Enhanced Wireless Amplifier

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Abstract

Amplifiers are devices used to generate a greater output signal when compared to its input signal. In equation form, \( V_{out} = \frac{V_{in}}{g} \) where \( V_{in} \) is the input voltage, \( V_{out} \) is the output voltage and \( g \) is the gain. \( g \) is a dimensionless and is a multiple of the input voltage and/or signal. Wire amplifiers are commonly linked to voltage gain, they are not linked to strictly voltage amplifications, as some parts of the output also increase. Amplifiers are used in countless circuits, but are well-known for being applied to the amplification of audio signals.

A typical configuration of an amplifier can be shown in the figure below:

For most applications, the amplifier will be configured to operate in a non-inverting mode. When the input signal is increased, the output signal will also increase. In this configuration, the gain of the amplifier is determined by the ratio of the input to the output. However, the amplifier can also be configured to operate in an inverting mode, where the output signal is opposite in polarity to the input signal. This is achieved by using feedback from the output to the input of the amplifier.

In some cases, the amplifier may also be configured to act in a non-inverting mode. A similar setup applies to the inverting mode, except that the feedback loop is placed on the positive input while the negative input is grounded. This configuration can be used to increase the negative terminal's gain without changing the input signal.

Overall Design

1. The NPI Playr

The NPI player starts the process. It simply provides a song to the Arduino where it will soon be processed and transmitted via Bluetooth.

2. The Transmission - Arduino Uno

The Arduino Uno is a very versatile platform that is intuitive for use. As such, it was a perfect platform for our design. We were going to need at least two of these boards one for the processing and transmission of the audio file and one for the reception and playback of the audio file. For now, the transmission board is not a need. Our Arduino Uno has an onboard Bluetooth Digital Converter (BLDC) which takes the analog output from the NPI player and then processes it through the Digital I/O pins of the Bluetooth Bee.

3. The Bluetooth Sticks

The Bluetooth Stick is a standard Bluetooth module that can be attached to the Arduino Uno. For our design, two Bluetooth Sticks were necessary: one to send the audio file and one to receive the audio file for playback. The Bluetooth Stick acts as a slave device to the Arduino Uno. If it is not attached, however, the Bluetooth Sticks also exhibit a hierarchical relation with each other, with the server being the master device of that pair. The receiving Bluetooth Bee receives the data from the server Bluetooth Bee and sends it to a Digital I/O pin on the receiving Arduino.

4. The Off-Board Digital-Analog Converter

The receiving Arduino Uno takes the output of the Bluetooth Bee and sends it to an off-board receiver-ladder network (as an R-2R ladder). The song's bits are spread across a parallel arrangement and fed to the network from 10 of the Digital I/O pins on the Arduino board in the form of discrete voltage levels (VH and VL) which are generated by the R-2R ladder. These levels are divided within the receiver network and the analog signals are produced from variation in voltage differences as separate pulses that are stored in a buffer amplifier or LDO. The output conversion is sent as the top of the ladder network and is then sent to the amplifying circuitry.

5. The Amplifier Circuit

The final step of our overall process is the amplifier circuit. It is composed of three distinct stages, which will be examined more thoroughly in the following sections. On a basic level, the amplifier acts to boost and modulate the gain of the audio file before it reaches the speaker through two separate operational amplifier (op-amps) stages and a buffer stage. While the op-amps control the gain, the buffer stage is needed to properly drive the speaker. The following sections will explain these stages in more detail.

The Amplifier Circuit

As previously mentioned, the amplifier circuit is broken into three separate stages before the final output is sent to the speaker. The first stage consists of an op-amp in positive feedback with a gain of 1.5 that acts as a pre-amp. The output of this pre-amp flows into an AC coupling capacitor and a variable resistor, called a potentiometer. The potentiometer can be manually adjusted by turning the screw on its top. In doing so, it will vary the gain of the second stage op-amp, which in turn will vary the feedback connected to the output of the third stage with the potentiometer. The potentiometer can be adjusted to create a gain of three on the second op-amp (75% turn). Before stepping occurs on the output of the second stage. From the second stage, there is a final output stage using two high-powered BJTs, the NPN-2950 and the PNP-2950. Since the output from the second op-amp will be a varying sine wave, generally one of these transistors will be on at any given time, though a small crossover distortion where both are on also exists.

Output

To reduce crossover distortion, two diodes were placed on the bases of each of these transistors to properly bias them. As a final measure, short circuit protection was also placed on the emitters of these transistors in the form of two very small resistors in parallel with each general-purpose transistor: the NPN-2950/300 and the PNP-2950/300. If the current flowing through the TIP series BJTs becomes too great, the voltage drop across the resistors will be equal to or greater than the necessary voltage to turn either of the general-purpose transistors on. In doing so, they will steal current from the TIP series transistors to prevent them from burning out. Finally, the output signal will flow in feedback to the potentiometer and to the speaker itself, which will play the audio file.