

# Лабораторная работа №9

## Задание 4

```
A = [2 0 -4 2;  
0 2 -2 4;  
-4 -2 2 0;  
2 4 0 2]
```

```
A = 4x4  
    2     0    -4     2  
    0     2    -2     4  
   -4    -2     2     0  
    2     4     0     2
```

```
B = [2; 4; 6; 8]
```

```
B = 4x1  
    2  
    4  
    6  
    8
```

```
C = [-2 2 2 2;  
2 0 0 2]
```

```
C = 2x4  
   -2     2     2     2  
    2     0     0     2
```

Определяем собственные числа

```
eig(A)
```

```
ans = 4x1  
   -4.0000  
   -0.0000  
    4.0000  
    8.0000
```

Выберем различные значения желаемой степени устойчивости  $\alpha$

```
a_1 = 4
```

```
a_1 = 4
```

```
a_2 = 2
```

```
a_2 = 2
```

```
a_3 = 0.05
```

```
a_3 = 0.0500
```

Далее решаем неравенства Ляпунова

```
x_0 = [1; 1; 1; 1]
```

```
x_0 = 4x1
```

```
1
1
1
1
```

```
%m = 25
```

```
cvx_begin sdp
variable Q(4, 4)
variable Y(4, 2)
variable P(4, 4)
variable Y1(1, 4)
variable m
minimize m
Q > 0.00001*eye(4);
```

Warning: The use of strict inequalities in CVX is strongly discouraged, because solvers treat them as non-strict inequalities. Please consider using ">=" instead.

Warning: This linear matrix inequality appears to be unsymmetric. This is very likely an error that will produce unexpected results. Please check the LMI; and, if necessary, re-enter the model.

```
P > 0.00001*eye(4);
```

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```
A'*Q + Q*A + 2*a_1*Q + C'*Y'+Y*C <= 0;
```

Warning: This linear matrix inequality appears to be unsymmetric. This is very likely an error that will produce unexpected results. Please check the LMI; and, if necessary, re-enter the model.

```
P*A' + A*P + 2*a_1*P + Y1'*B' + B*Y1 <= 0;
```

Warning: This linear matrix inequality appears to be unsymmetric. This is very likely an error that will produce unexpected results. Please check the LMI; and, if necessary, re-enter the model.

```
%[P x_0;
%   x_0' 1] > 0;
%[P Y1';
%   Y1 m] > 0;
cvx_end
```

Calling SDPT3 4.0: 49 variables, 16 equality constraints

```
-----
num. of constraints = 16
dim. of sdp   var = 16,   num. of sdp blk = 4
dim. of free  var = 9 *** convert ublk to lblk
*****
SDPT3: Infeasible path-following algorithms
*****
```

```

version predcorr gam expon scale_data
HKM      1      0.000 1      0
it pstep dstep pinfeas dinfeas gap      prim-obj      dual-obj      cputime
-----
0|0.000|0.000|4.1e+02|1.8e+02|3.5e+04| 7.518963e-11 0.000000e+00| 0:0:00| chol 1 1
1|0.921|0.848|3.2e+01|2.7e+01|1.5e+03|-6.608881e-01 6.257316e-04| 0:0:00| chol 1 1
2|0.802|0.780|6.4e+00|5.9e+00|2.2e+02|-1.545705e+00 9.275532e-04| 0:0:00| chol 1 1
3|0.942|0.678|3.7e-01|1.9e+00|6.2e+01|-4.210807e+00 7.431312e-04| 0:0:00| chol 1 1
4|0.534|0.076|1.7e-01|2.3e+00|1.9e+02|-3.395275e+02 8.934701e-04| 0:0:00| chol 1 2
5|0.248|0.217|1.3e-01|1.8e+00|1.2e+02|-1.773911e+03 2.042671e-03| 0:0:00| chol 1 2
6|0.694|0.022|4.0e-02|2.3e+00|6.3e+05|-2.083650e+06 2.132149e-03| 0:0:00| chol 1 2
7|0.001|0.001|4.0e-02|2.8e+00|1.3e+06|-2.105299e+06 1.439026e-02| 0:0:00| chol 1 2
8|0.977|0.005|9.2e-04|3.3e+00|1.3e+07|-1.466281e+07 5.522844e-03| 0:0:00| chol
  linsysolve: Schur complement matrix not positive definite
  switch to LU factor. lu 2 11
9|0.000|0.145|9.1e-04|3.4e+00|1.4e+07|-1.466309e+07 1.553156e-02| 0:0:00| lu 2 14
10|1.000|0.225|1.9e-03|2.6e+00|3.3e+07|-6.410700e+07 9.928620e-03| 0:0:00| lu 2 1
11|0.458|0.149|1.1e-03|2.7e+00|1.8e+08|-3.088970e+08 9.483588e-03| 0:0:00| lu 2 1
12|1.000|0.196|1.6e-03|2.7e+00|1.4e+09|-2.375785e+09 1.075413e-02| 0:0:00| lu 3 3
13|1.000|0.118|1.8e-02|2.9e+00|1.3e+10|-1.852470e+10 1.011102e-02| 0:0:00| lu 3 2
14|1.000|0.207|1.4e-01|2.3e+00|3.9e+10|-1.143547e+11 1.193153e-02| 0:0:00| lu 4 6
15|1.000|0.149|2.3e+00|2.5e+00|8.2e+11|-1.874693e+12 8.304746e-03| 0:0:00| lu 4 ^ 6
16|1.000|0.121|4.0e+01|2.7e+00|1.2e+13|-2.074551e+13 1.139003e-02| 0:0:00| lu * 4 5
17|1.000|0.094|2.0e+02|3.0e+00|1.2e+14|-1.623851e+14 1.027419e-02| 0:0:00| lu * 4 4
18|1.000|0.207|1.7e+03|2.4e+00|3.5e+14|-9.433070e+14 1.195604e-02| 0:0:00| lu * 5 7
19|1.000|0.172|3.1e+03|2.5e+00|5.9e+15|-1.373815e+16 7.947876e-03| 0:0:00| lu * 6 ^16
  stop: primal infeas has deteriorated too much, 4.4e+05
20|1.000|0.133|3.1e+03|2.5e+00|5.9e+15|-1.373815e+16 7.947876e-03| 0:0:00|
  prim_inf,dual_inf,relgap = 3.06e+03, 2.50e+00, 4.28e-01
  sqlp stop: dual problem is suspected of being infeasible
-----
number of iterations      = 20
residual of dual infeasibility
certificate X              = 1.72e+00
reldist to infeas.        <= 2.54e-02
Total CPU time (secs)     = 0.41
CPU time per iteration    = 0.02
termination code          = 2
DIMACS: 1.3e-01  0.0e+00  2.2e+00  0.0e+00  -1.0e+00  6.7e-02
-----

-----
Status: Unbounded
Optimal value (cvx_optval): -Inf

```

```
%m
```

И находим матрицу регулятора K:

```
K = Y1*inv(P)
```

```
K = 1x4
    -374.4557   -34.1858   287.9065  -125.1188
```

```
L = inv(Q)*Y
```

```
L = 4x2
    1.3552   -5.5598
   -1.3552  -16.1896
   -1.3552   16.1932
   -1.3552   -5.5560
```

Далее определим корни матрицы  $A+BK$ :

```
LC = eig(A+L*C)
```

```
LC = 4×1 complex  
-7.1158 +10.9317i  
-7.1158 -10.9317i  
-6.8414 + 0.0000i  
-4.0000 + 0.0000i
```

```
BK = eig(A+B*K)
```

```
BK = 4×1  
-121.6831  
-17.9305  
-7.2350  
-4.3174
```