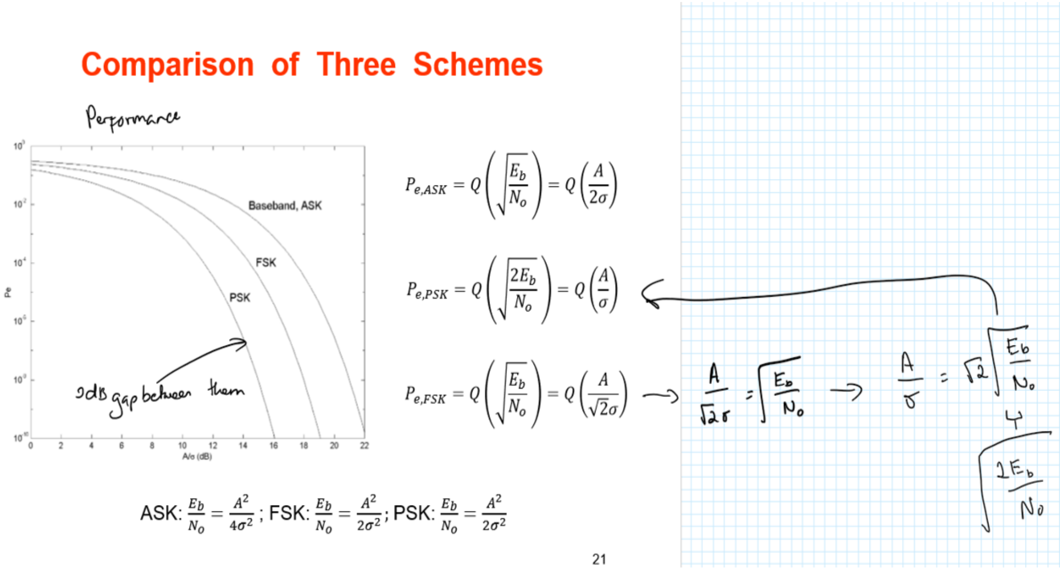
Questions and Answers for Week 7

Question:

I'm a bit confused on how the probability of error for the FSK and PSK are different, I did the maths on the right and aren't they the same?



Answer:

Your math on the right is correct! You demonstrate that the relationships between E_b/N_o and A/σ for FSK and for PSK are same ($\frac{E_b}{N_o} = \frac{A^2}{2\sigma^2}$), as shown at the bottom of this slide.

But, for the same A/σ, BER is $Q(A/(\sqrt{2}\sigma))$ for FSK while it is $Q(A/\sigma)$ for PSK. They are different!

Question:

I am looking at the demodulation diagram on Lecture 10 slide 16. Why is the output from the coherent detector operating at f_0 subtracted from that of f_1 to give y?

Answer:

y is a defined variable, which carries sufficient information for decision.

If "0" is transmitted, then lpf output at the branch operated of f0 will be desired the signal together with the effect of the noise at f0, denoted at A+n0, and lpf output operated at f1 has only noise at f1 , denoted as n1 (the two noises, n0 and n1, are independent since they are at different frequencies). In that case, y=n1−(n0+A) =−A+n, where n=n1−n0.

Similarly, if "1" is transmitted, then y=(A+n1)−n0=A+n.

Therefore, we can determine whether "0" or "1" is transmitted by checking whether y≥0 or y<0.

Question:

please may you explain what you mean by the "1st case dominates error probability ..." in the following:

Distribution of the Envelope

- Symbol 0 sent → envelope, r(t) = $\sqrt{n_I^2(t) + n_Q^2(t)}$,
  with Rayleigh distribution
  $$f(r) = \frac{r}{\sigma^2} e^{-r^2/(2\sigma^2)}, \quad r \geq 0$$
- Symbol 1 sent →the envelope, r(t) = $\sqrt{(A + n_I(t))^2 + n_Q^2(t)}$
  with Rician distribution
  $$f(r) = \frac{r}{\sigma^2} e^{-(r^2+A^2)/(2\sigma^2)} I_0\left(\frac{Ar}{\sigma^2}\right), \quad r \geq 0$$
- 1st case dominates the error probability when $\frac{A}{\sigma} \gg 1$.

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Answer:

Denote f0(r) as the density function of the envelope when 0 is transmitted, which is with Rayleigh distribution, and f1(r) as the density function of the envelope when 1 is transmitted, which is with Rician distribution.

Usually, the detection threshold is set to be A/2, that is, decision will be 0 if the envelope of the received r(t)<A/2 and decision will be 1 otherwise.

If using the above rule for detection, the probability of error will be $P_{e,0} = Pr\{r(t) > A/2\} = \int_{A/2}^{+\infty} f_0(r)dr$ when 0 is transmitted (case 1)); the probability of error will be $P_{e,1} = Pr\{r(t) < A/2\} = \int_0^{A/2} f_1(r)dr$ when 1 is transmitted (case 2). The slide says that case 1 dominates when A/σ>>1, that is, Pe,0>>Pe,1 in this case.

Question:

What is the definition of the symbol duration? is it the time taken to represent an individual bit?

Answer:

Yes. You are right. It is the time taken to represent an individual bit.