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Building a Low-Cost White-Noise Generator

A design idea for a white-noise generator is realized and revised. Two low-noise amplifiers (LNAs) in cascade amplify the noise produced by a reverse-biased Zener diode operating in junction-breakdown mode, producing white noise with a bandwidth of several hundred megahertz. The test results show that a fairly wideband white noise can be generated using several inexpensive components.

White noise, which is defined as noise with constant power spectrum, is useful for measuring and testing wide-band communication circuits. Commercially available white noise generators are usually very expensive. The design idea presented in this article is an inexpensive method that produces white noise up to several hundred MHz.

This white noise generator is based on the avalanche noise generated by a zener breakdown phenomenon. It is created when a PN junction is operated in the reverse breakdown mode. The avalanche noise is very similar to shot noise, but much more intense and has a flat frequency spectrum (white). The magnitude of the noise is difficult to predict due to its dependence on the materials.

Basically the circuit has 2 portions: a zener diode, and MAX2611 Low Noise Amplifiers (LNA). The diode is reverse-biased and noise output is taken from the anode. The MAX2611 is a wide-band Low-Noise-Amplifier with 19dB gain operating from DC to 1GHz.

Summary of Test Results

The white noise generator circuit is realized with 2 boards, one for the MAX1916 and the zener diode, one for the MAX2611 LNA. The output trace from the anode of the zener to the input of the LNA is designed to be 50Ω. The output of the LNA is measured by a Rhode & Schwarz Spectrum Analyzer. For practical purpose, noise power of –60dBm or above is desired within the frequency band of interest.

After several experiments, I obtained the following results:

1. The noise output power is mostly decided by the diode's breakdown voltage. I have used zener diodes with breakdown voltage of 4V(1N749), 5.1V(1N751), 5.6V(1N752), 7.5V(1N755), and up to 12V(1N759). 12V zener generated noise power is at least 15~20dB higher than that generated by 5V zener.
2. Even with 12V zener, 20dB gain from the LNA is not enough to produce noise power higher than -60dBm. We need at least two LNAs in cascade (38~40dB gain).
3. The output noise power is almost independent of the source current. With the potentiometer, the current into the diode can vary from 0mA to 100mA. Within this source current range, the noise power varies pretty randomly within ±1dB. It seems in zener diode breakdown phenomena, the avalanche noise dominates over other noise source, such as shot noise (which is proportional to current), flicker noise and thermal noise.
4. The frequency / power spectrum of the output noise is not perfectly flat over a wide frequency range. As shown in test result Figure 3, from 1MHz to 100MHz, noise power drops almost 10dB. This could be because of higher on-board attenuation for higher frequency components.
5. 2 LNAs were used in cascade for the white noise generator, which produced 38~40dB gain.

The circuit is shown in **Figure 1**, and the test result is shown in **Figure 2**. In **Figure 2**, the bottom curve is the instrument noise floor (measured when everything is OFF). The second curve from bottom is the noise output from the LNA when the diode is OFF. The top 2 curves are noise output spectrum at 10mA and 60mA diode current respectively.

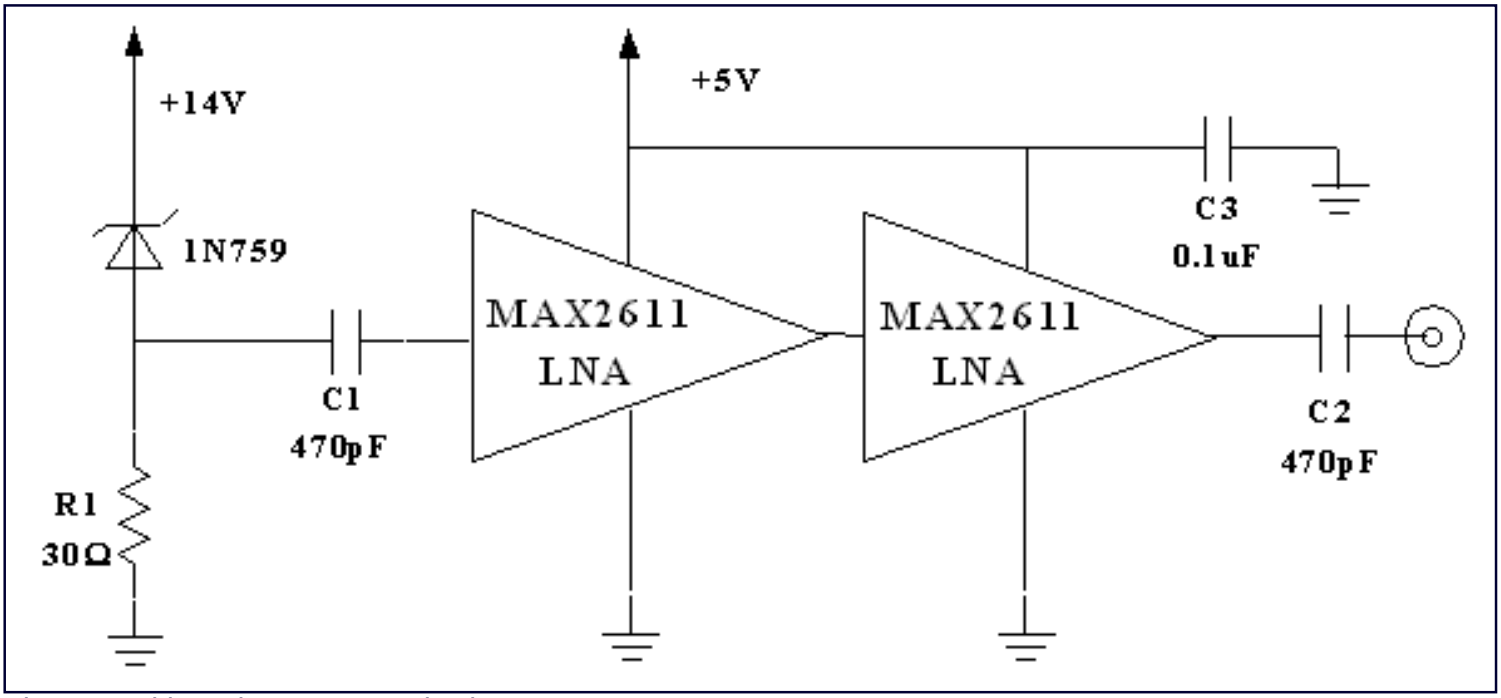

Figure 1. White-noise generator circuit

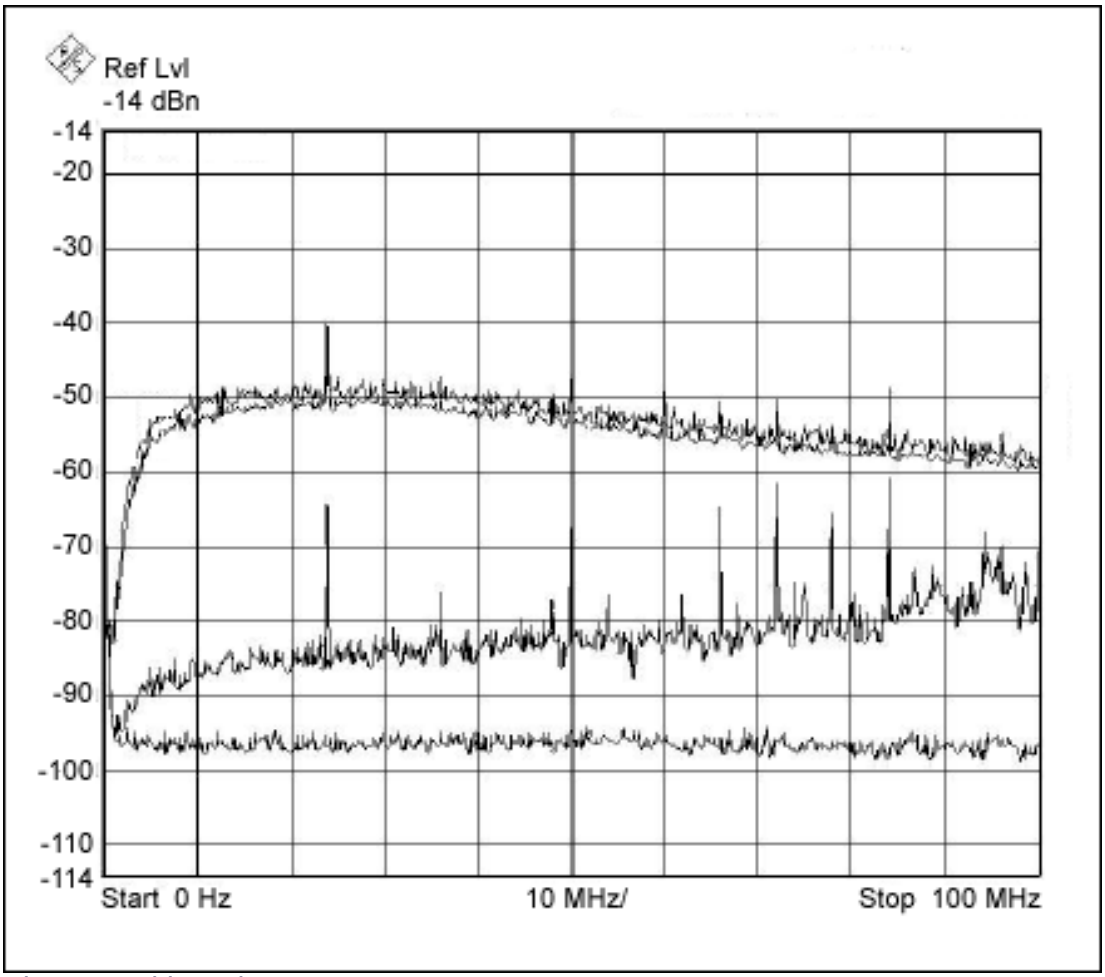

Figure 2. White-noise generator output spectrum

Conclusion

In this article, a design idea of a White Noise generator is realized The test result shows a pretty wide-band white noise generated with several inexpensive components.

A similar version of this article appeared in the September-October 2004 issue of *Electronica* magazine.

More Information

MAX2611: QuickView -- Full (PDF) Data Sheet -- Free Samples