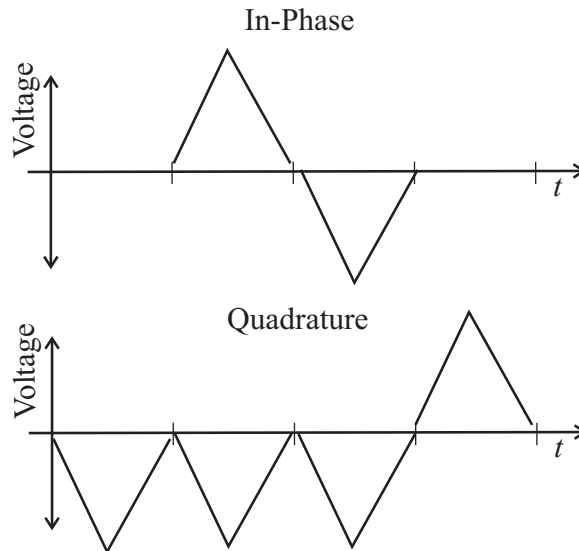


ECE 6390: Satellite Communications and Navigation Systems

Solutions to TEST 2 (Fall 2010)

1. Digital Transmissions:

(a) The signals look like this:



- (b) Nyquist rate is $10 \text{ MHz} \times 2$ for 20 Msamples/sec, \times three channels \times 8 bits/sample = 480 Mbits/sec
- (c) Symbol rate is $1/2$ bit rate since this form of QAM sends 2 bits/symbol. Thus $T_s = 1/R_s = 4.2\text{ns}$.
- (d) 48 dB
- (e) 1) Lempel-Ziv is lossless compression; video typically allows for lossy compression, further reducing the bit stream; 2) the compression scheme as described in the problem does not take advantage of patterns and redundancies between color streams or video frames.

2. Dish Antennas and Noise:

- (a) For a dish with peak gain of 100,000 (50 dBi), $G/T = 100,000/T_{sys} = 1000\text{K}^{-1}$, which implies $T_{sys} = 100 \text{ K}$. If the physical temperature in open sky is 30 K, then the device temperature of the LNA must be approximately 70 K (neglecting the effects of any other RF devices).
- (b) $NF = (1 + T_d/T_o) = 1.24$

- (c) With exactly half of the presumably symmetric pattern illuminating the ground (290 K) and open sky (30 K), the effective noise temperature would be the average: 160 K.

3. Rain Fade:

- (a) For 12 GHz $k_v = .0168$ and $\alpha_v = 1.20$. For 1 km of rain distance traveled, the attenuation is estimated to be 4.2 dB.
- (b) The rain rate of 100 mm/hr occurs corresponds to between .001% and .003% occurrence. With interpolation, this is about 0.0026%.
- (c) i. + Satellite transmits at horizontal polarization – the lossiest form of attenuation.
- ii. = Satellite moves to a higher orbit (look angles are the same) – nothing really changes from the point of view of precipitation attenuation.
- iii. - Satellite is moved to earth station's zenith (same distance) – directly overhead, the signal will travel through the least amount of precipitation.
- iv. - Carrier frequency is decreased – less lossy since rain drop size is electromagnetically smaller.
- v. - Temperature drops and rain turns to sleet – ice/snow less lossy than rain.
- vi. + - = Doppler shift between spacecraft and earth station increases – could argue any 3 answers; could increase or decrease slightly depending on polarity of Doppler shift; could argue that the shift is too small to matter in overall attenuation.
- vii. = The earth station's LNA is swapped for a regular amplifier – does not influence **precipitation** attenuation.
- viii. = A rain-resistant dish is used at the earth station with more aperture area – increased gain does not influence **precipitation** attenuation.
- ix. + The altitude of the rain storm clouds increases – more rain to travel through.
- x. - Some joker drops a surfactant in the rain clouds, shrinking the average size of the rain drop for a given rain rate – smaller raindrops scatter less by proportion.