# Averaged Models

Enter state-space model matrices for both of the states

**(% i1)** A1:matrix([0,-1/L],[1/C,0]);

(A1) $$\begin{pmatrix} 0 & -\frac{1}{L} \\ \frac{1}{C} & 0 \end{pmatrix}$$

**(% i2)** B1:matrix([1/L,0],[0,-1/C]);

(B1) $$\begin{pmatrix} \frac{1}{L} & 0 \\ 0 & -\frac{1}{C} \end{pmatrix}$$

**(% i3)** C1:matrix([0,1],[1,0]);

(C1) $$\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$$

**(% i4)** D1:matrix([0,0],[0,0]);

(D1) $$\begin{pmatrix} 0 & 0 \\ 0 & 0 \end{pmatrix}$$

**(% i5)** A2:matrix([0,-1/L],[1/C,0]);

(A2) $$\begin{pmatrix} 0 & -\frac{1}{L} \\ \frac{1}{C} & 0 \end{pmatrix}$$

**(% i6)** B2:matrix([0,0],[0,-1/C]);

(B2) $$\begin{pmatrix} 0 & 0 \\ 0 & -\frac{1}{C} \end{pmatrix}$$

**(% i7)** C2:matrix([0,1],[0,0]);

(C2) $$\begin{pmatrix} 0 & 1 \\ 0 & 0 \end{pmatrix}$$

**(% i8)** D2:matrix([0,0],[0,0]);

(D2) $$\begin{pmatrix} 0 & 0 \\ 0 & 0 \end{pmatrix}$$

Averaged model matrices

**(% i9)** a:ratsimp(A1*D0+A2*(1-D0));

(a) $$\begin{pmatrix} 0 & -\frac{1}{L} \\ \frac{1}{C} & 0 \end{pmatrix}$$

**(% i10)** b:ratsimp(B1*D0+B2*(1-D0));

(b) $$\begin{pmatrix} \frac{D0}{L} & 0 \\ 0 & -\frac{1}{C} \end{pmatrix}$$

**(% i11)** c:ratsimp(C1*D0+C2*(1-D0));

(c) $$\begin{pmatrix} 0 & 1 \\ D0 & 0 \end{pmatrix}$$

**(% i12)** d:ratsimp(D1*D0+D2*(1-D0));

(d) $$\begin{pmatrix} 0 & 0 \\ 0 & 0 \end{pmatrix}$$

DC model, needs to be done first

**(% i13)** U0:matrix([Vin],[Iout]);

(U0) $$\begin{pmatrix} Vin \\ Iout \end{pmatrix}$$

**(% i14)** X0:-invert(a).b.U0;

(X0) $$\begin{pmatrix} Iout \\ D0\ Vin \end{pmatrix}$$

**(% i15)** Y0:(d-c.invert(a).b).U0;

(Y0) $$\begin{pmatrix} D0\ Vin \\ D0\ Iout \end{pmatrix}$$

Remaining AC model vectors

**(% i16)** e:(A1-A2).X0+(B1-B2).U0;

(e) $$\begin{pmatrix} \frac{Vin}{L} \\ 0 \end{pmatrix}$$

**(% i17)** f:(C1-C2).X0+(D1-D2).U0;

(f) $$\begin{pmatrix} 0 \\ Iout \end{pmatrix}$$

AC model, just define the input vector and expand B and D

**(% i18)** u:matrix([vin],[iout],[dhat]);

(u) $$\begin{pmatrix} vin \\ iout \\ dhat \end{pmatrix}$$

**(% i19)** b:addcol(b,e);

(b) $$\begin{pmatrix} \frac{D0}{L} & 0 & \frac{Vin}{L} \\ 0 & -\frac{1}{C} & 0 \end{pmatrix}$$

**(% i20)** d:addcol(d,f);

(d) $$\begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & Iout \end{pmatrix}$$

Transfer functions

**(% i21)** S:s*diagmatrix(2,1)-a;

(S) $$\begin{pmatrix} s & \frac{1}{L} \\ -\frac{1}{C} & s \end{pmatrix}$$

**(% i22)** Si:ratsimp(invert(S));

(Si) $$\begin{pmatrix} \frac{C L s}{C L s^2+1} & -\frac{C}{C L s^2+1} \\ \frac{L}{C L s^2+1} & \frac{C L s}{C L s^2+1} \end{pmatrix}$$

**(% i23)** x:ratsimp(Si.b.u);

(x) $$\begin{pmatrix} \frac{C\,D0\,s\,vin+C\,Vin\,dhat\,s+iout}{C\,L\,s^2+1} \\ \frac{D0\,vin-L\,iout\,s+Vin\,dhat}{C\,L\,s^2+1} \end{pmatrix}$$

**(% i24)** x:expand(x);

(x) $$\begin{pmatrix} \frac{C\,D0\,s\,vin}{C\,L\,s^2+1}+\frac{C\,Vin\,dhat\,s}{C\,L\,s^2+1}+\frac{iout}{C\,L\,s^2+1} \\ \frac{D0\,vin}{C\,L\,s^2+1}-\frac{L\,iout\,s}{C\,L\,s^2+1}+\frac{Vin\,dhat}{C\,L\,s^2+1} \end{pmatrix}$$

**(% i25)** x:collectterms(x,vin,iout,dhat);

(x) $$\begin{pmatrix} \frac{C\,D0\,s\,vin}{C\,L\,s^2+1}+\frac{C\,Vin\,dhat\,s}{C\,L\,s^2+1}+\frac{iout}{C\,L\,s^2+1} \\ \frac{D0\,vin}{C\,L\,s^2+1}-\frac{L\,iout\,s}{C\,L\,s^2+1}+\frac{Vin\,dhat}{C\,L\,s^2+1} \end{pmatrix}$$

**(% i26)** y:collectterms(expand(ratsimp(c.Si.b+d).u), vin, iout, dhat);

(y) $$\begin{pmatrix} \frac{D0\,vin}{C\,L\,s^2+1}-\frac{L\,iout\,s}{C\,L\,s^2+1}+\frac{Vin\,dhat}{C\,L\,s^2+1} \\ \frac{C\,D0^2\,s\,vin}{C\,L\,s^2+1}+\frac{C\,Iout\,L\,dhat\,s^2}{C\,L\,s^2+1}+\frac{C\,D0\,Vin\,dhat\,s}{C\,L\,s^2+1}+\frac{D0\,iout}{C\,L\,s^2+1}+\frac{Iout\,dhat}{C\,L\,s^2+1} \end{pmatrix}$$

**(% i27)** tf:y[1][1];

(tf) $$\frac{D0\,vin}{C\,L\,s^2+1}-\frac{L\,iout\,s}{C\,L\,s^2+1}+\frac{Vin\,dhat}{C\,L\,s^2+1}$$

**(% i28)** Hvv:coeff(tf,vin);

(Hvv) $$\frac{D0}{C\,L\,s^2+1}$$

**(% i29)** Hvi:coeff(tf,iout);

(Hvi) $$-\frac{L\,s}{C\,L\,s^2+1}$$

**(% i30)** Hvd:coeff(tf,dhat);

(Hvd) $$\frac{Vin}{C\,L\,s^2+1}$$