Practical Assignment № 2

Optimal Control

variant number : 6

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Optimal control design for LTI plant (LQR)

1. Symbol description and experimental values（Group 6）

- Symbol description

Symbol	Definition
K	feedback controller
Q, R	parameter matrices
$x(0)$	initial condition
P	auxiliary matrix
J	secondary target function

- experimental values

№	A	b	Q	r
6	$\begin{bmatrix} 0 & 1 \\ 9 & -1 \end{bmatrix}$	$\begin{bmatrix} 1 \\ 0 \end{bmatrix}$	$\begin{bmatrix} 1 & 0 \\ 0 & 2 \end{bmatrix}$	1

2. Simulate the closed-loop system with the initial conditions $x(0) = [1, 0]^T$. Plot separately the variables x_1, x_2, u and J. Calculate steady-state value J

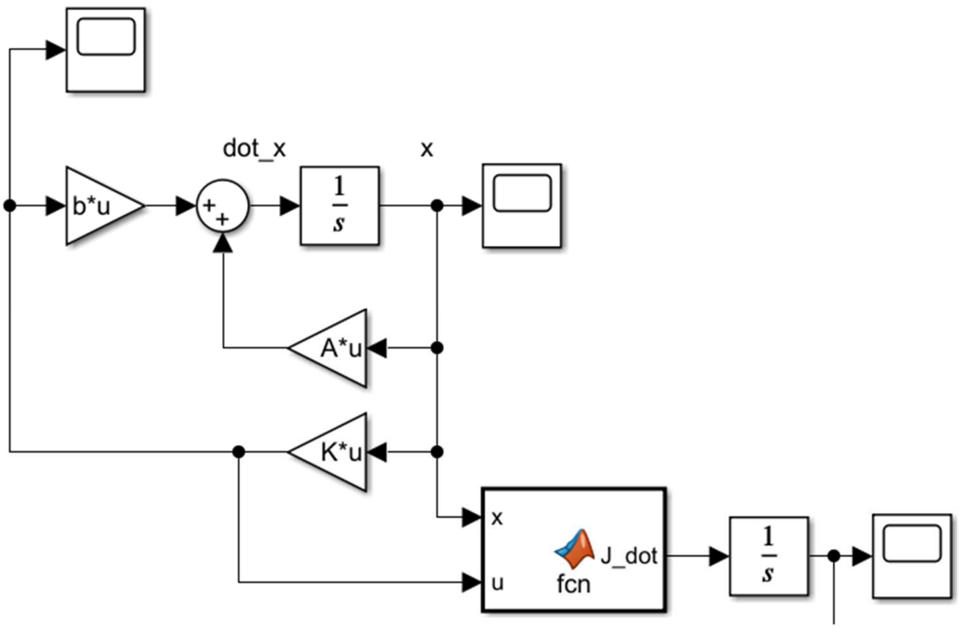
calculation MATLAB codes：

```
% LQR
clear all
A = [0 1;9 -1];
b = [1;0];
Q = [1 0;0 2];
r = 1;
[K,P] = lqr(A,b,Q,r);
J = [1 0]*P*[1;0];
```

Calculation result(steady-state value J)

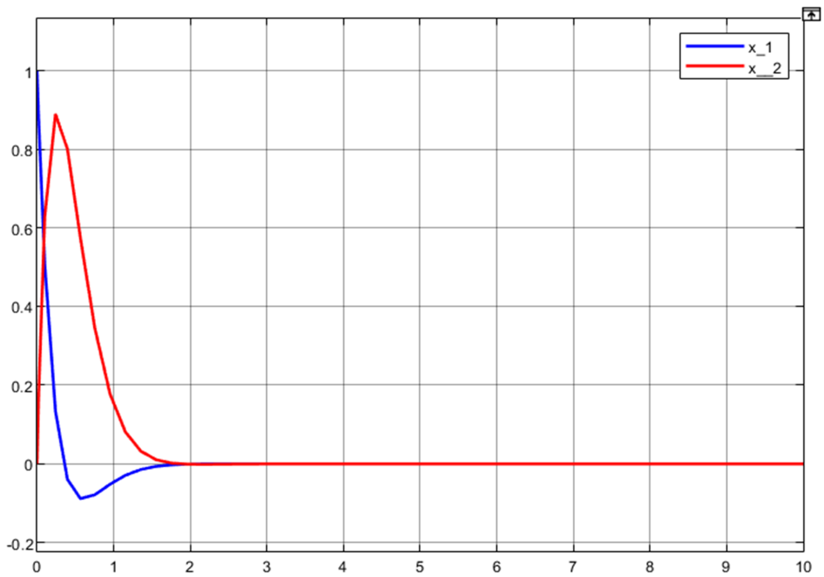
$$J \approx 6.1583$$

Simulink models

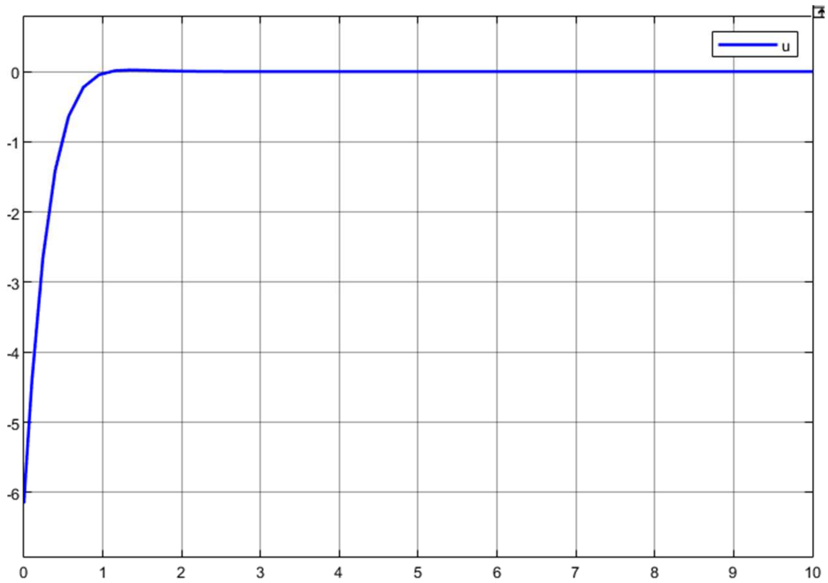


Simulink Results

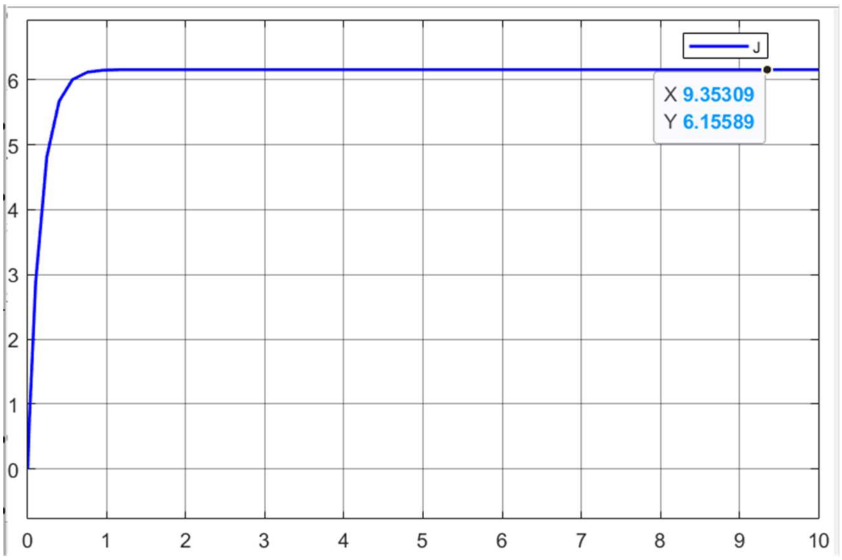
- State variables x(t)



- Control variables u(t)



- steady-state value$J \approx 6.15589$It's very close to what we calculated



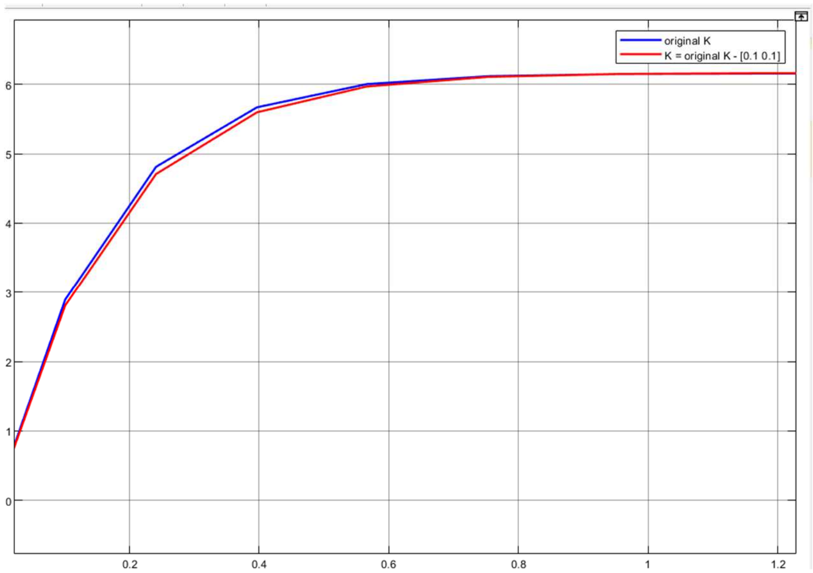
3. **Negligibly change K so that the system preserves the stability, and repeat the experiment № 2 with the same simulation time. Compare with results obtained in № 2 and make a conclusion.**

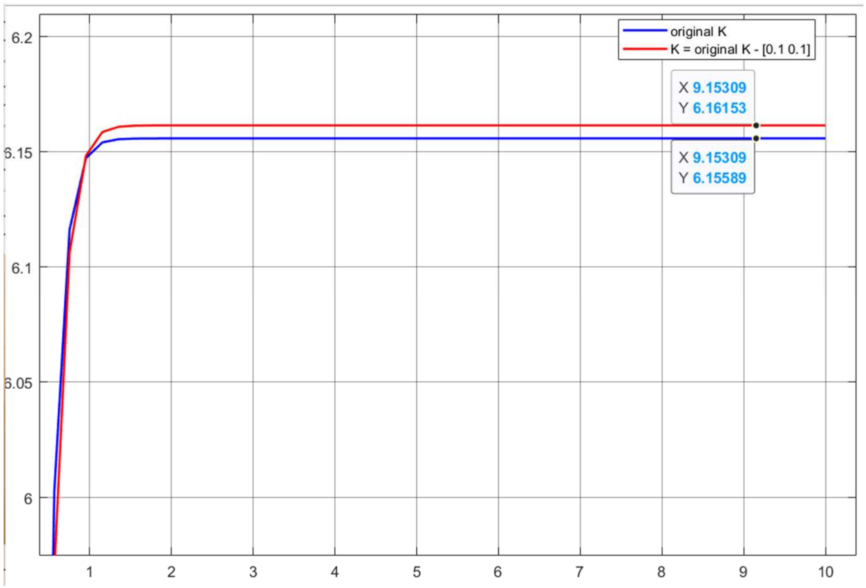
Let's change K as follows:

$$K = K - [0.1 \quad 0.1]$$

Simulation Results

- **steady-state value**





Conclusion:

From the experimental results, it can be seen that :

1. **the steady-state value J changes after a small change in the value of K, and the growth rate of J before it reaches the steady state also changes**

4. **Simulate the closed-loop system for three different coefficients r and three different matrices Q if $r > 0, Q = kQ^*, k$ is positive gain, matrix Q^* is equal to Q according the task variant. Plot the variables x_1, x_2, u and J.**

In order to test the influence of the change of R and Q on the control results, we controlled one variable and changed the other variable using the following experimental conditions:

- Group 1

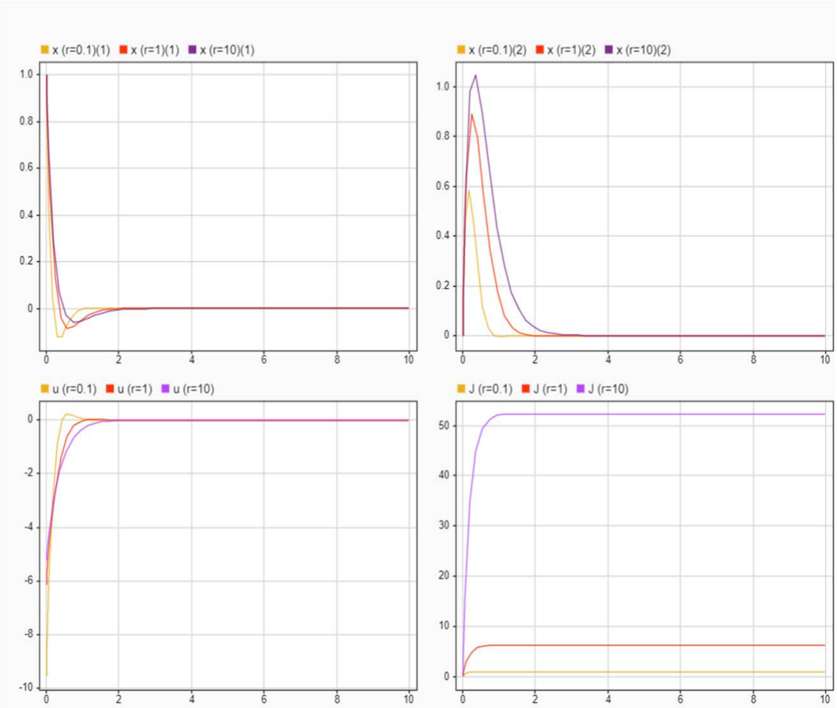
$$
\begin{aligned}
r = 0.1, Q = Q^* \\
r = 1, Q = Q^* \\
r = 10, Q = Q^*
\end{aligned}
$$

- Group 2

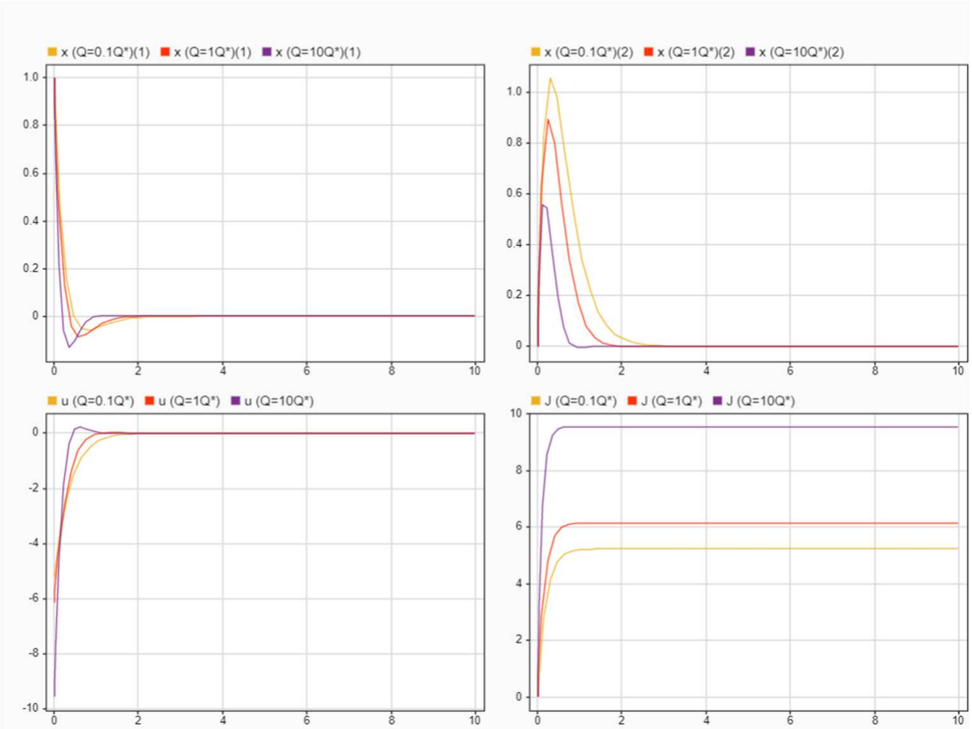
$$
\begin{aligned}
r = 1, Q = 0.1 * Q^* \\
r = 1, Q = 1 * Q^* \\
r = 1, Q = 10 * Q^*
\end{aligned}
$$

The experimental results are as follows:

- Group 1



- ## Group 2



conclusion:

From the experimental results, it can be seen that J increases with the increase of $|Q|, r$