Receivers, Antennas, and Signals – 6.661

Issued: 4/15/03

Problem Set No. 10   Due: 4/24/03

Problem 10.1

A music signal 20-10,020 Hz (B = 10 kHz) is to be communicated around a home and yard using an isotropic transmitter with peak power P watts. Assume the path loss is (somehow) limited to -70 dB, where we define path loss as the ratio of power received to total power radiated.   Assume the receiver noise temperature plus interference is equivalent to T_R = 4000K. Further assume the dynamic range of the music is 40 dB (ratio of the loudest to weakest musical moments), and the desired SNR for the weakest passages is 20 dB.

What maximum average transmitter power P_t is required to drive a matched antenna in order to achieve these specifications using single-sideband synchronous carrier (SSBSC) modulation? Briefly explain your method and any assumptions. Does your numerical answer seem intuitively plausible?

Problem 10.2

Repeat Problem 10.1 for FM with $\beta^* \cong 10$.

a) What transmitter power P_t is required to meet the FM threshold requirements?

b) What transmitter power P_t is required to meet the output SNR requirements?

c) Approximately what is the maximum β^* we need here? Explain briefly.

Problem 10.3

The advantages of pre-emphasis and compensating de-emphasis filters in FM communications systems is suggested in the text shortly after Equation (4.7.29). Why might an FM broadcast station with peak power limited by FCC regulations not want to use this method? What about an FM broadcast station with limited average power?

<u>**Problem 10.4**</u>

Large nearby stars have angular diameters of ~0.001 arc second or ~5×10^{-9} radians. Assume we wish to use a pair of telescopes and aperture synthesis to image *the region around* such a star *within a radius of ~0.1 arc second* at 1-micron wavelength with resolution sufficient to detect sinusoidal intensity variations of period 10^{-8} radians. Also assume that several other stars are located in various directions at a distance of ~1 arc second from the first, *and that these are the only sources beyond 0.1 arc second (and are of no interest).*
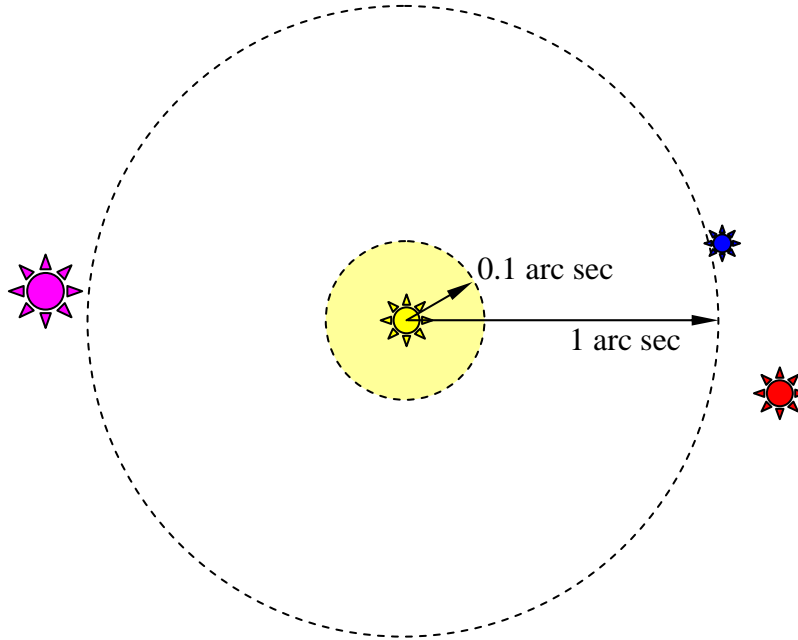
a) What is the minimum diameter telescope (m) we need to use to avoid aliasing? Assume uniformly illuminated telescope apertures.

b) What is the maximum separation (m) required between the two telescopes?

c) How many distinct observations of fringe magnitude and phase are required to construct a complete two-dimensional image with the desired resolution (10^{-8} radians/period)?

d) If these measurements of magnitude and phase were to be made simultaneously, what is the minimum number of telescopes required?