Chapter 4

Examples

Identification of a reduced order controller for an active suspension

The discrete time identified model of the active suspension at the sampling frequency of fs= 800 Hz is contained in the file mods.mat. The orders of the model are nA=6, nB=8 d=0 (the delay is contained in B) :

A =

1.0000 -1.6184 1.6617 -1.8469 1.6278 -1.3491 0.7239

B =

0 0 0 0 -0.3149 2.8144 -2.5972 -1.9891 2.0869

The model feature a double derivator behaviour and has three vibration modes.

The nominal robust controller (file reg0.mat) contains a fixed part $H_R = 1 + q^{-1}$. Its complexity is nR=11 and nS=13. For a standard pole placement, by solving the Bezout equation (with H_R), the resulting controller will have the orders : nR=5, nS=7 (but not robustness can be directly assured).

R =

Columns 1 through 7

0.0803 0.2609 0.4962 0.7528 0.9763 1.0760 1.0087

Columns 8 through 12

```
   0.8360    0.5846    0.3350    0.1701    0.0555
S =

  Columns 1 through 7

   1.0000    2.1288    2.4944    2.8160    2.8554    2.0158    0.9458

  Columns 8 through 14

  -0.0408   -1.0447   -1.5059   -1.3851   -1.1084   -0.6337   -0.1600
```

To reduce the complexity of the controller we will use simulated data generated by the feedback connection of the plant model and the nominal controller. The external input is a PRBS generated by a 10-bit shift register with a clock frequency of fs/4. (file excs.mat)

One uses the function :

» [Rt,St,Table]=cor(r,B,A,R,S,[1 1],1,0.00125)

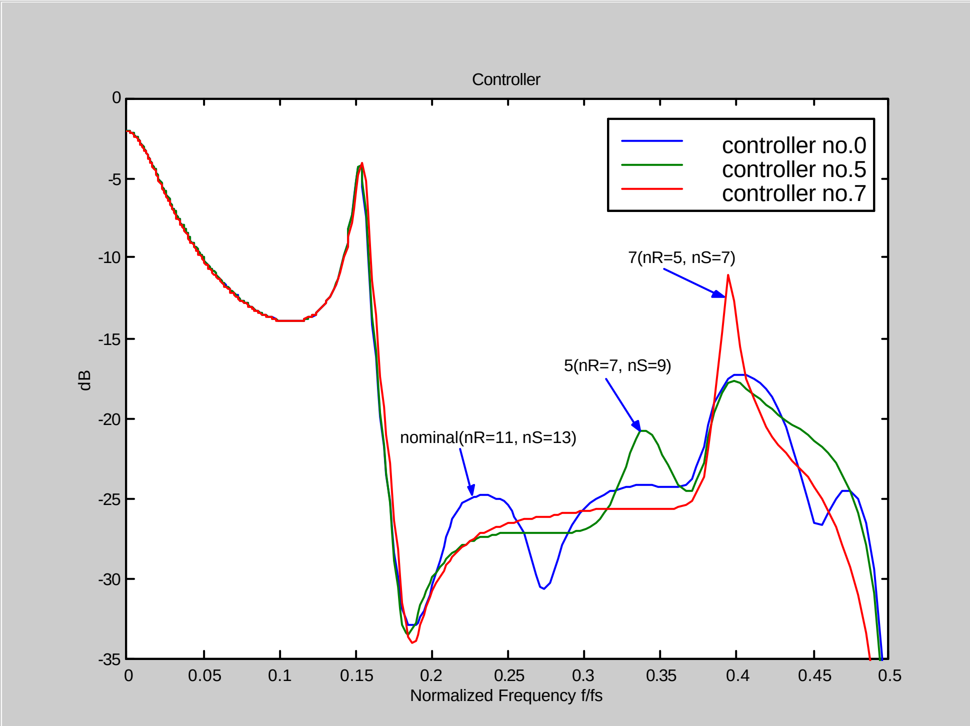
This function itself uses conid with the default values. The results are summarized in the following table. The No. 0 corresponds to the nominal controller and the other numbers in the first column correspond to the various reduced order controller obtained for various nR and nS. All the controllers up to no. 7 can be used. The Vgap with respect to the nominal controller characteristics and nominal sensitivity functions remain small. No. 5 and no.7 have been selected. No;5 still verifies the Vinnicombe stability criterion (sufficient condition) and No.7 has the complexity of the pole placement design.

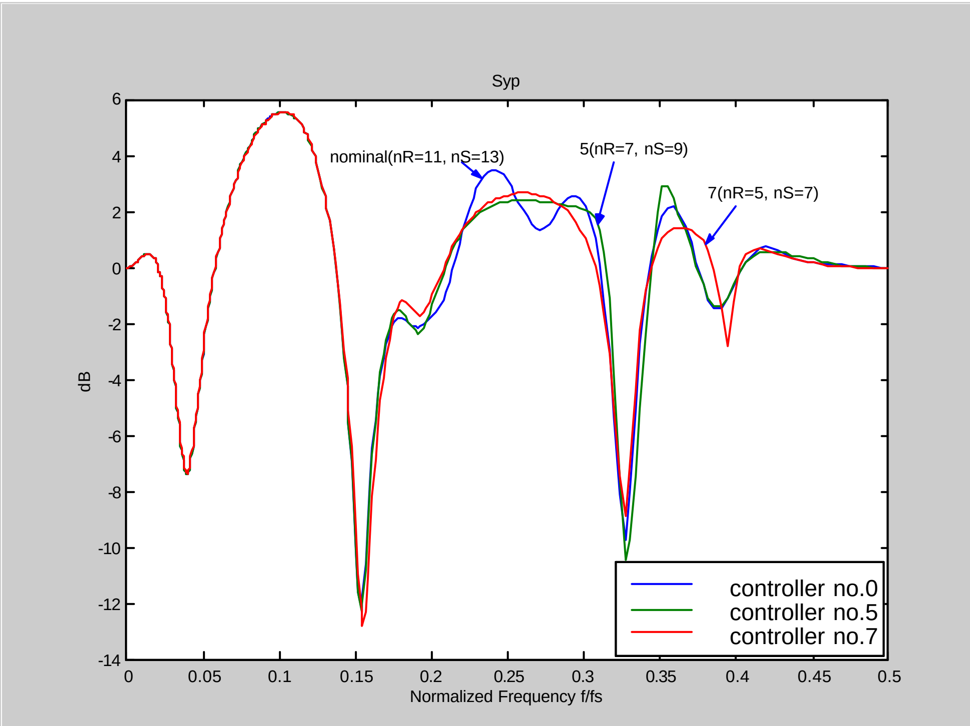
No.	nR	nS	Vg(R/S)	Vg(Sup)	Vg(Syp)	St-margin	Max(Syp)[fmax]	stable
0	11	13	0.0000	0.0000	0.0000	0.0756	5.55[81.90]	1
1	11	13	0.0352	0.0336	0.0707	0.0763	5.56[81.90]	1
2	10	12	0.0362	0.0334	0.0678	0.0826	5.56[81.90]	1
3	9	11	0.0365	0.0586	0.1578	0.0645	5.56[81.90]	1
4	8	10	0.0441	0.0451	0.0838	0.0849	5.56[81.90]	1
5	7	9	0.0390	0.0414	0.1221	0.0692	5.55[81.90]	1
6	6	8	0.3349	0.0708	0.2239	0.0552	5.62[81.90]	1
7	5	7	0.1873	0.1353	0.1191	0.0719	5.55[81.90]	1
8	4	6	1.0000	1.0000	1.0000	0.0000	20.74[167.46]	0
9	3	5	0.9566	1.0000	0.9843	0.0000	6.38[170.97]	0
10	2	4	0.4587	1.0000	1.0000	0.0000	6.51[86.26]	0
11	1	3	0.4240	0.3787	0.3685	0.0550	9.60[77.77]	1
12	1	2	0.4132	0.3421	0.5279	0.0307	11.79[176.37]	1
13	1	1	0.4446	0.1961	0.3991	0.0491	8.71[181.94]	1
14	1	0	0.5359	0.5124	0.5915	0.0836	6.30[201.81]	1

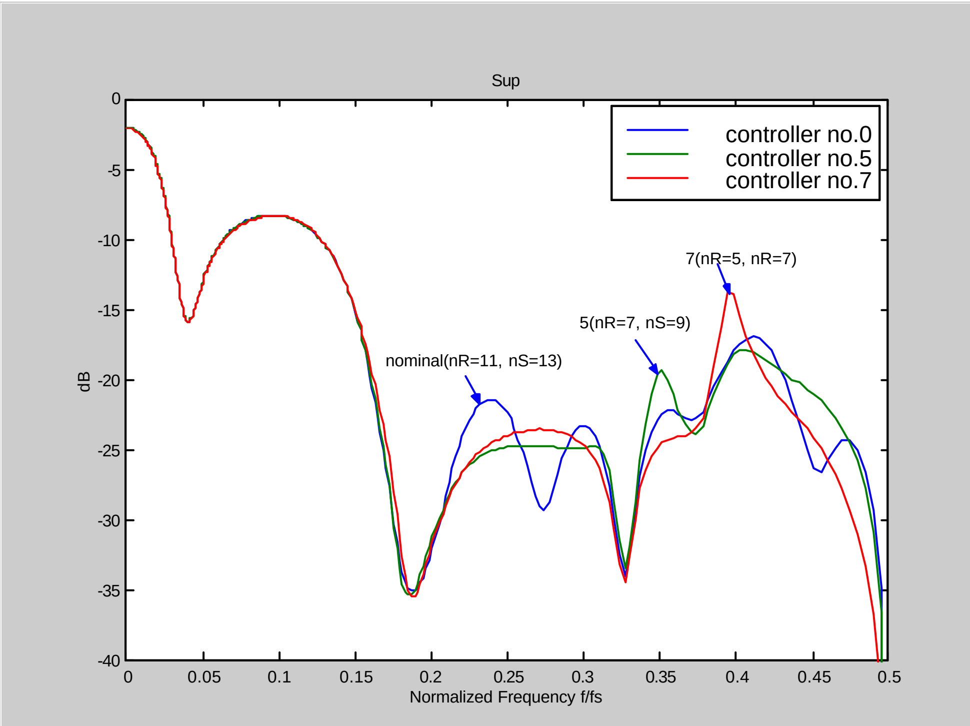
The characteristics of the various controllers can be compared by using compcon function.

compcon(B,A,Rt,St,[0,5,7])

The following figures show a comparison of the frequency characteristics of the various controllers (0,5,7) and the achieved output sensitivity and input sensitivity functions. One can observe that the characteristics of the reduced order controllers is very close to those of the nominal controller, particularly in the low frequencies up to 0.25 fs. Note that the PRBS used enhances the frequencies below 0.25fs.


Controller
controller no.0
controller no.5
controller no.7
7(nR=5, nS=7)
5(nR=7, nS=9)
nominal(nR=11, nS=13)
dB
0
-5
-10
-15
-20
-25
-30
-35
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
Normalized Frequency f/fs


Syp
nominal(nR=11, nS=13)
5(nR=7, nS=9)
7(nR=5, nS=7)
controller no.0
controller no.5
controller no.7
dB
Normalized Frequency f/fs
6
4
2
0
-2
-4
-6
-8
-10
-12
-14
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5


Sup
controller no.0
controller no.5
controller no.7
7(nR=5, nR=7)
5(nR=7, nS=9)
nominal(nR=11, nS=13)
dB
Normalized Frequency f/fs
0
-5
-10
-15
-20
-25
-30
-35
-40
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5