

332:426

Wireless PCS Problems

Spring 2006

1. **Ricean Distribution:** We talked about the Ricean distribution which arises when you have a strong line of sight propagation component coupled to random but much smaller signals arriving with random amplitudes and phases at a receiver.

Well, derive it. Use the Rayleigh workup as a base, but add in a strong line of sight (say, in-phase) component. You may use any resources you like (except each other) for this problem.

2. **Cora, Data the Dog and Marty the Angry Squirrel:**

Cora the Communications Engineer and her mostly deaf dog Data are out playing in a field one day. Data is doing what most dogs do in big fields. Cora is testing out her new wonder-goodie audio equipment – four loudspeakers, a special amplifier and a microphone – when she sees Martin T. Scuiris the squirrel, her arch nemesis. Data has a taste for squirrels, but Martin is both wiley and deadly, so Cora does not want Data to see Martin. Martin on the other hand, starts squealing delightedly trying to catch Data’s attention.

Luckily, unbeknownst to Martin, Data is mostly deaf and ONLY hears sound at a particular frequency – 1000 Hz. However, from previous experience, Cora knows Martin’s ears are highly sensitive, so if she whistles to Data on his frequency, Martin will hear and whistle himself, drawing Data to him and certain doom.

Cora thinks quickly and realizes she has four loudspeakers and her special home-brewed amplifier has the capacity to delay the signal going into each speaker by an arbitrary amount. What she’d like to do is set up the speakers in some spatial pattern around her, adjust the delays appropriately and then whistle into her microphone. From her knowledge of phased array antennas, she knows that if she phases things properly, Data will hear her whistle and come running, while Martin will hear almost nothing.

Assume Cora arranges her loudspeakers as in FIGURE 1, the speaker separations are six inches, Data makes an angle of  $\theta$  with horizontal axis as shown while Martin makes an angle  $\omega$  as shown. Also assume that the amplitudes of the sinusoids that Cora feeds into the loudspeakers are identical and that both Martin and Data are far away from the loudspeakers (say 1000 feet). You may treat the loudspeakers as isotropic point sources of sound and you may assume that sound travels at a speed of 1000 feet per second in air.

Please answer the following questions and carefully label any diagrams you supply. HINT: Carefully define your performance metric. Signal power ratios are often a useful measure.

- (a) What delays  $d_i$  should Cora supply to each speaker so that the signal reaches Data with maximum intensity? Note that we do not care about Martin just yet. Sketch the radiation pattern which results from the resultant loudspeaker phasings (write a computer or Matlab program to do this).

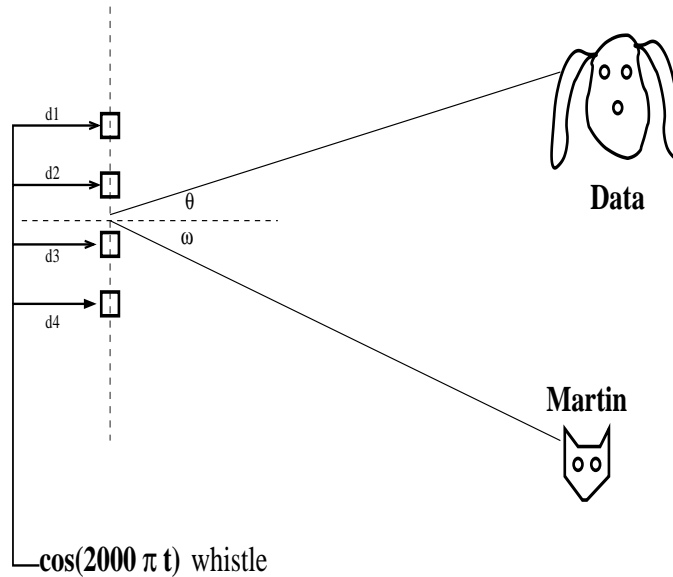


Figure 1: Figure for Cora, Data and Martin problem.

- (b) Now assume the same set up as FIGURE 1, but now Cora needs to phase the loudspeakers so that Martin hears as close to nothing as possible. What delays  $d_i$  should Cora supply to each speaker? Sketch the radiation pattern which results from the resultant loudspeaker phasings (write a computer or Matlab program to do this).
- (c) Now assume that Cora decides to be aggressive and instead of warning Data wants to send a strong 1KHz signal to blast Martin's ears off while sparing Data's ears. What should the  $d_i$  be?
3. **Antenna Resolution:** The radio telescope dish at Arecibo, Puerto Rico operates at 10GHz and has a diameter of 300 meters (three football fields). If two distant radio sources (stars) are a light year ( $\approx 10^{16}$ m) apart from one another, and can each be seen distinctly through the Arecibo telescope, please provide an upper bound on their distance from Earth. State all approximations.