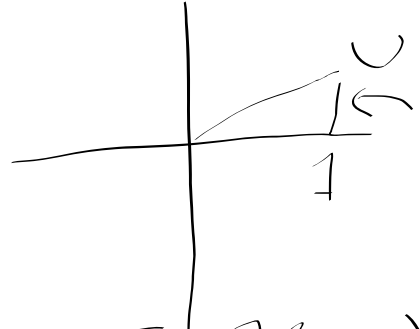


$$f = \angle \left(\frac{2U^k X[k] - U^{k-1} X[k-1] - U^{k+1} X[k+1]}{2X[k] - X[k-1] - X[k+1]} \right)$$

$$U = e^{i2\pi/N} \approx 1 + i\frac{2\pi}{N}$$



$$f = \frac{k2\pi}{N} + \angle \left(1 + \frac{X[k+1](U-1) + X[k-1](\bar{U}-1)}{2X[k] - X[k-1] - X[k+1]} \right)$$

$$\approx \frac{k2\pi}{N} + \text{Im} \left(\frac{i\frac{2\pi}{N} X[k+1] - i\frac{2\pi}{N} X[k-1]}{2X[k] - X[k+1] - X[k-1]} \right)$$

$$\approx \frac{k2\pi}{N} + \frac{2\pi}{N} \text{Im} \left(\frac{X[k+1] - X[k-1]}{2X[k] - X[k+1] - X[k-1]} \right)$$