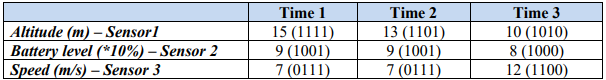
1. Assume that a typical voice signal occupies a bandwidth of 4 kHz, and we need to transmit three separate voice signal simultaneously. Using Frequency Division Multiplexing with Amplitude Modulation, choose three carrier frequencies such that the voice signals can be combined without interfering with each other. The modulated version of each of these signals will occupy 8 kHz of bandwidth in the frequency domain, since the AM signal contains two sidebands (a copy and a mirror image of the original signal). Therefore, the most efficient method will place the signals immediately next to each other, requiring a total of 24 kHz (i.e. 8 kHz per signal).
2. Due to budget cuts, you’re told that you must achieve the same task with only half the bandwidth! Determine a method to combine the three voice signals into a channel with a bandwidth of 12 kHz, from 20 to 32 kHz. Show the configuration, using the frequency domain.
3. UAV sensor reports (altitude, battery level, speed) are being sent using TDM. Each sensor sends a 4-bit data packet a time. Assume that the first 3 data packets from each sensor are shown in the table below, show the data stream in binary on the channel.



Questions: Assuming that the data rate of the channel is 100 kbps.

a. What is the frame rate (frame per second – fps) of the channel?

b. What is the maximum bit rate for each sensor?

1. **Encode a binary word 11001 into the even parity hamming code.**
2. **Let us assume the even parity hamming code from the above example (111001101) is transmitted and the received code is (110001101). Now from the received code, let us detect and correct the error.**
3. On a wireless link, the probability of packet error is 0.2. A stop and wait protocol is used to transfer data across the link. The channel condition is assumed to be independent from transmission to transmission. What is the average number of transmission attempts required to transfer 100 packets?
4. Compute the fraction of the bandwidth that is wasted on overhead (headers and retransmissions) for a protocol on a heavily loaded 50 Kbps satellite channel with data frames consisting of 40 bits header and 3960 data bits. Assume that the signal propagation time from the earth to the satellite is 270 msec. ACK frames never occur. NAK frames are 40 bits. The error rate for data frames is 1% and the error rate for NAK frames is negligible.
5. A TCP machine is sending windows of 65535 B over a 1 Gbps channel that has a 10 msec one way delay.
6. What is the maximum throughput achievable?
7. What is the line efficiency?
8. Draw the different coding scheme for data 1010110010.

(a) NRZ (b). RZ (c) Bipolar

1. Assume we need to download text documents at the rate of 100 pages per minute. What is the required bit rate of the channel?