NANYANG TECHNOLOGICAL UNIVERSITY
School of Electrical & Electronic Engineering

EE/IM4152 Digital Communications

Tutorial No. 1 (Sem 1, AY2016-2017)

1. Similar to the definition of band-limited signals, a signal $g(t)$ is time-limited if $g(t) = 0$ for $|t| > T$, where T is the duration of the signal. It can be shown that a band-limited signal cannot be time-limited, and vice versa. A relatively simple proof of this can be obtained by contradiction (see Wozencraft and Jacobs, *Principles of Communication Engineering. NY: John Wiley & Sons*, 1965).

   (a) Suppose $X(f) = G(f)H(f)$ is band-limited to B Hz, where $G(f)$ is not necessarily band-limited and $H(f) = \text{rect}(f/2B)$ is the transfer function of an ideal low-pass filter. Show that $x(t) = F^{-1}[X(f)]$ cannot be time-limited.

   (b) Choose two pairs of functions from the Fourier transform table to illustrate this concept.

2. A signal $g(t) = \text{sinc}^2(5t)$ is sampled (using uniformly spaced impulses) at a rate of (i) 5 Hz, (ii) 10 Hz and (iii) 20 Hz. For each of the three cases:

   (a) Sketch the spectrum of the sampled-data signal $\bar{g}(t)$.

   (b) If the sampled-data signal $\bar{g}(t)$ is passed through an ideal low-pass filter of bandwidth 5 Hz, sketch the spectrum of the output signal.

3. Determine the bandwidth B for each of the following signals. Accordingly, compute the corresponding Nyquist sampling rate $f_s = 2B$ and the Nyquist sampling interval $T_s = 1/f_s$.

   (a) $s_1(t) = \text{sinc}(2000t)$

   (b) $s_2(t) = \text{sinc}^2(2000t)$

   (c) $s_3(t) = s_1(t) + 2s_2(t)$

   (d) $s_4(t) = s_1(t)s_2(t)$

   (e) $s_5(t) = s_1(t) \otimes s_2(t)$

   Note that the symbol '⊗' denotes the convolution operation.