EPFL

Disal

Lab 6

School of Architecture, Civil and Environmental Engineering

EPFL, SS 2019-2020

http://disal.epfl.ch/teaching/signals_instruments_systems/

Lab 6 Outline

- Concept:
  - Convolution Review
  - Continuous-Time Transforms
  - Discrete-Time Transforms
  - Aliasing
- Tools:
  - Matlab

Reminder: Convolution

- Review convolution
- Write your own convolution function

$$(f*g)(t)=\int_{-\infty}^{\infty} f(\tau)\cdot g(t-\tau)d\tau$$

$$\downarrow$$

$$(f*g)[n]=\sum_{m=-\infty}^{\infty} f[m]\cdot g[n-m]$$

```
No symbolic tool
conv() → Numerical convolution
```

Symbolic Toolbox in MATLAB

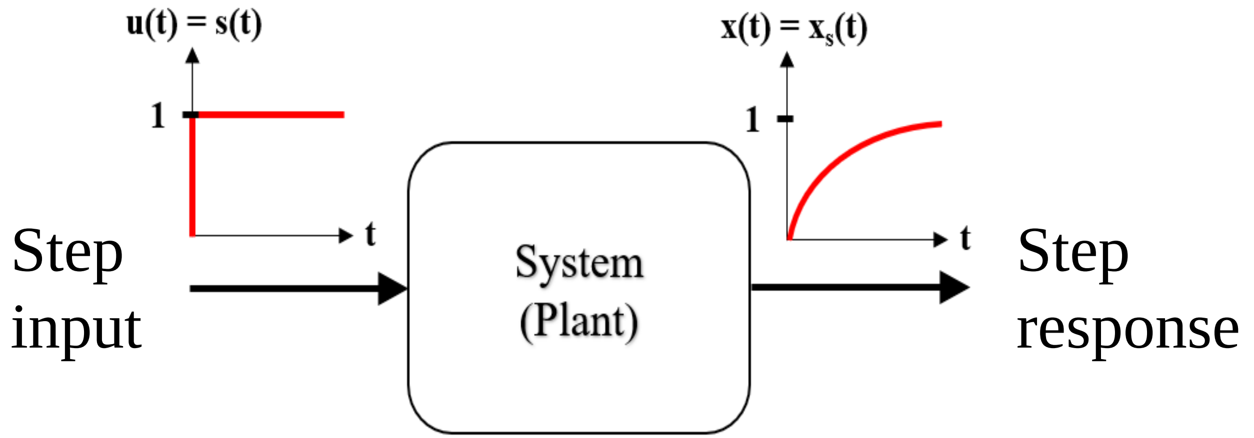
- syms x,y → Define symbolic variables
- assume(x>0) → Assumption on variables
- sympref('HeavisideAtOrigin',1)→ Symbolic preferences
- fplot() → Plot symbolic functions
- Heaviside() → Step function
- tf() → Define transfer function
- step() → Plot step response
- int() → Symbolic integration

*** Check MATLAB help to learn how to use it

Reminder: Impulse and Step Response

- **Impulse response:** Time evolution of its output when input is impulse function

- **Step response:** Time evolution of its output when input is step function



Reminder: Fourier Transform

$$\hat{f}(\xi) = \int_{-\infty}^{\infty} f(t) \cdot e^{-i2\pi\xi t} dt$$

$$f(t) = \int_{-\infty}^{\infty} \hat{f}(\xi) \cdot e^{i2\pi t\xi} d\xi$$

The Fourier Transform is a special case of the Laplace Transform

`fourier()` → Symbolic CT Fourier Transform

`ifourier()` → Symbolic Inverse CT Fourier Transform

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Reminder: Laplace Transform

$$F(s) = \mathcal{L}\{f(t)\} = \int_{-\infty}^{\infty} e^{-st} f(t) dt$$

$$s = \sigma + i\omega$$

*The Laplace transform is an extension of Fourier transform to allow analysis of broader class of signals and systems

*Check transform tables in appendix

`laplace()` → Symbolic Laplace Transform

`ilaplace()` → Symbolic Inverse Laplace Transform

Reminder: Z Transform

$$X(z) = \mathcal{Z}\{x[n]\} = \sum_{n=-\infty}^{\infty} x[n] z^{-n}$$

$$z = Ae^{j\varphi} \text{ or } z = A(\cos\varphi + j\sin\varphi)$$

*Similar to Laplace transform but for discrete signal and systems
*Check transform tables in appendix

ztrans() → Symbolic Z-Transform
iztrans() → Symbolic Inverse Z-Transform

Reminder: Discrete Time Fourier Transform

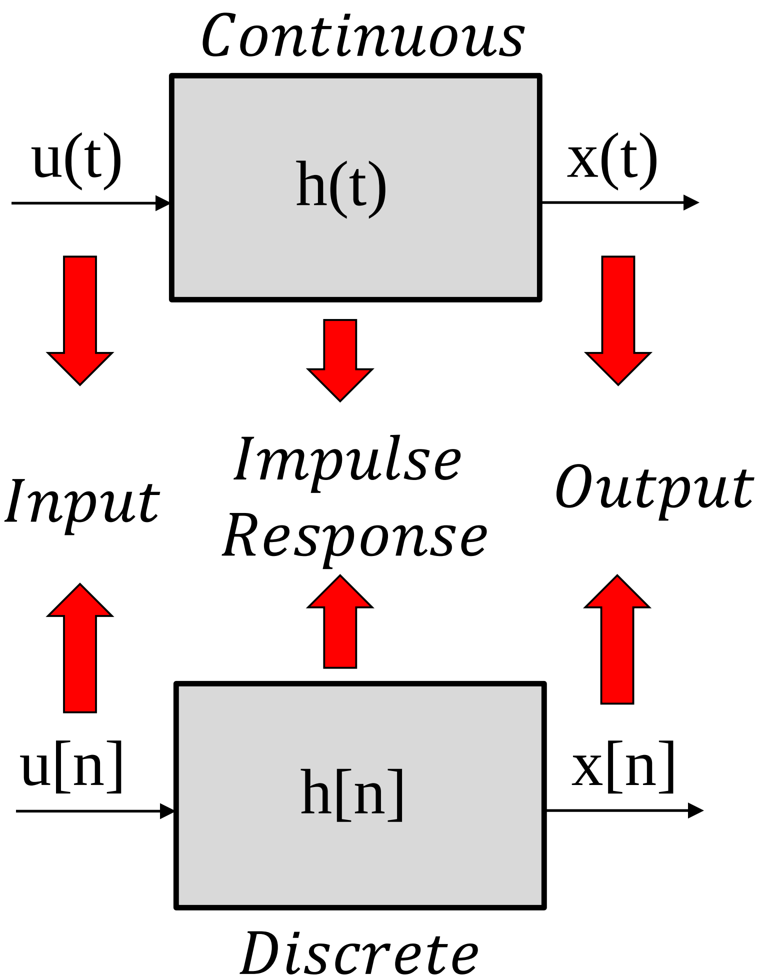
$$X(\omega) = \sum_{n=-\infty}^{\infty} x[n] \cdot e^{-i\omega n}$$

The Discrete-Time Fourier Transform is a special case of the Z Transform

Transform discrete-time signals from time-domain to frequency domain (continuous spectrum)

```
No direct symbolic tool
fft() → Numerical DF Transform
ifft() → Numerical Inverse DF Transform
```

System Analysis with Transforms



- $x(t) = u(t)*h(t)$
- $X(s) = U(s)H(s)$
- $X(s) = \mathcal{L}(x(t))$

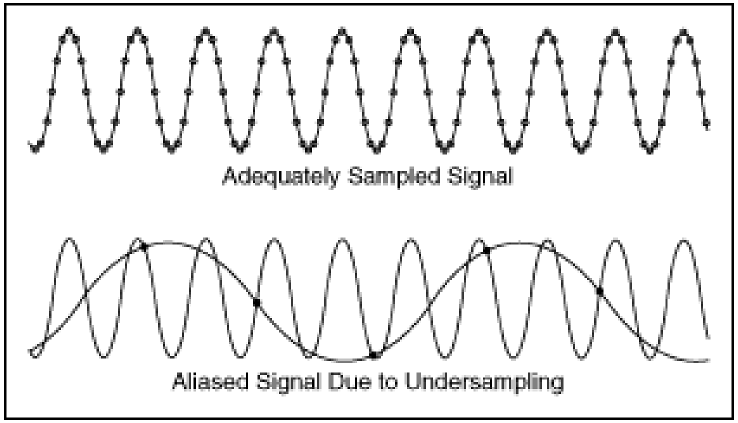
Cont. Transfer function

- $x[n] = u[n]*h[n]$
- $X(z) = U(z)H(z)$
- $X(z) = Z(x[n])$

Disctrete Transfer function

Reminder: Aliasing

- An effect that causes different signals to become indistinguishable when sampled



- Nyquist rate: fs > 2B

Sampling frequency fs must be at least two times greater than the maximal signal frequency B

General Remarks

- Questions for which you need to use Laplace and Z-Transform tables are Bonus
- Check MATLAB help to learn how to use functions
- Check given material, carefully read explanations and templates
- Pay attention to Hints and Notes
- It is about 3h, assistance will be given
- New lab, designed for you, will be improved

Feedback form

Please fill the feedback form for Lab 6!