7.3 模拟乘法器及其应用

乘法器符号

实现的功能

$$u_O = Ku_X u_Y$$

7.3.1 乘法器的工作原理

1．对数乘法器

由 $u_O = Ku_X u_Y$

$$= e^{\ln Ku_X u_Y}$$

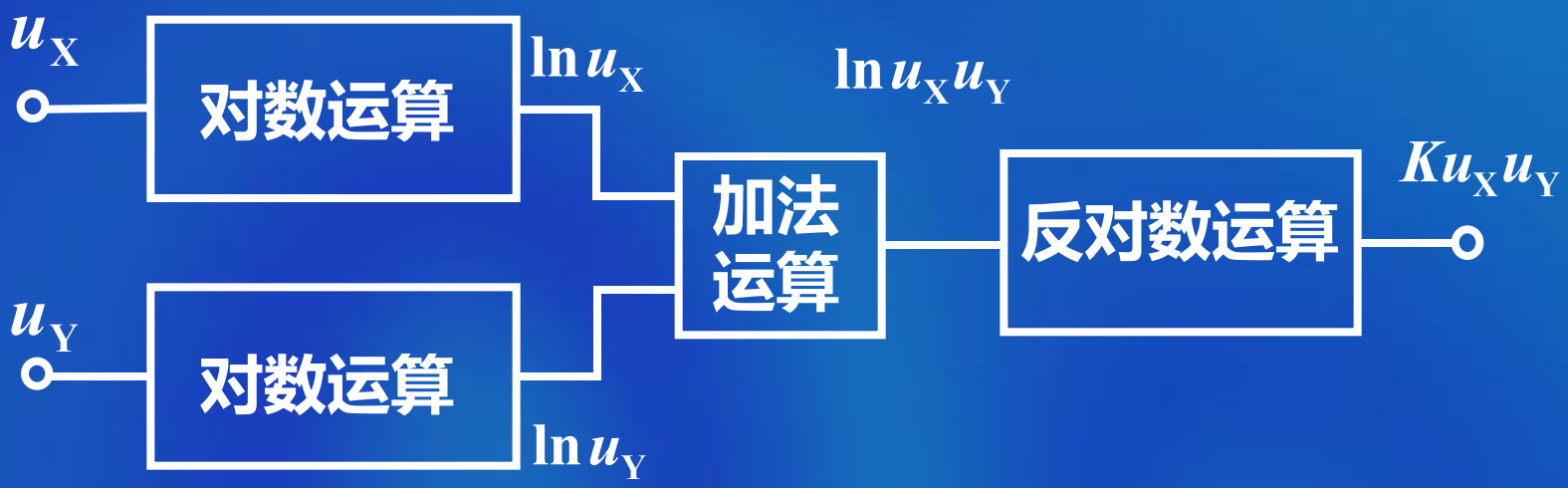
$$= e^{\ln K_1 u_X + \ln K_2 u_Y}$$

式中 $K = K_1 K_2$

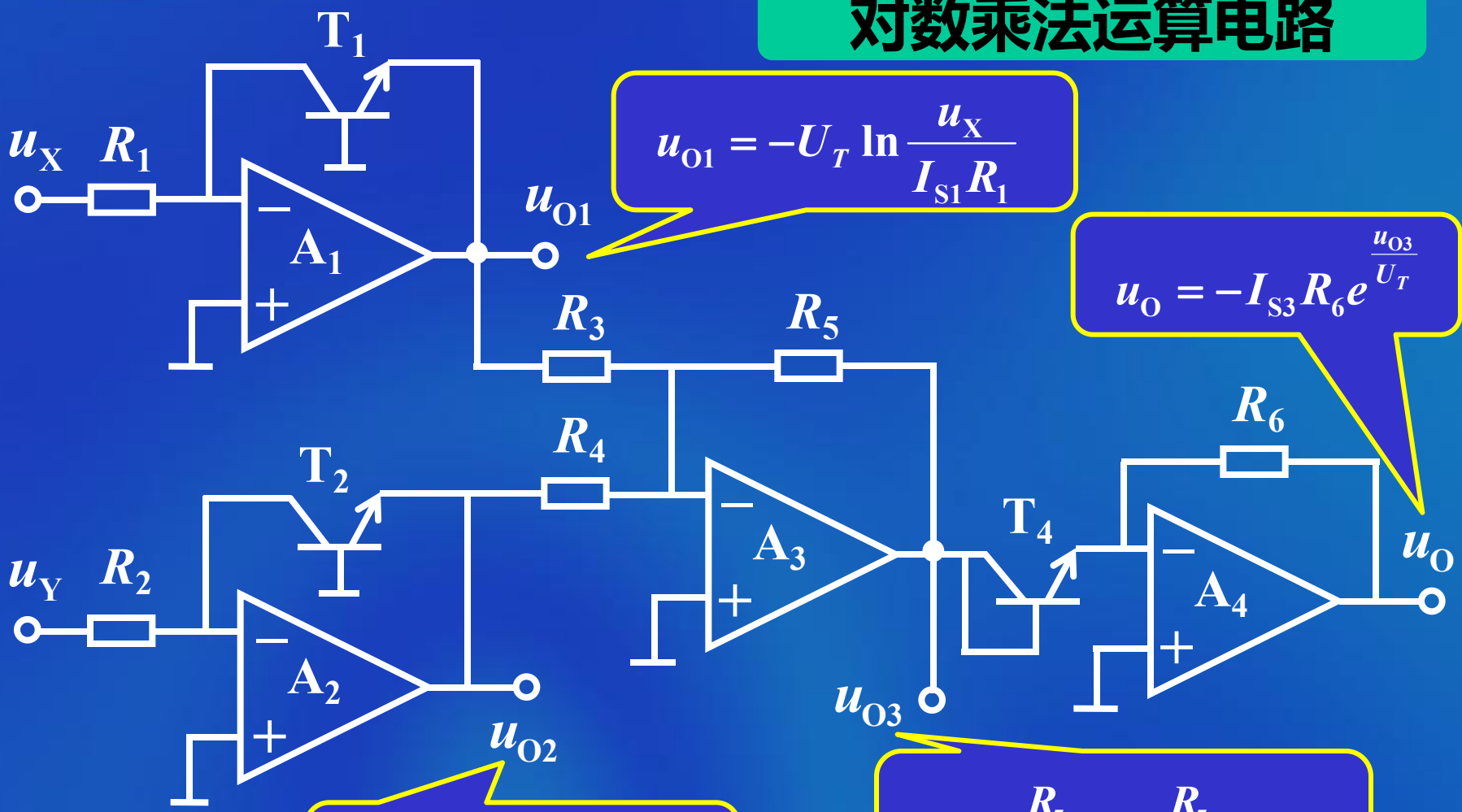
可利用对数电路、加法电路和反对数电路实现的乘法运算功能。

$$u_O = Ku_X u_Y = e^{\ln K_1 u_X + \ln K_2 u_Y}$$

原理框图



对数乘法运算电路



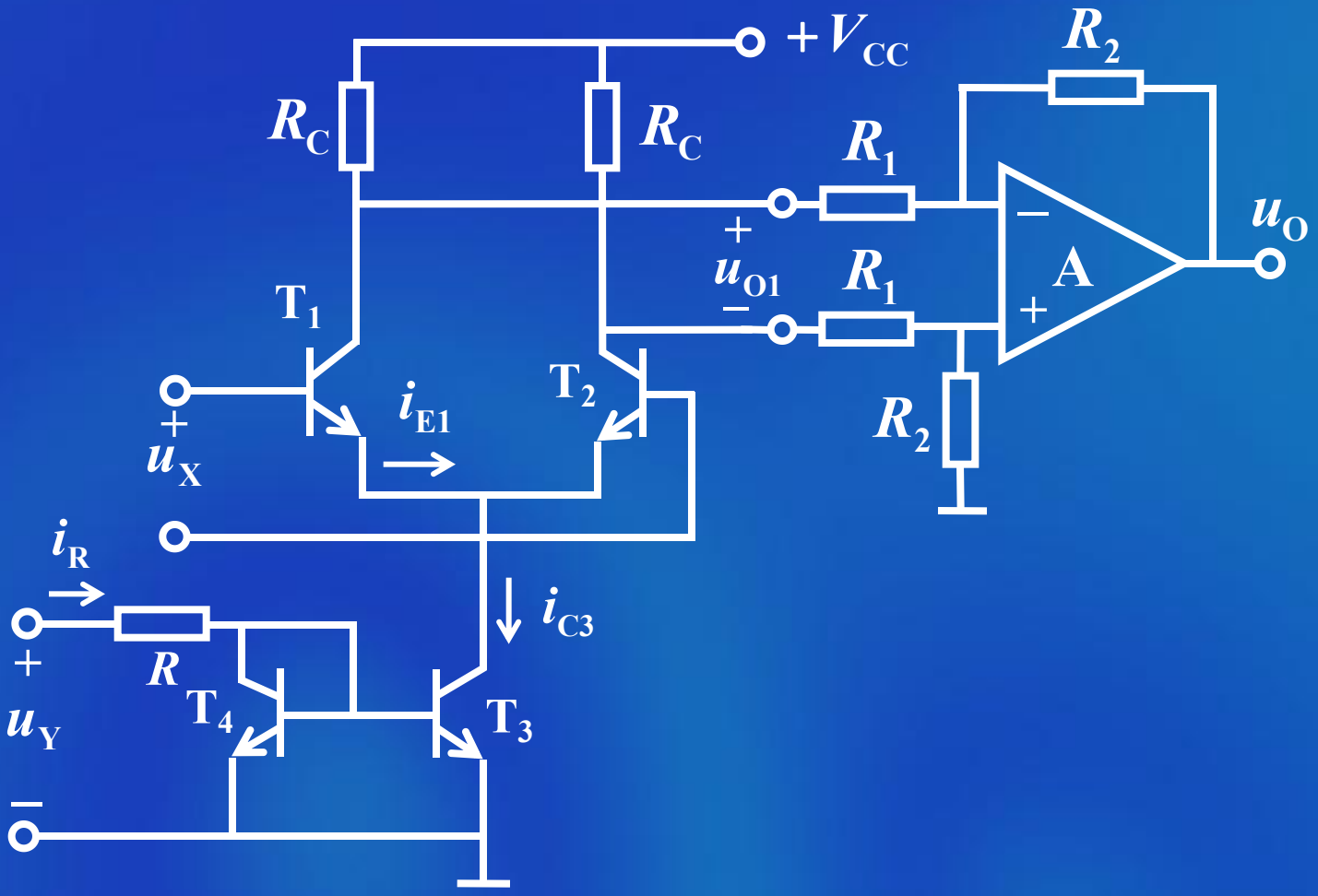
$$u_{O1} = -U_T \ln \frac{u_X}{I_{S1} R_1}$$

$$u_O = -I_{S3} R_6 e^{\frac{u_{O3}}{U_T}}$$

$$u_{O2} = -U_T \ln \frac{u_Y}{I_{S2} R_2}$$

$$u_{O3} = -\frac{R_5}{R_3} u_{O1} - \frac{R_5}{R_4} u_{O4}$$

2. 变跨导式乘法器

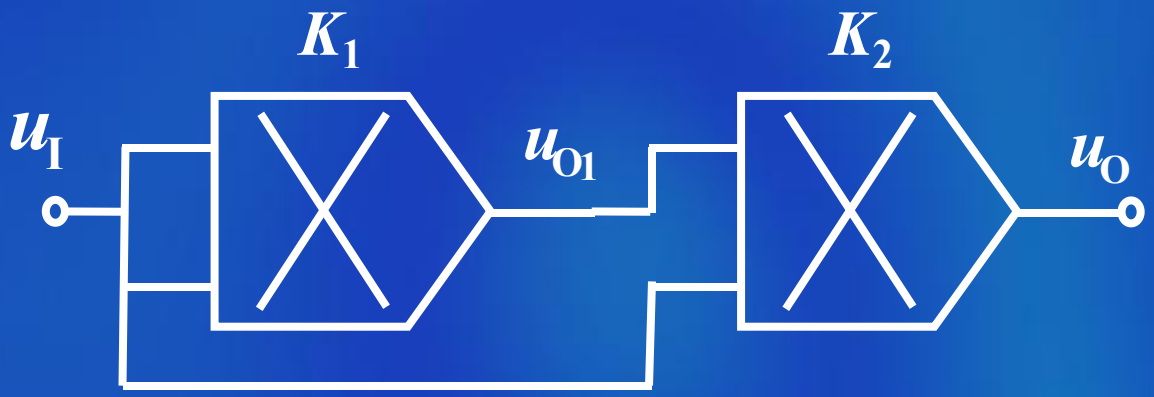


7.3.2 乘法器应用电路

1. 平方运算电路

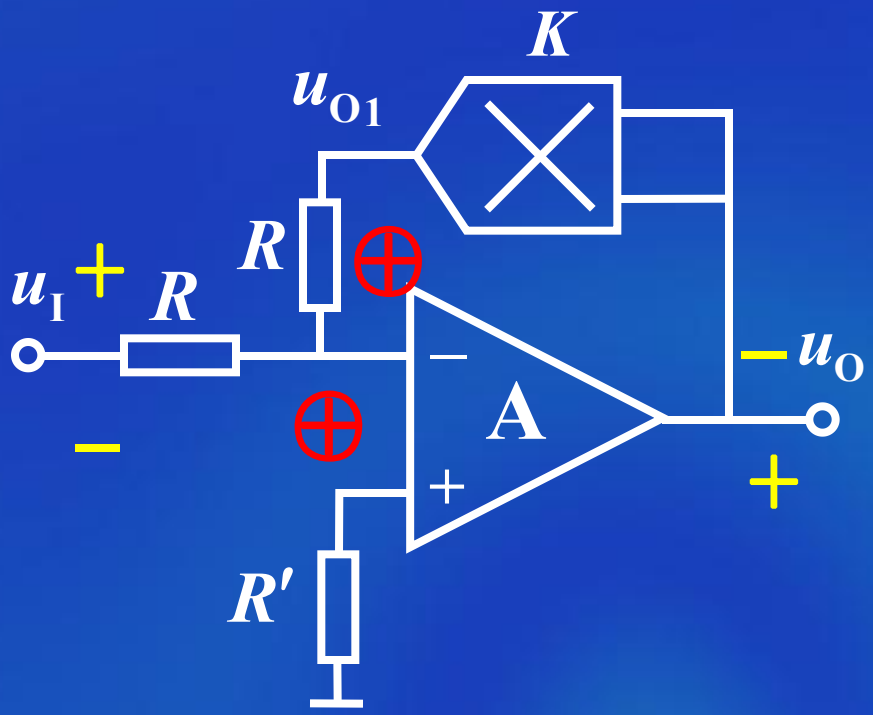
$$u_O = Ku_I^2$$

立方运算？



$$u_O = K_1K_2u_I^3$$

2．开平方运算电路

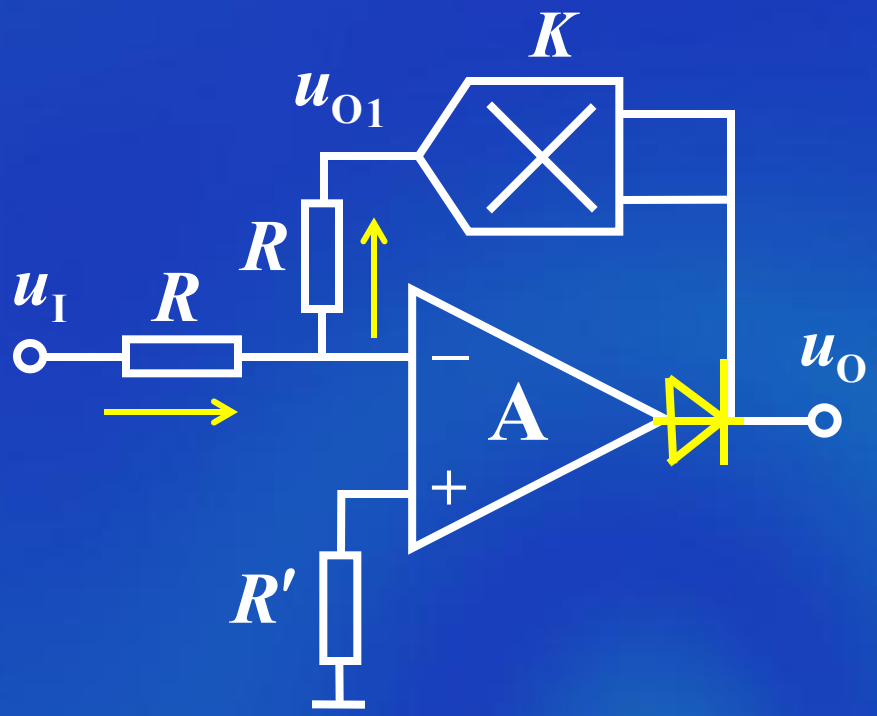


由图可知

u_I	u_O	u_{O1}	
+	−	+	正反馈
−	+	+	负反馈

故 $(u_I < 0)$

2．开平方运算电路



问：如何防止u_I突然为正，导致运放出现闭锁现象？

由图可知

$$u_{O1} = Ku_O^2$$

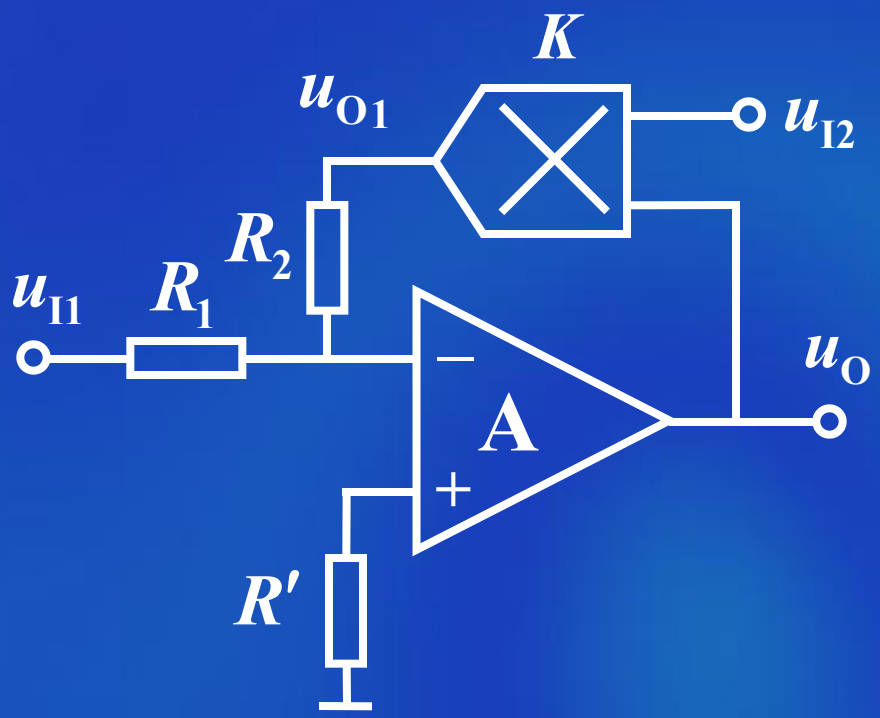
$$\frac{-u_{O1}}{R} = \frac{u_I}{R}$$

故

$$u_O = \sqrt{-\frac{u_I}{K}}$$

$$(u_I < 0)$$

3. 除法运算电路



由图可知

u_{I1} u_O u_{I2} u_{O1}

+ − + − 负反馈

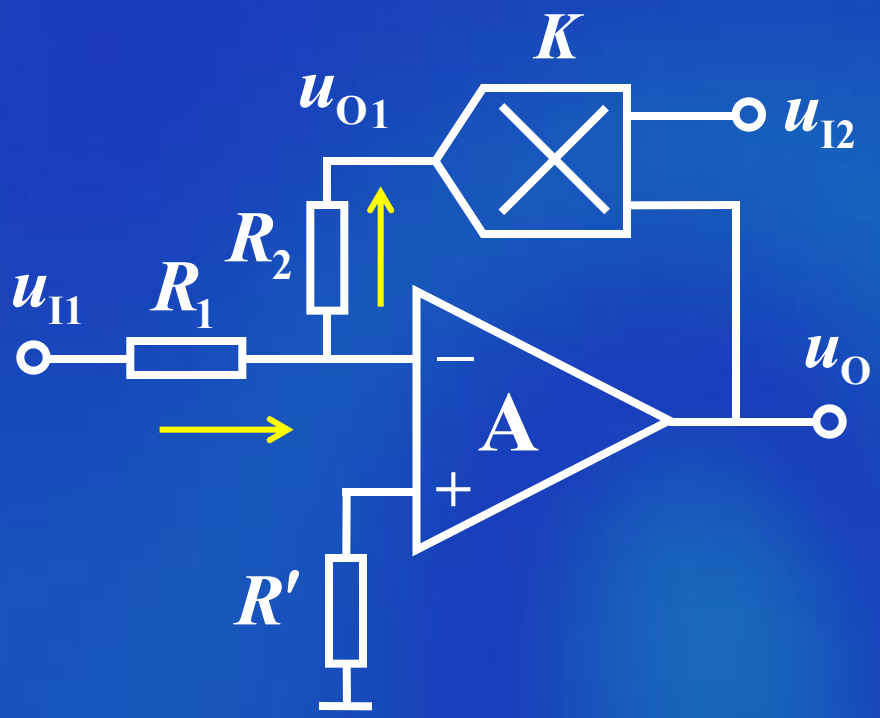
− +

+ − + + 负反馈

− + − −

故 $u_{I2} > 0$

3. 除法运算电路



由图可知

$$u_{O1} = Ku_O u_{I2}$$

$$\frac{-u_{O1}}{R_2} = \frac{u_{I1}}{R_1}$$

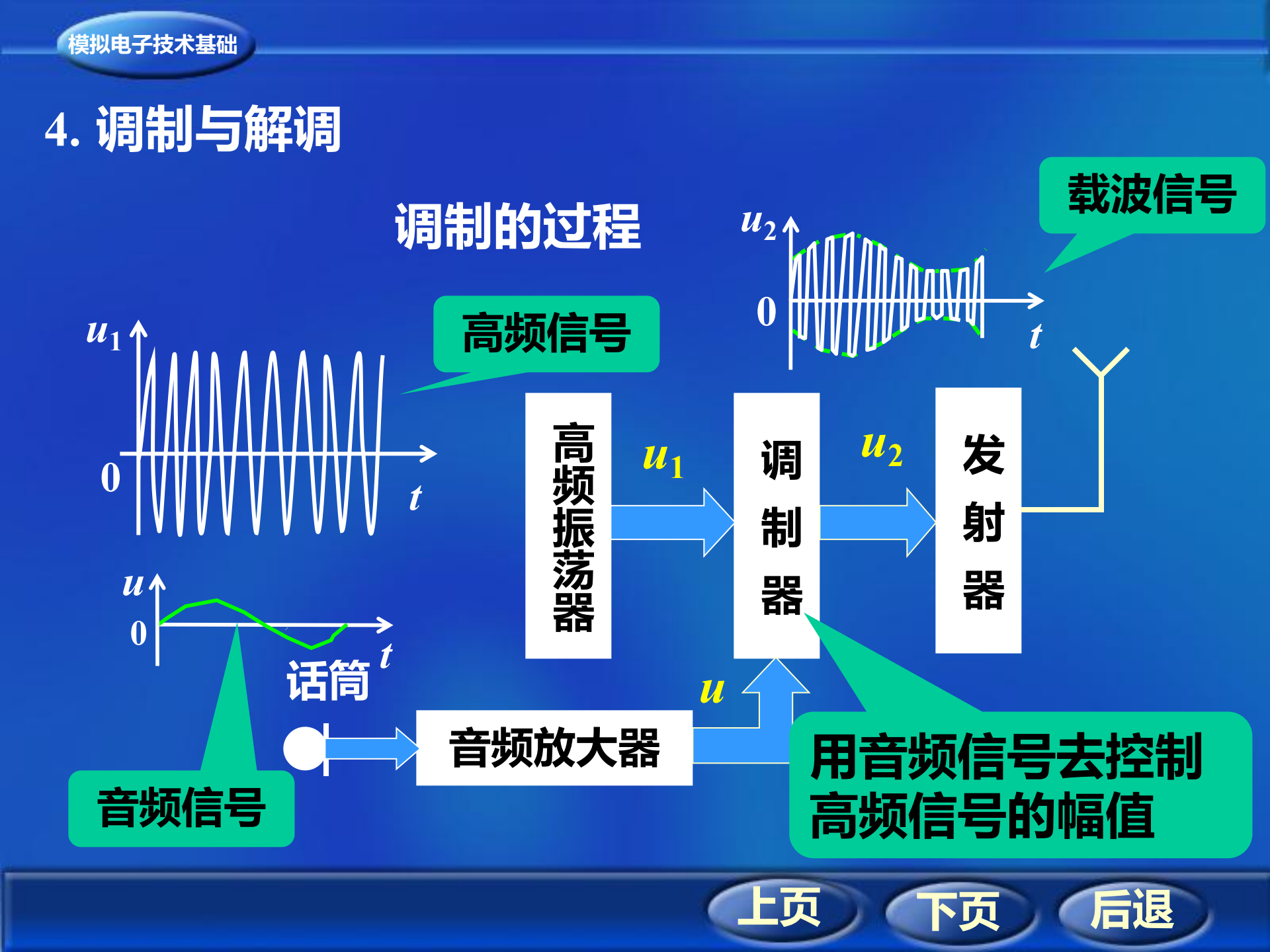
故

$$u_O = -\frac{R_2}{KR_1}\frac{u_{I1}}{u_{I2}}$$

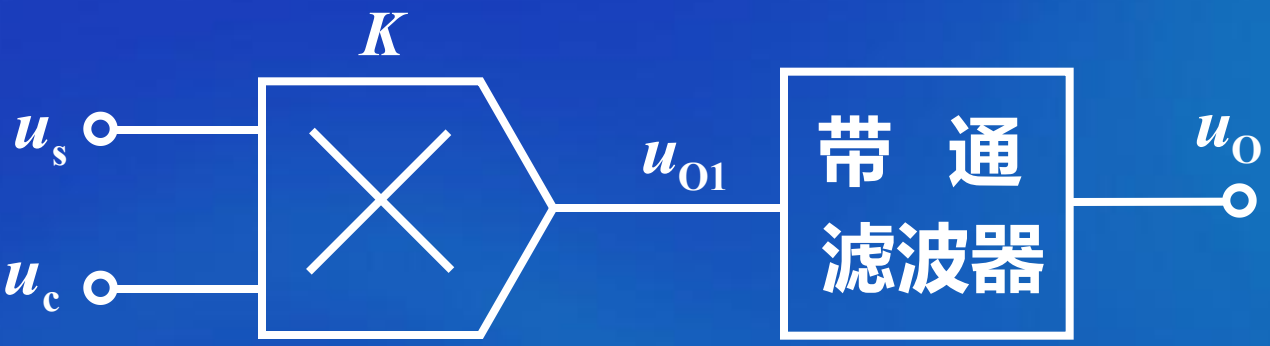
$u_{I2} > 0$

4. 调制与解调

调制的过程

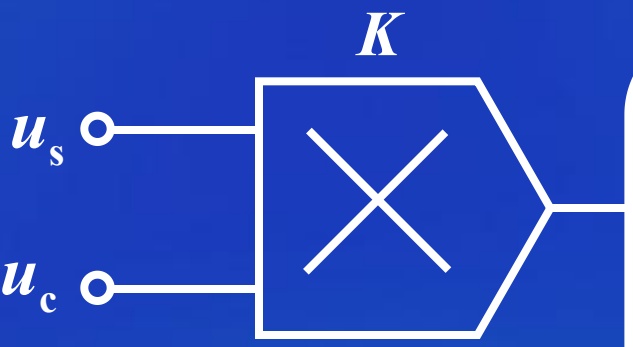


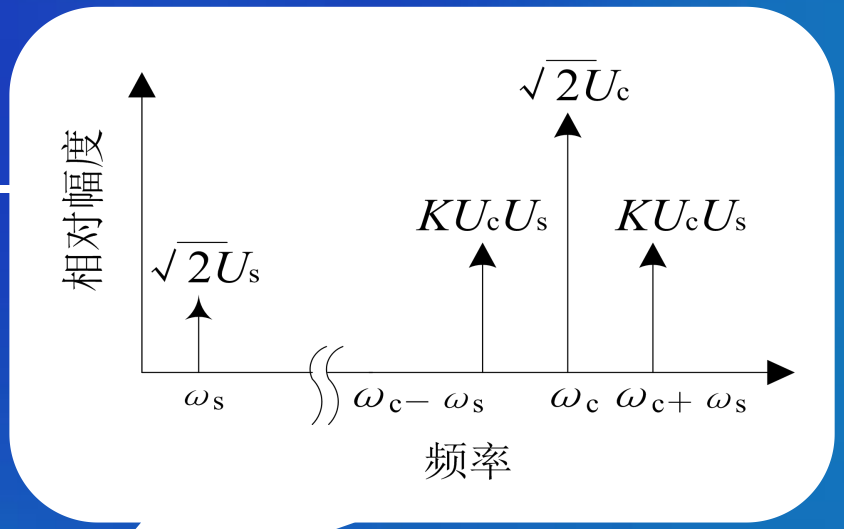
幅度调制原理框图



音频信号 $u_s = \sqrt{2}U_s \cos\omega_s t$

载波信号 $u_c = \sqrt{2}U_c \cos\omega_c t$





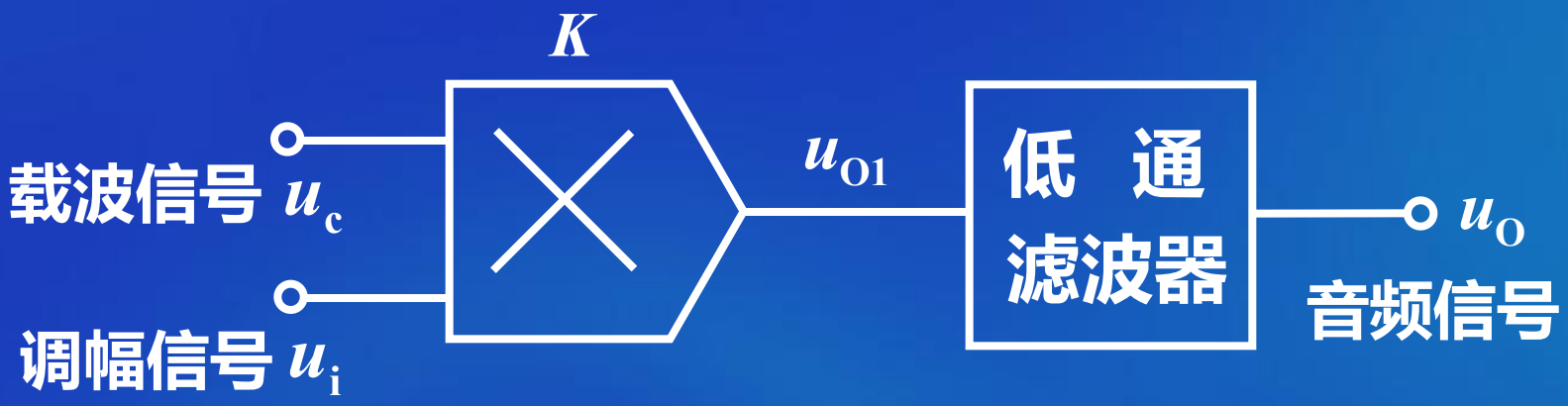
$$u_{O1} = Ku_c u_s$$

$$= KU_cU_s\left[\cos(\omega_c+\omega_s)t + \cos(\omega_c-\omega_s)t\right]$$

滤除单边带信号

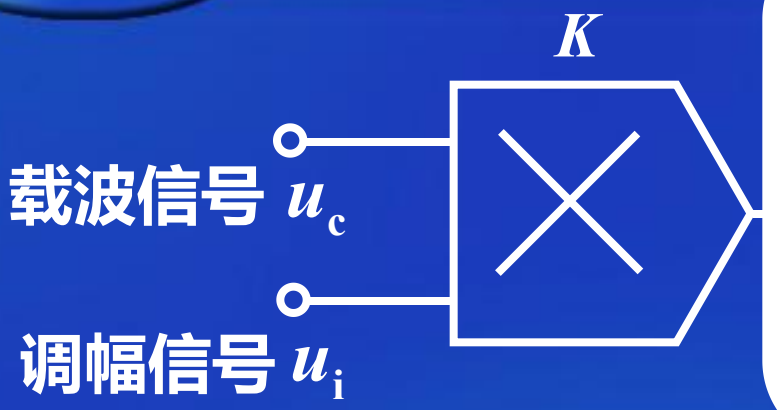
输出信号 $u_o = KU_cU_s\cos(\omega_c-\omega_s)t$

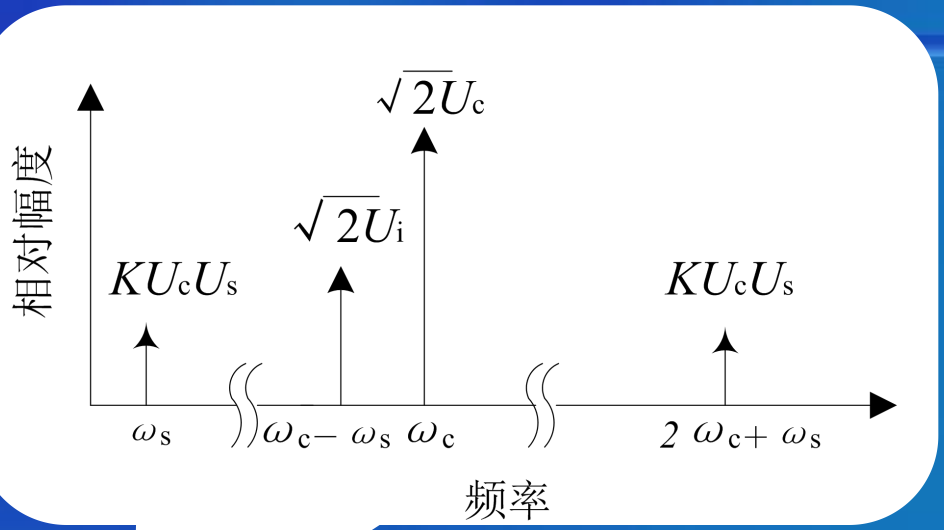
幅度解调原理框图



载波信号 $u_c = \sqrt{2}U_c \cos\omega_c t$

调幅信号 $u_i = \sqrt{2}U_i \cos(\omega_c - \omega_s)t$





$$u_{O1} = KU_cU_i[\cos\omega_s t + \cos(2\omega_c - \omega_s)t]$$

滤除高频信号

输出信号信号 $u_O = KU_cU_i\cos\omega_s t$