Compute a IMC controller to ensure a settling time of the closed loop system less than 5 seconds

Compute and declare my transfer function

The transfer function has the following form:

$$H_f(s) = \frac{K_f}{s(T_f s + 1)}$$

Knowing that my values are Kf = 4 and Tf = 8, the function becomes:

$$H_f(s) = \frac{4}{s(8s + 1)}$$

I declare my transfer function in code:

```
Kf = 4;
Tf = 8;
Hf = tf(Kf,[Tf 1 0]);
```

Separate my function into good part and bad part

```
Pg = Hf; %% good part
Pb = 1; %% bad part
```

Invert the good part

```
Pg_inv = inv(Pg)
```

```
Pg_inv =

  8 s^2 + s
  ---------
      4

Continuous-time transfer function.
```

Apply a filter of order of the good part denominator

```
Pg
```

```
Pg =

      4
  ---------
```

```
  8 s^2 + s

Continuous-time transfer function.
```

```
order = 2; %% order of the good part denominator
```

Calculate starting value for lambda

```
lambda = Tf/10;
```

Calculate filter's denominator

den = $(\lambda s+1)*(\lambda s+1)=\lambda^2 s^2+2\lambda s+1$

```
filter = tf(1,[lambda^2 2*lambda 1])
```

```
filter =

           1
  --------------------
  0.64 s^2 + 1.6 s + 1

Continuous-time transfer function.
```

Calculate the equivalent controller

```
C = minreal(Pg_inv*filter)
```

```
C =

  3.125 s^2 + 0.3906 s
  --------------------
  s^2 + 2.5 s + 1.562

Continuous-time transfer function.
```

```
R = minreal(C/(1-C*Hf))
```

```
R =

  3.125 s^2 + 0.7812 s + 0.04883
  ------------------------------
      s^2 + 2.625 s + 0.3125

Continuous-time transfer function.
```

Compute the closed loop

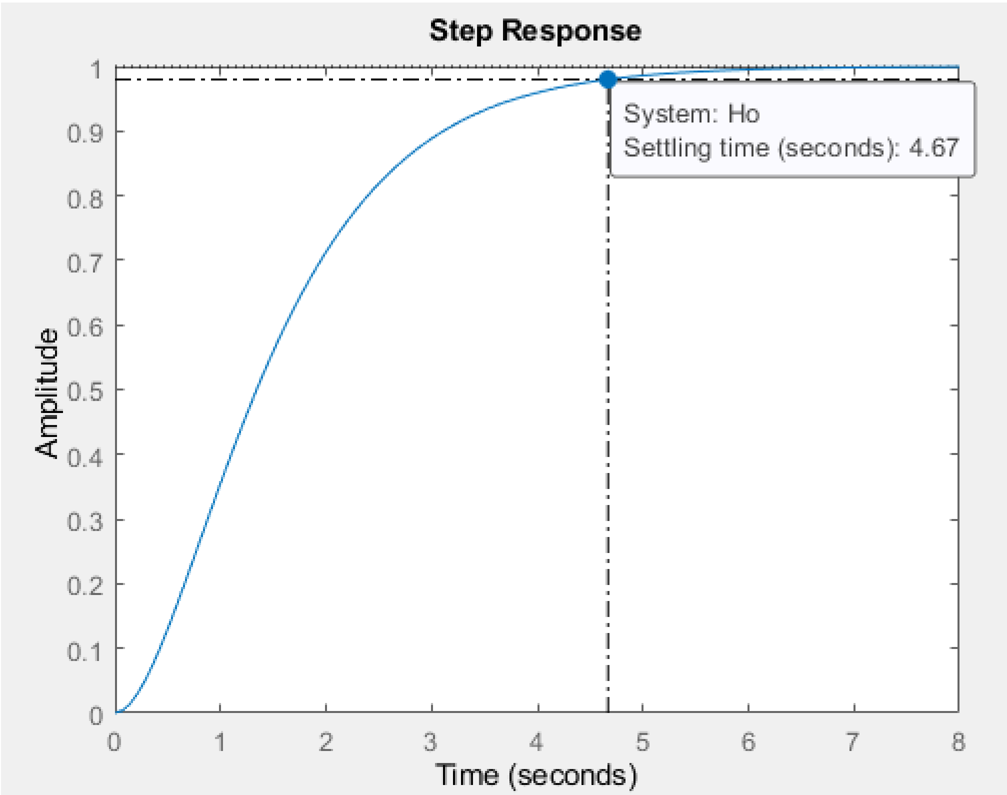
```
Ho = minreal(R*Hf/(1+R*Hf))
```

```
Ho =

        1.562 s^4 + 0.7812 s^3 + 0.1465 s^2 + 0.01221 s + 0.0003815
  ------------------------------------------------------------------------
  s^6 + 3 s^5 + 2.906 s^4 + 1.023 s^3 + 0.1663 s^2 + 0.01282 s + 0.0003815
```

```
Continuous-time transfer function.
```

```
% step(Ho)
```



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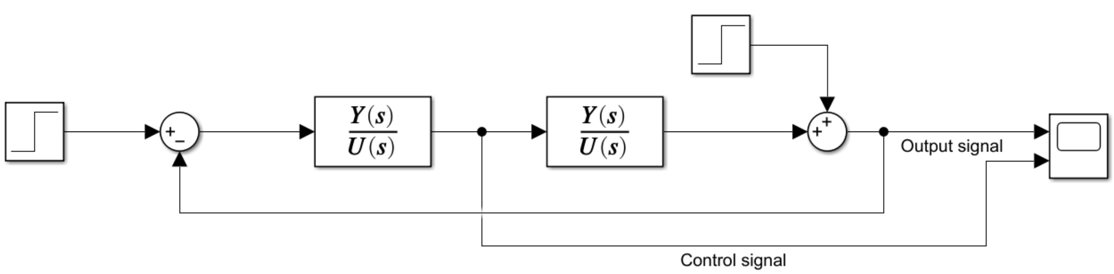
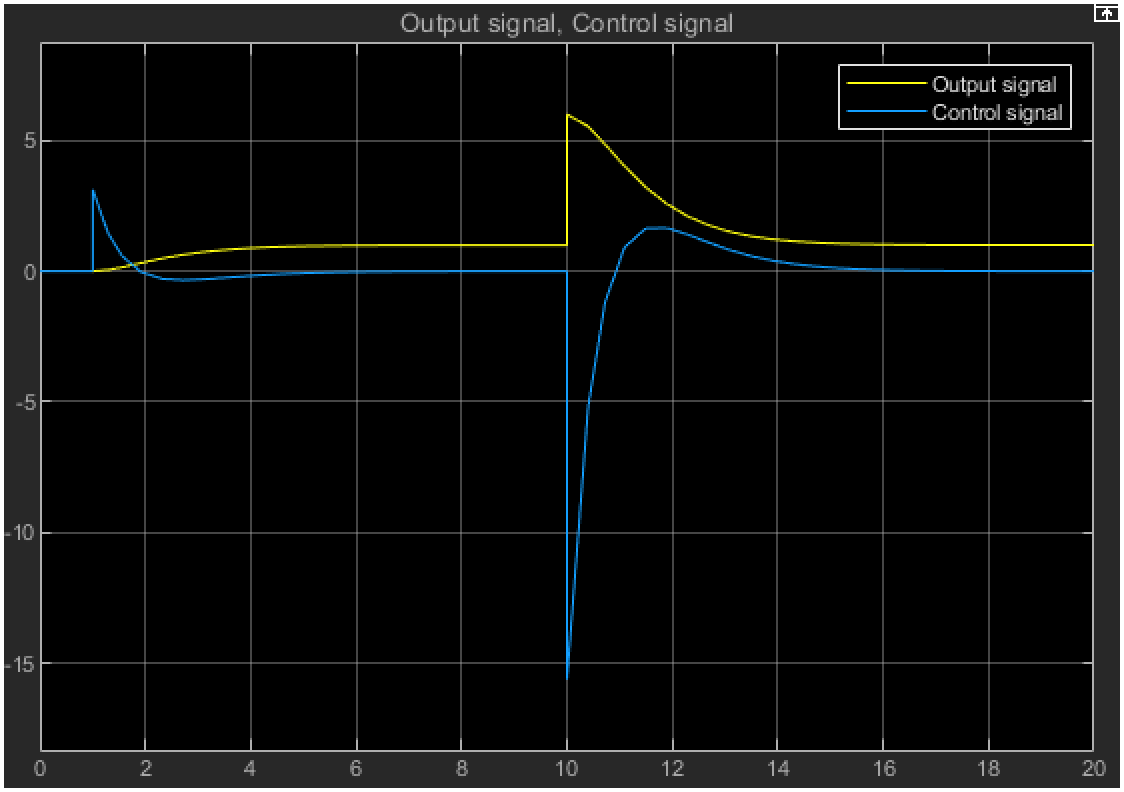
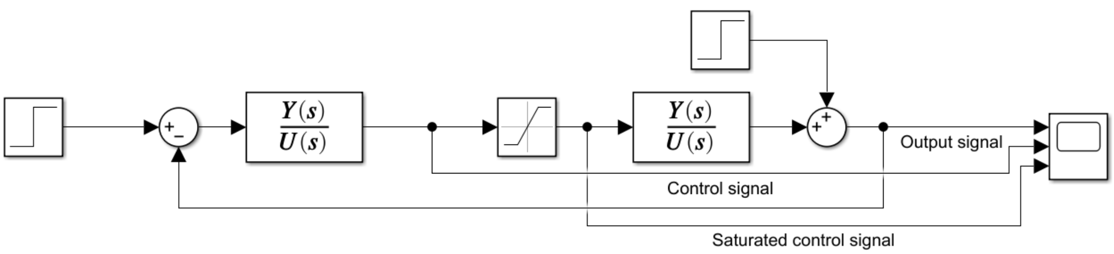
Without saturation and with a perturbation of value 5



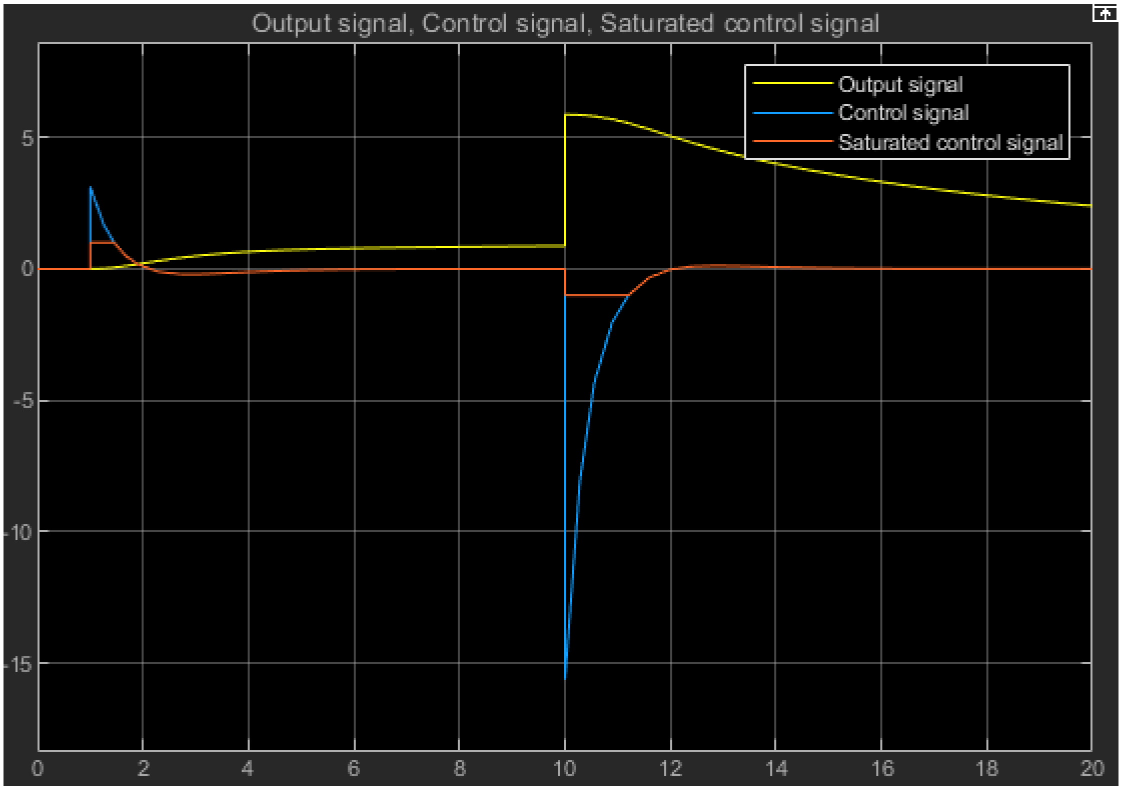
Without a limitation, the controller can generate a signal as big as it needs in order to get the output at the steady state value in the same settling time disregarding the value of the perturbation.



With saturation between [-1,1] and same value of perturbations



In a realistic situation our controller will be greatly affected by the value of the perturbations, because the control signal can't pass the physical limitations, in our case [-1,1], so the settling time will raise with the increasing value of the perturbations.


Output signal, Control signal, Saturated control signal
Output signal
Control signal
Saturated control signal
5
0
-5
-10
-15
0
2
4
6
8
10
12
14
16
18
20