1.5 Volt Headphone Amplifier

This circuit stabilizes the quiescent voltage across the speaker at the exact level necessary to get the desired maximum available volume at minimum battery draw. This more than doubles the battery life compared to just connecting a simple resistor between the base and collector of the output transistor. This (class A) type of amplifier is the only kind of amplifier that you can use at such a low voltage with simple discreet components. A (class A) amplifier has a maximum efficiency of 50% which is not great for batteries. Stabilizing the quiescent current to the minimum necessary to do the job would be a big help. Also, to minimize the chance of damaging the earphone, the amount of DC pushed through it should be minimized.

I determined that 700mV P-P produced plenty of volume with the headphones I was using. I therefore set the quiescent voltage across the speakers to 370mV. I measured 12.5mA of battery draw and had plenty of volume. The sound quality was surprisingly good. I think it's worth the additional parts to more than double the battery life. It may also allow the use of a smaller battery, which could be a lot bigger deal than the added transistors.
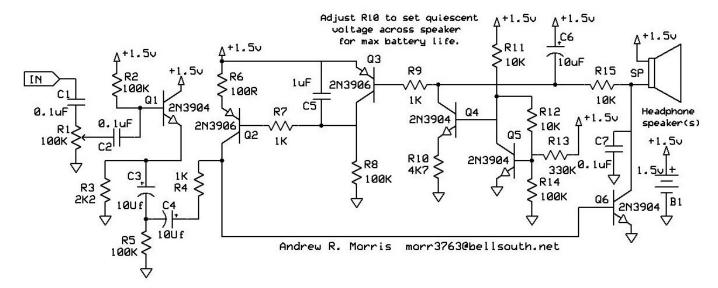
Adjust the value of R10 to set the desired quiescent voltage across the speaker(s). For maximum stability, Q3, Q4 and Q5 should be in very close temperature proximity with each other. The input impedance of the circuit is approximately equal to R4 (1K in this case) without the buffer circuit (Q1) and about 50K with the buffer circuit and volume control. If your circuit can drive the load impedance of the amplifier itself you can leave out the buffer circuit which is everything ahead of R4. In testing, I got unity gain with a 16 ohm load (both earphones) with a pot set at 3.1K as R4. With one earphone (32 ohms), unity gain was established with 7.8K as R4. The circuit was unaffected by battery voltage until it shut down at about 0.8 volts (32 ohm load) and about 0.85 volts at 16 ohm load. Batteries are considered by the industry to be depleted at 0.9 to 1.0 volts per cell. Note: You can increase the gain and/or input impedance, possibly eliminating the buffer circuit (Q1) by replacing Q6 with a BC337.

If you delete Q4 and Q5 and their related components, the circuit will hold 0.55 volts across the speaker(s). If you need a higher quiescent voltage, connect a resistor across C6. In the circuit shown here the gain was measured at about 3 with a 16 ohm load. The gain of the circuit is set by R4 and changes mainly with the beta of the transistor used as

Q6. Battery voltage (within limits) has little effect because Q1 is an emitter follower and the current through Q6 is stabilized.

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