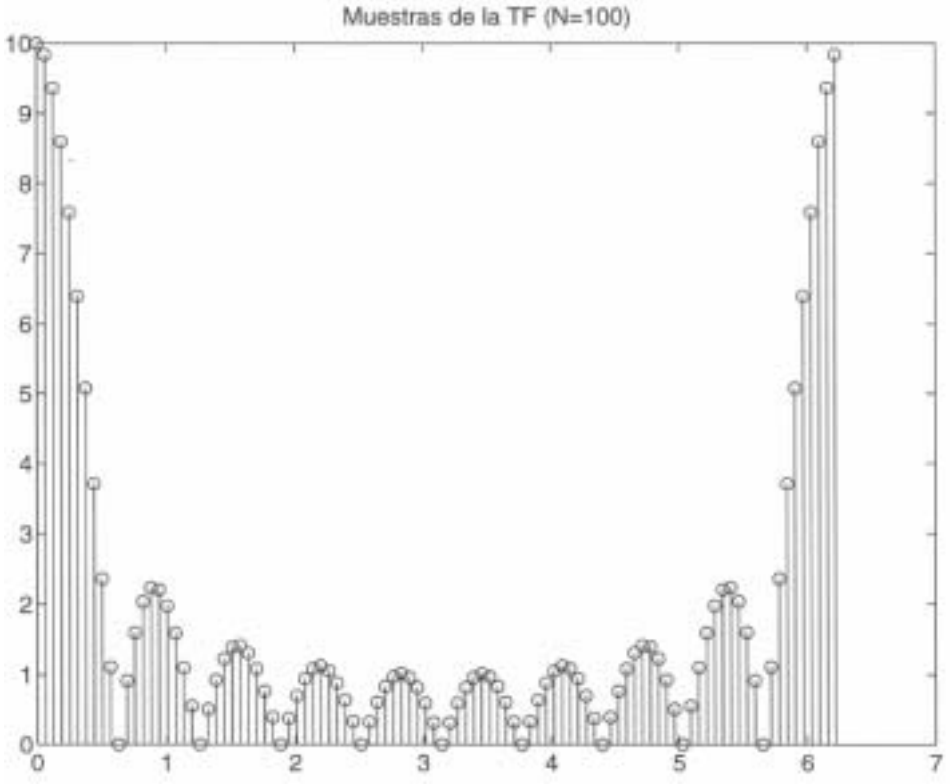

Muestras de la TF (N=10)
10
9
8
7
6
5
4
3
2
1
0
0
1
2
3
4
5
6
7


Senhal periodica resultante (N=10)
1.2
1
0.8
0.6
0.4
0.2
0
-10
-5
0
5
10
15
20


x(n): duracion L=10
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2
4
6
8
10
12
14
16
18
20


Muestras de la TF (N=20)
10
9
8
7
6
5
4
3
2
1
0
0
1
2
3
4
5
6
7


Muestras de la TF (N=50)
10
9
8
7
6
5
4
3
2
1
0
0
1
2
3
4
5
6
7


Muestras de la TF (N=100)
10
9
8
7
6
5
4
3
2
1
0
0
1
2
3
4
5
6
7

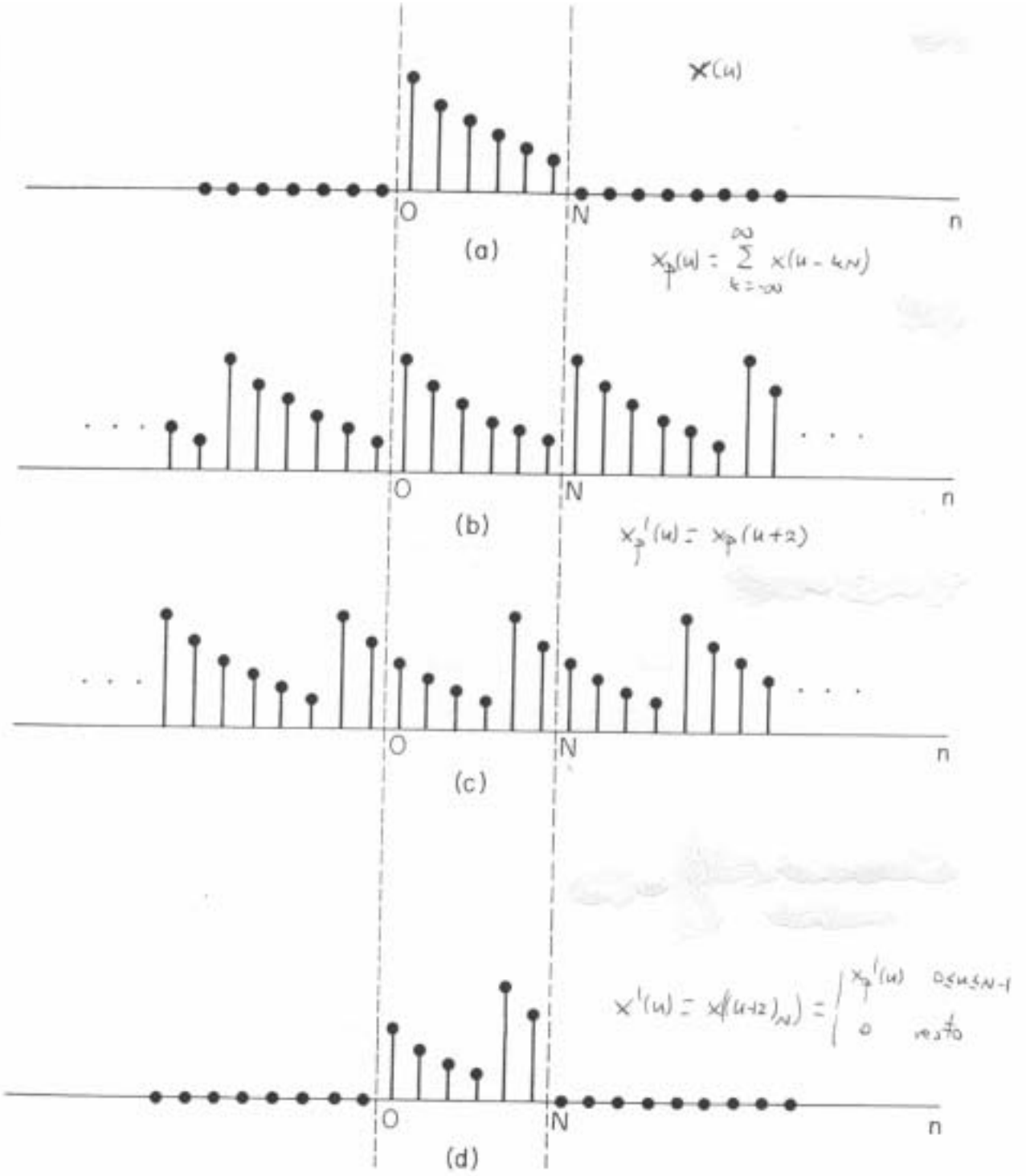


Figure 8.12 Circular shift of a finite-length sequence; i.e., the effect in the time domain of multiplying the DFT of the sequence by a linear ph

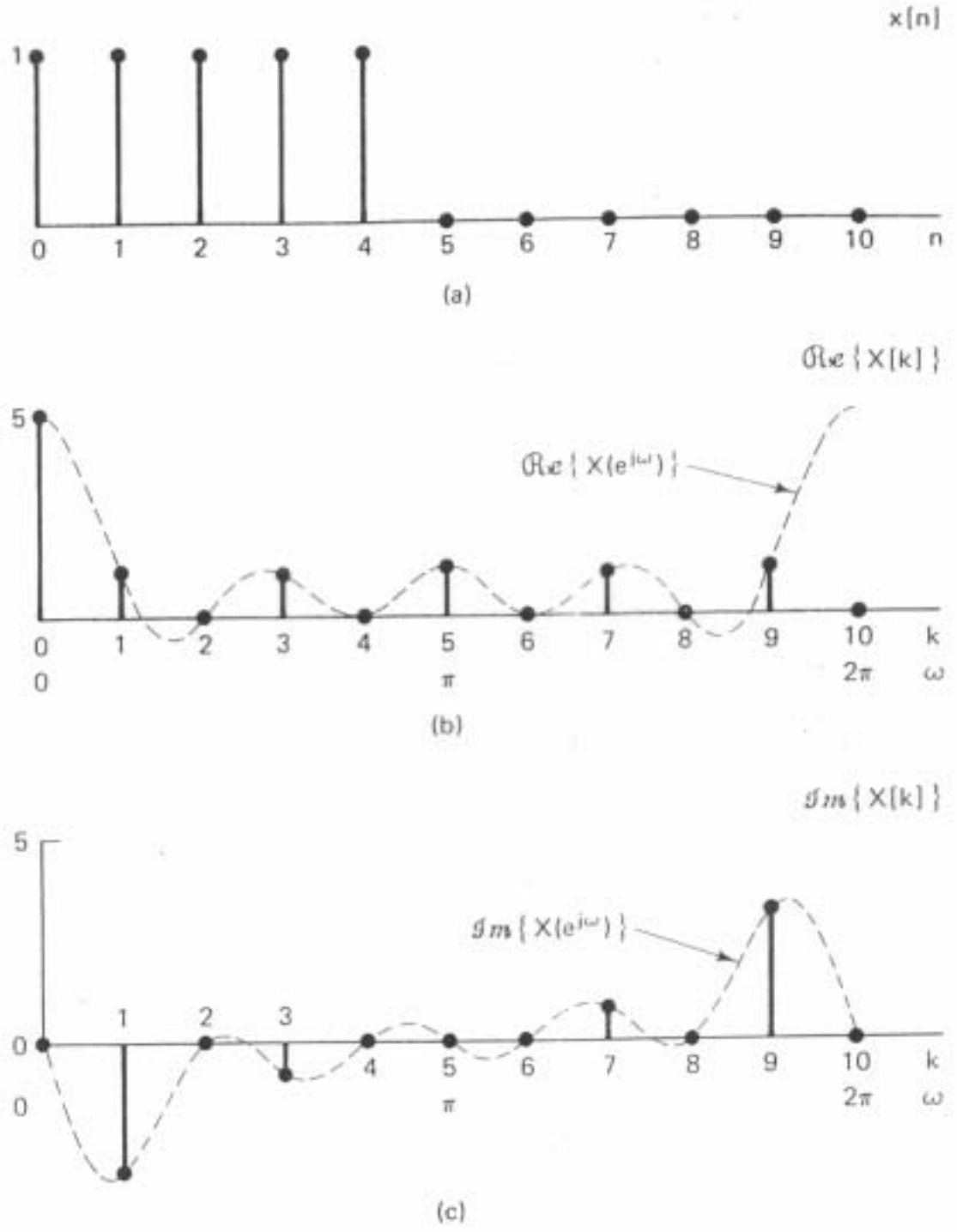


Figure 8.13 (continued) (d) and (e) The real and imaginary parts of the dual sequence $x_1[n] = X[n]$. (f) The DFT of $x_1[n]$.

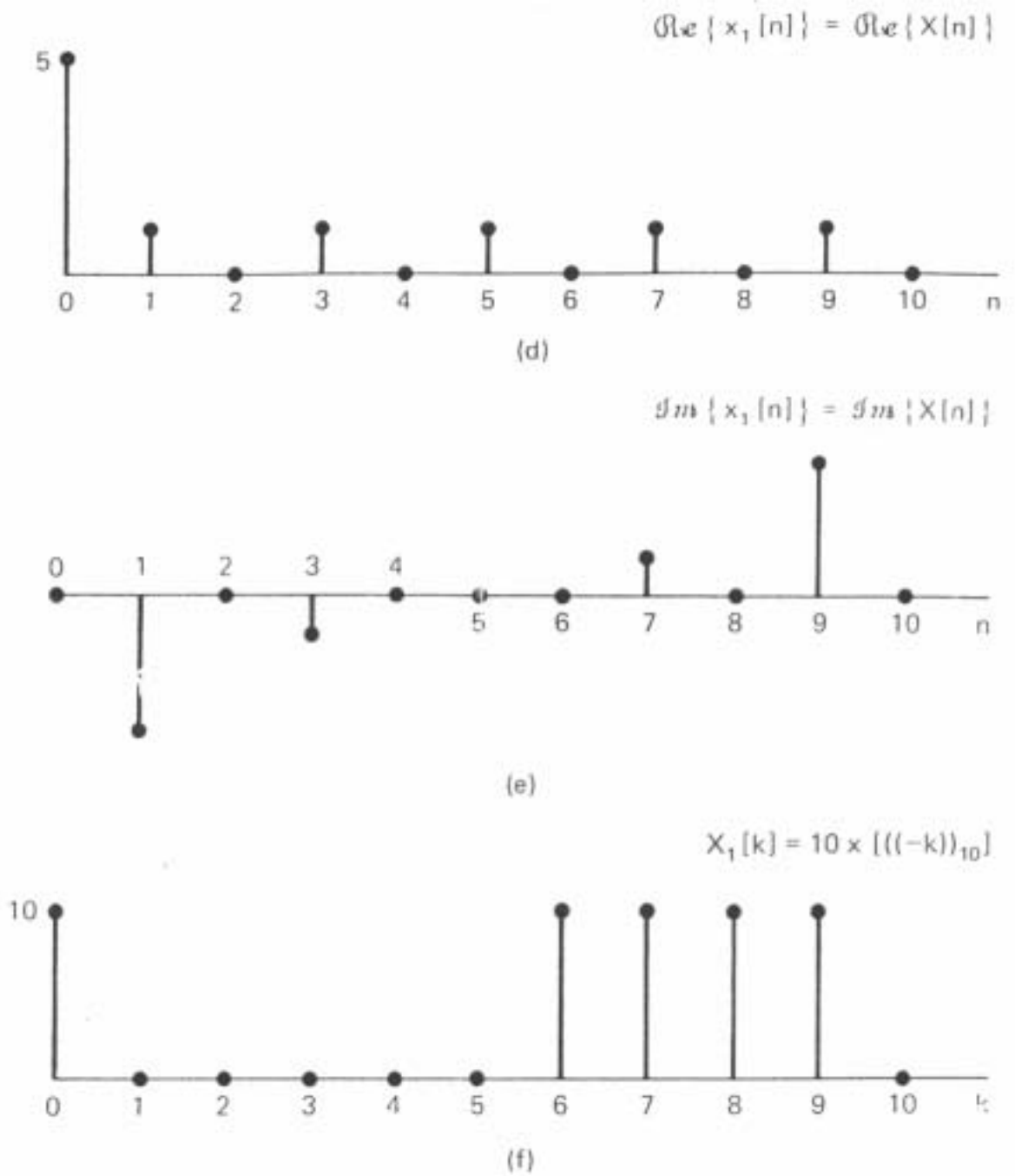


Figure 8.13 (*continued*) (d) and (e) The real and imaginary parts of the dual sequence $x_1[n] = X[n]$. (f) The DFT of $x_1[n]$.

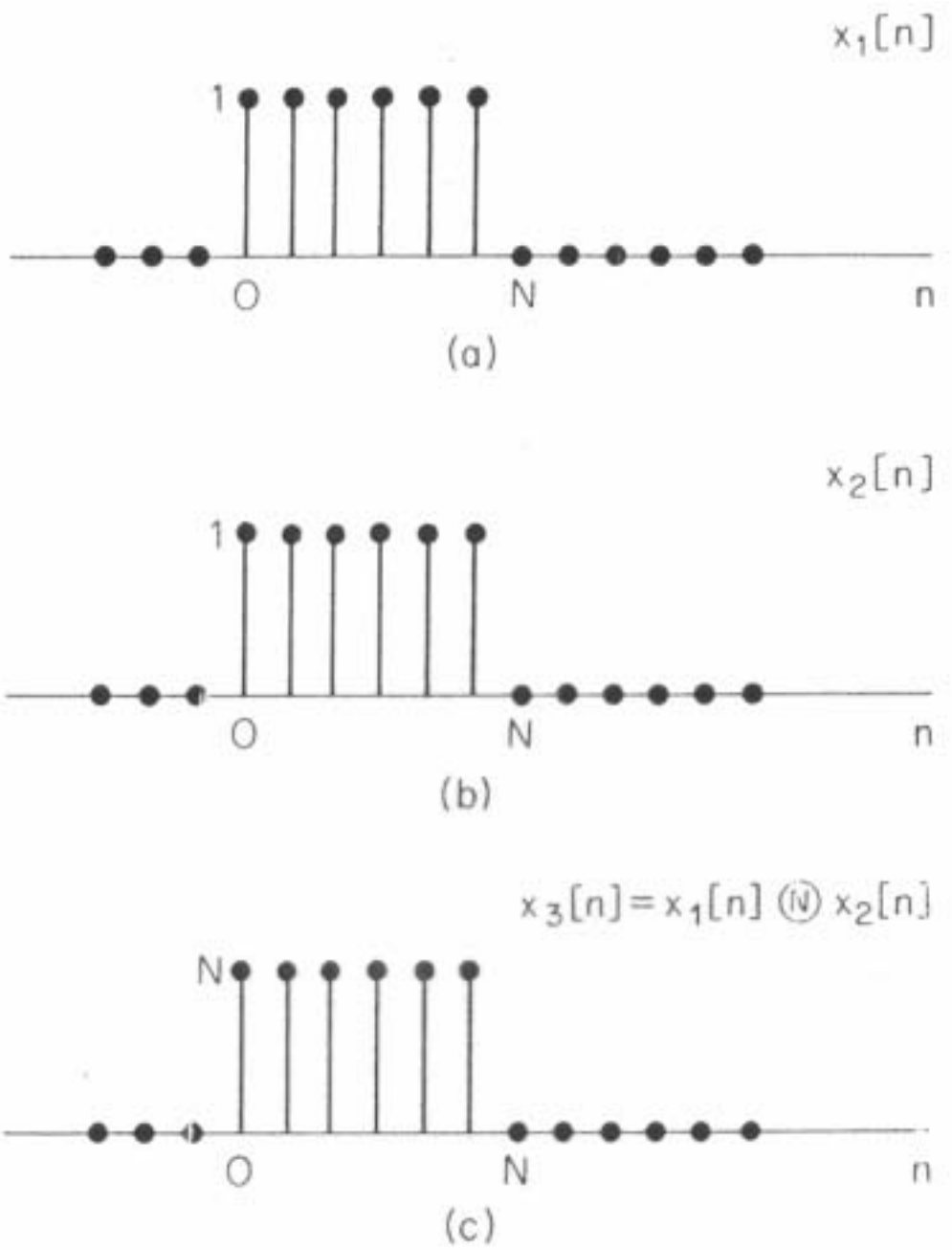


Figure 8.15 *N*-point circular convolution of two constant sequences of length *N*.

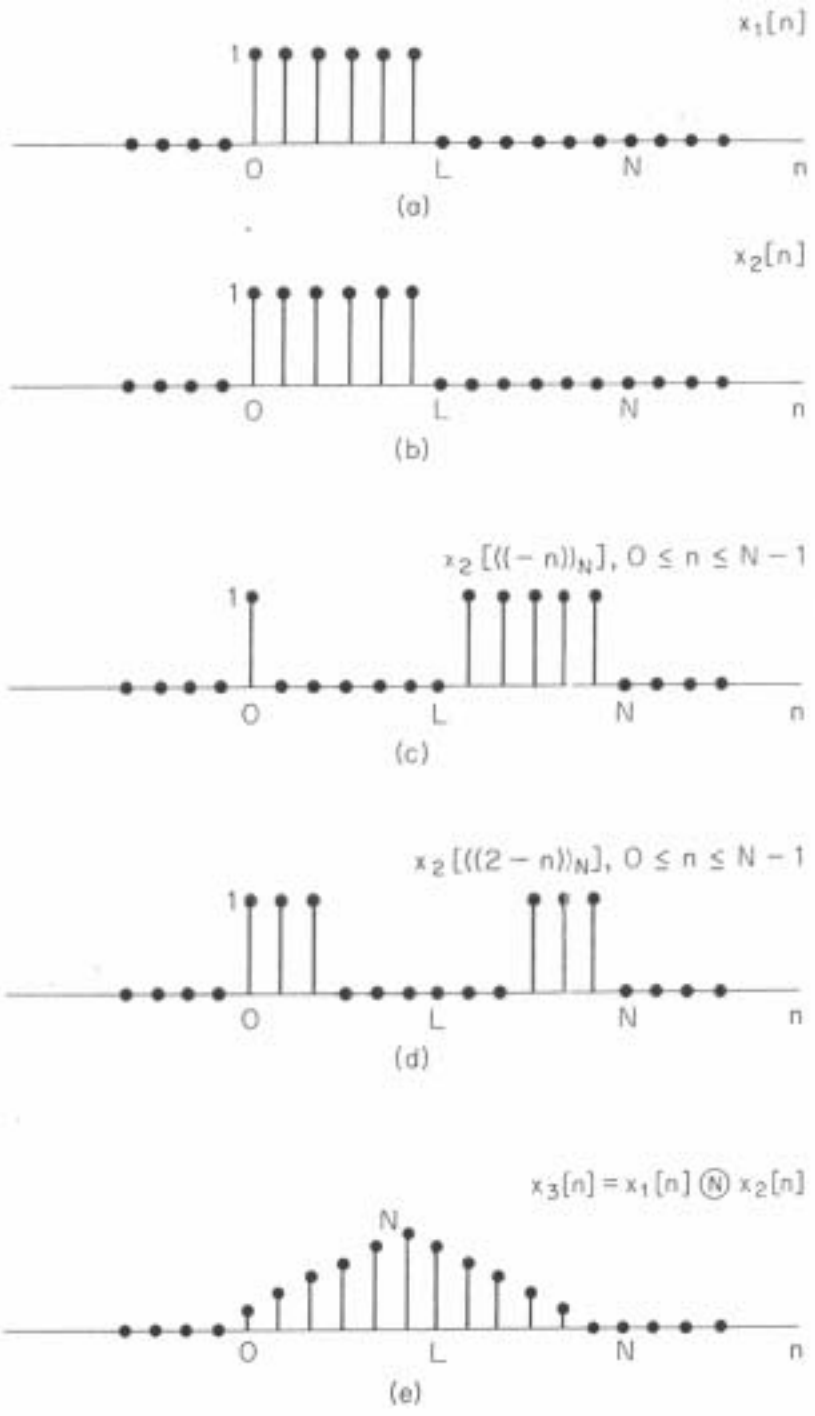
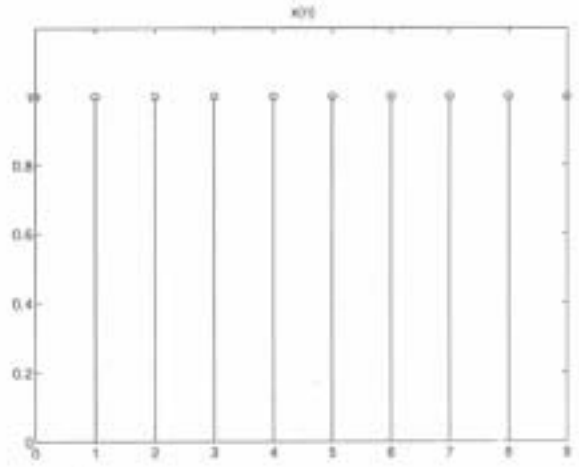
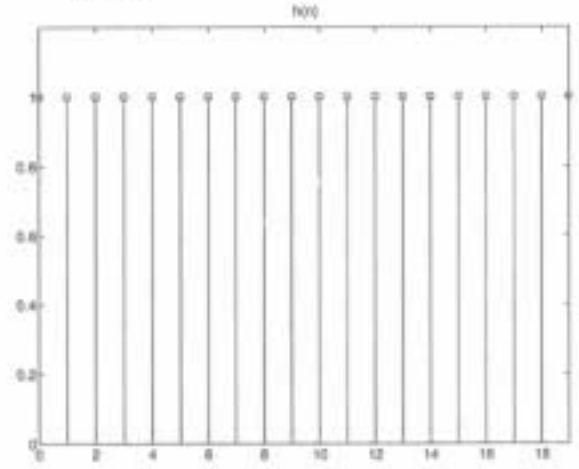


Figure 8.16 $2L$-point circular convolution of two constant sequences of length L.

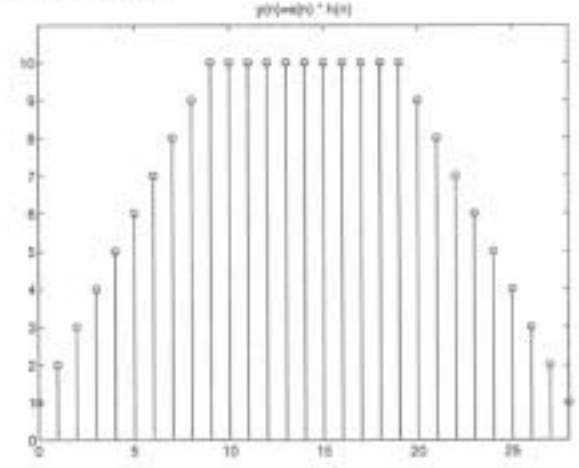
$x(n)$



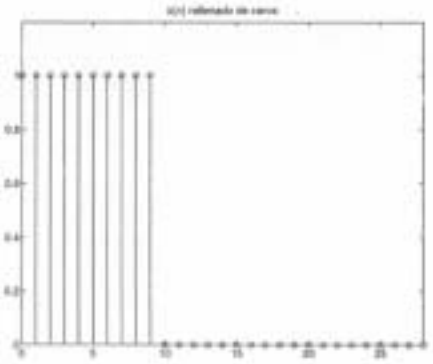
$h(n)$



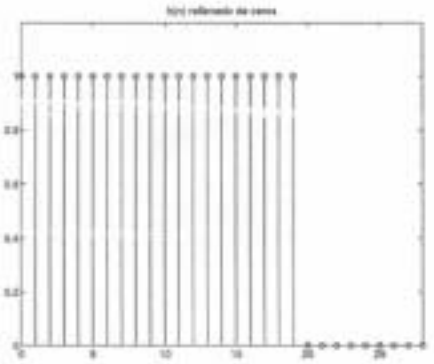
$y(n) = x(n) * h(n)$



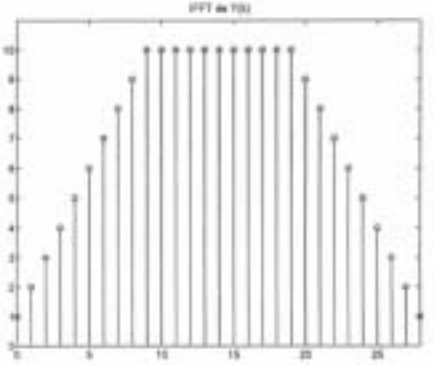
x(n)



h(n)



y(n)



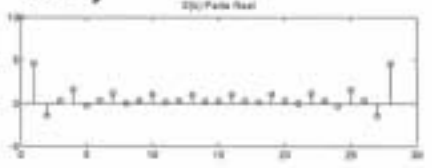
DFT

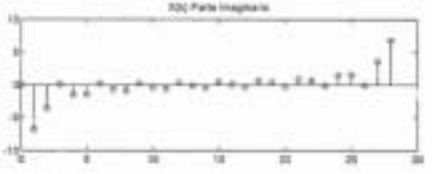
DFT

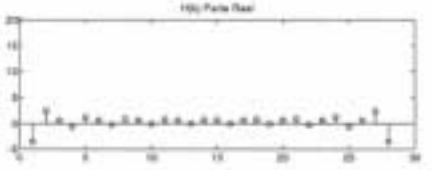
H(k)

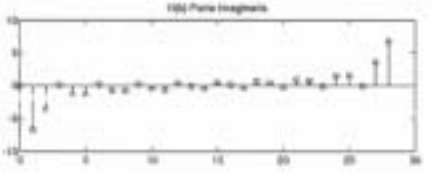
IDFT

X(k)

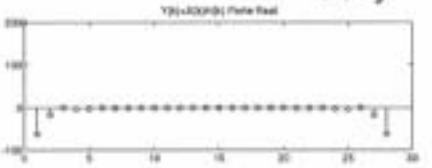


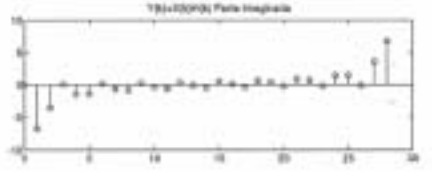






Y(k)





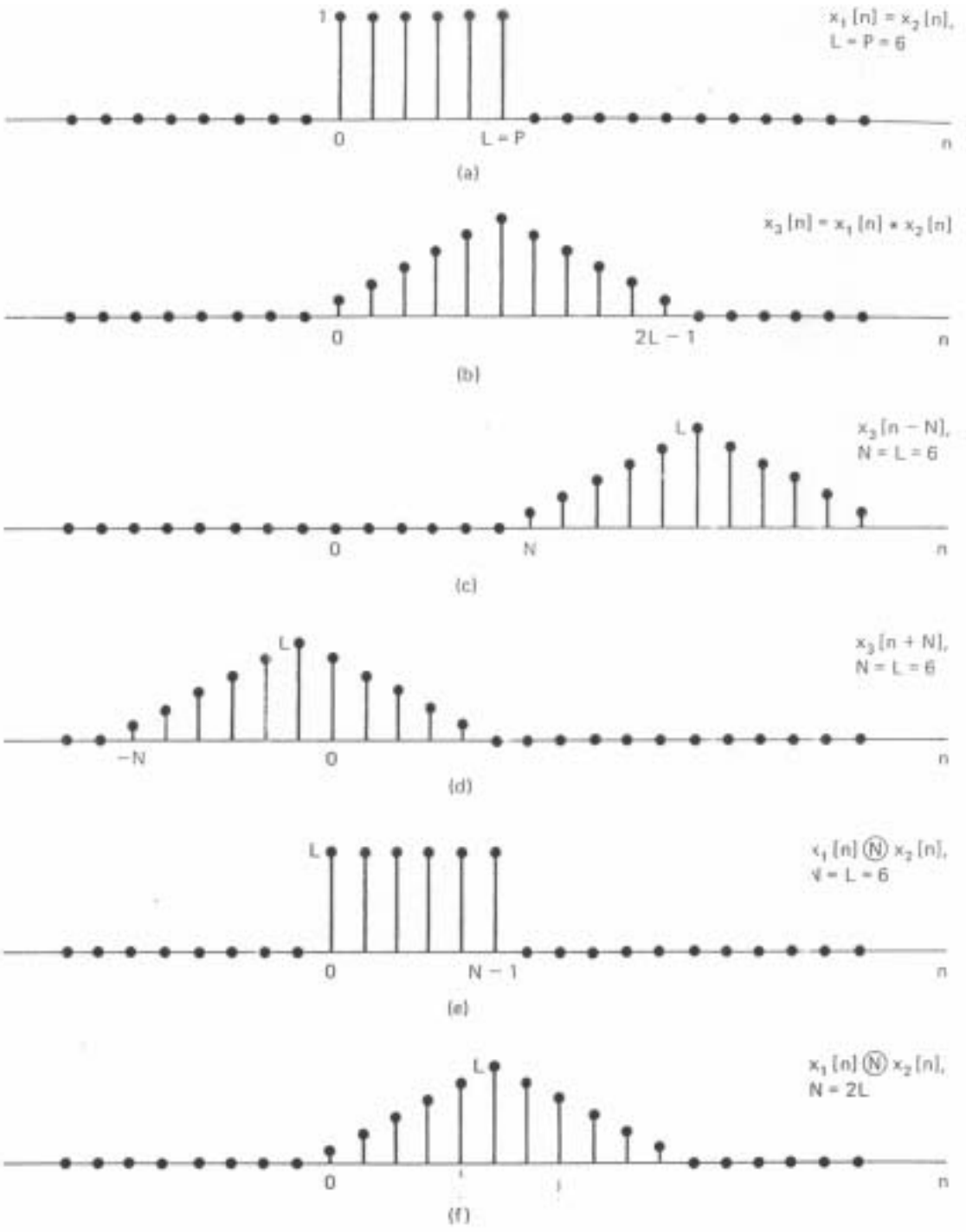
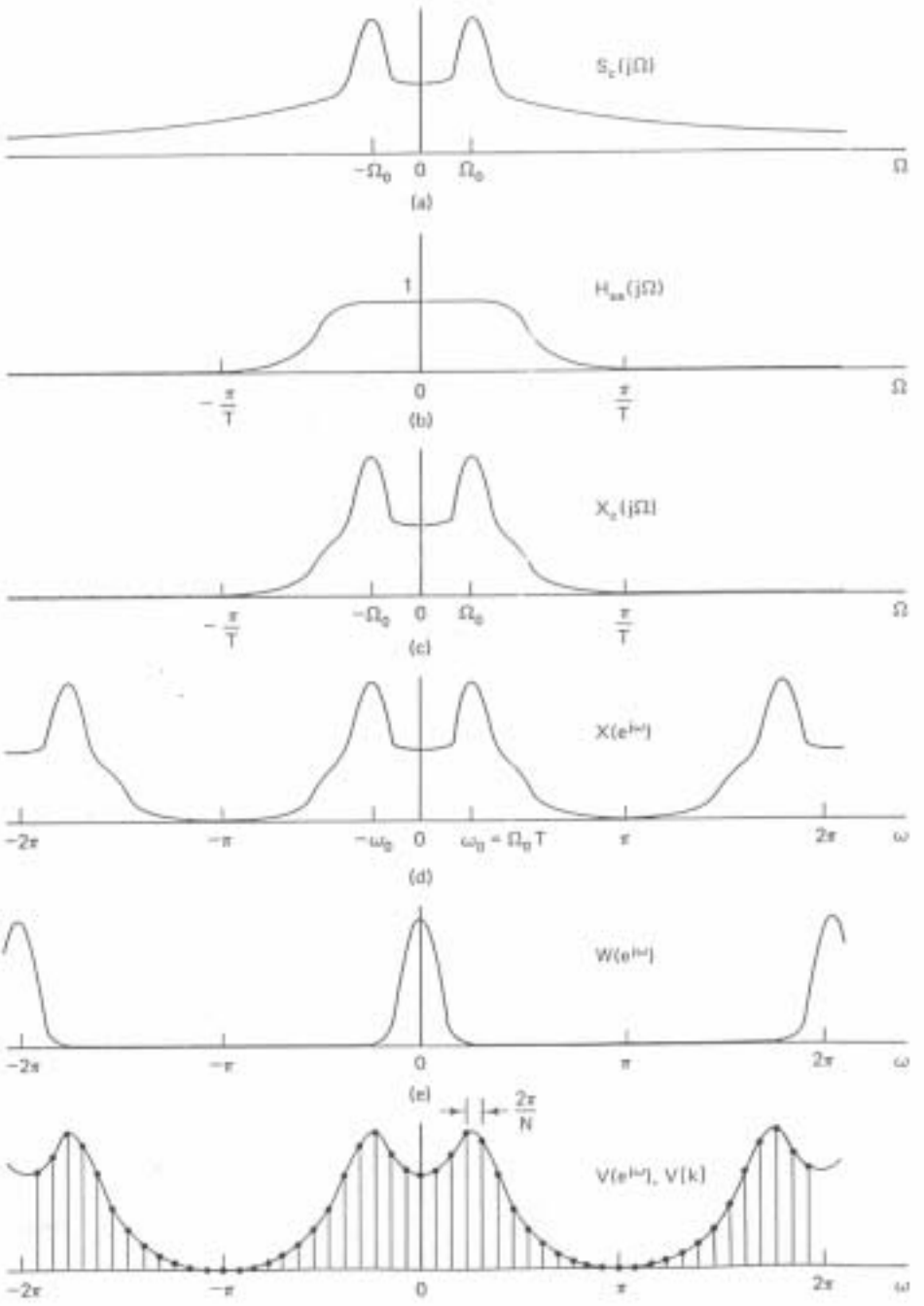


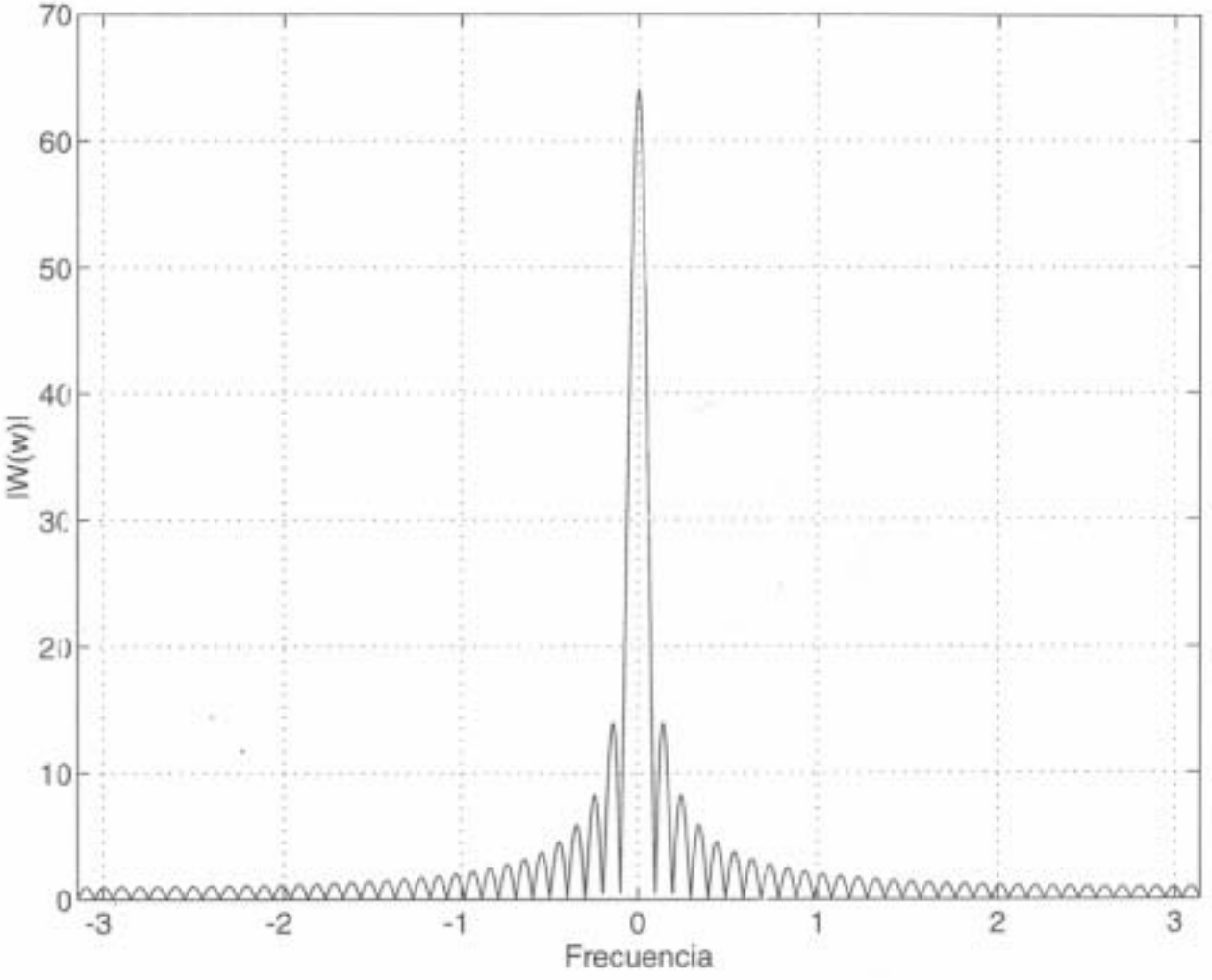
Figure 8.18 Illustration that circular convolution is equivalent to linear convolution followed by aliasing. (a) The sequences $x_1[n]$ and $x_2[n]$ to be convolved. (b) The linear convolution of $x_1[n]$ and $x_2[n]$. (c) $x_3[n - N]$ for $N = 6$. (d) $x_3[n + N]$ for $N = 6$. (e) $x_1[n]$ ⑥ $x_2[n]$, which is equal to the sum of (b), (c), and (d) in the interval $0 \le n \le 5$. (f) $x_1[n]$ ⑫ $x_2[n]$.

Figure 11.1 Processing steps in the discrete-time Fourier analysis of a continuous-time signal.

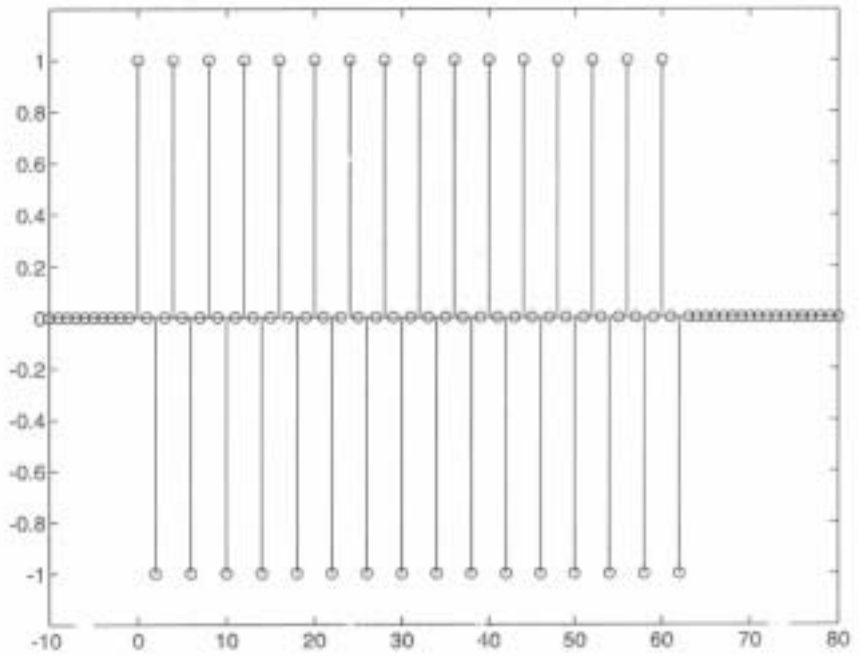


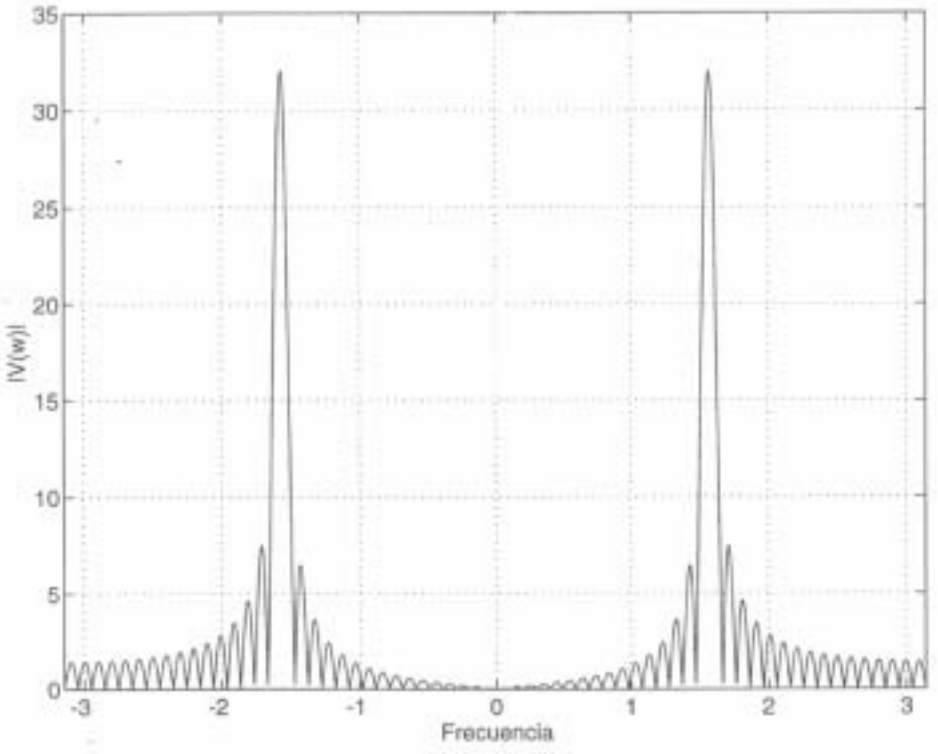
Ventana Rectangular L=64

$$|W(e^{j\omega})| = \frac{sen(\omega L/2)}{sen(\omega/2)}$$

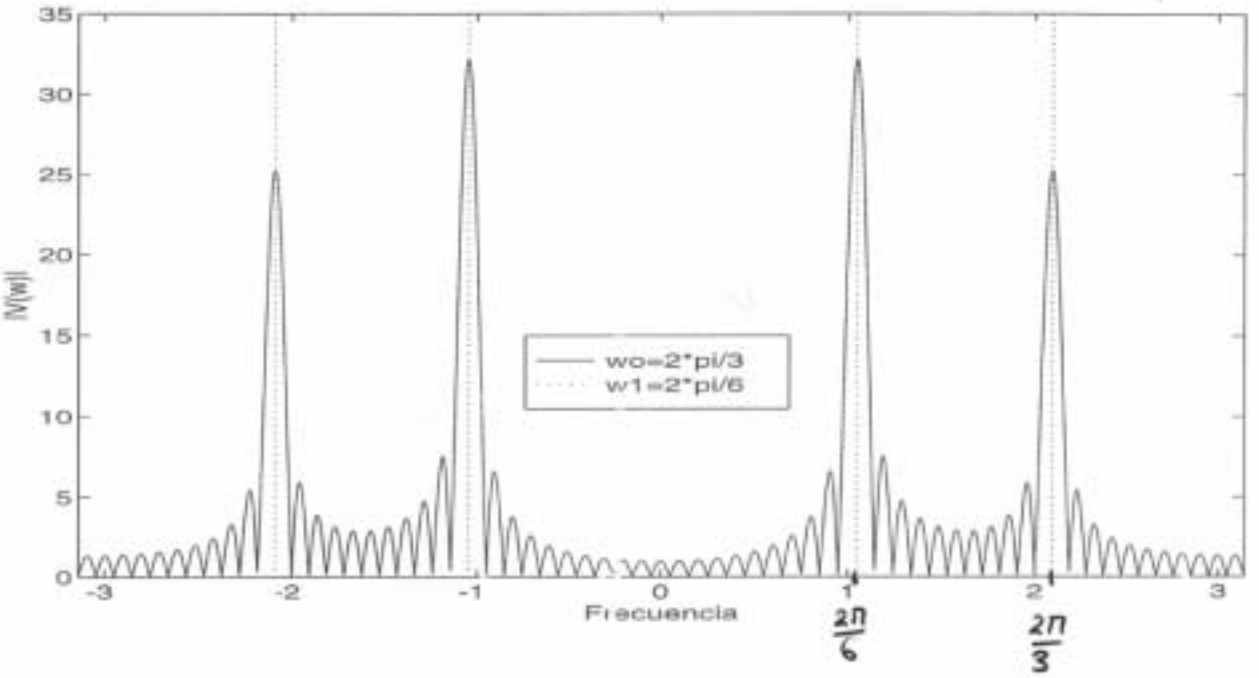


$$x(n) = cos\left(\frac{\pi}{2}n\right) \qquad n = 0, \cdots, 63$$

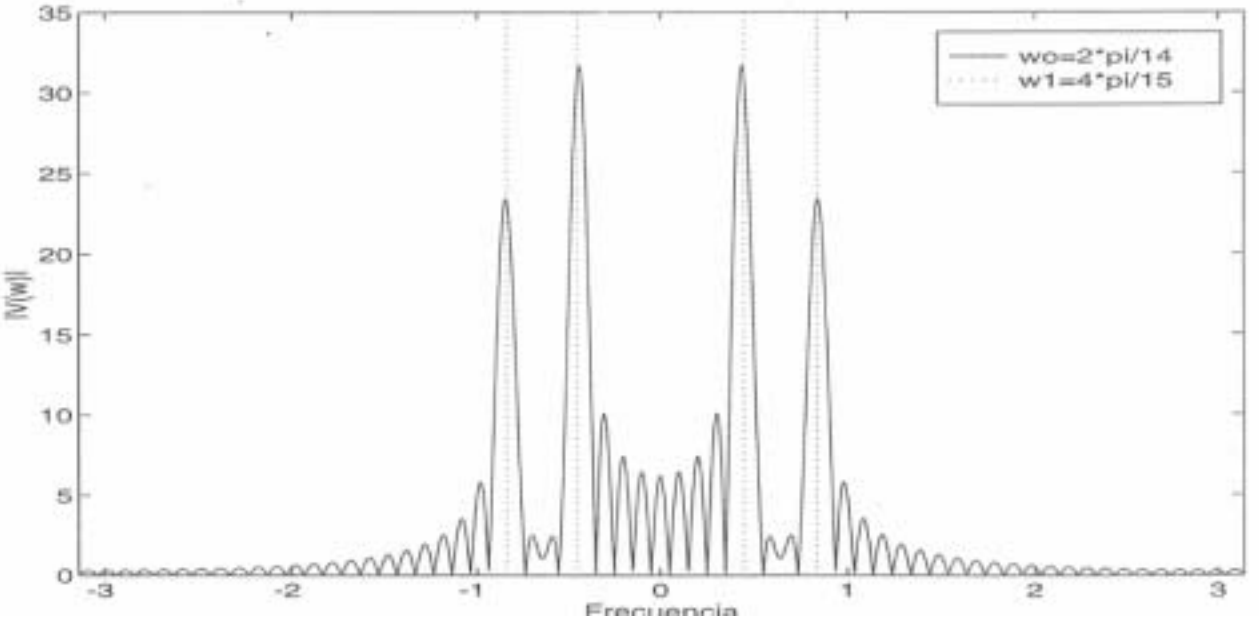




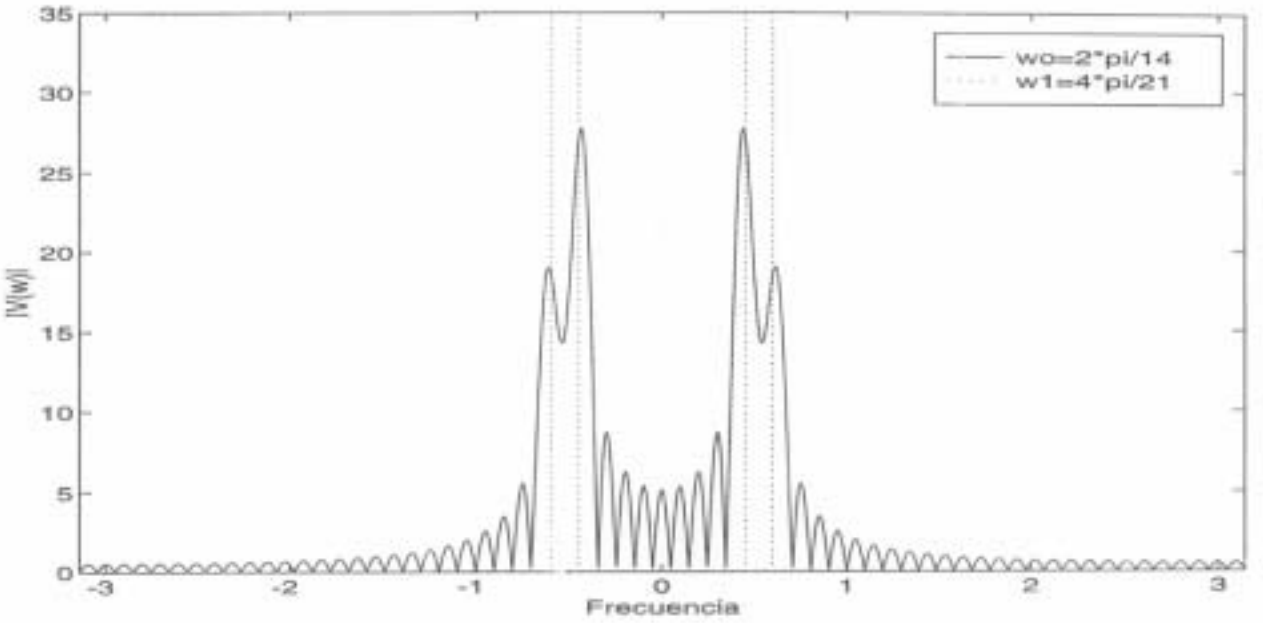
$$\omega_0 = \frac{2\pi}{3} \qquad \omega_1 = \frac{2\pi}{6}$$



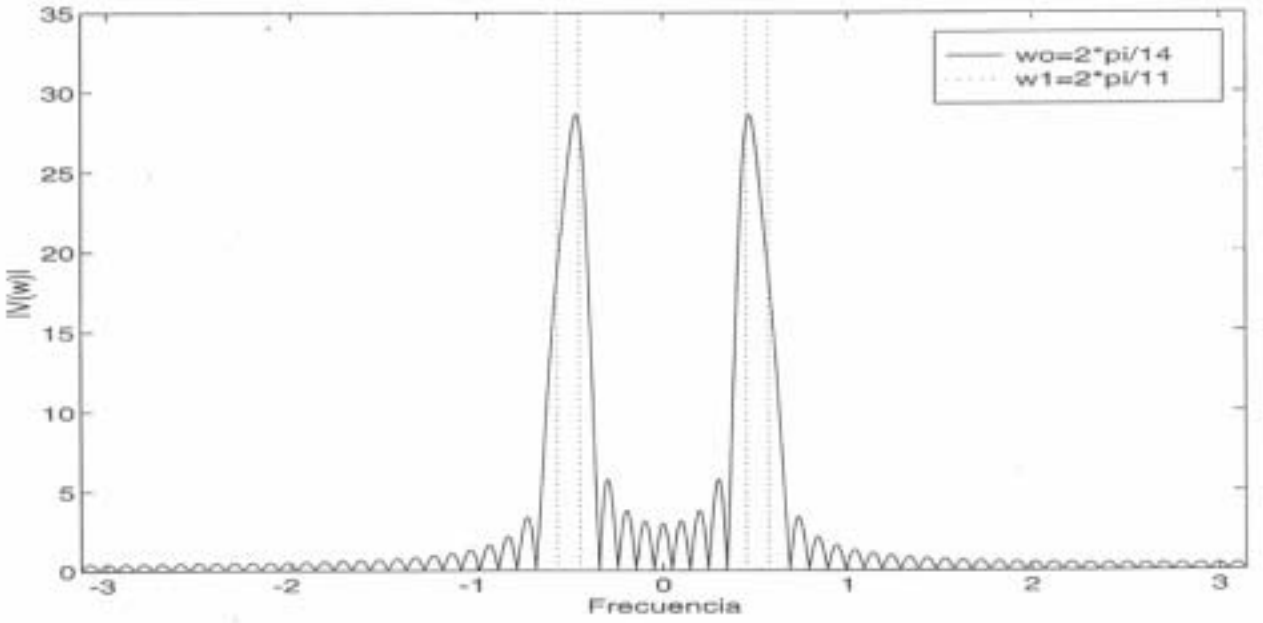
$$\omega_0 = \frac{2\pi}{14} \qquad \omega_1 = \frac{4\pi}{15}$$



$$\omega_0 = \frac{2\pi}{14} \qquad \omega_1 = \frac{4\pi}{21}$$

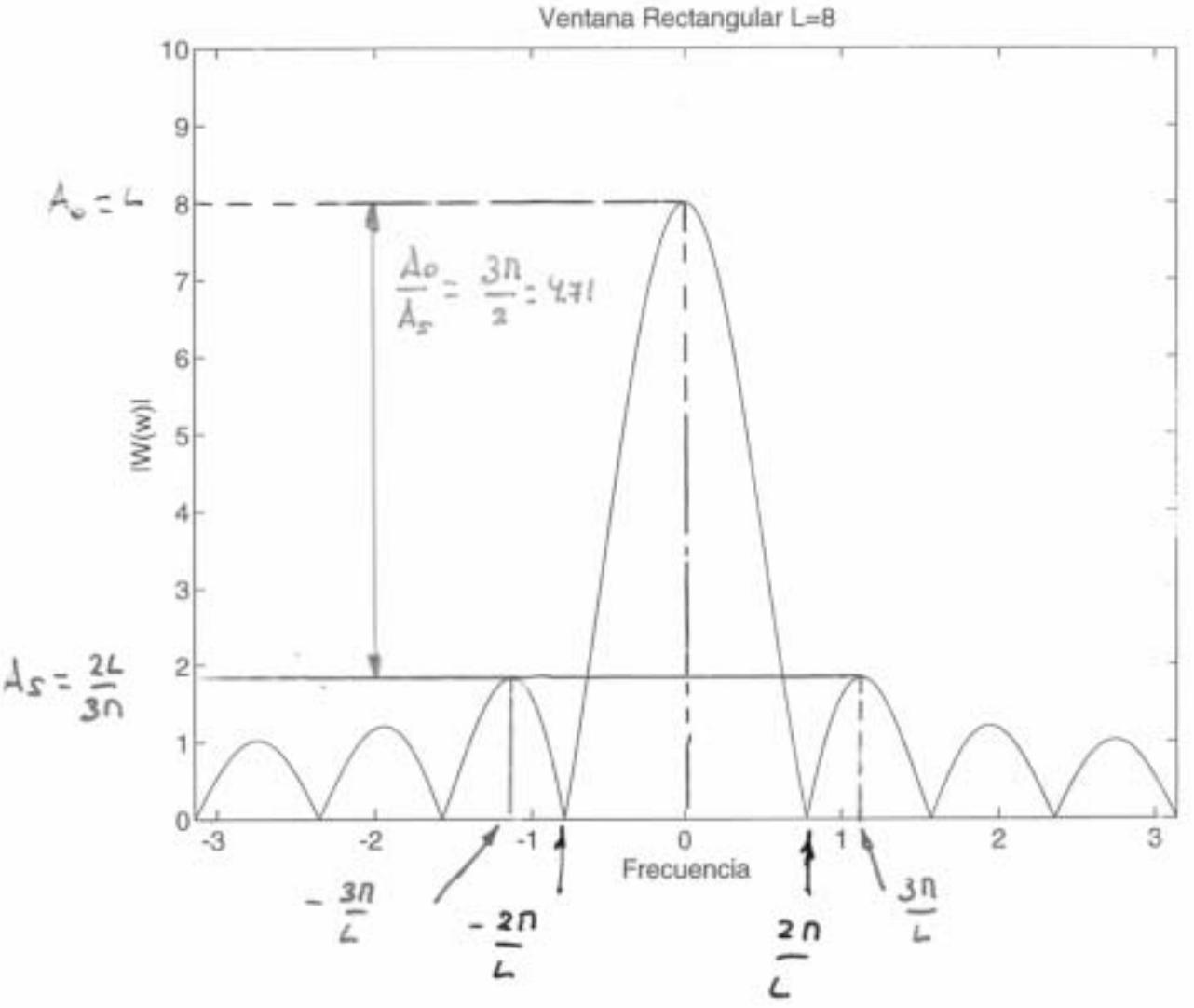


$$\omega_0 = \frac{2\pi}{14} \qquad \omega_1 = \frac{2\pi}{11}$$

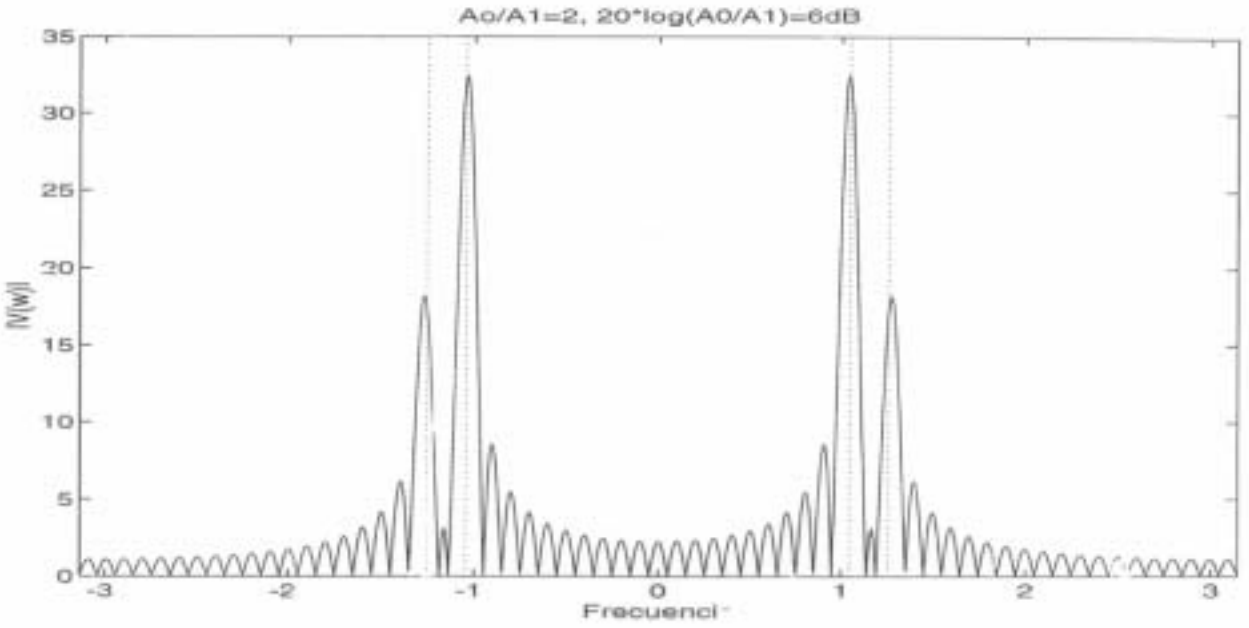


Ventana Rectangular L=8

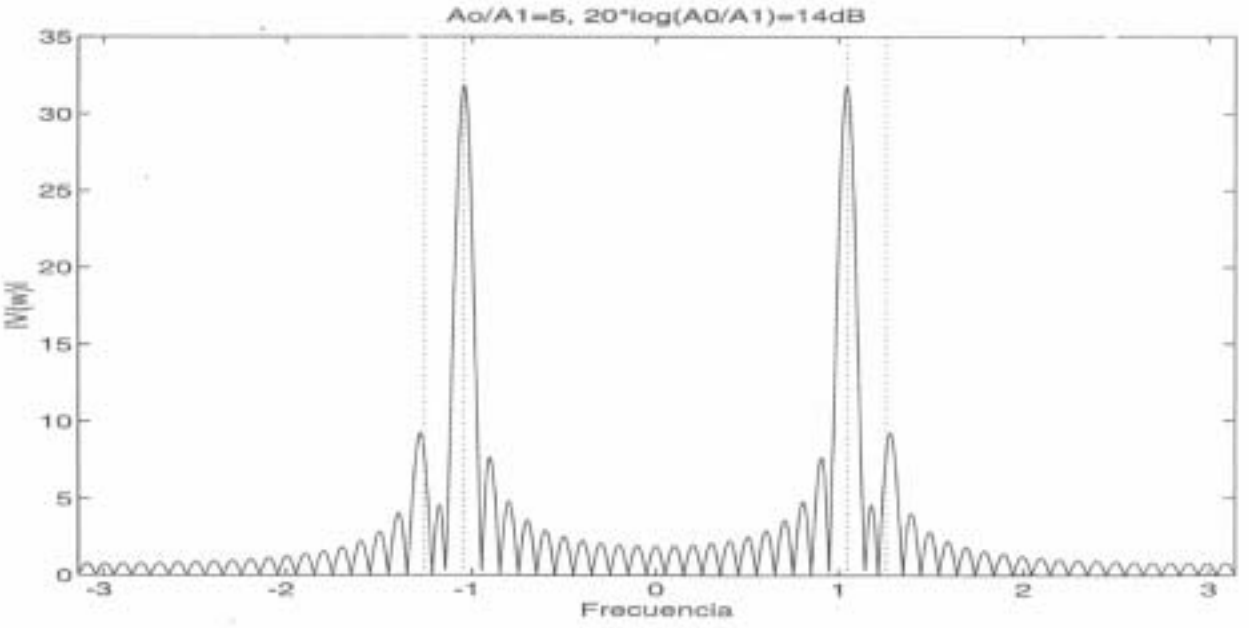
$$|W(e^{j\omega})| = \frac{sen(\omega L/2)}{sen(\omega/2)}$$



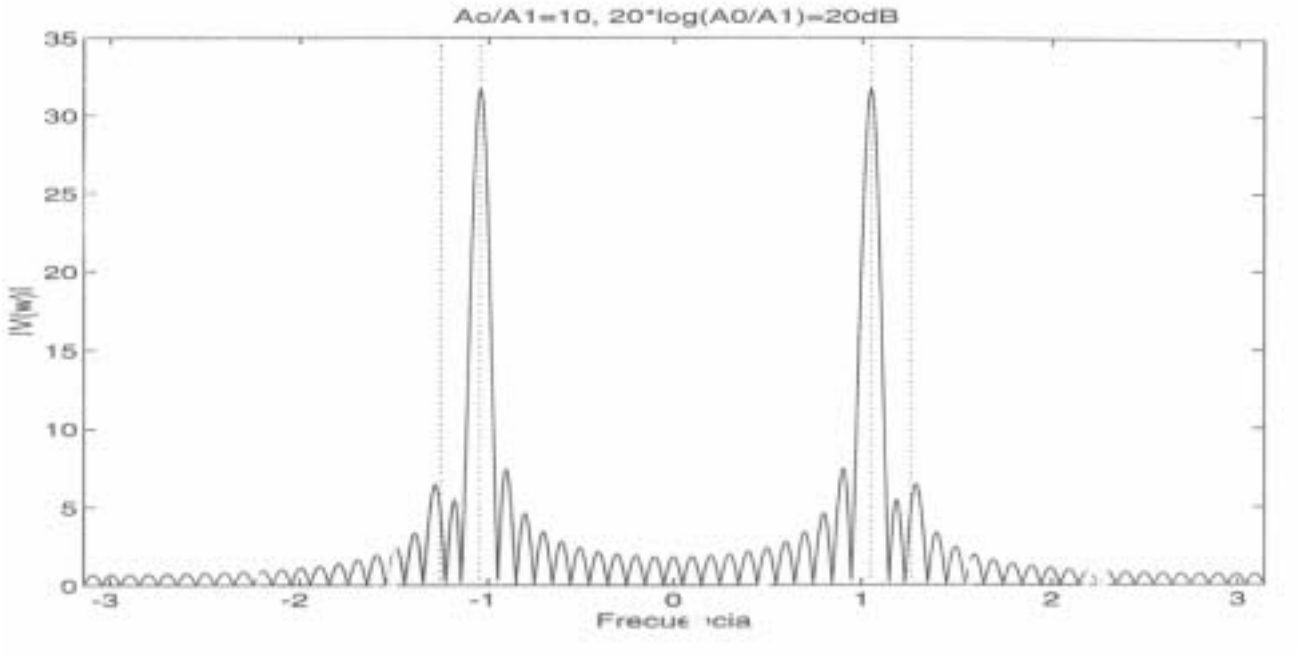
$$\omega_0 = \frac{2\pi}{6} \quad \omega_1 = \frac{2\pi}{5} \quad A_0/A_1 = 2 \quad 20\,log\,(A_0/A_1) = 6dB$$

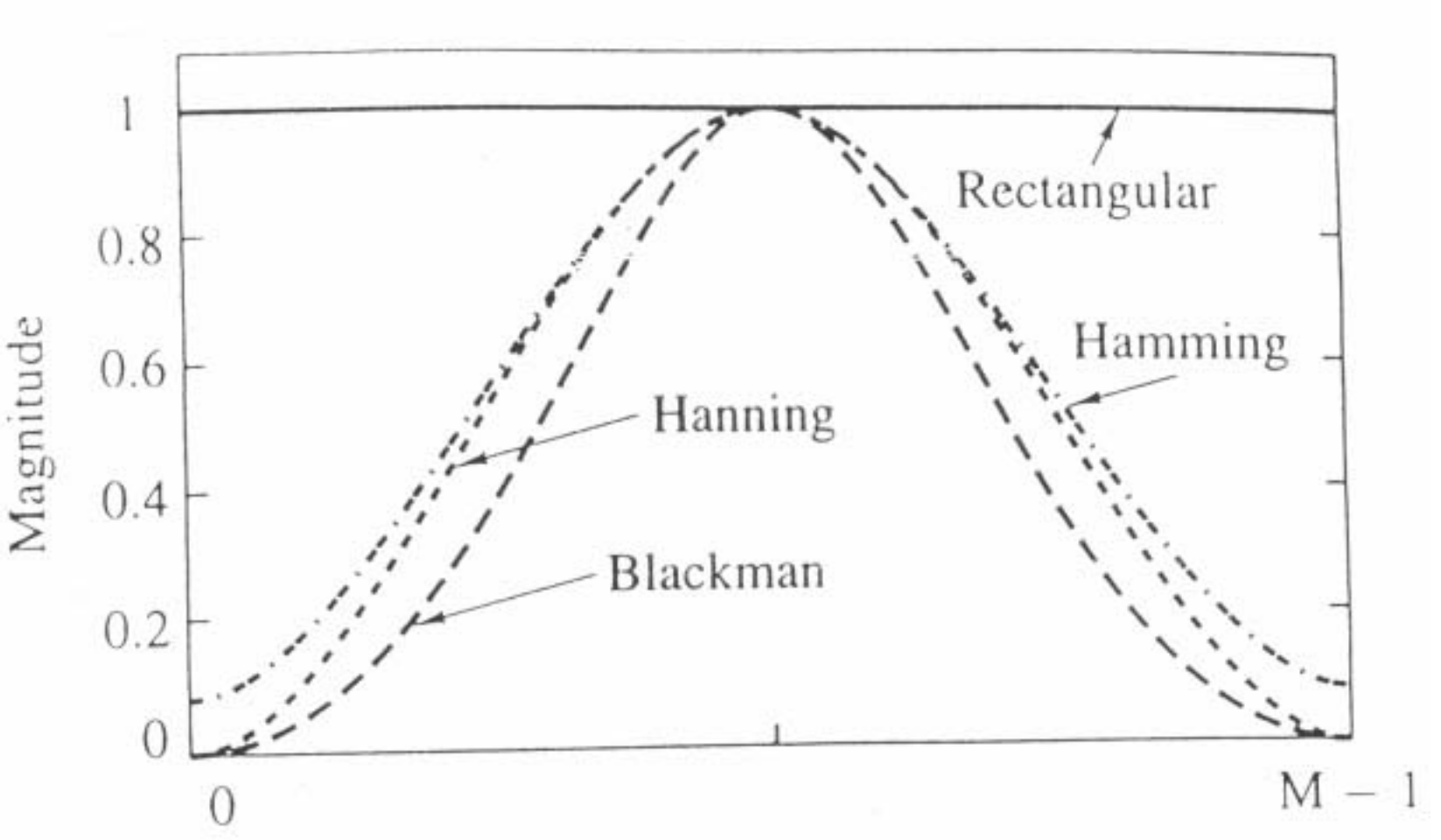


$$\omega_0 = \frac{2\pi}{6} \quad \omega_1 = \frac{2\pi}{5} \quad A_0/A_1 = 5 \quad 20\,log\,(A_0/A_1) = 14dB$$



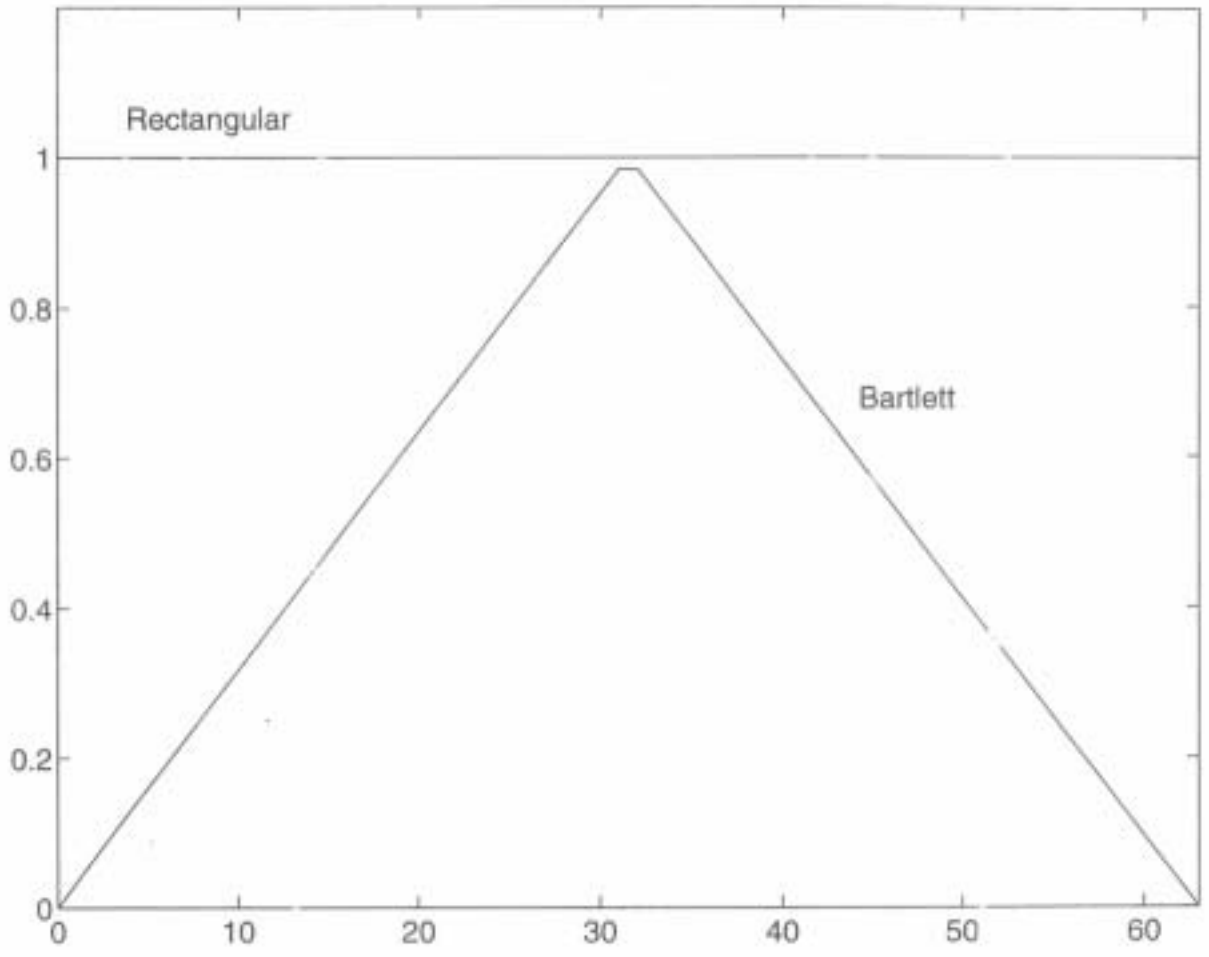
$$\omega_0 = \frac{2\pi}{6} \quad \omega_1 = \frac{2\pi}{5} \quad A_0/A_1 = 10 \quad 20\,log\,(A_0/A_1) = 20dB$$




Magnitude
1
0.8
0.6
0.4
0.2
0
0
M − 1
Rectangular
Hamming
Hanning
Blackman

Ventana de Bartlett (triangular) L=64

$$w(n) = 1 - \frac{\left| n - \frac{L-1}{2} \right|}{L-1}$$



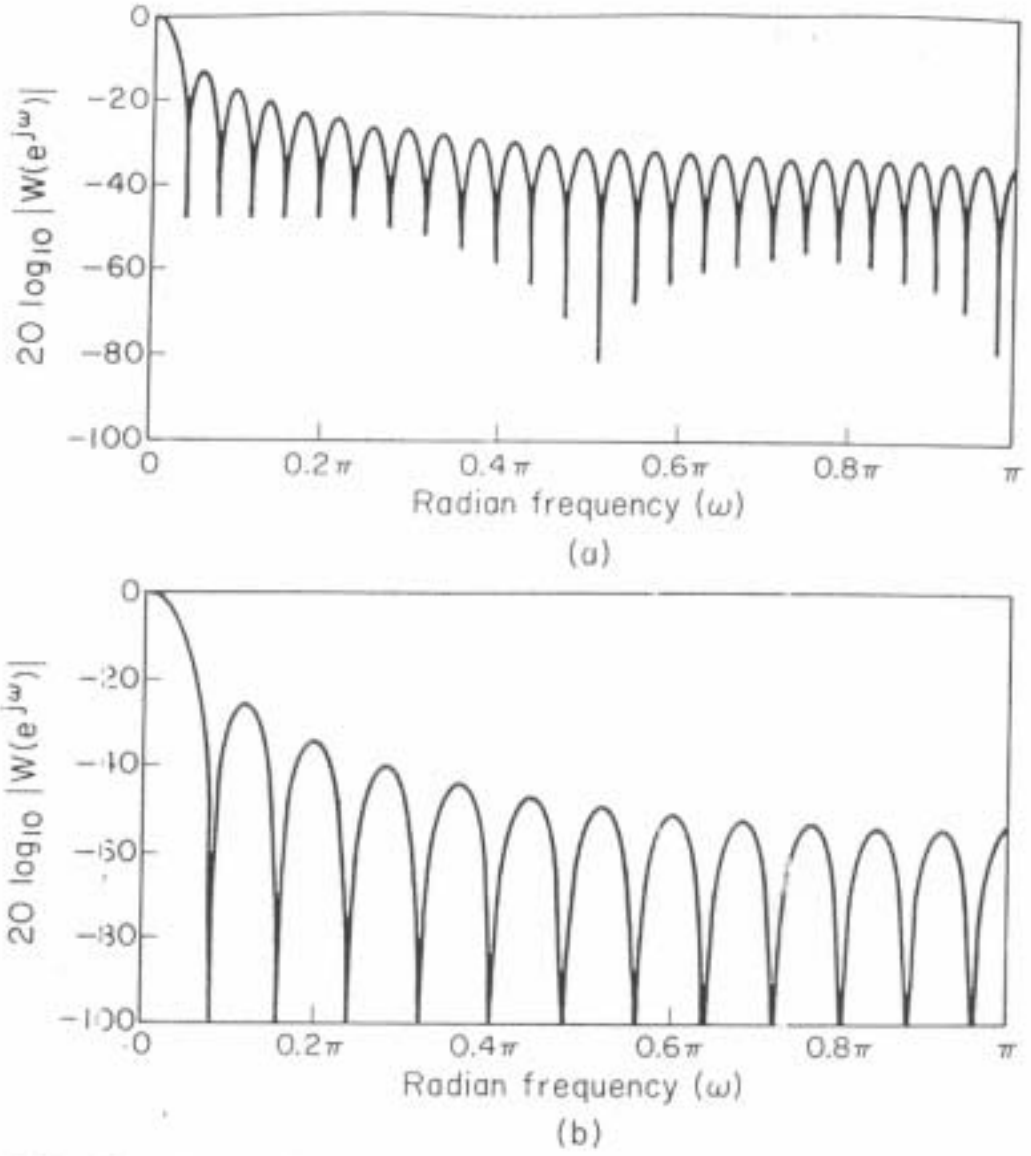
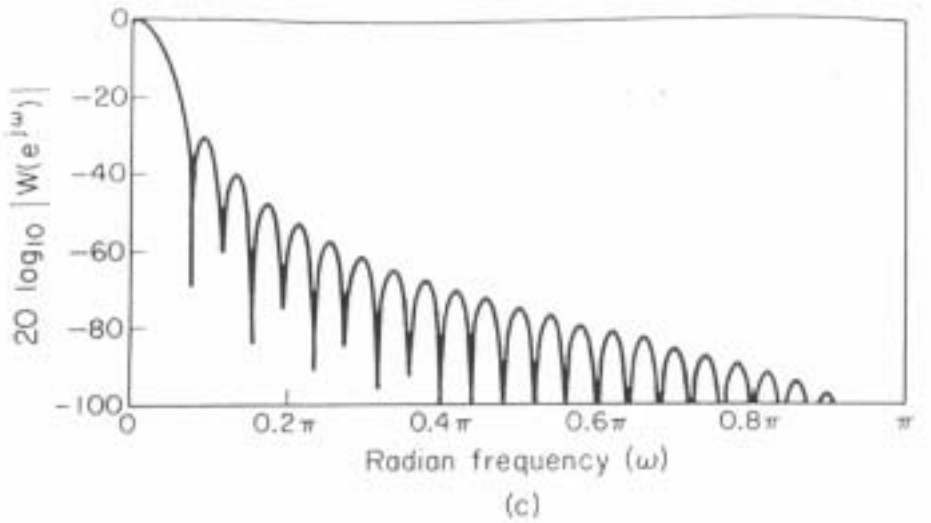
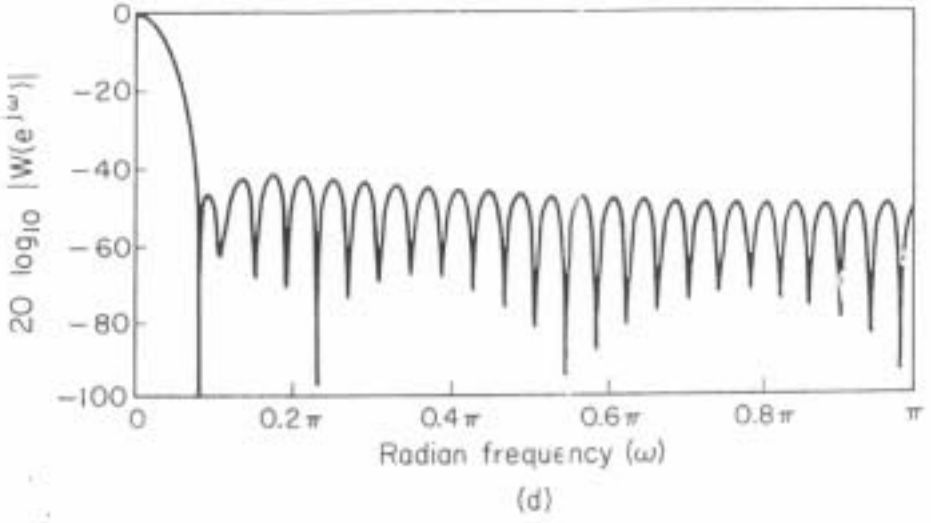


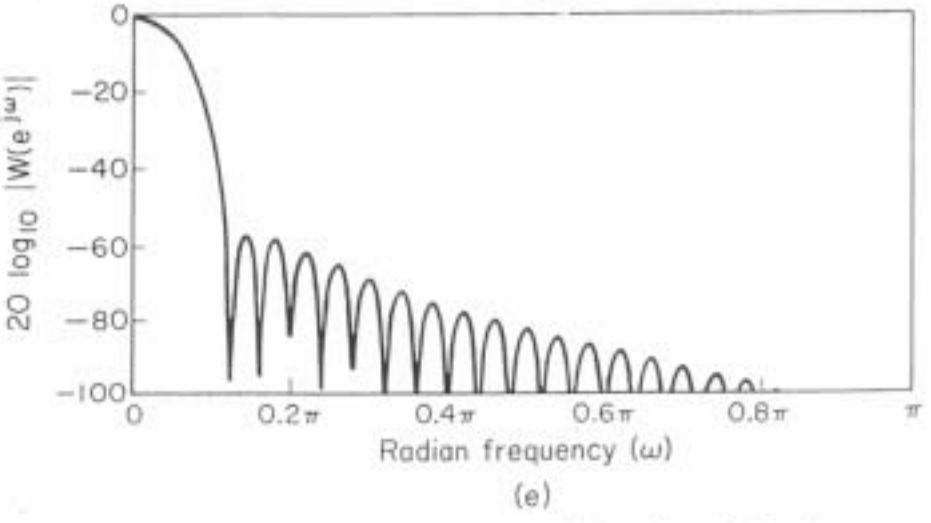
Figure 7.30 Fourier transforms (log magnitude) of windows of Fig. 7.29. (a) Rectangular. (b) Bartlett.



(c)



(d)

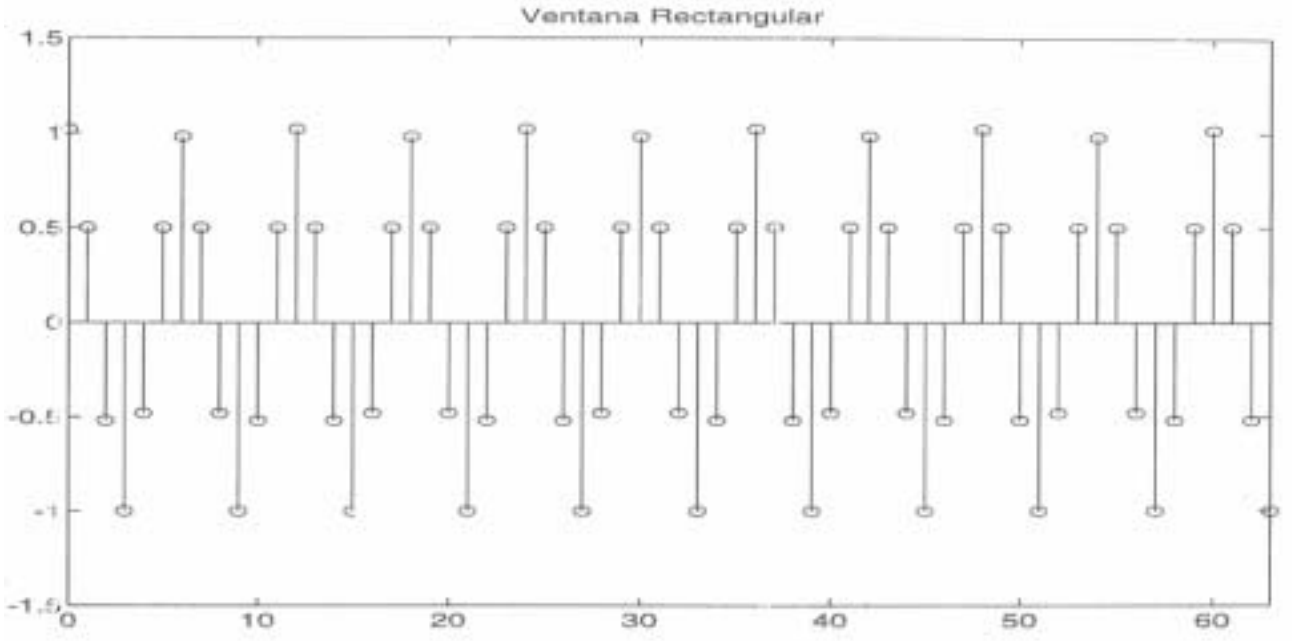


(e)

Figure 7.30 (*continued*) (c) Hanning. (d) Hamming. (e) Blackman.

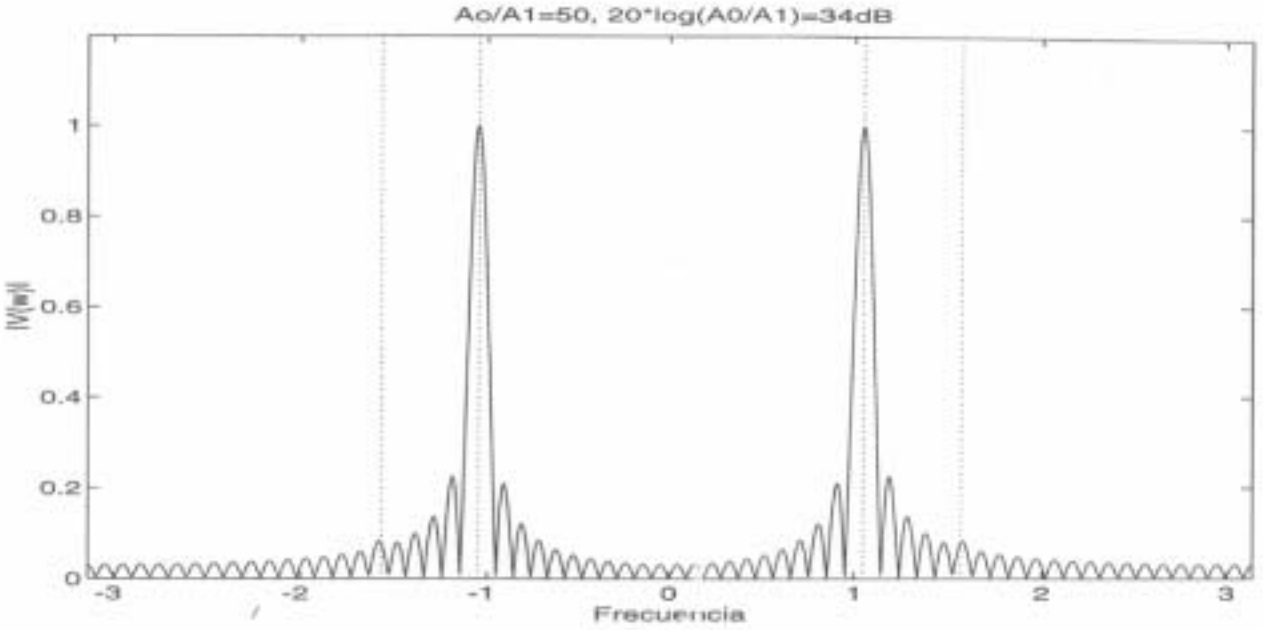
Ventana Rectangular

$$x(n) = cos\left(\frac{2\pi}{6}n\right) + 0.02cos\left(\frac{2\pi}{4}n\right)$$

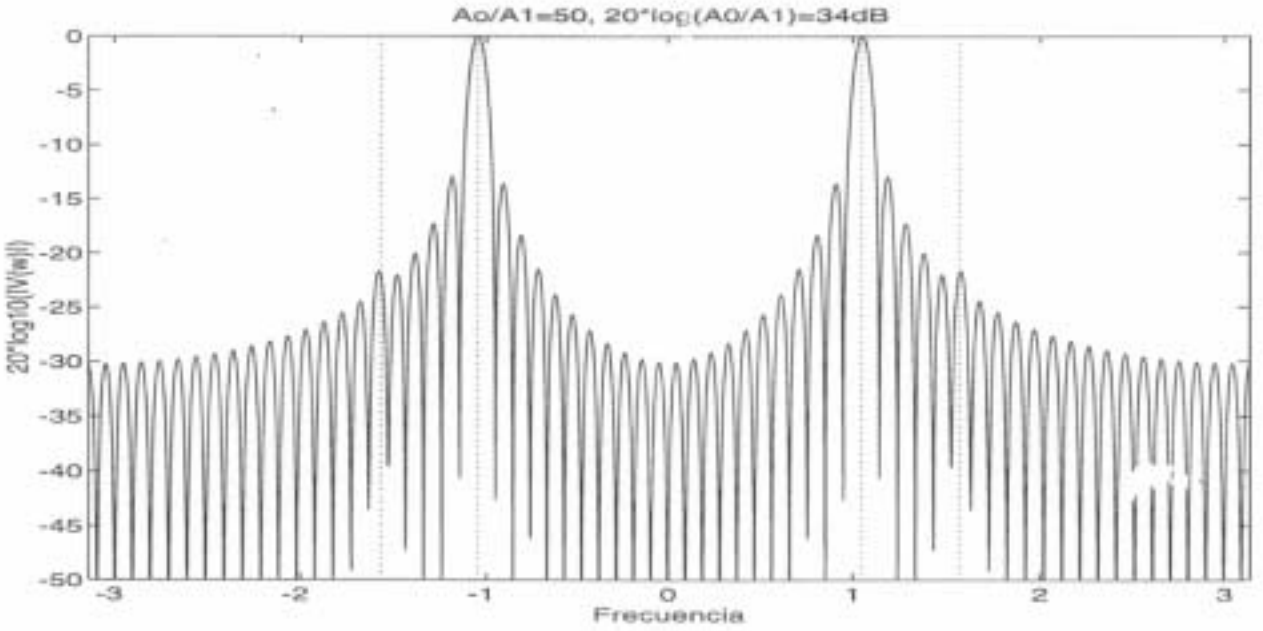


$$A_0/A_1 = 50 \qquad 20\ log\,(A_0/A_1) = 34dB$$

Ventana Rectangular (Escala lineal)

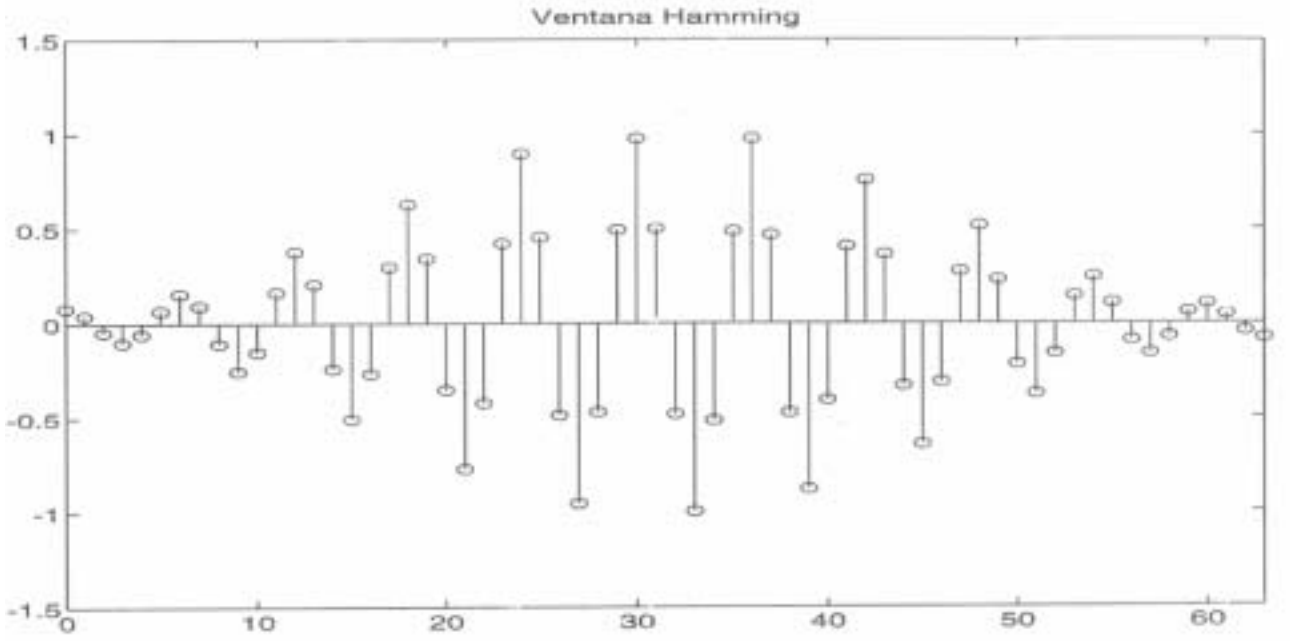


Ventana Rectangular (Escala logarítmica)



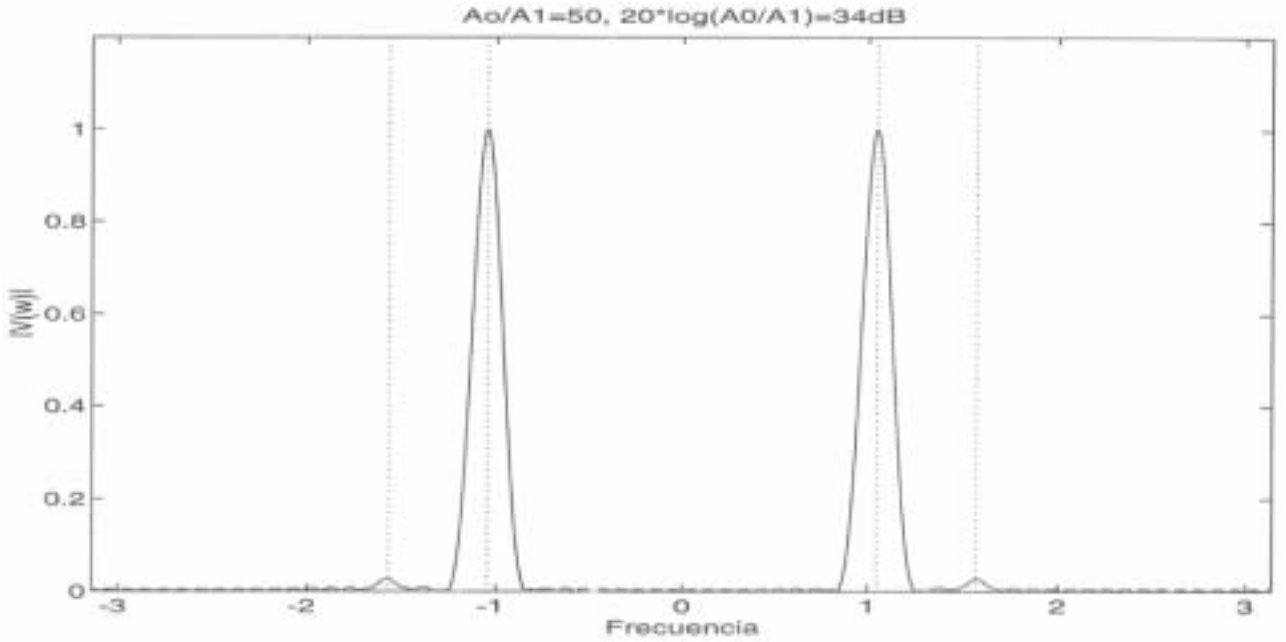
Ventana de Hamming

$$x(n) = cos\left(\frac{2\pi}{6}n\right) + 0.02cos\left(\frac{2\pi}{4}n\right)$$

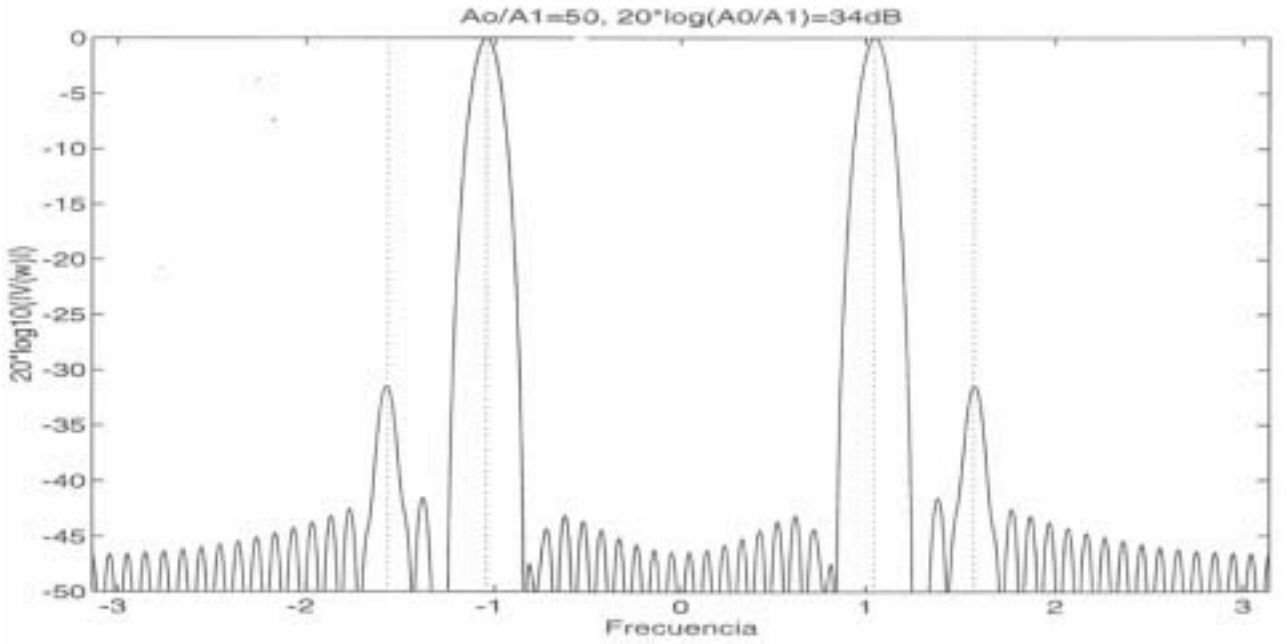


$$A_0/A_1 = 50 \qquad 20\ log\,(A_0/A_1) = 34dB$$

Ventana de Hamming (Escala lineal)

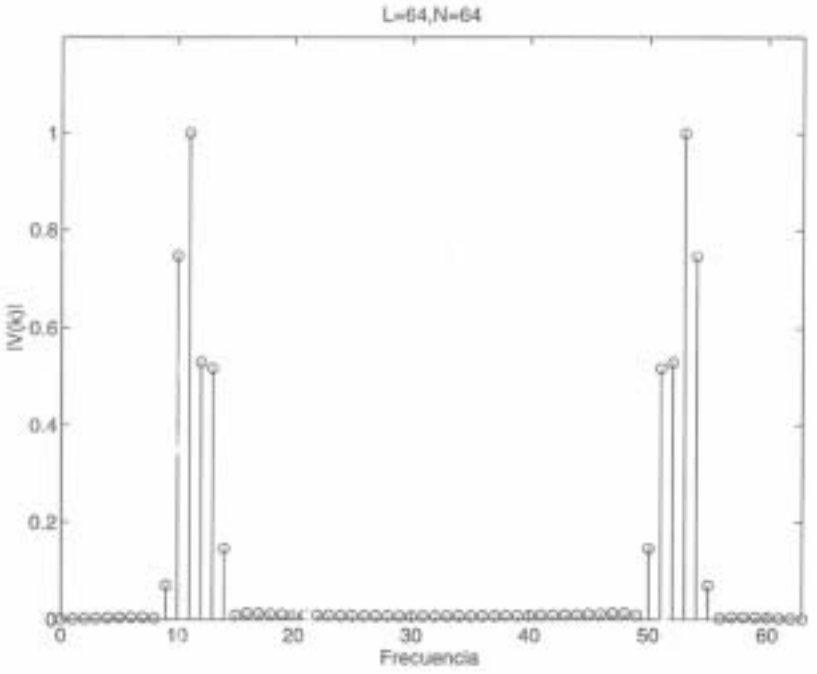


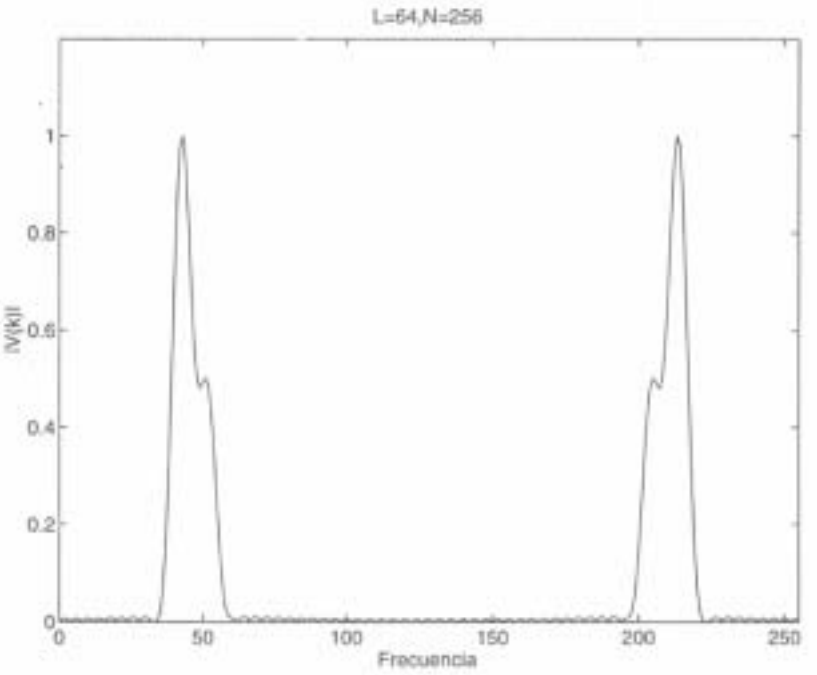
Ventana de Hamming (Escala logarítmica)



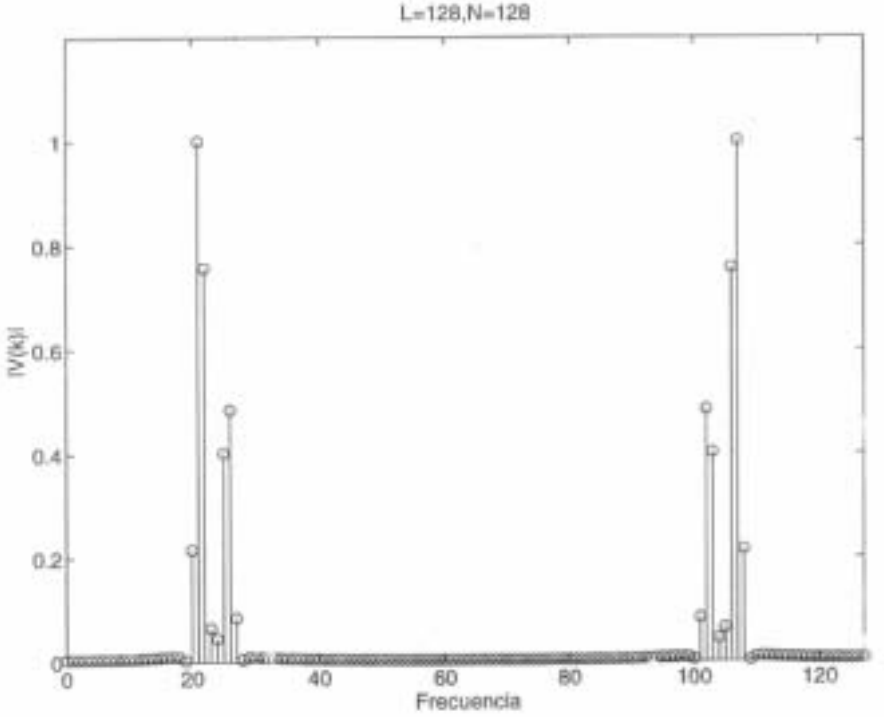
$x(n) = 0.5 \cos \frac{2\pi}{6} n + \cos \frac{2\pi}{5} n$, ventana Hamming

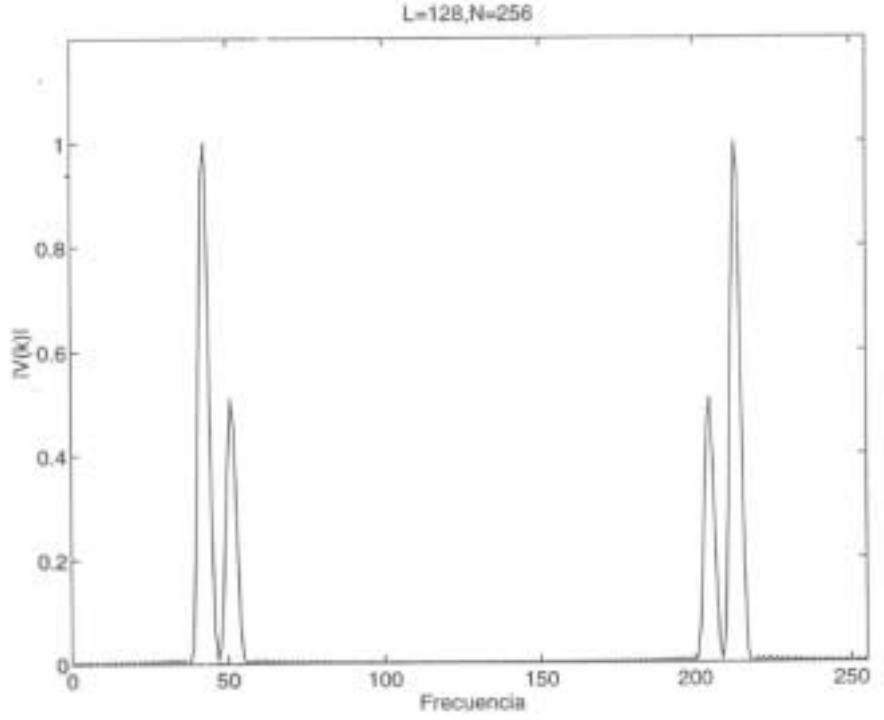
Efecto del muestreo en frecuencia en la DFT

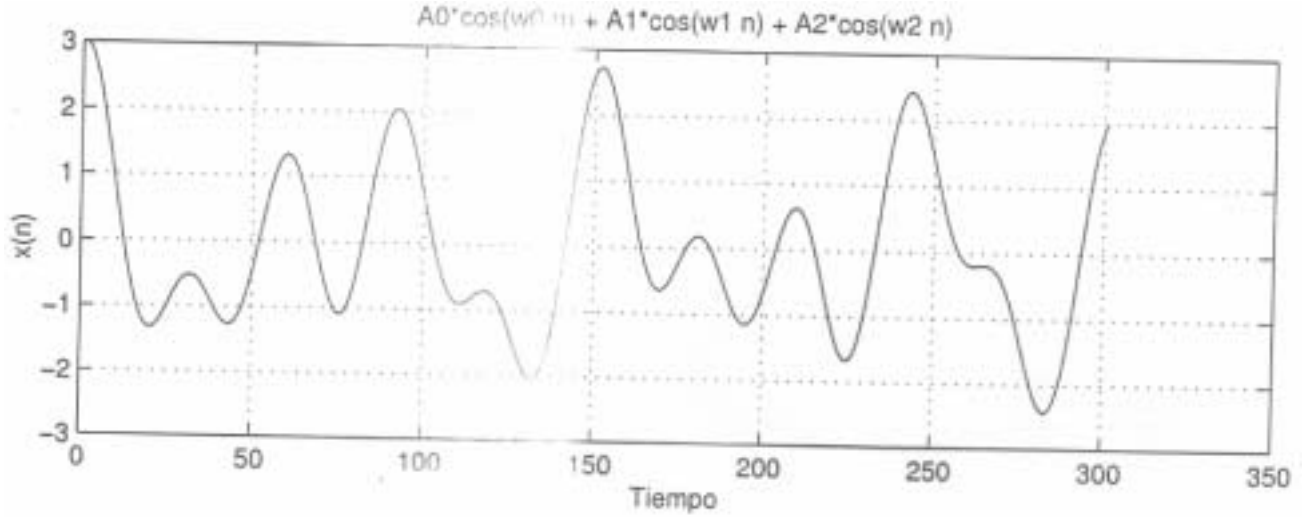


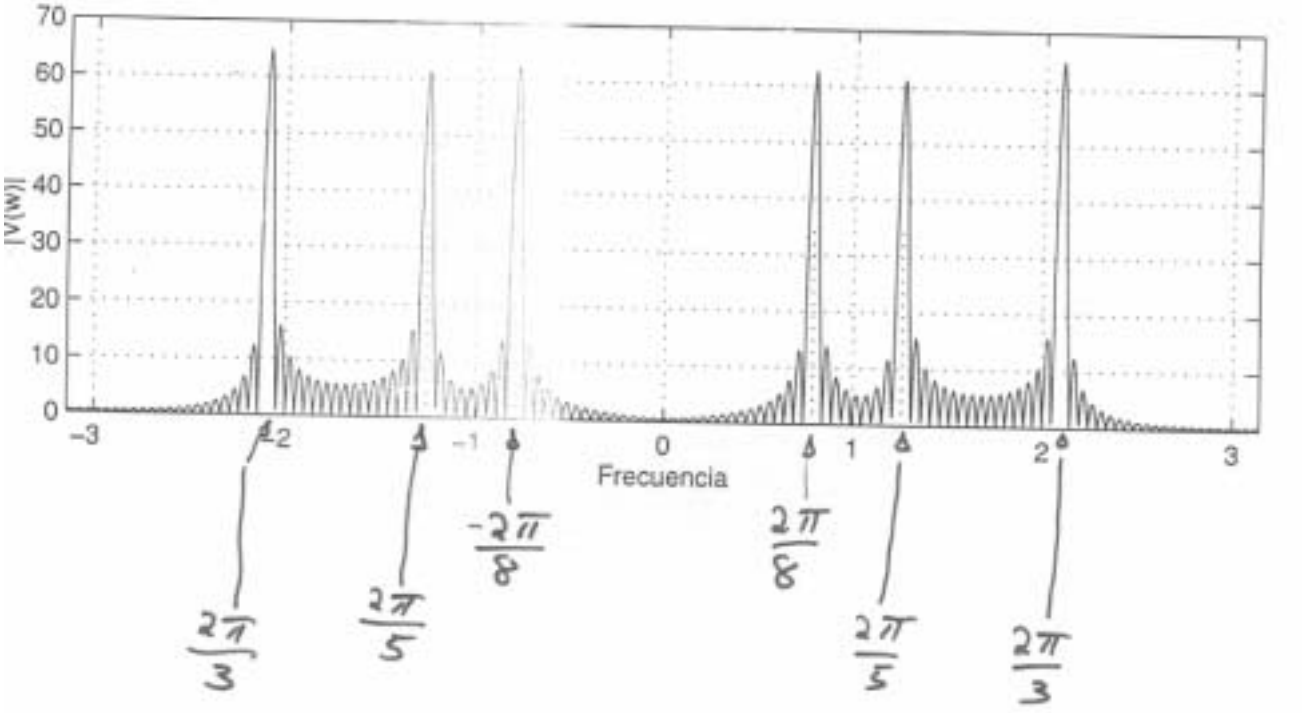


Efecto del muestreo en frecuencia en la DFT






A0*cos(w0 n) + A1*cos(w1 n) + A2*cos(w2 n)
x(n)
Tiempo


|V(w)|
Frecuencia
2π/3
2π/5
-2π/8
2π/8
2π/5
2π/3

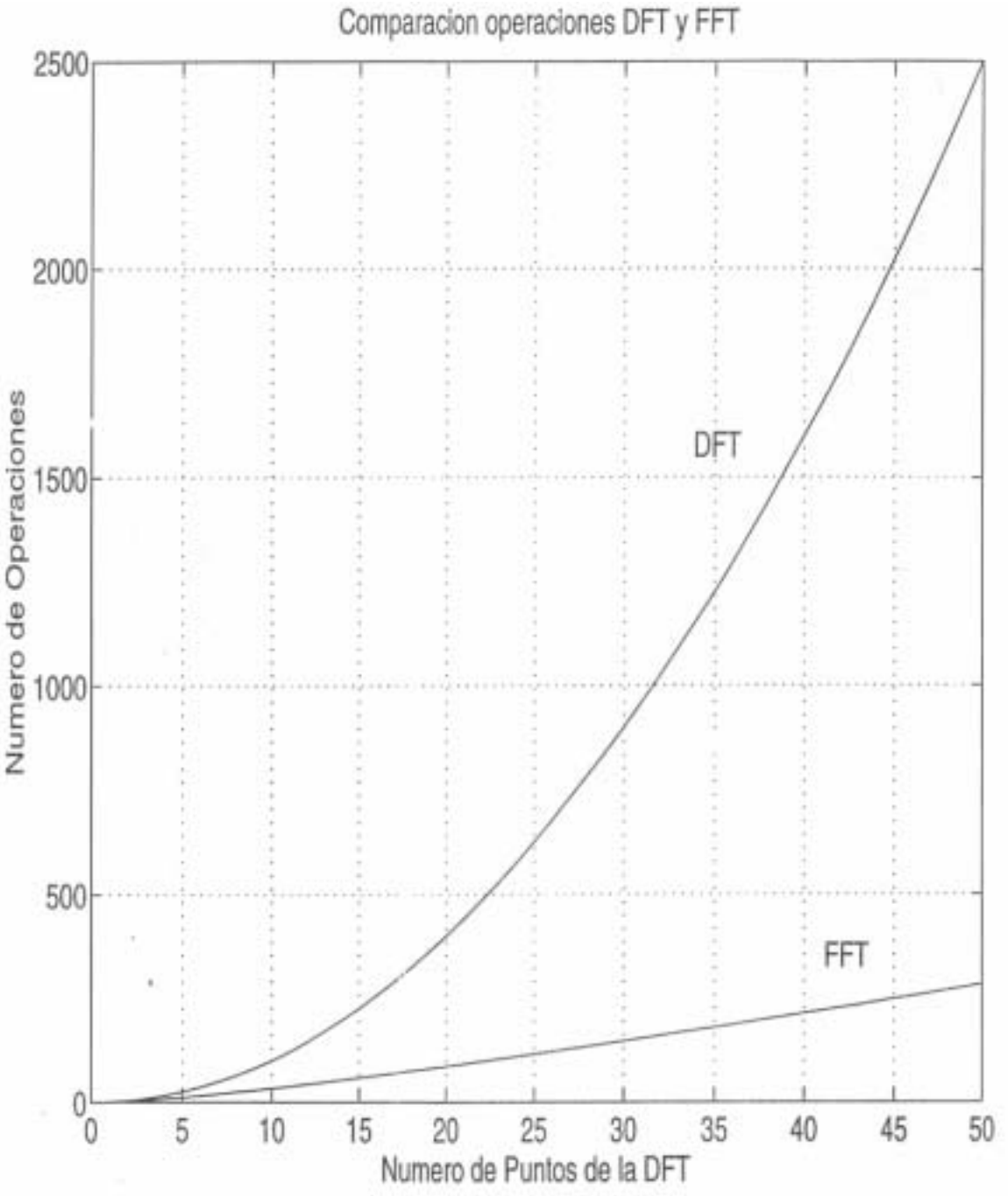

Comparacion operaciones DFT y FFT
2500
2000
1500
1000
500
0
Numero de Operaciones
DFT
FFT
0
5
10
15
20
25
30
35
40
45
50
Numero de Puntos de la DFT

TABLE 6.1 COMPARISON OF COMPUTATIONAL COMPLEXITY FOR THE DIRECT COMPUTATION OF THE DFT VERSUS THE FFT ALGORITHM

Number of Points, N	Complex Multiplications in Direct Computation, N^2	Complex Multiplications in FFT Algorithm, $(N/2)\log_2 N$	Speed Improvement Factor
4	16	4	4.0
8	64	12	5.3
16	256	32	8.0
32	1,024	80	12.8
64	4,096	192	21.3
128	16,384	448	36.6
256	65,536	1,024	64.0
512	262,144	2,304	113.8
1,024	1,048,576	5,120	204.8

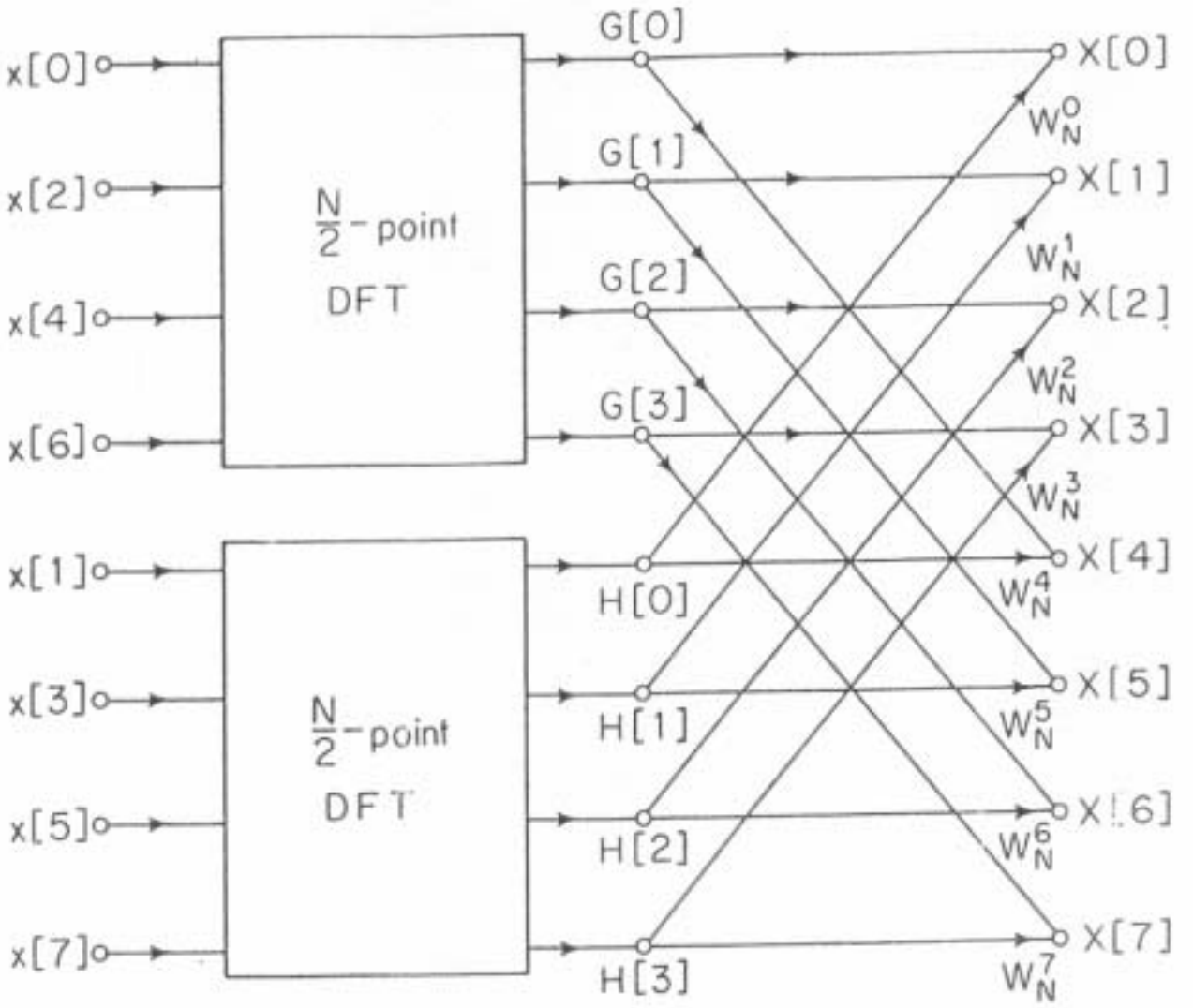


Figure 9.3 Flow graph of the decimation-in-time decomposition of an N-point DFT computation into two $(N/2)$-point DFT computations ($N = 8$).

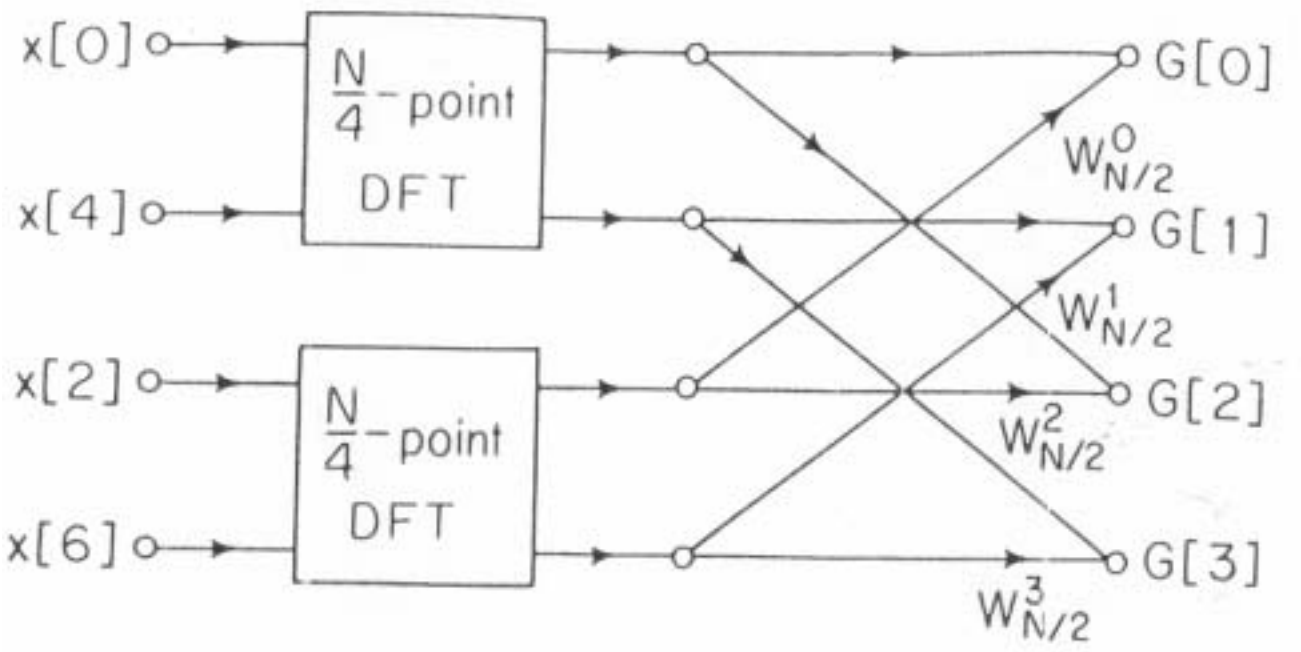


Figure 9.4 Flow graph of the decimation-in-time decomposition of an $(N/2)$-point DFT computation into two $(N/4)$-point DFT computations ($N = 8$).

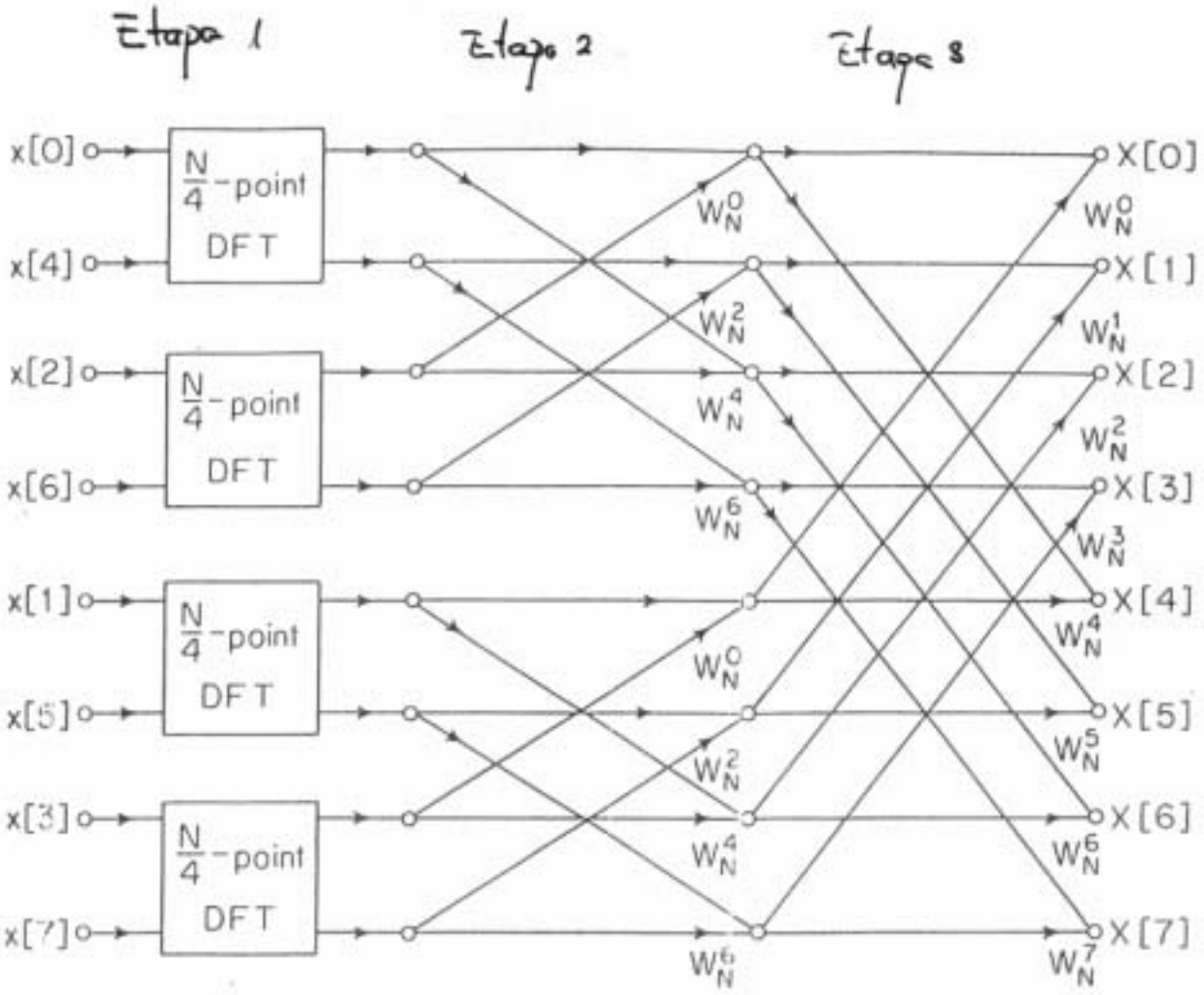


Figure 9.5 Result of substituting Fig. 9.4 into Fig. 9.3.

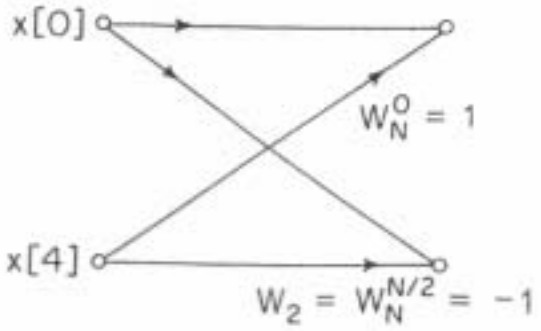


Figure 9.6 Flow graph of a 2-point DFT.

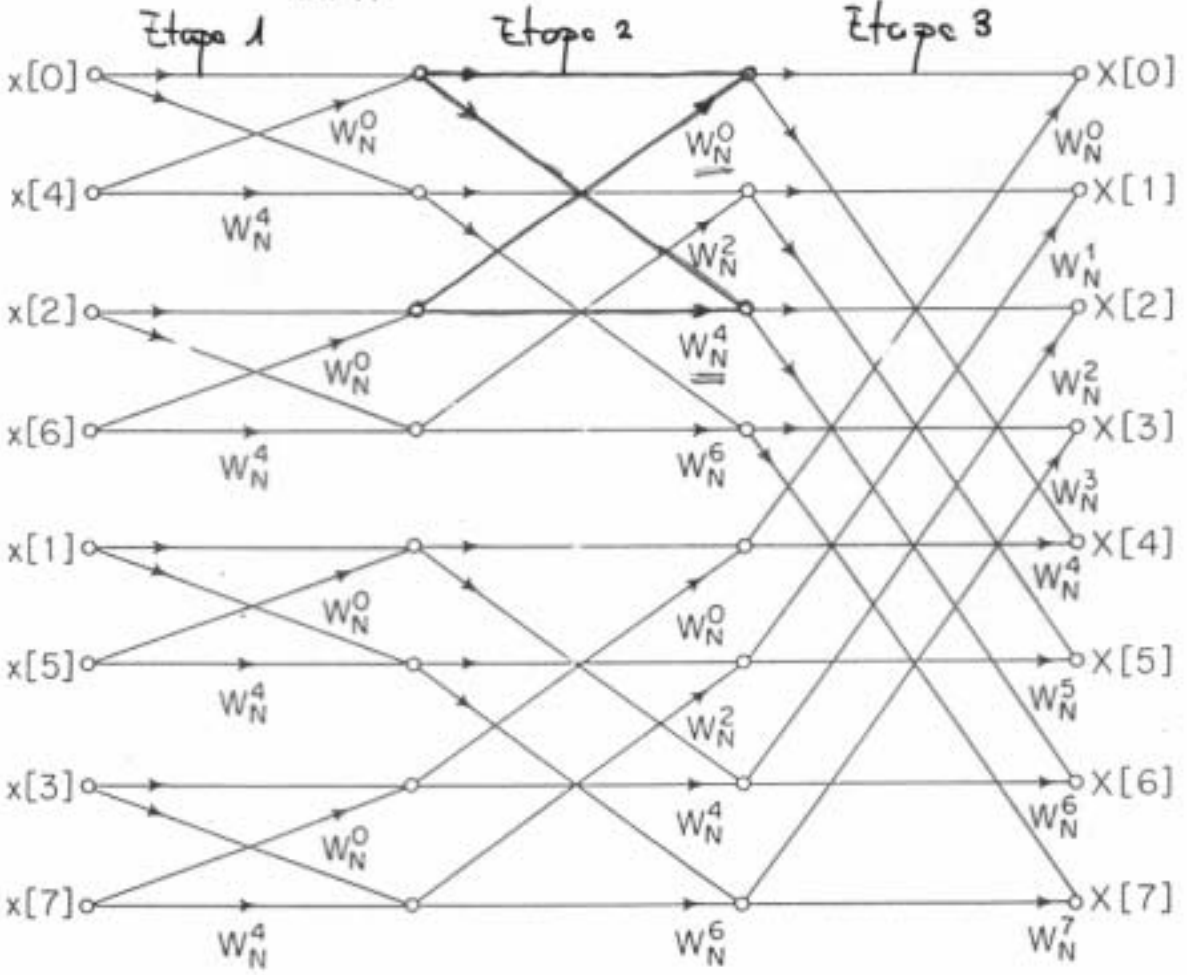


Figure 9.7 Flow graph of complete decimation-in-time decomposition of an 8-point DFT computation.

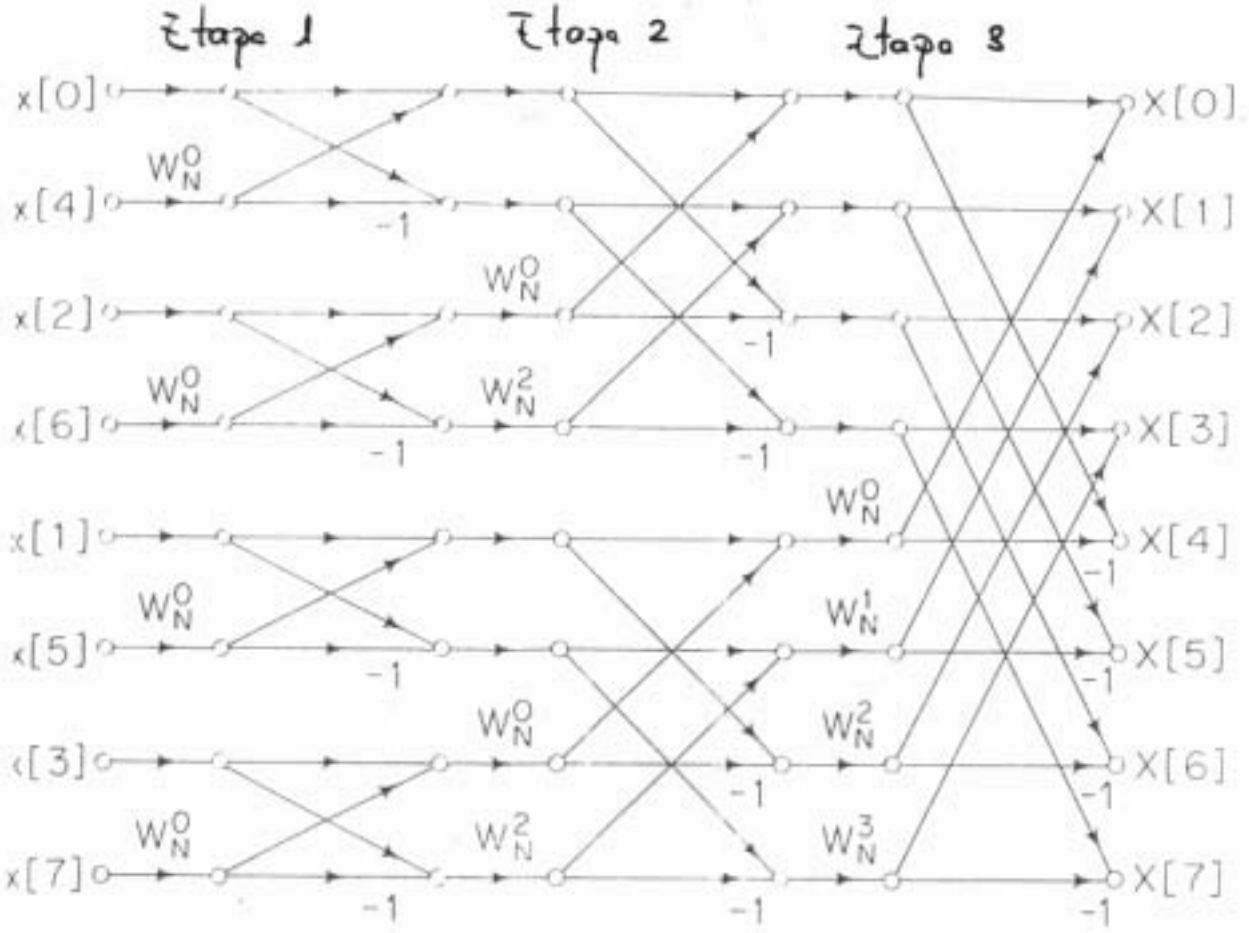


Figure 9.16 Flow graph of 8-point DFT using the butterfly computation of Fig. 9.9.