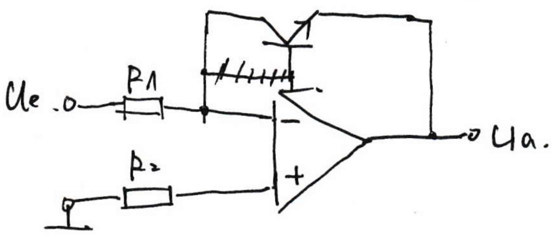
Logarithmierenschaltung



U_{BC}为0. 没有厄立~~电扩~~效应. 让T体管工作在临界点.

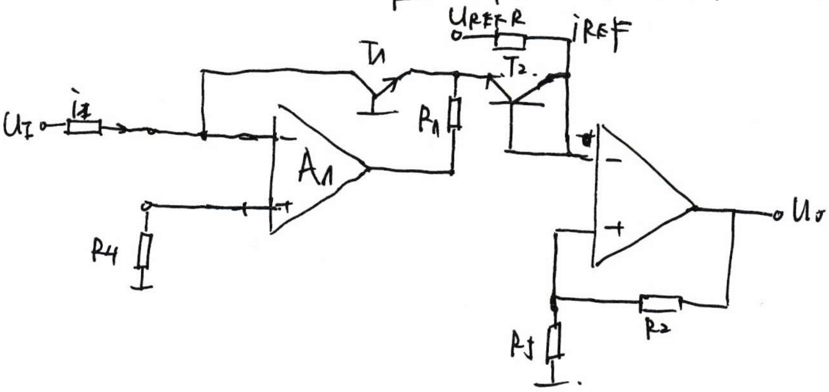
$$\frac{U_e}{R_1} = i_c \longrightarrow i_e = i_c = I_s \exp\left(\frac{U_{BE}}{U_T}\right)$$，其中 $U_{BE} = -U_a$.

$$U_{BE} = -U_a = U_T \ln\frac{I_e}{I_s}$$

电路很取决于 I_s, U_T, 受温度影响

I_s 可以由对 $\ln\frac{I_e}{I_s}$ 做差. 约去. 那么就需要二个晶体管,

$$U_o = \frac{R_1}{R_2}\cdot U_T \ln\frac{I_e}{I_{ref}}$$ (大概形式). 用热敏电阻抵消 U_T.



- T1. $U_{BC1} = 0$ • T2. $U_{BC2} = 0$.
- $U_o = K\cdot(U_{BE2} - U_{BE1})$

$$\frac{U_o}{R_3+R_2}\cdot R_3 = U_{BE2} - U_{BE1} \Rightarrow U_o = \left(1+\frac{R_2}{R_3}\right)U_T \ln\frac{U_I}{I_R\cdot R_I}$$

对于 Vorlesung.

$$U_x = \frac{R_2}{R_1+R_2}U_o = U_{BE1} - U_{BE2} = U_T \ln\frac{I_{e1}}{I_s} - \ln\frac{I_{e2}}{I_s}$$

$$U_o = 2.3\left(1+\frac{R_1}{R_2}\right)U_T \lg\frac{I_{e1}}{I_{e2}} \leftarrow \boxed{\begin{matrix} k\lg^x = \ln^x \\ 10^{\lg x} = \ldots \end{matrix}}$$

换底公式.

$\ln x = y_1 \Rightarrow x = e^{y_1} = (e^{\lg e} \cdot 10)^y$

$\lg x = y_2 \Rightarrow x = 10^{y_2}$ $= \frac{y_1}{y_2} =$

用 R_2 来控制 U_T.

$$R_2(T) = R_{20}[1+TC(T-T_0)]. \quad U_T = \frac{kT}{e} = U_{T0}\cdot\frac{T}{T_0}.$$

$$\frac{d}{dT}\left(1+\frac{R_1}{R_2}\right)\cdot U_T = 0 \Rightarrow \frac{U_{T0}}{T_0} + R_1\cdot\frac{U_{T0}}{R_{20}}\left[\frac{T}{1+T_C(T-T_0)T_0}\right]'$$

$$\Rightarrow U_T' + R_1\frac{U_T'\cdot R_2 - R_2'\cdot U_T}{(R_2)^2} = \left(1+\frac{R_1}{R_2}\right)U_T' - \left(\frac{R_1}{R_2}\right)^2\cdot U_T\cdot R_2' = 0.$$

$$\left(1+\frac{R_1}{R_2}\right)\frac{U_{T0}}{T_0} - \left(\frac{R_1}{R_2}\right)^2\frac{U_{T0}}{T_0}\cdot T\cdot R_{20}\cdot T_C = 0 \Rightarrow T_C =$$

$$1+\frac{R_1}{R_2} - \frac{R_1}{R_2}\cdot\frac{T_C\cdot T_0}{1+T_C(T-T_0)} \Rightarrow \frac{R_1}{R_2}\frac{1-T_C\cdot T_0}{1+T_C(T-T_0)} + 1 = 0$$

$$1 - T_C\cdot T_0 = -\frac{R_2}{R_1} - \frac{R_2}{R_1}T_C\cdot(T-T_0)\Big|_{T=T_0} = \left(1+\frac{R_{20}}{R_1}\right)/T_0 = T_C$$ 大. 用来设置电阻.

Verstärker mit Dioden in der Gegenkopplung. 另一种对数电路.

$i_D = I_S \exp\frac{U_D}{U_T} \Rightarrow U_D = U_T \ln\frac{i_D}{I_S}$

$U_{a1} = -(U_{D1}+U_{D2}) = -2U_T \ln\frac{i_e}{I_S}$

$U_{a2} = U_{D3}+U_{D4} = 2U_T \ln\frac{i_{Ref}}{I_S}$

$U_a = -\frac{R_2}{R_1}(U_{a1}+U_{a2}) = -\frac{R_2}{R_1}\left[-2U_T\left(\ln\frac{i_e}{I_S}\cdot\frac{I_S}{i_{Ref}}\right)\right]$

$= \frac{R_2}{R_1}\cdot 2U_T \ln\frac{I_e}{I_{Ref}} = 4.6\frac{R_2}{R_1}U_T \lg\frac{I_e}{I_{Ref}}$

Tempratmabhängigkeit.

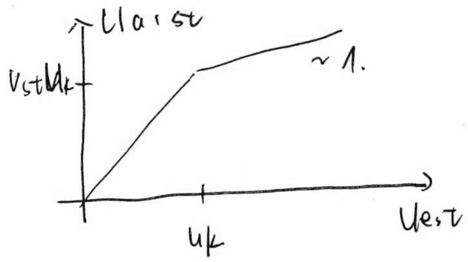
$\delta U_a = \frac{dU_a}{dT}\delta T = 4.6\frac{R_2}{R_1}\lg\left(\frac{I_e}{I_{Ref}}\right)\cdot\frac{U_{T0}}{T_0}\delta T$

R_1 可以做成热敏电阻补偿 U_T.

$d\frac{U_T}{R_1}\Big|_{T=T_0} = 0 \Rightarrow$

$\frac{\frac{U_{T0}}{T_0}\cdot R_1 - U_T\cdot R_{10}\cdot T_C}{|R_1|^2}\Big|_{T=T_0} = \frac{T_C - \frac{1}{T_0}}{R_{10}}U_{T0} = 0.\quad T_C = \frac{1}{T_0} = 3.33\times10^{-3}K^{-1}$. 形式简单.

"A/1 – Verstärker"



$U_{a,t} = \begin{cases} V_{st}\cdot U_{e,st} & 0 \le U_{e,st} \le U_K. \\ (V_{st}-1)U_K + U_{e,st}. & U_K < U_{e,st}. \end{cases}$

$1.5\times10^{-5} \longrightarrow 1.5\times10^{-4}$

20 – 01.

(1) $U_{B1} = \frac{R_4}{R_3+R_4}U_{a1} = U_{BE1} - U_{BE2} = U_T \ln\frac{I_F}{I_{REF}}$.

$\Rightarrow U_{a1} = \left(1+\frac{R_3}{R_4}\right)U_T \ln\frac{I_F}{I_{REF}}$.

(2) $\frac{\partial U_{a1}}{\partial T}\Big|_{T=T_0} = 0 \Rightarrow \ln\frac{I_F}{I_{REF}}\left[\frac{U_{T0}}{T_0} + R_3\cdot\frac{\frac{U_{T0}}{T_0}\cdot R_4 - R_4' U_T}{|R_4|^2}\right] \Rightarrow \ln\frac{I_F}{I_{REF}}\left[\frac{U_{T0}}{T_0} + \frac{R_3}{R_{40}}\left(\frac{U_{T0}}{T_0} - R_{40}T_C\cdot U_{T0}\right)\right]$

$\Rightarrow \frac{\partial U_{a1}}{\partial T}\Big|_{T=T_0} = \ln\frac{I_F}{I_{REF}}U_{T0}\left(\frac{1}{T_0} + m\frac{1}{T_0} - mT_{C4}\right).\quad m = R_3/R_4.$

$\Rightarrow \frac{m+1}{T_0} = mT_{C4} \Rightarrow m = \frac{1}{T_{C4}\cdot T_0 - 1} = \cancel{\frac{1}{10.5-1}} \approx \frac{1}{1.05-1} = 20.$

(3). $P_L = \cancel{1\times10^{-3}W} = 1mW \triangleq 0dBm \quad P_H = 10mW \triangleq 10dBm.$

$P_R = P_S - d.S\ [dBm] \quad P_{R,mW} = 1mW\cdot 10^{\frac{P_S - dS}{10}}$

$S = 10km.\quad P_{RL} = -10dBm = 0.1mW \Rightarrow I_{F_L} = 1\times10^{-4}\times0.5 = 5\times10^{-5}A = 50\mu A.$

$P_{RH} = 0dBm = 1mW \Rightarrow I_{FH} = 500\mu A.$

$S = 70km$ $\quad P_{R2} = 0 - 70dB = -70dBm = 1\times10^{-3}\times10^{-7} = 10^{-10}$ W. $\quad I_{F\cdot L} = 50pA$.

$\Rightarrow I_{F\cdot H} = 500pA$.

4). $\boxed{\cancel{P_H = 10mV = 10dBm \Rightarrow}}$ $\quad I_{F\,max} = 5\times10^{-4}A$.

$U_{a1} = (1+m)U_T \ln\frac{I_{Fmax}}{I_{REF}} \Rightarrow \frac{I_{Fmax}}{I_{REF}} = e^{\frac{U_{a1}}{(1+m)U_T}}$

$$I_{REF} = \frac{I_{Fmax}}{e^{\frac{(1+m)U_T}{U_{a1}}}} = \frac{5\times10^{-4}}{e^{\frac{2}{21\cdot 26\times10^{-3}}}} = 80.1\,nA.$$

$P_{REF} = 21.2\,k\Omega$.

5).

$\Delta U_{a2} = \Delta U_{a1}\cdot\left(\frac{R_1+R_2}{R_1}\right) = \Delta U_{a1}\left(1+\frac{R_2}{R_1}\right)$

$\Delta U_{a1} = (1+m)U_T\left(\ln\frac{I_{Fmax}}{I_{REF}} - \ln\frac{I_{Fmin}}{I_{REF}}\right) = (1+m)U_T\ln 10 = 2.3\cdot(1+m)U_T = 1.2558$

$\frac{R_2}{R_1} = \frac{\Delta U_{a2}}{\Delta U_{a1}} - 1 = 0.99 \approx 1.$

20-02.

1) $U_{a1} = -(U_{D1}+U_{D2}) = -2U_T\ln\frac{I_e}{I_{D0}} \quad U_{a2} = 2U_T\ln\frac{I_{REF}}{I_{D0}}$

$\cancel{U_a = \frac{R_1+R_2}{R_1}}\ U_a = \frac{-R_2}{R_1}\cdot(U_{a1}+U_{a2}) = \frac{-R_2}{R_1}\left(2U_T\ln\frac{I_{REF}}{I_e}\right) = \frac{R_2}{R_1}2U_T\ln\frac{I_e}{I_{REF}}$

2). $\ln x = \lg x/\lg e \Rightarrow U_a = 4.6\frac{R_2}{R_1}U_T\lg\frac{I_e}{I_{REF}}$.

$U_{a,lg} = U_{a1}|_{10I_e} - U_{a1\cdot I_e} = 4.6\frac{R_2}{R_1}U_T\lg\frac{10I_e}{I_e} = 4.6\frac{R_2}{R_1}U_T$

3) $I_{e,max} = I_{e,min}\cdot10^3$ $\quad 1V = \frac{R_2}{R_1}U_T\cdot4.6\lg\frac{1\times10^{-4}}{I_{REF}}$. $\Rightarrow 1\times10^{-4}\cdot1\times10^{-7} = I_{REF}^2$

$\cancel{\Delta U_{a,lg} = 3\cdot4.6R_2/R_1\cdot U_T\lg\frac{I_{max}}{I_{min}}}$ $\quad -1 = \frac{R_2}{R_1}U_T\cdot4.6\lg\frac{1\times10^{-7}}{I_{REF}}$. $\Rightarrow I_{REF} = 3.16\,nA$.

$\cancel{R_1 = 3\cdot4.6\cdot R_2\cdot U_T/\Delta U_a = \ }$ V. $\Rightarrow R_1 = 538\,\Omega$

4). ~~Aus~~ Vorlesung – Skript.

wenn. $T_c = \frac{1}{T_0}$ $\quad \left.\frac{\partial U_a}{\partial T}\right|_{T=T_0} = 0.$

$= 0.0033\ldots/K.$

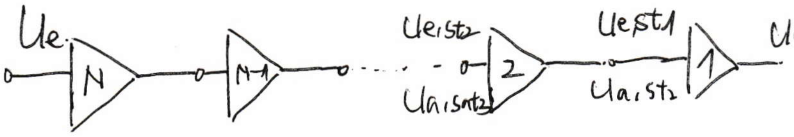
Aus die Gleichung, die Temperatur ist abhänig von U_T. und I_s

von "$\ln\frac{i_{D1}}{I_s} - \ln\frac{i_{D2}}{I_s}$" kam die Auswirkung von I_s kompensiert. mit I_s nicht zu tun.

für $U_T \sim T$. muss von eine Tempatumabhängige Widerstände kompensiert.

wie. $(1+\frac{R_1}{R_2})U_T$ oder $\frac{R_1}{R_2}U_T$. [R_2 ist abhängig von Temp T.

Lo-03.

1) 

$$U_{a,st} = \begin{cases} V_{st} \cdot U_{e,st} & 0 \le U_{e,st} \le U_k \\ (V_{st}-1)\cancel{V_{st}}\, U_k + U_{e,st} & U_{e,st} \ge U_k \end{cases}$$

2) $U_{e,st1} = U_{a,st2} = U_k$. $V_{st} = 4 > 1$. Alle $U_e \le U_k$

$\Rightarrow U_{e,1} = U_{a,st N+1} = \dfrac{U_k}{V_{st}^{N-1}} = 97.7\,\mu V$.

$U_a = V \cdot U_k = 400\,mV$.

3). $U_{e,2} = \dfrac{U_k}{V_{st}^{N-2}} = 390.6\,\mu V$

$U_a = U_k \cdot V_{st} + (V_{st}-1)U_k = \cancel{2(V_{st} \ldots)U_k - U_k}$. $700\,mV$

4) $U_{e,3} = \dfrac{U_k}{V_{st}^{N-3}} = 1.56\,mV$ $U_{a,3} = 1\,V$.

5) $U_{e,i} = \dfrac{U_k}{V_{st}^{N-i}}$ $U_{a,i} = [4 + 3(i-1)]\, U_k$

$= [(V_{st}-1)\, i + 1]\, U_k$.

6) $\dfrac{U_{e,i}}{U_{e,i-1}} = \dfrac{V_{st}^{N-(i-1)}}{V_{st}^{N-i}} = V_{st}$ $\Delta U_a = (V_{st}-1)U_k = 300\,mV$.

$\Delta U_e = \lg V_{st} = 0.6$. $U_{a,lg} = \dfrac{(V_{st}-1)U_k}{0.6} = 500\,mV$.

7) $U_a = \dfrac{\Delta U_a}{\Delta U_e} \lg \dfrac{U_e}{U_{ref}} = \Delta U \cdot \lg \dfrac{U_e}{U_{ref}} + \dfrac{U_{e,i-1}}{U_{ei}}$

$i = 1$

$\cancel{V_{st} \cdot U_k = (V_{st}-1)U_k \cdot \lg\left[\dfrac{U_e}{U_{ref}} \dfrac{U_k}{V_{st}^{N-1}} + V_{st}\right]}$

$\cancel{V_{st} \cdot U_k = (V_{st}-1)U_k \cdot \lg \dfrac{U_k V_{st}^{N-1} + U_k/U_{ref}}{U_{ref} V_{st}^{N-1}}}$ lg

$V_{st} \cancel{U_k} \cdot \lg V_{st} = (V_{st}-1)\cancel{U_k} \cdot \lg \dfrac{\frac{U_k}{V_{st}^5}}{U_{ref}}$

$U_{ref} = \dfrac{U_k}{V_{st}^5} \cdot 10^{-\frac{V_{st} \lg V_{st}}{V_{st}-1}}$

$U_{ref} \cdot 10^{\frac{V_{st} \lg V_{st}}{V_{st}-1}} = \dfrac{U_k}{V_{st}^5}$

$\Rightarrow 1.537 \times 10^{-5}\, V$.

$15.4\,\mu V$.