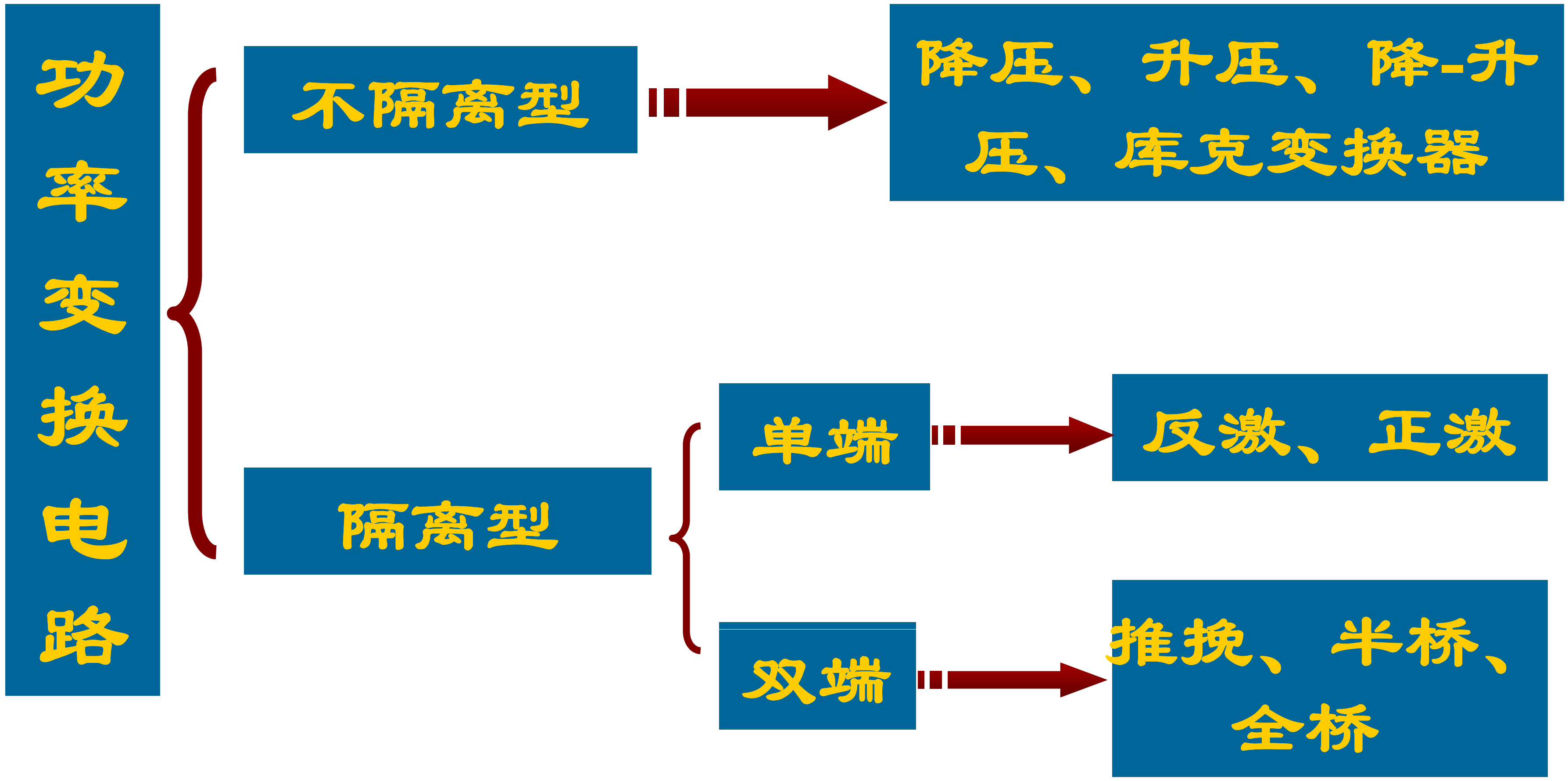
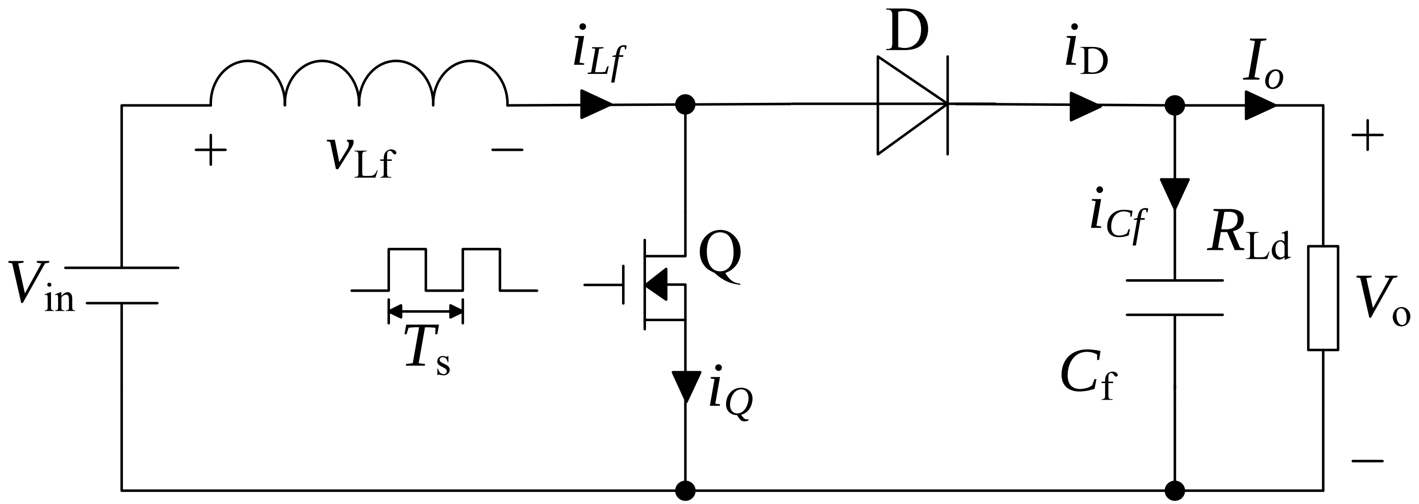
# 第五章 基本开关型调整器——Boost变换器



# 5.1 Boost变换器基本原理




输出电压Vo比直流输入电压Vin高的原因?

$$E=\frac{1}{2}L_f I_{Lf}^2$$

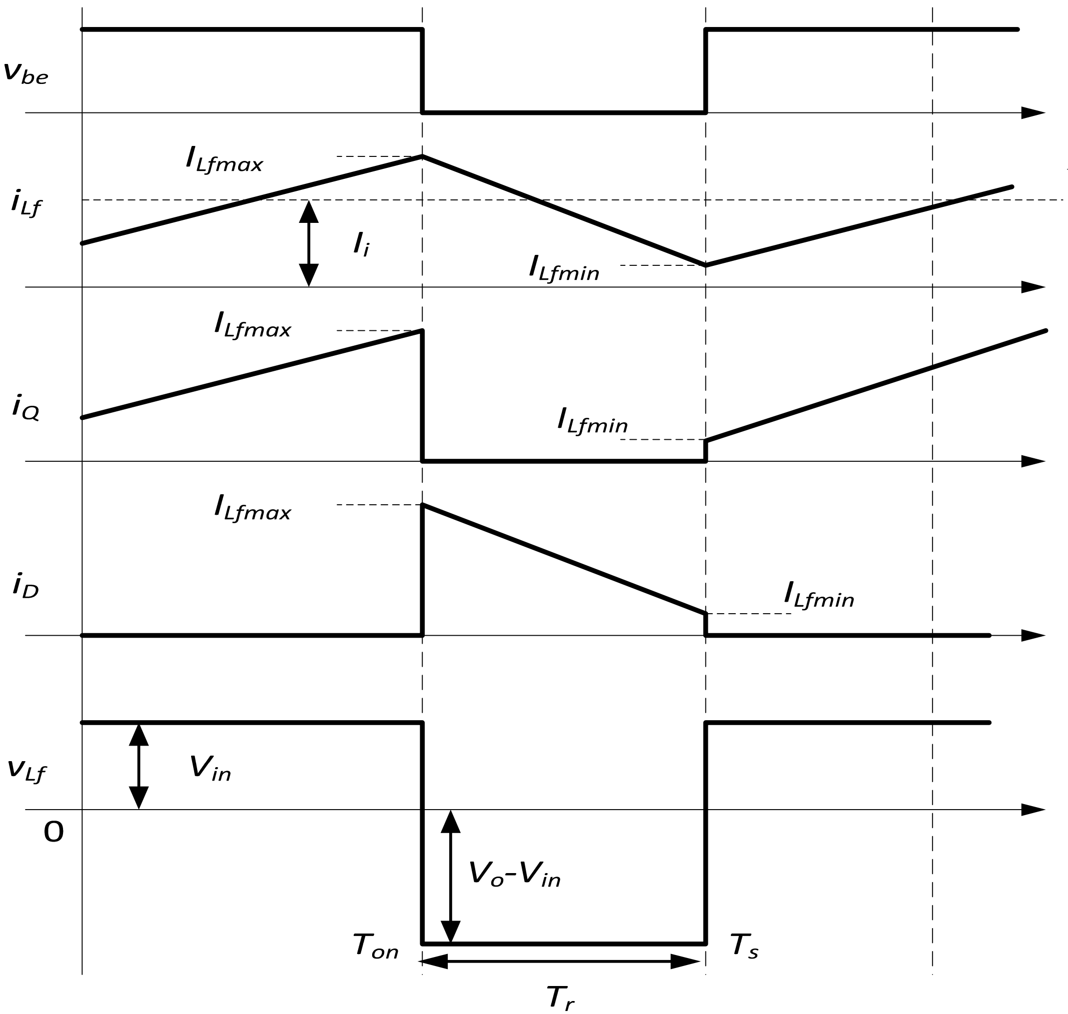
1、开关管Q导通，电感储能。

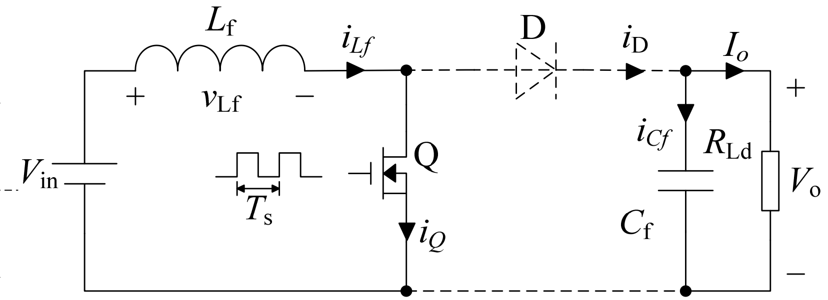
负载由电容C提供。所以电容C应选取得足够大。

2、开关管Q关断时，Lf的电压极性颠倒，Lf经D向Cf充电，使Cf两端电压（泵升电压）高于Vin。电感储能给负载提供电流并补充Cf单独向负载供电时损失的电荷。

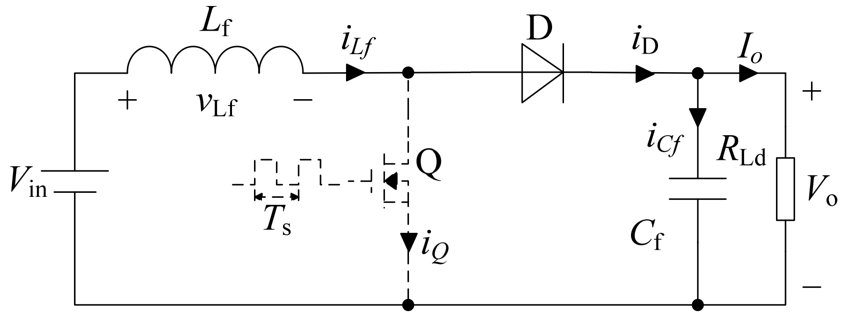
# 第五章 Boost变换器

## 电流连续时的工作模式(CCM)



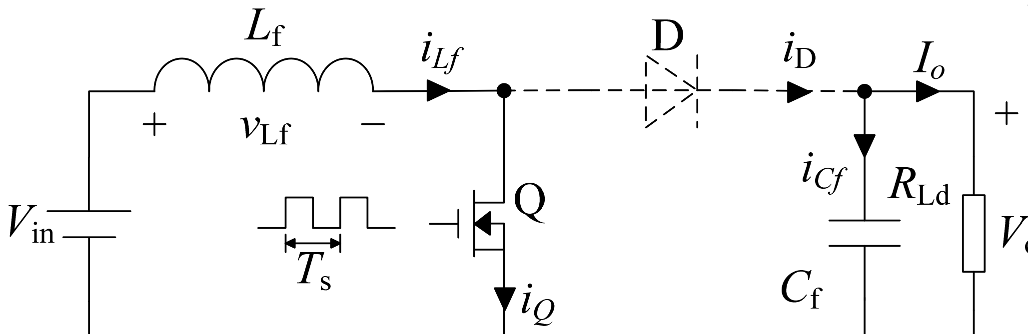



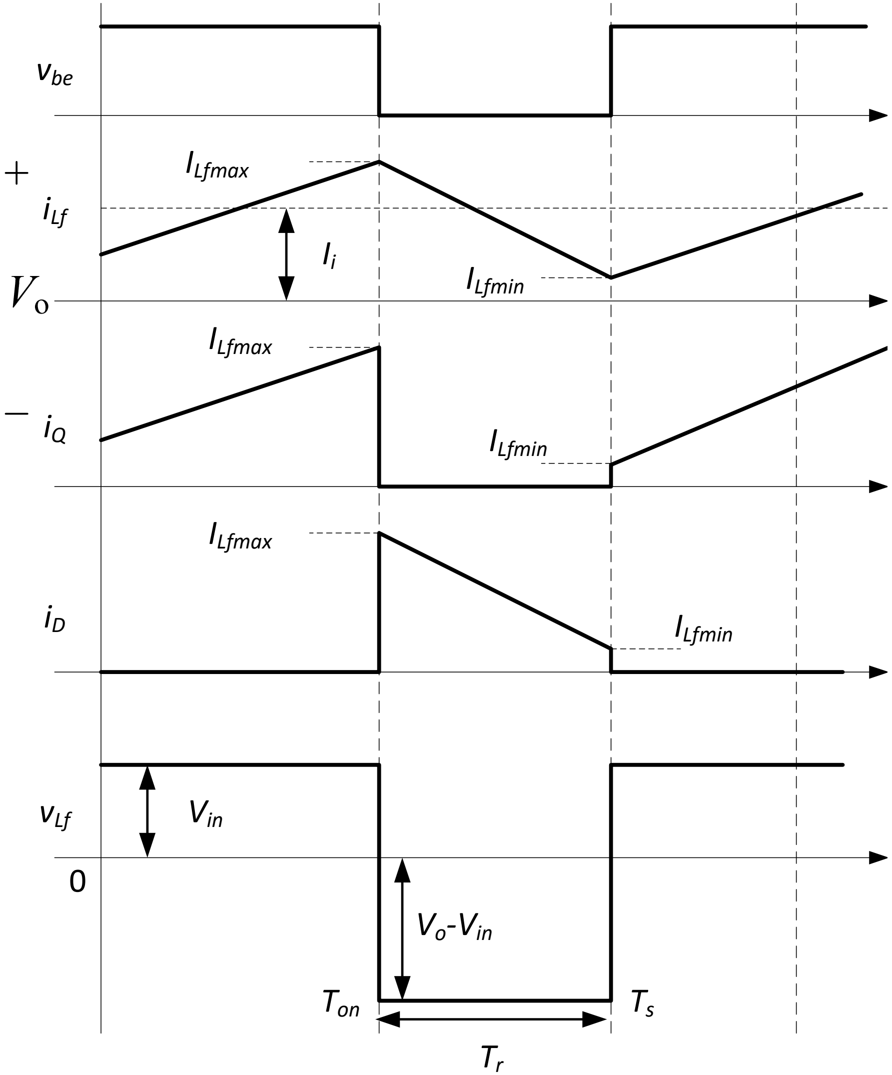

Mode 1




Mode 2

## Mode 1 [0， $t_{on}$]

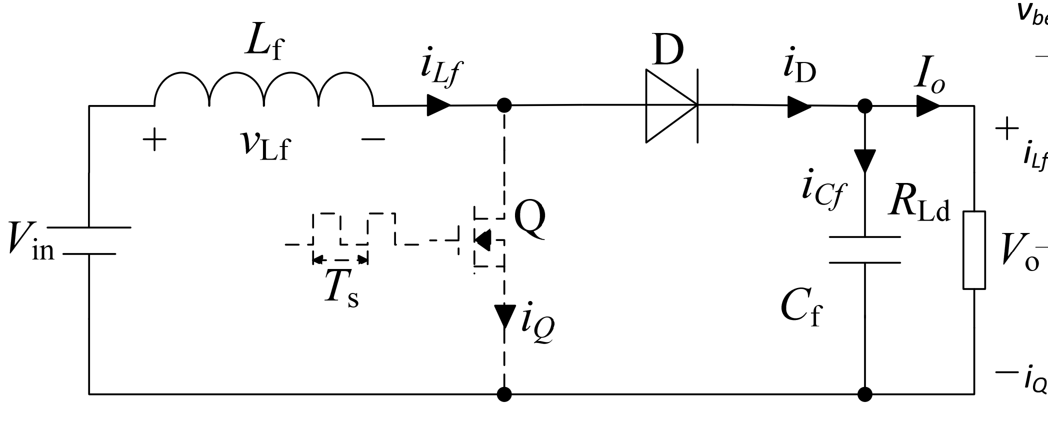


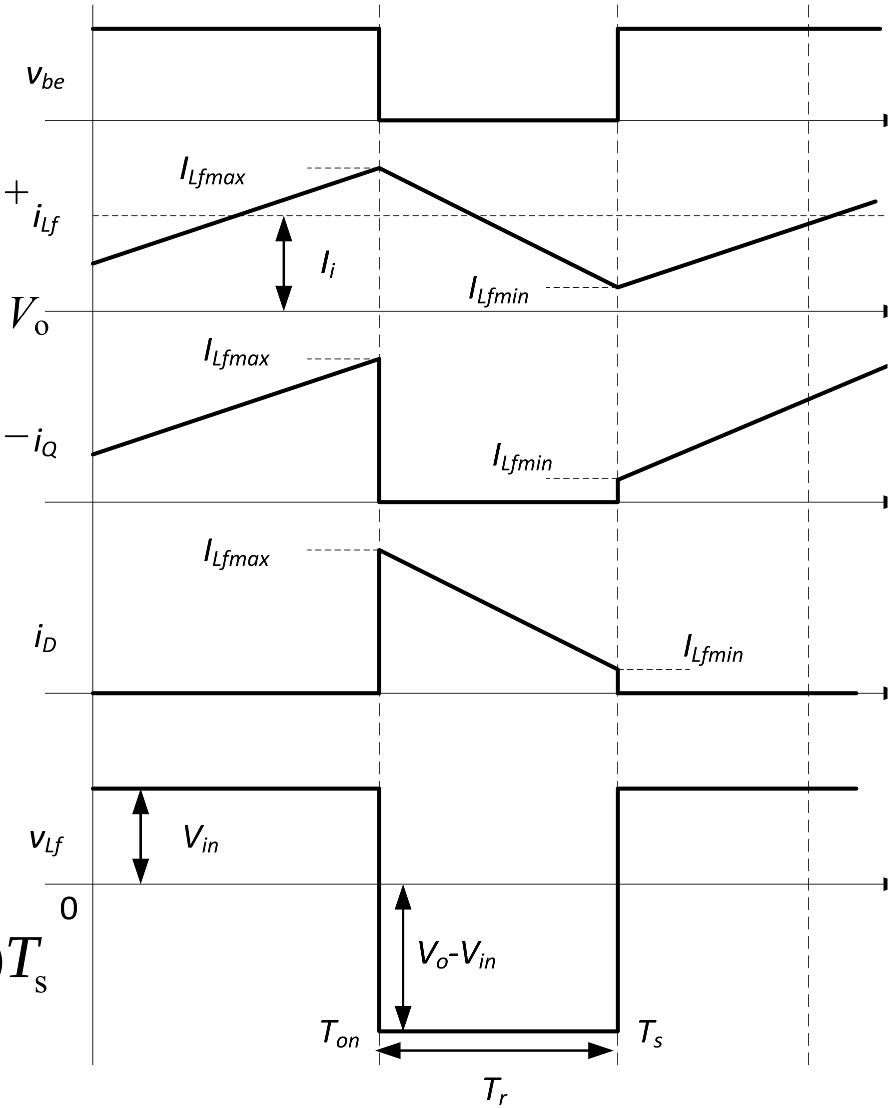




$$v_{Lf} = L_f \frac{di}{dt} = V_{in}$$

$$\Delta I_{Lf(+)} = \frac{V_{in}}{L_f} T_{on} = \frac{V_{in}}{L_f} DT_s$$

## Mode 2 [$t_{on}$， $t_s$]




$$v_{Lf} = L_f \frac{di}{dt} = V_{in} - V_o$$

$$\Delta I_{Lf(-)} = \frac{V_o - V_{in}}{L_f}(T_s - T_{on}) = \frac{V_o - V_{in}}{L_f}(1-D)T_s$$

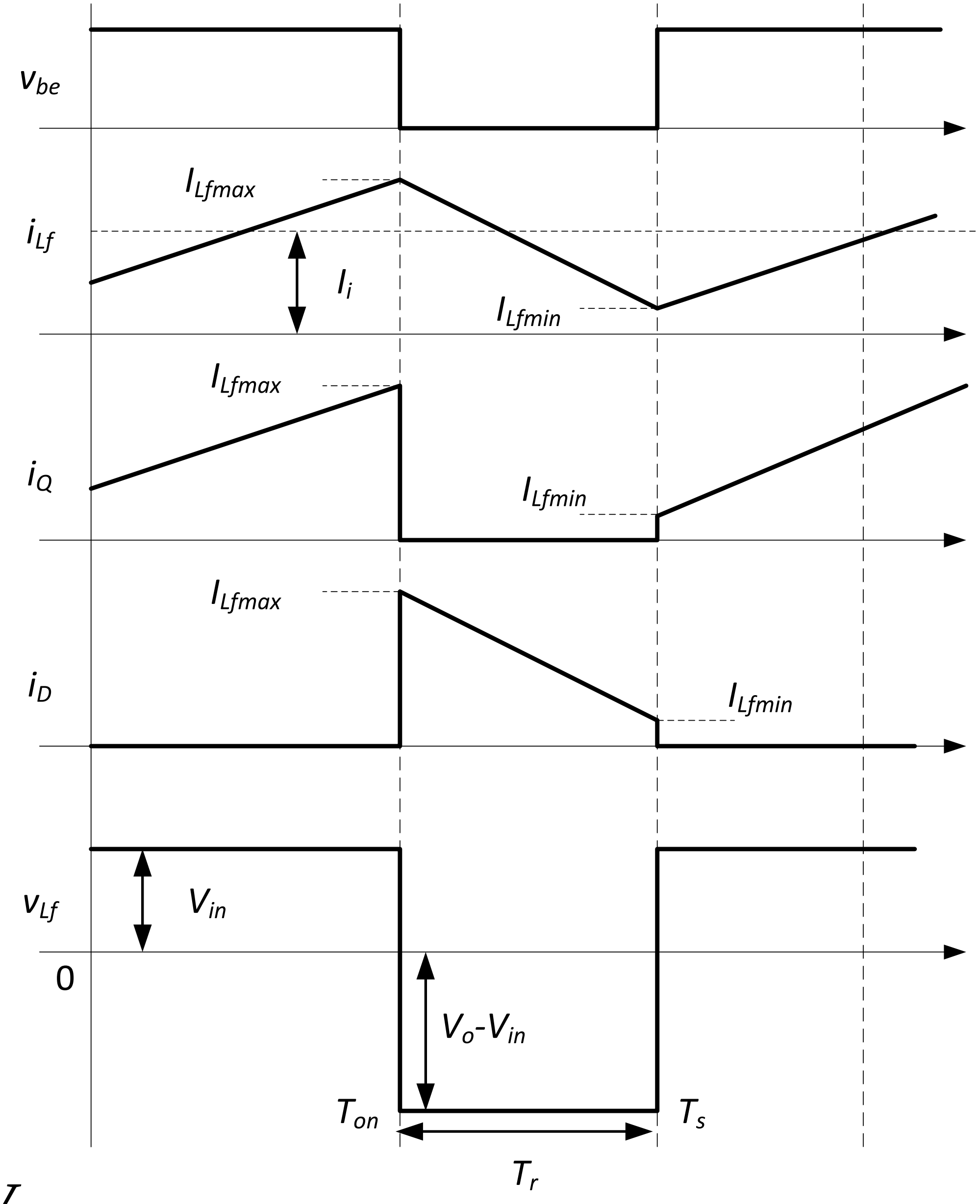
## 基本关系：

$$\Delta I_{\mathrm{Lf}(+)} = \Delta I_{\mathrm{Lf}(-)} = \Delta I_{\mathrm{Lf}}$$

$$\frac{V_{\mathrm{in}}}{L_{\mathrm{f}}} DT_{\mathrm{s}} = \frac{V_{\mathrm{o}} - V_{\mathrm{in}}}{L_{\mathrm{f}}} (1 - D) T_s$$

$$\frac{V_{\mathrm{o}}}{V_{\mathrm{in}}} = \frac{1}{1-D} = \frac{T_{\mathrm{S}}}{T_{\mathrm{S}} - T_{on}}$$

$$I_{\mathrm{in}} = \frac{I_{\mathrm{Lf\,min}} + I_{\mathrm{Lf\,max}}}{2}$$




若Boost变换器的损耗可忽略，则有

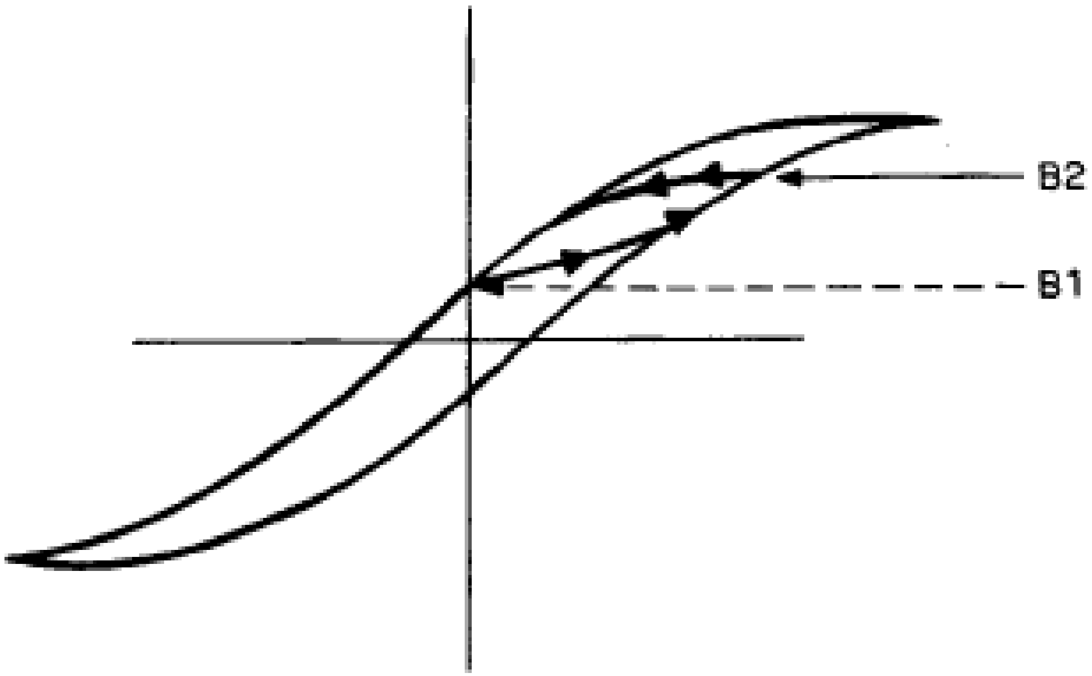
$$\frac{I_o}{I_{in}} = 1 - D \qquad I_D = I_o$$

$$I_Q = I_{in} - I_o = \frac{D}{1-D} I_o$$

Q和D分别截止时 $V_Q = V_D = V_o$

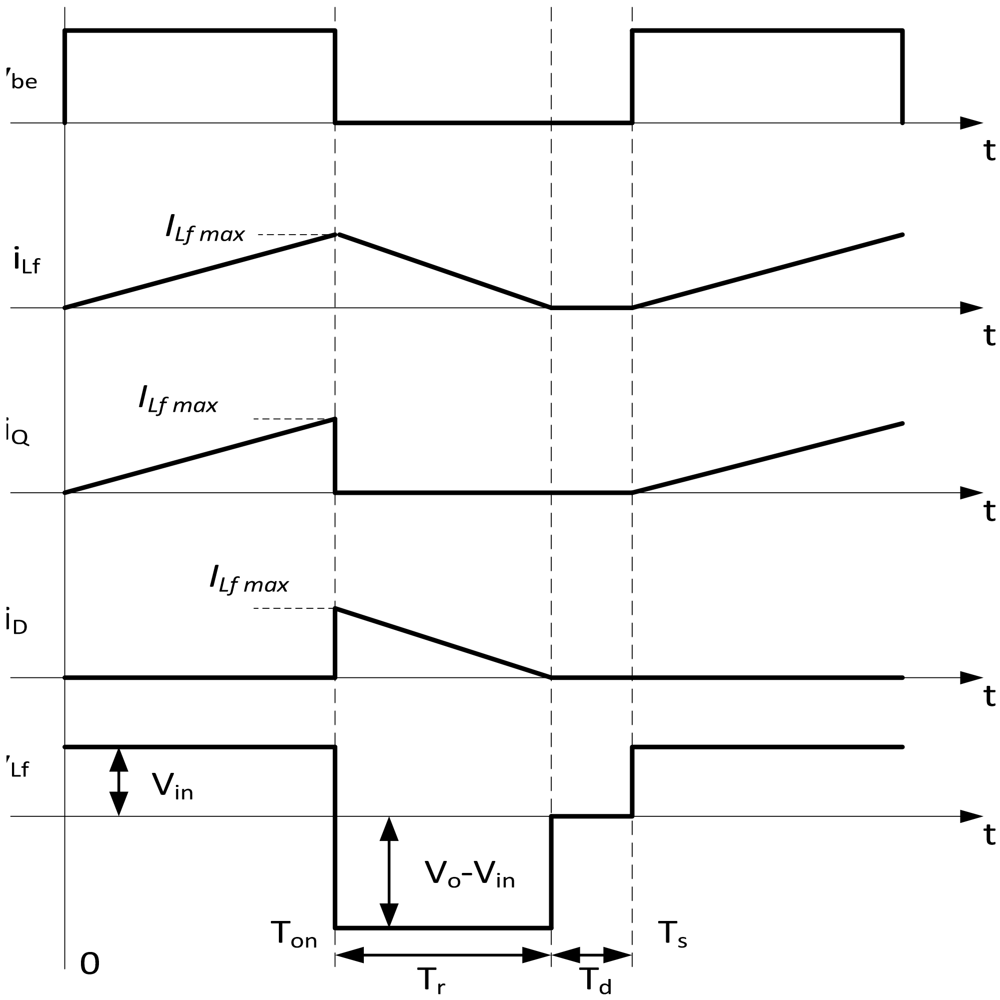
法拉第电磁定律： $$E = NA_e\left(dB/dt\right)\times 10^{-8}$$

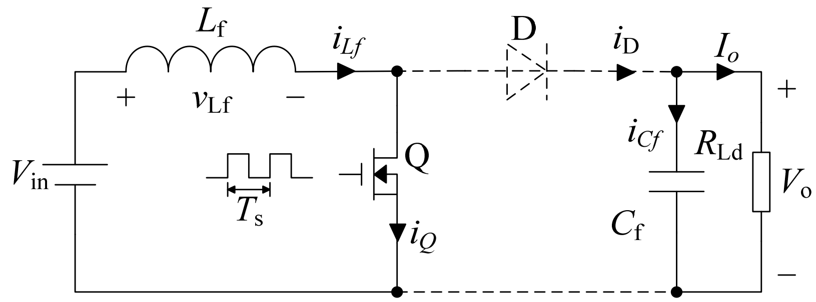
$$dB = \frac{Edt\times 10^{+8}}{NA_e}$$



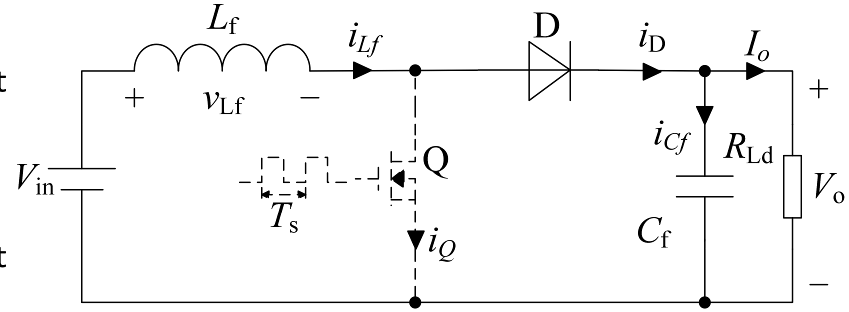

$$V_{\mathrm{in}}T_{on} = \left(V_{\mathrm{o}} - V_{\mathrm{in}}\right)T_{off}$$

# 电流断续时的工作模式(DCM)

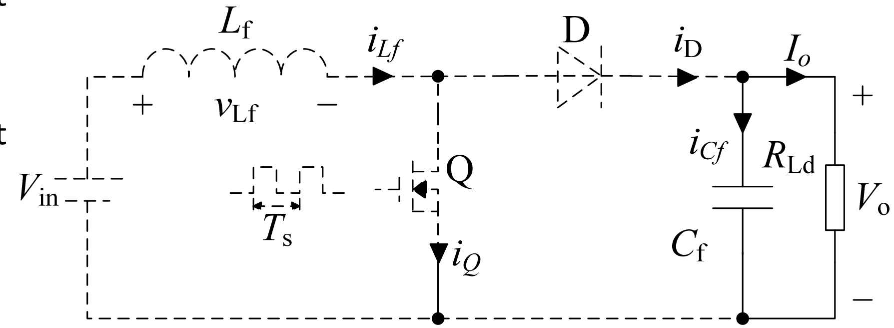



Mode 1




Mode 2




Mode3

## 电流断续时的工作模式(DCM)

一个周期内电感储存的能量：

$$E=\frac{1}{2}L_f I_{L\max}^2$$

假设能量传递效率100%：

$$P_L=\frac{\frac{1}{2}L_f I_{L\max}^2}{T}$$

电感电流下降时，电流流经Vin，给负载提供能量：

$$P_{in}=V_{in}\frac{I_{L\max}}{2}\frac{T_r}{T_s}$$

输送给负载的总功率：

$$P_t=P_L+P_{in}=\frac{\frac{1}{2}L_f I_{L\max}^2}{T_s}+V_{in}\frac{I_{L\max}}{2}\frac{T_r}{T_s}$$

由于 $I_{L\max}=V_{in}T_{on}/L_f$

$$P_t=\frac{\frac{1}{2}L_f\left(V_{in}T_{on}/L_f\right)^2}{T_s}+V_{in}\frac{V_{in}T_{on}}{2L_f}\frac{T_r}{T_s}=\frac{V_{in}^2T_{on}}{2T_sL_f}\left(T_{on}+T_r\right)$$

令 $\left(T_{on}+T_r\right)=kT_s$， $k<1$

如果输出电压为Vo，输出负载电阻为Ro，则

$$P_t=\frac{V_{in}^2T_{on}}{2T_sL_f}\left(kT_s\right)=\frac{V_o^2}{R}$$

或 $V_o=V_{in}\sqrt{\dfrac{kR_oT_{on}}{2L_f}}$

设定整个周期的**20%**为死区时间***T*$_{dt}$**。这样将保证**L**的电流在**Q**导通前降到零。

$$T_{on\max} + T_r + T_{dt} = T$$

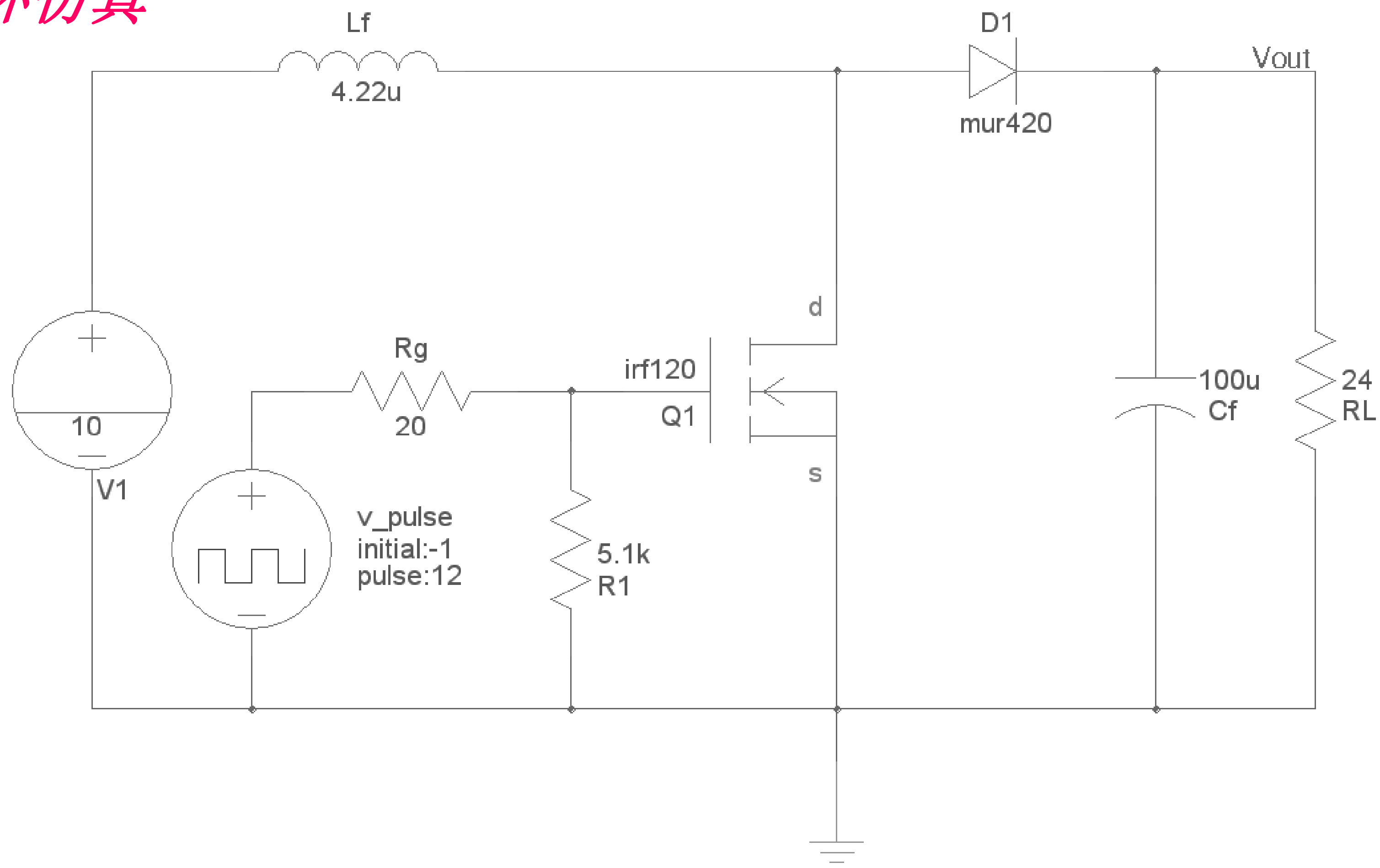
$$T_{on\max} + T_r = 0.8T$$

$$V_{in\min} T_{on\max} = (V_o - V_{in\min}) T_r$$

$$T_{on\max} = \frac{0.8T(V_o - V_{dc\min})}{V_o}$$

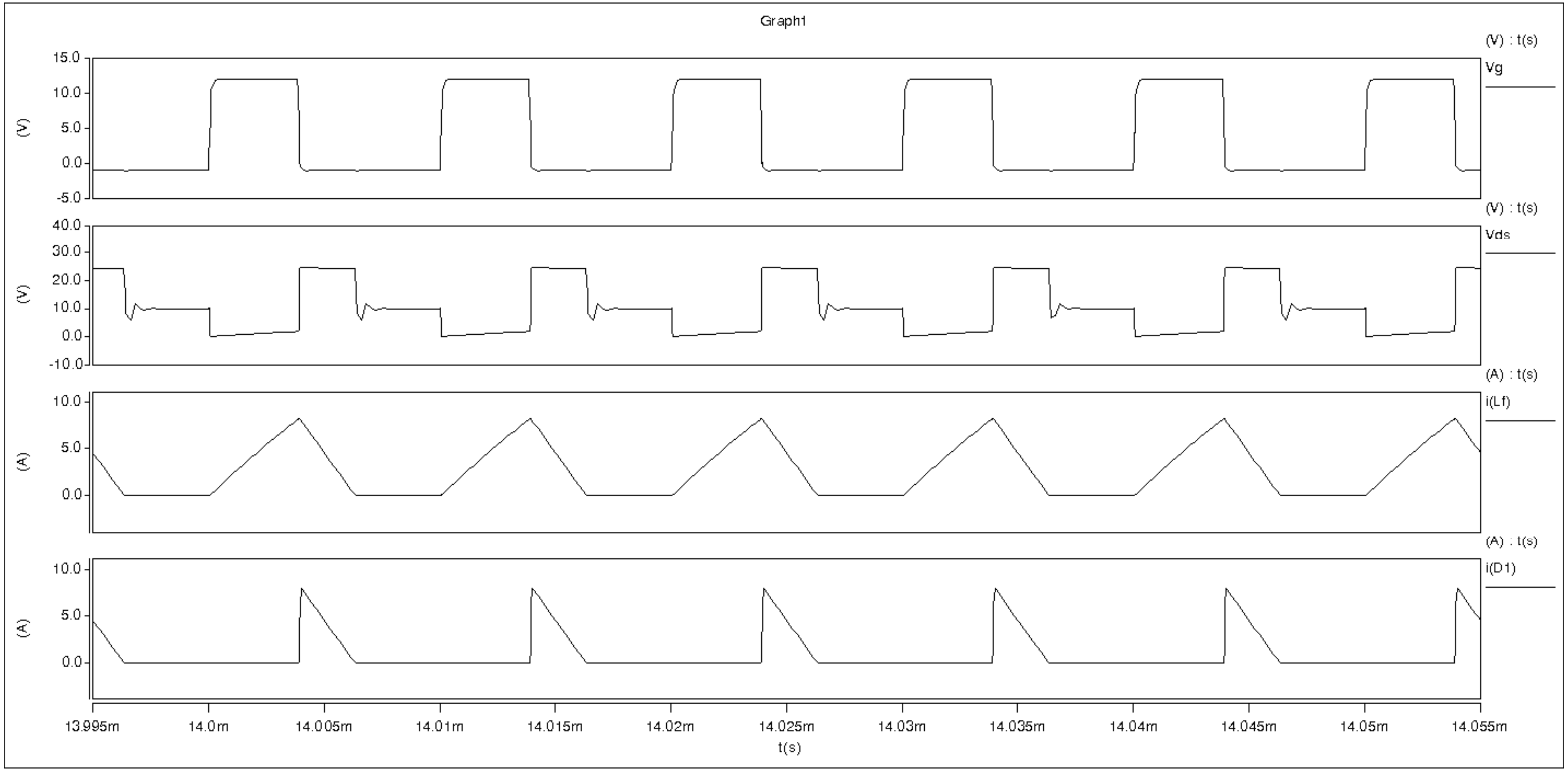
# 5.2 Boost变换器仿真

## *开环仿真*



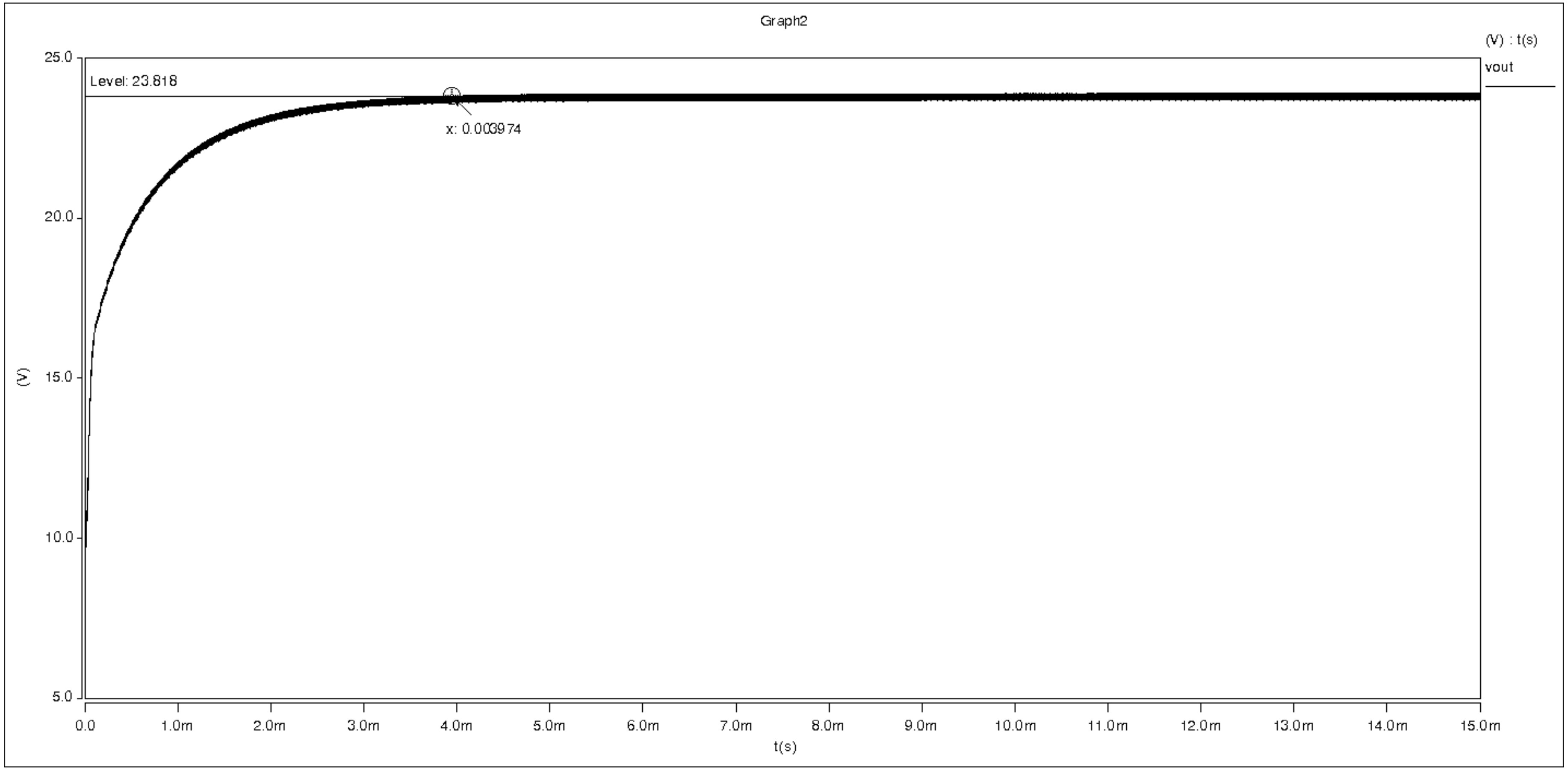

Boost变换器开环仿真模型图

# 5.2 Boost变换器仿真




Boost变换器开环仿真关键点波形

# 5.2 Boost变换器仿真

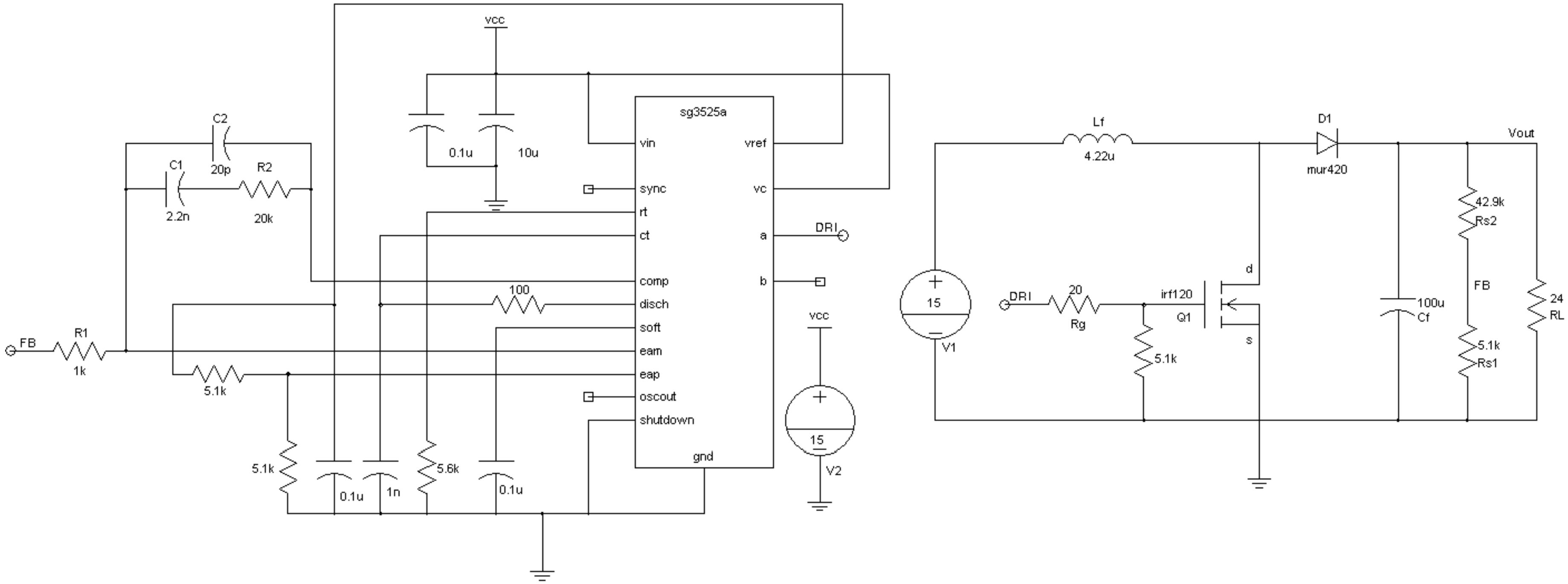



Boost开环仿真输出电压波形

输出电压稳定在23.82V。

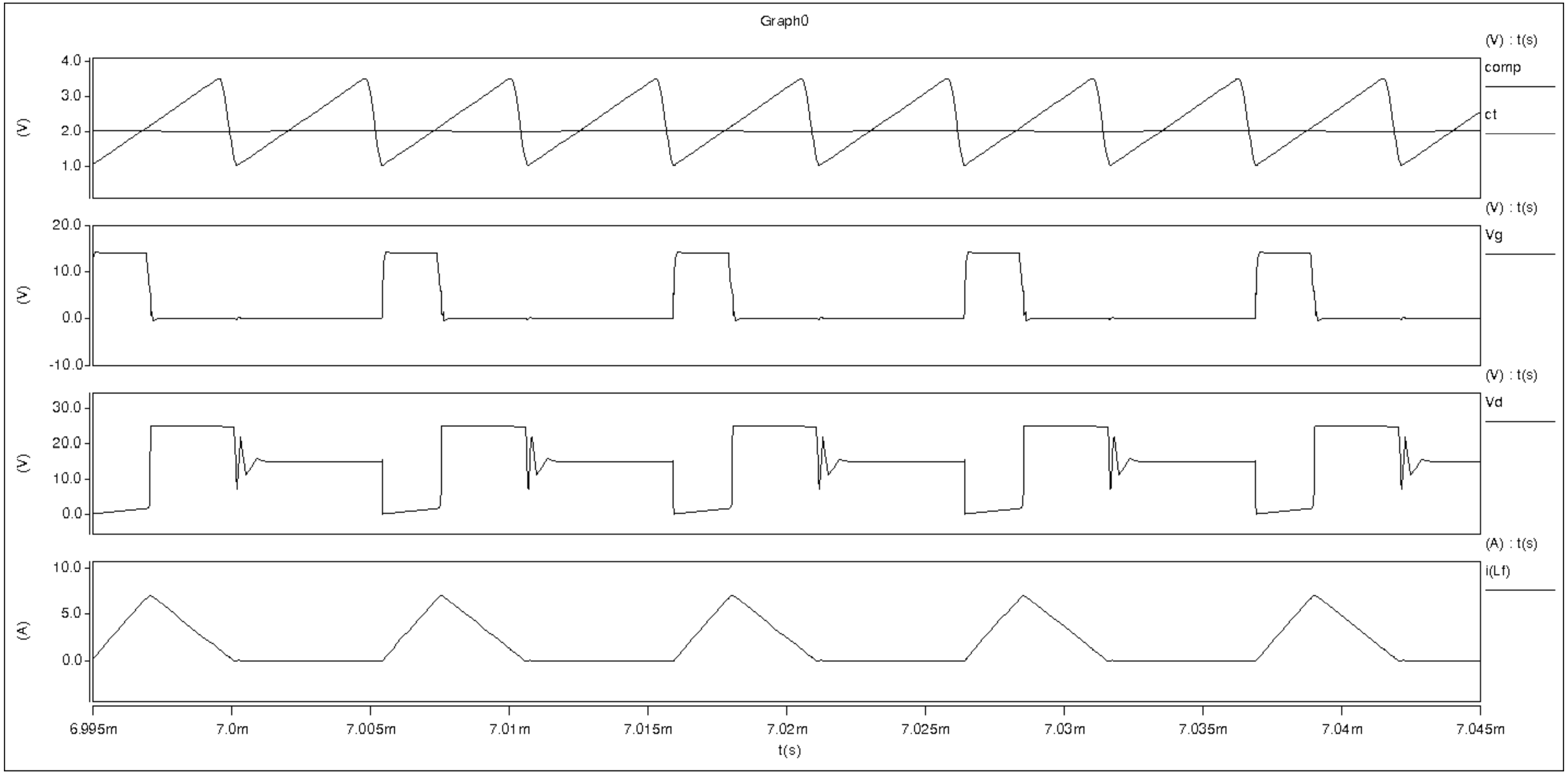
# 5.2 Boost变换器仿真

## *闭环仿真*



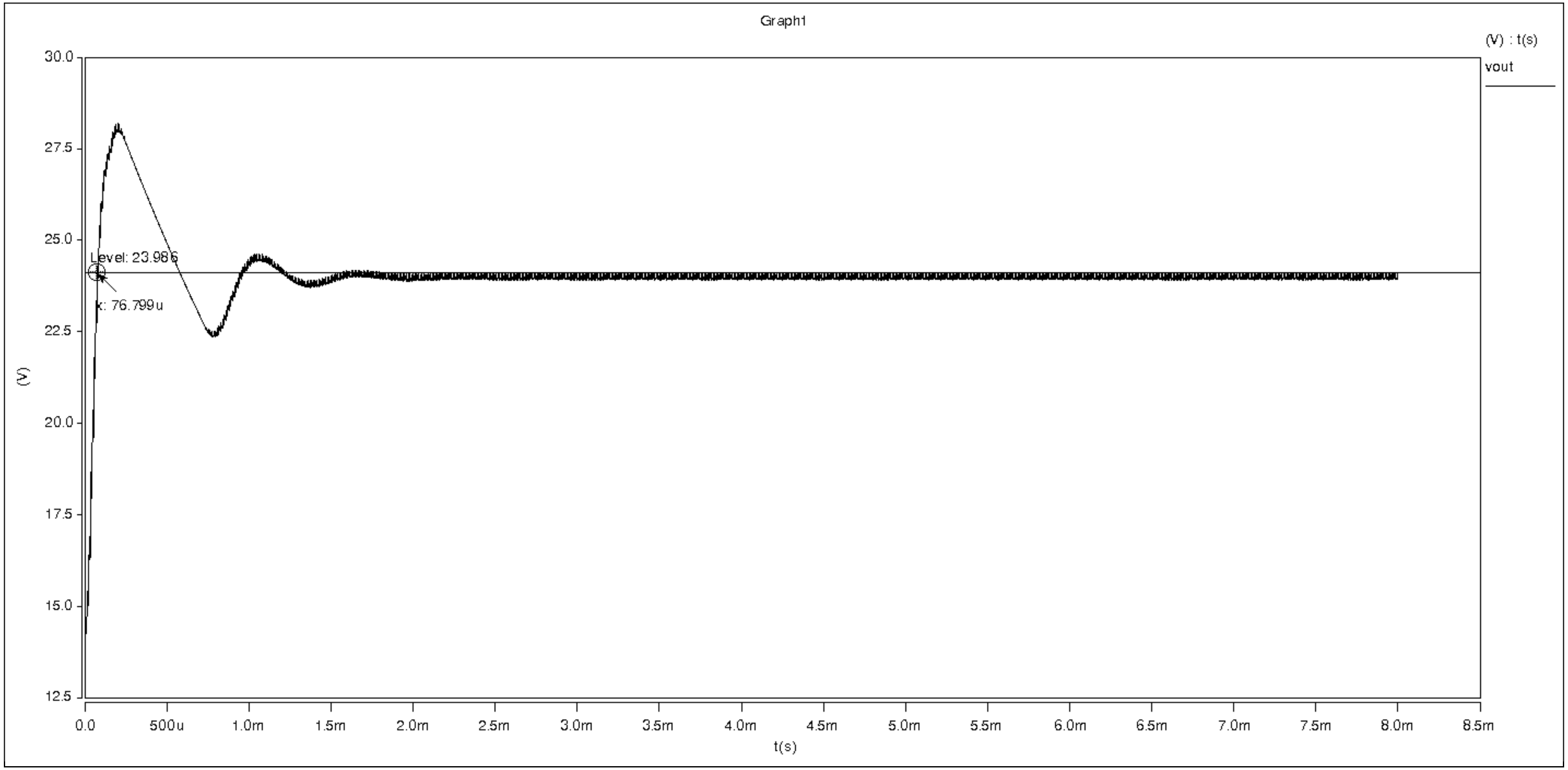

基于SG3525控制的Boost变换器的仿真模型图

# 5.2 Boost变换器仿真




Boost变换器闭环仿真关键点的输出波形

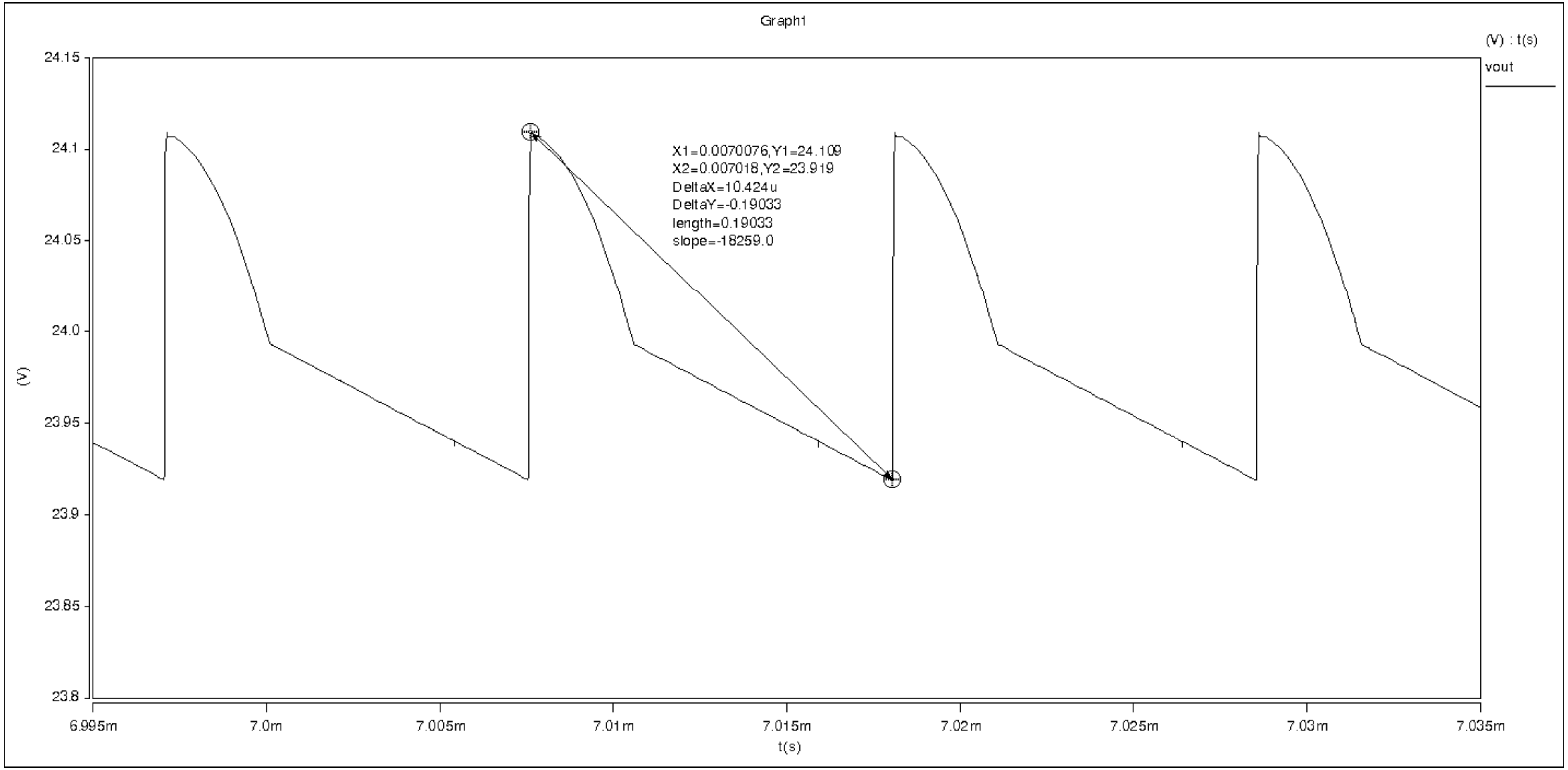
# 5.2 Boost变换器仿真




Boost变换器闭环仿真输出电压波形

输出电压基本稳定在23.98V

# 5.2 Boost变换器仿真




Boost变换器闭环仿真输出电压纹波

其电压纹波为0.19V，在1%内