Test Results of Strange AGC Behavior with PowerSDR on HPSDR

By W6XX, February 5, 2011

I recently installed Power SDR, W5WC Version 1.19.3.2, Date: 12-31-10. The setup is an HPSDR 3-board combination of Ozzie, Mercury and Penelope. My computer uses an Intel Core 2 Duo, 2.4GHz, 2GB RAM. The firmware versions are Ozy 1.7, Mercury 2.9, Penelope 1.2.

In listening to on the air HF SSB signals I noticed some audio distortion and non ideal AGC behavior compared to listening to the same signals on an analog receiver. The AGC performance is better than with the previous Power-SDR version but on my system it still leaves a lot to be desired. In an effort to see what is happening I ran some test on the Mercury board with stepped level and analog variable level CW signals. I also did the same tests on a Flex1500 and an Elecraft K3.

The main conclusions are as follows. These apply to the latest PowerSDR versions for both HPSDR and the Flex 1500. The AGC slope option is not implemented properly. The Hang-Threshold control does not work properly. If the Hang-Threshold setting is anything greater than zero, for falling signals the hang and decay times are not invoked. At Hang-Threshold settings greater than zero the AGC provides no gain control on falling signals until the signal is interrupted or it reaches some very low level. It behaves as if an infinite hang-time were invoked. As there are interactions between these various setting there may be other undiscovered problems. The test methodology and results are described in detail below.

The test setup consists of a synthesized signal generator with HP 3555B (10dB) and HP 3555C (1dB) step attenuators for level stepping. I can also vary the level over about a 25dB range with the analog level control on the signal generator. On some tests I also used a push-button attenuator with 20 and 10 dB steps to introduce 20 dB step changes. The audio output was monitored on a Tektronix oscilloscope and a digital voltmeter. For comparison I also ran similar tests on a Flex 1500 and an Elecraft K3.

First I wanted to know if this was something unique to my system and this software version or if it might be due to errors or incorrect algorithms in the Power-SDR. I sent the test details to Joe-K5SO and he very kindly ran the same tests on his system. At first he could not duplicate my results. He then discovered the reason for the difference. For a signal source, Joe used his HP8642 signal generator using its internal attenuator to step the amplitude in 10 dB steps. That signal generator interrupts its output very briefly while the attenuator is switching. This short interruption was enough to allow the AGC to reset on each step and yield different results. He switched to an external attenuator that did not interrupt the signal and was then able to duplicate my results.

I suspect most modern signal generators briefly interrupt their output as the attenuators are switched. This interruption as you step downward causes the PowerSDR AGC to reset itself on each step and the audio output response falsely appears to behave normally. This may be the reason that this anomaly has gone undiscovered.

I ran additional tests in an effort to better understand how the AGC is presently operating and better define any problems observed. The results of those tests are described below.

Figure 1 shows the measured input versus output running PowerSDR W5WC v1.19.3.2. The test conditions are Preamp-ON, 14.35MHz, USB-2.4kHz BW, AGC-T=90 AGC-Slow, AGC Slope Zero, Hang-Threshold-Zero.

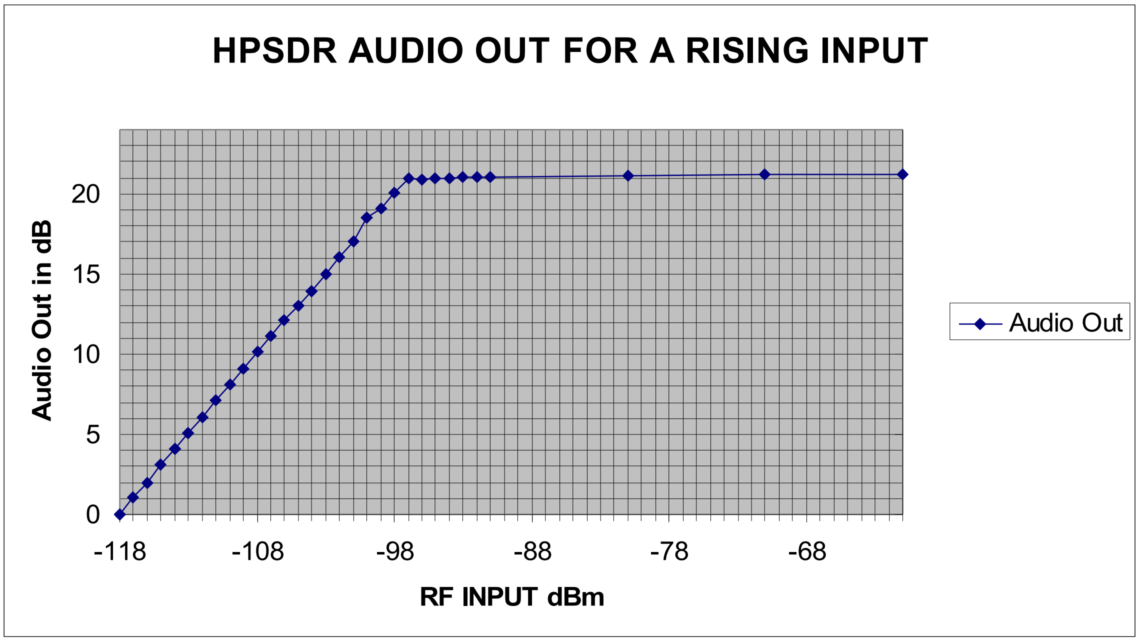

Figure 1 HPSDR AGC Characteristic for A Rising Input Signal

This response is for a rising signal level. It was always identical regardless of the AGC-Slope and Hang-Threshold settings. This response is as would be expected for a properly behaving AGC function except for the fact that the Slope-Control has no effect.

Next the receiver input versus output was measured for a downward stepping signal amplitude. Figure 2 shows the response. Note that the response is not identical to that of a rising input. For a receiver that is operating properly one would expect it to be identical for both cases, upward stepping inputs and downward stepping inputs.

If the AGC-Hang-Threshold setting is greater than zero the output follows the downward stepping input linearly after the amplitude shift exceeds the slope setting in dB. The Hang- Time and Decay-time settings have no effect. The Hang and Decay times are not invoked by the downward going signal.

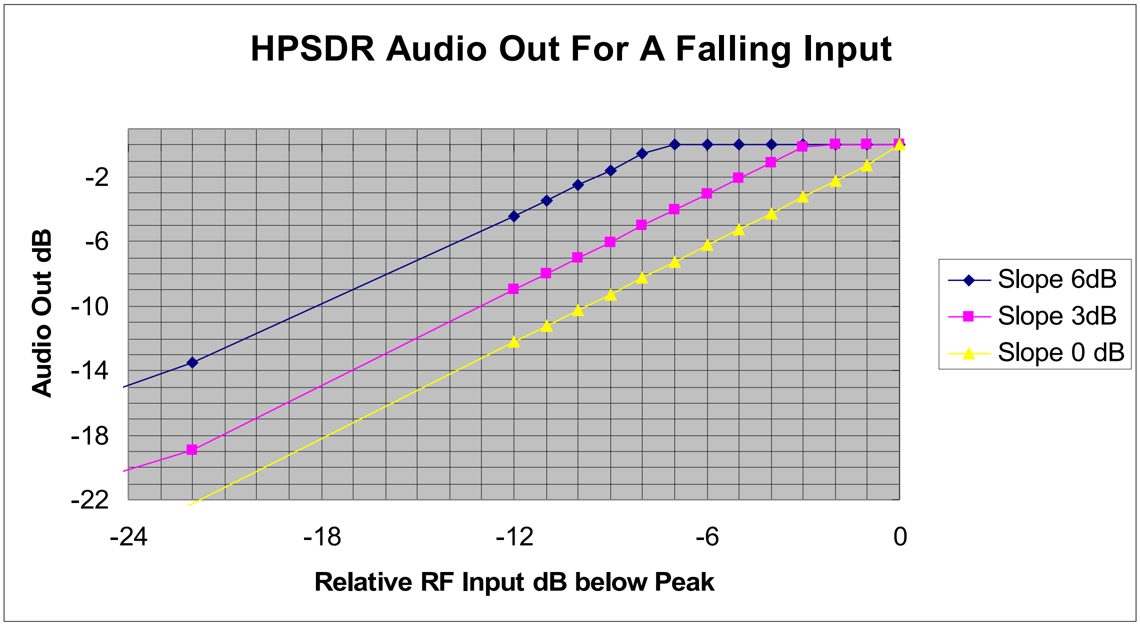

Figure 2 HPSDR AGC Characteristic for a Falling Input Signal

The Zero-dB point (peak) on the graph is referenced to the highest signal level seen by the AGC prior to starting the downward amplitude excursion. The AGC keys the start of its slope effects to that point. For example if the signal level applied prior to starting a downward excursion was -20 dBm, that point would represented by the zero-dB point on the X-axis. If the starting level were -40 dBm it would likewise be represented by the zero-db point and the portion of the response curve shown look essentially identical.

With the Hang-Threshold set to zero, for signals above AGC threshold, on downward amplitude steps the audio output level is returned to its full level as set by the AGC after the Hang and Decay times have expired. The Hang-Time occurs first, followed by the Decay-Time.

So far I have been unable to determine that the Hang-Threshold setting has any effect on AGC operation except for the zero setting versus a non-zero setting effects described above.

A remaining question I wanted to answer was whether the same issue exists in the latest versions of Power-SDR used by Flex Radio or if it is only something that has been introduced in the converted versions of Power-SDR for HPSDR? To investigate I ran similar test on a Flex 1500. The results are described below.

The test system was as above except for Flex 1500 receiver and the computer a Del Latitude E4200, CPU Core2 Duo 1.6GHz, Ram 3GB. The PowerSDR version was Beta 2.0.16.

The response for a rising input is shown in Figure 3. The test conditions were AGC-T 80, AGC-Threshold 10, Preamp 0dB, 2.4 kHz USB, Rx Noise Floor was -109 dBm.

For a rising input the response is similar to that of HPSDR except that the noise floor and AGC thresholds are different because of preamp setting and differing architectures.

As with HPSDR the response was always identical independent of the AGC-Slope and Hang-Threshold settings.

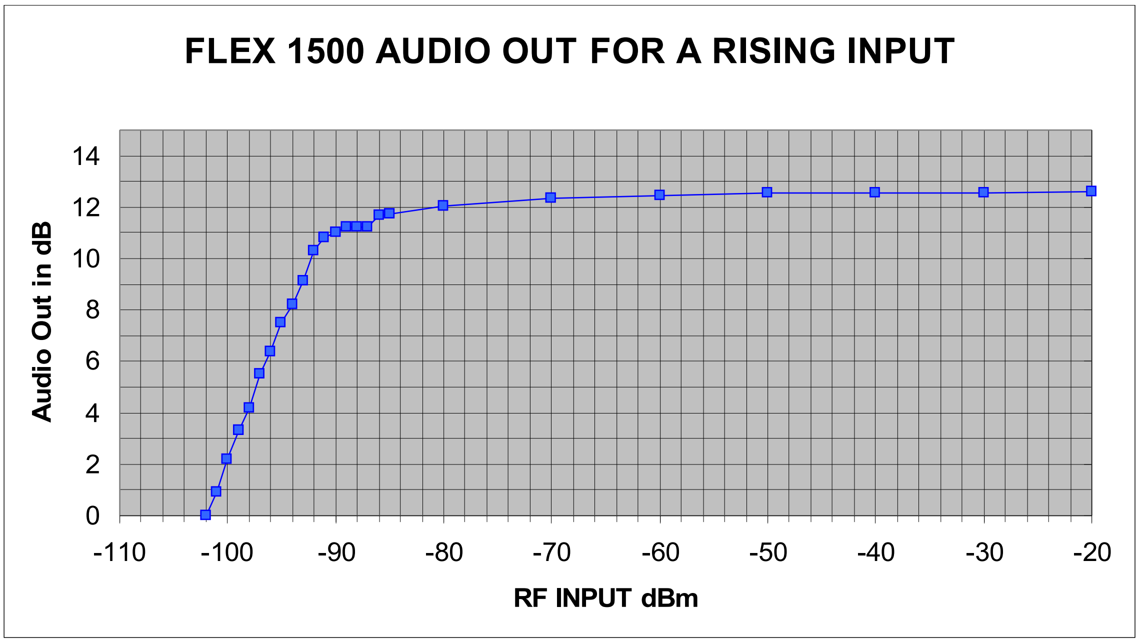

Figure 3 Flex 1500 AGC Characteristic for a Rising Input Signal

The response for a falling input signal at various AGC slope settings is shown in Figure 4. The falling response characteristics are also very similar to those of HPSDR. Instead of producing a sloped response the AGC simply produces a flat audio output level extending over a range from the peak level to the point where the signal has dropped by an amount equal to the slope setting. If the AGC Hang-Threshold setting is Zero, the Slope setting has no effect. On the falling signal test the Flex1500 seems to be more sensitive to the brief interruptions introduced by step attenuators. The test is best done with a continuously variable attenuator or the limited range analog level control provided on some older signal generators. Signal generators that use continuously variable waveguide beyond cutoff attenuators such as in the older Measurements Corporation generators work well.

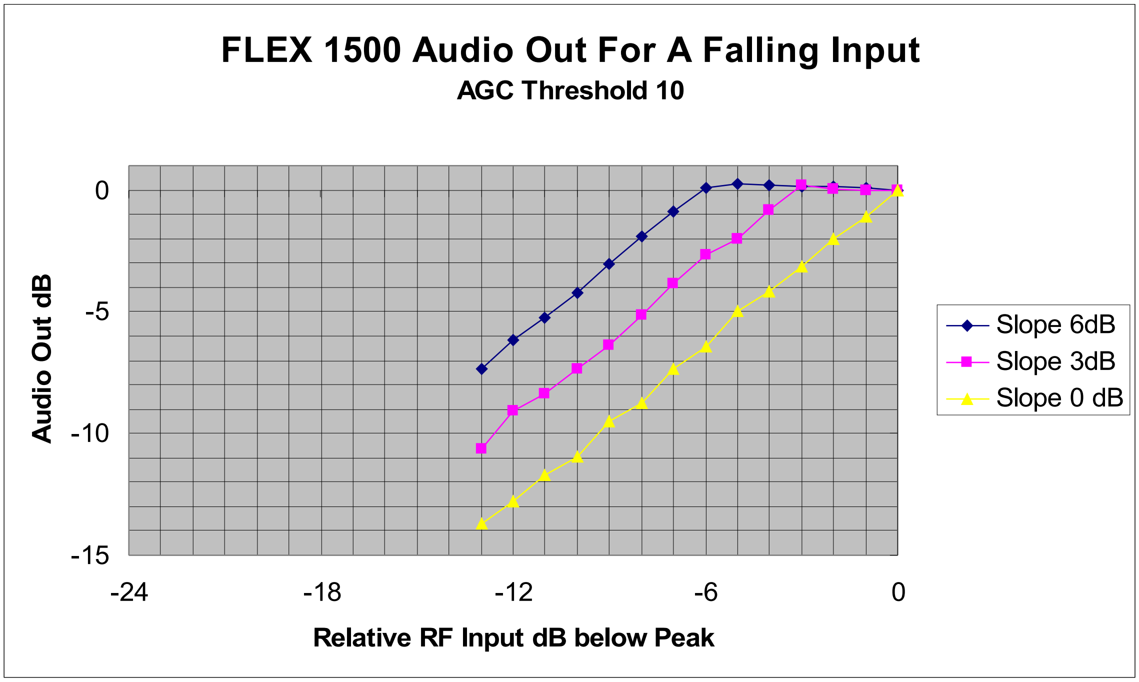

Figure 4 Flex 1500 AGC Characteristic for a Falling Input Signal

To obtain an example from other receivers that use a digital AGC system offering adjustable slope and hang options, I did a similar test on my Elecraft K3. The results are shown in Figure 5. On it, the slope setting uses a numbered scale of zero to fifteen. A setting of fifteen provides a flat slope and zero setting provides the steepest slope. On the K3 the measured slopes for rising and falling signal levels are identical. This is as it should be.

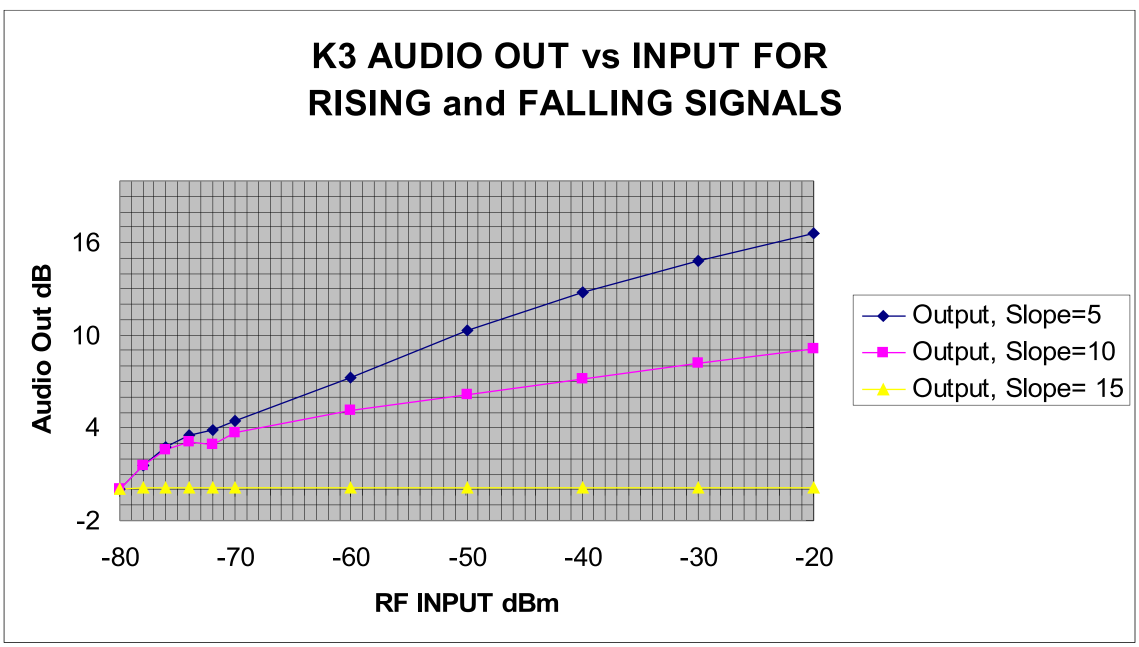

Figure 5 Elecraft K3 Input vs Output For Three Slope Settings.

My conclusions are as follows. Unless my test method is somehow flawed or I am completely misunderstanding the intent of the Power-SDR AGC design, it is not operating properly. The AGC response characteristics should be identical for rising and falling signals except for the response delays introduced by the Hang and Decay times.

The AGC slope option is not implemented properly. PowerSDR does not produce a properly sloped response such as that shown above from the K3 transceiver. The Hang threshold control does not work properly in PowerSDR. It would be highly useful to provide some type of calibrated indicator showing where the Hang-Threshold is set. An alternative might be an indicator to show when the threshold is being exceeded. Perhaps the best indicator would be a line on the Pan-Adapter display indicating the Hang-Threshold placement. For this type of indicator it should automatically correct for the difference between the panadapter noise-bandwidth level and the noise-bandwidth level at the selected receiver bandwidth.

A question for implementing AGC slope control might be, what should be used for the end points over which the slope is established. On the low signal end the obvious point to use is the AGC threshold. On the high end ADC full scale seems a likely choice. The current slope actions of PowerSDR are linked to the highest signal level recently seen by the AGC.

Having an AGC system where the AGC and the Hang and Slope features work properly is highly desirable for HF operation. The current AGC action of PowerSDR substantially degrades the otherwise excellent performance of which the Mercury receiver is capable. Setting the hang threshold to zero makes the current system only moderately acceptable.

An excellent paper on SDR-AGC by Phil Harman VK6APH can be found at *support.flex-radio.com/Downloads.aspx?id=98 .98.*
This paper describes the way I think the AGC system should work.

In conclusion I again want to thank Joe, K5SO for making time in his busy schedule to perform test and for his helpful analysis and advice.

Any comments, observations or corrections on the information presented here will be appreciated.