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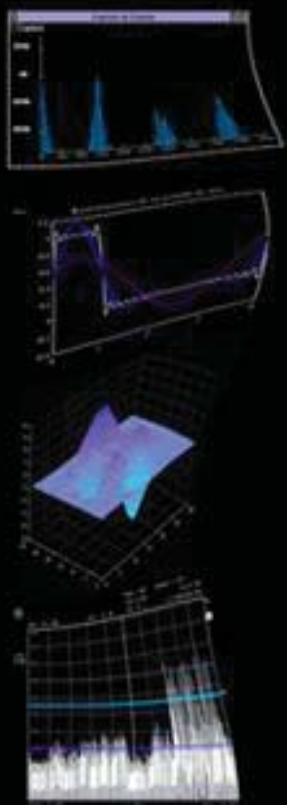
**ICTP Latin-American Advanced Course on FPGA Design for Scientific  
Instrumentation**

*19 November - 7 December, 2012*

**Transformada Discreta de Fourier**

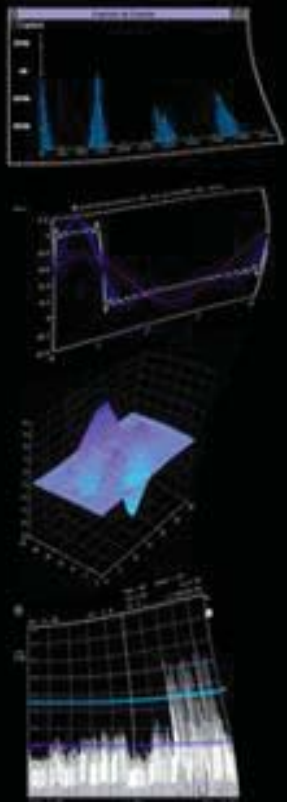
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ARGENTINA*

# Transformada Discreta de Fourier



# Transformada Discreta de Fourier

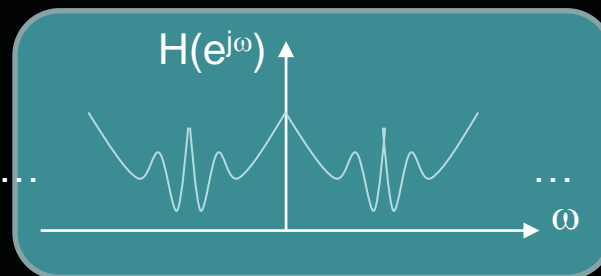
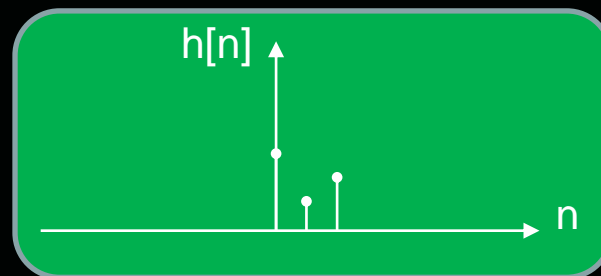
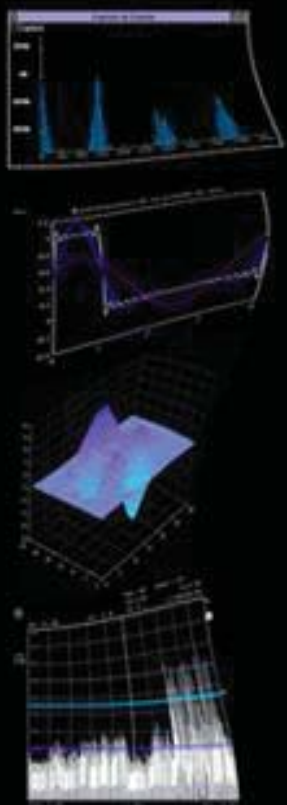
## Transformada Discreta de Fourier



<b>Transformada</b>	$TDF\{x[n]\} = X[k] = \sum_{n=0}^{L-1} x[n] e^{-j\frac{2\pi kn}{L}}$ $k = 0; 1; \dots; L-1$
<b>Antittransformada</b>	$TDF^{-1}\{X[k]\} = x[n] = \frac{1}{L} \sum_{k=0}^{L-1} X[k] e^{j\frac{2\pi kn}{L}}$ $n = 0; 1; \dots; L-1$

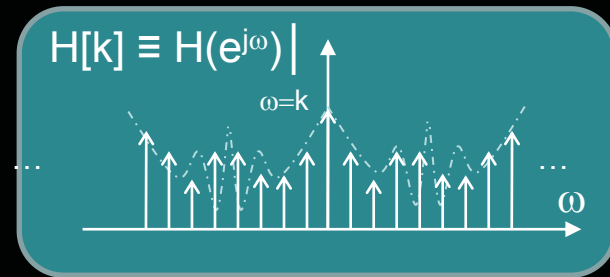
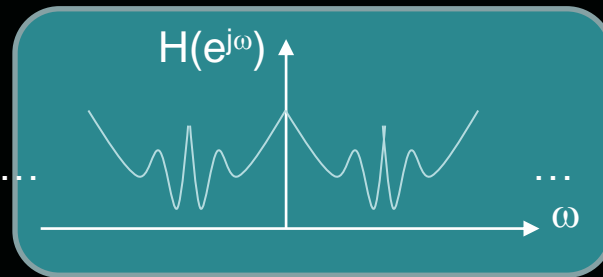
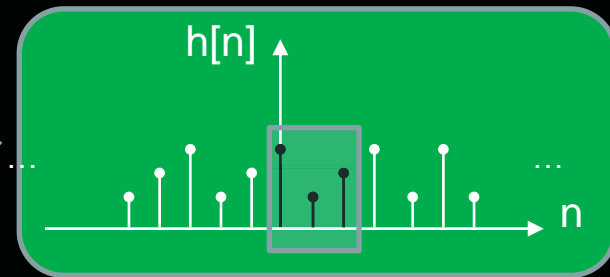
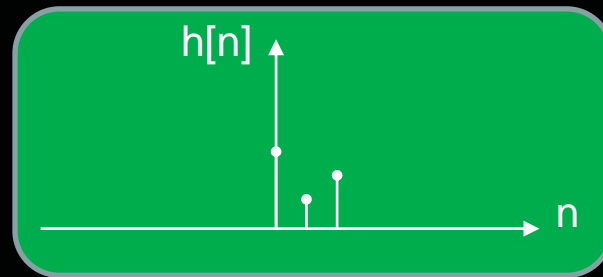
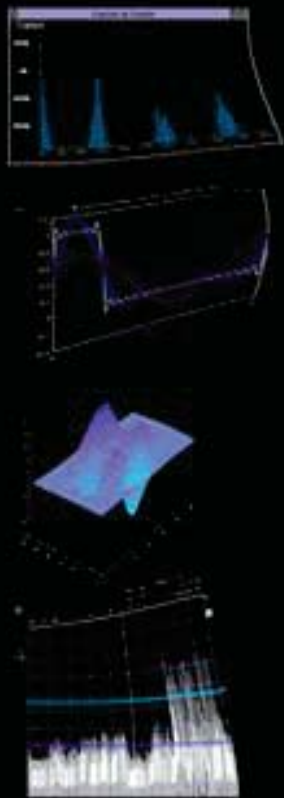
# Transformada Discreta de Fourier

Replicar periódicamente



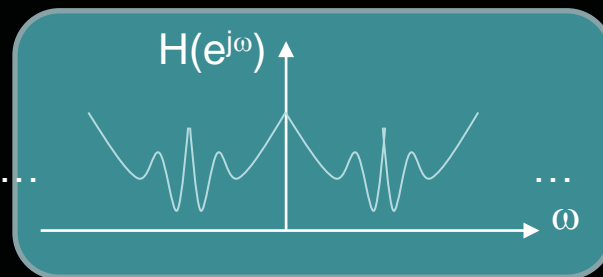
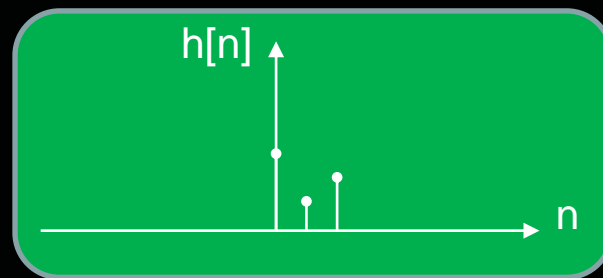
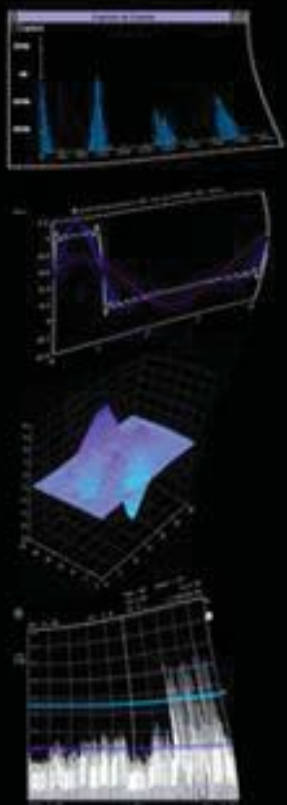
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Replicar periódicamente



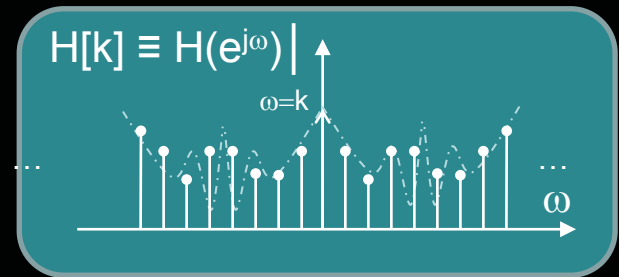
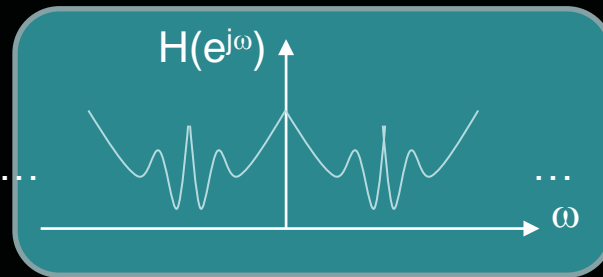
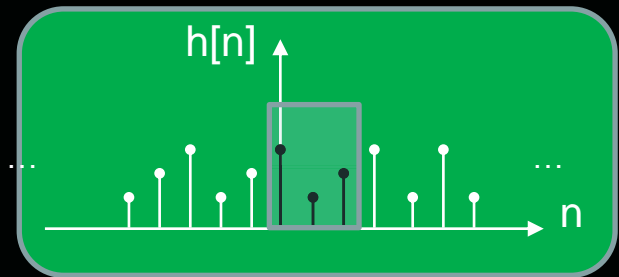
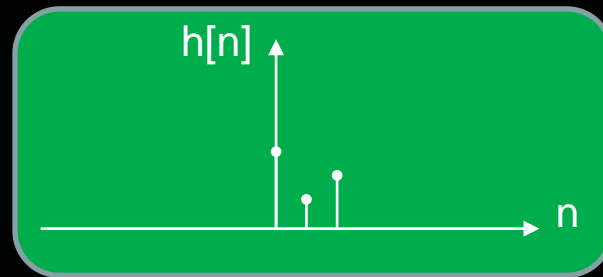
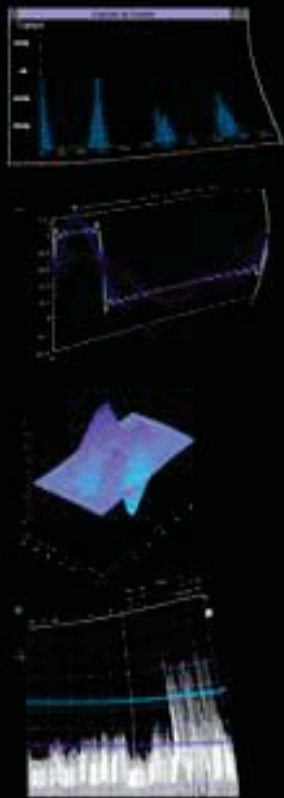
# Transformada Discreta de Fourier

Muestrear el espectro



# Transformada Discreta de Fourier

Muestrear el espectro



# Transformada Discreta de Fourier

## Propiedades

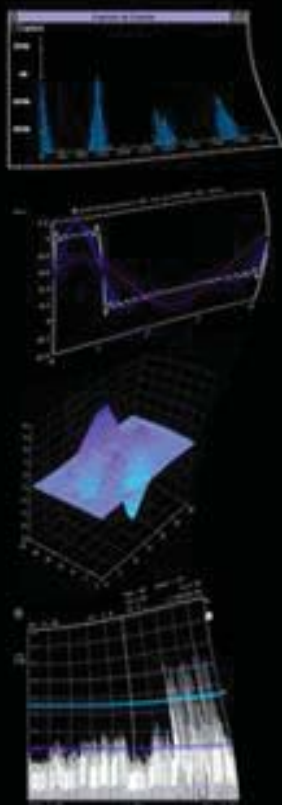
### Periodicidad

$$x[n] \stackrel{TDF}{\leftrightarrow} X[k] \Rightarrow X[k] = X[k + mL] \quad m \in \mathbb{Z}$$

### Simetría

$$x[n] = x_{\Re}^e[n] + x_{\Re}^o[n] + jx_{\Im}^e[n] + jx_{\Im}^o[n]$$

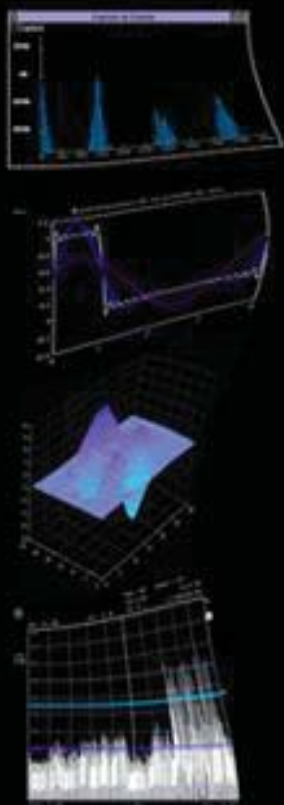
$$X[k] = X_{\Re}^e[k] + X_{\Re}^o[k] + jX_{\Im}^e[k] + jX_{\Im}^o[k]$$





# Transformada Discreta de Fourier

## Propiedades



### Linealidad

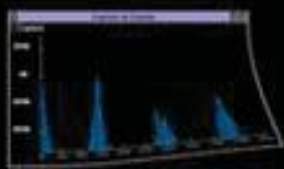
$$c_1 x_1[n] + c_2 x_2[n] \xleftrightarrow{TDF} c_1 X_1[k] + c_2 X_2[k]$$

### Reflexión circular

$$x\langle[-n]\rangle_L \xleftrightarrow{TDF} X\langle[-k]\rangle_L$$

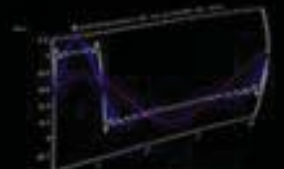
# Transformada Discreta de Fourier

## Propiedades



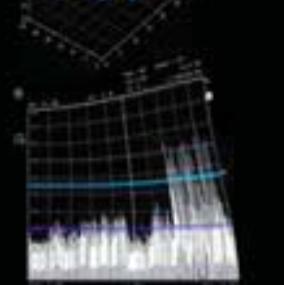
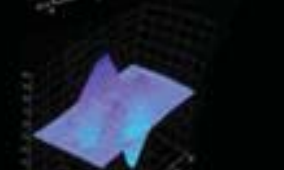
### Desplazamiento Circular Temporal

$$x\langle [n \sim l] \rangle_L \stackrel{TDF}{\leftrightarrow} X[k] e^{-j\frac{2\pi lk}{L}}$$



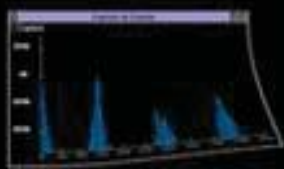
### Desplazamiento Circular Espectral

$$x[n] e^{j\frac{2\pi ln}{L}} \stackrel{TDF}{\leftrightarrow} X\langle [k \sim l] \rangle_L$$



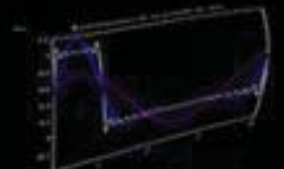
# Transformada Discreta de Fourier

## Propiedades



### Modulación

$$x_1[n] x_2[n] \stackrel{TDF}{\leftrightarrow} \frac{1}{L} X_1[k] \otimes X_2[k]$$



### Conjugación

$$x^*[n] \stackrel{TDF}{\leftrightarrow} X^*[L-k]$$

