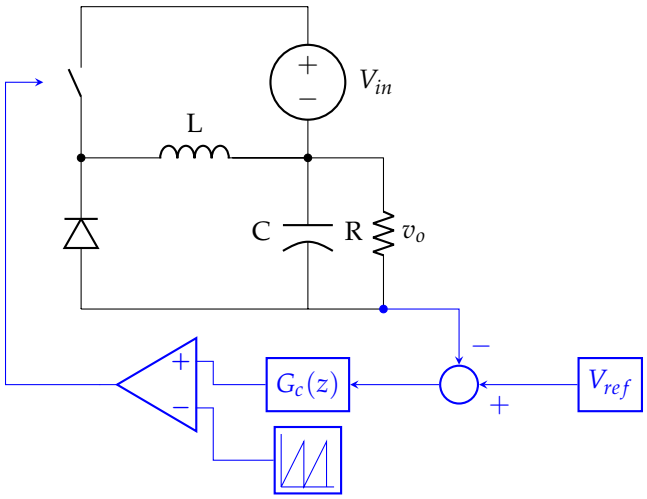
DIGITAL CONTROL OF POWER ELECTRONICS

Digital Voltage Mode Control of Buck-Boost Converter

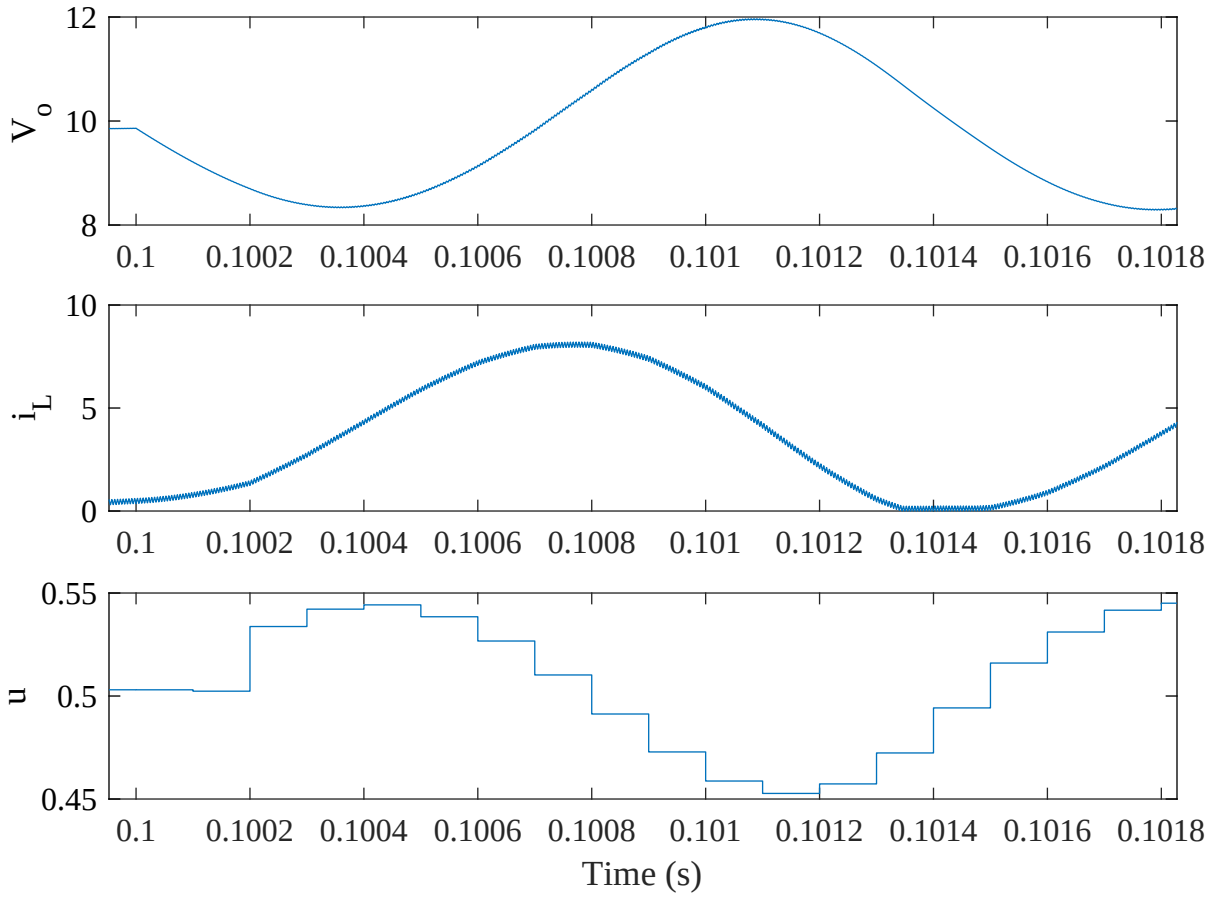



```
%% Buck Boost voltage mode
clear
Vin = 10
Vo = 10
d = 0.5
L = 100e-6
C = 247e-6
r = 0.01
Po = 20
fsw = 200e3
R = Vo^2/Po

Le = L / (1-d)^2

% plant transfer function

s=tf('s');
opts = bodeoptions('cstprefs');
opts.FreqUnits = 'Hz';

Gp = Vin/(1-d)^2 * (1-s*d*Le/R) * (1+s*r*C) / (Le*C * (s^2 +s*(1/(R*C) + r
    /Le) +1/(Le*C)))
bode(Gp,opts)
grid on
poles = pole(Gp)
zeros = zero(Gp)


% design controller

fc = 1e3
pm = 60
kfb = 1
```

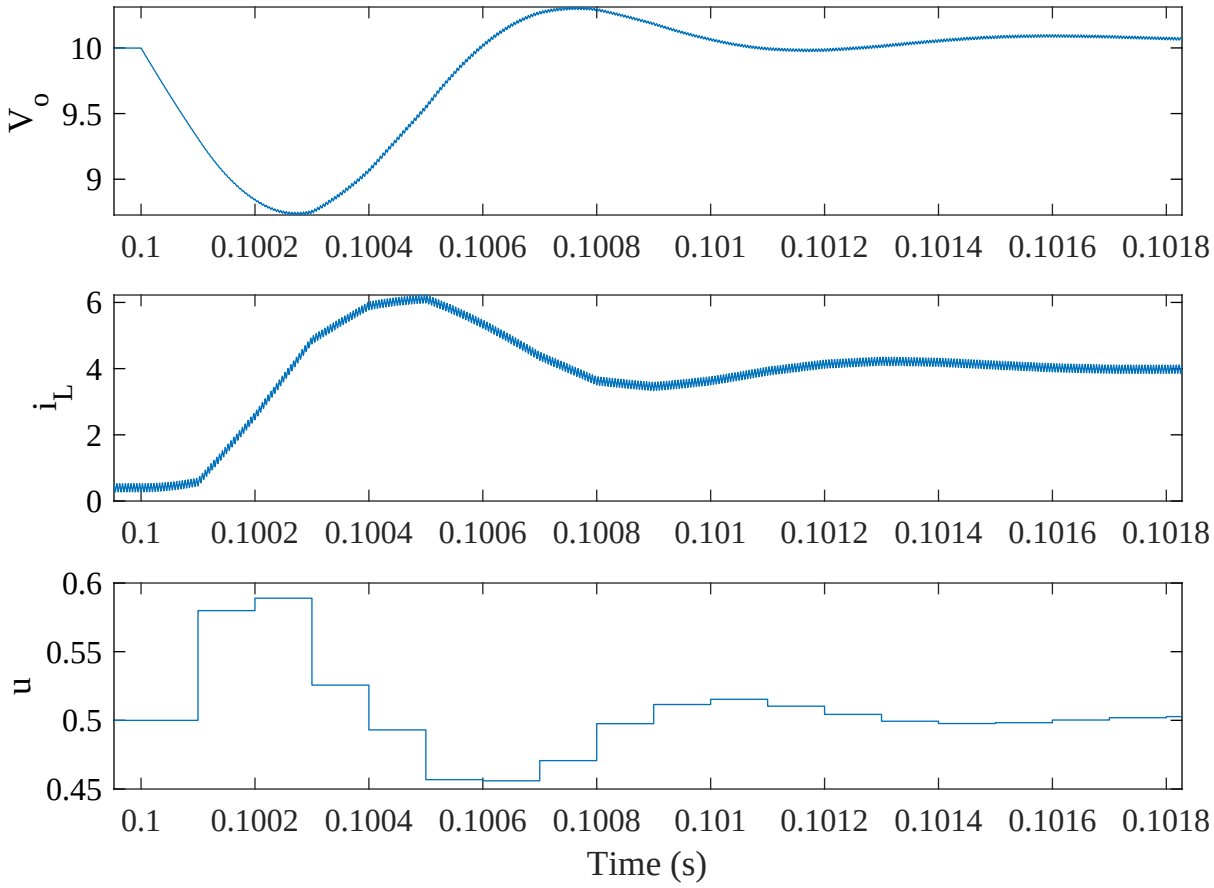
```
Gpwm = 1

[gain phase] = bode(Gp,2*pi*fc)
phase = -phase;
phiboost = -90 + pm - phase
kboost = tand(45 + phiboost/4)
gaincontroller = 1 / (kfb * Gpwm * gain)
fz = fc/kboost
fp = fc*kboost
kc = gaincontroller * 2*pi*fz/kboost
wz = 2*pi*fz
wp = 2*pi*fp

Gc = kc/s * (1+s/(2*pi*fz))^2 / ((1+s/(2*pi*fp))^2);
```

```
Ts = 1/10e3;
Z=tf('z',Ts);
sback = ((Z-1)/(Z*Ts));
gc_dig_backward_10k = minreal(kc/sback * (1+sback/(2*pi*fz))^2 / ((1+sback
   /(2*pi*fp))^2))
gc_dig_zoh_10k = c2d(minreal(Gc),Ts,'zoh')
gc_dig_tustin_10k = c2d(minreal(Gc),Ts,'tustin')

Ts = 1/50e3;
Z=tf('z',Ts);
sback = ((Z-1)/(Z*Ts));
gc_dig_backward_50k = minreal(kc/sback * (1+sback/(2*pi*fz))^2 / ((1+sback
   /(2*pi*fp))^2))
gc_dig_zoh_50k = c2d(minreal(Gc),Ts,'zoh')
gc_dig_tustin_50k = c2d(minreal(Gc),Ts,'tustin')
```

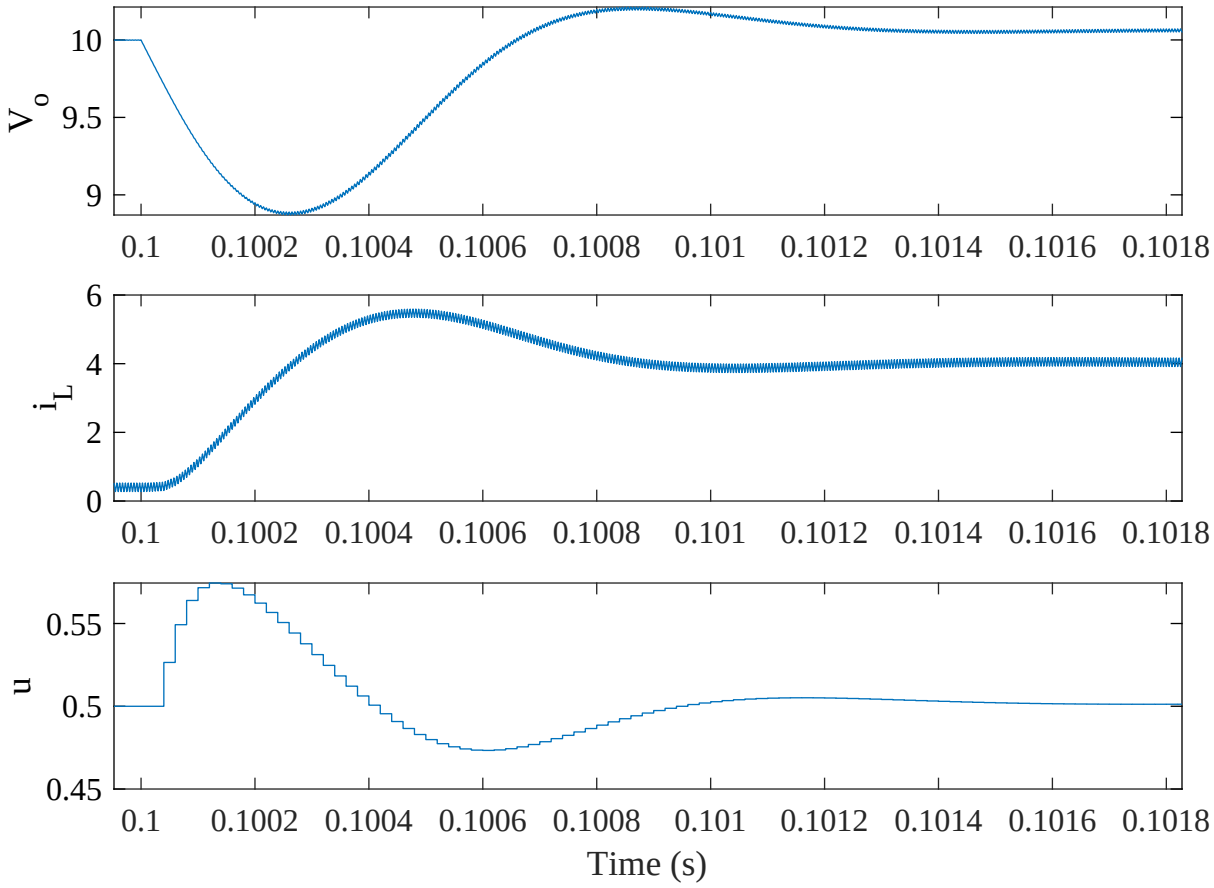
$$G_c(z) = \frac{0.089296\,z^3 - 0.16364\,z^2 + 0.074972\,z}{z^3 - 1.3758\,z^2 + 0.41114\,z - 0.035312} \tag{1}$$



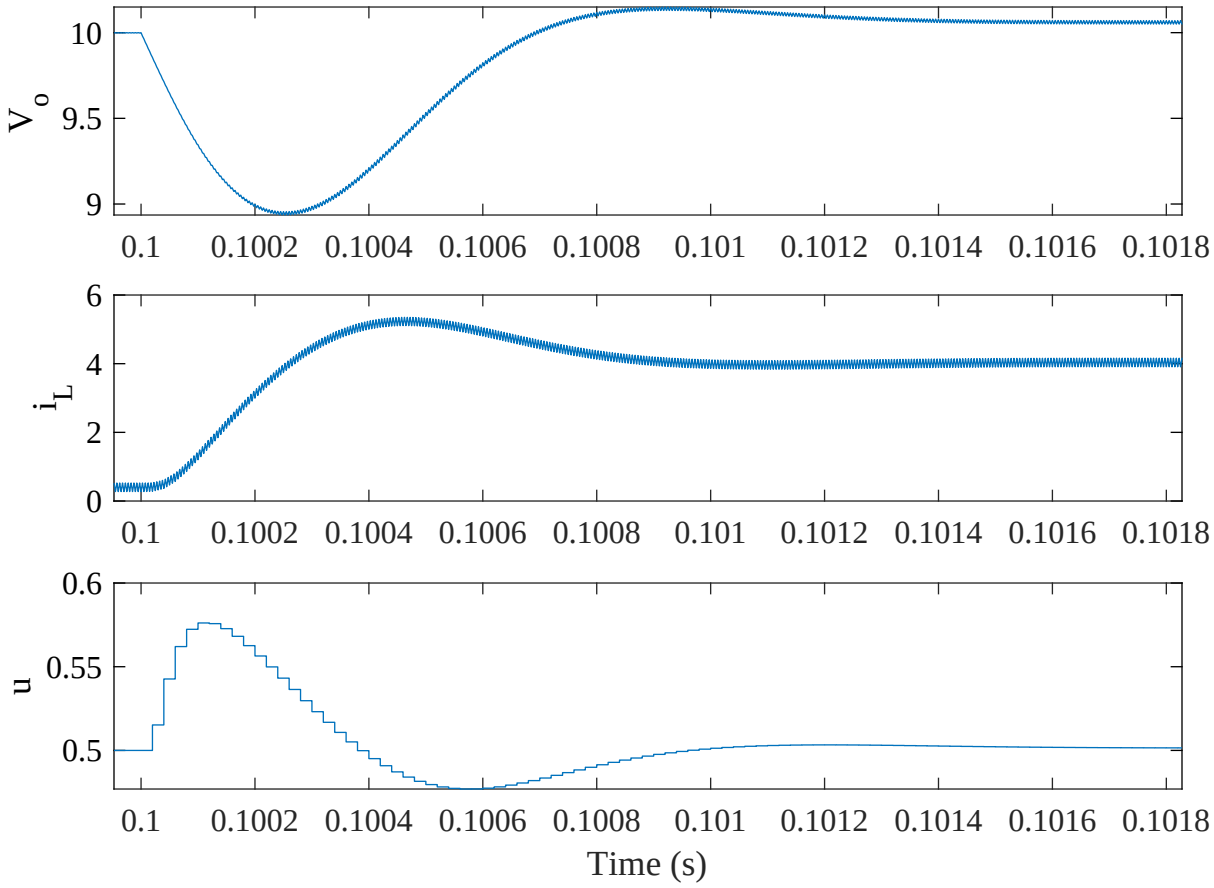
$$G_c(z) = \frac{0.1162z^3 - 0.09589z^2 - 0.1153z + 0.09677}{z^3 - 0.2655z^2 - 0.5996z - 0.1349} \tag{2}$$

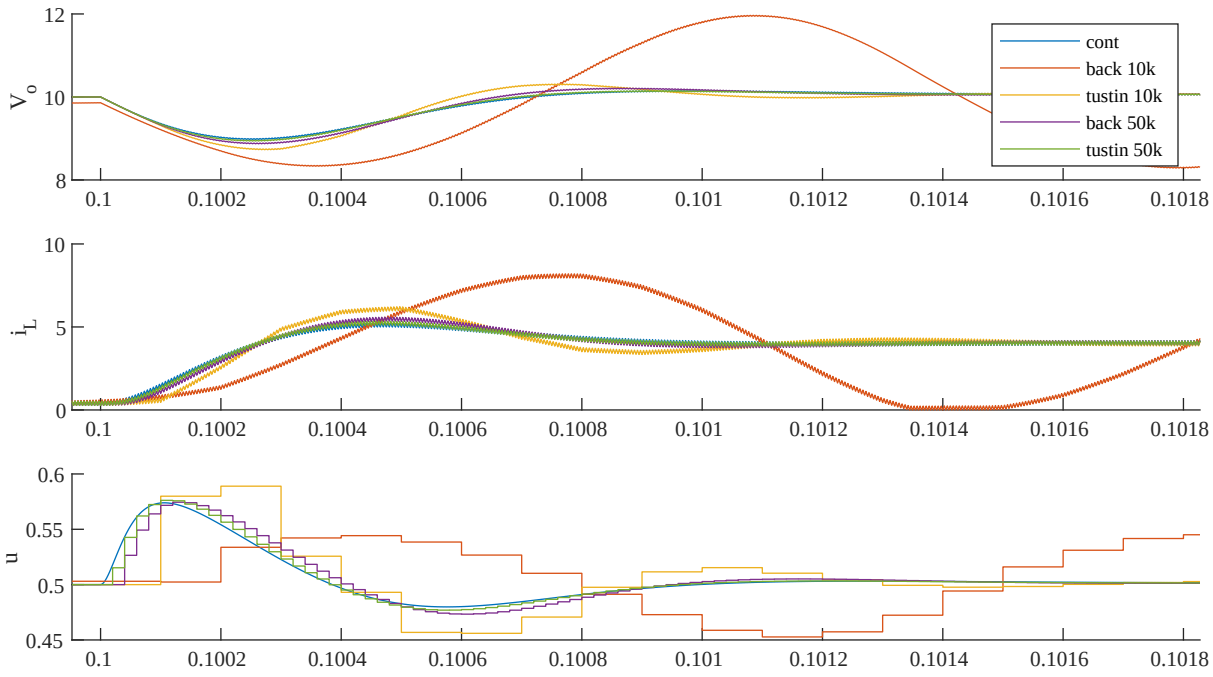


$$G_c(z) = \frac{0.12668\,z^3 - 0.24881\,z^2 + 0.12217\,z}{z^3 - 2.0728\,z^2 + 1.3605\,z - 0.28772} \tag{3}$$



$$G_c(z) = \frac{0.1054z^3 - 0.1016z^2 - 0.1054z + 0.1016}{z^3 - 1.793\,z^2 + 0.9502\,z - 0.15721} \tag{4}$$




12
10
8
V_o
cont
back 10k
tustin 10k
back 50k
tustin 50k
0.1
0.1002
0.1004
0.1006
0.1008
0.101
0.1012
0.1014
0.1016
0.1018
10
5
0
i_L
0.6
0.55
0.5
0.45
u