UNIVERSITY OF ILLINOIS
Department of Electrical and Computer Engineering
ECE 417 Multimedia Signal Processing

Lecture 5 Sample Problems

Problem 5.1

Suppose $s[n] = \sum_{m=0}^{P-1} S_m e^{jmn\omega_0}$, and $s_f[n] = w[n]s[n + fK]$, where $w[n]$ is the rectangular window,

$$w[n] = \begin{cases} 1 & 0 \le n \le N-1 \\ 0 & \text{else} \end{cases}$$

Find $S_0(e^{j\omega})$, the DTFT of the zero'th frame, in terms of $\text{dsinc}(\theta, L) = \frac{\sin(\theta L/2)}{L\sin(\theta/2)}$, S_m, P, and $R = L/P$, which is the number of pitch periods per window. Notice that your answer doesn't depend on R being an integer, or even a rational number.

Problem 5.2

Suppose $s[n] = \sum_{m=0}^{P-1} S_m e^{jmn\omega_0}$, and $s_f[n] = w[n]s[n + fK]$, where $w[n]$ is any window. Notice that $s[n + fK] = s[n] * \delta[n + fK]$, that is, shifting $s[n]$ to the left in time is the same thing as convolving with an impulse at time $n = -fK$. Using this observation, or using any other approach that you find convenient, find the DTFT of $s_f[n] = s[n + fK]w[n]$ in terms of $W(e^{j\omega})$, P, S_m, and the fixed phase-shift terms $\theta_{fm} = 2\pi mfK/P$.

Problem 5.3

Suppose $s[n] = \sum_{p=-\infty}^{\infty} h[n - pP]$. Find $S_f(e^{j\omega})$ in terms of θ_{fm}, P, $W(e^{j\omega})$, and $H(e^{j\omega})$.