10.1 An open-loop buck converter has $V_{Inom} = 28$ V, $D_{nom} = 0.5$, $r_{DS} = 55$ mΩ, $V_F = 0.4$ V, $R_F = 25$ mΩ, $V_O = 12$ V, $R_{Lmin} = 1.2$ Ω, $L = 40$ μH, $r_L = 100$ mΩ, $C = 100$ μF, and $r_C = 50$ mΩ. Determine z, f_z, f_0, ξ, Q, p_1, p_2, and f_d.

$V_{I\,nom} = 28V$

$V_o(s) = V_i d(s) = \frac{Z_2 s}{Z_1 s + Z_2}$

$Z_2 = \frac{R_L\left(r_C + \frac{1}{sC}\right)}{R_L + r_C + \frac{1}{sC}}$

$r = D_{nom} r_{ds} + (1 - D_{nom}) R_F + r_L$

$= 0.14\,\Omega$

$z = \frac{1}{r_C C} = \frac{1}{0.05 \times 100 \times 10^{-6}} = 200$ krad/s

$f_z = \frac{1}{2\pi}\sqrt{\frac{R_{Lmin} + r}{L_C C (R_{Lmin} + r_C)}}$

$= 2.605$ kHz

damping ratio $= \frac{C(R_{Lmin} r + r_C r_L) + L}{2\sqrt{LC(R_{Lmin} + r)(R_{Lmin} + r_C)}} = 0.39$

quality factor:

$$Q = \frac{1}{2\zeta} = \frac{1}{2\times0.39}$$

$$= 1.29$$

$$P_1, P_2 = -\sigma \pm j\omega_d = -6336 + j15057.18 \text{ rad/s}$$

$$P_2 = -6336 - j15057.18 \text{ rad/s}$$

$$f_d = \frac{\omega_d}{2\pi} = \frac{15057.18}{2\pi} = 2.39\text{kHz}$$

10.2 An open-loop buck converter has $V_{Imin} = 24$ V, $V_{Inom} = 28$ V, $V_{Imax} = 32$ V, $D_{nom} = 0.5$, $r_{DS} = 55$ mΩ, $V_F = 0.4$ V, $R_F = 25$ Ω, $V_O = 12$ V, $R_{Lmin} = 1.2$ Ω, $L = 40$ µH, $r_L = 100$ mΩ, $C = 100$ µF, and $r_C = 50$ mΩ. Determine T_{po}.

For $R_L = R_{Lmin} = 1.2\Omega$

when $V_I = V_{Imin}$

$$T_{po} = V_{Imin}\frac{R_{Lmin}}{R_{Lmin} + r} = 24 \times \frac{1.2}{1.2 + 0.14}$$

$= 21.49V = 26.644\, dBV$

At $V_I = V_{Inom}$

$$V_o = V_{Inom} \frac{R_{Lmin}}{R_{Lmin} + r} = 28 \times \frac{1.2}{1.2 + 0.44} = 27.94\, dB$$

For $V_I = V_{Imax}$

$$V_o = V_{Imax} \frac{R_{Lmin}}{R_{Lmin} + r} = 32 + \frac{1.2}{1.2 + 0.14}$$

$$= 28.66V = 29.15\, dBV$$

For $R_L = R_{Lmax} = 12\,\Omega$

At $V_I = V_{Imin}$

$$V_o = V_{Imin} \frac{R_{Lmax}}{R_{Lmax} + r} = 24 \times \frac{12}{12 + 0.14}$$

$$= 27.5\, dBV$$

At $V_I = V_{Inom}$

$$V_o = V_{Inom} \frac{R_{Lmax}}{R_{Lmax} + r} = 32 \times \frac{12}{12 + 0.14}$$

$$= 31.63V = 30dBV$$

11.3 The boost converter has $V_{Inom} = 156$ V, $V_O = 400$ V, $D_{nom} = 0.65$, $R_{Lmin} = 1.778$ kΩ, $r_{DS} = 1$ Ω, $R_F = 0.0171$ Ω, $L = 30$ mH, $r_L = 2.1$ Ω, $C = 1$ μF, $r = 2.756$ Ω, and $r_C = 1$ Ω. Determine T_{po} and $T_n(\infty)$.

$$T_{po} = \frac{V_O}{1-D_{nom}} \frac{R_{Lmin}(1-D_{nom})^2 - r}{R_{Lmin}(1-D_{nom})^2 + r}$$

$$= 1114.3V = 60.9dBV$$

$$T_p(\infty) = -\frac{V_O}{1-D_{nom}} \frac{r_C}{R_{Lmin}+r_C}$$

$$= -\frac{400}{1-0.65} \frac{1}{1778+1} = -0.6424V$$

$$|T_p(\infty)| = -3.84dBV$$

11.4 The boost converter has $V_{Inom} = 156$ V, $V_O = 400$ V, $D_{nom} = 0.65$, $R_{Lmin} = 1.778$ kΩ, $r_{DS} = 1$ Ω, $R_F = 0.0171$ Ω, $L = 30$ mH, $r_L = 2.1$ Ω, $C = 1$ μF, $r = 2.756$ Ω, and $r_C = 1$ Ω. Determine M_{vo}.

$f = 0$

$$M_{V0} = \frac{1}{1 - D_{nom}} \frac{R_{Lmin}}{R_{Lmin} + \frac{r}{(1-D_{nom})^2}}$$

$$= \frac{1}{1 - 0.65} \times \frac{1778}{1778 + \frac{2.756}{(1-0.65)^2}} = 9 \text{ dB}$$

11.7 The boost converter has $R_{Lmin} = 1.778$ kΩ, $r_{DS} = 1$ Ω, $R_F = 0.0171$ Ω, $L = 30$ mH, $r_L = 2.1$ Ω, $C = 1$ μF, $r = 2.756$ Ω, and $r_C = 1$ Ω. Determine $Z_o(0)$ for $D = 0.1$, 0.5, 0.8, and 0.9.

$D = 0.1$

$$Z_0 = \frac{r R_{Lmin}}{R_{Lmin}(1-D)^2 + r} = \frac{2.756 \times 1778}{(1-0.1)^2 \times 1778 + 2.756}$$

$= 3.4 \Omega$

$D = 0.5$

$$Z_0 = \frac{2.756 \times 1778}{1778(1-0.5)^2 + 2.756} = 10.96 \Omega$$

$D = 0.8$

$$Z_o(D) = \frac{2.756 \times 1778}{1778 \times (1-0.8)^2 + 2.756} = 66.3296\,\Omega$$

$D = 0.9$

$$Z_o = \frac{2.756 \times 1778}{1778 \times (1-0.9)^2 + 2.756} = 238.61\,\Omega$$