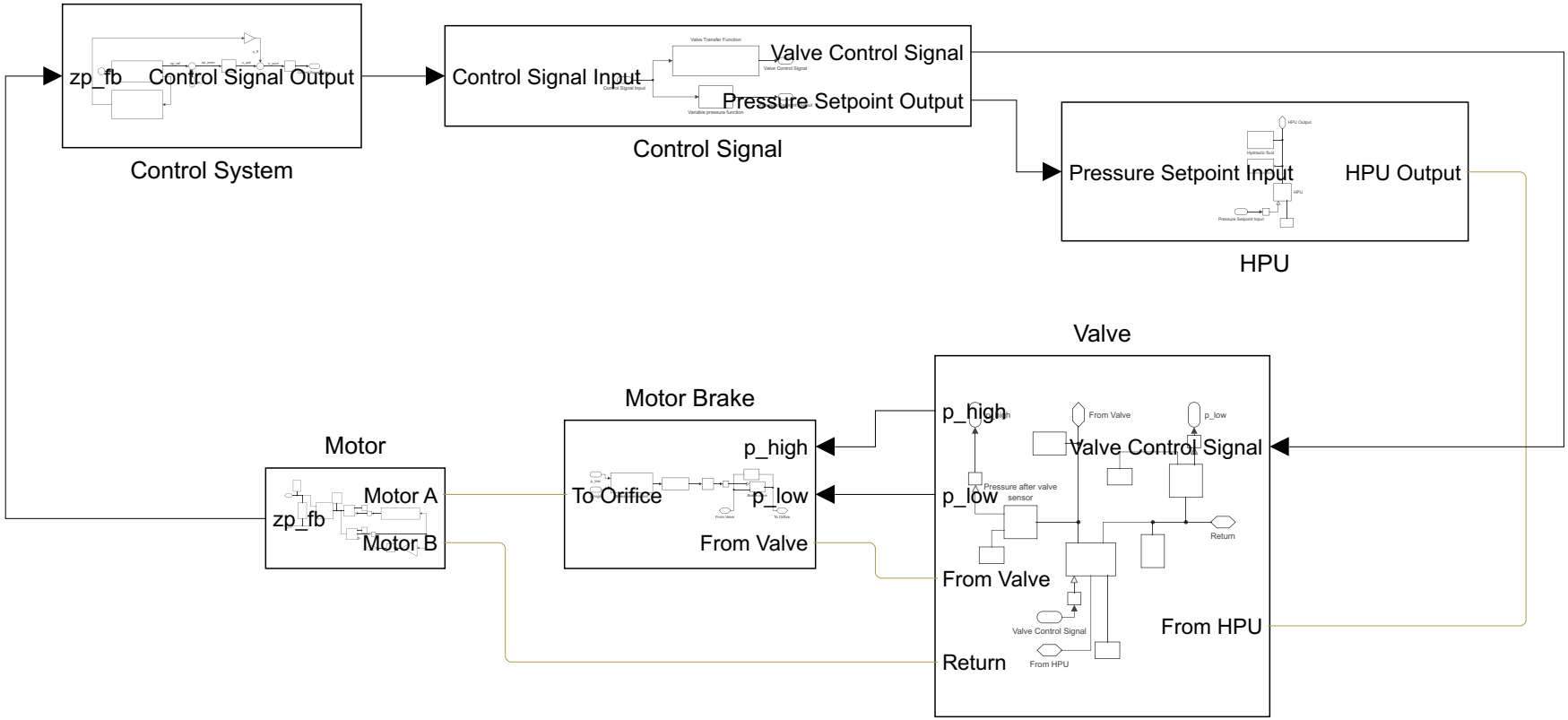
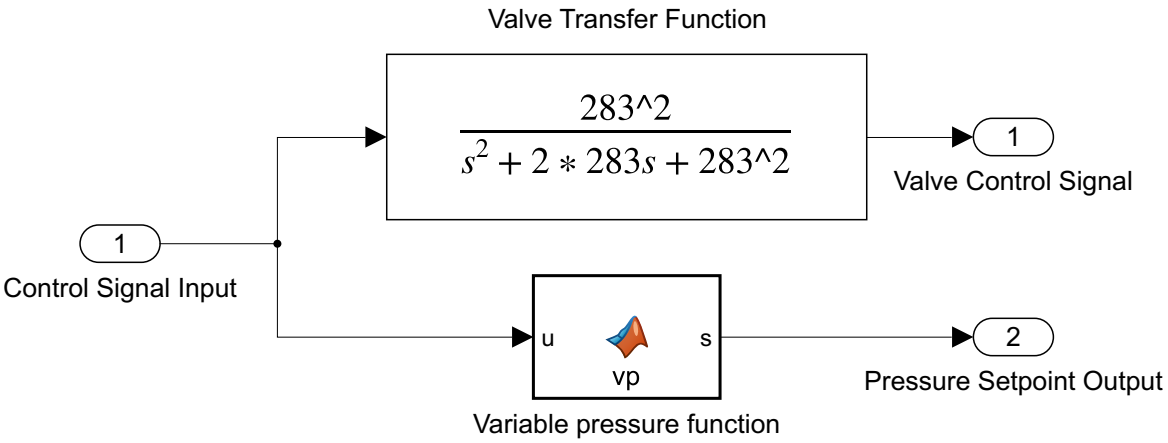
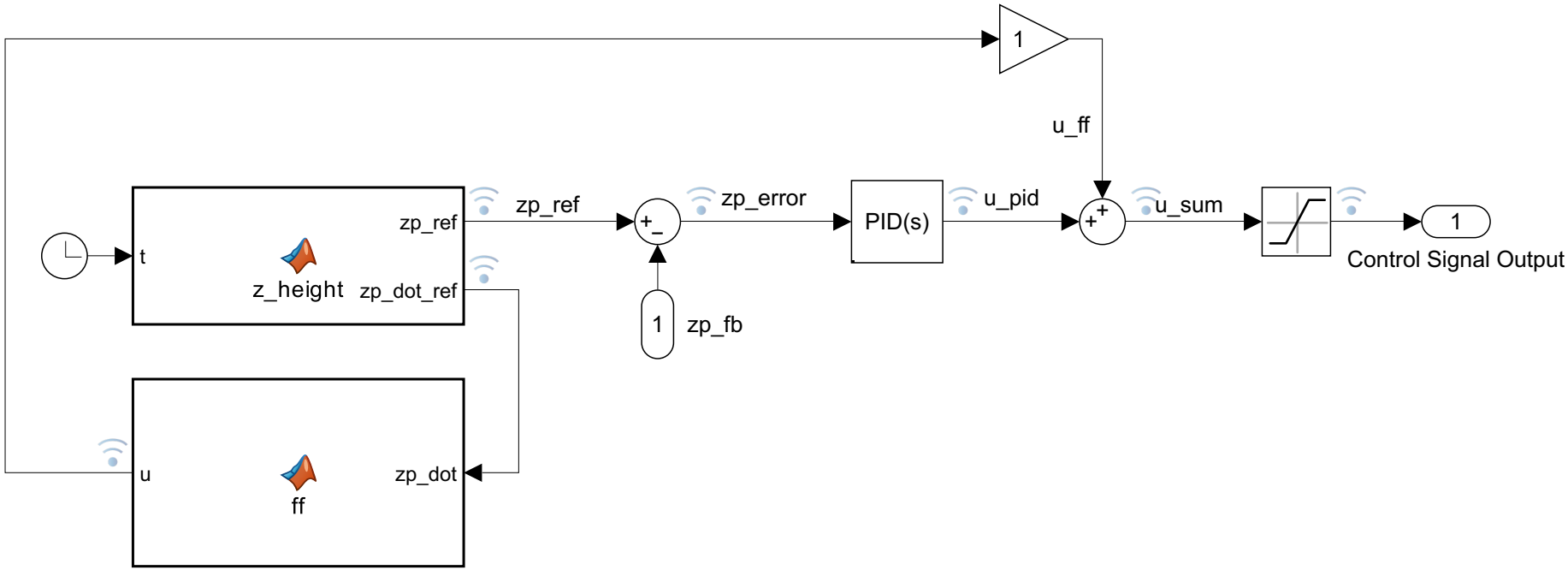

zp_fb
Control Signal Output
Control System
Control Signal Input
Valve Control Signal
Pressure Setpoint Output
Control Signal
Pressure Setpoint Input
HPU Output
HPU
Valve
p_high
p_low
From Valve
Valve Control Signal
Pressure after valve sensor
Return
From Valve
From HPU
Return
Motor Brake
p_high
To Orifice
p_low
From Valve
Motor
Motor A
zp_fb
Motor B

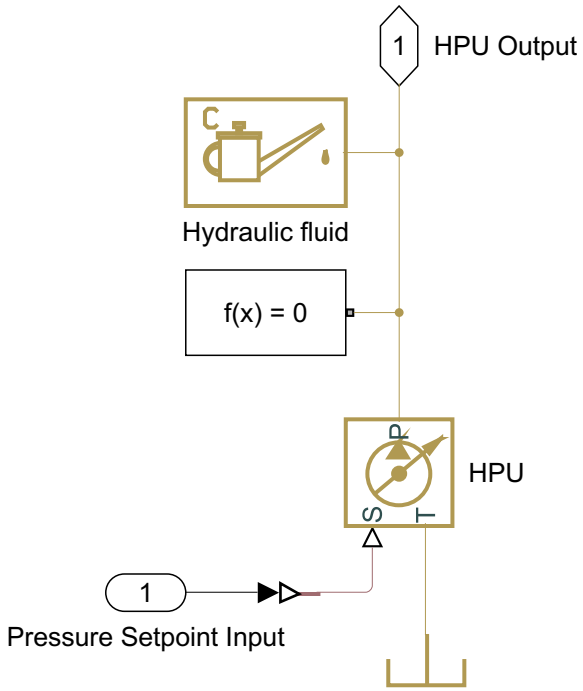

Valve Transfer Function
283^2
$s^2 + 2 * 283s + 283^2$
1
Valve Control Signal
1
Control Signal Input
u
vp
s
2
Pressure Setpoint Output
Variable pressure function

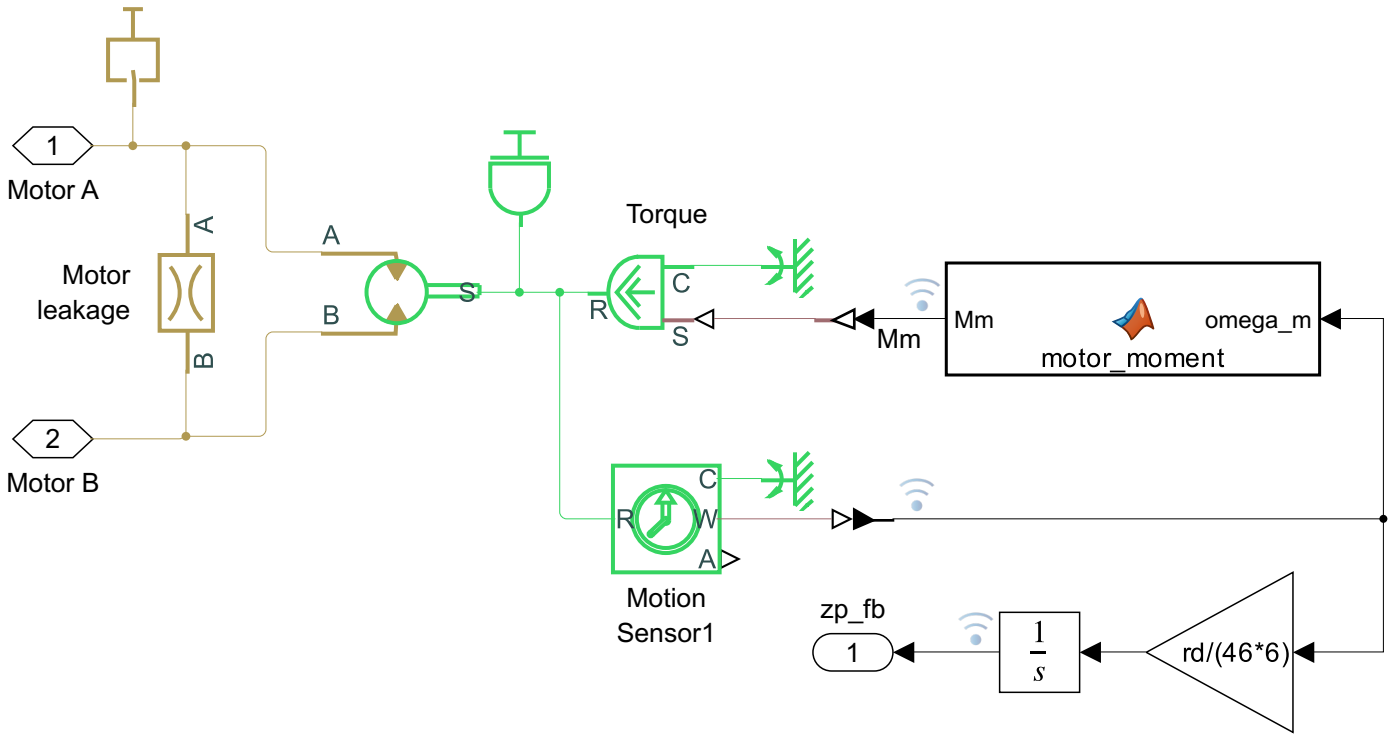
```
function s = vp(u)

if(u > 0)
    s = 260e5;
else
    s = 120e5;
end
```


1
u_ff
zp_ref
zp_ref
t
z_height
zp_dot_ref
+
−
zp_error
PID(s)
u_pid
+
+
u_sum
1
Control Signal Output
1
zp_fb
u
ff
zp_dot

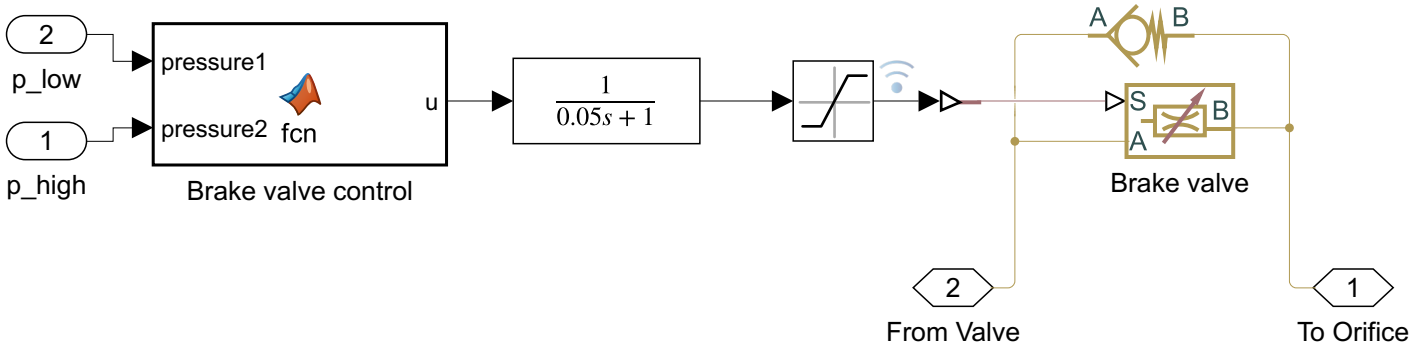
```
function [zp_ref, zp_dot_ref]  = z_height(t)

z_w = 0.8; % m
T_w = 10; % s

zp_ref = z_w * sin((2*pi*t)/T_w);
zp_dot_ref = (2*z_w*pi*cos((2*pi*t)/T_w))/T_w;
```

```
function u  = ff(zp_dot)

dd = 0.45;
rho = 875; % kg/m^3

Dm = 28.1*10^-6; % m^3/rev
n = (zp_dot/(dd/2)) * 46  * 6 / (2*pi); % rev/s

Q = (Dm*n);

Cd = 0.7;
Admax = (5.324e-5)*2; % m^2

u = (Q/(Cd*Admax * sqrt(2/rho*35e5))); % dp = p_mo = pressure metering orifice
```

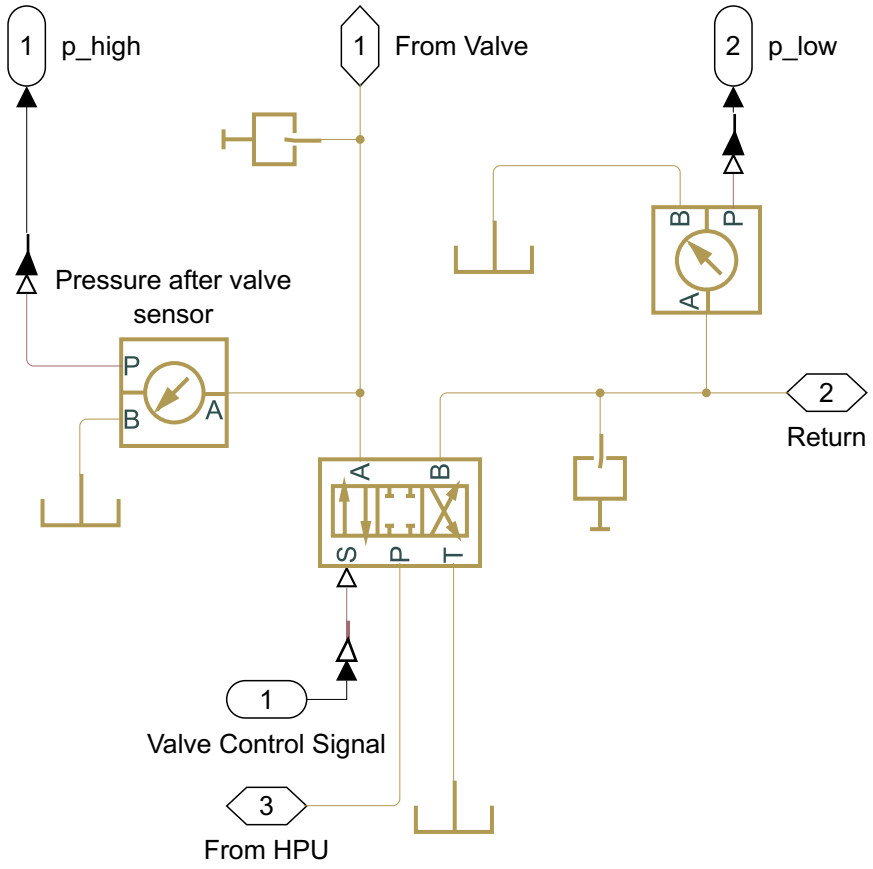

1
HPU Output
C
Hydraulic fluid
f(x) = 0
P
S
T
HPU
1
Pressure Setpoint Input


1
Motor A
2
Motor B
Motor
leakage
A
B
A
B
S
Torque
C
R
S
Mm
Mm
motor_moment
omega_m
C
R
W
A
Motion
Sensor1
zp_fb
1
1
s
rd/(46*6)

```
function Mm = motor_moment(omega_m)

n_sh = 3; % shieves
i_g = 46; % gearbox ratio
m_pl = 9000; % kg
d_D = 0.45; % m
mu_eq = 0.15; % -
omega_0 = 5; % rad/s
g = 9.81; % m/(s^2)

Mm = -1 * (m_pl*g*d_D)/(2*n_sh*2*i_g) * (1 + mu_eq * tanh(omega_m/omega_0));
```


2
p_low
1
p_high
pressure1
pressure2
fcn
u
Brake valve control
1
0.05s + 1
A
B
S
B
A
Brake valve
2
From Valve
1
To Orifice

```
function u = fcn(pressure1,pressure2)

p_cr = 20; % bar
dp_fo = 10; % bar, delta p_fully_open

u = ((pressure1*1e-5) - (pressure2*1e-5) - p_cr)/dp_fo;
```


1
p_high
1
From Valve
2
p_low
Pressure after valve sensor
P
B
A
B
P
A
A
B
S
P
T
2
Return
1
Valve Control Signal
3
From HPU