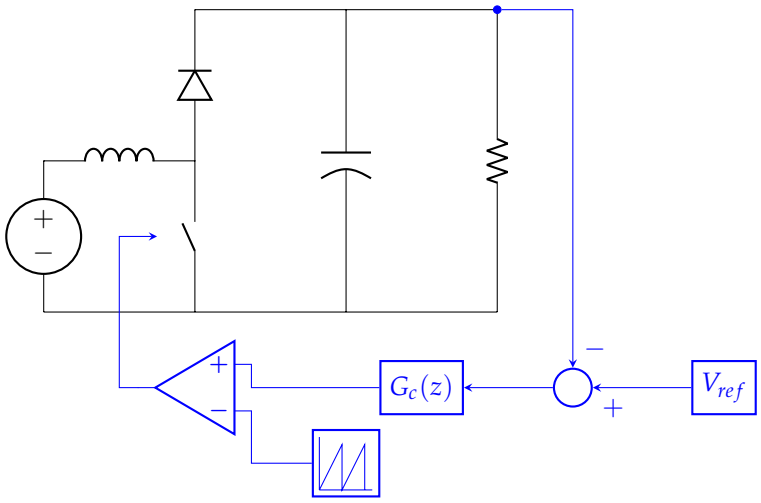
DIGITAL CONTROL OF POWER ELECTRONICS

Digital Voltage Mode Control of Boost Converter

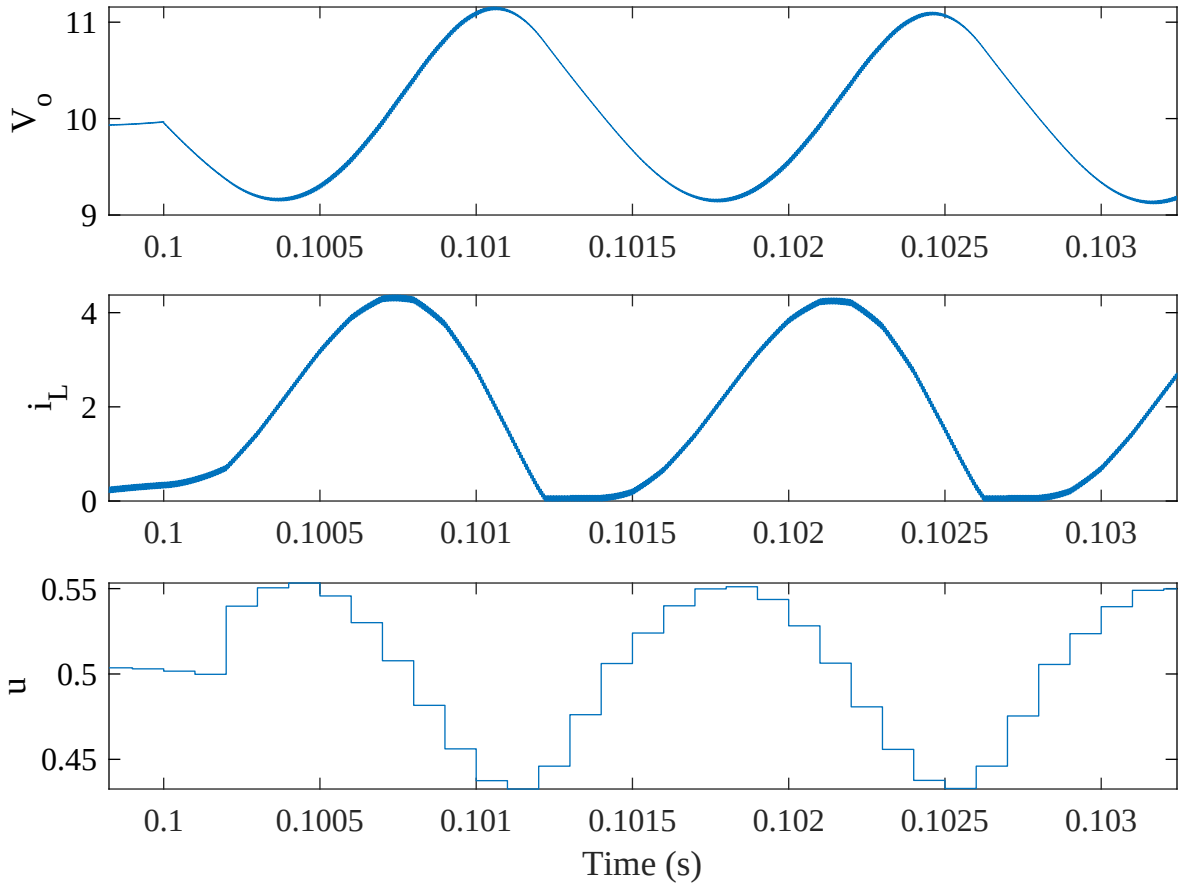



```
clear
Vin = 5
Vo = 10
d = 0.5
L = 100e-6
C = 247e-6
r = 0.01
Po = 10
fsw = 200e3
R = Vo^2/Po

Le = L / (1-d)^2

% plant transfer function

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

Gp = Vin/(1-d)^2 * (1-s*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
```

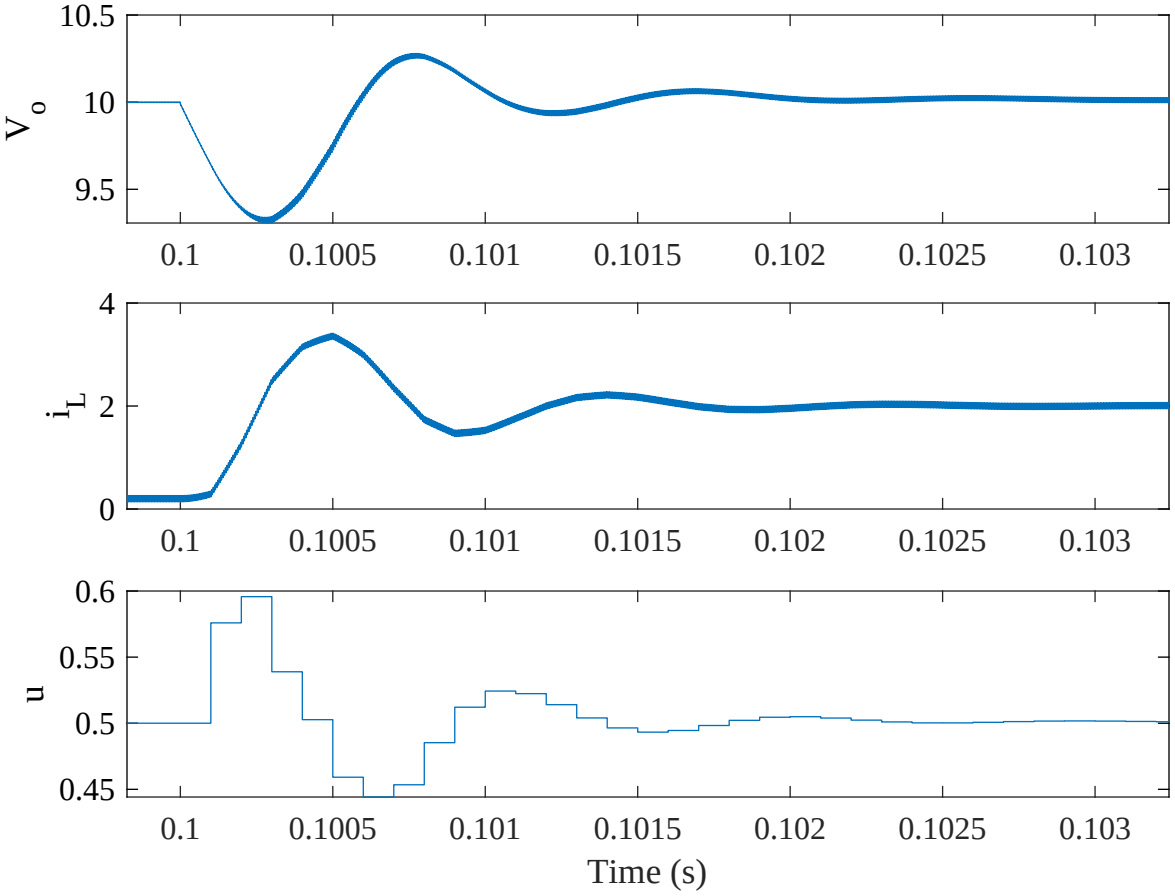
```

[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);
```

```
% digital controllers
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')
```

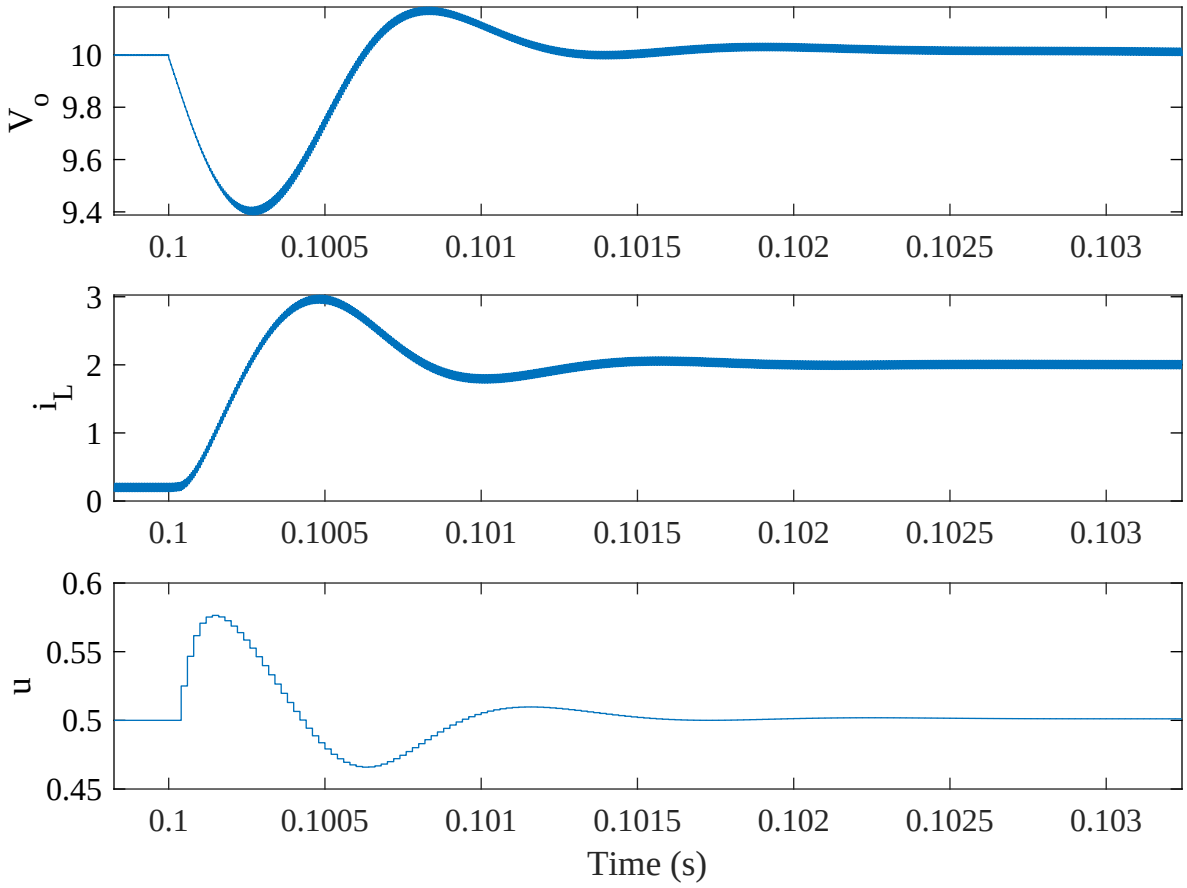
$$G_c(z) = \frac{0.171229527\,s^3 - 0.30990707\,s^2 + 0.140224636\,s}{s^3 - 1.42030112\,s^2 + 0.464464374\,s - 0.0441632572} \tag{1}$$



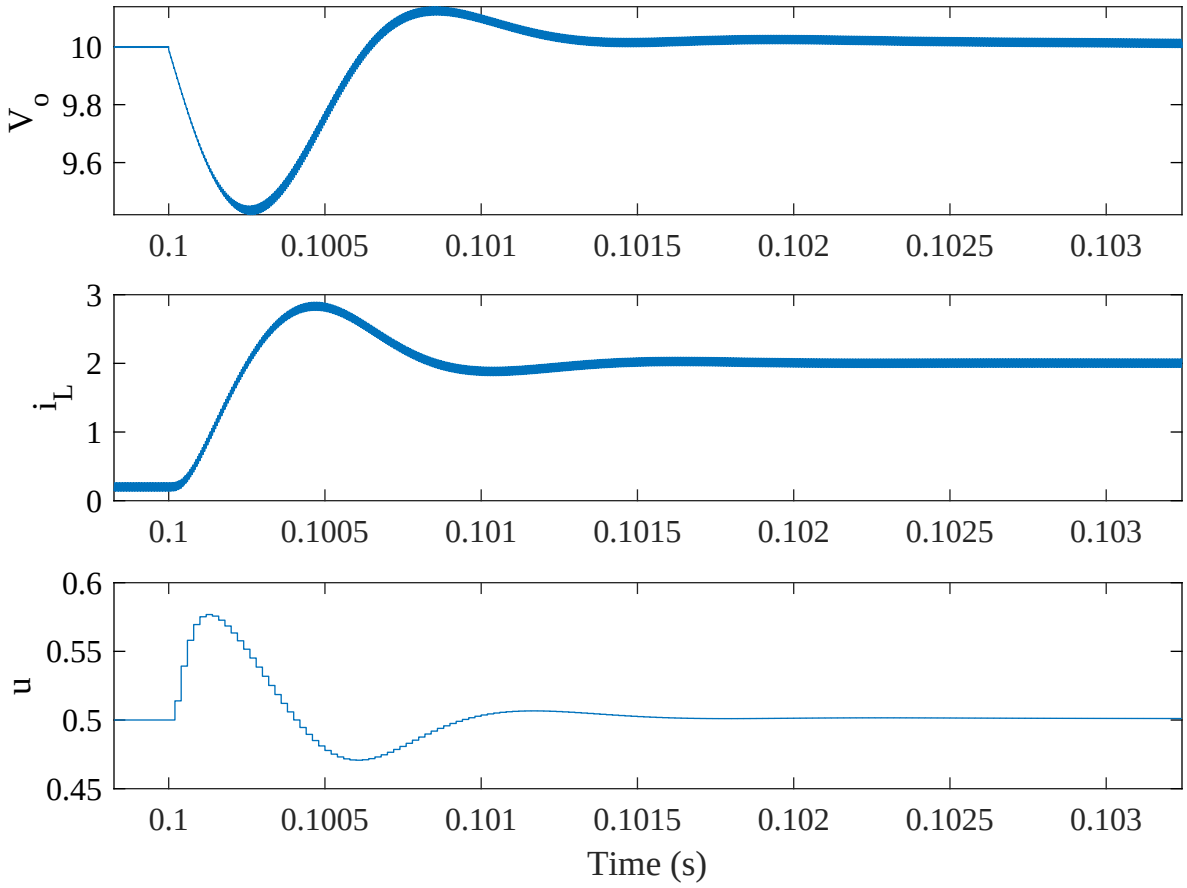
$$G_c(z) = \frac{-0.212146244\,s^3 + 0.169803267\,s^2 + 0.2100334\,s - 0.171916111}{-1.0\,s^3 + 0.389252317\,s^2 + 0.5174945\,s + 0.0932531832} \tag{2}$$

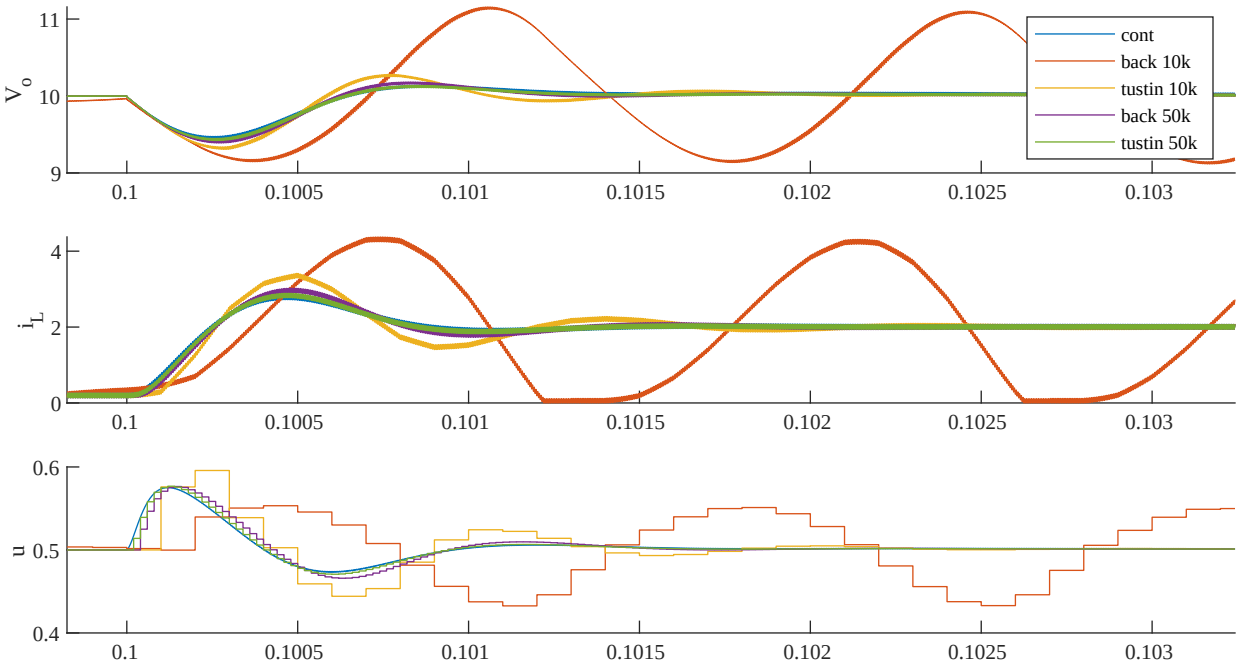


$$G_c(z) = \frac{0.215740841\,s^3 - 0.422603799\,s^2 + 0.206954291\,s}{s^3 - 2.1417489\,s^2 + 1.46764654\,s - 0.32589764} \tag{3}$$



$$G_c(z) = -\frac{1.0\ \left(-0.171276339\,s^3 + 0.164154939\,s^2 + 0.171202315\,s - 0.164228963\right)}{s^3 - 1.90729511\,s^2 + 1.11309122\,s - 0.205796105} \tag{4}$$




V_o
i_L
u
cont
back 10k
tustin 10k
back 50k
tustin 50k
0.1
0.1005
0.101
0.1015
0.102
0.1025
0.103