Digital Signal Processing SS 2024 – Exercise 2

Digital Signal Processing Tutorial

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Exercise 1

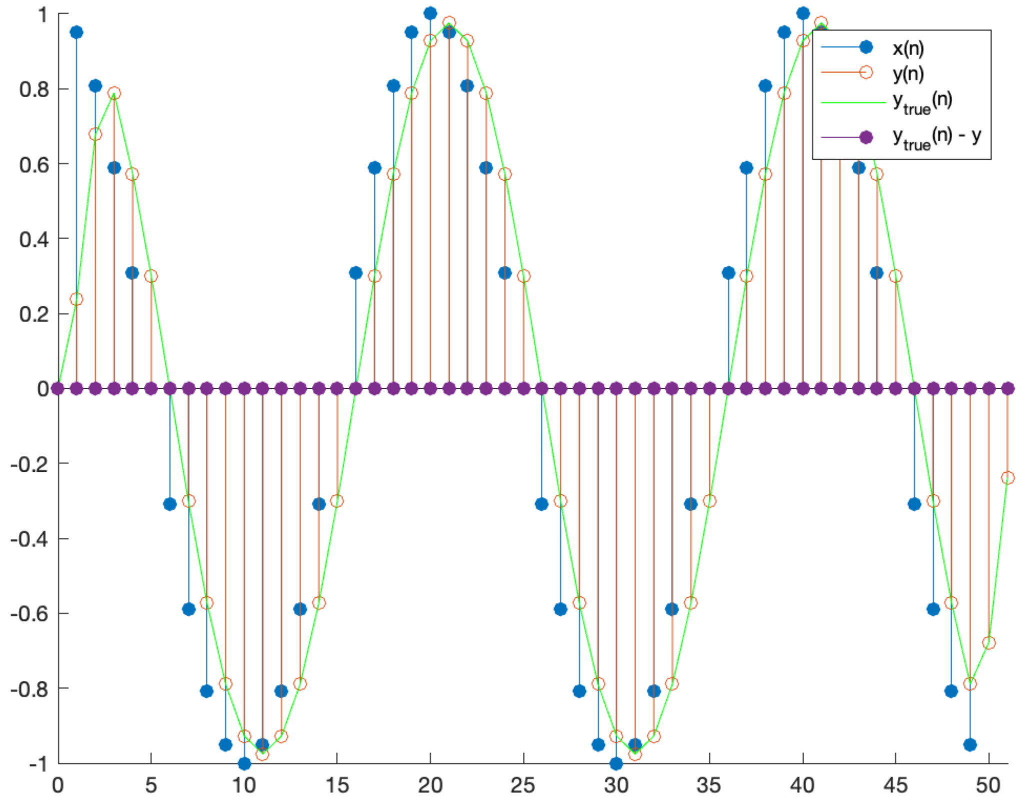
Exercise 2

Exercise 3

We have the impulse response of an LTI system $h[n] = (0.25, 0.5, 0.25)$ at sample indices $n = (0, 1, 2)$. The input signal is $x[n] = \cos\left(\frac{2\pi}{20}n\right)$ for $0 \leq n < 50$.

a) From the lecture: If $x[n]$ and $h[n]$ have finite lengths N_x and N_h, the length of the output signal results to $N_y = N_x + N_h - 1$. In our example we have $N_x = 50$ and $N_h = 3$, therefore we can calculate the length of the output signal L_y (N_y in the lecture) as $\underline{L_y = 52}$.

b) For the actual implementation, see code `Ex03.m`. Here it was important to explicitly define $x[n]$ to be 0 outside the given range.



c)

d) As we can see in the plot, the "true" y and our calculated y match up.

Exercise 4

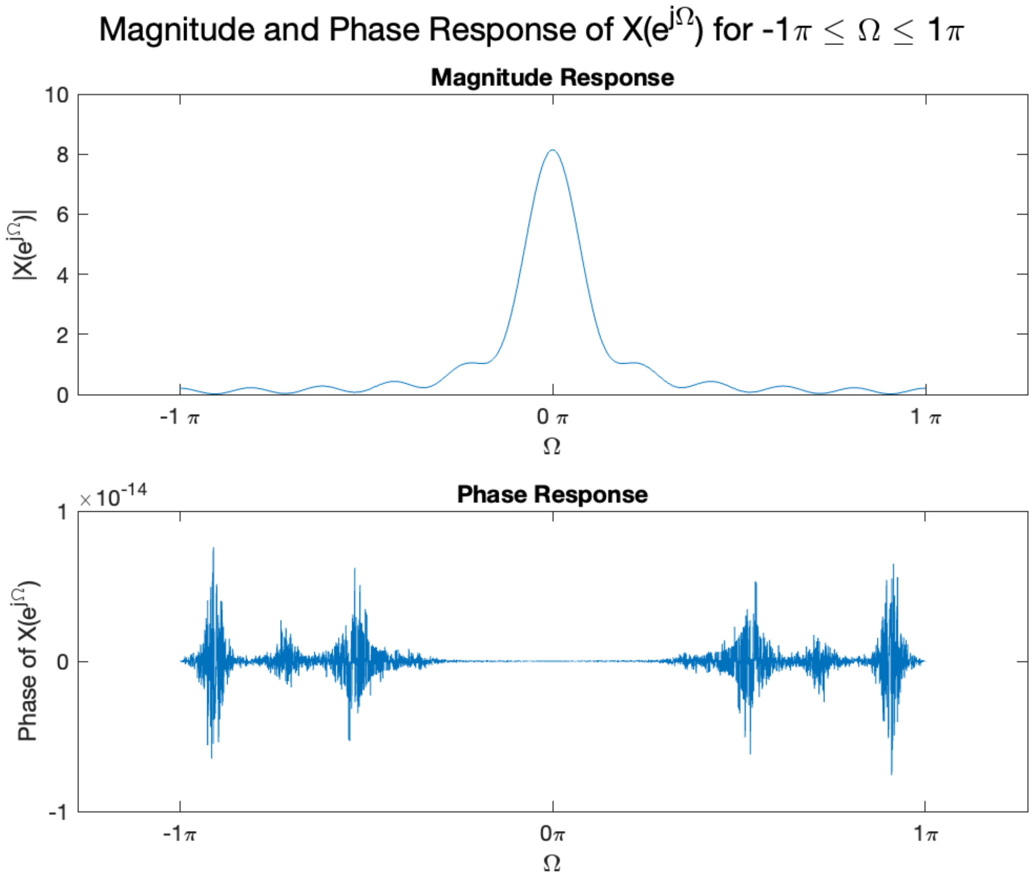
a) See `Ex04.m` for the full code, here I show only the function `dtft`:

```
function X = dtft(x, n, w)
    % DTFT Computes Discrete-time Fourier transform
    % @param    x: finite duration sequence over n
    % @param    n: sample position vector
    % @param    w: frquency location vector
    % @return   X: DTFT values computed at w frequencies

    X = x * exp(-1j .* n' * w);

end
```

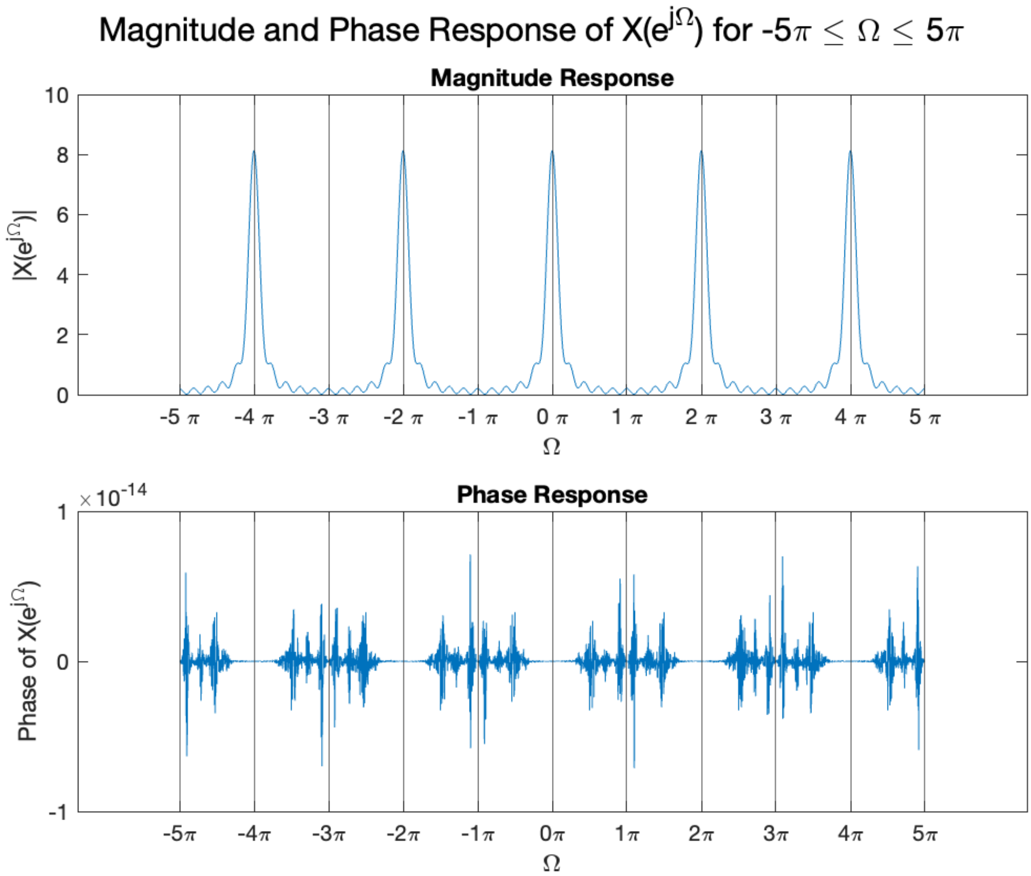
We call the function via `X = dtft(@x, n, w)`, where

- `x(n) = ((0.8).^abs(n)) .* (u(n+10) - u(n-11))` with `u(n) = 1.*(n>=0)`
- `n = -10:10`
- `w = linspace(Omega * -pi, Omega * pi, 1000)` for `Omega = 1`

b) What I can observe on the y-axis of the phase response plot is that the phase response for the settings described above is very small, in fact less than 10^{-14}.



c) If we change `Omega` from `Omega = 1` to `Omega = 5`, we can see that the magnitude response has peaks and troughs at multiples of π. We can also see that the phase response seems to be mirrored and flipped around the y-axis (graphic on next page).


Magnitude and Phase Response of X(e^{jΩ}) for -5π ≤ Ω ≤ 5π
Magnitude Response
|X(e^{jΩ})|
10
8
6
4
2
0
-5 π
-4 π
-3 π
-2 π
-1 π
0 π
1 π
2 π
3 π
4 π
5 π
Ω
Phase Response
×10^{-14}
Phase of X(e^{jΩ})
1
0
-1
-5π
-4π
-3π
-2π
-1π
0π
1π
2π
3π
4π
5π
Ω