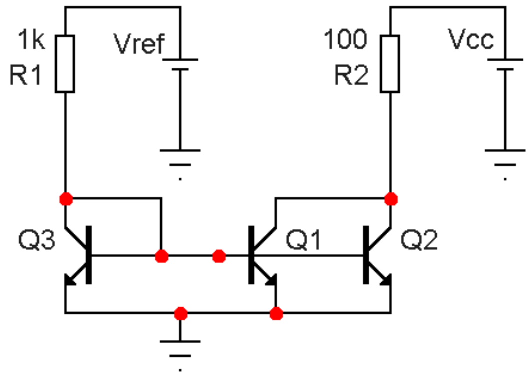
1. Vcc=20 Volt, V_{be} =0.7 Volt and β=10

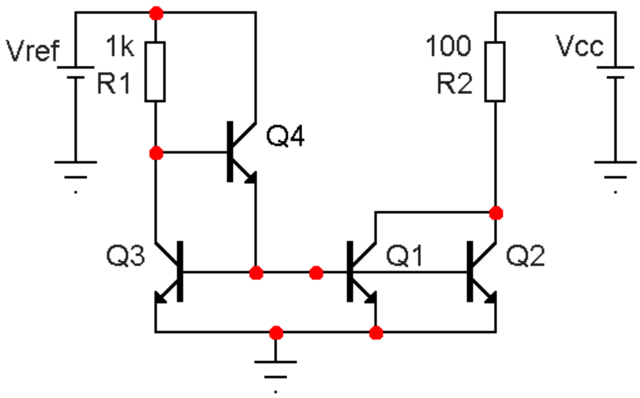


a. Calculate Vref to make I_{R2}=100mA

Bereken Vref zodat I_{R2}=100mA

Answer: Vref=65.7 Volt

2. Vcc=20 Volt, β=10

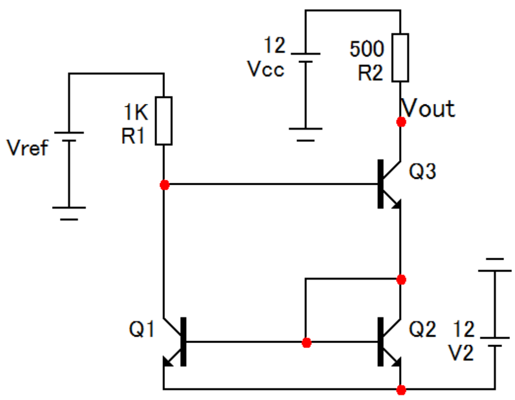


a. Calculate Vref to make I_{R2}=100mA

Bereken Vref zodat I_{R2}=100mA

Answer: Vref=52.76 Volt

3. $\beta_{1,2,3} = \infty$ V_{be} =0.7 Volt, Vref=10Volt



a. Calculate I_{R1}

Bereken I_{R1} als Vref=0 Volt

b. Calculate minimum value for Vcc ($V_{cb(Q3)}$=0.5 Vmin.)

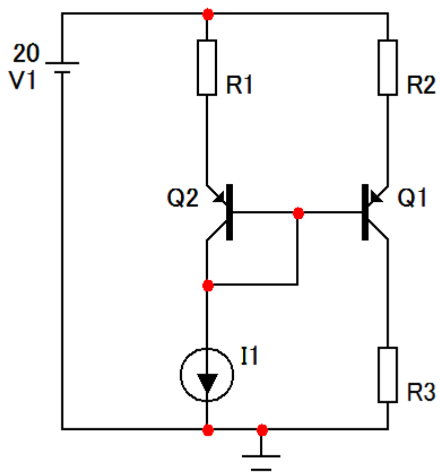
Bereken minimale waarde van Vcc ($V_{cb(Q3)}$ =0.5 Vmin.)

Answers: I_{R1}=10.6mA

Vcc_{min} = 0.2 Volt

4. R_1 =47Ω , R_2 =10R_1 and I1=10mA, $V_{cb(Q1)} > 0.5Volt$

$\beta_{Q1} = \beta_{Q2}$ Early voltage is infinity and $V_{be(Q1)} = V_{be(Q2)}$



a. Calculate the current through R3

Bereken de stroom door R3

b. Calculate the maximum value for R3

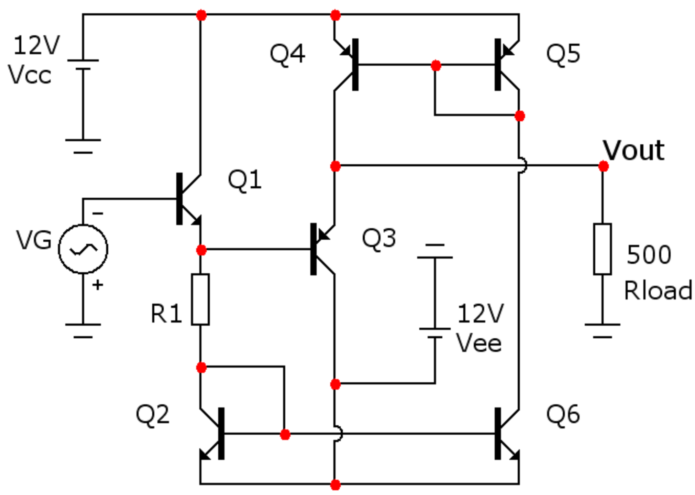
Bereken de maximale waarde voor R3

Answers: $I_{R3} = 1mA$

R_3 < 18.33 K

5. $V_{be} = 0.7Volt$ $\beta_{1,2,3,4,5,6} = \infty$

$V_G = 0.1 \times \sin(\omega t)$



a. Find the DC-value for Vout if $I_{c1}=I_{c3}$.
This should not be calculated. Give a short explanation

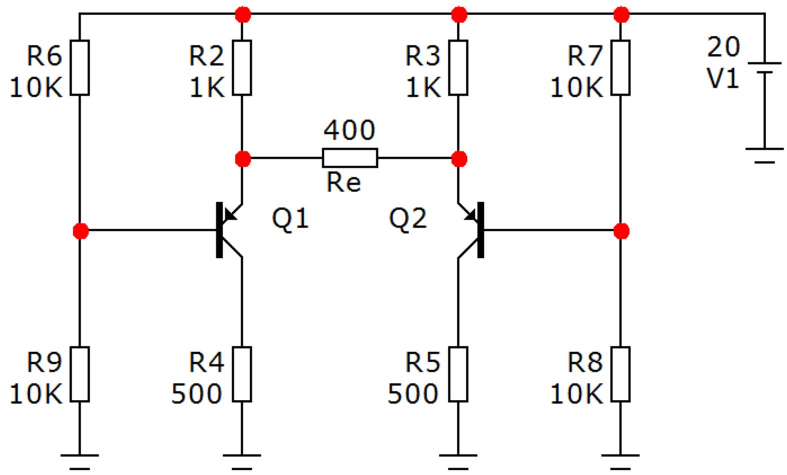
b. Calculate R1 to make I_{e1}=5mA

Answers:

a. Vout is zero, because $I_{e1} = I_{e2}$, results in $V_{be1}=V_{be2}$

b. R1=2260

6. $V_{be(Q1)}=V_{be(Q2)}$=0.7 Volt
$\beta_{Q1,Q2}$=10



a. Find the DC current through Re

b. Calculate the current through R2

c. Calculate the voltage Vc1

Answer questions d,e and f with:
R6=20K and R9=30K
All betas are infinity !!!!!

d. Calculate the DC current through Re

e. Calculatie the current through R2

f. Calculate the voltage Vc1

Answers:

a. Zero because of balanced condition

b. I_{R2}=6.39 mA

c. Vc1=2.9 Volt

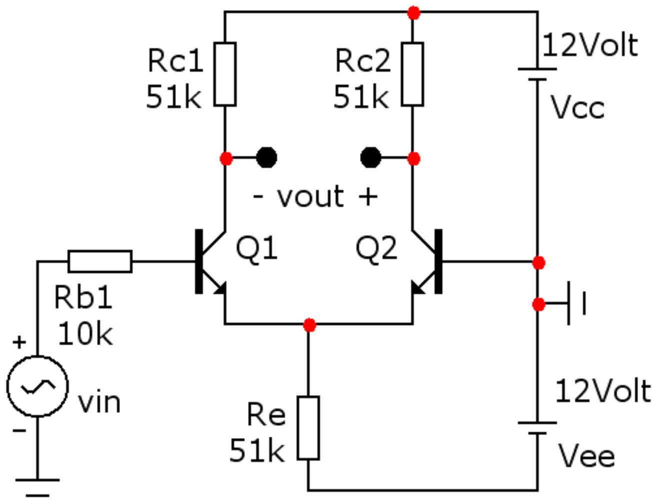
d. I_{Re}=5mA

e. I_{R2}=7.3mA

f. Vc1=1.15 Volt

7. $\beta_{1,2} = \infty$ and V_{be} =0.7 Volt

$V_{in} = 1mV\sin(2000\pi t)$



a. Calculate I_{cQ1} and I_{cQ2}

Bereken I_{cQ1} en I_{cQ2}

b. Calculate V_{cQ1} referred to ground

Bereken V_{cQ1} t.o.v. aarde

c. Draw the small signal equivalent circuit

Teken het klein signaal vervangingschema

d. Calculate the signal voltage at the base of Q_1

Bereken de signaalspanning op de basis van Q_1

e. Use the small equivalent circuit to calculate the gain

$A_v = \frac{vout}{vin}$ Neglect the signal current through Re

Gebruik het klein signaal vervangingschema ter bepaling van de versterking $A_v = \frac{vout}{vin}$ Verwaarloos de signaalstroom door Re

f. Calculate the amplitude of $v_{cQ1}(t)$ referred to ground

Bereken de amplitude of $v_{cQ1}(t)$ t.o.v. aarde

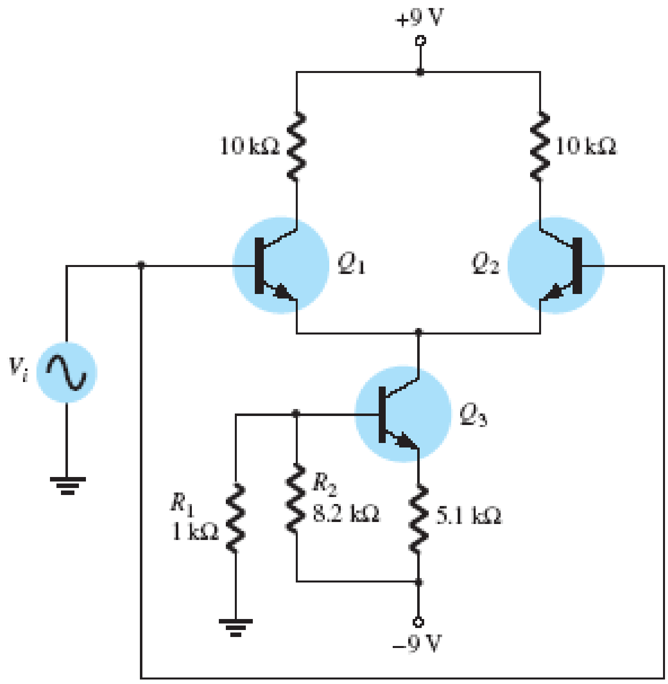
Answers: a. collector currents 0.111mA, b. $V_{c(Q1)}$=6.35 Volt, c. See textbook, d. $v_{b(Q1)}$ = equal to vin
e. A_v =218, f. $v_{c(Q1)}$ =109 mV

8. Current gain of Q1,…Q3 is 75
Output resistance Q3 is 200 KΩ

a. Calculate the common mode gain (A_{vc})

$A_{vc} = \frac{v_{c(Q1)}}{V_i}$ (definition)

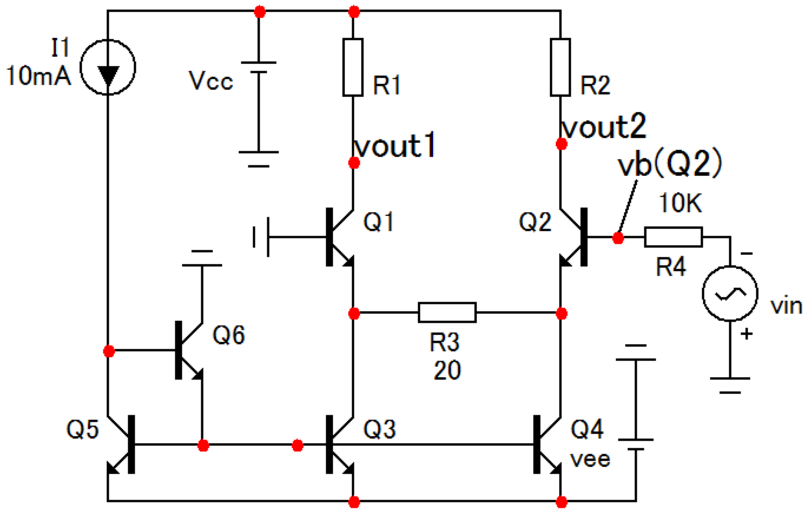
Answer: A_{vc} =25e-3



9. R1=R2=200Ω

$\beta_1 = \beta_2 = \beta = 20$

$\beta_3 = \beta_4 = \beta_5 = \beta_6 =$ infinity



a. Find the numerical value of the gain

$$A_{v1} = \frac{vout_1}{vb(Q_2))}$$

b. $$A_{v2} = \frac{vb(Q_2)}{vin}$$

Answer:

a. $$A_{v1} = \frac{vout}{vb(Q_2)} = \left(\frac{\beta}{1+\beta}\right)\frac{R_1}{2r_e + R_3} = 2.64$$

b. $$A_{v2} = \frac{R_{ib2}}{R_{ib2} + R_4} = \frac{(1+\beta)(2r_e + R_3)}{(1+\beta)(2r_e + R_3) + R_4} = 0.131$$

10. All betas are infinity

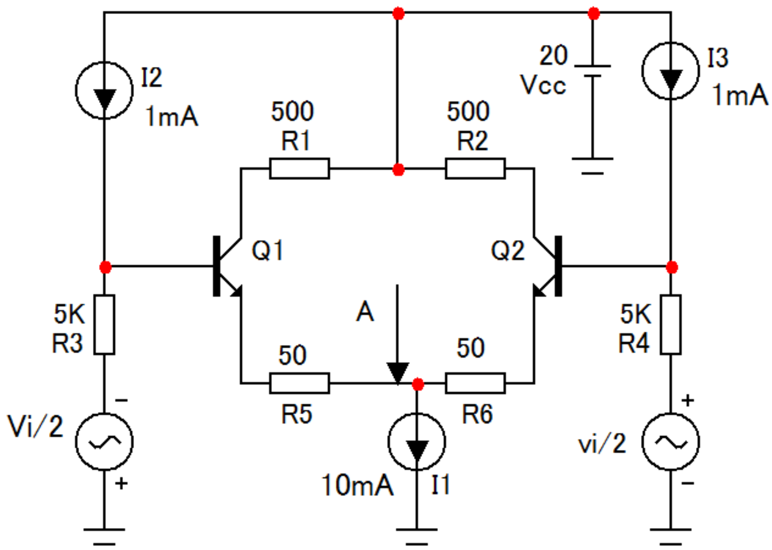
a. Calculate the DC voltage at the base of Q1 and Q2

b. Calculate the DC voltage at the collector of Q1 and Q2

c. Draw the small equivalent diagram

d. Use the equivalent diagram to find the differential gain if the difference of the collector voltages is defined as the output voltage.

$$A_v = \frac{v_{c1} - v_{c2}}{v_i}$$



Answers:

a. Vb1=5 Volt

b. Vc1=17.5 Volt

c….

d. A_v=9.06

11. …

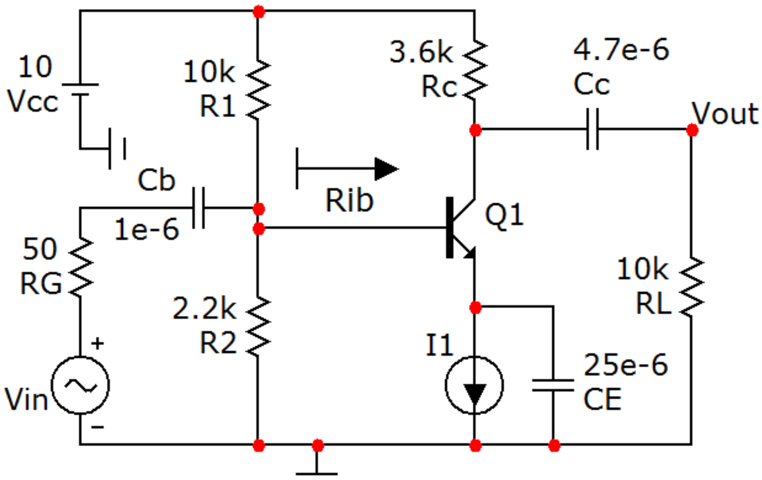
a.

b.

1. $\beta_{Q1} = 20$, $I_1 = 1$ mA

   $V_{in} = 0.001 \times \sin(2000\pi t)$

   I_1 is current source !



a. Draw the small signal equivalent circuit, including the capacitors. Only equivalent T-model is allowed.

b. Find the expression for calculating R_{ib} (assume that the emitter is grounded)

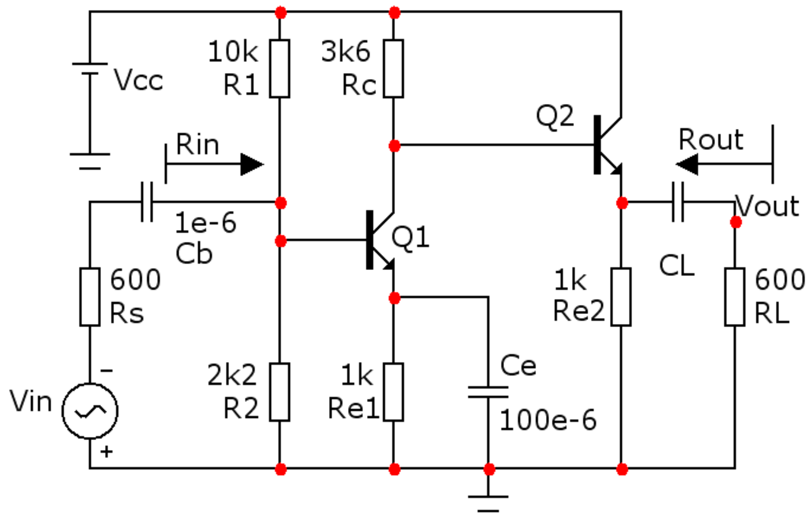
c. Calculate the low-cutoff frequency [Hz] for Cb=1µF with R_{ib} =1000 Ω

d. Calculate the low-cutoff frequency caused by Cc. (C_c =4.7µF)

e. Calculate the low-cutoff frequency for C_E =25µF. Use β=∞

Answers: a. Check sheets b. $R_{ib} = (1+\beta) r_e$ c. f_{-3dB}=230Hz d. f_{-3dB}=2.49Hz e. f_{-3dB}=1538Hz

2. $\beta_{Q1} = \beta_{Q2} = \infty$ & Vcc=15Volt



a. Calculate the collector currents of Q1 and Q2

   Bereken de collectorstromen van Q1 en Q2

b. Draw the small signal equivalent circuit, with short circuited capacitors.

   Teken het kleinsignaal vervangingschema met kort gesloten condensatoren.

c. Write down the expression to calculate the mid band gain. Gain definition is:

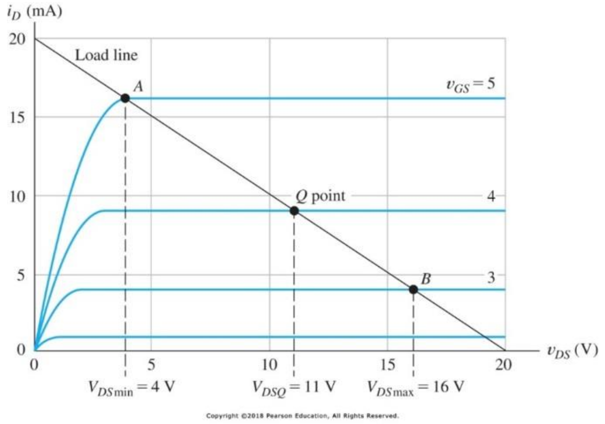
$$A_v = \frac{V_{out}}{V_{in}}$$

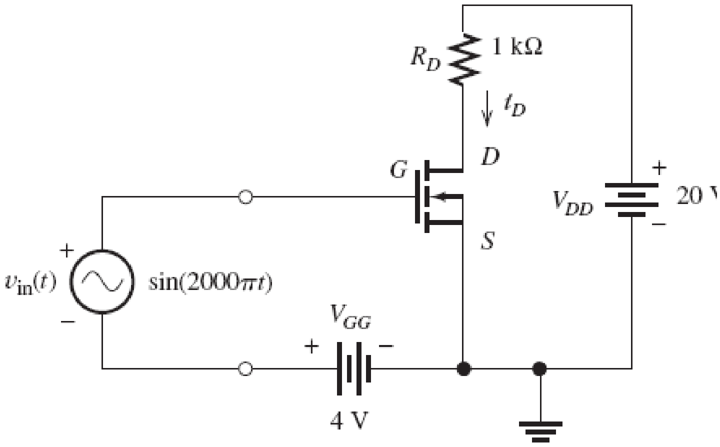
The numerical value is not requested.

Vermeld de uitdrukking waarmee de mid band versterking berekend kan worden. De versterking is gedefinieerd als: $A_v = \frac{V_{out}}{V_{in}}$ Numerieke waarde wordt niet gevraagd.

3.
a.
b.
c.

1. Given circuit and related graph





a. Suppose the Qpoint is valid, what will be the not distorted maximum amplitude of the output signal? (voltage between drain and source)

b. Suppose the Qpoint B is valid what will be the not distorted maximum amplitude of the output signal?

c. Suppose the Qpoint A is valid what will be the not distorted maximum amplitude of the output signal?

Answers: a. 7 Volt top

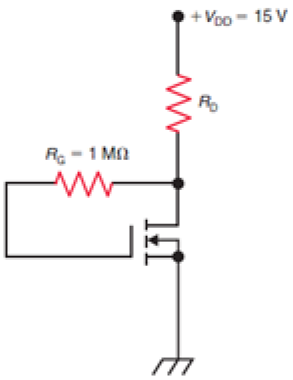
b. 4 Volt top

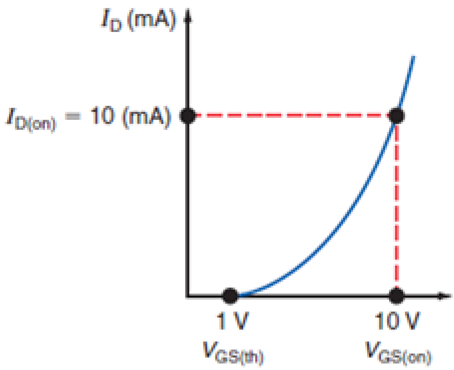
c. 0 Volt

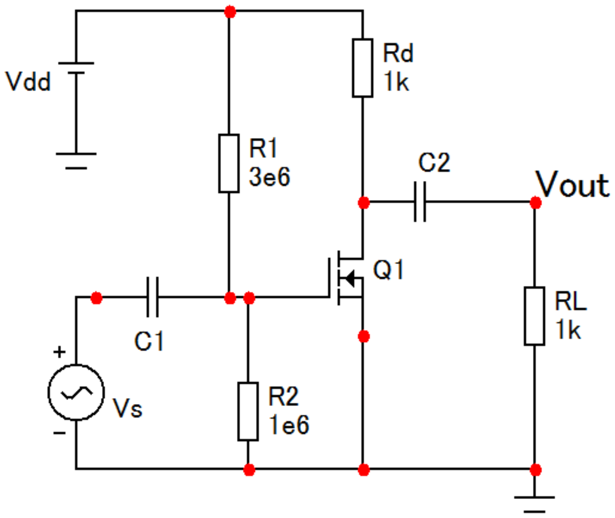
2. See schematic and MOSFET characteristics

a. Calculate R_D to make I_D=10mA

Answer: 500Ω







3. $I_D = k(V_{GS} - V_{to})^2$

$$g_m = \frac{dI_d}{dV_{GS}} \approx \frac{\Delta I_d}{\Delta V_{Gs}} \quad g_m = 2k(V_{GS} - V_{to})$$

V_{th}=2 Volt and K=0.004

Vdd=10 Volt

a. Calculate the DC drain voltage referred to ground

b. Calculate midband signal voltage gain

$$\left(def.: \quad A_v = \frac{v_{RL}}{V_s} = \frac{Vout}{V_s} \right)$$

Answers: a. $V_d = V_{dd} - I_d R_d = 10 - 0.001 \times 1000 = 9\,Volt$

b. $g_m = 2 \times 0.004 \times (2.5 - 2) = 0.004\ {}^{mA}/_{V}$

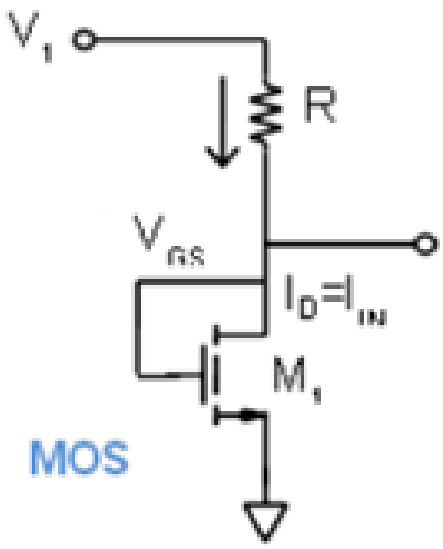
$i_d = g_m v_{gs} \quad and \quad v_d = i_d \times (R_d // R_L)$

$A_v = \frac{v_{out}}{v_s} = 2$

4. Given circuit to create a specific V_{GS} Voltage

Use: $I_d = K\left(V_{GS} - V_{to}\right)^2$

$K = 200\ {}^{\mu A}/_{V^2}$, V_{to}=2 Volt and V_1=10 Volt



a. Calculate R to make I_D=100 µA

b. Calculate V_{GS}

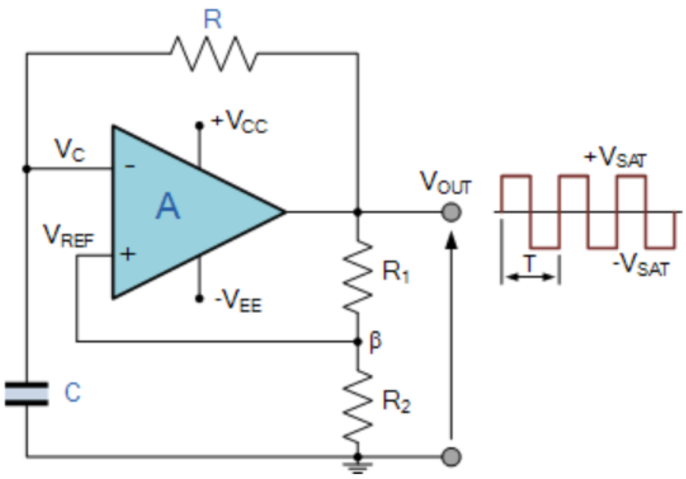
Answers: a. R=72928 Ω

b. V_{GS}=2.70 Volt

5.

6.

7.



1. The Opamp is ideal. Vcc=10 Volt, Vee= -5 Volt
   $R_1=R_2=1K$, R=1K and C=1µF

a. Calculate the threshold voltages
   V_{UT} & V_{LT} $(V_{sat}=V_{cc})$
b. Find the expression for charging and discharging C
c. Calculate the charging time and discharging time.
d. Sketch the wave form $v_{cap}(t)$

Answers:

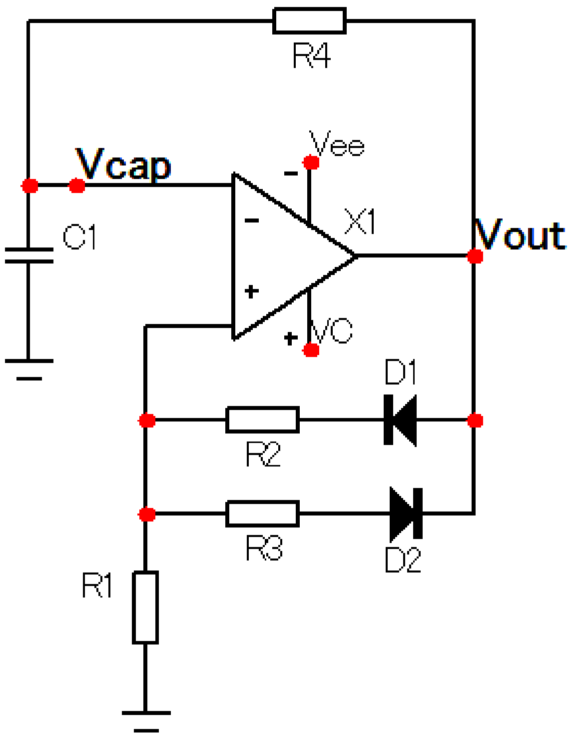
$$V_{UT}=\frac{R_2}{R_2+R_1}V_{cc}=5\,Volt, V_{LT}=\frac{R_2}{R_2+R_1}V_{ee}=-2.5\,Volt$$

$$v_c(t)=V_{cc}-(V_{cc}-V_{LT})e^{\frac{-t_{ch}}{\tau}}$$

$$v_c(t)=V_{ee}-(V_{ee}-V_{UT})e^{\frac{-t_{dis}}{\tau}}$$

$$t_{ch}=\tau\ln\left(\frac{V_{LT}-V_{cc}}{V_{UT}-V_{cc}}\right)=(1e-3)\ln\left(\frac{-2.5-10}{5-10}\right)=0.92ms$$

$$t_{dis}=\tau\ln\left(\frac{V_{UT}-V_{ee}}{V_{LT}-V_{ee}}\right)=(1e-3)\ln\left(\frac{5-(-5)}{-2.5-(-5)}\right)=1.39ms$$



2. $R_1=R_4=1K$, $V_{cc}=-V_{ee}=10$ Volt and Opamp is ideal.
   $V_{out(max)}=V_{cc}$ and $V_{out(min)}=V_{ee}$
a. Calculate R2 and R3 to create upper and lower threshold voltages of 6 Volt and -4 Volt
b. Calculate C1 to make τ=1ms

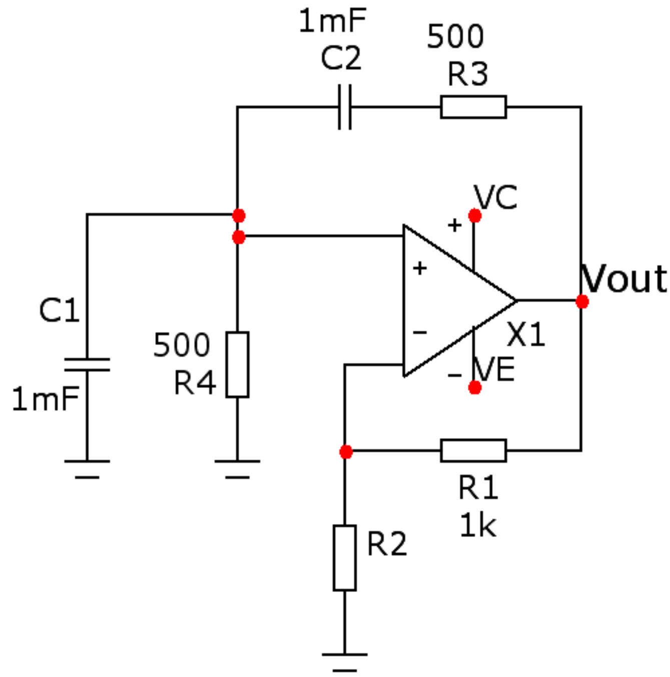
Answers:

a. $V_{UT}=\frac{R_1}{R_1+R_2}Vcc \quad R_2=\frac{R_1(Vcc-V_{UT})}{V_{UT}}$

$V_{LT}=\frac{R_1}{R_1+R_3}Vee \quad R_3=\frac{R_1(Vee-V_{LT})}{V_{LT}}$

b. $C_1=\frac{\tau}{R_4}=1\mu F$

3. Frequency of oscillation is $f_r = \frac{1}{2\pi RC}$



a. Calculate the frequency of oscillation
b. What is the relationship between the voltage at the none inverting input and the output, in case the circuit oscillates.
c. Calculate the critical value for R2
d. Which component must be replaced by a bulb for gain control. The resistance of a bulb increase if the applied voltage increase (pos. temp. coefficient)

4. Phase locked loop

a. Draw the blockdiagram of the PLL.
b. What is the main function of the PLL ?
c. Give a short description about the capture range (Lock range is not equal to the Cap. Range)
d. Which block is responsible for the “lock speed”?

5.
a.
b.