

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

$$x(t) = \cos(2\pi t) \times \sin(6\pi t) \quad (1)$$

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

```

1 close all
2 clear
3 clc
4 Ts=0.01;
5 t=0:Ts:8;
6 x=cos(2*pi*t).*sin(6*pi*t); % sinal no tempo
7 X=fft(x); % transformada
8
9 N=length(t);
10 f=(0:(N-1))/(N*Ts); % compare com a expressao do tutorial
11 figure
12 subplot(2,1,1)
13 plot(f,abs(X)); % grafico de magnitude
14 ylabel('|X|')
15 subplot(2,1,2)
16 plot(f,angle(X)*180/pi); % grafico de fase
17 xlabel('f [Hz]')
18 ylabel('\angle X [deg]')
19
20 figure
21 plot(t,x)
22 xlabel('t [s]')
23 ylabel('x(t)')
24
25 G=tf([10],[1 1 10]); % funcao de transferencia do sistema
26 u=0.2*randn(N,1); % ruído de entrada
27 y=lsim(G,u,t'); % resposta do sistema
28
29 figure
30 plot(t,u,t,y)
31 legend('u','y')
32 xlabel('t [s]')
33
34 Y=fft(y);
35 figure
36 subplot(2,1,1)
37 semilogx(f(1:end/2),20*log10(abs(Y(1:end/2))));
38 ylabel('|Y|')
39 subplot(2,1,2)
40 semilogx(f(1:end/2),unwrap(angle(Y(1:end/2)))*180/pi);
41 xlabel('f [Hz]')
42 ylabel('\angle Y [deg]')
43
44 U=fft(u);
45 G2=Y./U; % funcao de transferencia estimada

```

```

46 figure
47 [mag,pha,w]=bode(G);
48 subplot(2,1,1)
49 semilogx(w/(2*pi),20*log10(squeeze(mag)),'b');
50 hold on
51 semilogx(f(1:end/2),20*log10(abs(G2(1:end/2))),'r');
52 ylabel('|G|')
53 legend('conhecida','estimada')
54 subplot(2,1,2)
55 semilogx(w/(2*pi),squeeze(pha),'b');
56 hold on
57 semilogx(f(1:end/2),unwrap(angle(G2(1:end/2)))*180/pi,'r');
58 ylabel('\angle G')
59 xlabel('f [Hz]')
60
61 a=[1 2 3 4 5];
62 b=[5 1 2 3 4];
63 c=conv(a,b) % convolucao no tempo
64 A=fft(a);
65 B=fft(b);
66 C=ifft(A.*B) % DFT inversa
67
68 la=length(a);
69 lb=length(b);
70 a=[a zeros(1,lb-1)] % zero-padding
71 b=[b zeros(1,la-1)] % zero-padding
72 A=fft(a);
73 B=fft(b);
74 C=ifft(A.*B)

```

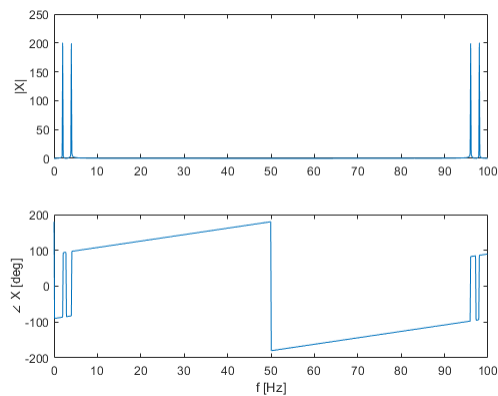
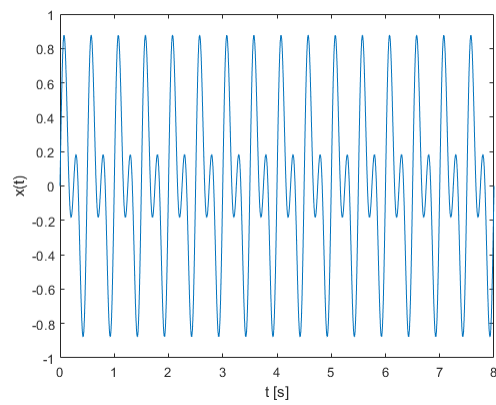
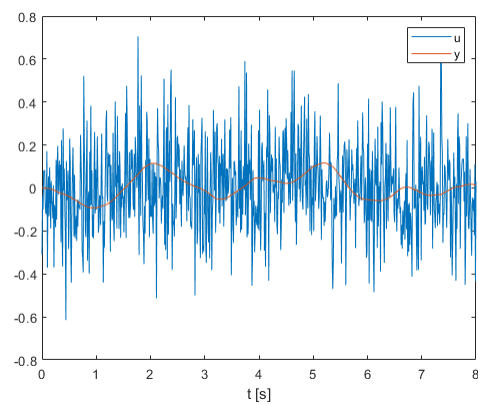
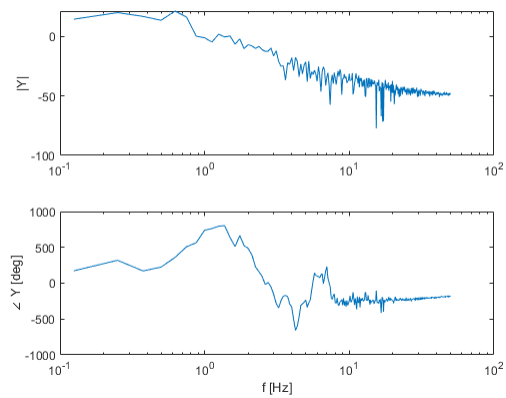


Figura 1: Gráfico

**Figura 2:** *Gráfico***Figura 3:** *Gráfico***Figura 4:** *Gráfico*

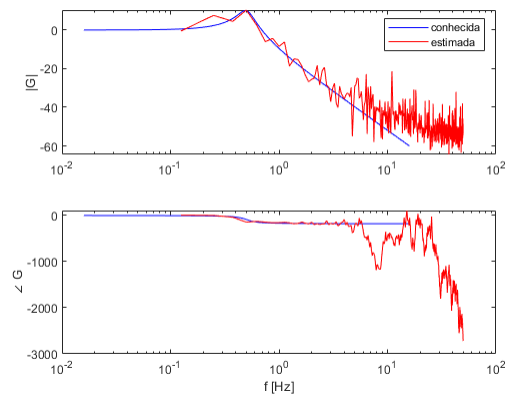


Figura 5: Gráfico



Figura 6: Command Window

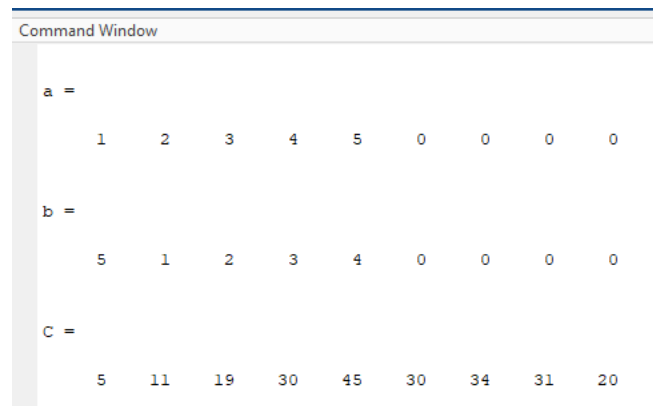


Figura 7: Command Window

II. EXERCÍCIO COMPUTACIONAL 11

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

```

1 close all
2 clear
3 clc
4
  
```

```

5 Ts=0.01;
6 t=1:Ts:20;
7 x=zeros(1, length(t)); % sinal no tempo
8 x(1)=0.9;
9 X=fft(x); % transformada
10
11 N=length(t);
12 f=(0:(N-1))/(N*Ts); % compare com a expres[U+FFFD] do tutorial
13 figure
14 subplot(2,1,1)
15 plot(f,abs(X)); % g[U+FFFD] de magnitude
16 ylabel('|X|')
17 subplot(2,1,2)
18 plot(f,angle(X)*180/pi); % g[U+FFFD] de fase
19 xlabel('f [Hz]')
20 ylabel('\angle X [deg]')
21
22 figure
23 plot(t,x)
24 xlabel('t [s]')
25 ylabel('x(t)')

```

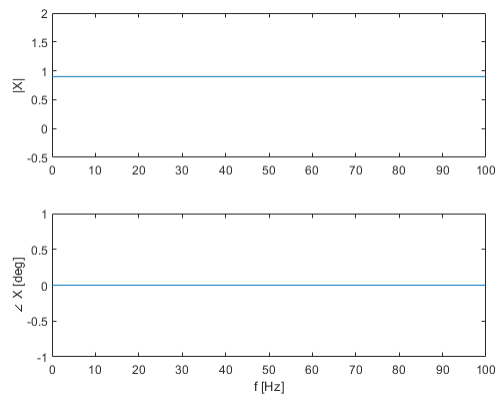


Figura 8: Gráfico

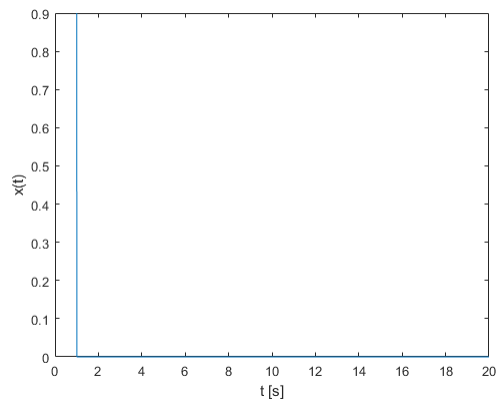


Figura 9: Gráfico

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

```

1 close all
2 clear
3 clc
4
5 Ts=0.01;
6 t=1:Ts:20;
7 x=zeros(1, length(t)); % sinal no tempo
8 x(5)=0.9;
9 X=fft(x); % transformada
10
11 N=length(t);
12 f=(0:(N-1))/(N*Ts); % compare com a express[U+FFFD] do tutorial
13 figure
14 subplot(2,1,1)
15 plot(f,abs(X)); % g[U+FFFD] de magnitude
16 ylabel('|X|')
17 subplot(2,1,2)
18 plot(f,angle(X)*180/pi); % g[U+FFFD] de fase
19 xlabel('f [Hz]')
20 ylabel('\angle X [deg]')
21
22 figure
23 plot(t,x)
24 xlabel('t [s]')
25 ylabel('x(t)')

```

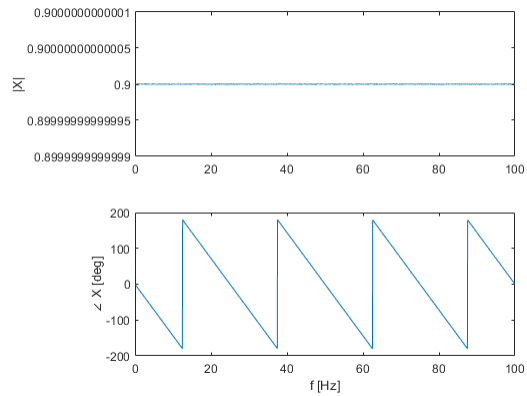


Figura 10: Gráfico

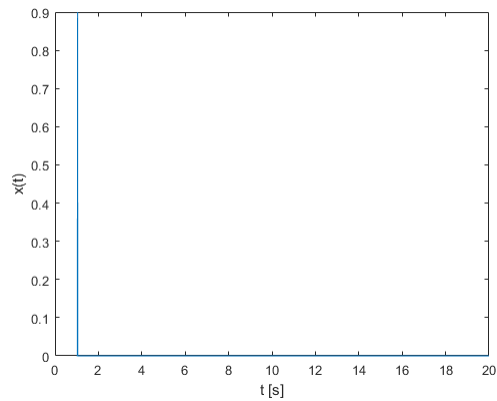


Figura 11: Gráfico

III. $x = \sin(2\pi \cdot 15 \cdot t) + \sin(2\pi \cdot 40 \cdot t);$

```

1  t = 0:1/100:10-1/100;           % Time vector
2  x = sin(2*pi*15*t) + sin(2*pi*40*t); % Signal
3
4  y = fft(x);                     % Compute DFT of x
5  m = abs(y);                     % Magnitude
6  y(m<1e-6) = 0;
7  p = unwrap(angle(y));           % Phase
8
9  f = (0:length(y)-1)*100/length(y); % Frequency vector
10
11 subplot(2,1,1)
12 plot(f,m)
13 title('Magnitude')
14 ax = gca;
15 ax.XTick = [15 40 60 85];
16
17 subplot(2,1,2)
18 plot(f,p*180/pi)
19 title('Phase')
20 ax = gca;
21 ax.XTick = [15 40 60 85];
22
23 n = 512;
24 y = fft(x,n);
25 m = abs(y);
26 p = unwrap(angle(y));
27 f = (0:length(y)-1)*100/length(y);
28
29 subplot(2,1,1)
30 plot(f,m)
31 title('Magnitude')
32 ax = gca;
33 ax.XTick = [15 40 60 85];
34
35 subplot(2,1,2)
36 plot(f,p*180/pi)
37 title('Phase')
38 ax = gca;
39 ax.XTick = [15 40 60 85];

```

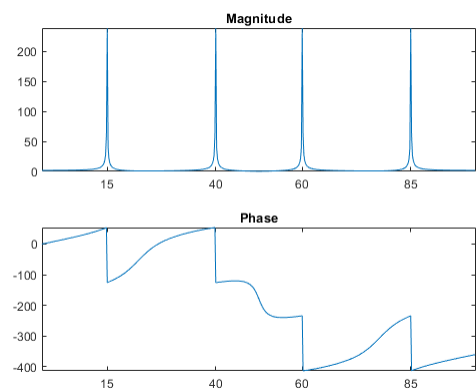


Figura 12: *Gráfico*