Full Name: Orkun İbrahim Kök

Department: EEE

Course Code: EEE313

Section: 02

Experiment Number: 03

Date: 03.04.2024

Lab 3 Experimental Report

Introduction

In the hardware part of third experiment, a complementary push-pull Class-B amplifier is created on a a breadboard with the specifications given below. The amplifier should deliver at least 2.19W to the 8.2Ω load resistor. The supply voltages are chosen as ±9V.

1. The amplifier should deliver at least a 2.19W power to an 8.2Ω resistance (12Vpp to an 8.2Ω power resistor) starting from 10Hz to 40KHz at the chosen gain value.

2. The harmonics (the highest is possibly the third harmonic) at the 2.25W output power level should be at least 40 dB lower than the fundamental signal at 1 KHz.

3. The power consumption at quiescent conditions should be less than 500mW.

4. The amplifier's overall efficiency (output power/total supply power) should be at least 45% at max power output at 1KHz.

Methodology

I created the circuit on the breadboard, however, I did some changes in the resistor values in order to get desired results. The incompatibility between LTspice simulation and hardware parts may happen due to the breadboard and circuit components quality. The designed circuit on breadboard can be seen in the figure below.

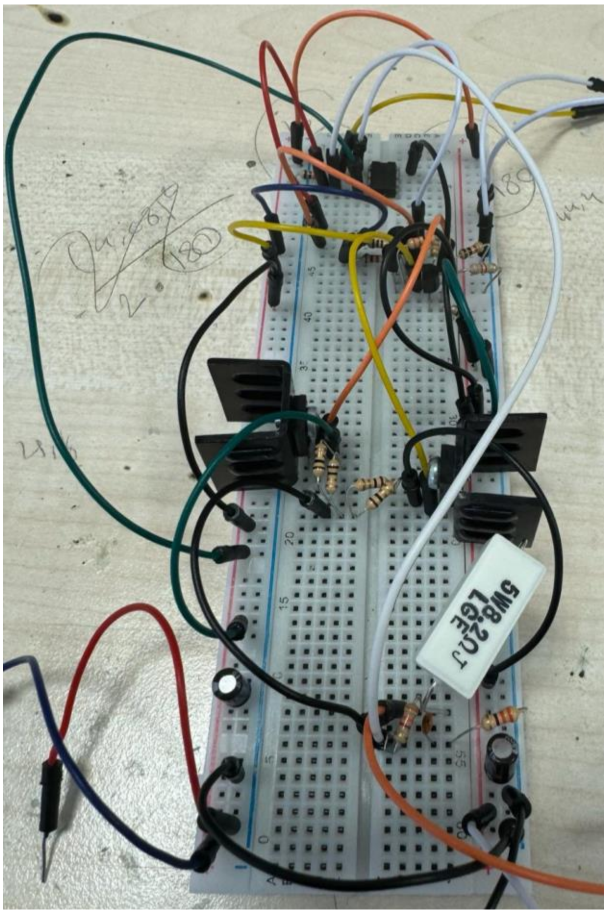

Figure 1: Designed Circuit

In preliminary report, I chose 33KΩ and 3.3KΩ as R4 and R5 resistors respectively. However, when I use these values, output sine wave became saturated therefore I changed their values to 3.3KΩ and 330Ω respectively. I also changed the capacitor connected parallel to R4 resistor from 20pF to 220pF to satisfy 1st requirement.

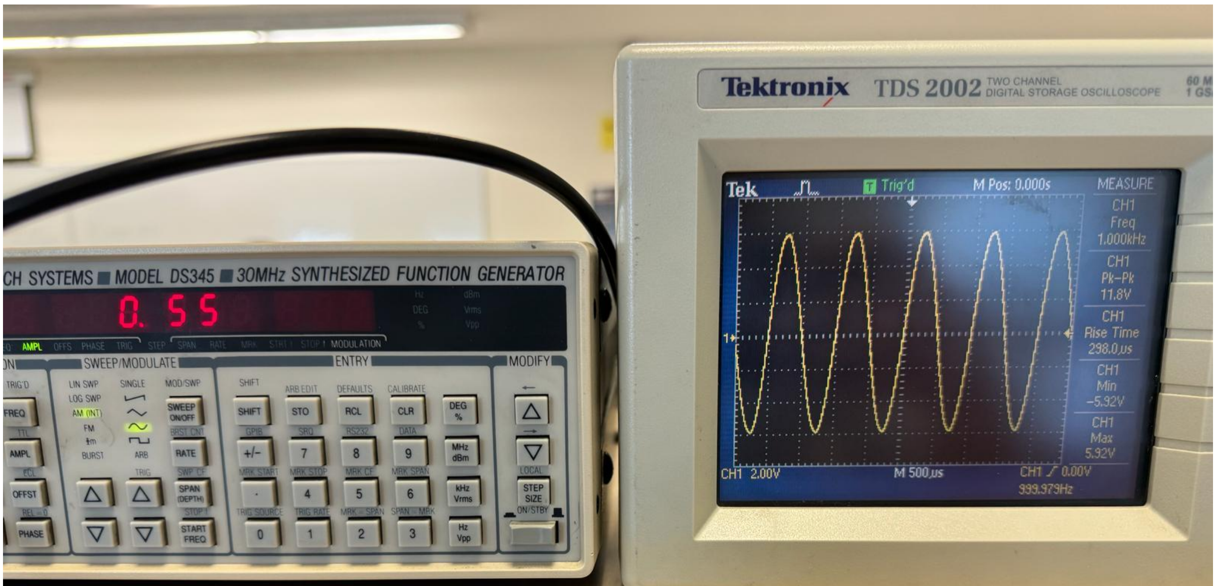

Figure 2: Output voltage = 11.8V at 0.55V AC input

When 0.55 AC input is given, output voltage max values is 5.92V. Calculating the dB gain from these values gives us the result as 20.63 dB gain.

Analysis

1st Specification:

Throughout the experiment, I adjusted my input AC voltage to 0.55V sine wave in order to prevent any saturations that may occur at the output signal. Figure 3 shows the output voltage value at 1KHz and Figure 4 shows the output voltage value at 40KHz.

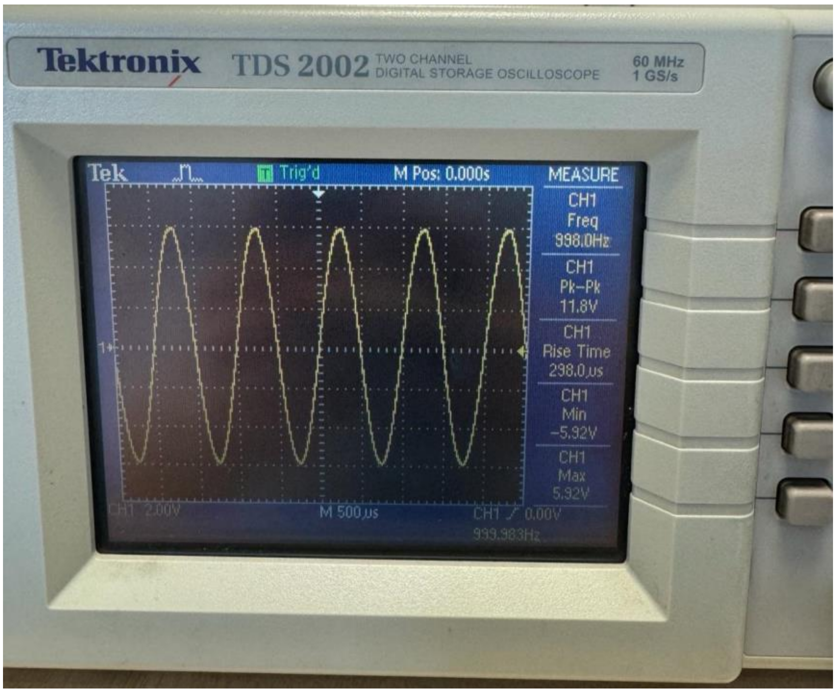

Figure 3: Output voltage = 11.8V at f = 1KHz

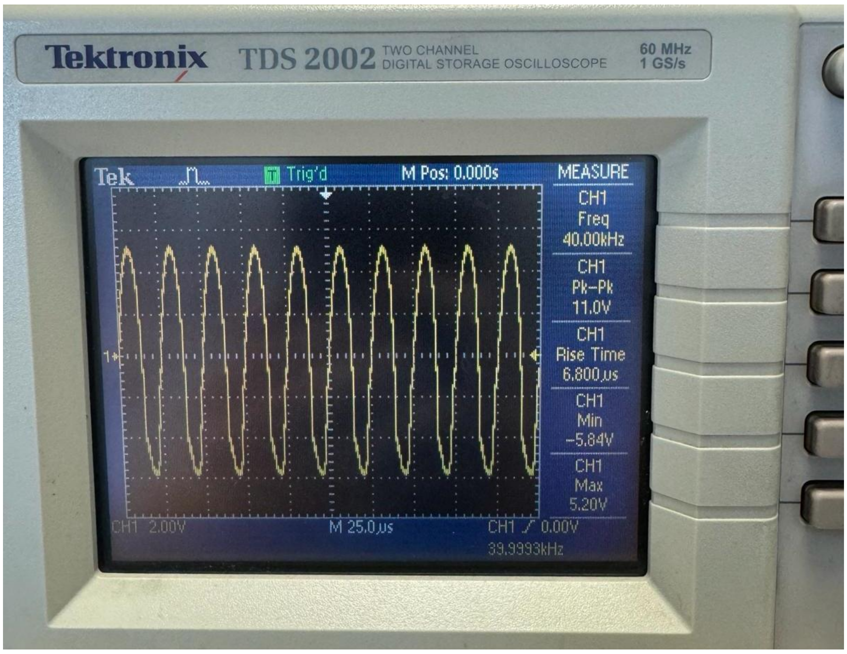

Figure 4: Output voltage = 11.0V at f = 40KHz

As seen from Figure 3 and Figure 4, output voltage varies between 11.8V and 11.0V, which is acceptable and in range. As I mentioned earlier, differences may occur due to breadboard's insensitiveness and number of connections that are made on the breadboard.

However, looking at the V_{max} value for Figure 3 (5.92V) and V_{min} value for Figure 4 (5.84V), there is not much difference. Power calculation using these values are given in the below equations.

$$P_{avg} = \frac{V^2}{R} * \frac{1}{2} \quad \text{(Eqn. 1)}$$

$$f = 1KHz\text{:}\ \frac{5.92^2}{16.4} = 2.14W$$

$$f = 40KHz\text{:}\ \frac{5.84^2}{16.4} = 2.08W$$

Both results are below the requirement, 2.19W, but Professor Atalar told that these results are inside the error range, also because my input voltage is less than 0.6V which is 0.55V, this closes the gap between the specification and my results. So, first specification is satisfied.

2nd Specification:

For this specification, dB difference between 1st and 3rd harmonics must be at least 40dB when frequency is 1KHz. Figure 5 shows the FFT graph of the output signal and harmonics at 1KHz and 3KHz.

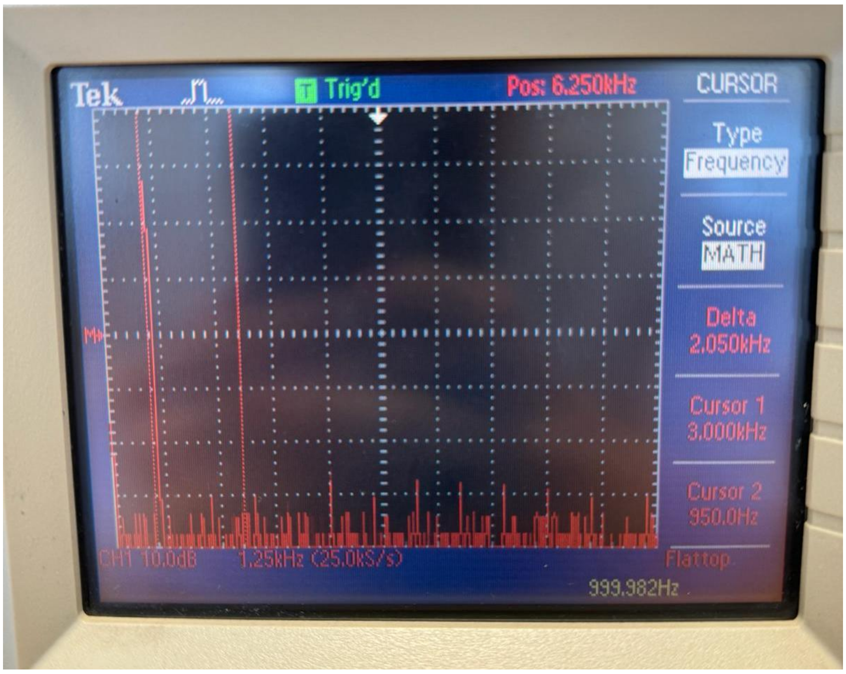

Figure 5: FFT graph showing 1st (1KHz) and 3rd (3KHz) harmonics

Figure 6 shows the corresponding magnitudes in dB scale.

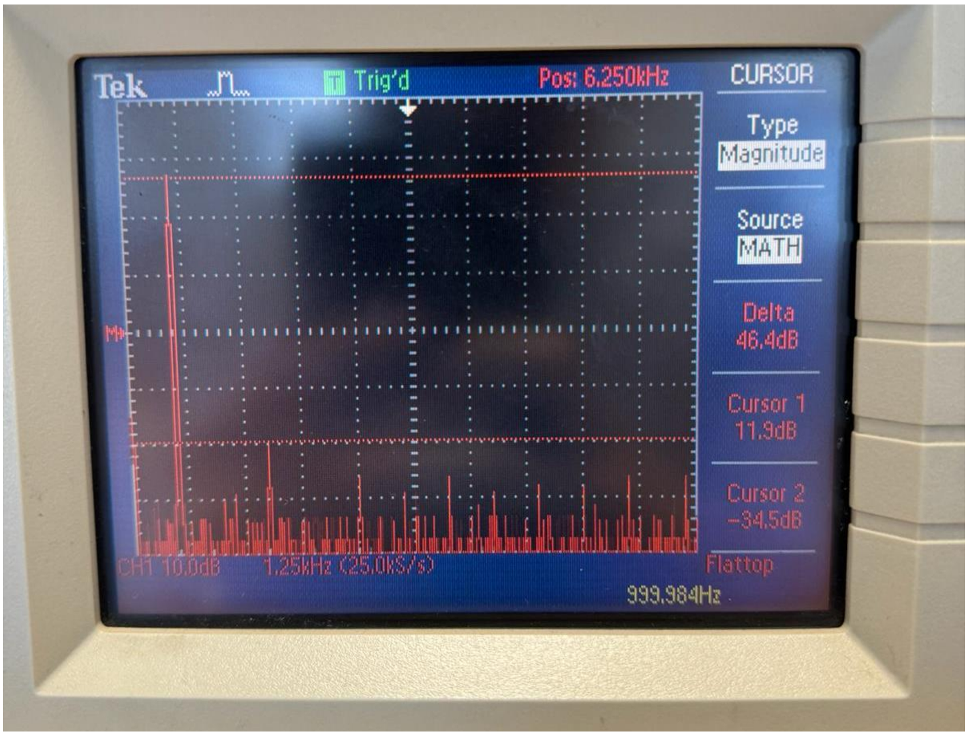

Figure 6: dB values of 1st and 3rd harmonics

As seen in the above figure (Figure 6), 1st harmonic's magnitude is 11.9dB and 3rd harmonic's magnitude is -34.5dB. 3rd harmonic is 46.4 dB lower than 1st harmonic. Therefore, second specification is satisfied.

3rd Specification:

For this specification, it is wanted that at quiescent condition, power consumption of the circuit should be less than 500mW. Quiescent condition means AC input voltage equals to 0. Below two figures shows the DC voltages and their ampere values.

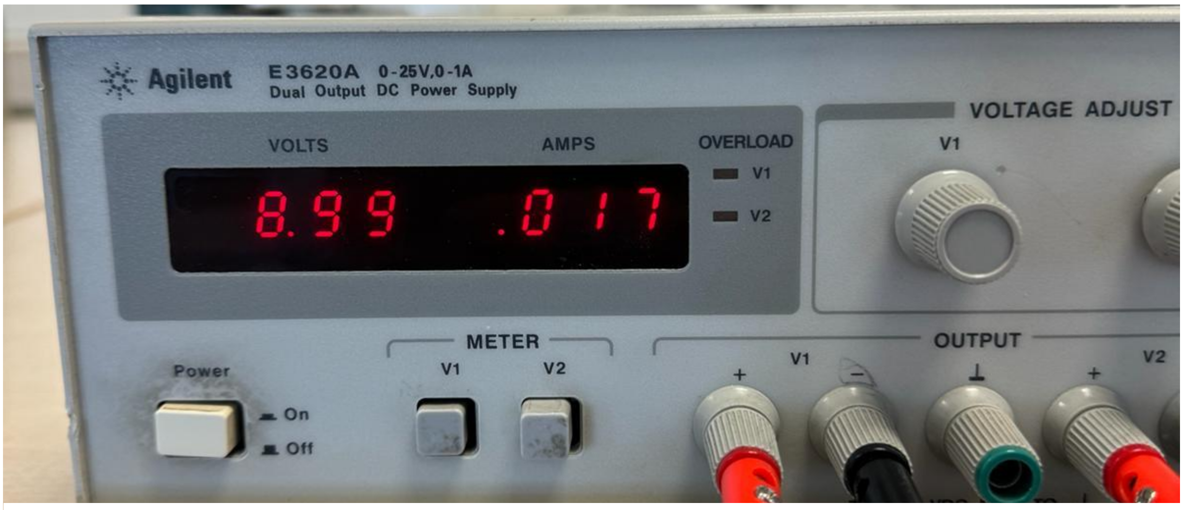

Figure 7: Supply voltage and current values for Vccm

Figure 8: Supply voltage and current values for Vcc

$$V_{cc} * I_{cc} + V_{ccm} * I_{ccm} \qquad \text{(Eqn. 2)}$$

$$9 * 0.19 + 8.99 * 0.17 = 324mW$$

Inserting the values into (Eqn. 2), I get 324mW as the quiescent condition power consumption. Therefore, third specification is also satisfied.

4th Specification:

Fourth and last specification requires that the amplifiers's overall efficiency should be at least 45% at 1KHz. Equation for calculating efficiency is given below (Eqn. 3).

$$\frac{P_{output}}{P_{supply}}$$

$$P = \frac{V^2}{R} = V * I \qquad \text{(Eqn. 3)}$$

Using (Eqn. 1) and (Eqn. 3), P_{output} and P_{supply} will be calculated.

$$P_{output} = \frac{5.92^2}{2 * 8.2} = 2.14W$$

The supply voltage and supply current values can be seen in the figures below.

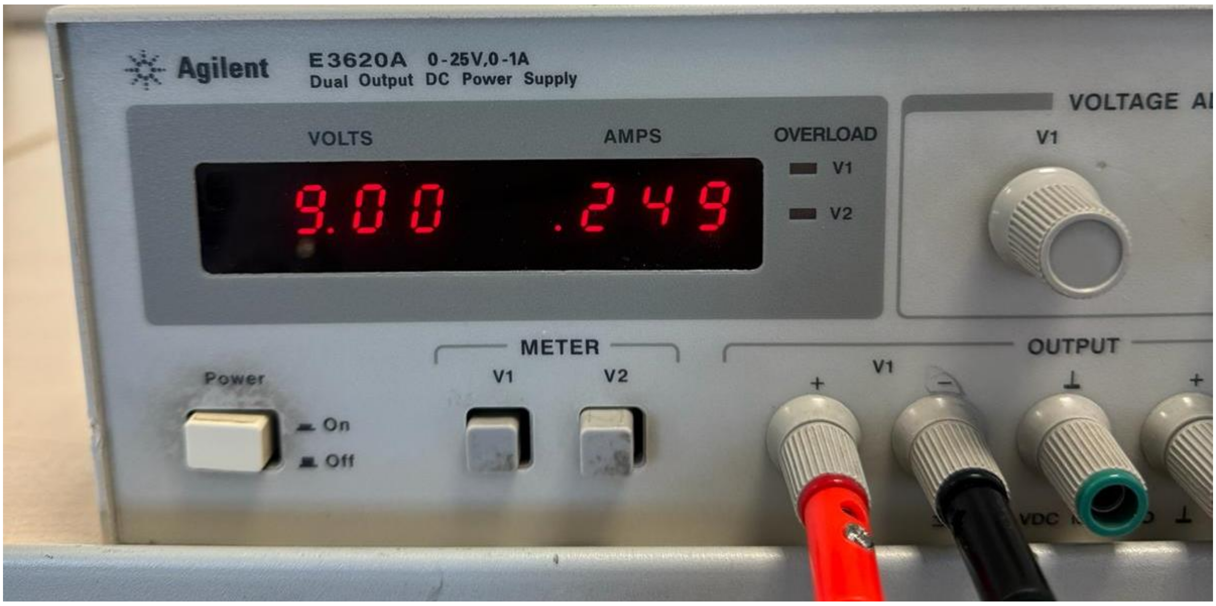

Figure 9: Supply voltage and current values for Vccm

Figure 10: Supply voltage and current values for Vcc

$$P_{supply} = 9 * 0.253 + 9 * 0.249 = 4.52W$$

$$Efficiency = \frac{2.14W}{4.52W} * 100 = 47.35\% \qquad \text{(Eqn. 4)}$$

As seen from (Eqn. 4), efficiency of the amplifier at 1KHz is 47.35%, which is above 45%. So, 4th specification is also satisfied.