1. Use Mason’s rule to derive the transfer function, \( G(s)=\frac{Y(s)}{U(s)} \), of the system below. Clearly state the forward path gains, loop gains, system determinant, and forward path determinants.

\[ \begin{align*}
U(s) & \xrightarrow{\Sigma} H_1 \xrightarrow{+} H_2 \xrightarrow{H_5} \Sigma \xrightarrow{} Y(s) \\
& \xleftarrow{\Sigma} H_3 \xrightarrow{+} H_4 \xleftarrow{} \end{align*} \]

2. Let’s consider a second-order type-2 charge-pump PLL:

- Find the specs for the loop filter such that \( \omega_n=2\pi*10 \text{ MHz} \) for \( \zeta = 1, 0.1, 0.5, 0.7, 2 \).
- Implement a linear macromodel (MATLAB, etc.) for the closed-loop system.
  - Plot the output phase transfer function (both magnitude and phase) and error transfer function (magnitude and phase) from 0.1 \( \omega_n \) to 10 \( \omega_n \). For both the magnitude and phase plots, overlay all the curves for the different \( \zeta \) values on one clearly labeled plot.
  - Plot the output phase and phase error transient response to a unit phase step. For both of these plots, overlay all the curves for the different \( \zeta \) values on one clearly labeled plot.
  - Using the information obtained from the frequency-domain and transient phase step plots, comment on the system behavior as \( \zeta \) changes.