[redacted]

Project 2

Experiments with Standard Power Amplifier Circuits

Three classes of power amplifier were designed and tested. Transistors used were TIP31C (npn) and TIP32C (pnp) type. Total power dissipation for both was 2W, for a transistor with no heat sink and ambient temperature of 25°C. Classes of power amplifiers were class-A, class-B and class-AB.

Class-A

This class of amplifier was easy to design, with biasing current and voltage, but low efficiency. As mentioned earlier, $P_T = 2W$ however 1.8W was choosen as a starting point for additional safety, thus:

[redacted]

Figure 1, below showed the design of the class-A amplifier. V_{cc} was choosen to be 12V, and $R_L = 20\Omega$ was assigned.

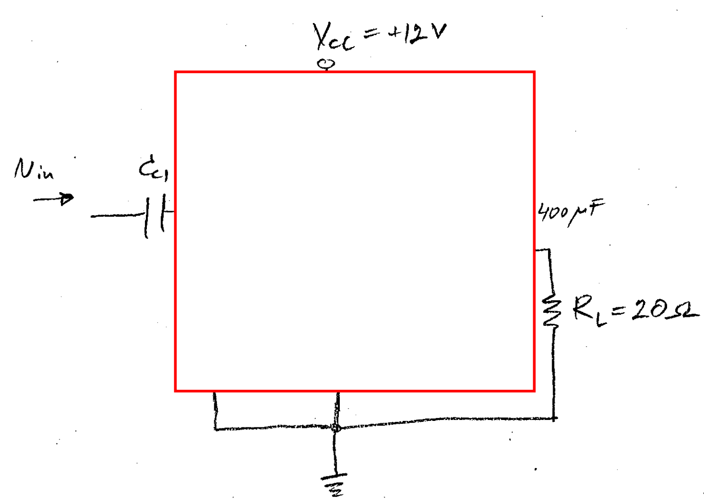


Figure 1. Design of a Class A Amplifier

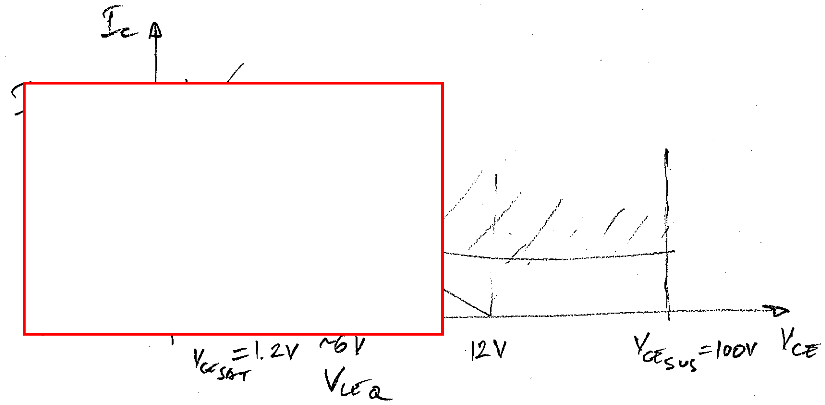


Figure 2. Safe Operating Area (SOA) Diagram

Diagram of a safe operating area was drawn based on the values from [redacted] 2, where:

[redacted]

Small circuit analysis was also performed in order to acquire the value of C_{E2}, and was based on figure 3, below.

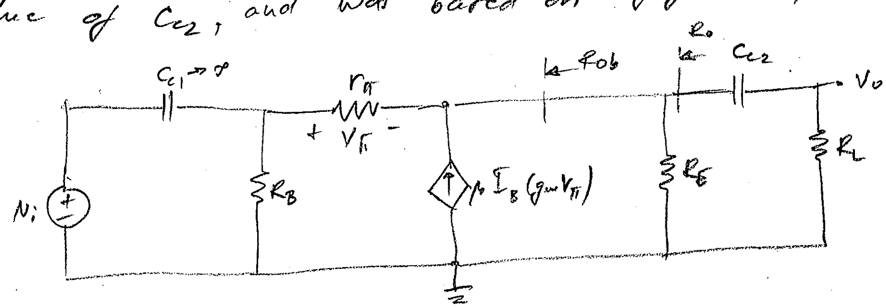


Figure 3. Small circuit equivalent

$$R_{ob} = \frac{V}{I} = \frac{V}{\frac{V}{r_\pi}(1+\beta)} = \frac{r_\pi}{1+\beta} \qquad r_\pi = \frac{V_T \cdot \beta}{I_{CQ}} = \frac{0.026V \cdot 25}{0.3A} = 2.167\Omega$$

$$R_o = (R_E \parallel R_{ob}).$$

$$R_o = \left(20\Omega \parallel \frac{2.167}{1+25}\right) = 0.083\Omega$$

$$\tau_s = C_{C2}(R_L + R_o)$$

for $f_L \leq 20\text{ Hz}$ $\quad \tau_s \leq \frac{1}{2\pi \cdot 20Hz}$, Thus $\quad C_{C2} \geq \frac{1}{2\pi \cdot 20Hz \cdot 20.083\Omega}$

$C_{C2} \geq 396\,\mu F$, $\quad C_{C2} = 400\,\mu F$ was choosen

Using $R_{th} = 0.1(1+\beta)R_E$ gave an R_{th} value of 52Ω. This value seemed low, since R_1 and R_2 would have been 74Ω and 175Ω respectively. These seemed as too low values, since current through them would have bee[illegible] 05kΩ and R_1 val[illegible] I_{CQ} close to 0.3A, Vol[illegible] nput circuit, a

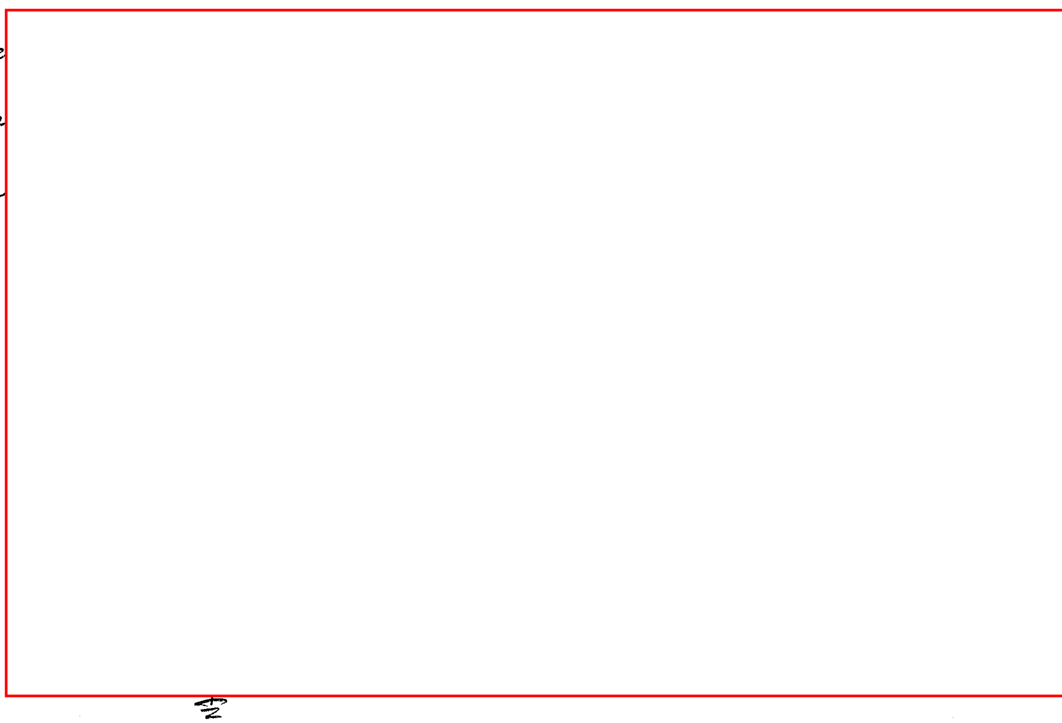


Figure 4. Input circuit

Efficiency of the class-A amplifier was calculated using the measured

As mentioned previously, this class of amplifier has low efficiency.

Class-B

This class of amplifiers had much higher efficiency, however it produced crossover distortion due to a dead band portion of the output curve. Design of the class-B circuit was shown in figure 5.

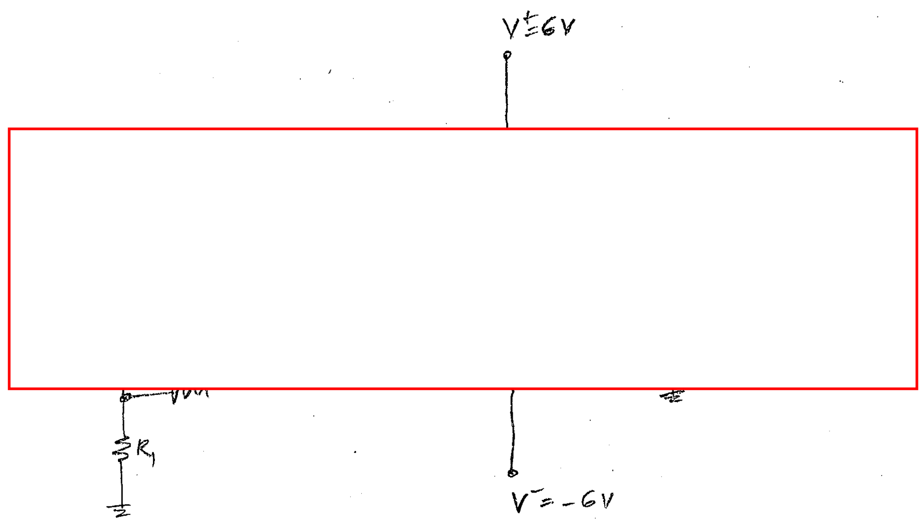


Figure 5. Class-B Amplifier

Based on the measured values, efficiency of the class-B amplifier was calculated :

This value was much higher than the efficiency of the class-A, however the clipping of the output signal was present (as expected).

Class-AB

Sacrificing some efficiency, class AB eliminates crossover distortion. Design of this circuit was shown in figure 6.

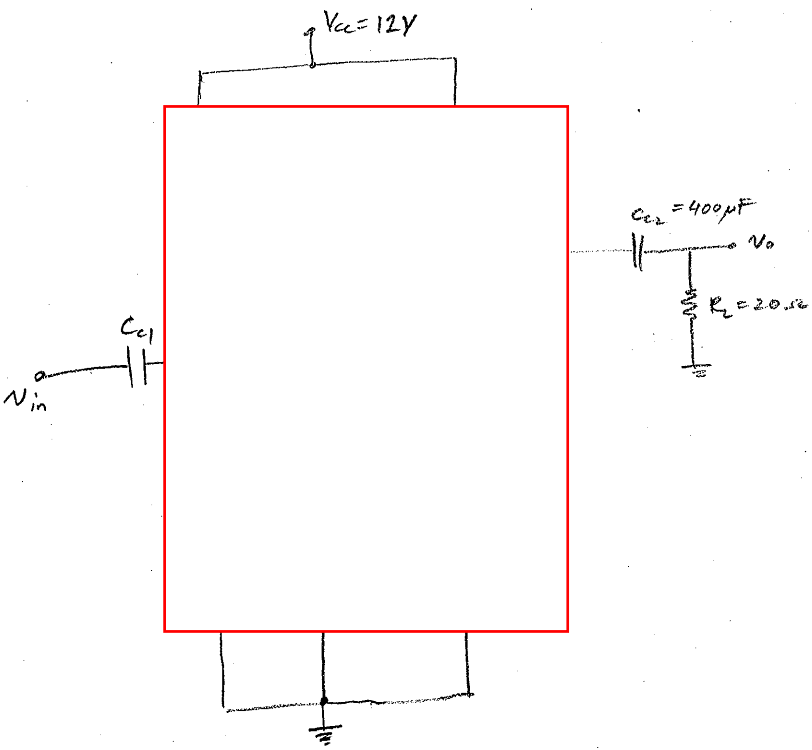
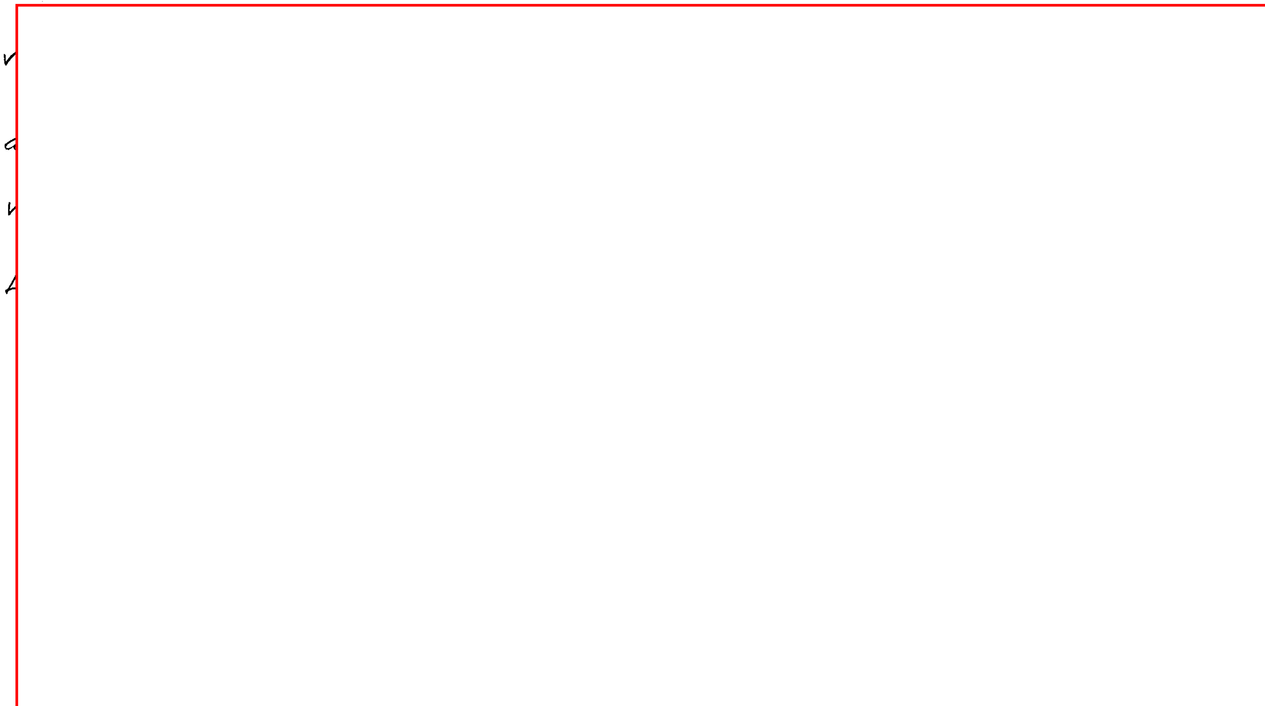


Figure 6. Class-AB Amplifier Design

Maximum current Transistor 2N5210 was rated for was 100 mA. Therefore, 50 mA for I_{CQ} was assumed. This value was enough to create biasing ...ut flow, ... This ... load



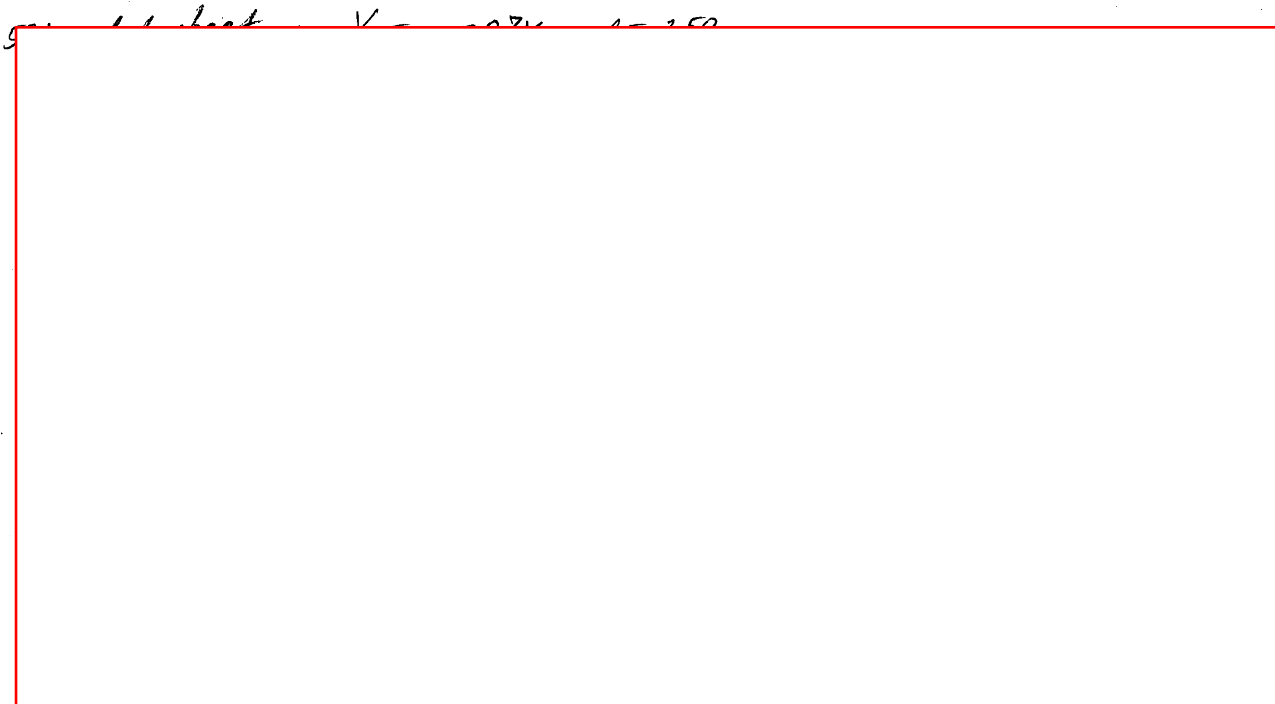
$V'_{CEQ} = 5V$ Figure 7. Transistor 2N5210 Load Line

$$R_3 = \frac{10.5V}{100mA} = 105\,\Omega$$

Two resistors of 220 Ω were used in parallel for R_3, to give $R_3 = 110\Omega$.

Biasing resistors, R_1 and R_2 were calculated based on information from

2N5...



7V

23 kΩ

kΩ

When the circuit was built and tested, $R_2 = 6.49\,k\Omega$ was used.

to achieve ... The discrepancy was due to Low $V_{BE\,on}$ assu-

...tions.

...and R_5).

...current

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signal distortion. It was noticed and showed in figure 10, some small distortion was still present. This distortion was increasing and becoming significant as the signal input was raised into the clip-off region.

Figures 8 to 10 show the signals of all three classes of amplifiers built.

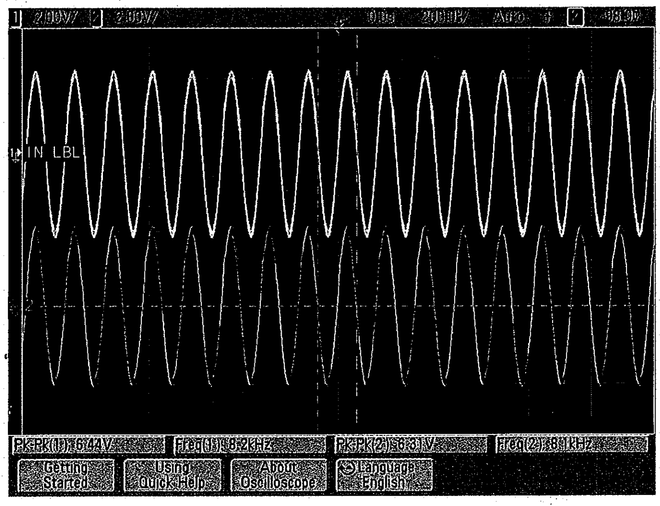

Figure 8. Class-A, Input (CH1) and Output (CH2) Signals

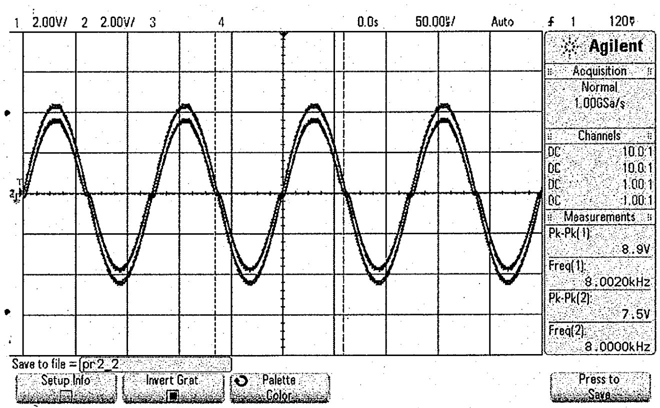

Figure 9. Class-B, Input (CH1) and Output (CH2) Signals

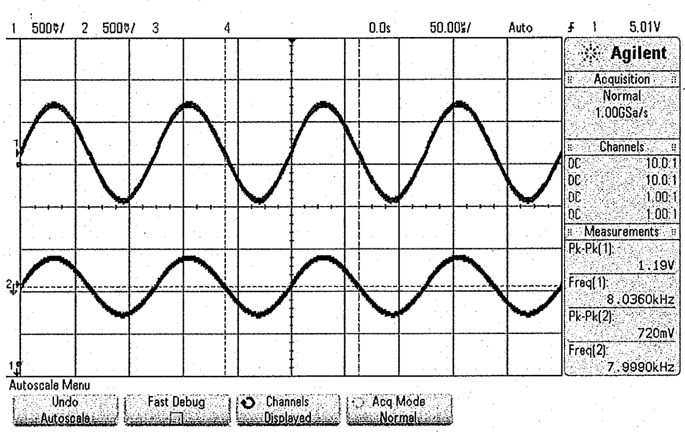

Figure 10. Class-AB, Input (CH1) and Output (CH2) Signals