5.4-2) The waveform at points b, c, d, and e are shown from top to bottom in the figure below. (The period of the message was set equal to five times the period of the carrier.)

5.4-3)

a) BW = 6300 Hz

b) \( v_o(t) = 2 \)

c) \( v_o(t) = 2 \left[ 10^7 \pi + 4000 \pi \cos(2000 \pi t + 0.3 \pi) + 300 \pi \sin(100 \pi t) \right] \)

d) The signal in part c) can be processed to recover \( m(t) \).
\[
m(t) = 20 \cos(2000 \pi t + 0.3 \pi) + 1.5 \sin(100 \pi t) \]
5.3-3) I believe this is the only system that exactly meets the specifications.

\[ f_{LO} = 13.18125 \text{ MHz} \]

\[ f_{o} = 6.01875 \text{ MHz} \]

\[ \text{BW} = 32.56 \text{ kHz} \]

At the output of the NBFM generator \( f_{c} = 150 \text{ kHz}, \Delta f = 10 \text{ Hz} \).

At the output of the first multiplier (x128) \( f_{c} = 19.2 \text{ MHz}, \Delta f = 1280 \text{ Hz} \).

The mixer produces sum and difference frequencies of \( f_{c} \) equal to 32.38125 MHz and 6.01875 MHz. The \( \Delta f \) is 1280 Hz at both carrier frequencies. Mixing does not change the \( \Delta f \) value.

At the output of the BPF \( f_{c} = 6.01875 \text{ MHz}, \Delta f = 1280 \text{ Hz} \). (Assuming \( B = 15 \text{ kHz} \), the required BPF bandwidth is 32.56 kHz.)

As specified, at the output of the second multiplier (x16) \( f_{c} = 96.3 \text{ MHz}, \Delta f = 20.48 \text{ kHz} \).

The first multiplier consists of seven frequency doublers (x 2\(^7\)).

The second multiplier consists of four doublers (x 2\(^4\)).

5.5-1) \[ H_d(f) = \frac{1}{j2\pi f} \]

The preemphasis filter is a differentiator. A signal can be FM modulated by integrating the message and phase modulating the result. The cascade connect of a preemphasis differentiator and FM modulator is therefore equivalent to PM modulation.

Similarly, a signal can be FM demodulated by differentiating the output of a PM demodulator. The cascade of an FM demodulator and an integrating deemphasis filter is equivalent to PM demodulation.

5.6-1) When tuned to \( f_{c} = 620 \text{ kHz} \), station at \( f_{c}' = 1530 \text{ kHz} \) will also be heard. \( f_{c}' \) is image of \( f_{c} \).

5.6-2) \[ f_{c}' = f_{c} + 2f_{IF} = 109.4 - 129.4 \text{ MHz} \]

The image band is outside the standard FM band.
5.6-3) 

a) 
\[ f_{LO} = f_c + f_W = 9.855 \text{ – } 10.355 \text{ MHz} \]

b) 
\[ f_c' = f_c + 2f_W = 10.31 \text{ – } 10.81 \text{ MHz}. \] 
No, the image band does not overlap the shortwave AM band.