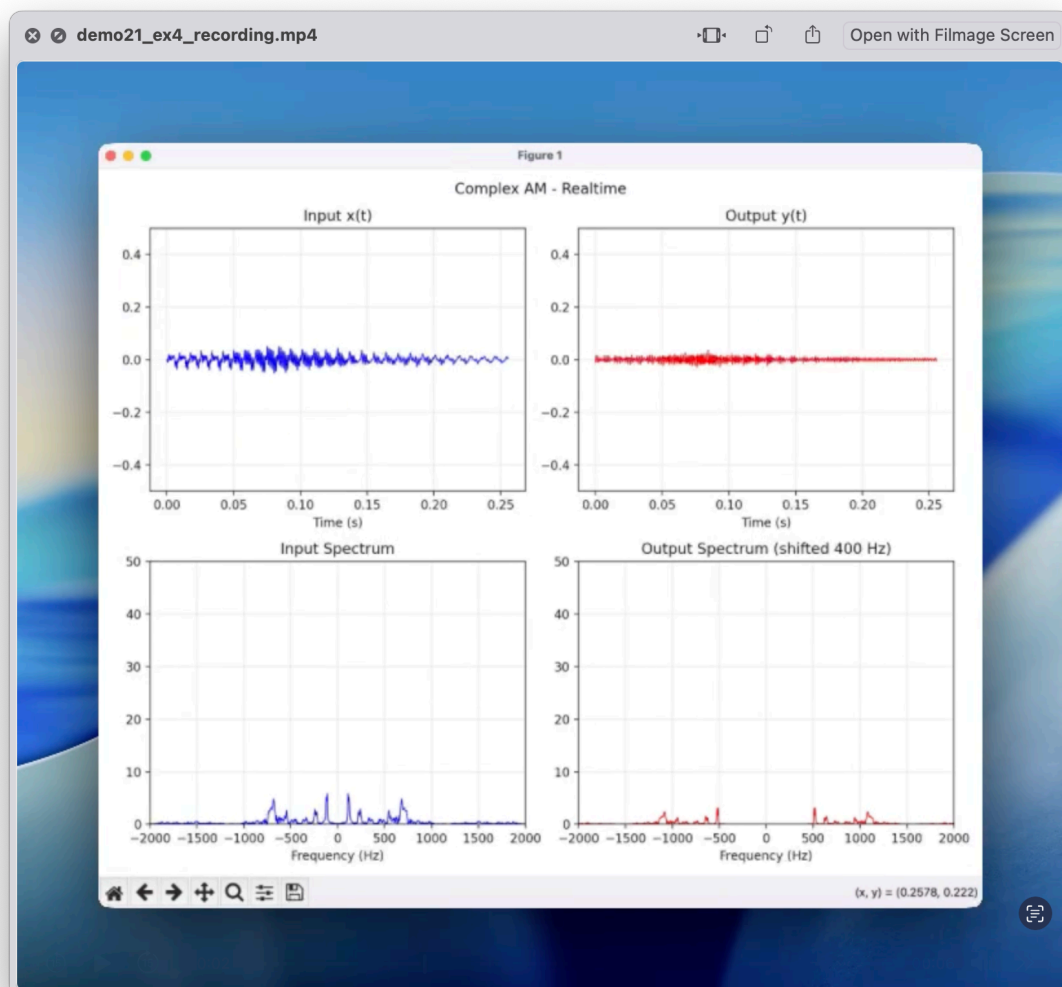


DSP Lab Demo 21 Ex4

This implementation demonstrates the complex AM effect for real-time speech processing with visualization.



The complex AM effect shifts frequencies without spectral overlap by:

1. Complex Filter Design:

- low-pass elliptic filter
- modulate coefficients: multiply by j^n (where $j = \sqrt{-1}$)

2. Signal Processing Chain:

$$\text{Modulation : } g(t) = r(t) * \exp(j2\pi f_1 * t)$$

- input $x(t)$ is real
- filter output $r(t)$ is complex
- output: $y(t) = \text{Re}[g(t)]$

Expected Results

- voice will sound higher-pitched and "robotic"
- the spectrum will be shifted by 400 Hz

Key Code Section

The complex filter creation:

```
b_lpf, a_lpf = signal.ellip(7, 0.2, 50, 0.48)
s = 1j ** np.arange(8)
b = b_lpf * s
a = a_lpf * s
```

The complex AM processing

```
r, zi = signal.lfilter(b, a, x, zi=zi)
g = r * np.exp(1j * 2 * np.pi * f1 * t)
y = np.real(g)
```