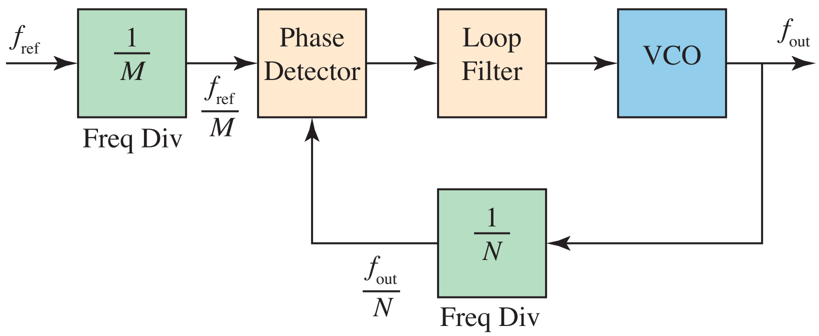
Set #9

Due Friday May 1, 2026

Problems:

1. **To be turned in**. The frequency synthesizer shown below is used to generate the local oscillator in an AM radio which tunes from 540 kHz to 1600 kHz, on 10 kHz channel spacings. Assume high side tuning for the LO and an IF frequency of 455 kHz. Determine M so that the minimum step size from the synthesizer is 5 kHz. Assume that $f_{\text{ref}} = 100$ kHz. Find the range of divider values N that will produce the needed range of $f_{\text{out}} = f_{\text{LO}}$ values.



2. **To be turned in**. Starting from the complex baseband PLL example in the Chapter 4 Jupyter notebook, perform the following simulation experiments:
   a.) For a first-order loop set `fn` = 10 Hz and `Kv` = 1, and with `Df` = 0 Hz (`Df` is the notebook notation for Δf), `fD` = 1 Hz, vary `fm` to verify that the amplitude of the recovered modulation on `ev` does follow the first-order lowpass model discussed in class. Be sure to verify the 3 dB frequency.
   b.) Switch to the second-order loop with `fn` = 10 Hz and zeta = 0.707. Repeat (a). The shape of the theoretical amplitude response versus `fm` can be found from the known form of $H(s)$ for this loop type and the fact that $\Phi(s) = M(s)/s$ for FM and $E_v(s) = s\Theta(s)/K_v$.
3. Consider using a simple lowpass filter for a loop filter, i.e.,

$$F(s) = \frac{a}{s+a}.$$

   Using linear loop analysis answer the following questions.
   a.) Find the closed-loop transfer function $H(s)$.
   b.) Suppose the input to the loop is an FM signal having $m(t) = Au(t)$. Find $\Theta(s)$, $E_v(s)$, and $e(t)$. Hint follow the steps of the notes example on page 4–42.
4. Z&T text 4.34.