Ripple Analysis ~ Cuk Converter

$$\Delta x = \left(A_1 X + B_1 V_g\right) DT_s$$

$$X = \begin{bmatrix} \frac{D^2}{D'R} \\ \frac{D}{R} \\ 1 \\ D \end{bmatrix} \frac{V_g}{D'}$$

$$\underbrace{\begin{bmatrix} \Delta i_1 \\ \Delta i_2 \\ \Delta v_1 \\ \Delta v_2 \end{bmatrix}}_{} = \left(\underbrace{\begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & \frac{1}{L_2} & -\frac{1}{L_2} \\ 0 & -\frac{1}{C_1} & 0 & 0 \\ 0 & \frac{1}{C_2} & 0 & -\frac{1}{RC_2} \end{bmatrix}}_{A_1} \underbrace{\begin{bmatrix} \frac{D^2}{D'R} \\ \frac{D}{R} \\ 1 \\ D \end{bmatrix} \frac{V_g}{D'}}_{X} + \underbrace{\begin{bmatrix} \frac{1}{L_1} \\ 0 \\ 0 \\ 0 \end{bmatrix}}_{B_1} V_g \right) DT_s$$

$$= \left(\begin{bmatrix} 0 \\ \left(\frac{1}{L_2} - \frac{D}{L_2}\right) \frac{V_g}{D'} \\ -\frac{D}{RC_1} \quad \frac{V_g}{D'} \\ \left(+\frac{D}{RC_2} - \frac{D}{RC_2}\right) \frac{V_g}{D'} \end{bmatrix} + \begin{bmatrix} \frac{1}{L_1} \\ 0 \\ 0 \\ 0 \end{bmatrix} V_g \right) DT_s$$

$$= \begin{bmatrix} \frac{1}{L_1} \\ \frac{1}{L_2} \\ -\frac{D}{D'RC_1} \\ 0 \end{bmatrix} V_g DT_s$$

$$\Delta^{(2)} x = \frac{A \, \Delta x \, T_s}{8}$$

$$= \underbrace{\begin{bmatrix} 0 & 0 & -\frac{D'}{L_1} & 0 \\ 0 & 0 & \frac{D}{L_2} & -\frac{1}{L_2} \\ \frac{D'}{C_1} & -\frac{D}{C_1} & 0 & 0 \\ 0 & \frac{1}{C_2} & 0 & -\frac{1}{RC_2} \end{bmatrix}}_{A} \underbrace{\begin{bmatrix} \frac{1}{L_1} \\ \frac{1}{L_2} \\ -\frac{D}{D' R C_1} \\ 0 \end{bmatrix} \frac{D V_g T_s^2}{8}}_{\Delta x} \quad \frac{T_s}{8}$$

$$\Rightarrow \quad \Delta^{(2)} v_2 = \frac{D V_g T_s^2}{8 L_2 C_2}$$

DVM — Discontinuous voltage mode

$$V_1 = \frac{V_g}{D'}$$

$$\Delta v_1 = -\frac{D\,V_g\,DT_s}{D'RC_1} \qquad \text{peak-to-peak voltage ripple.}$$

To avoid DVM $\quad \left|\Delta v_{1,\,pk-ave}\right| < V_1$

$$\Rightarrow \quad \frac{D^2 V_g T_s}{2\cancel{D'}RC_1} < \frac{V_g}{\cancel{D'}}$$

$$\Rightarrow \quad C_1 > \frac{D^2 T_s}{2R}$$