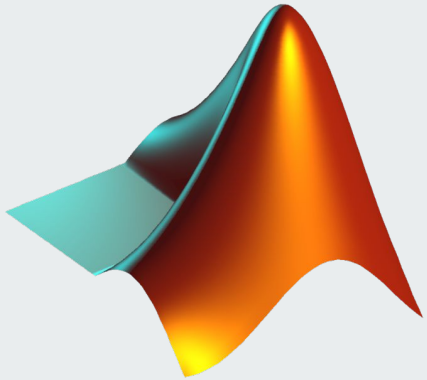
Curso de Programação em MATLAB
72 - Transformada Discreta de Fourier



ΣExataMenteSπ

YouTube

ExataMenteS

Transformada de Fourier

Análise Espectral

Mais fácil entender as coisas no domínio da frequência

Mais barato em termos de custo computacional

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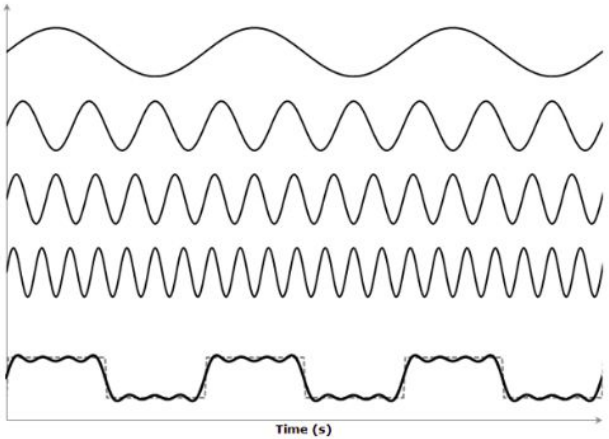


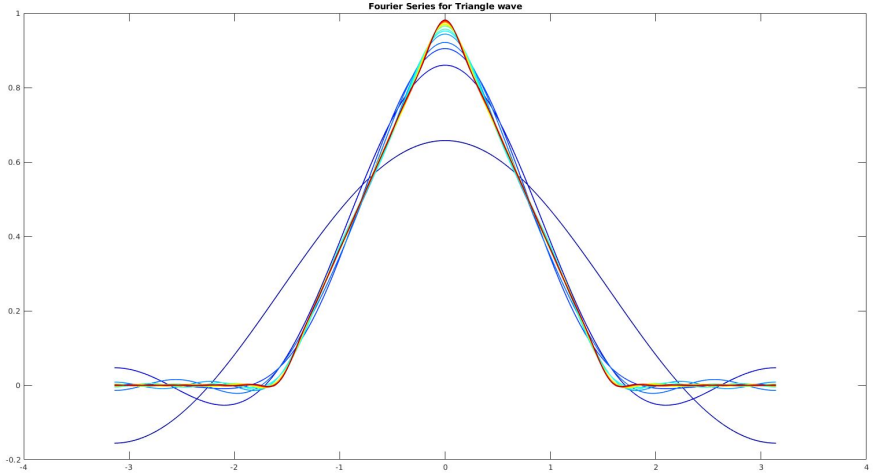
$$X(f) = \int_{-\infty}^{+\infty} x(t) e^{-j2\pi ft}\, dt$$

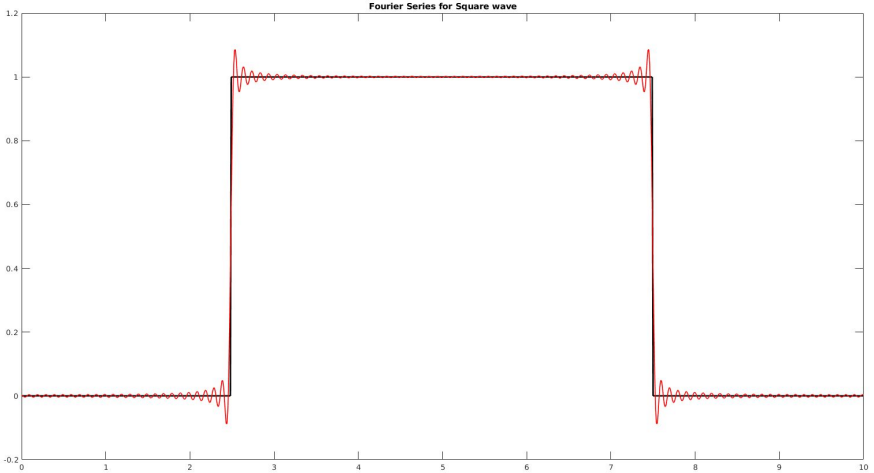
Série de Fourier

$$g(t) = a_0 + \sum_{m=1}^{\infty} a_m \cos\left(\frac{2\pi mt}{T}\right) + \sum_{n=1}^{\infty} b_n \sin\left(\frac{2\pi nt}{T}\right)$$

$$= \sum_{m=0}^{\infty} a_m \cos\left(\frac{2\pi mt}{T}\right) + \sum_{n=1}^{\infty} b_n \sin\left(\frac{2\pi nt}{T}\right)$$

Série de Fourier





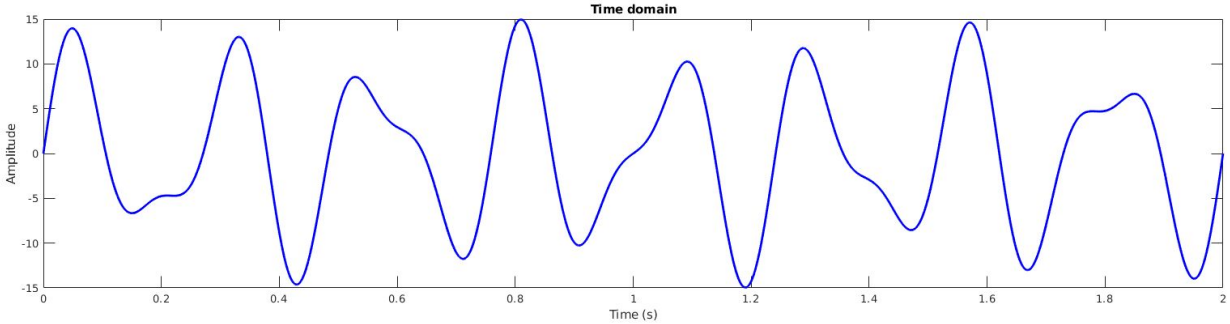
DTFT (Transformada de Fourier Discreta)

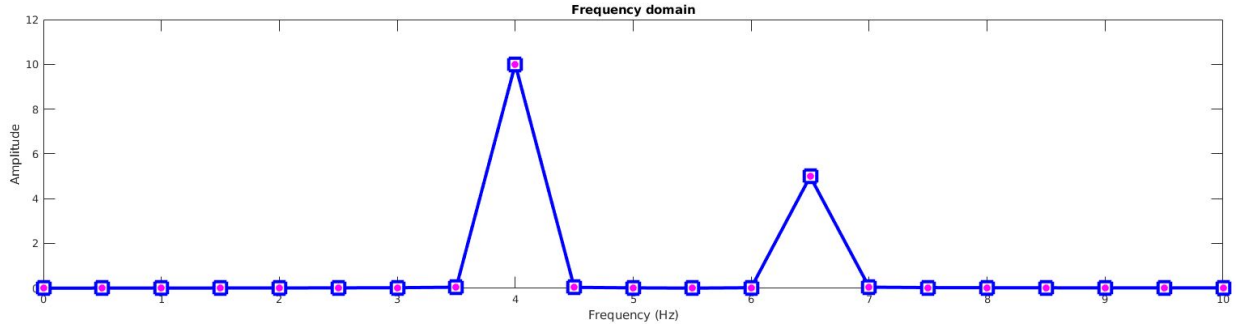
Criar um sinal

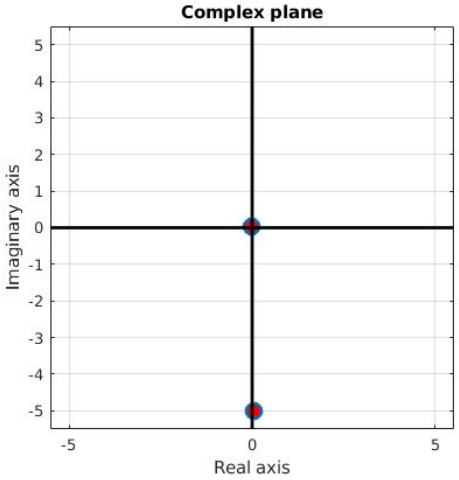
Criar uma onda senoidal complexa

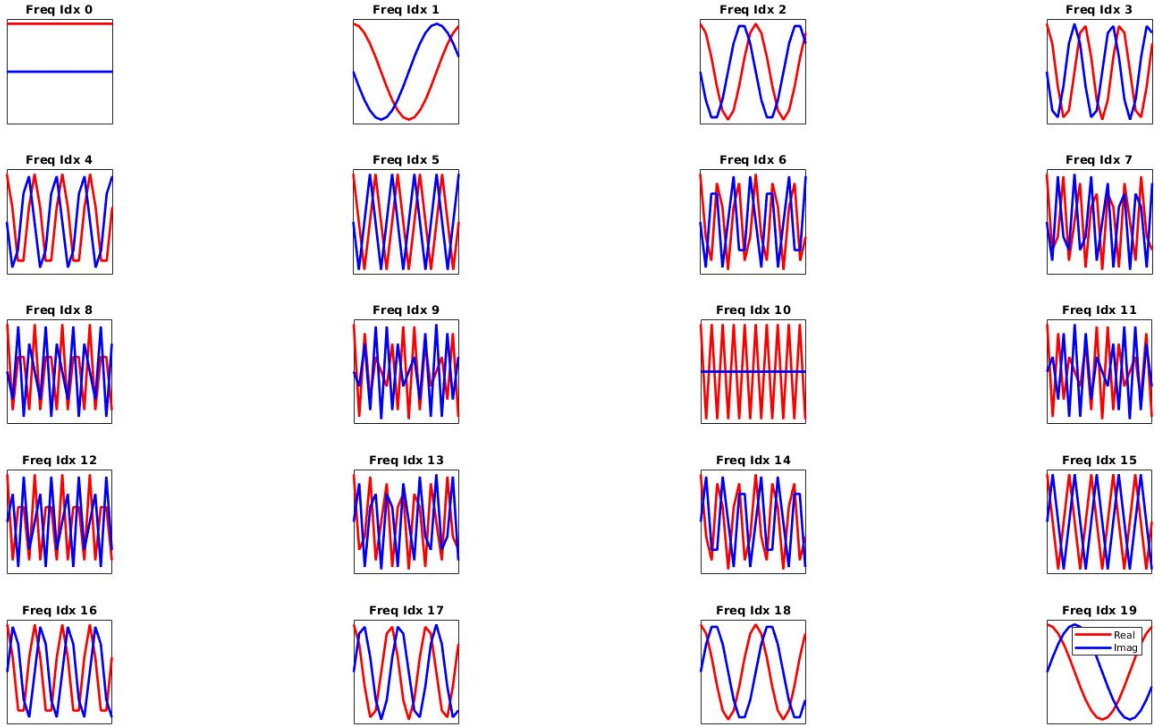
Calcular o produto escalar entre a onda senoidal e o sinal

$$
\begin{aligned}
X_k &= \sum_{n=0}^{N-1} x_n \cdot e^{-\frac{i2\pi}{N} kn} \\
&= \sum_{n=0}^{N-1} x_n \cdot \left[\cos\left(\frac{2\pi}{N} kn\right) - i \cdot \sin\left(\frac{2\pi}{N} kn\right) \right],
\end{aligned}
$$


Time domain
Amplitude
Time (s)


Frequency domain
Amplitude
Frequency (Hz)


Complex plane
Imaginary axis
Real axis


Freq Idx 0
Freq Idx 1
Freq Idx 2
Freq Idx 3
Freq Idx 4
Freq Idx 5
Freq Idx 6
Freq Idx 7
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Freq Idx 9
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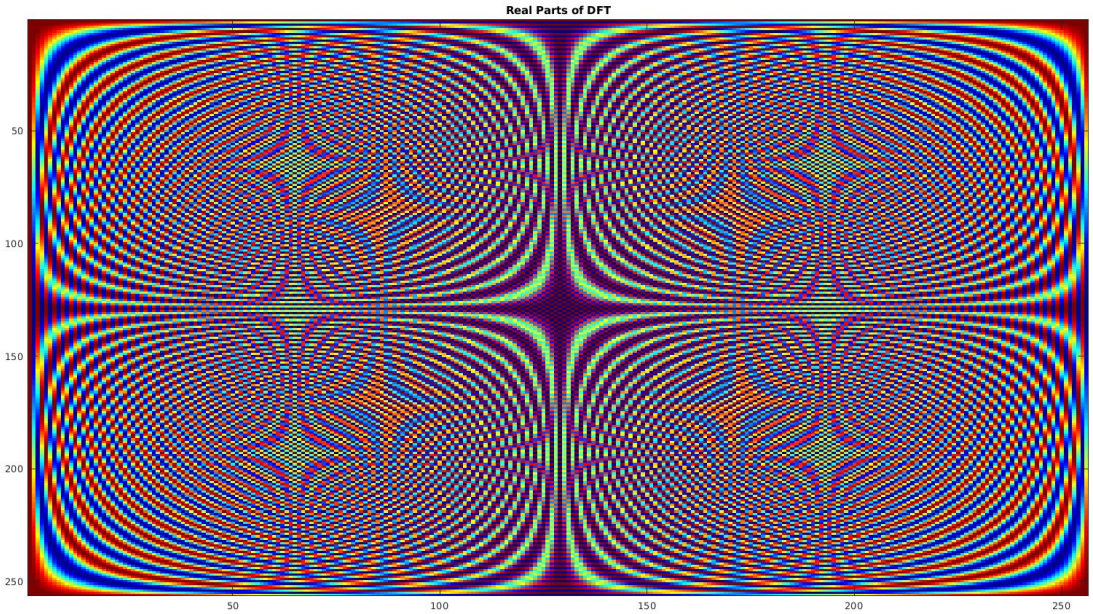
Freq Idx 14
Freq Idx 15
Freq Idx 16
Freq Idx 17
Freq Idx 18
Freq Idx 19
Real
Imag

DTFT (Transformada de Fourier Discreta)

$$\mathcal{O}(n^2)$$

$$\begin{bmatrix} \hat{f}_1 \\ \hat{f}_2 \\ \hat{f}_3 \\ \vdots \\ \hat{f}_n \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 & \cdots & 1 \\ 1 & \omega_n & \omega_n^2 & \cdots & \omega_n^{n-1} \\ 1 & \omega_n^2 & \omega_n^4 & \cdots & \omega_n^{2(n-1)} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 1 & \omega_n^{n-1} & \omega_n^{2(n-1)} & \cdots & \omega_n^{(n-1)^2} \end{bmatrix} \begin{bmatrix} f_1 \\ f_2 \\ f_3 \\ \vdots \\ f_n \end{bmatrix}$$

DTFT (Transformada de Fourier Discreta)



Amplitude Espectral & Densidade Espectral

$$P = Amp^2$$

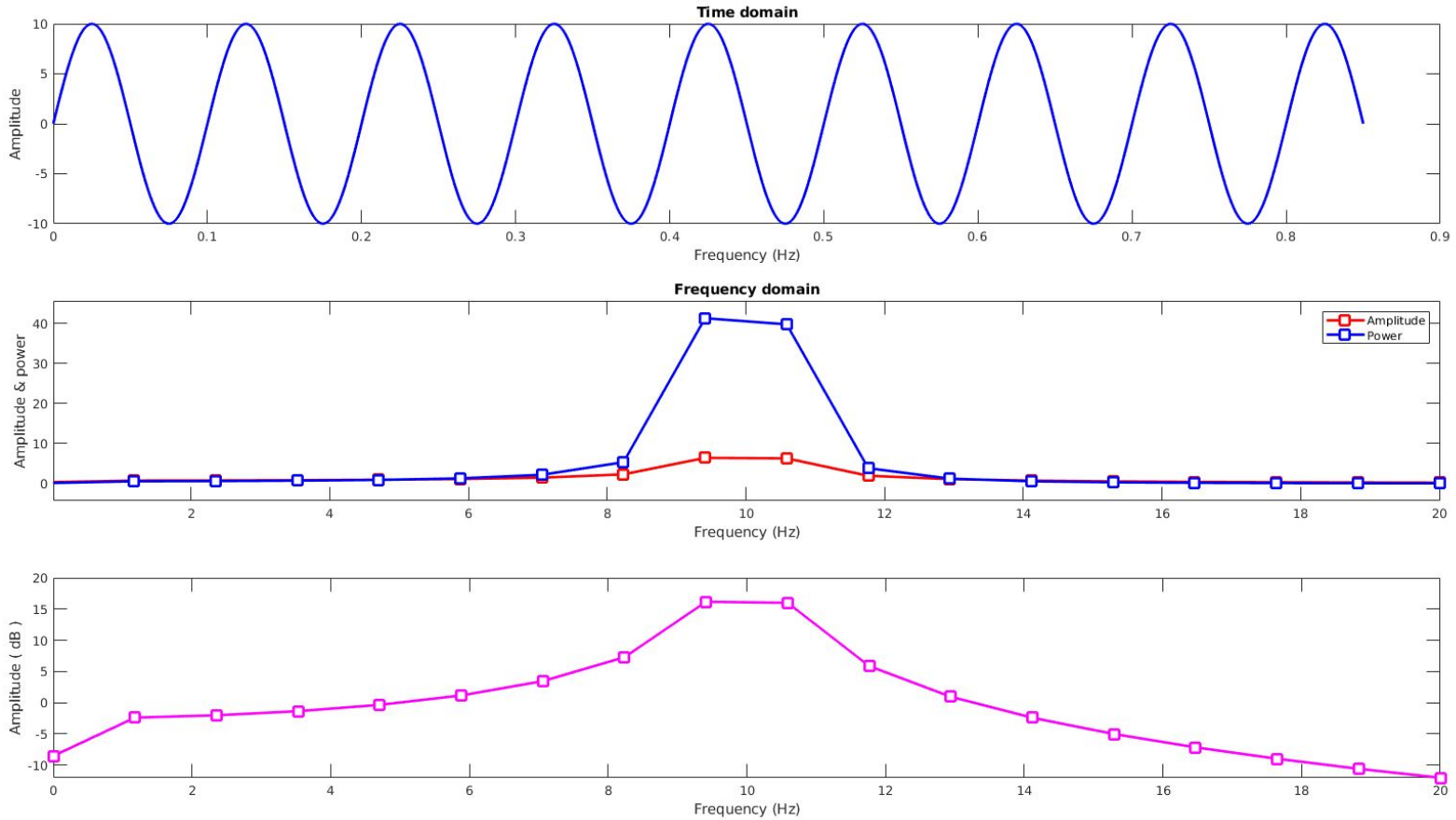
Conservação de energia no tempo e na frequência

Na direita temos a soma dos “Power Values”

E na esquerda os pontos no tempo

Teorema de Parseval

$$\sum_{n=0}^{N-1} |x[n]|^2 = \frac{1}{N} \sum_{k=0}^{N-1} |X[k]|^2$$


Time domain
Amplitude
Frequency (Hz)
Frequency domain
Amplitude & power
Amplitude
Power
Frequency (Hz)
Amplitude (dB)
Frequency (Hz)