Audible Field Strength Monitoring Enables Remote Measurements

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I find it useful to build and use test equipment that presents measurement data to the user as a variable audible pitch (frequency) in place of, or in addition to, a visual display. Analog meters and digital displays that present data for visual observation require the dedicated use of two valuable resources: your vision and your attention. I offer an alternative method that lets you divert your vision and much of your attention to another task, such as holding test probes in place and adjusting a critical circuit parameter, while letting you hear the result. The human ear easily differentiates very small frequency changes, allowing very high analog resolution and thus high sensitivity to small changes.

One recent example uses an ATtiny85 CPU as an accessory added to a digital multimeter to enable precision analog resolution [i,ii] from the digital instrument. Earlier, voltage-to-frequency converters such as the LM331 were the basis for such applications.

The instrument described here is an RF field strength meter with the output as an audible pitch based on the LM331 voltage-to-frequency converter. I meant this to be an instrument for the amateur radio community to make remote measurements of relative field strength. I thought it would prove useful to monitor radiated signal level at some distance from a transmitting source for antenna comparisons or other far field measurements. The output is in the 300–3000 Hz audio range for transmission back to the listener. I built versions with an AD8307 logarithmic detector that works up to 500 MHz and with an AD8313 that works up to 2.5 GHz. I also suggest a version based on the AD5513 from a previous article[iii] that would work up to 4 GHz. **Figure 1** shows the circuit built into a pair of Altoids tins with the circuitry in one compartment and the power source in the other. This version used 4xAAA cells and a low dropout 5 volt regulator, but the version with 3xAAA cells and no regulator in the schematic below is simpler and works fine.

Figure 1 Circuitry and batteries built into a pair of Altoids tins

I walked around my workplace with the AD8307 prototype and listened to different sources of RF. When I heard the data exchange as an RF reader interrogated my employee badge, I got the idea that this could become a cell phone and Wi-Fi detector. That might prove useful to sense such devices. I built up another prototype using an AD8313 logarithmic detector with 2500 MHz response to sense cell phones and Wi-Fi. With it I could tell which laptop had its wireless enabled when I walked up and down the aisle on a commercial airline flight with headphones connecting to the unit in my pocket. Because airlines want RF emitters turned off, and because I worked for an airplane company that offers incentives for intellectual property, I patented this method. See the details in patent 7,898,395 online. Boeing owns the patent, but hobbyists can use the concept to build their own.

In the shack, you read the meter of an ordinary instrument, but remote operation requires a way to return measurement data to the user while making adjustments that affect the remote reading. Conversion of the field strength reading to a varying audible pitch allows return of the measurement data via an audio modulated radio link or a telephone line (I started using this technique in the late 1980s to monitor the photocurrent of a remote optical receiver in a laser communications link with the microphone end of a telephone handset in a modem speaker cup!).

How it works

Figure 2 shows a block diagram of the audible field strength monitoring instrument.

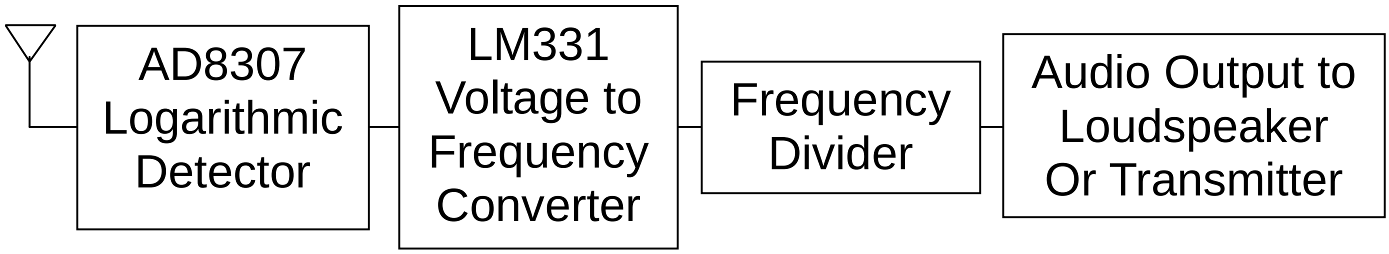

Figure 2 Functional Block Diagram of RF Field Strength Meter with Audible Output

The Analog Devices AD8307 accepts a 90 dB input dynamic range of RF signals in the audio to 500 MHz range and compresses it into a monotonic DC voltage output range with about a 2 Volt excursion. I selected parameters to match the output voltage range to obtain the desired 300 to 3000 Hz audio frequency range from the voltage-to-frequency converter that matches the audio band-pass of both the telephone system and amateur radio FM transceivers.

Voltage-to-frequency converters output narrow pulses with low audible energy. I set the frequency twice as high and divide the output by two with a toggle flip-flop to yield a rectangular wave with high audible energy. A type D flip-flop with the not Q output connected to the D input forms a toggle flip-flop. Two flip-flops in parallel offer twice the drive current to the built in speaker. **Figure 3** shows a semi-pictorial schematic of the 500 MHz instrument as a bottom view wiring guide. Adding a 1 μF capacitor from OFS pin 3 to ground enables the AD8307 logarithmic detector to work down to low audio frequencies as well.

Figure 3 500 MHz version of Audible Field Strength Meter using AD8307

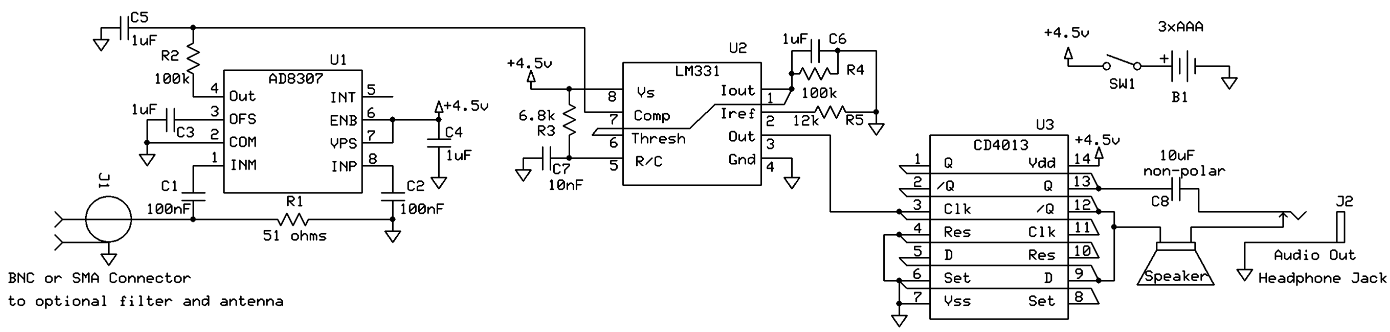

Figure 4 illustrates example circuit waveforms at the wide dynamic range RF logarithmic detector input, the output of the logarithmic detector to the voltage-to-frequency converter, the output pulses from the voltage-to-frequency converter, and the output of the toggle flip-flop frequency divider. The logarithmic RF detector accommodates an immense dynamic range, making this instrument much more useful than one based on a simple diode detector.

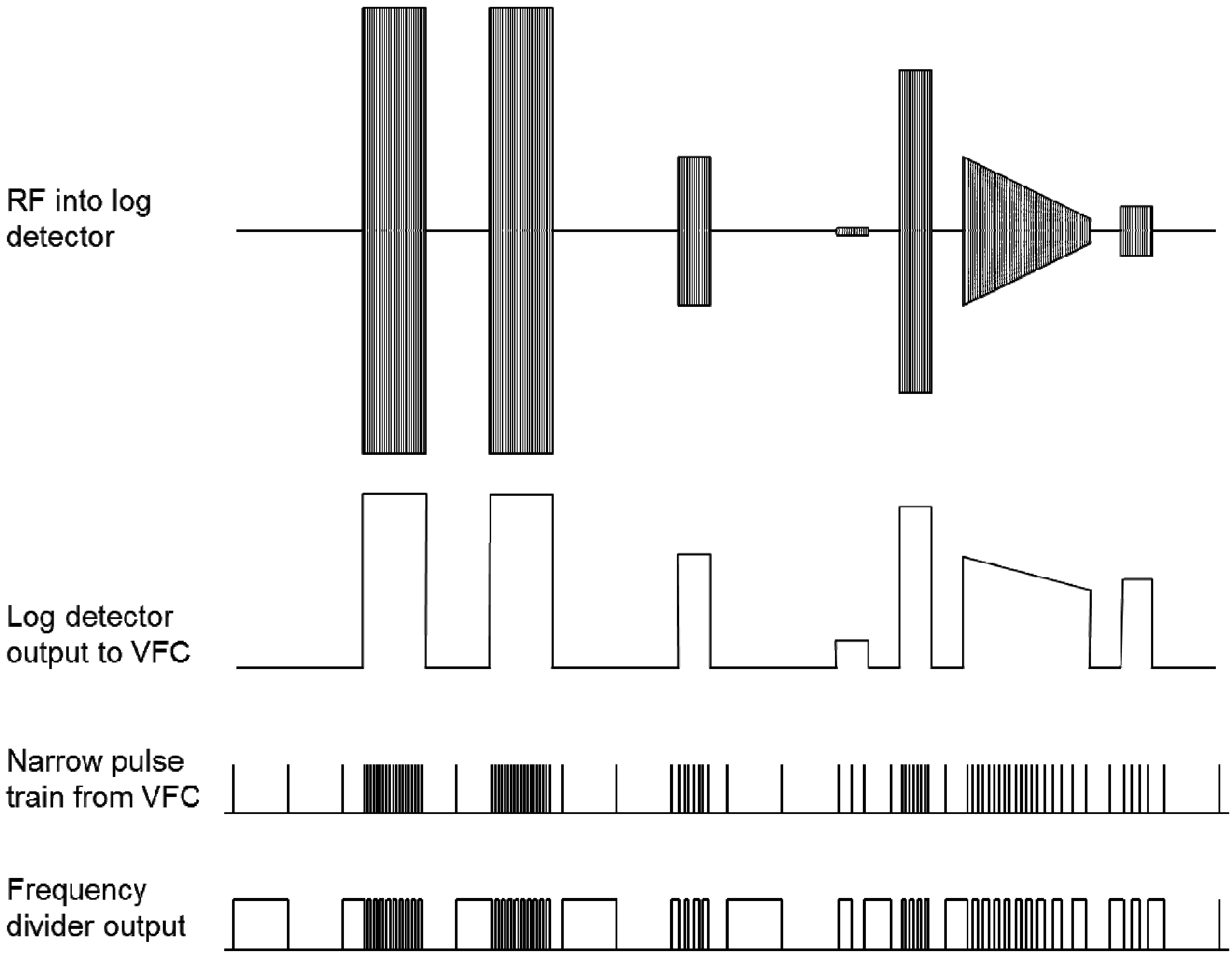

Figure 4 Example Circuit Waveforms

Microwave Versions

Figure 5 shows the front-end for the 2.5 GHz version using the AD8313 logarithmic detector.

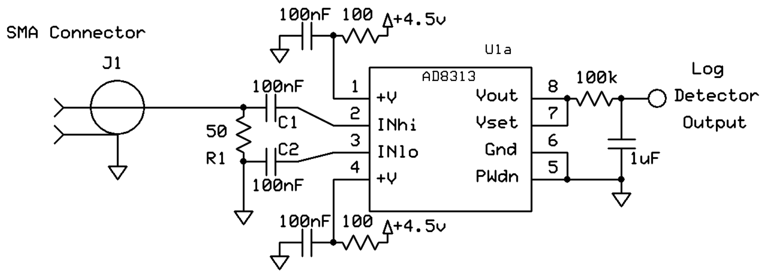

Figure 5 Front-end for Audible Field Strength Meter using 2.5 GHz AD8313

Figure 6 shows the front-end for the 4 GHz version using the ADL5513 logarithmic detector.

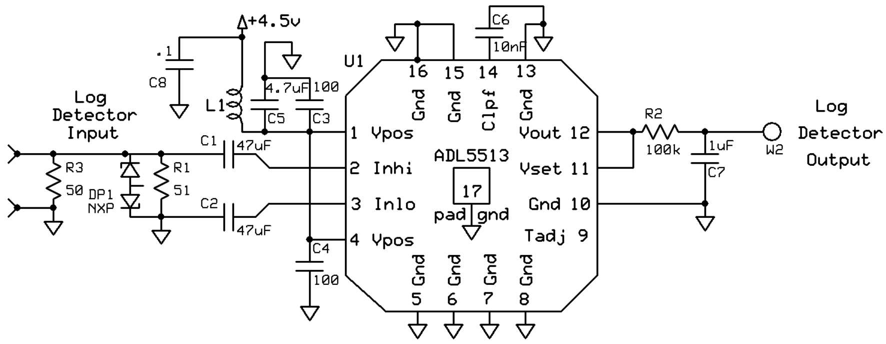

Figure 6 Front-end for Audible Field Strength Meter using 4 GHz ADL5513

The microwave versions hear the digital transactions of my Wi-Fi router. These units prove very useful when you want to hear whether an RF source is operating. I use them in my work frequently and think you will find them useful.

Dr. Sam Green, WØPCE, is a retired aerospace engineer living in Saint Louis, Missouri. He holds undergraduate and graduate degrees in Electronic Engineering from Northwestern University and the University of Illinois at Urbana respectively. Sam specialized in free space optical and fiber optical data communications and photonics. Sam is currently designing and prototyping innovative targets for guns with laser bullets. Sam became KN9KEQ and K9KEQ in 1957, while a high school freshman in Skokie, Illinois, where he was a Skokie Six Meter Indian. Sam held a Technician class license for 36 years before finally upgrading to Amateur Extra class in 1993. He is a member of ARRL, a member of the Boeing Employees Amateur Radio Society (BEARS), a member of the Saint Louis QRP Society (SLQS), and a member of the Bi-State Amateur Radio Society. Sam is a Registered Professional Engineer in Missouri and a Life Senior Member of IEEE. Sam is named as inventor on eighteen patents.

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[i] Add Audible Analog Resolution to Your Digital Multimeter, Sam Green WØPCE, CQ Dec, pp. 18-22
[ii] Fun with Voltage-to-Frequency Converters, Sam Green WØPCE, QEX March/April 2013 pp. 7-10
[iii] Microwave Version of Wideband QRP SWR Meter, Sam Green WØPCE, QEX January/February 2018 pp. 16-18