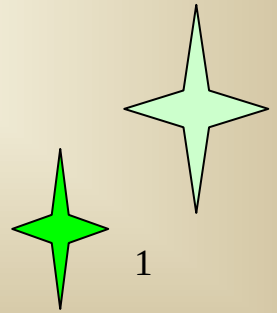
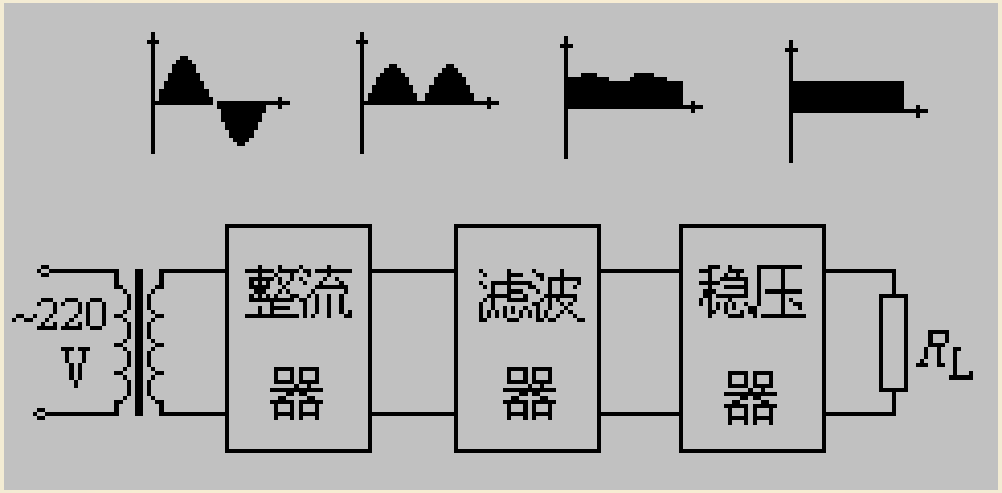
11 直流稳压电源



11.1 概述

直流电源的组成



变压器：交流降压；

整流器：将交流电变为单向脉动的电压；

滤波器：减少波形脉动，使波形平滑；

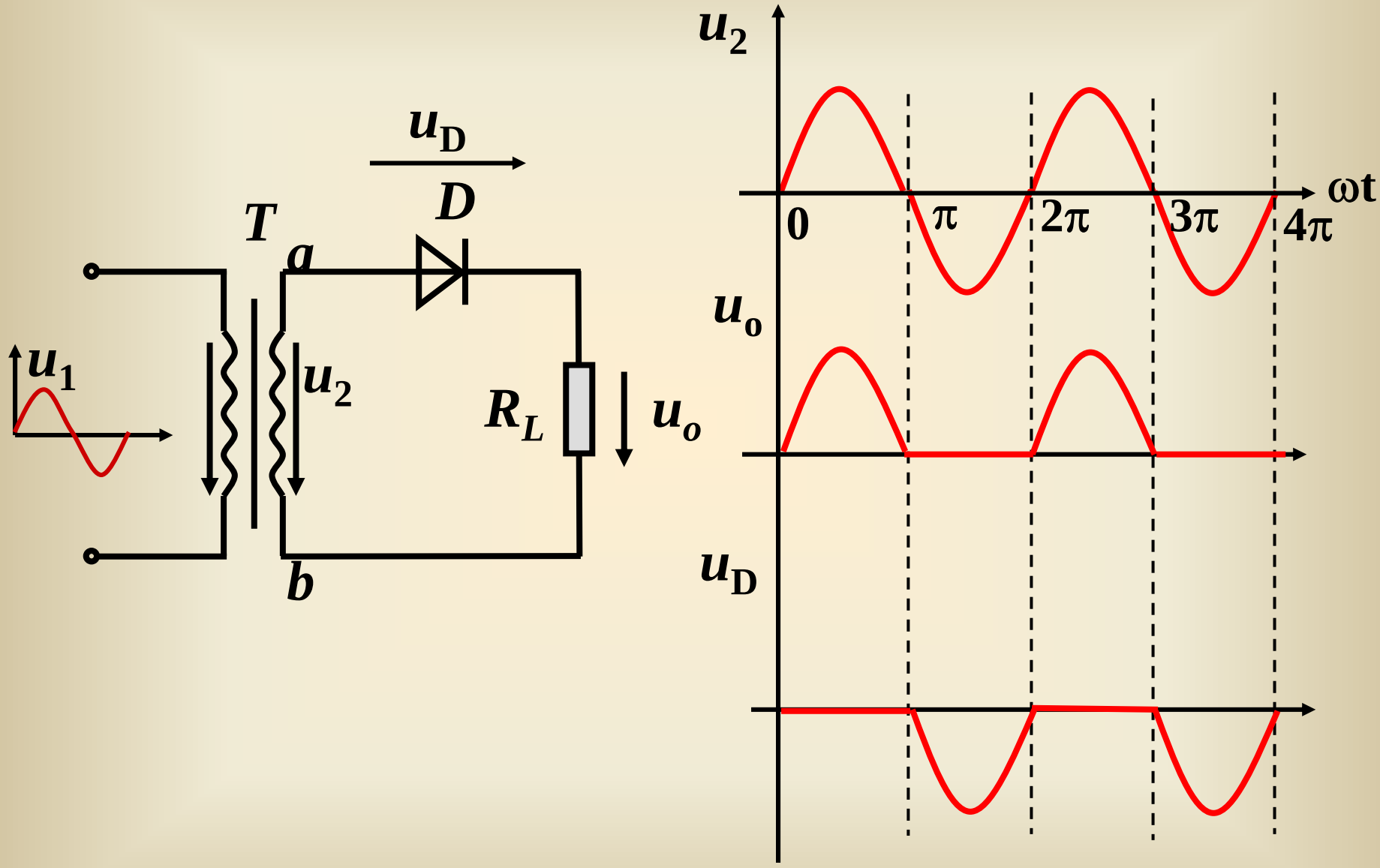
稳压器：负载变化或电网波动时使输出电压稳定。

11.2 单相整流电路

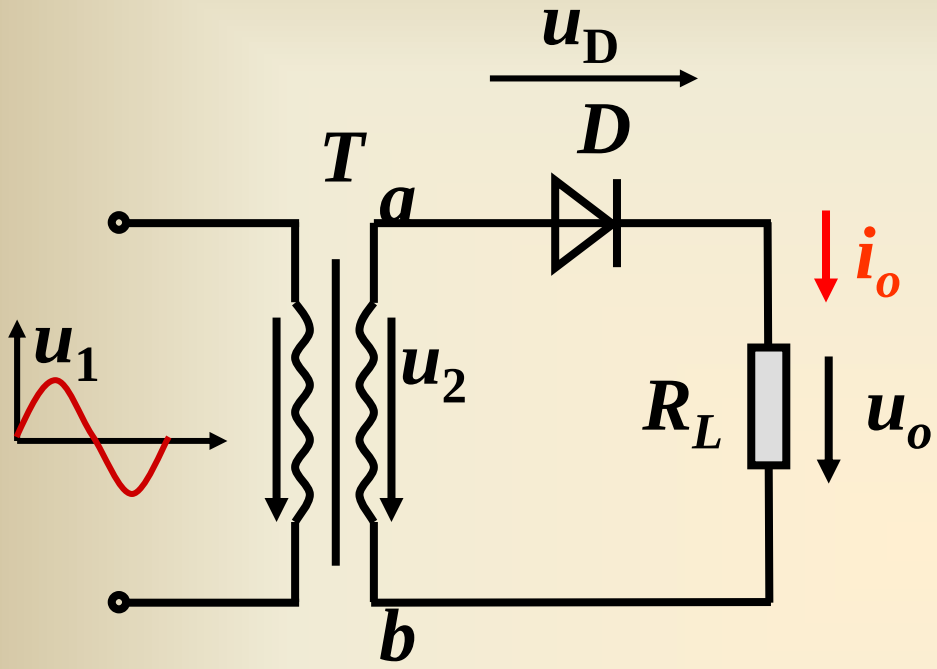
单相整流电路种类：

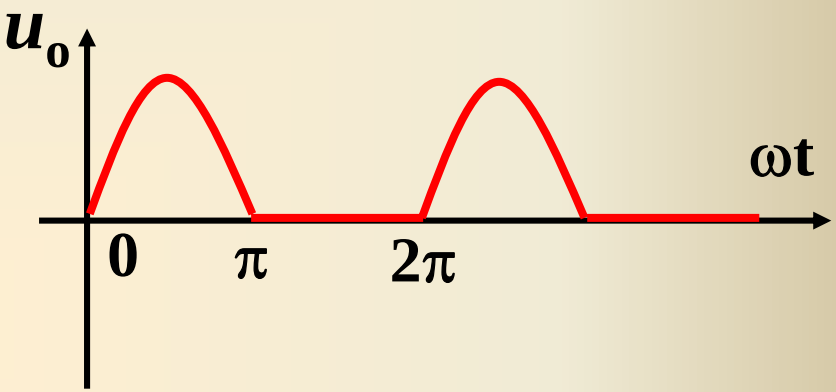
半波、全波、桥式、倍压等

• 11.2.1 单相半波整流电路



输出电压平均值（U_o）,输出电流平均值（I_o）:





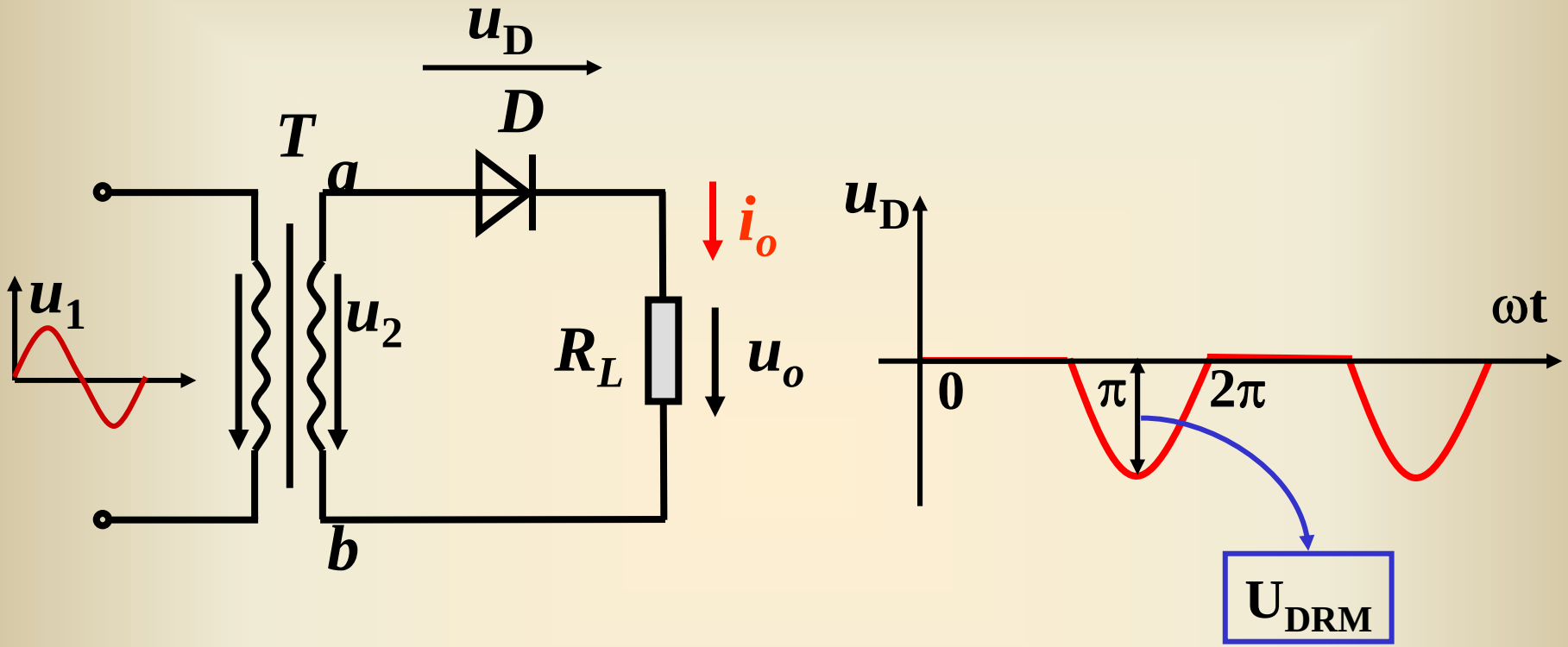
$$U_o = \frac{1}{2\pi}\int_0^{2\pi} u_o\, d(\omega t) = \frac{1}{2\pi}\int_0^{\pi} \sqrt{2}U_2 \sin\omega t\, d(\omega t)$$

$$= \frac{\sqrt{2}U_2}{\pi} = 0.45U_2$$

$$I_o = U_o / R_L = 0.45\, U_2 / R_L$$

U_2为有效值

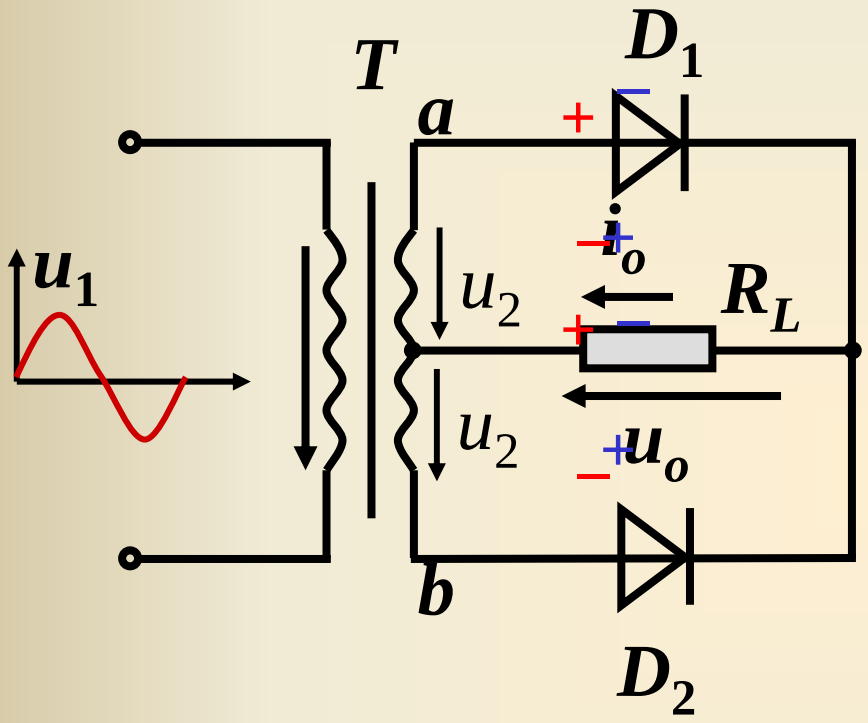
二极管上的平均电流及承受的最高反向电压：



二极管上的平均电流：　$I_D = I_O$

承受的最高反向电压：　$U_{DRM} = \sqrt{2}U_2$

• 11.2.2 单相全波整流电路



原理：

变压器副边中心抽头，
感应出两个相等的电压u_2

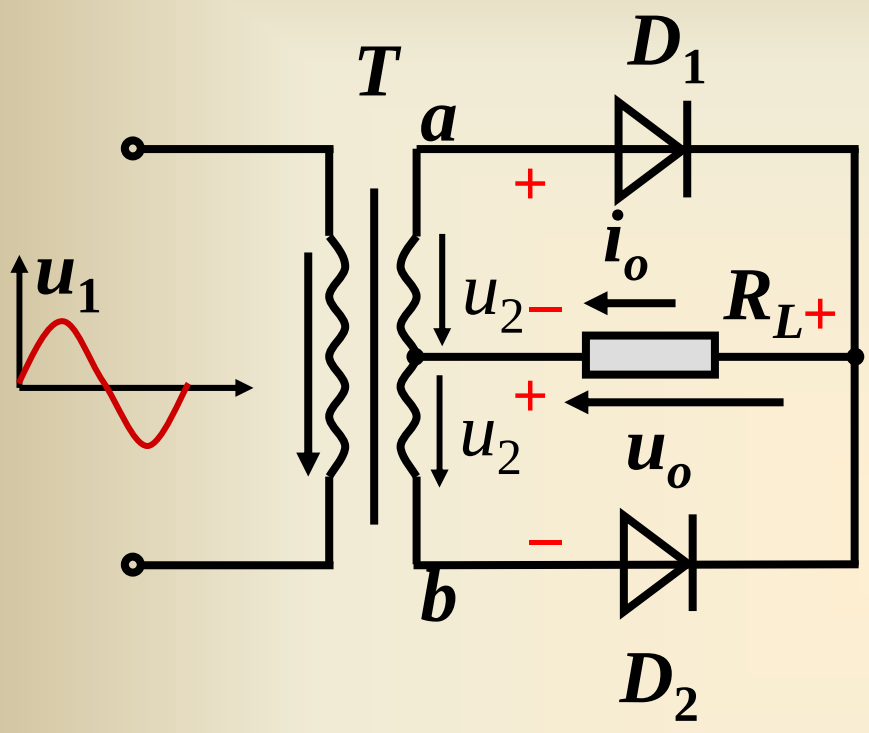
当u_2正半周时， D_1导通，

D_2截止。

当u_2负半周时， D_2导通，

D_1截止。

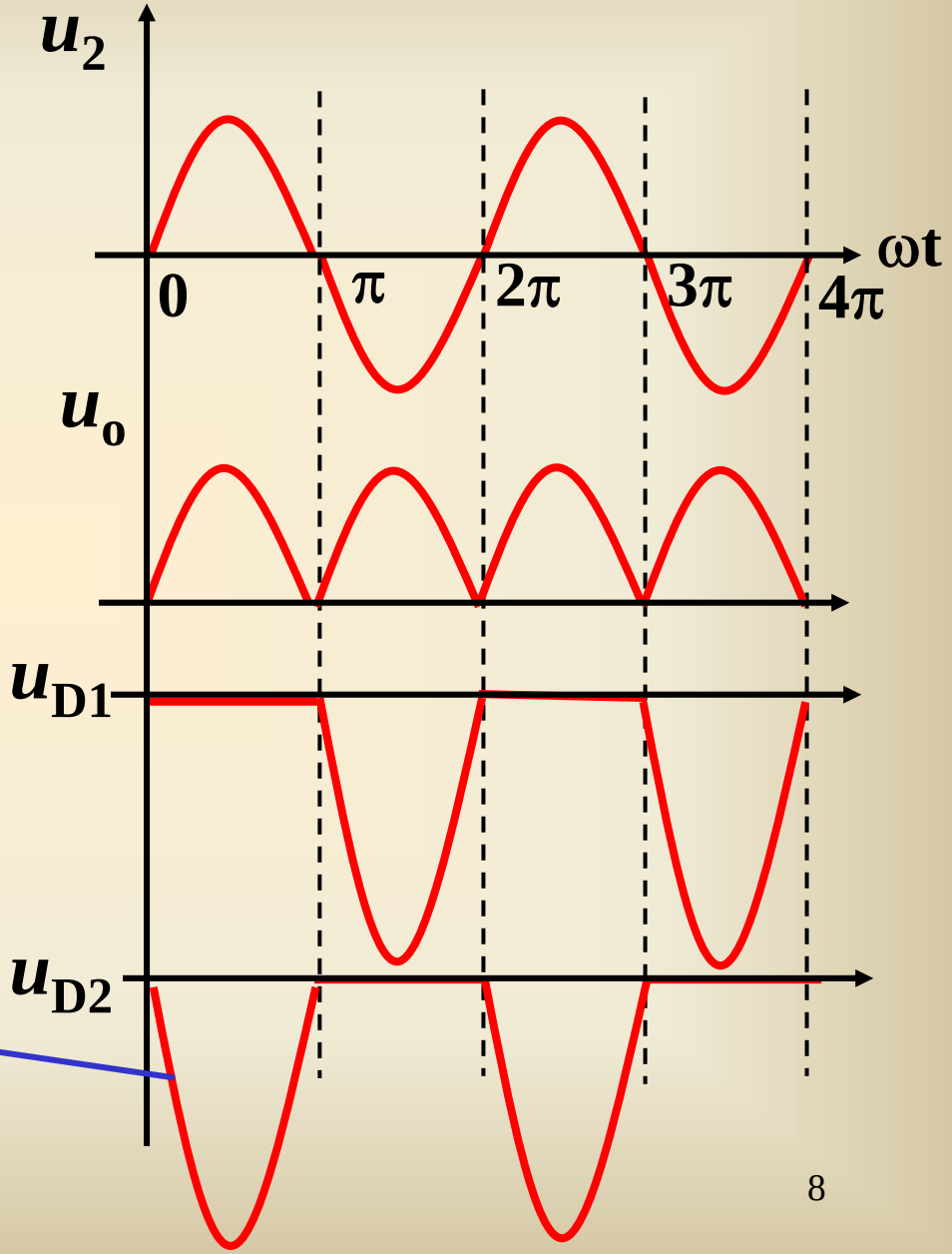
单相全波整流电压波形



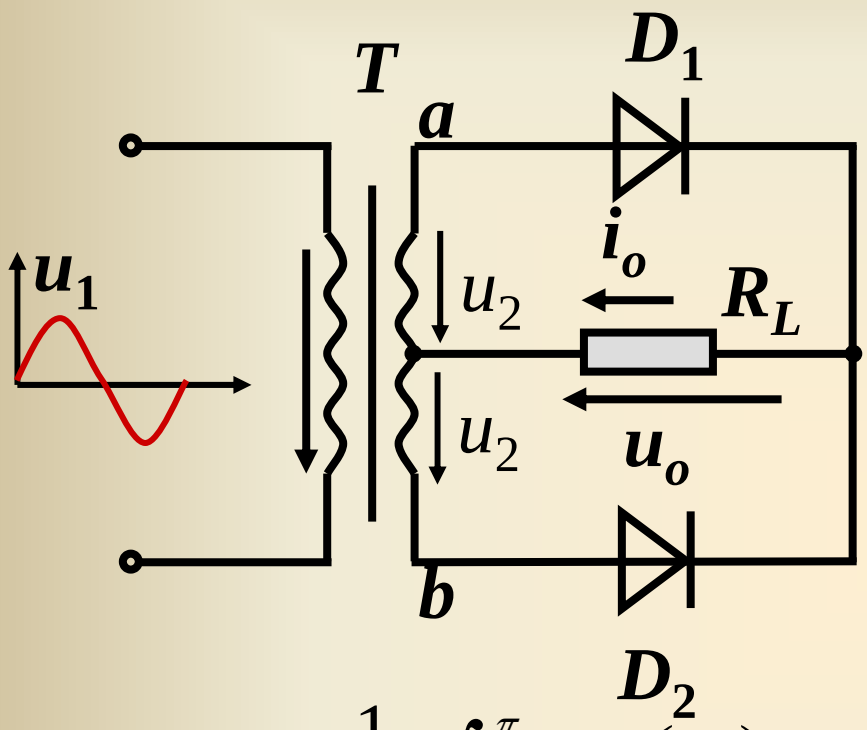
忽略二极管正向压降

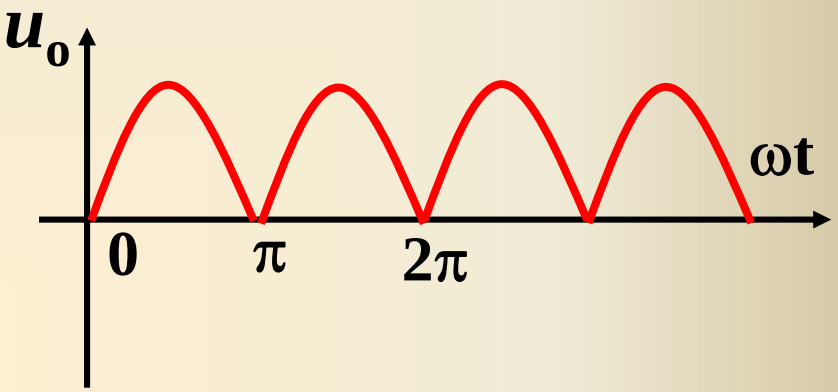
$0 \sim \pi$:

$u_{D2} = 2u_2$



输出电压平均值（U_o）,输出电流平均值（I_o）:



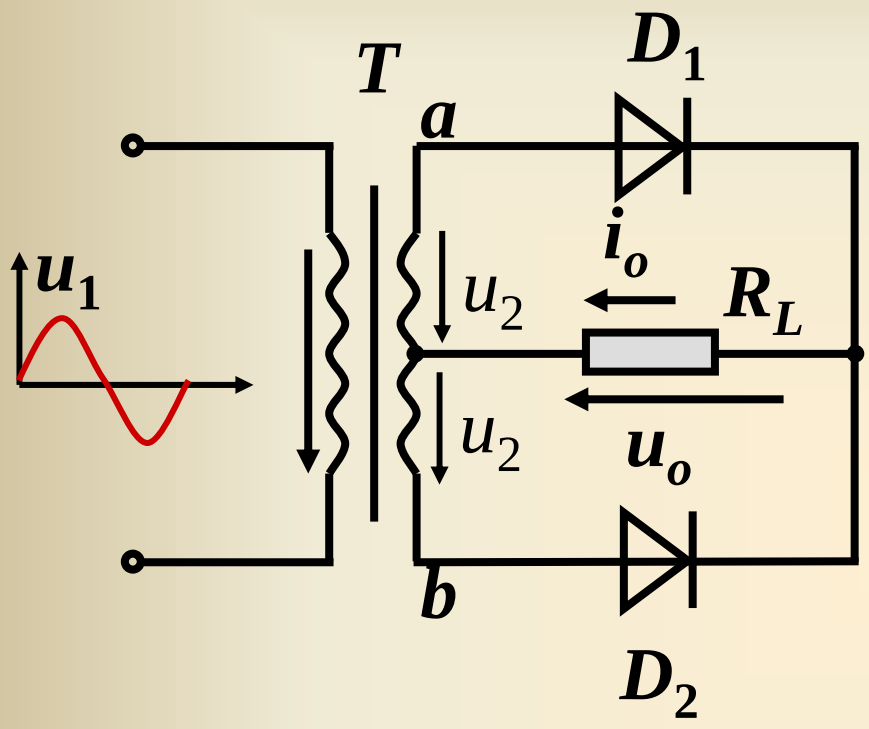


$$U_o = \frac{1}{\pi}\int_0^{\pi} u_o\, d(\omega t) = \frac{1}{\pi}\int_0^{\pi} \sqrt{2}U_2 \sin\omega t\, d(\omega t)$$

$$= \frac{2\sqrt{2}U_2}{\pi} = 0.9\,U_2$$

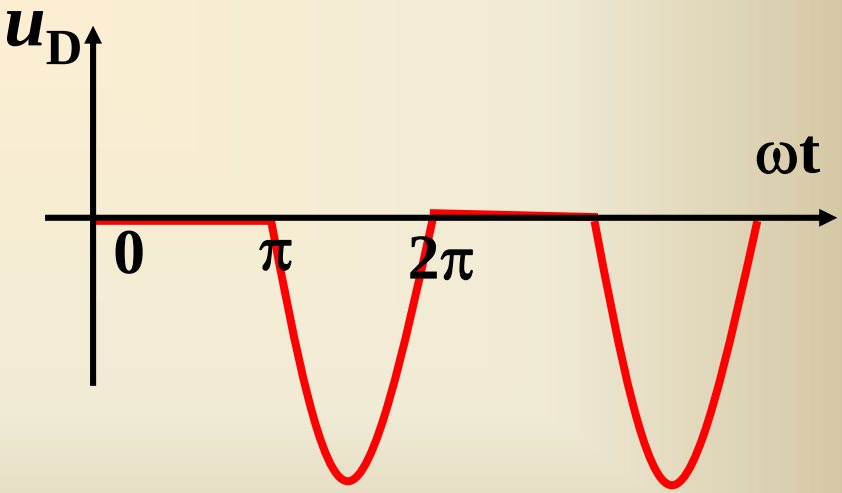
$$I_o = U_o / R_L = 0.9\,U_2 / R_L$$

二极管上的平均电流及承受的最高反向电压：



二极管上的平均电流：

$$I_D = \frac{1}{2} I_o$$

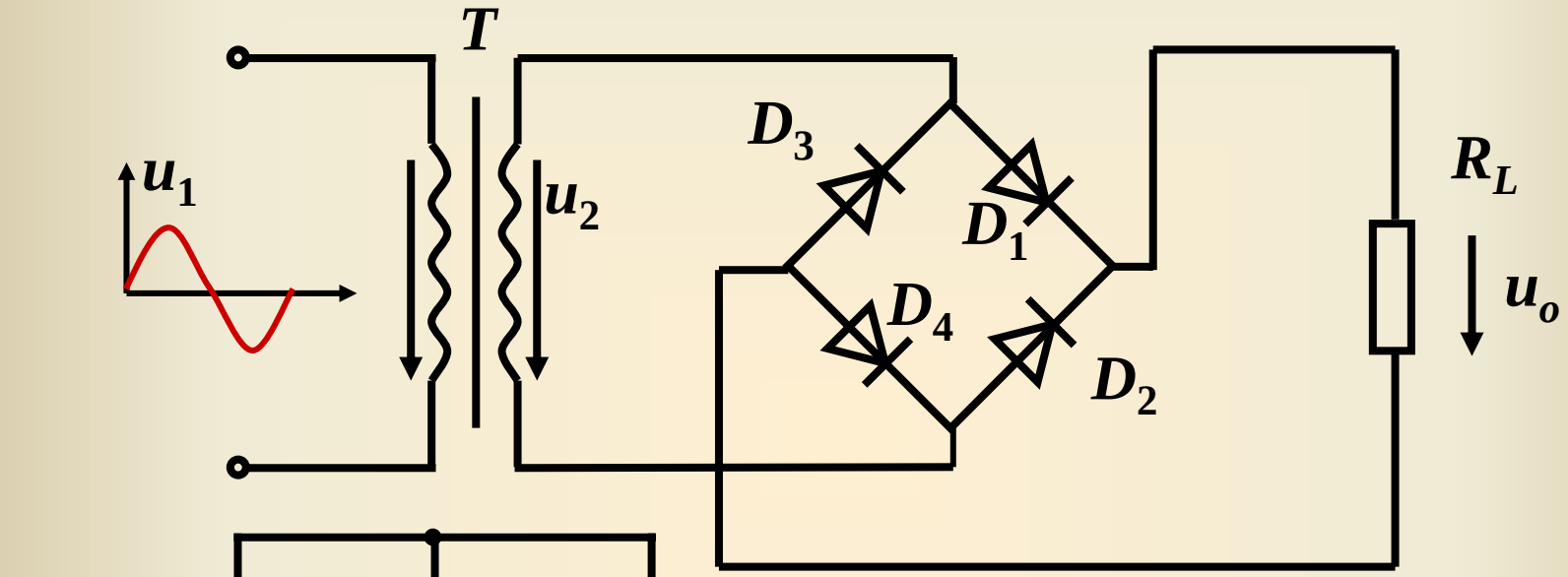


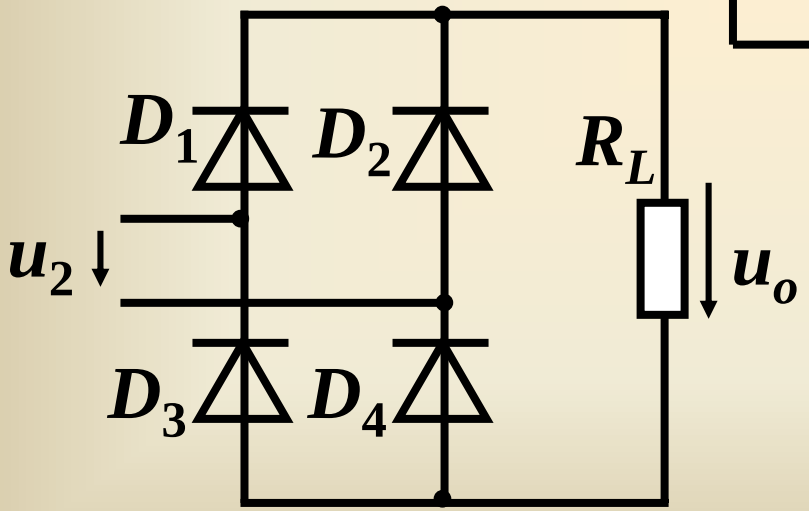
二极管承受的最高反向电压：

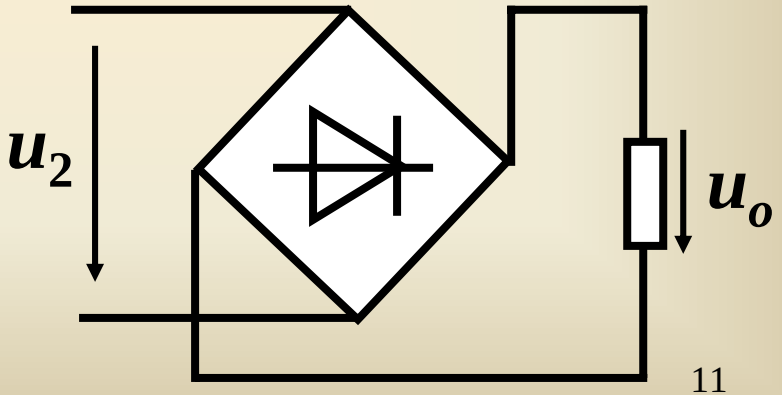
$$U_{DRM} = 2\sqrt{2}U_2$$

11.2.3 单相桥式整流电路

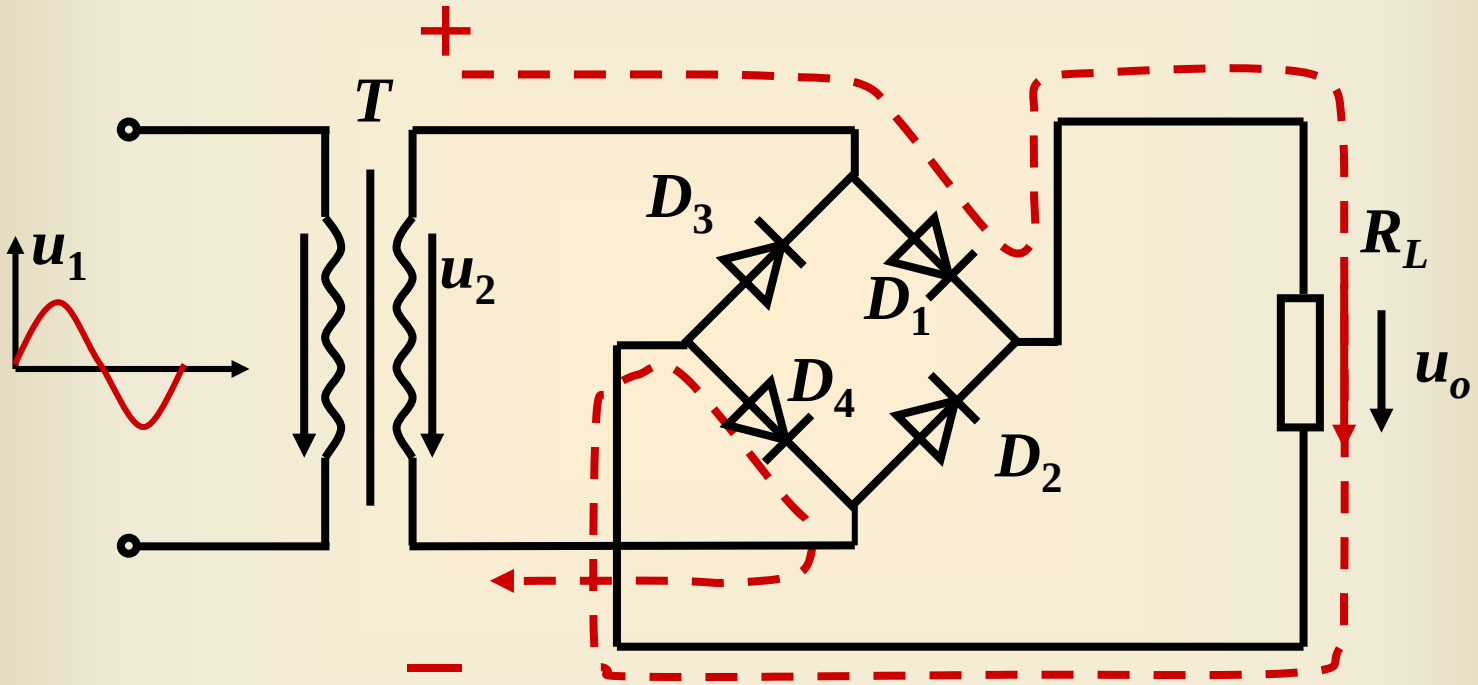
组成：由四个二极管组成桥路





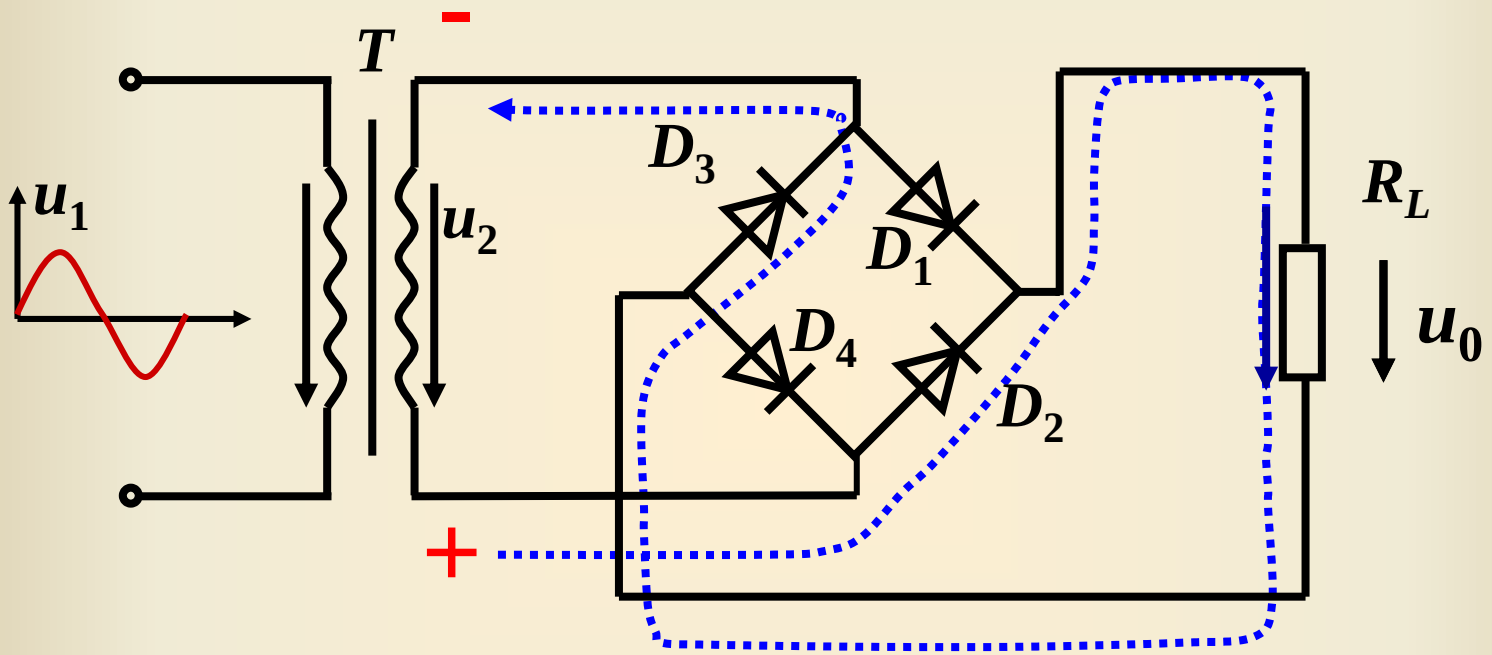


u_2正半周时电流通路



D_1、D_4导通，D_2、D_3截止

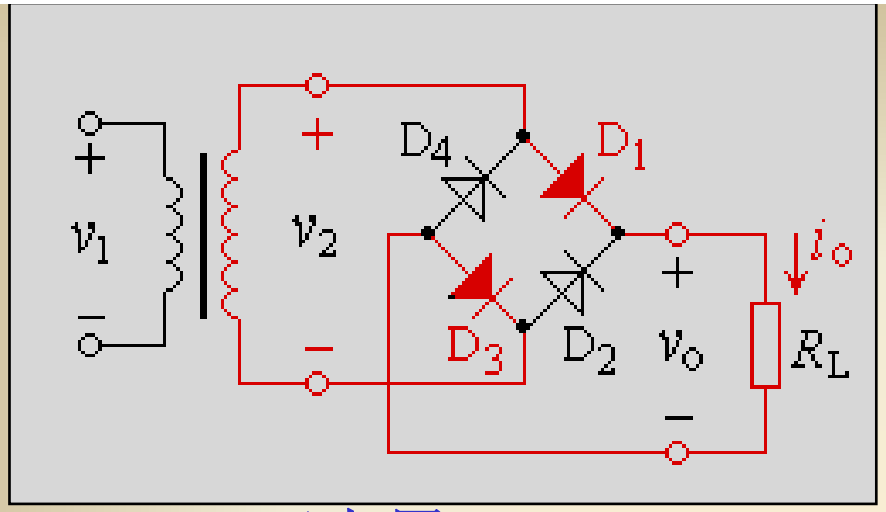
u_2负半周时电流通路



D_2、D_3 导通， D_1 、D_4截止

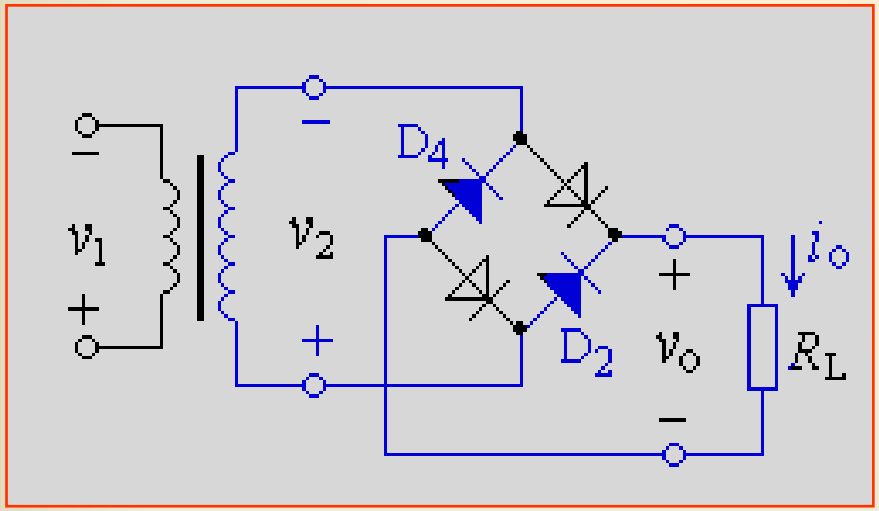
（1）工作原理

利用二极管的单向导电性

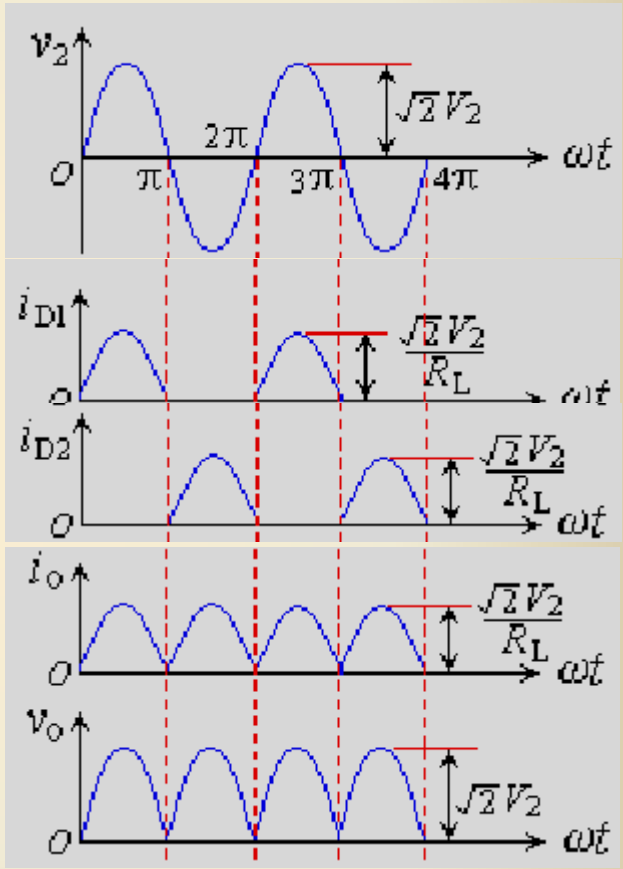


正半周

负半周



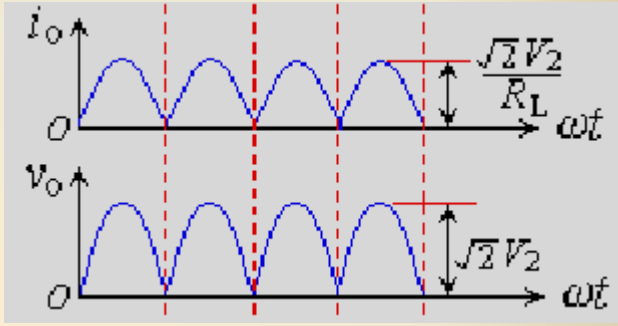
（a）桥式整流电路



（b）波形图

(2) 参数计算 ——输出与D

输入（交流）—用有效值(V_2)；
输出（交直流）—用平均值；
整流管正向电流—用平均值；
整流管反向电压—用最大值。



输出平均电压为 $V_O = V_L = \frac{1}{\pi}\int_0^{\pi}\sqrt{2}V_2 \sin\omega t \mathrm{d}\omega t = \frac{2\sqrt{2}}{\pi}V_2 = 0.9V_2$

流过负载的平均电流为 $I_L = \frac{V_o}{R_L} = \frac{0.9V_2}{R_L}$

流过二极管的平均电流为 $I_D = \frac{I_L}{2}$

二极管所承受的最大反向电压 $V_{Rmax} = \sqrt{2}V_2$

脉动系数S:

最低次谐波的幅值与平均值的比值

将输出电压做傅里叶分解：此时谐波分量中的最低次谐波幅度最大

$$v_O = \sqrt{2}V_2\left(\frac{2}{\pi} - \frac{4}{3\pi}\cos 2\omega t - \frac{4}{15\pi}\cos 4\omega t + \cdots\right)$$

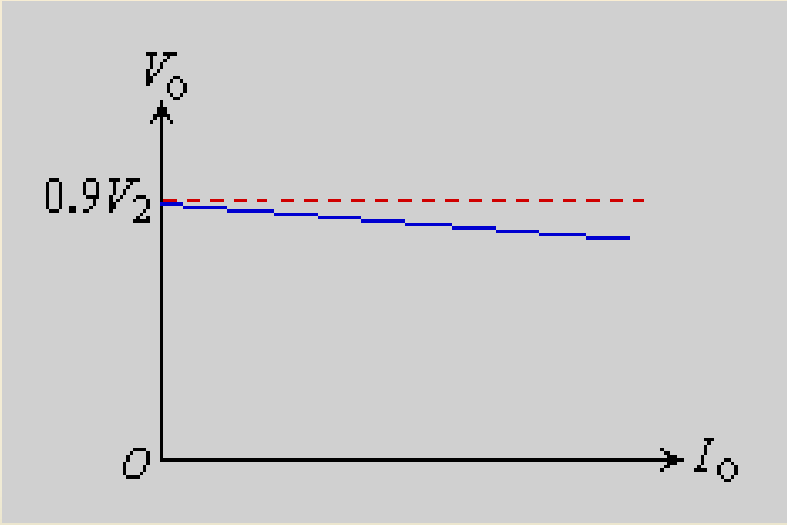
$$S = \frac{4\sqrt{2}V_2}{3\pi} \Big/ \frac{2\sqrt{2}V_2}{\pi} = \frac{2}{3} = 0.67$$

(3) 负载特性曲线

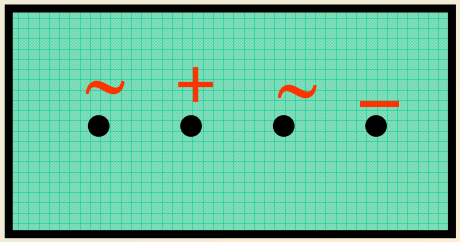
是指输出电压与负载电流之间的关系曲线

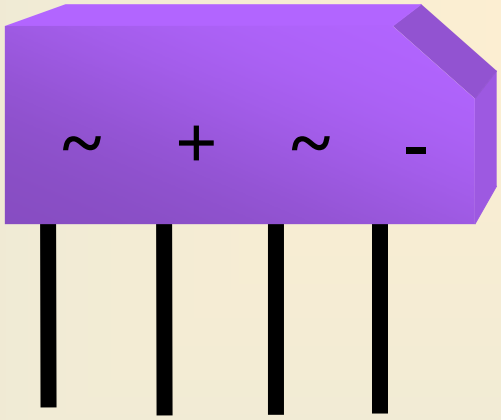
$$V_O = f(I_O)$$

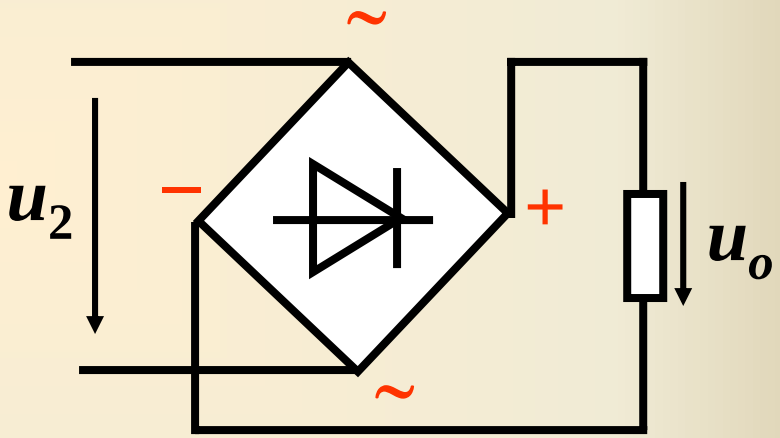
曲线的斜率代表了整流电路的内阻



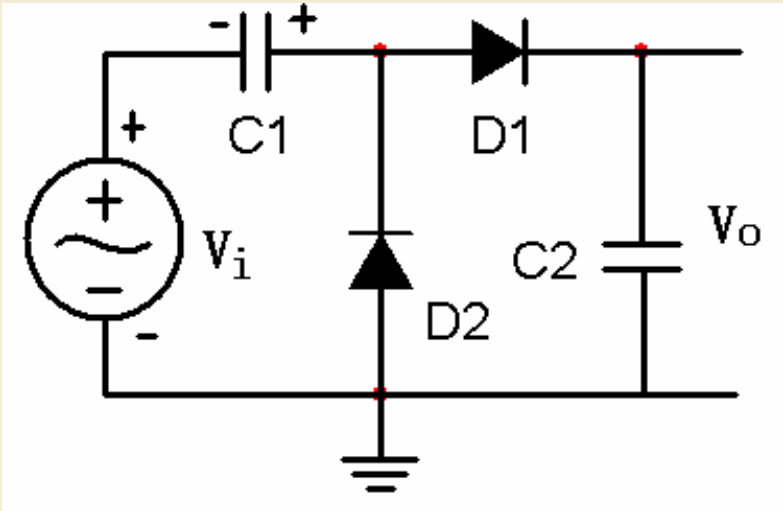
集成硅整流桥：





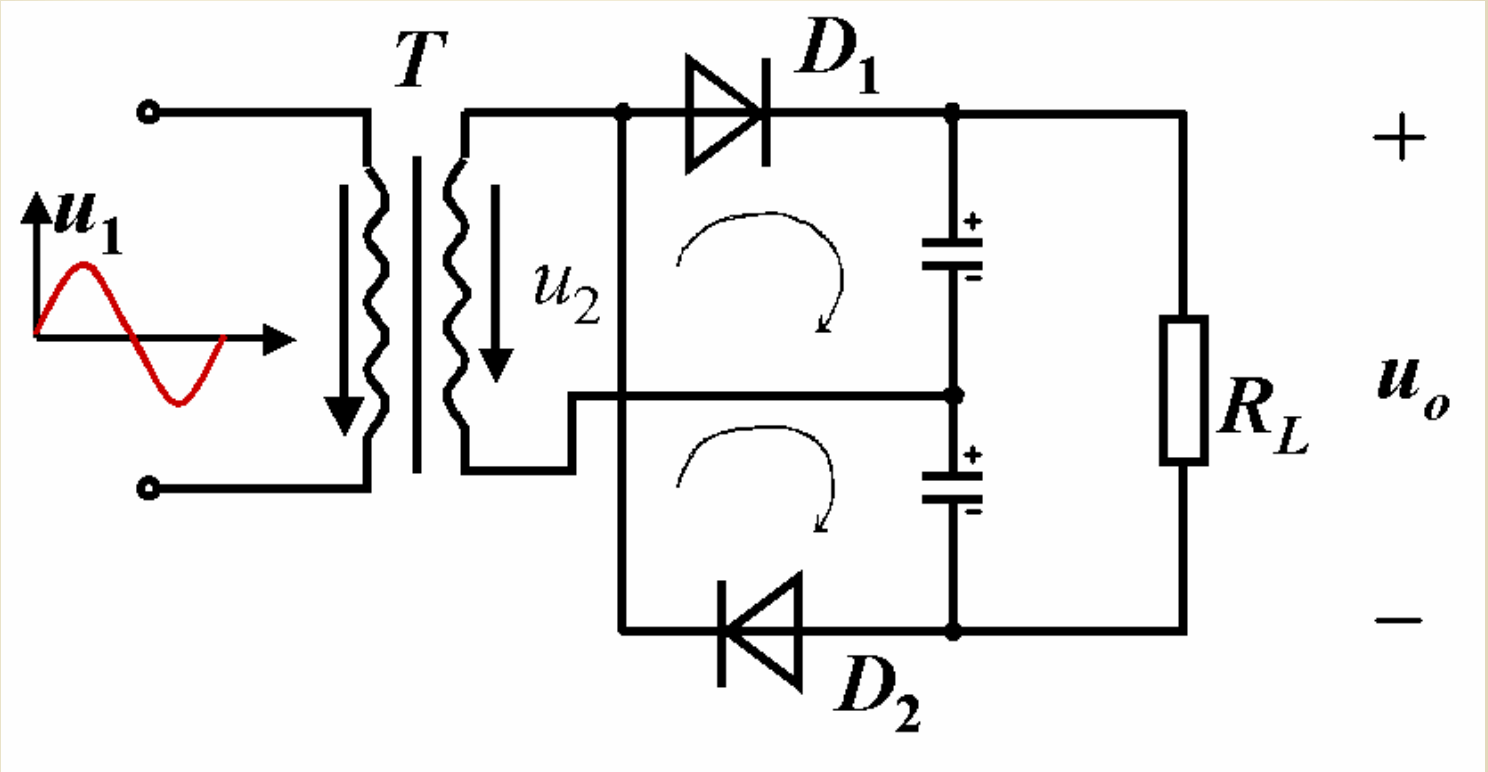


• 11.2.4 单相倍压整流电路

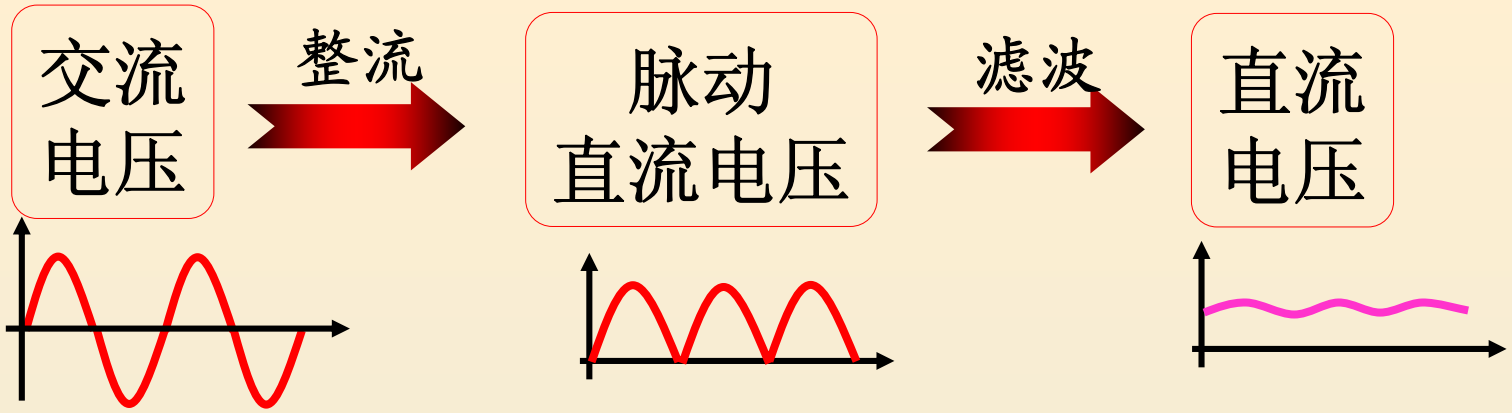


负半周：D2导通，C1上电压为Vi，右正左负

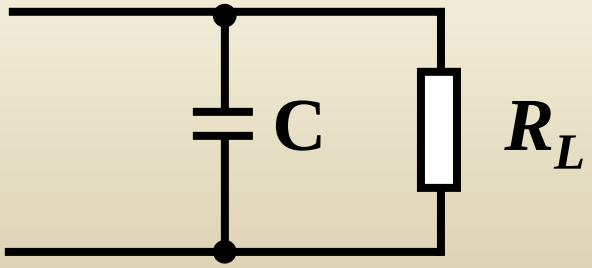
正半周：D1导通，为C2充电，充电电压为C1上电压＋Vi

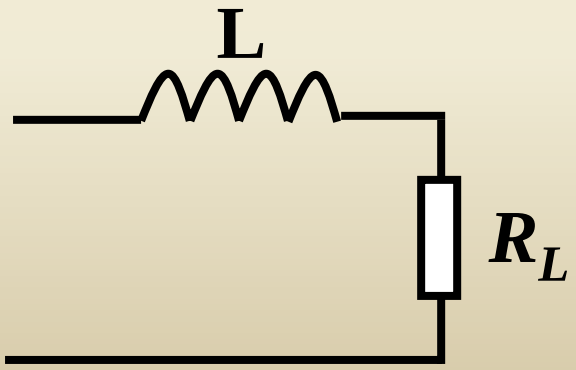

T
D1
u1
u2
RL
uo
+
−
D2

11.3 滤波电路



滤波电路的结构特点：电容与负载 R_L 并联，或电感与负载R_L串联。



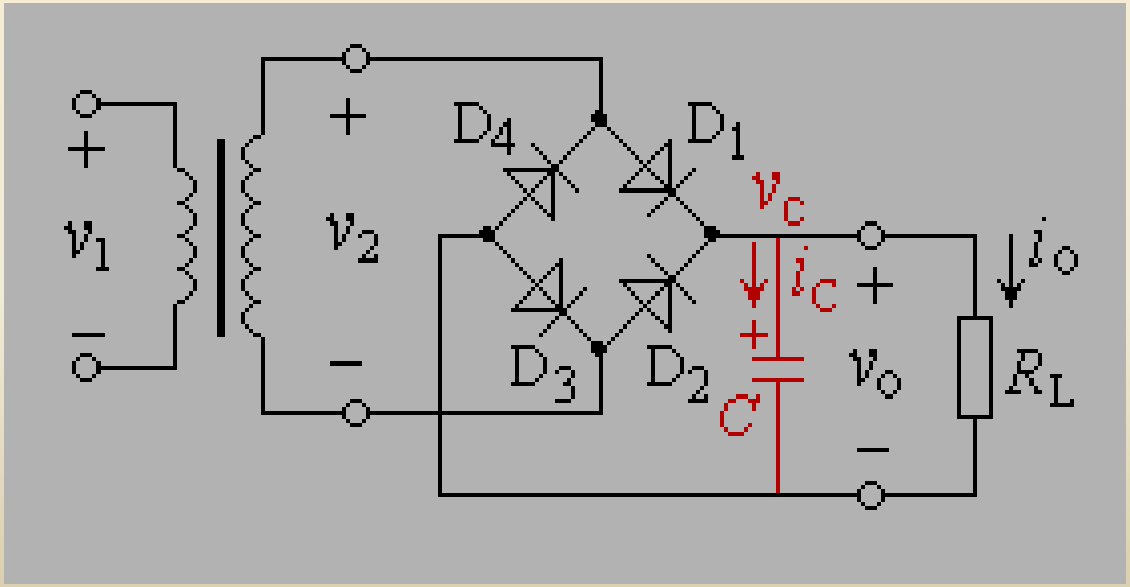


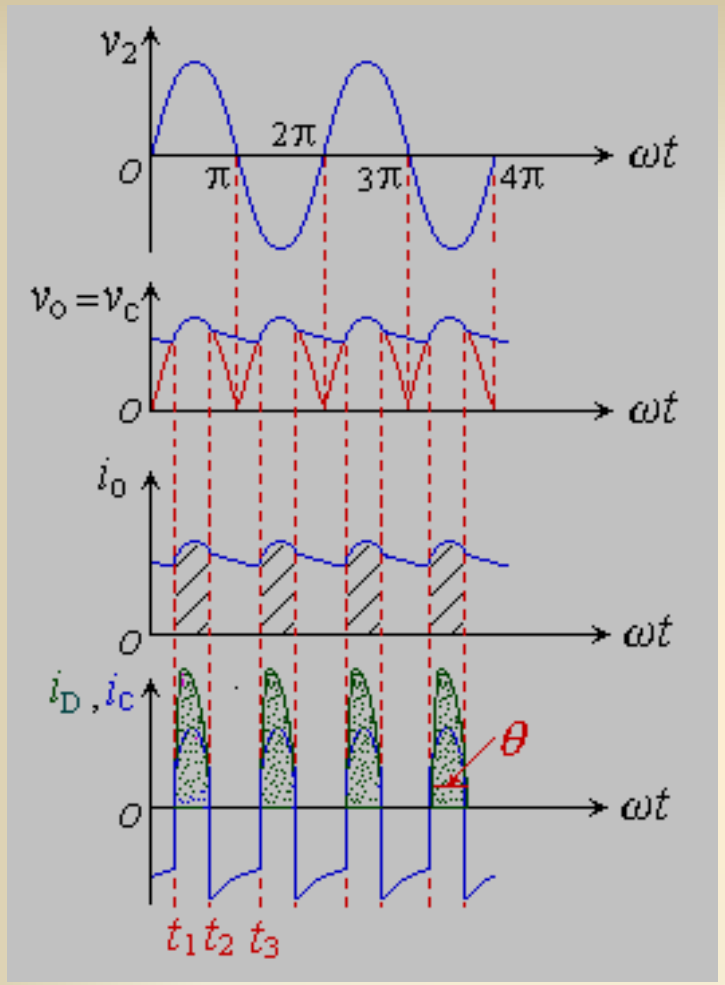
11.3.1 电容滤波电路

(1)滤波的基本概念

利用电抗性元件**储能**作用

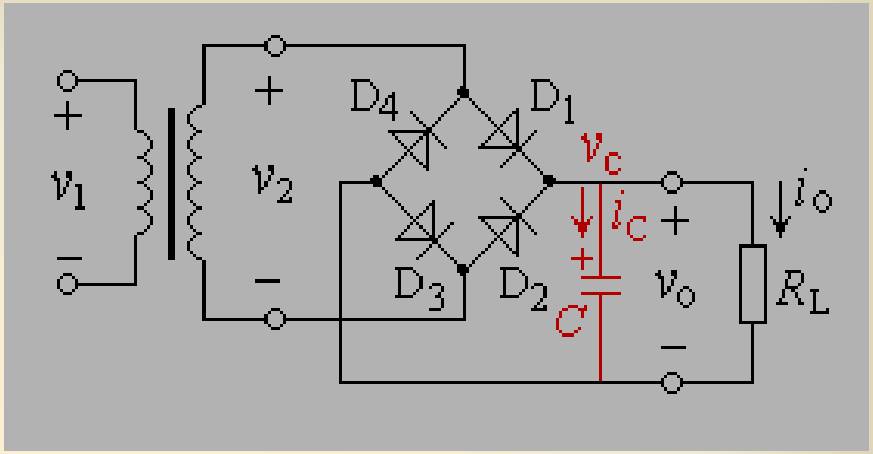
（2）电容滤波电路



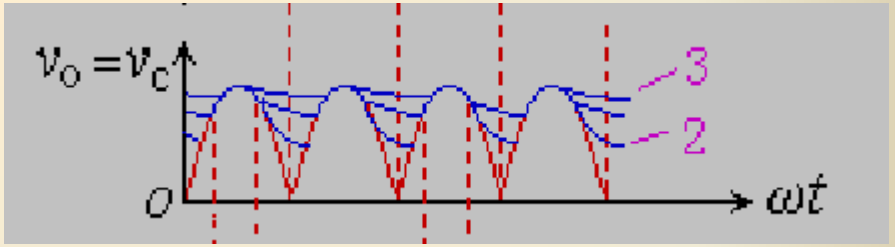


电容滤波波形图

(3)滤波原理

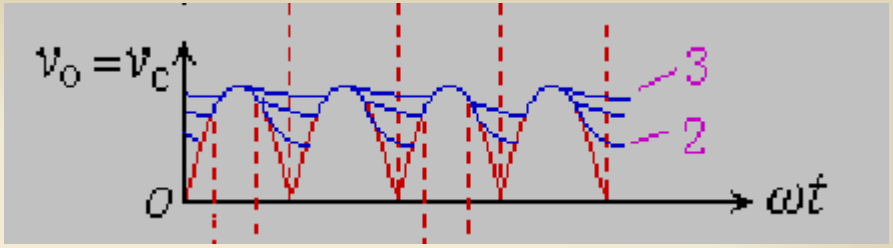


$R_L C$变化?



滤波波形变化

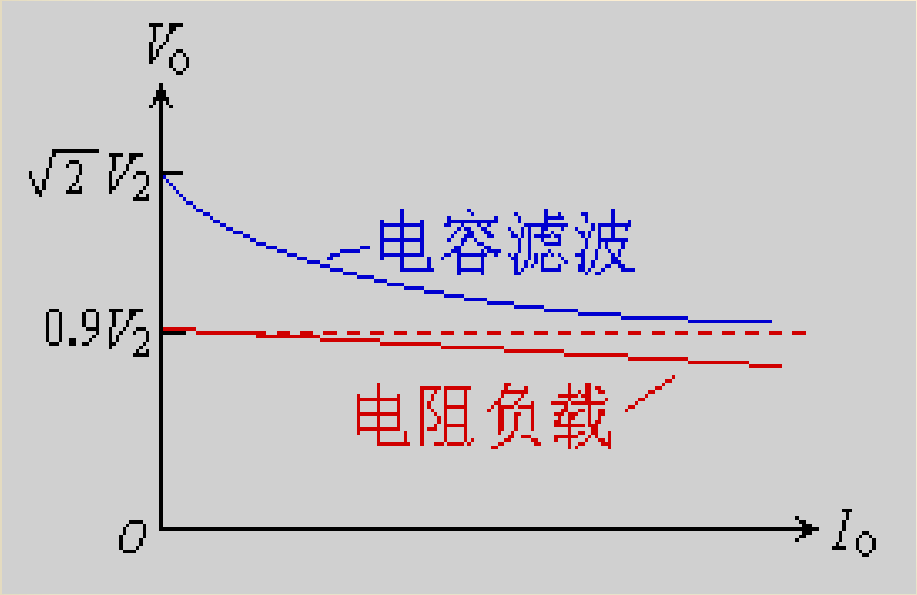
(4)参数计算



当C选择合适时：

$$V_o \approx 1.2V_2$$

(5) 外特性（负载特性）适合于小电流R_L



$R_L = \infty$ ， $V_O = \sqrt{2}V_2$

$C = 0$ ， $V_O = 0.9V_2$

选C条件:

$$\tau_d = R_L C \geq (3\sim5)\frac{T}{2}$$

$$V_O \approx 1.2V_2$$

11.4 稳压电路

11.4.1 稳压电路概述

11.4.2 硅稳压管稳压电路

11.4.3 线性串联型稳压电源

11.4.1 稳压电路概述

稳压电路的作用：