Example 20.1: Step Response for Model Preditive Control

File: `Ch20_E01.m`

The response to a unit step input characterizes a stable linear system for Model Predictive Control (MPC). This example shows how the step response is discretized and labeled.

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```
clear all;
addpath('utilities');
```

First Order plus time-delay model

Create a first-order transfer function of the form

$$G(s) = \frac{K \exp^{-\theta s}}{\tau s + 1}$$

```
K = 5;
tau = 15;
theta = 8;

G = tf([K],[tau 1],'IOdelay',theta,'TimeUnit','minutes');
```

Step Response

The time grid is chosen long enough for the step response to approach a steady state. The sample time needs to be short enough to capture the transient behaviors.

```
dt = 5;
tpred = 80;

% Calculate Step Response

t = (dt:dt:tpred)';
S = step(G,t);

% Display Table

k = (1:length(t))';
displaytable([k,t,S],'',{'k','t(k)','S(k)'});
```

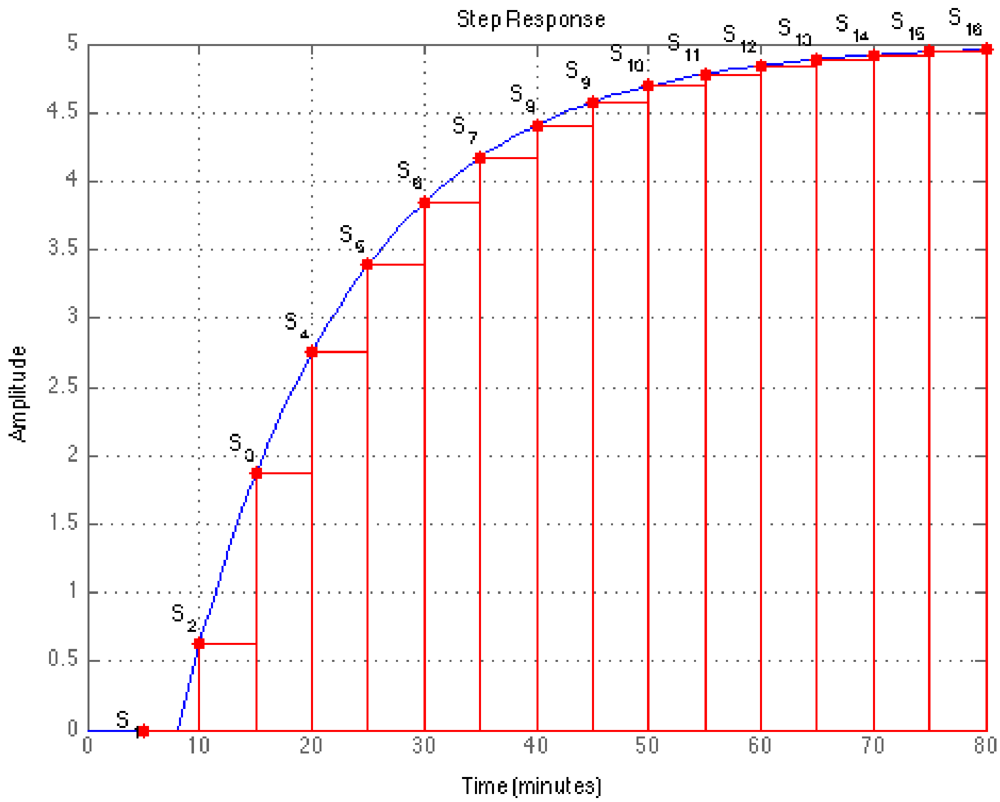
```
       k      t(k)      S(k)
```

1	5	0
2	10	0.62413
3	15	1.8646
4	20	2.7534
5	25	3.3902
6	30	3.8465
7	35	4.1735
8	40	4.4078
9	45	4.5757
10	50	4.6959
11	55	4.7821
12	60	4.8439
13	65	4.8881
14	70	4.9199
15	75	4.9426
16	80	4.9589

Step Response Plot

The Matlab `stairs` command plots the step response. This is combined with the continuous time step response to show the relationship between the continuous time response and the discretized step response.

```
figure(1);clf;
step(G,max(t));
hold on;
plot(t,S,'r.','Markersize',20);
stairs(t,S,'r');
plot([t';t'],[zeros(1,length(t));S'],'r');
plot(t,zeros(length(t),1),'r');
for k = 1:length(t)
    text(t(k),S(k)+0.15*sign(S(k)),sprintf('S_{%d}',k),'HorizontalAlignment','Right');
end
hold off;
grid;
```



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