

# 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 = 25
```

```
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);
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|7.6e+01|3.4e+02|2.9e+06| 0.000000e+00  0.000000e+00| 0:0:00| chol  1  1
1|0.093|0.157|6.9e+01|2.9e+02|5.6e+05| 0.000000e+00 -1.112921e+03| 0:0:00| chol  1  1
2|0.499|0.292|3.5e+01|2.0e+02|1.4e+05| 0.000000e+00 -3.749977e+03| 0:0:00| chol  1  1
3|0.959|0.971|1.4e+00|6.0e+00|4.6e+03| 0.000000e+00 -2.411783e+03| 0:0:00| chol  1  1
4|0.674|0.849|4.7e-01|9.2e-01|8.6e+02| 0.000000e+00 -5.170128e+02| 0:0:00| chol  1  1
5|0.828|0.413|8.0e-02|5.4e-01|4.7e+02| 0.000000e+00 -3.135106e+02| 0:0:00| chol  1  1
6|0.881|0.923|9.6e-03|4.3e-02|4.6e+01| 0.000000e+00 -3.565048e+01| 0:0:00| chol  1  1
7|1.000|0.961|5.7e-06|2.5e-03|3.0e+00| 0.000000e+00 -2.290694e+00| 0:0:00| chol  1  1
8|1.000|0.986|1.4e-06|1.4e-04|8.2e-02| 0.000000e+00 -2.874110e-02| 0:0:00| chol  1  1
9|1.000|0.939|1.0e-07|4.0e-05|1.1e-02| 0.000000e+00 -1.127009e-03| 0:0:00| chol  2  2
10|1.000|1.000|1.1e-08|9.9e-06|2.3e-03| 0.000000e+00 -7.446923e-04| 0:0:00| chol  2  2
11|1.000|0.942|4.6e-09|1.2e-04|4.9e-04| 0.000000e+00  5.959833e-06| 0:0:00| chol  2  2
12|1.000|0.944|9.7e-10|2.6e-05|3.9e-05| 0.000000e+00  3.856221e-06| 0:0:00| chol  3  3
13|1.000|0.988|1.7e-10|2.0e-06|6.1e-07| 0.000000e+00 -4.050674e-08| 0:0:00| chol  6  5
14|1.000|0.988|7.0e-11|3.2e-08|7.7e-09| 0.000000e+00 -1.729296e-09| 0:0:00| chol
linsysolve: Schur complement matrix not positive definite
switch to LU factor. lu 11  1
15|1.000|0.506|1.1e-11|4.1e-10|5.4e-09| 0.000000e+00 -1.22239e-09| 0:0:00|
stop: max(relative gap, infeasibilities) < 1.49e-08
-----

number of iterations      = 15
primal objective value    = 0.00000000e+00
dual objective value      = -1.2223899e-09
gap := trace(XZ)          = 5.41e-09
relative gap              = 5.41e-09
actual relative gap       = 1.22e-09
rel. primal infeas (scaled problem) = 1.09e-11
rel. dual      "      "      "      = 4.11e-10
rel. primal infeas (unscaled problem) = 0.00e+00
rel. dual      "      "      "      = 0.00e+00
norm(X), norm(y), norm(Z) = 5.0e+02, 2.6e+02, 1.3e-08
norm(A), norm(b), norm(C) = 3.9e+01, 2.6e+01, 1.0e+00
Total CPU time (secs)    = 0.34
CPU time per iteration   = 0.02
termination code         = 0
DIMACS: 1.1e-11  0.0e+00  4.1e-10  0.0e+00  1.2e-09  5.4e-09
-----

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

```

```
%m
```

И находим матрицу регулятора K:

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

```
K = 1×4
    0.0208    -1.7326    -2.2439    -0.2078
```

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

Далее определим корни матрицы A+BK:

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

```
BK = 4x1 complex  
-2.0939 + 9.5369i  
-2.0939 - 9.5369i  
-2.1875 + 0.0000i  
-7.0000 + 0.0000i
```