THE OSCILLATING AMPLIFIER

You say you built a simple little battery-powered audio amplifier, and instead of amplifying the darn thing just sits there and oscillates? You say you put a capacitor from +V to ground and it still oscillates? You say you don't know what to do next? Cheer up, you can fix it!

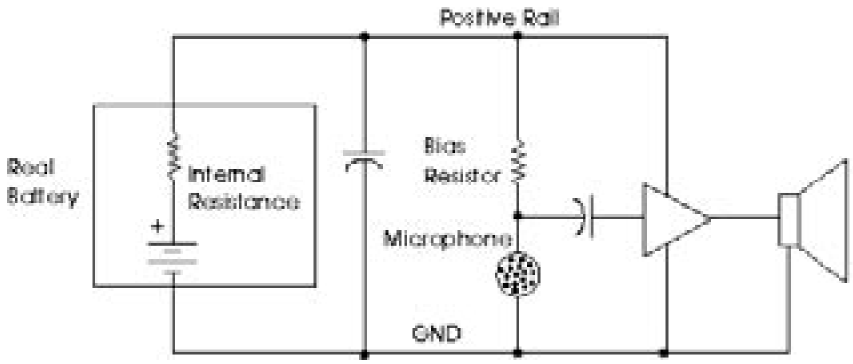

Figure 1

The problem is feedback from the amplifier's output back to it's input through the positive voltage rail. You say you knew that, and that's why you put a 10 uF cap across the 9 Volt battery? Well, let's look at it carefully. Suppose you're using one of those popular capacitor microphones. They need to be biased to +V to operate. Look at the circuit in ***Figure 1***. You see that the DC bias voltage on the microphone comes directly from +V via a resistor. So if there is any AC "ripple" on +V, it will show up at the input to the amplifier. Where would ripple come from you ask? Well I'll tell you.

Real batteries have some internal resistance, and as you use them that resistance gets bigger. Also, the wires used to build the circuit (or the copper traces on a circuit board) have a small amount of resistance. Amplifiers such as the LM386 can easily put out 500 mW of signal, which from a 9-volt battery means an AC current of over 50 mA due to the audio signal.

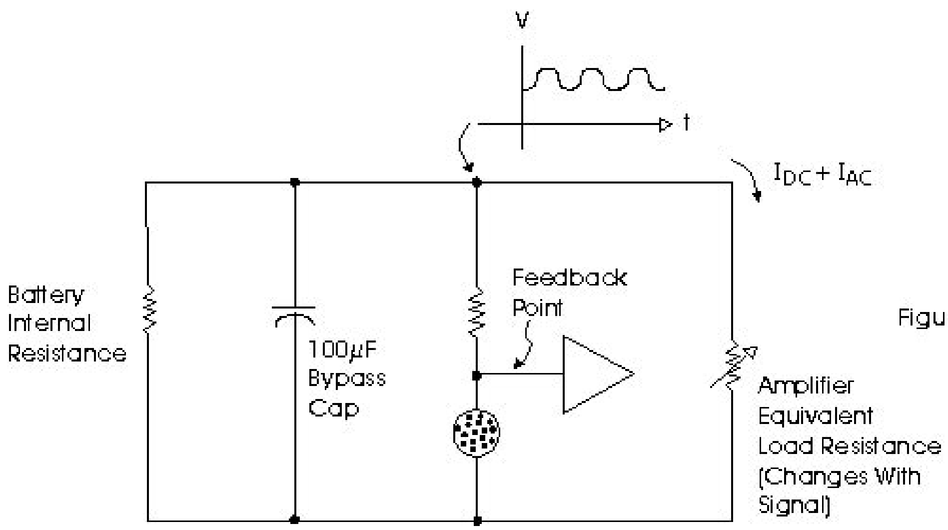

Figure 2

Look at ***Figure 2***. Suppose the internal resistance of the battery is 1 Ohm. Then 50 mA of AC current will cause 50 mV of AC ripple on the +9 rail. Likewise, suppose you have .05 Ohms of resistance in the wiring. Then you'll get 2.5 mV of ripple. While 2.5 mV may not sound like much, note that through the biasing it ends up at the input to the amplifier, where it causes more output on the load leading to more current being drawn and more ripple voltage getting back to the amplifier input. In other words, you've got feedback!

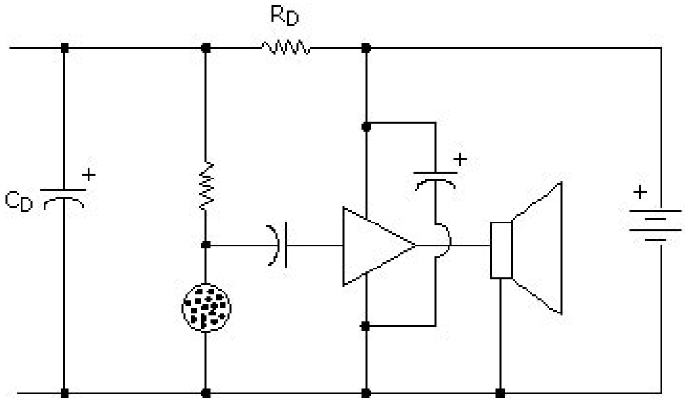

Figure 3

What about the cap across the battery you ask? At 60 Hertz, the impedance of a 100 uF cap is about 27 Ohms, which is considerably bigger than the resistances we've been talking about. A capacitor alone may not be enough. What you need is decoupling. ***Figure 3*** shows a typical decoupling circuit. First off, you want to connect the battery (or other voltage source) directly to the amplifier with a capacitor right across the amplifier's power pins. Then you want to build an RC low-pass filter into the +V rail for the rest of the circuitry (RD and CD). You want to make the break-frequency (1 / 2piRC) at least 10 times lower than the feedback frequency that is occurring. Be careful that you don't make RD too big, or the DC drop across it will be too much.

For example, if the problem is 60 Hz, then with RD = 1000 Ohms C should be at least 27 uF, with values like 47 uF or 100 uF being better. Use the formula:

```
             1
C  =  ---------------    where f is the troublesome frequency.
      2p x (10f) x R
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Another approach is to use a zener diode. Zener diodes of 5.1 V or higher are actually avalanche diodes, which have a very low resistance when they are conducting at their break-down voltage. Look at ***Figure 4***. Basically, we power the amplifier from the battery, but power the rest of the circuit from a separate power rail. See ***Figure 4***.

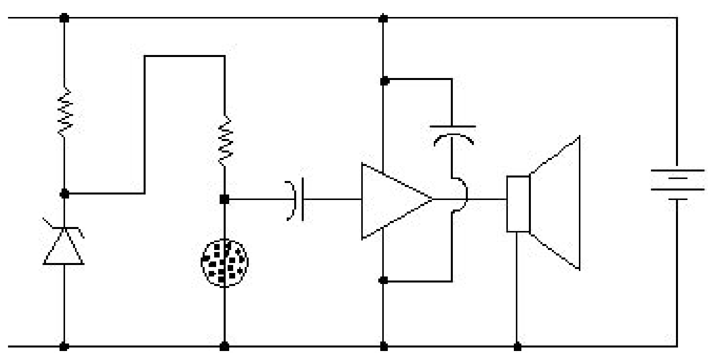

Figure 4

In summary, accidental feedback through the power supply is one of those things designers must be aware of, otherwise it sneaks up and bites you.