Ex 01

Chapter 1. Introduction to Signals and Systems

Date (yy/mm/dd): 2021 / 12 / 28

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Math Problem: (20 = 5 × 4 points/each)

- Let $x(t)$ be the complex exponential signal $x(t) = e^{j\omega_0 t}$ with radian frequency ω_0 and fundamental period $T_0 = 2\pi/\omega_0$.
- Consider the discrete-time signal $x[n]$ obtained by uniform sampling of $x(t)$ with sampling interval T_s. That is, $x[n] = x(nT_s) = e^{j\omega_0 nT_s}$
- Find the condition on the value of T_s so that $x[n]$ is periodic.

Answer:

If $x[n]$ is periodic with fundamental period N_0, then

$$e^{j\omega_0(n+N_0)T_s} = e^{j\omega_0 nT_s} \cdot e^{j\omega_0 N_0 T_s} = e^{j\omega_0 nT_s},$$

Thus, we must have

$$e^{j\omega_0 N_0 T_s} = 1$$

Therefore, $\omega_0 N_0 T_s = \frac{2\pi}{T_0} N_0 T_s = 2\pi m$, m = positive integer

Or, $\frac{T_s}{T_0} = \frac{m}{N_0}$ = rational number

Thus $x[n]$ is periodic if the ratio T_{0m} of the sampling interval and the fundamental period of $x(t)$ is a rational number.

$$\hookrightarrow T_s = \frac{T_{0m}}{N_0}$$

MATLAB Problem: (80 = 8 × 10 points/each plot)

- Setup MATLAB environment and practice some useful commands such as figure, plot, subplot, xlabel, ylabel, set, grid, axis, title, suptitle, strcat, num2str, rand, length, real, imag.
- Develop a MATLAB program to plot 8 subplots in a figure as showed in the next page. $x[n] = e^{(\sigma+j\omega_0)T_s n}$, ($n$=-100:1:100; T_0=0.5; T_s=0.01; $\sigma = \pm 1$)

```
n = -100:1:100
```

```
n = 1×201
 -100 -99 -98 -97 -96 -95 -94 -93 -92 -91 -90 -89 -88  ···
```

```
T0 = 0.5
```

```
T0 = 0.5000
```

```
Ts = 0.01
```

```
Ts = 0.0100
```

```
wo = (2 * 3.14) / T0
```

```
wo = 12.5600
```

```
xpls = exp((1 + 1i * wo) * Ts * n)
```

```
xpls = 1×201 complex
 0.3679 + 0.0023i 0.3683 + 0.0489i 0.3629 + 0.0956i 0.3516 + 0.1417i  ···
```

```
xmin = exp((-1 + 1i * wo) * Ts * n)
```

```
xmin = 1×201 complex
 2.7182 + 0.0173i 2.6678 + 0.3541i 2.5766 + 0.6787i 2.4467 + 0.9862i  ···
```

```
Xrplus = real(xpls)
```

```
Xrplus = 1×201
 0.3679 0.3683 0.3629 0.3516 0.3344 0.3115 0.2831 0.2497  ···
```

```
Xiplus = imag(xpls)
```

```
Xiplus = 1×201
 0.0023 0.0489 0.0956 0.1417 0.1865 0.2292 0.2691 0.3055  ···
```

```
Xrmin = real(xmin)
```

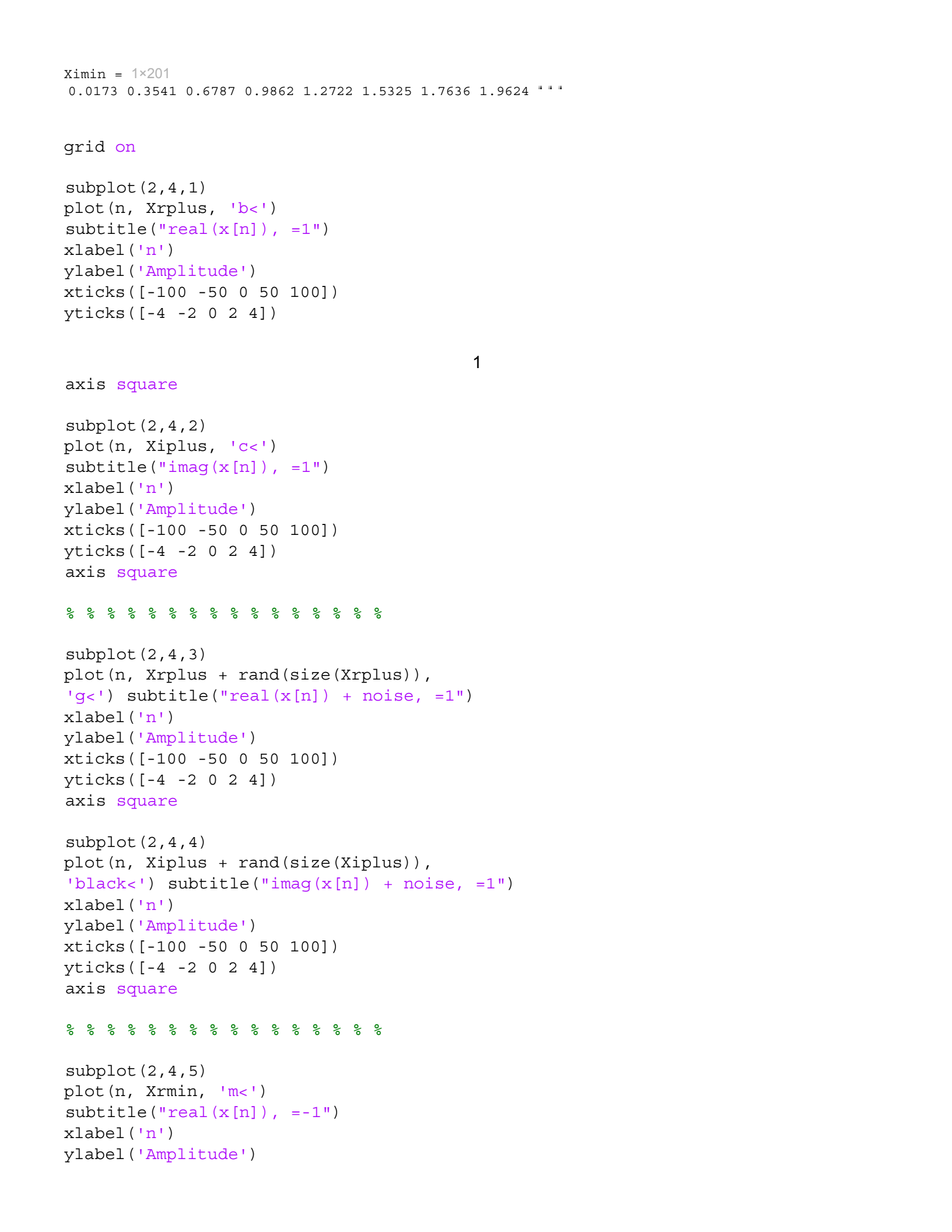
```
Xrmin = 1×201
 2.7182 2.6678 2.5766 2.4467 2.2809 2.0826 1.8556 1.6040 ···
```

```
Ximin = imag(xmin)
```

```
Ximin = 1×201
 0.0173  0.3541  0.6787  0.9862  1.2722  1.5325  1.7636  1.9624  ···
```

```
grid on

subplot(2,4,1)
plot(n, Xrplus, 'b<')
subtitle("real(x[n]), =1")
xlabel('n')
ylabel('Amplitude')
xticks([-100 -50 0 50 100])
yticks([-4 -2 0 2 4])
```




```
axis square

subplot(2,4,2)
plot(n, Xiplus, 'c<')
subtitle("imag(x[n]), =1")
xlabel('n')
ylabel('Amplitude')
xticks([-100 -50 0 50 100])
yticks([-4 -2 0 2 4])
axis square

% % % % % % % % % % % % % % %

subplot(2,4,3)
plot(n, Xrplus + rand(size(Xrplus)),
'g<') subtitle("real(x[n]) + noise, =1")
xlabel('n')
ylabel('Amplitude')
xticks([-100 -50 0 50 100])
yticks([-4 -2 0 2 4])
axis square

subplot(2,4,4)
plot(n, Xiplus + rand(size(Xiplus)),
'black<') subtitle("imag(x[n]) + noise, =1")
xlabel('n')
ylabel('Amplitude')
xticks([-100 -50 0 50 100])
yticks([-4 -2 0 2 4])
axis square

% % % % % % % % % % % % % % %

subplot(2,4,5)
plot(n, Xrmin, 'm<')
subtitle("real(x[n]), =-1")
xlabel('n')
ylabel('Amplitude')
```

```
xticks([-100 -50 0 50 100])
yticks([-4 -2 0 2 4])
axis square

subplot(2,4,6)
plot(n, Ximin, 'r<')
subtitle("imag(x[n]), =-1")
xlabel('n')
ylabel('Amplitude')
xticks([-100 -50 0 50 100])
yticks([-4 -2 0 2 4])
axis square

% % % % % % % % % % % % % % % %

subplot(2,4,7)
```



```
plot(n, Xrmin + rand(size(Xrmin)), 'white<')
subtitle("real(x[n]) + noise, =-1")
xlabel('n')
ylabel('Amplitude')
color=gca
```

```
color =
 Axes with properties:

 XLim: [-100 100]
 YLim: [-2 4]
 XScale: 'linear'
 YScale: 'linear'
 GridLineStyle: '-'
 Position: [0.5422 0.1100 0.1566 0.3412]
 Units: 'normalized'

 Show all properties
```

```
color.Color = 'g'
```

```
color =
 Axes with properties:

 XLim: [-100 100]
 YLim: [-2 4]
 XScale: 'linear'
 YScale: 'linear'
 GridLineStyle: '-'
 Position: [0.5422 0.1100 0.1566 0.3412]
 Units: 'normalized'

 Show all properties
```

```
xticks([-100 -50 0 50 100])
yticks([-4 -2 0 2 4])
axis square

subplot(2,4,8)
plot(n, Ximin + rand(size(Ximin)), 'yellow<')
subtitle("imag(x[n]) + noise, =-1")
xlabel('n')
ylabel('Amplitude')
xticks([-100 -50 0 50 100])
yticks([-4 -2 0 2 4])
axis square

% % % % % % % % % % % % % % % %



sgtitle("x[n] = e^{(\sigma + j * w0) * Ts * n}")
```

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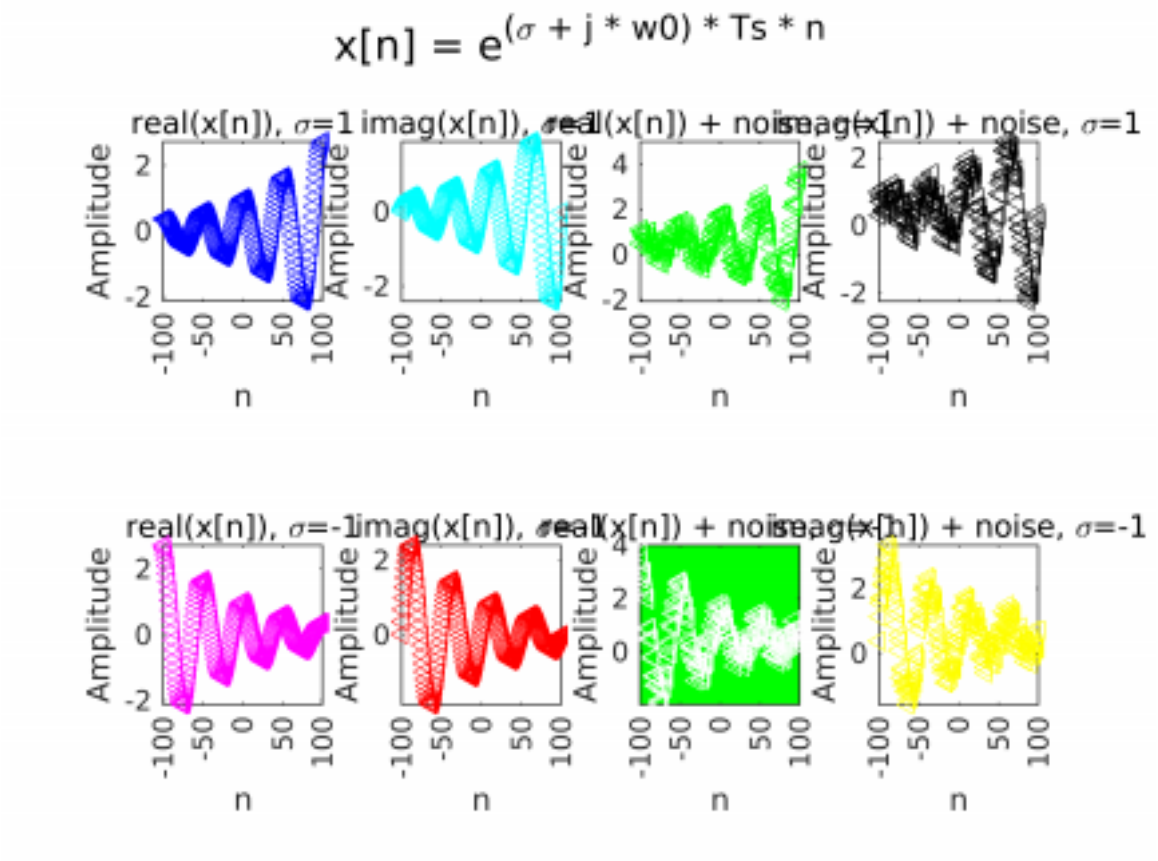

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