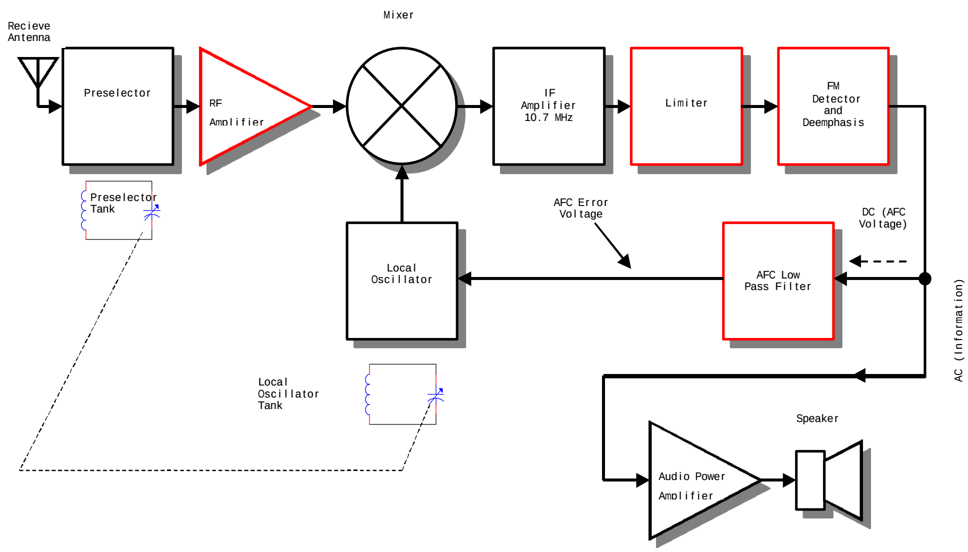
Homework #9 Solution Set

(17 points - 1 per problem)

1. *Draw a block diagram of a superheterodyne FM receiver, showing which sections are new or different from an AM receiver.*



[Figure 9-1]

New sections: Limiter, RF Amplifier, AFC
Different sections: Detector, IF Amplifier

2. *What is the function of the limiter in an FM receiver*?

The function of the limiter is to remove amplitude variations from the FM signal prior to detection. This removes most noise from the signal.

3. *Give two reasons for the use of an RF amplifier in FM receivers.*

a) Amplification of incoming RF signal above mixer noise floor.
b) Prevention of local oscillator reradiation.

4. *What is the purpose of the AFC system in an FM receiver? What type of FM receivers do not require AFC*?

The AFC system compensates for local oscillator drift, which is especially troublesome at the VHF frequencies required for FM broadcast. Synthesized FM receivers do not require AFC.

5. *Why do FM receivers use a 10.7 MHz IF, instead of 455 KHz as AM receivers use*?

The higher IF is used because an FM broadcast signal occupies a 200 KHz bandwidth, which is much wider than the 10 KHz bandwidth for AM broadcast.

6. *Calculate the range of local oscillator frequencies required for an FM weather receiver (161 MHz to 163 MHz) with an IF of 10.7 MHz, assuming high-side injection.*

   a) Minimum: $f_{lo} = f_c + f_{if} = 161MHz + 10.7MHz = \underline{\underline{171.7MHz}}$

   b) Maximum: $f_{lo} = f_c + f_{if} = 163MHz + 10.7MHz = \underline{\underline{173.7MHz}}$

7. *Why isn't AGC needed in FM receivers*?

   AGC isn't required because FM receivers are not sensitive to amplitude variations. The limiter stage removes amplitude information before detection, so signal strength is not an issue.

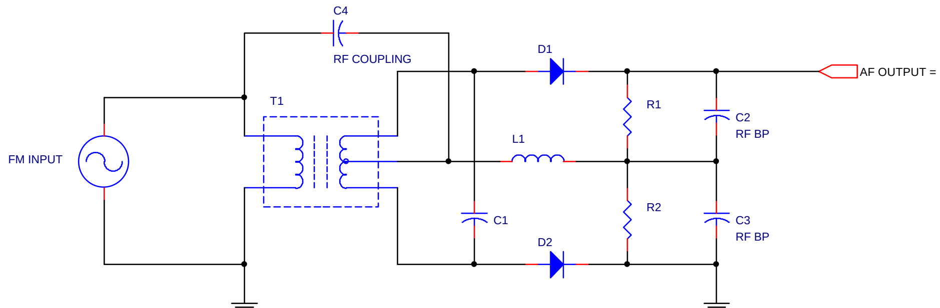
   NB: *Communications grade* FM receivers may indeed have an AGC system, due to the wide range of signal strengths they may be required to process.

8. *How does a slope detector work? Why isn't this type of detector used in FM receivers*?

   A slope detector first converts the FM signal to AM by allowing the FM signal to swing up and down in frequency within one of the skirts of a resonant filter. The resulting AM signal is then diode detected.

   This isn't a practical FM detector because of the dual response (there are two skirts on the bandpass filter), and also because of the distortion added by the nonlinearity of the tank circuit frequency response curve and AM envelope detector.

9. *Draw the schematic diagram of a Foster-Seeley FM detector. Explain the purpose of each component in the circuit.*



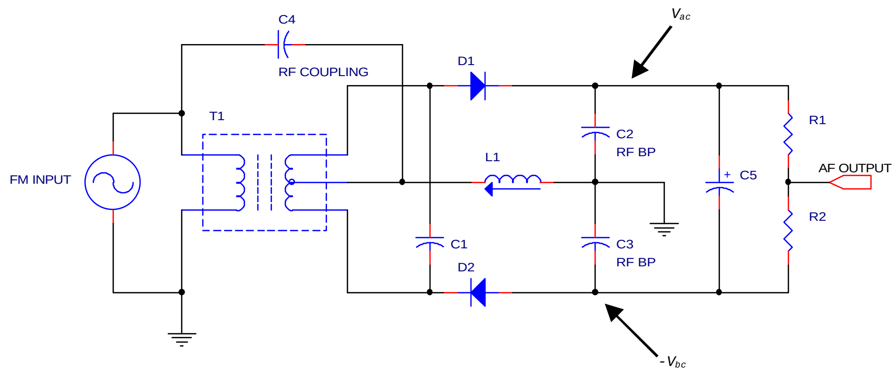
[Figure 9-4c]

Component functions:

T1: Phase splits incoming signal form A and B vectors.
C1: Resonates secondary of T1 to f_{center}
C4/L1: Forms virtual reference source C

D1: Computes magnitude of vector Vac
D2: Computes magnitude of vector Vbc
R1/R2: Algebraically sums Vac and Vbc vectors to form audio output signal
C2/C3: RF bypass capacitors, removes RF carrier from audio output

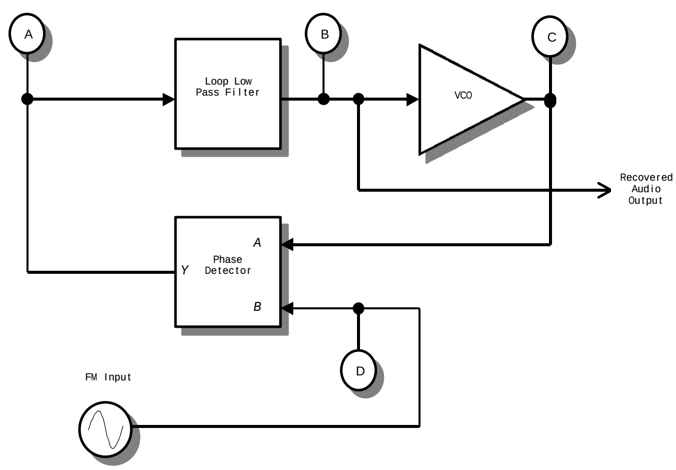
10. *Draw the schematic diagram of a ratio detector. What advantage does it have over the Foster-Seeley circuit*?



[Figure 9-6]

The advantage of the ratio detector is its built-in limiting action contributed by C5.

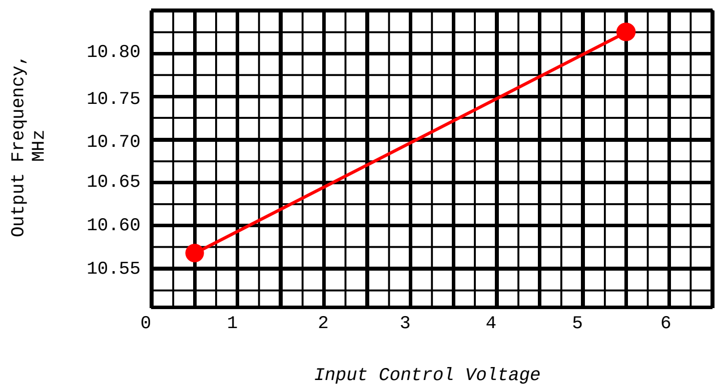
11. *Draw a block diagram of a PLL FM detector. Explain its operation using outline format.*



[Figure 9-8]

Operation:
A. IF signal is applied as reference frequency.
B. Loop attempts to make VCO follow reference.
   1. During this process, VCO control voltage varies in step with the incoming frequency changes.
   2. The changing VCO control voltage is a copy of the original information.
C. The VCO output is unused.

12. *An FM signal with a center frequency of 10.7 MHz is driving the PLL FM detector of figure 9-8. The carrier is being modulated by a 1 KHz audio signal, producing a deviation of 50 KHz. If the VCO in the PLL has the transfer characteristic of figure 9-9, calculate the resulting peak-to-peak audio output voltage.*



[Figure 9-9]

Since the carrier is deviating +/- 50 KHz and the center frequency is 10.7 MHz, the minimum frequency is 10.65 MHz (2V control) and the maximum frequency is 10.75 MHz (4V control). The output is therefore (4V-2V) = 2 Vpp.

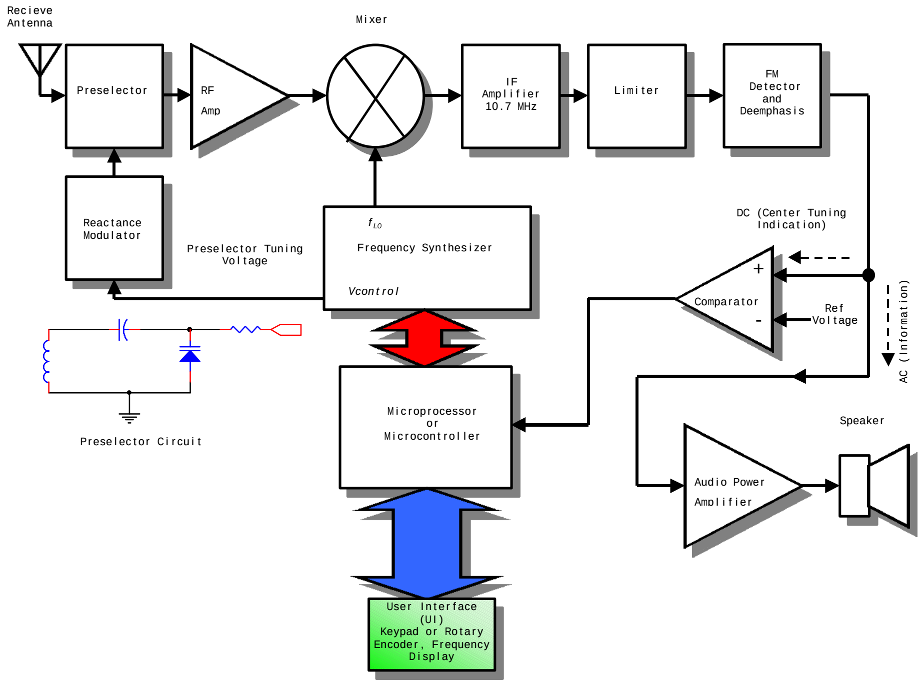
13. *Explain the procedure for aligning a quadrature FM detector.*

A quadrature detector is very easy to align. The technician simply applies the center frequency to the detector's input (usually 10.7 MHz) using an RF generator, and then monitors the DC voltage at the right hand portion of R2. The quadrature coil is adjusted until this voltage is one-half (50%) of Vcc; this provides a 45 degree phase shift between the two gate inputs.

14. *The receiver of figure 9-13 is inoperative. None of the RF sections seem to work, but the audio amplifier (U1) works quite well; a 1 KHz audio signal injected at the positive end of C30 is readily (and loudly!) passed at the speaker. What is probably wrong? (What should have been checked before injecting a signal at C30?)*

The power supply voltages to both the AF and RF sections should have been checked first. The tuner's filtered power supply voltage can be checked at the positive end of *C1*, and the AF section's power supply can be checked at the positive side of *C29*.

15. *Draw a block diagram of a synthesized FM receiver.*

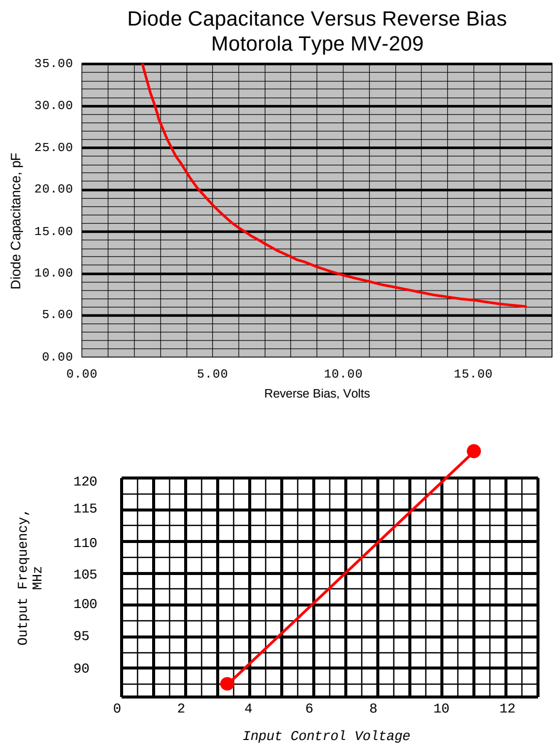


[Figure 9-14]

16. *Explain how tracking is achieved electronically in a synthesized FM receiver.*

In a synthesized receiver, tracking is achieved by routing the control voltage for the local oscillator synthesizer VCO to a reactance modulator (usually a varactor diode or diodes) at the preselector. Thus, when the synthesizer changes the LO frequency, the preselector follows in step.

17. *A synthesized FM receiver uses a 214 nH inductance and a Motorola MV-209 tuning diode in its preselector. Its PLL synthesizer has a VCO transfer characteristic as shown in figure 9-15. The VCO tuning voltage is fed directly to the MV-209 in the preselector to attain tracking. The tuning voltage is 10 V. Calculate (a) The resulting LO frequency; (b) The carrier frequency, f_c , that the receiver is tuned to; (c) The preselector resonant frequency.*



[Figure 9-15]

a) From the graph, $\underline{\underline{f_{LO} = 120\ MHz}}$ @ Vtune = 10 V.

b) $f_c = f_{LO} - f_{if} = 120\ MHz - 10.7\ MHz = \underline{\underline{109.3\ MHz}}$

c) The diode capacitance is 10 pF @ Vtune = 10 V, so:

$$f_{pre} = \frac{1}{2\pi\sqrt{L_{pre}C_d}} = \frac{1}{2\pi\sqrt{(214nH)(10\,pF)}} = \underline{\underline{108.8MHz}}$$