

WINDOWS AND FIGURES OF MERIT

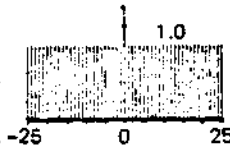
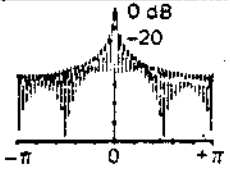

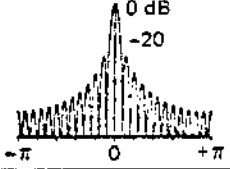
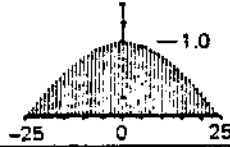
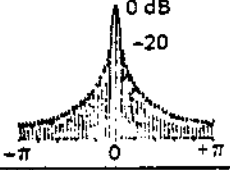
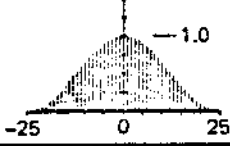
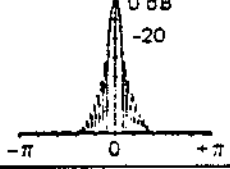

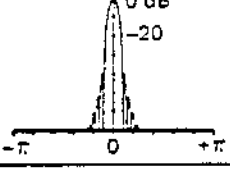

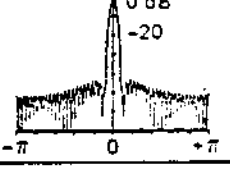
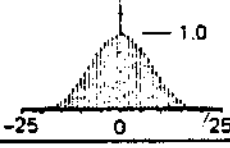
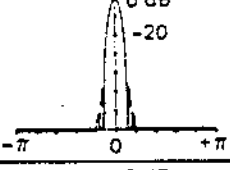

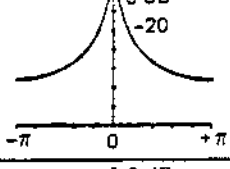

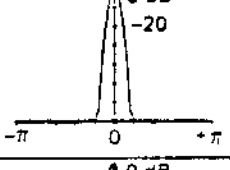
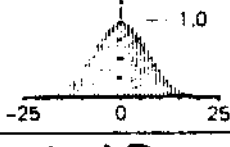
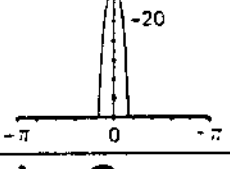
FROM: WINDOWS, HARMONIC ANALYSIS AND THE DISCRETE FOURIER TRANSFORM; frederic j harris;
SUBMITTED TO IEE PROCEEDINGS; AUGUST 1976.



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COMPARISON OF WEIGHTING FUNCTIONS

WEIGHTING FUNCTIONS		HIGHEST SIDELobe LEVEL (dB)	ASYMPTOTIC ROLL-OFF (dB/OCTAVE)	3 dB BANDWIDTH (Δf)	EFFECTIVE NOISE (Δf)	
	TIME	FREQUENCY				
1			-13	6	0.85	1
2			-26	12	1.25	1.35
3			-23	12	1.17	1.26
4			-32	18	1.4	1.5
5			-39	24	1.61	1.73
6			-42	6 dB/OCT BEYOND 5 Δf	1.3	1.36
7			-48	30	1.88	1.9
8			NONE	18 MONOTONIC	1.5	1.6
9			-64	26	1.78	1.83
10			-70	38.5	1.70	1.79



WINDOW	HIGHEST SIDE LOBE LEVEL (dB)	SIDE LOBE FALL OFF (dB/OCT)	COHERENT GAIN	EQUIV. NOISE BW (BINS)	3.0-dB BW (BINS)	SCALLOP LOSS (dB)	WORSE CASE PROCESS LOSS (dB)	6.0-dB BW (BINS)	
RECTANGLE	-13	-6	1.00	1.00	0.89	3.92	3.92	1.21	
TRIANGLE	-27	-12	0.50	1.33	1.28	1.82	3.07	1.78	
COS ² (X)	$\alpha = 1.0$	-23	-12	0.64	1.23	1.20	2.10	3.01	1.65
	$\alpha = 2.0$	-32	-18	0.50	1.50	1.44	1.42	3.18	2.00
	$\alpha = 3.0$	-39	-24	0.42	1.73	1.66	1.08	3.47	2.32
	$\alpha = 4.0$	-47	-30	0.38	1.94	1.86	0.86	3.75	2.59
HAMMING	-43	-6	0.54	1.36	1.30	1.78	3.10	1.81	
RIESZ	-21	-12	0.67	1.20	1.16	2.22	3.01	1.59	
RIEMANN	-26	-12	0.59	1.30	1.26	1.89	3.03	1.74	
DE LA VALLE-POUSSIN	-53	-24	0.38	1.92	1.82	0.90	3.72	2.55	
TUKEY	$\alpha = 0.25$	-14	-18	0.88	1.10	1.01	2.96	3.39	1.38
	$\alpha = 0.50$	-15	-18	0.75	1.22	1.15	2.24	3.11	1.57
	$\alpha = 0.75$	-19	-18	0.63	1.36	1.31	1.73	3.07	1.60
BOHMAN	-46	-24	0.41	1.79	1.71	1.02	3.54	2.38	
POISSON	$\alpha = 2.0$	-19	-6	0.44	1.30	1.21	2.09	3.23	1.69
	$\alpha = 3.0$	-24	-6	0.32	1.65	1.45	1.46	3.64	2.08
	$\alpha = 4.0$	-31	-6	0.25	2.08	1.75	1.03	4.21	2.58
HANNING-POISSON	$\alpha = 0.5$	-35	-18	0.43	1.61	1.54	1.26	3.33	2.14
	$\alpha = 1.0$	NONE	-18	0.38	1.73	1.64	1.11	3.50	2.30
	$\alpha = 2.0$	NONE	-18	0.29	2.02	1.87	0.87	3.94	2.65
CAUCHY	$\alpha = 3.0$	-31	-6	0.42	1.48	1.34	1.71	3.40	1.90
	$\alpha = 4.0$	-35	-6	0.33	1.76	1.50	1.36	3.83	2.20
	$\alpha = 5.0$	-30	-6	0.28	2.06	1.68	1.13	4.28	2.53
GAUSSIAN	$\alpha = 2.5$	-42	-6	0.51	1.39	1.33	1.69	3.14	1.86
	$\alpha = 3.0$	-55	-6	0.43	1.64	1.55	1.25	3.40	2.18
	$\alpha = 3.5$	-69	-6	0.37	1.90	1.79	0.94	3.73	2.52
DOLPH-TCHEBYSHEV	$\alpha = 2.5$	-50	0	0.53	1.39	1.33	1.70	3.12	1.85
	$\alpha = 3.0$	-60	0	0.48	1.51	1.44	1.44	3.23	2.01
	$\alpha = 3.5$	-70	0	0.45	1.62	1.55	1.26	3.36	2.17
	$\alpha = 4.0$	-80	0	0.42	1.73	1.65	1.10	3.48	2.31
KAISER-BESSEL	$\alpha = 2.0$	-46	-6	0.49	1.50	1.43	1.46	3.20	1.99
	$\alpha = 2.5$	-57	-6	0.44	1.66	1.57	1.20	3.38	2.20
	$\alpha = 3.0$	-69	-6	0.40	1.80	1.71	1.02	3.56	2.39
	$\alpha = 3.5$	-82	-6	0.37	1.93	1.83	0.89	3.74	2.57
BARCLON-TEMES	$\alpha = 3.0$	-53	-6	0.47	1.56	1.49	1.34	3.27	2.07
	$\alpha = 3.5$	-58	-6	0.43	1.67	1.59	1.18	3.40	2.23
	$\alpha = 4.0$	-68	-6	0.41	1.77	1.69	1.05	3.52	2.36

TABLE 1. WINDOWS AND FIGURES OF MERIT

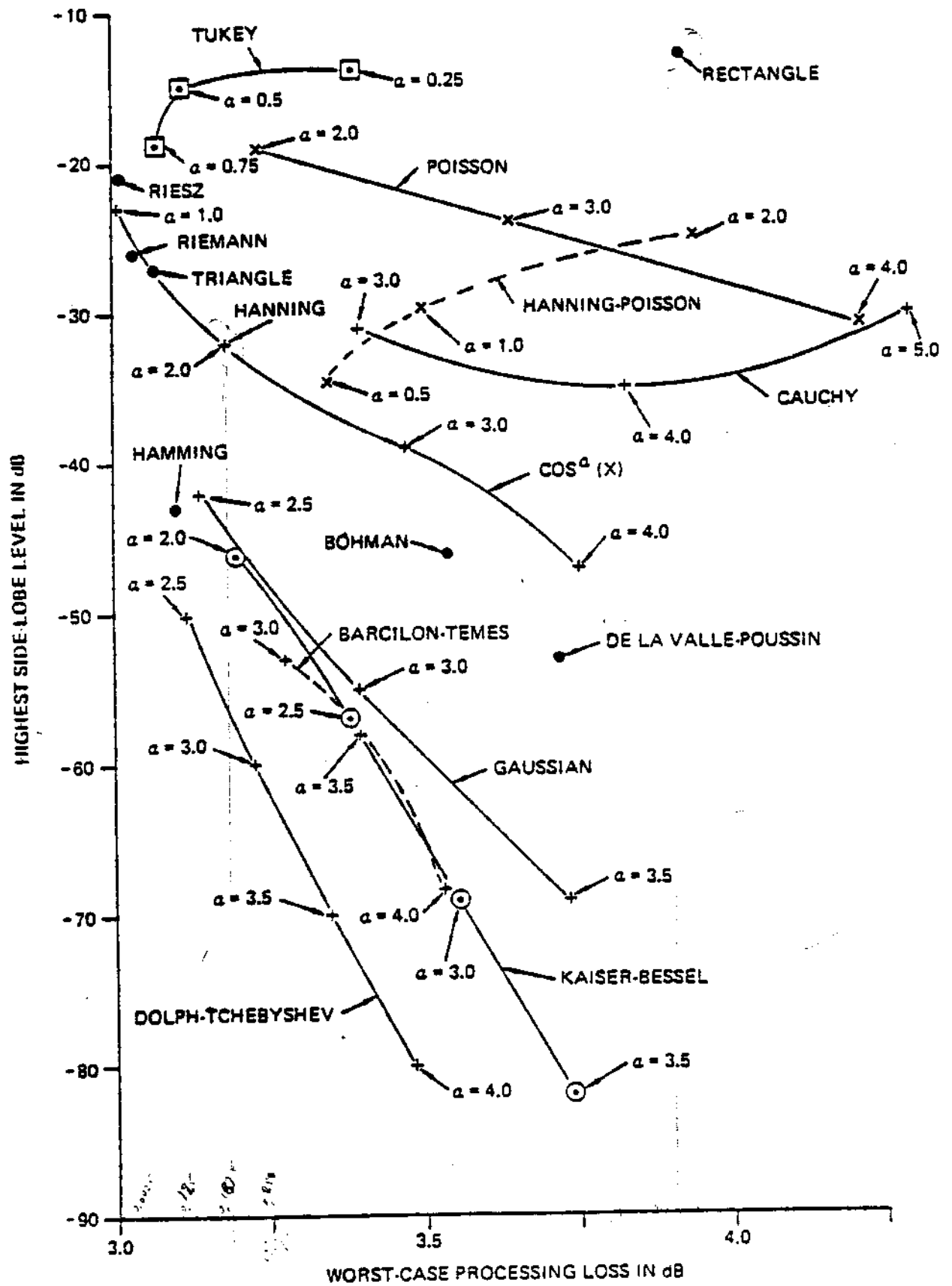


Figure 10. Comparison of Windows for Side-Lobe Level and Worst-Case Processing Loss

3.187

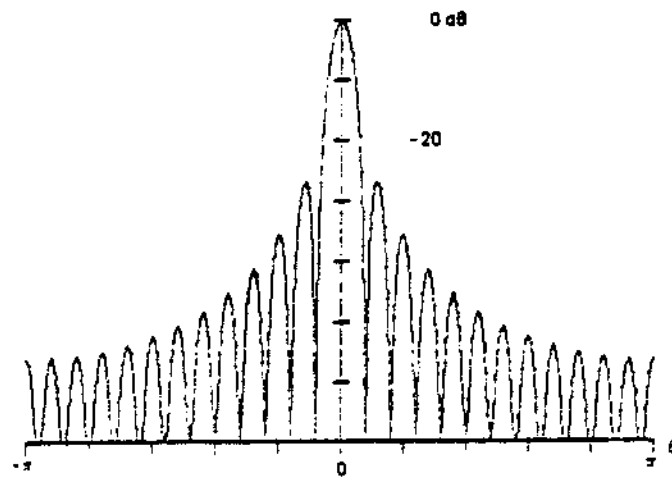
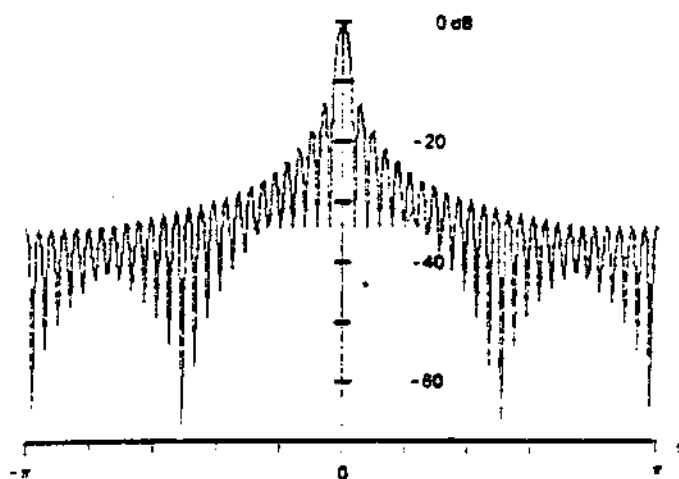
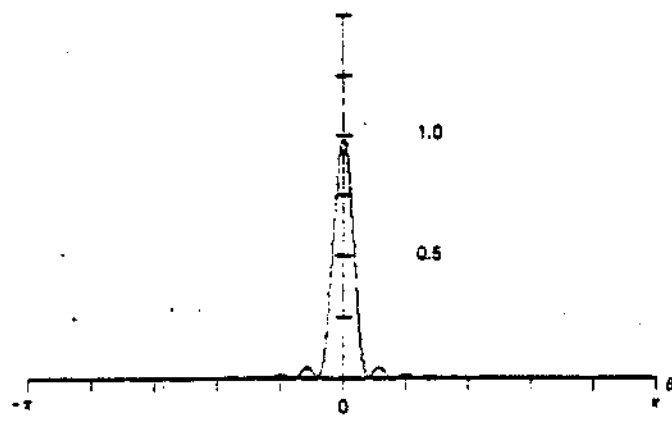
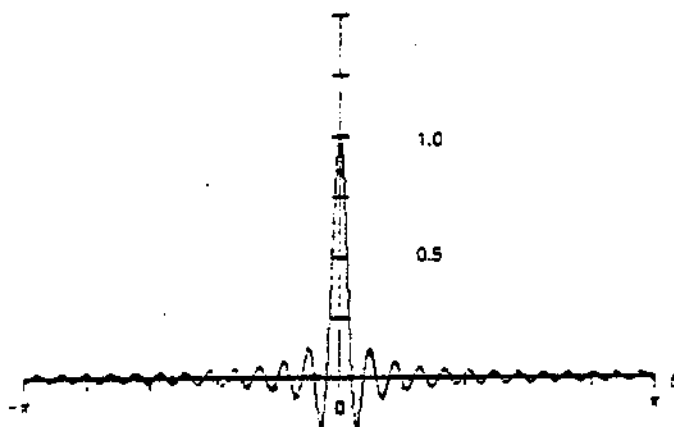
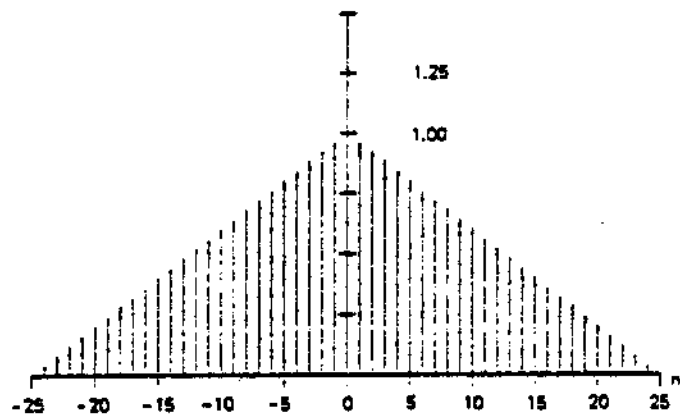
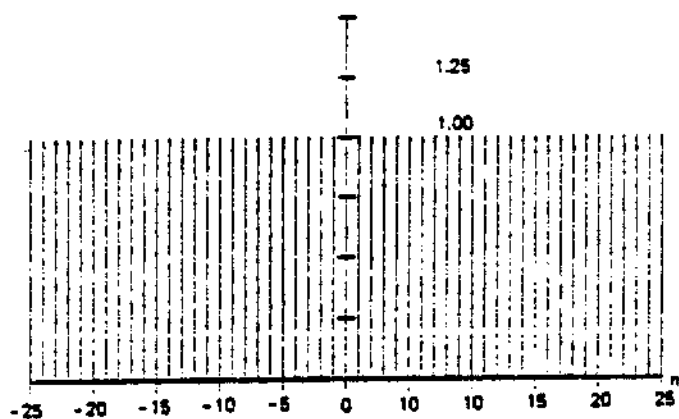


Figure 11. Rectangle Window, Fourier Transform, and Log-Magnitude of Transform

Figure 12. Triangle Window, Fourier Transform, and Log-Magnitude of Transform

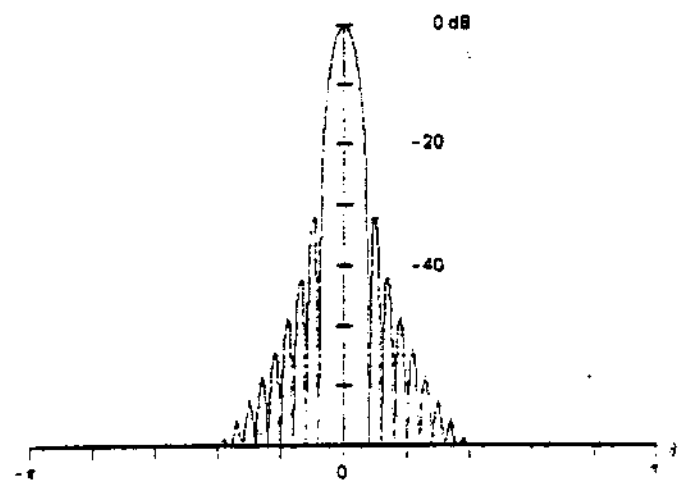
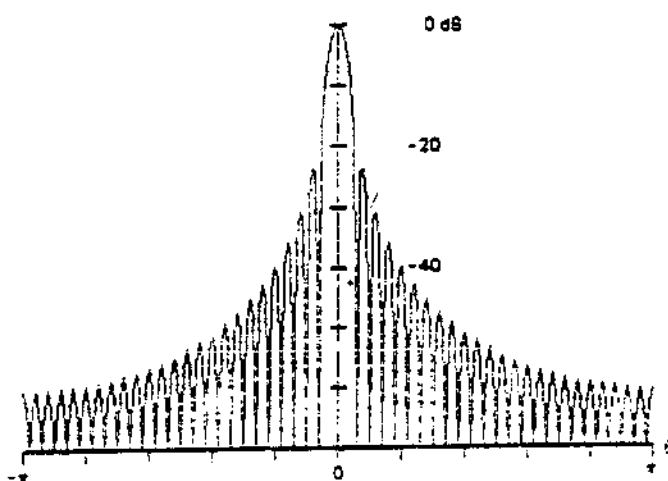
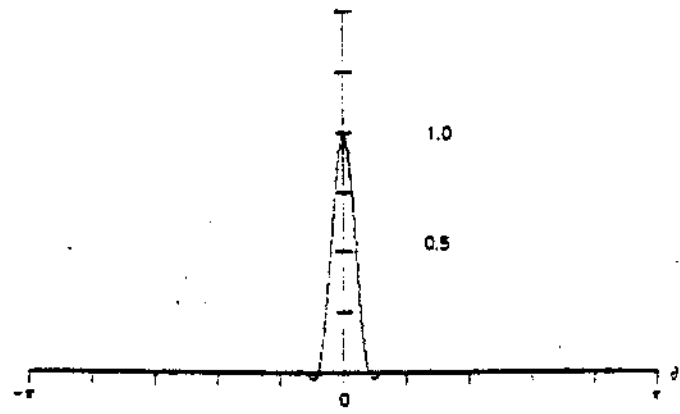
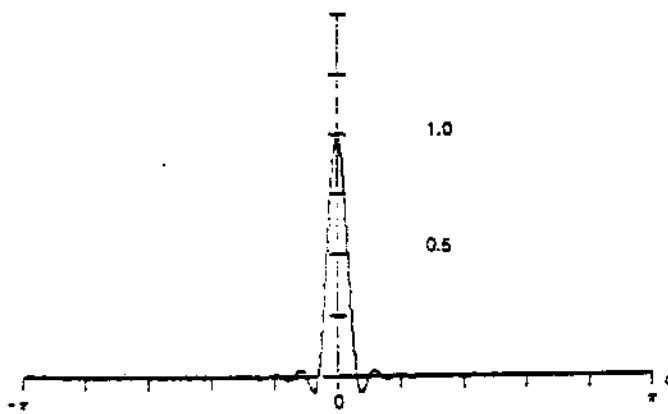
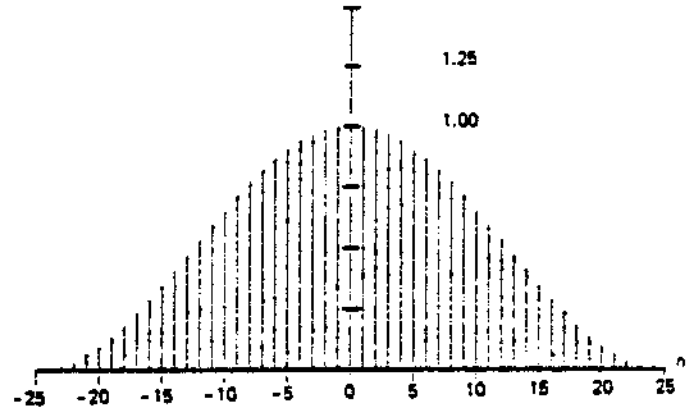
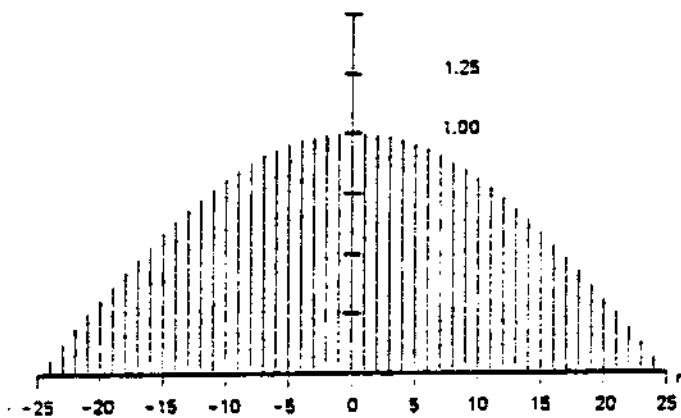


Figure 14. $\text{Cos}(n\pi/N)$ Window, Fourier Transform, and Log-Magnitude of Transform

Figure 15. $\text{Cos}^2(n\pi/N)$ Window, Fourier Transform, and Log-Magnitude of Transform

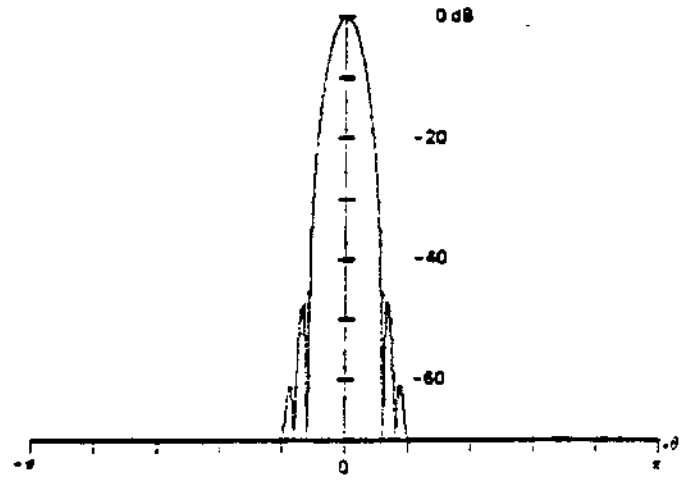
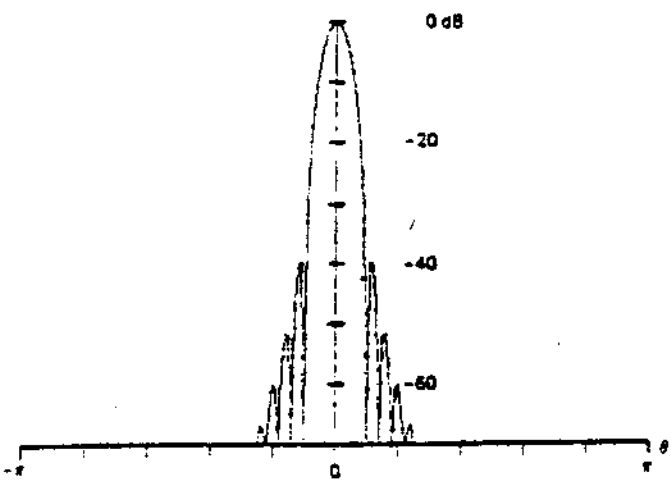
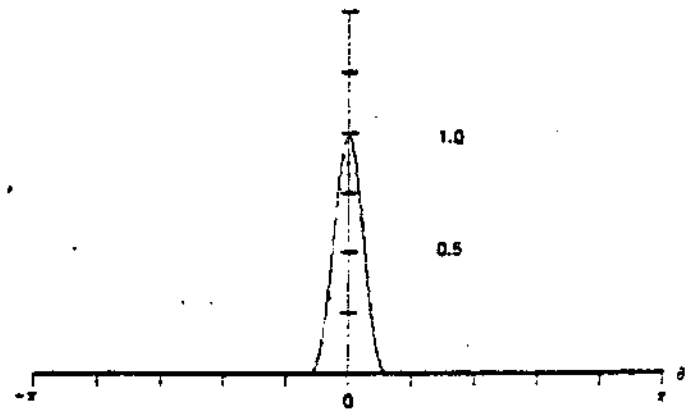
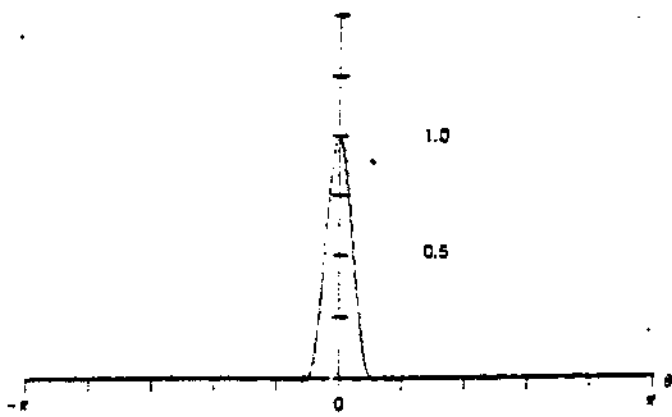
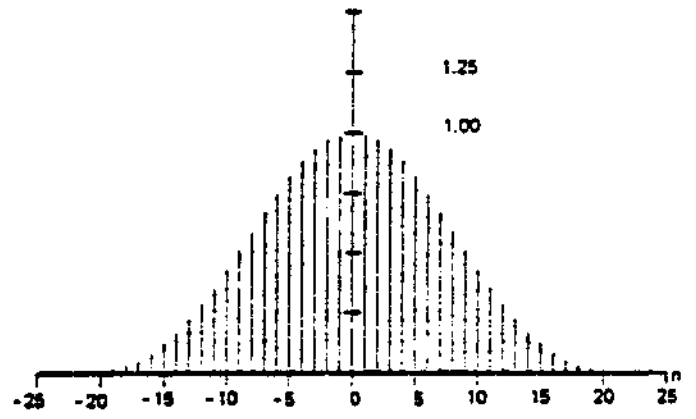
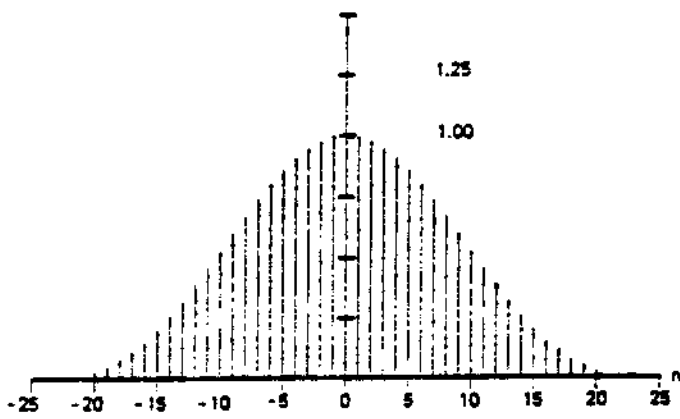


Figure 16. Cos^2 ($n\pi/N$) Window, Fourier Transform, and Log-Magnitude of Transform

Figure 17. Cos^4 ($n\pi/N$) Window, Fourier Transform, and Log-Magnitude of Transform

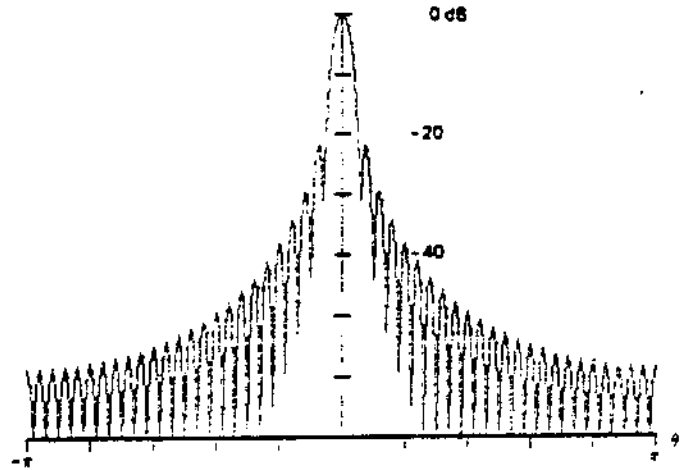
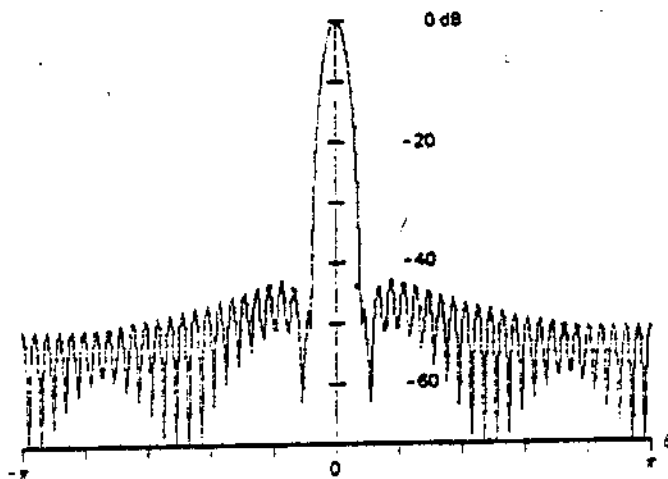
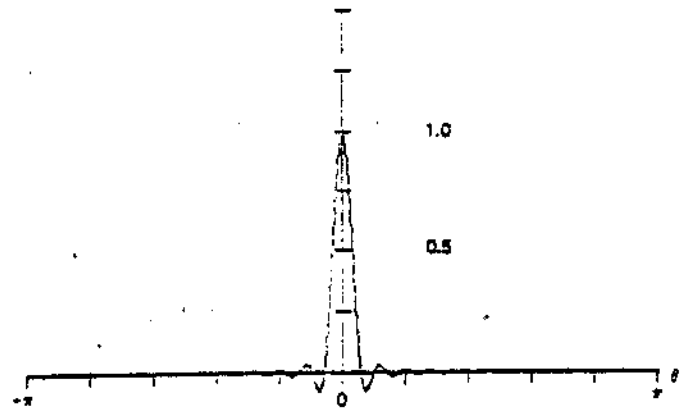
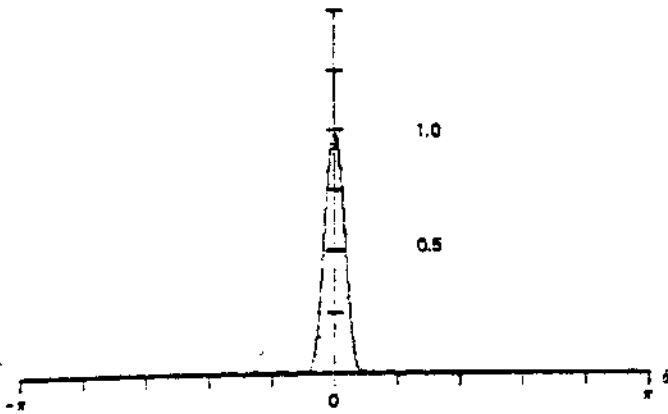
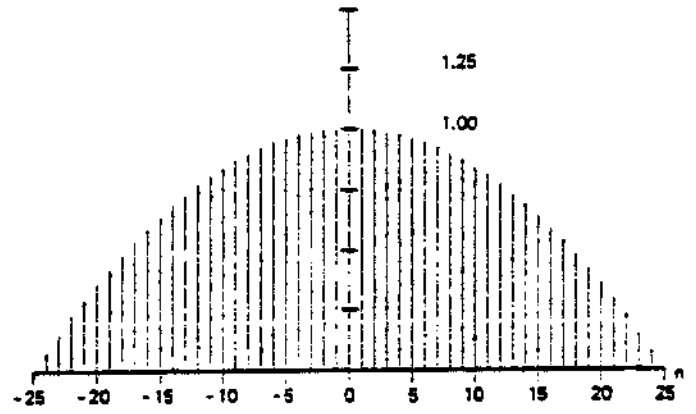
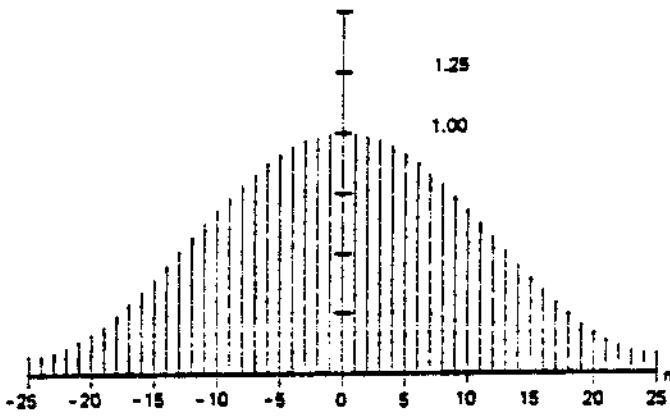


Figure 19. Hamming Window, Fourier Transform, and Log-Magnitude of Fourier Transform

Figure 20. Riesz Window, Fourier Transform, and Log-Magnitude of Transform

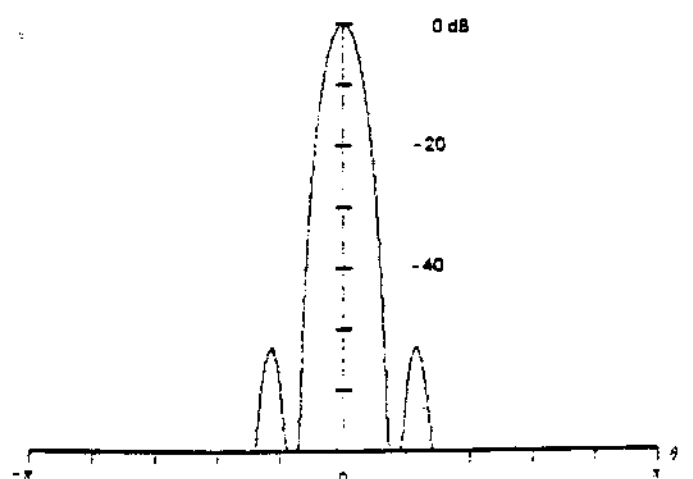
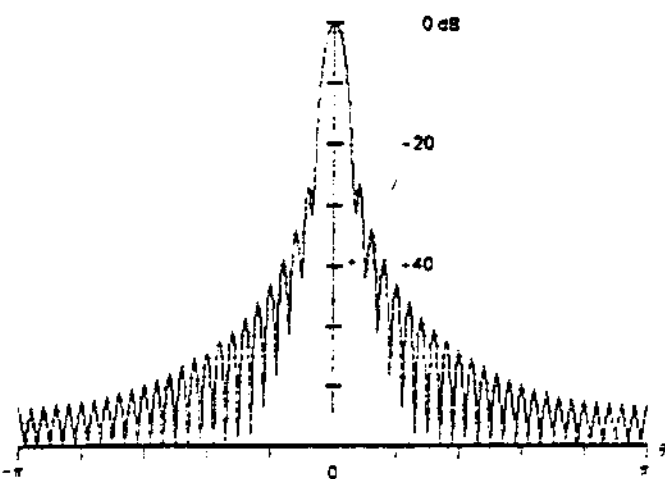
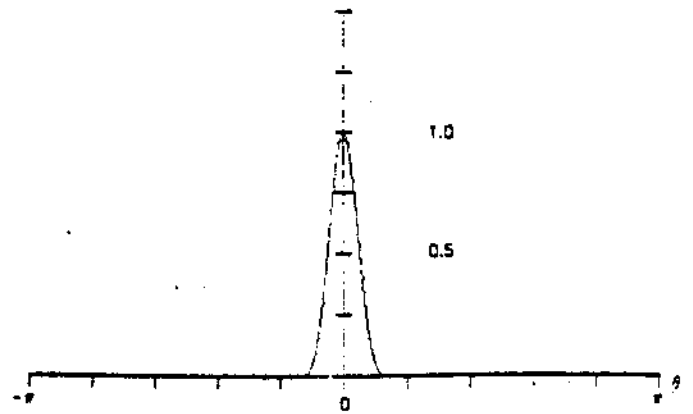
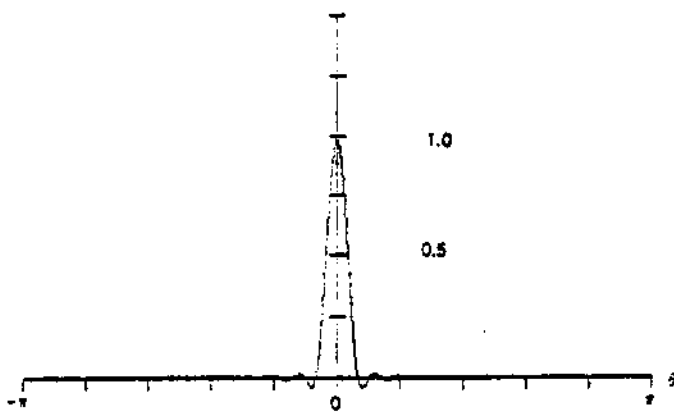
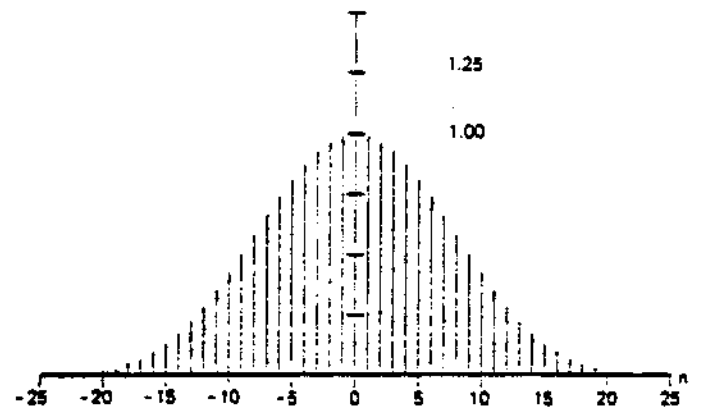
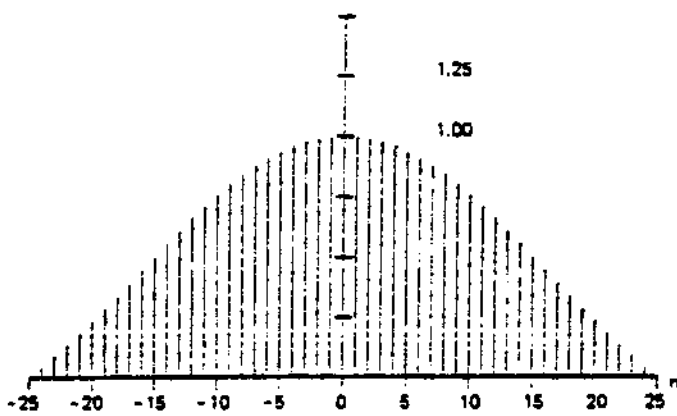


Figure 21. Riemann Window, Fourier Transform, and Log-Magnitude of Transform

Figure 22. Je la Vallée-Poussin Window, Fourier Transform and Log-Magnitude of Transform

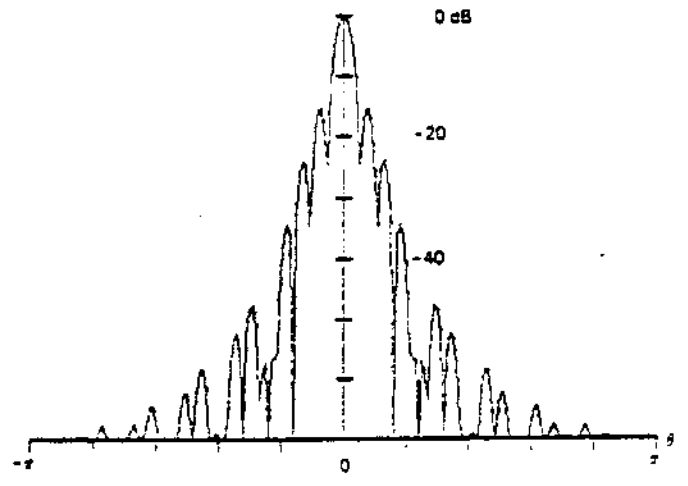
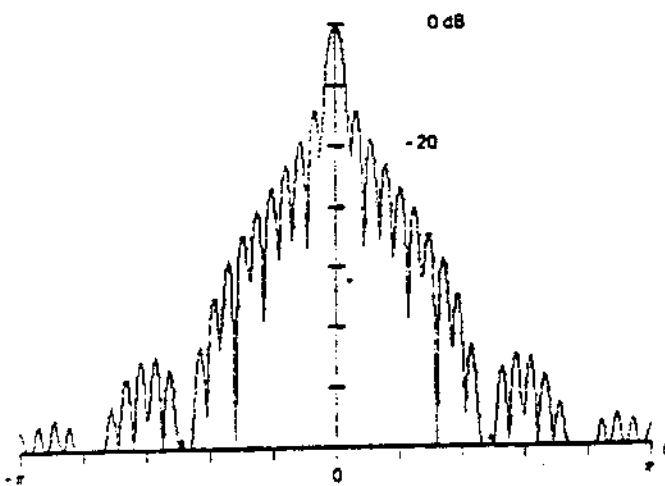
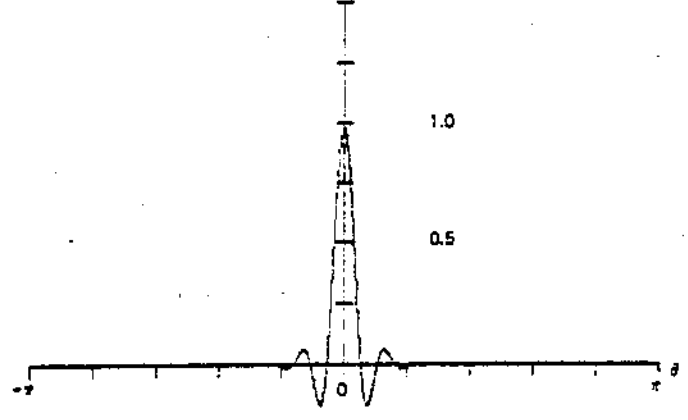
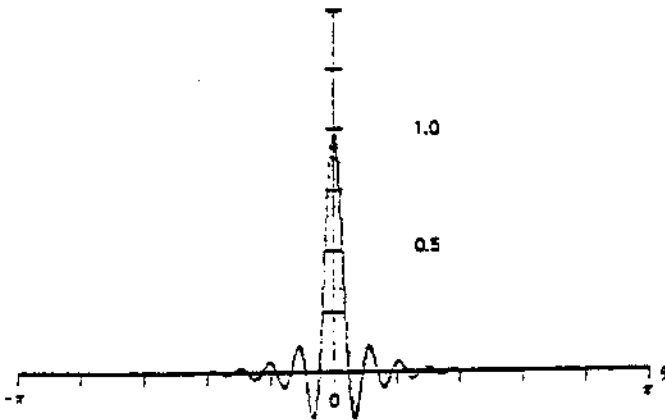
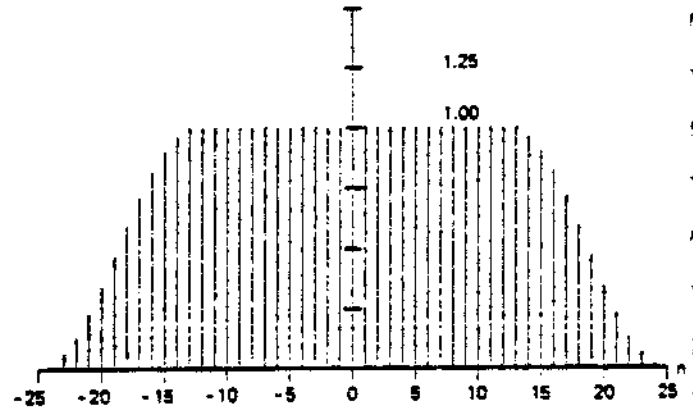
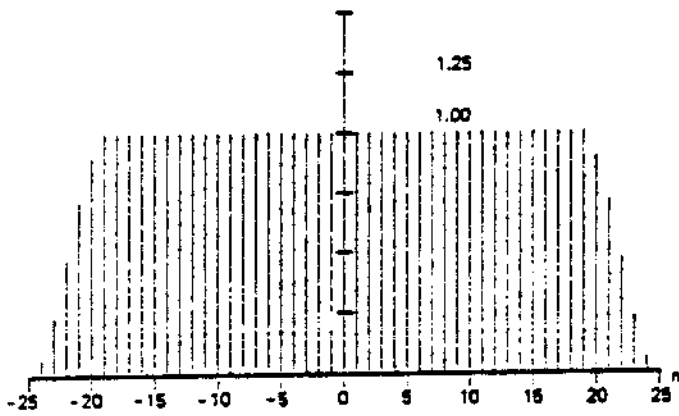


Figure 23. 25% Cosine Taper (Tukey) Window, Fourier Transform and Log-Magnitude of Transform

Figure 24. 50% Cosine Taper (Tukey) Window, Fourier Transform and Log-Magnitude of Transform

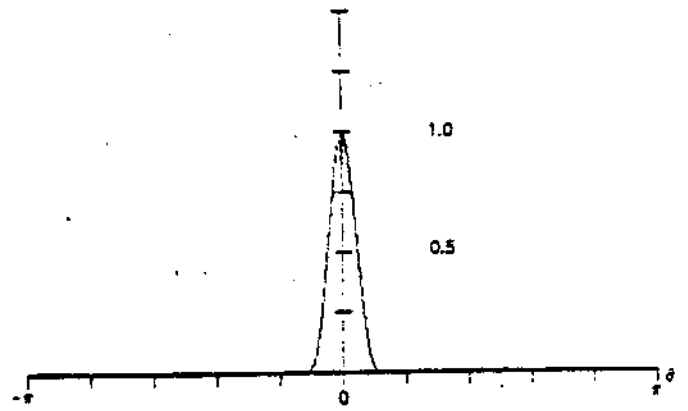
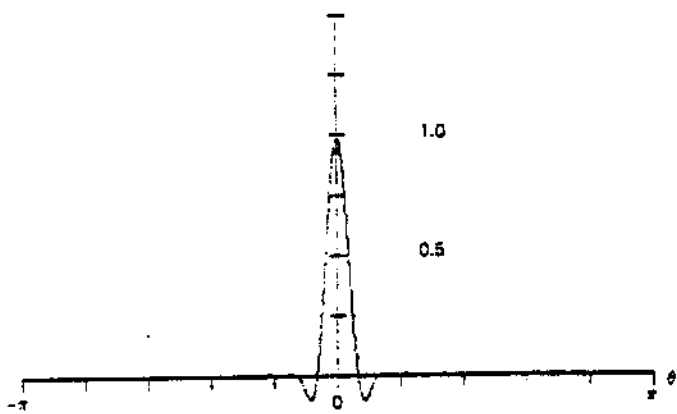
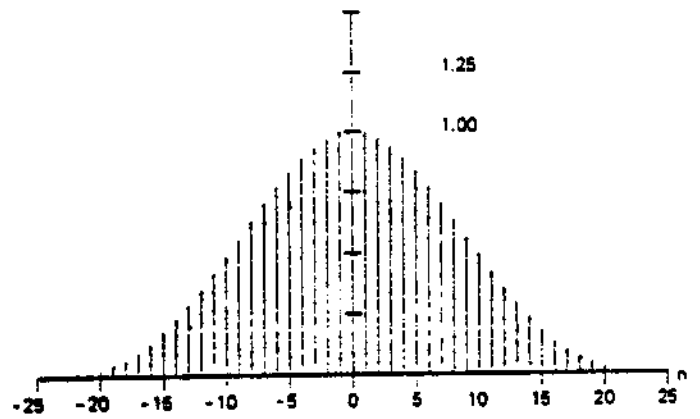
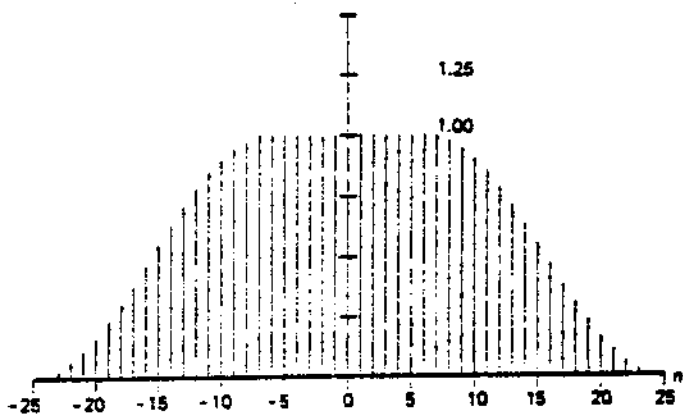


Figure 25. 75% Cosine Taper (Tukey) Window, Fourier Transform and Log-Magnitude of Transform

Figure 26. Bobman Window, Fourier Transform, and Log-Magnitude of Transform

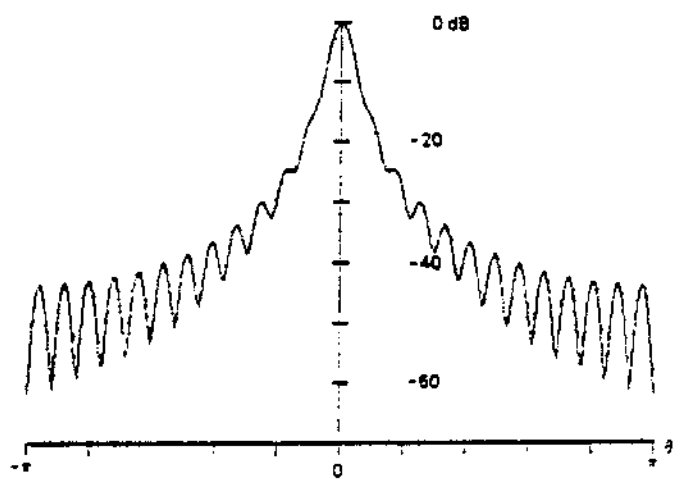
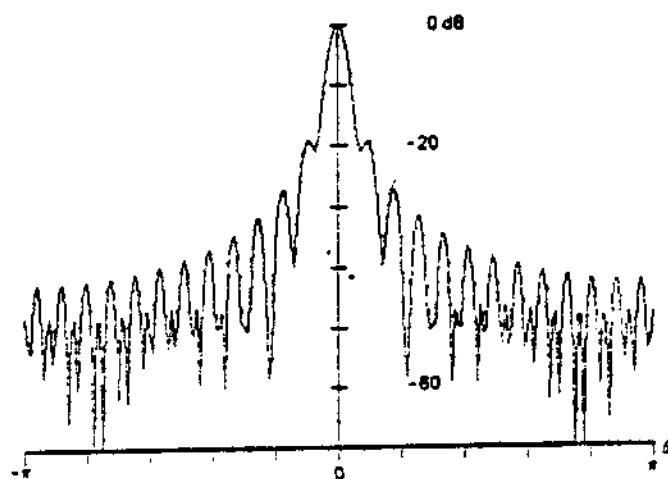
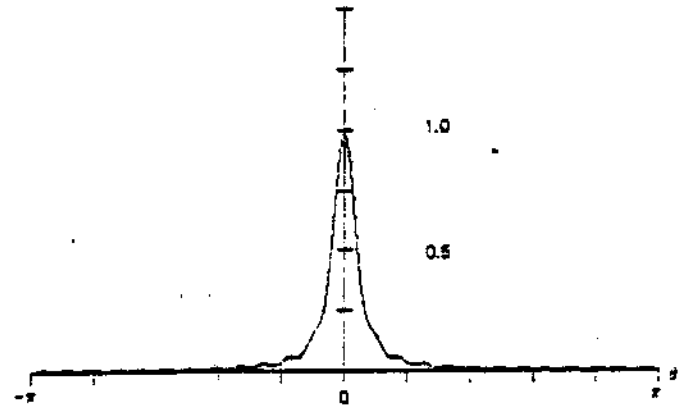
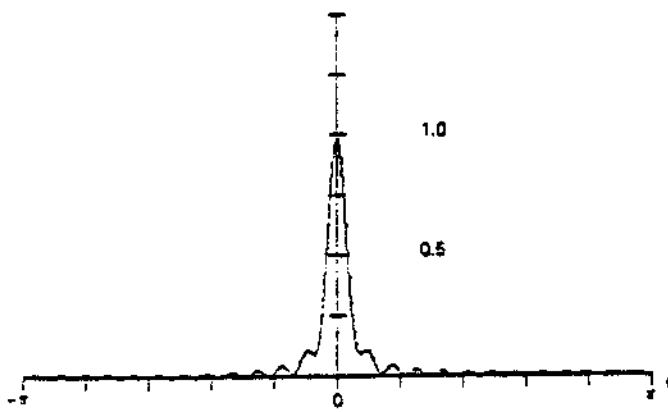
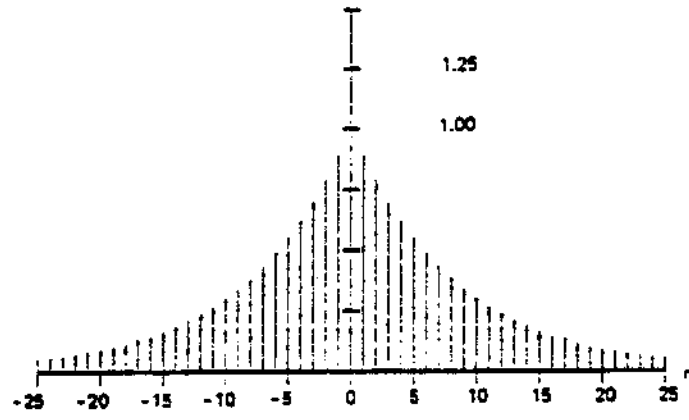
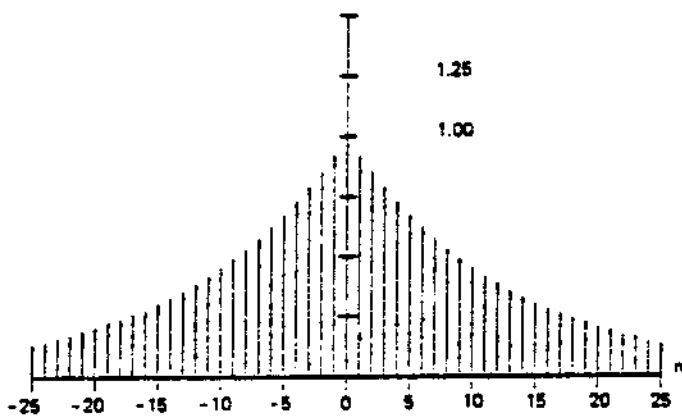


Figure 27. Poisson Window, Fourier Transform, and Log-Magnitude of Transform. ($\alpha = 2.0$)

Figure 28. Poisson Window, Fourier Transform, and Log-Magnitude of Transform. ($\alpha = 3.0$)

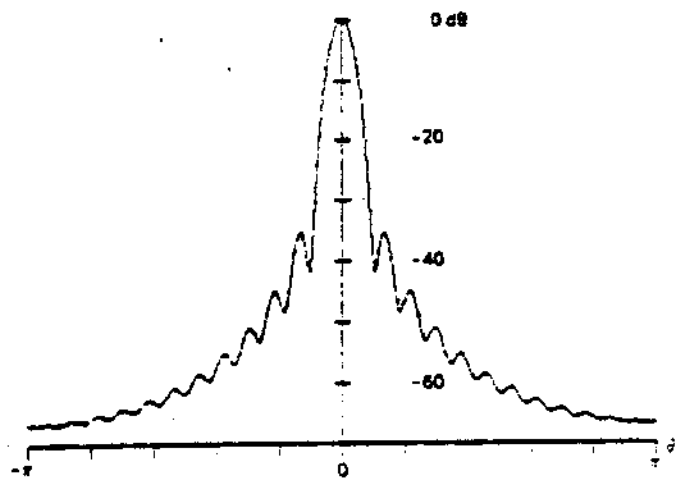
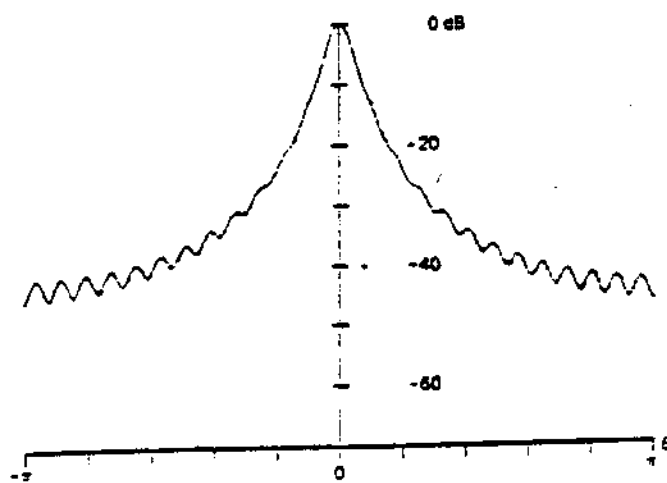
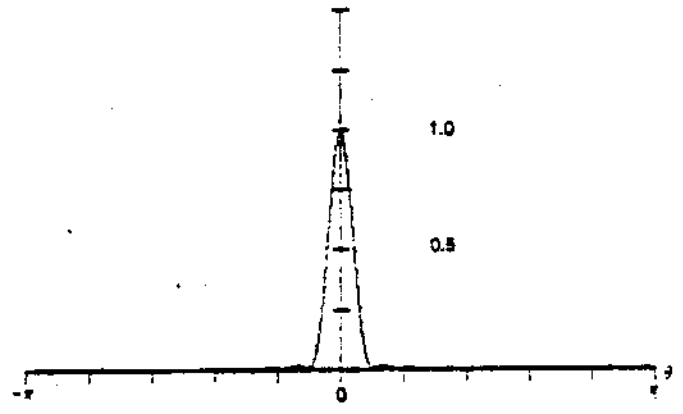
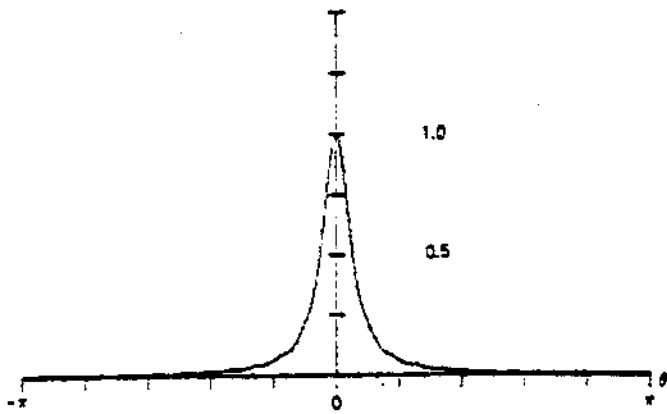
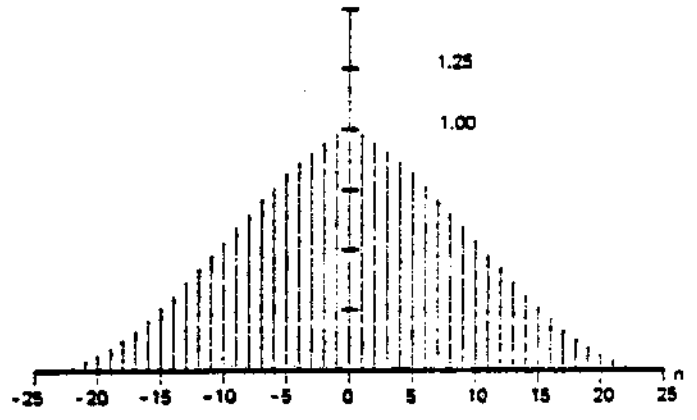
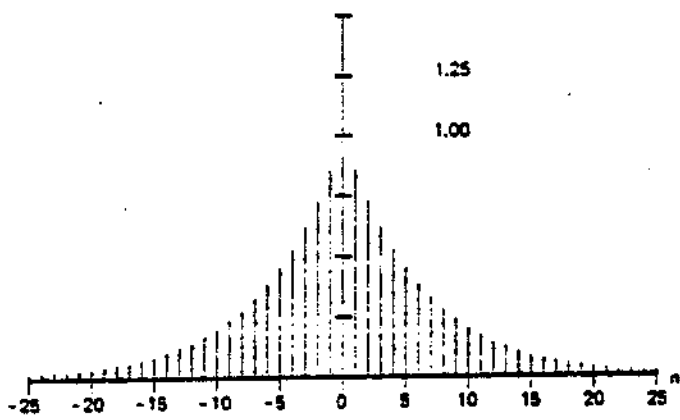


Figure 29. Poisson Window, Fourier Transform, and Log-Magnitude of Transform. ($a = 4.0$)

Figure 30. Hanning-Poisson Window, Fourier Transform, and Log-Magnitude of Transform. ($a = 0.5$)

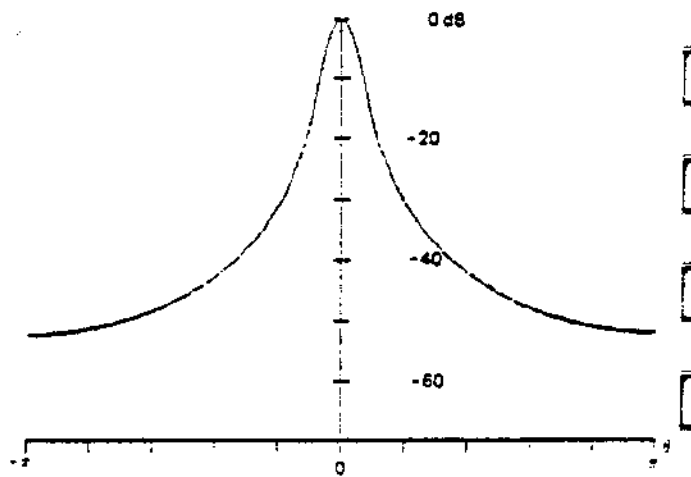
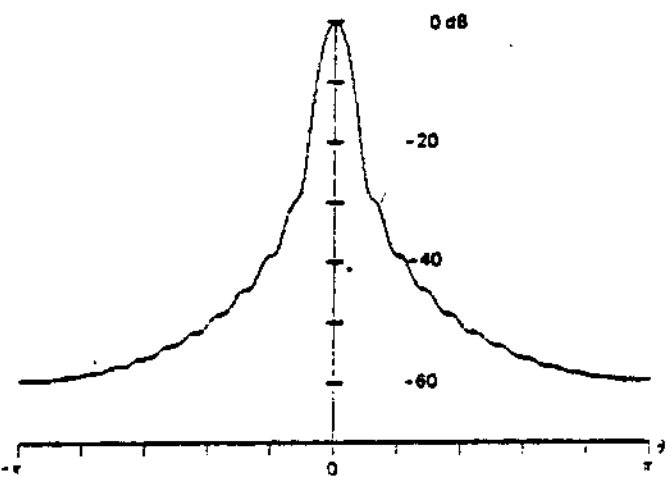
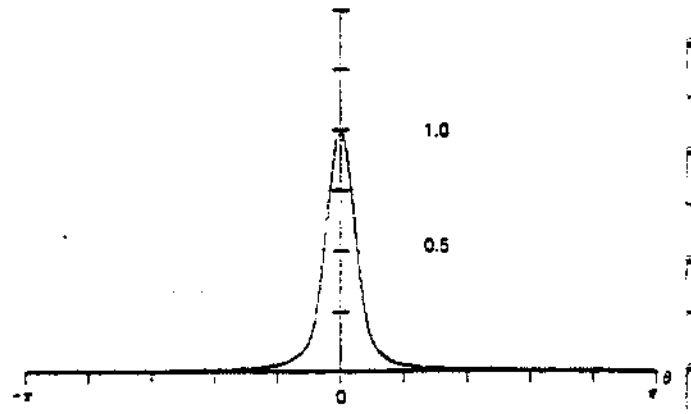
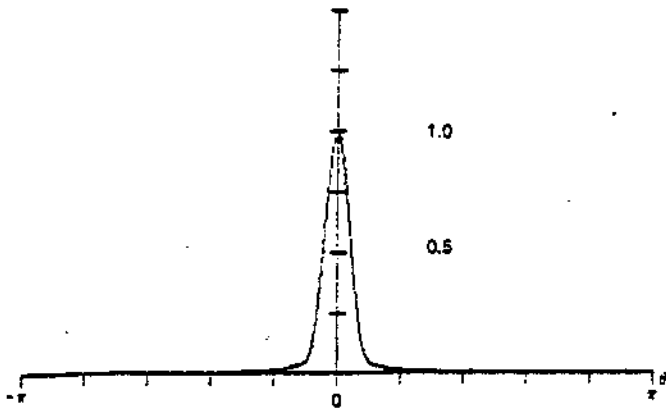
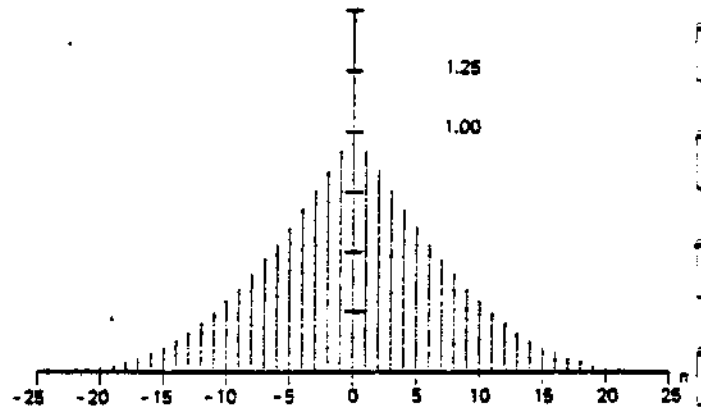
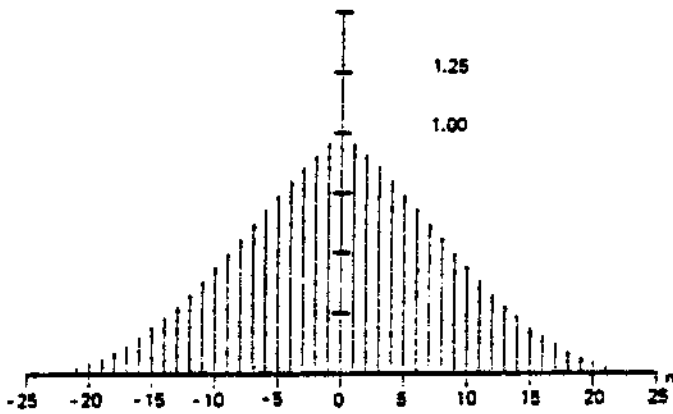


Figure 31. Hanning-Poisson Window, Fourier Transform, and Log-Magnitude of Transform. ($\alpha = 1.0$)

Figure 32. Hanning-Poisson Window, Fourier Transform, and Log-Magnitude of Transform. ($\alpha = 2.0$)

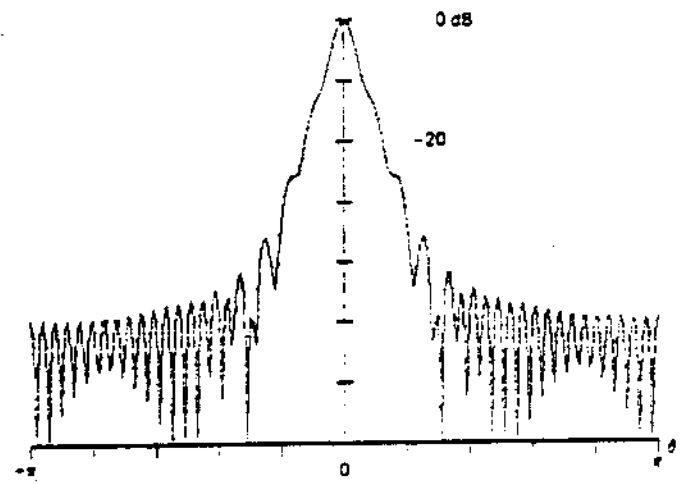
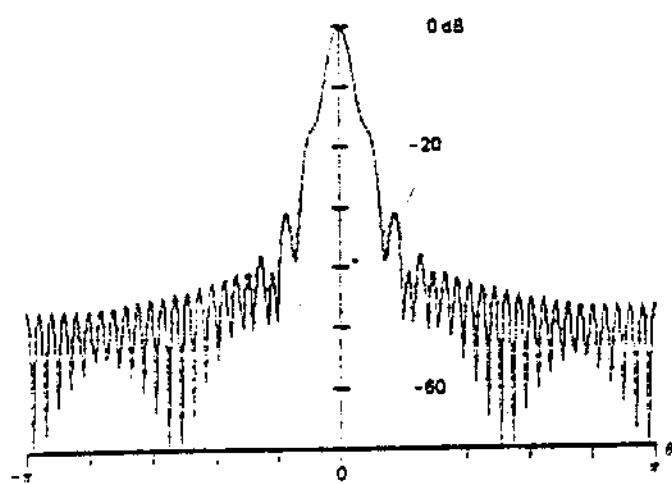
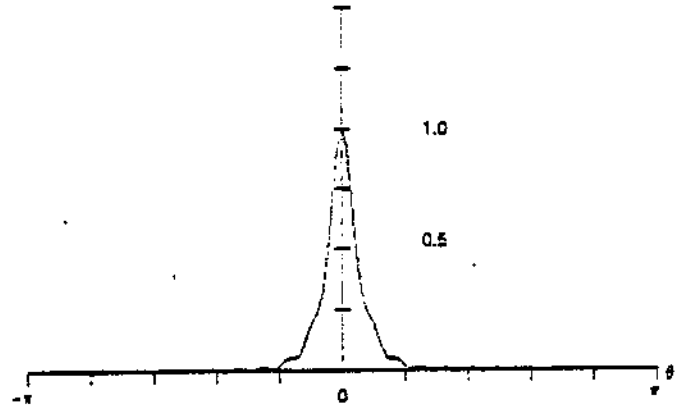
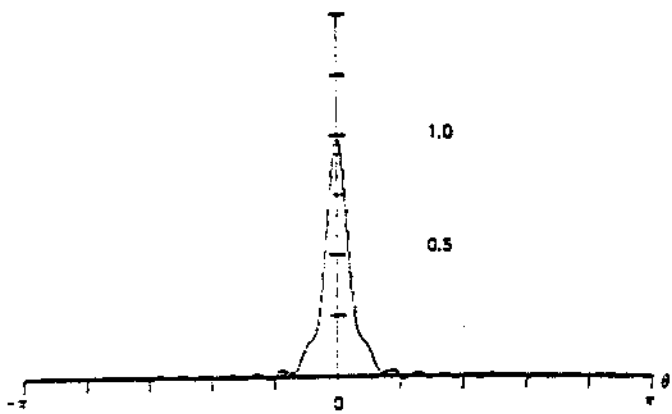
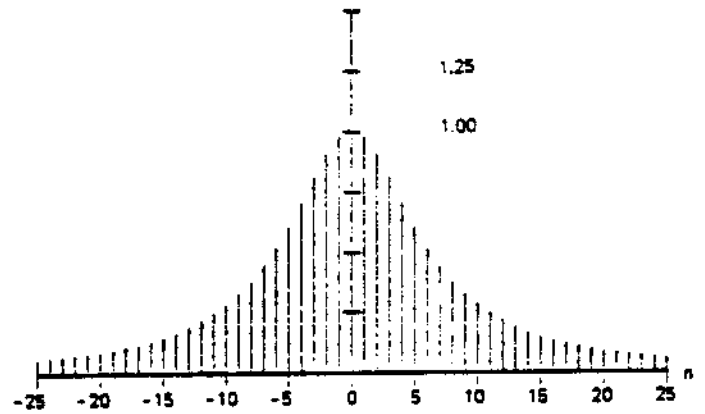
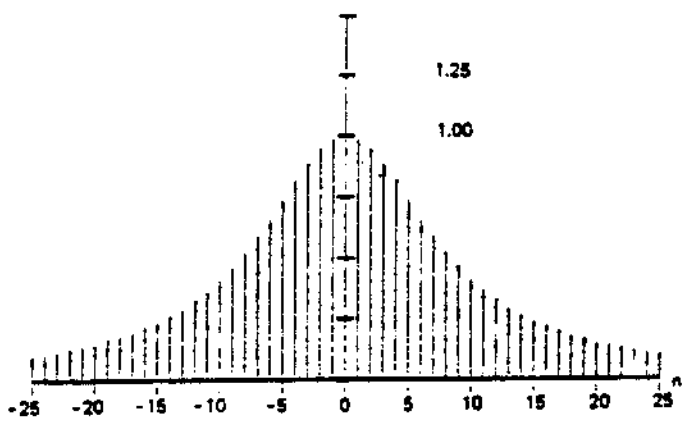


Figure 33. Casby Window, Fourier Transform, and Log-Magnitude of Transform. ($a = 3.0$)

Figure 34. Casby Window, Fourier Transform, and Log-Magnitude of Transform. ($a = 4.0$)

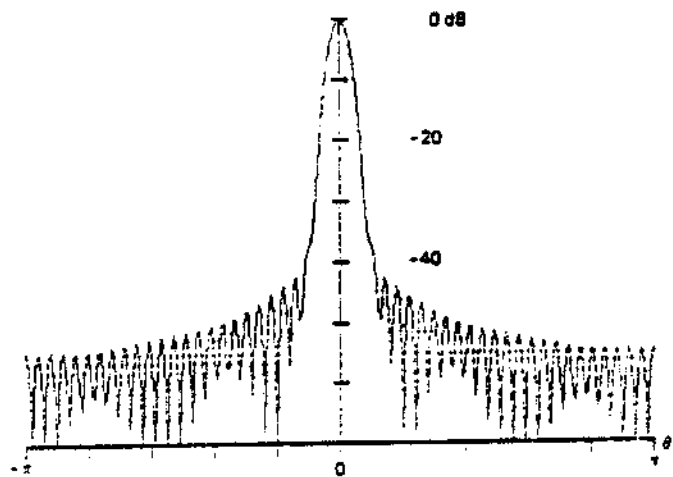
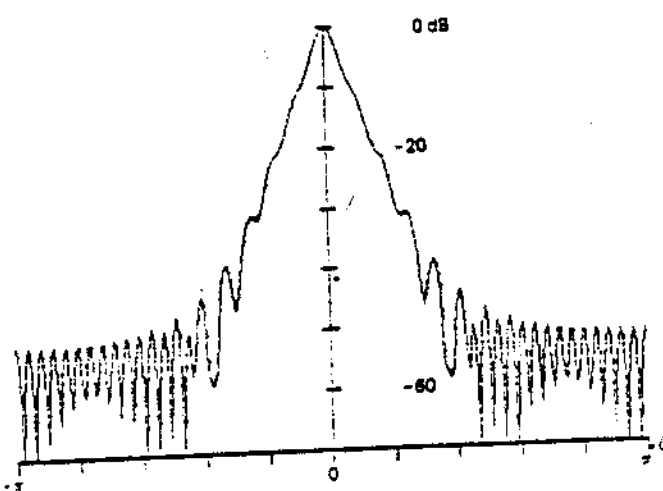
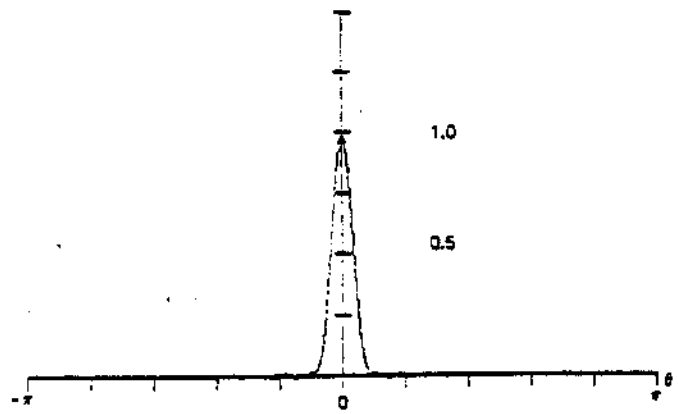
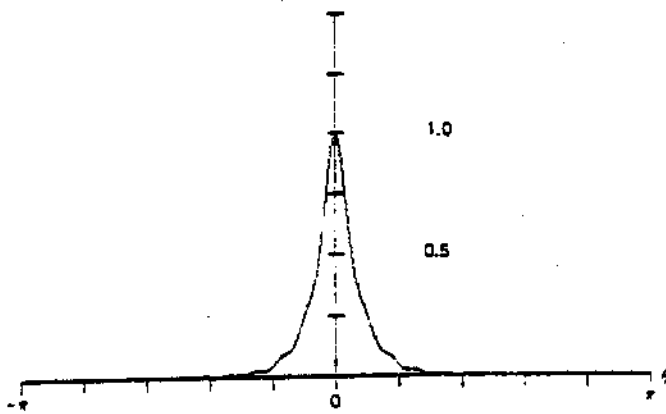
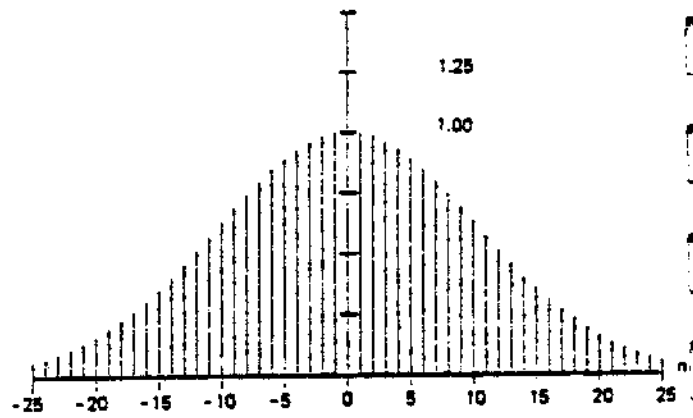
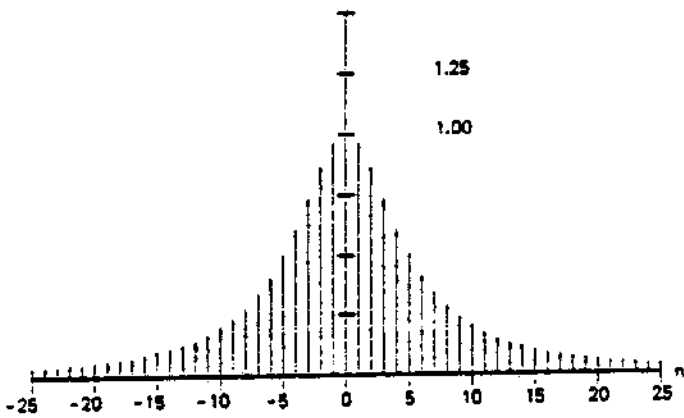


Figure 35. Cauchy Window, Fourier Transform, and Log-Magnitude of Transform. ($a = 5.0$)

Figure 36. Gaussian Window, Fourier Transform, and Log-Magnitude of Transform. ($a = 2.5$)

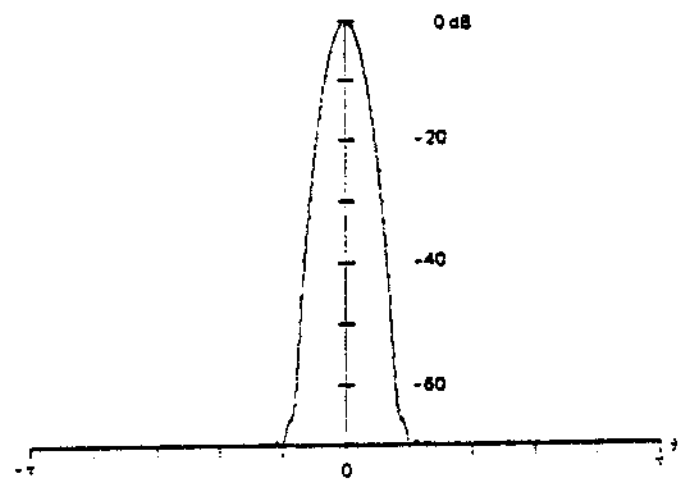
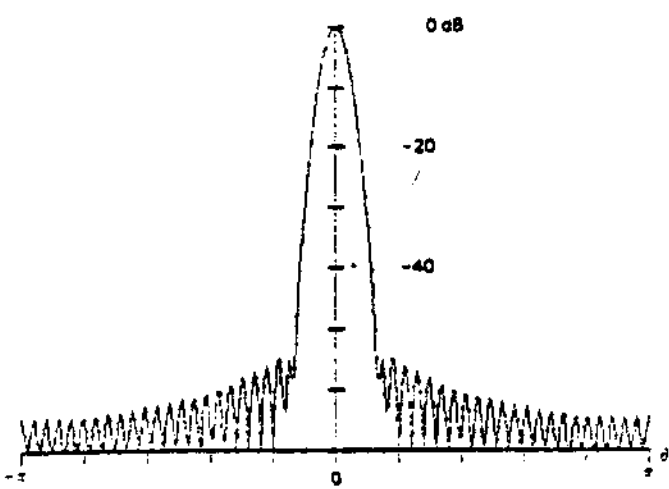
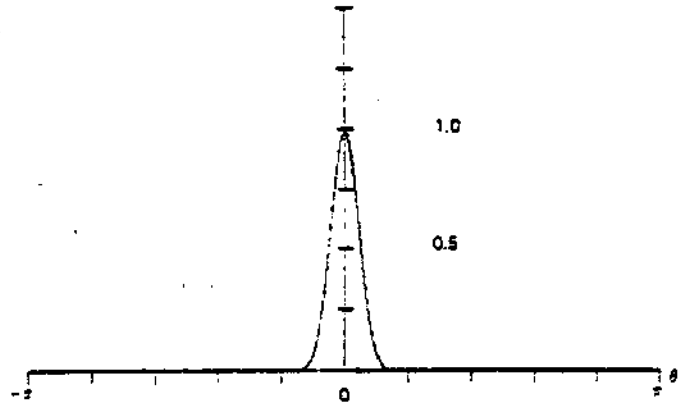
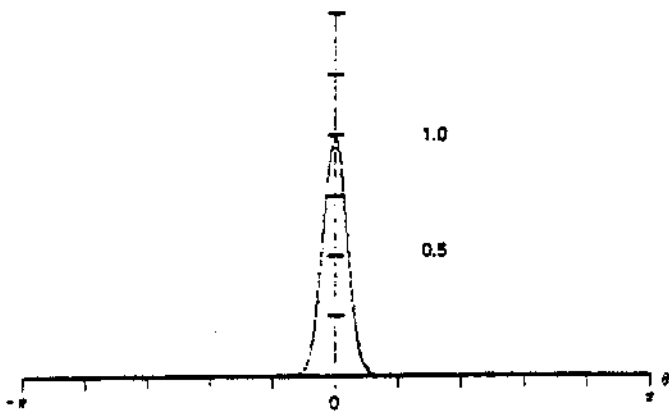
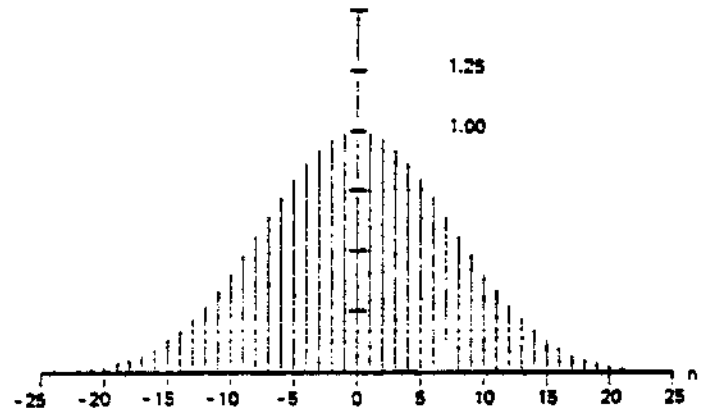
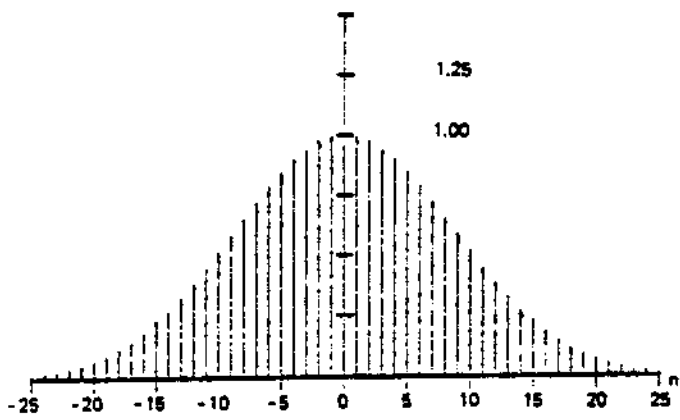


Figure 37. Gaussian Window, Fourier Transform, and Log-Magnitude of Transform. ($a = 3.0$)

Figure 38. Gaussian Window, Fourier Transform, and Log-Magnitude of Transform. ($a = 3.5$)

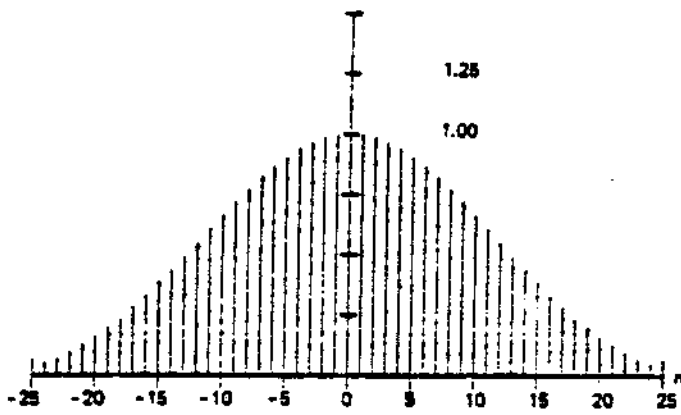


Figure 39. Dolph-Tchebyshev Window, Fourier Transform, and Log-Magnitude of Transform. ($\alpha = 3.5$)

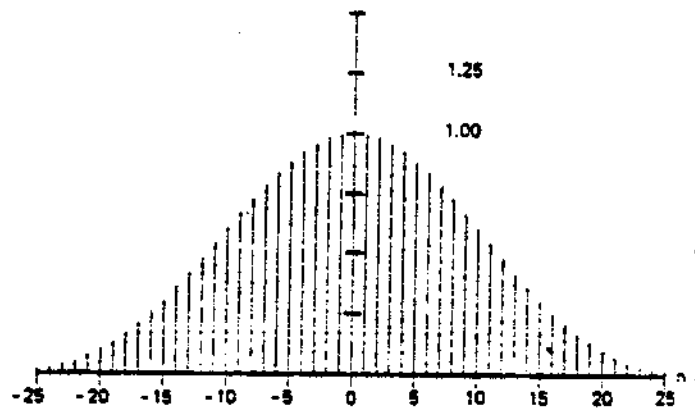


Figure 40. Dolph-Tchebyshev Window, Fourier Transform, and Log-Magnitude of Transform. ($\alpha = 3.0$)

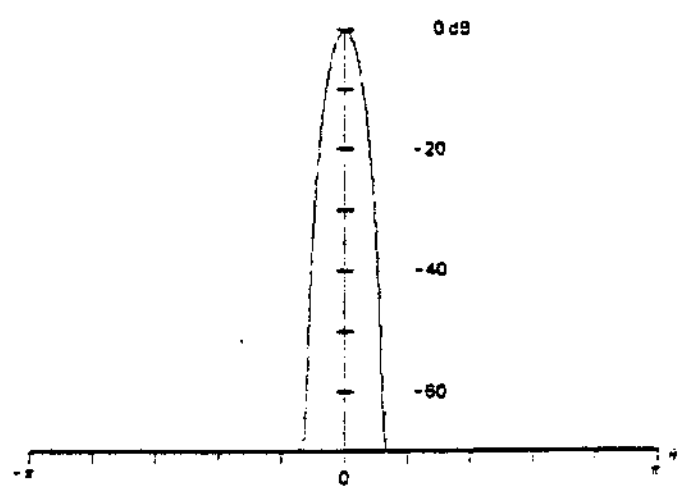
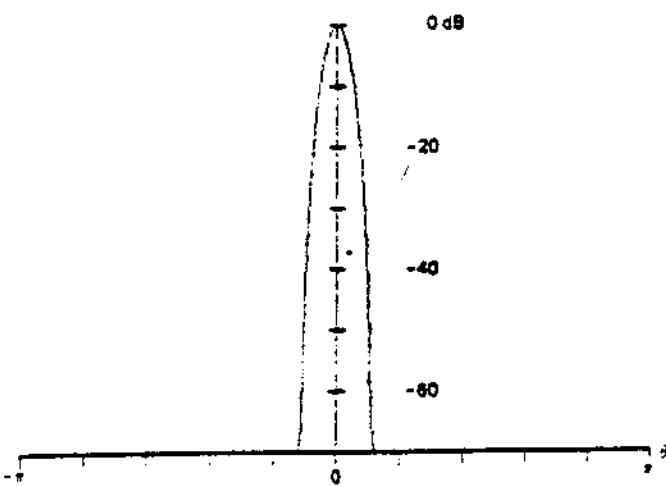
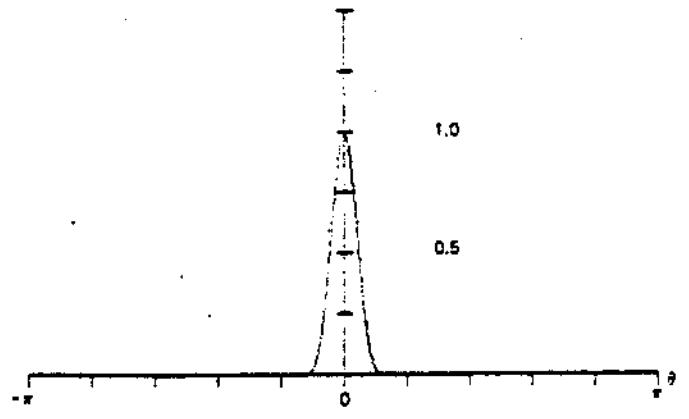
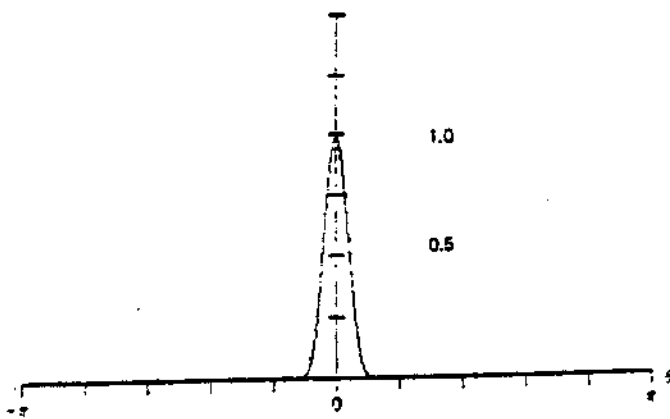
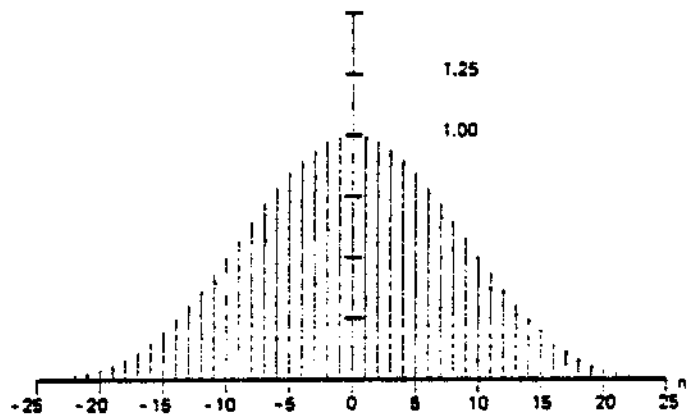
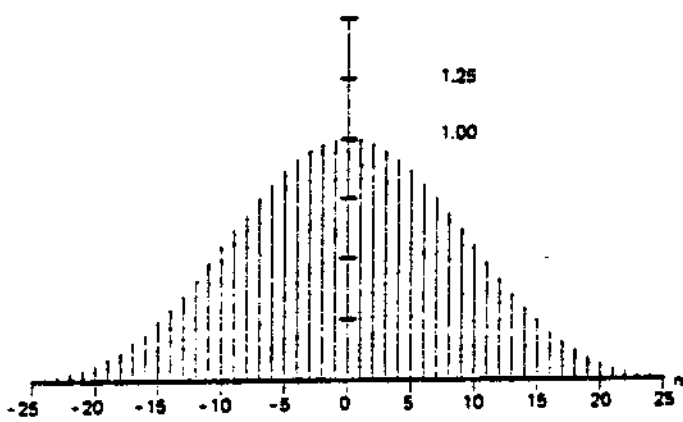


Figure 41. Dolph-Tchebyshev Window, Fourier Transform, and Log-Magnitude of Transform. ($\alpha = 3.5$)

Figure 42. Dolph-Tchebyshev Window, Fourier Transform, and Log-Magnitude of Transform. ($\alpha = 4.0$)

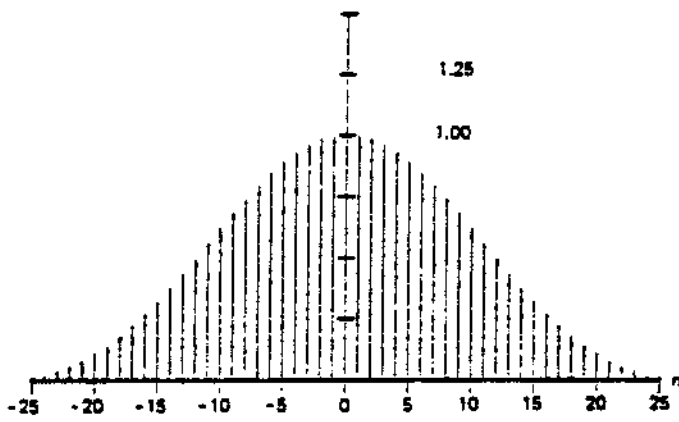


Figure 43. Kaiser-Bessel Window, Fourier Transform, and Log-Magnitude of Transform. ($\alpha = 2.0$)

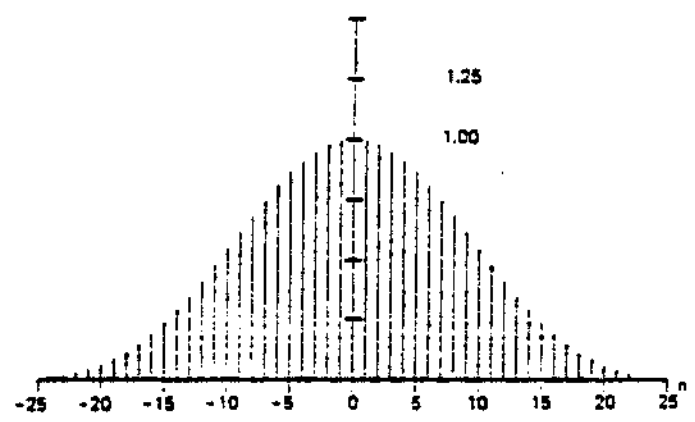
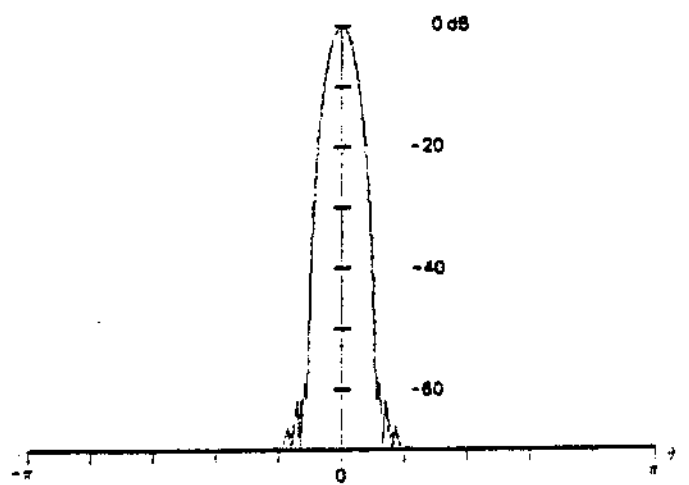
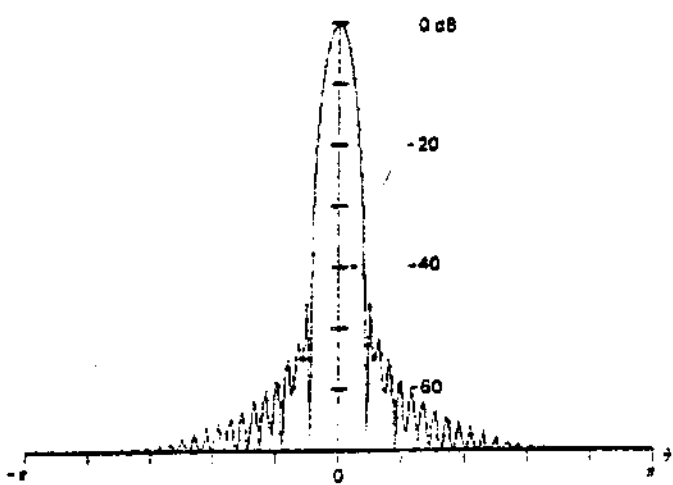
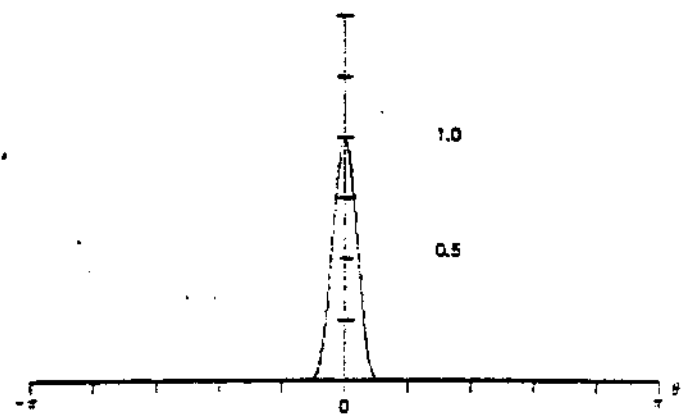
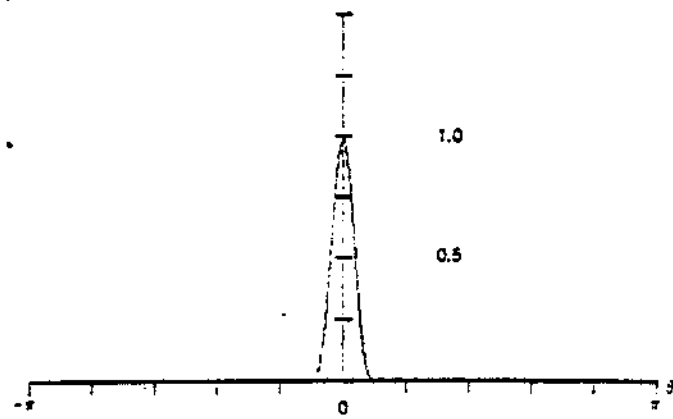


Figure 44. Kaiser-Bessel Window, Fourier Transform and Log-Magnitude of Transform. ($\alpha = 2.5$)



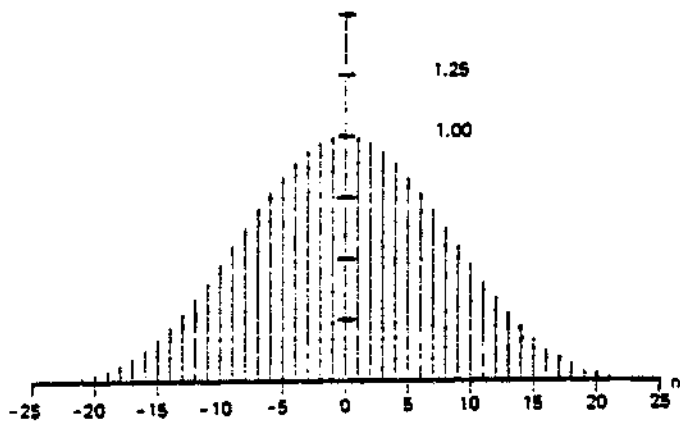


Figure 45. Kaiser-Bessel Window, Fourier Transform, and Log-Magnitude of Transform. ($\alpha = 1.0$)

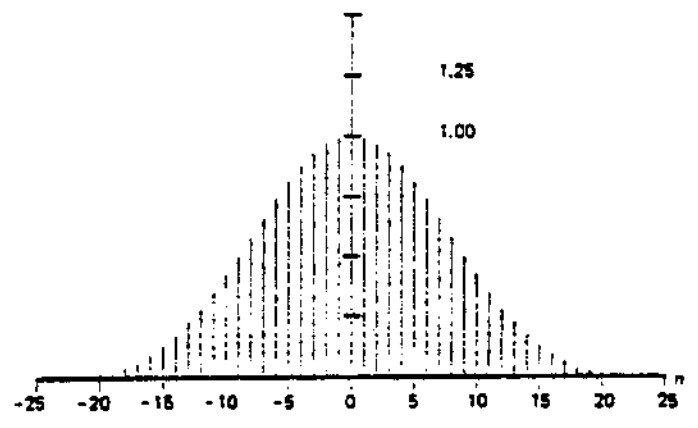


Figure 46. Kaiser-Bessel Window, Fourier Transform, and Log-Magnitude of Transform. ($\alpha = 3.5$)