

# 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 = 7
```

```
a_1 = 7
```

```
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
```

Warning: A non-empty cvx problem already exists in this scope.  
It is being overwritten.

```
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);
```

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.

```
A'*Q + Q*A + 2*a_3*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_3*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|2.2e+02|1.8e+02|3.4e+04| 7.518963e-11  0.000000e+00| 0:0:00| chol 1 1
1|0.920|0.829|1.7e+01|3.0e+01|1.6e+03| -6.605426e-01  4.255683e-04| 0:0:00| chol 1 1
2|0.667|0.794|5.7e+00|6.3e+00|1.9e+02| -1.307982e+00  5.200482e-04| 0:0:00| chol 1 1
3|1.000|0.694|6.8e-06|1.9e+00|5.1e+01| -3.637220e+00  3.999049e-04| 0:0:00| chol 1 1
4|1.000|0.081|1.7e-05|2.3e+00|2.3e+02| -4.917615e+02  3.717921e-04| 0:0:00| chol 1 1
5|1.000|0.217|1.5e-07|1.8e+00|3.5e+02| -8.838079e+03  3.294473e-04| 0:0:00| chol 1 1
6|1.000|0.022|1.0e-07|2.3e+00|4.5e+06| -1.492354e+07  3.260540e-04| 0:0:00| chol 1 1
7|1.000|0.001|4.6e-04|2.8e+00|1.7e+08| -2.769173e+08  6.423307e-04| 0:0:00| chol 1 1
8|1.000|0.204|6.0e-07|2.2e+00|5.7e+08| -1.963723e+09  2.240388e-04| 0:0:00| chol 1 1
9|0.103|0.070|1.6e-05|2.6e+00|3.0e+09| -6.089015e+09  3.380357e-04| 0:0:00| chol 1 1
10|1.000|0.095|1.1e-04|2.9e+00|3.7e+10| -5.698520e+10  5.793170e-04| 0:0:00| chol 2 1
11|0.133|0.082|1.8e-04|3.2e+00|8.1e+10| -9.896926e+10  5.220880e-04| 0:0:00| chol 2 1
12|1.000|0.138|2.2e-04|3.3e+00|4.4e+11| -4.948669e+11  5.914993e-04| 0:0:00| chol 2 2
13|1.000|0.170|5.1e-04|3.2e+00|2.0e+12| -2.319234e+12  5.554529e-04| 0:0:00| chol 2 2
14|1.000|0.274|9.3e-03|2.3e+00|4.0e+12| -1.110039e+13  4.190935e-04| 0:0:00| chol 2 2
15|0.856|0.139|4.4e-02|2.5e+00|6.9e+13| -1.500957e+14  4.483396e-04| 0:0:00| chol 2 2
16|1.000|0.095|9.5e-02|2.8e+00|9.7e+14| -1.549375e+15  4.500345e-04| 0:0:00| chol 2 2
stop: primal infeas has deteriorated too much, 7.6e+00
17|1.000|0.117|9.5e-02|2.8e+00|9.7e+14| -1.549375e+15  4.500345e-04| 0:0:00|
prim_inf,dual_inf,relgap = 9.49e-02, 2.83e+00, 6.23e-01
sqlp stop: dual problem is suspected of being infeasible
-----

number of iterations      = 17
residual of dual infeasibility
certificate X              = 1.07e-05
reldist to infeas.        <= 1.98e-07
Total CPU time (secs)     = 0.36
CPU time per iteration    = 0.02
termination code          = 2
DIMACS: 1.5e-07  0.0e+00  2.2e+00  0.0e+00  -1.0e+00  3.9e-02
-----

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

```

%m

И находим матрицу регулятора K:

$K = Y1 \cdot \text{inv}(P)$

$K = 1 \times 4$   
 -10.8399   -5.0097   10.8711   -5.5545

$L = \text{inv}(Q) \cdot Y$

$L = 4 \times 2$   
 0.7691   -2.5809  
 -0.7691   -5.1949  
 -0.7691   5.1949  
 -0.7691   -2.5809

Далее определим корни матрицы  $A+BK$ :

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

```
LC = 4x1 complex  
-1.1617 + 6.3620i  
-1.1617 - 6.3620i  
-4.0000 + 0.0000i  
-2.1524 + 0.0000i
```

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

```
BK = 4x1 complex  
-4.5354 + 9.9871i  
-4.5354 - 9.9871i  
-0.4862 + 0.0000i  
-3.3708 + 0.0000i
```