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Improved Efficient Class B Power Amplifier using Negative feedback

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Abstract
Effectiveness and linearity of the audio and power amplifiers are critical elements of communication systems. For critical low power, the active part in amplifiers should be class-B biased, i.e. zero bias. To preserve the level of distortion conventional, negative feedback is applied. Consequently, a nonlinear dynamic feedback loop is obtained. This paper emphasis on the design of the amplifier and establishing stability measures via newly developed techniques. This paper shows the improved efficiency of 87 % of class B power amplifier using negative feedback

Keywords
Class B Amplifier; Negative Feedback; Pushpul Circuit; class B amplifier Efficiency; cross over distortion

1. Introduction

The power potency of an amplifier, distinct as the relation of power input to power output, increases moving from class A to class D [1]. In universal conditions, we tend to see that a class A amplifier, with dc bias at half the provision voltage level, uses a decent quantity of power to sustain bias, even with no voltage applied. This gives us much distorted output signal, specifically with very low inputs, when a small input ac power is conveyed to the load [2]. Which is of course, the extreme class A amplifier efficiency, which occurs for the maximum output voltage and current fluctuate, is only 25% with a straight or sequence fed load connection and 50% with a transformer connection to the output. Class B function; provide a highest efficiency which is 78.56%. Class D amplifier is most efficient amplifier and provides efficiency of 90%. in view of the fact that class AB is combination of class A and class B in bias, so its efficiency falls between 25% to 78.56% [3]. Tab 1, Recapitulates the power efficiency and operation cycles of classes. While using class B power amplifier a complementary symmetry push pull circuit is used, two transistors NPN and PNP are used to provide out of phase cycles of both transistors [4]. Use of transformer is also possible here but transformer is large in many applications. Circuit without a transformer but using push pull circuit can also provide the similar function like transformer in smaller cost and size. [5].

Classes	**A**	**AB**	**B**	**C**	**D**
Operation Cycle	360°	180° to 360°	180°	Less than 180°	Pulse operation
Power Efficiency	25% to 50%	Between 25% (50%) and 78.5%	78.5%		Typically over 90%
°Class C is usually not used for delivering large amounts of power, thus the efficiency is not given here.					

Table 1: Power Amplifier classes and operations

This research paper includes a negative feedback path to improve the linearity and a resistor is used to control gain in feedback path, this will improve linearity and control gain by decreasing cross over distortion, feedback path is taken from the output of push pull circuit and given on inverting input of amplifier.

1.1 Complementry Symmtery Push Pull Circuit

To reduce the distortion of low frequencies like audio etc a common way is used which is complementary symmetry push pull circuit at output stage to get the missing half. The function of push pull circuit is

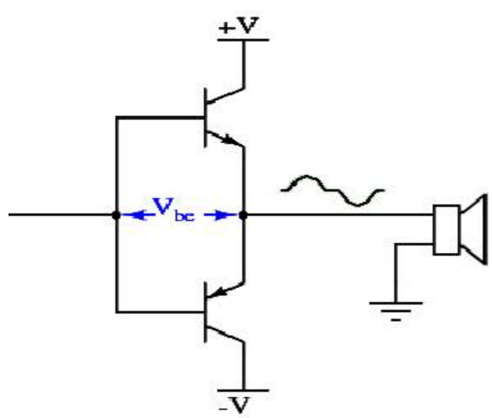

Figure 1: Pushpull Circuit

Given in figure 1. Two NPN and PNP transistors are used to get anti phase signals from a phase splitter are given to the bases of a pair of transistors so that every transistor conducts for half cycle and a complete signal is taken from output. A PNP and NPN transistors are used here with common emitter output.

1.2 Cross over Distortion

The main and very big problem in class B complementary symmetry push pull circuit is that every transistor conducts for only half cycle. As shown in figure 2.

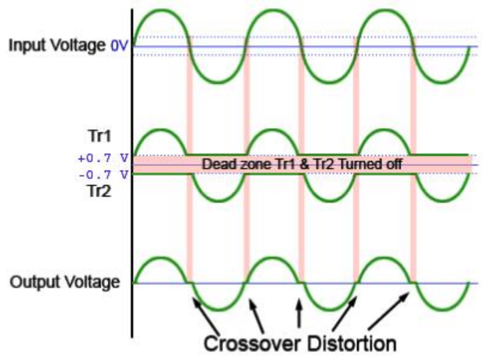

Figure 2: Crossover Distortion

When a waveform passes through zero volts, distortion occurs on each cycle of the signal waveform. Since the transistors don't have biased base, when there base/emitter voltage is increased from 0.7V, both transistors will start conduction. Which creates distortion of about 1.4V around the zero volts line (from −0.7V and +0.7V) the signal waveform will not be amplified during this voltage, which causes distortion during crossover from one transistor to another transistor. The impact distorted signal on the output depends to a little extent on the amplitude of the output signal, the higher the amplitude the less significant the distorted 1.4 volts becomes.

2. Related Work

Modern Electronics and communications network requires low distortion and efficient power amplifiers. Class A amplifiers make low distortion, however its PAE (power added efficiency) is less than 50%. Efficiency can be improved by using it with switched mode amplifiers. This shows IMD (high intermodulation distortion) multi-tone applications. Complementary symmetry push pull class B amplifier gives us much improved efficiency, almost 78.56%, having distortion like class A amplifier. For working in sub octave bandwidths, a standard class B push pull power amplifier can be changed by using a single ended class B power amplifier with a low pass or band pass filter. A single ended class-B amplifier can attain high power added efficiency and high third order intermodulation (IM3) containment at the same time if (Id), the drain current against (Vgs) gate to source voltage characteristic is linear over threshold. It is also experienced that common drain class B amplifier has very small distortion, and the distortion is much less responsive to biasing circumstances than similar common source configurations [15].

3. Methodology

In the above sections, the advantages and disadvantages of power Amplifiers have been discussed in the following work, a method is proposed to increase the efficiency of class B power amplifier, the gain of the amplifier can be controlled by employing negative feedback mechanism and accordingly crossover distortion is reduced significantly. A very useful and powerful concept in electronics is negative feedback, particularly in amplifiers and Op-Amps etc. Additionally, the response of the amplifier becomes more linear with good efficiency.

4. Equations

For measurement of circuit efficiency this is equation is been used.[13]

$$\%\boldsymbol{\eta} = \frac{\boldsymbol{P_o(ac)}}{\boldsymbol{P_i(dc)}} \times \mathbf{100\%} = \frac{\boldsymbol{V_l^2(p)2R_l}}{\boldsymbol{Vcc}[(\frac{2}{\pi})(\frac{V_L(p)}{R_L})]} \times \mathbf{100\%} \ldots\ldots \text{ (1)}$$

Maximum output power is transferred to load when

$$\boldsymbol{maximum\ P_0(ac)} = \frac{\boldsymbol{V_{cc}^2}}{\boldsymbol{2R_l}} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \text{ (2)}$$

The maximum average value of current from input is

$$\boldsymbol{max\ P_i(dc) = Vcc\ (max\ I_{dc}) = Vcc} \left(\frac{\boldsymbol{2Vcc}}{\boldsymbol{\pi R_l}}\right) = \frac{\boldsymbol{2V_{cc}^2}}{\boldsymbol{\pi R_l}} \ldots .. \text{ (3)}$$

Maximum power dissipation of transistor is

$$\boldsymbol{Maximum\ P_{2Q} = 0.5} \left(\frac{\boldsymbol{2V_{cc}^2}}{\boldsymbol{\pi^2 R_l}}\right) \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \text{ (4)}$$

Equation for Feedback and Gain

$$\boldsymbol{A_f} = \frac{\boldsymbol{V_o}}{\boldsymbol{V_s}} = \frac{\boldsymbol{A}}{\boldsymbol{1+\beta A}} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \text{.(5)}$$

5. Simulation/Results

In order to test the efficiency of the proposed scheme, we design a circuit in Multisim as shown in figure 3.

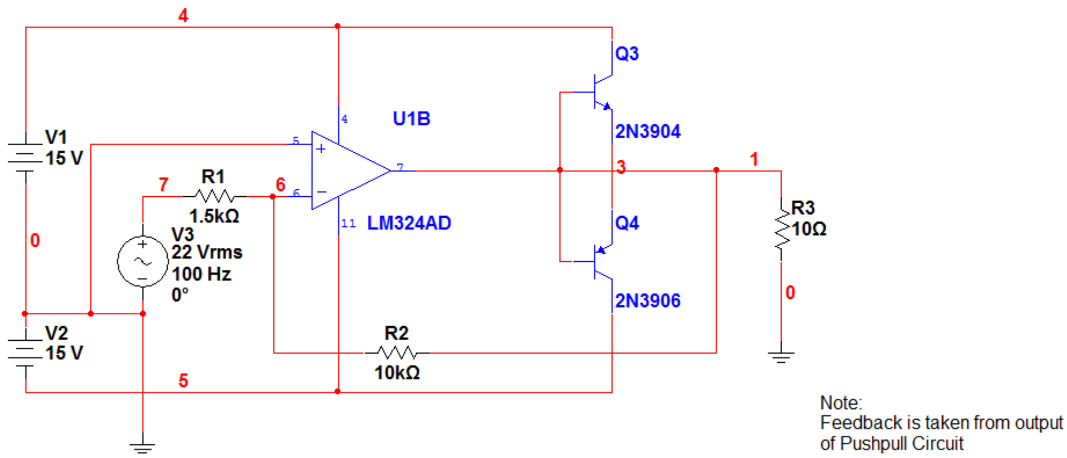

Figure 3: Class B Power Amplifier with Push pull Output

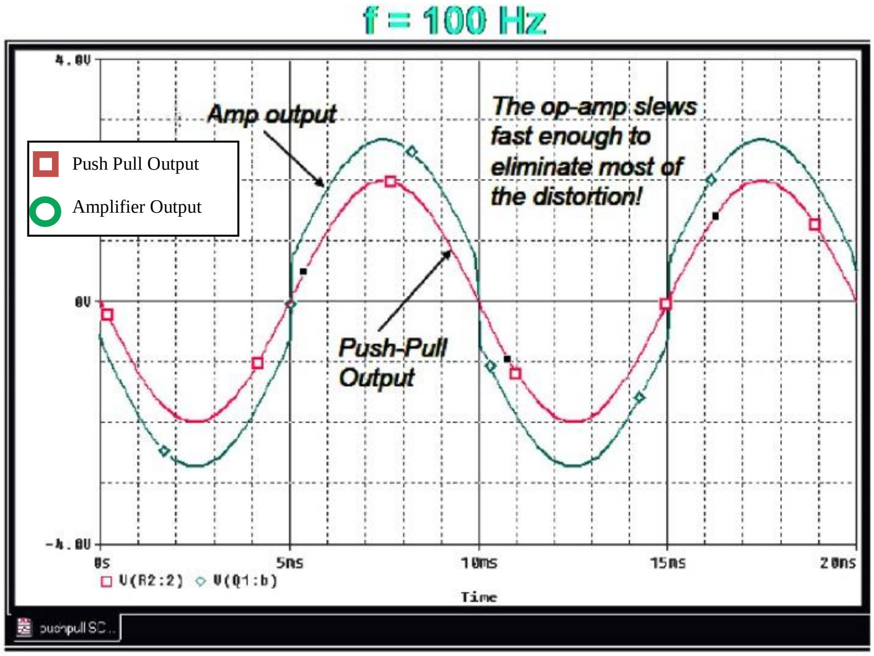

Figure 4: Push Pull and Amplifier Output with 100 Hz

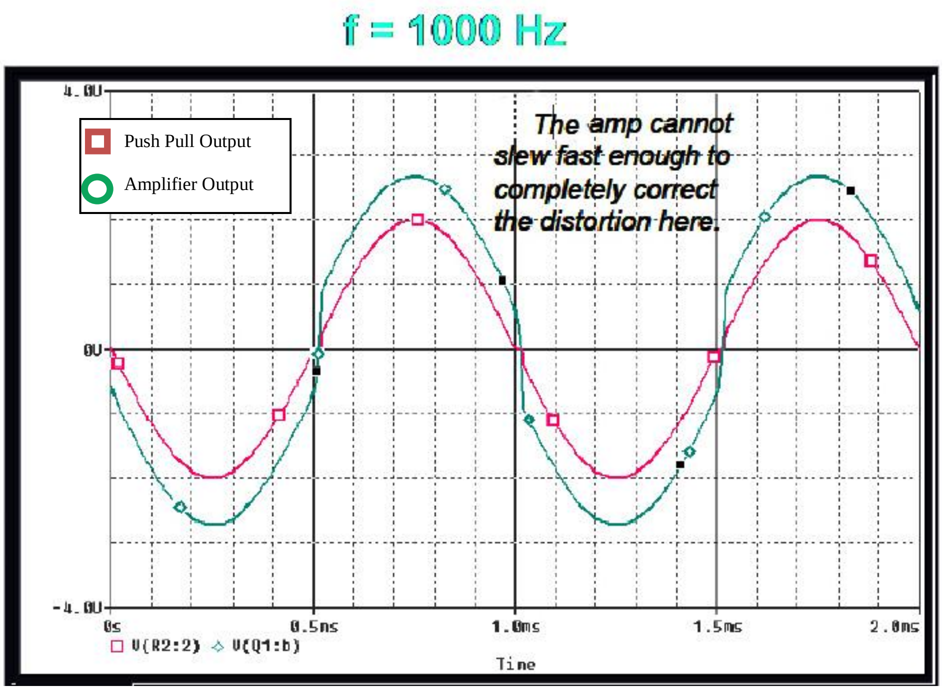

Figure 5 Push Pull and Amplifier Output with 1 KHz

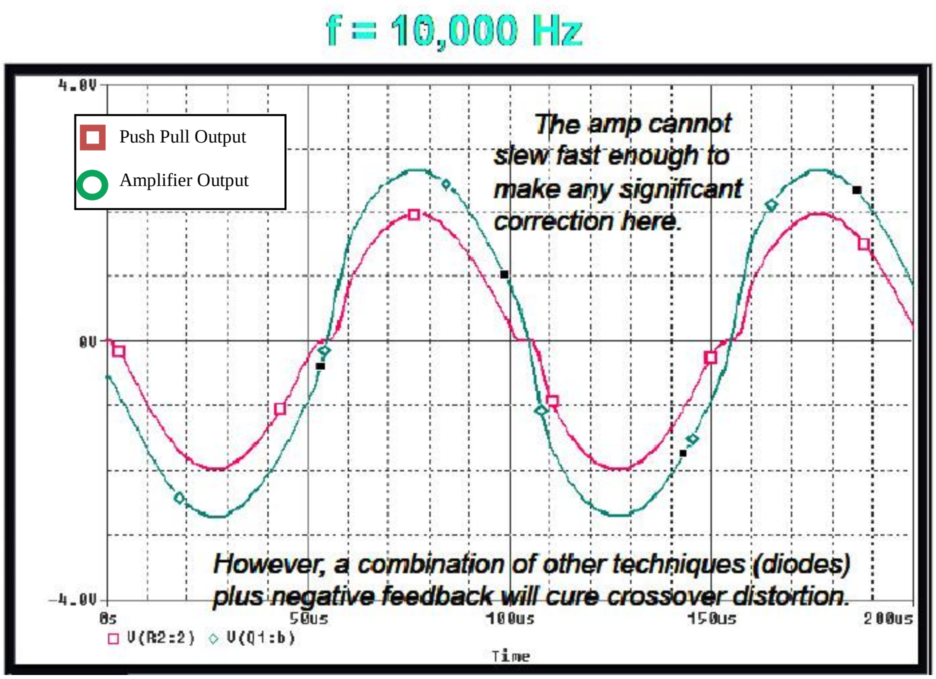

Figure 6 Push Pull and Amplifier Output with 10 KHz

The output of the circuit is shown in the figure 4 – 6 for frequencies of 100Hz, 1 KHz and 10 KHz. Figure 4 shows the output of the push pull amplifier. As can be seen, the output of push pull amplifier is much linear than that of class B amplifier. Additionally, increasing efficiency will also increase the gain. Amplifiers gain can be controlled by increasing or decreasing the value of feedback resistor Rf. This relationship between gain and efficiency is readily observed in Table 2. Table 2 shows the efficiency for different circuit parameters. First, we used 17.7 V as input voltage and 10k as R_f which gives us maximum gain of 20 db and maximum percent efficiency of 87.57 %. Secondly, we then use 22v input and 10k R_f with 1.5k Rin which decreases gain and efficiency of circuit. Figure 4 - 6 shows that, by using complementary symmetrical circuit (Push pull) the output signal becomes a complete of 360◦ with a cross over distortion of ± 0.7 V. This crossover distortion is then reduced using negative feedback connection as shown in Figure 3.

Input Voltage	**R1, R2,**	**R3/RL**	**Efficiency %η**	**Av**	**A_f**	**Max P_{2Q} (W)**
17.7 V	1k,10k	8 Ω	87.57 η	20db	0.58	3.97 W
22 V	1.5K, 10K	10 Ω	85 η	13db	0.43	4.92 W

Table 2, Mathematical results after compilation of equations

6. Conclusion

In this paper, we analyse the performace of class B power equipped with negative feedback. The model circuit proposed is tested for various frequency and diverse components. It is observed that, the efficiency of class B power amplifier is improved upto 87.5 %. Additionally, the feedback path in the respective topology provide linearity in the output and a reduced crossover distortion of the final waveform.

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