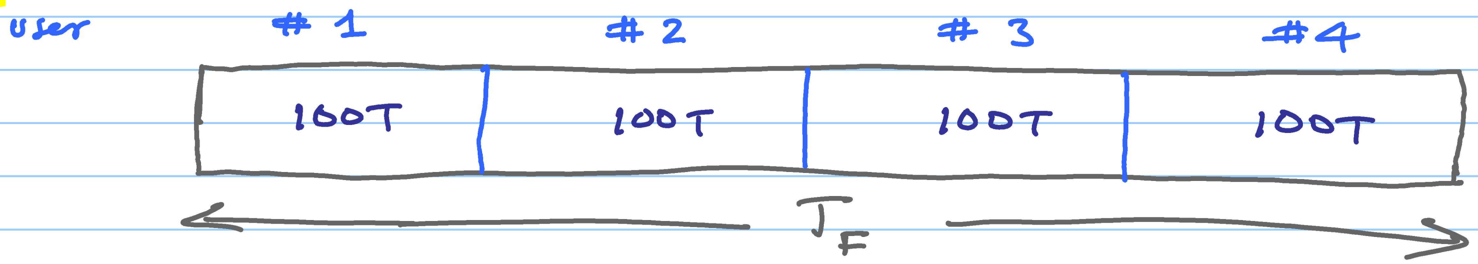
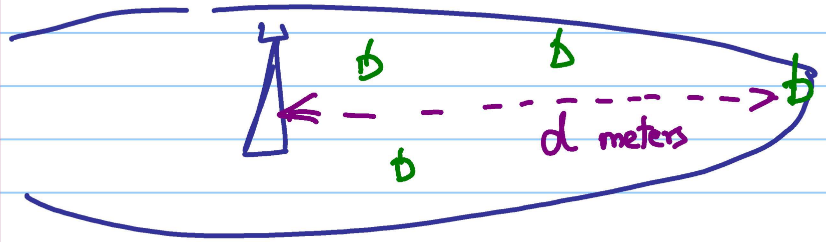
EE6323 Wireless Systems Design

# Tutorial #1 (Feb.28, 2021)

## Q. #1

Consider the below TDMA Uplink frame with 4 user slots





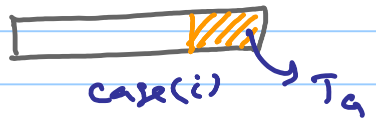
← Round Trip Time (RTT) $= \frac{2d}{c}$

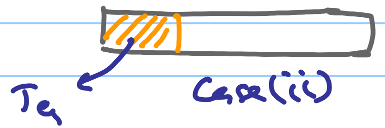
where $c = 3\times10^8$ m/s

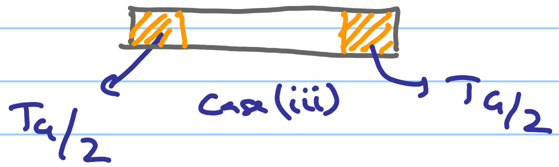
For the above system, answer the following questions

(1a) If $T = 1\mu sec$, and $d = 1.5$ km is required, how many bits of Guard Time $T_G$ is required in each slot? What is the corresponding bit rate of the uplink system? Also, what is the per user bit rate?

(1b) In the previous question, how must the guard-time $T_g$ be placed within the slot? Consider the below 3 cases







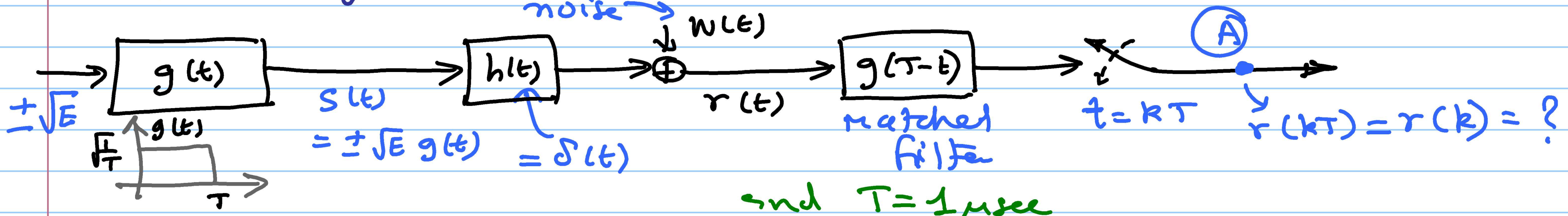
Which choice is the best, and why? Explain

(1c) Now, if $d = 6$ km is required, what $T_G$ will be needed? In this case, what is the overhead, expressed as a percentage of the slot time? (Note: slot time is $100T$).

(1d) By changing only the frame duration $T_F$, can the overhead %age be made the same for $d = 6$ km as that in (1a)? What is the tradeoff in making $T_F$ larger?

**Q #2**

Let us go back to the TDMA uplink for 4 users with $T_F = 400T$ (i.e., $100T$ for each user). Consider the below block diagram for the Tx and Rx (baseband equivalent) chain and $T = 1\mu$sec



Using the above block-diagram answer the following:

(2a) Give an expression for $r(kT) = r(k)$.

(2b) If $w(k)$ is AWGN with variance $N_0/2$, what is the concise expression for the Signal to Noise ratio (SNR) at Ⓐ ?

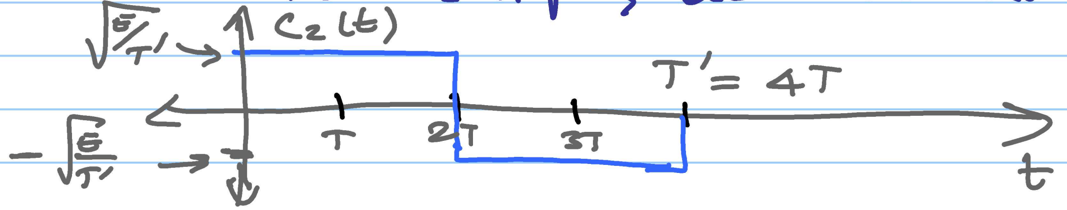
(2c) What is the peak power, $P_p$, and the average power, $P_A$, of user #2 if the user is sending 100 bits in $T_F$ secs ?

(2d) If user #2 reduces Tx bit-rate by 75% (i.e., user #2 now sends only 25 bits in $T_F$ seconds by using $\underline{\underline{T' = 4T}}$), what will be the new $P_p'$ and $P_A'$ ?

(2e) If Power Received at base-station $P_R = P_p / d^2$, by how much %age is the link distance increased by the operation in (2d)? Explain clearly.

**Q # 3 :** Now, let us consider a DS-CDMA system where all the 4 users on their uplink transmit in the entire $T_F = 100T' = 400\mu sec$ frame. Here $T' = 4T = 4\mu sec$

Recall the 4 orthogonal codes used by the 4 users to distinguish their bits. For example, user #2 uses $c_2(t)$ given below:



$$c_2(t) \longrightarrow \overline{c}_2 = \begin{bmatrix} 1 \\ 1 \\ -1 \\ -1 \end{bmatrix} ;$$

$\rightarrow c_2(1)$

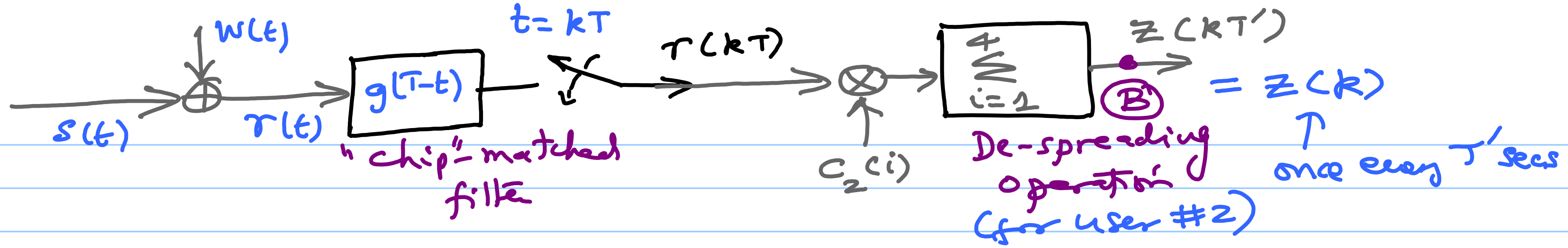
$\rightarrow c_2(4)$

"code" vector

Every $T' = 4T$, either an information symbol $I(kT) = 1$ (for bit "1") or $I(kT) = -1$ (for bit "0") is sent by user #2 by sending either $c_2(t)$ or $-c_2(t)$, respectively.

either $c(t)$ or $-c(t)$

Now consider the processing of $r(t) = s(t) + w(t)$ by the DS-CDMA receiver as described in the block diagram below.



(3a) Give an expression for $z(k)$.

(3b) What is the peak power, $P_P$, and average power, $P_A$, spent by user #2? How does this contrast with corresponding answers for TDMA in (2c)?

(3c) At location Ⓑ, what is the expression for the SNR?

Hint: use the fact that noise samples obtained at the output of the sampler are self-white and mutually uncorrelated with the signal samples.