Problem 4.15

Consider first the action of the mixer with the two inputs: voltage-controlled oscillator (VCO) output and crystal oscillator output. The mixer produces an output of its own whose frequency is the difference between the instantaneous frequency of the VCO and the crystal oscillator frequency.

The mixer output is applied to the frequency discriminator followed by a low-pass filter. By design, the output produced by the frequency discriminator has an instantaneous amplitude that is proportional to the instantaneous frequency of the FM signal applied to its input. Accordingly, the amplitude of the signal produced by the frequency discriminator is proportional to the difference between the VCO frequency and the crystal oscillator frequency.

In light of these considerations, we may now make the following statements:

- When the FM signal $s(t)$ produced at the VCO output has exactly the correct frequency, the low-pass filter output is zero.
- Deviations in the carrier frequency of the FM signal $s(t)$ from its assigned value will cause the frequency discriminator-filter output to produce a dc output with a polarity determined by the sense of the carrier-frequency drift in the FM signal $s(t)$. This dc signal, after suitable amplification is, in turn, applied to the VCO in such a way as to modify the instantaneous frequency of the VCO in a direction that tends to restore the carrier frequency of the FM signal $s(t)$ to its correct value.

In summary, the application of feedback applied to the VCO in the manner described in Fig. 4.19 has the beneficial effect of stabilizing the carrier frequency of the FM signal produced at the VCO output.