INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY
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AV 331 – Digital Signal Processing Lab

Labsheet-6 - LTI System and Group delay

1. Write a program to create N=100 samples of a Gaussian pulse

$$s(t) = \frac{1}{\sqrt{2\pi\sigma}} exp - \frac{(t-\mu)^2}{2\sigma^2}$$

with $\mu = 0$ and $\sigma = 2$ in the range $-5 \leq t \leq 5$ and plot the waveform $s(n)$

2. Generate two modulate Gaussian pulse with center frequency $\omega_1 = 0.34\pi$ and $\omega_2 = 0.6\pi$ separately and

$$s_1(n) = s(n)cos(\omega_1 n)$$
$$s_2(n) = s(n)cos(\omega_2 n)$$

generate a signal $x(n) = [s_1(n), s_2(n)]$

3. Consider the digital resonator with transfer function given by

$$H(z) = b_0 \frac{1 - z^{-2}}{1 - 2rcos(\Phi)z^{-1} + r^2 z^{-2}}$$

   a) Determine the constant b_0 for the normalization condition $|H(e^j\Phi)| = 1$. Compute the value of b_0 for $r = 0.9$ and $\Phi = 0.34\pi$.
   b) Determine the impulse response $h[n]$ of the above resonator and plot it for $r = 0.9$ and $\Phi = 0.34\pi$.
   c) For $r = 0.9$ and $\Phi = 0.34\pi$, plot the magnitude response in dB, phase response and group-delay. Determine the exact 3-dB bandwidth

4. Find the response $y(n)$ to the input $x(n)$ generated from question(2) and $h(n)$ generated from question(3). Comment on the response.

5. Design a the digital resonator with center frequency $\omega = 0.6\pi$ from pole zero plot [use the command $zp2tf$ to convert pole zero to coefficient of the transfer function] and find the response of the system for the input given in question(2).

6. An LTI system is described by the difference equation

$$y(n) = bx(n) + 0.8y(n-1) - 0.81y(n-2)$$

   a) Determine the frequency response $H(e^{j\omega})$ of the system in terms of b
   b) Determine b so that $|H(e^{j\omega})|_{max} = 1$. Plot the resulting magnitude response.
   c) Graph the wrapped and the unwrapped-phase responses in one plot.
   d) Determine the response $y[n]$ to the input $x[n] = 2cos(\pi n/3 + \pi/4)$.