Digital systems

Lab 5, DSP

Objective

Students should check basic properties of digital systems for easy systems implemented in Matlab

Theoretical aspects

The following aspects shall be explained.

1. Functions in Matlab
   - define in a dedicated file
   - input and output arguments
2. Functions as discrete systems
   - one input vector, one output vector
   - implements some mathematical transformation of the input vector
3. Functions as arguments to another function
   - a function can have an input argument another function
   - example at board
4. Properties of discrete systems:
   - linearity:

$$H\{a \cdot x_1[n] + b \cdot x_2[n]\} = a \cdot H\{x_1[n]\} + b \cdot H\{x_2[n]\}$$

   - time invariance:

$$H\{x[n-k]\} = y[n-k], \text{ where } y[n] = H\{x[n]\}$$

Exercises

1. Create a function `mysys1()` that implements the following system H_1:

$$y[n] = H_1\{x[n]\} = \frac{1}{4}x[n] - \frac{1}{2}x[n-1] + \frac{1}{4}x[n-2]$$

   - the function takes 1 input argument `x` and outputs 1 result vector `y`

2. Create a function to test linearity of a system, `test_linear()`, by checking if the linearity equation holds

   - the function shall take one input argument, a **function handle** of the system function, e.g. the function will be called as `test_linear(@mysys1)`
   - inside, the function shall generate two random vectors `x` and `y` and two random constants `a` and `b`
   - the function shall apply the system (the argument function) to `a*x`, `b*y`, and `a*x + b*y`, and shall check if the results verify the linearity equation
   - the check shall be repeated for 5 times, with 5 different randomly generated data
   - if the linearity equation holds every time, the function shall return 1; otherwise the return value shall be 0

3. Create functions to implement other two systems, and check their linearity also

$$y[n] = H_1\{x[n]\} = n \cdot x[n] + 5$$

$$y[n] = x[n] + 0.5x[n-1] + 1$$

$$y[n] = (x[n])^2 + 4$$

4. Implement a similar function to test time invariance of a system

   - the system will be applied to a vector `x`, and to `x` prepended with a variable number of zeros (i.e. time delayed)
   - the outputs shall be checked if they verify the time invariance equation

Final questions

1. TBD