Chapter 4
Computer Simulation

Chapter 4 Computer Simulation of Power Electronic Converters and Systems 61

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System to be Simulated

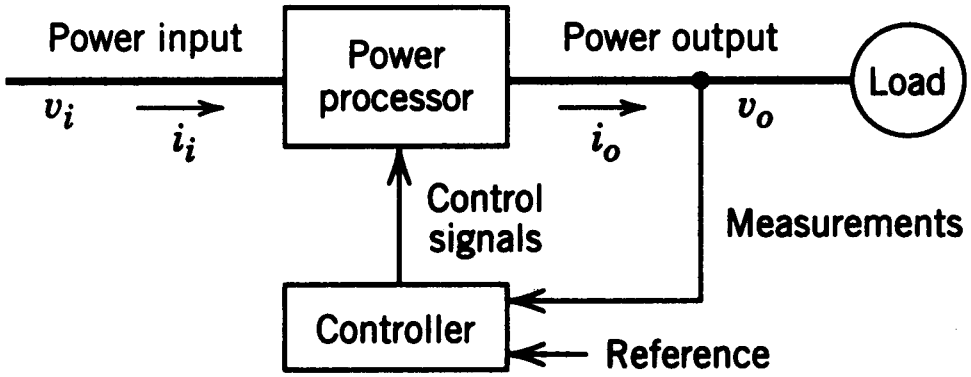


Figure 4-1 Power electronics system: a block diagram.

- Challenges in modeling power electronic systems

Large-Signal System Simulation

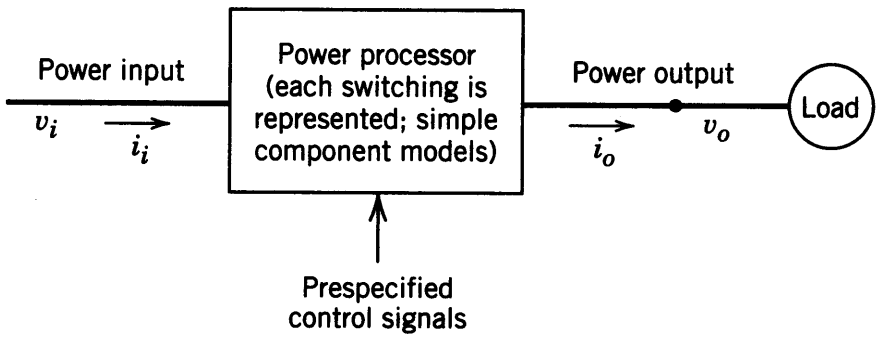


Figure 4-2 Open-loop, large-signal simulation.

- Simplest component models

Small-Signal Linearized Model for Controller Design

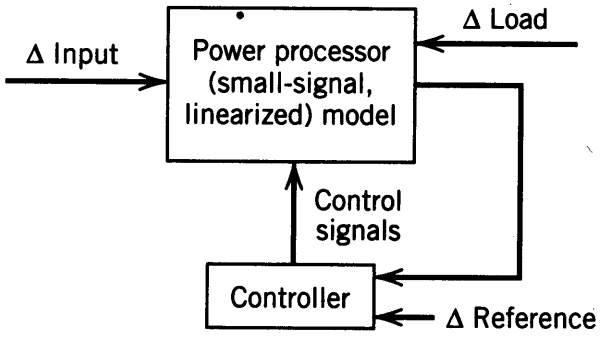


Figure 4-3 Small-signal (linear) model and controller design.

- System linearized around the steady-state point

Closed-Loop Operation: Large Disturbances

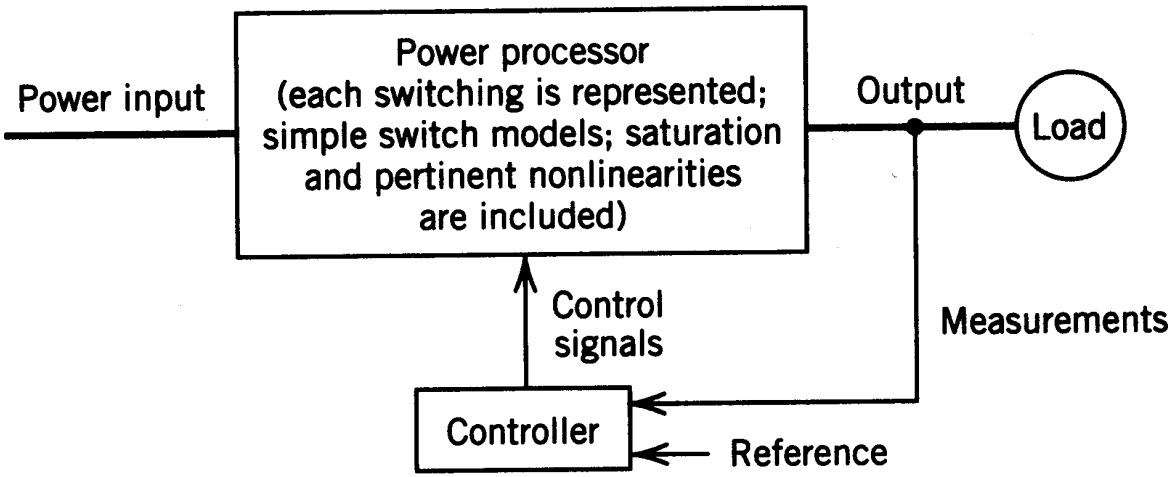


Figure 4-4 Closed-loop, large-signal system behavior.

- Simplest component models
- Nonlinearities, Limits, etc. are included

Modeling of Switching Operation

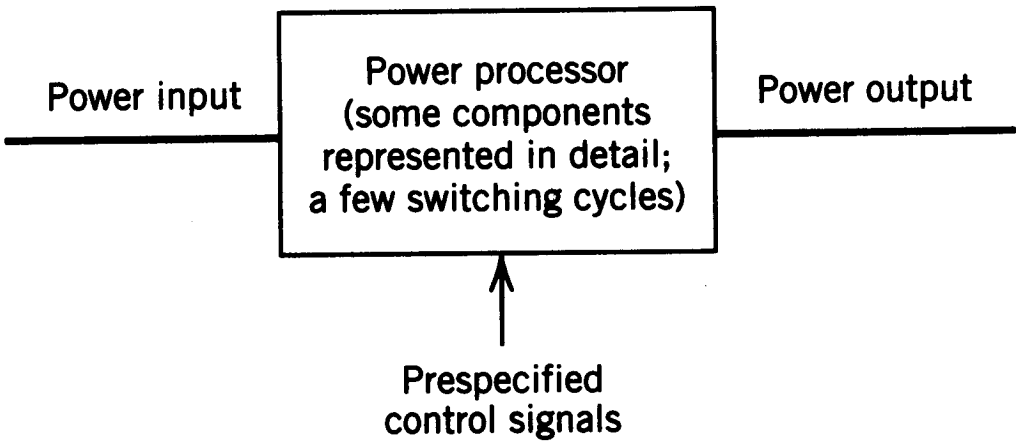


Figure 4-5 Switching details.

- Detailed device models
- Just a few switching cycles are studied

Modeling of a Simple Converter

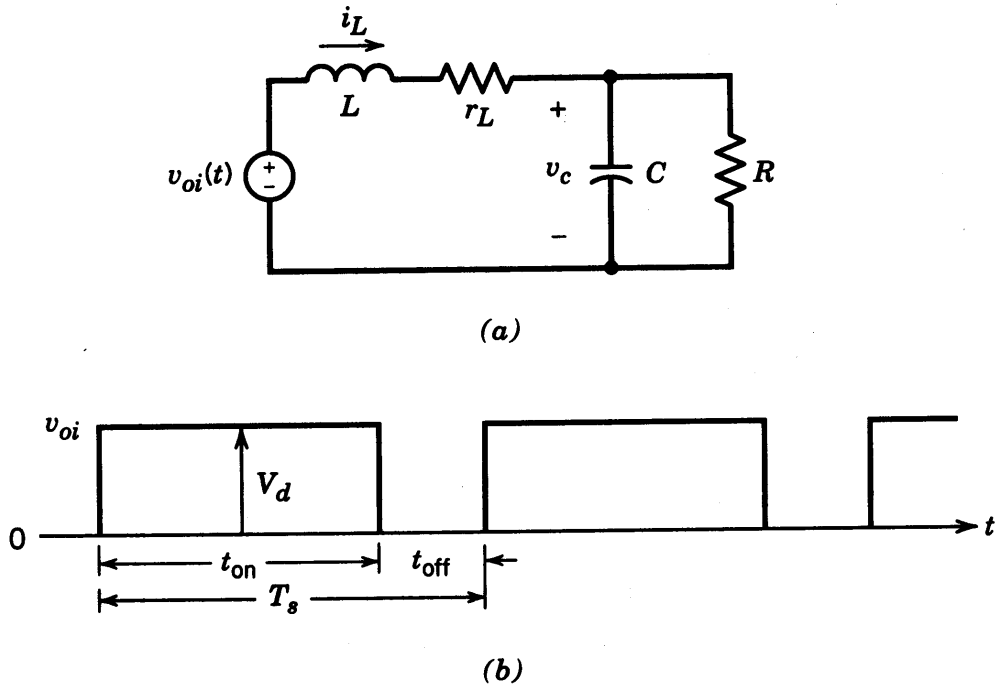


Figure 4-6 Simplified equivalent circuit of a switch-mode, regulated dc power supply (same as in Fig. 1-3).

- Input voltage takes on two discrete values

Trapezoidal Method of Integration

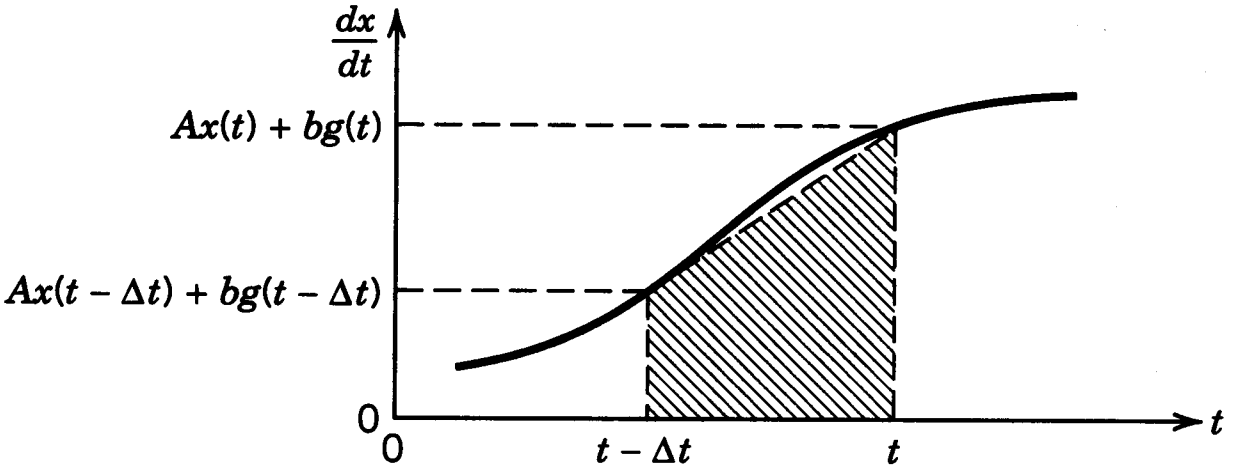


Figure 4-7
Trapezoidal method of integration.

- The area shown above represents the integral

A Simple Example

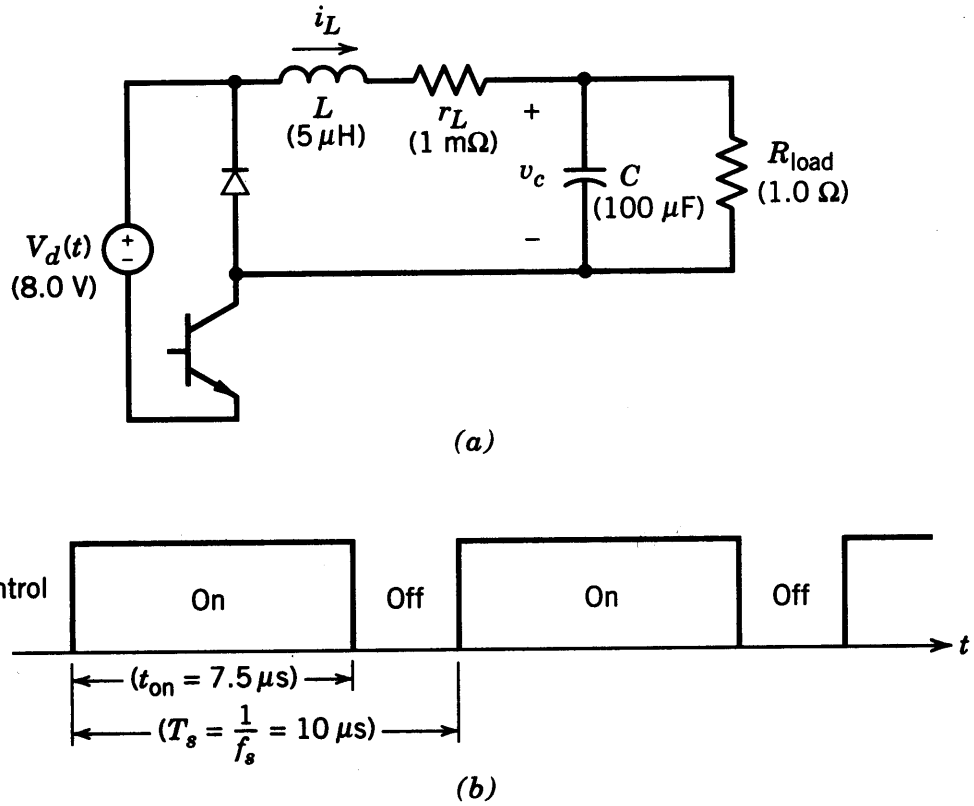
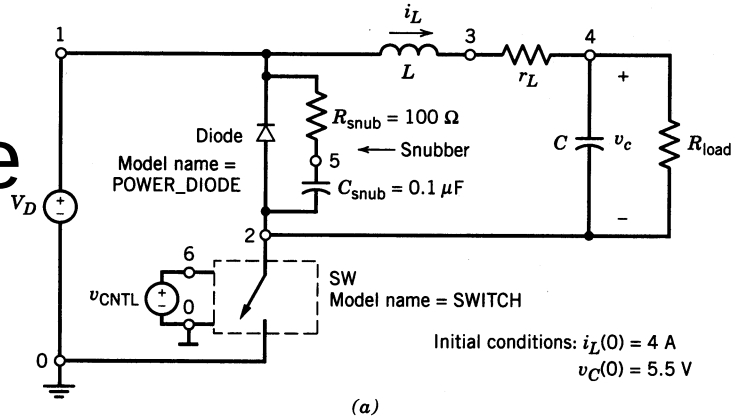


Figure 4-8 (a) Circuit for simulation. (b) Switch control waveform.

- The input voltage takes on two discrete values

Modeling using PSpice



(a)

```
PSpice Example
*
DIODE   2   1   POWER_DIODE
Rsnub   1   5   100.0
Csnub   5   2   0.1uF
*
SW      2   0   6   0   SWITCH
VCNTL   6   0   PULSE(0V,1V,0s,1ns,1ns,7.5us,10us)
*
L       1   3   5uH    IC=4A
rL      3   4   1m
C       4   2   100uF  IC=5.5V
RLOAD   4   2   1.0
*
VD      1   0   8.0V
*
.MODEL POWER_DIODE D(RS=0.01,CJO=10pF)
.MODEL SWITCH VSWITCH(RON=0.01)
.TRAN   10us   500.0us   0s   0.2us   uic
.PROBE
.END
```

(b)

Figure 4-9 PSpice simulation of circuit in Fig. 4-8.

- Schematic approach is far superior

PSpice-based Simulation

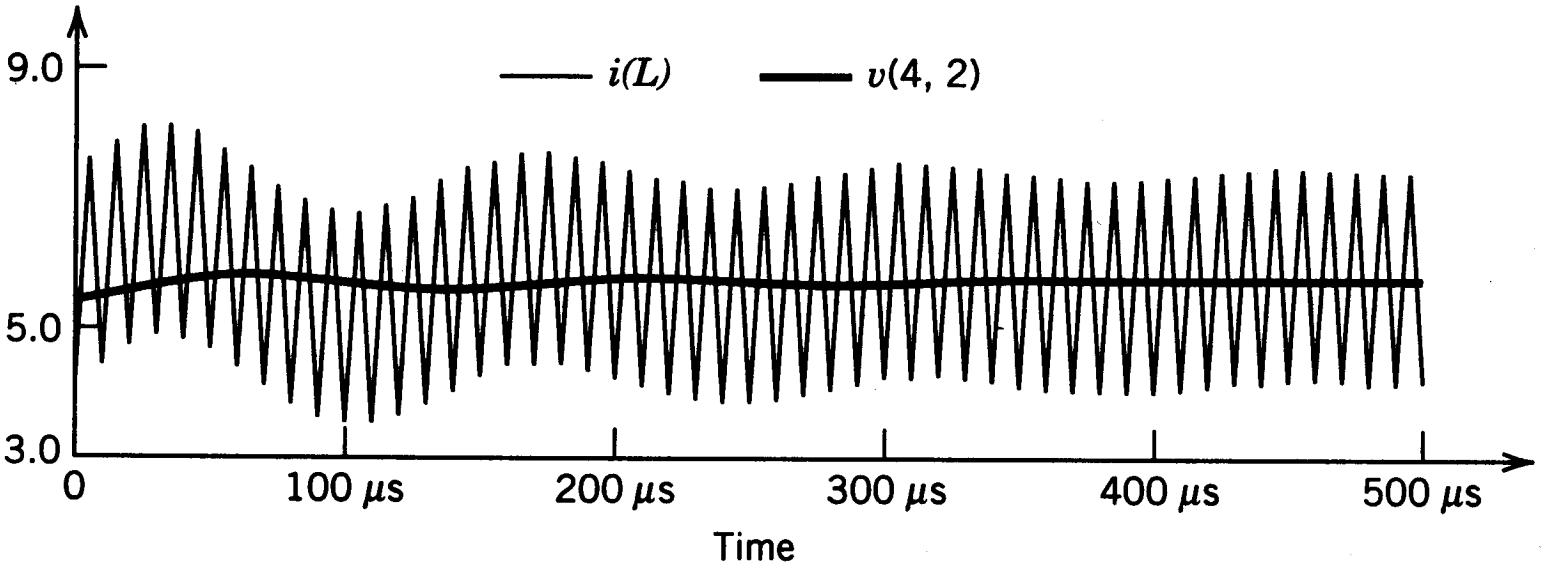
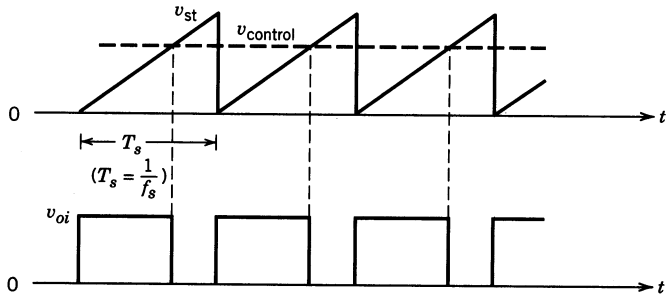


Figure 4-10 Results of PSpice simulation: i_L and v_c.

- Simulation results

Simulation using MATLAB



(a)

```
% Solution of the Circuit in Fig. 4-6 using Trapezoidal Method of Integration.
clc,clg,clear
% Input Data
Vd=8; L=5e-6; C=100e-6; rL=1e-3; R=1.0; fs=100e3; Vcontrol=0.75;
Ts=1/fs; tmax=50*Ts; deltat=Ts/50;
%
time= 0:deltat:tmax;
vst= time/Ts - fix(time/Ts);
voi= Vd * (Vcontrol > vst);
%
A=[-rL/L -1/L; 1/C -1/(C*R)];
b=[1/L 0]';
MN=inv(eye(2) - deltat/2 * A);
M=MN * (eye(2)+ deltat/2 * A);
N=MN * deltat/2 * b;
%
iL(1)=4.0; vC(1)=5.5;
timelength=length(time);
%
for k = 2:timelength
x = M * [iL(k-1) vC(k-1)]' + N * (voi(k) + voi(k-1));
iL(k) = x(1); vC(k) = x(2);
end
%
plot(time,iL,time,vC)
meta Example
```

(b)

Figure 4-11 MATLAB simulation of circuit in Fig. 4-6.

MATLAB-based Simulation

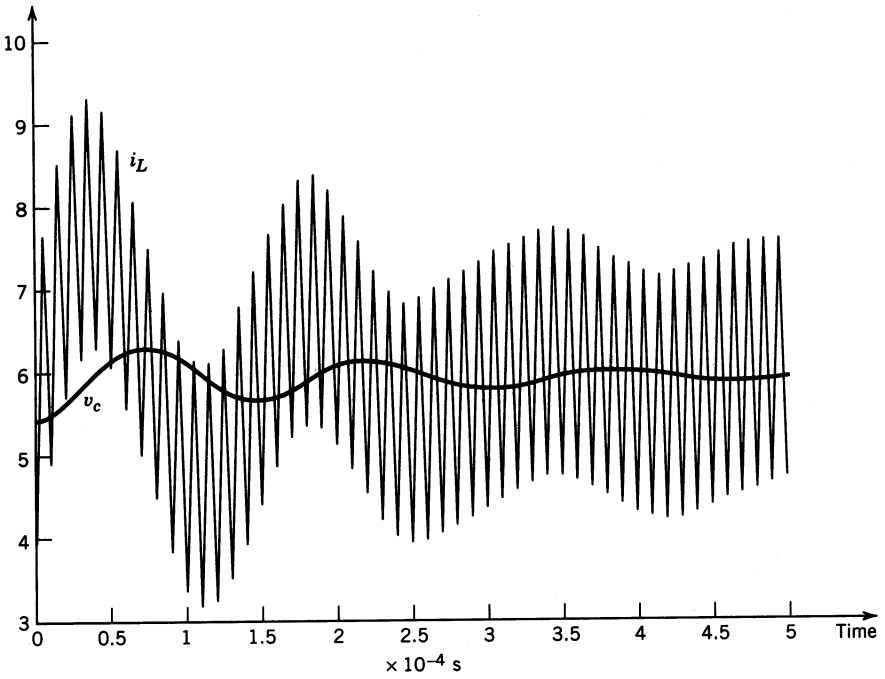


Figure 4-12 MATLAB simulation results.

- Simulation results