Aula 11

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I. Tutorial 11

O objetivo dessa prática é familiarizar o aluno com o uso da ferramenta conhecida como FFT (Fast Fourier Transform). Calculemos a FFT de uma amostra do sinal

$$x(t) = cos(2\pi t) \times sen(6\pi t) \tag{1}$$

Abaixo tem todo o código rodado no Matlab e seus respectivos gráficos e mensgens.

```
close all
clear
clc
Ts=0.01;
t=0:Ts:8;
x=cos(2*pi*t).*sin(6*pi*t); % sinal no tempo
X=fft(x); % transformada

N=length(t);
f=(0:(N-1))/(N*Ts); % compare com a expressao do tutorial
figure
subplot(2,1,1)
plot(f,abs(X)); % grafico de magnitude
ylabel('|X|')
subplot(2,1,2)
plot(f,angle(X)*180/pi); % grafico de fase
xlabel('f [Hz]')
ylabel('\angle X [deg]')

figure
plot(t,x)
xlabel('t [s]')
ylabel('x(t)')

G=tf([10],[1 1 10]); % funcao de transferencia do sistema
u=0.2*randn(N,1); % ruido de entrada
y=lsim(G,u,t'); % resposta do sistema

figure
plot(t,u,t,y)
legend('u','y')
xlabel('t [s]')

Y=fft(y);
figure
subplot(2,1,1)
semilogx(f(1:end/2),20*log10(abs(Y(1:end/2))));
ylabel('|Y|')
subplot(2,1,2)
semilogx(f(1:end/2),unwrap(angle(Y(1:end/2)))*180/pi);
xlabel('f [Hz]')
ylabel('\angle Y [deg]')

U=fft(u);
G2=Y./U; % funcao de transferencia estimada
```

```
figure
[mag,pha,w]=bode(G);
subplot(2,1,1)
semilogx(w/(2*pi),20*log10(squeeze(mag)),'b');
hold on
semilogx(f(1:end/2),20*log10(abs(G2(1:end/2))),'r');
ylabel('|G|')
legend('conhecida','estimada')
subplot(2,1,2)
semilogx(w/(2*pi),squeeze(pha),'b');
hold on
semilogx(f(1:end/2),unwrap(angle(G2(1:end/2)))*180/pi,'r');
ylabel('\angle G')
xlabel('f [Hz]')

a=[1 2 3 4 5];
b=[5 1 2 3 4];
c=conv(a,b) % convolucao no tempo
A=fft(a);
B=fft(b);
C=ifft(A.*B) % DFT inversa

la=length(a);
lb=length(b);
a=[a zeros(1,lb-1)] % zero-padding
b=[b zeros(1,la-1)] % zero-padding
A=fft(a);
B=fft(b);
C=ifft(A.*B)
```

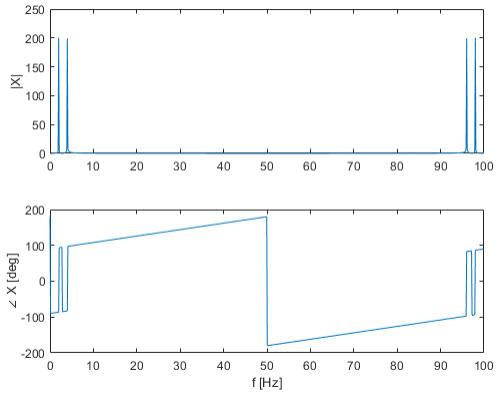

Figura 1: *Gráfico*

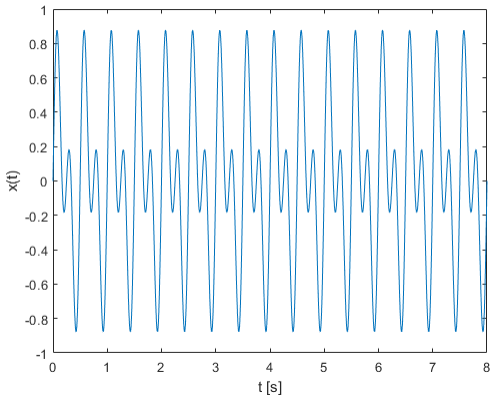

Figura 2: *Gráfico*

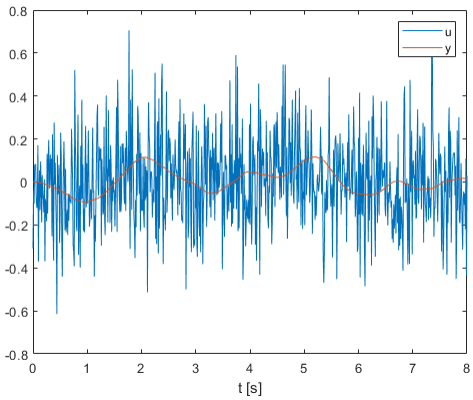

Figura 3: *Gráfico*

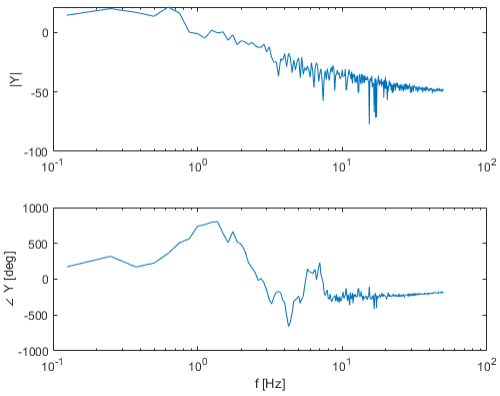

Figura 4: *Gráfico*

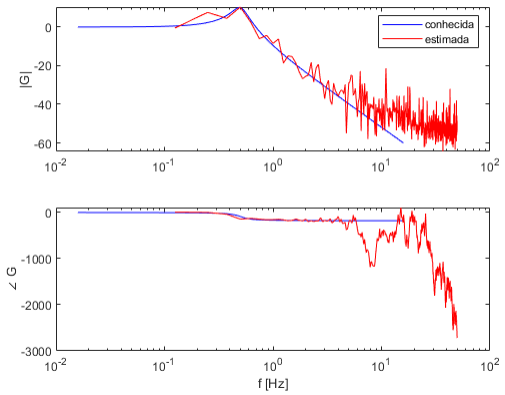

Figura 5: *Gráfico*

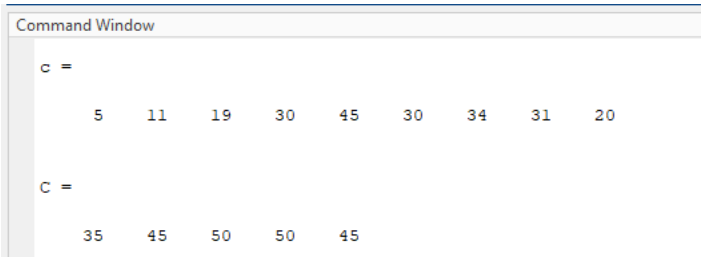

Figura 6: *Command Window*

Figura 7: *Command Window*

II. Exercício Computacional 11

I. $x_2[n] = 0.9\delta[n]$

```
close all
clear
clc

```

```
Ts=0.01;
t=1:Ts:20;
x=zeros(1, length(t)); % sinal no tempo
x(1)=0.9;
X=fft(x); % transformada

N=length(t);
f=(0:(N-1))/(N*Ts); % compare com a expressão do tutorial
figure
subplot(2,1,1)
plot(f,abs(X)); % gráfico de magnitude
ylabel('|X|')
subplot(2,1,2)
plot(f,angle(X)*180/pi); % gráfico de fase
xlabel('f [Hz]')
ylabel('\angle X [deg]')

figure
plot(t,x)
xlabel('t [s]')
ylabel('x(t)')
```

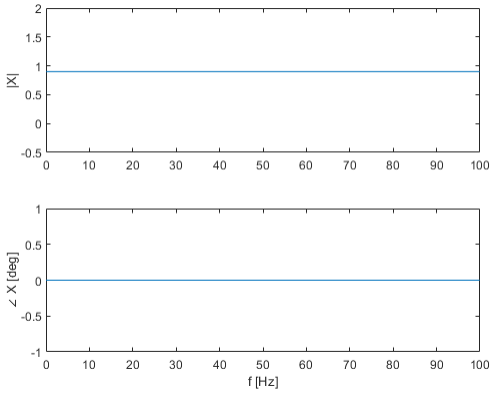

Figura 8: *Gráfico*

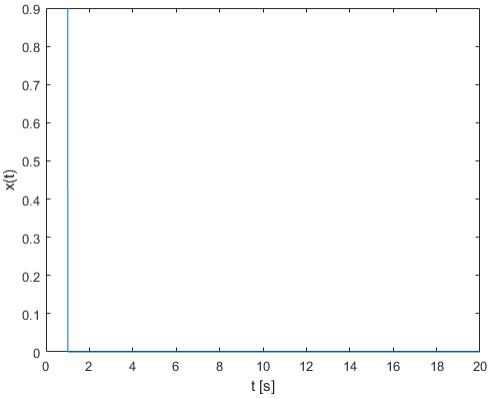

Figura 9: *Gráfico*

II. $x_1[n] = 0.9\delta[n-5]$

```
close all
clear
clc

Ts=0.01;
t=1:Ts:20;
x=zeros(1, length(t)); % sinal no tempo
x(5)=0.9;
X=fft(x); % transformada

N=length(t);
f=(0:(N-1))/(N*Ts); % compare com a expressão do tutorial
figure
subplot(2,1,1)
plot(f,abs(X)); % gráfico de magnitude
ylabel('|X|')
subplot(2,1,2)
plot(f,angle(X)*180/pi); % gráfico de fase
xlabel('f [Hz]')
ylabel('\angle X [deg]')

figure
plot(t,x)
xlabel('t [s]')
ylabel('x(t)')
```

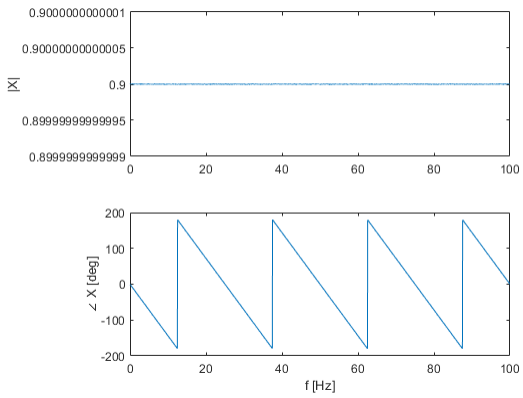

Figura 10: *Gráfico*

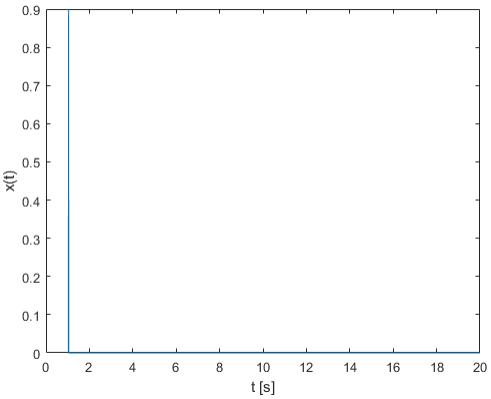

Figura 11: *Gráfico*

III. x = sin(2*π*15*t) + sin(2*π*40*t);

```
t = 0:1/100:10-1/100;                     % Time vector
x = sin(2*pi*15*t) + sin(2*pi*40*t);      % Signal

y = fft(x);                               % Compute DFT of x
m = abs(y);                               % Magnitude
y(m<1e-6) = 0;
p = unwrap(angle(y));                     % Phase

f = (0:length(y)-1)*100/length(y);        % Frequency vector

subplot(2,1,1)
plot(f,m)
title('Magnitude')
ax = gca;
ax.XTick = [15 40 60 85];

subplot(2,1,2)
plot(f,p*180/pi)
title('Phase')
ax = gca;
ax.XTick = [15 40 60 85];

n = 512;
y = fft(x,n);
m = abs(y);
p = unwrap(angle(y));
f = (0:length(y)-1)*100/length(y);

subplot(2,1,1)
plot(f,m)
title('Magnitude')
ax = gca;
ax.XTick = [15 40 60 85];

subplot(2,1,2)
plot(f,p*180/pi)
title('Phase')
ax = gca;
ax.XTick = [15 40 60 85];
```

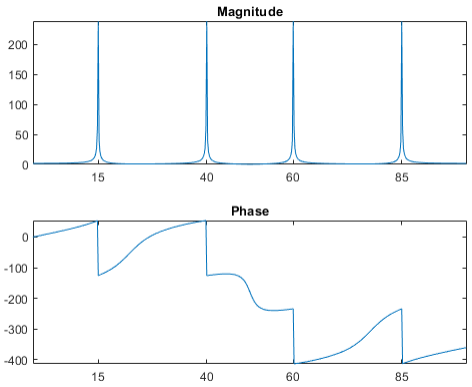

Figura 12: *Gráfico*