

***Preamplifier And Loudspeaker & Muting design for a studio  
series stereo amplifying system***



Project Advisor  
(Muhammad Rizwan)

Submitted by  
(Bilal Amjad-081220135)  
(Hassan Tariq-081220176)

Department of Electrical Engineering  
School of Science and Technology  
University of Management and Technology

# ***Preamplifier And Loudspeaker & Muting design for a studio series stereo amplifying system***

Project Report submitted to the  
Department of Electrical Engineering, University of Management and Technology  
In partial fulfillment of the requirements for the degree of  
Bachelor of Science  
In  
Electrical Engineering

Advisor Name: - Muhammad Rizwan

Advisor Signature:-\_\_\_\_\_

(Bilal Amjad-081220135)

(Hassan Tariq-081220176)

## **Abstract**

**In our final year project we successfully amplified any random signal with less power dissipation and higher efficiency using Class D amplifying System. Firstly we implement using Class A and calculated power dissipation that is too large. So, we did research on different Classes of amplifying system and selected Class D because this is highly efficient amplifying Class. For Analog Class D amplifying System, we implemented three blocks. Firstly, modulation blocks which takes the random audio signal and compares it with triangular carrier signal and superimpose into the carrier and generate PWM signal. Secondly, Switching Output block (Inverter, Gate Driver, Switching MOSFET'S) takes the output of PWM and amplifies it up to the required level. Gate driver is necessary to operate switching MOSFET'S according to the requirement, the proposed gate driver features consumes much less energy as well as minimized conduction and switching (delay time, rise time, reverse recovery time, fall time and decay time) losses. Thirdly, Low Pass Filter block is to recover back our original random signal. For Digital Class D amplifying system, we implemented three blocks. Firstly, UPWM (Uniform Pulse Width Modulation) block which takes the digital signal and turn into in stair-case signal which further is given to the Switching output block. We implemented UPWM using microcontroller PIC 16F877A.**

## Dedication

First of all we are very thankful to ALLHA ALMIGHTY who has given us enough courage to complete.

Then

Dedicated to our kind teacher

**Muhammad Rizwan & Our Parents**

Who enlightened our minds with Knowledge, tried  
To include the spirit of hard work and dedicational us  
So that we could have a BRIGHT FUTURE in terms  
Of being good human and turn out to be competent  
Engineers with powers to take challenging  
ENGINEERING PROBLEMS.

# Table of Content

<b>Table of Contents</b>	<b>Page No.</b>
<b>SECTION-I</b>	
<b>Class D amplifying System</b>	
<b>Chapter No.1 Introduction</b>	<b>8</b>
1.1 What is class D amplifier?	9
1.2 Why should I use Class D	9
1.3 Comparison with others Classes	9
1.4 Advantage associated with Class D	12
1.5. Types of Class D amplifying system	14
<b>SECTION-II</b>	
<b>Analog Class D amplifying System</b>	
<b>Chapter No. 2 Block Diagram</b>	<b>15</b>
2.0 Block Diagram of analog class D	16
<b>Chapter No. 3 PWM Block</b>	<b>17</b>
3.0What is basically Modulation	18
3.1Types of Modulation	18
3.2 Comparison of Natural and Self Oscillating PWM	19
3.3 Modern PWM Topologies	20
3.4 Why we use this Block?	21
3.5 How we implement this block?	21
3.6 Software simulation using LM324	21
3.7 Hardware implementation using LM324	23
38 Software Implementation using 555 Timer	23
<b>Chapter No.4 Switching Output Stage</b>	<b>26</b>
4.0 Block Diagram of Switching Output Stage	27
4.1 What inverter basically is?	27

4.2 Why we use this block?	28
4.3 Shoot Through	28
4.4 How we implement this block?	28
4.5 Software Simulation using IC7404	31
4.6 Software Simulation using 2N3904	31
4.7 Hardware Implementation using 2N3904	32
4.8 What is gate driver?	33
4.9 Why we use this?	33
4.10 Function of gate driver	33
4.11 Topologies for gate driver	38
4.12 Software Simulation using IR2101	39
4.13 Software Simulation using conventional gate driver	41
4.14 Hardware Implementation using conventional gate driver	42
4.15 Gate Driver losses with conventional gate driver	43
4.16 Total Harmonic Distortion (THD)	51
4.17 THD and Dead Time	53
4.18 Advantages and Disadvantages of conventional gate driver	53
4.19 What is switching MOSFET'S stage?	53
4.20 Why we this?	54
4.21 Topologies in Class D w.r.t switching MOSFET'S stage	54
4.22 Selected MOSFET type	56
4.23 How we it can work in H-Bridge Configuration	56
4.24 Software Simulation	57
4.25 Hardware Implementation	59
4.26 Modification to remove Inverter Stage	59
4.27 Power Losses in MOSFET'S	60
<b>Chapter No.5 Filter Block</b>	<b>62</b>

5.0 What basically filter is?	63
5.1 Type of Filters	63
5.2 Ideal and real filters	64
5.3 Continuous time Low Pass Filter	65
5.4 Cutoff frequency	66
5.5 Why we use LC low pass filter?	66
5.6 Differences between RC, LC, RLC filters and advantages over the other	67
5.7 Software Simulation on MATLAB	78

### **SECTION-III**

#### **Digital Class D Amplifying System**

<b>Chapter No.6 (Approaches to Implement Digital Class-D)</b>	<b>71</b>
6.0 Approaches to Implement Digital Class-D	72
6.1 Block Diagram of D-Class D using UPWM	72
6.2 Block Diagram of D-Class D using N-Bit DAC	72
<b>Chapter No.6 (Digital Class D Amplifying System Using UPWM)</b>	<b>73</b>
6.2 Sub-Blocks of UPWM	74
6.3 Difference between UPWM and NPWM	75
6.4 Software Simulation using 16F877A	76
6.5 Code of Microcontroller 16F877A	82
6.6 Hardware Implementation using 16F877A	84

# **SECTION-I**

## **CLASS –D Amplifying System**

### **Chapter No.1**

#### **Introduction**

## **Class D Amplifier**

We use audio amplifiers for reproducing input audio signal with required volume and power levels, efficiently and with low distortion. The audio frequency is between 20Hz to 20 kHz, so the amplifiers have must good response over this range.

### **1.0 What Class D amplifier is?**

The Class D amplifier is one of the types of amplifying system.

A Class D amplifier uses pulse-width modulation circuitry to keep its output transistors operating either all the way on or all the way off. [1]

In this all the output stages not derive in the linear mode and its output stage switches between the positive and negative power supplies so as to produce a train of voltage pulses. A modulator must be included to convert the audio input into pulses. The frequency content of the pulses includes both the desired audio signal and significant high-frequency energy related to the modulation process. A low-pass filter is often inserted between the output stage and the speaker to minimize electromagnetic interference (EMI) and avoid driving the speaker with too much high frequency energy.

### **1.1 Why should I use Class D?**

Because Class D amplifiers are very efficient, they provide the best use of the finite power available from a battery or other limited power source. Furthermore, this high efficiency eliminates heat-sinking requirements for most amplifiers below 10W output power. Class D amplifiers do not heat their neighboring components, reducing the ambient temperature in the enclosure. Additionally, the thermal efficiency of Class D amplifiers allows them to use standard IC packages with no special consideration for thermal dissipation.[1]

### **1.2 Comparison with other classes:**

Amplifiers are usually designed to be operated with a particular value of bias supplied to the active devices (i.e. transistors). For linear operation, the active device(s) must be operated in the linear part of their **transfer characteristic**

#### **Class A:**

The *Class A* topology uses one of the transistors as a dc current source, capable of supplying the maximum audio current required by the speaker. Good sound quality is possible with the Class A output stage, but power dissipation is excessive because a large dc bias current usually flows in the output-stage *transistors*. [2] This form of operation is known as **Class A** and the **bias point** is adjusted to the mid-point of the linear part of the transfer characteristic. The **bias point** is adjusted to the mid-point of the linear part of the transfer characteristic.

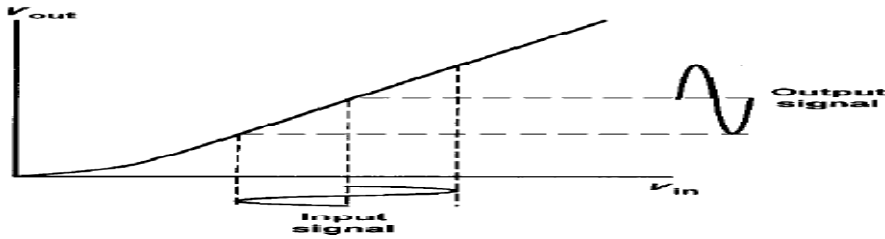


Figure-Class A Topology [3]

### Class B:

The *Class B* topology eliminates the dc bias current and dissipates significantly less power. Its output transistors are individually controlled in a push-pull manner, allowing the MH device to supply positive currents to the speaker, and ML to sink negative currents. This reduces output stage power dissipation, with only signal current conducted through the transistors. The Class B circuit has inferior sound quality, however, due to nonlinear behavior (*crossover distortion*) when the output current passes through 0 and the transistors are changing between the on and off conditions. [2]

The output signal will only comprise a series of positive half-cycles and the active device(s) will only be conducting during half-cycles of the waveform (i.e. they will only be operating 50% of the time). This mode of operation is known as **Class B** and is commonly used in high-efficiency push-pull power amplifiers where the two active devices in the output stage operate on alternate half-cycles of the waveform. [3]

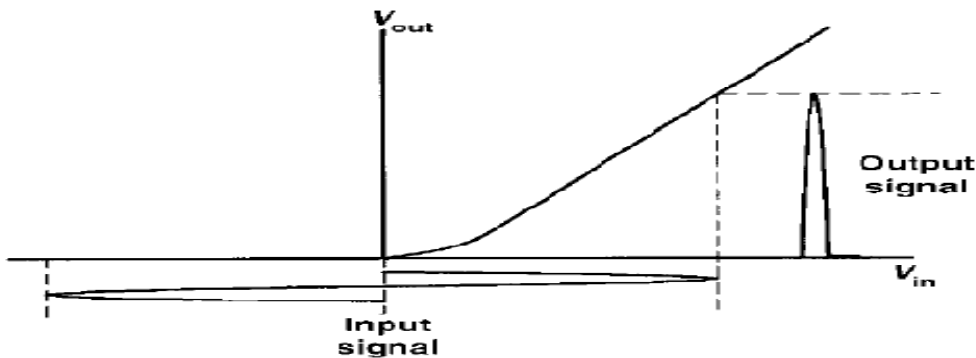


Figure- Class B Topology [3]

### Class AB:

*Class AB*, a hybrid compromise of Classes A and B, uses some dc bias current, but much less than a pure Class A design. The small dc bias current is sufficient to prevent crossover distortion, enabling good sound quality. Power dissipation,

Although between Class A and Class B limits, is typically closer to Class B. Some control, similar to that of the Class B circuit, is needed to allow the Class AB circuit to supply or sink large output currents.[2]

This is the case in which we reducing the bias even further while further increasing the amplitude of the input signal.

Here the bias point has been set at the projected cut-off point. The negative portion of the output signal becomes cut off (or **clipped**) and the active device(s) will cease to conduct for this part of the cycle. This mode of operation is known as **Class AB**. [3]

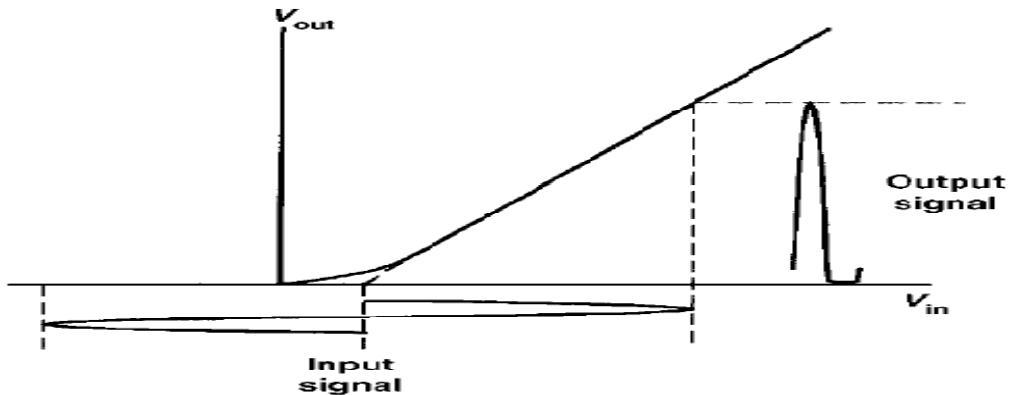


Figure. Class AB Topology [3]

### Class C:

Here the bias point is set at beyond the cut-off (zero) point and a very large input signal is applied. The output waveform will then comprise a series of quite sharp Positive-going pulses. These pulses of current or voltage can be applied to a tuned circuit load in order to recreate a sinusoidal signal. In effect, the pulses will excite the tuned circuit and its inherent flywheel action will produce a sinusoidal output waveform. This mode of operation is only used in RF power amplifiers that must operate at very high levels of efficiency.

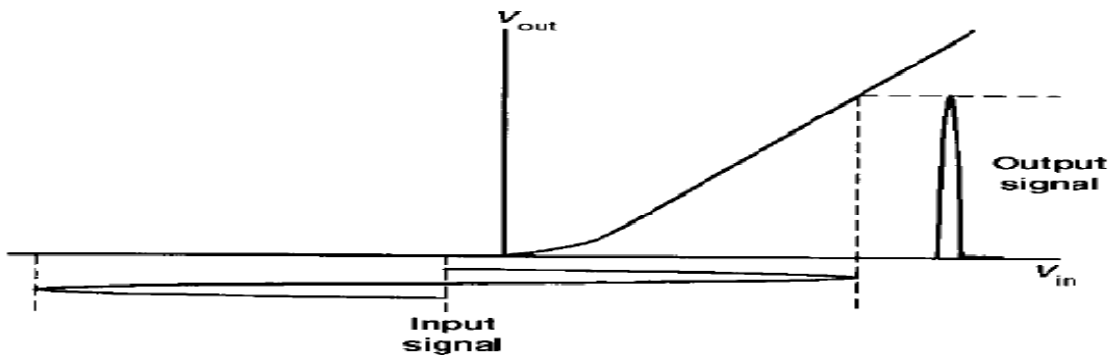


Figure-Class C Topology [3]

### 1.3 Advantages associated with Class-D

#### 1) Power Dissipation less

As we above say that in this output is not linear and the output Mosfets or transistors have zero current ( $I_{DS}$ ) when not switching and low voltage ( $V_{DS}$ ) across the junction when they are conducting. And power dissipation is

$V_{DS} \cdot I_{DS}$ , so ideally there is zero power dissipation in Class-D.

Figure compares ideal output-stage power dissipation ( $P_{DISS}$ ) for Class A and Class B amplifiers with measured dissipation for Class D amplifier, plotted against power delivered to the speaker ( $P_{LOAD}$ ), given an audio-frequency sine wave signal. The power numbers are normalized to the power level,  $P_{LOAD max}$ , at which the sine is clipped enough to cause 10% total harmonic distortion (THD). The vertical line indicates the  $P_{LOAD}$  at which clipping begins. Significant differences in power dissipation are visible for a wide range of loads, especially at high and moderate values. At the onset of clipping, dissipation in the Class D output stage is about 2.5 times less than Class B, and 27 times less than Class A. Note that more power is consumed in the Class A output stage than is delivered to the speaker—a consequence of using the large dc bias current.

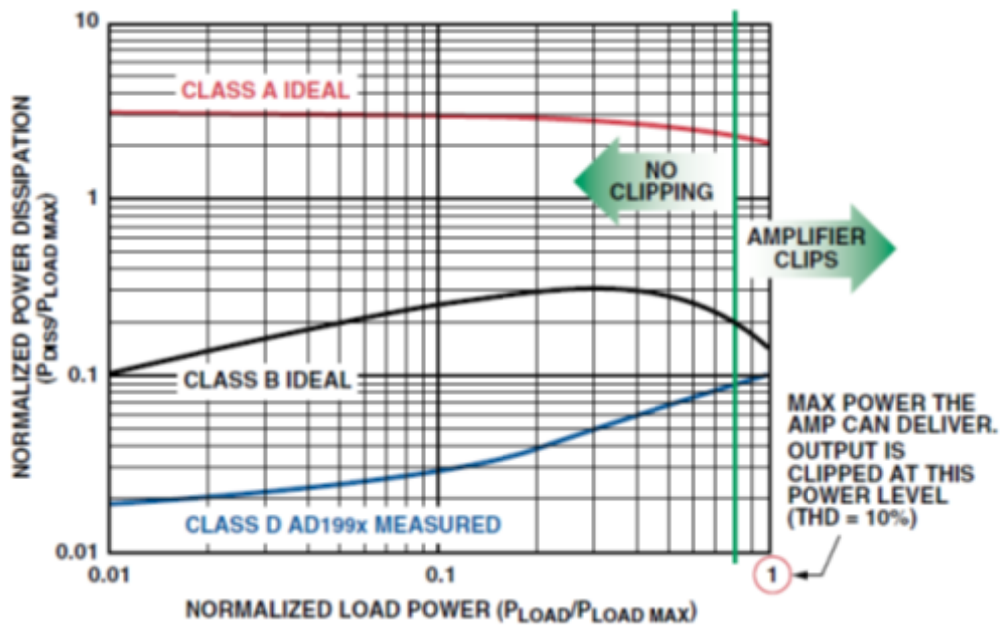


Figure-Power dissipation comparison of Class A and B with D [2]

#### 2) Efficiency

Efficiency increases as the Power dissipation decreases.

Output-stage power efficiency,  $Eff$ , is defined as

---

At the onset of clipping,  $Eff = 25\%$  for the Class A amplifier,  $78.5\%$  for the Class B amplifier, and  $90\%$  for the Class D amplifier.

At this level, the Class D output-stage dissipation is nine times less than Class B, and 107 times less than Class A.

For an audio amplifier with 10-W  $P_{LOAD\ max}$ , an average  $P_{LOAD}$  of 1 W can be considered a realistic listening level. Under this condition, 282 mW is dissipated inside the Class D output stage, vs. 2.53 W for Class B and 30.2 W for Class A. In this case, the Class D efficiency is reduced to 78%—from 90% at higher power. But even 78% is much better than the Class B and Class A efficiencies—28% and 3%, respectively.

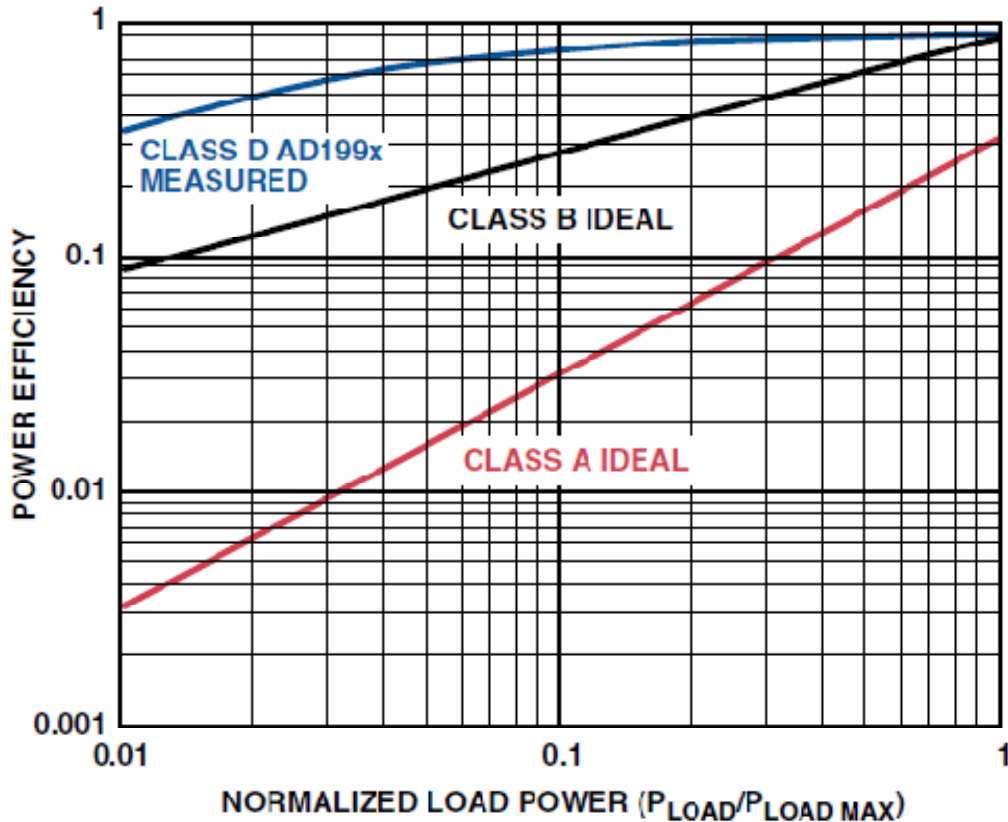


Figure-Relation of efficiency of Class A and B with D [2]

### **3) Battery Life**

Because there is less dissipation than battery life increases. If powered from a battery, a linear output stage would drain battery charge faster than a Class D design. In the above example, the Class D output stage consumes 2.8 times less supply current than Class B and 23.6 times less than Class A—resulting in a big difference in the life of batteries used in products. [2]

### **4) No need of Heat Sink Plates**

Due to less power dissipation

## **1.4Types of Class D amplifying System**

There are two Types in Class D amplifying system

1. Analog Class D amplifying system
2. Digital class D amplifying system