Linear Systems and Signals

Representing signals computationally

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Learning objectives

The learning objectives for this section are:

- represent CT signals in numerical simulation using the sampling frequency
- generate and plot standard DT and CT signals mentioned above
- window signals in time

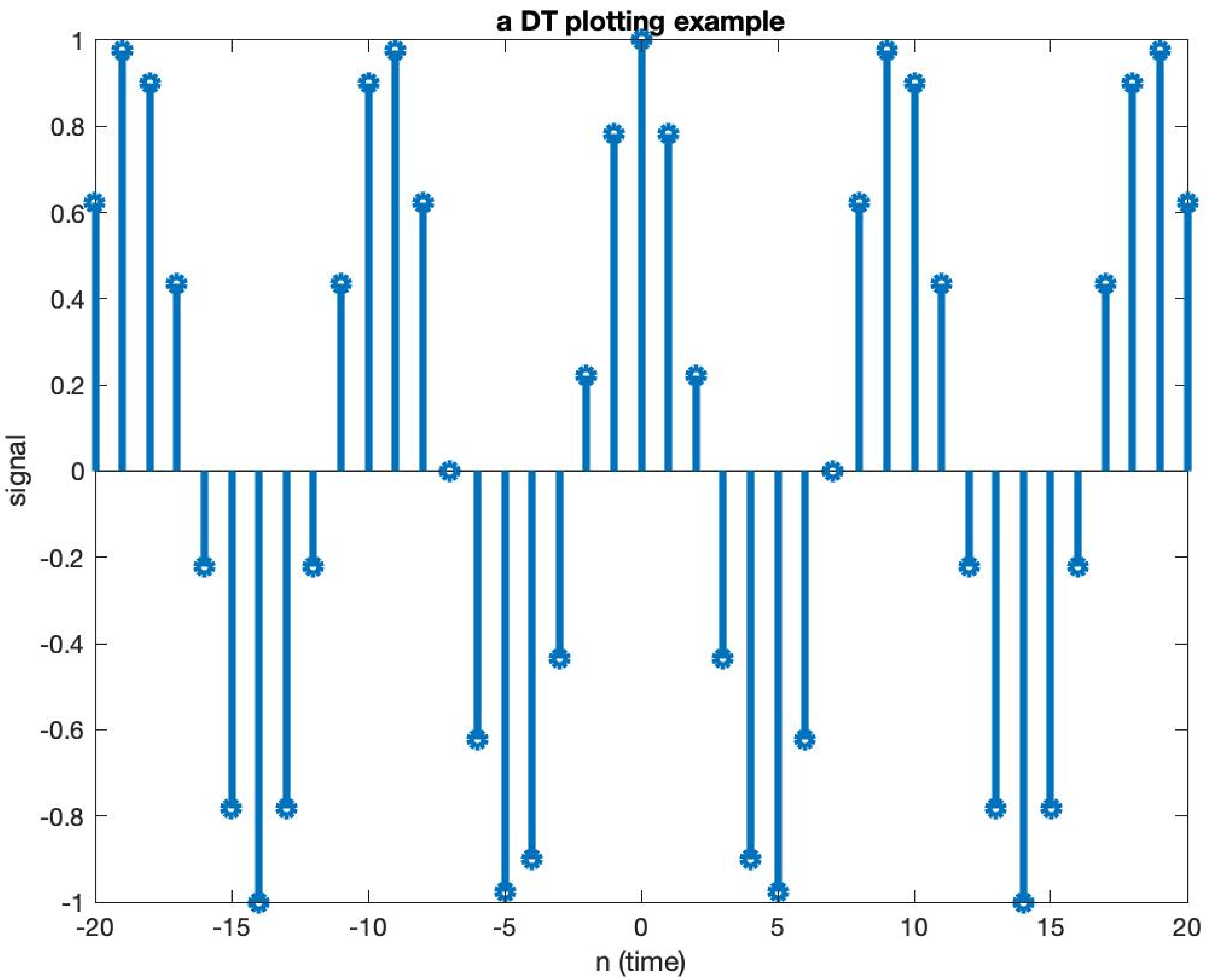
Representing a signal in DT

Representing a signal in DT in MATLAB is easy. It's just a vector. You can plot it using `stem()`.

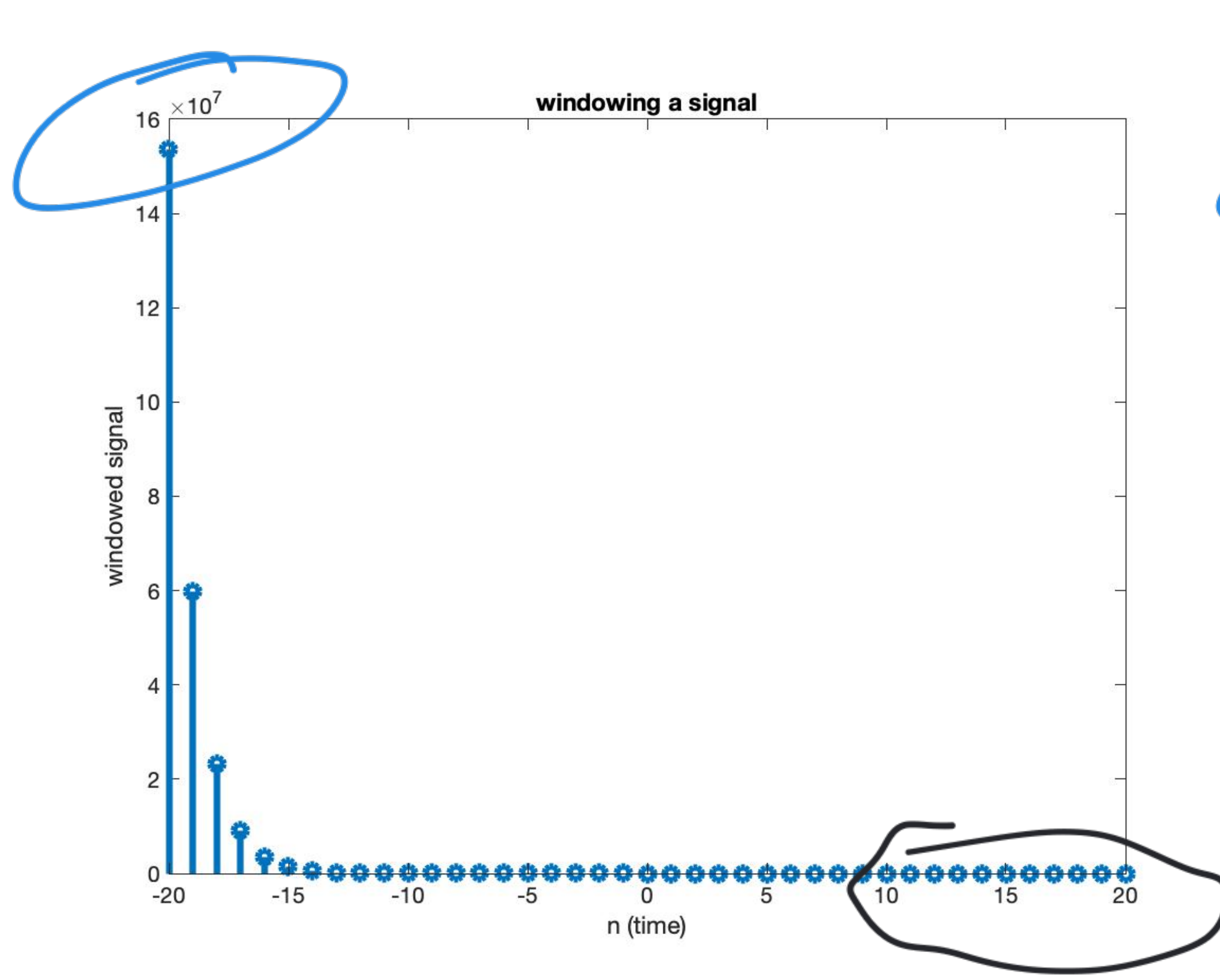
Code Example 1: a simple DT signal

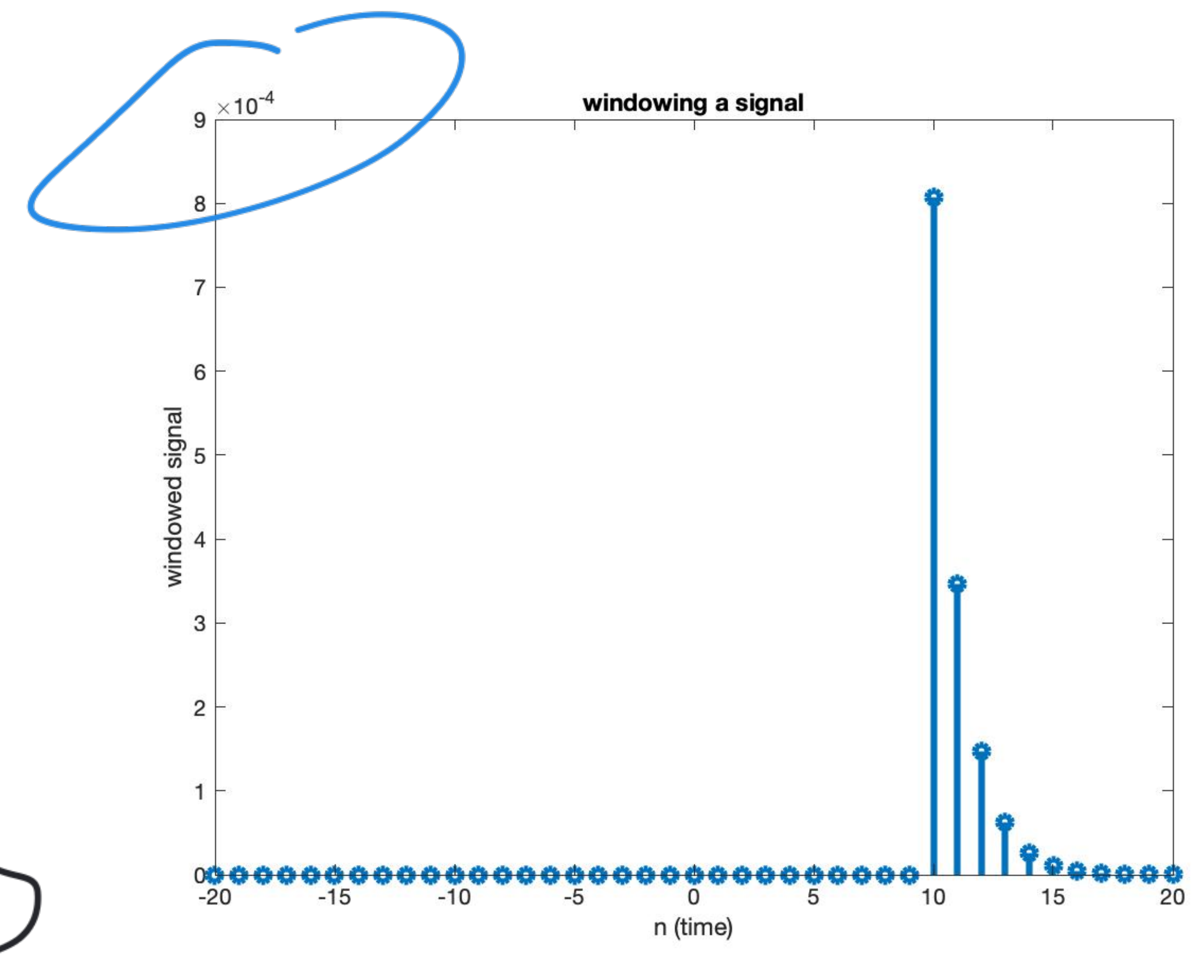
```
xsig = @(n) cos((3*pi/14)*n);
n = (-20):20;
x = xsig(n);
figure;
stem(n,x,'LineWidth',3);
xlabel('n (time)');
ylabel('signal');
title('a DT plotting example')
print('DT_plot_example.png', '-dpng');
```

The plot


a DT plotting example
signal
n (time)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-20
-15
-10
-5
0
5
10
15
20

Windowing signals





We can window signals by multiplying by the window:

Code Example 2: windowing a signal

```
xsig = @(n) exp(-0.4*n);
n = (-20):20;
window = n [redacted] .* (n >= 10);
x = xsig(n) .* window;
figure; stem(n,xsig(n),'LineWidth',3);
figure; stem(n,x,'LineWidth',3);
```

Real and imaginary parts

We can also get the real and imaginary parts of a complex signal:

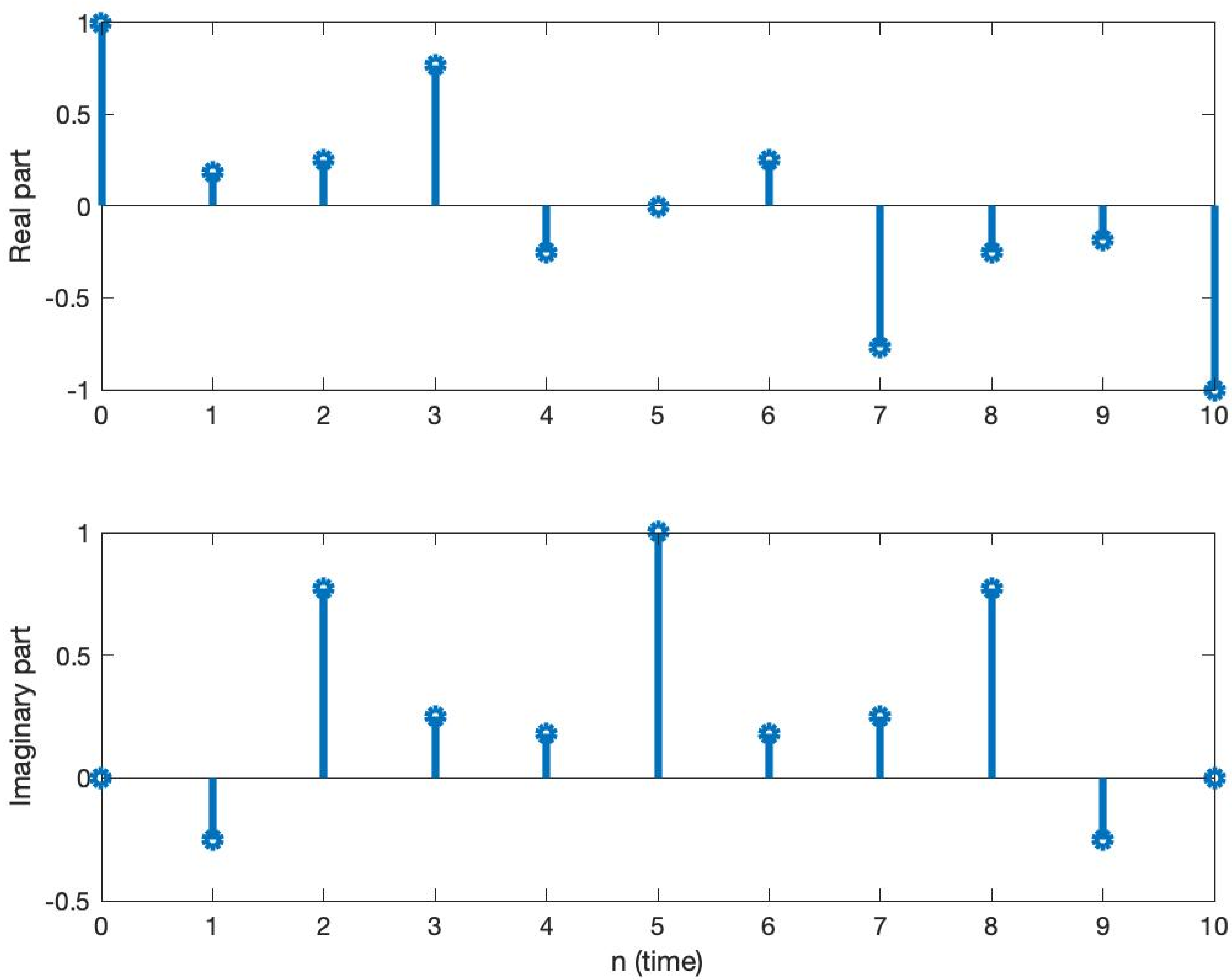
$$x(t) = e^{-j0.3\pi n} \cos(0.4\pi n) \quad (1)$$

Code Example 3: real/imaginary

```
xsig = @(n) exp(-j*0.3*pi*n) .* cos(0.4*pi*n);
n = 0:10;
figure;
subplot(2,1,1); stem(n,real(xsig(n)),'LineWidth',3);
ylabel('Real part');
subplot(2,1,2); stem(n,imag(xsig(n)),'LineWidth',3);
xlabel('n (time)');
ylabel('Imaginary part');
print('DT_reim_example.png', '-dpng');
```

1 2

The plot



1
0.5
0
-0.5
-1
Real part
0
1
2
3
4
5
6
7
8
9
10
1
0.5
0
-0.5
Imaginary part
n (time)

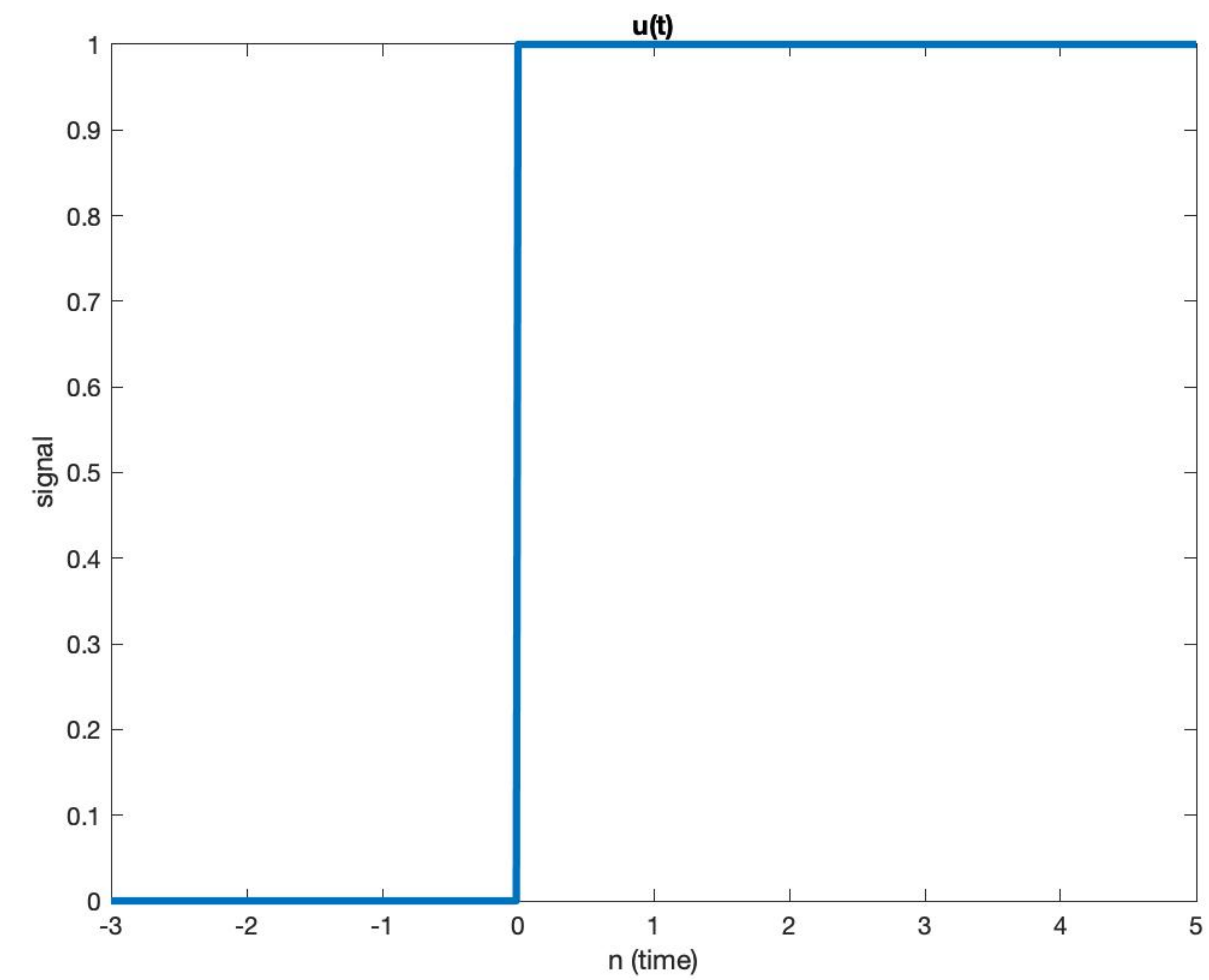
Representing a signal in CT

We have to *simulate a CT signal with a DT signal*. The idea is to use a small enough interval Δt so that

$$x[n] = x(n\Delta t) \tag{2}$$

is a good approximation of $x(t)$. Each element of $x[n]$ is a sample of $x(t)$ spaced every Δt. The sampling frequency is $f_s = \frac{1}{\Delta t}$.
How do you choose f_s? It depends on what your signal is like – if it has a lot of high-frequency elements you need f_s to be larger. We will revisit this at the end of class when we discuss the *Nyquist rate* which says how fast you have to sample a signal to be able to accurately reconstruct it.

Example: step

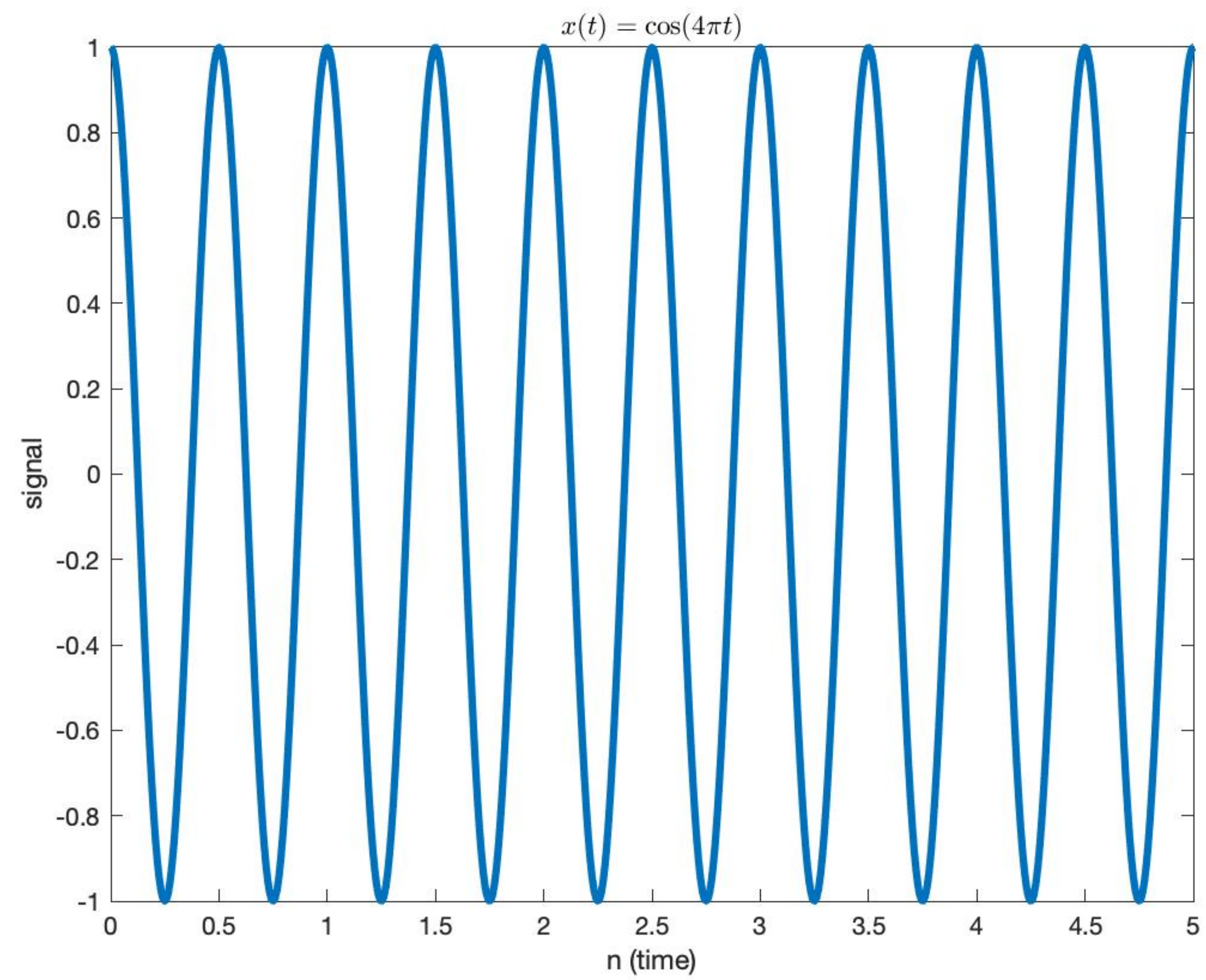


Code Example 4: step function

```
fs = 1e4;
t = (-3):(1/fs):5;
figure; plot(t,heaviside(t),'LineWidth',3);
```

u(t)

Example: a sinusoid



Code Example 5: sinusoid

```
fs = 1e6;
t = 0:(1/fs):5;
xsig = @(t) cos(4*pi*t);
figure; plot(t,xsig(t),'LineWidth',3);
```

Try it yourself

Problem

Try to simulate some of the signals we have seen so far as examples. What happens if you choose a sampling rate that is too low?