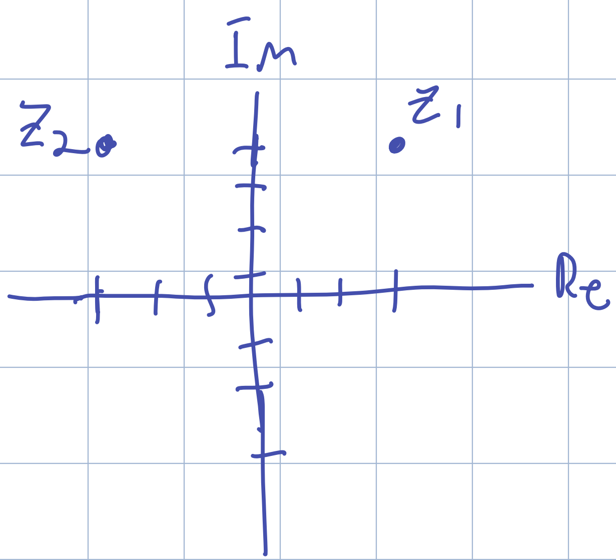
Problem Set 1 Due 1/31/2025

1. $Z_1 = 3+4j$ and $Z_2 = -3+4j$

a)



b) $3+4j$
$-3+4j$

$8j$

c) $3+4j$
$-3+4j$

6

d) $(3+4j)(-3+4j)$

$-9+12j-12j+16j^2$

$-9-16$

$= \boxed{-27}$

e)

$$\frac{3+4j}{-3+4j}\left(\frac{-3-4j}{-3-4j}\right) = \frac{-9-12j-12j-16j^2}{9+12j-12j-16j^2} = \frac{7-24j}{27}$$

$$\frac{7}{27} - \frac{24j}{27}$$

f) $z_1 = 3+4j$

take the magnitude

$\sqrt{zz^*}$

$= \sqrt{(3+4j)(3-4j)}$

$= \sqrt{9-12j+12j-16j^2}$

$= \sqrt{9+16}$

$= \sqrt{25} = 5$

g) $z_2 = 3-4j$

$\sqrt{zz^*}$

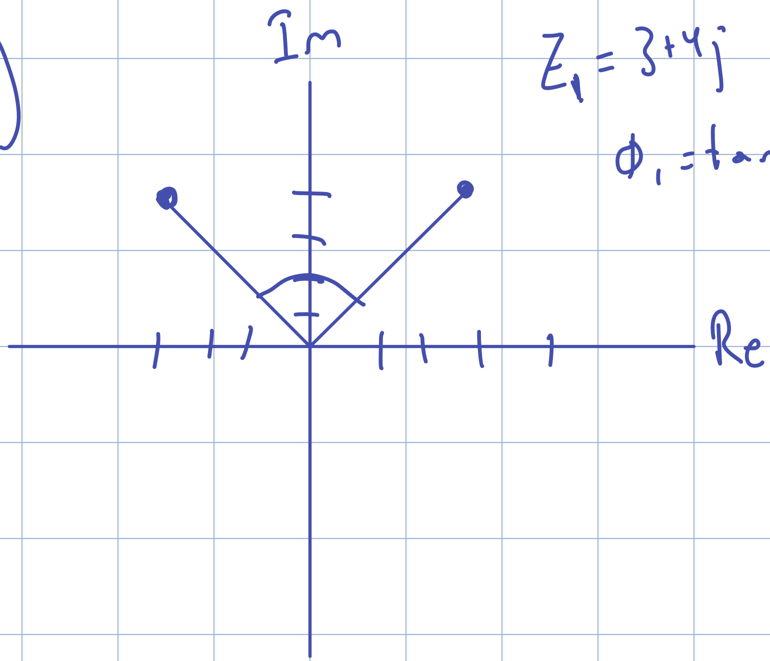
$$= \sqrt{(-3-4j)(-3+4j)}$$

$$= \sqrt{9-12j+12j-16j^2}$$

$$= \sqrt{9+16}$$

$$= \sqrt{25} = 5$$

h)



$Z_1 = 3+4j$

$\phi_1 = \tan^{-1}\left(\frac{4}{3}\right)$

$Z_2 = -3+4j$

$\phi_2 = \tan^{-1}\left(\frac{4}{-3}\right)$

j) Polar form

$$Z_1 = 5e^{j\tan^{-1}\left(\frac{4}{3}\right)}$$

$$Z_2 = 5e^{j\tan^{-1}\left(\frac{4}{-3}\right)}$$

2) Euler's Identity: $e^{j\phi} = \cos\phi + j\sin\phi$

$$\cos\phi = \frac{e^{j\phi} + e^{-j\phi}}{2}$$

$$\cos(2\pi f t) = \frac{e^{2\pi j f t} + e^{-2\pi j f t}}{2}$$

$$\cos(2\pi f t) = \frac{\left(\cos(2\pi f t) + \cancel{j\sin(2\pi f t)}\right) + \left(\cos(-2\pi f t) - \cancel{j\sin(2\pi f t)}\right)}{2}$$

$$= \frac{\cancel{2}\cos(2\pi f t)}{\cancel{2}}$$

$$\cos(2\pi f t) = \cos(2\pi f t = \frac{e^{2\pi j f t} + e^{-2\pi f t}}{2}$$

$$\sin(2\pi f t) = \frac{e^{2\pi j f t} - e^{-2\pi j f t}}{2}$$

$$\frac{e^{2\pi j f t} - e^{-2\pi j f t}}{2} = \frac{\cos(2\pi f t) + j\sin(2\pi f t) - \left(\cos(2\pi f t) - j\sin(2\pi f t)\right)}{2}$$

$$= \frac{\cancel{\cos}(2\pi f t) + j\sin(2\pi f t) - \cancel{\cos}(2\pi f t) + j\sin(2\pi f t)}{2}$$

$$= \frac{\cancel{2} j\sin(2\pi f t)}{\cancel{2}}$$

$$\frac{e^{2\pi j f t} - e^{-2\pi j f t}}{2} = \sin(2\pi f t)$$

3. $V_1(t) = 4\cos(2\pi f_1 t)$

a) $V_2(t) = 4\cos(2\pi f_2 t - \phi)$

$P = V_1(t) V_2(t)$

$P(t) = 4\cos(2\pi f_1 t) \cdot 4\cos(2\pi f_2 t - \phi)$

$= 16\cos(2\pi f_1 t)\cos(2\pi f_2 t - \phi)$

$= 8(\cos(2\pi (f_1 - f_2) t + \phi) + \cos(2\pi (f_1 + f_2) t - \phi))$

$8\cos(2\pi(f_1 - f_2)\cancel{f} t + \phi) + \cos(2\pi(f_1 + f_2) t - \phi)$

$f_+ = f_1 + f_2 \quad f_- = f_1 - f_2$

b)

$P_{max} = 8[\cos(0) + \cos(4\pi f_1 t)]$

$= 8[1 + \underbrace{\cos 4\pi f_1 t}_{=1}]$

$= 8[1 + 1]$

$= 16$

16 is the correct number because $\cos(2\pi f_1 t)$

and $\cos(2\pi f_2 t - \phi)$ maximum value is one.

4.)

$$V_1(t) = \Re\{\exp(j(2\pi f t - \phi))\}$$

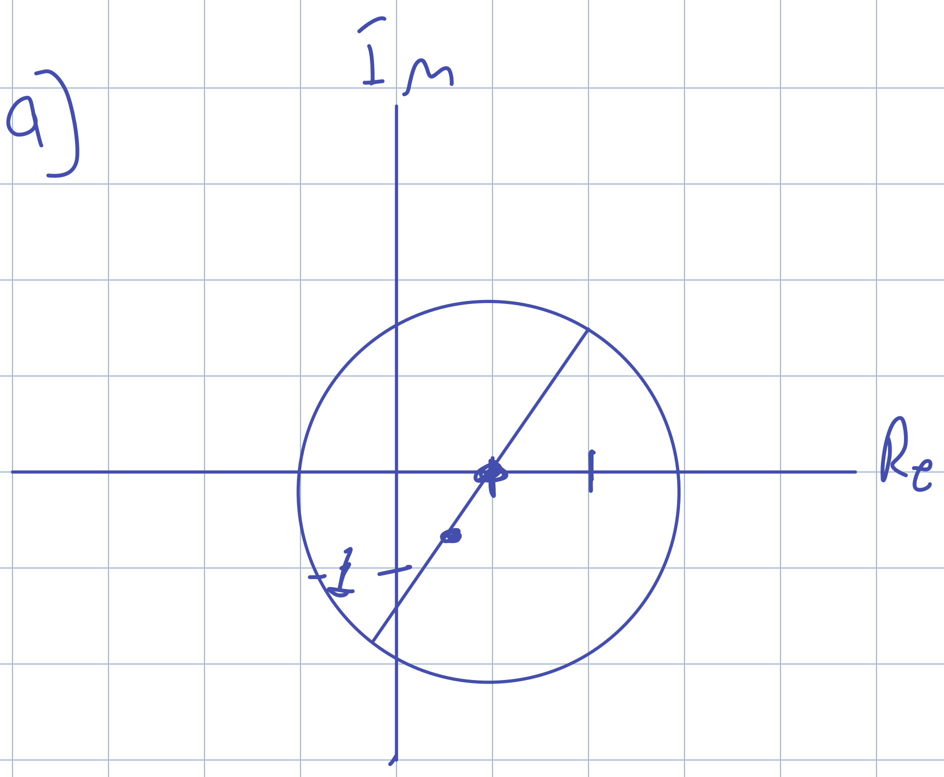
$$V_2(t) = \Re\{\exp(2\pi j f t)\}$$

$$\exp(j(2\pi f t - \phi)) = \exp(j 2\pi f t) \cdot \exp(-j\phi)$$

$$\exp(2\pi j f t) = \exp(j 2\pi f t) \cdot 1$$

$$V_1(t) = \exp(-j\phi), \quad V_2(t) = 1$$

a)



b)

$$Z = \exp(-j\phi) + 1$$

$$\exp(-j\phi) = \cos(\phi) - j\sin(\phi)$$

$$Z = (\cos(\phi) - j\sin(\phi)) + 1$$
$$= (1 + \cos(\phi)) - j\sin(\phi)$$

Magnitude of Z

$$|Z| = \sqrt{(1 + \cos(\phi))^2 + (-\sin(\phi))^2}$$
$$= \sqrt{1 + 2\cos(\phi) + \cos^2(\phi) + \sin^2(\phi)}$$
$$|Z| = \sqrt{2 + 2\cos(\phi)}$$

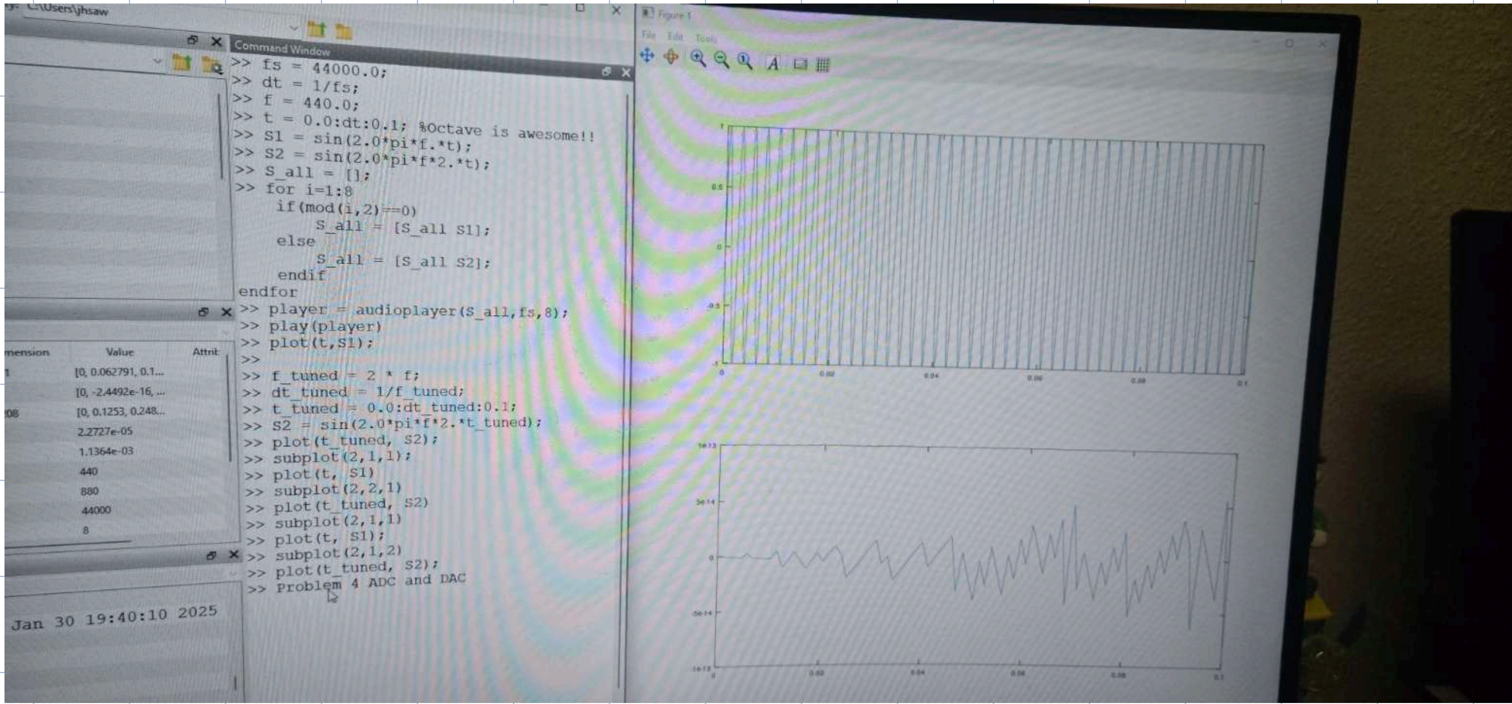
$$\theta = \tan^{-1}\left(\frac{-\sin(\phi)}{1 + \cos(\phi)}\right)$$

c) $|Z| = 2\left|\cos\left(\frac{45}{2}\right)\right| = 1.85$

$$|z| = 2\left|\cos\left(\frac{0}{2}\right)\right| = 2$$

$$|z| = 2\left|\cos\left(\frac{180}{2}\right)\right| = 0$$

in phase (0°) the magnitude doubles to 2 out of phase (180°) the magnitude cancelled to 0


Command Window
>> fs = 44000.0;
>> dt = 1/fs;
>> f = 440.0;
>> t = 0.0:dt:0.1; %Octave is awesome!!
>> S1 = sin(2.0*pi*f.*t);
>> S2 = sin(2.0*pi*f*2.*t);
>> S_all = [];
>> for i=1:8
if(mod(i,2)==0)
S_all = [S_all S1];
else
S_all = [S_all S2];
endif
endfor
>> player = audioplayer(S_all,fs,8);
>> play(player)
>> plot(t,S1);
>>
>> f_tuned = 2 * f;
>> dt_tuned = 1/f_tuned;
>> t_tuned = 0.0:dt_tuned:0.1;
>> S2 = sin(2.0*pi*f*2.*t_tuned);
>> plot(t_tuned, S2);
>> subplot(2,1,1);
>> plot(t, S1)
>> subplot(2,2,1)
>> plot(t_tuned, S2)
>> subplot(2,1,1)
>> plot(t, S1);
>> subplot(2,1,2)
>> plot(t_tuned, S2);
>> Problem 4 ADC and DAC
Jan 30 19:40:10 2025
Value
Attrit
[0, 0.062791, 0.1...
[0, -2.4492e-16, ...
[0, 0.1253, 0.248...
2.2727e-05
1.1364e-03
440
880
44000
8

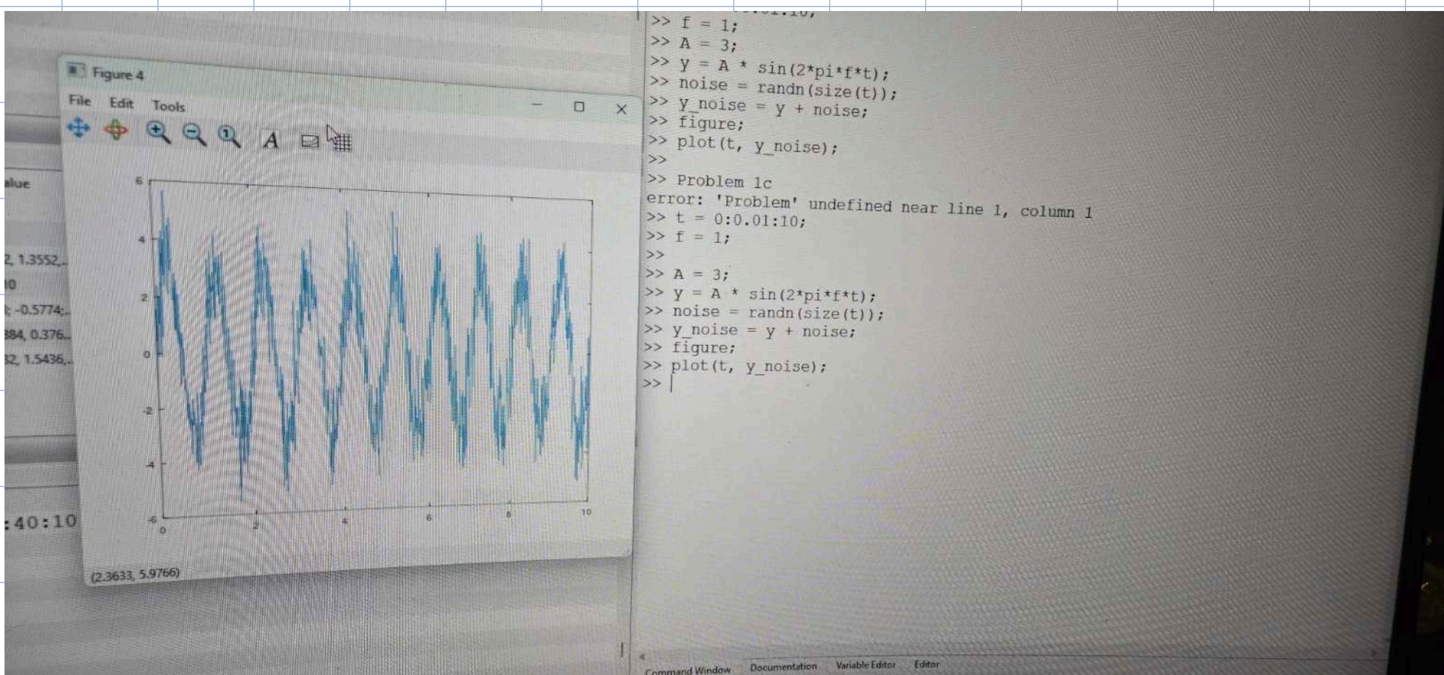


Figure 4
File Edit Tools
(2.3633, 5.9766)
>> f = 1;
>> A = 3;
>> y = A * sin(2*pi*f*t);
>> noise = randn(size(t));
>> y_noise = y + noise;
>> figure;
>> plot(t, y_noise);
>>
>> Problem 1c
error: 'Problem' undefined near line 1, column 1
>> t = 0:0.01:10;
>> f = 1;
>>
>> A = 3;
>> y = A * sin(2*pi*f*t);
>> noise = randn(size(t));
>> y_noise = y + noise;
>> figure;
>> plot(t, y_noise);
>>
Command Window
Documentation
Variable Editor
Editor