Lecture S21 Muddiest Points

General Comments

Today, we began talking about the relationship between duration and bandwidth. For any given signal shape, there is an inverse relationship between duration and bandwidth. The optimal signal shape, in terms of minimizing both duration and bandwidth (as we have defined it) turns out to be a Gaussian.

Responses to Muddiest-Part-of-the-Lecture Cards

(8 cards)

1. ***You had***

$$\textit{bandwidth} \approx \frac{2\pi}{T}$$
$$\textit{duration} \approx 2T$$
$$\textit{duration} \times \textit{bandwidth} = 4\pi$$

   Should the last equal sign be approximate (≈)? (1 student) Yes.

2. ***Why do we want to minimize the bandwidth multiplied by the duration? I think it is because bandwidth and duration are inversely proportional, and we want to minimize both, but I'm not sure. (1)*** You are basically correct. Yes, we want to minimize both in many situations. Since for any given signal shape, bandwidth and duration are inversely proportional, minimizing the product will tell us the best shape.

3. ***What is the difference between single sided and double sided? (1)*** In the context of today's lecture, I'm not sure what you are asking. Please see me and ask again.

4. ***So, signals and systems is interesting, but how do we work backwards? How do we build a circuit we want to produce a certain circuit? (1)*** If you are interested in a specific type of circuit (e.g., an amplitude modulation circuit), many people have studied this problem, and you can find good examples of circuits in reference works. If you are interested more generally in analog or circuit design, I'm sure that there are good courses at MIT on the topic. Increasingly, circuit design is being replaced by programming. That is, there are folks (at MIT and elsewhere) who think that generic radio frequency circuits should be implemented with software, not hardware, since chip clock speeds now allow computation at speeds fast enough for radio frequency applications.

5. ***When you minimized the duration-bandwidth product, why was the integral raised to the*** $1/2$ ***power:***

$$\Delta t \, \Delta\omega = \frac{\left(\int t^2 g^2(t)\, dt\right)^{1/2} \left(\int \dot{g}^2(t)\, dt\right)^{1/2}}{\left(\int g^2(t)\, dt\right)}$$

   (1) Because the definition of the duration Δt and the bandwidth $\Delta\omega$ have the square root in their definitions.

6. ***You said a shock [or a spark] produces a large bandwidth pulse. I've noticed that at my desk when I get a static shock, my speakers produce a pulse also. Is this like EMP? (1)*** Sort of. More to the point, a very short spark is much like an impulse of current. The impulse of current produces EM radiation, which is high bandwidth because it is very short. The result is that electronic equipment that is sensitive to EM is likely to be affected, since many frequencies are present in the spectrum of the resulting EM signal.

7. ***Is there something significant about the Gaussian being the optimal signal? I remember from 6.041 that the long term probability for a system ended up looking like a Gaussian. (1)*** You're talking about the central limit theorem, which states that, under the right conditions, the probability density of a random variable that is the sum of many independent random variables is a Gaussian. So the Gaussian shows up in other similar contexts. I'm not sure, though, if there is a connection between the central limit theorem and the duration-bandwidth result.

8. ***Class should be earlier. (1)*** [Note that this card has appeared every lecture this term.] Yes, I know. We're working on having classes next year start at 8:00 a.m.