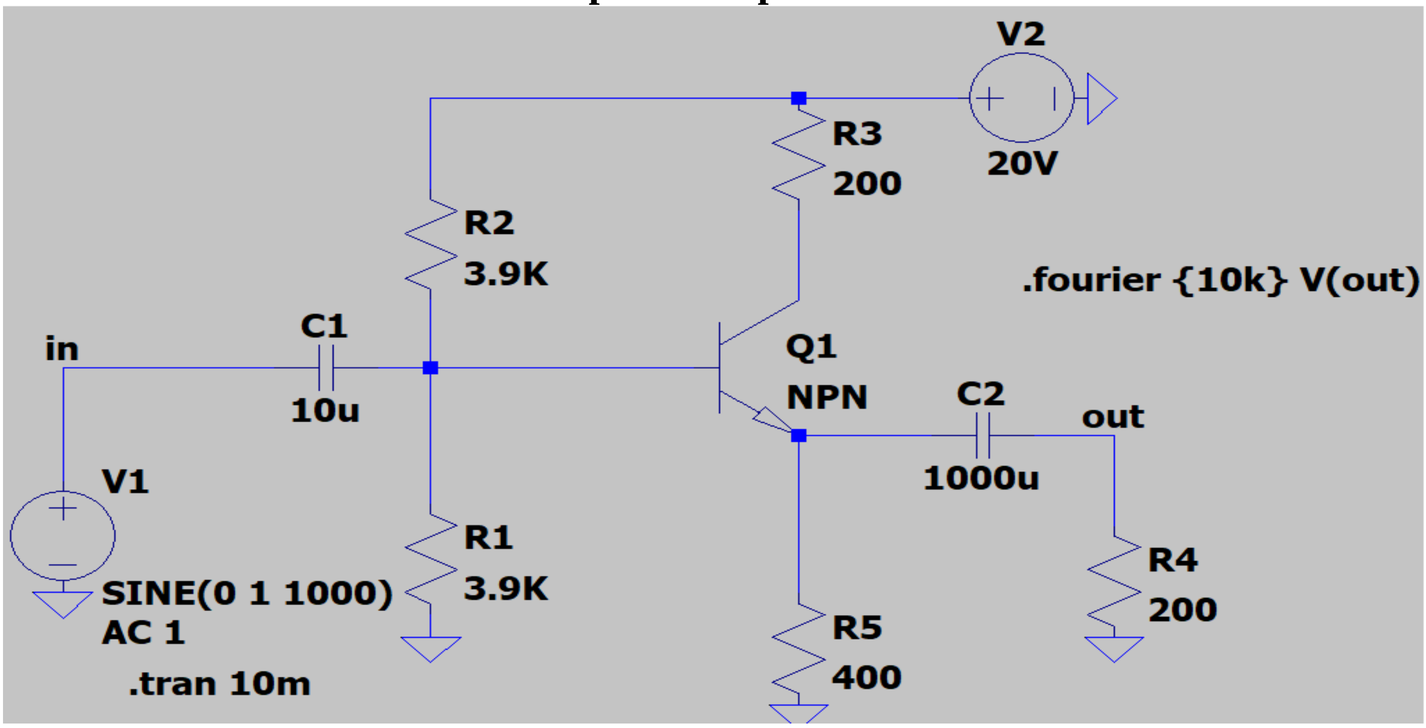
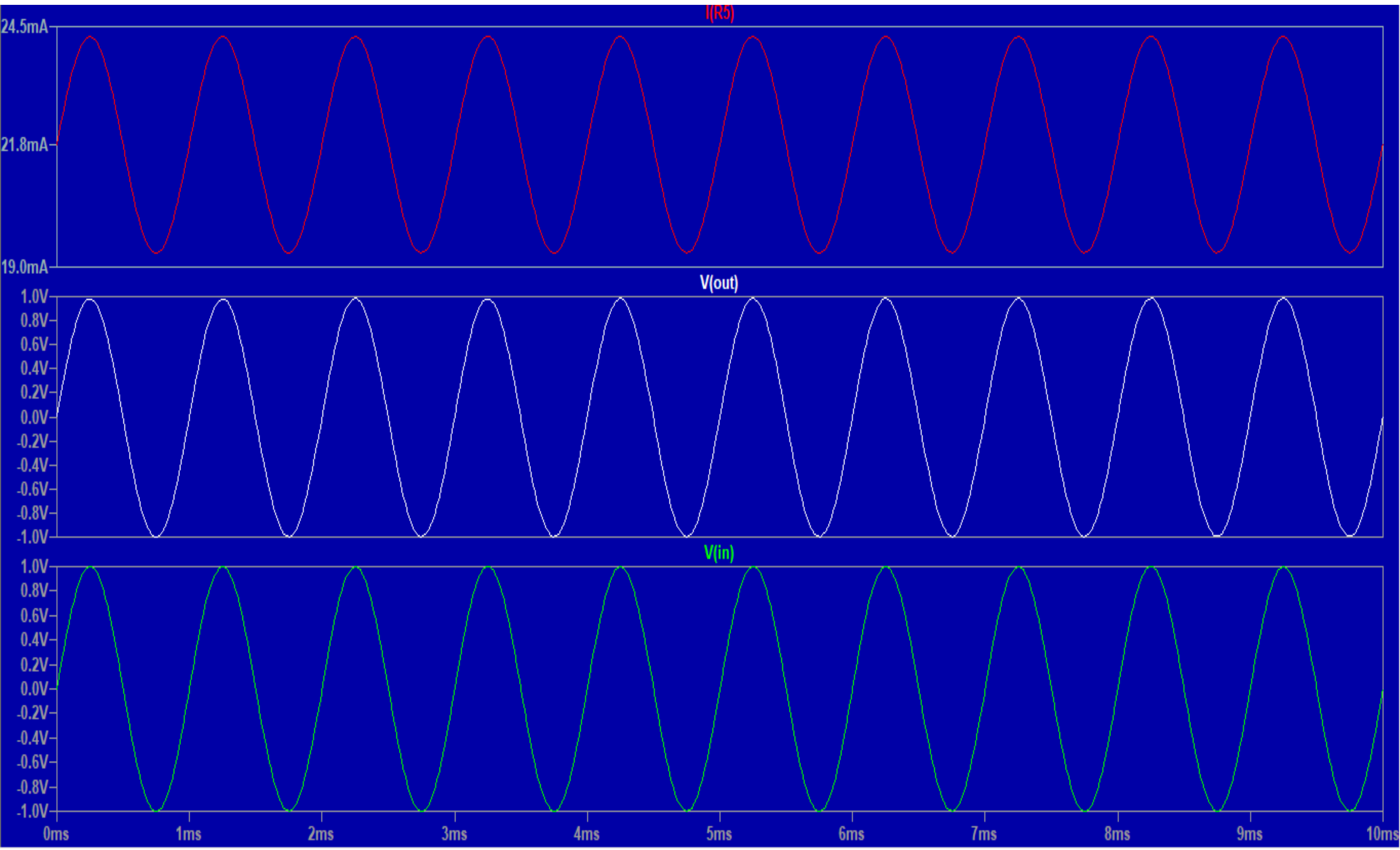
3 laboratory work
Investigation of power amplifier

Work aim: – to learn and understand about transistor power amplifier and its parameters, circuits.

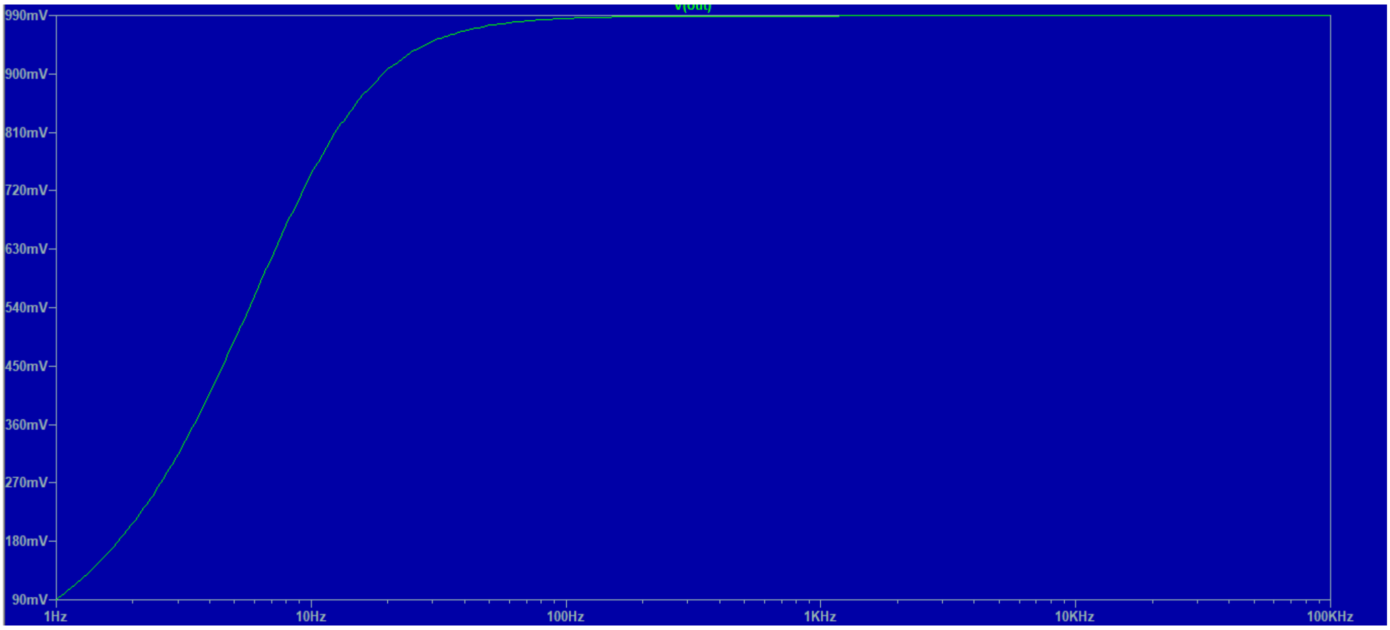
Class A power amplifier



Transient Response of input, output, current I_E of Class A power amplifier:



AC Response and Bandwidth



$U_{-3dB} = 990mV \,/\, \sqrt{2} = 0.7000357134V$

$f_{-3db} = 8.8100034$ Hz

DC values of U_b, U_k, U_e, I_b, I_k, I_e :

U_b: 9.85723 V	**I_b: 75.5218 uA**
U_k: 15.458555 V	**I_k: 22.7072 mA**
U_e: 9.1130911 V	**I_e: -22.7828 mA**

vrms: RMS(v(out))= <u>2.4958</u> FROM 0 TO 0.003

P_{out} is output signal power

$P_{out} = u_{out}^2 \,/\, R_a = (\underline{2.4958})^2 \,/\, 200 =$ <u>*0.0311450882 W*</u>

P_{DC} is DC power from supply

$I_{DC} \sim I_e$ *(average value)*

$P_{DC} = U_{DC} \cdot I_{DC} = 20 \,.\, 22.7828\text{x}10^{-3}$

$= \underline{0.455656 \text{ W}}$

Power Gain $= P_{out} / P_{in} =$

$0.0311450882 / 0.0091530024 = \underline{3.4027182381 \text{ W}}$

$P_{in} = P_{in\ RMS} = V_{in\ rms} \,.\, I_{in\ rms} =$

$2.8272359327 \text{ V} \,.\, 1.618719238\text{x}10^{-3}\text{A} =$

$\underline{4.5765011946\text{x}10^{-3}}$ W

R_{out} – amplifier output resistance

$$R_{out} = R_3 \ ((u_{out1} / u_{out}) - 1)$$

$u_{out1} = 3.9719388 \text{ V} / \sqrt{2} = \underline{2.8085848599} \text{ V}$

$u_{out} = 3.4422098 \text{ V} / \sqrt{2} = \underline{2.4340093262} \text{ V}$

$R_{out} = 200 \,.\, ((2.8085848599 / 2.4340093262) - 1)$

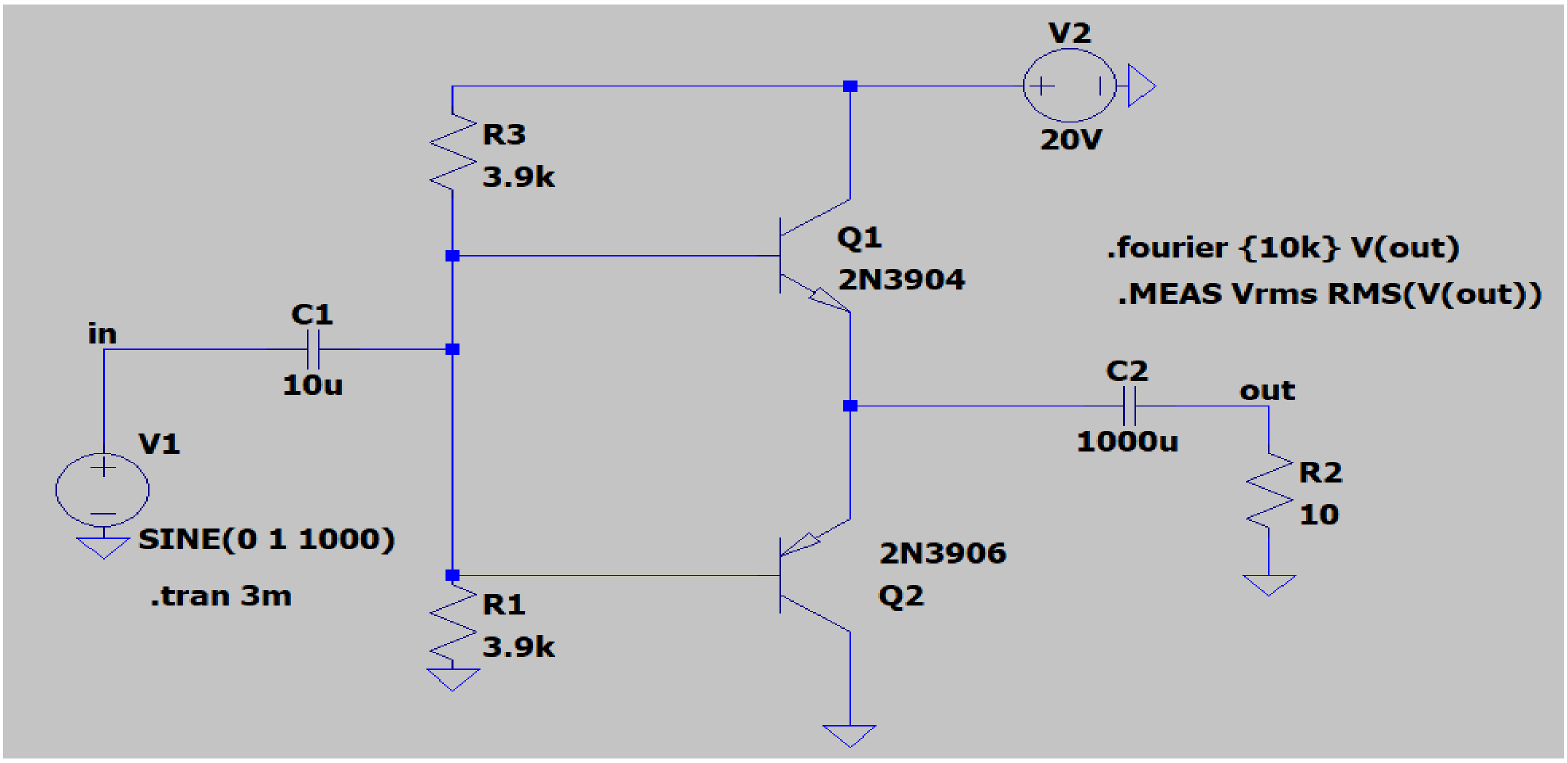
$= \underline{30.77847974} \ \Omega$

power loss $\Delta P = P_{DC} - P_{out}$

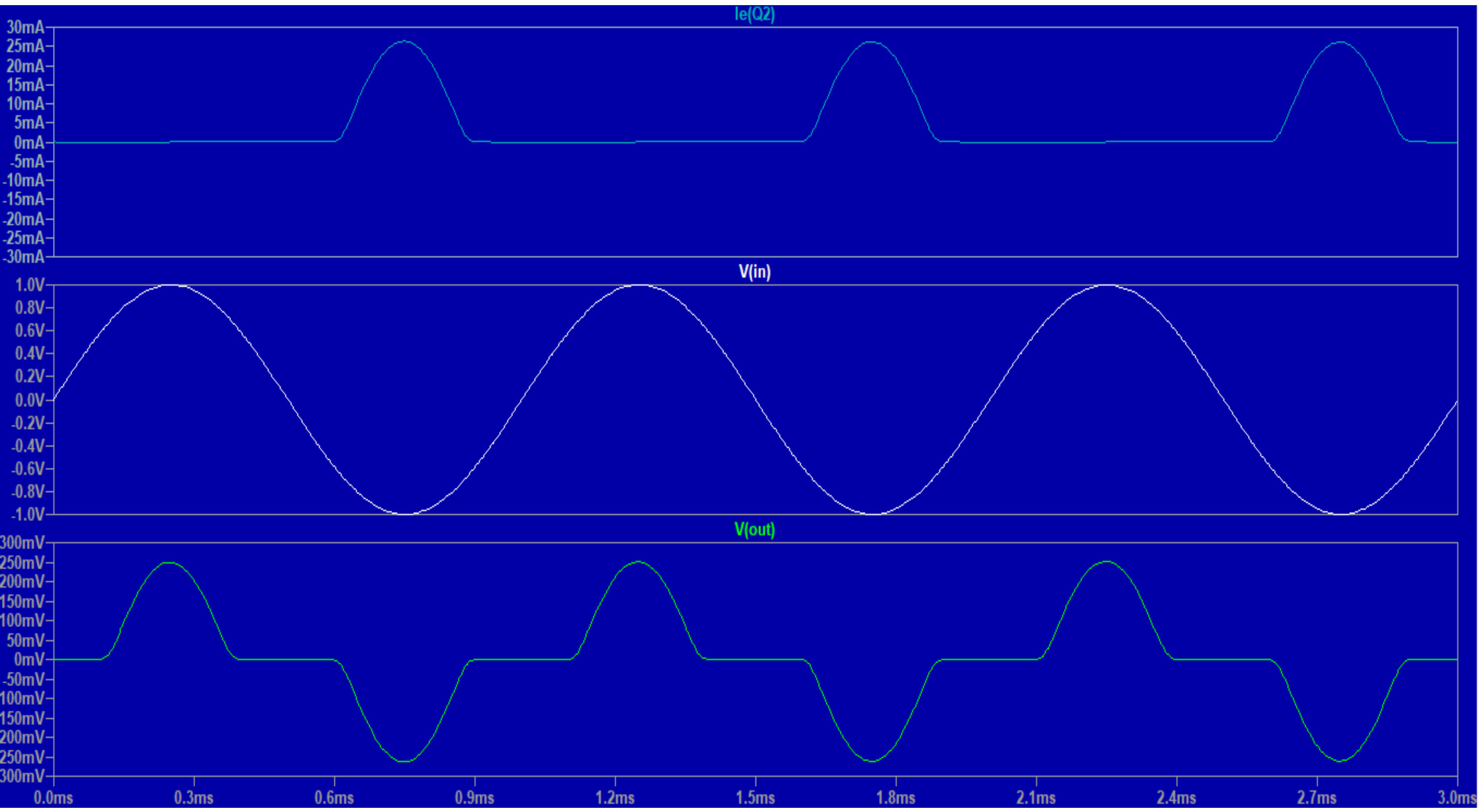
$= 0.455656 - 0.0311450882 = \underline{0.4245109118 \text{ W}}$

$\eta = P_{out} / P_{DC} = \underline{0.068352196}$

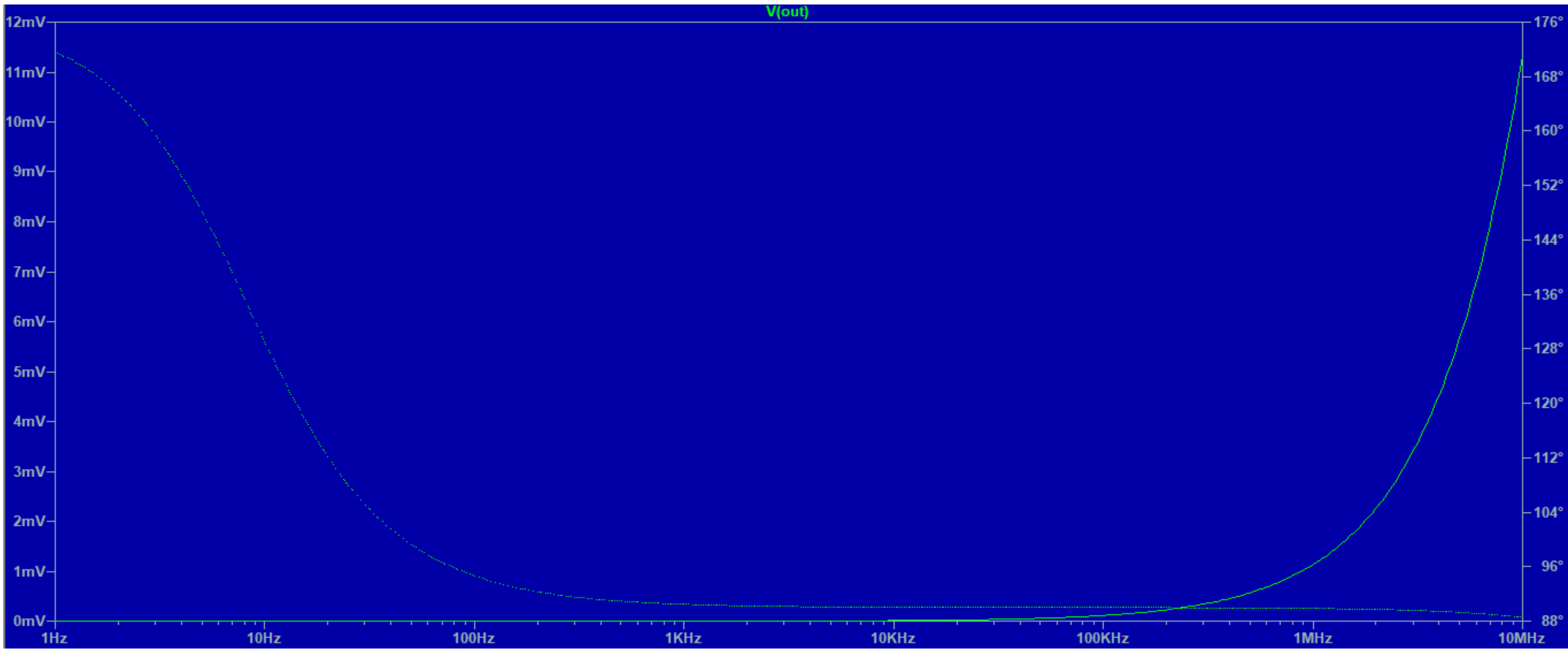
Class B Power Amplifier



Transient response



AC Response and Bandwith (-3dB)



$$U_{-3dB} = 11.305323mV / \sqrt{2} = 7.9940705568\ mV$$

$$f_{-3dB} = 7.0421207MHz$$

DC values of U_b, U_k, U_e, I_b, I_k, I_e :

U_b: 10 V **I_b: 10 pA**

U_k: 20 V **I_k: 10.08 pA**

U_e: 9.9979 V **I_e: -10.02499 pA**

vrms: RMS(v(out))=0.00652789 FROM 1 TO 1e+07

P_{out} is output signal power

$P_{out} = u_{out}^2 / R_a = (0.00652789)^2 / 10 = \underline{0.0000042613}$ W

P_{DC} is DC power from supply

($P_{DC} = U_{DC} \cdot I_{DC}$) $I_{DC} \sim 1/\pi * I_{ep}$

(I_{ep} is peak value of Q1 emiter or Q2 emiter)

I_{ep} = **0.0317516413 pA**

$P_{DC} = U_{DC} \cdot I_{DC} = 20 \ . $ **0.0317516413 =**

= **<u>0.6350328626</u>** pW

Power Gain = P_{out} / P_{in} = $\underline{4.26100000E\text{-}16\ W}$

$P_{in} = P_{in\ RMS} = V_{in\ rms} \ . \ I_{in\ rms} = 1x10^{-10}$

$0.\underline{177287049616\ V\ .\ \ 644.27349x10^{-12}\ A\ =}1x10^{-10}$

1. R_{out} – amplifier output resistance

$$R_{out} = R_3 \ ((u_{out1} / \ u_{out})-1)$$

u_{out1} =0.7076175951 V $\quad\quad$ u_{out} = 0.1772870496 V

R_{out} = 29.914223639 Ω

power loss $\Delta P = P_{DC} - P_{out}$ =

0.6350328626 *pW* – 0.0000042613 W = <u>- 0.0000042613 W</u>

$\eta = P_{out} / P_{DC}$ = <u>6.71036139E-21</u>

SPICE Error Log: C:\Users\templ\OneDrive\Masaüstü\labwork 3\Draft1.log

```
Circuit: * C:\Users\templ\OneDrive\Masaüstü\labwork 3\Draft1.asc

Direct Newton iteration for .op point succeeded.
N-Period=1
Fourier components of V(out)
DC component:-3.55417e-05

Harmonic          Frequency          Fourier          Normalized
 Number             [Hz]            Component          Component
    1             1.000e+4          7.019e-5           1.000e+0
    2             2.000e+4          6.257e-5           8.915e-1
    3             3.000e+4          5.385e-5           7.672e-1
    4             4.000e+4          4.601e-5           6.555e-1
    5             5.000e+4          3.957e-5           5.638e-1
    6             6.000e+4          3.444e-5           4.907e-1
    7             7.000e+4          3.034e-5           4.323e-1
    8             8.000e+4          2.704e-5           3.852e-1
    9             9.000e+4          2.434e-5           3.468e-1
Total Harmonic Distortion: 168.141291%(198.278953%)

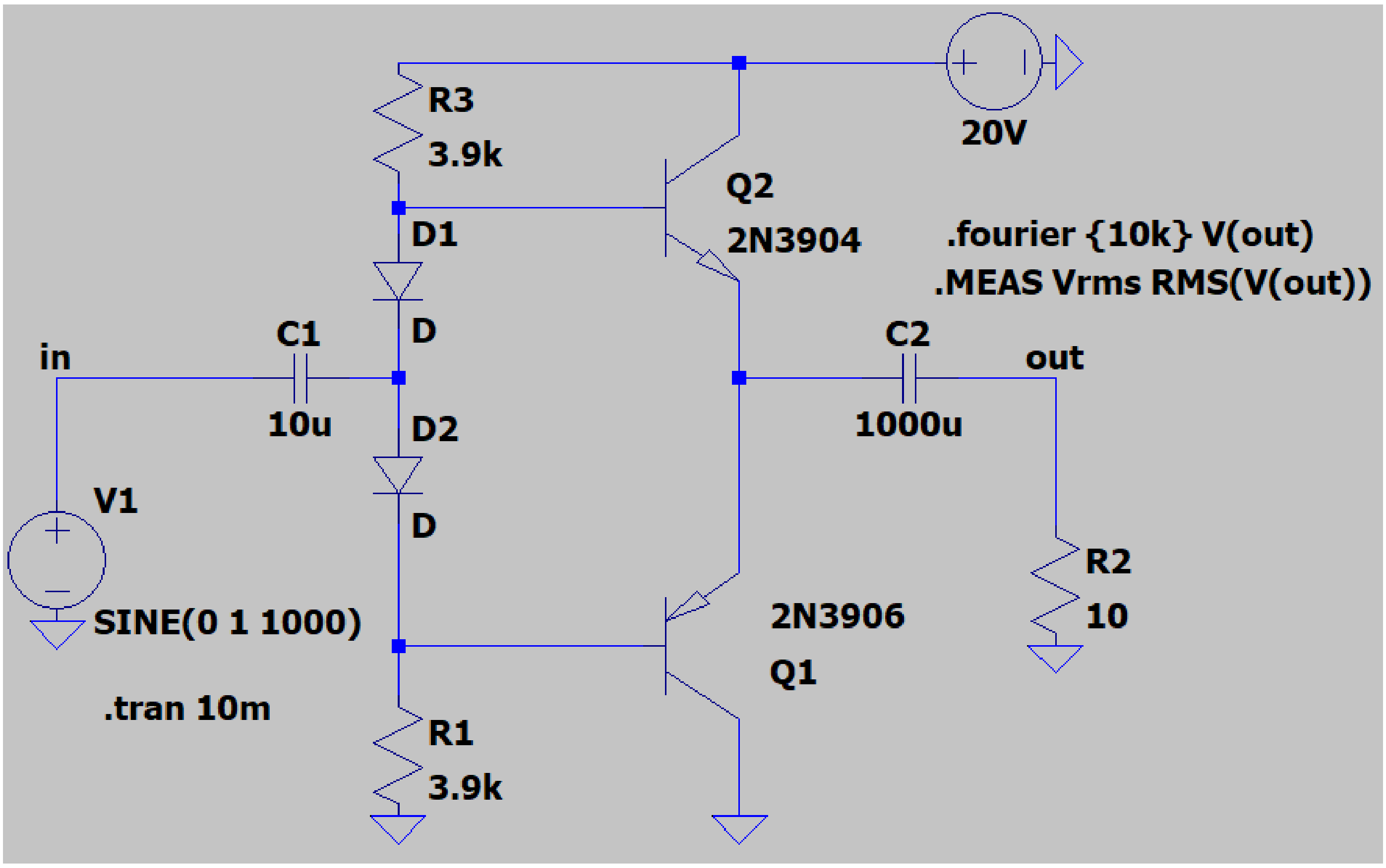


vrms: RMS(v(out))=0.132291 FROM 0 TO 0.003

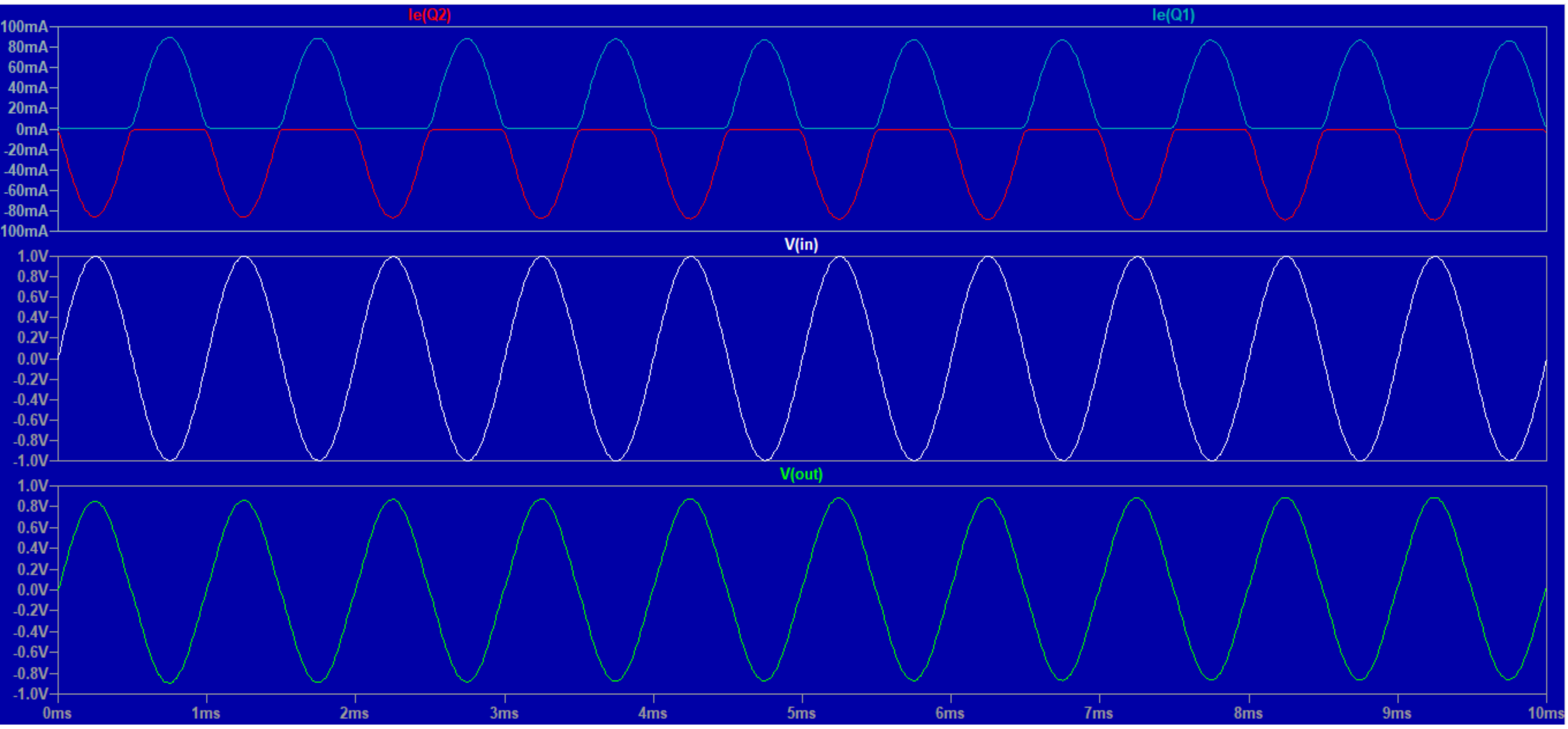

Date: Wed May  6 21:02:54 2020
Total elapsed time: 0.144 seconds.

tnom = 27
```

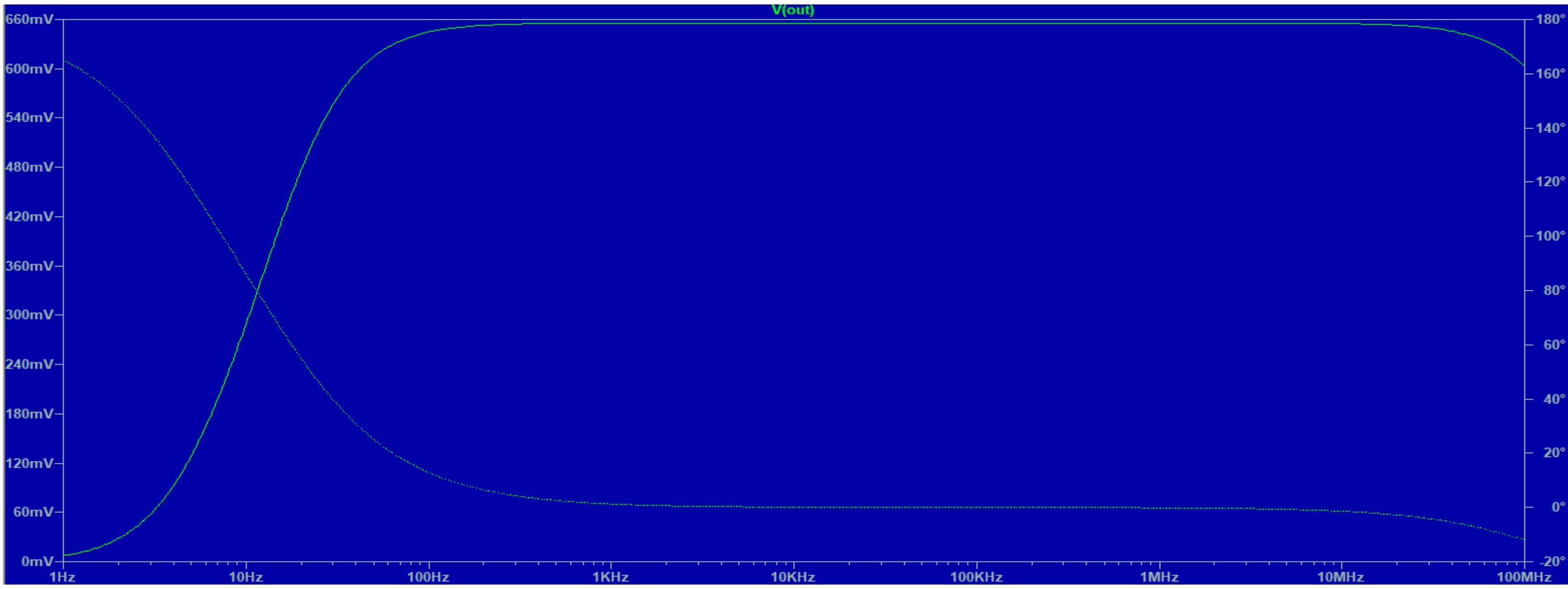
Class AB Amplifier



Transient response of AB power amplifier



AC Response and Bandwidth



$$U_{-3dB} = 0.4666904756 \text{ V}$$

$$f_{-3db} = 19.276997\text{Hz}$$

SPICE Error Log: C:\Users\templ\OneDrive\Masaüstü\labwork 3\power b\Draft2.log

```
Circuit: * C:\Users\templ\OneDrive\Masaüstü\labwork 3\power b\Draft2.asc

Direct Newton iteration for .op point succeeded.
N-Period=1
Fourier components of V(out)
DC component:-0.211479

Harmonic          Frequency        Fourier          Normalized
 Number             [Hz]          Component          Component
    1             1.000e+4         1.608e-1          1.000e+0
    2             2.000e+4         7.794e-2          4.848e-1
    3             3.000e+4         5.178e-2          3.220e-1
    4             4.000e+4         3.883e-2          2.415e-1
    5             5.000e+4         3.106e-2          1.932e-1
    6             6.000e+4         2.588e-2          1.610e-1
    7             7.000e+4         2.219e-2          1.380e-1
    8             8.000e+4         1.943e-2          1.209e-1
    9             9.000e+4         1.729e-2          1.075e-1
Total Harmonic Distortion: 71.098552%(77.678570%)



vrms: RMS(v(out))=0.610729 FROM 0 TO 0.01


Date: Fri May  8 00:12:03 2020
Total elapsed time: 0.230 seconds.

tnom = 27
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DC values of U_b, U_k, U_e, I_b, I_k, I_e :

U_b: 10 V I_b: 10 pA

U_k: 20 V I_k: 10.08 pA

U_e: 9.9979 V I_e: 17.76 fA

vrms: RMS(v(out))=0.636995 FROM 1 TO 1e+08

P_{out} is output signal power

$P_{out} = u_{out}^2 / R_a = (0.636995)^2 / 10 = 0.040576263$ W

P_{DC} is DC power from supply

($P_{DC} = U_{DC} \cdot I_{DC}$) $I_{DC} \sim 1/\pi * I_{ep}$

(I_{ep} is peak value of Q1 emiter or Q2 emiter)

$I_{ep} = 89.348271$mA

$P_{DC} = U_{DC} \cdot I_{DC} = 20 \ . \ 0.0351612025 = \underline{0.70322405\ W}$

Power Gain = P_{out} / P_{in} = 0.040576263 / $5x10^{-10}$

=$\underline{8.11525300E-13}$

$P_{in} = P_{in}$ RMS = Vin rms . Iin rms

= 0.7059449482 . $7x10^{-10}$ = $\underline{5x10^{-10}}$

2. R_{out} – amplifier output resistance

$$R_{out} = R_3\ ((u_{out1}/\ u_{out})-1)$$

u_{out1} = 709.4682425499 mV u_{out} = 620.8701948287 mV

$R_{out} = \underline{1.426997921}\ \Omega$

power loss $\Delta P = P_{DC} - P_{out}$ =

0.70322405 - 0.040576263 = $\underline{0.662647787\ W}$

$\underline{\eta = P_{out} / P_{DC} =}$ 0.040576263 / 0.70322405 = $\underline{0.0577003346}$

Conclusion

At the end of the experiment, the result that I acquired is not accurate to the theory also values of the efficiency and power gain are not satisfying bccause of their low values. The efficiency of Class A amplifier expected to be lowest but in this situation it was the highest so its not accurate to the theory also the Class AB Amplifier suppose to be higher than Class A amplifier and lower than Class B amplifier but in this condition its the lowest amplifier. When it comes to power gain Class A amplifier has the highest value and Class AB amplifers follows it and Class B amplifier has the lowest power gain value which is also not accurate to the theory