NANYANG TECHNOLOGICAL UNIVERSITY
School of Electrical and Electronic Engineering

E6101 DIGITAL COMMUNICATIONS

Tutorial 3

1. Multiplying a preferred pair *m*-sequences $\{x_i\}$ and $\{y_i\}$ chip by chip gives rise to a Gold code $\{g_i\}$ where $\{g_i\} = \{x_i\ y_i\}$. Prove mathematically that the periodic autocorrelation values $\phi_{gg}(k) = \sum_i g_i\, g_{i+k}$ of the Gold code generated can at most take the same 3 values as the cross-correlation of $\{x_i\}$ and $\{y_i\}$. Note a preferred pair *m*-sequences have only 3 periodic cross-correlation values.

2. (a) The *m*-sequence $\mathbf{m}_1$ is generated using a linear feedback shift register (LFSR) generator with primitive polynomial 100101 and initial shift register contents 00001. Determine and write down the first 16 chips of $\mathbf{m}_1$.

   (b) In a 2-cell CDMA downlink, scrambled Walsh Hadamard codes are used as the CDMA spreading codes. The scrambling code of Cell 1 is $\mathbf{m}_1$, while the scrambling code of Cell 2 is a shifted version of $\mathbf{m}_1$. There are 2 users in Cell 1: User "A" wants to transmit two data bits [1 0] and is assigned the Walsh Hadamard code [01100110], User "B" wants to transmit [0 1] and is assigned another Walsh Hadamard code [11110000]. Determine the CDMA signal vector to be transmitted by Cell 1. Express your answer using the signal mapping $0 \rightarrow +1$, $1 \rightarrow -1$.

3. A CDMA downlink user transmits one bit of information using a scrambled WH code:

   WH code [1 0 1 0] scrambled by the *m*-sequence [1 1 1 0 0 1 0]

   The channel is an additive white Gaussian noise (AWGN) channel and the received chip signals $\boldsymbol{r}$ are shown below, where the first 2 samples (underlined) denote the propagation delays introduced by the channel:

   $\boldsymbol{r} = [\underline{-0.04, -0.06}, +0.53, +0.87, -1.14, -1.19]$

   Given that the system makes use of the binary mappings $1 \rightarrow +1$ and $0 \rightarrow -1$ for transmission, determine the transmitted bit.