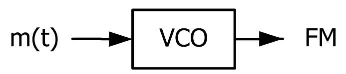
3.6.5 Generation of WBFM

DIRECT METHOD

Using the Voltage–Controlled Oscillator (VCO), at which the output signal frequency varies linearly with the input control voltage. The principle of such circuit is charging L and/or C in a tuned oscillator as:

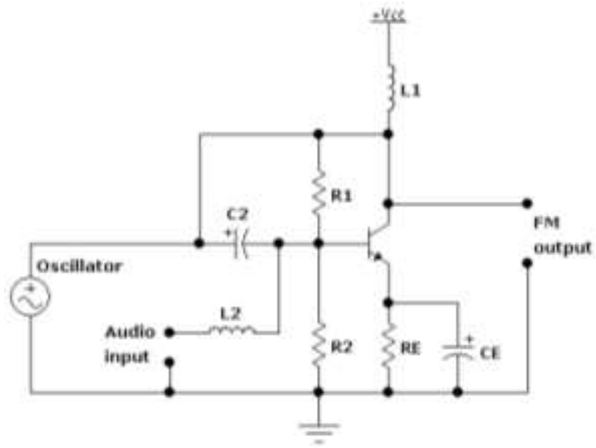
$$f_o = \frac{1}{2\pi\sqrt{LC}}$$



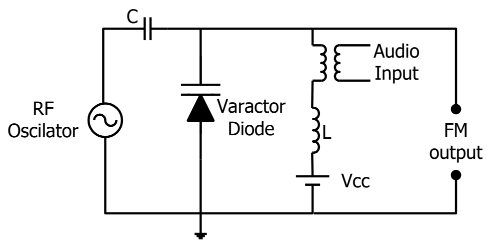
The following are examples of a VCO:

(1) *The Transistor Reactance Modulator*: Here, the h_{fe} of the transistor is caused to vary by changing the operating point of the transistor according to the varying in audio signal. The equivalent C is changed as:

$$C_{eq} = \frac{h_{fe}R_2C_2}{h_{ie} + R_2}$$

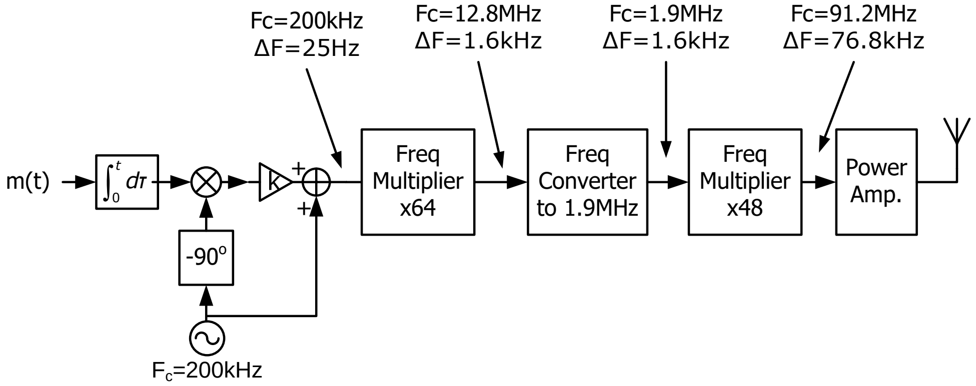


(2) *The varactor diode modulator*: The varactor diode capacitance varies with its bias (V_{cc} and the audio input signal).



INDIRECT METHOD

Also called Armstrong's method. First, it generates NBFM, then it changes the signal to WBFM via frequency multipliers and converters.



3.6.6 Demodulation of FM Signals

(1) *Zero Crossing Detectors*: because the information is contained in the zero crossings of the FM waveform, it is possible to clip (limit) the amplitude of the FM waveform, which results in a square wave. Counting the zero crossings in each time interval is an indication of the amplitude of the Baseband signal.

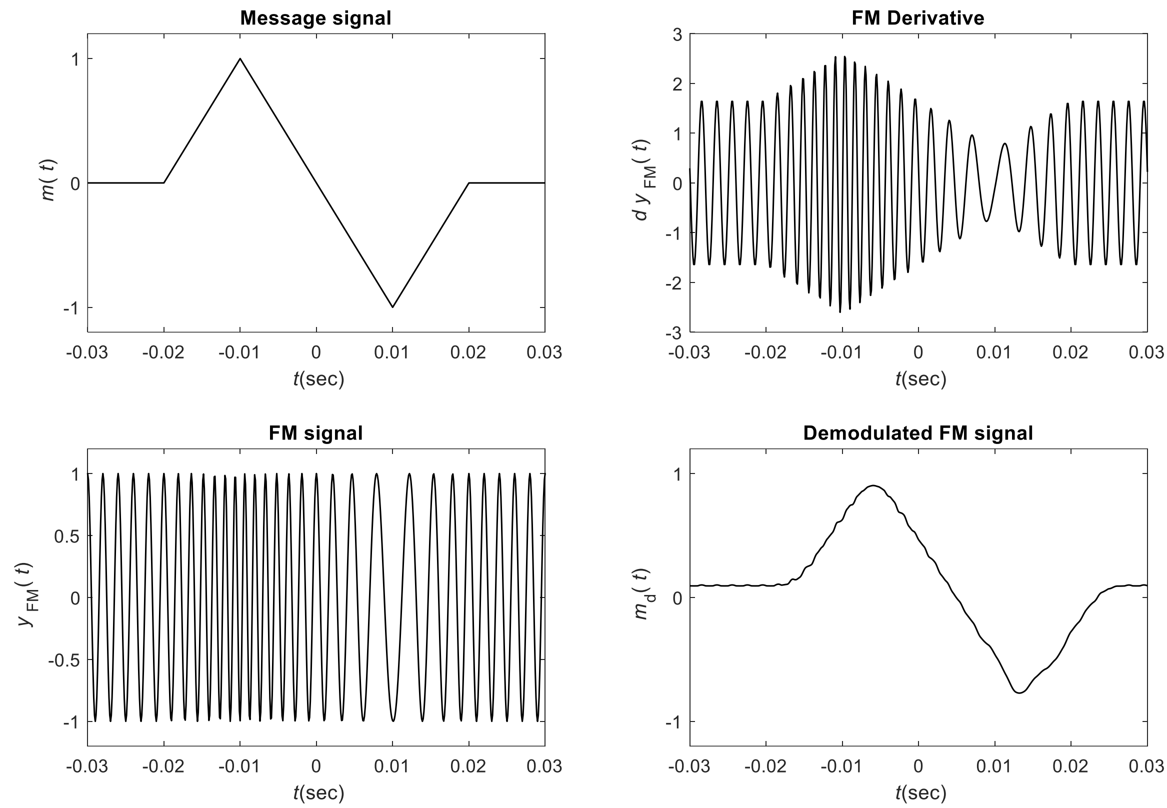
(2) *Differentiator*: the equation of the FM (below) can be demodulated using a differentiating circuit.

$$y_{FM}(t) = A_c \cos\left(\omega_c t + k_F \int_0^t m(\varepsilon) d\varepsilon\right)$$

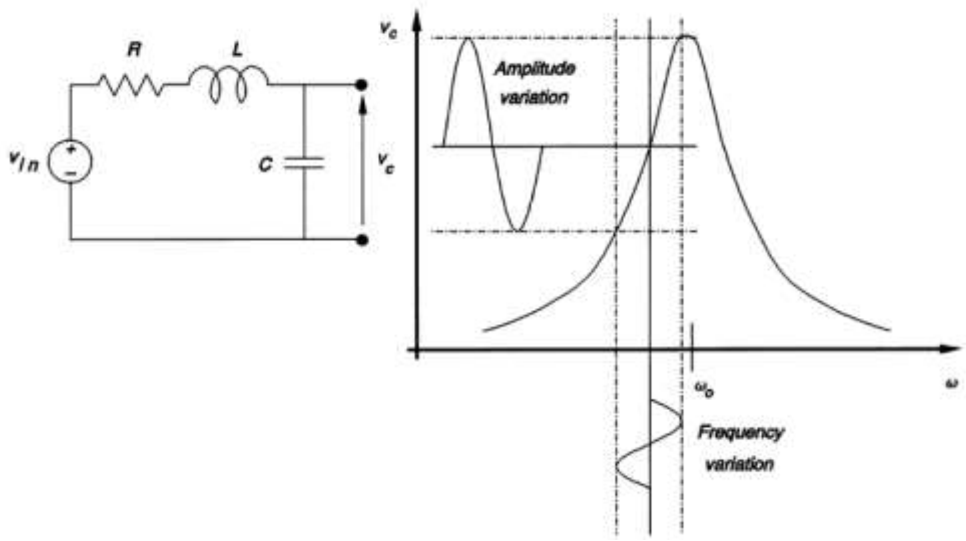
$$\frac{d}{dt}\left(y_{FM}(t)\right) = \frac{d}{dt}\left\{A_c \cos\left(\omega_c t + k_F \int_0^t m(\varepsilon) d\varepsilon\right)\right\}$$

$$= A_c[\omega_c t + k_F m(t)] \sin\left(\omega_c t + k_F \int_0^t m(\varepsilon) d\varepsilon - \pi\right)$$

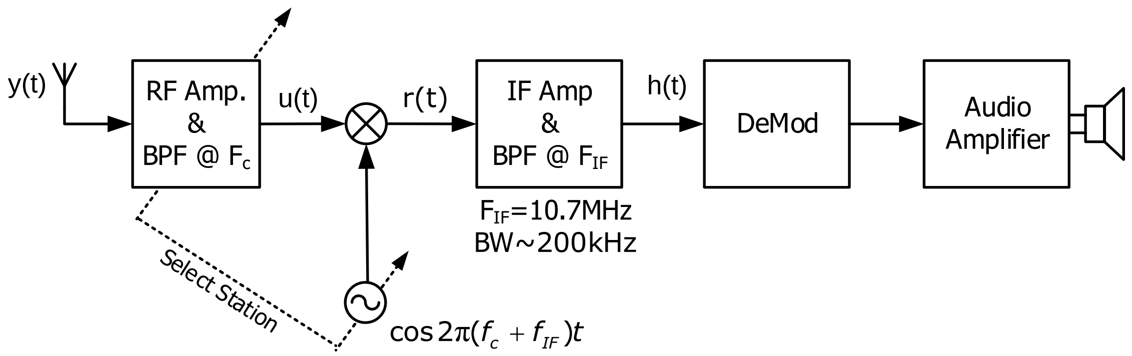
The following example illustrates the decoding procedure.



(3) *Discriminator*: The purpose of the discriminator is to convert the variation of frequency to a variation of amplitude (inverse of VCO). The simplest circuit of Discriminator is a tuned RLC circuit that has a rapid change of amplitude with frequency on both sides of the resonance frequency, especially when the Q factor of the circuit is high.



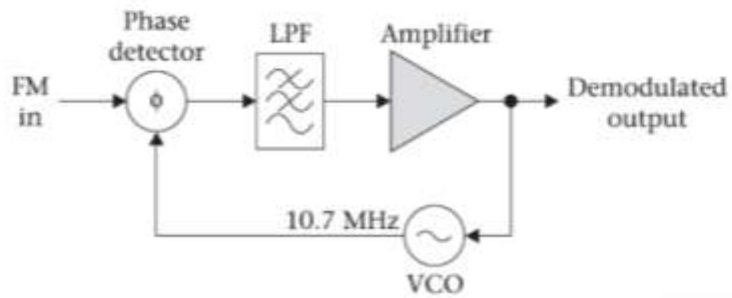
(4) *Super–heterodyne*: is the typical receiver of the commercial FM broadcast stations. This system is like the AM Super–heterodyne receiver but with $f_{IF} = 10.7$MHz.



The frequency band of FM radio broadcasting is 88MHz to 108MHz, with $\beta \geq 5, \Delta_f \leq$ 75kHz. While $\Delta_f \leq$ 25kHz for the sound portion of TV broadcasting. Practically, $\Delta_f =$ 15kHz for both FM radio and TV.

Each commercial FM radio broadcast station is allocated a 150kHz channel plus 50kHz guard band. The bandwidth given in FM radio stations is very large compared to AM radio stations; therefore, the sound resolution is significantly enhanced.

(5) *PLL*: A typical modern FM receiver uses a PLL subsystem as the detector. The PLL is insensitive to amplitude variations and can perform the Frequency-to-Voltage conversion; it can therefore be used as an FM detector.



The PLL detector works in the following manner: The free VCO runs at the intermediate frequency 10.7MHz. The incoming signal, if unmodulated, locks up with the VCO signal, causing there to be no signal output from the LPF stage. Now let us assume that the incoming signal has been modulated by a single audio tone. The phase detector will output an error voltage to the VCO to drive the VCO into lock-up with the incoming signal. Because the incoming signal frequency is deviating both above and below the 10.7 MHz rest frequency at a certain number of cycles per second, the VCO will do the same, following the input-signal frequency variations. The error voltage from the LPF, which drives the VCO, will be identical to the original modulating signal, and hence is taken as the demodulated output.

3.6.7 Summary

- Generally, AM techniques are simpler than those for FM in terms of the required electronic circuits and the system structure (Tx and Rx). Hence AM systems are cheaper. However, one significant drawback of AM systems is that they tend to be rather sensitive to impulsive interference which can be caused by say: lightening or car ignition noise, since the information is contained in the instantaneous amplitude of the signal.
- Unlike AM, FM is a nonlinear modulation process. Accordingly, spectral analysis of FM is more difficult than for AM.
- For a certain f_m, the bandwidth of FM is controlled by β.