KAUNAS UNIVERSITY OF TECHNOLOGY

FACULTY OF ELECTRICAL AND ELECTRONICS ENGINEERING

DEPARTMENT OF ELECTRONICS ENGINEERING

Analogue Devices

T170B303

Project report

STUDENT NAME : ULAS CAN ACAR

Transistor Amplifier Design

It is need to design transistor amplifier with specifications.

Table 1. Specifications of transistor amplifier

Variant	Input voltage (sinusoid), Vrms	Voltage gain	Supply voltage, V	Load resistance, Ω	Low critical frequency (-3dB), Hz
1.	0,010	100	+20	10000	20
2.	0,020	120	+15	8000	30
3.	0,005	200	+10	9000	40
4.	0,050	180	+30	7000	50
5.	0,035	150	+25	14000	25
6.	0,015	90	+12	15000	10
7.	0,025	100	+14	12000	20
8.	0,010	50	+8	10000	30
9.	0,005	200	+5	15000	40
10.	0,008	400	+24	10000	20

Semester work assign

Eil. Nr. / No.	Studento pavardė, vardas / Student's surname, name	Variantas / Variant
1.	Abdul Salam Asif	1
2.	Acar Ulas Can	2
3.	Bacevičius Rimas	3
4.	Di Lorenzo Federico	4
5.	Gante Shankar Dhanalakshmi	5
6.	Rodriguez Sanchez Alvaro	6
7.	Tchuisseu Ndjionkou Armel	7

DC DESİGN PROCESS

First, the required output compliance from the amplifiers is found by converting the value V_{out} to a peak to peak value. The value of V_{out} is found as :

$$V_{out} = A_v V_{in} = 2.4 \text{ V}$$

The peak to peak output voltage is found as

$$V_{PP} = 2.828 V_{out} = 6.78816 \text{V}$$

Therefore minimum value of V_{CEQ} is

$$V_{CEQ} = V_{PP} / 2 = 3.39408 \text{ V}$$

since $3.39408 < V_{cc} / 2$, we will use $V_{CEQ} = 7.5$ V

at $I_{CQ} = 2$ mA the 2N3904 has a value of $h_{FE} = 70.$,
using this value to find I_E

$$I_E = I_{CQ} (1 + 1/h_{FE}) = 2.03 \text{ mA}$$

The value of V_E found as

$$V_E = 0.1 V_{CC} = 1.5 \text{ V}$$

and the value of R_E found as

$$R_E = V_E / I_E = 738\ \Omega \quad (750\ \Omega \text{ nominal })$$

using 750 Ω R_E, the value of V_E recalculated as

$$V_E = I_E \,.\, R_E = 1.5225\ V$$

Now, V_{RC} found as

$$V_{RC} = V_{CC} - (V_{CEQ} + V_E) = 5.9775\ V$$

and R_C found as

$$R_C = V_{RC} / I_C = 3\ K\ \Omega \quad (\text{using } 3\ K\ \Omega)$$

This completes the emitter collector circuit next step of designing base circuit is to find V_B as

$$V_B = V_E + V_{BE} = 2.215\ V$$

next I_B found as

$$I_B = I_{CQ} / h_{f(min)} = 14.3\ \mu A$$

and I_2 is set as

$$I_2 = 10 I_B = 143\ \mu A$$

Now, R_2 determined as follows

$$R_2 = V_B / I_2 = 15.490 \ (15\ K)$$

using $R_2 = 15K$. The value of I_2 now recalculated as

$$I_2 = V_B / R_2 = 147.6 \ uA$$

The value of I_1 found as

$$I_1 = I_2 + I_B = 162 \ uA$$

The Value of V_1 found as

$$V_1 = V_{CC} - V_B = 12.785$$

Finally, the value of R_1 is found as

$$R_1 = V_1 / I_1 = 78k\ \Omega \ (75K\Omega)$$

At this point we need to take a look at ac operations of our biasing circuit
the first step is the to determine the total ac resistance in the collector circuit

The resistance found as

$$r_C = R_C \parallel R_L = 4.6\ k\ \Omega$$

from the spefication of sheet r'_e found as

$$r'_e = h_{ie} / h_{fe} = 29\ \Omega$$

and the Av found as $h_{ie} = 3.5\ k$ $h_{fe} = 120$

$$A_v = (h_{fe}\ .\ r_C)\ / h_{ie} = 158$$

the required voltage gain was given as 120 we can swamp the emitter to <u>reduce</u> the gain to desired value

$$A_v = r_C / (r'_e + r_E)$$

$$r_E = (r_C - r'_e A_v) / A_v$$

This equation will give use the method value of rE when used with correct value of r'_e and the desired value of A_v

For this circuit :

$$r_E = 9.33\ \Omega \ \text{(using 9.1 ohm)}$$

Calculating İnput impedance

$$Z_{base} = h_{fe} r'_e = 3.5 \text{ k } \Omega$$

$$Z_{in} = R_1 \| R_2 \| Z_{base} = 12 \text{ k } \Omega$$

Calculating the value of A_i

$$A_i = \dot{I}_{out} / \dot{I}_{in}$$
$$A_i = h_{fe}(Z_{in}\, r_C / Z_{base}\, R_L)$$
$$= 236.58$$

Calculating h_{ie} and h_{fe}

$$h_{ie} = \sqrt{(h_{ie(min)} \text{ x } h_{ie(max)})} = 3.16 \text{ k}$$
$$h_{fe} = \sqrt{(h_{fe(min)} \text{ x } h_{fe(max)})} = 200$$

Calculating R_{in} and f_{1B}

$$R_{in} = R_1 \| R_2 \| h_{ie} = 12 \text{ K } \Omega$$

low critical frequency = 30 Hz

$$f_{1B} = 1 / (2\pi(R_S + R_{in})C =$$
$$C = 0.47 \text{ uF}$$

$f_{1C} = 1 / (2\pi(R_C + R_L)C =$
$C = 265\ uF$

$R_{out} = R_E \parallel (r'_e + R_{th}/h_{fe})$

$R_{th} = R_1 \parallel R_2 \parallel R_s = 10.08\ K\ \Omega$

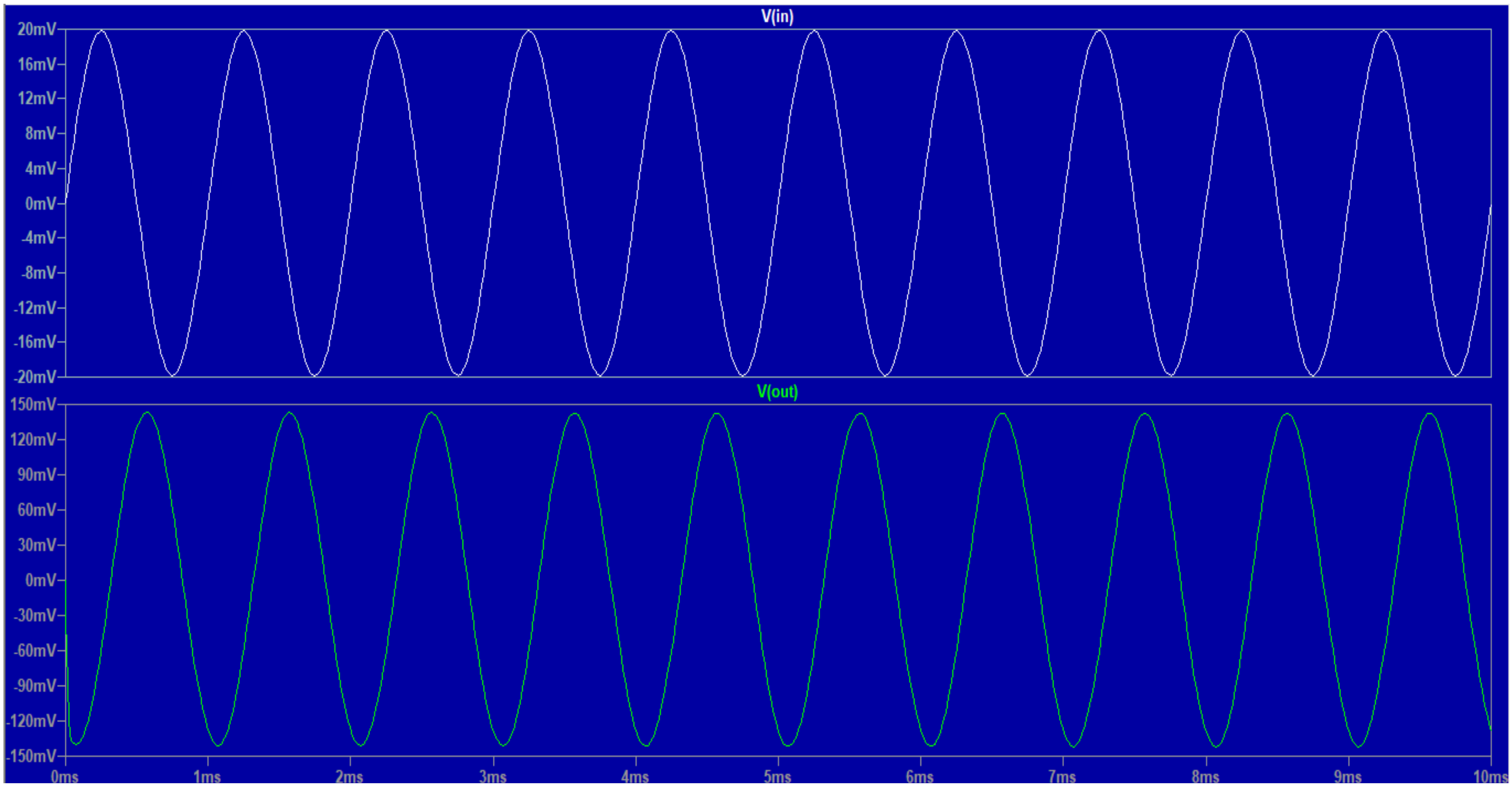
$R_{out} = 10.18\ K\ \Omega$

$f_{1E} = 1 / (2\pi R_{out} C_E)$

$C_E = 0.5uF$

Simulation Results

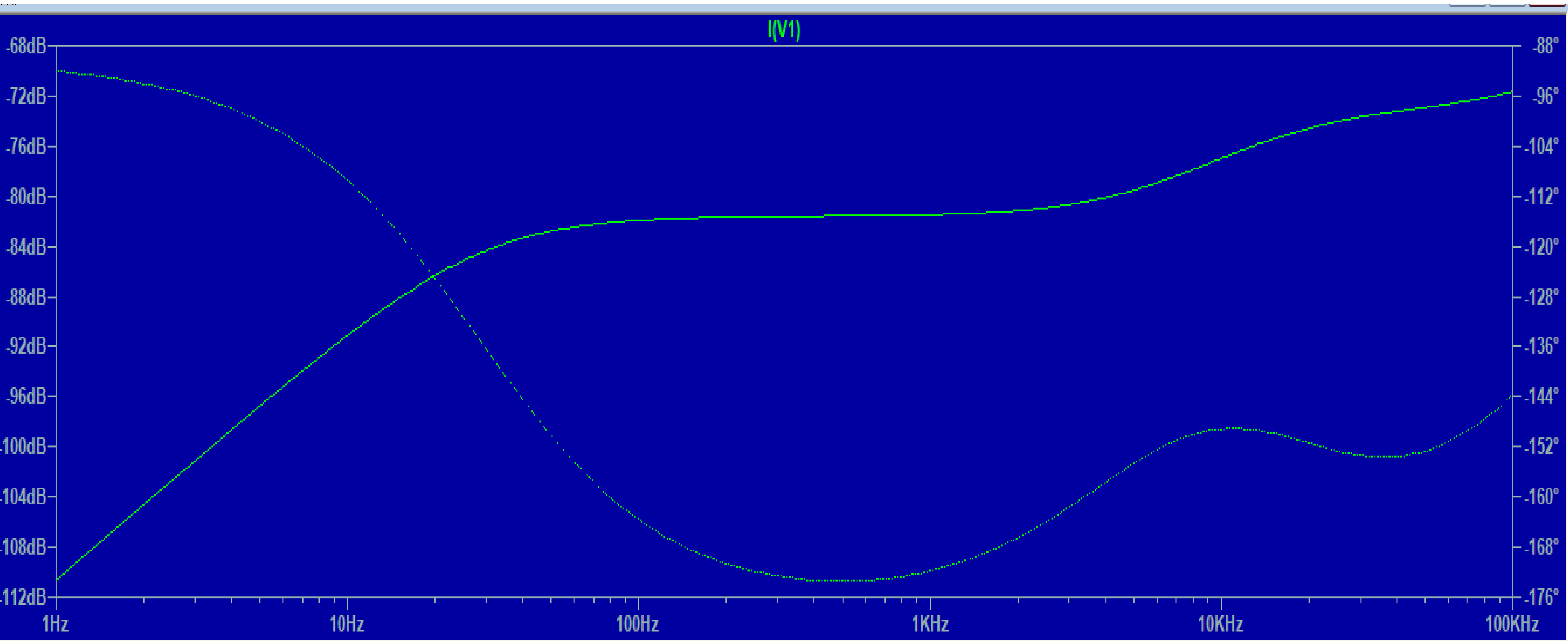
Transient Analysis

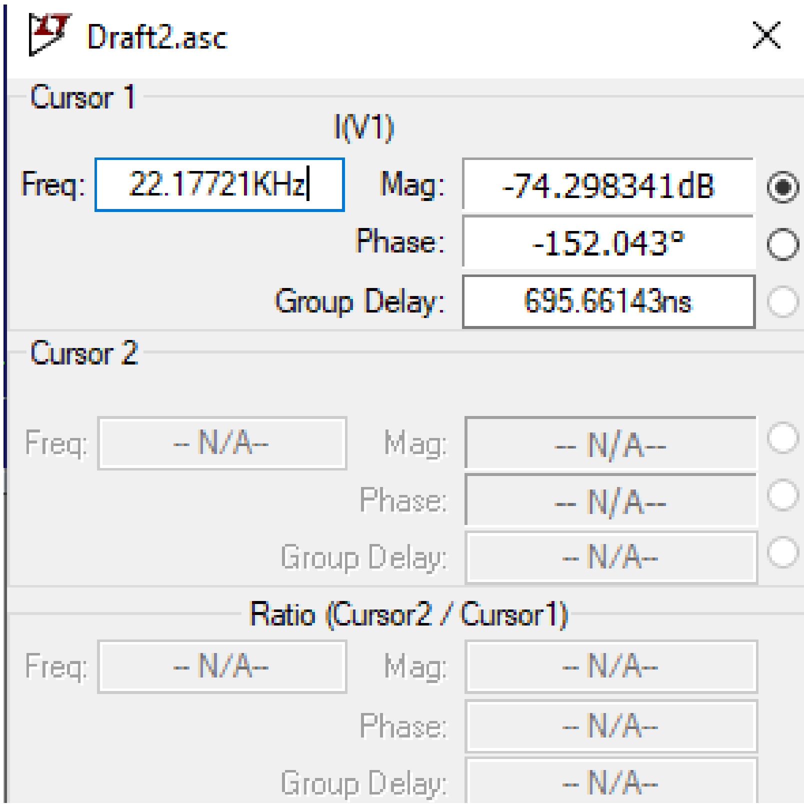


Voltage Gain = V_{out} / V_{in} acording to transient analysis

142.60765mV / 19.785522mV = 0.7383 V

AC Analysis





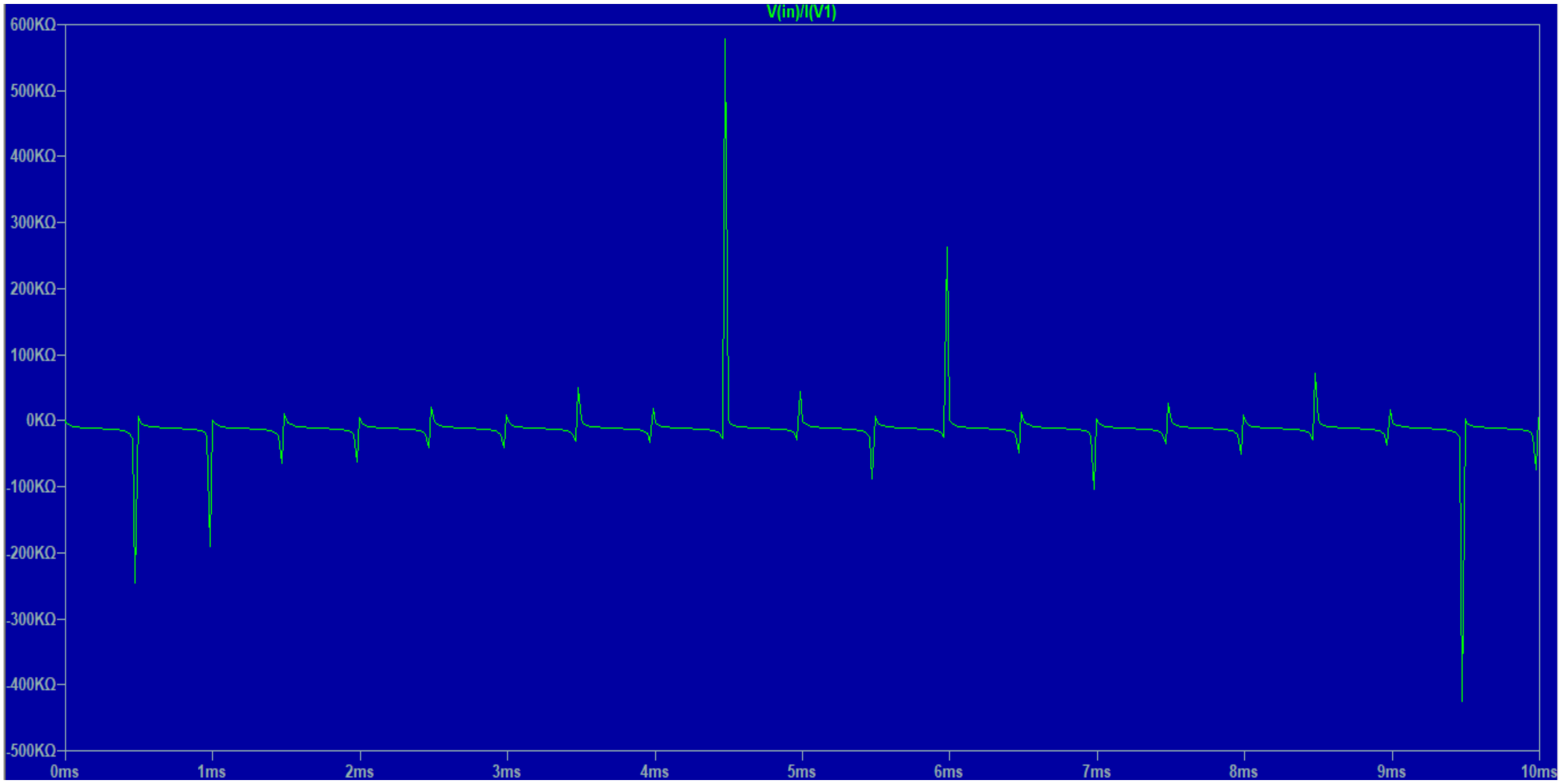
Bandwith at -3dB

Total Harmonic Distortion

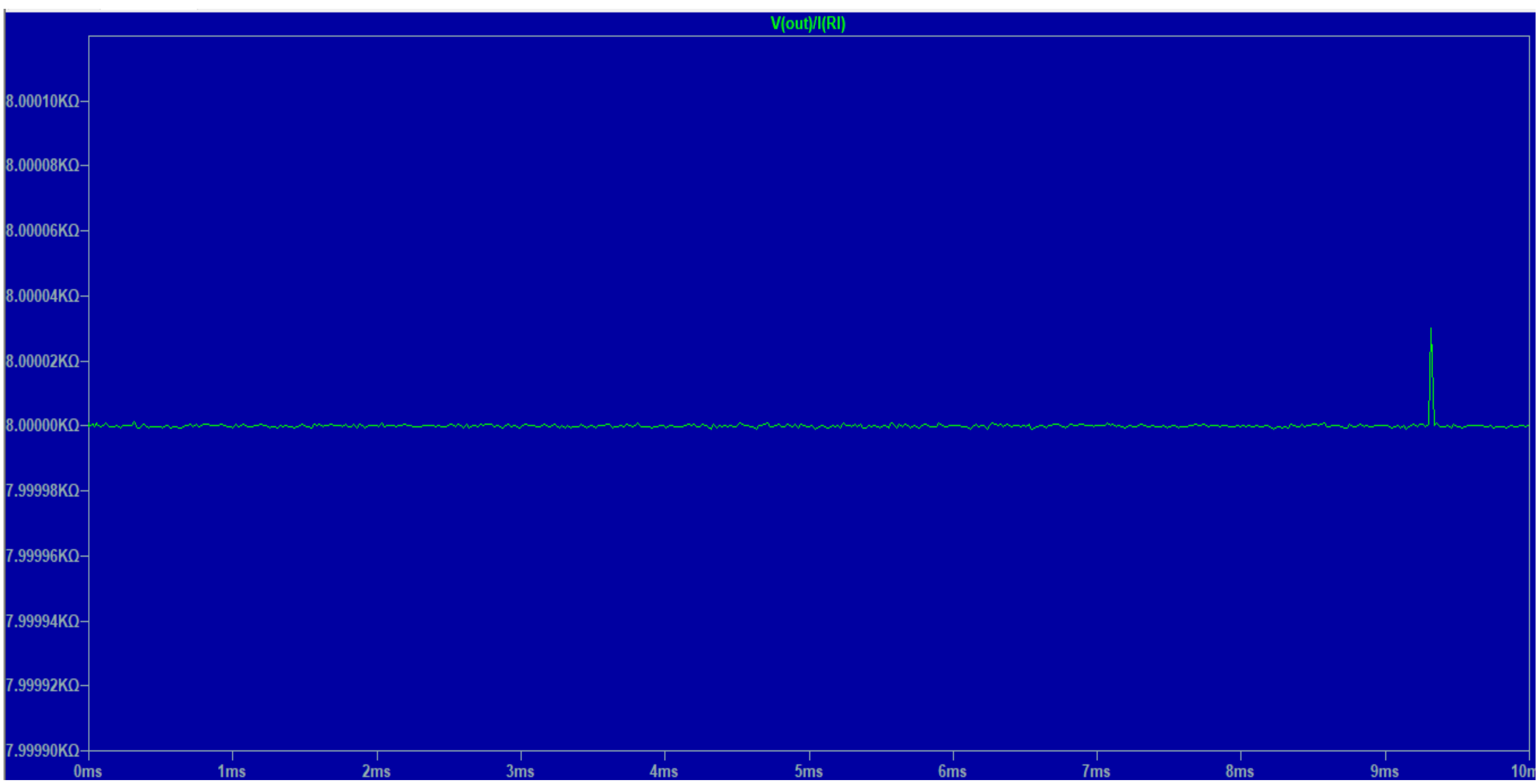
SPICE Error Log: C:\Users\templ\OneDrive\Masaüstü\New folder\Draft2.log

```
Circuit: * C:\Users\templ\OneDrive\Masaüstü\New folder\Draft2.asc

Direct Newton iteration for .op point succeeded.
N-Period=1
Fourier components of V(out)
DC component:-0.101787

Harmonic        Frequency       Fourier         Normalized
 Number           [Hz]          Component        Component
    1           1.000e+4        1.941e-2         1.000e+0
    2           2.000e+4        9.602e-3         4.947e-1
    3           3.000e+4        6.395e-3         3.294e-1
    4           4.000e+4        4.800e-3         2.473e-1
    5           5.000e+4        3.909e-3         2.014e-1
    6           6.000e+4        3.186e-3         1.641e-1
    7           7.000e+4        2.738e-3         1.410e-1
    8           8.000e+4        2.398e-3         1.235e-1
    9           9.000e+4        2.132e-3         1.098e-1
Total Harmonic Distortion: 72.735073%(79.482621%)



Date: Tue Jun  2 13:06:52 2020
Total elapsed time: 0.090 seconds.

tnom = 27
temp = 27
method = modified trap
totiter = 2105
```

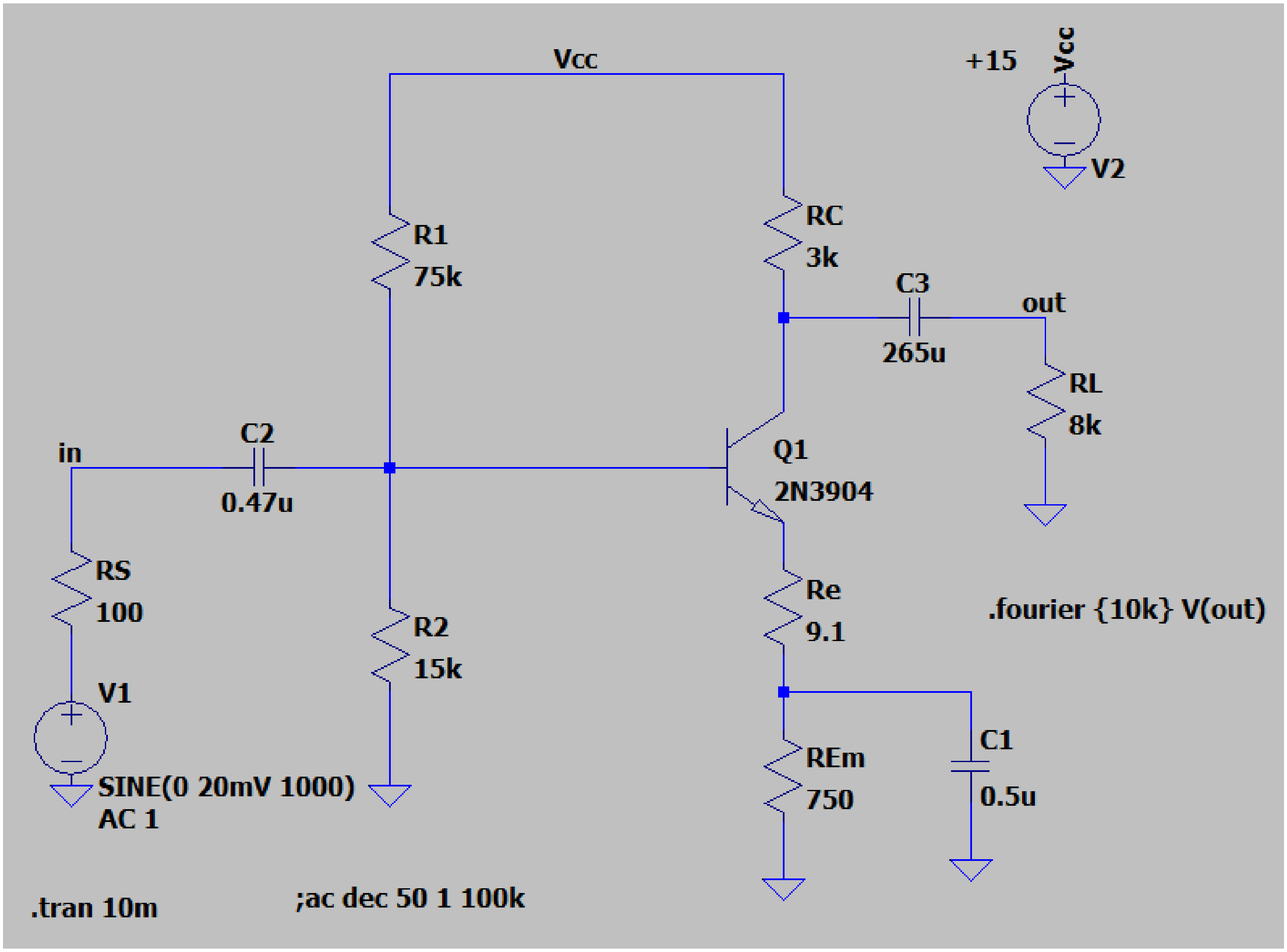
İNPUT İMPEDANCE BY GRAPH OF V(in) / I(V1)



OUTPUT İMPEDANCE BY GRAPH OF V(out) / I(R_L)



TRANSİSTOR AMPLİFİER



CONCLUSİON:

The task was to design a transistor amplifier with the given parameters.
So first of all, I start to calculate the required output compliance from the amplifiers by converting the value V_{out} to a peak to peak value. I set a I_{CQ} value and determined h_{fe}, h_{i}e values for the 2N3904 transistor therefore, I used this values on calculations which is explained in the paper above in calculation section
to find correct values for resistors to get desired gain on amplifier with given parameters but on calculation process my gain was lower than desired gain so ı couldnt get higher gain than given gain to use emitter swamp so ı had to change current on collector I_{CQ} from 1mA to 2mA after that I could use emitter swamp and finally achieved desired gain on theory so until here the resistors values are calculated and ready to put on circuit however, the filter capacitors on circuit were not calculated so ı had to use the formula with given low critical frequency value to acquire necessary filter capacitor values in order to get desired gain therefore the desired transistor amplifier circuit was created due to calculations