

Experiments with Standard Power Amplifiers

Three classes of power amplifiers, class ‘A’, class ‘B’, and class ‘AB’ were designed and built using the available complimentary npn/pnp TIP31 transistors in order to deliver a large amount of power. All three power amplifier circuits obtained an input signal was designed as shown in the Design and calculation. The op-amp was to amplify the input signal from the signal generator to the entire signal at the output side of the power amplifiers.

Class ‘AB’ Power Amplifier

The design of this class of power amplifier is shown in the Design and calculation section. A 100uF capacitor was connected to the input side of the driver circuit to allow only the AC signal from the op-amp to be fed to the driver circuit. As shown in the results and plots section (Figure 1 and 2), measurements of the signal gain were measured at every stage to ensure no significant attenuation. During the experiment, the power transistors experienced thermal runaway and the problem was solved by connecting emitter resistors (RE) on each transistor. A lower RE resistor value was selected to avoid high attenuation of the signal. Vcc was increased when distortion was observed at the output (Figure 3). Icq, Vrms, and Vcc were obtained and $P_{Load}$ was provided.

Class ‘B’ Power Amplifier

The power transistor base terminals were both connected to the output of the op-amp stage as shown in the designed and calculation section. Output waveform was obtained as shown in Figure 4. As expected, distortion was observed and total harmonic distortion calculated using the frequency domain waveform (Figure 5) obtained from running FFT of the output waveform. The total harmonic distortion was provided in the final and design section and $P_{Load}$ was obtained.
**Class ‘A’ Power Amplifier**

Class ‘A’ power amplifier was designed as shown in the design and calculation section. R2 resistor was obtained using a potentiometer. To obtain a biased amplifier circuit, Vce was measured using a multimeter while the potentiometer adjusted to obtain a Vce of ½(Vcc), then the pot resistance noted. The resistor was experimentally obtained to be 131Ω, which was a bit higher than the calculated value of 116Ω. Input and output waveform was displayed on the oscilloscope. The input signal was 1 Vpeak and the output signal was 0.5 Vpeak as shown below.

**Conclusion**

Class ‘AB’ power amplifier appeared to be a better choice because the efficiency was reasonable compared to the other power amplifiers, and no distortion was observed. Class ‘B’ power amplifier had a higher efficiency but the distorted output was the problem. Class ‘A’ power amplifier had a lower efficiency compared to the other two power amplifier.
\begin{align*}
V_{CE} &= \frac{1}{2} V_{CC} = \frac{1}{2}(10) = 5V \\
V_{BE} &= 5V \\
I_e &= 0.249 A \\
V_C &= 0.5V \\
R &= 22 \Omega \\
V_{CC} &= 10V
\end{align*}
DESIGN AND CALCULATION

1) CLASS 'AB' P.A

\[ V^+ = 10V \]
\[ V^- = -10V \]

\[ R_1 = \frac{110}{260.2} \]
\[ = 6.25 \]
\[ \approx 11.665\% \]

**Measured Values**
### Class 6 PA

- $V^+ = 10V$
- $V^- = -10V$

#### Measured Values

- $I_{CQ} = 0.1654 \, \text{A}$
- $I_{CE} = 0.1653 \, \text{A}$
- $V_C = 1.87 \, \text{V}$
- $V_C = 10 \, \text{V}$

#### Frequency (Hz) | V-Values (V)
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_1$</td>
<td>1042.1</td>
</tr>
<tr>
<td>$V_2$</td>
<td>2003.3</td>
</tr>
<tr>
<td>$V_3$</td>
<td>2962</td>
</tr>
<tr>
<td>$V_4$</td>
<td>5044</td>
</tr>
<tr>
<td>$V_5$</td>
<td>7126</td>
</tr>
<tr>
<td>$V_6$</td>
<td>9047</td>
</tr>
</tbody>
</table>

#### THD

\[
THD = \frac{V_1^2 + V_2^2 + V_3^2 + V_4^2 + V_5^2 + V_6^2}{V_1^2} \times 100
\]

\[
= \frac{0.1171^2 + 0.07652^2 + 0.05769^2 + 0.03086^2 + 0.02458^2}{2.172^2}
\]

\[
= 5.917 \times 10^{-3} \times 100
\]

\[
= 0.5917 \%
\]
RESULTS AND PLOTS

Op-Amp gain

Figure 1: Op-Amp input and output waveform. Observed gain was 6.42
Figure 2: Driver circuit output (Green waveform). Gain of this stage was calculated using the output of the op-amp stage and the output of this stage. Gain = 0.825
Class ‘AB’ Power Amplifier

Figure 3: Input and output waveform for class ‘AB’ power amplifier. Attenuation of the input voltage was observed
Class ‘B’ Power Amplifier

Figure 4: Input and output waveform for class ‘B’ Power amplifier. Distortion was observed and total harmonic distortion was calculated.
Class 'B' Harmonics (FFT)

clear all
close all
clc

[v,T,vT] = xlsread('class_b.xlsx');
t = v(:,1);
x = v(:,2);

dt = t(2)-t(1);
Fs = 1/dt;
NFFT = length(x);
Y = fft(x,NFFT)/(length(x));
X = fftshift(Y);
f = linspace(-Fs/2,Fs/2,length(X));
figure
subplot(2,1,1)
plot(f,abs(X),'r')
subplot(2,1,2)
plot(f,angle(X),'r')

Figure 5: Frequency domain plot of class B output waveform
Figure 6: Input and output waveform of class ‘A’ Power amplifier. Attenuation of the input voltage was observed.