Appendix D

Vehicle Linear Model Data

The fourteen-order linear system matrices used for actuator fault detection filter design are:

$$A = \begin{bmatrix} -22.42 & -0.12 & 0 & 0 & 0 & 0 & 0 & \cdots \\ 306.69 & -29.75 & 331.11 & -1.17 & -196.62 & -2278.82 & 56.77 & \cdots \\ 0 & 0.06 & -0.68 & 0.06 & 0.51 & 5.95 & -0.18 & \cdots \\ 0 & -0.00 & -0.07 & -9.03 & -0.33 & -2.84 & -18.33 & \cdots \\ 0 & -0.00 & 0.02 & -0.00 & -3.55 & -41.21 & 0.03 & \cdots \\ 0 & 0 & 0 & 0 & 1.00 & 0 & 0 & \cdots \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & \cdots \\ 0 & -0.00 & -0.03 & -9.75 & -0.41 & -1.62 & -60.48 & \cdots \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & \cdots \\ 0 & -0.02 & 0.18 & -0.01 & -0.59 & -7.05 & 0.32 & \cdots \\ 0 & -0.00 & 0.01 & 0.33 & 0.05 & 0.53 & -0.17 & \cdots \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & \cdots \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & \cdots \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & \cdots \end{bmatrix}$$

$$
\left.\begin{matrix}
\cdots & 0 & 0 & 0 & 0 & 2.35 & 0 & 0 \\
\cdots & 2.92 & -3169.84 & -273.50 & 2.99 & 0 & -0.07 & 0 \\
\cdots & -0.00 & 15.84 & 1.40 & -0.34 & 0 & -0.00 & -1.09 \\
\cdots & -1.83 & -0.79 & -0.10 & -23.98 & 0 & -0.00 & 123.72 \\
\cdots & -0.00 & -9.21 & -0.81 & 0.01 & 0 & 0.00 & 0.04 \\
\cdots & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\cdots & 1.00 & 0 & 0 & 0 & 0 & 0 & 0 \\
\cdots & -6.05 & -0.09 & -0.10 & 0.91 & 0 & -0.00 & 134.16 \\
\cdots & 0 & 0 & 1.00 & 0 & 0 & 0 & 0 \\
\cdots & -0.01 & -40.09 & -3.59 & 0.06 & 0 & 0.00 & 0.39 \\
\cdots & -0.01 & 2.03 & 0.19 & -5.62 & 0 & 0.00 & 49.17 \\
\cdots & 0 & 0 & 0 & 0 & -90.91 & 0 & 0 \\
\cdots & 0 & 0 & 0 & 0 & 0 & -1.25 & 0 \\
\cdots & 0 & 0 & 0 & 0 & 0 & 0 & -80.00
\end{matrix}\right] \tag{d.1a}
$$

$$
B = \begin{bmatrix}
0 & 0 & 0 \\
0 & 0 & 0 \\
0 & 0 & 0 \\
0 & 0 & 0 \\
0 & 0 & 0 \\
0 & 0 & 0 \\
0 & 0 & 0 \\
0 & 0 & 0 \\
0 & 0 & 0 \\
0 & 0 & 0 \\
0 & 0 & 0 \\
90.91 & 0 & 0 \\
0 & 1.25 & 0 \\
0 & 0 & 80.00
\end{bmatrix} \tag{d.1b}
$$

$$
C = \left[\begin{matrix}
1.00 & 0 & 0 & 0 & 0 & 0 & 0 & \cdots \\
0 & 1.00 & 0 & 0 & 0 & 0 & 0 & \cdots \\
0 & 0.06 & -0.68 & 0.06 & 0.51 & 5.95 & -0.18 & \cdots \\
0 & -0.00 & -0.07 & -9.03 & -0.33 & -2.84 & -18.33 & \cdots \\
0 & -0.00 & 0.02 & -0.00 & -3.55 & -41.21 & 0.03 & \cdots \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & \cdots \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & \cdots \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & \cdots \\
0 & 0 & 3.54 & -0.01 & -2.24 & -26.36 & -19.11 & \cdots \\
0 & 0 & 3.58 & -0.01 & -2.30 & -26.33 & 19.09 & \cdots \\
0 & 0.04 & 3.02 & -0.01 & -1.76 & -20.06 & -16.88 & \cdots \\
0 & 0.03 & 3.12 & -0.01 & -1.89 & -22.20 & 17.93 & \cdots
\end{matrix}\right.
$$

$$
\begin{matrix}
\cdots & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\cdots & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\cdots & -0.00 & 15.84 & 1.40 & -0.34 & 0 & -0.00 & -1.09 \\
\cdots & -1.83 & -0.79 & -0.10 & -23.98 & 0 & -0.00 & 123.72 \\
\cdots & -0.00 & -9.21 & -0.81 & 0.01 & 0 & 0.00 & 0.04 \\
\cdots & 1.00 & 0 & 0 & 0 & 0 & 0 & 0 \\
\cdots & 0 & 0 & 1.00 & 0 & 0 & 0 & 0 \\
\cdots & 0 & 0 & 0 & 1.00 & 0 & 0 & 0 \\
\cdots & -1.63 & 29.89 & 2.54 & -2.56 & 0 & -0.00 & -0.00 \\
\cdots & 1.67 & 29.86 & 2.61 & 2.24 & 0 & -0.00 & -0.00 \\
\cdots & -1.47 & -27.90 & -2.45 & -2.50 & 0 & -0.00 & 0 \\
\cdots & 1.53 & -30.88 & -2.62 & 2.56 & 0 & -0.00 & 0
\end{matrix} \Bigg] \qquad (d.1c)
$$

$$
D = \begin{bmatrix}
0 & 0 & 0 \\
0 & 0 & 0 \\
0 & 0 & 0 \\
0 & 0 & 0 \\
0 & 0 & 0 \\
0 & 0 & 0 \\
0 & 0 & 0 \\
0 & 0 & 0 \\
0 & 0 & 0 \\
0 & 0 & 0 \\
0 & 0 & 0 \\
0 & 0 & 0
\end{bmatrix} \qquad (d.1d)
$$

The twelveth-order linear system matrices used for sensor fault detection filter design are:

$$
A = \Bigg[\begin{matrix}
-22.42 & -0.12 & 0 & 0 & 0 & 0 & \cdots \\
306.69 & -29.75 & 331.11 & -1.17 & -196.62 & -2278.82 & \cdots \\
0 & 0.06 & -0.68 & 0.06 & 0.51 & 5.95 & \cdots \\
0 & -0.00 & -0.07 & -9.03 & -0.33 & -2.84 & \cdots \\
0 & -0.00 & 0.02 & -0.00 & -3.55 & -41.21 & \cdots \\
0 & 0 & 0 & 0 & 1.00 & 0 & \cdots \\
0 & 0 & 0 & 0 & 0 & 0 & \cdots \\
0 & -0.00 & -0.03 & -9.75 & -0.41 & -1.62 & \cdots \\
0 & 0 & 0 & 0 & 0 & 0 & \cdots \\
0 & -0.02 & 0.18 & -0.01 & -0.59 & -7.05 & \cdots \\
0 & -0.00 & 0.01 & 0.33 & 0.05 & 0.53 & \cdots \\
0 & 0 & 0 & 0 & 0 & 0 & \cdots
\end{matrix}
$$

$$\begin{matrix} \ldots & 0 & 0 & 0 & 0 & 0 & 0 \\ \ldots & 56.77 & 2.92 & -3169.84 & -273.50 & 2.99 & -0.07 \\ \ldots & -0.18 & -0.00 & 15.84 & 1.40 & -0.34 & -0.00 \\ \ldots & -18.33 & -1.83 & -0.79 & -0.10 & -23.98 & -0.00 \\ \ldots & 0.03 & -0.00 & -9.21 & -0.81 & 0.01 & 0.00 \\ \ldots & 0 & 0 & 0 & 0 & 0 & 0 \\ \ldots & 0 & 1.00 & 0 & 0 & 0 & 0 \\ \ldots & -60.48 & -6.05 & -0.09 & -0.10 & 0.91 & -0.00 \\ \ldots & 0 & 0 & 0 & 1.00 & 0 & 0 \\ \ldots & 0.32 & -0.01 & -40.09 & -3.59 & 0.06 & 0.00 \\ \ldots & -0.17 & -0.01 & 2.03 & 0.19 & -5.62 & 0.00 \\ \ldots & 0 & 0 & 0 & 0 & 0 & -1.25 \end{matrix}\Bigg] \tag{d.2a}$$

$$B = \begin{bmatrix} 2.35 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & -1.09 \\ 0 & 0 & 123.72 \\ 0 & 0 & 0.04 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 134.16 \\ 0 & 0 & 0 \\ 0 & 0 & 0.39 \\ 0 & 0 & 49.17 \\ 0 & 1.25 & 0 \end{bmatrix} \tag{d.2b}$$

$$C = \Bigg[\begin{matrix} 1.00 & 0 & 0 & 0 & 0 & 0 & \ldots \\ 0 & 1.00 & 0 & 0 & 0 & 0 & \ldots \\ 0 & 0.06 & -0.68 & 0.06 & 0.51 & 5.95 & \ldots \\ 0 & -0.00 & -0.07 & -9.03 & -0.33 & -2.84 & \ldots \\ 0 & -0.00 & 0.02 & -0.00 & -3.55 & -41.21 & \ldots \\ 0 & 0 & 0 & 0 & 0 & 0 & \ldots \\ 0 & 0 & 0 & 0 & 0 & 0 & \ldots \\ 0 & 0 & 0 & 0 & 0 & 0 & \ldots \\ 0 & 0 & 3.54 & -0.01 & -2.24 & -26.36 & \ldots \\ 0 & 0 & 3.58 & -0.01 & -2.30 & -26.33 & \ldots \\ 0 & 0.04 & 3.02 & -0.01 & -1.76 & -20.06 & \ldots \\ 0 & 0.03 & 3.12 & -0.01 & -1.89 & -22.20 & \ldots \end{matrix}$$

$$\begin{matrix} \cdots & 0 & 0 & 0 & 0 & 0 & 0 \\ \cdots & 0 & 0 & 0 & 0 & 0 & 0 \\ \cdots & -0.18 & -0.00 & 15.84 & 1.40 & -0.34 & -0.00 \\ \cdots & -18.33 & -1.83 & -0.79 & -0.10 & -23.98 & -0.00 \\ \cdots & 0.03 & -0.00 & -9.21 & -0.81 & 0.01 & 0.00 \\ \cdots & 0 & 1.00 & 0 & 0 & 0 & 0 \\ \cdots & 0 & 0 & 0 & 1.00 & 0 & 0 \\ \cdots & 0 & 0 & 0 & 0 & 1.00 & 0 \\ \cdots & -19.11 & -1.63 & 29.89 & 2.54 & -2.56 & -0.00 \\ \cdots & 19.09 & 1.67 & 29.86 & 2.61 & 2.24 & -0.00 \\ \cdots & -16.88 & -1.47 & -27.90 & -2.45 & -2.50 & -0.00 \\ \cdots & 17.93 & 1.53 & -30.88 & -2.62 & 2.56 & -0.00 \end{matrix} \Bigg] \tag{d.2c}$$

$$D = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & -1.09 \\ 0 & 0 & 123.72 \\ 0 & 0 & 0.04 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & -0.00 \\ 0 & 0 & -0.00 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} \tag{d.2d}$$

Appendix E
Fault Detection Filter Design Data

This appendix collects data associated with fault detection filter designs of Section 4. Section E.1 has the data for a fault detection filter design for fault group three, the four wheel speed sensors. Section E.2 has the data for a fault detection filter design for fault group four, the four wheel speed sensors.

E.1 Design Data for Fault Group Three

This appendix presents data associated with the fault detection filter design for fault group three, the four wheel speed sensors. The design details and a discussion are in Section 4.2.1.

For each eigenvalue $\lambda_{i_j} \in \Lambda_i$, the left eigenvectors v_{i_j} generally are not unique and must be chosen from a subspace as $v_{i_j} \in V_{i_j}$ where V_{i_j} is found by solving (4.2)

$$\begin{bmatrix} A^T - \lambda_{i_j} I & C^T \\ \hat{F}_i^T & 0 \end{bmatrix} \begin{bmatrix} V_{i_j} \\ W_{i_j} \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

There are twelve V_{i_j} associated with twelve eigenvalues. Only two V_{i_j}, the two associated with the front left wheel speed sensor fault, are shown here.

$$V_{y_{w_{fl1}}} = \begin{bmatrix} 0.0147 & -0.0095 & 0.0089 & -0.0572 & 0.1287 & 0.9898 \\ 0.0009 & -0.0006 & 0.0005 & -0.0033 & 0.0041 & -0.0008 \\ -0.0680 & -0.1045 & -0.2833 & -0.3041 & -0.3300 & 0.0279 \\ -0.1436 & -0.2173 & -0.0126 & -0.5593 & -0.6139 & 0.0476 \\ -0.0010 & -0.0036 & -0.0021 & -0.0121 & -0.0036 & -0.0002 \\ 0.0100 & -0.0087 & 0.0032 & -0.0526 & 0.0543 & -0.0104 \\ -0.1343 & 0.0826 & 0.9460 & -0.1194 & -0.0980 & 0.0001 \\ 0.0176 & -0.0340 & 0.0090 & -0.1649 & 0.1749 & -0.0329 \\ 0.4216 & -0.8713 & 0.1488 & 0.1971 & -0.0085 & -0.0035 \\ -0.0751 & 0.1252 & 0.0007 & 0.6939 & -0.6443 & 0.1262 \\ 0.8790 & 0.3985 & 0.0489 & -0.1635 & -0.1980 & 0.0066 \\ -0.0001 & -0.0000 & -0.0003 & -0.0003 & -0.0003 & 0.0000 \end{bmatrix}$$

$$V_{y_{w_{fl2}}} = \begin{bmatrix} -0.0077 & 0.0039 & -0.0135 & 0.4552 & -0.8901 & 0.0166 \\ -0.0003 & 0.0001 & -0.0005 & 0.0042 & 0.0021 & -0.0027 \\ 0.0098 & 0.0673 & 0.2871 & 0.1475 & 0.0793 & 0.4276 \\ -0.1385 & 0.0536 & 0.0486 & 0.2694 & 0.1533 & 0.7997 \\ -0.0014 & 0.0012 & 0.0025 & 0.0091 & 0.0048 & 0.0079 \\ -0.0031 & 0.0013 & -0.0026 & 0.0627 & 0.0315 & -0.0326 \\ -0.3370 & -0.3002 & -0.8473 & 0.0387 & 0.0369 & 0.1386 \\ 0.0048 & 0.0010 & -0.0121 & 0.2002 & 0.1006 & -0.1002 \\ 0.0897 & 0.9304 & -0.3524 & -0.0069 & 0.0052 & 0.0030 \\ 0.0020 & -0.0034 & 0.0008 & -0.8059 & -0.4057 & 0.3461 \\ -0.9268 & 0.1918 & 0.2698 & -0.0581 & -0.0280 & -0.1649 \\ 0.0000 & -0.0000 & 0.0003 & 0.0001 & 0.0001 & 0.0004 \end{bmatrix}$$

The left eigenvectors are chosen from $v_{i_j} \in V_{i_j}$ as the set with the greatest degree of linear independence. The matrix of assigned left eigenvectors $\tilde{V}$ is

$$\tilde{V} = \left[v_{0_1}, v_{0_2}, v_{0_3}, v_{0_4}, v_{y_{w_{fl1}}}, v_{y_{w_{fl2}}}, v_{y_{w_{fr1}}}, v_{y_{w_{fr2}}}, v_{y_{w_{rl1}}}, v_{y_{w_{rl2}}}, v_{y_{w_{rr1}}}, v_{y_{w_{rr2}}} \right]$$

$$
= \begin{bmatrix}
0.2991 & 0.0000 & -0.0000 & -0.9542 & -0.0000 & 0.0000 & \dots \\
-0.0001 & -0.0002 & 0.0000 & -0.0000 & -0.0017 & 0.0052 & \dots \\
0.0119 & 0.0434 & -0.0131 & 0.0037 & -0.4802 & -0.2551 & \dots \\
0.1401 & -0.1312 & -0.3954 & 0.0439 & -0.6638 & -0.3524 & \dots \\
0.0013 & -0.0009 & -0.0037 & 0.0004 & -0.0126 & 0.0008 & \dots \\
-0.0012 & 0.0002 & -0.0005 & -0.0004 & -0.0316 & 0.0708 & \dots \\
0.2894 & -0.2470 & -0.8074 & 0.0907 & 0.3290 & 0.1744 & \dots \\
-0.0175 & 0.0031 & -0.0078 & -0.0055 & -0.1006 & 0.2234 & \dots \\
-0.2274 & -0.9478 & 0.2053 & -0.0713 & -0.0254 & 0.0095 & \dots \\
0.0446 & -0.0280 & 0.0265 & 0.0140 & 0.4558 & -0.8500 & \dots \\
0.8678 & -0.1439 & 0.3855 & 0.2720 & -0.0280 & 0.0530 & \dots \\
0.0000 & 0.0001 & -0.0000 & 0.0000 & -0.0005 & -0.0002 & \dots
\end{bmatrix.
$$

$$
\begin{bmatrix}
\dots & 0.0000 & -0.0000 & -0.0000 & -0.0000 & 0.0000 & -0.0000 \\
\dots & -0.0009 & -0.0054 & -0.0212 & -0.0007 & 0.0219 & 0.0008 \\
\dots & 0.5079 & -0.0023 & 0.0003 & -0.2479 & 0.0140 & -0.2304 \\
\dots & -0.7729 & 0.0055 & 0.0053 & -0.8662 & -0.0570 & 0.8683 \\
\dots & -0.0088 & 0.0039 & -0.0102 & -0.0033 & -0.0105 & 0.0048 \\
\dots & 0.0031 & 0.0444 & -0.1179 & -0.0009 & -0.1176 & -0.0080 \\
\dots & 0.3784 & -0.0025 & -0.0026 & 0.4275 & 0.0280 & -0.4265 \\
\dots & 0.0176 & 0.2375 & -0.9924 & -0.0068 & -0.9902 & -0.0660 \\
\dots & 0.0316 & -0.0205 & -0.0006 & -0.0013 & 0.0006 & -0.0180 \\
\dots & 0.0028 & 0.9688 & 0.0146 & -0.0738 & 0.0194 & -0.0789 \\
\dots & 0.0002 & -0.0503 & -0.0211 & 0.0041 & -0.0213 & 0.0031 \\
\dots & 0.0005 & 0.0000 & -0.0000 & 0.0005 & -0.0000 & 0.0006
\end{bmatrix}
$$

where

$$
\begin{array}{rclrcl}
v_{0_1} & \in & V_{0_1} & v_{0_2} & \in & V_{0_2} \\
v_{0_3} & \in & V_{0_3} & v_{0_4} & \in & V_{0_4} \\
v_{y_{w_{fl1}}} & \in & V_{y_{w_{fl1}}} & v_{y_{w_{fl2}}} & \in & V_{y_{w_{fl2}}} \\
v_{y_{w_{fr1}}} & \in & V_{y_{w_{fr1}}} & v_{y_{w_{fr2}}} & \in & V_{y_{w_{fr2}}} \\
v_{y_{w_{rl1}}} & \in & V_{y_{w_{rl1}}} & v_{y_{w_{rl2}}} & \in & V_{y_{w_{rl2}}} \\
v_{y_{w_{rr1}}} & \in & V_{y_{w_{rr1}}} & v_{y_{w_{rr2}}} & \in & V_{y_{w_{rr2}}}
\end{array}
$$

The matrix $\tilde{W}$ associated with the left eigenvectors $\tilde{V}$ is

$$
\tilde{W} = \left[w_{0_1}, w_{0_2}, w_{0_3}, w_{0_4}, w_{y_{w_{fl1}}}, w_{y_{w_{fl2}}}, w_{y_{w_{fr1}}}, w_{y_{w_{fr2}}}, w_{y_{w_{rl1}}}, w_{y_{w_{rl2}}}, w_{y_{w_{rr1}}}, w_{y_{w_{rr2}}}\right]
$$

$$= \begin{bmatrix} 3.1340 & 0.0475 & -0.0087 & -7.0773 & 0.5261 & -1.5937 & \cdots \\ 0.0240 & -0.0486 & 0.0116 & -0.1165 & -0.0064 & 0.1703 & \cdots \\ 0.1726 & 0.7200 & -0.1664 & 0.0690 & -0.0379 & -1.2071 & \cdots \\ 0.0977 & -0.0613 & -0.1967 & 0.0453 & 0.4735 & -0.3263 & \cdots \\ 0.0161 & 0.1358 & 0.0176 & 0.0061 & -0.4006 & -0.3341 & \cdots \\ 0.2604 & -0.1254 & -0.2117 & 0.1250 & 0.0587 & -2.4525 & \cdots \\ -0.5476 & 0.2188 & -0.3407 & -0.2320 & -1.7301 & 9.2842 & \cdots \\ 0.2466 & -3.2948 & -17.4840 & -0.3811 & -3.2417 & -17.0804 & \cdots \\ -0.0000 & -0.0000 & 0.0000 & -0.0000 & 0.5766 & 0.0589 & \cdots \\ -0.0000 & -0.0000 & 0.0000 & -0.0000 & 0.0000 & 0.0000 & \cdots \\ 0.0000 & 0.0000 & -0.0000 & 0.0000 & -0.0000 & -0.0000 & \cdots \\ 0.0000 & 0.0000 & -0.0000 & 0.0000 & -0.0000 & -0.0000 & \cdots \end{bmatrix}$$

$$\begin{bmatrix} \cdots & 0.2793 & 1.6517 & 6.4910 & 0.2300 & -6.7146 & -0.2571 \\ \cdots & -0.0784 & -0.1105 & -0.5915 & -0.1546 & 0.5887 & -0.1013 \\ \cdots & 0.4392 & 0.3352 & -0.0791 & 1.7645 & -0.1720 & 1.7127 \\ \cdots & 0.3324 & -0.2558 & 1.0693 & 0.0188 & 1.0810 & -0.0187 \\ \cdots & 0.5166 & -0.1356 & -0.0141 & -0.2256 & 0.0014 & -0.3392 \\ \cdots & -0.3991 & -2.2347 & 5.3986 & -0.2538 & 6.3527 & 0.8144 \\ \cdots & -0.0502 & -9.5742 & -0.0536 & 0.6232 & -0.0978 & 0.5578 \\ \cdots & -9.2347 & -7.0837 & 32.5183 & -16.9163 & 31.4442 & 18.7676 \\ \cdots & -0.0000 & -0.0000 & 0.0000 & -0.0000 & -0.0000 & -0.0000 \\ \cdots & -0.4555 & 0.5162 & 0.0000 & -0.0000 & -0.0000 & -0.0000 \\ \cdots & 0.0000 & -0.0000 & 2.3178 & 1.1515 & -0.0000 & 0.0000 \\ \cdots & 0.0000 & -0.0000 & 0.0000 & 0.0000 & -2.3751 & 0.8506 \end{bmatrix}$$

The fault detection filter gain L is found from (4.4), $\tilde{V}^T L = \tilde{W}^T$ and is

$$L = \begin{bmatrix} 7.69 & 0.12 & -0.01 & -0.01 & -0.00 & -0.04 & \cdots \\ -306.69 & 27.24 & 0.22 & 0.19 & -0.13 & 23.12 & \cdots \\ 0.01 & 0.08 & -1.43 & 0.09 & 1.04 & 0.42 & \cdots \\ 0.13 & 0.01 & -0.16 & 0.31 & -0.11 & 0.18 & \cdots \\ 0.00 & -0.51 & 17.06 & -44.36 & 4.24 & 46.22 & \cdots \\ -0.00 & 0.58 & -13.13 & 0.06 & -4.21 & -28.33 & \cdots \\ 0.26 & -0.00 & 0.01 & 0.30 & -0.02 & 0.06 & \cdots \\ -0.02 & -0.05 & 1.45 & -0.63 & 0.47 & -3.05 & \cdots \\ -0.20 & 0.02 & -0.45 & -0.01 & -0.09 & 0.06 & \cdots \\ 0.04 & 0.03 & 0.51 & 0.07 & -0.08 & -0.31 & \cdots \\ 0.78 & -0.00 & -0.02 & 0.01 & 0.01 & 0.12 & \cdots \\ 0.00 & -186.37 & 2481.31 & 64.36 & -80.30 & 148.64 & \cdots \end{bmatrix}$$

$$
\left.\begin{array}{crrrrrr}
\cdots & 0.06 & 0.44 & 0.00 & 0.00 & -0.00 & -0.00 \\
\cdots & -0.26 & 4.45 & -0.00 & 0.00 & -53.97 & -53.73 \\
\cdots & -1.74 & 1.70 & -0.36 & -0.34 & -0.71 & -0.59 \\
\cdots & 1.26 & 28.02 & 0.26 & -0.22 & -1.00 & 0.85 \\
\cdots & -216.65 & -867.22 & -43.03 & 39.17 & 80.36 & -68.11 \\
\cdots & 11.29 & -1.91 & 0.32 & 4.51 & 1.99 & -2.63 \\
\cdots & 0.41 & 8.69 & 0.07 & -0.07 & 0.13 & -0.11 \\
\cdots & 0.80 & -23.48 & 0.40 & -0.93 & -2.25 & 2.15 \\
\cdots & -0.17 & -0.56 & -0.04 & -0.04 & 0.08 & 0.07 \\
\cdots & -9.75 & 1.55 & 0.06 & 0.39 & -0.16 & -0.43 \\
\cdots & -0.14 & -6.85 & 0.00 & -0.03 & -0.02 & 0.06 \\
\cdots & -580.26 & 2141.09 & -62.03 & -164.78 & 466.76 & 651.96
\end{array}\right] \tag{e.1}
$$

The output projection matrices $\hat{H}_{y_{w_{fl}}}$, $\hat{H}_{y_{w_{fr}}}$, $\hat{H}_{y_{w_{rl}}}$ and $\hat{H}_{y_{w_{rr}}}$ are as follows.

$$
\hat{H}_{y_{w_{fl}}} = \left[\begin{array}{rrrrrrc}
1.0000 & 0.0000 & -0.0000 & 0.0000 & 0.0000 & -0.0000 & \cdots \\
0.0000 & 0.0043 & -0.0631 & -0.0027 & 0.0007 & -0.0021 & \cdots \\
-0.0000 & -0.0631 & 0.9757 & 0.0674 & 0.0867 & -0.0313 & \cdots \\
0.0000 & -0.0027 & 0.0674 & 0.3023 & 0.1353 & 0.3567 & \cdots \\
0.0000 & 0.0007 & 0.0867 & 0.1353 & 0.2517 & -0.0936 & \cdots \\
-0.0000 & -0.0021 & -0.0313 & 0.3567 & -0.0936 & 0.8168 & \cdots \\
-0.0000 & -0.0061 & -0.0085 & 0.0901 & -0.0223 & -0.0463 & \cdots \\
-0.0000 & 0.0003 & -0.0002 & 0.0021 & -0.0006 & -0.0011 & \cdots \\
0.0000 & -0.0155 & 0.0815 & -0.2296 & -0.3915 & 0.1026 & \cdots \\
-0.0000 & 0.0000 & -0.0000 & 0.0000 & -0.0000 & 0.0000 & \cdots \\
-0.0000 & -0.0000 & 0.0000 & 0.0000 & 0.0000 & -0.0000 & \cdots \\
0.0000 & -0.0000 & 0.0000 & 0.0000 & 0.0000 & -0.0000 & \cdots
\end{array}\right.
$$

$$
\left.\begin{array}{crrrrrr}
\cdots & -0.0000 & -0.0000 & 0.0000 & -0.0000 & -0.0000 & 0.0000 \\
\cdots & -0.0061 & 0.0003 & -0.0155 & 0.0000 & -0.0000 & -0.0000 \\
\cdots & -0.0085 & -0.0002 & 0.0815 & -0.0000 & 0.0000 & 0.0000 \\
\cdots & 0.0901 & 0.0021 & -0.2296 & 0.0000 & 0.0000 & 0.0000 \\
\cdots & -0.0223 & -0.0006 & -0.3915 & -0.0000 & 0.0000 & 0.0000 \\
\cdots & -0.0463 & -0.0011 & 0.1026 & 0.0000 & -0.0000 & -0.0000 \\
\cdots & 0.9883 & -0.0003 & 0.0267 & 0.0000 & -0.0000 & -0.0000 \\
\cdots & -0.0003 & 1.0000 & 0.0006 & -0.0000 & 0.0000 & 0.0000 \\
\cdots & 0.0267 & 0.0006 & 0.6610 & -0.0000 & 0.0000 & -0.0000 \\
\cdots & 0.0000 & -0.0000 & -0.0000 & -0.0000 & 0.0000 & -0.0000 \\
\cdots & -0.0000 & 0.0000 & 0.0000 & 0.0000 & -0.0000 & 0.0000 \\
\cdots & -0.0000 & 0.0000 & -0.0000 & -0.0000 & 0.0000 & -0.0000
\end{array}\right] \tag{e.2a}
$$

$$
\hat{H}_{y_{w_{fr}}} = \left[\begin{array}{rrrrrrl}
1.0000 & 0.0000 & 0.0000 & 0.0000 & -0.0000 & -0.0000 & \cdots \\
0.0000 & 0.0042 & -0.0623 & -0.0010 & 0.0023 & -0.0021 & \cdots \\
0.0000 & -0.0623 & 0.9773 & -0.0532 & 0.0921 & 0.0225 & \cdots \\
0.0000 & -0.0010 & -0.0532 & 0.2016 & -0.1514 & 0.2985 & \cdots \\
-0.0000 & 0.0023 & 0.0921 & -0.1514 & 0.2915 & 0.0383 & \cdots \\
-0.0000 & -0.0021 & 0.0225 & 0.2985 & 0.0383 & 0.8879 & \cdots \\
0.0000 & -0.0050 & -0.0057 & -0.0729 & -0.0101 & 0.0273 & \cdots \\
-0.0000 & 0.0002 & 0.0008 & 0.0102 & 0.0014 & -0.0038 & \cdots \\
0.0000 & 0.0000 & -0.0000 & 0.0000 & -0.0000 & -0.0000 & \cdots \\
-0.0000 & -0.0174 & 0.0806 & 0.2017 & -0.4166 & -0.0877 & \cdots \\
0.0000 & -0.0000 & 0.0000 & -0.0000 & 0.0000 & 0.0000 & \cdots \\
0.0000 & -0.0000 & 0.0000 & -0.0000 & 0.0000 & 0.0000 & \cdots
\end{array}\right.
$$

$$
\left.\begin{array}{lrrrrrr}
\cdots & 0.0000 & -0.0000 & 0.0000 & -0.0000 & 0.0000 & 0.0000 \\
\cdots & -0.0050 & 0.0002 & 0.0000 & -0.0174 & -0.0000 & -0.0000 \\
\cdots & -0.0057 & 0.0008 & -0.0000 & 0.0806 & 0.0000 & 0.0000 \\
\cdots & -0.0729 & 0.0102 & 0.0000 & 0.2017 & -0.0000 & -0.0000 \\
\cdots & -0.0101 & 0.0014 & -0.0000 & -0.4166 & 0.0000 & 0.0000 \\
\cdots & 0.0273 & -0.0038 & -0.0000 & -0.0877 & 0.0000 & 0.0000 \\
\cdots & 0.9933 & 0.0009 & 0.0000 & 0.0208 & -0.0000 & -0.0000 \\
\cdots & 0.0009 & 0.9999 & 0.0000 & -0.0029 & 0.0000 & 0.0000 \\
\cdots & 0.0000 & 0.0000 & -0.0000 & -0.0000 & -0.0000 & 0.0000 \\
\cdots & 0.0208 & -0.0029 & -0.0000 & 0.6443 & -0.0000 & -0.0000 \\
\cdots & -0.0000 & 0.0000 & -0.0000 & -0.0000 & -0.0000 & 0.0000 \\
\cdots & -0.0000 & 0.0000 & 0.0000 & -0.0000 & 0.0000 & 0
\end{array}\right] \quad \text{(e.2b)}
$$

$$
\hat{H}_{y_{w_{rl}}} = \left[\begin{array}{rrrrrrl}
1.0000 & 0.0000 & -0.0000 & -0.0000 & -0.0000 & -0.0000 & \cdots \\
0.0000 & 0.0106 & -0.0607 & -0.0477 & 0.0231 & 0.0212 & \cdots \\
-0.0000 & -0.0607 & 0.8686 & -0.1648 & 0.0110 & -0.0009 & \cdots \\
-0.0000 & -0.0477 & -0.1648 & 0.7369 & -0.2094 & -0.0029 & \cdots \\
-0.0000 & 0.0231 & 0.0110 & -0.2094 & 0.1044 & -0.0051 & \cdots \\
-0.0000 & 0.0212 & -0.0009 & -0.0029 & -0.0051 & 0.9995 & \cdots \\
-0.0000 & -0.0006 & -0.1267 & -0.1929 & -0.1201 & -0.0028 & \cdots \\
0.0000 & 0.0004 & 0.0072 & 0.0109 & 0.0068 & 0.0002 & \cdots \\
0.0000 & 0.0000 & -0.0000 & 0.0000 & 0.0000 & 0.0000 & \cdots \\
0.0000 & 0.0000 & -0.0000 & 0.0000 & -0.0000 & 0.0000 & \cdots \\
0.0000 & -0.0598 & 0.2589 & 0.2885 & -0.1857 & 0.0048 & \cdots \\
-0.0000 & -0.0000 & 0.0000 & -0.0000 & -0.0000 & -0.0000 & \cdots
\end{array}\right.
$$

$$
\left.\begin{matrix}
\cdots & -0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & -0.0000 \\
\cdots & -0.0006 & 0.0004 & 0.0000 & 0.0000 & -0.0598 & -0.0000 \\
\cdots & -0.1267 & 0.0072 & -0.0000 & -0.0000 & 0.2589 & 0.0000 \\
\cdots & -0.1929 & 0.0109 & 0.0000 & 0.0000 & 0.2885 & -0.0000 \\
\cdots & -0.1201 & 0.0068 & 0.0000 & -0.0000 & -0.1857 & -0.0000 \\
\cdots & -0.0028 & 0.0002 & 0.0000 & 0.0000 & 0.0048 & -0.0000 \\
\cdots & 0.8556 & 0.0082 & 0.0000 & 0.0000 & 0.2362 & 0.0000 \\
\cdots & 0.0082 & 0.9995 & -0.0000 & -0.0000 & -0.0134 & -0.0000 \\
\cdots & 0.0000 & -0.0000 & 0 & -0.0000 & -0.0000 & 0.0000 \\
\cdots & 0.0000 & -0.0000 & -0.0000 & 0 & -0.0000 & 0.0000 \\
\cdots & 0.2362 & -0.0134 & -0.0000 & -0.0000 & 0.4247 & 0.0000 \\
\cdots & 0.0000 & -0.0000 & 0.0000 & 0.0000 & 0.0000 & -0.0000
\end{matrix}\right] \quad \text{(e.2c)}
$$

$$
\hat{H}_{y_{wrr}} = \left[\begin{matrix}
1.0000 & -0.0000 & -0.0000 & -0.0000 & -0.0000 & -0.0000 & \cdots \\
-0.0000 & 0.0079 & -0.0750 & 0.0276 & 0.0007 & -0.0222 & \cdots \\
-0.0000 & -0.0750 & 0.8882 & -0.1346 & -0.0005 & -0.0035 & \cdots \\
-0.0000 & 0.0276 & -0.1346 & 0.7679 & -0.2226 & -0.0030 & \cdots \\
-0.0000 & 0.0007 & -0.0005 & -0.2226 & 0.1085 & -0.0048 & \cdots \\
-0.0000 & -0.0222 & -0.0035 & -0.0030 & -0.0048 & 0.9994 & \cdots \\
-0.0000 & -0.0184 & -0.1079 & -0.1688 & -0.1297 & -0.0030 & \cdots \\
0.0000 & 0.0006 & 0.0061 & 0.0096 & 0.0073 & 0.0002 & \cdots \\
0.0000 & 0.0000 & -0.0000 & 0.0000 & -0.0000 & 0.0000 & \cdots \\
0.0000 & 0.0000 & -0.0000 & 0.0000 & -0.0000 & 0.0000 & \cdots \\
-0.0000 & -0.0000 & 0.0000 & -0.0000 & 0.0000 & -0.0000 & \cdots \\
0.0000 & -0.0243 & 0.2527 & 0.2849 & -0.1740 & 0.0029 & \cdots
\end{matrix}\right.
$$

$$
\left.\begin{matrix}
\cdots & -0.0000 & 0.0000 & 0.0000 & 0.0000 & -0.0000 & 0.0000 \\
\cdots & -0.0184 & 0.0006 & 0.0000 & 0.0000 & -0.0000 & -0.0243 \\
\cdots & -0.1079 & 0.0061 & -0.0000 & -0.0000 & 0.0000 & 0.2527 \\
\cdots & -0.1688 & 0.0096 & 0.0000 & 0.0000 & -0.0000 & 0.2849 \\
\cdots & -0.1297 & 0.0073 & -0.0000 & -0.0000 & 0.0000 & -0.1740 \\
\cdots & -0.0030 & 0.0002 & 0.0000 & 0.0000 & -0.0000 & 0.0029 \\
\cdots & 0.8741 & 0.0071 & 0.0000 & 0.0000 & -0.0000 & 0.2296 \\
\cdots & 0.0071 & 0.9996 & -0.0000 & -0.0000 & 0.0000 & -0.0130 \\
\cdots & 0.0000 & -0.0000 & -0.0000 & 0.0000 & 0.0000 & 0.0000 \\
\cdots & 0.0000 & -0.0000 & 0.0000 & -0.0000 & -0.0000 & 0.0000 \\
\cdots & -0.0000 & 0.0000 & 0.0000 & -0.0000 & -0.0000 & 0.0000 \\
\cdots & 0.2296 & -0.0130 & 0.0000 & 0.0000 & 0.0000 & 0.3544
\end{matrix}\right] \quad \text{(e.2d)}
$$

E.2 Design Data for Fault Group Four

This section presents data associated with the fault detection filter design for fault group four, the throttle actuator, the brake actuator, the steering actuator and the manifold air mass sensor faults. The design details and a discussion are in Section 4.2.2 The matrix of assigned left eigenvectors $\tilde{V}$ is

$$
\begin{aligned}
\tilde{V} &= \left[v_{u_{\tau_{b1}}}, v_{u_{\tau_{b2}}}, v_{0_1}, v_{0_2}, v_{0_3}, v_{0_4}, v_{0_5}, v_{0_6}, v_{0_7}, v_{0_8}, v_{u_{\alpha_1}}, v_{u_{\alpha_2}}, v_{u_\beta}, v_{y_{m_a}}\right] \\
&= \left[\begin{array}{rrrrrrrl}
0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & \dots \\
0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & \dots \\
-0.2987 & -0.0798 & -0.0347 & -0.2210 & -0.0072 & -0.1135 & -0.0660 & \dots \\
0.2474 & -0.0862 & -0.0975 & 0.1370 & -0.0600 & -0.2142 & -0.0554 & \dots \\
0.0741 & 0.2022 & -0.0180 & -0.0077 & 0.7732 & 0.0533 & -0.5932 & \dots \\
0.0969 & 0.8501 & 0.4343 & -0.0493 & -0.0974 & -0.1769 & 0.1505 & \dots \\
0.6112 & -0.1922 & 0.3729 & -0.2343 & -0.3427 & 0.2620 & -0.4229 & \dots \\
0.5307 & 0.2180 & -0.6104 & -0.2680 & 0.1409 & 0.2070 & 0.3641 & \dots \\
-0.2724 & 0.3714 & -0.4539 & 0.1310 & -0.4681 & 0.3416 & -0.4727 & \dots \\
-0.1459 & 0.0026 & -0.1328 & -0.8021 & -0.1030 & -0.4189 & -0.1773 & \dots \\
-0.2900 & -0.0119 & 0.2551 & -0.3776 & 0.1484 & 0.7095 & 0.2277 & \dots \\
0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & \dots \\
0.0033 & -0.0108 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & \dots \\
0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & \dots
\end{array}\right. \\
&\qquad \left.\begin{array}{lrrrrrrr}
\dots & 0.0000 & 0.0000 & 0.0000 & -0.4154 & -0.4154 & 0.0000 & 0.0000 \\
\dots & 0.0000 & 0.0000 & 0.0000 & -0.0304 & -0.0304 & 0.0000 & -0.0334 \\
\dots & -0.0674 & -0.0227 & -0.0321 & 0.8761 & 0.8761 & 0.0005 & 0.9632 \\
\dots & 0.1102 & 0.1017 & 0.1833 & 0.0017 & 0.0004 & -0.5040 & 0.0009 \\
\dots & 0.0725 & -0.2177 & 0.0046 & -0.0241 & -0.0242 & -0.0075 & -0.0266 \\
\dots & 0.1496 & -0.8294 & 0.2028 & 0.0000 & 0.0000 & -0.0006 & 0.0000 \\
\dots & 0.5781 & 0.0477 & -0.3889 & 0.0000 & 0.0000 & 0.0000 & 0.0000 \\
\dots & 0.5729 & -0.1711 & 0.0478 & 0.0028 & 0.0028 & -0.0026 & 0.0030 \\
\dots & -0.2232 & -0.2393 & 0.3537 & 0.0000 & 0.0000 & 0.0000 & 0.0000 \\
\dots & -0.2431 & -0.0606 & -0.1128 & -0.2413 & -0.2413 & -0.0020 & -0.2653 \\
\dots & -0.4294 & -0.4017 & -0.7955 & -0.0014 & -0.0015 & -0.3289 & -0.0017 \\
\dots & 0.0000 & 0.0000 & 0.0000 & -0.0112 & -0.0119 & 0.0000 & 0.0000 \\
\dots & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 \\
\dots & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & -0.7986 & 0.0000
\end{array}\right]
\end{aligned}
$$

where

$$
\begin{array}{rclcrcl}
v_{u_{\tau_{b1}}} & \in & V_{u_{\tau_{b1}}} & \qquad & v_{u_{\tau_{b2}}} & \in & V_{u_{\tau_{b2}}} \\
v_{0_1} & \in & V_{0_1} & & v_{0_2} & \in & V_{0_2} \\
v_{0_3} & \in & V_{0_3} & & v_{0_4} & \in & V_{0_4} \\
v_{0_5} & \in & V_{0_5} & & v_{0_6} & \in & V_{0_6} \\
v_{0_7} & \in & V_{0_7} & & v_{0_8} & \in & V_{0_8} \\
v_{u_{\alpha_1}} & \in & V_{u_{\alpha_1}} & & v_{u_{\alpha_2}} & \in & V_{u_{\alpha_2}} \\
v_{u_\beta} & \in & V_{u_\beta} & & v_{y_{m_a}} & \in & V_{y_{m_a}}
\end{array}
$$

The matrix $\tilde{W}$ associated with the left eigenvectors $\tilde{V}$ is

$$
\begin{aligned}
\tilde{W} &= \left[w_{u_{\tau_{b1}}}, w_{u_{\tau_{b2}}}, w_{0_1}, w_{0_2}, w_{0_3}, w_{0_4}, w_{0_5}, w_{0_6}, w_{0_7}, w_{0_8}, w_{u_{\alpha_1}}, w_{u_{\alpha_2}}, w_{u_\beta}, w_{y_{m_a}} \right] \\
&= \left[\begin{array}{rrrrrrrl}
0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & \ldots \\
-0.3985 & 2.1071 & -0.0011 & -0.0153 & -0.5254 & -0.0527 & 0.4772 & \ldots \\
5.2129 & -30.3751 & -0.0633 & -0.2311 & -2.1086 & -0.3043 & 1.8758 & \ldots \\
-0.6640 & -0.4129 & 0.6576 & 0.3023 & -0.1710 & -0.2946 & -0.4125 & \ldots \\
-0.0144 & -0.5023 & 0.0763 & -0.3587 & 2.5332 & -0.0086 & -2.4937 & \ldots \\
-2.6707 & -1.5851 & 5.6803 & 2.8445 & -1.6433 & -2.6140 & -5.0102 & \ldots \\
0.7404 & 1.1030 & 1.3954 & 8.7177 & 2.4947 & 5.5332 & 1.1599 & \ldots \\
-10.2358 & -10.5460 & 16.9547 & 13.0929 & 46.8558 & -13.5944 & -65.6255 & \ldots \\
-2.8892 & -14.0216 & 0.4363 & 0.5322 & -74.6867 & -5.6399 & 67.4728 & \ldots \\
2.2630 & 17.8320 & -0.3809 & -0.6196 & 72.6355 & 5.3593 & -65.4520 & \ldots \\
3.4007 & 12.0161 & 0.4531 & -0.0412 & 82.5552 & 6.4825 & -75.2208 & \ldots \\
-1.0436 & -22.6153 & -0.3933 & 0.8835 & -78.7647 & -5.6159 & 71.8864 & \ldots
\end{array} \right. \\
& \qquad \left. \begin{array}{lrrrrrrr}
\ldots & 0.0000 & 0.0000 & 0.0000 & 1.6614 & 3.7382 & 0.0000 & 10.2391 \\
\ldots & -0.0551 & 0.1783 & -0.0013 & -0.9469 & -0.7825 & 0.0009 & -0.8789 \\
\ldots & -0.2684 & 0.6723 & -0.0262 & -0.6606 & -0.2928 & -0.0017 & -0.4836 \\
\ldots & -0.5631 & 0.2499 & 0.0809 & -0.0018 & 0.0026 & 0.1598 & 0.0012 \\
\ldots & 0.1675 & -1.3179 & -0.0569 & 0.6414 & 1.3682 & 0.0278 & 1.1846 \\
\ldots & -8.0615 & 2.6989 & -0.8829 & -0.0100 & -0.0232 & -0.0714 & -0.0197 \\
\ldots & 3.6905 & 0.4336 & 2.0548 & 0.9218 & 2.1104 & 0.0171 & 1.7975 \\
\ldots & -4.3303 & -5.1871 & 13.0855 & -0.6735 & -1.3325 & -7.3383 & -1.1740 \\
\ldots & -7.6009 & 25.4596 & 0.2275 & 0.5095 & 1.1843 & 0.2158 & 1.0052 \\
\ldots & 7.4717 & -24.7021 & -0.2517 & -1.0911 & -2.3345 & -0.2088 & -2.0197 \\
\ldots & 8.0677 & -28.0256 & -0.5744 & 0.5309 & -0.8923 & -0.0534 & -0.3551 \\
\ldots & -7.4781 & 26.7949 & 0.7636 & 2.3150 & 3.0237 & 0.0384 & 3.0126
\end{array} \right]
\end{aligned}
$$

The fault detection filter gain L found from (4.9), $\tilde{V}^T L = \tilde{W}^T$ is

$$L = \left[\begin{array}{rrrrrrc} 100.33 & 6.83 & 15.00 & 0.12 & 29.87 & -0.04 & \dots \\ -306.69 & -15.59 & 405.89 & 3.54 & 80.18 & -442.98 & \dots \\ -0.00 & -1.37 & 12.59 & 0.12 & 3.95 & -13.94 & \dots \\ 0.00 & -0.24 & -0.61 & -1.01 & 2.60 & 8.74 & \dots \\ 0.00 & -0.70 & -3.27 & -0.03 & 3.64 & 0.79 & \dots \\ 0.00 & -0.02 & -0.06 & -0.00 & 0.49 & -1.44 & \dots \\ 0.00 & -0.04 & -0.17 & -0.00 & 0.22 & -0.70 & \dots \\ 0.00 & 0.02 & 0.18 & -1.08 & -0.15 & -12.01 & \dots \\ 0.00 & -0.04 & -0.16 & -0.00 & 0.27 & 0.84 & \dots \\ -0.00 & 0.39 & -3.21 & -0.03 & -0.58 & 4.99 & \dots \\ 0.00 & -0.06 & -0.17 & -0.40 & 0.74 & 2.61 & \dots \\ -3027.92 & -239.30 & -534.91 & -4.36 & -1065.10 & 1.59 & \dots \\ -0.00 & -196.99 & 2649.44 & 23.23 & 104.54 & -120.99 & \dots \\ -0.00 & 0.18 & 0.50 & 0.60 & -2.01 & -6.49 & \dots \end{array}\right.$$

$$\left.\begin{array}{crrrrrr} \dots & 47.69 & -28.13 & 25.51 & -48.83 & -55.88 & 26.71 \\ \dots & -49.87 & 861.41 & -1354.33 & 1270.58 & 1534.55 & -1405.89 \\ \dots & -2.84 & 28.89 & -45.73 & 41.99 & 52.36 & -45.78 \\ \dots & -15.97 & -20.21 & -35.32 & 34.12 & 39.29 & -38.53 \\ \dots & 1.49 & 74.30 & -102.96 & 100.08 & 114.05 & -108.98 \\ \dots & -0.03 & 1.81 & -2.70 & 2.65 & 2.96 & -2.87 \\ \dots & 0.24 & 5.62 & -5.27 & 5.12 & 6.26 & -5.97 \\ \dots & 0.80 & -34.87 & 3.14 & -3.00 & -4.59 & 4.42 \\ \dots & 0.27 & 3.83 & -5.14 & 4.79 & 5.68 & -5.20 \\ \dots & -10.98 & -6.83 & 10.91 & -9.84 & -13.07 & 10.24 \\ \dots & -4.54 & -23.55 & -8.92 & 8.58 & 10.12 & -9.93 \\ \dots & -1700.87 & 1002.82 & -910.40 & 1741.89 & 1993.37 & -953.17 \\ \dots & 95.53 & 1803.00 & -228.45 & -149.32 & 531.03 & 501.29 \\ \dots & 11.93 & 31.10 & 26.59 & -25.68 & -29.88 & 29.31 \end{array}\right] \tag{e.3}$$

The output projection matrices $\hat{H}_{u_\alpha}$, $\hat{H}_{u_{\tau_b}}$, $\hat{H}_{u_\beta}$ and $\hat{H}_{y_{m_a}}$ are as follows.

$$
\hat{H}_{u_\alpha} = \left[\begin{matrix}
0.8886 & 0.0680 & 0.1377 & 0.0012 & -0.0183 & -0.0001 & \cdots \\
0.0680 & 0.0062 & 0.0109 & 0.0001 & -0.0009 & -0.0000 & \cdots \\
0.1377 & 0.0109 & 0.0263 & 0.0002 & 0.0457 & 0.0002 & \cdots \\
0.0012 & 0.0001 & 0.0002 & 0.0000 & 0.0001 & 0.0000 & \cdots \\
-0.0183 & -0.0009 & 0.0457 & 0.0001 & 0.9962 & -0.0000 & \cdots \\
-0.0001 & -0.0000 & 0.0002 & 0.0000 & -0.0000 & 1.0000 & \cdots \\
0.0129 & 0.0006 & -0.0168 & -0.0001 & 0.0022 & 0.0000 & \cdots \\
0.0000 & 0.0000 & -0.0000 & -0.0000 & 0.0000 & 0.0000 & \cdots \\
-0.1168 & 0.0098 & -0.0321 & -0.0003 & -0.0149 & -0.0002 & \cdots \\
-0.1209 & 0.0074 & -0.0001 & 0.0000 & -0.0164 & -0.0002 & \cdots \\
-0.1464 & -0.0265 & -0.0556 & -0.0005 & -0.0187 & -0.0002 & \cdots \\
-0.1587 & -0.0239 & -0.0008 & -0.0000 & -0.0218 & -0.0002 & \cdots
\end{matrix}\right.
$$

$$
\left.\begin{matrix}
\cdots & 0.0129 & 0.0000 & -0.1168 & -0.1209 & -0.1464 & -0.1587 \\
\cdots & 0.0006 & 0.0000 & 0.0098 & 0.0074 & -0.0265 & -0.0239 \\
\cdots & -0.0168 & -0.0000 & -0.0321 & -0.0001 & -0.0556 & -0.0008 \\
\cdots & -0.0001 & -0.0000 & -0.0003 & 0.0000 & -0.0005 & -0.0000 \\
\cdots & 0.0022 & 0.0000 & -0.0149 & -0.0164 & -0.0187 & -0.0218 \\
\cdots & 0.0000 & 0.0000 & -0.0002 & -0.0002 & -0.0002 & -0.0002 \\
\cdots & 0.9984 & -0.0000 & 0.0141 & 0.0146 & 0.0180 & 0.0195 \\
\cdots & -0.0000 & 1.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 \\
\cdots & 0.0141 & 0.0000 & 0.8316 & -0.1670 & -0.2181 & -0.2223 \\
\cdots & 0.0146 & 0.0000 & -0.1670 & 0.8334 & -0.2159 & -0.2219 \\
\cdots & 0.0180 & 0.0000 & -0.2181 & -0.2159 & 0.7158 & -0.2887 \\
\cdots & 0.0195 & 0.0000 & -0.2223 & -0.2219 & -0.2887 & 0.7034
\end{matrix}\right] \tag{e.4a}
$$

$$
\hat{H}_{u_{\tau_b}} = \left[\begin{matrix}
0 & -0.0000 & 0.0000 & -0.0000 & 0.0000 & 0.0000 & \cdots \\
-0.0000 & 0.0063 & -0.0595 & -0.0005 & 0.0016 & 0.0000 & \cdots \\
0.0000 & -0.0595 & 0.9964 & 0.0087 & 0.0001 & 0.0000 & \cdots \\
-0.0000 & -0.0005 & 0.0087 & 0.0001 & -0.0003 & 0.0000 & \cdots \\
0.0000 & 0.0016 & 0.0001 & -0.0003 & 1.0000 & -0.0000 & \cdots \\
0.0000 & 0.0000 & 0.0000 & 0.0000 & -0.0000 & 1.0000 & \cdots \\
-0.0000 & -0.0000 & -0.0000 & -0.0000 & 0.0000 & 0.0000 & \cdots \\
-0.0000 & -0.0000 & -0.0000 & -0.0000 & 0.0000 & 0.0000 & \cdots \\
0.0000 & 0.0000 & -0.0000 & 0.0000 & 0.0000 & -0.0000 & \cdots \\
-0.0000 & 0.0000 & -0.0000 & 0.0000 & 0.0000 & -0.0000 & \cdots \\
0.0000 & -0.0402 & -0.0024 & -0.0000 & 0.0001 & 0.0000 & \cdots \\
-0.0000 & -0.0339 & -0.0020 & -0.0000 & 0.0001 & 0.0000 & \cdots
\end{matrix}\right.
$$

$$\begin{matrix} \cdots & -0.0000 & -0.0000 & 0.0000 & -0.0000 & 0.0000 & -0.0000 \\ \cdots & -0.0000 & -0.0000 & 0.0000 & 0.0000 & -0.0402 & -0.0339 \\ \cdots & -0.0000 & -0.0000 & -0.0000 & -0.0000 & -0.0024 & -0.0020 \\ \cdots & -0.0000 & -0.0000 & 0.0000 & 0.0000 & -0.0000 & -0.0000 \\ \cdots & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0001 & 0.0001 \\ \cdots & 0.0000 & 0.0000 & -0.0000 & -0.0000 & 0.0000 & 0.0000 \\ \cdots & 1.0000 & -0.0000 & 0.0000 & 0.0000 & -0.0000 & -0.0000 \\ \cdots & -0.0000 & 1.0000 & 0.0000 & 0.0000 & -0.0000 & -0.0000 \\ \cdots & 0.0000 & 0.0000 & 1.0000 & -0.0000 & 0.0000 & 0.0000 \\ \cdots & 0.0000 & 0.0000 & -0.0000 & 1.0000 & 0.0000 & 0.0000 \\ \cdots & -0.0000 & -0.0000 & 0.0000 & 0.0000 & 0.9984 & -0.0014 \\ \cdots & -0.0000 & -0.0000 & 0.0000 & 0.0000 & -0.0014 & 0.9988 \end{matrix}\Bigg] \tag{e.4b}$$

$$\hat{H}_{u_\beta} = \Bigg[\begin{matrix} 0.0000 & -0.0000 & 0.0000 & -0.0000 & 0.0000 & 0.0000 & \cdots \\ -0.0000 & 0.0010 & 0.0003 & 0.0002 & 0.0005 & 0.0000 & \cdots \\ 0.0000 & 0.0003 & 0.0050 & -0.0063 & 0.0485 & 0.0002 & \cdots \\ -0.0000 & 0.0002 & -0.0063 & 0.9999 & 0.0006 & 0.0000 & \cdots \\ 0.0000 & 0.0005 & 0.0485 & 0.0006 & 0.9959 & -0.0000 & \cdots \\ 0.0000 & 0.0000 & 0.0002 & 0.0000 & -0.0000 & 1.0000 & \cdots \\ 0.0000 & -0.0004 & -0.0188 & -0.0004 & 0.0025 & 0.0000 & \cdots \\ 0.0000 & -0.0000 & -0.0000 & -0.0000 & 0.0000 & 0.0000 & \cdots \\ -0.0000 & 0.0187 & -0.0140 & 0.0028 & -0.0173 & -0.0002 & \cdots \\ 0.0000 & 0.0167 & 0.0186 & 0.0030 & -0.0189 & -0.0002 & \cdots \\ -0.0000 & -0.0153 & -0.0330 & 0.0035 & -0.0217 & -0.0002 & \cdots \\ 0.0000 & -0.0117 & 0.0238 & 0.0039 & -0.0251 & -0.0003 & \cdots \end{matrix}$$

$$\begin{matrix} \cdots & 0.0000 & 0.0000 & -0.0000 & 0.0000 & -0.0000 & 0.0000 \\ \cdots & -0.0004 & -0.0000 & 0.0187 & 0.0167 & -0.0153 & -0.0117 \\ \cdots & -0.0188 & -0.0000 & -0.0140 & 0.0186 & -0.0330 & 0.0238 \\ \cdots & -0.0004 & -0.0000 & 0.0028 & 0.0030 & 0.0035 & 0.0039 \\ \cdots & 0.0025 & 0.0000 & -0.0173 & -0.0189 & -0.0217 & -0.0251 \\ \cdots & 0.0000 & 0.0000 & -0.0002 & -0.0002 & -0.0002 & -0.0003 \\ \cdots & 0.9982 & -0.0000 & 0.0158 & 0.0164 & 0.0201 & 0.0218 \\ \cdots & -0.0000 & 1.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 \\ \cdots & 0.0158 & 0.0000 & 0.8163 & -0.1829 & -0.2373 & -0.2431 \\ \cdots & 0.0164 & 0.0000 & -0.1829 & 0.8169 & -0.2358 & -0.2435 \\ \cdots & 0.0201 & 0.0000 & -0.2373 & -0.2358 & 0.6917 & -0.3149 \\ \cdots & 0.0218 & 0.0000 & -0.2431 & -0.2435 & -0.3149 & 0.6751 \end{matrix}\Bigg] \tag{e.4c}$$

$$
\hat{H}_{y_{m_a}} = \left[\begin{array}{rrrrrrl}
0 & -0.0000 & -0.0000 & -0.0000 & 0.0000 & 0.0000 & \ldots \\
-0.0000 & 0.0478 & 0.0950 & 0.0008 & -0.0121 & -0.0001 & \ldots \\
-0.0000 & 0.0950 & 0.1966 & 0.0017 & 0.0231 & 0.0000 & \ldots \\
-0.0000 & 0.0008 & 0.0017 & 0.0000 & -0.0001 & 0.0000 & \ldots \\
0.0000 & -0.0121 & 0.0231 & -0.0001 & 0.9992 & -0.0000 & \ldots \\
0.0000 & -0.0001 & 0.0000 & 0.0000 & -0.0000 & 1.0000 & \ldots \\
0.0000 & 0.0084 & -0.0008 & -0.0000 & 0.0001 & 0.0000 & \ldots \\
-0.0000 & 0.0000 & -0.0000 & -0.0000 & 0.0000 & 0.0000 & \ldots \\
0.0000 & -0.0615 & -0.1765 & -0.0016 & 0.0042 & -0.0000 & \ldots \\
0.0000 & -0.0664 & -0.1496 & -0.0013 & 0.0035 & -0.0000 & \ldots \\
0.0000 & -0.1159 & -0.2367 & -0.0021 & 0.0054 & -0.0000 & \ldots \\
0.0000 & -0.1208 & -0.1971 & -0.0017 & 0.0042 & -0.0000 & \ldots
\end{array}\right.
$$

$$
\left.\begin{array}{lrrrrrr}
\ldots & 0.0000 & -0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 \\
\ldots & 0.0084 & 0.0000 & -0.0615 & -0.0664 & -0.1159 & -0.1208 \\
\ldots & -0.0008 & -0.0000 & -0.1765 & -0.1496 & -0.2367 & -0.1971 \\
\ldots & -0.0000 & -0.0000 & -0.0016 & -0.0013 & -0.0021 & -0.0017 \\
\ldots & 0.0001 & 0.0000 & 0.0042 & 0.0035 & 0.0054 & 0.0042 \\
\ldots & 0.0000 & 0.0000 & -0.0000 & -0.0000 & -0.0000 & -0.0000 \\
\ldots & 0.9999 & -0.0000 & 0.0005 & 0.0006 & 0.0010 & 0.0011 \\
\ldots & -0.0000 & 1.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 \\
\ldots & 0.0005 & 0.0000 & 0.9540 & -0.0402 & -0.0646 & -0.0559 \\
\ldots & 0.0006 & 0.0000 & -0.0402 & 0.9646 & -0.0569 & -0.0496 \\
\ldots & 0.0010 & 0.0000 & -0.0646 & -0.0569 & 0.9083 & -0.0801 \\
\ldots & 0.0011 & 0.0000 & -0.0559 & -0.0496 & -0.0801 & 0.9296
\end{array}\right] \tag{e.4d}
$$

References

Bakker, E., L. Nyborg, and H. Pacejka 1987. Tyre Modeling for use in Vehicle Dynamics Studies. pages 1–15. SAE. Paper 870421.

Bakker, E. and H. Pacejka 1989. A New Tyre Model with an Application in Vehicle Dynamics Studies. pages 83–93. SAE. Paper 890087.

Banavar, R. N. and J. L. Speyer 1991. An Linear-Quadratic Game Approach to Estimation and Smoothing. In *Proceedings of the American Control Conference*, pages 2818–2822.

Basseville, M. and I. Nikiforov 1995. *Detection of Abrupt Changes : Theory and Applications*. Prentice Hall. Edited by Thomas Kailath.

Beard, R. V. 1971. *Failure Accomodation in Linear Systems through Self-Reorganization*. PhD thesis, Department of Aeronautics and Astronautics, Massachusetts Institute of Technology, Cambridge, MA.

Bell, D. J. and D. H. Jacobsen 1973. *Singular Optimal Control.* Academic Press.

Blaydon, C. C. 1967. Recursive Algorithms for Pattern Classification. Research note, Office of Naval Research.

Bourlard, H. and C. J. Wellekens 1994. *Connectionist Speech Recognition : A Hybrid Approach.* Kluwer Academic Press.

Brogan, W. L. 1991. *Modern Control Theory.* Prentice-Hall, 3rd edition.

Cebon, D. and D. E. Newland 1983. The Artificial Generation of Road Surface Topography by the Inverse FFT Method. In *Proceedings of the 8th IAVSD Symposium on the Dynamics of Vehicles on Roads and Railway Tracks*, pages 29–42.

Chichka, D. F. and J. L. Speyer 1995. An Adaptive Controller Based on Disturbance Attenuation. *IEEE Transactions on Automatic Control*, Vol. AC-40, No. 7:1220–1233.

Clements, D. J. and B. D. O. Anderson 1978. *Singular Optimal Control: The Linear-Quadratic Problem*, volume 5 of *Lecture Notes in Control and Information Sciences.* Springer-Verlag.

Douglas, R. K. 1993. *Robust Fault Detection Filter Design.* PhD thesis, The University of Texas at Austin, Austin, TX.

Douglas, R. K. and J. L. Speyer 1995a. An $\mathcal{H}_\infty$ Bounded Fault Detection Filter. In *Proceedings of the American Controls Conference.*

Douglas, R. K. and J. L. Speyer 1995b. Robust Fault Detection Filter Design. In *Proceedings of the American Controls Conference.*

Douglas, R. K. and J. L. Speyer 1996. Robust Fault Detection Filter Design. *AIAA Journal of Guidance, Control, and Dynamics*, Vol. 19, No. 1:214–218.

Douglas, R. K., J. L. Speyer, D. L. Mingori, R. H. Chen, D. P. Malladi, and W. H. Chung 1995. Fault Detection and Identification with Application to Advanced Vehicle Control Systems. Technical report, University of California, Los Angeles, MANE Dept. Final Report Prepared for California PATH Program.

Doyle, J. C. 1984. Lecture Notes on Advances in Multivariable Control. ONR/Honeywell Workshop, Minneapolis, MN.

Doyle, J. C., K. Glover, P. P. Khargonekar, and B. A. Francis 1989. State-Space Solutions to Standard $\mathcal{H}_2$ and $\mathcal{H}_\infty$ Control Problems. *IEEE Transactions on Automatic Control*, Vol. AC-34, No. 8:831–847.

Emami-Naeini, A., M. M. Akhter, and S. M. Rock 1988. Effect of Model Uncertainty on Failure Detection: The Threshold Selector. *IEEE Transactions on Automatic Control*, Vol. AC-33, No. 12:1106–1115.

Francis, B. A. 1979. The Optimal Linear-Quadratic Time-Invariant Regulator with Cheap Control. *IEEE Transactions on Automatic Control*, Vol. 24, No. 4:616–621.

Frank, P. M. and J. Wünnenberg 1989. Robust Fault Diagnosis Using Unknown Input Observer Schemes. In Patton, R., P. Frank, and R. Clark, editors, *Fault Diagnosis in Dynamic Systems*. Prentice Hall.

Funahashi, K.-I. 1989. On the Approximate Realization of Continuous Mappings by Neural Networks. *Neural Networks*, Vol. 2.

Gill, R. 1983. The Influence of Correlated Random Road Excitation Processes on Vehicle Vibration. In *Proceedings of the 8th IAVSD Symposium on the Dynamics of Vehicles on Roads and Railway Tracks*, pages 449–459.

Green, M. and D. J. Limebeer 1995. *Linear Robust Control*. Prentice-Hall.

Haykin, S. S. 1994. *Neural Networks : A Comprehensive Foundation*. Maxwell Macmillan International, New York.

Hedrick, J. K., D. H. McMahon, and D. Swaroop 1993. Vehicle Modeling and Control for Automated Highway Systems. Technical report, University of California, Berkeley. UCB ITS PRR 93-24.

Hornik, K., M. Stinchcombe, and H. White 1989. Multilayer Feedforward Networks are Universal Approximators. *Neural Networks*, Vol. 2.

Jacobson, D. H. 1971. Totally Singular Quadratic Optimization Problems. *IEEE Transactions on Automatic Control*, Vol. AC-16, No. 6:651–658.

Jones, H. L. 1973. *Failure Detection in Linear Systems.* PhD thesis, Department of Aeronautics and Astronautics, Massachusetts Institute of Technology, Cambridge, MA.

Kučera, V. 1972. A Contribution to Matrix Quadratic Equations. *IEEE Transactions on Automatic Control*, Vol. AC-17, No. 6:344–347.

Kwakernaak, H. and R. Sivan 1972. The Maximally Achievable Accuracy of Linear Optimal Regulators and Linear Optimal Filters. *IEEE Transactions on Automatic Control*, Vol. AC-17, No. 1:79–86.

Lee, G. H. 1994. *Least-Squares and Minimax Methods for Filtering, Identification and Detection.* PhD thesis, University of California, Los Angeles.

Lippmann, R. P. 1987. An Introduction to Computing with Neural Nets. *IEEE ASSP Magazine*, Vol. 4:4–22.

Lukowski, S. A., M. L. Chu, D. R. Tener, and P. W. Claar II 1990. Open-Loop, Fixed-Control Simulation of a Vehicle Undergoing Steering and Acceleration Maneuvers. pages 1–12. SAE. Paper 901658.

Lukowski, S. A. and L. Medeksza 1992. Vehicle Cornering Behavior Analysis Using a General Purpose Simulation Methodology. *Total Vehicle Dynamics*, Vol. 1:49–54.

Mangoubi, R. S., B. D. Appleby, and G. C. Verghese 1994. Stochastic Interpretation of $\mathcal{H}_\infty$ and Robust Estimation. In *Proceedings of the 33rd Conference on Decision and Control*, pages 3943–3948. IEEE.

Massoumnia, M.-A. 1986. A Geometric Approach to the Synthesis of Failure Detection Filters. *IEEE Transactions on Automatic Control*, Vol. AC-31, No. 9:839–846.

Massoumnia, M.-A., G. C. Verghese, and A. S. Willsky 1989. Failure Detection and Identification. *IEEE Transactions on Automatic Control*, Vol. AC-34, No. 3:316–321.

Moore, B. C. 1981. Principal Component Analysis in Linear Systems: Controllability, Observability, and Model Reduction. *IEEE Transactions on Automatic Control*, Vol. AC-26, No. 1.

Moore, B. C. and A. J. Laub 1978. Computation of Supremal (A, B)-Invariant and Controllability Subspaces. *IEEE Transactions on Automatic Control*, Vol. AC-23, No. 5.

Morgan, N. and H. Bourlard 1995. Continuous Speech Recognition. *IEEE Signal Processing Magazine*, Vol. 5:25–40.

Morse, A. S. 1973. Structural Invariants of Linear Multivariable Systems. *SIAM Journal of Control*, Vol. 11, No. 3:446–465.

Moylan, P. J. and J. B. Moore 1971. Generalizations of Singular Optimal Control Theory. *Automatica*, Vol. 7:591–598.

Nguyen, T. M. 1996. Modeling and Simulation of Road Vehicles. Master's thesis, Department of Mechanical and Aerospace Engineering, University of California, Los Angeles, CA.

Nikiforov, I. V. 1995. A Generalized Change Detection Algorithm. *IEEE Transactions on Information Theory*, Vol. 41, No. 1:171 - 187.

Oshman, Y. and I. Y. Bar-Itzhack 1985. Eigenfactor Solution of the Matrix Riccati Equation - A Continuous Square Root Algorithm. *IEEE Transactions on Automatic Control*, Vol. AC-30, No. 10:971–978.

Pacejka, H. B. and E. Bakker 1991. The Magic Formula Tyre Model: Tyre Models for Vehicle Dynamics Analysis. In *Proceedings of the 1st International Colloquium on Tyre Models for Vehicle Dynamics Analysis*, pages 1–18.

Peng, H. 1992. *Vehicle Lateral Control for Highway Automation.* PhD thesis, Department of Mechanical Engineering, University of California, Berkeley, CA.

Rhee, I. and J. L. Speyer 1991. A Game Theoretic Approach to a Finite-Time Disturbance Attenuation Problem. *IEEE Transactions on Automatic Control*, Vol. AC-36, No. 9:1021–1032.

Richard, M. D. and R. P. Lippmann 1991. Neural Network Classifiers Estimate Bayesian Aposteriori Probabilities. *Neural Computation*, Vol. 3:461–483.

Robson, J. D. 1980. Road Surface Description and Vehicle Response. *Int. Journal of Vehicle Design*, Vol. 1, No. 1:25–35.

Schumacher, J. C. 1983. The Role of the Dissapation Matrix in Singular Optimal Control. *System and Control Letters*, Vol. 2, No. 3:262–266.

Shiryayev, A. N. 1977. *Optimal Stopping Rules.* Springer-Verlag, New York.

Smith, D. E. and J. M. Starkey 1992. Effects of Model Complexity on the Performance of Automated Vehicle Steering Controllers: Model Development, Validation, and Comparison. *Vehicle System Dynamics*, Vol. 24:163–181.

Speyer, J. L. and J. E. White 1984. Shiryayev Sequential Probability Ratio Test for Redundancy Management. *AIAA Journal of Guidance, Control, and Dynamics*, Vol. 7, No. 5:588 – 595.

Veillette, R. J., J. V. Medanić, and W. R. Perkins 1992. Design of Reliable Control Systems. *IEEE Transactions on Automatic Control*, Vol. AC-37, No. 3:290–304.

White, J. E. and J. L. Speyer 1987. Detection Filter Design: Spectral Theory and Algorithms. *IEEE Transactions on Automatic Control*, Vol. AC-32, No. 7:593–603.

Willems, J. C. 1971. Least-Squares Stationary Optimal Control and the Algebraic Riccati Equation. *IEEE Transactions on Automatic Control*, Vol. AC-16, No. 6:621–634.

Willems, J. C. 1982. Almost Invariant Subspaces: An Approach to High Gain Feedback Design – Part II: Almost Conditionally Invariant Subspaces. *IEEE Transactions on Automatic Control*, Vol. AC-27, No. 5:1071–1085.

Willumeit, H. P., M. Necular, A. Vikas, and A. Wohler 1992. Mathematical Models for the Computation of Vehicle Dynamic Behavior During Development. *Total Vehicle Dynamics*, Vol. 1:41–48.

Wonham, W. M. 1985. *Linear Multivariable Control: A Geometric Approach.* Springer-Verlag, New York, 3rd edition.

Yaesh, I. and U. Shaked 1993. Game Theory Approach to Finite-Time Horizon Optimal Estimation. *IEEE Transactions on Automatic Control*, Vol. 38, No. 6:957–963.

Yip, C. K., D. N. Crolla, and D. N. L. Horton 1992. The Influence of Aerodynamic Effects on Car Handling. *Total Vehicle Dynamics*, Vol. 1:11–23.