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CS 35201
Homework 2

1. If a binary signal is sent over a 3-kHz channel whose signal-to-noise ratio is 20 dB, what is the maximum achievable data rate? How about when the channel is noise free.

A) with noise

B $\log_2 (1 + S/N)$ = maximum number of bits/sec

10 $\log_{10}(S/N)$= 20 --> S/N= 100

3000 $\log_2(1+100)$= 3000(6.6582114828)=19,974.63445 bits/sec

B) without noise

2 B log2 M= C

2(3000) $\log_2(2)$=6000(1)=6000 bits/sec

2. Ten signals, each requiring 4000 Hz, are multiplexed onto a single channel using FDM. What is the minimum bandwidth required for the multiplexed channel? Assume that the guard bands are 400 Hz wide. What is maximum achievable data rate with 8-level signals ?

A) What is the minimum bandwidth required for the multiplexed channel?

(10*4000)+(9*400)= 43,600Hz

B) What is maximum achievable data rate with 8-level signals ?

2 B log2 M= C

2(43,600)$\log_2(8)$=87,200(3)=261,600 bits/sec

3. What is the latency of a call originating at the North Pole to reach the South Pole if the call is routed via Iridium satellites? Assume that the switching time at the satellites is 10 microseconds and earth's radius is 6371 km. Assume speed of light is 3×10^8 m/s.

(750+6371)*1000=7,121,000 m radius

2*3.14*7,121,000 = 44,742,562.57 m circumference

44,742,562.57m/2= 22,371,281.29m distance from north pole to south pole

22,371,281.29m /300,000,000=0.07457093763 sec latency from north pole to south pole without satellites

180 degrees from north pole to south pole/ 32 degrees between each satellite= 5.625 satellites from north pole to south pole we'll round up to 6 since there can't be fractions of a satellite

10 microseconds/1,000,000= .00001 sec switching time per satellite

so,

0.07457093763 + (.00001*6)= 0.07457093763 + .00006= 0.07463093763seconds total latency from north pole to south pole

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4. In a typical mobile phone system with hexagonal cells, it is forbidden to reuse a frequency band in an adjacent cell. If 840 frequencies are available, how many can be used in a given cell?

Each cell has six sides so for each cell in use we need to reserve 7 cells. One for use and six for each of the used cell's sides.

So, 840 frequencies/ 7 cells= 120 usable cells

5. Code Division Multiple Access (CDMA) is critical technology used in both cell phones and WiFi. Another name for that is Spread Spectrum.

(a) Briefly explain why do we call it Spread Spectrum?

We call it spread spectrum because, we take a signal with a particular bandwidth and spread it over a wider bandwidth in the frequency domain.

(b) How does direct sequence work? Give an example not in book or my lecture notes.

Direct sequence is a technique in which a transmitted signal is divided and transmitted simultaneously on as many frequencies as possible within a given frequency band. Direct sequence then adds redundant bits to the data to make it more immune to interference.

Example: GPS

(c) How does frequency hopping work? Give an example not in book or my lecture notes.

Frequency hopping is a technique in which transmitted signals are continuously changed among many different frequencies within a large spectral band.

Example: a variation adaptive frequency-hopping is used in Bluetooth