Solution to Exercises From 04 Feb 2004

1. Express in dB the gain of an amplifier with output of 60W, when the input is 120 mW.

   We note that since the units of output and input is watts, we are comparing power (as opposed, say, to voltage), so we can use the expression for gain straightforwardly, giving:

   \[
   \text{gain}_{\text{dB}} = 10 \log \left( \frac{P_{\text{out}}}{P_{\text{in}}} \right)
   \]

   \[
   = 10 \log \left( \frac{60}{0.12} \right)
   \]

   \[
   = 10 \log(500)
   \]

   \[
   = 10 \times 2.699
   \]

   \[
   \approx 27 \text{ dB}
   \]

2. If attenuation results in an output of .013 × input (measured in Watts), express this loss in dB.

   Once again, we see from the units, watts, that we are dealing with power, so we use the same formulation as in question 1, giving:

   \[
   \text{gain}_{\text{dB}} = 10 \log \left( \frac{P_{\text{out}}}{P_{\text{in}}} \right)
   \]

   \[
   = 10 \log(0.013)
   \]

   \[
   = 10 \times -1.89
   \]

   \[
   = -18.9 \text{ dB}
   \]

   And, negative gain is loss, so we can report the loss is 18.9 dB.

3. Sketch the QAM signal for “CaT” in 8-bit ASCII with even parity (parity bit goes rightmost). Do also for Manchester.

   This exercise asks for the same kind of drawing that appears on slide 03.28. To do this we need two things: (1) the bit patterns we’re going to send, (2) the representation of bits in the QAM scheme to be used, i.e., the number of bits per sample we are sending (how many distinct phases and amplitudes per sample).

   For (1), the solution is easily obtained from an ASCII character set table, giving us:

<table>
<thead>
<tr>
<th>C</th>
<th>a</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 1 2 3 4 5 6 7</td>
<td>0 1 2 3 4 5 6 7</td>
<td>0 1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>1 1 0 0 0 1 1 1</td>
<td>1 0 0 0 0 1 1 1</td>
<td>0 0 1 0 1 0 1 1</td>
</tr>
</tbody>
</table>

   Following this, then, the 24 bits (8 groups of 3, as shown in bottom row above) we send are, in order (left to right):

   110 000 111 000 011 100 101 011
For (2), we use the same 3 bit/baud coding scheme as was presented in class (see slide 29, class 3). This gives us a pair \((\Delta\phi, A)\) where \(\Delta\phi\) is the phase shift, and \(A\) the amplitude, for each group of 3 bits. Using this scheme, we get:

<table>
<thead>
<tr>
<th>Bit Sequence</th>
<th>Phase Shift</th>
<th>Amplitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>110</td>
<td>270</td>
<td>low</td>
</tr>
<tr>
<td>000</td>
<td>0</td>
<td>low</td>
</tr>
<tr>
<td>111</td>
<td>270</td>
<td>high</td>
</tr>
<tr>
<td>000</td>
<td>0</td>
<td>low</td>
</tr>
<tr>
<td>011</td>
<td>90</td>
<td>high</td>
</tr>
<tr>
<td>100</td>
<td>180</td>
<td>low</td>
</tr>
<tr>
<td>101</td>
<td>180</td>
<td>high</td>
</tr>
<tr>
<td>011</td>
<td>90</td>
<td>high</td>
</tr>
</tbody>
</table>

And to draw the QAM signal, we combine pieces of carrier as dictated by the table above, giving us:

![QAM Signal Graph]

The question then asks for the same thing to be done using Manchester transmission. We recall that Manchester represents a 1 bit with a mid-bit-time transition from low to high, a 0 with a mid-bit-time transition from high to low. Remembering that we are sending the bits *serially* (from first to last), starting with the least significant bit, we get a picture like this:
Calculate the ratio of signal to quantization noise for 18-bit PCM encoding. How does this compare to ordinary audio CD?

We recall the expression for $\text{SNR}_{\text{PCM}}$ is: $\text{SNR}_{\text{PCM}} = 6.02n + 1.76 \text{ dB}$. where $n$ is the number of bits we use. Thus we have only to plug 18 in, obtaining:

$$\text{SNR}_{\text{PCM}} = (6.02 \times 18) + 1.76 \text{ dB}$$

$$= 108.36 + 1.76 = 110.12 \text{ dB}$$

We recall from slide 03.48 that the $\text{SNR}_{\text{PCM}}$ for audio CD is 98.1 dB. So, using 18-bit quantizing improves our signal to noise performance by about 12 dB.

For the figure below, (a) calculate the overall dB and (b) find the output

Since we are working with dB, we know that multiplicative effects of amplification become additive. So, we can simply add the gains and losses along the line, giving the overall gain (or loss) as: $52 - 63 + 38 = 27 \text{ dB}$.

Knowing the overall gain, 27 dB, and the input power, we can determine the output power:
\[ \text{gain}_{\text{dB}} = 10 \log \left( \frac{P_{\text{out}}}{P_{\text{in}}} \right) \]

\[ 27 = 10 \log \left( \frac{P_{\text{out}}}{0.15} \right) \]

With a little rearranging, we see

\[ \frac{27}{10} = \log \left( \frac{P_{\text{out}}}{0.15} \right) \]

\[ 10^{\frac{27}{10}} = \frac{P_{\text{out}}}{0.15} \]

\[ 0.15 \times 10^{\frac{27}{10}} = P_{\text{out}} \]

\[ 18.9 = P_{\text{out}} \text{ Watts} \]