3.27 In addition to saturation due to clipping, another common type of nonlinearity is the *dead-zone* nonlinearity shown in Figure 3.13.4. The algebraic representation of a dead zone of radius a is as follows.

$$F(x,a) \triangleq \begin{cases} 0 & , \quad 0 \le |x| \le a \\ x & , \quad a < |x| < \infty \end{cases}$$

Suppose $f_s = 2000$ Hz, and $N = 100$. Consider the following input signal where $0 \le k < N$ corresponds to one cycle.

$$x(k) = \cos(40\pi kT) \quad , \quad 0 \le k < N$$

Let the dead-zone radius be $a = 0.25$. Write a MATLAB script that does the following.

(a) Compute and plot $y(k) = F[x(k), a]$ vs. k.

(b) Compute and plot the magnitude spectrum of $y(k)$.

(c) Compute and print the total harmonic distortion of $y(k)$ caused by the dead zone. Here, if d_i and θ_i for $0 \le i < M$ are the cosine form Fourier coefficients of $y(k)$ with $M = N/2$, then

$$\text{THD} = \frac{100(P_y - d_1^2/2)}{P_y} \ \%$$

Solution

```
% Problem 3.27

% Initialize

function prob3_27       % include this to make F(x,a) a local function
clc
clear
a = 0.25;

% Construct the input signal

fs = 2000;
T = 1/fs;
N = 100;
k = 0 : N-1;
```

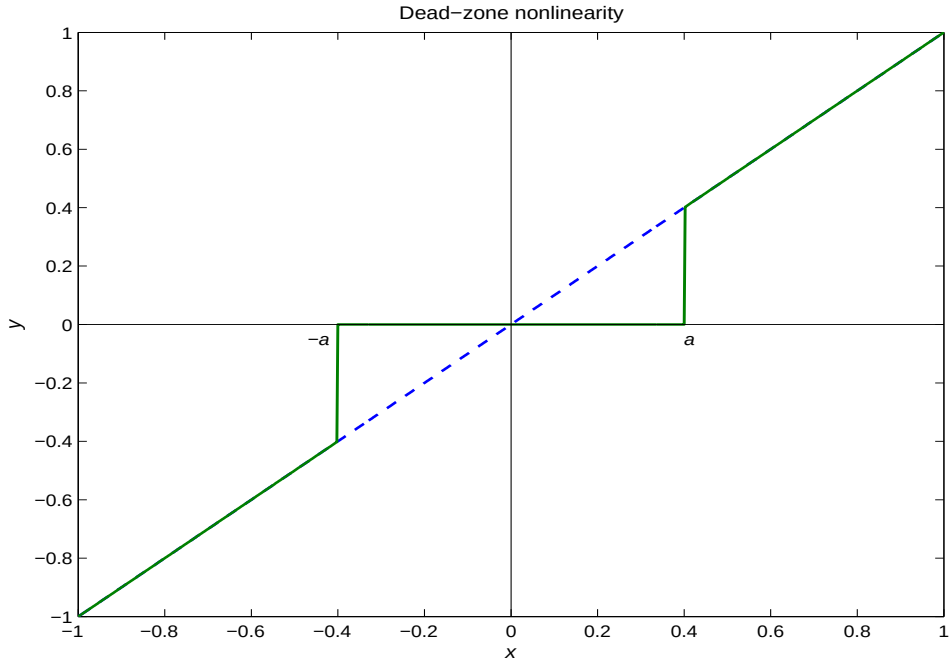
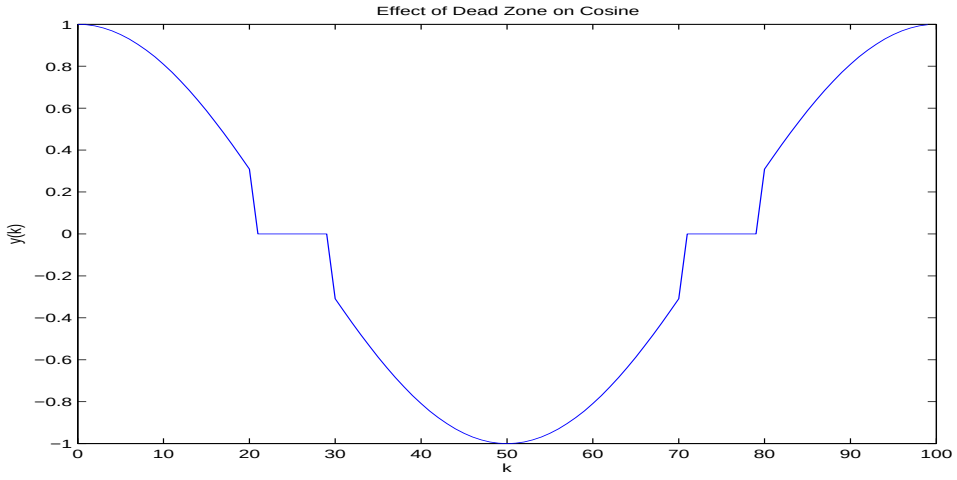


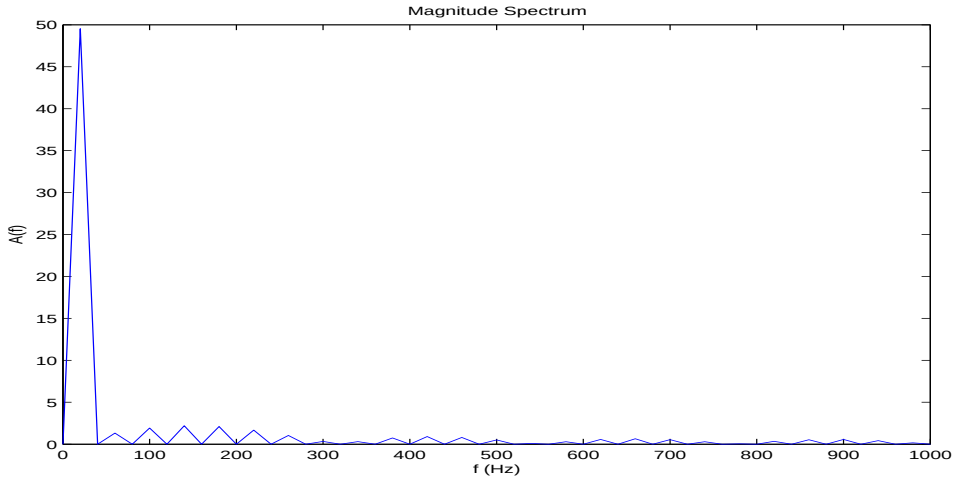
Figure 3.13.4: Dead-Zone Nonlinearity of Radius a

```
x = cos(40*pi*k*T);

% Plot y(k) = F[x(k),a)]

y = F(x,a);
figure
plot (k,y)
f_labels ('Effect of Dead Zone on Cosine','k','y(k)')
f_wait

% Plot magnitude spectrum

Y = fft(y);
A = abs(Y);
f = linspace (0,(N-1)*fs/N,N);
figure
i = 1 : N/2 + 1;
plot (f(i),A(i))
f_labels ('Magnitude Spectrum','f (Hz)','A(f)')
f_wait

% Find total harmonic distortion

d = 2*abs(Y)/N;
P_y = (1/4)*d(1)^2 + (1/2)*sum(d(2:N/2).^2);
```

```
THD = 100*(P_y - (1/2)*d(2)^2)/P_y;
fprintf ('\nTotal Harmonic Distortion = %g percent\n',THD)

function y = F(x,a)

% Dead-zone function

y = x;
i = find(abs(x) <= a);
y(i) = 0;
```



(a)



(b)

(c)

Total Harmonic Distortion = 0.932876 percent