

# Лабораторная работа №9

## Задание 2

```
A = [-7 0 0 0;  
0 3 0 0;  
0 0 2 7;  
0 0 -7 2]
```

```
A = 4x4  
-7    0    0    0  
 0    3    0    0  
 0    0    2    7  
 0    0   -7    2
```

```
B = [0; 7; 0; 6]
```

```
B = 4x1  
 0  
 7  
 0  
 6
```

Определяем собственные числа

```
eig(A)
```

```
ans = 4x1 complex  
 2.0000 + 7.0000i  
 2.0000 - 7.0000i  
-7.0000 + 0.0000i  
 3.0000 + 0.0000i
```

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 = 100
```

```
m = 100
```

```

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);
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;
P*A' + A*P + 2*a_2*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;

```

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 Y1';
 Y1 m] > 0;

```

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.

```

cvx_end

```

Calling SDPT3 4.0: 74 variables, 47 equality constraints

```

-----
num. of constraints = 47
dim. of sdp   var = 18,   num. of sdp blk = 4
dim. of free  var = 24 *** convert ublk to lblk
number of nearly dependent constraints = 4
To remove these constraints, re-run sqlp.m with OPTIONS.rmdepconstr = 1.
*****
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|7.7e+01|3.4e+02|1.1e+07| 0.000000e+00  0.000000e+00| 0:0:00| chol  1  1
1|0.093|0.156|6.9e+01|2.9e+02|2.2e+06| 0.000000e+00 -4.386439e+03| 0:0:00| chol  1  1
2|0.501|0.292|3.5e+01|2.0e+02|5.6e+05| 0.000000e+00 -1.486136e+04| 0:0:01| chol  1  1
3|0.968|0.972|1.1e+00|5.7e+00|1.7e+04| 0.000000e+00 -9.334578e+03| 0:0:01| chol  1  1
4|0.962|0.919|4.1e-02|5.2e-01|1.5e+03| 0.000000e+00 -1.200100e+03| 0:0:01| chol  1  1
5|1.000|0.904|2.2e-06|7.7e-02|1.9e+02| 0.000000e+00 -1.350046e+02| 0:0:01| chol  1  1
6|1.000|0.967|5.0e-07|1.8e-02|1.2e+01| 0.000000e+00 -3.096473e+00| 0:0:01| chol  1  1
7|1.000|0.879|7.7e-08|6.2e-03|2.3e+00| 0.000000e+00 -3.650566e-01| 0:0:01| chol  1  1
8|1.000|0.874|1.5e-08|2.0e-03|4.3e-01| 0.000000e+00 -6.143678e-04| 0:0:01| chol  1  1
9|1.000|1.000|2.5e-09|4.2e-04|7.0e-02| 0.000000e+00 -3.761272e-03| 0:0:01| chol  2  2
10|1.000|0.893|5.0e-10|1.6e-04|1.3e-02| 0.000000e+00  2.098078e-03| 0:0:01| chol  2  2
11|1.000|0.943|1.2e-10|2.1e-05|1.3e-03| 0.000000e+00  3.539040e-04| 0:0:01| chol  2  2
12|1.000|0.969|3.3e-11|7.0e-05|1.1e-04| 0.000000e+00  3.537280e-05| 0:0:01| chol  3  3
13|1.000|0.988|1.4e-11|5.9e-06|7.0e-06| 0.000000e+00  3.011120e-06| 0:0:01| chol
warning: symqmr failed: 0.3
switch to LU factor. lu 30  1
14|0.033|0.513|9.3e-11|3.7e-07|1.3e-04| 0.000000e+00 -1.277494e-04| 0:0:01| lu  3  1
15|1.000|0.981|1.7e-12|6.9e-06|4.4e-06| 0.000000e+00 -2.226808e-06| 0:0:01| lu  4  1
16|1.000|0.979|2.2e-13|2.3e-07|7.9e-08| 0.000000e+00 -5.483775e-08| 0:0:01| lu 30  1
17|1.000|0.703|3.1e-12|4.2e-09|1.5e-08| 0.000000e+00 -9.153473e-09| 0:0:01|
stop: max(relative gap, infeasibilities) < 1.49e-08
-----
number of iterations      = 17
primal objective value    = 0.00000000e+00
dual  objective value     = -9.15347274e-09
gap := trace(XZ)          = 1.46e-08
relative gap              = 1.46e-08
actual relative gap       = 9.15e-09
rel. primal infeas (scaled problem) = 3.08e-12
rel. dual      "      "      "      = 4.16e-09
rel. primal infeas (unscaled problem) = 0.00e+00
rel. dual      "      "      "      = 0.00e+00
norm(X), norm(y), norm(Z) = 2.2e+02, 1.6e+02, 3.4e-09
norm(A), norm(b), norm(C) = 3.9e+01, 1.0e+02, 1.0e+00
Total CPU time (secs)    = 0.87
CPU time per iteration   = 0.05
termination code         = 0
DIMACS: 3.1e-12  0.0e+00  4.2e-09  0.0e+00  9.2e-09  1.5e-08
-----

-----
Status: Solved
Optimal value (cvx_optval): +0

```

```
%m
```

И находим матрицу регулятора K:

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

```
K = 1x4
    0.1940    -2.2459    -2.8600     0.2203
```

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

Далее определим корни матрицы A+BK:

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

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

```
BK = 4×1 complex  
-2.3843 +10.5174i  
-2.3843 -10.5174i  
-2.6305 + 0.0000i  
-7.0000 + 0.0000i
```