

Guidelines for the Development of Power Loss Reduction Circuits of Class A Audio Amplifiers using Appropriated Voltage Adjustment Technique with Small Input Signal

Piyanut Rattha*, Vithaya Chamnanphrai, Angkana Charoenmee, and Juttupong Namsom

Faculty of Engineering, Rajamangala University of Technology Isan, Khon Kaen Campus, Thailand

piyanatrattha@gmail.com*

Abstract. Audio amplifiers are the classical, commonly used electronic circuits; especially, in the applications of high wattage amplifiers; where the Class A audio amplifiers are the most acceptable and have the best sound quality. However, they would have low rate of expansion, as well as, low efficiency. For example, the famous Class A circuit model: Krell KSA-100 that consists of power amplifiers with 3 pairs of composites using the power supply plus minus 45 volts can cause high current and high power consumption all the time, i.e., with input signal voltage is zero, the circuit generates a current flowing through the final power amplifier, 1-amp pair. This results in high total current to reach 3 amps or 137 watts at all times. The researcher will conduct research to reduce the power loss in such conditions by reducing the power supply voltage more the circuit is still ready to expand the audio signal effectively as previous. Experiment by adjusting the input voltage with AC power transformer, can be adjusting from 28 to 145 volts, to allow DC power to vary the voltage in the range of 10 and 45 volts. Input 100 mV_{p-p} input signal, 1kHz Sine wave frequency at 8-ohm load and reduced the voltage from 45 volts until the output amplifier can still maintain the input signal. Experimental results show that when reducing the power supply voltage, the power loss is reduced accordingly.

Where the output signal remains distorted as the input signal is not distorted. This article describes the techniques for adjusting the voltage appropriately for Class A audio amplifiers circuit and the study of the enhancement of Class A audio amplifiers with the technique to crease the TD circuit (Tracking Class D) or DC voltage distribution circuit for the final power expansion According to the size of the audio signal received the input using a 32-bit processor as an automatic control to develop Class A audio amplifiers for better performance.

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1. Introduction

The amplifier circuit with the best sound quality and the most accurate sound transmission from the past to the present is still a Class A [8] amplifier circuit, which is due to the last signal bias amplifier arrangement at the point of the transistor or at the center

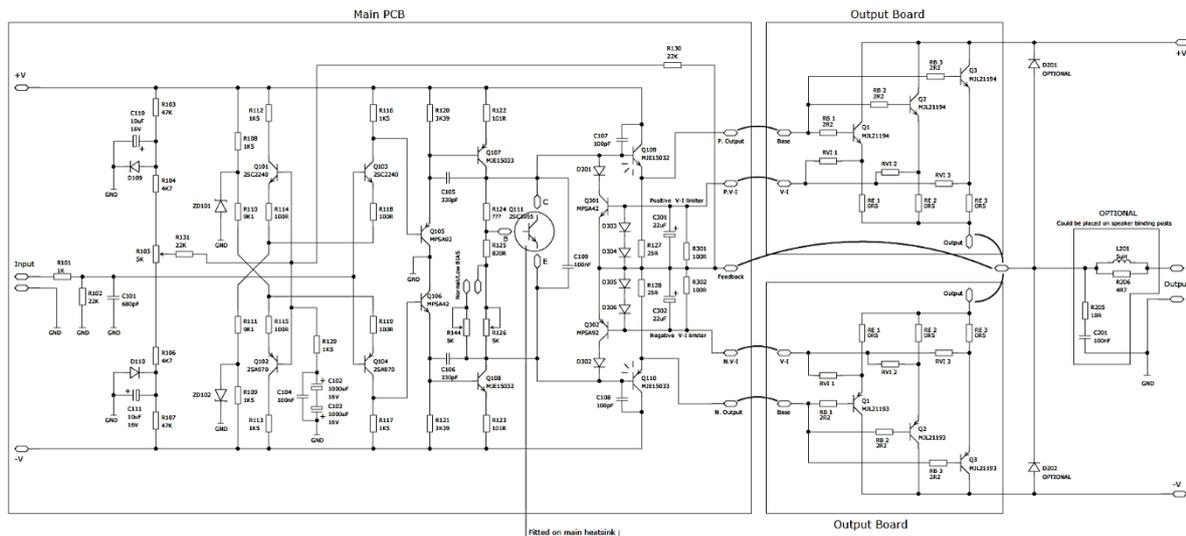


Fig. 1: Class A Krell KSA-100 circuit sample

position of DC load line in order to prepare for the signal extension of those two phases. The transistors that were biased at the Q-Point point will bring the current all the time, which is called a calm stream. The power loss value will be 1/2 of all power and will be the highest wattage of that Class A expansion circuit.

The researchers saw the importance of the loss of power in Class A audio amplifiers, as in the picture shown in Fig. 2, hence, using the technique of adjusting the power supply voltage appropriately with the input signal to conduct research and experiment with the circuit Krell KSA-100 [6] in Fig. 1 to show the results of the experiment that while there are no signal inputs, the circuit can operate without losing unnecessary power with the technique of adjusting the pressure perfectly.

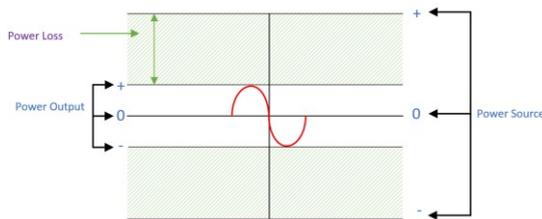


Fig. 2: shows the power loss of Class A audio amplifiers.

2. The basis of the amplifier

The development of various types of amplifiers is called Class such as Class A, Class B, Class AB, Class H [9] Class TD, which can be divided according to the circuit function and has different features. For example, amplifiers Class AB is an amplified circuit that has biased transistors during half cycle and full cycle, which has the capacity of 50% expansion. The Class AB circuits have simple circuit configurations and have a quality sound that can amplify the signal to a larger size, with distortion less than Class D.

The disadvantage of Class AB [18] [19] is that it requires constant voltage supply in order to make the circuit works, which is constantly losing power and the expansion device has the same coefficient of heat as Class A.

The Class H amplifier, the system uses power supply from 2 levels or more by means of changing the voltage level according to the input signal. When there is a small signal, the power supply will adjust the low voltage level to a suitable level and when the signal level is increased, the system will work like the Class AB system and less efficient. The Class D amplifiers [10][11][16][17][20], the input signal is converted into a PWM waveform in a rectangular pulse while the general audio signal is a sine wave. The Class D audio amplifier works in switch mode, which is set to enable or disable and adjust the width or duty cycle of PWM. The Class D amplifier circuit is a circuit that has the power of amplification up to 85%. The limitation of Class D is usually limited to working at low frequencies because the signal amplification in the outgoing sector must filter PWM waves into rectangular waveforms in order to return to a frequency signal in a sine wave. A typical Class D amplifier will filter frequencies up to 500 Hz, which is the frequency for the subwoofer only. The TD amplifier [15] will supply the voltage to the final

power amplifier as appropriate depending on whether the amplifier is Class A or Class AB, the output signal therefore has the same sound quality due to input signal to output is not converted to a PWM signal like Class D, resulting in a lesser frequency response distortion.

The Class A amplifiers [1] [5] have outstanding sound quality and have output signals like input signals, but the disadvantage is that there is a loss of current since no amplification. Transistor signals work all the time, resulting in a large amount of heat accumulation, low expansion rate and power efficiency of only 25% amplification, as shown in the equation "Eq. (4)" [7] due to the bias transistor being in the active range, which brings the current all the time, resulting in a steady stream of flow throughout, so that the point of work has a swing range of output signals not lower than the cutoff point.

$$\text{When } V_{(\text{max})\text{peak}} = \frac{V_{cc}}{2} \tag{1}$$

$$P_{\text{out}} = \frac{V_{(\text{max})\text{peak}}^2}{2R_c} = \frac{(V_{cc}/2)^2}{2R_c} = \frac{V_{cc}^2}{8R_c} \tag{2}$$

$$P_{\text{source}} = V_{cc}I_c = V_{cc}\left(\frac{V_{cc}}{2R_c}\right) = \frac{V_{cc}^2}{2R_c} \tag{3}$$

Therefore, the highest efficiency

$$\begin{aligned} \eta_{\text{max}} \% &= \frac{P_{\text{out}}}{P_{\text{source}}} \times 100 = \frac{V_{cc}^2 / (8R_c)}{V_{cc}^2 / (2R_c)} \times 100 \\ &= \frac{1}{4} \times 100 = 25\% \end{aligned} \tag{4}$$

3. Design and experiment

In order to experiment, when the smallest input signal that the circuit is still able to operate with amplification, the researcher has tested according to the work plan designed in Fig. 5 by entering the 1 kHz 100 mV_{pp} sine wave signal frequency. Adjusting the power supply voltage from 45 volts to the lowest voltage that the circuit can still maintain the output signal like an input signal. Then the results from the test were measured by the output power value compared to the input power.

3.1 Testing by the Simulation program

Experiment by simulation program, PSpice, for joining circuit in Krell KSA-100 pattern. From the circuit, will see the operation in the pattern of balanced current amplification that started from receiving wave from input via coupling, and eliminated interference by the input circuit before sending the wave into the differential amplifier circuit. Whereof, both the positive and negative sides had the circuit controlling the constant current source (CCS). The result of the amplifying on both sides was forwarded into the voltage amp stage. The circuit was arranged in the Darlington complementary pattern as shows in Fig. 3. The wave from the voltage amp stage was forwarded to the driver circuit before eliminating the wave from the emitter to the current amp stage or output stage as shown in Fig. 4.

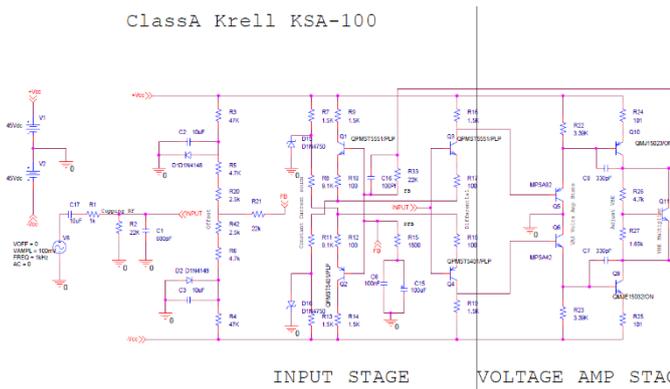


Fig. 3: Krell KSA-100 circuit from the simulation program

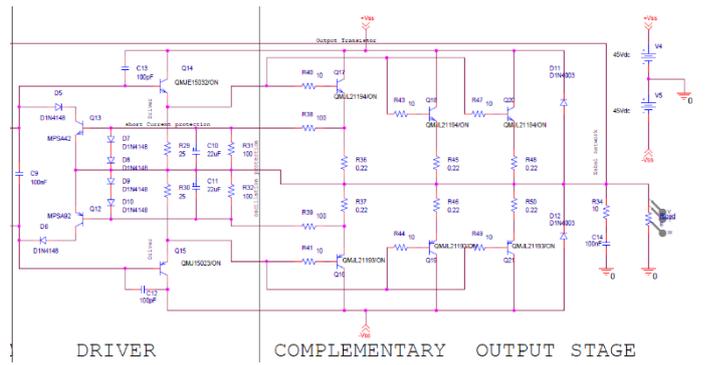


Fig. 4: Krell KSA-100 circuit from the simulation program

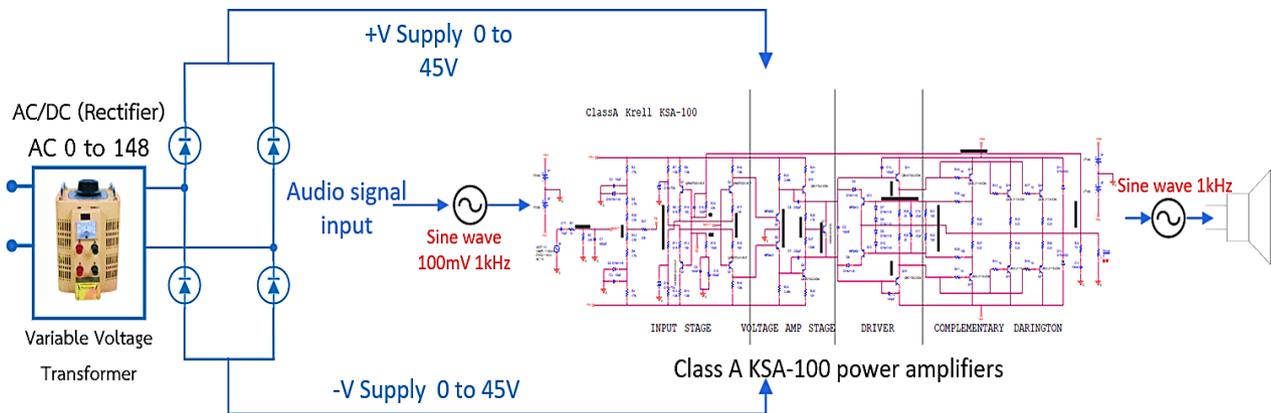


Fig. 5: the experimental test-rig configuration

Joint load at 8 ohms after joining the circuit according to Krell KSA-100 pattern. Then level the bias transistor voltage at the VBE Multiplier stage of the circuit to let the current flow through the transistor of the output stage of 1 amp per pair. The circuit operated in Class A mode at voltage of power supply 45 volt. Next, sine wave at 1 kHz 100 mVp-p was released to the input. Voltage probe of the program was taken to catch at the output graph of the wave as shown in the Fig. 6 at a voltage of 1.5 volts peak. Then made the power probe catch at the power supply and the output. And leveled the voltage of power supply to be lower from 45 volts until the output wave was stable like the input wave. It was noticed that the power source (P_{Source}) was reduced from 137 watts to only 8 watts, but the output power (P_{out}) was still the same at 0.195 watts as shown in the Fig.7. From the experiment shown that the power consumption could be reduced up to 127 watts, and the circuit could still function as the before.

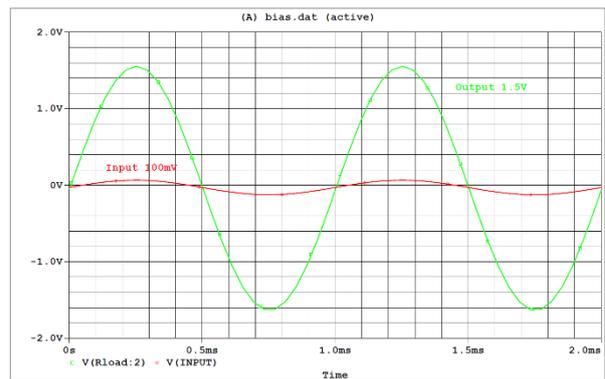


Fig. 6 Graph showing results from the simulation

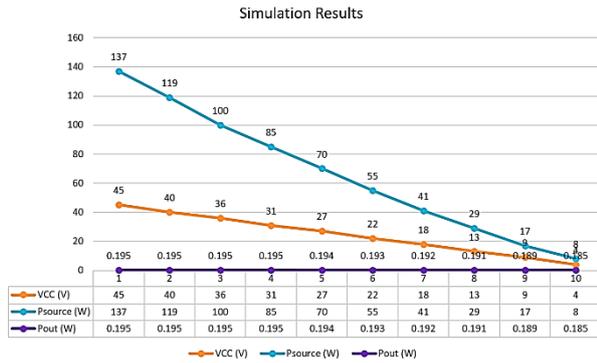


Fig. 7: Graph showing results from the simulation

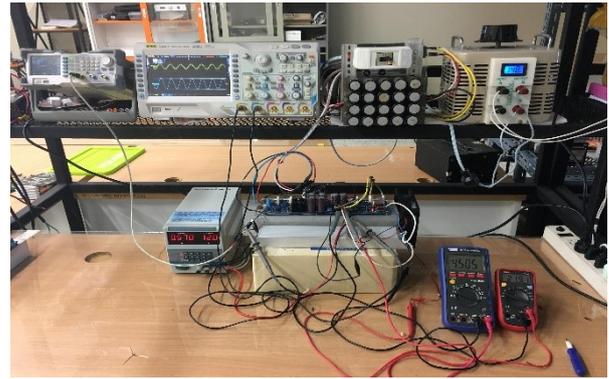


Fig. 8: Krell KSA-100 circuit

3.2 Testing with the actual circuit

Started with taking an adjustable transformer to be used as a device adjusting the input voltage to adjust the AC voltage according to the experimental design chart in Fig. 5. Then released the input wave by the electric generator to the electric receiver of the circuit at the sine wave frequency of 1kHz 100 mV_{p-p} and joint load at 8 ohms. After that, reduced the voltage by the adjustable transformer, and used the meter to read the DC voltage from the rectifier circuit to obtain a voltage of 45 volts and then released it to the Krell KSA-100 circuit. When the circuit is working, used an oscilloscope to read the waveform of the output wave of the circuit. From the experiment, the sine wave is at 1 kHz 1.3 volts peak as shown in the Fig. 9. Then reduced the voltage from 45 volts to the lowest as the circuit could maintain the output wave to be stable as the input wave. The experimental result shown that Krell KSA-100 circuit can reduce the power supply voltage to a minimum of 5 volts, with its wave still unchanged from the input wave.

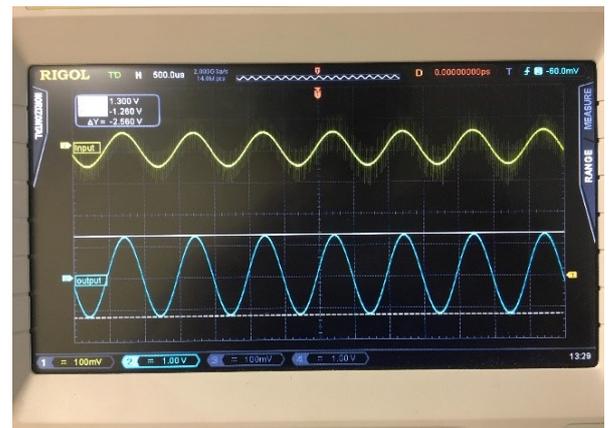


Fig. 9: Graph showing results from the actual experiments

VCC (Volte)	Simulation Value		Experiment Value	
	P _{Sources} (W _{RMS})	P _{Output} (W _{RMS})	P _{Sources} (W _{RMS})	P _{Output} (W _{RMS})
45	137	0.195	128	0.149
40	119	0.195	54	0.149
36	100	0.195	36	0.149
31	85	0.195	22	0.149
27	70	0.195	15	0.149
22	55	0.195	10	0.149
18	41	0.195	7	0.149
13	29	0.195	4	0.149
9	17	0.195	1	0.149
4	8	0.195	0	0.149

Table 1: Simulation results and actual experiment results

From the graph in Fig. 10 shows that when adjust the power supply voltage, the power of the power source (P_{source}) will decrease as well, from the original 128 watts at 45 volts, down to 0.16 watts at 5 volts. While the output power (P_{out}) is still at 0.149 watts and the output wave is still not distorted and the circuit can still work as before. If the voltage is reduced to more than 5 volts, the sine wave starts to distort from the input wave. It is indicated that the circuit is not stable at the power supply voltage which is below 5 volts.

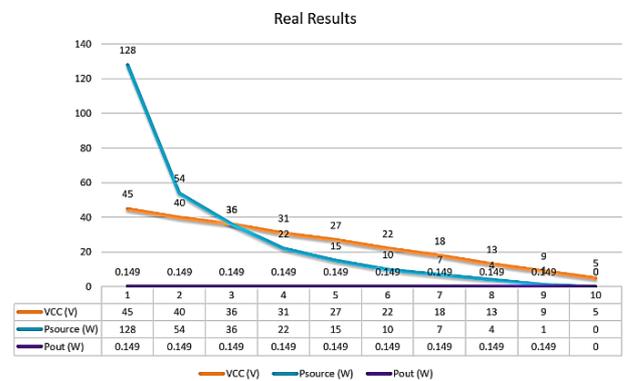


Fig. 10: Graph showing results from experiments

4. Conclusions

From the experiment to adjust the voltage to be appropriate by the circuit development process that reduces the power loss of Class A audio amplifier with the appropriate voltage adjustment techniques that have been tested with the Krell KSA-100 circuit.

The simulation results show that the power consumption can be reduced by 129 watts, the lowest voltage at 8 volts, with the circuit still able to amplify the signal. The results of the experiment with real circuits can reduce 127 watts of power at the minimum 5 volts as shown in Table 1. From Fig. 7 and Fig. 10, we will notice that the graph of the power source (P_{Source}) that is reduced with the unequal ratio is caused by the temperature coefficient on the magnification of the transistor. In the simulation, the program will not accumulate heat like the experiment with real circuits and the results from the experiment are consistent with the goals of the design according to the plan. After that, the researcher will apply the technique to adjust the voltage appropriately to further develop into a technique to supply DC voltage to the final power amplifier Class A according to the size of the audio signal that is received via the input using a 32 bit processor to be an automatic control function called Class TD or TD (Tracking Class D) for further improving the sound quality and efficiency.

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Biographies



Piyanut Rattha received his bachelor's degree in Electronics and Telecommunication Engineering, Faculty of Engineering, Rajamangala University of Technology Isan, Khonkaen Campus, Khonkaen District, Khonkaen Province, Thailand.



Juttupong Namsom received his bachelor's degree in Electronics and Telecommunication Engineering, Faculty of Engineering, Rajamangala University of Technology Isan, Khonkaen Campus, Khonkaen District, Khonkaen Province, Thailand.



Augkhana Chareanme was born in Thailand. She received her Ph.D. from Mahasarakham University, Thailand. She is a lecturer of Electronics and Telecommunication Engineering, Faculty of Engineering, Rajamangala University of Technology Isan, Khonkaen Campus, Thailand. Her research interests include android operating system, smart home, Smart farm, microcontroller on FPGA.



Wittaya Chamnanprai was born in Thailand. He received his Ph.D. from Mahasarakham University, Thailand. He is a lecturer of Electronics and Telecommunication Engineering, Faculty of Engineering, Rajamangala University of Technology Isan, Khonkaen Campus, Thailand. His research interests include microprocessor, IoT, smart home, smart farm, embedded system and computer programming.