1. A square wave's fundamental has amplitude 1.273. What is the amplitude of its 7th harmonic? Give 3 decimal places.

   _____

2. What happens when the modulation index goes above 1?

   ☐ The carrier disappears

   ☐ The envelope folds over and an envelope detector distorts the message

   ☐ The signal gets louder with no side effects

   ☐ The bandwidth halves

3. An FM signal has Δf = 50 kHz and f_m = 10 kHz. What is β?

   _____

4. What is the thermal noise floor in a 1 MHz bandwidth, in dBm?

   _____ dBm

5. What SQNR does a 12-bit quantiser give for a full-scale sine, in dB? Give 1 decimal place.

   _____ dB

6. How many bits does each symbol of 64-QAM carry?

   _____

7. What codeword lengths does Huffman give for probabilities 1/2, 1/4, 1/4?

   ☐ 1, 2, 2

   ☐ 1, 2, 3

   ☐ 1, 1, 2

   ☐ 2, 2, 2

8. A licence grants only 3 kHz for that 3 kHz voice signal. What can you do?

   ☐ Send a single sideband

   ☐ Filter the double-sideband signal down to 3 kHz

   ☐ Raise the carrier frequency

   ☐ Nothing; it cannot fit

9. A 1 MHz carrier is modulated by a 2 kHz tone. Where are the sidebands?

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   ☐ 1 MHz and 2 MHz

   ☐ 2 kHz and 1 MHz

   ☐ 998 kHz and 1002 kHz

10. For narrowband FM (β much less than 1), the bandwidth is about

    ☐ f_m

    ☐ 2f_m, like AM

    ☐ 2Δf

    ☐ Zero

1. **0.182**

   Odd harmonics fall as $1/k$: $1.273/7 = 0.182$.

2. **The envelope folds over and an envelope detector distorts the message**

   With m > 1 the term 1 + m · x(t) goes negative, so the envelope no longer follows the message.

3. **5**

   $\beta = \Delta f / f_m = 50/10 = 5$.

4. **-114 dBm**

   $-174 + 10\log_{10}(10^6) = -174 + 60 = -114$ dBm.

5. **74.0 dB**

   $6.02 \times 12 + 1.76 = 74.0$ dB.

6. **6**

   $\log_2 64 = 6$.

7. **1, 2, 2**

   Merge the two 1/4s into 1/2, then merge with the other 1/2. The average, 1.5 bits, equals H.

8. **Send a single sideband**

   One sideband carries the whole message in W. Filtering the voice itself below 3 kHz would delete part of it.

9. **998 kHz and 1002 kHz**

   The sidebands sit at $f_c \pm f_m$.

10. **2f_m, like AM**

    With $\Delta f \ll f_m$, Carson gives $2(\Delta f + f_m) \approx 2f_m$.

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