

```

clc;clear;
close all
load S19_DTSSfit

```

## Section 2: LQR

```

q = 1;
Q = q * transpose(dtss_fit.C) * dtss_fit.C;

R = 1E-1*diag([0.9 0.8]);
G = lqr(dtss_fit,Q,R);

Fs = 20;
Ts = 1/Fs;
T = 8;
N = T / Ts;
F = Fs / N;
t = 0:Ts:T;
t = t(1:end-1);

```

## Extra Credit

```

A = dtss_fit.A;
B = dtss_fit.B;
C = dtss_fit.C;
D = dtss_fit.D;
R = 1E-4*diag([0.199, 0.352]);

% initial states
x_hat_minus = zeros(6,N);
x_hat = zeros(6,N);

% initial outputs
y = zeros(2,N);

% initial error covariance
P_minus = zeros(6,6,N);
P_minus(:,:,1) = ones(6,6);

% initial input
u = zeros(2,N);
u(:,1) = 7 * randn(2,1);

x = zeros(6,N);
for k = 2:N
    % nomial plant
    theta(:,k) = sqrt(R) * 0.1*randn(2,1);
    x(:,k) = A * x(:,k-1) + B * u(:,k-1);
    y(:,k) = C * x(:,k) - D * u(:,k) + theta(:,k);

    % Prediction
    x_hat_minus(:,k) = A * x_hat_minus(:,k-1) + B * u(:,k-1);

```

```

P_minus(:, :, k) = A * P_minus(:, :, k-1) * A'; % assume no processing noise

% Correction
K(:, :, k) = P_minus(:, :, k) * C' * inv(C * P_minus(:, :, k) * C' + R);
x_hat(:, k) = (eye(6) - K(:, :, k) * C) * x_hat_minus(:, k) + K(:, :, k) * y(:, k) - (K(:, :, k) * D) * u(:, k);
P(:, :, k) = (eye(6) - K(:, :, k) * C) * P_minus(:, :, k);

u(:, k) = - G * x_hat(:, k);
end

y_hat = C * x_hat + D * u;

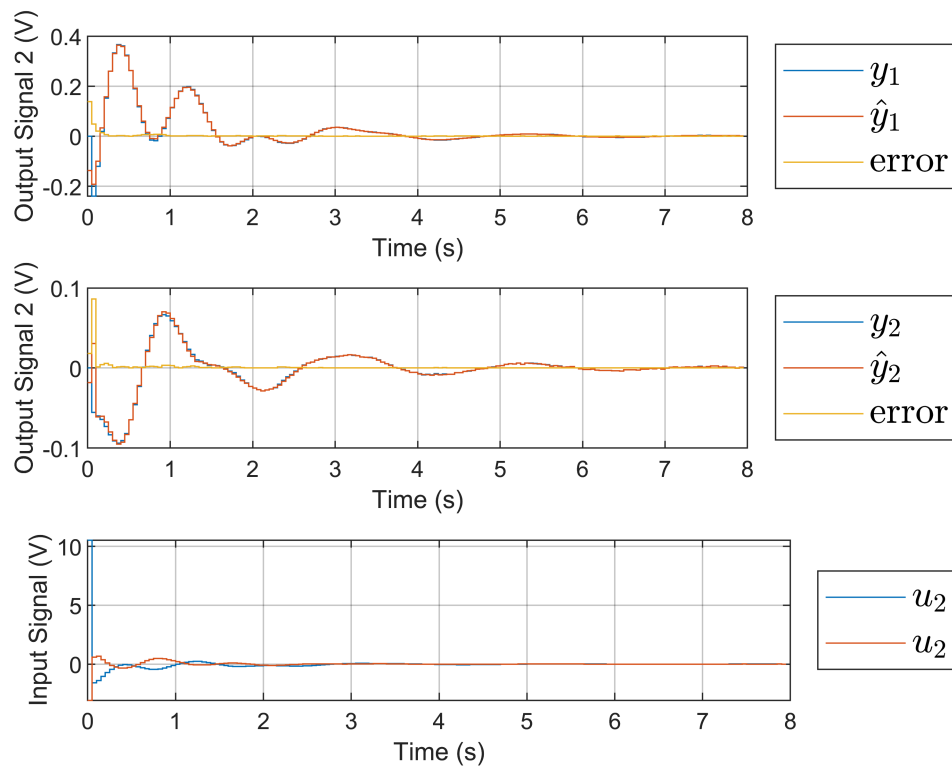
```

## Plot results

```

figure
subplot(3,1,1)
stairs(t,y(1,:))
hold on
stairs(t,y_hat(1,:))
stairs(t,abs(y_hat(1,:)-y(1,:)))
grid on
ylabel('Output Signal 2 (V)')
xlabel('Time (s)')
legend({'$y_1$', '$\hat{y}_1$', 'error'}, 'Interpreter', 'latex', 'FontSize', 14, 'Location', 'Eastoutside')
subplot(3,1,2)
stairs(t,y(2,:))
hold on
stairs(t,y_hat(2,:))
stairs(t,abs(y_hat(2,:)-y(2,:)))
grid on
ylabel('Output Signal 2 (V)')
xlabel('Time (s)')
legend({'$y_2$', '$\hat{y}_2$', 'error'}, 'Interpreter', 'latex', 'FontSize', 14, 'Location', 'Eastoutside')
subplot(3,1,3)
stairs(t,u')
ylabel('Input Signal (V)')
xlabel('Time (s)')
grid on
set(gcf, 'Color', 'white')
legend({'$u_2$', '$u_2$'}, 'Interpreter', 'latex', 'FontSize', 14, 'Location', 'Eastoutside')

```



```
figure
subplot(2,1,1)
hold on
grid on
for m = 1:2
    for p = 1:6
        plot(t,squeeze(K(p,m,:)))
    end
end
ylabel('Kalman Gains')
xlabel('Time (s)')
hold off

subplot(2,1,2)
hold on
grid on
for m = 1:6
    for p = 1:6
        plot(t,squeeze(P(p,m,:)))
    end
end
ylabel('P Matrix Element')
xlabel('Time (s)')
hold off
```

