Matthew Rothlisberger
2018-11-07

# Audio Amplifier Engineering Notes

A – Two twelve-volt supplies in series were chosen because the circuit requires a dual supply, and because the rail-to-rail voltage of 24 V is well within the maximum voltage range, 36 V, of the LF411 operational amplifier. Ground is placed between the voltage supplies.

B – A pair of polarized electrolytic power-supply filtering capacitors are connected from each rail to ground, using their high capacitance to provide necessary bypass of power supply impedance. This method helps to eliminate power-supply instability, and resulting distortion, caused by heavy loads like the power amp. The capacitors were placed physically close to the power amp to provide filtering where it is most needed.

C – Two pairs of ceramic disc capacitors with a 100 nF capacitance were also placed across the rails and ground in order to bypass the internal impedance of the large electrolytic capacitors, and further increase the circuit stability. One pair was placed in the preamplifier, and one was placed near the output.

D – This signal source and 600 ohm resistor represent the dynamic microphones or oscillators used as input for the amplifier. They are connected from the first op-amp's input to ground.

E – A 100K resistor is placed in parallel with the noninverting input of the first op-amp in order to create a voltage divider and bring the amplifier's input impedance from around a trillion ohms to a hundred thousand ohms, increasing the current from the input and improving signal pickup.

F – The LF411 was selected for the amplifier as an upgrade over the older LM741, and has useful features such as JFET inputs which draw no current, a slew rate 30 times faster than the LM741, a low input offset voltage, and good performance over a wide range of amplitudes and frequencies.

G – The overall voltage gain of the preamplifier is 972, and it uses three op-amps in the non-inverting configuration, chosen for its excellent preservation of the signal. The first op-amp has a gain of 12, the largest of the three, in order to boost the minuscule input signal to a more useful level as quickly as possible and prevent noise and losses.

H – The other two preamplifier op-amps each have a voltage gain of 9 to finish increasing the signal voltage to an appropriate level for the power amplifier. An overall gain of 972 was chosen because testing showed that a gain of around 1000 produced good results when a microphone, an oscillator, or a phone were connected to the input.

I – This is the high-pass filter used for dc offset and very low frequency blocking prior to the power amplifier. It was designed by choosing a resistor value of 10K and a 3 dB point of 20 Hz, then solving $\omega_{3dB} = {}^{1}/_{RC}$ to find a good capacitor value. The passband of this filter begins at around 42 Hz, low enough to accommodate voice and almost all music without attenuation.

Matthew Rothlisberger
2018-11-07

J – The power amplifier uses two methods to eliminate crossover distortion and maintain a clear sound. The first, here, is the use of a noninverting follower op-amp at unity gain, with the inverting input connected to the amplifier output. This provides a high-impedance buffer between the preamplifier and the emitter follower, as well as making use of negative feedback to maintain an output signal as close as possible in voltage to the preamplifier output.

K – The second method used to eliminate crossover distortion is diode biasing of the power transistors to hold their bases 0.6 V above or below the signal from the op-amp, so that the emitter follower conducts the entire signal wave. The 1N4148 diode was chosen for its fast switching ability, as well as its bias voltage, which is very similar to that of the power transistors.

L – When using a diode-biased emitter follower, as seen here, transistor base current must be provided from resistors connected from the base to the rails, in series with the biasing diodes. The base current must be selected so that the output current is appropriate to the power supply and speaker at peak output swing. With a peak signal voltage of 4 V, incorporating the diode bias and the supply rails gives a voltage difference from rail to transistor base of 7.4 V at peak. The desired output current is 0.5 A, and since the approximate current gain of the power transistors is 100, the appropriate base current is 5 mA. Plugging 7.4 V and 5 mA into $R = {}^{V}/_{I}$ returns 1.5 kilohms, a resistor value that works well.

M – The main portion of the push-pull emitter follower output stage is a pair of power transistors, npn and pnp. The MJE15034 and MJE15035 were selected for this application because of their high current gain and ability to handle currents 4 to 8 times greater than this amplifier's output current. They have a steady bias voltage and are thermally stable with heat sinks attached, as well.

N – A pair of one ohm power resistors are placed between the power transistor emitters and the output. These prevent thermal runaway in the transistors and diodes; without them temperature in these components would increase unchecked and render the circuit useless. Since normal ${}^{1}/_{4}$ watt resistors would be destroyed by the high current, 5 W power resistors are used here.

O – This 8 ohm power resistor represents the speaker connected to the amplifier output; many speakers used with this circuit have an input impedance of 8 ohms. This means that peak power dissipation will be around 2 watts at 0.5 A output current.