# An Audio Feedback Amplifier for DC Receivers

Wes Hayward, w7zoi, 22April2021, 16june21(minor edit) ..

(Captions in blue.)

The first audio amplifier stage in a classic direct conversion (DC) receiver with a passive switching mixer is doubly important. First, it is the first gain stage in the receiver, so the stage noise impacts the overall receiver noise figure. Second, this amplifier serves as the termination for the mixer. As such, it should have a 50 ohm input impedance. A circuit that has become the standard audio preamp in these receivers is a common base amplifier biased for a DC emitter current of 0.5 mA. The input impedance of such an amplifier is 26/I(dc mA). This circuit, which first appeared in the amateur literature in the classic paper by W7EL (QST, August, 1980), is shown below.

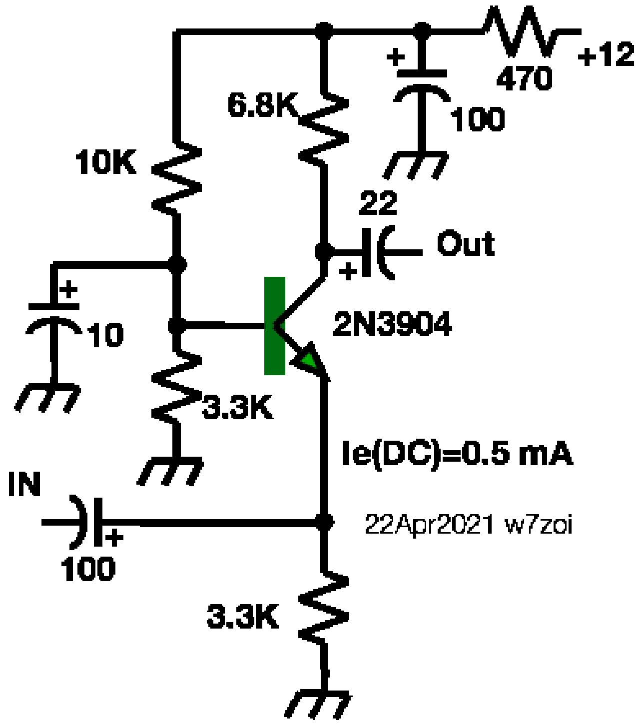


**Fig 1. Classic first stage audio amplifier for a direct conversion receiver with a diode ring mixer. This amplifier has an input impedance close to 50 ohms. A typical noise figure is 6 to 8 dB.**

The circuit of Fig 1 is adequate for most applications, it falls down when strong signals are encountered. We don't expect excessive dynamic range from a bipolar amplifier that has such a low DC emitter current. A suggested solution changes the bias to increase the DC current. This drops the input impedance. The impedance is then brought back to 50 ohms by inserting resistance in series with the input. But this resistor serves to trash the noise figure of the amplifier.

A very common small signal RF amplifier circuit is a feedback circuit. This begins as a common emitter amplifier, biased to a high current in order to minimize distortion that would otherwise compromise the dynamic range. Amplifier gain is then reduced with negative feedback in two forms. One is emitter degeneration, or *series feedback*, where a resistor is inserted in the emitter lead. The other, *parallel feedback*, results from a resistor from the collector to the base. Both feedback forms reduce overall stage gain. But series feedback will increase both input and output impedance while parallel feedback decreases these impedance values. The details for the design of such amplifiers is at http://w7zoi.net/fba_with_simple_model.pdf . One major deficiency with this circuit is that port terminations affect the impedance seen at an opposite port. That is, changing the load at the output will change the input impedance. Numerous examples of this feedback amplifier are found in Experimental Methods in RF Design, ARRL 2003. (Book coauthored with KK7B and W7PUA. Now out of print.)

Negative feedback can be applied to a common emitter **audio** amplifier. An example circuit is shown in Fig 2 below.

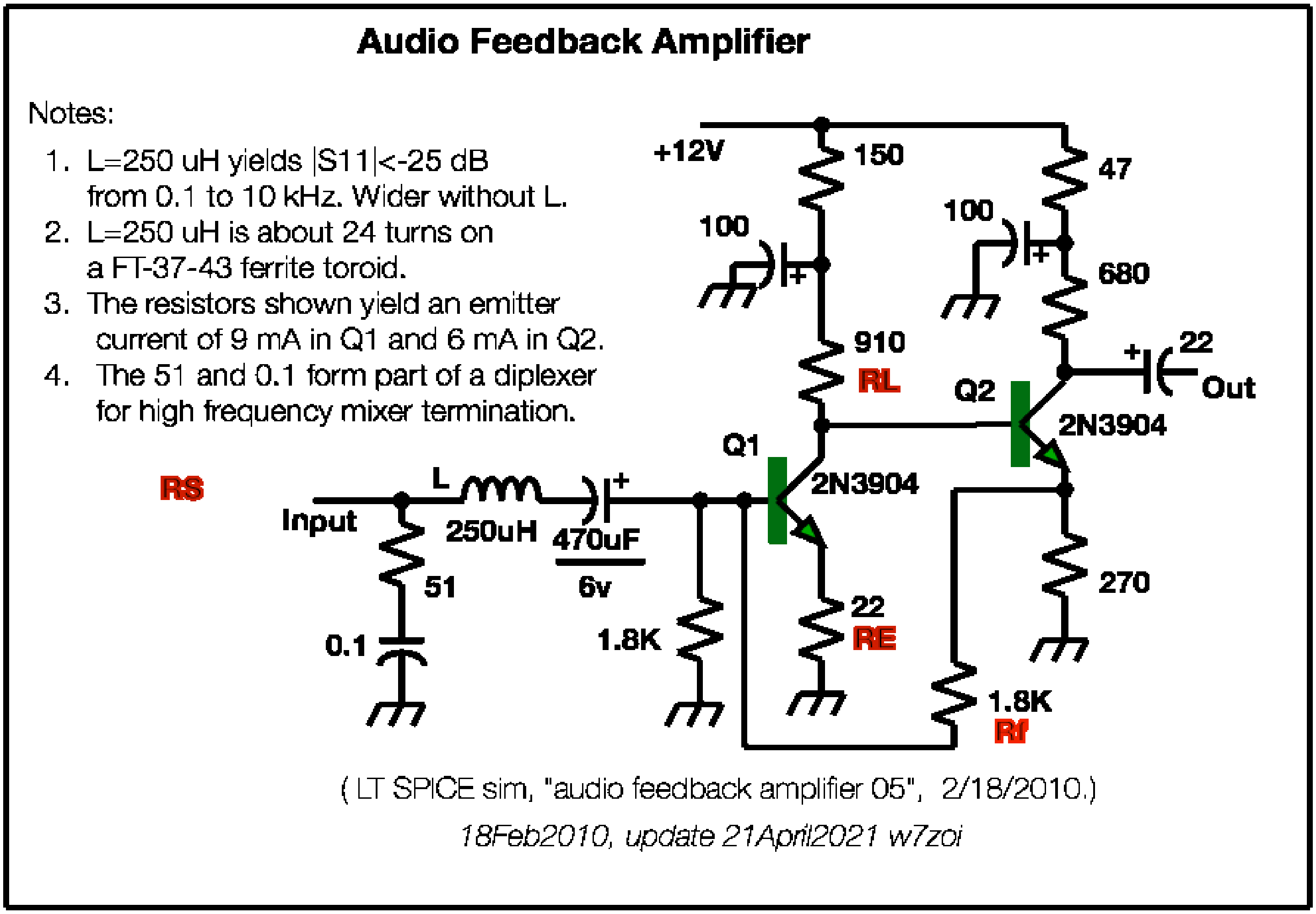


**Fig 2. This audio amplifier has a 50 ohm input impedance from less than 100 Hz up to about 10 kHz. The bandwidth is much wider if the input inductor is removed. The inductor is included, for it improves the 50 ohm input match in the communications audio range.**

This amplifier differs from the usual RF cousin, for it has two stages. Q1 is the main feedback amplifier. It has a voltage gain of 910/25 = 36. The load for this stage is the 910 ohm collector resistor, which does not change as the Q2 output changes. As such, this is a termination insensitive amplifier, a TIA. Q2 has a voltage gain of 680/270 = 2.5. Overall output is extracted from the collector of Q2. Q2 also serves as an emitter follower. The emitter voltage is in phase with the collector voltage of Q1. Hence, the resistor from Q2 emitter to Q1 base is the parallel feedback element usually associated with these feedback amplifier circuits. A resistor from Q1 base to ground combines with the feedback resistor to set the Q1 bias current. In this example, the emitter currents for Q1 and Q2 are 9 and 6 mA, respectively.

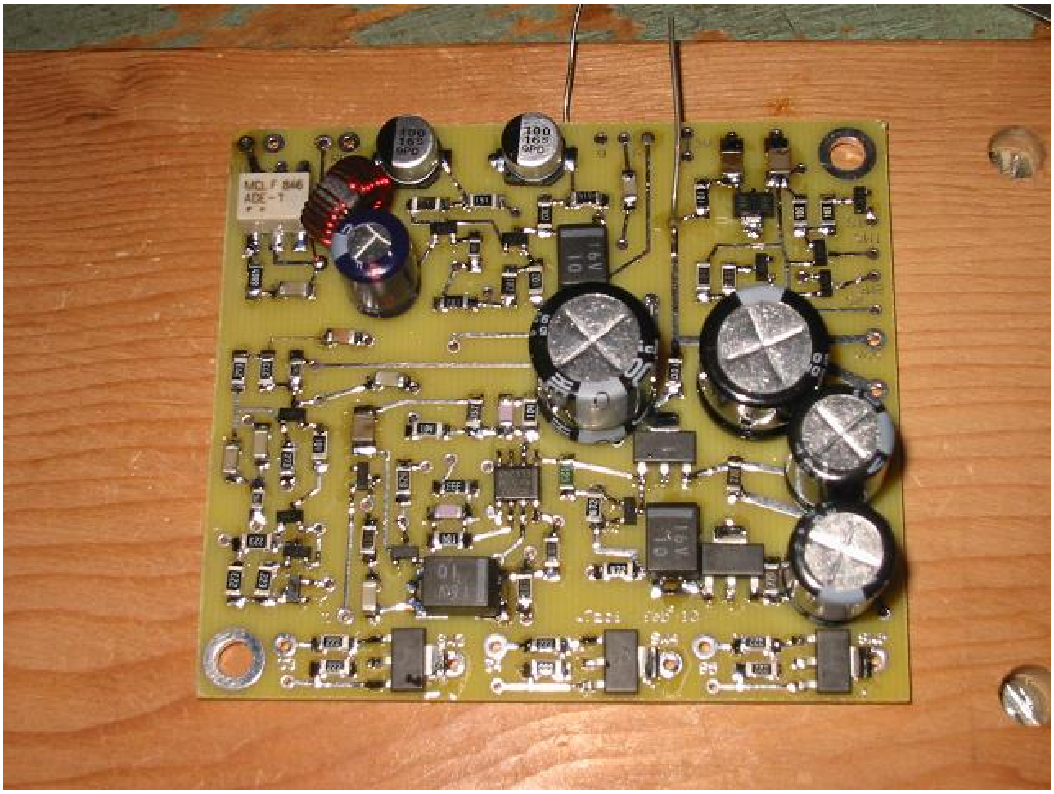

**Fig 3. This photo shows an audio amplifier chain for a receiver. A diode ring product detector is included on the board. The detector and the input amplifier are in the upper left corner of the board. Note the inductor. Some leaded electrolytic capacitors were available and were used in an otherwise all-SMT design.**

The amplifier in the photo of Fig 3 was turned on and measured. Gain was as expected. The product detector was bypassed and the input impedance was measured with a low level audio source and a low frequency return loss bridge. The critical noise figure and distortion performance have yet to be measured. While the example design is for an audio amplifier with 9 mA Ie, there is nothing to preclude an amplifier of up to 50 mA, or even more, just as we do with post mixer amplifiers for RF. It would be very useful to study the large signal performance with both simulations and measurement with an eye toward optimization. The 910 ohm load may well be too high, which would allow Q1 to become voltage limited. The reader is urged to investigate these things in detail and not to merely file the circuit into his or her catalog of circuits. The SPICE schematic for this circuit is shown below.

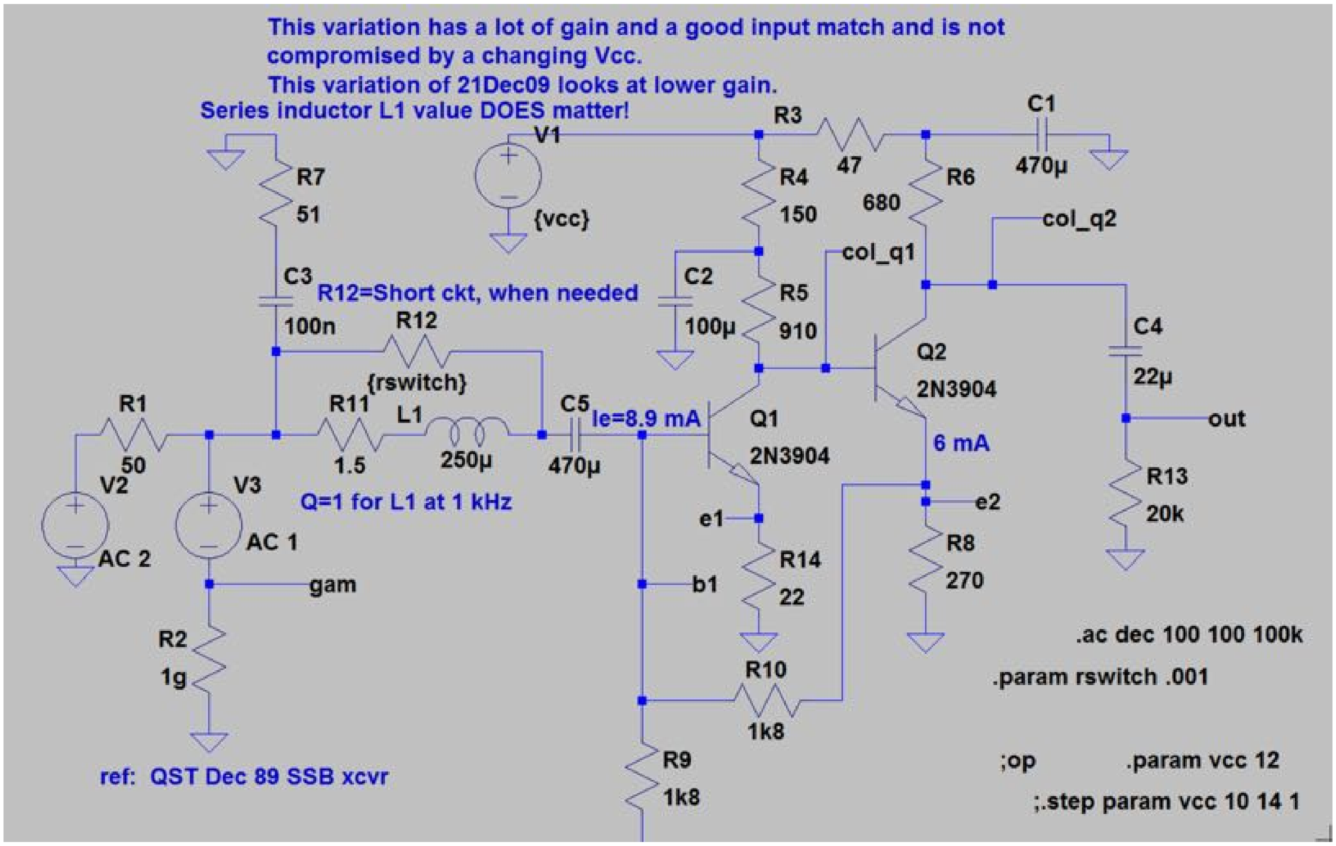


**Fig 4. This is the SPICE simulation schematic for this circuit.**