GLED431: An Ultra Low Noise Led Reference Cell

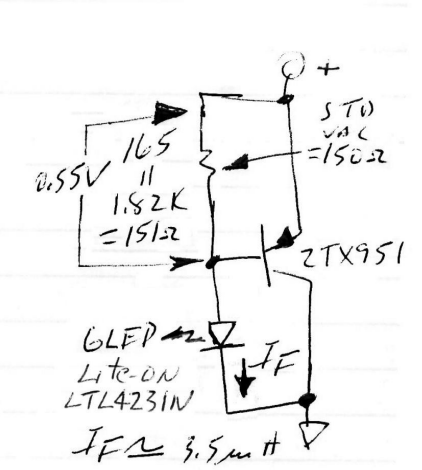
REFERENCES AND REGULATORS, WHATS NEW

GLED431: AN ULTRA LOW NOISE LED REFERENCE CELL

DECEMBER 18, 2015 | WALT JUNG 1 COMMENT

Looking for a low noise reference circuit for an audio regulator, at 2.5V? But you've found bandgap circuits too noisy? Read on!

Consider the simple circuit to the right, which I call the GLED431. Just 3 low cost parts, all easy to get It acts like an extremely low noise 2.5V zener. On my setup, noise measures around 2nV/√Hz, so if you take out the measuring system noise, the actual noise is likely below 1nV/√Hz. Really quite good. We'll have more on this later on, in 2016.



This GLED431 circuit is very simple, and works as a 2.5V shunt reference with ultra low noise.

While the GLED431 performance is very high for noise, you will need to apply about 5mA (or more) to make it work. Yes indeed, this current threshold is much higher than that of the TL431. But, it also has around 1/100 the noise! ***Caveat(1): The voltage won't be as tight as typical bandgap ICs, nor as low for temperature drift. Those are conscious tradeoffs.***

Here are some Vout measurements on a sample set of 5 LTL-4231Ns, in the lab prototype shown, after 1 minute warmup:

#1: 2.5094V, #2: 2.5093V, #3: 2.5069V, #4: 2.5019V, #5: 2.5062V

Not too shabby! In the schematic, the leftmost R values are just as shown from lab tests, as trimmed for the 2.500V target Vout. Obviously, just use a single 150Ω RN60D unit for this R. Note that the forward voltage of the LTL-4231N green LED (LiteOn) and the Vbe of the ZTX951 (Diodes Inc.) conveniently add, producing the desired Vout of 2.5V. ***Caveat(2): These two parts should not be changed if you expect to get close to 2.500V!***

In use, if you are building say, a 5V regulator, select a series resistor so that 5mA is supplied to the GLED431 cell (499Ω). With this, also be sure to select a very low noise op amp, and reduce all the surrounding resistances, so as to minimize *their* noise contributions. Finally, be careful to minimize capacitive loading.

I am now releasing this simple version, as a Christmas present to the readers. Stay tuned for more, have fun with the GLED431, and have a great holiday!

Walt Jung

December 24, 2015

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ONE THOUGHT ON "GLED431: AN ULTRA LOW NOISE LED REFERENCE CELL"

★ Walt Jung
JANUARY 18, 2016 AT 11:17 AM

From the DIYaudio thread by Jack Walton.

Quote: "Is there any particular reason to use ZTX951? How about BC560 low noise PNP?"

Response: Caveat 2 is the answer re the ZTX951 for the target Vout, plus the fact that it also offers lowest noise. This isn't just theory, *it was* tested.

Comments about dynamic Z aren't relevant to the cited application, with the GLED431 cell operated within a regulator with the cell biased from the output (i.e., the example 5V reg below, with an R2 = 499 ohm from 5V). This demonstrates the principle, as resistors R2/R3/R4 and Vref set the current *in* R2, and thus the cell bias of 5mA.

Caveat3: It certainly works in principle, as do dozens of other *such* hookups I've used over many years. But, no detailed testing was done with the specified (low noise) op amp... just with SPICE, where it worked like a champ. Watch the power and loading on whatever op amp is used, as well as the maximum input voltage (V1), plus the device common mode voltage ratings. And, have fun with it!

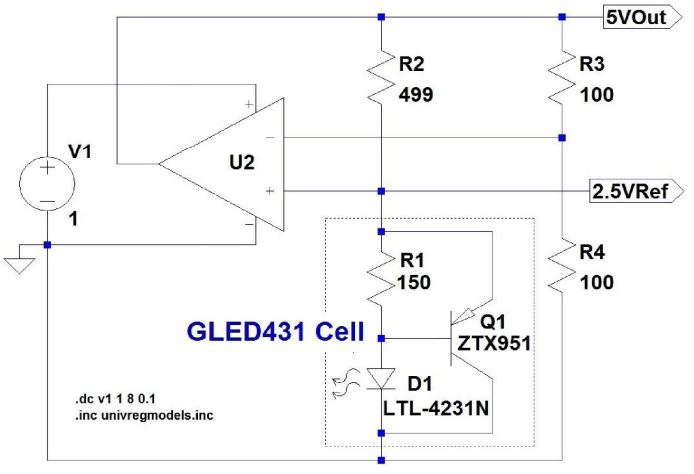
Walt Jung

January 20, 2016

***Addendum of March 8, 2016**:*

*The circuit originally shown with a LT6200 op amp was/is intended as a conceptual **example of** low noise reference voltage scaling, not a complete working regulator!*

The LT6200, like many low noise op amp devices, also has a very high bandwidth. From that it follows that it can readily oscillate. There are past caveats here and elsewhere about using very high BW parts within regulators (AD797, etc). Always proceed with caution, and make good use of a scope to monitor the output.



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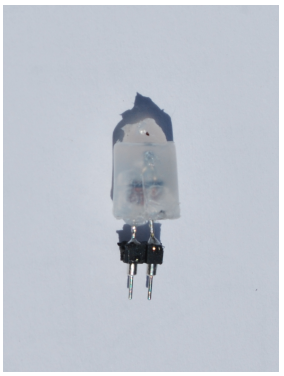
Addendum of December 26, 2016:

As noted, the GLED431 circuit is not one for high Vout temp stability. If that is critical, use a TL431 or other IC reference.

But, it is nevertheless also true that the best drift will be realized if the temp-sensitive parts D1/Q1 are buffered from room air currents. A cheap and simple way to do this is to place them back-to-back, and assemble the circuit on a two-pin header strip. Once soldered up and checked for function and correct Vout, then slide a length of plastic tubing over the completed circuit, as follows.



In doing this final step, first use squeeze some silicone compound within the tubing, before applying it over and around the GLED431circuit. This step surrounds and isolates D1/Q1 within the silicon, as well as holds the tubing in place, once the silicon has set up.

The sample photo to the left shows the general idea. The components of the GLED431 circuit can just be seen through the translucent tubing.

I have no doubt that this will greatly minimize the temperature bouncing of Vout.