Possible Path Forward on Calibration for Radio Jove

Un-calibrated Observations

Calibration of power level expressed as antenna temperature are useful for characterizing the background noise levels for observers, but is not necessary for casual observations of Jupiter and the Sun. Calibrators were not part of the original Jove toolkit for participants and need not be required now for more casual observers who just want to share there observations with others. The lack of a calibrator should not discourage anyone from participating in Radio Jove.

Calibrators for those who want them

Moving forward, we of course no longer have the RF Associates calibrators, however, as has been often noted, SDRuno and the SDRPlay receivers appear to produce quite accurate power readings. If our goal for scientific observations is to have calibrations accurate to within 1 dBm, these tools should suffice as measurement devices for as long as they are available. I propose that we encourage users who own a SDRPlay and want calibrated observations to purchase or build their own noise generating circuits and calibrate them with SDRuno and some additional software that we will provide for free. The major components of a project like this are discussed below.

Commercial rf noise generating circuits are available from prices ranging from about $20 to thousands. We are interested in the low end of that range, of course. A typical inexpensive circuit board is shown below. Some of these boards can generate noise powers of nearly zero dBm (or 1 milliwatt into a 50 ohm load). This is far too strong a signal to be useful for our purposes and must be attenuated. This can be accomplished by simply adding barrel type attenuators (about $12 each) to their outputs. Experimentation has shown that at least for this particular board, the output can be reduced by lowering the supply voltage from 12 to 5 VDC to obtain an output in the range of -70 dBm to -80 dBm.

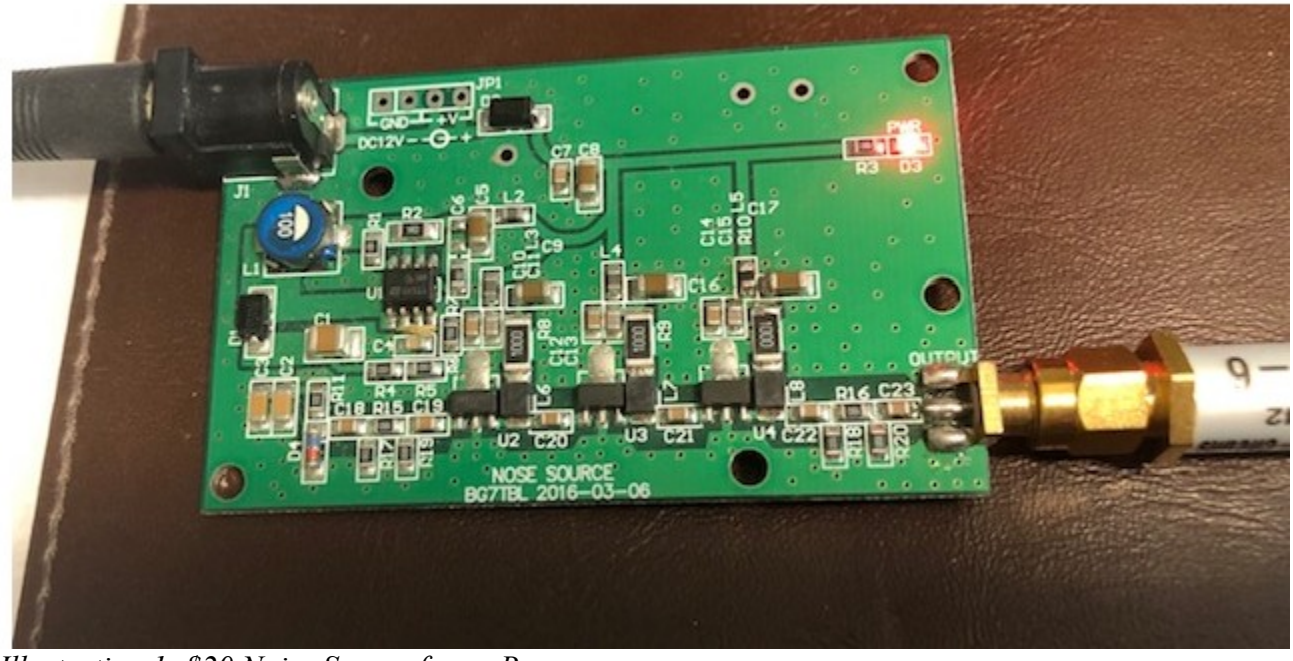


Illustration 1: $20 Noise Source from eBay.

Single Frequency Calibrators

Those who wish to make calibrated observations with a Jove kit receiver or a different analog receiver, may easily create (build a circuit out of parts) or purchase a commercial noise source and use it with the appropriate amount of attenuation. If they own an SDRPlay receiver, they may it to calibrate or characterize the noise source.

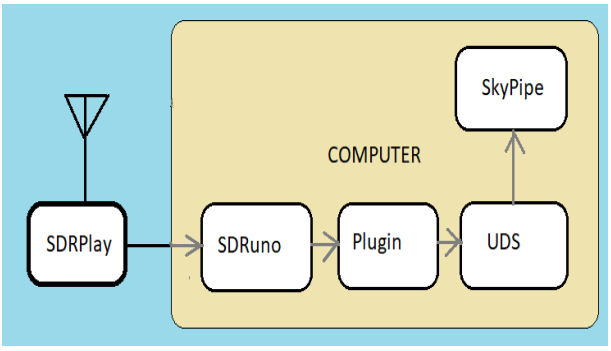
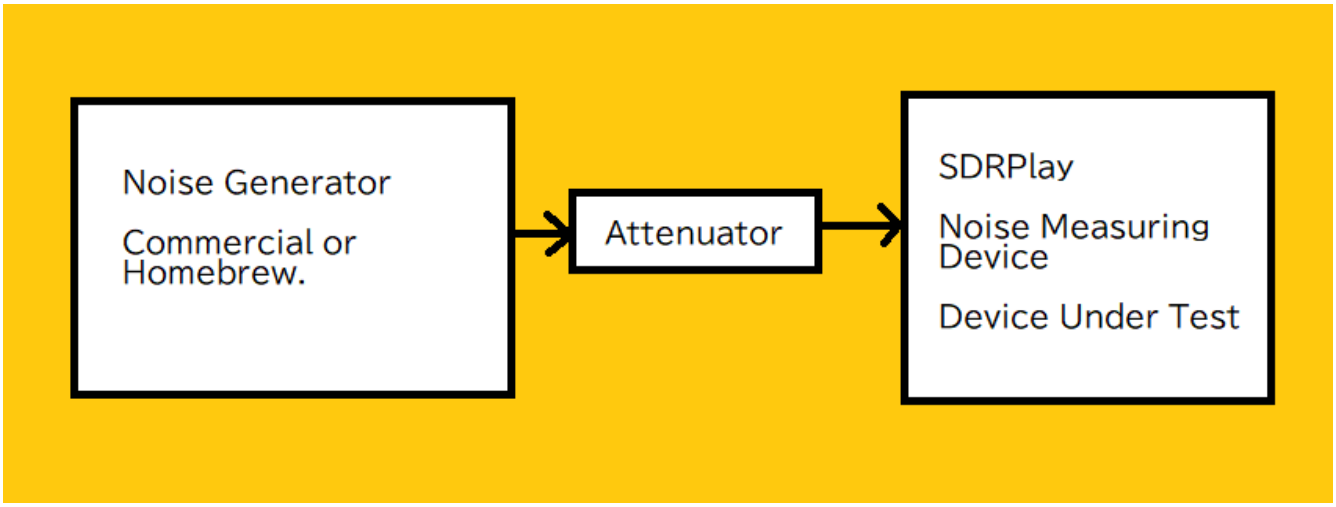


Illustration 2: Creating single frequency calibrated strip charts with SDRuno.

User's with SDRPlay receivers have the ability to create single frequency strip charts from the accurate power readings produced in the SDRuno program and the appropriate plugin. The details of this configuration can be seen in the document HowToConnectRSP-SDRuno2.pdf

One might ask why bother with a hardware calibrator if you have a SDRPlay receiver? The answer is that a calibrated noise source is a useful tool that allows you to compare the performance of different radios and pieces of test equipment. For our purposes, it is also a useful educational exercise, and the end result, a single step noise calibrator, while useful in its own right, can be the starting point for a multi-step calibrator that is useful over a wide range of frequencies and calibration levels.. The ultimate result will be a MKII compatible device that can be used seamlessly with RSS.



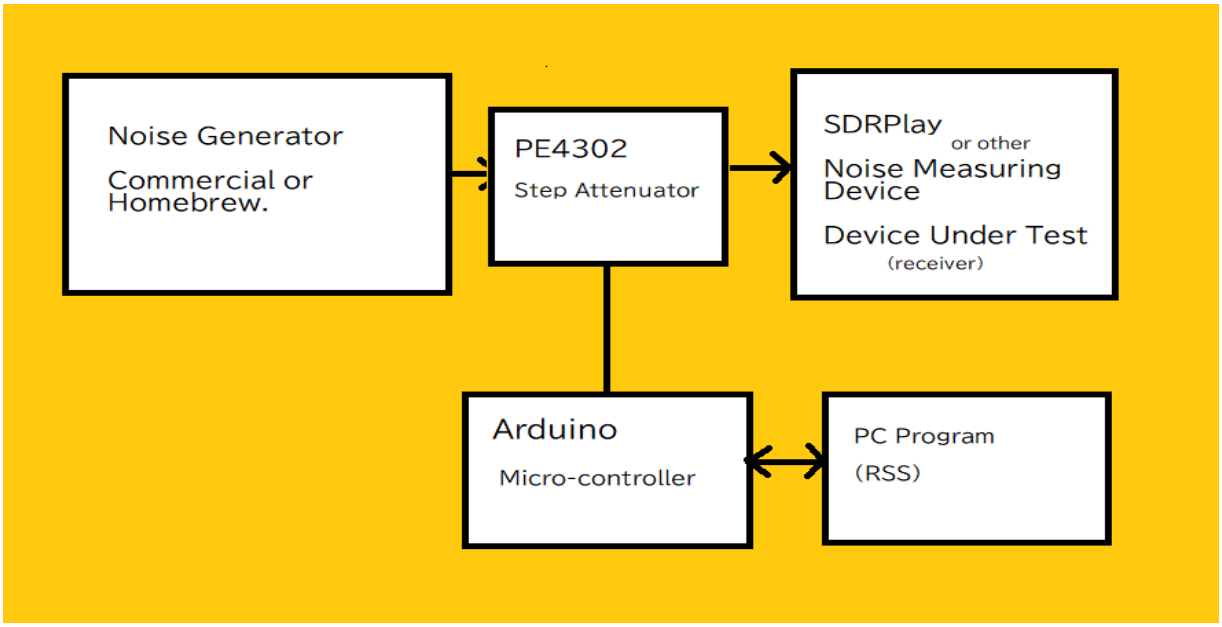
A radio frequency noise generator can is generally followed by a 50 ohm fixed attenuator that reduces the output to the desired level, provides the proper impedance to both the generator and it's target, and buffers them from each other electrically. The diagram above suggests that the target might be a SDRPlay receiver or other noise measuring device or a receiver or other DUT. Once characterized with the SDRPlay or other noise measuring device, the noise generator may be used with other receivers.

If a noise calibration source is only used in one narrow frequency range (a few kHz or tens of kHz as would be typical of a standard Jove receiver kit) then there is no great advantage to the output level be constant over a wide range of frequencies (many MHz). The noise calibrator can be characterized just

at the frequency of use. The generally good linearity of sound card ADC readings and the Jove receiver architecture has allowed us to use a single frequency noise source to calibrate strip chart observations over a wide range of input levels. It is less certain that a single frequency calibration will be useful for other receivers with less linear dynamic response than the Jove receiver.

The 2080CF calibrator from RF Associates used an output of about 25,000 degrees or around -94 dBm. A suitable single frequency noise source for this level can be made with just a few discrete components costing about $6 (not including a case and connectors and bypass switch). A simple design could be promoted as a useful beginner's project. People with SDRPlay's could measure these noise sources for people who do not have a way to measure it themselves. This might be a very attractive option for users who bought RJ receivers and do not have a calibrator.

Multi-step Calibrators



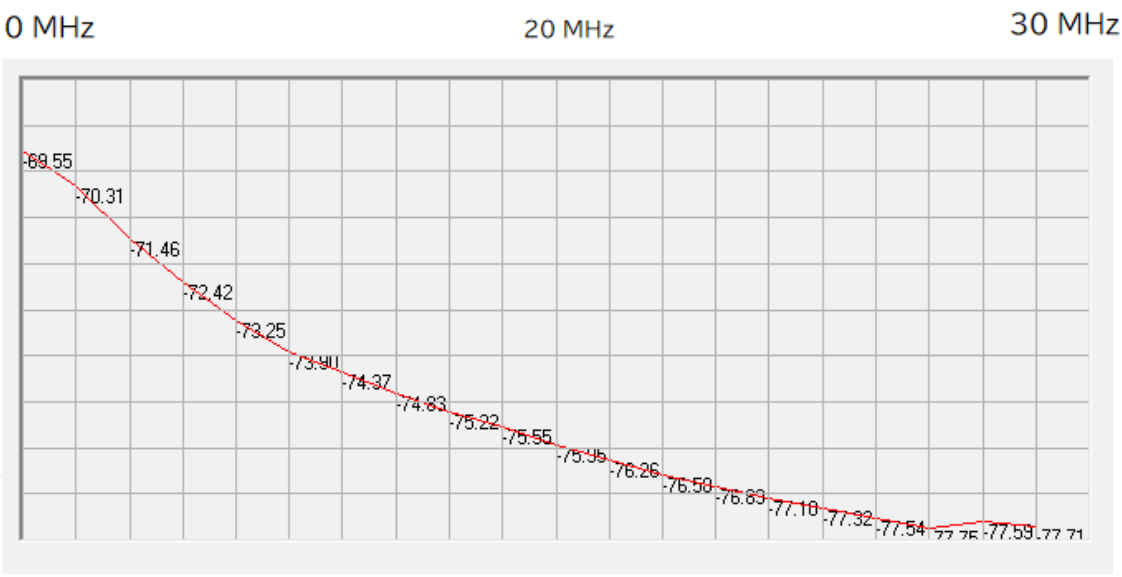
In this case a multi-step calibrator that provides a number of noise output levels is a better choice. A multi-step calibrator reveals non-linearities in the receivers response and allows for corrections to be made in the measurements that accounts for these. So even for single frequency analog receivers, the multi-step calibrator has advantages.

For SDR style receivers and spectrographic observations, multi-step calibration is essential. In a multi-step calibrator the noise source itself remains at a fixed high level and a step attenuator is used to provide the range of output levels. Step attenuators can be made from resistor pads introduced into the circuit by DPDT toggle switches or relays.

The PE4302 is an integrated circuit step attenuator that may be found commercially packed like the picture above for about $20. The device may be set to any level of attenuation from zero to 31.5 dB using TTL compatible control lines. The attenuator may be set by a small micro-controller over these control lines. In turn, the micro-controller can be attached to a PC over a USB-serial connection. If more than 31.5 dB of attenuation is desired these devices may be cascaded as they are in the current MKII calibrator design.

The only other major component needed is a micro-controller. The ubiquitous Arduino Uno or its little sister the Arduino Nano can easily perform the task for under $10. These devices are easy to obtain and can be programmed without an additional hardware programmer. The Arduino software development IDE is simple to use and commonly understood by maker hobbyists, engineering students, and others. The MKII also uses an Arduino and PE4302 attenuator (actually two of them) in it's design. The MKII is more complicated and has antenna relays and other circuits to facilitate dual polarization calibrations.

Characterizing the multi-step calibrator can again be done with a SDRPlay receiver, SDRuno software, the plugin and an additional program that I created to automatically step through a number of frequencies, and average a large number of noise readings at each frequency. Below is a graph created by the program showing a noise generator output measured over a range of 20 MHz.



Output of BG7TBL noise source, 12V supply, 35 dB Attenuation to SDRPlay1A (AM 6K BW)

Conclusion

I propose that I (we?) develop a single frequency calibrator project as well as one that approximates the functionality of the MKII and uses the SDRPlay1A as a measurement device to characterize/calibrate it. The project will be reproducible using off-the-shelf modules and standard connectors. There may be a small amount of soldering but I will try to find alternatives. I will discuss pitfalls of design and construction, software, and potential enhancements. Perhaps someone will decide to put them together and characterize them for others, or design a cheap circuit board that can be mass produced. More likely just a few people will build them and the technology will age out, but I would like it to be an open source, experimentation-encouraged project. The project could be hosted on the Jove website or wherever makes sense. My hope is that this idea can suffice to cover the "what are we going to do about calibrators?" question until something else evolves.

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