

# EE 567

## Handout 2

### Generation of FM Waves

There are two basic methods of generating FM waves. One is *indirect FM* and the other is *direct FM*.

In the indirect method of producing frequency modulation, the modulating wave is first used to produce a narrowband FM wave and next frequency multiplication is used to increase the frequency deviation to the desired level.

In the direct method of producing frequency modulation, the carrier frequency is directly varies in accordance with the input baseband signal.

#### Direct FM

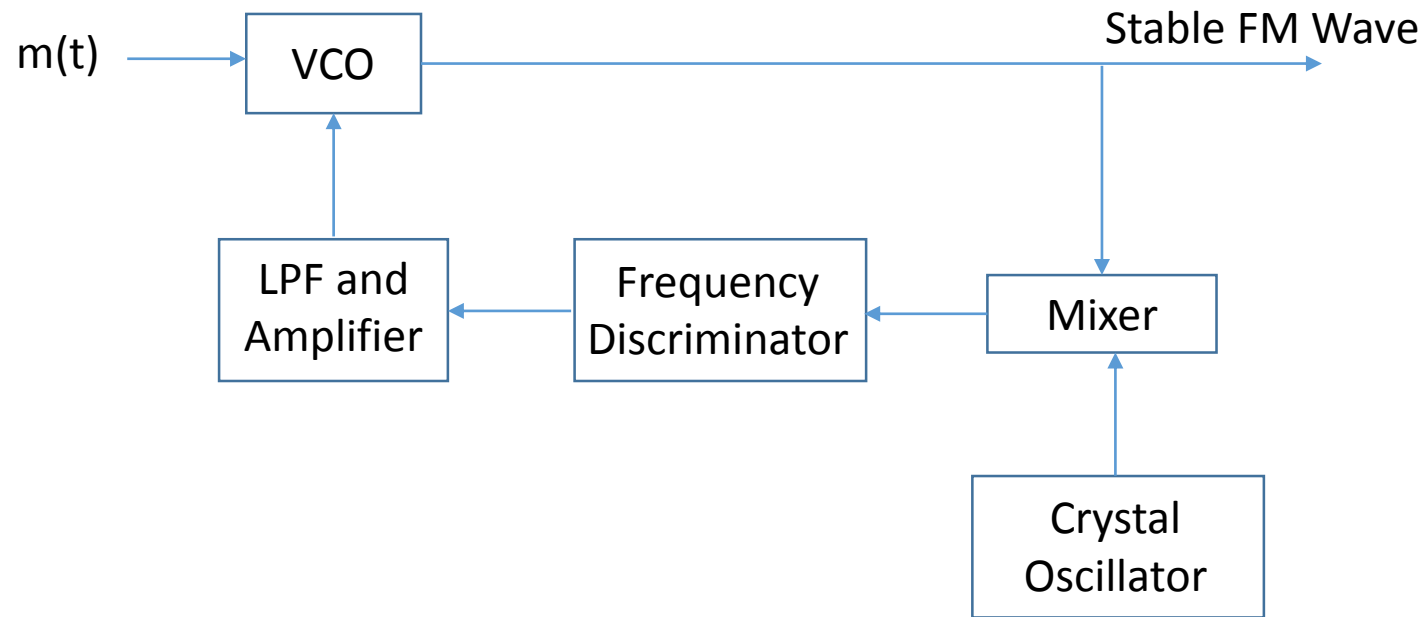
In a direct FM system, the instantaneous frequency of the carrier wave is varied directly in accordance with the baseband signal by means of a device known as a *voltage-controlled oscillator* (VCO). See the figure below.

This configuration permits the attainment of good oscillator stability, constant proportionality between output frequency change and input voltage change, and the necessary modulator bandwidth to achieve wideband FM.

If we do not have a highly stable oscillator it is necessary to provide some auxiliary means by which a very stable frequency generated by a crystal will be able to control the carrier frequency. One method of doing this is shown below.

The output of the FM generator is applied to a mixer together with the output of a crystal-controlled oscillator, and the difference frequency term is extracted. The mixer output is next applied to a frequency discriminator and then low-pass filtered. A frequency discriminator is a device whose output voltage has an instantaneous amplitude that is proportional to the instantaneous frequency of the FM wave applied to its input. When the FM transmitter has exactly the correct carrier frequency the low-pass filter output is zero. However, deviations of the transmitter carrier frequency from

its assigned value will cause the frequency discriminator-filter combination to develop a d.c. voltage with a polarity determined by the size of the transmitter frequency drift. The d.c. voltage, after suitable amplification, is applied to the VCO in such a way as to modify the frequency of the oscillator in a direction that tends to restore the carrier frequency to its required value.



**Figure 1.** Stable Frequency Generator.