

Speech Signal Processing Homework Assignment 3

4.3. Which of the following pairs of tones is perceived as the louder tone (and by how many phons):

(a) 20 dB *IL* at 1000 Hz or 20 dB *IL* at 500 Hz

(b) 40 dB *IL* at 200 Hz or 30 dB *IL* at 2000 Hz

(c) 50 dB *IL* at 100 Hz or 50 dB *IL* at 1000 Hz.

5.11. Show that if $|a| < 1$,

$$1 - az^{-1} = \frac{1}{\sum_{n=0}^{\infty} a^n z^{-n}}$$

and thus, that a zero can be approximated as closely as desired by multiple poles.

5.12. The transfer function of a digital formant resonator is of the form

$$V_k(z) = \frac{1 - 2|z_k| \cos \theta_k + |z_k|^2}{1 - 2|z_k| \cos \theta_k z^{-1} + |z_k|^2 z^{-2}},$$

where $|z_k| = e^{-\sigma_k T}$ and $\theta_k = 2\pi F_k T$.

- (a) Plot the locations of the poles of $V_k(z)$ in the z -plane. Also plot the corresponding analog poles in the s -plane.
- (b) Write the difference equation relating the output, $y_k[n]$, of $V_k(z)$ to its input, $x_k[n]$.
- (c) Draw a digital network implementation of the digital formant network with three multipliers.
- (d) By rearranging the terms in the difference equation obtained in part (b), draw a digital network implementation of the digital formant network that only requires two multiplications.

- 5.17.** The shape of the glottal pulse from the vocal cords can be approximated by the impulse response of a second-order filter with system function:

$$G(z) = \frac{az^{-1}}{(1 - az^{-1})^2}, \quad 0 < a < 1.$$

- (a) Plot the glottal pulse model impulse response, $g[n]$, for $a = 0.95$ and for $a = 0.8$.
- (b) Plot the corresponding log magnitude response, $20 \log_{10} (|G(e^{j\omega})|)$, in dB versus ω (or versus f) for the two values of a used in part (a) of this problem.
- (c) The effect of lip radiation can be modeled by a single zero at $z = 1$. Repeat part (b) with the inclusion of this extra zero.
- (d) Draw a flow graph representation of the system that models the combined glottal pulse and lip radiation effects.