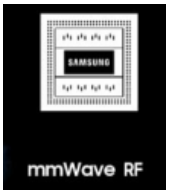
Data Communications Midterm Exam (2019.10.24)

☞ You can answer either **in English or in 한글**.

☞ **Specify correct units (e.g. bps, Hz, bits, baud, dB)** for full credits!!! (부정확한 단위는 감점요인임!!!)

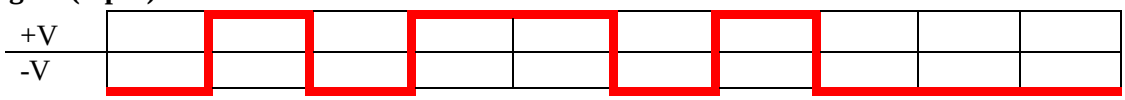
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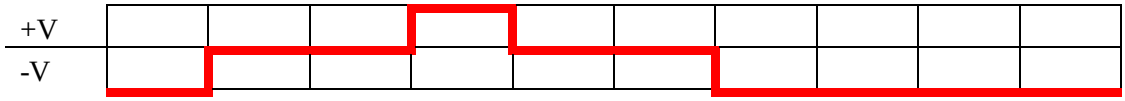
1. 5G communication technology uses "millimeter waves." Millimeter waves have less than 10 millimeters as the wavelength. Considering the speed of light is 3×10^8 m/s, what is the minimum frequency that begins to produce a millimeter wave? **(3pts)** _____**30 GHz**

2. Today's cars employ multiple in-vehicle communication technologies such as Controller Area Network (CAN) and Ethernet. The former uses NRZ-L and the latter, MLT-3. As an engineer, you have implemented a CAN-to-Ethernet trans-coder that translates the CAN signal into Ethernet signal. What output would your trans-coder produce for the following CAN signal input? Draw your answer with thick lines along appropriate edges. (Assume that $-V \equiv 0$, $+V \equiv 1$ for NRZ-L, and MLT-3 is at $-V$ at the beginning.) **(5pts)**

   CAN signal (input):



   Ethernet signal (output): ***/* Draw your answer below, along appropriate edges */***

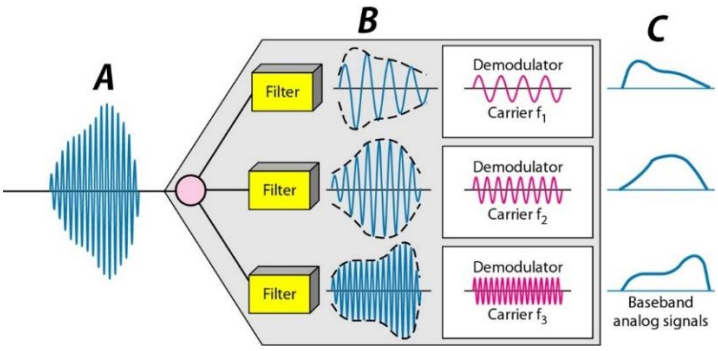


3. A communication medium provides the frequency band between 917 and 918 MHz. The SNR on this band is 3 (not 3 dB).
   A. What is the Shannon limit on the achievable data rate for this communication channel? _____**2 Mbps**_____**(2pts)**
   B. What would be the symbol rate if we want to use only a half of this theoretical capacity and employ 16QAM? _____**250 kbaud** _____**(2pts)**
   C. At 16QAM, what is the maximum bit rate that the Nyquist model would predict for this channel? _____**8 Mbps** _____ **(2pts)**
   D. Why does the Nyquist model predict an unachievable rate? Answer in less than four words. (Hint: channel assumption) _____**assumed noiseless channel** _____ **(1pt)**
   E. Can you use Manchester encoding to put the data onto this band? (Y/N) __**N** ___ **(1pt)** Why (or why not)? Answer in less than four words._____ **not lowpass band**_____ (Hint: property of the given band) **(2pts)**

4. Consider a signal transmitting at 12 Mbps for QPSK. Assuming the value of d = 0,
   A. What is the bits per symbol? ___**2 bits** _____ **(1pt)**
   B. What is the baud rate? _____**6 Mbaud** _____ **(1pt)**
   C. What is the bandwidth? ____**6 MHz** _____ **(2pts)**

5. A multiplexer combines four 100 kbps channels using a time slot of 2 bits.
   A. What is the frame rate? _____**50000 frames/s** _____ **(2pts)**
   B. What is the frame duration? ___**20 μs** _____ **(1pt)**
   C. What is the bit rate on the multiplexed line? ____**400 kbps** _____ **(1pt)**

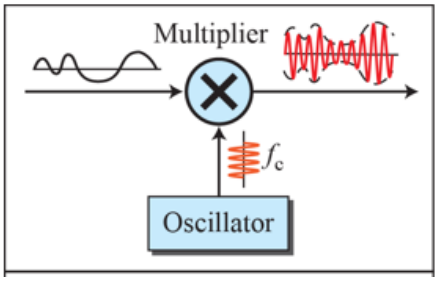
6. In the process depicted in the following figure,
   A. What is being done? Answer in two key words. _____**FDM Demultiplexing**_____ **(3pts)**
   B. What is the minimum bandwidth ratio of A to B (i.e., A/B)? ___**3:1**_____ **(2pts)**
   C. What is the minimum bandwidth ratio of B to C (i.e., B/C)? ___**2:1**_____ **(2pts)**



7. For the following statements, answer true (T) or false (F). **(0.5pts each, 12 pts total)**
   A. Virtual Circuit Identifier (VCI) is the address of the destination used in virtual circuit networks. __**F** ___
   B. Binary Amplitude Shift Keying (ASK) uses discrete frequency components. ___ **F** _____
   C. Circuit switching was first used in telephone networks. ___ **T**__
   D. A low-pass channel with bandwidth 100 kHz can support the maximum bitrate of 200 kbps in baseband transmission. __ **T** __
   E. Spread spectrum techniques such as FHSS inevitably lead to bandwidth waste. ___ **F** __
   F. Different frequency components can travel at different speeds in a given medium. ____ **T** ___
   G. WDM is used for multiplexing analog input signals, and FDM and TDM are for digital signals. ___ **F** ___
   H. Nyquist sampling theorem requires sampling at twice the highest frequency of a given signal as the necessary and sufficient condition for full reconstruction of the signal. __ **F** ___
   I. The bandwidth in Herz and the bandwidth in bps are proportional. ___ **T** ___
   J. dB_m is not equivalent to dB. ___ **T** __
   K. Switching is necessary because we cannot afford dedicated communication lines between all end points. __ **T** __
   L. Virtual circuit is a type of circuit switching. _ **F** ___
   M. We can use either FDM or TDM with circuit switching. __ **T** _
   N. The bandwidth-delay product tells us the maximum amount of data that can be on the move on a communication channel. __ **T** __
   O. If a signal power becomes one half of the original, the attenuation is 2 dB. __ **F** ___
   P. Scrambling has advantages over block coding in terms of bit rate. ___ **T** __
   Q. Our general goal in communication is to increase the data rate while decreasing the signal rate. __ **T** ___
   R. The device used in FM is Voltage Controlled Oscillator. ____ **T** _____
   S. DC components are especially problematic in low-pass channels. ___ **T** __
   T. In datagram networks, it is the lack of resource reservation that makes packets experience delay at switches. _ **T** ___
   U. There are 512 "invalid" data codes in the 8B/10B block coding, after accommodating the disparity control.___ **T** __ (Hint: disparity ≡ differences in numbers of 1s and 0s in the given block of bits)
   V. QAM is a combination of ASK and PSK. ___ **T** ___
   W. A disadvantage of statistical multiplexing is inefficiency. ___ **F** _____
   X. If SNR is 0 dB, communication is not possible.___ **F** __

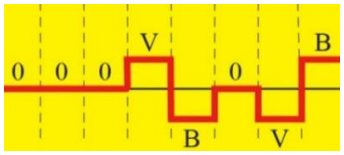
8. Suppose you are designing a toy 1B/2B "block coding" to be used with NRZ-L.
   A. How many "valid" code words should there be that correspond to the original data bits? ____ **2**____**(2pts)**
   B. Considering the disparity control, what would be your choice of the valid code words? _____ **01, 10** _____**(2pts)**
   C. Compared with Manchester, this toy system (1B/2B+NRZ-L) has the same signal rate. In case you minimized the disparity in (B), what is the additional benefit of your system over Manchester? Answer in two words. _____ **error detection** _____ **(3pts)**

9. Answer the questions about the following figure.
   A. What is being performed here? Answer in less than three words._ **amplitude modulation**_____ **(2pts)**
   B. If the bandwidth of the input is X, what is the bandwidth of the output? ___ **2X** _____**(1pt)**
   C. What is the standard value of the answer of problem (B), when used in broadcasting? ___ **10 kHz** __**(2pts)**



10. In a PCM system that uses 256 signal levels for quantization, a low-pass analog signal with bandwidth 4 kHz is digitized.
   A. What should be minimum sampling frequency for the analog signal? ____ **8 kHz** _____**(2pts)**
   B. What is the bitrate *N* that is produced by the PCM? ___ **64 kbps** _____**(2pts)**
   C. What is the minimum bandwidth $B_{min} = N/r$ (in Hertz) if we use the Manchester code to carry the digitized information? Here, *N* is the bitrate and *r* is the bits/symbol. ____ **128 kHz** _____ **(3pts)**

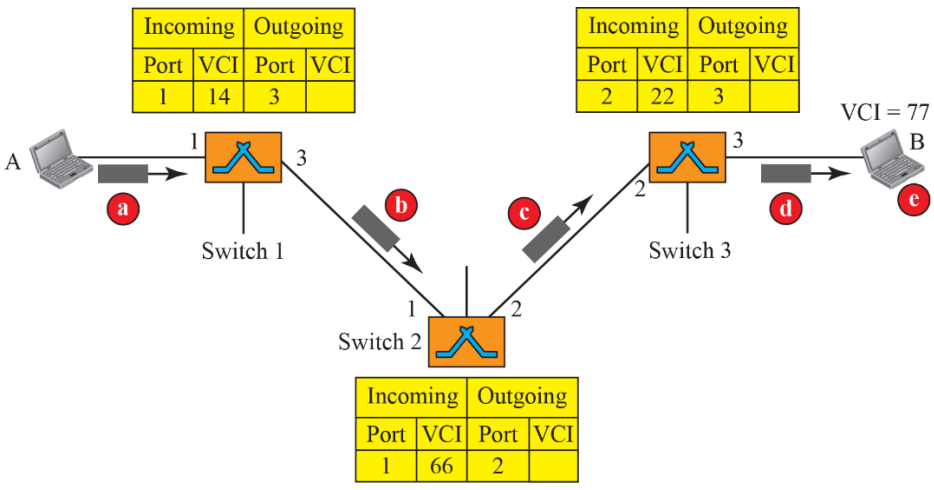
11. For the depicted scrambling scheme that encodes bits 100000000 (but only showing the last 8 bits portion in the figure), answer the questions below.



   A. What was the previous signal level? ____ **high** _____ **(2pts)**
   B. This technique complements AMI. What problematic aspect of AMI does the above figure help with? Answer in one word. _____ **synchronization**_____ **(2pts)**

12. Answer the following questions about the figure below.
   A. Which phase of the three-phase communication in virtual circuit networks does the following figure implement? _____ **connection setup**_____ **(2pts)**
   B. What is an essential piece of information that the small packets should carry? Answer in less than four words._____ **"B"** _____ (Hint: find the answer in the figure) **(2pts)**
   C. What is the most important aspect that this figure does not show, which minimizes the communication delay for data packets? Answer in two words._____ **resource reservation** _____**(2pts)**

   D. What are the values to be filled in the empty VCI boxes in the tables of Switch 1, 2, 3, respectively? ___ **66** ___, __ **22** ___, __ **77** ____ **(3pts)**



13. What will your choice be if you are given the following requirements for the line coder? Choose among the given line coding schemes below.
    A. No DC component, self-synchronization, low complexity (i.e., no multi-level/multi-transition)__ **c**_ **(2pts)**
    B. Low bandwidth (i.e., same as NRZ), self-synchronization _____ **f**_____**(2pts)**
    C. Long-distance, no synchronization, low bandwidth, no DC component _____ **e**_____**(2pts)**
    D. Self-synchronization, error detection through redundant signal, DC balance ___ **d**____ **(2pts)**
    E. Was used in USB ___ **a**____ **(2pts)**

a. NRZ-I	***b. NRZ-L***	***c. Manchester***	***d. 8B6T***	***e. AMI***	***f. 4D-PAM5***	***g. MLT-3***

14. In QPSK, the phase is such that the in-phase component is $-\pi/2$ (radian) and the quadrature component is π (radian). What is the phase of the final transmitted signal? ___ **-3/4 π** _____ **(3pts)**

15. We have four sources, each creating 250 characters per second. If the interleaved unit is a character and 1 synchronizing bit is added to each frame, what is
    A. The duration of each frame _____**4 ms**_____**(2pts)**
    B. The number of bits in each frame _____**33 bits**_____ **(2pts)**
    C. The data rate of the link _____**8.25 kbps**_____ **(3pts)**

16. Answer the following questions regarding the figure below.
    A. What does this figure have to do with Frequency Hopping Spread Spectrum (FHSS)? Answer briefly. _____**the actress is the inventor**_____ **(1pt)**
    B. What is the technology that your smartphone has and uses FHSS? _____**Bluetooth**_____ **(2pts)**

