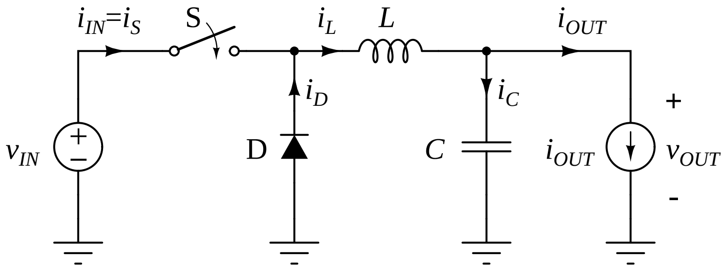
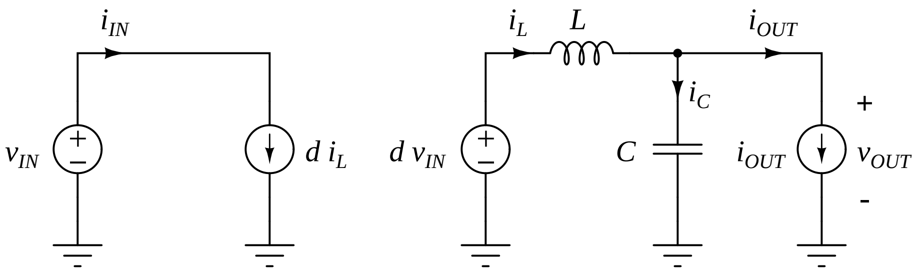
Upravljanje konvertorima



Slika 1: Buck konvertor.

$$\overline{i_S} = \langle i_S \rangle = d\, i_L$$

$$\overline{v_D} = \langle v_D \rangle = d\, v_{IN}$$



Slika 2: Usrednjen model buck konvertora.

Sistem jednačina stanja

$$\frac{di_L}{dt} = -\frac{1}{L}\, v_{OUT} + \frac{1}{L}\, d\, v_{IN}$$

$$\frac{dv_{OUT}}{dt} = \frac{1}{C}\, i_L - \frac{1}{C}\, i_{OUT}$$

jednačina izlaza (mada je u pitanju ulaz, ali je u sistemu jednačina stanja i_{IN} izlazna promenljiva)

$$i_{IN} = d\, i_L$$

Nelinearnosti $d\, v_{IN}$ i $d\, i_L$

Mali signali, vrednost signala u radnoj tački i odstupanje

$$d = D + \widehat{d}$$

$$v_{IN} = V_{IN} + \widehat{v}_{IN}$$

$$v_{OUT} = V_{OUT} + \widehat{v}_{OUT}$$

$$i_L = I_L + \widehat{i}_L$$

$$i_C = I_C + \widehat{i}_C = \widehat{i}_C$$

$$i_{OUT} = I_{OUT} + \widehat{i}_{OUT}$$

$$i_{IN} = I_{IN} + \widehat{i}_{IN}$$

Ustaljeno stanje

$$\frac{di_L}{dt} = 0$$

$$\frac{dv_{OUT}}{dt} = 0$$

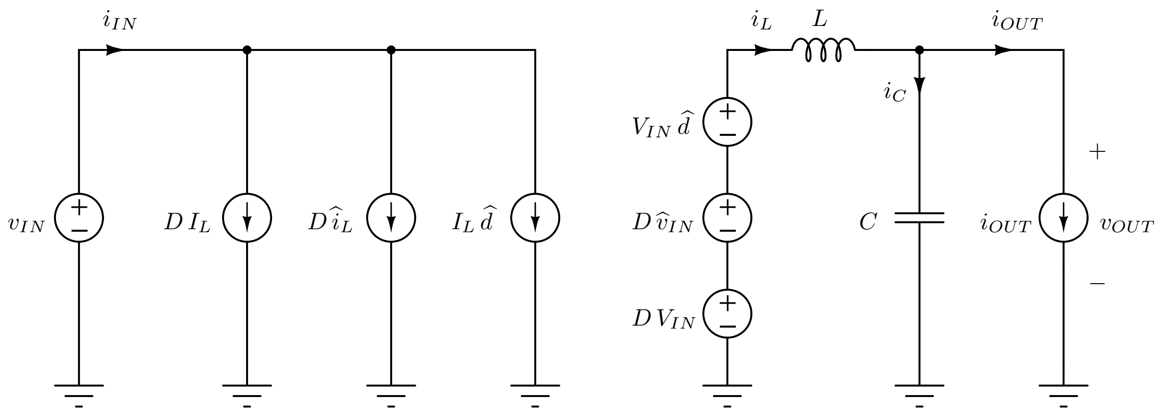
$$0 = -V_{OUT} + D\,V_{IN}$$

$$0 = I_L - I_{OUT}$$

$$V_{OUT} = D\,V_{IN}$$

$$I_{OUT} = I_L$$

Linearizacija



Slika 3: Linearizovan model buck konvertora.

$$d\,v_{IN} = (D + \widehat{d})(V_{IN} + \widehat{v}_{IN}) = D\,V_{IN} + V_{IN}\,\widehat{d} + D\,\widehat{v}_{IN} + \widehat{d}\,\widehat{v}_{IN}$$

$$d\,i_L = (D + \widehat{d})(I_L + \widehat{i}_L) = D\,I_L + I_L\,\widehat{d} + D\,\widehat{i}_L + \widehat{d\,\widehat{i}}_L$$

$$\widehat{d}\,\widehat{v}_{IN} \approx 0$$

$$\widehat{d\,\widehat{i}}_L \approx 0$$

$$d\,v_{IN} \approx D\,V_{IN} + V_{IN}\,\widehat{d} + D\,\widehat{v}_{IN}$$

$$d\, i_L \approx D\, I_L + I_L\, \widehat{d} + D\, \widehat{i}_L$$

linearizovan sistem jednačina stanja

$$\frac{di_L}{dt} = -\frac{1}{L}\, v_{OUT} + \frac{1}{L}\, D\, V_{IN} + \frac{1}{L}\, V_{IN}\, \widehat{d} + \frac{1}{L}\, D\, \widehat{v}_{IN}$$

$$\frac{dv_{OUT}}{dt} = \frac{1}{C}\, i_L - \frac{1}{C}\, i_{OUT}$$

$$i_{IN} = D\, I_L + I_L\, \widehat{d} + D\, \widehat{i}_L$$

ili

$$\frac{di_L}{dt} = -\frac{1}{L}\, v_{OUT} + \frac{1}{L}\, D\, v_{IN} + \frac{1}{L}\, V_{IN}\, \widehat{d}$$

$$\frac{dv_{OUT}}{dt} = \frac{1}{C}\, i_L - \frac{1}{C}\, i_{OUT}$$

$$i_{IN} = D\, i_L + I_L\, \widehat{d}$$

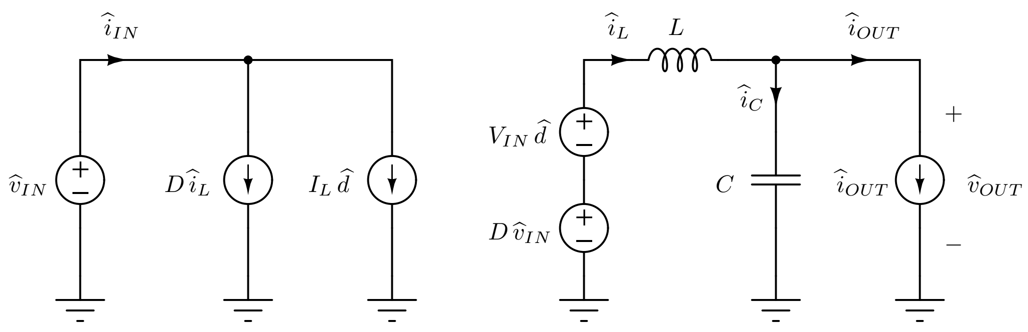
odnosno

$$\frac{d(I_L + \widehat{i}_L)}{dt} = -\frac{1}{L}\, V_{OUT} - \frac{1}{L}\, \widehat{v}_{OUT} + \frac{1}{L}\, D\, V_{IN} + \frac{1}{L}\, D\, \widehat{v}_{IN} + \frac{1}{L}\, V_{IN}\, \widehat{d}$$

$$\frac{d(V_{OUT} + \widehat{v}_{OUT})}{dt} = \frac{1}{C}\, I_L + \frac{1}{C}\, \widehat{i}_L - \frac{1}{C}\, I_{OUT} - \frac{1}{C}\, \widehat{i}_{OUT}$$

$$I_{IN} + \widehat{i}_{IN} = D\, I_L + D\, \widehat{i}_L + I_L\, \widehat{d}$$

Primenom teoreme superpozicije



Slika 4: Linearizovan model za male signale buck konvertora.

$$\frac{d\widehat{i}_L}{dt} = -\frac{1}{L}\, \widehat{v}_{OUT} + \frac{1}{L}\, D\, \widehat{v}_{IN} + \frac{1}{L}\, V_{IN}\, \widehat{d}$$

$$\frac{d\widehat{v}_{OUT}}{dt} = \frac{1}{C}\, \widehat{i}_L - \frac{1}{C}\, \widehat{i}_{OUT}$$

jednačina izlaza

$$\widehat{i}_{IN} = D\, \widehat{i}_L + I_L\, \widehat{d}$$

sada je sistem linearan

Prenosne funkcije:

$$H_1(s) = \frac{\widehat{v}_{OUT}(s)}{\widehat{d}(s)} = \frac{V_{IN}}{1 + s^2LC}$$

$$H_2(s) = \frac{\widehat{v}_{OUT}(s)}{\widehat{v}_{IN}(s)} = \frac{D}{1 + s^2LC}$$

$$H_3(s) = \frac{\widehat{v}_{OUT}(s)}{\widehat{i}_{OUT}(s)} = -\frac{sL}{1 + s^2LC}$$