

Rarely Asked Questions

Strange stories from the call logs of Analog Devices

Glass Diodes May See the Light — and Hum

Q. A few months ago you discussed how to prevent the inherent high frequency (HF) noise of a switching supply from escaping into sensitive analog circuits and corrupting them. My op-amp output hums and no amount of supply filtering helps. What should I do?

A. Small children who've recently discovered riddles will tell you that bees hum because they don't know the words. Op-amps usually hum for other reasons.

The classical reason for an electronic circuit to hum was line frequency (or, more usually, double line frequency) ripple on the dc supply. This is addressed by enlarging the supply decoupling capacitors or, better, by using an electronic voltage stabilization circuit—which has the side-effect of attenuating low frequency (LF) ripple. Modern switching supplies, as we have seen, generate large amounts of HF noise, which must be imprisoned at the supply and not allowed to escape. They rarely have LF noise problems, so your supply is probably not the cause. Measure its LF noise with an oscilloscope or spectrum analyzer to confirm this.

Another cause of hum is line frequency currents in the signal line or ground (the dreaded "earth loop") due to line currents or voltages being too close to signal circuitry. Again, possible cures were discussed in the earlier "Imprison Noise" RAQ and work well at LF as well as HF. If you have successfully implemented HF noise reduction, you have probably addressed most causes of power supply related LF noise as well. Test this by operating your circuit from batteries (with



simple linear IC regulators to stabilize voltages if necessary), putting a resistive load on your switching supply to simulate the op-amp's consumption. Check noise with the switching supply on and off.

If you still have hum you must look for the mechanism by which it is entering the op-amp. A surprisingly common way is by photo-current from input protection diodes. Glass packaged silicon diodes behave as photocells. If they are illuminated with modulated light, their leakage current is modulated by the light; and, if the modulation is 120 Hz (100 Hz in some countries) from line-operated fluorescent lights, the circuit incorporating them will hum. The effect is not characterized by diode manufacturers and may vary widely from one "identical" device to another. Fix the problem by using plastic diodes rather than glass ones.

¹ Another reason to hum is implicit in the story of the man who went into a bar and noticed a pianist playing requests with a small monkey collecting his tips in a fez. While he listened the monkey drank his beer. He tapped the pianist's shoulder "Do you know your monkey drank my beer?" "No," replied the pianist, "but hum it - I expect I can fake it."
² Please see the Lock Down That Noise - Don't Let It Escape RAQ at <http://www.analog.com/raq/noise>.

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Have a question involving a perplexing or unusual analog problem? Submit your question to:
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