第六章　集成运算放大器及其应用电路

知识要点：

集成运放的宏模型及常用的功能电路。集成运放的使用典型电路、性能指标及误差分析。

1.1 集成运放应用电路

1.1.1　反相放大器和同相放大器

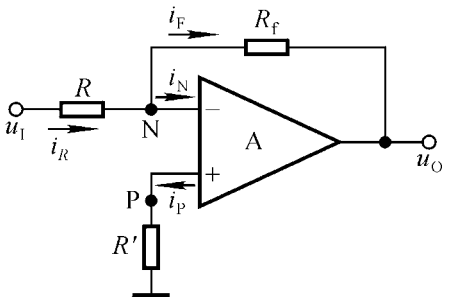
左图：反相放大器：

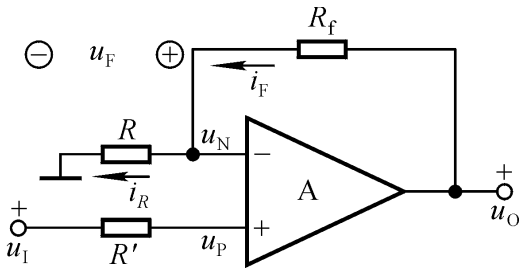
$$i_R = \frac{u_I}{R} = i_F,$$

$$v_o = -i_F R_f = -\frac{u_I}{R} R_f = -\frac{R_f}{R} u_I$$

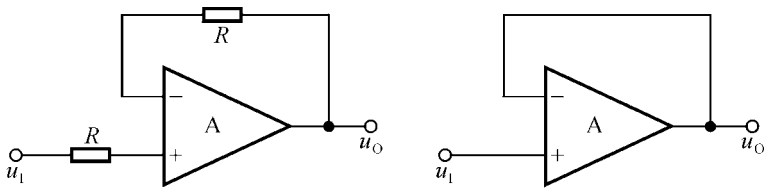
右图：同相放大器：

$$u_N = u_P, \qquad i_F = \frac{u_N}{R} = \frac{u_P}{R} = \frac{u_I}{R} \quad , \quad u_o = i_F R_f = \frac{u_N}{R} R_f = \frac{u_P}{R} R_f = \frac{u_I}{R} R_f$$





同相放大器，当 R 无穷大时，变成电压跟随器。



1.1.2　运算电路

一、同相加法器和反相加法器

左图：同相加法器：

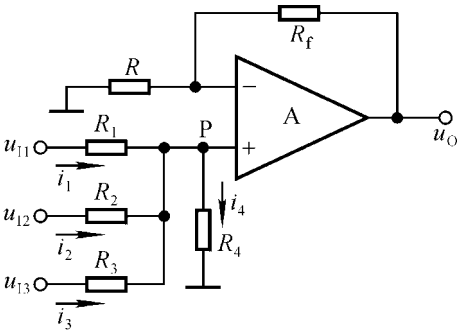
$u_P = R_P(\frac{u_{I1}}{R_1}+\frac{u_{I2}}{R_2}+\frac{u_{I3}}{R_3})$，$R_P$=R1//R2//R3//R4。

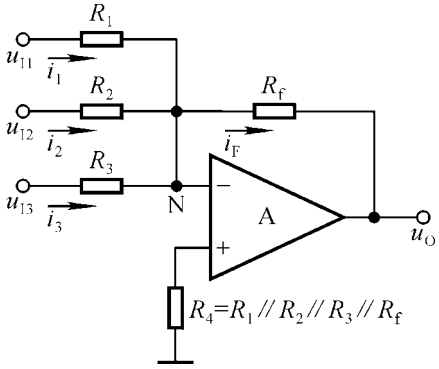
当 R_N=R_P 时，同相放大器的输出与输入关系：

$$uo = R_f(\frac{u_{I1}}{R_1}+\frac{u_{I2}}{R_2}+\frac{u_{I3}}{R_3})$$

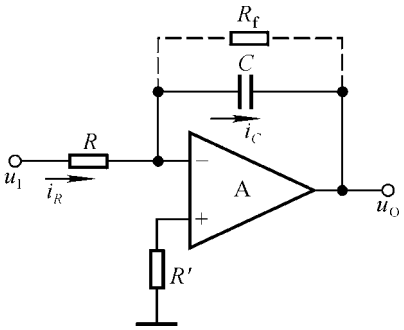
右图：反相加法器：

$$uo = -(\frac{R_f}{R_1}u_{I1}+\frac{R_f}{R_2}u_{I2}+\frac{R_f}{R_3}u_{I3})$$

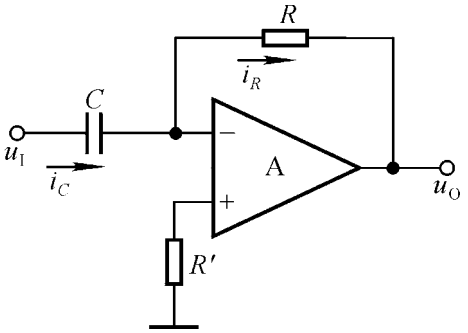




二、积分器和微分器

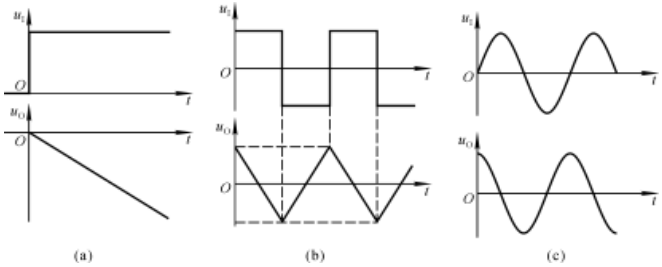


左图：积分器电路

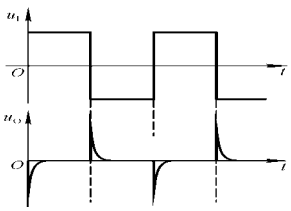


右图：微分运算电路

$$u_o = -\frac{1}{C}\int i_C dt = -\frac{1}{RC}\int u_t dt$$

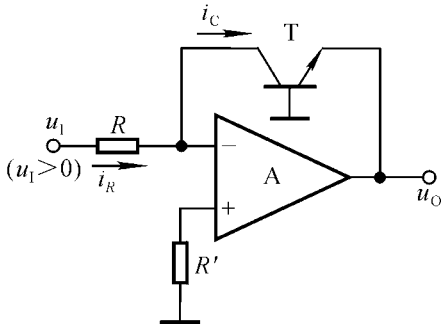


$$uo = -i_R R = -RC\frac{du_I}{dt}$$

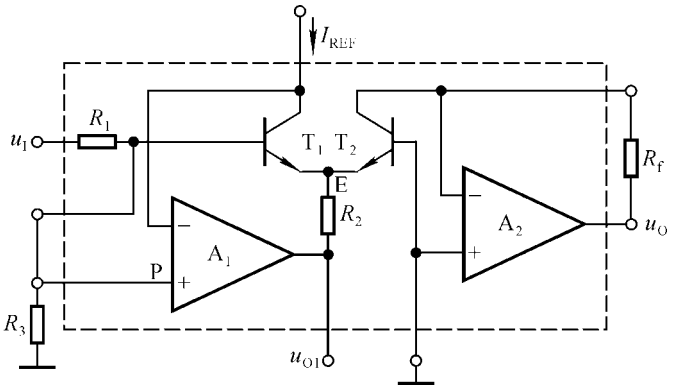


三、对数和反对数变换电路

$$i_C = i_R = \frac{u_I}{R}, \quad i_C = \alpha i_E = I_s e^{\frac{u_{BE}}{U_T}}, \quad u_{BE} \approx U_T \ln\frac{i_C}{I_S}, \quad uo = -u_{BE} \approx -U_T \ln\frac{u_I}{I_S R}$$

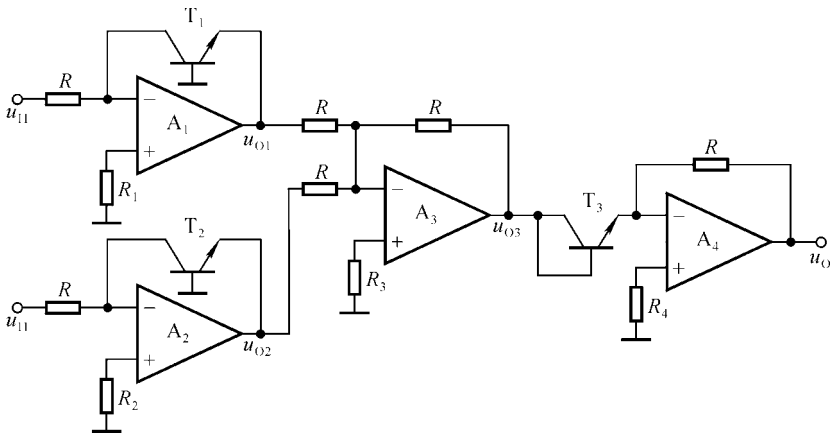


R 和 T 互换则可组成反对数运算电路。



集成对数运算电路

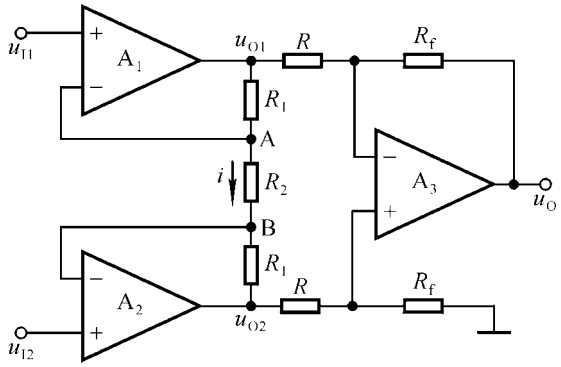
四、乘、除法运算电路



$$u_{o1} = -U_T \ln\frac{u_{I1}}{I_S R}, \quad u_{o2} = -U_T \ln\frac{u_{I2}}{I_S R}, \quad u_{o3} = -(u_{o1} + u_{o2}) = U_T \ln\frac{u_{I1}u_{I2}}{(I_S R)^2}$$

$$u_o = -I_S R_e \frac{u_{o3}}{U_T} = -\frac{u_{I1}u_{I2}}{I_S R}$$

五、仪用放大器



$$u_{I1} - u_{I2} = \frac{R_2}{2R_1 + R_2}(u_{o1} - u_{o2}), \quad u_{o1} - u_{o2} = (1 + \frac{2R_1}{R_2})(u_{I1} - u_{I2})$$

$$u_o = -\frac{R_f}{R}(1 + \frac{2R_1}{R_2})(u_{I1} - u_{I2})$$